DISSERTATION

# A TRANSPORTATION CORRIDOR RUNS THROUGH IT: PEOPLE, WILDLIFE, AND TRANSPORTATION SYSTEMS IN NATIONAL PARKS AND BEYOND

Submitted by

Amanda Ruth Hardy

Graduate Degree Program in Ecology

In partial fulfillment of the requirements

For the Degree of Doctor of Philosophy

Colorado State University

Fort Collins, Colorado

Fall 2012

Doctoral Committee:

Advisor: Kevin Crooks

Lisa Angeloni
Peter Newman
Tara Teel
Dave Theobald

## ABSTRACT

## A TRANSPORTATION CORRIDOR RUNS THROUGH IT: PEOPLE, WILDLIFE, AND TRANSPORTATION IN NATIONAL PARKS AND BEYOND

Transportation systems are the arteries of society; our quality of life depends on the mobility of goods, services, and connectivity to other communities. Transportation infrastructure also shapes and drives our interactions with landscapes, habitat, and wildlife. In this dissertation, I assessed how the construction and use of a recreational pathway in a national park affected ungulates, human activities, and wildlife viewing opportunities in an existing transportation corridor. Shifting gears from the effects of transportation on wildlife and human activities in national parks, I also describe pioneering efforts to adapt how transportation and environmental regulatory agencies offset unavoidable impacts of transportation projects, with goals of improving the efficiency of transportation project delivery and effectiveness of ecological mitigation across larger landscapes.

Expanding transportation corridors in national parks to incorporate recreational pathways can affect wildlife, visitors, and opportunities to see wildlife. I conducted a Before-After-Control-Impact assessment of elk (*Cervus canadensis*) and pronghorn antelope (*Antilocapra americana*) responses to recreational pathway construction and use in an existing transportation corridor in Grand Teton National Park, USA. I measured activities of these ungulates and humans before pathway construction (2007), during construction (2008), and for two years after the pathway opened to public use (2009, 2010) in a treatment area with the pathway and an adjacent control area without it. If ungulates avoided pathway activities, I predicted that, in the treatment as compared to the control: 1) standardized counts of ungulates viewed from the road would decline; 2) ungulates would be seen farther from the road; 3) the probability of ungulates responding behaviorally would increase, and 4) observations of vehicles stopped, people afoot and wildlife viewing activities would decrease given fewer opportunities to view wildlife during and after pathway construction. Contrary to predictions, the number of elk viewed did not decrease and the distance of elk from the road did not increase in the treatment relative to the control after pathway installation. Further, the probability of elk behaviorally responding in the treatment was lower, not higher, compared to the control during and after pathway construction, particularly in early season, potentially suggesting tolerance or habituation to human activities. Although the number of pronghorn viewed and their behavioral responsiveness did not differ in the treatment relative to the control, pronghorn shifted farther from the road after construction in the treatment, supporting the prediction that pronghorn avoided pathway activities during the mid-season peak in park visitation. In contrast to the prediction of reduced wildlife viewing opportunities following pathway construction, I observed more vehicles parked and people afoot in 2010 in the treatment than in other years, particularly in the late season. Although I saw fewer people engaged in viewing wildlife in the treatment and control in 2009, wildlife viewing activities recovered in the treatment relative to the control in 2010. Despite direct habitat loss, widening the human footprint, and a shift in pronghorn groups away from the transportation corridor during the annual peak in park visitation, pathway construction and use did not appear to greatly impact ungulates or reduce visitor opportunities to see elk and pronghorn in the travel corridor.

In addition to quantifying patterns in ungulate and human activities as defined above, I conducted a repeated measures study assessing vehicle, pedestrian, and bicycle activities occurring at times when ungulates were visible near an existing transportation corridor in Grand Teton National Park between June and October, before (2007), during (2008), and for two years

after (2009, 2010) the installation of a recreational pathway along the road. Bicycle and pedestrian activities increased additively with the opening of the pathway. All human activities were influenced by the year, season, time of day, and species of ungulate (elk, moose, mule deer, moose) seen near the road; generally, we recorded more human activities during the second year after the pathway opened, during midday hours, in late season (September 1-October 15), and when moose were present. Alongside concurrent studies assessing ungulate responses to pathway activities, patterns of human activities observed in this study offered feasible explanations for the coexistence of ungulates and park visitors similar to what was observed prior to the introduction of the pathway. I caution, however, that changes in temporal patterns of human activities and increases in pathway activities across the region has the potential, over time, to affect wildlife, visitors' safety on the road and pathway, and wildlife viewing experiences. This study offers baseline information that could be useful in the process of defining ecological, social, and managerial indicators to adaptively manage human activities in transportation corridors with pathways to protect wildlife, maintain wildlife viewing opportunities, and provide visitors with safe, non-motorized recreational transportation modes in national parks.

Finally, I presented a case study of a multi-agency effort in Montana to create an alternative approach to offset unavoidable impacts associated with multiple highway reconstruction projects. Typically, mitigation of unavoidable adverse impacts occurs on a project-by-project basis and commonly attempts to restore the same affected resource as close to the site where the impact occurs. This piecemeal approach may fulfill regulatory requirements but greater mitigation value may be achieved for a similar investment by evaluating and prioritizing off-site mitigation opportunities in the context of the entire ecosystem. Further,

project-by-project environmental permitting practices involve repetitious procedures that sometimes unpredictably delay project delivery. In 2006, federal regulatory agencies released guidance encouraging agencies to collaboratively and strategically plan infrastructure projects and related mitigation with goals of conserving and connecting important habitats, while increasing predictability and transparency of planning and regulatory permitting processes. This guide, entitled, “Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects,” was used by an interagency group in Montana to create the “Integrated Transportation and Ecosystem Enhancements for Montana” (ITEEM) process. As the first effort in the nation to “pilot” Eco-Logical’s guidance, cooperating agencies gained insights that may help others follow Eco-Logical’s framework. I summarized Montana’s efforts to adapt the ideas and guidance in Eco-Logical to create the ITEEM process and offer practical considerations for other interagency working groups to increase the efficiency of transportation project delivery while mitigating adverse impacts where the conservation efforts are most needed.

# ACKNOWLEDGEMENTS

There are many people and organizations that I am indebted to for their support. To start, I want to thank my former colleagues at the Western Transportation Institute at Montana State University (WTI-MSU). My years of working with these professional researchers to develop the Road Ecology Program at WTI-MSU played a pivotal role in my choosing to pursue this degree.

The National Park Service (NPS) funded the pathway study in Grand Teton National Park through a grant from the Federal Highway Administration (FHWA), administered by the Cooperative Ecosystems Study Unit. Additional funding support was provided by Rocky Mountain Goat Foundation, Anheuser-Busch Environmental Fellowship, The Hill Memorial Fellowship, and the Oscar and Isabel Anderson Graduate Scholarship. I appreciate guidance and support provided by NPS personnel Steve Cain, Sarah Dewey, Cindy O'Neill, John Stephenson, and Margaret Wilson. Rebecca Blaskovich, Casey Brown, David Ellsworth, Danny Kinka, Kathleen Knighton, Kendra Martinez, Melinda Scott, Tim Sullivan, and Kristin Van Ort assisted with field data collection. Phil Chapman, Amy Davis, and Libo Sun provided statistical assistance and Andre Breton saved me from the throes of inefficiency with his database management wizardry. I am particularly grateful for the devoted efforts of Casey Brown and Melinda Scott; I could not have asked for more dedicated, supportive, and encouraging colleagues and friends to have by my side throughout the years working in Grand Teton National Park.

The FHWA funded the project coordinator position to facilitate the development of the Integrated Transportation and Ecosystem Enhancements for Montana (ITEEM) process and the Montana Department of Transportation (MDT) funded the initiation of the pilot study. The following agency representatives were instrumental in creating Montana's ITEEM process:

Janice Brown, Ted Burch, Paul Garrett, Craig Genzlinger and Carl James, FHWA; Jim Walther, Jean Riley, Bonnie Gundrum, and Pat Basting, MDT; Scott Jackson, US Fish and Wildlife Service; Todd Tillinger, Army Corps of Engineers; Steve Potts, Environmental Protection Agency; Jeff Ryan, Montana Department of Environmental Quality; Glenn Phillips, Steve Knapp, and T.O. Smith, Montana Fish, Wildlife, and Parks; Jim Claar and Fred Bower, US Forest Service.  We thank Jeff Berglund, the consultant pilot study project manager, Michelle Arthur, and the rest of the team from PBS&J for their contributions to the pilot study.  We thank Kevin Crooks, Roger Dodds, Dave Willey, Bonnie Gundrum and Paul Sturm for their helpful reviews of that manuscript.  The contents of that chapter reflect the views of the authors, and contents do not necessarily reflect the official policies of the participating agencies.  It was a pleasure to coauthor that chapter with Deb Wambach, wildlife biologist at MDT, for a book entitled "Safe Passages:  Highways, Wildlife, and Habitat Connectivity" (2010, Island Press).  I thank the editors of that book, Jon Beckman and Jodi Hilty of the Wildlife Conservation Society, and Anthony Clevenger and Marcel Huijser of the Western Transportation Institute at Montana State University, as well as the staff at Island Press, for the opportunity to contribute and for their excellent editing efforts.

I will sincerely miss the students, staff, and faculty in the Graduate Degree Program in Ecology; Department of Fish, Wildlife, and Conservation Biology; Department of Human Dimensions of Natural Resources, School of Global Environmental Sustainability; and the Warner College of Natural Resources at Colorado State University.  I am so fortunate to have had the opportunity to be a part of this remarkable academic community; the positive energy and supportive atmosphere allowed me to maintain excitement, motivation, and momentum while challenging me in on many levels.

I genuinely valued the direction and contributions of my committee members, including Lisa Angeloni, Peter Newman, Tara Teel, and Dave Theobald. Their input, professional advice, and instruction over the years has influenced my work and expanded my professional repertoire significantly. My adviser, Kevin Crooks deserves special recognition for his amazing mentorship. Kevin is an exemplary professor, scientist, and kind human being with a knack for keeping me focused and motivated. It has truly been an honor and pleasure to work with Kevin and words fall short of expressing how much I sincerely appreciate his commitment to helping me succeed in this academic endeavor.

Last, none of this would have been possible without the encouragement of friends and family. I am blessed to have many friends, old and new, near and far, that have provided professional, academic, and emotional support to me; without ado, these people know who they are, and I thank you from the bottom of my heart for your loving kindness. I am very thankful for the caring support provided by amazing McKee family and my father, J. Roger Dodds. Finally, I would like to dedicate this to my mother, Mary Ann Heilprin, who always believed in me.

TABLE OF CONTENTS

# CHAPTER ONE[1]

## Introduction

Transportation systems in parks and recreation areas allow millions of people to access and experience an array of natural and cultural resources that park managers aim to protect in perpetuity. Roads and automobile traffic in parks and elsewhere, however, impose negative impacts on natural terrestrial and aquatic systems, destroying and altering habitats , spreading non-native biota (Trombulak and Frissell 2000), modifying and creating barriers to animal movements (Riley et al. 2006), masking and interfering with animal auditory communications and sensing (Barber et al. 2010), and killing organisms that attempt to cross roads but are struck by vehicles (Trombulak and Frissell 2000, Evink 2002, Forman 2003). Road impacts on wildlife are thus a considerable concern for park managers (Ament et al. 2008). To reduce motor vehicle impacts on park resources, diversify recreational experiences, and increase safety for non-motorized travelers, there is a growing interest in alternative transportation options such as recreational pathways to complement park roads.

While pathway systems provide non-motorized travel and recreation opportunities for park visitors, with the potential to reduce traffic congestion and decrease bicycle-automobile conflicts, such infrastructure widens transportation corridors and extends the human footprint into habitats that may be important to wildlife. Human activities can affect wildlife space and habitat use, circadian activity patterns, foraging behavior, body condition, disease susceptibility, reproductive success, sex ratio, social development, mating systems, and social structure (see review in Bejder et al. 2009). In parks where wildlife are seen near roads, recreational activities on pathways may prompt animals to change activity patterns, avoid habitats near recreational

---

[1] Manuscript coauthored with K.R. Crooks.

pathways, and increase vigilance and energy expenditures (Knight and Cole 1995, Fairbanks and Tullous 2002, Taylor and Knight 2003, Borkowski et al. 2006, George and Crooks 2006).

In 2006 Grand Teton National Park (GTNP), USA, adopted a transportation plan that called for a paved, multi-use pathway system to accommodate bicyclists, pedestrians and other non-motorized travel modes (National Park Service 2006). Under the plan, 36.0 km of paved pathways could be installed 15.2 to 45.7 m from existing roads that traverse open habitats where pronghorn antelope [*Antilocapra americana*] and elk [*Cervus canadensis nelsoni*] are frequently seen during summer and fall months and are a primary wildlife viewing attraction inside the park. Adding a recreational pathway along a well-traveled road known for wildlife viewing opportunities is unprecedented in a US national park (National Park Service 2006), thus it was uncertain how this new infrastructure might affect wildlife and wildlife viewing opportunities and experiences. Wildlife viewing, particularly elk, was identified as the second most important reason that people visit GTNP and the surrounding region, second to seeing the Teton Mountains (Loomis and Caughlan 2004). Of particular conservation interest, the small population of pronghorn that reside in GTNP during summer and fall months participate in the longest land mammal migration (~150 km one way) in North America, south of central Canada (Berger 2004). While much attention has been dedicated to protecting this important migration corridor (Berger 2003) and reducing the multitude of stressors that these migrating pronghorn encounter, including landscape bottlenecks, fencing, and housing and energy development on winter range (Sawyer et al. 2005), it is equally important that summer habitats in the park remain a refuge for ungulates.

To address these concerns, we evaluated ungulate responses to the first phase of pathway installation (7.7 km) and the accompanying diversification of human activities in the park's transportation corridor. Our specific objective was to assess pronghorn and elk distribution and behavioral responses to pathway construction and changes in human activities after pathway use ensued in GTNP. To do so, we implemented a repeated measures Before-After-Control-Impact (BACI) assessment study; such BACI designs increase inferential strength of environmental impact studies but are uncommon in transportation ecology research (Roedenbeck et al. 2007, Fahrig and Rytwinski 2009). We recorded human activities and ungulate distribution and behavior data before pathway construction (2007), during construction (2008) and for two years after the pathway was open to public use (2009 and 2010) in a treatment area with the pathway and an adjacent control area without it. If ungulates avoided or were disturbed by pathway activities, we predicted that, in the treatment as compared to the control: 1) standardized counts of ungulates viewed from the road would decline; 2) ungulates would be seen farther from the road; 3) behavioral responses indicative of disturbance to ungulates would increase; and 4) observations of vehicles stopped, people afoot and wildlife viewing would decline given fewer opportunities to view wildlife during and after pathway construction.

## Methods

### *Study area*

This study was conducted in Grand Teton National Park (GTNP) in northwestern Wyoming, USA (43-50'00" N, 110-42'03" W) in habitats visible from 19.4 km of the Teton Park Road (TPR) between Moose and Spalding Bay Road (Figure 1). Elevations ranged from 1962 to 133 meters at the southern and northern ends of the study area, respectively. Landscapes visible from the TPR were characterized by flat valley plains dominated by dry sagebrush (*Artemesia*

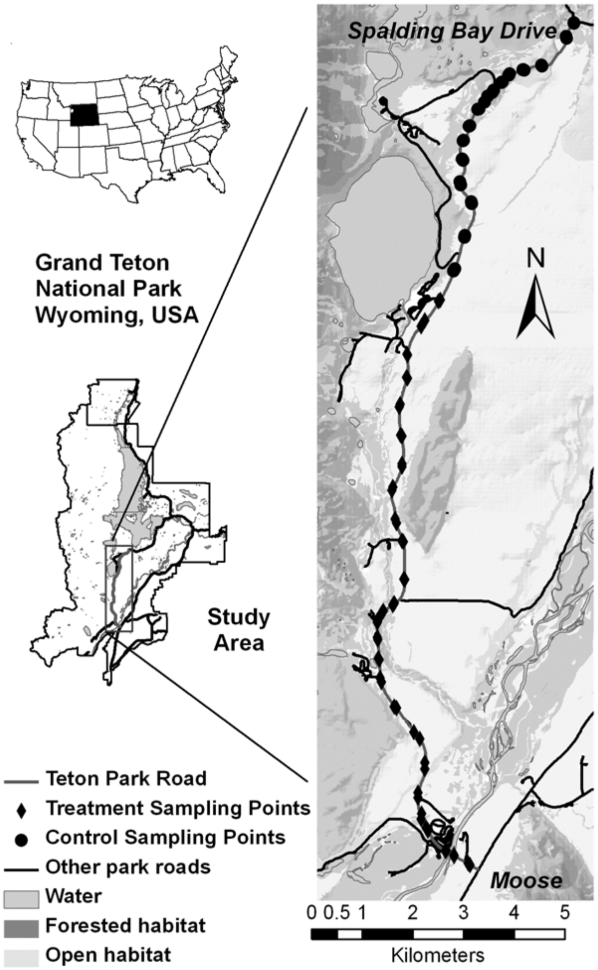

**Figure 1. The study area included ~3250 hectares of visible area (~41% of total terrain within 2 kilometers of the road) from 19.4 km (12 miles) of the existing Teton Park Road (TPR) between Moose and Spalding Bay Road in Grand Teton National Park, Wyoming, USA. In 2007, there was no pathway in the study area. In 2008, construction of 12.5 kilometers (7.7 miles) of paved pathway next to the road created a treatment area (n=25 scan points). The northern 6.9 km (4.3 miles) of the TPR in the study area had no pathway and served as a control (n=17 scan points). Scan points standardized survey search effort and maximized terrain visibility from the TPR.**

spp.) shrublands with patches of lodgepole pine (*Pinus contorta*), Douglas fir (*Pseudotsuga menzesii*), aspen (*Populus tremuloides*) and riparian zones with willow (*Salix* spp.) and cottonwoods (*Populus angustifolia*). The study area provided summer and fall habitat for resident and migrating ungulates, including elk, pronghorn antelope, mule deer (*Odocoileus* *hemoinus*) and moose (*Alces alces*). Thousands of park visitors passed through the study area on the TPR each year, with peak visitation typically occurring in July. While most people traveled on the TPR in motor vehicles, a small portion of visitors opted for non-motorized travel modes and recreation (e.g., bicycling, walking).

In 2008, 12.5 kilometers (7.7 miles) of pathway was constructed along the TPR in the southern end of the study area to accommodate non-motorized travel between South Jenny Lake and Moose. The installation and public use of the 3.05 meter wide paved route along the existing road created a "treatment" area within the larger study area (Figure 1). The northern end of the study area, along 6.9 km of the TPR between South Jenny Lake Junction and Spalding Bay Road, provided a "control" site where no pathways were constructed during this study.

### *Field methods*

We conducted systematic road surveys and focal sampling methods to repeatedly measure variables of interest in the treatment and control area before (2007), during (2008) and after (2009-2010) pathway installation and use in the treatment area. We focused on eight response variables: 1) number of ungulates viewed per road survey; 2) distance of ungulate groups to TPR; 3) probability of ungulates behaviorally responding during a group behavior scan; 4) probability of ungulates behaviorally responding during a focal animal sample; 5) number of vehicles stopped per survey; 6) number of people observed afoot per survey, 7) frequency of people watching wildlife per survey, and 8) frequency of people traveling off-road/pathway per survey.

Road survey methods involved two observers systematically traversing the 19.4 km TPR study area to sample human and ungulate activities observed from the road. Surveys were conducted typically 1-2 times a day from June through October, with start times staggered 12-14 hours and survey direction alternated. Surveys typically spanned 2-4 hours depending on ungulate activity in the corridor. Observers traveled in a truck at ~48 km/h through the study area, stopping at 42 “scan points” (control n=17; treatment n=25) established approximately 160-800 meters apart where views of the landscape were maximized. Observers also stopped opportunistically to record data if ungulates were observed between scan points. At each scan point, immediately upon stopping, we recorded the number of vehicles stopped, people afoot, and bicyclists (passing and stopped) within 200 meters of the scan point. In 2008, 2009 and 2010, we also recorded the presence of at least one person apparently looking directly at wildlife (herein referred to as wildlife viewing) or traveling off-road/pathway at each scan point. After recording human activities, observers searched the landscape for ungulates using binoculars and scopes. Ungulates groups were delineated as animals with nearest neighbor distances <100 meters within groups and >100 meters between groups following Childress and Lung (2003), who described this as the maximum distance at which elk respond to conspecific vocalizations. For each ungulate group observed, we recorded the time of observation, species, location, and total number of animals in the group. Location of the group was determined based on the observers’ location, distance between observers and the ungulate group, and a compass azimuth to the center of the group. Once the initial herd data were collected, we recorded behavior only if the herd was within 500 meters of the sampling point to ensure accuracy of behavioral observations (Brown et al. 2012). One observer scanned the group from left to right and recorded each animal’s behavior. Behaviors were categorized in a manner similar to definitions by Childress and Lung (2003), Borkowski et al. (2006) and Brown et al. (2012) as follows: bedded; feeding; grooming (i.e., licking or scratching oneself or another); scanning (i.e., standing with head at or above shoulder level, but not apparently alarmed); traveling (i.e., walking); vigilant (i.e., displaying alarm or acute attention toward some stimulus); flight (i.e., running in response to some stimulus); defensive (i.e., kicking, biting or charging towards another animal); and mating (i.e., rut behaviors observed in the fall months such as grouping and pursuing cows or sparring between bulls).

