

# **Wildlife Data Collection and Potential Highway Mitigation along State Highway 75, Blaine County, Idaho**

By

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<b>16. Abstract</b> This report investigates historic and recent road mortality data (mostly for mule deer and elk) along a 26 mi long road section of S.H. 75 in Blaine County, Idaho (between Timmerman Jct (Jct with Hwy 20) and the Trail Creek Bridge in Ketchum, Idaho). The project aimed to review potential mitigation measures (presented in a separate report), and to collect and analyze historic and current wildlife-vehicle collision (WVC) data and provide advice on potential mitigation measures, including animal detection systems (this report). Road mortality data were collected by the Idaho Department of Transportation (carcass data), the Idaho Highway Patrol (wildlife accident data), the Western Transportation Institute and the public. The public was asked to enter road mortality data as well as live animals observed in a web based database. The minimum number of road killed deer and elk along the 26 mi long road section was estimated at 134 in 2007, a sharp increase over previous years (25-40), most likely because of increased search and reporting effort. The road mortality data were used to identify road sections that had the highest number of road-killed mule deer and elk: between mile post 118.4 and 119.1, just north of Hailey. This section was reviewed with regard to the suitability for the installation of an animal detection system. Based on the projected costs and benefits of animal detection systems, the benefits of an animal detection system at the location described above may be much greater than the costs for such a system. Furthermore, different systems and their characteristics are discussed with regard to their potential implementation at the road section identified above. Finally, six options are presented with regard to the implementation of mitigation measures for the road section concerned. These include, but are not limited to animal detection systems.					
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## EXECUTIVE SUMMARY

Blaine County, in cooperation with the Idaho Transportation Department (ITD), published a Request For Proposal (RFP) to gather more information about the wildlife-vehicle collisions and the potential installation of an animal detection system along the 26 mile long section of State Highway 75 (SH 75) between the junction with Hwy 20 (Timmerman Jct) and the Trail Creek bridge in Ketchum. The ultimate purpose of the effort is to contribute to a future reduction in animal-vehicle collisions, especially with mule deer and elk. This translates into increased public safety, reduced wildlife mortality, and reduced economic losses due to property damage along the road section concerned.

A literature review on mitigation measures to reduce collisions with large animals was an integral part of this project and was published as a separate report (Huijser & Kociolek 2008). This report however, focuses on the analyses of historic road mortality data and the collection and analyses of additional road mortality data and live observations of animals (mostly mule deer and elk) for the 26 mi long road section. These data were collected and analyzed to identify road sections with the highest number of road-killed mule deer and elk and to help guide the selection of appropriate mitigation measures. As requested in the RFP the selection of appropriate mitigation measures focuses specifically on the suitability of implementing an animal detection system.

This study used historic and recent road mortality and live animal observations from different entities. Carcass removal data (2004-2007) from the Idaho Transportation Department showed an increasing trend in the number of reported wildlife-vehicle collisions involving deer and elk. Other sources of data included Idaho Highway Patrol wild animal accident data, Western Transportation Institute (WTI) road mortality survey data and dead wildlife reports from the public. The latter were entered by the public in a web based data base. These four data sources were combined and analyzed to estimate the total number of reported deer/elk-vehicle collisions in the study area per year and to identify road sections with the highest concentrations of these collisions. There were an estimated 134 reported road killed deer and elk in the study area in 2007, considerably higher than the previous annual estimates (25-40). Engaging the public to report their observations in combination with conducting systematic road mortality surveys is likely to be the cause of the dramatic increase in the number of reported road killed deer and elk in 2007. It is unknown whether an increase in population size of deer and elk occurred which could also have contributed to an increase in reported wildlife-vehicle collisions. To gain a better understanding of wildlife activity in the area, WTI also investigated potential wildlife crossings under two bridges across the Big Wood River, Idaho Fish and Game deer and elk population survey data, and the public's live wildlife sightings along the roadway.

The road mortality data were used to identify road sections that had the highest number of reported road-killed mule deer and elk: between mile post 118.4 and 119.1, just north of Hailey. This section was reviewed with regard to the suitability for the installation of an animal detection system. Overall, the road, traffic and surrounding landscape at this road section appear suitable for the installation of an animal detection system. Thought should be given though to the traffic volume and how much it is projected to increase in the near future and what that may mean for having or allowing animals to continue to cross at grade. In addition, careful thought should be given to potential changes in the surrounding landscape and how that might affect animal movements and deer- and elk-vehicle collisions in this road section, and the long-term return on

potential mitigation measures. Also, if and when the road is reconstructed, the space in the right-of-way should still allow for the installation of an animal detection system, and safe pull outs for operation and maintenance, and potentially also for researchers should be provided for.

Based on the projected costs and benefits of animal detection systems, the benefits of an animal detection system at the location described above may be much greater than the costs for such a system. Furthermore, different systems and their characteristics are discussed with regard to their potential implementation at the road section identified above. Finally, six options are presented with regard to the implementation of mitigation measures for the road section concerned. These include, but are not limited to animal detection systems.

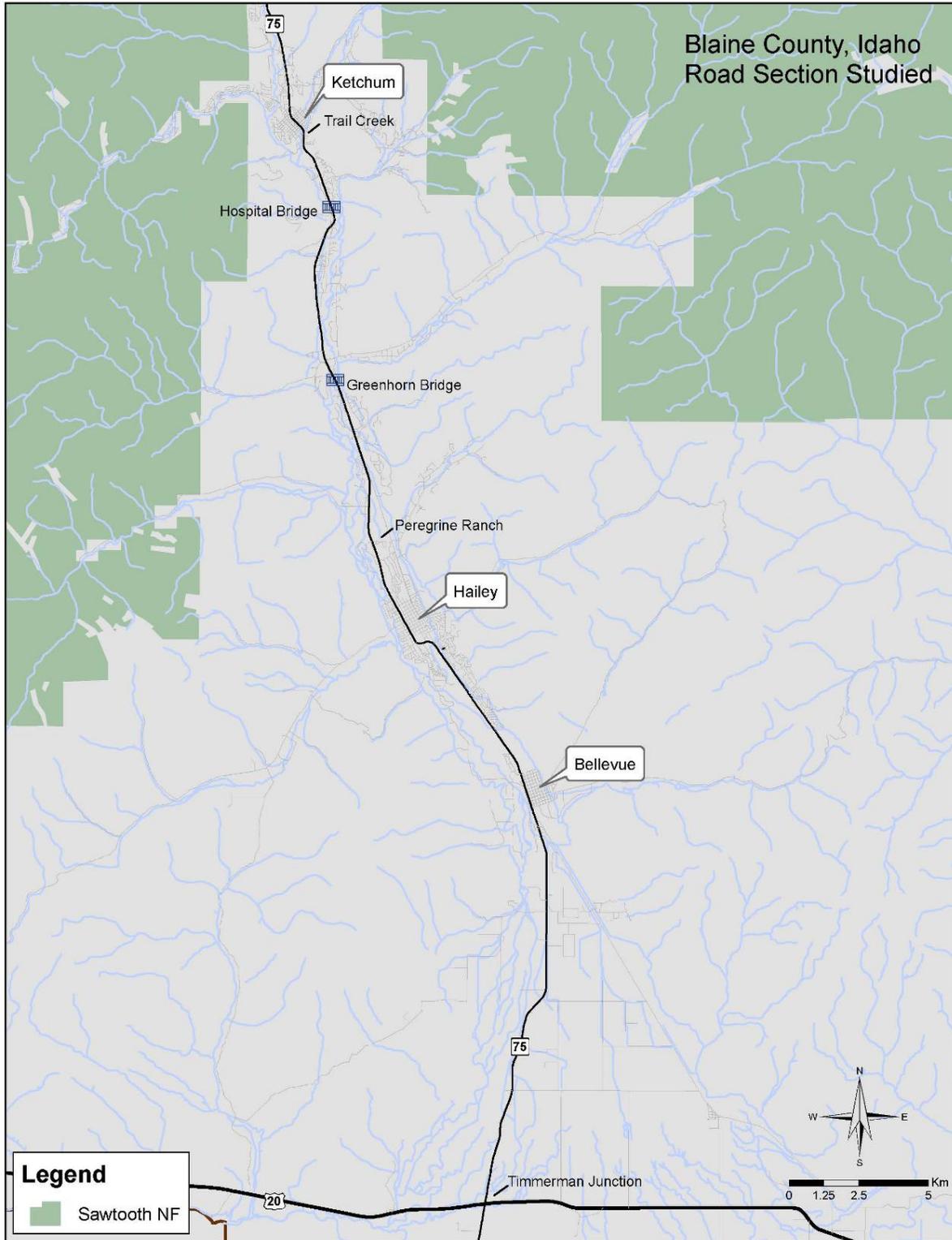
## 1 INTRODUCTION

### 1.1 Background

Animal-vehicle collisions affect human safety, property and wildlife. In the United States the total number of deer-vehicle collisions was estimated at more than 1-1.5 million per year (Conover et al. 1995; Huijser et al. 2007a). These collisions were estimated to cause 211 human fatalities, 29,000 human injuries and over one billion dollars in property damage a year (Conover et al. 1995). These numbers have increased even further over the last decade (Hughes et al., 1996; Romin and Bissonette 1996; Knapp et al. 2004; Khattak 2003; Tardif and Associates Inc. 2003; Huijser et al. 2007a).

In most cases the animals die immediately or shortly after the collision (Allen and McGullough 1976). In some cases it is not just the individual animals that suffer. Road mortality may also affect some species on the population level (van der Zee et al. 1992; Huijser and Bergers 2000). Some species may even be faced with a serious reduction in population survival probability as a result of road mortality, habitat fragmentation and other negative effects associated with roads and traffic (Proctor 2003). In addition, some species also represent a monetary value that is lost once an individual animal dies (Romin and Bissonette 1996; Conover 1997).

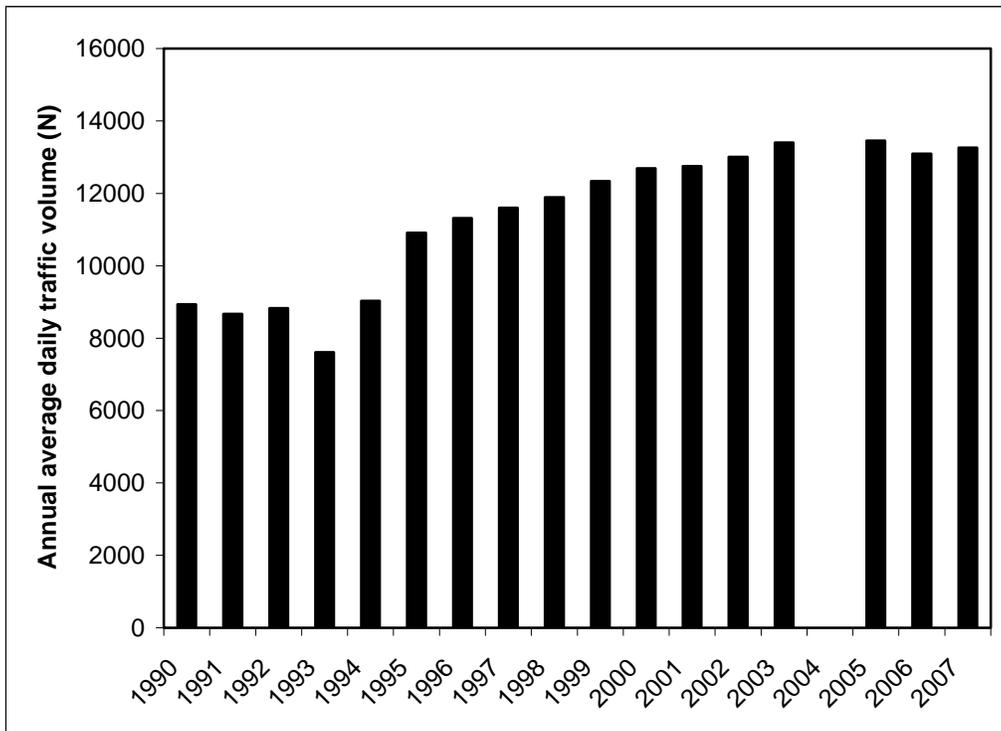
In a growing number of states, wildlife-vehicle collisions (WVCs) are one of the top safety issues that generate interest and concern with the public and the media. A 26 mile section of State Highway 75 (SH 75) between Timmerman Junction (Jct. with Hwy 20) and the Trail Creek Bridge in Ketchum, Idaho is an example of a road that has the public and transportation managers concerned about wildlife-vehicle collision safety issues (Figure 1). The road configuration no longer meets safety and transportation capacity needs, especially not considering the recent and projected increase in the level of human activity and development in the area (Blaine County, 2006) (Figure 2, 3, 4, and 5). Therefore, the Idaho Transportation Department (ITD) is planning for road reconstruction (ITD 2008). The project under consideration includes widening the roadway from Bellevue to Ketchum (two travel lanes in each direction, a center turn lane and shoulders) (ITD 2008). In addition, between Timmerman Junction and the City of Bellevue one lane in each direction plus passing lanes are considered (ITD 2008).



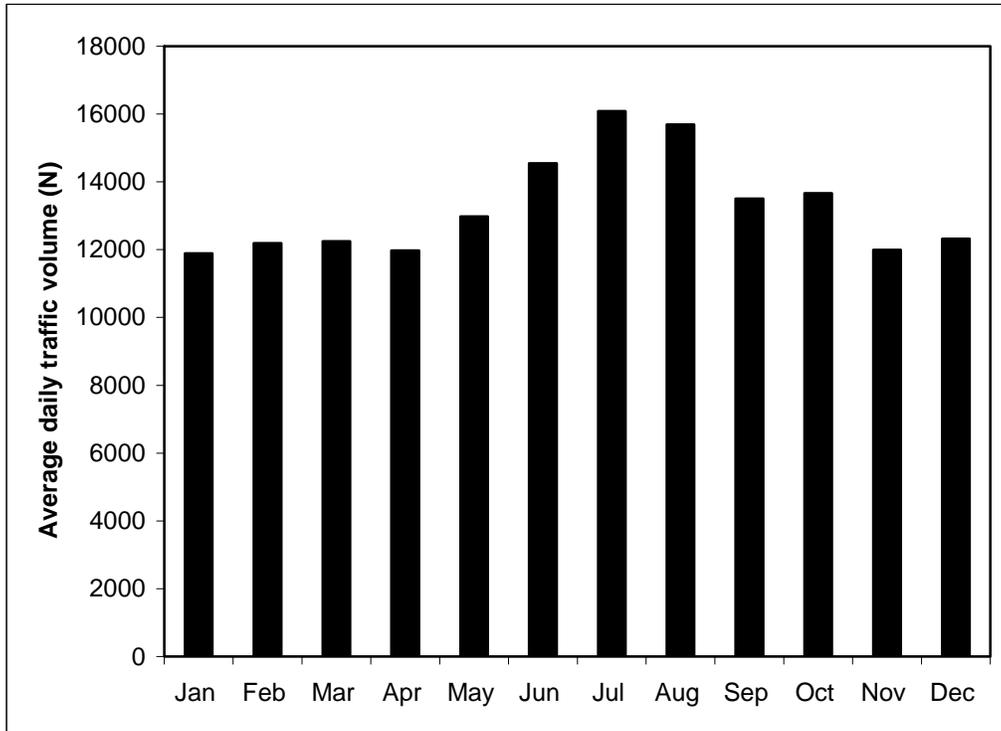
**Figure 1: The 26 mile long road section of SH 75 under study. The road section starts at Timmerman Junction (junction with Highway 20) at the south end, and ends at the Trail Creek Bridge in Ketchum. In addition, the map shows the location of two bridges across the Big Wood River that may be used by large mammals as a wildlife underpass.**



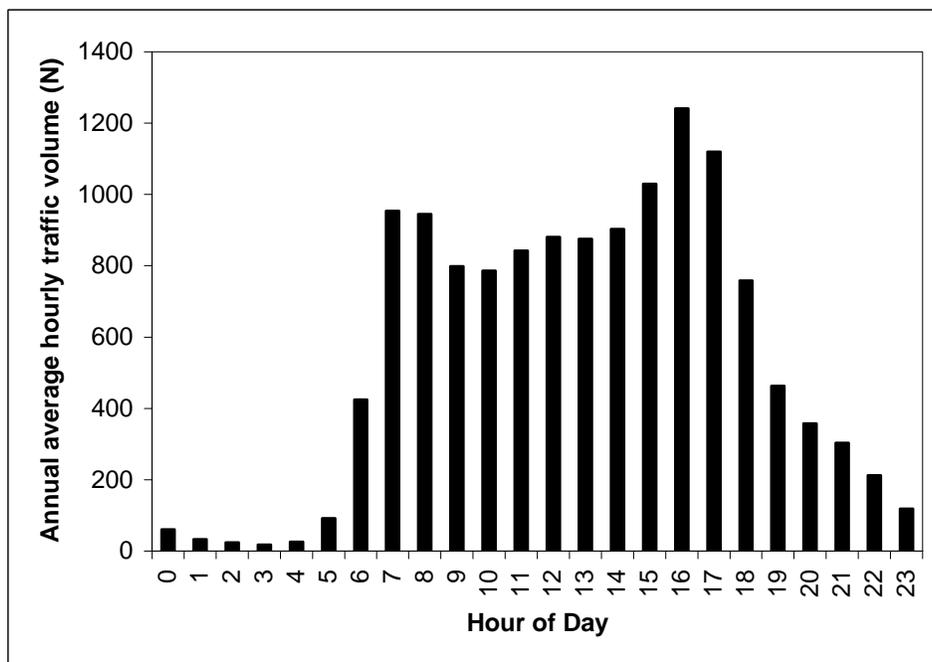
**Figure 2: The current road configuration of SH 75 is thought to no longer meet safety and transportation capacity needs and is scheduled for reconstruction (© Marcel Huijser, WTI-MSU).**



**Figure 3: Annual Average Daily Traffic volume along SH 75 (Counter/segment code 002230, MP 119.400, 2.9 mi N of Bullion St. in Hailey) (Data provided by ITD). No data were available for 2004.**



**Figure 4: Average Daily Traffic volume per month in 2007 along SH 75 (Counter/segment code 002230, MP 119.400, 2.9 mi N of Bullion St. in Hailey) (Data provided by ITD).**



**Figure 5: Annual Average Hourly Traffic volume in 2007 along SH 75 (Counter/segment code 002230, MP 119.400, 2.9 mi N of Bullion St. in Hailey) (Data provided by ITD).**

In addition, Blaine County, ITD, Idaho Department of Fish and Game, and the public have concerns about the number of WVCs on this section of SH 75 and how these WVCs could increase to an even higher level as the result of the potential reconstruction of the road (Blaine County 2006). The number of wildlife-vehicle collisions on this road section is estimated at 30-50 every year [(Parrish 2002) cited in Shapiro & Associates 2003]. Most of the recorded collisions are with mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) (Shapiro & Associates 2003; Blaine County 2006) (Figure 6).



**Figure 6: Road-killed mule deer along SH 75 (© Marcel Huijser, WTI-MSU).**

Warning signs for large mammals have been installed between Timmerman Jct and Ketchum (Figure 7 through 11). As part of this project the Western Transportation Institute at Montana State University made an inventory of all warning signs for large mammals and speed limit signs on the road section under study (Figure 12 and 13). Wildlife warning signs are unlikely to be effective though (see review in Huijser et al., 2007a; b) and the current level of WVCs is considered too high by Blaine County, ITD, Idaho Department of Fish and Game, and the public, despite the presence of the warning signs.



**Figure 7: Standard deer warning sign along SH 75**



**Figure 8: Standard deer warning sign with hinges (option to display only in certain seasons) along SH 75 (© Marcel Huijser, WTI-MSU).**



**Figure 9: Enhanced (orange square) deer warning sign along SH 75 with distance indication (© Marcel Huijser, WTI-MSU).**



**Figure 10: Enhanced (orange square) game warning sign along SH 75 (© Marcel Huijser, WTI-MSU).**



**Figure 11: Cattle warning sign along SH 75 (© Marcel Huijser, WTI-MSU).**

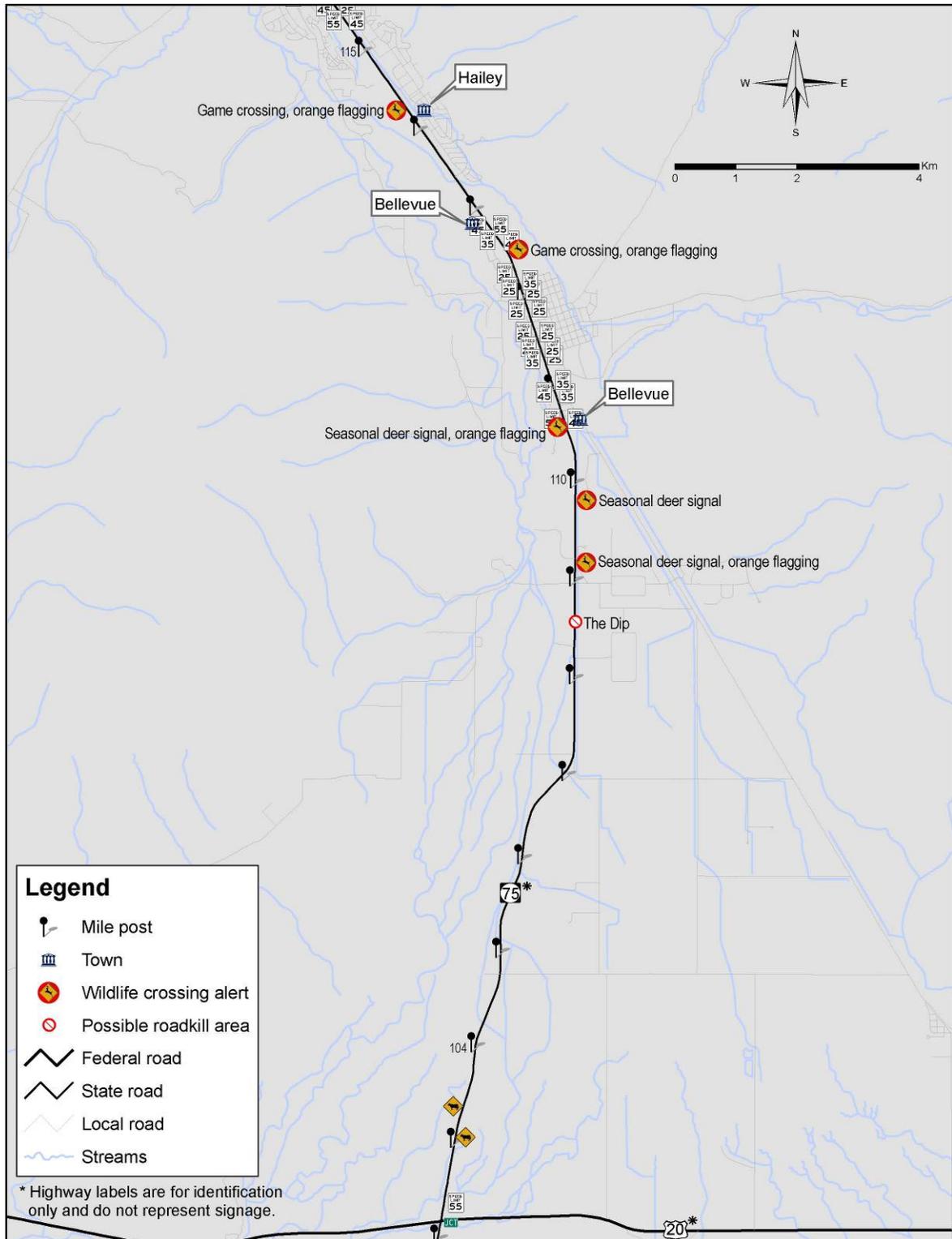


Figure 12: All large mammal warning signs and speed limit signs along the section of SH 75 under study (southern half). Road signs on the left side of the road are for south bound traffic, road signs on the right side of the road are for north bound traffic.

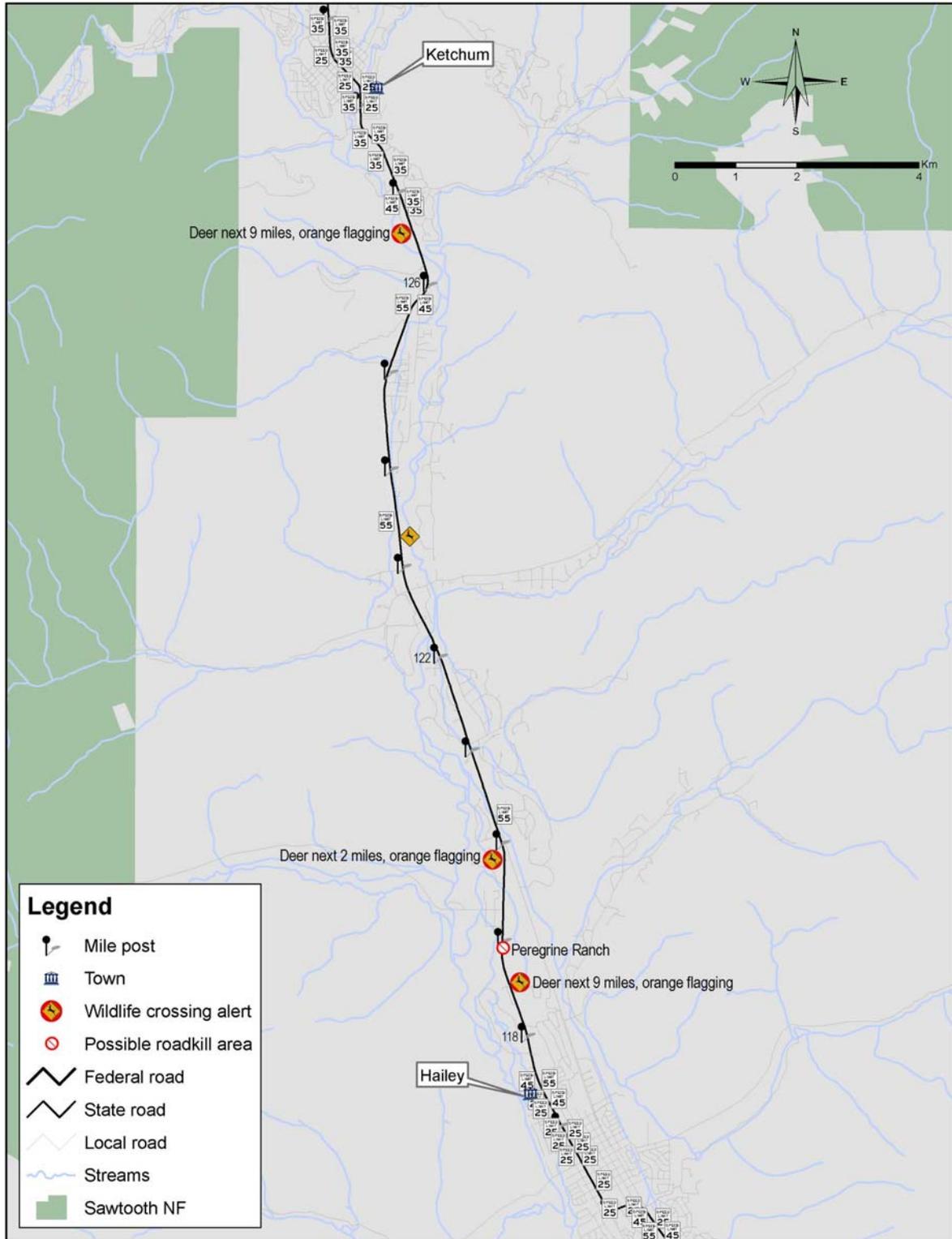


Figure 13: All large mammal warning signs and speed limit signs along the section of SH 75 under study (northern half). Road signs on the left side of the road are for south bound traffic, road signs on the right side of the road are for north bound traffic.

Mitigation measures that may reduce WVCs with large mammals (deer size and larger) substantially (>80%) are limited to wildlife fencing in combination with safe crossing opportunities (e.g. wildlife under- and overpasses or animal detection systems in a gap in the fence), or animal detection systems that are installed over longer road sections (Huijser et al 2007b; c). However, the existing level of human activity and development along the transportation corridor appears to make the wide-spread use of wildlife fencing difficult, and the open and flat topography allows for relatively few natural opportunities for wildlife underpasses or overpasses.

Animal detection systems detect large animals (e.g., deer (*Odocoileus* sp.), elk and/or moose (*Alces alces*)) as they approach the road. When an animal is detected, signs are activated to warn drivers that large animals may be on or near the road at that time. The drivers can then respond to the warning signals by reducing their speed, increasing their alertness, or both. This may result in fewer and less severe collisions with large animals. There are very few published data on the effectiveness of animal detection systems in reducing collisions with large animals. Nonetheless, the available data are very encouraging; 82% (Kistler 1998; Romer and Mosler-Berger 2003; Mosler-Berger and Romer 2003); review in Huijser et al. 2006) and 91% (Dodd & Gagnon 2008).

## 1.2 Mule deer and Elk Presence and Movements in the Valley

Mule deer are migratory in the Wood River Valley with their migration corridors running north-south (Pers. com. IDFG personnel at kickoff meeting October 2006). In the winter there are relatively few deer as most of them migrate south. Those that leave are partially replaced by other individuals from other areas. One deer herd attempts to overwinter near the 125.5 mile marker but generally has poor survival (Pers. com. IDFG personnel at kickoff meeting October 2006). It is thought that most deer-vehicle collisions occur in April/May.

Elk inhabit the valley year-round (Pers. com. IDFG personnel at kickoff meeting October 2006). It is thought that elk are involved in WVCs at generally the same locations year-round, especially south of Bellevue, near the Peregrine Ranch north of Hailey, and south of Ketchum. Most elk-vehicle collisions are thought to occur from mid-August through the fall, with relatively low numbers during winter. Near Bellevue elk congregate at haystacks for part of the winter, reducing the number of road crossings in winter. Other elk cross the road twice a day near the Peregrine Ranch; in the morning they move towards river on the west side of the road, and in the evening they move towards the Peregrine Ranch on the east side of the road to forage. There are more elk near Peregrine in winter (50-60) compared to other times of year (20) (Pers. com. IDFG personnel at kickoff meeting October 2006).

## 1.3 Tasks and Research Questions

Blaine County, in cooperation with ITD, published a Request For Proposal (RFP) to gather more information about the wildlife-vehicle collisions and the potential installation of an animal detection system along the 26 mile long section of State Highway 75 (SH 75) (Blaine County 2006). The ultimate purpose of the effort is to eventually contribute to a reduction in animal-vehicle collisions, especially with mule deer and elk. This translates into increased public safety, reduced wildlife mortality, and reduced economic losses due to property damage along the road section concerned.

