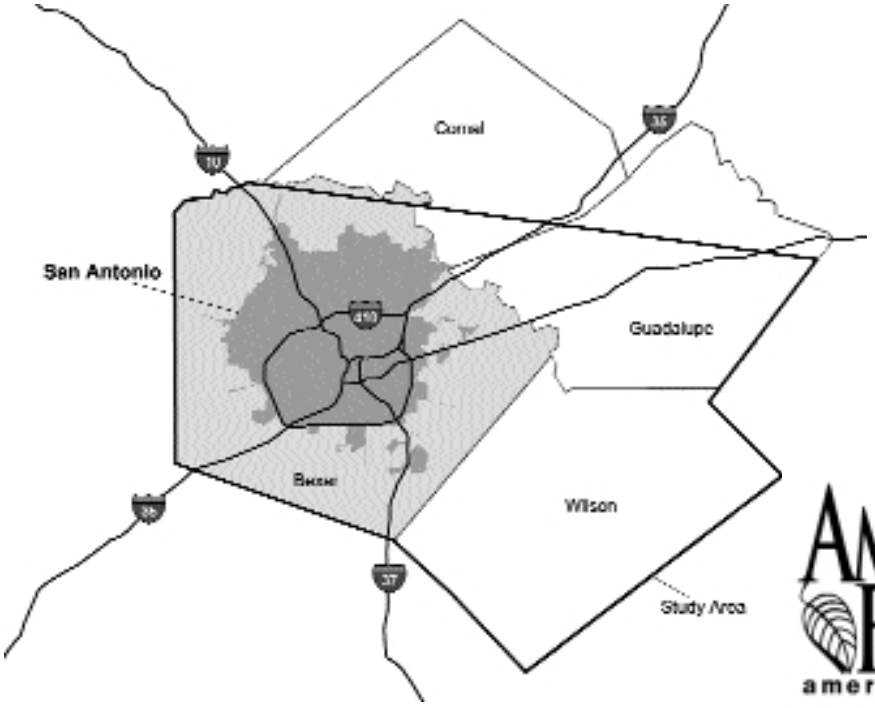
November 2002

Urban Ecosystem Analysis San Antonio, TX Region

Calculating the Value of Nature

Report Contents



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Project Overview

AMERICAN FORESTS conducted an Urban Ecosystem Analysis of the San Antonio Region to determine how the landscape has changed over time with its economic benefits for ecological services. The analysis assessed the change in land cover and its associated values using data from satellite images spanning a 16-year period from 1985 to 2001. The analysis covered 1.6 million acres of land including the City of San Antonio, Bexar County, and portions of Wilson, Guadalupe, and Comal Counties.

The City of San Antonio and its surrounding environs lay at the confluence of four ecological regions, a situation unique in all of Texas. These ecoregions—Blackland prairie, Post oak savanna, South Texas plains, and Edwards Plateau—are each distinct in their soil, flora, and fauna. Also of note are the many springs, creeks, and rivers which arise in the immediate vicinity and to areas west and northeast of San Antonio as a result of fault lines along one the of nation's largest karst limestone aquifers. This feature, together with the varied vegetation, produces a migratory flyway par excellence.

San Antonio is currently the 9th largest city in the United States (2000 Census) and has seen its population increase by nearly 25% over the last decade. With such an increase in population comes increased pressure on natural resources. Less vegetation and increased impervious surfaces mean higher costs for clean air, water, and energy.

An analysis of tree cover within the San Antonio region reveals tree loss trends in three distinct analysis areas. As might be expected, the most dramatic loss of tree cover occurred within the City of San Antonio. The city saw it's heavy tree cover (areas with greater than 50% canopy) decline by nearly 39%, from 63,522 acres in 1985 to 38,753 acres in 2001. The Greater San Antonio Area, including Bexar County and surrounding suburbs saw its heavy tree cover drop from 26% to 20% and the entire San Antonio Region that included portions of the three surrounding counties declined from 22% to 19% over the same 16 year period.

The analysis used Geographic Information Systems (GIS) technology to measure the structure of the landscape, with emphasis on tree cover. Regional changes in the landscape were analyzed using satellite images. A detailed look at the urban forest's economic value was conducted using low-level digital imagery of 22 study sites and AMERICAN FORESTS' CITYgreen® software. CITYgreen is a desktop GIS software used by local government agencies and engineering groups for decision support.

Major Findings

The Greater San Antonio Area, including Bexar County and surrounding suburbs has changed significantly since 1985. Forests have declined and urban areas have expanded.

■ In 1985, areas with heavy tree canopy (50% or greater tree cover) covered 26% of the area (201,000 acres). By 2001, that number had fallen to 20% (156,000 acres)—a loss of over 22% of the densely forested areas.

