US 93 North Wildlife-Vehicle Collision and Wildlife Crossing Monitoring

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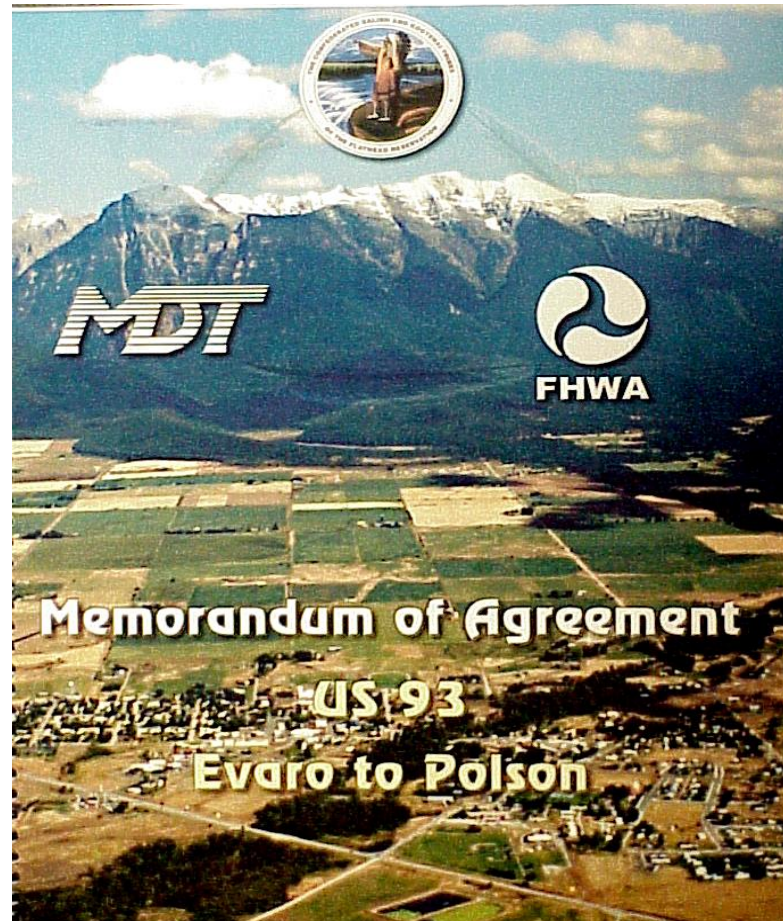
MONTANA STATE UNIVERSITY | College of ENGINEERING | Western Transportation Institute

US93 N, Flathead Indian Reservation, Montana (2002-2015)

- “Road is a visitor”
- Respectful to land
- “Spirit of the place”
- Cultural values
- Natural resources



Main Questions

- Human safety: Wildlife-vehicle collisions
- Habitat connectivity: Wildlife use crossing structures
- Cost-benefit analyses

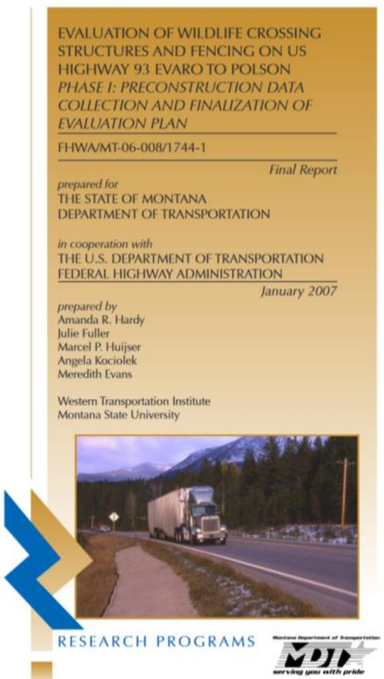
- Contract research
- WTI-MSU and CSKT
- Students and other partners at MSU and UofM

2 Projects, 1 Purpose

“Before”

2002-2007

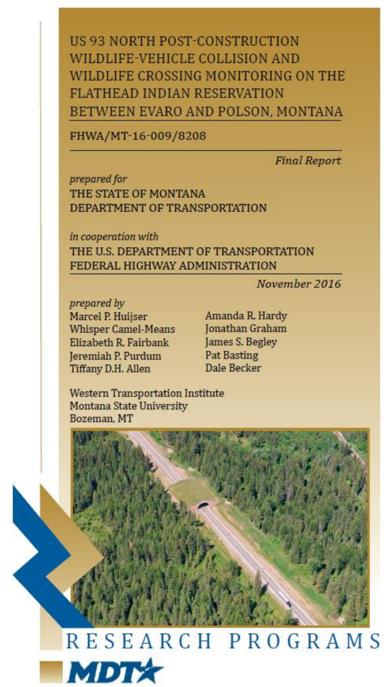
Data 2002-2005



“After”

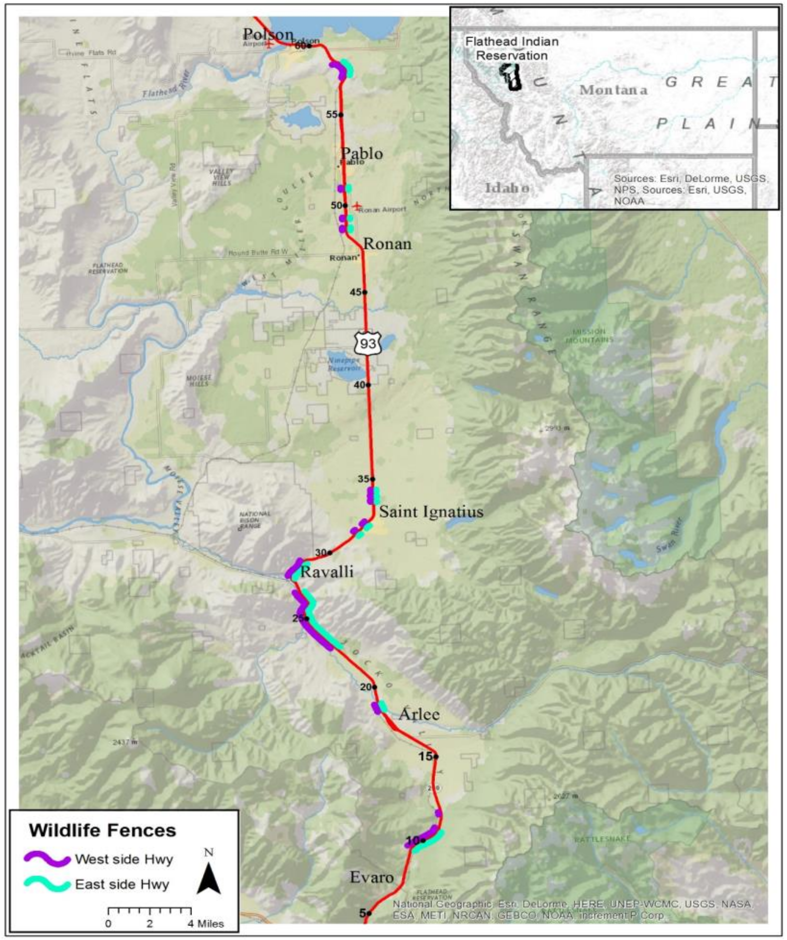
(2008) 2010-2016

Data 2002-2015



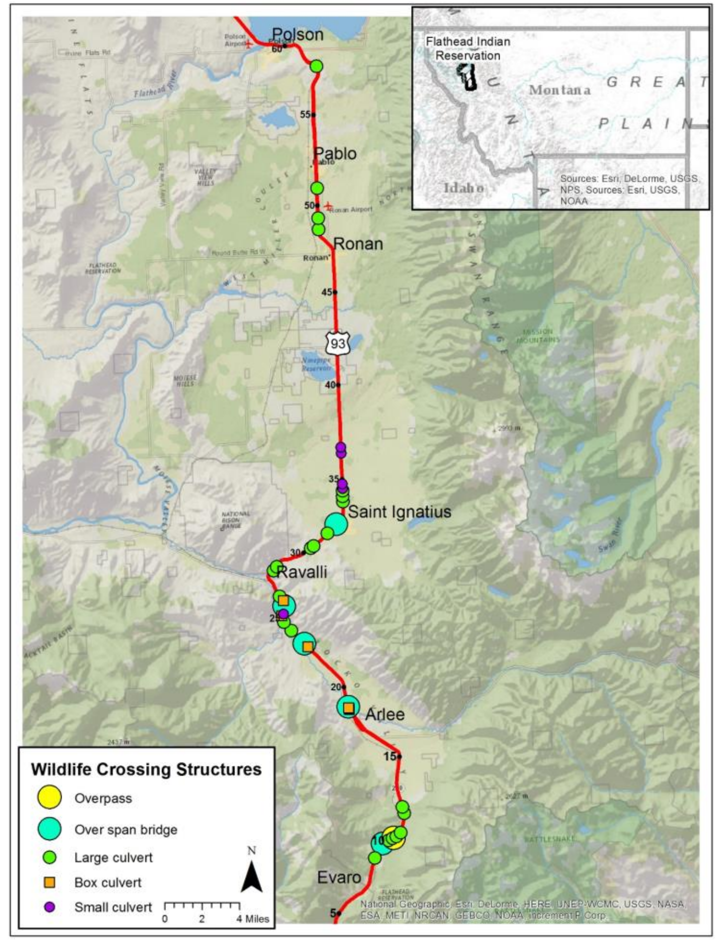
Fences

8.71 miles (14.01 km) both sides



Crossing structures

39 locations for mammals

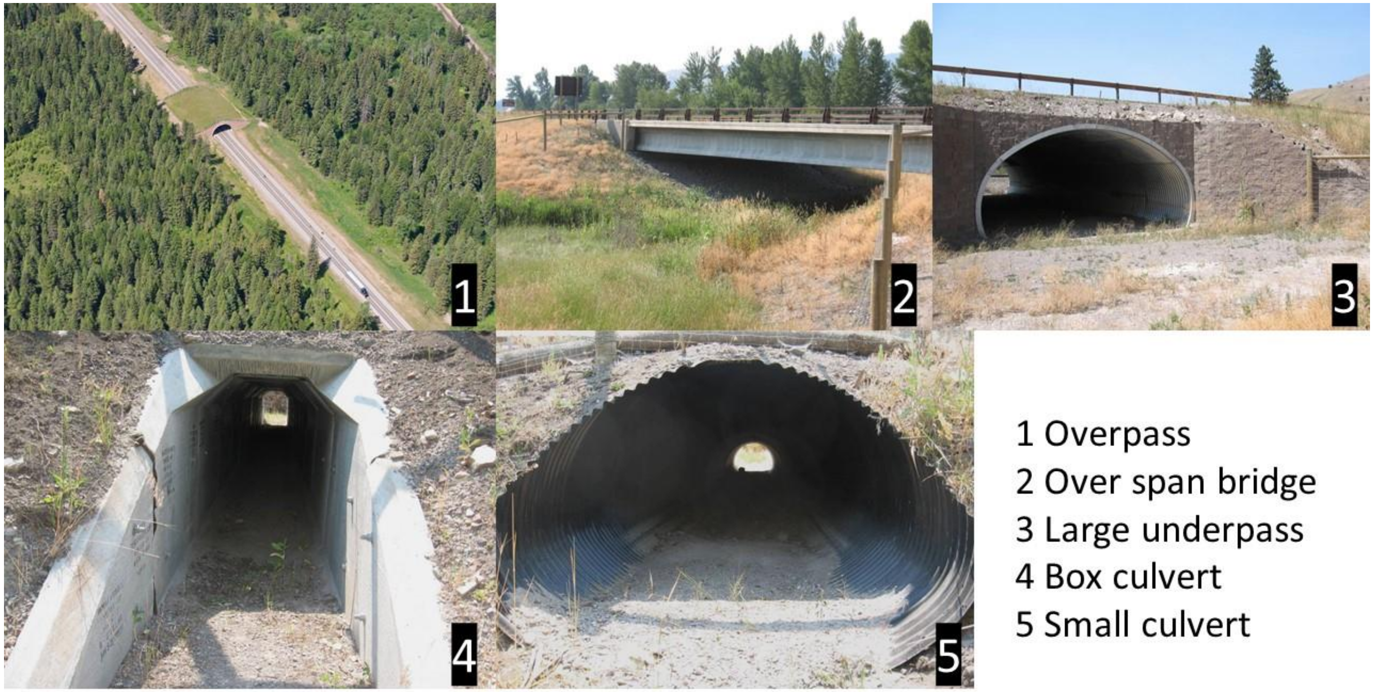


Fences

Functions:

