December 17, 1998

Jeff Beattie
Natural Resource Analyst
American Forests
Washington, DC 20006

Dear Mr. Beattie:

Enclosed is our report entitled Using CITYgreen as an Ecological Analysis & Communication Tool. It was written at American Forests during the period of October 24, 1998 through December 17, 1998. Preliminary work was completed in Worcester, Massachusetts, prior to our arrival in Washington, DC. Copies of this report are simultaneously being submitted to our advisors Chrys Demetry and Angel Rivera for evaluation. Upon faculty review, the original copy of this report will be catalogued in the Gordon Library at Worcester Polytechnic Institute. We appreciate the time that you and others at American Forests have devoted to us.

Sincerely,

Ryan Avey

Milissa Cormier

Manna Neghassi

Carl Nielsen

Report Submitted to:

Chrysanthe Demetry and Angel Rivera

Washington, DC, Project Center

By

Ryan Avey

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In Cooperation With

Jeff Beattie, Natural Resources Analyst

American Forests

CITYGREEN AS AN URBAN ECOSYSTEM ANALYSIS

& COMMUNICATION TOOL

December 17, 1998

This project report is submitted in partial fulfillment of the degree requirements of Worcester Polytechnic Institute. The views and opinions expressed herein are those of the authors and do not necessarily reflect the positions or opinions of American Forests or Worcester Polytechnic Institute.

This report is the product of an education program, and is intended to serve as partial documentation for the evaluation of academic achievement. The report should not be construed as a working document by the reader.

Abstract

Urban planners and policy makers often overlook the benefits that urban forests provide to their surrounding communities. The goal of this project is to evaluate the ability and potential of an economic analysis of tree cover to address the major environmental concerns of the Chesapeake Bay area, and influence public policy and urban planning nationwide. This project, commissioned by American Forests, has three specific objectives: to quantify the benefits associated with tree cover in terms of stormwater management, air quality, and energy conservation; to conduct research and interviews related to the usefulness of CITYgreen software; and to make recommendations on how to improve this process and to increase its value to its users.

The work presented in the following report has been equally contributed to by the following individuals: Ryan Avey, Milissa Cormier, Manna Neghassi, and Carl Nielsen.

The students of this project would like to give special thanks to the following individuals for their contributions during the past seven weeks:

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1.0 EXECUTIVE SUMMARY

American Forest is a non-profit organization founded in 1875. One of their main objectives is analyzing urban ecosystem of several U.S. cities with the help of their software package, CITYgreen. CITYgreen is a program that measures the function and economic value of various urban ecosystems, giving planners and policymakers the data they need to support urban natural resource management programs. It achieves this by placing dollar values in terms of savings, for benefits that tree cover and other resources provide, such as stormwater runoff reduction, pollution removal, and energy conservation.

The objective of our project was to give American Forest recommendations on ways in which they can improve ground-truthing and inventory methods, improvements to CITYgreen, and ways to better communicate their findings, from both the technical and qualitative studies of these urban ecosystems, to environmental planners and public policymakers. This, in turn, will aid them in the completion and reporting of their current Chesapeake Bay Project.

Our methodology primarily consisted of the following: CITYgreen analyses of Arlington, VA and Baltimore, MD; archival research on the Chesapeake Bay watershed; and interviews with urban planners, public policymakers, and CITYgreen users. In order to make useful recommendations, we were required to go through the process involving the data collection from six sites in Arlington, VA, inputting this information into CITYgreen, and running the analysis. From this first-hand experience we were able to give several suggestions to American Forests. However, before presenting these suggestions we needed to understand the role of environmental planners and public

policymakers, how they are related to each other, and how CITYgreen's capabilities can aid them in their work. We went about this by interviewing planners and policymakers from different cities, namely Arlington, VA and Baltimore, MD, to understand their positions and their opinions of such a CITYgreen analysis. In addition, we surveyed the people who purchased CITYgreen to obtain their different reactions, perspectives, and suggestions. We took all this information into account when giving American Forest our recommendations.

Our conclusions deal with the evaluation of the CITYgreen process in its entirety. From this we were able to obtain the strong and weak aspects of this process, determine the potential impact CITYgreen could have on the Chesapeake Bay, and suggest to American Forests possible steps for the future. By investigating the whole CITYgreen process, we learned more about how the tree cover benefits can effectively be utilized by planners and policymakers and best address the major environmental issues concerning them. This helped us arrive at some conclusions and recommendations useful to American Forests.

From our results and analysis, we have arrived at the following conclusions. First, we have concluded that many of the Chesapeake Bay's problems can be addressed, or even solved, using a CITYgreen analysis. For example, many of the Bay's general problems involves non-point source pollution, which can then be linked to stormwater runoff, an area addressed in a CITYgreen analysis. Another example of a community that could benefit from a CITYgreen analysis is Arlington, VA, whose planners have defined excess stormwater runoff as the major issue there. Secondly, American Forests must decide the future of CITYgreen software and refine its intentions and focus.

Currently, CITYgreen is being used widely by urban planners, policymakers, and large and small communities alike. As a result, each of these types of users has different expectations of the program's capabilities. We recommend that American Forests establish a firm marketing strategy, targeting their primary users. Once these marketing and development strategies have been defined, the CITYgreen process could then be further improved to best address the needs of these target users: policymakers, urban planners, or both. Finally, we generally feel that CITYgreen *is* a good communicative tool for educating communities of tree cover benefits, and could potentially impact urban planning and policymaking of those areas.

Based upon the conclusions mentioned above, we were able to make the following recommendations and suggestions to American Forests and Arlington, VA. We feel that American Forests should choose one of two alternatives when deciding how to market and improve CITYgreen in the future. The first alternative would be to continue marketing the software as a public policy and communication tool, while making some general improvements to the program and system. Some of these improvements include a custom tree-data entry system, a new planting function, more versatile growth modeling capabilities, and modifications to the users' manual. The second alternative for American Forests would be to further extend CITYgreen's capabilities to incorporate the needs of both public policymakers and urban planners. This would call for perhaps more drastic changes to the program in the future, such as algorithms that are more complex and more specific to the study region, and even the possibility of creating versions of CITYgreen: a simplified version for small communities and a more sophisticated one for larger-scale studies.

We further recommend that Arlington, VA set a final goal equal to American Forests' recommended forty percent tree coverage for the entire city. This project would involve an initial focus on planting and conserving trees in residential areas, in an attempt to reach fifty-percent residential tree coverage. Also, Arlington should consider increasing tree cover in industrial areas, due to the fact that thirty-two percent of the county is industrial.

Overall, American Forests should improve the way in which the communities being studied apply a CITYgreen analysis. Once the Chesapeake Bay Project is completed, American Forests should direct their efforts towards communities who are most interested in its findings, and whose major environmental problems are best addressed by its Chesapeake Bay CITYgreen analysis.

2.0 INTRODUCTION

Forests are valuable natural resources, providing their surrounding ecosystems with numerous benefits. For example, the roots of trees help reduce stormwater runoff through absorption. In addition, trees shade houses and buildings, conserving energy and reducing cooling costs. Trees can even remove carbon from the atmosphere through sequestration and store it as chemical bonds. They also eliminate other harmful pollutants from the air we breathe. These are just a few of the many benefits trees and forests can provide.

Our project is an exploration of how urban forests can protect other natural resources, and benefit entire communities, namely the Chesapeake Bay watershed. That area has become one of much interest in recent years, both because of its rapidly increasing population and because the health of the estuary has declined. Thus, this Chesapeake Bay Project is a good example of how CITYgreen can be used to show the importance of tree cover in maintaining ecological prosperity. For this reason, American Forests commissioned this project and decided to conduct an ecological analysis of this area in order to address these environmental concerns.

American Forests hopes to promote an awareness of the importance of urban forests, and the stability of their ecosystems. Urban planning currently does not take into account important natural resource information such as the importance of tree cover. One example given by Jeff Beattie, of American Forests, is that the effects tree cover can have on water quality are not seriously considered in public policy development. This project is designed to assign values to these natural resources and determine how to best communicate these findings to key public policy makers and to urban planners.

Ultimately, American Forests strives to affect urban planning and public policy making through such an economic analysis on tree cover.

This project addresses one fundamental question: How can valuing tree cover economically most effectively (1) address the major environmental concerns and (2) ultimately affect the urban planning of the Chesapeake Bay watershed? To address the two issues stated above, the project can be broken down into three objectives: (1) assigning economic value to the benefits of tree cover in terms of stormwater management, air quality, and energy conservation, in the Chesapeake Bay Area (especially Arlington, VA and Baltimore, MD), (2) relating these findings to major and specific environmental issues of the area, and (3) communicating these findings to American Forests, and giving recommendations concerning the CITYgreen analysis process and its impact.

The results and conclusions from this data analysis will be of particular interest to American Forests, policy makers, and urban planners of the Chesapeake Bay area. Our data analysis of specific sites within the Bay watershed will help to communicate the importance of its tree cover in terms of three areas of savings: energy conservation, pollution reduction, and stormwater reduction benefits. American Forests will use these findings to influence decisions regarding public policy and urban planning.

Our methodology can be grouped into five main tasks. Throughout the entire project, we conducted archival research of the most important environmental issues of the Chesapeake Bay area. As the project progressed, we concentrated this research on two specific areas of the Bay: Arlington, VA and Baltimore MD. Our second major project task was collecting data. We visited six sample sites in Arlington, VA, a Chesapeake

Bay Project site. At these sites, trees were located on an aerial map, measurements were taken, and a visual analysis of the surroundings was recorded. Upon completing this data collection, this raw data was then entered into the CITYgreen software, where a complex algorithm was used to analyze the tree cover of the site economically. The fourth task was to conduct interviews with government officials, urban planners, and CITYgreen users. These interviews, along with the results from the other tasks, provided us with the information needed to make meaningful recommendations to American Forests. These recommendations will help improve the CITYgreen process, and help American Forests communicate tree cover's value to the Chesapeake Bay communities, ultimately impacting public policy and urban planning of that region.

Worcester Polytechnic Institute's Interactive Qualifying Project (IQP) addresses a topic that relates science and technology to society. It is designed to require students to understand the priorities of society, develop the ability to communicate effectively with diverse groups, organize and derive solutions to complex problems, and gain an awareness of the interrelationships between technology and people. This project satisfies the IQP requirements by relating environmental data to the social aspect of urban planning.

This report was prepared by members of Worcester Polytechnic Institute Washington, DC. Project Center. The relationship of the Center to American Forests and the relevance of the topic to American Forests are presented in Appendix A.

3.0 LITERATURE REVIEW

This project, sponsored by American Forests, involves the investigation of the Chesapeake Bay area ecosystem and its influence on public policy. This literature review gives important background information on ecosystems, the Chesapeake Bay watershed, and other related areas. The material presented here will help to familiarize the reader with important information directly related to this project. The contents of this literature review will include the following: introduction to ecosystems, urban ecosystems and forests, benefits and problems of ecosystems, the Chesapeake Bay area, laws and public policy, and ecosystem analysis using CITYgreen software.

3.1 Introduction to Ecosystems

An ecosystem is generally defined in Marion Webster's Third International Dictionary as an ecological community considered together with the nonliving factors of its environment as a unit. American Forests (1996c) has defined an ecosystem as the interaction between biological species and their non-biological environment, which function together to sustain life.

The interrelation between an ecosystem's organisms and physical factors through the flow of energy and chemicals form the ecosystem's trophic (See Glossary) structure (Ecology, 1997). Trophic structure is a way of defining an ecosystem using a system which groups organisms based upon feeding level, their resultant energy flow, and chemical cycling patterns. The living mass of a given population at any given time is called its biomass; a change in mass with time is referred to as net productivity (Ecology, 1997).

An important component of any ecosystem is plants, and in terrestrial systems, they are among the most important. About fifty percent of the dry mass of a tree is composed of carbon. When trees are cut down, they can no longer absorb carbon from the air. Also if the wood is later incinerated, the carbon from its mass goes into the air. An increase in carbon in an ecosystem's atmosphere can have many detrimental effects including a rise in temperature. In this manner, a tree's carbon storage and sequestration abilities play vital roles in the carbon cycle.

Ecosystems, according to Golley (1997), are structured into three major parts: (1) the physical envelope of air or water that surrounds the living unit and provides its climate; (2) the substrate on which the living unit rests or is anchored, such as soil, rock, or bottom sediments; and (3) the plants, animals, and microorganisms living within the given habitat. There are various types of ecosystems, and they are defined according to the following characteristics: geological features, soils, climate, and organism availability. Some examples are forests, fields, lakes, rivers, and oceans (Golley, 1997).

3.1.1 Urban Ecosystems and Urban Forests

An urban ecosystem is significantly different from a rural ecosystem. "Urban" refers to a city and its surrounding suburban communities. There are greater levels of air pollution in an urban ecosystem, and the ways in which water, air, and nutrients are cycled are sometimes very different (American Forests, 1996b).

Any arrangement of trees in an urban setting is classified as an urban forest (Fernandez, 1993). This may include urban forests as small as a row of trees along a sidewalk or as large as forests covering many acres of land. Fernandez (1993) defines a forest ecosystem as a terrestrial plant community dominated by trees. The ability of a forest ecosystem to function depends upon the vertebrates, invertebrates, and microorganisms that live there, as well as its connections to the surrounding air and water systems. Trees are interdependent with the air and water systems that surround them, depending on these systems for life. Trees also act as natural filters that keep the air and water clean. The air and water quality within the environment is crucial to the health of the ecosystem. Because trees improve the air and water quality of an urban forest, they too are equally important to an ecosystem's health.

Forests, unlike many other terrestrial ecosystems, have a pronounced vertical distribution of critical forest components such as foliage, wood, subordinate vegetation, and root system (Moll, 1997). As stated by Moll (1997), foliage distribution is an extremely important factor in forest structure. Foliage is important because it provides the surface area where photosynthesis takes place. A tree's leaves are also directly related to leaf area index, a term used to describe the photosynthetic structure of a forest. The leaf area index of a forest relates the surface area of foliage to the ground surface, and is also linked to the forest's water balance and to the age of the stand (See Glossary).

With an adequate water supply the leaf area of a forest increases. Water balance is defined by Moll (1997) as ground water available to the vegetation versus water evaporated from leaves, and is directly related to the water supply. The age of a stand is the time elapsed since the last ecological disturbance, and also impacts a forest's leaf area. In addition to foliage, wood, bark, and roots make up a forest's components. Wood and bark are the connective tissues that make up the stems and branches. They are used to conduct water and nutrients to the foliage and to provide lateral support. The root system is a major structural component of a forest ecosystem. It is located in the surface soil, approximately three to six feet down. This system of coarse woody roots, fine absorbing root, and mycorrhizae (See Glossary) acts to anchor the tree, transport water to upper parts of the tree, and absorb water and nutrients from the soil.

Streams and oceans are often affected by watershed disturbances (See Glossary), such as clear cutting, occurring in the surrounding forests. These effects are especially crucial if the disturbances occur in the watershed (See Glossary) immediately adjacent to the body of water (Meyer, 1997). One effect is that the nature and extent of vegetation on the watershed affects water flow and flooding intensity. Additionally, water chemistry and concentrations of various nutrients are altered as they are absorbed by forest vegetation. Also, high tree population also decreases the amount of light reaching a given body of water, thus maintaining a moderate water temperature. The amount of sediment entering the water also affects watershed activities. For example, dead wood falling into the water can provide nutrients and a habitat for water life. This organic matter produced by the forests provides a food source for these water organisms.

As stated earlier, these watershed areas are susceptible to disturbances in the forests (Grier, 1997). The surrounding water may be altered by any practices within the forest, especially in the part of the watershed immediately adjacent to the bay. A watershed ecosystem may also be altered by lumbering, introduction of new species, road construction, or uncontrolled chemical input. These chemicals may come from industry or sewer systems, and may include acids that alter plant growth.

3.2 Benefits of Urban Forestry

It is commonly known that trees provide beneficial functions to their surrounding environment, making them an important part of many ecosystems. Urban areas have smaller amounts of vegetation, making the average temperature higher compared to rural areas. For example, tests done by the EPA (Environmental Protection Agency) on the city of Atlanta, GA showed that there was up to a twelve degree temperature difference between downtown Atlanta and the surrounding rural suburbs (American Forests, 1996d).

Trees help keep temperatures lower by absorbing the sun's rays, which they use for energy to make food. Generally, this benefit varies from species to species, depending on the size and shape of the leaves. In an urban setting, trees that are close to windows will help to keep cooling costs low in the warm months. Furthermore, vegetation also absorbs water that would otherwise runoff into storm sewers. This water helps to maintain the soil and its organisms in addition to keeping it from drying out. Through the presence of this moisture and shade, the overall temperature is kept moderate. This is just one example of the benefits of trees to their ecosystem.

3.2.1 Lower Temperatures in Forested Areas

A centralized area of high temperature, for example downtown Atlanta, is called a heat island. Darker materials in the city, such as roofing shingles or asphalt, store more heat from the sun than lighter-colored materials such as grass (Rosenfeld, Romm, Akbari, & Lloyd, 1996). These rays of light transport heat energy away from the earth, resulting in a cooler temperature on the surface. Trees also reflect some sunlight back up to the sky, and can even absorb any unreflected radiation. This energy is then used to stimulate evaporation, a process in which heat energy is used to transfer water from a liquid to a gas, resulting in cooler temperatures. This process of keeping stored heat to a minimum results in a more rapid nighttime loss of stored heat from light colored areas such as parks, than from dark colored areas such as parking lots (Heisler, 1995). In this way, the combination of absorption, reflection, and evaporation has a very beneficial cooling effect on urban forests.

3.2.2 Other Important Benefits

Trees perform many other beneficial functions as well. For one thing, trees reduce the amount of the sun's harmful ultraviolet rays reaching the earth's surface via absorption. Likewise, the leaves and branches of trees filter the air and remove dust, ash, pollen, smoke, harmful gases, and other pollutants (Nowak, 1994). This results in better overall air quality of the urban forest, without actually removing these pollutants from the ecosystem. As Tagtow (1990) states, trees in urban forests can protect cities from the hot summer sun and defend them from cold winter winds. They also provide noise reduction by deflecting and absorbing sound waves with their trunks, branches, and leaves. Some other social benefits of urban forests include physical and psychological boundaries, human contact with nature, and the many aesthetic aspects that can serve as refuge from the hustle and bustle of urban life (Tagtow, 1990).

3.3 Problems within Urban Forests and Ecosystems

Modern urban ecosystems are altered by many environmental problems. When considering the water media alone there are problems with erosion and direct water pollution, both of which are influenced by deforestation. One task of the environmental engineer involves designing stormwater removal, storage, and treatment facilities. These facilities must be designed to handle a maximum storm event within their given planning horizon. As a logical consequence, the cost of the facility increases with a needed increased capacity. The presence of trees can decrease the amount of stormwater runoff and therefore save money in building these facilities. By removing trees for construction of stormwater runoff facilities, engineers sometimes overlook the many naturally occurring benefits trees provide, including stormwater runoff reduction, pollution removal, and energy conservation. (Moll & Petit, 1994). If the environmental impacts are considered in planning, future necessary corrective measures can be prevented. By considering the relationship between natural and human-made environments and incorporating it into planning decisions, many problems facing urban ecosystems can be eliminated (Moll & Petit, 1994).

3.3.1 Erosion

Erosion is defined by Nebel (1996) as the process in which soil and humus (See Glossary) particles are picked up and carried away by either water or wind. Erosion may occur gradually over time, or suddenly, as adjacent farm fields are washed into a river during a heavy storm, for example. In terrestrial ecosystems, such as the area surrounding the Chesapeake Bay, a blanket of plants provides cover for and binds the soil together with its complex system of roots (Nebel, 1996). Without this protection, seemingly harmless rainfall could start splash erosion (See Glossary). A decrease in infiltration (See Glossary) will cause an increase in stormwater runoff, which in turn causes sheet erosion (See Glossary). In addition, when raindrops combine in small streams, they cause gully erosion (See Glossary). Trees and grass counteract these three types of erosion by preventing direct contact of the falling rain with the soil. In this way, the plants bear the initial impact, and the rain slowly infiltrates the soil.

3.3.2 Water Pollution

Erosion contributes to water pollution through sedimentation (See Glossary), which can affect both the natural and the economic benefits of the Chesapeake Bay. Sedimentation causes many problems: clogs channels, fills reservoirs, kills fish, and generally upsets the ecosystems of streams, rivers, bays and estuaries (Nebel & Wright, 1996). In particular, sediment buildup in waterways may cause problems with shipping traffic, which makes it an economic concern. Consequently, this type of pollution can also block light, affecting small plants that are low on the food chain. Any disruption in this food source can effect the rest of the food chain and therefore have large effects on the whole bay ecosystem.

3.3.3 Deforestation

Forest ecosystems are extremely efficient systems both for holding and recycling nutrients and for holding and absorbing water, because they maintain and protect a very porous, humus-rich topsoil (Nebel &Wright, 1996). When an area is deforested, the tree canopy can no longer protect the soil and the impact of rainwater causes compacting and sealing of the porous topsoil. This compacting of the soil can have two drastic effects: runoff and leaching (See Glossary).

Runoff occurs as a result of the reduction of underground spaces. Much like a sponge under pressure, the compacted soil can not hold a lot of water. The topsoil becomes saturated with water and can slide off of any area with a slope and into waterways, leaving barren subsoil that continues to erode (Nebel & Wright, 1996).

Leaching (See Glossary) involves the removal of materials that are present in or on the topsoil. This happens when the nutrients, buried wastes, and other compounds are dissolved in water and carried away. Thus, the material that leaches off as a result of loss of tree cover can contaminate ground water (Nebel & Wright, 1996).

In farming areas and in rain forests, leaching is of particular concern, but it could be crucial to any ecosystem. In some ecosystems, including rainforest ecosystems, the soil is lacking nutrients as a result of leaching. All of the nutrients which support the luxuriant growth of tropical forests are held in the biomass (See Glossary) (Nebel & Wright, 1996). Therefore, removal of the biomass through deforestation or other means will leave the system with poor soil, lacking in nutrients. If trees were cut down because the land was intended for agricultural purposes, the soil would be depleted of nutrients in a very short period of time through leaching, further increasing the possibility of water contamination.

3.4 The Chesapeake Bay Watershed

The Chesapeake Bay is the largest estuary (See Glossary) in the United States (Cronin, 1988). The Bay is 156 miles long and 25.6 wide at its broadest point and contains 11.5×10^9 m^2 of surface area and a volume of 74×10^9 m^3. Its deepest point is 53 m (175 ft) but only averages 8 m (27 ft) of depth. It receives most of its water from four states including New York, Pennsylvania, Maryland and Virginia, and receives lesser portions from West Virginia and Delaware. Principal inflow comes from the Susquehanna system providing fifty percent of all fresh water entering the system. In addition to the Susquehanna, the Potomac River provides eighteen percent, the James River provides fourteen percent, and the remaining comes from all the other rivers of the eastern shores.

According to Hines & Stroup (1983), some other important features of the Bay vary. The amount of fresh water entering the system in relation to the salt water from the ocean can influence the temperature and currents. Estuarine chemistry, they say, is influenced by rainfall, temperature, water flowing into the system, oxygen demand, nutrients, many toxicants and other chemicals.

3.4.1 Estuaries

Estuaries are coastal bodies of water emptying into the seas or oceans of the world through semi-restricted openings within which the salt water from the sea is diluted by fresh water from land drainage (Pritchard, 1985). According to Pritchard (1985), such systems behave like reservoirs because of their physical, chemical and biological features that differ from those of the ocean. Generally speaking, uncontaminated estuaries are extremely fertile, supporting a large quantity of animal and plant organisms.

The sheltered waters and extensive tidal shorelines of estuaries also provide ports, industrial and residential sites, and even tourist attractions (Beardsley, 1980). These attractions are the reason that estuarine shorelines are usually the first place to be populated when countries are colonized from the sea. Beardsley (1980) reasons that due to their social and economic importance, as well as the chemical and biological complexities, estuaries have become the center of attention of much scientific study and technological advancement in various parts in the world.

Estuaries are naturally complex and dynamic, and can be affected by various sudden changes, according to Loesch (1991). They are also subject to the small fluctuations that occur over long periods of time such as dry years, wet years, and years of average annual rainfall, as well as to the smaller but more frequent daily, monthly and seasonal changes.

Despite the research and knowledge developed by recent scientists and institutions, and even their predecessors, much of the scientific and technological importance remains to be discovered. Thus, it is not yet possible to answer many of the critical questions concerning estuaries like the Chesapeake Bay.

3.4.2 The Chesapeake Bay as an Important Resource

The Chesapeake Bay is a valuable natural resource, as explained by Loesch (1995). For instance, the Bay's blue crab production averaged eighty-six million pounds annually from 1983 to 1992, contributing to more than half the nation's catch. More than half of the nations soft-shelled clams also comes from the Bay. During the warmer months several species of fish enter the Bay to feed on its rich food supply. The Chesapeake is also an important commercial waterway and contains one of the nation's five major North Atlantic ports, the Hampton Roads Complex.

Waterfowl and other birds migrating south along the Atlantic stop to find food and shelter in the many marshes that are located in the Chesapeake Bay area (Loesch, 1995). It is also a winter home for swans, Canada geese and a variety of ducks including canvasbacks, pintails, scoters and ruddy ducks. During the winter of 1992 to 1994, an average of 28,000 swans 300,000 geese and 650,000 ducks lived on the Bay.

3.4.3 The Chesapeake Bay as a Threatened Resource

The Chesapeake Bay is an extremely complex ecosystem that continues to grow commercially. However, this increase in industrial, recreational, and urban activities continues to threaten the Bay and its living resources (Beardsley, 1980). For example, in recent years, over-harvesting and loss of habitat threatens the fish and shellfish species. These two factors, in addition to disease, have also lowered the oyster population. Furthermore, excess sediment and nutrients have greatly decreased the Bay's water quality. Hypoxia and anoxia (See Glossary), two of Beardsley's (1980) examples, are particularly harmful to benthic species (See Glossary)- Finally, toxic substances accumulate in the tissues of birds, fish, and shellfish. The concentration of these toxins are also known to increase with higher location on the food chain.

3.4.3.1 Current Environmental Problems of the Chesapeake Bay Watershed

The Chesapeake Bay area, and society as a whole, faces many environmental problems desperately in need of solutions. Problems that need to be addressed in the Chesapeake Bay area include stormwater runoff, water quality, lack of tree cover, endangered species, pollution, and fragmentation.

Non-point source pollution (See Glossary) is one of the most serious problems threatening Maryland's water resource today (The Problem, 1998). The definition of non-point source pollution is runoff caused by stormwater or irrigation water. It may contain several types of pollutants, namely: sediment, nutrients, toxins, and pathogens. These substances are deposited in lakes, rivers, wetlands, and bays. There are many general sources of non-point source pollution: agriculture, urban stormwater runoff, mining, forestry, septic systems, recreational boating, and construction. These pollutants threaten the health of Maryland's water resources, especially the Chesapeake Bay (The Problem, 1998).

Another environmental problem is the Pfiesteria piscicida, a toxic dinoflagellate. It is the primary cause of fish kills and disease. Pfiesteria has a complex life cycle that includes at least twenty-four different forms. Depending on its stage in life, Pfiesteria ranges from 5-450 um along the major cell dimension, and 7-60 um in diameter. This organism can be found in bottom mud or sediment of the North Carolina estuaries. The small cells swim toward the fish and excrete potent toxins which cause open bleeding sores to the skin. Pfiesteria feeds on tissue and blood from these sores. After the fish is dead, this organism feeds on its remains (Pfiesteria, 1998).

The Pfiesteria piscida microbe is one of the latest environmental menaces to the Chesapeake Bay. Pfiesteria has killed thousands of fish in the Bay within the last two years. Many scientists believe this is non-point source pollution originating from uncontrolled animal waste, and are therefore outside the scope of the law. Chicken manure and hog slurry, common fertilizer ingredients, is believed to have contained the microbe. The loss of tree cover in this area can be linked to this problem because it was carried to the bay along with the increasing stormwater runoff. As a direct result of deforestation, the microbe entered the Chesapeake Bay, where it infected thousands of fish and wildlife (Pfiesteria, 1998).

An additional implication of runoff into the Chesapeake Bay is "nutrient shock." "Nutrient shock" occurs when large amounts of melting snow combine with stormwater to produce abnormally high amounts of freshwater runoff into the Bay. This results in a large reduction in the nutrient concentration of the Bay and may be devastating to the organisms living there.

Another major area of concern to the Chesapeake Bay ecosystem is the destruction of natural riparian zones (See Glossary). Due to their importance to the Bay, the planting of man-made riparian zones is extremely important. A riparian zone is an area of trees and various other types of vegetation that is located along the shoreline of any body of water. Riparian zones are typically divided into three areas: the streamside zone, the middle zone, and the outer zone. A riparian zone, or buffer, maintains the integrity of a waterway through its many functions. It helps to provide clean water by filtering nutrients contained in lawn fertilizers, chemicals, pesticides, and sediments out of stormwater. Riparian zones act as forest buffers by stabilizing stream banks and preventing erosion (Riparian, 1998).

A forest buffer can keep stream temperatures cooler through its shade. Many species are very sensitive to temperature change; therefore this shade is essential for the survival of many fish and other aquatic species. The trees provide habitats for many species of birds and other animals. In addition to their benefits to wildlife, riparian zones have many other economic and aesthetic benefits, including lowered utility bills, increased property values, blocked noise pollution and enhanced privacy (Riparian, 1998).

One of the more recent concerns in the Chesapeake Bay watershed is that of forest fragmentation (See Glossary), as pointed out by Blankenship (1998). The Chesapeake Bay watershed, according to Bay Program figures, is losing more than 100 acres of woodlands a day. Not to mention, in the last decade, the watershed has lost more than 471,000 acres of forests—an area half the size of Delaware. The problem lies in more than just amounts of deforestation, however. According to Blankenship (1998) it is the fact that today, the biggest problems result from the fact that forests remain as "patches" of various sizes, often disconnected from any other woodlands. This is known as fragmentation.

Blankenship (1998) points out that when forests are fragmented, the individual pieces add up to far less than the whole. Small, fragmented forests often do not provide many of the services people value, from recreation to wildlife habitat to water quality protection. In addition, fragmentation results in social and economic problems as well.

According to Blankenship (1998), forests and forest values can be diminished in many ways by fragmentation. These impacts involve forest health and diversity, forest habitat, forest ecology functions, economically viable forest units, forest recreation, and community livability. First, fragmented forests can have a higher incidence of exotic species and invasive weeds, and may be more vulnerable to insect and disease attacks such as the southern pine beetle and fire. Secondly, Wildlife populations are dramatically impacted by forest fragmentation, resulting in lower species diversity or even elimination as habitat is reduced and natural corridors are degraded or destroyed. In addition, environments, altered severely by development and associated stormwater practices, can produce changes in streams, such as increased flooding frequencies, and lower heath and water quality. Fragmentation and ownership parcelization can also lead to a greatly reduced or completely eliminated base for valuable forest product production, a major contributor to local and state economies. Furthermore, this could also lead to reduced access for privacy, and lost recreational opportunity. Finally, despite the attractiveness of economic development to rural communities, forest loss during growth and development can reduce economic diversity and lower the quality of life in a community (Blankenship, 1992).

The Chesapeake Bay Program is a unique regional partnership among many of the Bay's state governments, as well as the federal government. This program has been leading and directing the restoration of the Chesapeake Bay since 1983. According to this program, nutrient pollution, or the abundance of nitrogen and phosphorous, is the most significant and widespread pollution threat to the Chesapeake Bay. As a result, the reduction of nutrients has become a major focus of the Chesapeake Bay Program's efforts. Many efforts have been made to reduce the amount of pollution flowing into the bay by the year 2000.

While many improvements have been made, some serious threats remain. As an example, in Old Town Alexandria, VA, and the District of Columbia, raw sewage still flows into the river after each rainstorm. Also, in urban west Alexandria, new homes are being built in a forested area along a tributary of Holmes Run, on land that was part of the Winkler Botanical Preserve—the city's only large native forest. Another example is near Mason Neck, several large new residential developments are being planned for this historic and, until recently, rural part of Fairfax County. The hog waste that the Smithfield meat processing company was allowed to dump in the Pagan River, a bay tributary, shows that Virginia has been more interested in economic development than the problem of clean water. Across the Potomac in Maryland, Charles County has chosen the pristine tidal Mattawoman Creek watershed as one of its primary growth areas, and is on the verge of approving construction of what amounts to a new city. If approved, the proposed twelve lane Woodrow Wilson Bridge would encourage urban sprawl and destroy valuable wetlands. All of these situations will increase the amount of pollutants flowing into the Chesapeake Bay and will lead to oxygen depletion, killing off many species of plants and animals.

3.5 Public Policy and Relevant Laws

Public Policy is an important factor affecting the way in which ecosystems and urban forests are managed. For more than a century, the government has passed legislation in response to an obvious need to help reduce the stress on our environment (Gilman, 1992). However, American Forests and many other organizations, as well as the general public, are strongly pushing for the implementation of more legislation. Public policy can help preserve our vital natural resources and prevent the destruction of our earth's ecosystems.

3.5.1 Policy Concerning Urban Forests & Ecosystems

As early as the 1800's, people began to realize the need for the conservation of natural resources, namely due to the excessive destruction of timber and firewood during that time. The first law dealing with the increase in timber harvesting was the Timber

Culture Act of 1873 (Gilman, 1992). By the late 19^{th} century, global awareness was growing and the push for conservation resulted in the emergence of numerous national parks and forests.

