
Final Report: 2/9/99

Regional Ecosystem Analysis Canton-Akron Metropolitan Area

Calculating the Value of Nature

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Regional Ecosystem Analysis Canton-Akron Metropolitan Area

Project Overview

AMERICAN FORESTS conducted a Regional Ecosystem Analysis of the Canton-Akron metropolitan area to determine how the landscape has changed over time. The analysis assessed the value of the region's ecology using data from three satellite images spanning a 24-year period from 1973 to 1997. Landsat Multi spectral and Thematic Mapper images were used to study an area approximately 975,000 acres in size, centered around the city of Canton and encompassing the surrounding urban, farm, and forested areas.

The Ecosystem Analysis uses Geographic Information Systems (GIS) technology to measure the changing structure of the landscape, with emphasis on tree cover. The changes in the landscape are measured with scientific and engineering formulas. Neighborhood level computer models were developed using CITYgreen® software—AMERICAN FORESTS' GIS application for calculating ecosystem benefits. The models represent five typical neighborhood landscapes and measure the effects of these landscapes on stormwater runoff and air quality.

The purpose of this project is to document the value of tree-covered landscapes to urban areas. Furthermore, this analysis provides local decision makers with the information and tools they need to measure the value of natural landscapes and incorporate more trees into future development.

Major Findings

The ecology of the Canton-Akron area changed dramatically in the 24-year period from 1973 to 1997.

- Areas with high vegetation and tree canopy coverage (those with 50% or greater tree cover) declined by 43%, decreasing from 350,000 acres to 200,000 acres.
- Areas with very low tree cover (less than 20%) increased by 41%, growing from 55% of the region to 77%.

A dollar value can be placed on these regional ecological changes.

- The loss of tree cover and increase in impervious surfaces increase the cost of stormwater management and the cost of air quality controls.

- From 1973 to 1997, stormwater flow during a 2-year peak storm event increased by an estimated 207 million cubic feet, a 28% gain. Replacing this lost stormwater retention capacity with reservoirs and other engineered systems would cost \$414 million (\$2 per cubic foot of storage facility construction cost).

- The total stormwater retention capacity of urban forest cover in 1997 was worth about \$1.1 billion, down from 1973's value of \$1.5 billion.

- Lost tree canopy would have removed about 35 million pounds of pollutants from the atmosphere annually, at a value of approximately \$8.3 million.

- Canton-Akron's urban forest improves air quality by removing the following pollutants: nitrogen dioxide (NO₂), sulfur dioxide (SO₂), carbon monoxide (CO), ozone (O₃), and particulate matter 10 microns or less (PM₁₀).

Growth in the urban landscape is the biggest single factor affecting the Canton-Akron ecosystem.

- Land use has changed from forest and farmland to urbanized areas. Even though urbanized areas have more trees than the previous farmland had, an increase in impervious surfaces has contributed to an overall loss in heavy tree cover and ecological value.

- The total loss in value from a declining urban forest canopy is worth \$422 million. (Lost tree canopy would have removed about 35 million pounds of pollutants from the atmosphere annually, at a value of approximately \$8.3 million, and eliminated 207 million cubic feet of peak stormwater flow, at a value of \$414 million).

Tree cover and natural resource information should be officially incorporated into the planning process.

- Existing natural landscapes should be recognized for their potential economic value.

- Increasing the average tree cover to 40% in urban areas would significantly improve the environment in the areas of stormwater management and air quality.

- Strategically planting trees will provide financial rewards to the Canton-Akron community, reducing erosion and stormwater problems and improving energy conservation, air quality, and wildlife habitat.

