THE EFFECT OF REDUCED ROADSIDE MOWING ON RATE OF DEER-VEHICLE COLLISIONS

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ABSTRACT

The investigation's objective was to determine if reducing roadside mowing causes measurable change in deer vehicle collision (DVCs) frequency. Decreased mowing may change vegetation structure which could affect deer density and/or behavior at the roadside, or motorists' ability to detect and react to deer entering the roadway. Both these effects would be expected to increase the DVC rate. However, the results of a literature review and survey of current practice conducted for the project indicated that no quantitative evaluation of this concept has been conducted.

The number of DVC/year were compared before and after mowing was reduced at six locations in Maryland and four locations in New York to determine if there was a statistically significant difference in DVC frequency between the two time periods. Three years of before data were compared to three years of after data, and the predictive relationship of mowing regime on DVC rate was also examined. Five study areas reported more DVC/year after mowing was reduced, four reported more DVC/year before mowing was reduced, and one experienced essentially no change. Results from three New York study areas were marginally significant ($p = 0.10$), but the direction of change was inconsistent. None of the Maryland study area changes were significant. The R^2 values between DVC and mowing were significant (p value <0.05) for only one of the ten study areas tested. Small sample sizes were used, and results should be interpreted with care. However, the results do not suggest a relationship between DVC frequency and mowing regime.

INTRODUCTION

This evaluation of the relationship between mowing practices and the frequency of deer-vehicle collisions (DVC) was conducted as part of a broader project examining the ecological and economic impacts of reduced roadside mowing. The project consisted of three tasks: 1) a review of published research focused on the ecological, economic, and safety impacts of roadside mowing practices; 2) a survey to define and document reduced roadside vegetation management policies currently applied in the United States; and 3) a quantitative assessment of the potential effect of reduced mowing on deer-vehicle collision (DVC) frequency in comparison to "typical" or more frequent mowing practices. The results of Tasks 1 and 2 are briefly summarized below.

Task 1 indicated that the vast majority of existing roadside vegetation best management practices and recommendations address safety, promotion of drainage, control of noxious and nuisance weeds, and promotion of desirable natural vegetation. One of the highest priorities for mowing near roadways is to maintain sight distance so motorists can observe and avoid other vehicles, animals or pedestrians, and to be able to read road signs. Best management practices and recommendations specifically addressing deer and other wildlife, based on results from this literature review, are comparatively rare and largely limited to two categories: (1) restricting the timing of mowing to protect ground nesting birds, and (2) selection of plants to revegetate roadsides that are less likely to attract large animals which may cause potential safety hazards to motorists.

Task 2 indicated a reduction in roadside vegetation mowing has occurred throughout the United States in recent years based on results from our survey of 24 state DOTs. Twenty-one of 24 states (88%) that responded to the survey reported a reduction in their mowing programs. For those 21 states that reduced mowing, 17 did so statewide while 4 reduced mowing in only some parts of their state. The timing of when roadside mowing programs were reduced varied from 1968 to 2010; however, nearly two-thirds (13/21=62%) of the states that had reduced mowing programs made their reductions in the past three years (2008-2010); 81% (17/21) in the past 7 years (2004-2010). Economic concern was the overwhelming reason provided why roadside mowing programs have been reduced in surveyed states with ecological concern being secondary. Ecological concerns included impacts on survival of ground nesting birds, establishment of native plants, and weed control.

The primary objective of Task 3 was to determine if reducing roadside mowing causes a measurable change (increase or decrease) in DVC frequency. A common perception is that decreased mowing may 1) change vegetation structure and/or composition which could affect deer movements, behavior, and/or density, and/or 2) reduced mowing could affect motorists' ability to detect and avoid deer entering the roadway. Both of these effects would be expected to increase the DVC rate. However, the results of Task 1 and task 2 indicated that no quantitative evaluation of reduced-mowing on DVC frequency has been conducted.

The project was funded by Deer Vehicle Crash Clearing House Pooled Fund, and because the results have not yet been fully reviewed by the Pooled Fund members, the results reported should be considered preliminary, as of November 15, 2012.

