Geographic Information Systems: A Valuable Tool for Wildlife Law Enforcement

Richard B. Minnis, *Box 9691, Mississippi State University, Mississippi State, MS 39762*

James Willcutt, *Box 9690, Mississippi Department of Wildlife Fisheries and Parks, Mississippi State, MS 39762*

Robert Griffin, *Box 9690, Mississippi Department of Wildlife Fisheries and Parks (ret.), Mississippi State, MS 39762*

Abstract: Geographic information systems (GIS) have become a commonly used technology in nearly all aspects of wildlife management except wildlife law enforcement. Law enforcement agencies in large municipalities have also been using GIS extensively to provide better and more efficient enforcement. All states in the Southeast have wildlife violation data in some database that can very quickly and easily link to available county spatial data. Pictorial examination of these data by county on a state-wide basis provides chiefs and supervisors an effective and easy way to evaluate existing programs. Having conservation officers plot specific locations of violations provides individual officers and district administrators a clear picture of an officer's work habits and "sphere of influence." Results of this examination into the use of GIS in wildlife law enforcement show that GIS can be easily integrated into existing programs and provide a large benefit to both officers and administrators. Additional benefits could potentially be derived by using the spatial capabilities of GIS to model behavior of violators, land use patterns near areas of violation, and population demographics of both violators and areas of violation.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 53: 488–500

The value of Geographic Information Systems (GIS) for the display and analysis of natural resource data is widely recognized in the wildlife and fisheries community. Using GIS to display current land cover conditions, monitor animal movements, and evaluate land use change in a given region of habitat selection for a species has become common-place. Similarly, use of GIS to monitor calls for service, officer activity, and service type within municipal law enforcement agencies is rapidly increasing (Quist 1999, Anon. 1991). Both disciplines have realized the flexibility, ease of use, and economic benefits of applying this rapidly expanding technology to the field.

In the 16 states which make up the Southeastern Association of Fish and Wildlife Agencies (SEAFWA) the average expenditure for law enforcement in 1997 was $12.7 million per state wildlife and fisheries agency (Anon. 1998). That equates to 23.6% of the total average agency budget of $53.7 million or $203 million for the entire Southeast (Anon. 1998). Each state in the Southeast averages 188 enforcement officers (range 94–433) with 2.22 (range 1.33–4.37) officers per county, 834.2 km^2 (range 163.8–616.2) per officer, and nearly 7,500 wildlife users (range 1,216–25,000) per officer. These figures point to the need to efficiently manage and evaluate officer deployment and manpower.

An informal telephone survey was conducted to question the enforcement divisions of all 16 SEAFWA states as to the current use of GIS technology in the wildlife enforcement field. Fifteen of the 16 states currently have a database system to manage their citation programs. One state indicated their program had recently crashed and they are in need of a new one. The one state without a system is in the process of developing a system in-house. Seven states enter the data at the state office, 6 at the district/region level, and 1 state uses the system of its State Police. Two states currently issue GPS units to field officers; however, only one of these use GPS to plot citations, and only on specific bodies of water. All states indicated they would be interested in learning more about the application of this technology in wildlife law enforcement and how agencies and personnel can use this technology to better manage and support our wildlife and fisheries resource.

Methods

Mississippi's District 1 Subdistrict C was used as the test study area for this research (Fig. 1). The subdistrict is in the northeast corner of Mississippi and is comprised of the 5 southernmost counties of District 1: Oktibbeha, Noxubee, Winston, Lowndes, and Clay counties. This subdistrict was chosen for the ease of availability to law enforcement officers and the progressive nature of the officers as a whole.

The area is a mixture of forested and agricultural areas, interspersed throughout suburban and some urban regions. The region is bisected by the Black Prairie physiographic region dominated by open grasslands. The Tennessee-Tombigbee waterway runs through the northeastern portion of the region, while the Noxubee River runs from the center of the subdistrict to the southeast (Fig. 1). Noxubee National Wildlife Refuge lies approximately in the middle of the subdistrict, with the Ackerman district of the Tombigbee National Forest lying on the western edge.

Data were examined at 2 different levels of precision. First, wildlife law enforcement violations from 1 January 1996 to 31 January 1999 were obtained for the entire state to do an assessment at the state-wide level. Data in the state-wide database included information about the perpetrator, the specific violation and the species of concern (Table 1). Secondly, specific locations of violations written between 1 July 1996 and 31 January 1999 were examined for a county- and officer-level assessment.

