April 2010

Urban Ecosystem Analysis Mecklenburg County and the City of Charlotte, North Carolina

Calculating the Value of Nature

Report Contents

2 Introduction and Project Overview

2-3 Major Findings Summary

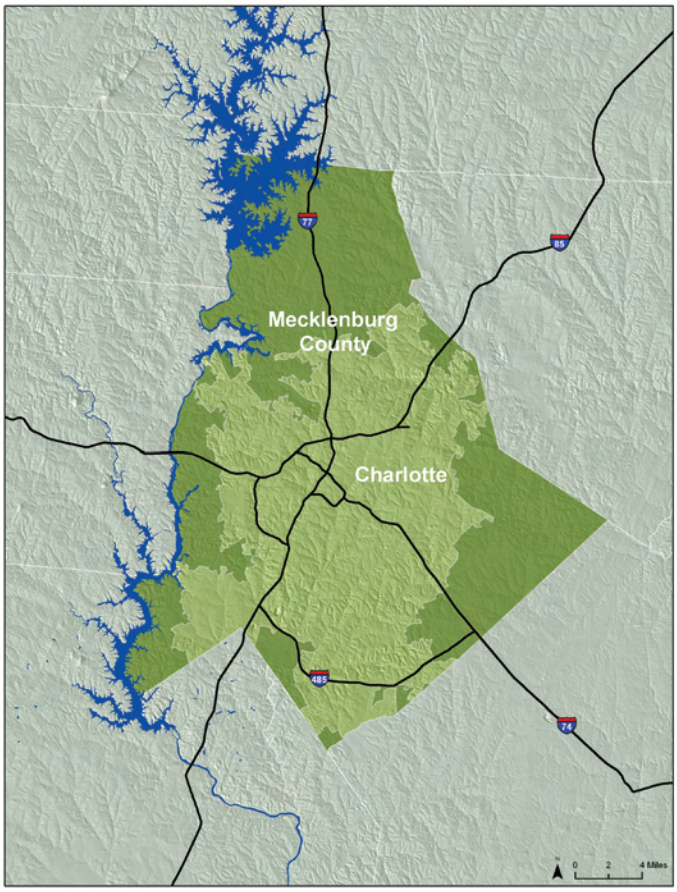
4-5 Land Cover Change Trends: Landsat 1985-2008

5-10 High Resolution Analysis 2008 and Ecosystem Benefits

10-13 Protecting Watershed Scale Tree Canopy for Water Quality

14 Implementation Recommendations

15-16 About the Urban Ecosystem Analysis



AMERICAN FORESTS®
americanforests.org

Introduction and Project Overview

Trees are important indicators of the health of a community's urban ecosystem. When trees are large and healthy, the ecological systems that support them are also healthy. Healthy trees provide valuable environmental benefits through the biological functions of their roots and leaves. These can be measured in terms of ecosystem services including reducing stormwater runoff, increasing carbon storage, and improving air and water quality. The greater the tree cover and the less the impervious surface in a community, the more ecosystem services are produced.

American Forests assesses the health and benefits of urban ecosystems through a process called Urban Ecosystem Analysis (UEA). This Urban Ecosystem Analysis of Charlotte Mecklenburg updates American Forests' earlier local, regional, and multi-state work including an UEA of Mecklenburg County in 2003, the Carolina Piedmont Green Initiative - an analysis of the 15 county region surrounding Charlotte in 2005, and an UEA of the Mountain Island Lake Watershed in 2007.[1]

With an understanding of these prior American Forests' projects and recognizing that the continued conversion of natural areas into urban areas contributes to increased management costs to preserve quality of life for its residents, the City of Charlotte commissioned American Forests to conduct this new UEA of Charlotte Mecklenburg to document current landcover change trends and to provide detailed data for decision making going forward. The project was made possible through a generous grant from our major contributor, The Women's Impact Fund, through the use of digital imagery provided by Mecklenburg County, and through additional funding from the City of Charlotte and the Blumenthal Foundation.

This new UEA used satellite imagery, GIS technology and American Forests' CITYgreen software, to analyze land cover of Mecklenburg County, including Charlotte and the towns of Davidson, Cornelius, Huntersville, Matthews, Mint Hill, and Pineville at two scales, spanning two time periods. The first analysis, a trend analysis, utilized moderate-resolution 30-meter Landsat imagery acquired in 1985 and 2008 to quantify land cover changes that occurred during this 23 year time period. The second analysis, a much more detailed high resolution analysis, used National Agricultural Imagery Program (NAIP) data from 2008 one meter pixel resolution digital imagery to determine current land cover for Mecklenburg County, the City of Charlotte, the McDowell Creek and Goose Creek Subwatersheds, and the County's stream buffer network in its entirety. In addition, 2002 high resolution data from the previous UEA was used to compare tree canopy changes with 2008 high resolution data.

The project's objectives are threefold: 1) To provide detailed information regarding land cover trends and their ecological implications relevant to both Mecklenburg County and the City of Charlotte; 2) to replace Charlotte Mecklenburg's aging 2002 high resolution land cover data with 2008 high resolution land cover data, so local staff, as project partners can analyze how to best preserve tree canopy, target tree planting and reforestation efforts and to enhance riparian vegetation corridors, all of which are vital to protecting the area's environmental assets; and 3) to provide tools to enable local decision makers to more effectively plan for and manage growth in Mecklenburg County, the City of Charlotte and surrounding towns. These tools, if used in accordance with recommendations in this report, will help the community improve air and water quality and minimize degradation of the area's tree canopy, stream network and remaining open space.

Unfortunately, this UEA confirms that Charlotte Mecklenburg has continued its trend of losing tree canopy and open space while its urban area has continued to expand. However, the good news is that the tools used to complete this analysis also offer feasible solutions. Charlotte Mecklenburg can use the tools and new data provided as part of this project to change this trend and maintain a healthy, sustainable tree canopy and maximize its ecosystem services benefits. With this goal in mind American Forests recommends that the community: 1) Integrate these new land cover data into its planning processes so that impacts from future growth and development can be anticipated and managed to preserve canopy wherever possible; 2) Use the integrated data to conduct additional and more detailed analysis of the community's natural assets using CITYgreen® software with consideration of the community's land use plans, zoning categories, transportation plans, etc.; 3) Guided by this additional analysis, establish tree canopy goals that can be attained within various zoning categories and key watershed areas as it continues to develop; and 4) Preserve and plant trees throughout Charlotte Mecklenburg on a continuing basis to obtain and sustain a suitable and level of tree canopy.

Major Findings Summary

An analysis of Landsat data, used to identify landcover change trends found:

- Between 1985 and 2008, Mecklenburg County, lost 33% of its tree canopy and 3% of its open space, while gaining 60% of urban area (Table 1). These changes resulted in the loss of the tree canopy's ability to naturally manage 252 million cubic feet of stormwater, valued at $504 million using a local engineering cost of $2 per cubic foot.[2]

The County's green infrastructure[3] also lost the ability to remove approximately 3.8 million lbs. of air pollutants annually, valued at $8.8 million per year, 192 million lbs. of carbon stored in trees' wood and 1.5 million lbs. of annual carbon sequestration—the rate at which carbon is stored.

- Between 1985 and 2008, the City of Charlotte lost 49% of its tree canopy and 5% of its open space while gaining 39% of urban area (Table 1).

