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Authors

Austin, John M.
Viani, Kevin
Hammond, Forrest
et al.

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A GIS-Based Identification of Potentially Significant Wildlife Habitats Associated With Roads in Vermont

John M. Austin (Phone: 802-476-0199, Email: john.Austin@anr.state.vt.us), Wildlife Biologist, Vermont Department of Fish and Wildlife, 5 Perry Street, Suite 40, Barre, VT 05641
Kevin Viani (Phone: 802-999-6872, Email: kevin.viani@state.vt.us), Environmental Specialist, Vermont Department of Fish and Wildlife, Concord, NH 03301,
Forrest Hammond (Phone: 802-885-8855), Wildlife Biologist, 100 Mineral Street, Suite 302, Springfield, VT 05156, and
Chris Slesar (Phone: 802-828-5743, Email: chris.slesar@state.vt.us), Environmental Specialist, Vermont Agency of Transportation, Montpelier VT 05633

Abstract: Since 1998, issues regarding wildlife conservation and transportation planning and development in the State of Vermont have become part of a rigorous collaborative effort between the Vermont Fish and Wildlife Department (Department) and the Vermont Agency of Transportation (Vtrans). In recent years, these efforts have become increasingly sophisticated and more broadly applied throughout the state to understand better the inherent conflicts and strategies for improving wildlife movement, reducing wildlife mortality, and improving the safety of the traveling public. Given the growing investment of interest and resources by these state agencies, it is necessary to identify potentially significant wildlife-linkage habitat (WLH) throughout the state. Such information would allow for these agencies to make informed decisions regarding the conservation of important WLH and investments for mitigation of impacts associated with transportation such as underpasses, land conservation, and other measures.

Geographic Information System (GIS)-based models have been developed in other states and in Canada to identify potentially significant WLH. Many of these projects have relied on landscape-level GIS data such as development density, habitat conditions, topography, among others. This project was designed to develop a GIS-based analysis using landscape-scale data to identify or predict the location of potentially significant WLHs associated with state roads throughout Vermont. This project relied on available GIS data including: (a) land-use and land-cover data; (b) development-density data; and (c) contiguous-habitat data (unfragmented habitat). The GIS conserved lands data was also used 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.

In addition, we developed a comprehensive, centralized database of all wildlife road mortality, wildlife road crossing, and related habitat data for all 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 created to record existing bobcat, amphibian, and reptile information. In order to expand and improve wildlife road-mortality data, this project developed a partnership with VTrans field staff enabling them to record a new array of wildlife road-mortality information in a consistent and reliable fashion.

The analysis, in conjunction with the newly updated wildlife road-mortality data, provides a scientifically based, planning tool that will assist both agencies in understanding and improving their abilities to conserve wildlife in Vermont with respect to transportation planning, permitting, and issues regarding secondary growth.

Introduction

During the past decade, the Department and Vtrans have learned a great deal about the effects of roads and related transportation on wildlife, habitats, 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 of 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 two 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. WLH 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 and interests. 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 for avoiding the effects of fragmentation and population isolation which, for some species such as wide-ranging carnivores (or even some species of salamanders) can lead to extirpation of populations.

GIS technology has proven to serve as an extremely useful tool for analyzing landscape-scale habitat data to identify important WLH (Connor et al. 1998; Stroms et al. 1992 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 roads throughout the state of Vermont will also allow Vtrans and the Department to coordinate and make 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 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 wildlife-linkage habitats. This project identifies and to a certain extent, prioritizes those areas most important for a variety of wildlife conservation needs and thus 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, as discussed above, it will improve efficiency of permit reviews by providing a degree of predictability not currently available; we will be able to identify areas with high probabilities for wildlife and habitat concerns that may require special attention in permit processes.

Methods

Since the spatial data used in this project was preexisting and designed for other purposes, each of the data layers required some modification and reclassification. The spatial information was organized within the model to reflect the influence of each data layer on wildlife-habitat suitability. The data layers were normalized to values ranging from 1-10. Normalization is the process of reclassifying data layers to a common scale so that each layer has equal impact on the final analysis. The GIS layers themselves were weighted as a percentage of their importance for purposes of identifying WLH in Vermont. Land-cover/land-use (LCLU) data were weighted at 27.5% for the project, development-density data were weighted at 45%, and “core” habitat data were weighted at 27.5%. The grid-cell size used in this project was a 25-meter-by-25-meter grid cell, which was consistent with that of existing Core Habitat and Land-Cover/Land-Use data. This weighting influenced the final analysis of the model in terms of the breadth of areas identified as WLH. However, in general, it did not seem to make a great deal of difference in the results of the model if slight modifications were made to these ranking values.

