HR-210

EFFECT OF WILDLIFE HIGHWAY WARNING REFLECTORS ON DEER-VEHICLE ACCIDENTS

FINAL REPORT
IOWA HIGHWAY RESEARCH BOARD
PROJECT HR-210

December 1984

IN COOPERATION WITH
IOWA CONSERVATION COMMISSION

Highway Division

Iowa Department of Transportation

Disclaimer

FINAL REPORT

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EFFECT OF WILDLIFE HIGHWAY WARNING REFLECTORS ON DEER-VEHICLE ACCIDENTS

BY

LEE GLADFELTER
WILDLIFE RESEARCH BIOLOGIST
IOWA CONSERVATION COMMISSION
WILDLIFE RESEARCH STATION
BOONE, IOWA 50036
PHONE 515-432-2823

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IOWA DEPARTMENT OF TRANSPORTATION

To Office Highway Division

Date February 7, 1985

Attention R. H. Given

Ref. No. 436/HR-210

From V. J. Marks VJM

Office Materials - Research

Subject Final Report HR-210 "Effect of Wildlife Highway Warning Reflectors on Deer-Vehicle Accidents"

The final report for Iowa Highway Research Board Project HR-210 is attached. Reflectors were installed at five deer crossing sites around the state. Two types of reflectors, Swareflex (red) and Bosch (clear), were evaluated.

Problems encountered with the reflectors included loss of reflectivity because of corrosion of the reflective aluminum backing, stress fractures in plastic lens, and mounting bracket failure. The manufacturer redesigned the mounting bracket adding support where it was lacking and replaced the broken-bracket reflectors.

The author concluded that the reflectors were "very effective in some areas and less effective in others" but an overall reduction of 41% in deer-vehicle accidents in the reflectorized areas and a 140% increase in deer-vehicle accidents in the remainder of the study counties.

VJM:kmd

cc: D. Anderson
G. Calvert

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Effects of Reflector Systems on Deer-Vehicle Accident Rates

Lee Gladfelter
Wildlife Research Biologist
Iowa Conservation Commission

INTRODUCTION

The number of deer-vehicle accidents in Iowa and around the country has steadily increased during the past 30 years. This is basically due to: (1) increased volume of traffic; (2) an expanding network of hard surface roads, especially 4-lane interstates; and (3) a general increase in deer populations. Initiation of a 55 MPH speed limit in 1974 and gasoline shortages in 1975 reduced deer-vehicle accident rates briefly, but since 1975, rates have continued to climb. Various methods of reducing these accidents have been attempted in other states. These include: installation of reflective devices, deer crossing signs, fencing, underpasses, clearing right-of-ways, and controlled hunting to reduce deer population size. These methods have met with varying degrees of success, depending on animal behavior, deer population fluctuations, method used, topography, road-side vegetation, traffic patterns, and highway configuration. This project was designed to evaluate a new method of reducing deer-vehicle accidents.

There are generally 4 important aspects of deer-vehicle accidents: danger to human life, vehicle damage, loss of a valuable wildlife resource, and cost of processing accident reports. In Iowa, during 1983, there were over 5,000 reported deer-vehicle accidents and probably many more that were not reported (Gladfelter 1984). The extent of human injury or death in Iowa is not known, but studies in southern Michigan show that human injuries occurred in about 4% of the deer-vehicle accidents (Allen and McCullough 1976). This would indicate that in Iowa there could have been 200 human injury cases from deer-vehicle accidents in 1983. These injuries usually occur from secondary collisions when motorists try to avoid a deer on the highway, and hit some other object. Vehicle damage from these accidents can run into thousands of dollars because of the high speed involved and the size of the animal. The total amount of vehicle damage occurring in Iowa is unknown, but if the average vehicle damage was between \$500-\$800 per accident, estimated property damage would be between \$2 1/2-\$4 million annually. The value of deer lost in these accidents cannot be estimated, but recreational potential of this natural resource is surely diminished for hunters and wildlife enthusiasts. Also, there is a great deal of money spent by governmental agencies for manpower to process accident reports and remove dead animals from highways.

