ADDRESSING DEER-VEHICLE ACCIDENTS WITH AN ECOLOGICAL LANDSCAPE GIS APPROACH

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Abstract

The problem of highway accidents involving animals is a nationwide and worldwide concern. In Michigan, property damage to vehicles, human injuries and fatalities, and potential reductions of local deer populations result from vehicle collisions involving white-tailed deer (*Odocoileus virginianus).* During 1997, Michigan had 65,451 reported deer-vehicle crashes. This is a 52.7% rise from 42,868 deer-vehicle collisions in 1988, according to Michigan State Police Crash Statistics. Kent County has had a consistently higher number of deer accidents than any other county in Michigan, with 2,035 in 1997.

To address this problem, the Kent County Deer-Vehicle Accident Reduction Study was undertaken. The study is using an ecological landscape perspective to investigate the interface of human population density and activity with deer population density and activity. Used in conjunction with educational efforts and speed reduction advisories, novel signs were placed in controlled test sites to study their effectiveness in changing driver behavior, and wildlife reflectors were implemented to test their effectiveness in changing deer behavior.

Designing successful accident reduction techniques requires understanding deer and human movement patterns and behaviors. Interactions between people and white-tailed deer are increasing in Kent County as populations of both deer and humans are on the rise. As humans move into historic deer habitat and deer invade human-dominated landscapes, conflicts are more likely to occur. Using the information gathered from the analysis and synthesis of data, this study will document the effectiveness of all measures implemented during this study period and the pioneering efforts of Kent County as a model for other areas in addressing the problem of deer-vehicle collisions.

Introduction and Background

Car-animal accidents are increasing in many locations around the world (Conover et al. 1995, Groot Bruinderink and Hazebroek 1996, Hughes et al. 1996, Ohtaishi 1996), with Michigan ranked in the top three in the United States for number of car-deer collisions. Kent County in Michigan=s lower peninsula (including Grand Rapids, Michigan=s second largest city) has consistently had a larger number of deer accidents than any other county in Michigan, with 2,035 in 1997.

In order to ameliorate this growing problem, the Kent County Deer-Vehicle Accident Reduction Study was undertaken. This study represents action toward implementing recommendations delineated by the report *Investigating Methods to Reduce Deer-Vehicle Accidents in Michigan* (Premo and Premo 1995).

As identified in this 1995 report and by a subsequent review of the most recent literature, deer road-kills have increased in most states where suitable trend data are available for analysis. Nearly all states have used some type of mitigation including signs, modified speed limits, fencing, over- and underpasses, reflective apparatus, habitat alteration, or public awareness programs. Despite this, few have done objective, systematic evaluations of the efficacy of those techniques (Romin and Bissonette 1996). It is clear that the problem of deer-vehicle accidents is far from being adequately addressed.

White-tailed deer populations have increased dramatically throughout much of their range over the past several decades and are reaching historic highs in some states. This increase is indicative of the species= adaptability, mobility, reproductive vigor, and lack of natural predators. The current literature continues to support the importance of habitat-based studies in finding solutions to problems of human-wildlife interactions, such as car-deer collisions. Recent findings are that deer habitat needs are met in areas with abundant grasslands and orchards with nearby hardwoods (especially oaks) for refugia. Furthermore, a moderate level of human development and forest fragmentation may actually enhance deer abundance by increasing amounts and accessibility of forage and reducing deer vulnerability to hunter harvest (Roseberry and Woolf 1998).

Kent County provides an excellent venue for implementing and monitoring a deer-vehicle accident reduction study, because it has all of the components that have allowed the density of deer to remain high, contributing to its distinction as the highest deer-car collision county in the state for the decade. Within Kent County, Algoma, Cannon, Courtland, and Plainfield Townships, just north of Grand Rapids, have a mixture of agricultural land, forested patches, riparian corridors, and growing subdivisions, and are the sites of many of the highest density locations of deer-vehicle collisions in the county. With commuter traffic crossing the townships at high rates of speed during the same time that deer activity is at its peak, it=s no surprise that collision numbers are so high and display an increasing trend.

