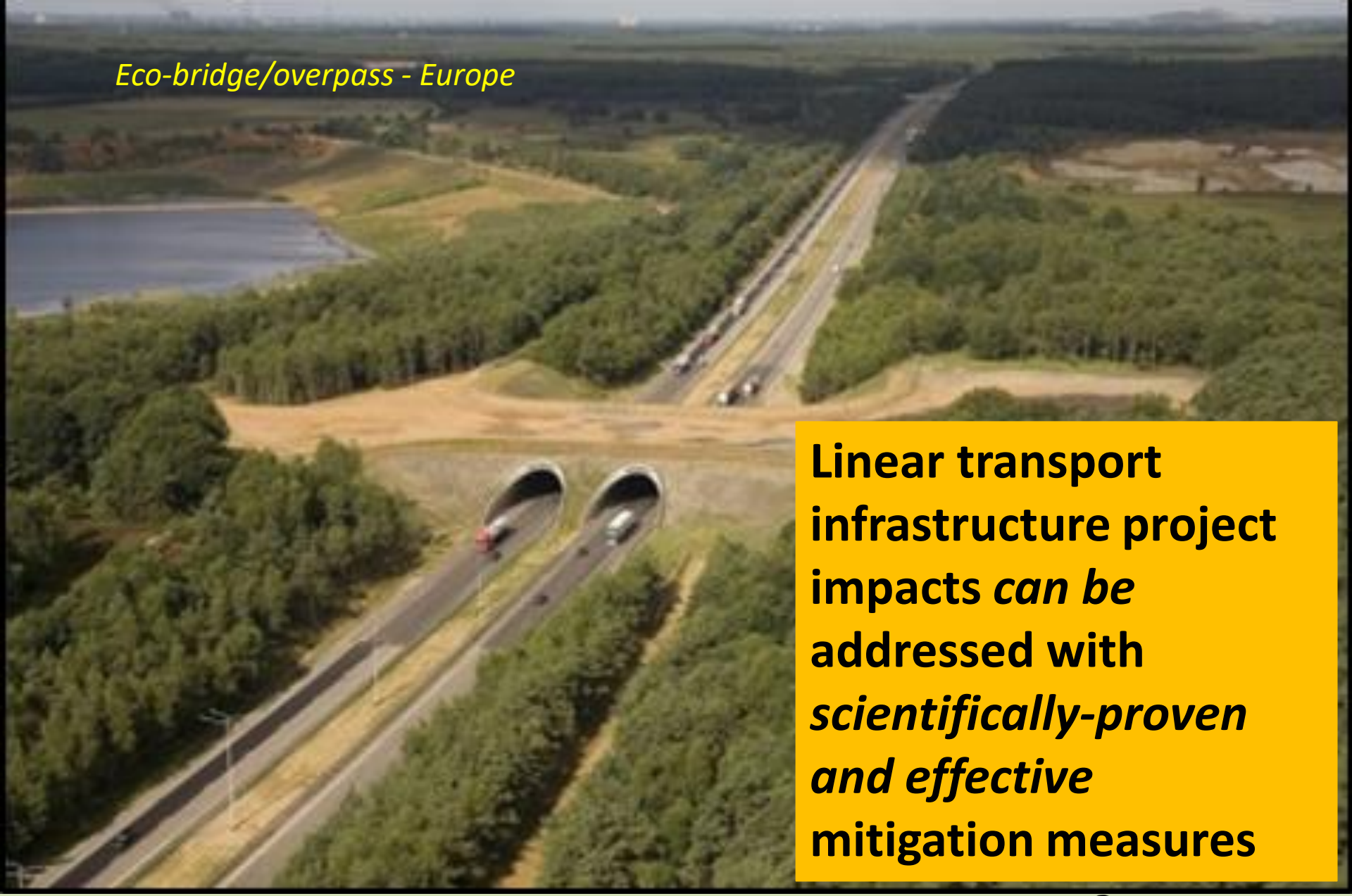
GREEN TRANSPORT INFRASTRUCTURE

Lessons Learned from Road Projects in North America and other Countries

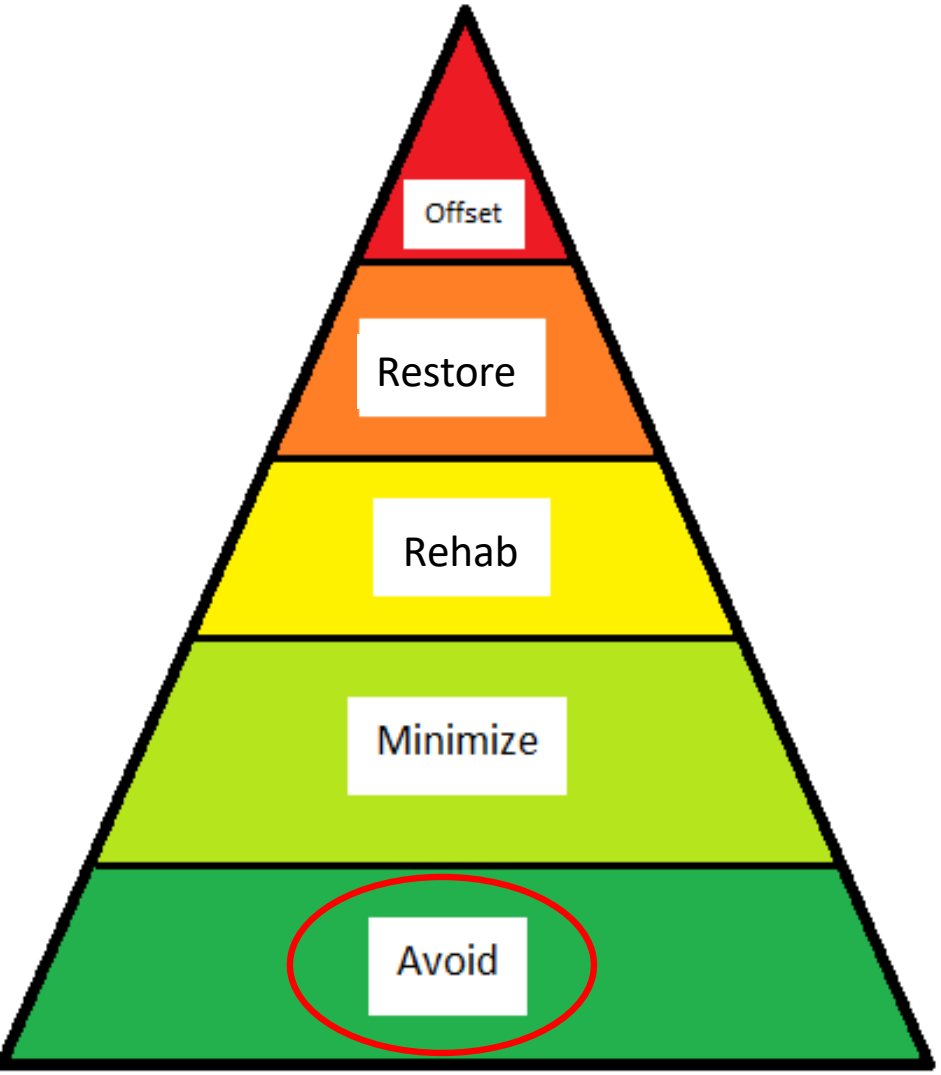
PLANNING AND IMPLEMENTATION OF GREEN TRANSPORTATION PROJECTS IN SOUTH ASIA

Wildlife Institute of India



Linear transport infrastructure project impacts *can be* addressed with *scientifically-proven and effective* mitigation measures

So, let's look at some of this ever-increasing proof being amassed from around the World as to the effectiveness of Green Infrastructure



MITIGATION HIERARCHY

AVOID IMPACTS

When possible, but especially in:

- Critical habitats
- Protected areas
- High biodiversity “hotspots”
- Areas not suited for transport construction (e.g., unstable soils)