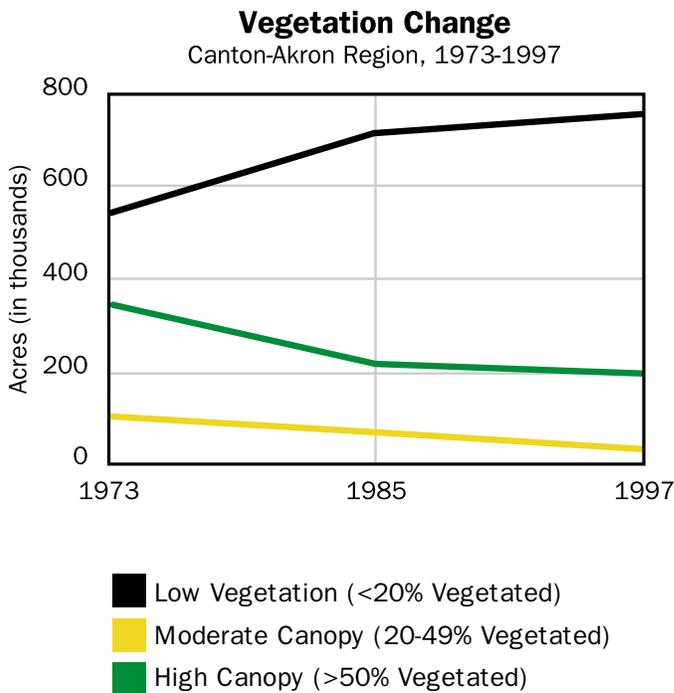
Regional Analysis

Canton-Akron Satellite Images

Landsat TM and MSS satellite images show the change in land cover in the Canton-Akron region over a recent 24-year period. Heavy tree cover is indicated in green and low tree cover associated with urban areas are in black. The analysis measures nine categories of tree cover, and data from the detailed analysis is used in all calculations. The visual images (*right*) combine the nine categories into three groupings to accommodate the limitations of printing the images at this scale.

Graphing Change

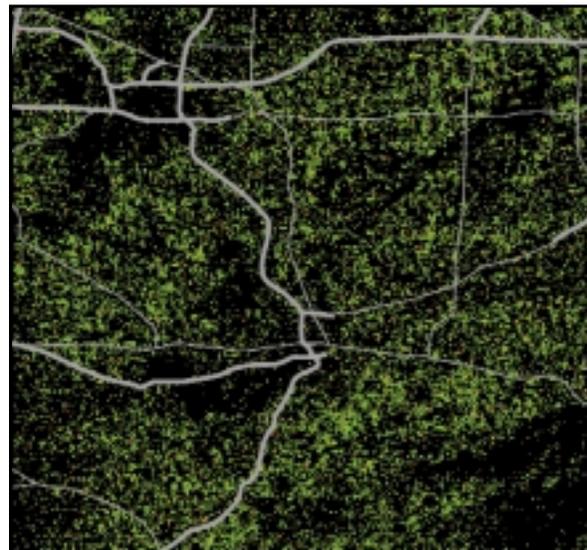
The change in vegetation, depicted in the satellite images (*right*), is represented in a line graph (*below*). The chart shows the change in vegetative cover over a 24-year period for three categories. Natural forest cover is represented by a green line and indicates places with greater than a 50% tree 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%. Open space, residential areas, and park land would all fall into this middle category.



Landsat MSS 1973 80 Meter Pixel Resolution



Landsat TM 1985 30 Meter Pixel Resolution



Landsat TM 1997 30 Meter Pixel Resolution

Neighborhood Level Analysis

What is a Neighborhood Level Analysis?

The Canton–Akron Ecosystem Analysis has two levels of detail. One is at a regional scale, covering approximately 975,000 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.

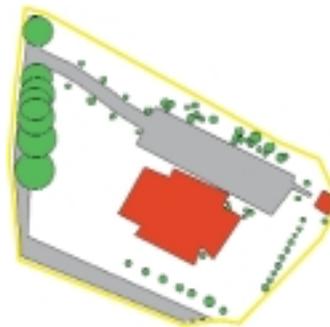
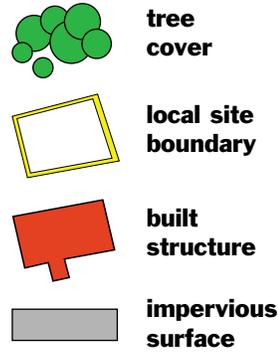
The neighborhood analysis is conducted in conjunction with local groups and agencies. This data is not yet available for the Canton-Akron area. Therefore, AMERICAN FORESTS has developed computer models to represent the structure of the landscape in various neighborhoods. Data gathered from local agencies and local databases were used extensively in building these models. The models are designed to simulate Canton-Akron’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 the total land area (identified in the regional summary). The findings from the neighborhood analysis are summarized in the table on page 5.

