A GIS-BASED IDENTIFICATION OF POTENTIALLY SIGNIFICANT WILDLIFE HABITATS ASSOCIATED WITH ROADS IN VERMONT

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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

<table>
<thead>
<tr>
<th>LCLU Type</th>
<th>Final Reclassification Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transitional</td>
<td>9</td>
</tr>
<tr>
<td>Water</td>
<td>5</td>
</tr>
<tr>
<td>Barren</td>
<td>5</td>
</tr>
<tr>
<td>Residential</td>
<td>1</td>
</tr>
<tr>
<td>Commercial</td>
<td>1</td>
</tr>
<tr>
<td>Industrial</td>
<td>1</td>
</tr>
<tr>
<td>Transportation</td>
<td>4</td>
</tr>
<tr>
<td>Other developed</td>
<td>3</td>
</tr>
<tr>
<td>Orchards</td>
<td>6</td>
</tr>
<tr>
<td>Other agricultural</td>
<td>5</td>
</tr>
<tr>
<td>Deciduous forest</td>
<td>10</td>
</tr>
<tr>
<td>Coniferous forest</td>
<td>10</td>
</tr>
<tr>
<td>Mixed forest</td>
<td>10</td>
</tr>
<tr>
<td>Forested wetland</td>
<td>10</td>
</tr>
<tr>
<td>Wetland</td>
<td>10</td>
</tr>
<tr>
<td>Row crop</td>
<td>6</td>
</tr>
<tr>
<td>Hay/pasture</td>
<td>5</td>
</tr>
</tbody>
</table>

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.

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 unfragmented 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

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

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 were 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.](image1)

![Fig. 2b. Values gradually increasing from village perimeter to areas of zero housing density (dark to light).](image2)
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:

\[
\text{Wildlife-Habitat Suitability} = (\text{LCLU}) \times 27.5\% + (\text{Housing Density}) \times 45\% + (\text{Core Habitat}) \times 27.5\%
\]

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.** Polylines 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.
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 maintenance 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.

<table>
<thead>
<tr>
<th>Wildlife-Linkage Habitat Rating</th>
<th>% of Bear Collisions</th>
<th>% of Moose Collisions</th>
<th>% of Total Road Mortality</th>
<th>% of Historical Wildlife Collisions AOT</th>
<th>Length (miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 9.0</td>
<td>2.2</td>
<td>0.5</td>
<td>12.4</td>
<td>0.0</td>
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<td>&gt; 8.5</td>
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<td>9.0</td>
<td>18.6</td>
<td>5.2</td>
<td>31.8</td>
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<td>&gt; 8.0</td>
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<td>29.2</td>
<td>34.0</td>
<td>14.1</td>
<td>149.8</td>
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<td>&gt; 7.5</td>
<td>29.9</td>
<td>43.8</td>
<td>48.1</td>
<td>28.6</td>
<td>340.3</td>
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<td>&gt; 7.0</td>
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<td>53.6</td>
<td>58.2</td>
<td>37.0</td>
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<td>&gt; 6.5</td>
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<td>85.9</td>
<td>71.4</td>
<td>1887.3</td>
</tr>
</tbody>
</table>

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.

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.
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

<table>
<thead>
<tr>
<th>Outside Champlain Valley</th>
<th>% of Bear</th>
<th>% of Moose</th>
<th>% of MATS Roadkill (not deer)</th>
<th>Amphibians and Reptiles</th>
<th>MATS Deer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating</td>
<td>(356)</td>
<td>(1384)</td>
<td>(237)</td>
<td>(28)</td>
<td>(209)</td>
</tr>
<tr>
<td>9.0</td>
<td>2.2</td>
<td>0.6</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>8.5</td>
<td>4.8</td>
<td>9.5</td>
<td>0.8</td>
<td>0.0</td>
<td>1.4</td>
</tr>
<tr>
<td>8.0</td>
<td>14.0</td>
<td>30.7</td>
<td>4.2</td>
<td>7.1</td>
<td>4.3</td>
</tr>
<tr>
<td>7.5</td>
<td>30.6</td>
<td>46.0</td>
<td>14.3</td>
<td>17.9</td>
<td>17.7</td>
</tr>
<tr>
<td>7.0</td>
<td>44.7</td>
<td>56.1</td>
<td>22.4</td>
<td>21.4</td>
<td>26.3</td>
</tr>
<tr>
<td>6.5</td>
<td>53.4</td>
<td>66.3</td>
<td>36.3</td>
<td>32.1</td>
<td>39.2</td>
</tr>
<tr>
<td>6.0</td>
<td>62.9</td>
<td>72.6</td>
<td>47.7</td>
<td>32.1</td>
<td>50.2</td>
</tr>
<tr>
<td>5.5</td>
<td>69.1</td>
<td>76.6</td>
<td>60.3</td>
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<td>73.6</td>
<td>79.1</td>
<td>70.9</td>
<td>32.1</td>
<td>71.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Within Champlain Valley</th>
<th>% of Bear</th>
<th>% of Moose</th>
<th>% of MATS Roadkill (not deer)</th>
<th>Amphibians and Reptiles</th>
<th>MATS Deer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating</td>
<td>(12)</td>
<td>(73)</td>
<td>(96)</td>
<td>(27)</td>
<td>(23)</td>
</tr>
<tr>
<td>9.0</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>8.5</td>
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<td>0.0</td>
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<td>8.0</td>
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<td>7.5</td>
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</tr>
<tr>
<td>7.0</td>
<td>25.0</td>
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<td>3.1</td>
<td>7.4</td>
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<tr>
<td>5.0</td>
<td>42.5</td>
<td>44.8</td>
<td>22.2</td>
<td>39.1</td>
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</tbody>
</table>

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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CONTROLLING TRANSPORTATION AND WILDLIFE-HABITAT LINKAGES THROUGH PARTNERSHIPS, PLANNING, AND SCIENCE NEAR LOS ANGELES, CALIFORNIA

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Abstract

Beginning in 1996, the National Park Service, Caltrans, and other agencies and organizations have worked together collecting, analyzing, and sharing data about regional wildlife-movement corridors within the Santa Susana Mountains, Simi Hills, and Santa Monica Mountains, near Los Angeles, California. This region is characterized by intense urban development, several major multi-lane highways, and large expanses of protected open space supporting abundant wildlife.

Scientific studies include radio telemetry of coyotes, bobcats, and mountain lions, monitoring of undercrossings and culverts to evaluate wildlife utilization, assessment of wildlife mortality along selected roadway segments, and geographic information system (GIS) analyses of potential wildlife-movement corridors adjacent to and across major highways. Results from these studies demonstrate that regional wildlife viability will depend on identifying and protecting habitat linkages and wildlife-movement corridors, particularly across major highways that bisect remaining open space.

In addition, the studies confirm that opportunities do exist to retain landscape connectivity, with many species found to utilize a variety of roadway-crossing structures. By combining the results of the science with transportation planning, Caltrans, the National Park Service, and other partners are now integrating on-the-ground conservation actions with needed transportation-improvement projects and regional transportation plans. Recent successes include the formation of a multi-agency and local participant group to identify and prioritize regional wildlife-movement corridors and to create plans for implementing enhancements.

Agencies and organizations are also sharing information about collaborative opportunities to fund and implement wildlife-corridor enhancement projects. GIS analyses, including least-cost path-linkage analysis, have been used to identify regional wildlife-connectivity requirements. These data will then be available to help to identify priority sites for on-the-ground enhancements.

Along one highway segment (State Route 23), National Park Service scientists are working with Caltrans planners and designers to install wildlife-proof fencing where mortality frequencies are high, enhance existing culverts and undercrossings to facilitate safe wildlife movement, and conduct detailed animal monitoring both before and after improvements to evaluate the success of various actions.

These improvements and monitoring are all linked to lane additions along the highway to improve transportation efficiency. In another location (Highway 101), National Park Service scientists are collaborating with Caltrans environmental specialists to design and install a wildlife-crossing structure along one of the last remaining habitat linkages between the Simi Hills and the Santa Monica Mountains.