PROJECT APPROACH

The effect of reduced mowing on DVC frequency could be tested experimentally or through a retrospective analysis of existing data. Because multiple years of observation before and after a mowing change are required to examine DVC rate trends, a retrospective approach was used. States with a suitable amount of before and after data available were identified in Task 2, and Maryland and New York were chosen as test cases from this group.

The number of DVC/year before and after mowing was reduced was compared to determine if there was a statistically significant difference in the number of DVC/year between the two time periods. This simple comparison of before/after data was followed by an examination of the predictive relationship between mowing regime and DVC rate, as well as the relationship of DVC frequency with Average Annul Daily Traffic (AADT) volume and annual buck harvest, a proxy for deer population size. As detailed in the discussion, DVC are known to be correlated to AADT and deer population size.

The analysis was conducted at two scales: 1) the roadway segment; and 2) county-wide. The respective mowing changes described below were implemented state-wide on all roads under state maintenance. However, a change in mowing regimes does not affect all locations along every roadway equally. The width of roadside mowed areas is defined by roadway design and varies greatly along most roads. The impact of reduced mowing should be greatest along roadway segments where reduced mowing affected the greatest width of ROW, and local State DOT personnel were asked to identify roadway segments with the greatest amount of area affected by the mowing change. County-wide data was analyzed as changes in county-wide DVC frequency may provide a more reliable indication of DVC trends. Annual county-wide DVC counts yield larger sample sizes, which should be less susceptible to random variation, as compared to individual roadway segments.

Because a change in DVC frequency is a safety issue, the analysis approach was modeled on standard practices for safety data analyses. The standard practice is to compare three years of crash data from before an improvement to three years of data from after improvement to determine if the improvement had any effect (e.g., 1, 2). Three years of pre- and post-treatment data is considered to provide an acceptable trade-off between collecting enough data to detect a statistically significant change and minimizing temporal effects that can influence the crash frequency independent of the safety improvement being analyzed. Crashes are rare events, and less than three years of data are unlikely to provide statistically sufficient sample sizes. However, longer time periods are likely to encompass other roadway and land use changes, changes in driver behavior, and/or changes in traffic volume, which can independently influence crash frequency and mask the effect of the roadway change being analyzed.

Study Areas

Maryland and New York were chosen for study because these two states met a number of criteria:

- Maryland reduced roadside mowing in 2009 and New York reduced mowing in 2008 (see below), making three years of before and after data available.
- Maryland and New York are located in a climatic zone where vegetation grows quickly and a change in mowing regime would be expected to rapidly have a measureable impact on the structure (e.g., height) of ROW vegetation.
- DVC data was known to be readily available from the Maryland State Highway Administration (MD SHA) and the New York State Department of Transportation (NYSDOT).
- Maryland and New York are contributing members of the Deer Vehicle Crash Clearing House Pooled Fund, which funded this study.

Maryland changed its mowing program in 2009, from 4-6 full cuts of the entire mowable area within the ROW from May through October, to two full cuts with up to four single passes along the shoulder from May to October. The assumed effect of this change would be longer periods of taller grass in ROW segments where the mowable areas are wider than a single mowing pass would cover (about 15 feet).

New York changed its mowing program statewide in 2008, but note that Region 6 reduced its mowing program in 2004. The change can generally be described as a change from 2-3 full cuts of the entire mowable area within the ROW between May and December, to a single full cut with one or two additional cuts of the clear zone only. The assumed effect of this change would be longer periods of taller grass in ROW segments where the mowable areas are wider than the clear zone (about 15-30 feet).

The location and frequency of DVCs are affected by a wide range of variables from the roadway and the adjacent landscape. However, reliable data describing changes to the roadway and adjacent landscape were not available. To account for the lack of data, there were assumed to be no changes to the roadway within the study area during the study period. To minimize landscape sources of variation, study areas that likely experienced relatively low amounts of land use change during the study period were chosen. In Maryland, data was requested from MD SHA Region 6, which consists of Allegany, Garrett, and Washington Counties, the western most part of Maryland. This part of Maryland is largely forested, minimizing the potential for changes in agricultural land use. The human population growth and subsequent changes in land use from 2006 through 2011 were also determined to be minimal in Allegany and Garrett Counties , which both recorded less than one percent population growth from 2000 to 2010 (3). Washington County reported an 11% rate of growth for 2000-2010, but the road segment used from this county (see below) is rural and aerial photography (Google Earth, 2012) indicates that land use around it remained consistent in from 2006 through 2011. In New York State, data from roadway segments located in rural areas was requested, and NYSDOT provided data from roadway segments in Allegany and Columbia Counties, which experienced a -2.0% and 0.0% rate of population growth respectively, from 2000-2010 (3).

Maintenance personnel at both State DOTs were contacted to identify roadway segments with large areas of previously-mowed ROW that were now mowed less frequently. In Maryland, the Region 6 Assistant District Engineer (ADE) was contacted. The ADE in turn requested that Region 6 maintenance personnel identify roadway segments meeting the requested criteria. For New York the Vegetation and Environmental Program Manager in the NYSDOT Office of Transportation Maintenance was contacted. The Program Manager in turn requested that regional Resident Engineers identify roadway segment meeting the same requested criteria as above.

For Maryland, District 6 provided six possible locations that varied in length from less than 0.2 miles to 7.1 miles in length. The two smallest segments were associated with a major interchange (I-68 and MD 219) and were dropped from consideration due to their small size and difficulty of interpreting crash locations associated with an interchange. The four roadway segments considered for analysis were:

- MD 36 – MD36/MD 47 intersection east to the MD36/MD35 intersection (3.0 miles; Allegany County)
- US 220 – US 220/I-68 interchange north to the MD/PA state line (3.7 miles; Allegany County)
- US 219 – Deep Creek bridge north to US 219/MD 42 intersection (3.8 miles; Garrett County)
- MD 67 – Mile post 5.1 north to MP 12.2 (7.1 miles; Washington County)
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For New York, Region 6 provided one possible location, and Region 8 provided two. All three locations were of a suitable length, and were considered for analysis. These locations were:

- I-86 – The entire length of I-86 within Allegany County (34.4 miles)
- Taconic State Parkway (TSP)- from RM 113.8 to RM 118.9 and from RM 126.7 to 131.6 (Columbia County; 10.0 miles total)

In addition to these six roadway segments, county-wide data from four of the counties in which these roadway segments were located was also considered, for a total of ten study areas. The counties considered consisted of Allegany and Garrett Counties in Maryland (Region 6), and Allegany (Region 6) and Columbia (Region 8) Counties in New York. As described above, these four counties had a growth rate of 1% or less during the 2000-2010 period, making an assumption of minimal land use change during the study period reasonable. Washington County was not considered as it had a growth rate of 11%.

DATA AND METHODS

As described in Segment 1 above, three types of variables were considered for analysis for analysis in addition to mowing regime. The number of DVC/year in a study area was the dependent variable, and AADT, buck harvest size, and mowing regime were the independent variables that DVC/year were tested against. These data and their sources are described in detail below.

DVC Data

Maryland and New York collect DVC data through their crash reporting systems. Crash reports are generally filed only when damage (to property or injury to vehicle occupants) warrants a call to the police. Therefore, crash data is known to underreport the actual number of DVC that occur (4, 5), but it does provide a reasonable index of DVC, and is widely used for a variety of DVC analyses (6). Carcass data also provide another index of DVC, though it is still an undercount because many deer leave the roadside before dying and other carcasses are salvaged. Currently, all states have standardized crash reporting systems in place, while only a few states have standardized carcass recording programs.

