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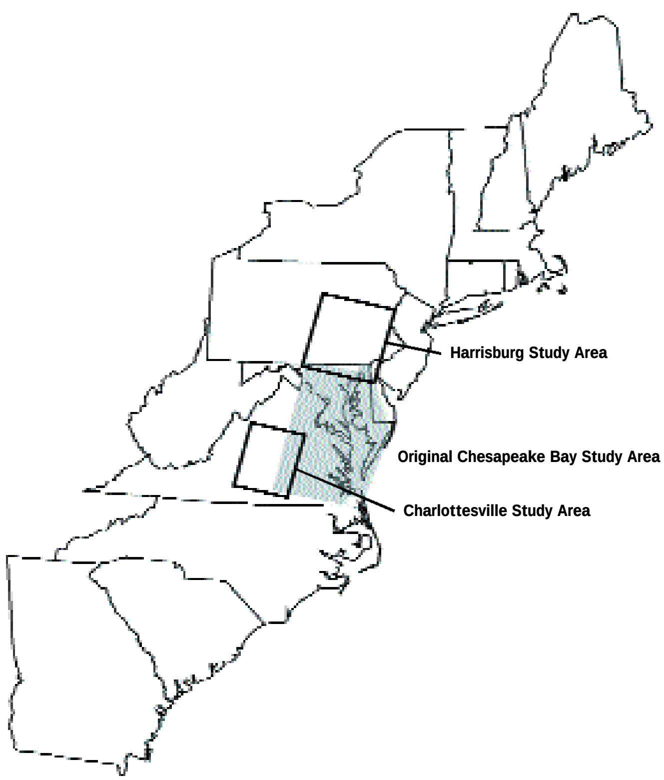
Regional Ecosystem Analysis Chesapeake Bay Watershed— Charlottesville, VA and Harrisburg, PA Areas

Calculating the Value of Nature

Report Contents



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Sponsored by the USDA Forest Service Chesapeake Bay Project

Project Overview

AMERICAN FORESTS originally conducted a Regional Ecosystem Analysis (REA) of the Chesapeake Bay Region in 1999. This study looked at how the landscape changed over time in an 11.4 million acre study area in the southeast portion of the Chesapeake Bay watershed. As an extension to that study, AMERICAN FORESTS has conducted similar analyses in two adjacent areas of the watershed. In the initial study, it was determined that the Chesapeake Bay had lost a significant amount of its tree cover—average canopy declined from 51% in 1973 to 39% in 1997. Similar trends have been identified in the new study areas surrounding Charlottesville, VA (5.3 million acres) and Harrisburg, PA (7.5 million acres). These two areas are the focus of this study.

The analysis uses Geographic Information Systems (GIS) technology to measure the changing structure of the landscape, with emphasis on tree cover. Regional changes in the landscape are analyzed through remote sensing image analaysis, while economic and environmental impacts are assessed using AMERICAN FORESTS' CITYgreen software.

Major Findings

The ecology of the Charlottesville and Harrisburg areas have changed dramatically since the 1970s. Natural forest cover has declined, while urban development has expanded.

- The dominant feature of the Charlottesville landscape in 1976 was forests. Heavily canopied areas (50% or greater tree cover) comprised 50% of the area (2,680,478 acres). Developed areas and farmland (with tree cover of less than 20%) comprised 44% of the land (2,325,031 acres). In 1973, the Harrisburg area was densely forested (greater than 50% canopy) on 36% of its land, while developed areas with low tree cover accounted for 59% of the area.
- By 2000, areas with little tree cover were dominant in both study areas. In fact, both areas saw similar trends in tree loss in all categories. Both Charlottesville and Harrisburg lost 19% of their heavily canopied areas (Harrisburg now having 2,127,345 acres with Charlottesville falling to just 2,184,387 acres in 2000)
- Average tree cover in the Harrisburg area declined from 36% to 31%, while average tree cover in the Charlottesville area declined from 49% to 41%.

Two subsets of the study areas were chosen for closer examination. Similar trends in tree loss were revealed in the Harrisburg Metro area (735,000 acres) as well as along the I-64 corridor between Charlottesville and Richmond (1.3 million acres).