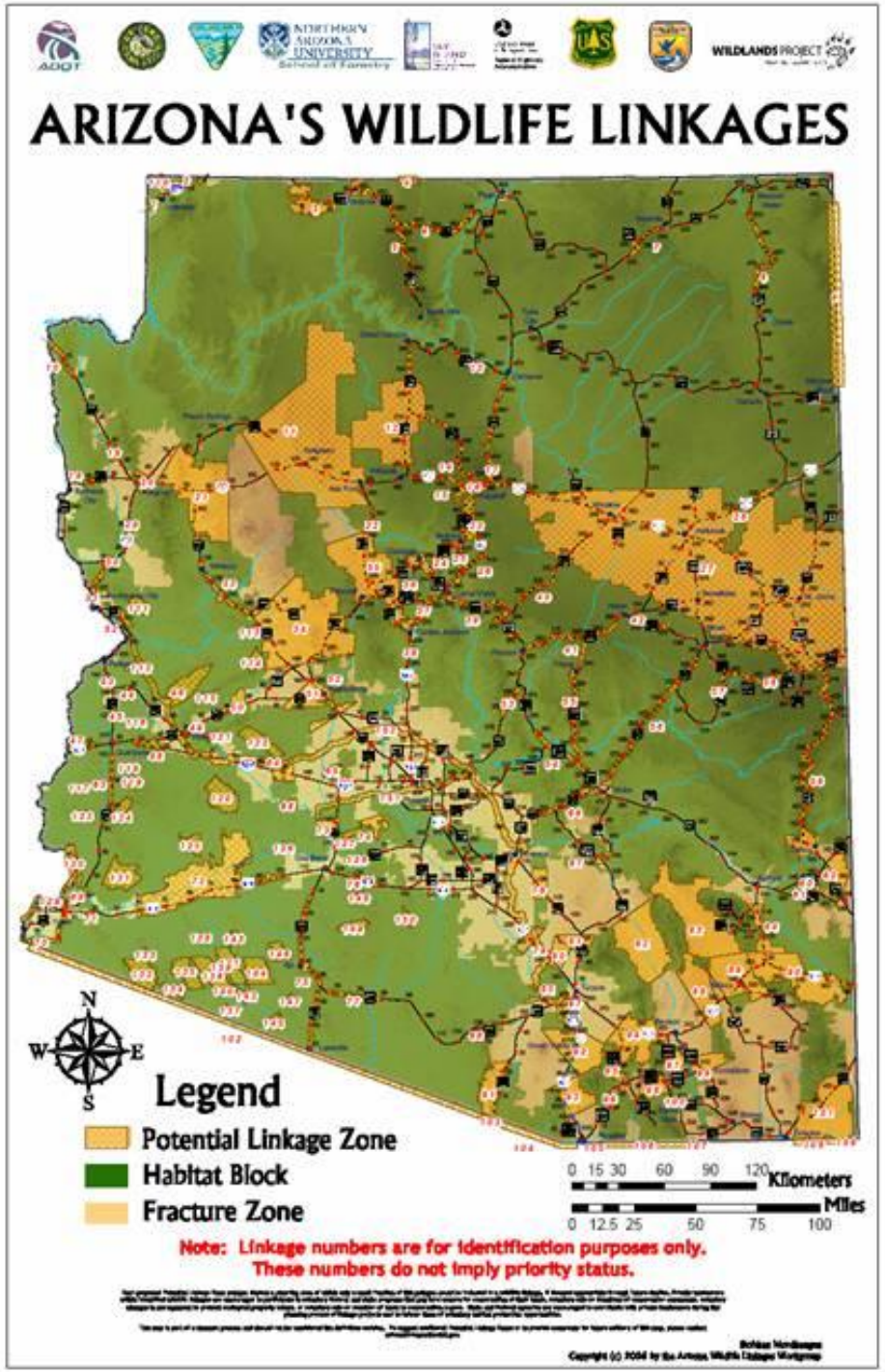
Mass slope failure - new road, Bhutan

PRESENTATION GOALS

- *Case Studies* addressing a range of green infrastructure to address impacts associated with transport projects:
  - ✓ Wildlife-vehicle/train collision incidence
  - ✓ Permeability and landscape connectivity

PRESENTATION GOALS

- Case Studies addressing a range of green infrastructure to address impacts associated with transport projects:
  - ✓ Wildlife-vehicle collision incidence and cost:benefit relationships
  - ✓ Highway permeability and landscape connectivity
- Highlight key *Lessons Learned* regarding the effectiveness of green infrastructure, including:
  - ✓ Role of traffic
  - ✓ Role of passage structure design (openness, spacing)
  - ✓ Wildlife preferences for overpasses vs. underpasses
  - ✓ New construction/reconstruction vs. "**retrofitting**" opportunities



AVENUES TO ADDRESS WILDLIFE-HIGHWAY CONFLICTS

Role of Retrofitting

- Priority highway with significant safety issues **1,220 km**
- Highway reconstruction completed since 2000 **95 km (8%)**
- Highway planned for future reconstruction (20 years) **150 km (12%)**

Retrofitting is an alternative to limited new highway construction to address **existing conflicts**

MINIMIZING WILDLIFE MORTALITY FROM TRAIN/VEHICLE COLLISIONS

- **Road Management** to minimize collisions

Low Cost
Mod-High Effectiveness

✓ Dusk to Dawn (Nighttime) Road Closures

- Especially appropriate for situations such as Protected Areas with limited traffic and where nocturnal species are present
- Still allows commerce and use by public
- Helps limit poaching - supports patrols
- Enforcement critical

✓ Seasonal road closures (e.g., during wildlife migrations)

- Generally politically difficult to employ

Gated nighttime road closure

MINIMIZING WILDLIFE MORTALITY FROM TRAIN/VEHICLE COLLISIONS

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Low Cost
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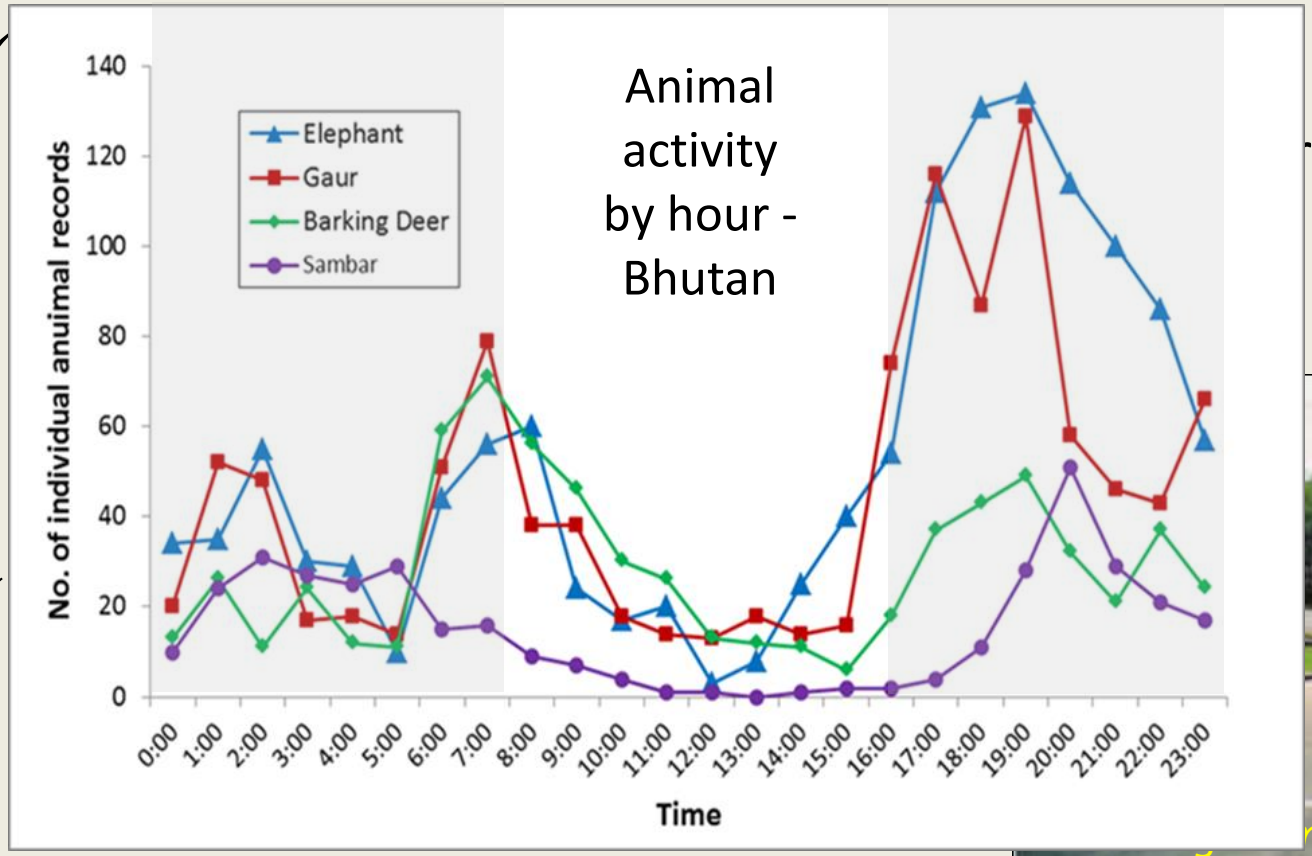

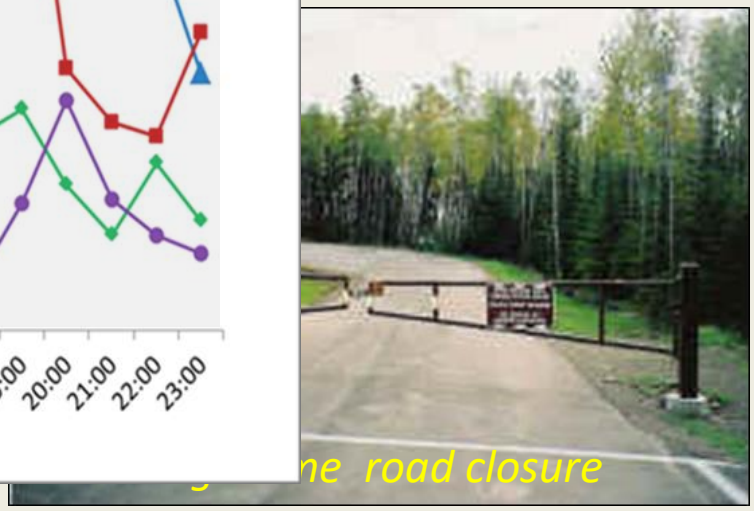

MINIMIZING WILDLIFE MORTALITY FROM TRAIN/VEHICLE COLLISIONS

- **ROAD MANAGEMENT** to minimize collisions

Low Cost
Mod-High Effectiveness

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CASE STUDY

Location: Royal Bardia National Park, Nepal

After a 4-year nighttime highway travel ban was lifted, the incidence of wildlife-vehicle collisions the following 3 years experienced a **6-fold** increase.