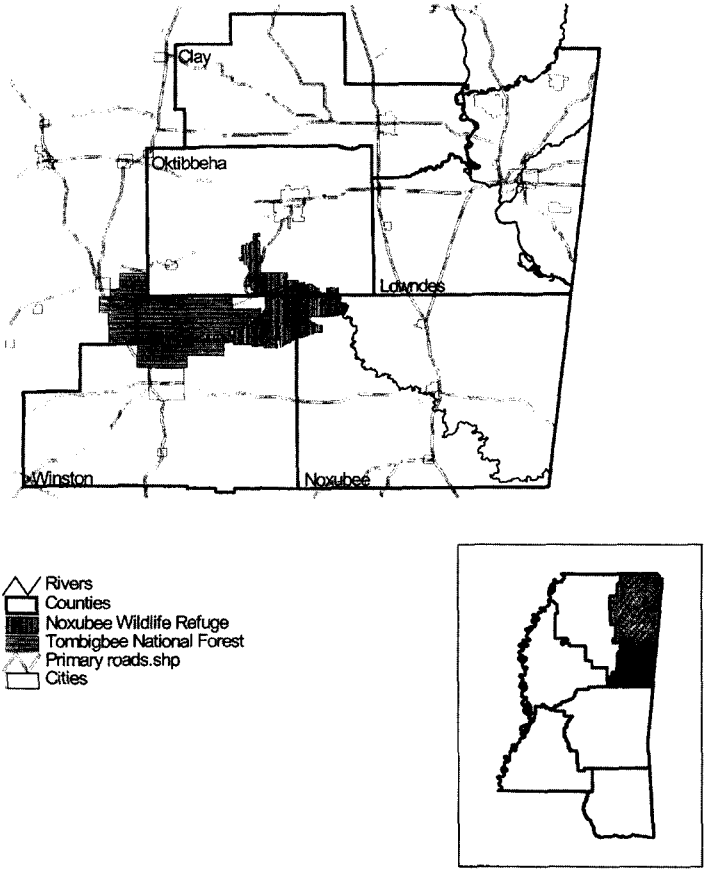

Figure 1. District 1, subdistrict C of the Mississippi Department of Wildlife, Fisheries, and Parks was chosen as the study site for the project.

Data from a small 1997 duck hunter harvest survey conducted by the MDWFP were obtained for comparison to the violation data. The survey asked hunters about the number of ducks harvested in each county during the 1997–98 season. The data on the number of ducks harvested by hunters were linked to each of the state counties for visualization. Hunter harvest numbers and waterfowl violations written for the same period were graphed for each county in ArcView GIS 3.1 (ArcView GIS Vers. 3.1 1998. Environ. Sys. Res. Inst. Inc., Redlands, Calif.) for comparison. State-wide violation data were also examined by deer headlighting violation type.

Wildlife law enforcement violations from 1 July 1996 to 31 January 1999 in District 1, subdistrict C of the Mississippi Department of Wildlife Fisheries and Parks (MDWFP) were selected as the sample data set for the detailed cite-specific analysis. Records were extracted from an existing district-maintained database and

Table 1. Data fields of wildlife law enforcement citations incorporated into a geographic information system for display and analysis.

Field name	Description
Ticket_no	Unique citation number
Ticket_date	Date ticket was written
Ticket_time	Time ticket was written
AM_PM	When ticket was written, either morning or evening
Last_name	Last name of perpetrator
First_name	First name of perpetrator
MI	Middle intial of perpetrator
Address	Address of perpetrator
City	City of residence of perpetrator
State	State of residence of perpetrator
Zip	Zip code of residence of perpetrator
DLN	Drivers license number of perpetrator
DLN_ST	State of issuance of drivers license of perpetrator
Birth_date	Date-of-birth of perpetrator
Sex	Sex of perpetrator
Race	Race of perpetrator
Badge_no	Badge number of conservation officer issuing ticket
County	County ticket was issued
District	Wildlife, Fisheries, and Park district ticket was issued
Type	Violation type (Wildlife, Fishing, Boating)
Viol_code	Violation code (Resident no license, baiting, etc.)
Species_code	Species being violated
Court_date	Date of court appearance

entered into a database in ArcView. Each citation included the same information as the state-wide database (Table 1).

