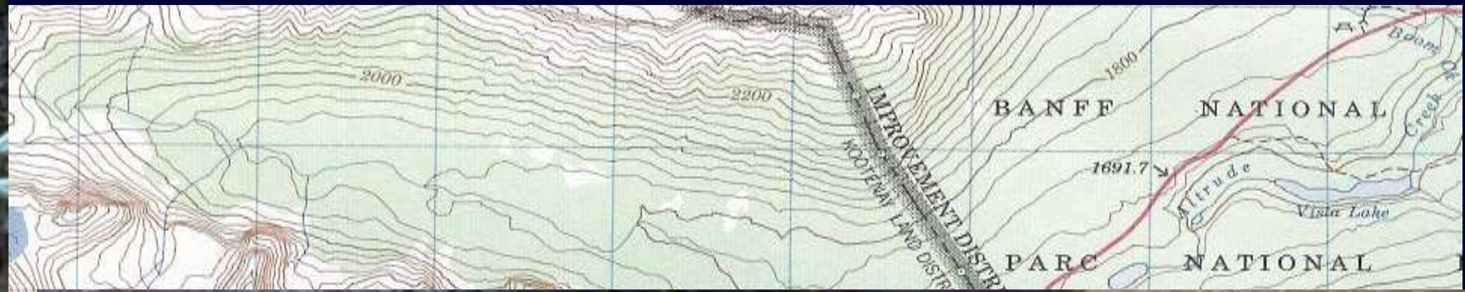



# Conserving Large Landscapes – One Highway at a Time


Alex Taylor


Tony Clevenger
Western Transportation Institute
Montana State University

# Content

1. Conserving Large Landscapes - Challenges

2. Keeping it Together – the Banff Way

3. Key research findings 1996-2014

4. Transferring the Science: Beyond Banff National Park

Alex Taylor

Trans-Canada Highway - Banff National Park, Alberta, Canada

# A Big Idea: Yellowstone to Yukon Conservation Initiative


Base map provided by Y2Y

Needs for large scale connectivity

Carnivores capable of long distance movements (wolves, lynx, grizzly bears, wolverines…)

Boundaries mean nothing…

Transboundary conservation needed

# Keeping the connections intact

## with landscape corridors and passages


# Roads – Can't live without 'em

Comparatively more detrimental than other types of fragmentation

Understanding mortality and fragmentation central to finding solutions.

Alex Taylor

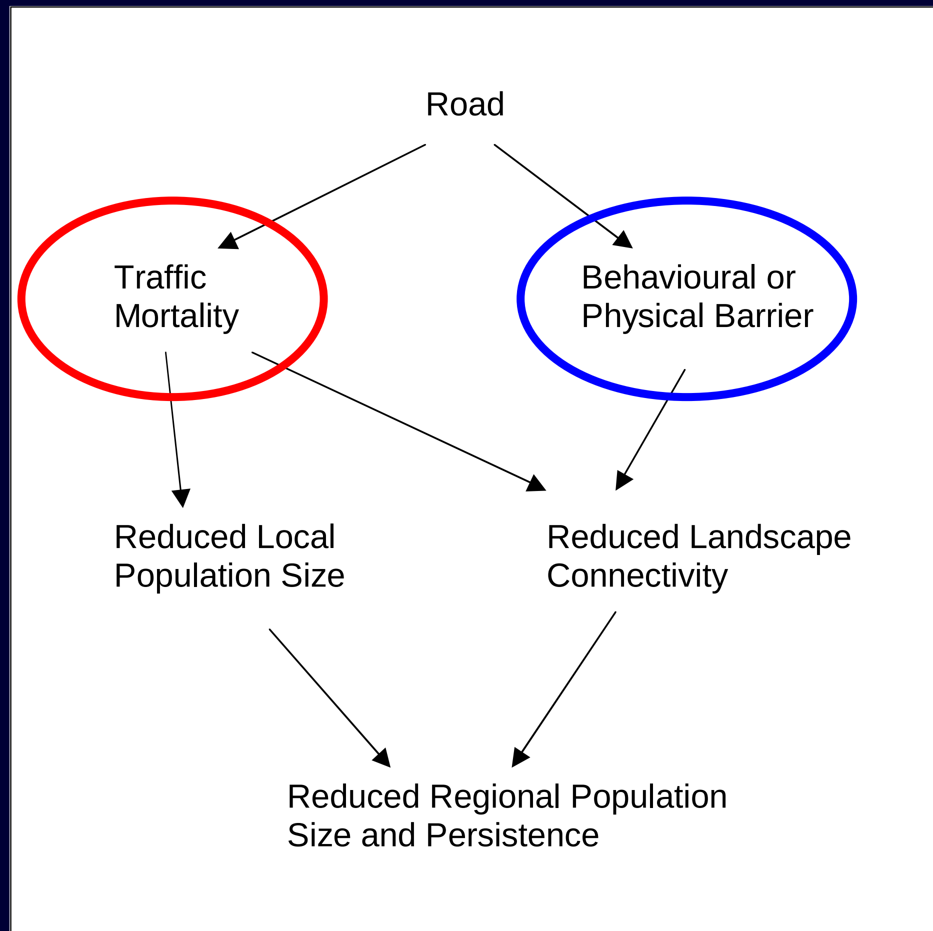
Banff-Bow Valley

Alex Taylor

# Effects of roads on population viability

## Mortality and Barrier Effects

Greater effect on
Long-term
viability




Forman et al. 2003

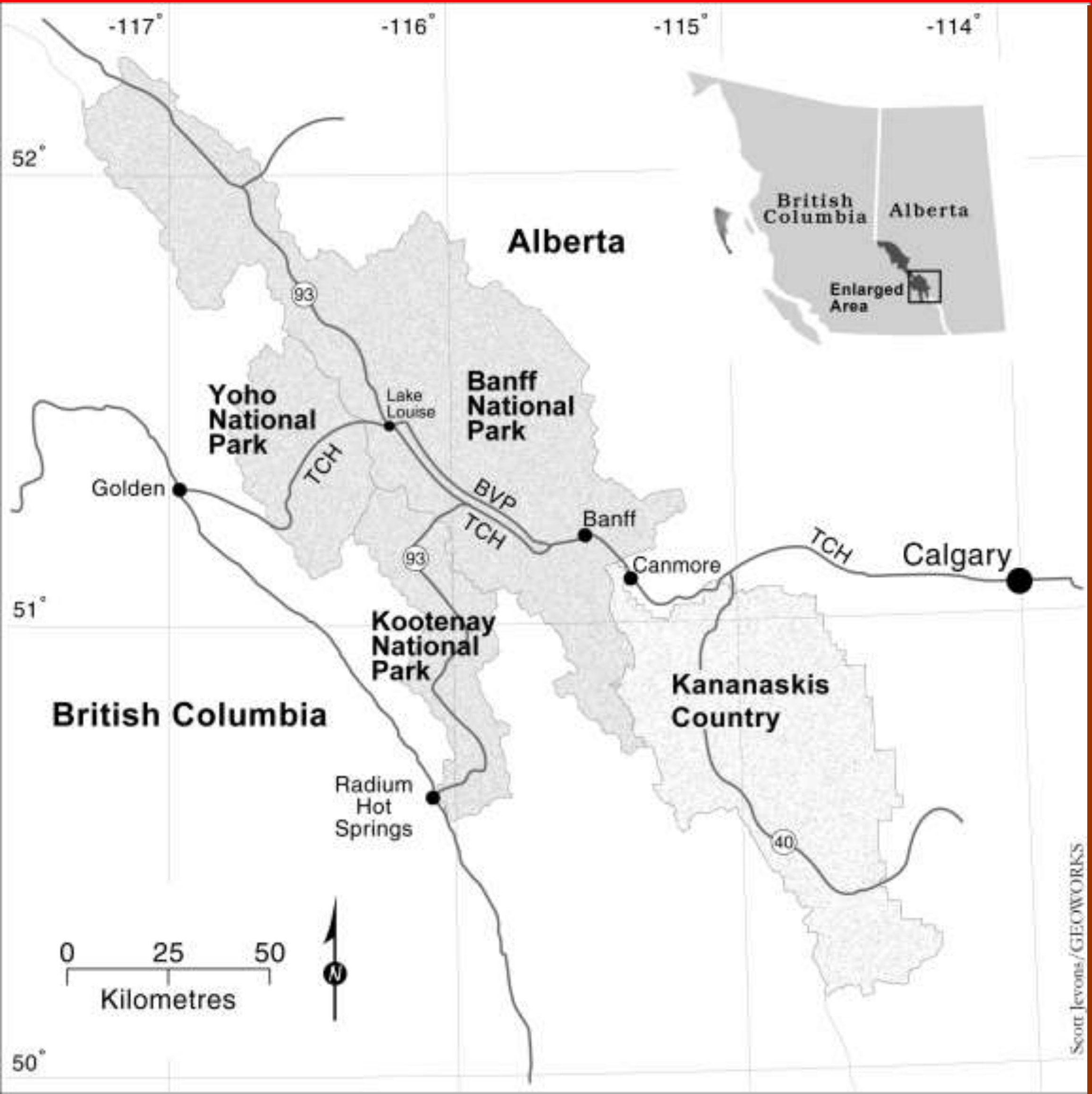
Forman et al. 2003

# The Power of Photographs to Educate and Raise Awareness


Highwaywilding.org

Lynx on Redearth Wildlife Overpass

# Trans-Canada Highway - Banff National Park, Alberta, Canada




## Banff-Bow Valley

Banff NP = 6640 $Km^2$

4 Mountain Parks= 20,235 $Km^2$
(Banff, Yoho, Kootenay, Jasper)

UNESCO World Heritage Site

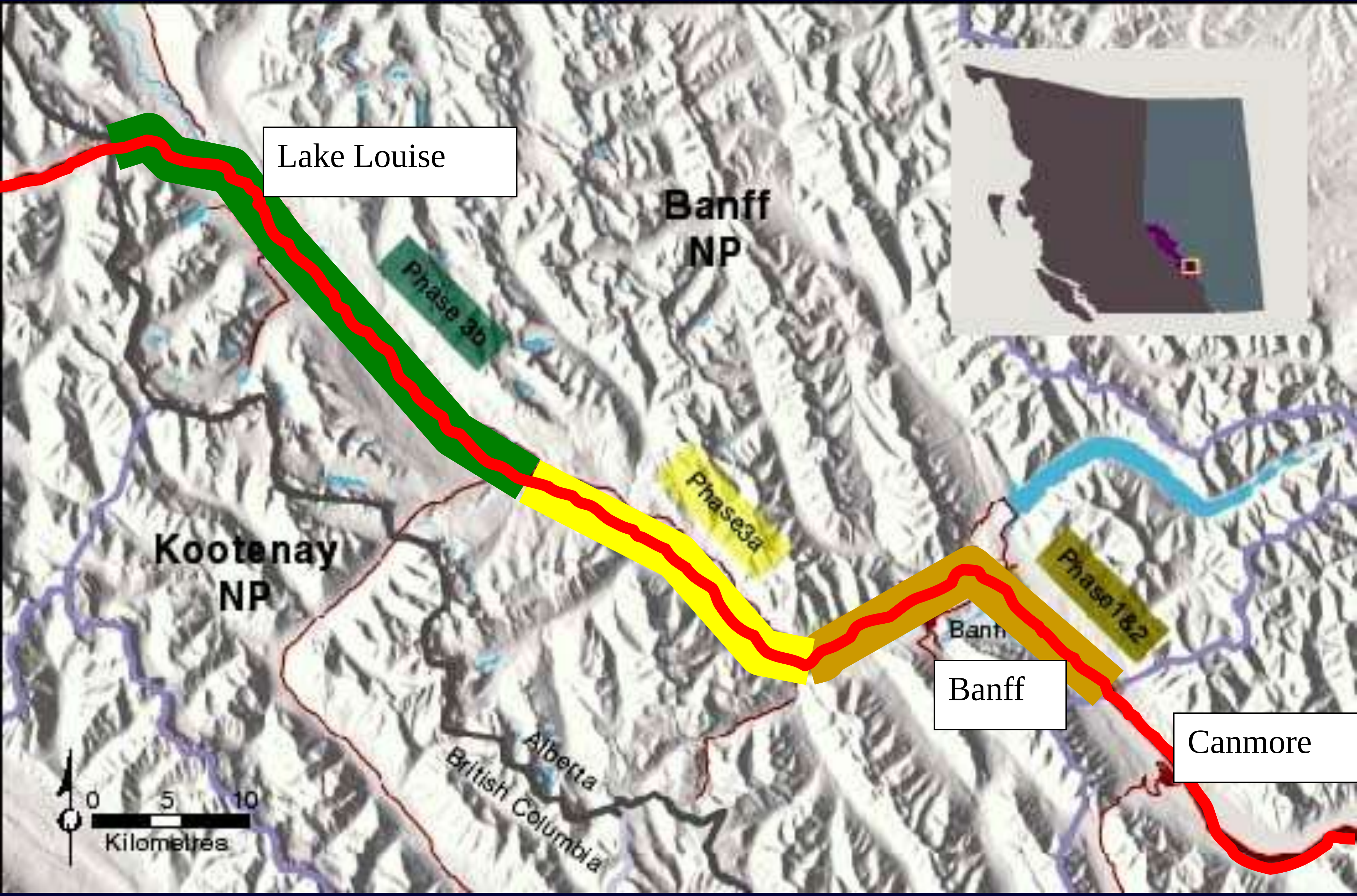
4 Million visitors per year

Large landscape context:
Critical fracture zone in Y2Y ecoregion

# What Must the Measures Do ???

Reducing Wildlife-Vehicle Collisions

Restoring Movements - Connecting Populations


Lake Louise
Banff
NP
Phase 3b
Phase3a
Phase1&2
Kootenay
NP
Banff
Banff
Canmore
Alberta
British Columbia
0
5
10
Kilometres

