DESTROYED VIRGIN LONGLEAF PINE STAND LIVES-ON DIGITALLY

John C. Gilbert, John S. Kush, and Rebecca J. Barlow[1]

Abstract--The Flomaton Natural Area (FNA) once stood as one of the few remnant fragments of virgin, old-growth longleaf pine stands (*Pinus palustris* Mill.) in the Southeast. This 80-acre stand contained trees over 200 years old. A restoration effort began in1994 to remove off-site trees and to reintroduce fire to the site after over 40 years of fire suppression. A geographic information system (GIS) database was created by compiling the digital data recorded for the FNA, including a stem-map of all longleaf pines ≥ 1-inch d.b.h. (diameter at breast height). The database also includes ages, heights, and crown class information, which provides opportunities for a 3-dimensional digital view of the stand structure. The GIS database contains information for over 4,000 trees. It provides a unique opportunity to spatially explore longleaf pine stand dynamics of a virgin stand and to learn more about long-term management of longleaf pine. The variations in densities, size classes, and ages across the stand will be evaluated to provide information about how longleaf pine grows and the stand dynamics of virgin, old-growth longleaf pine. Gap dynamics of openings in the stand will also be examined, including information about successful regeneration. Despite the successful restoration work and demands to save the stand, the FNA was clearcut in 2008. The stand now lives on in digital form and continues to serve as an educational tool and as a beacon for the acts of mismanagement and loss of the longleaf pine ecosystem today.

INTRODUCTION

The Flomaton Natural Area (FNA) once stood as one of the few remnant fragments of virgin, old-growth longleaf pine stands (*Pinus palustris* Mill.) in the Southeast. This 80-acre privately owned stand was located within the city limits of Flomaton, AL. The FNA was a good representation of virgin stands of longleaf pine described by early authors like Schwarz (1907) and Wahlenberg (1946) based on the size and age distribution of the trees. Varner and Kush (2004) described the FNA as one of 15 remnant old-growth sites left across the species' range, which only represented 0.00014 percent of presettlement longleaf pine extent collectively. This stand had trees over 200 years old and was burned regularly until 1950 when all burning and fuel management ceased until 1994.

A restoration effort began in1994 to remove off-site trees and to reintroduce fire to the site after over 40 years of unnatural fuel accumulations and the associated risk of wildfire. These treatments created opportunities for successful longleaf pine natural regeneration and the potential for recovery of its understory structure and associated plant and wildlife components (Kush and others 2004). During over 20 years of research and restoration work on the FNA, detailed stand information was recorded for the site and used for monitoring changes to the overstory, understory, and soils associated with the restoration efforts. The field data recorded for the FNA provide a unique opportunity to gain insight into its stand dynamics and to learn more to aid long-term management of longleaf pine.

Despite the successful restoration work and demands to save the stand, the FNA was clearcut in 2008. Kush (2009) published an obituary for the FNA describing its restoration and demise. Now, only the digital data remain as a record of the stand; it provides opportunities for spatial representations of the FNA that can be used by coming generations to learn more about virgin old-growth longleaf pine. The FNA lives on in digital form and will serve as an educational tool to future researchers and managers.

METHODS

Stem-mapped Longleaf Pine

A geographic information system (GIS) database was created by compiling the field data recorded for the FNA and converting it to digital form, including a stem-map of all longleaf pines ≥ 1 inch d.b.h. (diameter at breast height). All GIS database development and analyses were completed in ESRI's ArcGIS 10. To create the stem-map, strategic point locations were setup throughout the stand, and coordinates were recorded with a sub-meter Global Positioning System (GPS) receiver at each point. Azimuth and distance measurements were recorded from the points to the surrounding trees with a survey laser. Coordinates were then calculated for each tree and entered into ArcGIS 10 to create a point

[1]Research Associate and Research Fellow, respectively, Auburn University, School of Forestry and Wildlife Sciences, Auburn University, AL 36849; and Assistant Extension Professor, Auburn University, Alabama Cooperative Extension System, School of Forestry and Wildlife Sciences, Auburn University, AL 36849.

Citation for proceedings: Holley, A. Gordon; Connor, Kristina F.; Haywood, James D., eds. 2015. Proceedings of the 17th biennial southern silvicultural research conference. e–Gen. Tech. Rep. SRS–203. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 551 p.

shapefile. The field data recorded for the trees included d.b.h., crown classification information, ring count at breast height, heights, and litter depths. The next step was to combine the point data with the field data to create a robust GIS database for the FNA. The database provides a unique opportunity to spatially explore longleaf pine stand dynamics of a virgin stand and to learn more about long-term management of longleaf pine. The variations in densities, size classes, and ages across the stand will be evaluated to provide information about how longleaf pine grows and the stand dynamics of virgin, old-growth longleaf pine. Gap dynamics of openings in the stand will also be examined, including information about successful regeneration.

