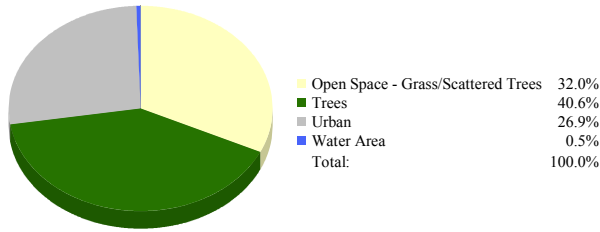
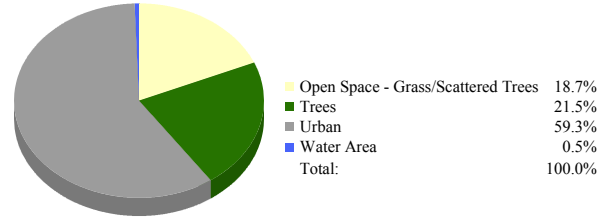


## Charlotte, NC 1984 Landcover



## Charlotte, NC 2003 Landcover



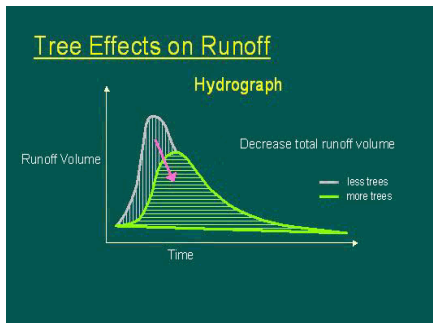
### Air Quality Results

#### Pounds Removed per Year

Pollutant	1984	2003
Carbon Monoxide:	224,467	118,784
Nitrogen Dioxide:	392,817	207,872
Ozone:	2,300,786	1,217,537
Particulate Matter:	1,683,502	890,881
Sulfur Dioxide:	729,518	386,048
<b>Total:</b>	<b>5,331,090</b>	<b>2,821,123</b>

### Stormwater Results

#### Storm Event Hydrograph



#### Stormwater Volume Change

2-yr, 24-hr Rainfall: 3.25 in.

\*Curve Number reflecting conditions in 1984: 77

\*Curve Number reflecting conditions in 2003: 84

Additional Storage volume of stormwater generated due to change in landcover from 1984 to 2003: 268,582,592 cu. ft.

Construction cost of retention facilities per cu. ft. of stormwater: \$2.00

Cost of the construction of retention facilities to store excess volume of stormwater: **\$537,165,184**

### Benefits Summary

#### Landcover Change (acres)

Landcover	1984	2003	Change
Trees:	62,953	33,314	-47.1%
Grass, Crops w/ veg. & fallow:	49,738	29,002	-41.7%
Urban:	41,823	92,110	120.2%
Water:	718	813	13.1%
Total Acres:	155,232		

#### Air Pollution Benefits

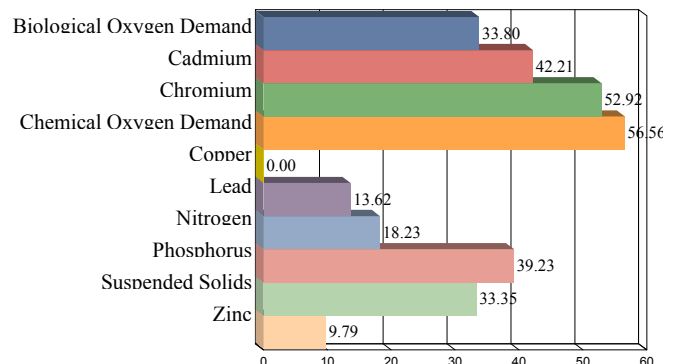
Pollutants Removed (lbs):	5,331,090	2,821,123	-2,509,967
\$ Amount:	\$12,371,759	\$6,546,927	-\$5,824,832
Carbon Stored (tons):	2,708,952	1,433,532	-1,275,420
Carbon Sequestered (lbs):	21,090	11,160	-9,929

#### Stormwater Benefits

Additional Storage Volume Needed:		276,494,557	268,582,592
Cost of Retaining Additional Volume of Runoff:		\$552,989,113	\$537,165,184

#### Water Quality (Contaminant Loading)

#### Percent Change in Contaminant Loadings from 1984 to 2003 due to land cover change



\*The stormwater calculations are based on curve number which is an index developed by the NRCS, to represent the potential for storm water runoff within a drainage area. Curve numbers range from 30 to 100. The higher the curve number the more runoff will occur. The change in curve number reflects the increase in the volume of stormwater runoff.