The State of Maryland Motor Vehicle Crash Report has a code for collision “with animal,” and DVC are coded as such and entered into Maryland’s crash data base. The New York State Department of Motor Vehicles Police Accident Report form has codes for collision “with animal” and “with deer,” and DVC may be coded as either at the discretion of the responding officer and entered as such into New York’s crash data base. The majority of “with animal” crashes are known to be DVC. In both states, these data are then compiled by the DOTs’ respective Safety programs, and are available by date and location, upon request. In addition to crash data, Maryland also systematically collects data on the location of deer carcasses removed from the roadway. The MD SHA Office of Maintenance has been using the Large Animal Removal and Reporting System (LARRS) to record the location of all deer (and other large animal) carcasses removed from the road by maintenance personnel since 2001. All carcass locations recorded using the LARRS are entered into a GIS data base that is maintained by the SHA Office of Maintenance, and these data are also available upon request.

MD SHA provided deer carcass data for 2006 through 2011 from the LARRS database for the four roadway segments chosen for study, as well as county-wide crash data for Allegany and Garrett Counties. LARRS data was used for the roadway segments, as typically more carcass locations are recorded then crashes are reported. Using LARRS data helped to ensure the sample size for the relatively short focal roadway segments in Maryland would be adequate. Carcass records were sorted by route and year to determine the annual number of DVC on each focal road segment. Crash data was provided by MD SHA pre-sorted by county, and used for the county-wide analysis, to improve its comparability to the New York county-wide analysis. NYSDOT provided all “with deer” and “with animal” state-wide crash records for 2001 through 2010. These data were then sorted to identify Allegany and Columbia Counties county-wide and focal roadway segment data sets for analysis.

AADT Data

As traffic volume increases, all types of crashes are including DVC increase, due to increased exposure. To examine the relationship of AADT to DVC in our study areas, AADT counts were acquired for the focal roadway segments and county-wide. The AADTs used were actual counts from permanent count locations, not estimates. For Maryland, 2006-2011 AADT data were available from MD SHA's on-line traffic volume maps for the four focal roadway segments. Traffic counters are located at roughly the beginning and end of the MD 36 and MD 67 focal roadway segments, and the average of the two reported annual values was calculated and used for subsequent analyses. US 220 and US 219 both had only a single counter, located near one end of the segment of interest. For the county-wide data, the average AADT from all counters that reported a count for every year of the study period was used. Data was only available in an electronic spreadsheet format for 2006-2010. The NYSDOT Traffic Data Services Bureau provided state-wide traffic count data from 1996 through 2010, with counters reported by county and road segment. These data were sorted by location and year. For the I-86 focal segments, the seven counters along that segment of roadway were averaged; for the TSP focal segment the three counters along it were averaged. For the county-wide data, the AADT from all counters that reported a count for every year of the study period were averaged.

Harvest Data

All other things being equal, DVC should be more common when deer populations are higher. Because deer populations are notoriously difficult to count or estimate, buck harvest frequency are commonly used as a proxy for deer population numbers. Generally, the number of buck permits available to hunters is nearly constant, and in the short term (i.e., 10 year increments) hunter effort appears to remain relatively constant. Therefore, fluctuations in the buck harvest should approximate fluctuations in the number of deer present across the landscape. Although the Maryland DNR does estimate deer populations (in part based on buck harvest statistics) the NYSDEC does not. For consistency, buck harvest data was used as a proxy for deer population in both states. County-wide buck harvest frequency for 2006 - 2011 for Allegany and Garrett Counties in Maryland were acquired from the *Maryland Annual Deer Report* (7). For Allegany and Columbia Counties in New York the 2007-2010 data from the *New York State White-tailed Deer harvest Summary* (8) was acquired, and directly from the NYSDEC for 2001-2006. Note that the New York 2003 harvest statistics were unavailable.

Analysis Methods

Each study area represented one data set, and each data set had three years of "before" and three years of "after" data, for a total of six observations/study area. The year mowing regime changed was considered and "after" year, because the change in vegetation height was immediate. Each observation contained four variables, consisting of the number of DVC/year, AADT, annual county-wide buck harvest, and mowing regime ("typical" or "reduced"). Initially, trends across the six year study periods were visually examined by plotting the DVC, AADT, and harvest data independently for all study areas using Excel charts,.