1. Keep wildlife from accessing the highway
2. Help guide wildlife towards the safe crossing opportunities

Crossing Structure Types

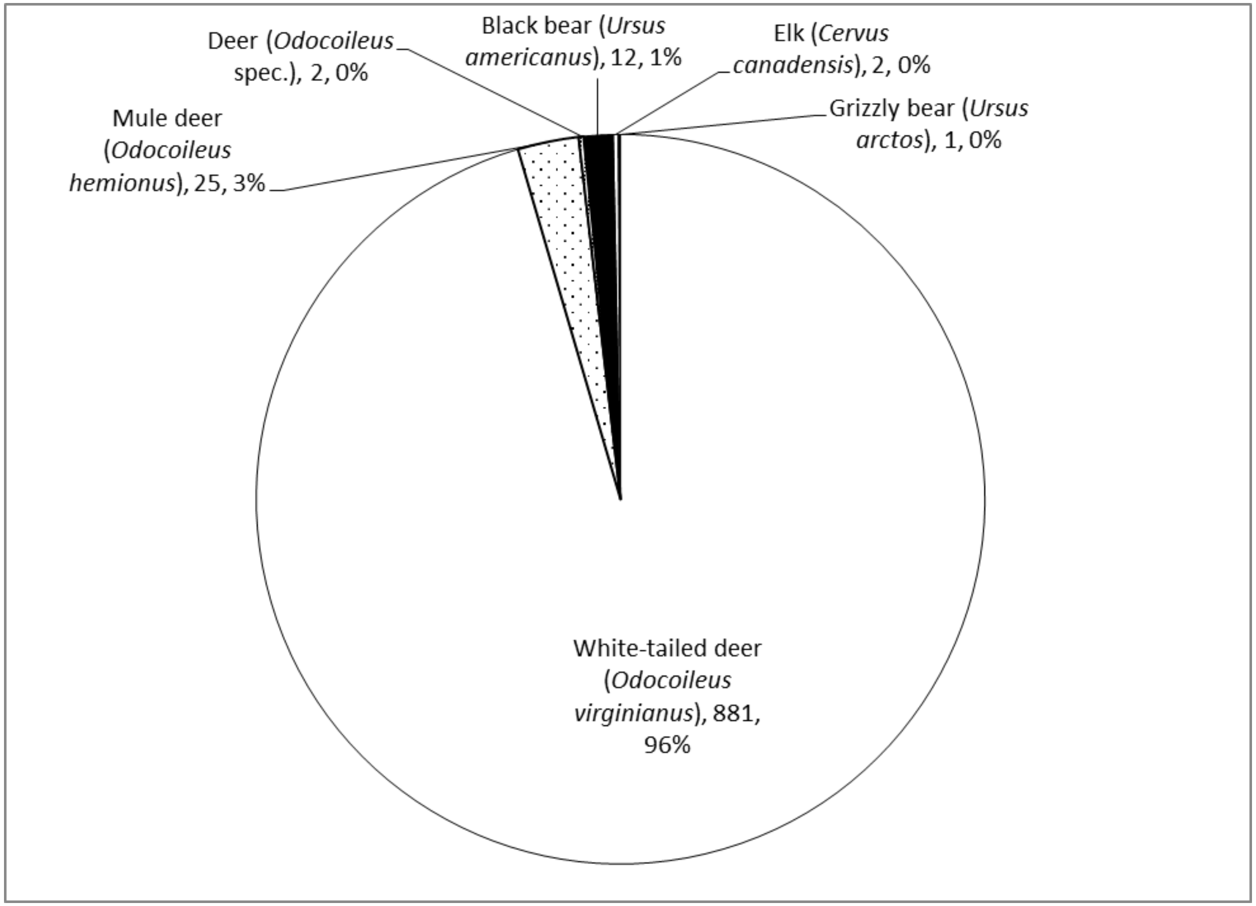


1 Overpass
2 Over span bridge
3 Large underpass
4 Box culvert
5 Small culvert

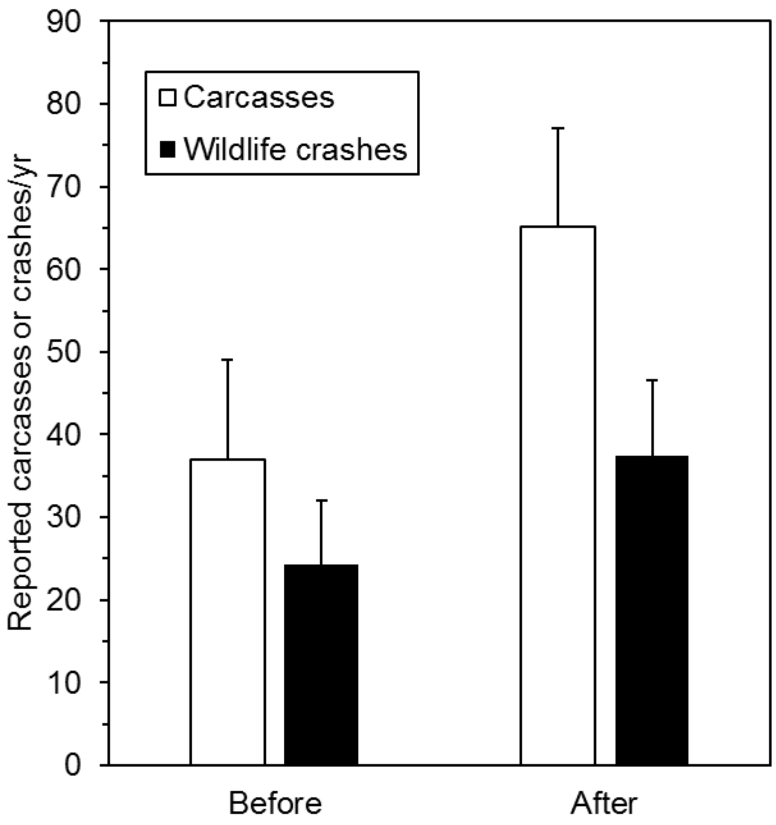
Functions

1. Allow wildlife to safely cross the highway
2. Reduce wildlife intrusions into fenced road corridor

Carcasses 2002-2015

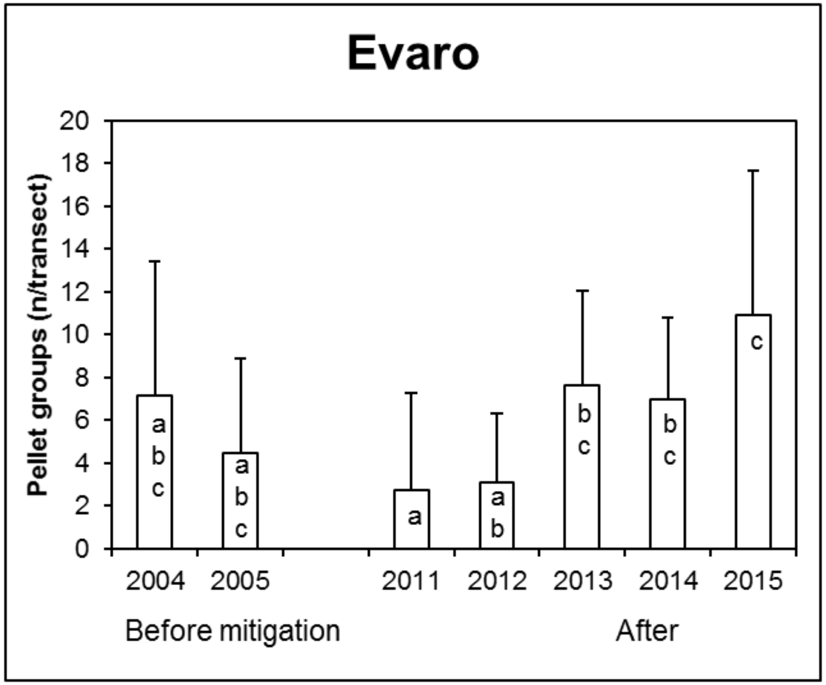


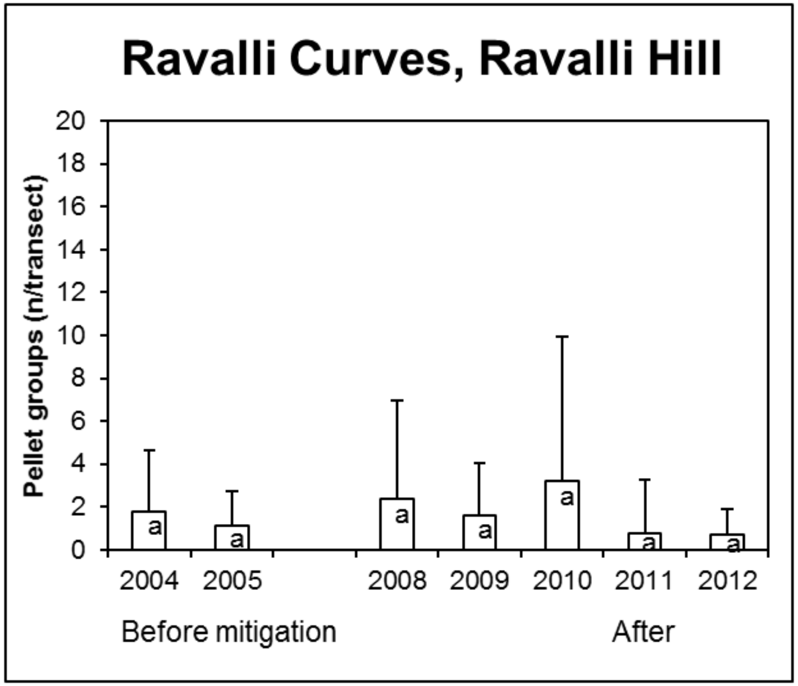
Wildlife-Vehicle Collisions



- Evaro-Polson (excl. Ninepipe area)
- Only 16.8% with fences !

