Geographic Information Systems in Wildlife Law Enforcement

Chad M. Dacus, *Box 9690, Mississippi State University, Mississippi State, MS 39762*

Richard B. Minnis, *Box 9690, Mississippi State University, Mississippi State, MS 39762*

James Willcutt, *Box 9690, Mississippi State University, Mississippi State, MS 39762*

Abstract: Geographic information systems (GIS) have been used in wildlife and fisheries management and research for many years. These systems are not being used, however, to the fullest potential in conservation law enforcement. At present, there are only 5 conservation law enforcement agencies in the United States using GIS. In Mississippi a GIS is being developed for use in conservation law enforcement. The Mississippi Department of Wildlife, Fisheries, and Parks, in conjunction with the Department of Wildlife and Fisheries at Mississippi State University, is involved in the development of this GIS. This paper will address the good (advantages), the bad (disadvantages), and the ugly (serious problems) in the development of this GIS. The information provided in this paper is to be used as a guide for conservation law enforcement agencies that are interested in establishing a GIS for use in their state. Another objective of this paper is to help conservation law enforcement agencies understand that the technologies that are being used by municipal police departments and in wildlife management can be used in conservation law enforcement. Suggestions presented are what we have found to work in Mississippi during the development stages of our GIS. Geographic information systems can provide officers the means for enforcement to become more pro-active and efficient at helping to manage and protect our wildlife resources by keeping the knowledge of all officers that have worked for an agency or in a specific area, with that agency and in that area. With this knowledge base in place, wildlife resources can be effectively protected and remain viable for years to come.

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Geographic information systems (GIS) have been used in wildlife and fisheries management and research for many years (Johnson 1990). This same technology is also being used in municipal police departments across the United States. These systems are not being used, however, to the fullest potential in conservation law enforcement. Harelson (1992) presented probably the first documented case of GIS being used in wildlife law enforcement. The purpose was to look at the geographic distribution of waterfowl arrests in Wisconsin and to enhance waterfowl enforcement.

At present, there are only 5 conservation law enforcement agencies in the United States using a GIS and 2 agencies that plan to implement a GIS in the next 5 years (C.M. Dacus and R.B. Minnis, unpubl. data). In Mississippi a GIS is being developed for use in conservation law enforcement. The Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP) in conjunction with the Department of Wildlife and Fisheries at Mississippi State University are involved in the development of this GIS. During the development there have been many obstacles to overcome. This paper will address some of these obstacles and the solutions that have been employed.

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Background

To begin this process there needs to be some understanding of the definitions of a GIS. Johnson (1990) defines GIS as computer-based systems for the manipulation and analysis of spatially distributed data. Also a GIS can be a computerized mapping systems that permits information layering to produce detailed descriptions of conditions and analyses of relationships among variables. The information in the GIS is based on drawing different spatial data on suitable media and overlaying them on one another to find interrelated points (Harries 1999).

Another system that is often used in conjunction with GIS is the global positioning system (GPS). This can be problematic when explaining uses of GIS. One of the reasons for this is most likely due to the similarity in the acronyms that are used in naming the 2 systems. A GPS is a set of satellites that are used to provide precise locations on the surface of the earth (Hurn 1989). GPS allows the user to record detailed information about any object while collecting highly active positional data (Ralston 1999). These 2 systems, GIS and GPS, can be and are used together but they can also be used independently. The fact that they can be used together, but do not have to, has caused some confusion when developing GIS for use in Mississippi. Some officers and supervisors inadvertently will refer to GPS when they are discussing GIS, and vice versa.

Citations lend themselves to spatial analysis. The only thing missing from the citation is a positional location; i.e., x and y coordinates. GPS units can be used to add this spatial component that is missing from the citation. Once there is a spatial component included in the dataset, this can be linked to existing data already provide on written citations; i.e., species, violation type, violator's names, etc. With all of this information linked together the officers can see what is being violated, who is doing the violating, and when the violation has occurred by where it happened.