We also conducted extended behavioral observations of individual focal animals during road surveys and opportunistically prior to and after surveys; we avoided collecting >1 focal sample from the same group in a day. We adapted focal animal sampling methods from Childress and Lung (2003). When an ungulate group was sighted within 500 meters of the road during a road survey, a focal animal observer continuously recorded the behavioral state (same categories as described above) and the timing of any changes in behavioral state for up to 15 minutes or until the focal animal moved out of view. If the focal animal sample occurred before or after a road survey, observers continued focal sampling as long as possible (up to 50 minutes) or until the focal animal moved out of sight.

*Data analysis*

Continuous response variables in our analyses included the numbers of ungulates viewed, vehicles stopped, people afoot, and the distance of ungulate groups from the TPR. Individual road surveys served as the experimental unit to analyze numbers of ungulates viewed, vehicles stopped, and people afoot. To standardize the number of ungulates viewed, we divided the count of ungulates observed per survey by hectares (ha) of terrain that could be seen from the road in each area. The area of terrain visible from the road was estimated using a viewshed analysis in a Geographic Information System (ArcMap v9.3, ESRI, Redlands, California, USA). This analysis determined the number of 10 by 10 meter cells with uninterrupted horizontal line of sight from the 84 scan sampling points (42 on each side of the road; Figure 1) along the TPR. Elevation of cells was estimated using a 10 meter resolution digital elevation model plus vegetation data that assumed an average height of various vegetation types represented in each cell. We used a 2 meter vertical offset at each scan point to elevate line of sight to approximate observer height when sitting in the truck. Target cells were vertically offset by 1 meter for pronghorn and 2 meters for elk to account for their different heights, and thus different visibility of each species. Hence, total numbers of elk and pronghorn seen in the control area during each survey were divided by 986 and 932 ha of visible area, respectively, representing 35.7% and 33.7% of the area within 2 km of road in the control area. In the treatment, the total numbers of elk and pronghorn seen per survey were divided by 2261 and 2111 ha of visible area, respectively, representing 45.2% and 42.2% of the area within 2 km of the road in the treatment area. Numbers of vehicles stopped and people afoot within 200 meters of scan sampling points were standardized for different sampling effort in each area by dividing total counts per survey by the number of scan sampling points in each area (control n=17; treatment n=25). We used observations of ungulate groups as the experimental unit to analyze distances of ungulates from the TPR and determined perpendicular distance of each group to the TPR using GIS, based on the group's location. Distance values from the TPR exceeding 1000 meters were difficult to accurately estimate. Thus, for statistical analyses, estimated distances exceeding 1000 meters were reclassified to equal 1000 meters to limit the influence of extreme observations in the data while retaining observations of groups that could be seen at far distances from some points on the TPR.

We used a generalized linear mixed model (PROC GLIMMIX, SAS v9.2, SAS Institute Inc., Cary, North Carolina, USA) to examine the fixed effects of year (2007, 2008, 2009, 2010), area (treatment, control) and their interaction (year*area) on each continuous response variable described above. Inferences drawn from the BACI experimental design were based on the interaction term in the model (Smith 2002); if statistically significant, this indicated that annual trends in the response variable(s) in the treatment and control differed, suggestive of a treatment (i.e., pathway) impact. We also included a random effect of survey nested within year given that number of animals viewed, their location relative to the road, and vehicles stopped and people afoot during a given survey may be influenced by environmental (e.g., weather, visibility, length and time of day) and biological (e.g., inter- and intraspecific interactions, plant phenology) factors during the survey. We square root-transformed continuous response variables to satisfy homogeneity of variance and normality assumptions of ANOVA methods. Degrees of freedom were estimated using the Kenward Roger method (Alnosaier 2007). We analyzed data separately for elk and pronghorn. Given the importance of the interaction term in the BACI design, reported results were restricted to year*area interactions and, if significant ($p<0.05$), subsequent *post hoc* Tukey-Kramer Honestly Significant Difference (HSD) tests of pairwise contrasts between years (2007-2008, 2007-2009, 2007-2010, 2008-2009, 2009-2010). Significant interactive effects were determined based on the statistical modeling using transformed data; thus, significant *post hoc* contrast estimates were reported on a transformed scale.

For group scan and focal animal sampling behavioral analyses, we created a binomial response variable, pooling flight, vigilance, traveling, and defensive behaviors as "responsive" behaviors, and bedded, feeding, grooming, scanning, and mating behaviors as "non-responsive" behaviors (Borkowski et al. 2006, Brown et al. 2012). For group scan data, this binomial response variable estimated the probability that an individual within a herd was responsive, while the focal animal binomial response variable estimated the probability that the focal animal was responding per second during the focal sampling period. We used logistic regression with a logit link function (PROC GLIMMIX, SAS v9.2) to assess whether year, area and their interaction predicted the probability of behavioral responsiveness. For focal animal data, we included a unique integer accounting for the random effect of the date nested within year. This random effect accounted for similar environmental factors (e.g., weather) and biological factors (e.g., presence of other ungulates, predators, humans) shared on days when >1 focal sample was collected on a single day. We also included a random effect of the individual animal to account for pseudoreplication of correlated behavioral responses originating from a single animal during a focal sample. For the group scan data, we included a random effect for survey nested within year to account for environmental and biological factors, and a random effect for group nested within survey and year to account for potential pseudoreplication issues of correlated behavioral responses within a group, given that an individual's response may be influenced by the behavior or number of other animals in the group (Childress and Lung 2003). Degrees of freedom were estimated using the Kenward Roger method. We analyzed each behavioral variable separately for elk and pronghorn; significant year*area interactions and subsequent *post hoc* Tukey-Kramer Honestly HSD tests of pairwise contrasts between years were reported on the transformed scale.

Preliminary analyses indicated season influenced the continuous and binomial response variables described above. Thus, in addition to analyzing annual trends, we also analyzed these response variables within each of three seasons: 1) early season (June to July 15), when ungulates were calving/fawning; 2) mid season (July 16 to August 31), when human visitation and temperatures peaked; and 3) late season (September 1 to October 15), when ungulates were influenced by the rut, hunting pressure beyond the study area and oncoming winter weather conditions.

Finally, we analyzed the presence (or absence) of at least one person per scan point engaged in wildlife viewing or off-road/pathway activities separately, using road survey as the experimental unit for both analyses. We applied the BACI approach estimating fixed effects of area, year (2008, 2009, 2010), and their interaction to assess if annual trends varied between the treatment and control in the number of sampling points where we saw at least one person viewing wildlife or traveling off-road and off-pathway. Given many low or zero counts per area per survey (i.e., a highly right-skewed distribution), we pooled seasons and used a generalized linear model (PROC GENMOD, SAS v9.2) specifying a log-link and negative binomial distribution; estimated dispersion parameters (1.81 for wildlife viewing and 0.48 for off-road/pathway) justified the use of a negative binomial distribution to model these data. To account for different numbers of sampling points in the treatment and control, the logarithm of the numbers of points in the control (n = 17) and treatment (n = 25) was used as an "offset" to standardize these data for these analyses (McCullagh and Nelder 1989). We used *post hoc* contrasts of significant year*area interactions to test for differences in trends in the treatment and control between years, and for significant contrasts we reported estimated differences of predicted means between years and areas on the log scale.

We presented effects plots to aid in interpretation of the results of all significant interactions; means and standard errors for these plots were derived from untransformed data, standardized when appropriate (i.e,. all variables other than herd distance to the TPR) to account for differences in the number of sampling points or visible terrain in the treatment and control.

## Results

### *Ungulate distribution and behavior*

During the four years of the study, we conducted 384 road surveys during daylight conditions, systematically sampling ungulate and human activities while cumulating a total of 8,250 km traversing the TPR in the study area. We recorded 1,321 elk groups comprised of 12,256 individual elk observations. Elk groups seen from the road ranged between 1 to 128 individuals (mean ± SE = 9.28 ± 0.41). Annual trends in the number of elk viewed varied between the control and treatment in early season (year*area $F_{3,97} = 4.34$, $p = 0.007$; Figure 2A), but not mid season (year*area $F_{3,94} = 0.80$, $p = 0.499$) or late season (year*area $F_{3,67} = 0.56$, $p = 0.643$) or when pooling among seasons (year*area $F_{3,254} = 0.90$, $p = 0.442$). Post hoc annual contrasts of the early season year*area interaction revealed a decrease in the number of elk viewed in the control between 2008 and 2010 (2008-2010 contrast estimate = 0.07 ± 0.02, $t_{193} = 3.90$, Tukey HSD $p = 0.010$) while detecting no annual differences in the number of elk viewed from the road in the treatment (all *post hoc* contrasts $t_{166} \leq |2.13|$ and Tukey HSD $p \geq 0.151$).

We measured distance from the road for 1,304 elk groups. We found no significant year*area interactions in the three seasonal analyses of distance from the road (all $F_{63} \leq 1.21$; all $p \geq 0.313$). However, pooling over seasons revealed a significant year*area interaction ($F_{3,438} = 2.64$, $p = 0.049$; Figure 2B). Although annual trends between the control and treatment appear qualitatively similar (Figure 2B), *post hoc* annual contrasts indicated that elk in the control were farther from the road in 2008, 2009, and 2010 compared to 2007 (2007-2008 contrast estimate = -6.19 ± 1.46, $t_{478} = -4.23$, Tukey HSD $p < 0.001$; 2007-2009 contrast estimate = -8.15 ± 1.47, $t_{497} = -5.56$, HSD $p < 0.001$; 2007-2010 contrast estimate = -5.56 ± 1.60, $t_{560} = -3.50$, HSD $p = 0.003$), whereas elk were farther from the road in the treatment only in 2009 compared to 2007 (2007-2009 contrast estimate = -2.98 ± 1.11, $t_{434} = -2.70$, HSD $p = 0.037$).

We conducted 419 elk group behavior scans including 3,722 individual scan observations. Pooling across all seasons, we found no significant year*area interactions ($F_{3,95} = 0.84$, $p = 0.478$). In early season, we detected a significant year*area interaction ($F_{3,165} = 4.45$, $p= 0.005$; Figure 2C); the probability of an elk responding in the treatment decreased in 2008 and 2009 compared to 2007 (2007-2008 contrast estimate = 1.96 ± 0.74, $t_{94} = 2.66$, Tukey HSD $p=0.043$; 2007-2009 contrast estimate = 1.84 ± 0.70, $t_{78} = 2.63$, HSD $p = 0.046$). In mid season,

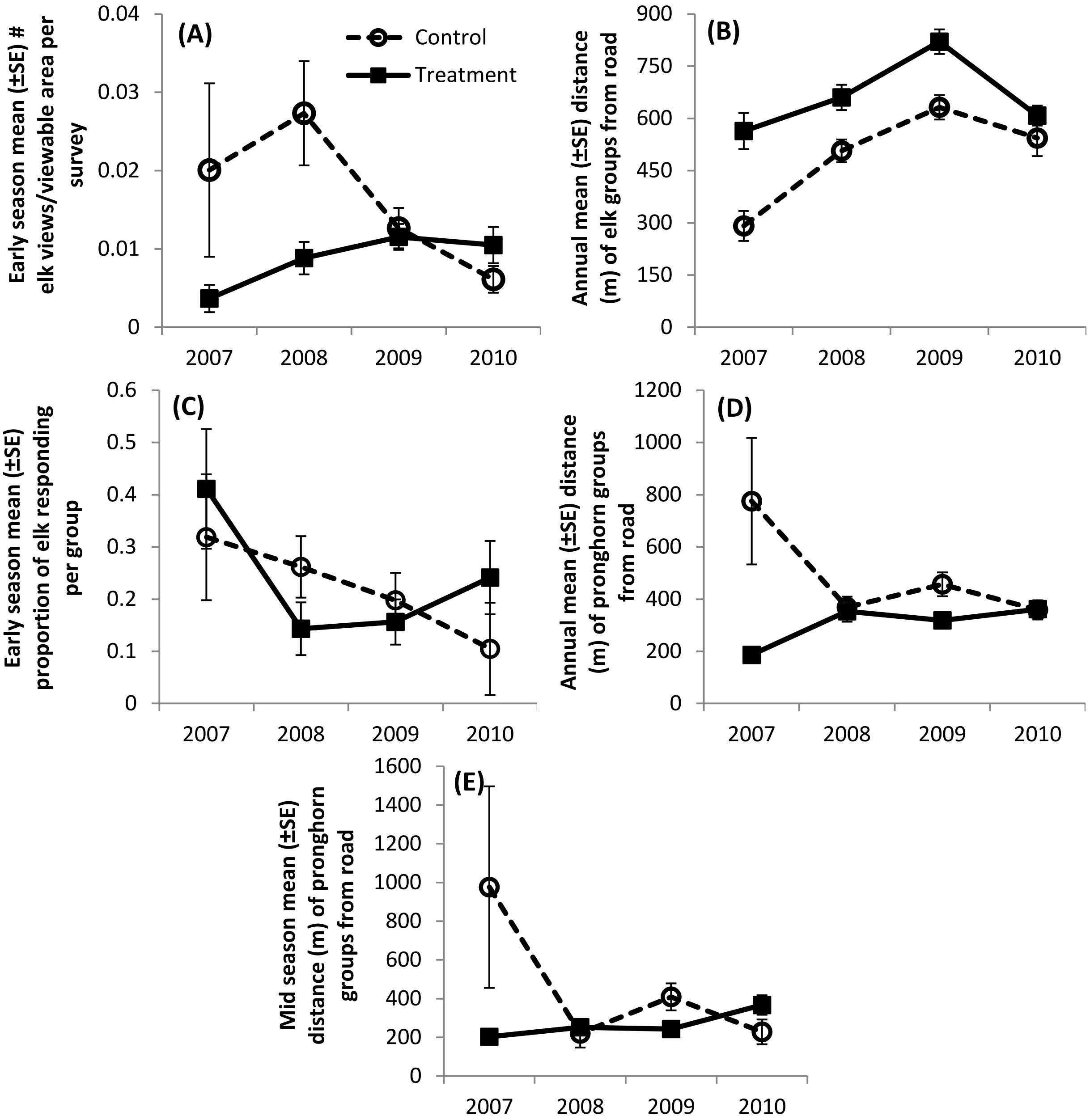

**Figure 2. Mean (± standard error) A) number of elk viewed per road survey in early season (June-July 15); B) distance of elk groups from the road; C) proportion of elk responding per group behavior scan in early season; and distance of pronghorn groups from the road (D) annually and (E) in mid season (July 16-August 31) in control and treatment areas in Grand Teton National Park, 2007-2010.**

we were able to conduct only 2, 3, and 8 behavior scans of elk groups in the control in 2008, 2009 and 2010, respectively, with no elk observed responding during these observations, thus precluding statistical analyses. In late season, the year*area interaction was not significant ($F_{3,63}$

= 0.081, $p$ = 0.493). Finally, we conducted 349 focal samples amounting to 81.5 hours of elk behavior data; no interaction terms were significant for both the annual ($F_{321}$ = 0.45; $p$ = 0.715) and seasonal (all $F_{64} \leq 2.22$; all $p \geq 0.094$) analyses.

We observed 728 pronghorn groups including 2055 pronghorn observations. Pronghorn groups ranged in size from 1-22 individuals (mean ± SE = 2.79±0.1); most (>95%) groups contained <10 animals. Seasonal and annual analyses failed to find significant year*area interactions for the number of pronghorn viewed from the road (all seasons $F_{75} \leq 1.43$ and $p \geq 0.241$; annual $F_{253}$ = 0.13 and $p$ = 0.941).

We measured distance from the road for 728 pronghorn groups. Pooling across seasons, the year*area interaction was significant ($F_{3,330}$ = 6.60, $p$ < 0.000; Figure 2D) with *post hoc* contrasts indicating pronghorn were farther from the road in the treatment in 2008, 2009 and 2010 compared to 2007 (2007-2008 contrast estimate = -3.95 ± 1.22, $t_{491}$ = -3.24, Tukey HSD $p$ = 0.007; 2007-2009 contrast estimate = -2.90 ± 1.06, $t_{508}$ = -2.75, HSD $p$ = 0.032; 2007-2010 = -4.36 ± 1.13, $t_{548}$ = -386, HSD $p$ = 0.001) while the average distance of pronghorn from the road in the control did not differ among years (all *post hoc* contrasts $t_{713} \leq |2.40|$; all $p \geq 0.079$). During mid season, pronghorn distance from the road in the treatment and control also diverged over years (year*area $F_{3,167}$ = 6.43, $p$ = 0.004; Figure 2E). *Post hoc* contrasts confirmed that during mid season, pronghorn were observed farther from the road in the treatment in 2010 than 2007 (2007-2010 contrast estimate = -4.42 ± 1.61, $t_{124}$ = -2.74, Tukey HSD $p$ = 0.034). Comparatively, in the control, pronghorn shifted closer to the road in 2008 and 2010 compared to 2007 (2007-2008 contrast estimate = 13.45 ± 4.67, $t_{168}$ = 2.88, HSD $p$ = 0.023; 2007-2010 contrast estimate = 12.64 ± 4.59, $t_{170}$ = 2.76, HSD $p$ = 0.033) but were farther from the road in 2009 compared to 2008 (2008-2009 contrast estimate = -6.27 ± 2.38, $t_{157}$ = -2.63, HSD $p$ =

0.045). There were no significant year*area interactions for distance of pronghorn from the road in the early ($F_{3,258} = 1.40$, $p = 0.243$) or late ($F_{3,104} = 2.40$, $p = 0.072$) seasons.

We conducted 412 behavior scans recording the behavior of 1067 pronghorn during our four-year study. No significant year*area interactions were evident for the early and late season analyses (all $F_{75} \leq 0.78$; all $p \geq 0.512$) or when pooling among seasons ($F_{198} = 0.99$; $p = 0.399$); low sample size precluded statistical analyses in mid season. We also conducted 287 pronghorn focal samples, recording 60 hours of pronghorn behaviors. We again detected no significant year*area interaction effects within each season (all $F_{105} \leq 2.75$; all $p \geq 0.069$) or when pooling across seasons ($F_{244} = 0.37$; $p = 0.692$).

*Human activities*

We recorded 12,086 vehicles stopped and 5,738 people afoot within 200 meters of the 42 scan points upon our initial arrival during 354 day road surveys over the four-year study. Annual trends in the numbers of vehicles stopped were significantly different in the treatment and control over the duration of the study (year*area $F_{3, 351} = 2.95$, $p = 0.033$; Figure 3A). Although effects plots of untransformed data suggest annual numbers of stopped vehicles increased post-construction in the treatment relative to the control (Figure 3A), *post hoc* contrasts of the transformed data failed to detect significant differences within areas between years (all $t_{>628} \leq |2.06|$; all HSD $p \geq 0.172$). The seasonal analyses, however, revealed diverging trends in the numbers of vehicles stopped in the treatment and control in late season (year*area $F_{3, 108} = 5.82$, $p = 0.001$; Figure 3B); the number of vehicles stopped in the treatment in late season in 2010 was higher than each year prior (2007-2010 treatment contrast estimate = -0.25 ± 0.09, $t_{198} = -2.65$, HSD $p = 0.045$; 2008-2010 = -0.25 ± 0.08, $t_{198} = -3.19$, HSD $p = 0.010$; 2009-2010 = -0.23 ± 0.08, $t_{198} = -2.90$, HSD $p = 0.023$). Comparatively, *post hoc* contrasts showed that the number of vehicles seen stopped in the control did not change during late season (all control contrast estimates $t_{198} \leq |2.31|$; all HSD $p \geq 0.102$). There were no significant interactions for stopped vehicles in the early and mid seasons (both $F_{110} \leq 1.05$; $p \geq 0.372$).

We found no divergence in annual trends of numbers of people observed afoot in the treatment and control during early and mid season (both year*area $F_{125} \leq 0.70$, $p \geq 0.554$) or when pooling among seasons (year*area $F_{3,\,350} = 1.21$, $p = 0.305$). The year*area interaction was significant, however, for the late season (year*area $F_{3,\,108} = 5.25$, $p$=0.002; Figure 3C); while no changes were detected for the number of people afoot in the control (all control contrast $t_{207} \leq |1.05|$, HSD $p \geq 0.719$), more people were observed afoot in the treatment in 2010 compared to 2008 (2008-2010 contrast estimate = -0.312 ± 0.08, $t_{207} = -3.91$, HSD $p = 0.001$).