As a precursor to these analyses, the normality of the variables in each data set was examined using the Shapiro Wilk test. This test was used as it is known to be appropriate for small sample sizes. Understanding the distribution of the data is relevant to interpreting the results accurately. The Wilcox Rank Sum test was used to compare the average DVC/year before and after mowing was reduced to determine if there was a statistically significant difference in average number of DVC/year between mowing regimes. This non-parametric test was used because of the small sample sizes. After the simple comparison of before/after data, the predictive relationship of mowing regime on DVC rate was examined using linear regression, as well as the relationship of AADT and annual buck harvest to DVC rate. These relationships were examined for each data set separately by regressing DVC against each of the other variables and examining the significance of the generated R^2 value. All statistical tests were implemented using a statistical package for the PC (Statistix 7, Analytic Software 2000).

RESULTS

Underlying Trends – Maryland

In Maryland, mowing was reduced in 2009. During the 2006-2011 study period, DVC frequency in the six Maryland study areas generally increased from 2007 through 2009, then declined though 2011. AADTs in all study areas varied by less than 10% over the study period, and were generally higher in the 2006-2007 portion of the study period. Buck harvest varied by 30% in Allegany County and 7% in Garret County across the six-year study period, and was generally highest in the 2006-2008 portion of the study period. As an example, Figure 1 illustrates data trends discussed for county-wide data from Allegany and Garrett Counties, MD.

Underlying Trends – New York

The study periods in New York differed by county, due to NYSDOT Region 6's early implementation of reduced mowing practices. Mowing was reduced in 2004, and DVC frequency in the Region 6 study areas (Allegany County and I-86) trended upward throughout their 2001-2006 study period, with the highest frequency occurring in 2006. Mowing was reduced in 2008 in NYSDOT Region 8, and the DVC frequency in the Columbia County study area trended upwards but remained relatively flat in the TSP study area across their 2005-2010 study period. AADTs varied from 1% to 6% across the six-year study periods in all four New York study areas, and did not show a consistent trend between the Allegany County and I-86 study areas (Region 6) or between the Columbia County and TSP study areas (Region 8). Buck harvest varied by 53% in Allegany County and 14% percent in Columbia County. These larger differences are due in part to an apparent dramatic decrease in New York State's deer population in the early 2000's, which now appears to be rebounding. This statewide trend is reflected in the harvest trends from the two study periods, with the highest harvest rates in Allegany County reported in 2002, and the highest rates in Columbia County reported in 2008.