An analysis of recent high resolution data[4] providing a snapshot in time and quantifying what a workhorse Charlotte Mecklenburg's current green infrastructure is to the community, found:

- As of 2008, Mecklenburg County had a 50% tree canopy cover, which provided 1.4 billion cubic feet of stormwater detention services, valued at $2.8 billion, removed 14.9 million lbs. of air pollutants at a value of $40 million per year, stored 7.5 million tons of carbon in trees' wood and sequestered 59,000 tons of carbon annually (Table 4).
- As of 2008, the City of Charlotte had a 46% tree canopy that provided 662 million cubic feet of stormwater detention services, valued at $1.3 billion, removed 7.2 million lbs. of air pollutants at a value of $19.2 million per year, stored 3.7 million tons of carbon in trees' wood and sequestered 28,000 tons of carbon annually (Table 4).
- Of Charlotte Mecklenburg's 32,000 acres of stream buffers (vegetation adjacent to streams that filters out water pollutants before they can enter streams), 22,627 acres (71%) is tree canopy. This buffer network removes 1.9 million lbs. of air pollutants annually, valued at $5.1 million, manages 177 million cubic feet of stormwater, valued at $354 million, stores 974,000 tons of carbon, and sequesters 7,600 tons of carbon per year (Table 4).
- Certain land areas within Charlotte Mecklenburg, like the McDowell Creek Subwatershed, are vital to protecting the area's drinking water. Yet even at the Subwatershed's current 51% tree canopy, the Environmental Protection Agency has documented McDowell Creek as an impaired stream and unfit for swimming. In these critical areas, losing additional tree canopy to urban development only exacerbates the water pollutants entering the Creek and increases the costs of providing drinking water to the community. For example, a 5% change from tree canopy to urban landcover in McDowell Creek Subwatershed would decrease the watershed's ability to naturally manage 4.9 million cubic feet of stormwater, valued at $9.8 million.
- Charlotte Mecklenburg's tree cover has declined for the last 23 years and new policies and practices will need to emerge to reverse this trend. Based upon this latest data, tree canopy in Mecklenburg County has reached the point where further decline will cause the County to fall below levels recommended by American Forests. Charlotte Mecklenburg is now at a crossroads that will set the course for environmental quality for decades to come. The data and tools provided with this UEA offer decision support tools to help Charlotte Mecklenburg communities maintain the recommended levels of tree canopy as they continue to grow. These tools will also allow local leaders and staff to calculate the positive contributions of not only halting decline, but enhancing green infrastructure. For example by increasing tree canopy from its current 50% to 55%, Mecklenburg County's ecosystem benefits would provide an additional 1.5 million lbs. of air pollutant removal annually, valued at $4 million, decrease 232 million cubic feet of stormwater runoff, valued at $464 million, increase carbon storage 772,000 tons and increase carbon sequestration 6,000 tons per year (Table 6).

The UEA process involves a technical analysis of a community's land cover data taken from satellite imagery and aerial photography, computer technology called Geographic Information Systems (GIS), and the application of scientific and engineering models developed by experts to quantify environmental benefits. In short, the UEA calculates the benefits the studied community derives from ecosystem services provided by its natural assets.

Upon completion of an UEA the community receives data that accurately depict and quantify the community's land cover by type (trees, open space, urban area, and water) and detailed information about the ecosystem services and associated financial benefits. American Forests also provides CITYgreen® software to the community's planners and managers which enable them to integrate data about the natural assets into growth and development planning and management endeavors. This in turn enables the community to design and adopt effective measures to protect and preserve the community's trees and other natural assets.

American Forests has conducted UEAs within 40 different urban areas across the country and documented a disturbing trend–urban areas are losing trees at an alarming rate while urban land cover like roads and buildings, has been increasing rapidly. This trend is harming local environmental assets and quality of life in significant ways and is also costing communities billions of dollars because ecosystem services are lost when trees are removed.

Land Cover Change Trends: Landsat 1985-2008

Using moderate resolution satellite data from Landsat imagery acquired in1985 and 2008, American Forests measured changes in four distinct land cover types: tree canopy, urban, open space, and water within Mecklenburg County. This moderate resolution data identifies land cover change trends between these years. The analysis quantified the impacts these changes had on stormwater management, air and water quality, and carbon sequestration and storage.

It is important to note that Landsat data is valuable for identifying general trends and comparing landcover from one period of time to another in large areas but these data are not used to determine where trees, open space and urban area are located due to its coarse scale. In contrast, the high resolution dataset discussed later in this report provides an accurate spatial location of landcover and is the appropriate resolution to use to determine land cover existing in smaller parcels. High resolution data are used for planning and management functions involved in achieving tree canopy and open space goals, etc. Because of the difference in resolution, Landsat data and high resolution data cannot be compared to one another.

Landcover change trends from this study continue to document tree canopy decline noted in the earlier UEAs. Between 1985 and 2008, Mecklenburg County lost 33% tree canopy and 3% open space while gaining 60% urban area. In the same time period, the City of Charlotte lost 49% tree canopy and 5% open space while gaining 39% urban area (Figure 1). Table 1 shows landcover percent change trends, both historic and projected trends to 2015, assuming that landcover continues to change at the current rates.

Figure 1. Mecklenburg County Tree Loss 1985-2008

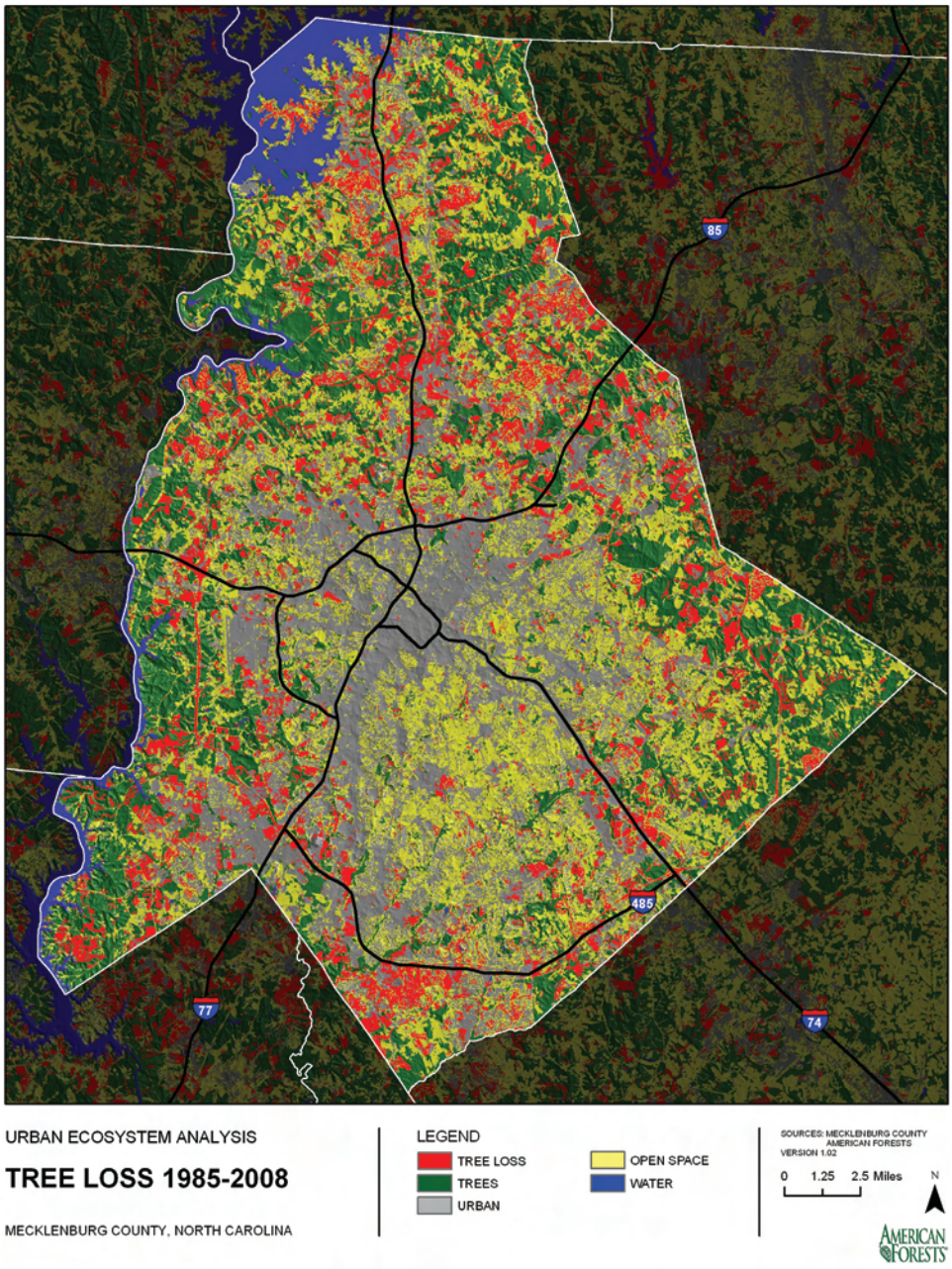


Table 1. Landsat Land Cover Percent Change Trends[5]

Landcover	1985-2008		Projected 2008-2015*	
	Charlotte	Mecklenburg Co.	Charlotte	Mecklenburg Co.
Open Space	-5%	-3%	-3%	-5%
Trees	-49%	-33%	-1%	-3%
Urban	39%	60%	4%	9%

There are ecological consequences when there is a loss of pervious land cover, such as tree canopy, open space and other vegetated areas, which defines an area's green infrastructure. There are also ecosystem impacts with an increase in urban areas. The 23-year trend data for Mecklenburg County shows that the loss of green infrastructure adversely affected the County's natural environment's ability to provide ecosystem services for air, water, and carbon (Table 2).