Land cover/land use (LCLU)

The LULC data used in this project was developed from Landsat Thematic Mapper Imagery. This data is designed for landscape-level analysis and is useful for broad scale wildlife-habitat interpretation. The smallest unit of land use was 2 acres, corresponding to a grid-cell size of 25 meters by 25 meters. The grid-cell size was consistent with that of core habitat.

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 reflect more accurately their relative importance as wildlife habitat, particularly for the movement of large mammals near roads. Element classifications were based on professional judgment by experienced wildlife biologists with the Department (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 enables the model to view habitat variables near roadways without discrediting the roadways altogether. It also allows there to be development LCLU types with lower ranking. This value assumes that it is more likely for wildlife to cross roads in areas without other types of development.

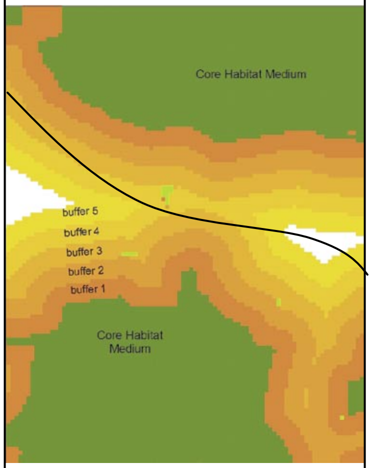
Table 1. LCLU reclassification values

LCLU Type	Final Reclassification 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

Core habitat

The Core Habitat GIS layer was developed by the University of Vermont's spatial analysis laboratory. The layer describes patches of unfragmented habitat throughout the state. This was accomplished by dividing the state into 25-square-meter grid cells and determining the presence or absence of anthropogenic feature such as roads, structures, buildings, agricultural lands, and quarries. For the 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.

Fig. 1. Unfragmented Habitat and least-cost travel analysis.



For purposes of this project, the core-habitat data layer was converted from a binary-raster format into a polygon shapefile. 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 unfragmentated habitat patches. Habitat patch size classifications are intended to represent the habitat interests of various wildlife species ranging from small mammals and reptiles and amphibians to larger wide-ranging mammals such as black bear, moose, and otter. 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. These size classifications were designed generally for comparative purposes and do not necessarily reflect the exact habitat-size requirements for specific species.

As shown in figure 1, the acreage of each core polygon was used to calculate corresponding buffer areas. In order to keep the buffers relative to the size of the unfragmented blocks, the buffers were created as a function of the size of the habitat patch. The first buffer was a function of the square root of the area of the core-habitat patch. This distance was multiplied by 2 through 5 to create five buffers around each polygon. The buffers were dissolved between each polygon so that buffers from two separate polygons would not be additive. This procedure made it 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 to non-core areas. The values were normalized to values of 1 to 10 to fit into the analysis (see Table 2).

Table 2. Core-habitat description

Description	Count	Explanation	Assigned Value
Large core	44	10,000+ acres	8
Medium core	230	1,500-9,999 acres	7
Small core	13,825	0-1,499 acres	6
Buffer 1		sqrt(ACRES)	5
Buffer 2		sqrt(ACRES) * 2	4
Buffer 3		sqrt(ACRES) * 3	3
Buffer 4		sqrt(ACRES) * 4	2
Buffer 5		sqrt(ACRES) * 5	1

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.

Housing density

Both the core habitat and the LCLU layers describe the presence of human development within an individual grid cell. In the LCLU data layer, all residential areas have an equal influence on the landscape and for ecological-modeling purposes. The core-habitat data layer discredits any grid cell with anthropogenic influences, but does capture the value of land near these core areas. The core-habitat data layer attempts to recognize the varying degrees of impacts 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 is important to more carefully 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 the ESRI Spatial Analyst extension, housing density was extracted from the existing point data layer. A 500-meter search radius was used to define houses per square mile for each 25-meter grid cell. These densities where normalized and arranged into ten classes, zero houses per square mile being the highest-ranking category and greater than or equal to 80 houses per square mile being the lowest-ranking category. Due to the broad array of wildlife species, this project considers 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. The data was organized to align the lowest value of housing (highest housing density) with the outer perimeter of town and villages (fig. 2a). The assigned values then gradually increase from the village to areas of zero housing density (fig. 2b).