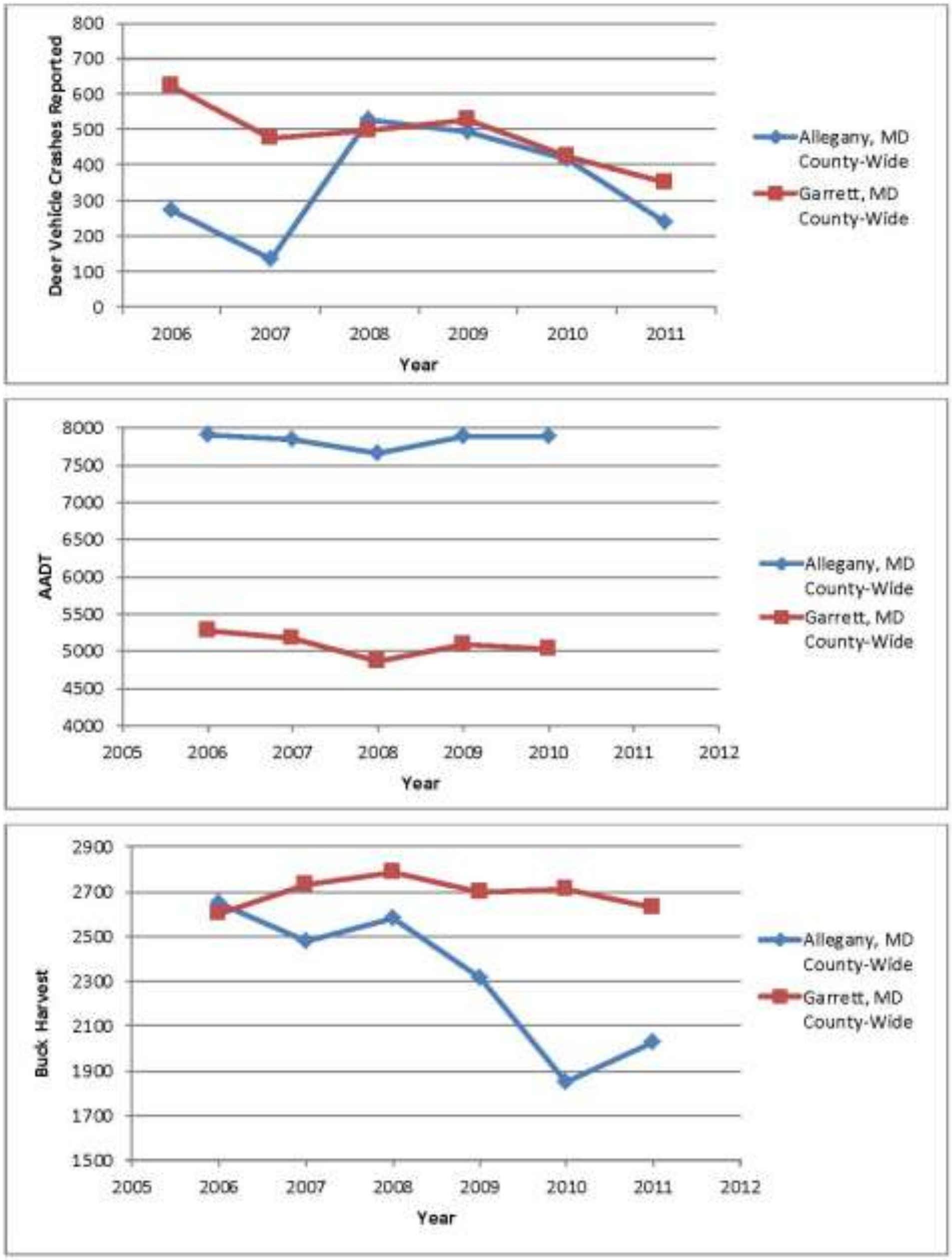

Figure 1. An example of data trends, county-wide DVC/year, AADT, and annual buck harvest for Allegany and Garrett Counties, MD.

Comparison of DVC Before and After Mowing Reduction

The average DVC/year in the three years before and the three years after mowing was reduced is reported in Table 1, by study area. Five of the study areas reported more DVC/year after mowing was reduced, four study areas reported fewer DVC/year after mowing was reduced, and one study area experienced essentially no change. Three of the four counties had higher DVC frequencies after mowing was reduced, but only one of these was even marginally significant (p =0.10). No trend was apparent among the focal segments, and the two marginally significant results were in the opposite direction.

TABLE 1. Comparison of Average DVC/Year Before and After Mowing Change, and the Relationship of DVC to AADT, Annual Buck Harvest, and Mowing Regime, by Study Area

	County Wide				Highway Segment					
	Allegany NY	Columbia NY	Allegany MD	Garrett MD	TSP	I-86	US220	MD 36	US 219	MD 67
DVC Before[1]	159.0	365.0	311.3	**531.3**	**24.7**	22.7	8.7	1.7	**13.7**	**12.7**
DVC After[1]	**191.7**	**583.0**	**382.7**	434.3	18.0	**36.3**	8.3	**2.7**	9.0	11.7
WRS p-value[2]	0.2	0.1	0.8	0.4	0.1	0.1	0.8	0.7	0.4	0.6
R2 AADT[3]	0.0365	0.6957	0.1819	0.3552	0.3485	0.3296	0.2854	0.3195	0.2624	0.1362
R2 Harvest[3]	0.7019	0.0628	0.0587	0.5146	0.3642	0.3136	0.0661	0.0234	0.0151	0.0005
R2 Mow[3]	0.4681	0.9171	0.2330	0.1699	0.4237	0.4522	0.0034	0.2195	0.2130	0.0177

[1] Average Annual DVC at each location before and after mowing was reduced. Greater average DVCs are in **bold**.