In 1979, a cooperative research project on a new deer reflector system developed in Europe was initiated by the Iowa Conservation Commission and the Iowa Department of Transportation. The main objective of this project was to evaluate the Swareflex and Bosch reflector systems in reducing deer-vehicle accidents on selected sites along 2-lane and 4-lane highways that intersect high deer density areas. Deer reflectors reflect light from vehicle headlights at 90° angles into adjacent road ditches. Resulting flashes from reflectors produce an optical warning fence which alerts animals of danger. The project was broken down into 3 phases of study which included: (1) documenting deer-vehicle accidents on study sites for 1 year prior to reflector installation; (2) documenting accident rates for 3 years with reflectors in place; and (3) recording accident rates for 1 year following removal of reflectors. In addition, information was obtained on traffic volume, county deer-vehicle accident rates, and required reflector cost and maintenance.

METHODS

Reflectors were installed at 5 deer crossing sites of 1/4 to 1 mile in length and distributed around the state to measure different driving conditions, traffic volume, deer densities and road types. A control area extending 1/2 mile on either side of the reflectorized site was delineated to document changes in deer travel patterns which might occur due to reflector operation. The 5 crossing site locations, type of reflectors used and dates of reflector installation and removal are:

Decorah - One mile east of Decorah on Highway 9, Winneshiek County. Swareflex reflectors installed 10 July 1980 and removed 14 July 1983.

North Burlington - One and 1/2 miles north of Burlington on Highway 61, Des Moines County. Swareflex reflectors installed 23 July 1980 and removed 19 July 1983.

South Burlington - Four miles south of Burlington on Highway 61, Des Moines County. Bosch reflectors installed 23 July 1980 and removed 19 July 1983.

Timmon's Grove - One mile south of Albion on Marshall County blacktop S-75. Swareflex reflectors installed 17 July 1980 and removed 12 July 1983.

Little Sioux - Interstate 29 north of Little Sioux near mile post 97, Harrison County. Swareflex reflectors installed 26 October 1979 and removed 26 July 1983.

Traffic counters were also installed and maintained at each crossing site to document changes in traffic volume. This variable was measured because deer-vehicle accident rates can be affected by changes in traffic volume or traffic patterns.

Conservation officers in charge of each reflector site were asked to record information on the date and time of each accident and sex and estimated age of each deer killed. Officers also visited each site at least once every 2 weeks to document the number of missing reflectors, cause of damage and if reflector maintenance was required. Local Iowa Department of Transportation road maintenence crews were responsible for replacing reflectors, posts and performing maintenence when necessary.

RESULTS AND DISCUSSION

Reflector Installation Cost

The cost of reflector installation varied between sites and was dependent upon type and number of reflectors used, location of installing personnel, and site characteristics (rock fill, curve, etc.). Reflectors were installed on both sides of the road at 66′ intervals for straight roadway and at 33′ intervals for curves. A crew of 3 people (1 technician and 2 assistants) and 2 vehicles (1 pickup and 1 passenger car) were required for installation. Vehicles were not required to be on the traveled portion of the roadway during installation, however, use of advisory signs and a vehicle with a rotating caution light was considered necessary for safety reasons.

"Swareflex" reflectors are marketed by the Strieter Corporation of Rock Island, Illinois and cost $14 each. Reflectors used in this study were purchased at the reduced price of $10 each for experimental purposes. "Bosch" reflectors cost $7 each, when a minimum of 1,000 is purchased, and are sold by the Robert Bosch Corporation of Broadview, Illinois. The average 1980 installation cost per reflector for "Swareflex" type reflectors was $21.34 or $3,414.40 for 1 mile of straight roadway. Installation costs include labor, travel time, meals and lodging, vehicle expense, reflectors, and delineator posts. The "Bosch" system cost $14.34 per reflector in 1980 or $2,294.40 for 1 mile of straight roadway. Roadways with curves cost more because of reduced reflector intervals. Approximately 16 crew-hours of labor (3-man crew) were required to install 1 mile of reflectors unless problems with a particular site required more time. Some travel time was included in cost estimates but varied depending on location of installing personnel. The 2 sites in Des Moines County were used to calculate the average cost and manpower requirements of reflector installation.

Deer-Vehicle Accidents

Thirty-four deer were killed during Phase 1 of the project, which was designed to benchmark the number of deer-vehicle accidents on the study sites before reflector installation (Table 1). In addition, 4 deer were killed in the 1/2-mile control areas on either side of the designated reflector sites. Added verification for Phase 1 was provided by data taken from conservation officer routine traffic kill reports for the preceding year (July 1978-June 1979) which indicated that 35 deer were killed in the approximate vicinity of 4 of the 5 proposed study sites. Information for the 5th site was not specific enough for use in this study.