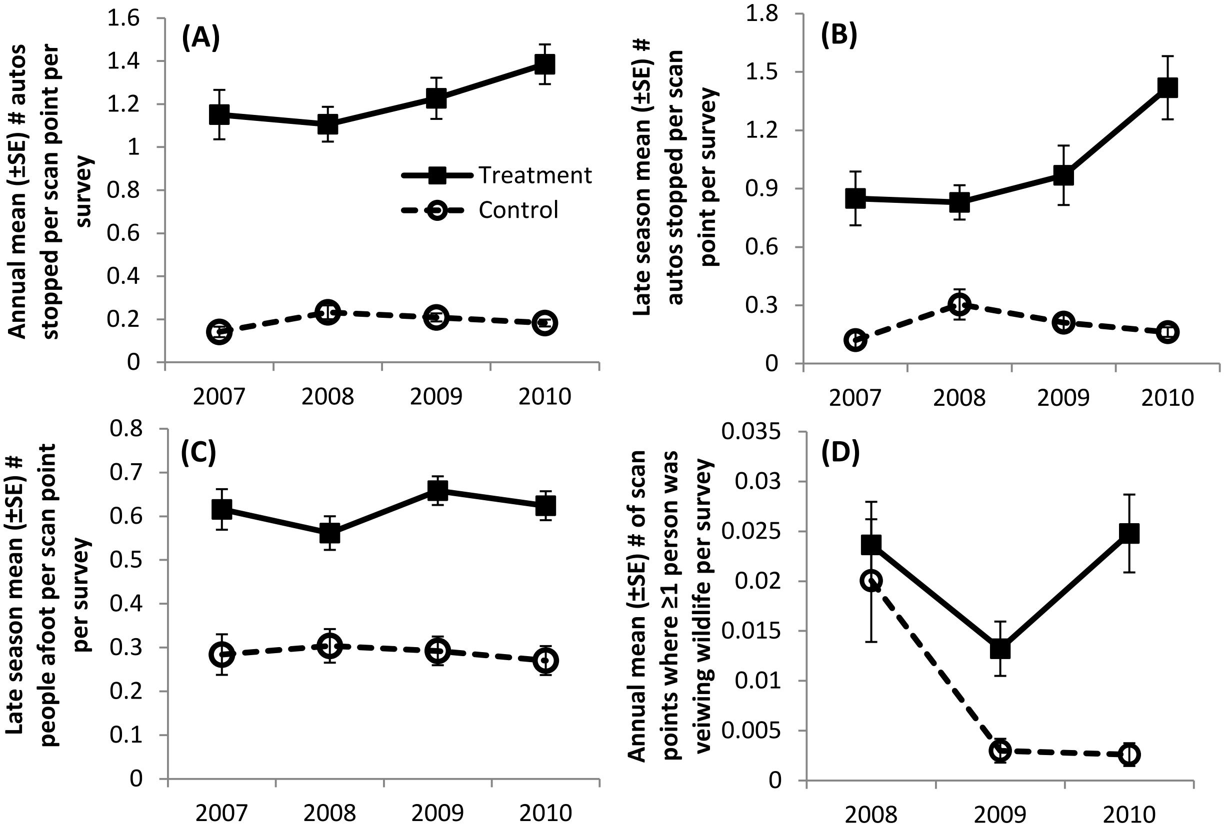

**Figure 3. Mean (± standard error) number per survey of (A) vehicles seen stopped annually and (B) in late season (September 1-October 15); C) people seen afoot in late season; and D) scan points where ≥1 people were seen viewing wildlife annually in control and treatment areas in Grand Teton National Park, 2007-2010.**

In 2008, 2009 and 2010, we observed at least one person watching wildlife in the study area during 34% of our surveys (n=319). Trends in wildlife viewing activity varied between the two areas during the study (year*area $\chi^2{}_2 = 16.24$, $p < 0.000$; Figure 3D). Specifically, *post hoc* contrasts revealed that the trends between areas and years varied from 2008-2009 ($\chi^2 = 5.52$, $p = 0.019$) and from 2008-2010 ($\chi^2 = 12.84$, $p < 0.000$). Wildlife viewing decreased in both the treatment and the control between 2008 and 2009, with a more pronounced decrease observed in the control (2008-2009 control contrast estimate difference = 1.902 ± 0.486, $z = 3.92$, $p < 0.000$; treatment contrast estimate = 0.581 ± 0.284, $z = 2.05$, $p = 0.041$). Wildlife viewing in the control in 2010 was lower than 2008 (2008-2010 contrast estimate difference = 2.042 ± 0.520, $z = 3.93$, $p < 0.000$) but not in the treatment (2008-2010 treatment contrast estimate difference $z = -0.18$, $p = 0.858$). In 2008, 2009 and 2010, we saw at least one person off-road and off-pathway during 49.8% of our surveys (n=319). Trends in this activity did not vary between the treatment and control during those years (year*area $\chi^2_2 = 0.32$, $p = 0.854$).

## Discussion

Expanding recreation opportunities and associated infrastructure in national parks can affect wildlife and visitors that value seeing wildlife (Knight and Cole 1995). Ungulate responses to human disturbances vary considerably and depend on a variety of factors, making generalizations difficult (Stankowich 2008). Thus, context-specific studies are necessary for park managers to assess effects of recreation and protect park resources, particularly in parks with wildlife viewing opportunities. This Before-After-Control-Impact study (Roedenbeck et al. 2007) assessed responses of elk and pronghorn to an unprecedented installation of a pathway in national park internationally known for its wildlife viewing.

In contrast to predictions of a pathway effect, numbers of elk that could be seen from the road corridor did not decrease in the treatment relative to the control area after the pathway was constructed and open to public use. In addition, although elk in the treatment area were seen farther from the road the first year of pathway use (2009) compared to prior to pathway installation (2007), elk in the control also were seen farther from the road in 2008, 2009, and 2010 compared to 2007. These results are counter to predictions of displacement of elk away from the road exclusively in the treatment if the pathway was affecting elk distribution. Further, elk behavioral responsiveness did not increase, but actually decreased, in the treatment compared to the control during construction and the first year of pathway use, particularly in the early season. Our findings are consistent with a concurrent study of GPS-collared elk in the same study area that concluded that pathway activities did not affect elk movements, habitat use, crossings of the Teton Park Road, or opportunities for visitors to see elk from the road (Sawyer et al. 2011). Another concurrent (2008) study measuring elk and pronghorn responsiveness to noise in the same study area also found that both species were less likely to behaviorally respond as noise levels and vehicle traffic intensified (Brown et al. 2012).

The reduction in behavioral responsiveness in elk in the treatment during the installation of the pathway suggests elk may have been habituating to human activities and the temporary disturbance associated with construction. Frequent exposure to predictable activities that result in neutral outcomes can induce habituation, a waning of response to inconsequential stimulus (Eibl-Eibesfeldt 1970, Bejder et al. 2009). This learned response is a behavioral adaptation that allows animals to dedicate attention and energy toward fitness-enhancing behaviors such as feeding, grooming, resting and mating rather than expending energy to flee non-threatening activities (Thompson and Henderson 1998). Ungulates have been known to habituate to regular exposure of non-lethal human activities (Stankowich 2008) and elk in particular have shown habituation patterns along roads and other areas disturbed by human activities (Lyon and Ward 1982, Morrison et al. 1995, Thompson and Henderson 1998). Such learned responses are cumulatively influenced by outcomes of an animal's previous encounters with humans (Bejder et al. 2006, Stankowich 2008, Bejder et al. 2009). In park settings, or in areas where hunting is prohibited and people do not typically approach wildlife directly, animals exposed to high-use human activity areas such as park roads have shown lower levels of responsiveness to human activities than might be expected (Thompson and Henderson 1998, Burson et al. 2000, Papouchis et al. 2001, Borkowski et al. 2006, Brown et al. 2012). The TPR has afforded access and wildlife viewing opportunities to millions of park visitors for decades. Prior to pathway construction, ungulates were visible from the road and many visitors stopped to view them. Assuming most elk observed in the study area habitually occupied these summer habitats over the years of this study, as confirmed by movement data collected from summer resident GPS-collared elk (Sawyer et al. 2011), these elk would have been familiar with and tolerant of human activities in this area of the park prior to the installation of the pathway. Thus, it is conceivable that the observed reduction in behavioral responsiveness during construction represents a short-term habituation response, with elk adapting to construction disturbance in order to maintain fitness-enhancing behaviors in their traditional summer range. Behavioral responsiveness did not continue to decline post-construction, however, and by the end of the study was not significantly different than the year prior to pathway construction. Overall, we conclude that the pathway did not have substantial negative impacts on elk behavior and distribution in the study area.

Similar to elk and contrary to predictions of a pathway effect, we did not detect changes in the number of pronghorn viewed or their behavioral responsiveness in the treatment relative to the control area. Compared to elk, pronghorn are considered to be more sensitive to human disturbances, exhibiting risk-avoidance behavior in proximity to roads with traffic (Berger et al. 1983, Gavin and Komers 2006). Indeed, pronghorn were somewhat more responsive than elk (mean ± SE proportion of pronghorn responding per group behavior scan = 0.296 ± 0.02 versus 0.245 ± 0.13 for elk group scans; proportion of time focal pronghorn were responding per focal sample = 0.30 ± 0.014 versus 0.261 ± 0.017 for elk focal samples), a pattern affirmed in a concurrent study conducted in the same GTNP study area assessing the effect of anthropogenic noise on elk and pronghorn (Brown et al. 2012). Pronghorn, however, were not more responsive in the treatment compared to the control, although it is possible our methods did not have the power to detect more subtle changes in pronghorn behavior.

Our results do indicate, however, pronghorn were displaced from the Teton Park Road after the pathway opened for recreational use, particularly in midsummer during peak human visitation, consistent with predictions of a pathway impact. Specifically, pronghorn in midsummer were detected on average about 165 m farther from the road in the treatment after the pathway opened compared to prior to pathway construction. Given the 12.5 km length of the TPR through the treatment area, this displacement results in an estimated 413 ha of habitat loss for pronghorn, although it is possible that pronghorn may use those habitats at night. Nonetheless, any habitat loss for this small subpopulation of pronghorn (National Park Service 2006) that summer in GTNP may have cumulative or additive conservation implications. These pronghorn endure the longest annual migration (~150 km one way; Berger et al. 2006) of any land mammal in North America south of central Canada, following a 6,000 year-old route; today, migrating pronghorn confront infrastructure including fences, highways, and housing developments that can affect pronghorn movements en route (Berger 2004, Berger et al. 2006).

Further, these pronghorn overwinter in the Upper Green River Basin where gas field developments are contributing to the loss of high quality winter habitat for pronghorn (Beckmann et al. 2012). If pathway activities were responsible for displacing pronghorn from summer habitats, employing strategies to reduce displacement responses may offer reasonable way to reduce cumulative impacts on this small subpopulation.

For example, one management option might be to not allow visitors to leave the road or pathway, an activity that is not regulated in most areas of the park unless people are approaching wildlife too closely. We observed at least one person off-road and off-pathway during half of our surveys, although annual trends did not vary between the treatment and control areas and were thus not suggestive of a pathway impact. About 38% of these observations were related to people leaving established infrastructure to view or photograph wildlife. We were unable to consistently and accurately establish whether these visitors left the road or left the pathway, thus we cannot determine if the pathway influenced the number of people approaching wildlife. Nonetheless, reducing off-road activity can reduce potential disturbance to ungulates (MacArthur et al. 1979, Cassirer et al. 1992, Knight and Cole 1995, Miller et al. 2001, Papouchis et al. 2001, Borkowski et al. 2006, Stankowich 2008).

The new pathway increased and diversified recreational activities in GTNP. Infrared trail counters deployed along the pathway in 2009 and 2010 detected as many as 148 pathway users per hour, peaking seasonally between June 15 and August 30, and daily between 1100 and 1600 hours (Costello et al. 2011). When the pathway first opened in 2009, wildlife viewing decreased in both the treatment and control areas compared to what we observed during the year of pathway construction. In 2010, however, wildlife viewing rebounded in the treatment but did not recover similarly in the control. Given no change in the quality or quantity of opportunities to stop and view scenery combined with no detected change in traffic volumes (Sawyer et al. 2011), these results do not support the prediction that pathway activities reduced wildlife viewing opportunities.

In conclusion, despite direct habitat loss, widening the human footprint, and a shift in pronghorn groups away from the road and pathway during the annual peak in park visitation, pathway construction and the first two years of use did not appear to greatly impact ungulates or reduce park visitor opportunities to see them in the travel corridor. However, we offer several notes of caution. First, ungulates that occupied habitat visible from park roads may not be representative of the entire population of ungulates in the larger region. There is potentially a self-segregating contingent of ungulates from the larger population that were less tolerant of human activities and actively avoided habitats seen from park roads even prior to the onset of this study (Bejder et al. 2006, Vistnes and Nellemann 2007). Second, for ungulates that do not avoid roads, such as those observed in our study, lack of displacement from human disturbance can still negatively impact fitness and population persistence, particularly if the disturbance is substantial but the costs of moving to avoid it are high (Gill et al. 2001); measures of stress, body condition, and reproductive success may provide additional insight into the potential effects of anthropogenic disturbance on these ungulates. Third, although ungulate tolerance to human activities may provide opportunities for park visitors to view them from the road, decreased behavioral responsiveness may also reduce an animal’s ability to visually detect predators and other potential threats (Sirot 2010). Likewise, it may lead to increased human conflict such as negative encounters with recreationists (Olliff and Caslick 2003) or collisions with vehicles (Ament et al. 2008), major concerns for park managers Finally, we did not measure how the pathway and associated transportation corridor may have altered more complex ecological interactions such as predator-prey relationships. For example, it might be possible that ungulates remained near the road because it served as a “predator shelter” (Berger 2007), providing protection from predators such as wolves, coyotes, or bears that might avoid the transportation corridor and associated human activities (Chalfoun 2011). Overall, although the new pathway offered alternative, non-motorized transportation options for visitors without major disruption of wildlife viewing opportunities, we suggest continued investigation of wildlife-human conflicts, pronghorn responses to pathway activities, and cumulative, synergistic, and cascading effects in and around the transportation corridor.

## Literature cited

Alnosaier, W. S. 2007. Kenward-Roger Approximate F Test for Fixed Effects in Mixed Linear Models. Oregon State University, Corvallis, Oregon.

Ament, R., A. Clevenger, O. Yu, and A. Hardy. 2008. An Assessment of Road Impacts on Wildlife Populations in U.S. National Parks. Environmental Management 42:480-496.

Barber, J. R., K. R. Crooks, and K. M. Fristrup. 2010. The costs of chronic noise exposure for terrestrial organisms. Trends in Ecology & Evolution 25:180-189.

Beckmann, J. P., K. Murray, R. G. Seidler, and J. Berger. 2012. Human-mediated shifts in animal habitat use: Sequential changes in pronghorn use of a natural gas field in Greater Yellowstone. Biological Conservation 147:222-233.

Bejder, L., A. Samuels, H. Whitehead, H. Finn, and S. Allen. 2009. Impact assessment research: use and misuse of habituation, sensitisation and tolerance in describing wildlife responses to anthropogenic stimuli. Marine Ecology Progress Series 395:177-185.

Bejder, L., A. Samuels, H. Whitehead, and N. Gales. 2006. Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. Animal Behaviour 72:1149-1158.

Berger, J. 2003. Is It Acceptable to Let a Species Go Extinct in a National Park? Conservation Biology 17:1451-1454.

Berger, J. 2004. The Last Mile: How to Sustain Long-Distance Migration in Mammals. Conservation Biology 18:320-331.

Berger, J. 2007. Fear, human shields, and the redistribution of prey and predators in protected areas. Biology Letters 3: 620-623.

Berger, J., S. L. Cain, and K. M. Berger. 2006. Connecting the dots: an invariant migration corridor links the Holocene to the present. Biology Letters 2:528-531.

Berger, J., D. Daneke, J. Johnson, and S. H. Berwick. 1983. Pronghorn foraging economy and predator avoidance in a desert ecosystem: Implications for the conservation of large mammalian herbivores. Biological Conservation 25:193-208.

Borkowski, J. J., P. J. White, R. A. Garrott, T. Davis, A. R. Hardy, and D. J. Reinhart. 2006. Behavioral responses of bison and elk in Yellowstone to snowmobiles and snow coaches. Ecological Applications 16:1911-1925.

Brown, C. L., A. R. Hardy, J. R. Barber, K. M. Fristrup, K. R. Crooks, and L. M. Angeloni. 2012. The Effect of Human Activities and Their Associated Noise on Ungulate Behavior. PLoS One 7:e40505.

Burson, S. L., III, J. L. Belant, K. A. Fortier, and W. C. Tomkiewicz, III. 2000. The effect of vehicle traffic on wildlife in Denali National Park. Arctic 53:146.

Cassirer, E. F., D. J. Freddy, and E. D. Ables. 1992. Elk responses to disturbance by cross-country skiers in Yellowstone National Park. Wildlife Society Bulletin 20:375-381.

Childress, M. J. and M. A. Lung. 2003. Predation risk, gender and the group size effect: does elk vigilance depend upon the behaviour of conspecifics? Animal Behaviour 66:389-398.

Chalfoun, A. 2011. Effects of pathways within Grand Teton National Park on avian diversity, abundance, distribution, nesting productivity, and breeding behaviors. Report for National Park Service, Grand Teton National Park, Wyoming.

Costello, C. M., S. L. Cain, R. M. Nielson, C. Servheen, and C. C. Schwartz. 2011. Impacts of a multi-use pathway on American black bears in Grand Teton National Park, Wyoming. Report for National Park Service, Grand Teton National Park, Wyoming.

Eibl-Eibesfeldt, I. 1970. Ethology: the biology of behavior. Holt, Rinehart & Winston, New York, New York.

Evink, G. L. 2002. Interaction between roadways and wildlife ecology. Transportation Research Board, Washington, D.C.

Fahrig, L. and T. Rytwinski. 2009. Effects of roads on animal abundance: an empirical review and synthesis. Ecology and Society 14:21.

Fairbanks, W. S. and R. Tullous. 2002. Distribution of pronghorn (*Antilocapra americana Ord*) on Antelope Island State Park, Utah, USA, before and after establishment of recreational trails. Natural Areas Journal 22:277-282.

Forman, R. T. T., D. Sperling, J.A. Bissonette, A.P. Clevenger, C.D Cutshall, V.H. Dale, L. Fahrig, R. France, C.R. Goldman, K. Heanue, J.A. Jones, F.J. Swanson, T. Turrentine, T.C. Winter. 2003. Road ecology science and solutions. Island Press, Washington, DC.

Gavin, S. D. and P. E. Komers. 2006. Do pronghorn (Antilocapra americana) perceive roads as a predation risk? Canadian Journal of Zoology 84:1775-1780.

George, S. L. and K. R. Crooks. 2006. Recreation and large mammal activity in an urban nature reserve. Biological Conservation 133:107-117.

Gill, J. A., K. Norris, and W. J. Sutherland. 2001. Why behavioural responses may not reflect the population consequences of human disturbance. Biological Conservation 97:265-268.

Knight, R. L. and D. N. Cole. 1995. Factors that influence wildlife responses to recreationists. Pages 70-79 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreationists: coexistence through management and research. Island Press, Washington DC.

Loomis, J. and L. Caughlan. 2004. Economic analysis of alternative bison and elk management practices on the national elk refuge and Grand Teton National Park: A comparison of visitor and household responses. U.S. Geological Survey, Biological Resources Discipline, Open File Report 2004-1305. 110pp.

Lyon, L. J. and A. L. Ward. 1982. Elk and land management. Pages 442-477 *in* J. W. Thomas and D. E. Toweill, editors. Elk of North America: ecology and management. Stackpole Books, Pennsylvania.

MacArthur, R. A., R. H. Johnston, and V. Geist. 1979. Factors influencing heart rate in free-ranging bighorn sheep: a physiological approach to the study of wildlife harassment. Canadian Journal of Zoology 57:2010-2021.

McCullagh, P. and J. A. Nelder. 1989. Generalized Linear Models, Second Edition. Chapman and Hall, London.

Miller, S. G., R. L. Knight, and K. M. Clinton. 2001. Wildlife Responses to Pedestrians and Dogs. Wildlife Society Bulletin 29:124-132.

Morrison, J. R., W. J. d. Vergie, A. W. Alldredge, A. E. Byrne, and W. W. Andree. 1995. The Effects of Ski Area Expansion on Elk. Wildlife Society Bulletin 23:481-489.

National Park Service. 2006. Transportation Plan Final Environmental Impact Statement. Page 368, Moose, Wyoming.

Olliff, T. and J. Caslick. 2003. Wildlife-human conflicts in Yellowstone: when animals and people get too close. Pages 18-22 Yellowstone Science. National Park Service, Yellowstone National Park.

Papouchis, C. M., F. J. Singer, and W. B. Sloan. 2001. Responses of Desert Bighorn Sheep to Increased Human Recreation. The Journal of Wildlife Management 65:573-582.

