

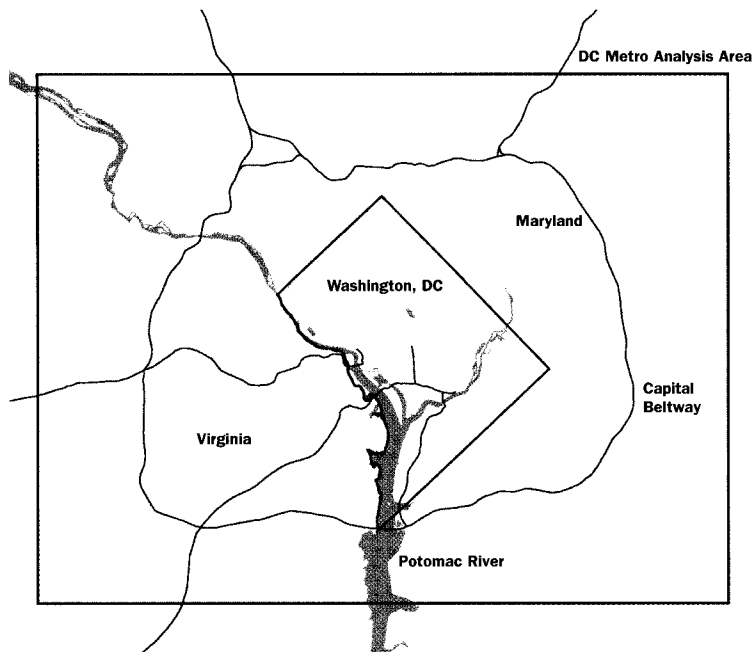
February 2002

Urban Ecosystem Analysis for the Washington DC Metropolitan Area

An Assessment of Existing Conditions and a Resource for Local Action

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ZONING COMMISSION
District of Columbia

Case 02-19

Exhibit 225

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Overview

AMERICAN FORESTS conducted an urban ecosystem analysis of 636 square miles of the Washington DC metropolitan area to build a “green infrastructure” data layer for use in community planning and development. The data was assembled using remote sensing images and data collected by satellite in the summer of 2001. The study produced detailed and reliable information about the region’s landcover features, especially its tree cover. Local agencies and groups can use the data for daily decision making. The community’s tree cover can be evaluated in budgetary as well as environmental terms.

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 are 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.

The data collected are unique because they contain both green infrastructure—areas covered with trees, shrubs, and grass and gray infrastructure—areas covered by buildings, roads, utilities, and parking lots. While municipalities commonly use geographic information systems (GIS) to map and analyze their gray infrastructure, they typically do not integrate trees and

other elements of the green infrastructure into their day-to-day planning and decision making processes. Reasons for this include 1) the lack of understanding of the ecological and economic value of trees and other environmental features, and 2) the absence of a means to readily use this information in commonly-used GIS systems.

This study addresses both of these impediments. Data documenting the environmental characteristics of trees are now available thanks to research from the U.S. Forest Service and the Natural Resources Conservation Service. This report describes how an accurate green data layer can be produced for a community’s GIS systems. Today we have a clear understanding of the active role trees play improving our urban environment. Those working in planning, urban forestry and related natural resource issues can now readily calculate the dollar value of these ecological benefits in their communities using CITYgreen software and these data.

When a community recognizes the value of its green infrastructure it starts a process that leads to a better, more cost effective community. Since communities are in a constant state of change, combining green and gray data is an essential element for building better communities. This report provides valuable information for improving the environment in the Washington, DC metropolitan area today, but it should also be used as a model for other communities to follow tomorrow.

Gray and Green Infrastructure

A planimetric map of a Washington DC neighborhood shows a neighborhood’s gray infrastructure including buildings and roads (left). Classified high-resolution satellite imagery, created for the District’s GIS, adds a green infrastructure data layer (right), with its associated environmental benefits, to use in planning decisions.



Creating A Green Infrastructure Layer

Adding a green infrastructure data layer to the 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, water and energy systems. By developing and using a green layer future decisions will include better information about the full range of community resources.

The first step in creating a green data layer for use in GIS is to acquire landcover data from satellites or specially equipped airplanes. The data are acquired during the growing season, when the leaves are on the trees. Specialists classify the images into useable data. They analyze the images to determine the different landcover types—areas covered in trees, grass, or open space can be distinguished from parking lots, building and roads. This analysis produces a green infrastructure data layer (see planimetric map, page 2) that can be added to the gray infrastructure which is commonly used in GIS for local planning.

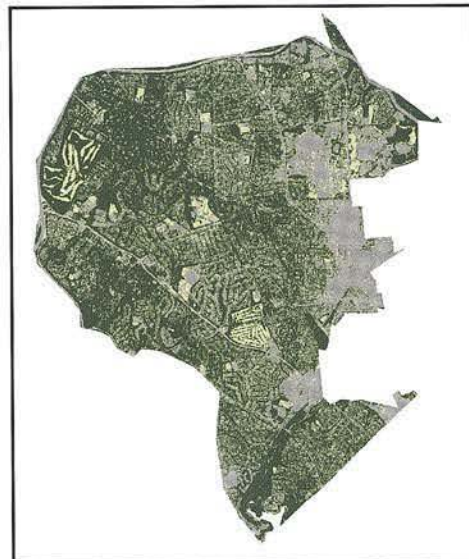
Adding a green data layer to a community's infrastructure pays big dividends. Trees reduce pollution and erosion from stormwater by slowing it and by reducing its peak flow, and they improve air quality by filtering pollutants from the air. The stormwater control value of an area's trees, for example, can be calculated using the green data layer. Thus, the greater the canopy coverage and the less impervious surface, the more environmental benefits. Communities can then devise strategies to increase tree cover and recognize their environmental benefits and management cost savings.

