October 2002

Projected Environmental Benefits of Community Tree Planting

A Multi-Site Model Urban Forest Project in Atlanta

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Project Partners: USDA Forest Service, Georgia Forestry Commission, Park Pride, Trees Atlanta, Arabia Mountain Heritage Area, and Atlanta Habitat for Humanity

Sponsored by: the USDA Forest Service and Georgia Forestry Commission

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Project Overview

AMERICAN FORESTS conducted a tree canopy analysis of three sites in the Metropolitan Atlanta Region. The findings of this report will be used as part of the Georgia Model Urban Forest, a project of the Georgia Forestry Commission (GFC). This project establishes trees as "green infrastructure" providing measurable environmental benefits for a city. Communities that use the Georgia Model Urban Forest approach can better understand, preserve, plant, and maintain trees and forests as an important community resource. AMERICAN FORESTS' portion of this project details the environmental values that the urban forest provides to the community. Specifically, the findings show that a site with strategically planted trees and reduced impervious paving can reduce stormwater runoff, improve air quality, reduce summer residential energy use and reduce air temperature.

In order to demonstrate how the Georgia Model Urban Forest approach can be implemented, three sites were selected to represent different urban conditions: the urban core, older suburbs and newer suburbs. The corresponding demonstration sites selected are:

- Turner Field parking lot in the City of Atlanta
- Arabia Mt. multi-use trail to be built along Klondike Road near Stonecrest Mall in DeKalb County
- Mount Zion Manor, seven Habitat for Humanity Atlanta, Inc. houses in the City of Atlanta.

At each site, environmental benefits were calculated under their existing conditions and then again after the sites were planted to maximize tree canopy and shade potential and to reduce impervious pavement. AMERICAN FORESTS' approach modeled tree growth over time and calculated the additional benefits of increased canopy.

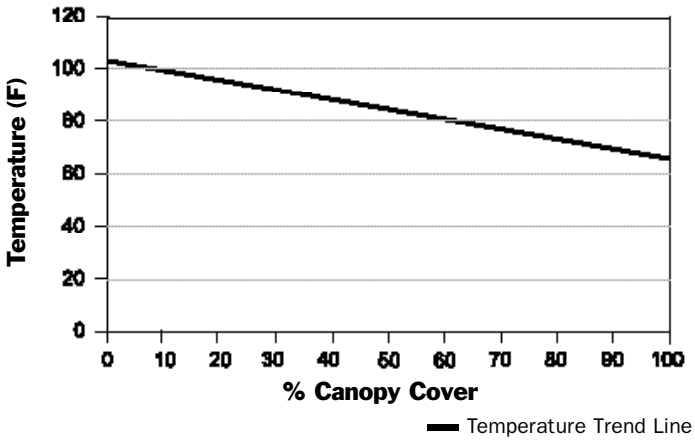
This information will be included in the Georgia Model Urban Forest project that documents the sites' improvements. Through video, printed educational materials and a public relations campaign, the Georgia Forestry Commission and project partners will raise public awareness of the importance of a well-planned, planted and maintained urban forest and encourage public decision makers and civic associations to actively support and manage their green infrastructure.

The tree canopy analysis, developed by AMERICAN FORESTS assesses the value of ecological features using scientific and engineering models that quantify the effects of the landscape on air, water and energy applied to an individual site's land cover, using Geographic Information Systems (GIS) technology. AMERICAN FORESTS' CITYgreen software was used to calculate the environmental benefits related to stormwater runoff, air quality, carbon storage and sequestration. For, Mount Zion Manor, the residential site, CITYgreen was also used to calculate summer energy savings from the direct shading of trees upon the seven residences.

A new component added for this project documented temperature change at the three sites under current conditions and with increased urban tree canopy. While this was not a research project, AMERICAN FORESTS collaborated with Dr. Jeffrey Luvall, (NASA) to measure summer temperatures from places in Atlanta with similar tree canopy and impervious surface conditions. Using remote sensing techniques, Luvall analyzed satellite imagery and measured temperature in the upper one-third of tree canopy (called surface radiant temperature) approximating air temperature.

Luvall provided the surface radiant temperatures for Southside Shopping Mall in Atlanta for 0%, 30% and 80% tree canopy conditions. AMERICAN FORESTS used these temperature/canopy correlations to derive temperatures of the three demonstration sites under current and planted and modeled conditions.