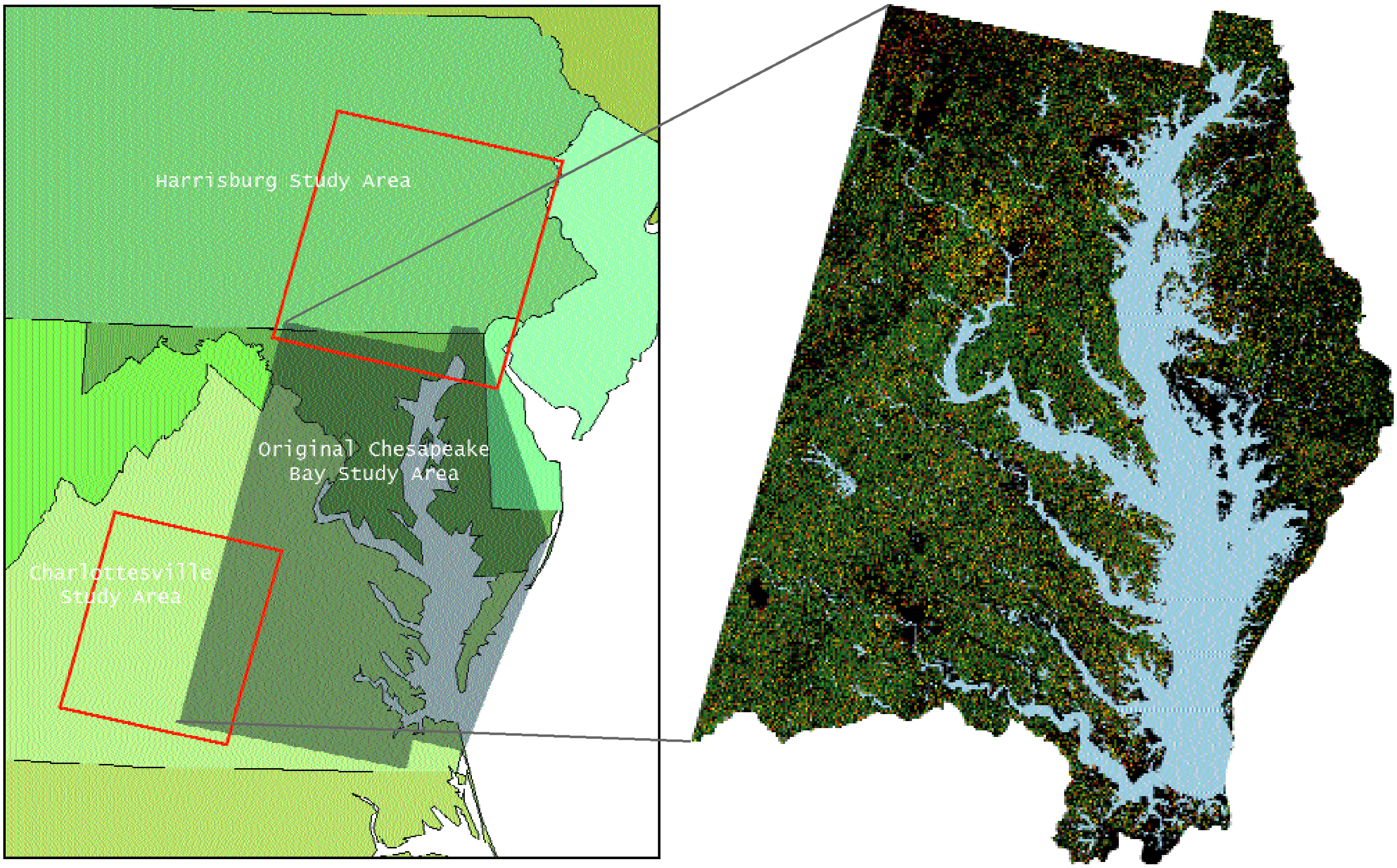
- Overall tree cover in the Harrisburg Metro area declined from 30% to 26%. Areas of heavy tree canopy (greater than 50%) fell to 22% in 2000, down from 28% in 1973. During this same time period, the metro area saw low tree canopy (areas of less than 20% tree cover) increase from 66% to 76%.
- The I-64 corridor saw a more dramatic loss of trees, seeing its average tree cover fall from 40% to 34%. Between Charlottesville and Richmond heavy tree canopy dropped from 44% to 35%, while low canopy increased from 47% to 63%. Since the early 1970s, the I-64 corridor has gone from a near balance of low and high canopy, to a drastic imbalance in favor of low tree cover and urban surfaces.

There are economic implications of tree loss for stormwater management and air quality in the Charlottesville and Harrisburg areas.