Law enforcement officers for the subdistrict were assembled, given a list of citations they had written during 1 July 1996 to 31 January 1999, and asked to manually plot the location of each citation onto 1:100,000 scale topographic paper maps for each county. All citation locations were then manually digitized into ArcView using the same topographic maps as a background reference coverage. The MDWFP citation number was used to reference each location to the main database of information.

The resulting GIS coverage was overlaid onto existing coverages of county lines, main highways, secondary roads, county roads, rivers, streams, outlines of cities, and outlines of national forests and wildlife refuges. State digital maps and all digital basemap information were provided by the Mississippi Automated Resource Information System (MARIS). Topographic maps at a scale of 1:100,000 were developed for each county and the subdistrict using SureMaps Raster digital scanned data (SureMaps Raster 1998. Horizons Tech., Inc. San Diego, Calif.).

Subdistrict wildlife citation data were examined in multiple ways. All citations were examined on the county and subdistrict level to look for unexplained "gaps" in enforcement efforts. Data were also examined by enforcement type (wildlife, fishing, or boating), species, officer, species within each violation type, and specific violation within each violation type. To examine the influence of a new program focusing on

waterfowl enforcement, waterfowl citations were plotted for the season of 1997–98 and 1998–99 for comparison. Numbers of citations were also graphed for analysis.

To determine an officer "sphere of influence" citations of individual officers were examined using minimum convex polygon estimation. ArcView Spatial Analyst (ArcView Spatial Analyst Vers. 1.1. 1998. Environ. Sys. Res. Inst., Inc. Redlands, Calif.) was used to develop surfaces of citation densities for individual officers and the whole subdistrict. This provided a different look at officer citation efforts. Individual officer citations were also looked at across years to determine changes in their "sphere of influence."

Results

State-Level Citations

One hundred and two waterfowl-related citations were written during the 1997–98 waterfowl season in Mississippi (Fig. 2*a*). The number of citations varied significantly by county, ranging from 0 to 22. A hunter harvest survey of portions of the state provides a partial pictorial summary of waterfowl harvest (Fig. 2b). Comparison of the 2 GIS coverages indicates either a lack of violations occurring in certain regions of the state, or a lack of emphasis being placed on waterfowl hunting by local conservation officers (Fig. 2).

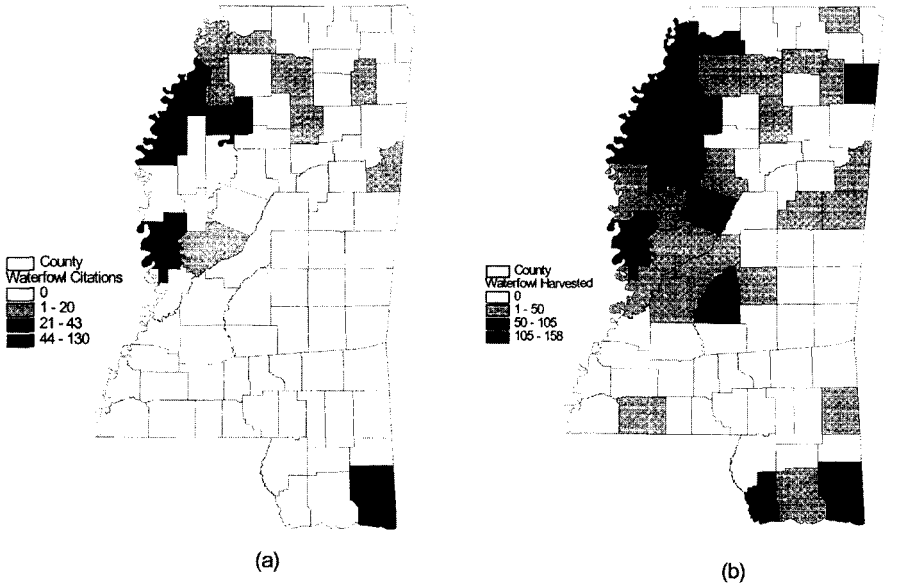

Figure 2. (a) Waterfowl related citations written between 1 July 1997 and 30 June 1998 and (b) numbers of ducks reported harvested by waterfowl hunters during the 1997–98 waterfowl season.

