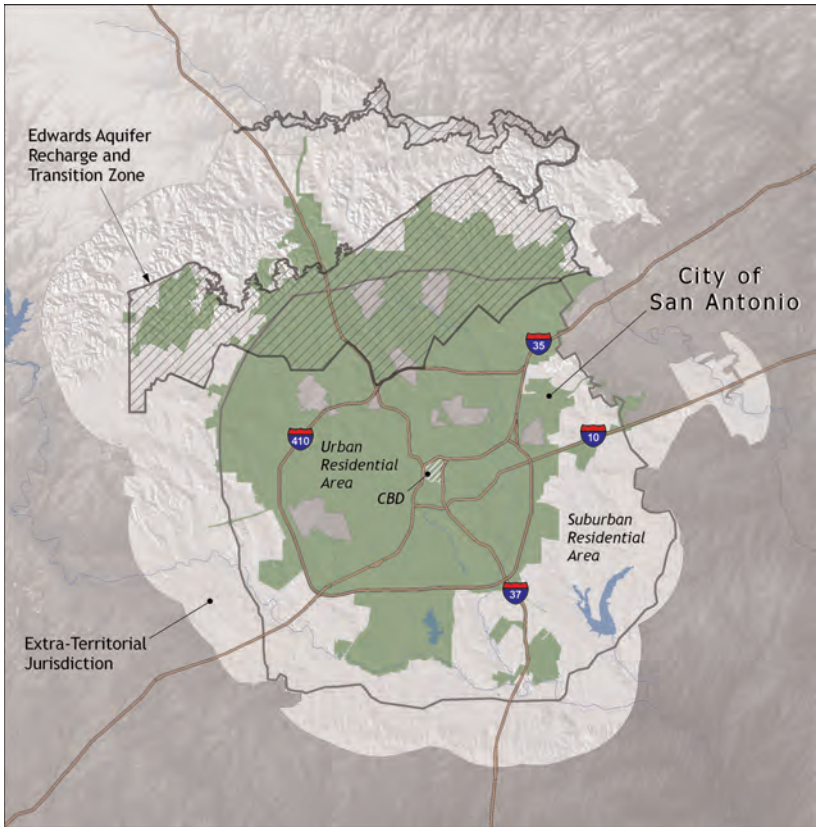
May 2009

Urban Ecosystem Analysis San Antonio, Texas

Calculating the Value of Nature

Report Contents



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Project Overview

Recognizing the many benefits that urban tree canopy brings to urban environmental quality and a growing concern of the loss of these benefits as the area continues to develop, the City of San Antonio engaged American Forests to update their previous Urban Ecosystem Analyses (UEA). The initial study published in November 2002 used 2001 Landsat satellite data and a subsequent study published in September 2003 used 2002 high resolution data. This analysis takes another snapshot in time to examine recent landcover changes and quantify the ecosystem benefits of the area's green infrastructure. The study examined three important geographic locations: the Extra-Territorial Jurisdiction (ETJ), City of San Antonio (COSA), and the Edwards Aquifer Recharge and Transition Zone (EARZ)—the City's sole source of drinking water and subject to a lot of development in recent years. As the area continues to develop, the ratio of impervious to pervious surface greatly influences the amount of stormwater runoff and water quality San Antonio must manage. This study also recommends suitable tree canopy goals, citywide and by landuse, needed to protect this vital resource and to meet San Antonio's environmental goals in accordance with current Master Plan policies, the Tree Preservation Ordinance and air and water compliance status.

The Urban Ecosystem Analysis in this study analyzed the ecology of landcover at two scales spanning two time periods. The first assessment utilized moderate-resolution (30 meter pixel resolution) data from Landsat satellite imagery taken in 2001 and 2006. While the resolution of Landsat data is too coarse for analyzing landuse scale areas, this chronological analysis shows historic trends. The second assessment used 2007 high-resolution (six ft. pixel resolution) digital imagery to calculate current landcover by landuse, city council district, and geographic location.

American Forests used CITYgreen software to calculate how these landcover changes impact the ecosystem services for mitigating stormwater runoff and air and water pollutants, and providing carbon storage and carbon sequestration. The stormwater formulas used in CITYgreen were calibrated to recent San Antonio stormwater events as measured by Pape-Dawson Engineers. For the first time, the City has an accurate measure of how landcover affects stormwater runoff for the entire ETJ and all the landcover contained within it.

This study also conducted predictive modeling scenarios to quantify the environmental benefits of enhancing San Antonio's tree canopy to American Forests' recommended canopy percentage levels. The evidence and data presented in this project will provide City leaders with the information to better integrate natural systems into future development decisions.

Data from this project gives City staff the ability to conduct their own assessments for on-going planning decisions. From a broader perspective, the urban ecosystem analysis offers the entire community a role in developing and maintaining its tree canopy and improving environmental quality.

