**Title**

Wildlife hot spots along highways in Northwestern Oregon



**Authors**

Lloyd, John
Casey, Alexis
Trask, Melinda

**Publication Date**

2005-08-29

# Wildlife Hot Spots Along Highways in Northwestern Oregon

**John Lloyd** (Phone: 503-224-3445, Email: jlloyd@masonbruce.com), Biologist, and **Alexis Casey** (Phone: 503-224-3445), Biologist, Mason, Bruce & Girard, Inc., 707 SW Washington Street, Suite 1300, Portland, OR 97205, Fax: 503-224-6524

**Melinda Trask** (Phone: 503-731-4804, Email: melinda.trask@odot.state.or.us), Biologist, Oregon Department of Transportation, 123 NW Flanders, Portland, OR 97209, and

**Abstract:** Determining locations where wildlife movement and highway operation conflict is an essential first step in making highways safer for motorists and animals. Using an expert-opinion approach, we identified 86 conflict areas (hot spots) for wildlife along state-maintained roads in the Oregon Department of Transportation's Region 1. Of the 757 miles of highway analyzed, 22% were identified as wildlife hot spots by expert teams, suggesting that the scope of this problem is substantial. Most of these hot spots were locations with frequent deer-vehicle collisions, although some were crossing locations for deer and elk that did not have frequent animal-vehicle collisions. Some hot spots were identified for non-focal species, including northwestern pond turtle, western painted turtle, coyote, bobcat, black bear, and beaver. Hot spots generally were associated with topographic features that directed animals towards highways, the presence of habitat adjacent to highways, or food resources that attracted animals. Six hot spots were considered high priority. The expert-opinion approach employed for this analysis was effective in rapidly assessing many miles of state-maintained highway for the presence of wildlife hot spots and may prove useful in addressing conflicts between wildlife and highways in other locales or on a statewide basis. Not all of the hot spots warrant mitigation, although we suggest that the areas identified in this analysis be examined more carefully during development of projects that may affect wildlife passage.

## Introduction

Nearly all human communities in North America are connected via roads. The movement of goods and people allowed by this unprecedented connectivity is fundamental, both economically and socially, to our society. However, while connecting human communities, the modern road network has fragmented the natural environment, leaving animal populations isolated from one another and thus at greater risk of extinction from genetic (Keller and Largiader 2003) or demographic factors (Lande 1988). Animal-vehicle collisions are one of the primary causes of fragmentation, because dispersing individuals that attempt to cross roads suffer elevated rates of mortality due to collisions with motor vehicles (e.g., Lode 2000). Animal-vehicle collisions thus can affect population viability both directly through increased mortality rates and indirectly through the demographic and genetic effects of population fragmentation.

The human costs of animal-vehicle collisions are also substantial, especially when involving large animals such as deer (*Odocoileus* spp.) and elk (*Cervus elaphus*). For example, Conover et al. (1995) estimated that 1.5 million collisions between motor vehicles and deer occur annually in the United States, killing 211 people, resulting in 29,000 human injuries, and causing $1 billion in property damage annually. When insurance costs, lost productivity due to human injury, and value of the animal killed are accounted for, the annual economic cost of collisions between deer and motor vehicles likely exceeds $2 billion (Danielson and Hubbard 1998). As populations of deer in North America continue to swell, the number of collisions and associated costs will continue to rise. In the United States, white-tailed deer (for example) numbered approximately 500,000 in 1900 and climbed to over 20,000,000 in 1996 (Hughes et al. 1996).

Numerous methods exist for allowing safe passage of animals across highways, ranging from relatively inexpensive efforts to modify the behavior of motorists (e.g., warning signs) or animals (e.g., reflective lights, repellents, or intercept feeding) to expensive construction of new infrastructure (e.g., wildlife overpasses or underpasses). However, the success of these measures is strongly influenced by their placement (Clevenger and Waltho 2000, Gloyne and Clevenger 2001, Ng et al. 2004), and thus any effort to maintain safe passage for wildlife and reduce animal-vehicle collisions must first identify the location of problem areas, or hot spots. In addition, the high cost of many passage solutions requires that efforts be prioritized to produce maximum returns on any investment in mitigation. Developing a comprehensive and efficient strategy for addressing the environmental, economic, and social costs of animal-vehicle collisions therefore must be predicated on an understanding of where conflicts between wildlife and highway operation are most severe.

