

A New Link for Geographic Analyses of Inventory Data

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ABSTRACT

The USDA Forest Service Forest Inventory and Analysis (FIA) data are widely used throughout the United States for analyses of forest status and trends, landscape-level forest composition, and other forest characteristics. A new software product, FIAMODEL, is available for analyzing FIA data within the ArcView® (ESRI, Inc.) geographic information system. The software allows linkages with other natural resource information, such as watershed boundaries or soil maps, in a format widely used by natural resource organizations, which allows organizations to analyze FIA data in a spatial context with little new investment in hardware or training.

Keywords: geospatial technologies; GIS; inventory and analysis

The USDA Forest Service Forest Inventory and Analysis (FIA) data provide information on forest status and trends for all ownerships across the United States. Estimates of timberland area, growing-stock volume, growth, removals, and mortality can be made at the state or sub-state level. To facilitate the use of these data, FIA created two standardized distribution formats. The Eastwide format (Hansen et al. 1992) is used for all states from North Dakota to Texas and eastward; the Westwide format (Woudenberg and Farrenkopf 1995) is used for all states to the west. These data are publicly available, and easily retrieved over the Internet at www.srsfia.usfs.msstate.edu/tables.htm.

During retrieval or subsequent processing, the data may be segregated by any of a number of classification variables (forest type, ownership class, county, age class, site index class, and others). Some excellent routines for generating tables are available at the FIA website or on CD from the FIA units.

The FIA data are widely used by federal and state agencies, industry, and nonprofit organizations for analyses of forest composition, growth, removals, and a wide variety of other ecological and economic issues. A large volume of information is available, but it is difficult to link the FIA data with other geographic data using the currently available tools. Natural resource organizations commonly examine geographic

resource data, and often have in-house expertise in the use of geographic information systems (GIS) to address resource issues in a spatial context. To date, it has been difficult for such organizations to link FIA data with other resource information in a GIS environment because the online FIA data are in text format. A thorough understanding of the data along with considerable resources are required to calculate variables like volume, removal, and growth from the raw numbers and to develop a relatively easy summary of those variables in a GIS.

Several years ago, Michigan Technological University (MTU) undertook the development of tools for analyzing FIA data in the ArcView® (ESRI, Inc.)

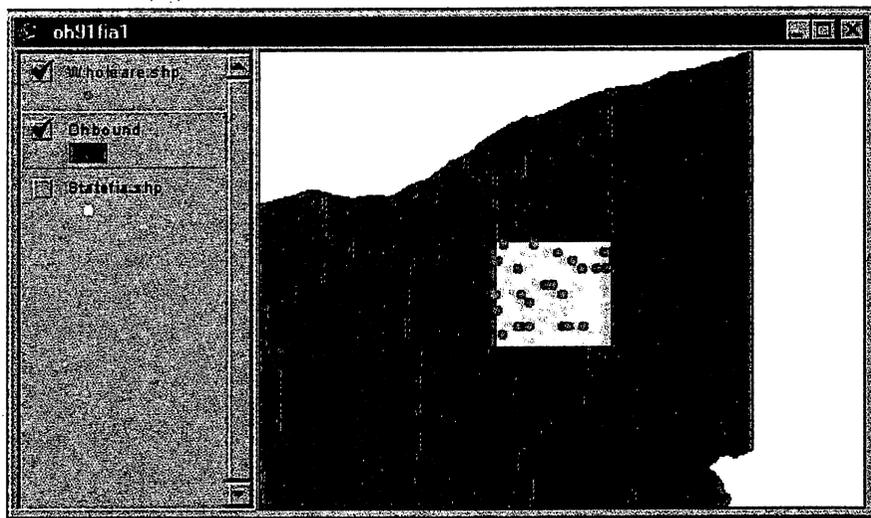


Figure 1. FIAMODEL screen display of a map of northeastern Ohio. Portage County is highlighted in yellow; FIA plots are in green.

