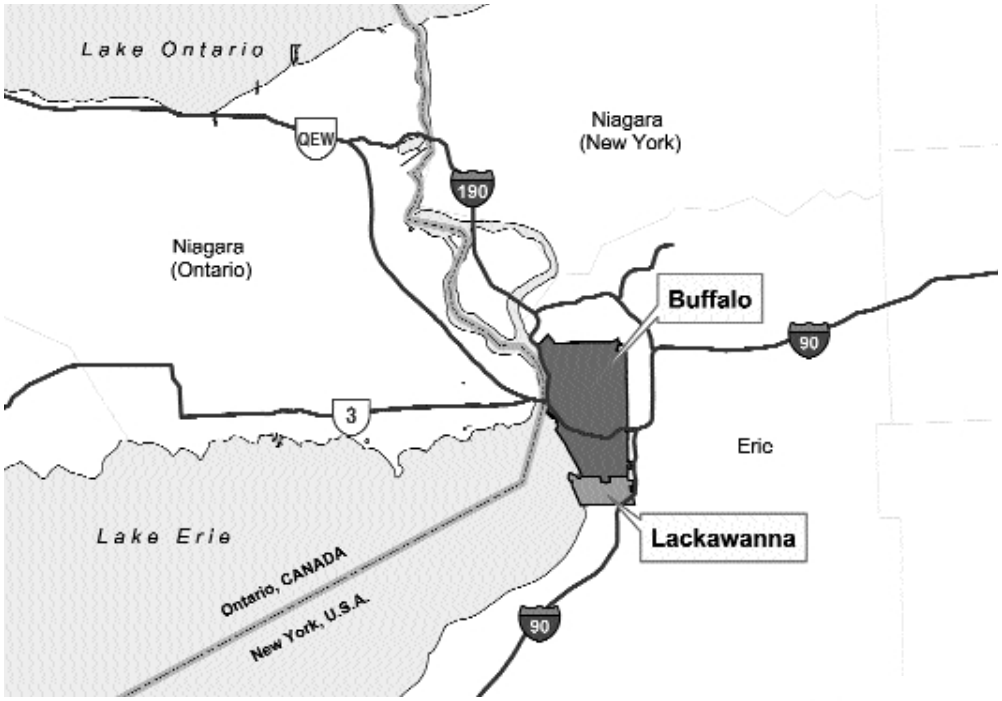
June 2003

Urban Ecosystem Analysis Buffalo-Lackawanna Area Erie County, New York

Calculating the Value of Nature

Report Contents



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Project Overview

AMERICAN FORESTS conducted an Urban Ecosystem Analysis for the cities of Buffalo and Lackawanna in Erie County, New York, using GIS (Geographic Information Systems) technology and high-resolution color aerial photography. The analysis focused on the tree cover of the area and the services that the trees provide: air pollution removal, carbon storage and sequestration, and stormwater runoff control.

The Buffalo-Lackawanna Urban Ecosystem Analysis is part of a larger effort in the Erie-Niagara region to understand the value of the natural environment as "green infrastructure" and for communities to work together on regional planning issues. Buffalo and Lackawanna have undertaken master planning efforts within the past few years, strongly emphasizing the responsible use of natural resources. The two cities have jointly been awarded an HUD Renewal Communities designation to refocus development, housing, and employment initiatives in underserved sub-areas of the cities. The USDA Forest Service Title VIII grant that partially funded this study is intended for projects serving inner city areas, making it a good companion project to the HUD initiative.

This study measures the major economic and ecological impacts of the urban forest, using models developed from measured data collected over decades of observation. Not measured are the various social benefits of trees. Studies indicate that green infrastructure, and trees in particular, positively contribute to a community's quality of life. While substantial, the benefits beyond air pollution removal, carbon storage and sequestration, and stormwater management were not included in this study. These extra benefits should be considered, nonetheless, when using green infrastructure in the decision-making process. This study gives a baseline figure for the value of trees, based on measurable values.

One major product of this study is a digital map of the area's landcover, a "green data layer", which allows local communities to integrate the green infrastructure into their planning. While the landcover map of the entire study area was used for much of this report, the scenario modeling section of the study (see page 4) examined specific sub-areas. This demonstrates the flexibility of having the green data layer for use in planning applications. Local decision-makers can take existing digital (GIS) map layers such as watershed boundaries, greenways, riparian corridors, or development plans and use them with the landcover data at almost any scale to make informed decisions and to incorporate green infrastructure into the planning process.