More specifically, the project had the following tasks and research questions (WTI 2006):

- Task 1a – Conduct literature review on animal detection systems
- Task 1b – Provide a summary of design alternatives (review of other mitigation measures)
- Task 2 – Re-analyze historic road mortality data
- Task 3 – Collect and help organize additional, current, road-kill data
- Task 4 – Collect wildlife crossing data at grade and under two existing bridges (see Figure 1)
- Task 5 – Collect wildlife population data
- Task 6 – Review potential sites and advise on the installation of an animal detection system
- Task 7 – Deliver final report

The tasks above are based on the following research questions:

- *Where do the greatest concentrations of road-killed mule deer and elk occur?*

This is addressed in tasks 2 and 3.

- *What is a realistic estimate of the number of animal-vehicle interactions in the project area on an annual basis?*

This is addressed in task 3.

- *What time of day do most animal crossings occur?*

This is addressed in task 2 and 3 based on animal-vehicle collision data collected by Idaho Highway Patrol. Furthermore, this question is answered through the data and time stamps on the photographs taken by the cameras in the culverts and under the two bridges across the Big Wood River (task 4). However, while the data indicate what species cross the road in what season and at what time, there is a possibility that different species may cross at different times at grade. Nonetheless, the data from the two bridges do provide an indication of what may be happening at grade. Finally, this question is addressed through the observations by the public of animals crossing the road (task 4). However, these data indicate when most animals are seen crossing the road rather than when most animals cross the road. Nonetheless, these data relate to when people are most likely to encounter animals on the road (a combination of wildlife activity and traffic volume).

- *What is the best available science on animal detection and animal warning systems that could be applied in the project area?*

This is addressed in tasks 1 and 6.

- *How should these systems be applied in the project corridor?*

This is addressed in task 6.

- *What are their advantages and disadvantages?*

This is addressed in task 1 and 6.

- *What system or combination of systems should be recommended for the SH-75 corridor as a demonstration project?*

This is addressed in task 6

Note that Tasks 1a and 1b are addressed in a separate report titled Wildlife-Vehicle Collision and Crossing Mitigation Measures: A Literature Review for Blaine County, Idaho (Huijser & Kociolek 2008) delivered in conjunction with this report.

## 1.4 Data Sources

This study is based on historic and recent data from different organizations [i.e., Idaho Transportation Department (ITD), Idaho Department of Fish and Game (IDFG) and Idaho Highway Patrol (IHP)] as well as data collected by Western Transportation Institute (WTI) researchers and the general public during the study period. The recent data collection period began March 12, 2007 and ended March 30, 2008. In addition to data collection and analysis of road mortality data and wildlife crossing data, this study also includes a literature review on animal detection systems and a summary of design alternatives.

**Table 1. Data sources used for this study**

Data source	Carcass or road mortality data		Accident data		Wildlife crossing or presence data	Wildlife population data	
	Historic	Recent	Historic	Recent	Recent	Historic	Recent
<b>ITD</b>	x	x					
<b>IDFG</b>	x					x	x
<b>IHP</b>			x	x			
<b>WTI</b>		x			x		
<b>Public</b>		x			x		

## **2 TASK 2: RE-ANALYSIS OF HISTORIC ROAD MORTALITY DATA**

### **2.1 Introduction**

The main purpose of tasks 2 and 3 (see Chapter 3) is to identify a road section that would be a candidate for the potential installation of an animal detection system. The efforts focus on mule deer and elk. Tasks 2 and 3, the re-analyses of existing road mortality data and the collection of new road mortality data, are also essential to evaluate the effectiveness of a potential future animal detection system. In this chapter we focus on task 2.

### **2.2 Search and Reporting Effort**

Carcass removal data collected by ITD was not consistently reported in the 1990s as no one appeared interested in the data (Pers. com. Ron Robinson, ITD, at kickoff meeting October 2006). This resulted in perhaps at least 50% underreporting (Pers. com. Ron Robinson, ITD, at kickoff meeting October 2006). Since 2002-2003 data collection on removed carcasses of large animals (e.g. deer and elk) has become much more consistent, and underreporting is thought to have been reduced (Pers. com. Ron Robinson, ITD, at kickoff meeting October 2006). However, ITD collects carcass removal data less consistently north of Ketchum where there are fewer houses, less traffic, and carcasses are often pulled off the road but not removed and thus not recorded. The carcass removal data of the 26 mile long road section under study are recorded by the same crew as part of a daily effort and carcasses from the 26 mile long road section are recorded with equal likelihood, regardless of the location on the 26 mile long road section (Pers. com. Ron Robinson, ITD, at kickoff meeting October 2006).

Accident data are collected by the Idaho Highway Patrol and managed by ITD (Pers. com. Ron Robinson, ITD, at kickoff meeting October 2006). The data only include incidents that involved serious accidents or where a police report was requested for insurance purposes. These thresholds do not necessarily depend on the location on the 26 mile long road section under study.

Based on the descriptions above, the authors of this report conclude that both the carcass removal data and the accident data qualify as “monitoring data”. Note that for the purpose of this research project, “monitoring” relates to “similar search and reporting effort for all locations along the 26 mile long road section. “Monitoring” in this context does not require or assume that all large mammal carcasses or accidents with large mammals are reported.

### **2.3 Road Sections with Highest Number of Deer- and Elk-Vehicle Collisions**

This section shows which road sections have the highest number of reported deer- and elk-vehicle collisions, based on data from before March 2007. In addition, these data helped the authors of this report select road sections where more intensive surveys were conducted in 2007 and 2008 to estimate potential underestimation of the number of deer- and elk-vehicle collisions reported through carcass removal efforts and accident data.

The following agencies provided data related to wildlife-vehicle collisions (WVCs) that involved deer and elk:

- Idaho Fish and Game (IDFG) – mule deer carcass data
- Idaho Transportation Department (ITD) – carcass removal data

- Idaho Highway Patrol (through ITD) – accident reports

Figures 14 and 15 show the locations of mule deer road kills in the 1970s and 1980s. Note that there was only one mule deer road kill reported in the area of Peregrine Ranch [mile posts (MP) 118.5-119.5] in eight years of available data; the road kill occurred in 1989 (Figure 15).

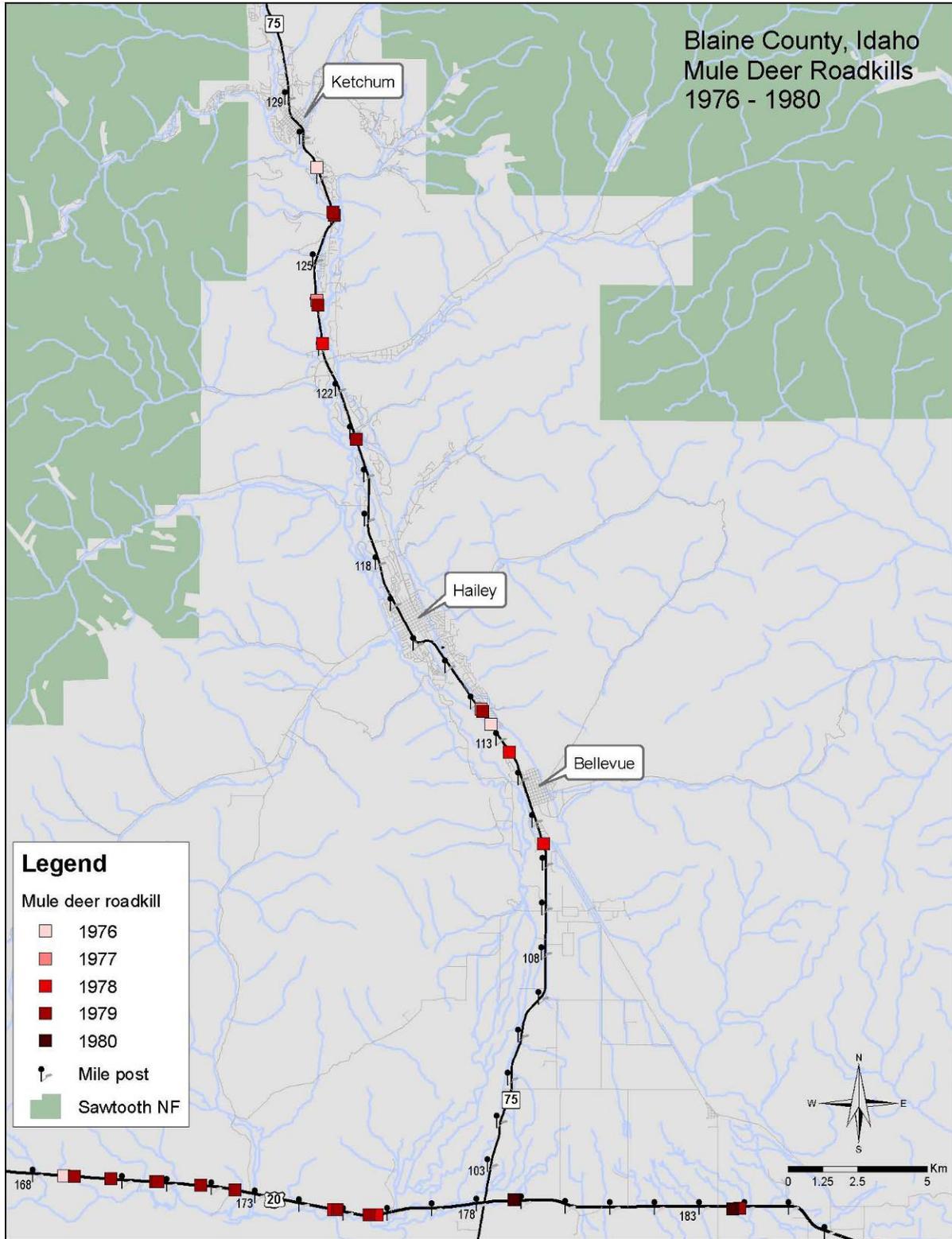


Figure 14: Historic mule deer carcass data from 1976 through 1980 (Data provided by IDFG).

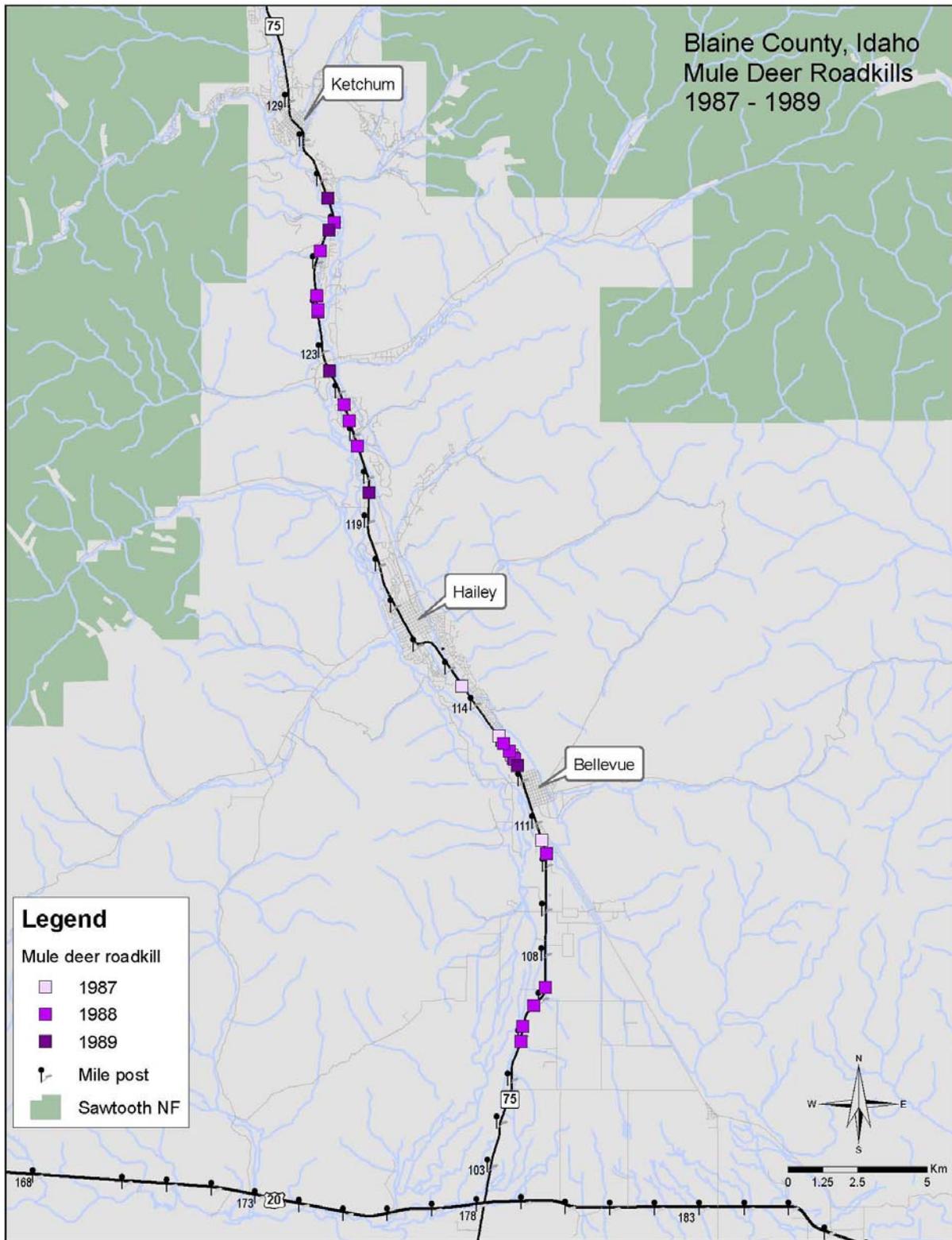


Figure 15: Historic mule deer carcass data from 1976 through 1980 (Data provided by IDFG).

To determine the road sections within the study area that had the highest number of WVC reports in recent years, available ITD carcass removal reports (n =72) were combined with available IHP wild animal accident reports (n=58). The 72 ITD deer and elk carcass reports were from June 2004 through January 2007. The 58 IHP wild animal accident reports were from January 1998 through December 2006. Due to the possibility of replicate reports of the same carcass by the two different agencies, the following rule was applied: ITD and IHP reports that were made within 1 day of each other and that were within 1 mile of each other were treated as suspected replicates. For four suspected replicates, IHP locations were used because they appeared to be more precise to the .1 mile. The combined data set thus included a total of 126 unique reports. The available historic WVC data (ITD carcass reports combined with IHP accident reports) indicates that WVCs are generally clustered between MP 107.5 – 109.8 and 118.0 – 127.0 (Figure 16). For graphical purposes, the study area was expanded from MP 102.1-128.1 to MP 102.0-129.0.

Two ITD reports made in April 2005 stated a range for the location of the carcass rather than a specific mile post. In these two cases, the provided range MP 119.0-122.0 was averaged to be MP 120.5. These two ITD April 2005 reports were deemed to be unique given that there were no IHP reports made in April 2005.

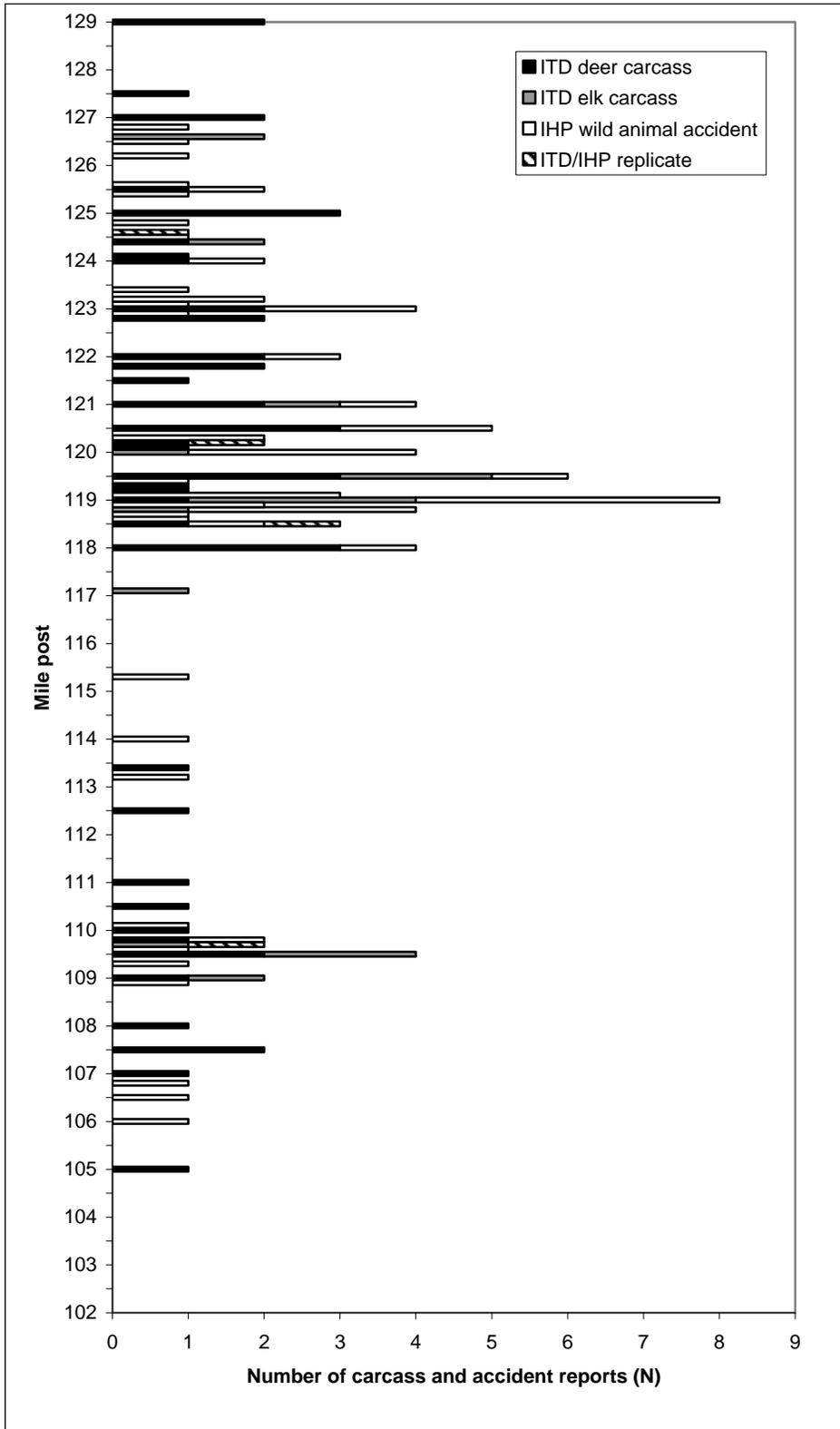


Figure 16: Locations of historic WVC reports by one-tenth of a mile (Total n = 126) (Data provided by ITD and IHP).

In order to more easily define the road sections (maximum length of .5 miles) with the highest concentration of historic WVCs, all reports were aggregated to the closest whole number or .5 mile post (Figure 17). If the mile post location was at .1, .2, .8 or .9 mile, it was merged with nearest whole number mile post. If the mile post location was at .3, .4, .6 or .7 mile, it was merged with the .5 mile post.

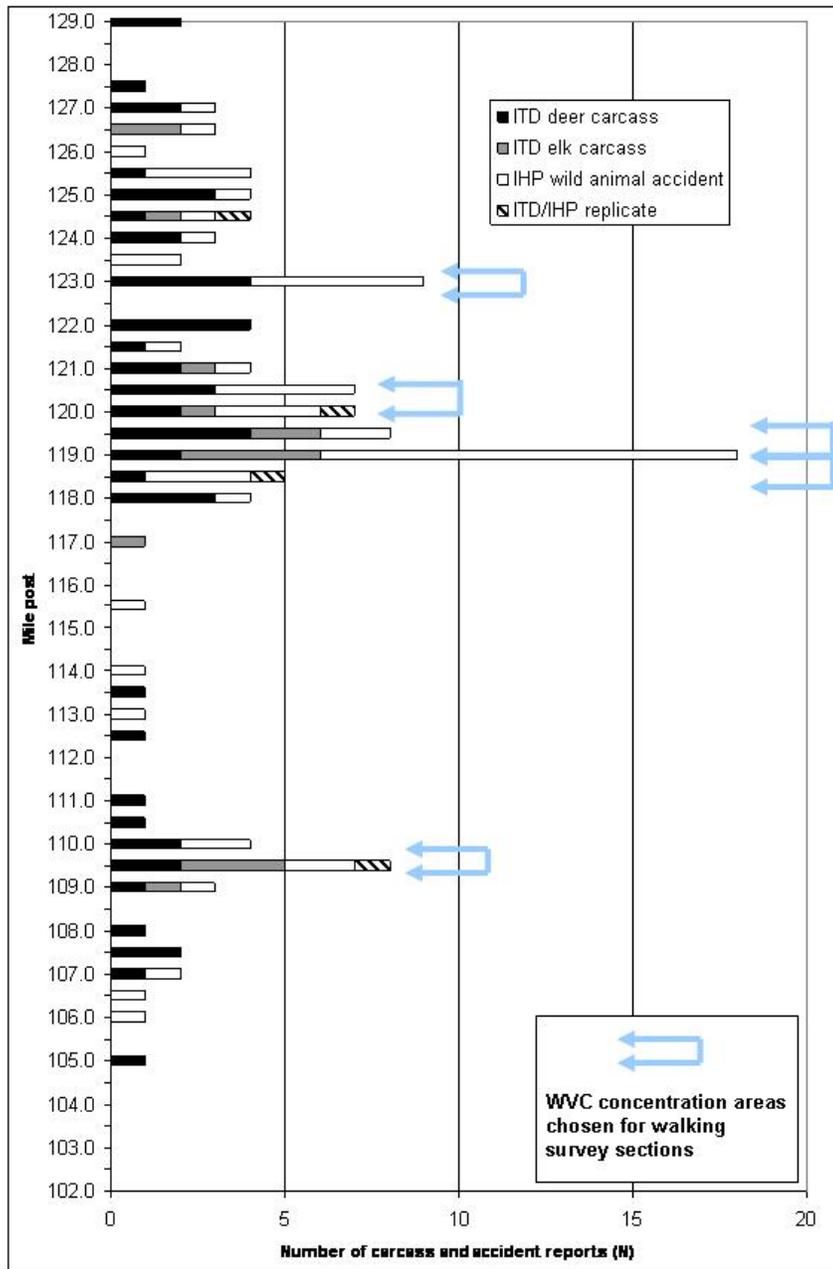


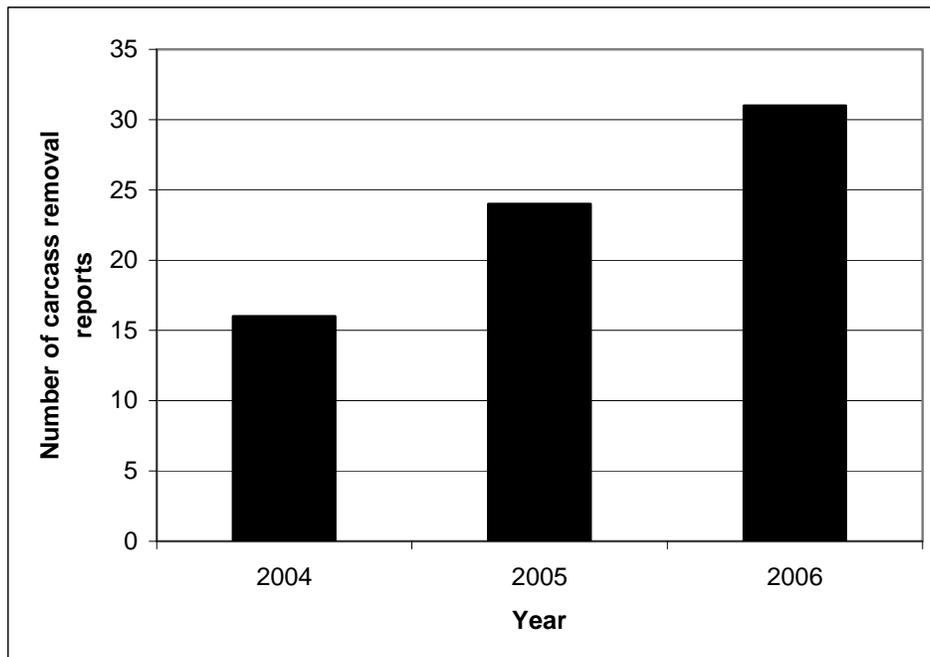
Figure 17: Locations of historic WVC reports aggregated to .5 miles (Total n = 126) (Data provided by ITD and IHP).

The following five road sections were selected for intensive WTI road mortality walking surveys (see Section 3.3):

- MP 109.5-109.8
- MP 118.5-119.0
- MP 119.0-119.5
- MP 120.0-120.5
- MP 122.8-123.1

## 2.4 Monthly Distribution of Deer- and Elk-Vehicle Collisions

Based on ITD carcass removal reports, the number of WVCs within the study area involving mule deer and elk increased from 2004 to 2006 (Figure 18). The carcass removal data were categorized by month and year (Figure 19). Based on this graph there appear to be gaps in the data. For example, in July 2004 the number of reported carcasses was 0 and in July 2005 it was 7, and in October 2004 it was 0 and in October 2006 it was 8. The authors of this report hypothesize that such apparent gaps in the data may be related to lost or misplaced data forms.



**Figure 18: Historic carcass removal data by year (2004 through 2006). Note: 2004 data appears to include reports from June through December only. (Data provided by ITD).**

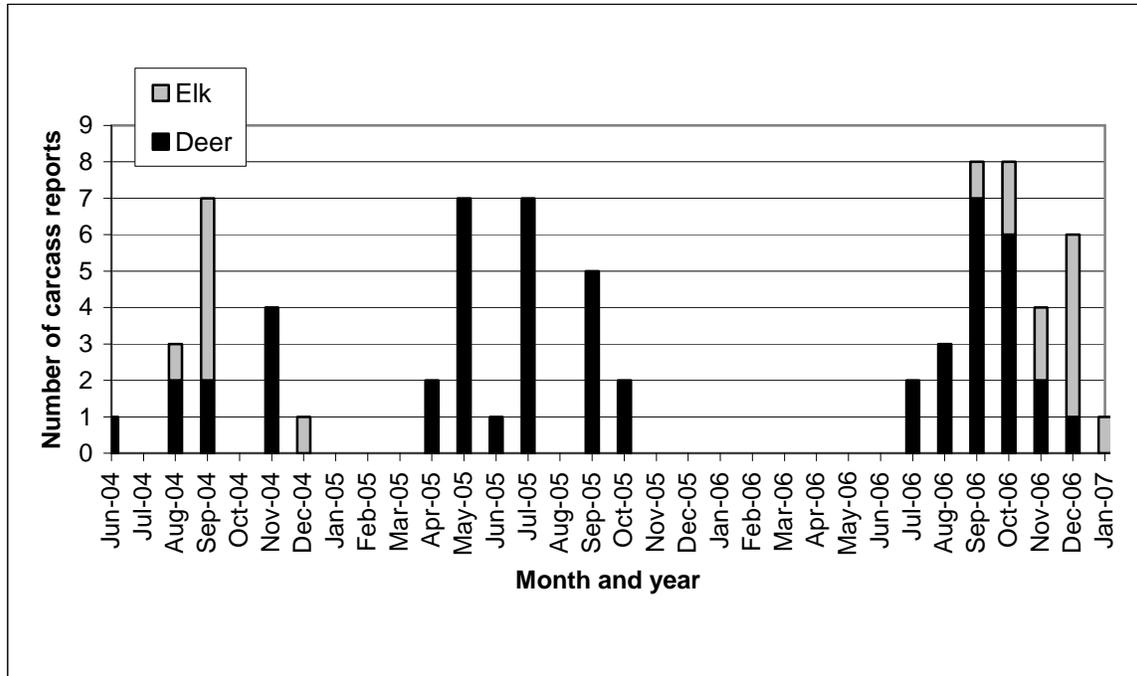
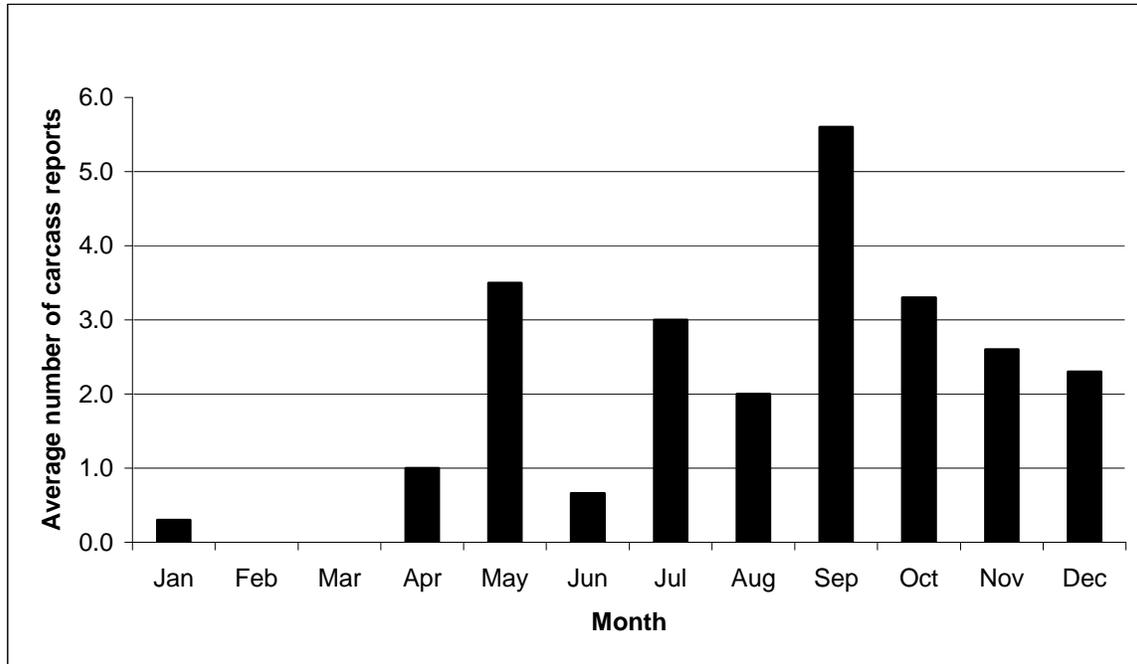


Figure 19: Carcass removal reports by month from June 2004 to January 2007. (Total n = 72). (Data provided by ITD).

Carcass removal data for elk and deer combined were categorized by month (regardless of year) and then averaged by number of years of available data (Figure 20). September had the highest average number of carcass removal reports followed by May and October. The data indicate that most carcass reports occur in summer to early winter (July through December) with another spike in spring (May).



