GEOGRAPHIC INFORMATION SYSTEMS IN SUPPORT OF INDEX OF BIOTIC INTEGRITY MONITORING IN GEORGIA STREAMS

Thomas L. Litts, Jr.

AUTHOR: Department of Natural Resources, Wildlife Resources Division, Fisheries Management Section, 2425 Marben Farm Road, Mansfield, GA 30055.
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Abstract. The Georgia Department of Natural Resources, Stream Survey Team (GDNR-SST) assesses fish assemblages in wadeable streams throughout Georgia and has sampled more than 600 stream sites in the Piedmont, Southeastern Plains, and Ridge and Valley ecoregions since 1998. The GDNR-SST, in cooperation with The University of Georgia Center for Remote Sensing and Mapping Science (UGA-CRMS), has developed a custom Geographic Information Systems (GIS) that is interfaced with an external relational database management system. This system enables the GDNR-SST to develop and maintain a comprehensive database representing this sampling effort and to automate many of the tasks associated with the process including; data entry, database management, IBI scoring, watershed delineation, and report generation. The GIS has been developed using Environmental Systems Research Institute's (ESRI) ArcView, the Avenue Scripting Language, Microsoft Access, and Visual Basic for Applications (VBA).

INTRODUCTION

In April of 1998, the Georgia Department of Natural Resources, Stream Survey Team (GDNR-SST) began sampling fish in Georgia's wadeable streams, marking the first effort by the GDNR Wildlife Resources Division (WRD) to systematically sample wadeable streams on a statewide basis. Though this effort is ongoing, the program requirements have resulted in the development of a comprehensive Geographic Information System (GIS) database representing the GDNR-SST sampling effort. In addition to storing data collected in the field, the database has been programmed to standardize and automate tasks required of the GDNR-SST, including data entry, data reporting, and watershed delineation. This paper serves to: 1) inform interested parties of the existence of this GIS database; 2) describe the development and functionality of the database; and 3) outline current and future uses of the GIS database.

BACKGROUND

To date, the GDNR-SST has sampled more than 600 sites in the Piedmont, Southeastern Plains, and Ridge and Valley ecoregions of Georgia (Griffin, et. al., 2001) (Figure 1). This has led to cataloged information on 167 fish species and more than 300,000 fish in ten of Georgia's major river basins. This intensive sampling effort is the outcome of a 1994 lawsuit in which the US Environmental Protection Agency (USEPA) ultimately mandated that the GDNR Environmental Protection Division (EPD) develop Total Maximum Daily Loads (TMDLs) for the State's impaired waters.

As a result, the GDNR-SST has been tasked with developing standardized biomonitoring techniques for

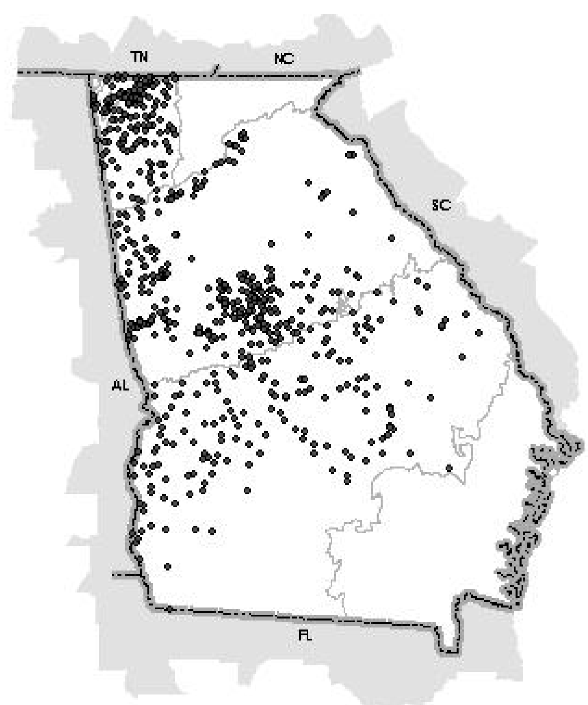

Figure 1. GDNR-SST sample locations and bordering state buffers.