Phase 2 of the project was designed to test accident rates following reflector installation. During this three-year study period, annual mortality of 16, 11, and 23 deer was recorded for all reflector sites combined (Table 1). If an average annual kill is calculated for the 3 years that reflectors were operational, there is an apparent reduction in traffic kill from 34 to 17 deer or 51% compared to Phase 1 of the project. Most of this reduction can be attributed to the Decorah and South Burlington reflector sites (Fig. 1). One of these sites contained Swareflex reflectors while the other had Bosch reflectors. The remaining 3 sites produced little change in traffic kill after installation of reflectors. It is not known why some sites experienced big reductions in accident rates while others did not.

Table 1. Deer-vehicle accidents in reflector and control areas during project Phases 1-3.

Project Phase	Deer killed in reflector areas	Deer killed in control areas	Total kill
1 - Without reflectors	34	4	38
2 - a. 1st year with reflectors	16	5	21
b. 2nd year with reflectors	11	9	20
c. 3rd year with reflectors	23	3	26
3 - Without reflectors	9	12	21

Accident rates in control areas associated with reflector sites generally increased after installation of reflectors (Table 1). If an average for the 3 years in Phase 2 of reflector operation is used, this increase was about 42% compared to Phase 1 of the project. This increase may be a factor of chance but is more likely due to deer avoiding reflector sites by traveling around them and entering areas where they are susceptible to traffic or the accident rate is responding to increased deer population levels in accordance with other nonreflectorized deer crossings in the counties. Even with the increased kill associated with the control areas, there was still an overall reduction of 41% following reflector installation.

One surprising result of the project was Phase 3, designed to measure accident rates following reflector removal. During this period, the accident rate within the previously reflectorized area decreased substantially and increased in the control areas (Fig. 2). This is difficult to explain since an increase in deer kill following reflector removal was expected. One explanation might be that deer were accustomed to avoiding the reflector sites and did not change their behavior when reflectors were removed. This could mean that reflector sites may not need to be permanent, but could be moved to new locations after 2 or 3 years. This would reduce the cost of this system to the agency and make it more practical to utilize reflectors. Another explanation might be a slight shift in deer behavior, crop patterns, etc. that would account for this change which closely resembles the pattern experienced during the 2nd year of Phase 2.

