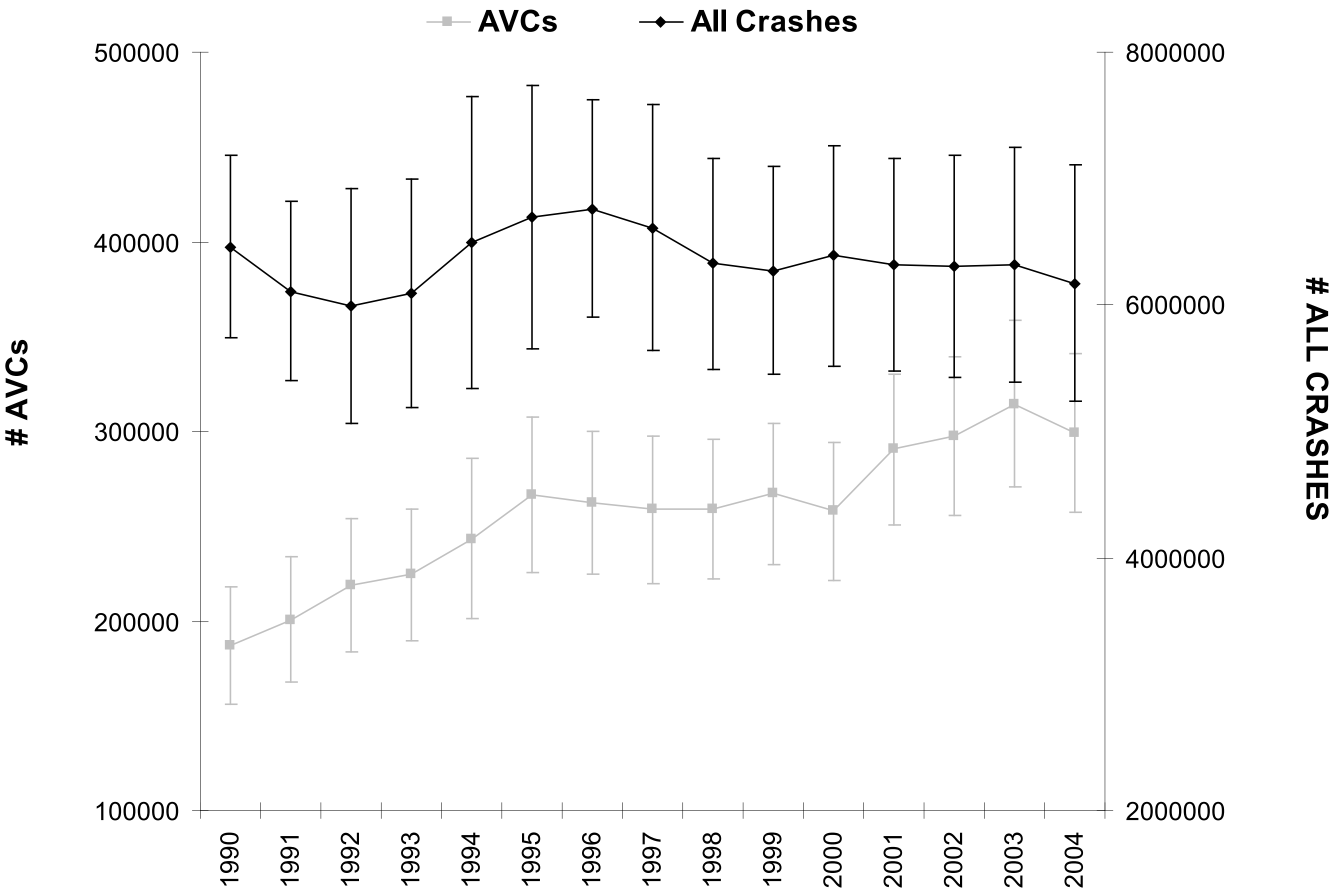
Road Ecology: What Do We Know?

Marcel P. Huijser, PhD

Human Safety



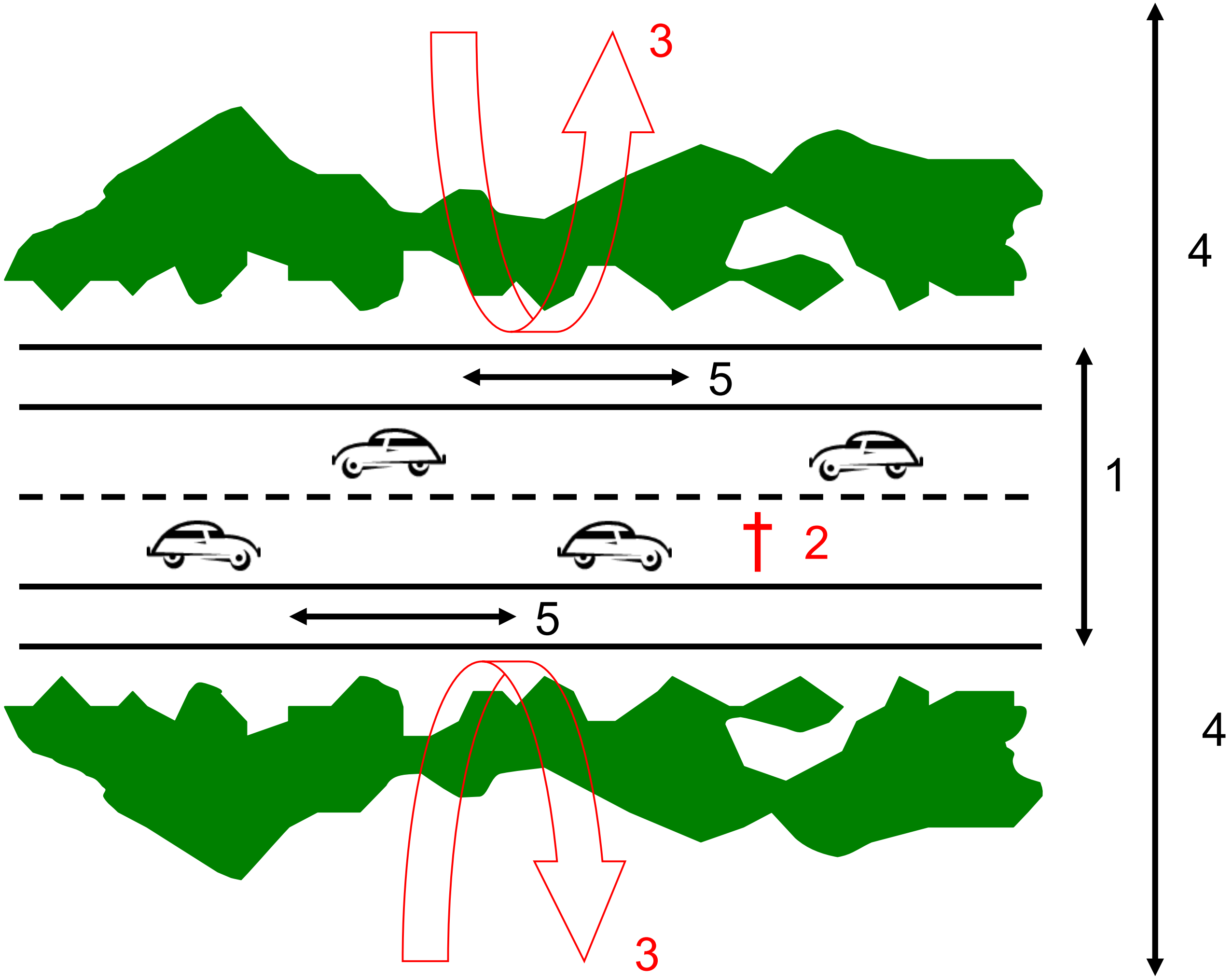
1-2 million large mammal-vehicle collisions/yr