Here, we detail the application of a rapid-assessment process (Ruediger and Lloyd 2003) that can be used to identify potential hot spots quickly for wildlife along highways. Our study area was a portion of the state of Oregon that includes mountainous, agricultural, and highly urbanized landscapes. We chose the study area as a test case to determine the value of the rapid-assessment process for conducting statewide analyses of potential hot spots. Throughout Oregon, collisions between wildlife (especially deer and elk) and motor vehicles have been identified as a significant problem in Oregon (ODFW 2003a, b). However, efforts to address the problem are hampered by a lack of information, most notably the location of areas where wildlife-vehicle collisions are most frequent and wildlife passage most limited. To address this information gap, we conducted a study to identify and prioritize wildlife hot spots along state-maintained highways within Region 1 of the Oregon Department of Transportation (ODOT). We focused on mule deer (*O. hemionus hemionus*), black-tailed deer (*O. hemionus columbianus*), and elk (*Cervus elaphus*) because of public concern for these species and because they pose the greatest risk to motorists when involved in collisions with motor vehicles. We also collected ancillary data about additional species.

## Methods

Wildlife hot spots are generally identified using data on the distribution of animal-vehicle collisions (Malo et al. 2004), predictive models of wildlife habitat (Clevenger et al. 2002), or by expert opinion (Clevenger et al. 2002, Ruediger and Lloyd 2003). We chose to use an expert-opinion approach because the data necessary for empirical modeling of wildlife hot spots is lacking for our study area and because expert opinion is faster and generally produces results equivalent to those obtained via empirical modeling (Clevenger et al. 2002, Ruediger and Lloyd 2003).

The study area consisted of the state-managed highway system within northwest Oregon (ODOT Region 1, including the counties of Multnomah, Washington, Clackamas, Columbia, and Hood River, as well as portions of Clatsop County and Tillamook County), including state routes, U. S. highways, and interstate highways. Prior to assembling expert teams, we split the study area into eight subregions, based approximately on the boundaries of maintenance units. Expert teams, comprised of local ODOT maintenance workers, local and regional biologists, and others with knowledge of local conditions, were then established for each subregion. In establishing these teams, we attempted to ensure that each was composed of members with detailed, site-specific information about the location of animal-vehicle collisions (e.g., staff of ODOT Maintenance) as well as members with broader-scale perspectives about the movements and habitat requirements of the focal species (e.g., wildlife biologists from Oregon Department of Fish and Wildlife (ODFW) and the U. S. Forest Service (USFS).

Expert teams were provided with GIS-based, paper maps of the subregion that presented information on topography, land ownership, location of streams and other waters, location of parks and open space, location of highways, and highway mileposts. To help team members accurately identify potential hot spots, expert teams were also provided with interactive, computer-projected GIS maps that included all of the layers provided on the paper maps as well as high-resolution (2-feet pixels), color-infrared digital photography of the entire study area. When a potential hot spot was identified, the team member provided a rationale for identifying the area as a hot spot. The hot spot was only recorded if the expert team reached unanimous consensus.

To ensure accurate representation of hot spots, each was mapped directly into a GIS database once the expert team had reached consensus. This allowed all team members to verify that the location was accurately described. Each hot spot was assigned a record number based on subregion and sequential identification number (e.g., the first hot spot identified in Subregion 8 was identified as 08-01). The following information was collected about each hot spot identified:

1. Basis for nomination.
2. Description of location, including highway mile markers and distinguishing topographic features.
3. Presence of any existing features that facilitate or encourage animal movement across the road.
4. Other species that may use this area as a road crossing.
5. Future threats to the value of the area as a wildlife crossing.
6. Priority to ODOT.