Temperature Canopy Trend



Using a linear regression created from Luvall's surface temperatures recorded under different tree canopy densities, notice that at an 80% tree canopy, surface temperatures are about 80 degrees F. Without trees, surface temperatures soar to over 100 degrees F. Using this graph, surface temperatures at other canopy densities around the area can be estimated. Temperatures are estimated to be 95.5 degrees F with a 15% tree canopy, 91.8 degrees F with a 25% canopy and 86.2 degrees with a 40% canopy.

Afternoon Ground Temperatures Measured in Sun and Tree Shade
(data provided by Trees Atlanta)

Date 2001	Location	Air Temp Fahrenheit	Condition	Temp in tree shade	Temp in full sun	Ave. % difference
Aug 15	Turner Parking Lot	89	Partly cloudy	106-112	138-142	22%
Aug 15	Midtown mall	90	Partly cloudy	93-97	133-135	29%
Sept. 6	Turner Parking Lot	89	Cloudy	94	124	24%
Sept. 6	Midtown	91	Mostly cloudy	94	130	28%
Sept 21	Turner Parking Lot	86	Mostly clear	85-92	127-128	31%
Sept. 21	Midtown	86	Mostly clear	85-90	127-129	32%
Average Difference						28%

For comparison, Trees Atlanta provided data on the temperatures measured with an infrared thermometer pointed at one small spot of asphalt in both sun and shade. While these temperatures are not sufficient to use for modeling, they show the dramatic temperature differences that tree shade provides.

Major Findings

Trees are an indicator of environmental quality because of their ability to moderate the effects of urbanization on air, water, and energy. The economic impacts of these changes on land cover are calculated using AMERICAN FORESTS' CITYgreen software. When trees are strategically added to each of the three study sites and grown for 20 and 30 years, the benefits of tree canopy are readily apparent.

If tree-planting standards were applied to all surface parking lots in the Downtown Atlanta Study Area, mature trees would provide stormwater savings valued at $491,000 and air pollution mitigation valued at $7,500 annually.

At Turner Field Parking Lot the existing trees only line the perimeter of the 4-acre parking lot. Trees Atlanta installed parking islands and planted 33 oak and maple shade trees. When the trees were "grown" 30 years to a 29% canopy cover, the surface temperatures decreased by about 10%. The total stormwater retention capacity of the mature tree cover is valued at $16,000. The urban forest improves air quality by removing nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (0_3), and particulate matter 10 microns or less (PM_{10}). With this increased tree canopy, air pollution is reduced and valued at $276 annually. When these tree-planting standards are applied to the 122 acres of surface parking lots in the Downtown Atlanta Study Area, the results demonstrate significant benefits.

The direct residential summer energy savings from maximizing tree shade at the seven Mount Zion Manor homes is estimated at $951 annually.

At Mount Zion Manor, the seven single-family homes had some trees, but they were not strategically planted for shade or energy conservation. The Georgia Forestry Commission developed an updated planting plan. The existing trees and the updated plan's trees were grown for 20 and 30 years and the environmental benefits compared. At 30 years of growth, the site had an overall 21% tree canopy and surface temperatures were reduced by 5.6 degrees.. With less energy used for air conditioning, less carbon is produced at local power plants. This savings, from avoided carbon, is estimated at 427,441 lbs. annually. The trees also provide savings on stormwater runoff retention facilities, valued at $3,000 and they reduce air pollution at an annual value of $119 for the seven-home site.

Planting trees and other vegetation along the Arabia Mountain Multi-Use Trail will provide an immediate 4-degree F. temperature reduction. When mature, these trees will reduce surface temperatures by 15 degrees F, reduce air pollution valued at $284 annually and provide one time stormwater runoff benefits valued at $12,600.

The Arabia Mountain Multi-Use Trail had an existing 13% tree canopy cover in the 2.27 acre abandoned railroad right of way. The proposed trail will be an 840-foot by10-foot wide paved path with trees, shrubs and ground cover planted on either side of the path. A CITYgreen analysis shows the immediate benefit of providing vegetation--a 4-degree F. temperature reduction along the path as well as reduction in stormwater runoff and air pollution mitigation. When the new landscape is grown 30 years, it will provide total stormwater runoff benefits valued at $12,600 and air pollution mitigation valued at $284 annually. The 30-year growth scenario estimates that the new landscape plan will reduce temperatures from 96.3 to 81.3 degrees.