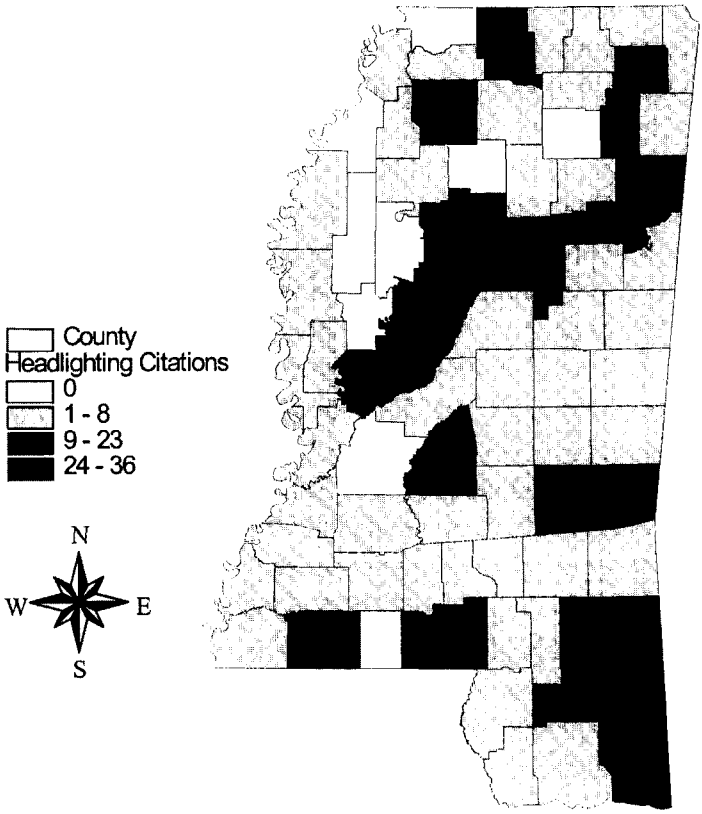

Figure 3. White-tailed dear headlighting citations written by the Mississippi Department of Wildlife, Fisheries, and Parks between 1 January 1996 and 31 January 1999.

Contrasting to the waterfowl violations is a state-wide assessment of white-tailed deer *(Odocoileus virginianus)* headlighting violations that were written during the period 1 January 1996 to 31 January 1999 (Fig. 3). Six hundred seventy-three headlighting citations were written across the state. Deer headlighting violations comprised 3% of the total number of violations written during this 3-year time frame.

District-Level Citations

Six records were not usable because officers were unable to recall the location of the violation. Five records were outside of the subdistrict in adjoining counties and were not included.

Examination of the subdistrict data immediately revealed apparent "gaps" where officers have not been working, or where they have merely not written citations for one reason or another (Fig. 4). A plot of the data by violation type revealed 767 wildlife violations (75% of total), 141 fishing violations (14%), and 115 boating violations (11%). Violations were written for 11 different wildlife and fish species.

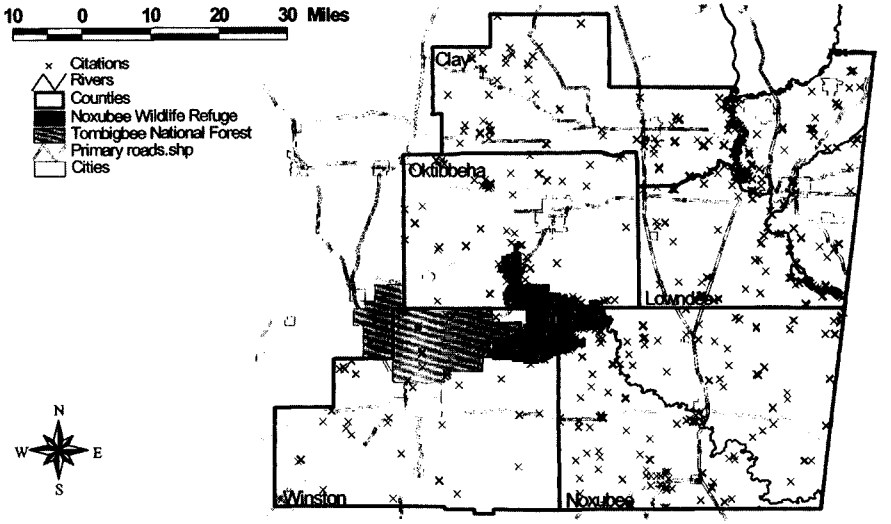

Figure 4. Specific location of wildlife law enforcement citations within Mississippi Department of Wildlife, Fisheries, and Parks' district 1, subdistrict C, 1 July 1996 to 31 January 1999.