The priority of each hot spot was based on the judgment of the expert team. In general, expert teams considered areas with an unusually high frequency of animal-vehicle collisions, documented or suspected crossings by sensitive or rare species, or deer and elk migratory routes. Medium-priority hot spots generally had lower rates of animal-vehicle collisions than high-priority hot spots or, in several cases, had no documented animal-vehicle collisions but were used frequently as a crossing location for wildlife. Low-priority hot spots typically had only scattered reports of animal use. We visited all of the hot spots identified as high priority by the expert teams, all of the hot spots used as road crossings by rare or sensitive species, and a randomly selected subset of the medium-priority hot spots to document site conditions, establish a photographic record of site conditions, and verify the information received.

## Results

### Overall

The total length of highways considered in this analysis was 757 miles (Table 1). Of the total highway miles considered, 170 miles, or 22%, were identified as wildlife hot spots. The expert teams identified 86 hot spots in Region 1. Most of these (44) were identified based on frequent deer-vehicle collisions. Elk crossings (10) and areas where both frequent elk crossings and frequent deer-vehicle collisions occurred (15) were also commonly noted by expert teams. Elk-vehicle collisions were not identified as a problem at any hot spot, and only one area was identified as a deer crossing without frequent deer-vehicle collisions. The remaining 17 hot spots identified included 15 areas noted for frequent collisions between motor vehicles and non-focal species (for example, coyote (*Canis latrans*), beaver (*Castor canadensis*), and northwestern pond turtle (*Emys marmorata marmorata*), two areas without frequent animal-vehicle collisions that were used as crossings by non-focal species, and one area with existing underpasses (cattle crossings) that might be used by wildlife.

The size of hot spots varied considerably. Most were greater than one mile long. The mean length of a hot spot was 2.3 miles (Table 1). However, the mean length was biased upwards by the inclusion of several extraordinarily long hot spots (e.g., a 15.5-miles long hot spot along I-84 in Subregion 5). The average median length of hot spots in each subregion was 1.7 miles. Median hot-spot length tended to be greater in the eastern portion of the study area, including the foothills of the Cascade Range (Subregions 7 and 8), Mount Hood and the Hood River drainage (Subregion 6), and the Columbia River Gorge (Subregion 5).

The number of hot spots identified in each subregion did not correspond with the total length of state-maintained highway in each subregion. Western subregions, especially those in the Coast Range (Subregions 1 and 2), had more hot spots identified than did eastern subregions (Subregions 6-8). Rural subregions tended to have longer hot spots and a greater percentage of highway miles in hot spots. For example, the two most urbanized subregions, Portland-Sylvan and Portland-Flanders, had only 10% and 16% of highway miles in hot spots, with an average length of 1.3 miles and 1.9 miles, respectively. In contrast, hot spots in the more rural Clatskanie, Cascade Locks, and Government Camp subregions accounted for more than 30% of total highway miles, and the average length of hot spots was greater (averaging 3 miles). Suburban subregions, such as Sandy and Estacada, were intermediate both in the percentage of highway miles in hotspots and the average length of hot spots.

Table 1. Summary statistics for wildlife hot spots identified along state-maintained highways in Region 1 of the Oregon Department of Transportation

| Subregion name (Subregion number) | Total miles of highway analyzed | Percentage of miles in hot spots[1] | Number of hot spots identified | Average length of hot spots (miles) | Median length of hot spots (miles) | Range of hot-spot lengths (miles) |
|---|---|---|---|---|---|---|
| **Clatskanie (1)** | 91 | 36 | 18 | 1.8 | 0.75 | 0.2 – 11 |
| **Manning (2)** | 98 | 16 | 17 | 0.9 | 0.9 | 0.4 – 1.4 |
| **Portland-Sylvan (3)** | 161 | 10 | 12 | 1.3 | 1 | 0.3 – 1.3 |
| **Portland-Flanders (4)** | 142 | 16 | 11 | 1.9 | 1.5 | 0.5 – 6 |
| **Cascade Locks (5)** | 74 | 39 | 7 | 4 | 2.5 | 1 – 15.5 |
| **Government Camp (6)** | 82 | 33 | 9 | 3.1 | 3 | 0.3 – 7 |
| **Sandy (7)** | 38 | 29 | 4 | 2.5 | 2.1 | 1 – 5 |
| **Estacada (8)** | 72 | 23 | 8 | 2.6 | 1.6 | 0.1 – 7 |
| **Total** | 757 | 22 | 86 | 2.3 | 1.7 | 0.1-15.5 |

[1] Calculated as total length of highway/total length of hot spots.

