Deer-Vehicle Crash Countermeasures Effectiveness Research Review

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ABSTRACT

During the last two years an extensive review of deer-vehicle crash (DVC) countermeasure documentation has been completed. Research and/or documents related to 16 different countermeasures were reviewed and are currently being summarized in a DVC Countermeasures Toolbox. An example of some of the countermeasure research reviewed includes documents related to deer whistles, warning signs and technologies, and roadside reflectors. The results of the ongoing countermeasures review contained in the toolbox are summarized in this paper. The toolbox is one of the first products from the Deer-Vehicle Crash Information Clearinghouse (DVCIC). The DVCIC is funded by the Wisconsin Department of Transportation and five states in the Upper Midwest (i.e., Michigan, Minnesota, Illinois, Iowa, and Wisconsin) are currently involved with the project. The final version of the DVC Countermeasures Toolbox, and the results of a DVC data management and characteristics survey should be completed by the end of 2003. These products, along with suggested standards for DVC countermeasure research and a regional data summary, are expected to be resources for transportation decision-makers.

Key words: countermeasures—deer-vehicle crashes—research review

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INTRODUCTION

It has been estimated that over 1.5 million deer-vehicle crashes (DVCs) occur each year in the United States, but less than half of them are reported (1). In Wisconsin, approximately one in seven reported crashes are DVCs. A summary of the reported DVC and/or animal-vehicle crashes for the Upper Midwest region is show in Table 1.

In July 2001, the Wisconsin Department of Transportation (WisDOT) initiated a regional DVC Information Clearinghouse (DVCIC). Five states in the Upper Midwest (i.e., Michigan, Minnesota, Illinois, Iowa, and Wisconsin) are involved with this project. During the last two years the clearinghouse staff has combed through hundreds of documents that summarize the current state of the knowledge related to DVC countermeasure effectiveness. The creation of this DVC Countermeasures Toolbox is ongoing and should be finalized this year. The goal is to provide a resource to transportation professionals that can assist them with their decisions related to the reduction of DVCs.

This paper summarizes the preliminary results of the toolbox document review that were available in June 2003. Additional reviews will be completed between June 2003 and the time of the Mid-Continent Transportation Symposium in August 2003. The results of the ongoing reviews will be presented at the symposium. Draft and final results of the reviews, as they become available, are also available at www.deercrash.com.

THE DVC COUNTERMEASURE TOOLBOX

The development of a DVC Countermeasures Toolbox is an ongoing task of the DVCIC staff. The objective of the toolbox is to provide information to decision-makers about the current state of the knowledge related to the effectiveness of DVC-reduction measures. The focus of the investigation is documented and published research, if available, about the relationship of 16 DVC countermeasures and their direct DVC impact. The characteristics of each measure that may impact its DVC-reduction effectiveness are also being identified. However, documentation about the “effectiveness” of the DVC countermeasures also ranges from the anecdotal to a comparably few peer-reviewed research journal publications. DVC countermeasure studies that are poorly documented, questionably designed, and/or invalid or unrepeatable in their statistical validity are also common. This situation is most likely the result of the variability, diversity, and complexity of the problem.
### TABLE 1. 2000/01 Upper Midwest Deer-Vehicle Crashes

<table>
<thead>
<tr>
<th>State</th>
<th>Pre-Hunt Numbers in Deer Herd</th>
<th>Deer-Vehicle Crashes</th>
<th>Deaths</th>
<th>Injuries</th>
<th>Vehicle Damage**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michigan</td>
<td>1,800,000</td>
<td>67,000</td>
<td>11</td>
<td>2,100</td>
<td>$114 mil</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>1,500,000</td>
<td>19,900</td>
<td>9</td>
<td>800</td>
<td>$34 mil</td>
</tr>
<tr>
<td>Minnesota*</td>
<td>960,000</td>
<td>19,000</td>
<td>2</td>
<td>450</td>
<td>$32 mil</td>
</tr>
<tr>
<td>Illinois</td>
<td>750,000 (est.)</td>
<td>22,900</td>
<td>5</td>
<td>920</td>
<td>$39 mil</td>
</tr>
<tr>
<td>Iowa*</td>
<td>210,000</td>
<td>7,800</td>
<td>3</td>
<td>600</td>
<td>$13 mil</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,220,000</strong></td>
<td><strong>136,600</strong></td>
<td><strong>30</strong></td>
<td><strong>4,870</strong></td>
<td><strong>$232 mil</strong></td>
</tr>
</tbody>
</table>

*2000 Reported deer-vehicle or animal-vehicle crashes.