One-meter resolution aerial imagery (left) and classified landcover data (right) produced from the imagery. This data was analyzed using CITYgreen to show the benefits of the green infrastructure.

Buffalo and Lackawanna comprise the central metropolitan area of the Erie-Niagara region, covering an area of 51 square miles. The area has experienced many changes in the past half-century, especially the decline of traditional industry and the decentralization of business. The region has seen a return of economic growth in the past decade; yet suburban development has outpaced growth within the cities themselves, leaving increasing amounts of vacant land. While the central city and immediately surrounding areas have lost population in recent decades, the "outer ring" suburbs and rural communities have grown continually since 1950. The number of households grew by 51% between 1950 and 1990, but the amount of urbanized land increased by 132%. Although development is a sign of a presently healthy economy, this unbalanced ratio of developed land to population will have serious negative economic and ecological consequences over a longer time period.

The Urban Ecosystem Analysis produced useful results and tools. However, its completion is not the end of a process; nor should green infrastructure planning stop at the boundaries of these cities. Instead, this analysis should be a starting point for additional efforts using the tools and data provided with this project to understand the value of the region's ecology, and the role of green infrastructure in setting planning goals that will meet the ecological needs of the community.

Major Findings

Buffalo-Lackawanna Results

The green data layer shows that trees are a vital and valuable part of the infrastructure in the Buffalo-Lackawanna region.

The two-city region has 12% tree canopy cover (3,726 acres) and 23% impervious surfaces (7,225 acres). This compares to a national average of 30% tree canopy. Results for the air pollution analysis showed that the region's existing trees remove 400,000 pounds of pollutants each year, at a value of $990,000. Storm water benefits are large, with trees lowering runoff by 30%. Overall, Buffalo-Lackawanna's trees reduce the amount of storm water to be managed by 17.7 million cubic feet during an average storm. Using a conservative average of $2 per cubic feet for stormwater detention facility construction, this service is valued at $35.5 million.

Ecosystems do not respect political boundaries, as seen in the Erie County area. Buffalo and Lackawanna share common watersheds, parklands, and weather events. Examining the Buffalo-Lackawanna region as a whole gave a sense of the high value of trees over a large area, and the large area analysis produced a baseline "green data layer" (Sept. 15, 2002) for future use on a regional level, and in concert with existing planning map layer files.

Buffalo Results

Trees perform valuable services for the City of Buffalo.

Buffalo currently has 12% tree canopy cover (3,111 acres) and 23% impervious surfaces (6,073 acres). While this is a modest canopy cover percentage, the city's trees perform valuable services. Each year, Buffalo's trees remove 335,000 pounds of pollutants from the city's air, a service valued at approximately $826,000. Buffalo's trees also provide substantial storm water benefits. Comparing this service to the cost for constructing man-made facilities to perform these functions (at $2 per cubic foot), trees provide the City of Buffalo approximately $34.3 million in avoided stormwater services.

Lackawanna results

Lackawanna covers a modest area, but the trees provide valuable services.

The Lackawanna study provides a good example of the high value of tree services even in a modest-sized study area. Lackawanna occupies just over seven square miles to the south of Buffalo, 13% (582 acres) of which is covered by trees. Lackawanna's trees remove 63,000 pounds of air pollutants per year, valued at $154,000. Lackawanna's trees provide their most valuable service through storm water control. The trees lengthen the stormwater's time of concentration during an average storm by approximately one hour, allowing their leaves and the ground to absorb more storm water. In addition, trees lower the overall amount of water that must be managed during a storm. This service has a value of approximately $5.1 million.

