GIS: A Tool for Analyzing and Managing Deer Damage To Crops

by

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ABSTRACT

A common problem of biologists and agriculturists trying to control white-tailed deer (Odocoileus virginianus) damage to crops is understanding the causes and alternative solutions to the damage over multi-county or state-wide areas. Deer damage a variety of crops in different ways at different times of the year. Crops damaged, types of damage, and damage severity are influenced by deer densities, distributions, movements and harvest, as well as field size and interspersion with surrounding land cover types and uses. The complexity of the interaction of these factors requires improved analysis if the most appropriate control methods are to be selected.

Geographic information systems (GIS) provide an efficient method to examine these factors, analyze their interrelationships, graphically depict how they interrelate, and assist in predicting future problems. Such an analysis also suggests why certain damage patterns occur where and when they do, where additional information is needed, the best format for data collection, and which damage control strategies are most likely to be successful in given areas.

The CRIES GIS was used to examine the deer damage problem in Michigan. Selected data on deer harvests, populations, and crop statistics were categorized, digitized and mapped. Data were combined in overlay maps and these provided a useful tool in examining patterns of deer damage. Various areas within the state were then delineated as separate deer damage problem areas and possible control strategies for each were proposed. Data necessary for an improved analysis of the deer damage problem were identified, as were problems in the present collection, tabulation and analysis of data. Recommendations were developed for the use of GIS in deer damage control.

INTRODUCTION

A common problem of biologists and agriculturists trying to control deer damage to crops is understanding the causes and alternative solutions to the damage over multi-county and state-wide areas. The population of white-tailed deer (Odocoileus virginianus) in Michigan has been estimated to have increased from 800,000 in 1977 to 2 million in 1989 (Langenau, 1989). This increase has resulted in some exceptional opportunities for recreation in the state. Michigan is the number 1 bowhunting state and in the top 5 deer firearm hunting states in the nation in terms of deer harvested, and over $300,000,000 accrues annually to Michigan from deer hunting (Wildlife Division, MDNR).

However, agriculture is also a major contributor to Michigan's economy and deer are causing serious damage to a variety of crops throughout the state. For farmers in certain local areas, the damage is economically devastating. Seven fields studied by the Cooperative Extension Service (CES) of MSU and the Michigan Department of Natural Resources (MDNR) showed that in these selected fields, deer damage to alfalfa ranged from 10-20% of the total yield and deer damage to red kidney beans ranged from 19-44% of total yield. Two Christmas tree growers, who counted the total number of trees that were unmarketable in a current year due to deer damage both tallied their losses in excess of $100,000 per year. While these figures reflect severe situations that are not typical for croplands across the state, they do serve to illustrate the impact that deer can have on certain farmers.

The MDNR has taken active steps to control deer populations in problem areas of the state through liberal deer harvest regulations, but agricultural interests continued to be concerned and early in 1988, requested the MSU Agricultural Experiment Station (AES) and the Cooperative Extension Service (CES) to direct their resources towards finding some solutions to the damage problems. The Department of Fisheries and Wildlife in the College of Agriculture and Natural Resources was asked by AES and CES to form a committee to make recommendations to direct AES and CES efforts.

The Deer Damage Committee (DDC) of the Department of Fisheries and Wildlife hypothesized that the deer damage problem in Michigan is especially difficult because it really is an aggregate of different types of problems. Therefore, generalized trends or solutions may not exist.

The DDC established the following objectives:

1. to provide a basis for considering the crop damage situation as not one, but a multitude of problems with variable characcteristics and often different potential solutions;
2. to classify deer damage problems in Michigan based on such factors as crop type, deer density,

management opportunities and constraints, temporal considerations, etc.;
3. to the extent possible, relate the taxonomy of damage problems to geographical regions, available strategies and techniques for controlling damage, and for research and communication needs;
4. to seek and include input from key agencies and personnel involved in the crop damage problem.
5. to consider the role of diverse public attitudes as a component of the issue and as an influence (constraint or catalyst) on the implementation of damage control methods; and
6. to suggest research and communication priorities; and provide a structure for guiding AES and CES short and long term responses to the deer damage situation.

Because much of the variation in deer damage is due to geographical differences, a geographic information system (GIS) was chosen as the best method for accomplishing objectives 1-3. This report describes the use of the GIS for problem definition and analysis and an evaluation of its potential utility for dealing with deer damage to crops in Michigan.

METHODS

A variety of factors influence the extent of deer damage and include but are not limited to types of crops, types of damage, deer density, distributions, movements and harvest, as well as field size and interspersion with surrounding land cover types and uses (Fig. 1). The complexity of the interaction of these factors requires improved analysis if the most appropriate damage control methods are to be selected.

We chose, as our primary data analysis tool, to graphically display the data on maps of the state. By overlaying selected maps we could compare information that was collected for different political units (e.g., the MDNR reports the number of antlerless permits issued by deer management units while crop statistics are reported by county). To standardize our comparisons and minimize the effects of extraneous factors (e.g., random year to year fluctuations), we analyzed data collected for the same year. Though we began our analyses in the spring of 1988, 1986 was the most recent year for which the statistics were available, except fruit and hay production data which were most recently available for 1982.

Information on deer densities, deer management statistics, deer-vehicle accidents, and crop statistics were compiled from a number of sources. These data were condensed, tabulated and summarized, and mapped on a county area base map (political boundary map) except for antlerless deer permits issued per square mile, which were mapped in deer management units (Fig. 2) digitized from the 1986 hunter's choice deer license application guide. Analysis and display of these digital data were on the CRIES geographic information system (Schultink et al. 1987) on a personal computer. This method allowed data to be combined in maps and provided a valuable tool in looking for patterns of relationships in the deer damage problem. However, the lack of data on some variables and the need to simplify data necessarily introduced some artifacts and the results should be viewed with that limitation in mind.

Crop and Forest Product Distributions

Michigan produces a variety of crops and forest products. All of these have some potential for deer damage problems. Information on crop production was obtained from the Michigan Department of Agriculture. We emphasize deer damage problems to corn (Fig. 3), beans (Fig. 4), potatoes (Fig. 5), hay (Fig. 6), and fruit trees (Fig. 7) because these crops represent those most affected by deer damage in the state. Other crops such as melons, carrots, beets, oats and barley, can suffer significant local problems, which should not be ignored, but were not felt to be of the same magnitude as for the five featured crops. In addition, Christmas trees also can incur considerable amounts of deer damage (M. Koelling, pers. comm.), but were not included in our analysis.

Units of measure vary by crop, but each crop is presented in relative categories of no production, and low, medium, and high production. Bean production was compiled by adding the production of soybeans, navy beans, and colored beans. Fruit tree production was compiled by adding production values of cherries and apples.

Deer Densities

Several methods have been tried to estimate deer densities in different areas within the state. Pellet group counts have been used by the MDNR in the Northern Lower Peninsula and the Upper Peninsula. The data produced by this method provide an index of relative changes in deer numbers, but are an indirect measure of actual population densities. Estimates have also been made based on the buck harvest in different districts of the MDNR (Langenau, pers. comm.). This method assumes that a certain percentage of the bucks are harvested in each area, and that the sex-age ratios of the herd are constant. It does not take into account variations in hunting intensities in different areas. Thus, both of these methods have limitations which make it difficult to use actual data for delineating areas of differing deer densities. We, therefore, determined estimates of deer densities based on a combination of these methods. Densities of deer were placed in high, medium or low categories for each county (Fig. 8). It should be further noted, that within a county, deer densities will vary from area to area. Deer densities will also vary seasonably, as will habitat use.

