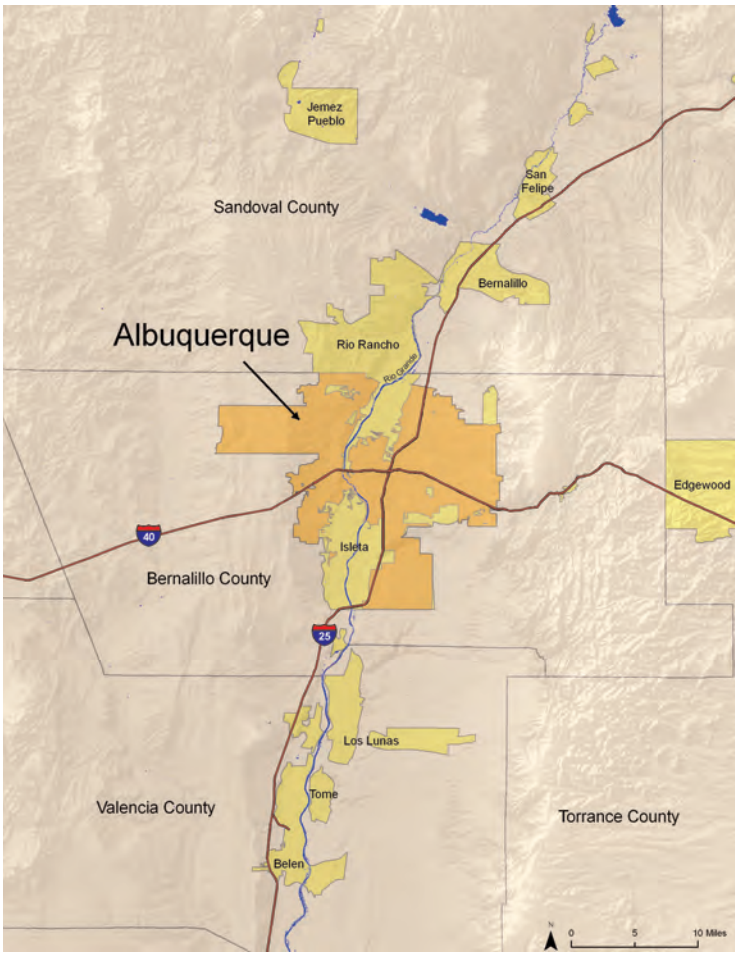
May 2009

Urban Ecosystem Analysis Albuquerque, New Mexico

Calculating the Value of Nature

Report Contents



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Project Overview

"We are ready to design the future of trees in the City of Albuquerque." - Mayor Martin J. Chávez

With a recognition and strong commitment toward sustainability and the multiple environmental and social values that trees bring to their community, the City of Albuquerque commissioned American Forests to conduct an urban ecosystem analysis of their urban forest. The findings of this study present a trend analysis to reveal how land cover, including tree canopy, has changed over the past 18 years while providing a more detailed analysis and dataset that can be used for ongoing planning as the city continues to develop. Albuquerque increased its population by one third between 1990 and 2008 and experienced immense economic growth. The tools provided with this project will help the city best utilize its green resources and make well-informed planning decisions with green infrastructure in mind.

The City's multi-pronged initiatives dovetail with the ecosystem services that trees in urban environments provide for slowing stormwater runoff and improving water quality, storing/sequestering carbon, and mitigating air pollution. By quantifying the ecological and economic value that trees bring to an urban community, city leaders can leverage their non-engineering benefits as part of their overall sustainability strategy.

The Municipal Forest Resource Analysis, conducted in August 2006, analyzed the environmental benefits of the City's public trees planted along streets and in parks. The recommendations included conducting a more comprehensive study of the entire urban forest, since public trees only represent a small fraction of a community's tree canopy. Using satellite imagery, GIS technology and American Forests' CITYgreen software, this Urban Ecosystem Analysis analyzed land cover for the entire city at two scales spanning two time periods. The first assessment utilized moderate-resolution 30-meter Landsat imagery acquired in 1990, 2001 and 2008. Even though the City has expanded during this time, the trend analysis used the most recent city boundary available as a common measure to show how the land cover has changed over the past 18 years. The second assessment used 2007 high-resolution (2ft. pixel resolution) digital imagery to calculate current land cover for the city, and the Bosque as well as by landuse, city council district, and planning zones.

In addition, this study modeled land use and land cover segments at different tree canopy percentages to demonstrate the increased ecosystem services that additional tree canopy can provide. The evidence and data presented in this project will provide City leaders with the information to better integrate natural systems into future development decisions. More importantly, city staff can incorporate ecosystem services provided by trees into their daily planning and sustainability initiatives using the metrics of an Urban Ecosystem Analysis.