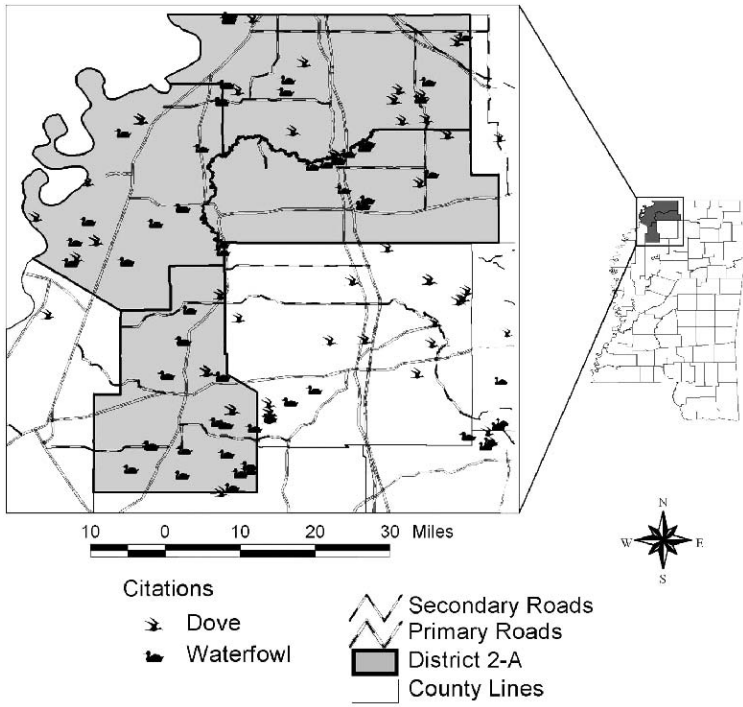

Figure 1. Conservation officers in Mississippi are provided citation distribution maps of their sub-district coded by species with all species on 1 map. Only 2 species are used and their symbols are enlarged on this map for clarity.

Methods

A mail survey was conducted in December 2000 to determine the extent of spatial technologies in conservation law enforcement agencies in the United States (C.M. Dacus and R.B. Minnis, unpubl. data). In the 16 states which compose the Southeastern Association of Fish and Wildlife Agencies (SEAFWA), there were 2 states with a GIS in place and 1 other that was to have a GIS in place by 2001. Twelve states entered citation information into a database and the citation information was being analyzed in various ways. Some of the analysis conducted on the data was number of citations per location, number of arrests per officer, number of arrests by violation type, and times of arrests. Approximately 41% of the conservation officers in the SEAFWA states had been issued GPS units for official use. In Mississippi, 53% of conservation officers had been issued GPS units for official use. However, in Mississippi only 1 district out of 7 recorded the coordinates of their citation locations. The lack of GPS units led to the first problem in the development of a GIS: no exact location of the citation.

In Mississippi, citation information has been recorded in a database since 1996. This past citation information was to be included in the GIS. The problem with using this "old" information was that no location information had been recorded on the citations. Since this old data was to be included in the GIS, the location was the key component that was missing and necessary in developing the GIS.

Meetings were held with all the conservation officers in Mississippi to introduce them to the GIS, explain the advantages/benefits they would receive from GIS, and to manually plot citation locations on paper maps. Maps of citation distribution per subdistrict and citation distribution maps by species (Fig. 1) are 2 examples of benefits from the GIS that were shown to the officers. It was explained to the officers that they would receive personalized maps of their home county/sub-district plotting all citations with their citations highlighted in a different color.

A listing of citations that had been written between 1 July 1996 and 30 June 2000 was given to each officer. They were asked to plot the citations on 1:100,000 scale county topographic maps. The maps were created using SureMaps Raster digital scanned data (SureMaps Raster, 1998, Horizons Technology, Inc., San Diego, Calif.). These citation locations were manually digitalized into ArcView 3.2 (ArcView GIS Version 3.2, 2000, Environ. Sys. Res. Inst., Inc. Redlands, Calif.).

Advantages

There are advantages and disadvantages in having the officers plot locations on paper maps. Plotting this old citation data makes it available to conduct research and to evaluate past enforcement activities. Minnis et al. (1999) described potential uses for a GIS in wildlife law enforcement that can be put to use immediately after these citation locations have been entered into the GIS. These uses range from contrasting a state-wide assessment of waterfowl citations versus white-tailed deer *(Odocoileus virginianus)* to looking for "gaps" between districts to evaluating an "officer's sphere of influence."