Major Findings

American Forests published an initial Urban Ecosystem Analysis (UEA) in November 2002 of the San Antonio region looking at the change in canopy coverage. Between 1985 and 2001 the City of San Antonio (COSA) had lost 39% of its heavy tree canopy cover (defined as areas with greater than 50% tree canopy).

This new analysis measured changes in five distinct landcover types: tree canopy, urban, open space/grasslands, bare soil, and water. In addition to measuring trend changes in the City, this analysis also examined landcover trend changes for the ETJ and the EARZ. The analysis quantified the impacts these changes have had on stormwater management, air and water quality, and carbon sequestration and storage.

2001-2006 Landcover Change Trend Data Using 30 meter Landsat Satellite Imagery

- Since the initial UEA was conducted, the findings show that between 2001 and 2006 the City lost 1,800 acres (3.4%) of tree canopy and 7,600 acres (6.8%) of open space/grasslands while gaining 7,400 acres (5.8%) of additional urban area (Table 1).
- The most dramatic tree canopy loss trend occurred in the Edwards Aquifer Recharge and Transition Zone with 3,200 acres (6.0%) of tree canopy and 4,400 acres (10.7%) of open space/grasslands removed while almost 6,000 acres (20.2%) of urban area were added.
- The overall ETJ showed more modest changes with a 2,600 acre (1.2%) and a 16,000 acre (3.9%) decline in tree canopy and open space/grasslands respectively and a 15,000 acre (9.5%) increase in urban area.

2001-2006 Loss of Ecosystem Services

- The loss of tree canopy and increase in urban areas has ecological consequences; loss of green infrastructure means that the region's natural environment is less able to provide ecosystem services for air, water, and carbon.
- COSA's vegetative landcover lost its ability to remove approximately 206,000 pounds of air pollutants annually, valued at $491,000 per year. The loss of tree canopy equated to a loss of 79,000 tons of carbon stored in trees' wood and a loss of 600 tons of carbon sequestered annually.
- Without tree canopy to reduce stormwater runoff volume, the City must manage an additional 58 million cubic feet of stormwater, valued at $37 million (using a local engineered cost of $0.64 per cubic foot.)
- Tree roots absorb water pollutants for which ten measures are available: Biological Oxygen Demand, Cadmium, Chromium, Chemical Oxygen Demand, Copper, Lead, Nitrogen, Phosphorus, Suspended Solids, and Zinc. Of these, each worsened, ranging from 0.91% for Zinc to 4.21% for Chemical Oxygen Demand because trees were removed from the land.
- The ETJ, COSA, and EARZ ecosystem benefits are detailed in Table 2.

Quantifying San Antonio's 2007 landcover and its ecosystem benefits provides ecological opportunities for the future

- The City of San Antonio has a 38% overall tree canopy. While this is higher than in many cities, it is less than American Forests' recommended 40% for this City. The 2% difference translates into an estimated additional 454,600 trees. When this increase in tree canopy is modeled, the ecosystem benefits include an additional 721,000 pounds of air pollutants removed annually, valued at $1.7 million, a decrease in 3.4 million cubic feet of stormwater runoff, valued at $2.2 million, an increase in carbon storage of 276,000 tons and an increase in carbon sequestration of 2,200 tons per year.
- When viewed from a landuse perspective, San Antonio's existing canopy falls short of American Forests' recommendations in each category: Urban residential (-3%), Suburban residential (-6%), Central Business District (-3%), and Commercial (-7%).
- Trees slow stormwater runoff, decreasing the amount of stormwater storage needed. In 2007 San Antonio's tree canopy provided 974 million cubic feet in stormwater detention services, valued at $624 million.
- Trees improve air quality by removing nitrogen dioxide (NO2), sulfur dioxide (SO2), carbon monoxide (CO), ozone (O3) and particulate matter 10 microns or less (PM10) in size. In 2007 San Antonio's tree canopy removed 13 million lbs. of these pollutants annually at a value of $30 million per year.
- Trees have a direct impact on the carbon footprint. Trees help clean the air by storing and sequestering carbon. Total storage and the rate at which carbon is stored (known as sequestration) can be measured. Based on the 38% tree canopy cover measured in this study, San Antonio's trees stored 5 million tons of carbon in trees' wood and sequestered 38,000 tons of carbon in 2007.
- In 2007 San Antonio had 113,000 acres of tree canopy (38%). The City had 84,000 acres of open space with grass and scattered trees (28%), 88,000 acres of impervious surface (30%), 9,500 acres of bare soil (3%), and 3,400 acres of water (1%).
- Tree canopy decline is often imperceptible since development is approved and trees are removed on a project-by-project basis. The City has the opportunity to protect and enhance their tree canopy by adopting recommended tree canopy goals that will vary by landuse. This ensures a coordinated effort in protecting tree canopy and recognizes the need to protect areas like the Edwards Aquifer Recharge and Transition Zone. A coordinated effort will maximize the urban forests' ability to provide ecosystem services which will serve the entire community.