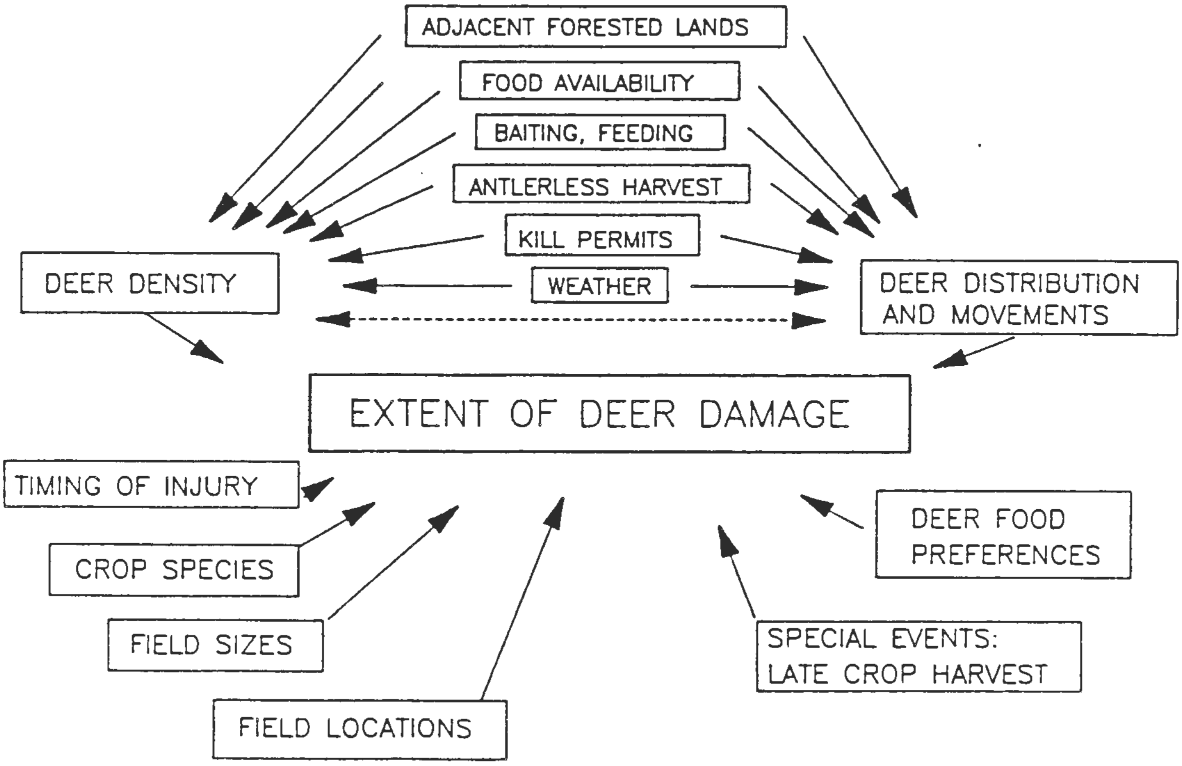


Figure 1. **Hypothesized Factors Influencing Deer Damage**

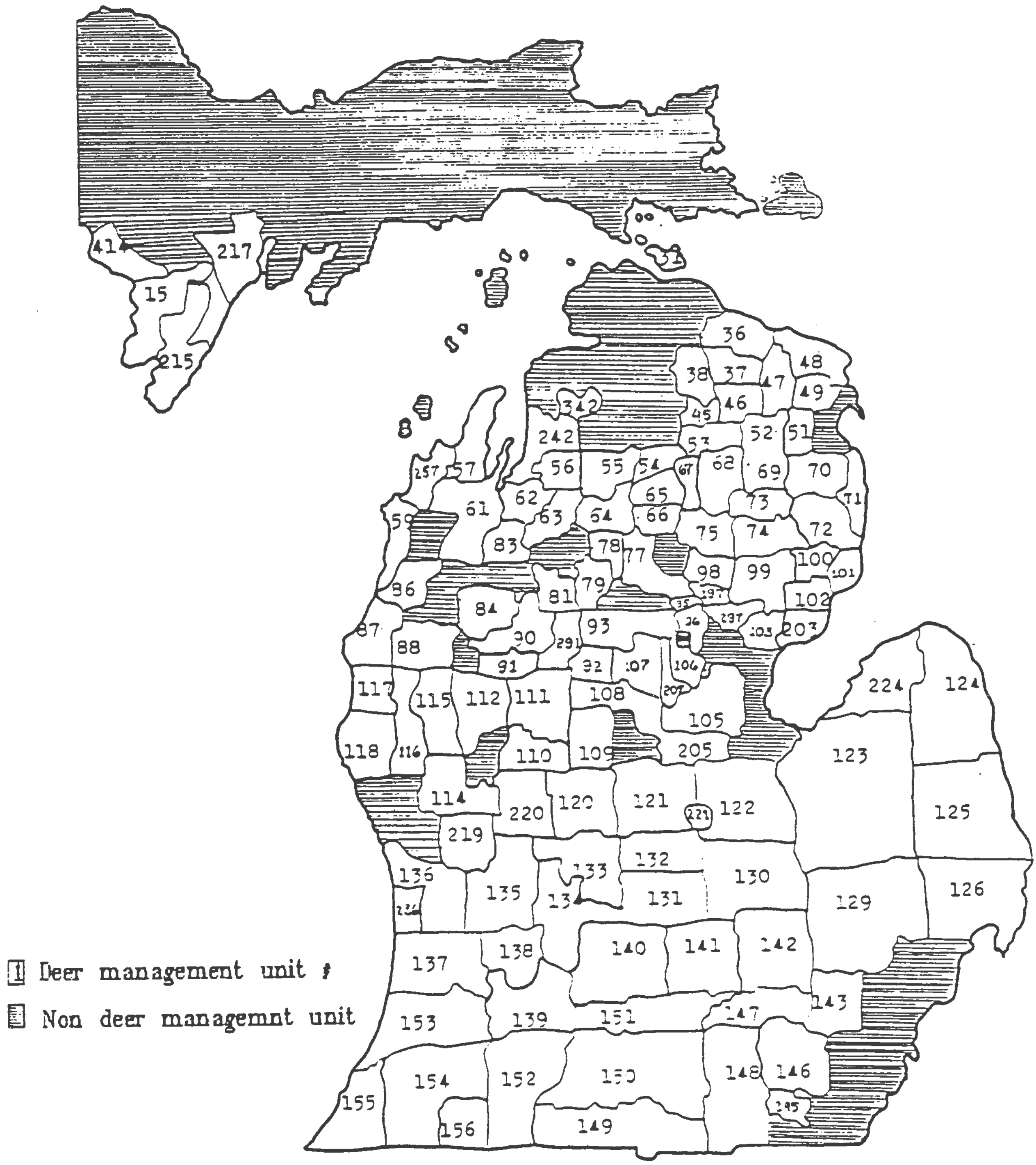


Figure 2. MDNR Deer Management Units, 1986

Figure 3. Corn Production by County (in Million Bushels), 1986

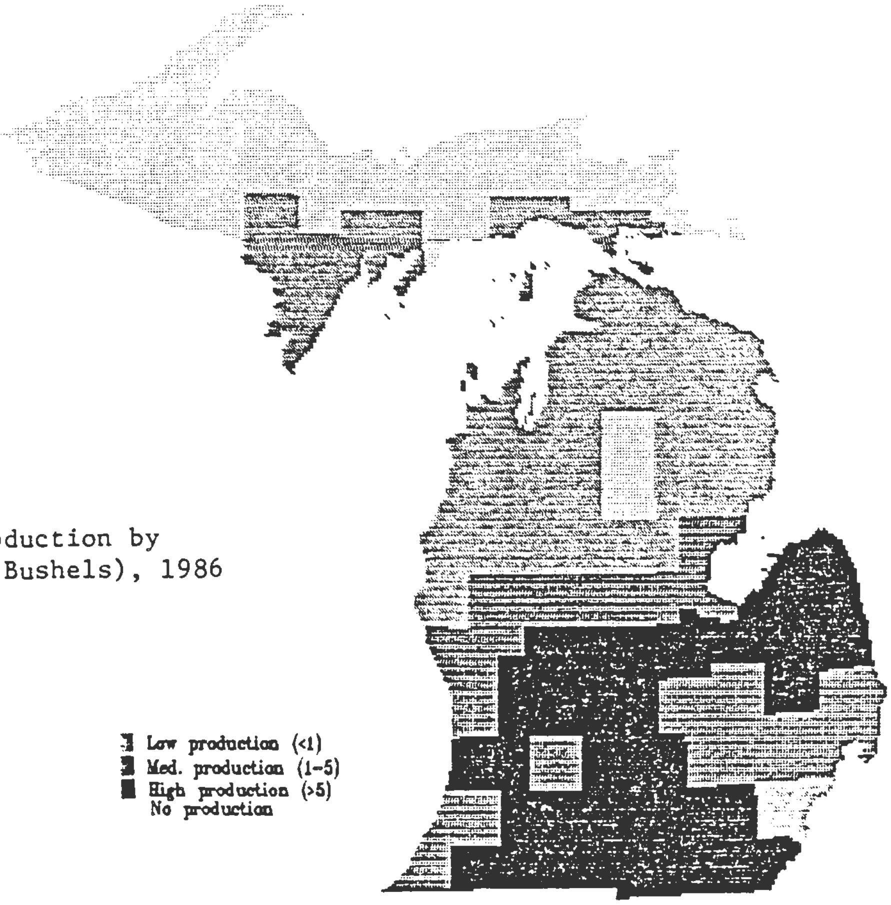
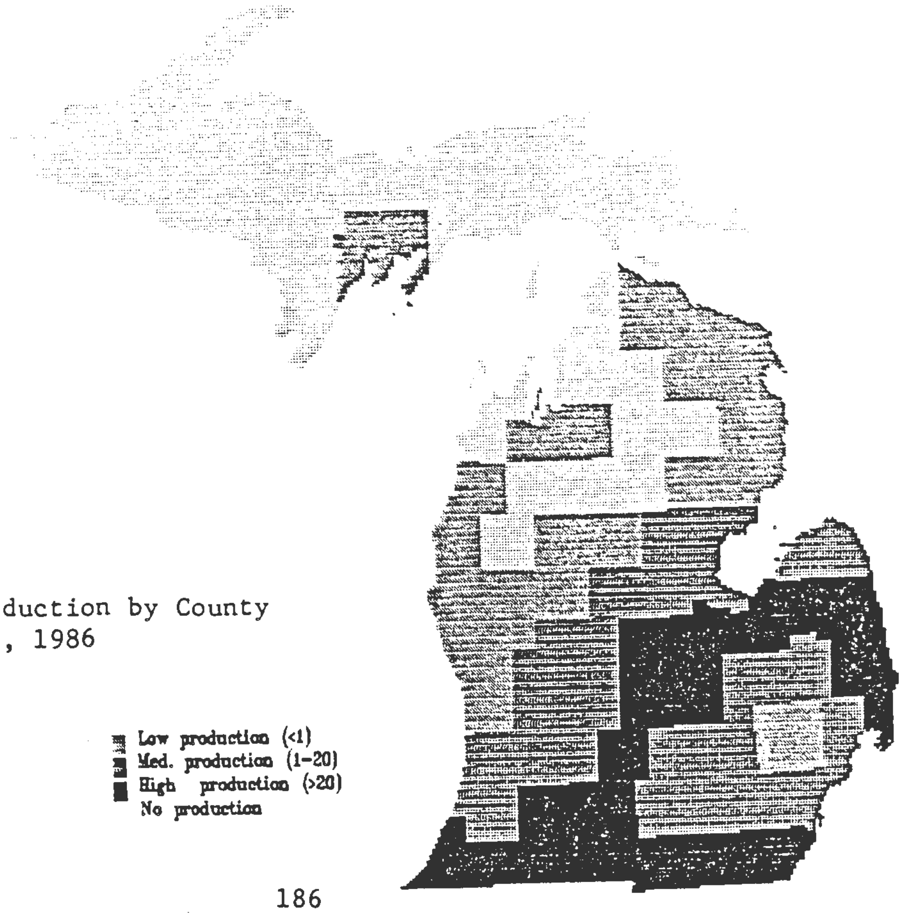