There are numerous other potential uses and advantages to using this old data in a GIS. One important advantage is this old data can provide feedback about past enforcement activities, which allows officers to be more proactive in future enforcement activities by being able to see past problem areas (Fig. 2). New officers see an immediate impact from maps of their county or management area because they can look at a visual representation of where the violations occur, thus reducing the learning curve for these officers. This can also benefit officers that have been assigned to a new area. They do not have to spend weeks, months, or even years learning where there are problem areas. With the GIS maps of citation distribution, these officers can quickly acclimate to this new territory.

Another potential use is modeling locations, times, dates, population demographics, habitat types, and violator attitudes. This may allow law enforcement agencies to become even more proactive in their enforcement activities. These models could be used to better understand when and where violators will be most active. This could be especially useful because some violators may exhibit patterns in their

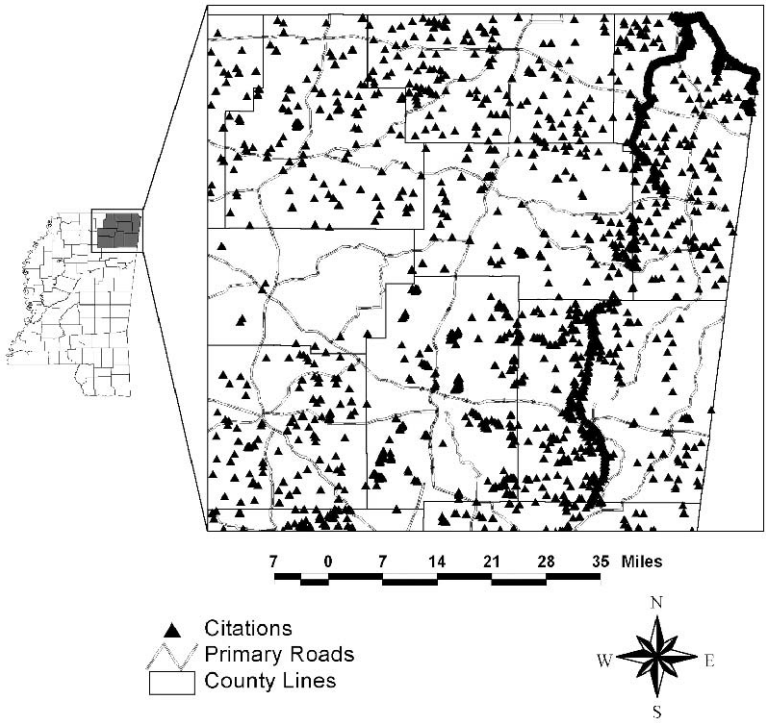

Figure 2. Officers can get a better idea of where there are problem areas within their work area by looking at a visual distribution of citation locations.

illegal activities. It would be very valuable to the field of conservation law enforcement to be able to know when and where violators will be most active.

Locations of citations could be related to ownership information, i.e., state-owned lands, federal-owned lands, hunting clubs, timber companies, etc. This could provide officers with a greater knowledge about the violations within an officer's area. For example, if a privately-owned section of land, i.e., a hunting club, consistently has had violation problems; other lands with the same ownership may also have similar problems.

Disadvantages

Plotting the old data on topographic maps can be disadvantageous for a couple of reasons. The main disadvantage and problem is how cluttered and congested these topographic maps can be after the officers plot their citations (Fig. 3). There are occasions when more than 1 citation is written at the same location. In cases such as this, officers place 1 point where the citations were written and then list out all of the cita-