In response to large opposition to the government's control over "national lands", the Forest Management Act of 1897 was passed. This national legislation limited the power the state and national government possessed concerning forest regulation. Throughout the early 20^{th} century, legislation was passed giving states the power to regulate land usage and the federal government power to acquire private land with the state's consent. Laws were also passed in the mid-1900's regulating government spending in forest management and aiding the reinforcement of our natural resources (Cross, Freely & Ierardi, 1995).

The Clean Air (1970) and Clean Water Acts (1970) are two more recent forms of policy that have created federally supervised regulatory programs for achieving a higher quality of air and water in the United States (Cross, Freely & Ierardi, 1995). The Clean Air Act Amendments are a series of amendments to the Clean Air Act of 1970, aimed at improving pollution control regulations created by the 1955 Air Pollution Act. The goals of these amendments, set by Congress and the Environmental Protection Agency (EPA), were to establish minimum state air quality standards under the National Ambient Air Quality Standards (NAAQSs). Under that Act, pollutants were classified according to their toxicity to humans, and emissions standards were created for main sources of these pollutants (Pourtney, 1990). Communities that do not meet the standards set forth in this document are classified as non-attainment areas.

The Clean Water Act of 1970 is the largest single water quality control piece of legislation ever passed. This act aimed to eliminate excessive pollution and littering of bodies of water in the country. The Clean Water Act consists of six titles summarized below (Pourtney, 1990):

1. Forbids the dumping of toxic pollutants, while providing funds for the construction of water treatment plants, waste management, and development of new technology to eliminate pollution.

2. Provides for federal funding for state water management and loan availability through the Federal Financing Bank.

3. Provides standards for the National Pollutant Discharge Elimination System (NPDES) which involves both technology and water quality based limits.

4. Requires licenses from all point-source discharges and allows for criminal prosecution for discharging without a license.

5. Gives the EPA the authority to enforce all titles of the Clean Water Act, gives any citizen the right to take civil action against violators, and allows states to bring suits against the federal government.

6. States that the EPA will match twenty percent of federal contributions to states provide that one percent or $100,000 is set aside for project planning.

Therefore, the Clean Air and Clean Water Acts aimed to improve the overall quality of ecosystems across the nation, namely in the areas of air pollution and water contamination. The CITYgreen program developed by American Forests can be used to address these two major issues, as well as other concerns of the Chesapeake Bay area, such as excess stormwater runoff and energy conservation. By placing an economic value on the Bay's natural resources, American Forests' Chesapeake Bay Project can further emphasize the importance of these Acts.

3.5.2 Public Policy of the Chesapeake Bay Watershed

Legislative decisions regarding the management of the Chesapeake Bay area ecosystem, as described by Yaffee (1996), largely come from the studies performed on the Chesapeake Bay by the EPA. In 1972, soon after Hurricane Agnes devastated the Mid-Atlantic States, the EPA conducted a five-year, twenty-five million-dollar study of the Chesapeake Bay area. The research focused on the resources, uses, and stresses of the Chesapeake Bay area. Five years later the Chesapeake Bay Commission (CBC) was created with representatives from Virginia, Pennsylvania, and Maryland. The Commission's objective was to coordinate approaches to state legislation regarding the Bay. The EPA's final report on the Chesapeake was issued in 1983.

The First Chesapeake Bay Agreement was signed by Maryland, Virginia, Pennsylvania, Washington DC, the EPA, and the Chesapeake Bay Commission in 1983. Of the ten areas of environmental concern enumerated in the EPA's report, three were given priority. Until that time, little had been performed on these three topics: nutrient enrichment, toxins, and decreases in submerged aquatic vegetation. The official objective of the program was to develop and implement cooperative plans to improve and protect water quality and the living the resources of the Chesapeake Bay (Yaffee, 1996).

The Second Chesapeake Bay Agreement was signed in 1987 and then amended again in 1992. The 1987 document addressed six issues: living resources, water quality, population increase, public education and participation, public access and governance. (Yaffee, 1996).

3.5.3 Organizations for the Preservation of the Chesapeake Bay Watershed

Many organizations have been formed to help increase awareness about the importance of the Chesapeake Bay ecosystem and to find solutions to its many problems. The Smithsonian Environmental Research Center (SERC), as stated in its mission statement, "is dedicated to increasing knowledge about the interaction of organisms with their environment and to disseminating this knowledge to improve our stewardship of the biosphere." The SERC has conducted many studies and research in the Chesapeake Bay area. They have concentrated on the following topics: global change, population and community ecology, and integrating ecosystem and community ecology.

Another example of these organizations is the Holland Island Preservation Foundation. Holland Island, located in Maryland, has a western shore that faces the Chesapeake Bay and eastern shore that faces Holland Straits. This island acts as a buffer to this vast area and provides protection from the Chesapeake Bay storms. The island also is a habitat for hundreds of shorebirds and waterfowl. Because of the rapid erosion and destruction of Holland Island, the Holland Island Preservation Foundation aims to stabilize and preserve the island, both for its ecological and sentimental value.

3.6 Software Used For Ecosystem Analysis

Remote sensing and Geographic Information Systems (GIS) together are crucial tools for the challenge resource managers have to face (Sample, ed, 1994). Remotely sensed data includes such things as aerial photographs and satellite imagery. GIS uses this kind of data and converts them into digital images to be analyzed. GIS software has become very useful in providing a scientific basis for evaluating the economic value of tree cover. The local analysis, derived from new software technology, provides numerical values for energy savings, stormwater runoff reduction, pollution removal, and carbon storage. These values can be used to plan for a healthier ecosystem.

3.6.1 ArcView - Global Information System

Developed by the Environmental Systems Research Institute (ESRI), ArcView is one of the most widely used Geographical Information Systems (GIS) desktop software available (ArcView GIS, 1996). It gives users the ability to visualize, query, and analyze data geographically. With ArcView, users are given a set of ready-to-use data that can be used to produce hundreds of different maps. Users can also use ArcView to create their own geographical data. Once a map is created, tabular data can be added to display, summarize, and organize the data geographically on the map. Along with the ability to create maps to display given data, ArcView's real advantage is its ability to solve problems by uncovering and analyzing trends and patterns in the data.

3.6.2 CITYgreen

In 1995, American Forests developed a desktop software package CITYgreen, ArcView application. CITYgreen is a software program for mapping urban ecology and measuring the economic benefits of trees, soil, and other natural resources (American Forests, 1996b). CITYgreen evaluates the tree cover of a region by formulating a savings estimate (in dollars) in terms of stormwater reduction benefits, energy conservation, and pollution removal. Some of these values are based on reduced engineering costs to a municipality. Others are implied "externality" costs, or implied costs to society from environmental degradation. For example, increased air pollution is assumed to increase health care costs to society as a whole. Public agencies assign financial costs to the production of a unit of air pollution based upon these resulting societal costs. The reduction of a unit of air pollution, therefore, is assigned a corresponding financial benefit. American Forests gives these CITYgreen analyses to urban planners to better inform them of the financial benefits trees give to a community.

The goal in developing CITYgreen software was to get community leaders to put the natural environment into their city planning. It is designed for use on personal computers to allow planners, engineers, local citizen groups, and natural resource managers to map local ecosystems and analyze their values (American Forests, 1995). The program uses satellite data, aerial photography, and ground surveys to define a city's ecostructure (American Forests, 1997).

3.6.2.1 CITYgreen - How Does It Work?

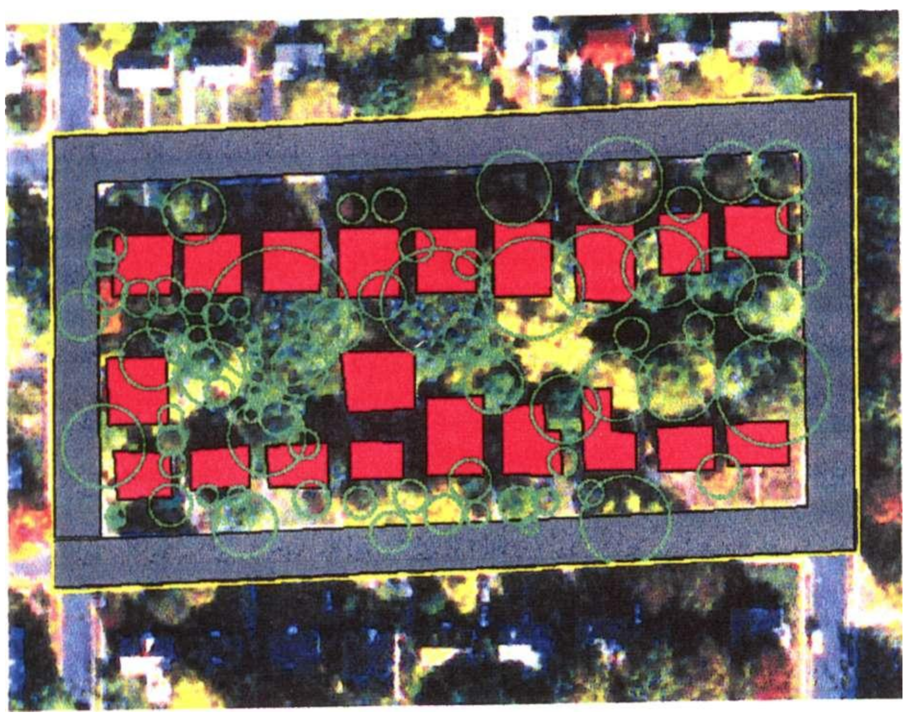
According to the American Forests CITYgreen Manual (1998), environmental policy and planning issues must be established by key public policymakers in order to create project goals when deciding how to better a community. The manual also recommends that before any data is collected or analyzed, one must identify the area's objectives, needs, and policy issues. CITYgreen users are able to utilize the GIS data sets of the area in order to begin the data analysis process. The process of evaluating community ecosystems also includes mapping and identifying, on an aerial photograph, land cover features such as tree canopy, vegetation, and bodies of water. Figure 3.1 shows how (a) an aerial photograph can be scanned into CITYgreen and (b) how land cover features can then be represented. Once field data is collected for these resources, EcoStructures (See Glossary) are formed by taking this land cover data and combining it with other data representing land use, neighborhoods, or watersheds. CITYgreen uses aerial photography as a means of creating maps for specific site-level analysis. The photo images are then projected onto a map using GIS data sets as a reference.

CITYgreen then incorporates local analysis programs, which include site statistics, carbon storage, pollutant removal, energy conservation, and storm-water runoff benefits. These statistics and results are incorporated with the GIS site map in the form of a data sheet (See Figure 3.2). CITYgreen provides the user with the estimated amount of pollutants (in pounds) that would be removed from the atmosphere and ground water annually, and the amount of money required to remove them by other means.

The savings displayed for energy conservation is given in terms of the amount of money that a homeowner can save in annual cooling costs, determined by the location of a tree relative to a building.

The benefits the user obtains for stormwater reduction are based upon the projected increase in stormwater runoff if there were no trees on the site. From this, an estimated amount of money is obtained in terms of how much the community is saving by eliminating the necessity of building larger stormwater facilities to handle the increase in runoff. Because there will be less water to handle, a facility could be designed with a smaller capacity, and therefore, less expensively. By combining the findings of the Local Analysis (See Glossary) with the EcoStructure map, it is possible to estimate the overall present, ecological condition of a watershed, town, city, or region.

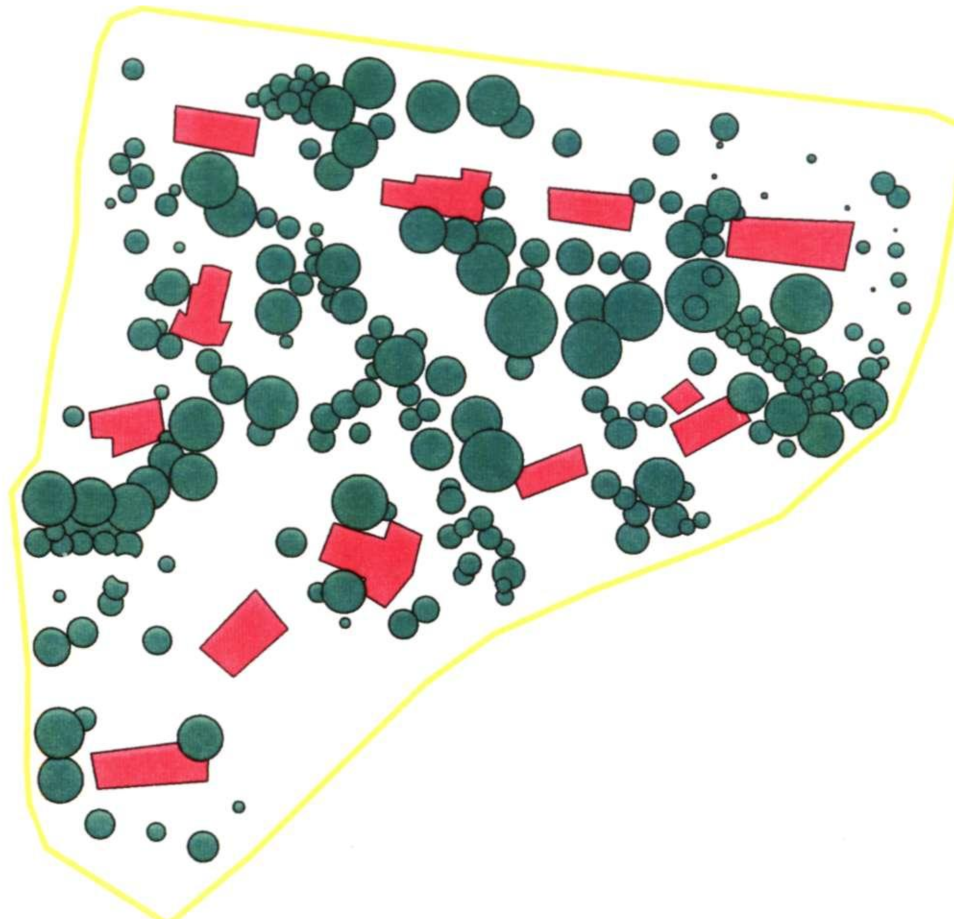
(a) Scanned Aerial Photo



(b) CITYgreen's Output: Simplification of Aerial Photo Including Resources

Figure 3.1: CITYgreen Site - (a) Aerial Image & (b) Resources

Sample Site



Study Site

- Total Area: 11.02 ac
- Canopy Area: 2.68 ac (24%)
- Grass Area: 6.37 ac (58%)
- Imperv Area: 1.17 ac (11 %)
- Building Area: 0.81 ac (7%)
- Water Area: ~ ac (~%)
- Number of Homes: 11
- Hydrologic Soil: B
- Percent Slope: 2.0
- Pond Percent: 0
- Rainfall Type: II
- Precipitation: 3.30 in
- Runoff Volume: 0.97 in

Tree Statistics

- Tree Count: 193
- Avg dbh: 12.2in
- Avg dbh Class: 1.6
- Avg Ht Class: 1.8
- Avg Health Class: 3.7
- Number of Species: 38
- Dominant Species: HEM (16%)
- Ownership (V|B|Unk): 100%|0%|0%

Carbon Benefits

- Carbon Storage: 86.42 tons
- Carbon Sequestration: 1.95 tons/yr

Energy Benefits

- Total Savings: $123.20 (1955.6kwh)
- Savings per Home: $11.20 (177.8kwh)

Pollution Removal Benefits

- Ozone: $254.15 (83.0lbs)
- S02: $15.40 (20.5lbs)
- N02: $104.88 (34.3lbs)
- PM 10: $225.24 (69.2lbs)
- CO: $3.78 (8.6lbs)

Stormwater Benefits *

- Runoff Reduction: 27.3%
- Time of Concentration Increase: 19.4%
- Peak Flow Reduction: 37.4%
- Avoided Storage**: 14514 cubic feet

*Stormwater results are based on existing trees compared with a 0% tree canopy condition
**Retention basin volume required if existing trees were removed.

4.0 METHODOLOGY

The main goal of this Interdisciplinary Qualifying Project was to determine the best way in which American Forests can accurately and effectively communicate the importance of tree cover using CITYgreen. The rapid reduction of tree cover over the past twenty years is largely responsible for many of the growing ecological problems affecting the Chesapeake Bay watershed. In response to this deforestation, American Forests strives to solve these problems by analyzing the benefits that urban forests have on the environment in an attempt to influence both policy making and urban planning.

We have found that trees serve as very important resources that often go over-looked when planning an urban community. Following our analysis, we made recommendations concerning the best method of applying an economic analysis of tree cover, so that it will (1) have a future impact on urban planning and (2) accurately address the major environmental problems of the area.

In order to connect the results of the analysis with the area we were studying, we researched the environmental issues that were most pressing at the present time. We were primarily looking for issues that could be addressed by a CITYgreen analysis, including stormwater, energy, and pollution problems. The research was used to investigate the possible connections that could be made between these issues and how the trees in the area affect them.

Field-level data collection took place at six sample sites in Arlington, Virginia. The process of collecting field data at study sites is referred to as ground-truthing. This number of sites allowed us to experience the CITYgreen process from beginning to end, while permitting us time to investigate the best methods of relaying this information. By ground-truthing at these sites, we were able to obtain data from at least one site representative of each division that Arlington has made for land use. These categories include residential, commercial, industrial, and mixed use. By examining a photo of one area, for example Arlington, individual sites were chosen to represent these land area types. The sites analyzed were representative of the northern region of the Chesapeake Bay watershed, and were chosen based upon the criteria mentioned above.

The software package CITYgreen was then used to perform data analysis. Through this analysis, values were assigned to the tree cover in the study site in terms of pollution removal, carbon storage, stormwater reduction, and energy savings. These values were then communicated to American Forests as an integral part of their large-scale analysis of the Chesapeake Bay watershed.

Based on our research and interviews in the area of our sample sites, we were able to conduct a more specific, detailed analysis of the Arlington and Baltimore regions. In addition to our values for strormwater reduction, energy savings and pollution removal, we were able to propose tree planting as a solution to the specific environmental problems of these areas. Through our research, we were able to learn what issues these communities are aware of, and through interviews, we were able to learn what issues are currently being addressed. A combination of this information above provided the Baltimore and Arlington regions with an analysis of their current ecological situation, as well as an insight to the economic impact of future projects. This information could allow for more ecologically sound decision-making in the future of the Arlington and Baltimore areas.

4.1 Environmental Research

After we ran the analysis and obtained economic values for the tree cover in our sites, we had to find ways to make these numbers significant to the Chesapeake Bay watershed area. We did this by relating the results to currently important environmental issues within Baltimore and Arlington.

One way of connecting the results that CITYgreen gave to us with the Chesapeake Bay was to do research on the Bay's current environmental concerns. Although the CITYgreen manual recommends that this process be completed before beginning an analysis, our research continued throughout our analyses of Arlington, VA and Baltimore, MD. We chose to use library research and interviews as a way to extend our knowledge of the major Chesapeake Bay issues, and to concentrate specifically on the area of data collection in Arlington. We conducted searches for articles written in the past few years to insure that we were relating our CITYgreen findings to present day issues. These searches were focused on the WWW, local newspapers and periodicals, and we also visited the Georgetown University library. Two major periodicals used were the Washington Post and the Baltimore Sun. These newspapers were chosen because they are among the most frequently read in this region, and contained the most publicized environmental problems and issues. Through research of environmental issues in this area, we were able to relate our recommendations to the Chesapeake Bay area. We also were able to make recommendations on how to improve the CITYgreen software itself by with CITYgreen users.

4.2 Interviews

Our knowledge of important local environmental issues and CITYgreen's potential ability to address them was obtained via two methods: through research and through interviews. Our interviews, which were conducted on five urban planners, two public policy makers, and several CITYgreen users, also helped us investigate the CITYgreen software program. We wanted to find ways to improve the program and make it versatile to fit the needs of different communities and improve upon the CITYgreen analysis process so that it could positively impact the remainder of the Chesapeake Bay project.

We interviewed public policy makers who had knowledge of how environmental laws are created. These people were also aware of what current ordinances exist. Some of these are laws that protect urban forests, water quality or wild life within a certain area. We asked questions that would help us gain a better understanding of what policy makers deal with, how they research, and how they propose policies, ordinances, and laws.

We have also interviewed urban planners who have worked within the Chesapeake Bay watershed area or similar urban forests and estuarine type areas. Our purpose in interviewing urban planners was to learn how useful CITYgreen is or could be in their area of work. We were interested in seeing what guidelines an urban planner must follow when making decisions concerning the removal or preservation of trees before building anything on a previously undeveloped site.

Our interviews of politicians and urban planners helped us learn the best methods of relating the knowledge that CITYgreen provides. By talking to these people, we wanted to see how to relay this data so that the environment and the importance of tree cover have a greater effect on their decision making. We chose to conduct interviews rather than focus groups or a mass survey because there were specific urban planners and governmental officials in the Chesapeake Bay area that American Forests had identified as valuable resources. These individuals were recommended to us by American Forests, and were ultimately chosen based upon their expertise in their areas of interest, and because they worked in the geographic areas where we performed data collection. We wanted to speak to each of these people individually to get their recommendations and opinions without the interference of any outside influences.

4.3 CITYgreen Users Survey

Part of our recommendations to American Forests concerned the CITYgreen software program. The third group of people we have interviewed is a small sample of the CITYgreen users who were identified as possible sources of valuable recommendations. To locate these interviewees we chose to do a short survey of all the people who have purchased CITYgreen, followed by telephone interviews. The objective of this questionnaire/interview combination was to first determine who was and who was not using CITYgreen, and then identify some of the good and poor aspects of the program. The follow-up interviews made it possible to ask more in-depth, open ended questions to selected CITYgreen users. We decided to use this method as opposed to a larger, more thorough survey for two reasons. First, we only wanted a sample of opinions from the people who had used CITYgreen most often. The small questionnaire allowed us to identify these people. Secondly, due to time constraints, and the fact that we will be spending much of our time collecting data and analyzing sample sites, a large survey would not be a practical method of choice. This survey was not meant to produce any form of statistical data. Nor will the results be used to describe trends or make generalizations concerning CITYgreen users. Its purpose was solely to identify the CITYgreen users with potentially useful feedback about the software program.

American Forests has a database containing the names, and contacts of all of the people who have purchased the CITYgreen software program. We used this information to send a short five-question survey (See Appendix D) to the current 183 CITYgreen owners. Thirty-three email surveys were distributed to all owners who had provided an email address to American Forests. The remaining 150 owners received the survey via first class mail. The questionnaire was divided this way assuming that email would produce a faster response rate, and we would be able to start interviewing before the remaining surveys began arriving. With this information, we chose candidates for follow-up phone interviews. Candidates were chosen based upon their responses to the initial survey. Any comments or suggestions about CITYgreen that would be of specific interest to our project were sufficient criteria in qualifying a respondent for a follow-up phone interview. In these interviews we posed new, more detailed questions, and asked them to elaborate on their written responses in order to determine their opinions of both the positive and negative aspects of CITYgreen software. We used this information, along with our own experiences with CITYgreen, to suggest possible changes to the program that could make the process of evaluating tree cover more efficient.

4.4 Aerial Photography

Aerial photographs of the selected sites were obtained from an aerial survey company. The photographs were then scanned into an image format, by the survey company, to be viewed using CITYgreen. Next, the photo images were map-rectified to a geographic map projection or coordinate system, using Geographic Information Systems (GIS) data sets as reference. For our purposes, we converted the coordinate system of the images from longitude and latitude to the Universal Transverse Mercator (UTM) map projection, which is compatible with the local area data.

4.5 Site Data Inventory

Once the photo images were digitized, an off-site inventory was created using CITYgreen. From the map projections, we were able to identify, outline, and print detailed maps showing the location and extent of the existing land cover, including tree cover, buildings, and impervious surfaces. Our next step was to create field maps and inventory sheets for data collection in the field. We used the Field Inventory Guide, provided by American Forests, to begin collecting data, or ground-truthing. The Field Inventory Guide is part of the CITYgreen User's Guide, and included information such as height and diameter class ranges, health codes, species abbreviations, and tree inventory sheets (See Appendix B). These codes made the process of entering data easier. When this data collection process was complete, we updated the pre-field inventory map in CITYgreen and prepared it for analysis.

Our own experiences with the ground-truthing process were extremely valuable to American Forests. At the time of our ground-truthing, a new CITYgreen manual was in the process of being constructed. Through our feedback concerning the overall data collecting process, as well as an evaluation of how well the previous users' manual described the process, we were able to aid American Forests in the writing of the new manual. This included sections that we felt should be discussed in the new version, as well as some ideas for a new "users' guide to ground truthing."

4.5.1 Data Collection

We surveyed six sites averaging three to five acres each in Arlington, VA. In general, smaller sites allow the surveyor to sample a greater number and therefore broader range of land types. Each of the sites that we collected data from, were chosen from aerial photo images based on density of homes, land use, area of impervious surfaces and canopy cover percentages. Our main guide at each of these sites was an inventory map created in CITYgreen. This map was composed of an aerial photograph with green circle overlays representing the tree canopy of each tree in the site. Each circle was labeled with a tree ID number making it possible for us to follow the map and take down the information about each individual tree on our inventory sheets.

In addition to the prepared materials mentioned above, we had some other tools that were crucial to the data collecting process. One of them was a diameter tape measure (DBH tape) that was provided to us by American Forests. This tape measure had inches on one side, and on the other was the calculated diameter in relation to the circumference of the tree. Another necessary item was a standard letter from the Arlington County Department of Parks and Recreation. This letter was addressed to homeowners to explain who we represented, the project that was being conducted, and why we would like their cooperation in letting us gather data on trees that are located on their property.

A major part of our recordings involved visually inspecting the trees. We located each tree on the map, correcting any discrepancies including missing or improperly recorded trees. Each added tree was assigned an identification number that was unique within that site. Trees were divided according to their location on public or private property. The purpose of this information is to determine to whom the dollar savings benefits would go. In addition, we had to identify each tree by genus and possibly species. The species was only required if there are differences within the genus regarding tree shade values or other benefits such as stormwater reduction. Species abbreviation codes are provided by American Forests.

The way in which we determined the species of each tree was by examining the trees leaves, and by recognizing the basic characteristics like how the lobes of the leaves were shaped, how many lobes there were, how the veins branched out from the midrib, and the leaves color. If the tree was a type of pine, we investigated the texture of the needles, examined how the needles were grouped together and looked at the acorn, if there was any. At times, but rarely, looking at the tree trunk was helpful.

The most convenient way to identify the species of a tree is to study its leaves. Trees can be divided into two categories, evergreen and deciduous (See Glossary), and methods of identification are different for each. To determine the species of an evergreen tree, we studied characteristics such as the texture, size, and grouping of its needles. If any cones were present, identifying characteristics are size, shape, and orientation on the branch. On the other hand, to determine the species of a deciduous tree, we looked at whether the leaves were smooth, or serrated, simple or compound, and pinnate or palmate. The size and number of lobes, leaf color, and presence of distinctive flowers or berries can also be helpful.

Some other data collection involved physically measuring of trees. Information such as trunk diameter and tree height is used by CITYgreen to calculate the benefits each tree contributes to the site. The trunk diameter is measured, with the DBH tape described above, from a standard Diameter at Breast Height (DBH) of 4.5' above ground level. Other standard procedures apply, for example, when taking the diameter of a tree located on a slope, the 4.5' height measured from the up-hill side of the tree. We cross-referenced this gross diameter with the Diameter Class Table provided by American Forests and assign a value from one to three. We could only estimate the height of the tree in order to determine the height class. The Height Class Table is similar to the Diameter Table, with categories ranging from one to three. These three categories ranged from zero to fifteen, fifteen to thirty-five, and greater than thirty-five feet accordingly.

Our next step was to look at the physical aspects of each tree. Health conditions that are evaluated include twig growth and presence of sprouting branches. For this reason, we entered a number ranging from one to five in the health column of our inventory sheets. Three points of reference were used when deciding on a number for the health of the crown, roots, and trunk:

1.) Very Poor: no new growth, heavy sprouting

Crown	more than 50 percent dead or dying
Trunk	large cavities or girdled
Roots	evidence of trenching and/or root cutting within five feet of

the base of the trunk. *

3.) Fair: some sprouting, moderate twig growth

Crown ten to thirty percent showing evidence of damage, structurally weak, may be holes, poorly pruned, evidence of die back or insect/disease problems. **

Trunk five to fifteen showing evidence of damage, cambial layer penetrated, but not girdled.

Root space confined by physical structure(s), may be planted too deeply. *

5.) Excellent: substantial twig growth in the last year, no sprouting.

Crown structurally strong, full, uniform, no die back or evidence of insect or disease problems.

Trunk not damaged

Roots not damaged, tree planted at proper depth.

* Ratings of two and four fall between the appropriate classes above.

** Although we were not able to identify specific types of disease or infestation, the resulting damage is visible none the less. Damage such as holes, rotten sections, and missing bark would be taken into account in the one to five health rating.

4.6 Data Analysis

The final report of a CITYgreen project contains two types of analyses. One is the analysis that is run by CITYgreen software. This analysis supplies the reader with an economic representation of tree cover benefits in dollars. The second is an analysis takes these dollar values that were calculated from the sites and uses them, along with land use data, to create an ecological analysis of the whole community. We performed both of these types of analysis on our data from Arlington County.

4.6.1 Results of CITYgreen

The analysis of the collected data included combining our findings with the aerial photographs in a way to produce an informative map quantifying the resources of the area in terms their economic value to that community. This value is communicated as dollars saved by the community resulting from the presence of tree cover. This savings is broken down into three main categories: stormwater reduction, air pollution reduction, and energy conservation. First, by using the aerial photographs and CITYgreen, we were able to identify, outline, and produce detailed maps showing the location and extent of the tree cover, buildings, and impervious surfaces of the site. We then used the revised field maps and completed inventory sheets to update the maps in CITYgreen. Once the maps and data sets matched what was found in the field, we were able to run the CITYgreen analysis portion of the program.

4.6.2 Determining Total Savings in Arlington

The second form of analysis includes the combination of historical satellite imagery with a projection of economic tree cover benefits over the entire region. Our first step was to obtain land use data from the planning department of Arlington County. This land use data divides Arlington into land use categories, including residential, commercial, industrial, and mixed use, as well as their respective percentages of the total acreage of Arlington County. Next, we divided each savings benefit by the total acreage of each site, to obtain a savings per acre value. We then projected these results over every acre of the county according to the land use that each site represents.

4.7 Presentation of Conclusions and Recommendations

Once the data analysis was completed for each region of interest, we presented these results to American Forests. These results led directly to the conclusions and recommendations that we gave to American Forests, key urban planners, and local policymakers.

Ultimately, the results of this project placed economic values on the tree cover at each sample site studied, in terms of stormwater reduction, air pollution removal, and energy conservation. The higher the dollar value given to a specific site's tree cover, the more valuable the tree cover is to that area. In other words, this dollar value communicates the amount of money the site is saving by maintaining all of its present tree cover. If those trees were not present, the community would eventually spend an equivalent amount of money addressing the areas mentioned above. The goal of this method was to better communicate the importance of tree cover to public policy makers, and to distinguish between areas of different ecological importance.

However, American Forests alone cannot address all the ecological problems of the country. For this reason, they hope to implement this CITYgreen analysis program in many communities across the nation, large and small alike. First, American Forests will conduct a large regional analysis of a specific US region. This analysis will show the rate of deforestation in that region over a twenty-year period. By revealing this study, American Forests hopes to spark interests among cities or towns located in "hot spots"—areas where tree cover is declining most rapidly. Any of these communities interested in conducting their own specific studies will be able to purchase CITYgreen. This will allow each specific community to use CITYgreen to address its specific environmental problems more effectively. It is our goal to conduct a thorough analysis of the entire CITYgreen process, and make recommendations on how to improve the implementation of this analysis in urban planning and public policy making.

After researching, collecting data, analyzing this data through CITYgreen, and conducting interviews, the results from these methods were compiled and used to make recommendations in the following three areas: (1) any suggestions that can improve the CITYgreen analysis and data-collecting processes, (2) the most efficient use of the CITYgreen analysis so that it can best address the pressing environmental problems of the Chesapeake Bay area, and (3) the potential for CITYgreen to have a positive impact on urban planning. Presently, there is a missing link between American Forests and urban planners. These recommendations will hopefully inform American Forests of an effective way in which the economic results of CITYgreen can be used to (1) address the pertinent problems of the area being analyzed, (2) impact future urban planning of that area, and (3) result in public policy that protects the most important, most valuable regions within the Chesapeake Bay ecosystem.

5.0 RESULTS

This chapter is a description of our findings obtained from each of our project tasks. It discusses the results of our research, interviews, survey, data collection, and CITYgreen analysis in detail. These results will be the main source of information when formulating conclusions and giving recommendations to American Forests.

5.1 Research of the Chesapeake Bay Area

Resulting from our Chesapeake Bay watershed archival research, we have identified some major environmental issues that are causing this area the most problems. We have found that some of these most damaging environmental problems can be linked to the increase in stormwater runoff, including non-point source pollution and the destruction of riparian zones.

As previously mentioned, non-point source pollution is one of the most serious problems threatening Maryland's water resource today. This becomes significant to our project not only because it relates to the Chesapeake Bay watershed, but also because non-point source pollution is defined as any runoff that is caused by stormwater or irrigation water. We have found that one of the most useful measurements performed by the CITYgreen software program is the reduction of stormwater runoff that results from tree cover. This means that CITYgreen could be used to address not only stormwater, but also non-point source pollution problems. With the information that is provided in a CITYgreen analysis, planners and developers could determine the most effective placement of new trees, and also the most important places to conserve existing trees, in order to prevent the increase of stormwater runoff and its resulting non-point source pollution.