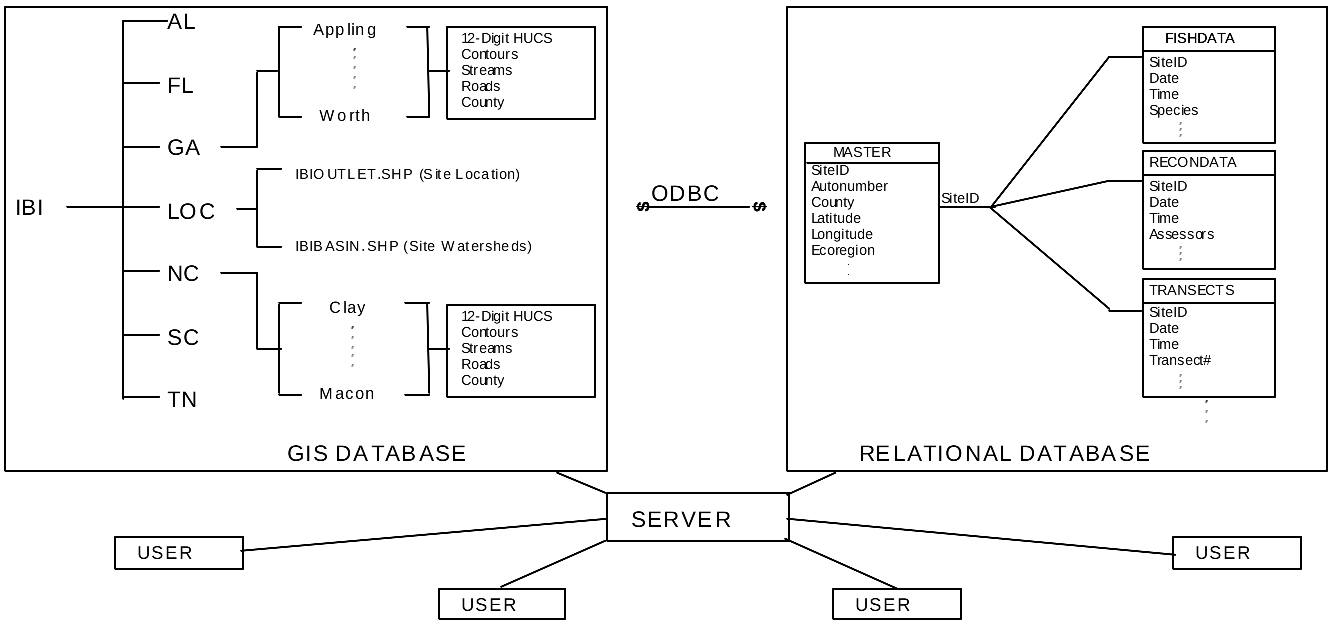

Figure 2. The GDNR-SST IBI database design.

sampling and evaluating fish populations in Georgia (Shaner, 1999; Shaner, 2001). In addition, the GDNR-SST is responsible for implementing these methods on a statewide basis and developing IBI scores for fish communities in Georgia's wadeable streams. The IBI scores are submitted to the GDNR-EPD and used in the placement/non-placement of streams onto Georgia's 303d list, which represents impaired streams.

The GDNR-SST collects field data on more than 70 parameters and generates at least 20 more during the IBI scoring process. In order to effectively manage this data volume, the GDNR-SST cooperated with The University of Georgia Center for Remote Sensing and Mapping Science (UGA-CRMS) to develop a GIS database that could be in interfaced with an external database management system.

DATABASE DESIGN

The GDNR-SST database is comprised of two components: 1) a GIS database and 2) a Microsoft (MS) Access database, which are linked using MS Open Database Connectivity (ODBC).

