May 2006

Urban Ecosystem Analysis SE Michigan and City of Detroit

Calculating the Value of Nature

Report Contents

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Project Overview

Building better communities is not just a matter of finding the right mix of land use, economics, and quality of life for its citizens. All of these essential components are built upon the existing natural systems that affect the water we drink and the air we breathe. While some may think that nature only exists outside the city, the complex interactions of our waterways, vegetation, soils and air systems are inextricably linked to the built elements of our cities. How they function greatly affects our communities and its citizens.

This project develops a digital model of the natural system that underpins the region—its green infrastructure. While tree canopy is the largest component of green infrastructure, it also includes other vegetative land cover along with its ecological interactions with soil, air, and water. The percentage of a community's tree canopy is like a barometer of how well this natural system is doing. Policies and practices that enhance or diminish green infrastructure will greatly impact a city's ability to manage its stormwater and comply with clean air and water regulations. This project provides the region with a technical analysis of landcover data and transfers the analytic capacity to use it to those working on land planning and environmental issues affecting their communities.

The natural systems in Southeast Michigan provide a solid foundation for its future growth, development and revitalization. Community leaders who embrace this natural foundation can reap considerable benefits; ignoring it is costly in terms of public expenditures to maintain built infrastructure. Weaving natural systems into the urban fabric also defines a vibrant community and enhances citizens' quality of life. This project demonstrates the value of working with nature and provides the community with the tools to do that effectively.

American Forests with support from the Michigan Department of Natural Resources (DNR) and the USDA Forest Service analyzed the effects of changing landcover in SE Michigan. This report demonstrates the ecosystem services that green infrastructure provides. The Urban Ecosystem Analysis (UEA) is a process that analyzes the green infrastructure in two ways. The first establishes a regional ecological context of growth and development by assessing eleven years of landcover change in nine counties using Landsat satellite imagery. At this moderate resolution, the analysis provides a graphic and measurable snapshot of how development has changed the landcover and what its impact has been on air and water quality and stormwater runoff. This trend analysis provides a framework for the region to adopt ecosystem-based public policies and set tree canopy goals to help fulfill their environmental mandates.

The second part of the UEA creates a high resolution digital model of the city of Detroit's green infrastructure and is designed to provide city leaders with the detailed data they need for on-going land planning decisions. This interactive data fits seamlessly into the city's Geographic Information System (GIS). This report demonstrates applications of the data and the tools needed to address local issues and offers recommendations of how to integrate green infrastructure into land use planning.

The SE Michigan Urban Ecosystem Analysis covered more than 3.67 million acres (5,729 sq. miles) and included nine counties: Wayne, Monroe, Washtenaw, Macomb, Oakland, Livingston, and Genesee, and portions of Ingham and Jackson, measuring landcover change between 1991 and 2002. The Detroit Urban Ecosystem Analysis covered the entire city of 89,215 acres (139 sq. miles) and used 2005 high-resolution imagery.

Framing the Issues with Green Infrastructure

Looking at SE Michigan and the city of Detroit from a natural systems perspective, green infrastructure affects several important natural resources, growth and planning issues. Local leaders must balance how the region will grow while preserving the natural systems necessary to maintain environmental quality. The Michigan DNR, Southeast Michigan Council of Governments (SEMCOG), city of Detroit Planning Department, and The Greening of Detroit, along with findings from this Urban Ecosystem Analysis provide statistical information about current local land use trends and issues necessary to understand the impact of land changes on the community.

- Between 1990 and 2000 land in Southeast Michigan developed three times faster than population increased (SEMCOG, 2003).

- Tree cover and open space in three watersheds: Ecorse, St. Claire and Rouge, have declined significantly between 1991-2002. This has increased stormwater runoff and has decreased air and water quality. (American Forests, 2006)

- In an effort to clean up the most polluted areas in the Great Lakes the U.S. EPA has identified the Detroit River, the St. Clair River and the Rouge River as "Areas of Concern". Their priorities include control of combined sewer overflows (CSOs), control of sanitary sewer overflows (SSOs), and point/nonpoint source pollution controls (EPA, 1998).

- SEMCOG projects that it will cost $14-26 billion over the next 30 years to address the overflow and capacity problems of the handling stormwater and sewage (SEMCOG, March 2003).

- Twenty-five counties in Michigan, including all the counties in this study are currently classified as 'non-attainment' for two air pollutants, ozone and particulates (2.5 microns in size). If not addressed, noncompliance of federal clean air regulations could jeopardize federal funding for highways (EPA, 2006).

- Between 1950-1990, Detroit lost half of its tree canopy to Dutch elm disease, development, and poor maintenance. In the last few years, Emerald ash borer killed 16 million trees statewide, further decreasing tree canopy (Detroit Free Press, 2006).

- 4,600 acres (66,000 lots) of previously-developed land in the city of Detroit is now vacant as development shifts to suburbs (SEMCOG, 2003).

While these statistics highlight serious environmental, economic, regulatory, and planning problems affecting quality of life for Michigan residents and business, green infrastructure ties each of these seemingly disparate issues together. From a natural systems perspective, green infrastructure can and should be incorporated into both revitalization and new development. For example, Detroit's local leaders' vision for a revitalized city offer opportunities to do just that.

- SEMCOG predicts that as developable land dwindles, land costs will rise and infill and redevelopment will fulfill the growing housing demand. This economic force will revitalize older communities in Detroit. This Smart Growth approach addresses economic, social and environmental redevelopment. Incorporating green infrastructure into redevelopment not only creates neighborhood vitality; its ecosystem functions help improve stormwater management and water quality functioning.

- The city of Detroit's Riverfront Conservancy is in the process of transforming the riverfront's industrial brownfields into commerce, housing, and recreation. The revitalization has attracted people back to the "heart and soul of Detroit"—the Detroit River.

- SEMCOG, the city of Detroit, the Greening of Detroit and other SE MI communities have embarked on establishing a regional greenways system that ties together several natural systems. Greenways are ideal locations to re-establish and enhance green infrastructure.

- Global ReLeaf of Michigan recognizes the importance of and works at regreening at a watershed level.

This report is not an end point of analysis but is the beginning of a process for decision making. It is a roadmap to show local leaders, planners, and citizens how to use the interactive green data and tools provided with this project. The report findings identify some landcover change trends, their ecosystem benefits, and examples of how local communities can put green infrastructure to its best use. The process continues by putting the project's tools into the hands of those who make day-to-day decisions about the future of SE Michigan and the city of Detroit, turning their vision for their communities into reality.

Major Landcover Change Findings

An Urban Ecosystem Analysis of SE Michigan, using Landsat Satellite imagery shows a net decline in green infrastructure (open space and tree canopy) and an increase in developed land over the last 11 years.

- There was a net decline in green infrastructure over the nine county SE Michigan region from 1991-2002. Open space declined 10% and tree canopy increased 2% while urban areas increased 21% during that time period (see Table 2, pg. 7).

- On a countywide basis, all but Livingston County lost a significant amount of open space; Wayne County (-33%) and Oakland (-26%) lost the most. All but Jackson and Ingham Counties gained significant urban area; Macomb (57%) and Monroe (34%) Counties increased the most.

- When measured by ecological unit, such as watershed, tree cover and open space declined significantly in three urban watersheds while urban area increased. Tree canopy and open space in the Rouge Watershed declined by 7% and 36% respectively, Ecorse declined by 18% and 35% respectively, and Lake St. Clair land declined by 14% and 51% respectively. During the same time, urban land increased in the Rouge by 26%, increased in the Ecorse by 20% and increased in Lake St. Clair by 9% (see pg. 7).