Another problem that is related to stormwater runoff is the microorganism Pfiesteria piscicida, a toxic dinoflagellate. It is the primary cause of fish kills and disease in the Chesapeake Bay watershed. As discussed before in our Literature Review, Pfiesteria is commonly found in bottom mud or sediment of North Carolina estuaries. These microscopic organisms swim toward a fish, excreting potent toxins which cause open-bleeding sores to the skin. Pfiesteria feeds on tissue and blood from these sores until the fish is dead, and then feeds on the remains.

The Pfiesteria piscida microbe is a relatively new concern to the Chesapeake Bay, where it has killed thousands of fish within the last two years. Many scientists believe this organism is yet another result of non-point source pollution originating from uncontrolled animal waste. Chicken manure and hog slurry, common fertilizer ingredients, are believed to have contained the microbe. The loss of tree cover in this area could have contributed to this problem because Pfiesteria was carried to the bay along with stormwater runoff. As a direct result of deforestation, the microbe entered the Chesapeake Bay, where it infected thousands of fish and wildlife.

In addition to damage that is inflicted by pathogens, such as the one discussed above, non-point source pollution can also cause "nutrient shock." This occurs when large amounts of melting snow combine with stormwater to product abnormally high amounts of freshwater runoff. This results in a large reduction in the nutrient concentration of the Bay and may be devastating to the organisms living there.

Yet another major area of concern to the Chesapeake Bay ecosystem is the destruction of natural riparian zones. Due to their proven importance to the Bay, the planting of man-made riparian zones has become extremely important. A riparian zone is defined as an area of trees and various other types of vegetation that is located along the shoreline of any body of water. It helps waterways, for example the Bay, by providing clean water via filtration of nutrients from stormwater, and by stabilizing stream banks, thus preventing erosion as well.

5.2 Interviews

To obtain information, relating CITYgreen to its application, it was necessary to interview three different groups of people: public policymakers, urban planners, and CITYgreen users. It was important to obtain information from all three of these viewpoints to aid us in an unbiased analysis of the CITYgreen process. The two public policymakers that we interviewed were Fred Deneke and Ed Macie of the United States Forest Service. In addition, we interviewed urban planners Priscilla Ryder of Marlborough, MA, Joan Becker-Kolsch and Christie Williams of Arlington, VA, and Donald Outen and Beth Strommen of Baltimore, MD. Lastly, we chose to conduct telephone interviews of a number of people who had responded to our mini-survey with intriguing comments about CITYgreen. A list of questions that were asked at each interview is located in Appendix C.

5.2.1 Public Policymakers

Our interviews of public policymakers were designed to help us connect the results that we obtain from CITYgreen to the effects that they could have in the real world. Our goal was to discover the best way to communicate tree cover benefits so that this information would reach policymakers and have a positive effect on environmental policies.

5.2.1.1 Fred Deneke, US Forest Service

The first person that we interviewed was Fred Deneke, the Assistant Director of Community Forestry for the US Forest Service.

Mr. Deneke first explained to us that the Forest Service is composed of three branches: (1) Green Lands, which regulates National Forests and federal lands, (2) Research, and (3) State and Private, which oversees non-federal forests. He works in this third branch, State and Private. Only a small percentage of US forested land is non-federal, and still a smaller section of this is defined as urban forests. The beginning of Urban Forestry dates back to the time when Dutch Elm disease was introduced to America from Europe and, since many cities lost their monocultures (See Glossary) of American Elm's, the epidemic caused a rise in awareness

Mr. Deneke illustrated that policies concerning urban forests are particularly important today because of the current rate of sprawl (See Glossary). One example that he used was the in the city of Chicago, IL. Between the years 1980 and 1990, there was a four- percent population growth and, as a result of land development, there was a forty-percent increase in sprawl. This large number makes the conservation of tree cover that much more crucial to combat the increase of stormwater runoff, which results from the increase in impervious surfaces.

Next, we inquired about his views of CITYgreen, and how this software relates to policies concerning urban forests. Mr. Deneke thought that one of the most beneficial capabilities of CITYgreen was the measure of change in tree cover over a time period of twenty years, which can be performed in the Regional Analysis. He believes that illustrating the harm that has actually been done can have a big impact on communities.

Fred Deneke introduced us to another ecological analysis software program that was developed by Andy Lipkis for use in Los Angeles called TREES. TREES, in Mr. Deneke's opinion, was a more effective planning tool for the Los Angeles community than CITYgreen would have been, because it contains a more complex algorithm. This algorithm is specific to tree species and other characteristics of the Los Angeles area.

CITYgreen in its present state, according to Fred Deneke, is not capable of being community specific in the way that TREES is. For this reason, he believes that CITYgreen is better applied as a public policy tool than as an urban planning tool. He believes that CITYgreen could be influential in the development of local ordinances, by providing information that will allow policymakers to make informed decisions. He sees the conservation of tree cover as a two step process. First, when developing, communities should try to maintain some tree cover. Second, they should try to put back tree cover in established cities. This process, also known as re-greening, is a way of environmentally retrofiting a community, and can also have additional benefits, including the creation of many new jobs.

When we asked Mr. Deneke for his opinion of why CITYgreen is not more widely used, he gave two answers: lack of necessary skills, and lack of funding for not only the software itself, but also training, and aerial photos.

In closing, he stated that the government works better if creative solutions are made at the local level. CITYgreen works best as a modeling tool when groups such as landscape architects, engineers, and planners work together. Fred Deneke believes that trees should be viewed as infrastructure and not just amenities, and mentions that in order for all of this to occur, people with environmental interests and concerns must be elected into local government positions.

5.2.1.2 Ed Made, US Forest Service

The second person interviewed was Ed Macie, also of the US Forest Service, who also works for the Forest Service, as the Southeast Regional Urban Community Forester. He worked with American Forests on an ecological study of tree cover in Atlanta, Georgia. Mr. Macie was more informed of the CITYgreen concept and history as opposed to the hands-on use aspect of the software. Mr. Macie also believes that CITYgreen is best used as a policy making tool. He stated that this is true especially at the local level, where it can result in better-informed decisions.

Mr. Macie also had many suggestions of improvements that could be made to the software program. One possible improvement would be to include a feature that could predict the effects of a development project. In other words, the user would be able to punch in a number for the increase in impervious surfaces, or the decrease in tree canopy cover, and CITYgreen would give effects in terms of stormwater increase, and other costs. This feature could also be used in another way to illustrate the positive effects that an increase in tree canopy cover would have. Another suggestion was to quantify more tree cover benefits and add them to the CITYgreen analysis. For example, human health benefits could somehow be quantified in terms of saved medical costs as a result of lower pollution levels.

Mr. Macie also had some suggestions as to why CITYgreen is not more widely used. He thought that the program was not completely understood, and also that the lack of time to complete data collection and entry plays a factor, as well as lack of expertise. He believes the answer to this problem is education, and more complete training. In our discussion, we thought of a possible solution to the latter problem. Mr. Macie suggested the possible development of a "CITYgreen junior", which would be a much less complicated, less expensive desktop version of CITYgreen. Then, as more people become familiar with the software and its benefits, it will be easier for them to learn to perform the more complicated analysis of the original CITYgreen program. This would be especially useful to smaller communities with budgets too small to purchase the satellite images and aerial photographs that CITYgreen currently requires as input.

5.2.2 Urban Planners

Our interviews of urban planners were designed to help us determine whether or not they feel the information that CITYgreen produces could be beneficial in their line of work. We also wanted to establish ideas of how CITYgreen results could be improved in such a manner that they could be used in plans for new developments and tree planting.

5.2.2.1 Priscilla Ryder, Conservation Officer

The first urban planner that we interviewed was Pricilla Ryder, the Conservation Officer for the city of Marlborough, MA. We chose Ms. Ryder because she had worked with American Forests on an ecological analysis of Marlborough. In addition she is familiar with the capabilities of CITYgreen.

Priscilla Ryder's job has two important parts: (1) reviewing site plans for building development and (2) promoting land conservation. She explained that in reviewing site plans for the development of a building, she has to consider the resulting stormwater runnoff, possible problems with drainage, and also the sites's relationship to any surrounding wetlands in the area.

Contrary to our prior belief, it was not the city of Marlborough's initial idea to take part in the project with American Forests. In fact, the city was chosen by the Metropolitan District Commissioner (MDC), who identified this community as a good site for this study plot.

Prior to taking part in this project, Pricilla Ryder had no knowlegde of the CITYgreen software program. She attended a workshop held at Worcester Polytechnic Institute, which helped her to get familiar with the program and its capabilities. Because this was her first experience with this program, we asked her what she was expecting to get out of it. Ms. Ryder commented that one reason that the CITYgreen program is helpful in the conservation of forested land is that it shows the benefits of existing conditions. This could help to save the time and money of having to replace trees after development.

Priscilla Ryder illustrated two obstacles that the city of Marlborough ran into. We believe many other communities may run into the same problems. One of these is the issue of time, which was mentioned quite frequently by Ms. Ryder. Many parts of the CITYgreen analysis process are very time consuming, for example, the time it takes to learn how to operate the system, as well as the time that has to be dedicated to the actual ground-truthing. A second obstacle is one that prevents the CITYgreen results from having an impact on the planning of a community. In order for these results to have an effect on the development or conservation practices of a community, there has to be changes in the way that ordinances are submitted and reviewed. Ms. Ryder commented that CITYgreen results do not quite fit into the current ordinance system in Marlborough, MA. She continued that because the current ordinances call only for her approval of site plans late in the planning process, new ordinances would be needed to incorporate a program like CITYgreen into the current system.

Ms. Ryder concluded that, overall, Marlborough's participation in this project was a good experience. She commented that the CITYgreen program could be useful to policymakers and that she has learned a lot. However, as it stands today, she would not know how to apply the results in her day to day activities, unless drastic changes were made in current practices to accommodate CITYgreen.

5.2.2.2 Joan Beker-Kolsch & Christie Williams, Environmental Planners

Joan Beker-Kolsch and Christie Williams, both environmental planners from Arlington, VA, were chosen to help us better relate CITYgreen's results for the community to the opinions of planners there.

According to Ms. Kolsch and Ms. Williams one of the biggest environmental concern facing Arlington County today is the issue of stormwater runoff. This county is just begining to use CITYgreen, which they feel has the potential to help them measure the benefits of trees in their area in terms of stormwater reduction benefits.

According to Ms. Kolsch, the most useful aspect of CITYgreen is the quantification, in terms of actual dollar figures, that it gives to the community. Both Ms. Kolsch and Ms. Williams agreed that the dollar value is what people respond to. Ms. Kolsch cited that in planning, they do not take into account the several benefits of trees, for example their capacity for pollution removal. She suggests that developers need to consider the environmental benefits of leaving some trees in place, instead of the current practice of clear-cutting, then later re-planting with saplings (immature trees). They both commented that one practical use of this program would be to manipulate the data to show what values are obtained when half of a proposed development site is clear-cut. This program could illustrate the drastic effects this has on stormwater runoff to developers. If consequences are considered before building plans are made, then perhaps the site could be developed in such a way as to leave some of the largest, most healthy trees in place.

Ozone has become a major environmental issue in the Arlington area as a result of the standards put forth in the Clean Air Act. Presently, Arlington is not meeting the standards that are required by this law. As a result of this, Arlington has been classified by the EPA as a non-attainment area. These environmental planners thought that CITYgreen's feature that measures the reduction of air pollution could be applied to this problem. If the amount of ozone that was reduced (in pounds) could be obtained, Ms.

Kolsch suggests that this number could then be submitted to the EPA. Currently the EPA suggests that cutting car emissions is a good way to reduce the amount of ozone in the atmosphere. This type of report would help to illustrate that, although the number of cars or emissions has not been cut, they are making progress towards the reduction of ozone by planting and conserving trees.

Joan Kolsch and Christie Williams also think that a numerical value for grow out will greatly influence a developer to leave some trees standing. For example, if a model site was created and then projected over a time period of fifteen years, CITYgreen could compare the savings of the original mature trees to small saplings that would be planted after construction. The savings of the original trees should be much greater and the models will show this difference in savings until the time when the new trees are mature.

The parks department of Arlington County has just received the CITYgreen software program and in the near future will be working closely with the environmental planning department. We mentioned that many owners of CITYgreen no longer use the program because they do not have the time, or resources to learn how to operate it. They agreed that this might be a concern with their department also, and that they will be looking into getting interns to perform the data collection process for them.

When asked how and to whom they would communicate the results of a CITYgreen analysis, they discussed town meetings, educational seminars, and their involvement with certain commissions. Both Ms. Kolsch and Ms. Williams attend commission meetings with developers, parks people, other urban planners, and everyday citizens. They concluded that CITYgreen could be used to promote the planting and preservation of trees by allowing those attending to have a visual conception of what is being discussed.

5.2.2.3 Beth Strommen, Environmental Planner

Beth Strommen is an Environmental Planner for the city of Baltimore. The major components of her job in the planning department include conservation work, reviewing site plans, and working with developers. In addition, she is the greenway coordinator for Baltimore. This position consists of managing the green-space of her area.

According to Ms. Strommen, the most important environmental issues facing Baltimore today include concerns over water quality, and stormwater management. These two issues are obviously closely related. She said that, although trees are important, their efforts are currently focused on these water issues mentioned above. Another environmental issue that is a concern today in that area is that of air quality. Currently, Baltimore is a severe non-attainment area (See Glossary). This means that they are not meeting the standards specified in the Clean Air Act for air quality.

Today, Baltimore is struggling with decisions concerning the many open lots that have resulted from many people leaving the city. They do not know if they should allow this land to be redeveloped, or if present structures should be torn down to restore some greenspace.

Presently, Baltimore does not make use of CITYgreen to aid in planning problems such as the type mentioned above. Ms. Strommen was unfamiliar with the CITYgreen software program and its capabilities. Although her department makes use of GIS systems for its various mapping needs, CITYgreen is relatively new to them, and currently only a few people know how to operate it.

5.2.2.4 Donald Outen, DEPRM

We interviewed Donald Outen, Chief of Policy, Planning, Research and Development for Baltimore County, MD. More specifically, he works for the Department of Environmental Protection and Resource Management (DEPRM). The interview consisted of a description of his job responsibilities, accomplishments of his department, his overall opinions on important environmental issues facing Baltimore County, possible solutions to those problems, and his overall opinion of CITYgreen and its usefulness.

The major area of interest for Donald Outen and the DEPRM is in growth management. Growth management involves protecting the natural forests of Baltimore County, improving water quality, down zoning, and managing watersheds. He believes the most important focus areas for environmental improvement are natural streams and channels from the three main reservoirs of the County.

The traditional issue of water quality is still, and will always be a major issue according to Mr. Outen. Once addressed, this will have local and regional implications. Improving the drinking water for the County will directly result in similar effects on the quality of the water emptying into the Chesapeake Bay. However, Mr. Outen is quick to point out that water quality is not the only solution to the channel issue. Restoration and creation of forest buffers is also important to the health of these channels. Forest buffers not only keep the nutrient levels high in these streams, but they also keep erosion to a minimum. It is often the case that forest buffers are less than twenty-five feet wide, these are not efficient enough to keep these channels ecologically sound. Mr. Outen believes a forest buffer of 100 feet is required in most cases. He also feels that the ability for forest buffers to provide channel stability, and an aquatic habitat for fish and other species are two qualities often overlooked by planners.

According to Mr. Outen, Maryland is the only state in the country with its own set of statewide conservation laws. In particular, Baltimore County has taken the lead in addressing many environmental issues, and changing their planning policies accordingly. In doing so, they have been recognized by the federal government as a good example for other interested and concerned communities to follow. In particular, Baltimore County has realized the urban and economic impact of unstable channels and waterways. Unstable channels, in time, could damage public infrastructure by downcutting and undermining sewer lines and laterals. In other words, once the water level drops below the sewer lines, the lines are no longer supported by the earth and may bend and eventually break. Also, concrete channels, often used in place of natural waterways, can also crack and leak in time. For this reason, Mr. Outen has led the effort to restore streams by removing concrete channels and forming natural streams with adequate forest buffers.

The Baltimore County DEPRM has developed their own method of identifying the areas of tree cover that are is most environmentally important to the county. This, in turn would aid the DEPRM in deciding which fragmented forest chains, or patchy areas of deforestation should be given top priority for improvement and replanting efforts. This process is called "A GIS - Methodology for Establishing a Greenway Corridor

System in a Fragmented Forest Landscape." It assigns high priorities to areas of vegetation and is a tool for locating quality patches and detrimental gaps in forest patches.

When asked for his thoughts about American Forests' CITYgreen software, Donald Outen first made it clear that, in his view, CITYgreen is good at what is does but is only a small piece of the puzzle. He also emphasized the fact that he is not aware of all of CITYgreen's capabilities, and has never actually used the software. However, based on what he knows about CITYgreen, he believes that there are other environmental issues and solution methods that CITYgreen does not address. For example, Mr. Outen does not believe that CITYgreen would be able to include a stream corridor restoration function, or stream stability benefits for forest buffer zones. He also pointed out that not every environmental situation could be accurately modeled. He feels, especially in the case of channel restoration projects, that a "real" approach should be taken in which past successful projects can be used as evidence of a successful environmental solution. Even for benefits that can be modeled, Mr. Outen added, it is difficult to get models to effectively reflect reality due to their many limitations. For some models, poor assumptions are made, or sometimes-linear algorithms are used for nonlinear relationships, purely out of necessity. One other criticism he has of CITYgreen is the fact that once a certain percentage of imperviousness is reached for a city, it is difficult to plant trees in non-impervious areas to bring that ratio back down again. In other words, unless the city starts planting trees in place of impervious surfaces, it will be impossible to dramatically change the ratio of impervious surface to tree cover.

Finally, Donald Outen offered some solutions to help increase the environmental health and decrease the rates of deforestation and imperviousness in communities. He believes that the increasing popularity of "old town" planning can be used as environmentally advantageous. As planners and citizens alike strive for more aesthetically pleasing pedestrian-style towns, they should consider the environmental issues as well. Rather than planting random streetside trees, they could research the most environmentally beneficial species instead.

Another solution to the imperviousness problem could be "town centers." Town centers are communities that are more densely populated, with less impervious surface and more vegetation than most towns. This philosophy is based upon tightly packed, multiple-story housing, with aesthetically pleasing surrounding urban forests. This was an extremely successful project for Baltimore County because the town's infrastructure was put in place before the developer bought the land. Thus the developer was already paying for the high population capabilities of the plots, and would most likely elect to build four-story buildings rather than cut his or her losses and build single-family houses.

Overall, Donald Outing feels that the general public still doesn't understand the environment enough. He believes that once the general public is educated, politicians will feel more comfortable making environmentally beneficial policy decisions, as they will also become popular decisions.

5.2.3 CITYgreen Users

A short survey was sent to the current 183 CITYgreen owners (See Appendix B). Of these surveys, thirty-three (33) were sent via email and the remainder by first-class mail. Our total response was twenty-nine (29) CITYgreen users, with seven (7) of those arriving by email. The following responses to the survey were then used in selecting and conducting follow-up telephone interviews.

5.2.3.1 Survey

Of the thirty-six responding to the short questionnaire, twenty-three of them have used CITYgreen at least once in their place of work. The thirteen responding non-users indicated that the software required more staff and staff hours than expected to get results. Some stated that input requirements were beyond their capabilities, and that the software was user-unfriendly. One person explained that he worked for a small community and that CITYgreen seemed to be geared to large city applications. However, of these eleven people, only eighteen of them still currently use CITYgreen. Some of the reasons for them discontinuing its use included lack of training, lack of satellite data in a compatible format, lack of staff time, loss of trained staff member, and other issues that combined into too many frustrating problems.

The CITYgreen users who responded indicated that their use of the program ranged from as frequently as daily or weekly, to as infrequently as yearly or less than once a year. Twelve of these surveyed people are using CITYgreen for site modeling, ten for an educational tool, six as a program evaluation, two for communicating outside their department, and two people each for justification of budget, communicating within the department, and consulting. Responding CITYgreen users included urban and regional planners, college professors, a grade school teacher, an environmental service worker, a consultant, and an employee of a conservation organization.

The responding CITYgreen users were asked to rate their satisfaction of the software from one, indicating very dissatisfied, to five, very satisfied. The average of the respondents was a 3.19, indicating slightly above "somewhat satisfied." The following are some suggestions CITYgreen users have made in their survey comments. Many of these were expanded upon during the follow-up interviews: (1) CITYgreen could use a custom data entry system for inputting tree data; (2) city specific information should be allowed to be input for more customized the algorithms; (3) the user manual needs to provide more information on the models; (4) customized reports should be easier to create; (5) different grow-out scenarios should be allowed in a single ArcView project; (6) more information on tree species should be provided; (7) a Unix version should be developed; (8) best and worst case scenarios should be included, to see affects with or without trees.

The responding CITYgreen users also supplied us with numerous problems and difficulties they had with the software: (1) Too much required data entry for tree information; (2) Too much work and needed to complete a project; (3) Training was too expensive, and marketing of the software did not identify software requirements; (4) Technical assistance has been less than satisfactory; (5) ArcView has problems and limitations; and (6) CITYgreen is not intuitive as to what tree data is mandatory in order to proceed with statistics and analysis.

5.2.3.2 Telephone Interviews

In order to obtain more detailed feedback concerning CITYgreen software, we contacted some of the CITYgreen buyers that had replied to our survey. We felt that these people can give us a better understanding of the pros and cons of CITYgreen and inform us of the extent to which it meets their requirements. We expanded upon some of the comments and concerns that were listed on these surveys that during these phone interviews. These people use CITYgreen for a wide variety of applications from educational purposes to ecological analysis. Thus, we were able to receive a wide range of perspectives and suggestions from their experiences with CITYgreen.

One of these users we chose for a phone interview is Steve Strickland, a City Forester for Macon, Georgia. He used CITYgreen for Regional-Level analysis to help detect the change in canopy using Satellite Images of the Macon, GA area from 1985 to 1992 to 1997. He explained that CITYgreen is very clear when showing the specific changes of the canopy over a ten to twenty year period, however CITYgreen's Regional Analysis can not determine the area type. For example, CITYgreen can not differentiate between a residential area and an agricultural area. Thus, he suggests that a land-use map needs to be developed as part of CITYgreen. He is currently in the process of using CITYgreen to determine where trees need to be planted in order to minimize the stormwater runoff, carbon reduction and other benefits to better the environment. Overall, Mr. Strickland feels that CITYgreen is a very beneficial tool when utilized for obtaining both a regional-level and local-level analysis.

We also contacted Rosi Dagit, a conservation biologist for California, who used CITYgreen for very different purposes. She uses this software program to help in determining fuel modification in relation to fire safety. She is closely studying a small region of California with an area of about eighteen square miles. This specific area is densely populated with highly flammable trees and wooden homes built in the 1920's, making it hazardous to vegetation, animals, and humans, because of the high risk of forest fire. The overall problem is to find out how these trees can be removed in order to prevent high flames and without increasing stormwater runoff. Ms. Dagit explained that ten or more years ago, most forest fires were cool fires. This means that they did not burn very high and therefore did not damage any canopy. Instead they remained relatively small and helped to control the buildup of decaying matter areas in which trees were over populated. CITYgreen is used for keeping the inventory of the homes and trees, and shows how a steep topography and deciduous trees play a role in effecting stormwater runoff. She suggested that CITYgreen should show the potential for fire due to the climate and the flammability of the trees, and perhaps have a model in which you can start a fire and see how it behaves due to these factors.

Fred Suffian, a high school teacher, uses CITYgreen as an educational tool for the 10^{th} grade level. These 10^{th} graders performed an analysis of a 57.6 acre watershed area around their high school. They went through the whole CITYgreen process, which includes data collecting from the site, inputting the data into CITYgreen and running the analysis for a year. Mr. Suffian pointed out that the ground-truthing is too time consuming and many students lack the patience to complete it, however after some time they understood what they needed to do in order to obtain ground-truthing information. They ran a tree growth simulation, a very important feature that CITYgreen offers, in which they planted 400 more trees in this site in addition to the 184 that were present.

Mr. Fred Suffian questions the algorithms because the pollution reduction benefits were extremely minimal after a fifteen to twenty year period. For instance, Fred Suffian questions why ozone reduction increased from 306 to 340 pounds, or how does carbon storage of that site decrease after planting more trees. He also wanted to know what type of conclusions one can draw by merely looking at these types of figures. In closing, Mr. Suffian suggested that CITYgreen should include a customized report in which you are able to check off what you want to include when running the analysis process, rather than going though specified detail of the site's features.

5.3 CITYgreen Site Evaluations

By running the CITYgreen analysis on each of the fifteen sites of the Baltimore, MD region, and the six sites of the Arlington, VA region, we were able to produce data sheets which include a picture, general information, and an economic evaluation of the benefits the tree cover has on each particular site. The various benefits emphasize the importance of tree cover and in term of how it helps the environment. As already explained, CITYgreen examines the existing tree cover of the area in terms of how much money is being saved. These savings were broken up into three areas consisting of stormwater runoff, pollution removal, and energy benefits. Thus, a dollar value was assigned to the tree cover, not to suggest that the tree cover is worth this amount, but rather to suggest the amount of money saved in that region. We have found that this information may play a major role in public policy decision making because CITYgreen is able to show concrete numbers in terms of savings. Along with the dollar values associated with each area of concern, other values are also given that could be interpreted ecologically.

Stormwater benefits were given in four areas: runoff reduction, peak flow reduction, time of concentration increase, and avoided storage. Runoff reduction and peak flow reduction were given in percentages of how much stormwater is being absorbed by the existing trees. The percentage given for the time of concentration shows the increase in time between stormwater reaching the earth and penetrating the ground resulting from the existing tree canopy cover. This is important because, if large amounts of water hit the ground all at once, as in a heavy rain event, it could not be absorbed and the water would just runoff the surface of the ground. The value given for avoided storage is given in cubic feet, showing us the stormwater retention facility volume that would be needed if the existing tree cover were removed.

Pollution removal benefits were in terms of how much money would need to be spent on the removal of Ozone, SO_2, NO_2, PM 10, and CO had the trees in these areas not been there. From this information, we became aware of how much of each pollutant, in pounds, is taken out of the air by the existing tree cover annually. Also, carbon benefits were given in terms of carbon storage and carbon sequestration. Carbon storage is the amount (in tons) of carbon stored currently by all the trees in the study site. Carbon sequestration is the amount of carbon removed from the atmosphere annually. This is important because too much carbon in the atmosphere leads to environmental problems, including the greenhouse effect.

Energy benefits were given in kilowatts of total savings for the whole area and each home in the study site. These numbers are based on the fact that trees can shade buildings and windows of houses. This would result in cooler buildings and homes during the summer and lower cooling costs for their owners. In addition, all benefits reported by CITYgreen are annual savings.

The information about each study site included its size (in acres), and how much of the area was covered with tree canopy, impervious surfaces, and buildings, both in acres and percentages. The tree statistics showed us the basic description of the trees, such as the species, the average health, average height, and average diameter at base height (DBH) or diameter at 4.5' above the ground.

5.3.1 Arlington

Tables 5.1 though 5.4 contain the results obtained from conducting a CITYgreen analysis on the six Arlington, VA sites that we ground-truthed. These site results can, in turn, be used to conduct an ecological analysis on tree cover for the entire city of Arlington.

Site Name	Canopy Coverage	# of Species	Dominant Species/% of total species	Health Class
Arlington A	0.26	28	AE/13%	3.0
Arlington B	0.2	12	LO/30%	3.2
Arlington C	0.4	26	SM/29%	3.0
Arlington D	0.12	8	LY/60%	2.8
Arlington E	0.22	23	RO/14%	3.2
Arlington F	0.47	14	RM/16%	3.2
Average	0.2783	18.5		3.07

Table 5.1 - Tree Composition and Health at Arlington Study Sites

Site Name	Total Savings Per Site	Savings Per Building
Arlington A	$1044.38	$34.81
Arlington B	NA*	NA*
Arlington C	$507.75	$25.39
Arlington D	$141.38	$47.13
Arlington E	$523.88	$40.99
Arlington F	$728.25	$121.38
Total	$2945.64	$269.70
Average	$589.13	$53.94

Table 5.2 - Energy Savings in Arlington Study Sites

* Site did not have buildings

Site Name	Study Area Acres	% Impervious Includes Bldgs	Soil Type	% Runoff Reduction	% Peak Flow Reduction	Avoided Storage (cubic Feet)
Arlington A	6.82	44%	B	29.10%	39.90%	10217
Arlington B	2.46	65%	B	21.20%	27.70%	3415
Arlington C	4.35	49%	B	40.70%	53.00%	10765
Arlington D	3.06	63%	B	13.70%	18.60%	2514
Arlington E	3.22	53%	B	24.20%	32.90%	4439
Arlington F	1.74	47%	B	45.70%	56.70%	4982
Total	21.65					36332
Average	3.61	53.50%		29.10%	38.13%	6055

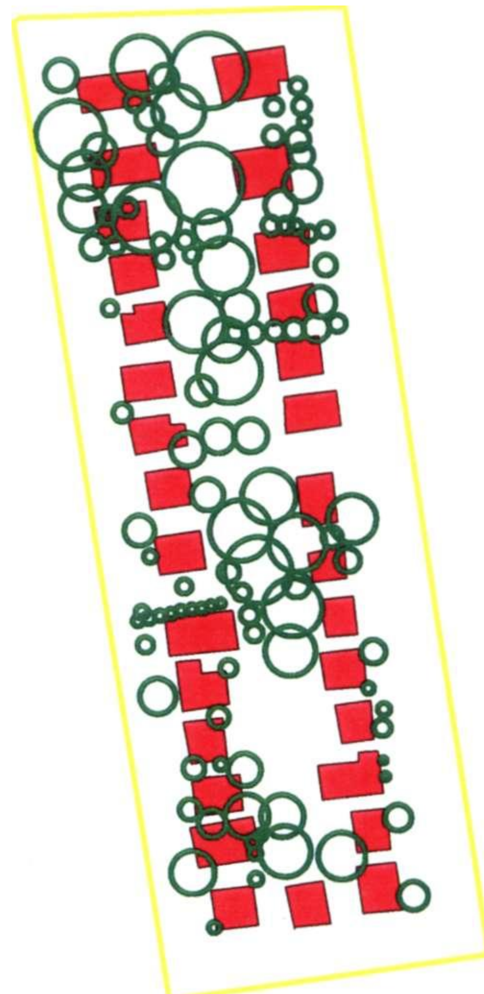
Table 5.3 - Stormwater Flow Reduction Benefits of Trees in Arlington Study Sites

Site Name	Current Storage (tons)	Annual Sequestration (tons)
Arlington A	78.25	0.14
Arlington B	15.53	0.35
Arlington C	94.58	0.27
Arlington D	11.8	0.27
Arlington E	22.6	0.51
Arlington F	44.02	0.13
Total	266.78	1.67
Average	44.46	0.28

Table 5.4 - Carbon Storage and Sequestration in Arlington Study Sites

Figures 5.1 through 5.6 are the data sheets produced after running a CITYgreen analysis on the six chosen sites in Arlington, VA. The values given on these sheets were then used to complete a full ecological analysis of Arlington.

