CO-388

DEVELOPMENT OF A GEODATABASE FOR USE IN FORESTLAND MANAGEMENT

CROSBY M., BOOTH M.
Mississippi State University, MISSISSIPPI STATE, UNITED STATES

ABSTRACT

Tracking historical events and current stand information on a forest property is a critical need for forest land managers. The opportunity to view all attributes of the property simultaneously with prior management activities allows for a dynamic, efficient tool to assist with periodic management plan development and to query for routine decision-making. To this end, Mississippi State University (MSU) is developing a stand-level geodatabase that integrates spatial and tabular data regarding forest properties managed by the Forest Operations Unit within the Forest and Wildlife Research Center (FWRC) at the University. This database holds spatio-temporal information for properties located throughout the State of Mississippi (USA). The spatial component is comprised of feature datasets to encompass information for 22,000+ acres on 22 separate forest properties (including stand and property boundaries), soils, political boundaries, transportation networks, utilities, cadastral features, and historical events. The historical events dataset contains feature classes for 11 separate events that could occur within any given stand. These include prescribed burns, fertilization, harvest, inspection (inventory), natural disaster, pre-commercial thinning, regeneration, research, site preparation, vegetation management, and miscellaneous activities. The historical events dataset is linked to the tabular component, maintained presently as a Microsoft Access database. This allows for the historical events to be populated with information regarding the date of occurrence, the type of event, and the impact of the event on the forest property. The results, to date, are approximately 500 separate event entries spanning approximately 60 years of the history of MSU forests and a database that will soon be integrated with ArcSDE and presented on the World Wide Web. This will provide a readily available resource for different user groups such as faculty, staff, students, advisory boards, donors, and recreational users interested in the history of the forestlands and the current management activities being implemented on MSU-managed forests. This methodology could prove useful to other organizations and institutions interested in providing information to the public and/or clients regarding a variety of management initiatives. Tracking historical events in conjunction with current resource attributes can assist researchers and public/management officials in the creation of effective management regimes to maximize the research, recreational, teaching, demonstration, and economic potential of MSU-managed forestlands.

BACKGROUND AND OBJECTIVES

Geographic Information Systems (GIS) are increasingly utilized for applications to forest resource management (Bettinger et al., 2009). These software systems provide a convenient, easily deployable method for mapping locations and storing attribute data at various levels of management. A further capability of this system is the ability to create geodatabases (GDB) allowing for large amounts of data to be stored in a single location relating to forest management practices. This data can then be used to assist in the development of management plans (Nishimura et al., 2004) and increase the efficiency of parties involved in their creation and implementation.

Databases can be utilized to store inventory information, allowing users to search available timber volumes by product class (Matney and Schultz, 1999). Nishimura et al. (2004) created a database that integrates inventory information with spatial locations for an area (the Saga Prefecture) of approximately 2,500 km2 in Japan. These database systems have the capability of storing large amounts of data and thus, can be utilized to cover large areas and the forest management/operations events that could occur.

MSU Forestlands

The MSU-FWRC Forest Operations Unit is involved with a myriad of forestland properties. A portion of these forestlands are directly managed by the Forest Operations Unit, while others demand only support of management operations from the unit. A diverse combination of ownerships and administrative structures results in varied management objectives (research, recreation, teaching, demonstration, and/or revenue) for the individual properties. The properties may be classified in three broad categories: 1) lands owned by MSU, 2) lands owned/held by the MSU Foundation (non-profit development entity), and 3) lands managed by the MSU-Mississippi Agriculture & Forestry Experiment Station (MAFES). (Table 1 and Figure 1.)

Table 1 - Properties supported by MSU – FWRC Forest Operations to be incorporated into the geodatabase.

PROPERTY NAME	LOCATION	ACRES
MSU Properties		
Columbus Air Force Base Property	Lowndes County	108
Player Property	Madison County	59
Sharp Forest	Tishomingo County	1600
Starr Forest	Oktibbeha & Winston Counties	8321
	Subtotal	10,088
Bulldog Forest (MSU Foundation) Properties		
Brand Forest	Clay & Chickasaw Counties	2133
Dunn Forest	Pearl River County	231
Gober Forest	Attala County	283
Harris Forest	Newton County	430
Holloway Reserve	Monroe County	345
Johnson (Col. K. D.) Forest	Scott & Leake Counties	400
Johnson (Linda) Legacy Forest	Lee County	28
Leopold Legacy Forest	Noxubee County	140
O'Quin Forest	Pike County	127
Phillips Forest	Lafayette County	223
Phillips-Guthrie (ACUB) Property	Forrest County	351
Shaw-O'Reilly Property	Kemper County	80
	Subtotal	4,771
MAFES Properties		
Coastal Plain Branch Experiment Station	Newton County	458
Delta Branch Experiment Station	Washington County	6,600
McNeal Research Unit	Pearl River County	32
North MS Branch Experiment Station	Marshall County	244
Pontotoc Ridge-Flatwoods Branch	Pontotoc County	80
Prairie Research Unit	Monroe County	60
	Subtotal	7,474
	TOTAL ALL PROPERTIES	**22,333**