- Older industrial cities like Detroit and the adjacent SE Michigan communities were established decades before 1990 hence the tree canopy changes that took place historically are not reflected in this study.* The most dramatic land cover change trends in the counties immediately surrounding Detroit—increase in urban areas and decrease in open space—indicate that green infrastructure needs to be increased. Increasing tree cover will have the greatest impact on improving green infrastructure (see page 6).

The net decline in green infrastructure (open space and tree canopy) and increase in urban areas (impervious surfaces) increases stormwater management costs and decreases water quality.

- Trees slow stormwater runoff, reducing peak flows and decreasing the amount of stormwater storage needed (TR-55 curve numbers). The loss in stormwater retention capacity in SE Michigan due to a loss in green infrastructure between 1991-2002 was 560 million cubic feet. Without green infrastructure, the cost of building stormwater retention ponds and other engineered systems to handle the increase in stormwater runoff is valued at an additional $1.12 billion. Stormwater costs were calculated for a typical 2-year peak storm event and a $2 per cubic foot construction cost for stormwater retention ponds. (see Table 1).

- From the additional stormwater runoff reported above, nine out of ten water quality contaminants recognized by EPA would worsen by 1-8% if trees were removed from the land.

- In 2005, 25 counties in Michigan were designated as non-attainment for ozone under the Clean Air Act. (EPA, 2004). All of the counties within this project area except for Jackson County received varying classification levels of non-attainment, requiring them to meet specific air quality standards. Trees improve air quality by removing nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3) and particulate matter 10 microns or less (PM_{10}) in size. During the eleven year time frame of this study, SE Michigan's 2% gain in tree cover increased its ability to remove approximately 1.43 million pounds of air pollutants annually, at a value of $3.4 million per year.

- Trees help clean the air by storing and sequestering carbon in their wood (USFS). Total storage and the rate at which carbon is stored (sequestration) can be measured. Because of the slight increase in tree cover between 1991-2002, trees increased carbon storage by a total of 800,000 tons and sequestered an additional 6,200 lbs annually.

The city of Detroit's green data layer provides a current picture of its green infrastructure and the ecosystem benefits it provides.

- As of 2005, high resolution satellite data shows that Detroit's landcover is comprised of 41,843 acres (47%) urban land (defined by impervious surfaces); 27,863 acres (31%) tree cover*; 17,860 (20%) open space (defined by grass and scattered trees); 1,335 (2%) bare soil; and 314 acres (less than 1%) water.

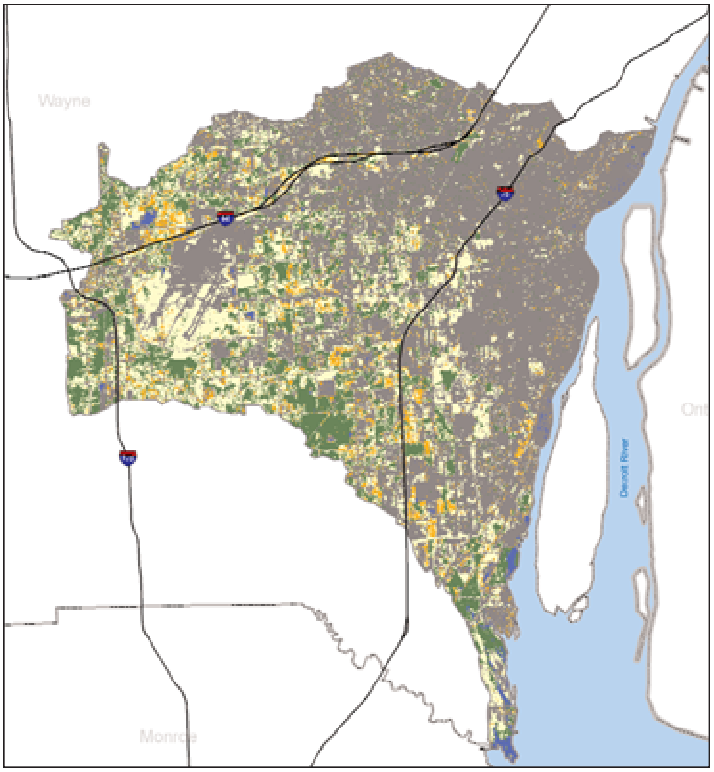
- Detroit's tree canopy provides 191 million cubic feet of stormwater management, valued at $382 million; 2.1 million lbs. of air pollution removal, valued at $5.1 million annually; stores 1.2 million tons of carbon and sequesters 9,334 lbs. of carbon annually (see Table 3, pg.9).

*Note: Even though pests and diseases have taken a huge toll on canopy cover in Southeast Michigan, two major losses were not reflected during the landcover change analysis time frame. The decline in tree canopy from Dutch elm disease occurred mostly between 1960-1990, so changes were apparent prior to 1990. The decline in tree canopy from Emerald Ash Borer has become apparent only after 2002, so tree canopy impacts are not fully reflected in this study.

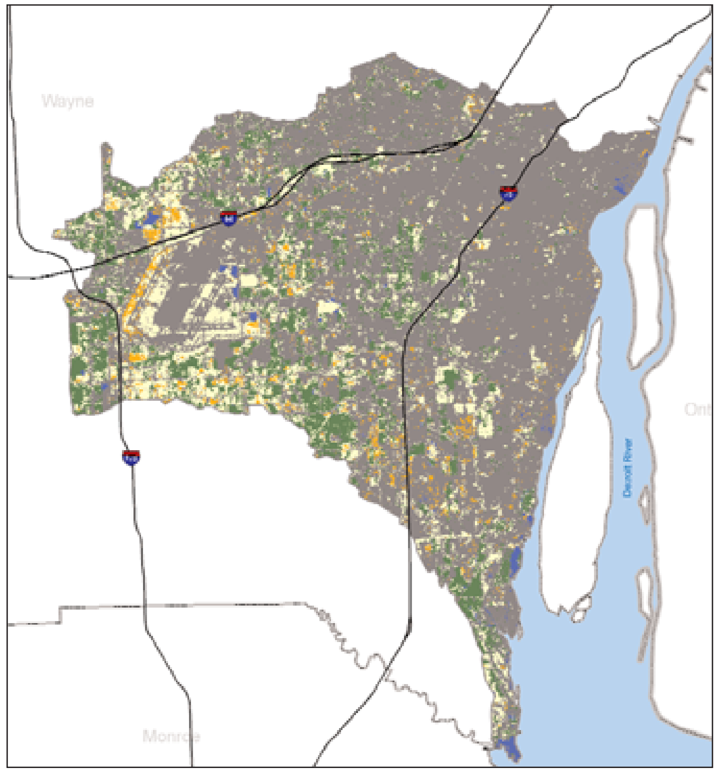
Table 1. Change in Ecosystem Services by County and Watershed, 1991–2002 Landsat

