

GIS in Disaster Recovery for the Historic Preservation of Trees

Alicia Williams, Tennessee State University Dept of Agriculture Sciences, Graduate Program; Current Employment: AMEC Earth and Environmental, Inc.

Dr. Robert Harrison, Tennessee State University Dept of Agriculture Sciences

ABSTRACT

This research applies geospatial analysis to the recovery of the trees at the historically significant site of the Hermitage, home of President Andrew Jackson, a 1200+ acre nineteenth century cotton plantation. The grounds suffered the devastating effects of an F3 tornado on April 16, 1998. Since that time, a landscape restoration effort has been underway to repair the damage caused by the storm. The mapping of existing plant materials and landscape features is a critical part of this restoration. The primary objective of this project was to utilize the latest geospatial analysis technology to identify and analyze the existing dendrological resources and those which were destroyed in the tornado. The groundwork laid in this project will serve as a firm foundation for future additions to the GIS for this property. Furthermore, it will serve as a model for other historic sites which have not yet begun their venture into geospatial analysis.

INTRODUCTION

Weather-related natural disasters have plagued mankind throughout history. Among the most destructive of weather phenomena, tornadoes have proven themselves to be especially erratic and unpredictable. Agricultural losses due to tornadoes rarely receive widespread public attention, but often amount to well over \$1,000,000,000 in a single season (1). The economic loss of food crops is usually reported in detail, but the loss of landscape and horticultural plants is much more difficult to measure and economically assess and is usually not reported as a single figure. Landscape and horticultural plant losses, in most cases, rival or exceed the losses to our food crops. In the event that tornado damage occurs to the landscape portion of a historically significant property, the problem and the economic impact are compounded quite significantly.

Natural disaster recovery efforts have historically been difficult and expensive, with an inordinate amount of time and effort invested in the assessment and planning stages. The rapid development of several new technologies has made available a set of highly effective tools that can be used to assess, plan, and manage recovery from natural disasters. Geospatial Information Systems (GIS) and Global Positioning Systems (GPS) can be used to provide the most accurate and powerful approach to damage assessment and recovery management.

The research undertaken for the development of this manuscript explores spatial analysis of the dendrological resources at the historically significant site of the Hermitage, home of President Andrew Jackson. This 1200+ acre estate has been a site of pilgrimage and education for more than 14 million visitors since its doors were opened to

the public in 1889 (2). Rachel's Garden is a 1.5 acre formal garden created in 1821 for President Jackson's wife, Rachel. It is surrounded by approximately 25 acres that comprised the heart of t Jackson's eighteenth century cotton plantation.



Figure 1. View of the front of the Hermitage Mansion along the guitar shaped Carriage Drive in 1997 (prior to the tornado of 1998). (Photo Courtesy of LHA)

The garden and much of the surrounding grounds suffered the devastating effects of an F3 tornado on April 18, 1998 which destroyed all of the garden's trees including the magnolia that had shaded the tomb for more than a century and that was traditionally said to have been planted by Jackson in memory of Rachel. While little damage was sustained by the mansion or the dozen other buildings which now occupy the site, more than 600 trees were destroyed in less than 5 minutes. More than 2500 trees suffered damage ranging from slight to major. In addition, 91 of the cedars planted by Jackson himself along the original carriage drive were destroyed (3). Since that time, a landscape restoration effort has been underway to repair the damage caused by this storm. The

mapping of existing plant materials and landscape features was a critical part of the restoration. The goal of this project was to classify the existing dendrological resources and those which were destroyed in the tornado, and analyze the extent of damage utilizing the latest spatial analysis technology. This information was vital to proper site-wide interpretation, archaeology efforts, landscape restoration, site-wide maintenance, conservation efforts and master planning.

Federal disaster aid helped fund a damage assessment of the destroyed trees during the initial clean-up by the National Park Service Cultural Resource Geographic Information System Department (CRGIS) (4). Volunteers and staff members spent countless hours removing logs and debris from the site. ReLeaf Nashville and fundraisers held by the site in conjunction with American Historic Trees, Inc., began the slow process of replanting the trees. A \$612,500 Transportation Enhancement Act grant was obtained from the Tennessee Department of Transportation through the Federal Highway Department to help restore the pre-tornado view-shed (5).