Mecklenburg County lost the ability to naturally manage 252 million cubic feet of stormwater, valued at $504 million. The City of Charlotte provided local engineered unit cost of $2 per cubic foot to calculate the value of mitigating this additional stormwater. Mecklenburg County's land cover also lost $8.8 in annual air pollution removal benefits, 192 million pounds of carbon storage and 1.5 million pounds of carbon sequestration annually.

Tree roots absorb water pollutants for which nine measures are available: Biological Oxygen Demand, Cadmium, Chromium, Chemical Oxygen Demand, Lead, Nitrogen, Phosphorus, Suspended Solids, and Zinc. In Mecklenburg County the amount of these contaminants entering streams and lakes worsened in the past 23 years. This chronological analysis provides valuable public policy information regarding the continual loss trends in tree canopy cover and associated ecosystem impacts.

For this UEA, American Forests used the U.S. Geological Survey's (USGS) 2001 National Land Cover Data (NLCD) as the baseline to update land cover change.[6] The USGS data, considered the gold-standard for land cover change analysis, was classified from 30-meter Landsat data acquired in 2001. American Forests utilized this dataset as the basis to compare land cover change from 1985 to 2008.

Table 2. Mecklenburg County Change in Ecosystem Services Landsat Data 1985-2008

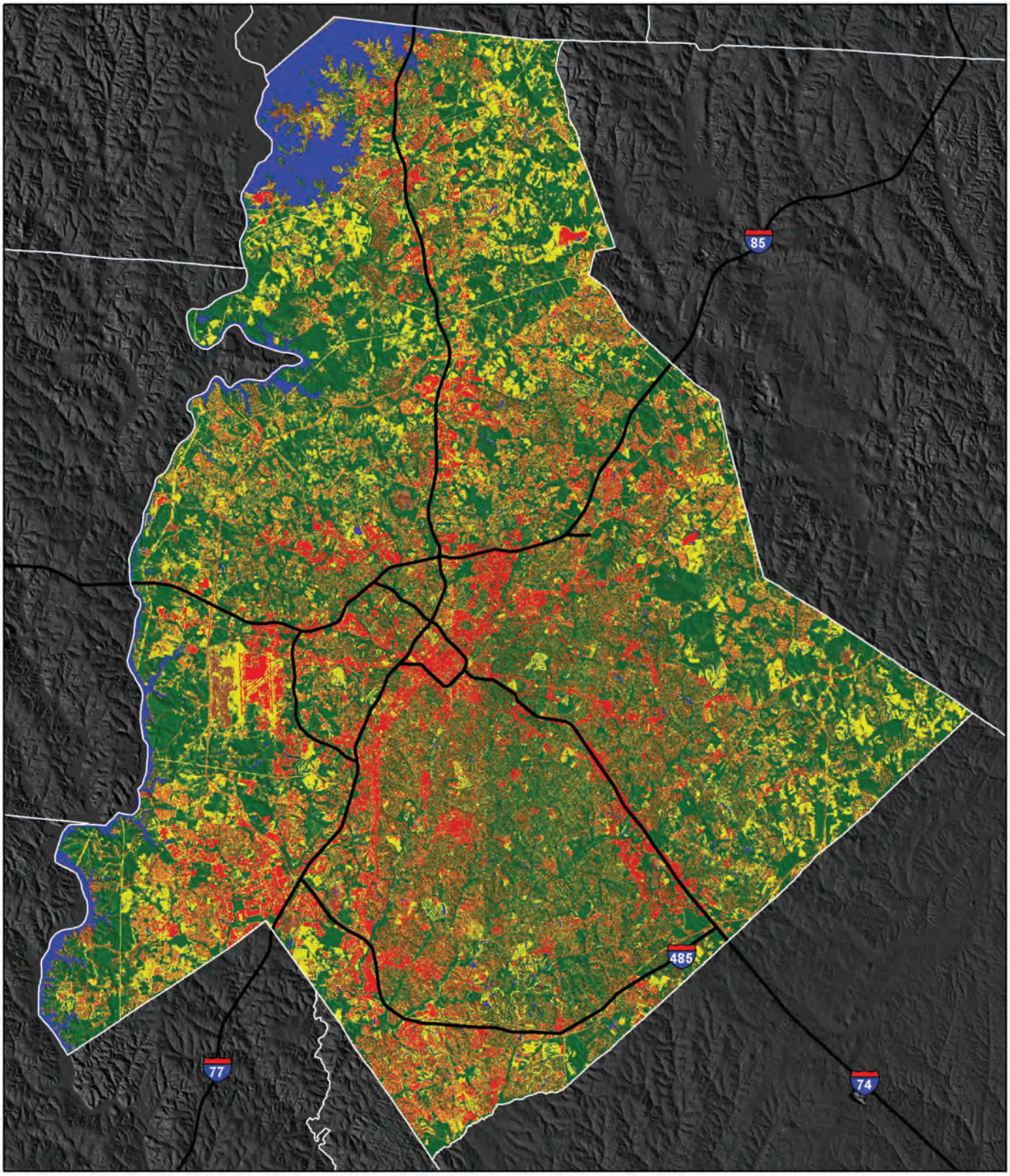
Tree Canopy Change	Loss of Air Pollution Removal	Loss in Removal Value	Loss in Stormwater Value	Loss in Stormwater Value @ $2/cu ft.	Loss of Carbon Stored	Carbon Sequestered
%	lbs./yr	dollar value	cu. ft.	dollar value	tons	tons
-33.0%	**-3,779,778**	**-$8,771,658**	**251,789,395**	**$503,578,789**	**-192,066,507**	**-1,495,289**

High Resolution Analysis 2008 and Ecosystem Benefits

To update the County's aging 2002 land cover data set, American Forests classified Mecklenburg County-provided 2008 NAIP data taken from high resolution imagery. This dataset provides a current snapshot of Charlotte Mecklenburg's landcover at a scale suitable to be further analyzed by the local community. Using these data, small areas of landcover within Charlotte Mecklenburg such as subwatersheds, zoning categories, and stream buffers can be accurately measured and related ecosystem services quantified. This dataset also provides Charlotte Mecklenburg with the most recently available planning and management tools.

American Forests classified these high resolution data into five land cover categories: trees, open space, urban area, bare soil, and water. American Forests then used CITYgreen software to conduct UEAs of Mecklenburg County, the City of Charlotte, the McDowell Creek Subwatershed, the Mecklenburg County portion of the Goose Creek Subwatershed, and the County's stream network and buffer zone in its entirety. As described in the Implementation Recommendations section on page 14, American Forests recommends that Charlotte Mecklenburg use this updated digital data set to identify areas for reforestation projects and engage the other community partners in reforesting these areas to improve stream health and water quality.

Figure 2. 2008 Mecklenburg County Landcover



URBAN ECOSYSTEM ANALYSIS

2008 HIGH-RESOLUTION CLASSIFICATION

MECKLENBURG COUNTY, NORTH CAROLINA

LEGEND	Acres (Percent of Total)
URBAN	91,230 (26%)
TREES	175,395 (50%)
OPEN SPACE	66,401 (19%)
WATER	15,654 (4%)
BARE	2,827 (<1%)