Findings for the Washington DC Metro Area

For the Washington, DC Metropolitan area, AMERICAN FORESTS used high-resolution (4 meter multispectral and 1 meter panchromatic) satellite imagery. From this data, AMERICAN FORESTS calculated stormwater runoff and air quality benefits for 102 Metro DC communities. The data shows that the tree cover varies from a high 72 percent canopy density in rural Mantua to a low 9 percent canopy in the very urbanized Friendship Village. While this study presents some overall findings, the real value of this project is to show how local communities can apply the data to their specific issues (see examples on pages 10-11). Building a tree canopy into communities is important for improving air and water quality as well as reducing management costs. Some highlights of the findings are presented below. A summary table of the data and findings from selected communities surveyed appears on page 14. See our website www.americanforests.org for a complete listing.

Bethesda Tree Cover

A classified high resolution satellite image of Bethesda, MD shows the land cover features needed to calculate air and stormwater benefits. Dark green represents tree cover, light green represents grass and open space, and gray designates impervious surface.



The Metro DC area's urban forest provides ecological benefits for managing stormwater and mitigating air pollution.

- The region is comprised of 187,767 acres of tree canopy (46%), 110,300 acres of impervious surfaces (27%), 70,747 acres of open space (17%), 27,072 acres of bare soil area (7%), and 11,036 acres of water (3%).
- The total stormwater retention capacity of the urban forest on these lands is 949 million cubic feet in avoided storage of water and is valued at \$4.7 billion (based on construction costs estimated at \$5 per cubic foot to build equivalent retention facilities).
- The urban forest provides air quality benefits by removing nitrogen dioxide, sulfur dioxide, carbon monoxide ozone and particulate matter 10 microns or less. The Metro DC area's urban forest removes 20 million pounds of pollutants from the air each year, a benefit worth \$49.8 million annually.

Within many of the 102 communities included in this data set, tree cover is low and local jurisdictions could benefit financially in terms of stormwater management and, air quality if their tree cover were increased.

- Within the 57 square mile area under the District of Columbia's jurisdiction, 46 percent is impervious, 22 percent is tree covered and 19 percent is open space (about 13 percent remains in other categories).
- Tyson's Corner, Virginia, a 3,164 acre jurisdiction with significant commercial property, has only a 29 percent tree cover with 53 percent impervious surface.
- Bladensburg, Maryland, one of the oldest communities in the region and at the head of the tidal portion of the Anacostia River, contains 25 percent tree canopy and 43 percent impervious cover over its 639 acres.