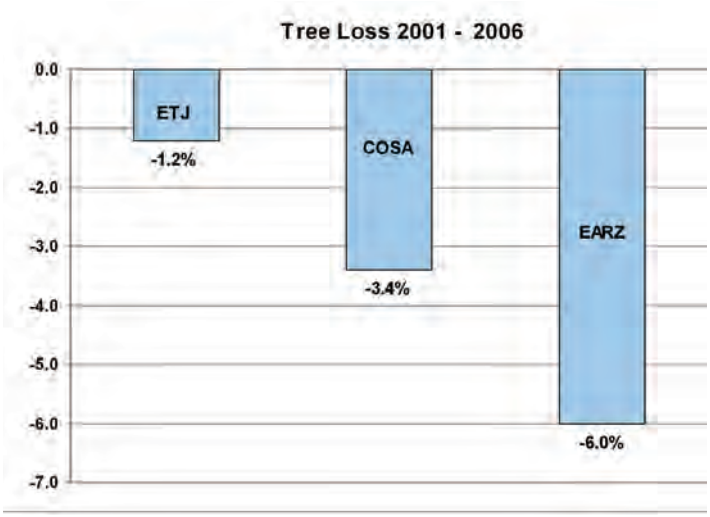
Landcover Change Trends: Landsat 2001-2006

San Antonio is indicative of tree canopy decline trends seen in many U.S. metropolitan areas over the last few decades. American Forests recommends that all metropolitan areas analyze the benefits of increased tree cover. Communities can offset the ecological impact of land development by planting trees and utilizing their natural capacity to clean air and water and slow stormwater runoff.

For this Urban Ecosystem Analysis, American Forests used the U.S. Geological Survey's National Landcover Data (NLCD) and a new classification methodology unavailable for the previous UEA analyses. The U.S. Geological Survey's data, now the gold standard for landcover change analysis, was classified from Landsat 30 meter pixel data from 2001 and 2006 data to document landcover change trends (Figure 1).

Table 1. San Antonio Landsat Data Changes Over Time

Landcover	ETJ Acres			City of San Antonio Acres			Edwards Aquifer Acres		
	2001	2006	% change	2001	2006	% change	2001	2006	% change
Trees	222,320	219,688	-1.2%	54,420	52,587	-3.4%	53,443	50,236	-6.0%
Open Space/grasslands	409,707	393,588	-3.9%	111,867	104,225	-6.8%	41,193	36,767	-10.7%
Urban	152,760	167,280	9.5%	128,198	135,637	5.8%	29,565	35,527	20.2%
Bare	3,398	7,658	125.4%	1,733	3,861	122.8%	1,538	3,198	107.9%
Water	7,507	7,278	-3.0%	2,545	2,459	-3.4%	121	121	0.0%



During 2001-2006, the Edwards Aquifer Recharge and Transition Zone (EARZ) showed the most dramatic loss of 6% in tree canopy, followed by a 3.4% loss in COSA and a 1.2% loss for the ETJ. Due to these landcover changes, the City lost the ability to store 58 million cubic feet of stormwater, valued at $37 million. A local engineered value of $0.64 per cubic foot was used to calculate the value of mitigating this additional stormwater (Pape-Dawson Engineers). San Antonio's tree canopy also lost $491,000 in annual air pollution removal value, 79,000 tons of carbon storage and 614 tons of carbon sequestration annually. The chronological analysis provides valuable public policy information showing general trends in landcover changes.

Table 2. San Antonio Change in Ecosystem Services as Measured with Landsat Data*

2001-2006	2001 Tree Canopy	2006 Tree Canopy	Tree Canopy Change	Tree Canopy Change	Loss of Air Pollution Removal	Loss of Air Pollution Removal Value	Loss in Stormwater Value	Loss in Stormwater Value @ $.64/cu ft.	Loss of Carbon Stored	Loss of Carbon Sequestered
	acres	acres	acres	%	lbs./yr	dollar value	cu. ft.	dollar value	tons	tons
ETJ	222,320	219,688	-2,632	-1.2%	-295,714	-$704,327	-93,036,121	-$59,543,117	-113,295	-882
COSA	54,420	52,587	-1,833	-3.4%	-205,968	-$490,572	-57,957,865	-$37,093,034	-78,911	-614
EARZ	53,443	50,236	-3,207	-6.0%	-360,132	-$857,757	-40,652,214	-$26,017,417	-137,975	-1,074

**Data was taken from 2001 and 2006 National Landcover Datasets so that historical data prepared in the same way could be compared.*

Figure 1. **Landsat Change Detection Analysis**
Tree Canopy Loss/Gain 2001-2006
City of San Antonio and Extra-Territorial Jurisdiction

Change detection performed using 30-meter pixel resolution Landsat imagery from 2001 and 2006.

Sources: American Forests, U. S. Geological Survey, City of San Antonio

Ecosystem Benefits by Landuse: High Resolution 2007 Data

To better understand how landcover and landuse impact ecosystem benefits generated by tree canopy, much finer, high-resolution, (2-ft, resampled to 6-ft) multi-spectral satellite imagery taken in October 2007 was classified into five landcover categories: trees (includes scrub); open space/grass/scattered trees; impervious surfaces; bare soil; and water (Figure 2). Landcover was also examined for four specific geographic areas: ETJ, COSA, EARZ, and City South; and four landuse classes: Urban Residential, Suburban Residential, Central Business District, and Commercial (Table 3).

