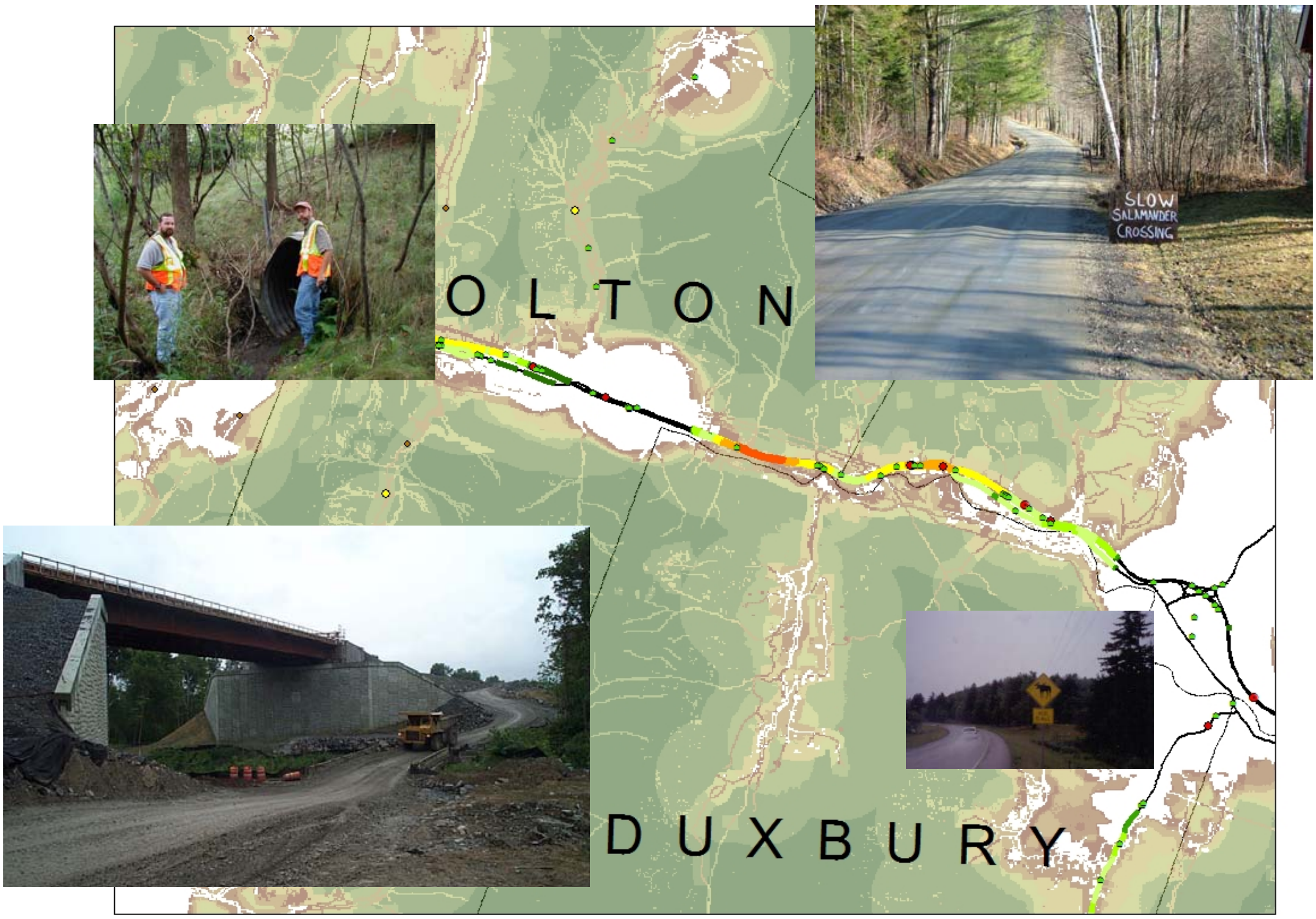
Vermont Wildlife Linkage Habitat Analysis

May 16, 2006

A GIS-Based, Landscape-level Identification of
Potentially Significant Wildlife Linkage Habitats
Associated with State of Vermont Roadways



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This project was developed in accordance with a grant from the Vermont Agency of Transportation (VTrans Research Advisory Council No. RSCH008-967).

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TABLE OF CONTENTS

Acknowledgments:

The Project Developers would like to acknowledge the financial and administrative support of the Vermont Agency of Transportation that was essential for the successful completion of this project. In particular, we wish to extend our sincere appreciation to David Scott, formerly Director of Project Development; John Narowski, head of the VTrans Environmental Section; and the VTrans Research Advisory Committee. We also wish to acknowledge the financial and administrative support of the Vermont Fish and Wildlife Department, in particular Ron Regan, Director of Operations, Tom Decker, Wildlife Biologist; and Craig McLaughlin, former Director of Wildlife.

Finally, the developers of this project note for the reader that this is a GIS-based, landscape-level model designed to predict the location of potentially significant wildlife linkage habitats associated with state highways. There are data gaps and there may be errors or inaccuracies in the habitat identified. The linkage habitats identified as a result of this project will be further refined with respect to our understanding of the species that may rely on them, the landscape features that tend to create them and the quality of available spatial data.

Executive Summary

This project represents a significant outgrowth of a broad fish and wildlife conservation and transportation planning initiative developed between the Vermont Fish and Wildlife Department (Department) and the Vermont Agency of Transportation (VTrans). Over the course of nearly a decade, the issues related to wildlife conservation and transportation planning and development have been well defined. Now, the safety, economic, social and conservation stewardship issues associated with wildlife and roads are considered contemporary and deserving of serious attention. This project is part of a broad-based effort within Vermont to better understand and address these serious issues to the benefit of both conservation and transportation interests.

Primary project accomplishments include:

1. Development of a centralized database of wildlife road mortality, wildlife road crossing, and related habitat data for individual species for which data exists throughout the state of Vermont. This involved updating an existing database developed for a complimentary project designed to compile all existing data on black bear road mortality, road crossing, and significant habitats. It also included incorporating all data on moose collisions and deer collisions. In addition, new databases were developed to record existing bobcat, amphibian and reptile information. In order to expand and improve wildlife road mortality data, a partnership and recording procedures were developed with VTrans field/district staff enabling them to record a new array of wildlife road mortality information.

