Regional Ecosystem Analysis Chattanooga, Tennessee Metropolitan Area

Calculating the Value of Nature

Report Contents

125 YEARS 1875-2000

AMERICAN FORESTS®

PEOPLE CARING FOR TREES & FORESTS SINCE 1875

Sponsored by the USDA Forest Service & the state of Tennessee

Regional Ecosystem Analysis Chattanooga Metropolitan Area

Project Overview

AMERICAN FORESTS conducted a Regional Ecosystem Analysis of metro Chattanooga, including parts of Hamilton, Catoosa, and Walker counties, to determine how the landscape has changed over time. The analysis assessed the loss of tree canopy and its associated values using data from satellite images spanning a 22-year period from 1974 to 1996. The analysis covered 262,357 acres of land. A detailed study of point samples from within the area was also conducted to determine the economic value of these changes.

The analysis used Geographic Information Systems (GIS) technology to measure the structure of the landscape, with emphasis on tree cover. Regional changes in the landscape were analyzed using satellite images. Detailed site inventories were analyzed using low-level digital imagery and AMERICAN FORESTS' CITYgreen® software to calculate the economic values of the area's urban forest.

Major Findings

The ecology of the Chattanooga area has changed dramatically since 1974. Forests have declined and urban development has expanded.

■ In 1974, heavy forest canopy (land with 50% or greater tree cover) comprised 42% of the area (111,341 acres). Developed areas and farmland (with tree cover of less than 20%) comprised 51% of the land area (134,360 acres).

■ By 1996, areas of less than 20% tree cover comprised nearly 75% of the land area studied, an increase of 46% totaling 196,381 acres. Heavily forested areas declined by 50% to cover 55,854 acres, comprising 21% of the land area studied.

■ Average tree cover declined from 39% to 22.5% of the land area studied, a decrease of 16.5%.

There are economic implications of tree loss for stormwater management and clean air in the Chattanooga area.

■ Tree loss in the Chattanooga area from 1974 to 1996 resulted in a 17% increase in runoff—an estimated 139.5 million cubic feet of water (based on the average 2-year, 24-hour peak storm event). Managing this amount of runoff using retention ponds and other engineered systems would cost $279 million (assuming a $2 per cubic ft. construction cost).

■ In 1996, metro Chattanooga's tree cover was worth about $758 million in stormwater retention capacity, down from 1974's value of $1.04 billion.

■ Lost tree canopy would have removed about 2.6 million pounds of pollutants annually, at a value of approximately $6.2 million.

■ Chattanooga's urban forest improves air quality by removing sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), and particulate matter 10 microns or less (PM_{10}).

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 its ecological, value. Tree cover is a good measure of the ecological health of the landscape.

■ Sprawl development has large negative environmental and economic consequences.

■ Increasing the average tree cover to 40% in the area would provide sizeable benefits.

■ Strategically planting trees in urban and suburban areas would substantially improve tree cover and the quality of air and water resources, enhance wildlife habitat, conserve energy, sequester greenhouse gases, and improve the quality of life.

Table 1. Metropolitan Chattanooga Vegetation Change and Associated Benefits

	1974	1996	Loss/Gain 1974-1996
Acres with 50% or more tree cover	111,341 (42%)	55,854 (21%)	-50%
Acres with 20%-49% tree cover	16,656 (6%)	10,122 (4%)	-39%
Acres with less than 20% tree cover	134,360 (51%)	196,381 (75%)	46%
Stormwater Management Value*	$1.04 billion	$758 million	$279 million
Air Pollution Removal Value (annually)	$19 million	$12.8 million	-$6.2 million
Annual Carbon Storage	3.6 million tons	2.4 million tons	-1.2 million tons

* Represents a one time savings and does not include additional savings from annual maintenance

