Title
Habitat connectivity study of the I-25 and US 85 corridors, Colorado

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Abstract: A growing economy and an influx of people to Colorado have fueled rapid growth and development along the Colorado Front Range, particularly in Douglas County. These factors contributed to transportation capacity and safety problems in the U.S. Highway 85 (US 85) and South Interstate 25 (I-25) Corridors. An Environmental Impact Statement (EIS) evaluated highway alternatives for a 16-mile section of US 85 and a 17-mile section of South I-25 between Colorado Highway 470 and Castle Rock, Colorado. As part of the EIS, the Colorado Department of Transportation and Federal Highway Administration provided initial funding for this study. The initial goal of this study was to identify wildlife species that cross the South I-25 and US 85 Corridors. Additional study objectives included an analysis of how (i.e., at- or below-grade) and where (i.e., habitat connectivity zones) these species crossed the US 85 Corridor. Through a Smart Growth grant, Douglas County's Division of Open Space and Natural Resources expanded this study to include a landscape linkage assessment of lands along the US 85 Corridor. The Study Area and surrounding landscape occur within the Chatfield Basin at the western edge of the Great Plains – Palouse Dry Steppe ecoregions. A mosaic of native habitats including grasslands, shrublands, woodlands, wetlands, and riparian areas in the Chatfield Basin provide for a diversity of wildlife species. Over 74,000 acres of parks, wildlife areas, open space, and other conservation areas in the Study Area have been preserved by Douglas County and state and federal agencies including, Chatfield and Roxborough State Parks, Woodhouse State Wildlife Area, Lambert Ranch, Plum Creek Riparian Corridor, National Forest System Lands; Highlands Ranch Open Space Conservation Area, Cherokee Ranch, and Daniels Park. Soot plate track stations, snow tracking, and landscape evaluation were conducted by this study. The South I-25 Corridor presents a more formidable barrier to wildlife movement than US 85. Three linkage zones of potential east-west habitat connectivity were identified for US 85 and none were identified for I-25. Properties within the three US 85 linkage zones were evaluated and conservation recommendations were identified for Douglas County Division of Open Space and Natural Resources. Deer and elk were recorded crossing highway corridors only at-grade. Movement patterns of many wildlife species appeared to correlate with drainages, topography, and habitat. Below-grade structures were used by large and small carnivores, rodents, and other wildlife taxonomic groups to cross the highway corridors. Predators, such as coyotes and foxes, tended to cross US 85 at-grade, while medium-sized mammals (badgers, raccoons, skunks, and weasels) tended to cross US 85 through below-grade structures. Feline predators, especially bobcats, were shown to use culverts for passing underneath US 85. Despite the barriers of I-25, coyotes, raccoons, cottontail rabbits, and woodrats use below-grade structures to cross the South I-25 corridor. Discussions with private landowners within the three linkage areas along the US 85 corridor, have identified an additional 2,100 acres for conservation. Negotiations with private landowners are ongoing.

Introduction
A growing economy and an influx of people to Colorado have fueled rapid growth and development along the Colorado Front Range, particularly in Douglas County. These factors contributed to transportation capacity and safety problems in the U.S. Highway 85 (US 85) and South Interstate 25 (I-25) Corridors. An Environmental Impact Statement (EIS) evaluated highway alternatives for a 16-mile section of US 85 and a 17-mile section of South I-25 between Colorado Highway 470 (C-470) and Castle Rock, Colorado. As part of the EIS, the Colorado Department of Transportation and Federal Highway Administration (FHWA) provided initial funding for this study. Through a Smart Growth grant, Douglas County's Division of Open Space and Natural Resources expanded this study to include a landscape linkage assessment of lands along the US 85 Corridor.