# 1980s - Phase 1 and 2

Mgt Objective: Reduce collisions with ungulates (100+ collisions each year)

# 1990s - Phase 3A

Mgt Objective: Reduce barrier effect for movement of large carnivores

# 2000s

Trans-Canada Highway across the Continental Divide


# Banff National Park, Alberta

40 WCs, 5 design types
3 time periods (1985, 1997, 2010)
Long-term monitoring (17 years)
Co-lateral wildlife research


| | |
|---|---|
| Lynx | Elk |
| Cougar | Moose |
| Bl Bear | |
| Gr Bear | Deer |
| Wolf | Sheep |
| Coyote | Wolverine |


# How do we monitor wildlife use at the crossing structures ?

1 Track pads at entrances used to quantify movement

2 Remote cameras: Photo-detection of animal movement on overpass

Comparison of monitoring methods -

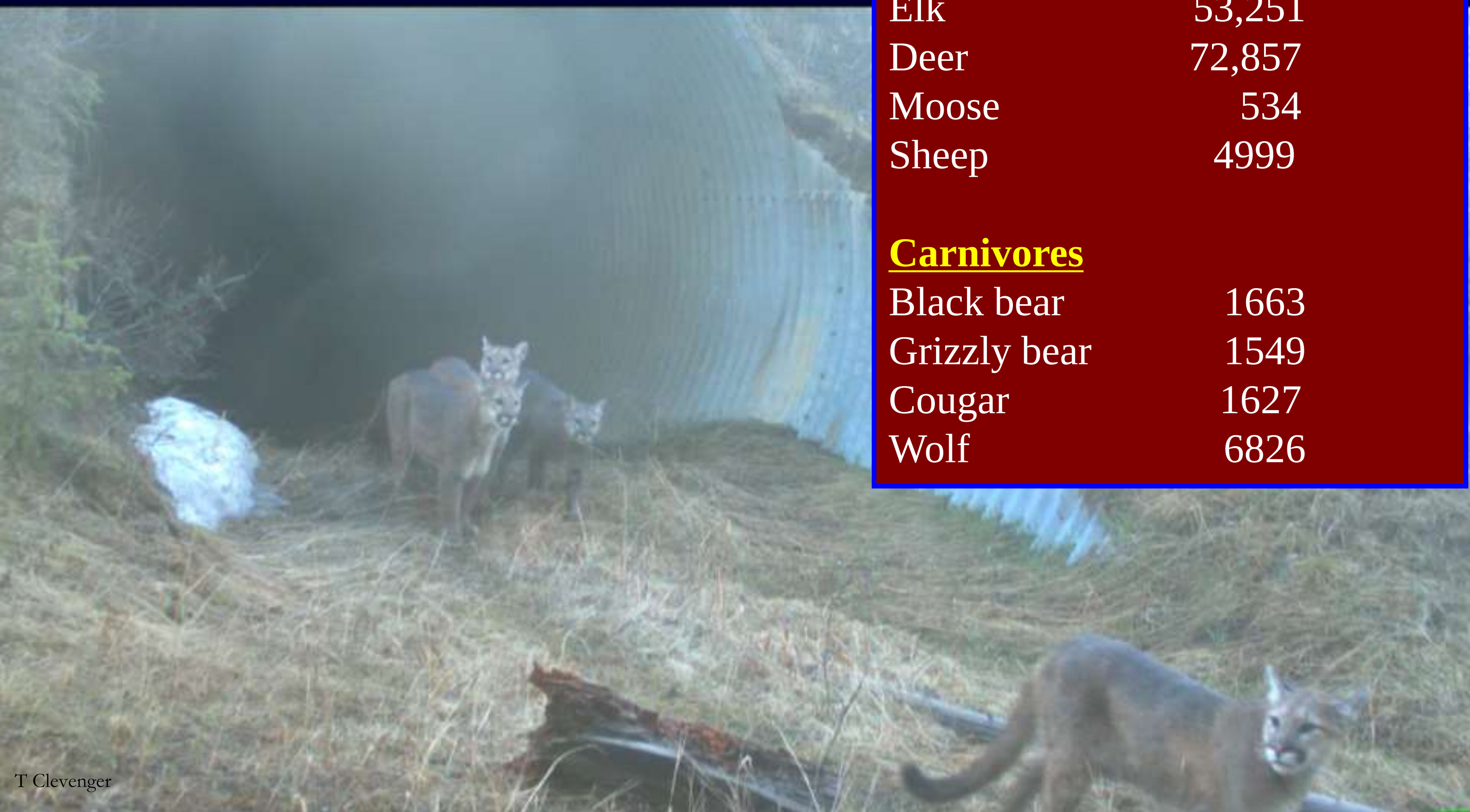
Ford et al. 2009. Journal of Wildlife Management 73: 1213-1222

T Clevenger

# Wildlife Crossing Structure Use
## Banff National Park, Alberta
(Nov 1996 to Mar 2014)

>150,000 detected crossings
11 spp. large mammals

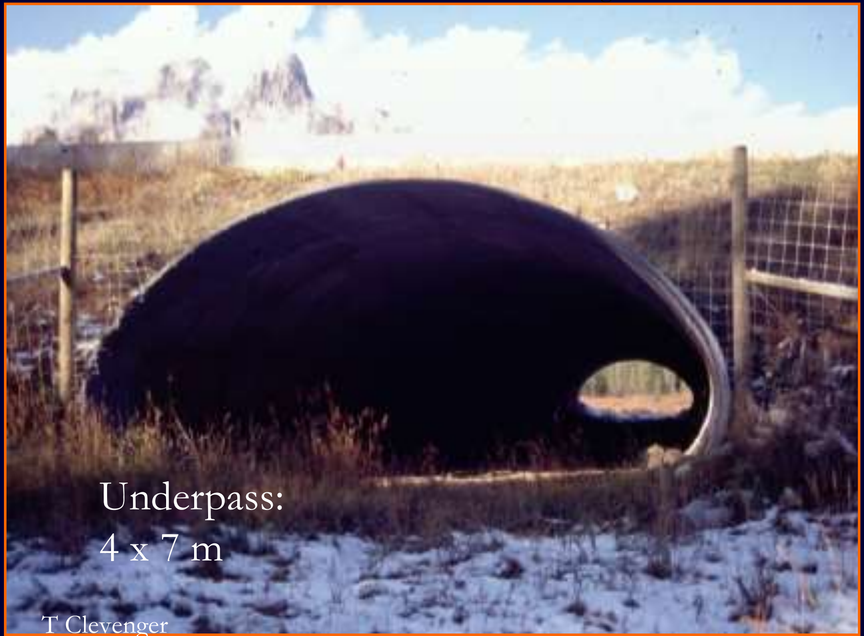
| | |
|---|---|
| **Ungulates** | |
| Elk | 53,251 |
| Deer | 72,857 |
| Moose | 534 |
| Sheep | 4999 |
| **Carnivores** | |
| Black bear | 1663 |
| Grizzly bear | 1549 |
| Cougar | 1627 |
| Wolf | 6826 |



# Design and Landscape Attributes for Crossing Structures


T Clevenger






# Wildlife Crossing Structure Use

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**Carnivores**

| | |
|---|---|
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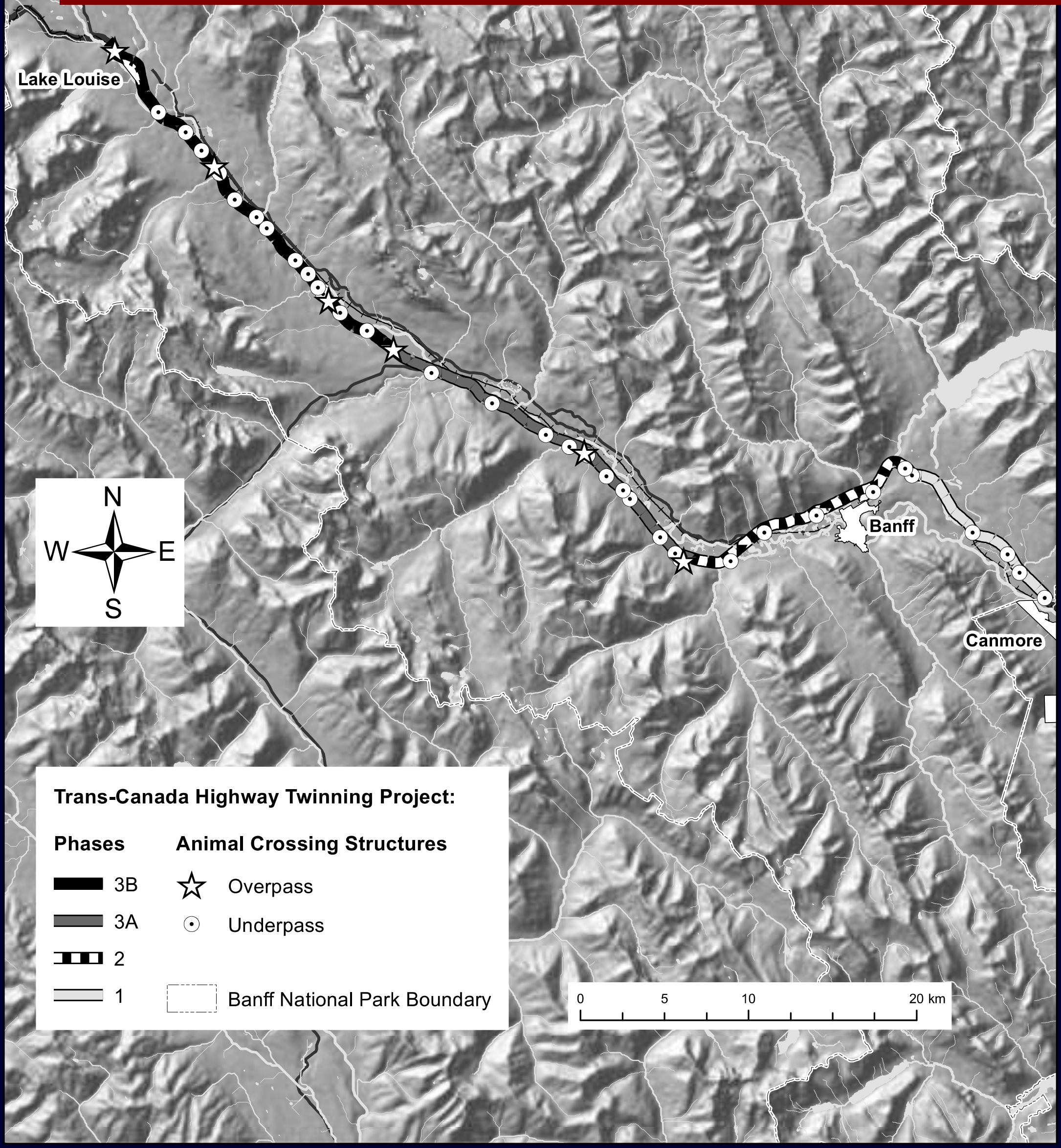
# Problems with "confounding variables"

## Conditions change from one structure to the next




Findings from 2 studies
Species-specific needs !