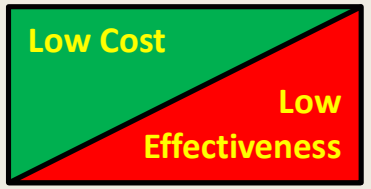
- May be politically difficult to employ

Gated nighttime road closure

MINIMIZING WILDLIFE MORTALITY FROM TRAIN/VEHICLE COLLISIONS

- **Motorist Alert Signage**

✓ Static Warning Signs



Generally **ineffective**

Motorists become *habituated* when animals are not encountered

✓ Flashing Warning Signs

Flash at peak times – migrations

A bit more effective – the more limited the they are activated, the better

MINIMIZING WILDLIFE MORTALITY FROM TRAIN/VEHICLE COLLISIONS

- **Reducing Motorist Speed with Design Measures**

Moderate Cost / Moderate Effectiveness

✓ Reduced Design Speeds

Lower Design Speeds for new roads

Construct roads with added curves

✓ Traffic Calming Treatments/Devices

Achieve slower speeds with treatments

Speed bumps (right), traffic circles, chicanes, raised medians, rumble strips

MINIMIZING WILDLIFE MORTALITY FROM TRAIN/VEHICLE COLLISIONS

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Moderate Cost

Moderate Effectiveness

CASE STUDY

Location: India

Traffic calming devices with signage are being used to create designated **Animal Corridors** to prevent collisions by reducing vehicle speeds

MINIMIZING WILDLIFE MORTALITY FROM TRAIN/VEHICLE COLLISIONS

- **At-Grade "Crosswalks" with Triggered Signage**

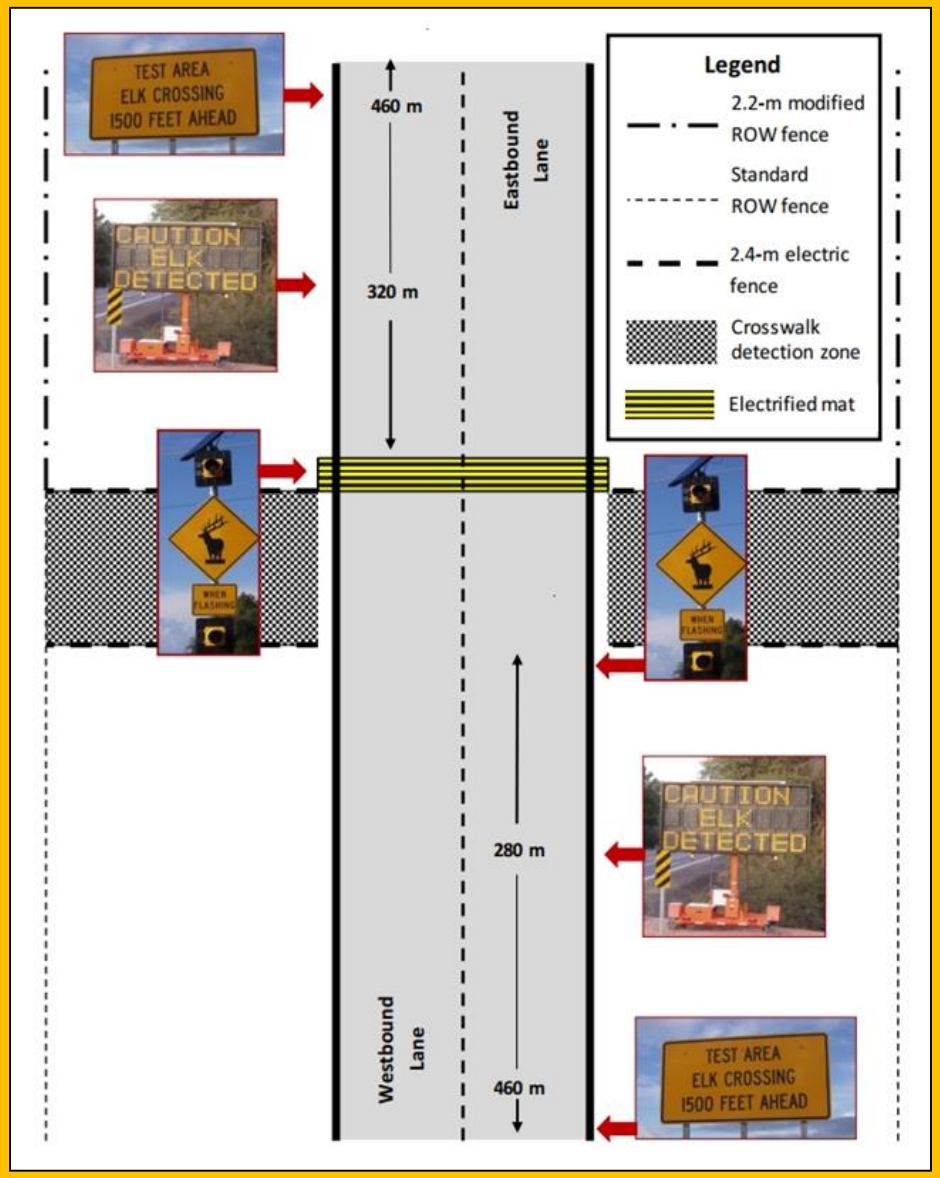
  Integrate animal-detection systems, wildlife fencing, and signage

  Mod-High Cost / High Effectiveness

  Best when *time and place specific* to when animals are present to prevent motorist habituation

  Can be alternatives to passage structures

  Maintenance intensive



CASE STUDY

Location: State Route 260, Arizona, USA

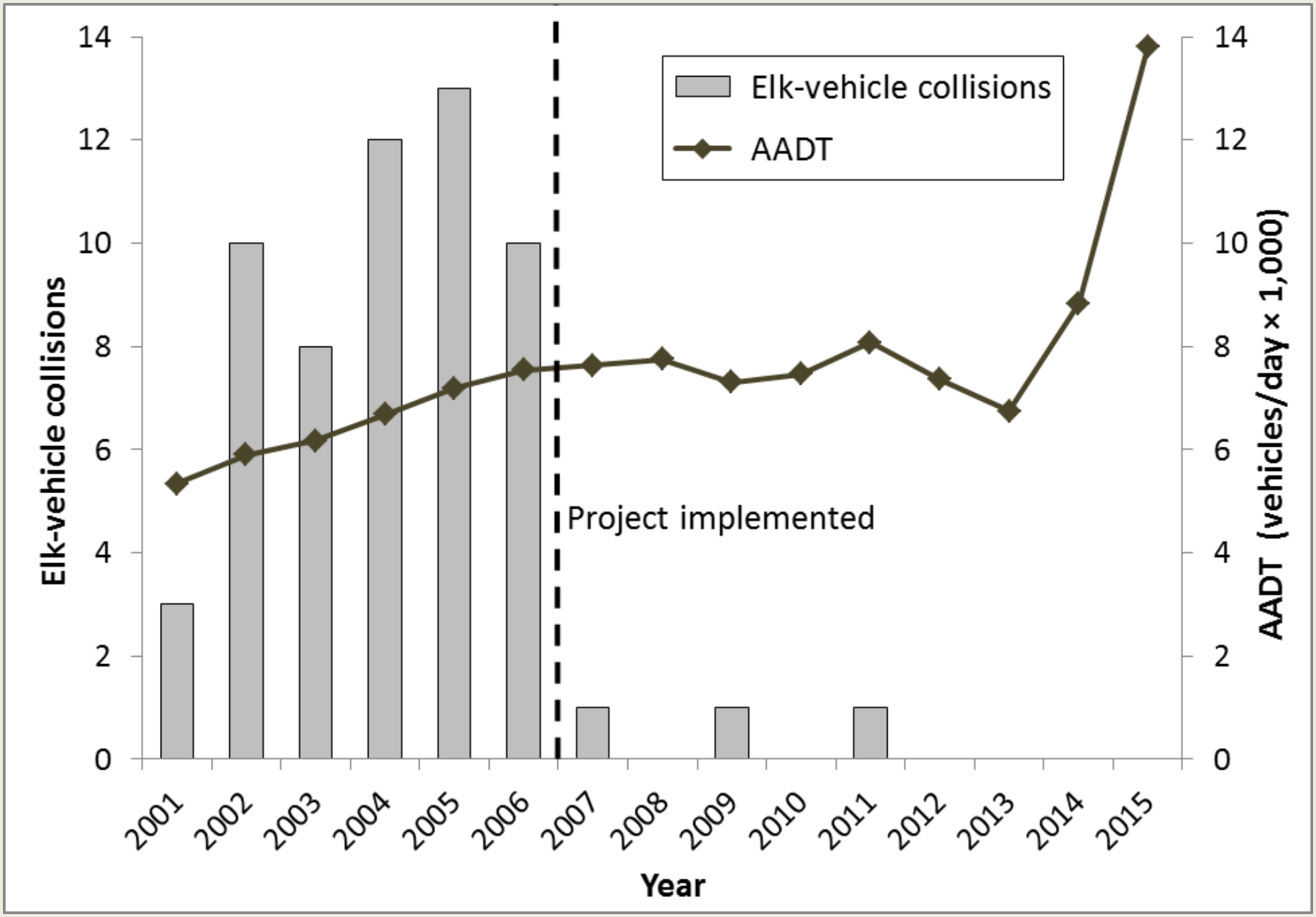
5 km fenced with a defined "crosswalk" to link existing underpasses