**Damage estimate assumes $1,700 property damage per reported crash.

The toolbox attempts to summarize the current state of the knowledge about the DVC-reduction capabilities of the countermeasures listed below. Those countermeasures in the list that are in italics are currently being summarized. The remainder of the summaries are in draft form. The reader is referred to the webpage (www.deercrash.com) for these draft summaries, and a complete listing of the references used.

- Noise/sound/whistle devices;
- Reflectors/mirrors;
- Deer crossing signs;
- Intercept feeding;
- Speed limit reduction;
- Highway lighting;
- Repellents;
- Deer flagging models;
- Deicing salt alternatives;
- In-vehicle technologies;
- Wildlife grade separations and crossings (e.g., overpasses, underpasses, and at-grade);
- Vegetation/roadside management;
• Hunting or herd management;
• Fences/barriers/one-way gates;
• Highway planning; and
• Public education-awareness.

NOISE/SOUND/WHISTLE DEVICES

The DVC reduction effectiveness of air-activated deer whistles has been investigated through the use of non-scientific before-and-after studies and some documented research into the hearing capabilities of deer. In general, the relatively poor design (e.g., sample size) and/or documentation of the before-and-after studies have produced conflicting results. No conclusions can be drawn from the studies reviewed as a whole, and better designs and documentation are recommended for future studies of this nature.

A small amount of documented/published research has been completed in the area of deer auditory capabilities and their reaction to air-activated whistles. In fact, a summary of a recently published study, and possibly the documentation of a county-level study in California, will be added to the upcoming final version of the toolbox. For the most part, however, it has been found that deer hear in the same range of sound as humans. It has also generally been concluded in the studies reviewed that deer did not react to vehicle-mounted air-activated deer whistles. The ability of whistles to produce the advertised level of sound at an adequate distance has also been questioned. Additional scientifically defined research about the effectiveness of air-activated deer whistles and similar non-air-activated devices is recommended.

REFLECTORS/MIRRORS

The reflector/mirror studies and literature reviewed for the toolbox were segmented into four categories. Past reflector/mirror research typically used either a cover/uncover, before-and-after, or control/treatment study approach to evaluate their impact. Researchers have also either observed deer movements as they evaluated the impact of roadside reflectors/mirrors on deer roadkill and/or DVCs or specifically considered deer behavior toward reflected light. Many of the studies summarized (which represent a sample of the many documents available), whether they focused on deer roadkill and DVC impacts or deer behavior, had conflicting results. Overall, 5 of the 10 studies summarized for the toolbox had conclusions that indicted roadside reflectors did not appear to impact deer roadkill or DVCs, and 2 of the 10 concluded that they did. Three of the 10 studies summarized appeared to reach inconclusive or mixed results. Most of the studies that evaluated deer behavior (many dealing with captive deer) were also inconclusive or concluded that the deer either did not appear to react to the light from the reflectors and/or quickly became habituated to the light. Unfortunately, the experimental designs and details of all the studies varied (their details are included in the draft toolbox at www.deercrash.com). Speculative and anecdotal information that exists about roadside reflector/mirror DVC-reduction effectiveness was not included in the summary.

At this point in time it is difficult to conclude the roadkill- or DVC-reduction effectiveness of roadside reflector/mirror devices due to the conflicting results of the studies summarized. It is recommended that the completion of a definitive roadside reflector/mirror DVC-reduction...
effectiveness study be considered. A well-designed widespread long-term statistically valid study of comparable and well-defined roadside reflector treatment and control roadway segments (with consideration given to local deer travel patterns) is suggested.

DEER CROSSING SIGNS

Two studies were summarized that implied there were speed reduction impacts related to the lighted deer crossing sign design improvements they were evaluating. However, the outcome of a more in-depth study by some of the same researchers of a lighted and animated deer crossing sign did not appear to indicate that the resultant vehicle speed reduction resulted in a reduction of the number of deer roadkill (i.e., DVCs). Unfortunately, these study results are based on only 15 weeks of data and the variability in DVCs and the factors that impact their occurrence also limits their validity and transferability. It is proposed that additional and more long-term research be completed to support or refute the speed- and DVC-reduction impacts of existing and proposed improvements to deer crossing warning signs.