Major Findings

Using moderate resolution satellite data from Landsat imagery acquired in 1990, 2001 and 2008, American Forests measured changes in six distinct land cover types: tree canopy, urban, open space/grasslands, scrub, bare soil, and water. This moderate resolution data identifies land cover change trends between these years. The analysis quantified the impacts these changes have had on stormwater management, air and water quality, and carbon sequestration and storage. Methodology for assigning a dollar value for each analysis is detailed on pages 8-9.

1990-2008 Landcover Change Trend Data Using 30 meter Landsat Satellite Imagery

- The findings show that overall between 1990 and 2008 the City lost 43 acres (7%) of tree canopy, 3,569 acres (24%) of open space/grasslands, and 11,586 acres (23%) of scrub while gaining 15,169 acres (28%) of additional urban area (Table 1).

- While tree canopy loss was not as dramatic as open space or scrub loss, development during this time primarily replaced these permeable land covers with impervious surfaces, creating negative environmental impacts as described below.

- Trends over this time period illustrate that the rate of tree loss slowed in the latter time frame, but that the rate of change increased for open space, scrub, and urban areas.

1990-2008 Loss of Ecosystem Services

- There are ecological consequences when there is a loss of pervious landcover, such as tree canopy, open space, and scrub, which defines the city's green infrastructure. There are also ecosystem impacts with an increase in impervious land cover.The loss of green infrastructure means that the region's natural environment is less able to provide ecosystem services for air, water, and carbon.

- The City's vegetative land cover has lost an ability to remove approximately 3,000 lbs of air pollutants annually, valued at $6,800 per year. The loss of tree canopy equates to a loss of 1,900 tons of carbon stored in trees' wood and a loss of 15 tons of annual carbon sequestration.

- Without tree canopy to reduce stormwater runoff volume, the City must manage an additional 31 million cubic feet of stormwater, valued at $185 million (using a local engineering cost of $6 per cubic foot).
- Tree roots absorb water pollutants for which nine measures are available: Biological Oxygen Demand, Cadmium, Chromium, Chemical Oxygen Demand, Lead, Nitrogen, Phosphorus, Suspended Solids, and Zinc. Of these, each worsened, ranging from 7% for Zinc to 57% for Chemical Oxygen Demand due to vegetation being removed from the land.

Quantifying Albuquerque's 2007 land cover and its ecosystem benefits provides ecological opportunities for the future

- The City of Albuquerque has a 6% overall tree canopy, recognizing that the climate, rainfall, and soils of the southwest support a more desert-like landscape. However, since this is a rapidly urbanizing area with a dramatically changing landscape, the city could benefit from increasing its tree canopy with species appropriate to this region and thus increasing its ecosystem benefits. For example, by increasing the canopy from 6 to 8%,or approximately 149,000 trees, the ecosystem benefits include an additional 655,000 lbs of air pollutants removed annually, valued at $1.4 million, a decrease in 1.1 million cubic feet of stormwater runoff, valued at $7 million and an increase in carbon storage of 416,000 tons and an increase in carbon sequestration of 3,238 tons per year.
- The Bosque currently has 37% tree canopy and removes 96,000 lbs. of air pollutants annually, valued at $219,000, manages 4.5 million cubic feet of stormwater, valued at $27 million, stores 61,000 tons of carbon and sequesters 475 tons of carbon per year.
- When viewed from a landuse perspective, Albuquerque has the opportunity to increase its tree canopy in different areas including: the Bosque, parking lots, residential, and flood control areas of the City. Alternative tree canopy scenarios and their ecosystem benefits for these areas are detailed in Table 6.
- Trees slow stormwater runoff, decreasing the necessary amount of constructed stormwater storage. In 2007 Albuquerque's tree canopy provided 20 million cubic feet in stormwater detention services, valued at $123 million, using a local $6/cubic foot local cost (CABQ).
- 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 (PM10) in size. In 2007, Albuquerque's tree canopy annually removed 454,000 lbs of these pollutants at a value of $1 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 6% tree canopy cover measured in this study, Albuquerque's trees stored 289,000 tons of carbon in trees' wood and sequestered 2,300 tons of carbon in 2007.
- In 2007 Albuquerque had 6,700 acres of tree canopy (6%). The City had 54,000 acres of open space with grass and scrub (45%), 39,900 acres of impervious surface (33%), 19,900 acres of bare soil (17%), and 334 acres of water (.3%).
- Development adds impervious surface and thus it is important to offset their environmental impacts by increasing tree canopy. Albuquerque has the opportunity to increase its urban forest by establishing tree canopy goals and thus increase the ecosystem benefits it provides. Such a coordinated effort will maximize the urban forests' ability to provide ecosystem services which will serve the entire community.