■ Areas with light tree canopy (less than 20% tree cover) expanded from 69% in 1985 (540,000 acres) to 77% in 2001 (605,000 acres). Though agricultural areas as well as urban areas fall under this category, the sharp increase in San Antonio's population over the last decade (22.3% - Census Bureau) suggests that this increase in areas with little tree cover is largely the result of urban expansion.

■ While areas of medium density canopy (20-49%) had the most significant percentage change, the total number of acres affected were small in comparison to the heavy and light canopied areas. In 1985, 6% of the Greater San Antonio Area (47,000 acres) was covered by medium density canopy. This number fell to just 3% by 2001 (27,000 acres) a loss of approximately 43%. This trend suggests that as new development occurs, tree canopy is not being conserved.

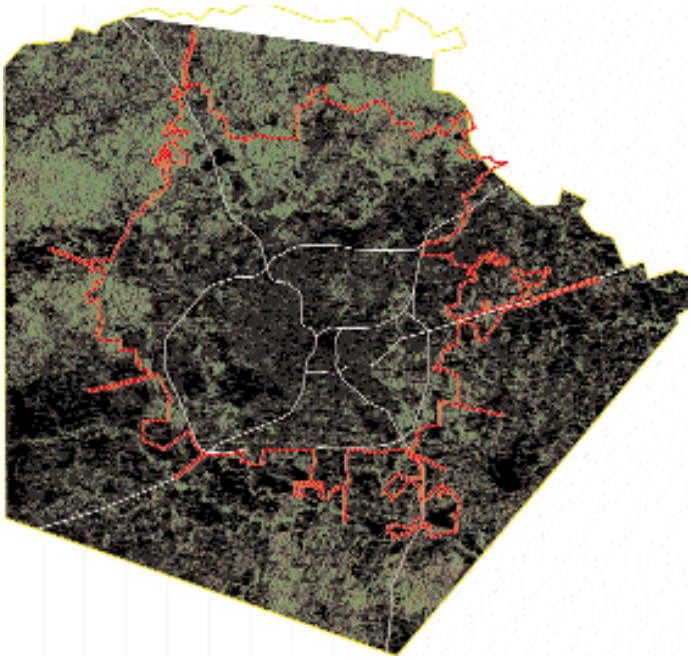
There are economic and ecological implications of tree loss for stormwater management, clean air, and energy consumption in the Greater San Antonio Area.

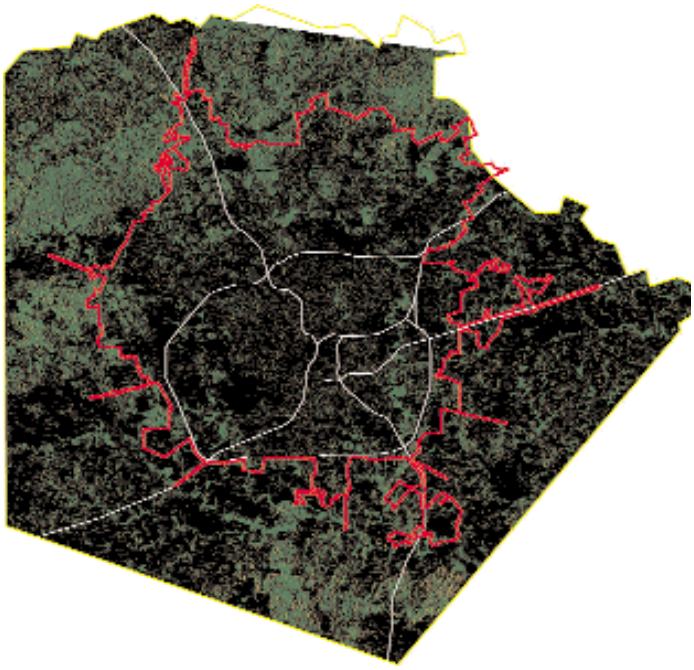
■ Tree loss in the Greater San Antonio Area between 1985 and 2001 resulted in an estimated increase of 73 million cubic feet of stormwater flow during a peak storm event (based on a 2-year, 24-hour storm event). Using a cost estimate of $2/cubic foot to build stormwater systems, this vegetation loss is equivalent in value to a one-time savings of $146 million.

■ The urban forest improves 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 (PM10). Tree canopy lost between 1985 and 2001 would have removed about 3.7 million more pounds of pollutants annually, at a value of approximately $8.9 million per year.

■ Trees also reduce energy consumption in the summer by providing direct shading to residential homes with air conditioners. The Greater San Antonio Area's tree cover saves the area an estimated $17.7 million in cooling costs annually.