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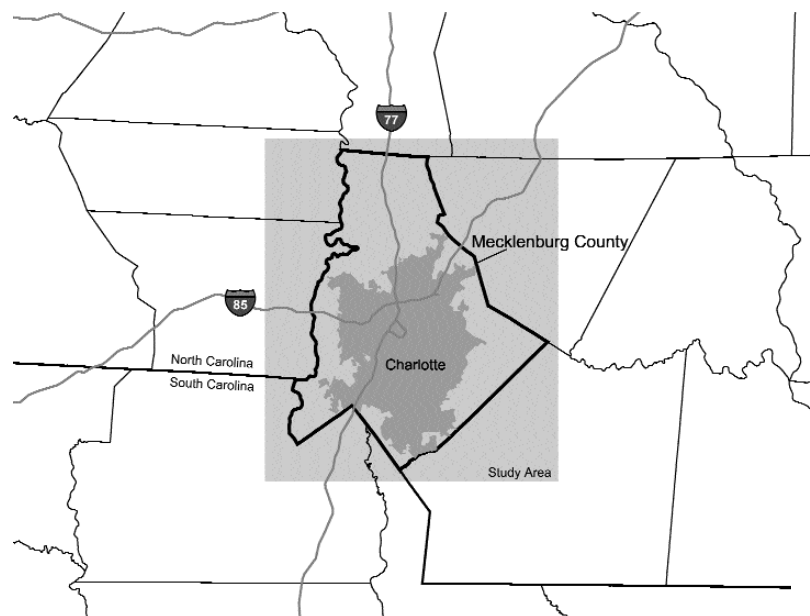
March 2003

# Urban Ecosystem Analysis Mecklenburg County, North Carolina

## Calculating the Value of Nature

### Report Contents

- 2** Project Overview and Major Findings
- 3** Lessons from Landsat
- 4-5** Mecklenburg County Green Data Layer
- 6** Case Studies in Areas of Rapid Development
- 7** Recommendations
- 8** About the Urban Ecosystem Analysis



## Project Overview

AMERICAN FORESTS, in conjunction with Federal, State, local, and business community partners, analyzed the effects of 17 years of changing landcover in Mecklenburg County, North Carolina. The results demonstrate the environmental impacts of tree loss on the cost of managing air quality and stormwater runoff, while providing local people with important information for planning and decision making.

The analysis covered more than 351,000 acres (549 square miles) of Mecklenburg Co. including the City of Charlotte as well as its rapidly developing suburbs. In addition to a time sequence analysis of the changing landcover using Landsat satellite imagery, a detailed assessment of the county's tree cover was conducted using high-resolution multispectral aerial imagery to produce a "green infrastructure" data layer for use in community planning, development and daily decision making. The analysis used Geographic Information Systems (GIS) technology to measure the structure of the landscape and model the effect of the landcover on air quality and stormwater movement.

The Charlotte Metropolitan Area is among the top ten fastest growing metro areas in the nation, and Mecklenburg County, which houses the city, has seen a 72% growth in population since 1980 (U.S. Census Bureau). With such a boom in population, some loss in natural vegetation is inevitable. However, the rate of urbanization and tree loss in Mecklenburg County surpasses even that of population growth. Between 1984 and 2001, the county saw a 127% increase in areas covered by impervious surfaces (streets, buildings, parking lots, etc). Without a balance between impervious and tree-covered land the county's citizens will face costly and unhealthy environmental consequences. Consider the lessons learned about growth and development of the I-485 Outerbelt. This study quantified the environmental effects of one completed segment south of Charlotte (see page 6). The environmental impact of the entire Outerbelt will be significant. If the project is completed without thoughtful planning, development could continue to be pushed away from the city center in a sprawl pattern. The challenge to the community is how to manage growth and foster mixed-use development while balancing green and gray infrastructure. Using the data from this study, planners will have the tools they need to manage, maintain, and balance the natural environment with the built one.

Conserving and fostering a healthy green infrastructure is more than an aesthetic choice, it's an economic one. The City of Charlotte ranks as the 9th worst in terms of ozone air pollution, and Mecklenburg County is the 12th worst county in the United States for ozone (American Lung Association – State of the Air 2002). If the Charlotte region falls into non-attainment status for ozone levels with the Environmental Protection Agency (EPA), the region stands to lose up to \$6 billion dol-

lars in federal funds for roads and highways. Trees function as natural filters of the air, removing such pollutants as ozone, carbon, and microscopic particulate matter. Employing tree conservation and forest restoration as a tool to help clean the air could potentially save the county billions of dollars while improving the quality of living for its residents. As a result of this study, planners and decision makers can put a value on their trees and project the benefits of increased tree cover in areas targeted for growth.

The study produced a rich data set describing the environment. The data coupled with its relevance and accessibility to those working at the local level, offers the opportunity for much better land use and development decisions than in the past. These data provide an important new resource for those working to build better communities—ones that are more livable, produce fewer pollutants, and are more cost effective to operate.