2. Development of a GIS-based Wildlife Linkage Habitat Analysis using landscape scale data to identify or predict the location of potentially significant Wildlife Linkage Habitats (WLH) associated with state roads throughout Vermont. For purposes of this project, WLH is a term used to describe those habitats associated with Vermont roads where wildlife move, migrate, and access various other habitats and parts of their range (similar to, but broader than, wildlife corridors). This project relied on available GIS data including: (a) land use and land cover data; (b) development density data (E911 house sites); and (c) contiguous or "core" habitat data from the University of Vermont. The GIS conserved lands data was also used for this project as a way of analyzing the feasibility for conserving or ranking potentially significant WLHs identified as a result of this project. These data were classified according to their relative significance with respect to creating potential WLH. The elements that comprise the overall GIS data layers were ranked in accordance with their relative significance to creating potential WLH. This is explained in detail in this report. The analysis, in conjunction with the newly updated wildlife road mortality data, provides a scientifically based, planning tool that will assist the Department and VTrans in understanding, addressing and mitigating the effects of roads on wildlife movement, mortality, habitat and public safety early in the design process for transportation projects. Site-specific use of this data will greatly benefit from field verification and incorporation of additional data on existing terrain, vegetation, developed lands, and associated highway structures such as guardrails and culverts that influence wildlife movement.

Introduction

During the past decade, the Department and VTrans have learned a great deal about the effects of roads and related transportation on wildlife, habitat and ecosystems (e.g., mortality, fragmentation, disruption of behavior, loss of habitat, and cumulative impacts associated with development) (Foreman and Alexander 1998, Trombulak and Frissell 2000, Jackson 2000). Scientific knowledge on issues related to the effects of transportation on wildlife and ecosystems has grown significantly in recent years as evidenced by the International Conference on Ecology and Transportation that occurs every 2 years (see ICOET Proceedings 1997, 1999, 2001, 2003). In Vermont, both the Department and VTrans have coordinated to advance the study, evaluation and understanding of issues regarding transportation planning and wildlife conservation in Vermont. The Department and VTrans have demonstrated a strong commitment to collaboratively addressing these common issues concerning wildlife conservation, safe roads, and a growing interest in developing more contemporary approaches for addressing the effects of transportation development on wildlife and ecological functions.

In states such as Florida, Oregon, Washington and Idaho, scientists and transportation planners have analyzed road conditions, human development, habitat conditions, animal movement data and other information to identify important wildlife corridors for wildlife conservation. Wildlife Linkage Habitat (WLH) and corridors possess certain features such as lack of human development, suitable vegetation, topography, water courses, and discreet habitat features. They are known or suspected to be used by animals that are representative of a wide array of species movement and habitat needs. WLH serve critical functions by allowing wildlife to move, migrate, disperse, reproduce and access important habitats within a large landscape context. Such habitat is critical to wide ranging carnivores, small furbearers or even reptiles and amphibians for avoiding the effects of fragmentation and population isolation, both of which, can lead to extirpation of populations.

Geographic Information System (GIS) technology has proven to serve as a critical tool for analyzing landscape-scale habitat data to identify important wildlife linkage habitat (Connor et al. 1998; Stroms et al. 1992). GIS technology has been used to model and predict the locations of important habitat for connecting large blocks of unfragmented habitat for a variety of wildlife species in many parts of the United States (Endries et al. 2003; Singleton et al. 2001). Accurate and detailed information pertaining to wildlife habitat distribution and quality allows for efficient and effective identification of significant wildlife resource issues by transportation planning and wildlife conservation agencies (Ruediger et al. 2003). The ability to identify significant WLH associated with Vermont State Highways will also allow VTrans and the Department to coordinate and cooperate while making fiscally sound, scientifically defensible investments in wildlife passage infrastructure, land and habitat conservation, and improved public safety measures.

Given the growth in our mutual understanding and appreciation for both environmental, engineering and transportation issues, and the prospects for future investments in mitigation to address concerns related to wildlife conservation and human health and safety, it behooves us to identify important WLH areas. This project identifies and allows for the prioritization of those areas most important for a variety of wildlife conservation needs and enables the Department, VTrans and other conservation organizations to make better decisions regarding transportation planning, design and when necessary, mitigation. Equally important, this information allows for the identification of areas where opportunities exist to reduce or avoid animal/vehicle collisions and improve individual and population migration success thus, improving the safety of the traveling public. Finally, , it will improve efficiency of permit reviews by providing a greater degree of predictability than is currently available. The Department and VTrans will be able to identify areas with high probabilities for wildlife and habitat concerns that may require special attention in permit reviews.

Methods

To arrive at the final WLH analysis, required the integration of publicly available spatial data and the modification of that information as it relates to wildlife habitat and movement. Each of the data layers used for this project was modified for purposes of this analysis, and then reclassified and normalized to values ranging from 1-10 (1=low value and 10=high value). The layers themselves were weighted as a percentage of their importance for purposes of identifying WLH in Vermont. Land use/land cover data were weighted at 27.5% for the project, development density data were weighted at 45% and “core” habitat data (unfragmented habitat blocks established by UVM, not to be confused with “core” habitat as defined on the Department’s black bear range map) were weighted at 27.5%. This is explained in more detail later in the report. This weighting had a significant influence on the final analysis of the model in terms of the breadth of areas identified as WLH. The following is a description of the preprocessing involved with each of the variables involved in the analysis.

a. Land Cover Land Use (LCLU):

The LCLU data used in this project was developed from Landsat Thematic Mapper Imagery that was created in 1994. This data is designed for broad scale landscape level analysis, as the smallest unit of land use mapped in this dataset was 2 acres, yet is useful and appropriate for the scope of this broad scale wildlife habitat analysis grid cell size of 25 meters by 25 meters. The grid cell size of 25 meters is consistent with that of the UVM core habitat GIS data layer.

Similar to other models (Endries et al. 2003 and Singleton et al. 2001), the classifications (ranks) for the elements that comprise the LCLU data were adjusted to more accurately reflect their relative importance as wildlife habitat, particularly for movement of large mammals near roads. Element classifications were based on professional judgment by Department Wildlife Biologists (Table 1).

During the ranking process, the transportation LCLU type was reclassified as a near mean value of 4 out of 10. This does not suggest that these areas provide suitable habitat, but rather is a function of the purpose of the project to identify important habitats in close proximity to roads. Using transportation as a value of 4 allows us to look at habitat variables near roadways without discrediting the roadways all together. It also allows there to be development LCLU types with lower ranking. What we assume with this value is that it is more likely that wildlife will be crossing roads in areas without the other types of development.