Arlington A



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Study Site
- Total Area: 6.82 ac
- Canopy Area: 1.77 ac (26%)
- Grass Area: 2.04 ac (30%)
- Imperv Area: 1.78 ac (26%)
- Building Area: 1.22 ac (18%)
- Water Area: ~ ac (~%)
- Number of Homes: 30
- Hydrologic Soil: B
- Percent Slope: 1.0
- Pond Percent: 0
- Rainfall Type: II
- Precipitation: 2.75 in
- Runoff Volume: 1.01 in

Tree Statistics
- Tree Count: 110
- Avg dbh: 13.6in
- Avg dbh Class: 1.8
- Avg Ht Class: 2.3
- Avg Health Class: 3.0
- Number of Species: 28
- Dominant Species: AE (13%)
- Ownership (V|B|Unk): 99%|1%|0%

Carbon Benefits
- Carbon Storage: 78.25 tons
- Carbon Sequestration: 0.14 tons/yr

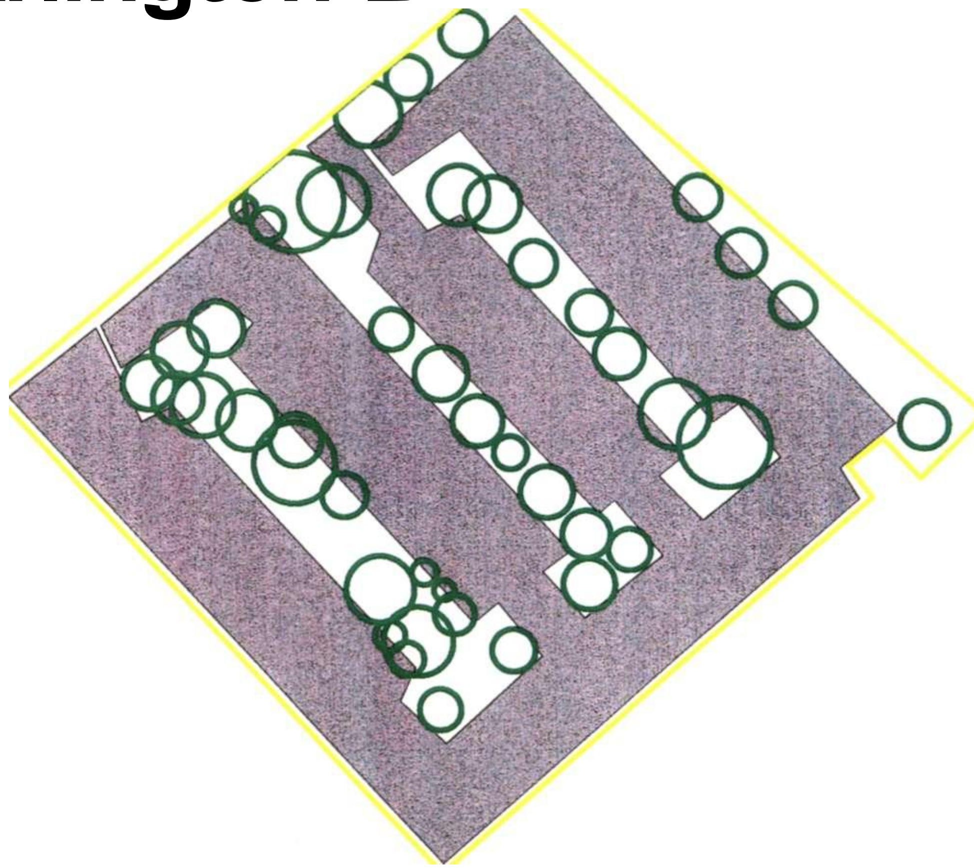
Energy Benefits
- Total Savings: $1044.38 (16577.4kwh)
- Savings per Home: $34.81 (552.6kwh)

Pollution Removal Benefits
- Ozone: $167.83 (54.8lbs)
- S02: $10.17 (13.6lbs)
- N02: $69.26 (22.6lbs)
- PM 10: $148.75 (45.7lbs)
- CO: $2.49 (5.7lbs)

Stormwater Benefits *
- Runoff Reduction: 29.1%
- Time of Concentration Increase: 24.3%
- Peak Flow Reduction: 39.9%
- Avoided Storage**: 10217 cubic feet

•Stormwater results are based on existing trees compared with a 0% tree canopy condition
"Retention basin volume required if existing trees were removed.

Arlington B



Study Site

Total Area: 2.46 ac
Canopy Area: 0.48 ac (20%)
Grass Area: 0.39 ac (16%)
Imperv Area: 1.59 ac (65%)
Building Area: 0.00 ac (0%)
Water Area: ~ ac (~%)
Number of Homes: 1
Hydrologic Soil: B
Percent Slope: 1.0
Pond Percent: 0
Rainfall Type: II
Precipitation: 2.75 in
Runoff Volume: 1.42 in

Tree Statistics

Tree Count: 44
Avg dbh: 12.8in
Avg dbh Class: 1.6
Avg Ht Class: 2.0
Avg Health Class: 3.2
Number of Species: 12
Dominant Species: LO (30%)
Ownership (V|B|Unk): 0%|100%|0%

Carbon Benefits

Carbon Storage: 15.53 tons
Carbon Sequestration: 0.35 tons/yr

Energy Benefits

Total Savings: $0.00 (No Buildings)
Savings per Home: $0.00 (No Buildings)

Pollution Removal Benefits

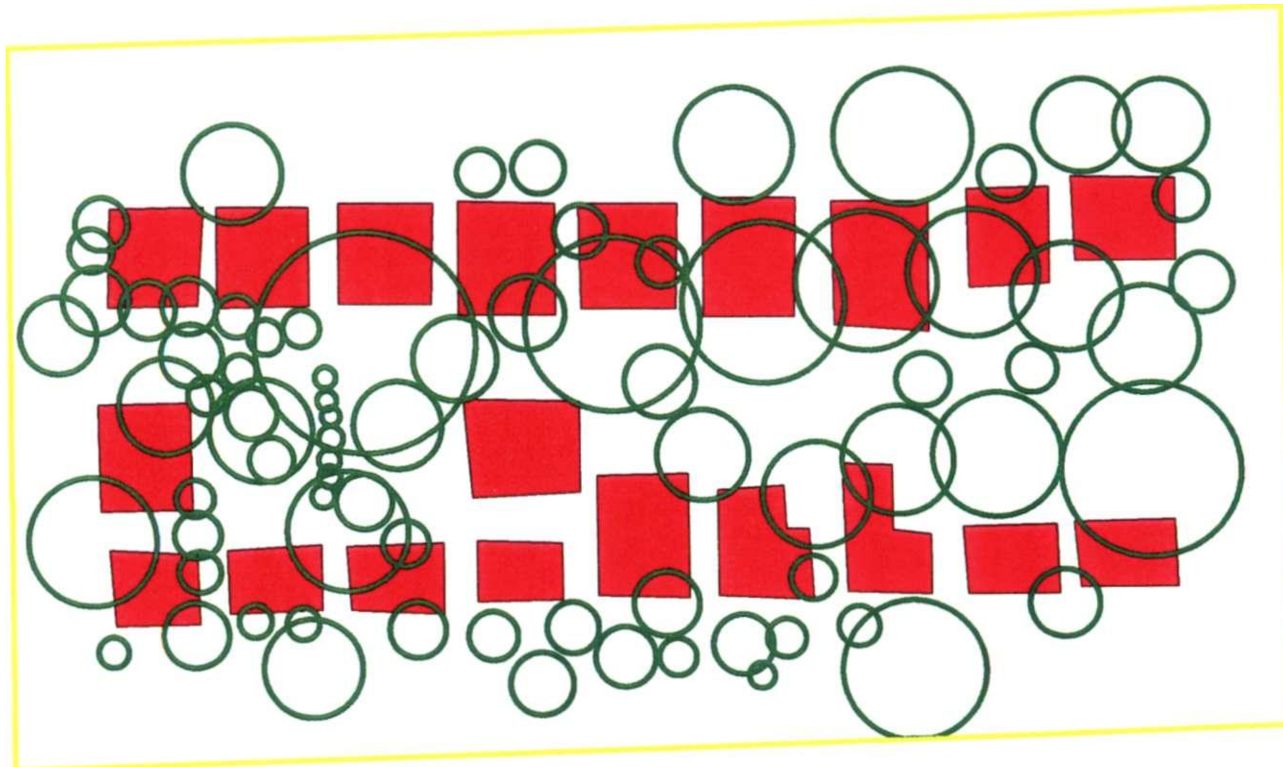
Ozone: $45.68 (14.9lbs)
S02: $2.77 (3.7lbs)
N02: $18.85 (6.2lbs)
PM 10: $40.48 (12.4lbs)
CO: $0.68 (1.6lbs)

Stormwater Benefits *

Runoff Reduction: 21.2%
Time of Concentration Increase: 21.2%
Peak Flow Reduction: 27.7%
Avoided Storage**: 3415 cubic feet

•Stormwater results are based on existing trees compared with a 0% tree canopy condition
"Retention basin volume required if existing trees were removed.

Arlington C



Study Site

Total Area: 4.35 ac
Canopy Area: 1.75 ac (40%)
Grass Area: 0.47 ac (11 %)
Imperv Area: 1.29 ac (30%)
Building Area: 0.83 ac (19%)
Water Area: ~ ac (~%)
Number of Homes: 20
Hydrologic Soil: B
Percent Slope: 1.0
Pond Percent: 0
Rainfall Type: II
Precipitation: 2.75 in
Runoff Volume: 0.99 in

Tree Statistics

Tree Count: 79
Avg dbh: 13.7in
Avg dbh Class: 1.9
Avg Ht Class: 2.3
Avg Health Class: 3.0
Number of Species: 26
Dominant Species: SM (29%)
Ownership (V|B|Unk): 0%|0%|100%

Carbon Benefits

Carbon Storage: 94.58 tons
Carbon Sequestration: 0.27 tons/yr

Energy Benefits

Total Savings: $507.75 (8059.5kwh)

Savings per Home: $25.39 (403.0kwh)

Pollution Removal Benefits

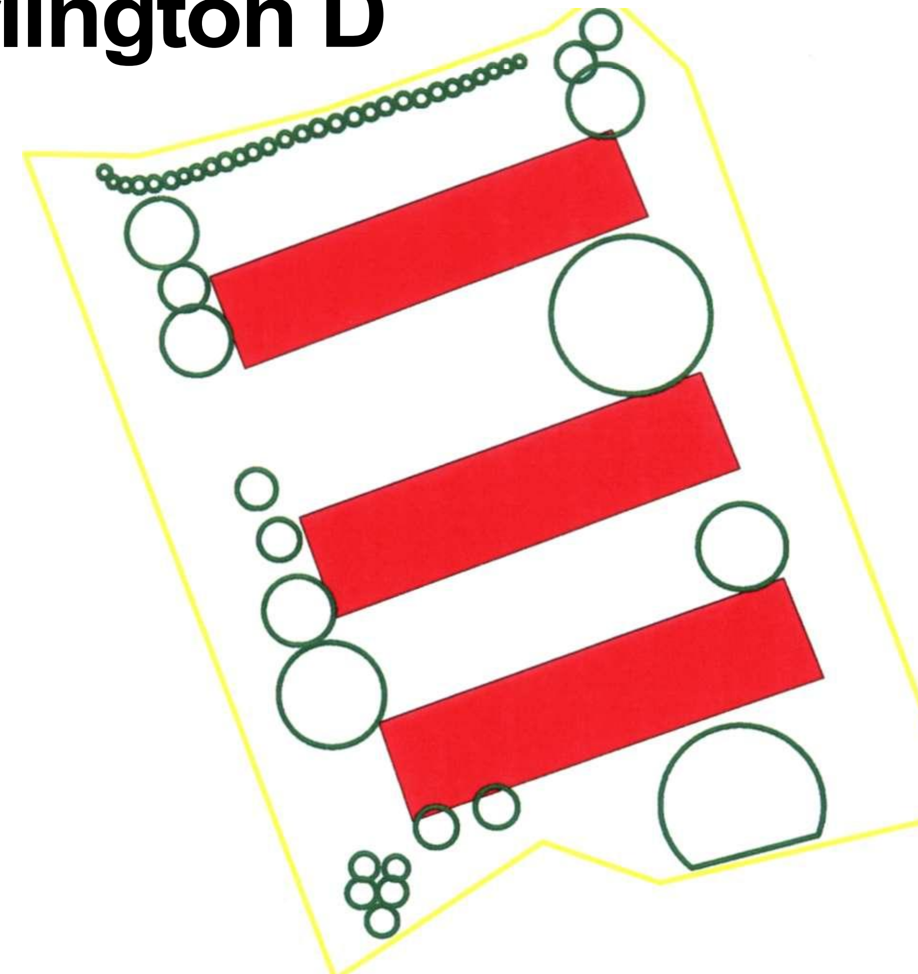
Ozone: $166.37 (54.3lbs)
S02: $10.08 (13.4lbs)
N02: $68.66 (22.4lbs)
PM 10: $147.45 (45.3lbs)
CO: $2.47 (5.6lbs)

Stormwater Benefits *

Runoff Reduction: 40.7%
Time of Concentration Increase: 42.3%
Peak Flow Reduction: 53.0%
Avoided Storage**: 10765 cubic feet

*Stormwater results are based on existing trees compared with a 0% tree canopy condition
**Retention basin volume required if existing trees were removed.

Arlington D



Study Site
- Total Area: 3.06 ac
- Canopy Area: 0.37 ac (12%)
- Grass Area: 0.80 ac (26%)
- Imperv Area: 1.15 ac (38%)
- Building Area: 0.75 ac (25%)
- Water Area: ~ ac (~%)
- Number of Homes: 3
- Hydrologic Soil: B
- Percent Slope: 1.0
- Pond Percent: 0
- Rainfall Type: II
- Precipitation: 2.75 in
- Runoff Volume: 1.43 in

Tree Statistics
- Tree Count: 48
- Avg dbh: 7.5in
- Avg dbh Class: 1.3
- Avg Ht Class: 1.5
- Avg Health Class: 2.8
- Number of Species: 8
- Dominant Species: LY (60%)
- Ownership (V|B|Unk): 100%|0%|0%

Carbon Benefits
- Carbon Storage: 11.80 tons
- Carbon Sequestration: 0.27 tons/yr

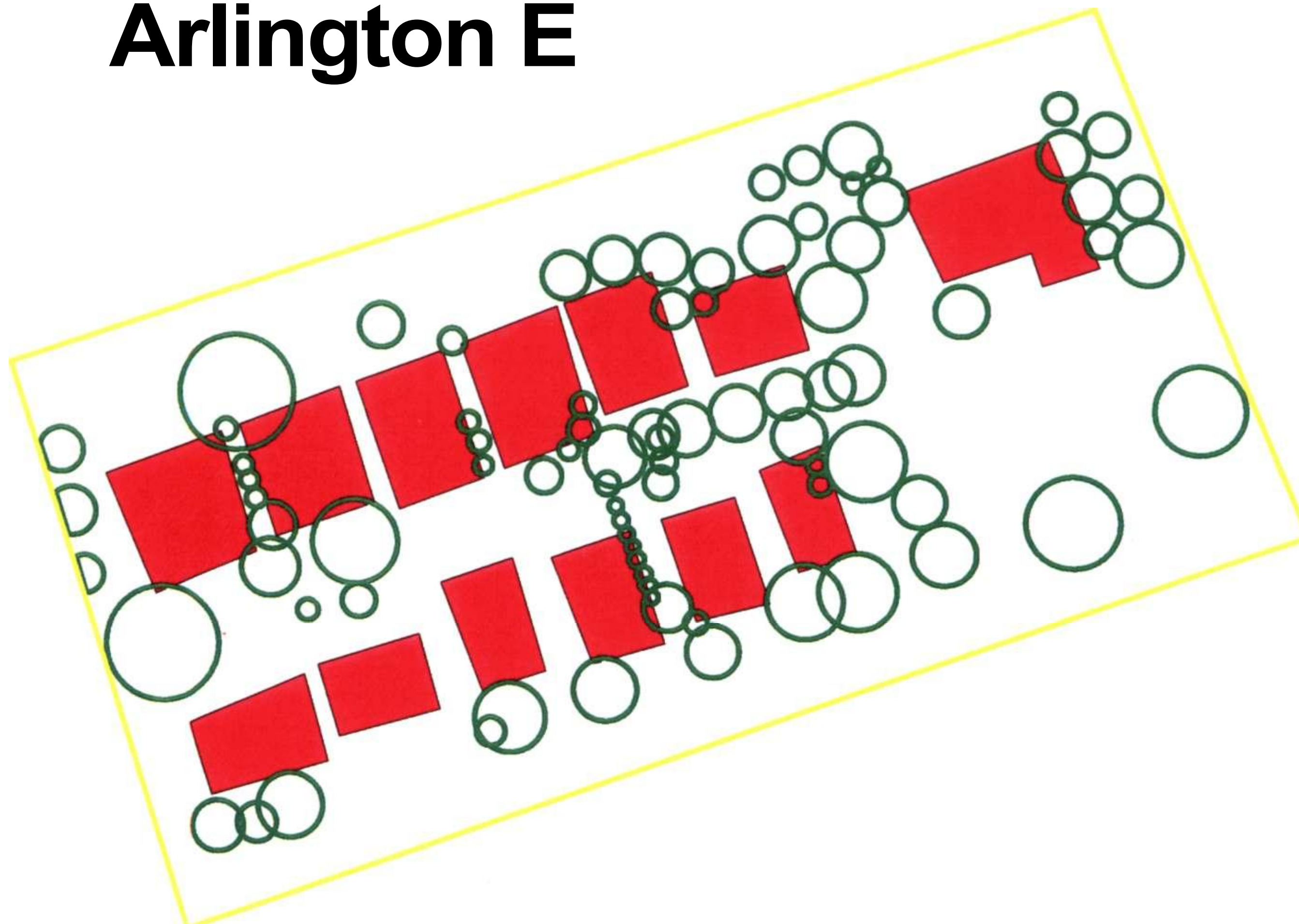
Energy Benefits
- Total Savings: $141.38 (2244.1kwh)
- Savings per Home: $47.13 (748.0kwh)

Pollution Removal Benefits
- Ozone: $34.67 (11.3lbs)
- SO_2: $2.10 (2.8lbs)
- NO_2: $14.31 (4.7lbs)
- PM 10: $30.73 (9.4lbs)
- CO: $0.52 (1.2lbs)

Stormwater Benefits *
- Runoff Reduction: 13.7%
- Time of Concentration Increase: 12.1%
- Peak Flow Reduction: 18.6%
- Avoided Storage**: 2514 cubic feet

*Stormwater results are based on existing trees compared with a 0% tree canopy condition
**Retention basin volume required if existing trees were removed.

Arlington E



Study Site

Total Area: 3.22 ac
Canopy Area: 0.70 ac (22%)
Grass Area: 0.80 ac (25%)
Imperv Area: 1.04 ac (32%)
Building Area: 0.67 ac (21%)
Water Area: ~ ac (~%)
Number of Homes: 13
Hydrologic Soil: B
Percent Slope: 1.0
Pond Percent: 0
Rainfall Type: II
Precipitation: 2.75 in
Runoff Volume: 1.19 in

Tree Statistics

Tree Count: 85
Avg dbh: 9.7in
Avg dbh Class: 1.4
Avg Ht Class: 1.8
Avg Health Class: 3.2
Number of Species: 23
Dominant Species: RO (14%)
Ownership (V|B|Unk): 79%|21%|0%

Carbon Benefits

Carbon Storage: 22.60 tons
Carbon Sequestration: 0.51 tons/yr

Energy Benefits

Total Savings: $532.88 (8458.3kwh)
Savings per Home: $40.99 (650.6kwh)

Pollution Removal Benefits

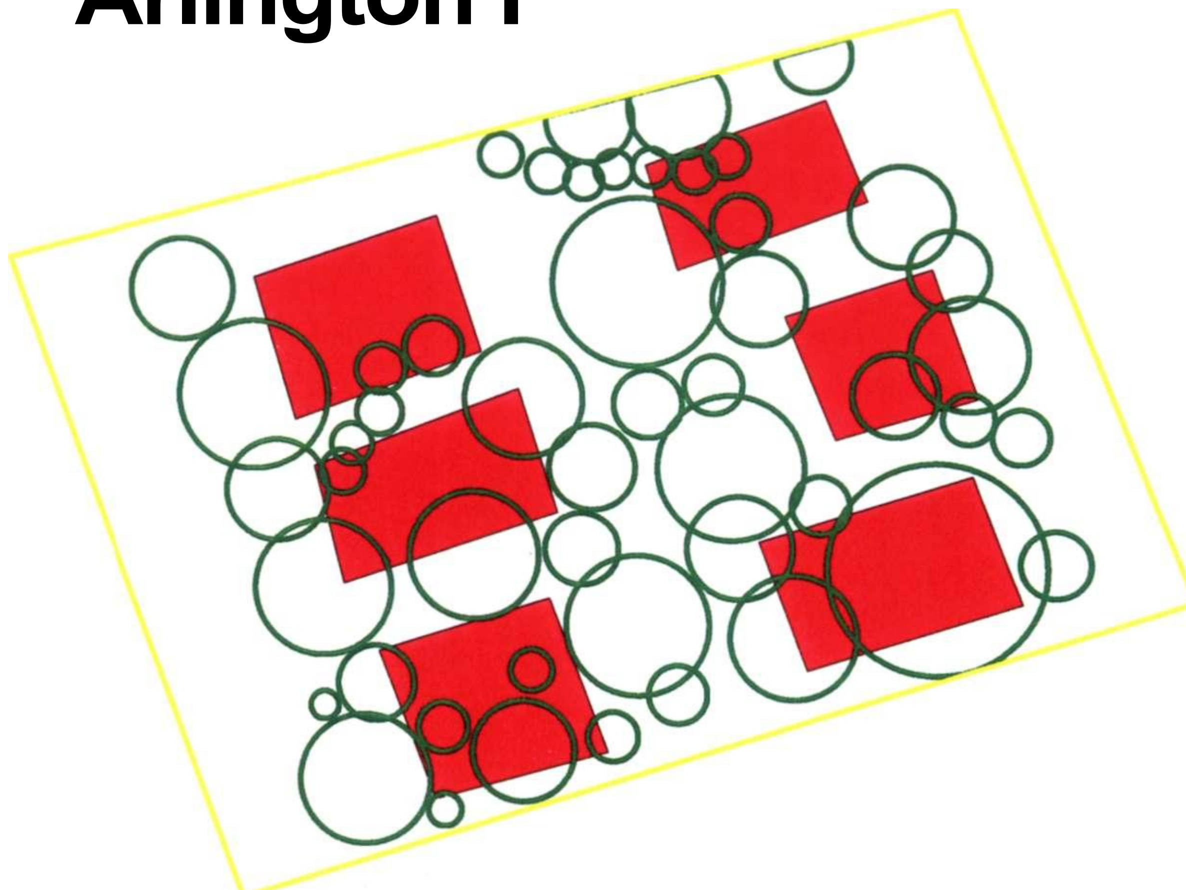
Ozone: $66.46 (21.7lbs)
S02: $4.03 (5.4lbs)
N02: $27.42 (9.0lbs)
PM 10: $58.90 (18.1 lbs)
CO: $0.99 (2.3lbs)

Stormwater Benefits *

Runoff Reduction: 24.2%
Time of Concentration Increase: 21.5%
Peak Flow Reduction: 32.9%
Avoided Storage**: 4439 cubic feet

"Stormwater results are based on existing trees compared with a 0% tree canopy condition
"Retention basin volume required if existing trees were removed.

Arlington F



Study Site
- Total Area: 1.74 ac
- Canopy Area: 0.82 ac (47%)
- Grass Area: 0.10 ac (6%)
- Imperv Area: 0.41 ac (23%)
- Building Area: 0.42 ac (24%)
- Water Area: ~ ac (~%)
- Number of Homes: 6
- Hydrologic Soil: B
- Percent Slope: 1.0
- Pond Percent: 0
- Rainfall Type: II
- Precipitation: 2.75 in
- Runoff Volume: 0.94 in

Tree Statistics
- Tree Count: 50
- Avg dbh: 14.3in
- Avg dbh Class: 2.0
- Avg Ht Class: 2.5
- Avg Health Class: 3.2
- Number of Species: 14
- Dominant Species: RM (16%)
- Ownership (V|B|Unk): 100%|0%|0%

Carbon Benefits
- Carbon Storage: 44.02 tons
- Carbon Sequestration: 0.13 tons/yr

Energy Benefits
- Total Savings: $728.25 (11559.5kwh)
- Savings per Home: $121.38 (1926.6kwh)

Pollution Removal Benefits
- Ozone: $77.43 (25.3lbs)
- S02: $4.69 (6.3lbs)
- N02: $31.95 (10.4lbs)
- PM 10: $68.63 (21 1lbs)
- CO: $1.15(2.6lbs)

Stormwater Benefits *
- Runoff Reduction: 45.7%
- Time of Concentration Increase: 50.5%
- Peak Flow Reduction: 56.7%
- Avoided Storage**: 4982 cubic feet

•Stormwater results are based on existing trees compared with a 0% tree canopy condition
"Retention basin volume required if existing trees were removed.

5.3.2 Baltimore

Figures 5.7 through 5.24 contain the results obtained from conducting a CITYgreen analysis on the fifteen Baltimore, MD sites. These site results were, in turn, used to conduct an ecological analysis on tree cover for the entire city of Baltimore.

Baltimore A

Study Site
- Total Area: 2.81 ac
- Canopy Area: 0.50 ac (18%)
- Grass Area: 0.52 ac (19%)
- Imperv Area: 0.53 ac (19%)
- Building Area: 1.26 ac (45%)
- Water Area: ~ ac (~%)
- Number of Homes: 4
- Hydrologic Soil: B
- Percent Slope: 1.0
- Pond Percent: 0
- Rainfall Type: II
- Precipitation: 2.75 in
- Runoff Volume: 1.42 in

Tree Statistics
- Tree Count: 47
- Avg dbh: 11.3in
- Avg dbh Class: 1.6
- Avg Ht Class: 2.3
- Avg Health Class: 3.5
- Number of Species: 9
- Dominant Species: AIL (51%)
- Ownership (V|B|Unk): 74%|26%|0%

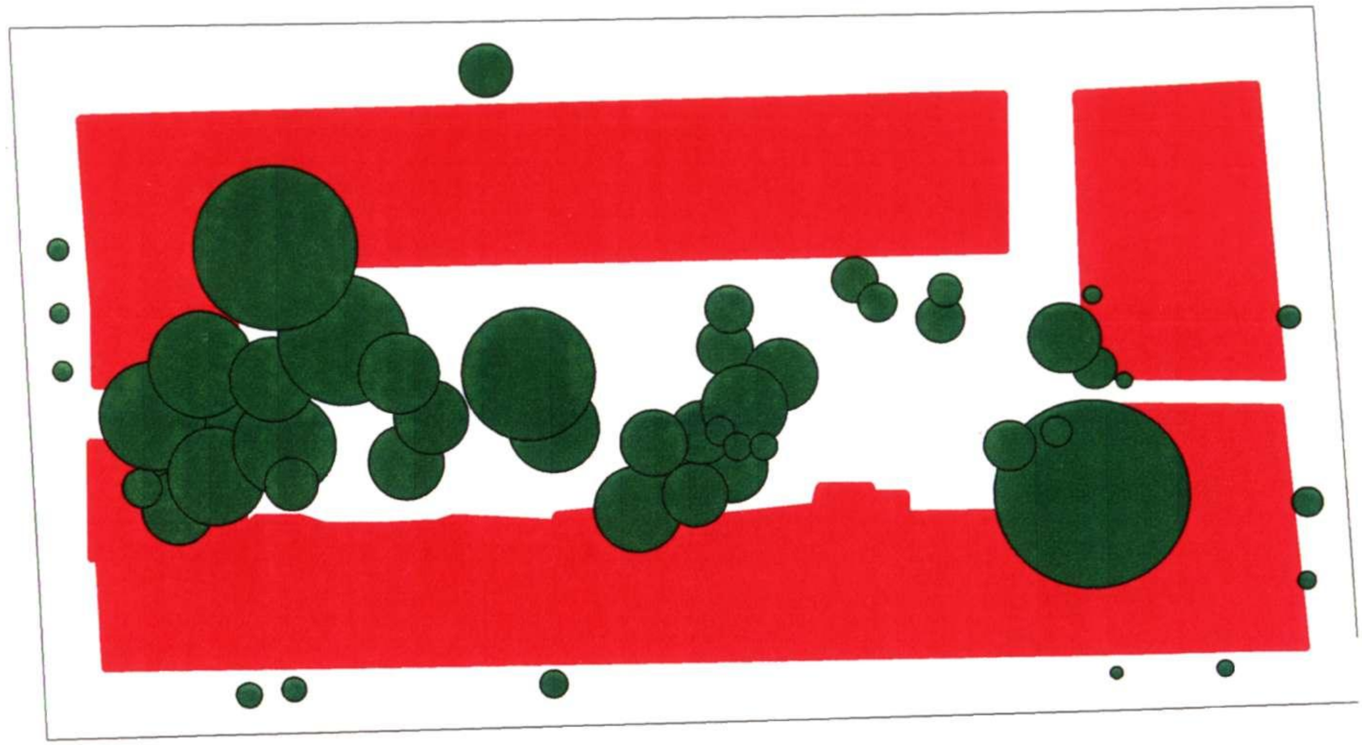


Figure 5.7: Baltimore, MD Site A

Carbon Benefits
- Carbon Storage: 21.98 tons
- Carbon Sequestration: 0.04 tons/yr

Energy Benefits
- Total Savings: $441.00 (7000.0kwh)
- Savings per Home: $110.25 (1750.0kwh)

Pollution Removal Benefits
- Ozone: $47.13 (15.4lbs)
- S02: $2.86 (3.8lbs)
- N02: $19.45 (6.4lbs)
- PM 10: $41.77 (12.8lbs)
- CO: $0.70 (1.6lbs)

Stormwater Benefits *
- Runoff Reduction: 19.5%
- Time of Concentration Increase: 18.8%
- Peak Flow Reduction: 25.7%
- Avoided Storage**: 3488 cubic feet

'Stormwater results are based on existing trees compared with a 0% tree canopy condition
"Retention basin volume required if existing trees were removed.

Baltimore B

Study Site

Total Area: 1.98 ac
Canopy Area: 0.03 ac (2%)
Grass Area: 0.19 ac (10%)
Imperv Area: 0.49 ac (25%)
Building Area: 1.26 ac (64%)
Water Area: ~ ac (~%)
Number of Homes: 3
Hydrologic Soil: B
Percent Slope: 1.0
Pond Percent: 0
Rainfall Type: II
Precipitation: 2.75 in
Runoff Volume: 2.17 in

Tree Statistics

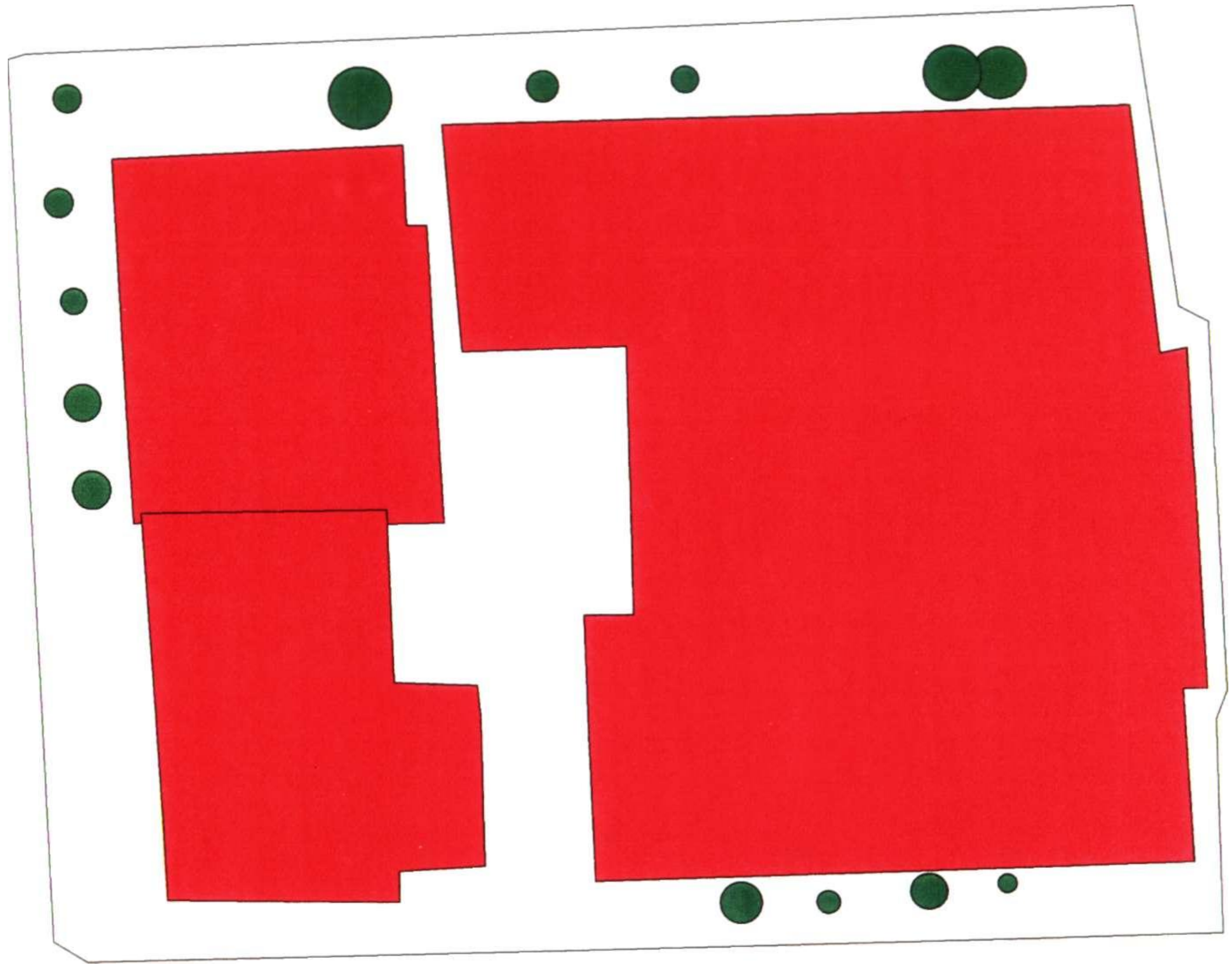
Tree Count: 14
Avg dbh: 5.3in
Avg dbh Class: 1.0
Avg Ht Class: 1.9
Avg Health Class: 3.4
Number of Species: 2
Dominant Species: LIN (57%)
Ownership (V|B|Unk): 0%|100%|0%

Carbon Benefits

Carbon Storage: 0.97 tons
Carbon Sequestration: 0.02 tons/yr

Energy Benefits

Total Savings: $62.63 (994.0kwh)
Savings per Home: $20.88 (331.4kwh)



Pollution Removal Benefits

Ozone: $2.85 (0.9lbs)
S02: $0.17 (0.2lbs)
NO2:$1.17(0.4lbs)
PM 10: $2.52 (0.8lbs)
CO: $0.04 (0.1 lbs)

Stormwater Benefits *

Runoff Reduction: 1.7%
Time of Concentration Increase: 2.0%
Peak Flow Reduction: 2.3%
Avoided Storage**: 272 cubic feet

*Stormwater results are based on existing trees compared with a 0% tree canopy condition
**Retention basin volume required if existing trees were removed.