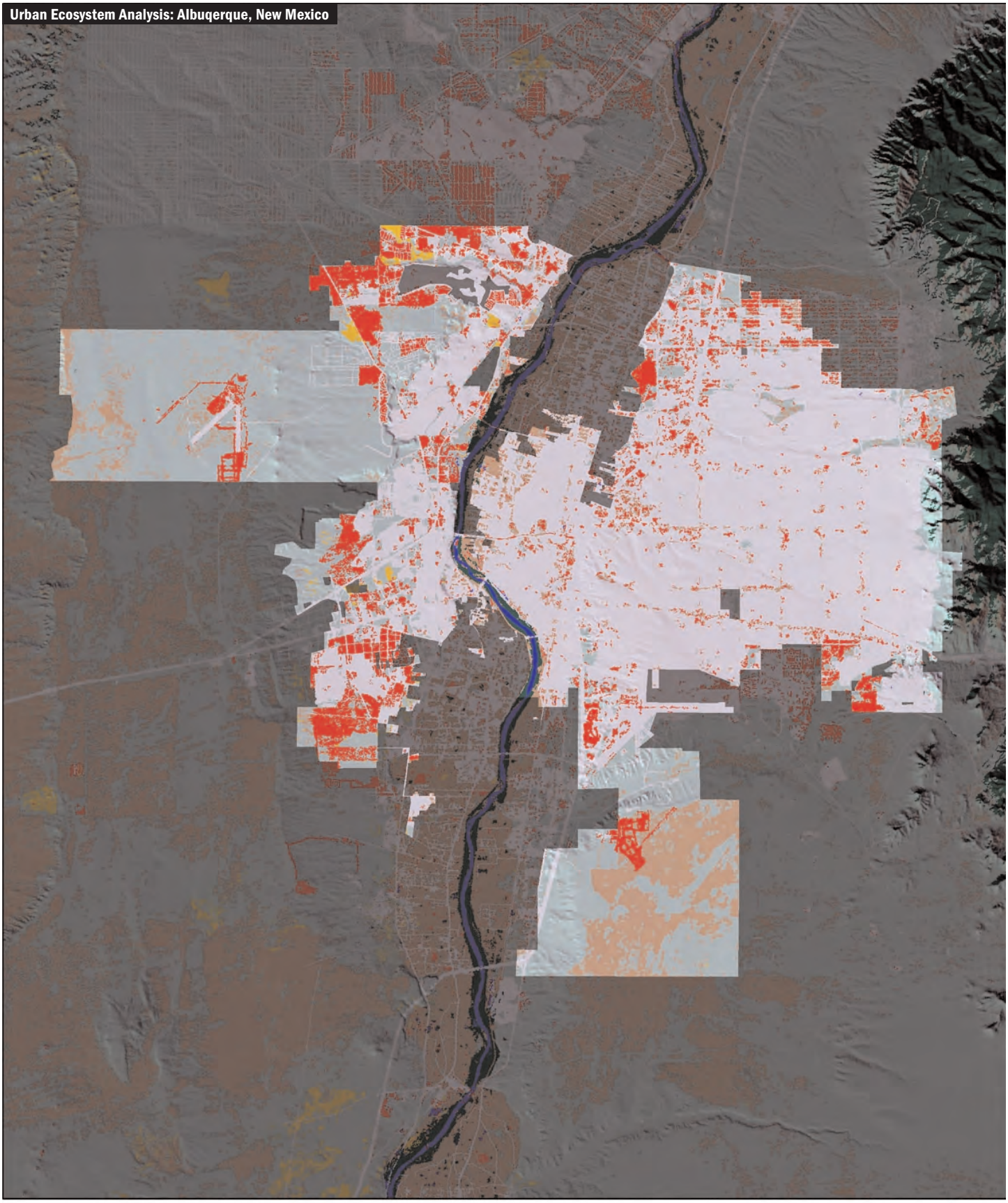


Figure 1.
Landsat-Derived Landcover and Urban Expansion 2001 - 2008

Land Cover Change Trends: Landsat 1990-2008

For this Urban Ecosystem Analysis, American Forests used the U. S. Geological Survey's (USGS) 2001 National Landcover Data (NLCD) as the baseline to update land cover change. The USGS data, considered the gold-standard for land cover change analysis, was classified from 30-meter Landsat data acquired in 2001. American Forests utilized this dataset as the basis to compare land cover change in 1990 and 2008. (Figure 1).

