Abstract

ArcGIS tools: Helping Re-green Washington, DC

Casey Trees Endowment Fund (CTEF) uses ArcGIS® tools to restore, enhance and protect the tree cover in Washington, DC. In the summer of 2002, CTEF led an unprecedented GIS citizen-based inventory of 109,000 street trees in the District of Columbia. Compaq iPaqs were programmed with ESRI's ArcPad® 6.0 to provide the data collection interface. Based on inventory findings, CTEF and DC's Urban Forestry Administration set an objective to fill the 23,000 empty tree spaces in 10 years.

Casey Trees partnered with NYPIRG/CMAP to develop an interactive mapping site using ESRI's ArcIMS® to make the data publicly accessible and easy to use.

The street tree inventory was the first step in creating a comprehensive GIS inventory of DC's green infrastructure. Further inventories and analysis supported by ArcGIS® software provide additional data for identifying other re-greening opportunities. The National Park Service has implemented this inventory interface and is considering using this model in national parks across the US.

Primary Author:

Holli Howard
Casey Trees Endowment Fund
1425 K Street, NW
Washington, DC 20005
hhoward@caseytrees.org
www.caseytrees.org

Introduction

The mission of the Casey Trees Endowment Fund is to restore, enhance and protect the tree canopy of Washington, DC in cooperation with local and federal government agencies, community groups and individual citizens. The vision is to make our nation's capital a model green city. Casey Trees is a non profit organization with eleven employees and approximately $1.5 million operating budget.

GIS tools are essential to optimize our resources to achieve an ambitious mission. The Environmental Systems Research Institute's, ESRI, suite of software including ArcGIS®, ArcIMS® and ArcPad® enable the organization to operate more efficiently and strategically to reach these goals. Casey Trees uses GIS:

- For inventory and data collection including building and maintaining a green infrastructure database of the District of Columbia
- For analysis of re-greening opportunity and to set objectives for programs and business planning
- To share information with citizens, city planners, partners and other agencies
- To track performance

In using GIS as a primary method behind the decision-making processes, Casey Trees can be strategic and operational within its efforts and methods to re-green DC. The ability to geo-reference, display, print and archive database and mapping information makes a GIS an invaluable tool for urban forest management.

The following illustrates in detail the implementation and use of GIS to inventory the street trees of Washington DC. This inventory has been the basis for many of the programs that followed including the Casey Trees interactive Tree Map, community tree plantings and basic strategic planning objectives. The highlights of these programs and initiatives will show how Casey Trees continues to rely on GIS and ESRI to re-green DC.

Background

The Casey Trees Endowment Fund (Casey Trees) was established in May 2001 with a $50 million grant from the Eugene B. Casey Foundation. The grant was used to establish an endowment that provides continuing funds to support the programs and activities of Casey Trees. It was a *Washington Post* article in November 1999 that inspired Ms. Betty Brown Casey to provide the endowment to establish the Casey Trees Endowment. The *Post* article featured dramatic color satellite photos (Figure 1), analyzed by American Forests, which illustrated a 64% loss of heavy tree cover over the District of Columbia between 1973 and 1997. This information, combined with the science and software to calculate the value of the ecosystem services trees provide, showed a good return to DC from Ms. Casey's grant.

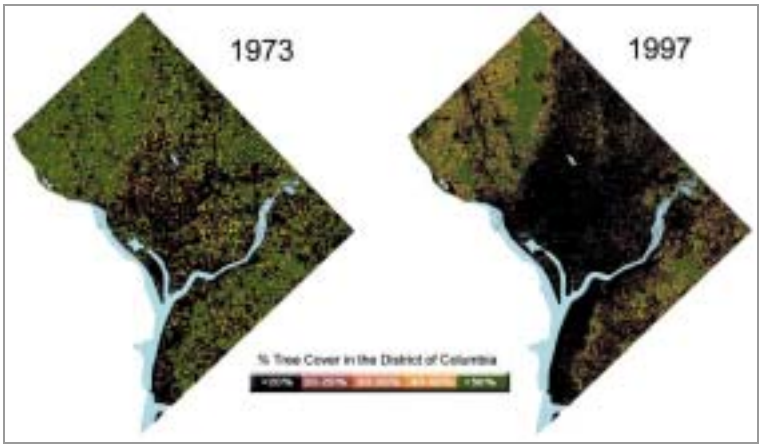

Figure 1 – Courtesy of American Forests, Washington DC

Inventory/Data Collection

The first step toward re-greening the city with street trees was to develop a state-of-the-art inventory of all DC's street trees. An outdated inventory created both a liability and missed opportunity for the city to plant and care for its street trees. An up to date inventory would form the baseline for setting objectives, developing methods and implementing programs to reach tree canopy goals and standards.