Table 1 – *LCLU Reclassification Values*

LCLU type	Final Reclass Value
transitional	9
water	5
barren	5
residential	1
commercial	1
industrial	1
transportation	4
other developed	3
orchards	6
other agricultural	5
deciduous forest	10
coniferous forest	10
mixed forest	10
forested wetland	10
wetland	10
row crop	6
hay/pasture	5

Note: the LCLU type descriptions are taken directly from the GIS LCLU layer through the Vermont Center for Geographic Information (VCGI).

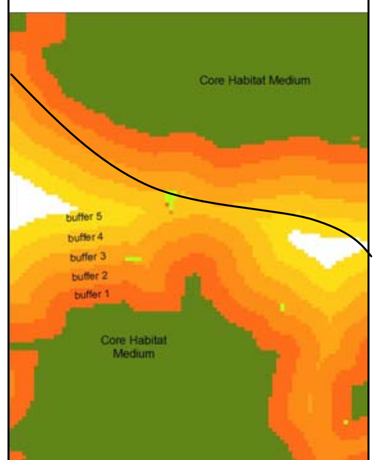
b. Core Habitat:

The Core Habitat GIS layer was developed by the University of Vermont’s spatial analysis laboratory. It describes patches of unfragmented habitat throughout the state. Derived from Landsat Thematic Mapper Imagery in conjunction with transportation information and house site information the dataset describes the presence or absence of anthropogenic features such as roads, structures, buildings, agricultural lands, and quarries for each 25 meter grid cell. For purposes of the core habitat project, it was assumed that the fragmenting features could influence ecological functions of a habitat patch out to 100 meters.

For purposes of this project, the core habitat data layer was converted from a raster format into a polygon shape file. This allowed for the calculation of the total acreage of each unfragmented area. Three classes of core habitat patch size were created in order to differentiate the relative values of unfragmented habitat patches. Habitat patch size classifications are intended to represent the habitat interests of various wildlife species ranging from small mammals, reptiles and amphibians to larger wide-ranging mammals such as black bear, moose (*alces alces*) and river otter (*Lutra Canadensis*). These categories are: (a) 0-1499 acres; (b) 1500 – 10,000 acres; and (c) greater than 10,000 acres. The second size classification was designed to include the home range habitat size of Vermont's wide-ranging mammals such as moose. The third and largest core area classification was a product of the data as 44 parcels were outliers with over 10,000 acres of unfragmented core habitat. It is assumed that the large habitat patches would provide suitable habitat for many species of wildlife (Noss and Cooperrider 1994; Meffe et al.; Hammond 2002). These size classifications were designed generally for comparative purposes and do not necessarily reflect the exact habitat size requirements for specific species.

The acreage of each core habitat polygon was used to calculate corresponding buffer areas, as shown in Figure 1. The buffer analysis enables us to examine the value of habitat outside the core habitat polygons based on proximity to those polygons. This is important to identify areas of overlap between buffers for separate core habitat polygons that may indicate a potential connection between those habitats. We are assuming that distance from core habitat polygons has some influence on animal movement and use of core habitats. In order to keep the buffer areas relative to the size of the unfragmented blocks the buffers were designed as a function of the area of the core habitat polygons. For each individual patch, the square root of the area in acres was used to calculate a distance in meters. This distance was multiplied by 1 through 5 to create 5 buffers around each polygon relative to its size. The buffers were dissolved between each polygon so that buffers from two separate polygons would not be additive. By doing this it was possible to receive a value for each cell corresponding to the highest value without giving higher values to those cells in between core habitat areas. Once the five buffers were created they were converted into raster format and added together. This created a gradient from core areas down to non-core areas. The final raster coverage describes three sizes of core habitat and five zones of areas close to core habitat and relative to the core areas' acreage. The values were normalized to values of 1- 10 to fit into the analysis (see Table 2).

Figure 1. *Unfragmented Habitat and least cost travel analysis.*



The buffer analysis allows the model to rank the value of habitat based on proximity to unfragmented habitat. Furthermore, the model can now reflect the potential for habitat patch size to influence wildlife habitat suitability.

Table 2. *Core Habitat Description*

Description	Count	Explanation	Assigned Value
large core	44	10,000+ acres	8
medium core	230	1500 - 9999 acres	7
small core	13,825	0 - 1499 acres	6
buffer1		√(ACRES)	5
buffer2		√(ACRES) * 2	4
buffer3		√(ACRES) * 3	3
buffer4		√(ACRES) * 4	2
buffer5		√(ACRES) * 5	1

c. Housing Density:

Both the core habitat and the LCLU layers describe the presence of development within an individual grid cell. In the LCLU data layer all residential areas have an equal influence on the landscape for ecological modeling purposes. The core habitat data layer accounts for the varying degrees of influence to habitat and wildlife associated with developed landscapes by providing a weighted value based on the distance from grid cells with developed lands to those without development. For purposes of this project, it

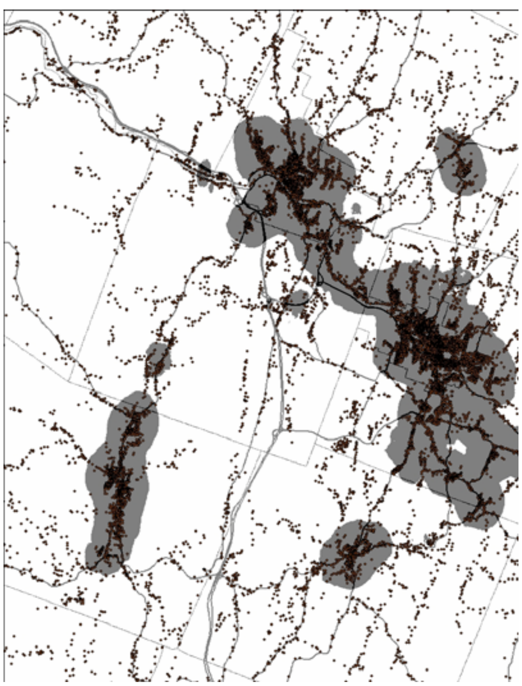


Figure 2a - lowest value category aligned with the perimeter of development centers