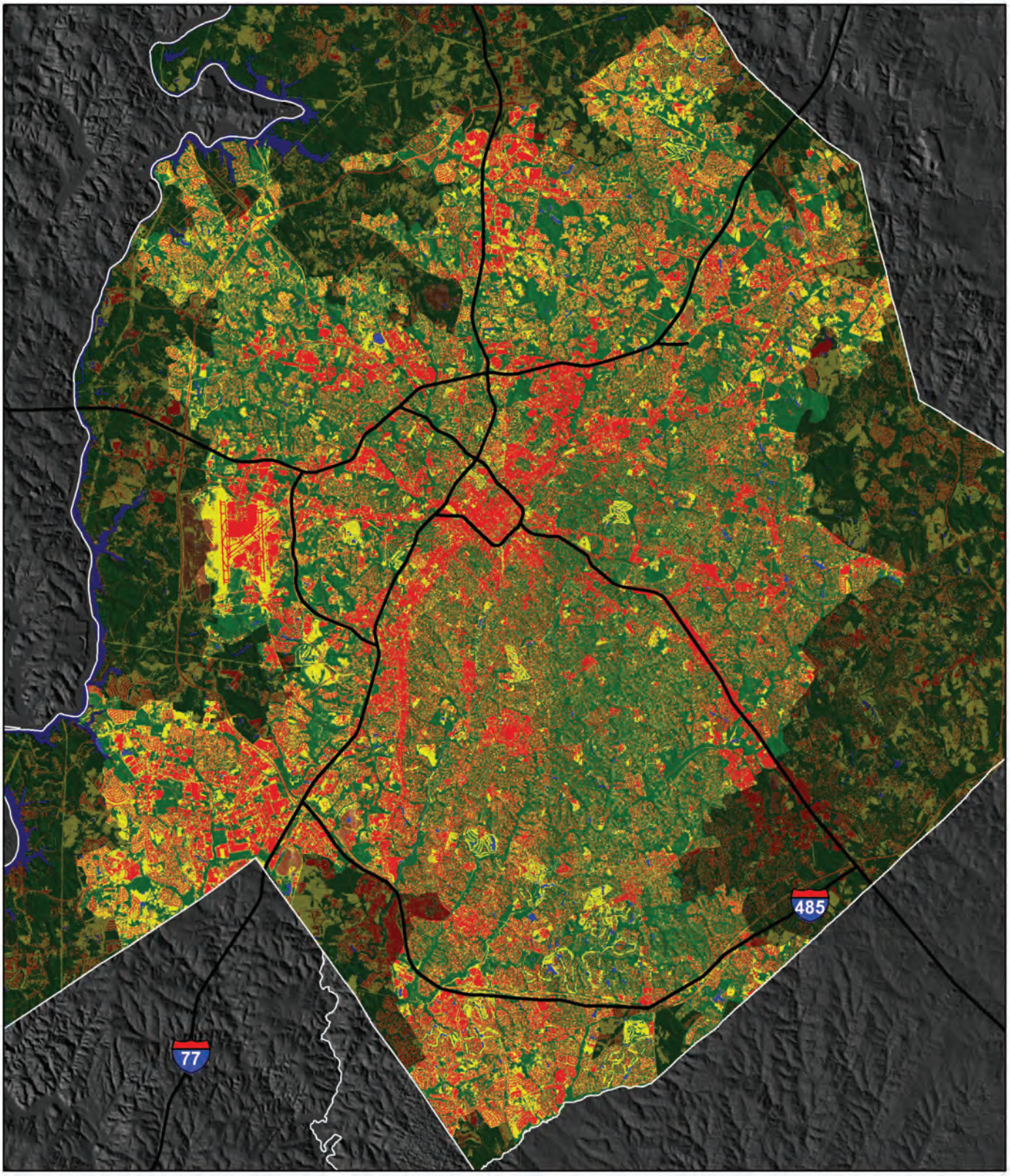
SOURCES: MECKLENBURG COUNTY
AMERICAN FORESTS
VERSION 1.02

0 1 2 Miles

N

AMERICAN FORESTS

Figure 3. 2008 Charlotte Landcover



URBAN ECOSYSTEM ANALYSIS

2008 HIGH-RESOLUTION CLASSIFICATION

CITY OF CHARLOTTE, NORTH CAROLINA

LEGEND	Acres (Percent of Total)
URBAN	48,866 (27%)
TREES	84,943 (46%)
OPEN SPACE	47,625 (26%)
WATER	1,051 (<1%)
BARE	1,078 (<1%)

SOURCES: MECKLENBURG COUNTY
AMERICAN FORESTS
VERSION 1.02

0 1 2 Miles

N

AMERICAN FORESTS

2002 and 2008 High Resolution Comparison

To determine landcover change trends during the most recent six year period, American Forests compared the 2002 high resolution data used in the previous UEA with 2008 high resolution data from this project after making appropriate data scaling and boundary adjustments. Since Charlotte gained land area due to boundary changes by 2008, this analysis used the 2008 boundary area in order to make an accurate comparison. The six year period shows that tree canopy continued to decline in both the City and County. Charlotte lost 3,231 acres of trees, a 2% decline and Mecklenburg County lost 9,475 acres of trees, a 3% decline over this six year period (Figure 4). If no action is taken to reverse this trend, and the rate of landcover change continues, projections to 2015 show that Mecklenburg County will lose an additional 20,500 acres of tree canopy and Charlotte will lose an additional 7,000 acres of tree canopy.

Figure 4. Actual and Projected Tree Canopy Decline in Charlotte Mecklenburg

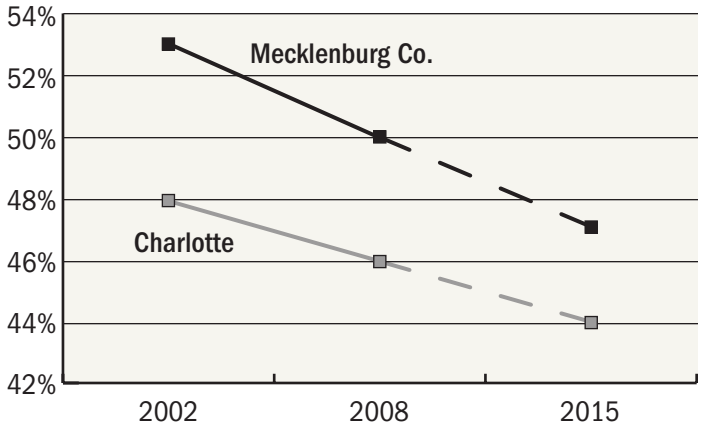


Table 3. Landcover, Tree Canopy and Population Comparison (4 meter pixel resolution)*

	2002**			2008**		
	Total Acres*	Canopy Acres*	Population***	Total Acres	Canopy Acres	Population***
Mecklenburg County	348,962	184,528 (53%)	746,427	349,162	175,053 (50%)	902,803
Charlotte	183,575	88,184 (48%)	579,684	183,575	84,953 (46%)	695,995

**The acreage reported in Tables 3 and 4 will be different due to data scaling adjustments made in order to compare 2002 and 2008 data.*
*** Since Charlotte's land boundaries changed during this time, the 2008 land boundary was used in both analyses to make an accurate comparison of canopy change. Even though the same boundary was used in both analyses, the acreage reported is slightly different due to data scaling adjustments when changing from a 1 meter to a 4 meter pixel resolution.*
****Population source: Charlotte Chamber: http://www.charlottechamber.com/index.php?submenu=population_estimates&src=gendocs&ref=PopulationEstimates2008&category=Demo_ecoProfile*

Stormwater Benefits

Trees reduce the volume of stormwater runoff by capturing some rain on their leaves and branches, which then evaporates back into the atmosphere. Other water is absorbed by the tree roots or infiltrates into the soil rather than running off the land. As a result less runoff must be managed by manmade infrastructure. In 2008, Mecklenburg County had a 50% tree canopy, which managed 1.4 billion cubic feet of stormwater, valued at $2.8 billion using a $2 per cubic foot value based on local costs (see Analysis Formulas, pg. 8). In 2008, Charlotte's 46% tree canopy provided 662 million cubic feet of stormwater management, valued at $1.3 billion.

Table 4. 2008 Tree Canopy and Ecosystem Services from High-Resolution Data (1 meter pixel resolution)

	Area	2008 Tree Canopy	2008 Tree Canopy	Air Pollution Removal	Air Pollution Removal Value	Carbon Stored	Carbon Sequestered	Stormwater Value*	Stormwater Value @ $2 per cu. ft
	acres	acres	percent	lbs./ yr	dollar value	tons	tons	cu. ft.	dollar value
Mecklenburg Co.	351,507	175,395	50%	14,853,127	$39,639,770	7,547,502	58,759	1,376,836,456	$2,753,672,911
Charlotte	183,570	84,943	46%	7,193,286	$19,197,318	3,655,213	28,457	661,848,956	$1,323,697,911
McDowell Cr. Wsd	18,628	9,427	51%	798,325	$2,130,555	405,663	3,158	70,323,500	$140,647,000
Goose Cr. Wsd**	7,161	4,380	61%	370,948	$989,979	188,494	1,467	38,711,659	$77,423,318
Stream Buffer Network	31,952	22,627	71%	1,916,118	$5,113,703	973,661	7,580	177,236,524	$354,473,048

*"*Stormwater analysis uses a 2yr, 24 hour storm event. The value of managing stormwater is based on current local construction costs of $2.00 per cubic foot (city of Charlotte).*
***Only the Mecklenburg County portion of the Goose Creek Watershed is included in this study.*

Water Quality Benefits

Trees provide very valuable water quality ecosystem services. Tree roots absorb water pollutants for which ten measures are available: Biological Oxygen Demand, Cadmium, Chromium, Chemical Oxygen Demand, Lead, Nitrogen, Phosphorus, Suspended Solids, and Zinc. For Mecklenburg County, water pollution, as measured in percent change in pollutant loading, would worsen, from 21% for Zinc to 132% for Chemical Oxygen Demand if the existing trees were removed from the land. For the City of Charlotte, water pollution, as measured in percent change in pollutant loading, would worsen, from 19% for Zinc to 108% for Chemical Oxygen Demand if the existing trees were removed from the land.