Study Objectives
The objectives of this study included gathering data and formulating conclusions and recommendations on the following aspects of the South I-25/US 85 corridors:
1. Identify which mammal species cross below- and at-grade in the study corridors
2. Identify and evaluate the landscape position and components of human disturbance, conservation areas, animal movement, and high quality wildlife habitat to identify linkage zones in the Chatfield Basin
3. Evaluate wildlife use patterns for culverts of differing sizes, shapes, and lengths
Study Limitations
Limitations of time and money and the need to address specific anthropogenic effects or impacts typically require investigators to carefully prescribe study boundaries and the intensity of data collection. This study was tailored to accomplish the study objectives, and conducted with the following four limitations:

1. The duration of the study was limited to one six-month period, mid-fall to mid-spring of 1999 – 2000 and late winter to early spring 2001. This time frame captured the seasonal increase in animal activity characteristic of winter to spring; however, it did not include the dispersal period for many mammals, which occurs in late summer through fall. The study was oriented toward assessing movement of large animals across US 85 and South I-25, and did not record movement of some mammals, such as bats, and other vertebrates, including reptiles and amphibians.

2. Weather also limited the ability to use snow tracking to collect at-grade wildlife movement data. The 1999, 2000, and 2001 winters in Douglas County were very mild and the lack of adequate snowfall limited the availability to use snow-tracking. The mild weather may have also limited animal movements such as the traditional down slope movement of elk during the winter months.

3. Another limitation of the study is that the use of small culverts by wildlife was not examined. Most of the study’s effort focused on underpass structures with 6-by 6-foot openings. This introduces a potential sampling bias against small organisms.

4. The study is a snapshot in time, an initial characterization of animals crossing these two highways, but not the complete picture in terms of seasonal variability and the use of small culverts.

Study Area Descriptions
The general study area is located in Douglas County, Colorado, and includes a 17-mile section of South I-25 and a 16-mile section of US 85 between C-470 to the north and Milepost 178 on I-25 south of Castle Rock, Colorado. The study area for soot plate tracking includes one tracking station (Station Number 4) under South I-25 at Milepost 188 south of the Castle Pines Interchange and five tracking stations (Numbers 1, 2, 3, 5-East, and 5-West) under US 85 between Titan Road and Daniels Park Road (figure 1).

The South I-25 corridor is a semi-rural, open landscape of gently rolling hills bounded on the north by C-470 and the Denver Metropolitan area and on the south by the town of Castle Rock. I-25 is a six-lane, median-divided limited access highway being considered for widening to eight lanes between C-470 and Meadows/Founders Parkway north of Castle Rock.

The US 85 corridor is relatively rural and open, but is abutted on the north by C-470 and the Denver metropolitan area (the planned community of Highlands Ranch) and on the south by the town of Castle Rock. The Burlington Northern Santa Fe Railroad and the Union Pacific Railroad operate along the west side of US 85 for the entire length of the US 85 Corridor. Within the study area, US 85 is a semi-rural two-lane highway being considered for widening to four lanes (six lanes north of Titan Road or Highlands Ranch North Parkway).

The study area and surrounding landscape occur within the western edge of the Great Plains – Palouse Dry Steppe eco-regions. Native habitats include grasslands, shrublands, woodlands, wetlands, and riparian areas.

Habitats within the study area landscape are fragmented by the two highway corridors and other roads, railroad corridors, industrial, commercial, and residential development, and associated human disturbance or activities such as fencing. The cumulative impact of this habitat fragmentation is a patchy landscape, where wildlife dispersal is made more difficult, where invasion by non-native species is significant, and where some degree of biodiversity has likely been lost over time. Somewhat countering the negative influence of major habitat fragmentation is the proximity of a number of large conservation areas, parks, and open space. The course of US 85 is roughly paralleled by the riparian corridor of Chatfield State Park to the north of the study area; Woodhouse State Wildlife Area (SWA), Lambert Ranch, Roxborough State Park, National Forest, Highlands Ranch Open Space Conservation Area (OSCA), Cherokee Ranch, Daniels Park, and the Plum Creek/East Plum Creek.
Methods
Three methods were employed in this study to collect data:

1. Using soot plate track stations at selected below-grade structures in both corridors
2. Snow tracking along selected US 85 Right-of-Way (ROW) highway segments
3. Landscape assessment and habitat evaluation along the US 85 corridor