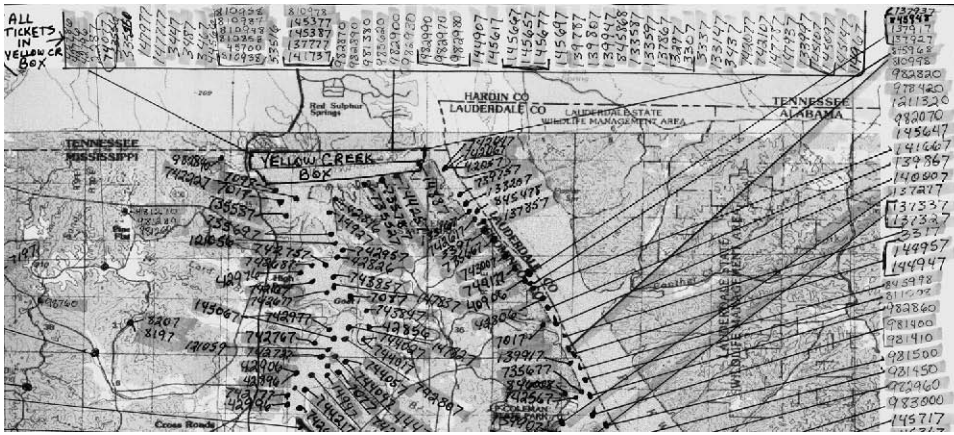

Figure 3. Conservation officers in Mississippi plot citation locations on 1:100,000 topographic maps created with SureMaps Raster version 2.03 These maps can become cluttered and congested when there are a large number of citations that are written in one area. The area marked "Yellow Creek Box" is an area that the officers could not determine specific locations.

tion numbers that were written at that location beside the point. It is important for the officers to write out the citation numbers, as this is the linking variable between the spatial database and the citation database that contains all of the citation information, i.e., offender's name, address, violation code, species code, etc.

Another disadvantage in having the officers plot the locations on the paper maps are that the locations of citations on bodies of water are approximated. On lakes and rivers there are not good landmarks that can be readily located on maps. There are, however, stretches or reaches in the river that can be used to plot groups of citations. However, there are coves or other areas of a lake that can be distinguished when plotting these citations. Even though these citation locations are not exact, they can still be used in analysis and to determine problem areas associated with these bodies of water (Fig. 4).

The time involved in plotting the citations on paper maps and then using heads-up-digitizing to enter the citations into the GIS is another disadvantage. The initial set up of the GIS takes much longer than the upkeep and maintenance of the system. Manual digitizing for a 15-county section of Mississippi containing 6,400 citations took approximately 26.5 hours. This does not take into account the time it takes officers to plot the citations on the paper maps or take into account the time it takes to correct the data entry errors. Also, data entry of citation information at the state or district office is not included in this time estimate. With the initial database in place, regular maintenance of the system will include digitizing much fewer points. If GPS units are used and the location coordinates are entered into the database, there will be no digitizing involved in maintaining and updating the system.

The last disadvantage in plotting the old citation data on paper map was that

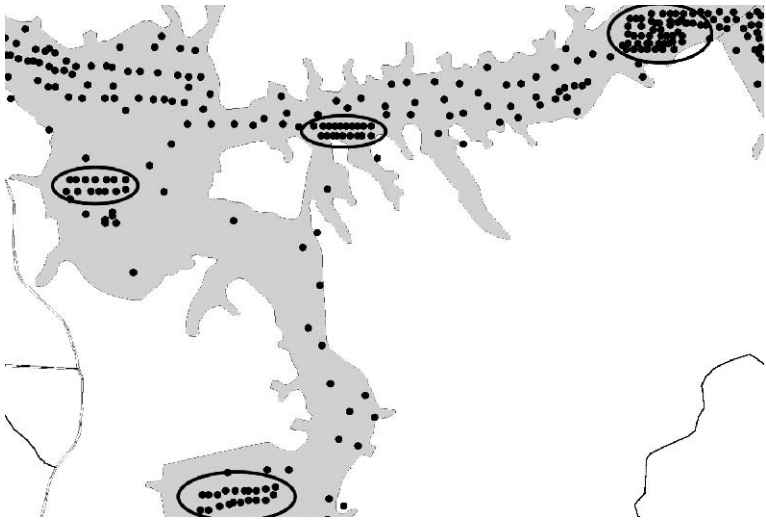

Figure 4. Citations plotted on water bodies are approximated, but these citation locations can still be used in analysis and to determine problem areas on lakes and rivers. This area is the same area as in Fig. 3. The areas circled approximate locations of these citations.

some citations could not be used. The main reason for citations not being able to be plotted was the officer that wrote the citation is no longer with the agency. In this scenario, the officer's partner plotted all of the citations he was familiar with, but there were still some citations that could not be plotted. This accounted for the largest number of citations that could not be incorporated into the database. Also, there were some citations that the officer could not remember the exact location. All of these citations can still be used for analysis on a county or district level, but not for analysis concerning the individual officer.