In the summer of 2002, Casey Trees led an unprecedented citizen-based inventory of every street tree in the District of Columbia primarily for the city's Urban Forestry Administration (UFA) to use and maintain in its planning, decision-making, and day-to-day operations. Thirty-five teams of university interns led over 500 people to collect information about street tree spaces and existing street trees throughout the 900+ miles of streets in DC.

GIS tools enables Casey Trees to attain its objectives for data collection:

- Develop and implement QC policies and procedures to achieve >95% data quality
- Develop and implement individual and team productivity measurements and reporting to finish by Aug 15th 2002
- Develop and implement field assessment, evaluation, and communications systems to track performance and ensure participant satisfaction and safety during training and data collection

Recent enhancements in field computer technology and software development made a citizen-based inventory of this size and quality possible within the short data collection timeframe. With data being collected on an estimated 3500 trees each day using a paper system these goals would have been virtually impossible to reach. The key implementation was the Geographic Information Systems (GIS)-enabled handheld computers that allowed field teams to enter data directly rather than recording onto paper forms. Commercial consultants, as well as public agencies including the USDA Forest Service, have led the way in bringing these tools to communities across the country. Compaq iPaq®'s were programmed with ArcPad® 6.0 to provide the data collection interface between the field crews and the data management team. A custom GIS program "The Tree Inventory Manager" enabled field scheduling, field assignments and performance measurements.

Developing the Data Collection Tools:

Use of a geographic information system for natural resources management of the District of Columbia has become standard. District-wide GIS datasets primarily created through orthophotographic interpretation already existed. These data, maintained by the Office of the Chief Technology Officer (OCTO) for the District and the Washington Area Transit Authority, provided a map base from which to start the GIS.

Though OCTO has a data set of DC's infrastructure including data directly relevant to urban forestry, the separation of tree ownership is not readily available. A street tree layer, depicting trees owned by the DC Department of Transportation's Urban Forestry Administration, had to be acquired from a few different sources and manipulated in ArcGIS®. OCTO provided a dataset of sites of existing municipal street trees. The end result was a geo-spatial point file depicting the locations of the trees between the sidewalk and the curb in UFA's jurisdiction. A data collection tool had to be developed that would allow efficient recording and manipulation of the site and tree attribute information.

Existing DC infrastructure shapefiles were brought together using ArcMap®. Management tasks specific to the district inventory required development of a custom software program, and this was provided by GIS programming contractor Spatial Systems, Inc. of Columbia, MD. The Tree Inventory Manager program (TreeInvMGR) was designed to provide teams with their assignments for data collection areas, bring data from the teams to the GIS and provide administration for a data-collection quality control process.

To collect the tree and site attributes in the field, an ArcPad® 6.0 application was developed in house with the interface of the TreeInvMGR. One of the attractive features of ArcPad® 6.0 is the ability to easily modify the user interface. This image illustrates the standard out-of-the-box toolbars provided by ArcPad® 6.0.

Figure 2

However, much of the functionality provided by these standard tools was not applicable to this inventory project. In order to make the inventory project ArcPad® 6.0 interface as easy to use as possible, tools that would not be utilized on this project were removed from the toolbar providing space for field GIS functions that were needed for the inventory. The buttons that are provided are mainly single-function tools, as opposed to the many multi-function tools on the standard bar (identifiable by the pull-down arrow next to the button). Buttons were designed and added to the stripped-down toolbar to give the resulting inventory toolbar, shown here. The tools added, from right to left, are:

- "Add tree/site" tool
- "Invalid tree/site" tool
- "Toggle ortho/vector" tool

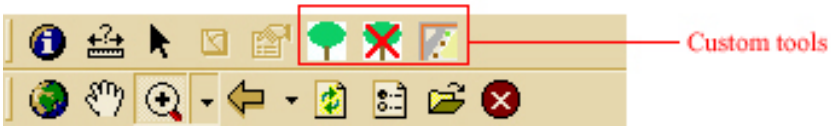

Figure 3

Another attractive feature of ArcPad® 6.0 is the ability to create custom attribute entry forms and validation rules for attribute entry (Figure 4B). Many types of attribute entry controls are available for ArcPad forms. Free-form text boxes, drop-down list boxes and sliders for numeric entry were used in this inventory project. ArcPad forms may consist of multiple, tabbed pages. This is allows grouping of similar attribute types and their arrangement in a logical or chronological manner.