Trees as Indicators of a Community’s Ecological Health

Even though urban ecology is much more complex than just trees, tree canopy cover is a good indicator of the health of an urban ecosystem. When urban forests are healthy, they provide communities with many valuable services that can be measured in dollar benefits. Two such services are: 1) slowing stormwater runoff and reducing peak flow and 2) improving air quality.

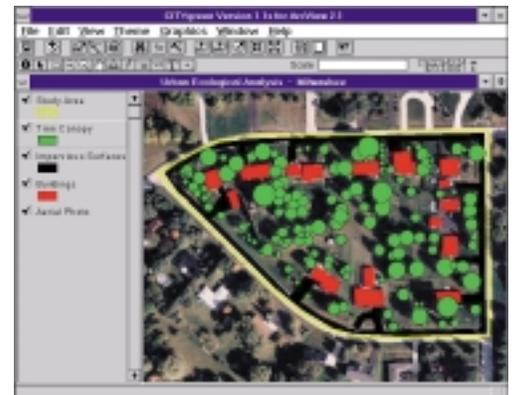
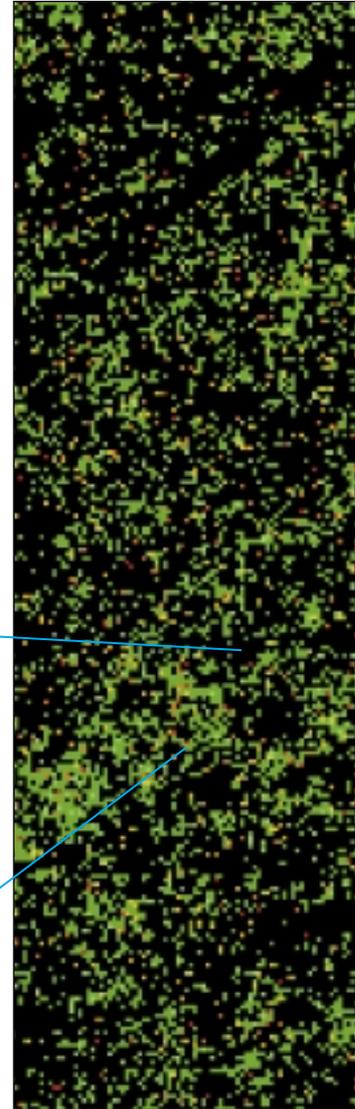
Cities spend tremendous amounts of money installing stormwater control systems and repairing damage from unmanaged water flow. In addition, cities that cannot meet EPA attainment levels for air and water quality jeopardize federal funding for capital improvements. Non-structural methods, including trees, can reduce stormwater runoff and improve air quality. The benefits they add increase the importance of maintaining and restoring the natural infrastructure of our communities.