Environmental Benefits of the Urban Forest

There are many components to the ecology of an urban area. Trees are an indicator of the health of the urban ecosystem, since their roots require adequate air, water, and soil to support them. Urban problems such as air pollutants, road salts, compacted soils etc. will all affect tree health. Conversely, when the tree canopy is plentiful and healthy, including those that line streets and cover parking lots, the less impervious surface, the better the soil structure and therefore the greater the environmental benefits they can provide. 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 3) reducing summer energy from direct shading of trees and 4) reducing temperature which further reduces energy consumption and air pollution. 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. Their environmental benefits underscore the importance of maintaining and restoring the natural infrastructure of our communities.

AMERICAN FORESTS developed CITYgreen software to analyze the effects of trees on air, water and energy in urban areas. American Forests uses CITYgreen to conduct a detailed analysis of how the structure of the landscape affects its function. This tool connects research and engineering formulas to place a dollar value on the work trees do. CITYgreen is used to show how different local design scenarios affect stormwater movement, temperature, energy conservation, 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 the volume of water that a containment facility must store. The TR-55 model, developed by the Natural Resources Conservation Service, measures stormwater movement in various storm events (see page 10).

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 PM_{10}. AMERICAN FORESTS used the method developed by the USDA Forest Service to calculate air quality. To calculate the dollar value for these pollutants, economists multiply the number of tons of pollutants by an "externality cost" or costs to society that are not reflected in marketplace activity (see page 10).

Carbon

Trees and other plants are the lungs of our planet. Trees absorb carbon, in the form of carbon dioxide and produce the air we breathe. Trees store carbon in roots, trunks and limbs, helping to remove atmospheric carbon, a by-product of burning fossil fuels, thus reducing pollution. Carbon in trees is measured in two ways: the total amount stored, which becomes greater as the tree ages, and the rate at which carbon is stored (called sequestration), which is faster in young trees and then slows as the tree matures.

Temperature

Trees provide direct shading to the gray infrastructure including buildings, parking lots, and road surfaces. Shading with trees not only reduces summer temperatures, but also indirectly reduces ozone, a primary component of air pollution. This has significant implications for the City of Atlanta, which is currently classified as non-attainment status for ozone, under the National Ambient Air Quality Standards (NAAQS) of the Clean Air Act. According to Lawrence Berkeley National Lab scientists, when the air temperature is 72 degrees F, all cities can reach air quality attainment, when the temperature rises to 90 degrees F, no city can.

Energy Use

Atlanta experiences a long, hot summer and residents spend approximately $400 per home on air conditioning per year according to the Georgia Power Company. Trees provide direct shading on buildings and can reduce air conditioning use, save energy costs and reduce emissions at the utility plant.

Avoided Carbon

Reducing energy use also reduces the amount of carbon pollution produced by utility companies. CITYgreen calculates the amount of kilowatt-hours of electricity conserved as a result of direct shading of trees. This number is multiplied by the fuel types Georgia uses in its electricity production to generate a value.

Demonstration Study Sites and Findings

Turner Field Parking Lot

Located in downtown Atlanta, Turner Field parking lot was devoid of trees except for a perimeter row of magnolias, oaks and maples along Fulton and Hank Aaron Drive and existing oaks at the parking island ends. Cars in the parking lot would bake under the hot summer sun. Trees Atlanta retrofitted the lot in 2001 by planting 33 oaks and maples of 3-1/2 inch caliper and low-growing holly shrubs in newly created parking islands. AMERICAN FORESTS used CITYgreen to model these trees at 20 and 30 years growth and compared environmental benefits with the existing trees modeled for the same growth period.

The Turner Field Parking Lot planting demonstrates the benefits of retrofitting parking lots under Atlanta's tree ordinance. When trees in parking islands are added and grown, the temperature drops dramatically as the environmental benefits for stormwater savings and air pollution rise. After 30 years of growth, the value of the added parking lots trees is apparent: the ground temperature is reduced by an estimated 10 degrees F. The value of reducing stormwater runoff becomes $16,000 and the annual air pollution removal value increases to $275.

While these values represent only one 4-acre parking lot, what if these planting requirements were implemented for all downtown surface parking lots? According to Caleb Racicot, Tunnell-Spangler and Associates, there are 122 acres of surface parking lots in the Downtown Atlanta Study Area. When this total surface parking lot acreage was modeled with a 7% canopy cover, the benefit savings make a tangible impact. Stormwater benefits increase to $311,000 and air quality benefits rise to $1,907 annually. When trees are "grown" for thirty years, stormwater benefits increase to $491,000 and air quality savings increase to $7,534 annually.