## Major Findings for Mecklenburg County

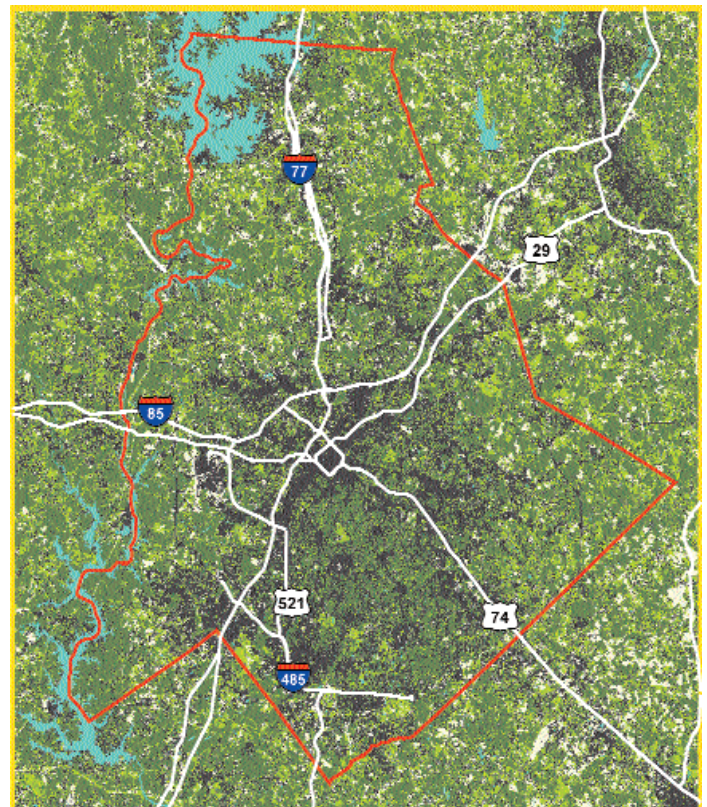
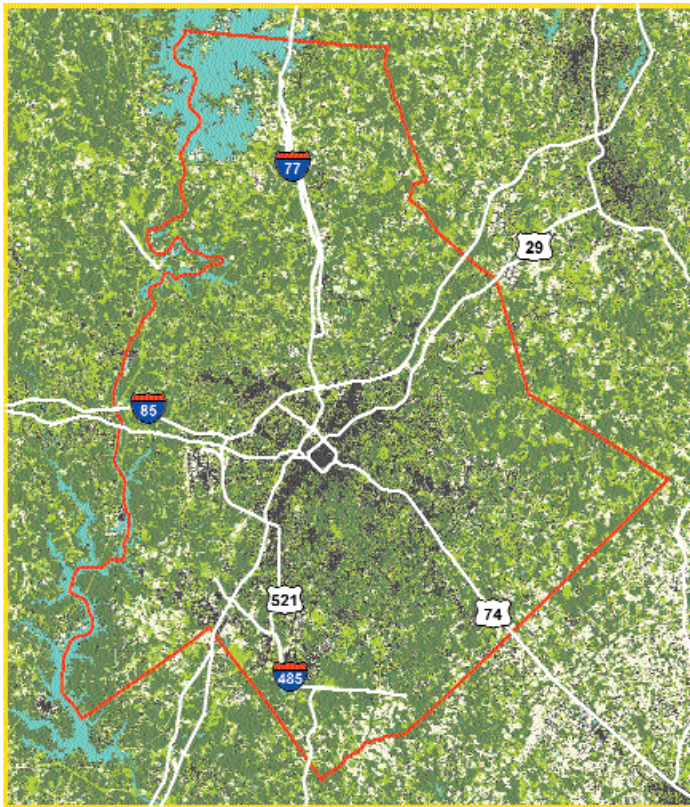
***Mecklenburg County's urban forest provides ecological benefits for managing stormwater and mitigating air pollution, valued at over \$200 million per year.\****

- Mecklenburg County is comprised of 184,935 acres of tree canopy (53%), 67,929 acres of open space (19%), 61,744 acres of impervious surfaces (18%), 21,745 acres of bare ground (6%), and 15,094 acres of water (4%).
- Between 1984 and 2001, Mecklenburg County lost over 22% of its tree cover and 22% of its open space. Over that same time period, the county's impervious surfaces increased by 127%.
- The total stormwater retention capacity of this urban forest is 935 million cubic feet. Without these trees, the cost of building the infrastructure to handle the increase in stormwater runoff would be approximately \$1.87 billion (based on construction costs estimated at \$2 per cubic foot).
- Urban forests provide air quality benefits by removing nitrogen dioxide, sulfur dioxide, carbon monoxide, ozone, and particulate matter of 10 microns or less. Mecklenburg County's urban forest removes 17.5 million pounds of pollutants from the air each year—a benefit worth \$43.8 million annually.

In Mecklenburg County, AMERICAN FORESTS used Landsat TM imagery (30-meter resolution) as well as high-resolution (4-meter multispectral) aerial imagery as the data source. From this data set, AMERICAN FORESTS calculated stormwater runoff and air quality benefits of the tree cover in the City of Charlotte and in the county as a whole. While this study presents general findings for the areas in question, the real value of this project is to show how local communities can apply the data to their specific issues.

\*Annual stormwater savings based on financing over 20 years at 6%.