Change in Environmental Benefits	2002 Tree Canopy (acres)	Additional Stormwater Management Needed (cu. ft.)	Stormwater Management Value ($)	Air Pollution Annual Removal Value (lbs.)	Air Pollution Removal Value ($)	Carbon Stored (tons)	Carbon Sequestered Annually (lbs.)
SE Michigan (9 counties)	1,009,000	560 million	1.12 billion	1.43 million	3.4 million	797,000	6,200
Genesee	415, 082	0	0	644,000	1.5 million	358,000	2,800
Ingham	73,000	49 million	99 million	534,000	1.3 million	297,000	2,300
Macomb	57,000	184 million	368 million	-942,000	-2.2 million	-523,000	-4,000
Jackson	152,000	0	0	1.1 million	2.6 million	616,000	4,800
Livingston	132,000	48 million	96 million	-340,000	-808,000	-189,000	-1,400
Monroe	47,000	253 million	507 million	-264,000	-627,000	-147,000	-1,100
Oakland	226,000	159 million	317 million	439,000	1 million	243,000	1,900
Washtenaw	143,000	0	0	642,000	1.5 million	356,000	2,800
Wayne	69,000	93 million	187 million	-387,000	-918,000	-215,000	-1,700
Clinton Watershed	136,000	168 million	336 million	209,000	496,000	116,000	900
Ecorse Creek Watershed	11,000	68 million	136 million	-194,000	-459,000	-107,000	-800
Area Draining to L. St. Clair	3,900	19 million	39 million	-48,000	-114,000	-27,000	-200
Rouge Watershed	69,000	113 million	226 million	-382,000	-905,000	-212,000	-1,600

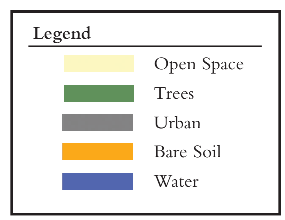
Regional and Watershed Landcover Change Analysis



Ecorse Watershed 1991 classified Landsat image



Ecorse Watershed 2002 classified Landsat image

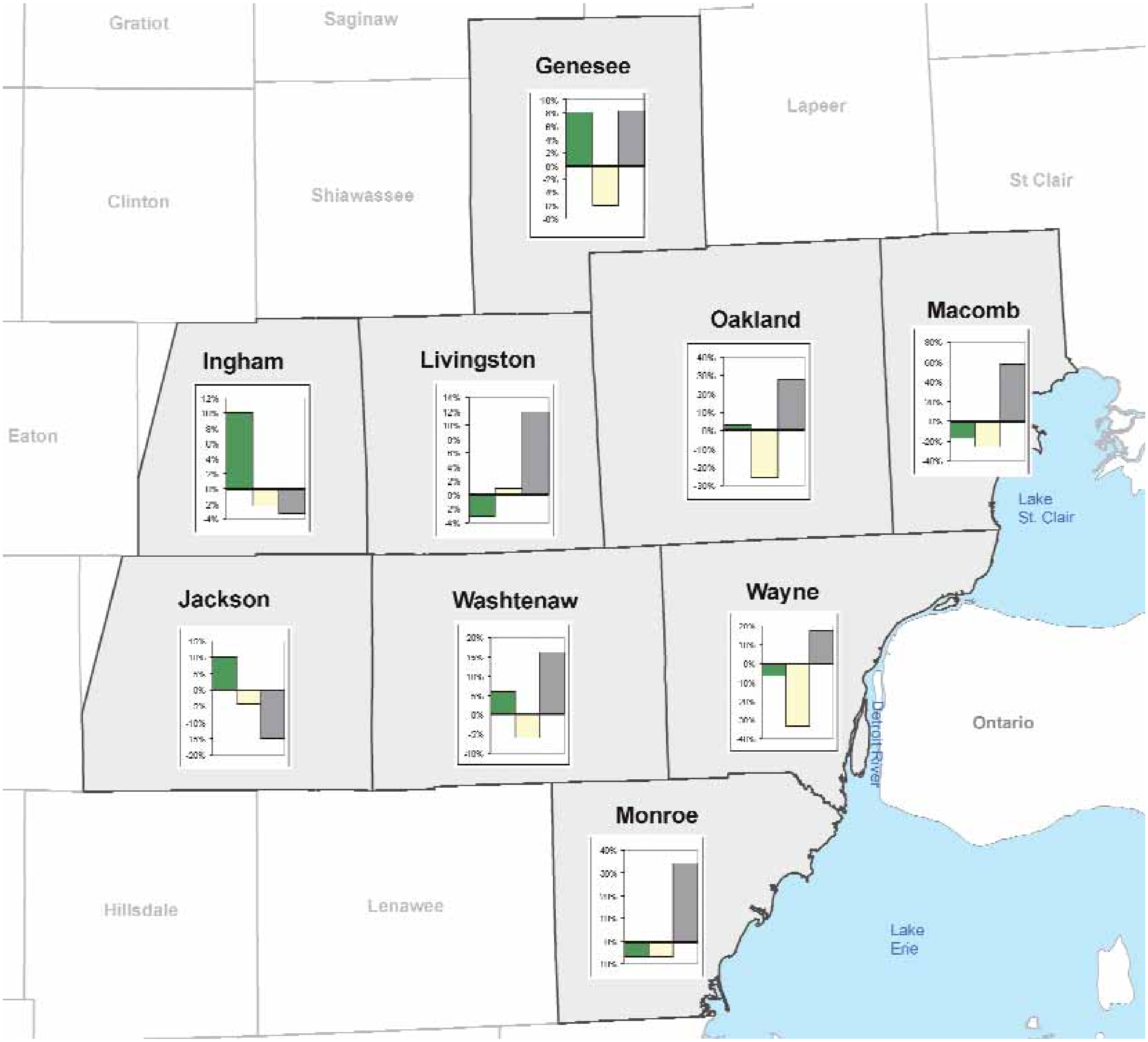


Landsat satellite imagery, collected in 1991 and 2002 is classified into different types of landcover such as tree canopy, open space, urban, and water. A comparison of the two years documents how landcover has changed from a greener to a grayer landscape as the region continues to develop. This stratified data is then used to measure the environmental impacts that the loss of green infrastructure has on air quality, carbon storage and sequestration, water quality and stormwater runoff.

The regional landcover data show a noticeable decrease in open space in Macomb, Wayne and Oakland Counties over the 11 year period. Loss of tree canopy occurred in Macomb, Monroe and Livingston Counties. Other counties gained a modest amount of tree cover. Older industrial cities like Detroit and surrounding SE Michigan communities were established decades before 1990, as urban development replaced agricultural lands. However, prior to European settlement these lands were originally forested. When converted to agriculture, they lost their natural ability keep the watershed and surface waters pristine. Planting urban trees, while vital to regain lost ecosystem benefits, will never be as efficient as the original forested ecosystem.

