Economic Analysis of Deer -Vehicle Collisions in Ohio

Ellen Wu
Department of Environmental Studies
Ohio University, Athens, OH

Abstract

More than 24,000 deer-vehicle collisions (DVCs) took place in the state of Ohio in 1996, yet Ohio state agencies still hesitate to try new mitigation techniques. Ohio primarily uses deer warning signs to reduce deer-vehicle collisions because state agencies question the effectiveness and economic efficiency of other mitigation approaches. The objectives of this research are to estimate the costs and benefits of reducing DVCs. Focusing on DVCs along two stretches of highway (US-33 and US-50) in Athens County, Ohio, all four mitigation strategies evaluated yield positive net gains. The technique demonstrated in this research can serve as an additional decision making tool for those with responsibility for installing DVC mitigations.

Introduction

Deer-vehicle collision accounts for a major percentage of highway accidents in Ohio. According to the Ohio Department of Highway Safety, approximately 95% to 98% of all Ohio's reported animal crashes involve white-tailed deer (*Odocoileus virginianus*). Ohio deer population has grown from 300,000 to 500,000 since 1990. (Source: Ohio Department of Natural Resources (ODNR), Division of Wildlife) With increasing deer populations and traffic volume, deer vehicle accident numbers in Ohio have grown by more than 400 cases each year since 1992. This trend of increased collisions gives the state of Ohio the third largest reported number of DVCs in the United States. To deal with this growing DVC problems, the Department of Transportation has traditionally used deer warning signs to inform drivers of this potential danger.

Focusing on two road segments in Athens County, Ohio, this study evaluates the costs and benefits of 4 potential DVC reducing strategies. Those four mitigation strategies include: crosswalks, underpasses, deer reflectors, and deer fencings. Research methodology in economic analysis and identification of benefit-cost components in reducing DVCs used in this paper are obtained through tracking literature related to animal-vehicle collisions. Unlike most biological and physical DVCs studies (Romin 1996, Arnold 1978, Tonkovich 1995, Kasul 1976, Helmer 1993, Bellis et. al. 1971), economic studies of DVCs focus on impacts to humans (Reed et. al. 1982) and ignore the economic value in wildlife. To synthesize these approaches, research includes four economic components associated with reducing DVCs: (i) vehicle accidents cost, (ii) deer value, (iii) deer nuisance cost, and (iv) mitigation costs in reducing DVCs.

The estimation of vehicle damage costs from DVCs (Hansen 1983, Pils and Martin 1979, Decker et. al. 1990, Myers 1969, Arnold 1978, and Kisner 1991) has received more attention than the potential costs to human fatality or injury (Culbertson and Stoll 1990) since the latter extent is believed less likely to result. This study uses information from the National Safety Council to define the costs associated with vehicle damages and human injury. The value of a deer is estimated with consideration given to deer hunting revenues (Martin 1978, Romin and Bissonette 1996) and deer venison value (Myers 1969). To account for deer nuisance costs, research from Ohio State University (Forster et. al. 1996) is used. Finally, to account for the costs of implementing a particular DVC reduction strategy, i.e., mitigation costs, this research uses cost and effectiveness estimated from mitigations (Halls et al. 1965, Griffis 1984, Reeve and Anderson 1993, Romin and Bissonette 1996).

The first part of this paper introduces the study area (Athens County) and the highways where most DVCs occurred in 1996 within Athens County. The second section identifies the associated economic components and data in reducing DVCs, as well as the approach used to evaluate each mitigation strategy. The third section of this study illustrates the connection between benefit-cost analysis (formula) and the case study for 1996 DVCs in Athens County. The paper concludes with a brief discussion of the results, potential limitation of the research, and future extensions.

Study Area

The study focuses on Athens County, in southeastern part of Ohio. The area is 74% forested (Fig. 1), and covers a land area of 483.57 sq. miles. This area is noted for its dense deer population and recreational hunting activity. In 1996, the legal deer harvest for Athens County was 4,084 (8 deer/sq. miles).

Two nine-mile road segments of the 1077 miles highways and roads in Athens County were chosen for the case study (Fig. 4). The first testing segment, along US-33, starts from southeast of Athens township and extends toward Dover township. This 4-lane highway has an average daily traffic volume of over 10,000 vehicles/day. The second section, along US-50, starts from the eastern Athens City and ends in Rome Township. This section is a 2-lane highway and has an average daily traffic volume of over 6,000 vehicles/day.

Economic Components

In evaluating alternative policy measures to reduce DVC, this research focuses on 4 components: (i) vehicle accident costs, (ii) deer value, (iii) deer nuisance cost, and (iv) mitigation costs. Given these components, each strategy can be evaluated on a net benefit basis. That is, comparing the costs of DVC reduction, to the benefits of DVC reduction. The identification and quantification of each DVC component is as follows. A more detailed description is given in Figure 5.

1. Vehicle accident economic costs

Vehicle accident economic costs in this research come from the National Safety Council (N.S.C., 1997). (The study assumes that there are no cost differences in DVCs vehicle accidents and other types of vehicle accidents. N.S.C.'s report includes not only the economic cost components, but also a measure of the value of lost quality of life associated with the deaths and injuries. This component includes given factors: wage and productivity losses, medical expenses, administrative expenses (include insurance, police, and legal cost), vehicle damage, and employer losses for accidents to workers. National Safety Council's estimation in each vehicle accident cost is shown as table I:

Table I: Economic Cost of Vehicle Accidents in USA, 1996

Economic Cost, 1996 (discount rate = 4%)	$/Accident
Human injury	35,700.00
No injury (property damages)	1,700.00

2. Deer value

To estimate the total value of a deer, one would want to include both use and non-use value (Kahn, 1995). Use value would account for that value associated with human use, such as deer hunting revenue, and medical purposes. Non-use values, alternatively, are associated with more intangible uses of deer, such as aesthetic, option, bequest, and altruistic values (Kahn, 1995). This study only includes use-values associated with deer hunting. Information was obtained from a 1996 Ohio University's questionnaire developed for the ODNR. The objective of the questionnaire (Fig. 2) was to determine how much money was spent on local goods and services by people visiting state wildlife areas in 1996-97. Of 5,016 responses, 1,274 respondents participated in deer hunting. For these 1,274 responses, this study calculates estimates associated with opportunity cost of time, gasoline cost, lodging cost, supplies cost, and other costs in deer hunting.