Figure 4. Bean Production by County (in Thousand Acres), 1986



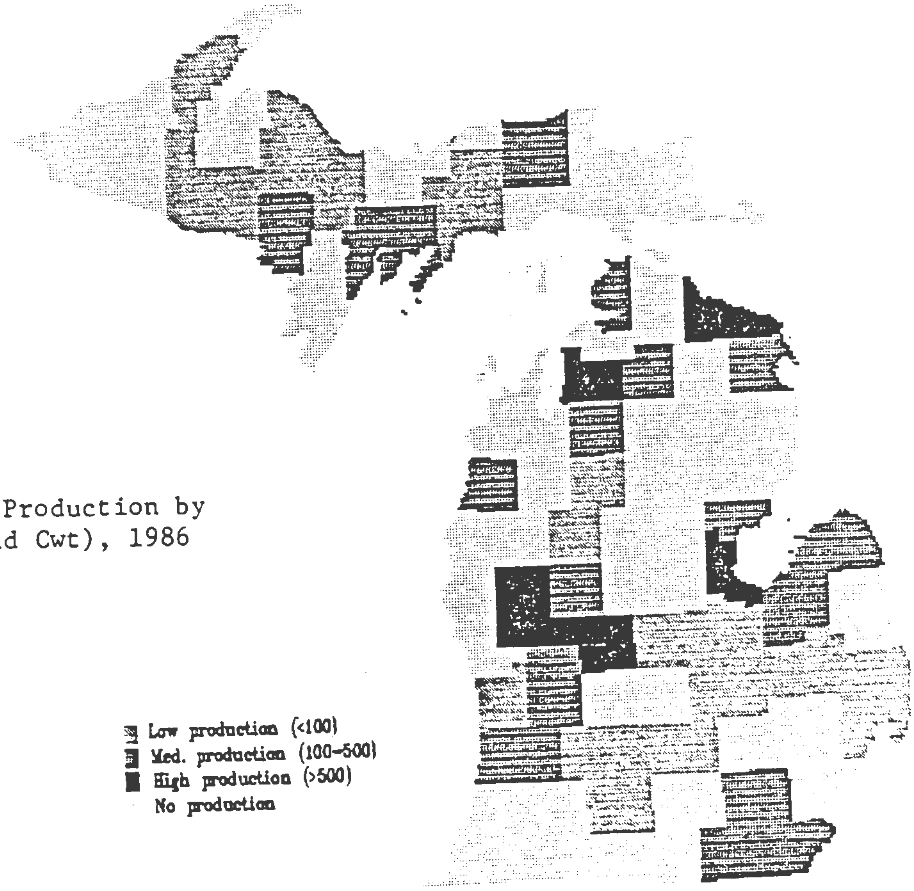


Figure 5. Potato Production by County (in Thousand Cwt), 1986

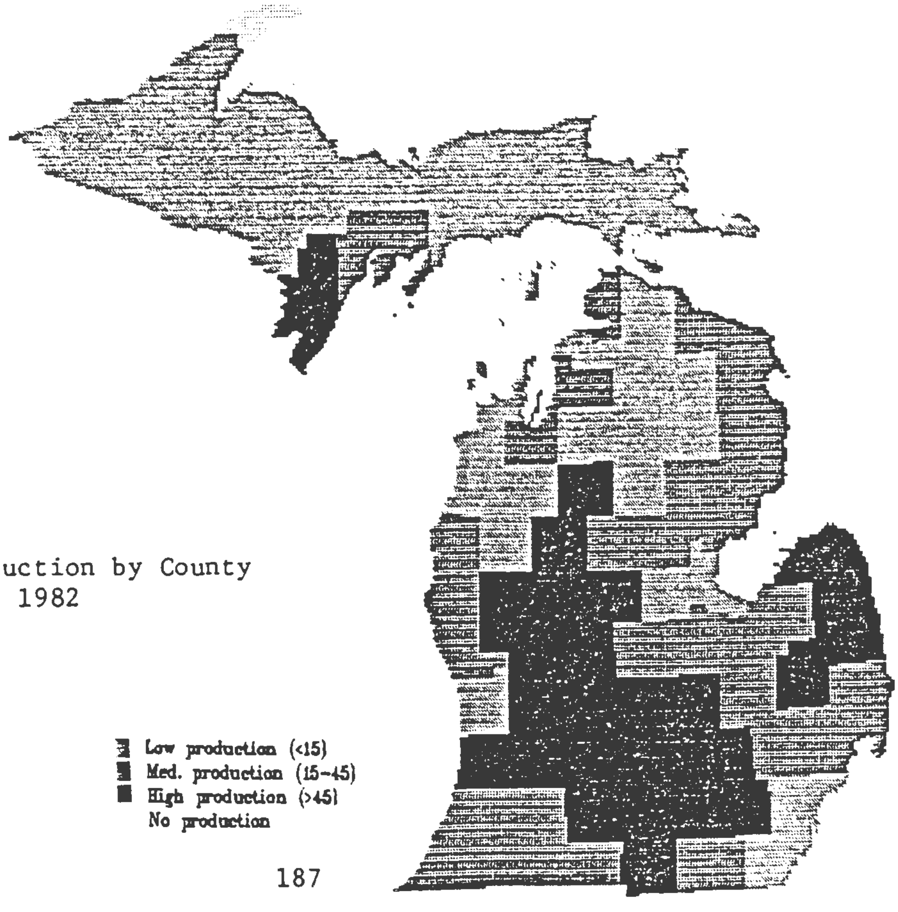


Figure 6. Hay Production by County (in Thousand Tons), 1982

Figure 7. Fruit Tree Production by County (in Million Lbs), 1982

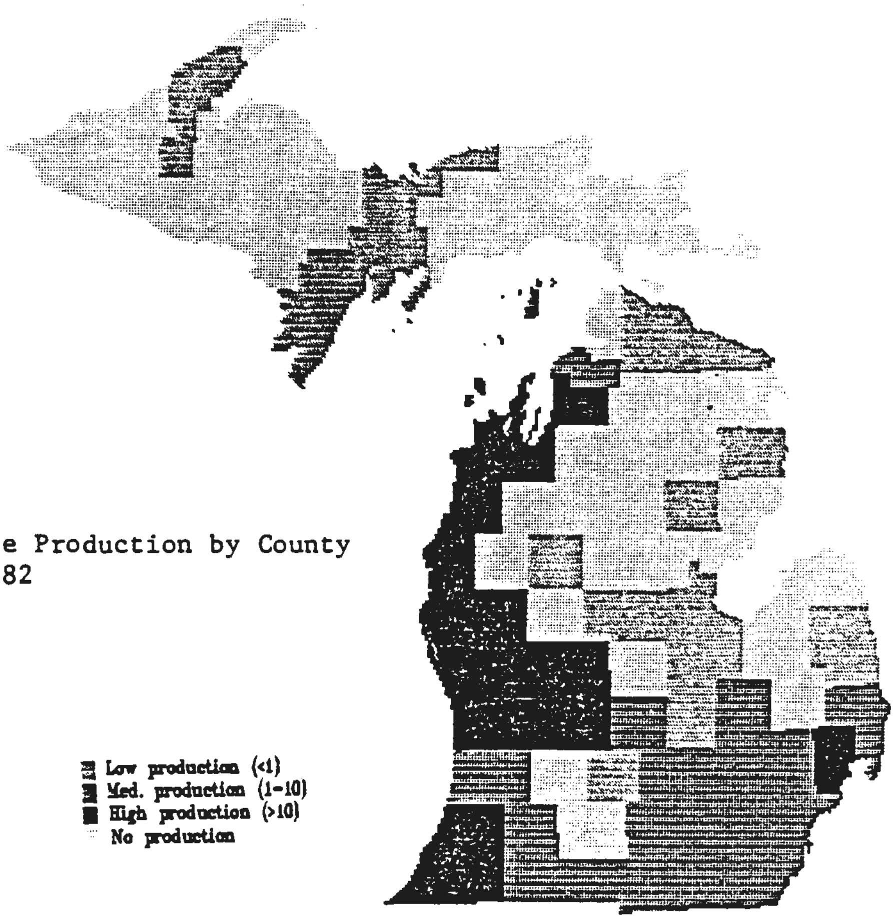
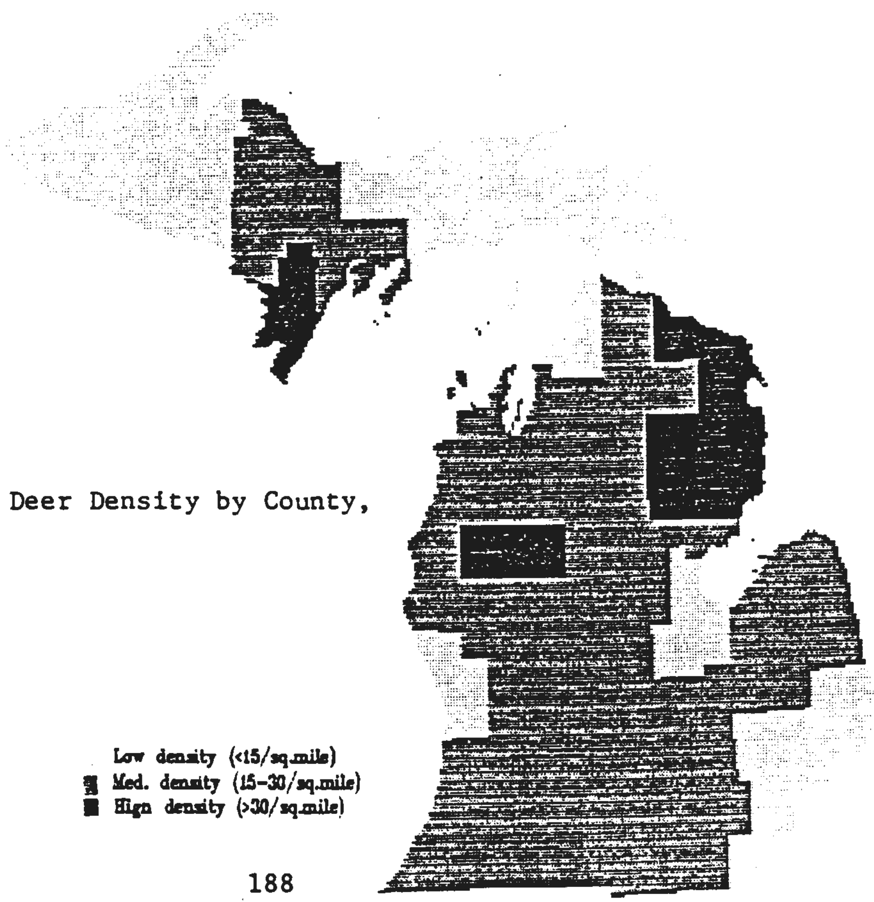


Figure 8. Estimated Deer Density by County, 1986



Another indicator of the size of the deer population is the number of deer-vehicle accidents recorded in each county. Data (Langenau and Rabe, 1987; Langenau, Pers. Comm.) are presented as the number of deer-vehicle accidents reported in 1986 per millions of traffic miles (Fig. 9). While the accuracy of these data is good, the number of accidents is a function not only of deer numbers and traffic miles, but also of road conditions, deer movement patterns, and vegetation patterns. Deer-vehicle accident rates within a county were also compared over time and can be used as one index of changing deer numbers. Data on the change in deer-vehicle accidents by county from 1980 and 1986 are presented in Figure 10.

RESULTS AND DISCUSSION

Evaluation of the data maps reveals the extent of variation in the factors affecting deer damage. Crop production varied throughout the state for each of the five crops considered. Similarly, deer parameters also varied widely. For example, Menominee county and counties in the west-central portion and northeastern corner of the lower peninsula had a high number of deer-vehicle accidents in 1986 (Fig. 9). Most of the counties in the southern half of the lower peninsula tended to have a low number of deer-vehicle accidents per millions of traffic miles. Only a few of the counties in both the northeastern and northwestern areas of the lower peninsula showed both high numbers of deer vehicle accidents and a high rate of change from 1980 to 1986 (Fig. 10). High rates of increase were also noted surrounding several urban/suburban areas including Detroit, Midland and Muskegon (Fig. 10). Ionia and Missaukee were the only two counties that reported a decrease in the deer-vehicle accident rate, 15% and 40%, respectively.

When deer densities (Fig. 8) are compared with the total number of permits issued to kill deer when they are causing damage (Fig. 11), it is apparent that deer density does not always correspond with damage as measured by the number of kill permits issued. Note that no kill permits were issued in portions of the high or medium deer density areas of northeast and southern Michigan. However, when fruit tree production (Fig. 7) is compared with deer density (Fig. 8) and kill permits issued to prevent damage to fruit trees (Fig. 12), areas of medium to high production correspond to areas of medium to high deer densities and medium to high numbers of kill permits issued. A notable exception is southwestern Michigan where deer densities are medium, fruit production is high and yet no kill permits were issued in this area. This discrepancy may be explained by 4 factors:

