REFERENCE

Bissonette, J.A. and P.C. Cramer. *NCHRP Report 615: Evaluation of the Use and Effectiveness of Wildlife Crossings*. Transportation Research Board of the National Academies, Washington D.C., 2008.

INTRODUCTION

The objective of this project was to develop guidelines for the implementation of wildlife-vehicle collision (WVC) mitigation methods that account for "…landscape permeability" (e.g., wildlife crossings). The *National Cooperative Highway Research Program (NCHRP) Report 615* includes these proposed guidelines and documentation of the tasks and research that were used in their development. This information also generally provided as part of the web-based interactive decision guide (a product of the *NCHRP Report 615* project) found at http://www.wildlifeandroads.org.

The tasks and individual projects that contributed to the wildlife crossing guidelines occurred in two phases and are briefly summarized below. The first phase included an investigation and documentation of current literature and a survey of professionals related to wildlife crossings. Gaps connected WVC reduction research and practice were also identified. The second phase of the NCHRP 615 project included five specific research efforts related to WVC data and/or wildlife crossings. The web-based interactive decision guide was also developed during the second phase.

PHASE I ACTIVITIES

Literature Review and Telephone Survey

Phase I of this project included a literature review and telephone survey to document the existing state-of-the-knowledge related to the positive and negative impacts of WVCs, roadways, and mitigation measures. The literature review resulted in a summary of 370 documents that were then entered into a database with a search engine at http://www.wildlifeandroads.org. This database includes a reference and annotated bibliographies to most, if not all, of the publications concerning WVCs and wildlife crossings from the United States and Canada after 1999. A select number of older and some international publications are referenced and/or summarized as well. The telephone survey is described below.

A telephone survey of more than 410 transportation and landscape ecology professionals was also one of the Phase I activities. At least one interview was completed with a person from each U.S. state and Canadian province. The objectives of the survey were to locate all known wildlife and aquatic crossings in the United States and Canada and to document current trends in the implementation and evaluation of wildlife crossings. Overall, 684 land crossings and 10,692 aquatic crossings were documented for North America (see www.wildlifeandroads.org).

Several trends connected to the implementation and evaluation of wildlife crossings were identified from the literature review and the survey. First, it was determined that more species, including those that are endangered, were being considered for roadway impact mitigation

measures. It was also concluded that more agencies were involved in the implementation of wildlife crossings than in the past and that there were more instances of multiple wildlife crossing structures along roadways, but that maintenance of these crossing structures was minimal. Several examples of wildlife crossings that encouraged landscape permeability (i.e., successful examples) were also noted. These examples included wildlife crossings of the Trans-Canada Highway in Banff National Park and U.S. Highway 93 in Montana and Arizona, as well as roadways in Florida and Vermont. The researchers also found that the scientific evaluation of wildlife crossings impacts was improving. Finally, the report authors assembled a list of general recommendations related to proper design of wildlife crossings from the information gathered during the telephone survey and literature review.

Research and Implementation Priorities

During Phase I of this project the researchers also completed an on-line survey of 444 transportation and ecology professionals. This survey asked each respondent to rank a list of 25 wildlife crossing research and implementation priorities (14 priorities were research-oriented and 11 were implementation-oriented) that was originally developed by the research team and suggestions by experts in the transportation ecology field. The survey respondents intuitively rank each priority based on their knowledge of its existing or potential cost-effectiveness, urgency, and overall effects. The wildlife crossing research or implementation priorities that were ranked as the top five included the following:

- Start to incorporate wildlife mitigation into the transportation planning process;
- Research the effectiveness of wildlife crossing structures;
- Start to consider the combination of several AVC mitigation measures that include wildlife crossings (for permeability of the roadway system);
- Start to combine conservation plans and connectivity analyses with the transportation planning process;
- Encourage the research and development of alternative and cost-effective wildlife crossings designs.

The second and fifth top ranked priorities were classified as research priorities while the other three were considered implementation priorities. Overall, the researchers found that the ranking results related to implementation or practice priorities had much more consensus among the respondents than the research priorities. The survey results were also categorized according to participant nationality (i.e., United States or Canadian), profession, and employer. The five priorities listed above were consistently among the top five for these groupings also.