The spectral analysis used to stratify landcover into different land cover classes can not distinguish canopy from scrub species such as mesquite and persimmon. Thus the percentages for tree canopy may be inflated. The ETJ south of the City is estimated to be heavily scrub and fewer trees, whereas the ETJ north of the city is estimated to be mostly trees and little scrub. As such, American Forests' canopy goal recommendations will reflect tree and scrub canopy together.

Table 3. 2007 Landcover by Geographic Area

	ETJ		Edwards Aquifer		Citywide		City South	
Landcover	2007 Acres	% Land-cover	2007 Acres	% Land-cover	2007 Acres	% Land-cover	2007 Acres	% Land-cover
Trees*	315,572	41.4%	66,903	55.0%	113,011	37.8%	17,399	35.9%
Open space/ Grasslands	302,333	39.7%	24,516	20.1%	84,290	28.2%	26,730	55.2%
Impervious	109,954	14.4%	23,692	19.5%	88,366	29.6%	2,283	4.7%
Urban:								
Bare soil	23,609	3.1%	6,206	5.1%	9,544	3.2%	616	1.3%
Water	9,886	1.3%	373	0.3%	3,366	1.1%	1,388	2.9%
Total Acres	761,354	100%	121,690	100%	298,577	100%	48,415	100%
Canopy %	41%		55%		38%		36%	

Landcover by Landuse

	CBD		Urban Res.		Suburban Res.		Commercial	
Landcover	2007 Acres	% Land-cover	2007 Acres	% Land-cover	2007 Acres	% Land-cover	2007 Acres	% Land-cover
Trees*	131	12.3%	34,576	32.0%	85,434	32.9%	8,915	13.1%
Open space/ Grasslands	84	7.8%	32,008	29.8%	115,466	44.5%	25,158	37.1%
Impervious	834	78.2%	38,687	36.0%	45,481	17.5%	29,017	42.8%
Urban:								
Bare soil	13	1.2%	1,772	1.6%	5,468	2.1%	4,516	6.7%
Water	5	0.5%	441	0.4%	7,461	2.9%	191	0.3%
Total Acres	1,066	100%	107,484	100%	259,310	100%	67,797	100%
Canopy %	12%		32%		33%		13%	

* Spectral analysis used to stratify landcover into different land cover classes can not distinguish canopy from scrub species such as mesquite and persimmon. As such the percentages for tree canopy may be inflated. The ETJ south of the City is estimated to be heavily scrub and fewer trees, whereas the ETJ north of the city is estimated to be mostly trees and little scrub.

Ecosystem Values of Green Infrastructure

A city's pervious landcover serves as its green infrastructure that provides many environmental benefits to a community including slowing stormwater runoff, improving water quality, protecting soil from erosion, improving air quality, 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 the landcover categories of tree canopy, open space/grasslands, bare soil, and water.

An Urban Ecosystem Analysis was conducted on landcover for each of the four landuse categories (Table 4), four geographic areas and ten City Council Districts (Table 5). San Antonio's urban forest contributes to its multiple ecosystem benefits. With 113,011 acres of tree canopy citywide, San Antonio's urban forest manages 974 million cubic feet of stormwater, valued at $624 million, removes 12.7 million lbs. of air pollutants annually, valued at $30.2 million per year, stores 4.9 million tons of carbon and sequesters 38,000 tons of carbon annually.

Table 4. San Antonio Ecosystem Services with 2007 High Resolution Imagery by Land Use

	Area	2007 Tree Canopy	2007 Tree Canopy	Air Pollution Removal	Air Pollution Removal Value	Carbon Stored	Carbon Sequestered	Stormwater Value	Stormwater Value @ $.64 per cu. ft
	acres	acres	percent	lbs./ yr	dollar value	tons	tons	cu. ft.	dollar value
Urban Res	107,484	34,576	32	3,883,518	$9,249,691	1,487,866	11,583	327,368,176	$209,515,632
Suburban Res	259,311	85,434	33	9,595,751	$22,854,981	3,676,355	28,621	702,596,006	$449,661,444
CBD	1,066	131	12	14,763	$35,162	5,656	44	1,824,932	$1,167,956
Commercial	67,796	8,915	13	1,001,331	$2,384,951	383,633	2,987	83,795,961	$53,629,415

Note that the sum of the land uses stormwater values doesn't total to the citywide value. This is because each land use has a specified soil type, whereas citywide, soil type must be generalized for the entire area. Stormwater calculations listed here are based on a 2-year, 24 hour storm event. Calculations from a 5-year, 24 hour storm event are included in the Map Book as part of this project.

