Berryman Institute - Project Self-Audit
(Final Report – Edited for SafeHomeAlabama.gov)

Project end date: January 31, 2005

Project title:

An Analysis of Deer Vehicle Crashes (DVCs) in Alabama
A Wildlife Management Perspective

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Project goal: Advancing our understanding of the human dimensions of wildlife, and exploring the role of wildlife management strategies in minimizing its adverse impacts.

Project objectives [as originally stated]:

1. Analyzing the determinants of deer vehicle crashes in Alabama and predicting their number.
2. Characterizing road fragments with relatively higher probability of deer vehicle crashes (DVCs) and evaluating the role of deer habitat in relation to the pattern and frequency of accidents.
3. Identifying cost effective and practical ways of mitigating deer-vehicle crashes (DVCs) in Alabama.

Synopsis of research activities per objective:

We obtained the following from the University of Alabama, Tuscaloosa:

- CARE (for Critical Analysis Reporting Environment) – a computer software developed by University of Alabama in collaboration with the Alabama Department of Transportation for road accidents analysis,
- Road crashes data for the period 1993-2004, and,
- Location specific information (GIS coordinates) about deer vehicle crashes (DVCs) that occurred in Russell County.

In addition, county level information was collected from various government and nongovernmental organizations for the period 1994 to 2003 on the following:

- Number of deer vehicle crashes (DVCs),
- Number of vehicles registered annually,
- Road miles,
- Whether a county belonged to a metropolitan statistical area or not.

- Deer density per square mile
- Land use pattern (in terms of the share of pasture, crop and woodland) and
- Number of hunting license sales
- Bag limits for antler-less deer

Significant findings/results per objective to date: Executive summary format.

I. Introduction

Based on data generated through Critical Analysis Reporting Environment (CARE) deer vehicle crashes (*DVCs henceforth*) have distinct features that are summarized below:

- Over the period 1994 through 2003, there were 27,780 DVCs suggesting an average of 2500 per year. Detail observations by individual year, however, show that crashes started rising in 1993 from 2187 to peak to 3153 in 1999 and then started falling to a level when DVCs were 2583 in 2003. As all the factors supposed to influence DVCs such as human population and registered vehicles per road mile have risen**, it must be the case that wildlife management strategies** such as limits on buck-gun days, hunting license sales, bag limits for antler-less and antlered deer, number of allowable does harvest, etc., enforced by wildlife managers, **and mitigation strategies put in place by Alabama Highway Security personnel** urging drivers to practice caution and monitoring devices to reduce crashes **must have been successful in reducing accidents since 1999**.

- Viewed on a weekly basis, DVCs start rising on Friday evening and peek Sunday morning but continue declining till Monday afternoon. On a particular day these crashes are high in the dawn and dusk, with dawn crashes in the range of 1000-1500 and those in the dusk in the range of 1500-3000. In a given year, crashes start rising during the month of October and continue till February. These are **the months where the two major activities of rut and hunting season coincide. To an extent the rise in DVCs during this these months must be attributed to these two activities.** But the key question to answer is this: why DVCs are higher on certain segments of the road than others? That is where an analysis of the role of wildlife habitat in causing DVCs seems to be warranted.

- While 80 percent of the DVCs occur in rural areas, these rural areas are essentially in counties that have large urban centers. For instance, rural areas in Jefferson, Lee, Baldwin, Montgomery, Madison counties alone accounted for 20 percent of all accidents that occurred over the period 1993 through 2003.

- Distinguished by type of road, CARE data suggest that county roads alone accounted for 40 percent of all DVCs followed by state roads where 30 percent of all DVCs occurred. The shares of Federal, Interstate and Municipal roads were respectively 20, 6 and 4 percent. This information should be helpful to the Highway Security personnel to program logistic activities accordingly.

- In terms of the severity of DVCs, of the total 27,780 crashes that occurred over the period 1993 through 2003, 25,445 entailed property damage, 2302 caused physical injuries and 33 resulted in fatalities.

