Title

Preliminary analysis of locations where wildlife crosses highways in the Southern Rocky Mountains

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PRELIMINARY ANALYSIS OF LOCATIONS WHERE WILDLIFE CROSSES HIGHWAYS IN THE SOUTHERN ROCKY MOUNTAINS

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Abstract: Highway/wildlife conflicts are becoming an acknowledged topic of concern for both conservation and transportation planners. Interest in relieving both direct mortality due to animal/vehicle collisions and road-caused habitat fragmentation is growing.However, solving these problems requires detailed information about characteristics of highway segments where wildlife focus their crossing activity. Most studies investigating crossing activity focus on underpass use, often along fenced highways. Therefore, a study investigating free-choice at-grade crossing using tracks to indicate crossing behavior was conducted. Locations where wildlife crossed a 12-mile stretch of highway were recorded for 18 months. Habitat variables associated with heavily used crossing locations and with random locations were then measured and compared. Preliminary results indicate that distinct crossing zones exist, varying in size and intensity of use, and that landscape scale habitat suitability and topographic form, as well as local features including roadcuts and roadside vegetation, play a role in determining where animals cross roads. These results suggest that to be biologically and cost effective, mitigation to reduce conflicts should be designed to accommodate the patterns of crossing activity that habitat features create. Additional analyses of these data provide further information about habitat as a basis for locating and designing mitigation and are anticipated to be available from the author in the near future.

Introduction

Background

Negative impacts of highways on wildlife were recognized almost as soon as the first highways were built, and researchers since that time have documented a wide variety of detrimental effects, as summarized by Trombulak and Frissell (2000). However, highway/wildlife interactions are just now becoming a widely acknowledged topic of concern for conservation and transportation planners (Forman 1998, Hourdequin 2000). In particular, there is a growing interest in relieving both direct mortality due to animal/vehicle collisions and road-caused habitat fragmentation (Ruediger 1998, Defenders 2001, FHWA 2000). For both these problems, detailed information about the characteristics of highway segments where wildlife focus crossing activity is required to design biologically as well as cost-effective solutions. Although a number of studies investigating animal use of underpasses to cross roads (e.g., Hunt et al. 1987, Yanes et al. 1995, Clevenger and Waltho 2000) as well as locations of animal/vehicle collisions (e.g., Allen and McCullough 1976, Romin and Bissonette 1996, Hubbard et al. 2000) have been conducted, studies detailing characteristics of locations where wildlife cross roads at-grade are uncommon (Singleton 2000). Therefore, the following study was conducted to determine if characteristics of at-grade highway crossing locations used by wildlife differ from random locations.

Overview of Study Design

The study focused on the relationship of the surrounding habitat to at-grade crossing locations. Additionally, comparisons between species passing over or under the highway via culverts were made. Two study areas, one on US 24 at Trout Creek Pass and one on I-70 at Vail Pass, were selected in the Southern Rocky Mountains of Colorado, USA. Study area selection criteria included the following: reasonable proximity to Denver, CO, the researcher's home base; the presence of a suitable roadside tracking medium year-round; and adjacent public land, to reduce potentially confounding effects of human disturbance associated with homes and businesses. Because data collection is currently ongoing at the Vail Pass site, only results from the Trout Creek site are reported below.

Determining if crossing locations differ from random locations is a two-step process. First, areas where animals focus crossing activity must be identified. Then, if such areas are identified, they must be compared to random points to determine if their characteristics differ. Features which may vary between crossing locations and random locations could either facilitate or impede travel and include the presence/absence of secure travel cover, food and water, level of topographic complexity, presence/absence of linear features (fences, streams, ridgelines, vegetation patches) that act to guide movement, and level of human activity.

Methods

Study Area

The US 24 study area was located in Chaffee County, CO, and extended from milepost (mp) 216, approximately two miles east of Johnson Village, to mp 226, approximately one mile east of Trout Creek Pass (figure 1).

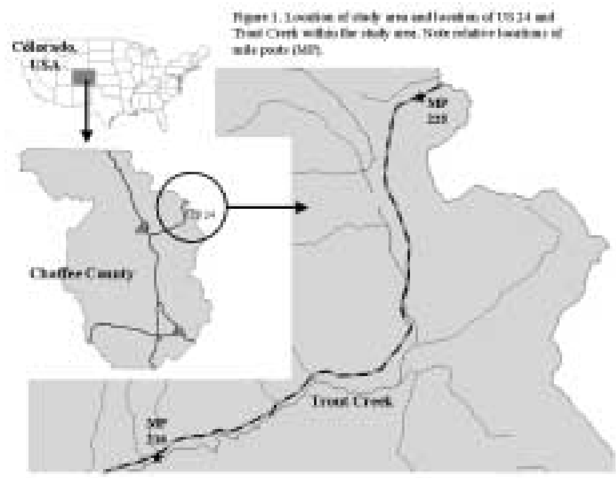

Fig. 1. Location of study area and location of US 24 and Trout Creek within study area.

US 24 is a two-lane road throughout the study area, except for the east side of Trout Creek Pass where a climbing lane creates a short section with three lanes. Lanes are 3.7 m wide, and shoulders are unpaved. Although US 24 is classified as an east-west highway, it runs predominately north-south from mp 221-226, the north end of the study area. The terrain in this part of the study area is rolling, and vegetation consists of open grasslands west of the US 24 and mixed coniferous forests to the east. The terrain in the south end of the study area is rugged and highly dissected by dry washes and rocky outcrops, and the vegetation consists of coniferous stands intermixed with aspen, deciduous shrubs and small, open meadows. Additionally, a well-developed shrubby riparian zone associated with Trout Creek, which parallels the road in highway in this section of the study area, is present. Elevations in the study area range from 2830 m at Trout Creek Pass to 2420 m at MP 216.

Data Collection

Track Data

The locations where medium- and large-sized mammals (mule deer, elk, coyotes, bobcat, mountain lion) crossed the highway, as indicated by their tracks, were recorded throughout the study area. These data were collected on 130 occasions from January 2000 through June 2001. Data were collected twice weekly, September through June, weather permitting. Data were collected only once a week during the summer months because very few tracks were found during this period. Data were collected along 11 randomly chosen 200 m transects and existing roadside substrates (fine-grained dirt, sand, or snow) used as a tracking medium. At each transect, the researcher walked along both sides of the highway at the pavement's edge and looked for tracks left in the unpaved shoulder. Track locations were recorded using a hand-held GPS devise\data logger that automatically recorded location while the researcher entered information through a menu-driven interface. All tracks of the same species observed within a 5-meter stretch were recorded as a single track record (TR). Each TR contains the following information: species of animal, number of animals, location (UTM coordinates), activity (cross, approach, parallel, undefined) and date. Activity was interpreted form the pattern of tracks. Data files from the data logger were downloaded into standard spreadsheet and ArcView shape file formats for analysis. Transect locations were randomly chosen and varied with each field session.

Structure Monitoring

Trackbeds were placed at both ends of 8 over-sized concrete box culverts and one single-span bridge located within the study area. On additional single span bridge just outside of the study area (mp 215) was also checked. These structures will be generically referred to as “structures” for the remainder of the paper. All structures spanned dry washes that only carried water during storm events. Trackbeds were made from locally available sand and dirt. Due to time constraints only two structures were randomly chosen and checked during each data collection session. Trackbeds and the roadside within 100 m of either side of the structure were checked for tracks to record if animals crossing at that location had crossed at-grade or used the structure. Animals were recorded as passing through a structure only when a matched set of tracks were observed at both ends. Additionally, the trackbeds, but not the adjacent roadside in the structures located in the drainages at mp 215.0 and 216.48 and in the Shields and Magee drainages, were checked as often as time permitted. These four large drainages were checked often because it was assumed they were most likely to be used, and it was useful to record the full variety of animals willing to cross under an unfenced road.

Choosing Locations For Analysis

Maps of TR locations revealed that TR tended to be clustered, creating distinct zones with many TR, few TR, or no TR. This pattern indicated that animals do focus activity along certain portions of the roadside, making comparisons between focal crossing locations to random points possible. Twenty random locations were identified using an ArcView script that placed points randomly along a line. Locations where animals focused crossing activity were identified by creating density maps of TR/m^2, using ArcView’s Spatial Analyst “calculate density” function. TR density for each 10 m x 10 m cell located along the roadside was calculated based on a 20 m search radius for all TR and for crossing TR only. Locations with a greater than average density of crossing TR then were designated as crossing zones (CRZ). The activity centers of CRZ were identified visually and designated as crossing hotspots (CHS), and these locations were used for all subsequent comparisons to random points.

Average TR/m^2 was estimated by dividing number of TR by the total area contained within a 20 m buffer of the study area highway centerline. The 20 m buffer corresponded to the 20 m search radius specified in Spatial Analyst’s density calculation. Because tracks are located at the edge of the road, rather then the center, this approach under estimated the total area searched for TR by Spatial Analyst, consequently resulting in an inflated estimate of the average number of TR/m^2. The result of using this higher average as a cut-off value is that only the highest density TR areas are considered for analysis below.

Local Scale Habitat Measurements

All random points and CHS were located in the field using their UTM coordinates. Local scale habitat measurements were then made on both sides of the highway, at both the pavement’s edge and 20 m from the pavement edge, for a total of four sets of measurements at each point. Additionally, the line-of-site and distance to cover measurements were made from the perspective of a medium-sized animal (e.g., coyote bobcat, mountain lion) as well as from the perspective of a large-sized animal (deer or elk). These two “animal’s eye views” of the habitat were simulated by placing a laser rangefinder on a monopod sized to elevate the eyepiece 0.8 or 1.6 m above the ground. Line-of-site distances and distances to cover, as observed through the rangefinder, were then recorded at both monopod heights. All variables measured are listed in Table 1. Additionally, the locations of all drainages and roadside barriers (cliff faces, guard rail, double fences) were recorded in the field using the GPS device. After conversion into ArcView data layers, these data were used to measure the distance of random points and CHS to roadside barriers in the lab, rather then in the field.

Table 1
Variables Measured in the Field for Comparison of Crossing Hotspots (CHS) to Random Points

	Variable Measured	Abbreviation	Notes
At Roadside			
	Line-of-Site (m) along roadway at 1.6 m, 0.8 m*	LOSAR	Two LOSAR measurements were taken at each point, one in either direction
	Distance (m) to nearest woody vegetation at 1.6 m, 0.8m*,♣	DVRS	Measurements were taken along eight equidistant radii emanating from the center of the point being measured, at both heights.
20 m From Roadside	Line-of-sight to roadway at 1.6 m and 0.8 m*,♠	LOSTR	View to road from point being measured, categorized as 0 = completely obstructed, 1 = partially obstructed, 2 = unobstructed.
	Distance to nearest woody vegetation at 1.6 m, 0.8m*,♣	DV20	Eight measurements were taken along eight equidistant radii emanating from the center of the point, at both heights.
	Minimum and maximum slope between roadside and 20 m from road side	MAXSL, MINSL	Measured in degrees

* These measurements were taken at both 0.8 m above the pavement surface and 1.6 m above the pavement surface.

♣ No values were recorded for radii that intersected rock, dirt, or woody vegetation greater then 70 m away from the point.

♠ Three observations were taken at each point, one looking straight to the road, and then two more, looking to the road 45° either side from the line of the first observation. The two side views were averaged.

Landscape Scale Habitat Measurements

Landscape scale habitat measurements were made in the lab, and considered habitat characteristics within a one-kilometer buffer of the study area centerline. Cover types, variety of cover types, and heterogeneity of cover types were evaluated using a digital vegetation coverage with a 25 m x 25 m pixel resolution. Produced by the Bureau of Land Management, this vegetation coverage is available for some watersheds in Colorado and is extensively ground truthed. Topographic form and variability were evaluated from the cover type data and the USGS 7.5 minute quadrangles that encompassed the area. Because cover-type is closely linked to elevation and exposure in semi-arid Colorado, areas with heterogeneous cover types were assumed to represent heterogeneous topographies. The orientation of major, linear topographic features (e.g., large drainages, ridgelines), which could act to guide animal movements, was evaluated from the quadrangles, as was variation in elevation.

Results

Descriptive Summary of Tracks

A total of 535 TR, representing 832 animals were recorded, and are summarized by species and activity in table 2. Mule deer were the most commonly recorded species (77 percent of all TR) and a nearly equal number of crossing and non-crossing (257 versus 278) TR were recorded. Only 7.1 percent of these TR were recorded from snowy surfaces. Although snow is a superior medium for tracking, this study area did not lend itself to snow tracking, as the snow usually melted rapidly after falling, leaving only a small window of opportunity for animals to make tracks and the researcher to record them. Additionally, the splash zone from passing vehicles and snowplows was wide and tended to obscure tracks left on the highway shoulder.

Table 2
Summary of TR by Species and Travel

TR designated as "Not Crossing" include those TR where the roadside pattern of tracks indicated that the animal approached but then doubled back, traveled parallel to the road, or left a track set that did not allow its behavior to be adequately interpreted (undefined). "Crossing" tracks either left matching tracks on both sides of the road or tracks on one side of the road that clearly approached the road and did not leave evidence of turning around or traveling parallel to the road.