Regional Analysis

Key: % Tree Cover

< 20%	20-29%	30-39%	40-49%	≥ 50%

Landsat MSS 1974 80 Meter Pixel Resolution

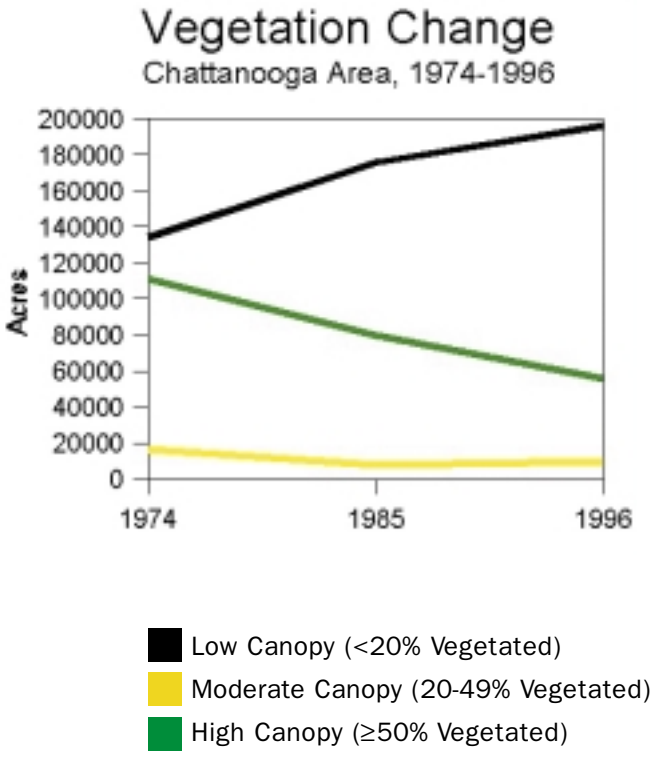
Landsat TM 1996 30 Meter Pixel Resolution

Satellite Images of Metropolitan Chattanooga

Classified satellite images show the change in land cover in the Chattanooga region over a recent 22-year period. High density tree cover (≥50%) is indicated in green, low density tree canopy (<20%) and impervious surfaces associated with urban areas are in black. The GIS analysis measures nine categories of tree cover. Canopy categories are displayed in five groupings to accommodate the limitations of printing the images at this scale.

Graphing Change

The changes in vegetation depicted in the satellite images *(above)* are represented by a line graph *(at right)*. The graph shows the change in tree cover over a 22-year period. Natural forest cover is represented by a green line and indicates areas with greater than or equal to 50% tree canopy. Developed areas are represented by a black line and indicate areas where tree canopy is less than 20%. The yellow line represents land where the tree cover is between 20% and 49%.



Local Level Analysis

The Chattanooga Regional Ecosystem Analysis has two levels of detail. One is at a regional scale, covering 262,357 acres, and the other is at a neighborhood scale, with each study site covering about 2 to 5 acres.

Using the land patterns identified from the regional image, low-level aerial photographs are used to document the landscape at the local or neighborhood scale. CITYgreen® software is used to determine detailed measurements of the local ecology's value.

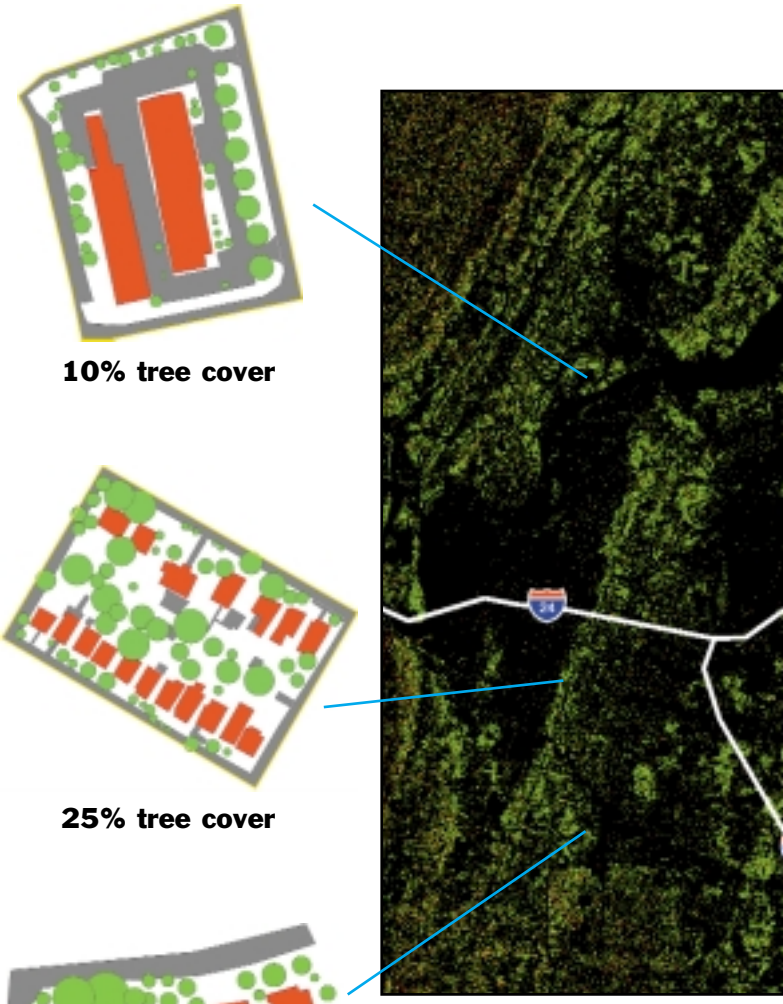
The local level analysis is conducted in conjunction with local groups and agencies. This data is not yet available for the Chattanooga area. Therefore, AMERICAN FORESTS has developed computer models to represent the structure of the landscape in various neighborhoods. Data gathered from local agencies and databases was used extensively in building these models.