Regional Ecosystem Analysis

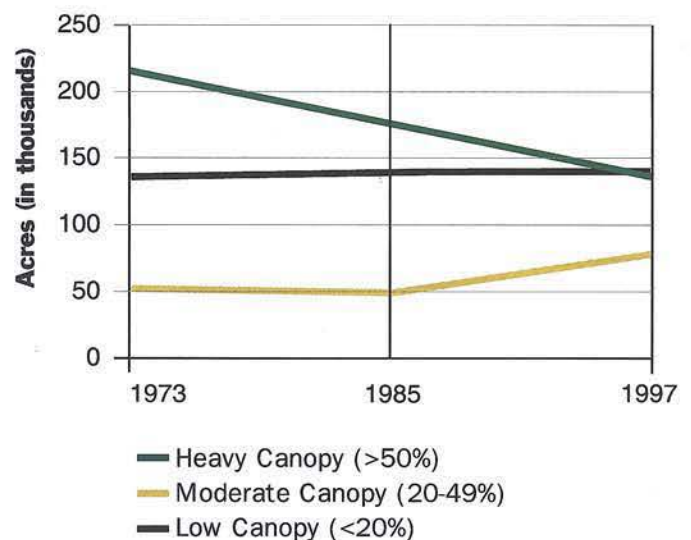


Lessons from Landsat

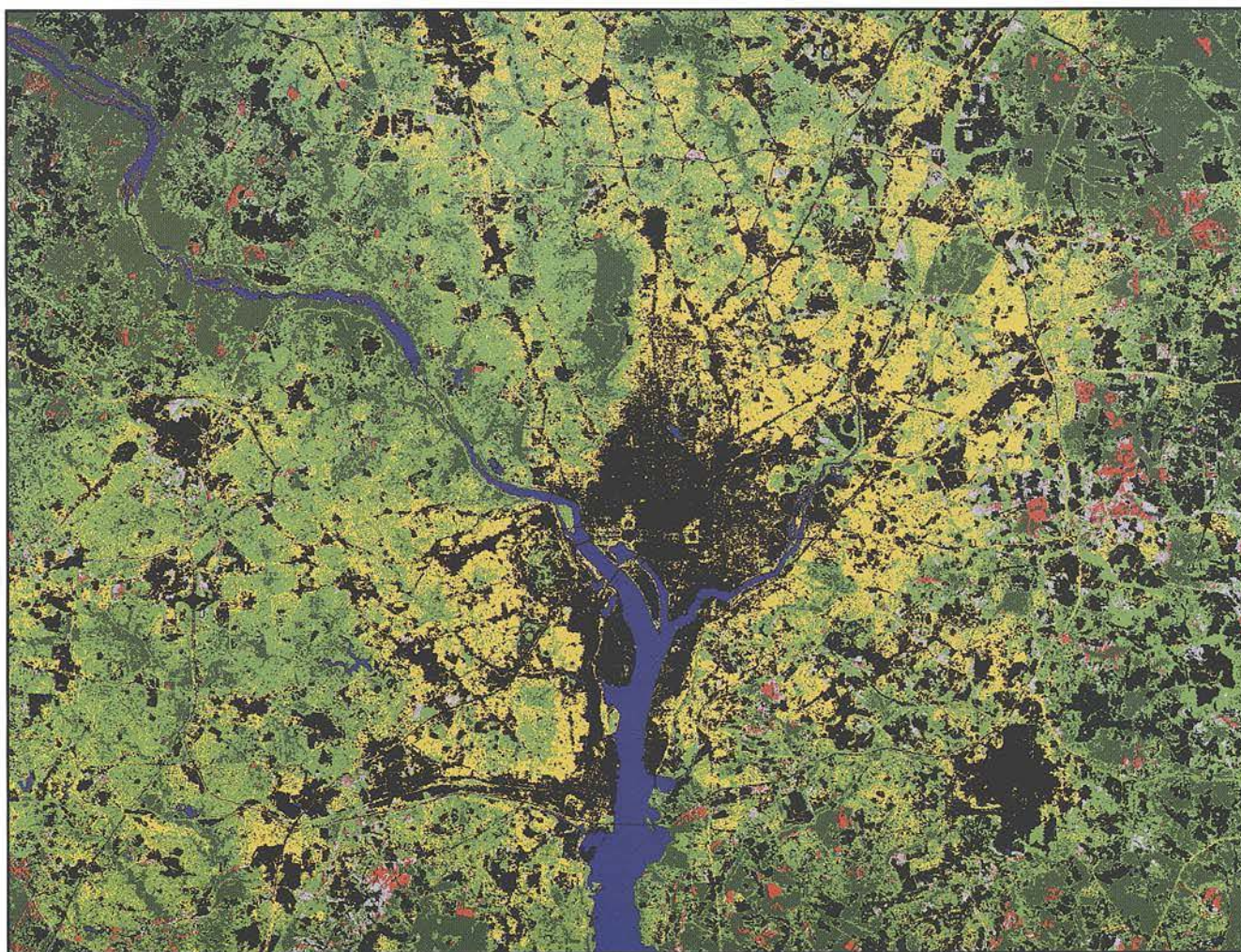
Landsat satellites have been in orbit around the Earth since 1972 and data from them allow us to look at changes in land-cover over time. AMERICAN FORESTS conducted a Regional Ecosystem Analysis of tree cover using three carefully selected Landsat images from the years 1972, 1985 and 1997 to determine how the vegetation has changed in the Washington DC Metro area over time. We found that heavy tree cover has declined more than 30 percent (green areas) while the low canopy areas (black) have increased by more than 20 percent. This trend was even more pronounced within the District of Columbia.

The Landsat images provide valuable public policy information showing general trends, but do not provide the high resolution data required for local planning and management activities. High resolution satellite imagery, that only recently has become available for public use, produces a 4 meter or better multispectral image. This finer resolution is needed to see individual trees having a 13.5 foot or larger canopy spread. AMERICAN FORESTS designated this canopy spread as the "average urban tree".

Tree Cover Change
in Washington, DC Metro Area



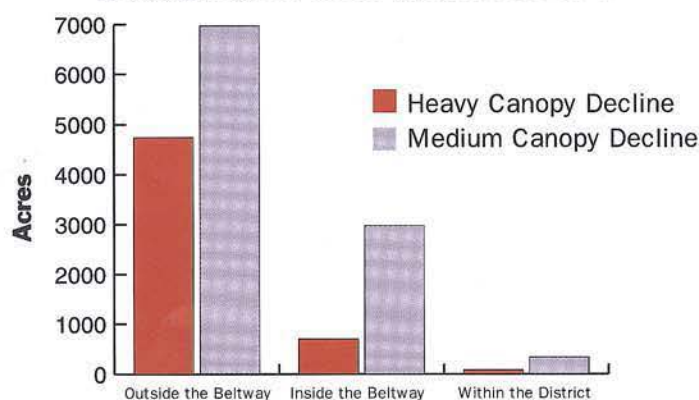
Washington DC Metro Area Land Cover Showing Tree Loss Hot Spots 1985-1997



Classified 1985 Landsat TM Data	Areas of Forest Decline by 1997
Heavy Canopy Forest	Heavy Canopy Forest
Medium Canopy Forest	Medium Canopy Forest
Low Canopy Forest	
Area Without Trees	

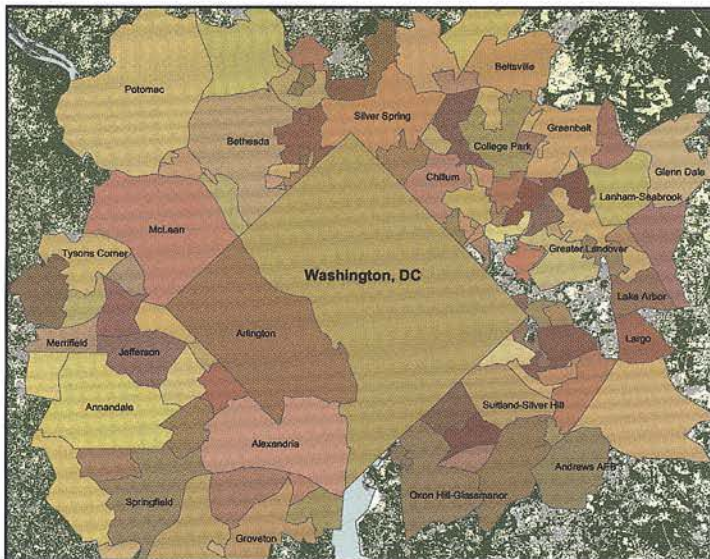
Additional analysis of the Landsat satellite data can provide valuable land use planning information along with showing areas of tree loss. The image above shows the results of a "change detection" analysis between 1985 and 1997. The change detection results were draped over the 1985 Landsat classified image. The red areas show where the greatest rates of tree loss have occurred and indicate where urban sprawl has been the most pronounced. Notice that most of the heavy tree canopy loss occurred outside the beltway.