Conservation Biology 14 (2000)
Biological Conservation 121 (2005)

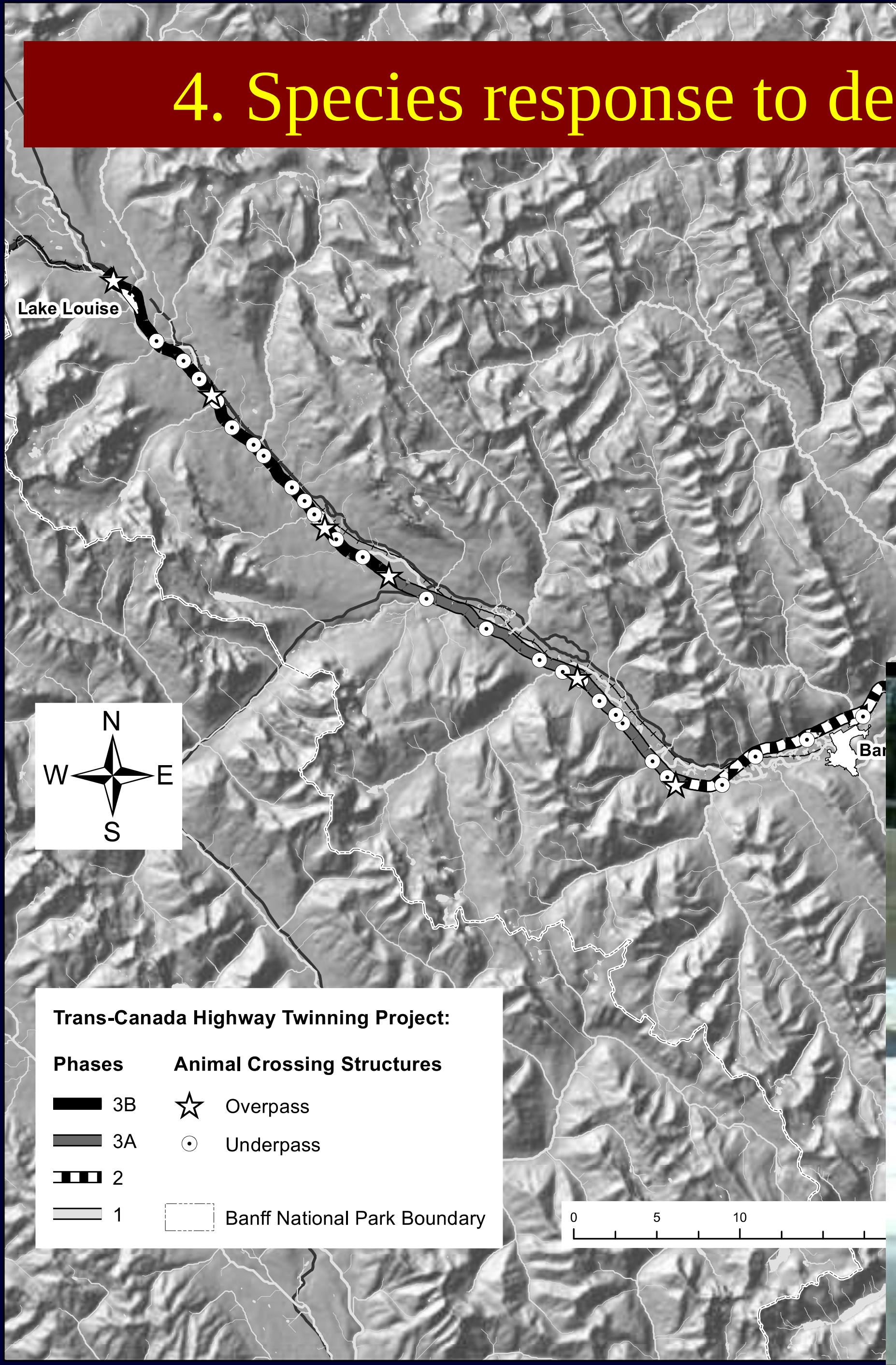
16-year results
Time-series analysis

Clevenger and Barrueto 2014. Final report to Parks Canada.

# 4. Species response to design and ecological factors

- Human use effects
- Species-specific needs
- Adaptation periods

Clevenger & Waltho Conserv Biol 14
Clevenger & Waltho Biol Conserv 121




# 16-year Time-Series Analysis

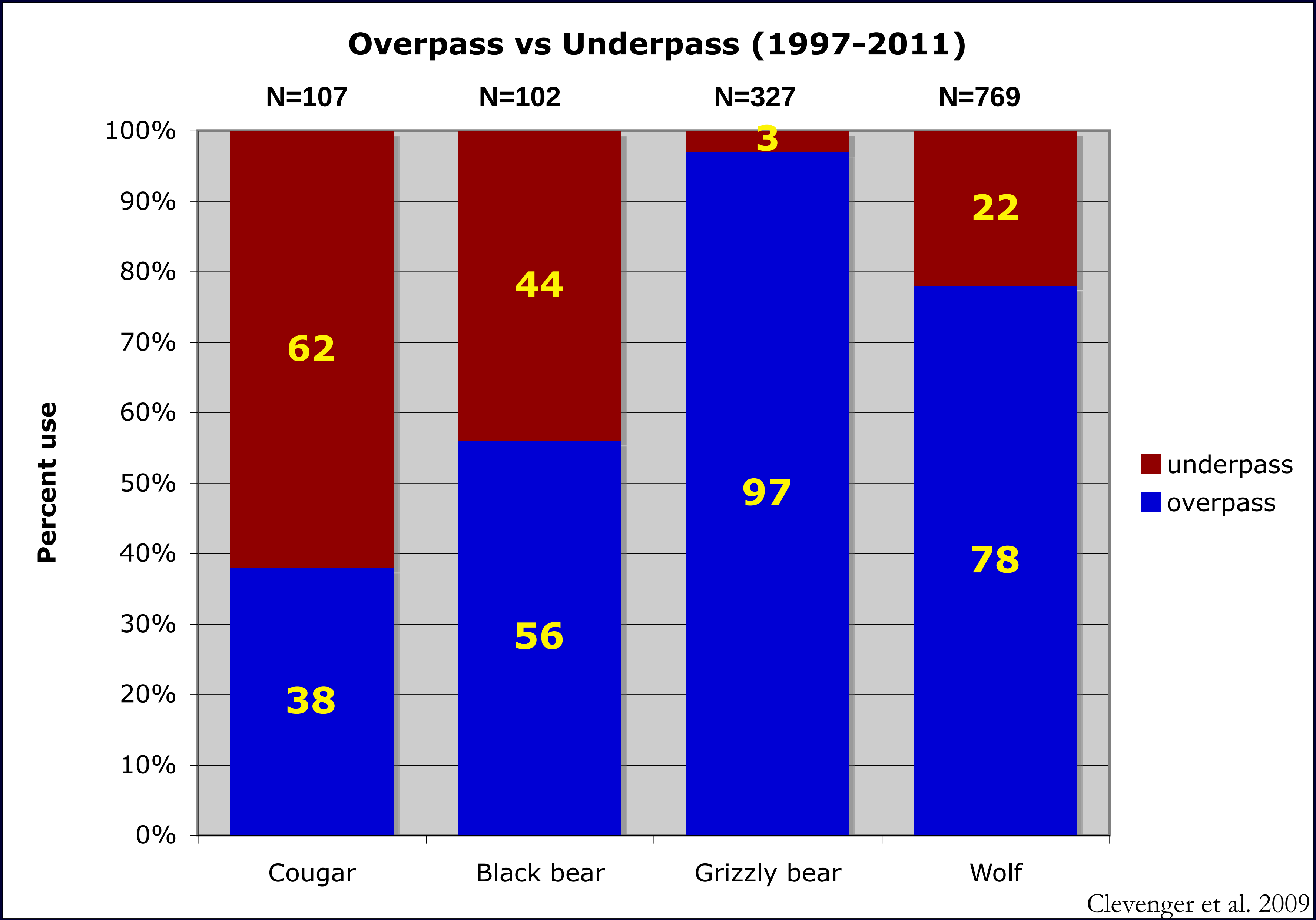
Table 5. A summary of full model results in analysis of long-term data to identify factors affecting movement of eight species of large mammals through wildlife crossing structures (WC). Direction of positive (+) or negative (-) effect on crossing numbers is provided for each covariate. Covariate categories are colour-coded: structural (grey), environmental (green), and human use (orange).

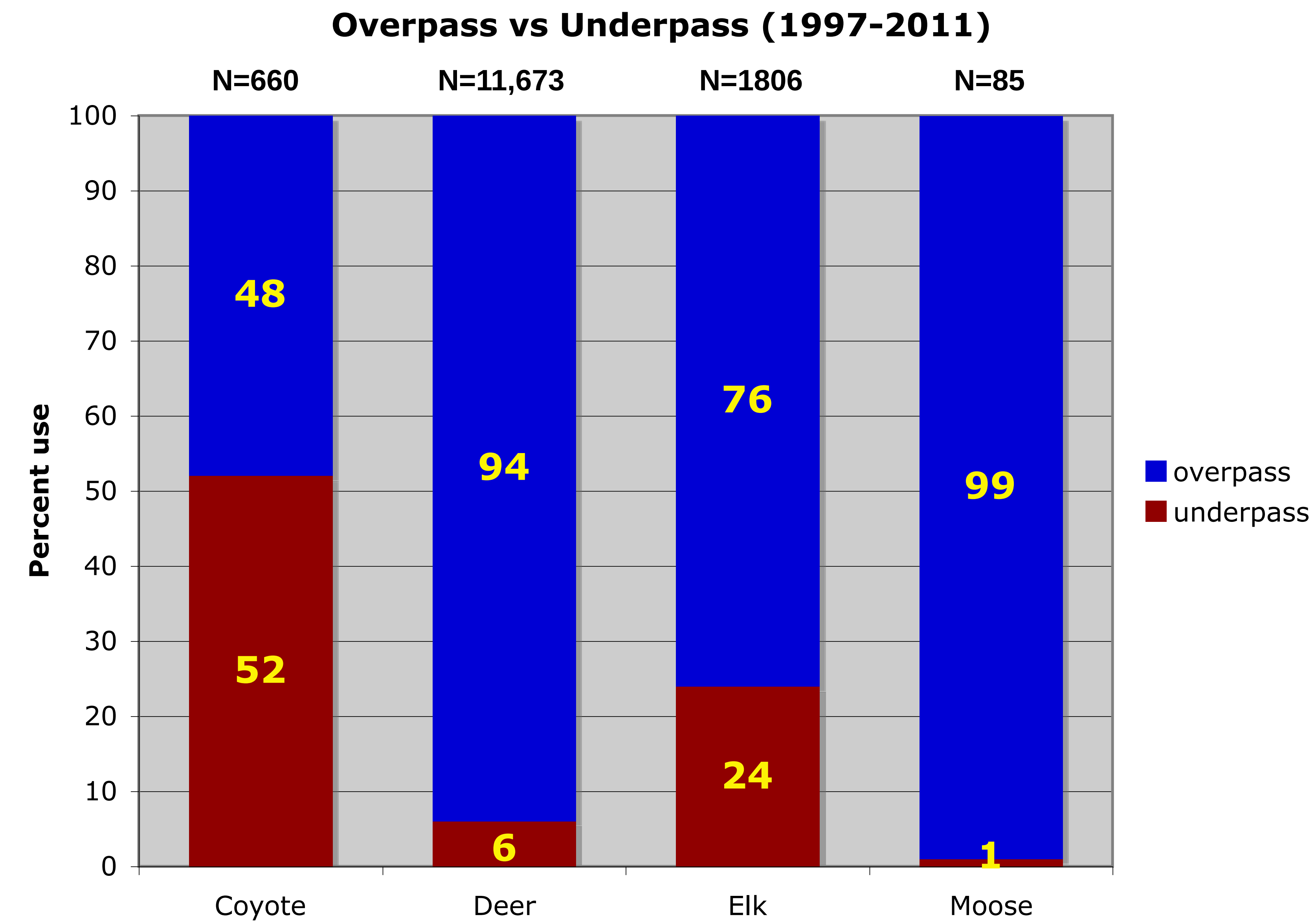
| Covariates[1] | Deer_2 | Deer_4 | Deer_8 | Deer_16 | Elk_2 | Elk_4 | Elk_8 | Elk_16 | Moose_16 | Grizzly_15 | Black bear_2 | Black bear_4 | Black bear_8 | Black bear_16 | Wolf_4 | Wolf_8 | Wolf_16 | Cougar_4 | Cougar_8 | Cougar_16 | Coyote_2 | Coyote_4 | Coyote_8 | Coyote_16 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Openness | + | + | + | + | + | + | + | + | | | | | | | + | + | + | | | | | | | | 11 |
| WC type | | | | | | | | | UP - | UP - | UP + | | | | | | | UP + | UP + | UP - | | | UP + | | 7 |
| Noise | | | | | | | | | | | | | | | | | | | | | - | - | | | 2 |
| Length | | | | | | | | | | | | | + | + | | | | | | | | | | | 2 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| Buff1 | | | | | | | | | | - | | | | | | | | | | | | | | | 1 |
| Buff5 | | | | | - | - | - | - | | | - | - | - | | - | - | - | | | | - | - | - | - | 14 |
| Rad.1km | + | + | + | + | + | + | + | + | | | | | | | | | | | | | | | | | 8 |
| Dist_water | | | | | - | - | - | - | | | + | + | + | + | | | | | | | | | | | 8 |
| 1km%forest | | | | | | | | | | | | | | | | | | | | | + | + | + | + | 4 |
| 1km%grass | | | | | | | | | | | | | | | | | | - | - | - | | | | | 3 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| Human use | | | | - | - | | | | | | | | | | + | - | - | | | | - | - | | | 7 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| ICC[2] | - | 0.108 | 0.718 | 0.742 | 0.722 | 0.522 | 0.439 | 0.428 | 0.880 | 0.572 | 0.558 | 0.128 | 0.128 | 0.061 | 0.124 | 0.086 | 0.291 | 0.338 | 0.169 | 0.384 | 0.929 | 0.147 | 0.144 | 0.186 | |

[1] See Table 2 for description of covariates used in analysis.
[2] ICC: Intraclass correlation coefficient (see Methods).

Clevenger and Barrueto 2014.