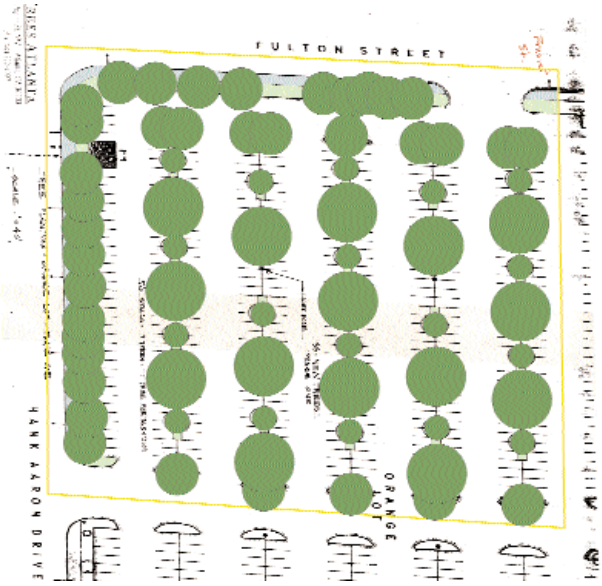
Turner Field Parking Lot Environmental Benefits Under Different Tree Canopy Conditions

Condition	% Tree Canopy	Est. Surface Temp. (°F)	Air Pollution Removal (annual)	Stormwater Savings * Total	Stormwater Savings * Annual	Carbon Storage (total tons)	Carbon Sequestration (annual lbs.)
Current Tree Canopy	5%	99.3	$49	$10,142	$884	7	300
Current + 20 year growth	10%	97.4	$91	$11,902	$1,038	17	60
Current + 30 year growth	12%	96.7	$116	$11,902	$1,038	22	80
Current + New trees at planting	7%	98.5	$62	$10,142	$884	8	380
Current + New trees+ 20 years growth	19%	94.3	$180	$13,436	$1,171	33	120
Current + New trees+ 30 years growth	29%	90.3	$275	$16,000	$1,395	52	180

**Annual Stormwater savings is based on financing over 20 years at 6%*
**Based on a $2 per cubic foot construction cost to build stormwater retention facilities*

Turner Field New Trees and Parking Islands at Planting

Turner Field New Trees Grown 30 Years



Planting trees and shrubs in a parking lot can dramatically reduce ground temperatures and increase environmental benefits.

Mount Zion Manor

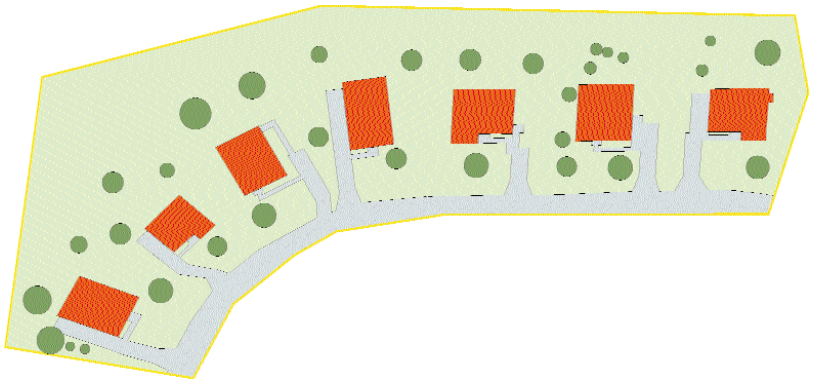
Habitat for Humanity in Atlanta, Inc. built seven new homes with minimal landscaping. The Georgia Forestry Commission developed a landscape plan that recommended removal of unhealthy trees, selected additional species, and sited new trees to maximize energy conservation. Since this is a residential study site, AMERICAN FORESTS used CITYgreen to calculate the energy conservation and avoided carbon emission values that trees provide in addition to the other environmental benefits discussed.

Six different scenarios demonstrated the environmental benefits of properly selecting, siting and maintaining trees in a residential area. When the trees were modeled at 20 and 30 years growth, the surface temperature decreased and the air pollution removal, energy savings and avoided carbon emissions increased significantly. Energy savings increased to $951. Avoided carbon absorption increased to over 427,000 lbs. per year reflecting that less fossil fuel is needed to cool homes. Stormwater benefits became significant when tree cover grew to 18%.