The Greater San Antonio Area Regional Ecosystem Analysis





Above: 1985 Tree canopy density in the Greater San Antonio Area, Landsat TM 30 meter resolution.
Right: 2001 Tree canopy density in Greater San Antonio Area Landsat TM 30 meter resolution.

Key: Tree Canopy Density

<20%	30-39%	≥50%
20-29%	40-49%	

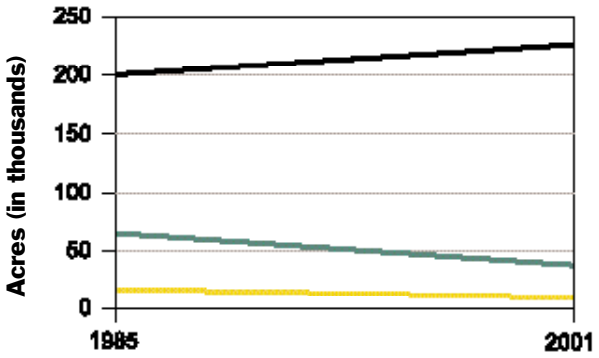
Satellite Images

Classified Landsat TM satellite images show the change in land cover for the Greater San Antonio Area between 1985 and 2001. Heavy tree cover is indicated in green (areas of greater than 50% canopy) and light tree canopy and impervious surfaces (areas with less than 20% canopy) associated with urban areas are in black. The analysis measures nine categories of tree cover, however the visual images above combine the nine categories into groupings to accommodate the limitations of printing the images at this scale.

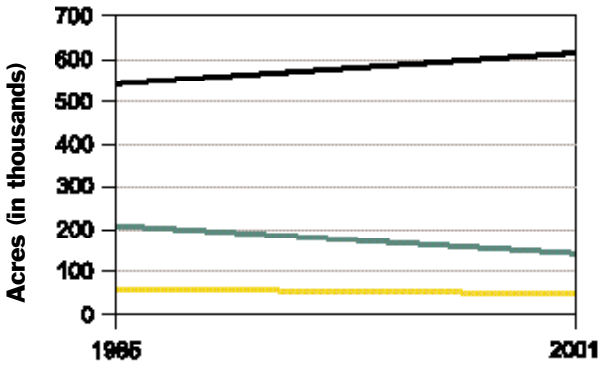
Graphing Change

The change in vegetation depicted in the satellite images above is represented in line graphs on the right. Both charts show the change in vegetative cover over a 16-year period for three categories. Natural forest cover is represented by a green line and indicates places with greater than or equal to a 50% tree canopy. Developed and agricultural areas are represented by a black line and indicate areas where tree canopy is less than 20%. The yellow line represents land where the tree cover is between 20% and 49%.

Vegetation Change
City of San Antonio, 1985-2001



Vegetation Change
Greater San Antonio Area, 1985-2001



Heavy Canopy (>50%)
Moderate Canopy (20-49%)
Light Canopy (<20%, including urban areas)

Local Level Analysis

What is a Local Level Analysis?

The local level analysis is a detailed assessment of a selected number of sample study points where high resolution aerial imagery, a site survey, and CITYgreen® software are used to calculate the effect of tree cover on air, water and energy. It is through this process that scientific and engineering data is connected to the regional assessment. The Alamo Forest Technical Committee sampled 22 sites stratified by land use and ecological zones within the Greater San Antonio Area. The land use categories included residential, commercial, and vacant. The ecological zones, based on soil type, included Post oak, Edwards Plateau, Blackland prairie, and South Texas plains. These distinct ecoregions pose difficulties in determining the appropriate sampling methodology for the project and future urban forest management needs and concerns. Each sample site covers an area of approximately 1-3 acres in size.

Aerial imagery of each sample site provided data about trees, grass, and impervious surfaces. Information collected in the field included number of trees, species, diameter, height, ground cover, tree health, and growing conditions. Additional information was collected on buildings regarding roof color reflectivity, number of windows, building height (number of stories), and if buildings were centrally air-conditioned. Other data were added to the calculations using national data sets for soil types and rainfall. CITYgreen software was used to calculate ecosystem benefits for each sample site. The results of these analyses were then extrapolated to the Greater San Antonio Area and the City of San Antonio.