**Subregional summary**

Of the 86 hot spots identified by the expert teams, six were considered high priority. Three high-priority hot spots occurred in the Portland-Sylvan subregion (Subregion 3), which includes the western side of the greater Portland metropolitan area. Two of these were segments of State Highway 217 in which amphibians, small mammals, and birds are frequently killed while attempting to cross the highway; the third was on U. S. Highway 26 and was noted for collisions between motor vehicles and deer, waterfowl, and raptors. A high-priority hot spot was identified on State Highway 213, near Milk Creek in the northern Willamette Valley (Subregion 4), based on the frequency of collisions between deer and motor vehicles. In the Cascade Locks subregion (Subregion 5), a high-priority hot spot for several species, including deer, elk, beaver, and several reptiles and amphibians, was identified along Interstate 84 in the Columbia River Gorge. Roadkilled animals are common in this hot spot, which is associated with an extensive wetland complex near Multnomah Falls. The sixth high-priority hot spot was located on State Highway 35 (Government Camp, Subregion 6) where the highway bisects an important migration corridor for deer and elk.

Many of the hot spots in the coastal mountains (Subregions 1 and 2) included moderately long stretches of highway, reflecting the fairly continuous forest cover adjacent to the highways in these subregions. Many hot spots in Subregions 1 and 2 appeared to be connected with ephemeral features of the landscape, such as aging clearcuts that provide foraging opportunities for deer and elk, although the expert teams also identified several hot spots that were influenced by topographic features. No high-priority hot spots were identified in these subregions. Indeed, the most significant hot spots in the coastal mountains of northwest Oregon appear to lie outside the western boundaries of the study area on the west slope of the Coast Range, where larger elk populations exist (D. Nuzum, ODFW, pers. comm.).

The two urban subregions (subregions 3 and 4) contained slightly lower proportions of hot spots than the more rural or mountainous subregions (all others) and also had hot spots that were significantly shorter in length than other subregions (Table 1). Many of the hot spots identified in Subregions 3 and 4 were associated with wetland features and were identified based on the frequency of collisions between motor vehicles and some combination of deer, small mammals, and waterfowl. Hot spots for deer were also associated with areas of remnant open space or other suitable, disturbed environments, such as golf courses and plant nurseries. Elk hot spots were uncommon in these subregions, mainly due to the lack of large blocks of suitable habitat.

Two high-priority hot spots occurred in the City of Beaverton, one of which was located near an area of open space along State Highway 217 (Site 03-04 and 03-05). Both sites are flanked by wetlands and pockets of natural habitat in an otherwise developed area. Good habitat, including wetlands and a golf course adjacent to the highway, exists for migratory birds and small mammals. However, the area immediately adjacent to the highway in both sites is heavily developed. Beaver, nutria (*Myocastor coypus*), raccoon (*Procyon lotor*), and birds are frequently killed in collisions with motor vehicles. The jersey barrier that runs through this section likely represents a significant barrier to most species that attempt to cross and may increase the risk of collision for animals that attempt to cross over the roadway.

Not all hot spots were associated with animal-vehicle collisions. For example, a hot spot was identified near a wetland complex because northwestern pond turtles and western painted turtles (*Chrysemys pictus*), both listed as Sensitive-Critical by ODFW, are thought to cross in this section. The site is located adjacent to the Burlington Bottoms Wildlife Area, just northwest of Portland (Site 03-08). It was ranked as a medium-priority site because the expert team had no information on whether roadkill was occurring at this hot spot. However, no culverts exist to allow animals to cross beneath the roadway, and thus any movement across the highway requires crossing four lanes of traffic. In addition, railroad tracks lie parallel and adjacent to the roadway on both sides, although several small culverts and a bridge allow passage beneath the railroad tracks. Collisions between ducks and motor vehicles are known to occur at this hot spot.