Software and Data

The GIS database consists of Environmental System Research Institute (ESRI) coverage and shapefiles representing hydrography, hypsography, roads, hydrologic unit boundaries, and GDNR-SST sample locations. The GIS data covers all of Georgia and a one county buffer for the bordering states of Alabama, Florida, North Carolina, South Carolina and Tennessee (Figure 1). Most of the baseline data for Georgia (i.e. roads, streams, etc.) was obtained from the Georgia GIS Clearinghouse and ranges in source scale from 1:12,000 to 1:100,000. The GIS data required for the bordering states was extracted from US Geological Survey (USGS) 1,100,000-scale digital line graph files (DLG) (USGS, 1989). All data are projected to the Albers coordinate system, cast on the North American Datum on 1983 (NAD83). ArcView GIS software, developed by ESRI, is employed on personal computers to view, manipulate, and generate data as required by the GDNR-SST.

Microsoft Access 2000 is employed as the relational database and contains nine tables storing the GDNR-SST field data (Figure 2). Each table within the relational database represents a component of the GDNR-SST field or IBI scoring activity. For example, the FISHDATA table is used to store data on fish species, quantity, weight, and physical abnormalities for each field sample, whereas the RECONDATA table is used to catalog data collected during field reconnaissance (GDNR-WRD, 2000). Each table in the relational database is linked to the MASTER table, which contains static information regarding the site, including latitude and longitude, county, ecoregion, and river basin. These tables are related to the MASTER table via the SITEID field. Although SITEID is used as the relational field, the unique identifier within the database is the sample or reconnaissance date. The date variable was chosen as the unique identifier because a site is never sampled more than once in a given day.

Database Functionality and Methods

In addition to storing field data, the MS Access database and ArcView have been customized to streamline, standardize, and automate aspects of the database development, IBI metric scoring, watershed delineation, and data reporting tasks. Specifically, the MS Access database has been customized using MS Visual Basic for Applications (VBA) to design graphical user interfaces (GUI) employed in the data entry process. These GUIs perform important quality assurance/quality control (QA/QC) functions by limiting user input options through list and check box controls, domain limits, and rules. Limiting user options and typing greatly reduces the potential for data entry errors.

As stated previously, the GDNR-SST is also responsible for developing IBI scores for fish assemblages in each stream it samples. When the GDNR-SST began sampling in 1998, the 13 individual metric scores (e.g. number of native species) that comprise an IBI score were calculated by hand (Shaner, 1999; Shaner, 2001). Two independent operators performed the manual scoring procedures as a QA/QC measure. Discrepancies in the scores were reviewed and resolved by the scorers and a third party. Unfortunately, the manual scoring exercise consumed an inordinate amount of time. In order to expedite the scoring and QA/QC process, the GDNR-SST and UGA-CRMS developed VBA modules within the MS Access database to automate the scoring process. IBI scores are still calculated manually, but only one time. The automated scoring procedures now account for the second IBI score in the QA/QC process. The manual scorer and database administrator resolve discrepancies thereby eliminating the need for a third party.

A critical component required to calculate the IBI score is drainage basin area. The GDNR-SST delineates drainage basins using a 'heads-up' digitizing technique. ArcView and the Avenue scripting language were employed to develop custom tools that aid the user in basin delineation. The primary datasets required for this procedure are 1:12,000-scale roads (Georgia Department of Transportation, 1997), 1:24,000-scale streams (Georgia GIS Clearing House, 2000), 1:24,000-scale 12-digit hydrologic unit codes (HUC) (USGS, 2000), and 1:100,000-scale contours (USGS, 1989).

In order to perform basin delineations, the outlet location (sample site) is required. The location of each sample site is captured and recorded (in decimal degrees) in the field using a Lowrance hand-held global positioning system (GPS) receiver. The GPS points are imported into an ArcView shapefile and projected to the Albers coordinate system. Site basins are then delineated using the contours, streams, and 12-digit HUC layers in a manner that minimizes interpretation dependence on the smaller-scale contours (Figure 3). Essentially, the contours are used to subdivide the 12-digit HUC and delineate a sample site drainage basin. To assess the reliability of delineating watersheds using 'heads-up' digitizing techniques, the GDNR-SST conducted a test comparing 30 watersheds delineated in both a 'heads-up' and traditional (digitizing tablet and 1:24,000-scale USGS topographic quadrangle maps) digitizing environment. The results indicate that 'heads-up' delineation techniques are sufficiently accurate, precise, and significantly faster than traditional digitizing methods.

