Effectiveness of Temporary Warning Signs in Reducing Deer-Vehicle Collisions during Mule Deer Migrations

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ABSTRACT

We evaluated the effects of temporary, prominently displayed signs in reducing deer–vehicle collisions (DVCs) during mule deer (*Odocoileus hemionus*) migrations. To conduct the study, we selected segments of 5 highways in 3 western states that were crossed by mule deer during seasonal migrations. Using local input and historical DVC data, we identified migration corridors used by deer. We separated these migration corridors into sections of equal length. Each section was separated by a buffer zone. We randomly assigned each section into treatment or control areas. In treatment areas we erected temporary warning signs equipped with reflective flags and solar-powered flashing amber lights. To evaluate the effectiveness of signs in reducing DVCs, we monitored deer mortalities during migration periods before and after signs were placed. We also monitored vehicle speeds to determine if the signs affected motorist behavior. DVCs in the treatment areas were reduced by 50%. Vehicle speeds also were reduced, but evidence suggested that the effect eroded during the second year of the study. Study results indicated that temporary signing can be a cost-effective technique when used on roads where DVC peaks occur in conjunction with seasonal migration periods and are isolated to narrow corridors.

INTRODUCTIN

Conover et al. (1995) estimated that more than 1.5 million deer (*Odocoileus sp.*)–vehicle collisions (DVCs) occur annually in the United States, involving 29,000 injuries and 200 deaths to humans. The estimated damage to vehicles exceeds $1 billion annually. Erie Insurance reported that deer claims for its insured vehicles have increased in each of the last 5 years, with an average of 13 claims per 1,000 vehicles in 2001, and an average cost of $1,860 per claim (Collision Week 2002). These estimates do not account for lost work days, human suffering and deaths, increased public concerns about being involved in a DVC, impacts to wildlife resources, and hunter opportunity (Decker and Gavin 1987, West and Parkhurst 2002).

Although few states have accurate means of monitoring and reporting DVCs, most state wildlife biologists and transportation department administrators believe that DVCs are increasing. They cite increased traffic volumes, abundant deer populations, and higher vehicle speeds as the main contributing factors (Sullivan and Messmer 2003). However, even given a common perception that DVCs are increasing, they differed regarding solutions and whether any management actions could truly reduce DVC risks and alleviate associated public concerns.

State wildlife management agencies have a legal mandate to manage wildlife resources for a diversity of interests. Thus, resolving conflicts between deer and humans continues to be a prominent concern (Decker and Richmond 1995). Human attitudes to deer, other wildlife and their management may be influenced by the risk of being involved in a DVC, contracting a disease, or damage to landscape plantings or agricultural crops (Decker and Gavin 1987, Kilpatrick and Walter 1997). Reducing these risks has become an essential part of contemporary wildlife management.

Ellingwood and Spignesi (1986) applied the concept of cultural carrying capacity (CCC) to the management of risks associated with overabundant deer populations. Several authors have applied CCC to determine public acceptance of hunting in residential areas to reduce deer–human conflicts (Kilpatrick and Walter 1999, Kilpatrick and LaBonte 2003). In these studies resident satisfaction with hunting as a management option increased in relation to herd reduction and corresponding damage abatement. These studies suggest that there also may be a relationship between deer density, the number of DVCs reduced, and public recognition that risks have been mitigated. West and Parkhurst (2002) reported a relationship between public DVC risk perceptions and deer density. The question that remains to be answered is, "What level of DVC mitigation would mitigate public concerns?" This question was beyond the scope of our study.

As important as the reduction in DVCs may be from a CCC perspective, it also has ecological ramifications. Many efforts to reduce wildlife–vehicle collisions, such as highway fencing, can have adverse ecological consequences if traditional migration patterns are interrupted or key resources are no longer accessible. In addition, DVCs have been cited as the leading cause of mortality and linked to population declines of several species including the Florida key deer (*O. virginianus clavium*) (Calvo and Silvy 1996, Foreman and Hersberger 1996). It is estimated that 75% of all key deer deaths are automobile related (Turbak 1999). In some areas of the western United States, DVCs are having an adverse effect on already declining mule deer (*O. hemionus)* populations (Lutz et al. 2003).