Riley, S. P. D., J. P. Pollinger, R. M. Sauvajot, E. C. York, C. Bromley, T. K. Fuller, and R. K. Wayne. 2006. A southern California freeway is a physical and social barrier to gene flow in carnivores. Molecular Ecology 15:1733-1741.

Roedenbeck, I. A., L. Fahrig, C. S. Findlay, J. E. Houlahan, J. A. G. Jaeger, N. Klar, S. Kramer-Schadt, and E. A. van der Grift. 2007. The Rauischholzhausen agenda for road ecology. Ecology and Society 12:11.

Sawyer, H., F. Lindzey, and D. McWhirter. 2005. Mule Deer and Pronghorn Migration in Western Wyoming. Wildlife Society Bulletin 33:1266-1273.

Sawyer, H., R. M. Nielson, F. Hornsby, and L. McManus. 2011. Grand Teton National Park pathway elk study. Western Ecosystems Technology, Inc., Laramie, Wyoming.

Sirot, E. 2010. Should risk allocation strategies facilitate or hinder habituation to nonleathal disturbance in wildlife? Animal Behaviour 80: 737-743.

Smith, E. P. 2002. BACI design. Pages 141-148 *in* A. H. El-Shaarawi and W. W. Piegorsch, editors. Encyclopedia of Environmetrics. John Wiley & Sons, Ltd., Chichester.

Stankowich, T. 2008. Ungulate flight responses to human disturbance: A review and meta-analysis. Biological Conservation 141:2159-2173.

Taylor, A. R. and R. L. Knight. 2003. Wildlife responses to recreation and associated visitor perceptions. Ecological Applications 13:951-963.

Thompson, M. J. and R. E. Henderson. 1998. Elk Habituation as a Credibility Challenge for Wildlife Professionals. Wildlife Society Bulletin 26:477-483.

Trombulak, S. C. and C. A. Frissell. 2000. Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. Conservation Biology 14:18-30.

Vistnes, I. and C. Nellemann. 2007. Impacts of human activity on reindeer and caribou: The matter of spatial and temporal scales. Rangifer 12:47-56.

# CHAPTER TWO[2]

## Introduction

Protected areas are managed to balance the goals of protecting wildlife and providing infrastructure to accommodate visitors. Transportation infrastructure influences how visitors encounter and affect wildlife within protected areas, with implications for the conservation of wildlife for the enjoyment and education of future generations. For example, roads destroy and alter habitats (Wilcove et al. 1998), spread non-native biota (Trombulak and Frissell 2000), modify and create barriers to animal movements (Riley et al. 2006), mask and interfere with animal auditory communications and sensing (Barber et al. 2010), and kill organisms that attempt to cross roads but are struck by vehicles (Trombulak and Frissell 2000, Evink 2002, Forman 2003). Road impacts on wildlife are a considerable concern for park managers (Ament et al. 2008).

To reduce the effects of motor vehicles, diversify recreational experiences, and increase safety for non-motorized travelers in protected areas, there is growing interest in alternative transportation options in protected areas (Gleason 2008). Combined with initiatives to increase nature-based recreation and physical activities in protected areas such as national parks (Gleason 2008, Hoehner et al. 2010), proposals to install pathways in protected areas are gaining momentum with health advocates (Brownson et al. 2000, Brownson et al. 2004, Hoehner et al. 2010). Pathway systems provide non-motorized recreational opportunities for park visitors, with the potential to reduce traffic congestion and decrease conflicts with vehicles. However, such infrastructure widens transportation corridors and extends the human footprint into habitats that may be important to wildlife. Human activities can affect wildlife space and habitat use, circadian activity patterns, foraging behavior, body condition, disease susceptibility,

---

[2] Manuscript coauthored with K.R. Crooks.

reproductive success, sex ratios, social development, mating systems, and social structure (see review in Bejder et al. 2009). Thus, recreational activities on pathways may impact not only wildlife populations, but also opportunities for park visitors to see wildlife.

In 2006 Grand Teton National Park (GTNP), USA, adopted a Transportation Plan that called for 36.0 km of paved, recreational pathways to be installed 15.2 to 45.7 m from existing park roads to accommodate non-motorized recreational and travel (National Park Service 2006). These roads and pathways traverse habitats in the park where pronghorn antelope (*Antilocapra americana;* herein referred to as pronghorn) and elk (*Cervus canadensis nelsoni*) are frequently seen, along with mule deer (*Odocoileus virgineaus*) and moose (*Alces alces*), during summer and fall months. Wildlife viewing, particularly elk viewing, was identified as the second most important reason that people visit GTNP and the surrounding region, second to seeing the Teton Mountains (Loomis and Caughlan 2004). Adding a recreational pathway along a well-traveled road known for wildlife viewing opportunities was unprecedented in a US national park (National Park Service 2006) when the installation of the pathway in GTNP was proposed. Thus, it was uncertain how this new infrastructure might alter human activities, and how such modified human activity might impact wildlife and human-wildlife interactions.

To address these concerns, we recorded human activities observed when ungulates were seen near the road prior to (2007) and during (2008) pathway construction, and for two years (2009, 2010) after the pathway was open for public use. We quantified pedestrian and bicyclist activities on the pathway in addition to vehicle, pedestrian and bicyclist activities on the road. We predicted that human activity patterns would vary depending on the year, season, time of day, and species of ungulate seen from the road. We expected to see an increase and diversification in non-motorized recreation activities upon the opening of the pathway for public use (2009, 2010). We also expected human activity to peak in the middle of the summer and during midday, reflecting increased visitation to the park during these times, and when larger ungulates (e.g., moose, elk) were present given public interest in these local "charismatic" species (Di Minin et al. 2012). We related our results to concurrent studies conducted in the same region assessing ungulate responses to pathway activities and to management considerations to minimize human-wildlife conflicts and maintain wildlife viewing opportunities while providing alternative transportation options for non-motorized travel.

## Methods

### *Study area*

This study was conducted in Grand Teton National Park (GTNP) in northwestern Wyoming, USA (43-50'00" N, 110-42'03" W) along 12.5 km of the Teton Park Road (TPR) between South Jenny Lake Junction and Moose Junction (Figure 4). Elevations ranged from 2067 to 1962 meters at the northern and southern ends of the study area, respectively. Approximately 2260 hectares of open habitats were estimated to be visible from the TPR based on a viewshed analysis conducted in a Geographic Information System (ArcMap v9.2, ESRI, Redlands, California, USA; Chapter 1). Visible terrain was characterized by flat valley plains dominated by dry sagebrush (*Artemesia* spp.) shrublands, with scattered patches of coniferous forest and riparian vegetation associated with water features. This area provided summer and fall habitat for resident and migrating elk, pronghorn, mule deer, and moose. Thousands of park visitors passed through the study area on the TPR each year, with peak visitation typically occurring in July. In 2008, 12.5 kilometers (7.7 miles) of paved pathway were constructed along the TPR between South Jenny Lake and Moose Junctions; in 2009 and 2010, the pathway was opened for non-motorized recreation and travel between these destinations.

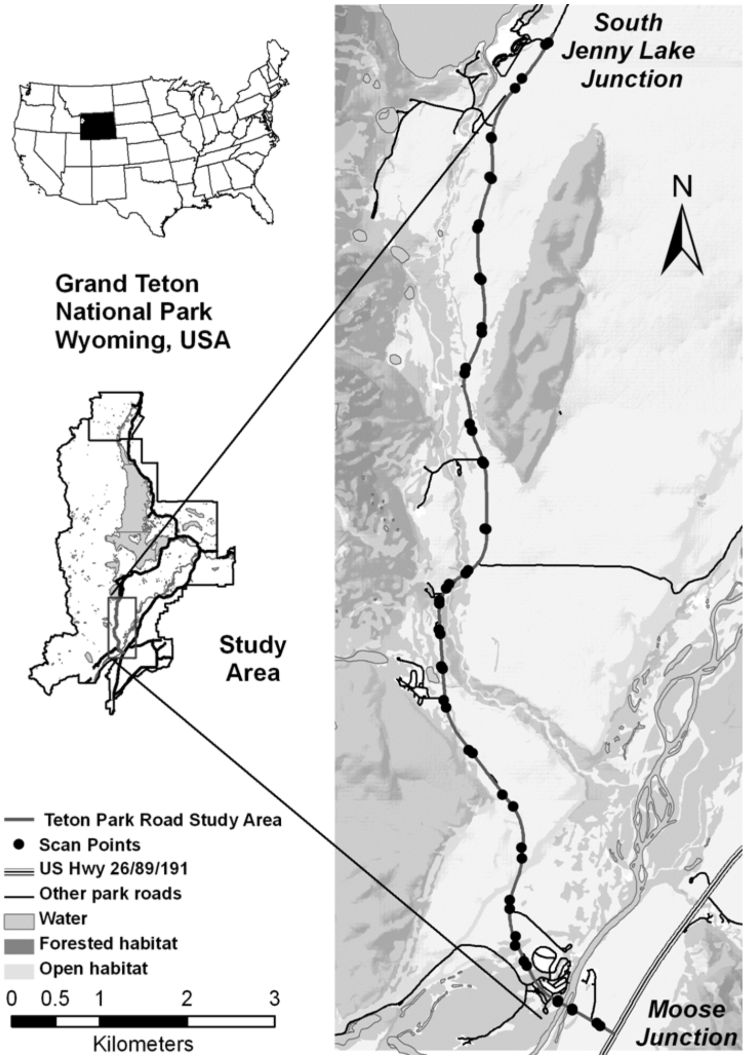

**Figure 4. The study area included approximately 2260 hectares of open habitat visible from 12.5 km (7.7 miles) of the existing Teton Park Road (TPR) between Moose and South Jenny Lake Junctions in Grand Teton National Park, Wyoming, USA. Scan points (n=25) standardized survey search effort and maximized terrain visibility from the TPR. In 2007, no pathway existed in the study area; in 2008, a paved pathway was constructed next to the road and in 2009 and 2010, the pathway opened for non-motorized recreational use.**

### *Field methods*

We conducted systematic road surveys to repeatedly measure human activities occurring in the transportation corridor from June through October of 2007-2010; human activity surveys were concurrent with an ongoing study of ungulate activity in the study area. Road survey methods involved two observers systematically traversing the 12.5 km TPR study area 1-2 times a day, with start times staggered 12-14 hours and survey direction alternated. Surveys typically spanned 2-4 hours depending on ungulate and human activity in the corridor. Observers traveled in a truck at ~48 km/h through the study area, stopping at 25 scan points established approximately ~160-800 meters apart where views of the landscape were maximized (Figure 1). At each scan point, observers searched the landscape for ungulates using binoculars and scopes; observers also stopped opportunistically if ungulates were observed between scan points. When an ungulate group was observed within ~500 meters of the TPR, the first observer recorded the date, time of day, and species of the group. Simultaneously, the second observer conducted an instantaneous scan sample of human activities occurring concurrently within 500 meters of our vehicle while the ungulate group was present. Scan sampling methods were conducted to capture a snapshot characterizing and quantifying human activities as promptly as possible to reduce the potential that our presence influenced the sample; if there was no human activity occurring within 500 meters of our truck when the scan was initiated, the observer continued to scan for activities for 15 seconds. In each scan sample, we counted: 1) motor vehicles passing on the road, stopped on the side of the road, and stopped in pullouts (e.g., paved parking areas), and 2) people afoot (herein, pedestrians) and bicycles on the road and pathway. Pedestrians included people that had alighted from their vehicles, which were most commonly observed, as well as people traveling afoot.

### *Data Analysis*

Using each scan sample as our experimental unit, we assessed the influence of year, season, time of day, and species of ungulate present on human activities described above. We pooled all pedestrian and bicyclist activities on the pathway and road to address overall changes in non-motorized activities after the pathway opened. The effect of year was categorized by the four years of our study (2007, 2008, 2009, 2010). The date of each observation was categorized into one of three seasons, as follows: 1) early season (June to July 15), when ungulates were calving/fawning; 2) mid season (July 16 to August 31), when human visitation and temperatures peaked; and 3) late season (September 1 to October 15), when ungulates were influenced by the rut, hunting pressure beyond the study area, and oncoming winter weather conditions. Time of observation was categorized by nine, two-hour blocks ranging from 0500-0659 to 2100-2259. The ungulate species present was categorized as elk, moose, mule deer, or pronghorn.

We used mixed models (PROC MIXED, SAS v9.2, SAS Institute Inc., Cary, North Carolina, USA) to examine the individual effects of year, season, time of day (time), and species of ungulates present during scans samples on the three vehicle activity measures (vehicles passing, stopped on road, stopped in pullouts) and on total number of pedestrians and bicyclists on the road and pathway combined. For each model, we included a random effect of survey nested within year given that human activities seen during a survey may be influenced by environmental (e.g., weather, visibility, length of day) and biological (e.g., presence of wildlife) factors. We square root-transformed response variables to satisfy homogeneity of variance and normality assumptions. Degrees of freedom were estimated using the Kenward Roger method (Alnosaier 2007). For significant ($p < 0.05$) main effects, we conducted subsequent *post hoc* Tukey-Kramer Honestly Significant Difference (HSD) tests; estimated differences were reported on a transformed scale. We included effects plots displaying means and standard errors of the original data to aid in interpretation of results.

## Results

Between 2007 and 2010, we conducted 306 road surveys, driving 3,825 km to repeatedly sample human activities in the study area. We recorded a total of 5,773 human activities in the presence of 708 ungulate groups. Seventy percent (n = 4,034) of our human activity observations were associated with vehicle activities on the road while the remaining 31% (n =

1,739) of our sample consisted of pedestrians and bicycle activities seen on the road and pathway. Most of the ungulate groups seen while we recorded human activities were comprised of pronghorn (44.4%, n=314) and elk (35.3%, n=250); we saw significantly fewer groups of moose (12.1%, n=86) and mule deer (8.2%, n=58).

*Vehicle activity*

We recorded 4,034 observations of motor vehicles during scan samples. Of these observations, most vehicles were passing (41.4%, n = 1,670; range: 0-17 per scan) or stopped on the side of the road (38.5%, n = 1,555; range: 1-27), while fewer vehicles were seen stopped in pullouts (20.1%, n = 809; range: 0-50; Figure 5).

The number of vehicle passing depended on the year, season, time of day, and species of ungulate present (Table 1; Figure 6a, b, e; Figure 7a). *Post hoc* tests confirmed that we counted fewer vehicles passing in 2009 compared to 2007 (2007-2009 estimate = 0.267 ± 0.113, $t_{231}$ = 2.36, Tukey HSD $p$ = 0.088), while more vehicles were seen passing in 2010 compared to 2008 (2008-2010 estimate = -0.511 ± 0.121, $t_{261}$ = -4.21, HSD $p$ <0.001) and 2009 (2009-2010 estimate = -0.4786 ± 0.102, $t_{285}$ = -4.68, HSD $p$ <0.001; Figure 6a). We also saw fewer vehicles passing during early season (June-July 15) than mid (July 16-August 30) and late (September 1-October 15) seasons (early-mid estimate = -0.246 ± 0.101, $t_{272}$ = -2.45, HSD $p$ = 0.040; early-late estimate = -0.267 ± 0.1, $t_{255}$ = -2.67, HSD $p$ = 0.022; Figure 6b). Generally, more vehicles were seen passing on the road in the middle of the day compared to early morning and late afternoon (Figure 7a). Specifically, *post hoc* tests confirmed fewer vehicles during: 1) 0500-0659 compared to each of the eight time blocks between 0700 and 2100 (estimates ranged from -0.467

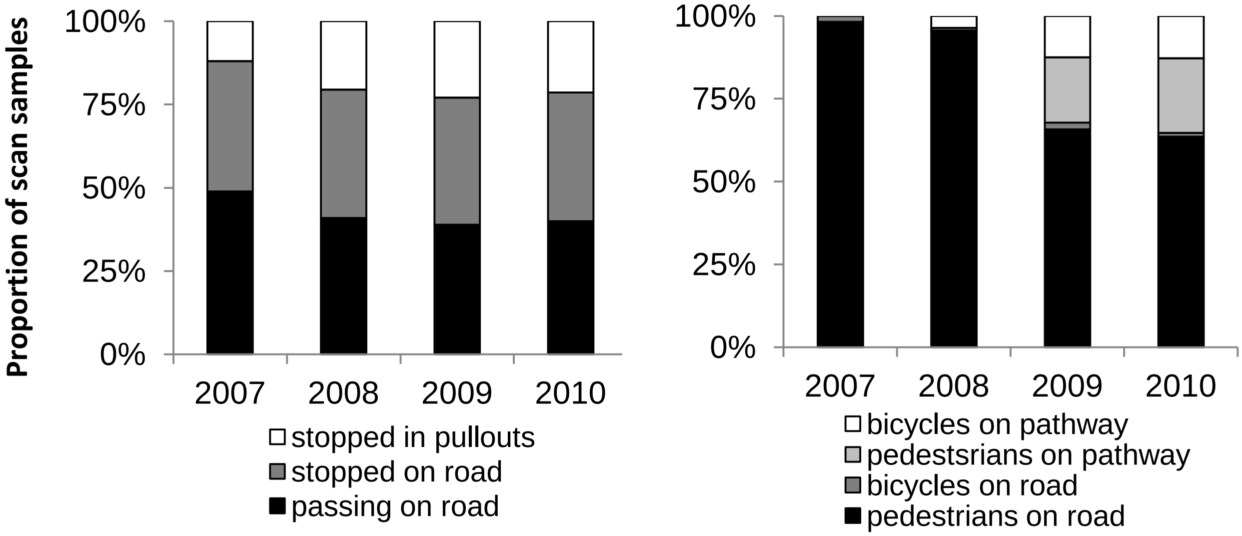

**Figure 5. Relative proportions of the types of a) vehicle and b) pedestrian and bicyclist activities counted during scan samples conducted when ungulate groups (n=708) were seen within 500 meters of the road.. Activities were sampled during road surveys conducted in June-October of 2007 (n=56), 2008 (n=53), 2009 (n=104), and 2010 (n=93).**

to -1.354 ± 0.148 to 0.187, $t_{373\text{-}592} \geq |\text{-}3.16|$, all HSD $p \leq 0.044$); 2) 0700-0859 compared to each of the five time blocks between 0900 and 1900 (estimates ranged from -0.068 to -0.887 ± 0.114to 0.151, $t_{403\text{-}593} \geq |\text{-}3.44|$, all HSD $p \leq 0.018$); 3) 0900-1059 compared to 1500-1659 (estimate = -0.490 ± 0.138, $t_{491} = -3.55$, HSD $p = 0.013$); and 4) 1900-2059 and 2100-2259 compared to 1300-1459 (estimates ranged from 0.373 to 0.819 ± 0.112 to 0.1932, $t_{378\text{-}564} \geq 3.33$, all HSD $p \leq 0.026$). Finally, passing vehicles were most frequent when moose were present (Figure 3e), a pattern confirmed by posthoc tests (moose – [elk, mule deer, pronghorn] estimates ranged from |0.173| to |0.576| ± 0.069 to 0.136, $t_{658\text{-}683} \geq |2.51|$, all HSD $p<0.001$). *Post hoc* tests also suggest a marginally significant trend of more vehicles passing when elk were present compared to pronghorn (elk-pronghorn estimate = 0.173 ± 0.069, $t_{658} = 2.51$, HSD $p = 0.059$).