1) orchards and vineyards in southwestern Michigan are large and interspersed with other forms of agricultural production as opposed to the smaller orchards interspersed with large tracts of public and private forested lands of northwest Michigan;
2) deer-vehicle accidents per million miles of traffic traveled (Fig. 9) are low to medium in this area as compared to other high fruit production areas where the deer-vehicle accident rate is medium to high, thus suggesting that deer densities in the southwest may be on the low end of the medium range;
3) winters in southwestern Michigan tend to be milder, thus allowing deer a greater abundance and variety of available foods;
4) criteria for issuing damage control kill permits differ among district biologists.

When comparing bean production (Fig. 4) with deer density (Fig. 8) and the number of permits issued to kill deer when they are damaging beans (Fig. 13), it is apparent that medium bean production and medium to high deer densities correspond to a medium to high number of kill permits issued. High bean production and medium deer densities correspond to low or no kill permits issued. These relationships suggest that deer damage is excessive in beans only where fields are relatively small and interspersed with woodlands and where deer densities are medium to high. The situation in the Saginaw Bay area is more difficult to interpret perhaps because this area has a wide variety of vegetation types not well interspersed that include woodlands, wetlands, large agricultural fields, 3 major metropolitan areas and a national wildlife refuge. Obviously, it is difficult to make generalizations about this area.

When comparing hay production (Fig. 6), deer density (Fig. 8) and kill permits issued (Fig. 14), the relationship is obvious. Kill permits to control damage to hay are issued only where hay is produced and deer densities are high. Significant damage to hay only occurs or becomes apparent in areas where deer densities are high.

There seems to be no consistent relationship among potato production (Fig. 5), deer density (Fig. 8) and kill permits (Fig. 15) issued to prevent damage to potatoes. Some biologists believe that digging up potatoes is not a common deer behavior and that unless the local deer population learns this behavior, the behavior is sporadic or non-existent. If true, this may explain the inconsistent relationship.

When comparing corn production (Fig. 3), deer density (Fig. 8) and kill permits issued for corn (Fig. 16), it is obvious that areas of high corn production and medium deer densities are not areas where a high or medium number of kill permits are issued. Kill permits are most frequently issued where deer densities are medium or high and where corn production is medium or low. These relationships may again reflect the effect of field size and interspersion with surrounding land use on deer damage and/or may show that agricultural producers may tolerate more deer injury to corn or may notice it less than injury to other crops.