Figure 2. Same view of the mansion as Figure 1 the day after the tornado on the front lawn of the Hermitage mansion with the cedars destroyed along the Carriage Drive during the tornado. (Photo Courtesy of LHA)



Figure 3. Cedars, *Juniperus virginiana*, along the Carriage Drive at the Hermitage traditionally said to be planted by Andrew Jackson himself twisted and splintered by the tornado. (Photo Courtesy of LHA)



Figure 4. The tomb of Andrew and Rachel Jackson in the shaded conditions which existed in Rachel's garden just prior to the tornado. The Magnolia and Shagbark Hickories shading the tomb were traditionally said to be planted by Jackson himself. (Photo Courtesy of LHA)



Figure 5. The tomb for Andrew and Rachel Jackson in the southeastern corner of the formal garden in 2003 after trees had been replanted during the restoration efforts. Weeping Willows were chosen because that is what Jackson ordered planted initially as a symbol of mourning for Rachel. Upon their death in the first years after being planted, they were replaced with the hardier magnolia. (Photo Courtesy of LHA)

OBJECTIVE

The primary objective of this project was to identify and analyze the existing dendrological resources at the historic site of President Andrew Jackson's 18th century cotton plantation and those which were destroyed in the tornado utilizing the latest geospatial analysis technology. The groundwork laid in this project will serve as a firm foundation for future additions to the GIS for this property. Furthermore, it will serve as a model for other historic sites which have not yet begun their venture into geospatial analysis.

METHODOLOGY

The Museum Collections Department at the Hermitage with the Gardens Department reviewed and assimilated records for landscape references during December of 2003 and January of 2004. A thorough review of all known existing documents and pictures which hold references to the landscape was conducted.

A search of microfilm of the Presidential Papers and the Ladies Hermitage Association meeting minutes was made by Fletch Coke in 1990. Those references were collated into Research Notebook #38C "The Hermitage Garden Notebook" which included plant and tree lists for the property. While the focus of that research project was the flowering plant material located in the formal garden located on the east side of the mansion, it included all references to trees in those papers (4).

Research Notebook #38C was the basis of research in 1991 by Lucinda Brockway, a historic landscape preservationist, to develop a restoration plan for the formal garden. This restoration plan was consulted for information regarding the dendrology of the historic core of the property.

During the week following the F3 tornado in April 1998, the National Park Service CRGIS performed a GPS Damage Assessment of the trees on the property. A crew of three from the NPS spent several days locating and identifying all the trees in the area immediately surrounding the mansion as well as along the main roadways and the Tulip Grove area. Both trees surviving and not surviving along with their circumferences were marked. Maps and tables showing the lists of 2,045 individually identified and numbered trees were made on June 24, 1999. Trees were tagged in the database as standing, fallen or severely damaged. Nine hundred forty-four trees were downed or severely damaged. The average circumference of standing trees before the tornado was 6.05 feet, and after the tornado it was 2.86 feet (4). The information was also given to the Hermitage in a CD format in ArcView 3.1. That software was purchased from ESRI by the LHA in order to be able to utilize the information in the future. Unfortunately those computerized records were lost and only the hardcopies of the information remained as of December 2003.

In the summer of 2002, as partial fulfillment of the Urban Forestry Tree Council for the State of Tennessee's Arboretum Certification Program requirements, an onsite inspection and update of the tree lists generated by the National Park Service CRGIS was conducted by the Head Gardener. Several trees on site at that time were noted to be

absent from the lists and were recorded. These were concentrated in the Visitor's Center parking lot and did not occur in the historic core of the property which the NPS had assessed.

Many changes to the landscape occurred during the five years following the tornado. Many trees were planted by different departments and groups. Trees damaged in the tornado, but not destroyed at that time, continued to suffer damage in subsequent storms. Many eventually died or were taken down due to safety concerns. Several landscape restoration projects occurred, including the Carriage Drive Restoration in October 2001 and the Lebanon Road Landscape Project in November 2003.