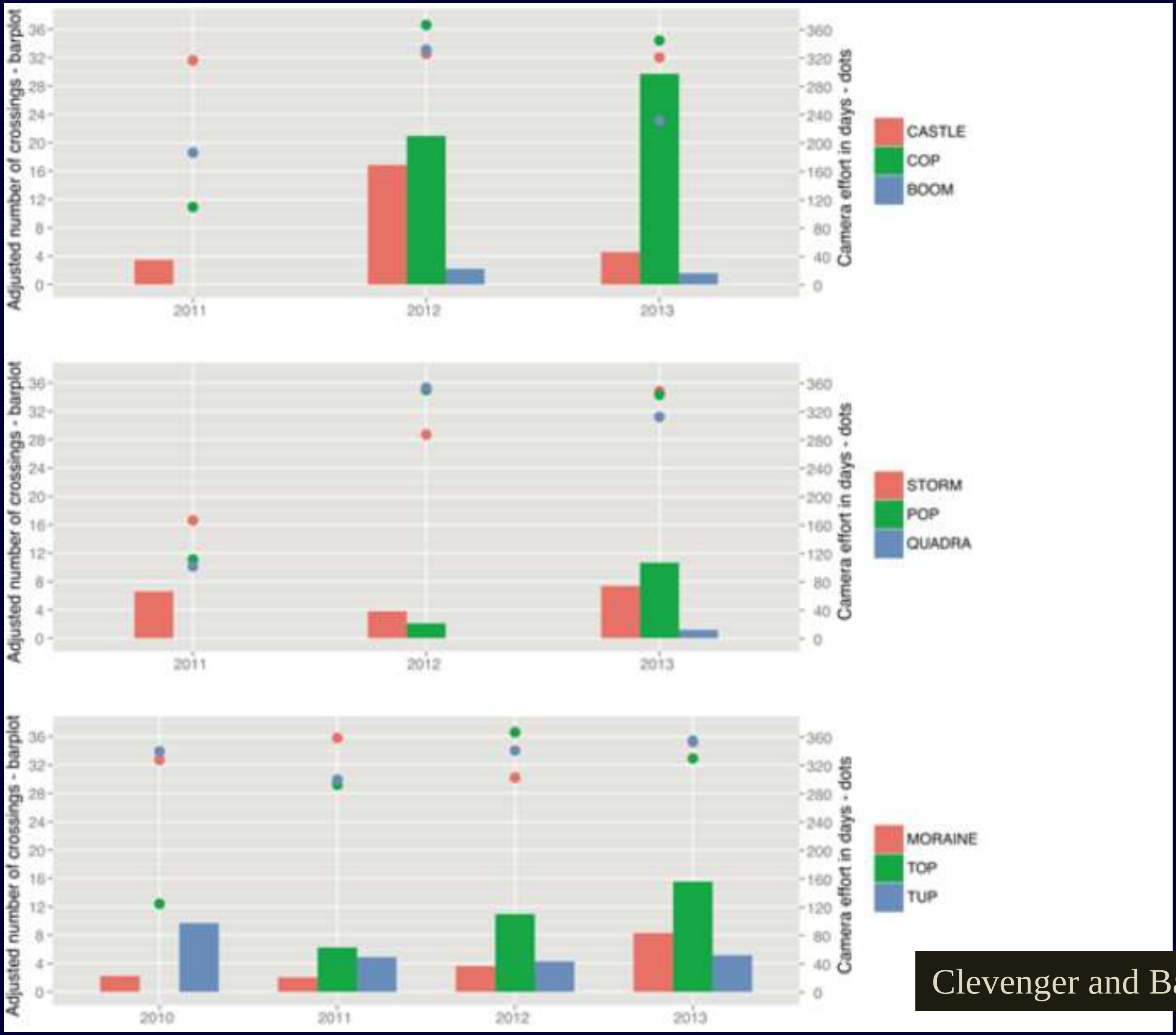
# Overpass/Underpass Comparison


Overpass vs Underpass (1997-2011)
N=107
N=102
N=327
N=769
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent use
62
38
44
56
3
97
22
78
Cougar
Black bear
Grizzly bear
Wolf
underpass
overpass
Clevenger et al. 2009




Clevenger et al. 2009

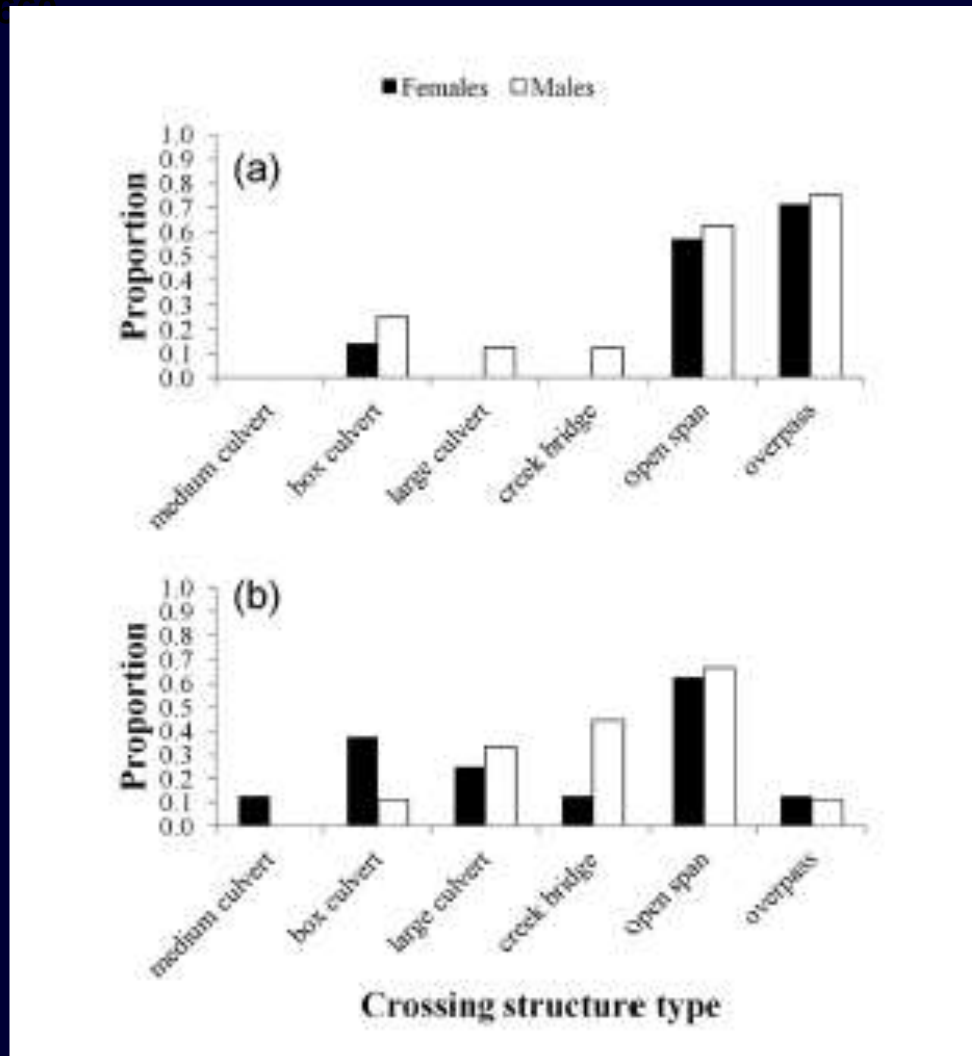
# Annual grizzly bear crossings at newly built overpasses and underpasses




Clevenger and Barrueto 2014

# Grizzly bear detections at WC types, 2006-08

Genotyping bears using crossing structures




Sawaya et al. 2013. Conservation Biology 27

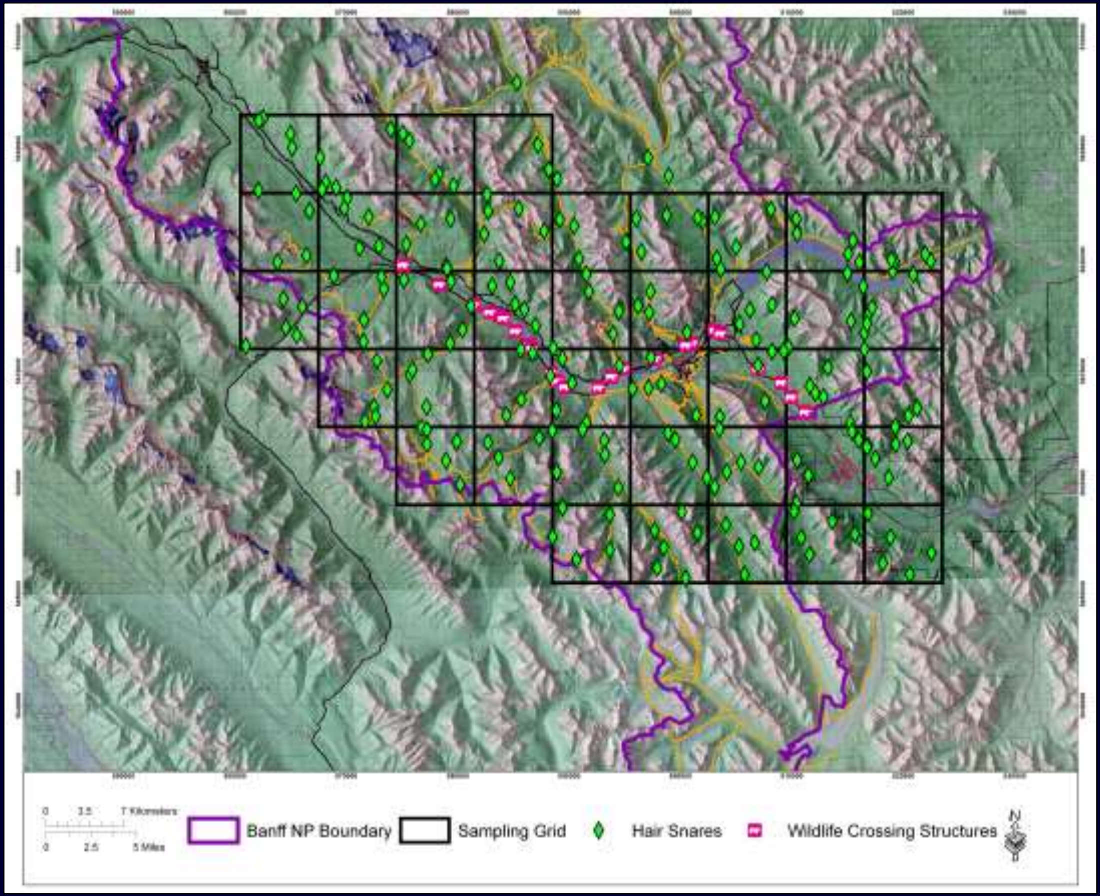
# Validity of prey trap hypothesis


Little et al. 2002. Biol  Conserv 107

# Validity of Prey Trap Hypothesis


Ford and Clevenger 2010. Conserv Biol 24

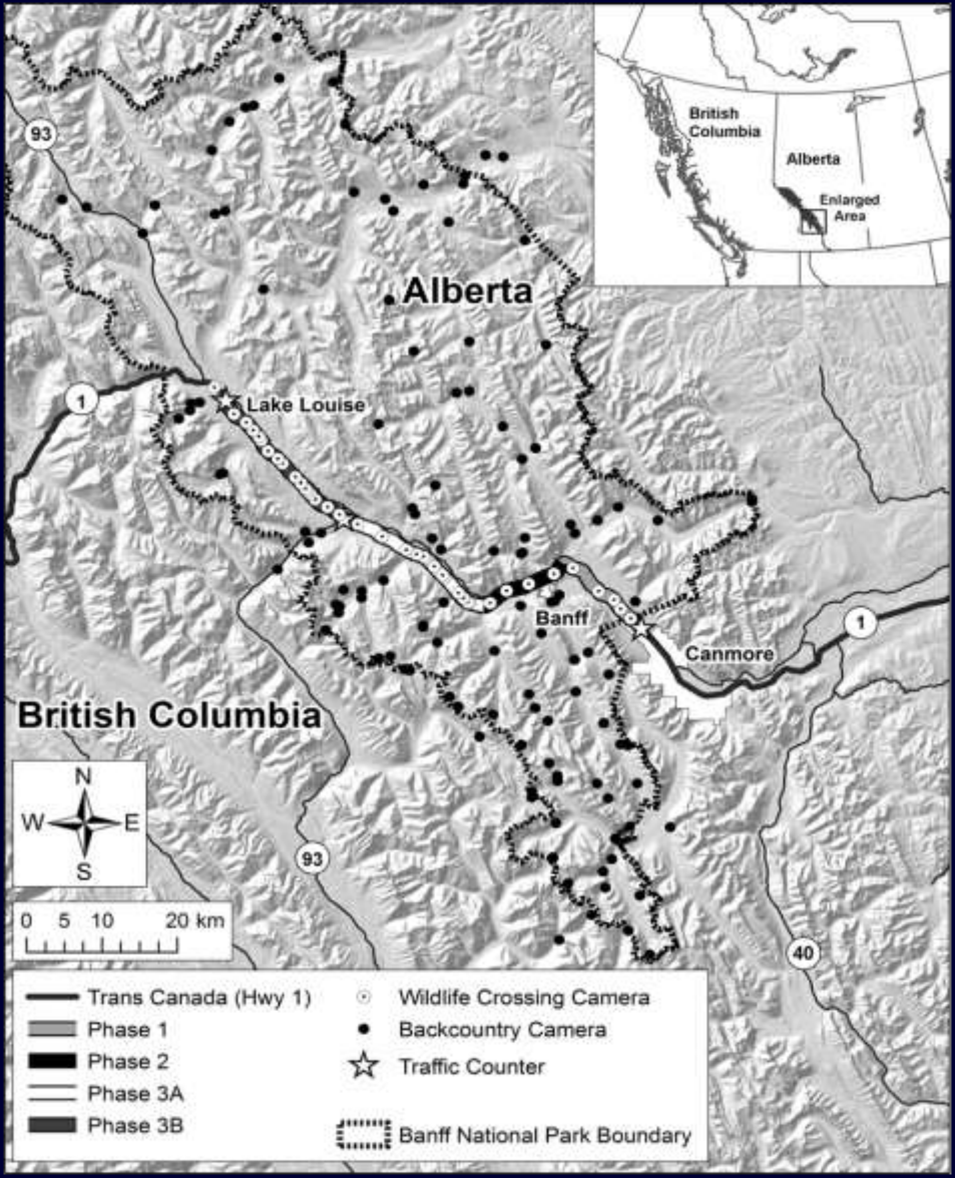
# Demographic connectivity and population-level benefits