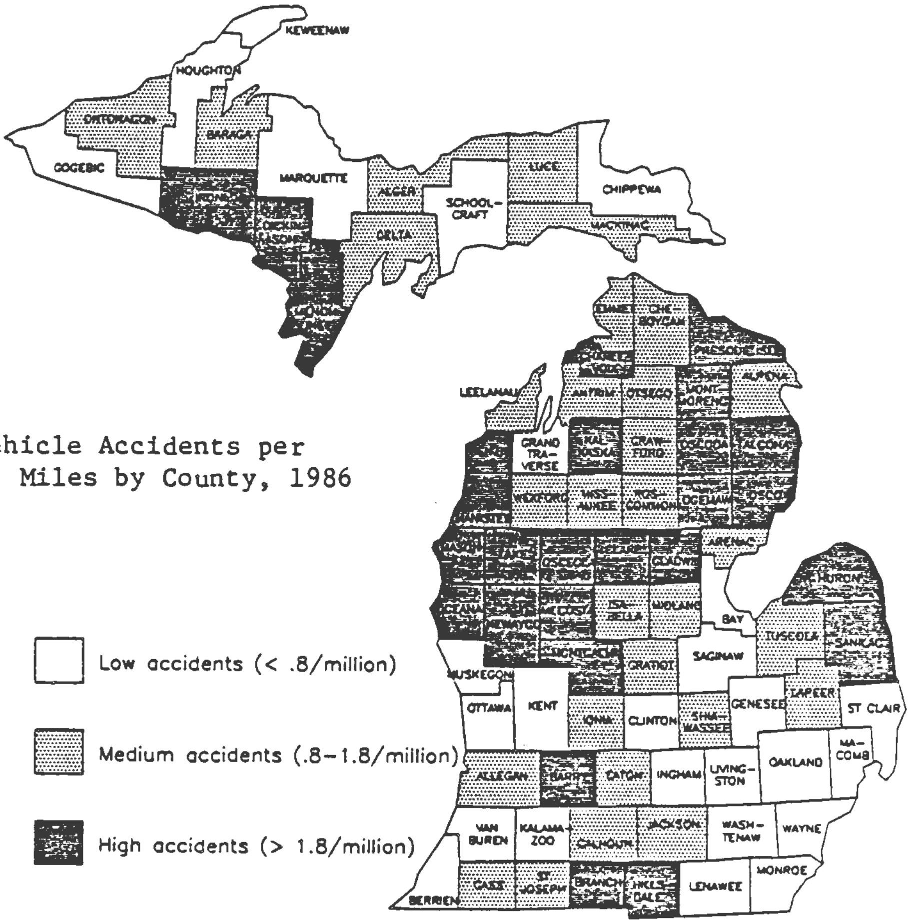


Figure 9. Deer-Vehicle Accidents per Millions of Traffic Miles by County, 1986

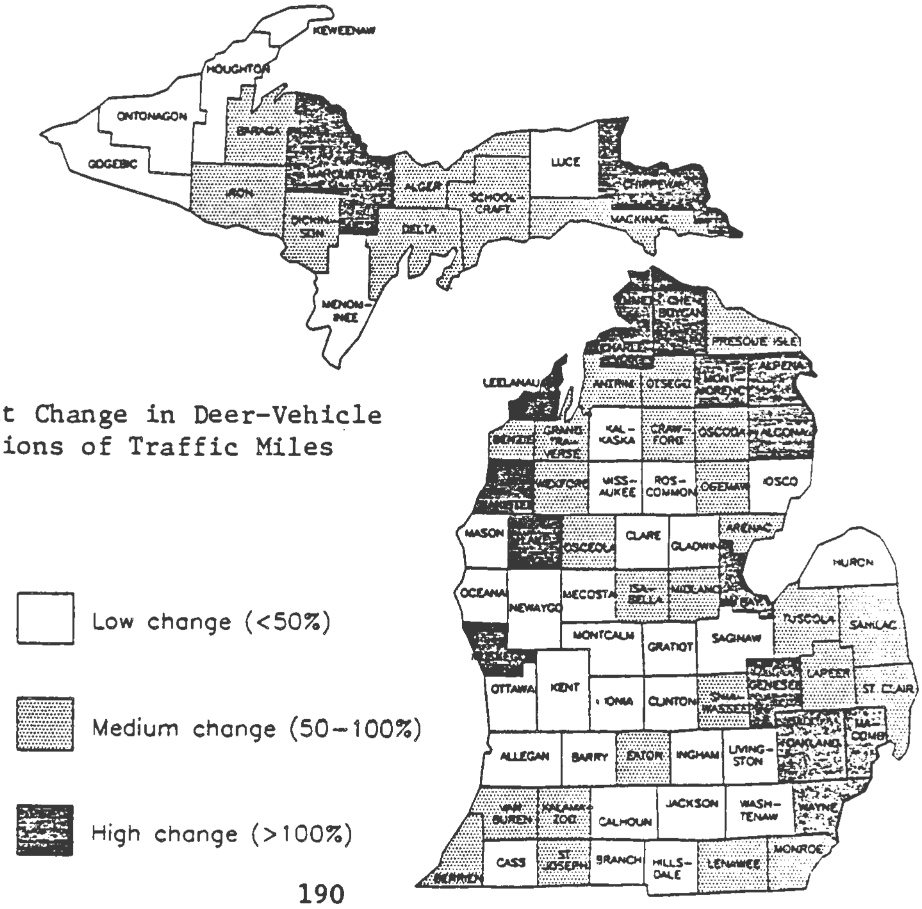


Figure 10. Percent Change in Deer-Vehicle Accidents per Millions of Traffic Miles from 1980-1986