Two Dimensional (2D) Digital Representations

A layout of just a single symbol for each tree shows the spatial distribution of the trees stem-mapped on the FNA. To provide the viewer with a chance to see the spatial distribution and size of trees, the symbols for each tree were scaled relative to its measured d.b.h. Adding more detail to the 2D representation, separate symbols were added for each of the crown classifications. The symbols were then scaled relative to its measured d.b.h. for each tree. This type of layout provides the spatial distribution, size, and crown position in one layout.

Raster Interpolation

The extensive number of points where data were collected on the FNA provides opportunities to go beyond simply looking at individual points. Due to limitations of funding, time, and efficiency, measurements cannot be taken everywhere. Data for the known points are used to interpolate or predict values for the surrounding areas where data were not collected. With the good coverage of point data, the inverse distance weighted (IDW) technique was used to calculate interpolations for the FNA, within the boundary of the stand. Other methods of raster interpolation techniques like nearest neighbor were attempted, but the IDW technique provided the best representation of the conditions on the ground. ESRI's ArcGIS 10 3D Analyst and the Raster Interpolation (IDW) tool were used for the analysis with litter depths, d.b.h. measurements, and ring counts at breast height (ESRI 2010). The results of the interpolations for each analysis were then classified into pertinent categories to display the data for each metric.

Three Dimensional (3D) Digital Representations

ESRI's ArcScene 10.0 was used to create an interactive 3D model of the stem-mapped longleaf pine on the FNA (ESRI 2010). The stem-map point shapefile was added to the view in ArcScene. Within ArcScene, a user can zoom into the stand, view individual trees or gaps, turn the view in any direction, and even fly through the stand. The closest representation to a longleaf pine tree was chosen from the 3D Trees Style Reference list under the symbol selector. To show the relative size of each tree, the 3D symbols for each stem-mapped longleaf pine were scaled using the measured diameters. The 3D stem-map was compared to the 2D representations to see differences in viewing individual trees, clusters of trees, gaps, and the stand as whole. Simulations were then completed by selecting trees using the attributes in the database. When the trees are selected, ArcScene adds a blue box around each symbol selected. Various simulations were completed to show the distribution of certain size classes, such as regeneration and older trees across the FNA.

RESULTS

2D Digital Representations

The longleaf pine stem-mapped data includes data for 4,167 trees. Diameters were measured to the nearest 0.1 inch. Measurements ranged from 0.7 to 32.3 inches d.b.h. Crown classifications were recorded for trees on the FNA. Classifications in the database for each longleaf pine include dominant, co-dominant, intermediate, suppressed, and no data. Two layouts were created to show a 2D view of the FNA. The first layout with a single symbol scaled for d.b.h. shows the true distribution of size classes for the longleaf pine on the FNA. Large trees were scattered across the stand, often in clumps. Smaller symbols representing the regeneration filled in gaps across the stand and were dense in the open utility line running through the northern portion. A second 2D view of the stand was created by showing different symbols for each crown classification and then scaling the symbol by d.b.h. This layout provides a pseudo-3D view of the stand by adding a classification for crown position along with the tree size, showing a good relationship between the two.

Raster Interpolation of Litter Depth

Due to the lack of fire for over 40 years, the FNA had unnatural fuel accumulation which was a major concern of the restoration effort. Extensive litter and duff measurements were taken across the FNA. The database contains over 3,000 measurements to the nearest 0.1 inch, with depths ranging from 0.5 to 16 inches. The use of prescribed fire was very difficult, especially around large old trees. To help create a better planning tool for prescribed fire, a raster IDW interpolation surface of litter depth was created for the FNA using the point data. The litter depths were classified in five categories: 0.5 to 2.5 inches, 2.6 to 5.0 inches, 5.1 to 7.5 inches, 7.6 to 10.0 inches, and 10.1 to 16.0 inches. The raster interpolation created a surface for the FNA showing the distribution of litter depths across the stand using a light- to dark-brown color ramp to show the increasing litter accumulations. The high accumulations show up in areas with high densities and larger trees. This surface could have been very useful for prescribed burn planning and mop-up during the FNA restoration by providing opportunities to prioritize areas known to have high accumulations of litter and near older trees. It could have aided in areas to focus mop-up procedures that might have prevented the loss of trees.

Raster Interpolation of D.B.H. and Ring Count

The IDW surface for diameters shows the size distribution across the FNA that highlights dense areas and gaps. The IDW surface was classified into nine categories using breaks in the data. The categories were < 4, 4 to 7, 8 to 10, 11 to 13, 14 to 17, 18 to 20, 21 to 23, 24 to 27, and > 27 inches d.b.h. The surface showed the distribution of tree sizes across the stand using a light- to dark-brown color ramp to show the increasing value for d.b.h. The surface showed the pockets of larger trees and clumps of smaller trees in a patchy structure. Basal areas in some of these dense pockets are well over 200 square feet per acre with trees from a variety of sizes.