PHASE II ACTIVITIES

Phase II of the project documented in *NCHRP 615* included five research efforts used to support the development of the wildlife crossing implementation and maintenance guidelines and decision-guide described at the end of this summary.

WVC Safety Performance Functions

The first research effort in Phase II used reported crash data to develop WVC prediction models. Safety performance functions (SPFs) were developed using an empirical Bayes approach

to quantify the relationships between the location of WVCs and one or more roadway characteristics (e.g., traffic volume, road length, road width, etc.) It is suggested that these models could be used to identify some of the roadway characteristics related to WVCs, help identify roadway segments for WVC mitigation, and estimate WVC mitigation effectiveness.

Overall, three safety performance functions were developed. The objective was to provide models that might account for the fact that a variety of roadway characteristic data are collected at different departments of transportation. The first model developed for WVCs per mile per year only required study segment length and annual average daily traffic volume. The second model required those same two input variables but also a terrain input (e.g., flat, rolling, or mountainous). Finally, the third model required the input variables from the first two models but also incorporated other road characteristics (e.g., average lane width, shoulder width, median type). In general, the variable with the most impact in all these models was traffic volume.

A second part of the WVC modeling effort included a comparison of how different databases related to WVCs might produce different results and ultimately mitigation measure planning or implementation decisions. The locations of reported WVCs and deer carcass removal data were compared using several methods (including regression models similar to the SPFs previously described). It was found that the use of these datasets (which describe the same safety problem) did produce different summary and modeling results. These differences could lead to differing decisions for WVC mitigation measure implementation. The choice and definition of the data used when evaluating the WVC safety problem is very important. The NCHRP report provides guidelines and recommendations for using WVC-related data effectively for modeling and choosing wildlife crossing locations.

Data Location Accuracy

The second research effort in Phase II investigated the importance and impact of data accuracy in defining the location of WVCs (i.e., defining the roadway or landscape factors that may be associated with WVCs). These site-specific roadway and landscape input variables were measured according to Geographic Information System and Global Positioning System data and were used with two sets of carcass data of different locational accuracy. The first dataset included the location of ungulate carcasses with an error of less than three meters (approximately 10 feet). The second dataset rounded these locations to the nearest 0.5-mile. The latter level of accuracy is more typical of the data collected by state transportation departments. Not surprisingly, the researchers found that models using more spatially specific data had more predictive power in the identification of the roadway or landscape factors that may have caused WVCs than those with less accurate data. It was recommended that more standardized and locationally-specific data be collected that describes or might impact the occurrence of a WVC. In addition, it was concluded that landscape and habitat variables (not normally collected by state departments of transportation) were better predictors of WVCs than roadway characteristic variables.

Hotspot Modeling

The third research effort in Phase II show the results of several different hotspot identification clustering techniques can be used to identify WVC hotspots (based on WVC carcass data) at various scales of application (i.e., roadway segment, statewide, etc.). Some of

the techniques considered include the Ripley's K-statistic, nearest neighbor measurements, and density measures. Finding the proper location for WVC mitigation measures (or retrofits of existing infrastructure) is critical. *NCHRP Report 615* summarizes the application of the hotspot identification clustering techniques considered and also notes some of the software that includes these evaluation methodologies.

Road Impacts on Small Mammals

The fourth research effort in Phase II assessed how roadways may impact the diversity and density of small mammals. Two field studies were completed in different locations. Data were collected by capturing small mammals at different distances from the roadway (and in some cases transmission line) right-of-way. The results of these studies appeared to show a variety of results. In Utah the diversity of species varied from year to year (i.e., in one year it was higher near the roadway right-of-way and in another it was lower) along with their density and abundance. The general conclusion was that the roadway had little impact on small mammal density. It appeared to be more influenced by micro-habitats. The study results from a site in British Columbia were also varied. No consistent pattern in abundance of species was found with the distance from the roadway but diversity of species was always lower in the right-of-way. It was proposed that some species may be impacted by the existence of a roadway but larger samples and more highly consistent habitats than considered in this project would be needed to find them.