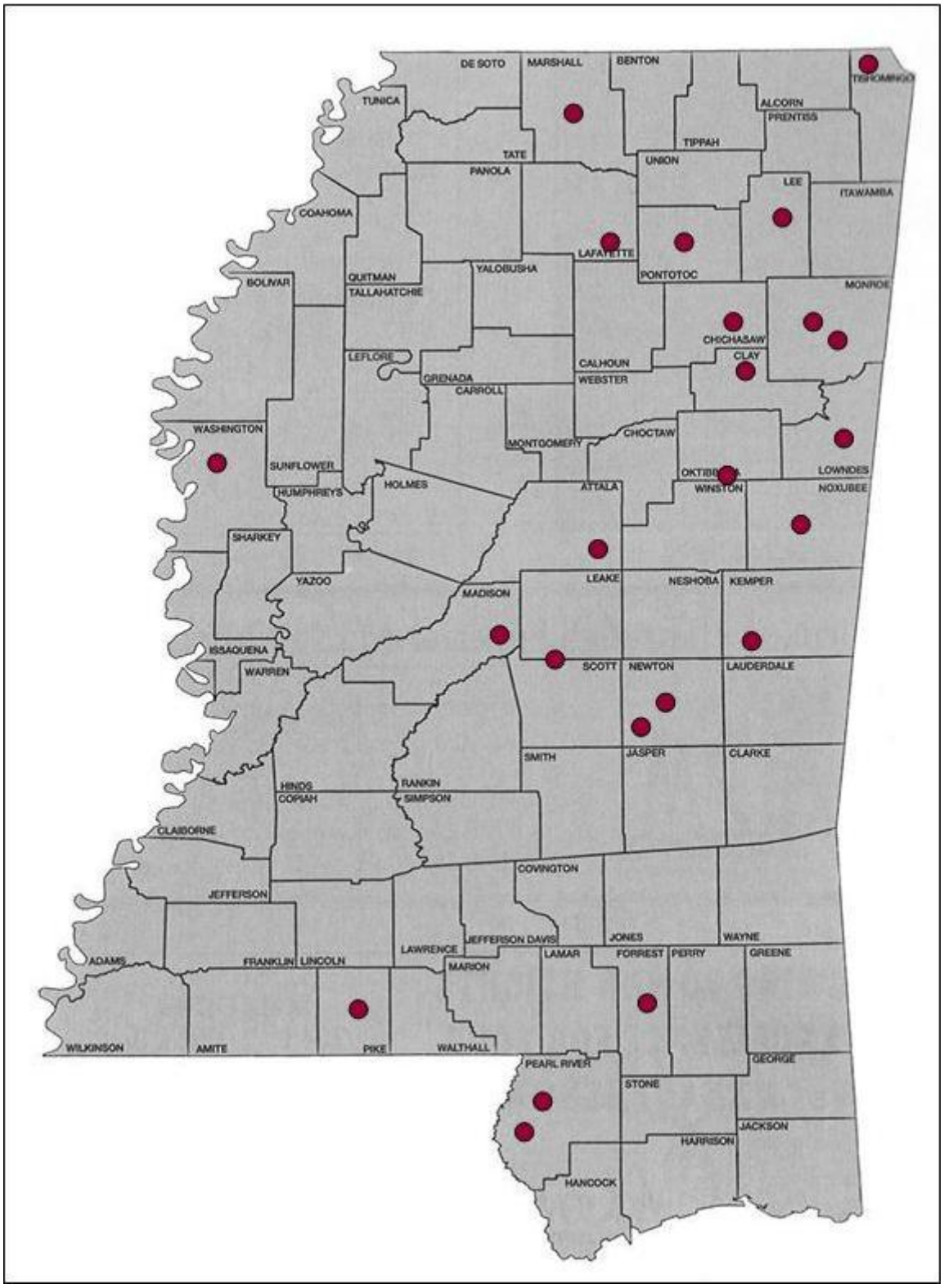

Figure 1 - Property locations throughout the State of Mississippi.