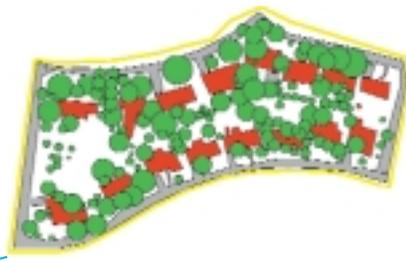
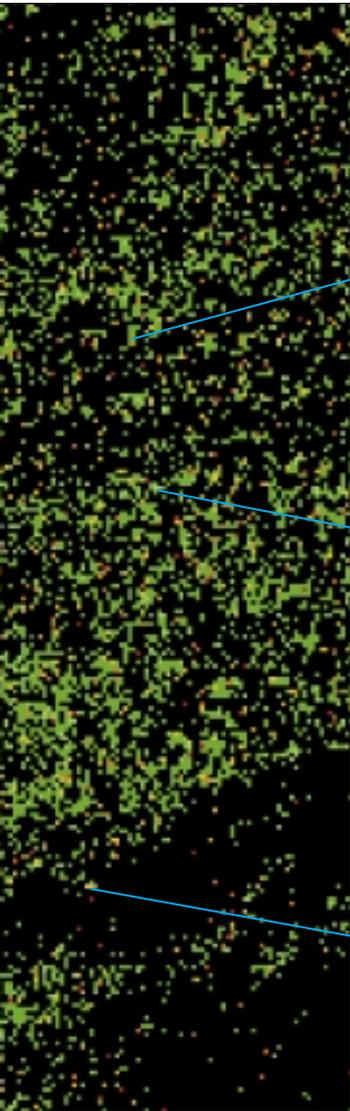
10% tree cover



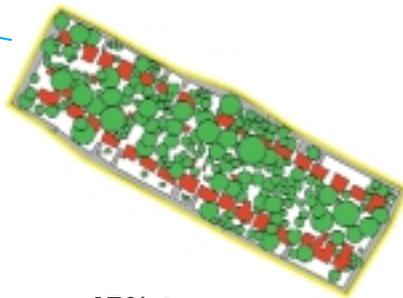
25% tree cover



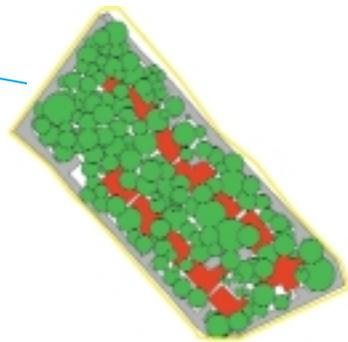
Aerial photography is used by CITYgreen® to conduct a neighborhood analysis.



35% tree cover



45% tree cover



60% tree cover

Satellite images provide the framework for a regional ecosystem analysis. Geographic Information Systems (GIS) technology sorts the landscape into landcover categories and this ecological patchwork, called Ecostructures (see pg.8) is used with CITYgreen® software.

How CITYgreen Analyzes Neighborhood Data

CITYgreen® software conducts a detailed analysis of how the structure of the landscape affects its function. For example, how do various neighborhood layouts affect stormwater movement and air quality? Scientists and engineers have developed mathematical formulas which measure these functions and which are incorporated into the CITYgreen® software program.

Stormwater Runoff

Trees and soil function as one to reduce stormwater runoff. Trees reduce stormwater flow by intercepting rainwater on their leaves, branches, and trunks. The intercepted water evaporates back into the atmosphere, reducing the total amount of runoff that must be managed in urban areas. Trees also slow down storm flow, reducing the volume of water that a containment facility must store. In addition, trees improve water infiltration characteristics of soil as biomass decomposes. The TR-55 model was used to measure stormwater (see page 8).

Local governments are looking toward non-structural stormwater management strategies, including trees, to reduce the costs of building stormwater control infrastructure. Trees' economic value for stormwater management is based on avoided storage of stormwater and the resulting reduced construction costs for retention ponds. Local construction costs are multiplied by the total volume of avoided storage to determine dollars saved.

In Canton-Akron, the existing tree canopy reduces the need for retention ponds by 540 million cubic feet per storm event (defined as the largest average 24-hour, 2-year storm). Using a \$2.00/cubic foot construction cost, trees currently save the region \$1.1 billion.