Distribution of Tree Canopy Loss
Washington, DC Metro Area 1985-1987



The greatest loss of tree canopy cover is most apparent outside the beltway, where most development occurs. Heavy tree canopy cover is considered 50% or greater density; medium tree cover is less than 50% density.

Building A Green Data Layer



Community Scale

DC Metro Area

The data are now available to the 102 communities that fall within the project study area. At the community scale, local decision makers must grapple with managing stormwater runoff, and comply with state and federal clean air and water requirements. Public agencies and jurisdictions spend tremendous amounts of money installing and maintaining stormwater management systems and repairing damage from flooding. Polluted runoff has recently been identified as the most difficult pollution problem to solve in the Chesapeake Bay watershed. Communities that cannot meet EPA attainment levels for air and water quality also jeopardize federal funding for capital improvements. Decision makers can use a green infrastructure data layer to integrate trees and other vegetation into community-wide planning, thus improving environmental quality.



Neighborhood Scale

Washington DC's Ward 1

When the data are considered at the neighborhood scale, specific tree canopy goals can be set along with other land use goals. The information can be used to help city governments establish priorities and achieve the most impact given available funding. In the commercially zoned areas of Ward 1 in Washington, DC, outlined here in red, tree cover is just 3 percent. Increasing the cover to 15 percent will result in more than \$300,000 in stormwater management and air quality benefits.



Project Scale

Kalorama Road

This is an aerial image (2 foot resolution) with a high resolution image (4 meter pixel resolution) of tree cover laid over the top. When new development or road widening projects are planned, agency personnel need to consider how existing and new trees fit into the plan. Will large trees suffer severe damage from new construction? Using the green infrastructure data layer in combination with the gray layer makes this planning easier. It also shows the importance assigned to trees as a community asset. Local ordinances, like the District's proposed *Urban Forestry Preservation Act of 2001*, create mechanisms to ensure that canopy goals are set and achieved. For neighborhood residents and visitors, trees are a welcome addition providing summer shade and saving energy.

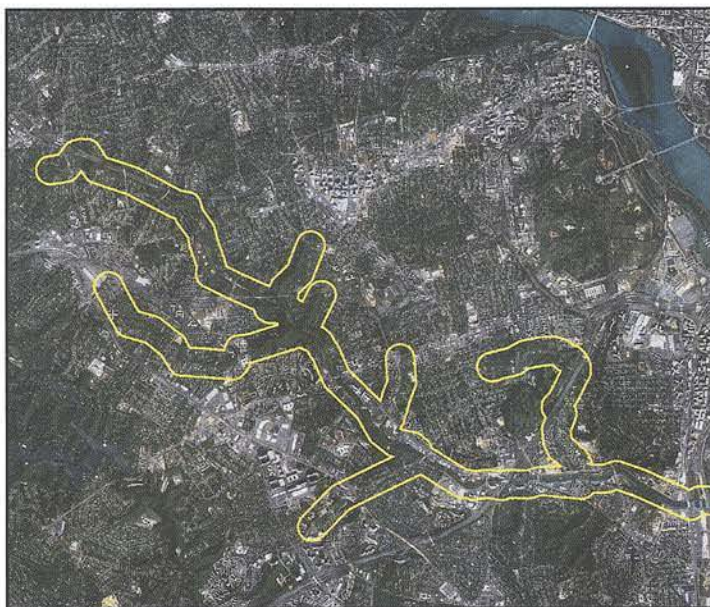
More than what meets the eye

At first glance many of the images here and throughout this report appear to be high resolution photographs. They really aren't. These images have been digitally assembled from large amounts of spatial and spectral data tied to various land characteristics. The images represent far more than the colors seen here; they contain a wealth of data from which tree cover and its benefits can be analyzed.

Communities can use this data along with CITYgreen software, to evaluate the environmental benefits and impacts of various growth, development, or management scenarios, including the benefits of strategic tree planting and maintenance programs. The data layer can be subdivided to fit any political or natural boundary of interest within the study area. Each scale of analysis can address different local issues.

Ecological Boundaries

A logical approach to tackling natural resource issues is to identify ecological boundaries and set tree cover goals for naturally-occurring land features. Most environmental issues such as reducing stormwater runoff, protecting water and air quality, and preserving wildlife habitat and open space cross political boundaries. The green data layer can be analyzed using ecological boundaries and can form the basis for more effective regional cooperation.