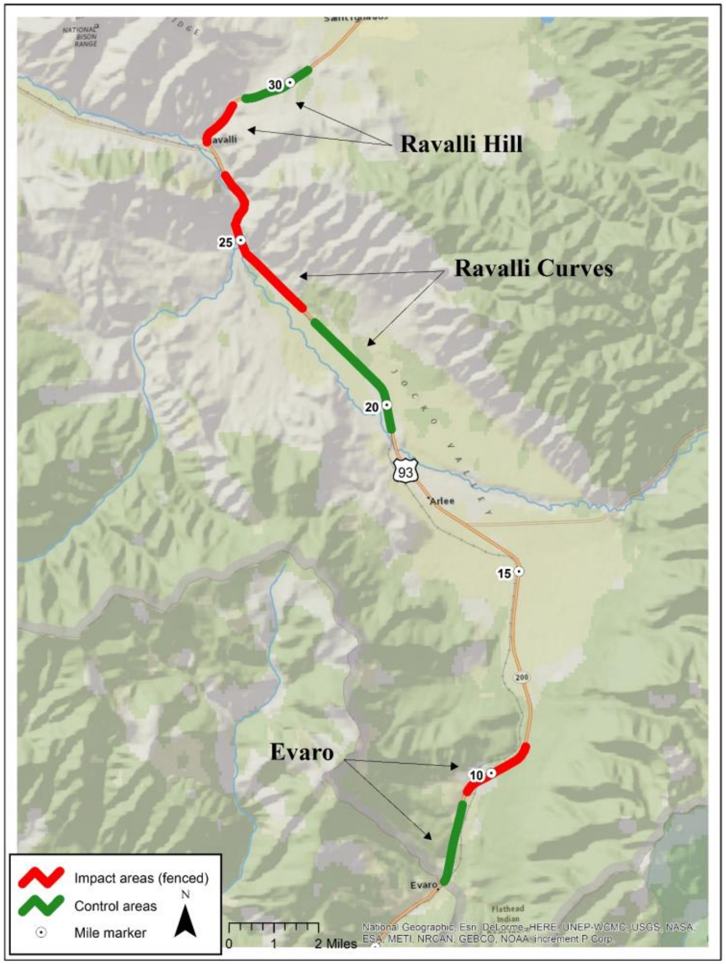
Deer Pellet Groups





Deer population similar before-after

BACI Study Design

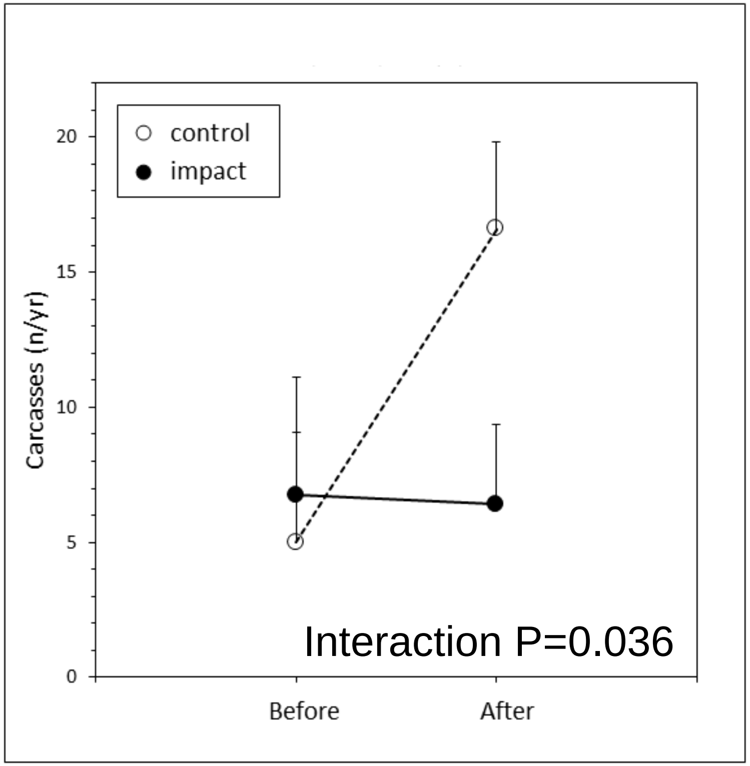


- 3 “long” fenced sections
- Before-After
- Control-Impact

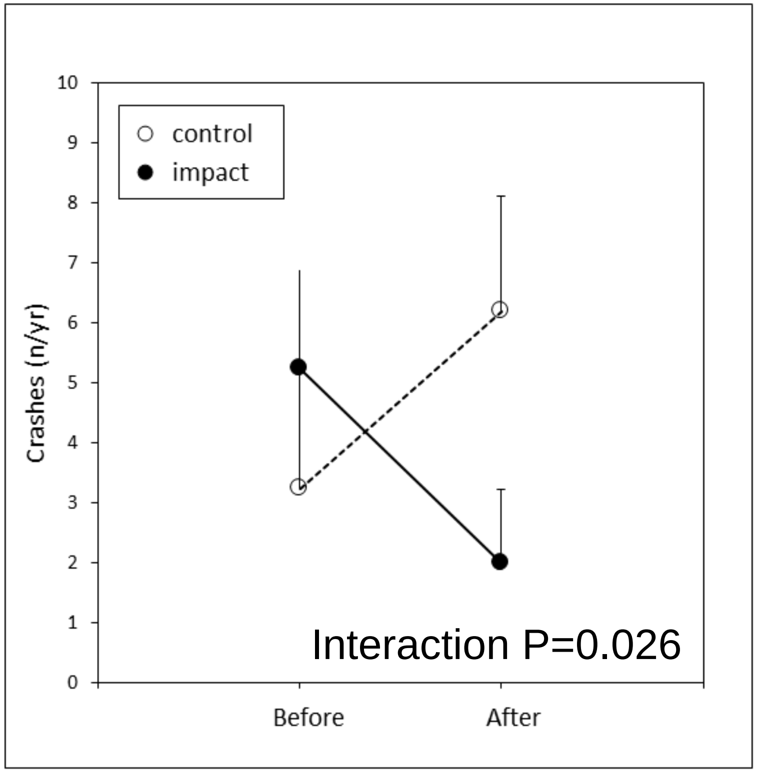
Effectiveness Fences

Effect of the highway reconstruction (before-after) on the number of carcasses/crashes depended on the treatment (wildlife fences and wildlife crossing structures vs. no fences)

Carcass data: -71%



Wildlife-crash data: -80%



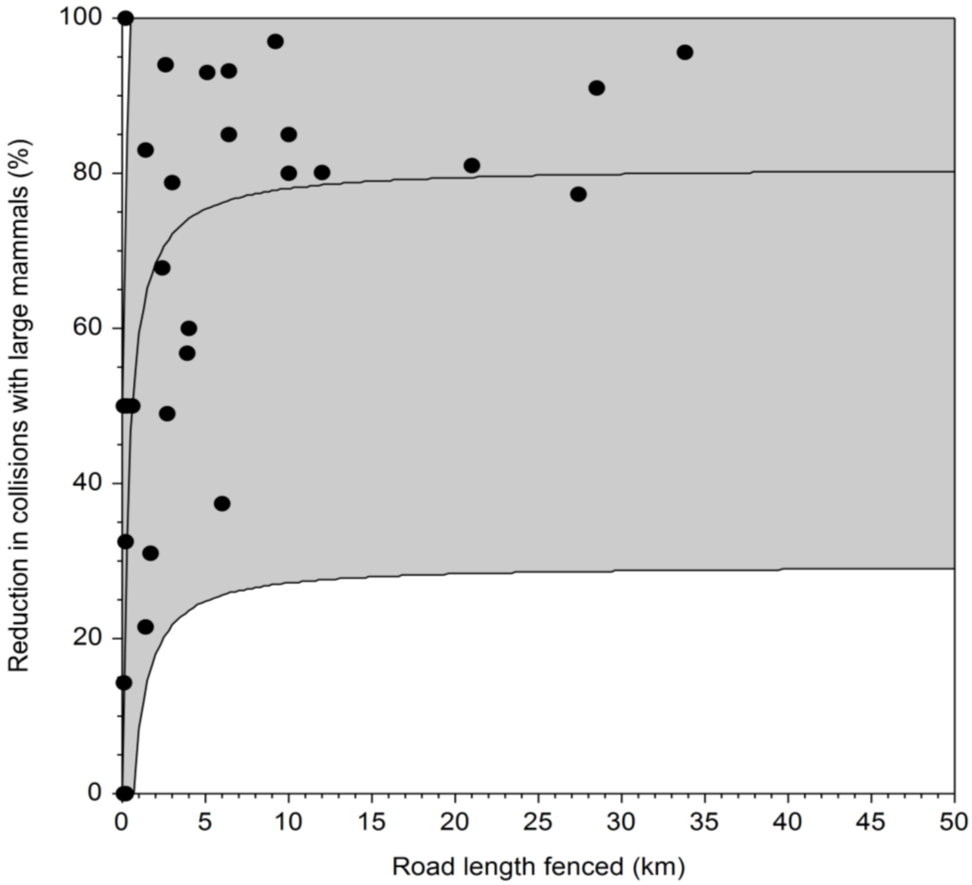
Situation

Trend to implement

- Crossing structures with limited wildlife fencing
- Crossing structures without wildlife fencing

Especially in multifunctional landscapes

Reducing Wildlife-Vehicle Collisions



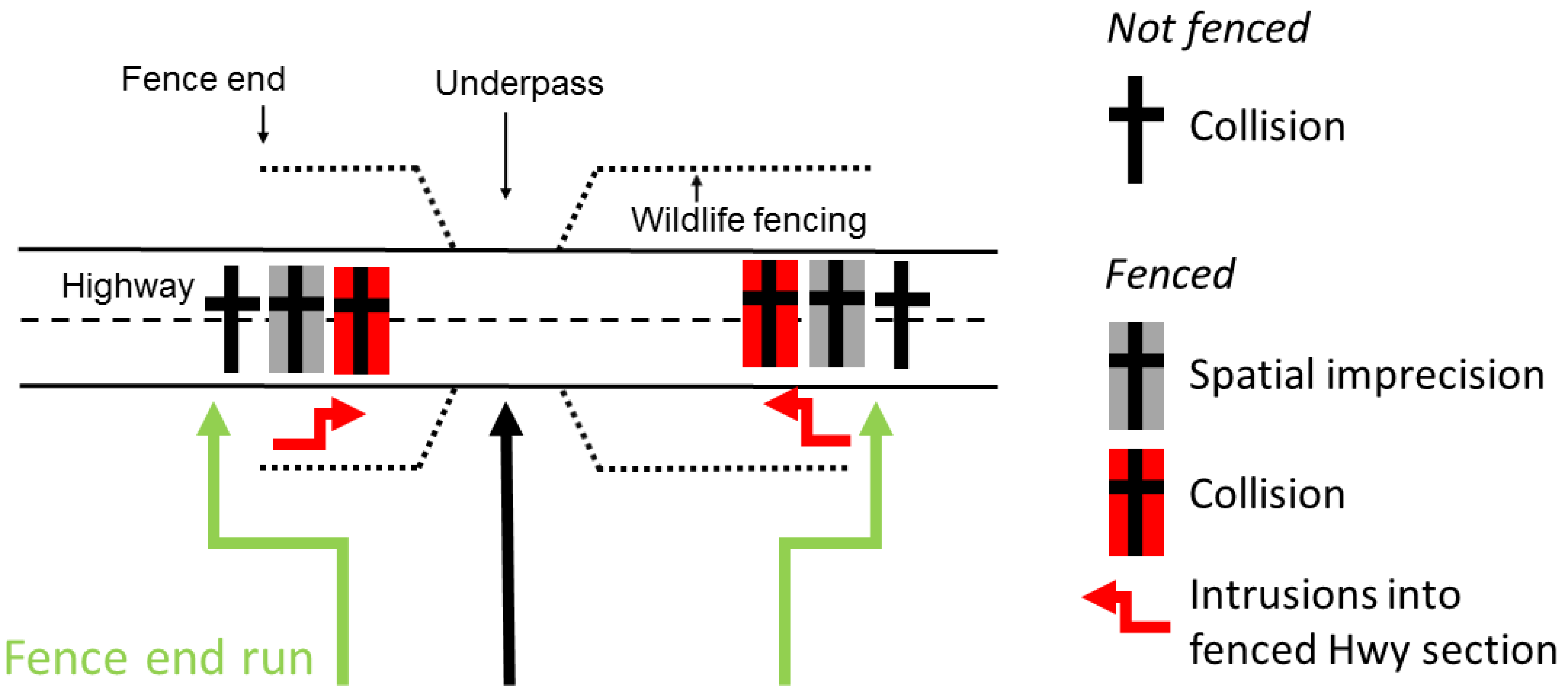
< 5 km 52.7%
range 0-94%

> 5 km: typically > 80%

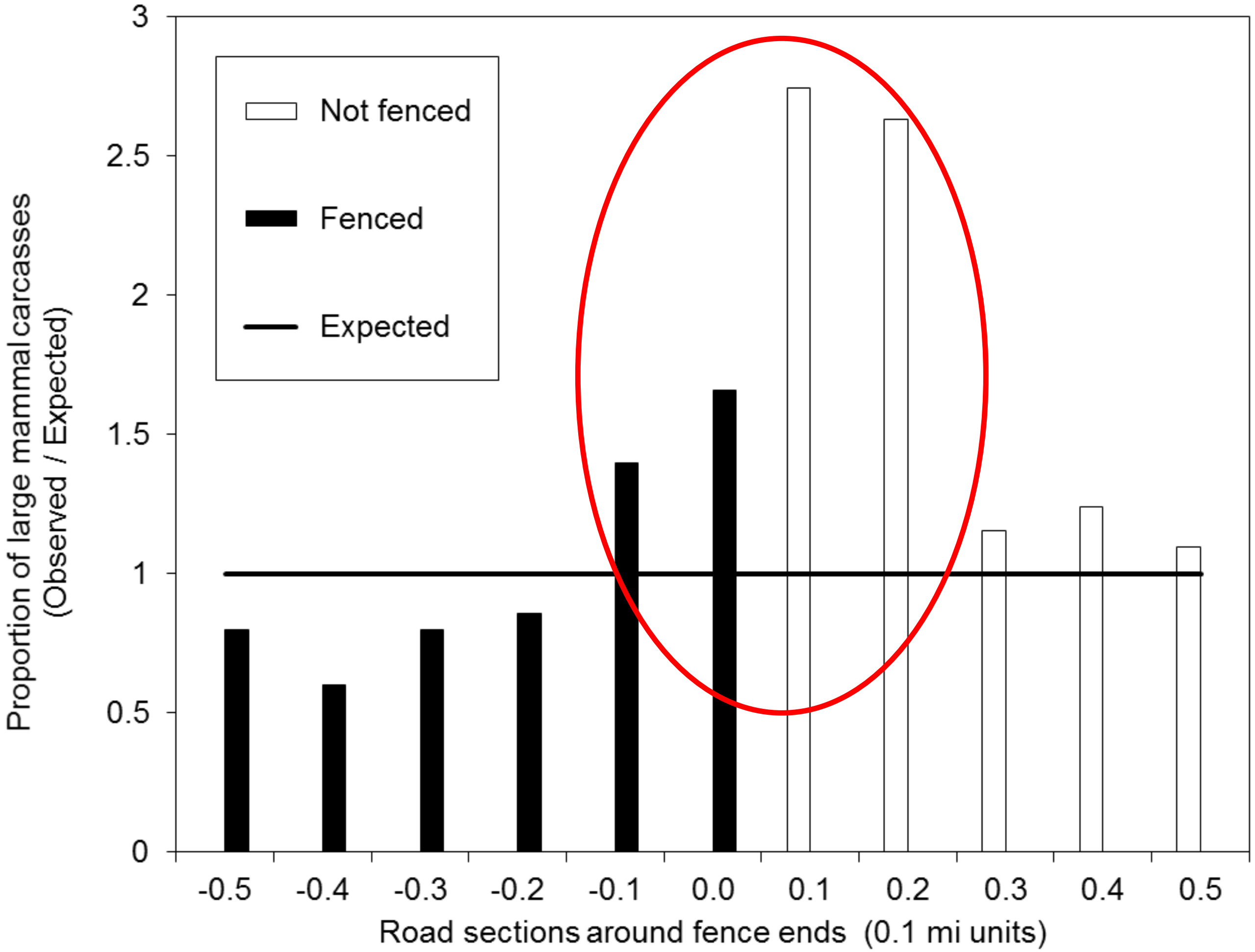
Reducing Wildlife-Vehicle Collisions

Why lower?

<5 km: under partial or full influence of fence end effects



Reducing Wildlife-Vehicle Collisions



Fence end effect
is indeed present

Reducing Wildlife-Vehicle Collisions

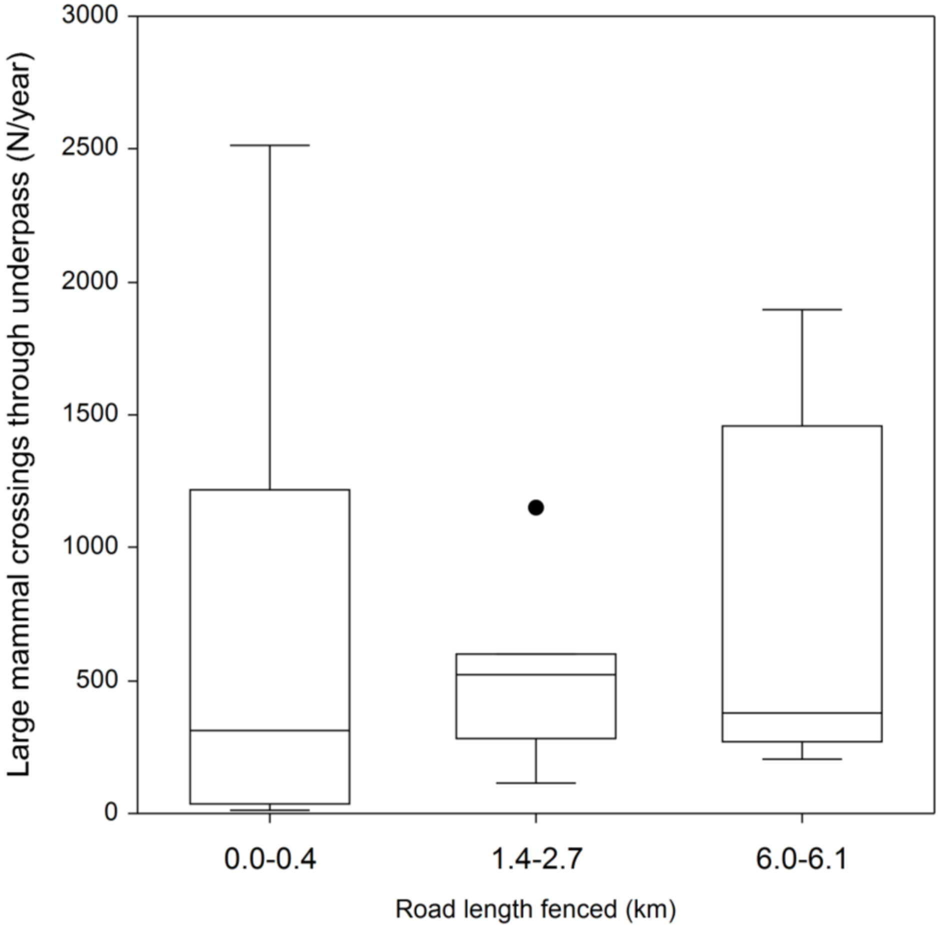
Why more variable?

Local situation fence ends
always different

Short fences (<5 km):
Fence end effect immediately
noticeable in overall effectiveness

Long fences (>5km):
Fence end effect diluted

Safe Crossing Opportunities for Wildlife



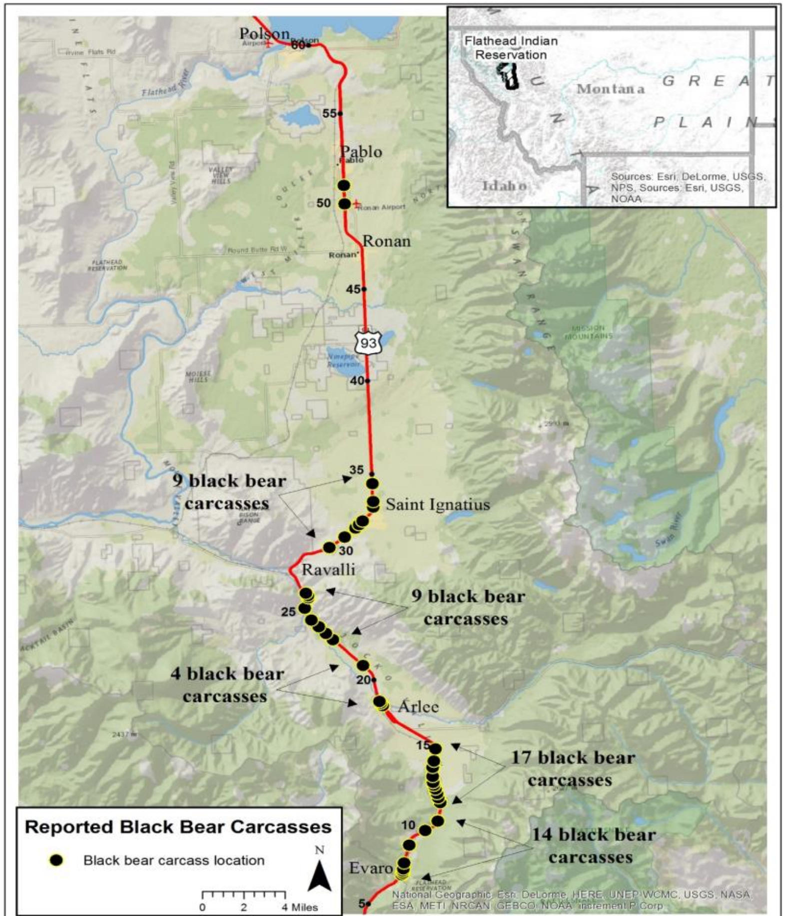
- Highly variable
- Short fences: can have high use
- Long fences: can have low use

Local situation very important

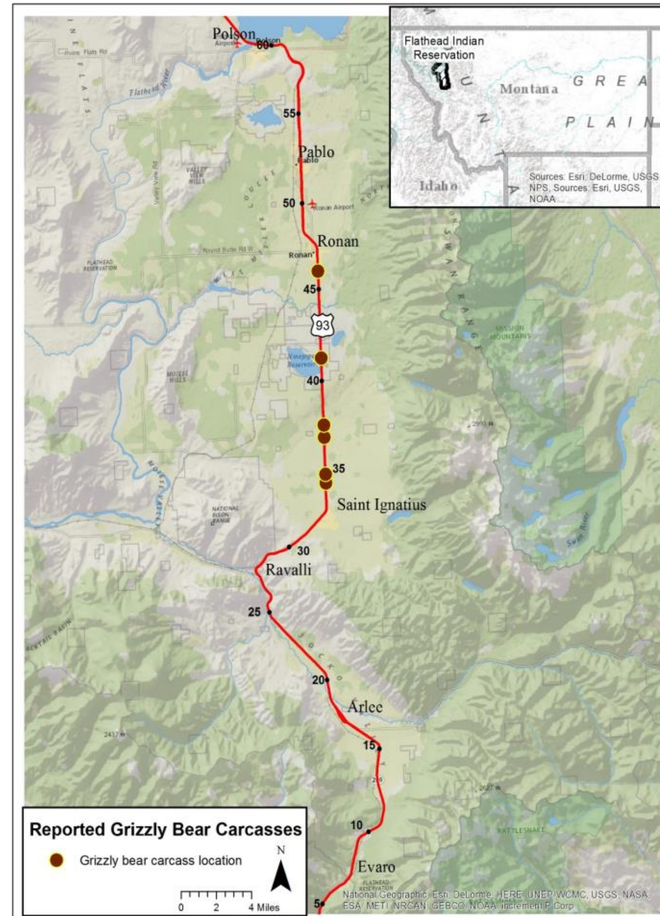
- Wildlife presence
- Habitat guides them to structure
- Factors that keep them away?