- Tree loss in the Charlottesville study area between 1976 and 2000 resulted in a 19% increase in stormwater runoff (from each 2-year peak storm event), an estimated 3 billion cubic feet of water. Costs to build stormwater retention ponds and other engineered systems to intercept this runoff would cost $6 billion ($2/cubic ft. of storage).
- Trees improve air quality by removing nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), and particulate matter 10 microns or less (PM10). In the Charlottesville area, lost tree canopy would have removed approximately 88.6 million pounds of these pollutants from the atmosphere annually, at a value of $218 million per year.
- Between 1973 and 2000, the Harrisburg area's tree loss resulted in an 8% increase in runoff, an estimated 1 billion cubic feet of water (from each 2 year peak storm event). The cost of building stormwater retention ponds and other engineered systems to intercept this runoff would total $2 billion ($2/cubic ft. of storage).
- Lost tree canopy in the Harrisburg study area would have removed about 100 million pounds of pollutants from the atmosphere each year. This translates into a cost of approximately $248 million annually.

Maintaining and restoring tree cover is a cost effective way to improve the environment.

- The natural landscape should be recognized for its economic, as well as ecological, value. Tree cover is a good measure of the ecological health of the Chesapeake Bay Watershed.
- Sprawl development has large negative environmental and economic consequences.
- Strategically planting trees in urban and suburban areas, and as buffers along streamsides throughout the region, would improve water quality in the Bay and its tributaries; improve air quality and wildlife habitat, conserve energy, sequester greenhouse gases, and improve the quality of life.



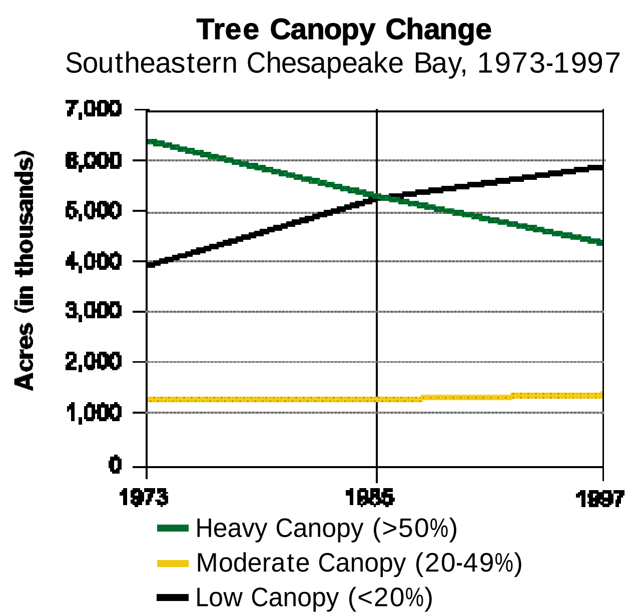
Regional Analysis

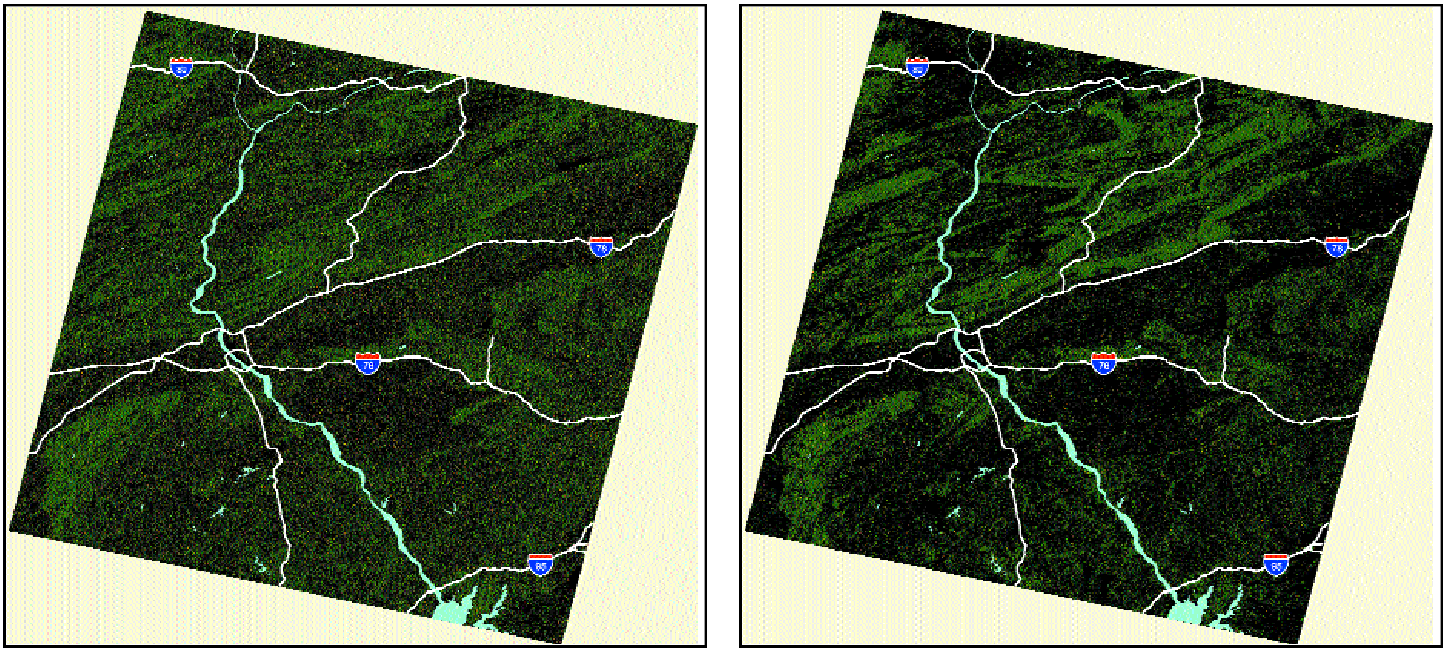
AMERICAN FORESTS' initial 11.4 million acre study area was analyzed in the southeastern Chesapeake Bay watershed. This area saw a dramatic loss in tree cover over a 24-year period. The above-right image is a classified Landsat TM image of the region in 1997. High tree cover is indicated in green and low tree canopy associated with urban areas and agriculture is in black. Areas of intermediate tree canopy values are represented in yellow and red. The analysis measures nine categories of tree cover, though these have been combined into six groupings to accommodate the limitations of printing at this scale.