The ring count at breast height surface also provides information about the variation of trees in the dense areas and gaps. Recorded ring counts at breast height ranged from 3 to approaching 300 years. The IDW surface was classified into nine categories using breaks in the data. The categories were 3 to 33, 34 to 48, 49 to 60, 61 to 72, 73 to 83, 84 to 95, 96 to 109, 110 to 133, and 134 to 267 rings counted at breast height. Due to potential variations in the amount of time it may have taken trees to reach breast height and to the occurrence of red-heart fungus (*Phellinus pini*), the authors estimate trees were over 300 years old. The surface showed the distribution of ring counts at breast height across the stand using a light- to dark-brown color ramp to show the increasing number of rings counted. The surface showed a good representation of clumps of older trees and areas where regeneration was present.

3D Digital Representations

The 3D representations created for the FNA provide an interactive digital recreation that can be used to explore the stand from almost any angle. Using ArcScene 10, the stand as a whole can be rotated in any direction. The user can zoom into the stand and look at individual trees or groups of trees. Examples of the entire stand can be shown from above, the side, and a profile view. Quick simple summary data can be created by utilizing the database of individual tree metrics in the attribute table (not shown). The frequency distribution for the d.b.h. field showed a 'reverse j' distribution, common for uneven-aged stands. An example simulation was also created to show the regeneration on the FNA by selecting all trees from 0.7- to 7.5-inches d.b.h. The interactive map and summary statics showed 1,897 trees within the selection and their distribution across the FNA. Potential users with a license for ArcScene could continue to explore the stand and create a variety of simulations and examples for longleaf pine restoration and management.

DISCUSSION

Although the FNA no longer exists as a physical stand, the 2D and 3D representations of it continue to provide valuable information for future generations. The 2D representations provide a good view of the spatial distribution of the stand including d.b.h. and crown positions. These conventional representations could easily be incorporated into slide presentations, poster displays, and webpages. Since stem-maps of virgin old-growth longleaf pine stands are rare, users could learn more about these systems by viewing layouts or exploring the stand with GIS and conducting additional analyses or simulations like thinnings to test different management options. The shapefiles could also be converted to a file format for use in programs like Google Earth, which could then be used to reach a broader audience not familiar with ArcGIS. The raster interpolations take the digital representations to the next level by showing surfaces for d.b.h., ring count at d.b.h., and litter depths. These d.b.h. and ring-count surfaces provide viewers with a chance to see the patchy nature of the uneven-aged stand by highlighting groups of similar-sized trees and also similar ring counts at d.b.h. or approximate ages. These representations help viewers see the patchy nature of an old-growth longleaf pine stand but also to show the tree groupings that are difficult to see in the 2D representations. The litter depth raster interpolation provides a surface showing areas where litter depths could be problems for prescribed fire operations. Examples like this from the FNA could continue to provide educational products to practitioners interested in longleaf pine restoration and in reintroducing fire into old-growth longleaf pine stands. The 3D representations using ArcScene bring the digital forest to life. These 3D representations provide opportunities for virtual simulations of the stand that can be used to explore stand dynamics of the FNA, from virtual tours to complex individual tree or gap dynamics. The FNA database provides many opportunities for future work. Taking the next step to customize trees and regeneration using more of the recorded individual tree metrics will make a more accurate display. These digital representations can be used to develop online educational tools for restoration and conservation of longleaf pine by providing a wide variety of interactive virtual simulations such as thinning and selection cutting, including group and individual-tree selections. These educational tools could be used to help the FNA reach natural resources professionals, students, private landowners, and other audiences.

CONCLUSIONS

There are still many unanswered questions about longleaf pine stand dynamics, especially for virgin, old-growth stands. Stands like the FNA are truly not replaceable. With the continued loss of old-growth longleaf pine stands and the scarcity of virgin stands, there are very few opportunities to visit and to learn about these ecosystems. Although we are in the midst of a resurgence of interest in longleaf pine, these efforts often concentrate on planting, while stands like the FNA are lost for future generations. Despite the physical loss of the FNA, it has been captured in digital form. The FNA will continue to serve as an educational tool, virtual demonstration, and a beacon against mismanagement and loss of longleaf pine ecosystems.

LITERATURE CITED

ESRI 2010. ArcGIS Resource Center Desktop 10 Help. URL: http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/What_is_ArcGIS_Desktop/00v200000005000000/ [Date accessed: May 31, 2013).

Kush, J.S.; Meldahl, R.S.; Avery, C. 2004. A restoration success: longleaf pine seedlings established in a fire suppressed old-growth stand. Ecological Restoration. 22(1): 6-10.

Kush, J.S. 2009. Obituary for Flomaton: one less virgin longleaf stand (Alabama). Ecological Restoration. 27(3): 247-248.

Schwarz, G.F. 1907. The longleaf pine in virgin forest. A silvical study. New York: John Wiley & Sons. 135 p.

Varner, J.M., III; Kush, J.S. 2004. Remnant old-growth longleaf pine (*Pinus palustris* Mill.) savannas and forests of the southeastern USA: status and threats. Natural Areas Journal. 24(2): 141-149.

Wahlenberg, W.G. 1946. Longleaf pine: its use, ecology, regeneration, protection, growth and management. 1st ed. Washington, DC: Charles Lathrop Pack Forestry Foundation. 429 p. In cooperation with: The U.S. Department of Agriculture Forest Service.