The Kent County Deer-Vehicle Accident Study is taking an ecological landscape perspective of the interface of human population density and activity with deer population density and activity. The multi-layered Geographic Information System (GIS) database that we have used in our analyses in ArcView™ is an excellent way of looking at the problem spatially as well as statistically. Using information gathered from the Kent County Road Commission (KCRC), Michigan Department of State Police Office of Highway Safety Planning, Grand Valley State University Water Resources Institute (WRI), Michigan Department of Natural Resources, and the current literature, we have the capability of identifying temporal and spatial patterns of deer-vehicle collisions at the landscape level in Kent County. This database has made it possible to identify high risk areas for deer-vehicle collisions and identify areas of focus to significantly reduce accidents.

Specific locations of deer-vehicle collisions were incorporated as a thematic layer into an information system known as a Decision Support System (DSS). This DSS was developed by WRI to provide KCRC decision makers with a tool designed specifically to enhance their data analysis, planning, and decision making process (Frye and Thompson 1997). It is a flexible system that allows the user to add additional data as conditions or concerns change. A number of layers of geographic information can be integrated to analyze interrelationships of features and attributes. In addition, the user can create and customize hard copy map products for use in informational and educational sessions with decision makers and the public.

Designing successful accident reduction techniques requires understanding of deer and human movement and behavior. Our efforts will more closely examine deer behavior and habitat use in areas of high road-kills interfaced with examination of changes in human population density and road use. Analysis of land use-land cover, topography, vegetation, roadways, waterways, and recent development will illuminate site specific characteristics for which particular mitigative techniques or combinations of techniques are appropriate.

Although deer road kills have increased significantly since 1980, a nation wide survey (Romin and Bissonette 1996) indicated that few management strategies for reducing accidents have been rigorously tested, and of those that have, many (Swareflex reflectors, warning whistles, highway lighting) have been shown to be ineffective. Future studies should focus on more promising techniques that address deer and human behavior to avert collisions.

Methods Considered

As delineated in the 1995 report, *Investigating Methods to Reduce Deer-Vehicle Accidents in Michigan*, measures have varying potential for application and effectiveness. Part of the consideration for which measures to use is cost and effectiveness. The following summarizes our evaluation of the potential of measures.

Public Awareness. Educational efforts and public awareness campaigns through a variety of methods including driver education and high school programs, hunter education, landowner education, commuter education, and involvement of local residents at the township level have very high potential for reducing accidents. Moreover, their effectiveness is testable by comparing numbers of collisions before and after implementation of education efforts. Information on deer behavior, when and where accidents are most likely, how to respond when a deer enters the road, and the danger and cost of accidents will better prepare drivers to avoid collisions.

Warning Signs and Limiting Speed. Although there is a general perception that signs are not effective, the right signs in the right place have not been adequately studied. Used in conjunction with educational efforts and speed reduction advisories, novel signs placed in high risk areas only during high risk times may be the most effective method for changing human behavior. It is recommended that if signs are used that they be placed in roadways determined to have significant history of wildlife collisions during the peak accident season so that drivers consider them a meaningful warning. This concept supports the recommendations of a MDOT report (Borton 1984) that deer warning signs continue to be used with special emphasis given to locating them to coincide with deer population shifts and accident concentrations.

Signs provide a coverage area larger than just the roads on which they are placed through a matrix of roadways signed at both ends of high risk areas entering and leaving the township. The cost of implementing 71 signs (17 special signs and 54 standard signs) is approximately $10,000 and would need to be only 10% effective to recover the cost in reduced accidents in one year. Because they are less expensive, signs don't have to be dramatically effective at reducing deer-vehicle collisions to be cost-effective.

Deer Population Management. The Michigan Department of Natural Resources has efforts currently in place in Region 9, including Kent County, for reduction of the deer herd through more liberal hunting limits. This coupled with educational efforts aimed at hunters around the state and landowners in Kent County is essential for decreasing the number of deer and thus the presence of deer on roads.