Table 1. Albuquerque Land Cover Change Trends 1990, 2001, and 2008

Albuquerque Landsat Land Cover (in acres)

	1990 acres	2001 acres	2008 acres	Change from 1990 to 2001 acres	Percent change %	Change from 2001 to 2008 acres	Percent change %	Change from 1990 to 2008 acres	Percent change %
Open Space	14,634	14,592	11,065	-42.1	0%	-3,527.0	-20%	-3,569.1	-24%
Scrub	49,710	44,631	38,124	-5,079.6	-10%	-6,506.8	-10%	-11,586.4	-23%
Trees	666	630	622	-35.8	-10%	-8.0	0%	-43.8	-7%
Urban	55,034	60,320	70,203	5,285.9	10%	9,883.1	20%	15,169.0	28%
Bare Soil	473	356	502	-117.0	-20%	145.5	40%	28.5	6%
Water Area	312	300	314	-11.6	0%	13.4	0%	1.8	1%

Even though the City acquired additional land during this time, the most recent City boundary was used for each year analyzed to hold city size constant in order to compare like land cover areas. Between 1990 and 2008, the urban category demonstrated the most dramatic increase while open space and scrub land declined. Scrub is defined as areas dominated by vegetation less than 5 meters tall with shrub canopy typically greater than 20% of the total vegetation (NLCD).

Tree canopy declined 7%, but since it only represents .5% of the total land cover, its changes were modest compared to the other land cover types. Due to all land cover changes, the City lost the ability to store 31 million cubic feet of stormwater, valued at $185 million. A local engineered value of $6 per cubic foot was used to calculate the value of mitigating this additional stormwater (CABQ)). Albuquerque's land cover also lost $6,800 in annual air pollution removal value, 1,900 tons of carbon storage and 15 tons of carbon sequestration annually. The chronological analysis provides valuable public policy information showing general trends in land cover changes.

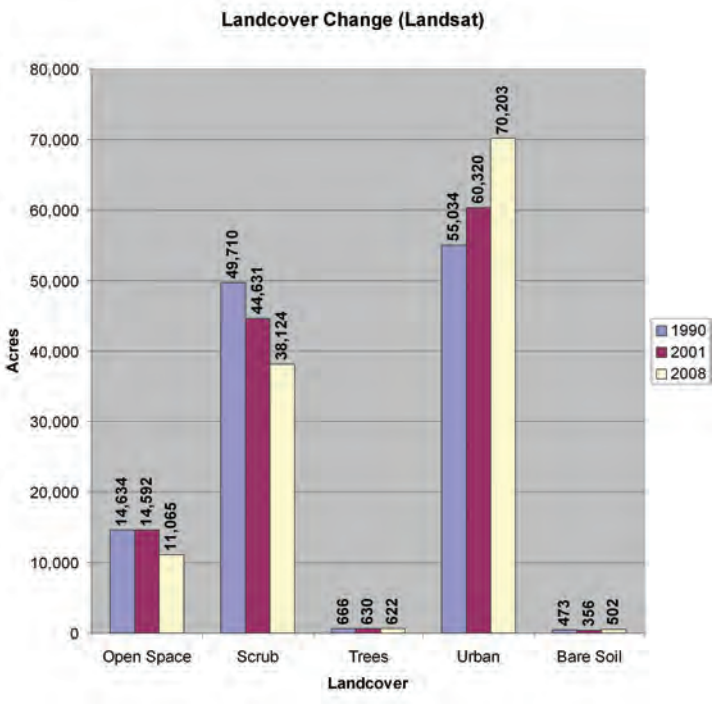


Table 2. Albuquerque Change in Ecosystem Services as Measured with Landsat Data

	Tree Canopy Change %	Loss of Air Pollution Removal lbs./yr	Loss of Air Removal Pollution Removal Value dollar value	Loss in Stormwater Value cu. ft.	Loss in Stormwater Value@ $6.00 cu ft. dollar value	Loss of Carbon Stored tons	Loss of Carbon Sequestered tons
1990 – 2001	-5.0%	-2,426	-$5,536	10,133,403	$60,800,420	-1,541	-12
2001 – 2008	-1.0%	-542	-$1,238	20,661,031	$123,966,186	-345	-3
1990 – 2008	-7.0%	-2,968	-$6,774	30,794,434	$184,766,605	-1,885	-15