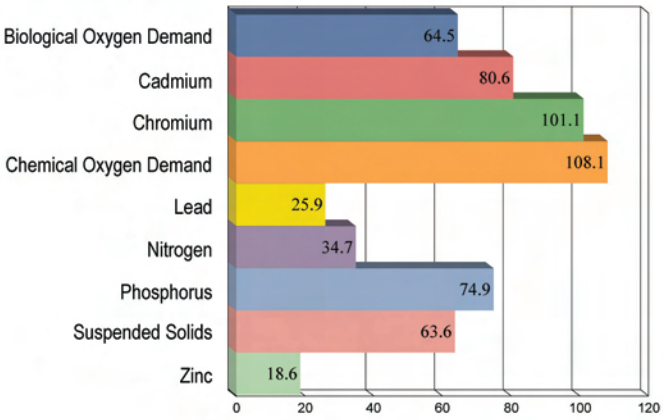
Air Quality Benefits

Air quality is of particular concern in the Charlotte Mecklenburg region because the Environmental Protection Agency (EPA) has designated Mecklenburg County and surrounding counties as a non-attainment area for ozone and carbon monoxide. "Sunlight and hot weather can cause ground- level ozone to form in harmful concentrations in the air. As a result, it is known as a summertime air pollutant. For this reason, the months of April through October often are referred to as the "ozone season" in this area."[7]

The air quality ecosystem services provided by trees are a big plus for the Charlotte Mecklenburg region. Tree canopy cools the air by evaporating water and by direct shading of buildings and pavement. This lowers the ambient temperature in cities (known as urban heat islands), reducing ground level ozone production and related smog conditions. While trees also emit hydrocarbons that contribute to smog ozone, research shows that because of trees cooling effects, they provide a net benefit in reducing air pollution.[8]

The ecological value of air quality ecosystem services is based on the UFORE model developed by the U.S. Forest Service. The dollar value is calculated based on externality costs to society (such as public health-related respiratory costs) due to the additional air pollution. Externality values are established by State Public Service Commissions. Mecklenburg County's urban forest removes 14.9 million lbs. of air pollutants annually, valued at almost $40 million per year. Charlotte's urban forest removes 7.2 million lbs. of air pollutants annually, valued at almost 19.2 million per year (Table 5).

City of Charlotte Water Pollutants As Measured In Percent Change in Contaminant Loading



Mecklenburg County Water Pollutants As Measured In Percent Change in Contaminant Loading

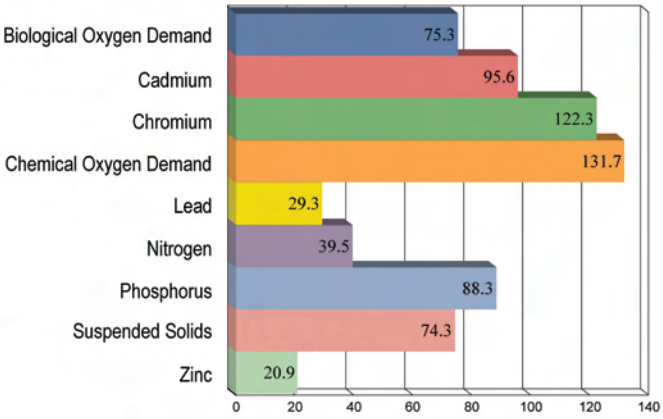


Table 5. Urban Forest Air Pollutant Removal Benefits

Air Pollutant	Mecklenburg Co.		Charlotte	
	Lbs. Removed per yr.	$ Value per yr.	Lbs. Removed per yr.	$ Value per yr.
Carbon Monoxide	625,395	$306,928	302,895	$148,653
Nitrogen Dioxide	1,094,441	$22,647,903	530,067	$1,872,752
Ozone	6,410,297	$3,866,715	3,104,675	$10,968,976
Particulate Matter	4,690,461	$11,064,084	2,271,714	$5,358,627
Sulfur Dioxide	2,032,533	$1,754,140	984,409	$849,576
Totals	**14,853,127**	**$39,639,770**	**7,193,760**	**$19,198,584**

Carbon Storage and Sequestration Benefits

Trees have a direct impact on the carbon footprint—the amount of atmospheric carbon a community produces that contributes to global warming. Trees provide a carbon sink by storing and sequestering atmospheric carbon in their wood. Both the total storage and the rate at which carbon is stored (known as sequestration) can be measured. Charlotte's tree canopy stores 3.7 million tons of carbon and sequesters 28,000 tons of carbon annually. Planting new trees and maintaining existing trees provide opportunities for the public and private sector to reduce their community's carbon footprint.

Modeling Ecosystem Benefits of Increased Tree Canopy

As mentioned earlier, Charlotte Mecklenburg continues to lose tree canopy cover and open space. Fortunately, Mecklenburg County is already using the data from American Forests' previous UEA and is poised to use the data set produced by this UEA for land use planning (see Implementation Recommendations, pg. 14) and to implement watershed management practices as described for McDowell Creek below. To illustrate how Charlotte, Mecklenburg County, and the local towns might go about reversing the trend of canopy loss and leverage the benefits that tree canopy provides, American Forests modeled an increase in Mecklenburg County's tree canopy from its current 50% to 55% and calculated the additional ecosystem service benefits this resource would provide in helping the community achieve its water and air quality goals.

If the County increased its canopy cover by 5% overall, the ecosystem services would provide an additional $4 million in annual air pollutant removal value, an additional 771,000 tons of stored carbon and an annual 6,000 tons of sequestered carbon, as well as 232 million cubic feet of additional managed stormwater, valued at $464 million. Table 6 details these increased benefits. Of course the region would also realize other benefits in the form of increased property value, increased tax revenue, reduced energy consumption, etc., not detailed in this report. Charlotte Mecklenburg planners can use the data set delivered with this project to establish overall tree canopy goals and also to stratify goals by land use. Staff can look for opportunities within public and private land to increase tree canopy cover which will improve overall environmental benefits. Tree planting and ongoing care engages all sectors of the community, where everyone has the opportunity and responsibility to contribute.

Table 6. Modeled Ecosystem Benefits from Increasing Mecklenburg County's Tree Cover

	2008 Tree Canopy	Modeled Tree Canopy	Additional Air Pollution Removal	Additional Air Pollution Removal Value	Additional Carbon Stored	Additional Carbon Sequestered	Additional Stormwater Mgmt Reduced	Additional Stormwater Value @ $2 per cu. ft*
	percent	percent	lbs./ yr	dollar value	tons	tons	cu. ft.	dollar value
Mecklenburg Co.	50%	55%	1,518,710	$4,053,109	771,721	6,008	-231,982,887	-$463,965,775

**Stormwater analysis uses a 2yr, 24 hour storm event. The value of managing stormwater is based on current local construction costs of $2.00 per cubic foot (source of unit cost: City of Charlotte).*