## Lessons from Landsat



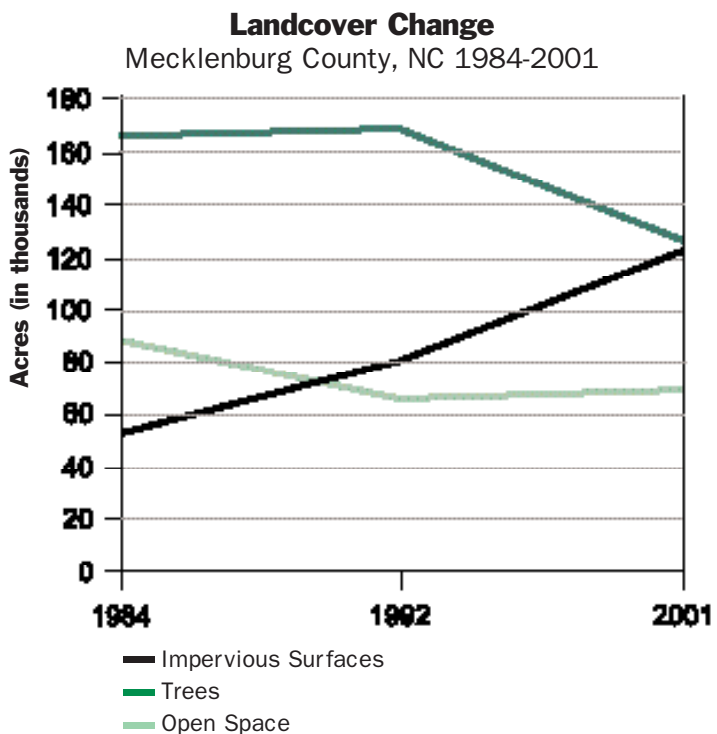
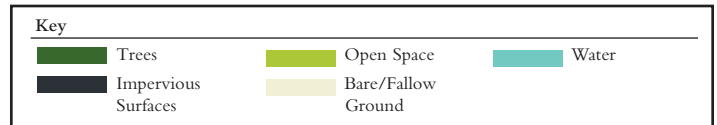
The classified Landsat images above illustrate landcover change in Mecklenburg County between 1984 (left) and 2001 (right).

AMERICAN FORESTS classified Landsat TM satellite images to show the change in tree cover for Mecklenburg County over a 17-year period. The analysis assessed the loss of tree canopy between 1984 and 2001. These images illustrate the boom of development south of Charlotte around the towns of Pineville and Matthews and along completed portions of the I-485 Outerbelt.

The Landsat images (above) provide valuable public policy information showing general trends in tree loss, but do not provide high-resolution data for local planning and management activities. High-resolution imagery (like that which is used in this study) produces a 4-meter or better resolution (compared to 30 meter with Landsat) and can be used to accurately inventory the tree cover in Mecklenburg County (see pages 4-5).

### Graphing Change

The change in vegetation depicted in the satellite images above is represented in a line graph on the right. The graph shows the change in landcover over a 17-year period for three categories. Data from three dates were analyzed and the graph shows an increase in the rate of development and tree loss between 1992 and 2001. The dark green line represents tree cover. Developed areas (streets, buildings, parking lots, etc.) are represented by a black line. The light green line represents vegetated open space (grass, farmland, etc.).



## Mecklenburg County Green Data Layer

### *Creating A Green Infrastructure*

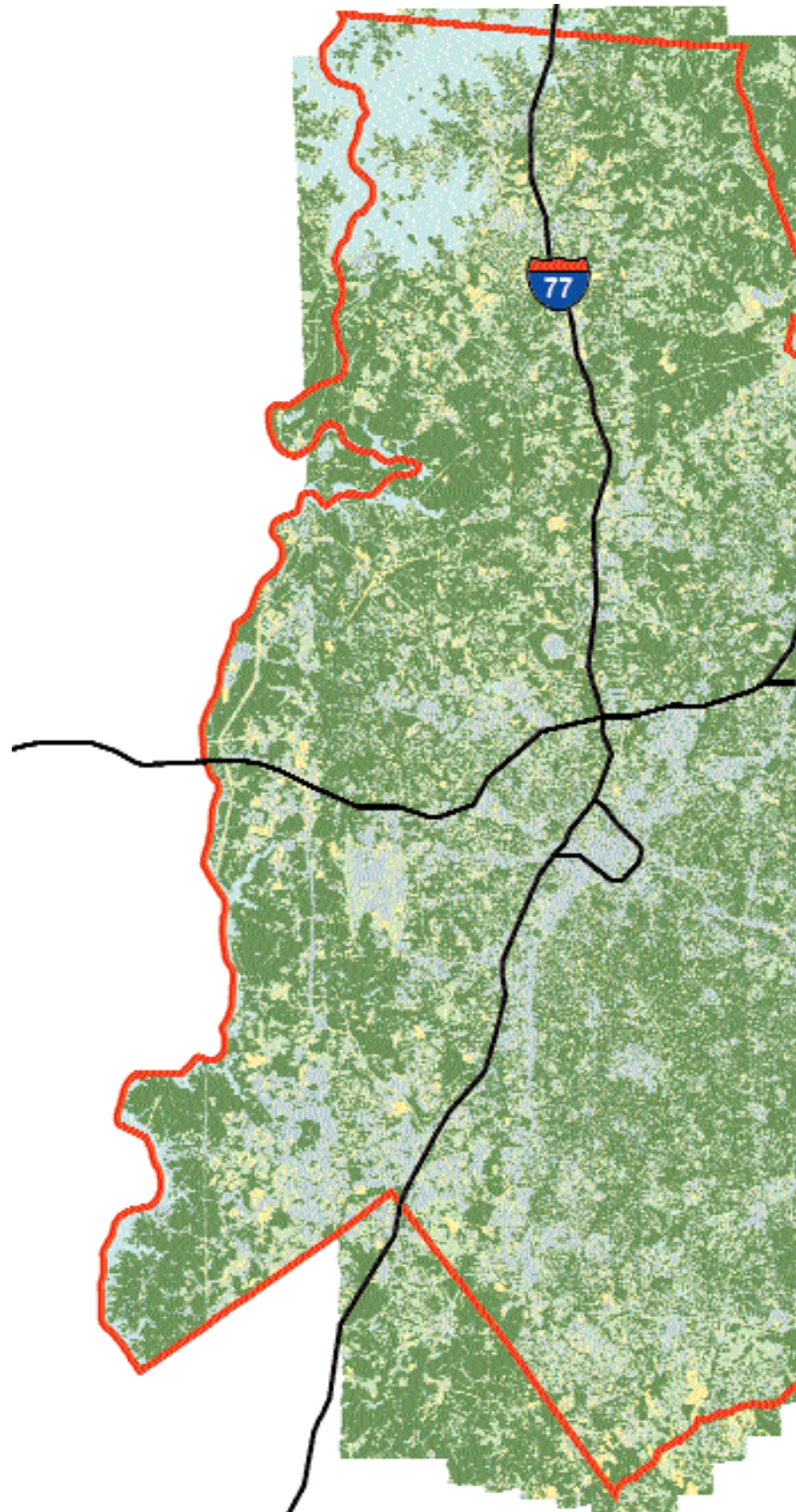
Adding a green infrastructure data layer to Mecklenburg County's decision making process introduces a new dimension to planning and development discussions, one that considers how to work with the natural environment instead of building costly infrastructure to manage air and water systems. By developing and using a green data layer, future decisions will include better information about the natural benefits of trees for air and water.