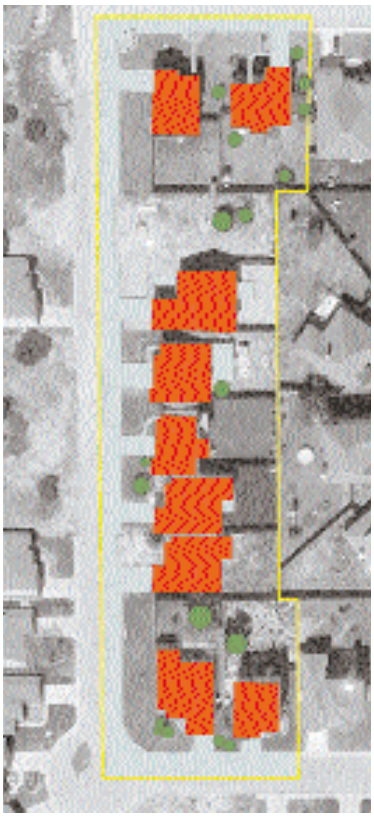
How CITYgreen is Used To Analyze Local Data

AMERICAN FORESTS uses CITYgreen software to conduct a detailed analysis of the structure of the landscape and to calculate the dollar benefits of trees. This analytical technique incorporates research and engineering formulas to place a dollar value on the work trees do. With CITYgreen it is possible to determine how various canopy cover classes affect stormwater movement, air quality, and energy conservation.

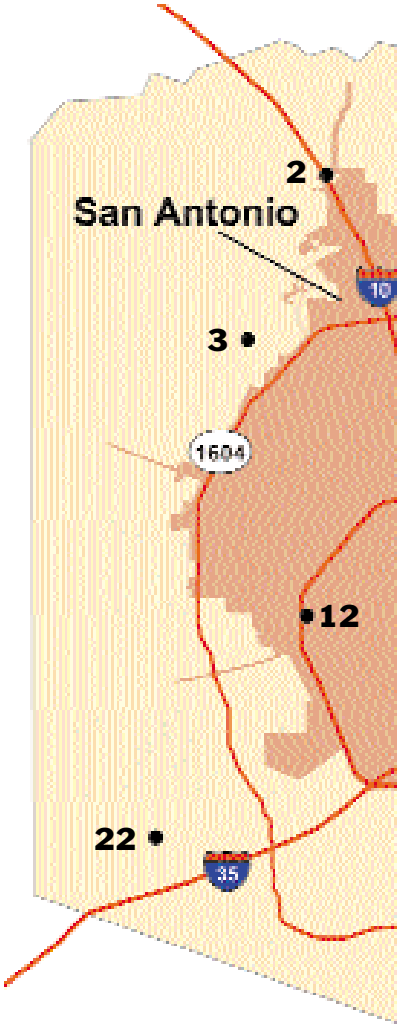
Stormwater Runoff

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 into the atmosphere and some soaks into the ground, reducing peak flows and thus reducing the total amount of runoff that must be managed in urban areas. Trees also slow storm flow, reducing the volume of water that containment facility must store. The TR-55 model, developed by the Natural Resources Conservation Service, measures stormwater movement in various storm events (see page 8).