On average, each Ohio deer hunter spent $47.29 on deer hunting activities in 1996. The equations used in this research to estimate deer hunting expenses are shown in Fig. 5. There were a total of 136,206 deer licenses purchased in 1996, and 158,000 deer bagged. Considering the costs of transportation, lodging, other cost, opportunity cost of time, and miscellaneous other costs, Ohio deer hunter's spent

on average $40.77 per deer bagged. Ohio government collected approximately $13.7 million on hunting license sale in 1996 (source: Ohio Division of Wildlife), the average license cost to hunt one deer is about $86.71. Finally, the average deer venison value is $55.06 in 1996 given that the market price of a pound of deer meat is one dollar and the total deer harvested weight is 14.5 million pounds in 1996 (ODNR). After the summation of Table II, average deer value in terms of hunting revenue is about $182.54 in 1996. (transportation, gas, lodging, other cost, supplies cost, and opportunity cost of time, deer hunting license, deer venison value = 40.77 $/deer + 86.71 $/deer + 55.06 $/deer = 182.54 $/deer)

Table II: Deer Value in Terms of Hunting Recreation

Deer Value in hunting	in 1996 dollar
opportunity cost of time, transportation cost, lodging cost, supplies and other costs	40.77 $/deer
license cost	86.71 $/deer
venison value	55.06 $/deer
Total	182.54 $/ deer

3. Deer Nuisance cost

Information of deer nuisance cost came from a 1995 survey of farmers conducted by the Department of Agricultural Economics of Ohio State University (Forster, et. al. 1996). Four thousand Ohio farmers were contacted by mail and telephone and asked the impacts of wildlife populations on their farming operations. Responses suggested that financial losses concentrate among fruits, livestock, nurseries, vegetables, and Christmas trees. Of the $45.15 million dollars of wildlife nuisance cost to Ohio farmers in 1996, 49.6 percent is attributed to deer nuisance (22.39 million dollars).

This study defined the life-long deer nuisance damages by setting up 5 years of wild deer longevity with four percent discount rate. Deer nuisance cost was categorized into the cost of reducing DVCs because saving deer life from deer-vehicle crashes will maintain deer populations and increase deer-nuisance costs. On average, then, each deer saved imposes an additional $207.38 cost on farmers.

4. DVCs Mitigation cost

Many mitigation measures are being used for deer vehicle collisions in the United States. Data of DVCs mitigation costs in this paper are mainly collected from state or government agencies and obtained through telephone and e-mail interview from different states in the USA. All the data are adjusted for inflation. DVCs mitigation costs include labor costs, design costs, material costs, and future maintenance costs. Table III shows the cost and effectiveness of each mitigation strategy.

Table III: Cost and Effectiveness of Different DVCs Mitigation

Mitigation Method	Cost/mile or Cost/structure	Effectiveness	Area and Data Source
Reflector	• $7,000 - $10,000/mile	87%	Minnesota, (Pafko and Kovach, 1996)
Fencing	• $150,000 - $250,000/mile	85%	Utah, (Romin, 1996)
Z-clip metal fence	• $21,648/mile	85% assume	Utah, (Neve, 1997)
Underpass (concrete)	• $110,000/structure	52%	Florida, (Lotz, 1997)
Crosswalk	• 4-lane highway $28,000 - 40,000/structure • 2-lane highway $15,000/structure	40%	Utah, (Lehnert, 1996)

Reflector, the swareflex wildlife roadside reflector, is designed to discourage animals from crossing the road in traffic during night time. The purpose of fencing (conventional fencing is a wall-like fence), however, is to totally stop wildlife from entering the highway. The cost and effectiveness of the fencing (table III) is for 8 ft height fence. Since the cost of Z-clip fence comes directly from manufacturer and no available literature can identify its effectiveness, this study assumed the effectiveness of Z-clip fence is the same as conventional fencing (the cost for Z-clip fence cost in table III is for 6 ft height). Finally, underpass and crosswalk (tunnel and overpass) are both designed for wildlife to cross highway.

To evaluate each strategy, the benefit of reducing DVCs is weighed against the costs of reducing DVCs. A successful DVC mitigation can minimize deer-vehicle collision number and avoid human injuries or fatalities. The study assumes that if a deer does not die by vehicle accidents, it has a certain probability of contributing to state deer hunting revenues. Therefore, reducing vehicle accident costs and saving deer is viewed as benefits. To complete the benefit-cost analysis, though, such benefits are weighted against both the costs to install and maintain the mitigation technology and in increase in deer nuisance costs. Because this study intents to find the returns per dollar spend in mitigation, the following equation is developed.

$$\frac{\text{Benefit}}{\text{Cost}} = \frac{\text{Benefits from reducing DVCs}}{\text{mitigation cost}} = \frac{(1) + [(2) - (3)]}{(4)}$$

where (1) = reduction in vehicle accident cost to humans
(2) = increase in deer value (in terms of hunting revenue)
(3) = increase in deer nuisance costs
(4) = DVCs mitigation cost

The reduction in vehicle accident costs can be calculated by mitigation effectiveness multiplied by the DVC costs in human injuries and property damages. The benefit of saving deer-kill on highways is obtained by taking the increasing deer hunting value multiplied by the "probability". The probability of killing a deer during DVCs that would otherwise have been killed by an Ohio hunter is 31.6%. It is obtained by dividing 158,000 (1996 hunter harvested deer number) by 500,000 (1996 Ohio deer population). Because the value of deer in this study is only in hunting, the problem for the study is to account for the negative consequences if the deer will not become hunting target. Since deer nuisance cost is the negative impact caused by reducing deer-kill in DVCs, it is obtained by multiplying deer-kill reduction number and unit deer nuisance cost.