Once the data has been entered, verified, and employed to compute the IBI score, the database is

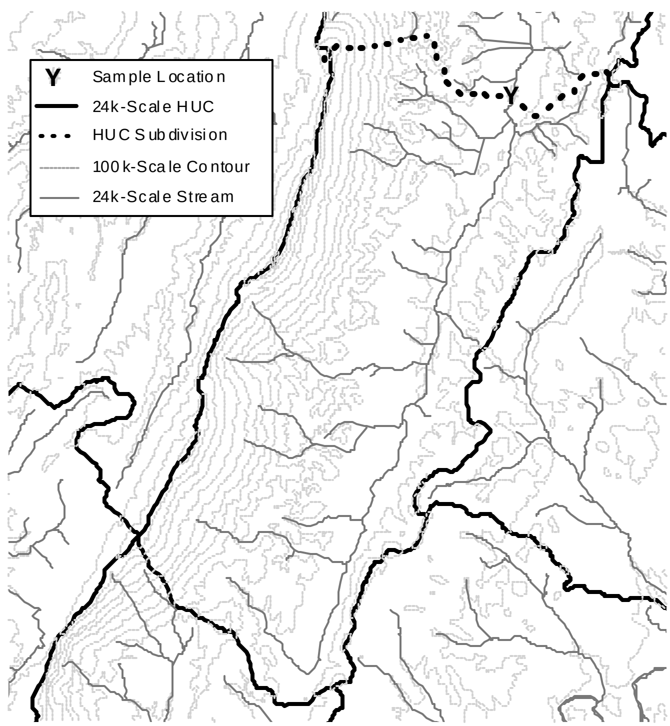

Figure 3. Subdivision of 1:24,000-scale HUC.

used to generate two reports that are submitted to GDNR-EPD. The first report generated from the MS Access database is tabular in nature and contains information describing site location, IBI score, stream characteristics, water quality, habitat information, and fish species. The second report is pictorial in nature and is generated using ArcView linked to the MS Access database (Figure 2). This report includes a site map, a site photo, and a summary of findings. Using MS ODBC to interface the GIS database with the MS Access database enables the GDNR-SST to produce site reports representing IBI scores, or any other data in the MS Access database, in a dynamic and automated manner.

DISCUSSION

The GDNR-SST has sampled and cataloged data on wadeable streams in Georgia for the past five years. As a result, a comprehensive database describing these efforts is being developed. Future sampling is scheduled for the Blue Ridge, Piedmont, Southeastern Plains, and Southern Costal Plain ecoregions of Georgia. This will advance the GDNR-SST knowledge of stream and fish community conditions throughout Georgia and further develop the database described in this paper.

The GDNR-SST currently receives requests from researchers, government agencies, students, and environmental consultants for all, or part of, this database. In order to facilitate delivery of this data, the GDNR-SST is working to provide Internet access to the database. Similarly, the GDNR-SST plans to take advantage of technological advancements in GIS database design. Specifically, ESRI has developed a database product called the Geodatabase (ESRI, 2003). Upgrading to the Geodatabase system will further streamline management of the GDNR-SST data by moving all database functions into one database management system and eliminating the need to link the GIS database and MS Access database using ODBC.

The GDNR-SST efforts have resulted in a sound database, developed in a standardized manner, that has undergone rigorous QA/QC procedures. The resulting database has enabled the GDNR-SST to catalog collections and automate process required of the program. Further, the GDNR-SST envisions additional applications for this database and encourages the water resources community to make use of this data source.

ACKNOWLEDGEMENT

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