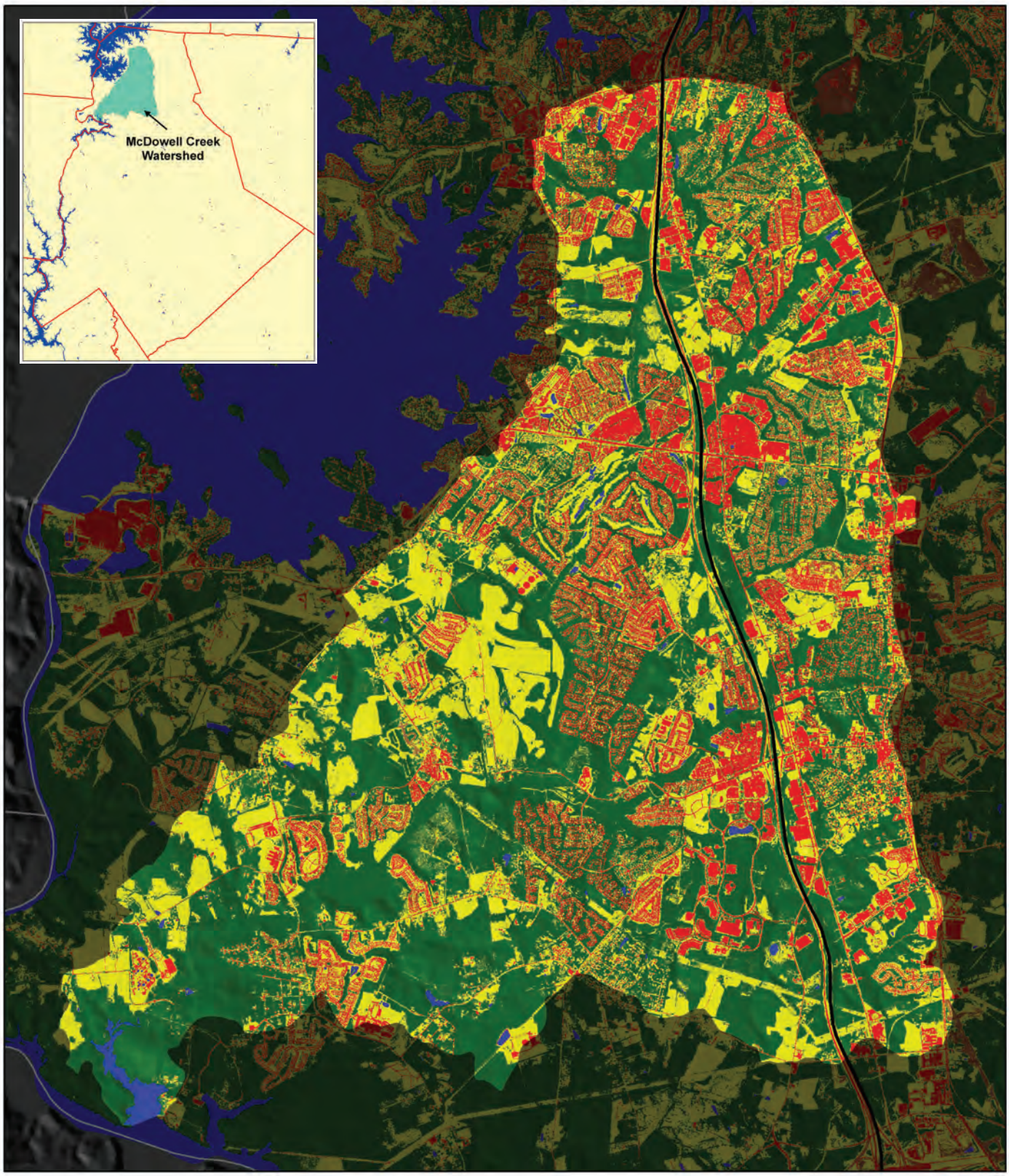
A community's pervious land cover serves as its *green infrastructure*; its protection and enhancement provides direct benefits to the taxpayer and improved environmental quality including slowing stormwater runoff, improving water and air quality, protecting soil from erosion, and storing atmospheric carbon. Green infrastructure includes vegetation and their complex interactions with soil, air and water systems. As defined in this project, green infrastructure includes tree canopy, open space, and water. American Forests used CITYgreen software to analyze the environmental and dollar value of each benefit. For more details and formulas used in each assessment visit: http://www.americanforests.org/resources/urbanforests/naturevalue.php

Protecting Watershed Scale Tree Canopy for Water Quality

McDowell Creek Subwatershed

In its most comprehensive analysis of the region, American Forests' Urban Ecosystem Center[9] and Michael Gallis and Associates[10] completed a study in 2007 of the Piedmont Crescent region,[11] an area covering seven states including North Carolina, to evaluate the natural system, the human network and their interactions. The findings showed that the ecosystem in the region, once designated as globally outstanding because of its lush flora and fauna,[12] is in a state of decline even greater than suspected. Growth and development across the region has resulted in natural land fragmentation, resource depletion, pollution, erosion, and species extinction.

Figure 5. 2008 McDowell Creek Watershed Landcover



URBAN ECOSYSTEM ANALYSIS

MCDOWELL CREEK WATERSHED

MECKLENBURG COUNTY, NORTH CAROLINA

LEGEND

- URBAN
- TREES
- OPEN SPACE
- WATER
- BARE

SOURCES: MECKLENBURG COUNTY
AMERICAN FORESTS
DATE: 03.feb.10

0 0.5 1 Miles

N

AMERICAN FORESTS

The magnitude and relevance of these findings are best illustrated at the watershed scale—where the importance of protecting urban forests for water quality touches everyone. In Mecklenburg County, this is best illustrated with two case studies—McDowell Creek and Goose Creek. The McDowell Creek subwatershed is 19,200 acres in area and has thousands of existing homes with many more planned. Water flows from McDowell Creek into Mountain Island Lake that provides eighty percent of the drinking water for 700,000 people who live in Charlotte Mecklenburg. This area's rapid development has severely threatened the community's water quality; McDowell Creek is already documented as an impaired stream under EPA regulations and is unhealthy for swimming. The main cause of this impairment is increased pollution from sediment and erosion as a result of development. McDowell Creek subwatershed, with its current 9,427 acres (51%) tree canopy, provides 70 million cubic feet in non-structural stormwater runoff management, valued at $141 million (Table 4).

The ecological impacts of losing tree canopy cover in this critical area will increase stormwater runoff and exacerbate the water pollutants flowing into Mountain Island Lake which can in turn increase the costs of providing drinking water. For example, a 5% change from tree canopy to urban landcover in the McDowell Creek Sub-watershed will decrease the ability to naturally manage 4.9 million cubic feet of stormwater, valued at $9.8 million in stormwater management alone. The damage to water quality for the city and county drinking water is a cost too high to measure. Increasing the tree cover in critical places, like planting trees to buffer the stream is a high priority task. The green data layer provided as part of this project will allow the local officials to identify the critical places and organize a replanting strategy.

Charlotte-Mecklenburg Storm Water Services and the North Carolina Division of Water Quality have long recognized the need to protect the area's drinking water supply. In response to this need, water supply watershed protection ordinances were implemented in the McDowell Creek Watershed in 1992. The ordinances only apply to the portions of McDowell Creek designated as Water Supply (WS) waters which are approximately located in the downstream third of the watershed. Subsequent to adoption of the watershed protection ordinance, the S.W.I.M. Buffer ordinance was implemented in 1999 that required undisturbed stream buffers throughout the McDowell Creek Watershed. Additionally, in 2003 Huntersville adopted a land development ordinance that required new development to implement low-impact development practices as well as dedicate a percentage of development area as open space. Implementation of these requirements has helped to hold the line on further degradation in the watershed; however it did not address pre-existing sources of pollution.

The Charlotte-Mecklenburg Stormwater Services staff developed the McDowell Creek Watershed Management Plan (2005) that sets water quality goals and presents a detailed plan of action to achieve them. The County, as a partner in this UEA project, will be able to use the new data set and software tools provided as part of this UEA to update its 2002 stream network data set, and to: 1) Identify areas for reforestation projects over the next three years; and 2) Engage with other community partners in reforesting these areas to improve stream health and water quality. Overall, the data will provide a baseline for future assessments, monitoring how effective the Watershed Management Plan has been, how effective Charlotte Mecklenburg stream buffer ordinances have been over the last six years, and what adjustments need to be made to protect and enhance tree canopy at the subwatershed scale like McDowell Creek.