Travel	**Crossing** (percent of each species crossing)	**Not Crossing** (percent of each species not crossing)	**Total** **(percent of all TR by species)**
Species			
Mule Deer	219 (53%)	194 (47 %)	413 (77.2 %)
Elk	40 (71%)	16 (29 %)	56 (10.5 %)
Coyote	10 (29%)	26 (71 %)	36 (6.7 %)
Lagomorpha spp.	7 (70%)	3 (30 %)	10 (1.9%)
Fox	1 (25%)	3 (75 %)	4 (0.7 %)
Mountain Lion	1 (100%)	-	1 (0.2%)
Bobcat	-	1 (100 %)	1(0.2%)
Other	2 (40%)	3 (60 %)	5 (0.9 %)
Unknown	-	7 (100 %)	7 (1.3 %)
Total	**278**	**257**	**535**

Descriptive Summary of Activity Zones, Crossing Zones, and Crossing Hotspots

Although TR was located throughout the study area, maps of all TR and only crossing TR revealed that both animal activity and crossing behavior was not evenly distributed. Only 25 percent of total TR and 11 percent of crossing TR were located north of Trout Creek. The low density of tracks and their diffuse pattern in this portion of the study area combined to yield only one distinct activity zone. Activity zones were defined as those areas that had at least an average number of TR/m^2. South of Trout Creek the distribution of total TR created both distinct and ill-defined activity zones. Short, isolated, but well-defined activity zones ranged between 25 and 50 m in length and were separated by areas with very few TR, which ranged in length from 200 to 900 m. Longer activity zones were created by clusters of higher density TR locations separated by much shorter (<150 m) low density TR zones. These longer activity zones ranged between 150 m and 900 m in length.

Eleven CRZ, defined as areas where high-density crossing locations were separated by less then 150 m, were identified and were all located in the south end of the study area. High density crossing locations were defined as those areas that had a greater then average number of crossing TR/m^2. Because a point location was required for comparative measurements, the center of the location were activity was greatest within each CRZ was designated as a crossing hotspot (CHS). Fourteen CHS were identified and these locations were compared to the 20 random points.

Comparison of Crossing Hotspots and Random Points

Local Scale

At the roadside, line-of-sight along the road (LOSAR) did not vary significantly between CHS and random points although they were somewhat longer at random points for both medium- and large-sized animals (table 3). Distance to woody vegetation (DVRS) that could act as cover was significantly shorter for CHS then random points for both sizes of animals (table 3). Additionally, for large animals, 37 percent of the observations taken at CHS encountered vegetation, while only 21 percent of those taken at random points did. For medium animals, 39 percent of observations taken at CHS and 30 percent taken at random points encountered vegetation.

Table 3
Comparison of Habitat Variables Measured at the Roadside for CHS and Random Points

A two-tailed t-test for equality of means was used to compare the two types of location and the significance level was set at $\alpha = 0.05$.

Variable	Average Value at CHS (m)	Average Value at Random Points (m)	α Value
LOSRS1.6	290	293	0.891
LOSRS.8	265	289	0.835
DVRS1.6	23	36	0.000
DVRS.8	22	28	0.015

Twenty meters from the roadside, the line-of-sight to the road (LOSTR) was significantly more obstructed at CHS then at random points for both sizes of animals (table 4). Distance to woody vegetation (DV20) that could act as cover was shorter for CHS than random points for both sizes of animals, but significantly so for medium-sized animals only (table 4). For large animals, 67 percent of the observations taken at CHS and 53 percent of those taken at random points encountered vegetation. For medium animals, 80 percent of observations taken at CHS encountered vegetation while only 40 percent taken at random points did.

Table 4
Comparison of Habitat Variables Measured at 20 mm from the Road for CHS and Random Points

A two-tailed t-test for equality of means was used to compare the two types of location and the significance level was set at $\alpha = 0.05$.

Variable	Average at CHS	Average Value at Random Points	α Value
LOSTR, 1.6 Straight to road	0.86	1.08	0.325
LOSTR, 1.6 Side view	0.39	0.86	0.013
LOSTR, 0.8 Straight to road	0.71	0.92	0.361
LOSTR, 0.8 Side view	0.23	0.77	0.004
DV20, 1.6	15	13	0.351
DV20, 0.8	10	20	0.000

The relationship of CHS to roadside barriers (roadcuts, guardrails) was also different from that of random points. A modified Monte Carlo simulation (n = 25) of 14 random points locations was conducted on the portion of the study area where the CHS were located. Results indicated that, on average, 47 percent of random points were located behind a barrier (range = 14 to 71 percent). None of the CHS was located behind a barrier, although, on average, they were within 13.5 m of the edge of a barrier.

Landscape Scale

Because all CHS as well as 75 percent of total TR were located in the southern part of the study area, landscape scale comparisons were made between parts of the study area, rather than on a CHS/random point basis. The location where Trout Creek passes under US 24 was used to divide the study area into two portions, the north end and the south end. The vegetative and topographic characteristics of the two ends are both quantitatively and qualitatively different within a one-kilometer buffer of the highway centerline. Vegetation is more heterogeneous in the south end. Thirty-one different cover-types, arranged in 3,417 variably shaped and sized patches, are found in the south end, while there are only 26 cover-types, arranged in 2,011 patches in the north end. Additionally, the largest north-end vegetation patches are larger then the largest south-end patches but have significantly shorter perimeters. This reflects the relatively unbroken nature of the large patches in the north end and the highly interdigitated nature of the large patches in the southern end.

As indicated by the cover type, topography of the south end is more variable in aspect and slope than the north end. On the north end, the landscape within one kilometer to the west of the highway is characterized by even, gentle slopes and a predominately eastern aspect; east of the highway the slopes are steep but even and maintain an almost unbroken westerly aspect. By comparison, although the landscape in the south end also slopes steeply and has a single predominant aspect (northwestern) east of the highway, the landscape west of the highway slopes unevenly and is variable in aspect. Only two major and 14 minor drainages bisect the highway on the north end, while the south end is bisected by six major drainages and 81 minor drainages. In general, all the major linear landscape features which could act as guide ways for animal movement, including breaks in cover type, drainages, and ridgelines, run parallel to the highway in the north end of the study area, but are either parallel or perpendicular to the highway in the south end.

Structure Use

The characteristics of the structures monitored for use and details of their use are summarized in table 5. Multiple track sets from the same species were often observed in the trackbeds, but it was not possible to determine if this represented one animal passing through multiple times or multiple animals passing through once. However, track sets from two or more species were relatively common. Notable crossings events include a beaver dragging branches through the Magee structure on four occasions, and deer beginning to use the concrete-bottomed structure at mp 216.48 in late November 2000, then continuing to use it consistently throughout the remainder of the study.

Table 5
Characteristics of Culverts Monitored for Use in the Study Area

Includes the number of times the structure was checked for tracks, and the number of times it was used by at least one medium- or large-sized animal to cross through. Small mammals and rabbits used all structures more often than the large animals but are not reported in these totals.

Location	Type*	Height (m)	Chamber Width/Total Width (m)	Length (m)	No. Times Checked**	No. Through Passes (%)	No. Of Endruns (%)
215.00	Single Span Bridge	14.00	24	11.50	49	45 (91%)	-
216.15	3 Chamber	3.00	3.40/10.20	14.00	23	11 (48%)	11 (48%)
216.48	3 Chamber	3.05	3.05/9.15	18.25	21/85	23 (27%)	15(71%)
216.85	2 Chamber	3.40	2.48/4.96	32.70	16	8 (50%)	12 (75%)
217.1	1 Chamber	2.50	2.50	27.50	19	1(5%)	5 (26%)
218.05	1 Chamber	2.50	2.50	22.10	17	5 (29%)	8 (47%)
Shields	3 Chamber	2.90	3.10/9.30	21.30	27/105	28 (27%)	8 (30 %)
Magee	3 Chamber	3.00	3.10/9.30	21.30	29/105	31 (29%)	18 (34%)
221.98	3 Chamber	2.40	3.10/9.30	14.60	29	4 (14%)	7 (24%)
222.60	Single Span Bridge	3.10	7.34	11.10	34	1 (3%)	6 (18%)

* Single span bridges have natural floors; all others have concrete floors.
**For 216.48, Shields, and Magee the first number in this column is the number of times the road surrounding the culvert was checked for evidence of end-running. The second number is the total number of time the trackbeds were checked for tracks. The at-grade roadside at 215.00 was never checked for end-runs.