Stream Buffers

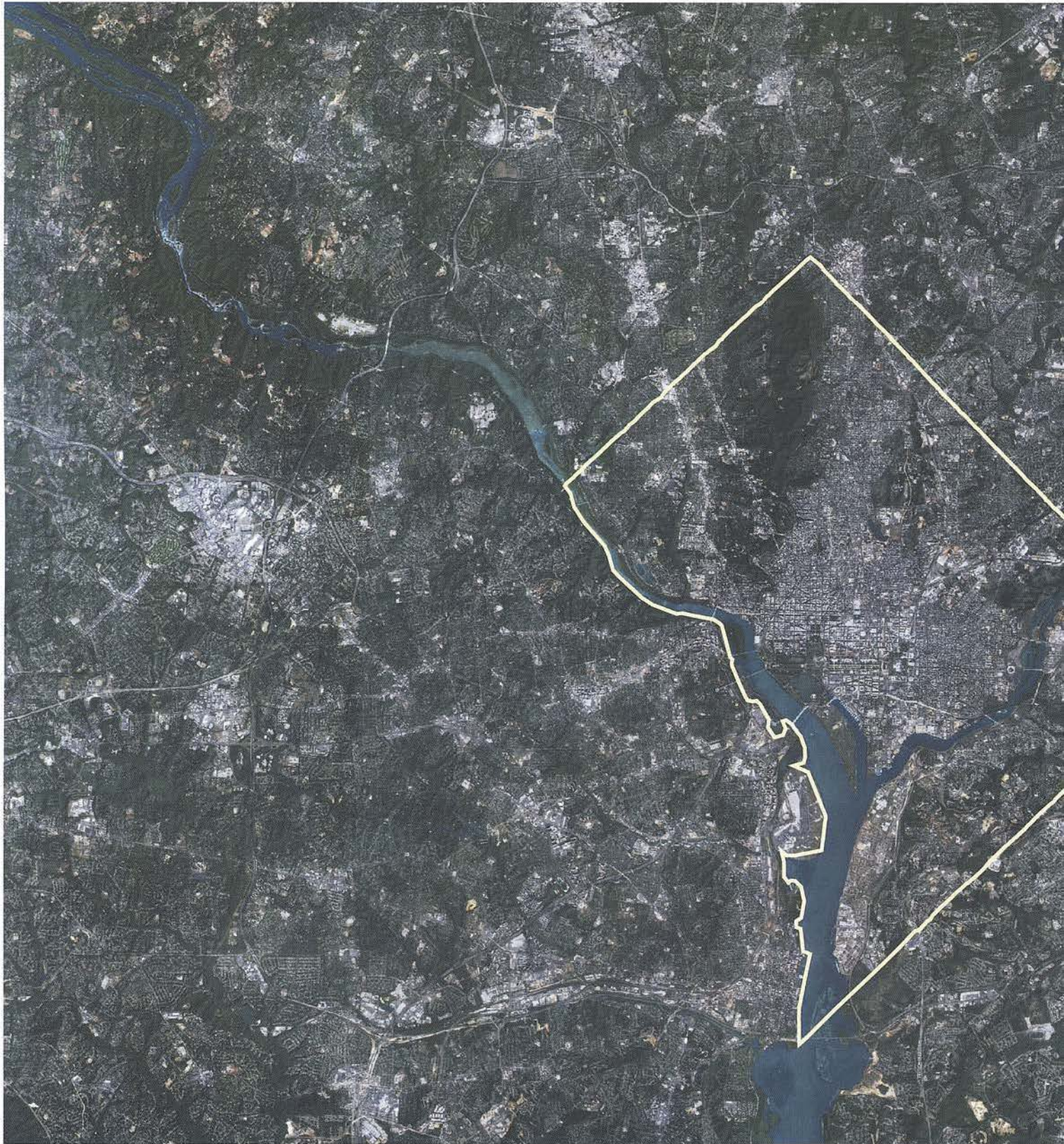
Streamside vegetation naturally filters out sediment and other pollutants from runoff before it enters a waterway. Shade from streamside trees is also critical to prevent dramatic increases in water temperatures that are lethal to fish and other aquatic life. Protecting and expanding these buffers is an important and cost effective way to improve the health of our streams and waterways. In the Four Mile Run watershed, a 400 meter wide area covers 2,400 acres. Less than half of this (46 percent) is tree covered. Impervious surfaces cover 33 percent of the buffer while 13 percent is open space. The current value of the existing trees in the buffer just to reduce and slow runoff is almost \$4 million.



Watershed Scale

On a watershed or sub watershed scale, such as the District's lower Anacostia River watershed, an analysis determined that 44 percent of the area is covered with impervious surfaces, 28 percent is tree covered and 26 percent is open space. The value of the green infrastructure is a total savings of \$13.5 million for stormwater control and \$800,000 in air pollution mitigation annually.

Washington DC Metro Area Tree Cover



In this view of Washington
a classified treecover data la



Using high resolution satellite imagery collected in the summer of 2001, AMERICAN FORESTS analyzed tree cover and created a green infrastructure layer for a 636 square mile area, expanding beyond the beltway. The data layer can be subdivided to fit any political or natural boundary of interest within the study area. Overall, the Metro Area tree cover currently provides \$4.7 billion in stormwater benefits and \$49 million in air pollution removal annually.