Overall, we demonstrate that by sharing expertise and experiences and by linking science and planning, regional wildlife-habitat connectivity can be enhanced in combination with needed transportation projects. This model of partnership and collaboration can be applied to other areas facing similar wildlife-conservation and transportation challenges.

Biographical Sketch: Dr. Ray Sauvajot is Chief of Planning, Science, and Resource Management at Santa Monica Mountains National Recreation Area and is a Senior Science Advisor for the National Park Service. Dr. Sauvajot also holds adjunct faculty positions at the University of California, Los Angeles and California State University, Northridge. Dr. Sauvajot designs and supervises ecological studies, manages science and research, and oversees cultural-resource programs and planning in the Santa Monica Mountains, adjacent to Los Angeles, California. As a National Park Service Science Advisor, Dr. Sauvajot also assists other units of the National Park System. Dr. Sauvajot’s research focuses on the effects of urban encroachment and habitat fragmentation on wildlife, including the effects of roads. Dr. Sauvajot obtained a B.A. degree in biology from the University of California, San Diego and M.S. and Ph.D. degrees in ecology from University of California, Davis.
Sierraville (California) Highway 89 Stewardship Team: Ahead of the Curve

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Abstract: Highway 89 stretches from north to south across California, through Sierra County from Sierraville to Truckee. The highway bisects an important portion of the Loyalton-Truckee deer herd, as well as important habitat for forest carnivores, amphibians and other wildlife on the Tahoe National Forest.

By 2002, several groups were working independently to investigate different aspects of animal-vehicle collisions along the highway. These independent efforts were the:

- Continuation of a 20-plus year collection of carcass information on SR 89 by Caltrans
- Investigation of the effects of roadside forest thinning on roadkill by University of California-Davis Agricultural Extension Service
- Investigation of radio-collared deer movements across the highway by California Department of Fish and Game
- Applications to study the effects of deicing salt on deer attraction by the Sierra County Fish and Game Commission
- Long-term connectivity and habitat planning by the USDA Forest Service

These groups and their efforts were brought together in 2002 when they were catalyzed by the USDA Forest Service into a stewardship team to work together collaboratively to improve the high wildlife mortality and increasing habitat fragmentation on the highway. Most efforts to mitigate similar highway impacts are precipitated by a department of transportation project.

In the case of SR 89, no improvement for SR 89 was planned by Caltrans. Thus, instead of responding to a tight project timeline and budget, the Stewardship Team was able to proactively develop a connectivity and mitigation plan using Caltrans’ large roadkill database, the Forest Service's large-scale habitat maps, and the other cooperators’ information.

In 2004, Caltrans independently funded a $720,000 wildlife-mitigation project on SR 89, thus allowing the Stewardship Team to use its connectivity plan as the basis for decisions on prioritizing wildlife crossing structures. The Stewardship Team is using the connectivity plan to propose further mitigation to Caltrans after the initial structure is constructed. The Stewardship Team has also secured grant funding to involve the local high school in a long-term investigation of how habitat connectivity and highway impacts are related.

This presentation traces the efforts of the Stewardship Team member agencies and how their diverse contributions, once coordinated, supported a grass-roots effort to mitigate highway impacts on SR 89.

Introduction

California State Highway 89 follows the east side of the Sierra Nevada Mountains for hundreds of miles through high sagebrush desert, rural ranching communities, and National Forest System lands (figure 1). Sierra County, California, has only a handful of small towns including Sierraville, none larger than 200 residents. North of Lake Tahoe, from the towns of Truckee to Sierraville, the Loyalton-Truckee Mule Deer Herd crosses the highway in large numbers during upslope and down-slope seasonal migrations. Resident deer cross within their home ranges numerous additional times.

Within the last five years, several groups of people independently recognized and tried to solve aspects of the deer/vehicle collision problem on Highway 89. Once these people were brought together into a cohesive team (the Sierraville Highway 89 Stewardship Team (Team)), their passion and skills resulted in a model example of grassroots accomplishments. This paper relates some of the Team’s accomplishments to date and anticipated accomplishments for the future.
The Team's experience is valuable to others because the combined efforts of several individuals and agencies have resulted in substantial accomplishments. The Team's contributions can be summarized in these areas:

1. No highway project is planned on Highway 89 for the foreseeable future. Therefore, any mitigation for highway impacts could not be rolled into another project, but instead must be a standalone. This determined the approach the Team would take to identify and promote mitigation opportunities.

2. Caltrans has consistently collected carcass data on Highway 89 for 23 years. While not unique, it is extremely unusual to have the longevity of a carcass database in an area that has seen few human developmental changes along a 16-mile distance (of the 33 miles total), thus allowing testing of the database for use in other situations.

3. The Team conducted a mid-scale habitat connectivity 'rapid assessment' (Ruediger and Lloyd 2003) of the lands within approximately 15 miles on each side of Highway 89. This connectivity assessment was based on readily available information gathered from local agencies, including USDA Forest Service habitat maps and the Caltrans carcass database. All species were considered, although the initial impetus for the Team's interest was deer/vehicle collisions.

4. The Team modified a process in use by Caltrans for some of its projects, the Value Analysis process (Caltrans 2003). This process helped select and prioritize opportunities for mitigation within the 33-mile stretch of Highway 89 between Truckee and Sierraville.

**Stewardship Team Members**

The Stewardship Team (figure 2) was formed when individual members realized others were working towards similar goals. Interestingly, prior to 2002 several agencies and individuals were independently working on aspects of the problem of deer/vehicle collisions. The California Department of Fish and Game (CDFG) had an ongoing research project to identify factors affecting the Loyalton-Truckee Mule Deer Herd. Among the issues were deer/vehicle collisions on Highway 89 and other highways within the herd’s range. Sierra County Fish and Game Commission had inquired of Caltrans on the possibility of reducing deicing agents, which may attract deer to roadside edges. Caltrans was continuing to collect carcass data along highways in several counties.

Among the most complete and continuously collected databases was Highway 89, resulting in an excellent database. The University of California (Davis) Agricultural Extension Service had begun to use the Caltrans carcass database to investigate whether a relationship existed between forest fuels treatments along highway edges and deer/vehicle collisions. The USDA Forest Service’s Pacific Southwest Research Station had begun to use Caltrans’ carcass database to investigate how to extract the maximum amount of useful information out of it and similar databases used elsewhere.

The Sierra County Board of Supervisors submitted a grant to the Caltrans Transportation Enhancements for ‘wildlife mitigation’ along Highway 89. The USDA Forest Service was interested in the effects of Highway 89 and others on the connectivity of several wildlife species between widespread units of the Tahoe National Forest.
The Tahoe National Forest recognized that a combined effort would be needed to organize these disparate efforts and also that specialized expertise in wildlife and highway issues would be needed to tackle the challenges. The Pacific Southwest Research Station was requested to organize, lead, and teach the Stewardship Team until local individuals could take over.

Individuals working on all these efforts convened in spring 2003 and the Sierraville Highway 89 Stewardship Team was formed to more efficiently reach mutual objectives. The Team agreed on these primary objectives:

1. Increase traveler safety by decreasing deer/vehicle collisions.
2. Reduce vehicle-caused mortality to all species of wildlife.
3. Maintain or improve habitat connectivity for all species across the highway, especially as highway traffic volume increases over time.

Although many of the Team members originally became interested in the topic because of deer/vehicle collisions, the Team wholeheartedly agreed that multiple species were affected by Highway 89 and needed to be included in any mitigation efforts.

As the Team progressed towards identifying the problem and potential solutions, more people became interested in the project. The California Highway Patrol and the Sierra County local government became involved. Sierra County applied for a Title III Grant to involve local schools in the research and solution-finding efforts of the project, resulting in a grant of $132,000. The California Deer Association granted the Team $5,000 for team members' expenses.

**Stewardship Team Assumptions and Agreements**

The Stewardship Team agreed to take a comprehensive, large-scale approach to mitigate Highway 89's impacts to wildlife. First among these agreements was to consider multiple species rather than define the issue as a deer/vehicle safety issue. This agreement led to the understanding that habitat connectivity was as important to consider as vehicle-caused mortality. The Team further agreed that any mitigation would be a very long-term process, likely spanning two decades, and agreed to continue to champion mitigation efforts as long as needed.