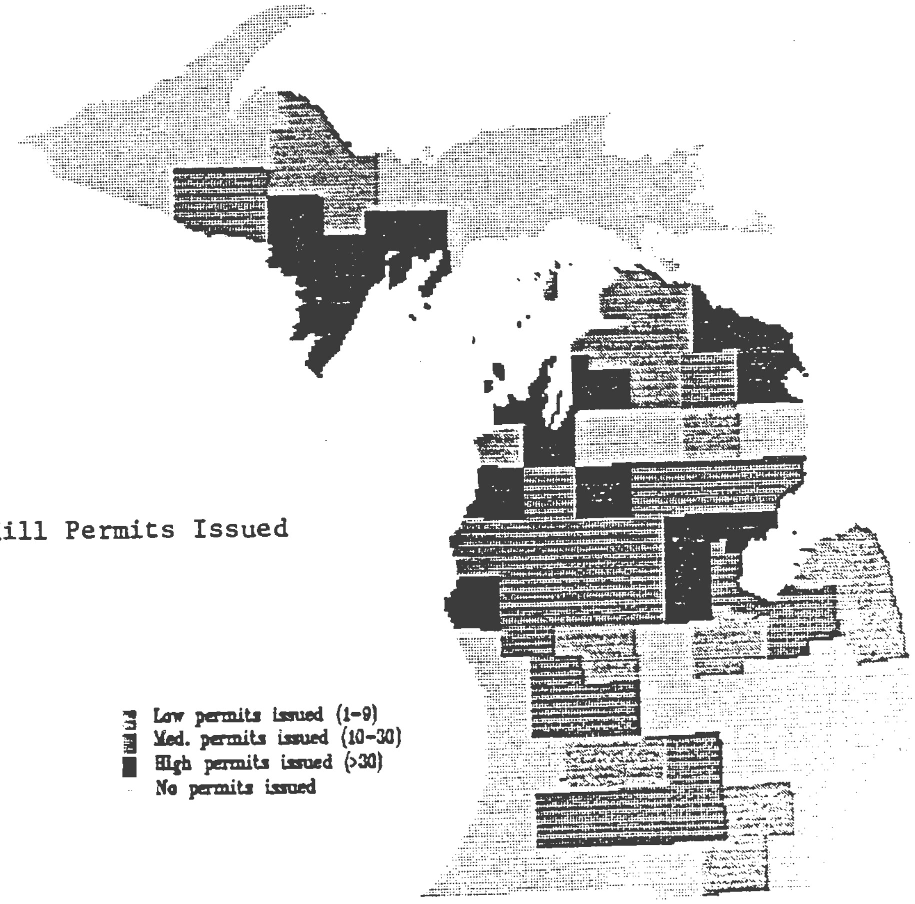


Figure 11. Total Kill Permits Issued by County, 1986

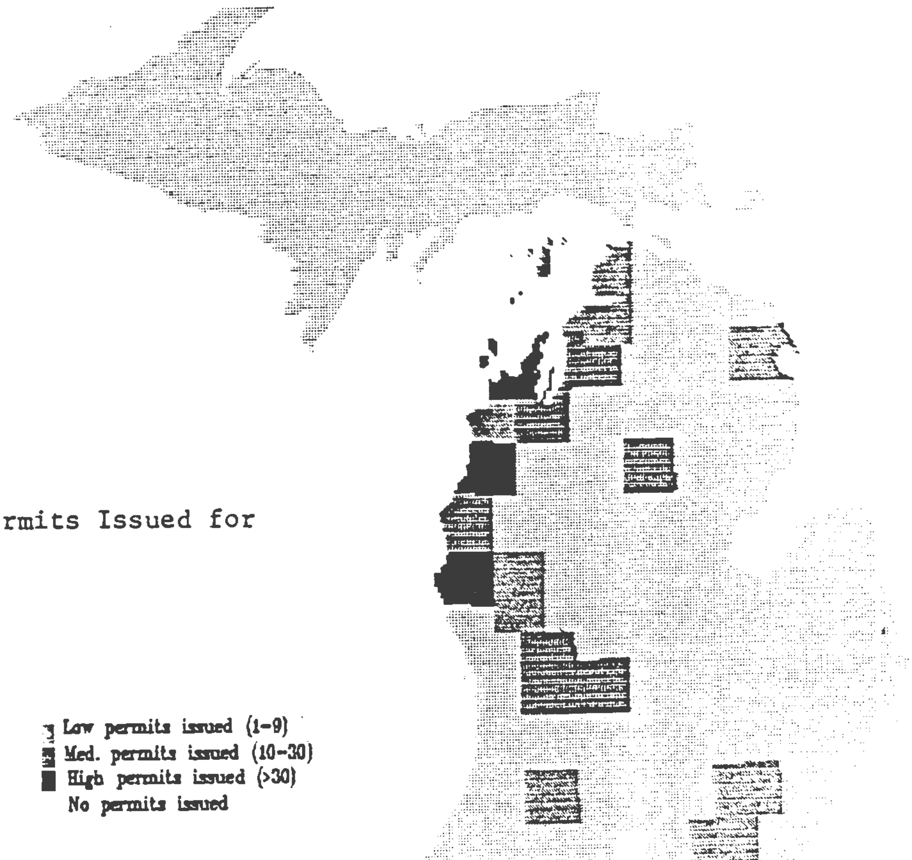


Figure 12. Kill Permits Issued for Fruit Trees, 1986

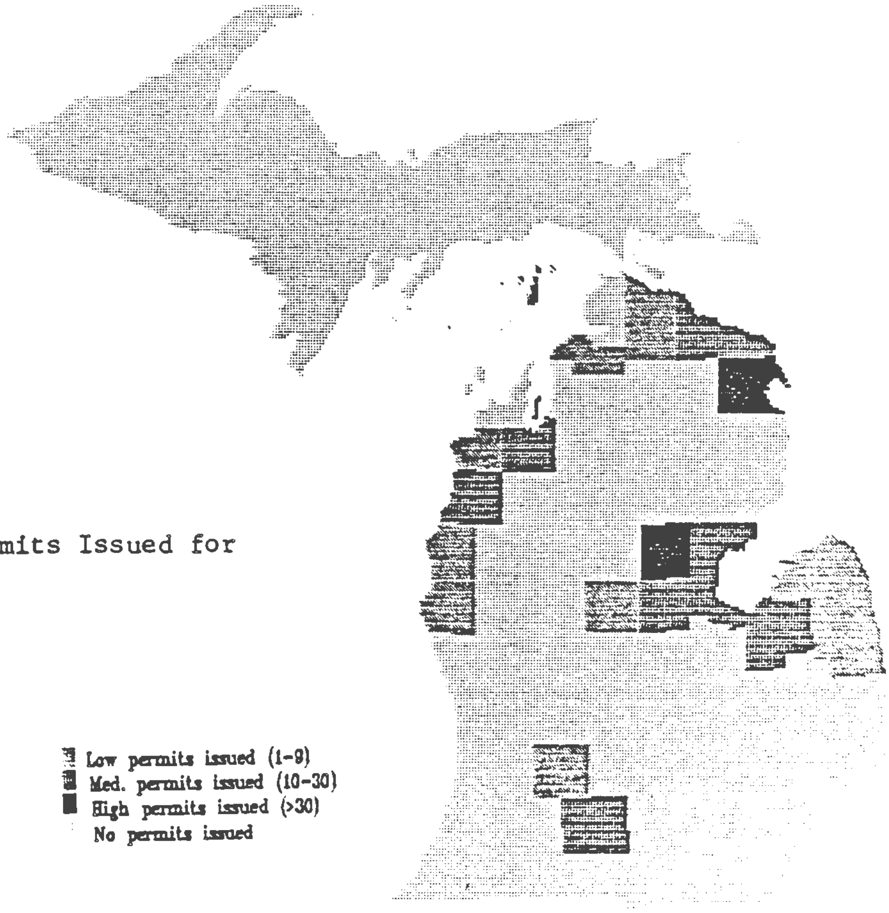


Figure 13. Kill Permits Issued for Beans, 1986

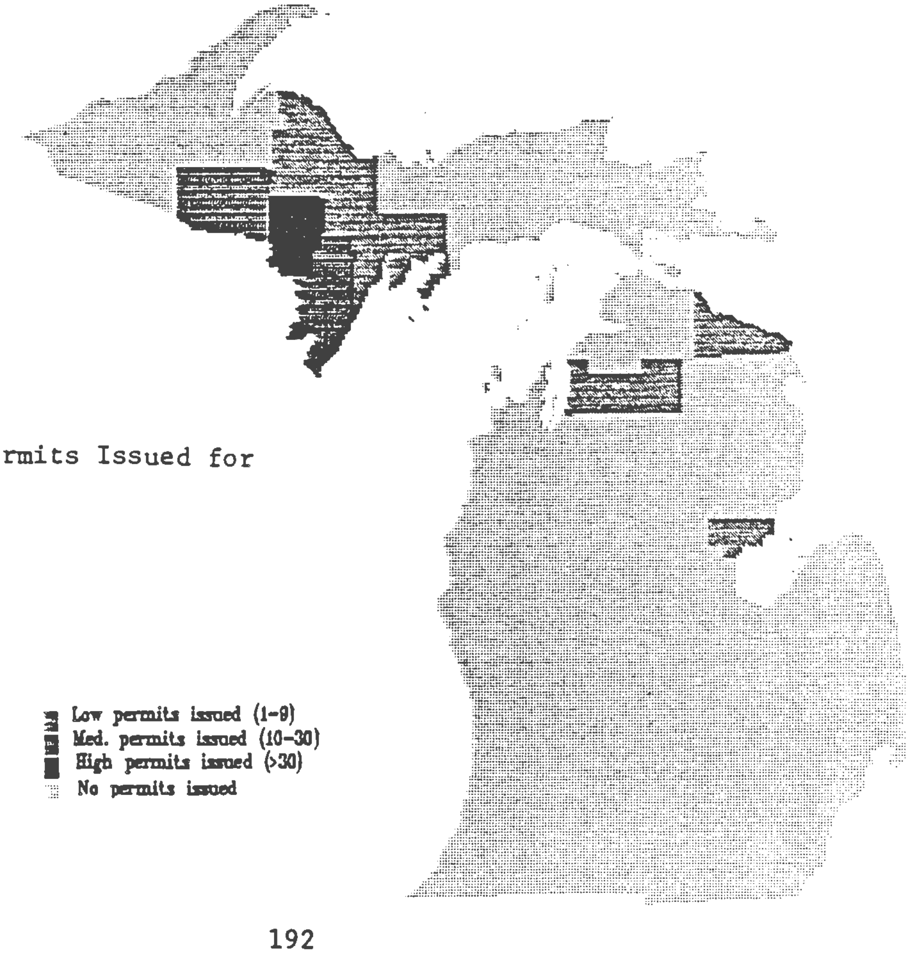


Figure 14. Kill Permits Issued for Potatoes, 1986

