Effectiveness of Wildlife Warning Reflectors in Reducing Deer-Vehicle Accidents in Washington State

JAMES A. SCHAFER, STEPHEN PENLAND, and WILLIAM P. CARR

ABSTRACT

The effectiveness of Swareflex Wildlife Reflectors in reducing deer-vehicle collision rates was tested on SR-395 in eastern Washington State, on which high mortality rates of white-tailed deer (Odocoileus virginianus) had previously been recorded. Reflectors were placed in four test sections and alternately covered and uncovered at regular intervals during the late fall to early spring period from 1981 to 1984. During this period 52 deer were killed at night in test sections when the reflectors were covered and 6 deer were killed at night when the reflectors were uncovered. This difference in deer-vehicle collision rates between the covered and uncovered periods is significant ($p < 0.005$), which indicates that the reflectors were effective on this highway during this time period.

Collisions between deer and automobiles produce a substantial economic cost through damage to vehicles, the loss of a valuable wildlife resource, and human injuries or fatalities. Since 1977, 3,142 deer-vehicle accidents have been recorded by the Washington State Department of Transportation (WSDOT). High accident rates have been estimated in other states, including 3,000 in Iowa in 1978 (1), 4,900 in Colorado in 1968 (2), an average of more than 12,600 annually between 1972 and 1976 in Michigan (3), and 22,000 annually in the early 1970s in Pennsylvania (4).

Pils and Martin (5) and Reed et al. (6) estimated that the average cost of vehicular damage in these kinds of collisions was $500 in 1978. Washington State Patrol records indicate that 108 reported deer-vehicle collisions resulted in $82,000 in automobile damages and six human injuries on just one 30-mile stretch of SR-395 in eastern Washington since 1977. Adding the costs of human deaths and injuries, Hanson (7) estimated that each deer-vehicle accident cost $730. The economic value of each deer killed is more difficult to quantify (8). Reed et al. (6), using a damage award from a Colorado District Court, placed the economic loss of a deer at $350 in 1976. Hartman (9) and Norman (10) placed a deer's value at more than twice this figure based on hunting expenditures alone. Clearly, the 200,000 annual deer-vehicle collisions on America's highways (11) result in the loss of many millions of dollars.

A new reflector system designed to reduce the number of deer-vehicle accidents has been developed in Austria. This system, called Swareflex Wildlife Reflectors (Figure 1), consists of a series of 6.5 x 2-in. red reflectors mounted along the roadway (Figure 2). Light from the headlights of an approaching automobile is reflected at right angles to the roadway by the reflectors, creating an "optical

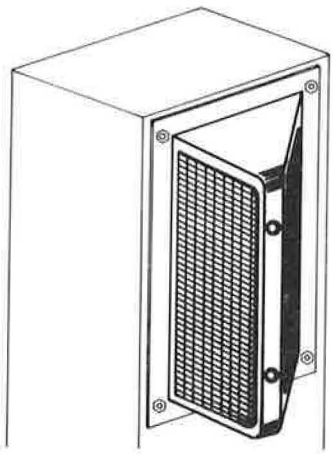

FIGURE 1 Wildlife warning reflector.

FIGURE 2 Reflector installation.

fence" that presumably causes deer to remain motionless until the automobile has passed and the optical fence has collapsed. Unfortunately, most tests of the effectiveness of the Swareflex Reflectors have consisted of before-and-after comparisons of deer kills that are confounded by variations of annual weather patterns, deer population densities, and traffic patterns. WSDOT used an experimental covered-uncovered design developed with the help of Charles T. Robbins of Washington State University that allows a valid statistical evaluation of the Swareflex Reflector system.

METHODS

Four test sections were established along SR-395 in an arid transitional ponderosa pine forest-grassland zone north of Spokane, Washington (Table 1). Each test section was placed in an area with high deer-vehicle accident rates. The sections ranged from 0.45 to 0.68 mile in length. Reflectors were placed at 66-ft intervals along straight road sections and 33-ft intervals on curves on both sides of the roadway, as suggested by the manufacturer.