**Figure 20: Combined deer and elk carcass removal reports by month. Note: June through January averages are based on three years of data while February through May averages are based on two years of data. (Data provided by ITD).**

Snow tracking was thought to be a feasible option from November through March (Pers. com. IDFG and ITD personnel at kickoff meeting October 2006). Given that some historic carcass removal reports for deer and elk occurred in winter, it is possible that snow tracking could generate meaningful data.

## 2.5 Hourly Distribution of Deer- and Elk-Vehicle Collisions

There were 58 WVC IHP accident reports from January 27, 1998 - December 1, 2006. All reported WVCs occurred in two periods: 5-11am and 5pm – 2am (Figure 21). The hour of day with the highest number of WVCs was 9-10 pm; 22% of all reported WVCs.

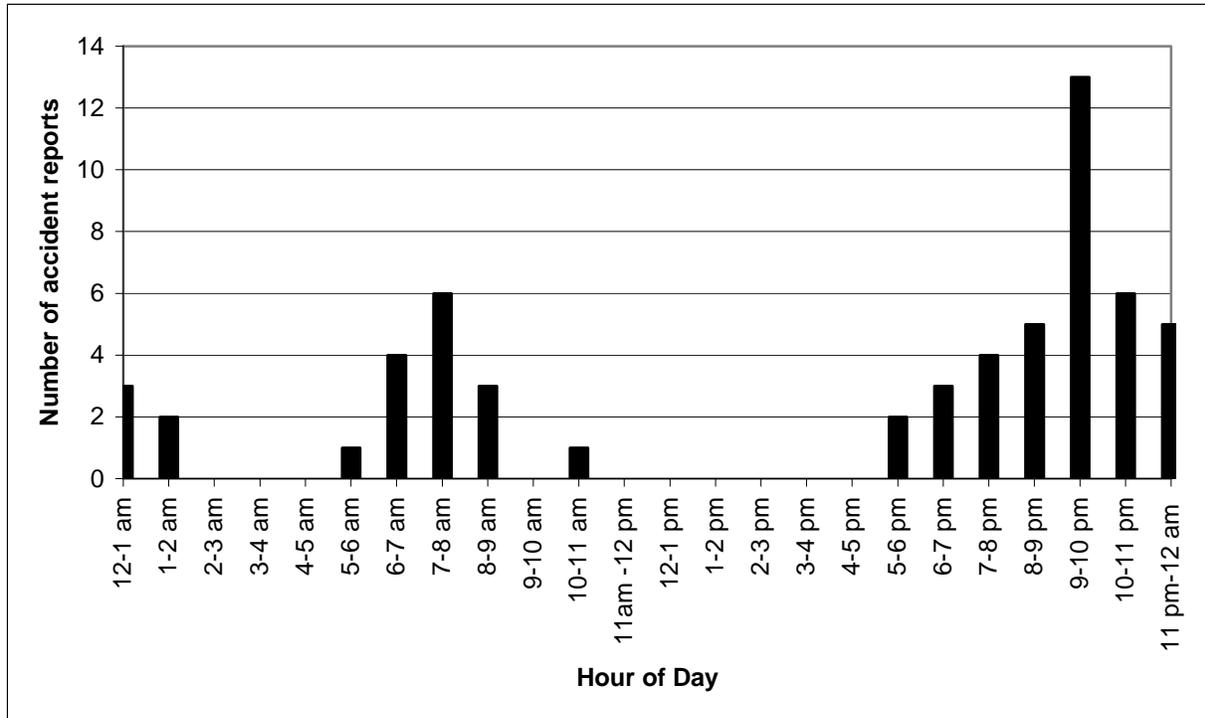


Figure 21: Wild animal accidents by time of day. (Total n = 58). (Data provided by IHP).

Seventy percent of the reported WVCs occurred in darkness (With no street lights, n=40; With street lights on, n=1) (Figure 22). Another 9% occurred during dawn or dusk, and the remaining 21% occurred during the day.

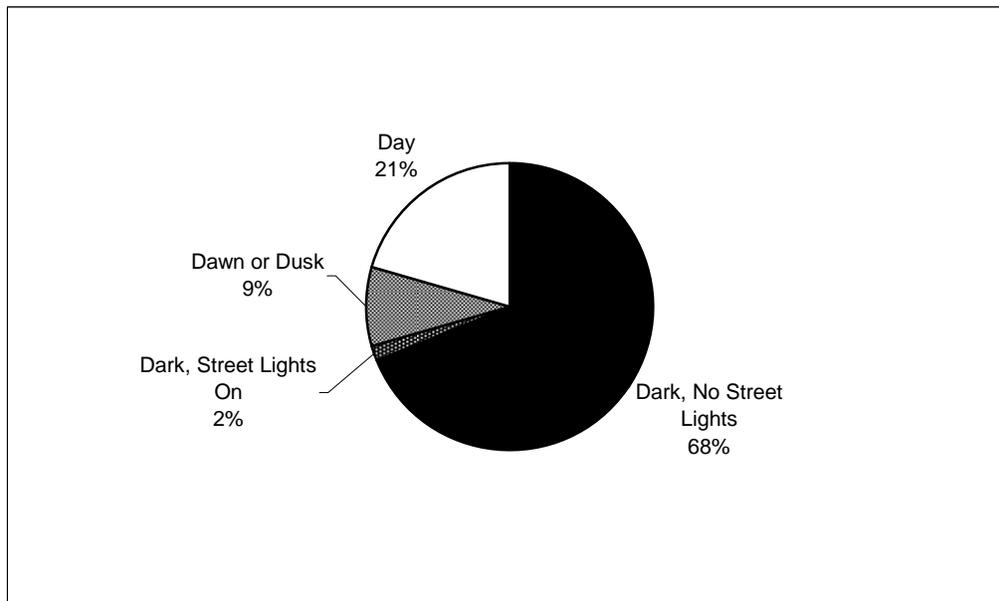


Figure 22: Relative percentage of wild animal accidents by lighting condition (Total n = 58) (Data provided by IHP).

### 3 TASK 3: ANALYSIS OF CURRENT ROAD MORTALITY DATA

#### 3.1 Carcass Removal Data

Idaho Transportation Department carcass removal reports from 2007 illustrate a continued growing number of reported deer- and elk-vehicle collisions in the study area over four consecutive years (Figure 23).

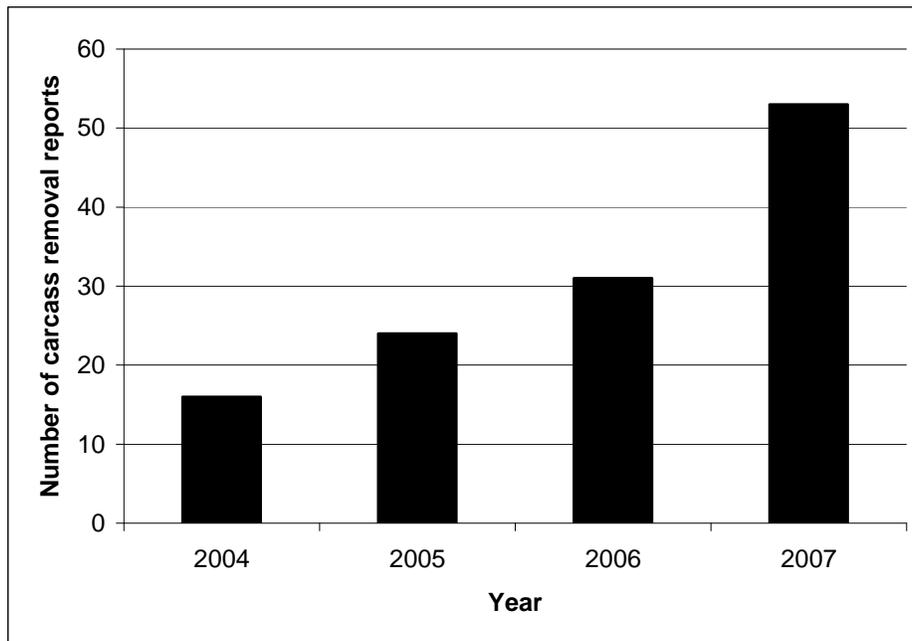


Figure 23: Carcass removal data by year (2004 through 2007). Note: 2004 data appears to include reports from June through December only (Data provided by ITD).

#### 3.2 Web-Based Wildlife Observation Data Collection by the Public

In order to increase our understanding of wildlife-vehicle collisions and wildlife movements across the road in the study area, the public was asked to submit their wildlife sightings into an online database called “Ketchum on the Road.” A variety of methods were used to inform the public about the website (Table 2).

**Table 2. Media and outreach activities to encourage the public to report wildlife observations**

<p><b>Variable Message Sign (VMS) deployment – oriented for northbound traffic only</b></p> <p>Mile post 117.2 McKercher north of Hailey April 12-19, 2007</p> <p>Mile post 107 near Walker Road south of Bellevue June 7-14, 2007</p> <p>Mile post 120.3 between Hailey and Ketchum November 2 - December 2, 2007</p>
<p><b>Promotions</b></p> <p>Fliers were posted in Ketchum, Hailey and Bellevue (eg., in businesses, libraries, County and Federal offices, etc.)</p> <p>The Environmental Resource Center published an announcement in their newsletter</p>
<p><b>Web and print media coverage</b></p> <p>Press release by Blaine County and Western Transportation Institute on March 12, 2007</p> <p>Blog announcement by Tom Bowman on April 17, 2007</p> <p>“A steady diet of road kill”, Wood River Journal, May 1, 2007  <a href="http://www.woodriverjournal.com/articles/2007/05/02/news/local_news/astory.txt">http://www.woodriverjournal.com/articles/2007/05/02/news/local_news/astory.txt</a></p> <p>“Information on wildlife road kill still sought”, Idaho Mountain Express, November 2, 2007  <a href="http://www.mtexpress.com/vu_breaking_story.php?bid=4523">http://www.mtexpress.com/vu_breaking_story.php?bid=4523</a></p> <p>“Study aims to solve road kill dilemma”, Idaho Mountain Express, November 7, 2007  <a href="http://www.mtexpress.com/index2.php?ID=2005117865&amp;var_Year=2007&amp;var_Month=11&amp;var_Day=07">http://www.mtexpress.com/index2.php?ID=2005117865&amp;var_Year=2007&amp;var_Month=11&amp;var_Day=07</a></p> <p>“Motorists contribute to road kill survey”, Idaho Mountain Express, March 12, 2008  <a href="http://www.mtexpress.com/index2.php?ID=2005119766">http://www.mtexpress.com/index2.php?ID=2005119766</a></p>
<p><b>Public Service Announcement</b></p> <p>played multiple times during the course of the study at the discretion of radio personnel</p> <p>KECH 95</p>
<p><b>Public Presentation</b></p> <p>Ketchum on the Road – Wildlife Reporting Website at The Community Library in Ketchum on Thursday, November 1, 2007 at 6:00pm.</p>

A link from the Blaine County website <http://www.blainecounty.org> (Figure 24) lead users to the wildlife report submission site <http://www.coe.montana.edu/wti/roadkill/BlaineCounty/Index.aspx> located on the WTI server (Figures 25-29).

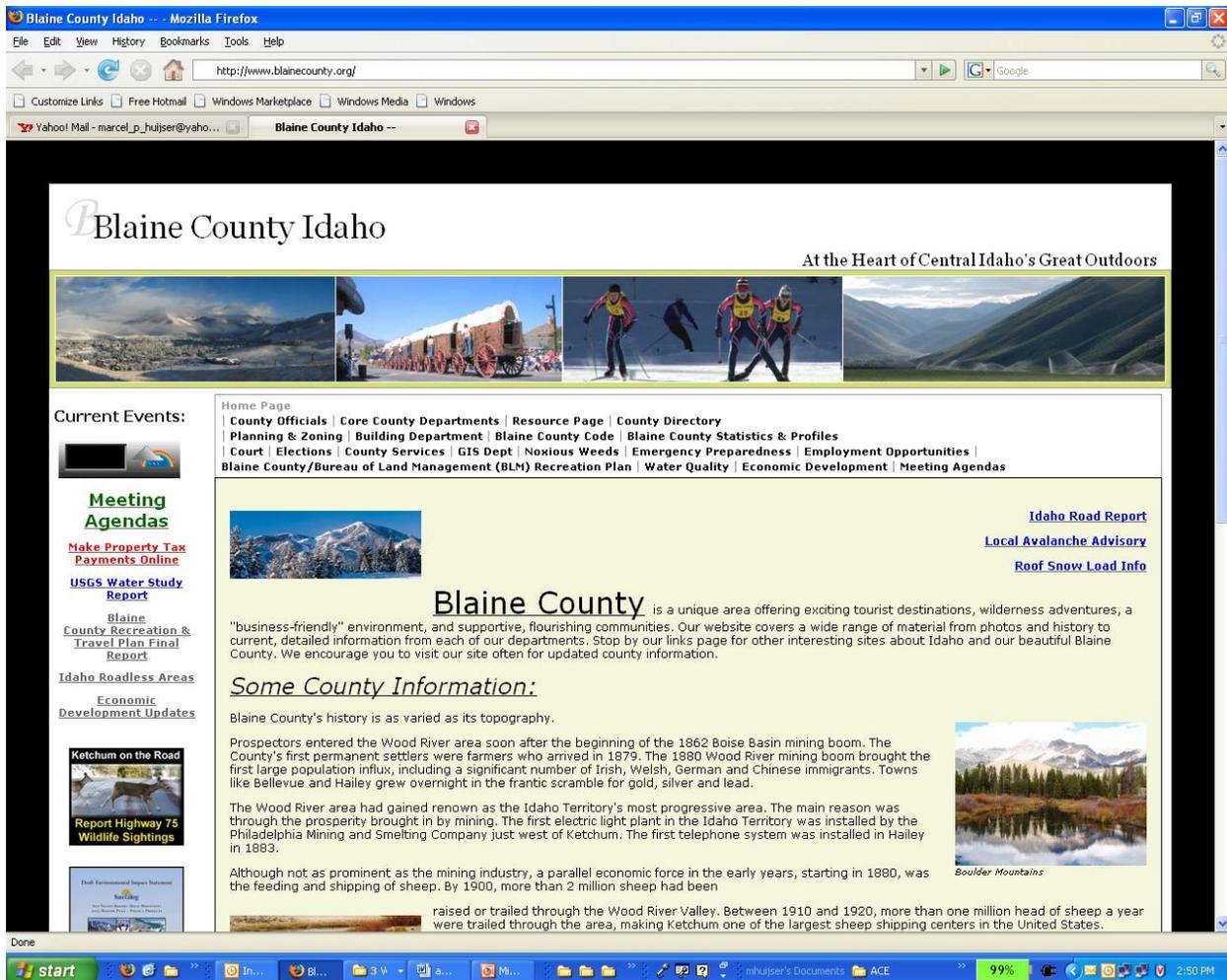


Figure 24: Screenshot of Blaine County’s website with a button link to “Ketchum on the Road: Report Highway 75 Wildlife Sightings” on left hand navigation bar.

**Ketchum on the Road: Wildlife Sightings**

Thank you for your interest in sharing information on wildlife sightings (dead or alive) along State Highway 75 between Timmerman Jct. (US Hwy 20) and Ketchum. The website is designed to collect **consistent** and **spatially accurate** information about animals that are killed by traffic or that cross the road successfully. Please only submit observations of wildlife seen **on the road or within the right-of-way**.

**Instructions:** The observation reporting map (see link below) has green markers that show landmark locations along the highway. To get started, find a green marker near where you made your wildlife observation. Zoom in on the map until you can identify the specific place where you spotted the animal(s) (dead or alive). Use the red markers, which appear when you zoom in, to indicate the location of your observation. Click on the red marker nearest your observation to record data.

**How your information will help:** Your observations will help Blaine County officials and wildlife biologists pinpoint locations on the highway where most animals, especially mule deer and elk, are killed by traffic or cross the road successfully. They will use this information to plan safety measures that help drivers avoid collisions with animals, and that allow safe passage for animals as they move across the road and through their habitat.

Click the following button to identify your observation location on the map.

(You must have JavaScript enabled to view the map. Please allow time for map files to download)

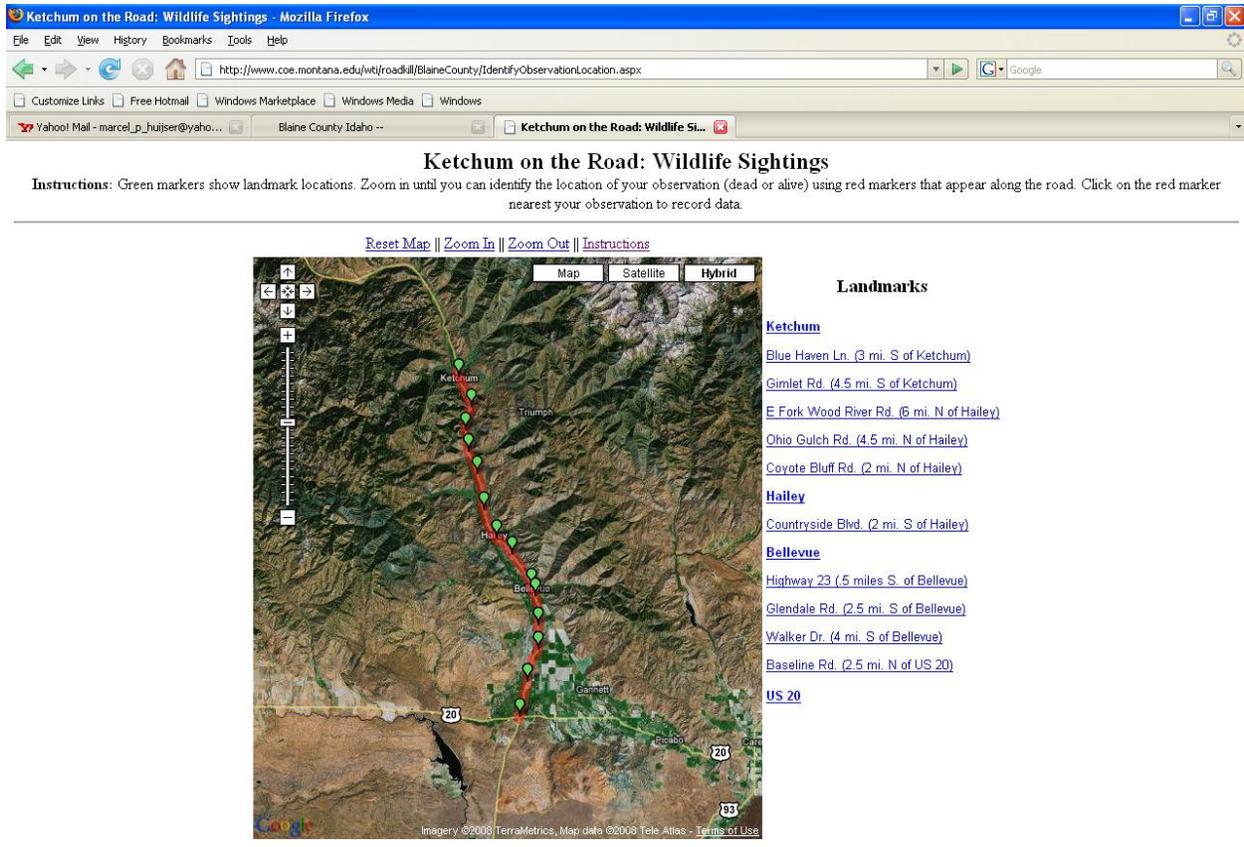
If you have any questions, please contact:

Don Wright  
Blaine County Operations Manager  
Phone: (208) 720-6346  
E-mail: [donwright@co.blaine.id.us](mailto:donwright@co.blaine.id.us)

Or

Marcel P. Huijser, PhD  
Principal Investigator, Research Ecologist  
Western Transportation Institute  
Montana State University (WTI-MSU)  
Phone: (406) 543-2377  
E-mail: [mhuijser@coe.montana.edu](mailto:mhuijser@coe.montana.edu)

Figure 25: Screenshot of introductory information about the database on WTI's website.



**Figure 26: Screenshot of Google Earth map depicting landmarks in study area and surrounding topography. This allowed users to zoom in on the appropriate road section.**

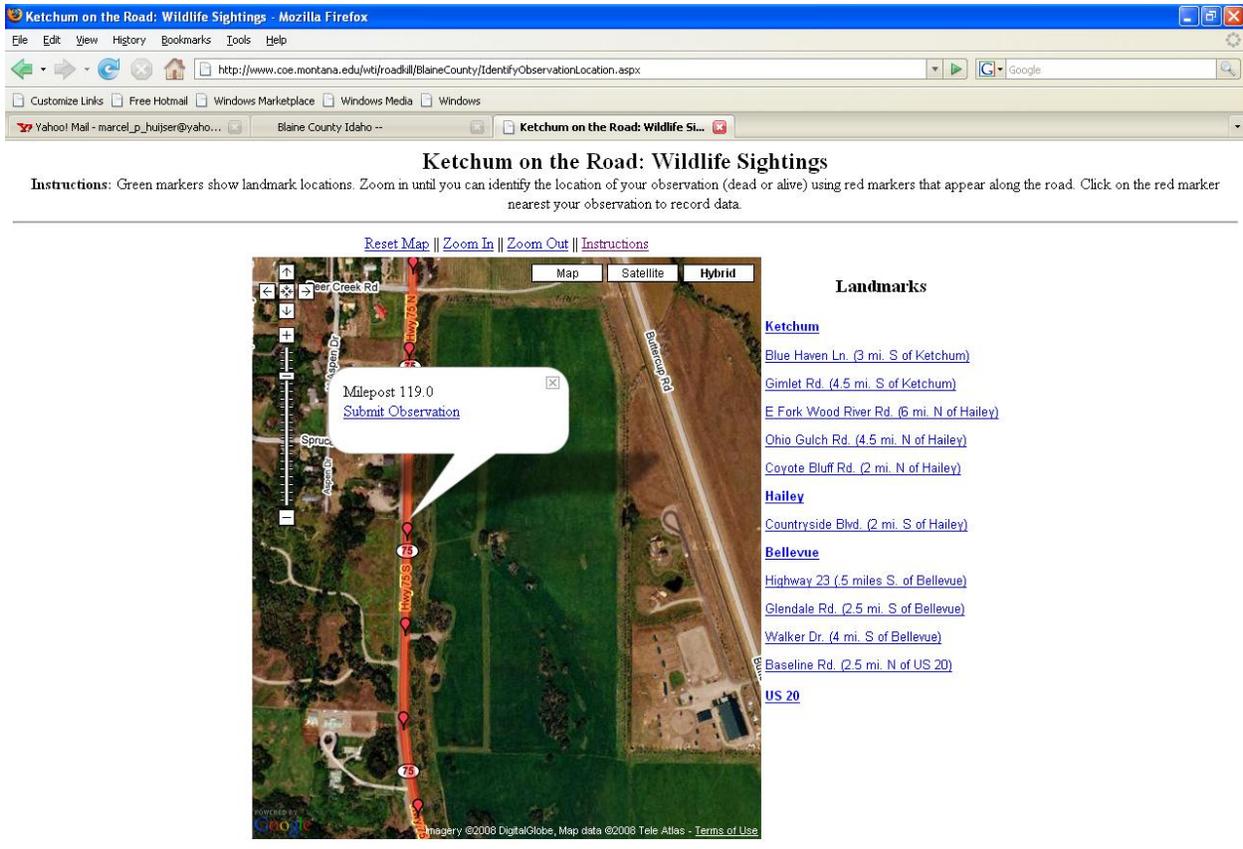


Figure 27: Screenshot of Google Earth map depicting landmarks in study area and surrounding topography. This screenshot shows 0.1 mi posts (red markers) around the 119.0 mi post.

**Blaine County: Wildlife Sightings**

- The questions below relate to the location you have just chosen.
- The questions below relate to one observation only. An observation is defined as: "animals that you saw at the same place, at the same time, that belonged to the same species, and that were all either dead or alive." If you saw animals at different locations, at different times, or if the animals belonged to different species, or if you saw both dead and alive animals, please treat them as separate observations and repeat the entire procedure.

The 0.1 mi location closest to your observation. (Filled in automatically.)

119.0

Did you observe (choose 1):

road-killed animal(s) (dead on road or within right-of-way)

live animal(s) (on road or within right-of-way)

What species?

(select)

[Click here for help identifying species. \(The Smithsonian Institute's North American Mammals site will open in a new window.\)](#)

How many individuals of that species did you see at that location? (Enter a number.)

On what date?

February 2008						
Sun	Mon	Tue	Wed	Thu	Fri	Sat
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	1
2	3	4	5	6	7	8

At what hour of the day?

(select)

Comments (free text)

Submit Observation

Figure 28: Screenshot of the data form for submitting a live or dead animal observation. Note: the tenth of a mile location obtained when clicking on a red marker on the previous page was automatically stored in the data form.

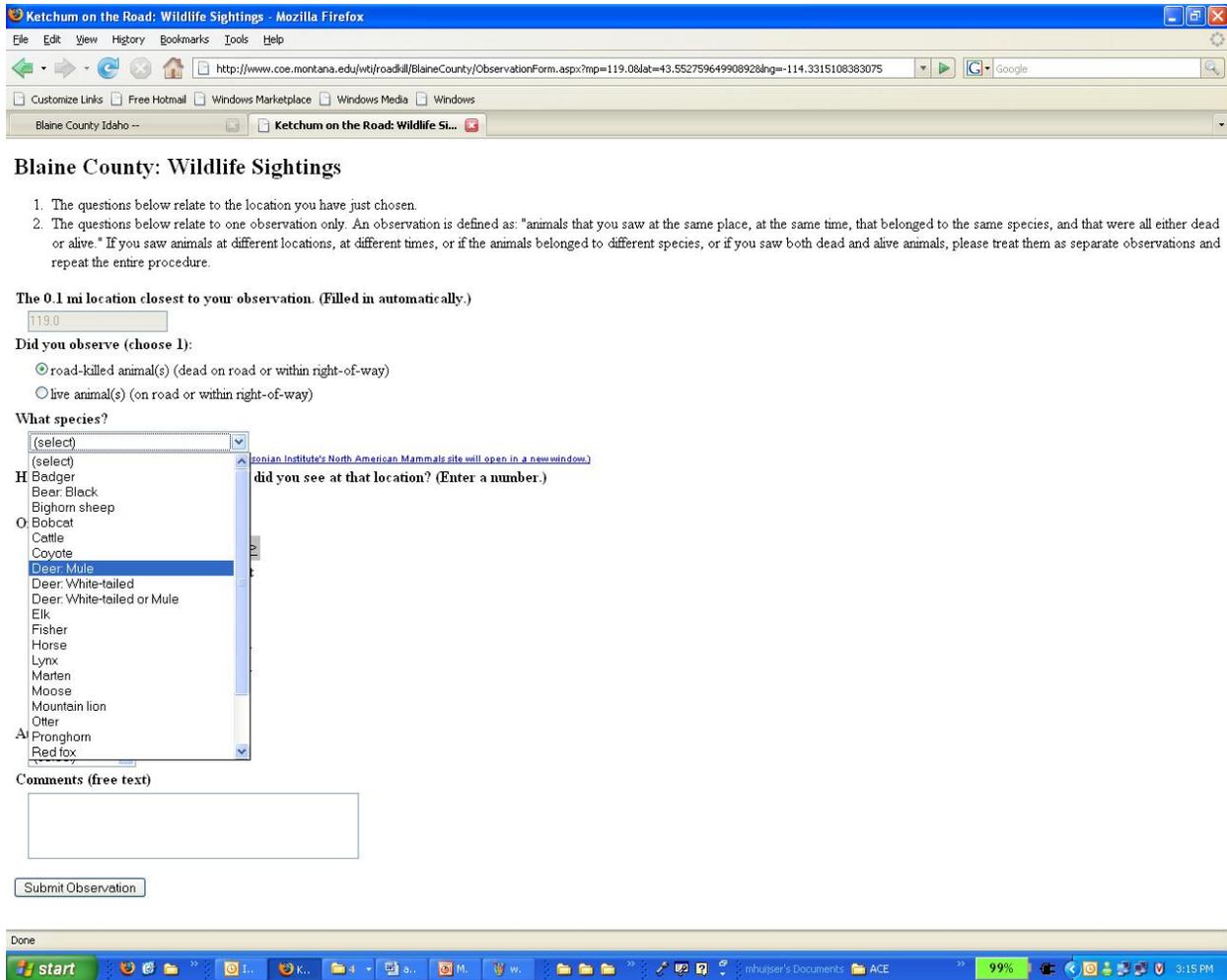


Figure 29: Screenshot illustrating easy-to-use drop down menus and space for free form comments.

On March 12, 2007, WTI and Blaine County issued a press release to the media stating that wildlife reporting website was online. In April, June and November, 2007, ITD deployed a variable message sign (VMS) to advertise the website for at least seven consecutive days (Table 2). The VMS rotated between two screens, the first of which requested the public to report wildlife on road the second of which directed them to the website (Figure 30).



**Figure 30: Two rotating screens of the variable message sign deployed by ITD (© Angela Kociolek, WTI-MSU).**

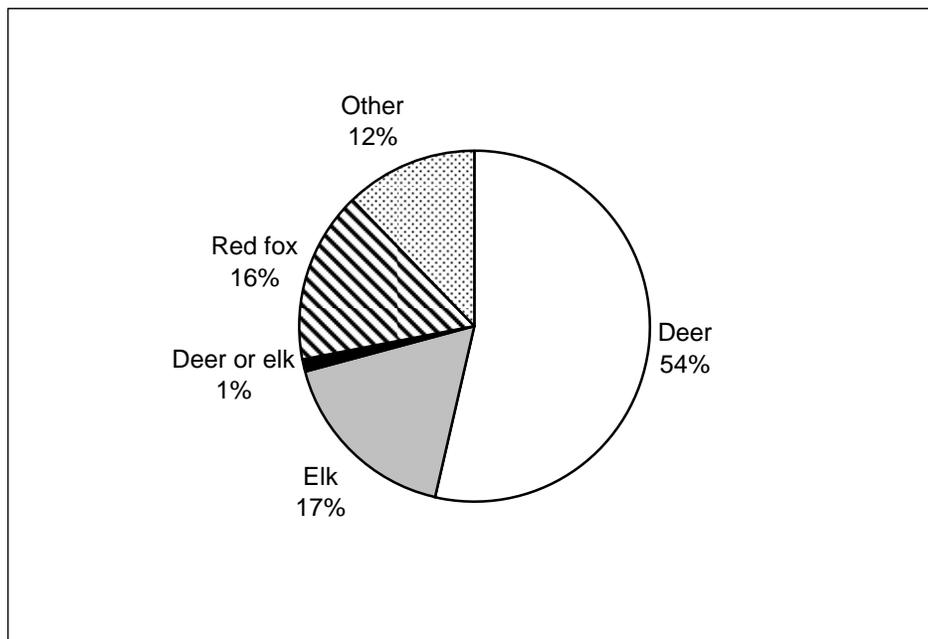
A total of 312 entries were made. The first entry by the public was made on March 28, 2007 and the last report included in our analysis was received on March 24, 2008. Three entries offered comments on the merits of phone versus internet reporting but did not offer any wildlife observations. Four entries included wildlife reports from outside of the stated study area. Ten entries included wildlife observations made before the study period. A total of 295 reports yielded wildlife observations from the road or right-of-way between mile post 102 near Timmerman Junction (Highway 20) and mile post 129 just north of Ketchum and were observed between March 25, 2007 and March 10, 2008 (Table 3). Note that for the purposes of the web-based mapping software, the study area was expanded to include the mile posts 102.0 and 129.0.