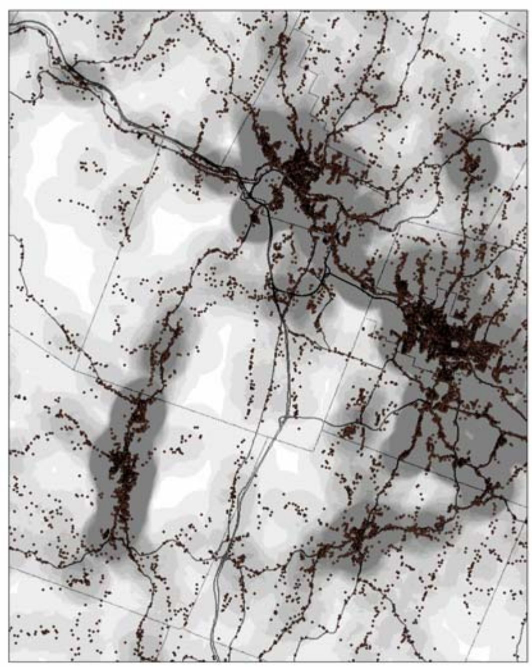


Figure 2b - Values gradually increasing from village perimeter to areas of 0 housing density (dark to light).

is important to account for the varying degrees of development and human influences on wildlife movement and habitat use. Therefore, a new data layer was designed using Emergency 911 information (e-sites) that locates all houses and buildings throughout the state. Using ESRI Spatial Analyst extension, housing density was extracted from the existing point data layer. A 500 meter search radius was used to approximate houses per square mile for each 25m grid cell. These densities where normalized and arranged into ten classes, 0 houses per square mile being the highest ranking category and greater than 80 houses per square mile being the lowest ranking category. Due to the broad array of wildlife species this project attempts to consider and the varying degrees of tolerance of those species to human activity, it is difficult to select a single development density that would apply for this project. Therefore, the data was organized to align the lowest value of housing (highest housing density) with the perimeter of town centers and villages (Figure 2a). The assigned values then gradually increase from the village to areas with 0 housing density (Figure 2b).

Similar to the other data layers, housing density is a measure of development, but the use of a density gradient allows for a consideration of the varying degrees of influence from human activities on wildlife movement and behavior. The analysis assumes that different species of wildlife and even behavior differences of individuals within a population of a given species of wildlife can tolerate different levels of human interaction where as in the other two layers most development is devalued altogether.

d. Process of Combining and Analyzing the GIS Data Layers

The GIS data layers used for this analysis were weighted according to their influence on habitat suitability and wildlife movement. Each layer represents a percentage of an equation for calculating the suitability of habitat with respect to wildlife movement. The final analysis used the following equation to calculate a Wildlife Habitat Suitability (WHS) value for each 25 meter x 25 meter grid cell:

Wildlife Habitat Suitability = (LCLU)*27.5% + (Housing Density)*45% + (Core Habitat)*27.5%

The analysis covers all regions of the state and, as a result, a myriad of habitat conditions (represented by the LCLU and core habitat data layers) so it doesn’t represent a true value or quality of the habitat on the ground but instead uses the known variables to generalize the probability of habitat being found in the grid cell.

A GIS data layer was developed, based on the WHS results that shows the relative value of habitat along state roads for wildlife movement. A one hundred meter buffer from transportation right-of-ways on state roads was applied to determine relative distance to WHS data. Road GIS data was applied to this buffer to produce each of the nine 0.5 mile increments of the wildlife crossing value. The nine increments produce priority areas along state roads. This information can then be used to target potentially significant WLH areas throughout the state.

e. Revised Process for Analyzing WLH Conditions in the Champlain Valley Biophysical Region:

Vermont is comprised of 8 different biophysical regions and the differences among these regions likely influences the movement of wildlife, species composition of an area, and the factors that create WLH. The Champlain Valley biophysical region is different from many of the other biophysical regions of the state in terms of topography, elevation, vegetation, natural communities, development, character and density , traffic volumes, among others. Results from the first WLH analysis did not identify any obvious areas of WLH. Therefore, we adjusted the analysis for purposes of more accurately identifying WLH within the Champlain Valley. In this case, GIS data for surface water and wetlands were added to the analysis. All variables were weighted differently from the original analysis as described below to better fit the conditions of that region of the state.

Using the Vermont Hydrology Dataset (VHD) describing streams derived at a scale of 1:5000 a Euclidean distance analysis created a surface in which almost every cell was affected by the fine scale of the data. Though at larger scales this information would be important in identifying isolated crossing locations at the landscape scale, it is too specific. The amount of “noise” or “clutter” created by identifying every waterway masked the trends and patterns the analysis was trying to portray. The final analysis used information from the National Hydrology Dataset (NHD) that was derived from a scale of 1:100,000. A Euclidian distance analysis using this information, though generalized, provides a better representation of the major stream corridors. The distance from all surface waters (streams, rivers, lakes, ponds) as well as all identified wetlands was classified in 50 meter intervals from 0 meters to 500 meters. The components of the surface water group are not additive meaning there is no preference given to areas near both a lake and a stream, instead the maximum value of any surface water is used.

Table 3. *Proximity to Surface Waters and Wetlands*

Distance from Water (meters)	Reclassification Values
0-50	10
50-100	9
100-150	8
150-200	7
200-250	6
250-300	5
300-350	4
350-400	3
400-450	2
450-500	1

Wetlands were used in much the same way as the surface water information using a Euclidian distance analysis. For each cell within 500 meters, a distance from the nearest wetland was calculated and classified in 50 meter intervals from 0 meters to 500 meters. The wetland information gives no priority to different sizes, types or densities of wetland but creates a gradual surface of distance to the nearest wetland.

Results

Results of this project include:

a. **Wildlife Habitat Suitability (WHS) –** 25m x 25m grid raster describes a value of habitat suitability. It uses housing density, LULC and core habitat information to create a gradually changing statewide coverage. This layer depicts the probability of finding suitable contiguous and linkage habitat conditions within each cell. It does not describe the actual quality of habitat in each cell.

b. **Wildlife Crossing Value (WCV) –** Polyline shapefile that describes the value of the Wildlife Habitat Suitability as it approaches the state highway system. This analysis was designed to use the Wildlife Habitat Suitability covereage to identify sections of the roadways that are associated with high Wildlife Habitat Suitability. The values of the WCV range from 1-10, ten being the most signifigant and 1 being the least signifigant. The relative ranking systems allows for relative priority areas within different regions. This provides a roadway specific description of potential WLH and may be useful for purposes of transportation planning and identification of sites that may be priority areas for wildlife crossing structures.

c. **Wildlife Road Mortality Data -** In addition, current wildlife road mortality data was applied to the WLH results to examine the extent to which areas of concentrated mortality occur within areas predicted as potentially significant WLH.

