Supplement to the San Antonio Urban Ecosystem Analysis Report

December 30, 2008

This document supplements the Urban Ecosystem Analysis for San Antonio, Texas. American Forests addresses the questions raised in stakeholder meetings held in October 2008 and public meetings held in December 2008 and clarifies the more technical aspects of the project.

1. Imagery

In answer to questions raised about how imagery for this project was collected and how different landcovers are distinguished from one another, Landsat imagery was collected from a satellite and the high resolution imagery was collected from a plane. In both cases, 4-band multispectral imagery includes spectral signatures that allow trained image analysts using specific software to distinguish landcover types such as tree canopy cover, impervious surfaces, bare soil, open space grasslands, and water. Visual characteristics to complement spectral signatures are also used by analysts to help distinguish features. For example, while spectral signatures may be somewhat similar, a visual texture will generally appear smooth for open space and rough texture for trees or scrub.

1.1 Landsat vs High Resolution Imagery Comparisons

There are several reasons why Landsat imagery can not be compared with high resolution imagery, which get into the details of resolution, the sensors of each imagery source, how data is captured, and the purpose of each type of imagery used in this project.

The Urban Ecosystem Analysis used two scales of imagery for two different purposes. Landsat satellite imagery, a moderate-resolution imagery at 30 meter-pixel resolution, was used to determine how landcover had changed over time. Using specialized software to classify the imagery into different landcovers, pixel size dictates the scale at which different landcovers are recognized. For example, in Landsat imagery a pixel is 30x30 meters- the equivalent of two basketball courts. Landsat registers the predominate landcover (such as trees, grasslands, bare soil, or urban) that falls within a 30 x30 meter area. This means that even if there are trees within a given area, if it is not the predominate landcover it will not register as trees. Changes in the landscape are shown by comparing two imagery of the same geographic location from different years. This study compared 2001 to 2006. Landsat data is valuable in giving us trend changes over time for large areas like the ETJ and COSA.

In contrast to Landsat imagery, high resolution imagery has a much finer resolution, and thus can register individual trees. According to an image comparison study, "The high-resolution Ikonos image (1-meter pixel resolution) identified more tree cover compared to Landsat (30 meter pixel resolution) on a regional scale. Considerable differences in ecostructure estimates were found between Ikonos and Landsat images when estimates from a local residential area were compared; especially in the tree and the grass cover estimates." In a residential area, Landsat measured a 5% tree canopy, whereas high

resolution imagery measured at 26% tree canopy. For this reason, one can not compare Landsat with high resolution imagery (Kanagaratnam, 2002).
Landsat imagery has 7 bands and high-resolution imagery has 4 bands, another reason why the two datasets can not be compared. Landsat imagery classification captures a mixture of canopy and non-canopy, the accuracy is based on building a model of separating out this mixture. In contrast, high resolution imagery is a direct measurement of canopy. This fact, in addition to its finer resolution means that analysts can recognize more tree canopy from high resolution than Landsat imagery.

For this study, 2-foot, 4-band, high resolution multispectral imagery was captured with a digital multispectral camera (DMC) from a plane. The leaf-on imagery was collected in October 2007. The imagery was resampled to a 6-foot pixel resolution which provided a file size manageable enough to enable ArcGIS software to work with the classified data for analysis. American Forests' partner, Sanborn, conducted the classification of imagery. American Forests verified the data. COSA staff also reviewed the data and was pleased with its accuracy.

1.2. Previous vs. Current Imagery Comparisons

Several questions were raised as to why American Forests did not compare the data from two previous Urban Ecosystem Analyses with this current project. Several reasons are discussed including rapidly changing improvements in imagery capture and classification methodologies, land boundary changes due to annexation, and calibration of stormwater formulas.

American Forests conducted an initial Urban Ecosystem Analysis of the San Antonio region using Landsat imagery from 2001 and a subsequent analysis using 2002 high resolution imagery. The current analyses use Landsat imagery from 2001 and 2006 and high resolution imagery from 2007. The field of imagery analysis is rapidly changing due to improvements in the capture and resolution of imagery. Geographic Information Systems (GIS) technology has also improved at a very fast rate and thus software that interprets the data has gotten even better over the last few years. To keep current with this changing technology American Forests employs the latest methodology standards.

<u>Landsat Imagery and Classification</u>

In a previous UEA, 2001 Landsat imagery was classified with the best technology available at the time. Imagery and classification techniques since this initial Landsat UEA was conducted have improved. American Forests now uses the U.S. Geological Survey's National Land Cover Data (NLCD) 2001 dataset as its baseline. NLCD products are considered the gold standard, for the remote sensing industry.