Graphing Change

The change in vegetation measured in the previous study is represented in a line graph at right. Graphs revealing similar trends to this one appear on the following pages for the Charlottesville and Harrisburg areas. All charts show the change in vegetation cover for three categories over the span of the study. Natural forest cover is represented by a green line and indicates places with greater than or equal to 50% tree canopy. Developed and agricultural areas are represented by a black line and indicate where tree canopy is less than 20%.

The yellow line represents a healthy mix of development and the natural environment where tree cover is between 20% and 49%. Open space, residential areas, and parkland would fall into this middle category.





Classified Landsat scenes of Harrisburg Study Area from 1973 (left) and 2000 (right). Green indicates areas of heavy tree cover (greater than 50%) and black indicates areas of low tree cover (less than 20%).

Economic and Ecological Implications

Urban ecology is more complex than tree cover. Nonetheless, trees are good indicators of the health of an urban ecosystem. The greater the canopy coverage, the less impervious surface and the greater the environmental benefits. Trees provide communities with many valuable services that can be measured in terms of dollar benefits. These include: 1) slowing stormwater runoff and reducing peak flow and 2) improving air quality. These quantifiable benefits can help community leaders recognize cost savings opportunities from increased tree cover.

Cities spend tremendous amounts of money installing stormwater control systems and repairing damage from flooding. Furthermore, cities that cannot meet EPA attainment levels for air and water quality jeopardize federal funding for capital improvements. Trees are an attractive non-built solution that reduces stormwater runoff and improves air quality. These benefits underscore the importance of maintaining and restoring the natural infrastructure of our communities.

How to Use CITYgreen® To Analyze Local Data

AMERICAN FORESTS uses CITYgreen® software to conduct a detailed analysis of how the structure of the landscape affects its function. This tool connects research and engineering formulas with Geographic Information Systems (GIS) to place a dollar value on the work trees do. With CITYgreen® AMERICAN FORESTS analyzed past land cover and compared it to the present land cover configurations in Harrisburg and Charlottesville.