Results

Of 404 DVCs in Athens County in 1996, there were 389 deer-vehicle accidents resulting in property (vehicle) damages and possible deer kill, 15 human injuries, none of which were fatal. According to economic analysis in the research, over one million dollars of economic loss was caused by these 404 DVCs in 1996. Most of these DVCs happened on US and State highways (Fig. 3).

Nine miles of highway 33 from Athens to Nelsonville was chosen as one testing section (Fig. 4). In 1996, 40 DVCs occurred in this section. These 40 DVCs resulted in 24 deer kill, 40 vehicles damaged, and 2 human injuries. The total economic damage from those 40 DVCs is $140,784 dollars in 1996. Deer nuisance cost from these 24 deer will costs Ohio farmers $4,977.

The second testing section, locating on US highway 50, had 46 DVAs in 1996. Those 46 DVCs lead to 31 deer kill, 46 vehicles damaged, and 3 human injuries. The cost of the 46 DVCs is $187,088 in 1996. Deer nuisance cost from these 31 deer will cost Ohio farmers $6,428. Table IV shows the benefit of reducing DVCs (by installing mitigations) on the two testing sections in 1996.

Table IV: Benefit of reducing DVCs

	Highway 33 Testing Section 40 vehicle damages 2 human injuries 24 deer kills	Highway 50 Testing Section 46 vehicle damages 3 human injuries 31 deer kills
vehicle accident cost	$139,400	$185,300
deer hunting value	$1,384	$1,788
deer nuisance cost	$4,977	$6,428
Benefit of reducing DVCs	$135,807 x (mitigation effectiveness)	$180,659 x (mitigation effectiveness)

Using information on Table III, Table IV, and Table V shows the benefit of the four mitigation strategies for both sections, also including the benefit-cost ratio of reducing DVCs on highway 33 and highway 50. US highway 50 is under expanding construction from existing 2-lane highway to 4-lane highway. With this construction, increasing vehicle volume and speed-limits will cause increased future deer-vehicle collisions. Therefore, Table V considered for both 2-lane and 4-lane in crosswalk DVC mitigation.

Table V: Benefit and Benefit-Cost Ratio of reducing DVCs

Mitigation	Mitigation Cost	Benefit (B-C Ratio) on Highway 33	Benefit (B-C Ratio) on Highway 50
Reflector	$10,000/mile	$118,152 (11.81)	$157,173 (15.71)
Fencing	$250,000/mile	$115,436 (0.46)	$153,560 (0.61)
Z-Clip Fence	$21,648/mile	$115,436 (5.33)	$153,560 (7.09)
Underpass	$110,000/structure	$70,619 (0.64)	$93,942 (0.85)
Crosswalk	4-lane: $40,000/structure 2-lane: $15,000/structure	4 -lane: $54,322 (1.35)	4 -lane: $72,263 (1.80) 2 -lane: $72,263 (4.81)

Medicine value of deer comes from the belief that deer body parts can be used to find useful drugs for human in the future. Medical value of deer is quite different between eastern and western societies even today. Deer and deer products have served as a source of deer medicine in Asian and other parts of Asia for more than two millennia, and still do so (Putman, 1988). Of course, most western medical system may question and doubt such ideas, and dismiss them as pure folklore. As to deer value in the ecosystem, most ecologists believe the survival of deer is important to even the long-term survival of the human species (Gowdy, 1997). On the other hand, economists believe the marginal deer value is minute as long as the deer population maintains a large number (Simpson, 1997). Between ecologists and economists, the diverse opinion toward the deer value in ecosystem makes intangible the ecosystem value of deer and no conclusions can be made at this moment. Because there is no agreement on how to quantify the medical value, ecosystem value, and the non-use value of deer, such values are not included in the analysis. However, such values, if included, would increase the economic effectiveness of mitigation conducted. Thus, the analysis conducted in this paper can be viewed as conservative.

Discussions

Deer-vehicle accidents were considered less severe than other traffic accidents (Tonkovich 1995), yet the accumulation of the loss of valuable wildlife resource, human injuries, and property damages over time are enormous. According to the economic analysis in this study, the 404 DVCs that occurred in Athens County in 1996 resulted in a loss of more than 1 million dollars. This magnitude of loss would suggest potential gains in evaluating alternative DVC strategies. Table V provides the benefit estimated and B-C ratios for each of the 4 strategies. In Table IV and Table V, "benefit" represents the money saving by reducing DVCs. Clearly, US-50 had more serious economic damages from deer-vehicle collisions. All benefit-cost ratios (Table V) for US-50 are higher than B-C ratios of US-33. B-C ratios which are smaller than one means that the mitigation cost exceeds the mitigation benefit. Conventional fencing and concrete underpass, for instance, are the two mitigations with the benefit smaller than the mitigation cost. Even with 100% DVCs reduction in both US-50 and 33, mitigations like conventional fencing and concrete underpass are still too expensive to afford. On the other hand, deer reflector B-C ratios are larger than 10 on both highways. Since both study segments last only about 9 miles, the cost of deer reflectors can be easily supported by the benefit of reducing DVCs. Despite the economic advantage, deer reflector's advantage in low light condition makes it preferable in the state of Ohio because the distribution of Ohio deer-vehicle accidents by time of day showed a peak occurring between 5 and 7am (20% of all DVCs)and 5 pm and 12 am (58%)(Fig. 6).

The assumption of mitigation effectiveness (Table III) in this paper came from past successful mitigation examples or studies. It is possible those effectiveness estimates are higher than they should be. If so, the real mitigation benefit may be decreased by decreasing mitigation effectiveness. On the other hand, because the paper only includes the deer values associated with hunting without covering other associated deer values, the real benefit of the mitigation could be higher than this analysis suggests.* Experts estimate that actual roadkill in most states is two times greater than reported. (source: Ohio Department of Transportation) If only one third of deer-vehicle collisions was reported to authorities, the economic loss from deer-vehicle accidents would likely be more severe than that suggested in this research.