Figure 4A

Figure 4B

Figure 4C

Figure 4A: Clipped collection area where brown points indicate trees 'To Be Collected'

Figure 4B: One of the five tree and site attribute recording pages

Figure 4C: Green points represent trees that have had their attributes "Collected"

Figure 5 - Using handheld technology in the field

Partners

The National Park Service is currently conducting this same type of inventory of the National Parks in the District of Columbia using the same application developed for the 2002 street tree inventory. The National Park Service is incorporating the use of a Trimble GPS as they can achieve the accuracy needed when a building or other permanent feature reference is not available. In the downtown core of DC, a GPS was not necessary with the reference infrastructure layers including buildings, streets and sidewalks. With the inclusion of the National Park Service inventory to the 2002 street tree data, the two tree inventories of Washington, DC, constitute an important beginning in GIS analysis and tracking of greening efforts.

Opportunity Analysis/Setting Objectives

The data provided from this inventory is now used as the baseline for many of our regreening programs, primarily Casey Trees community tree planting program. Based on the inventory findings, Casey Trees and UFA set an objective to fill the 23,000 empty tree spaces in 10 years. In cooperation with the District, Casey Trees has focused the street tree re-greening efforts on the species of a Dutch Elm disease resistant 'Princeton' American Elm.

There are strict guidelines for planting street trees in DC based on protection of people and property, tree health and civic character of the city. Trees are planted by species by block or avenue. In the plan there are many streets designated as 'historical elm streets'. A constraint is to avoid any side of the street that has overhead utility wires. This has been a maintenance and economic problem for many city utility companies for years. Querying these constraints and other planting requirements on the desktop makes the search for community elm planting events a less labor intensive process. Many sites can be found or eliminated by efficiently reviewing analysis decreasing time spent in the field.