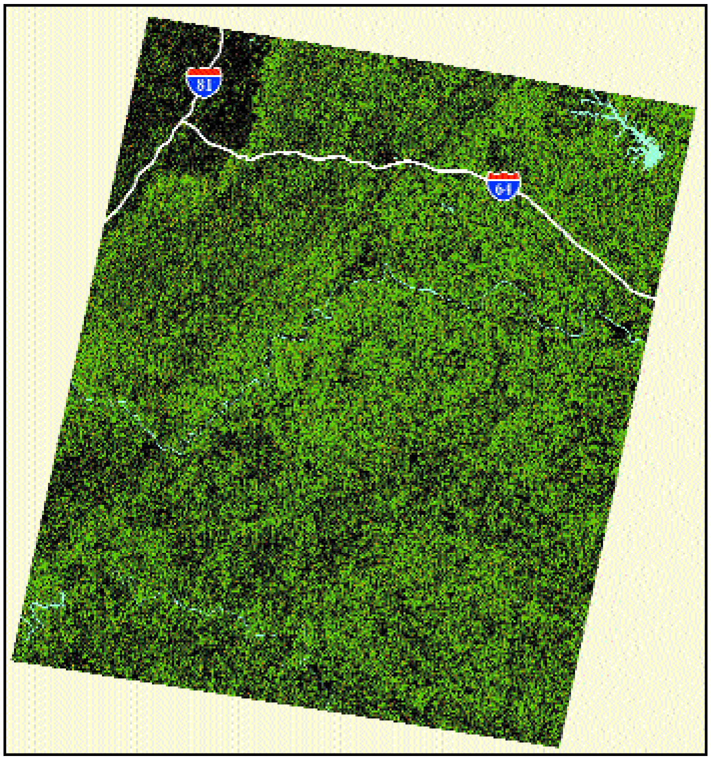
Stormwater

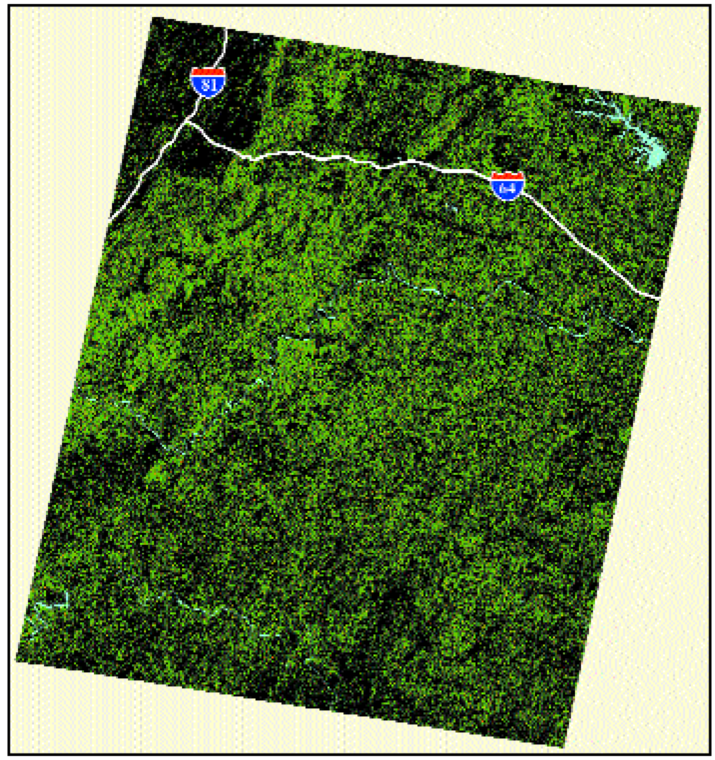
Trees and soil function together to reduce storm water runoff. Trees reduce stormwater flow by intercepting rainwater on leaves, branches, and trunks. Some of the intercepted water evaporates back into the atmosphere, and some soaks into the ground reducing the total amount of runoff that must be managed in urban areas. Trees also slow storm flow, reducing the volume of water that a containment facility must store. The TR-55 model, developed by the USDA Natural Resources Conservation Service, measures stormwater movement in various storm events (see page 8).

Local governments are looking toward non-built stormwater management strategies, including trees, to reduce the cost of constructing stormwater control infrastructure. The value of trees for stormwater management is based on cost avoided for storage of stormwater in retention ponds. Local construction costs for building containment facilities are multiplied by the total volume of avoided storage to determine dollars saved by trees.