Allometrically Scaled Wildlife Crossings

The fifth and final research effort in Phase II studied the potential of using allometric scaling to identify wildlife crossing locations. This scaling approach is an attempt to locate wildlife crossings based on the movement of specific species. The researchers indicate that this method allows the animals to "tell" the roadway designer where to install a wildlife crossing. The report summarizes how this approach could help determine the placement and spacing of wildlife crossings through a better understanding of animal movement and habitat composition. It accounts for the characteristics of species and their ability to cross roadways instead of simply relying on WVC and/or animal carcass data when wildlife crossing locations are being considered. The researchers, however, also stressed that allometric scaling domains can only be used as a first step in the placement and spacing of wildlife crossings. They indicated that it should be used in conjunction with a knowledge of migration patterns, local understanding of animal movements across roadways, and WVC hotspot locations. When all this information is used together and integrated it is suggested that landscape permeability and roadway safety will be improved.

WEB-BASED DECISION GUIDE

The Phase I and II activities and research outlined in this summary were used to develop an interactive web-based decision guide that, among other things, assists in the selection, configuration, and location of wildlife crossings. It also includes guidance for the monitoring and evaluation of crossings. The guide can be found at the website http://www.wildlifeandroads.org. This website also contains an interactive map and a search engine that describes existing and planned wildlife crossings in North America, links to external websites focused on roadways and wildlife, and a literature database with linked key words.

The decision guide can be launched from the www.wildlifeandroads.org homepage and it contains five steps or sections. The user moves through these steps, and each contains more specific and detailed sub-steps. Guidance is provided on the website on how to complete each of the steps and sub-steps. These five steps and their associated sub-steps in the decision guide are listed below:

- Step 1 Resource Evaluation (a general outline of mitigation planning procedures)
  - 1.1 Identify Scope of Transportation Plan/Project
  - 1.2 Identify Wildlife and Fisheries Issues
  - 1.3 If a Mitigation Need: Identifying Goals and Objectives
- Step 2 Identify Solutions (specific strategies for implementing wildlife crossings)
  - 2.1 Select General Mitigation Type
  - 2.2 Determine Placement
  - 2.3 Determine Configuration
  - 2.4 Determine Maintenance Needs
  - 2.5 Estimate Cost Effectiveness
  - 2.6 Determine Monitoring and Evaluation Plan
- Step 3 Select and Create a Plan (integrate information from Steps 1 and 2 to create a plan for implementation, etc.)
  - 3.1 Document Decisions in Implementation Plan
  - 3.2 Develop Maintenance Agreements
  - 3.3 Identify Implementation Liaison
- Step 4 Construction (implement wildlife crossings)
  - 4.1 Implement Monitoring Plan
  - 4.2 Implement Maintenance Plan
- Step 5 Monitor and Evaluate (methods to learn from past implementation and adjustment)
  - 5.1 Evaluate Monitoring Plan Results
  - 5.2 Evaluate Maintenance Plan Results
  - 5.3 Modify as Needed – Possible Return to Earlier Steps

DVCIR CENTER FINDINGS

This NCHRP report contains a large amount of useful wildlife crossing and wildlife-vehicle collision mitigation information. This information is provided in hard copy and at www.wildlifeandroads.org. The literature summary and wildlife crossing database, along with the content of the decision guide, should be of value to those in need of current (as of the document publication date) state-of-the-knowledge information related to wildlife crossing implementation (along with information about various other WVC reduction measures). It is believed this is also the only project to produce WVC crash models that are based on currently accepted standards for crash data modeling. These models were developed using data that is normally collected by state departments of transportation and they may meet the requirements of the soon to be released *Highway Safety Manual*. Additional research by the project team also showed that the selection of the database used to define the location of a WVC problem is important, that the use of more accurate data would produce better predictive models, and that landscape variables (not normally collected by state departments of transportation) are better

predictors of WVC locations of concern than roadway characteristic variables. The use of various hotspot modeling approaches and an application of allometric scaling for locating wildlife crossings were also demonstrated. The project activities focused on small mammals, although briefly summarized here, isn't particularly relevant to the deer-vehicle crash focus of this website. In general, it is recommended that jurisdictions considering the implementation of deer-vehicle crash countermeasures explore the website for this NCHRP document and its results.