Figure 5.8: Baltimore, MD Site B

Baltimore C

Study Site
- Total Area: 4.17 ac
- Canopy Area: 0.86 ac (21 %)
- Grass Area: 2.31 ac (55%)
- Imperv Area: 0.54 ac (13%)
- Building Area: 0.47 ac (11%)
- Water Area: ~ ac (~%)
- Number of Homes: 19
- Hydrologic Soil: C
- Percent Slope: 5.0
- Pond Percent: 0
- Rainfall Type: II
- Precipitation: 2.75 in
- Runoff Volume: 1.19 in

Tree Statistics
- Tree Count: 64
- Avg dbh: 12.8in
- Avg dbh Class: 1.6
- Avg Ht Class: 1.4
- Avg Health Class: 3.5
- Number of Species: 21
- Dominant Species: RM (27%)
- Ownership (V|B|Unk): 92%|8%|0%

Carbon Benefits
- Carbon Storage: 38.00 tons
- Carbon Sequestration: 0.07 tons/yr

Energy Benefits
- Total Savings: $180.38 (2863.1 kwh)
- Savings per Home: $9.49 (150.7kwh)

Pollution Removal Benefits
- Ozone: $81.51 (26.6lbs)
- SO_2: $4.94 (6.6lbs)
- NO_2: $33.64 (11.0lbs)
- PM 10: $72.24 (22.2lbs)
- CO: $1.21 (2.8lbs)

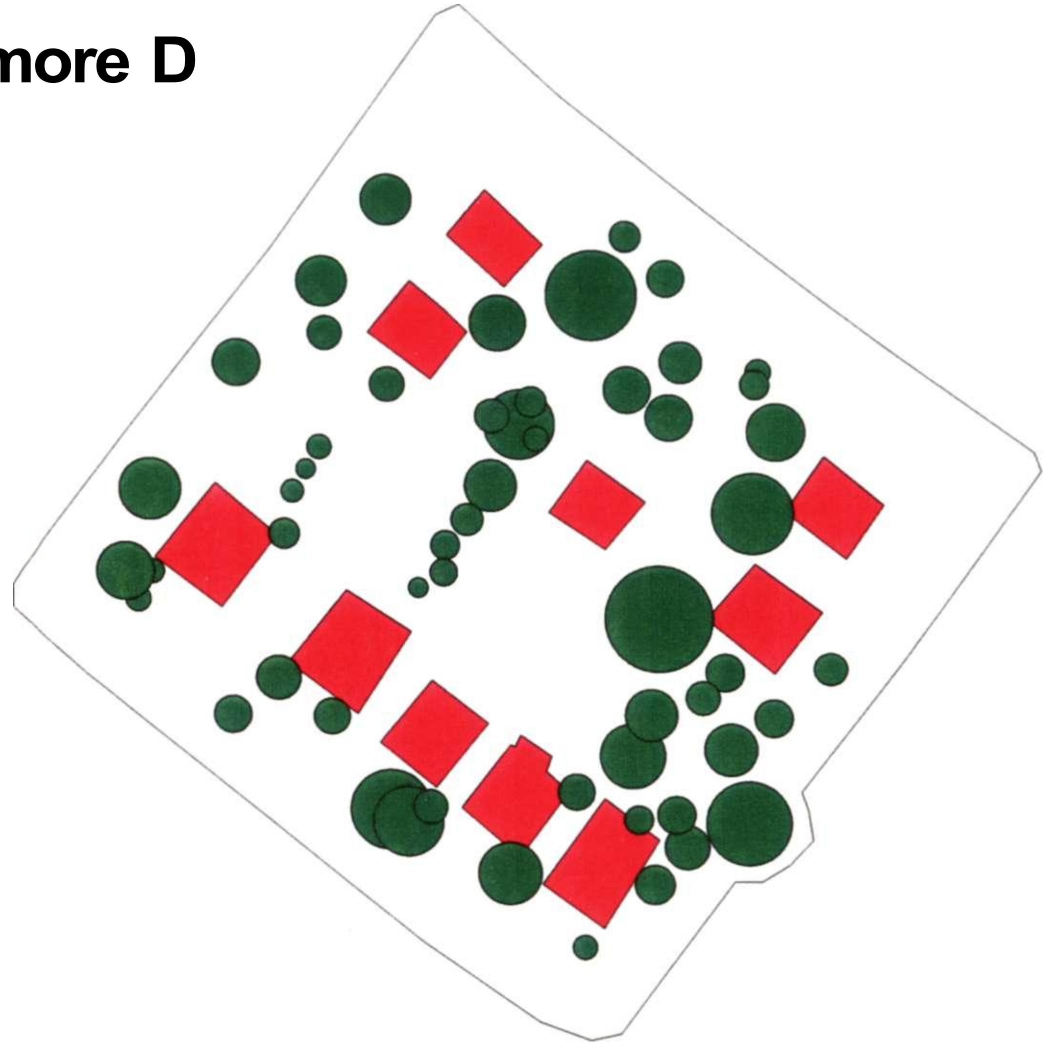
Stormwater Benefits *
- Runoff Reduction: 15.8%
- Time of Concentration Increase: 12.2%
- Peak Flow Reduction: 20.3%
- Avoided Storage**: 3393 cubic feet

*Stormwater results are based on existing trees compared with a 0% tree canopy condition
**Retention basin volume required if existing trees were removed

Figure 5.9: Baltimore, MD Site C

Baltimore D

Figure 5.11: Baltimore, MD Site D



Study Site

Total Area: 2.91 ac
Canopy Area: 0.46 ac (16%)
Grass Area: 1.56 ac (54%)
Imperv Area: 0.57 ac (20%)
Building Area: 0.31 ac (11%)
Water Area: ~ ac (~%)
Number of Homes: 10
Hydrologic Soil: B
Percent Slope: 1.0
Pond Percent: 0
Rainfall Type: II
Precipitation: 2.75 in
Runoff Volume: 0.85 in

Tree Statistics

Tree Count: 51
Avg dbh: 12.8in
Avg dbh Class: 1.9
Avg Ht Class: 2.1
Avg Health Class: 3.2
Number of Species: 19
Dominant Species: NM (16%)
Ownership (V|B|Unk): 76%|24%|0%

Carbon Benefits

Carbon Storage: 20.51 tons
Carbon Sequestration: 0.04 tons/yr

Energy Benefits

Total Savings: $401.25 (6369.1kwh)
Savings per Home: $40.13 (636.9kwh)

Pollution Removal Benefits

Ozone: $44.01 (14.4lbs)
S02: $2.67 (3.6lbs)
N02: $18.16 (5.9lbs)
PM 10: $39.00 (12.0lbs)
CO: $0.65 (1.5lbs)

Stormwater Benefits *

Runoff Reduction: 20.4%
Time of Concentration Increase: 13.0%
Peak Flow Reduction: 27.6%
Avoided Storage**: 2318 cubic feet

*Stormwater results are based on existing trees compared with a 0% tree canopy condition
**Retention basin volume required if existing trees were removed.

Baltimore E

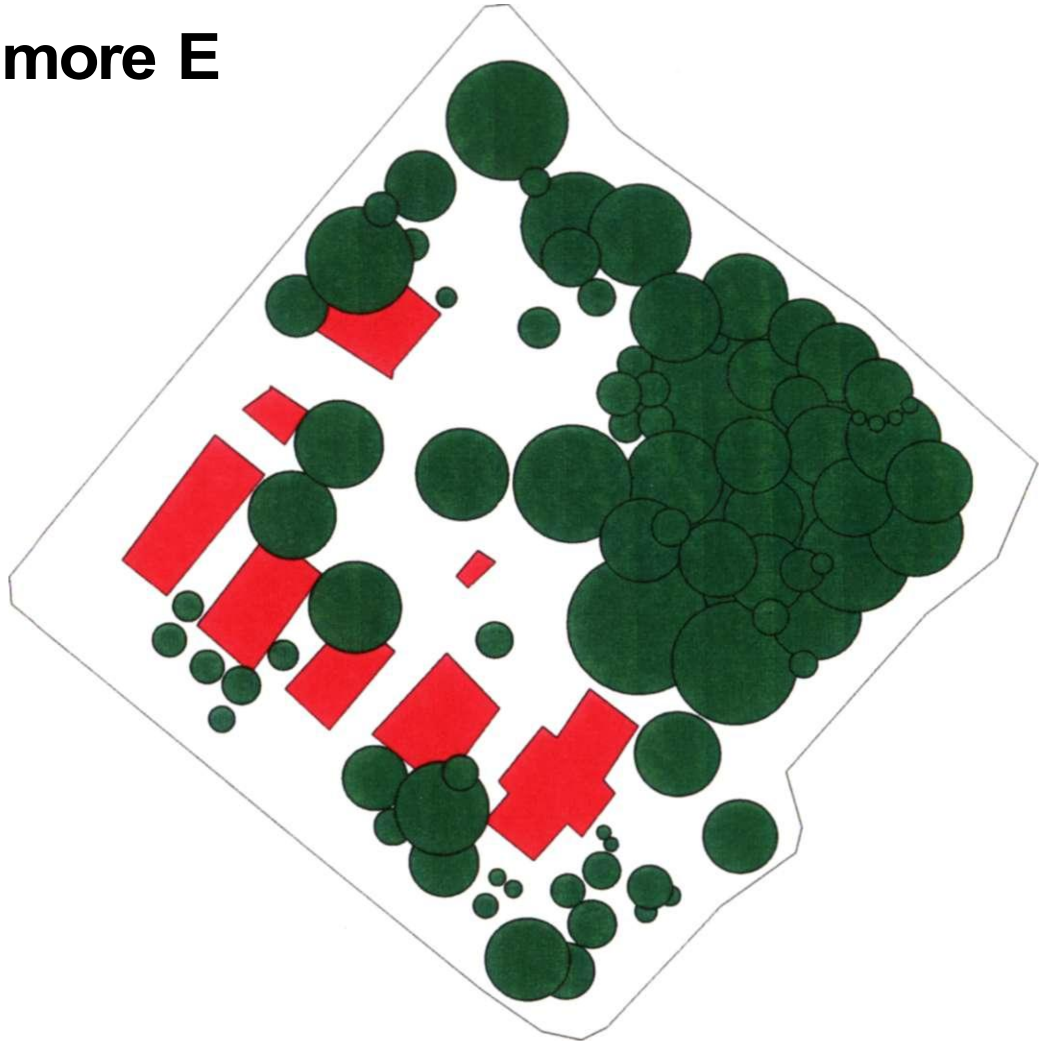


Figure 5.12: Baltimore, MD Site E

Study Site

- Total Area: 2.79 ac
- Canopy Area: 1.17 ac (42%)
- Grass Area: 0.99 ac (36%)
- Imperv Area: 0.34 ac (12%)
- Building Area: 0.28 ac (10%)
- Water Area: ~ ac (~%)
- Number of Homes: 7
- Hydrologic Soil: B
- Percent Slope: 1.0
- Pond Percent: 0
- Rainfall Type: II
- Precipitation: 2.75 in
- Runoff Volume: 0.61 in

Tree Statistics

- Tree Count: 78
- Avg dbh: 12.7in
- Avg dbh Class: 1.8
- Avg Ht Class: 2.2
- Avg Health Class: 3.6
- Number of Species: 20
- Dominant Species: BL (23%)
- Ownership (V|B|Unk): 90%|10%|0%

Carbon Benefits

- Carbon Storage: 51.87 tons
- Carbon Sequestration: 0.09 tons/yr

Energy Benefits

- Total Savings: $297.38 (4720.2kwh)
- Savings per Home: $42.48 (674.3kwh)

Pollution Removal Benefits

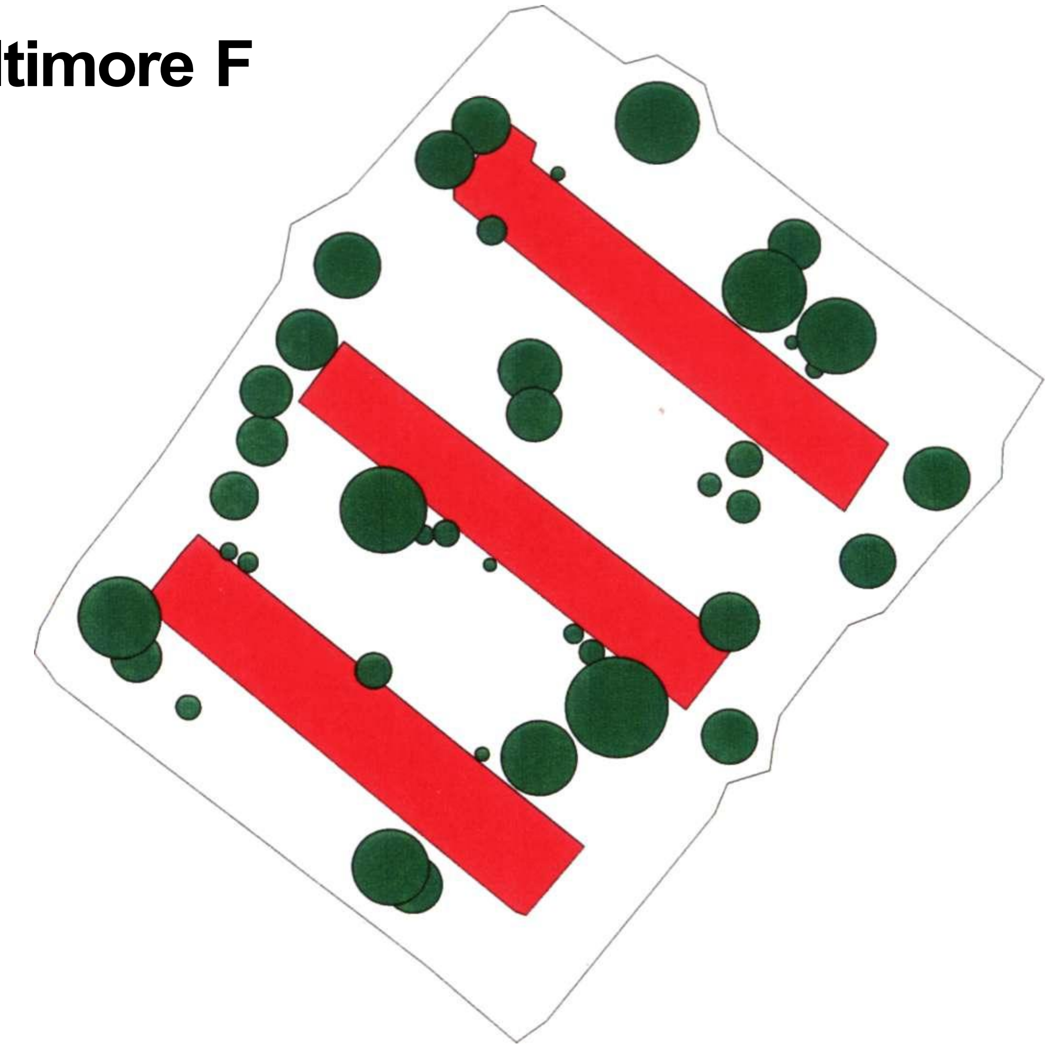
- Ozone: $111.25 (36.3lbs)
- S02: $6.74 (9.0lbs)
- N02: $45.91 (15.0lbs)
- PM 10: $98.60 (30.3lbs)
- CO: $1.65 (3.8lbs)

Stormwater Benefits *

- Runoff Reduction: 47.0%
- Time of Concentration Increase: 37.1%
- Peak Flow Reduction: 58.9%
- Avoided Storage**: 5511 cubic feet

•Stormwater results are based on existing trees compared with a 0% tree canopy condition
"Retention basin volume required if existing trees were removed.

Baltimore F



Study Site

Total Area: 3.63 ac
Canopy Area: 0.51 ac (14%)
Grass Area: 1.31 ac (36%)
Imperv Area: 1.01 ac (28%)
Building Area: 0.81 ac (22%)
Water Area: - ac (~%)
Number of Homes: 3
Hydrologic Soil: B
Percent Slope: 1.0
Pond Percent: 0
Rainfall Type: II
Precipitation: 2.75 in
Runoff Volume: 1.18 in

Tree Statistics

Tree Count: 38
Avg dbh: 16.3in
Avg dbh Class: 2.0
Avg Ht Class: 2.5
Avg Health Class: 3.8
Number of Species: 16
Dominant Species: LIN (18%)
Ownership (V|B|Unk): 76%|24%|0%

Carbon Benefits

Carbon Storage: 22.44 tons
Carbon Sequestration: 0.04 tons/yr

Energy Benefits

Total Savings: $433.13 (6875.0kwh)
Savings per Home: $144.38 (2291.7kwh)

Pollution Removal Benefits

Ozone: $48.13 (15.7lbs)
S02: $2.92 (3.9lbs)
N02: $19.86 (6.5lbs)
PM 10: $42.65 (13.1 lbs)
CO: $0.72 (1.6lbs)

Stormwater Benefits *

Runoff Reduction: 16.5%
Time of Concentration Increase: 12.8%
Peak Flow Reduction: 23.0%
Avoided Storage**: 3089 cubic feet

•Stormwater results are based on existing trees compared with a 0% tree canopy condition
"Retention basin volume required if existing trees were removed.

Figure 5.13: Baltimore, MD Site F

Baltimore G

Study Site
Total Area: 4.65 ac
Canopy Area: 1.11 ac (24%)
Grass Area: 2.36 ac (51%)
Imperv Area: 0.78 ac (17%)
Building Area: 0.40 ac (9%)
Water Area: ~ ac (~%)
Number of Homes: 11
Hydrologic Soil: D
Percent Slope: 2.0
Pond Percent: 0
Rainfall Type: II
Precipitation: 2.75 in
Runoff Volume: 1.48 in

Tree Statistics
Tree Count: 109
Avg dbh: 12.3in
Avg dbh Class: 1.6
Avg Ht Class: 2.0
Avg Health Class: 3.6
Number of Species: 20
Dominant Species: AIL (15%)
Ownership (V|B|Unk): 95%|5%|0%

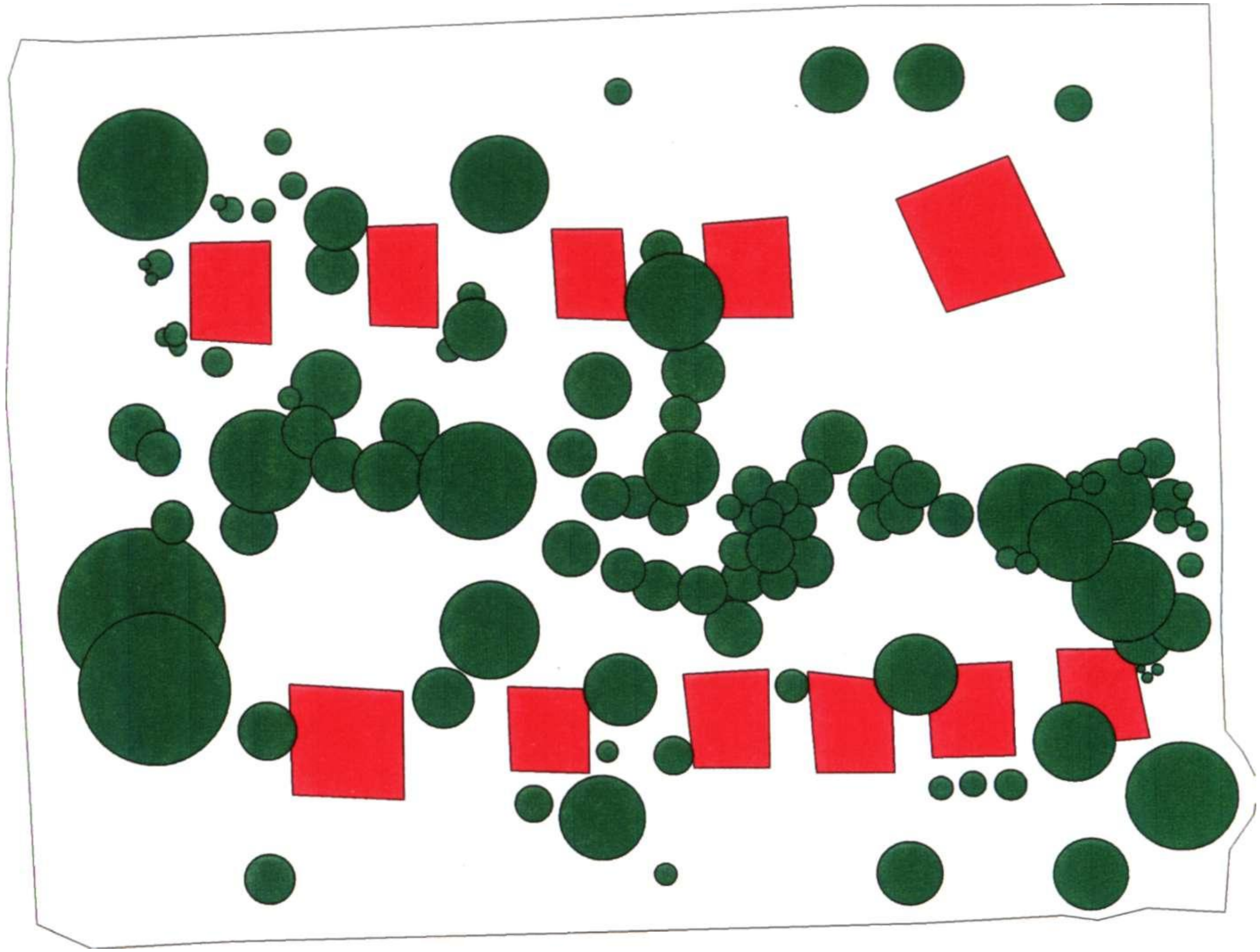


Figure 5.14: Baltimore, MD Site G

Carbon Benefits
Carbon Storage: 49.00 tons
Carbon Sequestration: 0.09 tons/yr

Energy Benefits
Total Savings: $451.50 (7166.7kwh)
Savings per Home: $41.05 (651.5kwh)

Pollution Removal Benefits
Ozone: $105.10 (34.3lbs)
S02: $6.37 (8.5lbs)
N02: $43.37 (14.2lbs)
PM 10: $93.14 (28.6lbs)
CO: $1.56 (3.6lbs)

Stormwater Benefits *
Runoff Reduction: 12.8%
Time of Concentration Increase: 11.5%
Peak Flow Reduction: 17.0%
Avoided Storage**: 3655 cubic feet

'Stormwater results are based on existing trees compared with a 0% tree canopy condition
"Retention basin volume required if existing trees were removed.

Baltimore H

Study Site
- Total Area: 5.75 ac
- Canopy Area: 1.19 ac (21%)
- Grass Area: 2.21 ac (38%)
- Imperv Area: 1.42 ac (25%)
- Building Area: 0.92 ac (16%)
- Water Area: ~ ac (~%)
- Number of Homes: 17
- Hydrologic Soil: D
- Percent Slope: 5.0
- Pond Percent: 0
- Rainfall Type: II
- Precipitation: 2.75 in
- Runoff Volume: 1.65 in

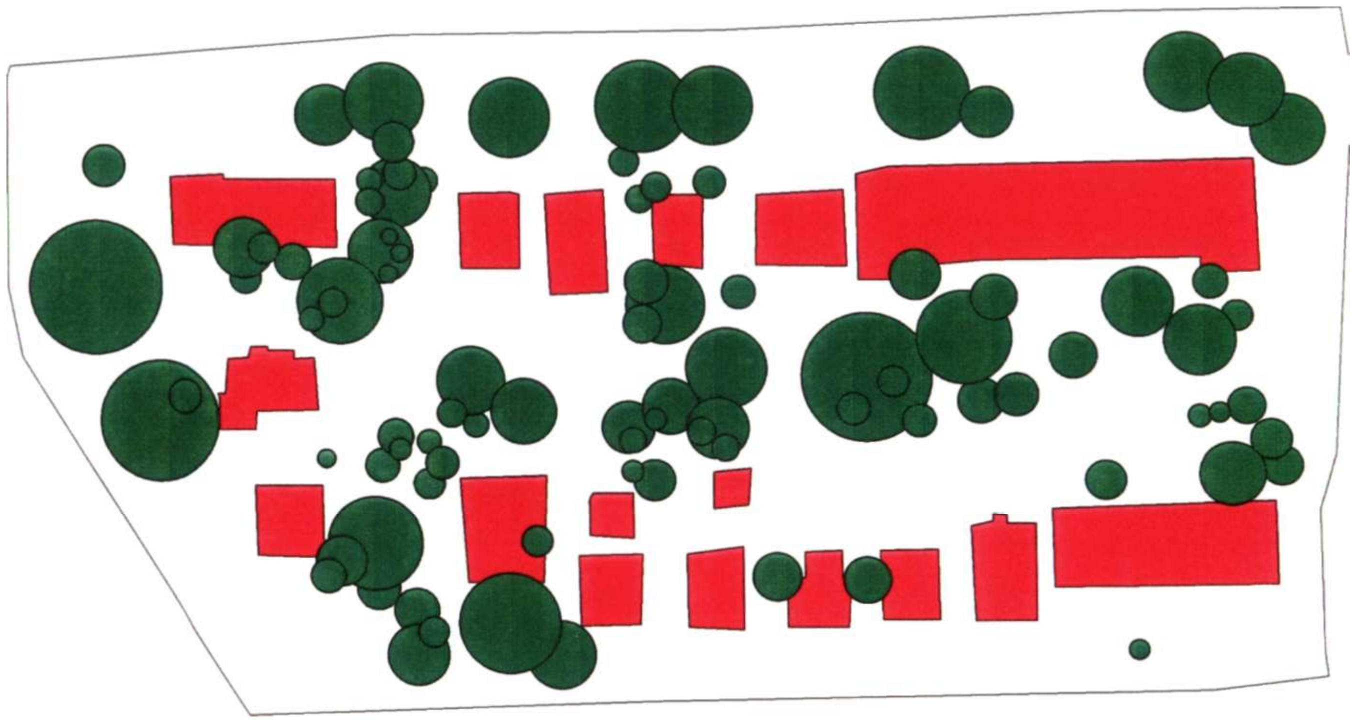


Figure 5.15: Baltimore, MD Site H

Tree Statistics
- Tree Count: 80
- Avg dbh: 13.7in
- Avg dbh Class: 2.0
- Avg Ht Class: 2.5
- Avg Health Class: 3.1
- Number of Species: 20
- Dominant Species: ELM (33%)
- Ownership (V|B|Unk): 80%|20%|0%

Carbon Benefits
- Carbon Storage: 64.23 tons
- Carbon Sequestration: 0.18 tons/yr

Energy Benefits
- Total Savings: $284.63 (4517.9kwh)
- Savings per Home: $16.74 (265.8kwh)

Pollution Removal Benefits
- Ozone: $113.00 (36.9lbs)
- S02: $6.85 (9.1 lbs)
- N02: $46.63 (15.2lbs)
- PM 10: $100.15 (30.8lbs)
- CO: $1.68 (3.8lbs)

Stormwater Benefits *
- Runoff Reduction: 10.9%
- Time of Concentration Increase: 10.7%
- Peak Flow Reduction: 13.6%
- Avoided Storage**: 4225 cubic feet

*Stormwater results are based on existing trees compared with a 0% tree canopy condition
**Retention basin volume required if existing trees were removed.

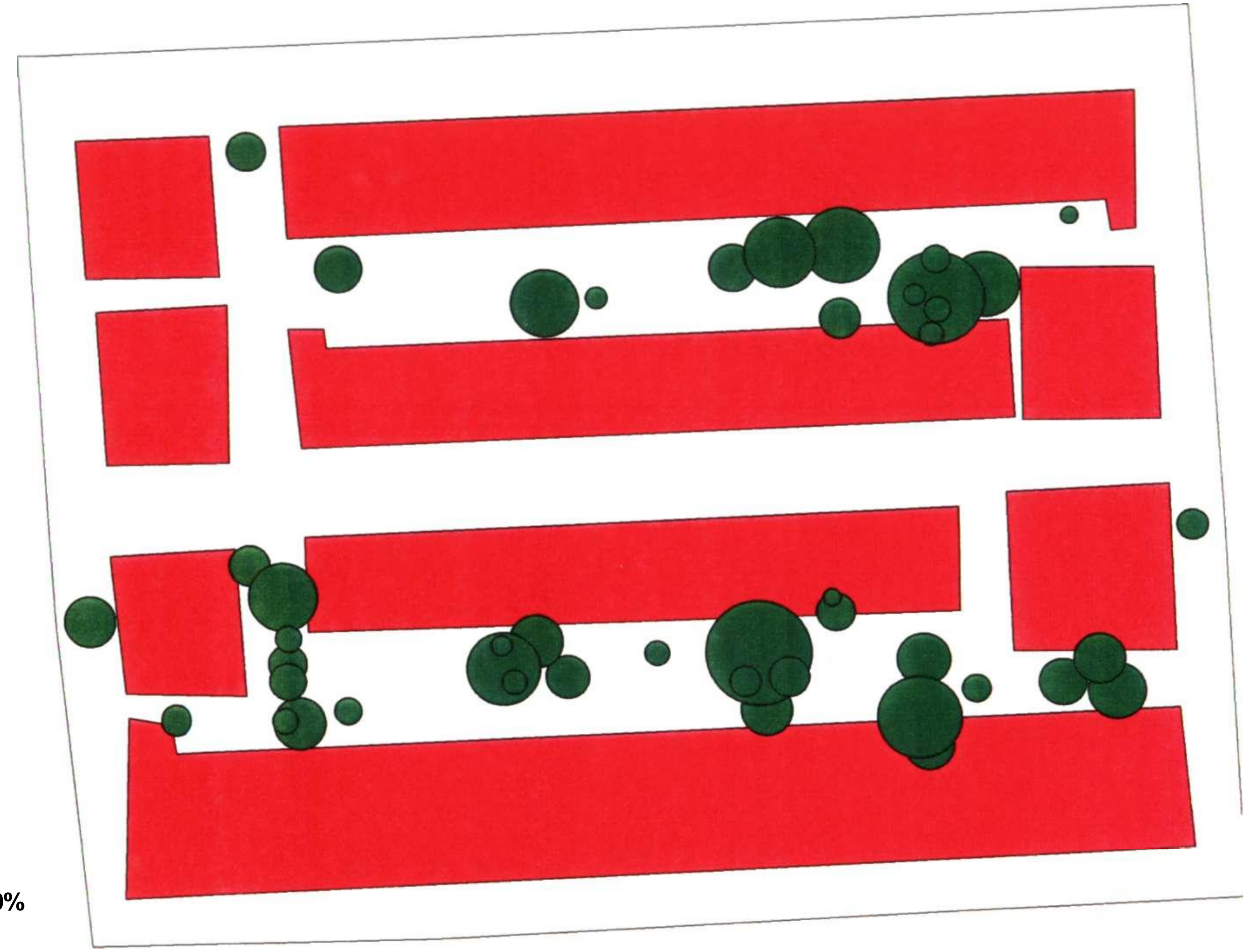
Baltimore I

Study Site
- Total Area: 3.76 ac
- Canopy Area: 0.24 ac (6%)
- Grass Area: 0.87 ac (23%)
- Imperv Area: 0.90 ac (24%)
- Building Area: 1.75 ac (46%)
- Water Area: ~ ac (~%)
- Number of Homes: 9
- Hydrologic Soil: C
- Percent Slope: 2.0
- Pond Percent: 0
- Rainfall Type: II
- Precipitation: 2.75 in
- Runoff Volume: 1.92 in

Tree Statistics
- Tree Count: 42
- Avg dbh: 9.9in
- Avg dbh Class: 1.4
- Avg Ht Class: 2.2
- Avg Health Class: 3.1
- Number of Species: 4
- Dominant Species: AIL (90%)
- Ownership (V|B|Unk): 98%|2%|0%

Carbon Benefits
- Carbon Storage: 7.87 tons
- Carbon Sequestration: 0.18 tons/yr

Energy Benefits
- Total Savings: $311.63 (4946.4kwh)
- Savings per Home: $34.63 (549.6kwh)



Pollution Removal Benefits
- Ozone: $23.17 (7.6lbs)
- S02: $1.40 (1.9lbs)
- N02: $9.56 (3.1 lbs)
- PM 10: $20.53 (6.3lbs)
- CO: $0.34 (0.8lbs)

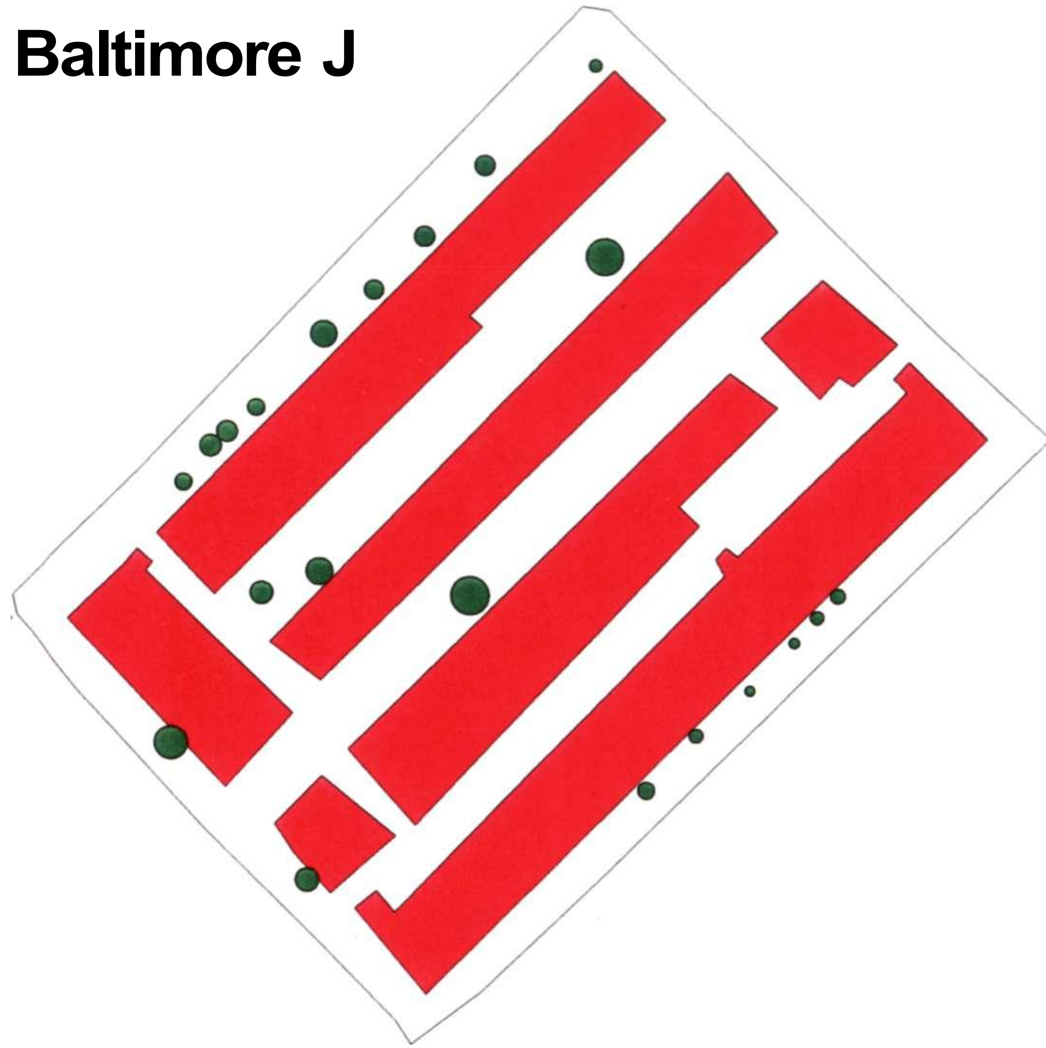
Stormwater Benefits *
- Runoff Reduction: 4.8%
- Time of Concentration Increase: 5.0%
- Peak Flow Reduction: 6.3%
- Avoided Storage**: 1321 cubic feet

*Stormwater results are based on existing trees compared with a 0% tree canopy condition
**Retention basin volume required if existing trees were removed.