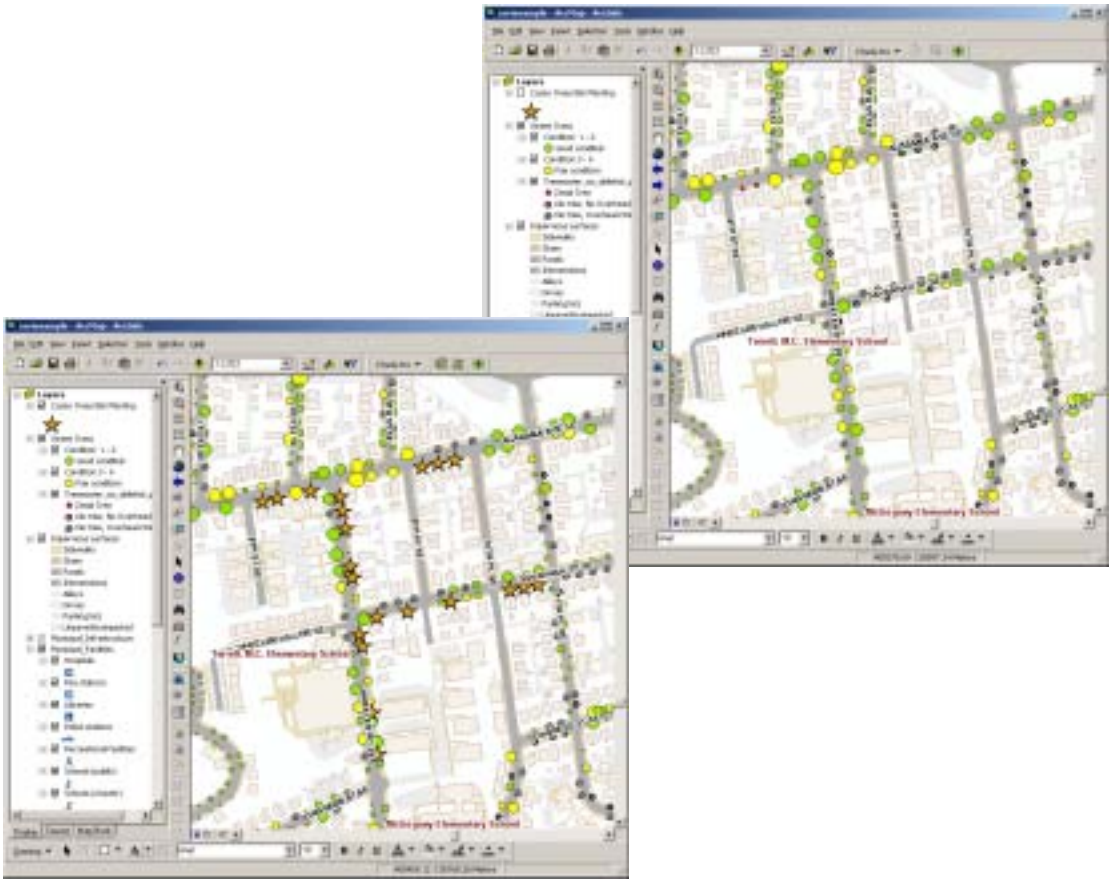

Figure 6 and 7 – Orange stars indicate elm trees planted based on the UFA planting requirements including the 2002 inventory of potential plantable spaces and overhead wire restrictions

Using the analysis and query functions in ArcMap®, Casey Trees has been able to highlight the empty/plantable spaces. In the spring of 2003, CTEF held 19 neighborhood meetings throughout the District to involve the citizens in the strategy for re-greening. With the GIS interpretation of potentially plantable spaces and the input from citizens on where they would like to see trees in their neighborhood Casey Trees was able to further refine the fall 2003 and spring 2004 elm planting efforts.

In the 2003/2004 planting season Casey Trees organized the plantings of over 1000 trees in the District in cooperation with many partners and extraordinary community support.

Figure 8 – Community Elm Tree Planting, 2004

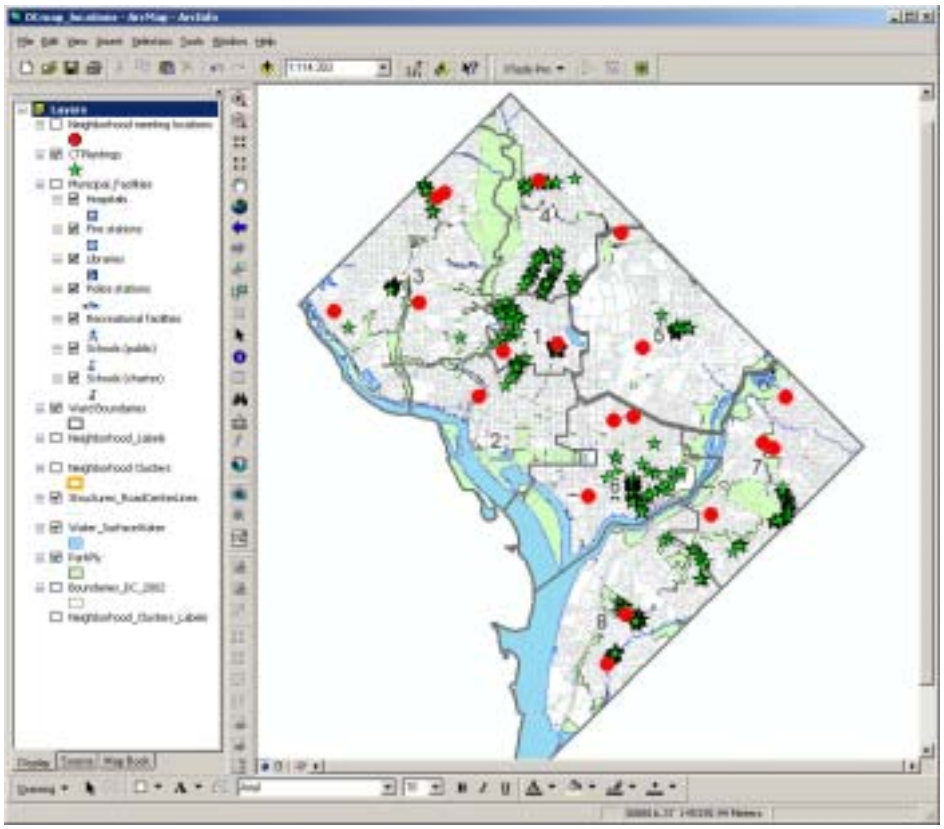

Figure 9 – Distribution of 19 neighborhood meetings conducted to ensure community input on tree planting efforts. Red points indicate meeting points – Green stars indicate Casey Tree planting sites

Sharing Information

Both Casey Trees and UFA used the street tree inventory for their management and operations and to coordinate activities between their organizations and other city agencies. Another important outcome of the inventory was to share street tree findings with the citizens, city planners and other partners. All could possibly use the data for further re-greening efforts or inspire more interest in urban green infrastructure.