At the time of the Team's formation, no budget existed for mitigation. The Team considered the lack of a constraining budget as an opportunity, because then we could choose mitigation based on its efficiency and priority, rather than by a project's budget limitations. Because Highway 89's impacts would require many individual mitigation solutions even as parts of an integrated mitigation package, the Team expected to promote improvement projects incorporating our recommendations or seek grants for separate mitigation projects.

Although formal agreement vehicles such as memoranda of understandings or the like have been discussed, to date the Team has no formal agreements.
Team members are seeking ways to use current accomplishments to leverage future research and mitigation opportunities. The Sierraville section of Highway 89 offers an unprecedented opportunity to conduct Before-After/Control-Impact studies, particularly using the long-term carcass database.

**Initial Accomplishments**

The Stewardship Team conducted a mid-scale connectivity analysis for all terrestrial species likely to be affected by Highway 89 using the general rapid assessment protocol of Ruediger and Lloyd (2003). We used available resources including local experience, habitat quality maps from USDA Forest Service data, the Caltrans carcass database, and mule deer movement information from the California Department of Fish and Game's ongoing research.

The connectivity analysis revealed few identifiable ‘hotspots’ where typical mitigation methods such as underpasses would work. Primarily this was because the topography allows for unconfined movements of many species, including deer, and the vegetation is homogeneous for long distances adjacent to the highway. Nevertheless, after field review, the Team identified five high priority locations between the Sierra/Nevada County line and Sierraville (16 miles).

The Caltrans carcass database is currently being used for several ancillary investigations. These will be the topics of future papers and are briefly described later in this paper.

Currently, no published tool exists to help transportation planners prioritize wildlife-mitigation sites within a highway stretch or to identify the tradeoffs among competing variables at each potential location. In a construction project, planning teams have a defined distance, timeline, and budget to constrain decisions. Often, interagency agreements define which species (if any) may receive status as worthy of mitigation. In the Sierraville Highway 89 project, no such constraints existed, therefore the choice of which target species, mitigation method, and location was unconstrained.

The connectivity analysis thus provided an excellent starting tool to identify and prioritize general locations and the species associated with those locations (figure 3). The species affected determine the range of mitigation options at a given site. Since the Team had no budget, cost was not a constraint, although we rejected solutions that were not cost effective. For example, the only mitigation solution currently available as a feasible engineering design in some of the hotspots would be an overcrossing; we rejected this option due to its high cost relative to the traffic volume expected in the next 50 years.

**Transportation Enhancements Grant**

At the time the Stewardship Team had completed the connectivity analysis and identified several potential mitigation options and specific locations, Caltrans notified us that the Sierra County Board of Supervisors Transportation Enhancements (TE) grant submission had been funded. The grant designates $720,000 for ‘wildlife mitigation.’ Caltrans has the authority to choose the mitigation option. However, the agency has relied heavily on the Team’s connectivity analysis and knowledge of the mitigation needs of the area in their required analysis stages.
Caltrans uses a Value Analysis study process on some of its projects (Caltrans 2003). This process helps improve the value of highway projects in several ways, including when multiple alternatives are identified or consensus is needed among stakeholders. The Stewardship Team modified the process to identify the best choice of location and mitigation type based on several variables defined by the Team. This process will be outlined briefly below and will be the subject of a future paper. Based on the connectivity analysis, field review, and the Value Analysis process, the Team recommended three locations and structure types to Caltrans as potential projects for the TE grant and requested a review from the agency to determine which of the options would be within the budget.

Caltrans agency engineers reviewed the Team’s recommended options and determined that one of the options would be within the TE budget. This option was the Team’s highest priority option (of the three chosen for this TE grant) as well (figure 3).

As of the date of this writing, the final decision on the type of mitigation option has not been chosen by Caltrans. However, it is likely to be an underpass at Kyburz Flat. In addition to an underpass, three small water-conveyance culverts were identified within the area to be fenced that could also be retrofitted to be suitable for small terrestrial fauna (figure 4).

Figure 3. This site was chosen as the highest-priority location for an improved underpass suitable for all local species. Instead of replacing this box culvert, Caltrans engineers suggested installing an additional underpass 5 meters to the right of this view because of reduced installation costs. Image by Michael DeLasaux.

Figure 4. The highest-priority mitigation option (a large underpass about 10 miles from this location) will need diversion fencing. The fencing will enable several other suitable, existing small culverts to function as small fauna passages because of the diversion. Image by Michael DeLasaux.
Funding for monitoring was included in the TE grant. This funding leveraged with other funds (including those from USDA Forest Service) will allow us to investigate experimentally for effectiveness several commonly used retrofitting options as well as new concepts, particularly with regards to noise moderation within the underpass.

Construction is planned for 2007. The Stewardship Team is prepared to continue to identify and seek funding for the remaining mitigation projects.

**Modified Value Analysis**

The Stewardship Team modified Caltrans’ Value Analysis process so that we could have an objective, transparent, and repeatable means of identifying which mitigation project to fund first. Because the TE was submitted by Sierra County, we narrowed the choices to the mitigation projects within Sierra County.

We further narrowed the choices to the stretch on the Truckee (south) side of a side road that diverted a considerable amount of traffic from Sierraville because the rate of increase in traffic volume would likely be greatest in this stretch. Within the remaining stretch, five major areas for mitigation projects remained.

The Value Analysis process allowed us to identify criteria for choosing among the remaining mitigation options, rank those criteria to determine how close each criterion met the Team's objectives, and then rate each mitigation option for fit to the criteria. However, while the Team believed the Value Analysis process we used was very helpful in illuminating our decision rationale, we also believed the process needed additional work to be fully useful as a standardized approach elsewhere.

For example, feasibility ranked highest among all 11 criteria (figure 5). Aesthetics ranked lowest. In this case, aesthetics were never more important than any of the other criteria. Although aesthetics would therefore not be a decisive factor in choosing a mitigation option, the Team felt it was important to include it because several stakeholders mentioned aesthetics during Team discussions.

For purposes of our analysis, we did not include cost because the Team decided that if the TE grant would be insufficient to pay for our highest priority, we would seek additional funds, rather than choose a less functional option.

![Figure 5. Modified Caltrans Value Analysis process performance criteria used for evaluating the priority of each potential mitigation option along Highway 89. Each criterion is compared to all others and ranked in relative closeness in meeting the Stewardship Team's objectives.](image-url)
The 11 criteria we used, in order of importance, were:

1. Feasibility
2. Adjacent habitat quality
3. The capability of the mitigation option to meet multiple species needs
4. Urgency (are conditions changing or are ephemeral opportunities available?)
5. Presence of human disturbance
6. Cost effectiveness
7. Adjacent land ownership
8. Maintainability
9. Safety
10. Environmental impact (of the mitigation itself)
11. Aesthetics

Safety ranked relatively low because the Team reasoned that functional mitigation would provide safety benefits and that mitigation options that provided safety benefits (but not ecological benefits) were less desirable. Many of these criteria are similar to those identified in the decision matrix used in Florida (Neal et al. 2003).

Caltrans Carcass Database

Carcass databases over unbroken, long-duration timespans are rare, particularly with consistently collected data. Further, carcass databases are more useful for information on wildlife issues than animal/vehicle collision data because many vehicle owners do not report animal/vehicle collisions.

Caltrans has collected information on carcass locations throughout many locations in California. However, the quality of the data is dependent on numerous factors, including the relative importance placed on it by maintenance supervisors over the years. The Sierra County section of Highway 89 is unusually complete and of long duration. Nevertheless, it was collected by crews of typical highway maintenance workers untrained in statistics. It is therefore an excellent database to use to determine how useful such databases are to inform decisions on mitigation options.

Pacific Southwest Research Station is currently developing a Microsoft Excel-based tool to help transportation planners answer some first approximation questions. One such question is how long it may be necessary to collect carcass data to identify ‘hotspots’ on a given stretch of highway under user-identified circumstances. The definition of ‘hotspot’ is user identified as well because some DOTs may have guidelines already.