Bear-vehicle collisions 2002-2015

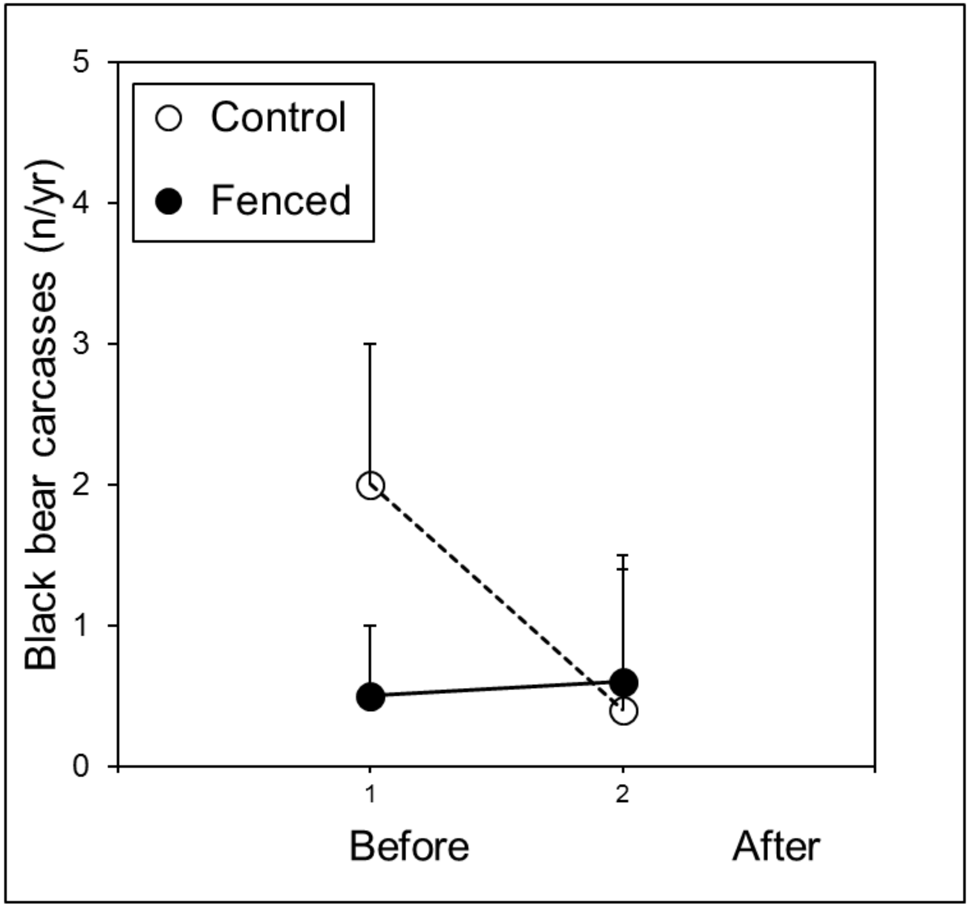
Black bears



Grizzly bears



Bear-vehicle collisions



Interaction P=0.320

No reduction in the
three main fenced areas

Why?
Large mesh sizes
Wooded posts
No overhang
Gaps in fence

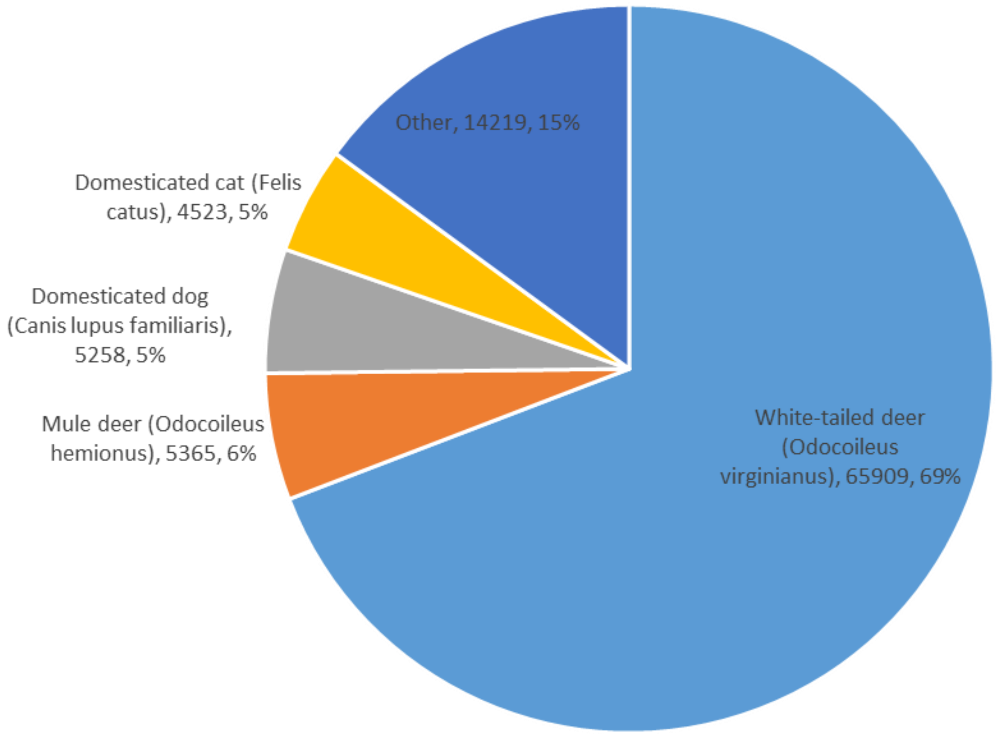
Conclusions

- 70-80% reduction wildlife-vehicle collisions in three main mitigated areas
- Increase in collisions in unmitigated sections
- Road length fences ≤5 km:

  Lower effectiveness, more variable

- No reduction in black bear mortality
- Grizzly bears continue to be hit

29 Structures, 5 years

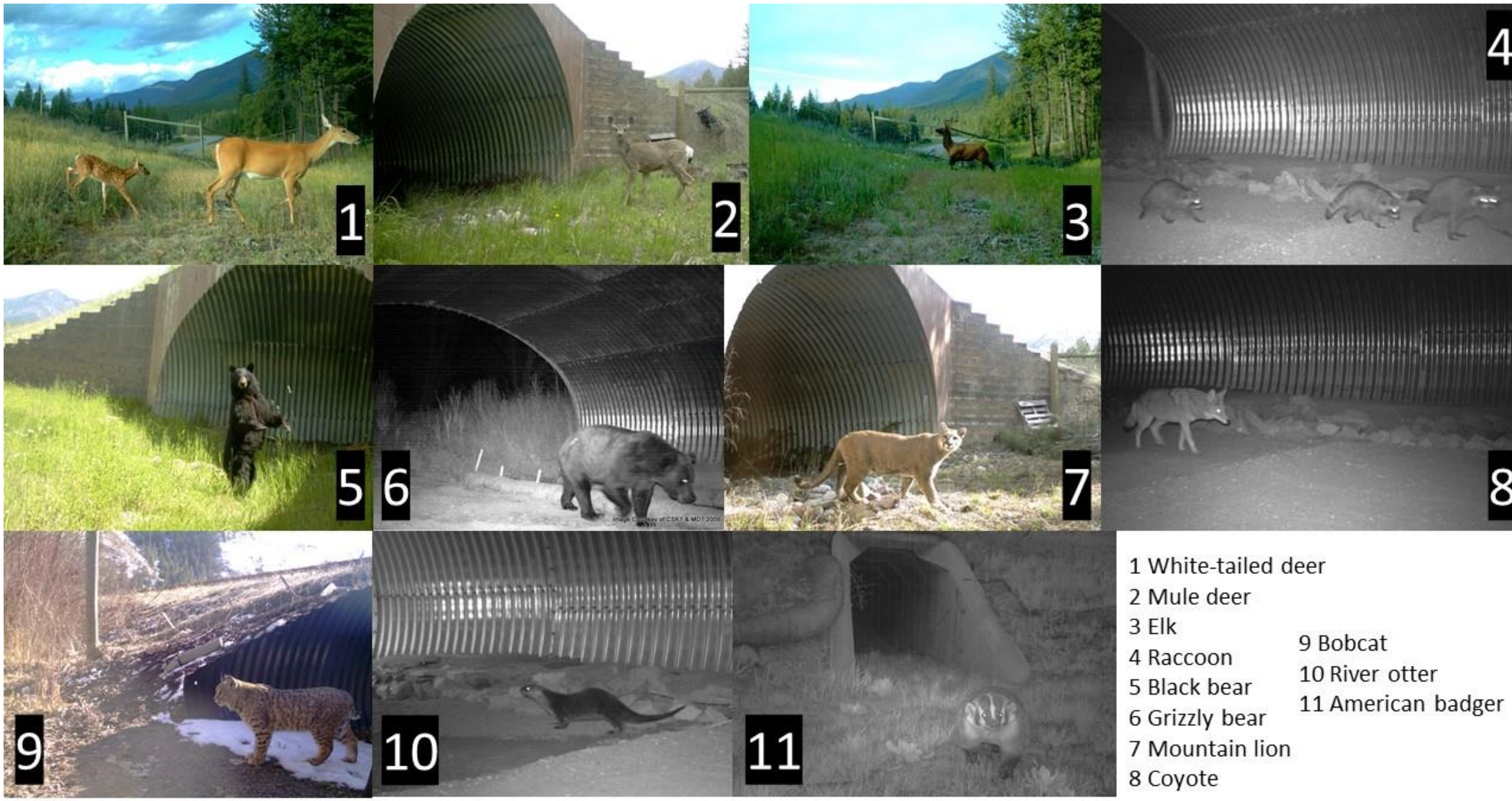


- 95,274 successful crossings
- 22,648 per year
- 20 wild medium-large mammal species

- 1,531 black bear
- 958 coyote
- 568 bobcat
- 227 mountain lion
- 29 grizzly bear
- 38 badger
- 32 elk
- 14 beaver
- 13 otter
- 3 moose

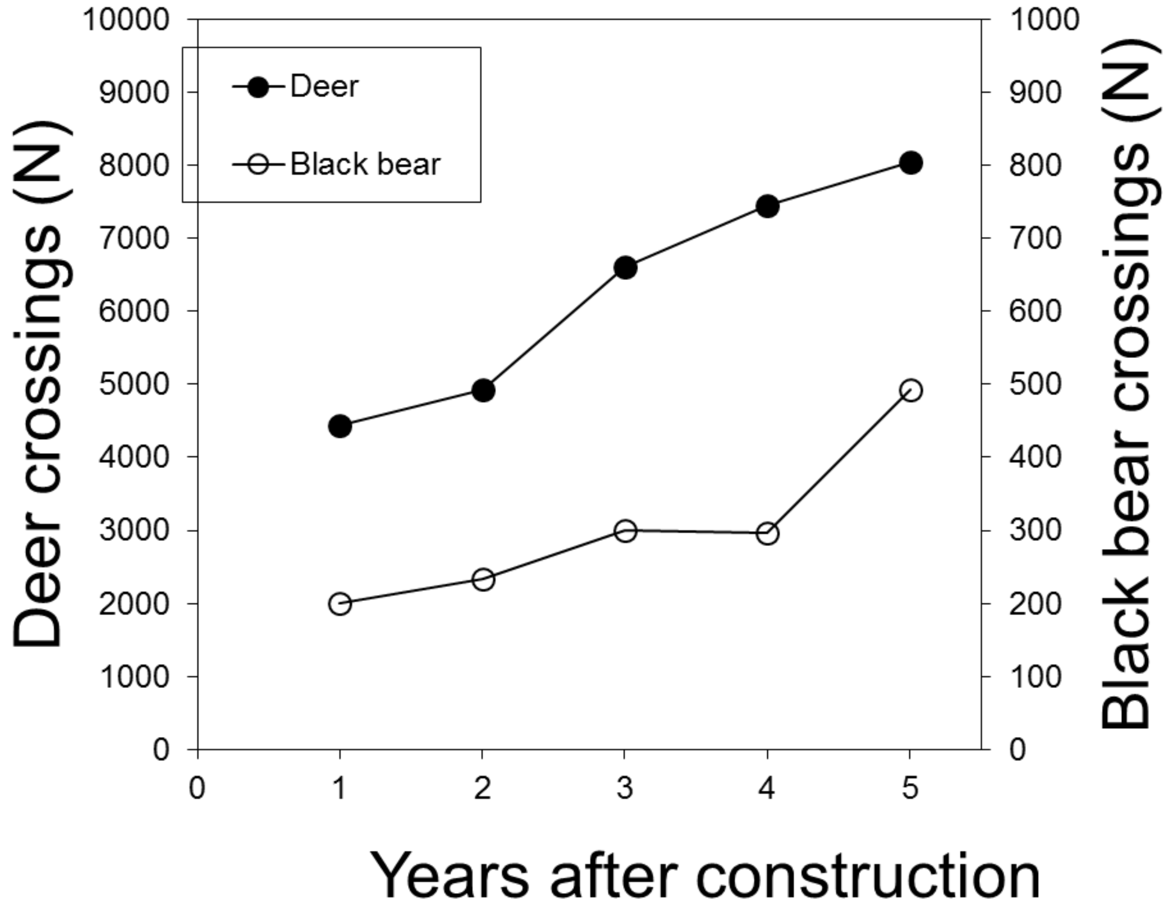
Courtesy of MDT, CSKT & WTI-MSU

Sample Use



1 White-tailed deer
2 Mule deer
3 Elk
4 Raccoon
5 Black bear
6 Grizzly bear
7 Mountain lion
8 Coyote
9 Bobcat
10 River otter
11 American badger

Learning Curve



Habitat Connectivity ???

Better

- Safe places to cross
- Less disturbance when crossing

Worse

- Wider road
- Higher design speed
- Increase traffic volume?
- Fewer places to cross

Deer and black bear

Before

38 Tracking beds

Random locations
Each 100 m long
5 double beds

Estimate based on a sample

Check and erase

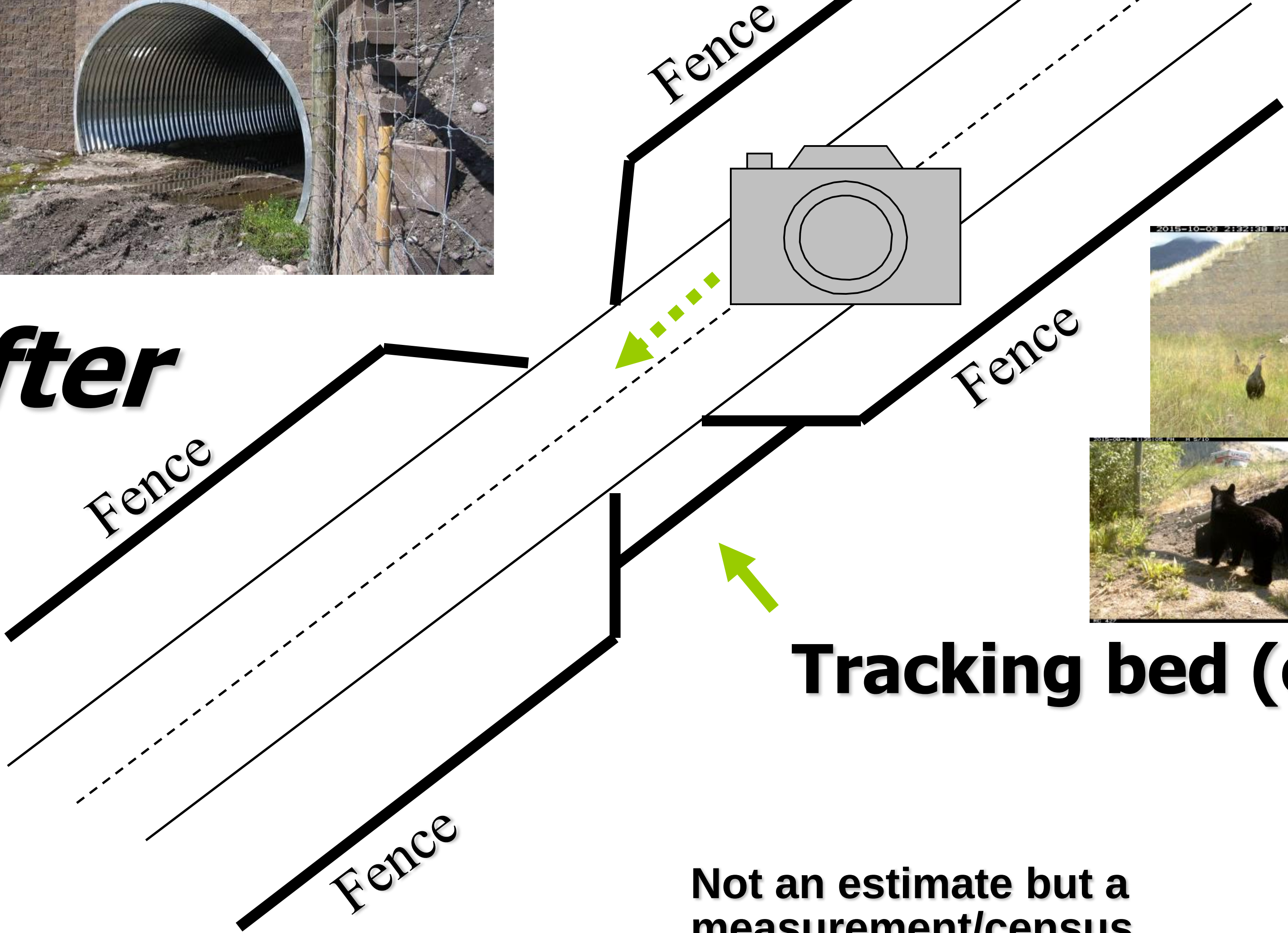
Black bear

Deer

Twice a week

Jun-Oct

After



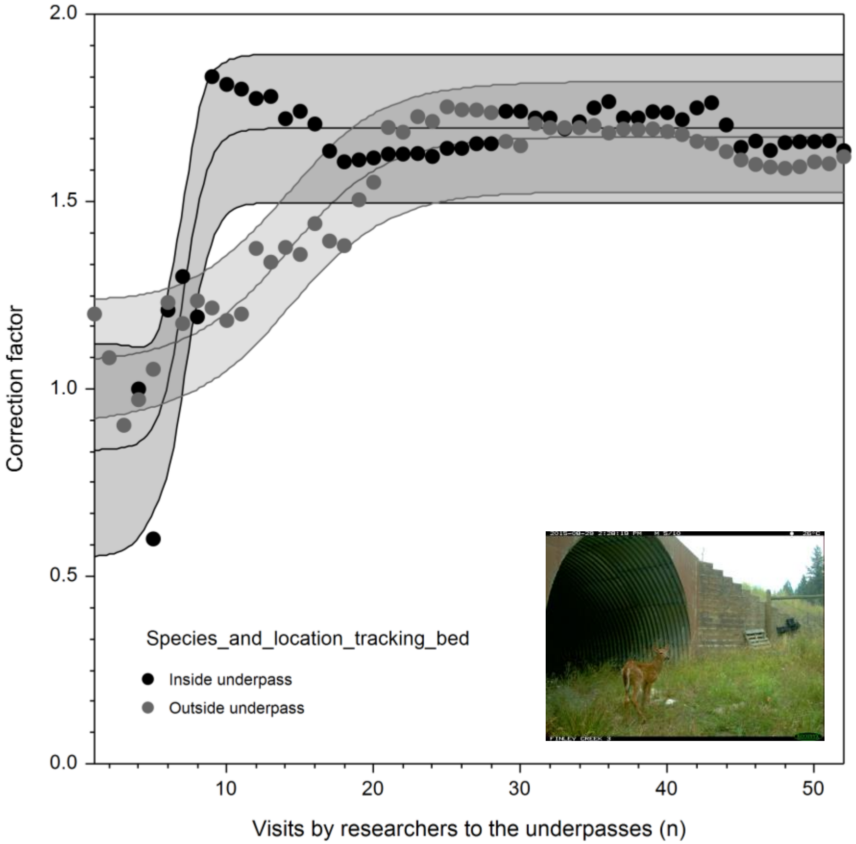
Tracking bed (outside)

Not an estimate but a measurement/census

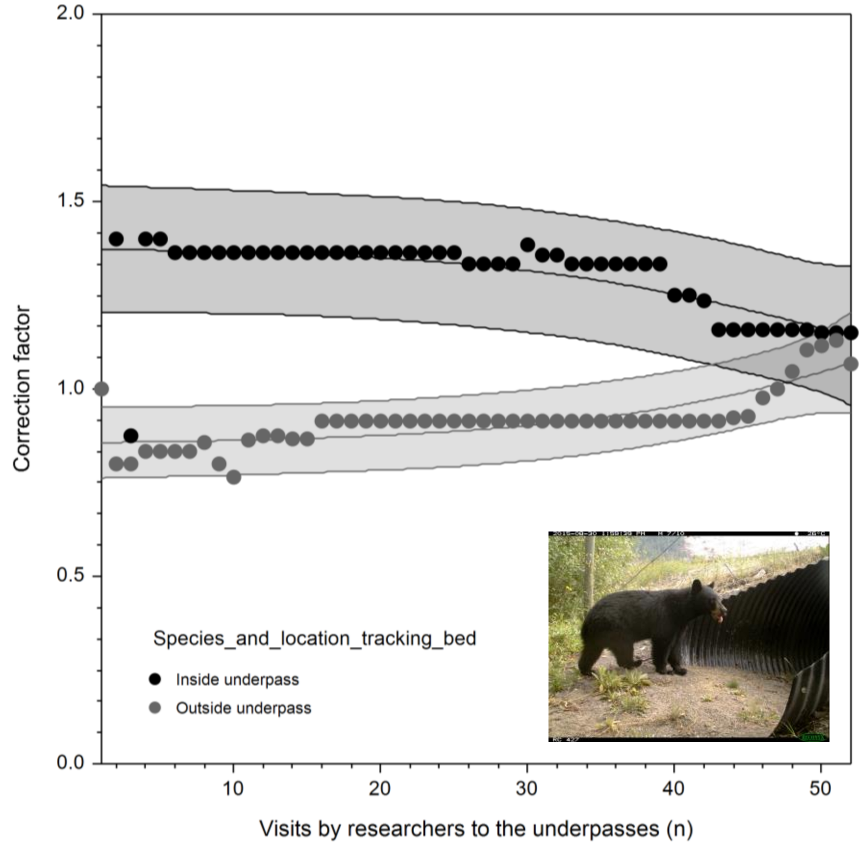
Correction Factor

Tracks – Camera Images

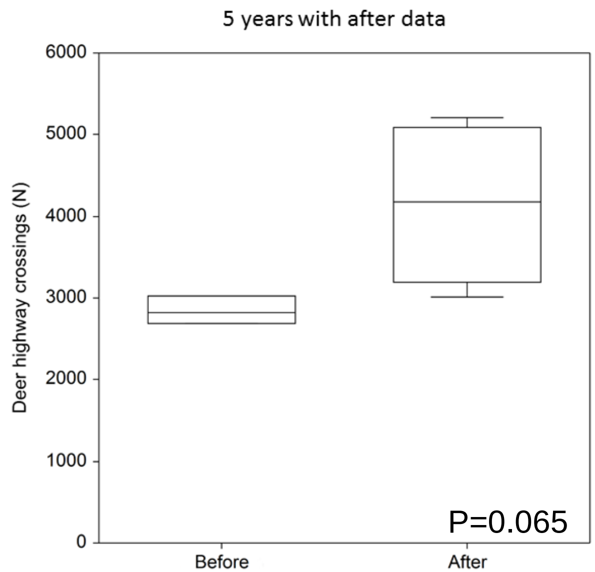
Deer: *1.623

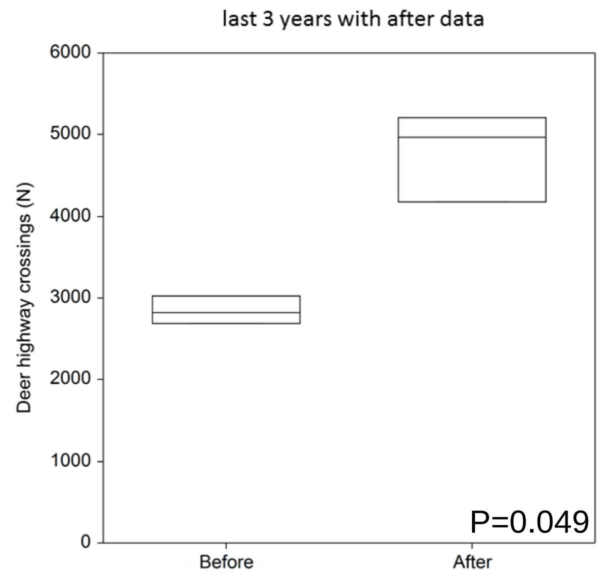


Black bear: 1.088

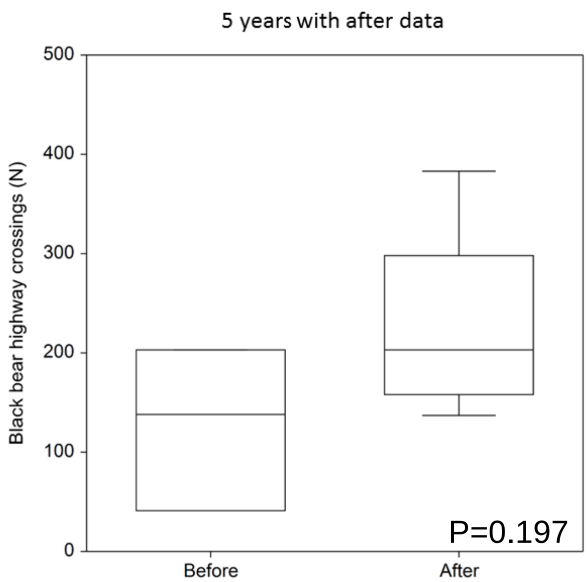


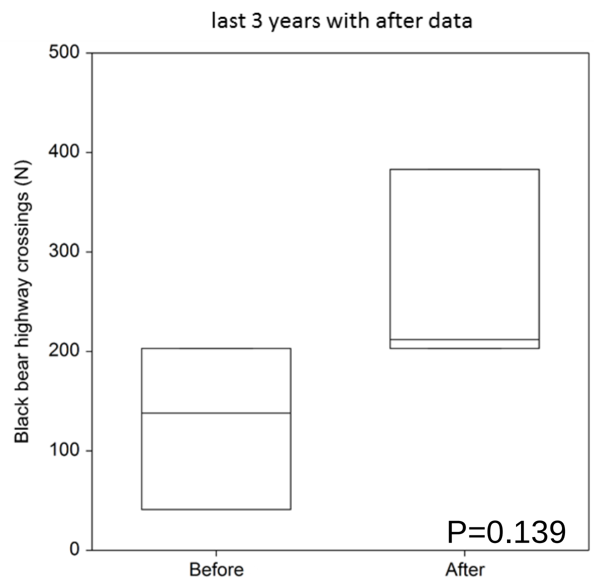
Habitat Connectivity: Deer





Habitat Connectivity: Black bear





Conclusions

- Substantial use by wildlife of crossing structures
- Learning curve
- Upgraded mitigated highway did not reduce connectivity for deer and black bear
- Connectivity maintained (black bear) or improved (deer)

Wildlife Guards

Concrete
ledge

Wildlife Guards

	Passage (N)			No passage (N)				
	Leaving highway	Accessing highway	Used ledge	Highway side fence	Safe side fence	Permeability accessing highway (%)	Permeability leaving highway (%)	Use ledge (% of all crossings)
Mule deer (*Odocoileus hemionus*)	56	3	7	0	665	0.45	100.00	11.86
White-tailed deer (*Odocoileus virginianus*)	8	17	4	0	1337	1.26	100.00	16.00
Coyote (*Canis latrans*)	9	12	6	0	259	4.43	100.00	28.57
Black bear (*Ursus americanus*)	12	21	0	0	19	52.50	100.00	0.00
Mountain lion (*Felis concolor*)	8	16	0	0	1	94.12	100.00	0.00
Bobcat (*Lynx rufus*)	6	11	1	0	4	73.33	100.00	5.88
Raccoon (*Procyon lotor*)	5	10	9	0	19	34.48	100.00	60.00

Wildlife Jump-Outs

Desirable

Undesirable

Wildlife Jump-outs

Tracking

Species	Jump down (N)	Jump up (N)	Top only (N)	Bottom only (N)	Jump down (%)	Jump up (%)
Deer spp. (*Odocoileus* spp.)	142	0	884	4655	13.84	0.00

Cameras

Species	Jump down (N)	Jump up (N)	Top only (N)	Bottom only (N)	Jump down (%)	Jump up (%)
White-tailed deer (*Odocoileus virginianus*)	15	0	203	154	6.88	0.00
Mule deer (*Odocoileus hemionus*)	11	0	23	77	32.35	0.00

Human Access Point

Human Access Point

Species	Enters fenced r-o-w (N)	Exits fenced r-o-w (N)	Only outside fenced r-o-w (N)	Only inside fenced r-o-w (N)	Permeability entering fenced r-o-w (%)	Permeability exiting fenced r-o-w (%)
White-tailed deer (*Odocoileus virginianus*)	61	79	219	6	21.79	92.94
Human (excluding data collectors)	5	4	0	0	100.00	100.00
Cattle (*Bos taurus*)	1	0	1	0	50.00	n/a
Raccoon (*Procyon lotor*)	1	0	1	0	50.00	n/a
Red fox (*Vulpes vulpes*)	1	0	0	1	100.00	0.00
Domesticated cat (*Felis catus*)	0	0	3	0	0.00	n/a
Dom. dog or coyote	0	0	3	0	0.00	n/a
Coyote (*Canis latrans*)	0	0	2	1	0.00	0.00

Cost-benefit analyses

- Costs:
  Equipment, installation, construction, operation, maintenance, removal

- Benefits:
  Reduced costs collisions

Huijser, M. P., J. W. Duffield, A. P. Clevenger, R. J. Ament, and P. T. McGowen. 2009. Cost–benefit analyses of mitigation measures aimed at reducing collisions with large ungulates in the United States and Canada; a decision support tool. *Ecology and Society* 14(2): 15. [online] URL: http://www.ecologyandsociety.org/vol14/iss2/art15/

E&S

Research, part of a Special Feature on Effects of Roads and Traffic on Wildlife Populations and Landscape Function

Cost–Benefit Analyses of Mitigation Measures Aimed at Reducing Collisions with Large Ungulates in the United States and Canada: a Decision Support Tool

Marcel P. Huijser[1], *John W. Duffield*[2], *Anthony P. Clevenger*[1], *Robert J. Ament*[1], and *Pat T. McGowen*[1]

ABSTRACT. Wildlife–vehicle collisions, especially with deer (*Odocoileus* spp.), elk (*Cervus elaphus*), and moose (*Alces alces*) are numerous and have shown an increasing trend over the last several decades in the United States and Canada. We calculated the costs associated with the average deer–, elk–, and moose–vehicle collision, including vehicle repair costs, human injuries and fatalities, towing, accident attendance and investigation, monetary value to hunters of the animal killed in the collision, and cost of disposal of the animal carcass. In addition, we reviewed the effectiveness and costs of 13 mitigation measures considered effective in reducing collisions with large ungulates. We conducted cost–benefit analyses over a 75-year period using discount rates of 1%, 3%, and 7% to identify the threshold values (in 2007 U.S. dollars) above which individual mitigation measures start generating benefits in excess of costs. These threshold values were translated into the number of deer–, elk–, or moose–vehicle collisions that need to occur per kilometer per year for a mitigation measure to start generating economic benefits in excess of costs. In addition, we calculated the costs associated with large ungulate–vehicle collisions on 10 road sections throughout the United States and Canada and compared these to the threshold values. Finally, we conducted a more detailed cost analysis for one of these road sections to illustrate that even though the average costs for large ungulate–vehicle collisions per kilometer per year may not meet the thresholds of many of the mitigation measures, specific locations on a road section can still exceed thresholds. We believe the cost–benefit model presented in this paper can be a valuable decision support tool for determining mitigation measures to reduce ungulate–vehicle collisions.

Key Words: *animal–vehicle collisions; cost–benefit analysis; deer; economic; effectiveness; elk; human injuries and fatalities; mitigation measures; moose; roadkill; ungulate; vehicle repair cost; wildlife–vehicle collision*

INTRODUCTION

Wildlife–vehicle collisions affect human safety, property and wildlife. The total number of large mammal–vehicle collisions has been estimated at one to two million in the United States and at 45 000 in Canada annually (Conover et al. 1995, Tardif and Associates Inc. 2003, Huijser et al. 2007b). These numbers have increased even further over the last decade (Tardif and Associates Inc. 2003, Huijser et al. 2007b). In the United States, these collisions were estimated to cause 211 human fatalities, 29 000 human injuries and over one billion US dollars in property damage annually (Conover et al. 1995). In most cases, the animals die immediately or shortly after the collision (Allen and McCullough 1976). In some cases, it is not just the individual animals that suffer. Road mortality may also affect some species on the population level (e. g., van der Zee et al. 1992, Huijser and Bergers 2000), and some species may even be faced with a serious reduction in population survival probability as a result of road mortality, habitat fragmentation, and other negative effects associated with roads and traffic (Proctor 2003, Huijser et al. 2007b). In addition, some species also represent a monetary value that is lost once an individual animal dies (Romin and Bissonette 1996, Conover 1997).