During the research process, the study identified a number of actions that will be necessary if deer-vehicle collisions are to be managed. First, governmental policies need to be more clearly identify the standard for DVC quantities and density. This research chose 1996 Athens County DVCs record as a prototype to find the economic consequences. In fact, economic loss caused by deer-vehicle collisions can be tracked and accumulated for years far before 1996. Therefore, setting up deer-vehicle collision standards in accumulation periods by deer population and human economic loss is fundamental in deer-vehicle collision management. Secondly, public education and forecasting in deer-vehicle collisions are crucial to reducing DVCs. Information should include not only where and when deer-vehicle collisions are likely to occur but also the proper defensive actions for drivers when deer appear on the road. Finally, more studies in deer behavior, the effectiveness in DVC mitigations, and wildlife economic value should be conducted. With all the above, positive control in deer-vehicle collision management should be possible.

Obviously, there is no single technique that can guarantee the solution to DVCs because of the narrow understanding of deer behavior. The prevention of future deer-vehicle collisions still relies on the finding improved technologies and mitigations. However, the economic analysis technique used in this study can be used as a decision making tool to help government agencies to find the economic efficiencies of different mitigations. Benefit-cost analysis of reducing deer-vehicle accidents provides a decision-making tool not often used by wildlife and highway agencies. Instead of looking at only the mitigation costs, better decisions can be made if agencies can predict that possible post-mitigation benefit can be gained. This study examines the economic possibilities of four available mitigations, and suggests that deer reflectors, fences (Z-Clip), and crosswalks are three potentially economically promising mitigation strategies. If reducing the loss of wildlife, improving highway safety, and economic efficiency can be obtained at the same time, millions of taxpayers' money can be saved through reducing deer-vehicle accidents by improving existing DVC mitigation.

Acknowledgment

The author of this paper would like to thank: ODNR -Division of Wildlife; Ohio Department of Public Safety; Institute for Local Government Administration and Rural Development (ILGARD) ODOT; and the National Safety Council for making possible the collection of much information in this paper. Special thanks are due to Dr. Gary Coombs, Dr. James K. Lein, Dr. Kurt A. Schwabe, Dr. Lloyd Herman and Dr. Gene Mapes.

References Cited

Arnold, D. A., 1978. Characteristics and Cost of Highway Deer Kills, Michigan Natural Resources. Wildlife Division. Wildlife and people: proceedings pp. 92-101

Arnold, D. A., 1978. Stalking Highway Deer, Michigan Natural Resources. Wildlife Division.

Bellis, E.D., H.B. Graves, B.T. Carbaugh, and J. P. Vaughan, 1971. Behavior, Ecology, and Mortality of White- tailed Deer along a Pennsylvania Interstate Highway. The Pennsylvania State University. Oct.

Culbertson, W.L., and R.J. Stoll, Jr. 1990. Deer-vehicle accidents in Ohio: 1984-1988 update. Ohio Department of Nature Resources, Division of Wildlife. Inserv.

Decker, D. J., K. Lee, M. Loconti, and N. A. Connelly, 1990. Incidence and Costs of Deer-Related Vehicular Accidents in Tompkins County, New York. HDRU Series 89-7, Cornell University, Ithaca, N.Y. Feb.

Forster, L., F. Hitzhusen, and R. Davis, 1996. Farmers' Perceptions of Financial Losses and Benefits from Wildlife. ESO 2300. April 5

Gowdy, J. M., 1997. The value of biodiversity: Markets, Society, and Ecosystems, Land Economics, Feb. 73(1):25~41

Griffis, J. L., 1984. Effects of Swareflex Wildlife Highway Warning Reflectors on Behavior and Mortality of White-tailed Deer. Master Thesis. April

Halls, L.K., C. E. Boyd, D. W. Lay, and P. D. Goodrum, 1965. Deer Fence Construction and Costs. Journal of Wildlife Management, v29 no. 4 Oct. pp. 885-888

Hansen, C. S., 1983. Costs of Deer-Vehicle Accidents in Michigan, Wildlife Society Bulletin. 11(2): 161-164

Helmer, J. W., 1993. Spatial Distribution of Deer-Vehicle Accidents in Summit County, Ohio 1988-1992: Implications for Urban Deer Management

Kahn, J. R., 1995. The Economic approach to environmental and natural resources. p.85~124

Kasul, R. L., 1976. Habitat Factors Associated with Mortality of Southern Michigan Wildlife on an Interstate Highway

Kisner, K., 1991. Herd on the Street, Insurance Review. v52 no. 8 Aug. pp. 32-35

Lehnert, M. E., L. A. Romin, and J. A. Bissonette, 1996. Trends in Addressing Transportation Related Wildlife Mortality. Proceedings of the Transportation Related Wildlife Mortality Seminar.

Lotz, M., 1997. New Wildlife Crossings Help Protect the Florida Panther. Florida Wildlife, March-April. pp. 6-9

Martin, W. E., and R. L. Gum, 1978. Economic Value of Hunting, Fishing, and General Rural Outdoor Recreation. Wildlife Society Bulletin v6 no. 1 spring pp. 3-8

Myers, G. T. 1969. Deer-Auto Accidents -Serious Business. Colorado Outdoors, May/June pp. 38-40

Pils, C. M., and M. A. Martin, 1979. The cost and chronology of Wisconsin Deer-vehicle Collisions, Bureau of Research, Madison. Nov.

Putman, R., 1988. The Natural History of Deer. Cornell University Press. Ithaca, New York. p. 153-175

Reed, D. F., D. I. Beck, and T. N. Woodard, 1982. Methods of Reducing Deer-vehicle accidents: Benefit-Cost Analysis. Wildlife Society Bulletin. 10:349-354

Reeve, A. F., and S. H. Anderson, 1993. Ineffectiveness of Swareflex Reflectors at reducing deer-vehicle collisions. Wildlife Society Bulletin. 21:127-132

Romin, L. A. and J. A. Bissonette, 1996. Deer-vehicle collisions: status of state monitoring activities and mitigation efforts. Wildlife Society Bulletin. 24(2): 276-283

Romin, L. A. and J. A. Bissonette, 1996. Temporal and spatial distribution of highway mortality of mule deer on newly constructed roads at Jordanelle reservoir, Utah. The Great Basin Naturalist. v56 Jan. 31 pp. 1-11

Simpson, R. D., 1997. Biodiversity prospecting, Resources, Winter, p.12~15.