Table 5. 2007 Ecosystem Services Using High Resolution Data by Geographic Area

	Area	2007 Tree Canopy	2007 Tree Canopy	Air Pollution Removal	Air Pollution Removal Value	Carbon Stored	Carbon Sequestered	Stormwater Value	Stormwater Value @ $.64 per cu. ft
	acres	acres	percent	lbs./ yr	dollar value	tons	tons	cu. ft.	dollar value
ETJ	761,354	315,572	41%	35,444,304	$84,420,579	13,579,534	105,720	2,577,353,854	$1,649,506,467
City of San Antonio	298,577	113,011	38%	12,693,069	$30,232,114	4,863,009	37,860	974,182,092	$623,476,539
Edwards Aquifer	121,690	66,903	55%	7,514,384	$17,897,620	2,878,935	22,413	519,940,487	$332,761,912
City South Area	48,415	17,399	36%	1,954,252	$4,654,601	748,719	5,829	151,813,217	$97,160,459
Council District 1	13,876	4,075	29%	457,673	$1,090,078	175,345	1,365	42,824,280	$27,407,539
Council District 2	35,170	9,125	26%	1,024,880	$2,441,039	392,655	3,057	85,694,399	$54,844,415
Council District 3	44,855	16,337	36%	1,834,940	$4,370,426	703,008	5,473	151,561,292	$96,999,227
Council District 4	30,952	9,189	30%	1,032,089	$2,458,209	395,417	3,078	78,442,652	$50,203,297
Council District 5	12,003	3,435	29%	385,771	$918,823	147,798	1,151	31,294,766	$20,028,650
Council District 6	36,669	17,812	49%	2,000,567	$4,764,913	766,464	5,967	142,348,185	$91,102,838
Council District 7	19,055	6,885	36%	773,262	$1,841,740	296,254	2,306	60,487,227	$38,711,826
Council District 8	38,027	18,379	48%	2,064,266	$4,916,631	790,868	6,157	147,276,760	$94,257,126
Council District 9	35,397	14,357	41%	1,612,587	$3,840,829	617,819	4,810	120,531,459	$77,140,134
Council District 10	32,574	13,418	41%	1,507,034	$3,589,426	577,380	4,495	114,871,551	$73,517,793

*The sum of the council districts' stormwater values doesn't total to the citywide value. This is because each council district and land use has a specified curve number related to water infiltration, whereas citywide, the curve number is a composite of the whole area so is more generalized.

**Stormwater analysis uses a 2yr, 24 hour storm event. The value of managing stormwater is based on current local construction costs of .64 per cubic foot (Pape-Dawson Engineers)