Landcover & Ecological Benefits

Area	Acres	% Trees	% Impervious	% Green Open Space	% Bare Urban Land	% Water	Air pollution removed annually (pounds)	Air quality Value (Annual)	Retention volume required to mitigate without trees (cubic feet)	Stormwater Control Value (One-time value)	Carbon stored (tons)	Carbon Sequestered annually (tons)
Buffalo/ Lackawanna	32,053	12	23	61	45	5	400,738	$988,971	20,802,695	$41,605,390	160,332	1,248
Buffalo	26,662	12	23	61	46	5	334,619	$825,799	17,143,263	$34,286,526	133,878	1,042
Lackawanna	4,549	13	22	60	34	5	65,592	$154,471	2,528,404	$5,056,808	25,043	195

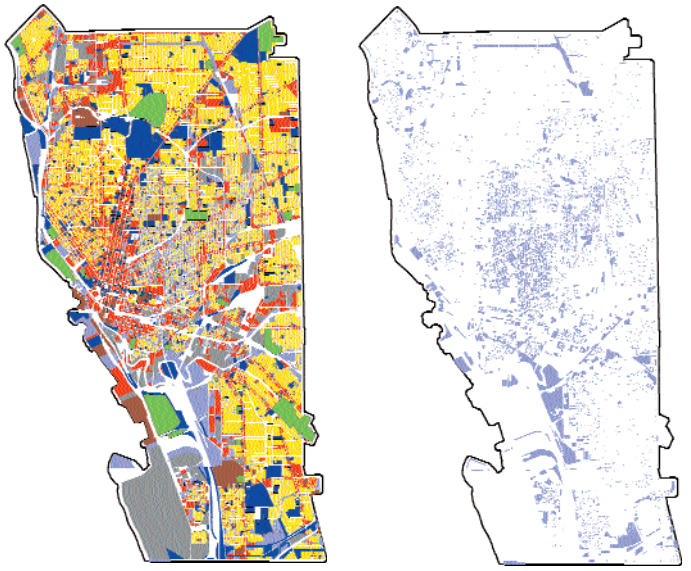
Modeling Alternate Scenarios

The Urban Ecosystem Analysis serves as a baseline for future and broader analysis of the Erie-Niagara region. One of the many uses of a green data layer is the ability to model alternate scenarios and to use these scenarios to set tree canopy goals.

Vacant parcels

AMERICAN FORESTS performed an example of scenario modeling using real estate parcels information and the classified land cover data. This scenario compared existing conditions on vacant land to the environmental benefits of increasing tree canopy. Using real estate parcel data supplied by the USDA Natural Resources Conservation Service, vacant residential and commercial parcels were identified, creating a separate GIS map layer (shapefile) containing just these parcels. The non-water vacant parcels were then analyzed using CITYgreen for the value of tree services. On the vacant parcels in Buffalo, Lackawanna, and the combined Buffalo-Lackawanna area, the results showed 18%, 25%, and 20% tree cover, respectively.

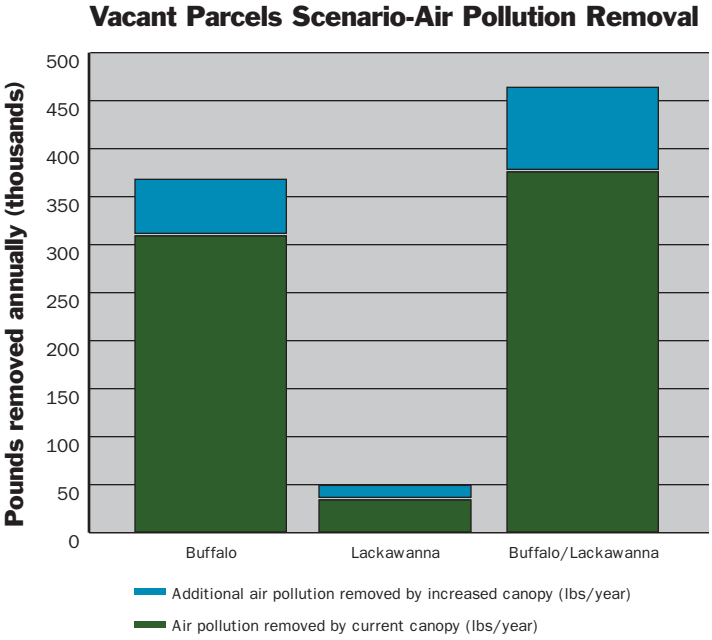
A new hypothetical scenario was created, increasing vacant parcel tree canopy to 50% (i.e. half the acreage of the vacant parcels designated as covered by trees). Landcover data showed that 31% of the acreage of vacant parcels in Buffalo and Lackawanna is open space, making the parcels good potential candidates for tree planting. Then the acreage that this scenario would occupy was calculated and added to the tree canopy acreage of the entire region. A new analysis showed the percentage of tree cover that this new canopy would represent. The increase of vacant parcels' tree canopy to 50% resulted in a gain of 2% to 3% of overall tree canopy for each of the study areas. The analysis showed the economic and ecological benefit that trees would have in the increased canopy scenario. The results are shown in the table below.