Human injuries:
N ~ 29,000/yr

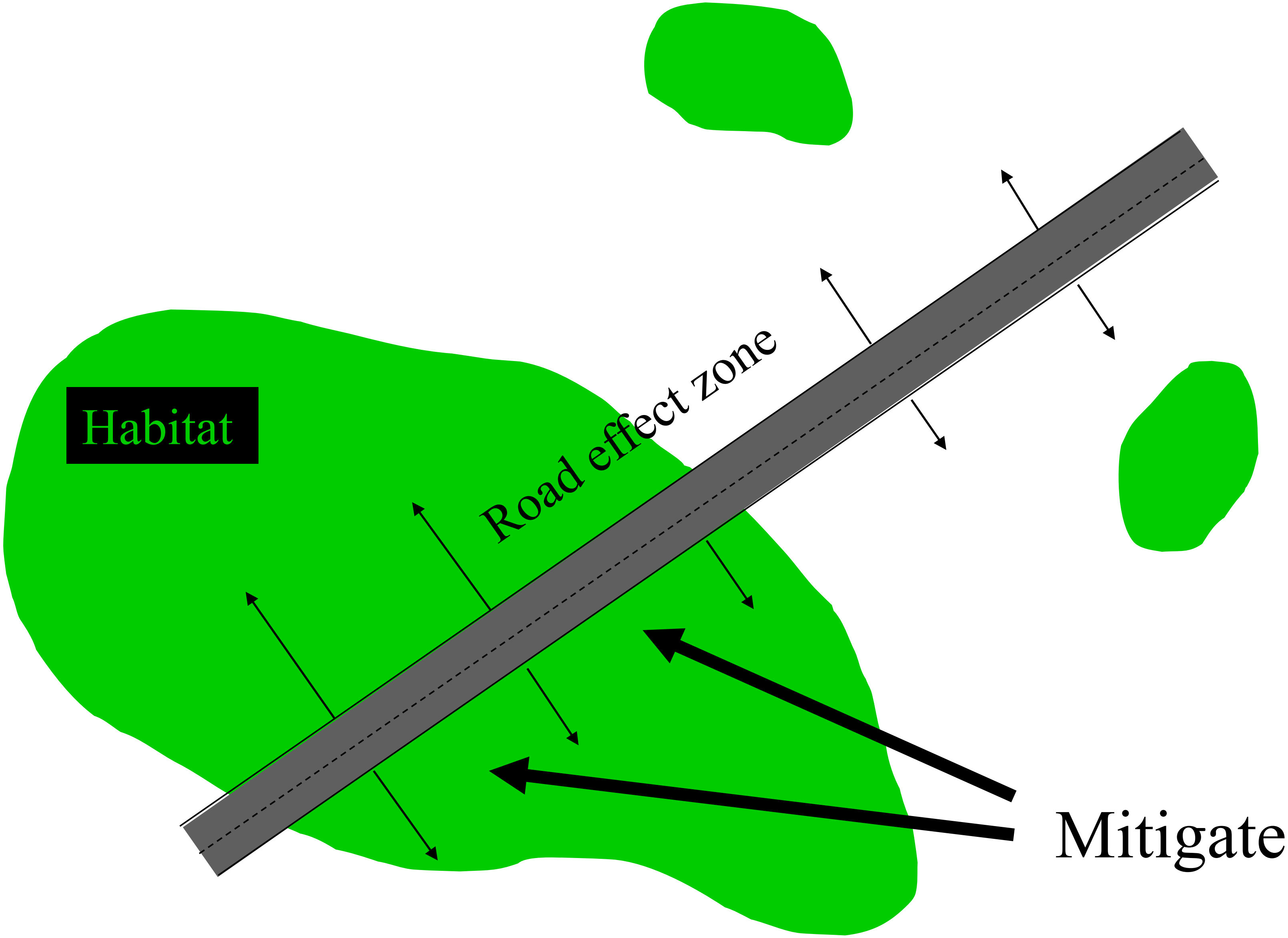
Human fatalities:
N ~211/yr

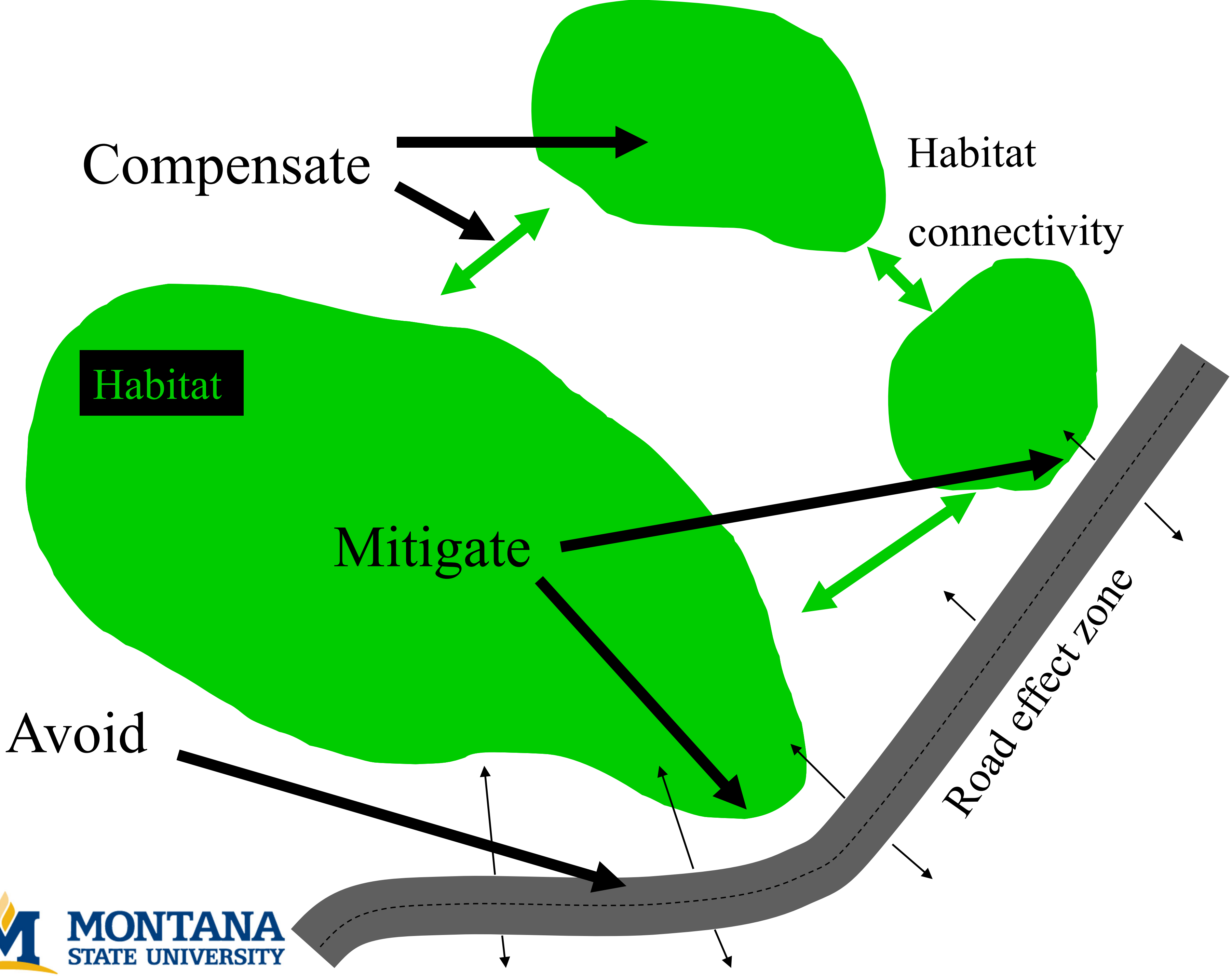
Huijser et al., 2008

Ecological Impacts Roads and Traffic



1. Loss of wildlife habitat
2. Road mortality
3. Barrier effect
4. Decrease in habitat quality (disturbance, pollution)
5. Ecological function of verges