One hot spot in the northern Cascade Mountains, in the Government Camp Subregion (Site 06-07), was singled out by the expert teams as the most important in the study because it encompasses a section of road that crosses an area used during migration by deer and elk. Although expert teams were asked only to prioritize hot spots within their respective subregion, expert team members who contributed to multiple subregions agreed that this hot spot was the most significant in Region 1. The highway in this hot spot, which is three miles long, is curvy and clear zones are limited, resulting in frequent deer-vehicle collisions. Although this hot spot includes a significant elk-migration route, elk-vehicle collisions are rare at present. The only mitigation measure employed within this hot spot is a deer-crossing sign near the turnoff to Cooper Spur Ski Area. The functionality of this hot spot may be threatened by the proposed expansion of Cooper Spur Ski Area, which would significantly increase traffic through this hot spot.

## Discussion

### Region 1 wildlife hot spots

Collisions between animals and motor vehicles are a significant problem in Oregon. Of the 757 highway miles analyzed in this study, approximately 22% were included in hot spots identified by the expert teams. The extent of these conflict areas suggests that allowing wildlife to move safely across Oregon's highways will yield substantial economic and environmental benefits. In particular, reducing the risk of collisions between motor vehicles and animals will mean fewer human injuries and fatalities, less money spent on vehicle repair and insurance costs, and reduced mortality in wildlife populations.

In addition, allowing safe passage for wildlife will also ensure that animals have access to all necessary habitats and resources and that connectivity among different populations is maintained. The necessary first step towards this goal is to identify those areas where conflicts between wildlife movement and highway operation are most severe. The results of the analysis presented here provide this information for Region 1 of ODOT.

Although deer-vehicle collisions were the basis of most of the identified hot spots, expert team members also identified crossing areas used by deer and elk in which collisions are not an issue, as well as hot spots used by a variety of other species, including black bear (*Ursus americanus*), bobcat (*Felis rufus*), river otter (*Lutra canadensis*), beaver, small mammals, birds, red-legged frogs (*Rana aurora aurora*), northwestern pond turtles, and western painted turtles. Hot spots generally resulted from one of three factors: topography that directed animals towards the road, suitable habitat in close proximity to the road, or food resources that attracted animals. Understanding the nature of hot spots is important, as it will influence the likelihood that animals continue to use the area in a similar fashion in future years. For example, hot spots resulting from topography or hot spots that include historical migration routes are likely to remain hot spots indefinitely.

In contrast, hot spots for deer that exist due to attractive foraging opportunities created by timber harvest may receive less use as the forest ages and food availability declines. Hot spots that are associated with ephemeral resources are unlikely to remain stable through time, and thus may be a relatively low priority when considering mitigation. Considering how forest practices may influence animal movement is especially important in the western parts of Region 1, where much of the land adjacent to state-maintained highways is subject to timber harvest.

The frequency, size, and extent of hot spots varied among subregions. Variation in the length and extent of hot spots likely reflects differences in the amount and configuration of habitat available in each subregion. In the urban subregions, the amount of available habitat is low and tends to be highly fragmented, and animals are concentrated into remaining islands of habitat. Hot spots generally occurred wherever roads bisected remnant habitat patches, thus producing the observed pattern of many short, distinctive hot spots in the urban subregions. With more available habitat and fewer artificial edges to focus movement, animals in the rural subregions may be less likely to encounter the highway at discrete locations, leading to longer hot spots that account for a greater percentage of total highway miles.

Regional differences in the size and frequency of hot spots may also be related to corresponding variation in the behavior and life history of the focal species. For example, black-tailed deer and elk from the Coast Range and the west slope of the Cascade Range either do not migrate at all or undertake much shorter seasonal migrations than mule deer and elk from the east side of the Cascade Range, where deep snow accumulations and cold temperatures often drive significant seasonal migrations (Verts and Carraway 1998). When roads intersect traditional migration routes, which tend to follow well-defined and narrow corridors, short and discrete hot spots with frequent animal-vehicle collisions are likely to result.

In contrast, west of the Cascade Range hot spots probably reflect the proximity of habitat to roads and the local population density of the focal species. In these areas, the animal-vehicle collisions that help define hot spots may reflect the movement of individual animals within a home range, rather than large-scale migratory movements, and the resultant hot spots may be longer and less pronounced. This may be especially true in areas where roads bisect large blocks of habitat that support locally dense populations of the focal species.