Figure 5.16: Baltimore, MD Site I

Figure 5.17: Baltimore, MD Site J

Baltimore J



Study Site
- Total Area: 4.61 ac
- Canopy Area: 0.07 ac (2%)
- Grass Area: 1.22 ac (27%)
- Imperv Area: 1.18 ac (26%)
- Building Area: 2.13 ac (46%)
- Water Area: ~ ac (~%)
- Number of Homes: 7
- Hydrologic Soil: B
- Percent Slope: 1.0
- Pond Percent: 0
- Rainfall Type: II
- Precipitation: 2.75 in
- Runoff Volume: 1.73 in

Tree Statistics
- Tree Count: 21
- Avg dbh: 6.3in
- Avg dbh Class: 1.2
- Avg Ht Class: 1.8
- Avg Health Class: 3.8
- Number of Species: 7
- Dominant Species: NM (38%)
- Ownership (V|B|Unk): 14%|86%|0%

Carbon Benefits
- Carbon Storage: 2.27 tons
- Carbon Sequestration: 0.05 tons/yr

Energy Benefits
- Total Savings: $192.75 (3059.5kwh)
- Savings per Home: $27.54 (437.1 kwh)

Pollution Removal Benefits
- Ozone: $6.68 (2.2lbs)
- S02: $0.40 (0.5lbs)
- N02: $2.76 (0.9lbs)
- PM 10: $5.92 (1.8lbs)
- CO: $0.10(0.2lbs)

Stormwater Benefits *
- Runoff Reduction: 1.8%
- Time of Concentration Increase: 1.6%
- Peak Flow Reduction: 2.4%
- Avoided Storage**: 535 cubic feet

"Stormwater results are based on existing trees compared with a 0% tree canopy condition
"Retention basin volume required if existing trees were removed

Baltimore K

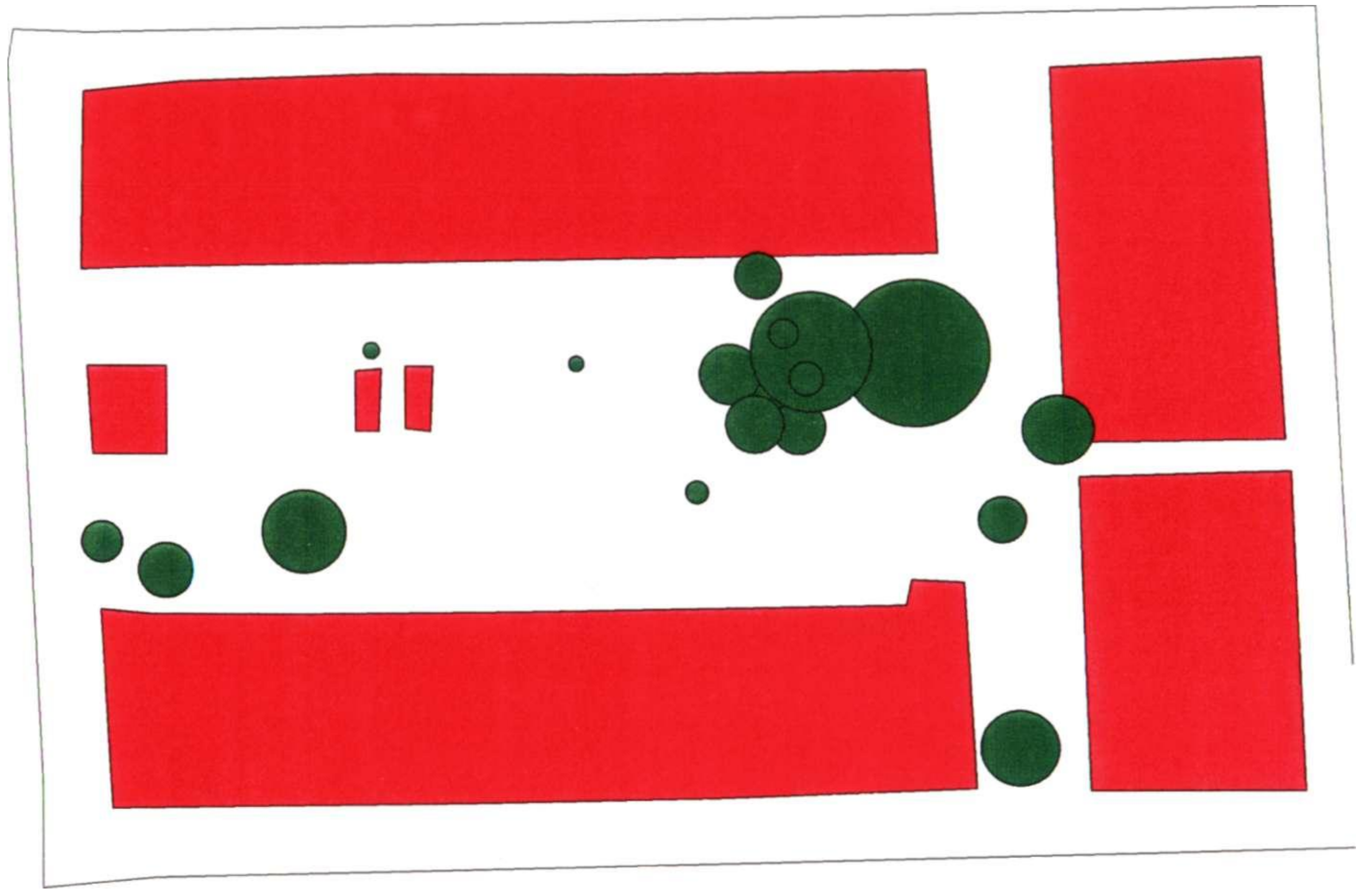


Figure 5.18: Baltimore, MD Site K

Study Site

- Total Area: 1.98 ac
- Canopy Area: 0.10 ac (5%)
- Grass Area: 0.51 ac (26%)
- Imperv Area: 0.51 ac (26%)
- Building Area: 0.86 ac (44%)
- Water Area: ~ ac (~%)
- Number of Homes: 5
- Hydrologic Soil: B
- Percent Slope: 1.0
- Pond Percent: 0
- Rainfall Type: II
- Precipitation: 2.75 in
- Runoff Volume: 1.64 in

Tree Statistics

- Tree Count: 15
- Avg dbh: 9.2in
- Avg dbh Class: 1.3
- Avg Ht Class: 1.9
- Avg Health Class: 2.5
- Number of Species: 5
- Dominant Species: AIL (73%)
- Ownership (V|B|Unk): 93%|7%|0%

Carbon Benefits

- Carbon Storage: 3.18 tons
- Carbon Sequestration: 0.07 tons/yr

Energy Benefits

- Total Savings: $37.13 (589.3kwh)
- Savings per Home: $7.42 (117.9kwh)

Pollution Removal Benefits

- Ozone: $9.34 (3.1 lbs)
- S02: $0.57 (0.8lbs)
- N02: $3.86 (1.3lbs)
- PM 10: $8.28 (2.5lbs)
- CO: $0.14 (0.3lbs)

Stormwater Benefits *

- Runoff Reduction: 5.8%
- Time of Concentration Increase: 5.2%
- Peak Flow Reduction: 7.4%
- Avoided Storage**: 728 cubic feet

'Stormwater results are based on existing trees compared with a 0% tree canopy condition
"Retention basin volume required if existing trees were removed.

Baltimore L

Study Site
- Total Area: 9.50 ac
- Canopy Area: 0.12 ac (1%)
- Grass Area: 3.28 ac (35%)
- Imperv Area: 4.51 ac (47%)
- Building Area: 1.59 ac (17%)
- Water Area: ~ ac (~%)
- Number of Homes: 8
- Hydrologic Soil: B
- Percent Slope: 1.0
- Pond Percent: 0
- Rainfall Type: II
- Precipitation: 2.75 in
- Runoff Volume: 1.56 in

Tree Statistics
- Tree Count: 147
- Avg dbh: 3.3in
- Avg dbh Class: 1.0
- Avg Ht Class: 1.0
- Avg Health Class: 3.8
- Number of Species: 15
- Dominant Species: RM (31%)
- Ownership (V|B|Unk): 99%|1%|0%

Figure 5.19: Baltimore, MD Site L

Carbon Benefits
- Carbon Storage: 3.86 tons
- Carbon Sequestration: 0.09 tons/yr

Energy Benefits
- Total Savings: $63.00 (1000.0kwh)
- Savings per Home: $7.88 (125.0kwh)

Pollution Removal Benefits
- Ozone: $11.34 (3.7lbs)
- S02: $0.69 (0.9lbs)
- N02: $4.68(1.5lbs)
- PM 10: $10.05 (3.1lbs)
- CO: $0.17 (0.4lbs)

Stormwater Benefits *
- Runoff Reduction: 1.5%
- Time of Concentration Increase: 1.2%
- Peak Flow Reduction: 2.3%
- Avoided Storage**: 834 cubic feet

"Stormwater results are based on existing trees compared with a 0% tree canopy condition
"Retention basin volume required if existing trees were removed

Baltimore M

Study Site
- Total Area: 11.52 ac
- Canopy Area: 3.67 ac (32%)
- Grass Area: 5.03 ac (44%)
- Imperv Area: 1.59 ac (14%)
- Building Area: 1.23 ac (11 %)
- Water Area: ~ ac (~%)
- Number of Homes: 42
- Hydrologic Soil: B
- Percent Slope: 1.0
- Pond Percent: 0
- Rainfall Type: II
- Precipitation: 2.75 in
- Runoff Volume: 0.69 in

Tree Statistics
- Tree Count: 184
- Avg dbh: 15.5in
- Avg dbh Class: 1.8
- Avg Ht Class: 2.1
- Avg Health Class: 3.7
- Number of Species: 32
- Dominant Species: NM (15%)
- Ownership (V|B|Unk): 86%|14%|0%

Carbon Benefits
- Carbon Storage: 162.48 tons
- Carbon Sequestration: 0.28 tons/yr

Energy Benefits
- Total Savings: $700.13 (11113.1 kwh)
- Savings per Home: $16.67 (264.6kwh)

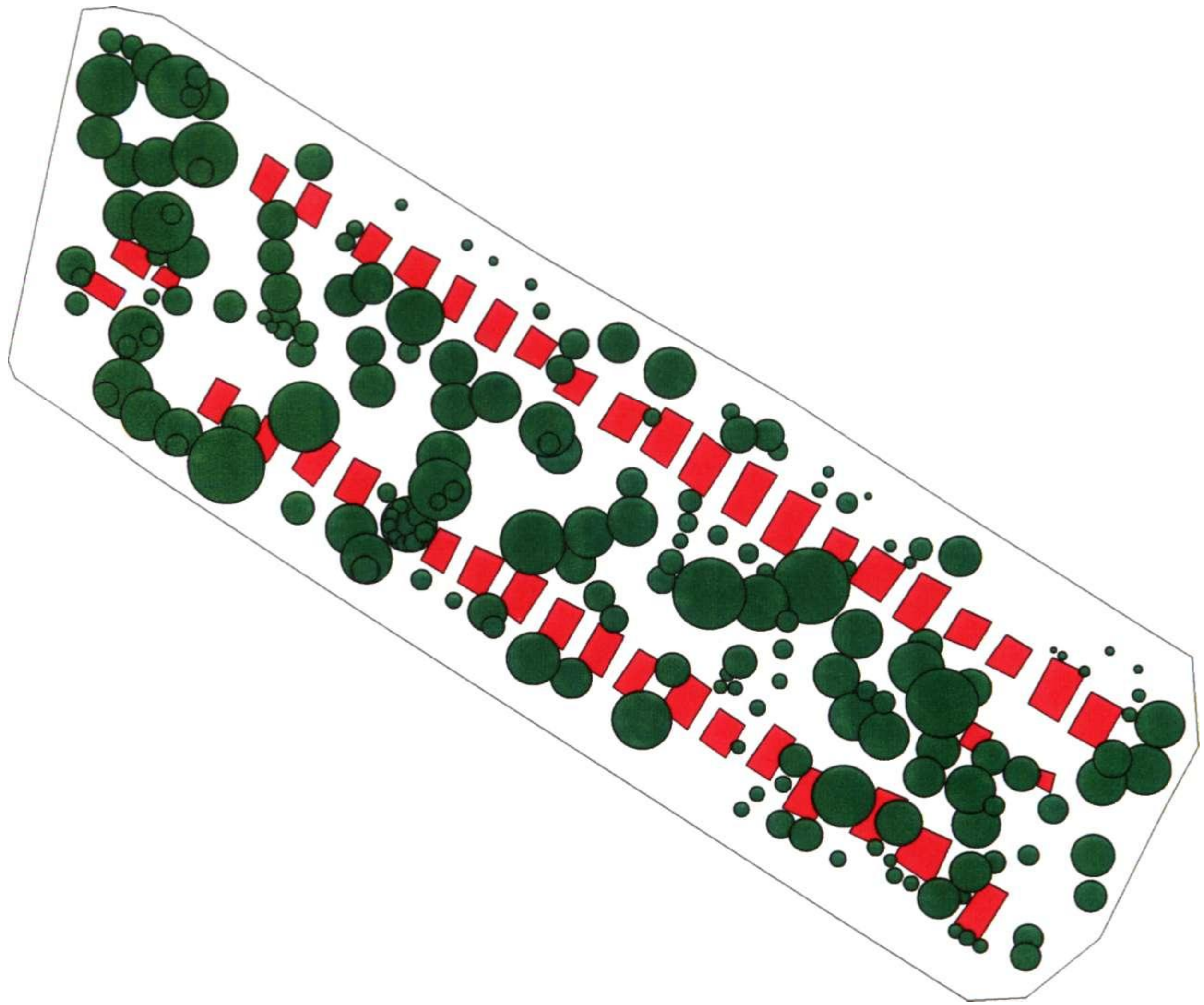


Figure 5.21: Baltimore, MD Site M

Pollution Removal Benefits
- Ozone: $348.50 (113.8lbs)
- S02: $21.12 (28.1 lbs)
- N02: $143.82 (47.0lbs)
- PM 10: $308.87 (94.9lbs)
- CO: $5.18(11.8lbs)

Stormwater Benefits *
- Runoff Reduction: 37.8%
- Time of Concentration Increase: 27.2%
- Peak Flow Reduction: 50.4%
- Avoided Storage**: 17486 cubic feet

*Stormwater results are based on existing trees compared with a 0% tree canopy condition
**Retention basin volume required if existing trees were removed.

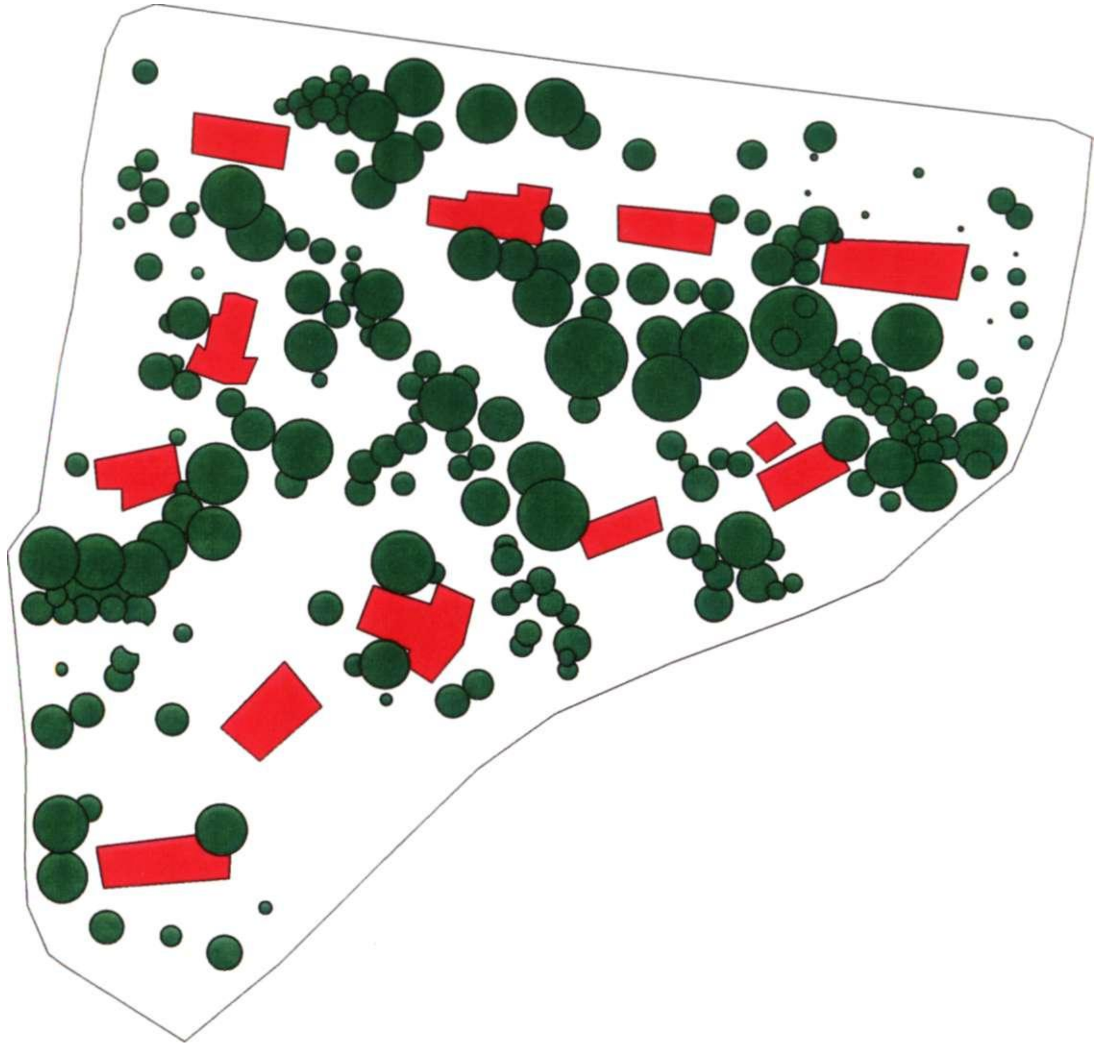
Baltimore N

Study Site
- Total Area: 11.02 ac
- Canopy Area: 2.68 ac (24%)
- Grass Area: 6.37 ac (58%)
- Imperv Area: 1.17 ac (11%)
- Building Area: 0.81 ac (7%)
- Water Area: ~ ac (~%)
- Number of Homes: 12
- Hydrologic Soil: B
- Percent Slope: 1.0
- Pond Percent: 0
- Rainfall Type: II
- Precipitation: 2.75 in
- Runoff Volume: 0.64 in

Tree Statistics
- Tree Count: 193
- Avg dbh: 12.2in
- Avg dbh Class: 1.6
- Avg Ht Class: 1.8
- Avg Health Class: 3.7
- Number of Species: 38
- Dominant Species: HEM (16%)
- Ownership (V|B|Unk): 100%|0%|0%

Carbon Benefits
- Carbon Storage: 86.42 tons
- Carbon Sequestration: 1.95 tons/yr

Energy Benefits
- Total Savings: $217.80 (3457.1kwh)
- Savings per Home: $19.80 (314.3kwh)



Pollution Removal Benefits
- Ozone: $254.15 (83.0lbs)
- S02: $15.40 (20.5lbs)
- N02: $104.88 (34.3lbs)
- PM 10: $225.24 (69.2lbs)
- CO: $3.78 (8.6lbs)

Stormwater Benefits *
- Runoff Reduction: 31.5%
- Time of Concentration Increase: 19.4%
- Peak Flow Reduction: 42.6%
- Avoided Storage**: 11857 cubic feet

*Stormwater results are based on existing trees compared with a 0% tree canopy condition
**Retention basin volume required if existing trees were removed.

Figure 5.22: Baltimore, MD Site N

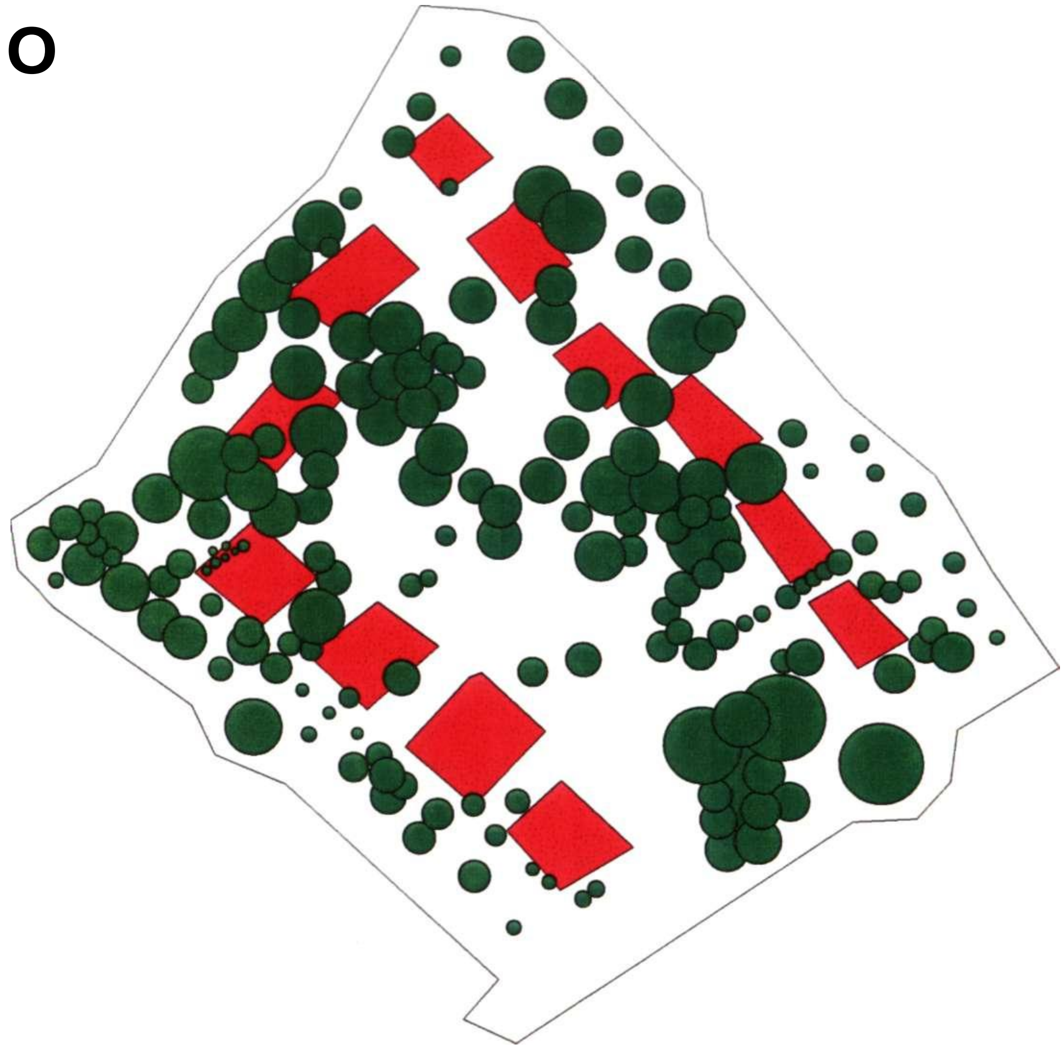
Baltimore O

Study Site
- Total Area: 7.33 ac
- Canopy Area: 2.09 ac (29%)
- Grass Area: 3.73 ac (51 %)
- Imperv Area: 0.54 ac (7%)
- Building Area: 0.97 ac (13%)
- Water Area: ~ ac (~%)
- Number of Homes: 13
- Hydrologic Soil: C
- Percent Slope: 1.0
- Pond Percent: 0
- Rainfall Type: II
- Precipitation: 2.75 in
- Runoff Volume: 1.12 in

Tree Statistics
- Tree Count: 165
- Avg dbh: 14.8in
- Avg dbh Class: 2.0
- Avg Ht Class: 2.4
- Avg Health Class: 4.6
- Number of Species: 37
- Dominant Species: RO (13%)
- Ownership (V|B|Unk): 82%|18%|0%

Carbon Benefits
- Carbon Storage: 112.65 tons
- Carbon Sequestration: 0.32 tons/yr

Energy Benefits
- Total Savings: $1069.88 (16982.1kwh)
- Savings per Home: $82.30 (1306.3kwh)



Pollution Removal Benefits
- Ozone: $198.18 (64.7lbs)
- S02: $12.01 (16.0lbs)
- N02: $81.78 (26.7lbs)
- PM 10: $175.64 (54.0lbs)
- CO: $2.95 (6.7lbs)

Stormwater Benefits *
- Runoff Reduction: 21.4%
- Time of Concentration Increase: 17.1%
- Peak Flow Reduction: 30.1%
- Avoided Storage**: 8093 cubic feet

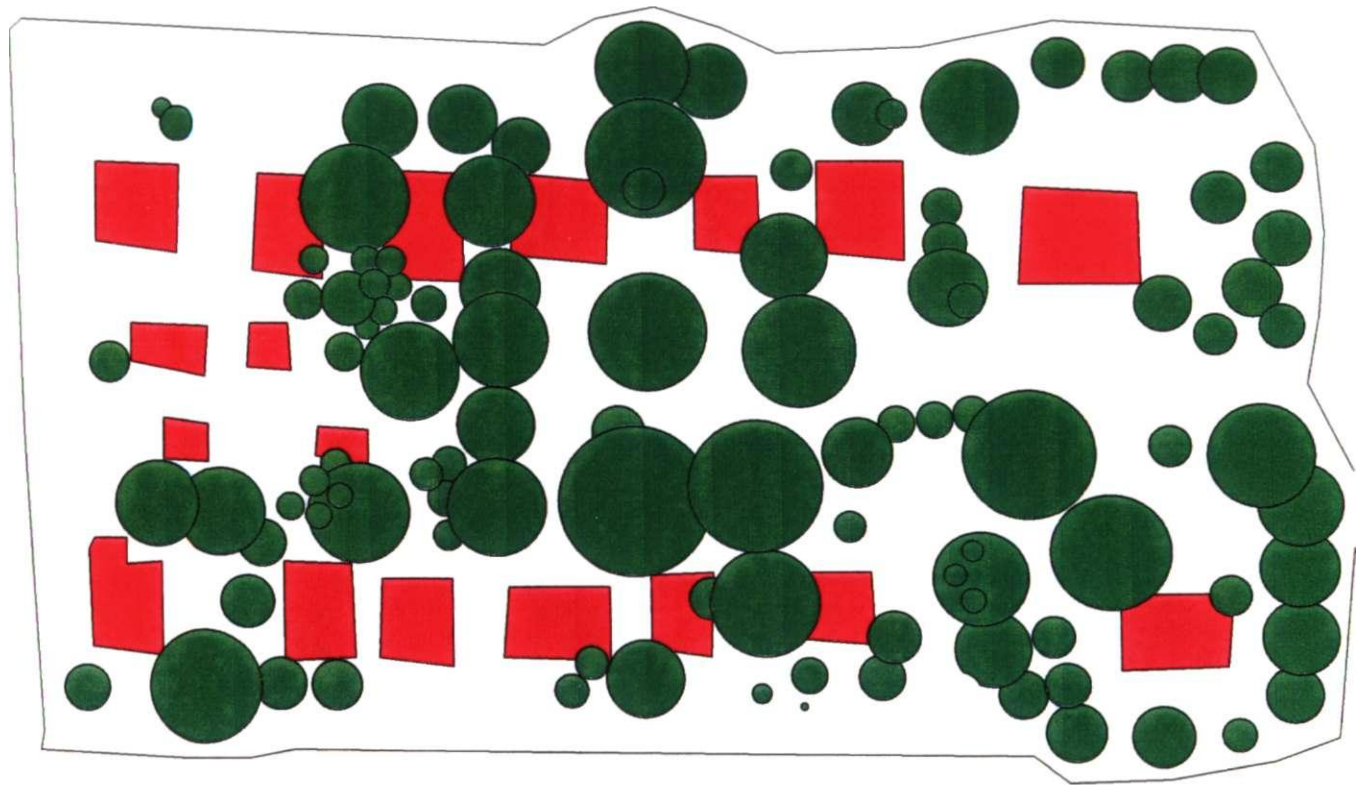
*Stormwater results are based on existing trees compared with a 0% tree canopy condition
**Retention basin volume required if existing trees were removed.

Figure 5.23: Baltimore, MD Site O

Baltimore P

Study Site

Total Area: 5.40 ac
Canopy Area: 1.68 ac (31 %)
Grass Area: 2.63 ac (49%)
Imperv Area: ~ ac (~%)
Building Area: 0.63 ac (12%)
Water Area: ~ ac (~%)
Number of Homes: 18
Hydrologic Soil: D
Percent Slope: 1.3
Pond Percent: 0
Rainfall Type: II
Precipitation: 3.10 in
Runoff Volume: 1.69 in



Tree Statistics

Tree Count: 96
Avg dbh: 15.0in
Avg dbh Class: 1.9
Avg Ht Class: 2.3
Avg Health Class: 3.2
Number of Species: 21
Dominant Species: NM (24%)
Ownership (V|B|Unk): 82%|18%|0%

Carbon Benefits

Carbon Storage: 74.53 tons
Carbon Sequestration: 0.13 tons/yr

Energy Benefits

Total Savings: $384.38 (6101.2kwh)
Savings per Home: $21.35 (339.0kwh)

Pollution Removal Benefits

Ozone: $159.84 (52.2lbs)
S02: $9.69 (12.9lbs)
N02: $65.96 (21.5lbs)
PM 10: $141.66 (43.5lbs)
CO: $2.38 (5.4lbs)

Stormwater Benefits *

Runoff Reduction: 15.0%
Time of Concentration Increase: 15.0%
Peak Flow Reduction: 20.4%
Avoided Storage**: 5882 cubic feet

*Stormwater results are based on existing trees compared with a 0% tree canopy condition
**Retention basin volume required if existing trees were removed.

Figure 5.24: Baltimore, MD Site P

6.0 ANALYSIS

Upon further analysis, many of the results obtained from research, data collecting, CITYgreen analysis, and interviews could be used to arrive at accurate conclusions about trends, issues, solutions and other information that will be helpful to us in making recommendations. This section consists of a thorough analysis of our interviews, research, ground-truthing experiences, and Local Analyses of Arlington, VA, and Baltimore, MD.

6.1 Interviews & Research

Both Fred Deneke and Ed Macie had similar thoughts on CITYgreen and tree cover's effect on public policy. Mr. Deneke spoke more generally about how valuing tree cover economically can affect policy and laws. Mr. Macie spoke more about CITYgreen itself, his experiences with the program, and his suggested improvements to the software.