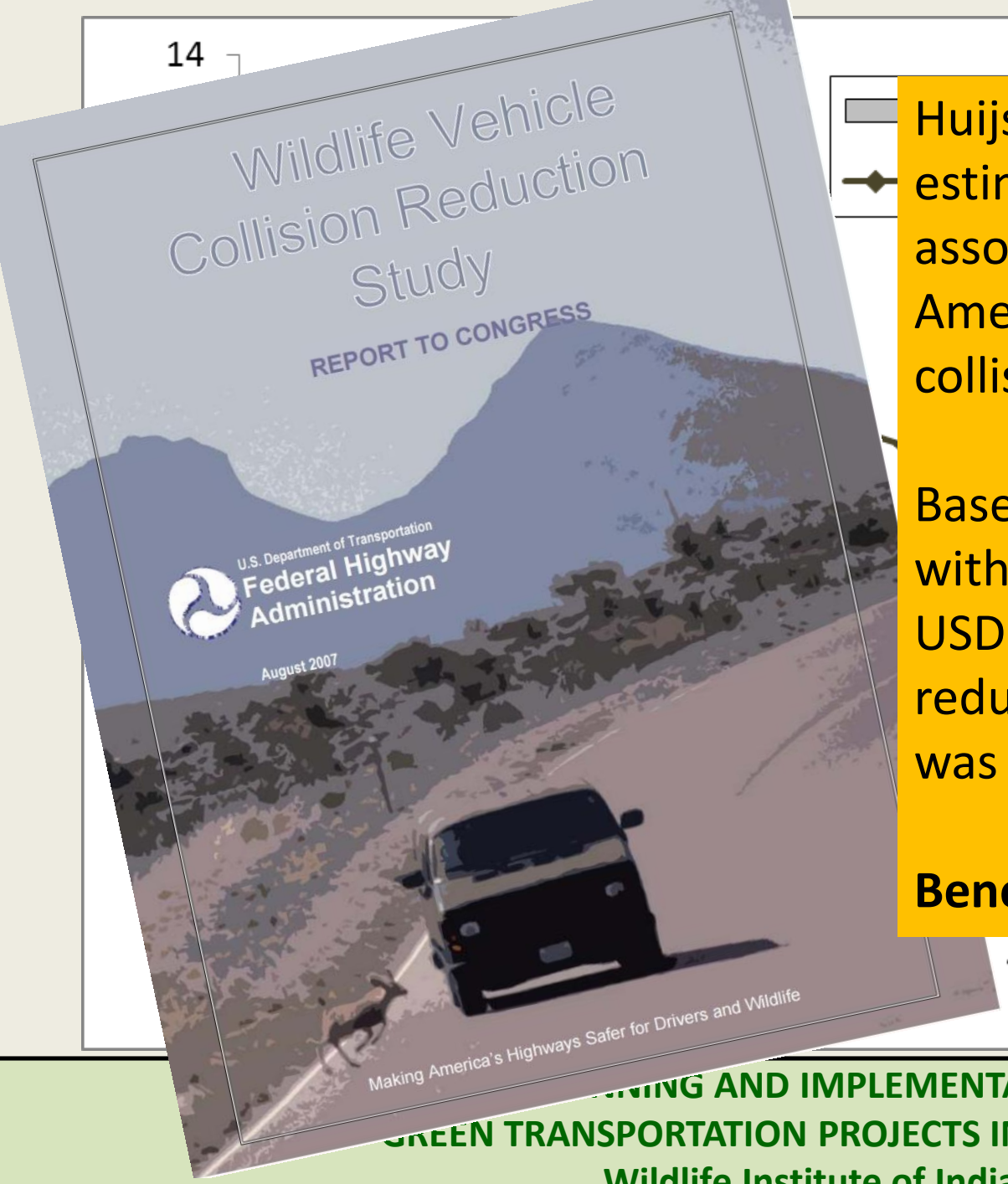
Only 1 crosswalk collision in >2,000 animal crossings

Reduced elk collisions **97%**

No motorist habituation in 9 years for speed reduction and increased alertness

Success due to *time*- and *location-specific* approach

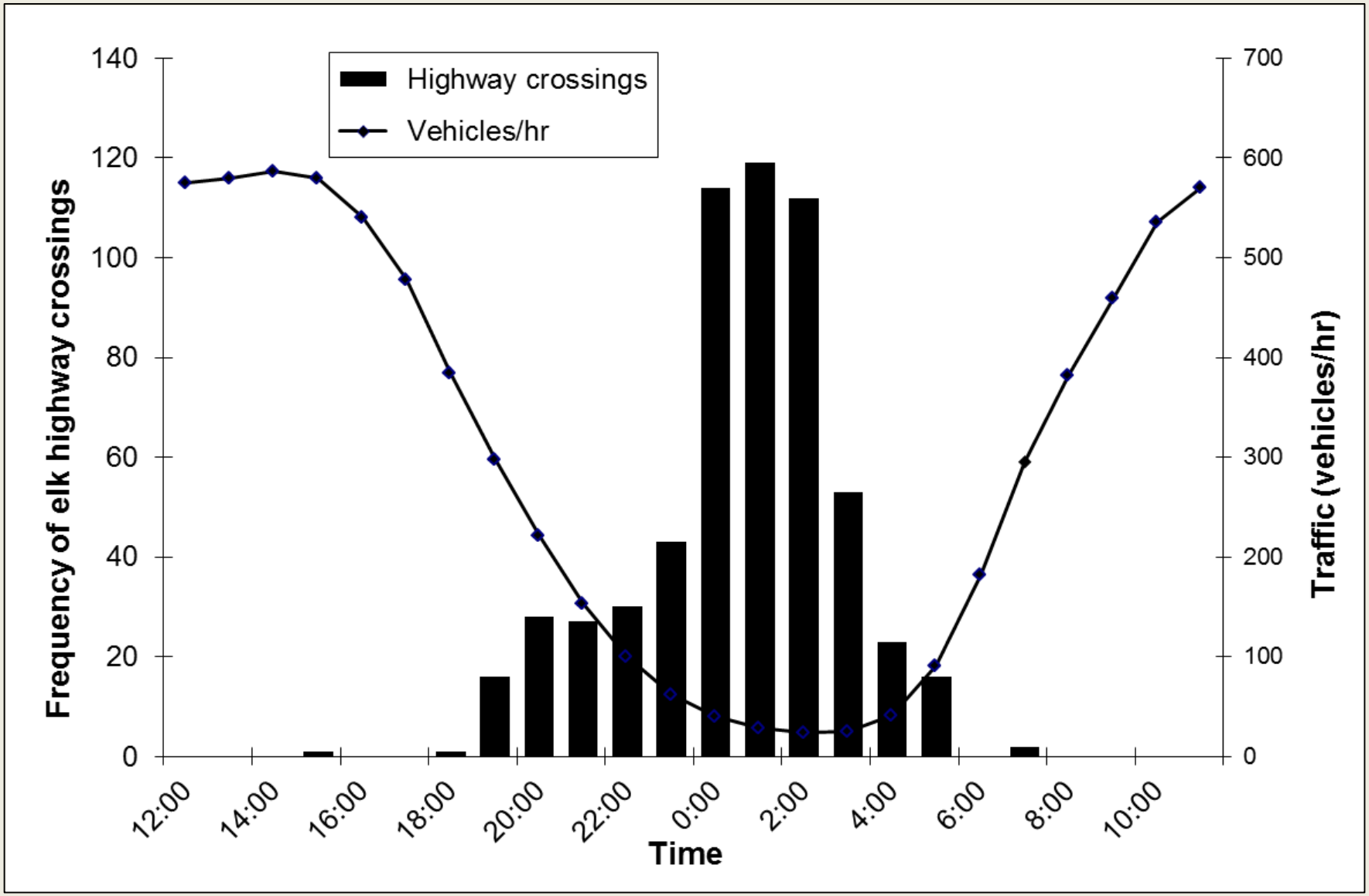

Elk-vehicle collisions
AADT
Project implemented
Elk-vehicle collisions
AADT (vehicles/day × 1,000)
Year
0
2
4
6
8
10
12
14
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015



Huijser et al. (2007, 2009) estimated all costs associated with North American wildlife-vehicle collisions, by species.

Based on the cost associated with elk collisions ($17,483 USD), the benefit from reduced elk-vehicle collisions was ≈$150,000 USD/year.

Benefits > Costs in 5 years


Highway crossings
Vehicles/hr
Frequency of elk highway crossings
Traffic (vehicles/hr)
Time
140
120
100
80
60
40
20
0
700
600
500
400
300
200
100
0
12:00
14:00
16:00
18:00
20:00
22:00
0:00
2:00
4:00
6:00
8:00
10:00

MINIMIZING WILDLIFE MORTALITY FROM TRAIN/VEHICLE COLLISIONS

- **At-Grade**

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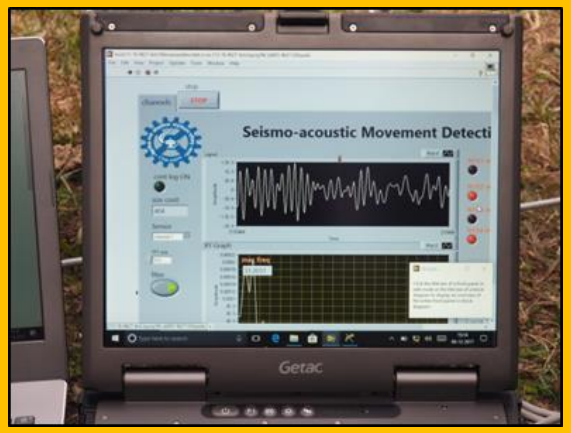
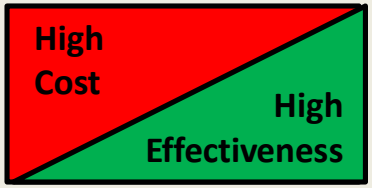


