COMPUTERIZATION OF THE ARKANSAS FISHES DATABASE

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Abstract—Until recently, distributional data for the fishes of Arkansas existed in the form of museum records, field notebooks of various ichthyologists, and published fish survey data; none of which was in a digital format. In 1995, a relational database system was used to design a PC platform data entry module for the capture of information on the fishes of Arkansas. The graphical user interface (GUI) consists of four screens for data entry of information on locality, habitat, collection details, and fish species. Values for most of the fields in the data entry screens were standardized to reduce input error and ensure consistency. Look-up tables allow the user to quickly select standardized values (e.g., fish species and family, river and stream systems, county, habitat) for many fields. Comment fields were incorporated to allow the user to record important information on individual specimens that was not amenable to standardization. The database is fully compatible with geographic information systems and each collection in the database is geo-referenced. The computerization of this large database of fishes was initiated as part of a cooperative effort with the USDA Forest Service to digitally capture historic information on fishes of the Ouachita National Forest. The agreement was later expanded to include fish records from the Ozark and St. Francis National Forests. Recently, records of fishes from the entire state were added to the database with funding from the Arkansas Game and Fish Commission. Currently, over 3,500 fish collections have been entered into the Arkansas Fishes Database.

BACKGROUND

In 1994 the first author, Henry W. Robison, and his staff completed the first tests of a data entry module to capture recent and historical fish distributional information on Arkansas fishes that existed only in manual files. The second author, L. Gayle Henderson, developed the module with assistance from the third author, Melvin L. Warren, Jr. The pilot study was completed in September 1995, and the module proved to be time-efficient and flexible. Data entry of Robison's Arkansas fish collections was begun in the fall of 1995 under a Challenge Cost-Share (CCS) agreement with the Ouachita National Forest (ONF), Southern Research Station, and The Nature Conservancy. This CCS agreement was extended later in partnership with The Nature Conservancy, the ONF Ecosystem Management Program, the ONF Fisheries Program, and Robison.

Data entry proceeded with records of fishes from within the proclamation boundaries of the ONF. Initially, the records entered were those of Robison; however, permission was secured subsequently from Neil H. Douglas, Northeast Louisiana University (NLU), to add the data from fish collections housed in their museum. This data was primarily from the fieldwork of Douglas and NLU graduate students. Later, data on Arkansas fishes from the large holdings of the Tulane University fish museum were added to the fish database.

The USDA Forest Service effort focused primarily on fishes living within or immediately downstream of the forest proclamation boundaries. Initial data entry concentrated on that subset of fish collections but also included collections from river systems in Arkansas that drain the ONF. In a subsequent CCS in 1997, fish collection data from the proclamation boundaries of the Ozark National Forest and the St. Francis National Forest were added to the expanding fish database. More recently, information from field collections made by Tom M. Buchanan, John L. Harris, Betty Crump, George L. Harp, and others in the national forest areas and elsewhere in Arkansas were added. The addition of other national forests and field collections of these individuals substantially increased coverage of federal and surrounding lands in Arkansas.

In 1998-99, supplemental funding was granted from the Arkansas Game and Fish Commission AGFC to include fish collections from all drainages in Arkansas. The result is a database covering the entire state of Arkansas which can be used by the USDA Forest Service, The Nature Conservancy, the AGFC, the Department of Arkansas Natural Heritage, and others in future planning, monitoring, and management efforts.

PERTINENT LITERATURE

The site-specific information now contained in the fishes of Arkansas database formed the basis of several scientific contributions that increased our knowledge of fish distribution, fish conservation status, and fish assemblage association with watershed characteristics. Robison and Buchanan (1988) published "Fishes of Arkansas" with dot distribution maps depicting over 3,000 fish collections within the state. These localities were located by hand on paper maps that are currently in the possession of Robison. None of the more than 3,000 collections was in a digital format, decreasing their utility for rapid manipulation, analysis, planning, and monitoring. This manually compiled information was later used by Matthews and Robison (1988), Matthews and others (1992), and Matthews and Robison (1998) for studies analyzing the distributions of Arkansas fishes and the geological, climatological, and water quality correlates that described faunal patterns across the state. Recently, the

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maps of Robison and Buchanan (1988), in part, formed the basis for an assessment of fish distribution, diversity, and conservation status for hydrologic units in the Ozark-Ouachita Highlands Assessment led by the USDA Forest Service (Standage 1999; Warren and Clingenpeel 1999; Warren and Hlass 1999; Warren and Tinkle 1999).

