Normandeau Associates, Inc. *Deer-Vehicle Crash, Ecological, and Economic Impacts of Reduced Roadside Mowing – Final Report*. Federal Highway Administration, Washington, D.C., May 2012.

This project, funded by the Deer-Vehicle Crash Information and Research Center Pooled fund, was developed to investigate reduced roadside mowing practices and their potential impact on the rate and location of deer-vehicle crashes (DVCs). Its primary objective was to determine, if possible, whether a reduction in roadside mowing could be connected to a measurable change (i.e., an increase or decrease) in DVCs. The research team that worked on this project completed three primary tasks. First, a literature review and summary was completed that focused on documented research connected to the safety, ecological, and/or economic impacts of roadside vegetation management. Then, a survey was completed to summarize the factors considered in "typical" existing roadside vegetation management policies within the United States. Lastly, the project team attempted to quantify and/or model the DVC and/or animal-vehicle crash (AVC) impacts of reduced, versus "typical" or more frequent, roadside mowing. The results of these tasks, along with a description of "best practices" in the area of roadside vegetation management and decision-making guidelines, are all documented in the final report referenced above.

A general conclusion reached by the research team based on their literature review was that the reasons for existing roadside vegetation management generally focused on vehicle safety, better drainage, the control of unwanted types of weeds, and/or the promotion of more desirable and natural vegetation. Those policies with a vehicle safety focus noted that roadside vegetation management was needed for proper driver sight distance to signs and to more easily detect animals and/or pedestrians attempting to cross the roadway. The research team found, however, that roadside vegetation management policies that specifically focused on deer or other animals were relatively sparse. In fact, the documentation they found on the ecological impacts of reduced mowing were generally limited to the timing of this activity to protect ground nesting birds and/or the selection of vegetation that was less appealing to large animals. No research-based literature was found that focused on the DVC impacts of roadside vegetation management or reduced mowing in North America. Three studies from Norway and Sweden, however, did consider some aspect of vegetation along roadsides or railways and their potential impact on moose collisions. Two of these studies have already been summarized in the toolbox document posted on the Deer-Vehicle Crash Information and Research Center Pooled Fund website (www.deercrash.org). The other study, by Andreassen, et al., appears to have considered the impact of several treatments, including forest-clearing, but reached no conclusion about its safety impacts (*1*).

More specifically, with respect to roadside vegetation and deer, the literature appears to show DVC- or AVC-related safety concerns that primarily focus on two issues. The first issue is whether the vegetation and/or maintenance approach attracts deer and/or other animals to the roadside. Some of the roadside habitat factors that may be impacted by mowing practices include location, timing, frequency, and height (*2*). In turn, these changes in habitat may be more or less attractive to deer and/or other animals. In addition, there are also particular types of vegetation choices that may be made to establish slope stabilization, for example, but may also be more attractive to deer (*3*, *4*). This aspect of roadside vegetation management is also described within the toolbox document posted on the Deer-Vehicle Crash Information and Research Center Pooled Fund website. One resource to use in the selection of roadside vegetation is the Minnesota Department of Transportation "Plant Selector" (http://dotapp7.dot.state.mn.us/plant/). Another study also showed that trimming woody vegetation in mid-summer may make the regrowth more attractive to deer (*5*). The second aspect of reduced roadside mowing policies that could have a safety impact was the potential increase in vegetation height and/or density. This situation could limit driver's sight distance into the roadside area and/or their ability to detect deer and/or other animals. The research team reviewed five studies that considered roadside visibility factors, but they noted that only one of the studies found visibility to have a significant relationship with DVCs (*6*, *7*, *8*, *9*, *10*). They also noted, however, that all of the studies used a definition of visibility that was not the same as the sight distance used by engineers in the design of roadways. Finally, the economic impacts of reduced roadside mowing were described. The survey results (described below) were used to show that the primary economic impact of reduced mowing was the potential for reductions in roadside maintenance labor and material costs. In addition, there could also be a decrease in DVC costs, but as noted above no research projects were found that have attempted to quantify that impact.

As noted, a survey was also done to determine current policies and practice in the area of roadside vegetation management. The survey was provided to 24 states. Nine of these states helped fund the Deer-Vehicle Crash Information and Research Center Pooled Fund. Email and phone interviews were used to apply the survey. Overall, 21 of the 24 states indicated that they had reduced their roadside mowing programs, and all but four of these states applied their reduction statewide. More than 60 percent of the states had implemented this reduction between 2008 and 2010 and more than 80 percent applied the reduction between 2004 and 2010. Economics (i.e., the reduction in costs) was the most cited reason for the reduction and ecological concerns (e.g., weed control, ground nesting birds, etc.) were a secondary purpose. Four of the states also listed positive and/or negative safety impacts as one reason for their policy. The positive safety impact of reduced mowing that was noted, however, was the shorter time periods maintenance personnel would need to be on the roadside. The negative safety impacts were related to concerns about potential reductions in sight distance and clear zone maintenance due to the reduction in mowing.