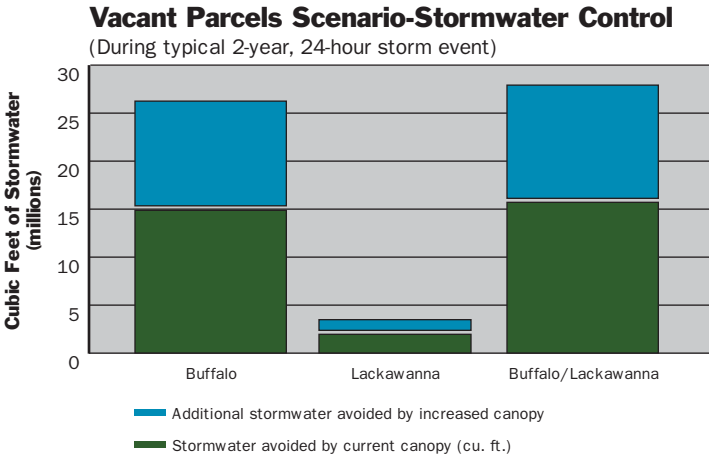


Real estate parcels designated by land use. On the right, the vacant parcels have been selected and made into a separate map layer.

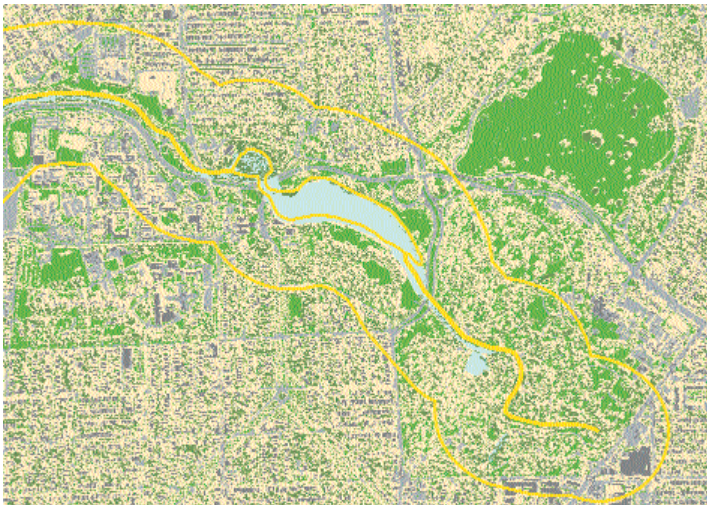
Vacant Parcels Scenario Data

	Additional air pollution removed by increased trees (lbs/year)	Additional carbon stored by increased trees (tons)	Additional carbon sequestered by increased trees (tons/year)	Additional stormwater avoided by increased trees (cu.ft./storm)
Buffalo	66,837	26,741	208	10,789,549
Lackawanna	10,801	1,321	34	1,434,154
Buffalo/Lackawanna	81,889	32,763	255	11,690,567





Riparian buffers



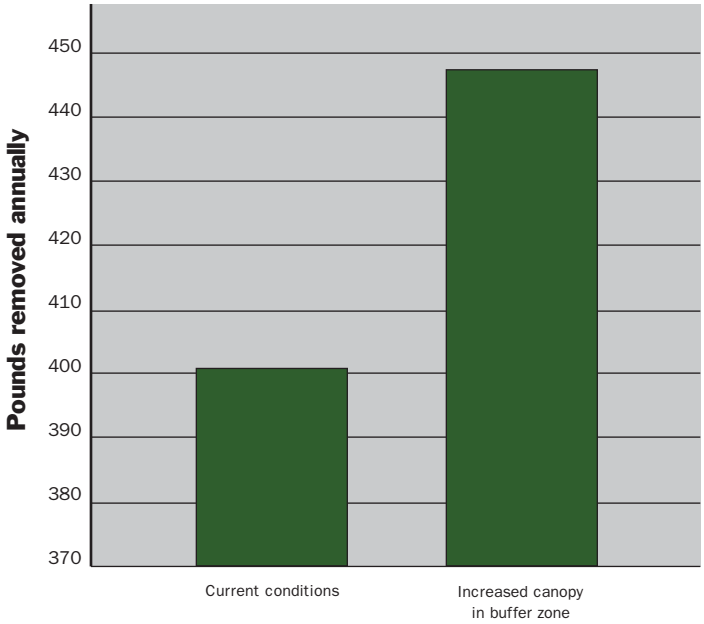
A zoomed-in view of the landcover data, showing a 1000-foot buffer drawn to designate the corridor along this river.