**Table 1. Main effects influencing mean number of vehicles passing on the road, stopped on the road, and stopped in pullouts, and pedestrians and bicycles on the road and pathway. Vehicle, pedestrian and bicycle activity were quantified when ungulates were seen within 500 m of the road (n=708) during 306 road surveys conducted in June-October of 2007-2010. Significant effects (*p* < 0.05) are indicated in bold font.**

| | | **vehicles passing on road** | | | **vehicles stopped on road** | | | **vehicles stopped in pullouts** | | | **pedestrians and bicycles** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **DF num** | **DF den** | ***F*** | ***p*** | **DF den** | ***F*** | ***p*** | **DF den** | ***F*** | ***p*** | **DF den** | ***F*** | ***p*** |
| **Year** | 3 | **250** | **9.42** | **<0.001** | **112** | **5.6** | **0.001** | **197** | **2.82** | **0.04** | **217** | **6.87** | **0.002** |
| **Season** | 2 | **274** | **4.66** | **0.01** | **138** | **12.29** | **<0.001** | 243 | 0.4 | 0.6717 | **241** | **7.33** | **<0.001** |
| **Time** | 8 | **494** | **13.92** | **<0.001** | 358 | 1.85 | 0.068 | **362** | **4.08** | **<0.001** | **566** | **5.09** | **<0.001** |
| **Species** | 3 | **667** | **12.05** | **<0.001** | **698** | **148.48** | **<0.001** | **702** | **5.45** | **0.001** | **637** | **96.98** | **<0.001** |

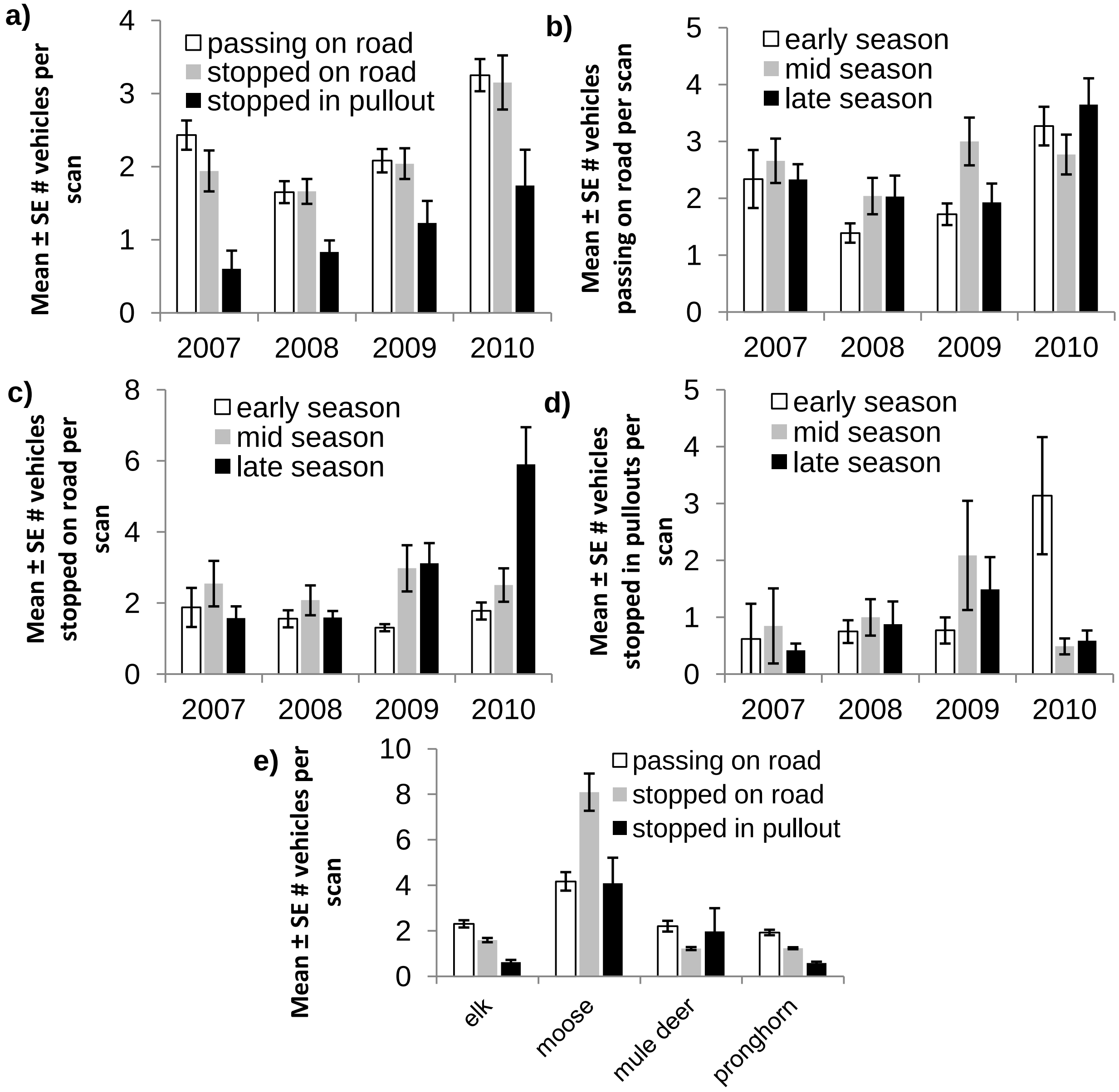

**Figure 6. Mean (± standard error) number of vehicles passing by on the road, stopped on the road, and stopped in pullouts, summarized by a) year; b-d) seasons (early: June-July 15; mid: July 16-August 30; late: September 1-October 15); and e) species of ungulate present. Observations of vehicles were recorded when a group of ungulates was seen within 500 m of the road (n=708) during 306 road surveys conducted in June-October of 2007-2010.**

The number of vehicles stopped on the road varied with year, season, and species of ungulate present (Table 1; Figure 6a, c, e). In 2010, more vehicles were stopped on the road than in any year prior ([2007-2009] – 2010 estimates ranged from -0.255 to -0.365 ± 0.085 to 0.100, $t_{119\text{-}138} \geq |2.99|$, all Tukey HSD $p \leq 0.017$; Figure 6a). We also saw more vehicles stopped on the

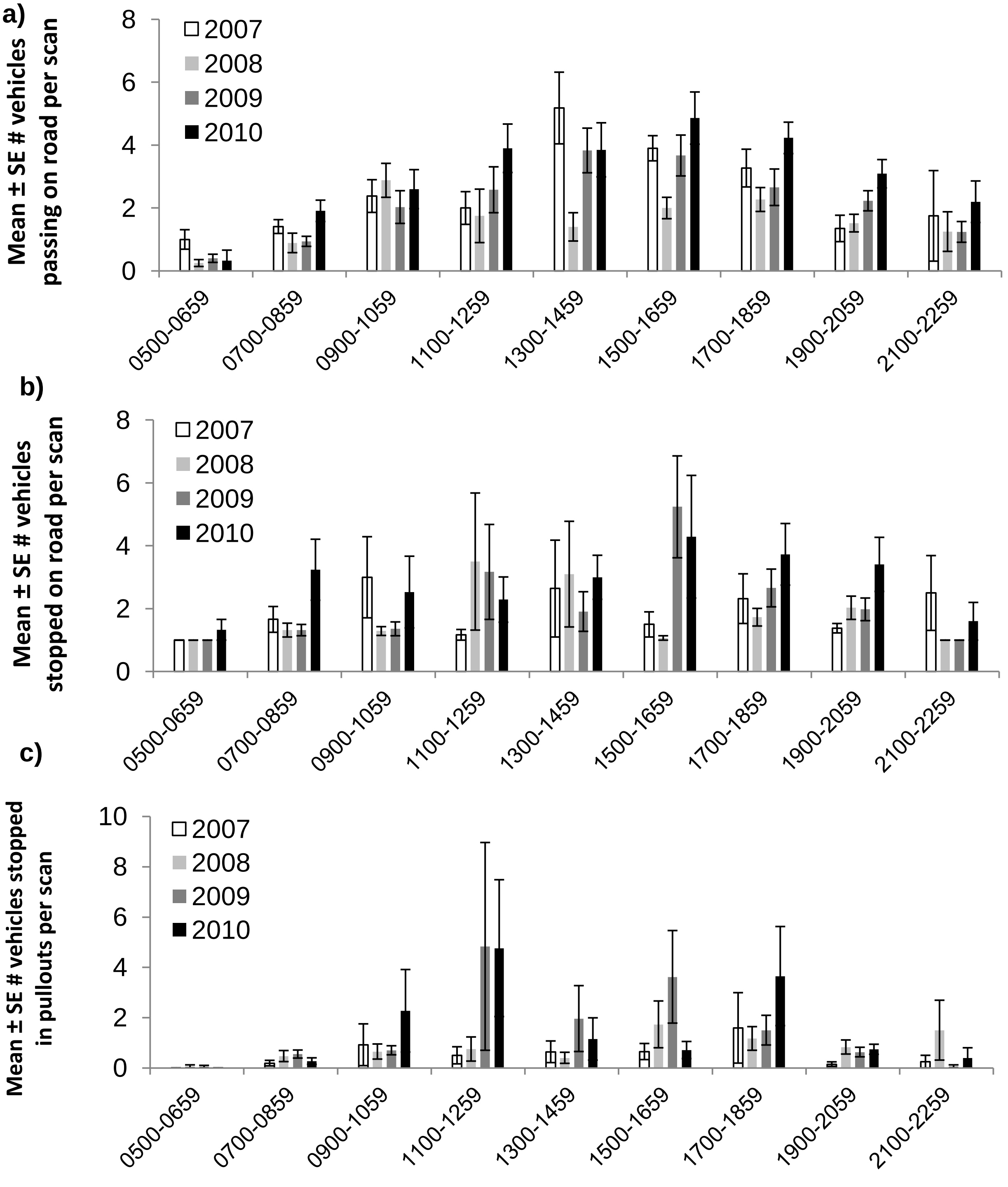

**Figure 7. Mean (± standard error) number of vehicles seen by time of day, for vehicles a) passing by on road; b) stopped on road; and c) stopped in pullouts. Observations of vehicles were recorded when a group of ungulates was seen within 500 m of the road (n=708) during 306 road surveys conducted in June-October of 2007-2010.**

road in mid and late season compared to early season (early – mid estimate = -0.259 ± 0.080, $t_{137}$ = -3.24, HSD $p$ = 0.004; early – late estimate = 0.0373 ± 0.079, $t_{124}$ = -4.74, HSD $p$ <0.001; Figure 3c) and when moose were present compared to when other ungulates were present (moose – [elk, mule deer, pronghorn] estimates ranged from |1.3| to |1.4| ± 0.068 to 0.095, $t_{658\text{-}683} \geq |2.51|$, all HSD p<0.001; Figure 3e). Time of day was a marginally significant predictor of vehicles stopped in the road (Table 1), with more vehicles stopped during midday (Figure 7b).

Significant main effects influencing vehicles stopped in pullouts included year, time, and species of ungulate present during scan sample (Table 1). We saw more vehicles stopped in pullouts in 2010 compared to 2007 (2010 – 2007 estimate = -0.304 ± 0.115, $t_{218}$ = -2.64, Tukey HSD $p$ = 0.044; Figure 6a), and during midday hours of 1100-1259 and 1500-1859 compared to 0500-0659 (estimates ranged from -0.626 to -0.867 ± 0.174 to 0.209, $t_{265\text{-}342} \geq |3.6|$, HSD $p \leq$ 0.011) and 1100-1259 compared to 0700-0859 (estimate = -0625 ± 0.172, $t_{458}$ = -3.63, HSD $p$ = 0.001; Figure 7c). Finally, the number of vehicles seen parked in pullouts when moose were present exceeded the number of vehicles parked in pullouts when elk were present (estimate = -0.464 ± 0.120, $t_{701}$ = -3.87, HSD $p$ <0.001; Figure 6e). Likewise, the number of vehicles parked in pullouts when elk were present exceeded that when pronghorn were present (elk-pronghorn estimate = 0.425 ± 0.116, $t_{703}$ = 3.67, HSD $p$ = 0.001; Figure 6e).

*Pedestrian and bicycle activity*

We sampled a total of 1,739 pedestrians and bicyclists during our scan samples over the four years of the study (Figure 5). The majority of these observations were comprised of pedestrians on the road (71%, n =1,239; range: 0-60 per scan), followed by pedestrians on the pathway (16.8%, n = 293; range: 0-58), bicycles on the pathway (10.4%, n = 180; range: 0-9), and bicyclists on the road (1.6%, n = 27; range: 0-3; Figure 8).

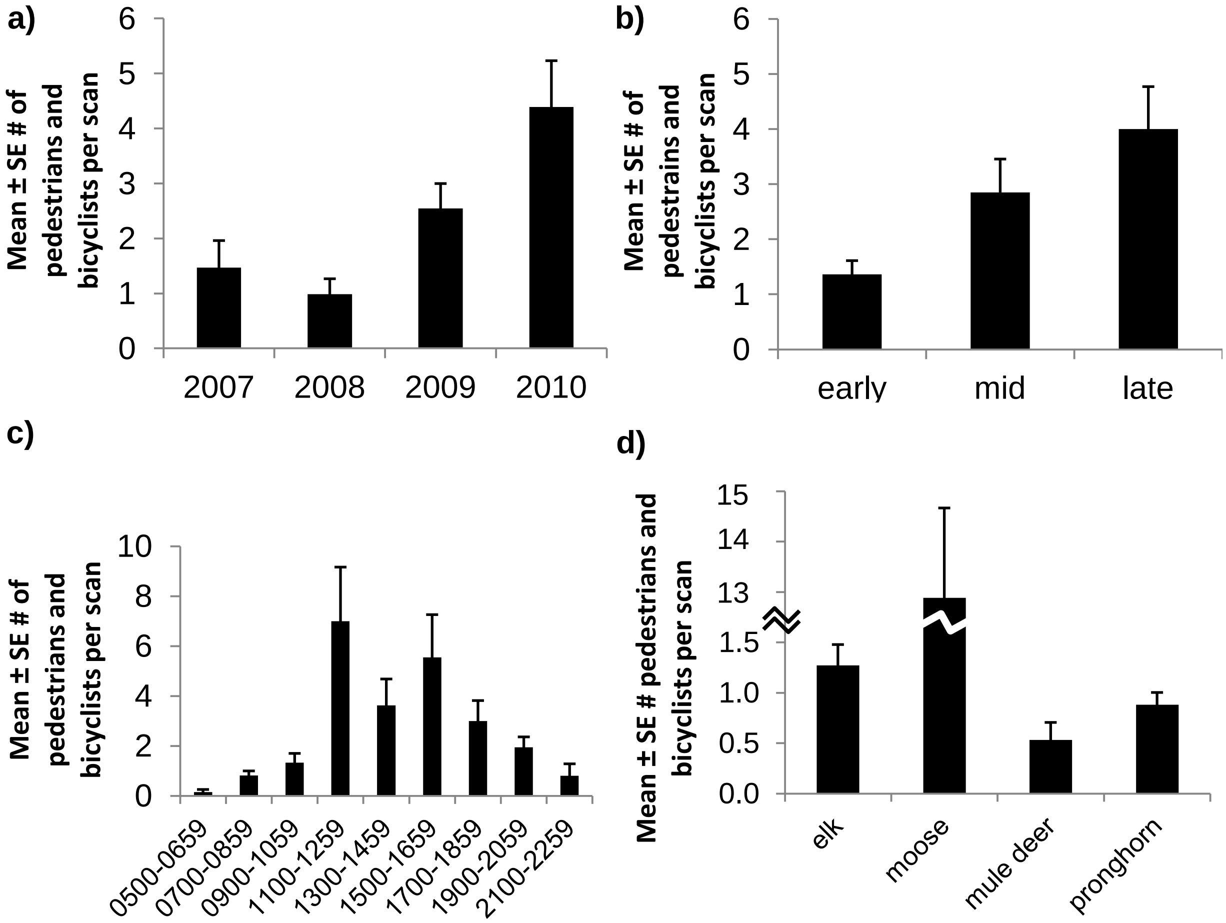

**Figure 8. Mean (± standard error) number of pedestrians and bicycles summarized by a) year; b-d) seasons (early: June-July 15; mid: July 16-August 30; late: September 1-October 15); and e) species of ungulate present. Observations of pedestrians and bicycles were recorded when a group of ungulates was seen within 500 m of the road (n=708) during 306 road surveys conducted in June-October of 2007-2010.**

Year, season, time of day, and species were significant predictors of pedestrian and bicycle observations (Table 1; Figure 8). We counted more pedestrians and bicycles in 2010 compared to all years prior ([2007-2009] – 2010 estimates ranged from -0.462 to -0.816 ± 0.177 to 0.211, $t_{223\text{-}240} \geq |2.62|$, all HSD $p \leq 0.046$; Figure 8a). During late season, we saw more pedestrians and bicyclists compared to early season (early-late estimate = -0.643 ± 0.170, $t_{239} = -3.78$, HSD $p < 0.001$; Figure 8b). During midday hours from 1100-1659, we saw more pedestrians and bicyclists combined than earlier in the day (Figure 5c; [0500-1059] – [1100-1659] estimates ranged from -0.831 to -1.477 ± 0.226 to 0.324, $t_{435\text{-}665} \geq |3.31|$, all HSD $p \leq$

0.032) and later in the day ([1100-1259] – [1700-2259] estimates ranged from 0.857 to 1.20 ± 0.266 to 0.347, $t_{513\text{-}614} \geq 3.20$, all HSD $p \leq 0.038$; Figure 8c). When moose were present, we counted substantially more pedestrians and bicyclists compared to when all other ungulate species were present (Figure 8d; estimates ranged from |2.016| to |2.38| ± 0.1327 to 0.1831, $t_{634\text{-}671} \geq |13.03|$, all HSD $p < 0.001$).

## Discussion

In parks where wildlife may be seen from roads, adding recreational pathways may change patterns of human activities, potentially impacting wildlife that occupy habitats near travel corridors (Knight and Cole 1995) along with visitor opportunities to see wildlife. The unique context of a landscape, its existing infrastructure, prior exposure of ungulates to human activities (Stankowich 2008), and motivations of recreationists (Lee et al. 2002) renders it difficult to predict how human activities and wildlife responses to those activities may be affected by construction and use of recreational pathways. Field studies documenting patterns of human activities before and after the introduction of a recreational pathway can provide useful information to managers (Boyle and Samson 1985, Fairbanks and Tullous 2002). This study offered an unusual opportunity to quantify patterns in vehicle, pedestrian, and bicycle activities in a transportation corridor before, during, and after the construction of a pathway along an existing road in a national park internationally known for its wildlife viewing opportunities.

Consistent with our prediction of increased and diversified non-motorized recreation after the pathway opened in Grand Teton National Park, we saw more pedestrians and bicyclists after the pathway opened for public use, particularly in 2010 compared to previous years. While the majority of the non-motorized activities sampled were classified as pedestrians on the road, we detected the anticipated increase in pedestrians and bicycles on the pathway, satisfying an objective of the park transportation plan to provide improved opportunities for safe, non-motorized travel and recreation (National Park Service 2006). This objective was motivated, in part, by the fact that two of the seven total traffic fatalities that have occurred in the park since 1994 involved bicyclists riding on the road. Interestingly, we found that bicycling on the road was a relatively rare activity in the study area prior to the introduction of the pathway, seen during our scan samples on only 4 occasions before the pathway and only once during construction. After the pathway was opened for public use, we continued to record bicyclists on the road, including 13 in 2009 and 9 in 2010. Bicyclists on the road may represent recreationists with strong motivations related to physical training goals, preferring to ride on the road to avoid having to slow down to maneuver around other bicyclists and pedestrians sharing the pathway. While the majority of bicyclists opted to ride on the pathway instead of the road, there remains a safety risk to bicyclists on the road.

As expected, non-motorized activities in the corridor were most frequently recorded midday. These findings are consistent with data from trail counters installed on the pathway by the National Park Service in 2009 and 2010, which detected a range of 0-148 pathway users per hour, peaking in the middle of the day (Costello et al. 2011). We note that a concurrent study of GPS-collar movement data of 29 black bears occupying habitats near the study area revealed a temporal shift in their activity patterns after pathway construction, increasing their movements near the pathway during crepuscular periods while reducing their activity during midday (Costello et al. 2011). Given that human activities on the road and pathway peaked midday, the changes in black bear daily activity patterns might reduce the likelihood of human-bear conflicts while allowing bears to maintain home ranges in the study area (Costello et al. 2011). Nonetheless, this shift in black bear activity results in a potential increase in the risk of bear-vehicle collisions, and perhaps conflicts with pathway users, during low-light conditions at dusk and dawn.

Non-motorized activities also varied by season, according to predictions. We saw more pedestrians and bicyclists in late season compared to early season, a finding that differed from the pathway trail counter data, which indicated that pathway activities peaked between June 15-August 30 with an average of ≥ 5 pathway users per hour (Costello et al. 2011). This discrepancy might be partially explained given that pedestrians on the road comprised the majority of observations in our dataset, which combined pedestrian and bicyclist activities on the road and pathway. Pedestrian activity on the road in particular was influenced by the species of ungulate present. In late season (September – October 15), we saw increased elk activity in the study area as cooler temperatures and snow at high elevations triggered migratory movements of elk from summer ranges north of the study to lower elevation winter ranges such as the National Elk Refuge south of the park; additionally, this elk migratory activity may have been further bolstered by elk that opted to travel through the study area inside the park to avoid hunting pressure outside the park (Smith 2007). The increased elk activity coincided with the rut, drawing wildlife enthusiasts and photographers from around the world seeking opportunities to hear bugling bull elk and to watch bulls spar and compete to mate with cows in harems. Consequently, the elk rut activity attracted more pedestrian and vehicle activity on the road (see below) during late season than other seasons.

As expected, vehicle activities were related to season, time of day, and year. Similar to temporal patterns seen in non-motorized activities, we recorded fewer passing and stopped vehicles in early season compared to later months. Passing and stopped vehicles also peaked during midday compared to morning and late afternoon, as expected given that the area that lacks morning and evening commuter influx and recreational activities in the park typically peak during midday (Schwartz et al. 2010, Costello et al. 2011). We also counted more vehicles after pathway construction, particularly in 2010. Our sampling of a limited area of the park reflected trends in overall park visitation data from June through October during our study (National Park Service 2011). Combining recreational and non-recreational users, visitation to GTNP was slightly higher in 2010 (2,818,722 visits) compared to 2007 (2,754,877), 2008 (2,673,034), and 2009 (2,643,892). Interestingly, these findings of increased vehicular traffic were in contrast with a speculated benefit of the pathway proposed by the environmental impact assessment, namely that opportunities for non-motorized recreation on the pathway could result in decreased traffic volumes (National Park Service 2006). Instead, our sampling may have detected an increase in visitors driving and parking in the study area in order to use the pathway, a suggestion consistent with an alternative conjecture considered in the environmental impact assessment of redistribution of park visitors towards the pathway (National Park Service 2006).