This tool can also be used as a first approximation of hotspots if users have little or no habitat information available for greater interpretation. Hotspot locations have limited utility for informing decisions on mitigation options; however, a first approximation with a simple tool may help transportation planners determine if further investigation of hotspot data with a more sophisticated tool may be useful.

The Caltrans Highway 89 carcass database is being used as one of several similar databases from around North America as part of the National Coordinated Highway Research Program's project 25-27: Evaluating the Effectiveness of Wildlife Crossing Structures. These databases will be used to develop and refine much more sophisticated tools for carcass and vehicle-collision databases, especially those with GIS-based habitat information available.

These results and tools will be available in a future publication.

Biographical Sketch: Sandra L. Jacobson is a wildlife biologist/research and management liaison at the Pacific Southwest Research Station, Redwood Sciences Laboratory, Arcata, California. Education: B.A. in zoology (1983), Humboldt State University, Arcata, California; M.S. in natural resources/wildlife (1986), Humboldt State University. Jacobson has served as a wildlife biologist for the USDA Forest Service since 1980, working on three national forests at the district and forest levels in California and Idaho. She has worked for the USDI Fish and Wildlife Service, California Department of Fish and Game, and the USDA Soil Conservation Service. As the district wildlife biologist for the Bonners Ferry Ranger District on the Idaho Panhandle National Forests for 13 years, she managed grizzly bears, woodland caribou, and other threatened or endangered wildlife in an interagency and international setting. Ms. Jacobson is the lead biologist for the Wildlife Crossings Toolkit website. She is a charter member of the Transportation Research Board’s Task Force on Ecology and Transportation and a team member for NCHRP 25-27’s Evaluating the Effectiveness of Wildlife Crossing Structures. She is a member of the UC Davis Road Ecology Center’s Scientific Advisory Committee. Currently, Ms. Jacobson is providing project-level technical expertise and training on wildlife and highway issues for several agencies around the country while acting as a research/management liaison at the Pacific Southwest Research Station.

References

WSDOT HIGHWAY MAINTENANCE: ENVIRONMENTAL COMPLIANCE FOR PROTECTED TERRESTRIAL SPECIES

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Abstract: Protected plant and wildlife species that grow, forage, nest, roost, or migrate near the Washington State Department of Transportation (WSDOT) highway system may be susceptible to impacts from routine maintenance activities. In response to community-driven concerns related to the conservation of protected terrestrial species and due to the lack of existing guidance for maintenance personnel when protected-species conflicts arose, WSDOT biologists and maintenance personnel worked together to develop new guidance. The purpose of the guidance is to provide maintenance personnel with resources that identify which projects occur in sensitive plant and wildlife areas and identify best management practices (BMPs) that can be implemented to minimize or avoid impacts to protected terrestrial species in Washington State.

Existing sensitive-species data and aerial photographs were used to identify locations of sensitive species and habitats and to develop guidance. To verify habitat presence, biologists conducted site visits to areas identified as possible sensitive habitats. The guidance document is in the form of a field handbook presented in a step-by-step format to facilitate use by WSDOT maintenance personnel. The guidance document provides maps and descriptions of sensitive areas, each identified by state route and milepost. Species information, such as species name, nest sites, wintering sites, or locations of sensitive habitats, are not identified in the guidance document. Alternatively, biologists placed the species into groups based on habitat needs and identified only the state-route mileposts that fall within each sensitive area. This process helped WSDOT prevent publicizing sensitive wildlife data in the guidance documents and avoided the need for evaluation of habitat by maintenance personnel.

Common maintenance functions were also broken down into groups. For each sensitive location and maintenance function group, a list of BMPs is provided. BMPs may include timing restrictions, equipment use restrictions, or overall activities that should be avoided during certain seasons. The document does not address all possible conditions that may arise during maintenance operations that could affect protected terrestrial species. Maintenance staff consult with their Regional Maintenance Environmental Coordinator prior to initiating any activity that is not addressed by the guidance document or if there is any uncertainty about the applicability of the guidance. Maintenance activities that are not able to comply with the guidance typically require a field review by a biologist and the development of site-specific BMPs. Maintenance personnel do not follow this guidance for emergency actions because separate procedures were previously developed that adequately address protected species compliance for emergency maintenance actions.

This project is currently being piloted with the Olympic Region Maintenance Program. Training courses conducted at individual maintenance sheds have provided opportunity for discussion and question and answer sessions. Biologists and maintenance personnel have had the opportunity to work together to learn each other’s programs, perspectives, and observations to improve the effectiveness of the environmental compliance guidance. The WSDOT Highway Maintenance Environmental Compliance Guidance for Protected Terrestrial Species Program has helped the Maintenance Program conduct their projects in a timely fashion without unnecessary delays and to remain good stewards of the environment.

Introduction

Washington State is well known for its diverse species and unique environments. Washington State is also home to many of the species protected by the Endangered Species Act (ESA) and the Migratory Bird Treaty Act (MBTA). Washington State laws or the Washington Administrative Code (WAC) also provide protection for many of these species. The Washington State Department of Transportation (WSDOT) maintains thousands of miles of roadway within our state that bisect terrestrial habitats occupied by these protected species. Protected plant and wildlife species that grow, forage, nest, roost, or migrate near the WSDOT highway system may be susceptible to impacts from routine maintenance activities. WSDOT is presented with the challenge of maintaining the public-transportation systems while protecting plant and wildlife species that occur along or near the WSDOT highway right-of-way (ROW). WSDOT maintenance personnel must prevent harm or harassment to species protected by the ESA, MBTA, or WAC when implementing highway-maintenance activities.

Section 7 of the ESA allows certain activities to be conducted that may impact an ESA-listed species. However, Section 7 provisions are limited to actions that have a federal nexus. Existing rules under Section 4(d) of the ESA provide limited coverage for projects that require in-water work and may have impacts to some ESA-listed fish species under the jurisdiction of the National Marine Fisheries Service (NMFS). WSDOT coordinates with NMFS for approval and permitting when 4(d) activities arise. WSDOT also coordinates with the U.S. Fish and Wildlife Service (USFWS) when conflicts arise with MBTA-listed birds nesting on WSDOT bridge structures and time-sensitive highway-maintenance activities are required that may harm the species. However, the majority of WSDOT maintenance activities that could impact terrestrial species protected under the ESA, MBTA, and WAC have no compliance provisions. Therefore, it is critical to provide guidance to maintenance personnel in the field, as well as to supervisors involved in the planning of activities to assure that WSDOT conducts their highway maintenance in compliance with laws that protect terrestrial species.
The unique environments of Washington State provide a home to a variety of protected terrestrial species and a large number of them regularly encounter the WSDOT highway system. Currently, Washington State is home to 14 ESA-listed endangered species, 32 threatened species, 14 species that are candidates to be listed, three proposed to be listed, 20 species with designated critical habitat, and two species with critical habitat proposed to be designated. Many of these species and habitats overlap or are regular inhabitants of the WSDOT highway ROW.

In response to community-driven concerns related to the conservation of protected terrestrial species and due to the lack of existing guidance for maintenance personnel when protected-species conflicts arise, WSDOT biologists and maintenance personnel worked together to develop a new program. The objective of the program is to determine where protected terrestrial species and habitat coincide with state routes, develop guidance that allows maintenance personnel to avoid or minimize impacts to these species and habitats, and ultimately facilitate project delivery with minimal delay.

**Maintenance Activities**

Maintenance activities that have the potential to disturb protected terrestrial species or impact habitat were grouped by function. Within each maintenance function group, we identified various pieces of equipment or activities and describe their applicability and how they may potentially impact species or habitat. Table 1 provides a list of the maintenance function groups, the equipment or activities within that group, and their applicability to the environmental guidance.