A number of management techniques have been implemented to reduce DVCs. These techniques are designed to either keep deer off roads (e.g., whistles, reflectors, fences, repellents, intercept feeding, alternative routes such as underpasses) or improve the ability of drivers to react (e.g., reduced speed limits, vegetation clearances, improved lighting, warning signs). Although many of these measures continue to be implemented, limited information is available for managers or traffic engineers regarding their effectiveness (Romin and Bissonette 1996, Sullivan and Messmer 2003). For example, fences are effective but expensive to build and maintain (Ward 1982, Feldhamer et al. 1986). Intercept feeding can be effective at certain locations but is labor intensive (Wood and Wolfe 1988). Deer apparently do not respond to deer whistles (Romin and Dalton 1992, Romin and Bissonette 1996), and evidence regarding the effectiveness of reflectors is mixed (Putman 1997, National Cooperative Highway Research Program 2002). A recent review of the literature confirms these findings and notes the lack of definitive evidence for many of the techniques (Hedlund et al. in press).

The most common DVC mitigation measure used by transportation departments continues to be permanent, static signs (Sullivan and Messmer 2003). These signs generally are placed at DVC locations to warn motorists about the risk and used so commonly that most motorists may fail to notice them or ignore them altogether (Insurance Institute for Highway Safety 1993, Hughes et al. 1996). Romin and Bissonette (1996) argued that motorists might alter their driving behavior if they were properly informed when DVC risks were greatest. High-DVC risk areas include migration corridors and feeding and bedding sites. High-DVC risk periods include the breeding and hunting seasons and seasonal migrations (Lutz et al. 2003).

We conducted the present study to determine if temporary warning signs prominently displayed during spring and fall mule deer migration periods would reduce DVC risks. The ability of a motorist to stop and safely avoid a hazard, like a deer, is reduced with increased vehicle speeds (Freedman and Esterlitz 1990). We hypothesized that motorists, when presented with a hazard warning and coupled with evidence of the existing danger such as live deer or carcasses near the roadway, would exercise increased caution (i.e., reduce vehicle speeds). Increased motorist caution might translate into fewer DVCs.

METHODS

We selected 5 highways in Utah, Nevada, and Idaho to conduct this study. The highways and corridors were identified after consultations with state wildlife officials and reviewing DVC data provided by transportation departments for every highway in each state. Each highway was crossed by mule deer herds during seasonal migrations. We identified migration corridors that bisected the highways. The corridors ranged from 8–21 km in length, exhibited the same vegetation and landscape characteristics, and could be separated into 2 sections of about equal length with at least a 1.6-km buffer zone. A coin flip determined which section within the corridor would be the treatment (signed) and the control (unsigned).

Utah Department of Transportation (UDOT) traffic safety engineers designed the signs that were installed in the right-of-way adjacent to the road surface. The signs consisted of standardized yellow and black colors and were equipped with reflective flags and solar-powered flashing amber lights (Solar Masters, Newport Beach, California) (Figure 1). The signs could be seen readily at all times of the day. The lights operated on a light-sensitive switch to automatically turn on at dusk and off at dawn. The National Highway Traffic Safety Administration (2002) reported that nationally 79% of motor vehicle collisions with animals in the last decade occurred between dusk and dawn.

We placed the larger rectangular signs (1.8 × 0.9 m) facing traffic at each end of the treatment corridor on the appropriate side of the highway (Figure 2). These signs were designed to inform motorists they had entered a deer migration corridor and of the length of the corridor. We placed smaller diamond-shaped warning signs (0.9 × 0.9 m) on both sides of the highway to face both directions of traffic at every mile point within the corridor. Signs were designed to remind motorists they were traveling through a migration corridor and of the distance to the exit. Both versions of warning signs were designed to be set up before migration periods and folded down, with the lights turned off and the flags removed, after migrations. We determined the specific dates and time periods of operation after consulting state wildlife biologists familiar with deer herd migration patterns. The signs were operated during both spring and fall migrations at the treatment sites.