OBJECTIVES

The computerization of the distributional data for the fishes of Arkansas was premised on information needs in four specific areas. First, there was a need to establish a Geographic Information System (GIS)-compatible fish research database for the state of Arkansas to document historical and present fish distributions. Second, a digital database would allow identification of unique ecological or taxonomic fish community assemblages and centers of fish diversity within and across drainages of Arkansas. Third, historical changes in stability and persistence of community assemblage patterns and historical trends in species distributions needed to be easily associated with land use. Finally, there was a need for geo-spatial tools to assess conservation status of individual Arkansas fish species. The primary objective of this paper is to describe the development and design of the database used to capture collection records for fishes across Arkansas and that can be used to meet these information needs.

DATABASE DESIGN

The initial design goal was to create a database structure that could incorporate diverse sources of data on fishes into a standardized central, digital repository and that would be flexible and extensible enough to meet anticipated future needs. Additional design considerations included standardization, portability, integration with GIS, ease of use, available PC platforms, and support. These factors together with the one-to-many nature of the primary data dictated the need for a relational database system (e.g., for each fish collection, many species were sampled). A relational system provided the needed master-detail database structures. Importantly, a relational database system also provided programming tools for developing modular code units for data entry, queries, and reports, user-friendly graphical user-interfaces (GUI), data entry validation procedures, and on-screen help displays.

Standardization of the fish collection data was a first step in the design process. The data originated from multiple sources with varying sampling techniques, measurement units, and recording methods. Agreement was reached on standardized values or value ranges for most fields. Attributes of standardized fields were stored in separate lookup tables and “related” to the main database tables as needed via a shared code. This approach provided standard variables, and standard categories for development of queries and analyses and reduced data redundancy and table sizes. Input errors were also reduced since users select values from a pick list rather than typing in the entry. In addition, comment fields were built into the design to capture field observations or specimen conditions that were important but not amenable to standardization.

Due to the magnitude of information related to each collection, data fields were grouped into four major categories, each with a separate data entry screen:

1. Location information (fig. 1), including county; physiographic region and section; river drainage and system; stream name; and exact locality of the sampling site

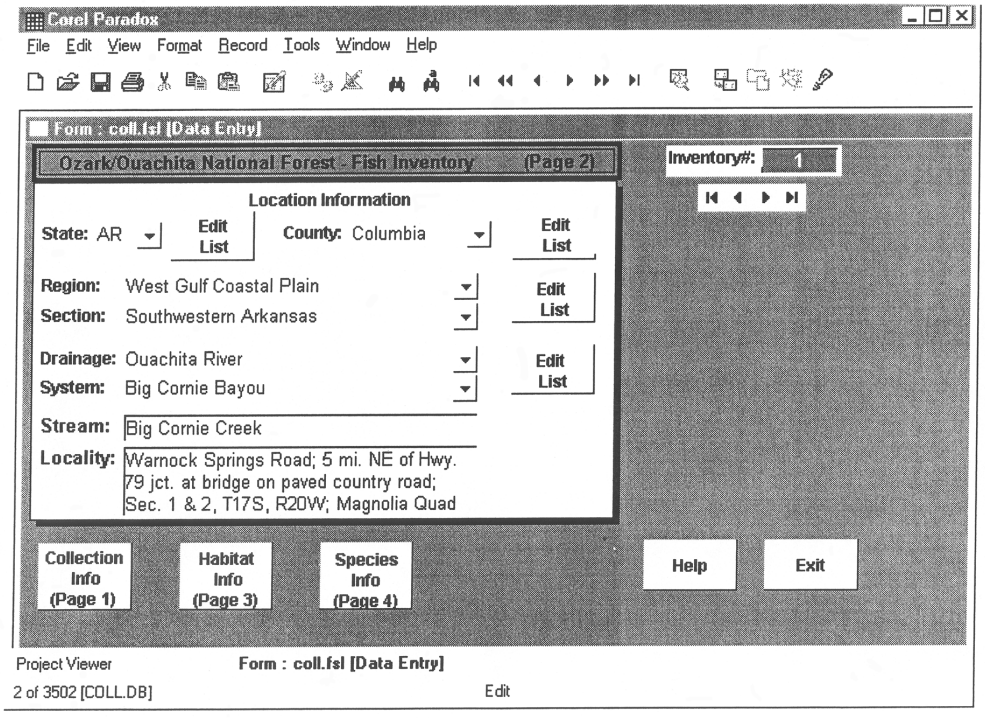

Figure 1—Data entry screen for location information.