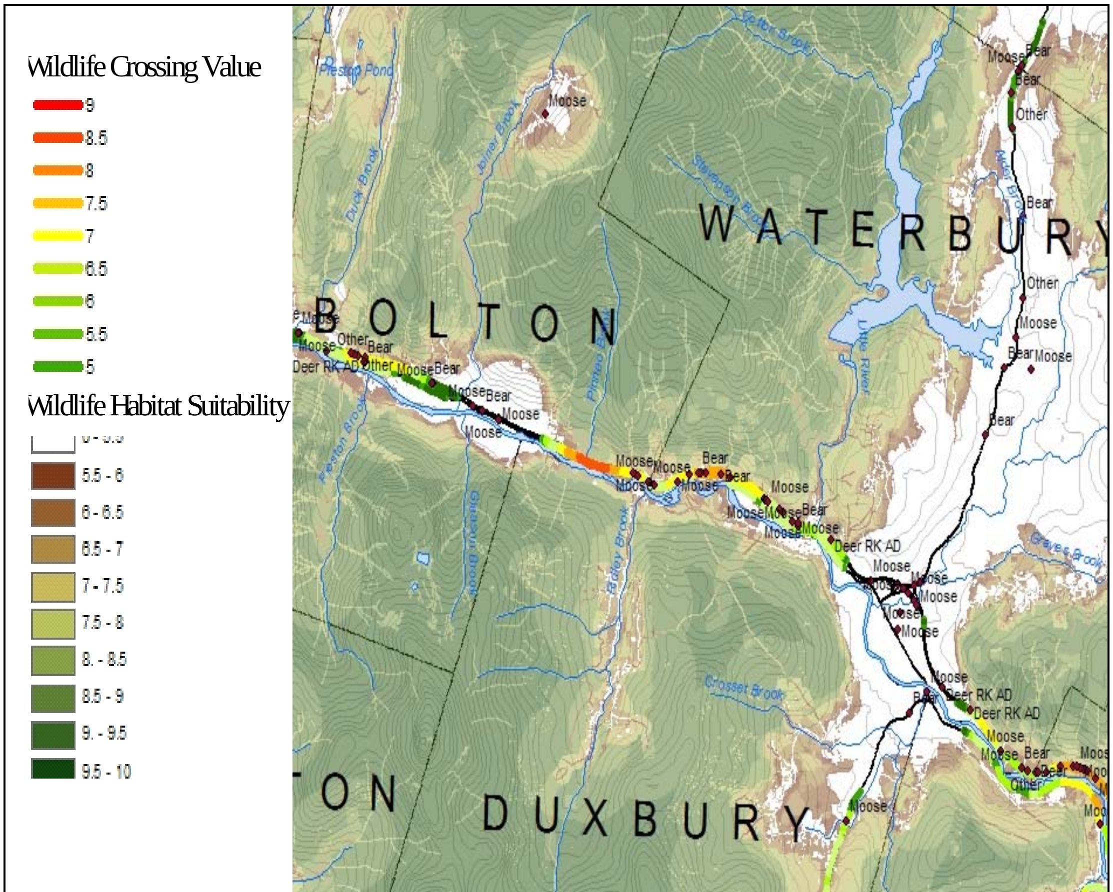


Figure 3 – *Final analysis depicting habitat suitability, wildlife linkage habitat values throughout a stretch of state highway, and road mortality data as point locations.*

Discussion

a. GIS and WLH Identification:

The WLH analysis was designed to objectively consider the suitability of habitats associated with state highways for wildlife movement. This analysis relied on several basic, landscape level databases including: (1) land cover and land use; (2) development density; and (3) "core" or contiguous habitat, hereinafter referred to as "core" habitat for purposes of consistency with the GIS data layer from Vermont Center for Geographic Information (VCGI). Conserved land GIS data was also included as a feasibility component to the analysis so that we could examine the extent to which potentially significant WLHs were associated with conserved lands, and whether conserved lands were already providing a positive benefit for WLHs. This information may prove beneficial for future decision-making regarding locations for wildlife passage structures and their long-term success, among others. The model identifies areas associated with the state road system that intersect critical or important wildlife corridors.

The landscape level GIS data used to identify potential WLH is expected to account for the broad, general habitat requirements of many species of wildlife ranging from wide ranging mammals such as black bear, otter and moose to smaller animals such as reptiles and amphibians. This analysis was also correlated to a statewide wildlife road mortality database to examine the extent to which road mortality data informs the identification of WLH. Though the model does not identify the best possible habitat for each individual species, it attempts to link large, undeveloped areas with relatively low human disturbance in association with conducive land use and land cover types. In addition, it does not implicate areas with a high frequency of road crossings, but rather areas with the highest probability of wildlife crossing at that location.

Other states and countries have conducted GIS based assessments to identify and prioritize important wildlife linkage habitat. Montana (Craighead 2001, Ruediger et al. 2004), Florida (Endries et al 2003) California (Penrod et al. 2001), Washington (Singleton et al. 2001), Iowa(Hubbard et al. 2000), New Mexico, and Utah (Carr et al. 2002, Ruediger et al 2005) represent some of the states that have conducted similar investigations. The Canadian provinces of Alberta, and British Columbia have also conducted similar investigations (Gibeau et al. 2001; Tremblay 2001). Some of these states and provinces have advanced beyond the planning and evaluation process and have modified their highway infrastructure based on their analysis of wildlife movement and habitat suitability data.

While GIS analytical techniques vary among WLH projects in other states, a common theme among these models is a process termed cost weighted coverage or least cost analysis (Singleton et al. 2001, Craighead 2001, Endries et al 2003, Gibeau et all 2001, Tremblay 2001, Carr et al. 2002). Cost weighted coverage is created through the reclassification of common landscape variables based on their relative impediment or benefit to wildlife movement. Setting these landscape variables to a common scale normalizes the data so that each variable is represented in the model or analysis based on its relative significance to wildlife movement. This process can be used as a model of least resistance to wildlife. The data layers used to perform such an analysis are generally similar among GIS modeling projects and include specific habitats, predefined wildlife movement areas, expert opinion models, species population density data, development density, land cover types and conserved lands (Endries et al 2003, Singleton et al 2002).