Wildlife Institute of India and others working to perfect elephant-railway detection (seismic and infrared camera) systems to be integrated with at-grade crossings and *advance* train alert signage

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

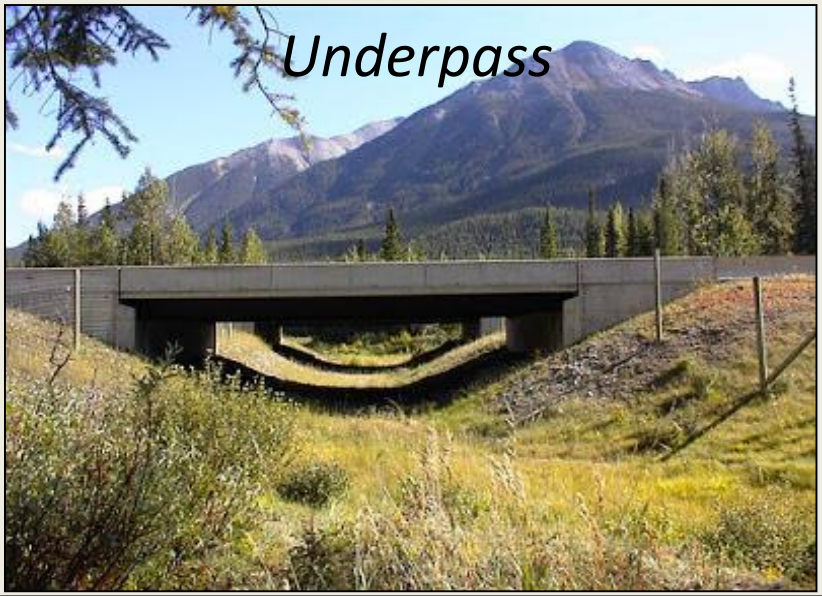
- **Wildlife Passage Structures**



Passage structures provide *grade-separated passage*:

✓ Underpasses - passage for animals BELOW highway or railway grade

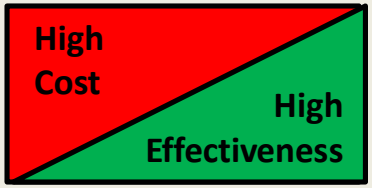
✓ Overpasses - passage for animals ABOVE highway or railway grade

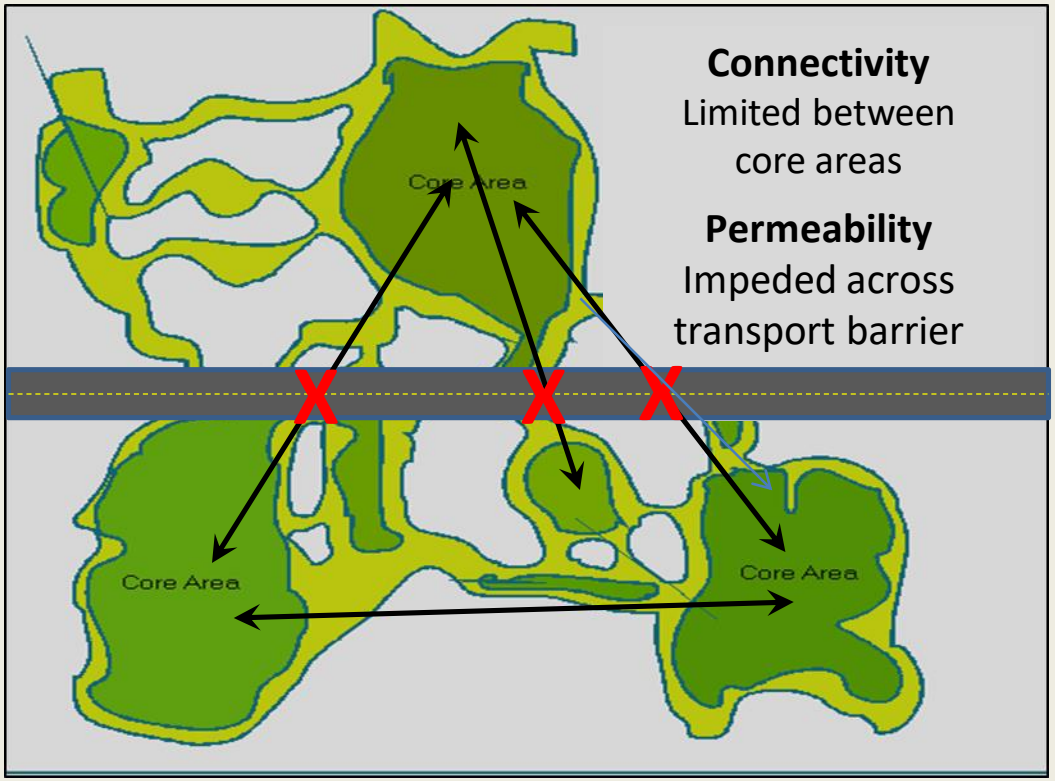


MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Passage Structures (with wildlife fencing):**

  Effective at promoting *permeability* & *connectivity*





Transport infrastructure and its traffic can be a huge barrier to movement of animals, fragmenting habitats, and isolating populations.

Passage structures are the most visible (and often the most costly) of mitigations

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Passage Structures (with wildlife fencing):**

CASE STUDY

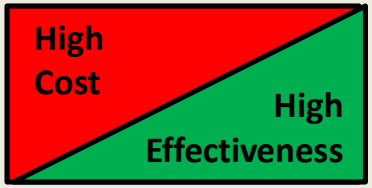
Location: Gobi-Steppe Ecosystem, Mongolia

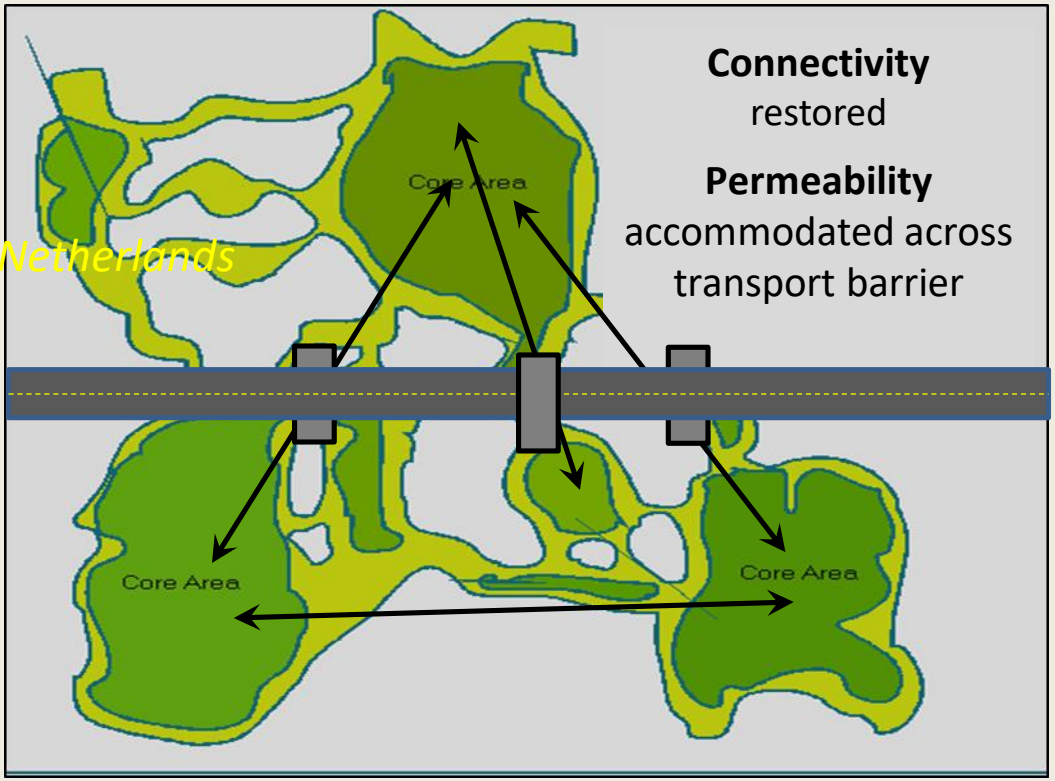
Low volume railway was a *near-total barrier* to the passage of Mongolian gazelle & the Asiatic wild ass (EN); animals fitted with GPS telemetry never crossed the railway's raised formation

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

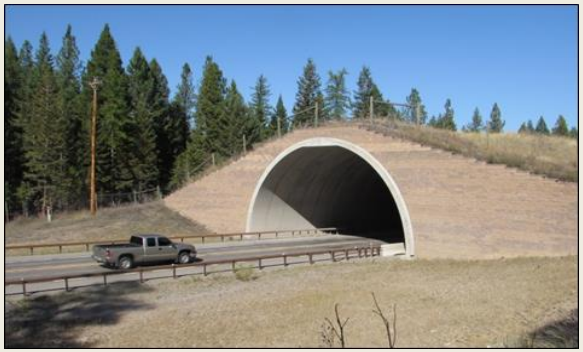
- **Passage Structures (with wildlife fencing):**

  Effective at promoting *permeability* & *connectivity*





Passage structures have been shown to be highly effective in promoting *permeability* across transport infrastructure and serving as linkages between core habitats.



MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Wildlife Underpasses** (medium to large animals)

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Wildlife Underpasses** (smaller animals)

Corrugated Metal Pipes *– can promote passage with modifications*

Grates

Wetted pipes *for amphibians*

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Wildlife Underpasses** (smaller animals)

CASE STUDY

Location: US Highway 93, Montana, USA

- Use of 3 1.2-m diameter metal pipe culverts with shelves (*dry* culverts) for small mammal passage were compared to 3 unmodified (*wet*) culverts.
- Cameras captured **14** small mammal species that crossed via *dry* culverts when water was present. **No** mammals used *wet* culverts at that time.


Rabbit on culvert shelf


Grates


***Wetted pipes** for amphibians*

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Oversizing of Drainage Culverts to Underpasses**
  - ✓ Provide cost effective "**dual-use**" structures for drainage *and* wildlife passage
  - ✓ Prevent blowouts from increasingly frequent extreme-weather events using oversized drainage structures at ***modest*** additional cost*

*_Intergovernmental Panel on Climate Change_ (IPCC). 2014: Climate Change 2014: Synthesis Report.

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Prefabricated Passage Structure Options**
  - ✓ Provide **fast** and cost-effective options, especially for **retrofitting**
  - ✓ Especially useful for remote locations – metal arches are readily transportable
  - ✓ For overpass and underpass applications

Metal Plate Arches

Pre-Cast Concrete Arches

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Prefabricated Passage Structure Options**
  - ✓ Well suited for ***retrofit*** options on existing infrastructure

CASE STUDIES

Location: Arizona, Utah, Nevada, Wyoming; USA

Retrofit under- & overpasses installed on numerous highways, including 4-lane Interstates, with minimal traffic disruption

Underpass – SR 86, Arizona

Overpass - Interstate 80, Nevada

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Prefabricated Passage Structure Options**
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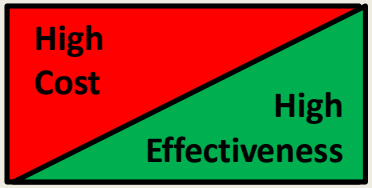
MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Role of Wildlife Fencing**



Considered *critical* to achieving effective passage structure use by wildlife (as well as reducing collisions)

Typically, passage structures are ineffective with <5 km of fencing

Fencing promotes permeability by funneling animals to passage structures

MINIMIZING IMPACT TO

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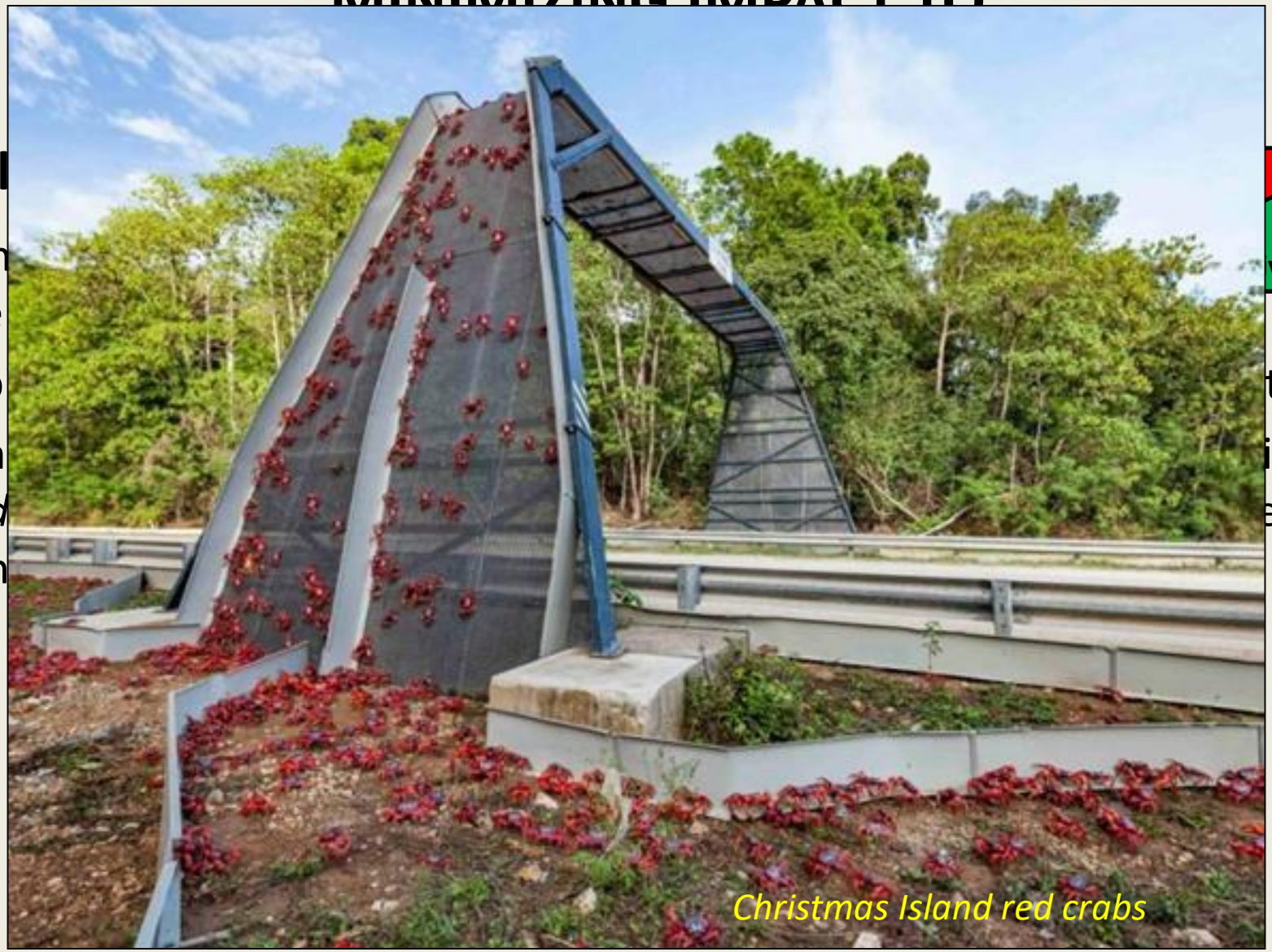

Christmas Island red crabs

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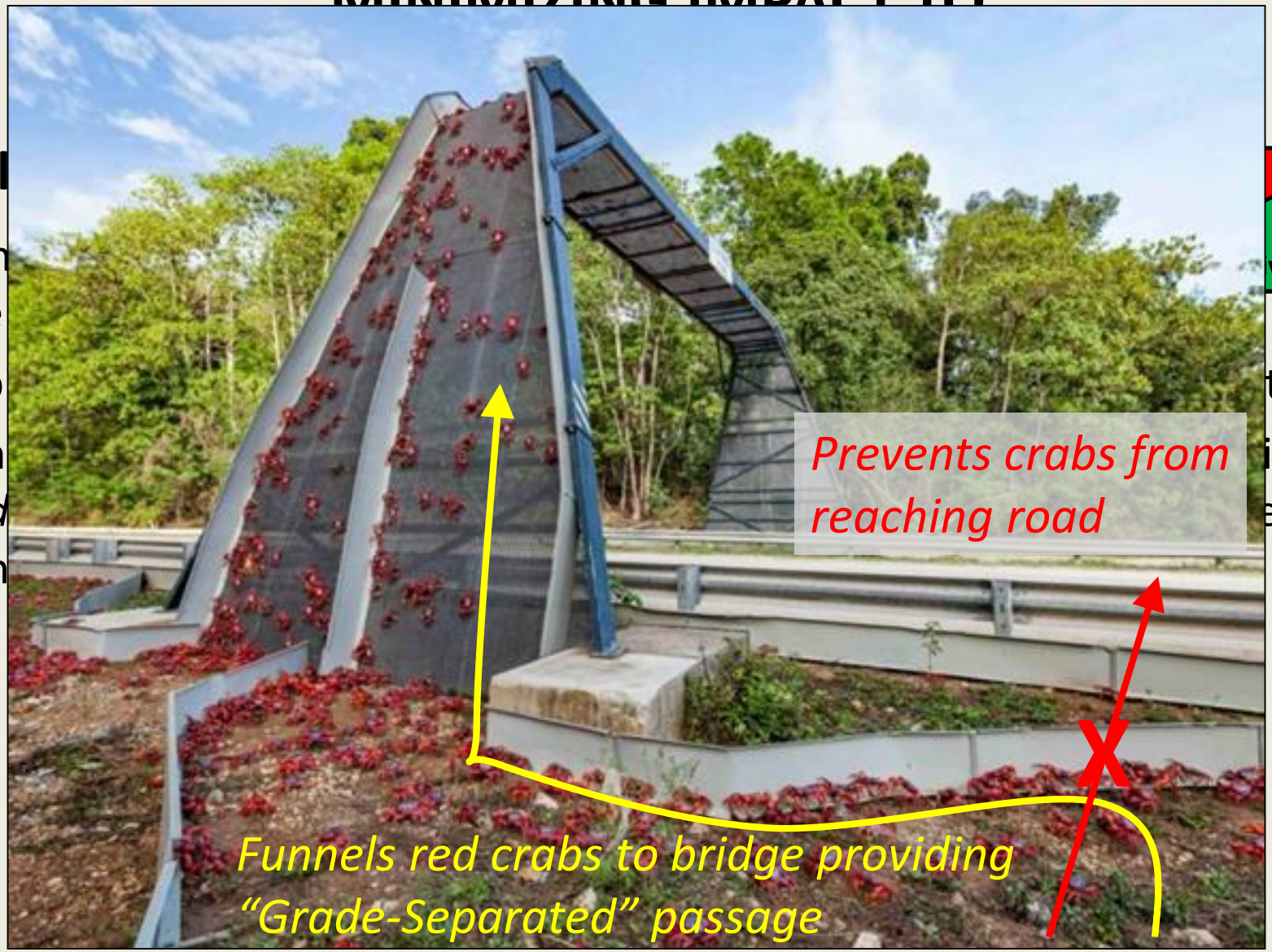