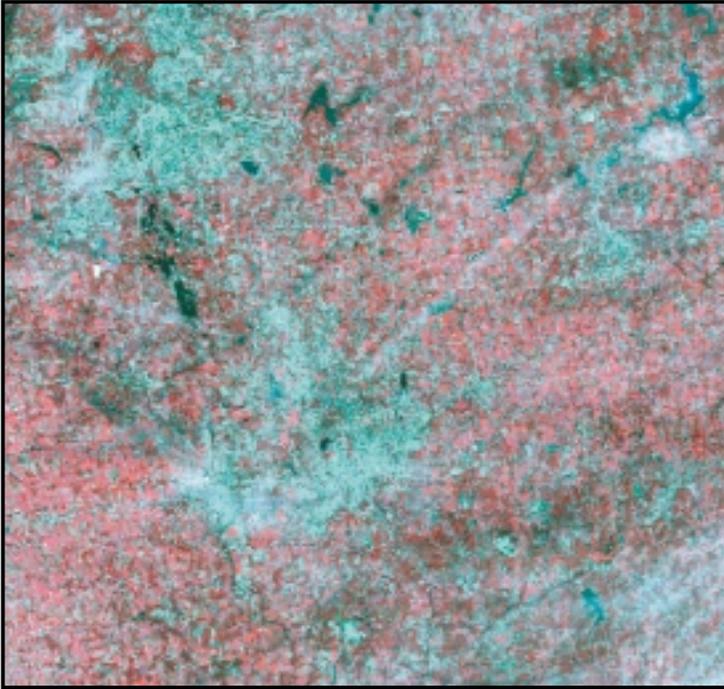
Air Quality

Trees provide air quality benefits by removing pollutants such as NO₂, CO, SO₂, O₃, 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. The cost savings associated with NO₂ and O₃ are \$6,750/t (metric ton), SO₂ is \$1,650/t; CO is \$950/t and PM₁₀ is \$4,500/t. In Canton-Akron, the existing tree canopy removes 78 million pounds of pollutants, valued at \$43 million. Tree cover as it existed in 1973 would have saved an estimated \$51 million.

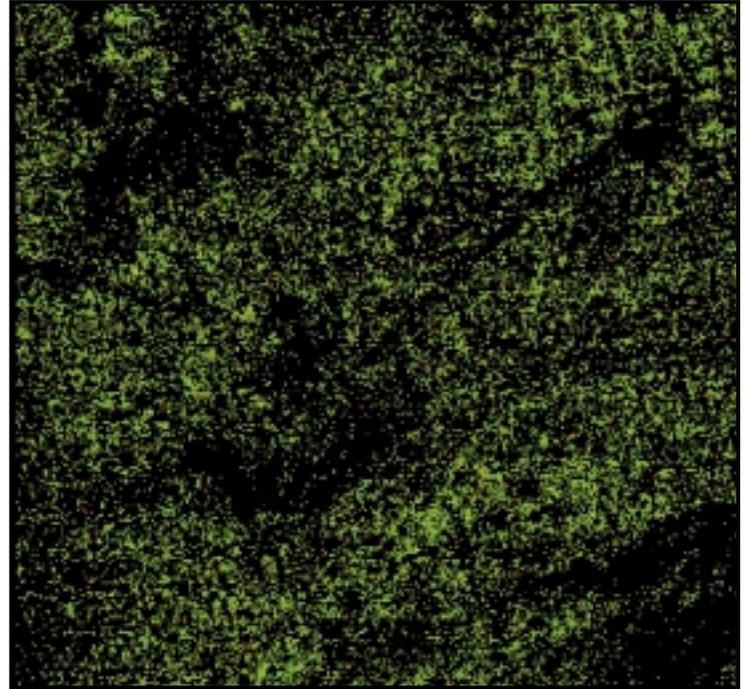
Summary Table, Canton-Akron Urban Forest Benefits, 1997

Air Quality Benefits		Stormwater Benefits	
Pollutants Removed (lbs.)	\$ Value	Cu./ft. Avoided	\$ Saved
78 million	\$43 million	540 million	\$1.1 billion

From Raw Satellite Data to Neighborhood Level Information



Raw Satellite Data 1997



Regional Analysis 1997

Combining Regional and Neighborhood Level Analysis

AMERICAN FORESTS' ecosystem analysis starts with raw satellite data as displayed upper left. The raw image shows vegetation in red and urban areas in aqua. The image produced from the raw satellite data does not show percent changes in vegetative cover. To determine tree cover, the raw satellite data shown in the above right image is analyzed using Geographic Information Systems (GIS). AMERICAN FORESTS uses ERDAS Imagine software and a subpixel classification technique to determine eight categories of tree cover and one category of less than 20% tree cover. Green areas are at one end of this spectrum and represent tree cover over 50%; areas less than 20% tree cover are in black.