The first step in creating a green layer for use in Mecklenburg County's GIS was to acquire land cover data from specially equipped airplanes flown in late summer 2002. Specialists classified the images into useable data. The images were analyzed to determine the different landcover types—areas covered in trees, grass or open space can be distinguished from parking lots, buildings and roads. This analysis produced a green infrastructure data layer that can be added to the gray infrastructure that is used by GIS professionals in Mecklenburg County and the City of Charlotte.

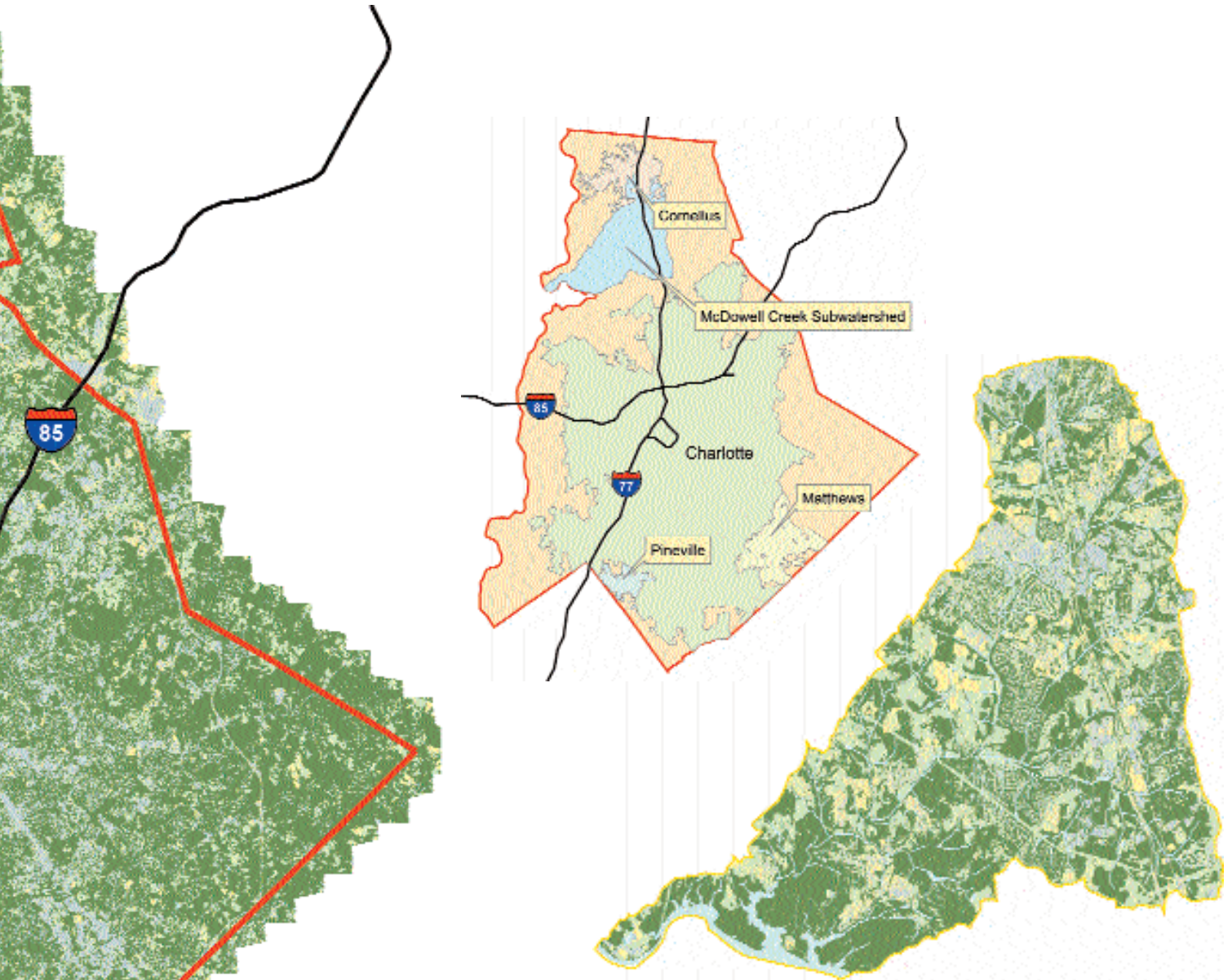
Adding a green data layer to Mecklenburg County's infrastructure will pay big dividends. Trees reduce pollution and erosion from stormwater by slowing it and by reducing its peak flow, and they improve air quality by filtering pollutants from the air. Using the green data layer, these values can be quantified for any area within the county. Hot spots of development, such as Charlotte's rapidly growing suburbs or areas around planned rapid transit interchanges, can be isolated and modeled for present and future tree cover benefits. Communities can then devise strategies to maintain or increase tree cover in these areas.