Figure 1
Design of Temporary Signs Placed within Treatment Corridors in Utah, Nevada, and Idaho, 2000-02

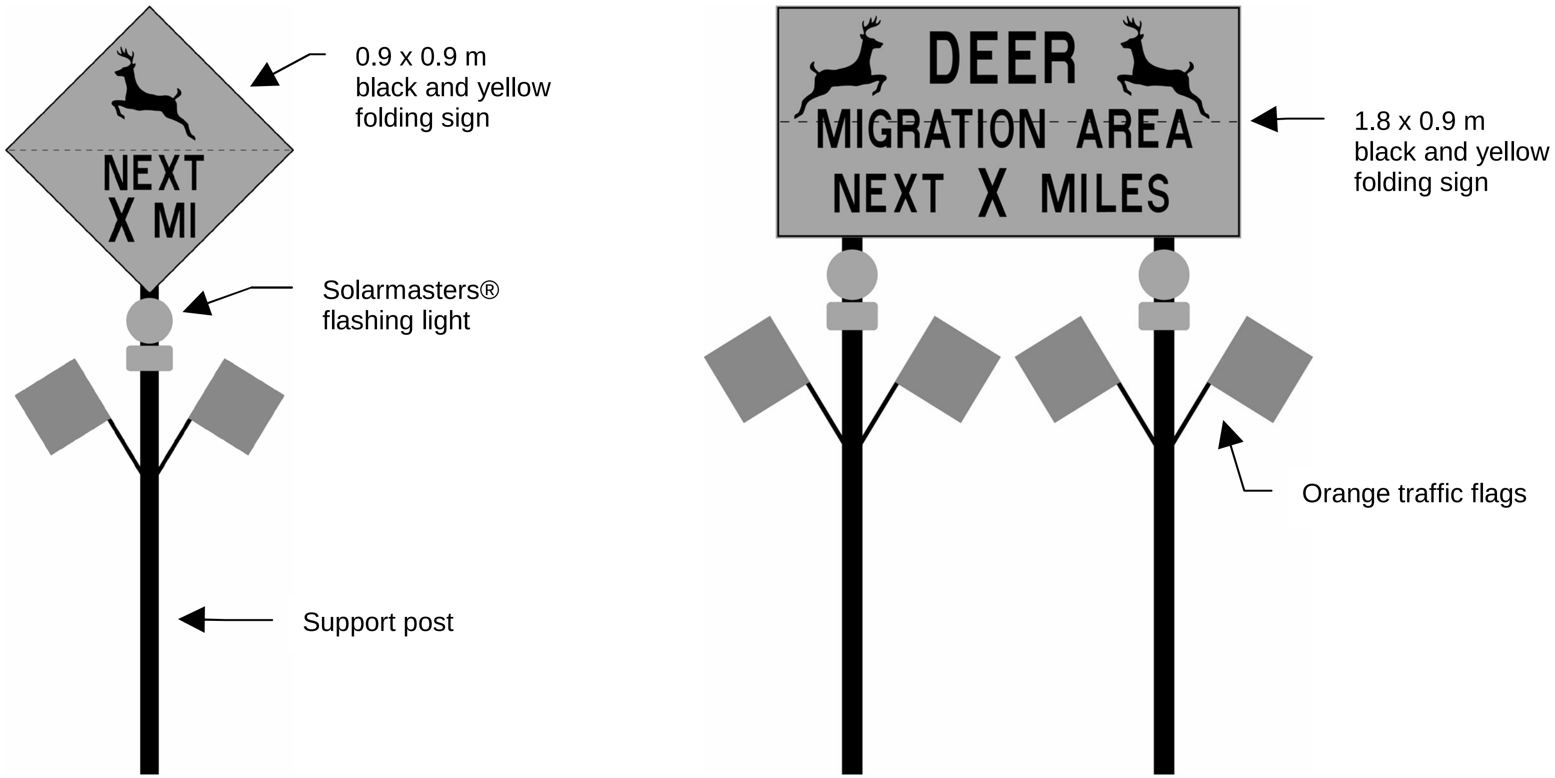
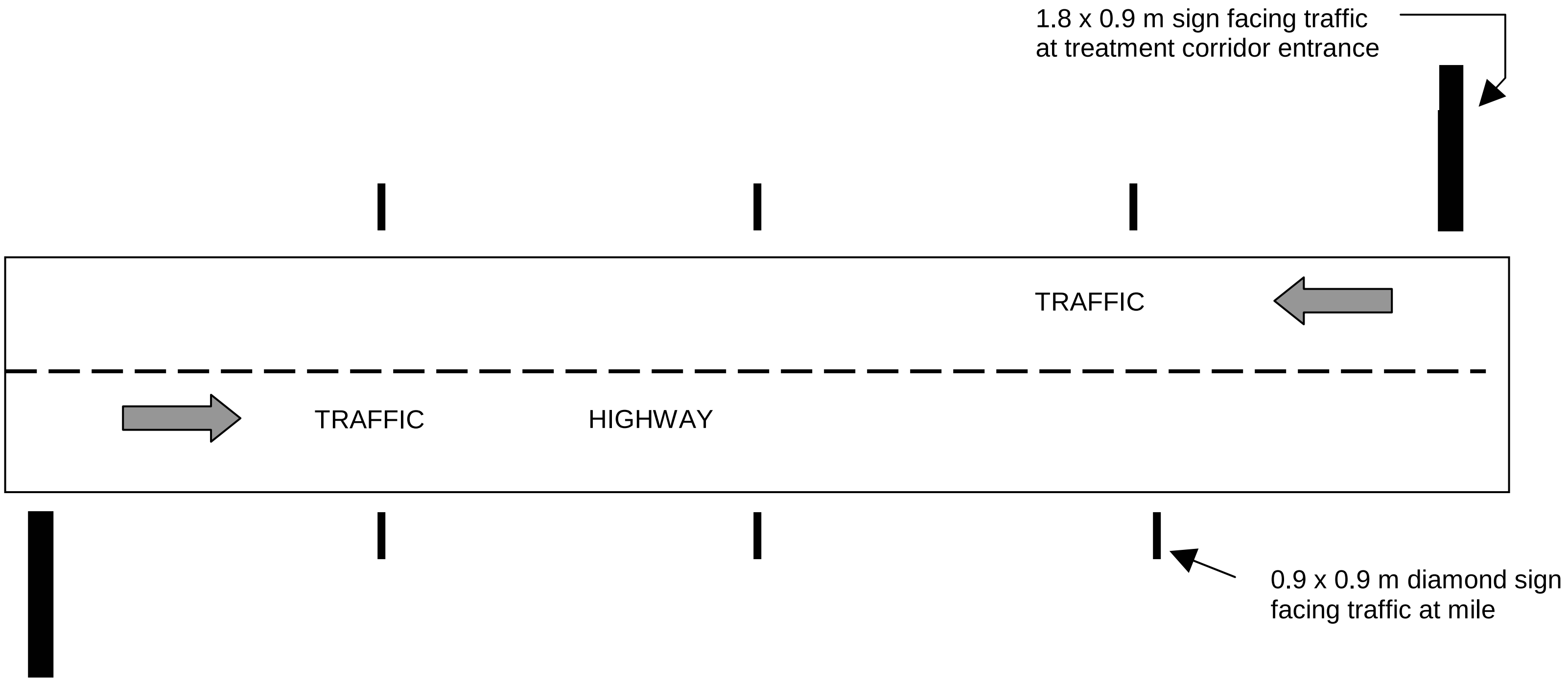