The regional level image contains a great deal of information that can be used by individual local governments. By "clipping" a city out of the regional view, the City of Canton for example, can determine tree canopy cover percentages for that area. From this image the community can be divided or stratified into various tree cover zones. These zones form the basis for a more detailed analysis.

How much does this tree canopy loss cost? By using aerial photography to point sample the different tree zones, a neighborhood level analysis using CITYgreen® software can be conducted. With this, a city can determine the economic value of its urban forest in terms of air quality, stormwater runoff reduction and energy conservation. AMERICAN FORESTS recommends that all cities in the Canton-Akron region conduct a neighborhood analysis using aerial photography and incorporate analysis findings into the city planning process.



Digital Aerial Photograph used for CITYgreen analysis.

What's Next for the Canton-Akron Area?

Recommendations

The Regional Ecosystem Analysis provides information about the value of natural resources to local governments. It is a public policy tool designed to assist in land-use planning and growth management. The recommendations below focus on tree cover because trees are a visible measure of the quality of the local environment. When urban trees are large and healthy, the ecology that supports them is also healthy. Large healthy trees are a result of healthy soils, adequate water, and healthy air. This report and the recommendations that follow bring together the expertise of ecologists, scientists, and engineers with computer mapping technology to evaluate the environment in the Canton-Akron area 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 gather more detailed information using aerial photographs, field surveys, and CITYgreen® software.

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

- Incorporate a natural resource data layer into the regional planning process.
- Use the data from this analysis as a basis for building that regional model.
- Obtain additional data for this model from city and county government.

(2) Recruit county and city governments as partners in creating a regional model.

- Establish data collection plots in local jurisdictions.
- Use information from the neighborhood level analysis for community planning.
- Utilize CITYgreen® and the AMERICAN FORESTS analysis technique to increase community participation.

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

- Develop urban tree canopy goals for the region and local areas:
 - 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 the value of trees into the land-use planning process by collecting data on local tree cover and analyzing the value of trees. The findings are used in the decision making process.

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 patterns. Each Ecostructure performs ecological functions differently and thus provides different values. For example, a site with a heavy tree canopy provides more stormwater reduction benefits than one with a light tree canopy.

In this study, the regional analysis provided an overview of tree cover change in the Canton-Akron Metropolitan Area. Using the tree cover percentage categories to model the area's Ecostructures, sample study sites were selected to further examine the effects of different tree canopy cover percentages on air quality and stormwater management. Further neighborhood analysis using aerial photos of representative Ecostructures is needed to refine the values given in the model analysis.

Data Used in this Study

Landsat satellite TM (30 meter pixel) and MSS (80 meter pixel) images were used as the source of land cover data to determine the change in vegetation from 1973 to 1997. To provide more detail to the analysis, AMERICAN FORESTS used a subpixel classification technique and divided land cover into nine vegetation categories.

AMERICAN FORESTS developed CITYgreen® as a Geographic Information Systems (GIS) software to analyze the value of trees and other natural systems as part of urban infrastructure. CITYgreen® is an application of ArcView, a GIS desktop software developed 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 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, for the US Forest Service, which calculates 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 externality costs, or costs to society not reflected in market place activity. For example, ozone is valued at \$1,650 per ton and nitrogen dioxide is \$6,750.

Acknowledgments for this Study

This analysis was sponsored by the **USDA Forest Service** as part of an ongoing effort to further public understanding of the contributions made by trees to urban ecosystems. Other contributors are:

The City of Canton
The City of Akron
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 a campaign to plant 20 million trees for the new millennium.

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 provides 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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