This study's Landsat data can not be compared with the previous study because two different methodologies of classification were employed. The previous classification was created using a different, less systematic supervised classification method. This study uses the same classification methods for all the dates. Not only does this allow us to compare 2001 to 2006 to see how landcover had changed over time, but using NLCD standardized methodology will allow consistent and reliable updates in the future.

High Resolution Imagery and Classification

In addition, imagery collection and classification differences in the high resolution imagery prevent us from comparing the previous study's 2002 imagery with the current 2007 imagery. When we tried a comparison, we found that tree canopy and open space percentages were higher and urban landcover lower in the 2007 data than in the 2002 data. There are two reasons for this due to substantial improvements in the imagery collection and classification techniques.

1. The 2002 data was taken from 3-band true color aerial imagery, the best imagery available at the time which did not collect infrared band data. The 2007 data was taken from 4-band multi-spectral imagery, which includes an additional infrared band. The band allows the camera's sensors to recognize more tree canopy and other vegetation. While it might appear that tree canopy had increased, it didn't; the new technology just allows us to better capture what is there.

New technology allows imagery to be collected at finer resolutions compared to five years ago. The 2002 high-resolution imagery was collected at a 1-meter pan sharpened image (4 meter multispectral with a 1 meter panchromatic image), whereas the 2007 imagery was collected at a 2-foot spatial resolution. The pixel resolution of acquired imagery determines the amount of detail available, even if the data is resampled. So, in this current project, even though the 2-foot data was resampled to 6-foot to create a file size small enough for ArcGIS to process, this resampled data still registers more detail than if the data was originally captured at a 6-foot pixel resolution.

2. The extra infrared band allows an image analyst to better classify the imagery collected-- translating spectral qualities of imagery into land cover types. Different bands register different levels of reflectance. On the infrared band, the spectral signature from vegetation is reflected and the spectral signature for impervious surfaces is absorbed. Analysts can also discern landcover classes visually by texture when landcover is collected at a finer pixel resolution. For example, an image analyst can discern that grassland appears smoother than scrub.

2. Ecosystem Analysis

American Forests conducts Urban Ecosystem Analyses, using the classified data as discussed above with CITYgreen for ArcGIS software. The CITYgreen software builds an elaborate model of the landscape by combining the classified image data with existing, spatial data sets of the soil types and rainfall measures specific to the area of study. The formulas used to calculate stormwater runoff, air and water quality, and carbon storage and sequestration are from peer-reviewed scientific and engineering sources including the U.S. Forest Service and the Natural Resource Conservation Service. In addition, new City-specific stormwater data and cost information is used in CITYgreen, and thus can't be compared to previous UEAs. Additional details on the formulas used in CITYgreen can be found on American Forests' website at:
http://www.americanforests.org/resources/urbanforests/naturevalue.php

2.1 Shapefiles and Areas of Interest

The areas of interest were specified in this project's original request for proposal. The shape files (polygons used to identify areas of interest) used in this project were obtained from the City of San Antonio staff. The size of the areas of interest of this project changed due to annexation that occurred in the city in the time frame between the studies. Areas were either annexed or deannexed during this time. Thus the current analysis can't be compared with the previous studies. Council Districts 3, 4, and 8 had significant changes in boundaries between 2003 and 2007 when data was collected. The acreages for the Edwards Aquifer represent the portion of the aquifer that fell within the extent of the City and the ETJ at the specified time. The actual real extent of the aquifer has remained the same. The areas of interest that changed are highlighted in yellow.

Differences in Study Boundary Area Size (in Acres)
San Antonio, TX
Areas that have changed in significant size are hightlighted

	Current Study	***2003 Study***	***2002 Study***
COSA	298,577	319,751	275,534
District 1	13,876	13,879	N/A
District 2	35,170	35,416	N/A
District 3	44,855	59,394	N/A
District 4	30,952	41,711	N/A
District 5	12,003	11,997	N/A
District 6	36,669	36,678	N/A
District 7	19,055	19,059	N/A
District 8	38,027	36,585	N/A
District 9	35,397	35,343	N/A
District 10	32,574	32,582	N/A
*Edwards Aquifer**	121,690	95,120	N/A
City South	48,415	37,138	N/A
ETJ	761,354	409,035	N/A

N/A = Boundary not used in study analyses
**The acreages for the Edwards Aquifer represent the portion of the aquifer that fell within the extent of the City and ETJ at the time.*
The actual real extent of the aquifer has remained constant.