Habitat
Road effect zone
Mitigate



Compensate

Habitat connectivity

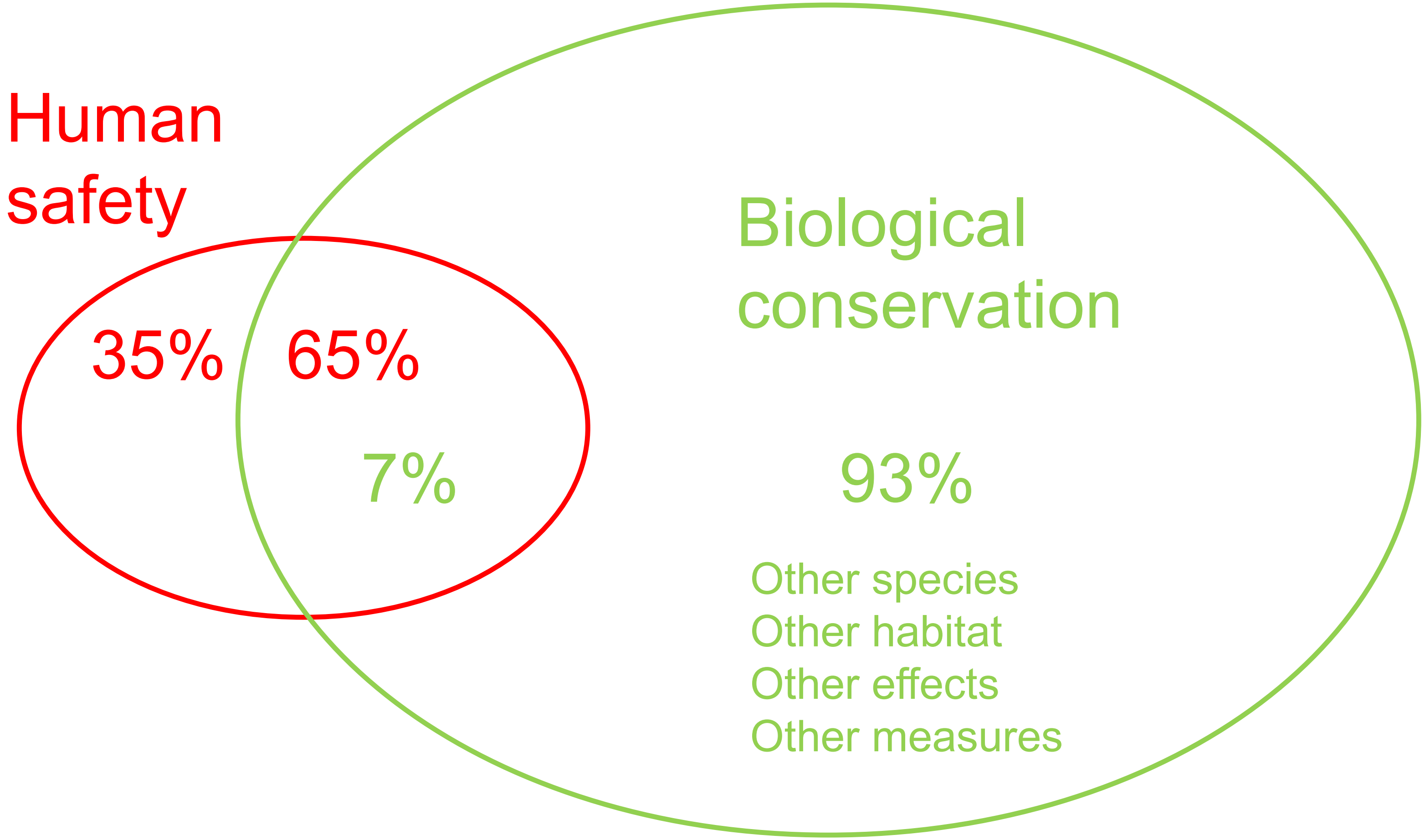
Habitat

Mitigate

Road effect zone

Avoid

Departure Point Matters!


Human safety

35%

65%

7%

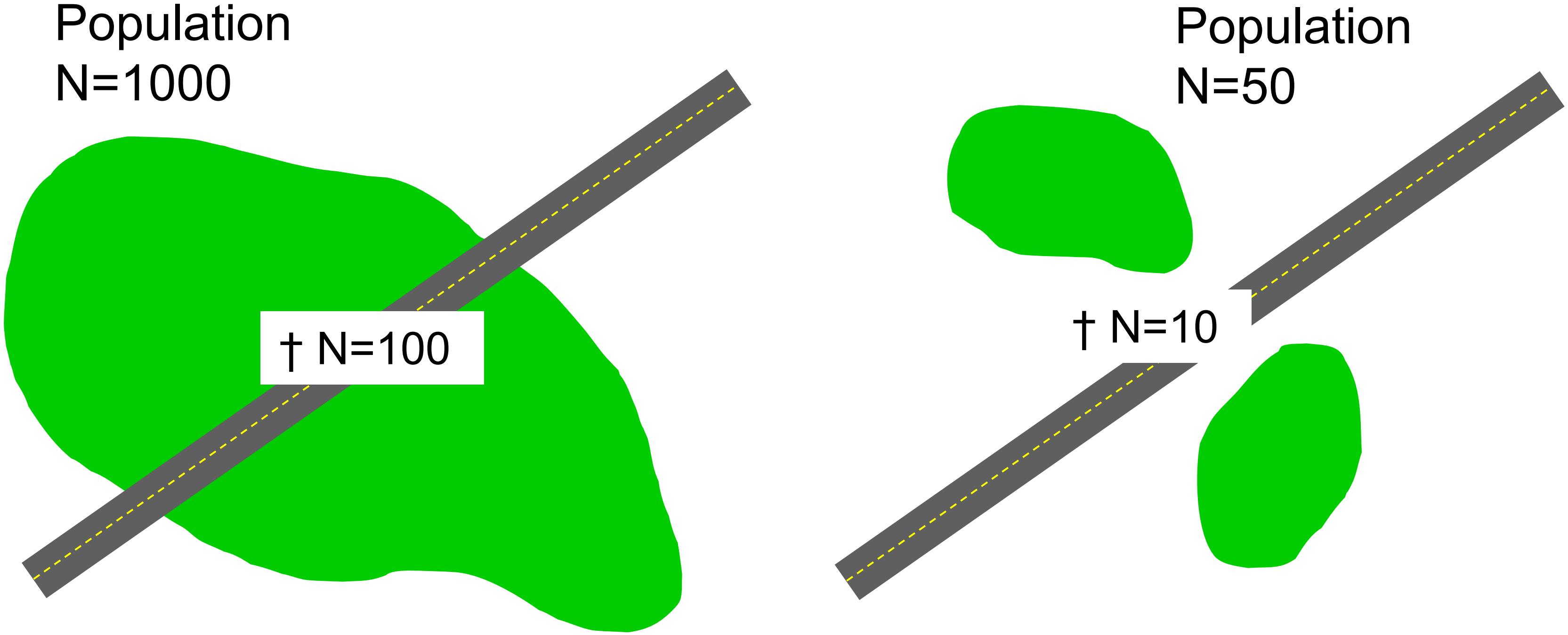
Biological conservation

93%

Other species
Other habitat
Other effects
Other measures

Hwy 2, Montana (Huijser & Begley, 2016)

Collision reduction for human safety
vs.
Mortality reduction for conservation



Population
N=1000

† N=100

Population
N=50

† N=10

… But we mostly focus on: human safety / reducing collisions

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

“We” Want ….

- Warning signs
- Vehicle speed reduction

Wildlife Warning Signs

- Standard ✗

- Enhanced ✗

- Temporary ✗ ✓

Huijser et al., 2015

- Animal detection system ✓

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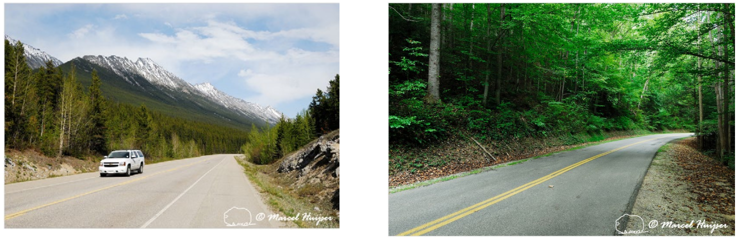
Reduce Posted Speed Limit

- Design speed

Lane and shoulder width, curvature, sight distance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- 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

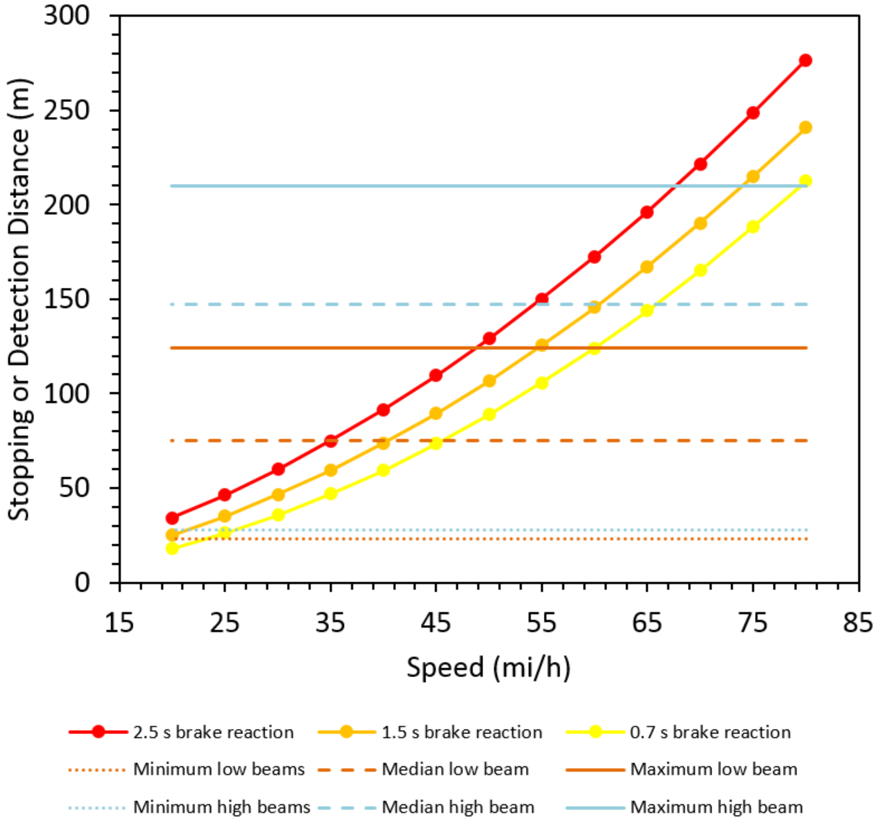


Figure 7. Stopping Distances and Detection Distances for Large Mammals (For more details on methods see Huijser et al., 2017)

Stopping distance
=

Reaction time (distance)
+
Braking distance

- Reducing speed typically not suitable for highways
- Perhaps suitable for park roads

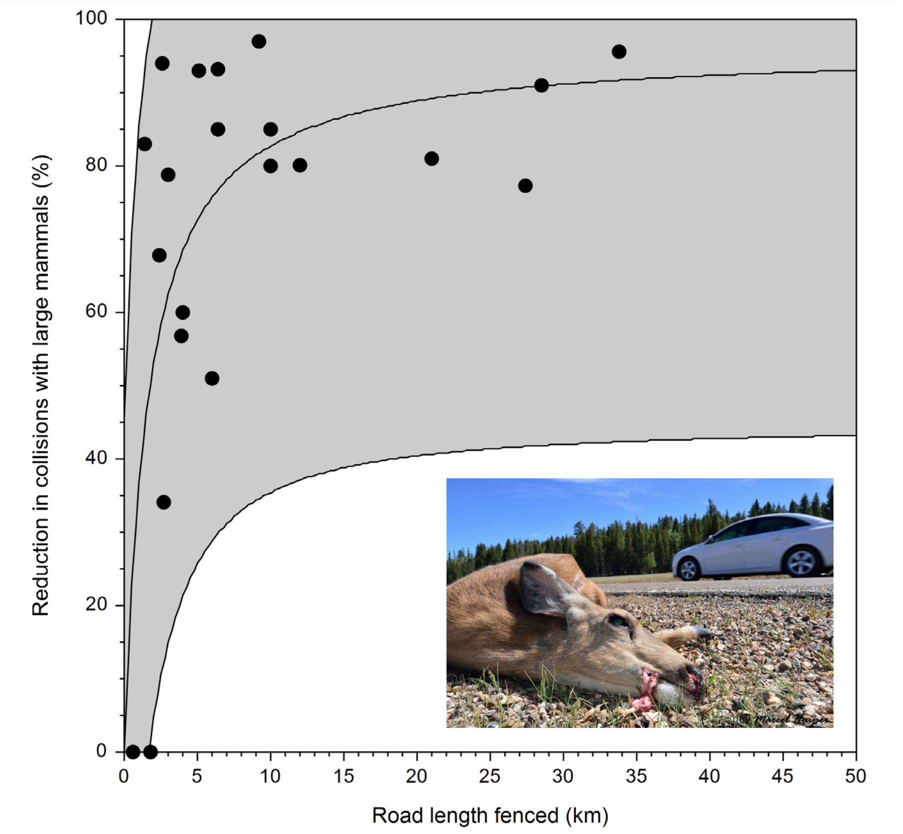
Huijser et al., 2017

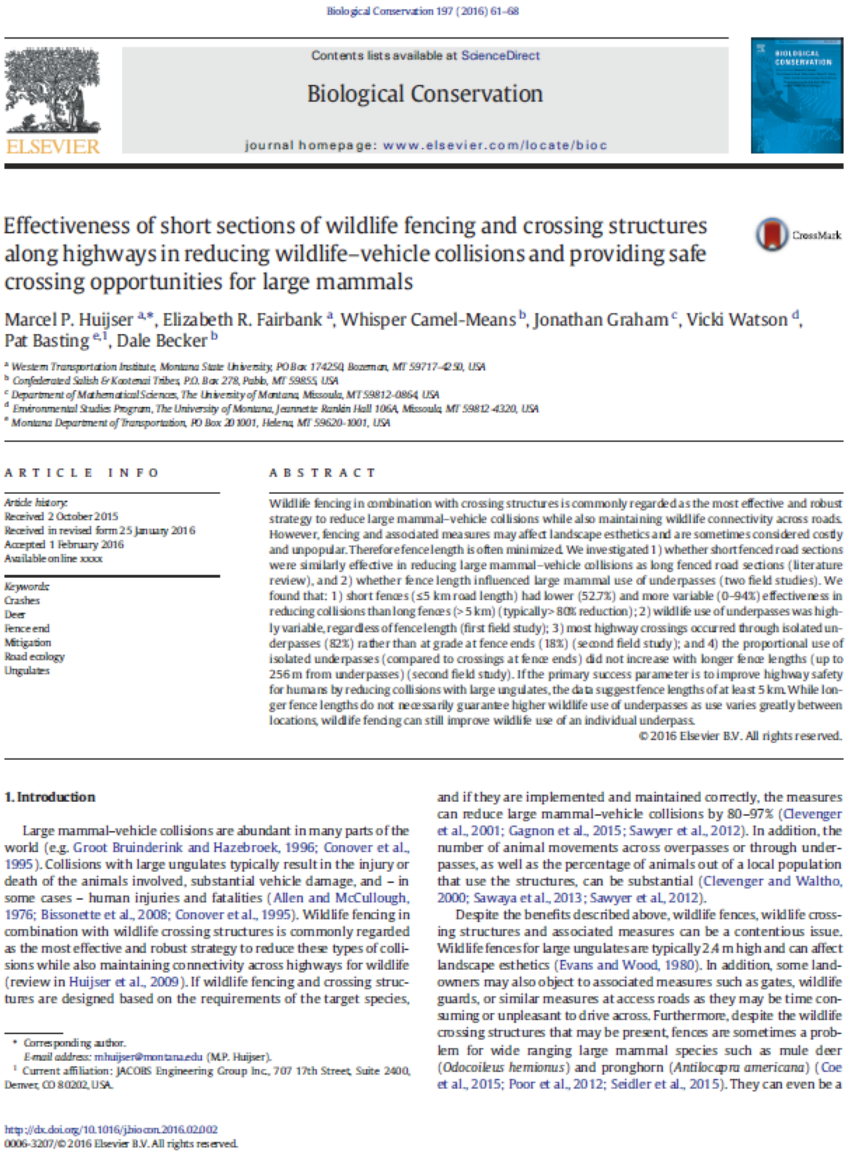
Reduce Collisions: Effective Measures

Standard “ungulate” fence

Animal detection systems

Collision Reduction





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Effectiveness of short sections of wildlife fencing and crossing structures along highways in reducing wildlife–vehicle collisions and providing safe crossing opportunities for large mammals

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ABSTRACT

Wildlife fencing in combination with crossing structures is commonly regarded as the most effective and robust strategy to reduce large mammal–vehicle collisions while also maintaining wildlife connectivity across roads. However, fencing and associated measures may affect landscape esthetics and are sometimes considered costly and unpopular. Therefore fence length is often minimized. We investigated 1) whether short fenced road sections were similarly effective in reducing large mammal–vehicle collisions as long fenced road sections (literature review), and 2) whether fence length influenced large mammal use of underpasses (two field studies). We found that: 1) short fences (≤5 km road length) had lower (52.7%) and more variable (0–94%) effectiveness in reducing collisions than long fences (>5 km) (typically >80% reduction); 2) wildlife use of underpasses was highly variable, regardless of fence length (first field study); 3) most highway crossings occurred through isolated underpasses (82%) rather than at grade at fence ends (18%) (second field study); and 4) the proportional use of isolated underpasses (compared to crossings at fence ends) did not increase with longer fence lengths (up to 256 m from underpasses) (second field study). If the primary success parameter is to improve highway safety for humans by reducing collisions with large ungulates, the data suggest fence lengths of at least 5 km. While longer fence lengths do not necessarily guarantee higher wildlife use of underpasses as use varies greatly between locations, wildlife fencing can still improve wildlife use of an individual underpass.

1. Introduction

Large mammal–vehicle collisions are abundant in many parts of the world (e.g. Groot Bruinderink and Hazebroek, 1996; Conover et al., 1995). Collisions with large ungulates typically result in the injury or death of the animals involved, substantial vehicle damage, and – in some cases – human injuries and fatalities (Allen and McCullough, 1976; Bissonette et al., 2008; Conover et al., 1995). Wildlife fencing in combination with wildlife crossing structures is commonly regarded as the most effective and robust strategy to reduce these types of collisions while also maintaining connectivity across highways for wildlife (review in Huijser et al., 2009). If wildlife fencing and crossing structures are designed based on the requirements of the target species, and if they are implemented and maintained correctly, the measures can reduce large mammal–vehicle collisions by 80–97% (Clevenger et al., 2001; Gagnon et al., 2015; Sawyer et al., 2012). In addition, the number of animal movements across overpasses or through underpasses, as well as the percentage of animals out of a local population that use the structures, can be substantial (Clevenger and Waltho, 2000; Sawaya et al., 2013; Sawyer et al., 2012).

Despite the benefits described above, wildlife fences, wildlife crossing structures and associated measures can be a contentious issue. Wildlife fences for large ungulates are typically 2.4 m high and can affect landscape esthetics (Evans and Wood, 1980). In addition, some landowners may also object to associated measures such as gates, wildlife guards, or similar measures at access roads as they may be time consuming or unpleasant to drive across. Furthermore, despite the wildlife crossing structures that may be present, fences are sometimes a problem for wide ranging large mammal species such as mule deer (*Odocoileus hemionus*) and pronghorn (*Antilocapra americana*) (Coe et al., 2015; Poor et al., 2012; Seidler et al., 2015). They can even be a

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Under- and overpasses needed, especially at higher traffic volumes

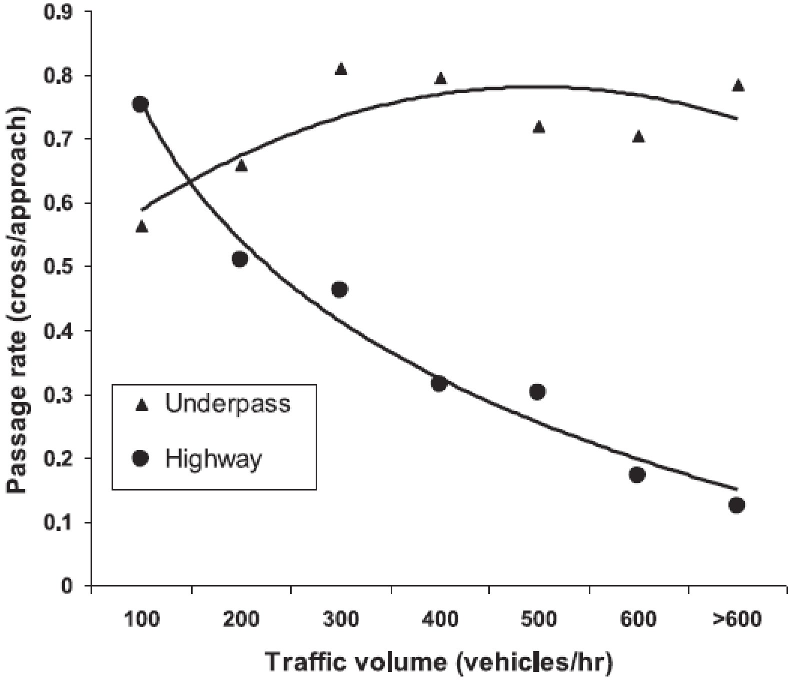

Figure 6. At-grade and below-grade (through 6 wildlife underpass) elk passage rates at varying traffic volume levels along State Route 260, Arizona, USA (figure from Gagnon et al. 2007c). At-grade passage rates determined from GPS telemetry tracking of 44 elk from 2003-2006 (Gagnon et al. 2007a) and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

Crossing Structure Types and Dimensions


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Overpass
50-70 m wide


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


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Large mammal
Underpass
7 m wide
4-5 m high


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Medium mammal
Underpass
1.5-2 m diameter


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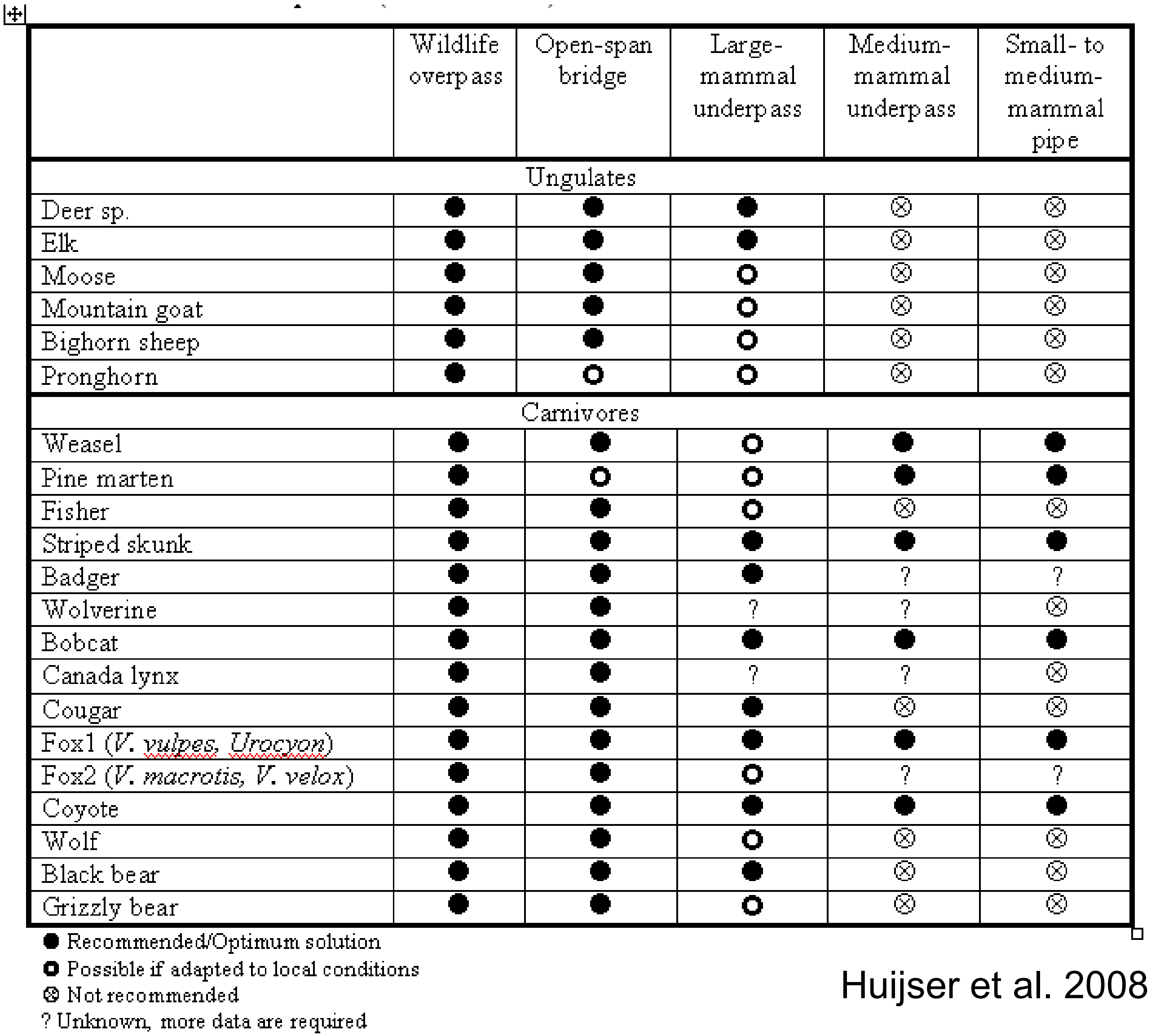
Small-medium
Mammal pipe
30-60 cm diameter

Species specific design



	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

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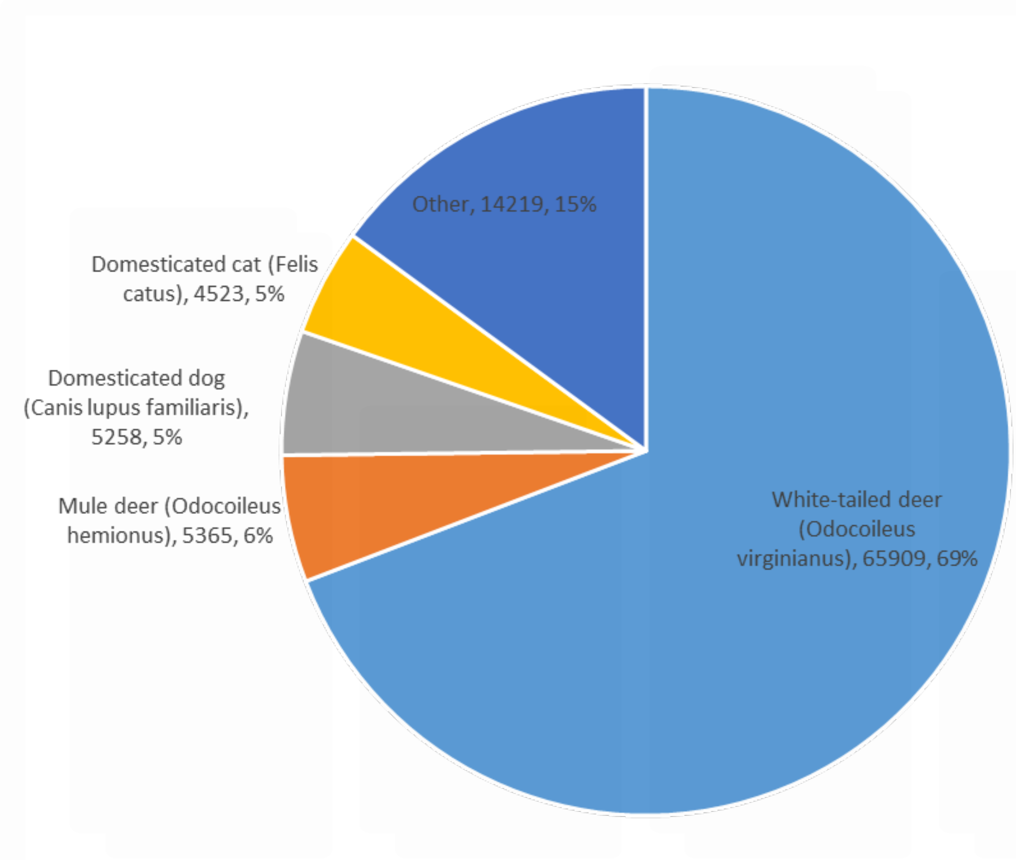
29 Structures, 5 years



Huijser et al. 2016

- 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

MDT

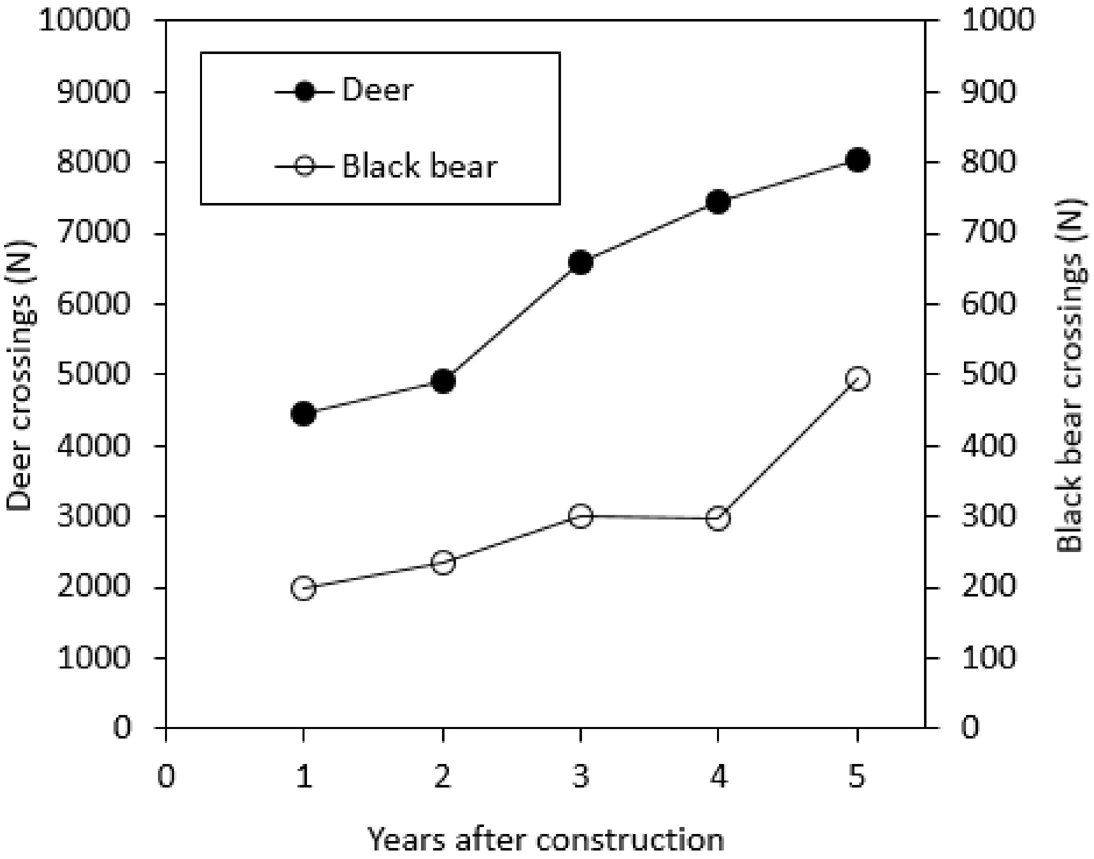
FHWA

Memorandum of Agreement

US 93

Evaro to Polson

Learning Curve



Huijser et al. 2016

Habitat Connectivity ???

Better

- Safe places to cross
- Less disturbance when crossing

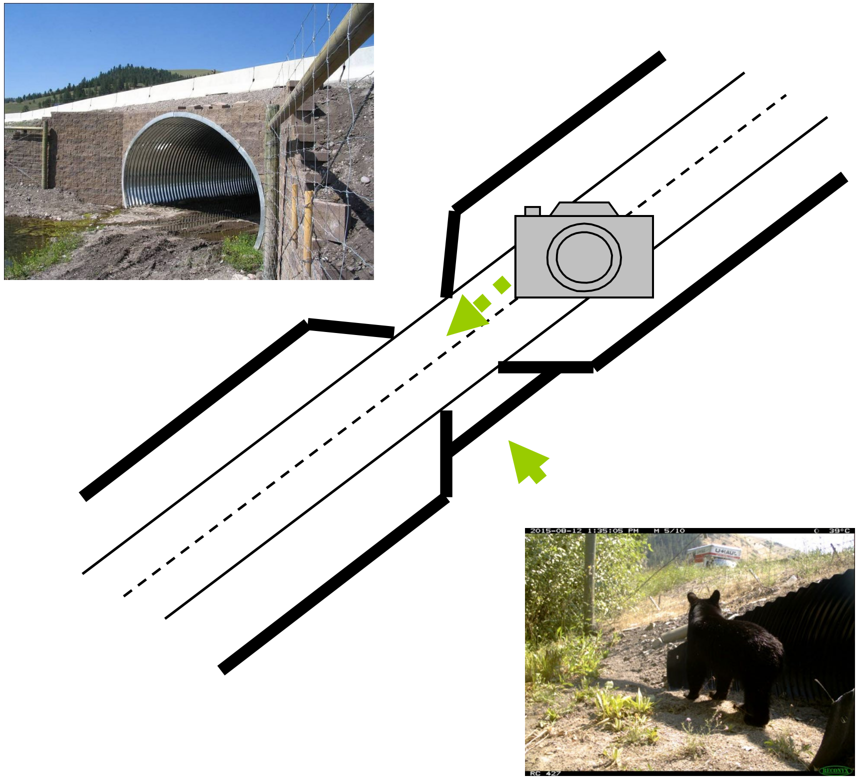
Worse

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

Deer and black bear crossings

Before

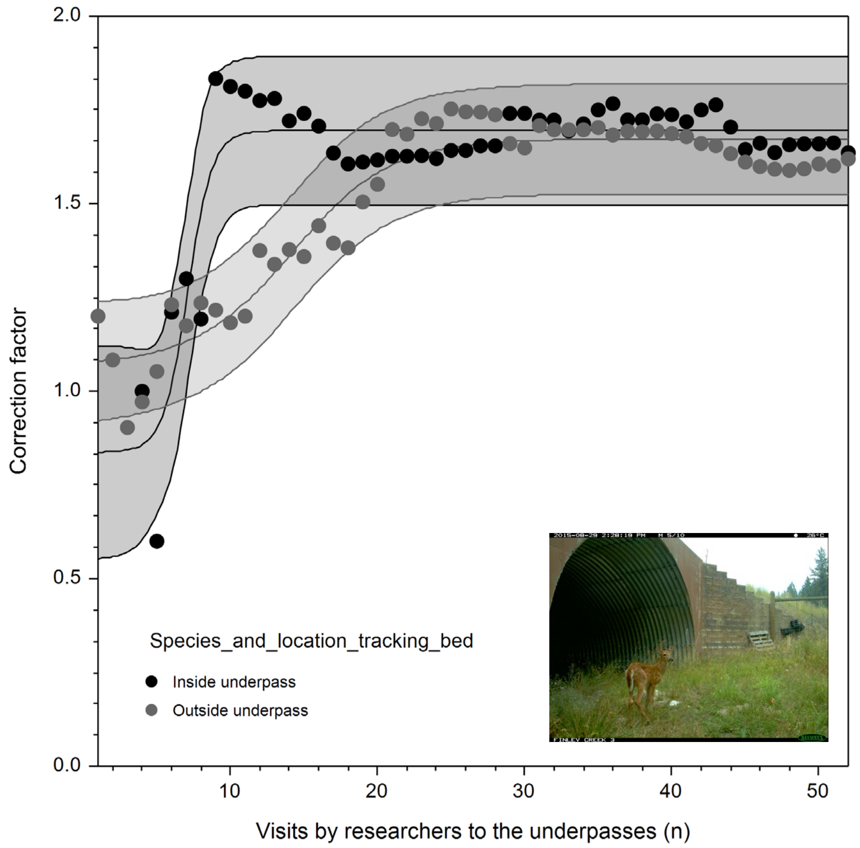
After



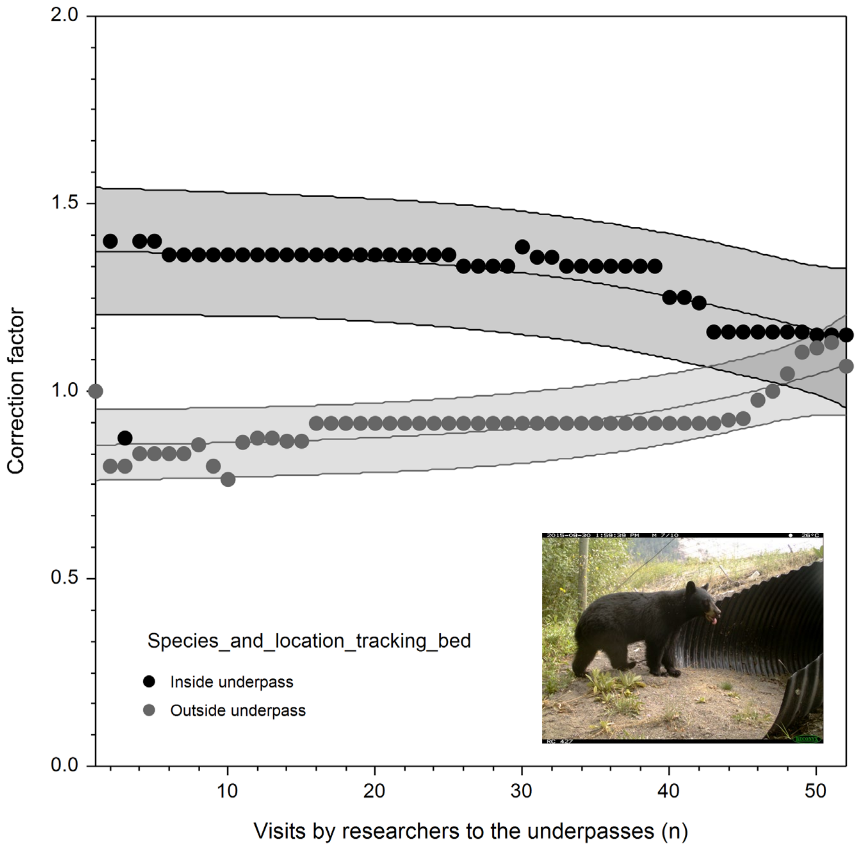
Correction Factor

Tracks – Camera Images

Deer: *1.623

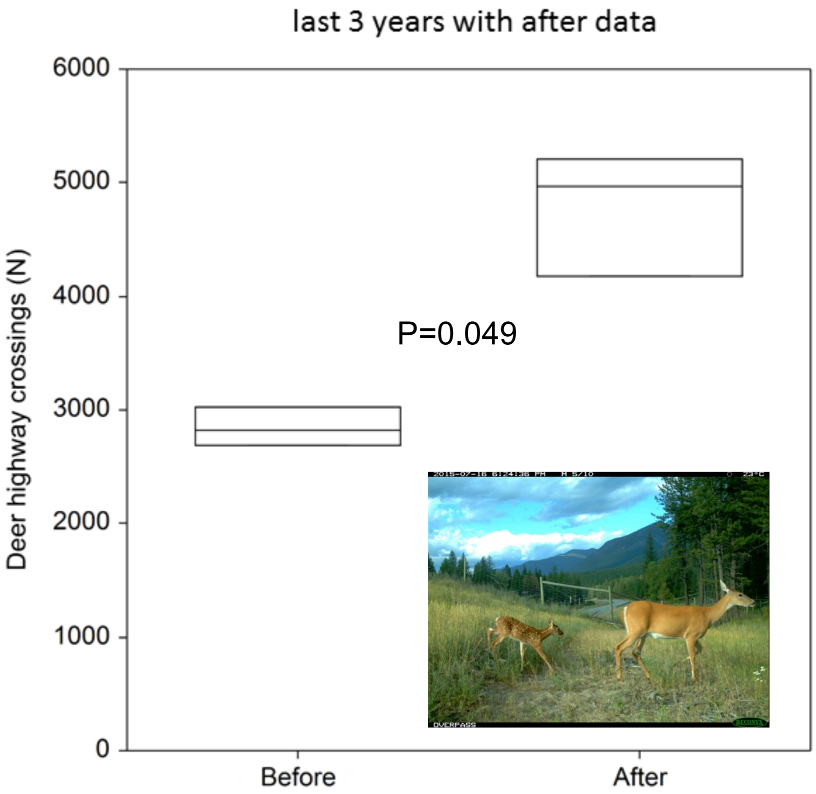


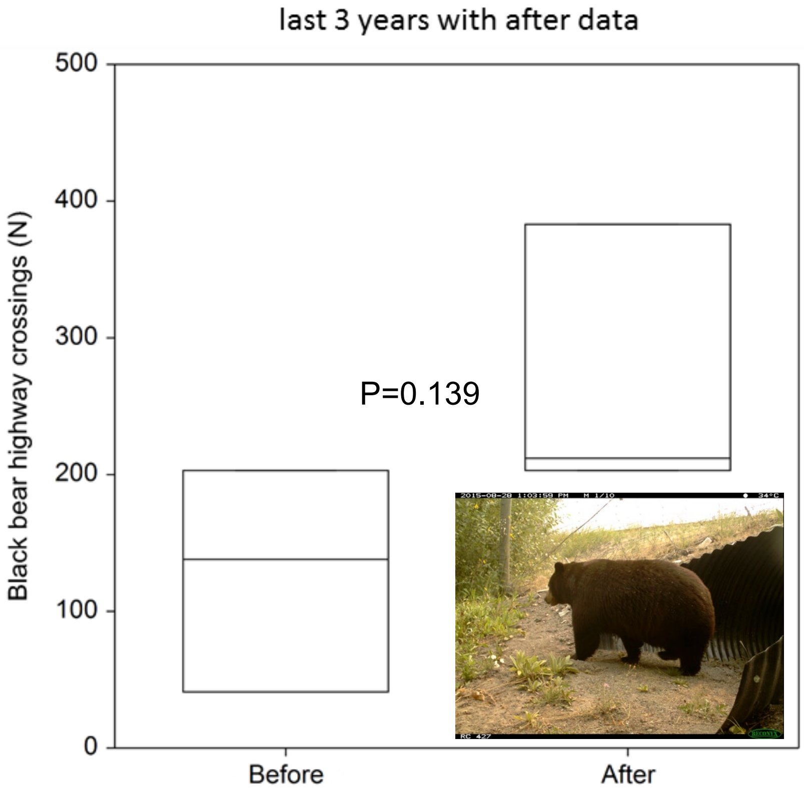
Black bear: 1.088



Huijser et al. 2016

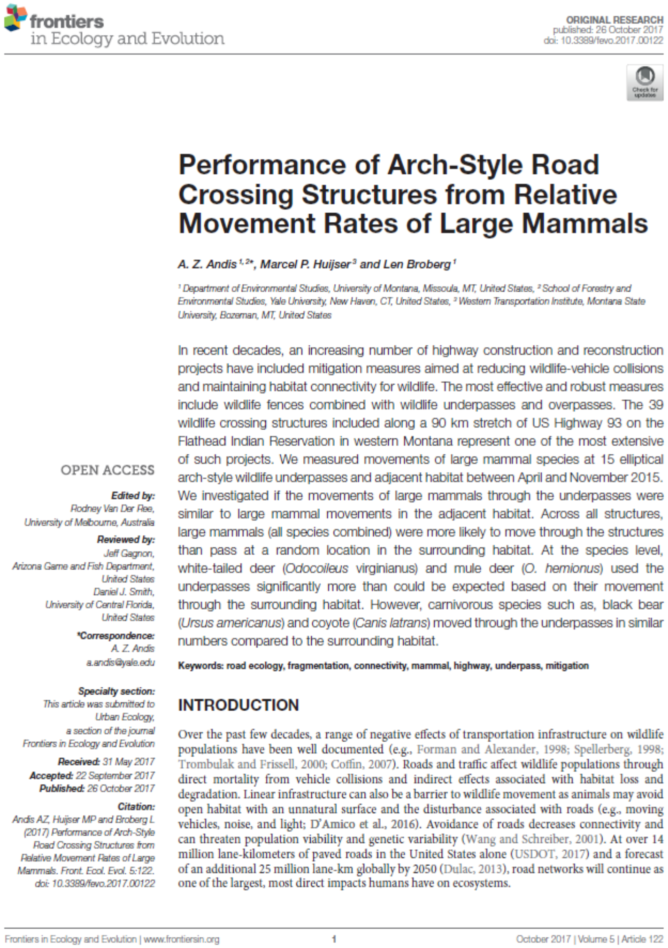
Habitat Connectivity


last 3 years with after data


last 3 years with after data

Huijser et al. 2016

Concentration Of Movements in Crossing Structures?



frontiers
in Ecology and Evolution

ORIGINAL RESEARCH
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Performance of Arch-Style Road Crossing Structures from Relative Movement Rates of Large Mammals

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In recent decades, an increasing number of highway construction and reconstruction projects have included mitigation measures aimed at reducing wildlife-vehicle collisions and maintaining habitat connectivity for wildlife. The most effective and robust measures include wildlife fences combined with wildlife underpasses and overpasses. The 39 wildlife crossing structures included along a 90 km stretch of US Highway 93 on the Flathead Indian Reservation in western Montana represent one of the most extensive of such projects. We measured movements of large mammal species at 15 elliptical arch-style wildlife underpasses and adjacent habitat between April and November 2015. We investigated if the movements of large mammals through the underpasses were similar to large mammal movements in the adjacent habitat. Across all structures, large mammals (all species combined) were more likely to move through the structures than pass at a random location in the surrounding habitat. At the species level, white-tailed deer (*Odocoileus* virginianus) and mule deer (*O. hemionus*) used the underpasses significantly more than could be expected based on their movement through the surrounding habitat. However, carnivorous species such as, black bear (*Ursus americanus*) and coyote (*Canis latrans*) moved through the underpasses in similar numbers compared to the surrounding habitat.

Keywords: road ecology, fragmentation, connectivity, mammal, highway, underpass, mitigation

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INTRODUCTION

Over the past few decades, a range of negative effects of transportation infrastructure on wildlife populations have been well documented (e.g., Forman and Alexander, 1998; Spellerberg, 1998; Trombulak and Frissell, 2000; Coffin, 2007). Roads and traffic affect wildlife populations through direct mortality from vehicle collisions and indirect effects associated with habitat loss and degradation. Linear infrastructure can also be a barrier to wildlife movement as animals may avoid open habitat with an unnatural surface and the disturbance associated with roads (e.g., moving vehicles, noise, and light; D'Amico et al., 2016). Avoidance of roads decreases connectivity and can threaten population viability and genetic variability (Wang and Schreiber, 2001). At over 14 million lane-kilometers of paved roads in the United States alone (USDOT, 2017) and a forecast of an additional 25 million lane-km globally by 2050 (Dulac, 2013), road networks will continue as one of the largest, most direct impacts humans have on ecosystems.

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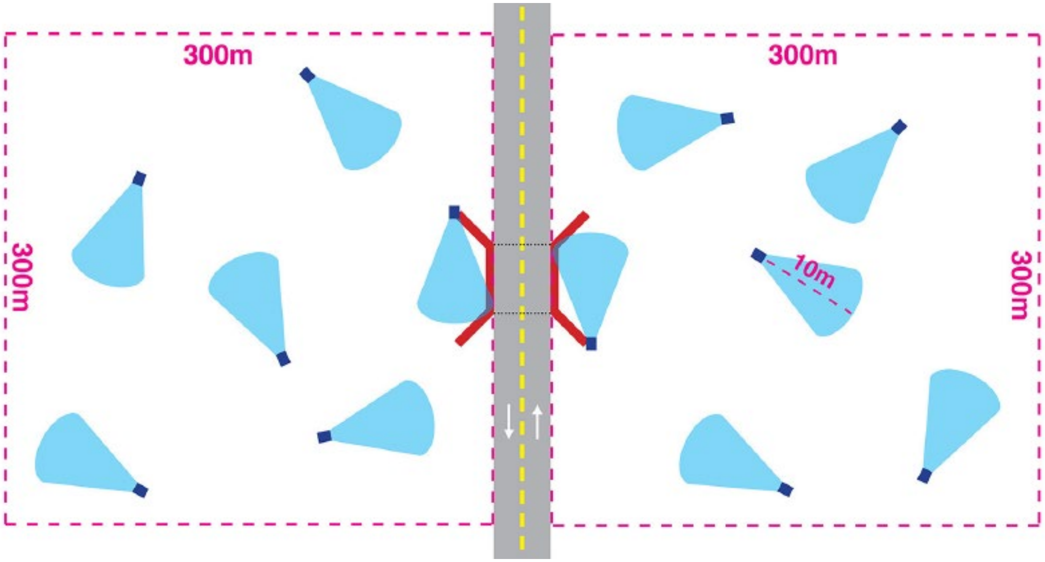


- 146% more large mammal movements at structures vs surroundings
- Full connectivity for large mammals? 40.7% road length permeable !!!

Andis et al. 2017

Ambition level?
Ecological Processes?

- Entire ecosystems
- Soil
- Hydrology
- Plants
- Animals

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

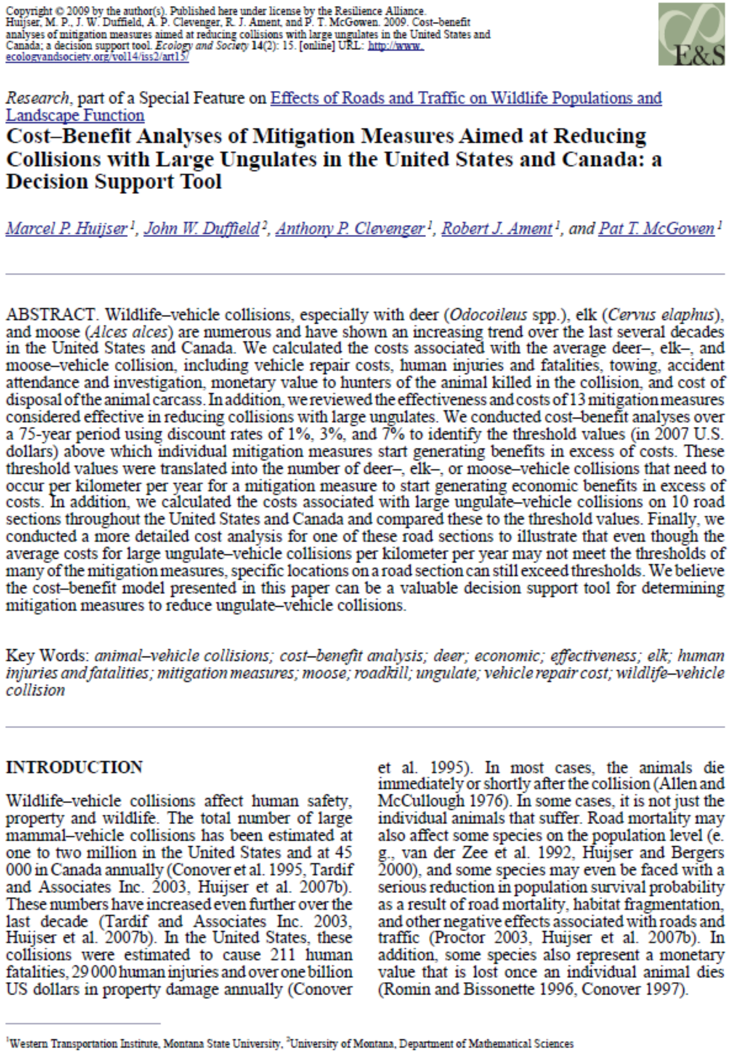
3. “Low volume park road”

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

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/

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).

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Huijser et al., 2009

Thanks!

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