[2] Wilcox Rank Sum test p-value. Values smaller than 0.05 indicated that central values of the two samples are significantly different

[3] R^2 value of the regression of the variable against DVC.

Results of the Shapiro Wilk normality tests indicated that the variables examined were normally distributed accept for AADT; four of the Maryland and one of the NY study area AADTs had significantly non-normal distributions. Table 2 reports the strength of the three tested variables in predicting the number of DVC in a study area, based on the significance of their R^2 values (which are reported in Table 1). In only 3 of 30 cases was the p-value significant, results which would be expected by chance. In general, the R^2 values for AADT were higher and the values for Harvest were lower (Table 1), but these trends should be interpreted with care due to the non-normality of some of the AADT data and due to the small sample sizes in general.

TABLE 2. Significance of the Relationship of All Variables Considered with Annual Number of DVC, by Location*

AADT		Harvest		Mow	
Study Area	**p-value**	**Study Area**	**p-value**	**Study Area**	**p-value**
NY Allegany	0.72	MD 67	0.97	US 220	0.91
MD Allegany	0.47	MD Allegany	0.93	MD 67	0.80
MD 67	0.47	US 219	0.82	MD Allegany	0.63
US 219	0.30	MD Garrett	0.79	US 219	0.36
MD Garrett	0.29	MD 36	0.77	MD 36	0.35
US 220	0.27	NY Columbia	0.63	MD Garr	0.23
MD 36	0.24	US 220	0.62	TSP	0.16
I-86	0.23	I-86	0.25	I-86	0.14
TSP	0.22	TSP	0.20	NY Allegany	0.13
NY Columbia	**0.04**	NY Allegany	**0.04**	NY Columbia	**0.01**

*Significant values (less than 0.05) are in **bold**.

DISCUSSION

Results

In general, the results neither supported nor contradicted a significant relationship between mowing regime and the number of DVC observed, at the segment scale or at the county-wide scale. None of the differences in the number of DVC before and after reduced mowing was significant at any of the study sites (Table 1). Additionally, the direction of change in DVC numbers (increase or decrease) was inconsistent, showing no clear trend across all study sites, although there was a non-significant tendency for more DVC to occur county-wide after mowing was reduced (Table 1). The R^2 values between DVC and mowing were significant for only one of the ten study area (Table 2). However, it should be noted that neither of the other two variables tested, both widely demonstrated to be correlated with DVC frequency as discussed below, appeared to have a strong relationship with the DVC rate either.

The data were tested using a method that made no assumption regarding normality and is deemed to be appropriate for small samples sizes. Safety data analysts have however, recognized the limitations of traditional statistical tests in finding true difference between the small sample sizes that are typically available for crash data. Small sample sizes were used for the focal roadway segments, particularly the Maryland segments. In response to these limitations, Empirical Bayes (EB) methods have been developed to predict the expected future rate of crashes at a given location. These predictive equations are generally composed of a location-specific Safety Performance Factor (SPF) that is generated from historical crash frequency using computationally intensive methods, and location-specific AADT values. Generating DVC-specific SPFs for the focal roadway segments used in this analysis was beyond the scope of this project.

Applying an EB approach to the small before/after DVC samples from the focal roadway segments might have provided different results for this study. However, it should be noted that EB methods are being adopted to examine crash “hot spots” (i.e., locations that have an excessive number of crashes), in part to determine if these hotspots are simply occurring due to chance. The focal roadway segments used for this analysis were not hotspots, and therefore their DVC frequency may be expected to experience less random variation over time and be more reliably examined using tradition statistical methods. Applying the EB approach to the county-wide data would not likely have provided different results as the spatial extent of the county-wide study area should dampen random variation in DVC frequency.