In some cases, a statewide analysis was designed for a single species of wildlife while others have designed an analysis for general groups or suites of wildlife (e.g., wide ranging mammals/carnivores). There are also general GIS analyses that incorporate species specific information and known biologically important areas, such as was done in Florida where information on 130 species was incorporated into a GIS linkage habitat model (Endries et al. 2003). In the State of Washington, a linkage habitat model relied on species specific habitat and movement data as well as general landscape level data related to large carnivore habitat (Singleton et al. 2001). This analysis found that the model that relied on broad, general landscape level GIS information provided an "adequate approximation of the broad landscape patterns common to the species specific models" (Singleton et al. 2001). Similar modeling efforts have not been conducted in New England.

Since this project was designed to address both wildlife movement and transportation safety an emphasis was placed on wide ranging mammals, particularly black bear and moose. Spatial GIS landscape data was available for analyzing the potentially suitable linkage habitat for these types of wildlife species. Additionally, road mortality and road crossing data exists for these species which allows for some consideration of correlation between the habitat variables and actual animal movement. However, given the general landscape variables used for this analysis, it is possible that the areas identified as potentially significant WLH may apply to a variety of wildlife that require connectivity across a broad area to access habitat, disperse, breed, reproduce, and find food.

b. Wildlife Road Mortality Data Collection and Correlation to WLH:

Historically, the Department and VTrans have collected vehicle collision data for white-tailed deer, moose, and black bear. This data has been collected for decades and the resulting database is extensive albeit concentrated in some regions and sparse in others. For most applications, we decided not to use deer road mortality data since deer vehicle collisions are not consistently reliable indicators of WLH. That is not to discount altogether the value of the deer road mortality data since there may be areas of concentrated deer road mortality that are indicative of high road crossing areas that are important to consider from a public safety standpoint.

In 2001, the Department created a statewide black bear GIS database. This information was collected from written information collected by the Vermont Fish and Wildlife district offices as well as from interviews with Department wildlife biologists, foresters and game wardens. The resulting database contains records dating back to 1971. Moose collision data originates from information recorded by Department game wardens and wildlife biologists that has been recorded in the state police CAD system. Due to the variation in how individuals recorded location information in this database, it was necessary to perform substantial quality control of the data. Based on quality control efforts, these road mortality locations within the databases are accurate to within one half-mile, though for most points the accuracy is much better. Based on the new data collection system developed as a result of this project, wildlife road mortality records are submitted by tenth of a mile marker or with UTM coordinates.

An expanded wildlife road mortality database was created to account for existing bobcat, reptile and amphibian road mortality and crossing information. Historic bobcat den habitat, feeding habitat, and road crossing information was organized in an excel database and digitized in Arcview. In 1995, this information was collected through surveys conducted by Department biologists with licensed trappers in Vermont. This is an incomplete database of bobcat habitat and road crossing information. Additional information will be incorporated into the database as it becomes available. Given the wide-ranging nature of bobcats, they may represent an important indicator species for purposes of identifying or confirming important WLH (Boyle 1987).

Road crossing and mortality information for amphibians and reptiles was collected by the Department through interviews with herpitological experts and professionals in Vermont. The source of this information ensured reliable data. Only those areas of large-scale species movement or where rare or unique species were known to cross roads were recorded. This information is also regional in nature and does not represent a complete understanding of the distribution and abundance of important habitats for amphibians and reptiles in Vermont.

Collecting reliable data on wildlife road mortality in a consistent fashion is a challenge given that it requires a great deal of time and attention. For purposes of this project, the Department and VTrans have developed a data collection system that relies on VTrans district road maintenance staff. This system includes a data collection protocol that is now being used by VTrans district maintenance staff. The system records information on ten species or groups of wildlife. This data collection protocol was implemented in January 2004 and at the current time (May 06) supports over 1000 records. In addition, the existing baseline institutional knowledge of well known wildlife road crossing or mortality locations was summarized through interviews with Vermont Fish and Wildlife Department Game Wardens, Wildlife Biologists and VTrans district field staff. This information is also included in the wildlife road mortality database.

This new wildlife road mortality data collection system has some inherent challenges with respect to long-term consistent collection of reliable data. The quantity and quality of data is contingent on the time and interests of VTrans District field staff and their ability to collect and record this sort of information. Data collection appears to vary among districts. In order for this program to be effective in the long-term, it will be essential for Department and VTrans biologists to maintain positive and effective communication with VTrans district field staff. Our ability to analyze road mortality data will improve as the database grows.

Table 3. illustrates the percent of wildlife collision events that have occurred within the different ranges of Wildlife Crossing Values. We found that 58% of total wildlife road mortality events occur within corridor ratings equal to or greater than 7 and that 75% of total road mortality events occur within corridor ratings greater than or equal to 6 which corresponds to slightly over a third of the state's major roadways. The percentages of wildlife being hit in high value areas, such as greater than 8.5, might seem surprisingly low, but relative to the length of roadways carrying these higher values explains there relative signifigance. In theory, if we were able to eliminate 100% of wildlife collisions from roads with Wildlife Crossing Values greater than 8.5 (totaling only 31.8 miles out of 2823) we would be reducing the yearly collisions by almost 20%. This might not be a very practical task but illustrates the correlation and accuracy of the Wildlife Linkage Habitat Analysis.