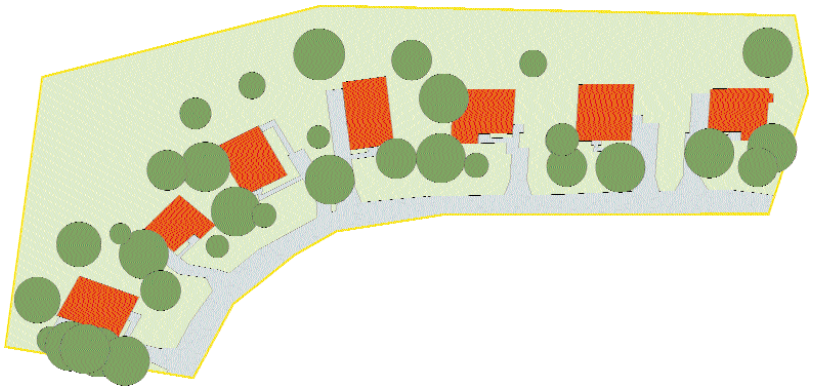
Mount Zion Manor Environmental Benefits Under Different Tree Canopy Conditions

Condition	% Tree Canopy	Est. Surface Temp. (°F)	Air Pollution Removal (annual)	Stormwater Savings *		Energy and Avoided Carbon Total Annual		Carbon Storage (total tons)	Carbon Sequestration (annual lbs.)
				Total	Annual	Energy Savings	Avoided Carbon (lbs.)		
Current Tree Canopy	6	98.9	$31	$0	$0	$50	24,651	6	20
Current + 20 year growth	10	97.4	$56	$0	$0	$248	123,060	11	40
Current + 30 year growth	12	96.7	$69	$0	$0	$416	206,738	13	40
Updated trees at planting	5	99.3	$29	$0	$0	$89	44,373	5	20
Updated trees+ 20 years growth	18	94.4	$98	$3,070	$268	$366	182,086	18	60
Updated trees+ 30 years growth	21	93.3	$119	$3,070	$268	$951	427,441	22	80

**Annual Stormwater savings is based on financing over 20 years at 6%*
**Based on a $2 per cubic foot construction cost to build stormwater retention facilities*



Mt. Zion Manor, updated trees at planting, reflects 12 new shade trees, the removal of 7 shade trees and several pines due to structural defects.



Mt. Zion Manor, updated trees grown 30 years

When trees are planted strategically, summer energy savings and avoided carbon emissions increase significantly.

Arabia Mt. Multi-Use Trail

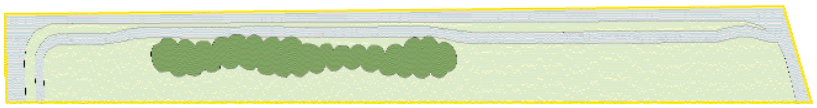
The proposed multi-use trail follows an old railroad right of way south of I-20 and east of Klondike Road in DeKalb County. The forested area was clear-cut in 1986. Currently there is a 13% tree canopy. The proposed trail will be an 840-foot by10-foot wide paved path with trees, shrubs and ground cover planted along the right of way. The trail starts at the Lithonia Woman's Center, crosses Covington highway, and terminates at a new mall under construction. A bike pavilion is also being planned. Roy Ashley Associates Landscape Architects is developing the plan along with the South River Watershed Alliance. AMERICAN FORESTS used the current condition of a 13% tree canopy, 29% impervious surface and 71% open space/meadow and compared this with the planting plan developed by the project partners. CITYgreen was used to grow the trees to 20 and 30 years and calculate the environmental benefits of the two scenarios.

The new planting plan, which includes oaks, maples, fringe trees, as well as shrubs and ground cover increases the tree canopy to 25% initially. The new planting provides immediate environmental benefits reducing summer temperature along the path by 4 degrees F., slowing stormwater runoff, reducing air pollution and absorbing atmospheric carbon. When the trees are grown to 20 and 30 years, their environmental benefits become substantial. Once the planted landscape grows for 20 and 30 years, temperature drops 12 and 15 degrees F respectively. At 30 years of growth, the tree canopy adjacent to the path will add $215 to air pollution value annually and over $3,200 in storm water runoff mitigation.