As expected, the species of ungulate present was an important predictor of both vehicular and non-motorized activity. We saw substantially more human activity when moose were present compared to when other ungulates were seen near the road, regardless of seasonal and daily influences. Most moose sightings occurred near the Snake River in Moose, Wyoming, where moose were tolerant of crowds of wildlife viewers, sometimes lingering in this area for days and attracting crowds exceeding 100 people. Indeed, increased moose sightings in 2010 (n=38, 44% of all moose sightings, representing 22% of the 2010 scan samples) may have contributed to the increased human activity we recorded in the final year of our study. We also recorded more human activity when elk were present compared to pronghorn and mule deer, indicating that elk attracted the most wildlife viewing after moose.

Quality wildlife viewing opportunities are an important and valued component of the visitor experience in Grand Teton National Park (Loomis and Caughlan 2004). Our results, in conjunction with concurrent studies of potential pathway impacts on ungulates, offer little evidence that construction and use of the pathway reduced opportunities for park visitors to see ungulates from the road. In our ungulate surveys concurrent with observations of human activities along the roadway, we did find that, on average, pronghorn were displaced by 164 meters from the road corridor after the pathway was opened for use, amounting to an estimated 413 hectares of indirect summer habitat loss for pronghorn (Hardy and Crooks in prep.). Nonetheless, pronghorn and elk continued to use habitats visible from the road after the pathway was installed. Correspondingly, we found levels of wildlife viewing in 2010 did not drop below those observed during construction and the first year of pathway use (Hardy and Crooks in prep.). Likewise, in a GPS telemetry study of elk in the study area, Sawyer et al. (2011) found that elk habitat use and road crossings patterns before, during, and after pathway construction were not affected by pathway activities.

Considering the potential influence of all human activities in the corridor before and after the introduction of pathway activities, activities on the road continued to be the dominant stimuli to which ungulates were exposed when they were near the road. While it will be appropriate to be vigilant for unique safety considerations associated with pathway use, increased levels of human activities on the road when ungulates were near the road in 2010 served as a reminder that the safety of people on the road will continue to require attention, particularly in the case of crowds of wildlife viewers that gather at moose sightings. Park management has proactively trained staff and volunteers to provide outreach to visitors to maintain proper wildlife viewing and pathway use etiquette. Ongoing support of these initiatives will help ensure the safety of visitors and wildlife and will play an important role in maintaining opportunities to see wildlife from the transportation corridor in the future.

This study documented changes in human activities over a four-year period spanning the onset of pathway use. We suggest that park managers continue to monitor human and ungulate activity in the transportation corridor along Teton Park Road. Given their sensitivity to human disturbances (Berger and Cunningham 1988, Fairbanks and Tullous 2002, Taylor and Knight 2003, Gavin and Komers 2006) and participation in the longest terrestrial migration in the continental United States (Berger 2004), pronghorn are of particular conservation concern (Hardy and Crooks in prep). Our study, along with concurrent studies of bird (Chalfoun 2011), bear (Costello et al. 2011), and ungulate (Sawyer et al. 2011, Hardy and Crooks in prep) responses to pathway activities, provide baseline data useful in developing integrative resource, social, and managerial indicators (Newman et al. 2001) that define limits of acceptable change in park resources and visitor experiences (Laven et al. 2005, Lawson et al. 2009). We predict that pathway use will increase as visitors learn about the opportunity to park their vehicles and experience the park afoot, on a bicycle, or via other non-motorized travel modes. Further planning and construction of pathway segments along existing roads will create a regional pathway system accessing other destinations within and beyond Grand Teton National Park (National Park Service 2006), including an extensive and popular system of pathways in and around Jackson, Wyoming, that accommodates more than twenty thousand pathway users annually (Kaliszewski 2011). Gradual increases in visitation, combined with a “product shift” of what constitutes an acceptable recreation experience, may result in cumulative and synergistic impacts that could go unrecognized or unappreciated (Shindler and Shelby 1995). Additional social science research examining visitor motivations and definitions of quality park experiences will be important to consider in the long-term management of the park transportation system. Ultimately, ongoing monitoring, collaboration, and outreach will be key to balancing goals of providing safe, efficient transportation and preserving opportunities to see wildlife in park transportation corridors.

## Literature cited

Ament, R., A. Clevenger, O. Yu, and A. Hardy. 2008. An Assessment of Road Impacts on Wildlife Populations in U.S. National Parks. Environmental Management **42**:480-496.

Barber, J. R., K. R. Crooks, and K. M. Fristrup. 2010. The costs of chronic noise exposure for terrestrial organisms. Trends in Ecology & Evolution **25**:180-189.

Bejder, L., A. Samuels, H. Whitehead, H. Finn, and S. Allen. 2009. Impact assessment research: use and misuse of habituation, sensitisation and tolerance in describing wildlife responses to anthropogenic stimuli. Marine Ecology Progress Series **395**:177-185.

Berger, J. 2004. The Last Mile: How to Sustain Long-Distance Migration in Mammals. Conservation Biology **18**:320-331.

Berger, J. and C. Cunningham. 1988. Size-Related Effects on Search Times in North American Grassland Female Ungulates. Ecology **69**:177-183.

Boyle, S. A. and F. B. Samson. 1985. Effects of Nonconsumptive Recreation on Wildlife: A Review. Wildlife Society Bulletin **13**:110-116.

Brownson, R. C., E. A. Baker, R. L. Boyd, N. M. Caito, K. Duggan, R. A. Housemann, M. W. Kreuter, T. Mitchell, F. Motton, C. Pulley, T. L. Schmid, and D. Walton. 2004. A community-based approach to promoting walking in rural areas. American journal of preventive medicine **27**:28-34.

Brownson, R. C., R. A. Housemann, D. R. Brown, J. Jackson-Thompson, A. C. King, B. R. Malone, and J. F. Sallis. 2000. Promoting physical activity in rural communities: Walking trail access, use, and effects. American journal of preventive medicine **18**:235-241.

Costello, C. M., S. L. Cain, R. M. Nielson, C. Servheen, and C. C. Schwartz. 2011. Impacts of a multi-use pathway on American black bears in Grand Teton National Park, Wyoming. Report for National Park Service, Grand Teton National Park, Wyoming.

Di Minin, E., I. Fraser, R. Slotow, and D. C. MacMillan. 2012. Understanding heterogeneous preference of tourists for big game species: implications for conservation and management. Animal Conservation:1-10.

Evink, G. L. 2002. Interaction between roadways and wildlife ecology. Transportation Research Board, Washington, D.C.

Fairbanks, W. S. and R. Tullous. 2002. Distribution of pronghorn (*Antilocapra americana Ord*) on Antelope Island State Park, Utah, USA, before and after establishment of recreational trails. Natural Areas Journal **22**:277-282.

Forman, R. T. T., D. Sperling, J.A. Bissonette, A.P. Clevenger, C.D Cutshall, V.H. Dale, L. Fahrig, R. France, C.R. Goldman, K. Heanue, J.A. Jones, F.J. Swanson, T. Turrentine, T.C. Winter. 2003. Road ecology science and solutions. Island Press, Washington, DC.

Gavin, S. D. and P. E. Komers. 2006. Do pronghorn (Antilocapra americana) perceive roads as a predation risk? Canadian Journal of Zoology **84**:1775-1780.

Gleason, R. 2008. Guide to promoting bicycling on federal lands. FHWA-CFL/TD-08-007, Federal Highway Administration, Lakewood, Colorado.

Hardy, A. R. and K. R. Crooks. in prep. Ungulate responses to recreational pathway use in a national park transportation corridor. Unpublished manuscript.

Hoehner, C. M., R. C. Brownson, D. Allen, J. Gramann, T. K. Behrens, M. F. Floyd, J. Leahy, J. B. Liddle, D. Smaldone, D. D. Spain, D. R. Tardona, N. P. Ruthmann, R. L. Seiler, and

B. W. Yount. 2010. Parks promoting physical activity: synthesis of findings from interventions in seven national parks. Journal of Physical Activity and Health **7**:S67-S81.

Kaliszewski, N. 2011. Jackson Hole trails project economic impact study. Thesis. University of Wyoming, Laramie, Wyoming.

Knight, R. L. and D. N. Cole. 1995. Factors that influence wildlife responses to recreationists. Pages 70-79 *in* R. L. Knight and K. J. Gutzwiller, editors. Wildlife and recreationists: coexistence through management and research. Island Press, Washington DC.

Laven, D. N., R. E. Manning, and D. H. Krymkowski. 2005. The Relationship Between Visitor-Based Standards of Quality and Existing Conditions in Parks and Outdoor Recreation. Leisure Sciences **27**:157-173.

Lawson, S., P. Newman, J. Choi, D. Pettebone, and B. Meldrum. 2009. Integrated transportation and user capacity research in Yosemite National Park: the numbers game. Transportation Research Record: Journal of the Transportation Research Board **2119**:83-91.

Lee, J.-H., D. Scott, and R. L. Moore. 2002. Predicting motivations and attitudes of users of a multi-use suburban trail. Journal of Park and Recreation Administration **20**:18-37.

Loomis, J. and L. Caughlan. 2004. Economic analysis of alternative bison and elk management practices on the national elk refuge and Grand Teton National Park: A comparison of visitor and household responses. U.S. Geological Survey, Biological Resources Discipline, Open File Report 2004-1305. 110pp.

National Park Service. 2006. Transportation Plan Final Environmental Impact Statement. Page 368, Moose, Wyoming.

National Park Service. 2011. Annual recreational visits to Grand Teton National Park. Public Use Statistics Office. http://www.nature.nps.gov/stats/viewReport.cfm Accessed August 6, 2011.

Newman, P., J. L. Marion, and K. Cahill. 2001. Integrating resource, social and managerial indicators of quality into carrying capacity decision-making. George Wright Forum **18**:28-40.

Riley, S. P. D., J. P. Pollinger, R. M. Sauvajot, E. C. York, C. Bromley, T. K. Fuller, and R. K. Wayne. 2006. A southern California freeway is a physical and social barrier to gene flow in carnivores. Molecular Ecology **15**:1733-1741.

Schwartz, C. C., S. L. Cain, S. Podruzny, S. Cherry, and L. Frattaroli. 2010. Contrasting Activity Patterns of Sympatric and Allopatric Black and Grizzly Bears. The Journal of Wildlife Management **74**:1628-1638.

Smith, B. L. 2007. Migratory behavior of hunted elk. Northwest Science **81**:251-264.

Stankowich, T. 2008. Ungulate flight responses to human disturbance: A review and meta-analysis. Biological Conservation **141**:2159-2173.

Taylor, A. R. and R. L. Knight. 2003. Wildlife responses to recreation and associated visitor perceptions. Ecological Applications **13**:951-963.

Trombulak, S. C. and C. A. Frissell. 2000. Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. Conservation Biology **14**:18-30.

Wilcove, D. S., D. Rothstein, D. Jason, A. Phillips, and E. Losos. 1998. Quantifying Threats to Imperiled Species in the United States. BioScience **48**:607-615.

# CHAPTER THREE[3]

## Introduction

Safe and efficient transportation is a critical component of strong economies and a high quality of life; however, transportation infrastructure can have negative consequences such as habitat loss and fragmentation for fish and wildlife populations (Evink 2002, Forman et al. 2003, National Academy of Sciences 2005, Clevenger and Wierzchowski 2006). While it is essential to efficiently construct and maintain transportation systems to serve our communities, it is equally important to avoid, minimize and compensate adverse impacts to our natural resources. In the United States, the environmental review process for infrastructure project planning and delivery requires reasonable efforts to avoid detrimental impacts to human and natural communities, as well as historic and cultural sites. Nevertheless, unavoidable impacts occur, and responsible parties are legally obligated to offset negative environmental effects to meet regulatory requirements (e.g., Section 7 of the Endangered Species Act, Section 404 of the Clean Water Act). Upon satisfying the terms of the myriad of regulations (see Brown 2006 for a complete list of regulations that must be addressed in the environmental review process), necessary permits are issued and construction is allowed to proceed.

The environmental review process for complex transportation projects is often the most time-consuming part of project delivery (Evink 2002, Government Accountability Office 2003). Traditionally, impact assessment occurs on a project-by-project basis and the task of developing appropriate measures to mitigate adverse impacts can require significant time and effort, sometimes imposing unpredictable and costly delays. Further, efforts to mitigate impacts are

---

[3] Originally published as Hardy, A.R. and D. Wambach. 2010. An Eco-Logical approach to transportation project delivery in Montana. *In* J.P. Beckmann, A.P. Clevenger, M.P. Huijser, and J.A. Hilty (Eds.) *Safe Passages: Highways, Wildlife, and Habitat Connectivity* (pp. 99-125). Island Press, Washington, DC.

commonly directed toward the affected resources at the project site; while this approach may satisfy regulatory requirements, it is questionable whether the ecological integrity of the disturbed area and adjacent habitats can be fully restored. This approach often overlooks other conservation opportunities in the affected region that might offer a better return for the mitigation investments. Recognizing such shortcomings of the environmental review process, Congress incorporated provisions into the last two transportation bills (1998 Transportation Equity Act of the 21st Century and the 2005 Safe, Accountable, Flexible and Efficient Transportation Equity Act: A Legacy for Users) to improve environmental stewardship and expedite the environmental review process for transportation projects (Government Accountability Office 2008).

In response to this challenge, an interagency team compiled guidance and examples for streamlining environmental reviews while more effectively protecting natural resources and ecosystem processes (Brown 2006). Entitled, “Eco-Logical: An ecosystem approach to developing infrastructure projects”, this document encourages federal and state agencies to strategically collaborate to target ecosystem-based mitigation for regional conservation priorities, early in the project planning and review process. By fulfilling regulatory obligations in advance of final design and construction, this approach has potential to reduce costly delays in project delivery while increasing the cost-effectiveness of mitigation efforts by focusing on prioritized conservation initiatives. The product of extensive discussions between infrastructure-development and regulatory agencies, Eco-Logical has earned executive-level reassurances that a flexible ecosystem approach for environmental reviews can be implemented under existing legal mandates.

An interagency group in Montana adaptively applied the ideas in Eco-Logical to create and pilot the "Integrated Transportation and Ecosystem Enhancements for Montana" (ITEEM) process. This chapter examines the events that motivated Montana agencies to rethink the environmental review process and how Eco-Logical influenced the development of the ITEEM process. We summarize the ITEEM process and describe how the process is being debuted in a pilot study effort. Finally, we synthesize Montana's experiences through the development and initial application of the process thus far, offering insights to other entities that may be embarking on their own path to streamline environmental reviews while improving environmental stewardship.

### *Historical and political setting for the Eco-Logical approach*

In 2002, Executive Order 13274, entitled "Environmental Stewardship and Transportation Infrastructure Project Reviews," directed agencies to streamline environmental reviews while enhancing environmental stewardship for transportation infrastructure projects. Valid concerns were raised that that the environmental review process would be compromised in the effort to speed up project delivery. To address these concerns and find creative solutions to address the Executive Order's charge, an interagency team of federal regulatory and infrastructure development agencies (including Bureau of Land Management, US Environmental Protection Agency, Federal Highway Administration, National Oceanic and Atmospheric Administration Fisheries Service, National Park Service, US Army Corps of Engineers, US Department of Agriculture Forest Service, US Fish and Wildlife Service, Volpe National Transportation Systems Center, the Knik Arm Bridge and Toll Authority) as well as Departments of Transportation (DOT) from several states (North Carolina DOT, Vermont Agency of Transportation, Washington DOT), was formed to explore integrated planning approaches to improve stewardship and reduce project delivery timelines. Building on related initiatives that encourage collaborative and balanced conservation approaches to address environmental reviews and mitigation efforts (Office of Environmental Protection 1995, Executive Order 13352 2004) and the “Enlibra Principles” (Western Governors’ Association 1999), the group developed the Eco-Logical guidance promoting ecosystem-based mitigation strategies to improve the environmental review process (Brown 2006).

Eco-Logical defines ecosystem-based mitigation as the practice of coordinating advanced mitigation of infrastructure project impacts by preserving, enhancing and creating habitat and ecosystem functions where such actions are most needed and where such contributions have been determined to be the most beneficial to regional conservation efforts (Brown 2006). When ecosystem-based mitigation is accomplished early in the planning of infrastructure projects, agencies capitalize on meaningful conservation priorities and opportunities that may be vanishing or becoming prohibitively expensive over time, increasing the cost-effectiveness and ecological effectiveness of mitigation investments. Advanced mitigation planning can be targeted to fulfill environmental regulatory requirements to avoid costly permitting delays while making important contributions to regional conservation initiatives. The ecosystem approach balances transportation project delivery and ecosystem conservation objectives, reflected in the following goals defined in Eco-Logical:

- ***Conservation:*** Protection of larger scale, multi-resource ecosystems;
- ***Connectivity:*** Reduced habitat fragmentation;
- ***Predictability:*** Knowledge that commitments made by all agencies will be honored – that the planning and conservation agreements, results, and outcomes will occur as negotiated; and

- ***Transparency:*** Better public and stakeholder involvement at all key stages in order to establish credibility, build trust, and streamline infrastructure planning and development.

To implement an ecosystem approach, Eco-Logical outlines three components that build upon each other through an adaptive feedback loop: integrated planning, mitigation options and performance measurement (Figure 9), briefly described below.

**Figure 9. Components of an ecosystem approach, as outlined in Eco-Logical (Brown 2006).**

### *Integrated Planning*

Establishing regional ecosystem conservation priorities is key to ecosystem-based mitigation. Integrated planning is pivotal in determining these priorities. Eco-Logical offers an eight step approach for integrated planning. Briefly, these steps involve developing collaborative partnerships, synthesizing information to identify regional conservation concerns and opportunities, considering how anticipated project impacts might be offset by identified conservation opportunities, and prioritizing opportunities that satisfy legal mandates. A consensus-based list of opportunities to offset impacts is then incorporated into the National Environmental Policy Act (NEPA) planning and permitting efforts for the project(s) in question. The final step of integrated planning evaluates how recommended mitigation options that advanced to the NEPA process were incorporated into the final project to address the regional conservation priorities.

### *Mitigation Options*

Eco-Logical describes and offers examples of different mitigation approaches including project-specific mitigation, multiple-project mitigation, ecosystem-based mitigation, off-site and/or out-of-kind mitigation, as well as mitigation banking, in-lieu-fee mitigation, and conservation banking techniques (Brown 2006). Benefits and draw-backs of each type of mitigation approach are explored in Eco-Logical, as are issues of accountability in ecosystem-based mitigation and conservation banking.

### *Performance Measurement*

The final component outlined in Eco-Logical occurs as infrastructure projects are completed and collaborators assess if desired outcomes were achieved. Based on this evaluation, adaptations to improve the next cycle of Eco-Logical steps are documented. The success of the ecosystem approach depends on adapting priorities, acknowledging successes and failures, and searching for solutions to problematic aspects of the process from one cycle to the next.

The concepts behind the three components described above, along with case studies examples and the Executive-level endorsements of Eco-Logical's approach, played important roles in Montana's efforts to create their own ecosystem-based approach to transportation project delivery. Even prior to the release of Eco-Logical, however, there was momentum to create a new approach to transportation project delivery in Montana, prompted by other influential factors.

### *Rationale for applying an Eco-Logical approach in Montana*

In 2002, multiple projects planned for the US Highway 93 (US 93) corridor in northwest Montana were identified as a high priority projects under Executive Order 13274. Legitimate concerns were raised regarding balancing environmental stewardship and expedited environmental reviews along the 460.2 kilometer (286 mile) corridor that traverses important wildlife habitats in the mountains and valleys of western Montana. Stakeholders involved in the US 93 reconstruction (not including projects on the Flathead Indian Reservation; see Becker and Basting 2010) began the process of developing a new, defendable approach to increase the efficiency of the review process for multiple projects while embracing environmental stewardship approaches in the region.

To achieve this goal, an Interagency Review Team (Review Team) was formed with upper-level managers from the Montana Department of Transportation (MDT); Federal Highway Administration, including Federal Lands Highways (FHWA); Montana Department of Fish, Wildlife and Parks (FWP); Montana Department of Environmental Quality (DEQ); Montana Department of Natural Resources and Conservation (DNRC); Confederated Salish and Kootenai Tribes (CSKT); US Environmental Protection Agency (EPA); US Army Corps of Engineers (Corps); US Fish and Wildlife Service (USFWS); and US Forest Service (USFS). The Review Team designated representatives from their respective agencies to form a Working Group to explore more efficient and effective environmental mitigation methods to decrease review times, while upholding important environmental protections in the US 93 corridor.