GIS, probably the most widely used GIS software by natural resource organizations in the United States. Most natural resource organizations have experience with this system and are quite comfortable using this software for the spatial analysis of natural resource information. The USDA Forest Service is among the more than 500,000 ArcView users worldwide (ESRI, Inc. 2001).

How It Works

In ArcView, a project consists of views, tables, charts, layouts, and Avenue[®] scripts for organizing work on a particular topic (ESRI, Inc.

1998). FIAMODEL projects have been developed for individual states. The USDA Forest Service North Central Research Station and MTU are providing to interested parties (at no cost) the projects for the most recent surveys of the 11 North Central states (forestry.mtu.edu/data/fiamodel); information on projects from other states in the Eastwide database is available from the authors on request.

In a nutshell, the online FIA data for an individual state are preprocessed to develop tables for use by the FIAMODEL Avenue scripts, greatly reducing the execution time required to produce analyses (see "Getting from

Here to There: Preprocessing FIA Data"). The scripts are software routines to

1. Select FIA plots.
2. Access preprocessed tables.
3. Calculate factors such as standing volumes, annual net growth, annual mortality, annual removals, composite stand tables, and species-specific growth and removal information.
4. Display the results on a computer screen, or send them to a file or a printer.

These scripts are event-driven: The user controls which routines are executed in FIAMODEL at any time. A number of menus, menu items, and buttons have been added to the normal ArcView user interface to create a dynamic and user-friendly environment.

The FIAMODEL projects execute in ArcView versions 3.0 through 3.2, with versions available for both the Windows NT and Windows 98 operating systems. A licensed copy of ArcView must be installed to use FIAMODEL. The FIAMODEL projects are upwardly compatible with ArcView 8.0, and an effort will soon be undertaken to develop FIAMODEL projects specifically for ArcView 8.0.

Example Analyses

The following examples illustrate some of the capabilities of FIAMODEL that use the GIS features, along with the scripts for processing

Getting from Here to There: Preprocessing FIA Data

Preprocessing involves a series of steps using a database management system (DBMS) and ArcInfo[®] (ESRI, Inc.):

1. The FIA data are downloaded in comma-delimited format from www.srsfia.usfs.msstate.edu/tables.htm.
2. A DBMS program is run to create two main summary tables and some additional tables used in the preprocessing. The first main table contains standing volumes, annual net growth, annual mortality, and annual removals by plot. The second includes sums of the previous variables for each species and dbh class by plot. Trees per acre is also included in the second main table.
3. The summary tables are exported from the DBMS and then imported into ArcInfo as Info[®] tables.

4. Using some of these imported tables, an Arc Macro Language (AML[®]) program is used to create a digital point map of the plots; the FIA plot attributes are associated with the points on this map.
5. A background map layer showing county boundaries is imported into ArcInfo.
6. The imported tables and maps are organized in the directory structure used by FIAMODEL.
7. FIAMODEL is set up for the given state. An Avenue script is initiated that tells the software the name of the point and background maps to use. This allows the software to automatically bring the maps into a view for display upon startup. FIAMODEL is now ready for the first user.

and summarizing the FIA data. These examples do not show the full extent of the system's capabilities, but they do illustrate typical analyses that might be done in a natural resource context. Other analyses, such as developing a composite stand table for a selected set of plots, can also be accomplished using FIAMODEL.

County summaries. One type of summary commonly compiled with FIA data is at the county level. *Figure 1* is a screen display from FIAMODEL; utilities have been used to highlight Portage County, Ohio, and display the FIA plots in the county. Summaries of volumes, growth, mortality, and removals can be developed for each tree species (*table 1*); detailed volume and growth information can be developed by size class for individual species (*table 2*). Multiple counties within a state can be selected for analysis at the same time.