**Table 3. Break down of public reports received via website**

Total public reports on website	312
Comments with no wildlife data	- 3
Reports from outside of study area	- 4
Reports of observations prior to the study period	-10
Total live (n=200) and dead (n=95) observation reports	295
Replicate reports of a single wildlife or carcass observation	- 39
Total unique live (n=184) and dead (n=72) reports	256

There were 200 reports of live animals including black bear, buffalo, coyote, mule deer, white-tailed deer, mule or white-tailed deer, elk, moose, red fox, and wolf (Table 3). Due to the possibility of multiple reports from different people for the same wildlife sighting, the following rule was applied: live observations of the same species that were reported to occur within 1 hour of each other and that were within .2 miles of each other were treated as replicates. In those cases where replicates had differing animal counts, the largest number was chosen. Based on this rule, sixteen reports related to replications of a single wildlife sighting, therefore, there were 184 unique live wildlife sightings.

There were 95 reports of dead animals, including mule deer, white-tailed deer, elk, red fox, raccoon, skunk, domestic dog, bird, and unknown species. Due to the possibility of multiple reports from different people for the same carcass sighting, the following rule was applied: dead observations of the same species that were reported to occur within 2 days of each other and that were within .2 miles of each other were treated as replicates. Based on this rule, 23 reports related to replicate reports of a single carcass, therefore, there were 72 unique reports of carcasses. Some collisions resulted in more than one carcass, therefore, the total unique carcass count for all species was higher than 72 (Figure 31).



**Figure 31: Public reports of unique carcasses by species. (Total n =82). “Other” category includes bird, raccoon, skunk, domestic dog and “unknown species”.**

This study was most concerned with vehicle collisions with large bodied mammals (i.e., deer size and larger) that pose a safety concern. In this area, and along this road section, the main interest was with mule deer and elk (see introduction). There were 50 unique dead deer and elk reports for a total of 59 carcasses. There were 158 unique live reports of deer, elk or moose, some of which reported more than one individual animal per sighting. Unique live and dead

reports (note that one report could relate to multiple animals) for all ungulate species combined (deer, elk and moose) were categorized by location (Figure 32). Most of the ungulate reports (live or dead) were focused between MP 117 and 127 (Figure 33-34). The highest concentration of carcasses was observed between MP 118.4 and 119.1 (Figure 34). The only other .1 mileposts with more than one carcass reported were MP 117.7, 120.3 and 125.7. It should be noted that a single dead deer report accounted for all five carcasses counted in MP 120.3. It is unknown whether there were indeed five carcasses seen in a single observation. See Section 4.3 for public crossing data analysis.

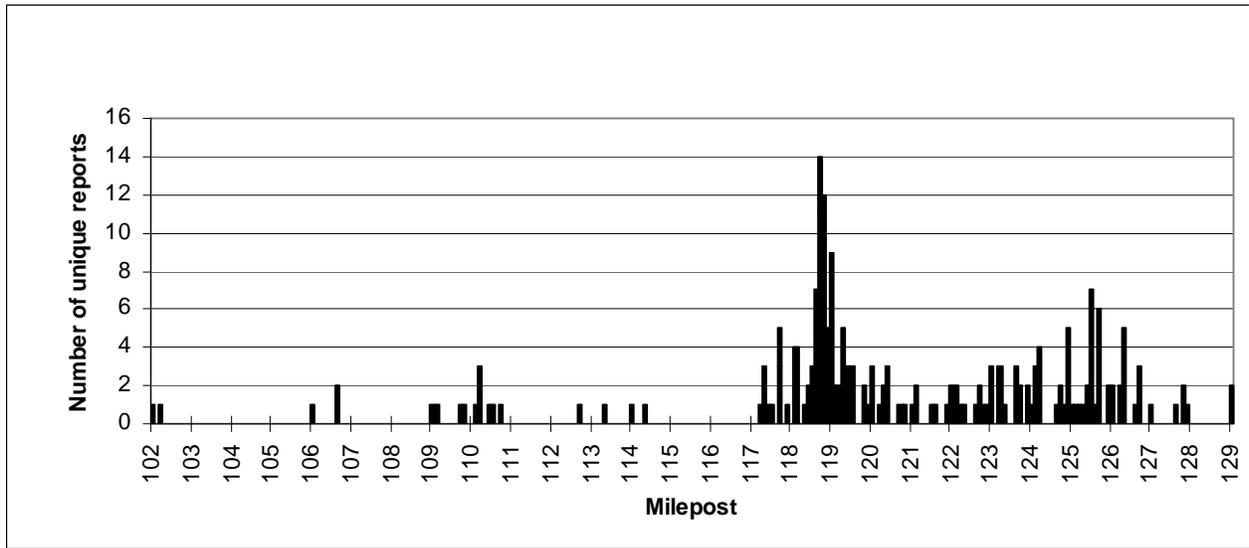


Figure 32: Public reports of unique ungulate reports (alive and dead combined) by milepost for the entire study area (Total n = 208). Note that this figure illustrates the number of unique reports only (i.e. one report may relate to multiple animals).

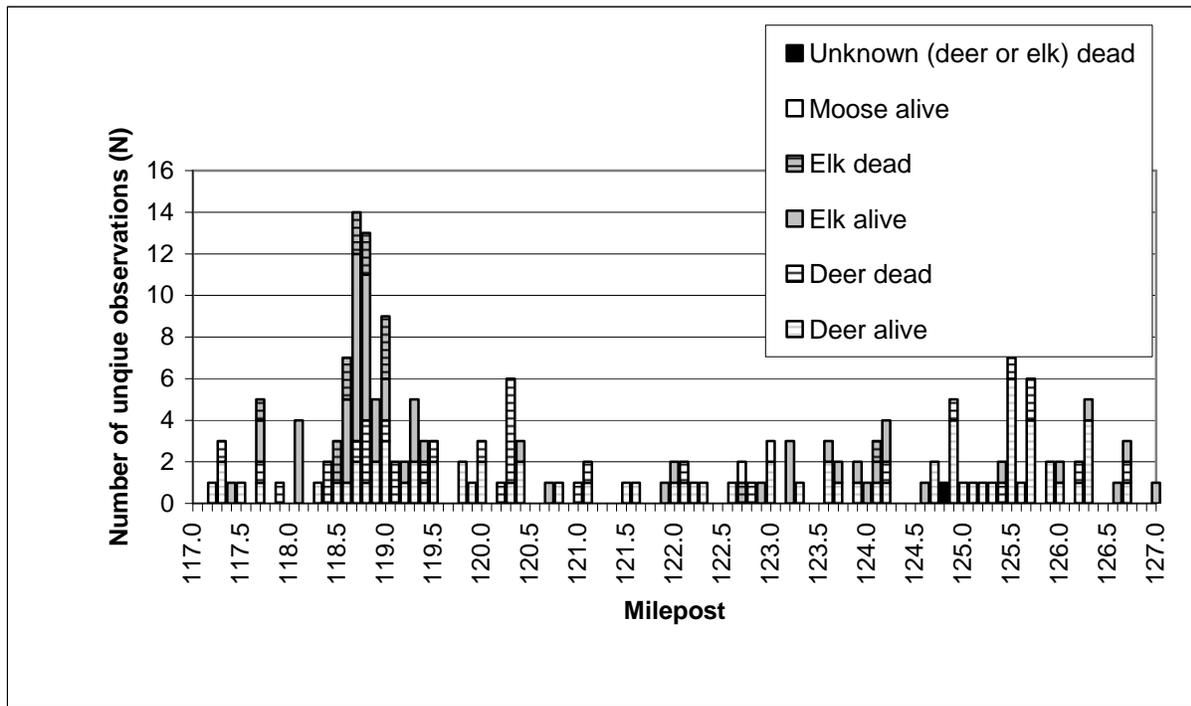
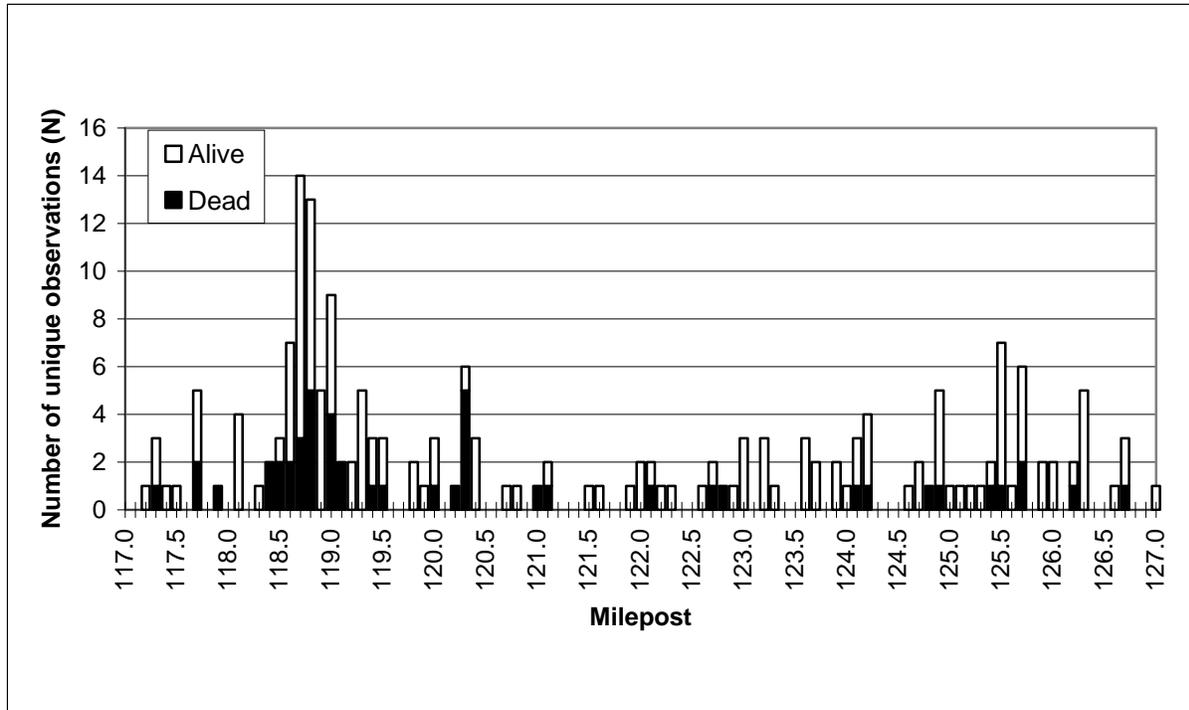


Figure 33: Public reports of unique deer, elk and moose carcasses (each carcass is counted in the graph) and unique alive reports (the number of reports of live animals is counted, but not the number of animals seen alive) by mile post for MP 117-127 (Total n = 187).



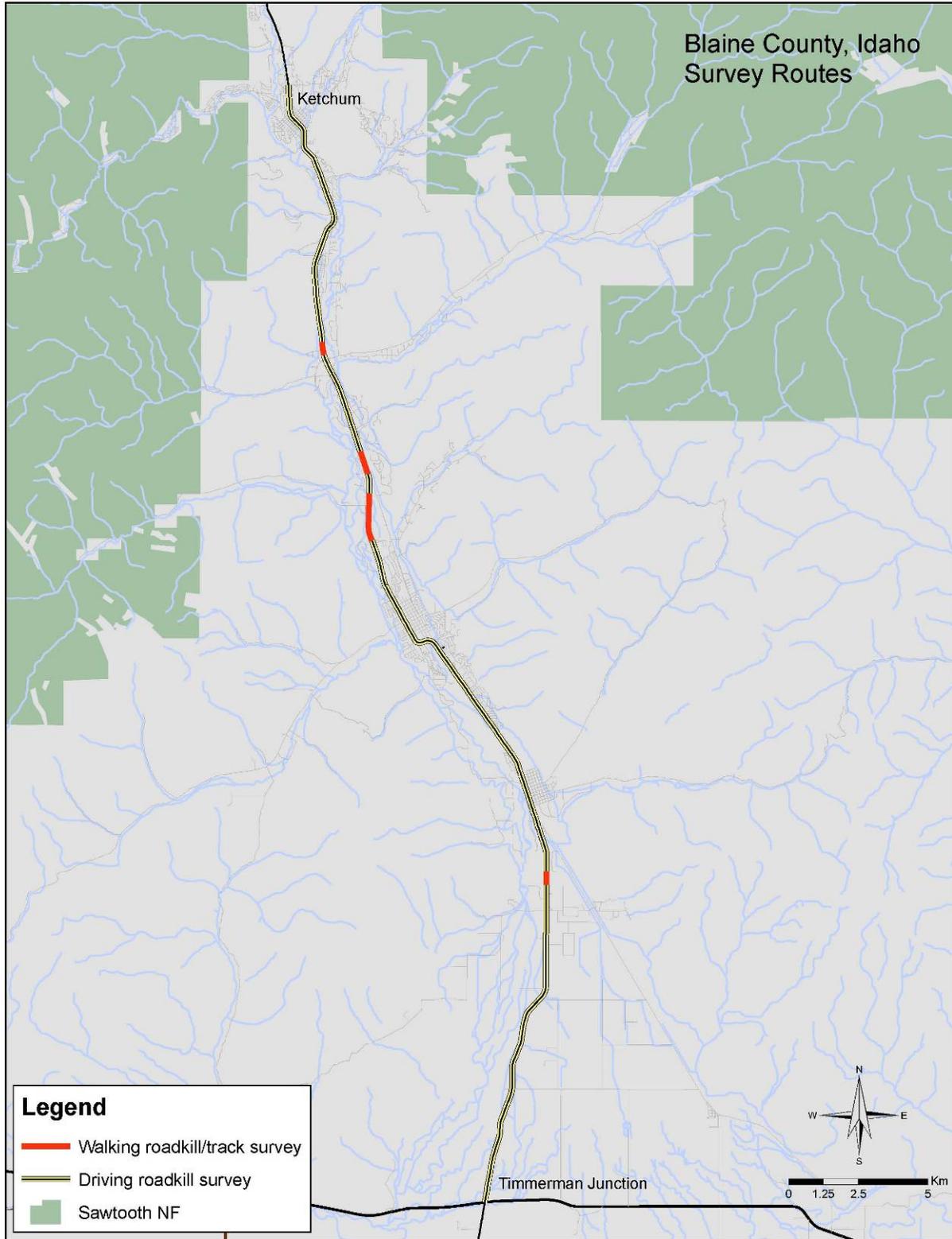
**Figure 34: Public reports of unique ungulate (deer, elk and moose) carcasses (each carcass is counted in the graph) and unique alive reports (the number of reports of live animals is counted, but not the number of animals seen alive) by mile post for MP 117-127 (Total n = 187).**

### 3.3 Road Mortality Data Collection by WTI

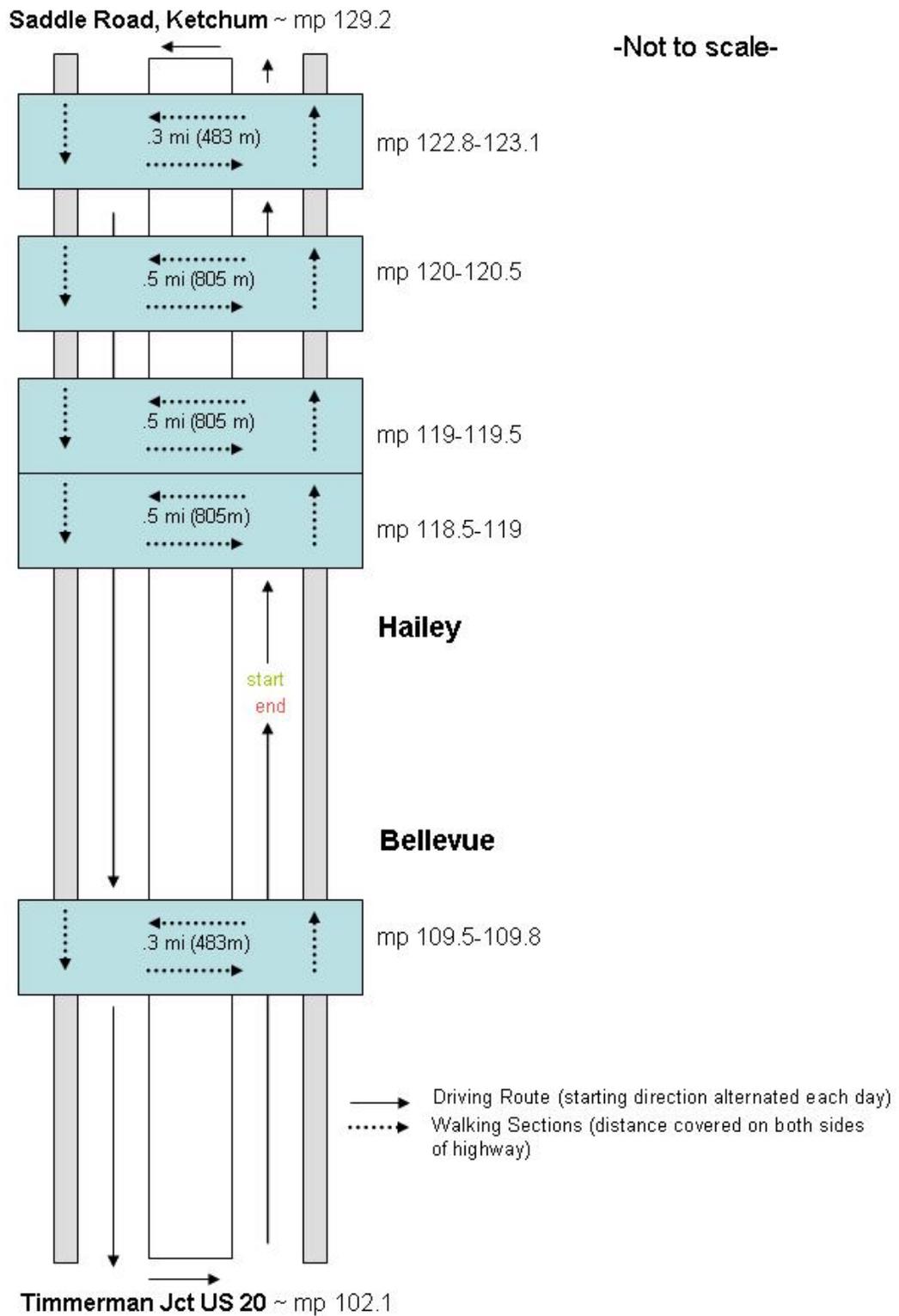
Road mortality surveys were conducted by WTI personnel four times during the study period for ten consecutive days each. In an attempt to capture seasonal differences, the survey periods were:

- April 10 - 19, 2007 (spring)
- July 2 - 11, 2007 (summer)
- October 28 – November 6, 2007 (fall)
- February 21 – March 1, 2008 (winter)

For safety reasons, surveys generally began after 9 am to avoid morning commuter traffic. A flashing amber light was mounted to the top of the vehicle and a hard hat and safety vest was worn when walking along the roadway. The 26 mi long road section was driven by the observer in both directions. The road section extended from Timmerman Junction (mile post 102.1) to Saddle Road just north of Ketchum (milepost 129.2) (Figure 35). Saddle Road was chosen as a convenient and safe turn around point. The initial direction of driving surveys alternated between heading north and south each day. The five road sections with the highest concentration of historic WVCs, as determined from the analysis of historic ITD carcass and IHP accident data (see section 2.3), were selected for walking surveys. The maximum length of each walking section was 0.5 miles. Walking surveys were conducted in the right-of-way on both sides of the road while facing traffic (Figure 35 - 36).



**Figure 35: Map of road mortality driving and walking survey routes. Note that road mortality walking survey sections are the same as the snow tracking section to be discussed in Section 4.1.**



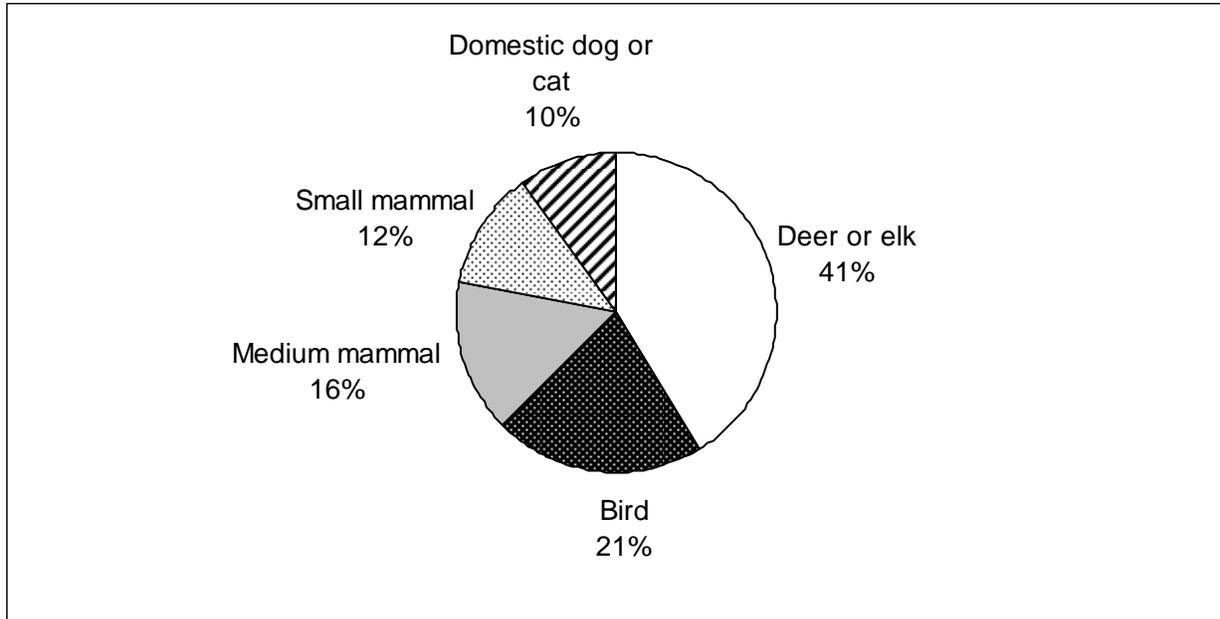
**Figure 36: Schematic presentation of the driving and walking road mortality survey routes.**

In addition to searching for actual animal carcasses directly, the surveyor also noted skid marks, blood stains, scavenging birds and any other sign of a wildlife-vehicle collision. Each carcass or WVC sign was recorded with a Road mortality Observation Collection System (ROCS) (PDA/GPS).

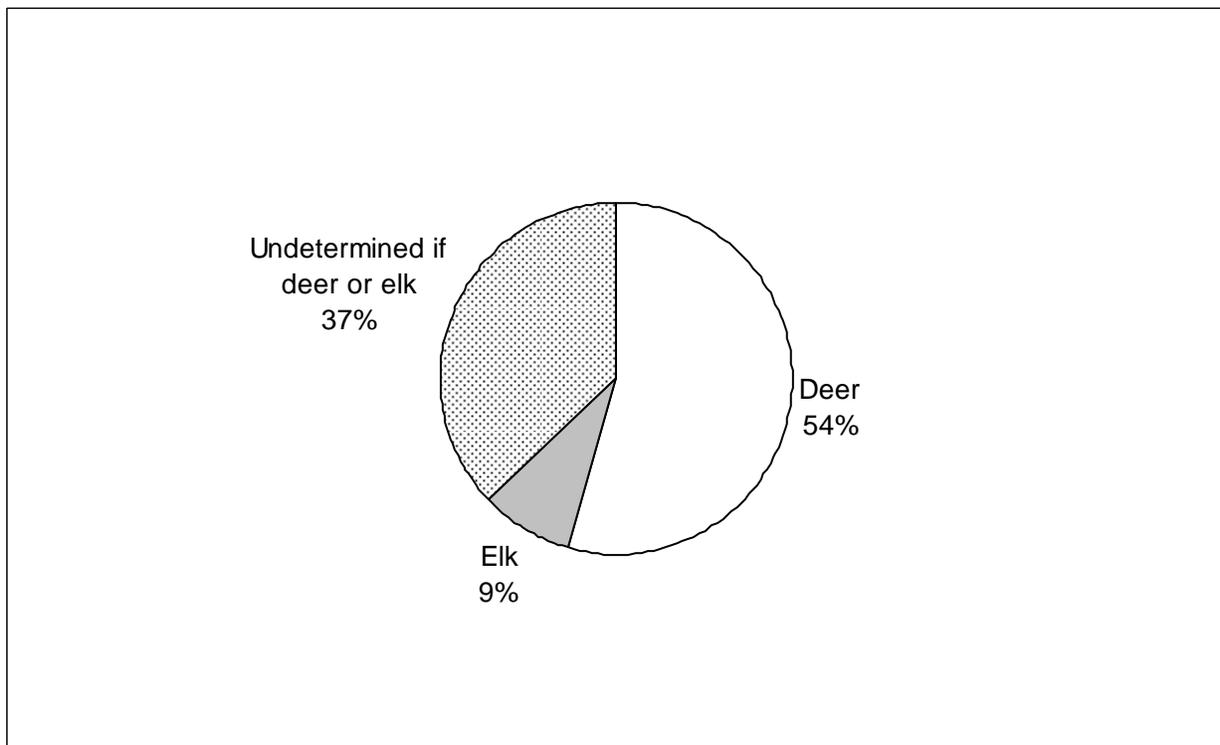
A total of 110 animal road kills were recorded during the four ten-day survey periods between April 2007 and March 2008 (Table 4). Seventy-nine percent were mammal (wild and domestic) carcasses of which ungulates accounted for 41%. Bird carcasses accounted for approximately 21% (Figure 37). A single reptile carcass was found during the entire survey period. A total of 46 ungulate carcasses were detected during the four ten-day survey periods (Figure 38).

**Table 4. Cumulative list of species detected during four ten-day road mortality surveys, 2007-08 (Total n = 110). Note: The “Unidentifiable Mammal” was not an obvious carnivore or ungulate.**

Species	Carcass Count	Species	Carcass Count
<b>Reptile</b>		<b>Mammal</b>	
Snake (species could not be determined)	1	Elk ( <i>Cervus elaphus</i> )	3
		Mule deer ( <i>Odocoileus hemionus</i> )	15
<b>Bird</b>		Deer species ( <i>Odocoileus sp.</i> )	8
Northern Flicker ( <i>Colaptes auratus</i> )	2	Red fox ( <i>Vulpes vulpes</i> )	6
American Robin ( <i>Turdus migratorius</i> )	7	Striped skunk ( <i>Mephitis mephitis</i> )	2
Bullock's Oriole ( <i>Icterus bullockii</i> )	1	Ermine ( <i>Mustela ermina</i> )	1
Black-billed Magpie ( <i>Pica hudsonia</i> )	7	Long-tailed weasel ( <i>Mustela frenata</i> )	1
Brewer's Blackbird ( <i>Euphagus cyanocephalus</i> )	1	Raccoon ( <i>Procyon lotor</i> )	4
Lincoln Sparrow ( <i>Melospiza lincolnii</i> )	1	Vole species (Family <i>Muridae</i> )	1
Unidentifiable bird	4	Ground squirrel ( <i>Spermophilus sp.</i> )	3
		Red squirrel ( <i>Tamiasciurus hudsonicus</i> )	2
<b>Domestic species</b>		Unidentifiable Carnivore	5
Cat ( <i>Felis catus</i> )	9	Unidentifiable Ungulate	19
Dog ( <i>Canis lupus familiaris</i> )	2	Unidentifiable Mammal	5

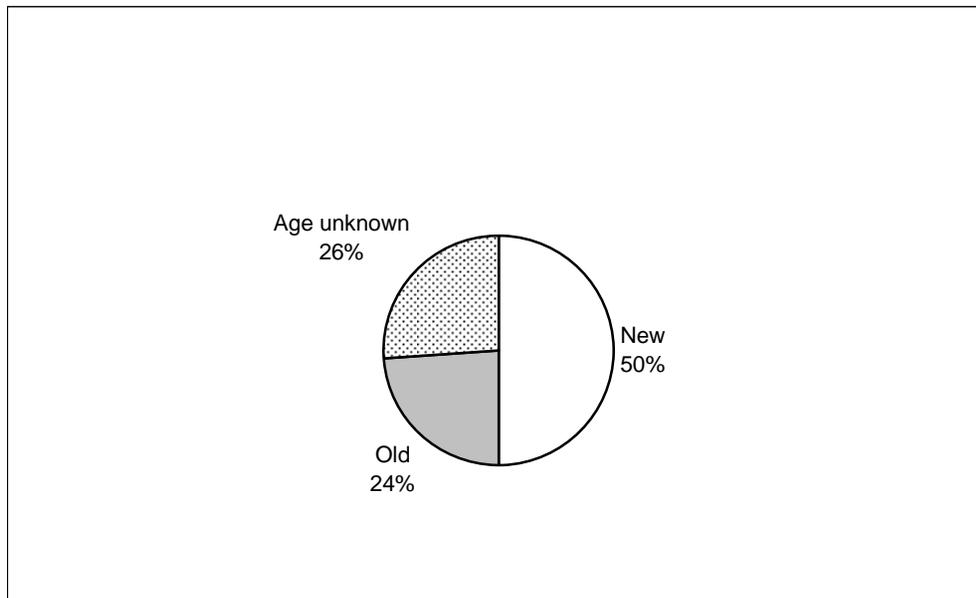


**Figure 37: Relative abundance of road kill observed during WTI surveys (Total n = 109).** “Medium mammal” includes raccoon, striped skunk, red fox and “unidentifiable carnivore”. “Small mammal” includes ermine, long-tailed weasel, red squirrel, ground squirrel, vole and “unidentifiable mammals” that were not obviously ungulate or carnivore. One snake was also found but this observation is not included in this graph.