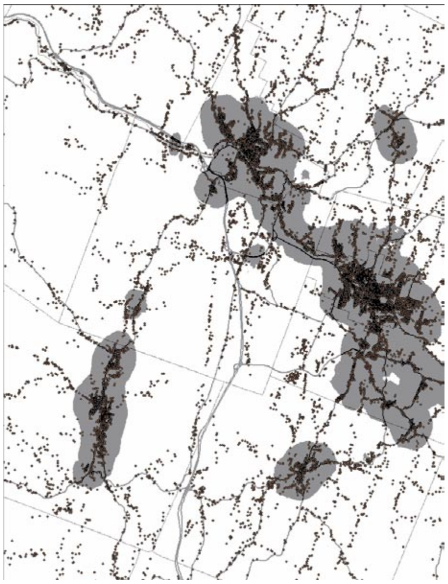


Fig. 2a. Lowest value category aligned with the perimeter of development centers.

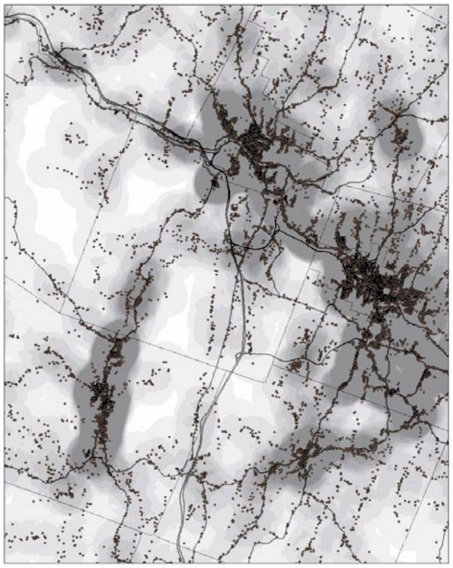


Fig. 2b. Values gradually increasing from village perimeter to areas of zero housing density (dark to light).

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

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 value for each 25-meter by 25-meter grid cell:

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

The results of this analysis cover all the various biophysical regions of the state and incorporate multiple habitat types. Thus, they do not represent a true value of habitat quality in the field, but instead rely on known variables to generalize the probability of suitable habitat being found in each grid cell.

Based on the WHS results, a GIS data layer was developed that depicts the relative value of habitat along state roads for wildlife movement. A 100-meter buffer from transportation right-of-ways on state roads was applied to determine relative distance to WHS data. Road GIS data was clipped to these buffers to produce each of the nine .5 increments of the wildlife crossing value. The nine increments produce priority areas within a region or district and were designed so a region could easily select areas with the highest or lowest suitability for potentially significant WLH.

Revised process for analyzing WLH conditions in the Champlain Valley biophysical region

Vermont is comprised of eight 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 model is likely suitable (from a general landscape scale) for most of the biophysical regions of Vermont, but without question is not well suited for identifying WLH within the Champlain Valley biophysical region. Therefore, we adjusted the analysis for the purpose 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.

Using the Vermont Hydrology Dataset (VHD) describing streams derived at a scale of 1:5,000 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.

Using a Euclidian distance analysis, wetlands were used in much the same way as the surface-water information. 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. 25-m by 25-m grid raster describes a value of habitat suitability. It uses housing density, LCLU, and core-habitat information to create a gradually changing statewide coverage. This layer describes 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. Polyline shapefile that describes the value of the Wildlife-Habitat Suitability within 100 meters of the road centerline. The Wildlife-Crossing Values are designed to identify areas in a region as relative priority areas. 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. Correlation of WCV and 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.