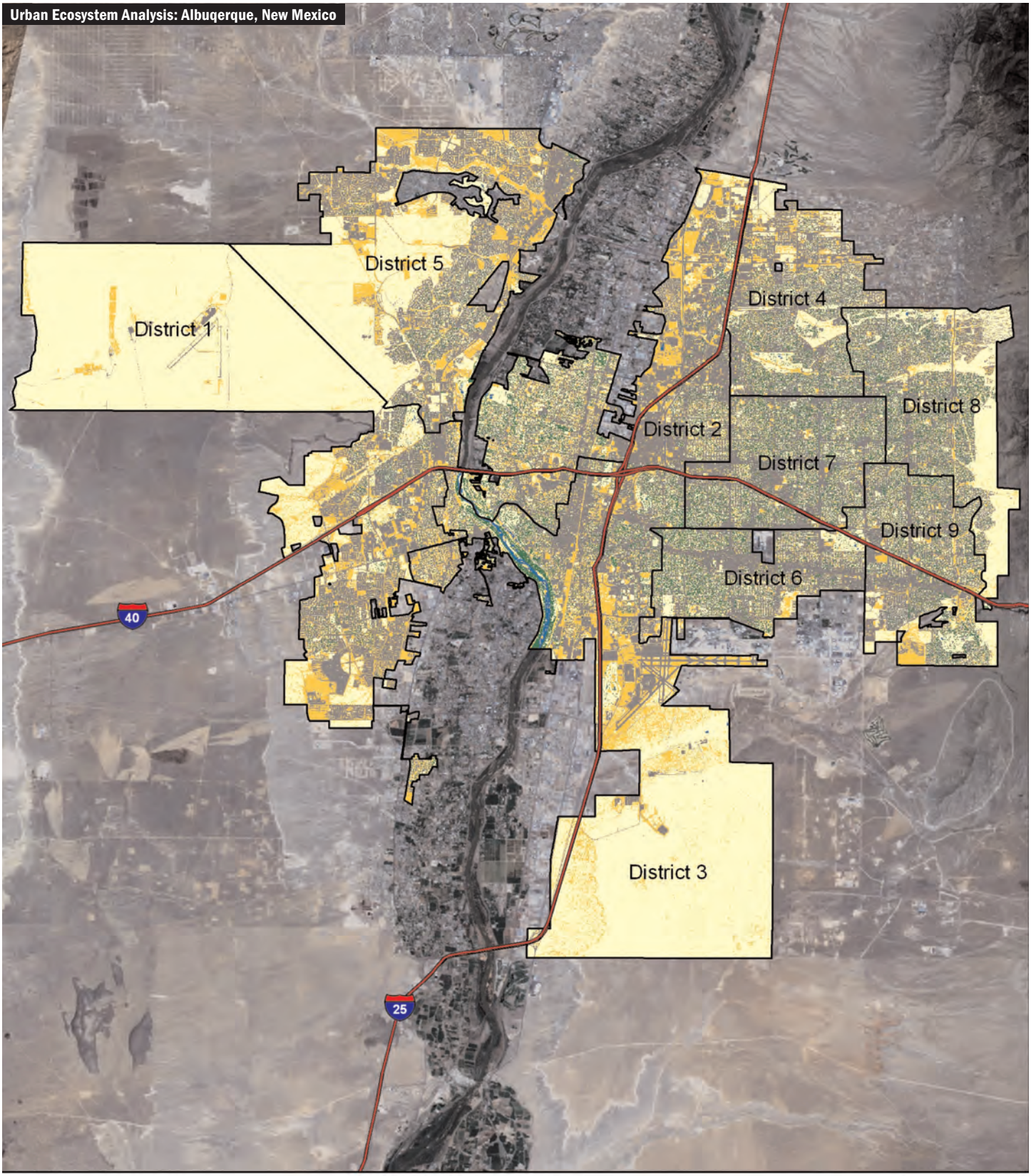


Figure 2.
2007 Land Cover
High-Resolution Classification
City Council Districts

Ecosystem Benefits by Landuse: High Resolution 2007 Data

To better understand how land cover impacts ecosystem benefits, a much finer, high-resolution, (2-ft, resampled to 6-ft) 4 band, multi-spectral satellite imagery acquired in June and July 2007 was classified into five land cover categories: trees; open space/grass/scrub; impervious surfaces; bare soil; and water (Figure 2). Land cover was also quantified by nine Council district (Table 3), 13 land use categories (Table 4) and 26 zoning areas (Table 5).

Table 3. Ecosystem Services by Council District

	Area acres	2007 Tree Canopy acres	2007 Tree Canopy %	Air Pollution Removal lbs./ yr	Air Pollution Removal Value dollar value	Carbon Stored tons	Carbon Sequestered tons	Stormwater Value* cu. ft.	Stormwater Value @ $6 per cu. ft** dollar value
Albuquerque	120,810	6,707	6%	454,403	$1,037,150	288,627	2,247	20,428,723	$122,572,338
Bosque	3,841	1,417	37%	95,991	$219,095	60,972	475	4,491,117	$26,946,703
Council District 1	27,400	369	1%	25,017	$57,100	15,890	124	999,894	$5,999,366
Council District 2	13,542	1,124	8%	76,165	$173,843	48,378	377	5,417,248	$32,503,487
Council District 3	26,475	1,078	4%	72,996	$166,608	46,365	361	2,020,299	$12,121,791
Council District 4	7,720	614	8%	41,592	$94,932	26,418	206	2,613,457	$15,680,744
Council District 5	17,491	383	2%	25,962	$59,256	16,490	128	1,688,569	$10,131,413
Council District 6	5,516	652	12%	44,158	$100,787	28,048	218	3,119,455	$18,716,730
Council District 7	7,098	1,003	14%	67,944	$155,079	43,157	336	5,005,421	$30,032,529
Council District 8	8,467	785	9%	53,171	$121,360	33,773	263	2,788,260	$16,729,559
Council District 9	7,101	700	10%	47,399	$108,185	30,107	234	3,018,099	$18,108,592

*The sum of the council districts' stormwater values does not total to the citywide value. This is because each council district 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 $6.00 per cubic foot.