The geodatabase allows for a dynamic tool to track the ever-changing portfolio of properties and address management objectives for individual properties or several considered simultaneously, all within the context of historical events. Once deployed to a web-based system, the intent is to allow a multitude of customers various levels of access to those properties of interest or that information pertinent to the needs of the individual user.

Objectives

The Forest Operations Unit seeks to utilize GIS software, in conjunction with Microsoft Access, to develop a geodatabase to store historical management events for all properties managed. The specific objectives are to develop a system that 1) facilitates the accurate location (spatially) of events on the landscape, 2) allows for tabular information of management activities to be stored for each event, and 3) enables users of the data to query information to develop future management plans for all properties. The final goal to be realized is to incorporate this information into an ArcSDE server and present it on the World-Wide Web. This will enable donors, students, researchers, and the general public access to this information.

APPROACHES AND METHODS

To maximize the potential of the GDB, information was obtained to facilitate mapping for each county in Mississippi and clipped to an extent of one section beyond the boundary of each forest property. The information was obtained from the Mississippi Automated Resource Information System (MARIS), a clearinghouse of geospatial information for the State of Mississippi, as well as forest boundaries derived from Global Positioning System (GPS) data. The data were stored in the GDB as a feature class for each property and grouped into feature datasets, according to its use. These feature datasets are grouped into one of five categories: Cadastral, Hydrology, Political, The_Forest, and Transportation (Table 2). Organizing the information in this manner allows for maps to be readily produced for forest properties managed by MSU.

Table 2 - Feature datasets and feature classes used in the creation of the GDB.

Feature Dataset	Feature Classes[a,b]	Description	Comment
Cadastral	*_Sections	Sections for property named	
	Latitude	Lines of Latitude for MS	
	Longitude	Lines of Longitude for MS	
Hydrology	*_Lakes	Lakes in Property Boundary	
	*_Streams	Streams in Property Boundary	
	*_Water_Bodies	Additional water bodies	Catfish Ponds, Lagoons, etc.
Political	Counties	County Boundaries	
	MS_Border	State Boundary	
The_Forest	*_Forest_Boundary	Boundary for forest property	
	*_Unit	Boundary for units in forest property	Some properties have multiple units
	*_Topology	Topology rules for forest property	
	Historical_Events	Historical events for all properties	Management activities
	Soils	Soils for State of Mississippi	
Transportation	*_Roads		
	*_Railroads		

a) the * indicates the name for a given forest property (e.g. Starr_Sections would denote all sections on the John W. Starr Memorial Forest

b) all feature classes were re-projected to: NAD_1983_StatePlane_Mississippi_East_FIPS_2301

c) the Historical Events feature class is the focus of the project and will be addressed in subsequent sections

This information forms the foundation of the GDB and allows for a robust tool for facilitating management activities. For the management of the Historical Events feature class, a database was created in MS Access that spatially links the event created to its corresponding forest property. There are two components for this system, a spatial component and a tabular component.

The Spatial Component

The spatial component of the database utilizes the information presented in Table 2. This information is valid for all properties managed by MSU and represents the most current stand and property boundaries available. The Historical Events are created for these areas and represent management activities that occurred within the given units during the history of their management. Historical Events can be created for a variety of management activities, including: burn, fertilize, harvest, inspection (inventory), natural disaster, pre-commercial thin, regeneration, research, site prep, vegetation management, and miscellaneous

(Table 3). These events are stored relative to their spatial location within the database, each with its own unique event ID (Figure 2).

Table 3 - Description of Historical Event types and information available for each type.

Event Type	Description	Information Available
Burn	Prescribed burns	Crew members, acreage burned, weather conditions/permit
Fertilize	Fertilization (spraying, etc.)	Type of fertilization and method, contractor
Harvest	Thinning, Final Harvest	Volumes, US Dollar amounts, purchaser, map of location
Inspection	Inventory	Type of cruise, # plots, stand and stock tables
Natural Disaster	Salvage after natural disaster	Volume damaged, maps
Pre-commercial thin	Pre-commercial activities	Tree removal, brush hog, etc.
Regeneration	Regeneration methods	Natural/Planted, species
Research	Research areas maintained by Faculty	Researchers information, locations, acreage
Site Prep	Site prep methods	Type (disc/bedding, rake, etc.)
Vegetation Management	Management methods	Methods (injections, spray)
Miscellaneous	Data that does not fit other categories	Primarily maps of historic stand boundaries