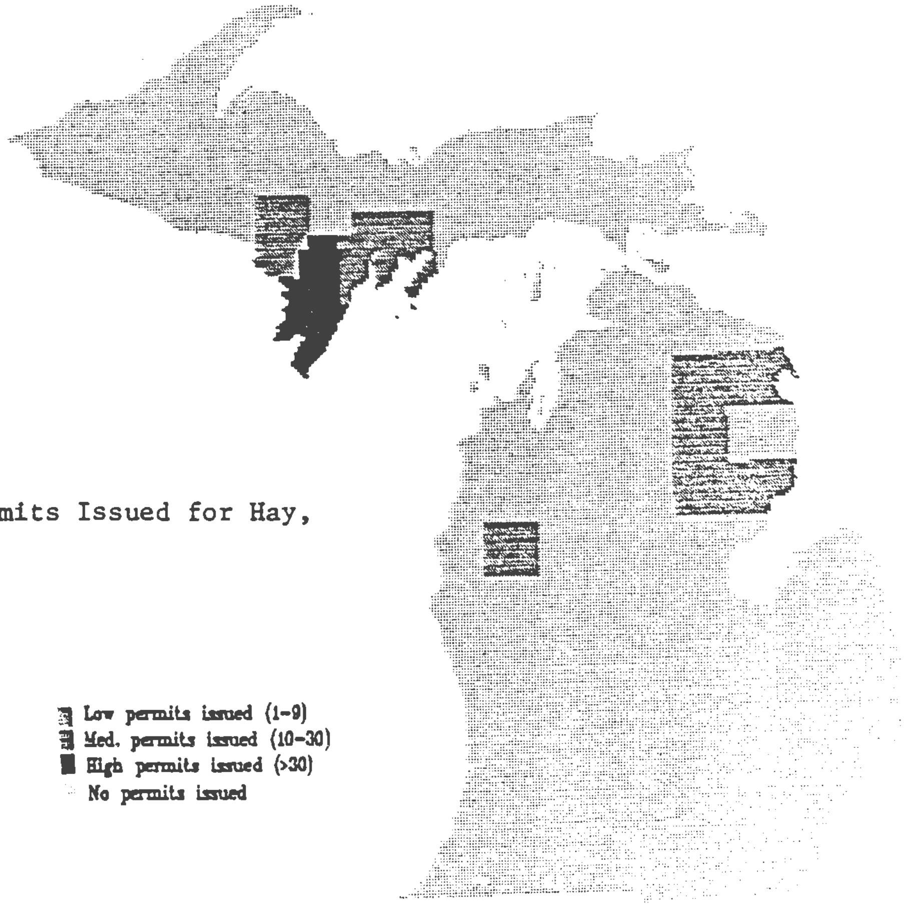


Figure 15. Kill Permits Issued for Hay, 1986

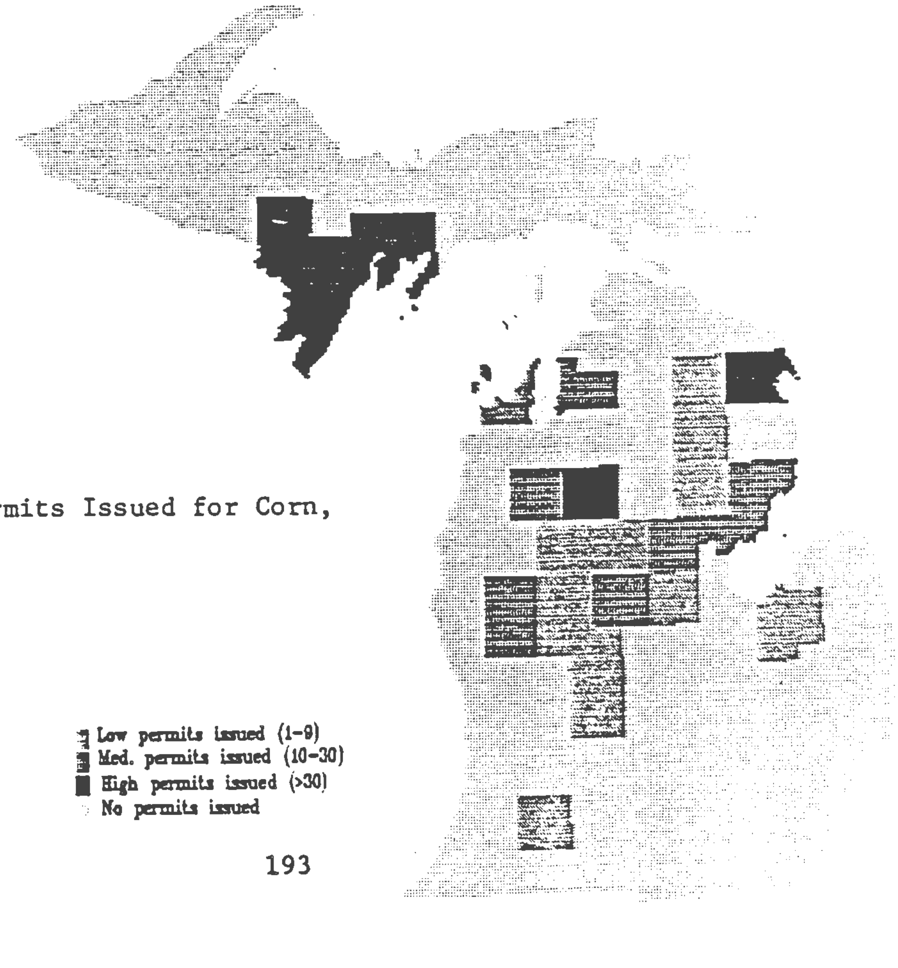


FIGURE 16. Kill Permits Issued for Corn, 1986

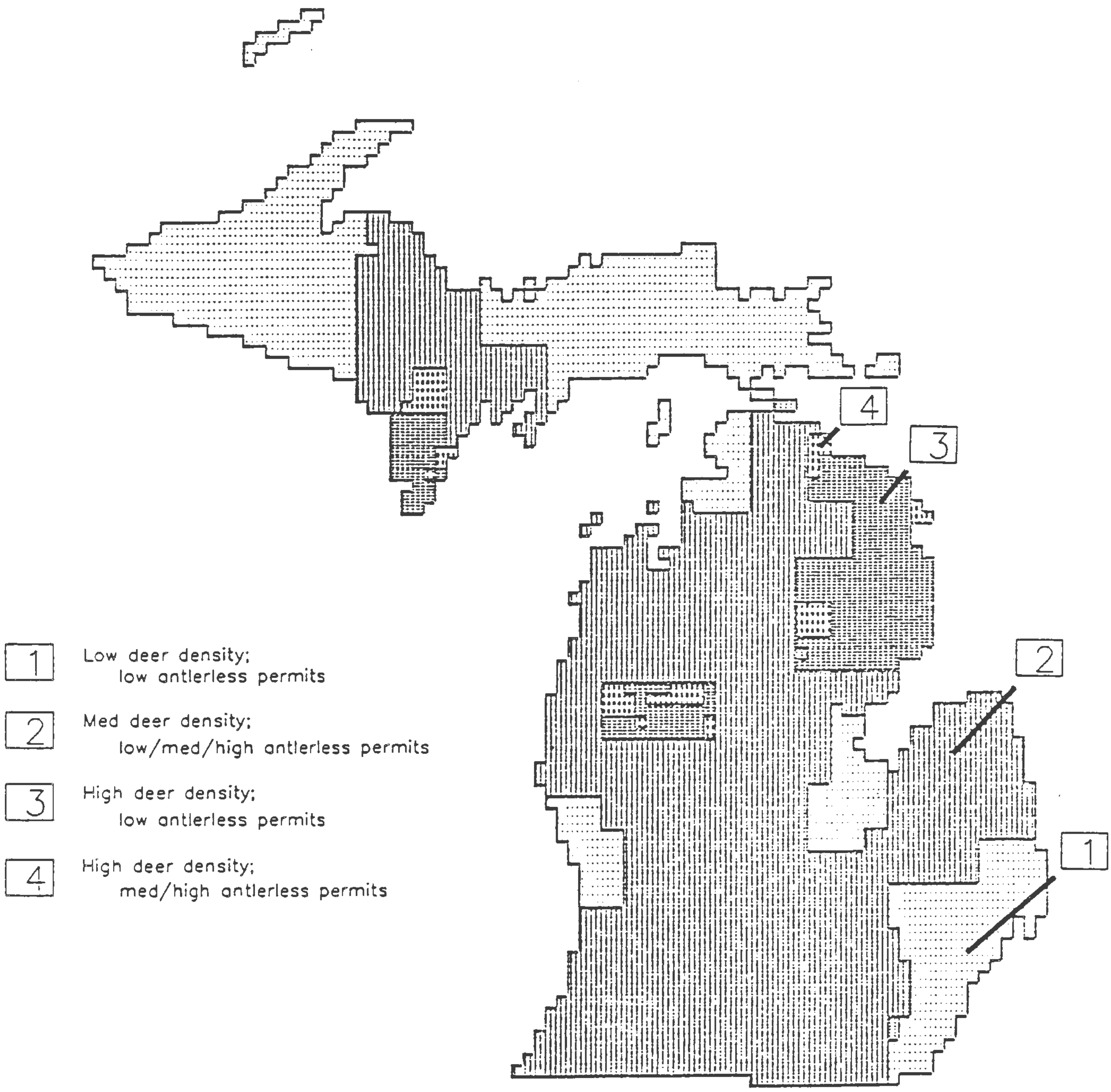


Figure 17 . Relationship Between Estimated Deer Densities and Number of Antlerless Permits Issued Per Square Mile in 1986.