2. Collection information (fig. 2), including collection or field identification number; collection date; collection interval, depth, and methods; and collectors
3. Habitat information (fig. 3), including 11 environmental variables: turbidity; vegetation; substrate; geology; shoreline condition; percent riffle; water depth and width; current; stream width; and water and air temperatures
4. Species information (fig. 4), including scientific name and family; number of individual species sampled; museum number; total length, standard length, and notes concerning sex, weight, spawning colors, and spawning condition.

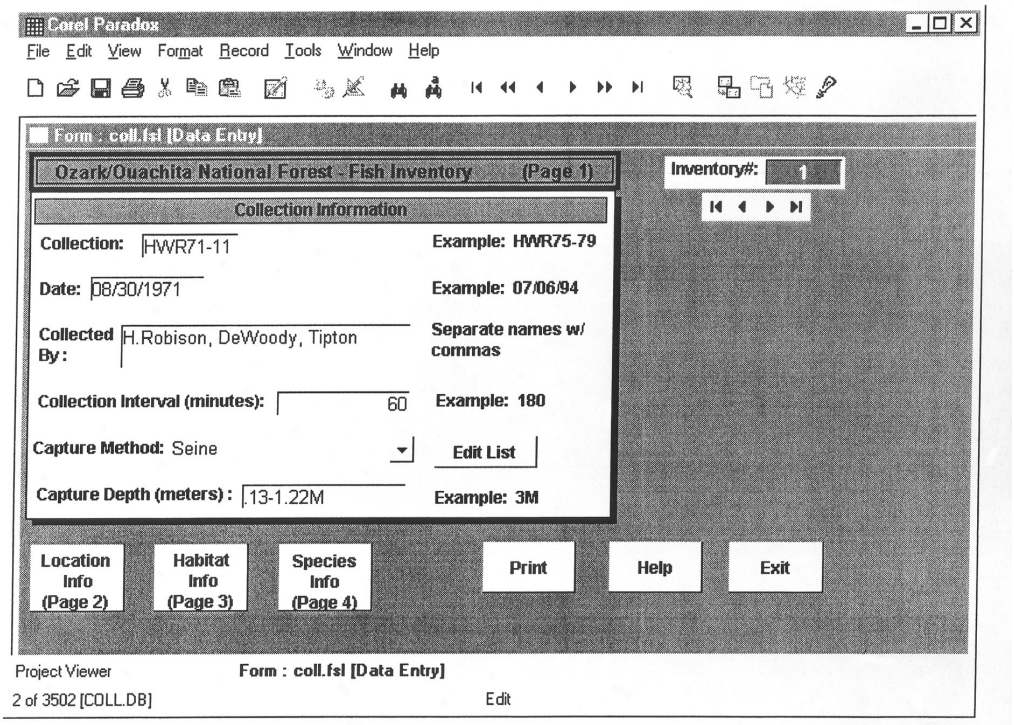

Figure 2—Data entry screen for collection information.