**Figure 38: Relative abundance of all road killed deer and elk detected during WTI surveys (Total n = 46).**

In some cases it was difficult to determine whether an animal was recently hit or if a scavenger had moved part of a carcass into view. In order to determine if a seasonal pattern exists, it is necessary to determine when the WVC took place. Each carcass or remnant of carcass was classified as “new”, “old” or “age unknown”. “New” indicates that the WVC clearly took place during one of the four survey periods. “Old” indicates the WVC likely took place before the individual ten-day survey periods started. “Age unknown” indicates there was no way to determine when the WVC took place. Twenty-four percent (n=11) of the carcasses were classified as “old,” that is, it was determined that the animal had not been hit during one of the four the discrete survey periods (Figure 39). If only new carcasses are considered, most road mortality occurred in fall followed by summer. If new and age unknown carcasses are considered, then most road mortality occurred in fall and spring (Figures 40-41).



**Figure 39: General age of carcasses detected during WTI surveys. (Total n = 46).**

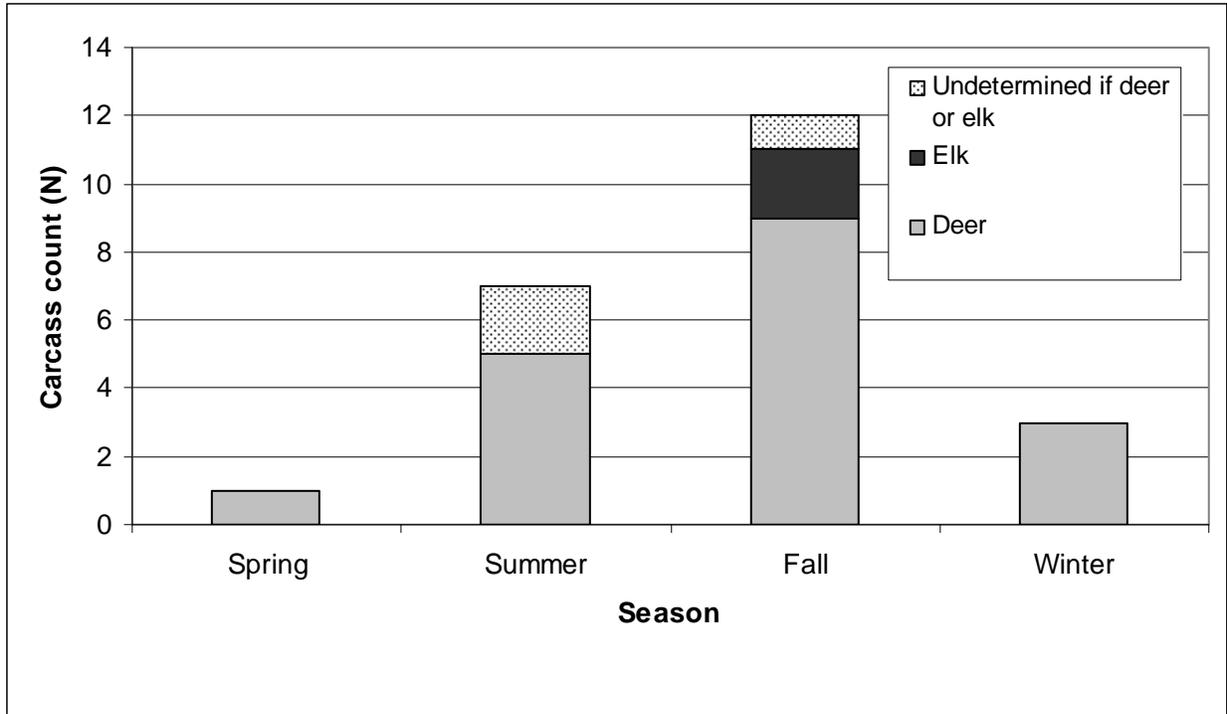


Figure 40: "New" mule deer and elk road kill detected during WTI surveys by season. (Total n = 23).

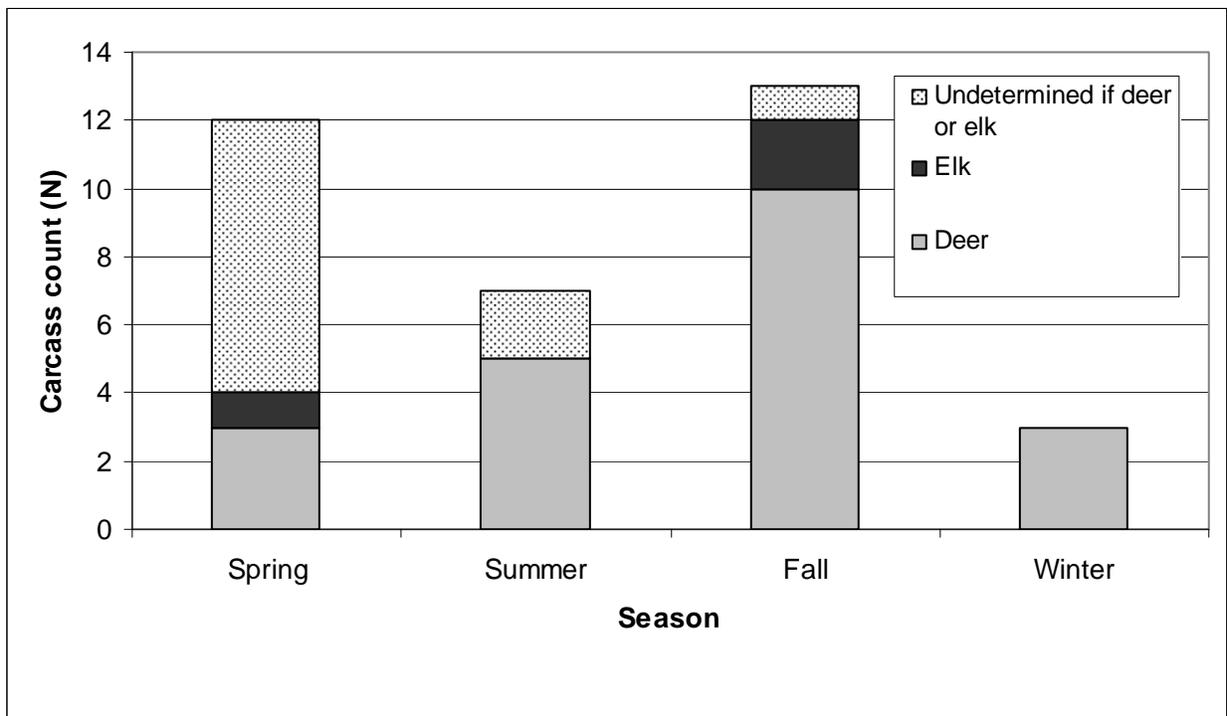


Figure 41: "New" and "age unknown" mule deer and elk road mortality detected during WTI surveys by season (Total n = 35).

All ungulate road kills detected during WTI surveys were found between MP 109.0 - 126.0 with the highest concentration found between MP 118.5-119.6 (Figures 42 and 43). Four out of five current (WTI) road mortality concentration areas match those found in the historical data (ITD and IHP) as defined in Section 2.3 (Figure 44). These current data confirm that historical data was useful in determining the locations of WVC concentration areas.

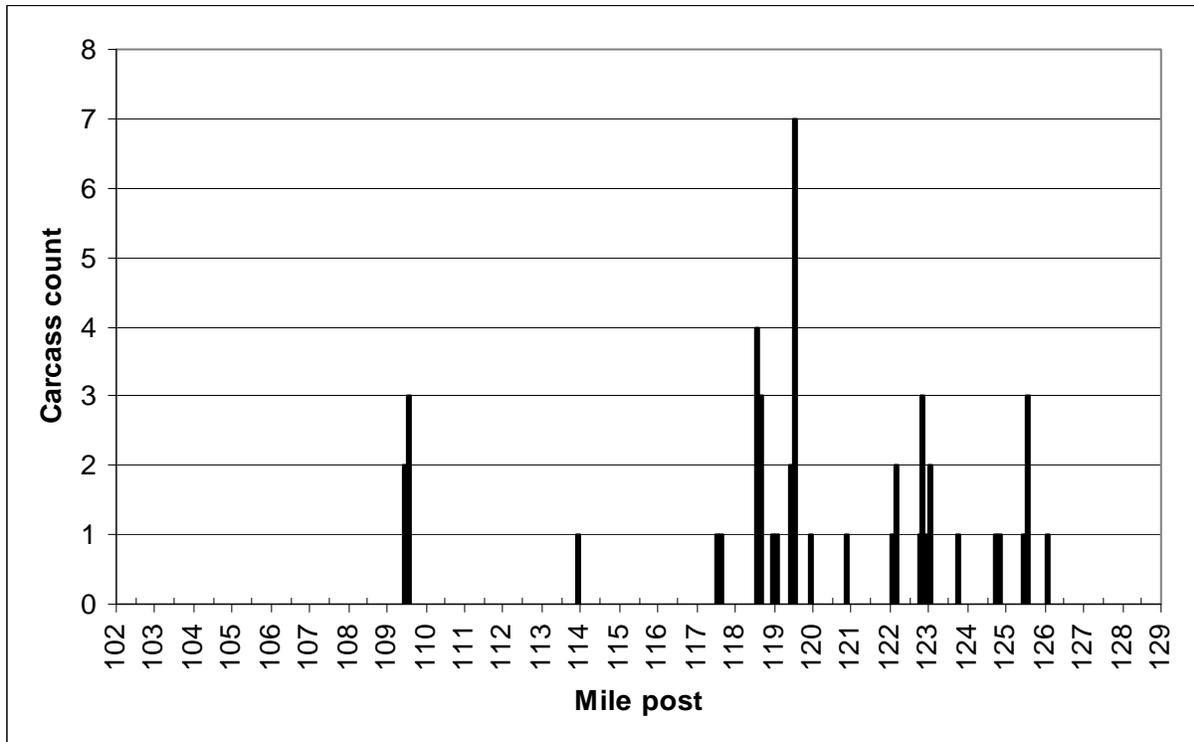


Figure 42: Distribution of mule deer and elk road mortality combined detected during WTI surveys by .1 mile. (Total n =46).

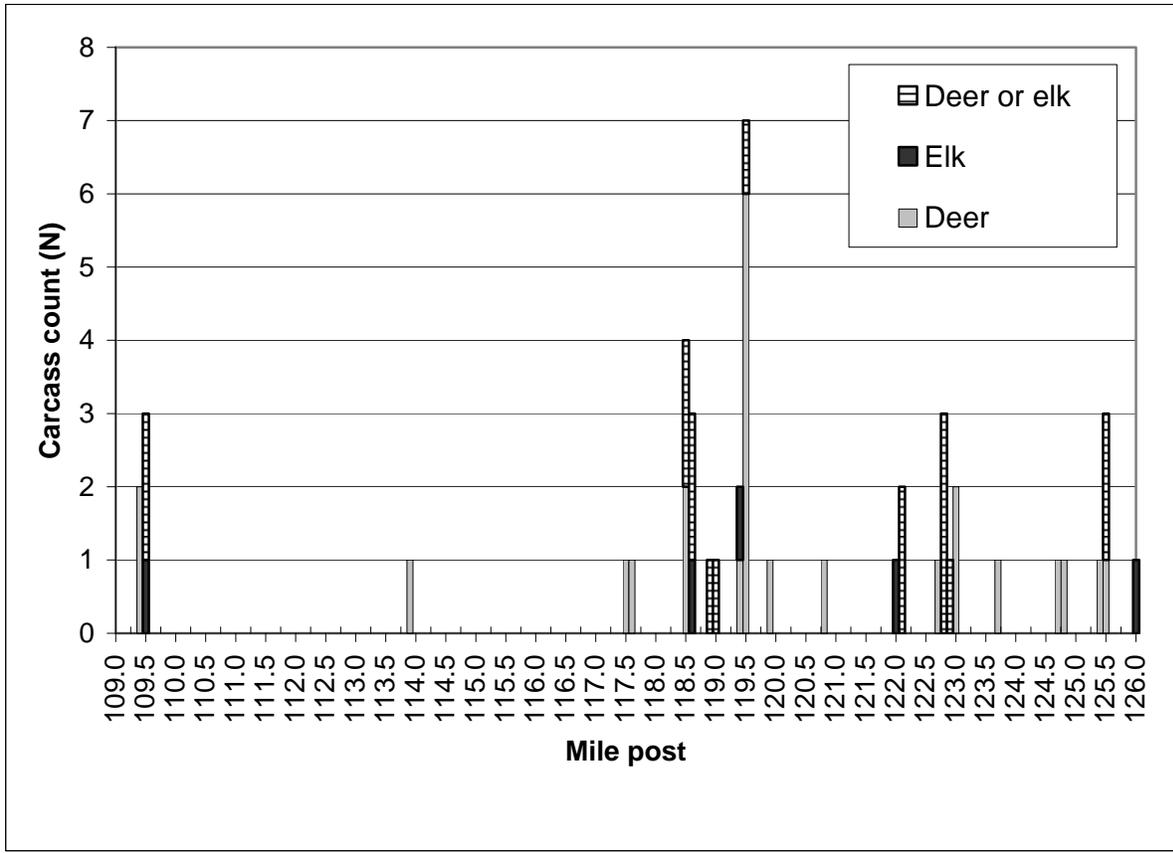
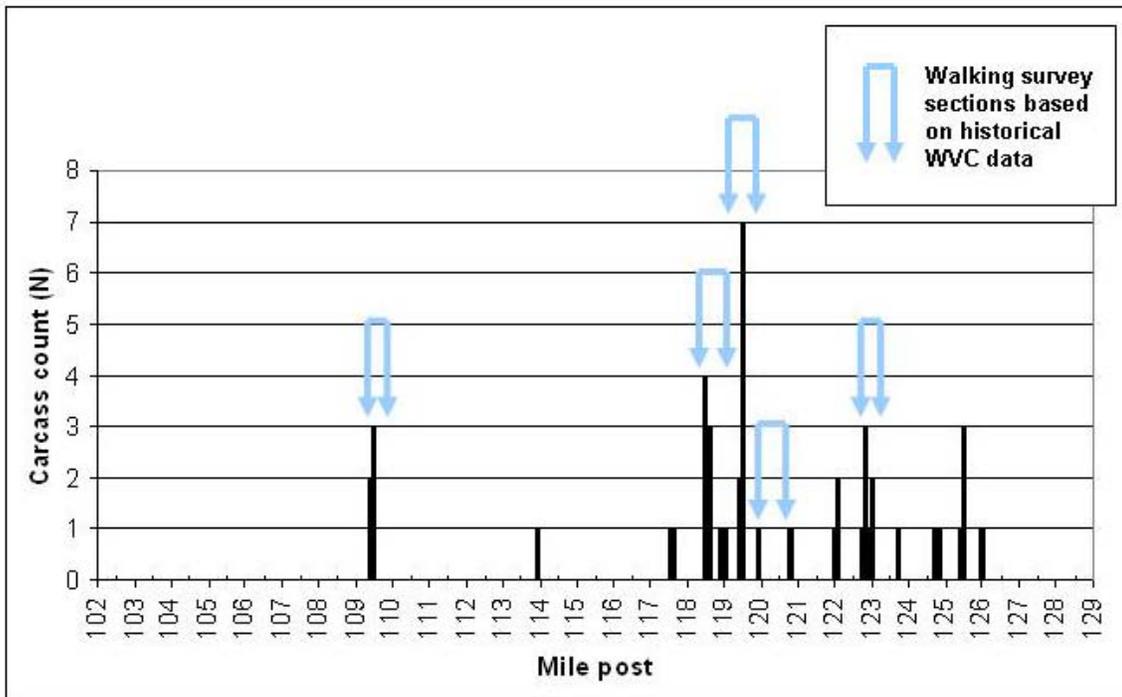


Figure 43: Distribution of mule deer and elk road mortality in subsection of study area between MP 109.0-126.0. (Total n = 46).



**Figure 44: Current road mortality concentration areas compared to historical concentration areas.**

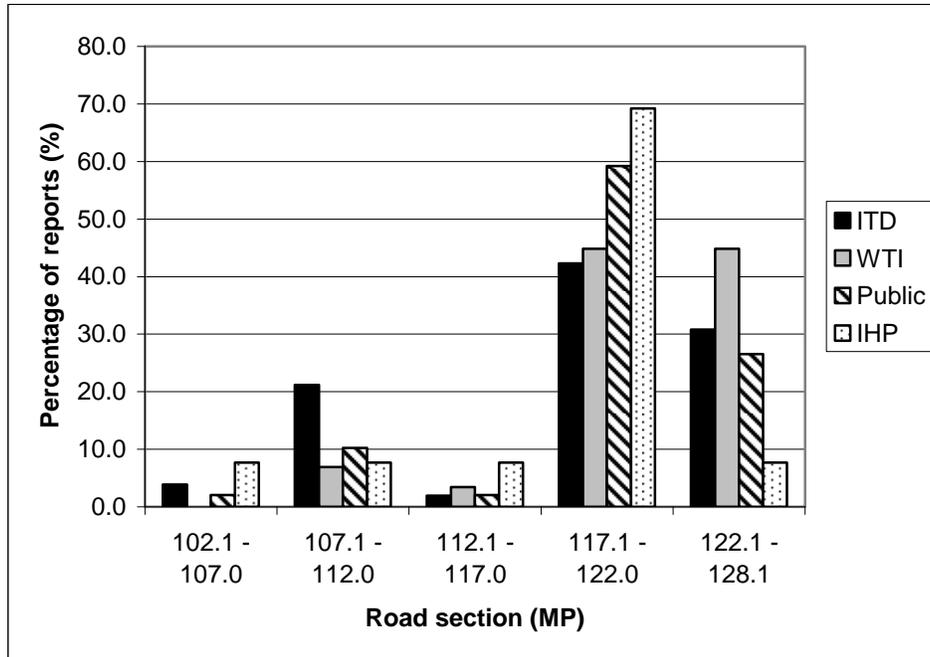
Road mortality data from all sources (ITD, IHP, WTI and the public) were compared to estimate the number of road killed mule deer and elk (carcass count) in the study area on an annual basis (Table 5). Replicate reports between different data sources were defined as carcasses found within .2 mile of each other and/or within 2 days of each other.

**Table 5. Reported carcass counts for deer and elk from different sources and combined minimum estimates per year.**

Calendar year	Data source				
	ITD	IHP	WTI	Public	Reported Total/Estimate
2004	16*	11	n/a	n/a	(27 minus two possible replicate reports) <b>25</b>
2005	24	8	n/a	n/a	(32 minus one possible replicate report) <b>31</b>
2006	31	10	n/a	n/a	(41 minus one possible replicate report) <b>40</b>
2007	53	17	26**	54	(150 minus 16 replicate reports) <b>134</b>
<p>* Data appeared to include reports from June to December only.</p> <p>** 2007 figure derived by subtracting carcasses found in 2008 (n=3) and carcasses found in April 2007 survey period which were categorized as “old” or “age unknown” (n= 17) from WTI carcass total of 46; 46-20 = 26 carcasses.</p>					

Note that the WTI data source in Table 5 represents only 30 survey days because it does not include the ten-day survey period conducted in the 2008 calendar year. This is noteworthy because it illustrates that systematic road mortality surveys detected in 30 days half of what ITD carcass monitoring detected in 260 days (5 work days x 52 weeks in a year = 260). Half of the “new” carcasses (n = 13) found during systematic road mortality surveys were found in the walking sections. The remaining 13 carcasses were found while driving. For all 2007 WTI carcasses (new, old, and age unknown) 21 of 43 were found during walking surveys.

Deer and elk road mortality reports from all sources (ITD, IHP, WTI and the public) were also compared to assess potential over or underreporting by these entities within different road sections in the study area (Figure 45). One possible replicate in the public data (two different reports for the same carcass) was removed. The total number of reports by each entity (ITD n = 52, WTI n = 29, Public n = 49, and IHP n = 13) per road section was converted to a percentage of the total. The greatest percentage of reports from all entities was in the MP 117.1 – 122.0 road section, however, WTI had an equal percentage (44.8%) in the MP 122.1-128.1 road section. It appears there may be slight underreporting by the public in the MP 107.1 – 112.0 road section given that the percentage of ITD’s reports was twice that of the public’s. Recall that WTI data is based on four ten-day survey periods only and that IHP data is based on “reported” accidents only.



**Figure 45: Percentage of deer and elk road mortality reports (not carcass count) by entity for study period March 12, 2007 – March 30, 2008 by 5-6 mile road sections. (Total n = 143; ITD n = 52, WTI n = 29, Public n = 49, and IHP n = 13) (Data provided by ITD, IHP and the public).**

Another way to estimate the minimum number of deer- and elk-vehicle collisions is to calculate the ratio of carcass observations in the sections surveyed by WTI on foot. In one year, ITD, IHP and the public reported 46 deer and elk carcasses in the walking sections (replicates deleted) and during the some time period, WTI personnel found an additional 12 deer and elk carcasses, resulting in an increase of 26.1% more. Along the entire 26 mi, ITD, IHP and the public reported 104 deer and elk carcasses (replicates deleted). Based on the 26.1% increase in observations in the walking sections, the total estimate of deer- and elk carcasses is 131 per year.

During the course of WTI surveys, it was found that environmental factors, including fallen snow, vegetation height, late season vegetation camouflaging color affected the surveyor’s ability to detect carcasses (Figures 46-48). Despite the use of an amber warning light and because of much of the study area is comprised of only two lanes, it was necessary to maintain a certain minimum driving speed and not intervene with the flow of traffic. Therefore, sometimes speed was greater than 50 mi/h which may have also limited the surveyor’s ability to detect carcasses.



**Figure 46: Fallen snow and mounds of plowed snow have the potential to hide carcasses (© Angela Kociolek, WTI-MSU).**



**Figure 47: This mule deer carcass was missed during a driving survey on at least one day; vegetation height from the perspective of the road and the need to maintain speed in the flow of traffic probably affected detection ability in this case (© Angela Kociolek, WTI-MSU).**



**Figure 48: The color of the dried grass matched the coat of this mule deer so well that this carcass was not detected during the driving survey but happened to be within a walking survey section (© Angela Kociolek, WTI-MSU).**

The total number of reported mule deer and elk carcasses was dramatically higher in 2007 compared to three previous years. This may be due to four main factors:

- 1) Engaging the motoring public to report road mortality.
- 2) Conducting systematic road mortality surveys that included walking sections of the study area.
- 3) A possible increase in deer and elk populations (see section 5.1)
- 4) A possible change in ITD carcass removal search and reporting effort.

Dividing the 2007 estimated minimum number of mule deer and elk carcasses ( $n=134$ ) by the number of miles in the study area ( $n = 26$ ), results in an estimated 5 carcasses per mile/year. See discussion of cost/benefits of wildlife-vehicle collision mitigation in section 8.2.3.

## 4 TASK 4: WILDLIFE CROSSING DATA

### 4.1 Snow Tracking Surveys

Snow tracking was attempted opportunistically during times of snow that coincided with road mortality data collection periods April 10-19, 2007 and February 21-March 1, 2008. In some cases, tracking efforts were hindered by plowing activities. Some tracks were also noted during October 28 – November 6, 2007 survey period when the area was free of snow. Wildlife tracks indicating crossing locations or parallel movements were recorded with a Global Positioning System (GPS) unit. In some cases, it was not possible to determine direction of travel. Tracks were documented in the walking road mortality survey sections only (Figure 35 and 36).

Deer, elk and canid, probably coyote, tracks were observed. In some cases, tracks from a single animal were observed. In other cases, it was clear that several animals passed in a particular location, sometimes stepping in each others tracks (Figure 49). The observations of deer and elk tracks were summarized in Table 6.



**Figure 49: Multiple elk tracks in the vicinity of MP 119.0.**

**Table 6. Deer and elk track observations during surveys 2007-2008.**

<b>Date observed</b>	<b>Species</b>	<b>Direction of travel</b>
4/10/2007	Elk	Undetermined
4/14/2007	Elk	Undetermined
4/16/2007	Deer	Undetermined
4/16/2007	Deer	Westward
4/18/2007	Elk	Westward
4/18/2007	Elk	Westward
4/18/2007	Elk or deer	Undetermined
4/18/2007	Elk	Parallel to road
4/19/2007	Deer	Westward
4/19/2007	Deer	Parallel to road
4/19/2007	Deer	Parallel to road
4/19/2007	Deer	Parallel to road
10/30/2007	Elk	Undetermined
10/31/2007	Elk and deer	Undetermined
10/31/2007	Elk	Undetermined
2/23/2008	Deer	Undetermined
2/23/2008	Deer	Undetermined
2/23/2008	Deer	Parallel to road
2/23/2008	Deer	Parallel to road
2/26/2008	Elk	Undetermined
2/26/2008	Elk	Undetermined
2/26/2008	Elk	Undetermined
2/28/2008	Elk or deer	Undetermined

Most deer tracks were noted in spring both crossing the highway and moving parallel to it (Figure 50). Elk tracks were noted in fall, winter and spring both crossing the highway and moving parallel to it (Figure 51). The highest number of tracks (deer and elk combined) within the walking survey sections were noted near MP 119.3 and MP 120.1 (Figure 52).

While not observed crossing the road, WTI-MSU personnel did observe four pronghorn (*Antilocapra americana*) at about mi post 119.45, about 50-60 m east of S.H. 75, on November 4<sup>th</sup>, 2007 at about 11:56 am (Observation by Angela Kociolek, WT-MSU). Since this species appears relatively rare in the valley, this observation was added to this report.

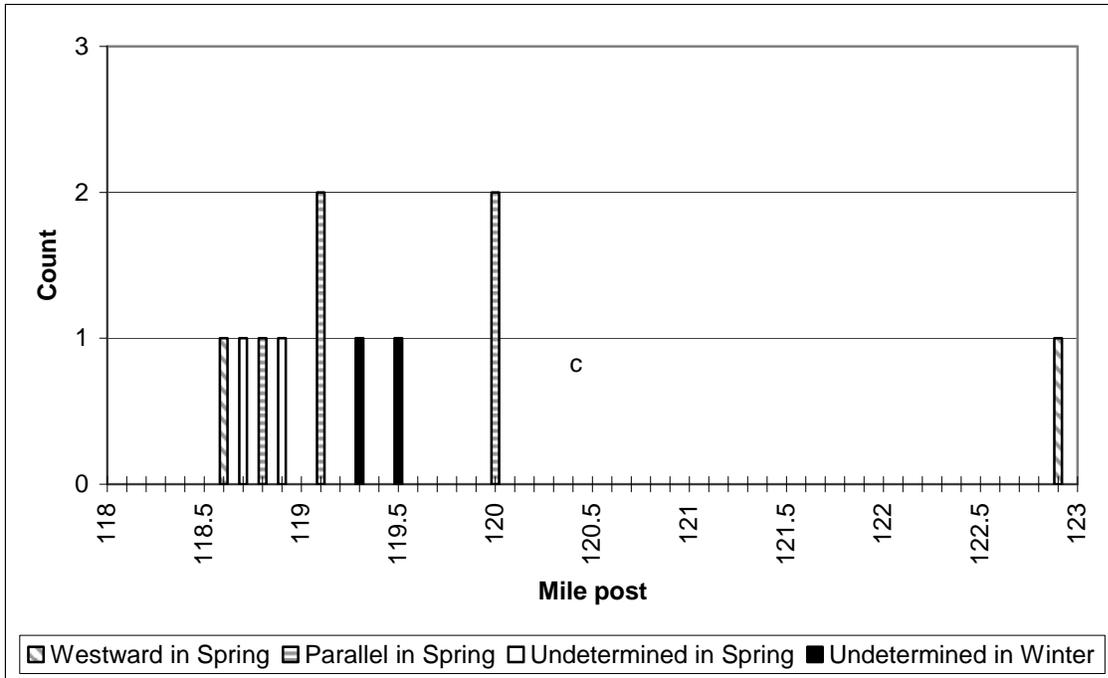


Figure 50: Distribution of deer track observations by .1 mile, directionality and season.

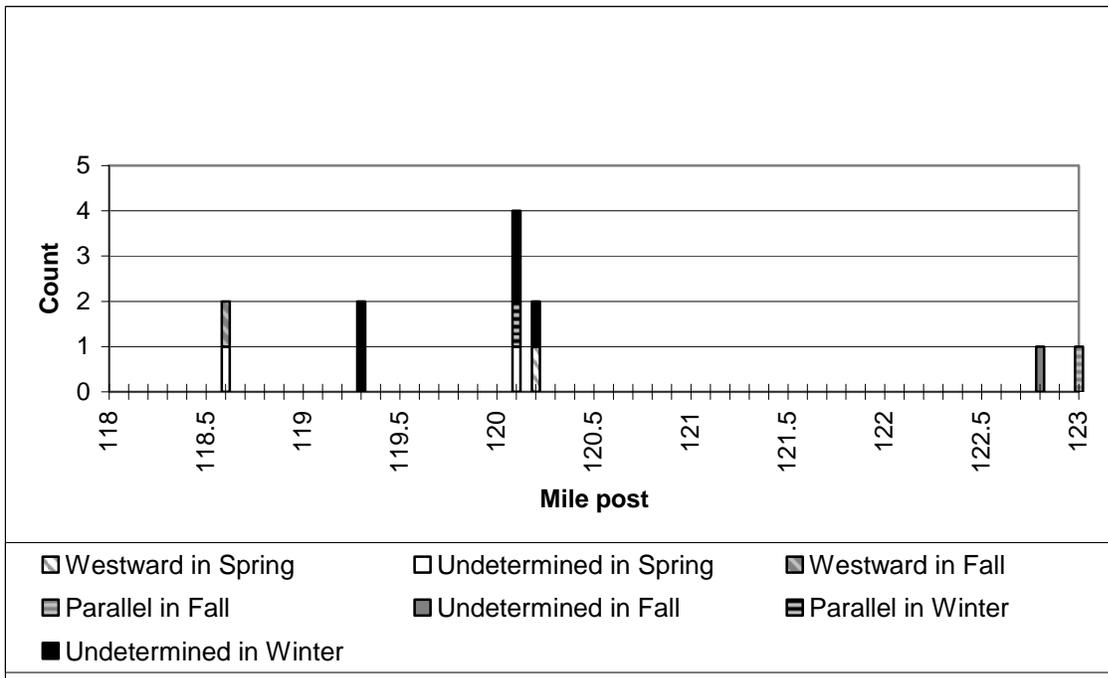


Figure 51: Distribution of elk track observations by .1 mile, directionality and season.