Soot Plate Tracking
Sooted track plates were used to establish tracking stations in four large culverts and under one bridge within a 5.5-mile stretch of US 85 and in one large culvert under South I-25 (table 1).
Table 1
Tracking Station Descriptions, US 85 and I-25, Douglas County, Colorado

<table>
<thead>
<tr>
<th>Station Number (Milepost)</th>
<th>Structure</th>
<th>Site Description</th>
<th>Dimensions</th>
<th>Openness Effect Index*</th>
<th>Potential Inhibiting Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 US 85 (195.15)</td>
<td>Bridge</td>
<td>Bar and liquor store on west side of US 85</td>
<td>9' high (H), 16' wide (W), 32' long (L)</td>
<td>4.50</td>
<td>Noise, lighting, human activity, and fencing</td>
</tr>
<tr>
<td>2 US 85 (192.0)</td>
<td>Multi-directional stone culvert</td>
<td>Undeveloped both sides of US 85</td>
<td>West side = 8'H, 12'W, 320'L East side = 9'H, 12'W, 320'L</td>
<td>West = 0.30 East = 0.34</td>
<td>Long and confining passage, riprap at west entrance; openness, and fencing</td>
</tr>
<tr>
<td>3 US 85 (189.65)</td>
<td>Concrete box culvert</td>
<td>House and dogs on west side of US 85</td>
<td>8'H, 8'W, 54'L</td>
<td>1.19</td>
<td>Dogs, human activity, concrete substrate, woody plant debris at west entrance; and openness</td>
</tr>
<tr>
<td>4 I-25 (188.0)</td>
<td>Concrete box culvert</td>
<td>Undeveloped both sides of I-25</td>
<td>7'H, 6'W, 188'L</td>
<td>0.22</td>
<td>Concrete substrate, culvert structural barrier, and openness</td>
</tr>
<tr>
<td>5-East US 85 (192.4)</td>
<td>Concrete box culvert</td>
<td>• Under US 85 • Developed east side of US 85 • Horse pasture on west side</td>
<td>6'H, 6'W, 85'L</td>
<td>0.42</td>
<td>Fencing and openness</td>
</tr>
<tr>
<td>5-West US 85 (192.4)</td>
<td>Concrete box culvert</td>
<td>• Under adjacent DC Road 18 • Horse pasture on east side • Undeveloped on west side</td>
<td>6'H, 6'W, 90'L</td>
<td>0.40</td>
<td>Fencing and openness</td>
</tr>
</tbody>
</table>

*Openness effect index is calculated as height (at opening) x width (at opening) / total length.

Soot plate tracking stations were positioned on the floor in the middle of each culvert length and animals detected on the track plates were assumed to cross the entire length of the structure. At each wildlife tracking station, two adjacent 14-inch-wide aluminum tracking plates were placed across the entire width of each underpass floor. The tracking plates were secured with metal screws to 0.25-inch thick plywood to produce a flat, stable surface and were then covered with soot using an acetylene torch. Once the soot plates were placed flush in the native substrate, the approach to each tracking plate was smoothed with a push broom for 5 feet in each direction.

Snow Tracking
For the second method, at-grade animal tracks were recorded opportunistically along the US 85 right-of-way two days following each snowfall during the 1999-2000 and 2000-2001 winters. Species location and direction of movement for observed tracks were recorded. Late-season tracking was accomplished in a similar manner; however, the warmer temperatures necessitated a track interpretation one-day after fresh snowfall.

Landscape Assessment And Habitat Evaluation
Individual parcels of land along the US 85 corridor were evaluated through a geographic information system (GIS) spatial analysis and through site inspections. The goal was to identify linkage zones across (east/west) and up and down (north/south) the study area. The initial step in the landscape assessment process involved developing maps showing land ownership, as well as important development, habitat, and physiographic features. Using these maps, and once permission for access was obtained, a multidisciplinary team evaluated habitat quality and quantity in the study area. Particular note was made of special topography features, human elements in the landscape, community ecology, and the potential for viable wildlife movement corridors over or beneath significant manmade barriers such as US 85. Field observations were recorded on specially developed Wildlife Habitat - Parcel Evaluation Forms for each evaluated property.