Citations that were written on management areas and/or national wildlife refuges were also problematic in some cases. Some officers knew the citation was written in a certain area of the management area but not the exact location. These citations were handled like the water citations in that they were placed in a section of the management area. Some citations written by United States Fish and Wildlife Service (USFWS) personnel on national wildlife refuges were given to MDWFP conservation officers. These citations were also plotted in a section of the refuge and not in an exact location.

Serious Problems

The data entry errors were the biggest problem that was incurred in the development of the GIS. The most frequent error was the citation numbers were incorrectly written on the maps. This is followed closely by the inability to read the officer's

handwriting on the maps. And lastly, the citation data entry in the state and district office was not consistent over years. All of these errors must be corrected before any analysis can be conducted. The inability to read the officers' handwriting was difficult at times. Most numbers could be determined, but it added time to the process. This problem could often be corrected by looking at a list of citations that were not plotted per officer and comparing the numbers to determine the correct citation number.

The final problem to be discussed is the apprehensiveness of the officers toward a GIS. This is mainly due to fear of new technologies and the idea that "big brother" is watching. Some officers that have been in an area for a long time may not see the need for this new technology and they may also think that this "new" way of looking at citation data will not aid in their enforcement activities. It is very important to relay to these officers that their knowledge of an area is very important to the wildlife law enforcement in that area. The knowledge that these officers have accumulated over their tenure as a conservation officer leaves with them when they leave an area or retire. With a GIS, at least some of this knowledge can be easily passed on to the next officer that comes into that area.

Recommendations

The first thing in developing a GIS is to determine whether or not the GIS is going to utilize old data, i.e., citations written in the past, or start from scratch and develop a GIS using only new data, i.e., citations written in the present. If the old data is to be used, meetings will need to be held with all conservation officers and they must plot the citation location on paper maps. Then these points must be digitized into the GIS. The most cost effective way of accomplishing these tasks is to fund a research project at a university or college. This research paper can not only collect and enter the data, but valuable analysis can also be obtained that can benefit the entire conservation law enforcement field. After the initial spatial database is established, the only thing the agency will need to do is to update and maintain the GIS on a regular basis.

If the old data is not available, a GIS can still be established for use in conservation law enforcement. A few steps should be taken to ensure the most efficient means of data collection. All officers should be issued GPS units to record the exact location of the violation. This will reduce the time involved in establishing the spatial database. Next, all citation data should be entered in a central location to reduce differences in data entry. If this is not possible, all data entry personnel should be trained in the same manner. The most important consideration when developing a GIS for use in conservation law enforcement is the standardization of the data to be collected by the officers. This can be as simple as making sure all officers use the same citation format and codes, i.e., species and violation codes, and can be as specific as making sure all officers collect citation locations in the same coordinate system and datum. For simplicity sake, we recommend that data be collected in decimal degrees (latitude/longitude) World Geodetic Systems 1984 (WGS 84). All GPS units come preset to latitude/longitude WGS 84 as a default. WGS 84 is believed to be the most accu-

rate datum for the entire world. The only change that needs to be made on the GPS unit is to change the coordinates from degrees, minutes, and seconds to decimal degrees. These data can be converted at a later time to a different projection, if so desired, with little effort.

Another projection commonly used is Universal Transverse Mercator (UTM). However, with UTM there can be confusion in areas that are split into 2 or more zones. In Mississippi, for example, the western half of the state is in zone 15 and the eastern half is in zone 16. Officers who work close to these zone lines will not get as accurate reading on their GPS units as officers who are in the center of the zone. Officers that may cross the zone lines in their enforcement activities may or may not remember to record the appropriate zone. Also, having 2–3 zones in 1 state makes handling the GIS data problematic. Data from zone 1 does not align with data from zone 2. Therefore, some conversion of the data will have to occur.