Table 3 – *Statewide matching of wildlife road mortality information and Wildlife Linkage Habitat Values (2004 data)*

Wildlife Linkage Habitat Rating	% of Bear Collisions	% of Moose Collisions	% of Total Road Mortality	% of Historical Wildlife Collisions AOT	Length (miles)
> 9.0	2.2	0.5	12.4	0.0	3.7
> 8.5	4.6	9.0	18.6	5.2	31.8
> 8.0	13.9	29.2	34.0	14.1	149.8
> 7.5	29.9	43.8	48.1	28.6	340.3
> 7.0	44.0	53.6	58.2	37.0	575.4
> 6.5	52.7	63.6	68.4	47.4	924.6
> 6.0	62.2	70.1	76.0	57.8	1295.0
> 5.5	68.2	74.7	81.8	66.1	1639.4
> 5.0	72.6	77.3	85.9	71.4	1887.3

Conserved Lands GIS Data Layer:

The final version of the Wildlife Linkage Habitat Analysis did not incorporate Conserved Lands information. Though some of the effects of conserved land, such as parcel size, location and distribution, may influence wildlife movement, this data was not integrated into the analysis because it would have added a significant source of bias. The analysis was designed to be independent of political and human factors that may not relate directly to wildlife movement. The use of this analysis for purposes of conservation and transportation planning should include the Vermont conserved lands data layer, useful for performing feasibility assessments for WLH planning. The use of this project and the Conserved Lands data layer enables the user to compare the abundance, size, location and distribution of conserved lands in conjunction to important WLH. This will provide for informed transportation planning and mitigation by allowing VTrans, the Department and others to target those lands necessary for ensuring the effectiveness of wildlife crossing structures and future land conservation efforts.

d. Regional Disparity of Road, Development and Habitat Conditions:

Scientists have classified 8 different biophysical regions in Vermont. The ecological differences among the 8 biophysical regions in Vermont are a function of many environmental variables including climate, geology, topography, soils, vegetation and correspondingly, animals (Thompson 2002). These differences are important considerations with respect to this WLH analysis since the variables identified for the majority of the state may not be applicable to the Champlain Valley.

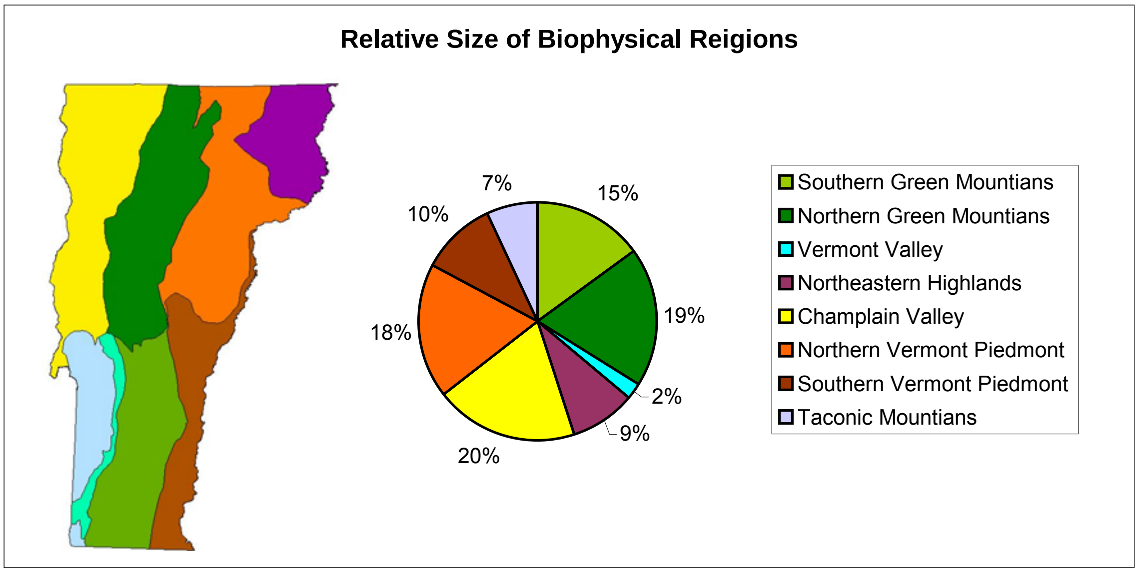


Figure 4. Biophysical regions of Vermont as identified by the Vermont Biodiversity Project report, Vermont's Natural Heritage, 2002.

The primary variables used for purposes of this analysis placed a high value on those areas with large patches of unfragmented habitat and/or with less developed land. This likely represents the interests of wide ranging mammals, and many species of wildlife that rely on similar habitat conditions. However, areas like the Champlain Valley support a great diversity of species, some of which are not found in many other parts of the state, and that require smaller areas of linkage habitat to move throughout suitable range/habitat and meet their life requisites. Given the ecological and geological factors of the Champlain Valley, wetlands, streams and rivers may serve a significant role in wildlife movement through the landscape. These habitat features are widespread within this biophysical region. Therefore, the analysis was adjusted using these variables to more accurately reflect the potential WLH in that region.

Distribution of historical wildlife road mortality data, as presented below, among the biophysical regions indicates that black bear and moose may not represent a useful indicator species of important linkage habitat in the Champlain Valley. On the other hand, existing amphibian and reptile road mortality data suggest that they represent a useful group of indicator species for identifying linkage habitats in areas like the Champlain Valley. This is a general illustration of this data and is limited to a large extent by the volume of road mortality data available. However it makes some interesting comparisons among biophysical regions. Bear collisions, while common in the mountainous regions of the state, have been recorded in low numbers in the