Tonkovich, M. J., 1995. Deer-Vehicle Accidents in Ohio: 1989-94 , ODNR Division of Wildlife, Forest Wildlife Research and Management Project, Sep.

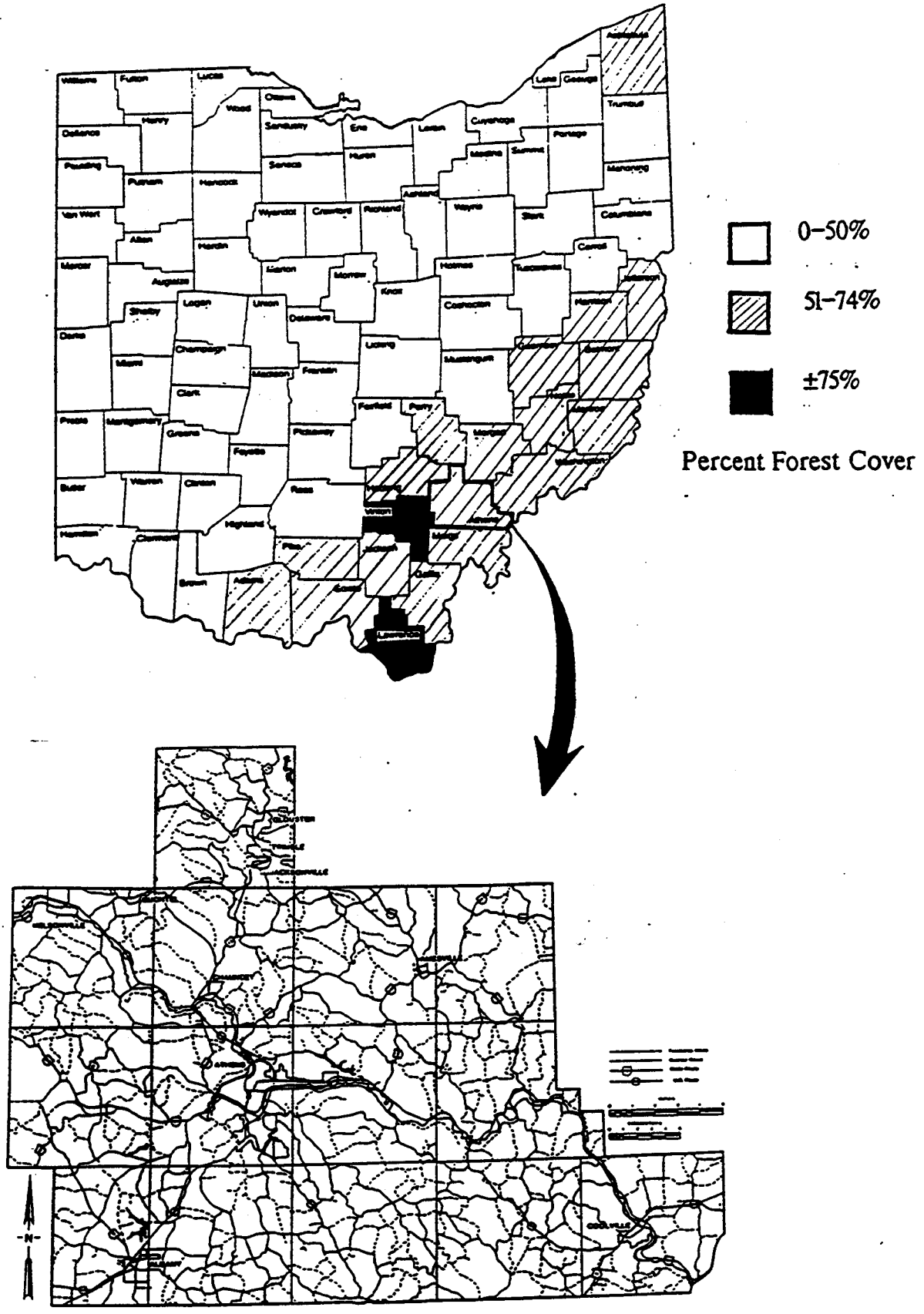
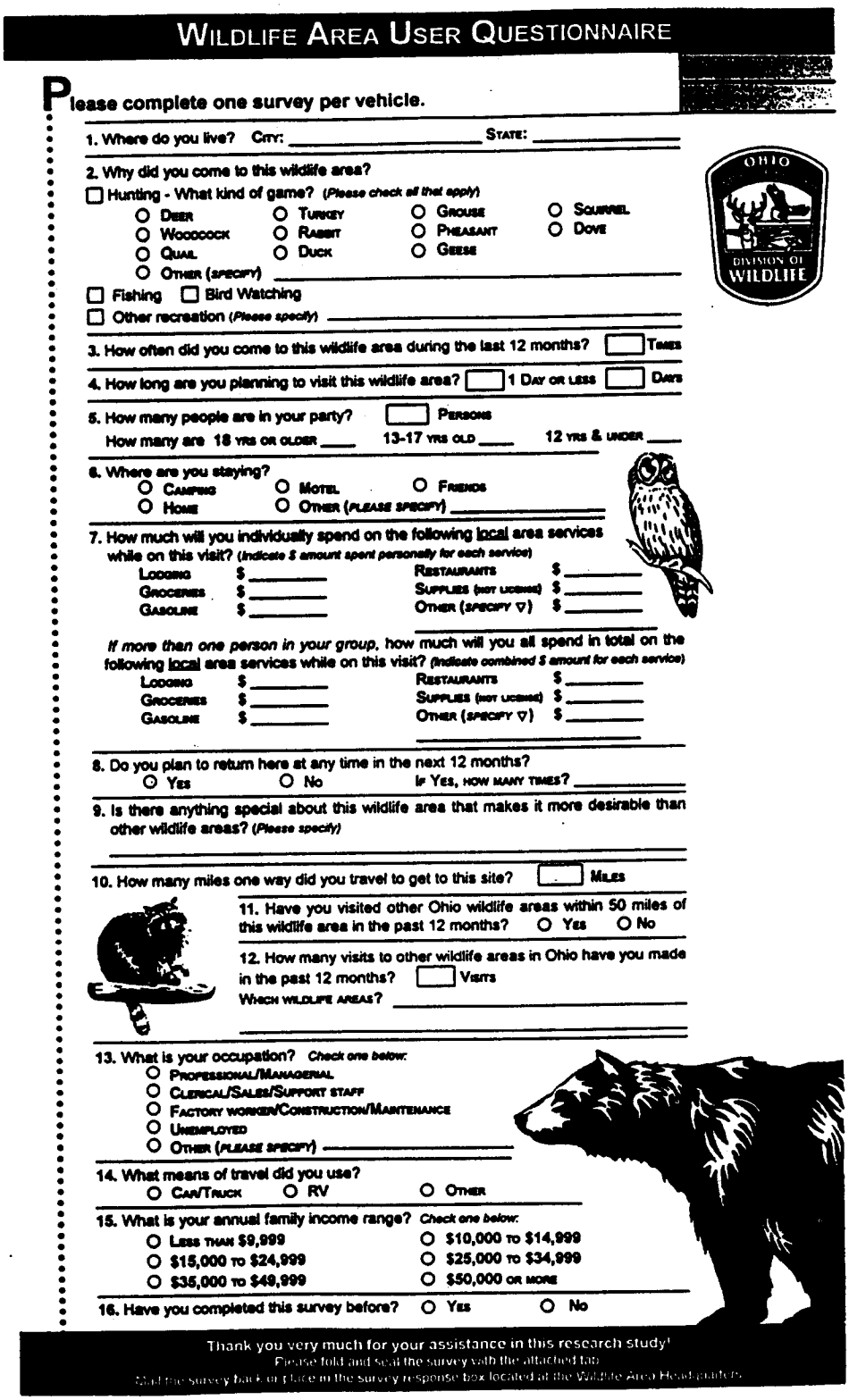