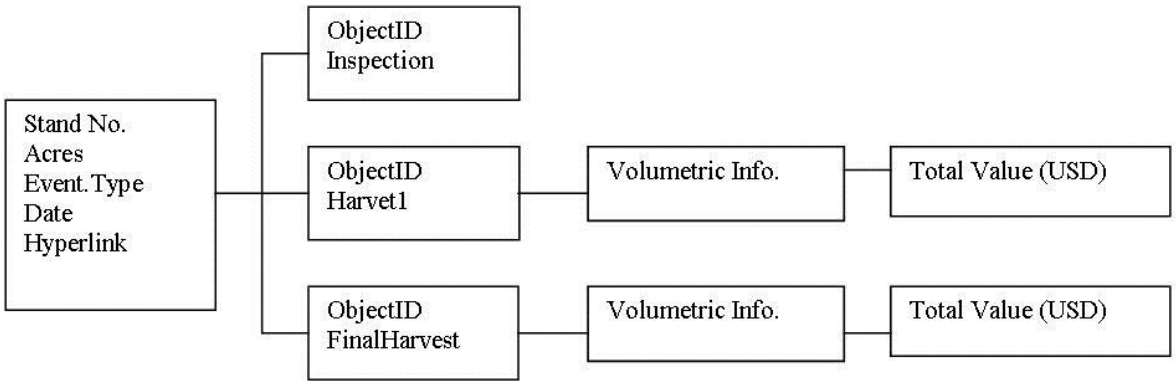

Figure 2 - Diagram of potential events for any stand in the database (adapted from Murray, 1999).

Historical Event Creation

The Historical Events feature class is the focus of the GDB. Spatial accuracy is paramount to its use as a management tool for MSU forests. Events created span the history of management of resources by MSU (dating back to 1949) and are linked to a Microsoft Access database (discussed in a subsequent section) to provide users of the data a means of viewing events spatially and temporally for a given location on an MSU-managed property. The events are created from maps and/or legal descriptions (based on the Public Land Survey System), providing an accurate location of events across the landscape. For more recent

events (year 2000 – present), stand boundaries are copied into the Historical Events feature class utilizing ArcMap's Editor tool (Figure 3). This method insures that calculated acreages remain constant for the various activities that could occur on a given stand. For real-time management activities or for those that do not follow stand boundaries, GPS data are also used to define the historical event area.

Once an area is selected or digitized, it is assigned an ObjectID (unique to each separate event) in the Historical Events feature class. The area is calculated in m2 and converted to U.S. acres for this application; this can be amended for areas that require different units of measure (e.g. hectares). Paper records of all management events are housed at MSU-Forest Operations offices and are digitized as .pdf files. In some instances, the maps are saved in .jpg format and georeferenced to locations on the properties. This allows for the events spanning historical stand boundaries to be digitized as separate records in the GDB (Figure 4).

