REFERENCE

Huijser, M.P., J.W. Duffield, A.P. Clevenger, R.J. Ament, and P.T. McGowen. Cost-Benefit Analyses of Mitigation Measures Aimed at Reducing Collisions with Large Ungulates in the United States and Canada: a Decision Support Tool. *Ecology and Society,* Vol. 14, No. 2, Article 15, 2009. [online] URL: http://www.ecologyandsociety.org/viewissue.php?sf=3D41

INTRODUCTION

The article summarized in this document focused on a project that was completed in response to the general lack of information about the cost-effectiveness of wildlife-vehicle collision (WVC) mitigation measures. It includes the results of cost-benefit calculations for 13 large ungulate WVC mitigation methods that the article authors have defined as "effective" (based on previous research). The information provided in the article could be valuable to those considering the implementation of WVC mitigation methods. It should be noted that the work summarized in this article is something of an extension of that completed for the WVC reduction Report to Congress. A summary of that report is on the DVCIR Center website (http://www.deercrash.com).

COST–BENEFIT CALCLUATIONS

Thirteen WVC mitigation measures were included in the benefit-cost calculations completed as part of this project. These measures were selected from more than 40 options based on a review of the research available about their WVC reduction effectiveness. It was concluded that all 13 of these mitigation measures had been the focus of one or more research projects that showed a reduction in WVCs. It was also acknowledged, however, that the effectiveness of each measure could be highly variable. The actual impact of any mitigation measure can be influenced by a number of factors connected to the specific context of the installation (e.g., terrain, maintenance levels, wildlife species, etc.). The references that were used to define the mitigation measure effectiveness and used in the cost-benefit calculations are provided in the article. However, no additional documentation or discussion was provided about the robustness of the research study experimental designs or analysis methodologies. The design and implementation details of the measures considered in the research studies were not compared to the assumptions used in the estimation of the mitigation measure costs. This information is important to the interpretation of the results summarized below. Details about the cost estimation assumptions are shared in Appendix 1 of the article.

The 13 mitigation measures evaluated in this study are listed in Table 1 along with the WVC reduction effectiveness (i.e., percentage reduction in WVCs) assumed for the benefit-cost calculations. The same references were used to define the effectiveness of more than one of the mitigation measures listed in Table 1 (as indicated by the similar percent reductions shown) and the last two are assumed to be 100 percent effective for the one kilometer (0.62 miles) used in the calculations. The present value cost (in 2007) of each mitigation measure for one kilometer (0.62 miles) of implementation is also provided. The authors indicate that the cost calculated includes estimates for the design, implementation, maintenance, and removal of each mitigation measure along a divided four-lane roadway. As indicated the details of these cost estimates are

Table 1. Mitigation Measure Collision Reduction and Present Value Cost

Mitigation Measure[1]	Wildlife-Vehicle Collision Reduction (Percent)	Present Value Cost (2007)
Seasonal Wildlife Warning Signs	26	$3,728
Vegetation Removal	38	$16, 272
Fence, Gap, Crosswalk	40	$300,468
Population Culling	50	$94,809
Relocation	50	$391,870
Anti-Fertility Treatment	50	$2,183,207
Fencing	86	$187,246
Fence, Underpass, and Jump-Outs	86	$538,273
Fence, Underpass, Overpass, and Jump-outs	86	$719,667
Roadside Animal Detection Systems (ADSs)	87	$1, 099,370
Fence, Gap, and ADS	87	$836,113
Elevated Roadways	100	$92,355,498
Road Tunnels	100	$147,954,696

[1]The mitigation measures are described to a certain extent in the article referenced and its appendices.

provided in Appendix 1 of the article. The assumed lifespan of each measure is also provided. This information was gathered from the literature and transportation officials. The 2007 present value cost shown for each measure was calculated using a three percent discount rate for a 75-year time period. The 75-year time period was applied to all the mitigation measures and represented the measure with the longest lifespan (i.e., underpasses and overpasses). Present value cost calculations were also completed for one and seven percent discount rates and can be found in the article.

The costs and benefits of the mitigation measures were compared on an annual basis. This approach allowed a more proper comparison of their costs and benefits. Several assumptions related to when the costs and benefits of each mitigation measure would occur within the time period considered and were applied within the calculations. For example, no benefits were assumed to occur in the first year of the mitigation measures shown in Table 1 that believe to have long planning and installation periods (note that only seasonal signing, vegetation removal, population culling, relocation, and anti-fertility treatments do not meet this requirement) . The benefits produced by each mitigation measure were also assumed to be relatively uniform during its lifespan. These benefits were calculated by applying the WVC reductions shown in Table 1 and the average cost of a WVC. The point in time when a mitigation measure becomes cost effective is when the annual benefit (i.e., WVC reduction) equals and exceeds the amortized annual cost. The cost of an average deer, elk, and moose collision was calculated using information from the existing literature. The average costs calculated were $6,617 for deer-vehicle collisions (DVCs), $17,483 for elk-vehicle collisions, and $30,760 for moose-vehicle collisions. These costs included the sum of “average” crash estimates for the vehicle repair, human injuries, human fatalities, towing/accident attendance/investigation, hunting value of the animal, and carcass removal/disposal. The severity cost estimates (e.g., property damage, injury, and fatalities) for an “average” crash are based on the total percentage of WVCs they represent. The benefit of the mitigation measures is provided by a reduction a particular number of WVCs. These costs are used to attach a monetary value to those reductions.