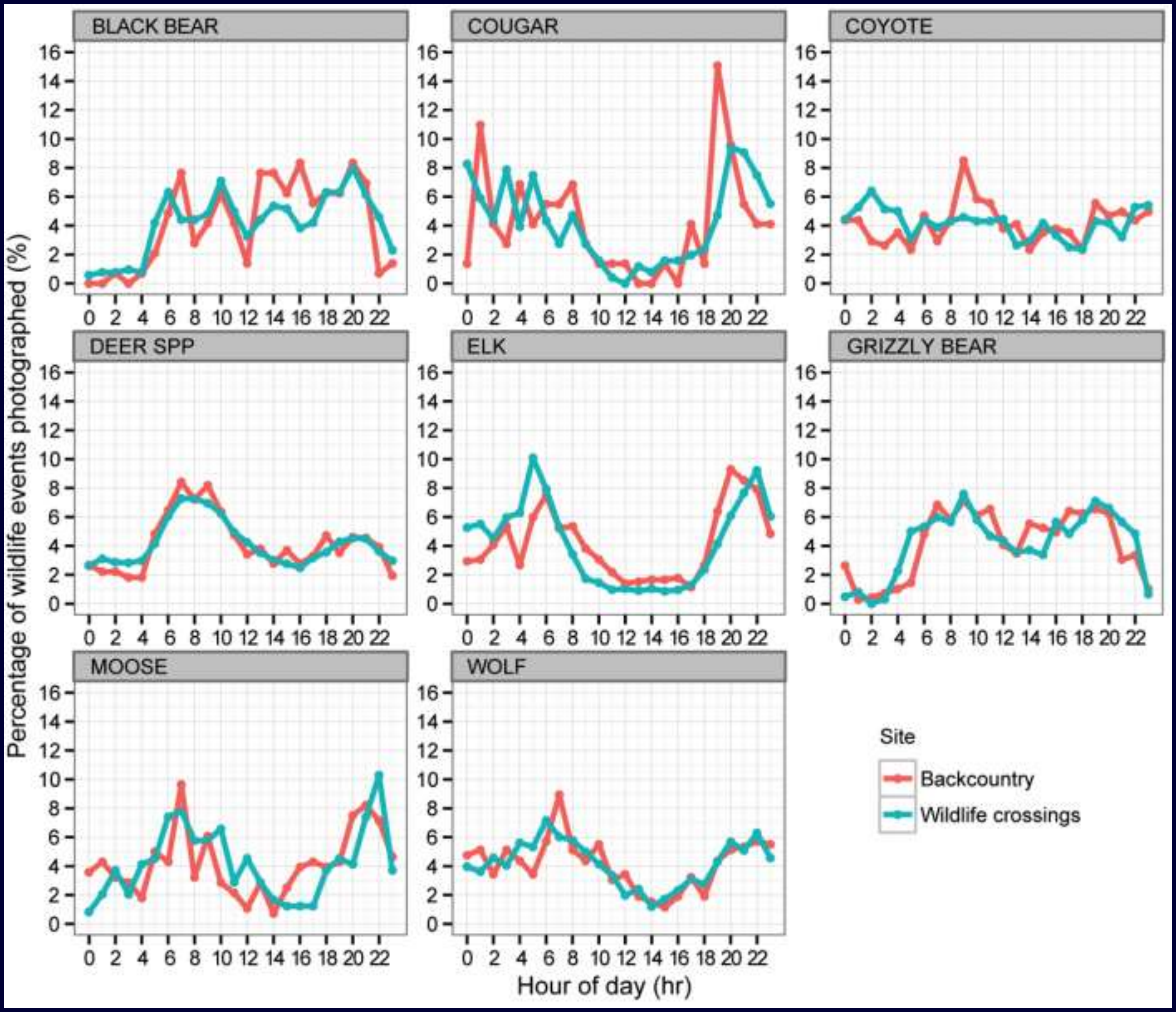
Sawaya et al 2013; Conservation Biology 27
Sawaya et al 2014; Proc Royal Soc (B) 281

# Anthropogenic effects on activity patterns of wildlife at crossing structures




Barrueto et al 2014
Ecosphere 5(3):27.

# Anthropogenic effects on activity patterns of wildlife at crossing structures

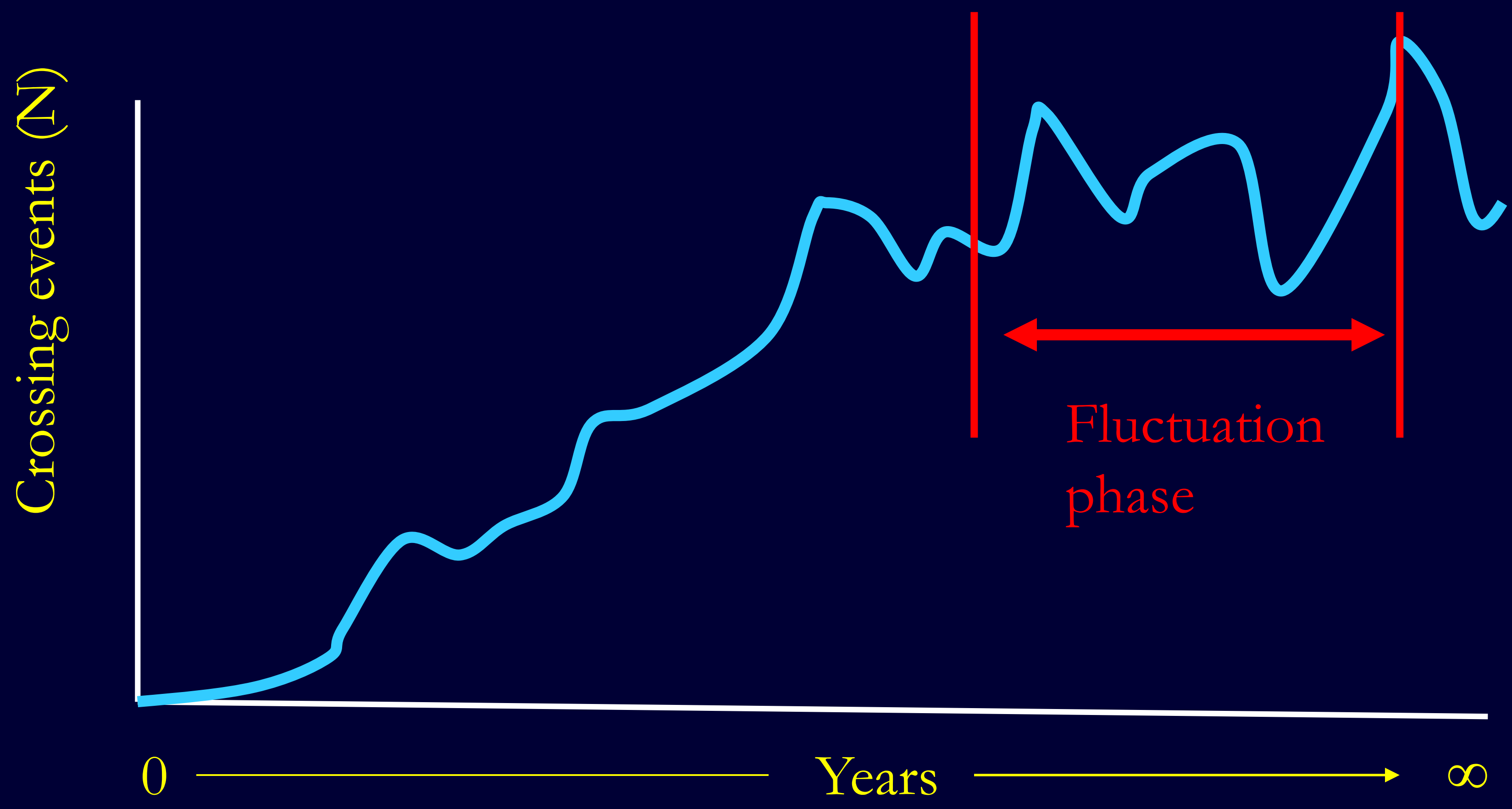



Barrueto et al 2014
Ecosphere 5(3):27.

# Adaptation/Learning, monitoring durations & sound data for mgt


- Monitoring duration
- Adaption/Learning periods
- Sound decisions based on systematic monitoring

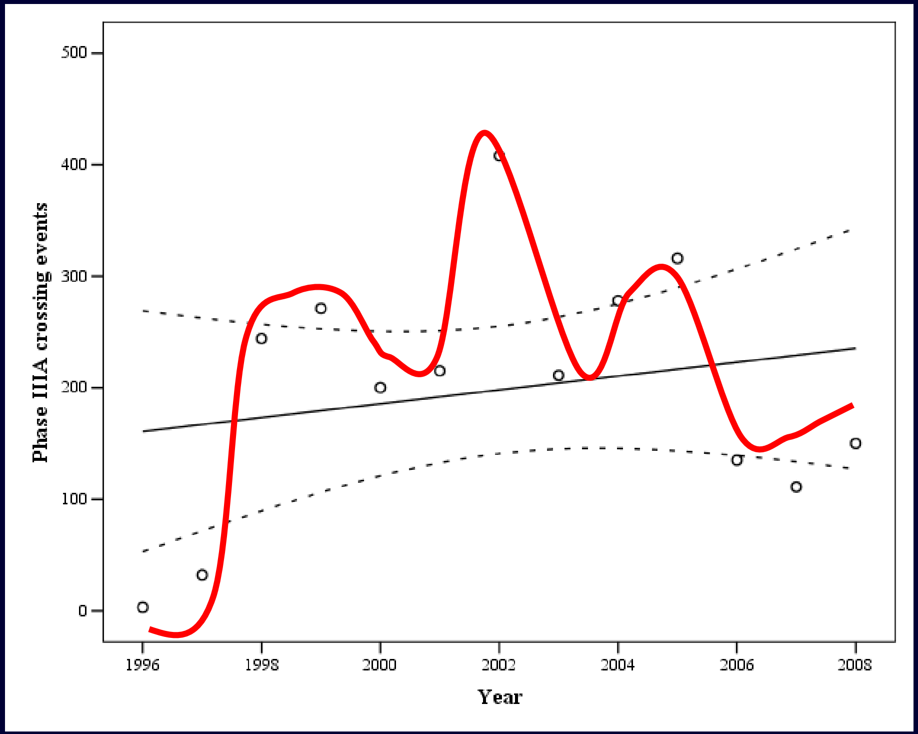
# Adaptation/Learning, monitoring durations & sound data for mgt



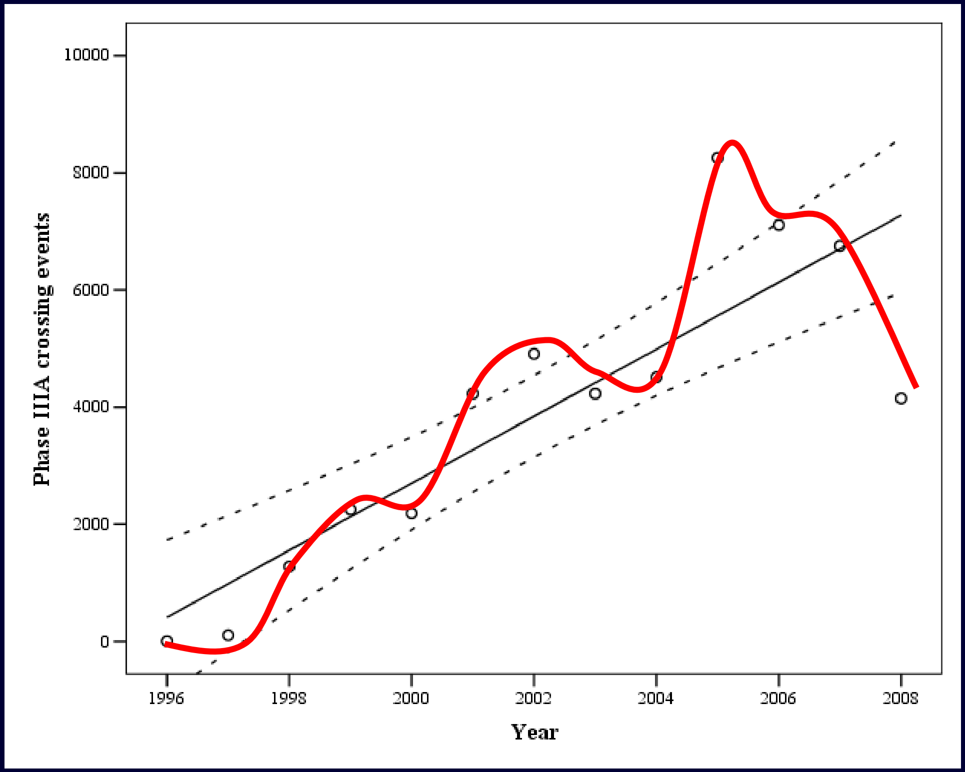

Generalized concept of adaptation of wildlife to crossing structures over time
Y-axis refers to number of crossing events. X-axis is number of years monitoring is conducted. (Clevenger et al. 2009).