Circular areas. Users often need FIA summaries for the area within a certain distance of a fixed point (e.g., within 70 miles of a mill). This kind of analysis can be easily accomplished if the location of the point of interest can be entered or determined in the GIS. *Figure 2* (p. 24) illustrates the FIA plots within 10 miles of a major highway intersection in Marquette County, Michigan. This plot selection uses the GIS to couple a roads data layer with the FIA plot data. This figure also illustrates another FIAMODEL capability: FIAMODEL allows the user to select plots based on any of the FIA variables such as ownership class, forest type, or county. Users can also select plots by 10-year age classes, 10-foot site index classes, and so on. Users can specify multiple classifications at the same time, such as "all 20- to 29-year-old aspen stands with site index values between 60 and 69 feet at age 50." The same set of tables is available for selected plots that is available for all plots within a selected geographic area.

Other resource polygons. Both of the previous examples can be conducted using other FIA analysis sources. Published bulletins (e.g., Thompson and Sheffield 1997) provide summary tables by county. Currently available FIA tools also have the ability to produce

Table 1. FIAMODEL growing stock report for timberland selected with the Portage County, Ohio, boundary.

Species	Current volume	Annual growth	Annual mortality	Annual net growth	Annual removal	Annual net change
..... 1,000s of cubic feet						
Black cherry	30,720.1	1,224.7	75.7	1,149.0	326.0	823.1
Yellow-poplar	20,042.6	1,107.5	0.0	1,107.5	440.0	667.5
Red maple	18,834.0	872.9	0.0	872.9	0.0	872.9
American beech	12,425.7	467.7	78.0	389.6	957.6	-568.0
Hickory sp.	10,608.3	248.3	12.0	236.3	76.3	160.0

NOTE: Table reports the five most common species and includes totals over all diameter classes by species.

Table 2. FIAMODEL growing stock report for black cherry on timberland selected with the Portage County, Ohio, boundary.

Diameter class	Current volume	Annual growth	Annual mortality	Annual net growth	Annual removal	Annual net change
..... 1,000s of cubic feet						
6	203.9	17.2	13.0	4.3	45.3	-41.1
8	3,530.3	204.2	20.2	184.0	29.1	154.9
10	2,625.2	113.1	42.5	70.6	23.2	47.4
12	8,574.9	324.7	0	324.7	28.6	296.0
14	6,805.0	283.1	0	283.1	199.7	83.4
16	2,004.2	76.0	0	76.0	0	76.0
18	2,406.5	75.7	0	75.7	0	75.7
20	1,984.8	78.6	0	78.6	0	78.6
22	1,792.0	30.1	0	30.1	0	30.1
24	375.7	8.5	0	8.5	0	8.5
26	417.6	13.5	0	13.5	0	13.5
Total	30,720.1	1,224.7	75.7	1,149.0	326.0	823.1

summary tables for circular areas about a known location.

FIAMODEL offers a useful new capability. One type of analysis that is extremely difficult to conduct without FIAMODEL is the linkage of FIA data with other natural resource data. In *figure 3* (p. 24), for example, a soil polygon from southeast Georgia is used to identify those FIA plots falling within the polygon. FIAMODEL can then develop any of the tables shown previously for this set of plots, or the subsetting tools discussed earlier could be used to develop tables for a particular ownership, forest type, and so on within this area.

This ability to link FIA data to other resource information is a new capability that is not available with existing tools. This capability is of potentially great use to many organizations. It is possible, for example, to develop analyses of forest resources for individ-

ual watersheds or ecological land types if a GIS layer exists defining their spatial extent. Maps of political boundaries or legislative districts, for example, can be linked to the FIA data to conduct resource analyses. This new capacity extends the utility of the FIA data, and opens the door to a greater variety of forest resource analyses.