Differences among subregions may also be due to the differences in the perceptions of members of expert teams. For example, maintenance crews in some subregions maintain written records of the location of many animal-vehicle collisions, allowing crews to provide more precise information about potential hot spots. In contrast, in subregions where maintenance crews did not record data on animal-vehicle collisions, expert team members were forced to rely on recollection and, in many cases, to approximate the location of hot spots. Thus, hot spots may appear to be longer in certain subregions simply because written records of animal-vehicle locations were not available.

In addition, because we did not establish strict criteria for identifying hot spots and instead relied on the best judgment of the expert teams, some variation may occur among subregions because perceptions of what constitutes a hot spot varied among expert team members. We attempted to minimize this bias by giving examples of what conditions might constitute a hot spot (e.g., unusually high rate of animal-vehicle collisions or frequent observations of animals crossing), but ultimately the opinion of the assembled experts dictated the identification of hot spots.

**Efficacy of the approach**

Despite the necessarily subjective nature of expert-opinion approaches, the approach outlined here proved a useful template for broader application throughout the state. Because the expert-opinion approach to identifying hot spots relies on existing information, it is far less expensive and time consuming than conducting field studies of animal movement. Few transportation projects operate on sufficiently long timelines to allow the multiple years of data collection and analysis necessary to achieve robust results. Habitat modeling can be used to predict hot spots along highways (e.g., Clevenger et al. 2002), but in most cases the detailed data necessary to build predictive models are lacking, as was the case for this study. For example, the landscape-level information available to predict the distribution of the focal species would have ruled out the presence of hot spots within the Portland metropolitan area, as urban areas are considered non-habitat. However, Portland does support urban-dwelling wildlife, including black-tailed deer, and animal-vehicle collisions are an important local issue.

The expert-opinion approach is also valuable because it draws on the vast, yet largely untapped, pool of local knowledge regarding wildlife and their movements. Although relying on local experts introduces an element of subjectivity, local ecological knowledge is used widely to address resource management issues, especially in remote and undeveloped areas where baseline empirical information is lacking (e.g., Mallory et al. 2003). The study area for this analysis is neither remote nor undeveloped, but baseline information on the location of wildlife hot spots is generally unavailable, both within the study area and throughout the state. Because this approach defines the scope and extent of the conflict between wildlife movement and highway operation, it may be especially useful as a first step in developing a comprehensive strategy for addressing wildlife movement along highways statewide.

One drawback of this approach is that it is difficult to apply to smaller species (such as amphibians and reptiles) that may experience high rates of roadkill but that are rarely observed by maintenance staff or other highway users. More detailed follow-up studies, including field surveys and habitat modeling, may be useful in refining information about the use of hot spots by these species. In addition, because the expert-opinion approach relies largely on observations of roadkilled animals, it does not identify sections of highway in which animals are prevented from crossing but in which animal-vehicle collisions are rare. This may be especially problematic when considering species that exhibit road-avoidance behaviors, including elk (Lyon 1979).

## Recommendations for Future Study

The hot spots identified in this analysis should not be considered a definitive list of areas where wildlife crossings are a concern, nor are the results appropriate as the basis for mitigation planning. Rather, the results presented here should help to focus future research and provide guidance during the scoping and planning phases of transportation projects. Research should be directed at the hot spots identified as high priority by the expert teams to better quantify existing conditions at each location. Collecting additional data on animal-vehicle collisions and conducting surveys to determine which species are using these hot spots, and with what frequency, will help in determining whether any mitigation efforts are needed, and if so, what form mitigation should take.

Although the priority hot spots should be the focus of additional work, all of the hot spots identified in this analysis should be considered during project development. Early scoping during project development has been identified as the most effective way to address wildlife hot spots. To facilitate this, the hot spots identified in this study will be added to the other environmental-data sources that are evaluated during project scoping for Region 1. Early identification of these potential conflict areas within a project site may allow the opportunity to budget for further evaluation of hot spots. Although specific mitigation measures will not be known until further analyses have been conducted, costs can be estimated for conceptual-mitigation strategies based on basic project and site information, such as type of hot spot, animals involved, adjacent land use (existing and foreseen future), and type of proposed project (pavement preservation vs. bridge rehabilitation, for example). In addition to project development and construction budgets, other avenues of funding further research and construction of mitigation measures are available, including Federal Highway Administration (FHWA) enhancement grants, wildlife agency grants, or possibly safety or maintenance funds.

Possible mitigation strategies include structural approaches, such as adding fencing or building dedicated wildlife overpasses or underpasses (reviewed in Evink 2002). For those hot spots associated with bridges, mitigation opportunities might include relatively minor modifications to the existing structure, such as adding a bench for wildlife passage on the fill slopes beneath the bridge. Changes to the management of roadside vegetation may also be useful, especially because many of the hot spots identified in this study appear to be related to the presence of food and cover adjacent to the road. Eliminating habitat features that attract deer and elk to the roadside has proven effective in other areas (Rea 2003). Intercept feeding, in which attractive food sources are created that draw animals away from the road, may also help to reduce the frequency of collisions at hot spots (Wood and Wolfe 1988). In general, reflectors, repellents, and warning signs are of little value in reducing animal-vehicle collisions, especially on high-volume highways (Romin and Dalton 1992, Reeve and Anderson 1993, Gordon et al. 2004).

Finally, developing a standardized system for recording and collecting data on the location and nature of animal-vehicle collisions would prove invaluable in addressing wildlife passage problems on major highways. Roadkill or animal-injury records are important data for the development of empirical models that could be used to refine the results of expert-opinion analyses. Currently, the decision to collect data about the location of animal-vehicle collisions and the species involved is left at the discretion of each ODOT maintenance district. The degree to which collision data are collected varies greatly. In some cases, no data are collected at all. Although expert opinion is useful in conducting rapid assessments for potential hot spots, it cannot be used to quantify the severity of a problem in any particular hot spot (e.g., the frequency of animal-vehicle collisions), and thus cannot be used as baseline information for evaluating the effects of mitigation. Implementing a standardized, agency-wide system for collecting data on animal-vehicle collisions will be useful in justifying any investments made in mitigation. Expert opinion is a useful tool for rapidly assessing a highway system, but empirical data, if properly collected, are more reliable and also allow for fully parameterized cost-benefit analyses.

**Biographical Sketches:** John Lloyd is a biologist with Mason, Bruce & Girard, Inc. He received a Ph.D. in wildlife biology from the University of Montana in 2003, after which he worked as a post-doctoral associate on the USDA Forest Service Highway 93 Wildlife and Fish Habitat Linkage Analysis project. In addition to road ecology, John has expertise in avian ecology, statistics and experimental design, and wildlife-habitat relationships.

Melinda Trask is a biologist in Region 1 of Oregon Department of Transportation and has been with ODOT for over 5 years. Her undergraduate degree was in environmental biology with an emphasis in wildlife ecology from California Polytechnic State University. Ms. Trask has a master of science degree from Oregon State University in rangeland resources and a master of science degree from Washington State University in environmental planning. Her main duty at ODOT is to help the agency maintain compliance with federal and state endangered-species acts. In addition to preparing biological assessments and conducting monitoring on a variety of projects, Ms. Trask coordinates and manages peregrine falcons for many ODOT bridges and has developed a region-wide system for tracking wildlife roadkill.

Alexis Casey is a biologist with Mason, Bruce & Girard, Inc. She has a bachelor of science degree in resource management with an emphasis in forest resources from the University of California Berkeley (2002). In addition to her work on wildlife crossings in Oregon, she has experience with forest management and rare plant studies in California, Oregon, and Washington. She is currently working on a variety of projects to assess the anticipated impacts of development activities on ESA-listed wildlife, fish, and plant species.

## References

Clevenger, A. P. and N. Waltho. 2000. Factors influencing the effectiveness of wildlife underpasses in Banff National Park, Alberta. *Conservation Biology* 14: 47-56.

Clevenger, A.P., J. Wierzchowski, B. Chruszcz, and K. Gunson. 2002. GIS-generated, expert-based models for identifying wildlife habitat linkages and planning mitigation passages. *Conservation Biology* 16: 503-514.