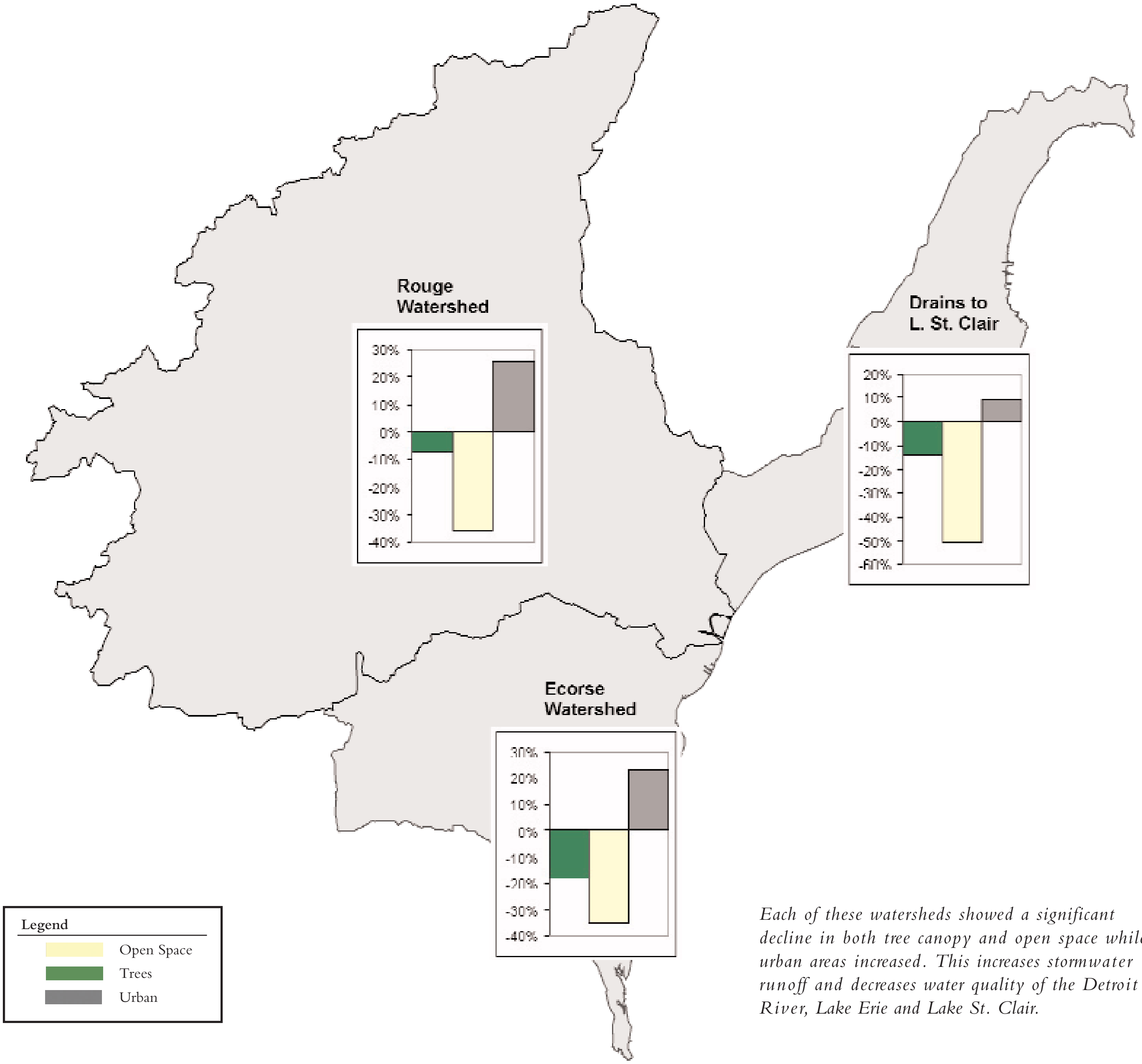
Watershed Changes

The most significant landcover changes are visible in the Rouge, Ecorse and Lake St. Clair watersheds, which have a direct impact on stormwater runoff and thus on water quality affecting the Detroit River, Lake Erie, and Lake St. Clair. For example, in the Ecorse Watershed with an 18% loss of tree cover, 35% loss of open space, and a 23% increase in urban land, the loss in stormwater retention capacity during the study period was 68 million cubic feet. This loss of stormwater retention capacity is valued at $136 million. In addition, trees' ability to absorb air polllutants diminished by 194,000 lbs., valued at $459,000; 107,000 fewer pounds of carbon were stored and 800 fewer pounds were sequestered annually. (see Table 1, pg. 4.) The change in landcover for the Ecorse watershed are depicted in the satellite images above.



Legend
- Open Space
- Trees
- Urban

The landcover change trends between 1991-2002 suggest that the greatest percentage of urban growth and green infrastructure decline occurred in the counties adjacent to Detroit. Tree canopy has increased in outlying counties, as formerly agricultural land is converted to residential land with planted trees.



Each of these watersheds showed a significant decline in both tree canopy and open space while urban areas increased. This increases stormwater runoff and decreases water quality of the Detroit River, Lake Erie and Lake St. Clair.

Table 2. Change in Landcover Between 1991 – 2002, Landsat

Region Total and Counties	Total Acres	Tree Canopy Cover 1991	Tree Canopy Cover 2002	Tree Canopy Cover Change	Open Space/Bare 1991	Open Space/Bare 2002	Open Space/Bare Change	Urban 1991	Urban 2002	Urban Change
9 county region	3.67 M	991,000	1 M	2%	1.9 M	1.7 M	-10%	665,000	839,000	21%
Genesee	415,082	102,000	110,000	8%	234,920	221,045	-6%	69,629	75,505	8%
Ingham	337,000	66,000	73,000	10%	236,177	230,812	-2%	32,330	31,305	-3%
Macomb	309,000	68,000	57,000	-17%	150,000	112,000	-25%	87,000	137,000	57%
Jackson	439,000	137,000	152,000	10%	260,000	249,000	-4%	30,346	25,885	-15%
Livingston	374,000	137,000	132,000	-3%	197,269	198,915	1%	27,427	30,869	12%
Monroe	356,000	51,000	47,000	-7%	256,000	238,000	-7%	44,000	66,000	34%
Oakland	580,000	220,000	226,000	3%	209,000	154,000	-26%	122,000	171,000	28%
Washtenaw	462,000	135,000	143,000	6%	272,000	255,000	-6%	45,000	54,000	16%
Wayne	394,000	74,000	69,000	-7%	109,000	72,000	-33%	206,000	248,000	17%
Clinton Watershed	493,000	133,000	136,000	2%	201,000	154,000	-24%	143,000	204,000	30%
Ecorse Creek Watershed	83,000	14,000	11,000	-18%	22,000	15,000	-35%	46,000	57,000	23%
Area Draining to L. St. Clair	66,000	4,500	3,900	-14%	7,700	3,800	-51%	53,000	58,000	9%
Rouge Watershed	291,000	74,000	69,000	-7%	70,000	45,000	-36%	133,000	167,000	26%

Detroit's Green Data Layer for Decision Makers

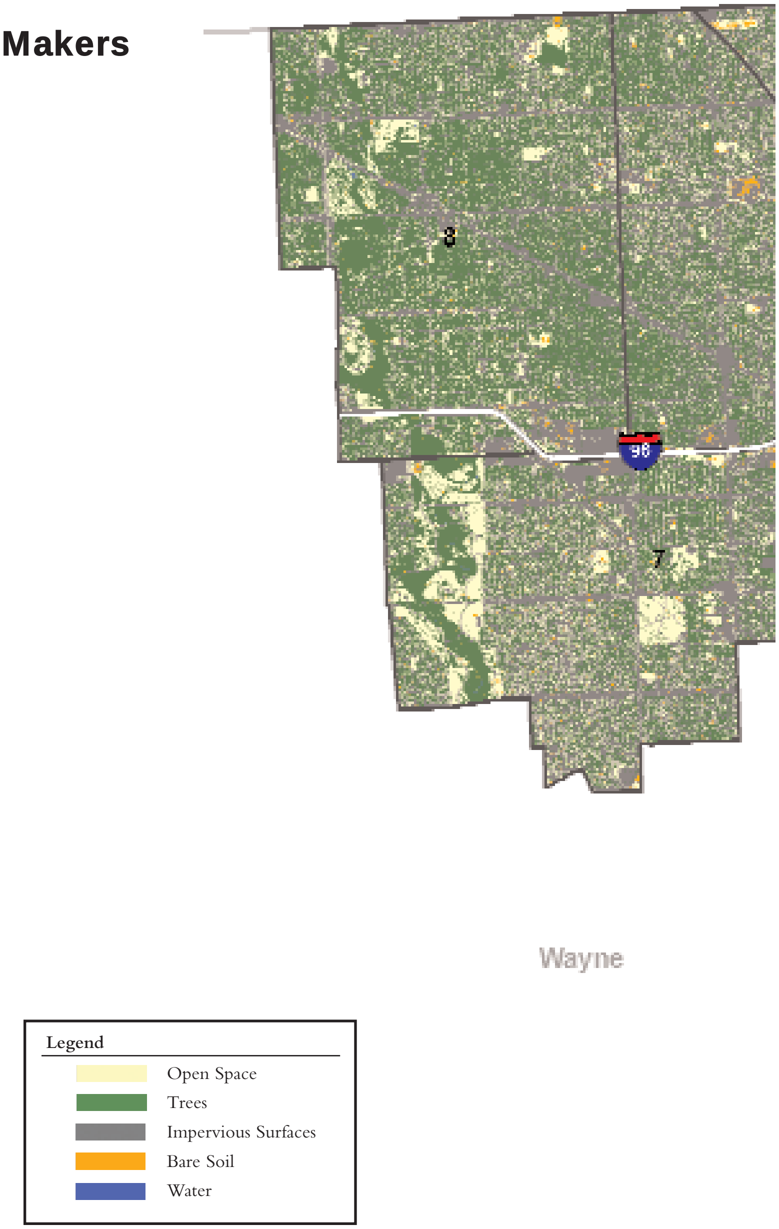
The Landsat images provide valuable public policy information showing general trends in tree loss and increase in impervious surfaces, but do not provide enough detail for local planning and management.