Predators, including mountain lion, bobcat, coyote, and fox, were recorded passing though structures far more frequently than they were recorded crossing at-grade. While this result is probably due, in part, to the superior care the tracking medium in the structures received, it suggests predators do not avoid, and may even prefer these structures when crossing roads. Conversely, elk were not recorded using any structure, and deer used only two structures (at mp 215.0 and mp 216.48). These low levels of use and records of end-running indicate ungulates do avoid crossing under the road. For all species, both the characteristics of a structure itself and the surrounding habitat appeared to play a role in the level of use it received. The single span bridge at mp 215 had a natural floor and was very open and received the most consistent levels of use, including large numbers of deer as well as some bobcats and coyotes. However, although big structures were generally used more than smaller ones, size did not guarantee use (table 5). The single span bridge and the three-chamber culvert located in the north end of the study area received no or very low rates of use.

Discussion

Habitat Characteristics, Crossing Hotspots, and Structure Use

Landscape-scale habitat variables played a role in determining where and how often animals approached the roadside and subsequently crossed the road. At the north end, animals were both less likely to approach the roadside and less likely to cross either at-grade or through structures. Habitat characteristics that might have dissuaded animals from approaching the road in this part of the study area include the extensive, flat, grassland cover type west of US 24 that lacked hiding cover and exposed animals to disturbance from the road. This cover type was also unsuitable habitat for mule deer, the animal most commonly recorded at the roadside in the study area. In contrast, the habitat was highly suitable for mule deer on both sides of the road in the south end of the study area, and open cover type areas adjacent to the road were topographically complex, limiting the amount of road-caused disturbance they received.

In addition to habitat suitability, the dominant, linear landscape-scale habitat features varied between the ends of the study area. In the north end, there were no linear features to act as guideways to the road's edge. Breaks in cover types, the Trout Creek drainage, and the ridgeline east of US 24, ran parallel to the road. The drainages located at mp 221.89 and 222.60, the largest linear features bisecting the highway in the north end, became relatively indistinct about 100 m from either side of the road. In the south end, multiple features that could lead an animal to the road were present. Although linear habitat features running parallel to the road included Trout Creek and a major ridgeline to the southeast, many smaller ridgelines and drainages bisected the road. Additionally, cover type patches did not create a predominant pattern that an animal traversing the landscape might conveniently follow.

After landscape scale features act to bring animals to the roadside, local scale features immediately adjacent to the road help to focus the location and intensity of crossing. All CHS identified were associated with locations where linear features bisected the road. Additionally, although CHS locations were not necessarily located in dense cover, vegetation that could provide cover was in close proximity to all CHS, as compared to random points. The combined effect of landscape- and local-scale habitat features focusing crossing activity is also reflected in the use of structures. Structures in the south end of the study area tend to be located along distinct, yet gently sloping drainages that extend one kilometer or more away from the roadside. Animals following these features are naturally led to structures, and some individuals appear to freely use these structures upon encountering them.

Implications for Reducing Wildlife/Highway Conflicts

Mitigation to reduce the impacts of highways on wildlife should take into account the "natural" CRZ created by habitat surrounding roads to be both biologically and cost effective. In areas where the topography and vegetation create relatively focused CRZ, underpasses and overpasses, with or without limited fencing, would be appropriate. Additionally, the road itself could be designed to increase its barrier effect and help direct animals to crossing passageways. However, in locations where landscape- and local-scale features result in diffuse, low intensity CRZ, substantial amounts of fencing might be required to lead animals to underpasses, and rates of use may, nevertheless, remain low. If mitigation is warranted in such areas, alternatives to underpasses may be a more sensible approach. Depending on the number of animals involved, as well as the rarity and biology of the species in question, realigning the road to take advantage of natural crossing focal points, raising or burying the road to provide longer potential crossing areas, or managing the habitat to provide better resources on one side of the road, thereby lowering the impetus to cross, may give better results for the money spent.

Additional analysis of these data, as well as comparison to the results from Vail Pass should provide further insight into designing mitigation to complement habitat-mediated crossing patterns. The potential to use habitat indicators to assist in identifying highway sections that are likely to conflict with wildlife movements will also be explored.

Biographical Sketch: Sarah A. Barnum graduated with an undergraduate degree in wildlife biology from the University of Vermont in 1988. After conducting research on nest site selection by the American Coot in the marshes of the Great Salt Lake, she received a master's degree in wildlife biology from Utah State University in 1994. After moving to Denver, she spent the next five years doing environmental impact assessments with a focus on T&E issues, first for a private consulting firm, then as an employee of the Colorado Department of Transportation. Ms. Barnum enrolled in UCD's Urban and Regional Planning Ph.D. program in 1999 and is conducting wildlife/highway interaction research, and anticipates graduating in the spring of 2002.

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