[1]Western Transportation Institute, Montana State University, [2]University of Montana, Department of Mathematical Sciences

Huijser et al., 2009, Ecology & Society

Benefits: Costs of collisions

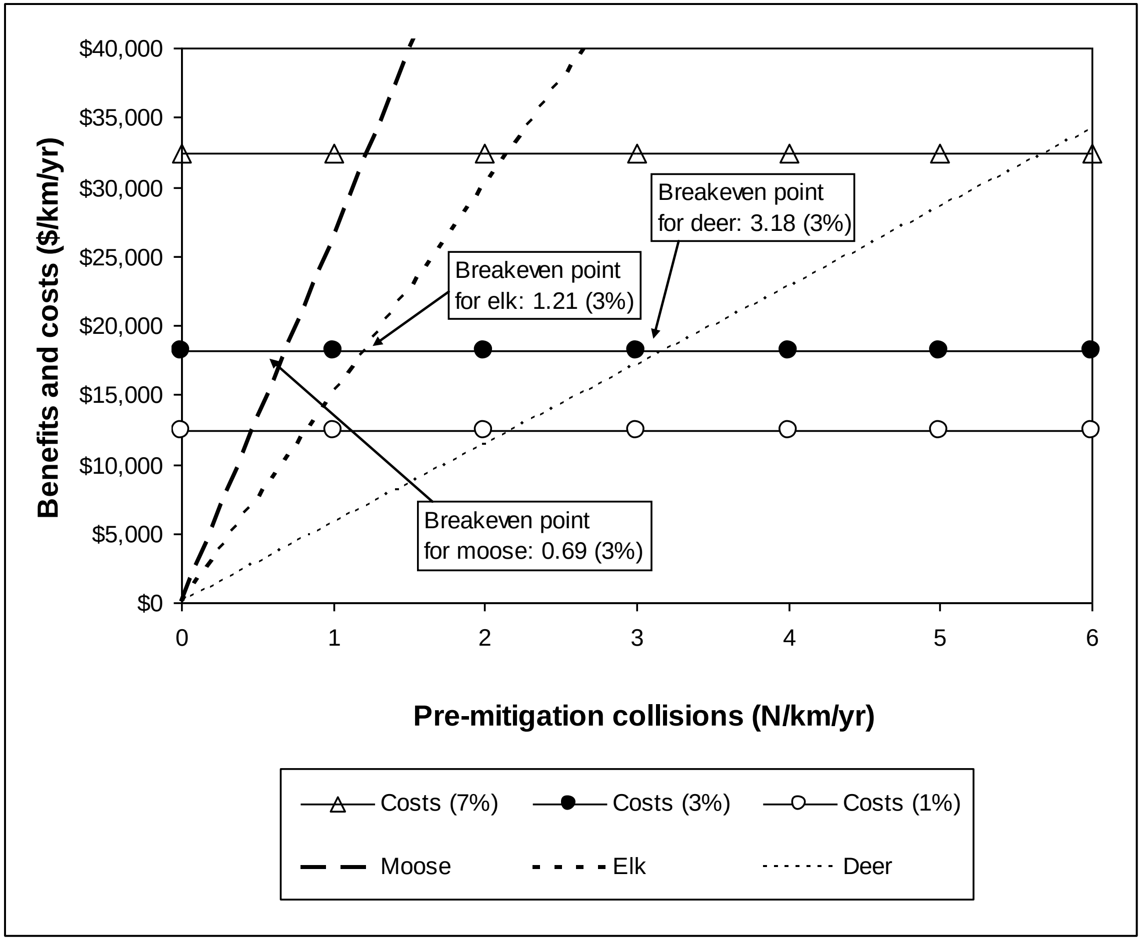
Description	Deer	Elk	Moose
Vehicle repair costs per collision	$2,622	$4,550	$5,600
Human injuries per collision	$2,702	$5,403	$10,807
Human fatalities per collision	$1,002	$6,683	$13,366
Towing, accident attendance and investigation	$125	$375	$500
Hunting value animal per collision	$116	$397	$387
Carcass removal and disposal per collision	$50	$75	$100
Total	$6,617	$17,483	$30,760

Huijser et al., 2009, Ecology & Society

Cost-benefit analyses

- 75 year long period
- Discount rate: 1%, 3%, 7%

Break-even points (fencing, underpasses, jump-outs)



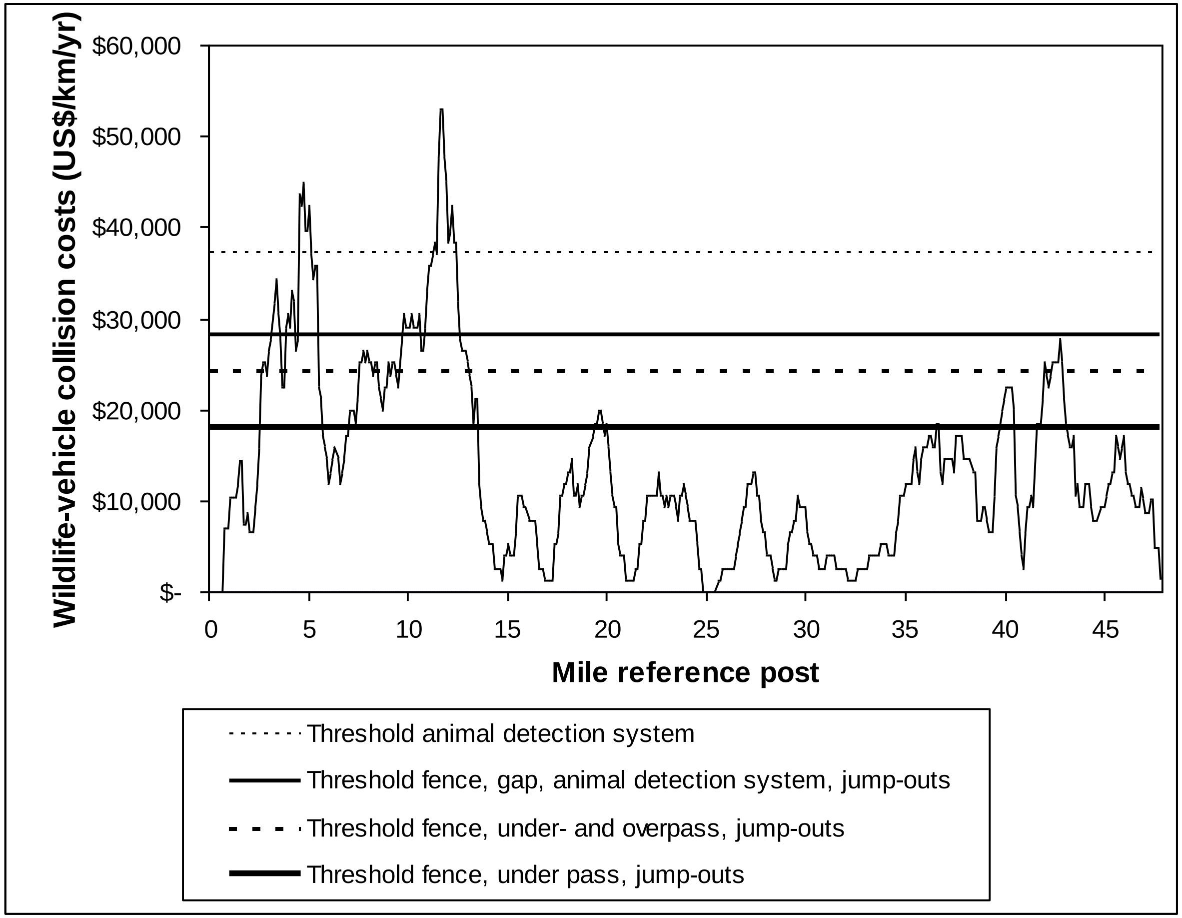
Huijser et al., 2009, Ecology & Society

≥80% reduction

Threshold values	Discount rate	Fence	Fence, under pass, jump-outs	Fence, under- and overpass, jump-outs	ADS	Fence, gap, ADS, jump-outs	Elevated roadway	Road tunnel
$/yr	1%	$5,223	$12,437	$15,975	$35,279	$25,634	$2,233,094	$3,328,567
$/yr	3%	$6,304	$18,123	$24,230	$37,014	$28,150	$3,109,422	$4,981,333
$/yr	7%	$8,931	$32,457	$45,142	$41,526	$34,437	$5,369,961	$9,246,617
deer/km/yr	1%	0.92	2.19	2.81	6.13	4.45	337.48	503.03
deer/km/yr	3%	1.11	3.18	4.26	6.43	4.89	469.91	752.81
deer/km/yr	7%	1.57	5.70	7.93	7.21	5.98	811.54	1397.40
elk/km/yr	1%	0.35	0.83	1.06	2.32	1.69	127.73	190.39
elk/km/yr	3%	0.42	1.21	1.61	2.43	1.85	177.85	284.92
elk/km/yr	7%	0.59	2.16	3.00	2.73	2.26	307.15	528.89
moose/km/yr	1%	0.20	0.47	0.60	1.32	0.96	72.60	108.21
moose/km/yr	3%	0.24	0.69	0.92	1.38	1.05	101.09	161.94
moose/km/yr	7%	0.34	1.23	1.71	1.55	1.29	174.58	300.61

Huijser et al., 2009, Ecology & Society

Example road section (MT Hwy 83, MT, USA)



Huijser et al., 2009, Ecology & Society

Cost-Benefit Model

- Collisions with large mammals are dangerous for people and expensive
- Mitigation measures are good for human safety and conservation, and can help society safe money

US93 N Costs and Benefits

Input:

- Evaro, Ravalli Curves and Ravalli Hill 76% reduction
- Shorter road sections 50% reduction
- Specific costs for the mitigation measures US93

Notes:

- Model is primary based on human safety
- Mitigation US93 N was primarily conducted because CSKT required it to protect cultural and natural resources

US93 N Costs and Benefits

Area	Costs	Benefits	Balance (benefits minus costs)	% Benefits related to costs	Balance (per mitigated km)
Evaro	$4,598,310	$456,949	-$4,141,361	9.94	-$3,919,676
Ravalli Curves	$4,179,416	$1,021,416	-$3,158,000	24.44	-$1,337,163
Ravalli Hill	$1,475,253	$322,553	-$1,152,700	21.86	-$1,545,579
Other	$11,106,895	$437,567	-$10,669,329	3.94	-$6,922,157
Total	$21,359,874	$2,238,485	-$19,121,389	10.48	-$3,351,450

US93 N Costs and Benefits

Why negative balance?

- Fences are relatively inexpensive
- Crossing structures are relatively expensive

- US93 N has relatively high concentration of crossing structures
- US 93 N has predominantly short fences which are less effective in reducing collisions
- US 93 N has predominantly no fences or short fences at isolated structures (high costs per mitigated mi)

Measures of Effectiveness

Human Safety	Met	Not met
Reducing Wildlife-Vehicle Collisions in All Fenced Road Sections	√	√
Reducing Wildlife-Vehicle Collisions in the Evaro, Ravalli Curves and Ravalli Hill Areas	√	√
Reducing Potential Collisions with Deer and Black Bear	√	
Biological Conservation		
Reducing Unnatural Mortality for Black Bears		√
Maintaining Habitat Connectivity for Deer	√	
Maintaining Habitat Connectivity for Black Bear	√	

“Mitigation measures US93 N are predominantly a success”

General recommendations

- Select fence and crossing locations carefully (human safety – habitat connectivity)
- Make stream crossings suitable for terrestrial mammals, but don’t forget higher and drier areas.
- Formulate objectives related to habitat connectivity and design accordingly (e.g. target species, population viability).
- Combine crossing structures with wildlife fences.
- Fenced road length >5 km (consider home range).
- Fences should cover hotspot and buffer zone
- Include fence end treatments
- Increase spatial accuracy collision data

Recommendations US93 N

- Fence maintenance program
- Tie short fenced sections together
- Implement effective fence end treatments (electric mats)
- Electric mats in bear areas (gaps and fence ends)
- Make concrete ledges wildlife guards inaccessible
- Remove human access point
- Retrofit connections wing walls structures – fences
- Vegetation maintenance wildlife jump-outs
- Investigate improvements to wildlife guards (broken legs ungulates) electric mats (grizzly bears), and wildlife jump-outs (lower, be careful!

Thanks!

Funding:

- Montana Department of Transportation
- Federal Highway Administration
- University Transportation Center program
- Grants awarded to CSKT
- Grants awarded to students

Help:

- MDT: Access to the right of way
- Confederated Salish Kootenai Tribes: advocating for mitigation measures, permission to conduct research on tribal lands
- Students: Tiffany Allen, Jeremiah Purdum, Hayley Connolly-Newman, Elizabeth Fairbank, Adam Andis
- Partners at UofM

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