A number of systems that combine dynamic signs and sensors are also being considered or have been installed (e.g., Montana, Indiana, Minnesota, and Wyoming). Several of these systems are briefly described in draft toolbox at www.deercrash.com. The recent development of these systems requires an initial evaluation of their activation reliability. One key to the successful application of these systems is the minimization of false activations. The operation and effectiveness of some of the systems described in the draft toolbox are currently being studied, but only the Nugget Canyon, Wyoming system analysis appears to have been documented at this time. The researchers doing the evaluation concluded that when the system worked properly it produced a small, but statistically significant, reduction in average vehicle speeds. However, they did not believe the observed average vehicle speed reduction would reduce DVCs. Reductions in average vehicle speeds were also found when the lights on the signs were continuously flashed and/or a deer decoy was introduced on the roadside. In fact, the largest average vehicle speed reduction calculated was when the lights were flashing and the deer decoy was present.

INTERCEPT FEEDING

Intercept feeding involves the provision of feeding stations outside the roadway area. The objective is to divert animals to the feeding areas before they cross the roadway. One study was found that attempted to evaluate the impact of this DVC countermeasure. The researchers generally concluded that intercept feeding might be an effective short-term mitigation measure that could reduce DVCs by 50 percent or less. However, the study results actually described appeared to be contradictory. In addition, there was no documentation of the number of DVCs that occurred along the roadway segments evaluated before the intercept feeding stations were in operation, and it was acknowledged by the researchers that the amount of deer roadkill counted along the segments were not proportional to the deer population near each segment. In general, the study investigators were of the opinion that the potential for a short-term reduction in DVC of 50 percent or less was not sufficient enough to justify the amount of work and funding necessary for the implementation of intercept feeding. It was suggested that intercept feeding might be combined with other countermeasures to increase its effectiveness. Two problems that might occur with the implementation of this countermeasure are that deer may become dependent on the food supply and more deer than typical might be drawn to the general vicinity of the roadway and the area. The appearance of chronic wasting disease in Wisconsin also makes this approach
undesirable.

**SPEED LIMIT REDUCTION**

Two studies that evaluated speed limit reduction as a potential DVC countermeasure were reviewed for the toolbox. In both cases the researchers suggested that there was a relationship between animal-vehicle collisions and posted speed limits. In certain instances, but not all, their research results appear to show a less than expected number of animal-vehicle collisions along roadway segments with lower posted speed limits. To reach this conclusion, one study statistically compared the proportion of roadway mileage with a particular posted speed limit to the proportion of animals killed along those segments. The other study compared the frequency and rate per roadway length of animal-vehicle collisions before and after a posted speed limit changes. No studies were found that focused on the number of white-tailed DVCs and posted speed limit.

There are several limitations to the research results presented in this summary. Overall, like the analysis of many other animal-vehicle crash countermeasures, the two studies summarized do not address, and/or attempt to control for, a number of factors that could impact the validity and usefulness of their conclusions. For example, neither study quantitatively considered the increase in traffic volume or adjacent animal population variability along the segments considered. The comparison of the proportion of animal-vehicle collisions to the proportion of roadway mileage also assumes a uniform distribution of animal population, and also tends to ignore any positive or negative correlations that might exist between roadway design, topography, posted speed limit, operating speed, and animal habitat. Effectively determining and defining a relationship (if any) between reduced posted speed limits (or operating speeds) and the number of animal-vehicle collisions along a roadway segment will require additional research studies that attempt to address, control for, and/or quantify the impact and potential interaction of these and other factors.

One of the studies summarized also concluded that the choice of vehicle operating speed appeared to be primarily impacted by the roadway and roadside design features (versus posted speed limit). This is a conclusion that is generally accepted in the transportation profession, and primarily supports the idea that a reduction in posted speed limit that is not considered reasonable by the driving public will generally be ignored (without significant enforcement presence). This type of situation has been shown to increase the general possibility of a crash (not DVCs) between two vehicles along a roadway because some drivers will slow and others will not.