The city of Detroit's landcover (89,215 acres) was classified using high resolution satellite data into landcover types as described for Landsat data. The result is a digital representation of the green infrastructure—called a green data layer—that fits seamlessly into the city's existing Geographic Information Systems (GIS). Having the ability to use a working model of the city's green infrastructure introduces a new dimension into planning and development discussions, one that considers how to work with the natural environment to reduce the need for building costly infrastructure to manage air and water systems.

The green data layer was created from a 1-meter Ikonos multi-spectral satellite imagery taken in 2005. This data has a higher resolution than the Landsat in which individual trees with a 6 ft. canopy spread can be seen. The image was classified into five land cover categories: tree canopy comprises 27,863 acres (31%); urban land (defined by impervious surfaces) 41,843 acres (47%); open space (defined by grass and scattered trees) 17,860 (20%); bare soil 1,335 (2%); and water 314 acres (less than 1%).

Separate studies conducted by American Forests and the US Forest Service estimate that mid to large cities east of the Mississippi currently have less than 30% tree canopy cover. American Forests recommends that cities boost their citywide average canopy cover to 40%, varying by land use (see recommendations page 13). When the landcover is viewed by city-designated Planning Cluster, clusters 8, 9, and 10 have a commendable 57%, 41% and 42% tree cover respectively.

However, not surprisingly, all of the city's Planning Clusters have high impervious surfaces ranging from 26% in Planning Cluster 8 to 62% in Planning Cluster 4. According to the Center for Watershed Protection, at 20% impervious surface, stormwater runoff rate begins to increase significantly. The city center is closest to the water, thus this land is also the most critical for conveying stormwater runoff and pollutants into the Detroit River. Boosting tree canopy in these critical Planning Clusters can have an even bigger impact than in other areas of the city.



The Urban Ecosystem Analysis measured water quality as a percent change in contaminant loadings due to land cover change. Planning Cluster 3's 28% tree canopy currently provides 7-27% improvement in nine out of ten water pollutants. Increasing green infrastructure would provide additional benefits. Conversely, if tree cover were not present, water pollutants would increase by these percentages.

The city of Detroit's landcover by planning cluster.

This 2005 high resolution, multispectral image classified into land-cover type fits into the city's GIS. This digital green data allows decision makers to analyze the ecosystem benefits of various planning scenarios.

Table 3. Detroit Ecosystem Services of Tree Canopy by Planning Cluster

Environmental Benefits By Planning Cluster	Acres	2005 Tree Canopy (acres and %)	Stormwater Management Value (cu. ft.)	Stormwater Management Value ($)	Air Pollution Annual Removal Value (lbs.)	Air Pollution Removal Value ($)	Carbon Stored (tons)	Carbon Sequestered Annually (lbs.)
Planning Cluster 1	10,953	2,832 (26%)	19.1 million	$38 million	220,000	$521,000	121,000	989
Planning Cluster 2	7,491	2,036 (27%)	10 million	$21 million	158,000	$374,000	88,000	682
Planning Cluster 3	11,656	3,209 (28%)	18.6 million	$37 million	249,000	$590,000	138,000	1,075
Planning Cluster 4	9,766	1,692 (17%)	8.7 million	$17 million	131,000	$311,000	72,000	567
Planning Cluster 5	9,455	1,731 (18%)	11 million	$21 million	134,000	$318,000	74,000	580
Planning Cluster 6	6,920	1,725 (25%)	11.6 million	$23 million	134,000	$317,000	74,000	578
Planning Cluster 7	10,777	3,954 (37%)	21.6 million	$43 million	307,000	$727,000	170,000	1,325
Planning Cluster 8	9,294	5,326 (57%)	33.8 million	$68 million	413,000	$980,000	229,000	1,784
Planning Cluster 9	7,133	2,945 (41%)	19.7 million	$39 million	228,000	$542,000	127,000	987
Planning Cluster 10	5,771	2,418 (42%)	17.2 million	$35 million	188,000	$445,000	104,045	810
Detroit	89,216	27,863 (31%)	190.8 million	$382 million	2.1 million	$5.1 million	1.2 million	9,334

Recommendations: Using A Green Data Layer to Address Local Issues

Though this report provides valuable information regarding regional land cover trends and their ecosystem benefits, the most important part of this project is the interactive digital data produced for the City of Detroit to conduct additional analyses for on-going local planning. American Forests recommends that each SE Michigan community acquire high resolution data for their on-going planning as well.

With the green data layer, CITYgreen software and training in its use, the City of Detroit now has the tools to put green infrastructure into 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, such as by Planning Cluster, or ecological, like Rouge River's sub-watersheds. Conducting analyses of these areas are useful to those who work in planning, brownfields redevelopment, stormwater management, water quality, air quality and urban forestry, as well as for conservation groups like The Greening of Detroit, who re-green neighborhoods and Global ReLeaf of Michigan, who work at a watershed level. Here are just a few ways to use green infrastructure to address local issues.

Revitalizing the Urban Core

In two surveys, residents identified their top priorities for their communities. After transportation, the management of suburban growth and the revitalization of urban core communities were their main concerns (SEMCOG 2002; Detroit Area Study 2001).

Detroit is reclaiming its riverfront, changing previous industrial land (brownfields) into commercial, recreation, and residential uses, under the guidance of The Detroit Riverfront Conservancy. Its mission is to "develop a vision and long-term plan for the development of parks, promenades, and other green spaces along the Detroit riverfront designed to enhance access and connections to the riverfront and respect ecological and conservation standards." There are many opportunities to incorporate the effective use of green infrastructure in this part of the city. Boosting tree canopy not only offers aesthetic appeal and shade for human comfort, but in this critical area of the city that drains into the Detroit River, also reduces stormwater runoff and filters water pollutants to protect water quality.

Modeling different green infrastructure scenarios on redevelopment projects allow planners and developers to weigh different percentages of landcover against meeting local regulations. Incentives could be given to developers who increase tree canopy cover to help satisfy clean air and water regulations.

Improving Water Quality

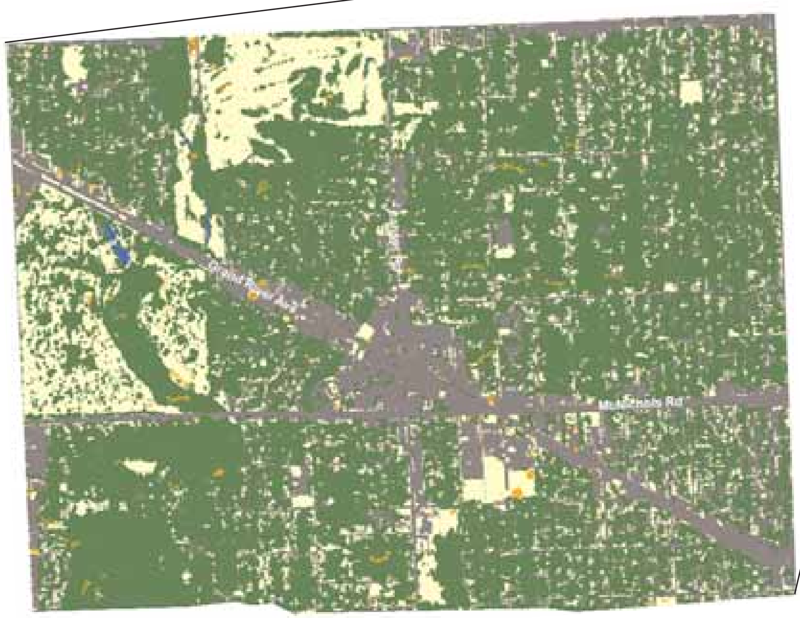
Two-thirds of residents surveyed indicated that water pollution from stormwater runoff was a problem in their communities. Protecting water quality in lakes and streams was one of their top priorities (after fixing roads). Moreover, they are very supportive of local government actions to improve water quality. (SEMCOG 2002; Detroit Area Study 2001). SEMCOG projects that it will cost $14-26 billion over the next 30 years to address the overflow and capacity problems of the region's stormwater and sewer systems, including illegal dumping of raw sewage into rivers.

SEMCOG recommends reducing the demand for building new infrastructure and lowering maintenance costs with watershed management, pollution prevention, and innovative design of new development (SEMCOG, March 2003). As this project shows, protecting and increasing overall green infrastructure as well as increasing forest buffers along streams provide beneficial improvements. Proposed changes can be modeled and quantified.

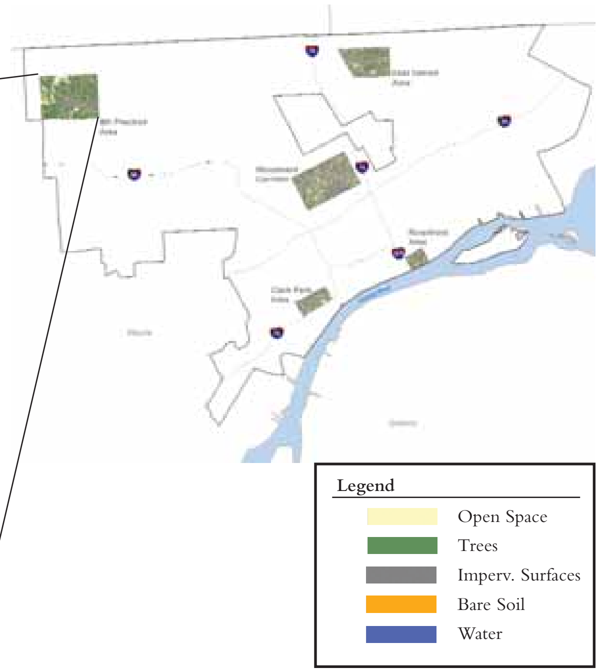
Neighborhood Greening

At the local level, neighborhood re-greening efforts often arise from the community. With assistance from non-profit groups like The Greening of Detroit, citizens are able to reclaim their neighborhoods. The Greening's Green Connections Program provides trees and landscaping for Detroit's police precinct headquarters and in adjacent neighborhoods to reconnect the public with police as part of community building. The Empowerment Zone Urban Space Initiative Project reclaimed vacant lots and converted them to community green space.

Green infrastructure not only provides environmental benefits, but provides positive action for community empowerment. The Greening of Detroit can use a green data layer of neighborhoods they've planted trees in (see page 11) as an outreach and education tool. By using the "scenario model" component of CITYgreen, residents can measure just how much the trees they plant today will improve their community as they mature.



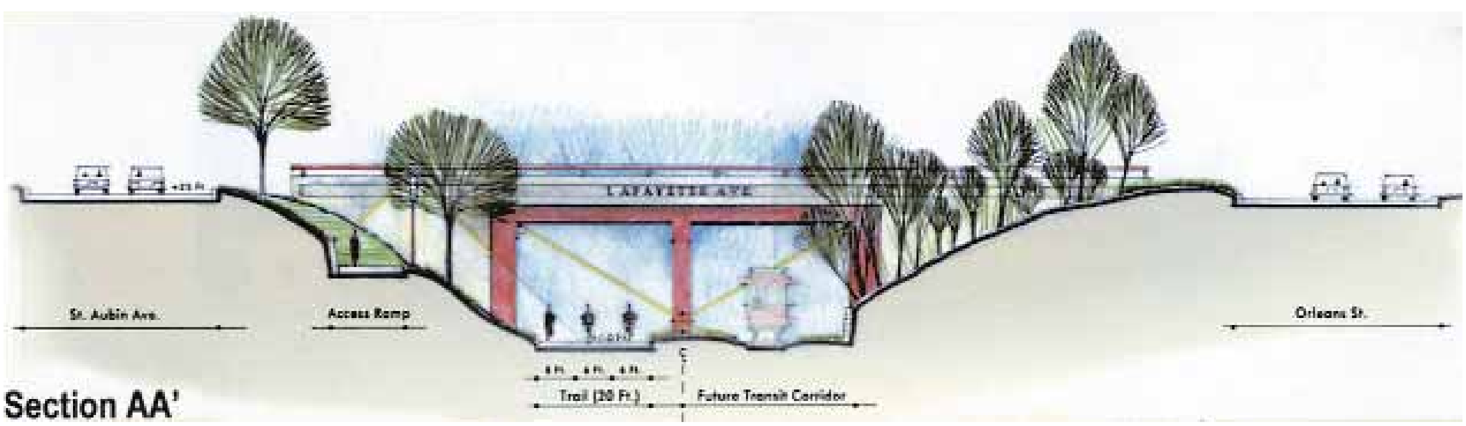
8th Precinct Area



The Greening of Detroit re-greens neighborhood areas like the ones viewed here. The digital green data layer fits seamlessly into GIS and can be used to prioritize planting areas and inspire citizens to plant by showing them the benefits of green infrastructure in their neighborhood.