As a portion of this thesis project, the original National Park Service CRGIS Damage Assessment list of trees was reentered into Microsoft Access, a relational database, with multiple fields indicating identification number, scientific name, common name, age or approximate age, diameter at breast height, source of origin, etc. Additionally, the trees noted to be missing from the original list were added, as were as many of the trees planted up to the December 2003 time period as was recorded. The new list contained 3039 trees. A second database was created which listed the trees planned for planting in the Lebanon Road Landscape Project. The second database contained 1077 trees and shrubs.

Precise maps of the historic core of the Hermitage Property were then generated through the use of ArcGIS. These maps contained layers from aerial photos, USGS geologic survey maps and tree location maps. Some layers were stored as shapefiles. Shapefiles are data structures that store geometric elements such as points, lines and

polygons that represent geographic features such as trees, trails and property boundaries. Other layers were stored as coverages. Coverages are data structures much like shapefiles that store relationships between the points, lines and polygons (6). All maps and data were projected using the UTM NAD 1983 system for Zone 16N. Statistical analyses were conducted on the data. A map was then created to show all trees on the property.

RESULTS AND DISCUSSION

Ninety-one species of trees, comprised of 2645 individuals, were found to be damaged on the grounds of the Hermitage by the tornado of 1998 (Table 1). Six hundred thirty-four trees from 45 species were killed in the tornado (Table 2). Seven species of trees had more than 10 trees killed.

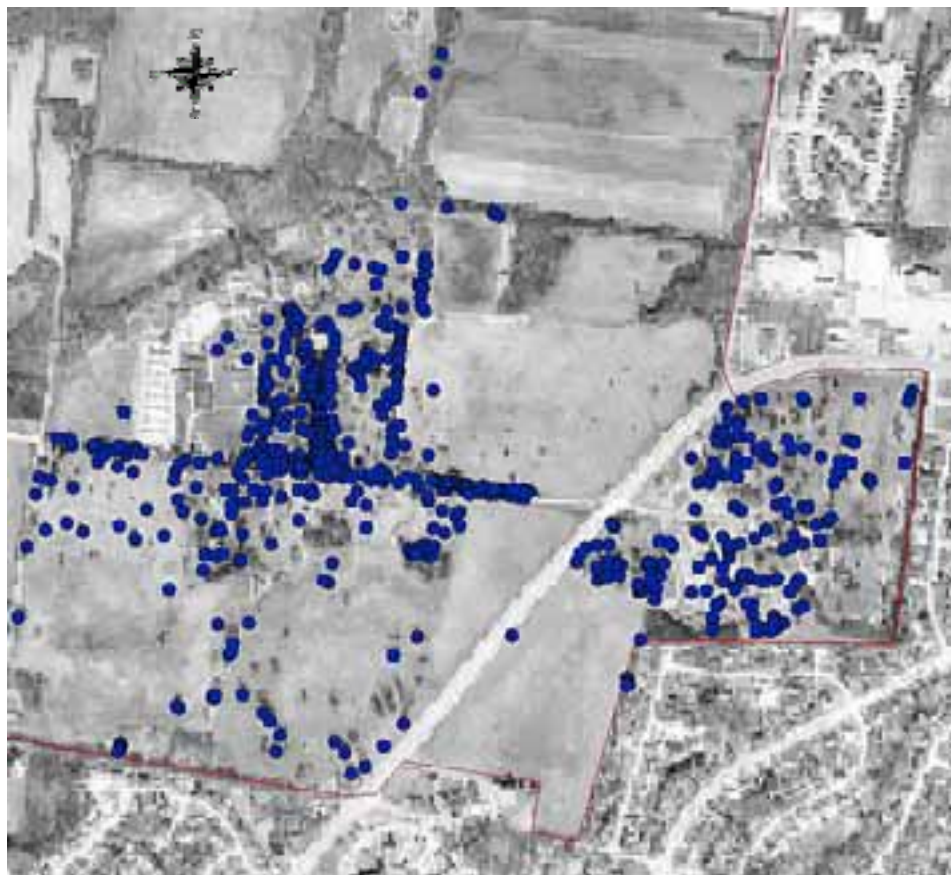


Figure 6. Location of all the trees destroyed on the Hermitage property in the 1998 tornado.