The models are designed to simulate Chattanooga's tree species, soil type, rainfall patterns and land-use configurations. In each model neighborhood, the greater the tree canopy percentage, the less impervious surface there is. The resulting benefits from these representative samples sites are multiplied by total land area for each category (identified in the regional summary).

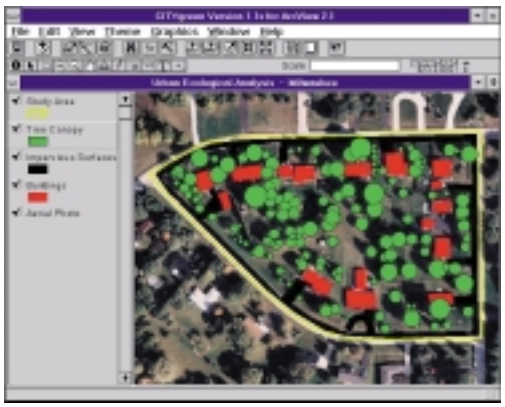
Trees as Indicators of a Community's Ecological Health

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 more environmental benefits. Trees provide communities with many valuable services that can be measured in dollar benefits. Two of the most critical are: 1) slowing stormwater and reducing runoff and 2) improving air quality. These quantifiable benefits can help community leaders recognize cost savings opportunities from increased tree cover.

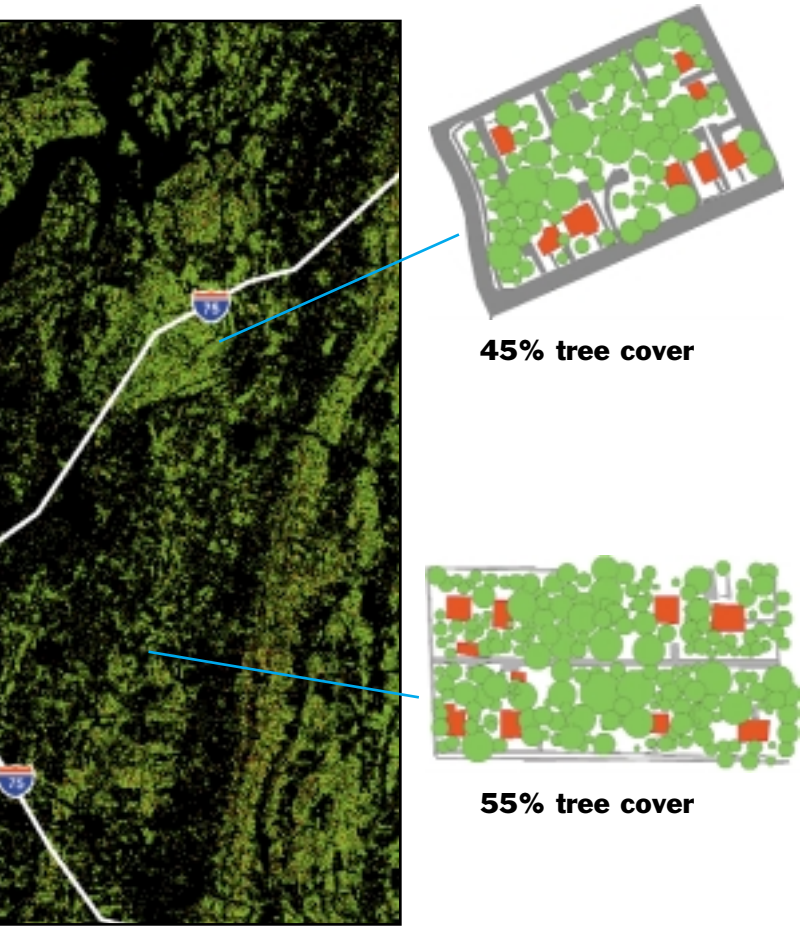
Cities spend tremendous amounts of money installing stormwater control systems and repairing damage from flooding. Furthermore, cities that cannot meet EPA attainment levels for air and water quality jeopardize federal funding for capital improvements. Trees are an attractive, non-built solution that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