Figure 2
Layout of Typical 6.5-km Treatment Corridor Used in Utah, Nevada, and Idaho, 2000-02



We counted the number of deer killed daily on the highways at both treatment and control sites during spring and fall migration periods before and after sign use to test the effectiveness of signs in reducing DVCs. We also monitored vehicle speeds at treatment and control sites before and after signs were in use to determine if the signs had the presumed effect of reducing vehicle speed.

Although we originally selected 16 sites for study, good historical DVC data for several sites were lacking. The only sites used to conduct this evaluation had daily counts of deer kills compiled by milepost at both treatment and control sites prior to and throughout the study period. The 5 sites that met study criteria were: 2 in Utah (Kanab and Mantua), 2 in Nevada (HD Summit #1 and HD Summit #2), and 1 in Idaho (Boise River). We placed signs at Kanab in 1997, at Mantua and Boise River in 2000, and at the HD Summit sites in 2001.

We monitored vehicle speeds at 5 of the original 16 sites, of which only 2 were in the group that had adequate deer mortality data. However, because all 5 had both treatment (signed) and control segments, they were appropriate for assessing the effect of signs on vehicle speed. We collected speed data at all 5 sites in 2000 and repeated measurements in 2001 at 2 sites with adequate deer mortality data (Boise River and Mantua).

We collected vehicle speed data just prior to migration periods and again during migrations when signs were in operation. We primarily monitored speeds between 1700 and 2300 hours on weekdays when road conditions were dry. Data collection periods lasted for 3 hours or until 100 vehicles were recorded. Speeds of free-flowing vehicles (separated from the preceding vehicle in the same lane by at least 4 seconds) were measured by a nondetectable laser speed gun (LTI 20-20, Laser Technology, Inc., Centennial, Colo.). Two observers inconspicuously positioned on the highway right-of-way, one near the center of the treatment area and one near the center of the control area measured speeds at the same time. To avoid measuring any residual effect of the signs, speeds in the control area were measured before those vehicles entered the treatment area. We corrected raw speed data for angle of observation, in accordance with the manufacturer's instructions. We classified vehicles as commercial (heavy trucks and tractor-trailers), trucks (pickups, sport utility vehicles, and vans), and sedans (regular 2-door and 4-door cars).

We used negative binomial regression to assess effectiveness of signs in reducing DVCs. The dependent variable was "killed," the number of deer killed for a specific period. Independent variables were: site (1 for Kanab, 2 for Mantua, 3 for HD Summit #1, 4 for HD Summit #2, and 5 for Boise River WMA), year (1995–2001), season (spring and fall), period (before and after), corridor (control and treatment), and signs (an indicator variable equal to 1 if and only if signs were in use [i.e., for treatment corridors during treatment periods]). In addition, "days," the number of days in the migration period, was added as an offset, assuming the expected number of deer killed was proportional to length of migration period.

We used logistic regression analysis to determine if signing affected motorist speeds. Our primary interest was to determine if signs reduced excessive vehicle speeds. Thus, the response variable selected was speeding, an indicator equal to 1 if a particular vehicle's speed was above the speed limit by 8 km/h or more and 0 otherwise. Independent variables were year (2000 and 2001), site (1 for Boise River, 2 for Mantua, 3 for Red Rocks, 4 for Montpelier, and 5 for Mackay), corridor (treatment and control), period (pretreatment and treatment), vehicle type (1 for car, 2 for light truck, 3 for heavy truck), and signs (another indicator equal to 1 if and only if signs were in use [i.e., for treatment corridors during treatment periods]).

RESULTS

Effects on DVCs

The raw data for the study (i.e., numbers of deer killed during fall and spring migration periods at treatment and control corridors at the 5 sites before and after signs were introduced) are presented in Table 1. After signs were introduced, deer mortalities at treatment sites relative to mortalities at control sites were reduced. Statistical tests confirmed this

Negative binomial regression provided an estimate of the change in DVCs at treatment sites associated with introduction of signs. Regression analysis resulted in a final model with a deviance-to-degrees-of-freedom ratio equal to 1.23 (Table 2), implying that the chosen model adequately fit the data (Cameron and Trivedi, 1998).

The estimate corresponding to signs was statistically significant ($\chi^2 = 4.22$, $P = 0.04$) and equaled –0.7121 (Table 2). The percent reduction in deer killed due to the signs was 1 minus the inverse logarithm of the coefficient times 100%. The best estimate of the reduction in deer mortality due to temporary lighted signs was 51% (confidence bounds: 3.2–75.1%). Using this percentage, an estimated 179 DVCs were prevented in the treatment areas during the study period.

The year and season variables were excluded from the model as statistically insignificant. The site variable was statistically significant; therefore, the combined estimate for the 5 sites might have been attributable to a single site. Therefore, we applied the same regression analysis to the dataset with sites extracted one by one (i.e., first sites 2,3,4,5; then sites 1,3,4,5; then sites 1,2,4,5; then sites 1,2,3,5; and finally sites 1,2,3,4). If 1 site had been responsible for the reduction in DVCs, a much smaller estimate would have been produced when the model was applied to 1 of the 5 "quartets" of sites. This did not happen; the 5 analyses estimated that the effect of temporary lighted signs on deer mortality ranged from –41.5% to –58.6%, which fell within the confidence bounds previously obtained. Other statistically significant chi-squares in Table 2 were not relevant to the effects of the signs.