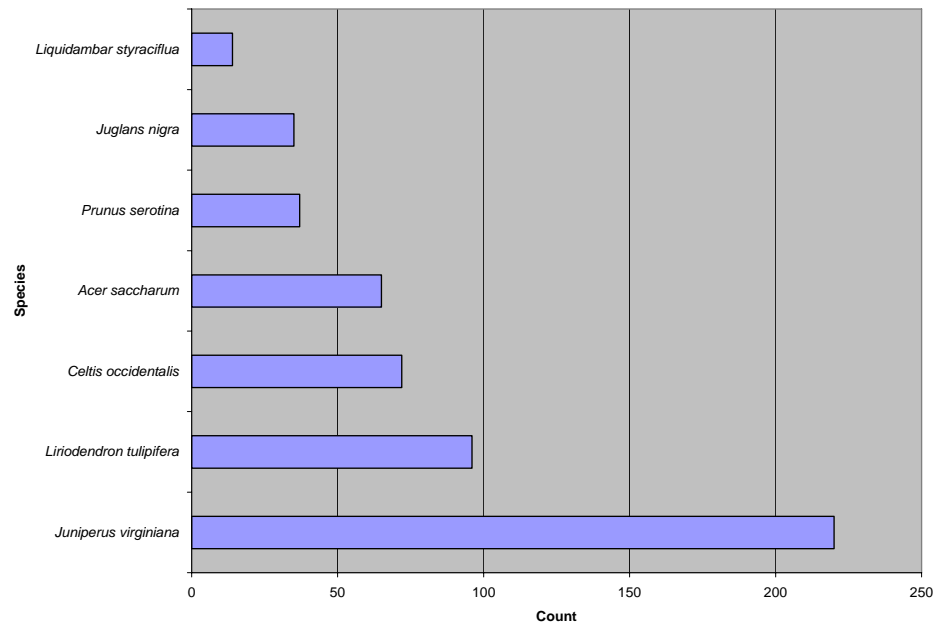


Figure 7. Species of trees which had more than 10 specimens destroyed in the 1998 tornado.

One hundred sixty-four trees of five species were replanted after the tornado in the historic core of the property. These were concentrated along the Carriage Drive and in the formal garden.

Six hundred sixty-one, representing 24%, of the total trees identified in the 1998 Tornado Damage Assessment were Eastern Red Cedars, *Juniperus virginiana*. Two hundred twenty were killed by the tornado, representing 34.7% percent of the total trees killed (Table 1). These were concentrated in the vicinity of the mansion (Figure 8). One hundred thirteen had a diameter at breast height of two feet (Figure 9).

Table 1. Table showing the number of trees destroyed in the 1998 tornado by species, where the number of trees was less than 5.

Common Name	Scientific Name	Count	% by Species
Cedar, Eastern Red	<i>Juniperus virginiana</i>	220	34.70
Tulip Poplar	<i>Liriodendron tulipifera</i>	96	15.14
Hackberry	<i>Celtis occidentalis</i>	72	11.35
Maple, Sugar	<i>Acer saccharum</i>	65	10.25
Cherry, Black	<i>Prunus serotina</i>	37	5.83
Walnut	<i>Juglans nigra</i>	35	5.52
Gum, Sweet	<i>Liquidambar styraciflua</i>	14	2.20
Elm	<i>Ulmus americana</i>	9	1.41
Hemlock, Canadian	<i>Tsuga canadensis</i>	9	1.41
Ash, Green	<i>Fraxinus pensylvanica</i>	8	1.26
Dogwood	<i>Cornus florida</i>	7	1.10
Oak, Red	<i>Quercus rubra</i>	7	1.10
Pear (Common)	<i>Pyrus communis</i>	5	0.78



Figure 8. Cedars, *Juniperus virginiana*, destroyed in the 1998 tornado.