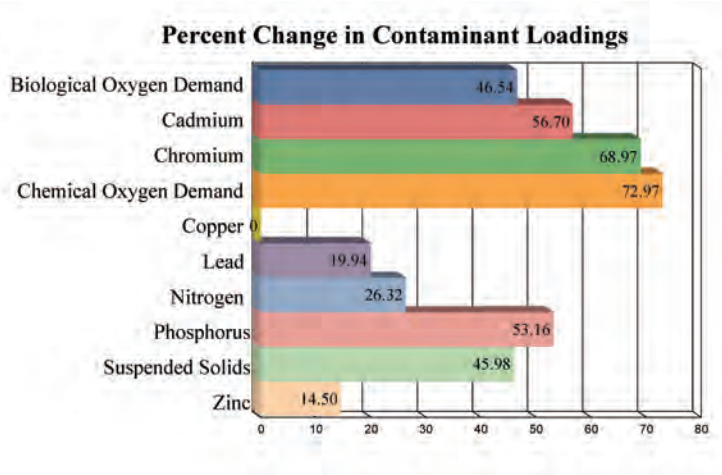
Stormwater Ecosystem Services

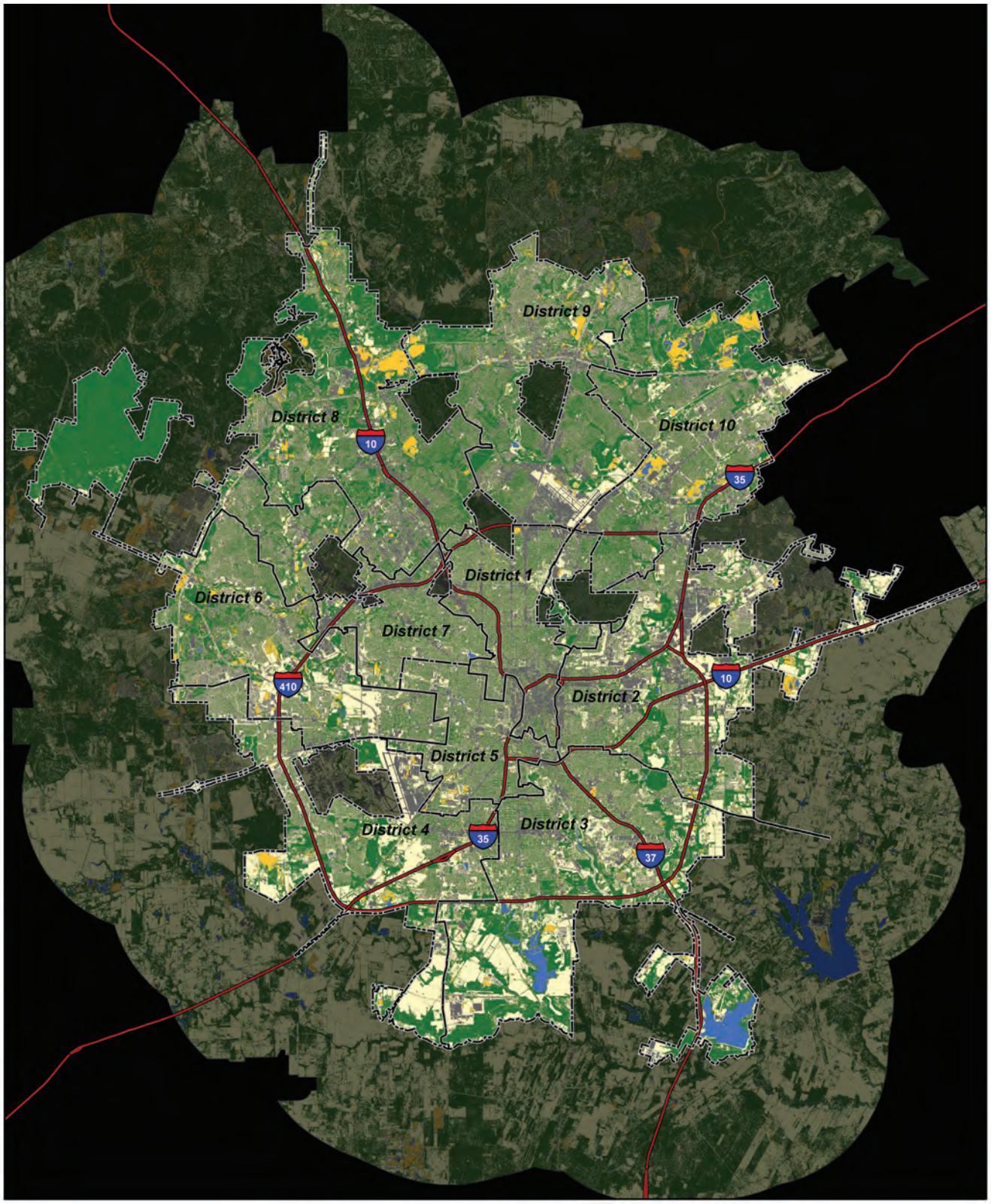
Trees reduce the volume of stormwater runoff by capturing some rain on their leaves and branches, which then evaporates back into the atmosphere. Other water infiltrates into the soil rather than running off the land, which must be managed. San Antonio's urban forest manages 974 million cubic feet of stormwater, valued at $624 million using a $0.64 per cubic foot value based on local engineering, construction, and land costs (Pape-Dawson Engineers).

A unique aspect of this Urban Ecosystem Analysis is that CITYgreen formulas used to calculate stormwater runoff reduction were calibrated with local stream gage data. For the first time, stormwater runoff is directly tied to the landcover, rather than just from select stream gage points. Pape-Dawson Engineers, a local engineering firm who has an extensive database of hydrology for the region, teamed with American Forests' hydrologist to calibrate the curve numbers used in CITYgreen. The methodology is provided as an addendum to this project.

Water Quality Ecosystem Services

Tree roots absorb water pollutants for which ten measures are available: Biological Oxygen Demand, Cadmium, Chromium, Chemical Oxygen Demand, Copper, Lead, Nitrogen, Phosphorus, Suspended Solids, and Zinc. Citywide, water pollution, as measured in percent change in pollutant loading, would worsen, from 15% for Zinc to 73% for Chemical Oxygen Demand if trees were removed from the land (a detailed graph of water pollutant loading for each analysis conducted in this project resides in the map book that accompanies this report).





2007 Land Cover
San Antonio
City Council Districts

Figure 2.

0 3 6 Miles

Land cover data derived from October 2007 aerial imagery (6 ft. resolution.)

Sources: American Forests, City of San Antonio

- Impervious Surfaces
- Open Space (Grass/Scattered Trees)
- Trees
- Urban: Bare
- Water

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Air Quality Ecosystem Services

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 Service Commissions. San Antonio's urban forest removes 12.7 million lbs. of air pollutants annually, valued at $30 million per year.

Trees have a direct impact on the carbon footprint. Trees help clean the air by storing and sequestering atmospheric carbon in their wood. Total storage and the rate at which carbon is stored (known as sequestration) can be measured. San Antonio's tree canopy stores 5 million tons of carbon and annually sequesters 38,000 tons of carbon.

Establishing Tree Canopy Goals

American Forests advocates that every city set a tree canopy goal for their community. Establishing this big picture perspective is an important step in ensuring that their valuable green infrastructure is maintained at minimum thresholds, even as the community continues to develop. These goals can be measured periodically by updating the Urban Ecosystem Analysis to see if the City reversed its loss trend.