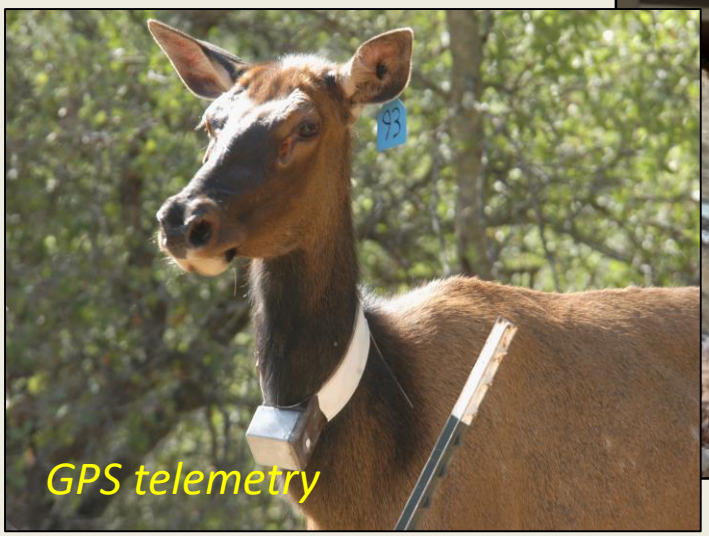
CASE STUDY

Location: State Route 260, Arizona, USA (30 km)

Phased reconstruction:

- 11 large underpasses (single span bridges)
- 7 large multi-span bridges

Initially, little fencing was erected - **focus of research**

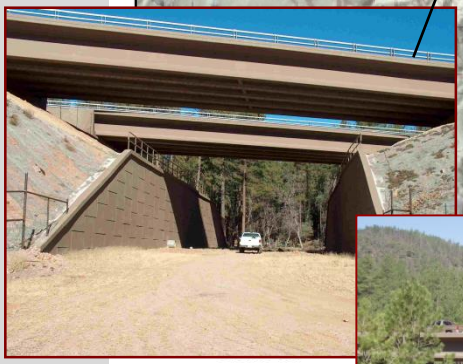


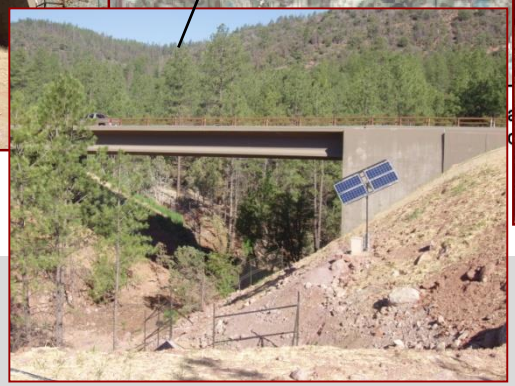
STATE ROUTE 260 PROJECT

Wildlife Underpasses
(8 of 11 monitored)

Wildlife Underpasses (11)

Bridges (6)



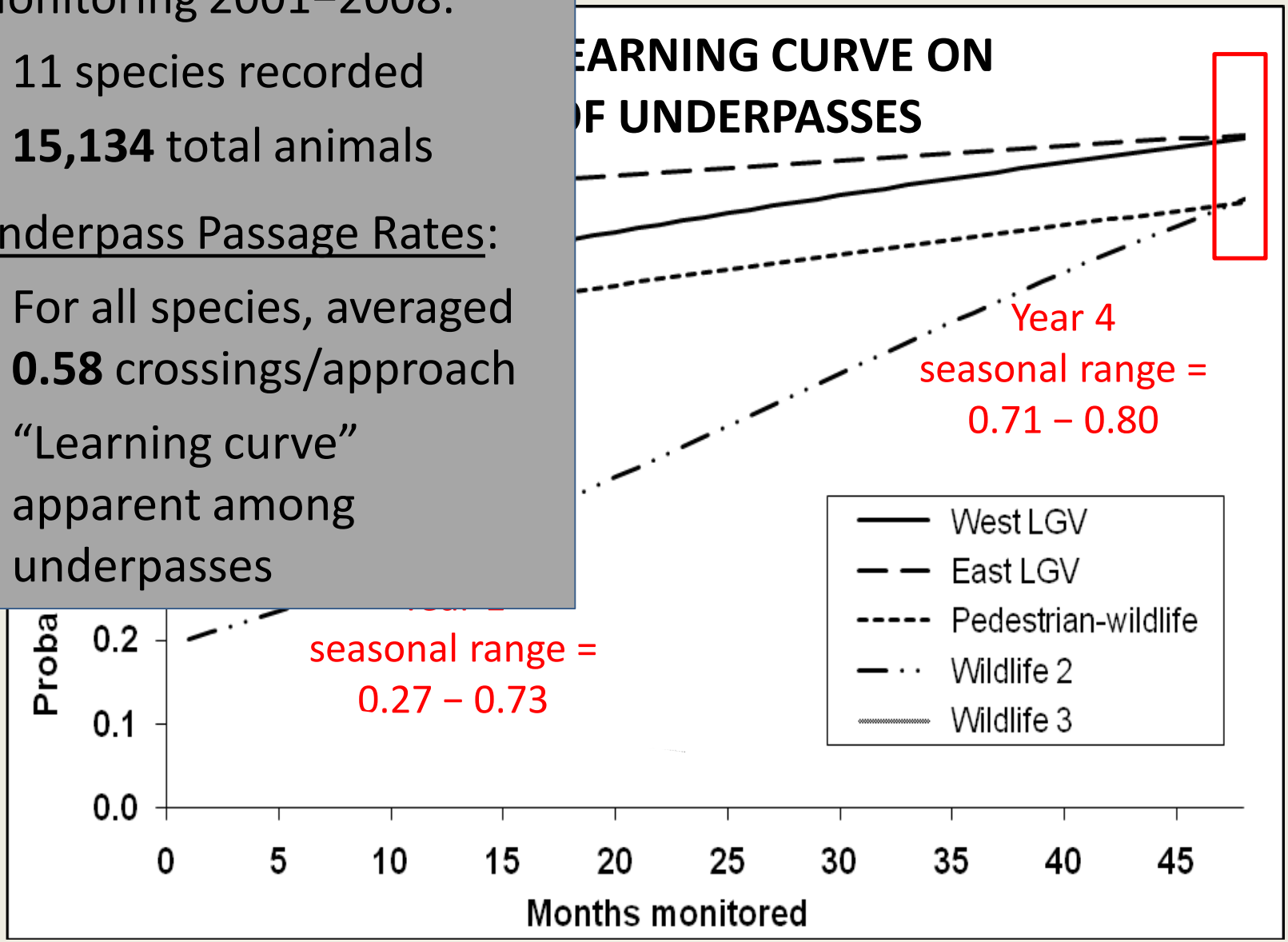


Monitoring 2001–2008:

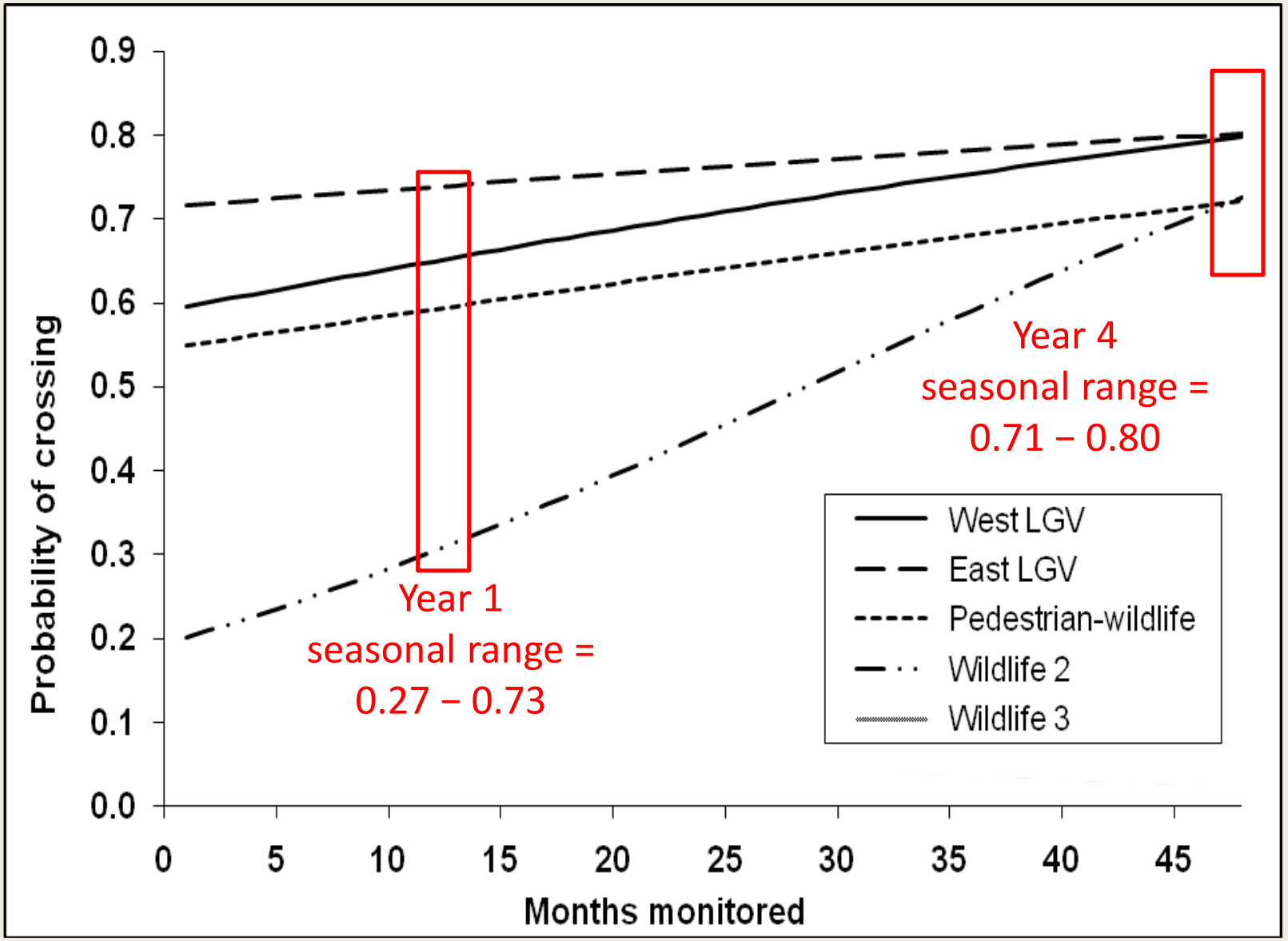
- 11 species recorded
- **15,134** total animals