Table 4. Ecosystem Services of Trees by Neighborhood Area

Environmental Benefits By Neighborhood Area	Acres	2005 Tree Canopy (acres and %)	Stormwater Management Value (cu. ft.)	Stormwater Management Value ($)	Air Pollution Annual Removal Value (lbs.)	Air Pollution Removal Value ($)	Carbon Stored (tons)	Carbon Sequestered Annually (lbs.)
Riverfront Area	236	42.4 (18%)	303,000	$606,000	3,200	$7,700	1,823	14
Clark Park	408	97 (24%)	653,000	$1.3 million	7,500	$18,000	4,162	32
Woodward Corridor	1,637	480 (29%)	2.7 million	$5.5 million	37,000	$88,000	21,000	161
East Detroit	990	401 (41%)	3 million	$5.9 million	31,000	$73,000	17,000	134
8th Precinct	1,900	1,200 (63%)	7.6 million	$15.3 million	93,000	$221,000	52,000	402



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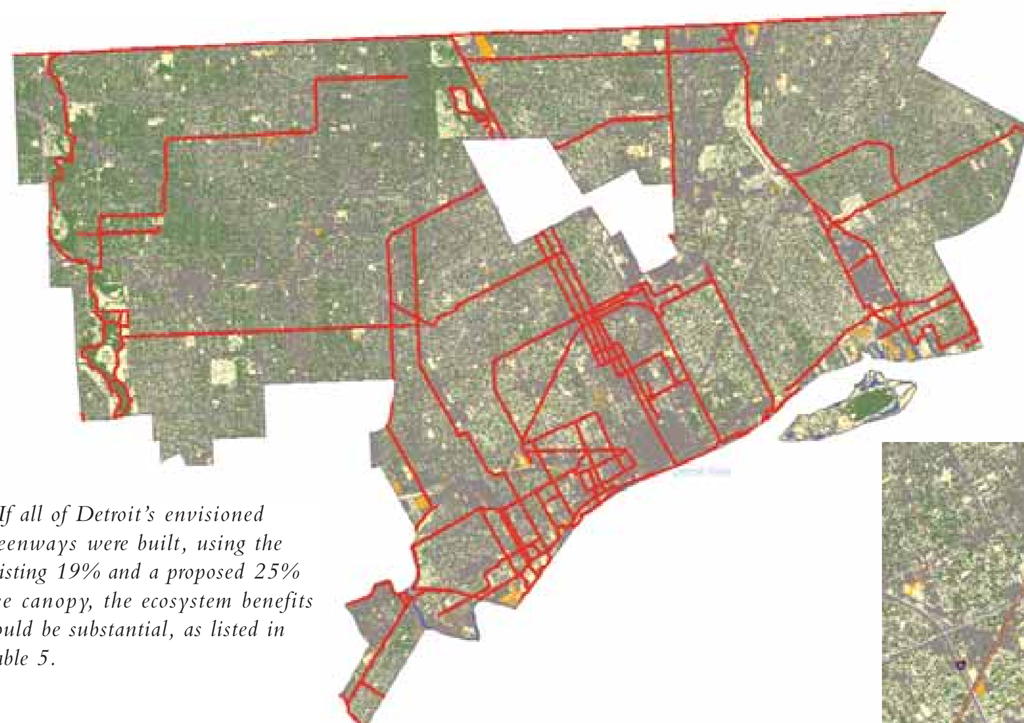
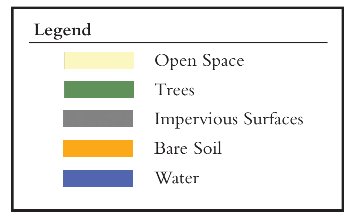
The proposed Dequindre Cut Greenway plan includes a vegetated buffer, which provides an ideal location for increasing the city's tree canopy. This design was used in the greenway modeling shown in Table 5.

Greenways

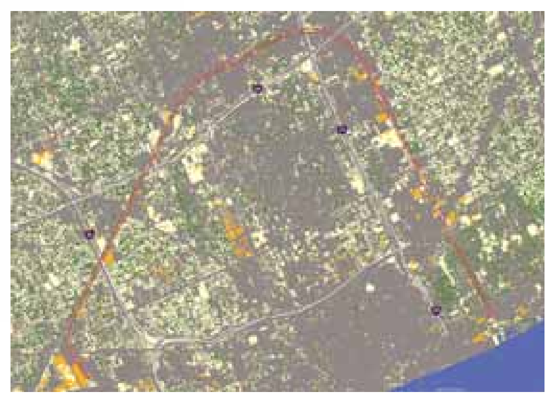
In established urban areas, it can be very difficult to find suitable space to increase green infrastructure. Greenways become vital corridors with which to re-establish green infrastructure, reconnect open space, and provide outdoor recreation. For example, the Dequindre Cut Greenway, an abandoned railroad right of way, is slated for phased implementation as a pedestrian and possible light rail corridor. The greenway's tree canopy, assuming a 150 ft. vegetative buffer and a measured 31% tree canopy, currently provides 227,000 cu. ft. in stormwater savings, valued at $455,000. If tree canopy were increased from an existing 31% to 40%, the greenway would reduce the amount of stormwater the city must manage by an additional 92,000 cubic ft. that is valued at $184,295. Tree canopy would also remove an additional 1,000 lbs. of air pollution annually, valued at $2,300.

SE Michigan is planning in a regional network of greenways. A recent Detroit public workshop sketched out a citywide greenways vision. Assuming a similar 150 ft. vegetated buffer, Detroit's envisioned 3,250 acres greenway's tree canopy system currently stores 3.8 million cu. ft. of stormwater and is valued at $7.6 million. If tree canopy were increased from 19% to 25%, the greenway would store an additional 1 million cu. ft. of stormwater, valued at $2 million. It would also remove an additional 16,000 lbs. of air pollution annually, valued at $38,000; and store an additional 9,000 tons of carbon. This type of information can justify investing in greenways for environmental improvement and cost-effective infrastructure investment, among their many other benefits.





^ If all of Detroit's envisioned greenways were built, using the existing 19% and a proposed 25% tree canopy, the ecosystem benefits would be substantial, as listed in Table 5.



v If all three phases of the Dequindre Cut Greenway were built, its ecosystem benefits would be significant. This greenway is modeled at the existing 31% and 40% tree canopy in Table 5.

Table 5. 2005 Ecosystem Services of Trees by Greenway Models

Detroit's Greenways Modeled*	Acres	2005 Tree Canopy (acres and %)	Stormwater Runoff (cu. ft.)	Stormwater Management Cost ($)	Air Pollution Annual Removal Value (lbs.)	Air Pollution Removal Value ($)	Carbon Stored (tons)
Dequindre Cut Greenway (existing)**	130	39.5 (31%)	578,000	$1.2 million	3,063	$7,300	1,700
Dequindre Cut Greenway (40% canopy model)	130	52 (40%)	486,000	$972,000	4,018	$9,500	n/a
All envisioned Greenways built (existing canopy)***	3,251	603 (19%)	15.4 million	31 million	46,831	$111,000	26,000
All envisioned Greenways (25% canopy model)	3,251	813 (25%)	14.6 million	29 million	63,033	$150,000	35,000

* Greenways assume a 150ft. Vegetated buffer and a 40ft. pedestrian and/or light rail corridor
** Existing Dequindre Cut Greenway tree canopy provides 227,000 cu. ft. in stormwater savings, valued at $445,000.
***All envisioned greenways' tree cover provides 3.8 million cu. ft. in stormwater savings, valued at $7.6 million.

Recommendations: Creating Public Policies that Incorporate Green Infrastructure

While change is implemented one project at a time, as noted in opportunities to increase green infrastructure on pages 10-12, it is best to first establish an overall policy framework. Then, set regional green infrastructure goals (since environmental issues cross political boundaries) to fulfill regulations for clean air and water. Finally institute specific polices at the local level where projects are implemented.

By quantifying the environmental and economic benefits of green infrastructure, existing provisions cited in local master plans, zoning ordinances, stormwater management plans, natural areas plans, tree and woodland protection ordinances and other legal documents can be more easily implemented. In addition, accomplishments can be measured, and cost benefit for project implementation justified. Here are some ways of building green infrastructure into existing public policies.