### *A Beginning*

Today there is a clear understanding of the active role trees play in improving the urban environment. Data documenting the environmental characteristics of trees are now available thanks to research from the USDA Forest Service and the Natural Resources Conservation Service. Though this report provides valuable information regarding the tree cover and its benefits throughout Mecklenburg County, the true strength of this project is in the data it provides for additional analyses as needed for local planning. With the land cover data set (pictured right) and CITYgreen software, communities in Mecklenburg County now have the tools they need to put trees back in the decision making process. The data produced for this study are flexible enough to be used in almost any way imaginable, along any boundaries—be they political or natural. From analyzing the value of trees along a major transportation corridor (see page 6) to assessing the tree cover in a watershed (next page) the data are useful to those who work on planning, stormwater management, water quality, and urban forestry.



*A high-resolution classified image of Mecklenburg County highlighting different land covers. Dark green represents tree cover, light green represent grass and open space, and gray designates impervious surface.*

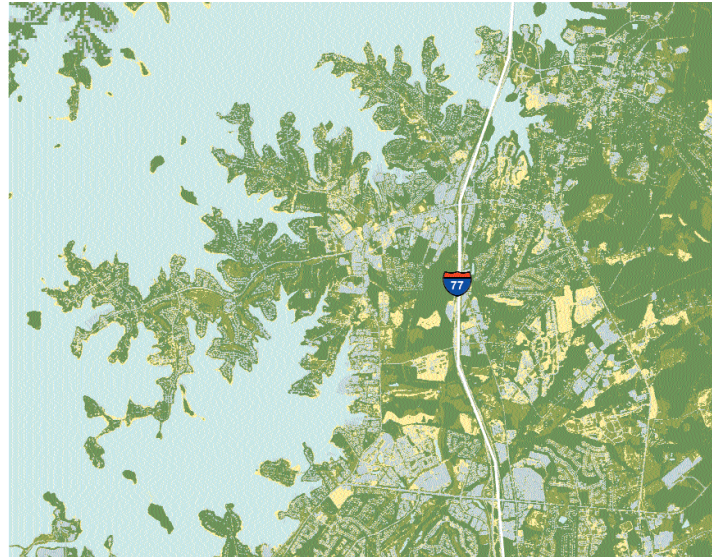
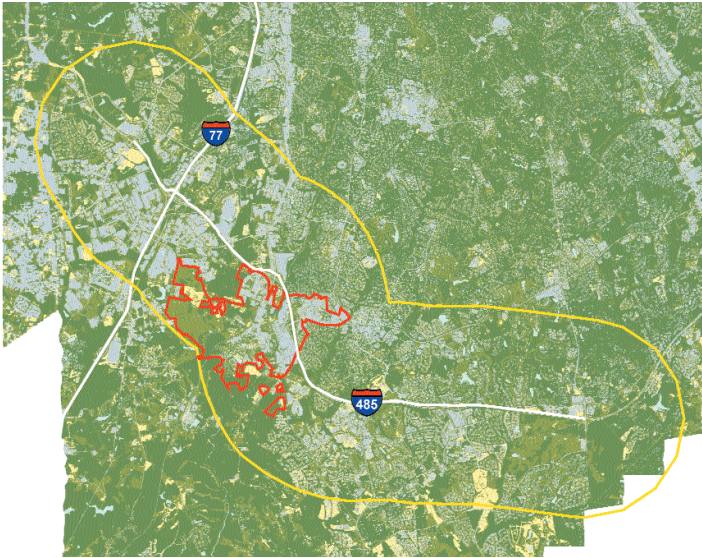


A dose-up of the McDowell Creek subwatershed. Clipped sections of Mecklenburg County's green data layer are available for further analyses.