2.2 Stormwater Analysis

American Forests' CITYgreen software incorporates the widely used and time tested TR-55 hydrologic engineering model for small urban watersheds developed by the Natural Resource Conservation Service (NRCS). This project provided a unique opportunity to calibrate the TR-55 curve numbers (an index of water percolation into the soil) to actual measured stream gage data. In addition, this is the first time that stormwater runoff can be correlated directly to the landcover using the high resolution data from this project rather than just specific locations gage data. The landcover data provides the City with the most accurate and comprehensive data for stormwater management to date.

American Forests partnered with Pape Dawson, Engineering for this project because of their hydrologic expertise in this region and their extensive work with COSA. Pape Dawson's role in the Urban Ecosystem Analysis was solely to provide the runoff data and models developed by Natural Resource Conservation Service (NRCS), San Antonio River Authority (SARA), and COSA. Troy Dorman, VP of Water Resources worked with Don Woodward, American Forests' hydrologist (formerly the national hydrologist with NRCS) to recalibrate CITYgreen's curve numbers specifically to San Antonio data. The methodology for calibration document is included as part of this project.

From our Proposal:

> "Pape-Dawson has worked in developing hydrologic models on all of the major watersheds in Bexar County within the past ten years. We are currently assisting the City of San Antonio, Bexar County and the San Antonio River Authority in updating models to reflect current land use and land cover. These models are calibrated to the available stream gage data and provide a means for assessing the impact of land use changes over time on storm water runoff. We have multiple existing land use/curve number data sets that have been developed by the NRCS, SARA, and CoSA as well as several developed in house."

Curve numbers, the basis of TR-55, take into account hydrologic soil type, rainfall, and landcover specific to the study area. The default curve numbers (used to calculate stormwater runoff volume) reflect a tree understory that is a midpoint between impervious and natural ground cover. CITYgreen software allows the user to specify an understory type, which is particularly useful when modeling alternate scenarios for a particular site.

Once calibrated to the local stormwater runoff data, American Forests conducted the Urban Ecosystem Analyses using new curve numbers. Thus, the previous study's stormwater figures can not be compared with the new information because of the calibrated curve numbers.

Pape Dawson provided the following construction costs used to calculate the management of stormwater runoff in San Antonio. Richard Mendoza, P.E., Assistant Director of Public Works for the City of San Antonio, concurred with this cost.
A cost of $.64 per cubic foot was used when calculating value of trees for stormwater runoff management. The costs cover a typical basin that would have a combination of earthen and concrete construction. This was a different dollar value than what was used in the previous UEA projects.

A local cost for containing stormwater runoff

Land	$0.28 / cubic foot
Engineering	$0.04 / cubic foot
Construction	<u>$0.32 / cubic foot</u>
Total	**$0.64 / cubic foot**

The UEA-generated stormwater volume can be thought of as a "large container of water" that would need to be managed if trees were not present. While San Antonio developers pay for stormwater managed on site, there is an additional public cost for increased infrastructure that supports new development. Costs include new roads and other impervious surfaces that increases stormwater runoff and is reflected in dollar values.

The UEA measured 2-year and 5-year storm events as requested by City staff. Tree canopy will not slow down stormwater runoff from 100 year storms, so it was not used in these calculations. The 2-year storm results are listed in the UEA report. Both the 2-year and 5-year storm numbers are reported in the Map Book that accompanies this project.

2.3 Air Quality Analysis

Air pollution removal rates are based on the U.S. Forest Service UFORE Model (Nowak, website) conducted in 55 cities. The reference city used in this project was based on air pollution removal rates in Austin, the closest city to San Antonio supported by this research. The air pollution removal dollar value used in CITYgreen is based on the Public Service Commission's rates for externality costs. Economists multiply the number of tons of pollutants by an "externality" cost, defined as a cost that society would have to pay in areas such as respiratory-related health care, if trees did not remove these pollutants.

An Early Action Compact with the U.S. EPA allows a region to devise their own strategies to improve its air quality status to avoid penalties for non-attainment. Maintaining and increasing tree canopy are voluntary strategies that San Antonio can use to improve air quality. Early Action Compact strategies must have measurable benefits; CITYgreen provides the City with a tool to measure air quality benefits of trees.

2.4 Carbon Sequestration and Storage

Trees have the ability to remove atmospheric carbon and store it in their wood. The carbon related function of trees is measured in two ways: storage or the total amount currently stored in tree biomass, and sequestration, the rate of absorption per year. Tree age greatly affects the ability to store and sequester carbon. Older trees store more total carbon in their wood and younger trees sequester more carbon annually.