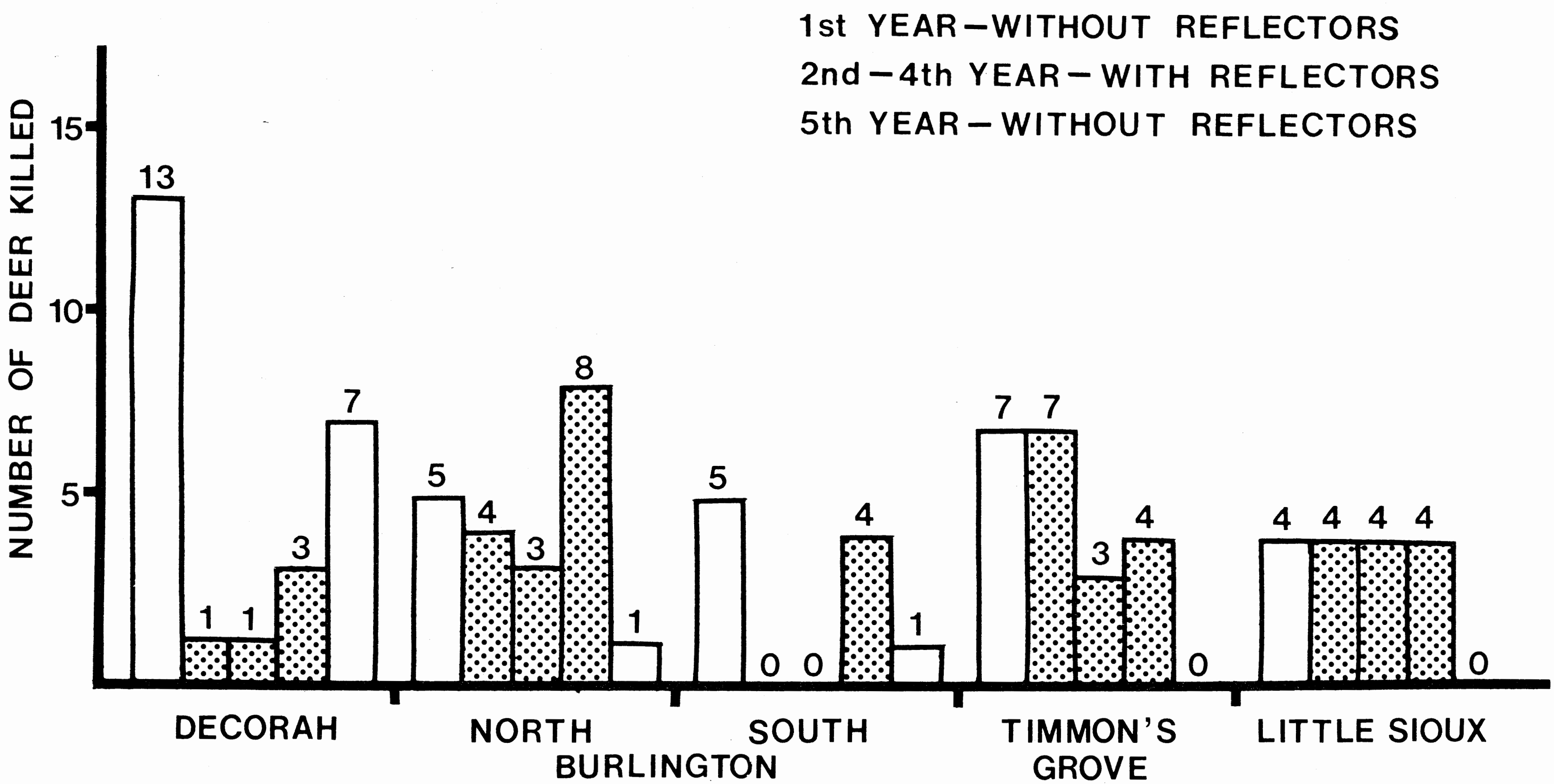

Figure 1. Number of deer killed at each reflector site, 1979-84.