To make the inventory information publicly available and accessible, Casey Trees launched its interactive "Tree Map" at www.caseytrees.org in March 2004. Designed by Community Mapping Assistance Project (CMAP) in NYC and modeled after Open Accessible Space Information System for NYC (www.oasisnyc.net), Casey Trees now has the data collected from the 2002 inventory online. The site shows 40 attributes of each of the city's street trees (Table 1). The environmental and economic values were analyzed by the USDA Forest Service using their UFORE Urban Forests Effects Model. CMAP used the existing OCTO shapefiles to create the base map and the applications enable the user to click on a specific tree and view all of the attributes for that tree. Again employing ESRI software, the program was developed using an ArcIMS® software customized with Visual Basic and ASP and runs through ArcSDE® and Microsoft SQL server.

Figure 10 – Tree Map Home Page at www.caseytrees.org/treemap.html

Figure 11 - Each of the layers shown in the map above are interactive allowing many opportunities for user interface. While each layer can be turned on or off there is also the option for labeling the feature with the ability to generate a customized map. In this case, the blue circle depicts the user's selected tree and the information collected and analyzed for that tree is displayed below (Table 1).

Elm, American (ID: CA-0668-100)

Scientific Name: *Ulmus Americana*
Condition Rating: Condition 1 - 2 Tree Value: $ 4,584

Height: 40 feet DBH: 17 inches Crown Radius: 20 feet

SITE INFORMATION:

Overhead Wires: None	Tree Grate: None
Curb: Permanent	Sidewalk: Permanent

TREE CONDITION INFORMATION: Condition 1 - 2

Tree has <5% deadwood with a lean of <5 degrees.
Wounds: = <10% circumference.
Decay is Absent
Stem corks are absent and root corks are absent.
Stem girdling roots = <15% stem circumference

ENVIRONMENTAL AND ECONOMIC VALUE:

Carbon Storage:	371.72 kg
Carbon Sequestration:	12.71 kg/year
Carbon Monoxide Removed:	60.099 g/year
Ozone Removed:	435.950 g/year
Nitrogen Oxide Removed:	145.232 g/year
Particulate Matter Removed:	305.459 g/year
Sulfur Dioxide Removed:	144.741 g/year
Total Pollution Removed:	$ 5.5884/year
Tree Value:	$ 4,584

Tree data as of August, 2002 Click here for Tree Map home.

Table 1 - Over 50 attribute records were recorded for each of the 109,000 DC street trees. A selection of the results are provided on the interactive Tree Map site, www.caseytrees.org. The environmental and economic values were calculated by the USDA FS UFORE model.

Tracking performance / Next Steps

In 2004, Casey Trees is focusing on research and analysis of the benefits of trees in an urban environment. A GIS based analysis is an important tool in our overall strategy for planning and monitoring Casey Trees performance in changing DC from 'gray to green'. The focus of the research is driven by GIS analysis, primarily using ArcMap and Spatial Analyst. The data collection and analysis will:

1. Research the relationship between tree cover and DC's social, economic and health statistics. This will aid in highlighting the benefits of trees in an urban setting and be the first step in the planning and tracking.

2. Guide and inform a geographical based methodology towards setting our tree planting objectives for the District.

3. Help determine overall key land cover targets and will continue to be used as a tool in tracking Casey Trees' progress in attaining those targets.

4. Integrate other GIS tools such as American Forest's City Green to support community based planning and planting strategies based on these tree planting objectives

Conclusion

A relatively new organization, Casey Trees has been visionary since establishment implementing state of the art technology not only in its re-greening efforts but in devising its approach to achieving the re-greening goals. GIS has moved to the forefront of government, corporate and independent agency management and research efficiency for non profit operations. The Casey Trees Endowment Fund is no exception. The use of ESRI products including ArcGIS®, ArcIMS® and ArcPad® has facilitated new opportunities for strategic and operational program management within the organization. In such a small organization, use of GIS software may seem a progressive step and it has put Casey Trees and partners on the cutting edge of technology in environmental and urban forest management practice.

Holli Howard
Casey Trees Endowment Fund
1425 K Street, NW
Washington, DC 20005
hhoward@caseytrees.org
www.caseytrees.org