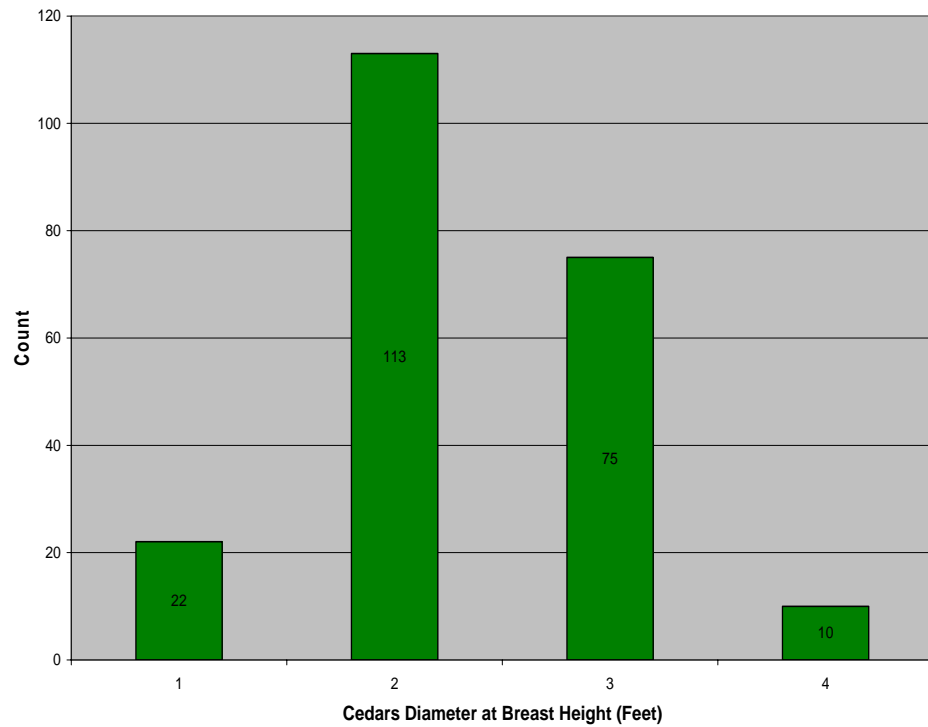


Figure 9. Diameter at breast height (DBH) in feet for Cedars, *Juniperus virginiana*, destroyed in the 1998 tornado.



Figure 10. Tulip Poplars, *Liriodendron tulipifera*, destroyed in the 1998 tornado.