Figure 1.
Percentage of forest land by Ohio County.
Source: Division of Wildlife, Ohio Department of Natural Resources.



WILDLIFE AREA USER QUESTIONNAIRE

Please complete one survey per vehicle.

1. Where do you live? CITY: _____ STATE: _____

2. Why did you come to this wildlife area?

☐ Hunting - What kind of game? *(Please check all that apply)*

○ DEER ○ TURKEY ○ GROUSE ○ SQUIRREL
○ WOODCOCK ○ RABBIT ○ PHEASANT ○ DOVE
○ QUAIL ○ DUCK ○ GEESE
○ OTHER (SPECIFY) _____

☐ Fishing ☐ Bird Watching

☐ Other recreation *(Please specify)* _____

3. How often did you come to this wildlife area during the last 12 months? ☐ TIMES

4. How long are you planning to visit this wildlife area? ☐ 1 DAY OR LESS ☐ DAYS

5. How many people are in your party? ☐ PERSONS

How many are 18 YRS OR OLDER ____ 13-17 YRS OLD ____ 12 YRS & UNDER ____

6. Where are you staying?

○ CAMPING ○ MOTEL ○ FRIENDS
○ HOME ○ OTHER (PLEASE SPECIFY) _____

7. How much will you individually spend on the following local area services while on this visit? *(Indicate $ amount spent personally for each service)*

LODGING $ _____ RESTAURANTS $ _____
GROCERIES $ _____ SUPPLIES (NOT LICENSE) $ _____
GASOLINE $ _____ OTHER (SPECIFY ▽) $ _____

If more than one person in your group, how much will you all spend in total on the following local area services while on this visit? *(Indicate combined $ amount for each service)*

LODGING $ _____ RESTAURANTS $ _____
GROCERIES $ _____ SUPPLIES (NOT LICENSE) $ _____
GASOLINE $ _____ OTHER (SPECIFY ▽) $ _____

8. Do you plan to return here at any time in the next 12 months?

○ YES ○ NO IF YES, HOW MANY TIMES? _____

9. Is there anything special about this wildlife area that makes it more desirable than other wildlife areas? *(Please specify)*

10. How many miles one way did you travel to get to this site? ☐ MILES

11. Have you visited other Ohio wildlife areas within 50 miles of this wildlife area in the past 12 months? ○ YES ○ NO

12. How many visits to other wildlife areas in Ohio have you made in the past 12 months? ☐ VISITS

WHICH WILDLIFE AREAS? _____

13. What is your occupation? *Check one below:*

○ PROFESSIONAL/MANAGERIAL
○ CLERICAL/SALES/SUPPORT STAFF
○ FACTORY WORKER/CONSTRUCTION/MAINTENANCE
○ UNEMPLOYED
○ OTHER (PLEASE SPECIFY) _____

14. What means of travel did you use?

○ CAR/TRUCK ○ RV ○ OTHER

15. What is your annual family income range? *Check one below:*

○ LESS THAN $9,999 ○ $10,000 TO $14,999
○ $15,000 TO $24,999 ○ $25,000 TO $34,999
○ $35,000 TO $49,999 ○ $50,000 OR MORE

16. Have you completed this survey before? ○ YES ○ NO

Thank you very much for your assistance in this research study!
Please fold and seal the survey with the attached tab.
Send the survey back or place in the survey response box located at the Wildlife Area Headquarters.

Figure 2.
Ohio Wildlife Area User Questionnaire, 1996-97. Data compiled by ILGARD, Ohio University, and financial support by the Ohio Department of Natural Resources.