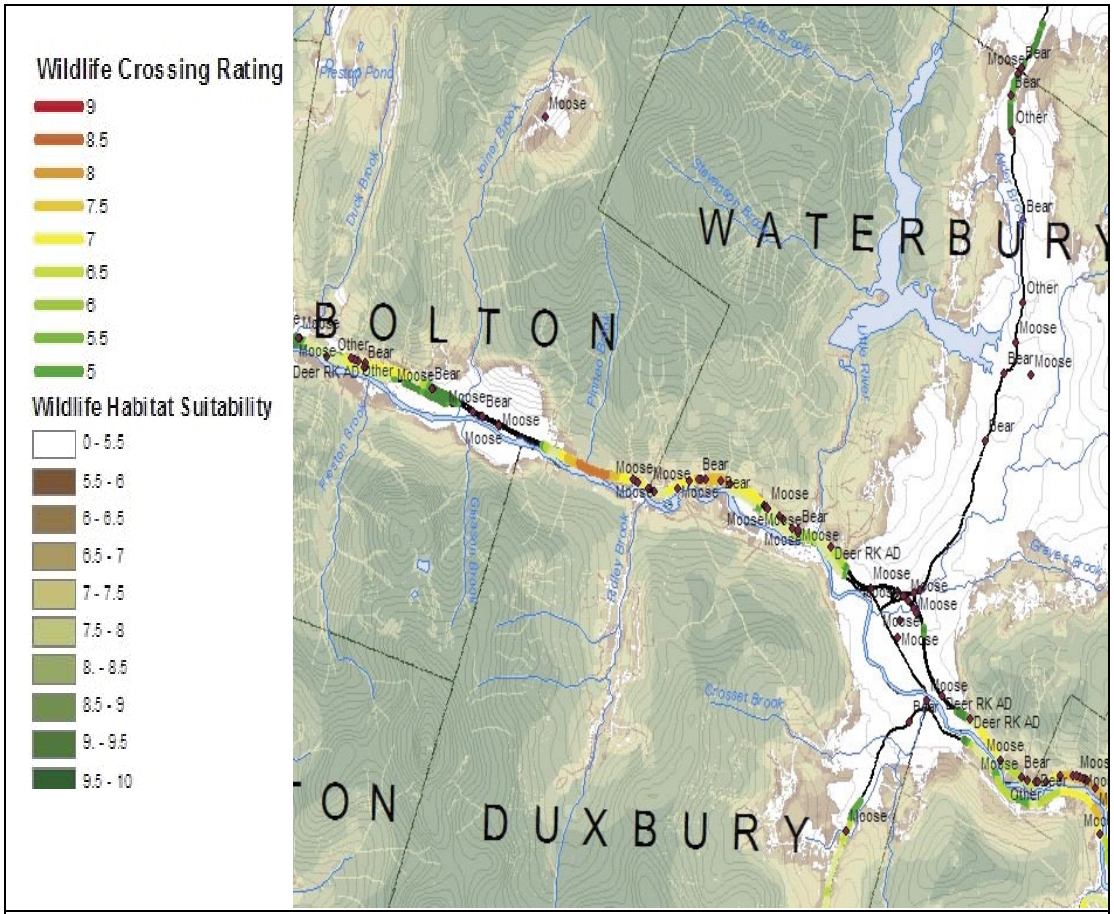


Fig. 6. Final analysis depicting habitat suitability, wildlife-linkage habitat values throughout a stretch of state highway, and road-mortality data as point locations.

Discussion

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 VCGI. Conserved-land GIS data were 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. 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), and Utah (Carr et al. 2002) 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 al. 2001, Tremblay 2001, Carr et al. 2002). Cost-weighted coverage (CWC) 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.

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 Washington State, 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.

Wildlife road-mortality data collection and correlation to the GIS WLH project

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. For most applications, we decided not to use the deer road-mortality data since we did not believe that deer represent a species whose movements are representative of WLH. In 2001, the Department created a statewide black bear GIS database. This information was collected from written information from the five wildlife districts as well as from interviews with wildlife biologists, foresters, and Department enforcement officers. The resulting database contains records dating back to 1971. Moose-collision data originates from information recorded by Department enforcement officers 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 now accurate to within 0.5 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 a Microsoft Excel database and digitized in Arcview. In 1995, this information was collected through surveys of licensed trappers in Vermont conducted by Department biologists. This is an incomplete database of bobcat habitat and road-crossing information and therefore does not represent the full distribution and abundance of important bobcat habitat. 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.