TABLE 1 Locations and Number of Deer Killed in Test Sections

Section	Milepost	Total Miles	No. of Deer Killed	
			Covered	Uncovered
A	214.40-214.90	0.50	11	0
B	217.26-217.94	0.68	8	1
C	218.53-218.98	0.45	17	2
D	219.85-219.97	0.67	16	3
	220.05-220.13			
	220.26-220.44			
	220.52-220.60			
	220.62-220.76			
	220.93-221.05			

The reflectors in each test section were alternately covered and uncovered at 1-week intervals between mid-October and mid-April each year from February 1981 to April 1984. The covered-uncovered period was extended to 2-week intervals after December 1982. Alternate test sections were paired so that reflectors in each pair were covered while reflectors in their adjacent sections were uncovered, and vice versa.

The highway was traveled daily by WSDOT maintenance personnel. The milepost location, estimated time of kill, and the covered-uncovered status of the Swareflex Reflectors were recorded for each dead deer found along the highway. A paired t-test (12) was used to compare the number of deer killed at night during periods when reflectors were covered with the number killed at night during periods when reflectors were uncovered.

RESULTS

A total of 1,619 deer were killed on state highways from 1981 through May 1984. This total included 594 (37 percent) that were killed on SR-395. Seventy percent of the 801 deer killed statewide at known times of the day were killed during the nighttime hours.

The number of deer killed on SR-395 during the mid-October to mid-April test period since 1981 was 363, or 61 percent of the total number killed on that highway. Seventy-three (20 percent) were killed within the 2.3 miles of the test sections. The 138 deer killed outside the test sections at known times of the day included 114 (83 percent) that were killed at night and 24 (17 percent) that were killed during the day.

Fifty-eight deer were killed at night in the test sections during the test period (Table 1). These included 56 white-tailed deer (Odocoileus virginianus) and 2 mule (O. hemionus) deer. Fifty-two deer (90 percent) were killed when the reflectors were covered, and six (10 percent) were killed when the reflectors were uncovered. The difference between the number of deer killed when the reflectors were covered and the number killed when the reflectors were uncovered is statistically significant ($p < 0.005$).

DISCUSSION OF RESULTS

Swareflex Reflectors have usually been evaluated by comparing the number of deer killed along roadways after reflector installation with deer kills recorded before reflector installation. These comparisons have usually revealed a reduction in deer-vehicle collisions after reflector installation (citations from personal communication with Strieter Corporation). But annual variations of considerable magnitude exist in rates of deer-vehicle collisions (Table 2), probably because of changing deer population densities, changing traffic patterns, differences in weather that affect deer movement, or other factors (3,13-16). These variations obscure the relationship between reflectors and deer-vehicle collision rates when comparisons are made over periods of time. The use of an alternating present-absent study design eliminates the effects of these large-scale variations and allows a statistical evaluation of reflector effectiveness. A present-absent study design was used by Woodard et al. (17) for 24 weeks in Colorado. Because 11 deer were killed on a 1-mile test section when the reflectors were present compared with 8 deer killed when the reflectors were absent, they concluded that the Swareflex Reflectors were not effective. However, they did not describe the method of censusing dead deer nor did they specify whether the deer were killed only at night.

Polished stainless-steel mirrors, often called Van de Ree reflectors, have also been tested for their ability to reduce deer-vehicle collisions. Gilbert (18) attempted to reduce the variations inherent in time comparisons by using Van de Ree mirrors in twelve 0.5-mile randomly located sections along a 14.8-mile freeway in Maine. After 3 years, four deer had been killed in mirrored sections and three had been killed in nonmirrored sections. This small sample size did not permit a statistical test

TABLE 2 Annual Numbers of Deer-Vehicle Collisions in Washington State

Location	No. of Deer-Vehicle Collisions							
	1977	1978	1979	1980	1981	1982	1983	Total
SR-395	99	240	174	119	185	187	308	1,312
Eastern Washington	168	394	246	227	218	220	361	1,834
Western Washington	263	241	201	124	87	184	208	1,308
State total	431	635	447	351	305	404	569	3,142

of mirror effectiveness. Even if the sample size had been sufficient, the interpretation of data from randomly located test sections would still be plagued by the nonrandom distribution of deer because of differences in topography and resource availability. Other tests on Van de Ree mirrors have generally employed a before-and-after study design (18). Most have concluded that the mirrors were ineffective, although one test in Maine offered a qualified success and one in the Netherlands reported a 100 percent reduction in the number of deer killed during a 4-year period.

