ANALYZING REGIONAL FIA DATA IN THE ARCVIEW™ GEOGRAPHIC INFORMATION SYSTEM[1]

David Reed, Scott Pugh, Pat Miles, and Kurt Pregitzer[2]

Abstract—The ArcView™ Geographic Information System (GIS) is probably the GIS that is most widely used by federal and state natural resource management agencies, industries, and non-profit institutions. As such, there is a great deal of expertise and comfort with this package within the FIA user community. The North Central Research Station and Michigan Technological University have recently cooperated in the release of ArcView GIS projects for each of the eleven North Central states. These projects facilitate analyses of current volume, net growth, mortality, and removals for any geographic region within a state, whether determined from ancillary polygon data (such as soil or watershed boundaries) or defined on-screen by the user. Current efforts are focused on developing a single project that will allow similar analyses that are not limited by state boundaries within the eleven-state North Central region.

INTRODUCTION

The users of USDA Forest Service Forest Inventory and Analysis (FIA) data include state and federal agencies, forest industry, other corporate entities, non-profit organizations, and private citizens. Many of these users utilize the ArcView™ (ESRI, Inc.) Geographic Information System (GIS) to facilitate their analyses of natural resource data. Many of the users of FIA data, therefore, have in-house expertise in the use of ArcView. They also typically have many other types of natural resource information, such as soil maps, watershed boundary delineations, political boundaries, transportation networks, etc., in ArcView format. To date, it has been difficult to link the FIA data with these other resource data, and it has been difficult for users to conduct their own flexible spatial analyses of FIA information.

The USDA Forest Service North Central Research Station and Michigan Technological University have recently cooperated in the release of ArcView projects for each of the eleven North Central States. In ArcView, a project is a file for organizing work consisting of views, tables, charts, layouts, and scripts (ESRI, Inc. 1998). These projects utilize FIA data as presented in the Eastwide database (Hansen and others 1992); the data files undergo a pre-processing routine to increase the speed of the ArcView Avenue scripts that execute the analyses. The projects are available at no cost from either organization, and allow users to conduct analyses of acreage, current volume, net growth, mortality, and removals by species or forest type for any geographically defined region within a state's boundaries. Users can subset plots within a defined region using any of the descriptive FIA variables such as landowner, forest type, age class, site index, and so on. Users can do multiple sorts so they can, for example, examine volume, productivity, and utilization for all of the 31-40 year old aspen plots within a large watershed.

The FIA ArcView GIS projects promise to be of great utility to users. It is currently awkward to conduct analyses across state boundaries, with users being required to define the areas of interest in each state, conduct the analyses of interest in each state, and combine the results outside of the GIS system. Current efforts are focused on developing a single ArcView project for the entire eleven-state North Central region. This will allow users to conduct analyses for any geographic area within the region, with the GIS seamlessly combining information across state boundaries to produce results in a single step.

EXAMPLE ANALYSES

The incorporation of multi-state functionality further increases the utility of the existing routines to users. In many instances, areas of interest do not follow state or other political boundaries. Watersheds and other ecological units cross state boundaries, many mills procure wood from more than one state, and so on. The first example illustrates an analysis utilizing FIA plots located within 25 miles of the point where the boundaries of Illinois, Iowa, and Wisconsin intersect (fig. 1). This selection utilizes FIA plots from the 1985 Illinois, 1990 Iowa, and 1996 Wisconsin surveys. Table 1 shows the volume, growth, mortality, and removal estimates for selected species from the 274,943 acres of timberland within this area. Table 2 provides detailed information on the volume and change of the northern red oak resources within this area by two-inch diameter class.

The second example illustrates the use of a polygon defined by another resource layer. This analysis utilizes the FIA plots occurring within a polygon defined by a particular class of alluvial soils in the southern portion of the region (fig. 2). This area contains FIA plots from the following surveys: 1990 Iowa, 1985 Illinois, 1998 Indiana, 1994 Kansas, 1994 Nebraska, and 1989 Missouri. The acreage of some of the most common forest types in this area is shown in table 3.

Tables 2 and 3 illustrate just some of the analyses available from the software. In addition, composite volumes, net growth, mortality, and removals (and their associated

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[2] Professor and Assistant Research Scientist, School of Forestry and Wood Products, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931; Forester, USDA Forest Service, North Central Research Station, 1992 Folwell Ave., St. Paul, MN 55108; and Professor, School of Forestry and Wood Products, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931, respectively.