Despite acknowledging the inefficiencies and inadequacies of the current environmental review system, the Working Group was understandably tentative about possible legal ramifications of revamping the existing review process. The Working Group’s momentum slowed as unanswered questions and lack of direction overshadowed the task of finding a plausible path toward streamlining the environmental review process for the US 93 projects. In the mean time, standard planning and compliance processes for the US 93 projects were already underway, such that pursuing a new approach for these projects at that point would be counterproductive in terms of shortening the environmental review timeline.

While little new ground was broken to streamline the US 93 environmental review process, the agencies recognized that they had initiated important discussions to improve the environmental review process. The Review Team asked the Working Group to redirect their efforts toward the Montana Highway 83 (MT 83) corridor, where two future highway reconstruction projects were in the earliest stages of planning, an important consideration when applying an ecosystem approach. By then, the Eco-Logical document was garnering buy-in from leaders of infrastructure and regulatory agencies alike. The FHWA Montana Division Office staff involved in developing the Eco-Logical document recognized that the Working Group might be able to apply the ideas in Eco-Logical to make headway on issues that had previously hindered progress. Per the Review Team's acceptance of the ideas in Eco-Logical, this guidance document was adopted by the Working Group as a foundational resource offering creative approaches to addressing difficult procedural, legal and environmental issues associated with planning, environmental review and project delivery.

With Review Team oversight, a committed Working Group, a focal region with transportation projects in the earliest stages of planning, and guidance and executive-level endorsements offered in Eco-Logical, momentum and direction materialized out of a period of admitted ambiguity. The final component that helped move the process development phase forward was a project coordinator, hired by FHWA to orchestrate the group's efforts and document the resulting discussions and agreements. Over the course of a year, the project coordinator and Working Group explored an array of potential approaches, discarded dead-end ideas, and eventually arrived at a common vision and methods for testing an ecosystem approach in Montana; the outcome of their diligent efforts was the first version of the "Integrated Transportation and Ecosystem Enhancements for Montana," or the ITEEM, process (Hardy 2008).

### *Integrated Transportation and Ecosystem Enhancements for Montana*

The ITEEM goals and desired outcomes, roles and responsibilities, dispute resolution process and tasks to apply the ITEEM process are presented below. The text below is a simplified version of the document used to guide the pilot study (Hardy 2008). The pilot study discussed later in the chapter.

#### *Desired outcome and goals*

The desired outcome of the ITEEM process is to balance environmental and transportation values by streamlining transportation program delivery while applying more effective ecosystem conservation. Schedule, cost, safety, quality, public input, regulatory requirements, ecological concerns and other factors are considered equally with no single factor dominating as the top priority. Specific ITEEM goals expand upon the Eco-Logical goals, as follows:

- ***Conservation***: Protection of larger scale, multi-resource ecosystems;
- ***Connectivity***: Enhanced or restored habitat connectivity and reduced habitat fragmentation;
- ***Early Involvement***: Early identification of transportation and ecological issues and opportunities ("issues" refer to potential impacts or concerns associated with the transportation projects under review or regional conservation initiatives; "opportunities"

refer to potential options to concurrently address mitigation requirements and conservation priorities);

- ***Cost Efficiency***: Making the best use of transportation program funding by focusing mitigation efforts where they would be most effective;
- ***Cooperation***: Finding solutions acceptable to all participating agencies;
- ***Predictability***: Knowledge that commitments made early in the planning process by all agencies will be honored – that the planning and conservation agreements, results, and outcomes will occur as agreed; and
- ***Transparency***: Better stakeholder involvement to establish credibility, build trust, and streamline infrastructure planning and development.

### *Roles and responsibilities*

Stakeholders share responsibility of finding solutions that meet both transportation and ecosystem conservation goals. One representative and an alternate from each participating agency will commit to serving in the ITEEM Oversight Group. Individual representatives in the Oversight Group serve as their agency's point of contact, representing their agency's interests and responsibilities. The Oversight Group will strive for consensus as they negotiate to optimize ecological conservation opportunities while reducing project development time and increasing the predictability of program delivery. It is the responsibility of the Oversight Group to identify issues and opportunities; prioritize opportunities to improve long-term cost-efficiency of mitigation efforts; apply programmatic approaches or establish Best Management Practices as appropriate; document recommendations and establish work groups dedicated to implementing recommendations; establish measures of success to evaluate and adapt the process to better meet goals and objectives; and ensure open and on-going communication between agency representatives and various stakeholders such as non-government organizations (NGOs) and people affected or interested in the project and conservation efforts in the region.

### *Dispute resolution*

In the event that consensus may not be achieved at any point in the ITEEM process, the dispute resolution process establishes a 2-week timeframe for issues to be resolved via the Oversight Group, during which time the conflicting parties will focus on resolving the disagreement via open discussion. If the unresolved issue is not critical to the process, the parties with contrasting points of view can respectfully "agree to disagree" with no further implications; these disagreements will be documented for the record. If the issues must be resolved for the process to effectively move forward and parties are unable to come to a solution within two weeks, the issue will be elevated to the Review Team for upper-level managers to make a final decision.

### *ITEEM process tasks*

The ITEEM process consists of six tasks that may be adapted in the future based on evaluation of the process. Each task is briefly described below.

#### Task 1: Establish regional boundaries

The Oversight Group will determine the region where multiple transportation projects in the early stages of planning are programmed to be delivered in the future (e.g., 5-20 years) and where conservation issues and opportunities need to be considered in the planning process. This region may be determined based on jurisdictional boundaries, but in striving for an ecosystem approach, the region could be delineated by ecologically-relevant features such as watershed boundaries.

#### Task 2: Compile and prepare information

With the assistance of a facilitator, participating agencies will be responsible for providing the best available data in a timely manner to identify issues and opportunities relevant to the programmed projects and regional conservation interests.  Additionally, the facilitator will hold a public open house to obtain relevant input and information from other stakeholders including the public and NGOs, ensuring transparency by accommodating public involvement early in the process.  Examples of the type of information and data to be collected may include the following (see Brown 2006 and Hardy 2008 for an extensive list of information that may be important to consider in the process):  land ownership, planned developments & projected land use change; traffic data & projections; conservation easements; State Wildlife Conservation Plan with fish and wildlife species ranges & critical habitat designations; road kill locations & numbers; habitat connectivity models; wetland locations; water quality impaired streams & local watershed management groups' efforts; culvert locations and fish passage data; and other regional collaborative conservation efforts.

The facilitator will organize and present a comprehensive list of the compiled data and sources to the Oversight Group who will determine the final set of information that will be referenced at a collaborative workshop, the next step of the process.  The facilitator will document justification for retaining or rejecting data and summarize the final set of information that will be referenced at the workshop; this memorandum will be distributed to participating agencies allowing them to prepare statements regarding issues and opportunities to be discussed further at the workshop.

### Task 3:  Workshop

The facilitator will organize a workshop for stakeholders to collaboratively discuss possible impacts of the proposed transportation projects and regional conservation opportunities that may could be tapped to offset negative effects. Workshop participation will be limited to the Oversight Group, a few agency technical staff, and representatives from local governments and NGOs with regional expertise and an understanding of the ITEEM process. The workshop may occupy 2-3 days and should be conducted within the identified region to foster a sense of place and facilitate timely field review of potential impact and mitigation sites of interest.

Workshop participants will refer to the information compiled during the previous task to identify issues and opportunities in the focal region at a coarse scale. The facilitator will organize a field review to further discuss and ground-truth the information to better hone recommendations. Potential opportunities determined to be infeasible due to physical, social or land use constraints will be eliminated through consensus. Practical options deemed worthy of further consideration after field review will be documented by the facilitator, and may include the following types of details:

- location, methods and schedule for implementation of mitigation:
- how potential mitigation option(s) offset impacts of the proposed projects and address regional conservation interests, regulatory statutes, and streamlining of transportation project delivery;
- identification of other areas or impacts that could relinquish substantial mitigation improvements in trade for focusing efforts and limited funding on particular conservation opportunities;
- opportunities to leverage funds for collaborative conservation initiatives (i.e., if mitigation can contribute to on-going regional conservation efforts); and
- workshop attendees' preliminary comments on the identified opportunities(s).

Documented opportunities will be prioritized and a final list of recommendations will be established via consensus among participants. Depending on the complexity of any given recommendation (e.g., recommendations that require coordination between several agencies, conservation easements, land swaps, etc.), work groups may be identified to further detail an implementation plan, including responsible parties, estimated costs, and necessary memorandums or agreements. The final list of recommended opportunities, as well the rationale behind culling other options, will be documented by the facilitator.

Finally, workshop participants will establish measures of success to evaluate and adapt the process for future application. Three factions should be considered when establishing measures of success and performance standards. First, the ITEEM process itself should be evaluated; this may include assessing different facets of the process such as data assimilation, identification of issues and opportunities, workshop field review and prioritization approaches and agency involvement. Second, infrastructure projects themselves should be appraised in terms of how mitigation recommendations were incorporated into the NEPA process, how permitting proceeds, and overall time to project delivery. Finally, ecological benefits realized through the process should be evaluated in terms of contributions to regional collaborative conservation priorities and initiatives. The participating agencies will determine appropriate and achievable measures for variables related to desired outcomes. Because it will take years to see many of the outcomes, the Oversight Group should plan periodic follow-up meetings to evaluate measures of success (see Task 6) until the commitments are satisfied completely.

### Task 4: Draft workshop report

The facilitator will compile documented recommendations and measures of success established during the workshop into a draft report. Participating agencies will have 45 days to review and comment on the draft report. After revision and agency approvals, the report will be made available for public comment for 30 days. A summary public and agency comments will be included in the final ITEEM report as an appendix, along with a summary of options not adopted.

### Task 5: Finalize ITEEM report

The facilitator will finalize the workshop report, including a signatory page to document agency concurrence. The final report will be referred to as the projects are moved through the NEPA review process; ultimately, recommendations put forth in the ITEEM report should expedite the process of finalizing mitigation plans in these planning documents. Oversight Group representatives will continue to serve as their agency's contact for further correspondence regarding the ITEEM report and recommendations.

### Task 6: Evaluate and adapt ITEEM process

The Oversight Group will meet periodically (e.g., semi-annually) to revisit the final report, discuss progress and outstanding issues, and to update measures of success. If changes to existing recommendations are deemed necessary, the Oversight Group will find a reasonable approach that all agencies can support. Additionally, the Oversight Group will compile necessary inputs for evaluating measures of success and will document progress, outstanding issues and suggestions to adapt the process in the future. These periodic meetings will take place until all commitments are fulfilled, which may take many years. Once agencies agree the commitments documented in the final report have been met, the Oversight Group will have a final meeting to document lessons learned and recommendations to improve the ITEEM process, resulting in an addendum to the final report, completing a single cycle of the ITEEM process.

### *Pilot Study: Testing the ITEEM process*

The agencies of Montana took a big leap by committing resources to create the ITEEM process (referred to as “the process”) as outlined above. Upper-level managers demonstrated their on-going commitment by allocating additional agency resources to implement the new approach in a pilot study. We recount how the pilot study has been carried out thus far, summarizing efforts taken to prepare for the workshop and how the workshop itself unfolded.

The pilot study began in June 2007 with the Review Team and MDT identifying two transportation projects that would be the focus of the pilot study. The two projects were reconstruction/rehabilitation projects for sections of the MT 83 corridor between Seeley, Montana, and the Clearwater Divide (Figure 2). The study area included a 15-mile corridor straddling the road where the two projects would occur and a larger region encompassing conservation interests beyond the road corridor. Issues and impacts related to the highway projects would be assessed within the 15-mile corridor. Opportunities to mitigate aquatic resource impacts would be considered across the entire Clearwater drainage plus the section of the Blackfoot drainage in Missoula County. Mitigation to offset terrestrial impacts would be considered across a larger region stretching from the junctions of MT 83 and MT 35 at the north end, and MT 83 and MT 200 at the south end, and extending from the crests of the Mission and Swan Mountain ranges to the west and east, respectively (Figure 10).

Several characteristics of the MT 83 study area offered an excellent testing ground for the pilot study. First, these projects were in their earliest stages of the planning process, lending an opportunity for the pilot study to potentially influence and streamline the environmental review and permitting processes. Second, by focusing on two highway projects, the pilot study would explore the feasibility of addressing mitigation needs for “batches” of projects rather than using the traditional project-by-project environmental review process. The MT 83 study area

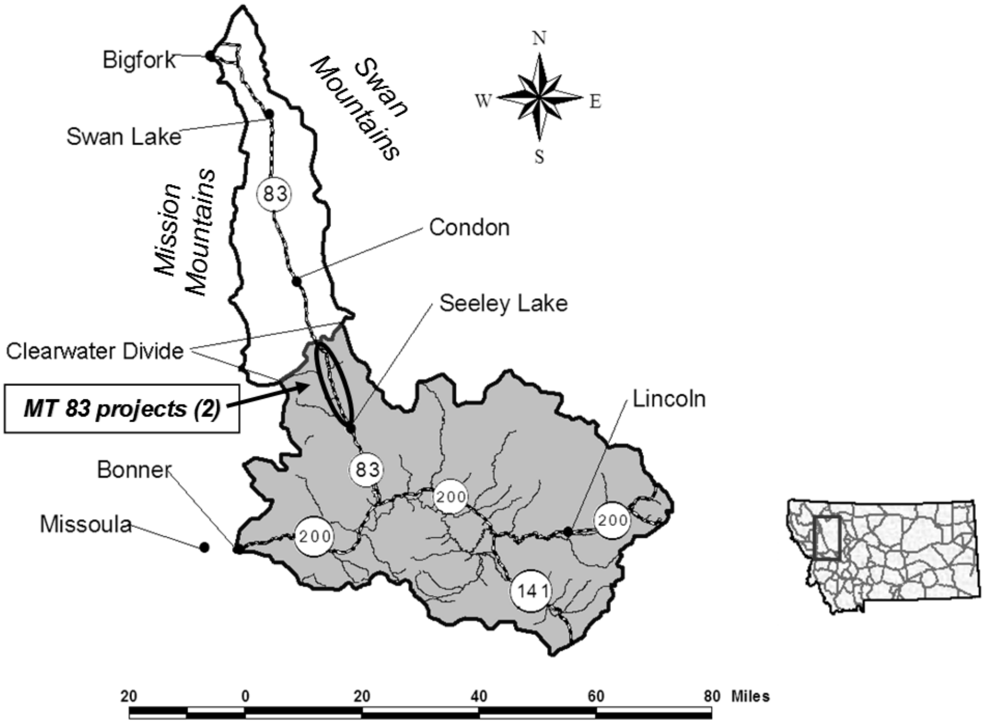

**Figure 10. The ITEEM Pilot Study regional boundaries encompassing two MT Highway 83 projects (highway project area) slated for future reconstruction and the larger area where regional ecological conservation opportunities were considered as potential targets for mitigation efforts to offset unavoidable impacts associated with the two highway reconstruction projects. Terrestrial conservation opportunities could be identified within the larger outlined area, while aquatic conservation opportunities could be identified within the watershed area identified in grey.**

encompasses important habitats for several federally-listed endangered or threatened wildlife species (e.g., grizzly bears [*Ursus arctos*], Canada lynx [*Lynx Canadensis*], Bull trout [*Salvelinus confluentus*]), and a number of sensitive plant and animal species as well as big game species. The presence of these species meant that the process would have to specifically address Section 7 of the Endangered Species Act as the projects could impact the listed species' critical habitats and habitat connectivity in the region. Additionally, land use and management in this region is overseen by numerous entities, requiring buy-in from numerous local stakeholders. Further, several watershed-based conservation initiatives and agency management plans were already underway in the region, ensuring that the process would need to consider collaborative partnerships directed at targeting mitigation to address established regional conservation goals.

Four levels of agency involvement participated in the pilot study: the Review Team (upper-level agency managers), Oversight Group (mid-level agency managers granted decision-making authority for pilot study implementation), Working Group (agency representatives most involved in accomplishing the steps of the process), and Technical Staff (agency representatives assisting with compiling relevant agency documents and information). Reporting to the Review Team, Oversight Group members were “the voice” of their respective agencies to make decisions and enter into tentative agreements on behalf of their agency. Working Group members served as the primary point of contact for their agency in the day-to-day tasks of the process and ultimately were the true shepherds of the pilot study. There was mentionable overlap between the Working Group and the Oversight Group members; in many cases the same person served in both roles.

Formal invitations to participate in the pilot study were also extended from MDT to the Commissioners of each of the four counties in the study area region. The invitation emphasized the importance of local buy-in to the process and incorporating future planning, zoning or development projects on the region as these actions could have notable effects on the identification and prioritization of ecological conservation opportunities.

Upon establishing agency representatives committed to the pilot study and defining the specific study area, MDT contracted a consultant to serve as a facilitator in February 2008 to compile information, facilitate the public involvement process and agency workshop, and document the evolution of the ITEEM process for one year as it is applied in this pilot study. The facilitator’s multi-disciplinary team, comprised of a project manager, environmental scientists, a GIS analyst, a logistics coordinator and two professional facilitators, embraced the underlying principals of Eco-Logical and demonstrated an understanding of the objectives of the process and goals of the pilot study. A kick-off meeting was held with the Working Group and the consultant to introduce the consultant's project team, determine the list of stakeholders to invite to participate in the process, and identify appropriate contacts for obtaining data. Format and protocols for data acquisition, pilot study timeline, a review of the dispute resolution process, and refinement of the regional boundaries for the pilot study were also addressed at this meeting.

Following this meeting, MDT and the consultant submitted a letter to Working Group members and agency technical staff requesting a list of the best available data that each agency wanted considered during the process, including relevant research studies, reports, point-data, maps and geo-spatial data layers. The letter also asked each agency to prepare a summary of their initial concerns and issues relating to the highway corridor and regional natural resources, along with conservation partnership opportunities in the pilot study region.

To complete the request for relevant information, the consultant advertised a public open house to catalyze public involvement and transparency of the process. Attendance at the open house was sparse, but attendees provided important contacts with several local NGO's that are active in the regional communities and already pursuing endeavors with goals comparable to those of the ITEEM process. Participation by these groups would prove invaluable with respect to local knowledge of issues and opportunities and would later provide a promising avenue for implementation of the pilot study outcomes at the local level.

The consultant spent most of the summer of 2008 compiling and summarizing the data and information for consideration in the process along with the issues and opportunities identified thus far.  The Working Group and consultant met to select a comprehensive yet manageable and relevant subset of information and data detailing critical issues and opportunities that would be discussed at the workshop and agencies presented their initial list of issues and potential opportunities that they would be advancing to the workshop for discussion.  After this meeting, the consultant summarized the pilot study progress to date for the Oversight Group, including the initial list of identified issues, opportunities and compiled information and data that would be advanced to the workshop.

The workshop, facilitated by the consultant, took place in Seeley, Montana over three days in late October 2008 and was attended by the Oversight Group members and agency technical staff, as well as several local government and NGO representatives.  The FHWA representative opened the workshop introductions, an overview of the ITEEM process and the pilot study's progress thus far.  Five NGO representatives presented their organizations' respective missions, and conservation initiatives within the greater study area.  The MDT representative summarized the highway project reconstruction objectives, development process and timeline, after which the consultant provided an overview of the compiled data and maps that would be used to inform decision-making during the workshop.

The afternoon of the first day of the workshop was spent reviewing the compiled fine-scale data used to identify issues and planning considerations in the 15-mile highway corridor and broader-scale information related to potential conservation partnership opportunities throughout the greater study area.  Discussions focused on regional ecological resources of interest including wildlife habitat linkages, grizzly habitats, lynx habitats, big game habitats, other sensitive species and species under special management status, bull trout and westslope cutthroat trout habitats, wetlands and recreational sites.  Within the 15-mile highway corridor, identified issues fell into six main categories: wildlife permeability, wildlife mortality, aquatic organism passage at stream crossings, water quality, wetland impacts, and adjacent land-use and development (as it may affect the long-term efficacy of some mitigation investments in the highway corridor). Beyond the highway corridor, issues and opportunities within the greater study area included wildlife-human interactions (e.g. due to increasing human development and habitat fragmentation/loss, bear conflicts in residential areas), acquiring conservation easements on private lands identified as important wildlife habitat or movement corridors, watershed management and fish passage restoration, and land-use practices and development pressures on private lands. These identified issues would drive the effort to find appropriate opportunities to address associated impacts during the remainder of the workshop.

On the second day of the workshop, participants travelled the highway corridor, stopping locations where opportunities and issues had been identified, such as stream crossings and areas where wildlife linkage zones intercept the highway. Interactions amongst participants in the field provided better understanding each others' concerns and interests, with significant pay-offs realized on the following day when the group would collectively select a final list of recommendations that would be considered in the NEPA reviews for the projects in question.