Road-crossing and mortality information for amphibians and reptiles was collected by the Department through interviews with herpetological 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 maintenace staff. The system records information on 10 species or groups of wildlife. This data-collection protocol was implemented in January 2004 and is ongoing. In addition, baseline institutional knowledge of well-known wildlife road crossing or mortality locations was summarized through interviews with Vtrans district area supervisors. 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 Vermont Fish and Wildlife Department game wardens, wildlife biologists, and Vtrans district field staff. Our ability to analyze road-mortality data will improve as the database grows.

Table 3 illustrates the percentage of wildlife collision events that have occurred in the different Wildlife Crossing Ratings. 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. This is significant since the corridor rating value of 6 or greater is associated with slightly over a third of the state's roadways. At first glance, 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 it seems to make more sense. 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) we would be reducing the yearly collisions by almost 20%. This might not be a very practical goal but it does illustrate the supposed accuracy of the model itself.

Table 1. Statewide matching of wildlife road-mortality information and wildlife linkage habitat values.

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 GIS project includes the Vermont conserved-lands data layer for purposes of conservation and transportation planning. Though some of the effects of conserved land (such as parcel size, location, and distribution) may influence wildlife movement, these data were not integrated into the analysis because they 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.

This data layer is very useful for performing feasibility assessments for WLH conservation and transportation planning. This project enables the user to examine the abundance, size, location, and distribution of conserved lands to WLH and plan for future land-conservation efforts in an informed fashion. This will be most useful for transportation planning and mitigation purposes by allowing Vtrans and the Department to target those lands necessary for ensuring the effectiveness of wildlife-crossing structures.

Regional disparity of road, development and habitat conditions

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

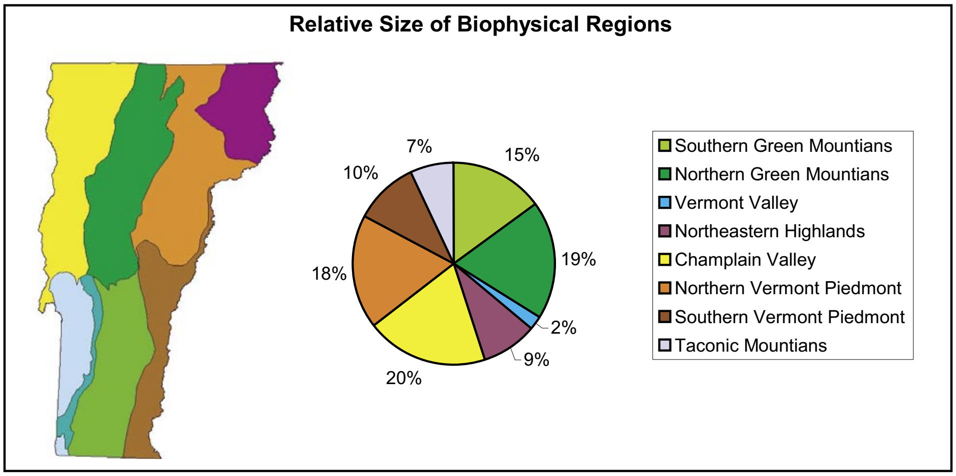


Chart 1. Relative size of biophysical regions.

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 very well, 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 conditions in that region.