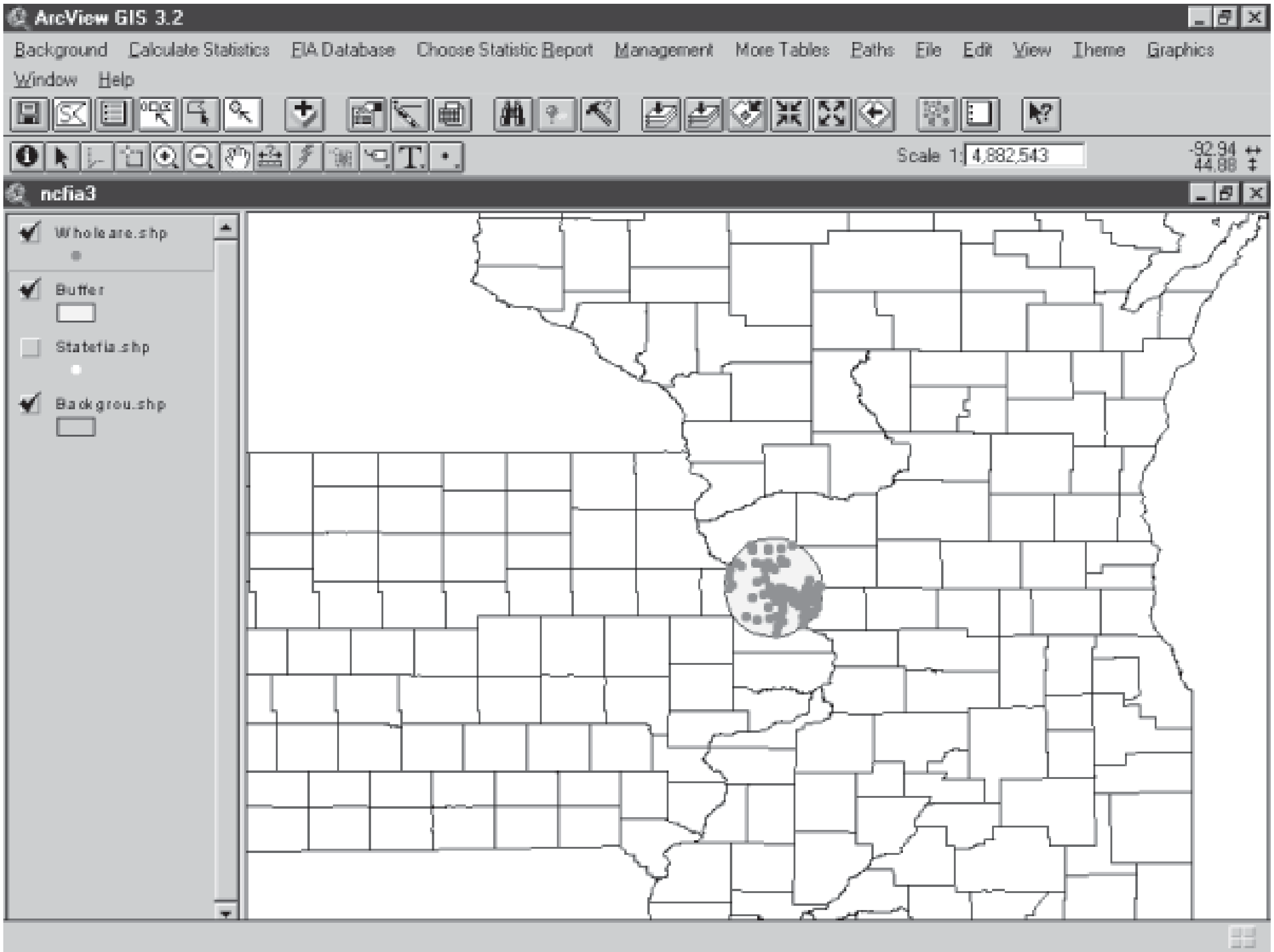

Figure 1—FIA plots located within 25 miles of the point where the boundaries of Illinois, Iowa, and Wisconsin intersect, obtained using the ArcView buffering function to define the area of interest, which is then overlain with the FIA plot location information.

Table 1—Current volume, growth, mortality, and removal estimates for selected species on the 274,943 acres of timberland within 25 miles of the intersection of Illinois, Iowa, and Wisconsin (fig. 1)

Species	Volume	Growth	Mortality	Net growth	Removals[a]
	1000 ft^3	- - - - - - - - - -	*-1000 ft^3/yr-*	- - - - - - - - - -	
Basswood	23,246.4	584.5	229.0	355.4	45.3
Elm	21,271.9	1,298.6	503.3	795.3	601.6
White oak	14,301.7	156.2	77.0	79.2	313.7
Northern red oak	12,921.7	460.4	91.6	368.8	2,257.9
Sugar maple	12,009.8	225.6	90.1	135.5	461.1

[a] Removals for Illinois 1985 are not available in the FIA inventory data or in the GIS-FIA Model. An estimate is available from a single year survey of mills (Hahn 1997).