Effects on Speeds

We combined vehicle speeds recorded at treatment and control corridors before and after signing for 2000 and 2001 to test the effect of signs on speeding (Table 3). We combined data for all vehicle types (cars, light trucks, and heavy trucks). The percentage of speeding vehicles at control corridors

Table 1
Deer Mortalities Recorded at Treatment and Control Sites in Utah, Nevada, and Idaho, 1995-2001

State and Site	Corridor	Milepost	Dates of Data Collection	Treatment	Control
Utah			*Prior to sign introduction*		
Site 1	Treatment	38-42	14 Oct 1995 to 1 Dec 1995	38	5
Kanab, Highway 89	Control	44-48	14 Mar 1996 to 1 May 1996	35	10
			14 Oct 1996 to 1 Dec 1996	34	5
			14 Mar 1997 to 1 May 1997	35	6
			Signs introduced fall 1997		
			15 Oct 1997 to 5 Nov 1997	8	4
			15 Mar 1998 to 4 Apr 1998	15	5
			17 Oct 1998 to 13 Nov 1998	16	4
			15 Mar 1999 to 6 Apr 1999	14	4
			17 Oct 1999 to 15 Nov 1999	16	6
			14 Mar 2000 to 16 Apr 2000	No data	No data
			20 Oct 2000 to 1 Dec 2000	No data	No data
			14 Oct 2001 to 30 Nov 2001	2	2
			15 Mar 2002 to 1 May 2002	14	4
Site 2	Treatment	6.5-9.5	*Prior to sign introduction*		
Mantua, Highway 91	Control	2.5-5.5	28 Nov 1996 to 24 Jan 1997	19	4
			28 Nov 1997 to 24 Jan 1998	12	4
			28 Nov 1998 to 24 Jan 1999	2	4
			28 Nov 1999 to 24 Jan 2000	4	1
			Signs introduced fall 2000		
			28 Nov 2000 to 24 Jan 2001	5	5
			4 Dec 2001 to 22 Jan 2002	9	20
Nevada			*Prior to sign introduction*		
Site 3	Treatment	82-85	1 Oct 1999 to 4 Nov 1999	9	15
HD Summit #1, Highway 93	Control	92-95	15 Mar 2000 to 8 May 2000	0	4
			1 Oct 2000 to 4 Nov 2000	24	24
			15 Mar 2001 to 8 May 2001	1	2
			Signs introduced fall 2001		
			1 Oct 2001 to 4 Nov 2001	6	8
			15 Mar 2002 to 8 May 2002	9	2
Site 4	Treatment	121-123	*Prior to sign introduction*		
HD Summit #2, Highway 93	Control	124-126	7 Dec 1999 to 5 Feb 2000	3	2
			15 Mar 2000 to 8 May 2000	10	2
			7 Dec 2000 to 5 Feb 2001	1	1
			15 Mar 2001 to 8 May 2001	0	1
			Signs introduced fall 2001		
			7 Dec 2001 to 5 Feb 2002	1	10
			15 Mar 2002 to 8 May 2002	5	2
Idaho			*Prior to sign introduction*		
Site 5	Treatment	16.8-20.8	12 Nov 1996 to 13 Feb 1997	8	24
Boise River WMA, Highway 21	Control	10-14	7 Mar 1997 to 1 May 1997	2	3
			12 Nov 1997 to 13 Feb 1998	19	15
			7 Mar 1998 to 1 May 1998	3	4
			12 Nov 1998 to 13 Feb 1999	17	10
			7 Mar 1999 to 1 May 1999	13	2
			12 Nov 1999 to 13 Feb 2000	26	23
			7 Mar 2000 to 1 May 2000	5	2
			Signs introduced fall 2000		
			15 Dec 2000 to 13 Feb 2001	15	16
			15 Mar 2001 to 15 Apr 2001	2	5
			12 Nov 2001 to 12 Jan 2002	9	23
			7 Mar 2002 to 1 May 2002	10	4