Goose Creek Subwatershed

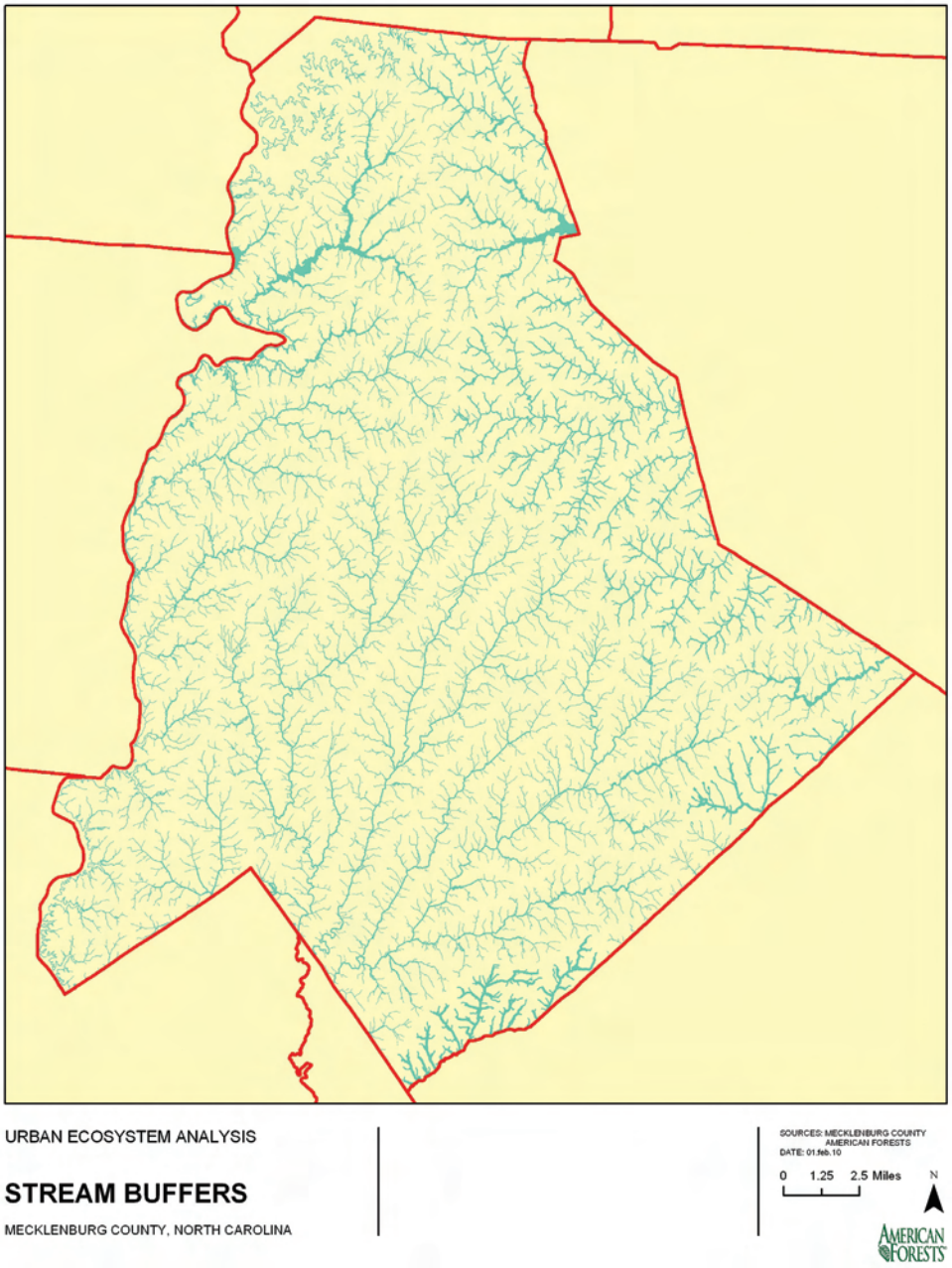
The Mecklenburg County portion of the Goose Creek Subwatershed is comprised of 7,161 acres of land of which 61% is currently tree canopy. In 2008, tree canopy provided 39 million cubic feet in stormwater management services, valued at $77 million (Table 4). The U.S. Fish and Wildlife Service designated Goose Creek as habitat for a federally-endangered species of fresh water mussel called the Carolina Heelsplitter. The Heelsplitter is an indicator species, known for its sensitivity to water pollution. Mussels need cool, clean, well-oxygenated water, typically found in stable creeks with stable banks to survive.

Goose Creek is currently listed as an impaired stream under criteria established by the Clean Water Act; the main cause of impairment is non-point source pollutants. Mecklenburg County and the Towns of Mint Hill, Stallings and Indian Trail, in accordance with State and Federal laws, have implemented the Goose Creek Water Quality Recovery Program to improve water quality conditions in Goose Creek in an effort to protect the Carolina Heelsplitter. Planting and maintaining existing vegetation in buffer areas that line creek banks is the best way to stabilize them.[13]

Stream Buffers

Mecklenburg County has 32,000 acres of stream buffers.[14] With 22,600 acres (71%) of tree canopy, this extensive network currently provides 177 million cubic feet of stormwater management, valued at $354 million (Table 4). The County has measured the pollutant removal benefits that riparian buffers naturally achieve by diffusing stormwater runoff–specifically removing 30% Nitrogen, 30% Phosphorus, and 85% of Suspended Solids (Diffuse Flow Requirement 15A NCAC 2B.0233(5)). Additional land cover analyses of watersheds throughout Charlotte Mecklenburg, like those completed here for Goose Creek and McDowell Creek can support local efforts to protect the entire stream network. Reforestation can reduce stormwater runoff into the streams, reduce pollutant loading now occurring in the streams, improve air quality and provide habitat for wildlife. County and citizen tree planting partnerships can significantly reduce the cost of reforestation and enhance this valuable resource that contributes to water quality without costly constructed infrastructure (see Implementation Recommendations pg. 14).

Figure 6. Mecklenburg County's Network of Forested Stream Buffers



Species diversity is an indicator of ecological health. The Piedmont Crescent region of the Southeast United States is recognized as *globally outstanding* by the World Wildlife Fund in *Terrestrial Ecosystems of North America*, (Island Press, 1999). As described in this report, the protection of the Carolina Heelsplitter in Goose Creek begs a broader question, why does species diversity matter? Humans thrive at the top of the food chain because a diverse set of species exists below them. What may seem to be an obscure species in a stream or woodland plays an important role in the conversion of energy and nutrients within the natural system so that people have the air, water and nutrients they need to thrive.

Implementation Recommendations

The digital data set included in this project is packaged into GIS interactive data layers compatible with existing GIS data so that Charlotte Mecklenburg staff and local leaders can use it to make well-informed planning decisions. American Forests recommends the following actions to better integrate green infrastructure into local decision making.

Use the green data layer and CITYgreen software to calculate the ecosystem services provided by existing tree programs

- Share the green data layer provided with this project among County and City departments concerned with ecosystem services.
- Test the impacts of changing tree canopy, impervious surfaces, and other land covers under different development scenarios. Using the high resolution data, analyses can be conducted on a neighborhood, subwatershed, or citywide scale.

Plan and establish tree canopy goals

American Forests recommends that Mecklenburg County adopt an overall 50%-55% tree canopy goal. This revised goal from the previous UEA responds to the continuing Countywide tree canopy decline trend, especially in critical watershed areas. Increasing canopy to the higher end of this range in key areas will have the most beneficial impact. Since the County is currently at the bottom of this recommended goal, this requires developing no net loss of canopy strategies for future development. This can be accomplished if Charlotte Mecklenburg will:

- Integrate these new land cover data into Charlotte Mecklenburg's planning processes so that impacts from future growth and development can be anticipated and managed to preserve canopy wherever possible. Where this is not possible, establish a tree replacement fee to plant trees elsewhere in the County.
- Conduct additional and more detailed analysis of the community's natural assets using CITYgreen software with consideration with the community's land use plans, zoning categories, transportation plans, etc.
- Use this additional analysis to guide the community in establishing tree canopy goals that can be attained within various zoning categories and key watershed areas as it continues to develop.
- Budget adequately to both maintain existing canopy and to plant trees throughout Charlotte Mecklenburg on a continuing basis until a suitable and sustainable level of tree canopy is achieved.

Use green data layer data to identify critical areas for reforestation

- Conduct additional UEAs to focus reforestation efforts on critical areas such as riparian stream buffers within McDowell Creek Subwatershed and the Goose Creek Subwatershed.

Use the findings from the Urban Ecosystem Analysis to increase awareness of the relationship between trees and environmental quality and to engage citizens in environmental improvement efforts like tree planting.