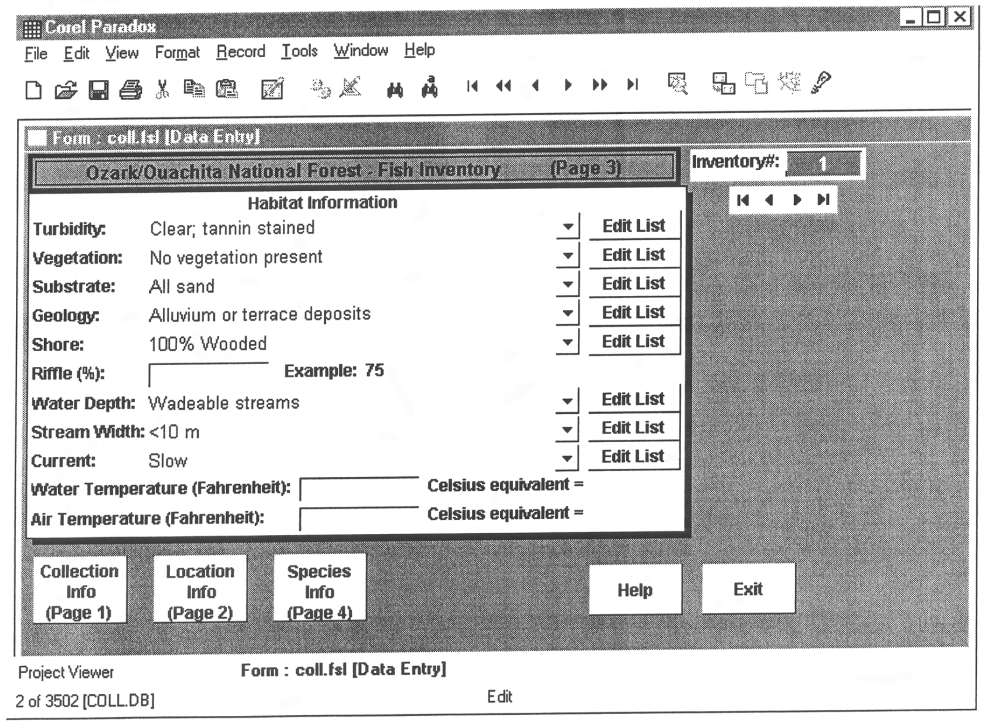

Figure 3—Data entry screen for habitat information.

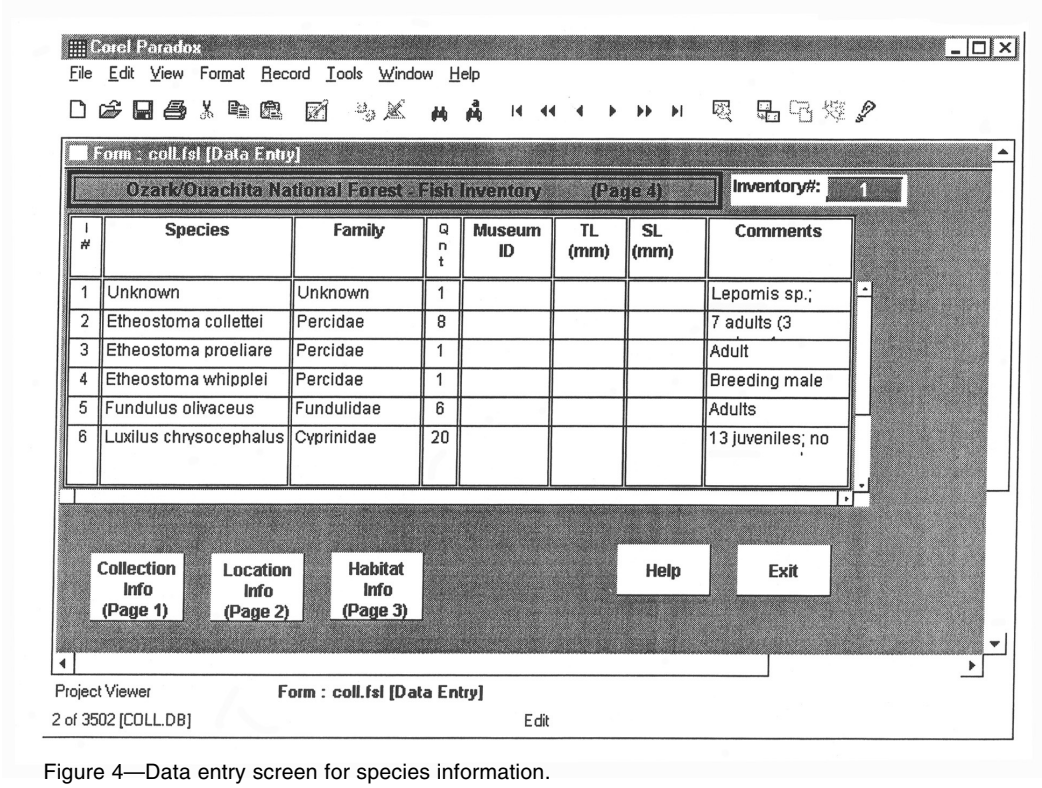

Figure 4—Data entry screen for species information.