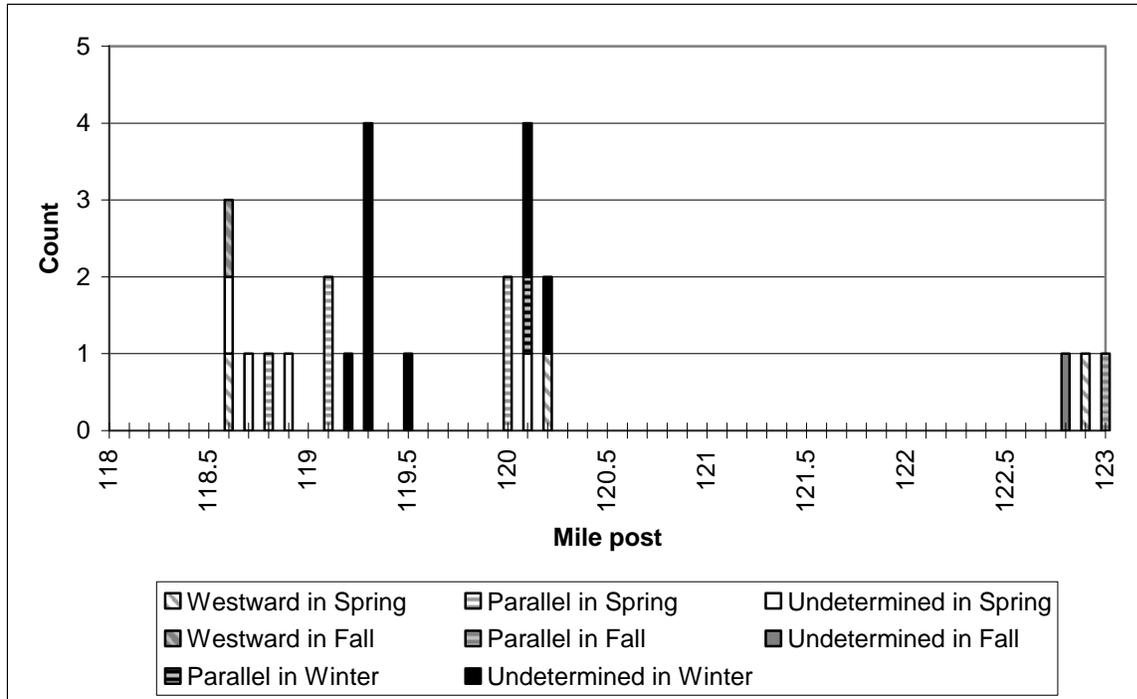


Figure 52: Distribution of deer and elk tracks combined by .1 mile, directionality and season.

#### 4.2 Camera Documentation of Crossing Activity under Two Bridges

In April 2007, four monochrome Reconyx PM35 remote infrared trigger cameras were deployed under the Greenhorn Bridge (Figures 53-55) and Hospital Bridge (Figures 56-58), one on each side of the structure (Figure 59). The purpose of the cameras was to document potential wildlife crossings under these two bridges, in lieu of crossing SH 75 at grade. Cameras were mounted into the wall inside theft deterrent camera boxes with cable and locks and informational stickers were affixed to the boxes (Figures 60-63).



**Figure 53: Vicinity of west side of Greenhorn Bridge looking north (© Angela Kociolek, WTI-MSU).**



**Figure 54: View of the south side of the Greenhorn Bridge looking west (© Angela Kociolek, WTI-MSU).**



**Figure 55: Camera mounted under Greenhorn Bridge (© Angela Kociolek, WTI-MSU).**



**Figure 56: Vicinity of east side of Hospital Bridge looking north. Note seams in bridge above sandy substrate where mule deer were often seen presumably licking minerals – discussed later (© Angela Kociolek, WTI-MSU).**



**Figure 57: View of south side of Hospital Bridge looking east (© Angela Kociolek, WTI-MSU).**



**Figure 58: Camera mounted under Hospital Bridge (© Angela Kociolek, WTI-MSU).**

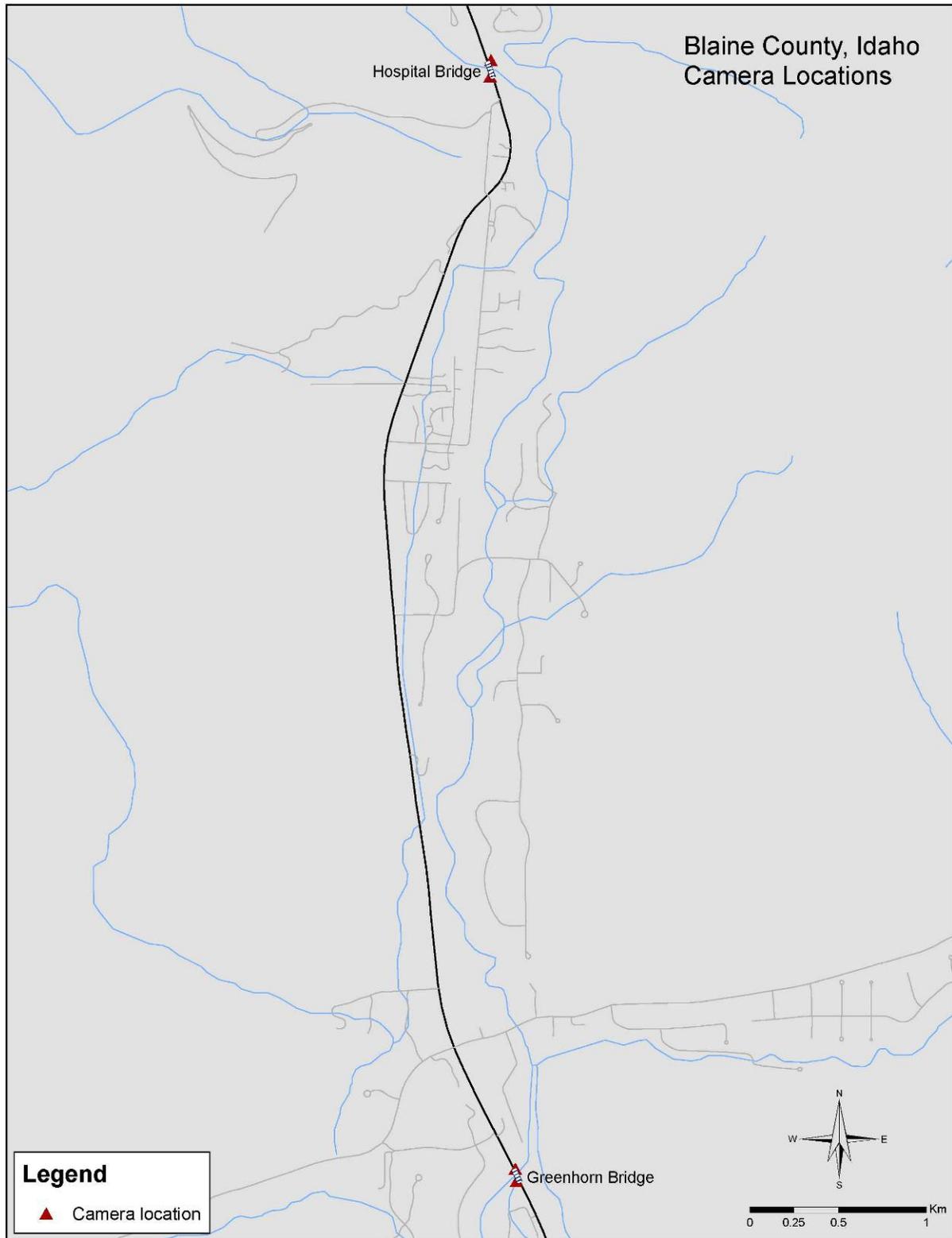


Figure 59: Map of camera locations (4 in total) under the two bridges across the Big Wood River.



Figure 60: Front view of mounted camera (© Angela Kociolek, WTI-MSU).

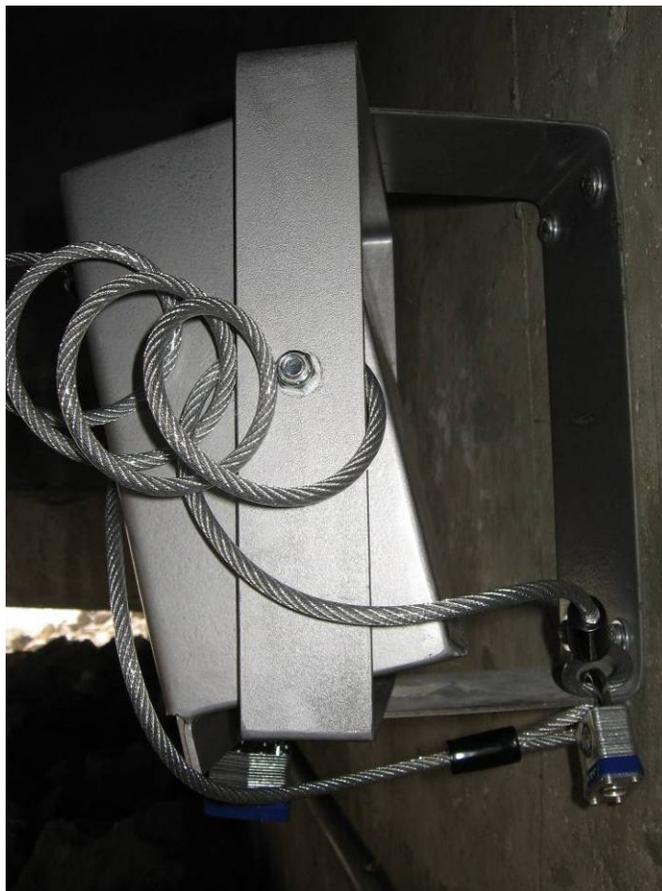


Figure 61: Side view of mounted camera (© Angela Kociolek, WTI-MSU).



Figure 62: Close-up of bolting mechanism (© Angela Kociolek, WTI-MSU).



Figure 63: Informational sticker on camera box (© Angela Kociolek, WTI-MSU).

Cameras were programmed to stamp images with a four letter code (GREE for Greenhorn and HOSP for Hospital) followed by N or S for the north or south side of the bridge; i.e., GREEN, GREES, HOSPN and HOSPS. The cameras were set to factory standards to take a series of three images per trigger one second apart. For the purposes of this study, a trigger is that entity which triggers the camera to take a photograph. If the trigger remains in the field of view of the camera, photographs continue to be taken at a rate of one image a second. Once the camera has been triggered, it will take three images to complete the series even if the entity is no longer in the field of view. A hired local contractor (Kaz Thea) monitored cameras and replaced Sunpak AA 2650 mAh Ni-MH rechargeable batteries and 1.0 GB Sandisk compact flash memory cards approximately once per month. Cameras remained in place from April 15 through at least

September 11, 2007. Around 22 October 2007, it was discovered that all four cameras had been stolen; the cameras were not replaced.

Images were copied onto a DVD taking care to name each folder with the correct location name (e.g., GREES) and month/year (e.g., Jun 07) so that images from each unique location and month were kept segregated. They were then mailed to WTI for identification of the species, investigation for other parameters (see later), and data analysis. Images were loaded into Silent Image – Map View Professional software for viewing. The number of images taken during the five month period ranged from 2,046 to 25,586 per camera (Table 7.) Note that images of WTI personnel and the local contractor taken during monthly checks were not included in image totals. However, WTI personnel were included in the total number of human triggers as it reflected human presence during the time of the study.

**Table 7: Total number of images taken at each camera location.**

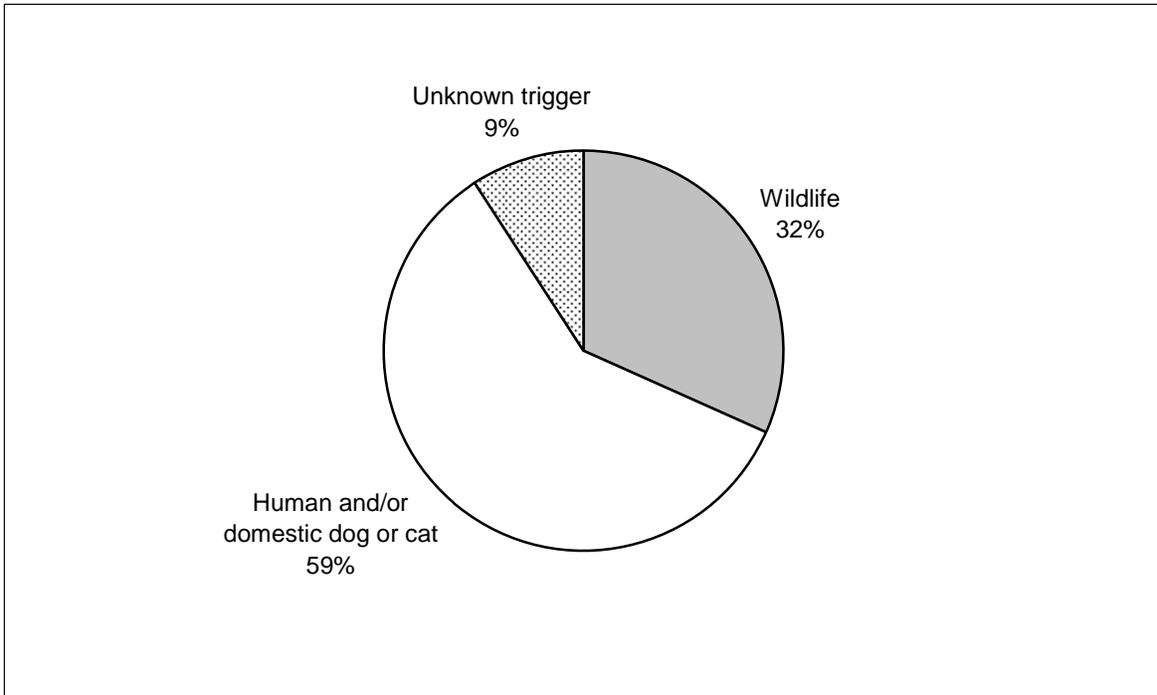
Camera location	Number of images taken
HOSPN	2046
HOSPS	25586
GREEN	3342
GREES	5550

The best image from each unique trigger was chosen for the assignment of searchable keywords related to the trigger. The key words were the basis for later data analysis. There were 2,196 unique triggers in total (wildlife, human-related or unknown). Each trigger was categorized as wildlife (to species level, if possible), human-related or “unknown trigger” (Table 8). Wildlife triggers were also categorized as 1.) whether or not a crossing event (completed movement from one side of the bridge to the other) took place and 2.) direction of travel. In the case of some small mammals (eg., a mouse) or birds that appeared to live under the bridges, the crossing event/direction of travel keyword was not applied.

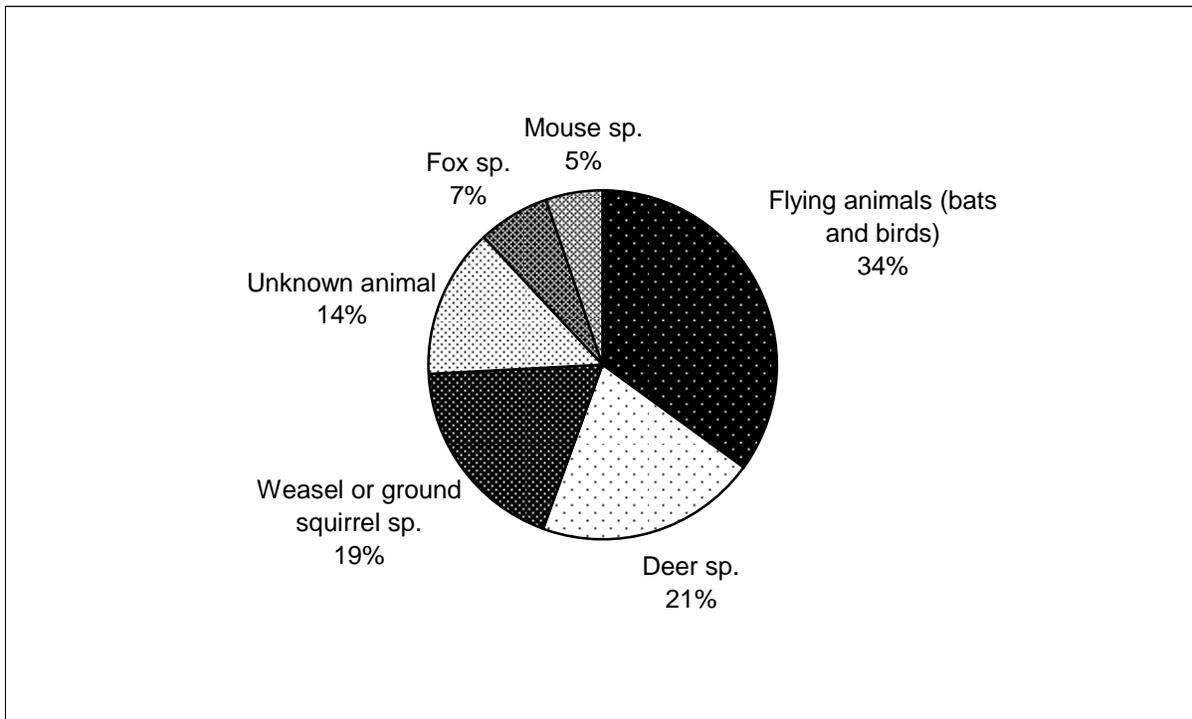
**Table 8: Trigger classifications.** This list expanded to fit new triggers types encountered during the course of months of viewing new images.

Human-related	Wildlife (listed alphabetically)	Unknown Trigger
Human	Bat (Order <i>Chiroptera</i> )	
Domestic dog	Bird (Class <i>Aves</i> )	
Domestic cat	Black Bear ( <i>Ursus americanus</i> )	
	Black bear and bat	
	Deer sp. ( <i>Odocoileus</i> sp.)	
	Fox sp. ( <i>Vulpes</i> sp.)	
	Possible kit fox ( <i>Vulpes macrotis</i> )	
	Ground squirrel sp. ( <i>Spermophilus</i> sp.)	
	Pine marten ( <i>Martes martes</i> )	
	Mountain lion ( <i>Felis concolor</i> )	
	Mouse sp. (Order <i>Rodentia</i> )	
	Mule deer ( <i>Odocoileus hemionus</i> )	
	Raccoon ( <i>Procyon lotor</i> )	
	Red fox ( <i>Vulpes vulpes</i> )	
	Red squirrel ( <i>Tamiasciurus hudsonicus</i> )	
	Striped skunk ( <i>Mephitis mephitis</i> )	
	Squirrel sp. (Family <i>Scuiridae</i> )	
	Unknown animal	
	Unknown mammal (Class <i>Mammalia</i> )	
	Weasel ( <i>Mustela</i> sp.)	
	Weasel or ground squirrel	

Humans and domestic animals accounted for 59% of all triggers while wildlife accounted for 32% (Figure 64). Nine percent of the triggers were unknown. There were 695 wildlife triggers, 129 of which were mule deer and 10 of which were deer but it is unknown whether they were mule deer or white-tailed deer. Flying animals, including bats and birds, triggered the cameras most, followed by deer (Figure 65). Cameras confirmed that a variety of wildlife cross under SH 75 along the Big Wood River corridor (Figure 66).



**Figure 64: Percentage of camera triggers classified by general type. (Total n = 2,196).**



**Figure 65: Percentage of camera trigger by wildlife classified by species group (Total n = 671). Other species that triggered the camera but accounted for less than 5% of the total are not shown; they include mountain lion (n = 1), black bear (n = 2) striped skunk (n = 5) and raccoon (n = 16).**



Figure 66. Clockwise from upper left: pine marten, raccoon, squirrels, black bear striped skunk, mountain lion, birds, red fox and other animals (not shown) were documented under the Greenhorn and/or Hospital Bridges (© WTI-MSU).

Mule deer appeared to use the area beneath the bridges to cross the highway corridor (Figure 67). Mule deer were most often detected lingering at the southern Hospital Bridge undercrossing presumably to lick minerals that dripped through seams from the road surface above onto the sandy substrate below (Figure 68-70). Note orientation of seams above sandy substrate in Figure 55.



Figure 67: Mule deer running west to east under the south side of the Hospital Bridge on May 19, 2007 at 9:42am (© WTI-MSU).



Figure 68: Seams in bridge concrete allow run off that settles on sandy substrate below (© Angela Kociolek, WTI-MSU).



Figure 69: Mule deer presumably mineral licking under south side of Hospital Bridge on July 23, 2007 at 8:50 pm (© WTI-MSU).



**Figure 70: Three mule deer lingering under south side of Hospital Bridge on September 3, 2007 at 1:53 am (© WTI-MSU).**

In an attempt to separate mineral licking events from crossing events, a cut off time of ten minutes was used in the analysis. Mineral licking activity resulted in lingering under the bridge sometimes for an hour or longer. Obvious crossing activity, on the other hand, usually happened within seconds. Sixty percent of all deer events resulted in a stay of ten minutes or more (Figure 71). Sixty-one percent of deer events that lasted ten minutes or more did not appear to result in a complete crossing (Figure 72). In contrast, of those deer events that lasted less than ten minutes, 38% did not appear to result in a complete crossing (Figure 73). Deer appeared to cross in both directions (east to west and west to east). Four (8%) of the less than ten minute events, were inconclusive regarding whether or not a crossing took place.

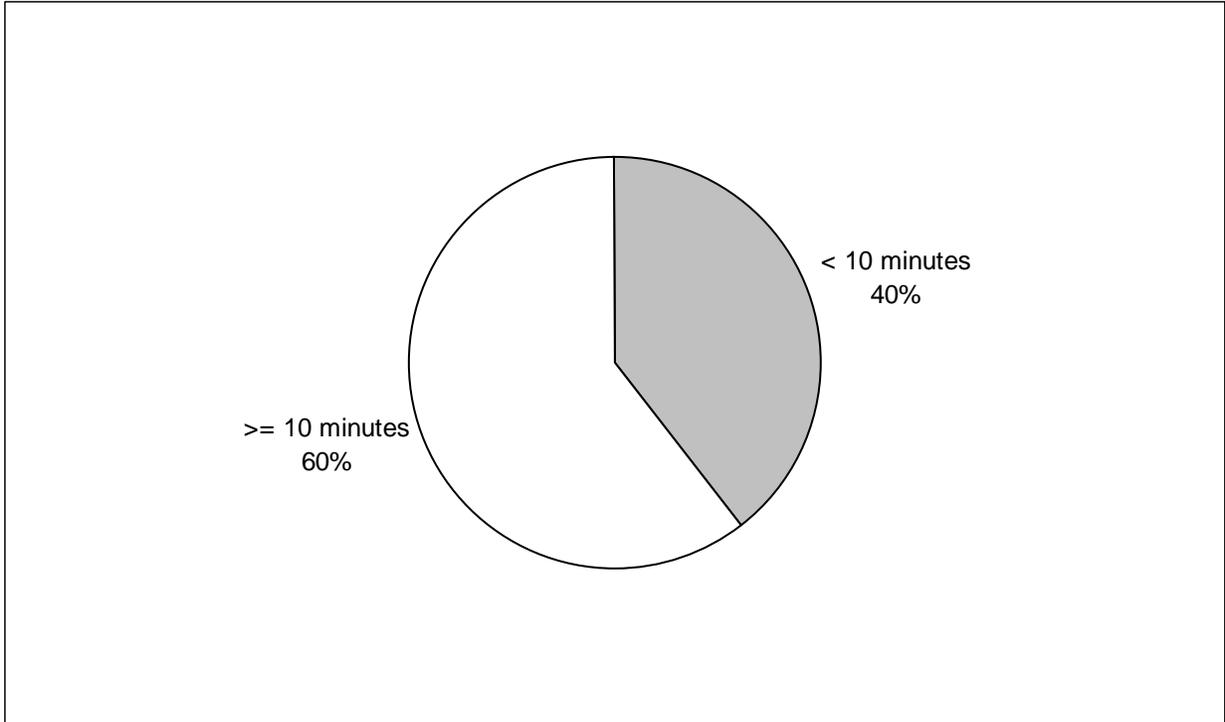


Figure 71: Percentage of deer events that lasted shorter or longer than 10 minutes (data from all 4 camera locations combined) (Total n = 129).

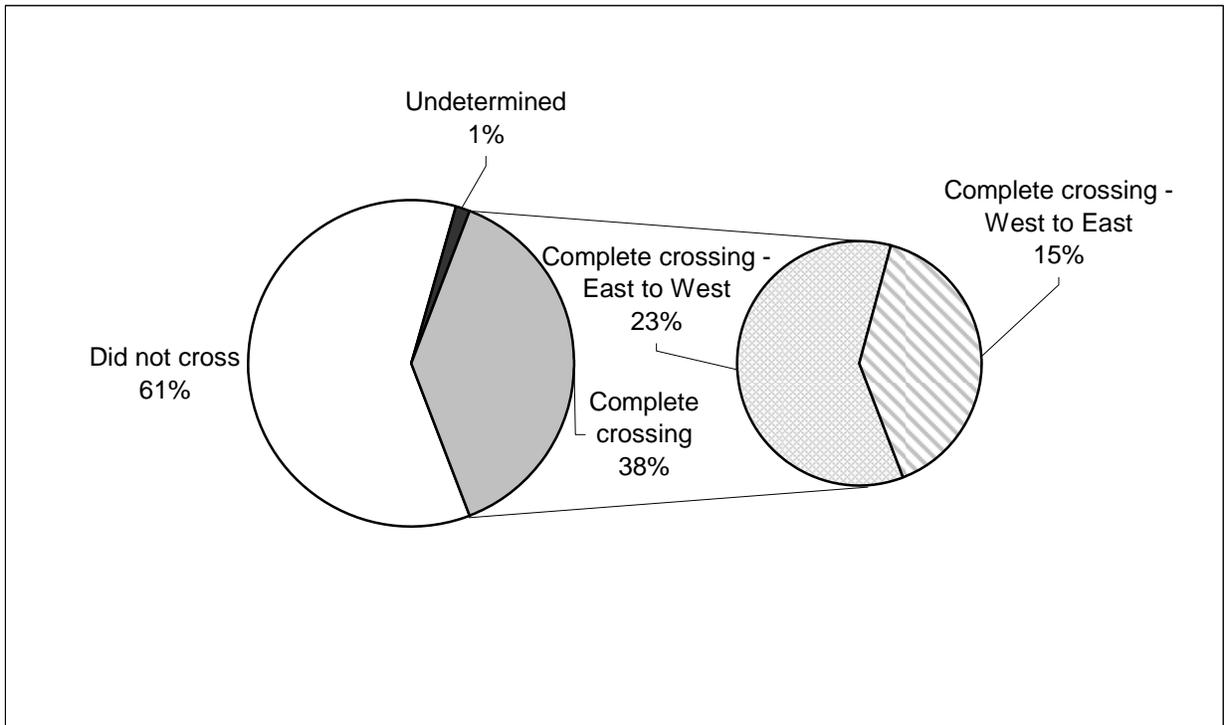
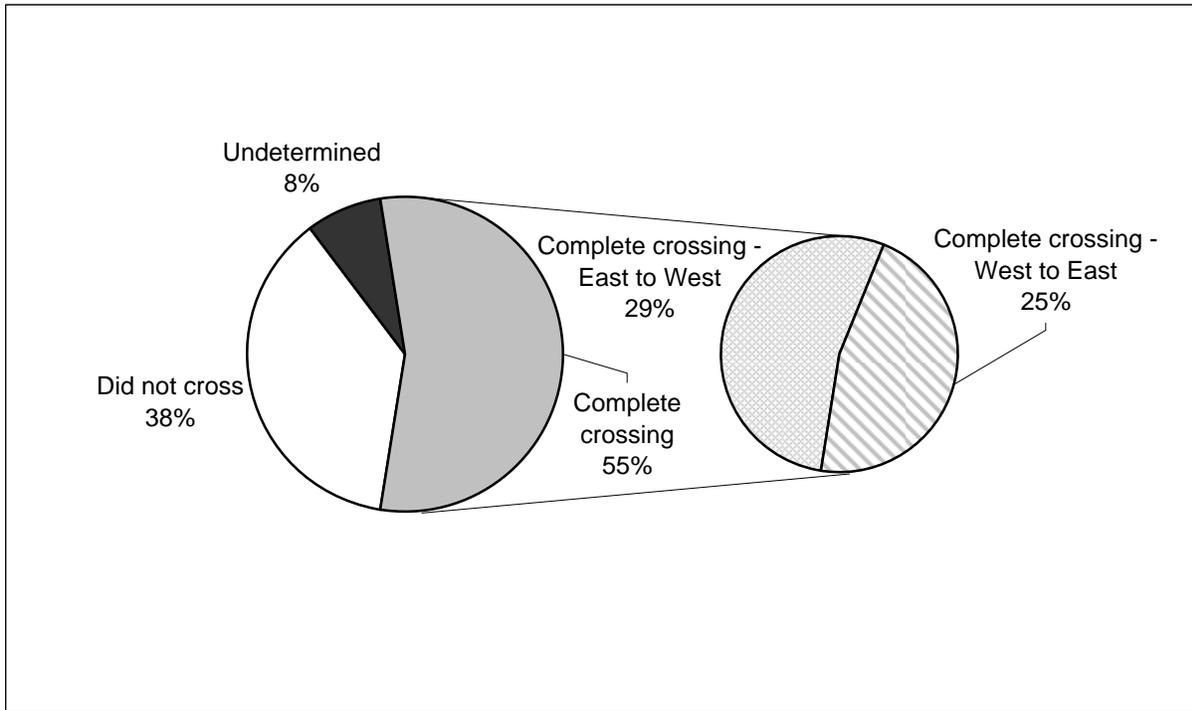


Figure 72: Percentage of the outcome of deer events which lasted greater than ten minutes (data from all 4 camera locations combined) (Total n = 78).



**Figure 73: Percentage of the outcome of deer events which lasted less than ten minutes (data from all 4 camera locations combined) (Total n = 51).**

While most deer events, regardless of duration of time spent under bridges, occurred between the hours of 8 pm and 3, some deer events also occurred throughout the day and night hours (Figure 74). Some deer were documented crossing under the bridges during morning and evening commuter traffic times. The cameras remained in place from mid-April to at least mid-September. During that time, deer events peaked in May and July (Figure 75).