Arabia Mt. Multi-Use Trail Environmental Benefits Under Different Tree Canopy Conditions

Condition	% Tree Canopy	Est. Surface Temp. (°F)	Air Pollution Removal (annual)	Stormwater Savings * Total	Stormwater Savings * Annual	Carbon Storage (total tons)	Carbon Sequestration (annual lbs.)
Current Condition	13	96.3	$69	$9,390	$819	13	200
With New Planting	25	91.8	$134	$10,346	$902	31	380
Current + New + 20 years growth	45	84.3	$243	$12,072	$1,052	33	1,500
Current + New + 30 years growth	53	81.3	$284	$12,598	$1,098	53	800

**Annual Stormwater savings is based on financing over 20 years at 6%*
**Based on a $2 per cubic foot construction cost to build stormwater retention facilities*



Arabia Mt. Multi Use Trail, with existing 13% tree canopy

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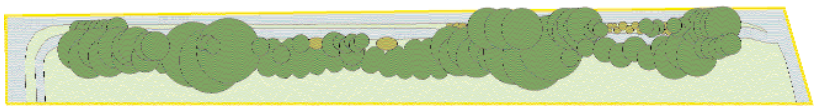


Arabia Mt. Multi Use Trail, with new planting grown for 30 years.

When the new planting is grown for 30 years, temperatures along the trail will decrease 15° F, reduce stormwater runoff and improve air quality.

Using This Information With The Model Urban Forest

The Regional Ecosystem Analysis of Atlanta Metropolitan Area that AMERICAN FORESTS conducted in 2001 from Landsat satellite and aerial imagery allowed us to measure tree canopy trends over the last three decades. The message from that analysis was clear; the region had lost a significant percentage of its heavy tree cover, the ecology was in a state of decline and the cost of this declining natural system is costly to residents.

The Georgia Model Urban Forest offers a method for promoting the green infrastructure at the site level. AMERICAN FORESTS' Urban Ecosystem Analysis quantifies how increasing tree canopy in new and retrofit design can increase future environmental and economic benefits.

Local agencies, citizen groups and decision makers are encouraged to use the information provided to better understand the relationship between trees and the environmental services that they provide. In addition, AMERICAN FORESTS recommends other ways in which the local community can use the Urban Ecosystem Analysis for future community planning:

■ Use trees as a valuable and essential element of the green infrastructure. Consider the dollar values associated with trees when making land use and design decisions.

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

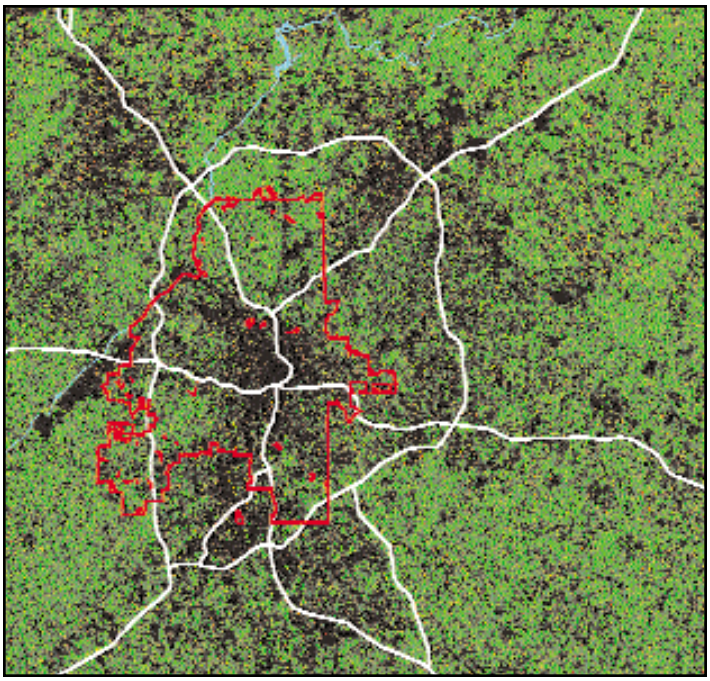
■ Set goals in order to increase and conserve tree canopy cover in urban areas, both in new development and in retrofit

Develop urban tree canopy goals for Atlanta based on AMERICAN FORESTS' guidelines for eastern US:
40% tree canopy overall
50% tree canopy in suburban residential zones
25% tree canopy I urban residential zones
15% tree canopy in the central business district