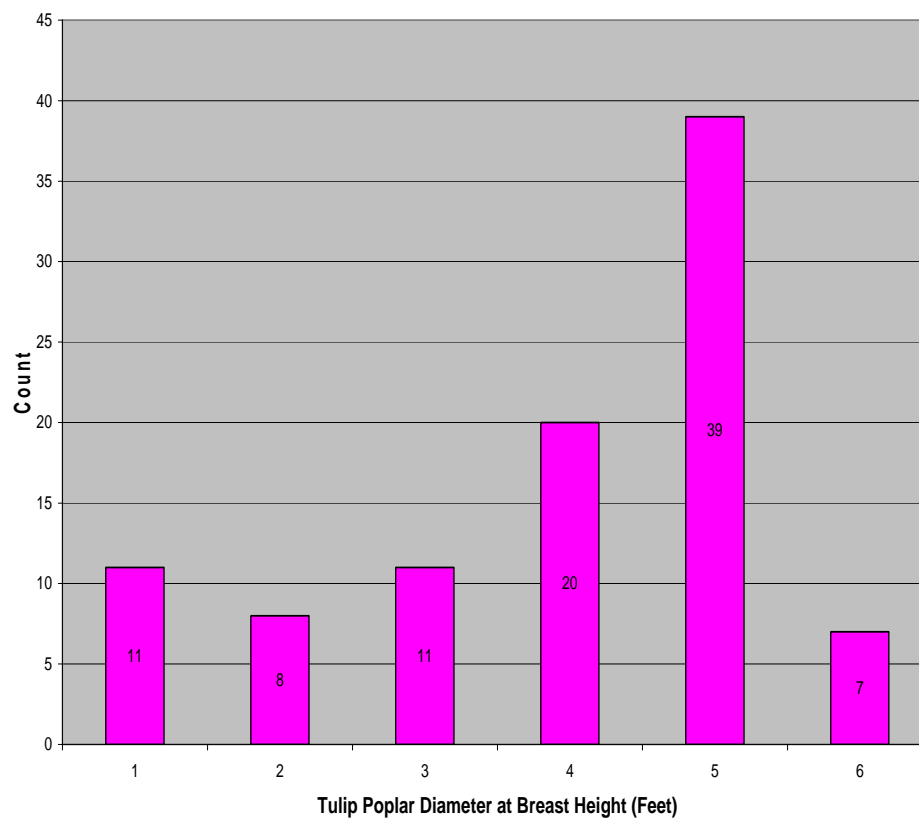


Figure 11. Diameter at breast height (DBH) in feet of the Tulip Poplars, *Liriodendron tulipifera*, destroyed in the 1998 tornado.



Figure 12. All the trees destroyed in the 1998 tornado in the 25 acre zone which makes up the historic core of the property. Note the guitar shape in the center which is the carriage drive and is mostly made up of cedars traditionally said to be planted by Andrew Jackson himself.

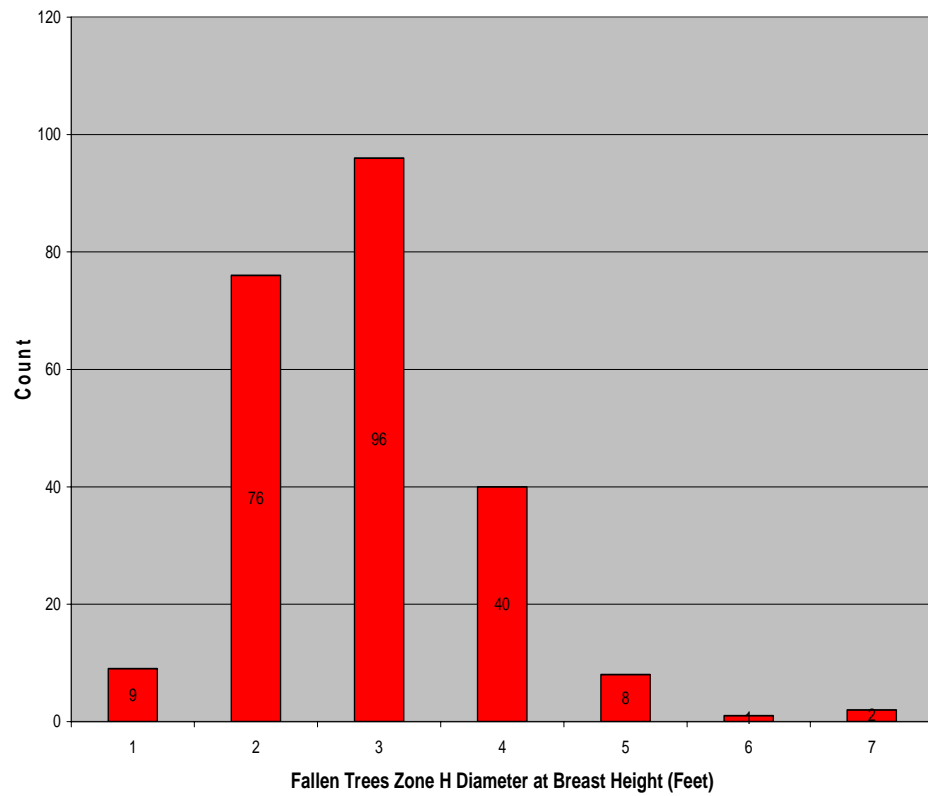


Figure 13. Historic core showing the diameter at breast height (DBH) in feet of all the trees destroyed in this zone in the 1998 tornado. Note that 96 trees had a DBH of 3 feet indicating their significant age.



Figure 14. The property's woodlot showing all the trees destroyed in this zone by the 1998 tornado. This zone runs along the main road into the property.