Another possible scenario involves riparian (stream and river) corridors. Tree cover is especially important along waterways for a number of reasons. Trees absorb a great deal of runoff that could otherwise cause flooding. Trees also anchor the soil along riverbanks and coastlines, preventing erosion. Thirdly, trees filter runoff, which greatly affects the water quality of a particular body of water and the health of the ecosystems and communities downstream. A 1000-foot ecosystem buffer was created around the major internal waterways in the Buffalo-Lackawanna area. The current 14% canopy of the buffer zone is higher than the regional average of 12%, but the 53% coverage of open space shows there is room for more trees. Moreover, approximately 7% of all land within this buffer zone is vacant open space, providing numerous prime sites for tree planting.

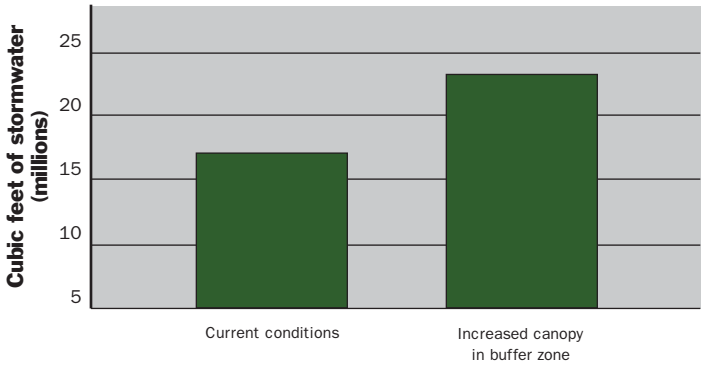
A hypothetical alternate scenario was analyzed, showing the effects of planting trees on all vacant parcels in the buffer zone. Doing so increased the tree canopy within the buffer zone to 21%, and in the entire Buffalo/Lackawanna region to 13%.

As the numbers show, even a small, targeted increase in tree canopy can have important effects. These examples are only two of many ways that planners, officials, and citizens can explore possibilities for increasing their tree canopy through planned, achievable tree goals. While the 21% canopy coverage may not be attainable throughout the 1000-foot ecosystem buffer area, this exercise demonstrates the impact that incremental increases in the green infrastructure can have. The vacant parcel and riparian corridor scenarios also demonstrate that there are options for the placement of trees in urban areas other than parks and streetscapes.

Riparian Buffer-Air Pollution Removal



Riparian Buffer-Stormwater Control



Riparian Buffer Data

Buffalo/Lackawanna Area	Canopy within 1000 ft. riparian buffer	Total canopy	Air pollution pounds removed annually	Savings (annual value)	Stormwater avoided (cu. ft.)	Savings (one-time value)
Current Conditions	14%	12%	400,738	$988,971	17,738,834	$35,477,668
Increased Canopy in Buffer zone	21%	13%	448,153	$1,105,986	23,418,313	$46,836,626

Recommendations

AMERICAN FORESTS' analysis of the Buffalo-Lackawanna region's green infrastructure is a benchmark for future thinking and planning of growth and development in the area. The following recommendations are offered to use in combination with the digital data provided:

Set tree goals

- Set tree canopy targets as a first step in the process of valuing nature's services as infrastructure. The green data layer produced by this study can be used seamlessly in the infrastructure planning process.
- Set specific, targeted goals for individual communities and categories of the urban forest (street trees, parks trees, open space, etc.), as well as the region as a whole. Even modest increases can have dramatic and valuable effects.
- Use AMERICAN FORESTS' general tree canopy goals for urban areas to develop achievable tree goals for the Buffalo-Lackawanna area:

40% tree canopy overall
50% tree canopy in suburban residential
25% tree canopy in urban residential
15% tree canopy in central business districts

Consider alternative scenarios for land development

- Use CITYgreen to envisage and quantify the benefits of targeted tree canopy improvements. Riparian corridors, vacant parcels, and other marginal areas can be put into good ecological use.
- Model and analyze the effects of zoning and growth plans on the tree canopy. A growth plan that results in tree canopy loss will be more expensive in the long run than one that works to balance green and gray infrastructure.