4. Stone Oak



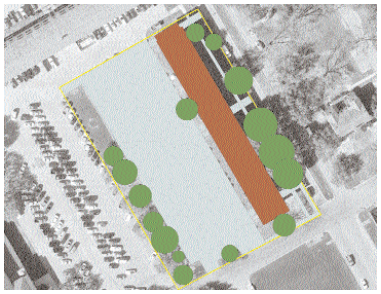
2.17 acres 2% Tree Canopy



6. Hidden Forest

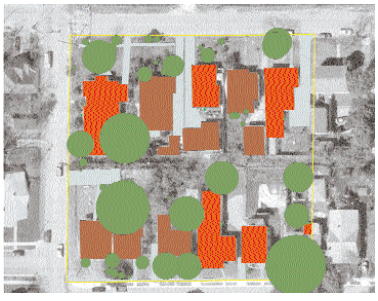
1.97 acres 54% Tree Canopy

7. Randolph AFB



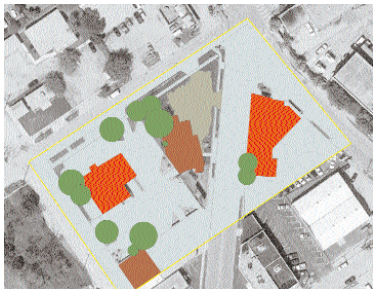
2.05 acres 16% Tree Canopy

9. Mahncke

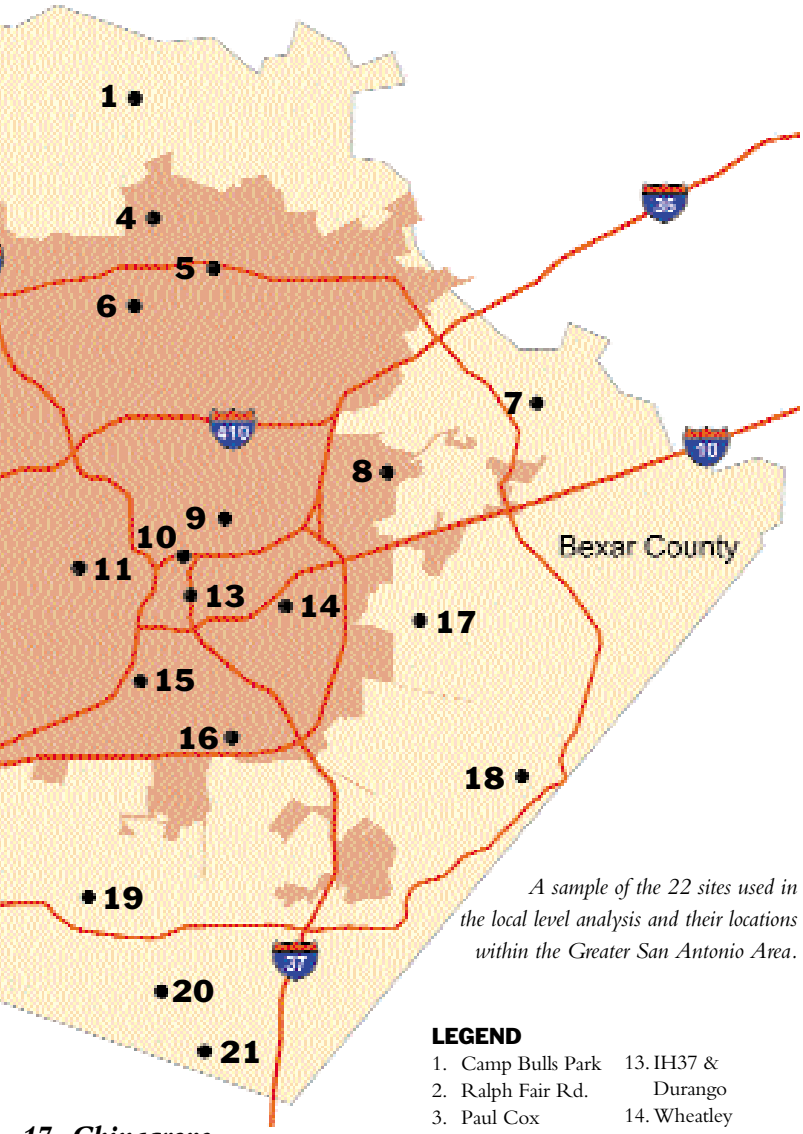


1.94 acres 24% Tree Canopy

10. Camden



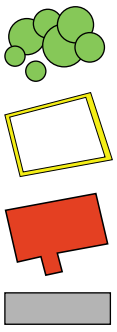
2.12 acres 10% Tree Canopy



A sample of the 22 sites used in the local level analysis and their locations within the Greater San Antonio Area.

LEGEND

1. Camp Bulls Park
2. Ralph Fair Rd.
3. Paul Cox
4. Stone Oak
5. H.E.B.
6. Hidden Forest
7. Randolph AFB
8. Rittman Park
9. Mahncke Park
10. Camden
11. W. Commerce
12. Lackland Terrace
13. IH37 & Durango
14. Wheatley Heights
15. Rosebud
16. San Juan Woods
17. China Grove
18. Sara Stuart Rd.
19. SAWS-Neal Rd.
20. CPS Tower
21. Sandview Rd.
22. Bradley Rd.



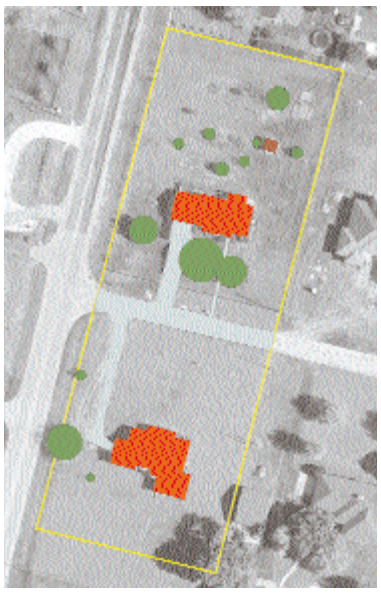
tree cover

local site boundary

built structure

impervious surface

17. Chinagrove



2.15 acres 5% Tree Canopy

Local communities are looking towards non-built stormwater management strategies, including trees, to reduce the cost of constructing stormwater control infrastructure. The value of trees for stormwater management is based on cost avoided for storage in retention ponds.