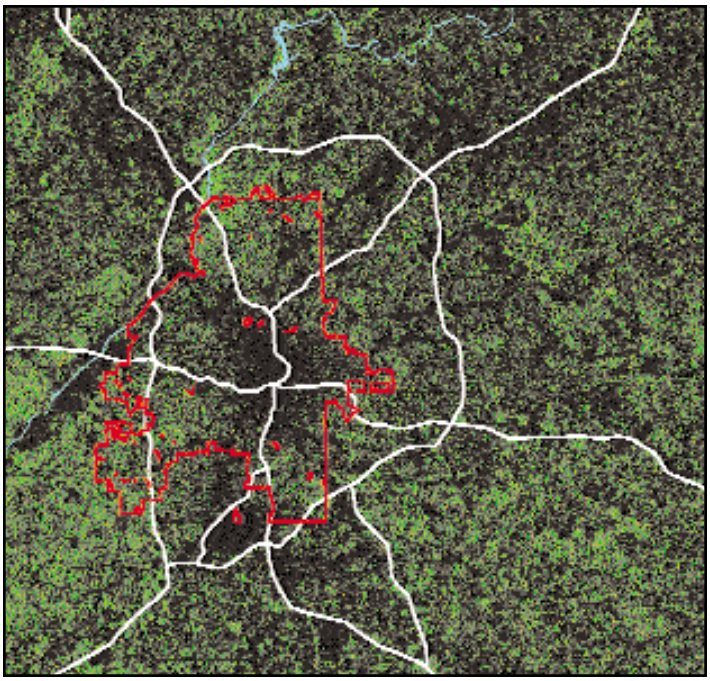
■ Utilize CITYgreen software and the AMERICAN FORESTS' Urban Ecosystem Analysis technique as a means of involving the community in the planning process

■ Expand the capacity and usefulness of this analysis by conducting UEA's using aerial imagery and high resolution, multi-spectral satellite imagery for citywide and countywide planning, as well as local site planning.

Regional Changes in Tree Cover



Landsat MSS 1974 80 Meter Pixel Resolution



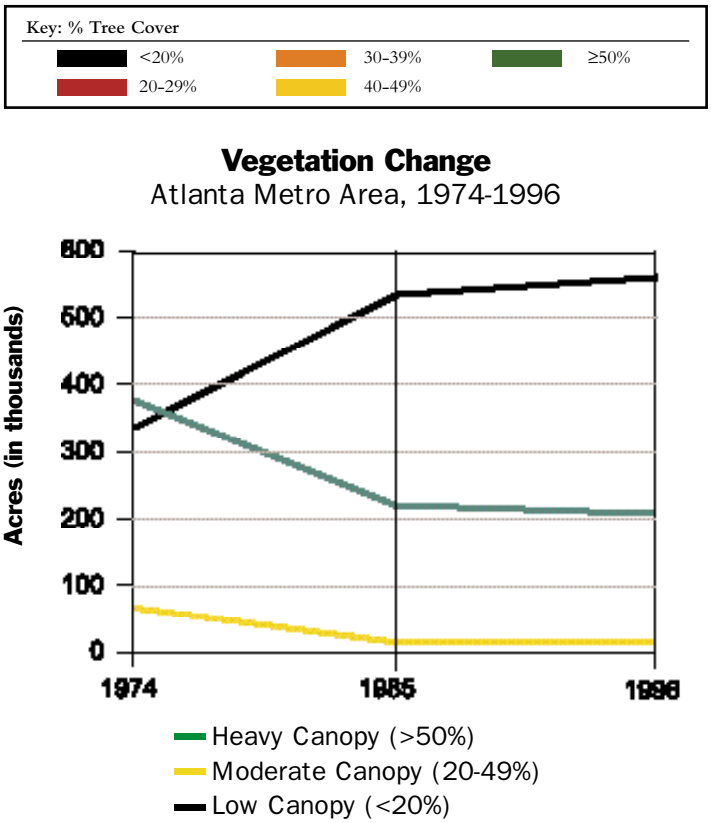
Landsat TM 1996 30 Meter Pixel Resolution

In 2001, AMERICAN FORESTS conducted a regional study of the Atlanta Metropolitan Area including 775,000 acres centered on the City of Atlanta. The study determined how the landscape had changed over time and calculated the impact of the changes on community management costs.