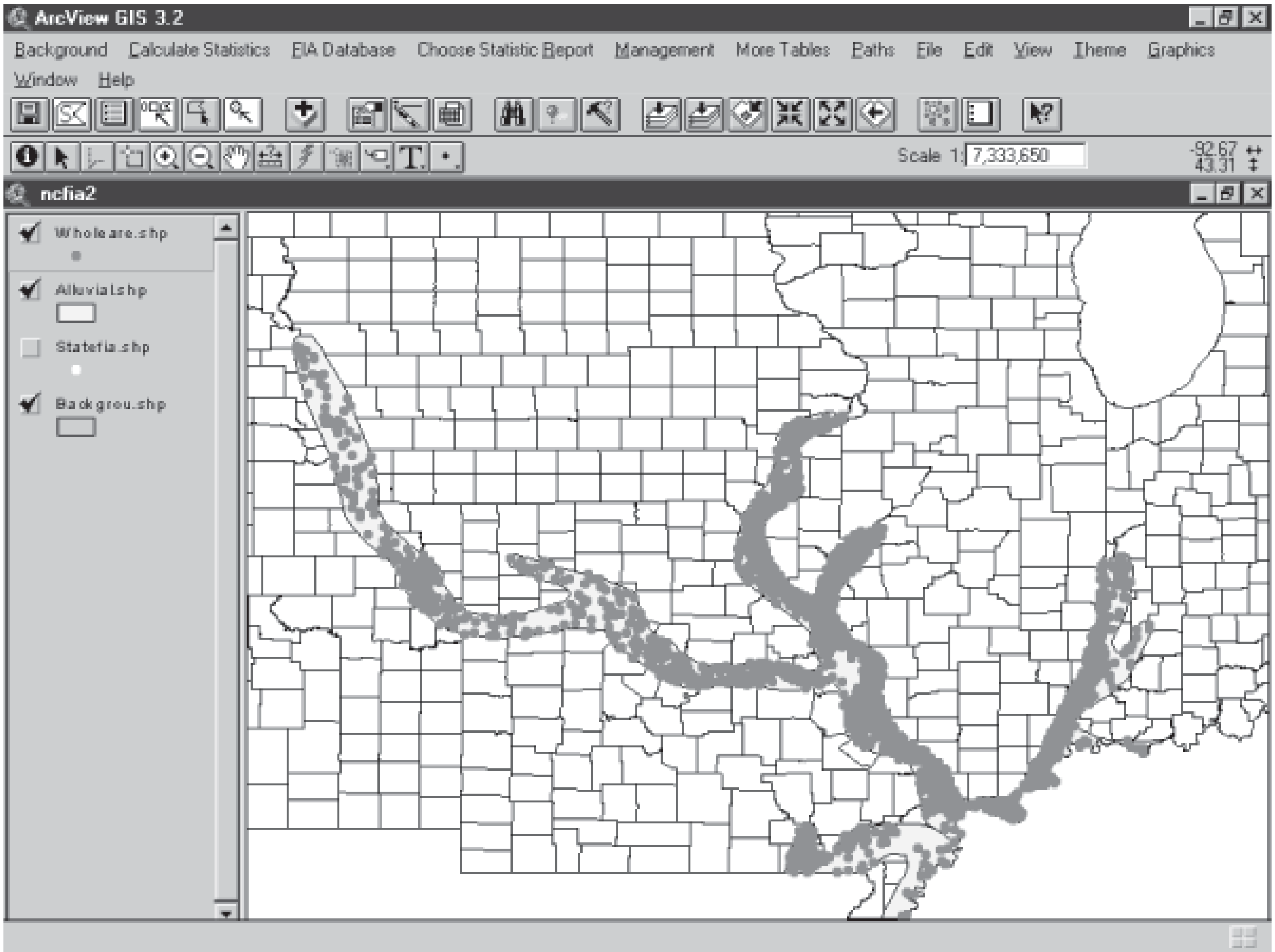

Figure 2—FIA plots occurring within a polygon defined by a particular class of alluvial soils in the southern portion of the North Central region, created by overlaying a general soils polygon coverage with the FIA plot location information.

Table 2—Volume and change of the northern red oak resources within 25 miles of the intersection of Illinois, Iowa, and Wisconsin (fig. 1) by two-inch diameter class

Diameter	Volume	Growth	Mortality	Net growth	Removals[a]
In.	*1000 ft*^{3}	- - - - - - - - - -	- - - - -	*1000 ft*^{3}*/yr* - - - - -	- - - - - - - - - -
4	0.0	96.6	0.0	96.6	0.0
6	150.1	7.2	8.9	-1.7	0.0
8	185.1	8.8	3.2	5.6	0.0
10	702.3	31.4	3.5	27.9	0.0
12	853.2	31.7	2.9	28.7	14.3
14	1,129.4	22.1	4.0	18.1	32.7
16	1,497.5	48.0	7.2	40.9	207.0
18	2,793.7	108.2	27.2	81.1	396.5
20	1,205.4	42.5	30.2	12.2	525.0
22	1,454.3	2.6	1.8	0.7	247.0
24	1,822.1	38.1	0.0	38.1	369.6
26	1,128.5	23.2	2.6	20.6	465.9
Total	12,921.7	460.4	91.6	368.8	2,257.9

[a] Removals for Illinois 1985 are not available in the FIA inventory data or in the GIS-FIA Model. An estimate is available from a single year survey of mills (Hahn 1997).