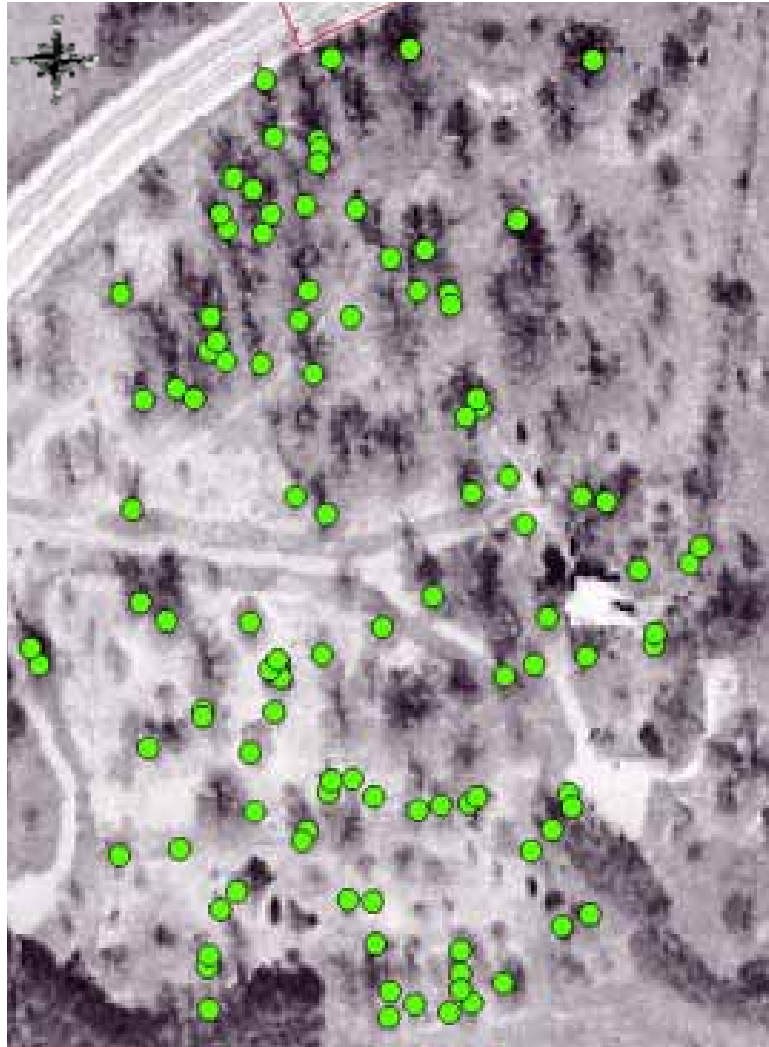


Figure 15. All the trees destroyed in the area of Tulip Grove Mansion, a second mansion on the property which is a Greek revival mansion built in 1836 for Andrew Jackson Donelson, the President's nephew.