Planning For Corridor Conservation
A plan was developed to conserve parcels in the linkage zones based data from the following methods:

- Soot plate and snow tracking
- Landscape assessment and habitat evaluation
Data Analyses
Data were analyzed by species and by species group. Species were pooled into functional groups (as shown in table 2) based on body size, behavior, ecology and trophic similarities to accommodate statistical analyses and because the number of species recorded was large while the number of track recorded for most species was small.

<table>
<thead>
<tr>
<th>Group</th>
<th>Wildlife Species and Domestic Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Mammals</td>
<td>elk, mule deer, white-tailed deer, mountain lion, bobcat, coyote, red fox</td>
</tr>
<tr>
<td>Medium Mammals</td>
<td>badger, raccoon, striped skunk, weasel</td>
</tr>
<tr>
<td>Small Mammals</td>
<td>cottontail rabbit, squirrel, woodrat</td>
</tr>
<tr>
<td>Domestic</td>
<td>all terrain vehicle (ATV), dog, house cat, human</td>
</tr>
</tbody>
</table>

Mouse tracks were recorded at all stations, but were not included in data analyses because the high number of tracks would bias the outcome of analyses. All statistical analyses were performed on a group basis because individual species counts were too low for valid analysis. All statistical tests were done with a significance level of $\alpha = 0.05$. Regression analyses for each species group and station were performed to evaluate temporal trends. Snow tracking data are not reported in this paper because of insufficient sample size.

Results and Discussion
Results are presented for soot plate tracking and habitat connectivity analysis.

Interstate 25 - Soot Plate Tracking Results
Eighty-eight track-counts comprised of four species (excluding mice) of wildlife and humans were detected at one soot plate track station (Station 4) between November 15, 1999, and May 31, 2000. Summaries of all tracks detected at Station 4 are displayed by species and species group in table 3 and table 4, respectively. No ungulate movement through the culvert was recorded, probably due to the small size of the culvert opening (8 by 8 feet) and small openness index (0.22).

US Highway 85 - Soot Plate Tracking Results
Nine hundred forty-three track-counts comprising 11 species of wildlife, two domestic species, humans, and one machine were detected at five soot plate track stations between November 15, 1999, and May 31, 2000. Summaries of all tracks detected at each of the five stations are displayed by species and by species group in tables 3 and 4, respectively.

| Table 3 | Summary of Track-Counts for Below-Grade Crossing Events by Species November 15, 1999-May 29, 2000 |
|-----------------|-----------------------------------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
Table 4
Summary of Track-Counts for Below-Grade Crossing Events by Species Group, November 15, 1999 - May 29, 2000

<table>
<thead>
<tr>
<th>Station</th>
<th>Mammal Groups</th>
<th>Domestic</th>
<th>Total</th>
<th>Number of Tracking Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Large Mammals</td>
<td>Medium Mammals</td>
<td>Small Mammals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of Tracking Days</td>
<td>Number of Tracking Days</td>
<td>Number of Tracking Days</td>
<td>Number of Tracking Days</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>104</td>
</tr>
<tr>
<td>2</td>
<td>49</td>
<td>36</td>
<td>61</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>29</td>
<td>22</td>
<td>22</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>2</td>
<td>69</td>
<td>10</td>
</tr>
<tr>
<td>5-East</td>
<td>34</td>
<td>31</td>
<td>186</td>
<td>12</td>
</tr>
<tr>
<td>5-West</td>
<td>30</td>
<td>37</td>
<td>144</td>
<td>26</td>
</tr>
</tbody>
</table>

There is a strong inverse relationship between the number of tracks of wildlife species versus those of domestic animals and people at Station 1, the station with the largest openness index (table 1). Openness is thought to be conducive to wildlife movement, so the small number of animal tracks at this relatively large underpass suggests that human and domestic species are a negative influence on wildlife use.