Table 1. Maintenance activities and potential environmental impact

<table>
<thead>
<tr>
<th>Maintenance Function Group</th>
<th>Applicability*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Roadway Maintenance</td>
<td>Environmental guidance applies due to potential:</td>
</tr>
<tr>
<td></td>
<td>- Disturbance impacts from pavement grinding, jack hammering, grader patching, shoulder regrade (pulling shoulders), and chip seal operations.</td>
</tr>
<tr>
<td>2. Drainage Maintenance and Slope Repair</td>
<td>Environmental guidance applies due to potential:</td>
</tr>
<tr>
<td></td>
<td>- Disturbance impacts from operation of excavators, back hoes, vactor trucks, jackhammers, and</td>
</tr>
<tr>
<td></td>
<td>- Habitat impacts from vegetation clearing outside of the developed right-of-way.</td>
</tr>
<tr>
<td>3. Roadside and Landscape Maintenance</td>
<td>Environmental guidance applies due to potential:</td>
</tr>
<tr>
<td></td>
<td>- Disturbance from brush cutting, hazard tree removal, operation of chain saws, and</td>
</tr>
<tr>
<td></td>
<td>- Habitat impacts from hazard tree removal, herbicide application, mowing, and vegetation clearing outside of the developed right-of-way.</td>
</tr>
<tr>
<td>4. Bridge and Tunnel Maintenance</td>
<td>Environmental guidance applies due to potential:</td>
</tr>
<tr>
<td></td>
<td>- Disturbance from common regional maintenance activities, and</td>
</tr>
<tr>
<td></td>
<td>- Nest removal from cleaning and washing activities.</td>
</tr>
<tr>
<td>5. Snow and Ice Control</td>
<td>Exempt.</td>
</tr>
<tr>
<td>7. Rest Area Operations</td>
<td>Exempt. Not applicable to the current rest areas in the region.</td>
</tr>
</tbody>
</table>

* Regardless of the maintenance function group, all emergency actions are exempt from this guidance.
Sensitive areas

Sensitive areas are sections of state routes that coincide with occurrences of protected terrestrial species or habitat. These sensitive areas are provided to maintenance personnel in the form of milepost sections of a state route. This approach allowed us to avoid publishing the precise locations of protected species. We located sensitive areas based on species or habitat presence, distance of the species or habitat from the state route, and suitability of the habitat.

Species groups

We grouped species based on their habitat requirements. All species included in this guidance are protected by the ESA, MBTA, or WAC. However, the guidance emphasizes ESA-listed species and habitat. Table 2 summarizes the species groups located in the WSDOT Olympic Region and their associated habitat.

Table 2. Summary of species in the Olympic Region and their assigned groups based on habitat requirements

<table>
<thead>
<tr>
<th>Species Group A</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat Type</td>
<td>Old-growth Forests</td>
<td>Riparian or Marine Forest</td>
<td>Ocean Beaches or Salt-spray Meadows</td>
<td>Prairie or Open Grasslands</td>
<td>Bridges</td>
</tr>
</tbody>
</table>
| Species Names  | □ Northern Spotted Owl  
    □ Marbled Murrelet  
    □ Bald Eagle | □ Brown Pelican  
    □ Western Snowy Plover  
    □ Oregon Silverspot Butterfly  
    □ Streaked Horned Lark | □ Golden Paintbrush  
    □ Kincaid’s Lupine  
    □ Nelson’s checkermallow  
    □ Whulge Checkerspot  
    □ Valley Silverspot  
    □ Mardon Skipper  
    □ Puget Blue  
    □ Streaked Horned Lark  
    □ Mazama Pocket Gopher | □ Peregrine Falcon  
    □ Osprey |

Species Group A

Species Group A includes those species associated with old-growth forests. Species included in Species Group A are northern spotted owl (Strix occidentalis caurina) and marbled murrelet (Brachyramphus marmoratus marmoratus). The USFWS has determined that the destruction, modification, or curtailment of habitat for these species is a significant factor in their decline (Federal Register 1990; Federal Register 1996). The northern spotted owl is a federally threatened species under the ESA (Federal Register 1990) and a Washington State endangered species (WAC 232-12-014). The marbled murrelet is a federally threatened species under ESA and Washington State threatened species (Federal Register 1992a; WAC 232-12-011). Critical habitat has also been designated for both species (Federal Register 1992b; Federal Register 1996). Both northern spotted owls and marbled murrelets are protected under the MBTA (50 CFR 10.13).

Northern spotted owls are nocturnal forest-dwelling owls that nest from March to June (Federal Register 1990) in stands with structural components typical of old-growth forests. Fledgling occurs from mid-May to late June, with parental care continuing into September (Federal Register 1990). Nesting generally occurs in cavities of large (>30 inches diameter at breast height [dbh]) coniferous trees and snags (Federal Register 1992b). Adult northern spotted owls require sufficient open space below the canopy to forage (Thomas et al. 1990 in Federal Register 1992b). Use of chainsaws, the sound of falling trees, and the sound of cutting downed wood have the potential to adversely affect northern spotted owls in western Washington between March 1 to July 15 if the sound occurs within 65 yards of the species (USFWS 2003). Use of heavy equipment and motorized tools has the potential to affect northern spotted owls adversely in western Washington during this same timeframe if the sound occurs within 35 yards of the species (USFWS 2003).

Marbled murrelets are seabirds; however, nesting occurs in stands with the structural components typical of old-growth forests usually located within 50 miles of saltwater (Rodrick and Milner 1991). All of the WSDOT Olympic Region falls within the range of the marbled murrelet. The marbled murrelet nesting season takes place in Washington from April through August and juveniles begin to fledge in June (Hamer and Nelson 1995a). These murrelets nest on “platforms” in the upper canopy of large coniferous trees (i.e. large or forked limbs, dwarf mistletoe [Arceuthobium spp.] infections, witches’ brooms, deformities, etc.) (Hamer and Nelson 1995b). They may fly over 50 miles from nest sites to coastal waters to forage for fish and return to the nest once a day (one visit by both parents), usually during dawn or dusk, to

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deliver prey to the juvenile (Nelson and Hamer 1995). Due to this unique foraging strategy, any interruption during prey delivery could have severe consequences. Murrelets generally follow streams, roads, and other open areas on their flights to and from the nest (Nelson and Hamer 1995). Use of chainsaws, the sound of falling trees, and the sound of cutting downed wood have the potential to affect marbled murrelets adversely between April 1 and August 5 if the sound occurs within 45 yards of the species (USFWS 2003). Use of heavy equipment and motorized tools has the potential to affect marbled murrelets adversely during this same timeframe if the sound occurs within 35 yards of the species (USFWS 2003).

Species Group A also includes designated critical habitat for northern spotted owls and marbled murrelets. Northern spotted owls require habitat suitable for nesting, roosting, foraging, and dispersing (Federal Register 1992b). Currently, 20 critical habitat units for northern spotted owls have been designated in Olympic Region; 18 of them are adjacent to or are intersected by WSDOT highways that are maintained by Olympic Region maintenance personnel. Based on this information, approximately 36 miles of WSDOT highway is classified as sensitive due to the presence of critical habitat and potentially being within 0.25 miles of nesting northern spotted owls.

Marbled murrelet critical habitat includes only those primary constituent elements that provide suitable nesting habitat (Federal Register 1996). Currently 541 critical habitat units have been designated in Olympic Region; 18 of them are adjacent to or are intersected by WSDOT highways that are maintained by Olympic Region maintenance personnel. Based on this information, approximately 39 miles of WSDOT highway is classified as sensitive due to the presence of critical habitat and potentially being with 0.25 miles of nesting marbled murrelets.

Due to the increased home range of northern spotted owls and marbled murrelets outside of the nesting season and the decreased threat of disturbance and habitat impacts outside of the nesting season, we are only providing guidance for activities that occur within nesting areas during nesting seasons. We have established guidance for the various maintenance activities that could affect nesting northern spotted owls and marbled murrelets or destroy northern spotted owl or marbled murrelet nesting habitat. Guidance for sensitive zones for Species Group A includes avoiding noisy activities that occur for more than one hour and are between March 1 and September 30. Guidance is also provided for tree removal in sensitive areas, with maintenance personnel contacting the Regional Maintenance Environmental Coordinator prior to removing any trees great than 12 inches dbh.