To enhance accuracy and ensure standardization, the user extracts most field entries from pull-down tables of master lists. Scientific names and respective families for fish species are selected as single entries from a standardized list of all fishes known to occur in Arkansas as documented by Robison and Buchanan (1988) and updated to reflect subsequent taxonomic changes (table 1). A hierarchical list of river drainages and stream systems was adopted from drainage units defined by (Matthews and Robison 1988) (table 2). Similar master lists provide standard political subdivisions (Arkansas county names) and physical and geologic divisions of the state (physiographic region and section, surface geology), (table 3). Others indicate the capture method or provide descriptors of conditions at the collection site and include: air and water temperature, current category, percent riffle habitat, water depth, substrate type, turbidity category, stream size, shore classes, and types of aquatic vegetation (table 4). As needed the master lists may be updated or expanded to accommodate other categories of information or create additional entry fields.

Table 1—Sample from species master list

Species	Family	Species code
Acipenser fulvescens	Acipenseridae	1
Alosa alabamae	Clupeidae	2
Alosa chrysochloris	Clupeidae	3
Ambloplites ariommus	Centrarchidae	4
Ambloplites constellatus	Centrarchidae	5
Ambloplites rupestris	Centrarchidae	6
Amblyopsis rosae	Amblyopsidae	7
Ameiurus catus	Ictaluridae	8
Ameiurus melas	Ictaluridae	9
Ameiurus natalis	Ictaluridae	10
Ameiurus nebulosus	Ictaluridae	11
Amia calva	Amiidae	12
Ammocrypta clara	Percidae	13
Ammocrypta vivax	Percidae	14
Anguilla rostrata	Anguillidae	15

Table 2—Sample from system-drainage master list

Code	System	Drainage
0	0-Unknown	0-Unknown
1	Mississippi River-Blytheville	Mississippi River
2	Mississippi River-West Memphis	Mississippi River
3	Mississippi River-Helena	Mississippi River
4	Mississippi River-Eudora	Mississippi River
5	Upper St. Francis River	St. Francis River
6	St. Francis River	St. Francis River
7	Tyronza River	St. Francis River
8	L'Anguille River	St. Francis River
9	Fifteen Mile Bayou	St. Francis River
10	Upper White River	White River
11	War Eagle Creek	White River
12	Kings River	White River
13	Long Terrapin-Dry Creek	White River
14	Bull Shoals-White River	White River
15	Crooked Creek	White River

Table 3—Physiographic section (region) and geology master lists

Section (Region)	Geology
Arkansas Valley (Arkansas Valley)	Alluvium or terrace deposits
Athens Piedmont Plateau (Ouachita Mtns.)	Chert
Boston Mtns. (Ozark Mtns.)	Dolomite
Bottomlands (MS Alluvial Plain)	Limestone
Central Ouachita Mtns. (Ouachita Mtns.)	Sandstone
Crowley's Ridge (Crowley's Ridge)	Shale
Fourche Mtns. (Ouachita Mtns.)	Unknown
Loessial Plains (MS Alluvial Plain)	
Salem Plateau (Ozark Mtns.)	
Southcentral Arkansas (West Gulf Coastal Plain)	
Southwestern Arkansas (West Gulf Coastal Plain)	
Springfield Plateau (Ozark Mtns.)	
Unknown (Unknown)	

Help screens were used to clarify instructions and provide examples of valid entries. Techniques for field-entry validation (e.g., numeric range checking) were employed as appropriate, and printable summary reports (fig. 5) aided verifying entry accuracy. An export routine for creating delimited-text files (ASCII) was provided to ensure the database could later be moved to other systems. The export routine also served as a secondary backup mechanism.

SOFTWARE EVOLUTION AND SYSTEM REQUIREMENTS

The custom application, ONF FISH, has undergone a series of revisions since its inception. The database was originally developed for the DOS platform using Paradox, a relational database development product of Borland (now Inprise). Factors in the selection of Paradox over other relational database systems included PC system requirements (Paradox requires less resources than other products, such as PC Oracle), Borland's reputation in database development and programming arenas, and previous developer experience with Paradox. The application includes four basic modules accessible from a single, menu-driven, graphical interface: Data, Reports, Queries, and Utilities. Emphasis to-date has been on data entry and editing, but each module can easily be further expanded as user needs evolve.