Although WSDOT's test of the Swareflex Reflectors was conducted during the late fall, winter, and early spring months, the distribution of deer-vehicle collisions reveals only a modest increase in the number of deer killed in February and March on SR-395 and other highways in eastern Washington (Figure 3). The number of deer killed by cars in western Washington peaks in the summer months and is lowest during the winter. Reports from other states have indicated that the most deer activity along highways and the highest mortality on highways occur in late fall and, to a lesser extent, in spring (3,4,14,19, 20). Reilly and Green (15) found a pronounced late winter-early spring peak in highway mortality of deer in northern Michigan that was in contrast to the fall peak of highway mortality in other parts of the state. Case (16) reported a peak in highway mortality of deer in Nebraska during May and June, and a somewhat smaller increase during October and November.

The manufacturer of the Swareflex Reflectors claims that the red color of the reflectors initiates an instinctive "freezing" response in deer. Evidence for this functional response to red color has been given by Backhaus (21) and discussed by Koenig (22) and Weis (23), although Severinghaus and Cheatum (24) stated that deer are color-blind. Whether the red color or simply the point source of light produces the functional response, the reflectors are effective only during the hours of darkness. Of the deer killed by vehicles at known times in Washington State, most are killed at night. A similar majority of the deer-vehicle accidents in other states also occur after sunset (2,3,20).

SUMMARY AND CONCLUSIONS

The economic cost of deer-vehicle collisions warrants consideration of effective preventive measures. The results and interpretations of previous studies of the effectiveness of deer mirrors have been hampered by small sample sizes and by influences of large-scale environmental factors on deer-vehicle collision rates over time when before-and-after comparisons are made. WSDOT employed an alternating cover-uncover study design to test the effectiveness of Swareflex Reflectors in an area

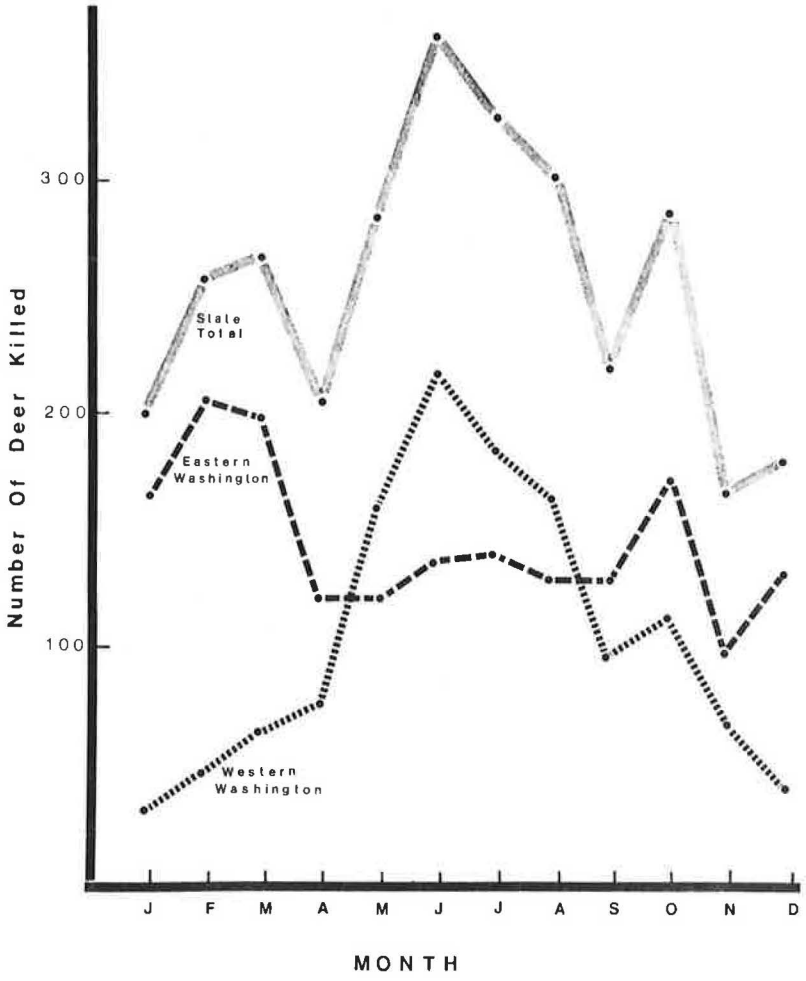

FIGURE 3 Average monthly distribution of deer-vehicle collisions between 1977 and 1983 in Washington State.

with historically high rates of deer-vehicle collisions. After 3 years, the reduction in the number of deer killed when the reflectors were uncovered was statistically significant. The Swareflex Reflectors were effective in reducing deer-vehicle collisions on this state highway in Washington.

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