In general, a number of states did mention DVCs or AVCs in their survey answers. They indicated that a desire to reduce DVCs and AVCs had impacted their woody vegetation clearing, the width of mowing, and/or their plant choices. However, 15 of the respondents also indicated that their policies were not impacted by a "perceived or demonstrated" decrease in DVCs. The other nine states "reported a perceived reduction" in DVCs. Five states also indicated that they considered DVCs in their roadside plant selection choices. Overall, the changes in roadside mowing applied in the responding states included reductions in mowing cycles and/or the area mowed. Only about eight states mentioned a change in mowing height and/or the timing of mowing. The researchers did conclude that the nine pooled fund states were relatively representative of the overall survey results.

The last task in this research was an investigation or analysis of DVCs before and after the implementation of reduced roadside mowing practices. The research team completed a naïve before-and-after comparison of DVCs per year along six roadway sections and for four counties. More specifically, three roadways sections in New York were considered. One was a 34.4 mile section along Interstate 86 and the other two sections were along the Taconic State Parkway and had a total length of 10.0 miles. Two counties in New York were also evaluated for county-wide analysis. In addition, four roadway sections (3.0 to 7.1 miles in length along MD 36, MD 67, U.S. 220, and U.S. 219) and two counties in Maryland were analyzed. Three years of DVC data were used in the analysis for both the before and after reduced roadside mowing time periods. The reduced mowing changes that were evaluated appear to represent about a 50 percent reduction in the number of "full cuts" to the entire mowable area within the ROW and the additional of some partial cuts along the shoulder or within the clear zone.

The research team also attempted to correlate or define the predictive relationship between DVCs per year and average annual daily traffic (AADT), buck harvest size, and the mowing approach. The data that were collected came from various sources. In Maryland roadside deer carcass collection data were used to represent DVCs and in New York reported crash data "with deer" and "with animal" were used. The AADT data came from the Maryland and New York transportation agencies and harvest data from the deer reports produced in each state. Overall, there were essentially three data points before and three after the mowing change for each of the six sections (the two segments on the Taconic Parkway were evaluated as one) and four counties. Therefore, the total sample size was small, with 30 data points before and 30 data points after the change in roadside mowing practice.

Two analysis methods of the data were completed by the research team. First, a naïve before-and-after comparison of DVCs per year along the six roadway sections and within four counties was completed. Then, the team applied a Wilcoxon rank sum test to the DVCs per year at these study sites to examine the significance of the change. The researchers indicated they used this test due to the small sample size. This test is nonparametric and can be used to examine whether two sample data sets are the same by calculating a sum of the ranks assigned to the observations in the samples. The research team also "examined the predictive relationship" between DVCs per year and the mowing change, AADT, and the buck harvest. Based on the documentation in the report it appears that they applied a regression analysis for each of the variables independently and then examined the R-squared value of the model fit. It is unknown whether simple linear or non-linear regressions were applied. It should be recognized that it appears the analyses were done on a study area by study area basis and that, if this approach was used, only three data points would be available for each variables before and after the mowing change.

The data analysis results of this project were based on the activities summarized above. Overall, it was concluded by the research team that the naïve before-and-after DVCs per year comparison showed that five study locations (three countywide and two section calculations) experienced an increase in DVCs per year, four study locations (one countywide and three section calculations) experienced a reduction in DVCs per year, and one location (section U.S. 220 in Maryland) had little to no change. In addition, the Wilcoxon rank sum test used by the researchers allowed them to conclude that the change in DVCs was marginally significant at three of the 10 locations, but that the changes at these three locations were inconsistent (e.g., positive and negative). It appears, however, that this test was also applied to only three data points before and after the reduced mowing policies. The research team then applied a regression analysis to investigate the potential relationship between DVC per year and three variables that were assumed to be independent (i.e., AADT, mowing change, and buck harvest). The type of relationships considered in this relationship analysis (e.g., linear, exponential, etc.) were not documented. The researchers did note that the AADT data at some locations were not normally distributed. Overall, the researchers found that only three of the 30 regression models had a *p*-value higher than the predetermined significance level. The report also included a summary of the regression R-squared values (a statistical measure of fit). The researchers cautioned that "…the results of this analysis should be interpreted with care."

The authors of this review agree with the caution expressed above. In general, it is believed that the small sample size and/or non-normality of the data make any statistical conclusions in this report relatively suspect. The naïve before-and-after analysis showed no trends and the statistical tests and predictive approaches that were applied, given the size of the datasets and type of data, limit the robustness of any conclusions related to statistical significance. The researchers acknowledged these weaknesses in their approach within the report. Therefore, it is proposed that their statements that "…the results do indicate that DVC rates are related to mowing regime," or, "there is little evidence to suggest that the mowing regime had a significant effect on the number of DVC observed…" should be evaluated in the context of these limitations. In general, it is proposed by this reviewer that the small data set and lack of robustness in the analyses do not allow any general conclusions to be made with respect to the potential relationship between DVCs per year and reduced mowing. In addition, the basic comparative analysis also showed the high levels of variability in DVC data and the factors that potentially impact DVCs. The researchers proposed a larger study with more control to overcome these weaknesses in their study. A study with more study locations, years of data, and more robust statistical analyses could also be considered. It is clear, however, that the analysis of factors that impact DVCs can be very difficult due to their number and variability.

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