In the Greater San Antonio Area, the existing tree canopy reduces the need for stormwater management by 678 million cubic feet. Using a $2 per cubic foot stormwater management cost, trees currently save the area $1.35 billion in one-time construction costs.

Air Quality

Trees provide air quality benefits by removing pollutants such as nitrogen dioxide, carbon monoxide, sulfur dioxide, ozone, and particulate matter less than 10 microns in size. To calculate the dollar value for these pollutants, economists multiply the number of tons of pollutants removed by "externality costs," or costs to society not reflected in marketplace activity, as established by state public service commissions. This figure represents costs that society would have paid, in areas such as health care, if trees did not remove these pollutants. In the Greater San Antonio Area, the existing tree canopy removes 17.6 million pounds of pollutants, valued at $42 million, annually. Tree cover as it existed in 1985 would have removed 21 million pounds of pollutants at a value of $51 million.

Energy Use

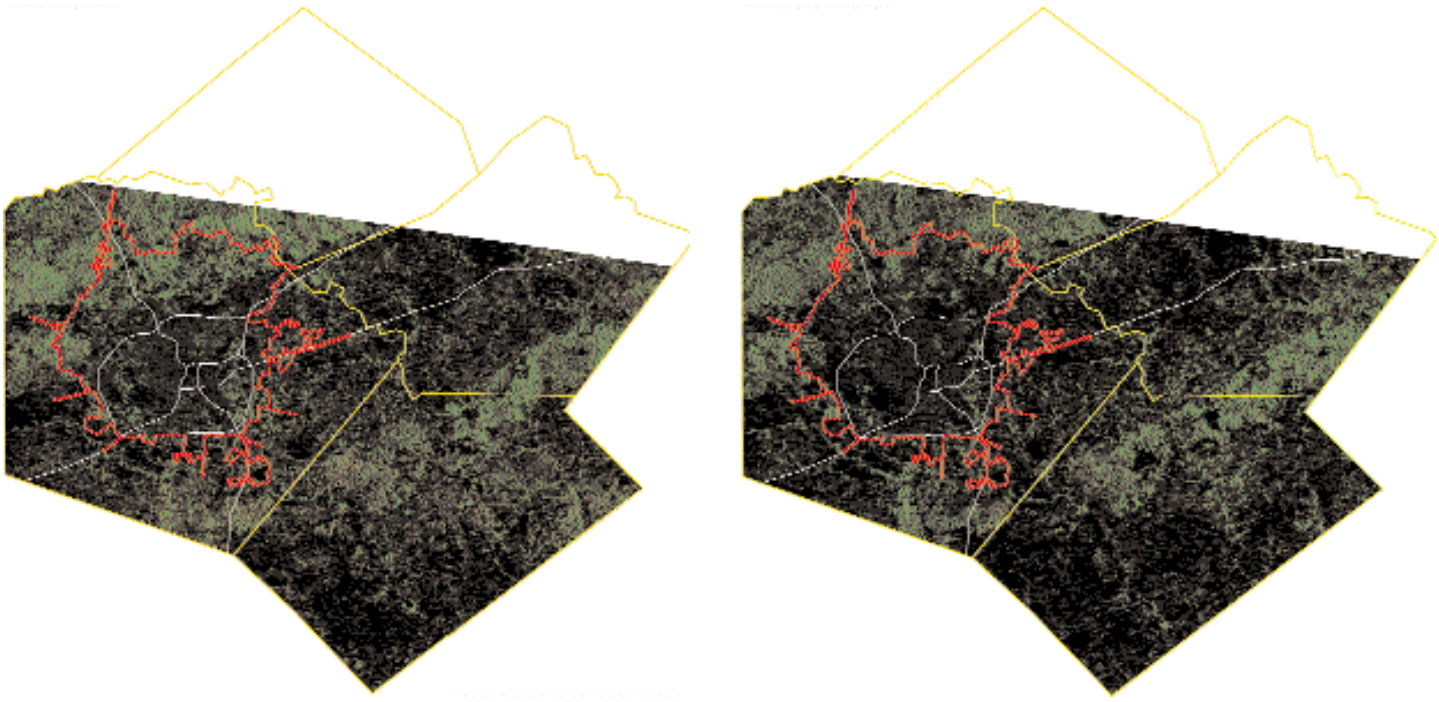
The Greater San Antonio Area experiences hot summers and residents spend approximately $555 per home (City Public Service) on air-conditioning per year. AMERICAN FORESTS' analysis suggests that the existing tree canopy in residential sample sites saves an average of $76 per home. (Note: Because USDA Forest Service research has thus far only modeled savings to residential-size buildings, values were not calculated for residential homes greater than two stories, commercial, or industrial sites.)