Table 4. Ecosystem Services by Land Use

		Area acres	2007 Tree Canopy acres	2007 Tree Canopy %	Air Pollution Removal lbs./ yr	Air Pollution Removal Value dollar value	Carbon Stored tons	Carbon Sequestered tons	Stormwater Value* cu. ft.	Stormwater Value @ $6 per cu. ft** dollar value
1	Agriculture	175	17	9%	1,118	$2,553	710	6	22,618	$135,711
2	Com/Retail	3,430	83	2%	5,647	$12,890	3,587	28	806,352	$4,838,110
3	Com/Service	3,974	183	5%	12,379	$28,255	7,863	61	1,322,229	$7,933,373
4	Drain/Flood Control	2,528	115	5%	7,762	$17,715	4,930	38	356,663	$2,139,978
5	Indus/Manufac.	1,716	33	2%	2,199	$5,019	1,397	11	177,531	$1,065,186
6	Multifamily	3,020	334	11%	22,608	$51,601	14,360	112	1,789,556	$10,737,335
7	Parking Lots/Struct	500	22	4%	1,459	$3,329	926	7	181,722	$1,090,329
8	Parks/Recreation	17,684	705	4%	47,738	$108,960	30,322	236	1,235,671	$7,414,024
9	Public/Institutional	4,325	197	5%	13,320	$30,403	8,461	66	974,973	$5,849,839
10	SF:Rio Grande East	19,921	3,294	17%	223,172	$509,378	141,754	1,104	12,461,050	$74,766,301
10	SF: Rio Grande West	8,808	499	6%	33,770	$77,078	21,450	167	2,906,434	$17,438,607
11	Transportation /Util.	5,067	17	<1%	1,128	$2,576	717	6	40,474	$242,843
12	Vacant/Other	30,936	175	<1%	11,878	$27,112	7,545	59	231,774	$1,390,646
13	Wholesale/warehouse	1,351	21	2%	1,409	$3,215	895	7	171,665	$1,029,988

*The sum of the land use categories' stormwater values does not total to the citywide value. This is because each 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. In addition, the total acreage of all the land uses is less than the citywide acreage because city streets wer not included in the land use boundaries.
**Stormwater analysis uses a 2yr, 24 hour storm event. The value of managing stormwater is based on current local construction costs of $6.00 per cubic foot.

Ecosystem Values of Green Infrastructure

A city's pervious land cover 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 land cover categories of tree canopy, open space/grass/scrub, bare soil, and water.

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. Albuquerque's urban forest manages 20 million cubic feet of stormwater, valued at $123 million using a $6 per cubic foot value based on local costs (CABQ).