**Species Group B**

Species Group B is designated for bald eagles (*Haliaeetus leucocephalus*). Bald eagles are terrestrial raptors that are generally associated with aquatic habitats for foraging purposes. The USFWS has determined that the decline of bald eagles was largely attributed to the widespread use of organochlorine insecticides, habitat loss, harassment and disturbance, shooting, electrocution from power lines, poisoning, and a decline in prey base (Federal Register 1978). The bald eagle is currently listed as a federally threatened species under ESA (Federal Register 1978) and Washington State threatened species (WAC 232-12-011). The bald eagle is also protected under the MBTA (50 CFR 10.13), and the Bald and Golden Eagle Protection Act (16 USC 668a-668c). Protection of nesting and wintering habitats are critical to the continued survival of the bald eagle (Federal Register 1999) and availability of suitable trees for nesting and perching is critical for maintaining bald eagle populations (USFWS 1986).

Biologists have characterized suitable bald eagle habitat as accessible foraging areas and trees that are large enough for nesting and roosting (Stalmaster 1987). Food availability, such as aggregations of waterfowl or salmon runs, is a primary factor attracting bald eagles to wintering areas and influences nest and territory distribution (Stalmaster 1987; Keister et al. 1987). Bald eagles generally nest in the same territories each year and often use the same nest repeatedly, although alternate nests in the territory may be used as well. Bald eagle nests in the Pacific Recovery Area are usually located in uneven-age stands of coniferous trees with old-growth forest components (USFWS 1986) that are located within 1 mile of large bodies of water (Stalmaster 1987). Factors such as relative tree height, diameter, tree species, form, position on the surrounding topography, distance from the water, and distance from disturbance influence nest-site selection. When foraging, bald eagles generally select perches in the tallest trees that provide an unobstructed view of the surrounding area.

Wintering bald eagles typically congregate in large aggregations where, most importantly, food is abundant. Suitable perch sites adjacent to foraging areas and winter-roost habitat are also necessary. In Washington, these criteria are typically met where waterfowl and salmon populations are present, as well as marine areas (Stinson et al. 2001). Communal night-roosting sites are traditionally used year after year and are usually the largest trees with the most open structure (Keister and Anthony 1983; Watson and Pierce 1998). These sites are often located in areas that provide a more favorable microclimate during inclement weather (Keister et al. 1985; Knight et al. 1983; Watson and Pierce 1998).

Human disturbance is a continuing threat to nesting and wintering bald eagles (USFWS 1986). Use of heavy equipment and motorized tools between January 1 and August 15 or October 31 and March 15 and within 0.25 miles (no line of sight) or 0.50 miles (line of sight) of bald eagle nesting or winter-roost sites is expected to result in an adverse effect (USFWS 2003). Bald eagles can occur in the Olympic Region throughout the year as both resident and wintering populations. Information obtained from the Washington Department of Fish and Wildlife (WDFW) indicates the presence of over 984 bald eagle nest sites distributed throughout Olympic Region, with 96 of the nest sites within 0.25 miles of a...
Western snowy plovers are coastal seabirds that breed on coastal beaches from southern Washington to southern California. Biologists have determined that the primary reason for the decline of the western snowy plover is due to loss of nesting habitat and disturbance of breeding western snowy plovers (i.e. crushing eggs) by humans and domestic animals (USFWS 2001a). Nesting season on the Washington coast occurs from early March through late September. Eggs are present from early March through the third week of July. Nest sites are generally flat, open areas with sandy or saline substrates. Vegetation and driftwood are present, but sparse. Nesting usually occurs within several hundred meters of water. To minimize disturbance to breeding and nesting western snowy plovers, the USFWS recommends preventing disruptive activities from occurring near nesting habitat and preventing off-road pedestrian or vehicular traffic through nesting habitat (USFWS 2001a). Therefore, we provided guidance for maintenance activities that may be disruptive to breeding and nesting western snowy plovers and activities that may impact western snowy plover habitat.

Most western snowy plovers remain in Washington State year round, while others migrate. In 1995, the breeding population in Olympic Region was restricted to one site, the Damon Point/Oyhut Wildlife Area at Ocean Shores (WDFW 1995); however, suitable habitat occurs at other coastal sites in Olympic Region. Recent estimates indicate the population at Damon Point and Oyhut Wildlife Area may have increased to up to nine nesting adults (Federal Register 2004). Due to the small population and documented concentrated use areas in Olympic Region, road projects are expected to have a very minor impact on this species.
Streaked horned lark are terrestrial songbirds that were once abundant in Puget Sound prairies and open coastal habitats (Stinson 2005). During nesting season, these larks are closely associated with spacious grasslands containing a significant amount of bare ground (i.e. bunchgrass-type habitat) but have adapted to nesting in grasslands at airports and on sandy coastal spits (Stinson 2005). Biologists have determined that the primary reason for the decline of streaked horned lark populations in Washington is due to the extensive destruction of native grasslands and disturbance during nesting season (Pearson and Hopey 2005).

Nesting season for the streaked horned lark is very long, typically beginning in early April with nest building and breeding displays, and seems to exhibit two peaks in clutch initiation, with the first peak from late April until early June and the second peak from late June to late July (Pearson and Hopey 2005). Biologists working towards the recovery of this species and others species associated with grassland and beach-dune habitat discourage the introduction of non-native plant species (i.e. European beachgrass [Ammophila arenaria]), off road vehicle operation, pedestrian presence, and land-management activities (i.e. mowing) while eggs are in nests (Pearson and Hopey 2005). In conjunction with these management recommendations, we provided guidance for maintenance activities that may be disruptive to nesting streaked horned larks or may impact nesting habitat. According to Pearson and Hopey (2005), management activities that benefit the western snowy plover will likely benefit the streaked horned lark. In Washington, suitable nesting habitat for western snowy plovers typically is occupied by nesting streaked horned larks. Therefore, the guidance we designed to minimize impacts to western snowy plovers will likely be protective of streaked horned larks.

The Oregon silverspot butterfly is a coastal subspecies of the widespread Zerene fritillary butterfly in montane western North America. Biologists believe that this subspecies is now extirpated from its historical range along the Washington coast (USFWS 2001b). The Oregon silverspot butterfly depends on a diverse wildflower habitat, including known caterpillar host plants and a variety of adult nectar plants and that are associated with fescue-dominated (Festuca spp.) montane grasslands, stabilized dunes, and marine salt-spray meadows (USFWS 2001b). Current efforts by WDFW and USFWS include conserving existing habitat, rehabilitating marginal habitat, and possibly reintroducing the species into its historical range along the Washington coast (USFWS 2001b). Management recommendations for the recovery of the Oregon silverspot butterfly include timely land-management activities (i.e. mowing) that foster growth of native species and prevent the spread of invasive plant species (USFWS 2001b).

The only known larval host plant for the Oregon silverspot butterfly is the early blue violet (Viola adunca). The early blue violet is a low-growing plant that needs open spaces or bare ground, which is common in fescue-dominated grasslands, dunes, and meadows. The adult Oregon silverspot has a late-summer flight period (July through September). Therefore, it depends on late-blooming nectar plants such as common California aster (Aster chilensis), western pearly everlasting (Anaphalis margaritacea), dune goldenrod (Solidago spathulata), yarrow (Achillea millefolium), and dune thistle (Cirsium edule).

The potential habitat for this species in the Olympic Region is limited to coastal areas along Grays Harbor County. We provided guidance for maintenance activities that may alter suitable Oregon silverspot habitat. Disturbance is not considered a limiting factor. Therefore, no guidance specific to limiting disturbances near Oregon silverspot butterflies is provided. Guidance includes avoiding clearing vegetation (grading, grubbing, filling) and applying herbicides outside of the vegetation-free zone (zone 1) of the WSDOT highway ROW along stretches adjacent to suitable habitat. Also, mowing is not recommended outside of zones 1 and 2 (zone 2 is the operational zone and is typically maintained for erosion, sight distance, vehicle recovery, and other purposes) of the WSDOT highway ROW during May and between July 1 and September 31 along highway segments with suitable habitat. Mowing is encouraged at these sites during the months of April, June, and after September.