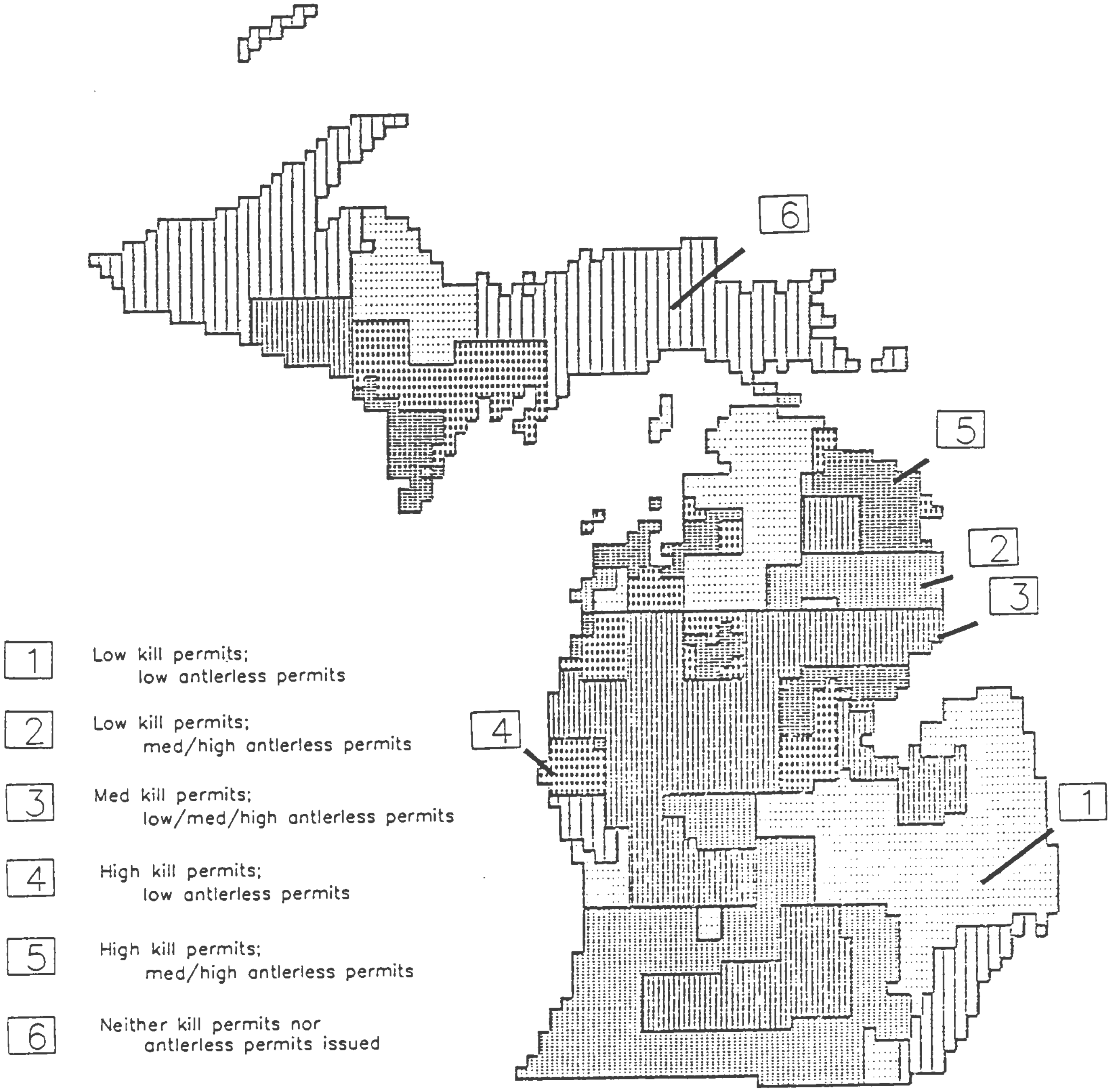


Figure 18. Relationship Between Kill Permits and Antlerless Permits Issued Per Square Mile, 1986

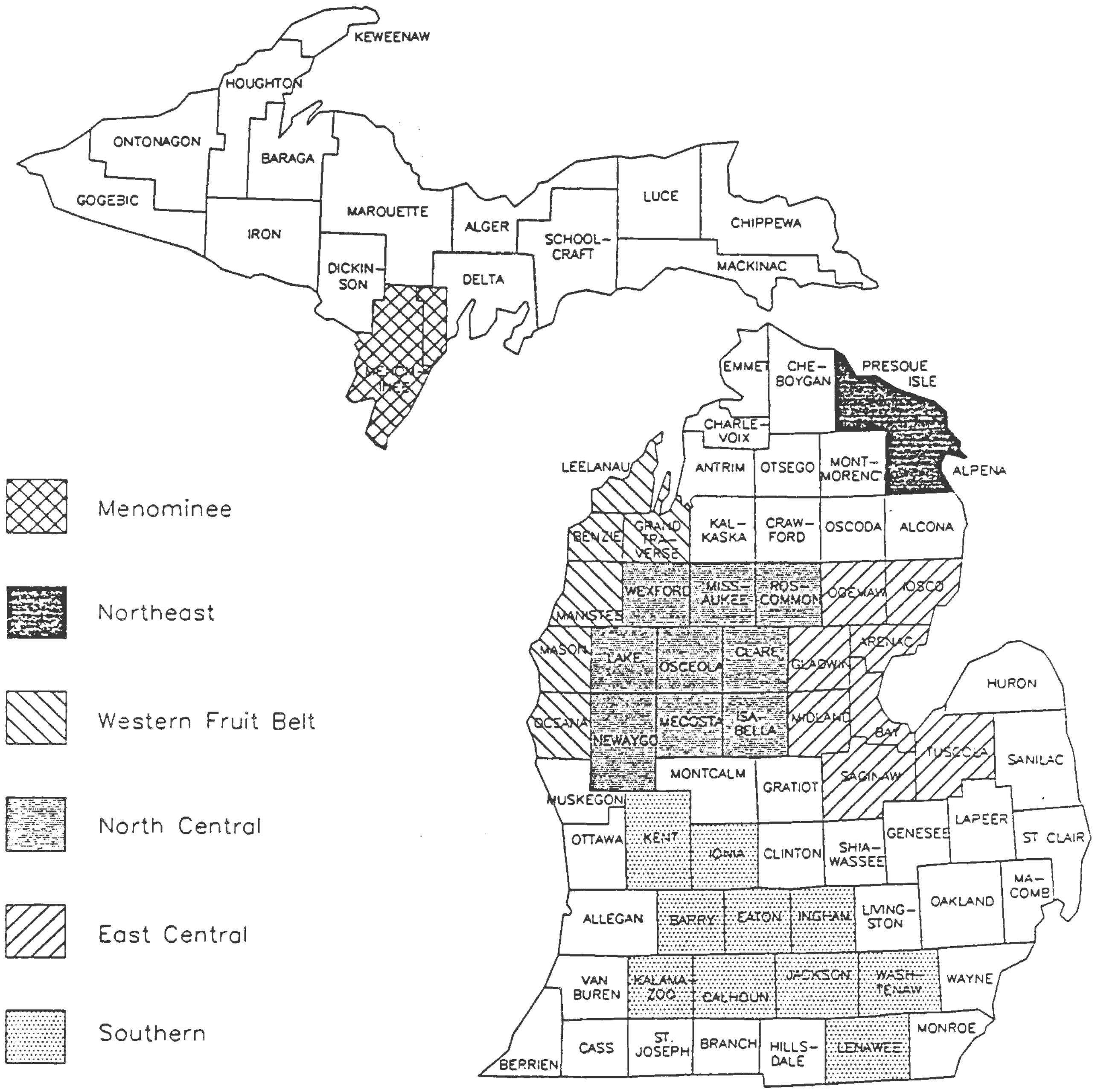


Figure 19. Michigan Deer Damage Problem Areas

Comparisons of deer density and deer population management techniques are also helpful (Fig. 17). Areas with high deer density and a relatively low number of antlerless deer hunting permits are issued also areas of where relatively large numbers of deer damage control kill permits are issued. This relationship suggests that deer damage could be reduced in some areas by issuing more antlerless permits to decrease deer density, providing there are sufficient numbers of hunters in the area of concern that will apply for and use antlerless permits. In some areas of Michigan too few hunters are willing to do so. Further, reducing deer density may not result in an acceptable proportional reduction in damage in some areas because of other influences already mentioned (field size, surrounding land use, etc.). These problems are best illustrated by comparing the number of kill permits issued to the number of antlerless permits issued (Fig. 18). Areas where relatively high numbers of kill permits and a relatively low number of antlerless permits are issued are not always areas of high deer density. Conversely, areas of high deer density are usually areas where both high numbers of kill permits and medium to high numbers of antlerless permits are issued.

A comprehensive description of deer damage throughout the state can be illustrated by integrating crop production, deer density, crop damage control kill permits issued and antlerless licenses issued (Fig. 19). The use of the GIS allowed for the identification of 6 different deer damage problem areas that appeared to have similarities within each area in terms of the type of damage, influencing factors and therefore, possible control strategies.

GIS VALUE

From these descriptions and comparisons, it is obvious the GIS is a useful tool for displaying complex data sets, delineating possible similarities and contrasts and proposing causative factors and possible solutions. However, a variety of problems limited the potential utility of this method.

1) Deer density estimates varied widely in reliability and as a result, the range within the scale used to describe deer density was wide enough to make some comparisons difficult.
2) The number of kill permits issued does not necessarily reflect the level of deer damage. Criteria for issuing permits differed widely with DNR district biologists. Attitudes and relationships among landowners and sportsmen vary by location and also affect the number of permits requested by agricultural producers. Standardization of the issuance of kill permits is needed for this variable to be an accurate indicator of deer damage.
3) Units of measurements for many variables were not standard. Further, units per county, especially crops statistics, were misleading because of differing distributions of production. The distribution of the production and its relationship with other land uses appeared more important in many cases than total production.
4) Mapping units changed over time for some variables such as deer statistics. Numbers were reported by district or county in some cases and by deer management units in other cases. The size and shape of deer management units also changed each year, adding complexity to the use of a GIS analysis.
5) Units of measurement, especially by county or district, were too large. A modified scale perhaps on a township basis would allow more realistic comparisons especially for land use patterns and would eliminate mapping artifacts. Michigan has a Resource Inventory System (MIRIS) that when completed will facilitate such comparisons.
6) Statistical analyses of the effects of the variables depicted in Fig. 1 are not possible at the present because of the problems with scale and data reliability. If these problems are corrected through development of standardized procedures and larger scale mapping, the GIS approach will allow for a quantitative assessment of the effects of many of the variables influencing deer damage and thus an enhancement of control strategies.

CONCLUSION

The use of GIS can be helpful in better describing and analysing deer damage problems and in developing optimum solutions to the problem. However, if this methodology is to be more useful in a quantitative manner, problems with data units, scale, standardization and reliability need to be overcome.

LITERATURE CITED

Langenau, E.E. 1989. Status of Michigan Deer Herd. Unpublished report of the Wildlife Division, Mich. Dept. of Nat. Resources. 9 pp.

Langenau, E.E. and M.L. Rabe. 1987. Deer-vehicle accidents in Michigan: a task force report. MI Dept. of Nat. Resour., Wildl. Div. Report 3072, Lansing, MI, 46 pp.

Schultink, G., B. Buckley, S. Nail, D. Brown, W. Enslin, S. Chen and J. Chen. 1987. User's guide to CRIES geographic information system. Dept. of Res. Dev., Michigan State University, E. Lansing, MI.

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