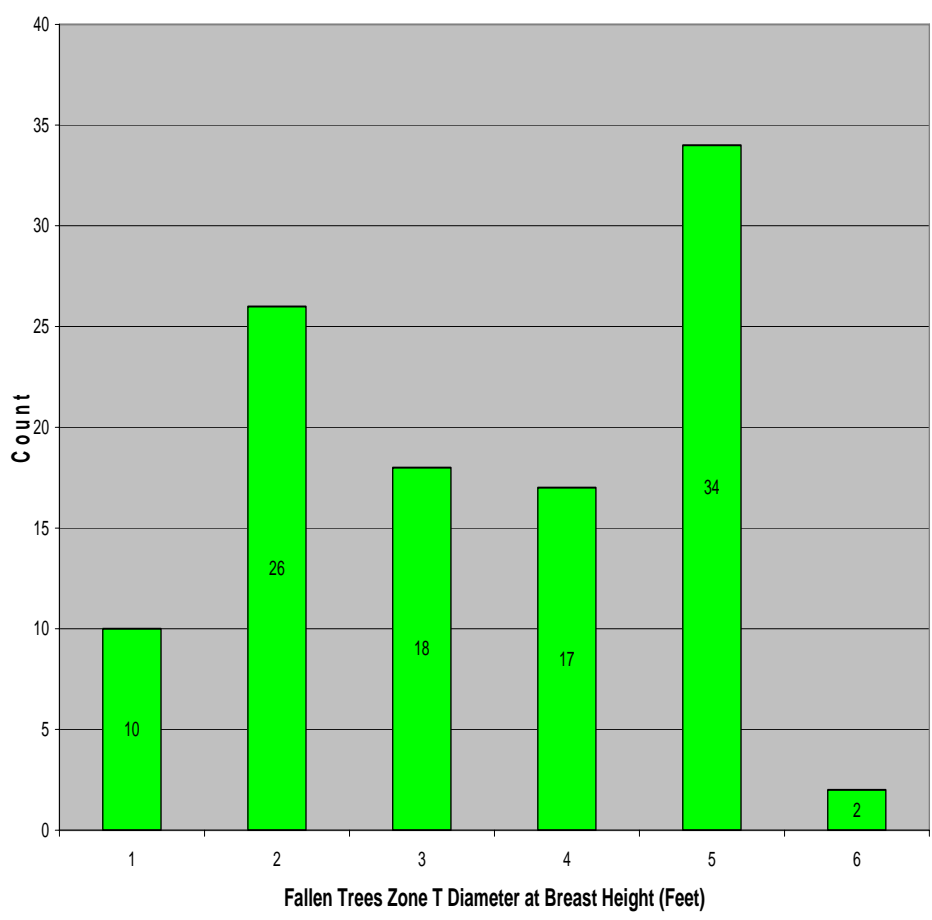


Figure 16. Tulip Grove area of the property showing the diameter at breast height (DBH) in feet of all trees killed in this zone by the 1998 tornado. Note that 34 had a DBH of 5 feet, indicating their significant age. These were mainly centuries old historic Tulip Poplars.

CONCLUSIONS

The bedrock of good scientific research is looking at old things in new ways in order to obtain new information about the subject being studied with the newest available technology. This project exemplifies that process. It pushed to the cutting edge the use of GPS technology in the preservation of historic landscapes.

Using the GIS and GPS technologies enabled the determination that 2645 trees representing 91 species sustained damage in the 1998 tornado. Six hundred thirty-four from 45 species were killed. Seven species had more than 10 trees killed. One hundred fifty-eight trees of five species were replanted in the historic core of the property following the tornado.

The information derived from this project is critical to the future preservation and interpretation of this important historic landmark in numerous ways. Archaeologists can analyze excavation possibilities for the future as well as past findings in relation to landscape features. Interpreters can relate to visitors the important role gardens and landscapes played in the life of the plantation and the people who lived in Tennessee, both owners and slaves. The curatorial staff can use the information for placing and verbiage of interpretation signs. Maintenance personnel can make informed decisions on upkeep, restoration, and repair priorities. Administrators can make great use of the information by using it in their decision-making processes and for long term planning purposes. The information and methodologies from this project can be shared with peer preservation groups such as the National Trust for Historic Preservation, the Networking Guide to Historic Landscape Resources, the Historic American Landscape Survey (HALS) and the National Park Service.

The groundwork laid in this project will serve as a firm foundation for future additions to the GIS for this property. Furthermore, it will be made available to serve as a model for other historic sites which have not yet begun their venture into geospatial analysis.

REFERENCES

1. NOAA (National Oceanic and Atmospheric Administration), National Climatic Data Center. Billion Dollar U.S. Weather Disasters 1980-200. <http://www.ncdc.noaa.gov> 3/7/2004
2. Ladies Hermitage Association. www.thehermitage.com . 10/24/2004
3. Kellar, Elizabeth. Hermitage Garden Tour Docent Notebook. 2002.
4. Coke, Fletch. The Hermitage Landscape: Before and After the 1998 Tornado. Hillsboro Press. 1999.
5. The Tennessean. Grants will help The Hermitage replace trees lost to '98 tornado". 5M. 12/20/2002.
6. Kennedy, Michael. The Global Positioning System and GIS, An Introduction. 2nd Edition. 2002. Taylor & Francis Inc. pg. 1, 173-176.

Author Information:

Alicia Williams, GIS Specialist
AMEC Earth and Environmental, Inc.
3800 Ezell Rd., Suite 100
Nashville, TN 37211
615-390-3574
alicia.williams@amec.com

Dr. Robert Harrison, Professor
Department of Agricultural Sciences
Tennessee State University
3500 John A. Merritt Blvd.
Nashville, TN 37209
615-963-5183
Rharrison@tnstate.edu