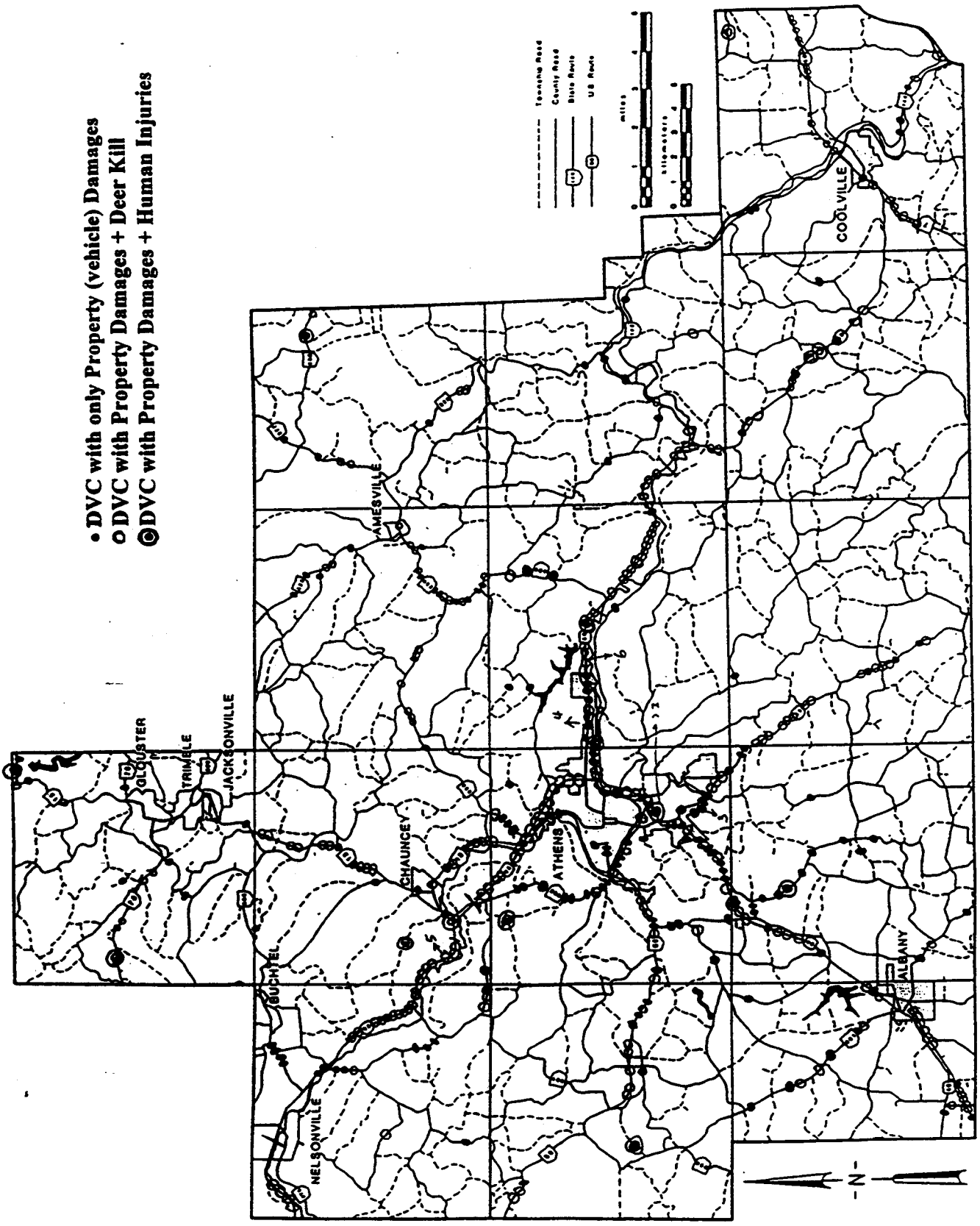


Figure 3.
Distribution of deer-vehicle accidents in Athens County, Ohio, 1996.