# Adaptation/Learning – How long do we need to monitor use??

## Species-specific trends, 1997-2008



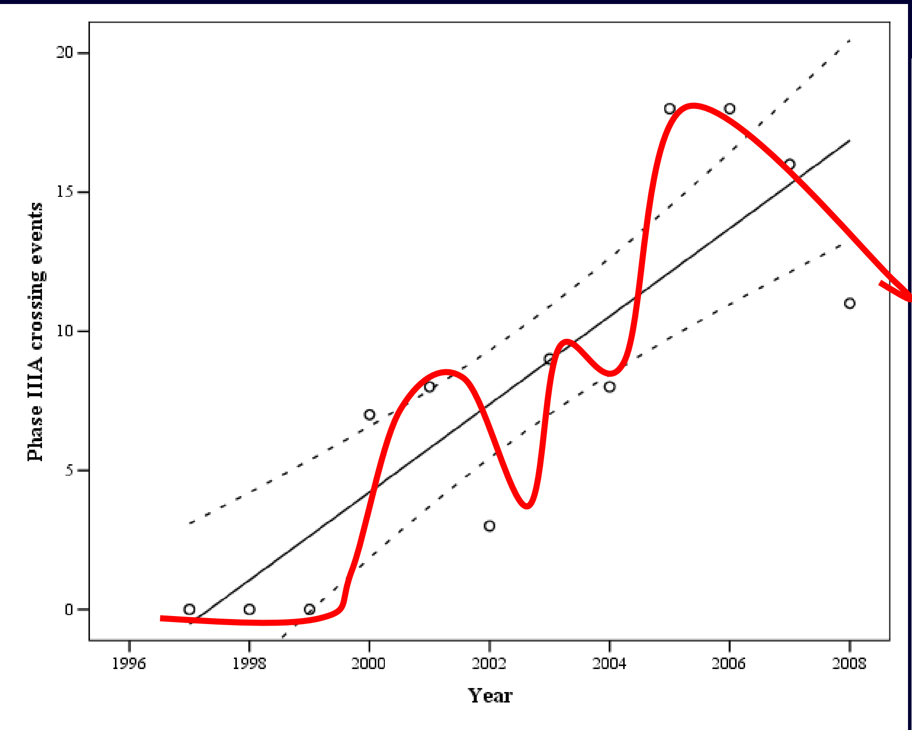

Coyote



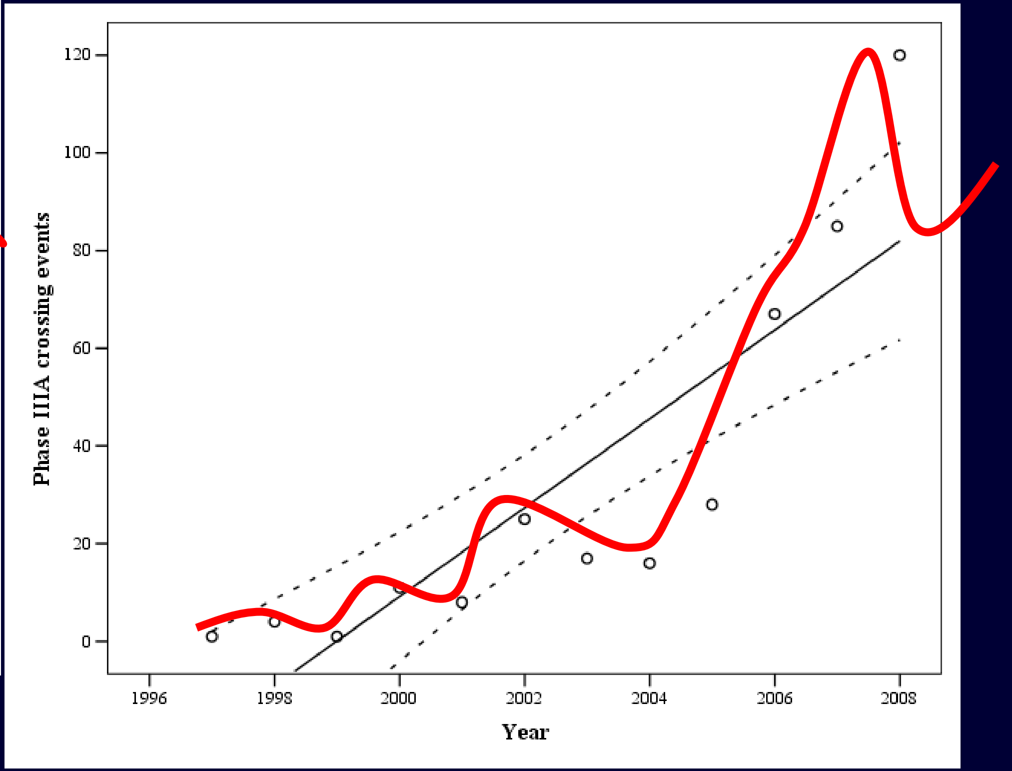

Deer

# Adaptation/Learning: How long do we need to monitor use ??

Species-specific trends, 1997-2008




Moose



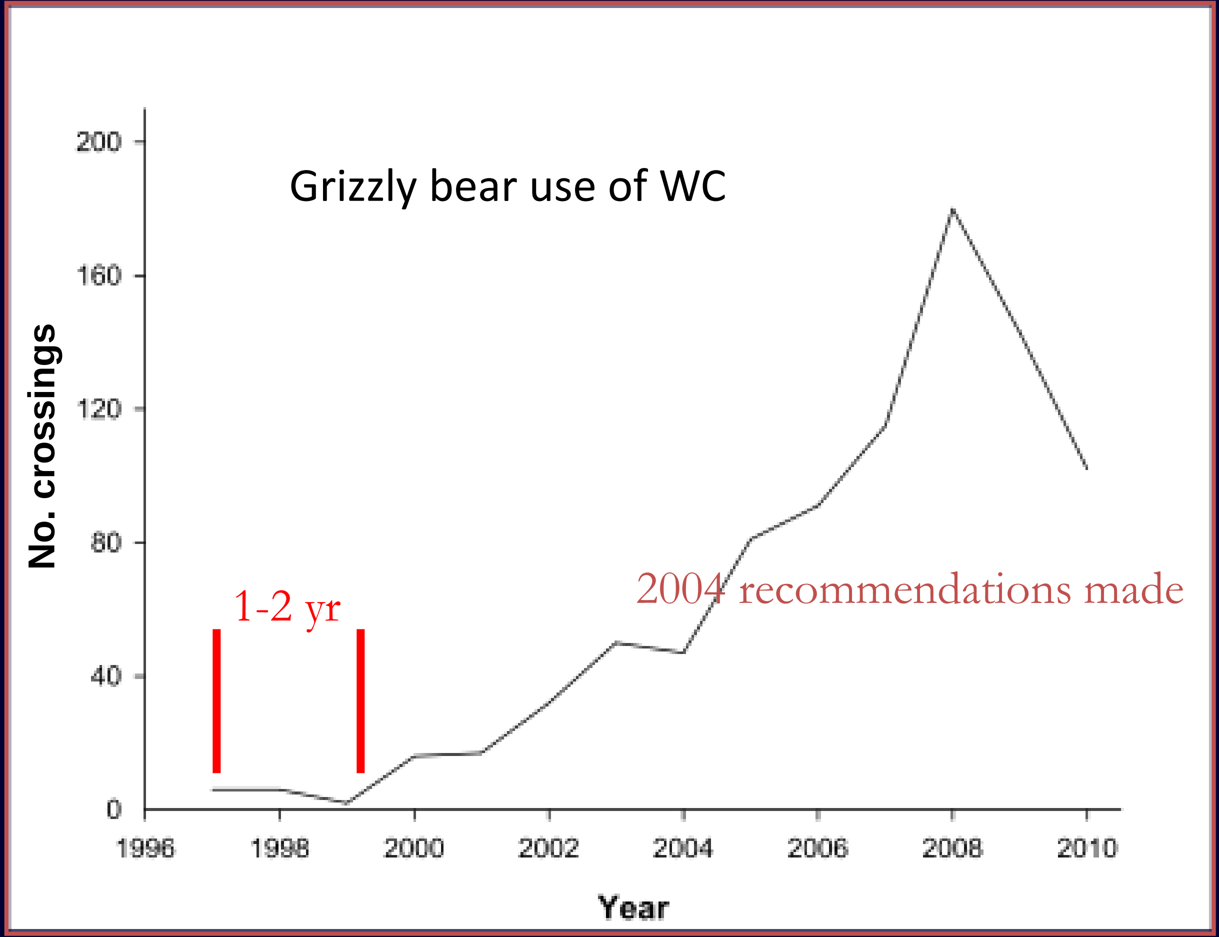

Grizzly bear

# Adaptation/Learning: How long do we need to monitor use ??

| Species | Initial period (years) | Second period (years) |
|---|---|---|
| Deer | 4 | 6 |
| Elk | 4 | 6 |
| Moose | 5 | 7 |
| Cougar | 3 | 3 |
| Black bear | 3 | 3 |
| Grizzly bear | 6 | 9 |
| Wolf | 6 | 9 |
| Coyote | 4 | 4 |
| Average (± SD) | 4.4 (1.2) | 5.9 (2.4) |

Number of monitoring years estimated for adaptation to wildlife crossing structures for eight species of large mammals in Banff National Park, 1997–2008 (Clevenger et al. 2009).

# Design recommendations based on short monitoring periods ???




(Clevenger, unpubl data 2011)


$$$ Costs $$$$   are important !

Are there cost-benefits to mitigation measures?

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

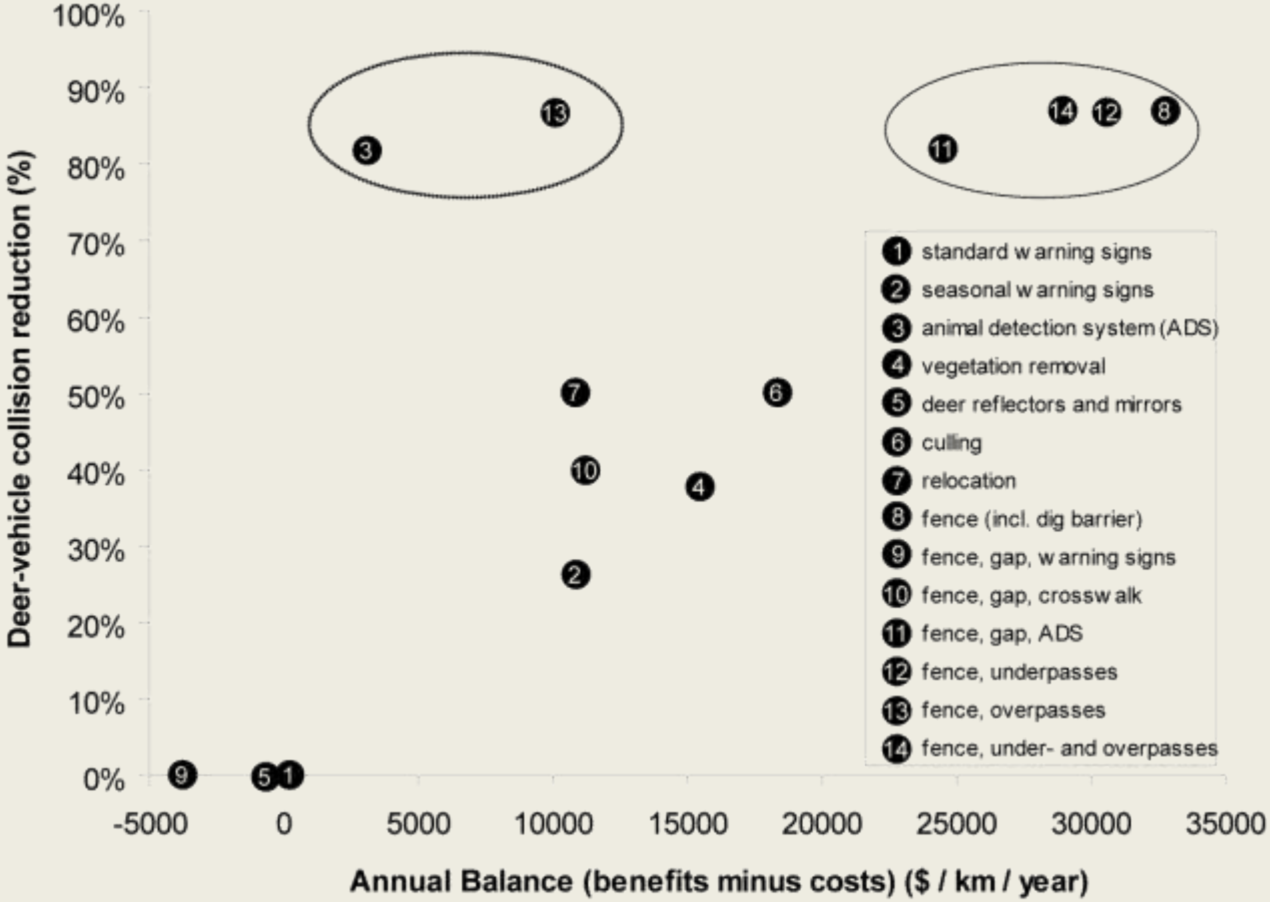
# Cost–Benefit Analyses of Mitigation Measures Aimed at Reducing Collisions with Large Ungulates in the United States and Canada: a Decision Support Tool

*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*

# Cost Effectiveness*: Balance and Remaining Costs for Different Mitigation Measures




*Wildlife-vehicle collision reduction study: a report to Congress. WTI, Montana State University (2007) at a Crossroads

Highway 3 Transportation Corridor Project


# Applying the Economics Model: Planning Mitigation for Highway 3 Crowsnest Pass

| Description | Deer<br><br>Dollars (2007) | Elk<br><br>Dollars (2007) | Moose<br><br>Dollars (2007) |
|---|---|---|---|
| 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. “Cost-benefit analyses of mitigation measures aimed at reducing collisions with large ungulates in North America; a decision support tool.” *Ecology and Society 14(2) [online]. http://www.ecologyandsociety.org/viewissue.php?sf=41.*


| Threshold values | Discount rate[1] | Fence | Fence, underpass, jump-outs | Fence, under- and overpass, jump-outs | ADS[2] | Fence, gap, ADS, jump-outs | Elevated roadway | Road tunnel |
|---|---|---|---|---|---|---|---|---|
| $ Cost (2007)/yr | 3% | $6,304 | $18,123 | $24,230 | $37,014 | $28,150 | $3,109,422 | $4,981,333 |
| Deer/km/yr | 3% | 1.1 | 3.2 | 4.3 | 6.4 | 4.9 | 470 | 752.8 |

Cost-benefit threshold

at a Crossroads

Highway 3 Transportation Corridor Project

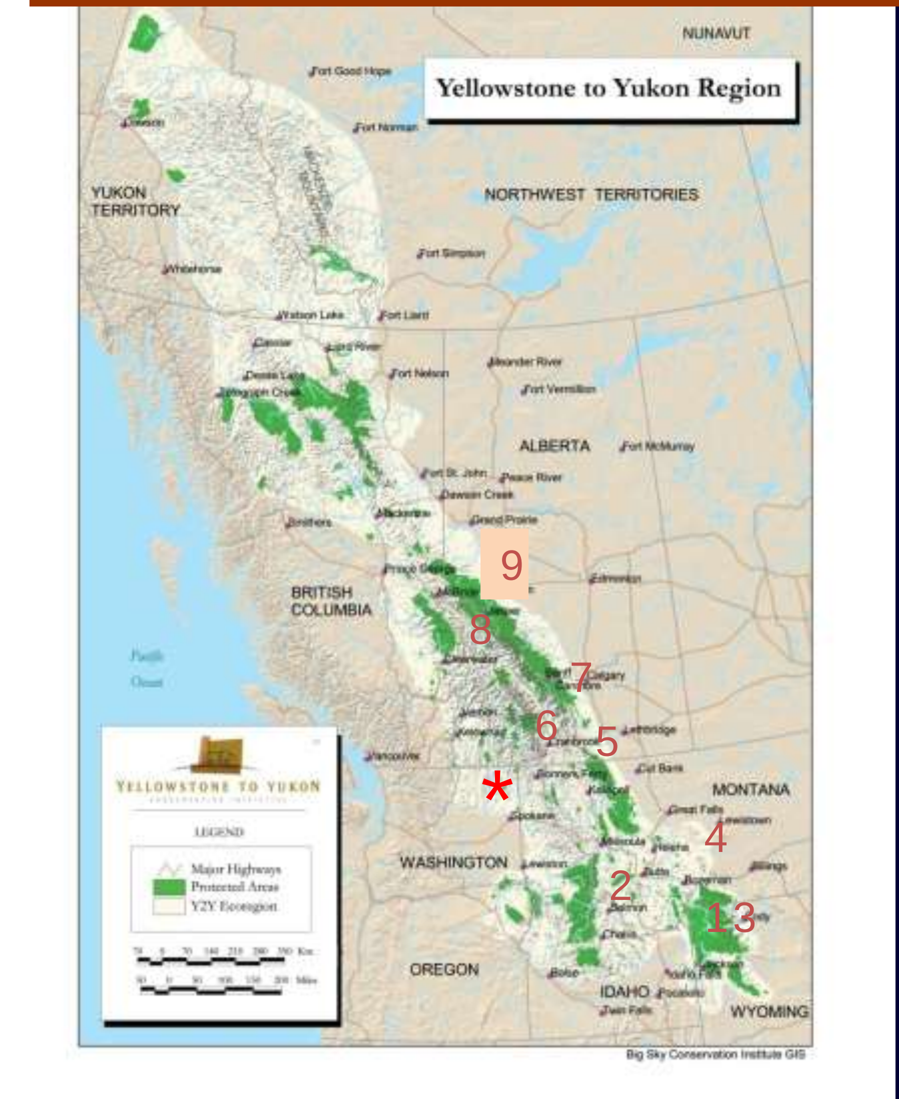

# Applying the Economics Model: Planning Mitigation for Highway 3 Crowsnest Pass

- Of the 9 emphasis mitigation sites in AB, 6 sites have the average or higher (average 3.2)
    - **Rock Creek (4.2)**
    - Leitch Collieries (3.8)
    - Crowsnest West (3.6)
    - **Crowsnest Lakes (3.4)**
    - Crowsnest East (3.4)
    - Iron Ridge (3.2)

# Wildlife Passage Projects in Y2Y

Facilitate connectivity/dispersal for fragmentation sensitive species

Ensure local scale linkages able to mitigate continental scale bottlenecks



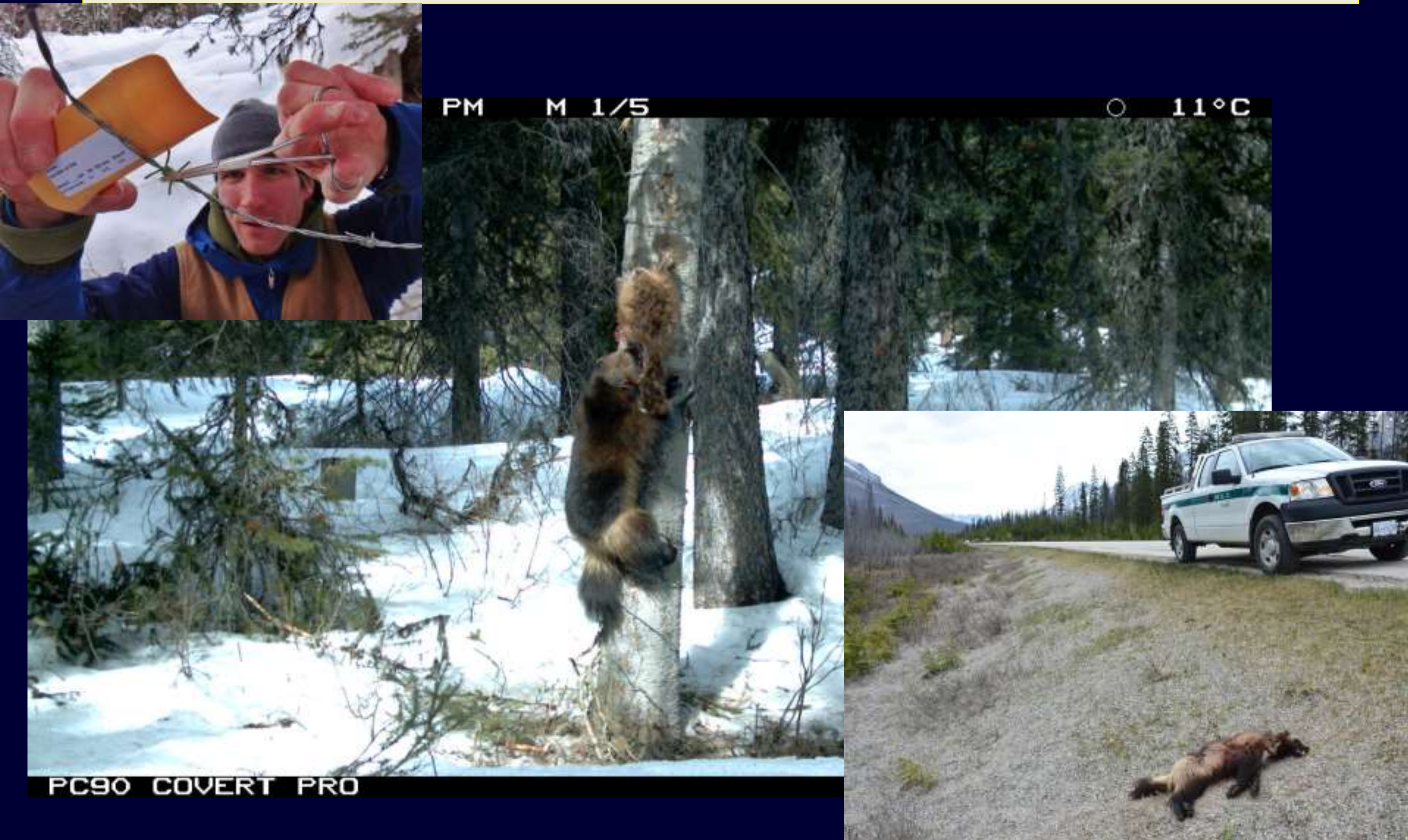

East-West Fracture Zones

1. Hwy 75, Ketchum, ID
2. Raynolds Pass, ID
3. Togwotee Pass, WY
4. I-90 Bozeman Pass, MT
5. U.S Hwy 93, MT
6. US Hwy 95, ID
7. **Hwy 3, AB-BC**
8. Kootenay NP, BC
9. **TCH-Banff-Yoho NPs,**

* I-90 Snoqualmie Pass, WA


Research Partnership 2009-14
WTI-Montana State University
Miistakis Institute
Woodcock and Wilburforce Foundations
Parks Canada
T Clevenger

# DNA Collection & Fragmentation Effects of TCH



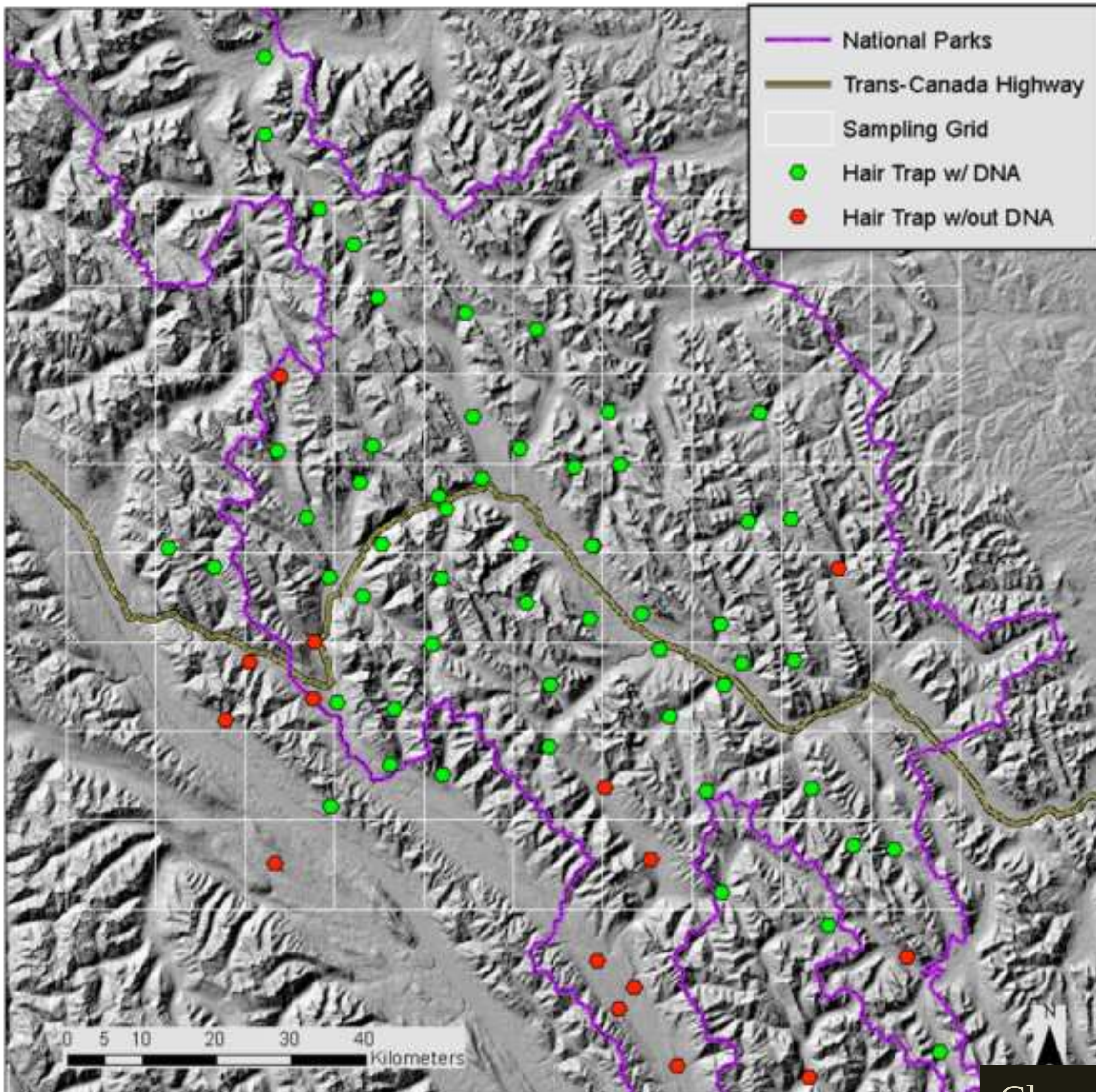
Effects of Transportation Infrastructure on Wolverine Movements, Gene Flow, and Population Connectivity