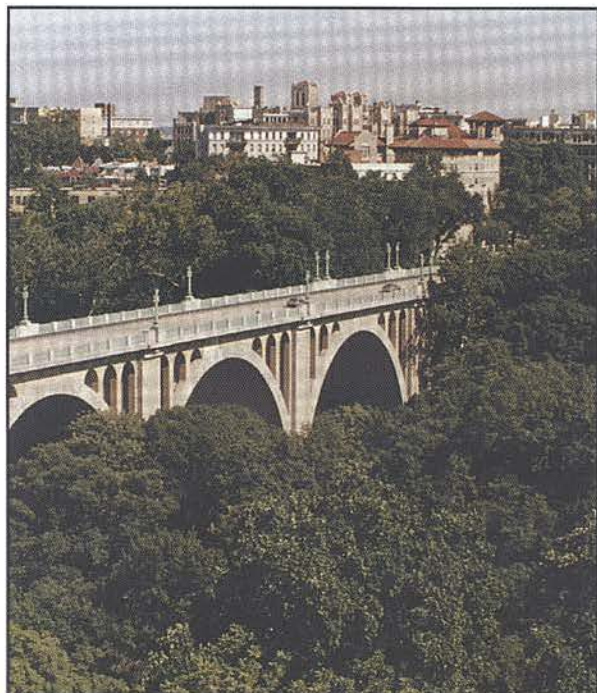
For more information: www.americanforests.org

Project Partners: USDA Forest Service, Casey Trees Endowment Fund, and National Capital Planning Commission

Green Data Layer Applied To Local Issues

Rock Creek Park

When tree cover dominates the landcover of an urban environment as it does along the Rock Creek Greenway, the trees are a much more important factor in controlling stormwater and improving air and water quality.



Michael Temchine



Four Mile Run Watershed

Urban watersheds, especially small ones in heavily populated areas have dramatically changed over the past 200 years. The Four Mile Run watershed that empties into the Potomac just south of National Airport covers over 13,100 acres. Today 40 percent of it is tree covered and 39 percent has been paved or built over with impermeable surfaces and many of its smaller tributaries are now in pipes underground. Local agencies and community groups are cleaning up Four Mile Run, using techniques like green infrastructure to mitigate urban pollutants.

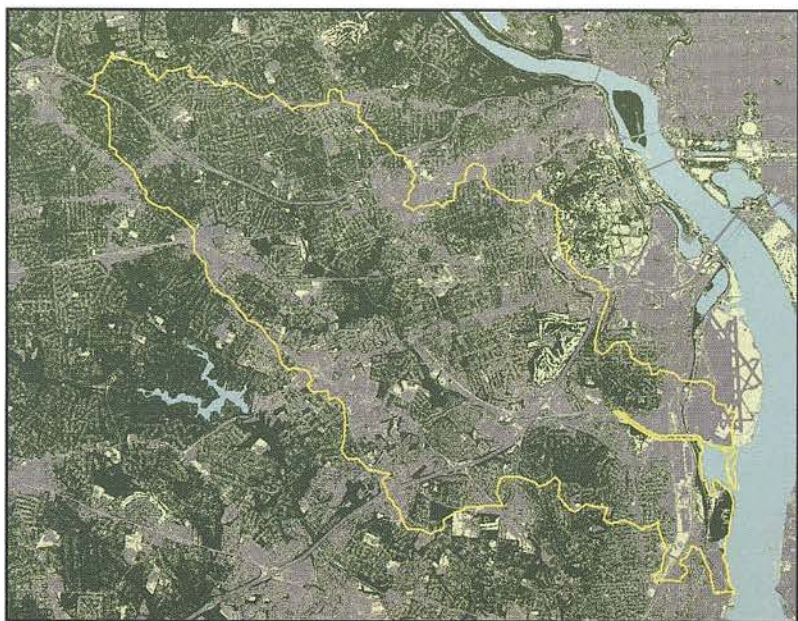




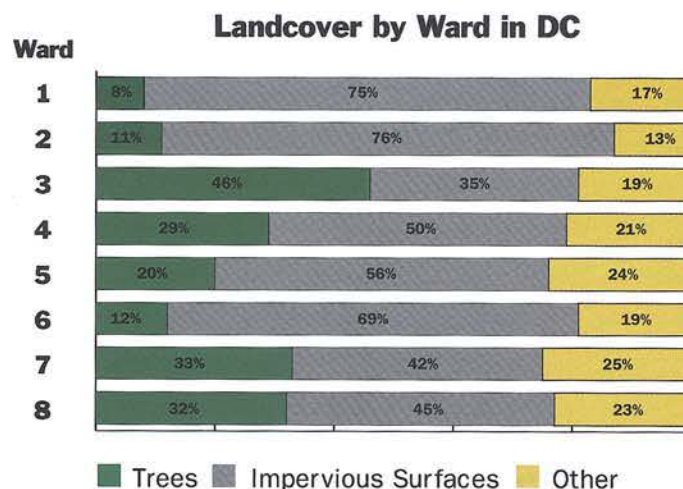
Image Classification

Compare this image to the one on pages 8–9. In this image, GIS analysts have categorized the detailed characteristics of reflected light (spectral analysis) and surface structures (spatial analysis) to create a gray and green “classified” image. Tree cover is represented in green and impervious urban surface in gray. Communities can use this data layer to tackle their local urban forestry issues.



Residential Neighborhoods

This lush residential neighborhood in Ward 3 of Washington DC has a 62 percent tree cover and 25 percent impervious surface. The District’s challenge is to maintain this high level of tree cover on public and private property in the midst of larger infill development that erodes available open space—space needed to grow large, healthy trees.



Arlington County

AMERICAN FORESTS’ study showing a decline in tree canopy and lost environmental benefits convinced Arlington’s County Board Chairman to invest in and improve the County’s urban forest. The County’s new comprehensive approach includes updating site plan review to encourage developers to plant and preserve trees, adding shade trees to public streets, redesigning streets to maximize trees’ growth potential, and encouraging homeowners to plant and care for trees on private property.