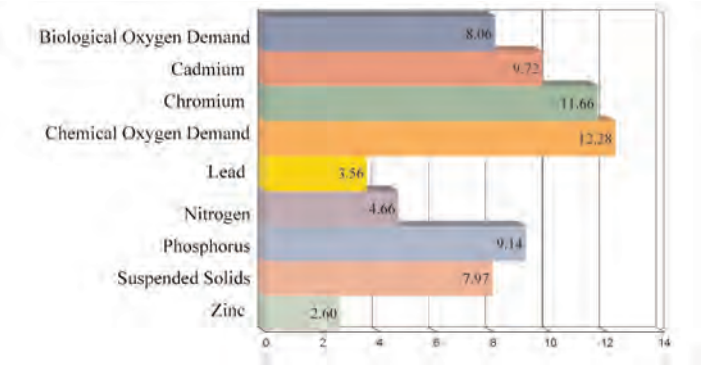
Table 5. Ecosystem Services by Zone

Code	Zoning	Area* acres	2007 Tree Canopy acres	2007 Tree Canopy %	Air Pollution Removal lbs./ yr	Air Pollution Removal Value dollar value	Carbon Stored tons	Carbon Sequestered tons	Stormwater Value* cu. ft.	Stormwater Value @ $6 per cu. ft** dollar value
RO-1	Rural & Open	77	3	4%	220	$501	140	1	11,950	$71,699
RO-20	Rural & Open Ag	5,358	1	0%	57	$129	36	<1	3,189	$19,136
RA-1	Res. & Ag, Semi-Urban	265	27	10%	1,844	$4,208	1,171	9	61,957	$371,741
RA-2	Res. & Ag.	1,384	266	19%	18,046	$41,190	11,463	89	785,038	$4,710,228
RA-1	Res: Houses	20,287	3,189	16%	216,027	$493,070	137,216	1,068	10,777,716	$64,666,297
M-H	Res: Mobile Homes	17	1	5%	56	$127	35	<1	6,587	$39,522
R-LT	Res: Houses & Limited Townhomes	2,813	52	2%	3,547	$8,097	2,253	18	247,415	$1,484,488
R-T	Res: Houses & Townhomes	786	41	5%	2,775	$6,334	1,763	14	221,234	$1,327,404
R-G	Res: Garden Apts.	2	<1	14%	19	$43	12	<1	816	$4,897
R-2	Res: Houses, Townshomes, Med. Density Apts.	1,189	107	9%	7,222	$16,485	4,588	36	506,322	$3,037,930
R-3	Res: Houses, Townshomes, High Density Apts.	1,412	163	12%	11,029	$25,173	7,005	55	822,311	$4,933,8667
RC	Res/Com.	18	1	8%	98	$224	62	<1	6,082	$36,492
RD	Res: Developing	5,466	315	6%	21,356	$48,743	13,565	106	1,236,320	$7,417,919
O-1	Office & Institutional	504	26	5%	1,760	$4,016	1,118	9	154,114	$924,685
C-1	Neighborhood Commercial	793	35	4%	2,352	$5,368	1,494	12	221,623	$1,329,740
C-2	Community Commercial	2,556	105	4%	7,096	$16,197	4,507	35	791,028	$4,746,165
C-3	Heavy Commercial	1,075	38	4%	2,566	$5,856	1,630	13	306,786	$1,840,716
IP	Industrial Park	1,984	51	3%	3,485	$7,955	2,214	17	197,482	$1,184,891
M-1	Light Manufacturing	1,617	34	2%	2,320	$5,294	1,473	11	259,850	$1,559,097
M-2	Heavy Manufacturing	1,590	31	2%	2,127	$4,854	1,351	11	33,534	$201,202
SU-1	Special Use	28,356	717	3%	48,585	$110,893	30,860	240	1,507,350	$9,044,100
SU-2	Special Neighborhood	9,681	249	3%	16,862	$38,486	10,710	83	853,716	$5,122,296
SU-3	Special Center	740	36	5%	2,438	$5,565	1,549	12	219,704	$1,318,223
H-1	Historic Old Town	18	2	10%	123	$280	78	<1	12,197	$73,181
P	Parking	57	3	6%	232	$530	148	1	18,465	110,790
P-R	Reserve Parking	15	1	4%	44	$101	28	<1	5,591	$33,543

*The total zoning acreage is less than the citywide or land use total acreages because the 26 zoning districts included in this study do not include all of the zoning areas in the city. Also streets are not included in the zoning district boundary file.

**Stormwater analysis uses a 2 year, 24 hour storm event. The value of managing stormwater is based on current local construction costs of $6.00 per cubic foot.

Percent Change in Contaminant Loadings



Water Quality Ecosystem Services

Tree roots absorb water pollutants for which ten measures are available: Biological Oxygen Demand, Cadmium, Chromium, Chemical Oxygen Demand, Lead, Nitrogen, Phosphorus, Suspended Solids, and Zinc. Citywide, water pollution, as measured in percent change in pollutant loading, would worsen, from 3% for Zinc to 12% for Chemical Oxygen Demand if trees were removed from the land.

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. Albuquerque's urban forest removes 454,000 lbs. of air pollutants annually, valued at $1 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. Albuquerque's tree canopy stores 289,000 tons of carbon and sequesters 2,300 tons of carbon annually.

Air quality is of particular concern in Albuquerque because of a combination of its high elevation, climate, and amount of impervious surface which causes inversions and traps air pollutants in the city. Albuquerque currently is in compliance for air quality standards as monitored by the US Environmental Protection Agency (EPA). However once the EPA adopts stricter ozone thresholds in 2010 from the current 84 parts per million to 75 parts per billion, the city may fall out of compliance.

Modeling Ecosystem Benefits of Recommended Tree Canopy Percentages

By increasing tree canopy cover, Albuquerque will increase the environmental services that tree canopy provides. The additional tree canopy percentages in different landuse categories were modeled to demonstrate these added ecological and economic benefits (Table 6). If the City increased its canopy cover by 2% overall, the ecosystem services would add an additional $457,000 in annual air pollutant removal value, an additional 127,000 tons of stored carbon and an annual 991 tons of sequestered carbon, as well as 1.1 million cubic feet of additional managed stormwater, valued at $6.9 million. Table 6 also quantifies the increased benefits by different land uses when tree canopy is increased by different percentages. The city can look for opportunities within specific land uses, such as in the Bosque, flood control zones, residential, and parking areas to increase tree canopy cover which will improve overall environmental benefits. Tree planting and ongoing care engages all sectors of the community, where everyone has the opportunity and responsibility to contribute.