**HIGHWAY LIGHTING**

One study was found that attempted to directly relate the existence of roadway lighting to a reduction in DVCs. This study also investigated the changes in deer crossing patterns and average vehicle speeds that might occur with the addition of lighting. The study researchers concluded that the addition of lighting did not appear to have an impact on DVCs, deer crossing patterns, or average vehicle speeds. However, they made this conclusion despite the fact that a reduction in the number of crashes per deer crossing appeared to decrease by about 18 percent with the addition of lighting along the roadway test segment. It is assumed, but it was not documented, that the investigators believed that this reduction was within the normal variability of the data evaluated. The addition of a taxidermy-mounted full-size deer in the emergency lane of the roadway segment did produce a reduction in average speed of about 8 mph when the lights
were activated. However, not enough speed data were available to validate these results. Additional research may be appropriate to evaluate the focused effectiveness of lighting as a DVC-reduction tool (versus a speed reduction tool).

REPELLENTS

A large number of studies, with varied approaches, have attempted to evaluate the effectiveness of numerous repellents on the feeding patterns of several different types of captive animals. The studies summarized in the draft toolbox investigated repellent impacts on white-tailed deer, mule deer, caribou, and elk. No studies were found that documented an attempt to test repellent effectiveness on deterring wild animals from approaching a roadside and roadway to feed.

Some of the factors evaluated in the studies summarized include type and number of repellents (e.g., predator urine, brand, odor, taste, etc.), status or application of repellent (e.g., spray, paste, etc.), concentration of repellent, animal hunger level, food type, and amount of rain or water occurrence after repellent application. All of the studies reviewed did find some type of feeding reduction with one or more of the repellents considered, but the variability and/or non-repeatability of the studies makes a direct comparison of their results difficult. One paper that was reviewed did attempt to discover some overall trends in the numerous repellent studies available. The repellent effectiveness results of twelve studies were ranked (i.e., 0 = ineffective to 4 = highly effective) and analyzed by two experts. It was concluded that Big Game Repellent™ and predator odors were typically the most effective of all the repellents. In addition, no significant difference was found in the ranking of area (i.e., primarily odor) and contact (i.e., spray or dust) repellents, or in the reactions to repellents between deer and elk (although white-tailed and mule deer appeared to react differently to predator odor). These results may be useful when choosing a repellent, but should also be used with the understanding that the comparison required a subjective, but expert, ranking to be completed.

The effective and economical application of repellents to potentially reduce roadside browsing of white-tailed deer would need to consider several factors. Some of these factors include how the repellent is applied, at what time intervals, cost, animal habituation, and the locations to which is it applied. Like most of the other countermeasures already summarized, the application of repellents as a DVC reduction tool would most likely need to be focused on “high” DVC locations rather than widespread. However, white-tailed deer (or other animals) may also just shift their browsing location if repellents are not applied in a widespread manner. The application of repellents in combination with other DVC reduction tools at “high” crash locations might be most appropriate.

DEER FLAGGING MODELS

Some experts believe that white-tailed deer raise their tails to expose their white undersurface as a warning communication between their species. Deer flagging involves the use of wood silhouettes of models of this warning stance on the roadside to warn deer away from the roadway. Only one study was found that investigated this approach to DVC reduction. None of the experiments in the study appeared to yield conclusive results that the addition of flagging models reduced the number of white-tailed deer that were observed and/or crossed the study roadway right-of-way. In some cases fewer deer were seen along the treatment segments than in the control segments, but in others the number of deer observed increased after the models were installed. The general fluctuations in deer movements and the variability in data observation
approaches (and time periods) also appeared to confound attempts, at least in some of the experiments, to connect deer behavior to the presence or absence of the flagging models. The researchers involved with the study generally concluded that they had failed to demonstrate that the use of deer flagging models was an effective method of reducing the number of deer observed along the highway right-of-way. They did not recommend their use. A similar and well-designed study in the future might be considered to validate or refute the results of this study.

DEICING SALT ALTERNATIVES

It has been speculated that the use of salt on the roadway for winter maintenance purposes has increased the number of DVCs. However, no research on the impact of salt or salt alternative use on DVCs was found. In the past, suggestions and/or studies of sodium chloride and its alternatives have typically focused on the water-related environmental impacts of these chemicals (e.g., surface runoff) rather than their potential DVC impact. A study that focuses on this subject is needed. Some areas in the country do not allow or have restricted the use of roadway salt and could be useful in this analysis. Any evaluation of roadway salt and/or salt alternatives on DVCs, however, would also need to consider their effectiveness at clearing the roadway pavement (which increases general safety) and their other benefits and costs.