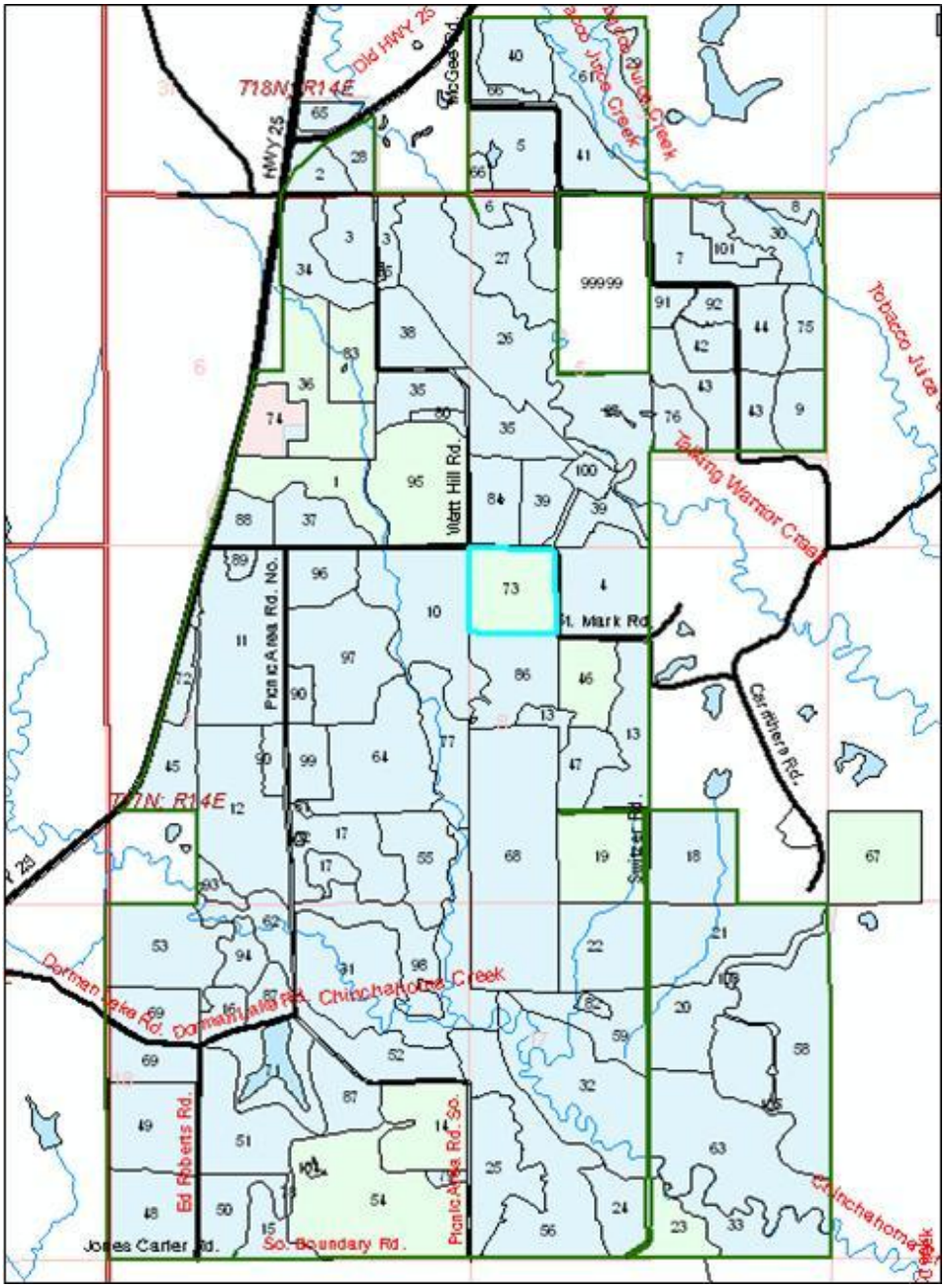

Figure 3 - Example of an event creation (outlined in blue) for a stand in the MSU forest.