The last major revision converted the application to object-based Paradox for Windows 5.0 and the Windows 3.1 platforms. The application now functions under Windows '95 and Paradox for Windows 7.0 (a Corel product). It is currently being ported to Delphi 5.0, a Windows '9x object-oriented development package originally developed by Borland and now owned by Corel as a result of their recent acquisition of Inprise. The new application will have the look-and-feel of a Windows '95 or Windows '98 application. Although still based on Paradox tables, the new application will not require Paradox as an underlying package at runtime. It will allow the use of tables created in any relational database system

Table 4—Master list of valid environmental categories

Environmental variables and values
Stream_width:
10-25 m
26-50 m
51-100 m
<10 m
>100 m
Unknown
Water_depth:
Large rivers
Medium-sized rivers
Streams w/pools too deep to wade
Tiniest headwater streams
Unknown
Wadeable streams
Current:
Moderate
None
Slow
Swift
Unknown
Turbidity:
Clear; distinct greenish cast
Clear; tannin stained
Moderately turbid
Slightly turbid
Spring-fed; very clear
Strongly turbid
Unknown
Substrate:
All gravel (mostly small)
All sand
Boulder and bedrock
Gravel-rubble mixture
Mud-sand mixture
Sand-gravel mixture
Unknown
Shore:
0-24 percent wooded
100 percent wooded
25-49 percent wooded
50-74 percent wooded
75-99 percent wooded
Unknown
Vegetation:
Aquatic vegetation beds of rooted aquatic plants
Justicia at stream margins
No vegetation present
Substrate covered with algae
Unknown

Inventory Summary

Printed: 03/21/00

Inventory#: 1121

Collection Information

ID:	HWR72-15	**By :**	H.W.Robison; Calhoun; Beene; Tipton
Date:	04/23/1972	**Method:**	Seine
Interval:	60		
Depth:	1.22M		

Location Information

County:	Lafayette, AR	**Stream :**	Red River
Region:	West Gulf Coastal Plain	**Locality :**	At Hwy. 160 ferry, 200 yds. N of ferry; on sand bar on east side of the river; T19S, R27W, Sec.13; Doddridge SE Quad
Section:	Southwestern Arkansas		
Drainage:	Red River		
System:	Lower Red River		

Habitat Information

Turbidity:	Moderately turbid	**Water Depth:**	Large Rivers
Vegetation:	No vegetation present	**Stream Width:**	51-100 m
Substrate:	Sand-gravel mixture	**Current:**	Moderate
Geology:	Alluvium or terrace deposits	**Water Temp (F):**	75
Shore:	0-24% Wooded	**Air Temp (F):**	82
Riffle(%):			

Species Collected

Item	Species	Family	Quantity	Museum ID	TL	SL	Comments
1	Unknown	Unknown	1				Lepisosteus sp. - skeleton
2	Cyprinella lutrensis	Cyprinidae	355				
3	Dorosoma cepedianum	Clupeidae	65				9 adults, 6 juveniles
4	Gambusia affinis	Poeciliidae	5				
5	Ictalurus furcatus	Ictaluridae	0				Taken by commercial fishermen
6	Ictalurus punctatus	Ictaluridae	12				Juveniles
7	Ictiobus bubalus	Catostomidae	1				Dead
8	Lepomis humilis	Centrarchidae	1				
9	Lepomis macrochirus	Centrarchidae	4				
10	Lepomis megalotis	Centrarchidae	2				
11	Menidia beryllina	Atherinidae	1				
12	Notropis atherinoides	Cyprinidae	31	TU93616			
13	Notropis buchanani	Cyprinidae	1				
14	Notropis potteri	Cyprinidae	12	TU93617			*NEW STATE RECORD - Verified by Dr. G.A.Moore, OSU
15	Notropis shumardi	Cyprinidae	816	TU93619			Males with small nuptial tubercles

Figure 5—Sample inventory report.

for which an Open Database Connectivity (ODBC) driver is available (including Paradox, Access, Oracle, or others). The new version will take advantage of the newest enhancements of Delphi, one of the most powerful Rapid Application Development (RAD) packages available today.

The current version requires at least an 80386-based PC with Windows '95, Paradox for Windows 7.0, 32MB RAM, and approximately 40MB free disk space for the ONF FISH application. However, a Pentium or better system with 64MB RAM is strongly recommended and will be required for future Delphi-based versions.