IN-VEHICLE TECHNOLOGIES

No published studies were found that evaluated the DVC-reduction capabilities of in-vehicle sensor or vision technologies. However, the application of these technologies in the general vehicle population is very recent and the ability to do this type of large-scale study probably has not been possible. An evaluation of the DVC reduction capabilities of these technologies for a wide range of drivers would be of interest. Their potential to reduce the number of DVCs (if properly used) appears to exist. Currently, the cost of in-vehicle vision systems is high, but it may decrease if demand and competition increases.

ONGOING REVIEWS

A preliminary scan of several documents related to wildlife grade separations/crossings and fencing/barriers/one-way gates reveals that these two measures have been widely implemented, and appear to have been studied to a larger extent than some of the other countermeasures previously discussed. These two measures are also commonly and appropriately implemented together. Determining the DVC-reduction effectiveness of one or the other may be difficult. In addition, the effectiveness of wildlife separations/crossings is also often measured by whether or not it is used by the animals for which it is built rather than the change in DVCs that might have occurred. Studies that focus on the effectiveness of different deer fencing heights have also been documented. It appears that these studies sometimes have conflicting results. Several studies focus on the use of fencing to protect of valuable crops. A fencing height of 8 to 10 feet is often suggested, but documentation about what percentage of white-tailed deer are removed from the right-of-way due to different fencing heights is still being pursued. Key factors related to deer fencing installation include location, length, height, surrounding topography, its relationship with grade separations (to allow migration), and the need for continuous maintenance.

The documentation available about the potential DVC-reduction impacts of vegetation/roadside management, hunting and herd management, highway planning, and public education/awareness
on DVCs need further evaluation. Roadside vegetation management documents typically do not
discuss the potential that policies or plantings have to attract white-tailed deer. Most of the
documents found focus on vegetation choices in gardens to avoid deer damage. The content of
these documents may have some limited transferability to roadside management and choices. As
expected, except on a small scale, the impact of hunting and heard management policies (and
their changes) and/or public awareness/education campaigns on DVCs is difficult to prove.
Overall, it has been shown in several studies that there is a relationship between the trends in deer
populations and the reported number of DVCs, but the cause and effect relationship between
these two factors needs additional investigation. The existence of a public education program in
the area of roadway safety is also a key component (along with engineering and enforcement).
Highway planning that focuses on locating roadways to minimize their impact on animal
migration patterns is also a good objective. The use of this DVC countermeasure would most
likely be focused on new roadway construction or complete reconstruction, but it might also be
used to identify “segments of DVC concern” along existing roadways.

CONCLUSIONS

The DVC countermeasures toolbox is being created to provide the level of information to
transportation professionals that allow them to make reasonable and knowledgeable DVC
countermeasure application choices and decisions. The objective is to provide more than an
annotated bibliography of the documents available, and allow the reader to reach their own
conclusions about the current state of the knowledge related to the countermeasures being
considered.

A review of the information in this paper and the more detailed summaries at
www.deercrash.com lead to the following conclusions. One, there are few, if any, definitive
“research-oriented” countermeasure effectiveness studies. This situation has probably occurred
because of the complexity of the DVC problem (e.g., the variability and/or validity of the data),
and a lack of resources (e.g., time and funding). Two, a common solution to the DVC problem is
unlikely, and it is expected that one or more countermeasures at select locations will be the key to
DVC reduction. Three, the countermeasures used should be matched with roadway locations or
segments that have the greatest potential to produce a DVC reduction and not just shift the
problem. Four, additional and definitive research projects must be designed for many of the DVC
countermeasures considered. These studies will most likely need to be broad in range (e.g.,
multi-state) and time (e.g., multi-year), and will require significant funding. It is suggested that
these evaluations start with some of the measures that have been used in the United States and
elsewhere for decades. Five, the proper completion of the activities above needs accurate DVC
reporting by location, and easy access to that crash report information. As indicated previously, it
is assumed that up to 50 percent of all DVCs may be unreported and undocumented.

DISCLAIMER

The contents of this report reflect the views of the author who is responsible for the facts and the
accuracy of the data presented herein. The contents do not reflect those of the Wisconsin
Department of Transportation or the Federal Highway Administration.
REFERENCES