### 2002 Forest Cover Benefits

	Acres	Tree Canopy	Stormwater Management Value (cu.ft.)	Stormwater Management Value (\$)	Air Pollution Annual Removal Value (lbs)	Air Pollution Annual Removal Value (\$)	Carbon Stored (tons)	Carbon Sequestered Annually (tons)
Mecklenburg County	351,450	53%	935,300,646	\$1,870,601,292	17,583,704	\$43,759,530	7,957,791	61,954
Charlotte	155,250	49%	398,386,345	\$796,772,690	7,182,574	\$17,874,849	3,250,591	25,307
McDowell Creek Subwatershed	20,780	51%	52,671,301	\$105,342,602	1,009,518	\$2,512,327	456,874	3,557
Cornelius	6,598	43%	15,334,061	\$30,668,122	271,987	\$676,877	123,092	958
Pineville	2,818	25%	4,969,561	\$9,939,122	66,966	\$166,653	30,306	236
Matthews	9,450	57%	34,917,446	\$69,834,892	514,903	\$1,281,410	233,028	1,814

## Case Studies in Areas of Rapid Development

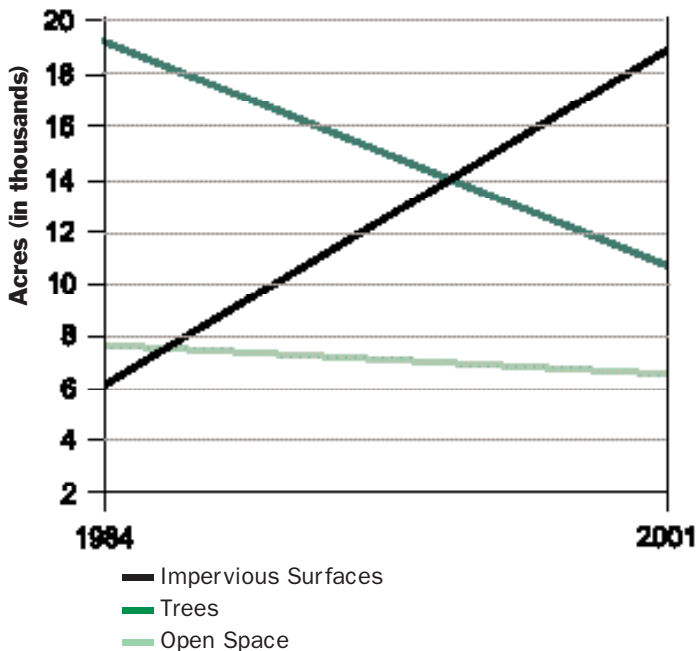


Growth trends in suburban Mecklenburg county indicate a high degree of sprawl. Towns like Pineville (at left, in red) are feeling the effects of the I-485 Outerbelt years before its completion. Cornelius (right) has also seen significant growth since 1984.

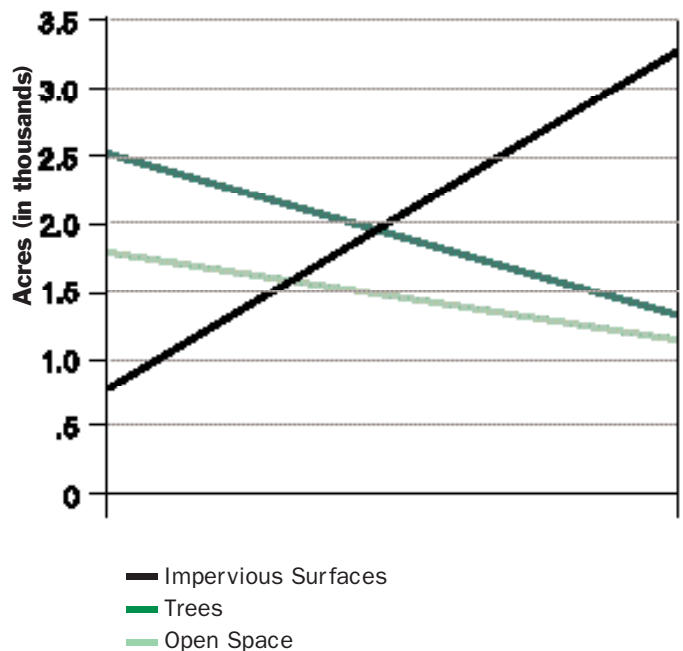
Though the I-485 Outerbelt has not yet been fully completed, development around completed sections of the road has been drastic. A two-mile buffer around a 12-mile section of I-485 was analyzed for its change in landcover between 1984-2001 (above left). The area included the town of Pineville and saw a 194% increase in impervious surfaces and a 42% decline in tree cover.

A similar analysis of the town of Cornelius (above right) on the banks of Lake Norman revealed even more staggering growth. The town of Cornelius experienced a 293% increase in impervious surfaces while losing nearly half (48.5%) of its tree cover.

**Landcover Change**  
I-485 Corridor 1984-2001



**Landcover Change**  
Cornelius, NC 1984-2001



## Recommendations

From the Landsat satellite analysis (page 3), it is clear that Mecklenburg County has lost significant tree cover over the last two decades (a 22% decline between 1984–2001). While this reveals a negative trend, communities need more detailed information in order to incorporate green infrastructure into their decision-making. AMERICAN FORESTS' analysis uses high-resolution imagery to do just that. This study provides a detailed assessment of the tree cover and quantifies ecological benefits for Mecklenburg County and the City of Charlotte. As the last two decades show, Mecklenburg County is growing at an astounding rate. If these trends continue, the balance between the natural and built environment will be in jeopardy. Trees can play an integral role in maintaining this balance.