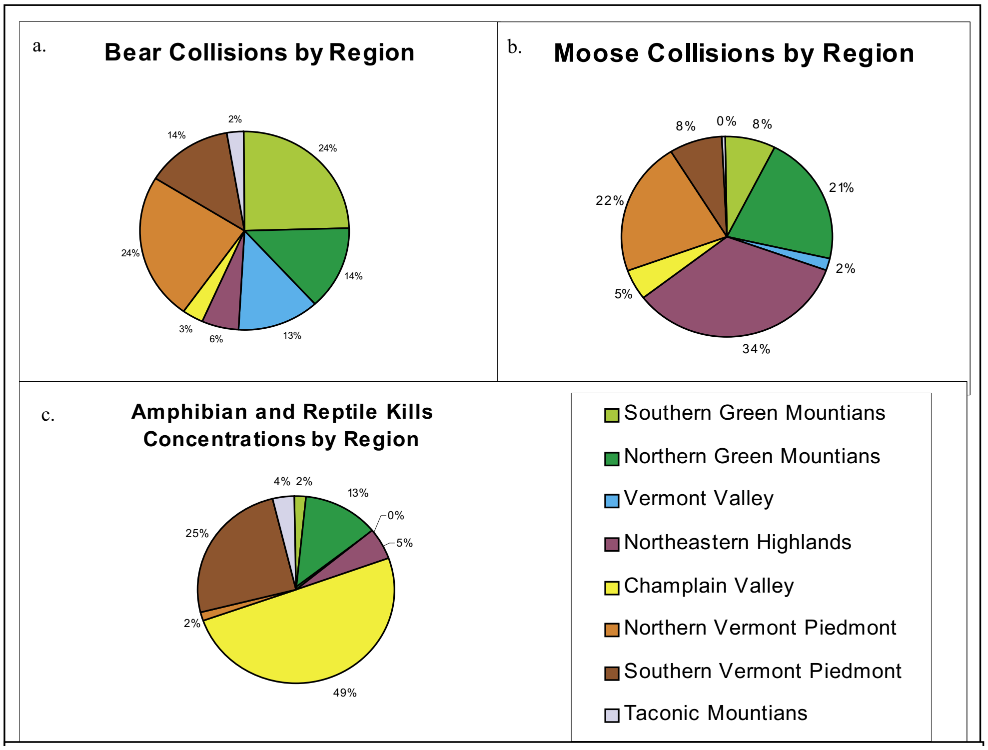


Chart 2. (a) Bear, (b) Moose, (c) Amphibian, and reptile collisions by biophysical regions.

Distribution of historical wildlife road-mortality data (Chart 2) associated with the biophysical regions indicates that black bear and moose may not represent a useful indicator species of important linkage habitat in areas like the Champlain Valley. Moose may not represent a useful indicator species in many areas of the state and further investigations are necessary to better understand their role in this WLH effort. However, existing amphibian and reptile road-mortality data suggest that perhaps amphibians and reptiles represent a useful group of indicator species for identifying linkage habitats in areas like the Champlain Valley. This is a very general illustration of this data and is limited to a large extent by the volume of road-mortality data available. Bear collisions are common in the mountainous regions of the state and there have been low numbers of bear kills in the 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, reporter effort, or (most likely) a combination of all of the above. The Taconic Mountain region of Vermont is a relatively small region and is limited with respect to the movement of large, wide-ranging mammals (at least by routes 7 and 7A) and the associated high level of development that appears to represent a significant barrier to wildlife movement for that region.

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 not surprising as these observations have been made for over a decade and appropriate warning signs have been established at most high-density moose-crossing locations.

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

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

Results of the road-mortality comparison to the WLH analysis illustrate these differences among biophysical regions and within the Champlain Valley region in particular. In order to address the different environmental factors in the Champlain Valley, the GIS model was adjusted to reflect more accurately the landscape conditions that may influence wildlife movement.

Contiguous conserved lands

Similar to the Core Habitat layer, the Contiguous Conserved Land layer attempts to value conserved lands in terms of size and proximity to areas identified as potentially significant WLH. However, whereas in the Core Habitat layer buffer zones are non-additive, zones in Contiguous Conserved Lands layer are additive. Thus this layer prioritizes both areas near the boundaries of pre-existing conserved land and areas that are located between two or more areas of conserved land. This component of the GIS project identifies areas for conservation/acquisition that may have the greatest value for wildlife in terms of connecting other important patches of habitat and ensuring the movement of wildlife through the landscape.

In the previous version of the analysis, this layer was removed. The reason for the removal was that the analysis was designed to locate wildlife corridors based strictly on the environmental factors of the site. To use the Conserved Lands information would then bias the corridors to follow already conserved corridors. One might argue that corridors will change and will eventually follow conserved lands anyway, but for the sake of this analysis the Conserved Lands information was best left out. With that said, however, Conserved Lands information should be used in conjunction with the wildlife-corridor information. This means the Wildlife Corridors would be described without the use of the Conserved Lands information, but decisions made regarding the corridor should not be made with existing conserved land information.

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 Department and Vtrans 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 only 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). Based on this information, a field-investigation protocol should be developed. We recommend that the Department and Vtrans 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.

Biographical Sketch: John Austin is a senior wildlife scientist with the Vermont Fish and Wildlife Department and coordinates inter-agency activities related to wildlife and transportation in Vermont.

Chris Slesar is an environmental specialist at the Vermont Agency of Transportation. He has an M.A. in Environmental Studies from Antioch University in Seattle.

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