ROADWAY MAINTENANCE, DESIGN, AND PLANNING POLICIES

A focused consideration of the wildlife habitat and movement impacts of a roadway or roadway system during its operation and development could reduce animal mortality (e.g., deer-vehicle crashes (DVCs). However, this level of consideration would generally need to expand upon the current requirements related to endangered or otherwise threatened species, and attempt to address the overall ecological impact of roadways on wildlife.

The most direct and obvious interaction between roadways and wildlife is animal mortality or DVCs. The purpose of this summary is to introduce and discuss a sample of the roadway maintenance, design, and planning decisions that might impact the number of DVCs. For a discussion of the wider range of the ecological impacts due to roadways (e.g., habitat fragmentation, reduced air quality, and increased noise and water runoff) the reader is referred to the recently published *Roadway Ecology: Science and Solutions* (*1*).

There are a number of roadway maintenance, design, and planning choices that might have an impact on the number of DVCs. The focus of the choices discussed in this summary are listed below:

1. Roadway Maintenance
    - Winter Maintenance
    - Roadside Vegetation Installation and Maintenance
    - Carcass Removal
2. Roadway Design
    - Posted Speed Limit
    - Curvature
    - Cross Section
    - Bridge Height and Length
3. Roadway Planning
    - Roadway Alignment Location
    - Project Programming

The "points of wildlife consideration" listed above range from very specific maintenance operational procedures and design choices to more general planning-level alignment and project programming decisions. In fact, the final section of this summary includes some general suggestions about how agencies might develop more ecologically sensitive roadways and roadway systems. Overall, the quantitative DVC-reduction that results from the specific activities and choices discussed here has rarely been studied, but if it has been it is discussed in more detail within the other countermeasures discussions within this toolbox.

Roadway Maintenance

Once a roadway has been constructed there are several maintenance-related decisions that could impact the number of DVCs. It has been generally suggested, for example, that the deicing and/or anti-icing salt mixtures used to keep roadways clear of ice and snow may also attract white-tailed deer and subsequently increase DVCs. This subject is the focus of the "Deicing Salt Alternatives" summary within this toolbox, and no research has been completed that quantifies the number of DVCs that might occur due to the application of roadway salt mixtures. The potential DVC impact does exist, however, and this factor could be considered in winter maintenance decisions. Alternatives to salt for winter maintenance do exist, but general safety (not just DVCs) and cost impacts would need to be evaluated to determine their feasibility.

It has also been generally suggested that choices related to the selection (usually decided during roadway design) and maintenance of roadside vegetation may also impact DVCs. In other words, certain types of vegetation and methods of roadside mowing (e.g., how much and how often) may attract white-tailed deer to the roadway. This subject is discussed in the "Roadside Vegetation Management" summary within this toolbox, but again almost no studies have been done to quantify which roadside vegetation choices and practices impact DVCs. Experts have created lists of plant species that are believe to be more attractive to white-tailed deer, and one of these lists is included in the "Roadside Vegetation Management" summary. Of course, the proper maintenance of roadside vegetation is also required for the safety of run-off-the-road vehicles, and impact how much roadside sight distance drivers would have to white-tailed deer.

Finally, another maintenance-related decision that may have an impact on general roadway safety (versus just DVCs) is the timing of white-tailed deer carcass removal. From a safety point-of-view the rapid removal of white-tailed deer carcasses from the roadway and roadside is the preferred approach for two reasons. One, white-tailed deer carcasses on the roadway and/or roadside of a high-speed roadway could (at least temporarily) be hazardous objects if hit by an errant run-off-the-road vehicle. The result of this type of collision could be the vehicle vaulting or rolling over. Two, white-tailed deer carcasses on the roadway can attract scavengers to the roadside to feed and this could result in a secondary animal-vehicle collision. Of course, decisions related to carcass removal also need to take into account, among other things, the probability of these types of events occurring and the general costs. The impact the carcasses may have on roadside maintenance equipment (e.g., mowers) should also be considered along with aesthetic.

Roadway Design

Several decisions can be made during the geometric design and signing of new or reconstructed roadways that could impact DVCs. However, the majority of the roadway design that occurs in the United States is within existing rather than new right-of-way (ROW). The decisions summarized in the following paragraphs are those related to posted speed limit, roadway curvature, cross-section, and bridge design. The DVC impacts of installing (and maintaining) exclusionary ROW fencing and deer crossing warning signs are discussed in their respective summaries within this toolbox. The choices or decisions related to the newer roadway alignment locations and project programming, on the other hand, are briefly discussed in the next section of this summary. Overall, each of these decisions will require a comparison of their potential cost and the benefits they offer to wildlife and safety.