Species Group D

Species in group D are located in glacial outwash prairies and alluvial valley meadows and include golden paintbrush (Castilleja levisecta), Kincaid’s lupine (Lupinus sulphureus kincaidii), Nelson’s checkermallow (Sidalcea nelsoniana), whulge checkerspot butterfly (Euphydryas editha taylori), mardon skipper butterfly (Polites mardon), Mazama pocket gopher (Thomomys mazama), and the streaked horned lark. Currently, golden paintbrush, Kincaid’s lupine, and Nelson’s checkermallow are all listed as federally threatened under ESA (Federal Register 1997, 2000, 1993b). The whulge checkerspot butterfly, mardon skipper butterfly, and Mazama pocket gopher are candidates to be listed as threatened or endangered under ESA (Federal Register 2005). The mardon skipper butterfly is also endangered under Washington State law (WAC 232-12-014).

Golden paintbrush, Kincaid’s lupine, and Nelson’s checkermallow are native wildflower species that are believed to have once flourished in the expansive native prairies of the Puget and Willamette Trough. Over time, the destruction of this habitat by development, the introduction of competitive non-native species, and the conversion of native grasslands for agricultural purposes has threatened the continued existence of these species (Caplow 2004, Federal Register 2000, USFWS 1998). Biologists involved with the recovery of these species recommend protecting remaining native grasslands, providing guidance for appropriate roadside-management techniques in areas with documented plants, and managing for invasive species (Caplow 2004, Federal Register 2000, USFWS 1998). Therefore, we provided guidance for maintenance activities that may directly impact golden paintbrush, Kincaid lupine, and Nelson’s checkermallow flowers or permanently alter their habitat.
The whulge checkerspot and mardon skipper butterflies require a diverse habitat with a wildflower population supportive of adult foraging and larval development (Fimbel 2004). Suitable habitat for these species also includes appropriate topography and sparse deciduous trees or forest “nooks” that create complex microclimates throughout the seasons (Fimbel 2004). This diverse and complex habitat is characteristic of native fescue-dominated grasslands of the Puget and Willamette Trough (Fimbel 2004).

Both of these butterflies have an early spring flight period, typically occurring from May through June. This timing is consistent with the bloom time of the early blue violet (Viola adunca), an important nectar plant for the adult mardon skipper and the bloom time of the common camas (Camassia quamash), desert parsley (Lomatium spp.), and broad-petal strawberry (Fragaria virginiana), known nectar plants for the adult whulge checkerspot. Also an important habitat component for these butterflies is the presence of summer food resources for pre-diapause larvae. Diapause for butterfly larva is a “sleep time” that begins before harsh winter conditions arrive and during which the larva does not grow. Fescue (Festuca spp.) is the primary larval host plant for the mardon skipper, while harsh paintbrush (Castilleja hispida) and English plantain (Plantago lanceolata) are important larval host plants for the whulge checkerspot. Protection of these native species and other species that make up native grasslands is critical for the recovery of these butterfly species (Fimbel 2004). Therefore, we provided guidance for maintenance activities that may alter mardon skipper or whulge checkerspot habitat.

The Mazama pocket gophers need open meadows, prairie, or grassland habitat with friable soils that are not too rocky (Stinson 2005). They are generally associated with glacial-outwash prairies in western Washington (Hartway and Steinberg 1997). Mazama pocket gopher habitat has been lost to development and succession to forest. What remains continues to be degraded by the invasion by Scotch broom (Cytisum scoparius) (Stinson 2005). These gophers do not usually occur where grassland has been taken over of dense Scotch broom (Steinberg 1996). Given these requirements, we provided guidance for maintenance activities that may permanently alter mazama pocket gopher habitat. Disturbance is not identified as a potential limiting factor. Therefore, no guidance that pertains to limiting disturbance was provided for Mazama pocket gophers.

The streaked horned lark was placed in species group C and D due to its overlap into both habitat types. Information on this species was provided in the previous species group. Management recommendations for the streaked horned lark coastal habitat represented in species group C also apply to its upland grassland habitat represented in this species group.

The guidance manual highlights sensitive areas where suitable habitat exists adjacent to the state route for Species Group D. Recommended guidance that may minimize impacts to habitat for Species Group D includes avoiding vegetation clearing (grading, grubbing, filling) and application of herbicides outside of zone 1 of the WSDOT highway ROW. Also, the guidance signals maintenance personnel to contact the Regional Maintenance Environmental Coordinator prior to mowing outside of roadside management zones 1 and 2 between March 15 and September 1.

Species Group E

Species in group E are those species that commonly nest on WSDOT bridges. Included in this group are American peregrine falcon (Falco peregrinus), osprey (Pandion haliaetus), and pelagic cormorant (Phalacrocorax pelagicus). American peregrine falcons have been delisted from protection under the ESA since 1999 (Federal Register 1999). However, they are still classified as an endangered species in Washington State (WAC 232-12-014) and are also protected by the MBTA (50 CFR 10.13). Osprey population declines have been noted (Levenson and Koplin 1984), but their population has not decreased to the point that they are endangered or threatened with becoming extinct. Regardless, they are protected under the MBTA (50 CFR 10.13) as are pelagic cormorants.

American peregrine falcons in Washington State may begin courtship displays at the nesting site as early as February (Hayes and Buchanan 2002). Eggs may be present at the nest site from April to June (Hayes and Buchanan 2002) and juveniles fledge by the end of July (Hayes and Buchanan 2002, Wilson et al. 2000). Like most falcons, peregrines do not build nests, instead, nesting pairs form a hollow, or a “scrape,” in loose rock or gravel (Hayes and Buchanan 2002). During the breeding period, these peregrines will protect their nest, eggs, and young from predators (including humans) at varying levels of intensity (Hayes and Buchanan 2002). Limited data suggests that peregrines have a tendency to return to the areas where they nested the previous year (Mearns and Newton 1984).

Established pairs of osprey also use the same nest year after year unless it is destroyed. If the nest is destroyed, the osprey pair usually rebuilds a new nest as close to the old site as possible (Westall 1986). Although constructed primarily of sticks, the osprey incorporates just about anything into its nest that is not tied down (Westall 1986). Osprey generally nest mid-May through June (Bent 1937 in Westall 1986), with juveniles fledging after eight weeks (Westall 1986), or by the end of September.

Pelagic cormorants are colonial-nesting seabirds and are year-round residents of some WSDOT bridges. They appear to be nesting on the underside of bridges as early as mid-March (Carey pers. comm. 2005). Nests are made from seaweed or other plant debris (Baicich and Harrison 1997). All juveniles fledge the occupied bridges by mid-October (Carey pers. comm. 2005).
Due to the susceptibility of American peregrine falcons, osprey, or pelagic cormorants to disturbances at nest sites, we provided guidance for highway-maintenance activities that may disturb nesting. A list of bridges with documented nests from these birds is provided in the guidance manual. We recommend avoiding noisy highway-maintenance activities (i.e. pavement grinding, jack hammering) during the nesting season. The sensitive seasons provided in the guidance manual for nesting American peregrine falcons, osprey, and pelagic cormorants are February 1 through July 15, April 1 through September 30, and March 15 through October 15, respectively.

The three bird species discussed above are the only identified species in Species Group E that may be impacted by common highway-maintenance activities. However, the Olympic Region Maintenance Program also conducts some bridge-structure maintenance and inspection activities that could, depending on the extent and location of the maintenance activity on the bridge, cause injury to other wildlife species nesting on bridges. In an effort to provide regional bridge-maintenance personnel with the ability to plan in advance and conduct work without injuring nesting wildlife species, we added a bridge appendix to this guidance manual. The appendix was written to be a stand-alone document and is provided only to regional bridge-maintenance personnel to minimize distribution of this sensitive information. This appendix identifies the species and the bridges where nesting is likely occurring. We included those species that WDFW and USFWS have asked WSDOT to protect. Maintenance personnel are signaled to inspect the bridge for nesting status prior to conducting the work. Inspecting the bridge first will prevent unnecessary implementation of BMPs if the species is not nesting. Species included in the appendix are American peregrine falcons, osprey, pelagic cormorants, golden eagles (Aquila chrysaetos), owls (Order Strigiformes), bats, (Order Chiroptera), swallows (Family Hirundinidae), American dippers (Cinclus mexicanus), and pigeon guillemots (Cepphus columba). Guidance includes inspecting the bridge for nesting status of the identified wildlife species and if the species is nesting, contacting the Regional Maintenance Environmental Coordinator prior to conducting work to determine the least-invasive means of conducting the activity.