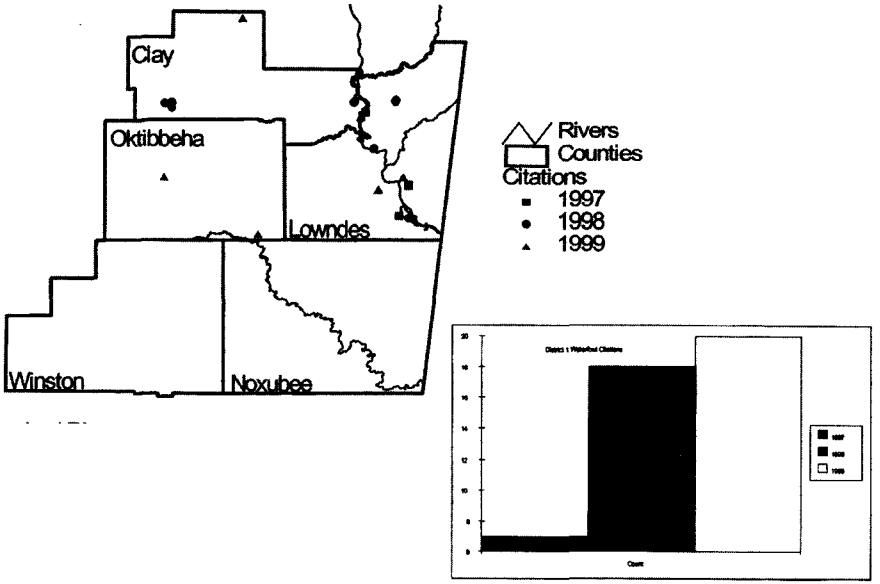

Figure 5. Specific location of waterfowl law enforcement citations within Mississippi Department of Wildlife, Fisheries, and Parks' district 1, subdistrict C, by year, 1 July 1996 to 31 January 1999. Bar chart represents the increase in citations written among years.