Several researchers have investigated the apparent relationships between DVC or roadside carcass locations and several roadway/roadside factors (*2*, *3*, *4*, *5*, *6*, *7*, *8*, *9*, *10*, *11*, *12*). Some models have also been developed to predict the probability a particular roadway segment might be a "high" DVC site (*2*, *3*, *4*, *5*). These models are discussed in more detail within the "Hunting or Herd Reduction" and "Speed Limit Reduction" summaries of this toolbox. The focus here is those factors related to posted speed limit, roadway curvature, and cross section. Gunther, et al.

found that more DVCs occur along roadway segments with a high posted speed limit, and the results of this study are presented in the "Speed Limit Reduction" summary of this toolbox (*6*). They did not discuss the potential correlations between posted speed limit and white-tailed deer habitat or density, but they did find that the vehicle operating speed along a roadway seemed to be impacted more by the alignment design (e.g., curvilinear versus straight) of the roadway than the posted speed limit (*6*). They suggest that a curvilinear design (and narrower lanes) to reduce vehicle operating speeds could reduce animal mortality (e.g., DVCs) along roadway segments where the posted speed limit cannot be reduced (*6*). It should be recognized, however, that it is common knowledge in the transportation profession that unreasonable posted speed limits will generally be ignored by drivers (unless highly enforced), and the inappropriate introduction of a curvilinear alignment and narrow lane designs could increase other types of crashes and/or impact roadside sight distance. Geometric roadway designs choices are also a tradeoff of, among other things, operational efficiency, driver expectations, natural topography, aesthetics, safety, and ROW needs. DVCs could be accounted for in the safety comparison of roadway alignment alternatives.

The relationships found between the location of DVCs or roadside carcasses and the cross section of a roadway have been somewhat mixed (*5*, *6*, *7*, *9*, *10*). For example, as previously mentioned, Gunther, et al. suggested that narrow lanes could reduce vehicle speeds and subsequently animal mortality (*6*). A study in Canada, however, did not find any difference in the number of DVCs when a roadway was increased from an undivided two-lane to a divided four-lane cross section, but the number of elk and big horn sheep collisions did increase (*7*). However, they also did not find a larger numbers of elk-vehicle collisions along the unfenced segments that had a concrete median barrier (*7*). In addition, Allen and McCullough found more roadside carcasses on two-lane than four-lane roadways, but Reilly and Green found an increase in roadside carcass after one roadway was widened (*9*, *10*). Finally, a Kansas study found that roadways with grass medians had higher reported DVC rates than those with median barriers, and those with median barrier had a higher reported DVC rates than two-lane undivided roadways (*5*). It would seem that roadway cross section design decisions could have a DVC impact, but more evaluation is necessary and it may be site specific. The results from three of the studies mentioned above are discussed in more detail in other summaries within this toolbox (*5*, *6*, *7*).

Bridge design decisions could also impact the number of DVCs that occur along a roadway. Animals will sometimes use roadway structures (i.e., underpasses and overpasses) if they are adequately sized, appropriately located, and not heavily used by vehicles and/or humans (See the "Wildlife Crossings" summary in this toolbox). In fact, crossings that are specifically designed (and combined with exclusionary fencing) for wildlife use exist throughout the world. The DVC-reduction effectiveness of these structures and/or the factors that impact their use by animals is the focus of the "Exclusionary Fencing" and "Wildlife Crossings" summaries in this toolbox. The focus here is those crossings along existing roadways (over valleys, ravines, and/or watercourses) that might also represent locations where animals might naturally travel. During roadway reconstruction the height and/or length of these bridges might be altered for their possible use by wildlife. For example, the slope walls or abutments of a bridge over a watercourse are often placed to minimize its length (and cost), but this type of design may also force the animals following the watercourse to cross the roadway surface at the overpass rather than under the bridge. A sufficient bridge length and height that provides level ground adjacent to a stream or river might reduce the occurrence of this movement across the roadway surface. Of course, bridge design decisions like these will also impact the cost of the bridge.

Roadway Planning

In some cases a new location must be chosen for all or part of a roadway alignment. At this stage in the development of a roadway or roadway system the alignment alternatives are still being evaluated, and the prioritization of improvement projects is still being determined. The characteristics of proposed project alignment alternatives are compared, shared with the public, and a preferred location chosen. In addition, the prioritization of improvement projects is often based on a measure of the problem significance. Existing and expected DVC or animal mortality impacts could be added to these planning-level evaluations. However, adequate information and predictive capabilities would need to be available to identify existing and potential problem locations for DVCs or animal mortality. Several researchers, as previously mentioned, have investigated and/or modeled the roadway and adjacent land use characteristics that seem to be correlated to a “high” number of DVCs or roadside carcasses (*2*, *3*, *4*, *5*, *6*, *7*, *8*, *9*, *10*, *11*, *12*). Some of the relationships that have been modeled are described in the “Hunting or Herd Reduction” summary in this toolbox. Others have also electronically combined, among other things, DVC and/or carcass data with landscape descriptors, species data, land uses, highway locations, expert opinions, and wildlife habitat/connectivity/linkage information within a geographic information system (GIS) (*13*, *14*, *15*). These systems have been used to identify existing or proposed “wildlife critical” roadway segments that bisect species habitat or habitat linkages (See “Wildlife Crossing” summary). This information could be considered in the roadway alignment comparison and project prioritization process. A few states have also begun or finished wildlife habitat or connectivity plans (See “Wildlife Crossing” summary).