Conover, M. R., W. C. Pitt, K. K. Kessler, T. J. Dubow, and W. A. Sanborn. 1995. Review of human injuries, illnesses, and economic losses caused by wildlife in the United States. *Wildlife Society Bulletin* 23: 407-414.

Danielson, B.J. and M.W. Hubbard. 1998. *A Literature Review for Assessing the Status of Current Methods of Reducing Deer-Vehicle Collisions. A report prepared for The Task Force on Animal Collisions.* Iowa Department of Transportation and Iowa Department of Natural Resources. 25 pp.

Evink, G. L. 2002. Interactions between roadways and wildlife ecology. *NCHRP Synthesis 305*. Transportation Research Board, Washington, D.C.

Gordon, K. M., M. C. McKinstry, and S. H. Anderson. 2004. Motorist response to a deer-sensing warning system. *Wildlife Society Bulletin* 32: 565-573.

Gloyne, C. C. and A. P. Clevenger. 2001. Cougar *Puma concolor* use of wildlife crossing structures on the Trans-Canada highway in Banff National Park, Alberta. *Wildlife Biology* 7: 117-124.

Hughes, W.E, A.R. Saremi, and J.F. Paniati. 1996. Vehicle-animal crashes: an increasing safety problem. *Institute of Transportation Engineers Journal* 66: 24-28.

Johnson, D. H. and T. A. O'Neil. 2001. *Wildlife-habitat relationships in Oregon and Washington*. Oregon State University Press, Corvallis, Oregon.

Keller, I., and C. R. Largiader. 2003. Recent habitat fragmentation caused by major roads leads to reduction of gene flow and loss of genetic variability in ground beetles. Proceedings of the Royal Society of London Series B 270:417-423.

Lande, R. 1988. Genetics and demography in biological conservation. *Science* 241: 1455-1460.

Lode, T. 2000. Effect of a motorway on mortality and isolation of wildlife populations. *Ambio* 29: 163-166.

Lyon, L. J. 1979. Habitat effectiveness for elk as influenced by roads and cover. *Journal of Forestry* 77: 658-660.

Mallory, M. L., H. G. Gilchrist, A. J. Fontaine, and J. A. Akearok. 2003. Local ecological knowledge of ivory gull declines in Arctic Canada. *Arctic* 56: 293-298.

Malo, J. E., F. Suarex, and A. Diez. 2004. Can we mitigate animal-vehicle accidents using predictive models? *Journal of Applied Ecology* 41: 701-710.

Ng, S. J., J. W. Dole, R. M. Sauvajot, S. P. D. Riley, and T. J. Valone. 2004. Use of highway undercrossings by wildlife in southern California. *Biological Conservation* 115: 499-507.

Oregon Department of Fish and Wildlife (ODFW). 2003a. *Oregon's mule deer management plan*. Oregon Department of Fish and Wildlife, Portland, Oregon.

Oregon Department of Fish and Wildlife. 2003b. *Oregon's elk management plan*. Oregon Department of Fish and Wildlife, Portland, Oregon.

Rea, R. V. 2003. Modifying roadside vegetation management practices to reduce vehicular collisions with moose *Alces alces. Wildlife Biology* 9: 81–91.

Reeve, A. F. and S. H. Anderson. 1993. Ineffectiveness of Swareflex reflectors at reducing deer-vehicle collisions. *Wildlife Society Bulletin* 21: 127-132.

Romin, L. A. and L. B. Dalton. 1992. Lack of response by mule deer to wildlife warning whistles. *Wildlife Society Bulletin* 20: 382-384.

Ruediger, W. and J. D. Lloyd. 2003. A rapid assessment process for determining potential wildlife, fish, and plant habitat linkages for highways. 205-225. C.L. Irwin, P. Garrett, K. P. McDermott, editors. *2003 Proceedings of the International Conference on Ecology and Transportation*. Center for Transportation and the Environment, North Carolina State University, Raleigh, North Carolina.

Verts, B. and L. Carraway. 1998. *Land mammals of Oregon*. University of California Press, Berkeley, California.

Wood, P. and M. L. Wolfe. 1988. Intercept feeding as a means of reducing deer-vehicle collisions. *Wildlife Society Bulletin* 16: 376-380.