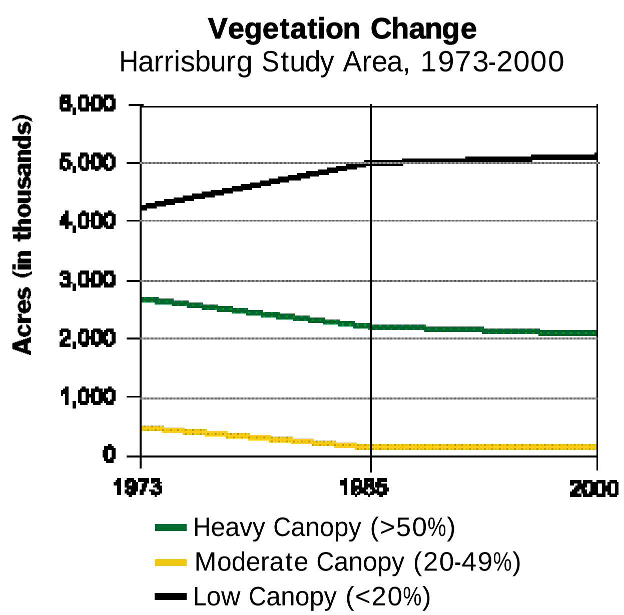
Air Quality

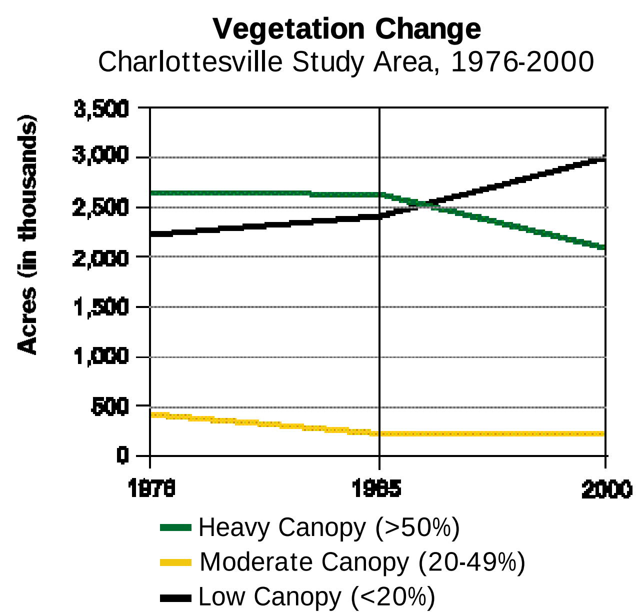
Trees provide air quality benefits by removing pollutants such as NO_2, CO, SO_2, O_3, and PM10. To calculate the dollar value for these pollutants (see page 8), economists multiply the number of tons of pollutants by an "externality cost" or costs to society that are not reflected in marketplace activity.





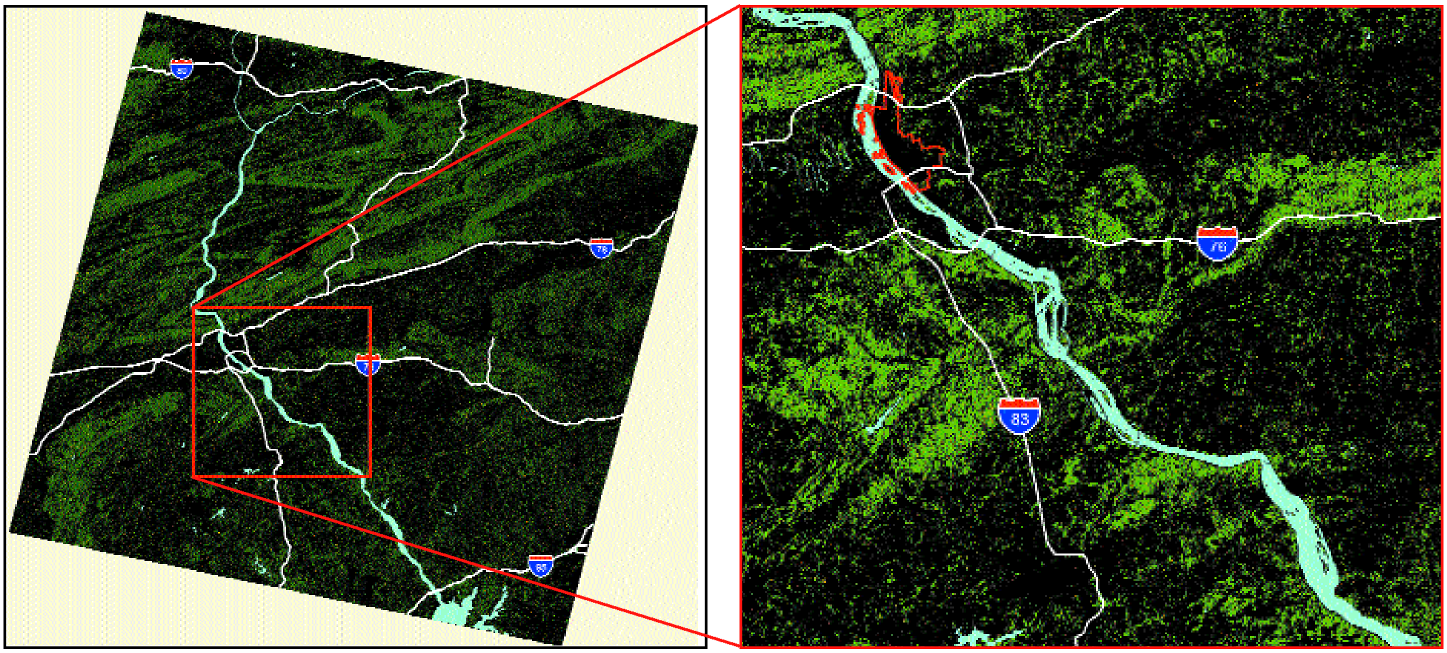
Classified Landsat scenes of Charlottesville Study Area from 1976 (left) and 2000 (right). Green indicates areas of heavy tree cover (greater than 50%) and black indicates areas of low tree cover (less than 20%).