Table 3—The timberland acreage of some of the most common forest types in the area defined in figure 2

Forest type	Acres
Maple-beech-birch	503,100
Oak-hickory	473,900
White oak-red oak-hickory	454,579
White oak	408,115
Elm-ash-cottonwood	377,100

standard errors) are available for all selected plots. A composite stand table giving average trees per acre by species and two-inch diameter class is also available in the single state projects. In general, all of these tables are available for the 50 most common species occurring in the region.

DISCUSSION

A concern with the analyses in figures 1 and 2 is that the data from the different states were taken at different times. These are the most recent publicly available data for the different states, but the result is that the data from the 1985 Illinois survey, which are now fifteen years old, are combined with the two-year old 1998 Indiana data. Without a commonly accepted stand projection system, these inventories cannot be updated to a common date. With the advent of the annual surveys, though, this problem with the timing of different state surveys will be greatly reduced. The ArcView projects can easily be updated when annual data from the various states are released, resulting in an annual regional project. This will provide users with up-to-date resource information in a GIS format with which they are familiar and are already comfortable using.

The latitude-longitude location information publicly released for the FIA plots does not represent exact plot locations. The coordinates are rounded off or randomly altered to mask exact plot locations; the method for doing this varies across the US. When combined in a GIS, this has the effect of including some plots within a polygon boundary that should not be there, and excluding some plots from a polygon that should really be included. In Michigan, some forested plot locations appear in Lake Superior, for example. For large areas, the effect of these distortions is minimal. For small areas, though, a rather large proportion of the total forest area can be involved. An analysis of the Michigan 1993 data indicates that county-level volumes estimated in the GIS by overlaying county boundaries with the FIA plot locations are almost always within 10 percent of the volumes estimated using the county code recorded in the Eastwide database (Hansen and others 1992). The imprecise plot location effect is minimized for geographic areas with low perimeter:area ratios, and increases as the amount of boundary area increases relative to the interior area. Circular areas, such as in figure 1, have low perimeter:area ratios and minimal errors introduced by imprecise plot locations. The introduced errors are still proportionally greater for smaller circles than they are for larger ones. Long, linear areas, such as riparian zones, have large perimeter:area ratios and may be expected to have relatively large introduced errors due to imprecise plot locations. It makes little sense to try to examine corridors less than two or more miles in width, for example, if the plot locations are only known to the nearest mile. Users can obtain some guidance from the estimated standard errors produced during the analyses; these are underestimates, however, because they do not fully consider the imprecise plot locations. Users need to check these precision estimates, and make sure that the number of plots or size of area selected results in a greater indicated level of precision than is really required.

The ArcView projects described here were taken directly from the data in the Eastwide database. The FIA data are pre-processed to speed the ArcView analyses, but summaries are based on the formulae given by Hansen and others (1992). At the state level, results from the ArcView projects match almost exactly with those from the respective state publications. The ArcView projects calculate standard errors for composite volume estimates, net growth, and removals; these are calculated using the ratio formulae given in the respective state reports. When data from different states are combined, a simple weighting procedure is used to estimate the standard errors for the total defined area.

Execution time is an issue with any software designed to manipulate large amounts of data. With tens of thousands of FIA plots and hundreds of thousands of tree records in the North Central region, a great deal of programming effort has gone into increasing the efficiency of the analyses illustrated here. All of the analyses illustrated in figures 1 and 2 and the results summarized in tables 1-3 can be obtained in about 20 minutes on a 233 MHz laptop computer provided the soils layer is available at the beginning as an ArcView theme.

SUMMARY

ArcView projects containing the FIA data for each of the eleven North Central states and associated data processing procedures are currently available from the US Forest Service North Central Research Station or Michigan Technological University. Many natural resource organizations use the ArcView GIS software and have in-house expertise for conducting analyses using this software. The individual state projects provide the capability for FIA data users to link FIA data to other natural resource data, and to conduct in-house analyses of natural resource information for any defined geographic region within a state. The regional model under development will extend these capabilities across state lines within the eleven-state North Central region. Both the individual state and the regional models will provide users with a vehicle to utilize annual inventory data, when available, to conduct quick analyses addressing a variety of resource issues.

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