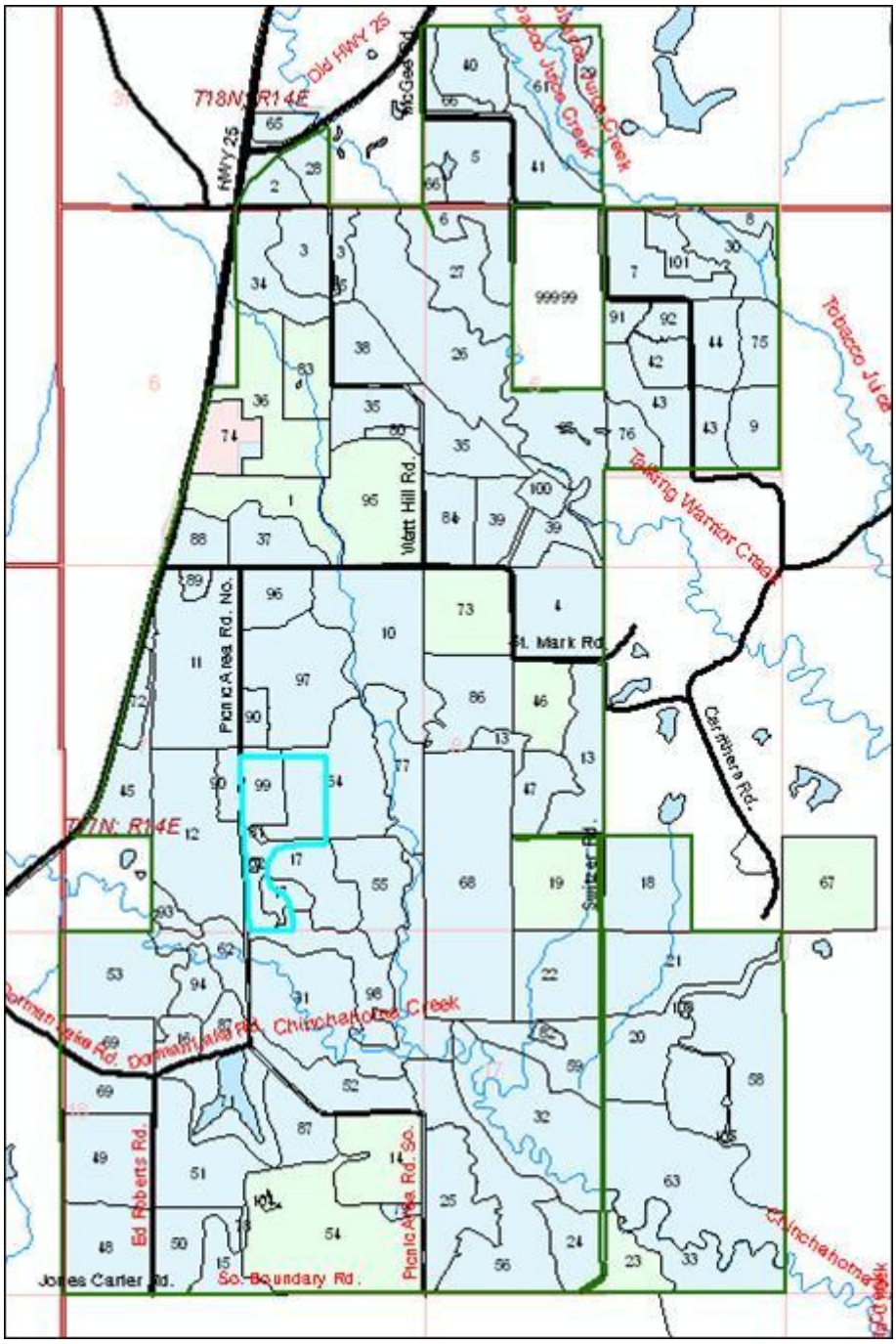

Figure 4 - Event created from historical map (outlined in blue) that spans multiple current stand boundaries.

The Tabular Component

After creation of the event spatially, a tabular database is linked to modify specific information about the attributes of the event. The tabular data is maintained via Microsoft Access (Figure 5). This database system was initiated by GeoTech, Inc. to house all information linked to the spatial events in the GDB. Fields in the MS Access and GDB are linked via the ObjectID (assigned by ArcMap) and the Event_ID (in Access). An Events table (Figure 6) was created and is linked to the attribute table relating to specific events (e.g. Harvest, Natural Disaster, etc.). This information can then be queried within ArcMap, providing current and historical event information about all properties managed at the operational scale at which the events occurred.

Figure 5 - Initial screen for entering the MS Access database to create tabular data for the events created.