Table 1. The District of Columbia Wards’ Ecological Benefits of Green Infrastructure

Ward	Air Pollution Lbs. Removed	Air Pollution Value	Retention Volume Required to Mitigate Loss of Trees	Stormwater Control Value
1	14,204.09	\$35,054	2,208,950	\$4,417,900
2	33,605.27	\$82,934	4,703,286	\$9,406,572
3	276,425.29	\$682,183	14,052,955	\$28,105,910
4	140,851.04	\$347,603	7,793,427	\$15,586,854
5	117,132.90	\$289,069	8,383,417	\$16,766,834
6	33,520.12	\$82,723	3,571,973	\$7,143,946
7	149,952.95	\$370,065	7,669,123	\$15,338,246
8	113,996.83	\$281,330	5,584,479	\$11,168,958

Benefits of Urban Forests

Trees as Indicators of a Community's Ecological Health

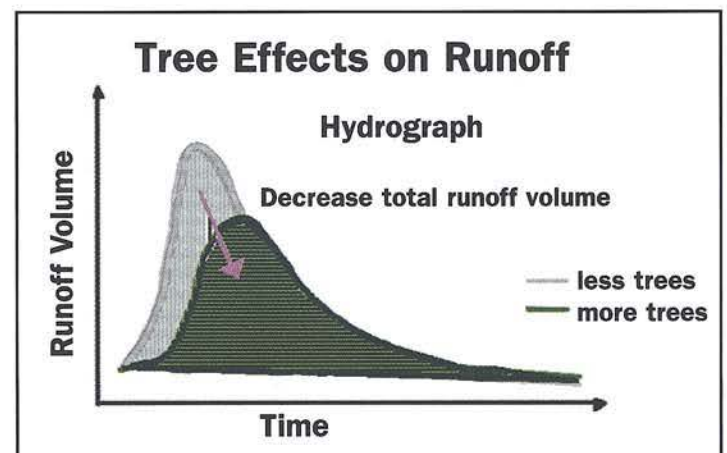
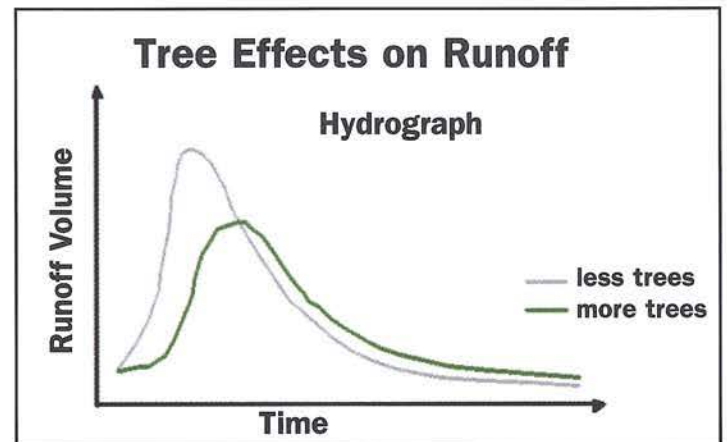
Urban ecology is more complex than tree cover. Trees, which make up the majority of the green in the green infrastructure, are good indicators of the health of an urban ecosystem. When trees are large and healthy, the ecological systems that support them including soils, air and water systems are also healthy. In turn, healthy trees provide valuable environmental benefits. There is a large difference in the ecological health and characteristics of areas within this region that have more tree cover than other areas. Comparing the amount of tree cover to impervious surface cover is another important indicator. The greater the canopy coverage, the less the impervious surface there is and the more environmental benefits.

Trees provide communities with many important benefits, not all of which can be measured in terms of dollar value. This report focuses on just two of the benefits that can be calculated for their “bottom line” contributions: stormwater management and improving air quality.

AMERICAN FORESTS developed CITYgreen software so that communities can quantify how the structure of the landscape affects its function. This tool connects research and engineering formulas to place a dollar value on the work that trees do. With CITYgreen, it is possible to determine how various canopy covers affect stormwater movement 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 and provides the basis for the calculations used in this study.





Air Quality

Local governments are increasingly 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 in this study is based on avoided cost 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.

In the Washington DC Metro area, the existing tree canopy reduces the need for retention structures by 949 million cubic feet. Using a \$5.00/cubic foot construction cost, trees saved the region \$4.74 billion per 30-year construction cycle.

Trees provide air quality benefits by removing pollutants such as NO₂, CO, SO₂, O₃, and PM10. 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. In the Washington DC Metro area, the trees removed 20 million pounds of pollutants, valued at \$49 million.

Stored and Sequestered Carbon

This study also analyzed the amount of carbon stored and sequestered per year. Carbon accounts for about half the dry weight of most trees. The carbon-related function of trees is measured in two ways: storage, or the amount currently stored in tree biomass, and sequestration, the rate of absorption per year. The region’s trees stored an estimated 81,000 tons. The trees sequester about 629 tons per year.

Recommendations

The Regional Ecosystem Analysis of Washington DC that AMERICAN FORESTS conducted in 1999 from Landsat satellite and aerial imagery gave us our first look at tree canopy trends over the last three decades. The message from the analysis was clear; the region had lost about 30% of its heavy tree cover, the ecology was in a state of decline and the cost of this declining natural system was costly to the residents.

From this earlier study, AMERICAN FORESTS also learned that communities need more detailed information in order to incorporate a green data layer into their decision making. Our current analysis uses high resolution imagery to do just that. This study provides a detailed assessment of the tree cover and quantifies ecological benefits for over 100 census places including the District of Columbia. The data from the analysis can and should be used by community leaders to make better landuse, development, and community management decisions. Trees are a valuable community resource and need to be incorporated into the decision making process.

The data from this analysis are available at no cost to communities who use it in conjunction with CITYgreen software for local planning and development. AMERICAN FORESTS recommends that communities establish tree canopy goals tai-

lored 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 a little different and needs to make their own decisions. 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.