	Air Quality (Annual benefits)		Carbon Benefits		Stormwater (Capital improvement benefits)	
	Pollutants Removed (lbs)	$ Value	Carbon Stored (tons)	Carbon Sequestered (tons/year)	Cubic ft. avoided	$ Saved
Charlottesville						
1976	318 million	$786 million	1.2 million	9,900	5.9 billion	$11.8 billion
2000	230 million	$567 million	920,000	7,200	5.0 billion	$10.0 billion
Harrisburg						
1973	481 million	$1.2 billion	1.9 million	15,000	4.5 billion	$9.0 billion
2000	381 million	$941 million	1.5 million	11,900	4.1 billion	$8.2 billion

Using Regional Data at a Local Level

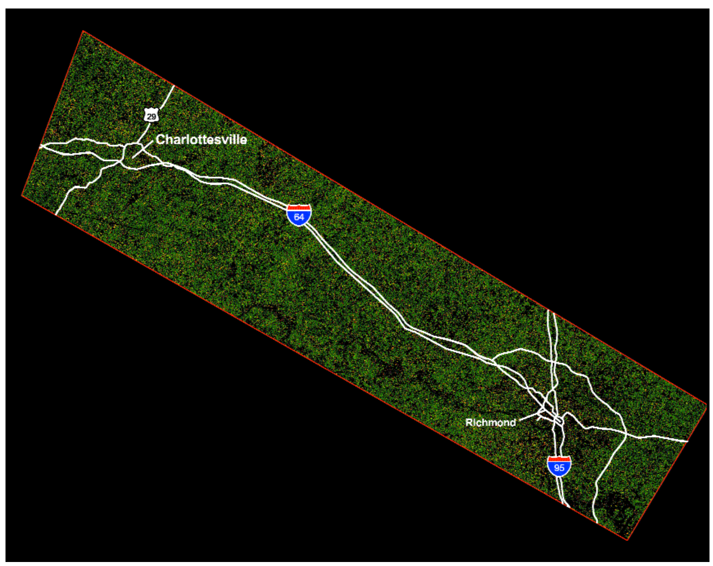


Classified 2000 satellite data of Harrisburg Study Area (left) and clip around Harrisburg Metro Area (right). Dark green areas indicate densely canopied forests, while black areas indicate less then 20% canopy.

Using Regional Data at a Local level

The regional level satellite images contain a great deal of information that be used by local decision makers. Local city or county governments can obtain sub-set clips of this data set for use in planning and decision-making. With this information, local groups can determine their current tree cover, and begin restoring it to a healthy level.

For example, a clip of the Harrisburg Metro area reveals that the area around this city has seen its average canopy drop from 30% in 1973 down to 26% in 2000. This includes a more than 21% loss in densely forested areas (greater than 50% canopy). Similarly, examining a clip of the I-64 corridor between Charlottesville and Richmond over the last few decades can allow us to see the impact of growth on tree cover between these two expanding cities. By 2000, tree cover in this corridor had dropped to 34%—down from 40% in the early 1970s.



Tree density along the I-64 corridor between Charlottesville and Richmond. Due to a lack of useable data for all desired dates, this classified satellite image is a mosaic of data from 1973 and 1976.

Recommendations

These findings address public policy questions for land-use planning and growth management using tree cover as a measure and indicator of environmental quality. When urban trees are large and healthy, the ecological system that supports them is also healthy. Healthy trees require healthy soils, adequate water, and clean air. This report brings together the expertise of ecologists, scientists, and engineers with computer mapping technology to evaluate the environment in the Chesapeake Bay Watershed and chart a course of action for future improvement. We encourage local agencies and the community to incorporate this data into the regional planning process and to gather more detailed information for local analyses using aerial photographs, high-resolution satellite imagery, and CITYgreen® software.