II. County level analysis using conditional fixed effects negative binomial regression

Methodology: Given the integer nature of DVCs and to account for temporal and spatial heterogeneity across counties, we chose to use a fixed effects negative binomial panel model to analyze DVCs in Alabama. The dependent variable was DVCs per year in each county while explanatory variables included the following variables:

Deer density per square mile
Number of registered vehicles per road mile
Share of cropland relative to woodland
Share of pastureland relative to woodland
Number of state-wide hunting license sales
Bag limits for antler-less deer
Whether or not a county belonged to a metropolitan statistical area (MSA)

We fitted both a poison and negative binomial regression for panel data. While the overall fit was highly significant (Prob > chi-squared statistic = 0.0000) and all the explanatory variables were statistically significant at 5 percent for each specification, the likelihood ratio test favored the use of negative binomial over the Poisson fit. This is understandable given that annual mean crash rate in each county significantly differed from its variance. A poison specification would have unnecessarily constrained the data.

Empirical Findings: With respect to the influence of various explanatory variables, results identified 4 factors to significantly increase DVCs. These included increases in the share of county pastureland relative to woodland, being a part of a statistical metropolitan area (MSA), having 31 or more deer per square mile (base category = 30 or less deer per square mile) and a relatively higher vehicle density per road mile. Thus, other things being equal, a unit increase in the share of pasture relative to woodland would increase the probability of a DVC by 26 percent, and that being part of an MSA would increase a county's probability of a DVC by 22 percent. Likewise, counties characterized by deer density in the range of 31 or more per square mile are 11 percent more likely to have a DVC than counties that have less than 31 deer per square mile.

On the other hand, factors that reduce the probability of a DVC include an increase in the share of cropland relative to woodland, hunting license sales and bag limits for antler-less deer. The variable limits for antler-less deer was significant with a one year lag. Since changes wildlife management strategies such as changes in bag limits and season length are more likely to impact the frequency of DVCs in the following year (or years), the finding that the variable "changes in antler-less deer bag limits" was significant only in lagged form is reasonable.

Discussion: Providing a perspective on the reasonableness of these estimates, note that these

findings are consistent with those by Schwabe et al.(2002) who used a fixed effects generalized linear regression model with autoregressive lag 1 [AR(1)] to analyze DVCs in the state of Ohio over the period 1977 to 1998. To our knowledge this is the only research study that analyzed DVCs using county as a unit of analysis unlike the other studies that have used road segments to analyze DVCs (See for instance, Bashore, T. L. et al. 1985; Finder, R. A, et al. 1999; Hubbard, M. W. et al. 2000, and Nielsen, C. K., 2003).

III. Location specific analysis using truncated negative binomial

To analyze DVCs in a spatially explicit manner (based on the spatial location of each crash) we related DVCs information to land cover, environmental variables, and road specific attributes (such as the number of lanes, whether the crash location was a no passing zone or not, and whether it was 25 miles or less relative to a residential and manufacturing area).

- Land cover and environmental variables were derived from the national land cover (NLCD; USGS, 1999), digital elevation models (DEM; USGS, 1999) and census hydrographic layer (2000). Using ArcGIS v.8.3 and ESRI's spatial analyst extension, we generated a series of surfaces (grain size 30 m) for our land cover classes representing the proportion of area for each land cover category (such as mixed woodland, evergreen woodland, deciduous forests, urban areas, fields, wetlands, open water bodies such as lakes, ponds, streams, transitional areas, recreational areas and land soil classes) in a circular area with a radius of 60, 120, 240, 480, 960, 1200, 1500 and 1800 meters from all DVCs locations.

- We fitted a truncated negative binomial model to relate DVCs to the three sets of covariates mentioned above. The use of this specification was justified because the dependent variable "number of crashes" was either 1 or more and could thus be considered as truncated. Though we fitted a range of other models such ordered logistic, poisson and negative binomial as well, the likelihood ratio tests favored the truncated negative binomial thus confirming the reasonableness of such a choice.