Wildlife Warning Reflectors. Studies of wildlife warning reflectors have failed to prove their effectiveness, often because of inadequate sample size (see reviews in Damas and Smith Ltd., 1983; Langenau and Rabe, 1987; Premo and Premo, 1995). To have an adequate sample size for a valid statistical test of 30% reduction in one year in the highest density deer collision sites in Kent County, approximately 35 miles of road would need to be covered. At a cost of $2,700B3,590 for one mile of reflectors and an additional cost of $500 per mile per year maintenance (from Strieter-Lite 1998 information sheet), the conservative cost for a test covering 35 miles of road for one year in Kent County would be in excess of $122,000. If the study was extended for additional years, the study area could be composed of a 6 mile stretch of road shown historically to have sufficient accident numbers to conduct a valid test. The cost for implementation of 6 miles of reflectors would be $36,000 plus an additional minimum cost of $15,000 maintenance over five years; this cost is for installation and maintenance only, not design, data collection, and analysis.

Mowing Practices, Right of Way Clearing, and Road Salt Use. Most deer-vehicle accidents occur in seasons when mowing and road salt use are not issues. Additionally, mowing policies are mandated to accommodate the pheasant populations on roadsides, and road salt use addresses an important safety issue.

Pass Structures and Fences. An effective measure to reduce deer-vehicle collisions is pass structures used in conjunction with miles of fencing to keep animals off roads and to funnel them into the passes. These efforts cost hundreds of thousands of dollars and are not feasible for large expanses of county-maintained rural roads.

Highway Design. The spatial analyses made possible by the GIS database will reveal patterns of deer movements that give insight into where deer cross roads and why. These patterns will be valuable for future planning of roads and optimal use of bridges and culverts to facilitate animal crossings beneath roads.

In-Vehicle Detection Devices. Sophisticated in-vehicle detection devices and roadside IVHS applications being developed as part of rural intelligent transportation system applications are promising countermeasures which should include consideration of animal-related crashes, but these are far off in the future.

Of these possible methods, the most feasible methods to implement and test are public awareness campaigns, warning signs, and speed reduction advisories in high risk times and areas. The Michigan State Police Office of Highway Safety Planning requested that we also incorporate a study of the effectiveness of wildlife reflectors as part of the Kent County Study.

Findings to Date

The data gathering, syntheses, and analyses we have conducted thus far in this study using the GIS database have allowed us to gain a better understanding of the nature and magnitude of the problem of deer-vehicle accidents in Kent County, and of potential countermeasures (Hindelang and Premo 1997). We have identified specific areas of highest density deer collisions, and time of day and season of highest risk, essential for creating a valid experimental design. Additionally, we have developed an index to take into consideration traffic counts related to number of accidents so that accidents per vehicle mile can be determined in areas of varying traffic density.

On the basis of this study, these are our findings to date:

1. The Kent County townships clustered around Grand Rapids are the sites of highest number of deer-vehicle collisions.
2. Deer-vehicle crashes tend to occur more frequently on two-lane rural roads.
3. November has substantially more accidents than any other month, and the months of October, November, and December have over 50% of the accidents of the whole year. On a seasonal basis, there is little change in traffic volume, thus deer behavior is probably the most important variable (Figure 1).
4. The greatest number of deer crashes occur in the early morning hours between 5 and 8 a.m., and in the evening between 6 and 11 p.m. These peak accident times are most likely related to a combination of increased traffic volume and deer activity (Figure 2).
5. The highest number of deer collisions involve drivers between the ages of 30 and 39, which is also the highest group of registered drivers in Kent County (Figure 3). However, drivers between the ages of 15 and 19 hit disproportionately more deer for the number of registered drivers in their age group (Figure 4).
6. Using GIS to visualize and select high density locations, we identified deer-vehicle crash clusters and their corresponding traffic counts to determine crashes per million vehicle miles. When compared with the animal crash rate per million vehicle miles on two-lane rural roads in Michigan of 1.3 (Highway Safety Information System), the calculated rate of 9.2 is substantially higher for some roads in Kent County. Although the problem of deer-vehicle crashes in Michigan, and in Kent County in particular, is widespread, there are specific locations where the density of accidents is much higher, and in some cases disproportionately high for the traffic volume.
7. Focusing on Algoma, Cannon, Courtland, and Plainfield Townships, which have many of the highest density locations of deer accidents in the county; within Kent County, the site of highest number of accidents within the state; and in Michigan, one of highest states in the