# DNA Collection Summary

| Sampling period | # Samples collected | # Samples attempted | # Genotypes | # Individuals | # Females | # Males |
|---|---|---|---|---|---|---|
| Pilot_results 2010 | 43 | 27 | 11 | 4 | 2 | 2 |
| Wtr 2010_2011 | 849 | 256 | 88 | 22 | 8 | 14 |
| Wtr 2011-2012_Transition | 295 | 54 | 22 | 13 | 7 | 6 |
| Wtr 2012-2013 | 1176 | 365 | 132 | 33 | 12 | 21 |
| Peripherals | 114 | 21 | 13 | 5 | 1 | 4 |
| Incidentals 2010-13 | 94 | 70 | 48 | 23 | 6 | 17 |
| Hawk Cr Killsite | 15 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | |
| **TOTALS** | **2586** | **793** | **314** | **64** | **25** | **39** |

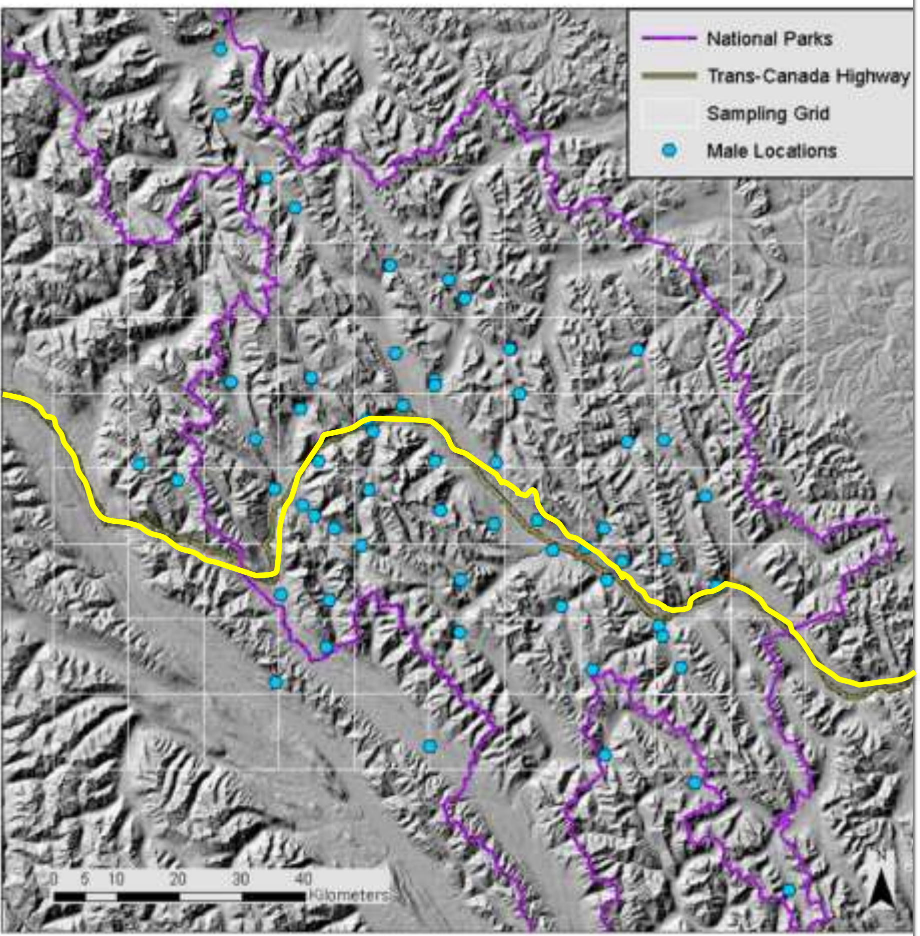
| | # Locations | Avg # Locations |
|---|---|---|
| Total | 314 | **4.91** |
| | | |
| Females | 93 | **3.72** |
| Males | 221 | **5.67** |

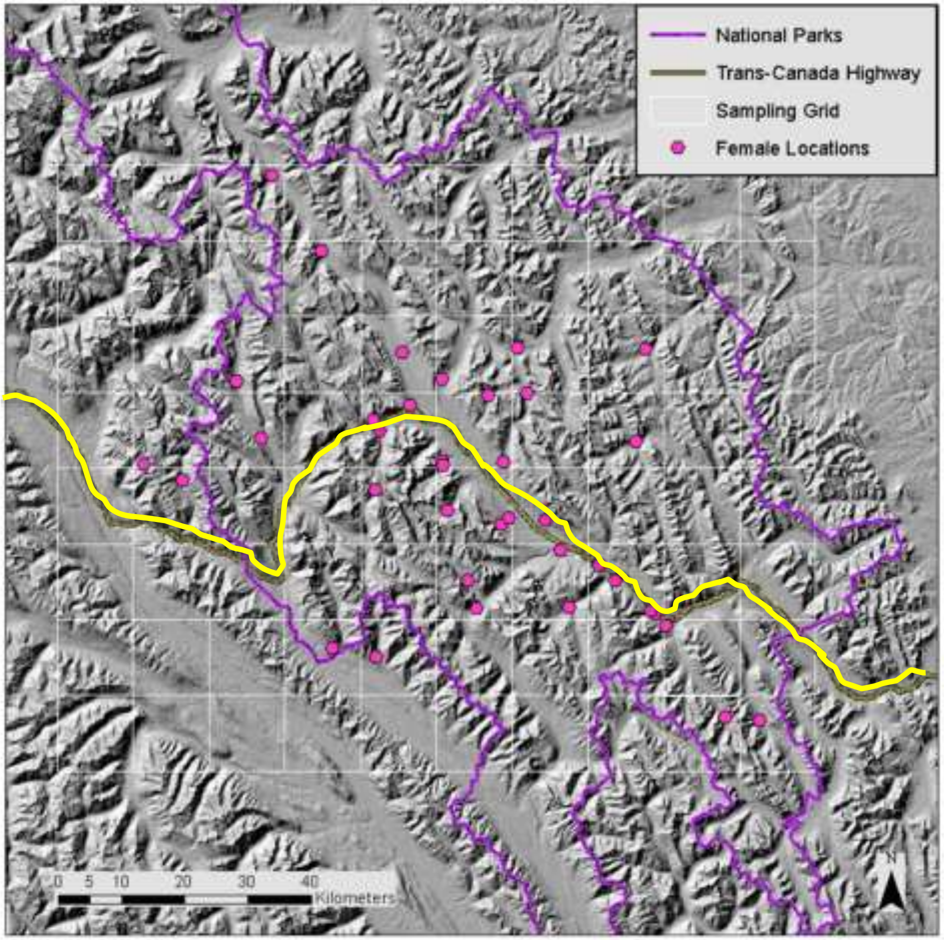
# Highway effects on wolverine population genetics




Clevenger and Sawaya 2014

# Highway effects on wolverine population genetics

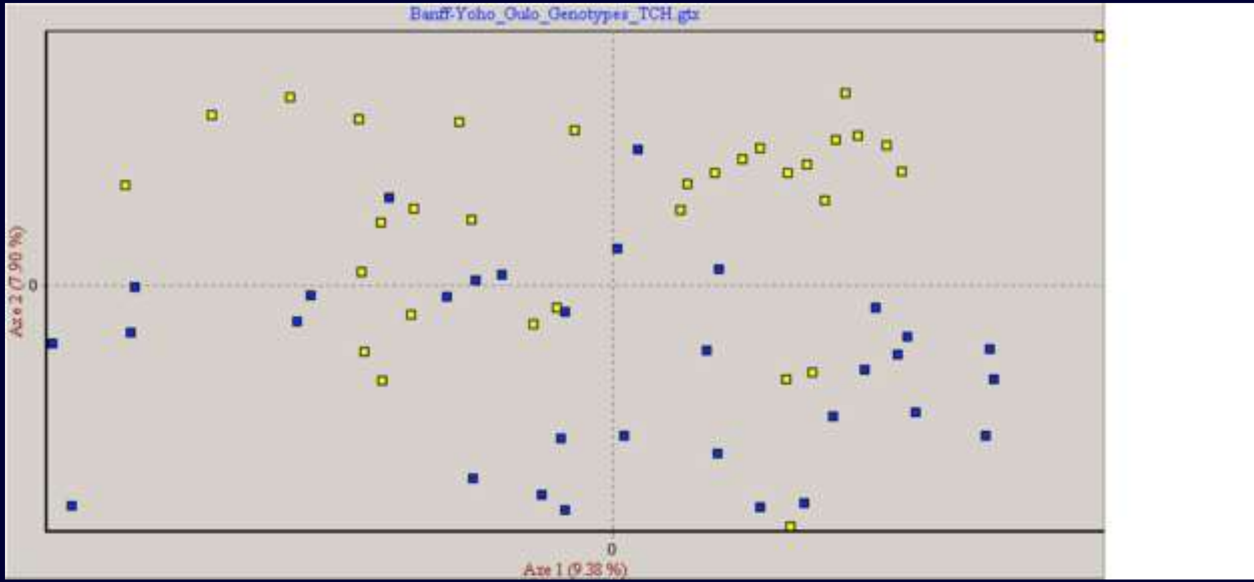


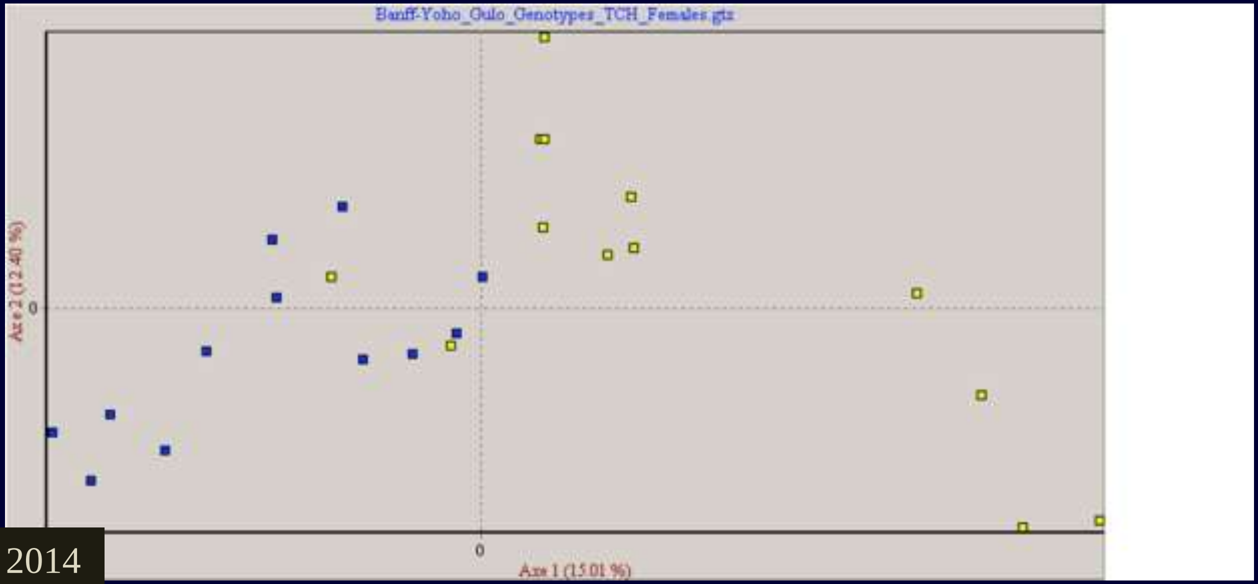




Clevenger and Sawaya 2014

# Fine-scale Genetic Structure

## Individual - Factorial Correspondence Analysis




Clevenger and Barrueto 2014

# Research Partnership

*Highway Wilding*

Parks Canada

WTI-Montana State University

Miistakis Institute, Mt Royal University

Woodcock and Wilburforce Foundations