Both gentlemen agreed that CITYgreen, in its current form, is a better public policy tool than a planning tool. They also mentioned the software TREES as a good example of a more effective planning tool, if it could be applied to other cities across the nation. Overall, they believe that CITYgreen is most effective as a means of communicating deforestation over a twenty-year period, using its regional analysis. This, in turn, demands the attention of public policymakers and the general public in that region, and eventually could result in new laws and ordinances to increase the canopy in that area. Also, they agree that in order for CITYgreen to become more useful to urban planners everywhere, it needs to better quantify tree cover, perhaps with more complex algorithms or with more benefits.

Further suggestions concerning improvements to CITYgreen itself can be arrived at best using the feedback from the program's users. Because of the way in which the small survey was written and distributed, and the fact that such a small percentage of CITYgreen users responded, the statistical results of the survey do not represent all CITYgreen users as a whole. In addition, generalizations, characterizations, and trends about CITYgreen users could not be identified when analyzing the results of this survey. However, some of the common responses and comments were helpful in getting an idea of some of the issues CITYgreen users are facing.

For example, the fact that only eighteen of the thirty-six CITYgreen purchasers that replied are still using the product indicates that there must be some dissatisfaction among CITYgreen users. However, due to the small sample of our survey, it can not be assumed that only fifty percent of all CITYgreen owners still use the product. Nevertheless, this high percentage of non-users was one our criteria in choosing to interview some of these customers, to find out some of the reasons behind their discontinued use. Also, the comments and suggestions supplied by the respondents, especially those seen most frequently, were of particular use in providing us with topics for telephone interviewing. The fact that two of the responding purchasers have never even been able to use CITYgreen is especially alarming. The urban planners have expressed two distinct opinions in their replies. Planners from smaller communities have complained that the input requirements such as satellite images were too expensive. However, some urban planners stated that CITYgreen's capabilities were not specific or accurate enough for their needs. Some teachers and professors expressed dissatisfaction with some of the program's more technical problems.

In our telephone interviews with three of these users, we investigated some of the difficulties that CITYgreen users have experienced, and then came up with some explanations for them. In many cases, when the user was dissatisfied, the reason was that they were not obtaining the figures that they had expected in terms of tree coverage benefits. Because they were not receiving their desired results, some CITYgreen users assumed that the algorithms of the program were not accurate. We aimed to find out if this assumption was true, or if the unsatisfactory results were a misunderstanding on the part of the user. This information would be helpful in our recommendations because it would assist us in determining which users' problems deserve the most attention.

One user, Fred Suffian, was dissatisfied because CITYgreen was not estimating the large increase in tree coverage benefits that he expected to see in a given time period. He did not think that the algorithms were accurate for performing a fifteen to twenty year period grow-out simulation, because the changes of the benefits were minimal. We decided that this could be explained by they way that trees were planted. The trees might not have been defined as part of the site and therefore CITYgreen did not register them when running the analysis. Another factor that Mr. Suffian might not have thought of is perhaps the trees are densely populated in some areas of the site and therefore the benefits may be relatively constant. Trees grow in a rate of a fraction of an inch in one year and, since the pollution reduction benefits are proportional to the size of the canopy, after fifteen years the canopy size would not change significantly. On the other hand, if Mr. Suffian wanted to see a large change in the benefits in that particular site that he had analyzed, he should have grown the trees for a longer time period, thirty years for example.

In the other two telephone interviews we conducted, both Rosi Dagit and Steve Strickland have been successfully using CITYgreen in their communities and are extremely pleased with the results they are getting. Ms. Dagit has effectively shown the increase in stormwater as a result of the necessary removal of pine trees for fire safety. Steve Strickland was successful in conducting a regional analysis of Macon, GA, and found that CITYgreen was very helpful in determining subtle changes in tree canopy over a twelve-year period. Thus, from our surveys and interviews of users, we feel that there is a wide range of satisfaction with the program, from user to user. It is evident that some users are attempting applications very different from American Forests' original intentions for the program. This, along with the fact some users may not understand the program fully, may be the reason for some of the dissatisfaction we have encountered.

6.1.1 Comparing and Contrasting Issues

From what we learned from the interviews and the information that we found from researching various resources such as the internet and articles from two of the major local newspapers, The Baltimore Sun and The Washington Post, we were able to compare and contrast some of the pertinent issues. In this way, we were able to pinpoint any trends or issues that concern the environment from the information obtained interviewing urban planners and policymakers, and from our research.

Most of the newspaper articles focused on the increase or decrease in phosphorus and nitrogen levels, air pollution, and the role that citizens and the government play in the effort to restore ecological vitality: "In urban areas, state and local governments have based their nutrient reduction efforts on two pollution control technologies: managing storm water runoff and treating waste water (as quoted from the Sunday February 23rd, 1997 edition of The Washington Post)." This quotation emphasizes the importance of tree preservation and the many functions trees can perform to help the environment.

The Deciduous Canopy Observatory (DCO), of the Smithsonian Environmental Research Center, is a facility that promotes scientific understanding and management of the deciduous forest canopies, which are critical components of the biosphere. A forest canopy sustains a great diversity of plant and animal species, and is the main location of energy and material exchange within the atmosphere. The overall objective of the Observatory is to understand the processing of energy and materials in canopies, and their behavior. Therefore, it can be stated that the preservation of canopy is necessary to maintain a healthy environment. This all connects to the purposes of CITYgreen, and how it displays the relevance of the preservation of tree cover and their benefits after running the analysis of a site. It also connects to the concerns that planners and policymakers deal with, for example, storm water runoff, and air pollution. CITYgreen's results can be used to recreate laws that support the needs of the different communities.

6.2 Ground-Truthing & CITYgreen Process

Having completed data collection first-hand in Arlington, VA, and a CITYgreen analysis of both Arlington, VA and Baltimore, MD, we were able to identify some problems that were encountered while going through the process ourselves.

Data collection was much more difficult for us than first anticipated. One major surprise was the length of time it took to collect data at each of the four to five acre sites. We learned our lesson the first day and selected smaller, one to two acre sites for the remainder of our data collection. There are also some fundamental problems with the process that may have affected the results of the CITYgreen analysis at those sites.

First, the health rating for a tree is very subjective. In other words, one ground-truther may give more or less value to some flaws such as rotting, poor crown, poor pruning, or growth space. Thus, the health value for the tree results in anyone's best guess. Secondly, height can not be accurately measured, and must be estimated by the person inventorying that specific tree. The accuracy of one's ability to estimate a tree's height is questionable. Finally, another difficulty of this process is the identification of tree cover from aerial photographs. The photographs are not extremely clear, especially when determining whether a batch of canopy is produced by one large tree, or a number of smaller ones.

We also found that the inventory process was fairly disorganized. This was a result of many factors, including being rushed for time, lack of experience, poor aerial photographs, and too many untrained ground-truthers, making transferring the information from the data sheets into CITYgreen difficult. Often times we had to refer back to the aerial photographs to make sure we were inputting the correct information. We also had to edit the trees in CITYgreen. In order to accomplish this, we had to look at the changes that were made to the site from ground- truthing. Due to the fact that it was practically impossible to determine the correct amount of trees from just looking at the aerial photographs, there were a lot of trees that had to be manually drawn in during data collection. All of these markings on the map were too dense or illegible in some areas. These areas, which are densely populated with trees, are very hard to read and had to be examined carefully before actually making the changes into CITYgreen. After completely transferring all the information, we ran the CITYgreen analysis of those sites.

6.3 Chesapeake Bay Site Analysis

From our interviews and CITYgreen analyses of Arlington, VA and Baltimore, MD, we needed to determine if CITYgreen has the potential to address the needs and concerns of the areas in which our sample sites were chosen. This section consists of two Local Analyses. First, we will discuss our findings from a detailed study of Arlington, VA. Then, we will also discuss our CITYgreen analysis of Baltimore, MD. Each of these sites is an integral part of the entire Chesapeake Bay Project.

6.3.1 Arlington, Virginia

After completing a CITYgreen analysis of Arlington, VA using the six chosen sample sites, we needed to determine the potential impact this analysis might have on the community. Furthermore we needed to look at how this analysis of Arlington will impact American Forests' Chesapeake Bay project.

We began by looking at a table provided by the Department of Community Planning, Housing, and Development. This table entitled *Zoning District Land Areas as Percent of Total County Land* gave us the necessary land use percentages we needed to project our site results over the whole county of Arlington.

We decided to break up Arlington into three land use categories. These categories were residential, commercial/mixed use, and industrial/other. Each of these land uses make up sixty percent, eight percent, and thirty-two percent of Arlington County respectively. From these percentages we were able to divide the 4,900 acres that make up Arlington County into the acreage amounts for each land use. Of the six study sites, four of these represented residential land use and the remaining two represented commercial/mixed and industrial/other. By combining the data of the four residential sites and taking an average of them to produce one set of residential land use data, we then had data for the three types of land uses.

From our results for each site we broke the value of savings down into the amount of money saved per acre, or in the case of stormwater, the amount of avoided stormwater storage in cubic feet per acre. These values are illustrated in Table 6.1 below.

Land Use Type	Energy Conservation (per acre)	Pollution Removal Benefits (per acre)	Stormwater Reduction (per acre)
Residential	$213.47	$75.98	2053 cubic ft
Commercial/Mixed	NA*	$44.10	1388 cubic ft
Industrial/Other	$46.20	$26.91	821 cubic ft

Table 6.1 - Summary of Benefits for Each Land Use in Arlington (per acre of land)

* Site did not have buildings (energy benefits based on tree's location relative to buildings)

The values listed in Table 6.1 above illustrate the average amounts of money saved, per acre of land, for each of the three land use categories we have studied. These values are given in terms of energy conservation, pollution removal and the amount of avoided stormwater storage in cubic feet per acre.

Finally, by multiplying the acreage amounts for each land use by the benefits per acre, we were then able to see the total benefits provided by tree cover over the whole county of Arlington. These values are illustrated in Table 6.2 below.

Land Use Type	Energy Conservation	Pollution Removal Benefits	Stormwater Reduction (ft^3)
Residential	$640,150.00	$227,850.00	6,156,500
Commercial/Mixed	NA*	$15,970.00	502,600
Industrial/Other	$71,536.00	$41,670.00	1,271,236
Total – Arlington	*$711,686.00*	*$2,854,900.00*	*12,450,336*

Table 6.2 - Summary of Total Benefits for All of Arlington

* Site did not have buildings (energy benefits based on tree's location relative to buildings)

Currently Arlington, VA, by maintaining its tree cover, is potentially saving an estimated $700,000 in energy conservation and an estimated $2.8 million in pollution removal benefits each year. As well as avoiding the storage of an estimated 12.5 million ft^3 of stormwater each year.

6.3.1.1 Site Modeling Using CITYgreen

After speaking with the environmental planners from Arlington, VA we discovered that their major concern is stormwater. We decided to investigate the potential of increasing the tree cover percentages in each of the specific land use sites to the American Forests' suggested percent canopy cover. Currently American Forests recommends cities set a canopy cover goal of forty percent overall. By looking at our results, we found that Arlington consists of twenty-six percent canopy cover. American Forests also states that residential areas should be able to reach a tree canopy of fifty percent, industrial/other fifteen percent, and commercial/mixed fifteen percent. By analyzing the data this way, we hoped to find an increase in avoided storage for stormwater benefits.

We first looked at the current canopy cover percentages at each site, finding that residential sites consist of an estimated thirty-four percent, industrial/other consist of an estimated twelve percent, and commercial/mixed consist of and estimated twenty percent. According to American Forests' standards, commercial/mixed is in a good state of tree canopy cover being five percent over the suggested amount. Therefore residential and industrial/other are the land uses that need some attention. By using CITYgreen's limited modeling capabilities we increased the canopy cover percentages of both the residential and industrial/other land use sites to the goals set by American Forests. We chose Site A in Arlington, VA as the representative residential land use site because it had a canopy cover percentage of twenty-six percent, which was the closest to the estimated thirty-four percent overall. We also chose Site D in Arlington, VA as the representative industrial/other land use site. Table 6.3 below shows the increase in canopy cover percentages of these two sites along with the change in avoided stormwater storage.

Land Use Type	Current Canopy Cover Percentage	Current Stormwater Benefits(ft^3)	Modeled Canopy Cover Percentage	Modeled Stormwater Benefits (ft^3)
Residential	26%	6,156,500	53%	9,400,000
Industrial/Other	12%	1,271,236	16%	1,700,000

Table 6.3 - Modeled Increase of Canopy Cover/Stormwater Benefits

By increasing the canopy cover percentage for residential land use, from the current twenty-six percent to the modeled fifty-three percent, we were able to see that the stormwater benefits increased by an estimated 3.2 million ft^3 in avoided stormwater storage per year. The same was true for industrial/other. Increasing the canopy cover from twelve percent to sixteen percent, we were able to see that the stormwater benefits increased by an estimated 430,000 ft^3 in avoided stormwater storage per year.

6.3.2 Baltimore, Maryland

By conducting our interviews in Baltimore, MD we have found that the immediate concerns of Baltimore may not coincide with the beneficial aspects that CITYgreen quantifies to the extent that Arlington's concerns do. According to Donald Outen, CITYgreen would not be capable of adequately addressing the current decrease in the channel stability of many of Baltimore's waterways. The value riparian zones have to the health of their adjacent waterways cannot be directly quantified by the current CITYgreen analysis method.

7.0 CONCLUSIONS

Based upon our thorough analysis of the results obtained from interviews, surveys, CITYgreen analyses, and our own experiences, we were able to arrive at some relevant conclusions for this project. These conclusions can be categorized into two different areas. First, we evaluate the entire CITYgreen process and identify its stronger and weaker aspects. Second, we address American Forests' Chesapeake Bay Project, and the potential impact a CITYgreen analysis could have on the Bay region. These two specific areas of conclusions then lead us to a more general answer to this project's fundamental question: How can CITYgreen's economic analysis of the benefits of tree cover (1) best address major environmental concerns, and (2) be effectively utilized by planners and policymakers of the Chesapeake Bay area?

This section is primarily a discussion of the current state of the entire CITYgreen process. Throughout the section, we discuss the strengths and weaknesses of many aspects of this process, as well as some major issues, problems, and areas of improvement. The Recommendations section following these conclusions will then provide some suggestions and recommended approaches concerning possible ways to address these topics.

7.1 Evaluation of CITYgreen Analysis Process

Our first task was to conduct a thorough evaluation of the overall CITYgreen process and determine the current effectiveness and use of its results. We will be drawing our conclusions on pre-data entry, ground-truthing, and the software itself. Then we will be evaluating the entire CITYgreen analysis process, and its ability to communicate the benefits and importance of tree cover.

7.1.1 Pre-Data Entry / Ground-Truthing

The first component of this process includes pre-data entry and ground-truthing, both of which are necessary in order to obtain the information needed to run a CITYgreen analysis of the particular area or region of interest.

Pre-data entry is mostly comprised of drawing all of the trees in an area on top of an aerial photo of that site. Aerial photos are beneficial because landmarks are important points of reference when viewing the site from a ground level perspective. For example, the multi-colored roofs of houses, or unusually shaped driveways can help to determine the location of trees. However, these photos need to be improved so individual trees can be distinguished. The drawing of trees over these site photos in CITYgreen is only as accurate as a guess and therefore is not very helpful in the field.

Prior to ground-truthing, data collectors need to be properly trained so that they can use their time effectively in the field. Two processes that could be modified to save time in the future would be the choosing of sites and the identification of tree species in the field. Although species-keys can be used for tree identification, the terms that are used in these books are foreign and too scientific for many people.

CITYgreen should provide the data collector with a more subjective means of determining both the height of trees and also their health. There should be guidelines to ensure that the whole tree is observed including the trunk, crown, and roots. This would eliminate the problem of rating a tree based only on one component.

Overall, the accuracy of the analysis depends on the quality of the data collection. If the data is inconsistent, then the results will not be reliable. Thus, the data collection is very important in the overall process of CITYgreen analysis and therefore, it is necessary to be properly educated in order to obtain accurate results.

7.1.2 CITYgreen Software Program

As indicated by the results from the survey and telephone interviews, some CITYgreen users have experienced a substantial amount of dissatisfaction with the software itself. After analyzing the various comments and suggestions provided by some frustrated users, we have arrived at the following conclusions, classified into two categories.

Some users are dissatisfied because they expect more from the software than it currently provides. The most common form of feedback contains suggested additional features to the program. In many cases, users, especially urban planners, want CITYgreen to perform tasks or functions beyond the original intentions of its creators. For example, some urban planners wanted the program to include algorithms, tree species, soil types, and other characteristics that were specific to their community, allowing the planner to conduct more accurate site by site analysis. However, the intended use of CITYgreen, according to American Forests, was to be an informative communication tool that could be generally used by any community nation wide, rather than a complex planning or engineering tool. Thus, the predicament that American Forests faces is whether they should try to address the desires of these urban planners, or continue to market the product based upon its original intentions. In order to address diverse needs of all its users, American Forests has to decide whether to make drastic changes to CITYgreen, or to develop multiple versions. On the other hand some users have provided suggestions regarding improvements and additions to CITYgreen that could make it a better policy and communicative tool. It is this feedback that requires American Forests' direct attention.

The second category of user feedback is more directed towards the technical problems experienced while using the software. These users have given comments that recommend improvements to the software's current capabilities, including improvements that would make the program more user friendly, run more smoothly, facilitate data entry, improve the users manual, and other suggestions that could be taken into consideration without changing the product's uses.

From both our own experiences with CITYgreen and the interviews with urban planners, policymakers, and CITYgreen users, we have concluded that CITYgreen is lacking in some major areas. First, CITYgreen is not an extremely user-friendly program. There are definitely areas in which the program can be redesigned to run more smoothly. However, once one is accustomed to the functionality of the program, it is not a particularly difficult program to use.

Secondly, the process of inputting tree data into the database within the program is difficult. Depending on the types of information gathered during ground-truthing, there might be many fields that are left empty when entering tree data. The fact that all of these fields are shown to the user misleads the user into believing that each of these types of tree data is necessary in order to run a complete analysis, therefore it becomes cumbersome. In actuality, only a certain number of tree statistics are necessary to run most analyses.

Another aspect to consider is the modeling and grow-out capabilities of CITYgreen. Currently, one can hypothetically "plant" new trees at a site by drawing them in and providing characteristics, a very time consuming process. Scenarios are then limited to simulations of tree maturation and increased savings over ten, twenty, thirty, or forty-year periods.

Also, we have found that any tree that overhangs a site area boundary will not be counted as contributing to the economic benefits of trees in that site. Presently, just before CITYgreen runs its analysis, it gives a total number of trees that will be counted in the calculation of benefits. However, it does not give an explanation for trees not being counted. If the user knew why some trees were not included, they could use the tool that is available for cutting trees into sections so that its benefits would be partially included in the analysis. This issue could be addressed in the CITYgreen user's manual.

Other areas of improvements include possible amendments to ArcView shortcomings and a more informative, easy-to-follow users manual. Despite these minor drawbacks, CITYgreen is an effective tool for communicating benefits of tree cover to communities, and can be used to help develop public policy. Meanwhile, there are other areas of improvement that would make CITYgreen more useful to urban planners as a site analysis and modeling tool. For example, urban planners would benefit more from the program if it was more specific to their needs or if it was a more accurate determination of savings for a particular site. However, American Forests should consider these only if they wish to drastically change the makeup of the program and its original intentions.

7.1.3 Current State of CITYgreen

Overall, CITYgreen is a tool geared towards communicating benefits of tree cover to communities in terms of stormwater reduction, pollution removal, and energy conservation. American Forests markets this product to policymakers, urban planners, and educators for this purpose. However, based upon the feedback from our interviews and surveys, and the fact that CITYgreen can be used for numerous applications, we believe that it is impossible for this one program to satisfy every user's desires and needs. CITYgreen is being used in many different applications and in many different communities. An urban planner's demands from the program differ greatly from a policy maker or educator. An urban planner may request a more complex modeling capability, or that engineering solutions be implemented. Similarly, a user in a large community demands that the program be more specific for the area of interest, or that the dollar values be more accurate. On the other hand, a user in a small community can not even afford the software, satellite imagery, aerial photography, staff, or necessary training to complete even the simplest of CITYgreen analyses. American Forests must either market the product based upon its current capabilities or consider developing improvements to the software to satisfy the needs of all its users.

7.2 Application of CITYgreen in Chesapeake Bay Project

From our analysis of Arlington and Baltimore, along with our research and interviews, we have discovered that many important environmental issues can be addressed, using CITYgreen software as a communicative tool. In particular, Arlington, VA should have an acute interest in our CITYgreen results, as stormwater damage is their major concern. In contrast, Baltimore, MD focuses more on riparian zone restoration and may not benefit from the Chesapeake Bay study as much. However, every community should be able to evaluate their overall state of increased deforestation over the last twenty years using American Forests' regional analysis of the Bay.

7.2.1 Ability to Address Pertinent Issues

From an analysis of the major environmental issues that we have discovered, it is evident that many of these issues can, either directly or indirectly, be addressed by a CITYgreen analysis. Increased stormwater runoff was identified as one major problem, causing "nutrient shock" and non-point source pollution in the Chesapeake Bay. CITYgreen is capable of showing tree cover's ability to decrease stormwater runoff and help to solve the resulting problems. Another environmental issue, the health of tree cover located in riparian zones, is mentioned as having another large effect on the overall ecological health of the Bay. A CITYgreen analysis could be conducted on such a forest buffer and those benefits could be further quantified. There are many environmental organizations and projects such as the Chesapeake Bay Program that might have a special interest in CITYgreen's capabilities to solve problems in their areas of interest.

American Forests is currently in the process of studying and analyzing the Chesapeake Bay area. From these intense studies, they will be able to understand more about why the Chesapeake Bay is a threatened resource and what needs to be done to prevent any permanent environmental damage from occurring. American Forest has concentrated its efforts on increasing ecological awareness throughout the nation. However, more can be done to communicate their findings to environmental planners and public policymakers, in addition to educating the general public about the pertinent issues pertaining to the Chesapeake Bay.

7.2.2 Importance to Specific Communities: Arlington, VA; Baltimore, MD

We have found that the importance of CITYgreen results varies from community to community. The reasons for this may vary from a community who is not capable to make use of these results to one who has other solutions in use. On the other hand, some communities are very excited about the information that a CITYgreen analysis would provide to them. One such community is Arlington County, Virginia. Due to the fact that Baltimore County suggested that CITYgreen would not be able to address their primary environmental concerns, we have decided to concentrate our efforts on Arlington, VA.

Arlington, VA has shown a strong interest in taking action against its rapidly declining urban forests. In the same manner, they are interested in the outcome of our preliminary study on the city, and especially in the overall Chesapeake Bay Project upon its completion. Because increased stormwater runoff is currently the major area of concern for urban planners of Arlington, CITYgreen would provide them with an excellent view of the extent to which deforestation is affecting their city.

Keeping in mind the fact that we only collected data from six sites within Arlington, we were able to conduct a preliminary analysis of the city. However, it is important to recognize the fact that a detailed, more accurate analysis will be conducted by American Forests in the future. Nevertheless, we have been able to make preliminary recommendations to American Forests and Arlington, VA.

Based, on American Forests' recommended forty percent tree cover for a typical US city, and on our calculations, Arlington, VA is below the goal amount with an average of only twenty-six percent tree cover. This is especially important because stormwater runoff could potentially be reduced if the city were closer to the recommended percentage. In fact, based on a six site projection of land use data and CITYgreen results, Arlington would be dealing with almost eight million more cubic feet of stormwater runoff annually than if there were no trees in the city at all. This corresponds to a twenty-seven percent runoff reduction due to the presence of trees. Thus, Arlington could be saving even more money on stormwater facilities if it could locate good planting sites and begin its approach to forty-percent tree coverage.

American Forests also recommends fifteen percent tree coverage in commercial and industrial land use areas, and fifty percent tree coverage in residential areas. According to our Local Analyses, Arlington, VA has twelve percent tree coverage in industrial areas, twenty percent coverage in commercial areas, and an average of thirty-four percent tree coverage in residential areas. Therefore, we conclude that the major area of improvement for increasing tree cover is in residential areas. Industrial areas are only slightly below the recommended percentage and would be the next priority for improvement. On the other hand commercial areas are the last priority, as they are actually above the fifteen percent recommended coverage.

Upon modeling sites representative of typical commercial and residential areas, we have been able to show that if tree coverage were increased to the recommended percentages, a significant amount of stormwater runoff would be reduced. If the industrial site were to increase its coverage from twelve to sixteen percent, it would save that area 1.7 million cubic feet in runoff, a 3.7 percent decrease. Moreover, if the residential site increased its tree coverage from thirty-four to fifty-two percent, its stormwater would be reduced by 9.4 million cubic feet, a 21.3 percent reduction.

It is also important to consider percent acreage of each land use within the city of Arlington. Because industrial areas make up thirty-two percent of Arlington's acreage, it also must not be ignored when planning tree plantings. In fact, if even if the residential areas are brought above their respective recommended amounts, the overall tree coverage in Arlington would still be less than forty percent. Therefore, even though industrial areas appear to be in a much better ecological condition than residential areas, tree coverage in those areas must also increase in order to achieve forty percent coverage for the entire city of Arlington.

7.2.3 Potential Impact on Bay Area Planning and Policy

Overall, an economic analysis of the Chesapeake Bay watershed will give a good regional representation of the decline in tree coverage over the past twenty years. If sample sites are strategically planned by American Forests, specific communities will also be able to use the Local Analyses' projected tree cover benefits to address the environmental concerns of their area most effectively. In addition, American Forests will be able to clearly present the rest of the nation an effective new tool for communicating the benefits of tree cover, both regionally and locally. Any given community could then potentially demonstrate the value of its tree cover to each individual citizen in that study area.

In summary, with some minor improvements to the CITYgreen process, along with thorough research of each community's issues and needs, an ecological analysis of the Chesapeake Bay, if effectively communicated to concerned citizens and officials, could ultimately have a positive impact on the urban planning and policymaking of the area.

8.0 RECOMMENDATIONS

In the previous chapter, we mentioned various procedures that American Forests could improve upon to make the economic evaluation of tree cover more efficient. In this chapter, we will address ways to improve or amend these problems.

8.1 Chesapeake Bay Project

With complete analyses of Arlington, VA and Baltimore MD, along with our information gathered via interviews and research, we have been able to make recommendations to American Forests and those communities concerning the Chesapeake Bay Project. First, we have made recommendations regarding the impact of the Arlington and Baltimore analyses on their respective communities. Then, we made general suggestions that should allow for a smoother completion of the Chesapeake Bay Project.

8.1.1 Local Analyses: Arlington & Baltimore

Considering the fact that Arlington, VA will have a particular interest in our findings, we have focused our recommendations on that specific analysis. Also, due to the fact that Baltimore County is focusing more on issues that are not directly addressed by a CITYgreen analysis, we recommend that American Forests either communicate to Baltimore the benefits that the program *does* address, or concentrate their efforts elsewhere.

Upon analyzing Arlington, VA using six sample sites, we have arrived at the following recommendations. First, we suggest to planners and policy makers of

Arlington that they should set a goal of forty percent tree coverage, the amount American Forests generally recommends to cities. We feel they should start this progress by using American Forests' analysis to impact more strict environmental legislature within the county and city. We also believe they should, in the beginning stages of this long process, concentrate their efforts in residential areas, due to its sub-par tree coverage. This could include both careful planning in those areas, as well as tree plantings. Also, we feel it is important for the city to consider industrial areas in their foci due to the fact that they too make up a large percentage of the overall city acreage. Finally, we recommend that American Forests conduct a more detailed and accurate analysis of Arlington using more sites, allowing for each land use category to be represented by several sample sites. This will result in a more representative sample of each land use throughout Arlington, VA.

8.1.2 Improvements to Remainder of the Project

Although many of our suggestions will require much consideration and planning on behalf of American Forests, we also have recommendations that could be put into relatively immediate action. In particular, some of these changes could be put into effect for use in the Chesapeake Bay project:

1) Choosing of data collecting sites - In order to make the data collector's time in the field most efficient, the sites should be kept relatively small, especially when they are located in a densely wooded area.
2) Data collection - The most important way to obtain accurate data is to be consistent. Data collectors can best accomplish this by dividing tasks, and

assigning them to individuals. This is important when collecting data that is a matter of opinion, namely tree height and health.

3) Training - In our experience, we received only a brief training in which we learned how to identify tree species. For anyone who has no experience with botany, this skill can not be attained in a short period of time. Therefore, we suggest that a certified forester accompany all inexperienced data collectors to insure that tree species are accurately identified.

4) Planning Department - We have found that some communities are more enthusiastic about participating in the CITYgreen project that others. We suggest that American Forests contact the Planning Departments of perspective communities to find out whether they would be interested in the results of this project. This would ensure that the results would be put to use, and also that American Forests would have full cooperation in obtaining information such as land use data.

8.2 Future Direction for CITYgreen Software

American Forests is faced with many difficult decisions in determining the future of CITYgreen and its potential use nationwide. We recommend, based upon American Forests' goals and aspirations, approaching this situation one of two ways. The first alternative would be for American Forests to improve upon CITYgreen's existing features, while continuing to market the product as originally intended—an effective means of communicating the benefits of tree cover. The second recommended option for American Forests would be to attempt to address the needs and demands of all of its users, both planners and policymakers alike. This would entail more drastic changes in the original intentions of the software, but may result in a more effective universal tool. Other options would include developing two separate versions of CITYgreen, or providing a customizing service to users, which could adapt the system to their individual needs. Each of the approaches and options above will be explained in more detail in the following two sections.

8.2.1 CITYgreen- Communication Tool

American Forests may decide to continue to market CITYgreen predominantly as a policy and communicative tool, in which a regional analysis examines change in tree cover over time and quantifies current tree cover using Local Analyses. If they opt to go in this direction, American Forests may still wish to consider the following recommended changes and improvements to the software itself, or to the analysis process overall.

One major area of improvement concerns the data entry and database system of CITYgreen. A custom, more flexible tree data entry would simplify this process. One component may be a menu where one could select the characteristics for which data was collected and a custom table would be provided for data entry.

Secondly, the user should be informed as to what data is necessary to conduct each type of analysis. Presently, the data table contains many optional columns. Perhaps the unnecessary data columns could be contained in an "additional features" drop down menu, and therefore added when needed by the user.

Another possible improvement would be custom grow out scenarios. This type of application would be used to determine the future benefits of trees. This would encourage planting of trees, and would help in determining where they would be the most beneficial. Options within this application could include choosing the species, as well as their location within a particular site. The user could select any number of years of growth instead of just a multiple of ten years, and best/worst case scenarios of benefits would be given according to possible ranges in health and growth.

Finally, the user's manual should explain fully why CITYgreen would not accept data on certain trees, for example, ones that hang over the boundary of the site. In this case, the guide should clearly state that the "cutting tool" must be used so that part of the tree is included in the analysis.

8.2.2 CITYgreen-Planning Tool

The alternative for American Forests would be an attempt to make CITYgreen a more effective planning tool without compromising its useful aspects as a policy tool. This decision would involve more in-depth changes to CITYgreen and might also compromise its use to smaller communities with less resources and funding. In this case, more complex, city-specific algorithms within the program would produce more precise and accurate dollar values upon analysis.

Also, we would recommend including the ability for the user to select his or her region of the country before conducting any analyses. This would automatically add additional information to the general package, including tree species, soil, climate, and rainfall amounts specific to that region. For example, if conducting an analysis of Boston, MA, the user would only have to enter the city and state he or she is analyzing. In turn, the program would recognize the analysis as taking place in a large city in the

Northeast region of the United States, and would apply the appropriate regional statistics to the calculations. Currently, much of this information must be retrieved by the user and entered manually. With this new feature, an analysis for Arizona would call for different algorithms and different characteristics than a similar analysis of Massachusetts, for example. This would be esFinally, we strongly recommend a planting function that allows a planner to easily place newly planted trees on a site, and then follow up with a grow-out scenario. The user could click on a planting button, place the hypothetical seedlings where desired, and identify the species of tree. This wold then allow him or her to carry out a grow-out model of the site, where the new plantings, as well as the pre-existing tree cover, will have matured over a specified time period. This would be a marked improvement from the current method that involves drawing small trees and estimating all their characteristics.

8.2.3 Multiple Versions of CITYgreen

As we have explained above, making CITYgreen more versatile also makes it more complex and expensive, excluding more and more small communities from its use. In fact, CITYgreen in its current form is beyond the capabilities of many small towns. For this reason, we recommend the following option to American Forests. If they wish to include planners and policymakers from both large and small communities, while continuing to improve CITYgreen's capabilities, making two versions of CITYgreen is a possibility. One version would be geared towards more complex, more city and region specific analyses, containing more accurate benefit values and pertaining to the specific needs of the users. The other version would be a less expensive, desktop version in which small communities could conduct site analyses without purchasing satellite images or even aerial photographs, and with the absolute minimum tree data requirements. Instead, this version could be a site-by-site modeling tool used for planting new trees, or even tree inventory. American Forests could still use their current version in conducting regional analyses and communicating sprawl over time, but could offer the other two versions based upon the users needs and desires. This would ultimately eliminate the difficult task of attempting to satisfy multiple applications with one software program.

8.3 Other Recommendations

Some of our recommendations concerning improvements to CITYgreen could be applied regardless of what American chooses to do in terms of marketing choices like the ones listed above. The following general suggestions are designed to make the CITYgreen process run more smoothly.