Table 6. Modeled Ecosystem Services

	2007 Tree Canopy acres	Modeled Tree Canopy %***	# of trees represented by an increase in canopy %*	Additional Air Pollution Removal lbs./ yr	Additional Air Pollution Removal Value dollar value	Additional Carbon Stored tons	Additional Carbon Sequestered tons	Additional Stormwater Management Reduced* cu. ft.	Additional Stormwater Value @ $6 per cu. ft** dollar value
Albuquerque	6%	8%	149,000	200,358	$457,304	127,262	991	-1,148,168	$6,889,008
		10%	298,000	364,048	$830,917	231,235	1,800	-1,954,103	$11,724,620
		15%	670,000	773,273	$1,764,951	491,166	3,824	-3,946,702	$23,680,212
Bosque	37%	45%	19,000	21,094	$48,144	13,398	104	-63,816	$382,893
		50%	31,000	34,103	$77,837	21,661	169	-105,854	$635,124
		55%	43,000	47,112	$107,530	29,924	233	-147,147	$882,881
Drainage/Flood Control	5%	9%	6,200	7,654	$17,471	4,862	38	-75,344	$39,413
Parking lots/structures	4%	10%	1,850	1,929	$4,403	1,225	10	-146,112	$876,671
		15%	3,400	3,623	$8,270	2,301	18	-241,979	$1,451,875
SFR_Rio Grand West	6%	10%	2,333	25,900	$59,116	16,451	128	878,235	$5,269,412
SFR_Rio Grand East	17%	20%	37,000	46,743	$106,688	29,690	231	-1,780,577	$10,683,461

*Calculating the numbers of trees this represents is based on modeling the canopy size of an "average urban tree" in Albuquerque considering both large and small trees and an average 30ft. diameter canopy spread (CABQ). See calculations template for details.

**Stormwater analysis uses a 2yr, 24 hour storm event. The value of managing stormwater is based on current local construction costs of $6.00 per cubic foot.

***Recommended canopy increases were modeled to replace open space/grass/scrub with tree canopy cover in all categories except in parking lots where a combination of open space/grass/scrub, bare soil, and impervious surface was replaced with tree canopy cover.

Recommendations

This project has quantified Albuquerque's green infrastructure—its land cover and corresponding ecosystem services. This digital data is packaged into GIS interactive data layers compatible with existing GIS data so that City staff can use it in future planning decisions.Use the data and CITYgreen® software provided with this project to run land cover development scenarios. The findings will quantify the impacts and the offsets that adding tree canopy will achieve.

Establish Citywide Tree Cover Goals

- Establish unified tree canopy goals for the entire City and also stratify these goals for landuse categories. Use the modeled ecosystem benefits at different canopy percentages in Table 6 as a starting point. Base goals on City's mandates for achieving environmental goals for air and water and work with the City's urban forester to determine available space. 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 analyses to quantify the progress made with current and new tree initiatives.
- Use CITYgreen scenario and replacement modeling capabilities to ascertain 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 land covers under different development scenarios. Using the high resolution data, analyses can be conducted on a neighborhood or citywide scale.

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 and conserving trees 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.

About the Urban Ecosystem Analysis

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

Data Used

American Forests calibrated land cover change based on the USGS 2001 National Landcover Dataset (NLCD). The USGS's NLCD data set is now the standard for Landsat-derived land cover change analysis. Imagery of Albuquerque was classified from 1990, 2001, and 2008 and land cover change trends were quantified and documented. American Forests classified the imagery into six land classes: trees, urban, open space, scrub, bare soil, and water.

For the high resolution imagery, NCDC acquired 2-foot pixel resolution, 4-band, multi-spectral satellite imagery in June and July of 2007. NCDC conducted a knowledge-based classification to divide the land cover into five categories: trees, open space/grass/scrub, 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 land cover 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.

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

UFORE Model for Air Pollution: CITYgreen® uses formulas from a model developed by David Nowak, PhD, of the USDA Forest Service. The model estimates how many pounds of ozone, sulfur dioxide, nitrogen dioxide, and carbon monoxide and particulate matter less than 10 microns are absorbed and filtered by tree canopies. The urban forest effects (UFORE) model is based on data collected in 55 U.S. cities. Dollar values for air pollutants are based on averaging the externality costs set by the State Public Service Commission in each state. Externality costs are the indirect costs to society, such as rising health care expenditures as a result of air pollutants' detrimental effects on human health. The UFORE model also estimates the carbon storage capacity and the annual amount of carbon sequestered by the tree canopy in a given area.

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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.