1. Expand the capacity and usefulness of this analysis for regional planning and growth management.

■ Incorporate a green data layer into the regional and local planning process.

■ Use the data from this analysis as a basis for setting regional tree cover goals.

■ Obtain additional data from city and county governments to extend the scale of this study.

2. Recruit county and city governments as partners in creating a regional standard for urban tree conservation and management.

■ Local governments should clip their data from the regional information and conduct a more detailed local analysis using high-resolution satellite imagery.

■ Use local analyses for community and neighborhood planning.

■ Utilize CITYgreen® software and the AMERICAN FORESTS analysis technique as a model for community participation.

3. Increase overall tree canopy in the Cheaspeake Bay Watershed to greater than 50%. Increase and conserve tree canopy in urban areas.

■ Develop urban tree canopy goals:

40% tree canopy overall

50% tree canopy in suburban residential

25% tree canopy in urban residential

15% tree canopy in the central business district

■ Implement innovative land-use planning techniques and engineering guidelines for saving existing trees and planting new ones.

■ Consider the dollar values associated with trees when making land-use decisions.

■ Use trees as a valuable and essential element of the urban environment.

■ Use CITYgreen® software as a tool to incorporate trees into land-use planning by collecting data on tree cover and quantifying the value of the trees. Use these findings in the decision making process.

About the Regional Ecosystem Analysis

AMERICAN FORESTS' Regional Ecosystem Analysis is based on the assessment of ecological structures—unique combinations of land use and land cover patterns. Each structure performs ecological functions differently and thus provides different values. For example, a site with a heavy tree canopy and few impervious surfaces provides more stormwater reduction benefits than one with low tree canopy.

In this study, the regional analysis provided an overview of tree cover change in two areas of the Chesapeake Bay Watershed. Landcover classifications of the study areas were conducted based on satellite imagery spanning the last 20-30 years. These areas were then modeled to assess the past and current benefits of their tree cover. Additional local analysis using high-resolution satellite data and aerial photos is needed to refine the local values given in the analysis.

Data Used in this Study

For regional analysis, Landsat satellite TM (30 meter pixel) and MSS (80 meter pixel) images were used as the source of land cover data. AMERICAN FORESTS used a subpixel classification technique and divided land cover into nine vegetation categories. Tree benefits were calculated using CITYgreen® software on a full pixel landcover classification of the satellite images.

AMERICAN FORESTS developed CITYgreen® software to help communities analyze the value of local trees and vegetation as part of urban infrastructure. CITYgreen® is an application of ArcView for Windows, a Geographic Information Systems (GIS) software developed by ESRI.

Analysis Formulas

TR-55 for Stormwater Runoff: The stormwater runoff calculations incorporate formulas from the Urban Hydrology of Small Watersheds model, (TR-55) developed by the USDA Natural Resources Conservation Service (NRCS), formerly known as the US Soil Conservation Service. Don Woodward, P.E., a hydrologic engineer with NRCS, customized the formulas to determine the benefits of trees and other urban vegetation with respect to stormwater management.

UFORE Model for Air Pollution: CITYgreen® uses formulas from a model developed by David Nowak, PhD, of the USDA Forest Service. The model estimates how many pounds of ozone, sulfur dioxide, nitrogen dioxide, and carbon monoxide are deposited in tree canopies as well as the amount of carbon sequestered. The urban forest effects (UFORE) model is based on data collected in 50 US cities. Dollar values for air pollutants are based on averaging the externality costs set by the State Public Service Commission in each state. Externality costs, are the indirect costs to society, such as rising health care expenditures.

Acknowledgements for this Study

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USDA Forest Service Chesapeake Bay Project
ESRI for GIS software
ERDAS for remote sensing software

For More Information

AMERICAN FORESTS, founded in 1875, is the oldest national nonprofit citizen conservation organization. Its three centers–Global ReLeaf, Urban Forestry, and Forest Policy–mobilize people to improve the environment by planting and caring for trees.

AMERICAN FORESTS' CITYgreen® software provides individuals, organizations, and agencies with a powerful tool to evaluate development and restoration strategies and impacts on urban ecosystems. AMERICAN FORESTS offers regional training workshops and technical support for CITYgreen® and is a certified ESRI developer and reseller of ArcView products. For further information contact:

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