The lack of a demonstrated relationship between DVC frequency and the reduction in mowing could stem from a variety of causes. Most simply, there may be no significant relationship, or the effect is so small that it cannot be readily detected. DVC are known or assumed to respond to a large number of variables from a variety of sources that can vary across space and/or time, including land use, habitat quality and structure, topography, roadway characteristics, and traffic (9). Some have the potential for substantial temporal variation while others do not. All have the potential to mask or swamp the effect of any other given variable.

Additionally, the reduced mowing practices in the study areas are incremental; clear zones from 15 up to 30 feet directly adjacent to the roadside are mowed on the same schedule as previously, and annual full cuts maintain all mowable areas as non-woody vegetation. The reduced mowing regime still maintained clear zones that should provide motorists with a similar level of visibility to observe deer entering the roadway. The major difference between the roadside vegetation before and after mowing was reduced appears to primarily be longer periods of taller grass outside the clear zone, with potentially some increase in the forb component of the mowed vegetation outside the clear zone. White-tailed deer feed primarily on woody vegetation, but also forbs (leafy perennials without woody stalks) in spring and early summer. A change in the structure of the grassy vegetation and marginal increase in the forb component would not be expected to substantially increase the number of deer that may already be using the roadside to some degree. If a change in vegetation in some areas did attract deer, the limited size of these areas would be likely to cause a minor, seasonal shift in the distribution of deer across the landscape, as these areas would be only a small portion of any given animal’s home range.

The lack of a relationship between DVC frequency and AADT and deer harvest was counterintuitive. All types of crashes increase as AADT increase, as more traffic creates more exposure. However, in all ten study areas changes in AADT were small across the study period, and because DVC are relatively rare events, DVC frequency may not be sensitive to such small amounts of variation. Numerous authors have demonstrated a predictive relationship between the size of deer harvests and DVC frequency (e.g. 5, 10, 11, 12, 13, 14). However, these relationships are often reported for variations in harvest sizes across space, or for longer time periods then the six-year analysis period used for this study. Additionally, AADT and the number of deer across the landscape likely interact with each other, as well as with many other variables, potentially making the relationship of a single variable with DVC rate difficult to detect.

Future Research

The most robust way to examine the contribution of mowing regime to DVC frequency would be by experimentally varying mowing regime as part of a Before-After-Control-Impact (BACI; e.g., 15) study design. With this approach, variations in the DVC frequency in the control areas can be used to account for the effect of other variables that could influence DVC frequency. This approach would entail monitoring the DVC frequency in the control and impact segments for a time period, changing the roadside mowing regime along the impact segments while maintaining the status quo on the control segments, monitoring the DVC frequency for another period of time, and then comparing results. Because DVCs are relatively rare events, a minimum of three years of before and after data would likely be needed to for adequate samples size and to minimize the influence of random variation.

To account for the influence of other variables, all roadway segments under study and the adjacent landscape would need to be monitored for changes to variables known or hypothesized to contribute to the DVC rate. This would include variations of AADT, and all changes to roadway features (e.g., pavement width, placement and type of guardrails/Jersey barrier, signage) and the local landscape (e.g., crop changes in abutting agricultural fields, new residential or commercial development, changes in recreational use of abutting open spaces). Because accurately monitoring deer population size is impractical, all study roadway segments should be subject to the same environmental factors that influence deer populations (e.g., climate, habitat type, hunting pressure) in order to accurately account for the influence of any changes in deer population size.

The source for DVC data could be crash reports, an existing carcass location recording program, or a carcass recording program implemented specifically for the study. If the crash reporting or existing carcass recording efforts can reasonably be expected to remain consistent during the entire study period, using these data sources would be most cost effective. All state DOTs have consistent AADT monitoring programs in place which can provide reliable traffic volume data. However, programs to consistently track changes to other variables are unlikely to exist. Monitoring these variables would be a specific responsibility of the research project. Identifying changes to these variables could potentially be accomplished through a combination of periodic visits to the study area to observe changes directly, interviews with DOT personnel, analysis of aerial photography, and/or monitoring of local media outlets.

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