The amount of carbon stored is based on the size of the tree, according to research conducted by Dr. David Nowak, U.S. Forest Service. "One half of a tree's dry weight is carbon" (Nowak, 1994). Thus larger trees have more carbon stored. Annual carbon sequestration (the amount of carbon removed from the atmosphere each year) is related to tree size and growth rates. Large trees with fast growth rates will remove more carbon annually than small trees with slow growth rates. Carbon sequestration slows down as a tree reaches maturity.

3.0 Tree Canopy Goals

American Forests recommends that every community adopt tree canopy goals as a comprehensive way of recognizing and enhancing the ecosystem services that trees provide to enhance air and water quality and reduce stormwater runoff—all impacts of urban communities. According to Mark Peterson, senior planner, SAWS, who consulted with Mayor Hardberger, the Mayor liked American Forests' approach in setting tree canopy goals as a simple and tangible way to reverse tree loss and be able to measure progress over time.

In this study, canopy percentage recommendations were not set to account for a specific canopy loss, but rather as a feasible goal to reach over time. Recognizing that urban density and amount of impervious surface will vary by land use, this study uses land use to stratify tree canopy goals. American Forests' recommended canopy goals for San Antonio were derived by first quantifying the existing canopy percentages for each land use, based on the most recent 2007 data available in this study.

We used a "feasible measure" that considered public, private and non-profit effort to achieve these goals. According to Michael Nentwich, city arborist, San Antonio currently plants 400 street trees and 800-1,000 park trees per year. In addition about 100 trees are planted at schools. City Public Services gives away 5,000 1-gallon trees per year. There are 200 potential tree planting basins in the central business district.

For ease of visualizing how a tree percentage increase would translate into a number of trees, American Forests calculated numbers of trees for each recommended land use based on the "average urban tree" in San Antonio. City staff defined "average" as having a 27-ft diameter, as specified in the tree ordinance. A calculator for translating tree canopy percentages into numbers of trees is included with this project.

For each land use, we considered whether a recommended goal is feasible over time, through a combined community effort. For example, in the urban residential area of the City, there are 163,647 single family homes. American Forests recommends increasing tree canopy in urban residential areas to 35%, a 3% increase which represents approximately 245,500 trees or 1.5 trees for every household. The actual number per household would be less because this does not take into account trees planted on public or commercial property. Using the data, CITYgreen software, and the tree calculator, city staff can measure the ecosystem benefits at various tree canopy percentages, as demonstrated in the report.

3.1 How many total trees to reach these goals?

If recommended tree canopy goals were translated into additional number of trees:

City of San Antonio: 40% goal
Central Business District 15%
Urban Residential 35%
Suburban Residential 39%
Commercial 20%
EARZ 55%
Total Trees: 545,600

Outside of the city limits within ETJ
Suburban Residential 39%
Total Trees: 573,700

GRAND TOTAL: 1,028,300 trees

4.0 Scope of Work

The purpose of the Urban Ecosystem Analysis was to identify urban forest canopy change trends over the last five years, obtain new data to quantify the current tree canopy, calculate the ecosystem benefits that San Antonio's tree canopy currently provides, and recommend tree canopy goals per landuse.

While American Forests recognizes that there are a whole host of other benefits—including other environmental and social benefits that trees provide, the scope of work focused on environmental benefits that could be measured. A soon to be published PAS report from the American Planning Association discusses multiple benefits of urban trees that do not have a tangible measurement (Schwab, 2008).

American Forests also recognizes that there are costs associated with planting and maintaining trees. Since costs vary widely depending on locale, landuse, size and type of tree, and who is ultimately responsible for its care; specific costs are not included in this study, but would be a next step for the city to implement as part of an action plan.

<u>What was not included in the scope of work:</u>

- Trees for endangered species
- Heat island
- Dust impacts on trees
- Energy savings
- Military bases and other cities within the San Antonio AOI
- Percent canopy goals per each watershed. This was not specified in the project scope of work but could be done as a supplemental contract
- Costs associated with planting and maintaining additional trees.

5.0 Other Documents Included in this Project

- Map Book of UEA Analyses for each of the areas of interest analyses within the report. One color hardcopy and a PDF are included with this project.
- Literature Search of Urban Forestry Programs That Cite Tree Canopy
- Relevant citations in San Antonio's Public Policies
- Stormwater Calibration Methodology
- Powerpoint presentation
- Tree calculator (canopy percentages into number of trees).

6.0 References and for Further Reading

American Forests website. http://americanforests.org/resources/urbanforests/

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