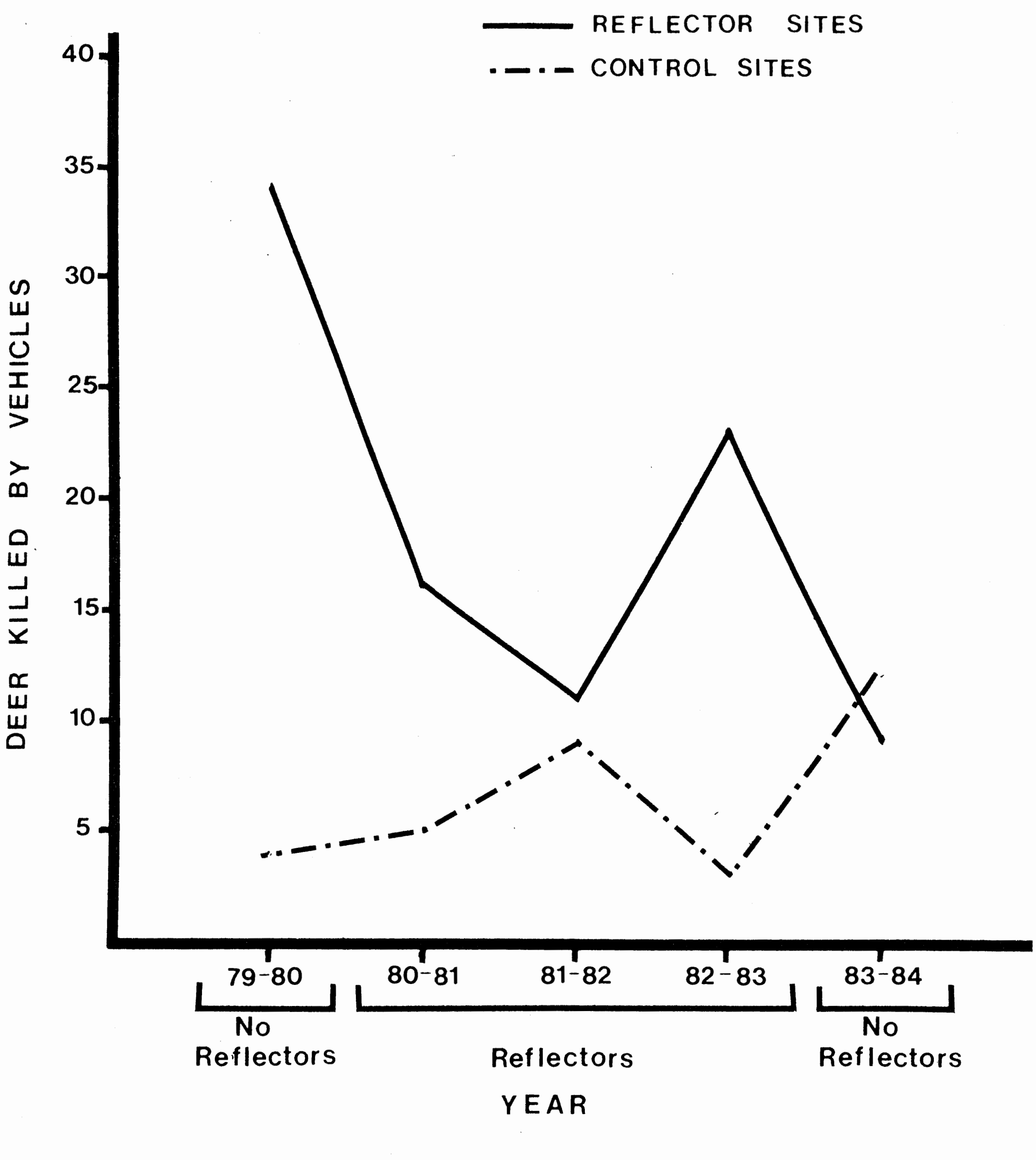

Figure 2. Deer killed by vehicles in reflector sites compared to control sites during 1979-84.

There are several major factors that impact traffic kill. One of the most important is deer population density. Changes in traffic kill when related to traffic volume is a good deer population trend indicator (McCaffery 1973). In counties that contained reflector sites, traffic kill increased 140% during the project period (Table 2). Increases ranged from 40% in Des Moines County to 486% in Winneshiek County. Deer densities in the immediate vicinity of reflector sites could not be measured, but it is assumed that they increased at approximately the same rate as in the remainder of the county. It is important to note that most reflector sites experienced the same or lower traffic kill following installation of reflectors in spite of these dramatically increasing deer population trends.

Table 2. Number of deer reported killed in vehicle accidents in counties with reflector systems, 1979-83.

	Deer killed in vehicle accidents					% change
County	1979	1980	1981	1982	1983	1979 to 1983
Des Moines	60	74	71	87	84	+ 40
Harrison	39	46	48	72	61	+ 56
Marshall	48	60	42	76	80	+ 67
Winneshiek	37	72	79	97	217	+486
Total	184	252	240	332	442	+140

The time of day for each accident was recorded to determine how many deer were hit during daylight hours when reflectors were inoperative. Twenty-three percent of the deer killed in reflector sites (Phase 2), were killed during daylight hours. Peak accident periods were from sunset to 4 hours after sunset and from 2 hours before sunrise to sunrise. These peak accident periods correspond to deer movement from daytime bedding areas to nocturnal feeding sites and then from feeding sites back to bedding areas in the morning.

The majority of deer-vehicle accidents during the project occurred between October and March. December accounted for 22% of the kill followed by November (21%), October (9%), March (9%) and May (8%). The peak period of mortality (November and December) corresponds to the peak rutting period for deer. During this time, mating activity causes animals to move extensively making them more susceptible to vehicle accidents.

The sex ratio of deer killed in traffic accidents during the project averaged 54% bucks compared to 46% does. This is slightly different from the statewide average of 47% bucks and 53% does (Gladfelter 1984). The difference is probably a factor of small sample size from the project.

Winter weather conditions and crop harvest patterns may be responsible for some of the annual variation in traffic kill during the project. Relatively open winters keep deer scattered in small isolated habitat while harsh winters concentrate deer in traditional wintering areas. Corn harvest is also important to the vulnerability of deer especially in October and November, months of high deer traffic mortality. The harvest of corn forces deer into more secure timbered habitat. It was difficult to clearly demonstrate the relationship between traffic kill and weather or crop patterns on the deer kill at reflector sites.