Expand green infrastructure analysis and planning

- Acquire classified landcover data for all areas in the region.
- Use this data for land use and green infrastructure planning.

Preserve existing trees

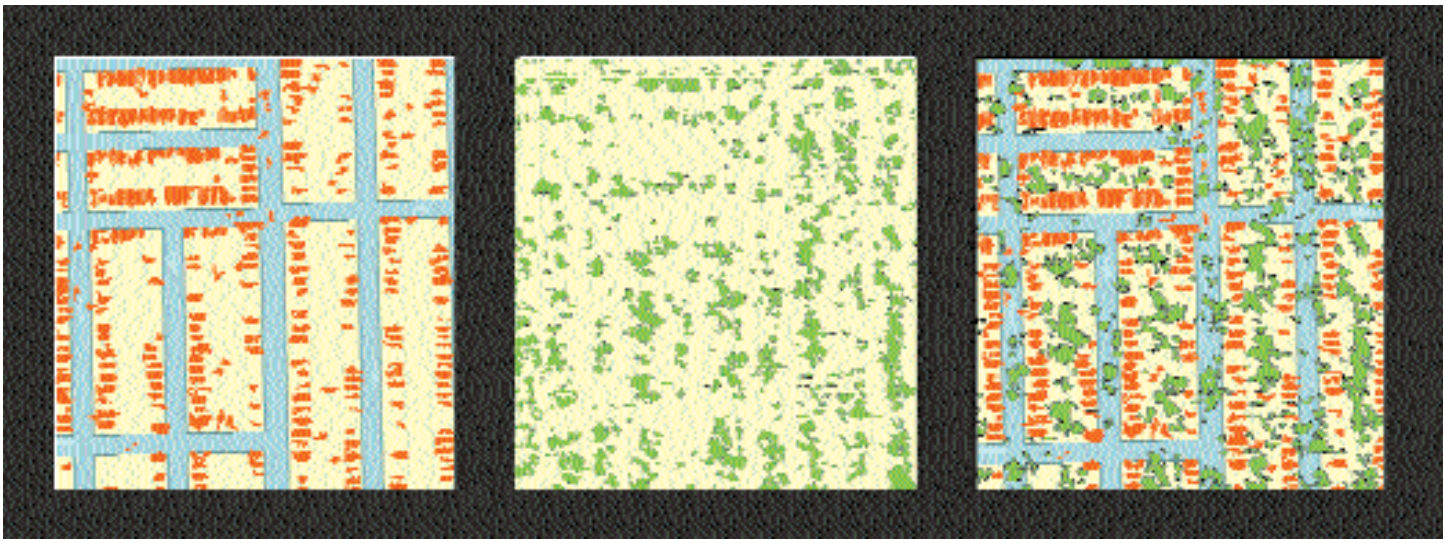
- Maintain trees to save money in the long run. As storms during the 2002-2003 winter have shown, trees can be a hazard if they are unhealthy. Alternatively, a healthy urban forest provides substantial benefits and is a good barometer of the overall health of the ecosystem.
- Educate and support property owners in caring for trees on private property. Public and private trees comprise the urban forest.

Work across traditional political boundaries

- Examine issues on a watershed, ecosystem, and regional basis. Use GIS, CITYgreen, and the green data layer to change the boundaries of regulation and problem solving. Regional study and collaboration is vital, as these valuable natural systems do not respect political divisions.
- Collaborate to formulate tree goals and ordinances that agree across political boundaries. Otherwise new business development will migrate to areas with less responsible green infrastructure requirements in place.