The most common species to cross the track plates was the woodrat, and the least common were the mountain lion, badger, and weasel (1, 2, and 3 tracks, respectively). Between these extremes are several species with intermediate number of tracks: coyote (26 tracks), cottontail (35 tracks), raccoon (48 tracks), red fox (60 tracks), bobcat (69 tracks) squirrel (72 tracks), and striped skunk (78 tracks). The highest individual species numbers at a specific station include woodrats at Stations 5-East (171 tracks), 5-West (136 tracks), and 4 (57 tracks), bobcat at Stations 2 (39 tracks) and 3 (20 tracks), squirrel at Station 2 (35 tracks), and striped skunk at Stations 5-West (31 tracks) and 5-East (27 tracks). The high incidence of woodrat tracks represent outlier values 4.4 (5-East) and 3.5 (5-West) times greater than the next highest value for another species (bobcat at Station 2) and 3 and 2.4 times the next highest woodrat value (Station 4). Woodrat home ranges are small, values for Colorado species are as small as 0.2 ha (derived from Fitzgerald, et al 1994).

Statistically, significantly fewer large mammals used Stations 5-East and 5-West compared to Station 2, while the opposite pattern existed for small mammals. Statistically more small mammals used Stations 5-East and 5-West compared to Station 2.

Woodrats were found to dominate track counts for the small mammal group at Stations 5-East and 5-West, while bobcats dominated track counts at Station 2. Along Snoqualmie Pass in Washington, a similar study on animal movements across I-90 found bushy-tailed woodrats to be the only small mammal that used shorter culverts versus longer culverts to cross I-90, and this difference was statistically significant (Singleton and Lehmkuhl 2000). Woodrats showed a different use pattern than cottontail rabbits and squirrels. As a group, small mammals used Station 2 significantly less than Stations 5-East and 5-West. Squirrels and cottontails used Station 2 significantly more than Stations 5-East and 5-West, while woodrats used Station 2 significantly less than 5-East and 5-West.

The lack of documented ungulate use at the five tracking stations is due to a number of factors including fencing and other barriers, human activity (especially at Station 1), lack of sufficiently open approaches, and insufficient culvert opening size and openness index values.

Based on regression analysis, there was a statistically significant positive temporal trend for 54 percent of the species groups by station. All stations that had a temporal trend had a positive trend in the number of tracks recorded. When grouped across stations, all species groups show a statistically significant increase in number of tracks between November-April. This trend is consistent with increased animal activity in response to increases in daylight and temperature, and onset of both the growing season and mating season.

Soot Plate Tracking Versus At-Grade Data
A comparison of soot plate tracking stations with at-grade snow tracking segments was conducted; however, there were insufficient at-grade data to statistically compare the two data sets. Although not statistically analyzed, the comparison of data sets appears to suggest the following.
• Canids, coyote, and fox, along with cervids, deer and elk, cross more often at-grade.
• Raccoons and mustelids (skunks, badger, and weasel) appear to cross US 85 more often below-grade.

Elk and deer only crossed above-grade; however, the absence of ungulate track-counts at the five track stations is likely due to the small underpass opening dimensions (i.e., openness effect factor) and the presence of obstructions such as fencing and riprap at the below-grade stations.

Linkage Zones
This study examined only limited data on habitat along the South I-25 corridor because there generally appears to be less opportunity for linking large blocks of habitat within the corridor. Therefore, this part of the study focused on US 85, where significant opportunities to conserve connectivity still remain. Three primary linkage zones were identified across US 85. These zones were designated Zone A, Zone B, and Zone C (figure 2).