The last day of the workshop was dedicated to honing the list of issues and opportunities, dropping those unsuitable for further consideration and prioritizing those remaining for action and implementation. It was suggested that agencies consider establishing a "restoration fund" to augment conservation efforts already underway. Agencies could contribute to the fund in advance of proposed projects while proponents of restoration and conservation projects could apply for monies to address conservation priorities. The securing of conservation easements on other private lands of ecological importance was also proposed. The Nature Conservancy, Trust for Public Land, and Plum Creek had been discussing transactions pertaining to a three-phased purchase of over 300,000 acres in the region over the next two years with the intent to transfer management of these lands to a mix of federal, state and private ownership. This complex transaction could take years to see through, and with these negotiations in their infancy, it was not possible to identify distinct conservation needs that could be addressed on these lands, should they be acquired. The feasibility of advanced investments of this nature requires further investigation into funding mechanisms and to determine if such funds need to be directed toward particular resource management objectives to fulfill permit obligations that the mitigation efforts are intended to address; the agencies are exploring these ideas further.

The group identified the purchase of parcels for wetland restoration as a possibility for interagency partnerships to leverage mitigation monies. The MDT had already established a wetland mitigation program in the region, but additional opportunities for compensatory mitigation were identified, such as adding additional wetlands to an existing wetland reserve or to properties adjacent to the highway corridor with potential wetland restoration opportunities that were noted during the field review. The MDT committed to look into the feasibility of wetland mitigation on these properties in an effort to establish additional wetland mitigation credits in the watershed. It was agreed that while wetland purchase and restoration may not be an immediate need within this particular watershed, if an ideal or important wetland project presented itself, the group would consider it a valid opportunity to collaborate with other stakeholders.

Research directed at understanding specific wildlife movements within the highway corridor was suggested as a potential mitigation outlet. Such research would need to consider the goals of increasing permeability of the highway to carnivore movements and reducing animal-vehicle collisions, particularly with ungulate species. Research of this nature could help identify and prioritize locations where crossing structures and exclusion fencing could most effectively intercept and accommodate wildlife movement across the road corridor, with the potential of incorporating such infrastructure into the future highway reconstruction project. Similar to the ideas suggested above, the group recognized that this would require further investigation regarding funding mechanisms and assurances of the validity of applying research to address regulations that mitigation intends to address.

While the ideas above generated more questions than explicit recommendations, the group was able to identify distinct mitigation recommendations specific to highway project planning and design considerations. Mitigation opportunities suggested for the highway corridor region included fish and wildlife passages in combination with exclusion fencing to guide animals under or over the roadway. Roadside vegetation management to facilitate at-grade wildlife crossings in selected areas where road alignments provide increased sight distances, and where wildlife warning signage or measures such as animal detection systems that warn drivers of crossing wildlife could be installed to reduce animal-vehicle collisions and increase safety. For other areas of the highway corridor, a curvilinear highway design that complemented the unique and wild character of the corridor was suggested along with the minimization of the construction footprint to reduce impacts to habitats near the highway. The inclusion of permanent erosion control facilities such as sediment basins were considered to reduce roadside animal attractants (e.g., to de-icing chemicals) and improve water quality. Potential conservation opportunities to compensate for project impacts across the broader study area included agency partnerships with local grass-roots efforts to facilitate private land acquisition and restoration (particularly in association with the recently-initiated Montana Legacy Project, an effort aimed at conserving important forestland currently owned by Plum Creek Timber Company in northwestern Montana), public education and outreach programs regarding “living with wildlife”, and cooperative efforts to open up large stream reaches to fish passage and wildlife movement corridors across private and public lands. These recommendations would be advanced to the NEPA environmental review process in hopes of shortening the time required to incorporate mitigation into project planning efforts.

The workshop concluded with an exploration of the successes and challenges uncovered during the pilot study to date. Everyone agreed that the pilot study has been a worthwhile endeavor, recognizing that the process is iterative and will be improved over time as the strengths and weaknesses of the approach materialize through implementation. The discussion turned to the transition of continued oversight and management through completion of the pilot study. It was proposed that management of the process after the workshop would shift from MDT to another entity capable of stewarding the commitments through implementation within the Seeley-Swan region over the long-term. The group agreed that, if possible, a local government or rural initiative organization would be the ideal entity for carrying the conservation efforts that emerge from the pilot study to fruition, while MDT and FHWA will be responsible for incorporating design considerations along the highway corridor into the NEPA process and scoping for the future highway projects where the ITEEM process may be applied.

The workshop accomplished many of the tasks described in the original ITEEM process, but several tasks remained after the workshop was finished. The group committed to further developing measures of success, identifying areas for process improvement, following-through on action items generated from Workshop discussions, presenting findings and recommendations to the Review Team for decision-making and documentation of agreements and commitments, and ultimately transferring the MT 83 ITEEM process to a local entity for implementation stewardship.

Following the development of measures of success, the consultant prepared a Draft ITEEM MT 83 Pilot Study Final Report in and circulated it for review and comment from the Working Group and Oversight Group members. The document included a recount of the milestones and tasks as executed through the pilot study; issues and concerns identified as planning considerations for the transportation project development; prioritized conservation partnership opportunities for the study area; and a summation of the established measures of success. A list of considerations and opportunities not advanced by the group, along with the rationale behind those decisions was included in that document.

After agency review and comment, the revised Draft Final Report will be made available for public comment. Public comments will be addressed by the appropriate cooperating agency and incorporated into the Final Report. The document will be finalized, including a list of workgroups formed to develop and execute action items and a schedule of future Oversight Group meetings intended to monitor and discuss the pilot study's progress as agreements and mitigation actions are fulfilled. Once finalized, the MT 83 ITEEM process pilot study commitments will be transferred to an appropriate local entity committed to manage the agreed-upon conservation actions with the assurances of long-term participation and support from the cooperating agencies.

### *Lessons learned: developing the ITEEM process*

Over the years of creating and piloting an ecosystem approach for transportation project reviews, road blocks were encountered. Acknowledging and addressing these setbacks ultimately improved the process, generating lessons learned along the way. We share these lessons to help other groups avoid pitfalls that may commonly be encountered in complex endeavors of this nature.

To start, while Eco-Logical was useful in the effort to develop the ITEEM process, this guidance document did not function as a cookbook with tested recipes guaranteed for success. Rather, examples therein helped participants understand the concepts of an ecosystem approach and how elements of this approach had been applied in other case studies. Further, and perhaps more importantly, Eco-Logical's endorsements by agency executives at the federal level provided Montana's upper-level agency managers reassurances that more creative and flexible approaches can be used while satisfying legal statutes of the environmental permitting processes. The Review Team's leadership was essential and having the Working Group agency representatives in direct communication with upper-level management and decision-making authority helped the group advance through difficult decisions at various stages of developing the process.

As the Working Group developed the process, it was helpful to focus on specific future highway projects. Representatives were better able to obtain relevant (rather than hypothetical) feedback from their agency colleagues by referring to the specific region where these projects would occur, particularly in regards to compiling regional data and information and the agency's initial list of issues and opportunities. Discussion of appropriate projects to focus on while developing the process also highlighted the necessity to work with projects in the earliest stages of development to successfully reduce project planning time and to capitalize on planning advanced mitigation to address regional conservation priorities before they disappear.

The importance of creating an environment of understanding, respect, and cooperation to work through challenging issues cannot be underestimated when working collaboratively to find a common vision amongst groups with different missions and interests. While agency representatives in the workshop had worked together for years, they had not previously been motivated to find the greater good for all when applying the traditional project-by-project method for environmental reviews. The traditional approach to project planning did not require agencies to understand each others' interests and missions resulting in misconceptions that initially hampered true collaboration. The agencies had to develop genuine team camaraderie to find approaches that not only satisfied their particular regulatory mandates but also the interests of the other agencies. Working Group representatives were asked to share professional, educational, personal histories and interests with each other, revealing commonalities that hadn't been discovered despite years of working together. Taking time for representatives to share their agency's mission and management plans further increased mutual understanding between agencies. One-on-one interviews between the project coordinator and representatives illuminated the history of the working relationships amongst the agencies, allowing for more responsive and strategic facilitation.

As the Working Group committed to numerous meetings to maintain momentum while developing the ITEEM process, conference calls and video conferencing were used at times to reduce travel costs, but face-to-face meetings supported team-building and helped maintain the group's momentum and accountability. A computer and projector were used to collectively view, comment on and revise interim products at the meetings, thus reducing the number of individual iterations necessary to finalize the language outlining the process. Agendas were essential to keeping the group on track and also served to document progress made on assigned action items, increasing the accountability of group members.

While developing the ITEEM approach, the Working Group held a two-day meeting in the study region of interest to examine how an on-site workshop might be incorporated into the process. Participants were better able to focus and engage with each other as they set aside other work demands. Intermingling in smaller groups, participants engaged in more effective exchanges that may not have emerged in more formal settings. The group seemed to relax more with each other as casual interactions occurred during interstitial periods and at meals, further building team camaraderie. This experience solidified the need to incorporate a multi-day workshop as a component of the process.

Along the same lines as conducting the field visit, it was useful to carry out proposed steps to reveal how each component of the process might unfold when implemented and what resources might be necessary to do so. With agency technical staff assistance, spatial data layers were compiled in a GIS and displayed to demonstrate the how this information could be used to make informed, collaborative decisions. The exercise prompted useful comments that may not have emerged had the group opted simply to envision how this step in the process might occur. For example, by viewing the digitized data, participants realized that the process should accommodate important information that may not be available in digital spatial data layers. Collectively viewing the projected data on a screen catalyzed group discussion, but the group also concluded that having complementary hardcopy paper maps could facilitate easier documentation of issues and ideas on the maps themselves. Further, while this trial only incorporated a handful of spatial data layers from different sources, agency technical staff had to put significant effort into preparing the data (e.g., converting all layers to the same geographic projection) for efficient, comprehensive viewing. Based on this experience, it was clear that this step would require specific technical skills and significant effort, which would require dedicating resources to hire a consultant to effectively accomplish this step.

Beyond logistics, this exercise also revealed how strategic conservation investment trade-offs could be collaboratively identified.  For example, when the group looked at locations of culverts determined to be barriers to aquatic organism passage, it was apparent that improving just a few particular culverts to pass fish could effectively open aquatic connectivity for an entire drainage while the same level of effort at other stream locations would do relatively less good for regional aquatic connectivity.  This reinforced the importance of collectively viewing and discussing relevant information as a group and helped root the group's understanding and faith in the developing and evolving process.

By vetting different aspects of the proposed process, the group was also able to drop some ideas from further consideration.  Discussions about a credit/debit system to quantify project impacts related to terrestrial mitigation opportunities dominated several meetings, but the group determined that this task alone could require significantly more time and effort to develop.  The group resolved simply to negotiate trade-offs, with the potential of adopting more formal procedures such as the analytical hierarchy process approach to guide decision-making (Saaty 1980) or other environmentally-sensitive adaptive planning approaches that have been applied elsewhere (Theobald et al. 2000, Beier et al. 2006, Hilty et al. 2006, Noss and Daly 2006).

The effort to develop the process was demanding but provided the necessary road map for the agencies to apply the process in a pilot study.  In summary, the most important aspects of developing the process included upper-level management involvement and support, building trust and camaraderie amongst agencies, group facilitation and accountability, and using trial-and-error to explore and find feasible approaches palatable to the agencies that would ultimately be carry out the ITEEM process. Lessons learned as the agencies created the ITEEM process would ultimately be useful in directing the pilot study.

### *Lessons learned: ITEEM pilot study*

The pilot study was initiated after the ITEEM process was drafted and approved by the collaborating agency leaders. However, even with an agreed-upon and well-documented process in place, interpretation of the process was not always congruent between stakeholders for a variety of reasons. In some cases this was due to agencies appointing new representatives that had not been involved in the development of the process during the previous year. Given that the pilot study venture diverges so significantly from the traditional environmental review process, many newcomers struggled to grasp the overarching purpose of the pilot study and their roles in the process. Smooth integration of these new players into the process was labored, resulting in delayed task completion and insufficient detail with regard to documenting their agency's issues and opportunities, and feelings of frustration and confusion.

Several approaches to address intra-agency coordination challenges were suggested. Inviting all the various levels agency representation (e.g., upper-level managers, technical staff) to the initial kick-off meeting could improve intra-agency understanding of roles, responsibilities, and goals and objectives of the process. Conducting interviews with each agency's team of representatives may flesh out misconceptions and concerns early in the process. Formalizing each agency's internal commitments to the process might unify and affirm their team's efforts; participating agencies could document their approach to internally addressing staff turnover and communication issues affecting their agency's ability to contribute effectively to the ITEEM process. To improve interagency communications, a website was created early in the process for the purposes of facilitating information transfer and monitoring milestones reached and yet to be completed. Unfortunately, it was under-utilized and rarely updated.

Thinking through the website function and design more carefully prior to the next cycle will likely enhance its usefulness as a communication tool used to increase the efficiency of the group.

Much of the pilot study prior to the workshop revolved around compiling relevant data that would be used to guide good decision making. The initial call for such information yielded hundreds of sources of data and maps that had to be filtered down to a manageable set of sources that comprehensively addressed issues and opportunities relative to future planning and management activities for the region. Having a consultant dedicated to this effort was essential to preparing this information for an effective workshop.

The first day of the workshop was dedicated to introductions, reviewing how the goals of the pilot study relate to stakeholder's interests, and reinforcing the tenets of the ecosystem approach. When discussing the intent and extent of the pilot study, different interpretations of the ITEEM process were revealed. While group discussion on the first day helped clarify many of these discrepancies, the less formal field trip interactions on the second day of the workshop seemed to solidify the group's understanding of differing perspectives and increased the sense of shared commitment to meet the goals of the pilot study. The field trip allowed the group to better understand MDT's approach to highway design features, including features incorporated into projects as a matter of standard practice, other features that could readily be incorporated into a highway projects and features that may not be feasible to incorporate into highway design plans due to other factors that must be balanced in highway design. The field trip allowed the group to see some of the techniques that could be incorporated in to highway design to benefit wildlife. It was suggested that the field trip might be held the first day of the Workshop, rather than the second, since it provided the group with such clarity regarding the issues of scale and practicability.

Because of the many collaborative conservation initiatives led by local government and NGO's were already underway within the pilot study region, the prioritization of new conservation opportunities seemed to be less critical than understanding how mitigation partnerships stemming from the pilot study might augment these ongoing projects. Additionally the fruition of the Montana Legacy Project seemed to dwarf the pilot study and emphasized the need for the process to adaptively integrate with these established conservation efforts. Newly acquired timber lands associated with the Montana Legacy Project would fall under management of state and federal resource agencies tasked with habitat restoration and long-term sustainability. Regional practitioners and conservation efforts would benefit most from integration of reliable but flexible mitigation commitments stemming from the ITEEM process, such as the restoration fund concept. The MT 83 ITEEM pilot study was a step behind these multiple large-scale conservation initiatives providing opportunities to direct mitigation toward established regional conservation goals, but making it challenging for the process to specifically pinpoint more than a handful of prioritized shovel-ready mitigation projects given that the transactions associated with leveraging mitigation funding required further investigation to ensure legal and financial considerations were met.

The ITEEM process was created to integrate ecosystem based mitigation and streamline transportation project development. The pilot study was initiated under those assumptions, but evolved into two distinct yet interrelated arenas of consideration. Issues and concerns pertaining to the future highway projects on MT 83 emerged as the easier, more discrete concept to address. The group's confusion began when it was discovered that the transportation projects were not clearly defined at this early stage in their conception and planning process and would not likely be programmed for a decade or more. Thus, focusing on mitigation opportunities for future potential impacts without sideboards, budgets, or a project scope resulted in collective frustration and slowed momentum. The larger-scale concept of identifying and prioritizing conservation opportunities for implementation through interagency partnerships was soon lost to the misunderstandings resulting from surreal highway project impacts and imaginary budgets. While participants were generally on board with the intent of the pilot study, the difficulty in exploring each of these scales separately (e.g., highway corridor versus the more extensive region around the corridor), while understanding their ecological connectedness and how permitting regulations could be met at both scales, required reiterative explanations and ultimately slowed progress. This challenge was not was not fully revealed until the Workshop, nor was the confusion completely overcome by all of the participants at the Workshop.

Given present-day risks to ecological integrity and the current conservation initiatives underway in the region, the group agreed that focusing more on collaborative partnerships and less on the planning considerations directed specifically at the future highway projects, would result in greater realized gains for the resources within the region and help to leverage investments. The group also concurred, however, that early and on-going coordination with regard to the transportation planning process is essential in fostering a better understanding of MDT's business process, building trust, and streamlining the project development by increasing predictability and efficiency.

The conclusions reached and recommendations made through the pilot study will form the foundation of an interagency collaboration that is committed to work towards streamlining the transportation planning and project development processes along the MT 83 corridor, while conserving the unique road-side culture and diverse biological resources in the area. The lessons learned from the pilot study, coupled with evaluation of the success criteria, will be applied to improve the next invocation of the ITEEM process.

## Conclusions

The path to developing the ITEEM process was not always straight given the pioneering nature of revamping the long-standing tradition of environmental review processes combined with diverse missions and interests of the respective agencies. By far, the greatest success of the pilot study was realized in renewed relationships and trust shared amongst the agency participants. Long-term success of the ITEEM process will be truly realized as interagency partnerships are formed to achieve meaningful conservation projects in advance of threats and impacts. While the recommendation-making phases of the pilot study will conclude in summer 2009 for the MT 83 region, implementation of the agreements will endure for years and the ITEEM process will be adapted to be applied in another cycle focused on other regions of ecological importance facing necessary planned infrastructure development.

## Literature Cited

Becker, D.M. and P.B. Basting. 2010. Reconstruction of US Highway 93: collaboration between three governments. *In* J.P. Beckmann, A.P. Clevenger, M.P. Huijser, and J.A. Hilty (Eds.) *Safe Passages: Highways, Wildlife, and Habitat Connectivity* (pp. 173-188) Island Press, Washington, DC.

Beier, P., K.L. Penrod, C. Luke, W.D. Spencer and C. Cabañero. 2006. South Coast Missing Linkages: restoring connectivity to wildlands in the largest metropolitan area in the USA. Pages 555-586 *in* K.R. Crooks and M. Sanjayan eds. Connectivity Conservation. Cambridge University Press, Cambridge, U.K.

Brown, J. 2006. Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects. Publication FHWA-HEP-06-011. Federal Highway Administration, U.S. Department of Transportation, Washington DC.

Clevenger, A.P. & J. Wierzchowski. 2006. Maintaining and restoring connectivity in landscapes fragmented by roads. Pages 502-535 *in* K.R. Crooks and M. Sanjayan eds. Connectivity Conservation. Cambridge University Press, Cambridge, U.K.

Evink, G. 2002. Interaction between roadways and wildlife ecology: a synthesis of highway practice. National Cooperative Highway Research Program Synthesis No. 305. Transportation Research Board, Washington D.C.

Executive Order No. 13,274. 2002. Environmental Stewardship and Transportation Infrastructure Project Reviews. Federal Register Vol. 67, No. 184.

Executive Order No. 13,352: 2004. Facilitation of Cooperative Conservation. Federal Register Vol. 69, No. 167.

Forman, R.T.T., D. Sperling, J.A. Bissonette, A.P. Clevenger, C.D. Cutshall, V.H. Dale, L. Fahrig, R. France, C.R.Goldman, K. Heanue, J.A. Jones, F. J. Swanson, T. Turrentine, and T.C. Winter. 2002. Road Ecology: Science and Solutions. Island Press, Washington, D.C.

Government Accountability Office. 2003. Highway infrastructure: perceptions of stakeholders on approaches to reduce project completion time. GAO-03-398, Washington, D.C.

__________. 2008. Highways and environment: transportation agencies are acting to involve others in planning and environmental decisions. GAO-08-512R, Washington, D.C.

Hardy, A.R. 2008. Developing the “Integrated Transportation and Ecological Enhancements for Montana” (ITEEM) Process: Applying the Eco-Logical Approach. Transportation Research Record: Journal of the Transportation Research Board. Energy and Environment Category 2011(2007): 148-156.

Hilty, J.A., W.Z. Lidicker Jr., and A.M. Merenlender. 2006. Corridor ecology: the science and practice of linking landscapes for biodiversity conservation. Island Press, Washington, D.C.

National Academy of Sciences. 2005. Assessing and managing the ecological impacts of paved roads. National Academies Press, Washington, D.C.

Noss, R.F. and K.M. Daly. 2006. Incorporating connectivity into broad scale planning. Pages 587-619 *in* K.R. Crooks and M. Sanjayan eds. Connectivity Conservation. Cambridge University Press, Cambridge, U.K.

Office of Environmental Protection. 1995. Memorandum of Understanding to foster the ecosystem approach. The White House, Washington, DC.

Saaty, T.L. 1980. The Analytical Hierarchy Process: Planning, Priority Setting, Resource Allocation. McGraw-Hill, New York.

Theobald, D.M., N.T. Hobbs, T. Bearly, J.A. Zack, T. Shenk, and W.E. Riebsame. 2000. Incorporating biological information in local land-use decision making: designing a system for conservation planning. Landscape Ecology 15(1): 35-45.

Western Governors' Association. 1999. Enlibra: a shared environmental doctrine. Western Governors' Association, Denver, CO.