Satellite images provide the framework for an Urban Ecosystem Analysis. Geographic Information Systems (GIS) technology sorts the landscape into landcover categories. Point sampling and CITYgreen software are then used to determine economic and environmental benefits associated with tree canopy.



Low level aerial photography is used by CITYgreen® software to conduct a local ecosystem analysis.



How CITYgreen® is Used 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 incorporates research and engineering formulas to place a dollar value on the work trees do. With CITYgreen® it is possible to determine how various canopy cover classes affect stormwater movement and air quality.

Stormwater Runoff

Trees and soil function together to reduce stormwater 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 peak flows and therefore reducing the volume of water that a containment facility must store. The TR-55 model, developed by the Natural Resources Conservation Service, provides a quantitative measure of stormwater movement in what is called, "an event model" (see page 8).

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

In the metropolitan Chattanooga area, existing tree canopy reduces the need for retention structures by 379 million cubic feet. Using a very conservative $2.00/cubic foot construction cost multiplier, trees currently save the metropolitan area $758 million per construction cycle (not including added savings derived from avoided maintenance costs).

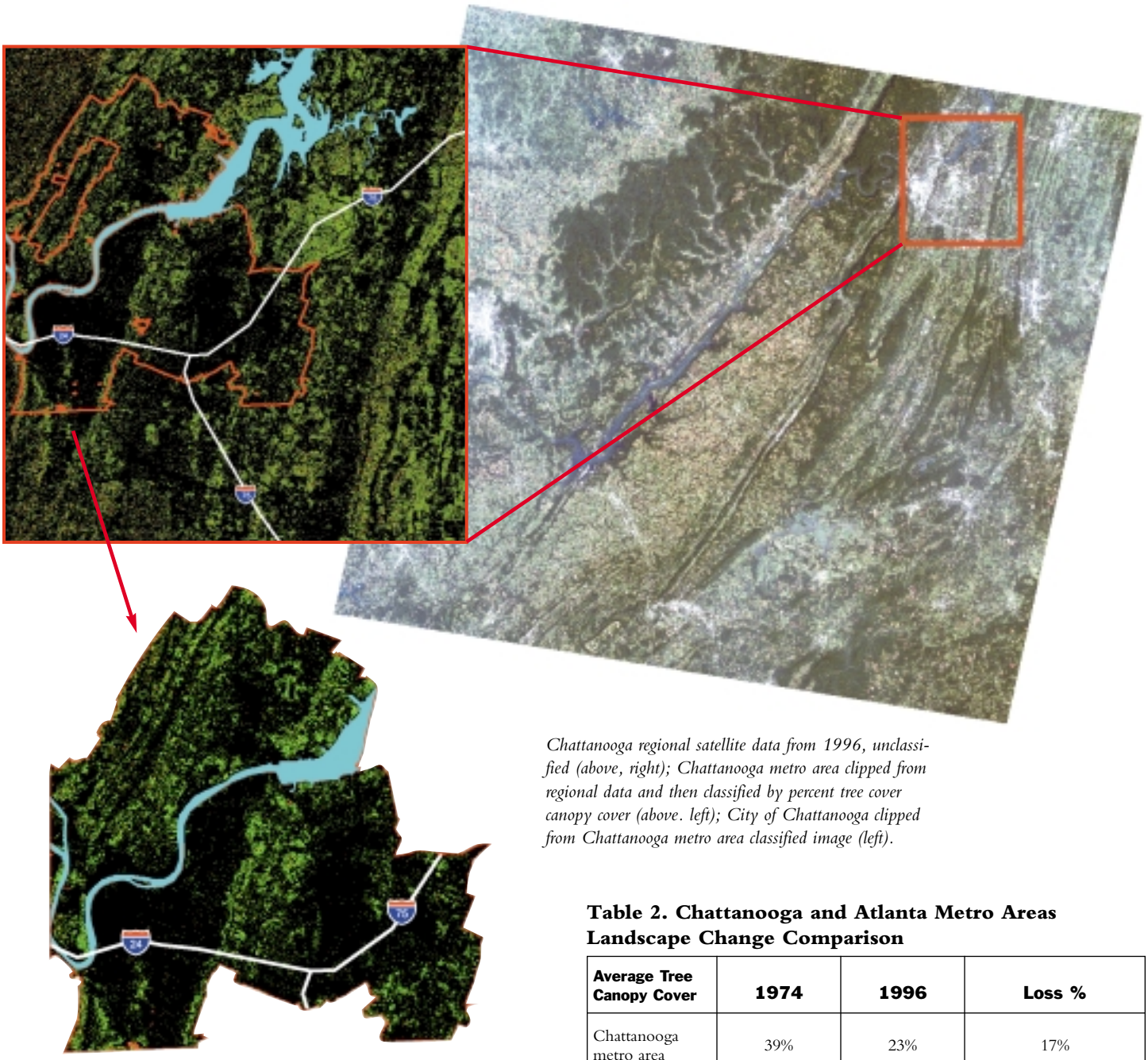
Air Quality

Trees provide air quality benefits by removing pollutants such as NO_2, CO, SO_2, O_3, and PM_{10}. 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. In the Chattanooga area, existing tree canopy removes 5.3 million pounds of pollutants, valued at $12.8 million. Tree cover as it existed in 1974 would have removed 7.9 million pounds of pollutants valued at approximately $19 million.