Setting Tree Canopy Goals

Local communities should set specific tree cover targets for various land use areas. They should be established with an understanding of current and future ecological and land use objectives. The historic tree cover in this region, prior to intensive settlement, may have been as high as 95 percent. AMERICAN FORESTS recommends the following benchmarks as a starting point for local discussion and goal-setting:

- 40% tree canopy overall
- 50% tree canopy in suburban residential
- 25% tree canopy in urban residential
- 15% tree canopy in the central business district

Metropolitan Washington DC Communities Land Cover and Ecological Benefits

The following communities have been selected from the 102 communities within the project scope. For a complete listing of communities and their benefits, visit AMERICAN FORESTS website: www.americanforests.org.

Community	Acres	% Trees	% Urban Bare	% Impervious	% Open Space	% Water	Air Pollution Lbs. Removed	Air Pollution Value	Retention Volume Required to Mitigate Loss of Trees	Stormwater Control Value
Alexandria	9,686.50	34	6	44	14	2	352,029.86	\$868,765.83	22,280,570.00	\$44,561,140.00
Andrews AFB	4,363.41	18	7	33	41	0	84,298.44	\$208,038.06	5,832,448.00	\$11,664,896.00
Arlington	16,140.92	41	7	38	14	1	707,209.23	\$1,745,304.26	41,655,967.00	\$83,311,934.00
Bethesda	8,438.99	50	6	29	14	0	452,532.03	\$1,116,792.66	23,088,525.00	\$46,177,050.00
College Park	3,473.94	33	11	33	21	1	124,235.24	\$306,597.09	6,850,211.00	\$13,700,422.00
Falls Church	1,280.54	53	7	33	7	0	72,483.15	\$178,879.37	3,834,710.00	\$7,669,420.00
McLean	10,928.53	59	6	25	10	0	689,068.73	\$1,700,535.77	35,598,026.00	\$71,196,052.00
New Carrollton	986.49	29	13	32	26	0	30,578.24	\$75,463.29	1,819,677.00	\$3,639,354.00
Seven Corners	435.70	35	9	45	11	0	16,627.65	\$41,034.97	1,045,815.00	\$2,091,630.00
Silver Spring	6,026.70	43	5	34	18	0	281,418.89	\$694,506.75	15,632,119.00	\$31,264,238.00
Takoma Park	1,358.02	45	7	29	18	0	66,182.69	\$163,330.63	3,345,427.00	\$6,690,854.00
Tysons Corner	3,164.13	29	10	53	9	0	97,083.63	\$239,590.31	7,250,841.00	\$14,501,682.00
Vienna	2,812.37	53	10	27	9	0	160,543.26	\$396,200.77	8,246,310.00	\$16,492,620.00
Washington DC	36,542.85	22	2	46	19	11	878,157.31	\$2,167,182.83	68,763,823.00	\$137,527,646.00

About the Urban Ecosystem Analysis

Ecological Structure Classification

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 a heavy tree canopy provides more stormwater reduction benefits than one with a light tree canopy.

Data Used

For the Regional Ecosystem Analysis, 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 urban ecosystem analysis, AMERICAN FORESTS used high resolution (4 meter pixel) multispectral satellite imagery. We used 1 meter panchromatic imagery to ground truth the multispectral imagery and for presentation. AMERICAN FORESTS used a full pixel "knowledge based" classification technique to categorize different land covers such as trees, impervious surfaces, open space and water.

Analysis Formulas

A CITYgreen analysis was conducted for each of the 102 communities within the Metro DC area as well as for the area as a whole. CITYgreen version 5.0 used the raster data from the high resolution image for the analysis. The following formulas are incorporated into CITYgreen software.

Stormwater Runoff: Stormwater runoff calculations incorporate formulas from US Natural Resources Conservation Service (NRCS) Technical Release 55.(TR-55). TR-55 is a model for estimating stormwater runoff in small urban watersheds and is widely used across the country for stormwater planning and urban engineering analyses. Don Woodward, PE, a hydrologic engineer with NRCS, customized the formulas to determine the benefits of trees and other urban vegetation with respect to stormwater management. CITYgreen calculates stormwater runoff volume, peak flow and time of concentration and can model the percentage change between two landcover scenarios.

UFORE Model for Air Pollution: CITYgreen uses formulas from a model developed by David Nowak, PhD, of the U.S. Forest Service. The model estimates the amount of ozone, sulfur dioxide, nitrogen dioxide, PM10 and carbon monoxide that is deposited in tree canopies as well as the amount of carbon sequestered by trees. The Urban Forest Effects (UFORE) model is based on data collected in 50 cities in the United States. Dollar values for air pollutants are based on averaging the externality costs set by State Public Service Commissions.

Acknowledgments

We gratefully acknowledge the support of the USDA Forest Service, the Casey Trees Endowment Fund and the National Capital Planning Commission as well as our corporate partners: ESRI for GIS software, and ERDAS for remote sensing software.

For More Information Consult our Web Site

AMERICAN FORESTS, founded in 1875, is the oldest national nonprofit citizen conservation organization. We have conducted a dozen urban ecosystem analyses over the last five years. Findings from the analyses have been featured in USA Today, US News and World Report, on CNN and NPR as well as in major city newspapers in Atlanta, Denver, Seattle, Washington DC and Baltimore.

AMERICAN FORESTS developed CITYgreen software for communities to analyze the value of their 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. We offer regional training workshops and technical support for CITYgreen and are a certified ESRI developer and reseller of ArcView products.

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