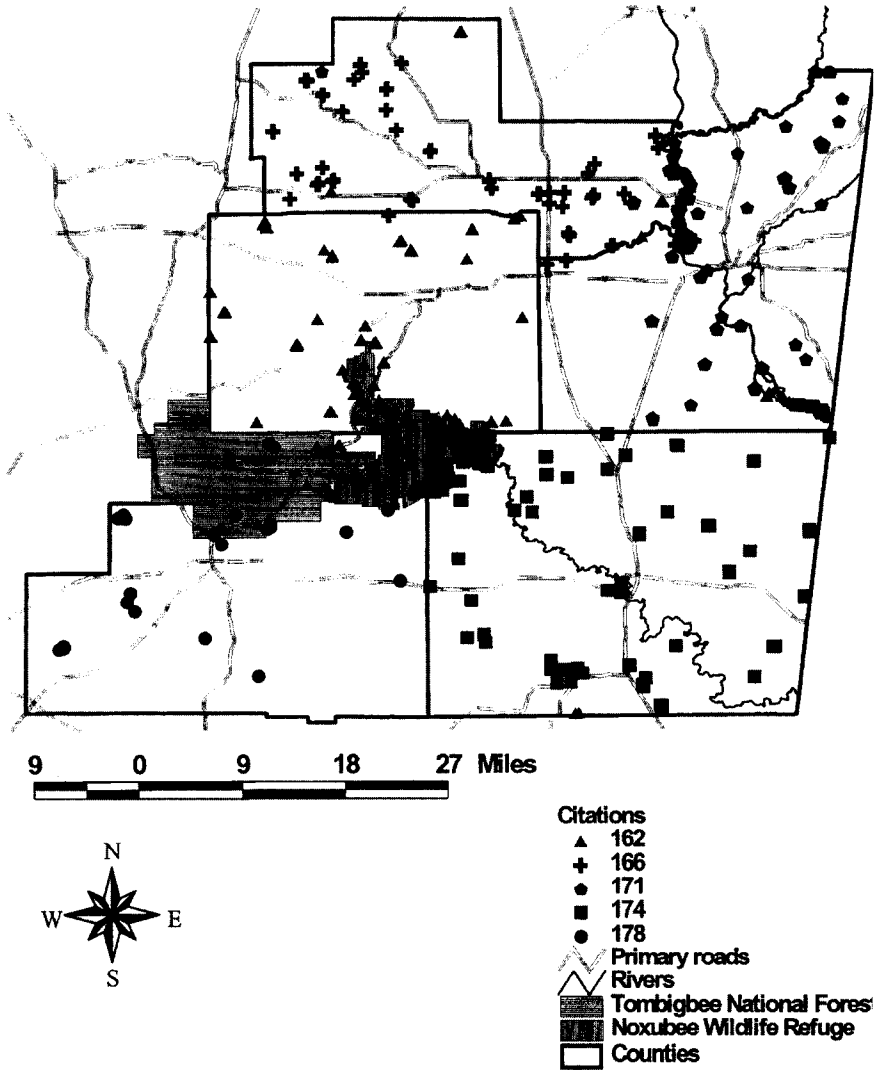

Figure 6. Specific location of wildlife law enforcement citations within Mississippi Department of Wildlife, Fisheries, and Parks' district 1, subdistrict C, by officer badge number, 1 July 1996 to 31 January 1999. Only 5 officer citations are shown for purposes of clarity.

The number of violations for each species ranged from 1 for coyotes *(Canis latrans)* and raccoon *(Procyon lotor)* to 463 for white-tailed deer.

During the 1998–99 waterfowl season, a program was implemented to emphasize waterfowl violations. Officers were asked to place a greater portion of their time on the activities surrounding waterfowl hunting. Officers in Subdistrict 1C did

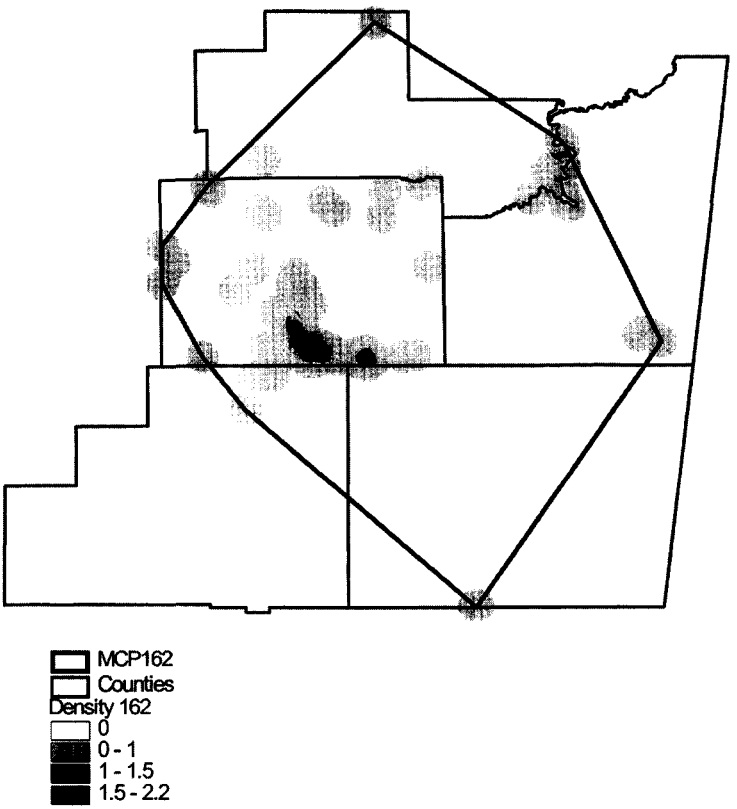

Figure 7. The minimum convex polygon estimation was used to calculate the "sphere of influence" of an individual officer. The density surface function was then used to refine the minimum convex polygon "sphere of influence" calculated using wildlife law enforcement citations within Mississippi Department of Wildlife, Fisheries, and Parks' district 1, subdistrict C, 1 July 1996 to 31 January 1999.

an excellent job and increased the number of waterfowl-related citations by 308% during this program (Fig. 5). A look at the spatial distribution of the citations, though, reveal that the emphasis was perhaps not equally placed throughout the subdistrict (Fig. 5).