To estimate the energy conservation savings of trees in the Greater San Antonio Area, the average savings of $76/home was projected across the Area's 344,000 single-family detached residences. Assuming that 67.8% of these residences use central air conditioning (Census Bureau), the estimated annual residential savings is approximately $17.6 million as a result of direct tree shading on residential homes.

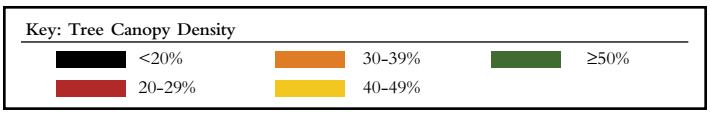
Stored and Sequestered Carbon

This study also analyzed the amount of carbon stored and sequestered per year in the Greater San Antonio Area's trees. Carbon accounts for approximately 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, or the rate of absorption per year. The Area's trees stored an estimated 7 million tons in 2001. The trees sequester approximately 56,000 tons per year.

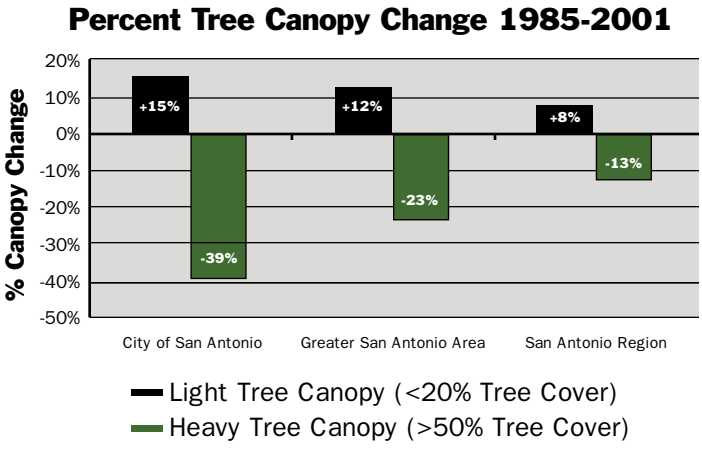
San Antonio Region



Classified Landsat TM images showing change in tree canopy in the San Antonio Region from 1985 (left) and 2001 (right).



An analysis of tree loss in the San Antonio Region, which includes Bexar County and portions of Wilson Guadalupe and Comal Counties, revealed trends similar to the Greater San Antonio Area, although not as dramatic. Heavy tree canopy declined from 22% in 1985 to 19% in 2001.



2001 Forest Cover Benefits

	Acres	Dense Tree Canopy	Stormwater Management Value (cu.ft.)	Stormwater Management Value ($)	Air Pollution Annual Removal Value (lbs)	Air Pollution Annual Removal Value ($)	Energy Savings - direct tree shading (kWh)	Energy Savings - direct tree shading ($)	Carbon Stored (tons)	Carbon Sequestered Annually (tons)
San Antonio Region	1,679,000	19%	1,428,612,000	$2.8 billion	36,682,000	$87.5 million	N/A	N/A	14,641,942	118,239
Greater San Antonio Area	788,000	20%	677,508,000	$1.3 billion	17,642,000	$42.1 million	321,550,000	$17.6 million	7,052,420	55,941
City of San Antonio	275,000	14%	215,694,000	$431 million	5,032,000	$12.0 million	262,686,000	$14.4 million	1,983,410	18,209

Recommendations

The San Antonio Region should develop a strategy for increasing its tree cover in this decade. Urban ecology is more complex than tree cover. Nonetheless, trees are good indicators of the health of an urban ecosystem. Trees require good soils, adequate water, and clean air. In addition to benefiting from these conditions, trees also help maintain them. Areas with greater canopy coverage and less impervious surfaces accrue greater environmental benefits. Trees provide communities with environmental benefits that can be measured in monetary value. These quantifiable benefits can help community leaders recognize cost savings opportunities from increased tree cover.

This report brings together the expertise of ecologists, scientists, and engineers with Geographic Information Systems (GIS) technology to evaluate the environment in the San Antonio Region. Local agencies and the community are encouraged to incorporate this information into the regional planning process and to gather more detailed data for local analyses using satellite imagery, aerial imagery, site surveys, and CITYgreen software.

Acquire high-resolution multi-spectral satellite imagery to accurately map the city's green infrastructure.

■ Once analyzed for land cover, this "green data layer" can be used to analyze the benefits of the tree cover within any boundary—political or ecological.

■ Incorporate this green data layer into citywide GIS systems, and distribute to local agencies for use in management and development decisions.

■ Determine the contributions trees make to air, water, and energy needs of the community during the design and engineering phase of construction, repair, or development projects.