Table 2
Negative Binomial Regression, Analysis of Parameter Estimates for the Statistical Model of Number of Deer Killed in Utah, Nevada, and Idaho, 1995-2001

Parameter	Degrees of Freedom	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square
Intercept	1	-2.0634	0.2248	-2.504	-1.6227	84.22
Site 1	1	-0.1911	0.3201	-1.8185	0.4362	0.36
Site 2	1	-0.361	0.3761	-1.0981	0.3761	0.92
Site 3	1	0.5431	0.366	-0.1743	1.2605	2.2
Site 4	1	-1.1631	0.4143	-1.9751	-0.3511	7.88
Site 5	0	0	0	0	0	—
Corridor*site 1	1	1.7666	0.3706	1.0403	2.4929	22.73
Corridor*site 2	1	0.5979	0.458	-0.2997	1.4955	1.7
Corridor*site 3	1	0.0188	0.4318	-0.8275	0.8651	0
Corridor*site 4	1	0.4554	0.5191	-0.5619	1.4728	0.77
Corridor*site 5	1	0.2506	0.3184	-0.3735	0.8747	0.62
Period	1	0.4955	0.2524	0.0007	0.9902	3.85
Corridor	0	0	0	0	0	—
Signs	1	-0.7121	0.3467	-1.3916	-0.0327	4.22
Dispersion	1	0.4175	0.0858	0.279	0.6246	—

Note: Independent variables analyzed included: Site 1 (Kanab), site 2 (Mantua), site 3 (HD Summit #1), site 4 (HD Summit #2), site 5 (Boise River WMA), *year* (1995-2001), *season* (spring and fall), *period* (before and after), *corridor* (control and treatment), and *signs* (an indicator variable equal to 1 if and only if signs were in use, i.e., for treatment corridors during treatment periods).

Table 3
Vehicles Exceeding Speed Limit by 8 km/h or More at Treatment and Control Sites in Idaho and Utah, 2000-2001

		Signs Not Up		Signs Up	
Site	Corridor	Vehicles N	Speeders N (%)	Vehicles N	Speeders N (%)
Boise River, Idaho	Control	270	93 (34)	211	54 (26)
	Treatment	340	64 (19)	243	10 (4)
Mantua, Utah	Control	233	50 (21)	212	33 (16)
	Treatment	208	42 (20)	219	22 (10)
Red Rocks, Idaho	Control	81	23 (28)	54	9 (17)
	Treatment	87	19 (22)	73	14 (19)
Montpelier, Idaho	Control	75	13 (17)	71	14 (20)
	Treatment	80	19 (24)	79	3 (4)
Mackay, Idaho	Control	76	8 (11)	100	13 (13)
	Treatment	90	6 (7)	118	6 (5)
Total	Control	735	187 (25)	648	123 (19)
	Treatment	805	150 (19)	732	55 (8)

changed modestly (from 25% to 19% for the 5 sites combined from pretreatment to treatment period), whereas the percentage at treatment corridors more than halved (from 19% to 8%).

The temporary lighted signs influenced vehicle speeds ($P < 0.01$) (Table 4). The odds of a driver not exceeding the speed limit by 8 km/h or more almost doubled when signs were in use (odds ratio: 1.94, confidence bounds: 1.28–2.96). Interaction between signs and vehicle type was significant ($P < 0.05$), indicating greater effectiveness on speeds of heavy trucks than on speeds of passenger vehicles.

Table 4
Logistic Regression, Odds Ratio (Probability Modeled is Speeding = 0) in Idaho and Utah, 2000-01

Effect	Point Estimate	Wald 95% Confidence Limits	
Year	1.65	1.30	2.08
Site 1 vs. 5	0.29	0.19	0.44
Site 2 vs. 5	0.40	0.26	0.60
Site 3 vs. 5	0.34	0.22	0.54
Site 4 vs. 5	0.27	0.14	0.51
Corridor	1.50	1.17	1.91
Period	1.40	1.08	1.82
Vehicle type 1 vs. 3	0.42	0.24	0.75
Vehicle type 2 vs. 3	0.44	0.25	0.79
Signs	1.94	1.28	2.96