Data were plotted several different ways to examine the "sphere of influence" of individual officers and the entire law enforcement group within the subdistrict. All citations were first coded by officer to get a complete picture of the subdistrict (Fig. 6). Citations for each individual officer were extracted and examined using minimum convex polygon home range analysis and density surface analysis (Fig. 7). Minimum convex polygon analysis provided the full extent of work coverage by each officer. The area covered by officers of this subdistrict averaged 1,426.3 km^2 with a range of 115.8 – 4,566.2 km^2. The density surface analysis was conducted on the entire subdistrict data set to determine the total area of influence for the region

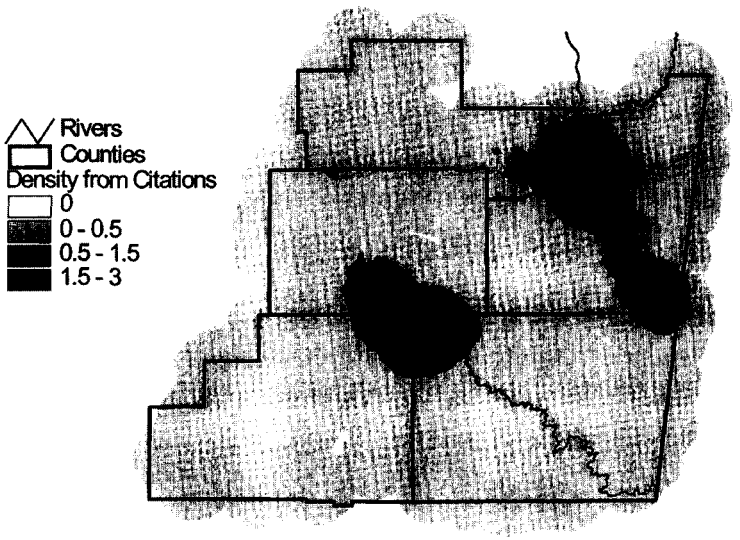

Figure 8. The density surface function was used to refine the minimum convex polygon sphere of influence of all conservation law enforcement officers using wildlife law enforcement citations within Mississippi Department of Wildlife, Fisheries, and Parks' district 1, subdistrict C, 1 July 1996 to 31 January 1999.

(Fig. 8). The density surface analysis does a good job of showing the user where officers are writing the most citations and, perhaps, having the greatest amount of influence on the wildlife user community.

Discussion

The data represented in this paper have implications at 3 different levels of law enforcement. Chiefs and supervisors would find data in figures 1–3 most useful in examining the influence of law enforcement on a state-wide basis. District supervisors would be most interested in the specific locations of citations throughout the entire district or subdistrict for evaluation of district level enforcement emphases and individual officer activities. Finally, officers could use the specific locations as an excellent self-evaluation tool and planning instrument for developing pro-active work habits.

Chiefs and Program Directors

The real value in using GIS technology in wildlife law enforcement is that it provides a new and effective means to summarize enforcement efforts, evaluate officer work habits, quantify and qualify violation data, and view citations in relation to other spatial information. Data in this paper are represented at 2 different scales, county-level information and cite specific information. Law enforcement chiefs and

program directors do not need to examine citation data on a cite specific level. They require a means to rapidly assess the effectiveness of the entire state-wide force. Therefore, data depicting citations on a county-by-county basis would be most useful (Fig. 1–3).

Even though the hunter harvest data are incomplete for the state, the picture is still visible. It is very clear from the waterfowl citation data and the hunter harvest survey that certain counties of the state are not being worked well for waterfowl or the hunters are not violating wildlife laws. Several counties have large numbers of ducks being harvested, and not a single violation being written. What may be depicted is a bias in interest in conservation officers across the state. Certain officers may choose to place emphasis on other species during the waterfowl season. An examination of the deer headlighting citations indicates that the officers are definitely working, just not on waterfowl. A chief or program director can at a glance notice these discrepancies and work with a district supervisor to alleviate the problems. Similarly, a program that places emphasis on waterfowl in subsequent years could be examined for effectiveness simply by examining a pictorial view of the two subsequent years' citations.

All of the states in the Southeast region were contacted to determine if GIS was being used for law enforcement. Only Virginia noted the use of GPS units to examine specific locations of citations, but only on a few specific water bodies. None of the states are currently using this technology on a state-wide basis. Every state indicated some form of database that is aggregated to the county level. These databases can be linked to existing digital databases of the state's counties in a matter of minutes. Chiefs and program directors would then have the capabilities of viewing citation data in this very informative manner.