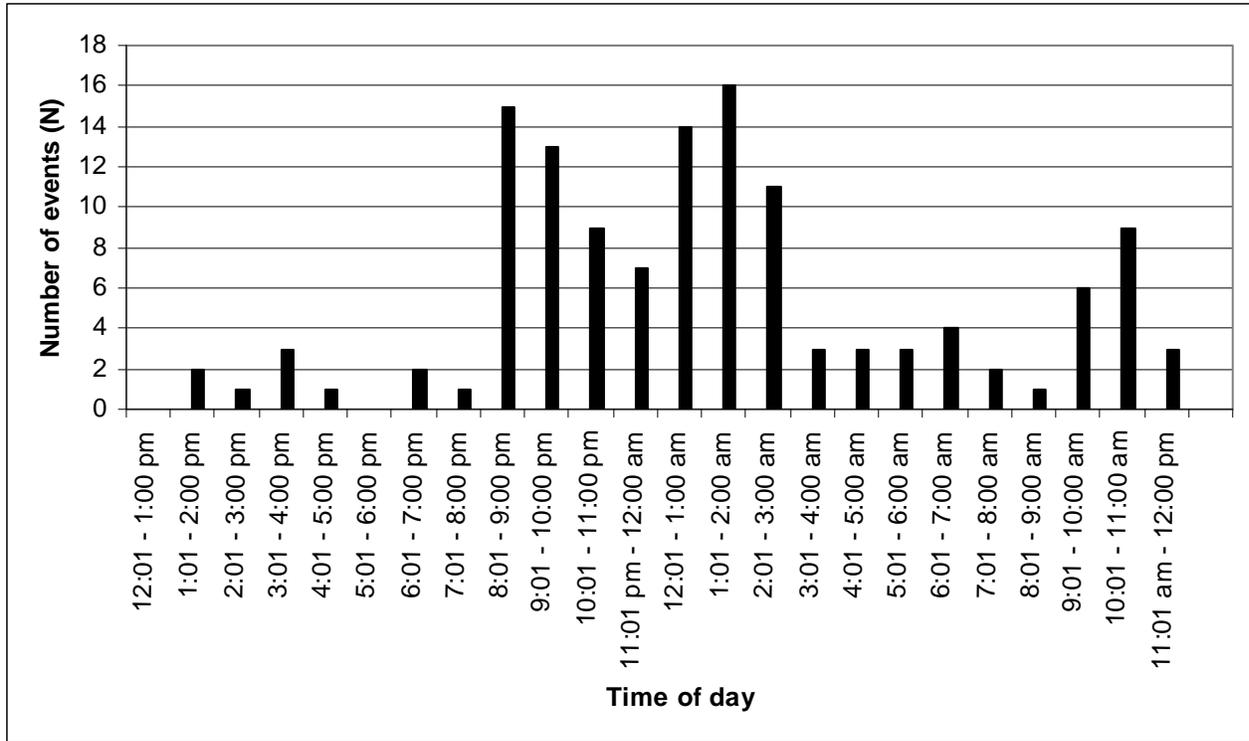


Figure 74: Hourly distribution of deer events from Apr 15 to Sep 11 2007.

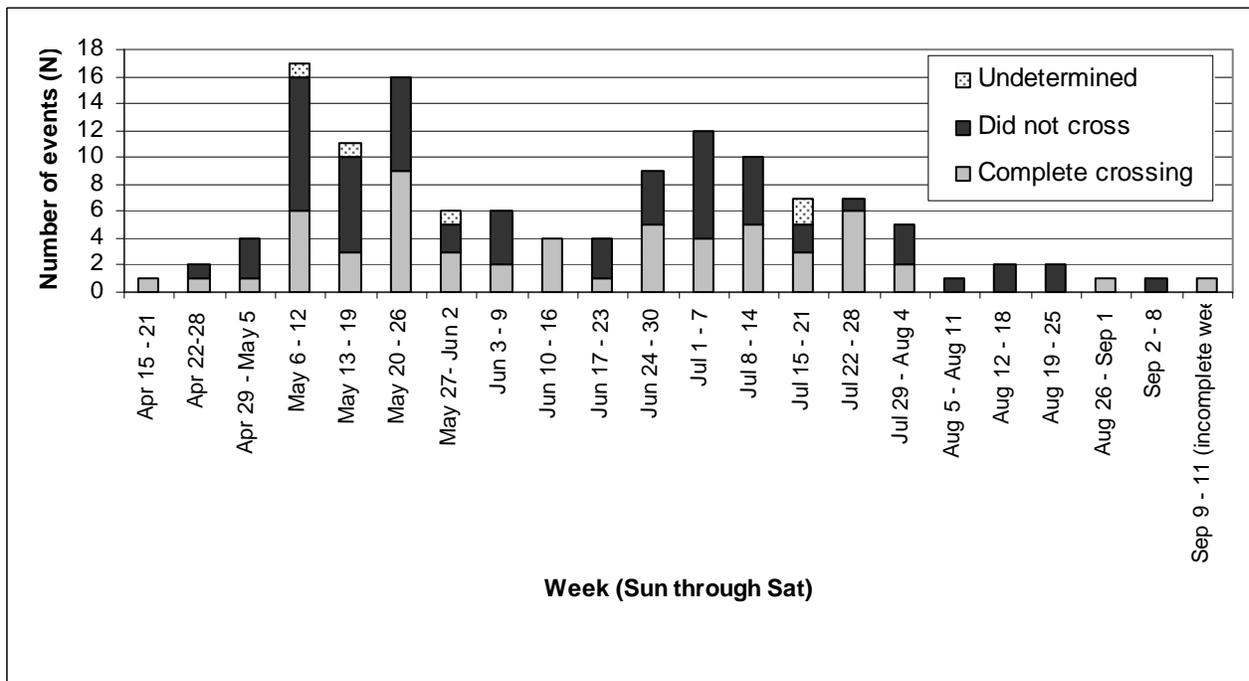


Figure 75: Deer use of area under bridges by week.

It is noteworthy that elk were not documented under the bridges, let alone crossing under one of the bridges between April 15 – September 11, 2007, even though observations of elk were logged on the website during the same time frame. While taking measurements in February 2008, moose droppings were documented along the length of the southern Greenhorn Bridge undercrossing. An analysis was done to determine the openness ratio (width x height / road width (Reed and Ward 1985)) of the underpass and compare to openness recommendations for mule deer and elk (Table 9).

**Table 9: Big Wood River Bridge Measurements (in meters).**

	Hospital		Greenhorn	
	North side	South side	North side	South side
road/bridge width	14	14	21	21
height (minimum clearance in main path)	3.05	1.97	2.25	2.2
length from end wall to center wall	11	11.5	21	25.5
high water*	5	4.5	5	8
low water*	6.5	11.5	10	25.5

Note: \*High and low water levels are estimated and should be thought of as a portion of length - or - the remaining terrestrial space available (including riprap) between outer wall and estimated high and low water levels.

Recommendations for openness from the literature are:

- Elk (Clevenger, unpubl. data):
 

Minimum:	Width: 5-6 m	Height: 2.5-3 m
Recommended:	Width: >7-10 m	Height: >3.5-4 m
  
- Mule deer (Gordon & Anderson 2003)
 

Minimum:	Width 6.1 m	Height: 2.4 m	Openness: 0.8
----------	-------------	---------------	---------------

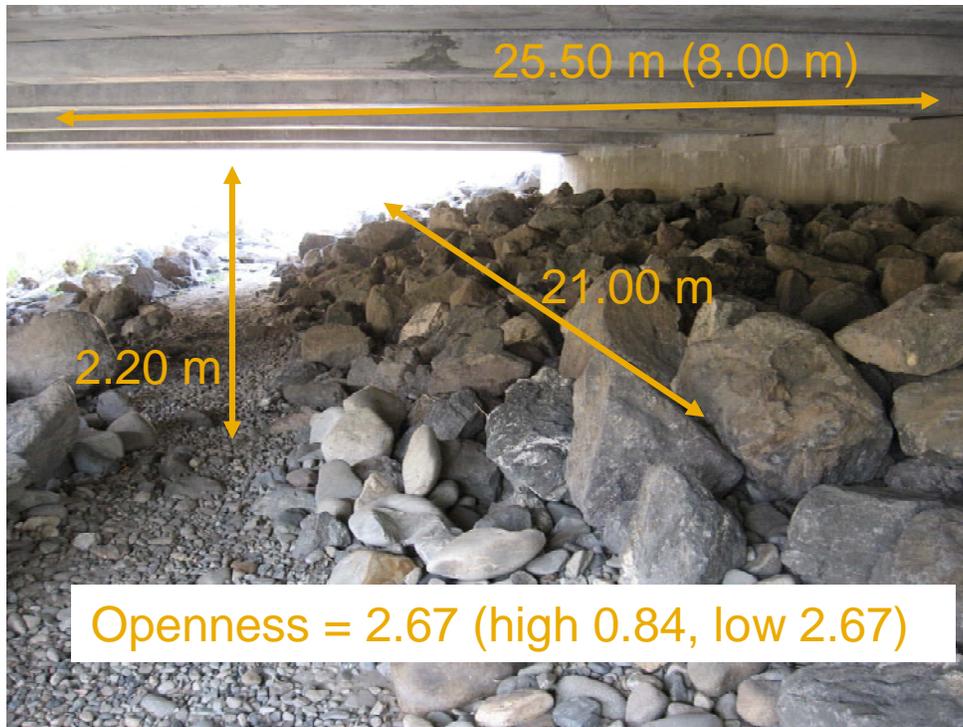


Figure 76: Openness ratio schematic for area under Greenhorn Bridge at high and low water (© Marcel Huijser, WTI-MSU).

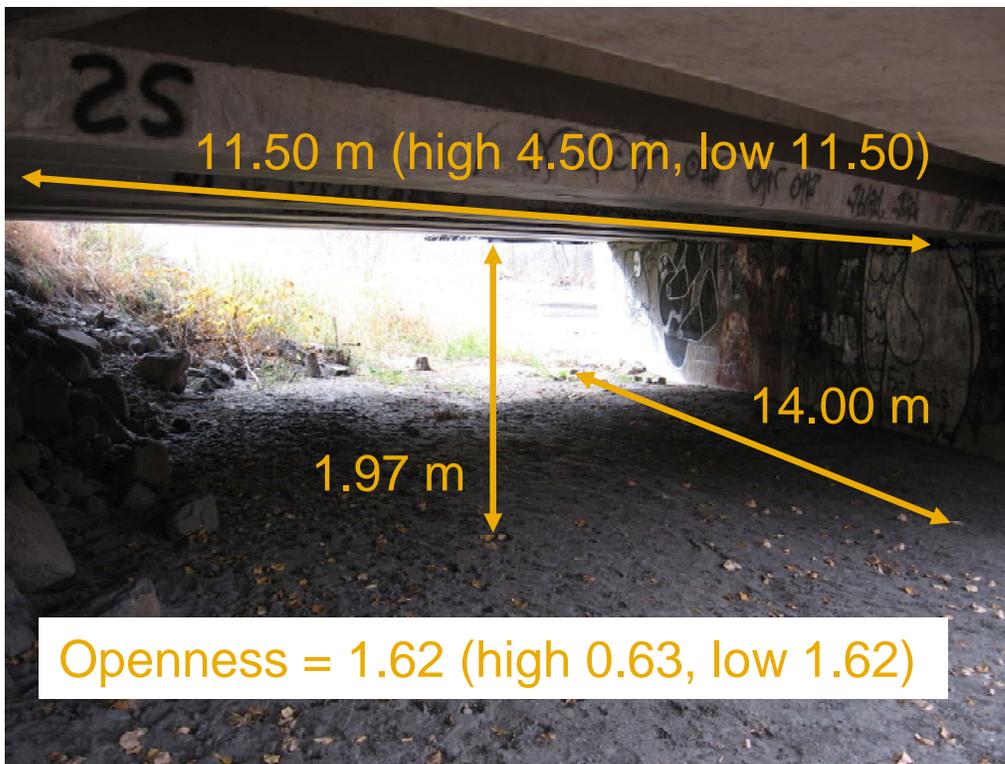
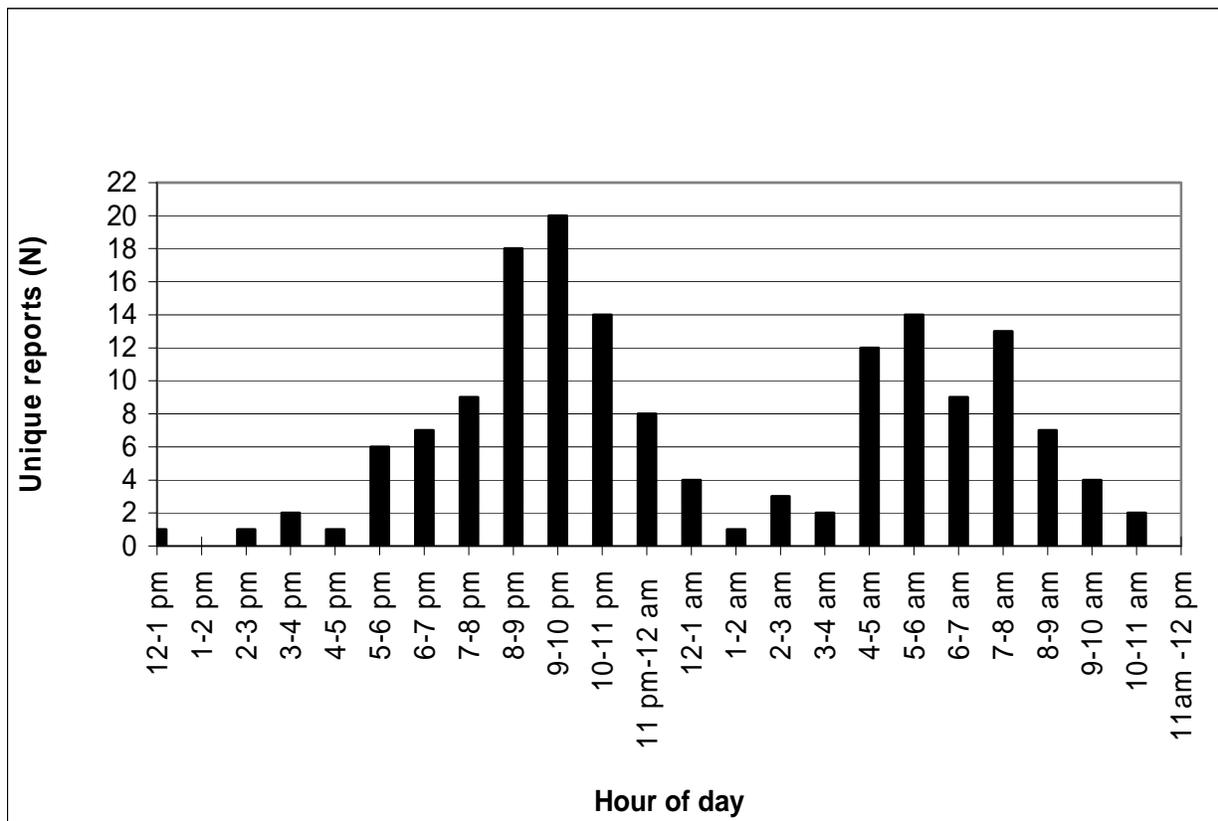


Figure 77: Openness ratio schematic for area under Hospital Bridge at high and low water (© Marcel Huijser, WTI-MSU).

### 4.3 Web-Based Animal Crossing Data Collection by the Public

Most live animal observations were made between 5 pm to midnight and 4 am to 9 am (Figure 78), a portion of which coincides with standard commuter drive times (see Figure 5). These data do not necessarily show the time of day when most crossings occur; they only show the time of day when most crossings were observed by the public. However, because the public observed most of the animals from the road at times when traffic volume was not particularly high, it is likely that the peaks in reports represent the times of day when animals are on or close to the road more frequently than at times when traffic volume was highest (see Figure 5).



**Figure 78: Distribution of unique live reports of ungulates (deer, elk and moose) only (Total n = 158). Note: reports may relate to multiple individual animals.**

If search and reporting effort is similar for all road sections, the live animal observations by the public also help identify locations where deer and elk cross the road most or where they are close to the road most. However, it is important to note that locations where animals cross most are not necessarily the same locations where animals are hit most (Clevenger et al. 2002). Nonetheless, it does show where safe crossing opportunities may need to be provided for. Note that the locations of the Greenhorn Bridge and Hospital Bridge do not coincide well with the highest number of live deer and elk observed by the public (Figure 79).

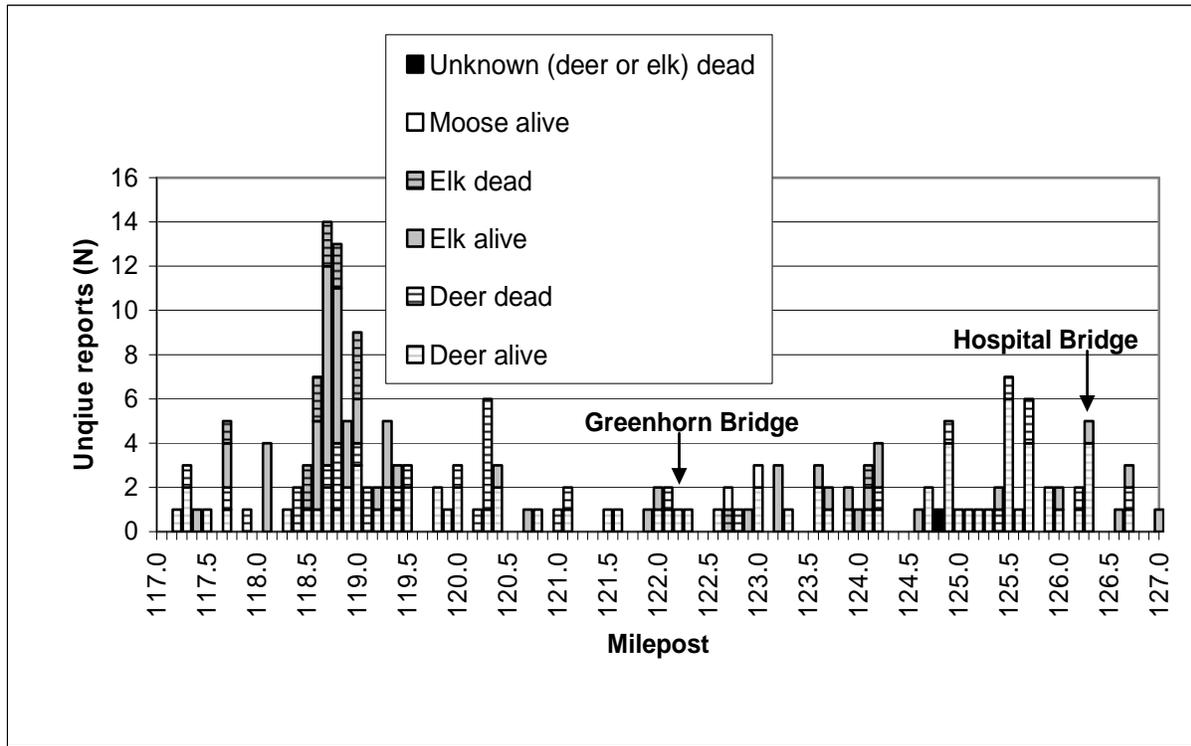


Figure 79: Distribution of elk and deer reports (live and dead) by .1 mile between MP 117-127 as previously shown in Figure 33 with the two bridges shown for comparison.

## 5 TASK 5: WILDLIFE POPULATION TRENDS

It is important to know whether an increase in deer- and elk-vehicle collisions in a given year may be correlated with an increase in population size. If so, an increase in deer- and elk-vehicle collisions may be, at least partially, explained by an increase in animal population size.

Elk population data in the vicinity of the study area were provided by IDFG for multiple years between 1993 and 2008. Sight-ability estimates indicate the elk population in unit 49 (east of SH 75) remained stable between 2004 and 2008 (Figure 80), which encompasses the study period. Sight-ability estimates for Unit 48 (west of SH 75) show elk numbers doubled from 2002 to 2006 (Figure 81). Given that the most recent Unit 48 survey was in 2006, there is no 2008 population estimate and it is unknown whether the elk population trend continued to increase in this unit during the study period. Similar population data is not available for mule deer because most deer migrate south out of the valley during the winter when surveys are conducted (Pers. com. Regan Berkeley, IDFG, at kickoff meeting October 2006).

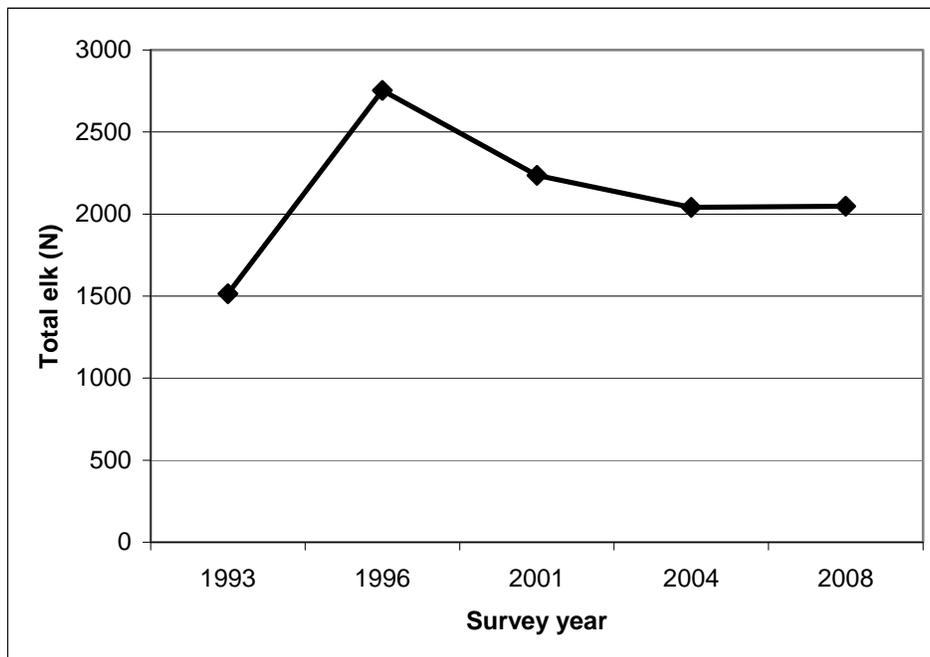


Figure 80: Unit 49 elk population trend (Data provided by IDFG).

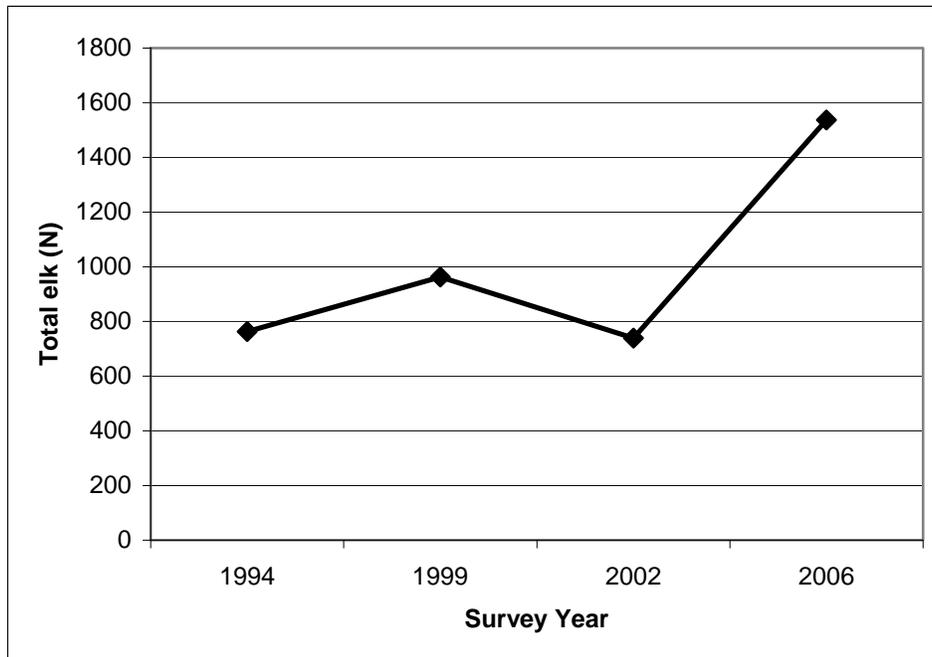


Figure 81: Unit 48 elk population trend (Data provided by IDFG).

## 6 TASK 6: REVIEW SITES FOR POTENTIAL INSTALLATION OF ANIMAL DETECTION SYSTEM

### 6.1 Site Suitability

Carcass reports from all available data sources (ITD (n = 52), IHP (n = 13), WTI (n = 29) and the public (n = 50) were combined. The total combined number of 144 carcass reports were made during the study period (March 12, 2007 to March 31, 2008). Reports within .2 miles and two days of each other were marked as replicates. There were 16 replicates, yielding a combined total of 128 unique carcass observations (Figure 82). If data sources reported a different one-tenth of a mile post for a replicate report, then the following hierarchy was applied in choosing the .1 mile: WTI data ranked highest in accuracy due to the known consistent use of ROCS (GPS). IHP data ranked next highest due to the fact that their location data often included up to three decimal places. ITD data was ranked next highest due to the fact that they stop the vehicle when reporting. The location data from the public were considered least accurate due to that fact that most people were probably driving when they made their observation and because they may have had to rely on their memory until they submitted their observation online. There was one case where two public reports were replicates and the report with more information was chosen as the more accurate of the two.

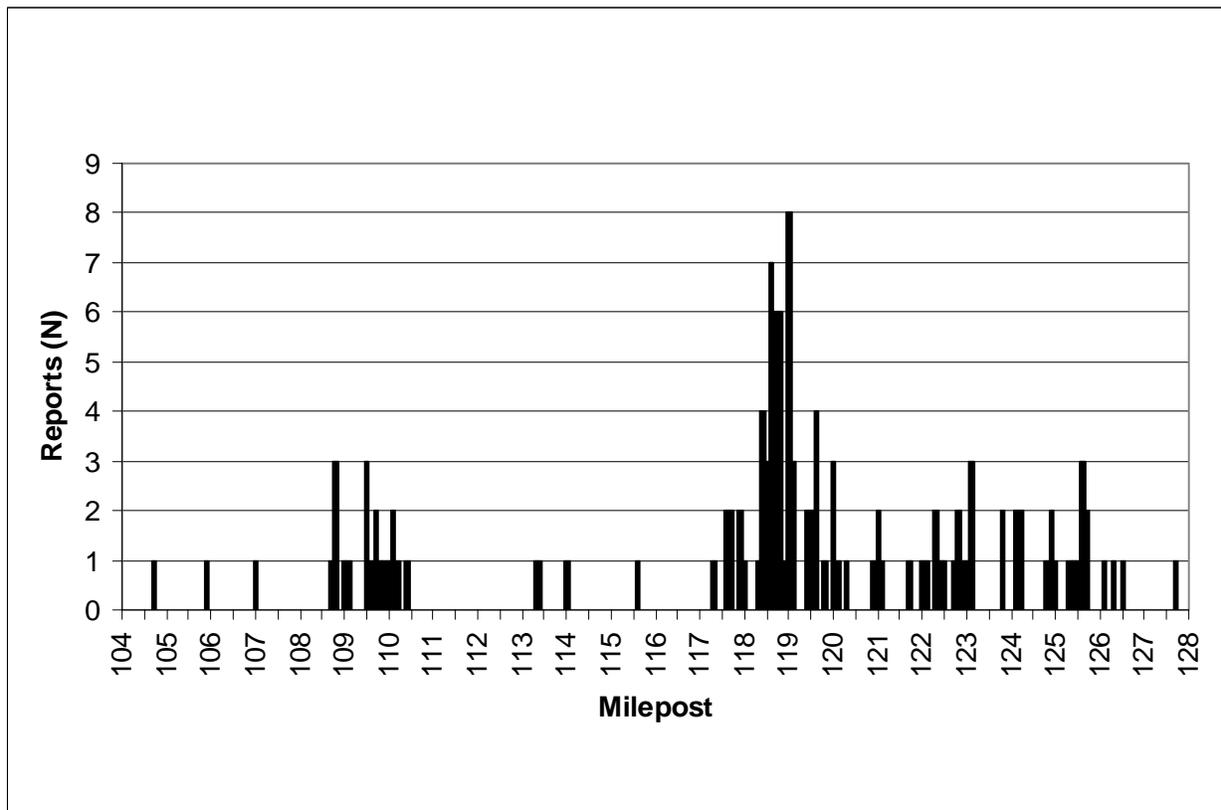


Figure 82: Spatial distribution of all carcass reports made during study period (Data provided by ITD, IHP, WTI and the public) (Total n = 128).

**Table 10: The six road sections (max 500m long; .3 miles) within the study area found to have the highest concentration of road mortality.**

Road section; maximum 500 m (.3 miles in length) (MP)	Combined carcass count from all available data sources during survey period
A. 109.5-109.8	7
B. 118.4-118.7	20
C. 118.8-119.1	18
D. 119.4-119.6	8
E. 122.8-123.1	7
F. 125.4-125.7	7

Suggested parameters for evaluating the suitability of a site for installation of an animal detection system are partially based on Huijser et al. (2006):

- a) Animal-vehicle collisions. The site should have a history of a relatively high number of animal-vehicle collisions with large animals, especially ungulates (e.g., deer, elk or moose). This is for two reasons: 1. the costs associated with the purchase, installation, and operation and maintenance of an animal detection system may be compensated by the savings associated with reduced animal vehicle collisions, and 2. if an animal detection system is evaluated for its effectiveness in reducing animal-vehicle collisions, historic data on animal-vehicle collisions should preferably be available (comparison in time). In addition, historic animal-vehicle collisions from control sites are helpful (comparison in space).
- b) Animal movements. The site should preferably be located in an area where many large animals (e.g., deer, elk or moose) are known to cross the road (daily movements or seasonal migration). Note: not all animal movements across a road result in animal-vehicle collisions. This may protect travelers against potential future animal-vehicle collisions and, in addition, the animals that cross the road should, at least theoretically, be better protected against potential future collisions with vehicles.
- c) Traffic volume. As traffic volume increases it becomes less and less desirable to have large animals cross at grade. In addition, above a certain traffic volume, the barrier effect of the road may be close to absolute with few animals that even try to still cross the road. In that type of situation, the problem of collisions has been large replaced by that of a barrier to animals.
- d) Terrain. The terrain must allow for the installation of an animal detection system. For example, an abundance of ridges, gullies and rocky outcrops may make a location less suitable for an animal detection system, especially break-the-beam systems. Difficult

terrain may also require more sensors and other equipment than relatively flat areas would require.

