

MANAGING NORTH CAROLINA STATE UNIVERSITY'S URBAN FOREST

Charlynn T. Smith
Research Associate

Hugh A. Devine
Professor & Associate Director for GIS

Department of Parks, Recreation and Tourism Management
Center for Earth Observation
North Carolina State University

ABSTRACT

In September 1996, Hurricane Fran ravaged the Raleigh area and destroyed hundreds of trees on the North Carolina State University (NCSU) campus. The Federal Emergency Management Agency subsequently reimbursed NCSU for the lost trees because the university was able to provide precise documentation of tree loss based on an inventory maintained by the Division of Grounds and Automotive Services. This experience demonstrated the value of NCSU's tree inventory and was the impetus for initiating a partnership with the Center for Earth Observation to create a more comprehensive Urban Forest Inventory and Management Program using geographic information systems (GIS) technologies.

At the time of Hurricane Fran, the university's tree inventory database consisted of separate AutoCAD maps of eighteen landscape care areas with an attached Paradox database file containing individual tree information. When viewing information on the computer, only one area could be viewed at a time. To create a master database containing all campus trees, the spatial and tabular data were converted to ArcView shapefile format and then realigned to match the campus survey map of streets and buildings. The ArcView GIS urban forest database has proven to be a very efficient management tool. Tree data can be displayed with other data layers such as streets, buildings, and walkways. Spatial analyses are used to identify trees in need of pruning, estimate budget needs, establish routes for watering newly installed trees, and produce maps for a variety of maintenance projects.

Future plans for NCSU's urban forest database include the addition of other data layers, such as planting beds, turf areas and shrubs. These data will provide a more complete picture of the natural environment and will allow managers to examine relationships between trees and the surrounding area. The landscape services staff also plans to calculate the benefits of the campus urban forest using American Forests *CITYgreen* software. The database will eventually become part of the NCSU Libraries data holdings to facilitate access by students and university personnel. The Urban Forest Inventory and Management Program has substantially improved the university's ability to manage both its natural and built environments.

INTRODUCTION

In September 1996, Hurricane Fran ravaged the Raleigh area and destroyed hundreds of trees on the North Carolina State University (NCSU) campus. The Federal Emergency Management Agency subsequently reimbursed NCSU for the lost trees because the university was able to provide precise documentation of tree loss based on an inventory maintained by the Division of Grounds Management. This experience demonstrated the value of NCSU's tree inventory and was the impetus for initiating a partnership with the Center for Earth Observation to create a more comprehensive Urban Forest Inventory and Management Program using geographic information systems (GIS) technologies.

At the time of Hurricane Fran, the university's tree inventory database consisted of separate AutoCAD maps of eighteen separate landscape care areas with an attached Paradox database file containing individual tree information. When viewing information on the computer, only one area could be viewed at a time. The goal of the project was to create an inventory using GIS software so that more efficient urban forest management strategies could be put in place.

METHODS

Structuring the Database

The GIS database was constructed using existing AutoCAD (r13) format map files. The first step was to select a suitable base map of the campus. NCSU Facilities Planning and Design provided a survey accurate AutoCAD file of campus streets and buildings. These two CAD layers were converted to ArcView shapefile format using ArcView's CAD Reader extension. The second step was to convert tree information from each of the eighteen separate CAD files to shapefile format. Each AutoCAD file included an attached Paradox database containing descriptive information for each tree. When the CAD file was converted to a new shapefile, the associated tabular data from Paradox automatically became attribute data for the new tree shapefile. At this point, the resulting database consisted of 18 separate tree data layers. The CAD files also included walkway spatial data that were converted to shapefiles for use as background layers.

Making it Match

The first problem we encountered was data alignment. The tree and walkway data did not align with the campus base map. Each of the shapefiles was examined individually to determine the required shift needed to align it with the surveyed base data. Using an “xy shift” Avenue script within ArcView, each set of data was shifted into alignment.

The shifting process worked well with the tree (point) data, however sidewalk information remained misaligned in many areas. This was due in part to the inaccuracy of the original sidewalk data. For our purpose of providing a detailed map of campus tree locations, the uncorrected sidewalk data was sufficient to provide appropriate background information.



FIGURE 1: *Tree data did not align with the survey accurate base map, notice tree point data appears on the shaded buildings and in roadways*

After the tree data were properly aligned to the base map, an Avenue merge script was used in ArcView to reduce the 36 separate layers into one tree data layer and one sidewalk data layer. Minor edits were required to eliminate duplicate arcs and tree points from two landscape care area maps that overlapped. At this point, the campus GIS database consisted of four data layers: buildings, streets, walkways and tree locations. Attribute information for each tree point data included tree-id, common name, botanical name, pruning needs, dbh, spread and height.

The GIS Database in Operation

Much of the first year was spent completing field work to make sure the attribute data was correct and that the spatial representation of the trees was accurate. Once the old database was brought into ArcView, the new campus tree inventory provided a seamless campus wide layer. The original CAD database and inventory showed that many of the campus trees were severely damaged or destroyed. Field work revealed that close to 200 trees needed removing from the database. Additionally we discovered approximately 400 were never included in the inventory. Those new trees were assigned an ID number and added to the database. Once the initial urban forest inventory was complete, Grounds Management personnel completed a short training course in ArcView GIS to become familiar with the new inventory system and learn the

capability of GIS applications. The lead supervisor with Grounds Management became the designated database user. This person uses ArcView on her desktop computer for maintenance decisions, creating field maps and organizing work crew tasks.



FIGURE 2: North campus display showing building, street, walkway and tree spread data layers

RESULTS

The GIS database comprises spatial layers and tabular information of trees, buildings, streets and walkways for more than 600 acres of the main NCSU campus. The original Paradox file allowed queries for all campus trees, but did not allow spatial display of campus wide information. The new GIS database allows campus wide maps or any area smaller area of campus to be quickly plotted out to scale with appropriate labels.