District Supervisors

Examination of the cite specific data by a district supervisor would reveal some apparently large "gaps" in the subdistrict where officers are not writing citations. Upon closer examination, we can explain some of the "gaps." A large area in the east and southeast section of Oktibbeha County appears to be nearly devoid of citations (Fig. 4). This area is predominately urban or suburban, containing the city of Starkville and the Mississippi State University campus. Also a part of this region is the black prairie belt. The black prairie area is mostly open terrain that is under intensive agricultural production. In both cases, violations toward wildlife and fisheries would be expected to be limited in comparison to the rest of the county.

Other areas, such as the approximately 163.2 km^2 region in the southwest corner of the subdistrict cannot be explained. Either officers are not reaching the edge of their county, or few violations are occurring. If it is the former, this may indicate a larger problem than is currently visible. If the officers in Winston County do not fully reach the county edge, and officers in the adjoining 3 districts do the same, a large "gap" of unpatroled territory of nearly 648 km^2 could possibly exist.

District supervisors are always in need of finding appropriate tools to evaluate and examine the effectiveness of their officers. GIS could be one of those tools. A

district supervisor can examine the distribution of citations written by an individual officer to determine the area the officer is working, whether the officer is cooperatively working with officers in adjoining counties, and the officer's work habits seasonally, daily, and over years. It must be noted that a supervisor must make a judgement as to whether he is viewing the actual occurrence of violations, or the work habits of the officer. The data presented in this paper do not necessarily reflect actual violation occurrence, but rather an unknown combination of violation occurrence and officer effort. There is no variable that fully examines officer effort represented in these data.

Viewing data by individual officers can help the supervisor better manage individual officers and allow the supervisor to provide better feedback to the officer. Examination of an individual officer's citations by species may indicate that the officer is placing most of his emphasis on one or two species. During the fall season, multiple species are available for consumptive use, but an officer may only be working one of those species. This would be readily visible with GIS technology.

To be more effective at enforcing wildlife laws, it would be helpful to have a better understanding of where and when violations are occurring. GIS allows supervisors to examine specific violation types, such as headlighting for deer, to look at location of occurrence and trends. These could be depicted by time of occurrence, day of week, etc. to better understand each violation type. Supervisors could then guide officers' work habits to more efficiently work these violation types.

Individual Officer

An officer could use this as an excellent self-evaluation tool and planning instrument for developing proactive work habits. It should seem natural to question why violations seem to occur in some areas and not in others. If the officer can offer no apparent explanation, then it should warrant further investigation on the officer's part, or raise questions by his supervisor.

An obvious implication of this data is for an officer, especially a relatively new officer to a county, to use these data to "learn" his county and thus as a planning tool. A good example may be dove citations. Where dove citations have been issued in the past would indicate the location of a dove field that has been a problem location in the past. An officer can examine the past dove violations and examine these locations prior to dove season. These data also will allow an officer to better plan his route of enforcement on the opening of season.

If an officer incorporates habitat information for these areas, he could look at other similar areas in his county for possible violations. A land cover map for his area could provide insights into areas less traveled. He may be able to find "out-of-the-way" areas that may need additional attention.

Finally, a group of officers can examine the degree of overlap or avoidance they have with one another. If 2 officers do not fully reach the edge of their territory, a large amount of land can be left unpatroled. These data show such areas very clearly (Fig. 6).

Implications

The use of GIS in wildlife law enforcement can provide invaluable information to Chiefs, supervisors, and officers. Chiefs and supervisors can examine individual citation types such as headlighting, commercial fishing, and other major violations on a state-wide basis to depict areas that need attention. District supervisors can use the specific citation locations to determine "sphere of influence" and tendencies to work in adjoining counties, or on specific projects, etc. for individual officers. Individual officers can use these program to do a self-evaluation on performance. It can also help a new officer "learn the county" at a much faster rate by being able to find where problems have been in the past.

Examination of these data will require making judgements as to whether we are measuring actual occurrences of violations or the work habits of officers, and will also be meaningful if data is collected for assisting officers. The ultimate goal should be to provide the means and assurance that enforcement becomes more pro-active and efficient at helping to manage and protect our wildlife resources.

Literature Cited

Anon. 1991. Mapping the latest trends in GIS technology in law enforcement. Am. City and County 106(5): 38pp.

Anon. 1998 Southeast Association of Fish and Wildlife Agencies Vital statistics 1997. NC Wildlife Resources Commission. 212 pp.

Quist, J. 1999. GIS crime mapping improves public safety. Nation's city weekly.