- Communicate the findings to media.
- Incorporate findings from the UEA into active citizen programs:
  - The Creek ReLeaf ® Program is a collaborative effort of the Charlotte Public Tree Fund, Charlotte Mecklenburg Stormwater Services, the Center for Sustainability at Central Piedmont Community College, and the Sierra Club Central Piedmont Group. Dedicated volunteers and financial supporters plant trees in riparian areas (floodplain and stream buffers) of Mecklenburg County. Visit: http://www.charlottetreefund.org/?page_id=20
  - Big Sweep is an award–winning grassroots nonprofit organization whose mission is a litter–free environment. They conduct year-round education to prevent litter and coordinate the annual North Carolina Big Sweep, to clean up statewide land and waterways. Visit: http://www.ncbigsweep.org/
  - Trees for Change is a collaborative program of the Charlotte Public Tree Fund and the Charlotte Tree Advisory Commission that educates local school children on the value of trees and then engages the students in a tree planting program either at their school or elsewhere in the community. Visit: http://www.charlottetreefund.org/?page_id=22
- Incorporate CITYgreen schools program into public schools to increase awareness of environmental issues, by teaching practical applications of GIS, math, science and geography. Curriculum is available through American Forests' Urban Ecosystem Center.

About the Urban Ecosystem Analysis

American Forests Urban Ecosystem Analysis is based on the assessment of "ecological structures"—unique combinations of landuse and land cover patterns. Each combination performs ecological functions differently and is therefore assigned a different value. For example, a site with greater tree canopy provides more stormwater reduction benefits than one with less tree canopy and more impervious surface.

Data Used

Landsat (30 meter pixel resolution) Imagery: To keep current with rapidly changing Geographic Information Systems (GIS) technology, American Forests calibrated land cover change for this UEA report based on the US Geological Survey (USGS) 2001 National Land cover Dataset (NLCD). The USGS's NLCD data set is now the standard for Landsat-derived land cover change analysis and was used to classify the imagery of Mecklenburg County for 1985 and 2008. This enabled very accurate comparison trends of the landcover data for these years to determine changes that occurred. Imagery from 1985 and 2008 also aligned almost perfectly, further increasing the accuracy of landcover change calculations. This approach also enables comparisons of this data to data collected in the future more reliable.

Unfortunately, the NLCD was not available when American Forests completed the previous UEA and this is but the first reason comparisons between the Landsat data from two UEAs should not be made. Second, the previous UEA reported landcover change for trees, open space and impervious surfaces (buildings, roads, and parking lots primarily). Since then, the Multi Resolution Land (MLRC) consortium redefined urban land cover and this broader category, as used in the new UEA, now includes not only impervious cover but adds landcover such as compacted gravel. Third, the time periods differ–1984 to 2001 in the earlier UEA and 1985 and 2008 in the current. Fourth, changes to both boundaries and acreage for Charlotte and Mecklenburg County have occurred since the previous UEA was completed. During this time period, Mecklenburg County lost 2,352 acres and Charlotte gained 28,336 acres of land.

To summarize, the Landsat data and landcover change trends from the previous UEA report are accurate and were based upon the best technology available at that time, they cannot however be reliably compared to the calculations based upon Landsat data in this new UEA for the reasons described.

NAIP High Resolution (1 meter pixel resolution) Imagery: For the high resolution imagery, Mecklenburg County acquired National Agriculture Imagery Program (NAIP) 1-meter pixel resolution, 4-band, multi-spectral satellite imagery in 2008. American Forests conducted a knowledge-based classification of this imagery to divide the land cover into five land cover categories: trees, open space, urban, bare soil, and water. The high resolution data was resampled to 4 meter, a size suitable for running ArcGIS to conduct these analyses. The classified data set provided with this project is at 1-meter. Although USGS redefined urban landcover as mentioned above, comparisons of the high resolution data from 2002 and 2008 for tree canopy are still valuable and instructive to indicate trends.

Analysis Formulas

Urban Ecosystem Analyses were conducted using American Forests' CITYgreen software®. CITYgreen for ArcGIS calculates the value of green infrastructure. Data inputs include rainfall, soil types and remotely sensed imagery. These data are used to populate scientific and engineering formulas so calculations of ecosystem services can be performed.

TR-55 for Stormwater Runoff: The CITYgreen stormwater analysis estimates the amount of stormwater that runs off a land area during a major storm. The stormwater runoff calculations incorporate volume of runoff formulas from the Urban Hydrology of Small Watersheds model (TR-55) developed by the U.S. Natural Resources Conservation Service (NRCS), formerly known as the U.S. 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.

The City of Charlotte staff provided a local average $2 per cubic foot dollar value for the CITYgreen stormwater calculations based on North Carolina State University study for wet ponds (2003) http://www.bae.ncsu.edu/stormwater/PublicationFiles/BMPCost&Benefit2003.pdf. This value was used in all the stormwater analyses. However, it is important to note that American Forests' Urban Ecosystem Center has worked with the retired national hydrologist of the National Soil Conservation Service and dozens of metropolitan areas around the country to determine the value per cubic foot and in many cases this value is significantly higher, in the range of $6 per cubic foot. It is therefore important that each community determine its own values to accurately calculate the stormwater benefits it would realize from its tree canopy.

L-THIA for Water Quality: Using values from the U.S. Environmental Protection Agency (EPA) and Purdue University's Long-Term Hydrological Impact Assessment (L-THIA) spreadsheet water quality model, the Natural Resources Conservation Service (NRCS) developed the CITYgreen water quality model. This model estimates the change in the concentration of the pollutants in runoff during a typical storm event given the change in the land cover from existing trees to a no tree condition. This model estimates the event mean concentrations of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD). Pollutant values are shown as a percentage of change.

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 and particulate matter less than 10 microns are absorbed and filtered by tree canopies. The urban forest effects (UFORE) model is based on data collected in 55 U.S. 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. The UFORE model also estimates the carbon storage capacity and the annual amount of carbon sequestered by the tree canopy in a given area.

Acknowledgements for this Study
We gratefully acknowledge the support of the following in conducting this study:

Donors:
Women's Impact Fund
City of Charlotte
Mecklenburg County
Blumenthal Foundation

Special thanks to:
Curt Walton, Charlotte City Manager
City of Charlotte Urban Forestry Staff, especially Tom Johnson
Mecklenburg County Stormwater Staff, David Kroening, Water Quality Manager
Mecklenburg County Mapping and Andy Goretti, Division Manager
Rick Roti, Project Consultant

For More Information
AMERICAN FORESTS, founded in 1875, is the oldest national nonprofit citizen conservation organization. Its three centers—Global ReLeaf, Urban Ecosystem Center, and Forest Policy Center—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, teacher workshops and technical support for CITYgreen and is a certified ESRI developer and reseller of ArcGIS products.

AMERICAN FORESTS, P.O. Box 2000, Washington D.C. 20013
Phone: 202/737-1944; Fax: 202/737-2457
Web: www.americanforests.org

Footnotes

1 UEA reports are available for download at: http://www.americanforests.org/resources/urbanforests/analysis.php

2 Source of unit cost: City of Charlotte

3 Green infrastructure is defined by pervious land cover, such as tree canopy, open space and other vegetated areas.

4 High resolution data (1meter pixel resolution) is used for day to day management decisions of smaller land areas such as subwatersheds, zoning categories, and stream buffers.

5 Based on a straight line projection of the two most recent data points (2001and 2008) assuming that all landcover trends continue.

6 Due to an update of land cover classification methodologies set by the Multi Resolution Land (MLRC) consortium and adopted as the national standard, land cover changes from previous Urban Ecosystem Analyses can not be compared with this one (see Data Used pg 15 for more information.)

7 2008 State of the Environment Report, Mecklenburg County, pg. 20 http://www.charmeck.org/Departments/LUESA/SOER+2008.htm)

8 Urban smog control: A new role for trees? http://findarticles.com/p/articles/mi_m1200/is_n1_v138/ai_9177813/pg_2/?tag=content;col1

9 American Forests' Urban Ecosystem Center is staffed with experts in ecological systems, image analysis, and Geographic Information System technology.

10 Michael Gallis and Associates is nationally recognized for its expertise on the Human Network and is located in the Charlotte region.

11 The Piedmont Crescent Report is available from American Forests upon request 202-737-1944

12 The Piedmont Crescent region of the Southeast United States is recognized as globally outstanding by the World Wildlife Fund in Terrestrial Ecosystems of North America, (Island Press, 1999).

13 http://stormwater.charmeck.org; select "Pollution Prevention"

14 Buffer width varies from 0-200 ft dependent on several criteria. First, buffer widths were determined from various ordinances (Watershed Protection Ordinance, SWIM Buffers and Post Construction Buffers); the most stringent was applied. Second, each of the ordinances have different applicability requirements (such as impervious triggers) and timeframe during which the ordinance was in place (e.g. SWIM was overtaken by Post Construction 2 years ago). Lastly, the starting point on the stream of the Post Construction Buffers is established in the field.