Fig. 2. US 85 Linkage Zones
Zone A represents the northernmost zone of viable habitat connectivity in the study area. This zone is dominated by the Beeman Creek and South Pollock Gulch drainages, both of which originate east of US 85 at an approximate elevation of 6,300 feet above mean sea level. These drainages flow west, ultimately crossing beneath US 85 at bridge structures. Neither drainage currently supports a year-round, permanent flow of surface water and water was not observed in either drainage during this study. The topography of this zone features a gentle slope from high ground in the vicinity of Daniels Park, to a low elevation represented by the channel of Plum Creek, west of US 85. The landforms are relatively diverse, offering creek bottoms, ridgelines, and slopes facing north, west, and south.

Zone B is dominated by unnamed streams draining the Cherokee Ranch property on the east side of US 85. These streams flow westward beneath US 85 at Stations 2, 5-East and 5-West. As with Zone A drainages, the unnamed drainages of Zone B arise at an approximate elevation of 6,300 feet, and drop to the low point of the valley represented by the channel of Plum Creek (elevation ~5,680 feet). The topography east of US 85 is also very similar to that found in Zone A, featuring dissected upland, prominent ridgelines, and slopes facing north, west, and south.

Zone C lies on the southern end of the Study Area. This zone is dominated by an unnamed drainage that flows south from Cherokee Ranch and beneath US 85 at tracking Station 3. This zone is shorter than the two previous zones considered, due to the close proximity of the Cherokee Ranch to the East Plum Creek Riparian Corridor. As with Zones A and B, topography on the Cherokee Ranch side of US 85 is generally steep and dips toward the creek channel found immediately south of the tracking station.

Linkage Zones And Corridor Conservation Planning
The combination of landscape assessment, habitat evaluation, and tracking data were used to develop a plan for preserving linkages between large conservation areas along both sides of the US 85 Corridor. Linkage zones and the conservation areas (in italics) they connect are:

- Zone A – Highlands Ranch OSCA, Daniels Park, Plum Creek Riparian Corridor, Chatfield State Park, and Woodhouse SWA
- Zone B – Highlands Ranch OSCA, Cherokee Ranch, Hobbs, Plum Creek Riparian Corridor, and Woodhouse SWA
- Zone C – Cherokee Ranch, East Plum Creek Riparian Corridor

Discussions and negotiations between a land trust and private landowners within the three linkage zones have identified a potential for over 2,100 acres of land that could be protected through fee-simple purchase or conservation easement.

Conclusions
Based on the results of tracking data, and on the landscape assessment and habitat evaluation, the following conclusions have been drawn:

1. A total of 14 species of mammals were documented to have crossed at- or below-grade in the US 85 and I-25 highway corridors. These species are mountain lion, bobcat, coyote, red fox, badger, raccoon, striped skunk, weasel, cottontail rabbit, squirrel, woodrat, mule deer, elk, and mice.

2. A wide variety of human sources of disturbance were identified in the study area, most of which tend to fragment the landscape and impede wildlife movement. The existing underpasses and culverts aid in wildlife movement. The major sources included road surfaces, railroad tracks, various types of fencing, inadequately sized or blocked highway structures, residential housing structures, commercial/industrial developments, and the actual presence of humans or domestic animals on the landscape.

3. The study area contains a relatively large group of properties that are designated as county open space, local or state parks, conservation easements, National Forest System lands, State Wildlife Areas. These lands, and intact riparian corridors. These areas together form an important patchwork of conservation properties within the overall Chatfield Basin landscape. The Plum Creek and East Plum Creek riparian corridors are essential north-south landscape elements in linking these conservation areas that lie on opposite sides of US 85.

4. Tracking Stations 2, 5-East, and 5-West (Zone B) and Station 3 (Zone C) had high use by large and medium mammals, whereas Station 1 exhibited high use by humans and domestics.
5. Canids (coyotes and foxes) and ungulates tended to cross US 85 at-grade, while the medium mammal group, largely mustelids, (badgers, raccoons, skunks, and weasels) tended to cross US 85 through below-grade structures.