As shown in this Urban Ecosystem Analysis, tree canopy continues to decline in the ETJ, COSA, and most dramatically in the Edwards Aquifer Recharge and Transition Zone. American Forests recommends that the City adopt tree goals per landuse as a strategy to help balance the competing pressures to develop and protect its drinking water. Tree canopy goals per landuse help the City meet its stated environmental and quality of life goals, including federal and local clean air and water regulations.

To help establish appropriate tree canopy goals specific to this area, American Forests conducted a review of the City's current policies (Master Plan and Unified Building Code relevant to tree canopy and environmental mandates) and a literature search citing examples of other communities that use tree canopy goals to meet their environmental objectives. Both reports are provided to the City as addendums to this project and can also be found online at American Forests' website: http://www.americanforests.org/resources/urbanforests/analysis.php.

In the City's Master Plan, (http://www.sanantonio.gov/planning/master_plan.pdf) policies indicate that great care is taken to protect the Edwards Aquifer Recharge and Transition Zone, including Goal 1: Policy 1b: "Develop and implement a management plan for landuse activities which includes the best management practices, based on scientific study that will protect the recharge and drainage zones of the Edwards Aquifer from pollution."

In Section 35-523 of the Unified Building Code regarding Tree Preservation, "it is stated public policy of the city to maintain, to the greatest extent possible, existing trees within the city and the ETJ, and to add to the tree population within the city and the ETJ…with the following objectives:

- To encourage the preservation of trees to provide health benefits by the cleansing and cooling of the air and contributing to psychological wellness.
- To encourage the preservation of trees to provide environmental elements by adding value to property, and reduction of energy costs through passive solar design utilizing trees.
- To encourage the preservation of trees to provide environmental elements necessary to reduce the amount of pollutants entering streams and to provide elements crucial to establishment of the local ecosystem.
- To provide tree preservation requirements and incentives to exceed those requirements that encourage the maximum preservation of trees."

In addition to the City policies regarding environmental quality, San Antonio is currently in attainment of the Federal air quality standard. However, with the adoption of the stricter standards, San Antonio expects to be designated non-attainment in March 2010. The mayor has signed the Mayors' Climate Protection Agreement and City staff is compiling San Antonio's greenhouse gas (GHG) baseline for 2005.

Ultimately, with the data and tools provided along with this analysis, American Forests' intent is to help communities calculate the value of their trees so that city leaders can make decisions with more complete information about the environmental and economic benefits of integrating "green" into their urban infrastructure.

Within the last fifteen years, many cities have become aware of the direct relationship between tree canopy and the ecosystem services they provide. This is evident from reviewing older literature such as the *U.S. Tree and Landscape Ordinances* published in 1989. Author Buck Abbey cites that a city's common precursor to setting citywide tree canopy goals was requiring a set number of trees be planted based upon square footage of site development. Abbey noted in a recent interview that since the book's publication, 13 communities now recognize tree canopy in their policy documents.

American Forests' literature review cites examples of four progressive U.S. communities that have adopted tree canopy goals: Roanoke, VA; Baltimore, MD; Sacramento Region and Rocklin, CA. Roanoke's city council adopted a 40% overall tree canopy

goal after an American Forests' Urban Ecosystem Analysis revealed that the city had only a 32% canopy. Even though other communities have not yet adopted this comprehensive approach, many other communities recognize tree canopy's multiple benefits and have written them into Comprehensive plans (Chapel Hill, NC; low impact development (LID) in Huntersville, NC; Watershed Management Plan (Charlotte-Mecklenburg County), air quality compliance tree protection ordinances (Kansas City), conservation development plans (Flower Mound, Texas), compliance with NPDES permits, and Phase II of the Clean Water Act (Baltimore County).

American Forests' recommendations of tree canopy goals for San Antonio are based on the area's existing tree canopy as quantified in this study, as well as local climate, soils, and rainfall patterns, and the City's mandate to protect its environmental quality and comply with federal regulations for air and water quality. American Forests' recommends a 40% citywide tree canopy goal as well as goals for each landuse. In addition, American Forests recommends a no-net loss in tree canopy for the EARZ because this area is so vital to the City's drinking water.

As of 2007, San Antonio's 38% overall tree canopy cover is 2% short of American Forests' 40% citywide recommendation for San Antonio (Table 6). Translating a goal into a rough estimate of trees needed, the City would have to plant an additional 454,600 trees based on a 27 ft. diameter tree canopy. With the modeling capabilities in CITYgreen software, American Forests projected the ecosystem benefits that this new tree canopy would add to the city (Table 7).

Table 6. San Antonio Recommended Tree Canopy Percentages

	Citywide	ETJ	CBD	Urban Res.	Suburban Res.	Commercial
Existing Canopy %	38%	55%	12%	32%	33%	13%
AF Recommended Canopy %	40%	55%	15%	35%	39%	20%
Difference in Canopy %	-2%	0%	-3%	-3%	-6%	-7%

Since trees also include scrub species such as mesquite and persimmon, tree canopy goals reflect this.