INTEGRATION WITH GEOGRAPHIC INFORMATION SYSTEM

In conjunction with development of the fish database application, efforts were made to ensure the information could be easily integrated into a GIS. As site-specific collections were entered, they were also located on paper copies of USGS 7.5 minute topographic maps (1:24,000) and coded with a unique identification number. Those maps are being maintained and continually updated by the first author as a physical record of fish collection localities in Arkansas. In late 1999, in an effort led by Alan Clingenpeel (ONF) and Brian Wagner (AGFC), all sampling locations were geo-referenced to state-wide coverages using PC ArcView, a product of Environmental Software Research Institute. Each sampling point on the paper maps was matched to the same point on a 1:24,000 digital topographic coverage of Arkansas. The resulting point coverage uses an ArcView table linking collection identification numbers with point labels. This table will be merged into the original fish database application tables so that all the fish data attributes may be used in map creation and geo-spatial analysis.

CONCLUSION

A digital, database repository linked to GIS is now developed for over 3,500 collections of fishes covering all of Arkansas. Importantly, the foundation of the database, the individual collection records, were critically examined so that the information is up-to-date and as error free as possible (Robison and Buchanan 1998 and subsequent updates by Robison). The abundance and distribution of the fishes of Arkansas are linked intimately to the habitat and water quality condition of streams and rivers these animals inhabit (Matthews and Robison 1988, 1998; Matthews and others 1992). As such, the database of fishes will be extremely useful to natural resource agencies in management, planning, and monitoring. The database gives natural resource managers an enhanced ability to examine fish distribution in association with rehabilitation, enhancement, or remediation of the state's running waters.

Future applications of the database are limited primarily by one's vision. The fish data application is currently extensible and will be even more so after full conversion to Delphi, which supports technologies such as Open Database Connectivity (ODBC), Object Linking and Embedding (OLE), and Active Data Objects (ADO) which would allow widespread sharing of data with other applications. Uses may ultimately extend well beyond management. Both Delphi and certain GIS products could be used to extend database products to the web. For example, web-based interactive maps could be created that display recent versus historical fish distributions. Guides to identification of fish species of Arkansas could be developed complete with photographs and detailed distributional maps for each species. Integration of the database with GIS provides managers with decision-making tools and visual communication modes that assist in prioritizing allocation of scarce resource management dollars, open the door to thoroughly examining management alternatives, and help convey and justify management decisions. In sum, the database is a powerful natural resource tool for the USDA Forest Service, The Nature Conservancy, the AGFC, the Department of Arkansas Natural Heritage, and state, federal, and local entities in future planning, monitoring, and management efforts.

ACKNOWLEDGMENTS

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LITERATURE CITED

Matthews, W.J.; Hough, D.J.; Robison, H.W. 1992. Similarities in fish distribution and water quality patterns in streams of Arkansas: congruence of multivariate analysis. Copeia. 1992(2): 296-305.

Matthews, W.J.; Robison, H.W. 1988. The distribution of the fishes of Arkansas: a multivariate analysis. Copeia 1988(2): 358-374.

Matthews, W.J.; Robison, H.W. 1998. Influence of drainage connectivity, drainage area, and regional species richness on fishes of the Interior Highlands of Arkansas. American Midland Naturalist. 139: 1-19.

Robison, H.W.; Buchanan, T.M. 1988. Fishes of Arkansas. Fayetteville, AR: University of Arkansas Press. 536 p.

Standage, R.W. 1999. Management indicator species. In: Chapter 2, U.S. Department of Agriculture, Forest Service. Ozark-Ouachita Highlands Assessment: aquatic conditions. Report 3 of 5. Gen. Tech. Rep. SRS-33. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 317 p.

Warren, M.L., Jr.; Clingenpeel, J. Alan. 1999. Aquatic habitats. In: Chapter 2, U.S. Department of Agriculture, Forest Service. Ozark-Ouachita Highlands Assessment: aquatic conditions. Report 3 of 5. Gen. Tech. Rep. SRS-33. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 317 p

Warren, M.L., Jr.; Hlass, L. 1999. Diversity of fishes. In: Chapter 2, U.S. Department of Agriculture, Forest Service. Ozark-Ouachita Highlands Assessment: aquatic conditions. Report 3 of 5. Gen. Tech. Rep. SRS-33. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 317 p.

Warren, M.L., Jr.; Tinkle, K. 1999. Endangered, threatened, and other aquatic species of special concern. In: Chapter 2, U.S. Department of Agriculture, Forest Service. Ozark-Ouachita Highlands Assessment: aquatic conditions. Report 3 of 5. Gen. Tech. Rep. SRS-33. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 317 p