Currently, the region's trees provide valuable services. With continuing development outside the cities' limits, the need for urban tree cover is more important than ever. No longer will the rural surroundings make up for low tree canopy cover in the cities. Maintaining and improving the green infrastructure has important, quantifiable benefits.

Right: A map of the current tree cover of the Buffalo and Lackawanna study area.



On the left is the "gray" infrastructure, as used by most decision-makers and planners. In the middle, the green infrastructure is shown, and on the right is the combined gray and green infrastructure. This green data layer integrates seamlessly with existing data used in municipal planning.

CITYgreen and the Urban Ecosystem Analysis

City planners use the term "infrastructure" to broadly indicate the aspects of the built environment that form the basis and setting for human endeavor and interaction; specifically, some examples are streets, sewers, utilities, and other systems used to manage the complex web of actions occurring in all populated areas.

CITYgreen is an extension to *ArcView for Windows*, a widely used GIS (Geographic Information Systems) software program from ESRI. CITYgreen is used to perform analyses of classified land cover data. These studies analyze the value of trees in terms of their contributions to infrastructure services normally carried out by built systems in the urban environment, providing a tool to integrate "green infrastructure" into the existing language and practice of planning.

Air Quality
Trees provide air quality benefits by removing pollutants such as nitrogen dioxide, carbon monoxide, sulfur dioxide, ozone, and particulate matter less than 10 microns in size according to USDA Forest Service research findings. The UFORE model developed by the Forest Service was used to calculate the amount of these pollutants that the trees remove. To calculate the value of these pollution removal services, economists multiply the number of tons of pollutants removed by "externality costs," or costs to society not reflected in marketplace activity, as established by state public service commissions. This figure represents costs that society would have paid in areas such as health care, if trees had not removed these pollutants.

Stored and Sequestered Carbon
This study also analyzed the amount of carbon stored and sequestered per year in the region's trees, using the UFORE model. Carbon accounts for about half the dry weight of most trees. The carbon-related function of trees is measured in two ways: *storage*, or the amount currently stored in tree biomass, and *sequestration*, the amount absorbed each year as the trees grow.

Stormwater
Trees and soil function together to reduce storm water runoff. Trees lower the amount of storm water flow by intercepting rainwater on leaves, branches, and trunks. Some of the intercepted water evaporates into the atmosphere and some soaks into the ground, reducing peak flows and thus reducing the total amount of runoff that must be managed in urban areas. Trees also slow storm water flow, reducing the volume of water that must be managed at once. The TR-55 model, developed by the Natural Resources Conservation Service, provides a quantitative measure of storm water movement and is the basis for CITYgreen's calculations of the storm water control benefits that trees provide. Communities that use increased tree cover to help manage storm water can reduce the cost of constructing storm water control infrastructure. The value of trees for storm water management has been calculated based on avoided costs of handling storm water runoff. Local storm water retainment facility construction costs are multiplied by the total volume of avoided storage of water to determine dollars saved by trees.

Data Used in this Study

Conducting an urban ecosystem analysis is a multi-step process, using powerful imaging and computer processing tools. The Buffalo-Lackawanna study required acquisition of new aerial imagery. AMERICAN FORESTS contracted with Emerge, Inc., a custom aerial imagery company, to obtain digital true-color aerial imagery of the study area at a one-meter resolution. Emerge flew over the area in September 2002, when the leaves were still on the trees, producing "leaf-on" imagery.

Landcover data was created from the aerial imagery using Feature Analyst software. Landcover types were separated into classes. Extracted classes: tree canopy, buildings, impervious surfaces, green open space, water, and bare urban land. Using CITYgreen 5, the land cover data was analyzed to calculate the value of the services that trees provide in the Buffalo-Lackawanna region.

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- USDI Fish & Wildlife Service
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- US Army Corps of Engineers
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- NY Sea Grant
- City of Buffalo Office of Strategic Planning
- City of Buffalo Mayor's Office of Support Services
- City of Buffalo Dept. of Public Works – Forestry
- Buffalo Environmental Management Commission
- Buffalo Olmsted Parks Conservancy
- Erie County Soil & Water Conservation District
- Erie County Dept. of Environment & Planning – Environmental Compliance Services

For More Information

AMERICAN FORESTS, founded in 1875, is the oldest national nonprofit citizen conservation organization. Its three centers—Global ReLeaf, Urban Forest, 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 their 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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