The data from this analysis are available at no cost to communities in Mecklenburg County who use it in conjunction with CITYgreen software for local planning and development. AMERICAN FORESTS recommends that communities establish tree canopy goals tailored to their administrative areas and then use CITYgreen to plan and manage their progress. New tree canopy goals can be accurately determined every few years by updating the images. AMERICAN FORESTS has provided generalized target goals, but realizes that every community is different and needs to set their own goals. Armed with this green data layer and CITYgreen software, communities can better assess their urban forest as a community asset and incorporate this green infrastructure into future planning.

### **1. Integrate the green data layer into municipal GIS systems.**

- Distribute to local agencies for use in management and development decisions.

### **2. Use the findings of this study to address public policy issues for land-use planning and growth management.**

- Currently, the consumption of acreage in Mecklenburg County is outpacing population growth. Encourage higher density development as one means of conserving tree cover—tree cover that can save the county millions of dollars in ecological services. High-density development can help minimize sprawl in areas around the rapidly developing I-485 Outerbelt.
- Encourage the use of mass transit systems instead of larger roads and more parking lots, thus allowing for the conservation of more natural tree cover.
- Add tree cover into stormwater management planning to improve the water recharge zones, critical in capturing water from smaller rainstorms and improving water levels of the Catawba River.

- Integrate trees into Smart Growth planning strategies, including mixed use and areas along mass transit corridors to promote walkable routes.

### **3. Consider the dollar values associated with trees when making land-use decisions.**

- A new residential tree ordinance in Charlotte eliminates clear-cutting and allows for higher density development as more trees are preserved.
- Adopt this principle in updating tree ordinances for the entire county and all Mecklenburg towns.
- Consider the value of trees for water quality. Non-point sources of pollution can be reduced as trees mitigate the flow of stormwater runoff. Conduct CITYgreen analyses in riparian buffers as well as watershed-wide tree studies to reinforce the value of trees to Mecklenburg County's water supply.
- Run CITYgreen analyses to compare development scenarios in creating a balance between housing density and providing adequate space to grow healthy trees.

### **4. Use CITYgreen to conduct additional local analyses.**

- Use CITYgreen software as a decision support tool to increase community participation.
- Empower teachers and students to think of trees as a valuable and essential element of the urban environment. Set up workshops for teachers on how to use CITYgreen software in the classroom.
- The shade that lush tree canopy provides residences in the summer time can greatly reduce the need for airconditioning. Conduct individual project-level analyses to determine the energy savings from trees for residential areas using CITYgreen.
- Update the tree cover analysis every five years to track future trends in forest canopy and associated benefits.

### **5. Setting Tree Canopy Goals**

- Local communities should set specific tree cover targets for various land use areas. Goals should be established with an understanding of current and future ecological and land use objectives. This stratification of goals is an important part of building a green infrastructure. By using available GIS zoning data for Mecklenburg County, targets can be set for residential, commercial, and industrial areas. Though development will continue in Mecklenburg County, a balance can be achieved between the natural and the built landscape.

AMERICAN FORESTS' General Tree Canopy Goals for Mecklenburg County

45–55% tree canopy overall

50% tree canopy in suburban residential

25% tree canopy in urban residential

15% tree canopy in central business districts



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## About the Urban Ecosystem Analysis

AMERICAN FORESTS Urban Ecosystem 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 time sequence analysis (page 3), Landsat Satellite TM (30 meter pixel) images were used as the source of landcover data. AMERICAN FORESTS used a knowledge-based classification technique to divide the landcover into five categories (water, trees, impervious surfaces, open space, and bare ground).

To create the green data layer, high-resolution (4 meter pixel) multispectral imagery was obtained from an airborne sensor. AMERICAN FORESTS used a knowledge-based classification technique to categorize different land covers such as trees, impervious surfaces, open space, and water. Classified Landsat imagery was resampled to 4 meters and used to fill in any gaps in the multispectral analysis (less than 15% of total land area).

### Analysis Formulas

A CITYgreen analysis was conducted for Mecklenburg County, the City of Charlotte, and several of the surrounding communities. CITYgreen version 5.0 used the raster data land cover classification from the high-resolution imagery for the analysis. 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, of the USDA Forest Service. The model estimates how many pounds of ozone, sulfur dioxide, nitrogen dioxide, and carbon monoxide are deposited in tree canopies as well as the amount of carbon sequestered. The urban forest effects (UFORE) model is based on data collected in 50 US cities. Dollar values for air pollutants are based on averaging the externality costs set by the State Public Service Commission in each state. Externality costs, are the indirect costs to society, such as rising health care expenditures as a result of air pollutants’ detrimental effects on human health.

## Acknowledgements for this Study

We gratefully acknowledge the support of the following individuals, agencies, and companies in conducting this study:

### Major Donors

USDA Forest Service  
Bank of America  
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Mecklenburg County

### Contributors

City of Charlotte	Bill Vandiver
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Town of Huntersville	Bob Perkowitz
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Town of Mint Hill	ERDAS for remote sensing
Bartlett Tree Research Labs	software
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Charlotte Tree Advisory Commission  
Thomas F. Lannin  
Lynn Wheeler  
Richard E. Roti

### 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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