Major Findings:

- Heavy tree cover declined from 48% in 1974 to 26% in 1996 (green areas) and low canopy areas increased from 44% in 1974 to 71% in 1996 (black areas).
- The tree loss resulted in a 33% increase in stormwater runoff (from each 2 year peak storm event). Costs to build stormwater retention facilities to intercept an increase would cost $1.18 billion ($2/cubic ft. of storage).
- Lost tree canopy would have removed 11 million pounds of pollutants annually at a value of approximately $28 million per year.
- Summer residential energy savings as a result of tree shade is estimated at $2.8 million annually.

The Landsat satellite images provide valuable public policy information showing general tree loss trends and resulting lost benefits. Since planning is implemented at a site level, individual projects can increase tree canopy cover and increase environmental benefits. Taken as a whole, the Atlanta community could reverse these trends, improve environmental quality and reduce their gray infrastructure costs.



The change in vegetation depicted in the satellite images is represented in this line graph.

Analysis Methodology

Ecological Structure Classification

AMERICAN FORESTS' tree canopy analysis is based on the assessment of "ecological structures"—unique combinations of land use and land cover patterns. Each combination performs ecological functions differently and is therefore assigned a different value. For example, a site with heavy tree canopy provides more stormwater reduction benefits than one with lighter tree canopy and more impervious surface.

Data Used

For the original study conducted in 2001, 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.

For the three study sites, the project partners provided maps. These paper maps were scanned into a digital form. AMERICAN FORESTS' staff digitized the land cover data—trees, impervious surfaces, houses, parking lots, bike trail etc. onto the plan. Project partners provided the designs for improving tree canopy cover and strategically siting trees for energy conservation.

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

CITYgreen version 5.0 used vector data created for documenting the land covers of the three study sites. The following formulas are incorporated into CITYgreen software.

TR-55 for Stormwater Runoff: The stormwater runoff calculations incorporate formulas from the Urban Hydrology of 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, and 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 as a result of air pollutants' detrimental effects on human health.

Energy Conservation: CITYgreen uses formulas for energy conservation developed by E. Gregory McPherson, PhD, and USDA Forest Service. The program estimates benefits of trees from direct shading of single-family residential buildings less than three stories tall. A 1-5 energy rating is assigned each tree based on distance and orientation from building, and its ability to shade a window and/or an air conditioner. Each home's annual energy use is multiplied by each associated tree's multiplier (interpolated from McPherson's research) to produce an estimate of dollar and kilowatt-hour savings per household. Annual energy costs for air conditioning are obtained from the local utility company or from the U.S. Department of Energy.

Avoided Carbon: CITYgreen avoided carbon module begins with kWh savings estimated in the energy module. Because different fuel sources emit different levels of carbon per unit of electricity production, the impact of a conserved kWh will vary depending o local fuel sources. To account for this, the amount of saved kWh from the energy module is multiplied by Energy Information Administration (EIA) data for state level fuel sources used I electricity production.

Temperature Modeling
Dr. Jeffery Luvall, National Aeronautical and Space Administration (NASA), used remote sensing to measure surface radiant temperatures emitted from satellite imagery. Temperatures were measured in the upper one-third of the tree canopy and approximates air temperature but can vary depending on tree species, wind and other conditions.

Luvall, recorded the surface radiant temperatures of trees at Southside Shopping Mall in Atlanta for 0%, 30%, and 80% tree canopy conditions. Temperatures were recorded on May 11, 1997; the air temperature was 76 degrees F. These temperature/canopy correlations established a trend that were used to model the three demonstration study sites under current and planted conditions to derive temperature differences.

As a comparison to Luvall's data, Trees Atlanta measured summer afternoon asphalt temperatures at Turner Field parking lot and the Midtown Promenade Shopping Center in Atlanta. The air temperature ranged from the mid-to upper 80's. Temperatures were recorded on sunny and cloudy days. This data is not sufficient to create a model, but provided a useful comparison of sun and shade temperatures.

Acknowledgements

Several agencies and organizations participated in the Georgia Urban Forest Model, providing expertise in planning, planting, video documentation, development of educational materials and public relations. Partners include:

Arabia Mountain Heritage Alliance, Trees Atlanta, Georgia Forestry Commission, Park Pride, Georgia Urban Forest Council, and Habitat for Humanity.

For our analysis, special thanks to Jeffrey Luvall, Senior Scientist, National Aeronautical and Space Administration (NASA) who provided temperature information under different tree canopy conditions in Atlanta and to Trees Atlanta for gathering additional temperature information.

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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