Establish a Green Infrastructure Framework by Setting Regional and Local Tree Cover Goals

- Establish an overall tree canopy goal for the region. Establish goals for specific land use categories. Incorporate these goals into planning policies and test achieving them with the UEA process. Maintain those targets as the region and community changes over time.

- SE Michigan communities should use American Forests' canopy goals as a guide, but each jurisdiction should develop its own goals to meet the needs of its unique community.

  • 40% tree canopy citywide

  • 50% tree canopy in suburban residential

  • 25% tree canopy in urban residential

  • 10-15% tree canopy in the urban core; greater in areas adjacent to rivers.

- Stratify tree canopy goals by land use; if canopy percentages are lower in one area, then set standards in other areas to reach the overall regional or citywide canopy goal.

Plan Regionally; Implement Locally; Test the Results

- Watersheds in SE Michigan directly impact water quality downstream, affecting rivers, lakes and drinking water. Counties that share watersheds need to plan collaboratively to ensure water quality downstream.

- Ordinances, plans, and guidelines would be more relevant and achievable if language included metrics for quantifying stated goals. All SE Michigan communities should acquire high resolution aerial or satellite imagery and have it classified into land cover categories—creating a green data layer. Conduct an Urban Ecosystem Analysis using CITYgreen software to assess potential landcover changes and development options.

- Use the modeling capabilities of CITYgreen software when looking at future growth. Test the impacts of changing tree canopy, impervious surfaces, and other land covers under different development scenarios against environmental quality objectives.

Use Green Infrastructure as a Cost-effective, Non-structural Best Management Practice (BMP's)

- In 2004, EPA reclassified SE Michigan's air quality to "marginal" non-compliance allowing jurisdictions more flexibility in choosing measures to reduce air pollutants. Increasing green infrastructure can help in meeting standards and stave off future air pollution as communities continue to develop.

- Examples of BMP's that utilize green infrastructure include:

  • Maintain vegetated buffer strips to improve stormwater infiltration

  • Minimize impervious surfaces

  • Preserve all natural vegetative buffers adjacent to waterbodies (e.g. 100 ft. from stream) for maintaining water quality, erosion protection, wildlife habitat.

- Quantify the costs of increasing green infrastructure against the costs of built infrastructure for slowing stormwater and improving water quality.

Increase Public Awareness, Build Community Support and Empowerment

- Use analysis findings in popular media to demonstrate and educate the public about the importance of conserving and enhancing the urban forest.

- 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.

Trees as Green Infrastructure

Urban forests provide enormous environmental benefits—among them improving air and water quality and slowing stormwater runoff. Yet, tree canopy in many U.S. metropolitan areas has declined significantly over the last few decades (American Forests, 2003). American Forests has analyzed the tree cover in more than a dozen metropolitan areas and documented changes. Over the last 15 years, naturally forested areas of the country located east of the Mississippi River and in the Pacific Northwest, have lost 25% canopy cover while impervious surfaces increased about 20%. All metropolitan areas analyzed needed to increase tree cover. Communities can offset the ecological impact of land development by planting trees—using their natural capacity to clean air and water and slow stormwater runoff.

American Forests developed the Urban Ecosystem Analysis process to:

- Measure tree canopy and quantify changes over time
- Quantify their ecological benefits.
- Calculate their dollar value.
- Communicate the positive impacts urban ecosystems have on reducing built infrastructure costs, while increasing environmental quality.
- Provide city staff with the tools and technology to incorporate trees and other vegetation—the green infrastructure into land use planning
- Build the capacity of policy makers to plan and manage their cities with green infrastructure to maximize their *natural* capital.

Trees: The Green Infrastructure

The physical framework of a community is called its infrastructure. These utilitarian workhorses of a city can be divided into green and gray. Green infrastructure are areas covered with trees, shrubs, and grass; gray infrastructure are areas of buildings, roads, utilities, and parking lots. Green infrastructure is porous, allowing water to soak into soil which naturally filters pollutants before entering rivers. Gray infrastructure is impervious, forcing water to runoff and which must be managed and cleaned before entering rivers.

Unlike gray infrastructure, the functional role of trees, as green infrastructure in cities is not adequately documented. Without quantifying its value, trees are not factored into the budget process. The size, shape, and location of a city's green infrastructure can be measured and the public utility functions they perform can be accurately calculated.

While both gray and green infrastructure are important in a city, communities that foster green infrastructure wherever possible are more livable, produce fewer pollutants, and are more cost effective to operate. However, balancing the gray with the green can be a serious challenge for a local government manager.

To establish a healthy balance of gray and green infrastructure, communities can now:

- Quantify the presence of green infrastructure and its function for air and water improvement.
- Once quantified, designate green infrastructure as a public utility (just as gray infrastructure is) in the budget process
- Establish a tree canopy goal or target (see page 13) as part of every development and management project to utilize its functional potential
- Adopt public policies, regulations, and incentives to increase and protect green infrastructure

With the advent of geographic information systems (GIS) that most cities currently use, staff can integrate the value of green infrastructure, as well as model the impacts of development scenarios into daily planning and management.

Using Satellite Imagery and GIS to Measure Infrastructure

While municipalities commonly use geographic information systems (GIS) to map and analyze their gray infrastructure, they typically don't have the ecological information nor the means to incorporate green infrastructure into GIS and the decision-making process.

This project addresses both of these impediments. Data documenting the environmental characteristics of trees is now available thanks to data provided by researchers from the U.S. Forest Service, the Natural Resources Conservation Service, the Environmental Protection Agency and Purdue University. This project creates and uses an accurate digital data layer—a green data layer that will fit easily within the city's GIS. Those working in planning, urban forestry and on related natural resource issues can now readily utilize this data to integrate green infrastructure into land use planning.

Two types of satellite imagery are useful for determining tree cover in cities. The Landsat satellite has been circling the earth since 1972 and therefore can provide a good view of the historic changes that have occurred. In the last few years, new satellites provide high resolution imagery, where individual trees with 6 foot crowns can be viewed. Landsat data is best used to understand change trends and to support general public policies. In contrast, high resolution satellite data is used to create a digital representation of a city's green infrastructure. This green data layer integrates well with other GIS data layers and is most useful for daily land use planning and management.

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 temporal land cover change analysis (page 4-5), landcover was derived from the 1991 and 2002 Landsat 30 meter pixel resolution. The imagery underwent a Level 1 knowledge-based classification technique to divide the landcover into five categories: trees; bare soil/cropland; open space/grass/scattered trees; urban; and water.

To create the green data layer (pages 6-7), 2005 Ikonos, high-resolution (1-meter pixel resolution) multispectral imagery was obtained between June 25th and August 16th. The imagery underwent a Level 1 knowledge-based classification technique to divide the landcover into five categories: trees; impervious surfaces; open space/grass/scattered trees; bare soil; and water.

Analysis Formulas

Urban Ecosystem Analyses using CITYgreen for ArcGIS software were conducted for both the regional SE Michigan and Detroit Urban Ecosystem Analyses, at the watershed, county, city, municipal planning clusters and local application scales. CITYgreen for ArcGIS 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 volume of runoff 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. For greater accuracy, a stormwater analysis was conducted for each Planning District and then values were added together to provide stormwater runoff for the entire city.

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, copper, 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 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 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.

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For More Information

American Forests, founded in 1875, is the oldest national non-profit citizen conservation organization. Its three centers–Global ReLeaf, Urban Ecosystem Center, 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, teacher workshops and technical support for CITYgreen® and is a certified ESRI developer and reseller of ArcView and ArcGIS products.

This report is available as a pdf at: www.americanforests.org/resources/urbanforests/analysis/php.

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