Discussion

When using FIA data, it is important to consider the precision of the estimates of forest status and trends. FIA plots are installed with different densities in different states; two plots that are near each other can be in very different ecosystems. As a result, the estimates for a fixed area of land can change dramatically across the United States and even within a state. For this reason, there is no fixed minimum area or number of plots required to produce meaningful estimates. The FIA publi-

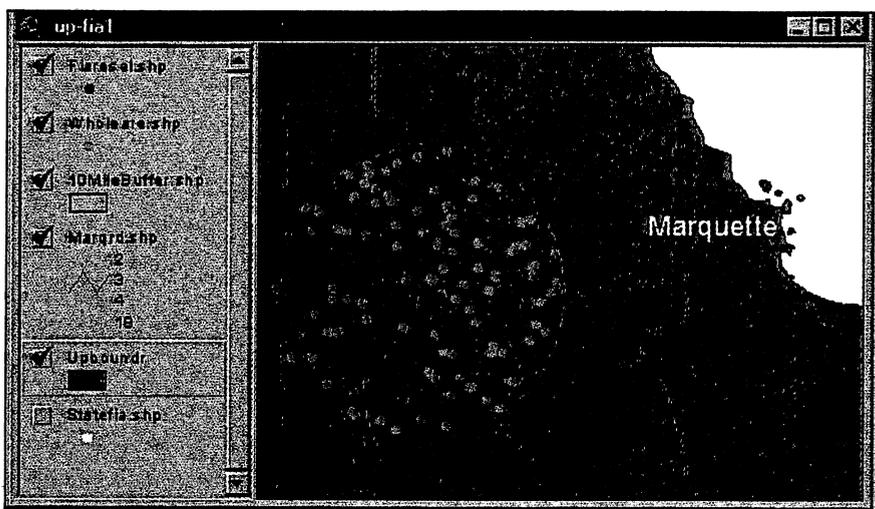


Figure 2. FIAMODEL screen display of a portion of central upper Michigan, with a 10-mile circle placed around a highway intersection west of the city of Marquette. FIA plot locations are in green; black spruce plots are in red.

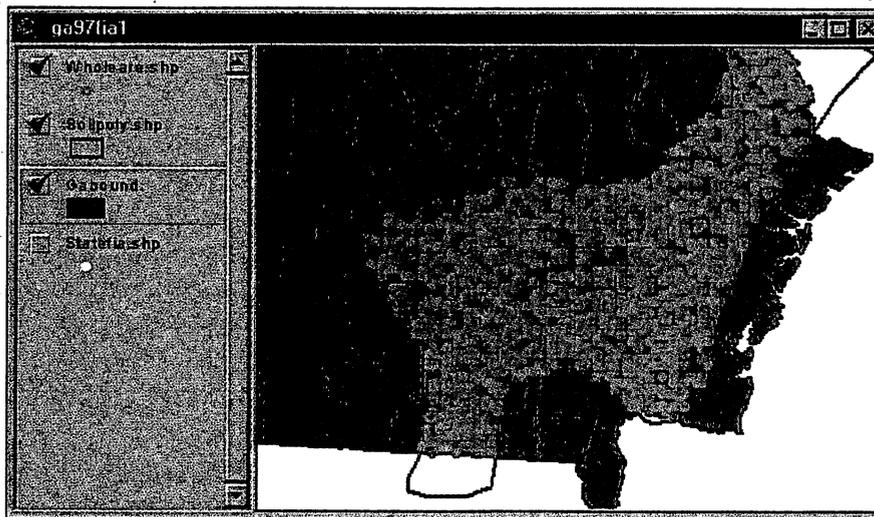


Figure 3. FIAMODEL screen display of southeast Georgia, with a soil polygon used as an overlay to pick out FIA plots with indicated locations falling within the polygon. FIA plot locations are in green.

cations describe the precision of the published volume and growth values, and FIAMODEL gives estimates of precision for similar quantities. Users must be aware, however, that estimates for small areas or estimates based on a small number of plots may not be very meaningful.

Another factor that affects the precision of the FIAMODEL estimates is that published FIA plot locations are not the true locations; the method of masking the locations varies from region to region, but the true locations are not made public in order to protect the integrity of the plots. As a result, some plots near geographic boundaries

appear to fall outside a given region when they are really within it, and vice versa. The net effect on the estimates declines as the size of the area increases, and the impact is less for circular areas with low perimeter:area ratios than it is for long, linear features such as riparian zones. Because most of the published plot locations are within a mile or so of the true location, it makes little sense to apply FIAMODEL to regions such as road corridors or narrow riparian zones.