- Still getting statistically significant estimates was not easy even when we used truncated negative binomial. The only variables that consistently turned out to be significant at any deer home range included "number of lanes", "distance to water bodies" "evergreen woodland" and elevation. Other land use variables such as mixed woodland, fields, deciduous forests, transitional areas were significant only for the 40, 50 and 60 radii (these ranges respectively correspond to areas of about 1130, 1750 and 2550 square acres). Results specific to the 1750 square acres deer range were especially interesting. The topographic variables (slope, curvature, elevation) showed the least variation across the sample observations, though part of problem here related to inter-correlation (correlation between the landscapes attributes steepness and elevation was statistically significant).

- The variable "Number of Lanes" was dichotomized as: If number of lanes equals 2 or less, dummyLane =1, else 0. The statistically negative coefficient on this dummy sug-

gested that increases in the number of lanes beyond 2 increases the probability of a DVC, and corroborates with a similar finding by Hubbard et al. (2000). Still, a priori our understanding in this respect was that the more the number of lanes, the lower the probability of a DVCs because more lanes should allow drivers to maneuver and manage. A possible explanation for this unexpected finding from our perspective could be that it is probably easier for a deer to hop and be out of the driver's way on a 2 or less lanes road than a road that has more than 2 lanes.

- The finding that none of the topographic variables except elevation were significant even marginally at any range suggested that one would need a diverse set of GIS coordinates (from locations such as Huntsville, Mobile, Auburn-Opelika, Montgomery, Dothan and a few other areas that would span Alabama's distinct land cover types) to unravel any possible role in influencing DVCs.

Unrealized or unsuccessful endeavors of project (if applicable to project): Explain reason(s) why planned research was not accomplished (weather, equipment failure, etc.). Explain unsuccessful endeavors (high risk research, exploratory, etc.).

The finding that none of the topographic variables turned out to be significant predictors of DVCs was a surprise. We still understand that topographic factors matter. The issue here seems to be the lack of a diverse GIS coordinates corresponding to diverse wildlife habitats in different regions of Alabama. Indeed there may be a way to demonstrate that topography plays a role in explaining why certain areas would be prone to more DVCs than others.

Applications or broader impacts of significant findings, including economic impacts or projected impacts:

The findings of this study has implications for deer management strategies, insurance premium, highway safety personnel logistic planning, deer hunters and above all drivers who bear the brunt of these DVCs in the form of property damage, physical injuries and sometime even fatalities. We understand that wildlife and humans can coexist provided we discern patterns in deer and human activities that would guide us to minimize such conflicts.

Project success relative to original objectives:

While results based on location specific analysis (see Section III above) were not conclusive, the use of count level data and its modeling in a panel negative binomial setting (See Section II above) certainly advanced our understanding of the underpinnings of deer vehicle crashes. These insights have implications for wildlife management strategies with respect to season's length, bag limits and hunting license sales.

Project leveraging (how these funds have been used to secure other funds):

Matching funds were obtained from the Center for Forest Sustainability, Auburn University,

Alabama.

Presentations at professional meetings to date: List only presentations directly related to the Berryman Institute project. Indicate whether poster or verbal presentation.

We are scheduled to present a paper directly related to the Berryman Institute project in Urban/ Rural Interfaces Conference organized by the School of Forestry and Wildlife Sciences, Auburn University, Alabama in Atlanta on March 16, 2005.

Publications: List related publications. Indicate whether in-review, or accepted for publication.

We plan to submit a manuscript titled "An Analysis of Deer Vehicle Crashes in Alabama – A Wildlife Management Perspective" to the Journal of Wildlife Management, late in March, 2005.

List post-docs and graduate students with title of thesis or dissertation, if completed, and estimated graduation date:

None to date

Outreach Activities: List activities undertaken to convey information to stakeholders.

Professor David Brown of the University of Alabama Tuscaloosa plans to write a newsletter regarding the results of this study. These results can be viewed at the CARE website by interested readers and stakeholders.

Submitted: P.I. James B. Armstrong_____ Date: 31/01/05

Dept. Head _____ Date: