Road Ecology: Are We Taking The Right Turns?

Marcel P. Huijser, PhD

This talk

- Some observations of our practices

- Human safety and biological conservation US Hwy 93 North, Flathead Indian Reservation, Montana

What do we typically do?

- Reduce collisions with large mammals ... mostly human safety

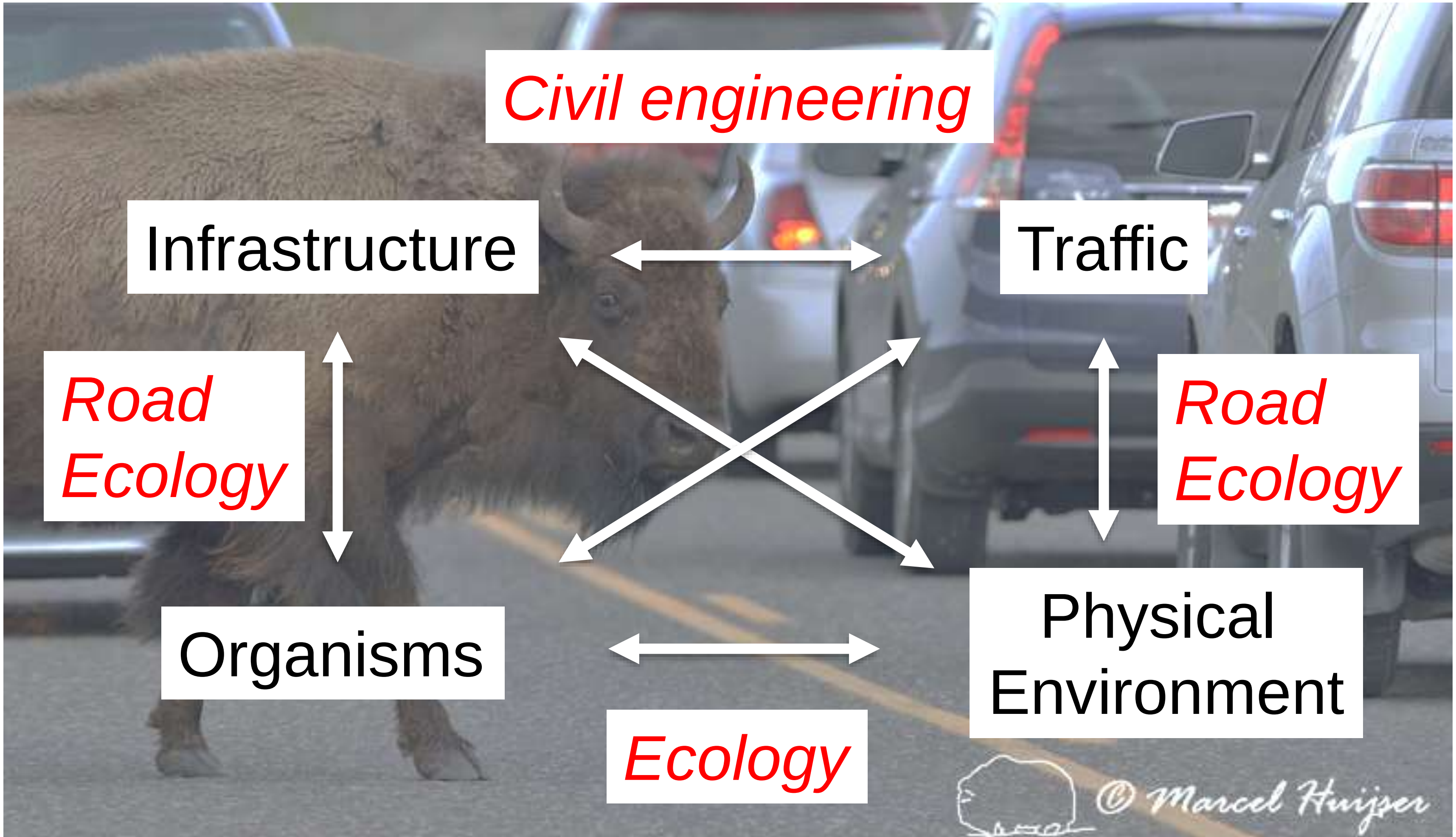


- Safe crossing opportunities for wildlife: conservation




Courtesy of MDT, CSKT & WTI-MSU

But… Road Ecology is much more!



“Transportation Ecology”

“Typical” Road Ecology Practice:	Road/Transportation Ecology:
Cars	Trains, Ships, Planes
Highways	Dirt roads, trails
Linear	3-D landscape
Terrestrial	Aquatic, Air
Biotic	Abiotic
Safety	Biological conservation
Large mammals	Small species
Mitigation	Avoidance, Compensation
Your wallet	Your quality of life

Where do we typically take action?

Selection typically based on:

- Human safety
- Crash data, Carcass removal data
- Large common mammal species

Selection typically not based on:

- Biological conservation
- Habitat and corridors
- Small or rare species

Example Carcass Removal Data

Hwy 2 , NW Montana

Table 1: The species included in the carcass removal database and their inclusion in the analyses based on human safety versus biological conservation.

Species	n	%	Removed from data	Human safety	Biological conservation: Federal level	Biological conservation: State level
White-tailed deer (*Odocoileus virginianus*)	3936	90.28		x		
Mule deer (*Odocoileus hemionus*)	180	4.13		x		
Elk (*Cervus canadensis*)	65	1.49		x		
Moose (*Alces americanus*)	38	0.87		x		
Unknown or not sufficiently specified	35	0.80				
Black Bear (*Ursus americanus*)	14	0.32		x		
Deer spp. (*Odocoileus* spp.)	11	0.25		x		
Coyote (*Canis latrans*)	10	0.23				
Striped skunk (*Mephitis mephitis*)	9	0.21				
Domesticated cat (*Felis catus*)	8	0.18	x	n/a	n/a	
Domesticated dog (*Canis lupus familiaris*)	8	0.18	x	n/a	n/a	
Other wild species, unspecified	8	0.18				
Raccoon (*Procyon lotor*)	5	0.11				
Gray wolf (*Canis lupus*)	4	0.09			Delisted (2011)	Delisted (2011)
Owl (Strigiformes)	3	0.07				
Painted turtle (*Chrysemys picta*)	3	0.07				
Cattle (*Bos taurus*)	2	0.05	x	n/a	n/a	
Grizzly bear (*Ursus arctos*)	2	0.05		x	Threatened	Of concern
Mountain Lion (*Puma concolor*)	2	0.05		x		
Beaver (*Castor canadensis*)	2	0.05				
Bobcat (*Lynx rufus*)	2	0.05				
Common raven (*Corvus corax*)	2	0.05				
Wild turkey (*Meleagris gallopavo*)	2	0.05				
Pronghorn (*Antilocapra americana*)	1	0.02	x	n/a	n/a	
Bighorn sheep (*Ovis canadensis*)	1	0.02		x		
Horse (*Equus ferus caballus*)	1	0.02	x	n/a	n/a	
Domestic, species not recorded	1	0.02	x	n/a	n/a	
Badger (*Taxidea taxus*)	1	0.02				
Bald eagle (*Haliaeetus leucocephalus*)	1	0.02			Delisted (2011)	Special status
Golden eagle (*Aquila chrysaetos*)	1	0.02				Of concern
Red fox (*Vulpes vulpes*)	1	0.02				
Turkey vulture (*Cathartes aura*)	1	0.02				
Total	4360	100				

Huijser & Begley, 2016

Common large mammals

Threatened and Endangered, or rare Species

Small species not Recorded at all

Departure Point Matters!

Table 11: Prioritization of the carcass removal hotspots based on human safety, biological conservation and economics. The raw data are in Appendix A.

	Secondary		
Departure point (primary)	Human safety	Biological conservation	Economics
Human safety	8.0 (100%)	5.2 (65%)	4.3 (54%)
Biological conservation	5.2 (7%)	76.8 (100%)	31.4 (41%)
Economics	4.3 (9%)	31.4 (68%)	46.4 (100%)

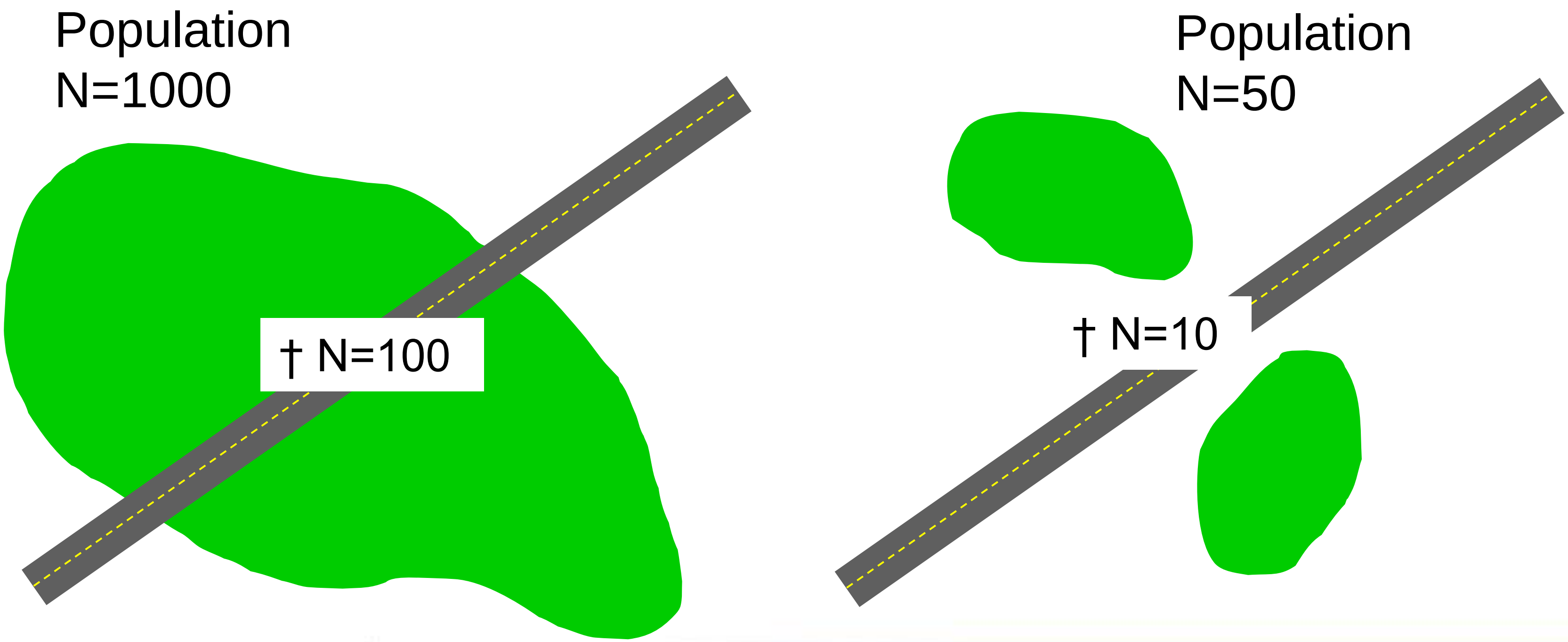
- Human safety: 8.0 miles (6.6%) out of 121.0 miles
- Of the 8.0 miles, 5.2 miles (65%) were also concern to biological conservation

- Biological conservation: 76.8 miles (63.5%) out of 121.0 miles
- Of the 76.8 miles, 5.2 miles (7%) were also a concern to human safety

Includes habitat and successful wildlife movements

Huijser & Begley, 2016

Collision reduction for human safety
vs.
Mortality reduction for conservation



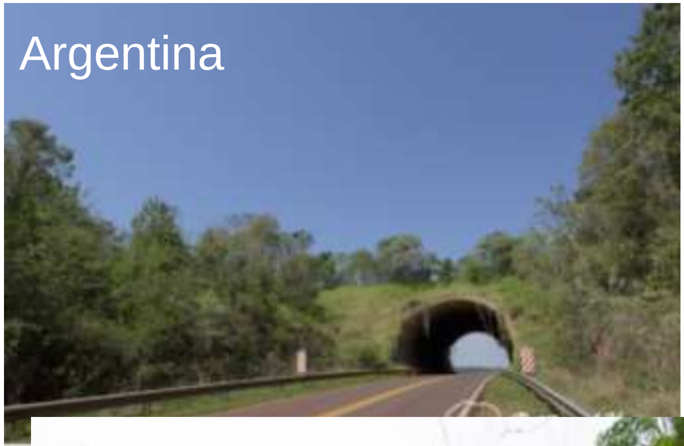
Biological Conservation:

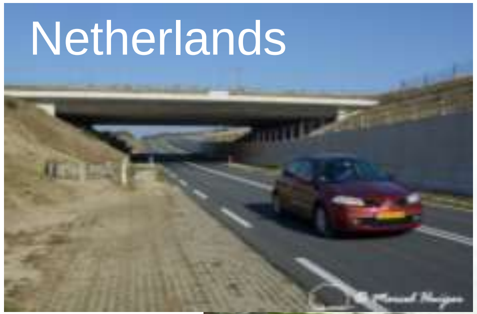
Some countries do it

So can you…

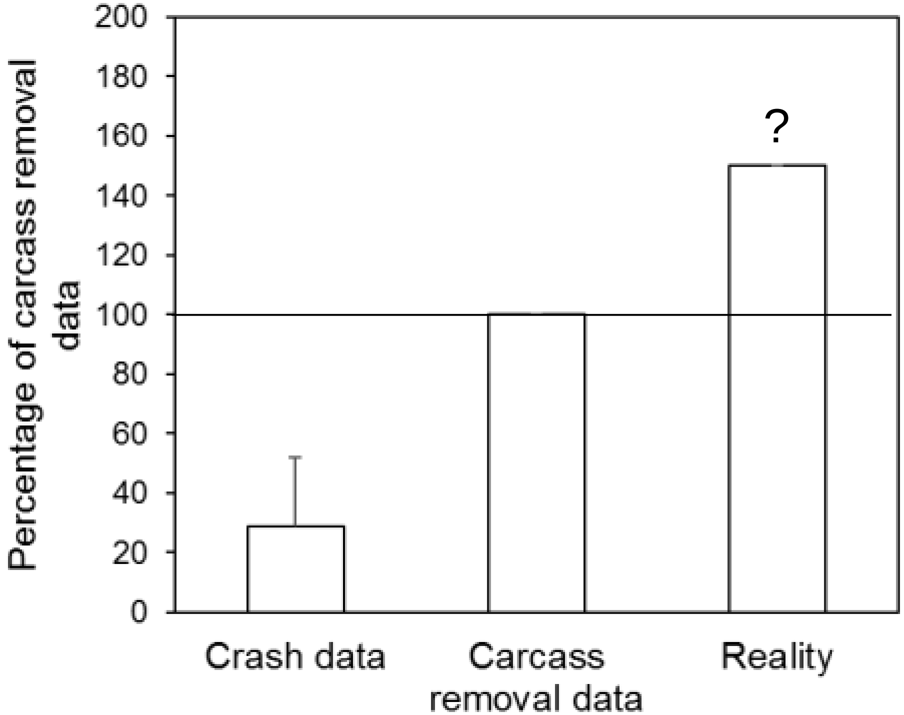
… if you want to!

1. Values vs. mandates
2. Voices
3. Allies
4. Action





How many collisions do you need to see before you take action?



Crash data thresholds

Carcass data misses animals that die off highway corridor

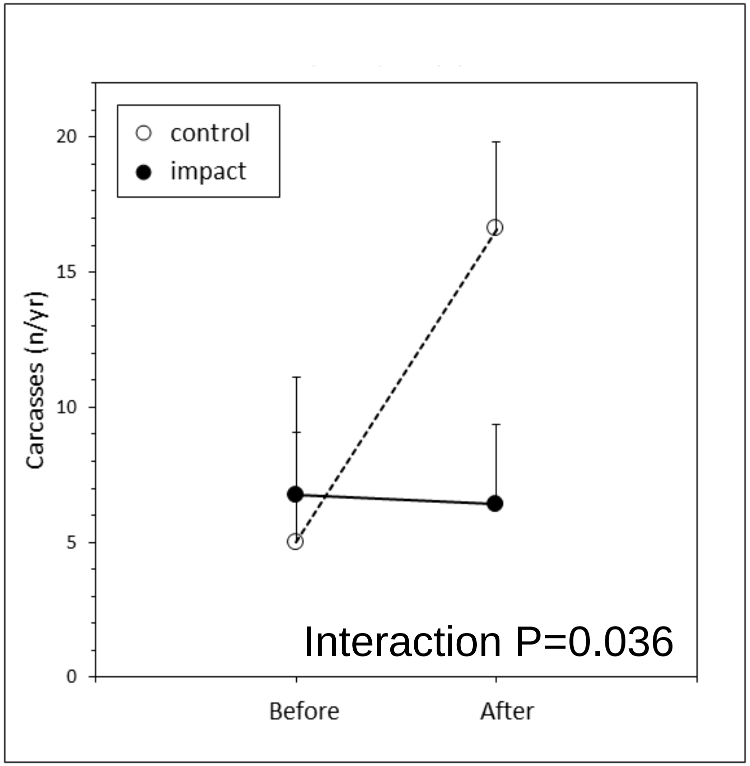
Carcasses taken by citizens

Huijser, in prep

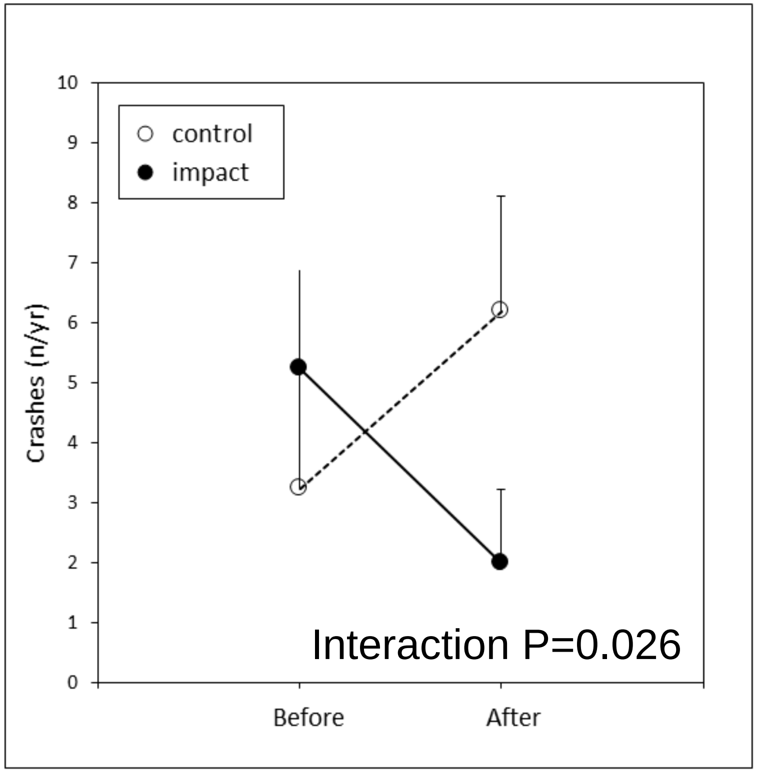
Reconstructing a rural highway?

Historic Collision data not a good predictor: BACI design

Carcass data: -71%



Wildlife-crash data: -80%



Huijser et al. 2016

“We” Want ….

- Simple
- Inexpensive
- Fast implementation
- Implementation over long distances

- Warning signs
- Vehicle speed reduction

Wildlife Warning Signs

- Standard




- Enhanced

- Temporary

Huijser et al., 2015

- Animal detection system


MONTANA STATE UNIVERSITY
College of ENGINEERING

Reduce Posted Speed Limit

- Design speed

Lane and shoulder width, curvature, sight distance

- Posted speed limit

Legal speed limit depicted on signs

- Operating speed

The speed that drivers actually drive

Reduce Posted Speed Limit

Design speed = Posted speed limit ✓

Good practice

Design speed ≠ Posted speed limit ✗

Speed dispersion, increase in crashes

Stopping Distance – Maximum Vehicle Speed

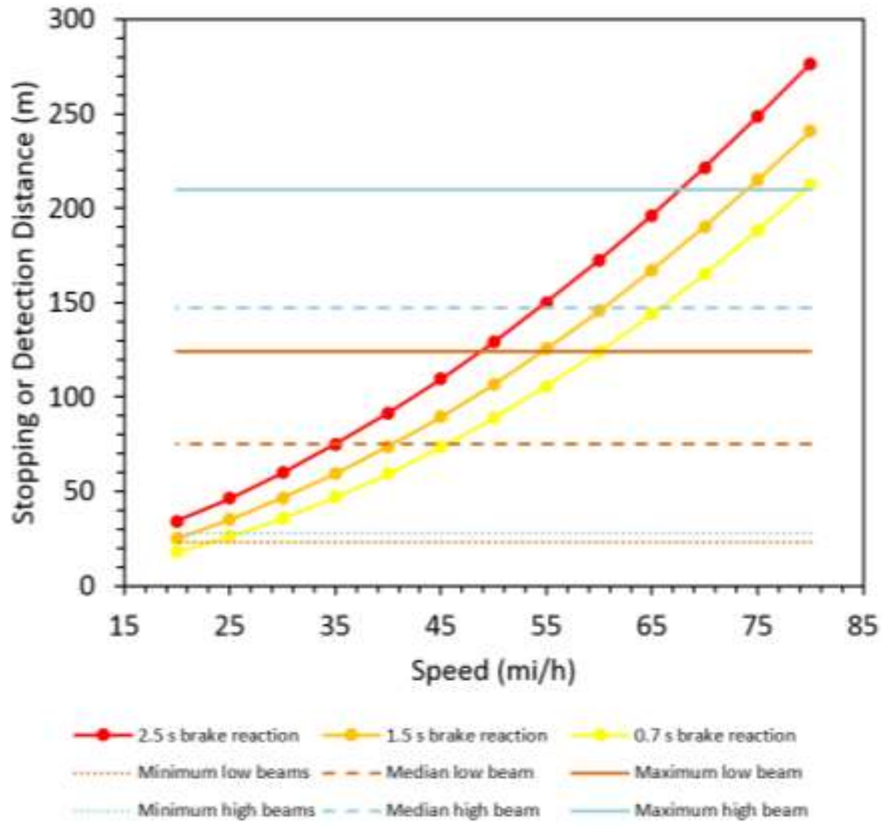


Figure 7. Stopping Distances and Detection Distances for Large Mammals (For more details on methods see Huijser et al., 2017)

Stopping distance
=

Reaction time (distance)
+
Braking distance

Not suitable for highways

Perhaps suitable for park roads

Type of Road - Mitigation Approach

1. “High Volume Through Road”

Purpose: to get from A to B fast and safe
>10,000 – 15,000 vehicles/day
High design speed
High posted speed limit
Physical separation traffic and wildlife

Measures:

- Fences, underpasses, overpasses

Type of Road - Mitigation Approach

2. “Low volume through road”

Purpose: to get from A to B fast and safe

- <10,000 vehicles/day
- High design speed
- High posted speed limit
- Physical separation traffic and wildlife

Measures:

- Animal detection systems but doesn’t address barrier effect!
- Fences, underpasses, overpasses

Type of Road - Mitigation Approach

3. “Low Volume Park Road”

Purpose: to see and experience

- Low design speed
- Low posted speed limit
- Mitigation should not affect landscape aesthetics

Measures:

- Low design speed
- Low posted speed limit
- Night time closure
- Seasonal closure
- Gates (information, physical barrier)
- Law enforcement personnel present

Reduce Collisions: Effective Measures

Standard “ungulate” fence

Negative view of fences

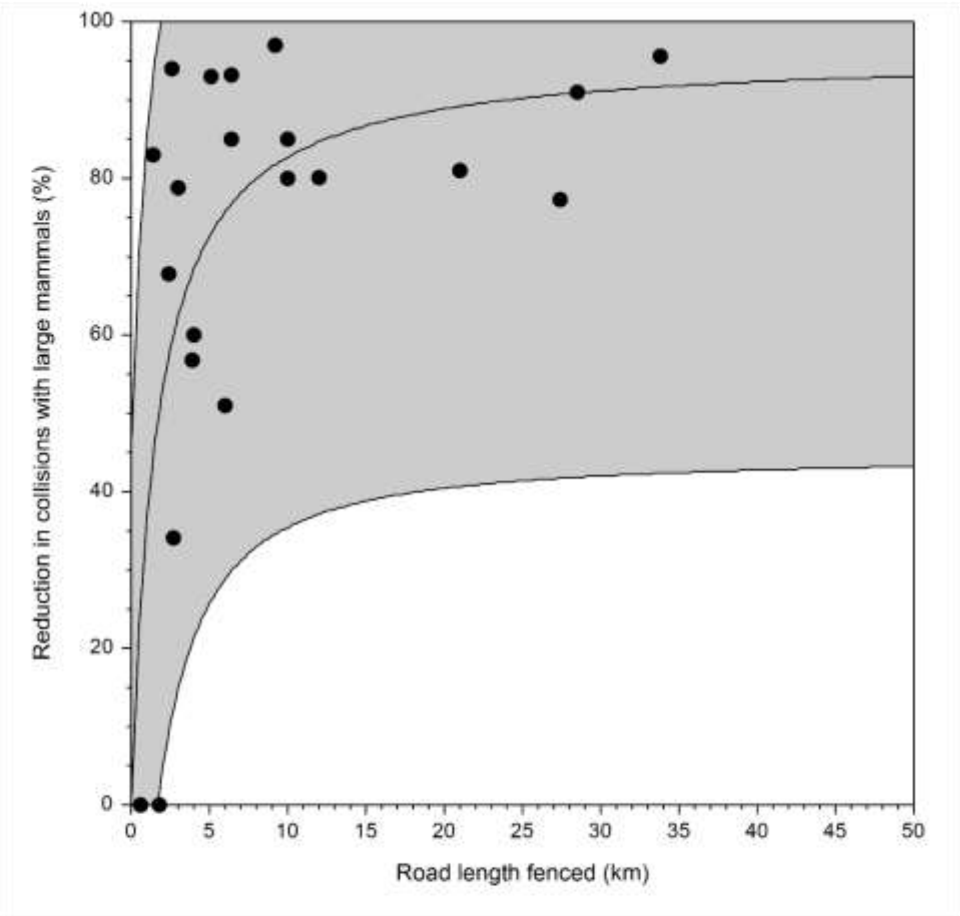
- Landscape aesthetics

- Unpopular with landowners
  (gates, cattle guards at access roads)

- "Expensive"
- Fences hinder wildlife movements
  long distance seasonal migration

- Injuries/fatalities

Reducing Wildlife-Vehicle Collisions



Huijser et al., 2016, Biological Conservation

< 3 mi 52.7%
range 0-94%

> 3 mi: typically > 80%

Crossing Structures needed, especially at higher traffic volumes

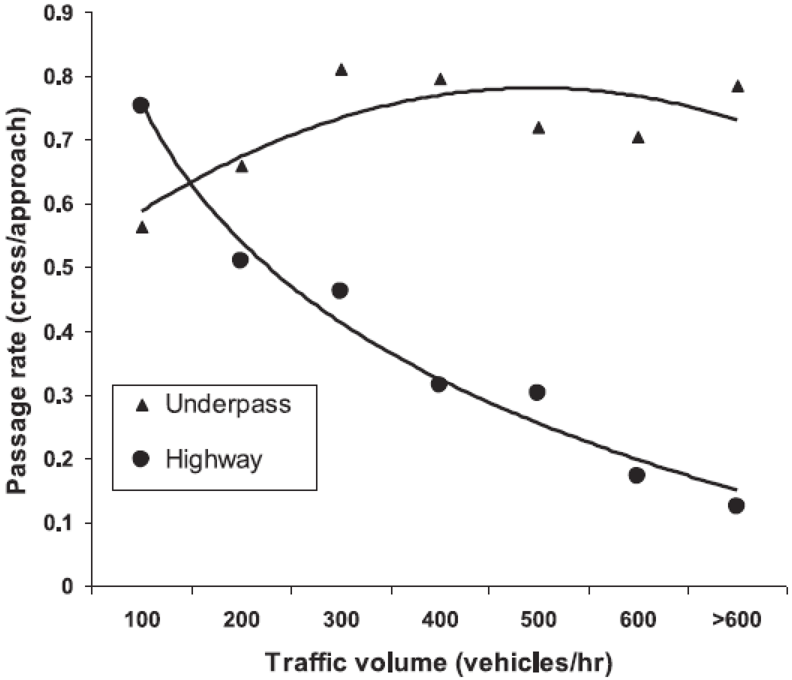


Figure 6. At-grade and below-grade (through 6 wildlife underpass) elk passage rates at varying traffic volume levels along State Route 260, Arizona, USA (figure from Gagnon et al. 2007c). At-grade passage rates determined from GPS telemetry tracking of 44 elk from 2003-2006 (Gagnon et al. 2007a) and below-grade underpass passage rates determined from video surveillance of wildlife use of underpasses from 2002-2006 (Gagnon et al. 2007b).

Dodd et al., 2007

Don’t Loose Track of Your Objectives

Fences need to cover hotspot and buffer zone

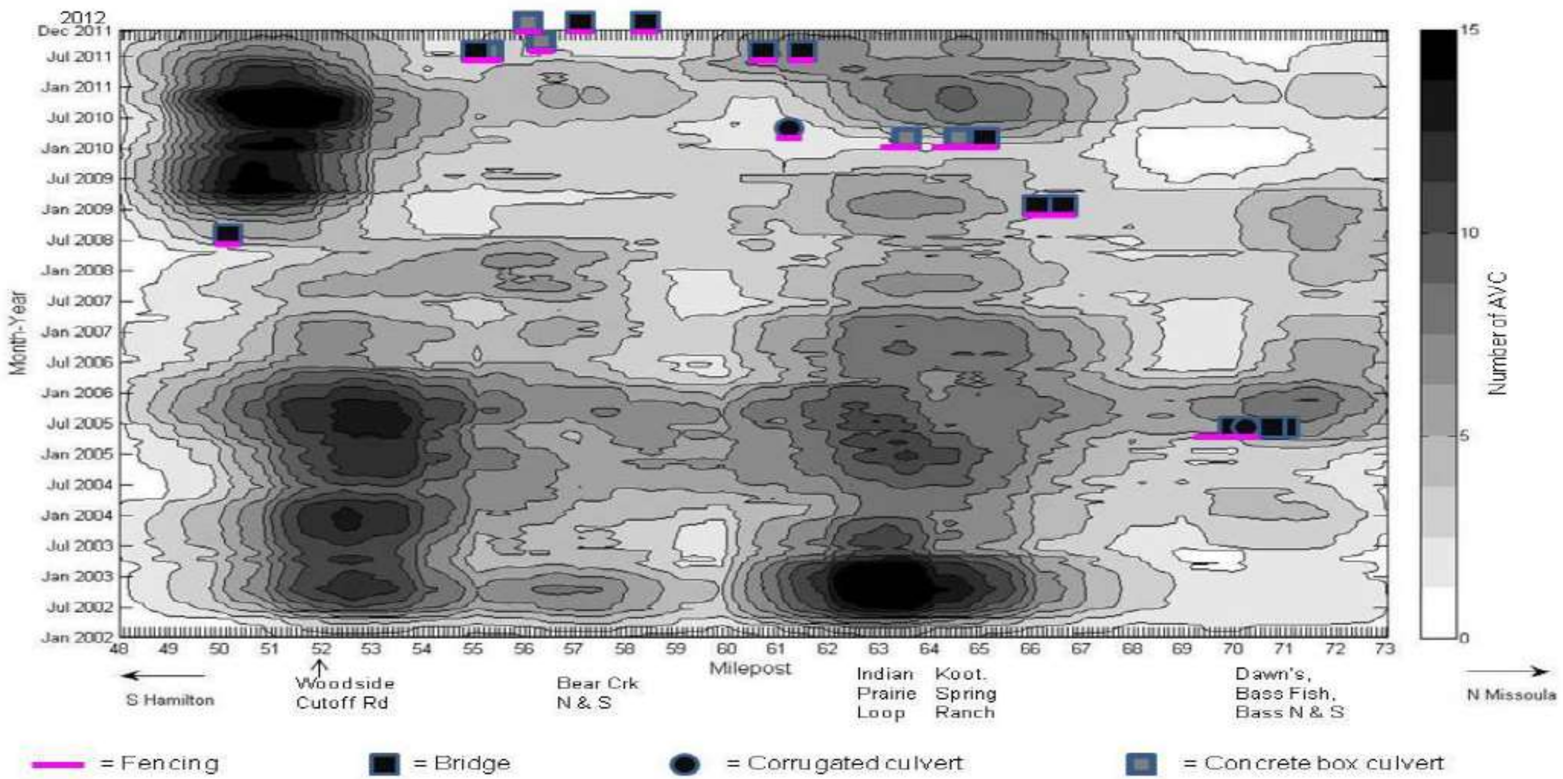


Figure 5. Kernel Density Analysis of AVC carcass data along US 93 South, mp 48 through 73. Darker spots reflect higher carcass counts at specific mile posts at six month intervals. Wildlife crossing structure type, location, date installed, and wildlife fencing are indicated.

Cramer et al. 2013

Needs – Design - Construction

Is anyone guiding the overall process?

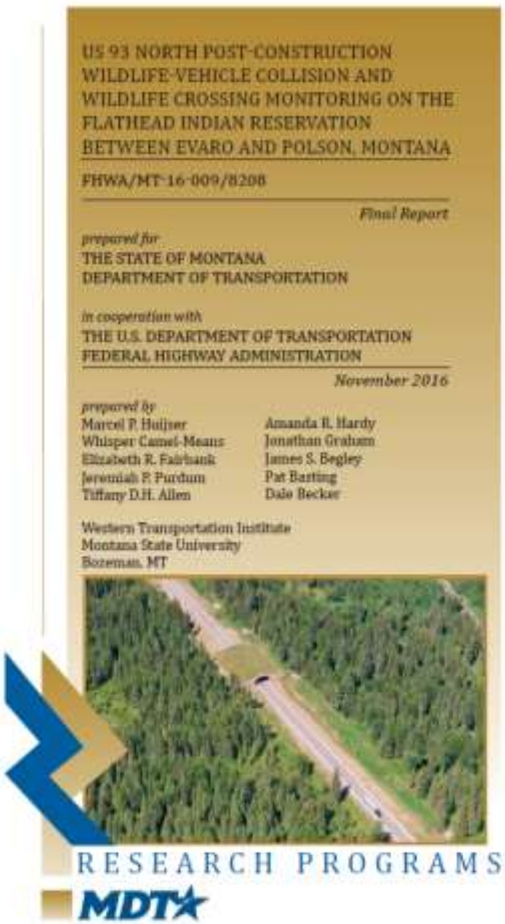
Continued coordination in the different stages

Details Matter!
Construction Oversight

Maintenance is Critical !

Include maintenance in responsibilities or contracts!

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


US 93 NORTH POST-CONSTRUCTION WILDLIFE-VEHICLE COLLISION AND WILDLIFE CROSSING MONITORING ON THE FLATHEAD INDIAN RESERVATION BETWEEN EVARO AND POLSON, MONTANA

FHWA/MT-16-009/8208

Final Report

prepared for
THE STATE OF MONTANA
DEPARTMENT OF TRANSPORTATION

in cooperation with
THE U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

November 2016

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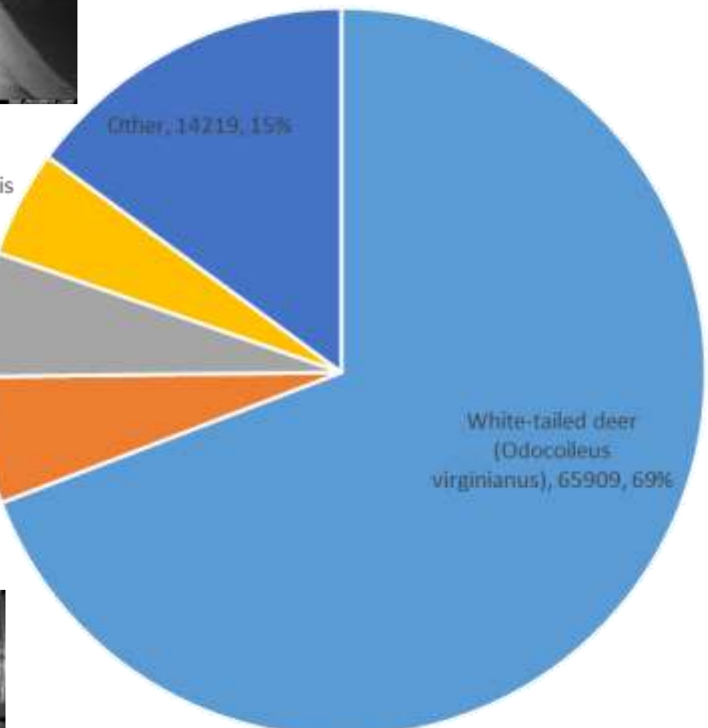
RESEARCH PROGRAMS
MDT

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

29 Structures, 5 years



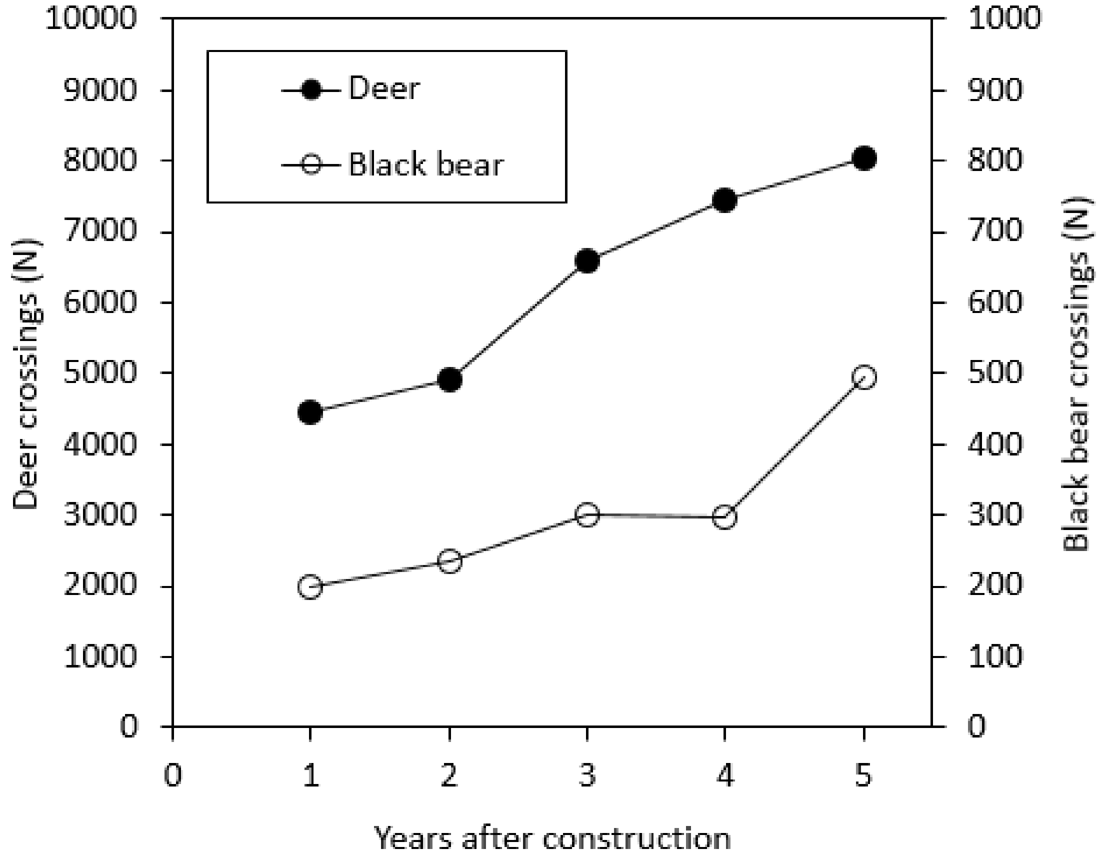
- 95,274 successful crossings
- 22,648 per year
- 20 wild medium-large mammal species

- 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

Huijser et al. 2016.

Learning Curve



Huijser et al. 2016

Ambition Levels

- Just build them, regardless of wildlife use
- "Substantial" wildlife use
- Viable wildlife populations
- Ecosystem processes
  - Migration routes
- Climate Change

Habitat Connectivity ???

Better

- Safe places to cross
- Less disturbance when crossing

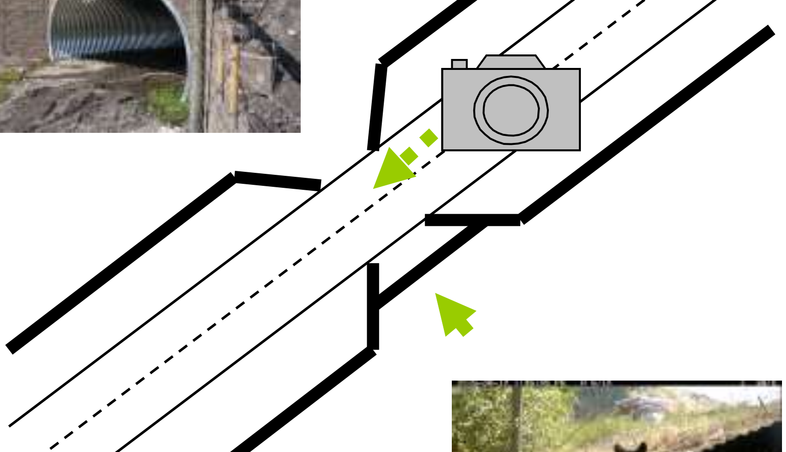
Worse

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

Deer and black bear crossings

Before

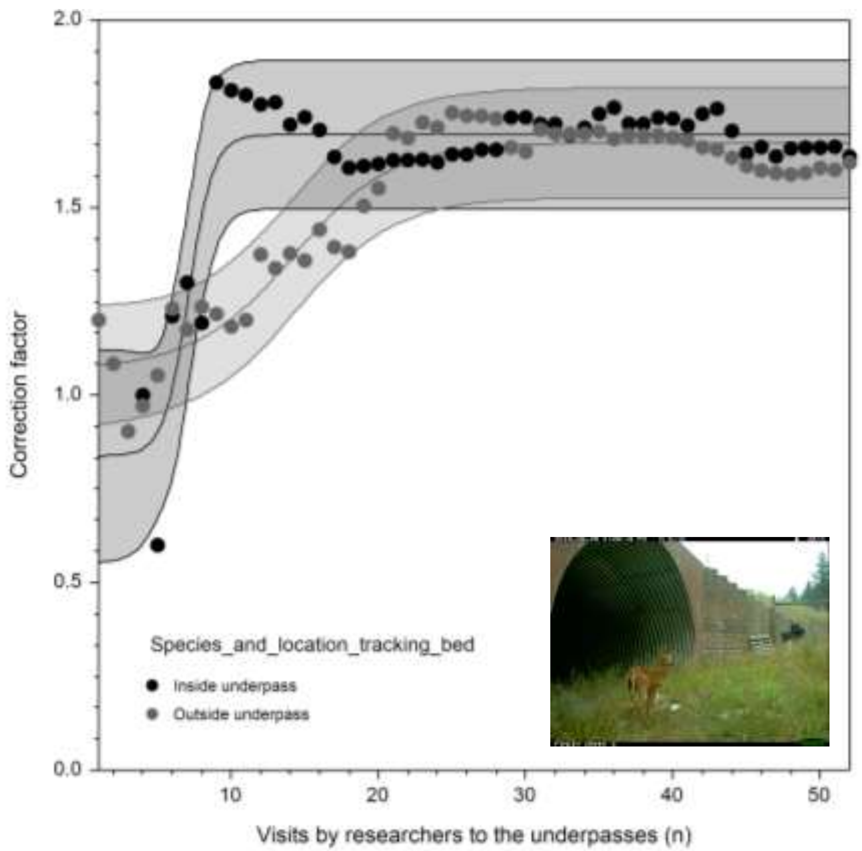
After



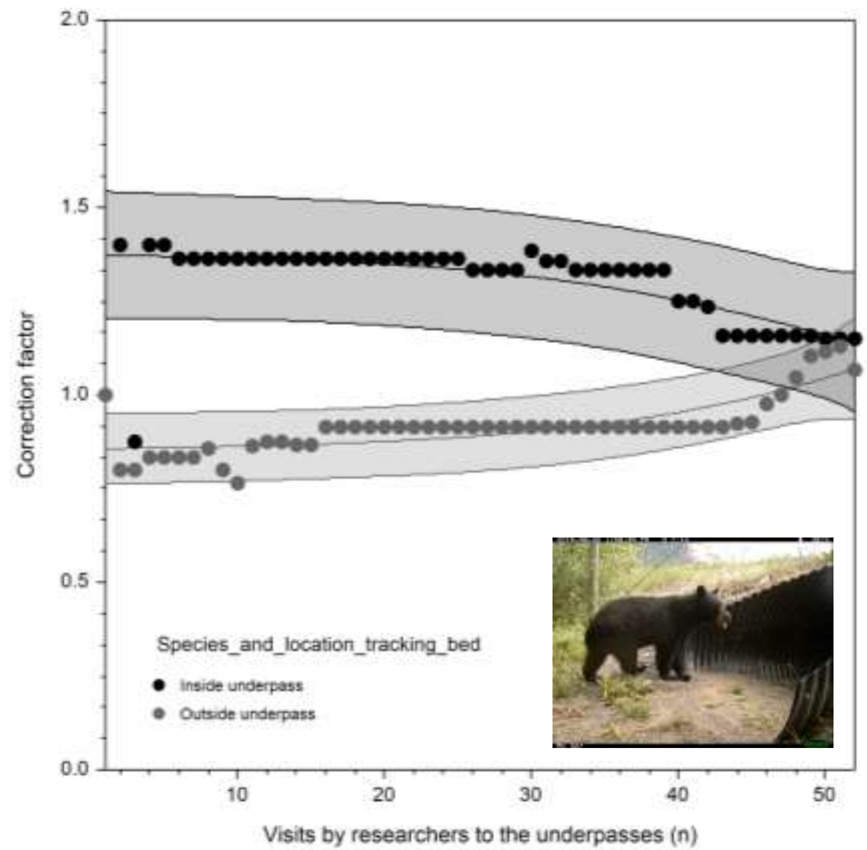
Correction Factor

Tracks – Camera Images

Deer: *1.623

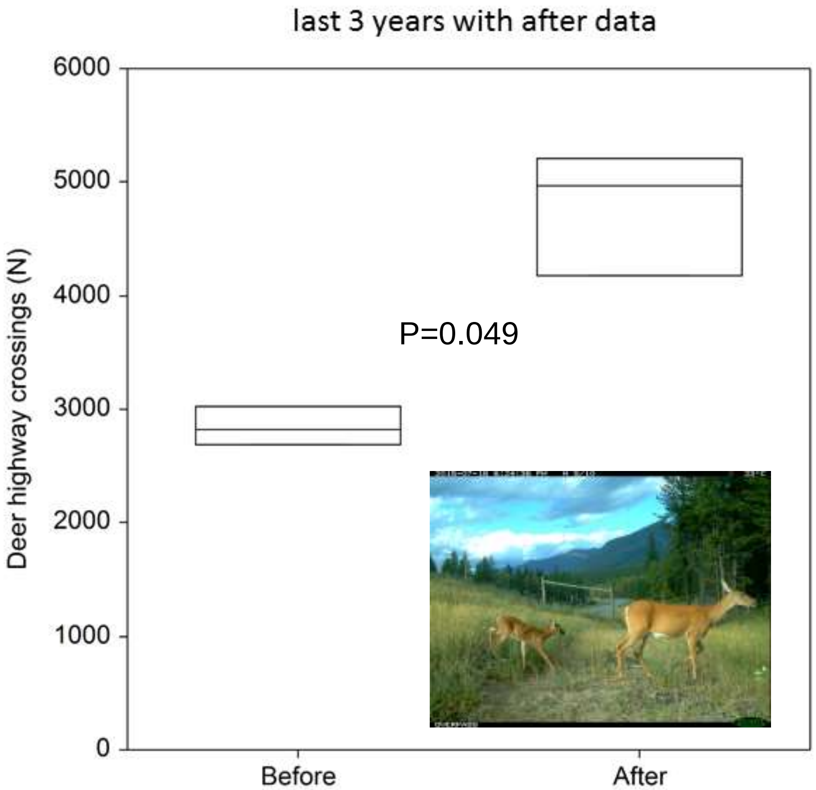


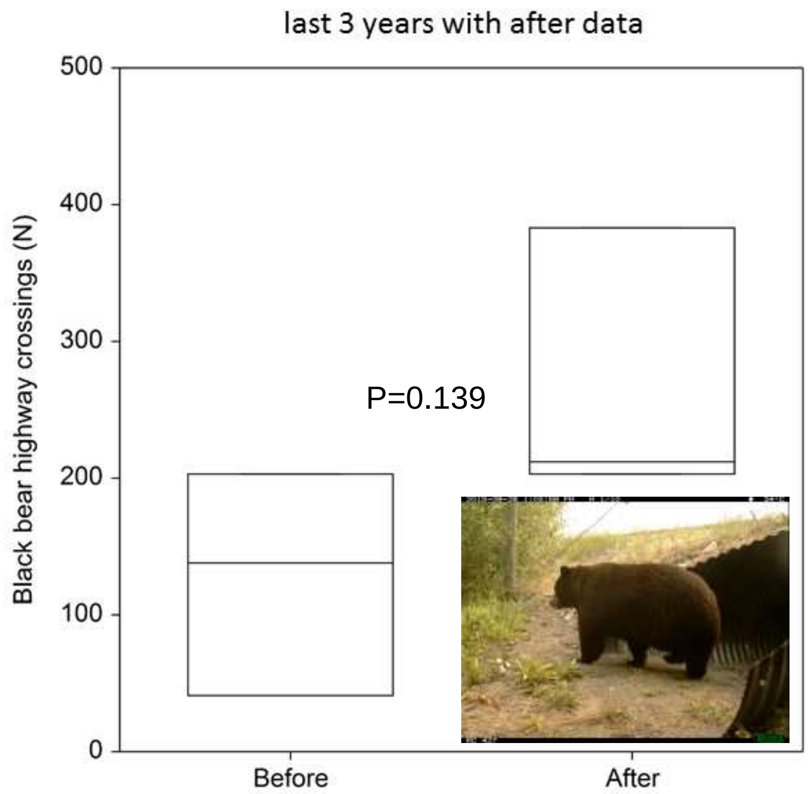
Black bear: 1.088



Huijser et al. 2016

Habitat Connectivity





Huijser et al. 2016

Concentration Of Movements in Crossing Structures?

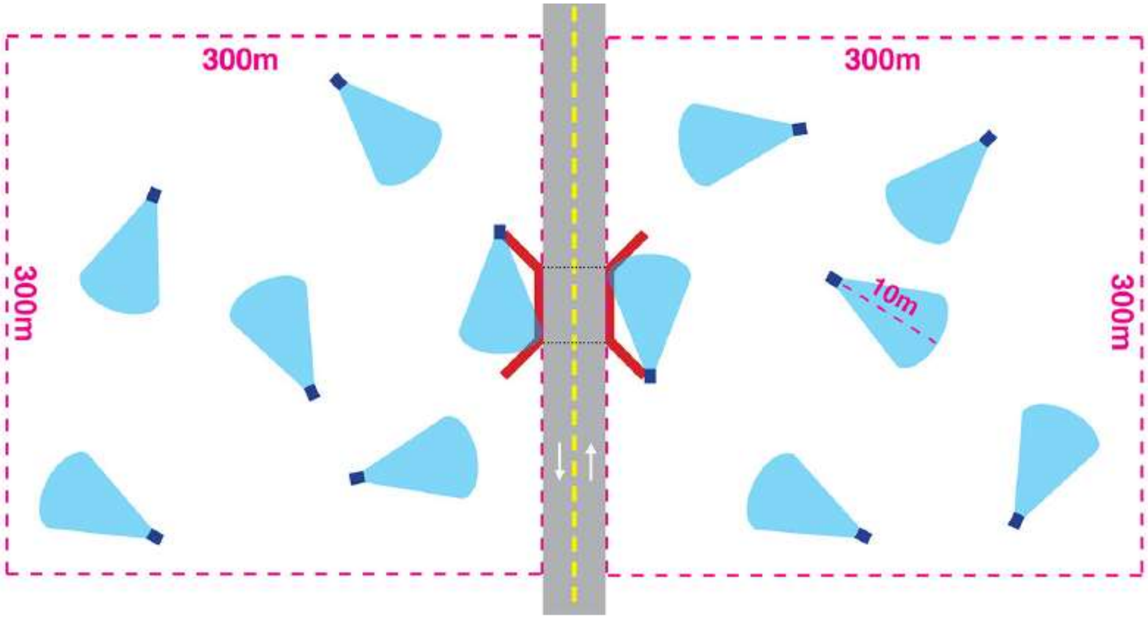
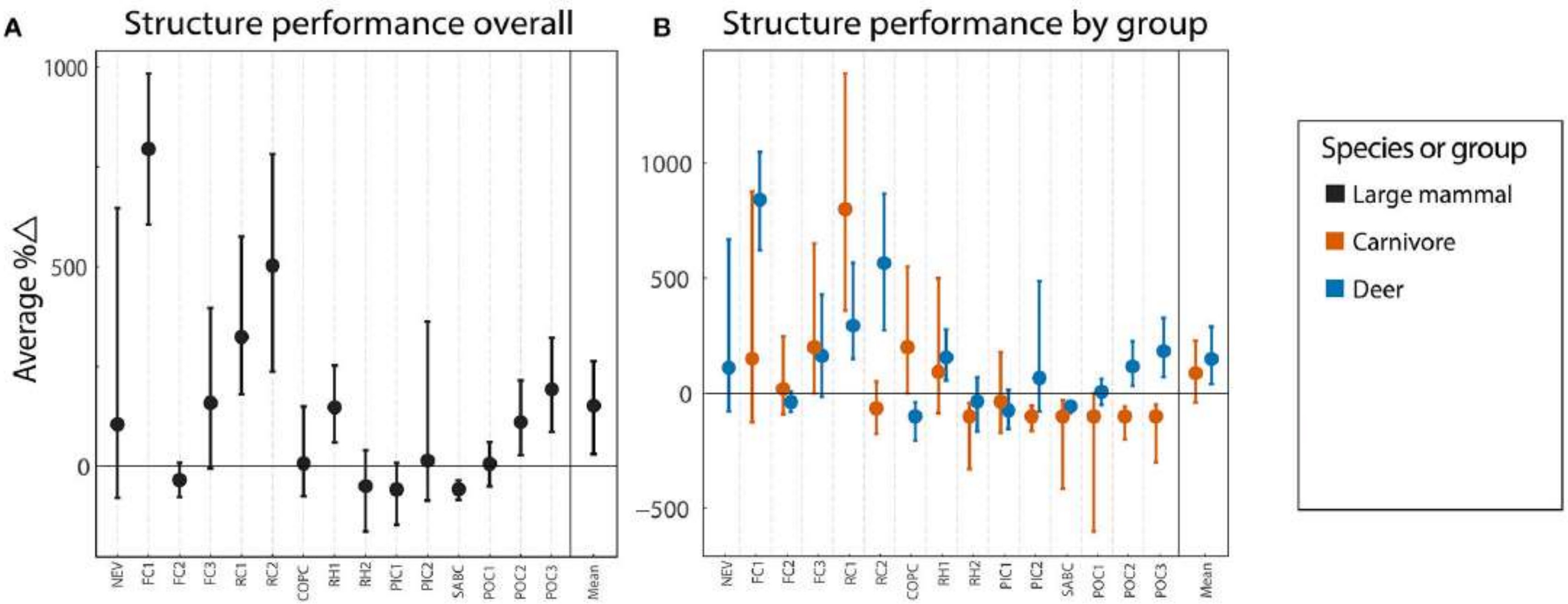


FIGURE 2 | Camera placements in relation to a wildlife highway crossing structure (not to scale). Twelve HyperFire PC900 Reconyx™ trail cameras (dark blue squares indicate cameras, light blue cone indicates approximate 40° sampling window) were installed at each site for ~2 weeks at each site. Ten cameras were installed at randomly generated points at least 50 m apart within a 300 m by 300 m area adjacent to each side of the structure (red lines represent concrete retaining walls associated with all crossing structures). Two cameras were installed at each entrance to the structure. Cameras were installed ~3 m from the ground and a stake was placed to demarcate a 10 m viewing distance commensurate with the viewing distance of the cameras at the structure entrance.

Andis et al. 2017

Concentration Of Movements in Crossing Structures?



- 146% more large mammal movements at structures vs surroundings
- Full connectivity for large mammals? 40.7% road length permeable !!!

Andis et al. 2017

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

Cost-benefit analyses
Large mammals

- Costs:

  Equipment, installation, construction, operation, maintenance, removal

- Benefits:

  Reduced costs

  of collisions

Benefits: Costs of collisions

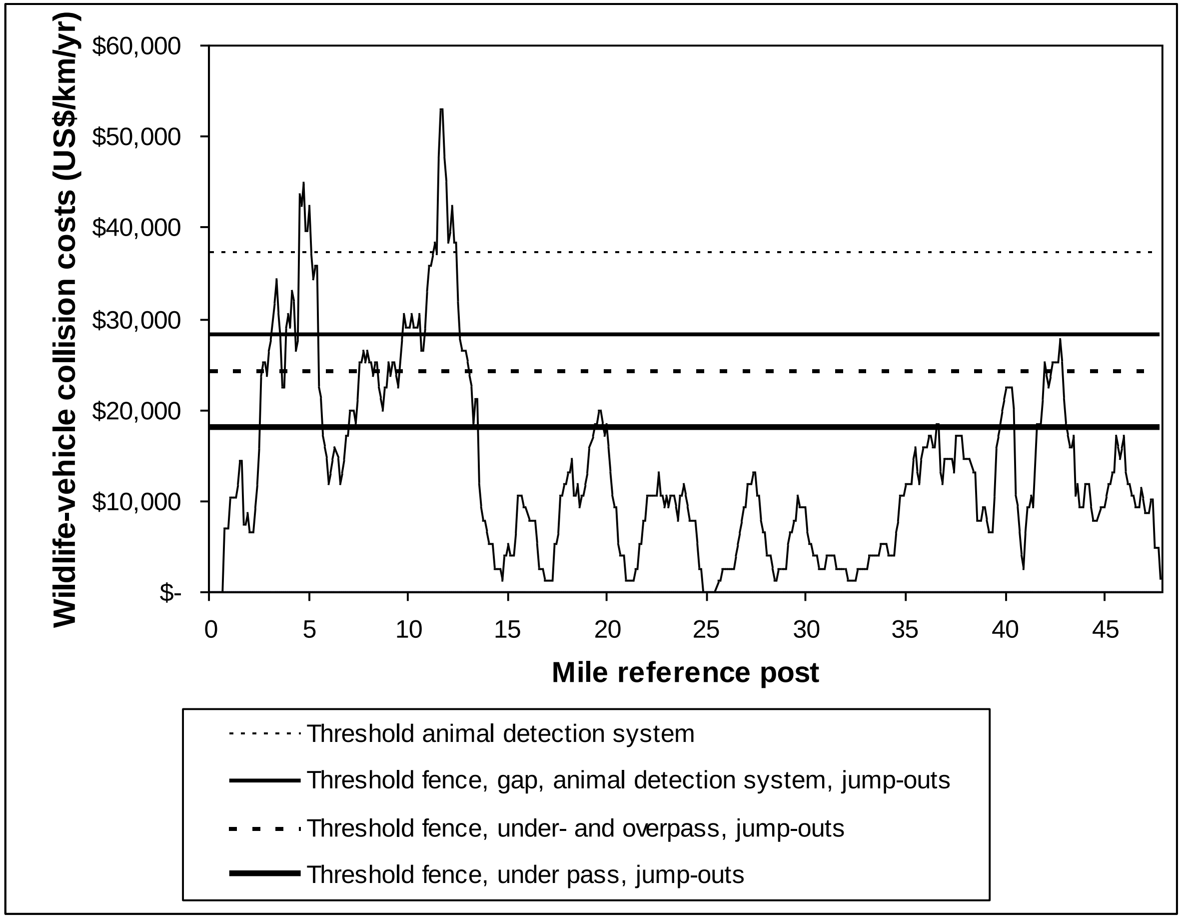
Description	Deer	Elk	Moose
Vehicle repair costs per collision	$2,622	$4,550	$5,600
Human injuries per collision	$2,702	$5,403	$10,807
Human fatalities per collision	$1,002	$6,683	$13,366
Towing, accident attendance and investigation	$125	$375	$500
Hunting value animal per collision	$116	$397	$387
Carcass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

Huijser et al., Ecology and Society, 2009

Cost-benefit analyses

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

Example road section MT Hwy 83, Seeley-Swan Montana



Huijser et al., 2009, Ecology & Society

Thank you!

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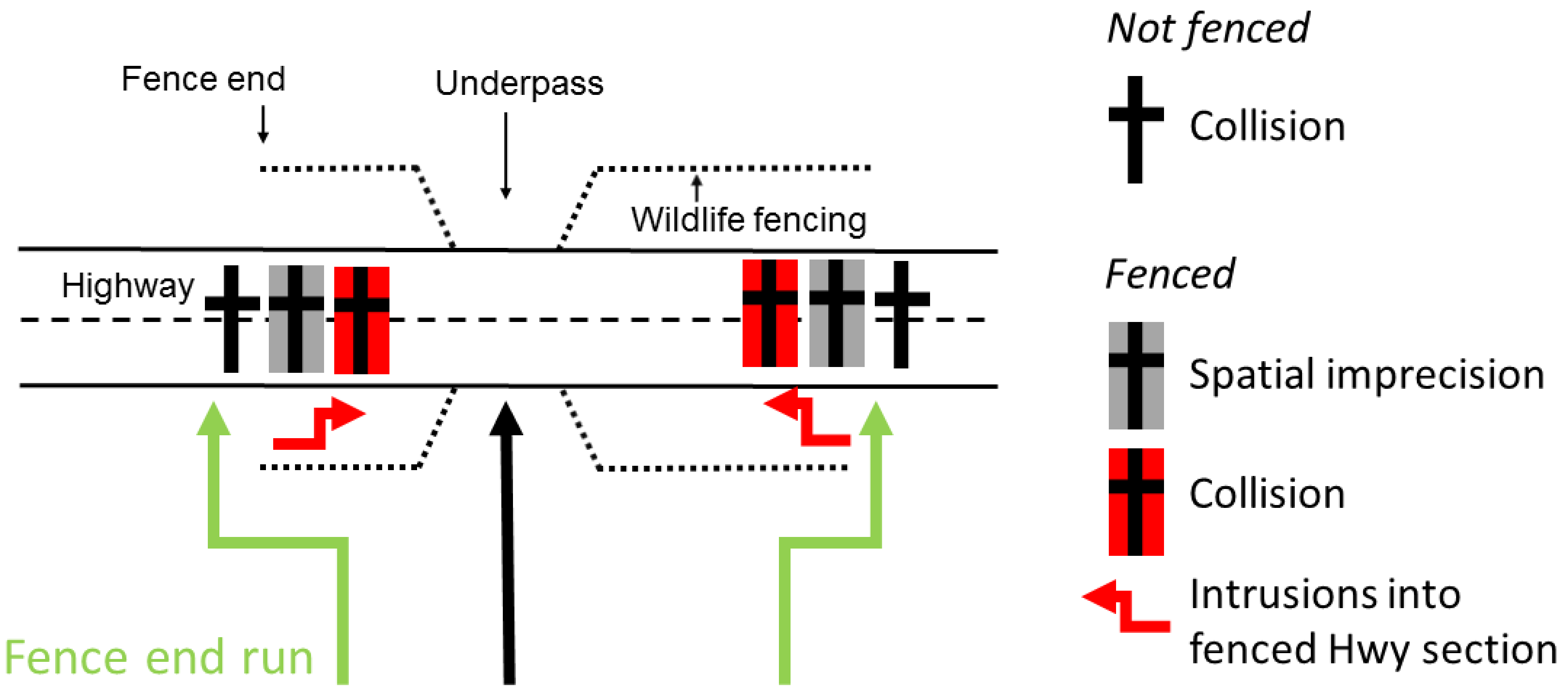
Reducing Wildlife-Vehicle Collisions

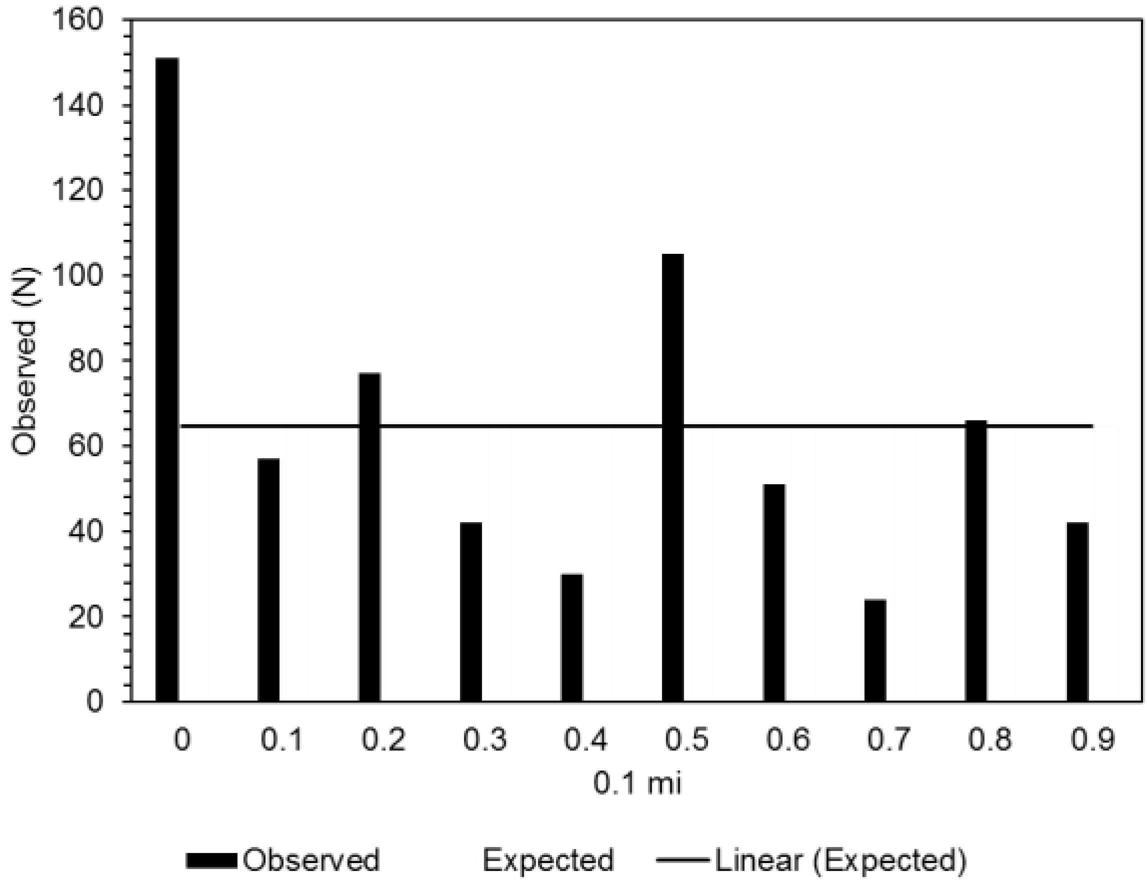
Why lower?

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



Huijser et al. 2016

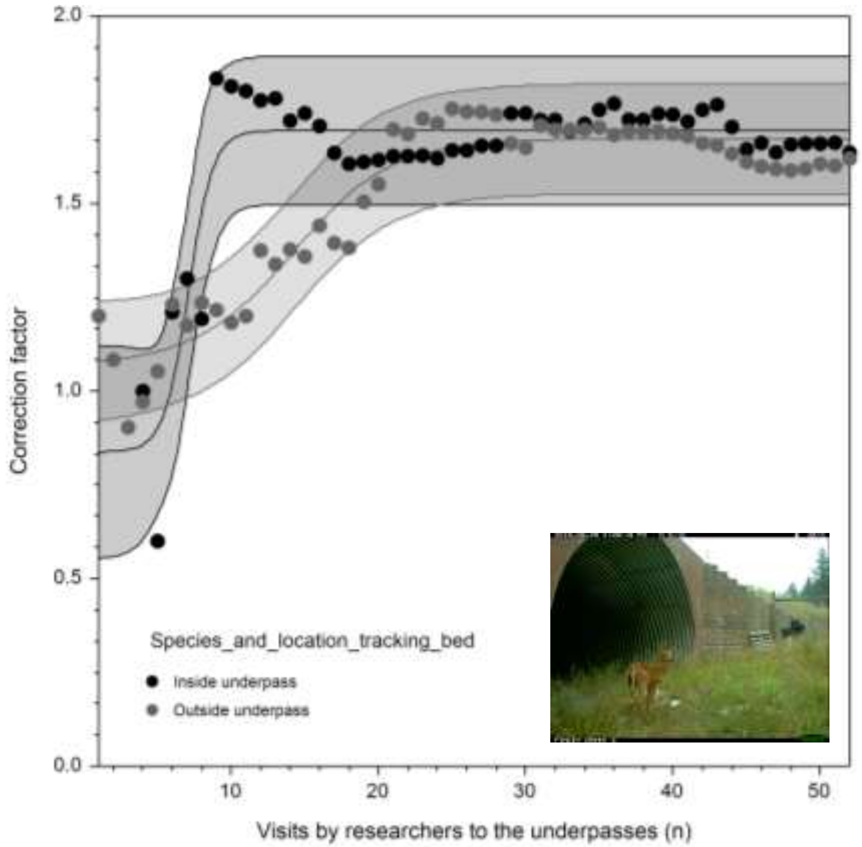
False sense of spatial accuracy



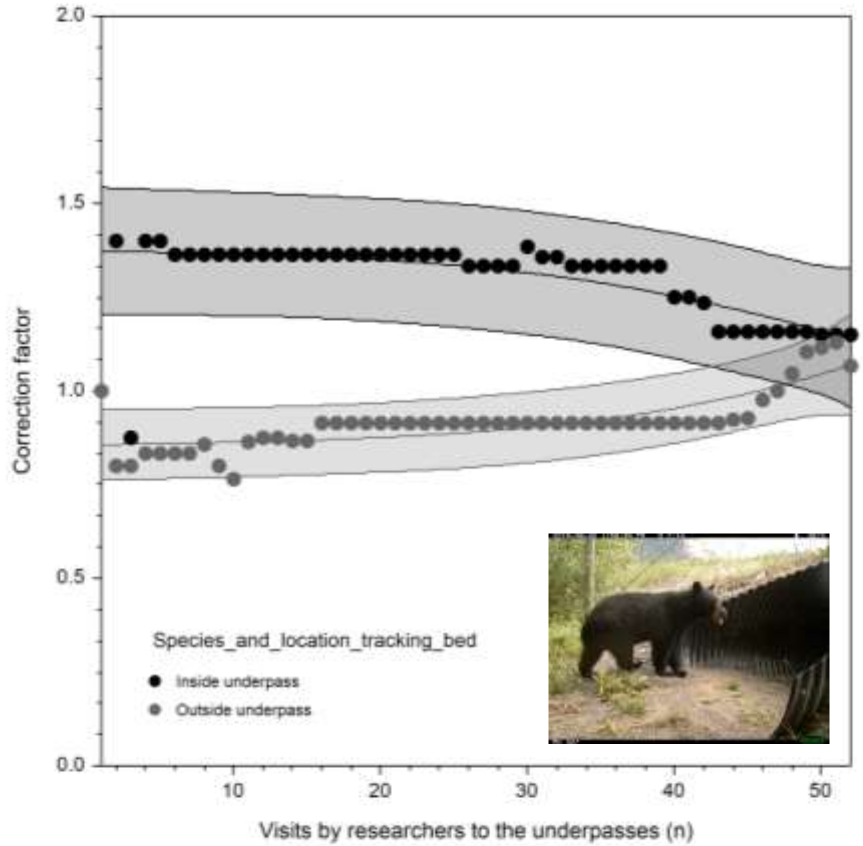
- Not accurate to 0.1 mi
- Real accuracy 0.5 or 1.0 mi
- Base exact location of safe crossing opportunities on other data and field review

Correction Factor
Tracks – Camera Images

Deer: *1.623



Black bear: 1.088



Huijser et al. 2016

Fence End Treatments / Escape

- Especially important for short fenced sections

access roads/ bike paths

- Escape opportunities: Jump-outs

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)

Conclusions

- Road length fences >5 km: 80-100% reduction in collisions with large mammals
- Road length fences ≤5 km: Lower effectiveness, more variable

- 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)

Crossing Structure Types and Dimensions

Overpass
50-70 m wide

Medium mammal
Underpass
1.5-2 m diameter

Over span bridge
>30 m wide
>4-5 m high

Large mammal
Underpass
7 m wide
4-5 m high

Small-medium
Mammal pipe
30-60 cm diameter

Species specific preferences

	Wildlife overpass	Open-span bridge	Large-mammal underpass	Medium-mammal underpass	Small- to medium-mammal pipe
Ungulates					
Deer sp.	●	●	●	⊗	⊗
Elk	●	●	●	⊗	⊗
Moose	●	●	○	⊗	⊗
Mountain goat	●	●	○	⊗	⊗
Bighorn sheep	●	●	○	⊗	⊗
Pronghorn	●	○	○	⊗	⊗
Carnivores					
Weasel	●	●	○	●	●
Pine marten	●	○	○	●	●
Fisher	●	●	○	⊗	⊗
Striped skunk	●	●	●	●	●
Badger	●	●	●	?	?
Wolverine	●	●	?	?	⊗
Bobcat	●	●	●	●	●
Canada lynx	●	●	?	?	⊗
Cougar	●	●	●	⊗	⊗
Fox1 (*V. vulpes, Urocyon*)	●	●	●	●	●
Fox2 (*V. macrotis, V. velox*)	●	●	○	?	?
Coyote	●	●	●	●	●
Wolf	●	●	○	⊗	⊗
Black bear	●	●	●	⊗	⊗
Grizzly bear	●	●	○	⊗	⊗

● Recommended/Optimum solution
○ Possible if adapted to local conditions
⊗ Not recommended
? Unknown, more data are required

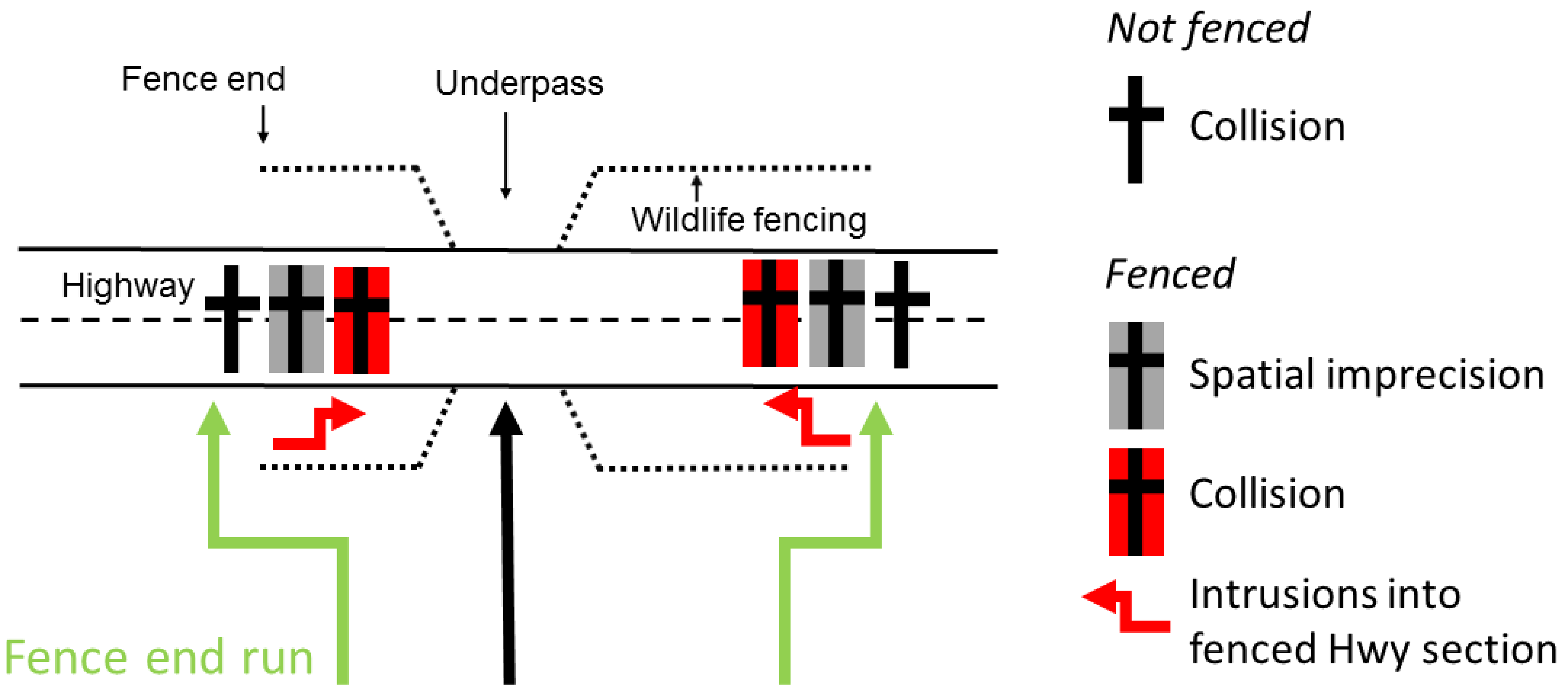
Huijser et al. 2008

MONTANA STATE UNIVERSITY

Reducing Wildlife-Vehicle Collisions

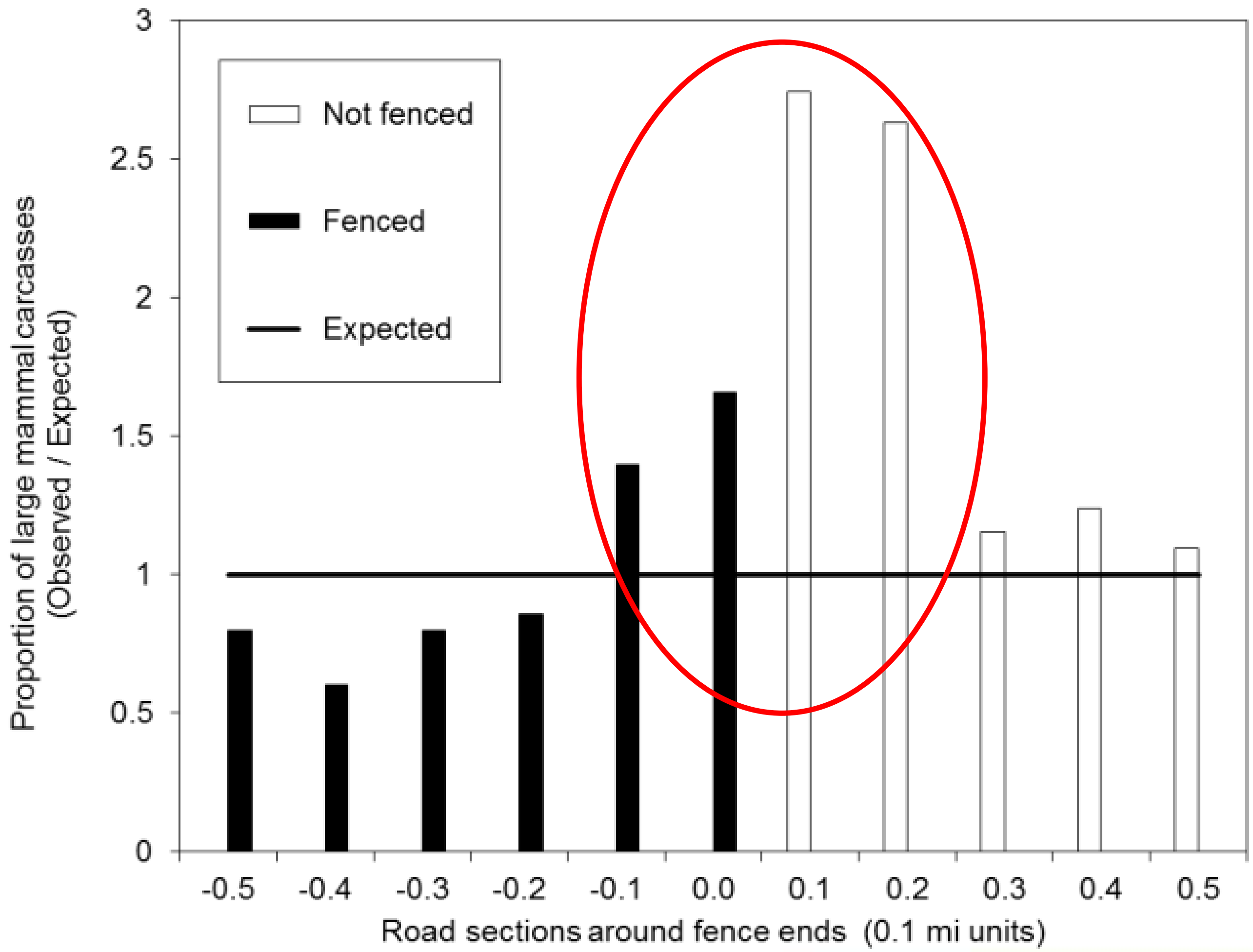
Why lower?

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



Huijser et al. 2016

Reducing Wildlife-Vehicle Collisions



Fence end effect is indeed present

Huijser et al. 2016

Reducing Wildlife-Vehicle Collisions

Why more variable?

Local situation fence ends always different

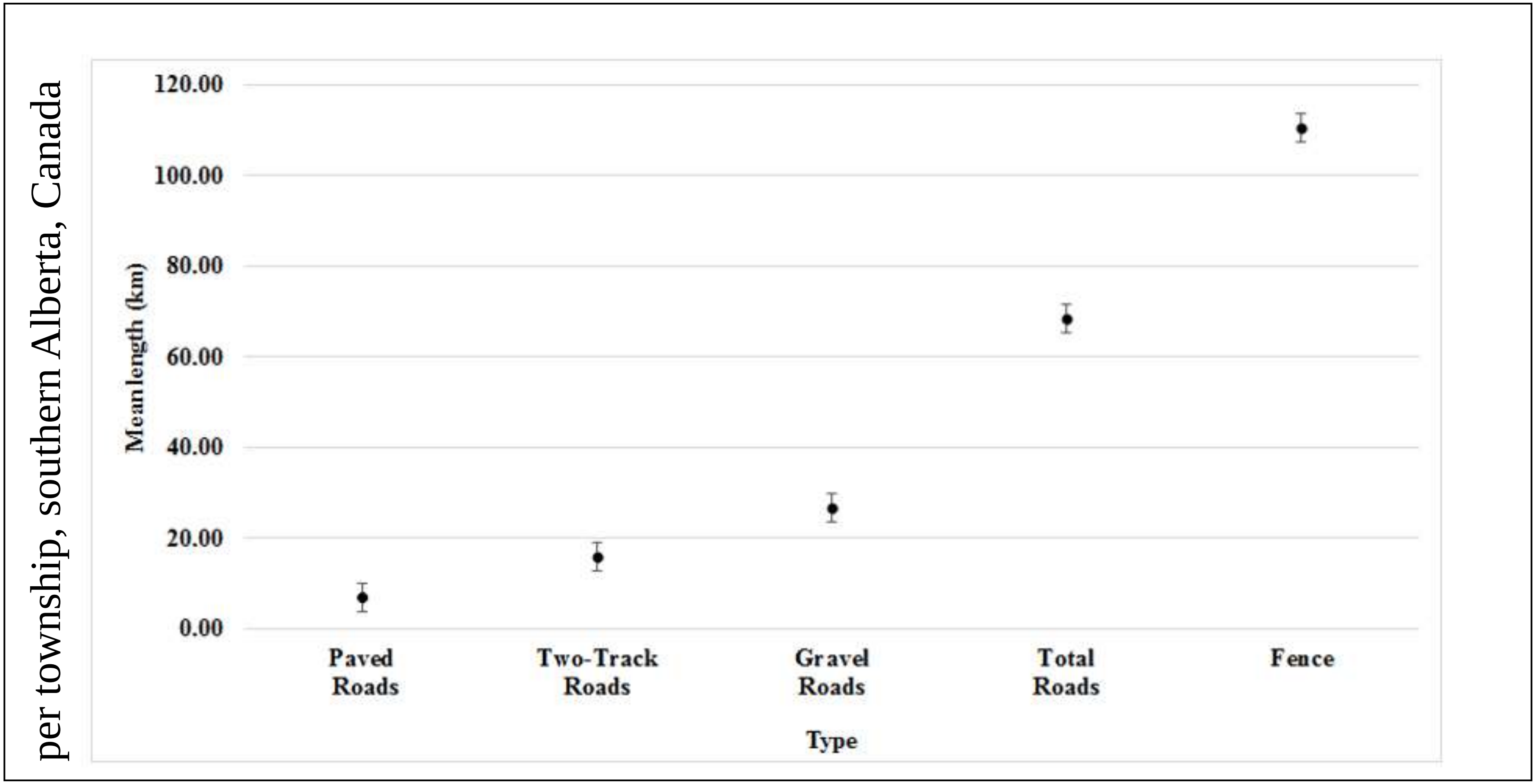
Short fences (<5 km):
Fence end effect immediately noticeable in overall effectiveness

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

Unnatural Linear Landscape Elements

- Roads
- Powerlines
- Pipelines
- Canals
- Fences

Fences vs. Roads

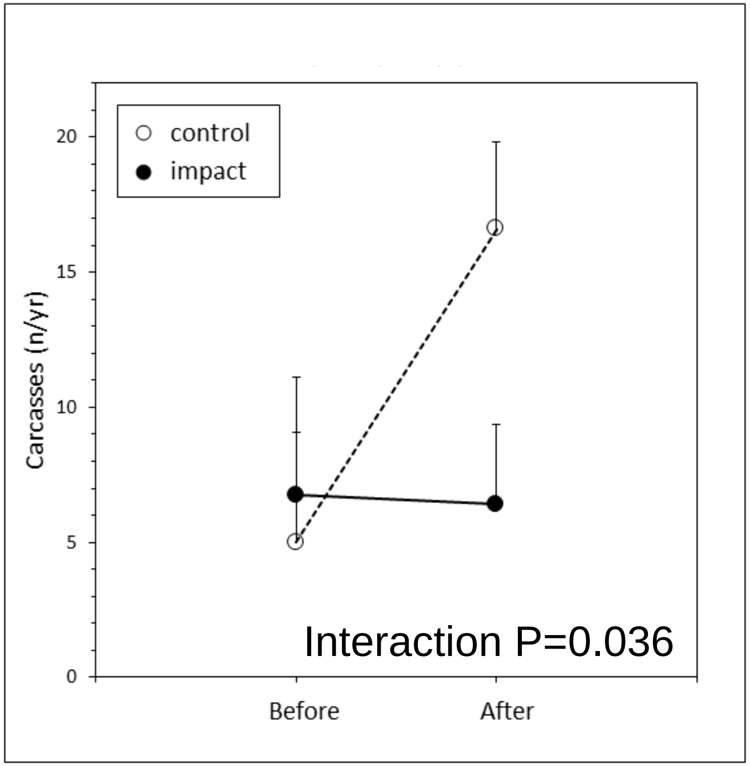


Jakes et al, in prep.

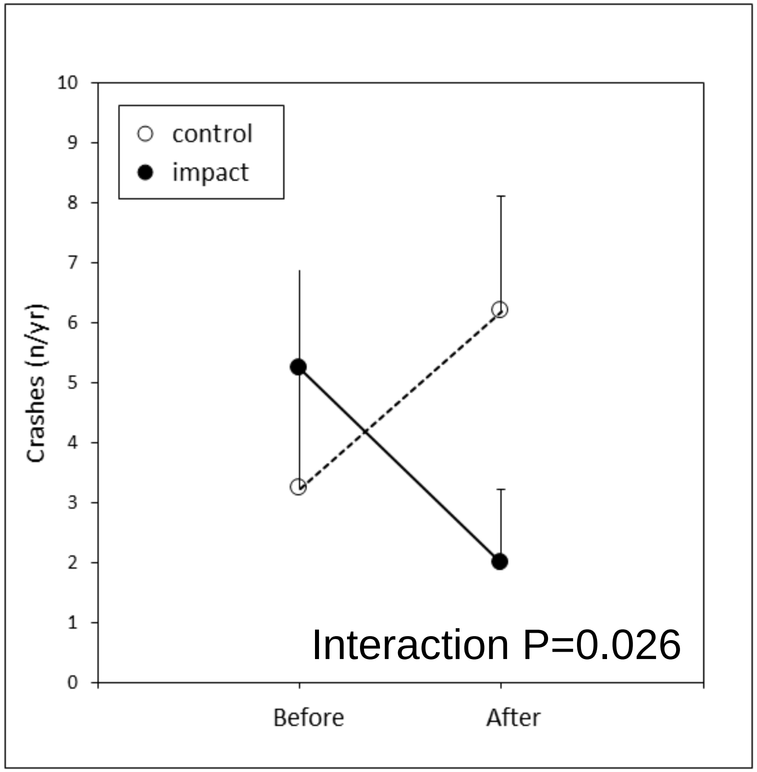
Effectiveness Fences

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 wildlife mitigation measures)

Carcass data: -71%

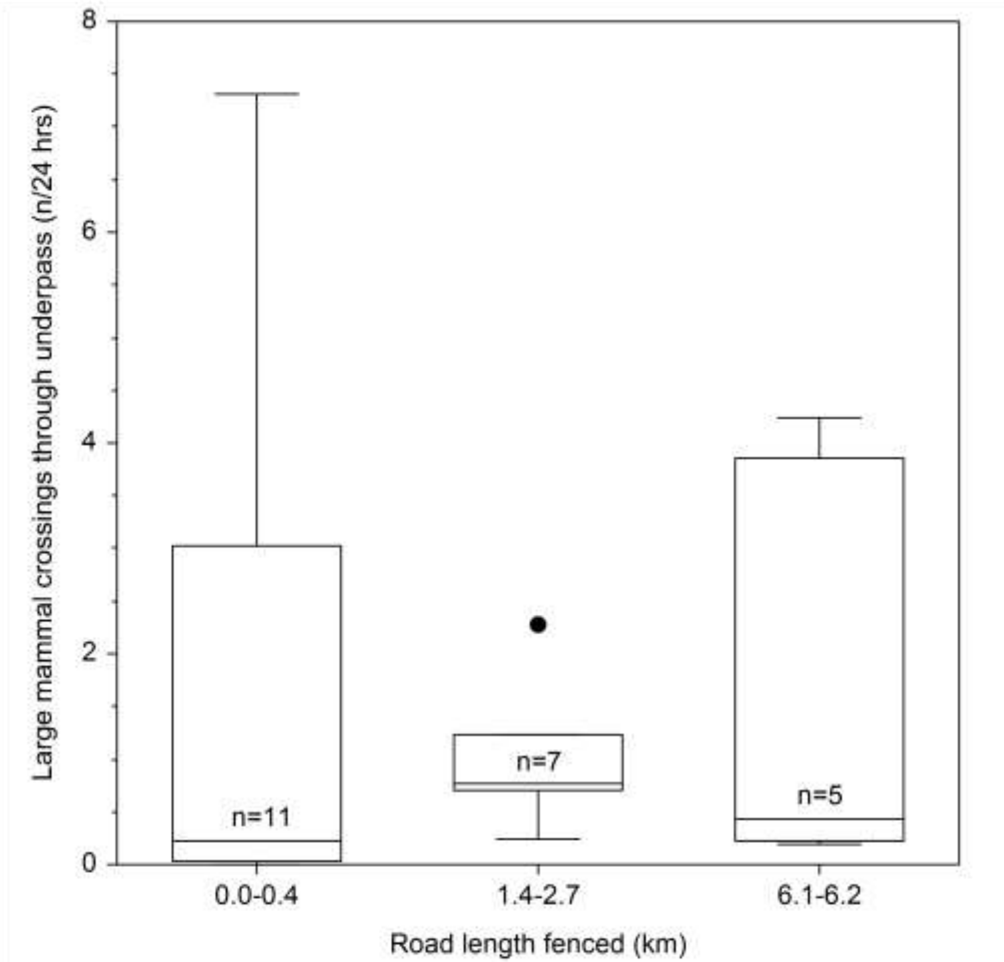


Wildlife-crash data: -80%



Huijser et al. 2016

Safe Crossing Opportunities for Wildlife



Huijser et al., 2016, Biological Conservation

- 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?

Where Are We?

Positive

- Huge increase in knowledge
- Mitigation measures implemented

Reduced collisions, improved human safety

Safe crossing opportunities provided

Can make economic sense

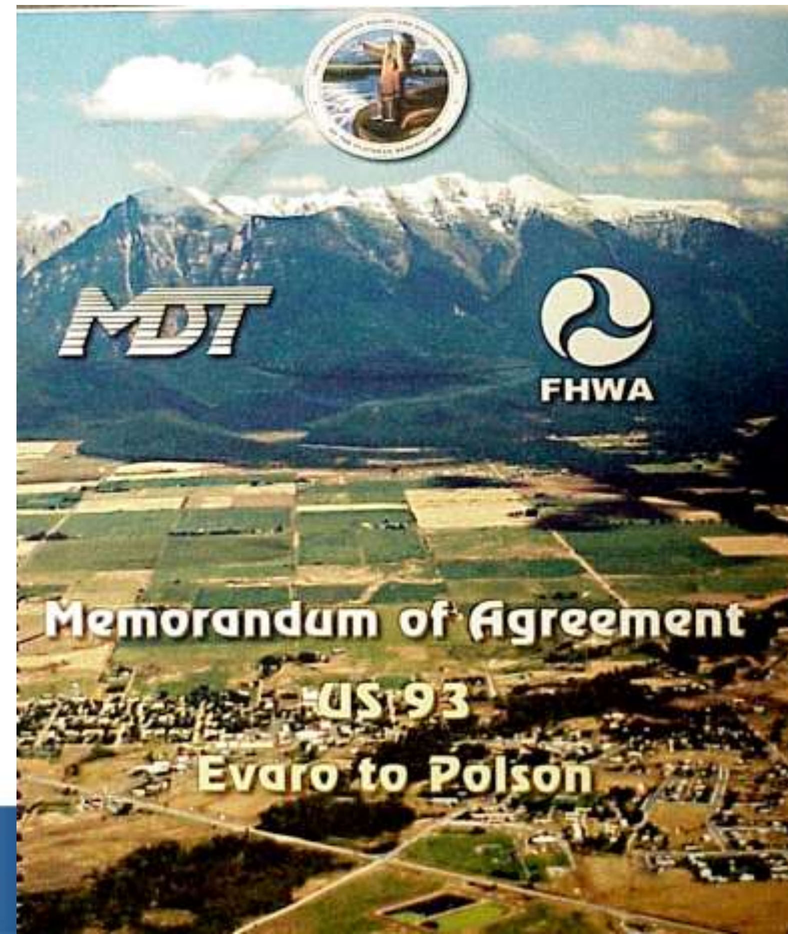
Are we doing it all wrong?


© Marcel Huijser

US93 North, Flathead Indian Reservation, MT

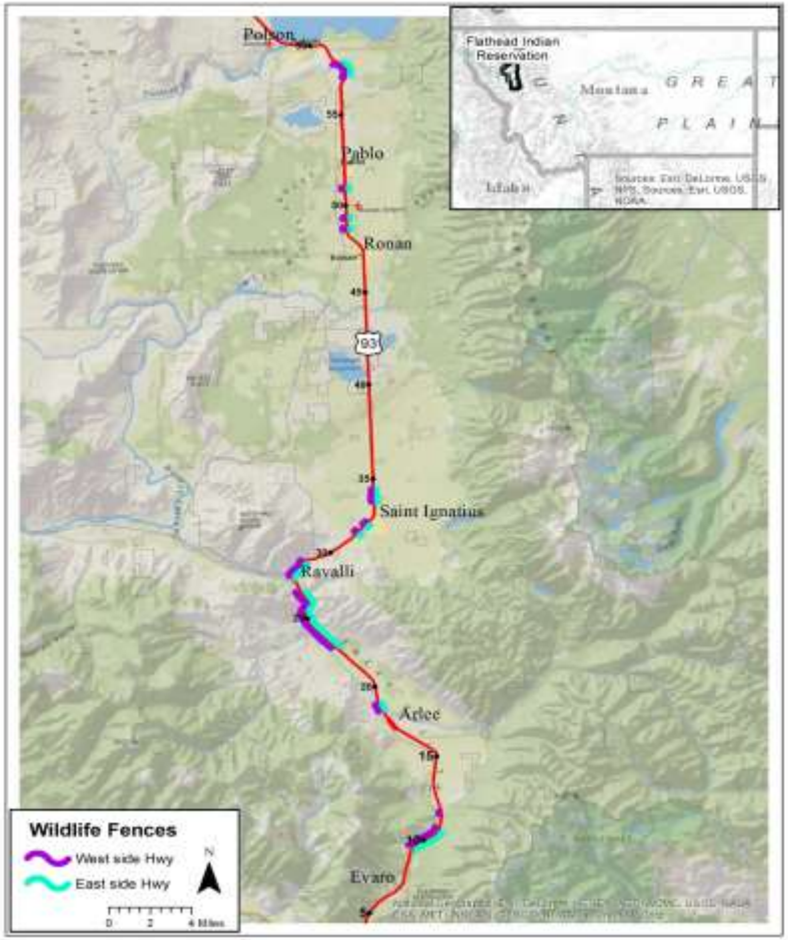
- “Road is a visitor”
- Respectful to land
- Respectful to “Spirit of the place”
- Cultural values
- Natural resources

- Agreement reconstruction: 2000
- Research 2002-2016



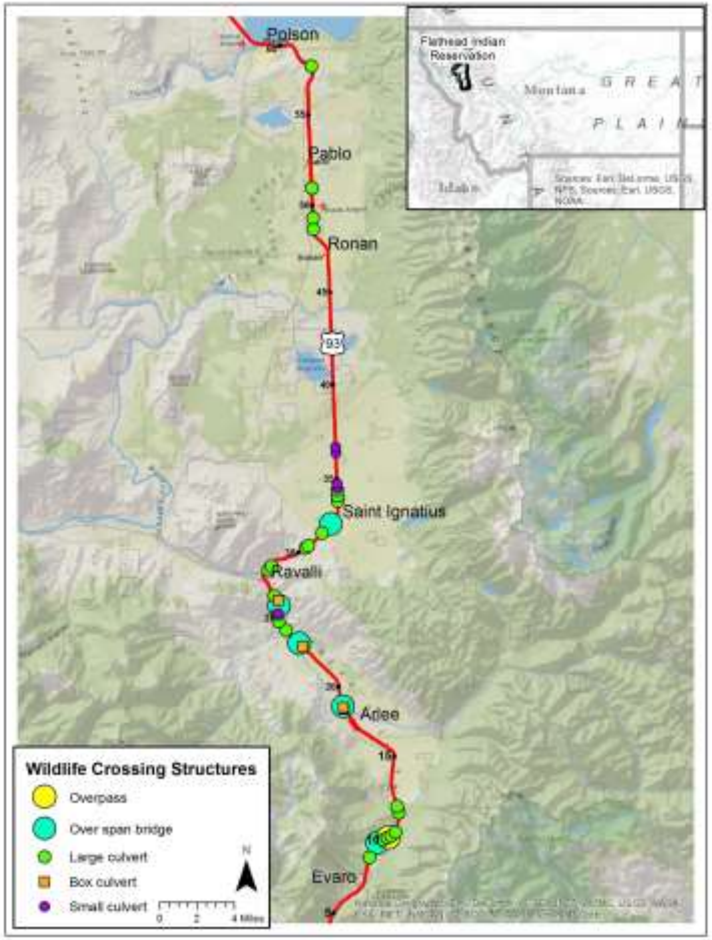
Fences

8.71 road miles (14.01 km)



Crossing structures

39 locations



Fences

Functions:

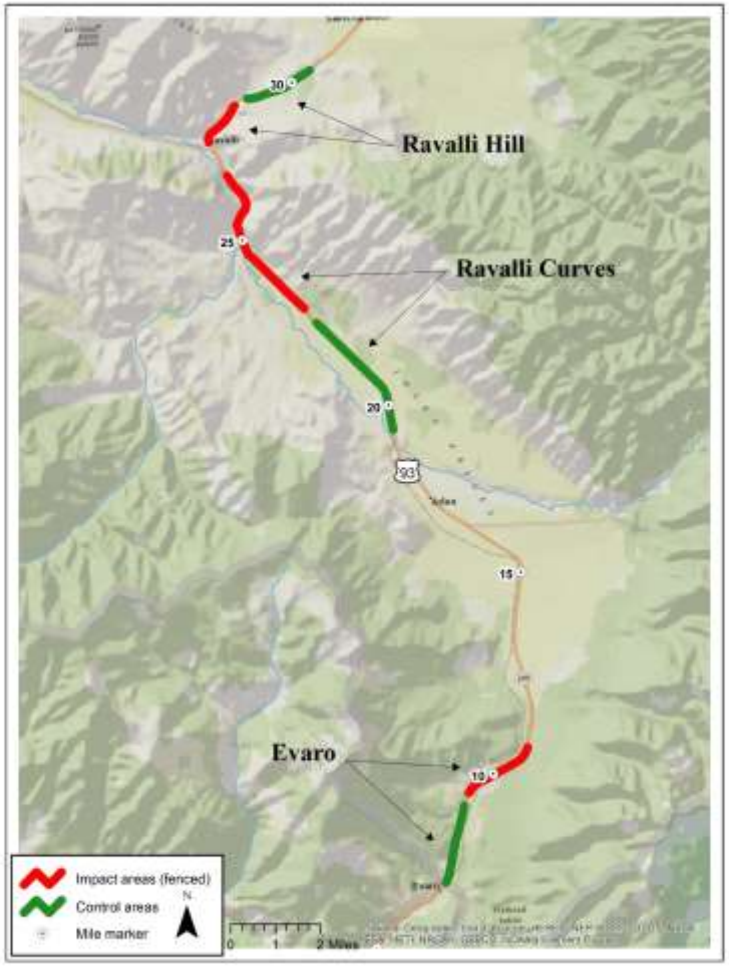
1. Keep wildlife from accessing the highway
2. Help guide wildlife towards the safe crossing opportunities

Crossing Structure Types and Dimensions

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

BACI Study Design



- 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 wildlife mitigation measures)

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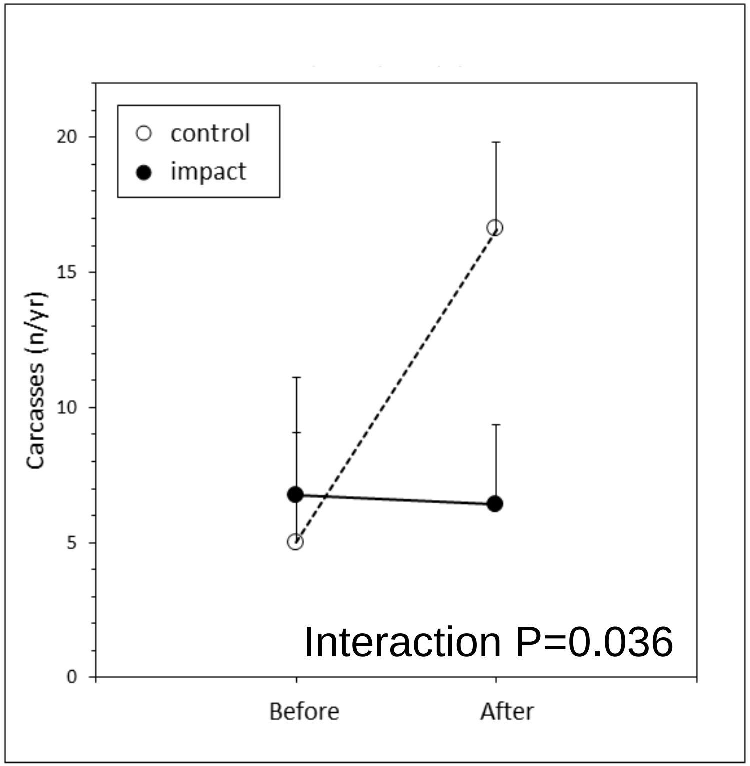

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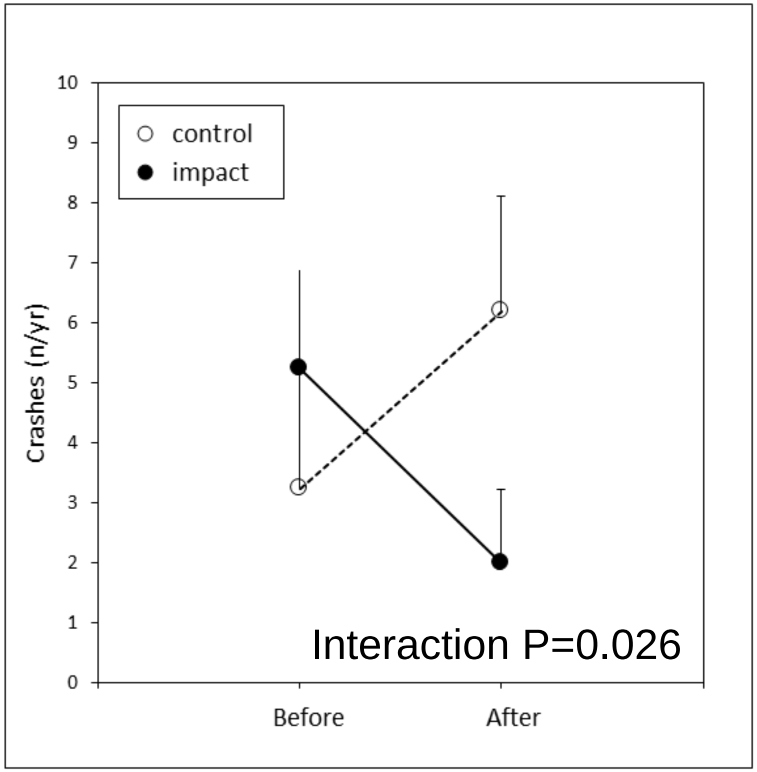
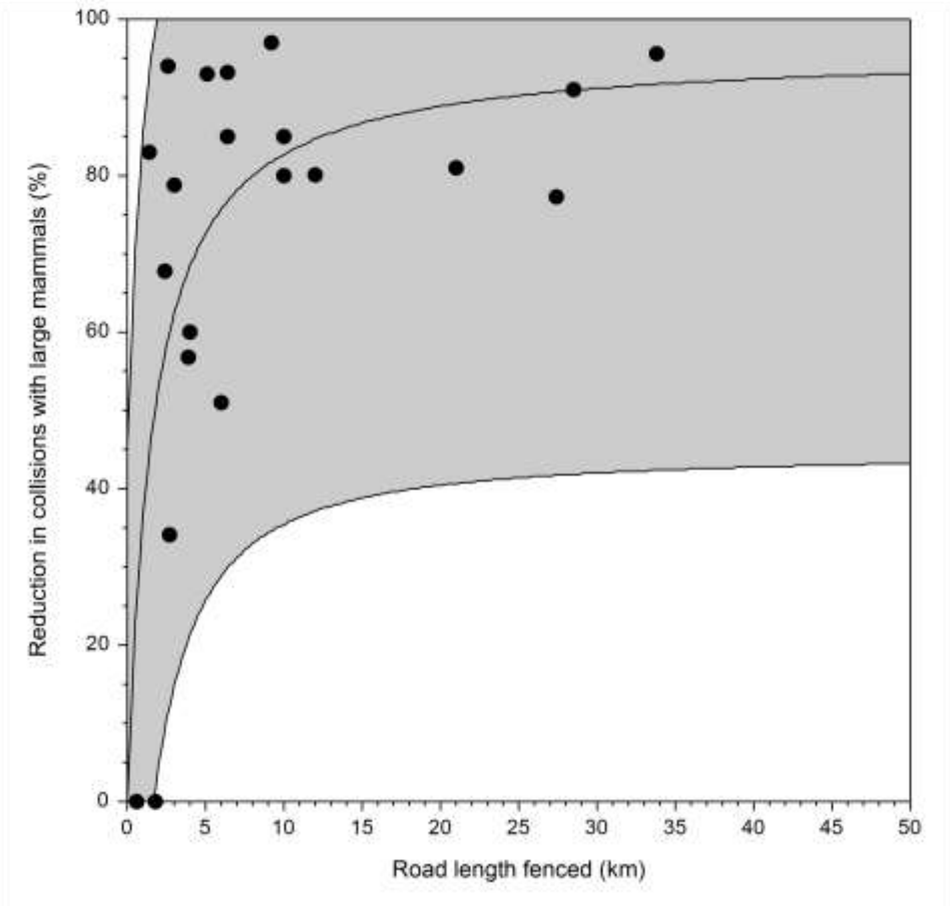


Huijser et al. 2016

Reducing Wildlife-Vehicle Collisions

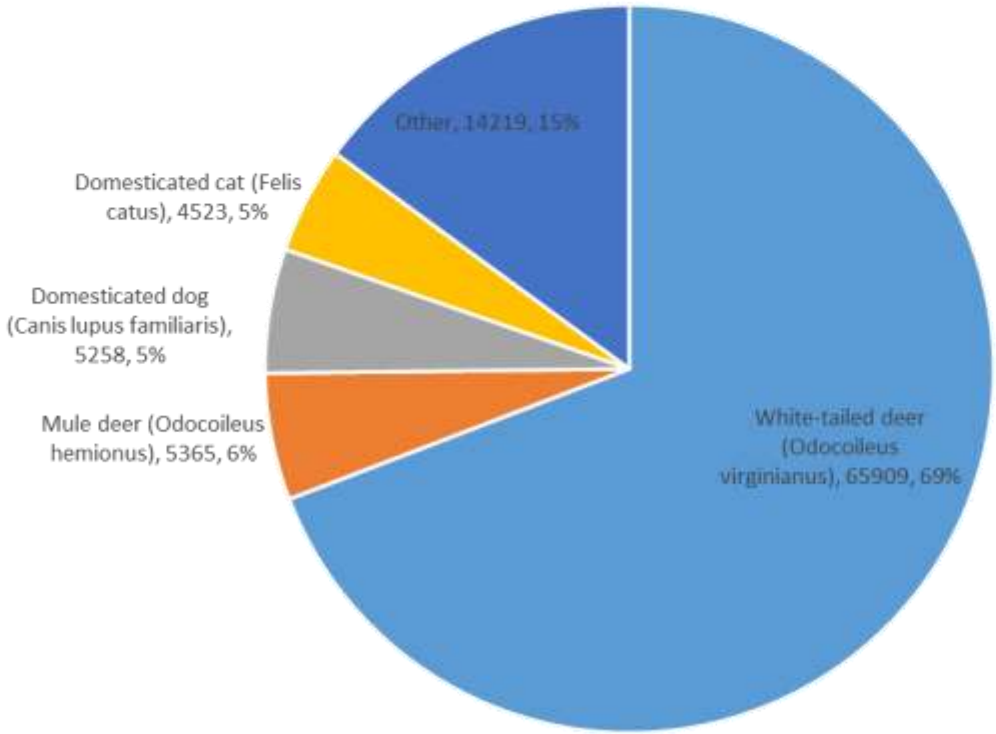


Huijser et al., 2016, Biological Conservation

< 5 km 52.7%
range 0-94%

> 5 km: typically > 80%

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

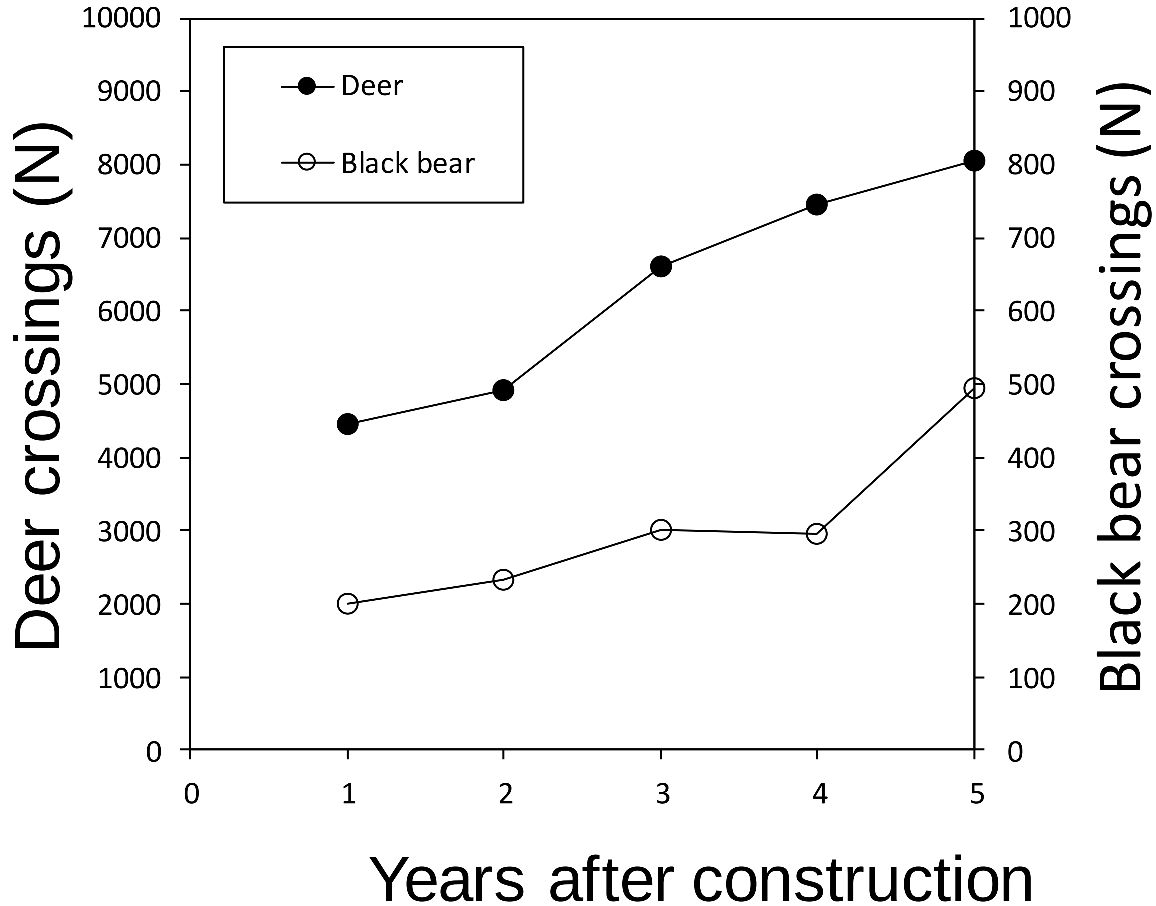
Huijser et al. 2016

Sample Use Underpasses

MONTANA STATE UNIVERSITY | College of ENGINEERING

Courtesy of CSKT, MDT and WTI-MSU

Learning Curve



Huijser et al. 2016

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

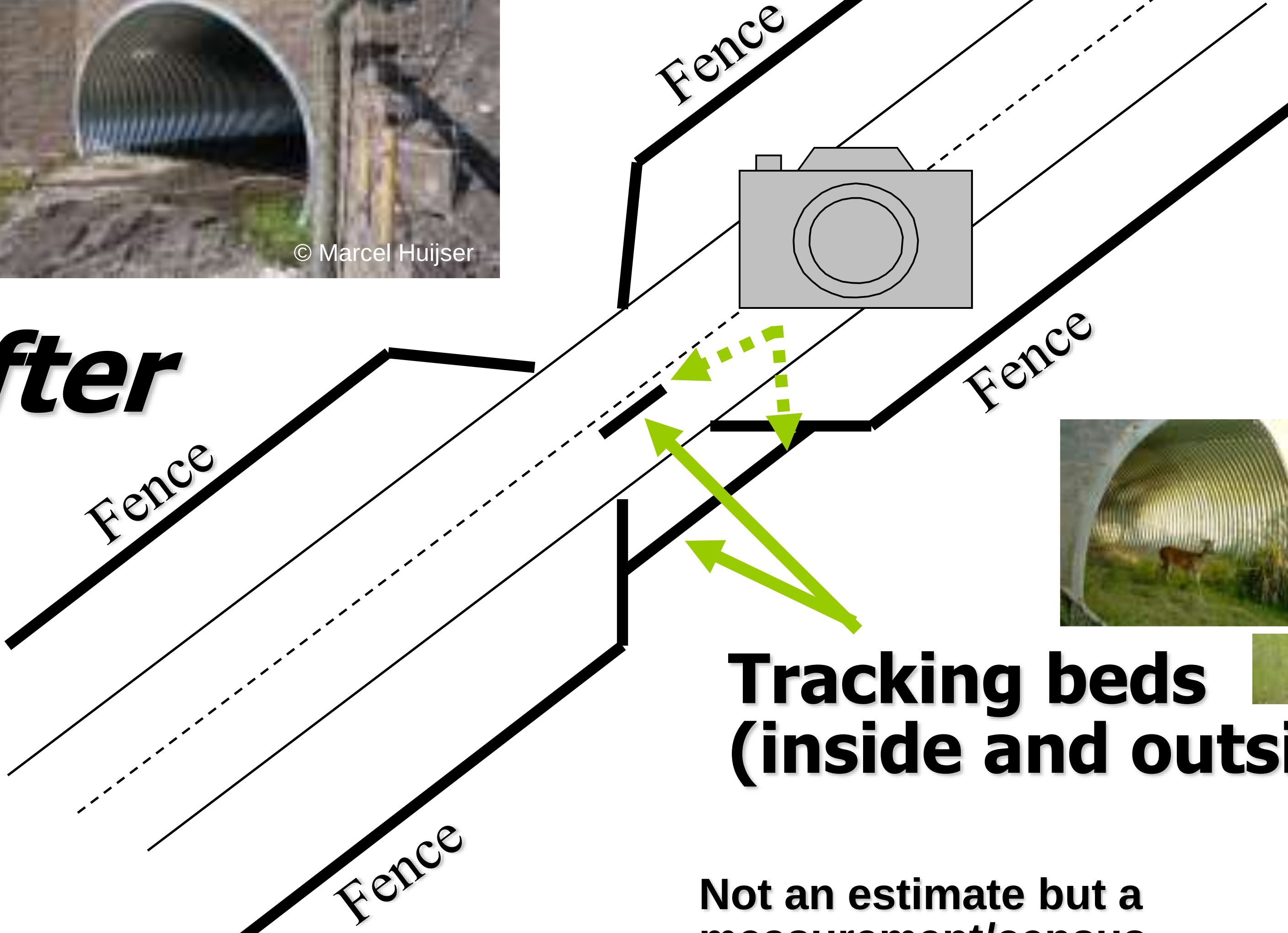
Black bear

Deer

Twice a week

Jun-Oct

After



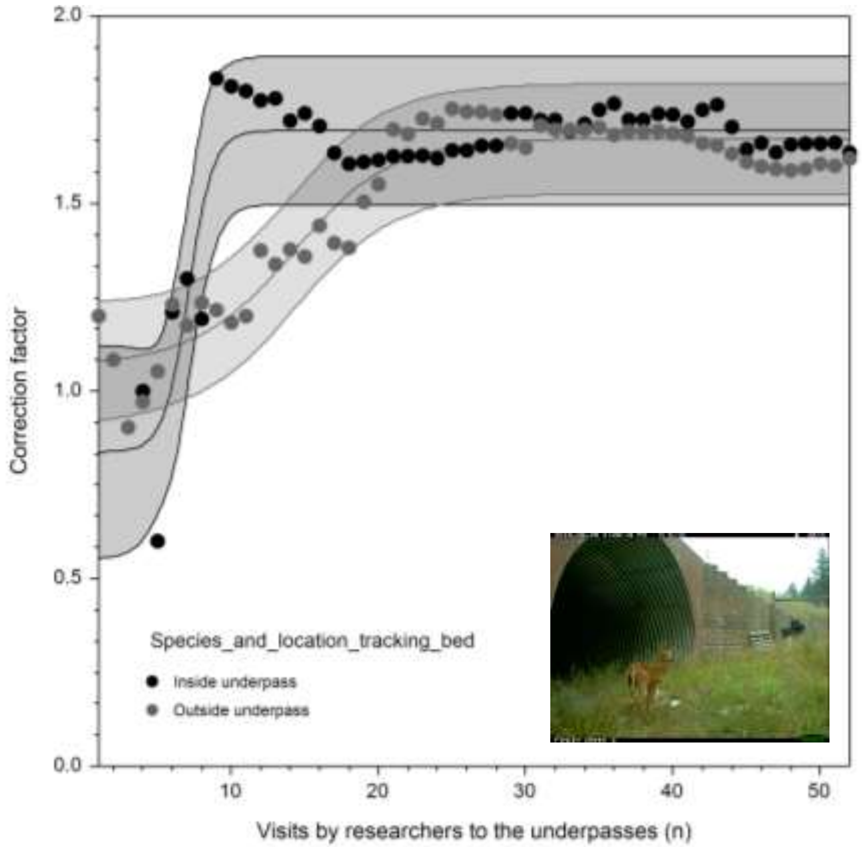
Tracking beds (inside and outside)

Not an estimate but a measurement/census

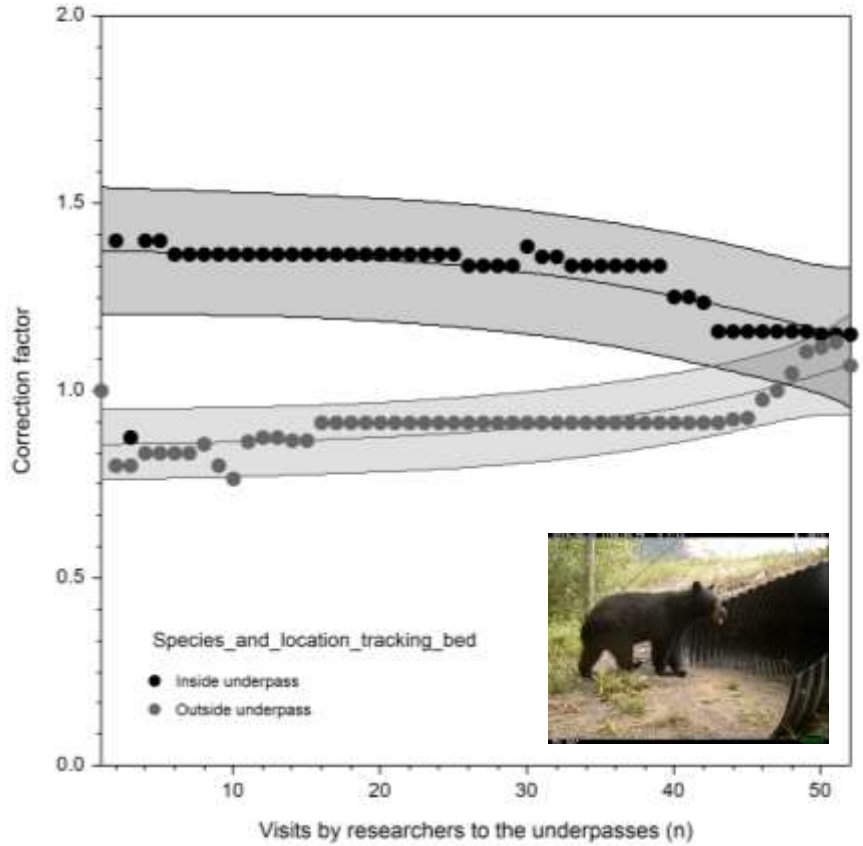
Correction Factor

Tracks – Camera Images

Deer: *1.623

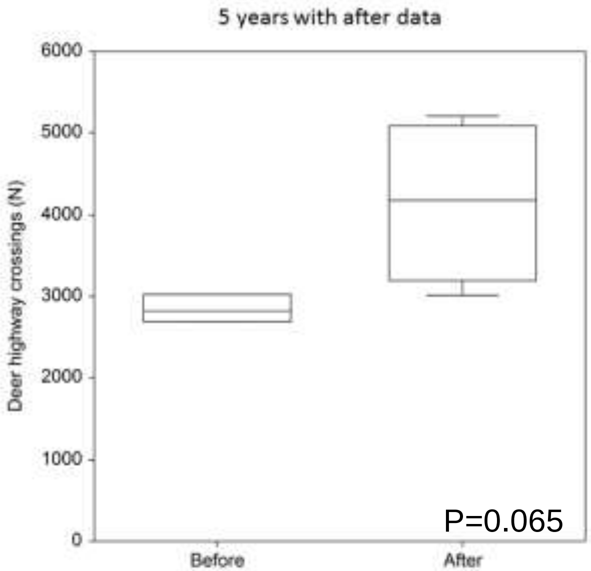


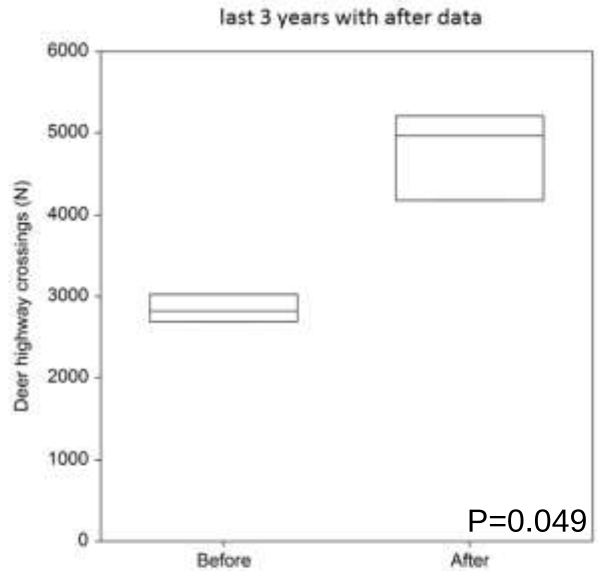
Black bear: 1.088



Huijser et al. 2016

Habitat Connectivity: Deer

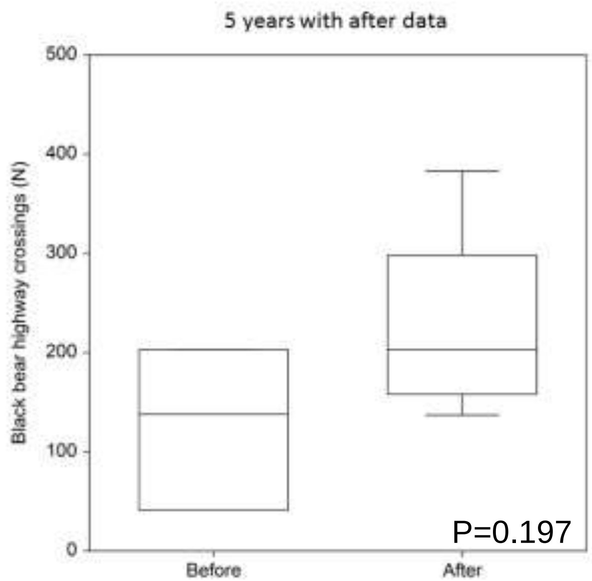


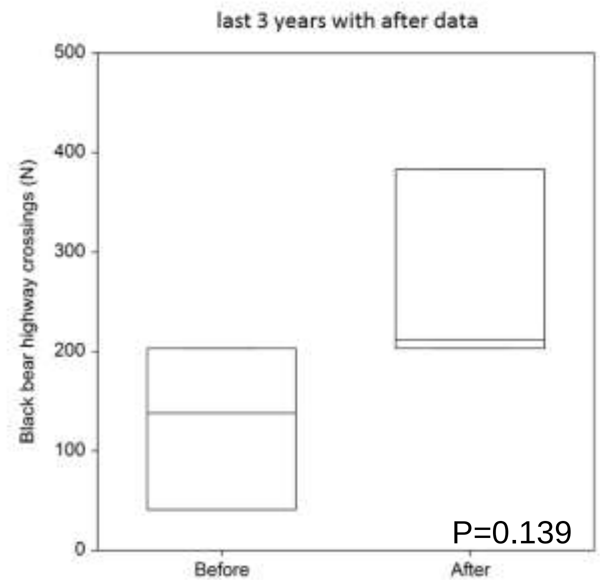





Huijser et al. 2016

Habitat Connectivity: Black bear








Huijser et al. 2016

Conclusions

- Road length fences >5 km: 80-100% reduction in collisions with large mammals
- Road length fences ≤5 km: Lower effectiveness, more variable

- 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)

Thanks!

Funding:

- Montana Department of Transportation
- Federal Highway Administration
- B and B Dawson Fund
- University Transportation Center program

Help:

- MDT: Access to the right of way
- Confederated Salish Kootenai Tribes: advocating for mitigation measures, permission to conduct research on tribal lands

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