Carbon

The carbon-related function of trees is measured in the amount of carbon currently stored as biomass and in sequestration, the rate of absorption per year. To estimate the amount of carbon stored and sequestered, the average amount of carbon per acre was multiplied by the total number of acres. The metropolitan Chattanooga area currently stores 2.4 million tons of carbon and sequesters an additional 4,000 tons of carbon annually. The lost value of carbon storage over the last 22 years is almost 1.2 million tons.

Using Regional Data for Local Analysis



Chattanooga regional satellite data from 1996, unclassified (above, right); Chattanooga metro area clipped from regional data and then classified by percent tree cover canopy cover (above. left); City of Chattanooga clipped from Chattanooga metro area classified image (left).

A regional level image contains a great deal of information that can be used by area local governments. AMERICAN FORESTS can provide a city or county with a sub-set of the Chattanooga regional data that shows tree canopy within the city limits. The data is valuable for land-use and conservation planning and can be sorted according to various tree cover categories. These categories form the basis for a more detailed analysis using CITYgreen®.

Table 2. Chattanooga and Atlanta Metro Areas Landscape Change Comparison

Average Tree Canopy Cover	1974	1996	Loss %
Chattanooga metro area	39%	23%	17%
Atlanta metro area	43%	26%	17%

In a separate study, AMERICAN FORESTS analyzed tree canopy cover and ecological change for fast-growing metropolitan Atlanta (777,385 acres), just south of Chattanooga. The findings show that metro Chattanooga's vegetation change is consistent with changes that occurred in the Atlanta area.

What's Next for The Chattanooga Area?