One of the initial goals of the Urban Forest Inventory and Management database was to create an efficient management tool for budget and maintenance. The GIS database has proved to be very effective for the Grounds Management staff. Currently one focus is on adding new fields of attribute information. Previously, pruning information was classified as “yes” (needs pruning) or “no” (no pruning). Now the trees that need pruning are placed into one of four prune classes. Pruning class I and II are considered fine pruning and the work is completed by university staff. Class III and IV pruning is major limb and / or tree removal that requires the work to be out-sourced to contractors. Landscape supervisors use this information to quickly determine budget needs for required contract work. Maintenance information has been added to the database, providing historic documentation for pruning actions taken on each tree.

As new attribute information is added to the tree record inventory, the Grounds Management staff creates new uses for the management program. Additional descriptive information for trees include tree type, evergreen or deciduous, and for certain types of blooming landscape trees, “flower color” is included. This information is used for landscape design plans.

As trees destroyed from Hurricane Fran were replaced, the new trees were marked with a “date installed” notation. This allowed the Grounds Management supervisor to quickly query the database for new installations, determine the best route for the water truck and print out a map for the crew so that they could locate and water the trees more efficiently.

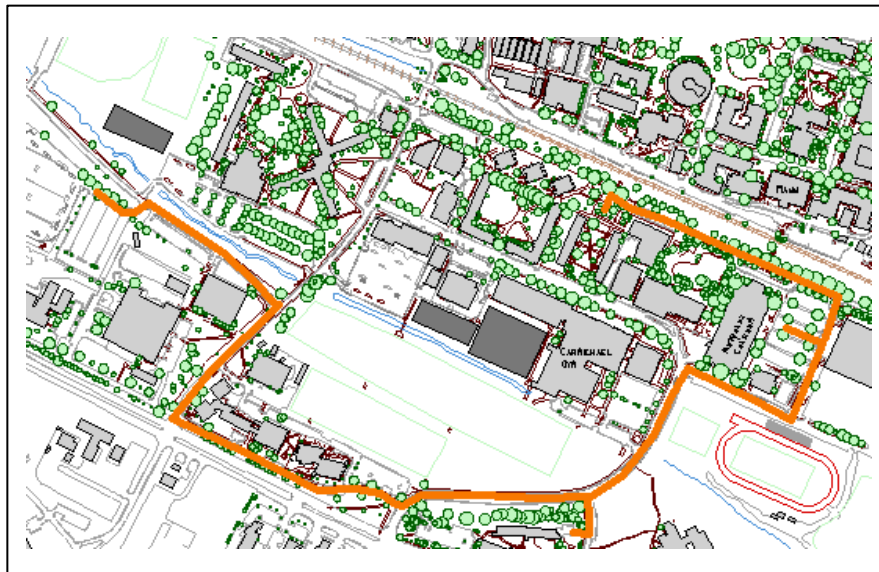


FIGURE 3: *Watering route for newly installed trees on south campus*

CONCLUSIONS

Efficient Management

A GIS is an efficient tool for urban forest management and inventory applications at NCSU. All areas of campus can be viewed simultaneously with the ability to access, query and / or summarize attribute information. For example, the ability to quickly query over 3000 trees to locate approximately 80 trees that require class III or Class IV pruning is essential during budget preparation. When organizing the work for those 80 trees, the Grounds Management supervisor can use all data layers to prioritize the work. Trees within 10 feet of a roadway have first priority for pruning work. A simple query can identify and map those maintenance needs with the highest priority. The database also allows for ease in printing field maps for work crews and contractors. The size of the NCSU campus and limited access to trees in courtyards for example, demands that contractors have a map showing tree location, access routes, building and street names. This assists both the university and the contract workers. Prior to converting the

inventory to a GIS, each landscape care area was viewed individually on the computer screen, if at all. Most often, personnel used worn paper maps of the 18 separate areas.

Visualization of the data is one of the better benefits a GIS offers. Queries are possible with database programs, however, GIS offers the capabilities of linking that database so that the results can be visually represented. This is a significant benefit for urban forest management. In our previous example, when querying for Class III and Class IV pruning, over 80 trees were selected. Viewing these results on the map display revealed that a group of willow oak trees (*Q. phellos*) next to each other required major pruning. At this point a supervisor can be sent to examine the group of trees to determine the cause of die back. Insects, nearby construction, or trees reaching the end of their lifespan are all possible reason for the problem.



FIGURE 4: A database query to locate high class pruning revealed need for closer examination of the cause of many trees in same area needing major prune work

Future Opportunities

With the Urban Forest Inventory and Management Program in place using ArcView GIS, future possibilities for the database appear unlimited. Plans at this time include the addition of other data layers, such as planting beds, turf areas, walkways and shrubs. Walkway management is the next major task for the program. A spatially accurate walkway database will provide boundaries as we add turf areas, mulch and plant beds. This information will be used not only in design plans, crew scheduling and budget preparation, but for more complete management of the natural and built environment.

Tree identification is a component of the current database. Using the “Hot-Link” feature of ArcView, digital images of specimen trees are being collected, and will be added to the database. A database user will be able to click on the point symbol representing a tree to display the photograph of that tree.

The data will eventually be a shared resource available from the NCSU Libraries. Thus campus planning and design personnel will be able to use the information when working with the built environment. Students in landscape architecture, forestry, park management and horticulture will also have access to the data for educational purposes.

Future plans also include the use of American Forests CITYgreen software to calculate the economic value of NCSU’s Urban Forest associated with storm water run off retention, carbon storage and sequestration and food and habitat benefits available to wildlife.