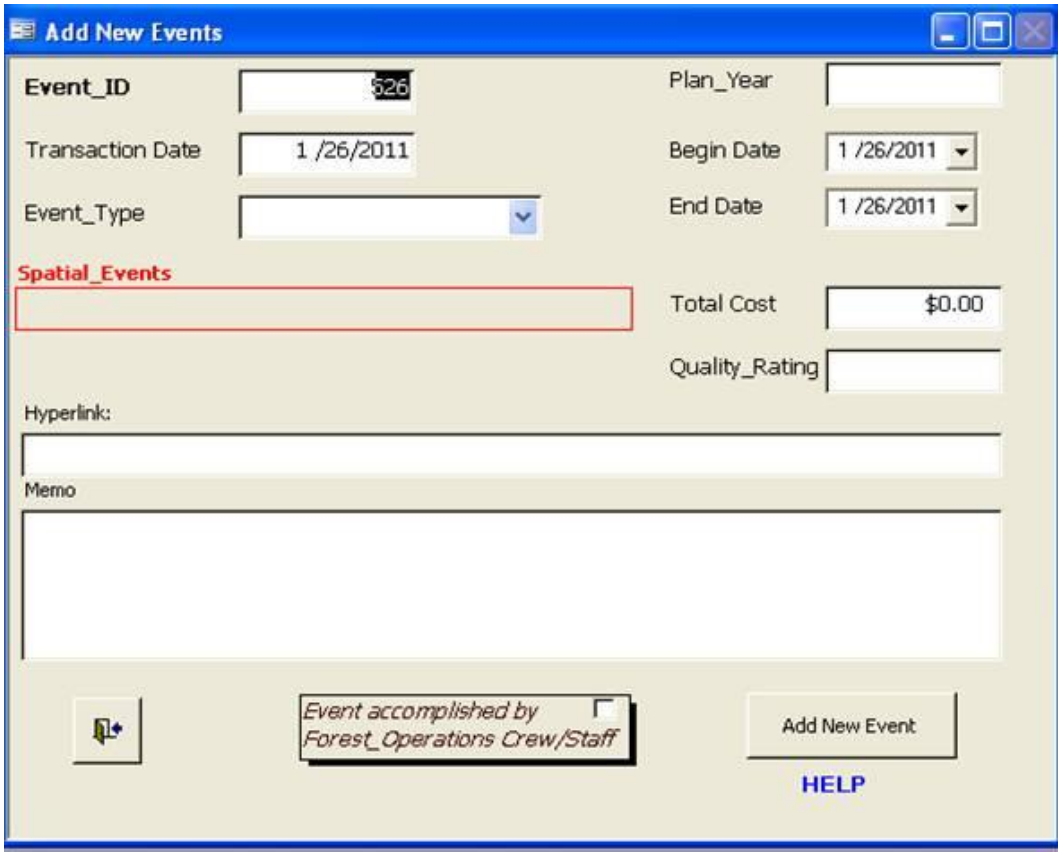

Figure 6 - Event creation form for tabular data.

Topology

Topology rules are an integral part to the quality of any GDB as they define the spatial relationships between features (ESRI, 2003). These rules ensure the spatial integrity of the stands found within each unit and thus, that the correct acreages are maintained for each stand. As feature classes can belong to one

topology only, topology rules are defined for each management unit. The rules employed for the units in the GDB are to prevent stands lying outside the boundary of the unit, to prevent gaps in the stands, and to prevent the stands from over-lapping (Table 4). Topology rules were validated and errors corrected before historical events were created for each unit.

Table 4 - Topology rules utilized for each feature class in the GDB.

Feature Class	Topology Rule	Feature Class	Use
*_Unit	Must Cover Each Other	Boundary	Ensures stands are within boundaries
*_Unit	Must Not Overlap		Ensures stands do not overlap
*_Unit	Must Not Have Gaps		Ensures stands are complete polygons

RESULTS

For each property currently in the GDB, property boundaries and ancillary information (roads, streams, etc.) have been accurately determined from either field-based GPS measurements, publicly available data, or digitized from paper maps. This information allows for each historical event to be shown in relation to features that could affect management decisions in the forest. Historical events have been created for over 500 separate management events that have occurred in MSU-managed forests since 1949. The process is on-going, as new events and properties will be added as management activities are executed.

Historical events are maintained within the boundaries of each unit. The number of events in each unit varies according to the level of management that has occurred within the unit. For example, the John W. Starr forest is the oldest forest property managed by MSU and is comprised of three units (Cypress Creek, Noxubee, and Talking Warrior). As the initial focus, this property contains a majority of the events currently in the database. The events also have temporal information, depicting all events that have occurred within a selected spatial extent (Figure 7). Upon selecting a desired stand, information is immediately available regarding all activities that have impacted that stand. This allows for a user to be informed of management activities through time.