8.3.1. Diameter

There are two changes that could be made that are related to the tree diameter component of the program. These additions would be an improvement on the accuracy of drawing trees on CITYgreen's inventory sheets. First, there is no need to plug in both the measured diameter and the diameter class of the tree. We suggest that the program automatically provide the class, based upon the same three categories. This would both save time and eliminate some room for error. Secondly, the program could use these entered diameters, along with the specified tree species to automatically draw the tree to scale, once the location is specified by the user. Presently, trees are drawn by estimation, which could effect the percent of tree canopy cover that is calculated for that site by the program, and therefore effect the analysis.

8.3.2 Ground-Truthing and CITYgreen Users Guide

Many of our recommendations on how to improve the ground-truthing process will involve changing the CITYgreen user's guide. We recommend that the CITYgreen manual should briefly address the possible difficulties one may experience when going through these procedures to better prepare the data-collectors. We believe that the data collecting section of this manual could be expanded to include more detailed sections on tree species and health.

8.3.2.1 Data Collecting Sites

One section of the manual should be a troubleshooting guide addressing the most common difficulties that the data-collector would perhaps face. This might include hints and useful tips that could make the data-collector's job easier. This will, in turn, make the data entry easier and more accurate once the ground-truthing is finished. One difficulty that arose often is when we manually drew in or crossed out trees over the CITYgreen printout of the site. This made the aerial photo of the site too crowded and very hard to read when inputting this data into CITYgreen. As an alternative, the manual can show them possible ways to keep the photo clear. If more than one group is collecting data at the same site, we recommend that the site should be divided into separate sections. Each section would be on its own page allowing each group to be responsible for their respective section.

Another section that the manual could include would be guidelines on the best methods of selecting representative data sites. As we mentioned in our analysis section, it is common to find a lot more trees within a site than expected from just examining the aerial photos alone. The data collection guide should explain that this is the most time consuming part of the CITYgreen process and therefore, small sites are most practical.

8.3.2.2 Tree Identification & Health Rating

To alleviate the stress of working through tree identification keys, the CITYgreen user guide could include a glossary of botany terminology and corresponding diagrams or drawings. If the data collectors know the parts of a leaf, it will be easier to eliminate groups and determine the species of the tree in less time. The health of a tree is determined through the examination of three parts of the tree: roots, crown, and trunk. Because this process can be so difficult, with varied results for the same tree, we suggest a more defined method of determining a tree's health. Points could be assigned for the satisfactory health of each component, and then these three numbers could be combined to give an overall health rating. This will insure that the whole tree is observed. For example, the data collector could give each section (trunk, root, crown) of the tree a value of zero, one, or two. If a part of the tree were damaged, then it would receive no credit. If that part were in fair condition, with no significant damage, it would receive a one. Similarly, a section with no damage would receive a two. This system could be further modified to weigh the health of one part of the tree more than other parts. For example, a tree can survive with damaged branches, and even grow back to compensate for this kind of loss. The same can be true for minor root damage. However, trunk damage is more serious because it not only provides the structural support for the tree, but also is the place through which nutrients are transported. If a maximum rating of two were allowed for each section, the total health rating could not exceed a six. This small change in the rating scale will not drastically change the algorithm that CITYgreen currently uses to run its analysis.

8.3.2.3 Tree Height

The estimation of tree height is very difficult, leaving room for a certain margin of error. The data entry table does not require the collector to get an exact height. There are three height classes to choose from.

One option would be to use a simple measuring technique that would require the ground-truther to stand a certain distance from the base of the tree. A device could be used in which the data collector must hold it a certain distance from his or her eyes (arm's length for example). Markings of one, two, and three could be put on this instrument so the tree could be accurately classified.

8.4 Closing

Once the Chesapeake Bay Project is completed, American Forests should direct their efforts towards communities that seem most enthusiastic, and whose major environmental problems are best addressed by its Chesapeake Bay CITYgreen analysis. Furthermore, American Forests must strategically choose study sites in the future, in areas where interest in the final product is visible.

APPENDIX A:

Mission and Organization of American Forests

Appendix A
American Forests

American Forests, formerly named the American Forestry Association, is the oldest conservation organization in the United States today. For more than 120 years, since 1875, American Forests has worked to ensure a sustainable future for our nation's forests. The objective of American Forests is to maintain and improve the health and value of trees and forests. The organization also strives to attract and cultivate the interest of citizens, industry, and government in trees and forests, and to bring Americans closer to forest resources through action-oriented programs, information, and communication. American Forests was influential in the creation of the National Forest System, the Forest Service, the National Park System, and state forestry agencies. Throughout American Forests' history, it has focused on finding the best ways to educate Americans about the management of trees and forests and has worked to join concerned citizens in the cause of protecting these forests.

The three primary areas of concern as identified by American Forests in the late 1980s and continuing today were:

1. The National Forest System and the ability of the Forest Service to provide adequate management and stewardship.
2. Forest Health, as impacted by air pollution, wildlife, insects, and disease.
3. Urban and Community Forests, and their proper management in order to enhance the quality of life for all people.

American Forests consists of thirty full time employees and over 100,000 members representing fifty states and several foreign countries. The association provides a voice in Washington that calls for improved national policies in all aspects of the environment affected by trees and forest. The association periodically publishes newsletters, brochures, policy research reports and educational materials. They also publish a magazine entitled American Forests, to further spread the conservation message.

American Forests is a non-partisan and non-profit organization. The organization's revenues are received largely from contributions, grants, contracts, and merchandise sales. According to the 1997 Annual Report, American Forests' revenues amounted to $4,201,656. The majority of these revenues are in turn spent on contracted services which provide money to such programs as Global ReLeaf, conservation advocacy, and urban and community forestry.

American Forests focuses on both national and global forest concerns through a program known as Global ReLeaf. The Global ReLeaf program is one of America's fastest growing conservation efforts, bringing individuals, companies, conservation groups, and governments at all levels together to restore and improve tree and forest conditions. The Global ReLeaf Coalition raises financial support for the planting of trees to improve shading, decrease summer peak temperatures, save energy, reduce pollution, and restore forest ecosystems that have been damaged by past abuse or neglect. It also supports international public education and action campaigns. The Global ReLeaf Coalition has five major areas of action:

A. An accelerated international information and education campaign that informs people about global environmental situations including global warming, its causes and potential environmental effects, leading to suggestions for action.

B. A referral service that helps people find technical assistance, planting materials, or action organizations. This service is available worldwide, through a growing network of Global ReLeaf cooperation organizations.

C. Direct assistance in helping conservation happen through tree planting and improvement programs. This being made possible largely through grants for tree planting programs or Global ReLeaf Heritage Forests, through the Global ReLeaf Fund.

D. Coordination of an intensified research effort to hasten the development of basic information needed to assist forest managers and policy makers.

E. National coordination for US policy reform effort, aimed mainly at federal laws, programs and budgets, but also focusing attention on needed changes in state laws and programs.

In the fall of 1995 Eddie Bauer and American Forests teamed up for the Eddie Bauer Global ReLeaf Tree Project, Add a Dollar, Plant a Tree. As of now, due to the contributions of Eddie Bauer customers and associates, the program has raised enough money to plant more than 1,300,000 trees with a goal to plant 2.5 million trees by the year 2000.

In their continuing effort at promoting the importance of trees, one of American Forests' most recent accomplishments was the development of a computer program called CITYgreen. This software is used for mapping urban ecology and measuring the economic benefits of trees, soils, and other natural resources. CITYgreen was developed in 1996, and is primarily used by city planners and policymakers. Presently, American Forests is working on improving this system to make it more user friendly, with the ultimate goal of having individual communities capable of doing their own ecological analyses using the CITYgreen software program. Through the efforts of the American Forests' members, their work, and programs such as Global ReLeaf the message of responsible forest care is being spread worldwide.

(Taken in part from "Impact of Riparian Buffers in the Chesapeake Bay's Lower Western Shore" in 1997, updated in 1998)

September 3, 1998

Dr. Susan Vernon-Gerstenfeld
Worcester Polytechnic Institute
100 Institute Road
Worcester, MA 01609-0180

Dear Dr. Gerstenfeld:

AMERICAN FORESTS is pleased to work with three WPI students again this Fall. It's been an enjoyable and productive experience for the past several and we think this year's IQP project will be as well.

For the past five years, Worcester Polytechnic students have helped AMERICAN FORESTS develop a software program called CITYgreen. CITYgreen measures the function and economic value of urban ecosystems, to give planners and policymakers the data they need to increase support for urban natural resource management programs. W.P.I, students have helped AMERICAN FORESTS develop inventory methods, develop the program's stormwater analysis module, apply the analysis to Baltimore Maryland, and survey land-use planning agencies about the potential for CITYgreen's use. Last year's IQP team helped develop a methodology to assess the effects of tree buffers in reducing nutrient and pollutant flow into the Chesapeake Bay.

This year we propose to have the students work with our staff to use CITYgreen to analyze the urban ecosystems of several U.S. cities. This project will be slightly different in the students will be involved in the direct application of the software rather than its development. A new version of the program will be released this summer, with updates and improvements that some of the past IQP teams have helped identify. Over the course of the spring and summer we expect to receive contracts to conduct urban ecosystem analyses of a number of U.S. cities, and to be very busy for the remainder of the year. There are a few discrete portions of the analysis process where the students can fit in well.

An urban ecosystem analysis is a multi-disciplinary process involving both technical and qualitative work, which is why we think the work will be a good fit to WPI's students. One area where students may focus their time is on researching local conditions in some of these cities, determining what natural resource issues dominate the public policy arena, how our analysis tools can best address these concerns, and how our findings should be presented in this context.

Some of the steps in the process with which the students are likely to be involved include:

1. **Identifying the policy and natural resource issues important to the city being analyzed.** Discussed in the preceding paragraph, this work could involve interviews, newspaper searches, or library research. The 1995 IQP team conducted exactly this type of work in Baltimore, MD.

Depending on the status projects at the time of the students' arrival they will likely be involved on **one** of the following two activities:

2. **Conducting analysis.** This work could involve data preparation, such as digitizing images, creating and organizing databases, and inputting inventory information as it arrived from the field. It could also mean conducting the GIS based analysis itself using CITYgreen and ArcView, which is not difficult but would require a day or two of preparation or tutorial, preferably during the September/October preparatory period, or:

3. **Developing presentation materials.**
This work could involve creating slides, posters, handouts or PowerPoint presentations to depict the analysis' results in a clear simple fashion.

For this project, we would recommend students with the following skills or interests:

1. Experience with, or interest in, Geographic Information Systems or similar computer applications
2. Experience with, or interest in, public policy formulation.
3. Experience with, or interest in, ecological issues
4. Experience, or interest in, land-use or urban planning

Please do not hesitate to call me (extension 216) or Cheryl Kollin (The Director of the Urban Forestry Center at extension 221) with any questions.

Sincerely Yours,

Jeff Beattie, Coordinator
Cool Communities

APPENDIX B:

Data Collecting Materials

Inventory Key

Land Cover

Canopy Cover		Grass/Shrub/Herbaceous Cover	
VT Very light canopy	(0-5%)	**VG** Very light GS cover	(0-5%)
LT Light canopy	(6-20%)	**LG** Light GS cover	(6-20%)
MT Medium canopy	(21-40%)	**MG** Medium GS cover	(21-40%)
HT Heavy canopy	(41-60%)	**HG** Heavy GS cover	(41-60%)
CT Covered by forest	(>60%)	**HG** Covered by GS	(>60%)

Impervious Ground Surface Cover	
VI Very light cover	(0-5%)
LI Light cover	(6-20%)
MI Moderate cover	(21-40%)
HI Heavy cover	(41-60%)
CI Covered by impervious	(>60%)

Land Use

SF — Single Family Residential
Land almost totally committed to single family residential use, may have some mixed residential areas with duplexes and small apartment buildings in the high density areas

MF — Multifamily Residential
Land occupied by apartment and townhouse complexes where net density generally exceeds 8 units per acre

MF-ROW — Multifamily Residential Rowhouse

COMM — Commercial and Services
Land used predominantly for the sale of goods and services- from office buildings to malls

IND — Industrial
Land associated with light or heavy manufacturing

INST — Institutional
Land occupied by educational, religious, health, correctional, and military facilities (small areas such as churches may be incorporated into another category)

PCG — Parks/Cemeteries/Golf Courses
Land structured as parks, cemeteries, or golf courses- in detailed studies, park type (playground, ball field, campground, pristine) should be specified

AG — Agriculture
Land regularly used to grow field crops or to pasture animals, land used for orchards, vineyards, or nurseries

TR — Transitional Areas/Undeveloped
Land where current or future use is not indicated

Soil Type

A = Pervious soils
B = Relatively pervious soils
C = Relatively impervious soils
D = Largely impervious soils

Diameter Class

1 = <10 inches diameter at breast height
2 = <10-20 inches diameter at breast height
3 = >20 inches diameter at breast height

Forest Health

1 = Very poor, no new twig growth, heavy sprouting;
Crown -more than 50% dead or dying;
Trunk with large cavity(s) or girdled;
Roots -evidence of trenching and/or root cutting within 5 feet of the base of trunk.
3 = Fair, some epicormic sprouting, moderate twig growth;
Crown -10-30% showing evidence of damage, structurally weak, may be holes, poorly pruned, evidence of dieback or insect/disease problems;
Trunk -5-15% showing evidence of damage, cambial layer penetrated, but not girdled;
Root space confined by physical structure(s), may be planted too deep;
5 = Excellent, substantial twig growth in the last year, no epicormic sprouting;
Crown is structurally strong, full, uniform, no dieback or evidence of insect/disease problems;
Trunk not damaged;
Roots not damaged, tree planted at proper depth;
Ratings of 2 and 4 fall between the appropriate classes above.

COMMON	SCIENTIFIC	CODE
Austrian Pine	Pinus nigra	TP
Fir	Abies spp.	FIR
Gingko	Gingko biloba	GKO
Douglas Fir	Pseudotsuga menzeisi	DGF
Larch	Larix laricina	
White Pine	Pinus strobus	WP
Red Pine	Pinus resinosa	RP
Scotch Pine	Pinus sylvestris	CP
Arborvitae	Thuja occidentalis	WC
Colorado Blue Spruce	Picea pungens	BU
Norway Spruce	Picea abies	NU
Hemlock	Tsuga canadensis	HEM
Juniper	Juniperis spp.	

Height Class

1 < 15 feet

2 15 - 35 feet

3 > 35 feet

Species List

COMMON	SCIENTIFIC	CODE
Red Maple	Acer Rubrum	RM
Sugar Maple	Acer Saccharum	GM
Norway Maple	Acer platenoides	NM
Japanese Maple	Acer Palmatum	JM
Silver Maple	Acer Saccharinum	SM
Red Oak	Quercus rubra	RO
White Oak	Quercus alba	WO
Pin Oak	Quercus Palulstris	PO
European Beech	Fagus Grandifoilia	EUB
White Ash	Fraxinux americana	WA
Crab Apple	Malus spp.	CRB
Fruit Apple	Malus spp.	CRB
Mulberry	Morus Alba	MLB
Willow	Salix spp.	WIL
Catalpa	Catalpa bigonoides	CAT
Black Cherry	Prunus serotina	BLC
Flowering Cherry	Prunus spp.	CHE
Butternut	Juglans nigra	BLW
Tree of Heaven	Ailanthis altissima	AIL
Elm	Ulmus americana	AE
Basswood	Tilia americana	LIN
Magnolia	Magnolia spp.	MAG
Sweetgum	Liquidambar styraciflua	SWG
Dogwood	Cornus florida.	DGW
Bradford Pear	Pyrus calleryana	BDP
Hawthorn	Crataegus spp.	HAW
Paper Birch	Betula papyrifera	PB
Honey Locust	Gleditsia triacanthos	HL
European Mtn. Ash	Sorbus americana	
Poplar	Populus spp.	POP

ARLINGTON COUNTY, VIRGINIA
DEPARTMENT OF PARKS, RECREATION AND COMMUNITY RESOURCES
2100 CLARENDON BOULEVARD, SUITE 414
ARLINGTON, VIRGINIA 22201
(703) 228-3323 • FAX (703) 228-3328
E-MAIL: prcr@co.arlington.va.us

TONI D. HUBBARD
DIRECTOR

Dear Resident,

The Arlington County Department of Parks, Recreation and Community Resources is cooperating with American Forests in conducting a regional ecosystem analysis of the Chesapeake Bay region. Aerial photographs of several sample sites in Arlington have been taken. Interns working with County staff will be collecting data from the ground to verify and quantify aerial and satellite imagery. We will need to identify and measure the types of trees on your property, detailing the trees' diameter, height and relative health.

The following persons will be collecting ground data: Lois Barb and Mark Snyder of Arlington County, Maggie Sone, Jerrel Mortan, Kinika Johnson and Shereese Gordon from the University of the District of Columbia, and the following people from American Forests in Washington, D.C.: Jeff Beattie, Ryan Avery, Carl Nielsen, Manna Neghassi and Milissa Cormier.

Thank you for your cooperation in allowing this short visit. The data will be collected during the weeks of November 16 and November 23. The survey will take only **20** minutes or so and will not disturb your property. If you do not want us to conduct this survey on your property, please contact us at 228-6557 and leave a message to that effect.

If you have any questions, please feel free to call me at the number above or my supervisor, Jamie Bartalon, at 228-7747.

Sincerely,

Mark R. Snyder
Urban Forester

TREE INVENTORY SHEET

Location: **Site #:**

	Tree ID TREE_ID	Private/ Public PUB_PRV	Species SPECIES	Code CODE	Trunk Diameter DIA_CLSS	 DIA	Height Class HT_CLSS	Health HEALTH

APPENDIX C:

Appendix C: Interview Questions

Ed Macie and Fred Deneke 11/16/98

1.) What is your title and job description?

2.) How many years have you been working with CITYgreen and/or urban forests?

3.) What role do trees play now, and what potential role could trees play in the forming of public policy and legislation?

4.) What is your general opinion of CITYgreen and its capabilities?

5.) How effective can CITYgreen be in communicating the importance or value of tree cover and other natural resources to a community? Can this then impact legislation of that area? How?

6.) Are you familiar with any other software or similar types of analysis that put value on tree cover in order to communicate its importance?

7.) Are you aware of any other similar software programs, or other alternatives to this means of analysis and communication?

* While these questions were our guidelines going into interviews, the conversations were not limited to the topics mentioned above.

Priscilla Ryder 11/30/98

1.) What is your job description?

2.) How did you hear about American Forests?

3.) What made you decide to do this type of ecological analysis of Marlboro?

4.) What were your expectations going into this project?

5.) To what degree have these expectations been fulfilled?

6.) Are you capable of performing a CITYgreen analysis, providing that the software would be available to you?

7.) What would you add to the analysis?

8.) What parts of the analysis were especially useful to you?

9.) Is there potential for this system to become a nationwide planning tool in the future?

10.) Do you think that this system is more useful as a planning tool, or a policy making tool?

* While these questions were our guidelines going into interviews, the conversations were not limited to the topics mentioned above.

Joan Beker-Kolsch and Christie Williams 12/2/98

1.) What is your title and job description?

2.) What are the biggest environmental issues that your community is facing today?

3.) Given the analysis of Arlington; would this information be useful to you? How? Is there anything that you would change or add?

4.) Would your department have the money, resources, and time to implement the use of this system?

5.) What are the daily requirements of your job? How could CITYgreen possibly fit in with these requirements?

6.) Who would you go to with this information to make a change? How? What would you say?

7.) How is urban planning related to public policy making?

* While these questions were our guidelines going into interviews, the conversations were not limited to the topics mentioned above.

Beth Strommen 12/4/98

1.) What is your official job title?

2.) What is a brief description of what you do?

3.) What are some of the environmental issues that you deal with?

4.) Which are the environmental issues that are most important to the Baltimore community today?

5.) Have you ever heard of CITYgreen?

6.) Do you know what this software program does?

7.) Do you work closely with developers?

* While these questions were our guidelines going into interviews, the conversations were not limited to the topics mentioned above.

Donald Outen 12/3/98

1. Describe what your department does, and in particular your job.
2. What are the major environmental issues is Baltimore facing today?
3. In your opinion, what are the solutions to these problems?
4. Do you think that CITYgreen could play a role in these solutions?
5. What is the best way to get these communities involved?

* While these questions were our guidelines going into interviews, the conversations were not limited to the topics mentioned above.

APPENDIX D:

CITYgreen Users Survey

Appendix D: CITYgreen users Survey

November 10, 1998

Dear CITYgreen user:

American Forests is asking users for their comments on CITYgreen so we can better meet your needs in future upgrades. If someone other than you is the primary user of CITYgreen, please forward this survey to him or her.

Please take a few minutes to answer the questions below and add any additional comments or questions you may have about CITYgreen. We may be contacting you by telephone for your brief comments and suggestions on how we can improve CITYgreen.

Please return this survey in the enclosed postage-paid envelope to: **American Forests, P.O. Box 2000 Washington,** D.C. **20013.**

Thank you for your time and cooperation.

Sincerely,

Ryan Avey

Urban Forest Center
(202) 955-4500 X209
ravey@wpi.edu

P.S. Please complete and return this questionnaire within five business days if possible. We appreciate your help.

Primary CITYgreen User:

Name / Title ______________________

Address ______________________

Work Phone ______________________

Email ______________________

Primary CITYgreen User:

•
Name / Title ______________________

Address ______________________

Work Phone ______________________

Email ______________________

Please circle your answers to the following questions below. Feel free to elaborate on any question or provide any additional comments at the bottom of the page or on the opposite side.

*

1. a. ~~Have you or someone in your organization used the CITYgreen software you~~ purchased? YES NO

   b. If NO, please explain why it hasn't been used, and skip the remaining questions.

2. a. Do you still currently use CITYgreen? YES NO

   b. If NO, for what reasons did you discontinue its use?

   ____

   ____

3. How often do you use CITYgreen?

   (a) Daily (b) Weekly (c) Monthly (d) Yearly (e) Less than once a year

4. For what purpose do you use CITYgreen? (please circle all that apply)

   (a) Communicating within the dept.

   (b) Communicating outside the dept.

   (c) Justification of budget/ program initiatives

   (d) Program evaluation

   (e) Site modeling

   (f) Educational Tool

   (g) Other ______________________

5. Please classify (circle) your organization type:

Local / Municipal Gov't	Non-Profit	Educational
Urban Planning	Conservation Org.	University/College
Parks/Rec/Urban Forestry	Other ________	K-12
Environmental Services		Other__________
Other _____________		

6. How satisfied are you with CITYgreen overall?

Satisfied   Somewhat   Dissatisfied   Very dissatisfied

Comments / Suggestions:

CITYgreen Users	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Comment
Dan Aken	Yes	Yes	Monthly	Prog.eval	Planning	3	Yes
Kristyn Albros	No						
Steve Boetger	No						
Bill Brash	Yes	Yes	Monthly	Site model	SCD	3	Yes
Jan Carlson	No						
Jon Chapman	Yes	No	Rarely	Budget		3	Yes
Paul Cook	No						
Sara Creedon	Yes	Yes	Yearly	Site model	Parks/Rec	3	Yes
Rosi Dagit	Yes	Yes	Weekly	Site model	Env. Serv	3	Yes
Rod Denning	Yes	Yes	Rarely	Education	College	4	Yes
David Edgell	Yes	No	Rarely	Site model	Planning	3	No
James Edgington	Yes	Yes	Monthly	Tree inventory	Parks/Rec	3	Yes
David Fuller	No						
Rochelle Garwood	Yes	No			Reg, Plan		
Harrie	Yes						
Dudley Hartel	Yes	Yes	By contract	Consult	Consult	4	No
Kim Hesse	No	No		Prog.eval	Urb.forest		
Frank Jenner	Yes	Yes	Rarely	Site model	Parks/Rec	3	No
Tom Kellogg	Yes	Yes	Yearly	Education	Gov.Asoc	4	Yes
Jim Kielbajo	No						
Jim Kirkland	Yes	Yes	Rarely	Education	College	3	No
Sally Krebbs	No						
Shellie O'Quinn	No						
Walter Paul	Yes	No					
Dr.Claudia Phillips	Yes	Yes	Yearly	Education	College	4	No
Pedro Rivera	Yes	Yes	Yearly	Site model	Env. Serv	3	Yes
Priscila Ryder	No						
Laura Simeff	Yes	No			Con. Org.	5	Yes
Charlynne Smith	Yes	Yes	Yearly	Education	College	4	Yes
Paul Spina	Yes	Yes	Yearly	Site model	Urban Plan	3	Yes
Steve Strickland	Yes	Yes	Weekly	Planting proj	Parks/Rec	4	Yes
Fred Suffian	Yes	Yes	Weekly	Site model	K-12	3	Yes
Melanie Sumter	No						
Elizabeth Walker	Yes	No			Planning	2	No
Unknown	Yes	Yes					

CITYgreen User Survey Responses

Glossary

abiotic:	Non-living
anoxia:	The absence of dissolved oxygen.
benthic:	Plants that grow under water. They are attached to or rooted in the bottom. These plants depend on the sun's rays penetrating the water for photosynthesis.
biomass:	The mass of biological material. Usually the total mass of a particular group or category, for example the mass of all of the producers within an ecosystem.
biotic:	Of or pertaining to living organisms.
DDT:	Dichlorodiphenyltrichloroethane. The first and most widely used of the synthetic organic pesticides belonging to the chlorinated hydrocarbon class.
deciduous:	Any species of tree that looses its leaves in the fall.
disturbance:	Any cutting down or other alteration of a natural forest.
Eco Structures:	CITYgreen's method of stratifying a city region into basic ecological components, using land cover and other data representing land use.
EPA:	Environmental Protection Agency. The federal agency responsible for control of all forms of pollution and other kinds of environmental degradation.
estuary:	An arm of the sea at the mouth of a river. A place where fresh water and salt water meet, and home to a diverse range of species.
evergreen:	A species of tree that stays green all year round.
fragmentation:	Forests remaining as patches of various sizes, often disconnected from other woodlands.
gully erosion:	Gullies, or ditches, large or small that are caused by water erosion.

humus:	A dark brown or black, soft, spongy residue of organic matter that remains after the bulk of dead leaves, wood, or other organic matter has decomposed. It is extremely valuable in enhancing the physical and chemical properties of soil.
hypoxia:	Low dissolved oxygen.
infiltration:	The process in which water soaks into soil as opposed to running off the surface.
leaching:	The process in which materials in or on the soil gradually dissolve and are carried by water seeping through the soil. It may result in the removal of valuable nutrients from the soil, or it may carry buried wastes into groundwater, thereby contaminating it.
local analysis:	A group of programs within CITYgreen that include Stormwater Runoff, Statistics, Carbon, Pollutant Removal, Energy Conservation, Wildlife Benefits.
monoculture:	When a population consists of only one species, For example, a forest full of sugar maple trees.
mycorrhizae:	Symbiotic soil fungi.
non-attainment area:	A community that is not currently meeting the standards set forth in the Clean Air Act for air quality.
non-point-source pollution:	Sources of pollution such as general runoff of sediments, fertilizer, pesticides, and other materials from farms and urban areas. Also called duffuse sources.
point-source pollution:	Specific points of origin of pollutants such as factory drains or outlets from sewage-treatment plants.
riparian zone:	A forest that borders any type of water system. This location means that these trees play an important role in the water quality of that system.
sedimentation:	The filling in of lakes, reservoirs, stream channels, and so on with soil particles, mainly sand and silt. The soil particles come from erosion, which generally results from poor or inadequate soil conservation practices in connection with agriculture, mining, and/or development.

sheet erosion:	The loss of a more or less even layer of soil from the surface due to the impact and runoff of a rainstorm.
splash erosion:	The compaction of soil that results when rainfall hits bare soil.
sprawl:	The taking of pieces of property and dividing them up for residential purposes.
stand:	A grouping of trees. Forest stand.
SAV:	Submerged Aquatic Vegetation. Aquatic plants rooted in bottom sediments growing under water depend on light penetration through the water for photosynthesis.
trophic:	The feeding level with respect to an organism's primary source of energy. Green plants are at the first trophic level, primary consumers are at the second, and secondary consumers are at the third.
watershed disturbance:	Any practice (such as lumbering) or chemical imput (such as acid deposition) that alters forest vegetation, an introduction of exotic species, or construction of roads that increases sediments to streams.
wetland:	Areas that are constantly wet and are flooded at regular intervals. A number of wetlands are marshy areas along coasts that are regularly flooded by tides.

References

Arc View GIS: The Geographic Information System for Everyone. (1996). *Environmental Systems Research Institute,* Inc.

American Forests. (1998). CITY green User's Manual for use with ArcView 3.1.

American Forests. (1996a). CITY green User's Manual for use with ArcView 2.1.

American Forests. (1996b). "Global Problems Local Solutions." Washington D.C.: American Forests. Autumn.

American Forests. (1997). "Sustainable Forests for Indonesia." Washington D.C.: American Forests. Winter/Spring.

American Forests. (1996c). "Urban Ecological Analysis: Executive summaries from selected communities." Washington D.C.: American Forests. June.

American Forests. (1996d). "Urban Ecological Analysis for Atlanta, Georgia." Washington D.C.: American Forests. March 7.

American Forests. (1995). "Urban Ecosystems: Breakthrough for CITYgreen." Washington D.C.: American Forests. Autumn.

Beardsley, R.C. (1980). Evolution of Physical Oceanography.

Blankenship, Karl. "Bay forests losing ground to fragmentation." Bay Journal September 1998, Volume 8, Number 6,1.

Campbell, Jante W., & Thomas, James P. "Chesapeake Bay Plume Study." North Atlantic Regional Water Resources. United States Army Corps of Engineers.

Cronin, W.B. (1988). The Chesapeake Bay Estuary.

Cross, Matthew, Freely, Michael, & Ierardi, James. (1995). IQP#95BO0331. Public Policy in Urban Watershed Modeling.

Ecology. (1997). "In McGraw-Hill Encyclopedia of Science and Technology. (Vol.5, P 625). New York: McGraw-Hill.

Fernandez, Jose, St. Marie, Daniel, & Woo, Phillip. (1993). IQP #93B0211 Inventory and Evaluation of Urban Forests.

Firestone, David B., & Reed, Frank C. (1993). Environmental Law for Non-Lawyers. South Royalton, VT: SoRo Press.

Gibbons, Boyd. (1984). "Do we treat our soil like dirt?" National Geographic, September, 350-389.

Gilman, Amy, Obie, Dennis, & Reardon, Matt. (1993). IQPB0081 The Future of Private Forest Management.

Golly, Frank. (1997). "Ecology, applied." In McGraw-Hill Encyclopedia of Science and Technology. (Vol.5, 634-638). New York: McGraw-Hill.

Grier, Charles C. (1997). "Forest Ecosystem-Characteristics." In McGraw-Hill Encyclopedia of Science and Technology. (Vol.7, 395). New York: McGraw-Hill.

Heisler, Gordon, Grant, Richard, Grimmond, Sue & Souch, Cathrine. "Urban Forests-Cooling Our Communities?" Inside Urban Ecosystems: Proceedings of the 7th Urban Forest Conference, New York, NY. September 12-16, 1995.

Horton, Tom. (1993). "Chesapeake Bay: Hanging in the balance." National Geographic, June, 2-35.

Loesch, M. N. (1995). The Chesapeake Bay Bibliography Vol. 5.

Meyer, Judy L. (1997). "Forest ecosystem-streams." In McGraw-Hill Encyclopedia of Science and Technology. (Vol.7, 399-400). New York: McGraw-Hill.

Moll, Gary & Petit, Jack. (1994.) "The Urban Ecosystem: Putting Nature Back in the Picture." Urban Forests. October/November 1994. pp8-15.

Mull, Gary A., & Grey, Gene. (1997). "Forestry, Urban." In McGraw-Hill Encyclopedia of Science and Technology. (Vol.7, 434). New York: McGraw-Hill.

NCSU Aquatic Botany Laboratory: Pfiesteria piscicida. http://www2.ncsu.edu/unity/lockers/project/aquatic_botany/pfiest.html. October 26,1998.

Nebel, Bernard J., & Wright, Richard T. (1996). The Way the World Works: Environmental Science. Upper Saddle River, New Jersey: Prentice Hall.

Nowak, David J. Air Pollution Removal by Chicago's Urban Forest. USDA Forest-Service General Technician Report. Report NE-189, 1994. p. 64.

Portney, Paul R., ed. (1990). "Public Policies for Environmental Protection." Resources For the Future. Washington D.C.

"The Problem." http://vvvvw.dnr.state.md.us/bay/czm/nps/problem.html. October 26, 1998.

Rosenfeld, A. H., Romm, J., Akbari, H., Lloyd, A. White Roofs and Shade Trees, The Cool Way to Reduce Smog. Technology Review. August 7,1996. Pp. 1-4.

Sample, V. Alaric, ed. (1994). Remote Sensing and GIS in Ecosystem Management. Washington D.C.: Island Press.

Stauble, J.F. & Wood, D.H. (1991). The Chesapeake Bay Bibliography Vol. 2.

Tagtow, R. March 1990. "The Need for Urban Communities." American City and Country pp. 74-76.

"Urban Riparian Forest Buffers." http://www.chesapeakebay.net/bayprograrn/facts/forests/urban.htm. October 26,1998.

Vig, Norman J., & Kraft, Michael E. (1997). Environmental Policy in the 1990's. Washington D.C.: CQ Press.

Yaffe, Stephen L., Phillips, Ali F., Frentz, Irene C, Hardy, Paul W., Maleki, Sussanne M., & Thorpe, Barbara E. (1996). Ecosystem Management in the United States. Washington D.C.: Island Press.