Most natural resource organizations already have experience and expertise using GIS software for natural resource analyses, so FIAMODEL often re-

quires very little training before implementation. If a user has never used a GIS before, a steeper learning curve is involved. But for many organizations, this software provides a new capability for analyzing FIA data in a spatial context that they can readily capitalize on with little new investment in hardware or training.

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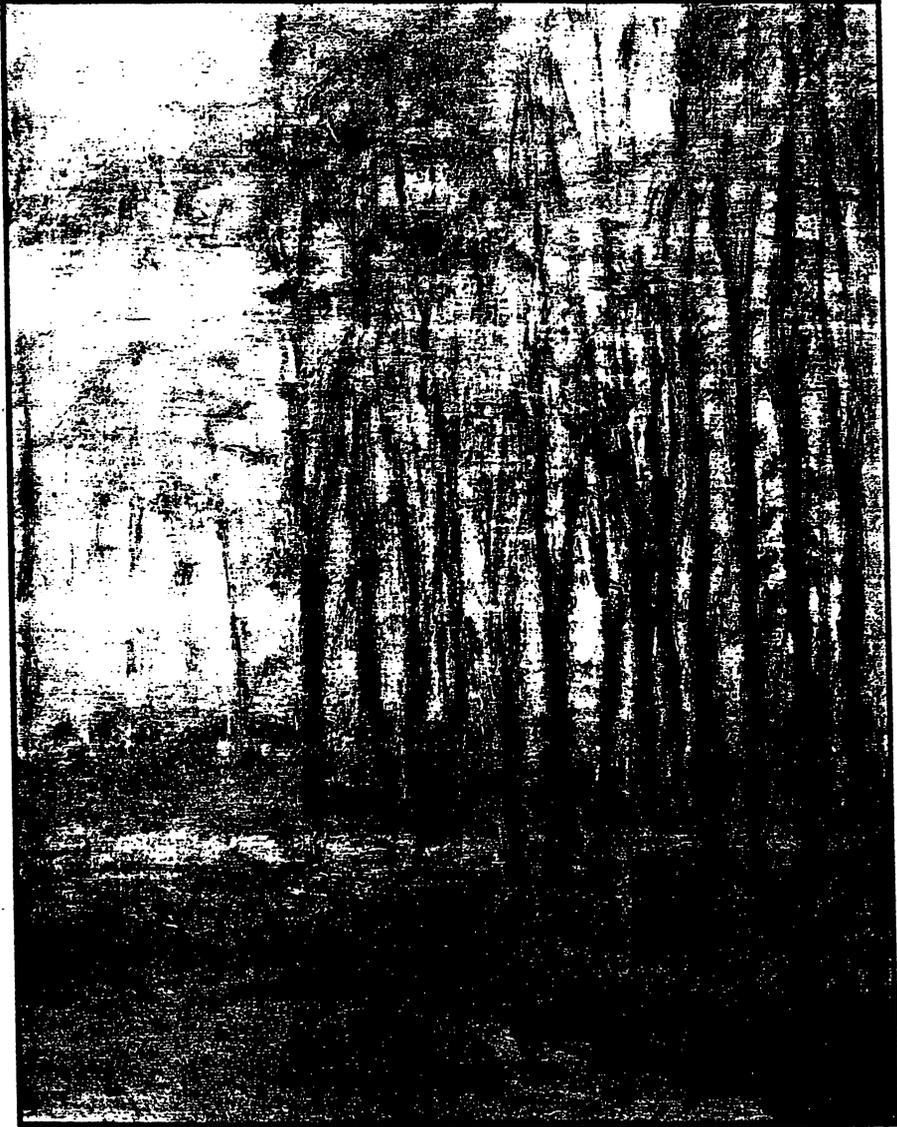
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