Modeling Ecosystem Benefits of Recommended Tree Canopy Percentages

By increasing tree canopy cover to recommended goals, the City will increase their environmental services that tree canopy provides. The additional tree canopy percentage in each landuse category was modeled to demonstrate these added ecological and economic benefits (Table 7). If San Antonio increased its canopy cover by 2% overall, the ecosystem services would add an additional $1.7 million in annual air pollutant removal value, an additional 276,278 tons of carbon stored and an annual 2,151 tons of carbon sequestered, as well as 3.4 million cubic feet of additional managed stormwater, valued at $2.2 million.

Table 7. Additional Benefits of Modeled San Antonio Ecosystem Services

Land Use	Additional Air Pollution Removal	Additional Air Pollution Removal Value	Additional Carbon Stored	Additional Carbon Sequestered	Decreased Stormwater Volume	Additional Stormwater Value @ $.64 per cu. ft
	lbs./ yr	dollar value	tons	tons	cu. ft.	dollar value
COSA	721,121	$1,717,553	276,278	2,151	3,358,739	$2,149,593
Urban res.	341,783	$814,052	130,945	1,019	2,691,324	$1,722,448
Suburban res.	1,763,063	$4,199,230	675,470	5,259	4,498,808	$2,879,237
CBD	3,202	$7,626	1,227	10	4,183	$2,677
Commercial	521,614	$1,242,371	199,842	1,556	2,880,229	$1,843,347

*Calculating the numbers of trees this represents is based on modeling the canopy size of an "average urban tree" in San Antonio considering both large and small trees and an average 27ft. diameter canopy spread. See calculations template for details.

Recommendations

This project has quantified San Antonio's green infrastructure—its landcover and corresponding ecosystem services. This digital data is packaged into a GIS interactive data layer compatible with existing GIS data so that City staff can use it in future planning decisions. American Forests recommends that the data and CITYgreen® software be used to run landcover scenarios, refine tree canopy goals over time, and quantify the progress made with current and new tree initiatives.

Establish Citywide Tree Cover Goals

Establish unified tree canopy goals for the entire City and stratify these goals for land use categories. Base these goals on City mandates for achieving environmental goals for air and water. Incorporate these goals into planning and development policies.

- Adopt unified tree canopy goals for the entire City and stratify these goals for landuse categories. Base these goals on City's mandates for achieving environmental goals for air and water. Incorporate these goals into planning and development policies.

Use the green data layer and CITYgreen to test new strategies to protect environmental quality

- Use CITYgreen scenario and replacement modeling capabilities to see if the strategy for enhancing urban forest canopy is achieving stated environmental goals.
- Use CITYgreen modeling to test strategies for attaining federal air quality compliance once stricter standards are adopted in 2010.

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

- Share the green data layer provided with this project with other city departments concerned with related ecosystem services.
- Test the impacts of changing tree canopy, impervious surfaces, and other landcovers under different development scenarios.

Launch a public education campaign to increase public awareness of the direct relationship between environmental quality and tree canopy. Encourage private citizens to plant trees on private property

- Use analysis findings in popular media to educate the public about the importance of their role in increasing the urban forest and the positive impact planting on private property will make.
- 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.

Photo: Gary Moll, American Forests

The urban forest along the River Walk.

About the Urban Ecosystem Analysis

American Forests Urban Ecosystem Analysis is based on the assessment of "ecological structures"—unique combinations of landuse and landcover 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

American Forests calibrated landcover change based on the USGS 2001 National Landcover Dataset (NLCD) to update the prior Urban Ecosystem Analysis rather than updating the 2002 data from the original UEA. Imagery and classification techniques have changed substantially since the initial analysis. The U.S. Geological Survey's landcover data set is now the standard for Landsat-derived landcover change analysis. Imagery of San Antonio was classified from 2001 and 2006 and landcover change trends were quantified and documented. American Forests classified the imagery into five land classes: trees, urban, open space, bare soil, and water.

For the high resolution imagery, Sanborn acquired 2-foot pixel resolution, 4-band, multi-spectral aerial photography in October 2007. Sanborn then conducted a knowledge-based classification to divide the landcover into five categories: trees, open space/grass/scattered trees, impervious surfaces (such as gravel parking lots), bare soil, and water. The high resolution data was resampled to 6 ft., a size suitable for running ArcGIS to conduct analyses.

Analysis Formulas

Urban Ecosystem Analyses were conducted using American Forests' CITYgreen software®. CITYgreen for ArcGIS used the high resolution landcover classification for the analysis. The following formulas are incorporated into the CITYgreen software.

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. Woodward in collaboration with Troy Dorman, Ph.D, P.E., Pape-Dawson Engineers, calibrated the curve numbers used in CITYgreen with local stream gage data within the ETJ. The methodology is described in an addendum to this report.

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 landcover 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 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.

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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.

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