6. Feline predators, especially bobcats, were shown to use culverts (Stations 2 and 3) for passing underneath US 85. There was a single tracking event recorded for a mountain lion in the long culvert associated with tracking Station 2. The culvert comprising Station 2 also exhibited the most large mammal tracks of any culvert monitored. This culvert represents the longest (320 feet) continuous culvert under US 85 and South I-25. Moreover, the culvert changes direction such that daylight from one opening cannot be seen from the other opening; changes type (concrete box to stone arch); and changes elevation so that the ceiling clearance is reduced in the middle of the culvert.

7. Habitat evaluation indicates that the primary east-west habitat connectivity zones for the Study Area occur in three zones (A, B, C).

**Recommendations**

Based on the results of the study, the following recommendations were provided to the Colorado Department of Transportation (CDOT) and Douglas County.

1. Douglas County should consider working with landowners and conservation groups along the US 85 Corridor and within the Chatfield Basin to identify and facilitate opportunities for land conservation within Zones A, B, and C.

2. CDOT should continue working with Douglas County and the Colorado Division of Wildlife (CDOW) to maintain existing habitat connectivity across the US 85 Corridor and to enhance connections, through highway and structure design, in Zones A, B, and C.

3. CDOT should consult with CDOW regarding appropriate wildlife and habitat mitigation required along the US 85 Corridor to offset unavoidable impacts to wildlife and habitat in the South I-25 and US 85 Corridors stemming from the final alternative selected from the current Environmental Impact Statement (EIS) process. Habitat mitigation along US 85 should consider enhancing vegetation in Zones A and C to funnel or motivate wildlife to use below-grade structures to cross the highway.

4. CDOT should coordinate with Douglas County and CDOW regarding acquisition of ROW in the US 85 Corridor, development within Zones A, B, and C, and opportunities for land conservation within these zones. Avoiding or managing development in these zones in conjunction with reviewing opportunities for excess ROW should be a priority during the design, construction, and mitigation phases of highway improvements along US 85.

5. Development should be planned and limited in important habitat areas, particularly the East Plum Creek/Plum Creek Riparian Corridors and the three connectivity zones.

6. Because highway underpasses of different sizes are used by different species, additional study of small (less than 6 by 6 foot) culverts should be conducted.

7. The existing diversity of culvert sizes and number of culverts under South I-25 and US 85 should be maintained even if it is determined that they are not required to maintain drainage. Culverts should be maintained by periodic assessment and cleaning so that they continue to allow for animal use. Culvert access areas should also be evaluated and maintained, particularly maintenance/enhancements to vegetative cover in areas leading to culverts. Culverts and bridges used by wildlife should not have lighting inside them or located at entrances. Culvert structures at Stations 1 and 3 should be enlarged to accommodate elk movement - a minimum of 13 feet in height.

8. Fencing, embankments, and riprap, used to define and control culvert openings at road edge, should be constructed to minimize their barrier effect to wildlife. Moreover, ROW and property fencing should be designed, located, or avoided at highway drainage structures to enhance permeability of the US 85 corridor.

9. Fencing should be used to direct wildlife to culvert entrances if it can be done without trapping wildlife on the highway. Fencing should only be used as culvert wings, directing wildlife approaching a culvert into the below-grade structure and away from at-grade crossing. However, as a long-term strategy, it is suggested that following any major roadway upgrades, the efficacy of at-grade and below-grade crossings be monitored to determine whether or not fencing is warranted. CDOW should be consulted when determining the need for, type, and extent of highway fencing.

10. The use of intelligent signage with infrared wildlife sensors to protect motorists and wildlife should be evaluated for US 85.

11. The new High Line Canal crossing under US 85 should be designed to accommodate large mammals.
12. Revegetation in areas of highway improvements should utilize native plant species and be used to motivate wildlife to use below-grade structures through screening or funneling.

13. Sound walls should be considered for wildlife crossing areas with excessive noise; however, their barrier to wildlife movement should also be considered. Necessity and design of any noise barriers should be considered with input from CDOW and Douglas County.

14. Monitoring of wildlife movement at- and below-grade of US 85 should be conducted at stations and segments identified in this study to determine the effectiveness of mitigation required as part of the South I-25/US 85 EIS.

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