Identifying Sensitive Areas

WSDOT Geographic Information System (GIS) and Biology staff queried Priority Habitat and Species (PHS) and other sensitive species databases to identify wildlife nest and roost sites, historical and current sensitive-plant locations, old growth, and critical habitat in the vicinity of WSDOT highway ROWs. State route sections that overlap with a 0.25-mile buffer around nest and roost sites were highlighted and mileposts identified for mapping purposes. Aerial photographs were used to identify possible prairie or open grassland areas that are adjacent to the state route. WSDOT Bridge and Structures staff assisted in the development of a list of WSDOT bridges with documented nesting/roosting wildlife based on bridge-inspection reports and personal communications.

WSDOT biologists conducted site visits to verify sensitive habitat presences. The habitat was delineated by a Global Positioning System (GPS) and data was converted into state route milepost sections by the GIS staff.

In the guidance document, WSDOT presents the location of sensitive areas (identified by state route and milepost) in map and table formats. Both formats are provided for each species group (assignment of species into groups is discussed above). Species information, such as species name and locations of nest sites, wintering sites, or sensitive habitats, are not identified in the guidance document. WSDOT developed this system to prevent publicizing or distributing PHS and other sensitive species data. Figure 2 provides an example of this system.
Figure 1. Example of the process used to determine sensitive zones of state routes. (a) PHS data overlaid with state routes. The figure shows the nest sites with a 0.25-mile buffer and its overlap with the state route. (b) Example from the guidance document. The guidance document only identifies the state route and mileposts that overlap with the buffer.

**Guidance implementation**

The guidance document is in the form of a field handbook presented in a step-by-step format to facilitate use by WSDOT maintenance personnel. The guidance document provides maps and descriptions of sensitive areas for each species group, identified by state route and milepost, as illustrated in figure 2. The first step for maintenance personnel is to determine if a maintenance activity will take place in one of these sensitive areas prior to conducting the work. If the activity will not occur within an identified sensitive area, the action may proceed without implication from this guidance. If the activity will occur within a section of state highway identified as sensitive, the reviewer identifies which species group(s) occur(s) in that highway section, then proceeds to Step 2.

Figure 2. Example of the sensitive areas for Species Group B in map format.
The second step for maintenance personnel is to determine if the proposed maintenance activity is applicable to the guidance. (No guidance was developed for those maintenance actions that pose no potential threat to sensitive species. Those actions were identified as “exempt”.) If a maintenance activity is not exempt, Best Management Practices (BMPs) will be assigned to the activity based on the species group(s) that are present, as illustrated in figure 3.

<table>
<thead>
<tr>
<th>Maintenance Activity</th>
<th>Species Group A</th>
<th>Species Group B</th>
<th>Species Group C</th>
<th>Species Group D</th>
<th>Species Group E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A-1</td>
<td>A-2</td>
<td>B-1</td>
<td>B-2</td>
<td>B-3</td>
</tr>
<tr>
<td>Group 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pavement grinding</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grader patching</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder re-grade</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(pulling shoulders)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Chip seal</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Jack hammering</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<td></td>
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<td>Group 2</td>
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</tr>
<tr>
<td>Maintenance Activity</td>
<td>Species Group A</td>
<td>Species Group B</td>
<td>Species Group C</td>
<td>Species Group D</td>
<td>Species Group E</td>
</tr>
<tr>
<td></td>
<td>A-1</td>
<td>A-2</td>
<td>B-1</td>
<td>B-2</td>
<td>B-3</td>
</tr>
<tr>
<td>Excavator/</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>backhoe operation</td>
<td></td>
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<tr>
<td>(over 1 hour duration)</td>
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<tr>
<td>Vactor truck</td>
<td>X</td>
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<tr>
<td>operation (over 1</td>
<td></td>
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<td>hour duration)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Jack hammering</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Vegetation clearing</td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>Group 3</td>
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<td></td>
</tr>
<tr>
<td>Maintenance Activity</td>
<td>Species Group A</td>
<td>Species Group B</td>
<td>Species Group C</td>
<td>Species Group D</td>
<td>Species Group E</td>
</tr>
<tr>
<td></td>
<td>A-1</td>
<td>A-2</td>
<td>B-1</td>
<td>B-2</td>
<td>B-3</td>
</tr>
<tr>
<td>Brush cutting</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Mowing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hazard tree</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>removal</td>
<td></td>
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<td></td>
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<tr>
<td>Chain saw use</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>Herbicide</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>application</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetation clearing</td>
<td>X</td>
<td></td>
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</tr>
</tbody>
</table>

Figure 3. BMPs for selected Olympic Region Maintenance Program activities. BMPs are defined in the guidance manual provided to Olympic Region Maintenance Program personnel and are based on management recommendations discussed in the “Species Groups” section of this paper.

BMPs are grouped based on management recommendations and guidance discussed in the previous section under individual species groups. A table (see figure 3) is provided in the guidance document to designate the appropriate BMP(s) that is recommended within a proposed work area. BMPs may include timing restrictions (i.e. during nesting season for birds, flight season for butterflies, or flowering season for wildflowers), equipment use restrictions (i.e. noisy equipment such as pavement grinding or jackhammering), or activities that should be avoided (i.e. vegetation clearing).
BMPs are guidance and are to be used as a planning tool. BMPs are not meant to stop projects from occurring. If a project cannot comply with the applicable BMPs, then maintenance personnel are signaled to contact their Regional Maintenance Environmental Coordinator to develop site-specific BMPs. Site-specific BMPs are designed to allow the project to continue while minimizing impacts to protected terrestrial species. Site-specific BMPs are developed cooperatively by maintenance personnel, the Regional Maintenance Environmental Coordinator, and a biologist.

The document cannot address all possible conditions that may arise during maintenance operations that could affect protected terrestrial species. Maintenance staff consult with their Regional Maintenance Environmental Coordinator prior to initiating any activity that is not addressed by the guidance document or if there is any uncertainty about the applicability of the guidance. The guidance documents are not applicable to emergency actions because separate procedures have been developed that address protected species compliance for emergency actions.

Due to the success implementing this new guidance document in the Olympic Region, maintenance staff reformatted the guidance handbook to facilitate data entry into the existing Personal Data Assistant system that documents statewide WSDOT environmental compliance. This BMP Field Guide has been printed and distributed to Olympic Region maintenance personnel and we are now beginning to work with other regions to implement the program in other areas of Washington State.

Biographical Sketches: Tracie M. O’Brien has been a wildlife biologist for WSDOT since January 2004. She has been involved in the creation and implementation of the WSDOT Highway Maintenance: Environmental Compliance for Protected Terrestrial Species project. She has been actively involved in creating site-specific BMPs for various maintenance projects. She will be leading the completion of this project statewide.

Bret Forrester, while working for David Evans and Associates, was a place-based biologist at WSDOT where he worked on a variety of tasks including Programmatic Biological Assessments and the initial draft of the WSDOT Highway Maintenance: Environmental Compliance for Protected Terrestrial Species. He has since moved on to work in the wildlife-management arena and is working for Tacoma Public Utilities.

Marion Carey is the fish and wildlife program manager for the Headquarters office of WSDOT. She is responsible for developing and implementing statewide policies like Programmatic Biological Assessments and the Highway Maintenance Manual for Terrestrial Species.

References
Federal Register. 2005. Review of Native Species that are Candidates or Proposed for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions. Proposed Rule. 70 (90): 24870-24934.