Note: Site 1 (Boise River, Idaho), site 2 (Mantua, Utah), site 3 (Red Rocks, Idaho), site 4 (Montpelier, Idaho), site 5 (Mackay, Idaho)

At the 2 sites where speeds were measured in both 2000 and 2001, there was some evidence that the effect of signs on speeds was reduced in 2001. In 2000 excessive speeds were reduced from 21% to 8% at the 2 treatment sites and changed little at control sites. In 2001 vehicle speeds were reduced by about half at both treatment and control sites. Further analysis confirmed this observation. When we included the 2-factor interaction of signs and year in the model, the corresponding estimate (–1.03) was negative and significant ($P < 0.05$), implying a higher effect in 2000 than in 2001.

DISCUSSION

Most signs warning motorists of possible presence of deer are static permanent signs and are not considered to be effective (Putman 1997, Sullivan and Messmer 2003). However, in the present study, temporary signing prominently displayed only at high-risk times resulted in an estimated 50% reduction in DVCs, although with wide confidence bounds.

The 5 sites differed for the time periods covered and when signs were introduced. There were more DVCs in the treatment than in the control area at 1 of the sites during the period prior to sign placement, although sections were of equal length. Data gaps also occurred at 2 of the sites. Reliable counts of daily deer mortality were not provided for any spring migration at Mantua or for fall 2000 and spring 2000 migrations at Kanab. Number of deer killed at each site during successive migration periods also varied as affected by weather and other seasonal factors. However, none of these factors affected the study design, which compared the number of deer killed at treatment and control sites before and after signs were used. There would be a problem only if there were systematic differences in these migrations between treatment and control sites within these corridors, an unlikely event.

Signs used in this study were prominent and designed to command attention. They were expected to increase motorist alertness to presence of deer, manifested in part by lower vehicle speeds. Our results indicated that signs reduced the likelihood of high vehicle speeds, but some evidence from 2 sites suggested the effect diminished over time. Thus, signs in the same location may lose their effectiveness over time. However, effects of signs on DVCs did not diminish. If effects were diminished, the percentage of DVCs that occurred in the treatment area relative to the control area would be expected to increase in the second year, and this did not happen. For example, at Mantua 50% of DVCs occurred in the treatment area during the first year and 31% during the second year (compared with 74% during pretreatment migrations). At Boise River 45% of DVCs occurred in the treatment area during the first year and 41% during the second year (compared with 53% during pretreatment migrations).

Management Implications

The need to manage DVCs is greatly magnified by increased public concerns (Decker and Gavin 1987). From a management perspective, it is unclear how much of a reduction in DVCs needs to occur before public concerns are mitigated. This remains a difficult task for wildlife managers. To accomplish this more information will be needed to quantify effects of specific management techniques on mitigating DVCs relative to public recognition that risks have been reduced.

Few scientific studies have been conducted to evaluate the performance of specific DVC reduction techniques (Romin and Bissonette 1996, Sullivan and Messmer 2003), resulting in uncertainty about what to recommend among the many possibilities. We undertook our study to evaluate the effectiveness of 1 specific management approach in reducing localized DVCs. Our results suggest the signs used in this study constituted an effective and low-cost technique to mitigate DVCs in areas where mule deer use narrow corridors to cross highways during seasonal migrations. Temporary signs are readily available through custom fabrication by transportation department sign shops or by altering existing signs. The costs associated with signing a 6.5-km stretch of highway averaged $1,740 (large signs: $400 each, small signs: $90 each, lights: $40 each). Although vandalism was an initial concern, only 3 lights and 1 sign were vandalized.

The success of these efforts relies on local wildlife biologists to identify when migration periods begin and end to guide activation of the signs. Use of this personal local knowledge provides a condition under which this technique may prove successful when more broadly applied in other areas of the country. One of the main difficulties in conducting this study was the lack of accurate and complete deer mortality data for highways identified as high-DVC risk areas. To eliminate this problem, we recommend that state wildlife agency and transportation department personnel coordinate and standardize data collection prior to implementing signing projects. Coordination will not only identify high-DVC areas but also ensure that signs operate properly to maximize human health and safety benefits and reduce deer mortalities.

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