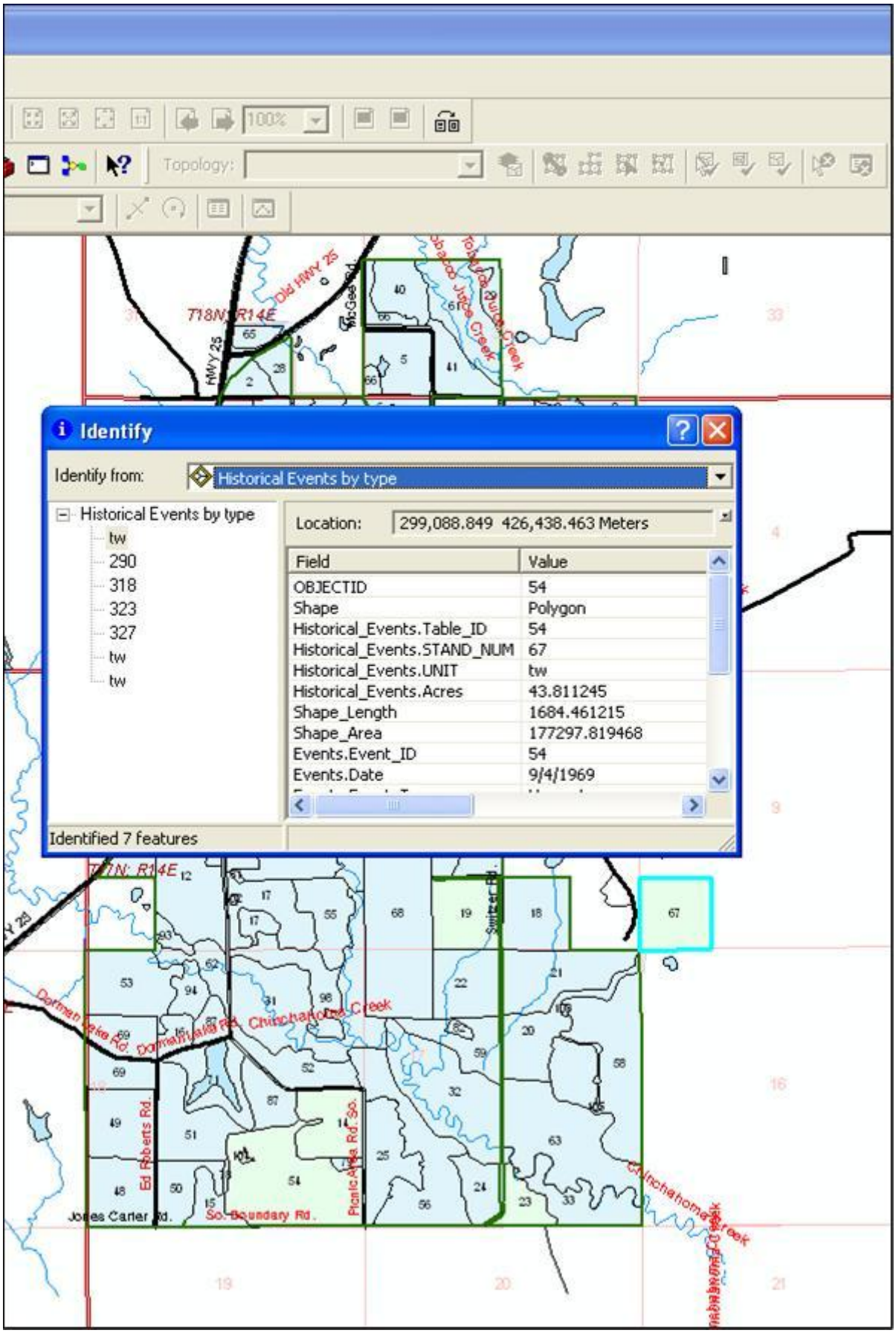

Figure 7 - Example of a stand selection. The identify window depicts all historical events that have impacted the selected stand.

As the database is currently structured, users can select a stand (or stands) within a chosen unit and view all management activities that have impacted a stand. Primary information pertaining to a stand can be viewed in the attribute table. Additionally, information can be accessed via linked .pdf documents. These events can be considered to determine future management plans for the forest (e.g. developing prescribed burn plans and harvests). The polygons created for each event allow for a real-time assessment of historical activities as they have taken place in the forest. This will help facilitate the efficient planning of future management activities by Forest Operations personnel.

CONCLUSIONS AND FUTURE PLANS

The GDB presented here integrates all information pertinent to forest management. The spatial component provides a method of accurately displaying the location of management activities across the landscape through the use of polygons while the tabular component stores all relevant information about the events and is linked to the spatial component through an event ID. While this GDB is utilized to provide information relating to the management of MSU Forests to faculty, staff, students, donors, or other users, the methodology can be adapted for any specific application. The tracking of historical events through the history of a forest property can provide invaluable information regarding the management of natural resources and maximize the research, recreational, teaching, demonstration and economic potential of MSU-managed forest lands.

Future plans include integrating the GDB with an ArcSDE platform to allow multiple users access to the information. Because the GDB is designed to house information for such a diverse collection of properties with various administrative functions, efforts will be made to incorporate multiple security levels to allow the individual user access only to the properties or information pertinent to his or her needs. The GDB will then be presented on the World-Wide Web, allowing for extension and outreach regarding natural resource management at MSU. The database will also be expanded to include all MSU-managed properties as events occur within additional management units.

BIBLIOGRAPHY

Bettinger, P., K. Boston, J. Siry, and D.L. Grebner. 2009. Forest Management and Planning. Academic Press, New York. 331 p.

Environmental Systems Research Institute. 2003. ArcGIS: working with geodatabase topology. An ESRI White Paper. Retrieved from: http://www.esri.com/library/whitepapers/pdfs/geodatabase-topology.pdf. 23pp.

Matney, T.G. and E.B. Schultz. 1999. The MIFI Dynamic Inventory Reporter. http://www.mifi.state.ms.

Murray, S. 1999. An area event system for forest management history. An ESRI White Paper. Retrieved from: http://www.esri.com/library/whitepapers/pdfs/forestwp.pdf. 32pp.

Nishimura, K., S. Takagishi, X. Zhao, and S. Nakamura. 2004. An integrated system for forest management and enterprise GIS using ArcGIS. In: Proceedings of the 24th Annual ESRI Users Conference. San Diego, CA. August 9 – 13, 2004. Retrieved from: http://proceedings.esri.com/library/userconf/proc04/docs/pap1280.pdf.