In a more general sense it has been proposed that the planning of a roadway alignment should recognize its “road effect zone” (*16*). This “road effect zone” is an area that could experience some type of adverse ecological impact due to the construction of the roadway. The size of this zone is much larger than the roadway ROW, and is a function of what impacts (e.g., air and noise quality) and animal species (e.g., sparrows, salmon, and/or and white-tailed deer) are considered in the evaluation. Forman and Deblinger have estimated that 19 percent of the land area in the United States is within a “road-effect zone” (*16*). Based on a wide range of ecological impacts (e.g., the influence of vehicle noise on birds, and water erosion) they have proposed that the average “road effect zone” includes everything within about 984 feet (300 meters) of the roadway edge, but that this value varies greatly even along one roadway (*16*). Another group of authors has also proposed the idea of designating certain roadways as “ecological highways” (*17*). This system would identify those roadways that have met certain wildlife-friendly criteria during their planning, design, operation, and maintenance (*17*). One criterion might be that the roadway is permeable and provides appropriate connectivity (e.g., wildlife crossings) between habitats (*17*).

Forman, et al. agree that the ecological impact of roadways can be large, and that it should be examined at a regional or state level rather than on a segment-by-segment basis (*1*). They proposed the following steps should be applied to develop a more ecologically sensitive roadway system (*1*). First, roadway alignments or systems that prevent or avoid an increase in ecological impacts should be encouraged. This is a "do-nothing" option. Second, if doing nothing is not possible or feasible, the ecological impact of each existing or proposed roadway alignment should be mitigated if possible (e.g., wildlife crossings/fencing, berms to reduce roadway noise, and stormwater management) (*1*). Some of the mitigation measures that might be possible for DVCs are discussed throughout this toolbox. The third step to developing an ecologically sensitive roadway system is to compensate for those impacts that cannot be avoided. This compensation would be similar to the process currently followed for wetland replacement, but be more encompassing. For example, the compensation might include enlarging specific areas of certain vegetation, restoring streams, and/or introducing habitats for bio-diversity or rare species (*1*).

Conclusions

Decisions that might have an impact on DVCs and animal mortality are made throughout the "life" of a roadway. This summary introduced and discussed some of the decisions connected to roadway maintenance, design, and planning. The maintenance activities described were related to the use of salt mixtures for snow and ice control, the installation and maintenance of roadside vegetation, and roadside carcass removal. Unfortunately, very little is known about the actual DVC impact of these activities.

The design decisions discussed in this summary were related to the posted speed limit, curvature, and cross section of the roadway, and bridge height and length. It has been proposed that narrower lanes and more curvilinear roadways (where possible) should reduce vehicle operating speeds and subsequently reduce DVCs. However, the general safety impacts of these designs and their cost also need to be considered. In addition, the studies that have investigated the potential DVC impact of wider roadway cross sections have produced conflicting results and more evaluation is necessary. The choices that must be made related to the height and length of reconstructed bridges could also consider the use of these facilities by animals.

The roadway planning discussion in this summary introduced the idea of considering wildlife impacts (including DVCs) as a factor in the comparison of alignment alternatives within the project prioritization process. Information about existing and potential DVC problems along specific roadway alignments would need to be available to accomplish this task, and some models and systems to assist decision-makers have been developed. For example, several roadway segments or systems have been investigated by combining, among other things, DVC or animal carcass information with highway and species habitat data within a GIS. This information is used to identify "wildlife critical" roadway locations. General suggestions were also made in this summary about the methods that could be used to develop a more ecologically sensitive roadway system.

It would appear that the consideration of existing or potential DVC impacts throughout the development of a roadway might help mitigate the DVC problem to some degree. The individual or cumulative DVC impacts of all or some of these decisions, however, have not been studied to any large extent. In addition, each of these decisions must also take into account the costs and benefits of the change in operating procedure or roadway design that may result. Clearly, some of these costs and benefits are much easier to quantify than others. In general, however, including the possible animal mortality impacts of a maintenance procedure or design/planning decision in the roadway development process appears to be an appropriate approach.

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