Traffic Volume

Another important factor in deer-vehicle accident rates is traffic volume. Logically, more traffic on a stretch of road should increase the opportunity for a collision with deer. This factor indicates the importance of documenting changes in traffic volume on reflector sites so that deer-vehicle accident rates can be adjusted to account for increased or decreased traffic volume.

Traffic volume varied between sites and time of year. The highest traffic volume was recorded at the South Burlington site with as high as 208,000 vehicles/month. The lowest traffic volume was at the Timmon's Grove site with 65,000 vehicles/month. Traffic volume on all sites was lowest in January increasing to a peak in July or August.

During the study, traffic volume increased at 4 of the sites and decreased at the remaining site (Table 3). Increases ranged from 3-12% while the overall average increase was 4% for all sites. However, the annual changes in traffic deer mortality when related to traffic volume appear to have little correlation (Fig. 3). Other factors such as small sample size, changes in deer density, weather, crop harvest, etc. may have been responsible for annual variations in deer kill.

Table 3. Comparison of traffic volume at reflector sites from 1979-80 to 1983-84.

Reflector site	Average vehicles/month[a] 1979-80	1980-81	1981-82	1982-83	1983-84	% change 1979-80 to 1983-84
Decorah	94,839	96,167	90,866	96,449	99,354	+ 5
N. Burlington	146,375	148,498	149,166	151,491	152,987	+ 5
S. Burlington	192,114	208,278	193,360	180,985	188,822	- 2
Timmon's Grove	71,368	72,510	68,634	65,141	73,351	+ 3
Little Sioux	157,246	160,707	158,081	162,884	175,912	+12
Average	132,388	137,232	132,021	131,390	138,085	+ 4

[a] Used the same months for each period to calculate average because of missing data in July and August, 1979.