There are 3 rules to consider when developing a GIS for use in conservation law enforcement: 1) determine your needs as an agency; 2) find software that will satisfy your needs; and 3) find hardware that will run the selected software (Miller 1995). These steps sound easy, but they can lead to much confusion. Determining the needs of a conservation law enforcement agency can be the most difficult of these steps. This is primarily due to the lack of information available on GIS uses in conservation law enforcement.

When selecting software to run the GIS it is important to select one that can easily be adapted to your needs. The first step is to determine if GIS software is already being used in the agency. Selecting the software that is already being used in another division of your state agency will cut cost and training time. Stallo (1995) stated that the greatest expense with most software involves the time required by personnel to become knowledgeable with the program. This gives even more reason to use a software package that your agency is already familiar with, and will decrease the incompatibility of data within the agency. ArcView GIS is currently being used by the MDWFP and the 4 other conservation law enforcement agencies that are currently using a GIS in conservation law enforcement nationwide (C.M. Dacus and R.B. Minnis, unpubl.data). In Mississippi, the MDWFP Wildlife Division was already using ArcView before the Law Enforcement Division decided to implement the use of GIS, so the decision was easy to make.

The final step in establishment of a GIS should be the selection of hardware that the software will run on. We suggest at least a Pentium class III personal computer running a version of Windows operating system (Microsoft Corp., Redmon, Wash.). The size of the hard drive is dependent on how much space you need. A 20-GB hard drive should be sufficient as long as you are not going to store a large number of images on the hard drive. A CD-ROM, floppy disc drive, a 250 MB ZIP disc drive, and a 19-inch or larger color monitor are all recommended.

It is very important to have a dedicated GIS computer that is not used for other tasks; i.e., word processing and sending/receiving e-mail. These activities will unnecessarily fill the hard drive and subsequently slow down the computer. We recommend dedicating the computer to the following software only: Windows operating

system, Microsoft Excel or other database management software, file unzipping software, and a GIS software package.

For an example, the following is a computer that is being used in the Department of Wildlife and Fisheries at Mississippi State University for conservation law enforcement research: Intel Pentium® III 1 Ghz processor, 40 GB hard drive, 255 MB RAM, internal 250 MB Iomega Zip drive, CD-ROM drive, 3.5-inch floppy disc drive, and a 21-inch Trinitron® flat display monitor. The software on this computer is: Microsoft Windows 2000, ArcView 3.22, ArcInfo 8.0, ERDAS Imagine 8.4, SureMaps Raster 2.03, Microsoft Excel 2000, Norton AntiVirus Corporate Edition 7.5, PKZIP for Windows 2.7, and NOVELL NetWare Services network software.

Conclusion

The information provided in this paper is to be used as a guide for conservation law enforcement agencies that are interested in establishing a GIS for use in their state. Another objective of this paper is to help conservation law enforcement agencies understand that the technologies that are being used by municipal police departments and in wildlife management can be used in conservation law enforcement. These suggestions presented are what we have found to work in Mississippi during the developmental stages of our GIS.

The best way to continue the progression of conservation law enforcement agencies from the days of folded paper maps into the digital age is through quality research. This research will not only benefit the agency, but it can aid in the progression of the entire conservation law enforcement profession. Such research will ensure that conservation law enforcement continues to advance in a world of ever changing technologies and ideas.

The most valuable aspect of a GIS in conservation law enforcement is that it can reduce the learning curve for an officer in a new area and keep all of the knowledge that is accumulated by these officers over the years within the agency. Today officers are dependent on their partners to help them learn about the areas that they will be working. A GIS will not replace the need for this interaction between partners, but it will help the officers to be more efficient and more effective in a shorter amount of time. Consider the scenario of an officer retiring unexpectedly and not being able to train the replacement officer. Without a GIS, this new officer will have to learn the county on their own, start a mental database of information, and get no input from the retiring officer's knowledge of the area. With a GIS, this same officer can "go back in time" and look at the citations that have been written to learn where there have been problem areas in the past within his work area.

Minnis et al. (1999) stated that the ultimate goal should be to provide the means for enforcement to become more pro-active and efficient at helping to manage and protect our wildlife resources. Geographic information systems can provide officers this means by keeping the knowledge of all officers that have worked for an agency or in a specific area, with that agency and in that area. With this knowledge base in place, wildlife resources can be effectively protected and remain viable for years to come.

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