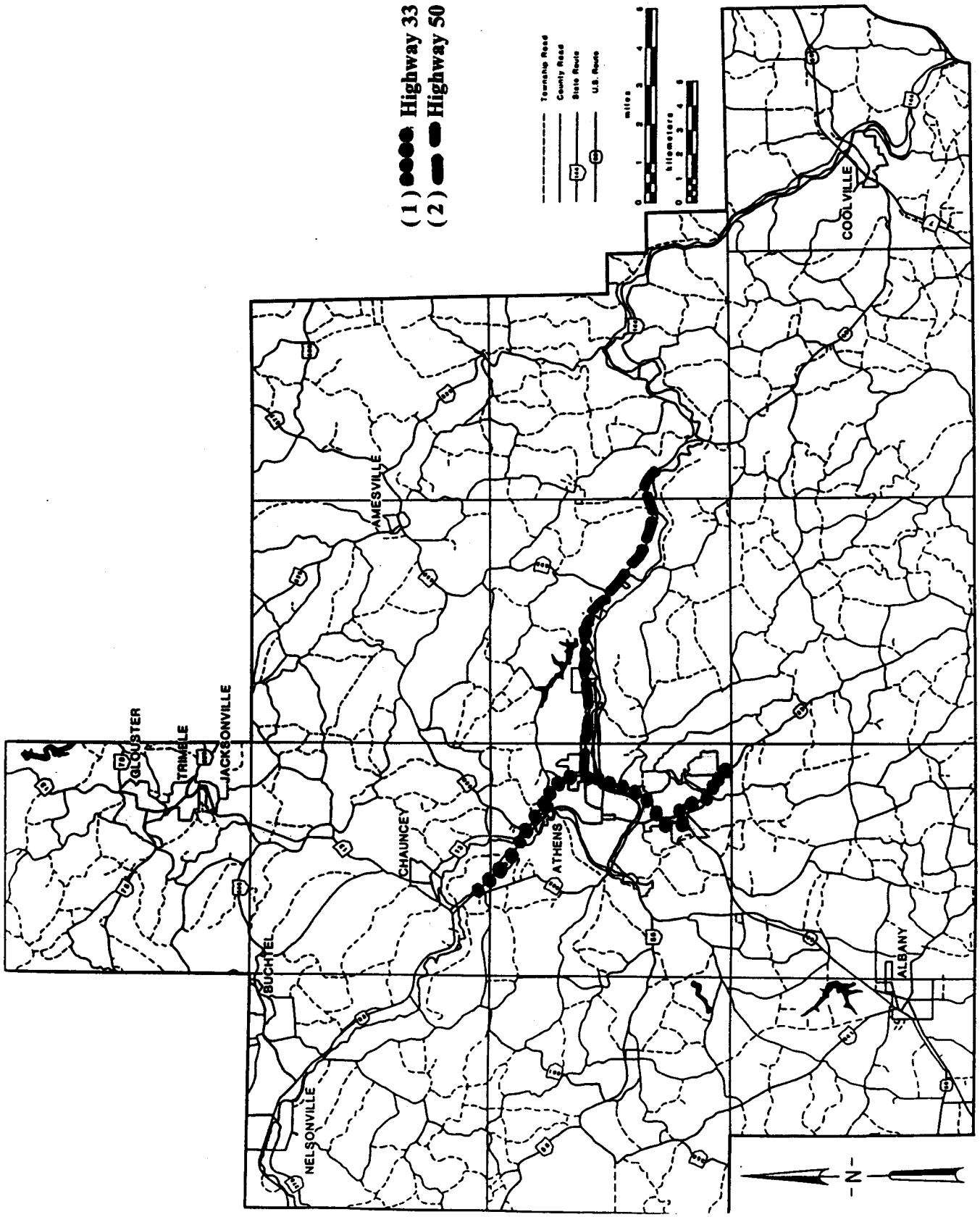


Figure 4.
Case study road segments in Athens County, Ohio, 1996.

Code	Component Title / Content
A	Vehicle Accident Cost 1. wage & productivity losses for employee and employer 2. medical expenses 3. administrative expenses (insurance, police, & legal cost) 4. vehicle damage 5. willingness to pay to avoid vehicle accident
B	Deer Value Use-Value: • Deer-Hunting Revenue: ♦Deer Hunting Opportunity Cost of Time/Wage Lost during Deer Hunting (O.C.T.) = round trip traveling time (days) X daily income ($/day) = 2.1* ♦Traveling Cost (T.C.) = round trip traveling mileages X 0.51 ($/mile) = 2.2* [1996 Transportation and Gas Cost (vehicle operation cost) = 51.43 cents/mile] Source: American Automobile Manufacturers Association Inc. *(Lodging Cost + Other Cost + O.C.T. + T.C.) X (1996 Ohio Deer Hunter Number) / (Hunter Harvested Deer Population)* *= ($/hunter)X(hunters/deer)* *=($47.29/hunter) X(136,206 hunters/158000 deer)* *=$/deer* ♦Deer Hunting License Cost = 1996 Ohio deer-hunting license revenue ($) 1996 Ohio hunter harvested deer population = ($13.7 million) / (158,000 deer) = 2.3* ♦Deer Venison Value = average deer weight X 60% X ($1.00/pound) = (14.5 million pounds/158,000 deer) X 60% X ($1.00/pound) = 2.4* (Sixty percent of deer is edible meat) • Deer Value in medical purposes & ecosystem Non-Use Value: Aesthetic Benefits, Option Value, Bequest Value, Altruistic Value
C	Deer Nuisance Cost: Deer Nuisance cost per deer lifespan (5 years) $\alpha=4$ $= \sum_{\alpha=0}$ (Ohio total deer nuisance costs in 1996) / (deer population) X [(1+discount rate) ^α] = 3.1* where α is deer longevity
D	Deer-Vehicle Collisions Mitigation Cost (Mitigation construction labor costs, design costs, materials, and maintenance costs.)

Figure 5.
Relationship of DVCs Benefit-Cost Components

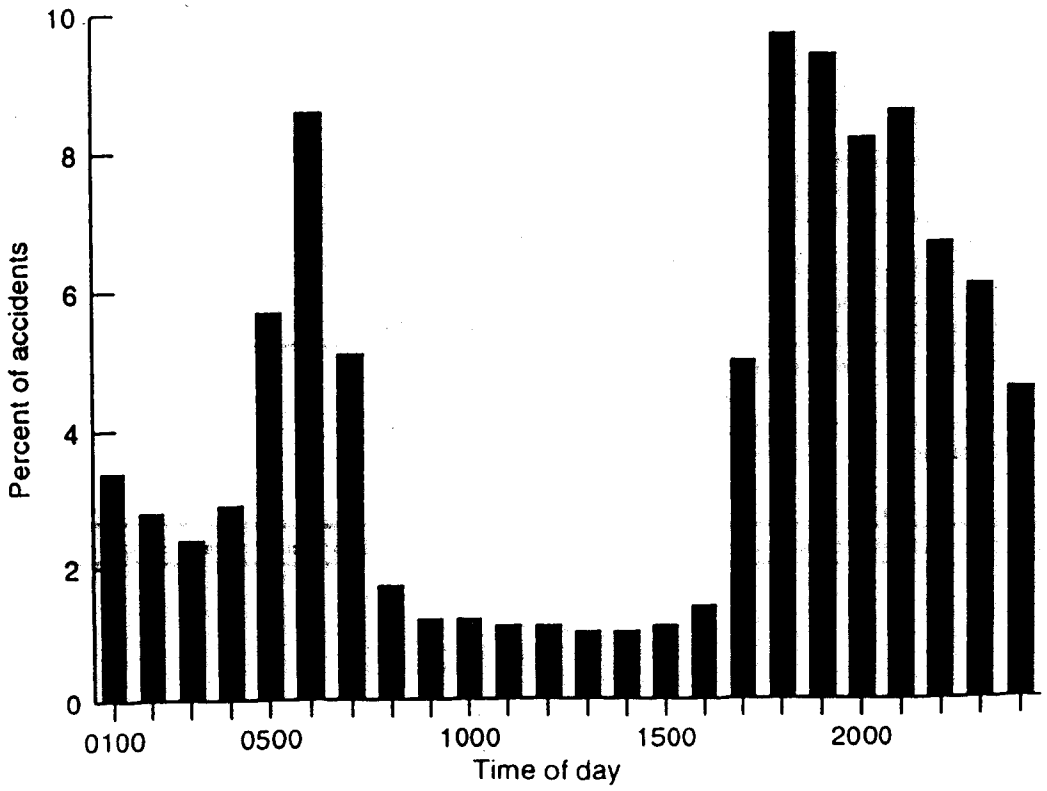


Figure 6.
Distribution of Ohio deer-vehicle accidents by time of day, 1989-96.
Data compiled by the Ohio Department of Public Safety.