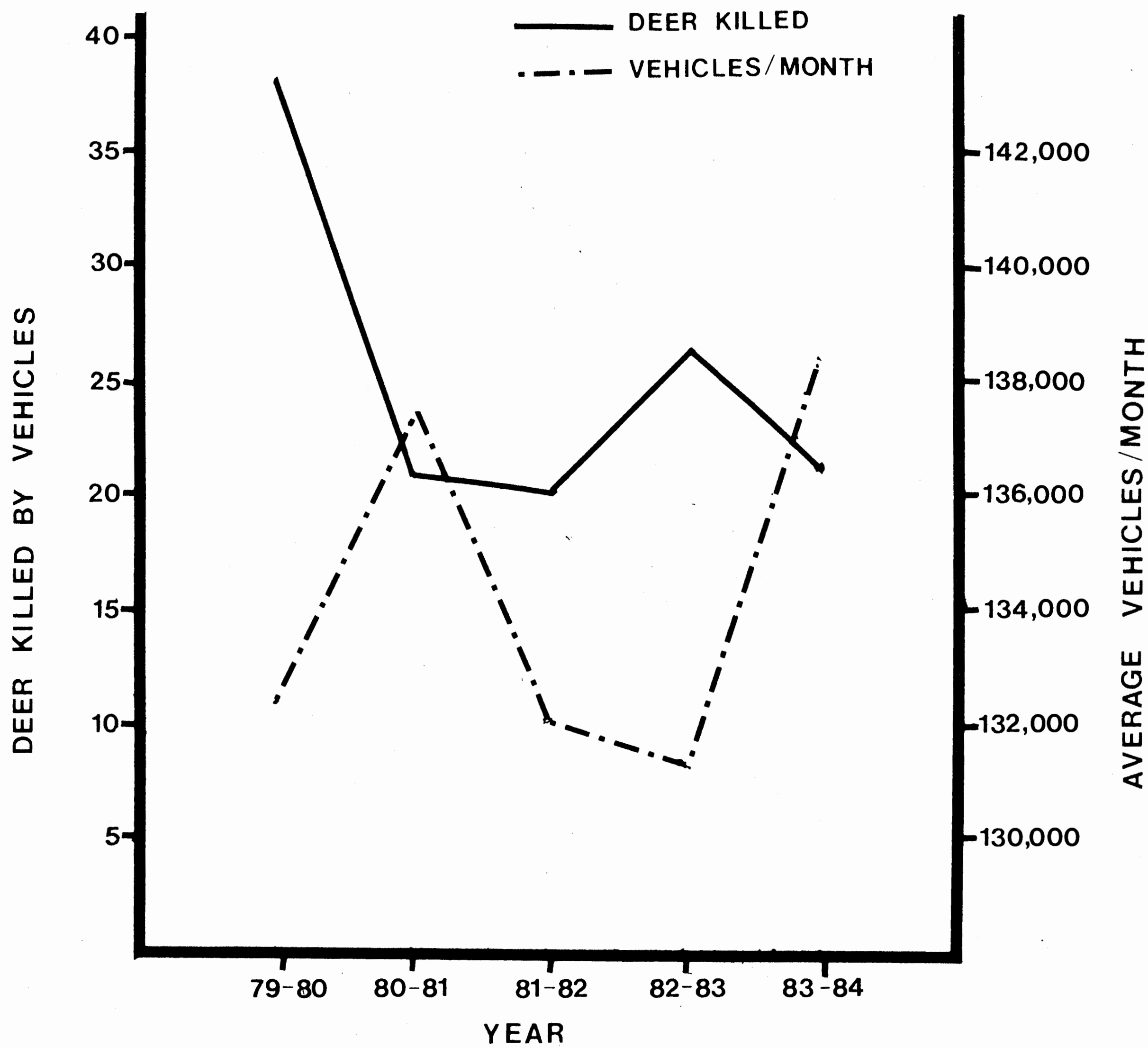

Figure 3. Total deer killed in both reflector and control sites compared to traffic volume in average vehicles/month, 1979-84.

Maintenance

Routine maintenance was performed by local DOT road crews and conservation officers. Cleaning after periods of rain and melting snow was necessary to keep reflectors bright and operable. DOT road crews were mainly responsible for replacement of reflectors and posts.

Problems

A major problem with structural design of Swareflex reflectors caused them to break off the delineator posts after several months of use. The problem occurred mainly on the Little Sioux (80 reflectors) and Timmon's Grove (28 reflectors) sites during 1980. The manufacturer corrected the problem by adding more support to the mounting bracket. This problem was not extensive enough to reduce the effectiveness of the reflector site during the majority of that test period (1 July 1980 to 30 June 1981).

Another major problem with the design of both the Swareflex and Bosch reflectors was discovered when reflectors were removed in 1983 for the final phase of the project. About 80% of the reflectors had lost 10-50% of their reflective abilities due to corrosion of the aluminum backing or reflective surface. This corrosion was probably due to moisture entering the reflector. Both reflector types are susceptible to this problem, and I believe the only reason that some were not affected is that a small percentage of the reflectors were replaced during the 3-year period and therefore had not been in service for a sufficient time to deteriorate. The problem appears to be of the kind that would continue with time and eventually result in total loss of reflective capabilities. This problem may have been of sufficient magnitude to affect the operational capabilities of the reflector system in the latter part of this study.

In addition, about 10-20% of the Swareflex reflectors had sustained stress fractures in the plastic reflective lens during the test period. These fractures were large enough to interfere with the reflected light pattern provided by the reflector. It appears that testing of reflectors before marketing by both manufacturers was insufficient to diagnose longevity of reflector systems. Both of these problems are correctable, and the manufacturers have taken steps to make appropriate changes in reflector design.

There was a small number of reflectors (less than 5%) broken off by vandals, car accidents, or unknown causes during the study. This loss was small enough that it was not considered detrimental to proper reflector site operation. Conservation officers and DOT road crews were issued extra reflectors and a tool kit to install missing reflectors during routine visits to the area.

CONCLUSIONS

It appears that reflectors have been very effective in some areas and less effective in others in reducing deer-vehicle accident rates. However, an overall reduction of 41% is impressive in light of the 140% average increase in deer-vehicle accidents that took place in the remainder of the study counties. It was apparent that deer avoided reflectorized segments of highway by traveling around them and entering areas where they were susceptible to traffic accidents. This was substantiated by the low traffic mortality in reflector areas after removal of reflectors (Phase 3). Reflector sites may not need to be permanent, but could be rotated every 2-3 years to reduce cost of implementing the project. Because of high cost, reflectors should be installed only in areas of high deer-vehicle accident rates. As these sites are identified and funding is made available, I would recommend that reflectors be installed to reduce human injury, personal damage, and loss of a valuable natural resource.

LITERATURE CITED

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