The researchers also estimated the annual number of deer, elk, and moose collisions that would need to occur for the annual cost-benefit of each mitigation measure to be equal to one. The focus of the Deer-Vehicle Crash Information and Research Center is deer-vehicle crashes (DVCs) reduction so the results of these calculations are shown in Table 2 for this type of incident. The number of crashes indicated in Table 2 is based on the threshold dollar amounts shown. If one kilometer of roadway is experiencing this level of cost (or deer collisions) then a mitigation measure might be considered. In the article, thresholds are also provided for elk- and moose-vehicle crashes.

Table 2. Annual Thresholds for DVC Mitigation Measures (at a 3 Percent Discount Rate)

Mitigation Measure[1]	US$/km/Year	Deer/km/Year
Seasonal Wildlife Warning Signs	121	<0.1
Vegetation Removal	530	0.2
Fence, Gap, Crosswalk	10,116	3.8
Population Culling	3,099	0.9
Relocation	12,764	3.9
Anti-Fertility Treatment	71,110	21.5
Fencing	6,304	1.1
Fence, Underpass, and Jump-Outs	18,123	3.2
Fence, Underpass, Overpass, and Jump-outs	24,230	4.3
Roadside Animal Detection Systems (ADSs)	37,014	6.4
Fence, Gap, and ADS	28,150	4.9
Elevated Roadways	3,109,422	470.0
Road Tunnels	4,981,333	752.8

[1]The mitigation measures are described to a certain extent in the article referenced and its appendices.

The article authors compared the thresholds in Table 2 to DVC and deer carcass data from 10 different road sections throughout the United States and Canada. They found that some of the data on these roads exceeded the thresholds. In other words, the benefits of implementing a measure would exceed its costs. The authors, however, cautioned against just using these threshold values for decision-making related to the implementation of mitigation methods. The benefit-cost calculations and thresholds were based on a series of estimates and assumptions that may not be true at a particular location or for a particular mitigation measure design. For example, Table 2 indicates that a given roadway section would require less than 0.1 annual deer-, elk-, and moose-vehicle collisions per kilometer in order to make seasonal wildlife warning signs cost-effective, but the estimated effectiveness of these signs is believed to be only 26 percent. Therefore, although it may be cost effective to implement a sign there will only be a reduction of about one in every four DVCs. If a bridge was installed, on the other hand, the reductions are generally about 100 percent, but would require a much larger amount of funding. The design of a mitigation measure and its effectiveness and cost also vary from location to location.

There are also mitigation measures that have low threshold values and high crash reduction effectiveness. Wildlife fencing was one of these mitigation measures, but fencing also results in negative impacts on connectivity and this was not taken into account with the benefit-cost analysis completed. Wildlife fencing with underpasses and jump-outs, or fencing with under- and overpasses and jump-outs can also be cost efficient but avoid some of these connectivity concerns. Animal detection systems also appeared to be cost-effective, but the researchers also cautioned that the effectiveness of this mitigation method was still questionable and the mitigation measure is experimental.

DVCIR CENTER FINDINGS

The authors of the article summarized in this document have generally completed a cost-benefit analysis of 13 wildlife-vehicle collision mitigation measures. The article and its appendices include descriptions of the mitigation measures and details about the approach used to complete the cost-benefit calculations. The information provided is useful (e.g., annual crash thresholds are provided), introduces the idea of cost-benefit analysis, and could potentially be used as a starting point in the consideration of mitigation measures. It provides a good idea, given the current state-of-the-knowledge, of the potential mitigation measures wildlife-vehicle collision reduction effectiveness. This knowledge, however, is very limited (i.e., the same studies are referenced for various measures – see Table 1 of this summary). In addition, questions about the robustness of the research results used in the analysis require evaluation of the original references (explaining the details of the analysis in these studies was beyond the scope of the article). It is acknowledged that the inputs to the process developed will change as more research is completed and additional information gathered. The costs used will also vary from location to location in many cases and need to be recalculated for each specific installation being considered. The design, installation, and effectiveness of a WVC or DVC mitigation measure is impacted by many factors and can be highly variable. Changes in these factors could have a significant impact on the economic viability of the mitigation measure implementation. The content of this article includes some valuable information that can be used by practitioners to do their own cost-benefit analysis for wildlife-vehicle collision mitigation measure comparison at particular locations (given the limitations noted in the article and this summary).