Encourage the use of increased tree cover as one strategy for meeting air pollution, energy, and stormwater management needs. Tree cover can be increased by planting more trees, saving trees during development, and better maintaining existing trees.

■ Expand tree plantings so that trees will contribute to the reduction of atmospheric pollutants.

■ Encourage residential tree planting programs to reduce household energy consumption.

■ Create tree-planting programs to target urban areas. Increase tree canopy to offset the "urban heat island effect" where the amount of impervious surfaces are greater than the tree canopy.

Use tree cover and the findings of this study as a guide for land-use planning and growth management.

Consider the financial value of natural resources during the public policy decision-making process. Ecological benefits of tree cover translate into economic benefits and should be used in land-use planning and growth management plans.

Continue to work towards increasing and conserving tree canopy cover in all urban land use areas.

■ Develop specific, measurable urban tree canopy goals for the each of the jurisdictions covered in this study. AMERICAN FORESTS established the following general guidelines for semi-arid cities throughout the United States. These goals should be further refined by local groups taking into account climate and geography.

25-30% tree canopy overall
35-40% tree canopy in suburban residential zones
20% tree canopy in urban residential zones
10% tree canopy in the central business districts

■ Take specific action to increase medium-density tree canopy (20-49% tree cover). As cities grow, they expand into natural areas and remove tree canopy. The medium density category can be considered a measure of how well trees are being incorporated into new development.

■ Conserve mature trees, recognizing their contributions in maximizing the environmental benefits of the city.

■ Institute a tree replacement program so that over time, the tree population will have an appropriate age distribution. This will ensure healthy mix of mature and young trees to maximize environmental benefits.

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 heavy tree canopy provides more stormwater reduction benefits than one with lighter tree canopy and more impervious surface.

In this study, the regional analysis provided an overview of tree cover change in the San Antonio Region. Using land use and tree cover percentage categories to model the area's ecological structures, sample sites were selected to further examine the effects of different tree canopy cover percentages on air quality, energy and stormwater management.

Data Used

Landsat Satellite TM (30 meter pixel) images were used as the source of land cover data. Landsat satellites have been circling the earth since 1972, providing a historical archive of land cover information. AMERICAN FORESTS used a subpixel classification technique and divided land cover into nine vegetation categories based on tree canopy density.

Analysis Formulas

The following formulas are incorporated into CITYgreen software.

TR-55 for Stormwater Runoff: The stormwater runoff calculations incorporate formulas from the Urban Hydrology of Small Watersheds model, (TR-55) developed by the US Natural Resources Conservation Service (NRCS), formerly known as the US Soil Conservation Service. Don Woodward, P.E., a hydrologic engineer with NRCS, customized the formulas to determine the benefits of trees and other urban vegetation with respect to stormwater management.

UFORE Model for Air Pollution: CITYgreen® uses formulas from a model developed by David Nowak, PhD, of the USDA Forest Service. The model estimates how many pounds of ozone, sulfur dioxide, nitrogen dioxide, and carbon monoxide are deposited in tree canopies as well as the amount of carbon sequestered. The urban forest effects (UFORE) model is based on data collected in 50 US cities. Dollar values for air pollutants are based on averaging the externality costs set by the State Public Service Commission in each state. Externality costs, are the indirect costs to society, such as rising health care expenditures as a result of air pollutants' detrimental effects on human health.

Acknowledgements for this Study

We gratefully acknowledge the support of the following governmental agencies and environmental organizations in conducting this study:

- The Alamo Forest Partnership
  Steering Committee Partners: City Public Service, City of San Antonio, Texas Forest Service, San Antonio Water System, Alamo Area Council of Governments, Department of Defense, National Park Service, Texas Parks & Wildlife Dept., University of Texas at San Antonio, SA Forest, San Antonio Trees, Bexar Audubon, Neighborhood Resource Center.

  Supporting Partners: Texas Department of Transportation, Keep San Antonio Beautiful, Inc., Texas Master Naturalist, San Antonio River Authority, Bexar County Environmental Services, Open Space Advisory Board.

- ESRI for GIS software
- ERDAS for remote sensing software

For More Information

AMERICAN FORESTS, founded in 1875, is the oldest national nonprofit citizen conservation organization. Its three centers—Global ReLeaf, Urban Forestry, and Forest Policy—mobilize people to improve the environment by planting and caring for trees.

AMERICAN FORESTS' CITYgreen software provides individuals, organizations, and agencies with a powerful tool to evaluate development and restoration strategies and impacts on urban ecosystems. AMERICAN FORESTS offers regional training workshops and technical support for CITYgreen and is a certified ESRI developer and reseller of ArcView products. For further information contact:

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