- e) Access roads. The number of access roads should be kept to a minimum to avoid gaps (blind spots) or excessive false positives caused by traffic turning on or off the road, depending on what sets off the sensors.
- f) Vegetation. The vegetation should allow for the installation of an animal detection system. For example, bushes and trees that grow up to the edge of the pavement increase the chance of triggering the system, i.e., they would cause excessive false positives for most area cover, or break-the-beam systems.
- g) Length road section. If an animal detection system is deployed as a stand alone mitigation measure, the road section must be at least 805-1609 m (0.5–1.0 mi) long to be able to accommodate for potential spatial errors in the location of historic road mortality data that was used to select the site. If an animal detection system is installed in a gap in a wildlife fence, the gap width can be variable, but a gap is typically between 30 and 200 m wide, depending on the range of the sensors and the local conditions.
- h) Changes in road or landscape. The road and surrounding landscape should not be scheduled to undergo major changes within the life span of the mitigation measure; for animal detection systems about 10 years. However, should changes in the landscape occur and change where animals cross the road and where animals are hit by vehicles, then one may consider relocating an animal detection system. Nonetheless, there are relocation costs involved for such an effort. In addition, major changes, other than the installation of the animal detection system, would confound the results of a potential study into the effectiveness of the animal detection system in reducing animal-vehicle collisions.
- i) Project partners. All the organizations and individuals that have jurisdiction or that are stakeholders in activities at the study site should support the project. This includes support for installation, operation and maintenance.
- j) Travel costs. The site should preferably be close to where operation and maintenance personnel have their offices. This reduces costs for travel and stay.
- k) Power. The site should allow for either solar power or a connection to 110 V power source.
- l) Pull-out. The site should preferably have a safe pull-out location for vendors and maintenance and research personnel.
- m) Controlled access. The site should preferably have a low risk of theft and vandalism, e.g., a controlled access road.

Sites B and C in Table 10 stand out as the two road sections [maximum 500 m (.3 miles in length)] that might benefit most from an animal detection system based on the number of reported collisions with deer and elk. These two road sections were further evaluated with regard to the potential installation of an animal detection system (Table 11). Because the sections are adjacent to each other the authors of this report decided to treat the two road sections as one. The southern edge is just north of mi post 118.4, just north of the intersection with Coyote Bluff Rd (Figure 83). For practical reasons the northern edge was extended until just south of the first access road past 119.1 (Deer Creek Rd) at about mi post 119.25 (Figure 83). Figures 84-89, and especially Appendix A, show the road, right-of-way and the surrounding landscape in the area.

**Table 11: The suitability of the road section between mile post 118.4 and 119.2 with regard to the installation of an animal detection system. + + + = strongly suitable; - - - strongly not suitable or a severe concern.**

Parameter	118.4-119.2
a. A-V collisions	+ + +
b. Animal movements	+ + +
c. Traffic volume	-
d. Terrain	+ +
e. Access roads	-
f. Vegetation	+ +
g. Length road section	+ + +
h. Changes road/landscape	?
i. Project partners	?
j. Travel costs	+ + +
k. Power	+ + +
l. Pull-out	+ + +
m. Controlled access	- -

The road section concerned not only has a relatively high concentration of deer- and elk-vehicle collisions, but the public has also observed the most deer and elk alive on or near the road in this road section.

Traffic volume peaks at about 16,000 vehicles a day in summer (see Figure 4). For most of the year traffic volume is about 12,000-13,000 vehicles per day though. This traffic volume is probably towards the upper end for where an animal detection system may be suitable. Above a certain traffic volume animals may shy away from crossing a road at grade altogether, and physically separating the animals from traffic, e.g. through wildlife under- and overpasses, may become more advisable.

The terrain is generally flat, with a shallow ditch in the right-of-way. In most areas the right-of-way is relatively wide, but in some areas trees, shrubs and fences are closer to the road reducing the effective width of the right-of-way. The curve at about mile post 118.7 may cause reduced sight distance and may require additional sensors.

On the east side of the road, there is one access road to the meadows (Peregrine Ranch) (Figure 83). On the west side of the road, there are 5-6 access roads or driveways (Figure 83).

Depending on traffic volume, access roads may lead to numerous false positives. However, the number of houses served by the driveways and access roads seems relatively low.



Figure 83: An aerial image of S.H. 75, just north of Hailey, between mi posts 118.4 and 119.2.



**Figure 84: View of the right-of-way, east side of S.H.75, about at mi post 119.0 (north of access road to meadows) looking north (© Marcel Huijser, WTI-MSU).**



**Figure 85: View of the right-of-way, east side of S.H.75, about at mi post 118.9 (access road to meadows), looking north (© Marcel Huijser, WTI-MSU).**



**Figure 86: View of the right-of-way, east side of S.H.75, about at mi post 118.9 (access road to meadows), looking south (© Marcel Huijser, WTI-MSU).**



**Figure 87: View of the right-of-way, east side of S.H.75, about at mi post 118.8, looking south (© Marcel Huijser, WTI-MSU).**



**Figure 88: View of the right-of-way, west side of S.H.75, about at mi post 118.85, looking north (© Marcel Huijser, WTI-MSU).**



**Figure 89: View of the right-of-way, west side of S.H.75, about at about mi post 118.85, looking south (© Marcel Huijser, WTI-MSU).**

The length of the road section concerned is about 0.85 mi (about 1.4 km); long enough to allow for some spatial error for the historic animal-vehicle collision data used to select the road section. It is also short enough to allow for the experimental installation of an animal detection system.

The road is scheduled for reconstruction, perhaps narrowing the right-of-way. The landscape adjacent to the road, especially the meadows of the Peregrine Ranch may or may not change. However, should the lands on the east and west side be developed into housing areas, the elk and deer movements in the area can be expected to change, perhaps making an animal detection system useless in this location.

The location is relatively close to ITD maintenance offices in Hailey, allowing for relatively easy operation and maintenance of the system.

Power lines run adjacent to the road and these could be used to supply power to the system, eliminating the need for relatively expensive and perhaps “ugly” looking solar panels.

The right-of-way allows for vehicles to pull off the road in multiple locations. However, road reconstruction may reduce pull-out options in this road section.

Currently anyone can stop almost anywhere in the road section concerned. This may make the system vulnerable to theft and/or vandalism.

Overall, the road section between mile post 118.4 and 119.25 appears suitable for the installation of an animal detection system, at least as an experiment. Thought should be given though to the traffic volume and how much it is projected to increase in the near future and what that may mean for having or allowing animals to continue to cross at grade, and how suitable an animal detection system will be. In addition, careful thought should be given to potential changes in the surrounding landscape and how that might affect animal movements and deer- and elk-vehicle collisions in this road section. Also, if and when the road is reconstructed, the space in the right-of-way should still allow for the installation of an animal detection system, and safe pull outs for operation and maintenance, and potentially also for researchers should be provided for.

## **6.2 Potential Costs and Benefits**

Between March 2007 and March 2008 there were 15 deer-, 18 elk-, and 6 deer- or elk-vehicle collisions reported between mi post 118.4 and 119.2. If the 6 deer- or elk- vehicle collisions are assigned to either deer or elk based on the 15 (deer):18 (elk) ratio, the total number of deer-vehicle collisions was 18 and the total number of elk-vehicle collisions was 21. The total number of collisions with large ungulates on this road section was 39. These numbers are based on a combination of all data sources: ITD, IHP, WTI and the public.

Animal detection systems have been reported to be able to reduce collisions with large ungulates by 82% and 91% (see review in Huijser & Kociolek 2008). Using the lower of these two estimates, an animal detection system, when deployed between mile post 118.4 and 119.2, may “prevent” 32 collisions with large animals per year (82% of 39 reported carcasses in March 2007- March 2008). The number of collisions that may be prevented with deer is 15 and with elk is 17. The costs associated with a deer- and elk-vehicle collision are estimated at about \$8,015

(deer) and \$17,475 (elk) (Huijser et al. 2007a). These estimates include vehicle repair, human injuries, human fatalities, towing, accident attendance and investigation, hunting and recreational value of the animal concerned, and carcass removal and disposal. This then translates into potential annual savings of \$120,225 for deer and \$297,075 for elk (total \$417,300).

An estimate for system design, purchase, installation, and operation and maintenance (assumed life span about 10 years) would be \$30,500 (not corrected for discounting). This is based on the following estimates: \$50,000 for an engineering plan (once), \$105,000 for equipment purchase, including signs (once), and \$15,000 for operation and maintenance (annually).

Based on these assumptions and estimates, an animal detection system at this location may save society \$386,800 (\$417,300-\$30,500) per year. Note that the total number of deer- and elk-vehicle collisions may have been particularly high between March 2007 and March 2008, but if 5 (instead of 18) deer-vehicle collisions would occur annually, or if 2 (instead of 21) elk-vehicle collisions would occur annually (without an animal detection system), a system may still break even. However, note that the costs and benefits are with different groups in society, just as with most other types of collision and collision reduction techniques. Reduced collisions reduce the costs for the insurance industry, and eventually reduce the premiums paid by their clients, but mitigation measures such as an animal detection system are typically paid for by government agencies.

### 6.3 System Type and Manufacturer Recommendations

The authors of this report strongly recommend selecting an animal detection system for which independent data on system reliability and/or effectiveness are available and that meet the requirements for reliability or effectiveness of the agency or organization concerned. Currently, the following vendors appear to produce animal detection systems that can be considered reliable and/or effective:

*Published data (see Huijser & Kociolek, 2008)*

Terry B. Wilson  
Director of Operations  
ICx Radar Systems (Scottsdale)  
8900 East Chaparral Road, Suite 1000  
Scottsdale, Arizona 85250  
(480) 483-1997 phone  
(480) 483-2011 fax  
(480) 216-2662 mobile  
E-mail: [terry\\_wilson@sensor-tech.com](mailto:terry_wilson@sensor-tech.com)  
Websites: [www.icxradarsystems.com](http://www.icxradarsystems.com) , [www.icxt.com](http://www.icxt.com)

Electrobraid Fence  
236 Water Street, Box 19  
Yarmouth, Nova Scotia, Canada, B5A 4P8  
Phone: (888)-430-3330  
Fax: (902)-749-0513  
Contact David Bryson: [dbryson@electrobraid.com](mailto:dbryson@electrobraid.com)  
<http://www.electrobraid.com/>

Calonder Energy  
“CAL 92”  
Willy Berchtold  
1436 Van Asche Drive  
Fayetteville, AR 72704, USA  
Phone: 479-521-0056  
E-mail : [info@calonderenergy.com](mailto:info@calonderenergy.com)

Sabik Oy  
P.O.Box 19  
FIN06151 Porvoo, Finland  
Visiting Address: Merituulentie 30, Porvoo  
General Phone: 358-19-560 1100, General E-mail: [sales@sabik.com](mailto:sales@sabik.com)  
Main contact: Kari Taskula, RandD Manager  
Phone: 011-358-19-560-1130, Fax: 011-358-19-560-1120, E-mail: [kari.taskula@sabik.fi](mailto:kari.taskula@sabik.fi)  
Website: <http://www.sabik.fi/>

*Anecdotic data (see Huijser & Kociolek 2008):*

David Rubin  
“Elk Highway Collision Avoidance System”  
Private effort for the Sequim Elk Habitat Committee, Washington Department of Transportation, Washington Department of Fish and Wildlife, and the US Department of Transportation.  
Phone: 360-681-8448, E-mail: [dnmir@olypen.com](mailto:dnmir@olypen.com)

E.L. Lewis Enterprises Inc.  
7465 Oak Park Village Drive, Suite #9  
St Louis Park MN 55426  
Main contacts: Erick Lewis / Jacqueline K. Barabash  
Phone: 952-936-9202 / 952-933-6935 / 612-597-8000, Fax 952-949-0944, E-mail:  
[sales@ericklewis.net](mailto:sales@ericklewis.net)  
Website: [www.ericklewis.net](http://www.ericklewis.net)

*The following vendors have their equipment currently subjected to reliability tests by WTI-MSU at a test facility in Lewistown, central Montana. An interim report has been published, but the results are not linked to individual vendors and their systems. This link will be provided in the final report:*

ASIM Technologies, Inc.  
P.O. Box 12  
505 Middlesex Turnpike, Suite 5  
Billerica, MA 01821, USA  
Main contact: Andreas Hartmann  
Phone: 978 667 5207, Fax: 978 667 8247, Toll-free: 1-866-664-ASIM(2746)  
E-mail: [ahartmann@asim-technologies.com](mailto:ahartmann@asim-technologies.com) Website: <http://www.asim-technologies.com/>

Terry B. Wilson  
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8900 East Chaparral Road, Suite 1000  
Scottsdale, Arizona 85250  
(480) 483-1997 phone  
(480) 483-2011 fax  
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Focusing on manufacturers who produce systems for which independent data on reliability and/or effectiveness suggest that their systems are reliable and/or effective, the ICx Radar Systems (formerly STS) system is able to cover relatively long distances (about 400 m between sensors) and should be considered when installing animal detection systems over relatively long road sections. The systems produced by Electrobraided Fence, Calonder Energy, and Sabik Oy cover shorter distances (several tens of meters up to perhaps 200 m) and may be better suited at a gap in a fence rather than for implementation over relatively long road sections. Note that the system produced by Sabik Oy is currently not available on the market, at least not in North America.

## 7 RECOMMENDATIONS

### 7.1 Future Data Collection

The authors of this report recommend that ITD continues to collect carcass removal data. This serves 3 purposes:

1. The data will help further pinpoint locations that may require mitigation measures.
2. The data will help document potential changes in road mortality clusters as a result of increasing development (houses), and associated changes in animal movement.
3. The data will help evaluate the effectiveness of potential mitigation measures (e.g. an animal detection system) through comparisons in time (before-after) and in space (treatment and control areas).

For the carcass removal data collection program, it is important that ITD:

1. Ensures consistent search and reporting effort, both in space (treat every road section the same) and in time (do not increase or decrease the effort). Note that the number of reported carcasses by ITD has increased consistently over the last 4 years. This may be related to the increase in traffic volume (see Figure 5), changes in deer- and elk movements and/or population size in the region, or an increase in the search and reporting effort.
2. Obtains spatially accurate data on the location of the carcasses, for example with the use of a GPS (see Ament et al. 2007) and that the species, at least for carcasses of deer size and larger, are identified to the species level (especially mule deer vs. white-tailed deer).
3. Adopts a data management protocol that minimizes the risk of data loss and that provides feedback to the observers. An example of tools and procedures that minimize data loss and that eliminate manual data entry is described in Ament et al. (2007).
4. For further considerations about carcass removal and accident data collection programs see Huijser et al. (2007c).

If procedures allow, it would be beneficial if IHP would be able to describe the species involved with animal-vehicle collisions, either as a “check box” or free space, on the accident reporting forms (see also Huijser et al. (2007c). For example, noting ‘mule deer’ or ‘elk’ versus ‘wild animal’ would provide substantial more and better information. For both agencies (ITD and IHP), it would be useful to specify whether the other agency was notified (and therefore, it is likely a report was filed) to make it easier to find carcass replicates.

The data collected by the public has had the following benefits:

1. Carcass removal and accident data collected by ITD and IHP was supplemented by the public and helped reduce the underestimation of deer- and elk-vehicle collisions. It is estimated that 54 unique carcasses were reported by the public in 2007.

2. The public reported other species, smaller than deer, which were killed on SH 75. This increased the understanding of what species are killed by cars on the road section concerned.
3. The data showed where deer and elk are observed on or close to the road. This type of information is best obtained by multiple observers that travel the route at different times of the day. Therefore this type of data is best collected by the public rather than an agency that may be able to “monitor” the entire route with more consistent search and reporting effort. However, with one observation session a day, perhaps at certain fixed times, agency efforts are likely to be substantially less effective than efforts of the public.
4. Public awareness was raised through the media, especially in combination with periodic press releases from WTI that provided feedback to the public with regard to the data entered. Increased awareness and participation in the data collection may help increase support for potential future mitigation measures.

## 7.2 Mitigation Measures

### 7.2.1 Current Situation

**Large mammal warning signs:** The current large mammal warning signs still result in a number of WVCs that is considered too high. Furthermore, deer warning signs are likely to be ineffective in reducing deer-vehicle collisions to begin with (see review in Huijser & Kociolek 2008).

**Speed limit signs:** The speed limit between the towns along SH 75 is generally 55 mi/h. Even though data are scarce, the number of WVCs may not decrease substantially unless actual vehicle speeds are reduced to 45 mi/h or less (see review in Huijser & Kociolek 2008). The design of the road is such that a lower speed limit is not advisable. One of the most important drawbacks of a posted speed limit that is much lower than the design speed and current operating speed is “speed dispersion” and massive enforcement. Speed dispersion (vehicles traveling at very different speeds) is associated with higher crash rates, and massive enforcement is likely to be required because of the discrepancy with the design speed. Note that the current plan for road reconstruction of SH 75 includes a design speed from Bellevue to Ketchum of be 50 mi/h while the highest design speed from Bellevue south to US-20 is projected to be 60 mi/h (Pers. Com, Connie Jones, Idaho Transportation Department, Mary 2008). The posted speed limits will be 5 mph less than the design speed limit, resulting in a decrease in the posted speed limit (from 55 to 45 mi/hr) between Hailey and Ketchum when compared to the current situation (see also Figure 12 and 13) (Pers. Com, Connie Jones, Idaho Transportation Department, May 2008). The lower design speed and posted speed limit between Hailey and Ketchum is related to the addition of six traffic signals (one in town, five outside of towns) to the current eight traffic signals that now exist in the project area (Pers. Com, Connie Jones, Idaho Transportation Department, May 2008).

**Existing bridges:** The two bridges across the Big Wood River appear to be readily used by deer (especially the south banks) and smaller species. However, they were not used by elk, at least not from April to September, 2007.

**Future changes in landscape and traffic volume:** Much of the land on both sides of the highway may be transformed from agricultural lands and (semi-) natural vegetation into houses and non-natural vegetation (Pers. com. IDFG personnel at kickoff meeting October 2006). Traffic volume is likely to increase as a result of this.

### 7.2.2 Recommended Additional Mitigation Measures

Huijser & Kociolek (2008) concluded that wildlife fencing and animal detection systems are the only two mitigation measures that can reduce WVCs with large animals substantially (>80%). Wildlife fencing increases the barrier effect of a road and should generally be combined with safe crossing opportunities such as wildlife under- or overpasses, or animal detection systems positioned in a gap of the fence. Huijser & Kociolek (2008) list the pros and cons of animal detection systems and wildlife fencing in combination with wildlife under- and overpasses. In addition, having large mammals cross the road at grade becomes less advisable with higher traffic volumes. Even though there is no research data to support this, it appears that having large animals cross at grade with traffic volumes exceeding 15,000-20,000 per day is probably not desirable. Average daily traffic volume within the study area is already close to 16,000/day in July (ITD data 2007), and about 12,000-13,000 at other times of the year (Figure 6). Finally, the data on the effectiveness of wildlife fencing in combination with wildlife underpasses and overpasses is much more robust than for animal detection systems; animal detection systems must still be considered experimental.

Land use changes are important over the life span of a mitigation measure. For animal detection systems the life span may be about 10 years, for wildlife fencing about 25 years, and for wildlife under- and overpasses about 75 years. Therefore, when considering different types of mitigation measures it is important to look at the future plans for the land adjacent to the road and how that may affect ungulate numbers and movements. Nonetheless, animal detection systems are at least somewhat mobile compared to wildlife fencing and under and overpasses and may offer a more adaptive strategy to reduce WVCs.

With regard to the implementation of mitigation measures, one could consider the following options:

Option 1: Do nothing. Accept a potential increase of WVCs and an increase of the barrier effect of the road, especially with increased development, road reconstruction and associated increase in traffic volume. Note that the road section with the highest concentration of mule deer- and elk-vehicle collisions is projected to have a posted speed limit (45 mi/h) after future road reconstruction that is lower than the current speed limit. With a potential future speed limit of 45 mi/h the number of mule deer- and elk-vehicle collisions may decrease between Hailey and Ketchum.

Option 2: Make the two existing bridges more attractive for use by large mammals by removing riprap and installing a more level path and finer rock substrate, especially on north banks (Figures 90-91); consider increasing available height of undercrossing during next reconstruction. Option 2 should probably be considered as an addition, even if option 3, 4 or 5 are chosen.

Option 3: Install a stand alone animal detection system, for a start between mi posts 118.4 and 119.2. It is advisable to combine the implementation of an animal detection system with research because of its experimental nature. Cost estimates: US\$50,000 for an engineering plan (once), US\$105,000 for equipment purchase, including signs (once, life span about 10 years), and \$15,000 for operation and maintenance (annually).

Option 4: Install a wildlife fence (for a start between mi post 118.4 and 119.2) with a gap (perhaps around mile post 118.8 or 118.9), and an animal detection system in the gap. It is advisable to combine the implementation of an animal detection system with research because of its experimental nature. Cost estimates: US\$131,600 for fencing (once, life span about 25 years),



**Figure 90: Riprap representative of the north banks under both bridges; deer were rarely documented on the north sides (© Marcel Huijser, WTI-MSU).**



**Figure 91: A trail has been cleared from riprap on the south bank of the Greenhorn bridge; deer have been observed crossing under the bridge here (© Marcel Huijser, WTI-MSU).**

50,000 for an engineering plan (once), US\$60,000 for equipment purchase, including signs (once, life span about 10 years), and \$15,000 for operation and maintenance (annually).

Option 5: Install a wildlife fence (for a start between mi post 118.4 and 119.2) with a wildlife underpass (perhaps around mile post 118.8 or 118.9). Minimum dimension for a potential underpass for large ungulates such as elk would be about 7 m wide and 4 m high. Monitoring of wildlife crossing structures is advisable. Cost estimates: US\$131,600 for fencing (once, life span about 25 years), 50,000 for an engineering/construction plan (once), US\$250,000 for an underpass (once, life span about 75 years), and \$15,000 for operation and maintenance (annually).

Option 6: Install a wildlife fence (for a start between mi post 118.4 and 119.2) with a wildlife overpass (perhaps around mile post 118.8 or 118.9). Minimum dimension for a potential underpass for large ungulates such as elk would be about 50 m wide. Monitoring of wildlife crossing structures is advisable. Cost estimates: US\$131,600 for fencing (once, life span about 25 years), 50,000 for an engineering/construction plan (once), US\$2,000,000 for an overpass (once, life span about 75 years), and \$15,000 for operation and maintenance (annually).

## 8 CONCLUSIONS

The purpose of this study was to evaluate different types of mitigation measures with regard to their effectiveness in reducing collisions with deer and elk, to investigate where deer- and elk are most frequently hit by traffic along the 26 mi section of S.H. 75 under study, and to investigate one or more road sections with regard to the potential installation of an animal detection system. A review of potential mitigation measures was presented in Huijser and Kociolek (2008). This report focused on the remaining questions (see also introduction).

More specifically, the research questions, and the answers, based on the data presented in this report are the following:

- *Where do the greatest concentrations of road-killed mule deer and elk occur?*

The greatest concentrations of road-killed mule deer and elk occur between MP 118.4-119.1 (see Figure 82, Table 10). If observations by the public of dead and live deer are combined, most deer- and elk are seen on or close to the road between mile post 117 and 127 (Figure 32).

- *What is a realistic estimate of the number of animal-vehicle interactions in the project area on an annual basis?*

A realistic minimum estimate of the number of reported deer- and elk-vehicle collisions in the study area on an annual basis is 134 for 2007 (Table 5). This estimate was based on combined data from ITD, IHP, WTI and the public. For previous years (2004 through 2006), the minimum estimate varied between 25-40 deer- and elk-vehicle collisions per year (Table 5), but these estimates were based on ITD and IHP data only.

- *What time of day do most animal crossings occur?*

At the two bridges, the highest number of deer was observed between 8:00 pm and 3 am (Figure 74). A second, much smaller peak in deer activity at the two bridges was observed between 9:00 am and 11 am (Figure 74). IHP data showed that most collisions with wild animals occur between 5 pm and 2 am and between 5 am and 9 am (Figure 21). The public observed most ungulates alive on or alongside the road between 5 pm and 12:00 am and between 4 am and 9 am (Figure 78). However, the observations by the public are likely to be related to traffic volume which fluctuates heavily over the course of a 24 hour period (see Figure 5). It is safe to say though deer and elk are on or close to the road in greatest numbers from late afternoon until at least midnight, and additional, but lower activity takes place in the morning (between 4:00 am until at least 9:00 am).

- *What is the best available science on animal detection and animal warning systems that could be applied in the project area?*

For the current state of the science on animal detection systems see overview in Huijser & Kociolek (2008). Based on this review, some animal detection systems are known to be able to detect large ungulates reliably and the available data suggest that animal detection systems may

reduce collisions with large ungulates by 82% or more. However, animal detection systems should still be considered experimental and a potential implementation along S.H. 75 should be seen as an experiment rather than the installation of a mitigation measure that is tried and proven.

- *How should these systems be applied in the project corridor?*

The road section between mile post 118.4 and 119.25 has the highest number of reported deer- and elk-vehicle collisions, and deer- and elk sightings (alive) on or along the road. Therefore this road section is recommended as the first road section where mitigation measures may be implemented. Overall, the road, traffic and surrounding landscape appear suitable for the installation of an animal detection system. Thought should be given though to the traffic volume and how much it is projected to increase in the near future and what that may mean for having or allowing animals to continue to cross at grade, and how suitable an animal detection system will be. In addition, careful thought should be given to potential changes in the surrounding landscape and how that might affect animal movements and deer- and elk-vehicle collisions in this road section within the life span of potential mitigation measures. Also, if and when the road is reconstructed, the space in the right-of-way should still allow for the installation of an animal detection system, and safe pull outs for operation and maintenance, and potentially also for researchers should be provided for.

- *What are their advantages and disadvantages?*

The advantages and disadvantages of animal detection systems when compared to wildlife fencing in combination with wildlife underpasses and overpasses are discussed by Huijser and Kociolek (2008). This overview is repeated here:

#### *Pros for Animal Detection Systems*

- Animal detection systems have the potential to provide wildlife with safe crossing opportunities anywhere along the mitigated roadway, but wildlife crossing structures are usually limited in number and they are rarely wider than about 50 m (54.6 yard).
- Animal detection systems are less restrictive to wildlife movement than fencing or crossing structures. They allow animals to continue to use existing paths to the road or to change them over time.
- Animal detection systems can be installed without major road construction or traffic control for long periods.
- Animal detection systems are likely to be less expensive than wildlife crossing structures, especially once they are mass produced.

#### *Cons for Animal Detection Systems*

- Although the available data on the effectiveness of animal detection systems with regard to collision reduction are encouraging, animal detection systems currently are not as “tried and proven” as wildlife crossing structures.
- Currently, animal detection systems only detect large animals (e.g., deer, elk, or moose). Relatively small animals are not detected, and drivers are not warned about their presence on or near the road.
- Wildlife crossing structures can provide cover (e.g., vegetation, living trees, tree stumps) and natural substrate (e.g., sand, water) allowing better continuity of habitat.

- Above a certain traffic volume, perhaps around 15,000-20,000 vehicles per day, animal detection systems may be less desirable as animals may shy away from crossing the road at grade and road mortality may be increasingly overshadowed by the barrier effect of the road.
- Some types of animal detection systems are only active in the dark and animals that cross during the daylight may not be protected.
- Animal detection systems usually require the presence of poles and equipment in the right of way, sometimes even in the clear zone, presenting a safety hazard of their own.
- Animal detection systems may substantially reduce the number of WVCs, but since they allow large animals to cross the road at grade, they will never completely eliminate WVCs.
- Animal detection systems can be aesthetically displeasing.
- Wildlife crossing structures are likely to have greater longevity and lower maintenance and monitoring costs.

The choice between animal detection systems (with or without wildlife fencing or wildlife crossing structures in combination with wildlife fencing) currently depends on whether the success of the project is defined as: 1) accomplishing a certain minimum result in terms of WVC reduction and/or safe crossing opportunities for wildlife (i.e. wildlife fencing in combination with wildlife underpasses or overpasses), or 2) conducting research that helps to further evaluate the effectiveness of different mitigation measures (i.e. animal detection system, with or without accompanying wildlife fencing). The choice also depends on the problem at hand (WVCs and/or lack of safe crossing opportunities for wildlife) and the species or species groups concerned, as well as the local situation, including road, right-of-way, and landscape characteristics. For additional considerations see Huijser et al. (2006a).

- *What system or combination of systems should be recommended for the SH-75 corridor as a demonstration project?*

Focusing on manufacturers who produce systems for which independent data on reliability and/or effectiveness suggest that their systems are reliable and/or effective, the ICx Radar Systems (formerly STS) system is able to cover relatively long distances (about 400 m between sensors) and should be considered when installing animal detection systems over relatively long road sections. The systems produced by Electrobraided Fence, Calonder Energy, and Sabik Oy cover shorter distances (several tens of meters up to perhaps 200 m) and may be better suited at a gap in a fence rather than for implementation over relatively long road sections. Note that the system produced by Sabik Oy is currently not available on the market, at least not in North America. Also note that the ICx Radar Systems (formerly STS) system can also be installed at a gap in a fence.

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**10 APPENDIX A: PHOTOS OF THE ROAD SECTION BETWEEN  
REFERENCE POSTS 118.4 THROUGH 119.3 (29 MAY 2008)**



**IMG\_1910, 118.4, eastside, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1911, 118.4, east side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1912, 118.4, west side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1913, 118.4, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1914, 118.4, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1915, 118.5, east side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1916, 118.5, east side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1917, 118.5, west side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1918, 118.5, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1919, 118.5, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1920, 118.5, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1921, 118.6, east side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1922, 118.6, east side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1923, 118.6, east side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1924, 118.6, west side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1925, 118.6, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1926, 118.6, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1927, 118.7, east side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1928, 118.7, east side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1929, 118.7, east side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1930, 118.7, west side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1931, 118.7, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1932, 118.7, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1933, 118.8, east side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1934, 118.8, east side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1935, 118.8, west side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1936, 118.8, west side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1937, 118.8, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1938, 118.8, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1939, 118.9, east side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1940, 118.9, east side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1941, 118.9, east side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1942, 118.9, west side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1943, 118.9, west side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1944, 118.9, west side, looking north (© Marcel Huijser, WTI-MSU).**



IMG\_1945, 118.9, west side, looking north (© Marcel Huijser, WTI-MSU).



IMG\_1946, 118.9, west side, looking north (© Marcel Huijser, WTI-MSU).



**IMG\_1947, 119.0, east side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1948, 119.0, east side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1949, 119.0, west side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1950, 119.0, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1951, 119.0, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1952, 119.1, east side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1953, 119.1, east side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1954, 119.1, west side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1955, 119.1, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1956, 119.1, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1957, 119.2, east side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1958, 119.2, east side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1959, 119.2, west side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1960, 119.2, west side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1961, 119.3, east side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1962, 119.3, east side, looking north (© Marcel Huijser, WTI-MSU).**



**IMG\_1963, 119.3, west side, looking south (© Marcel Huijser, WTI-MSU).**



**IMG\_1964, 119.3, west side, looking north (© Marcel Huijser, WTI-MSU).**