Recommendations

These findings raise 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 Chattanooga area and chart a course of action for future improvement. We encourage the Chattanooga area leaders to incorporate this data into the local planning process.

(1) Use the findings of this study to address public policy questions for land-use planning and growth management

■ Consider the financial value of natural resources during the public policy decision-making process. Urban ecosystems provide concrete financial benefits to municipalities. Investment in resource management should capture these benefits.

■ Incorporate a natural resource data layer into the local planning and zoning process. Before decisions are made that change the landscape, consider the benefits of conserving existing trees and increasing tree canopy cover.

(2) Consider the dollar values associated with trees when making land-use decisions.

■ Use CITYgreen® software as a decision support tool to increase community participation.

■ Implement innovative land-use planning techniques and engineering guidelines to save existing trees and plant new ones.

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

(3) Increase and conserve the tree canopy cover in urban areas.

■ Develop measurable urban tree canopy goals. Recommended goals are based on urban forest canopy cover patterns in US cities. Metro Chattanooga should strive for:

40% tree canopy overall
50% tree canopy in suburban residential zones
25% tree canopy in urban residential zones
15% tree canopy in the Central Business Districts

(4) Use additional GIS applications for land-use planning.

■ 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 the findings in the decision making process.

(5) Develop best practices to increase tree cover in new developments.

■ Develop standards and recommend techniques for tree protection on construction sites.

(6) Conduct additional analyses every five years to track future trends in forest canopy and associated benefits.

About the Urban Ecosystem Analysis

Ecostructure Classification

AMERICAN FORESTS' Urban Ecosystem Analysis is based on the assessment of ecostructures, unique combinations of land use and land cover present in a city. Each ecostructure performs ecological functions differently, providing different benefits and values. For example, a site with heavy tree canopy provides more stormwater runoff reduction benefits than one with minimal tree cover.

In this study, the regional analysis provided an overview of tree cover change in the Chattanooga area. Using the tree cover percentage categories and local land-use data to identify the area's dominant ecostructures, sample study sites can be selected and analyzed using CITYgreen®. Further local level analysis is needed to refine the benefit estimates derived from AMERICAN FORESTS' neighborhood models (page 4-5).

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.

AMERICAN FORESTS developed CITYgreen® software to help communities analyze the value of local trees and vegetation as part of the urban infrastructure. The program calculates the benefits of different tree canopy and land use configurations, models development options, evaluates landscape ordinances and determines long-term financial impacts. CITYgreen® is an application of *ArcView for Windows*, a desktop GIS made by ESRI.

Analysis Formulas

TR-55 for Stormwater Runoff: The stormwater runoff calculations incorporate formulas from the Urban Hydrology for Small Watersheds model, (TR-55) developed by the US 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 US Forest Service. The model estimates how many pounds of ozone, sulfur dioxide, nitrogen dioxide, PM_{10}, 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 indirect costs to society, such as rising health care expenditures.

Carbon: A method to assess a dollar value for carbon is evolving; it is premature to assign a dollar value at this time.

Acknowledgments for this Study

We gratefully acknowledge the support of the following agencies and business partners in conducting this study.

USDA Forest Service
State of Tennessee
City of Chattanooga
ESRI for GIS software
ERDAS for remote sensing software

For More Information

AMERICAN FORESTS, founded in 1875, is the oldest national nonprofit citizens conservation organization. Its three centers–Global ReLeaf, Urban Forests, and Forest Policy—mobilize people to improve the environment by planting and caring for trees. Global ReLeaf 2000 is AMERICAN FORESTS' campaign to plant 20 million trees for the new millennium, which includes ecosystem restoration projects throughout the southeastern US.

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. Prepared analyses such as this report and GIS land cover data sets for other municipalities within the Chattanooga region are available by order.

AMERICAN FORESTS
P.O. Box 2000 Washington DC 20013
phone:202/955-4500; fax: 202/955-4588
email:cgreen@amfor.org, website: www.americanforests.org
Click on "Trees, Cities & Sprawl"

125 YEARS 1875-2000
AMERICAN FORESTS®
PEOPLE CARING FOR TREES & FORESTS SINCE 1875

GLOBAL RELEAF 2000