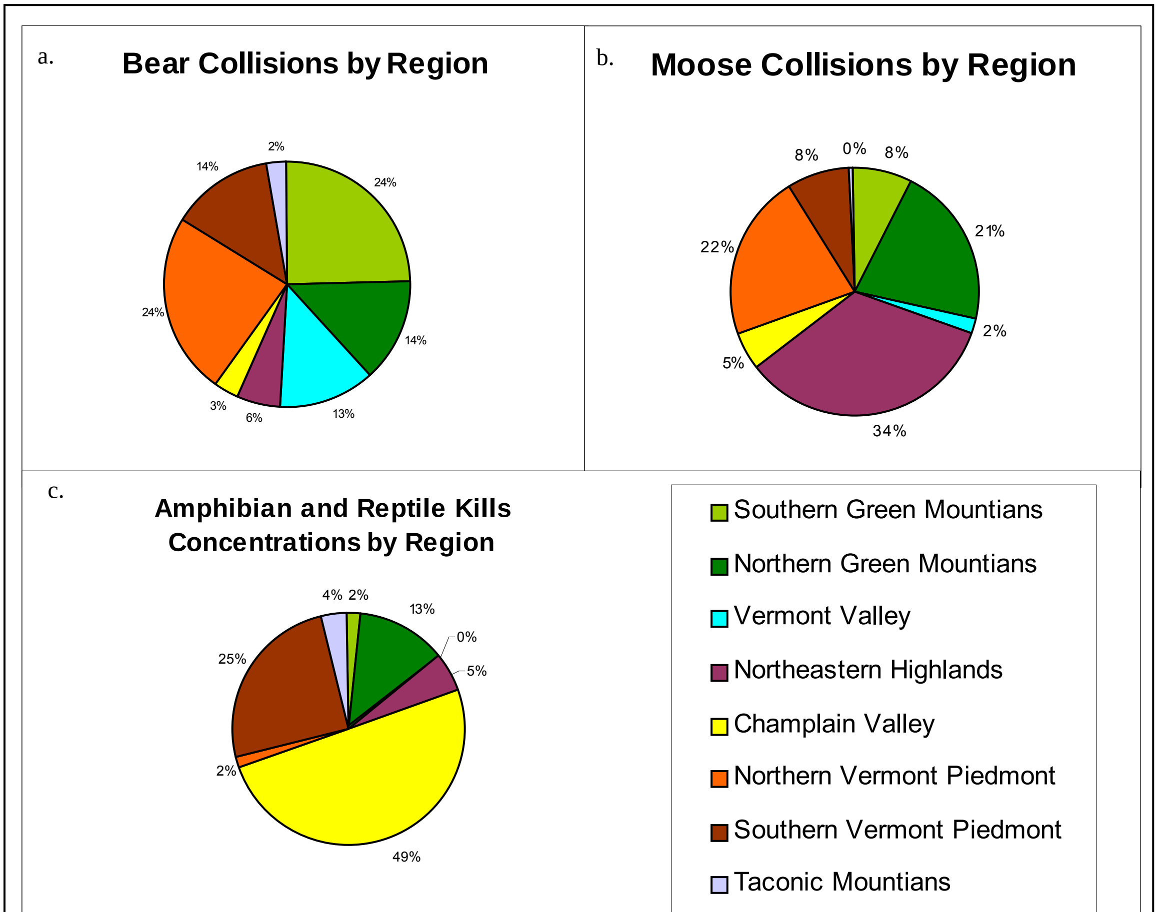


Figure 5. *(a) bear and (b) moose (c) amphibian and reptile collisions by biophysical regions.*

Champlain Valley, Taconic Mountains and the Northeastern Highlands. The relatively low number of reported bear road mortality data for these regions may be due to habitat conditions, traffic volume, road conditions and /or reporter effort The Taconic Mountain region of Vermont is relatively small and there are limits with respect to the movement of wildlife, particularly large, wide ranging mammals, by routes 7 and 7A and the associated high level of development in that area.

Moose road mortality data indicates the greatest concentrations of moose/vehicle collisions occur in the northeast highlands (10% of Vermont), northern Vermont piedmont and northern green mountains. This is corroborated by observations that have been made for over a decade and placement of appropriate warning signs that have been established at many high density moose crossing locations.

Results of the road mortality comparison to the WLH analysis illustrate these differences among biophysical regions and within the Champlain Valley region in particular.

Table 4. Comparison of wildlife crossing values and associated road mortality outside and within the Champlain Valley Biophysical Region.

Outside Champlain Valley						
Crossing Rating	% road sample	% of Bear (356)	% of Moose (1384)	% of MATS Roadkill (not deer)(237)	Amphibians and Reptiles (28)	MATS Deer (209)
9.0	0.1	2.2	0.6	0.0	0.0	0.0
8.5	1.2	4.8	9.5	0.8	0.0	1.4
8.0	5.7	14.0	30.7	4.2	7.1	4.3
7.5	12.4	30.6	46.0	14.3	17.9	17.7
7.0	20.1	44.7	56.1	22.4	21.4	26.3
6.5	31.1	53.4	66.3	36.3	32.1	39.2
6.0	42.6	62.9	72.6	47.7	32.1	50.2
5.5	52.9	69.1	76.6	60.3	32.1	77.5
5.0	60.2	73.6	79.1	70.9	32.1	71.3
Within Champlain Valley						
Crossing Rating	% road sample	% of Bear (12)	% of Moose (73)	% of MATS Roadkill (not deer)(96)	Amphibians and Reptiles (27)	MATS Deer (23)
9.0	0.0	0.0	0.0	0.0	0.0	0.0
8.5	0.0	0.0	0.0	0.0	0.0	0.0
8.0	0.3	8.3	0.0	0.0	0.0	0.0
7.5	1.6	8.3	1.4	2.1	0.0	0.0
7.0	3.5	25.0	6.8	3.1	7.4	0.0
6.5	11.5	33.3	13.7	18.8	18.5	0.0
6.0	22.1	41.7	23.3	20.8	18.5	17.4
5.5	32.9	41.7	38.4	28.1	18.5	34.8
5.0	42.4	41.7	42.5	44.8	22.2	39.1

In order to address the different environmental factors in the Champlain Valley, the GIS model was adjusted to more accurately reflect the landscape conditions that may influence wildlife movement.

Conclusions and Recommendations

This project represents an important initial effort towards identifying and understanding significant WLH throughout the state of Vermont. This information will prove useful for identifying wildlife habitat issues that may be associated with transportation development projects in a timely fashion and thus, reduce the time necessary to address those issues in the planning and permitting processes. It will also enable the VTrans and the Department to make informed decisions regarding the appropriate degree of mitigation necessary to address impacts to WLH or other significant habitats, as well as to make financially responsible decisions regarding the locations of wildlife crossing infrastructure.

It is important to note that this is a preliminary, landscape-scale assessment of WLH in Vermont. Additional field investigations will be necessary to confirm, on a site-by-site basis, the significance of any given WLH identified as a result of this project. Site-specific considerations for understanding the functions and values of WLH include guardrails, bridges, culverts, fence openings, areas of dense vegetation near road edges, sharp curves in the road alignment, and ridgelines along roads, among others (Hammond 2002). A field investigation protocol should be developed based on this information. We recommend that VTrans and the Department continue to focus on a refined assessment of WLHs in areas throughout the state that are targeted for transportation improvement, new infrastructure, land conservation, or other issues of mutual interest.

We recommend that this GIS project continue to be refined with any new applicable data that may become available in the foreseeable future. This model deserves a broader scientific peer review. We recommend that other experts outside of Vermont be asked to review the GIS project and the underlying assumptions that guide it.

Finally, it is essential to maintain the wildlife road mortality database that was developed as a result of this project. We strongly recommend that this database and associated data collection efforts be maintained by both Agencies. A modest financial commitment is necessary for an annual update of the database and the corresponding GIS data layer.

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