country for deer collisions, we feel confident that in this venue we have a better sample size for a valid study than nearly anywhere in the world.

Discussion and Future Study

In this setting with very high density Ahot spots,@ we have determined what sample size is necessary to capture statistically significant reductions in deer-vehicle collisions to test the effectiveness of mitigative measures. Unless an adequate sample size is considered, the reduction in accidents may reflect no more than random variation over time or area.

Analysis of our data in Kent County reveals that declines and increases occur from month to month and year to year in areas where there are no countermeasures in place, simply due to natural variation. It is crucial to monitor effectiveness of deer-vehicle accident reduction measures over great enough time and area based on sound statistics to adequately determine if the efforts have any greater effect than chance alone. This is especially true when the results may be the basis for decisions on very costly countermeasures.

In Algoma Township, there were 528 deer-vehicle collisions, and in Cannon Township, 453, from 1992B1996 (around 100 each year with increases in the recent years) and the majority of those occurred in October, November, and December. We identified seven stretches of road in Algoma Township for the road sign test site where over 76% of the accidents in the township occurred. In an average year, those 35 miles of roadway provide just a large enough number of deer-vehicle accidents over the period of October through December to determine if the countermeasures have any greater effect than natural variation (assuming a 30% reduction in deer-vehicle collisions in the test area). If the study was extended for an additional year, the statistics would hold even more power.

Considering the sample size realities of conducting a valid test, even in a location that has more accidents than most places, short-term experiments conducted on small stretches of road are nearly guaranteed to fall short of sample size required. Such studies are of little or no value relative to determining the effectiveness of countermeasures. This is of no small consequence as erroneous conclusions can be drawn in determining if measures work when they really do not or if measures do not work when they really do. Determining an adequate sample size for a valid statistical test has been an important accomplishment of this study. This underscores the importance of adequate sample size in studies in other locations around the state and country.

During the summer of 1998, a county-wide public education campaign was implemented, informing residents and commuters of the risk for deer collisions in Kent County, the county with the highest number of deer accidents in the state. We incorporated information on deer behavior, alerting motorists about where and when the danger of deer-vehicle collisions is greatest. This awareness will better prepare drivers to avoid such collisions. Components included: driver education and classroom units to educate cohorts of new drivers, landowner education, hunter education, commuter education, and public awareness campaigns. In this effort we partnered with the State Coalition to Reduce Car-Deer Accidents and they provided posters and brochures.

On October 1, 1998, Kent County Road Commission placed novel deer warning signs on seven roads in Algoma Township where 76% of all of the car-deer accidents in that township occur. Engineers at Kent County Road Commission created a novel sign depicting a car colliding with a deer and an advisory beneath. Deer warning signs have never been used in Kent County prior to this study. Signs were placed only on roadways determined by our GIS analysis to have significant history of wildlife collisions during the peak accident season so that drivers consider them a meaningful warning. The signs were all removed by December 31, 1998. This test site will be compared with the control site of Cannon Township where there was no treatment.

For the study of wildlife warning reflectors, three control sites and three test sites were selected. Each stretch of road is two miles long (for a total of six miles control and six miles test). The test sites are in Plainfield Township and all have high rates of car-deer collisions per million miles driven, despite very different traffic densities. These three sites will be compared with matched control sites in Courtland and Cannon Townships for effectiveness in reducing nighttime deer-vehicle collisions. The reflectors were installed with on-site inspection by John Strieter, owner of Strieter-Lite Wild Animal Highway Warning Reflector System. Some alterations were made as a result of his advice, and he gave his final approval on the manufacturer=s prescribed installation method. The reflectors will remain in place year-round.

The Michigan State Police Office of Highway Safety Planning has not yet released their 1998 Crash Statistics**.** When the data are released, we will analyze the effectiveness of all of the measures implemented during this study. We have recommended that the measures be continued for the next several years to continue to monitor their effectiveness.

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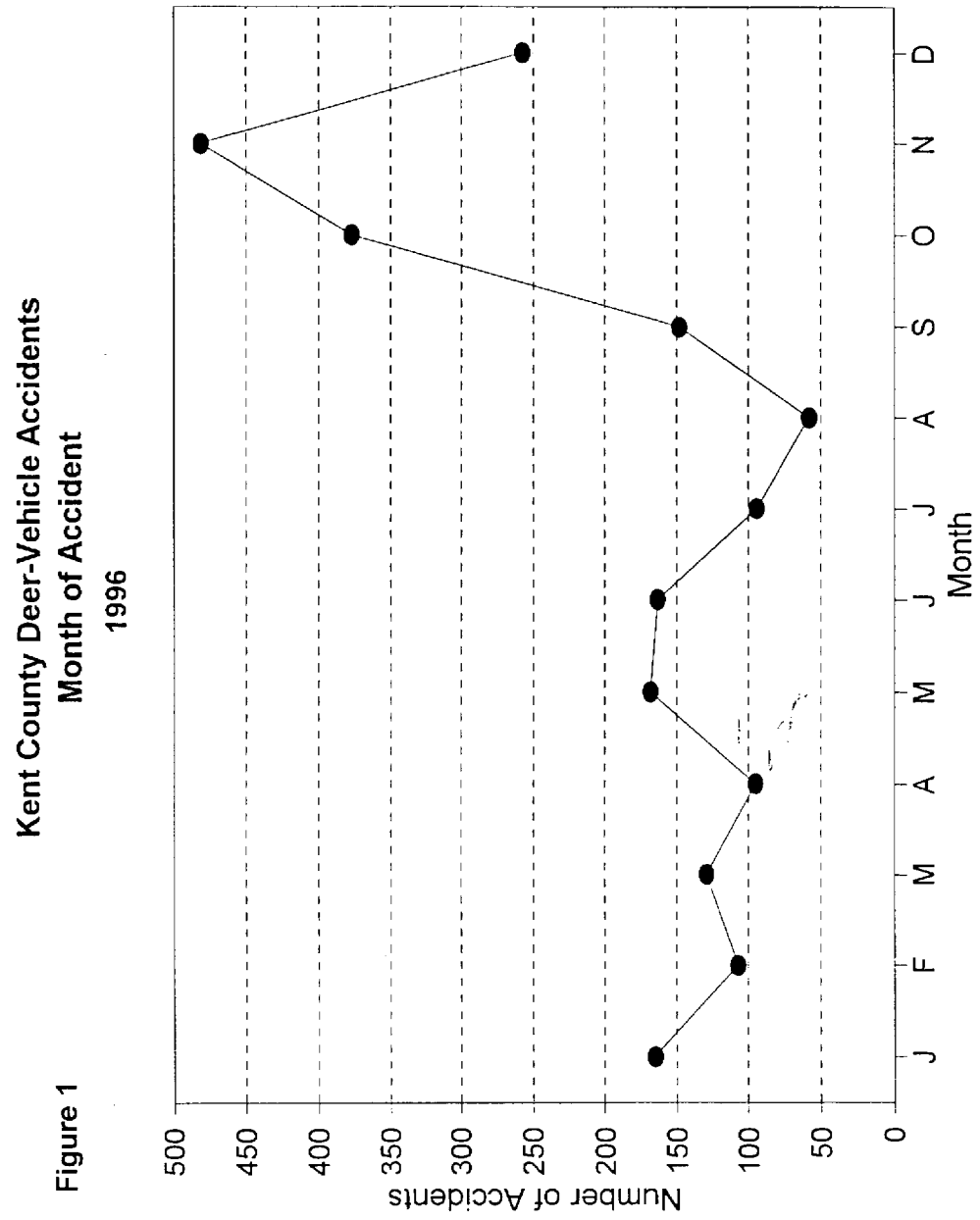
Kent County Deer-Vehicle Accidents
Month of Accident
1996
Number of Accidents
0
50
100
150
200
250
300
350
400
450
500
J
F
M
A
M
J
J
A
S
O
N
D
Month

Figure 1

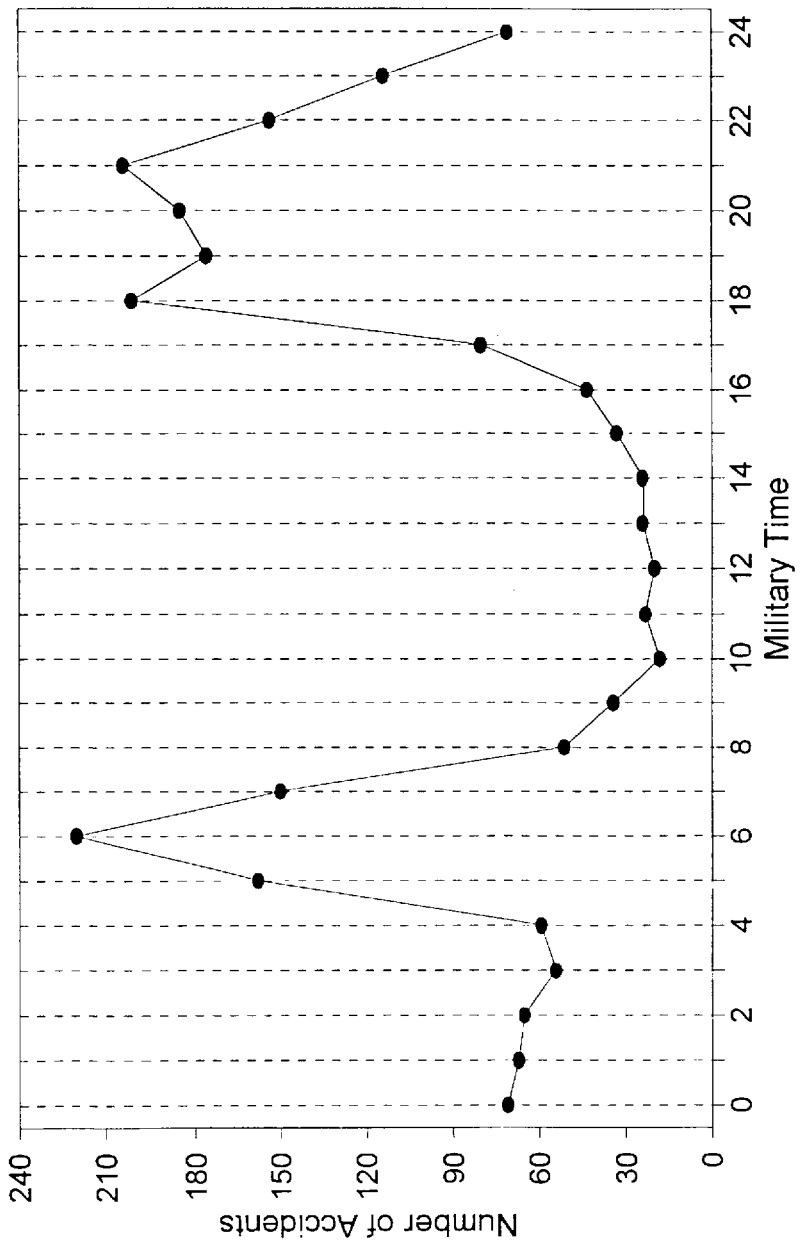
Kent County Deer-Vehicle Accidents
Time of Accident
1996
Number of Accidents
240
210
180
150
120
90
60
30
0
0
2
4
6
8
10
12
14
16
18
20
22
24
Military Time

Figure 2

Kent County Deer-Vehicle Accidents
Gender of Drivers in Deer Collisions
1996

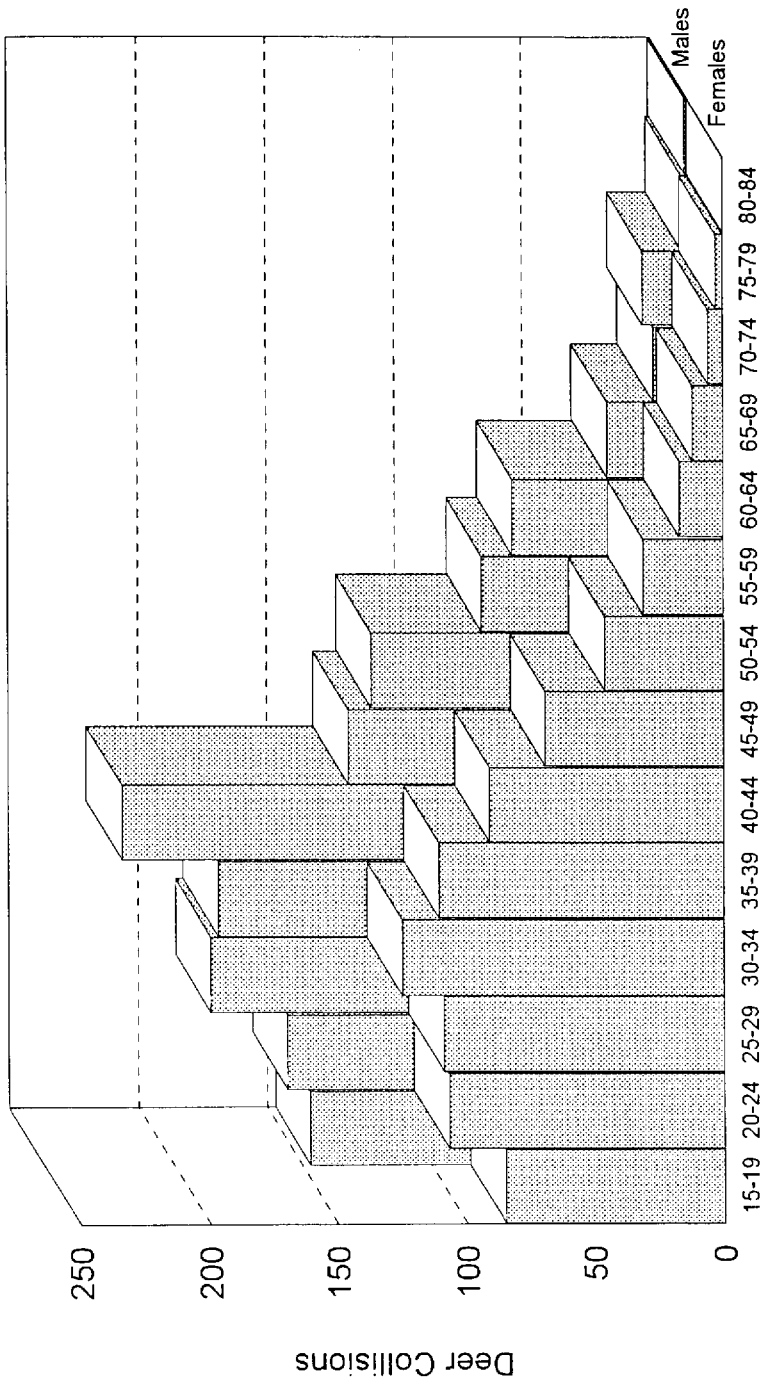

Figure 3

Figure 4

Kent County Deer-Vehicle Accidents
Accidents of Registered Drivers by Age
1996