<u>Underpass Passage Rates</u>:

- For all species, averaged **0.58** crossings/approach
- "Learning curve" apparent among underpasses



IMPACT OF LEARNING CURVE ON ELK USE OF UNDERPASSES



Monitoring 2001–2008:

- 11 species recorded
- **15,134** total animals

<u>Underpass Passage Rates</u>:

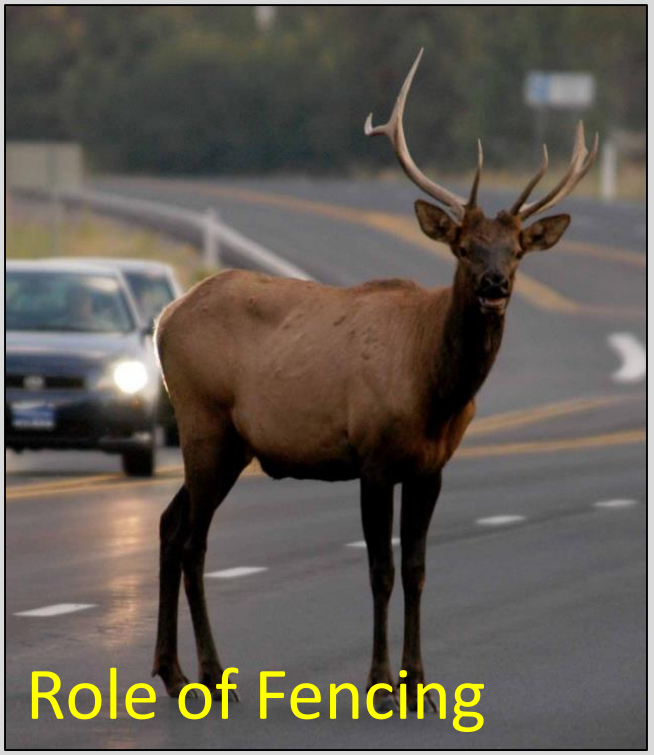
- For all species, averaged **0.58** crossings/approach
- For elk and deer:

  0.12 crossings/approach ***without*** fencing

  0.56 crossings/approach ***with*** fencing (**+367%**)

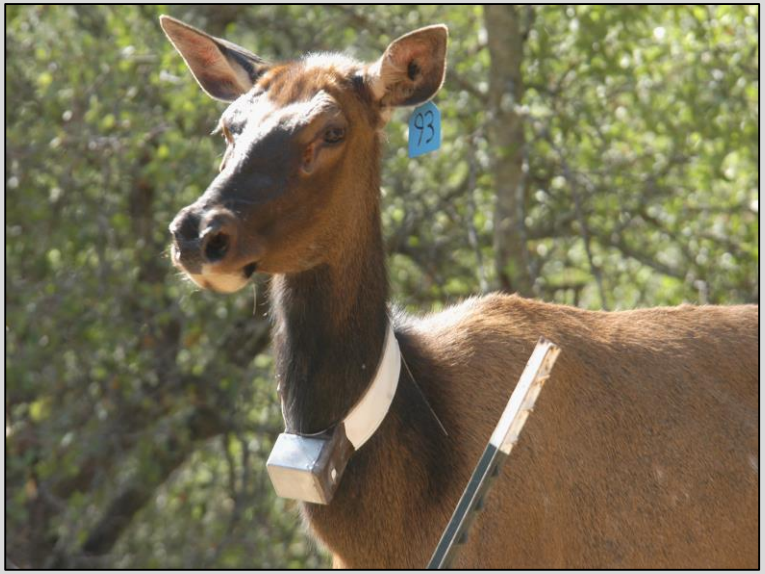
<u>Elk-Vehicle Collisions</u>:

- **283%** increase *without* fencing
- **76%** reduction *with* fencing



SR 260 HIGHWAY AFTER-CONSTRUCTION PERMEABILITY

Passage Structures *and* Fencing Promote Highway Permeability



Elk

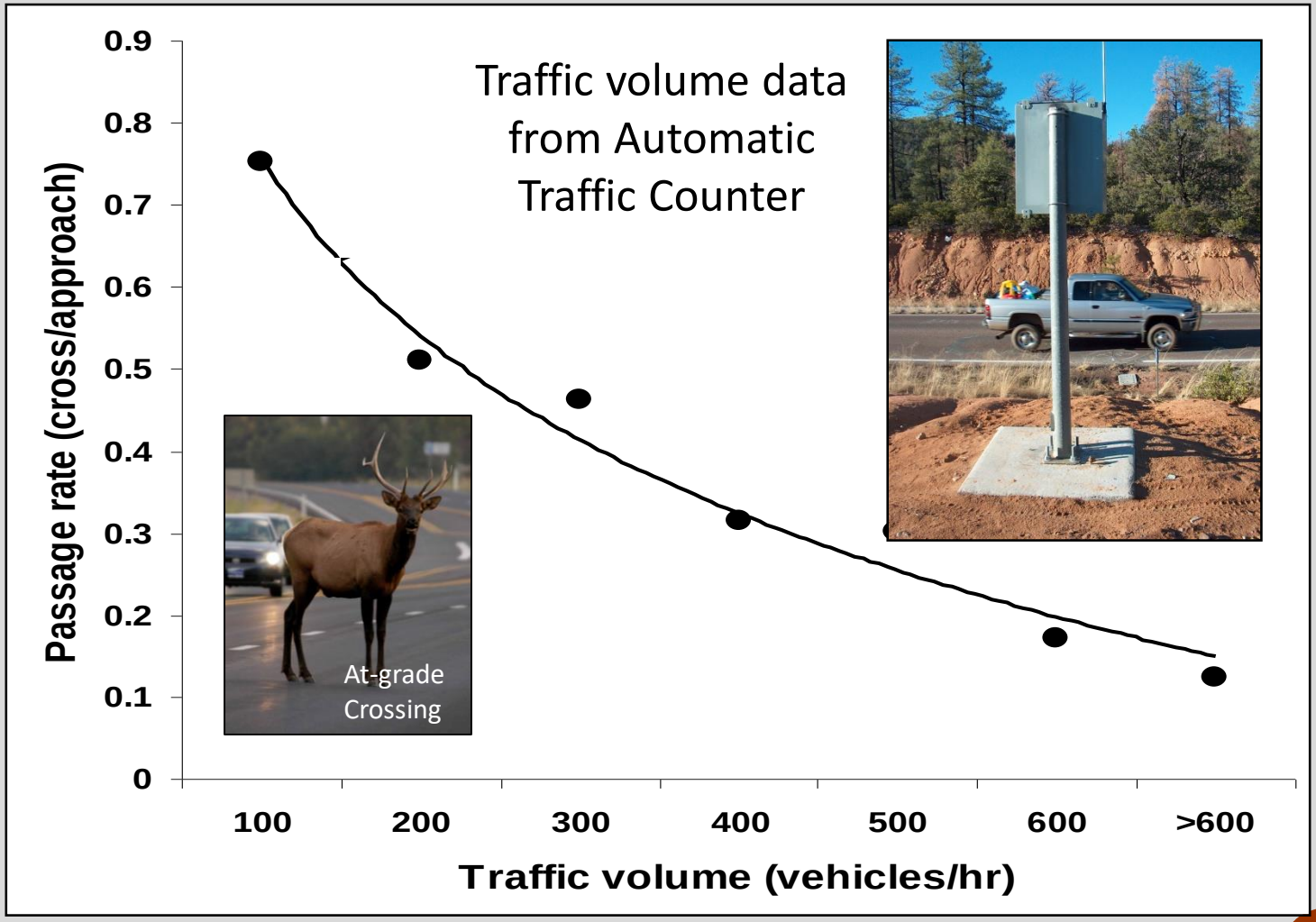
- Passage rate increased **58%** to before-reconstruction level (0.82 crossings/approach)

White-tailed deer

- Passage rate increased **533%** over the before-reconstruction level (0.03 crossings/approach)

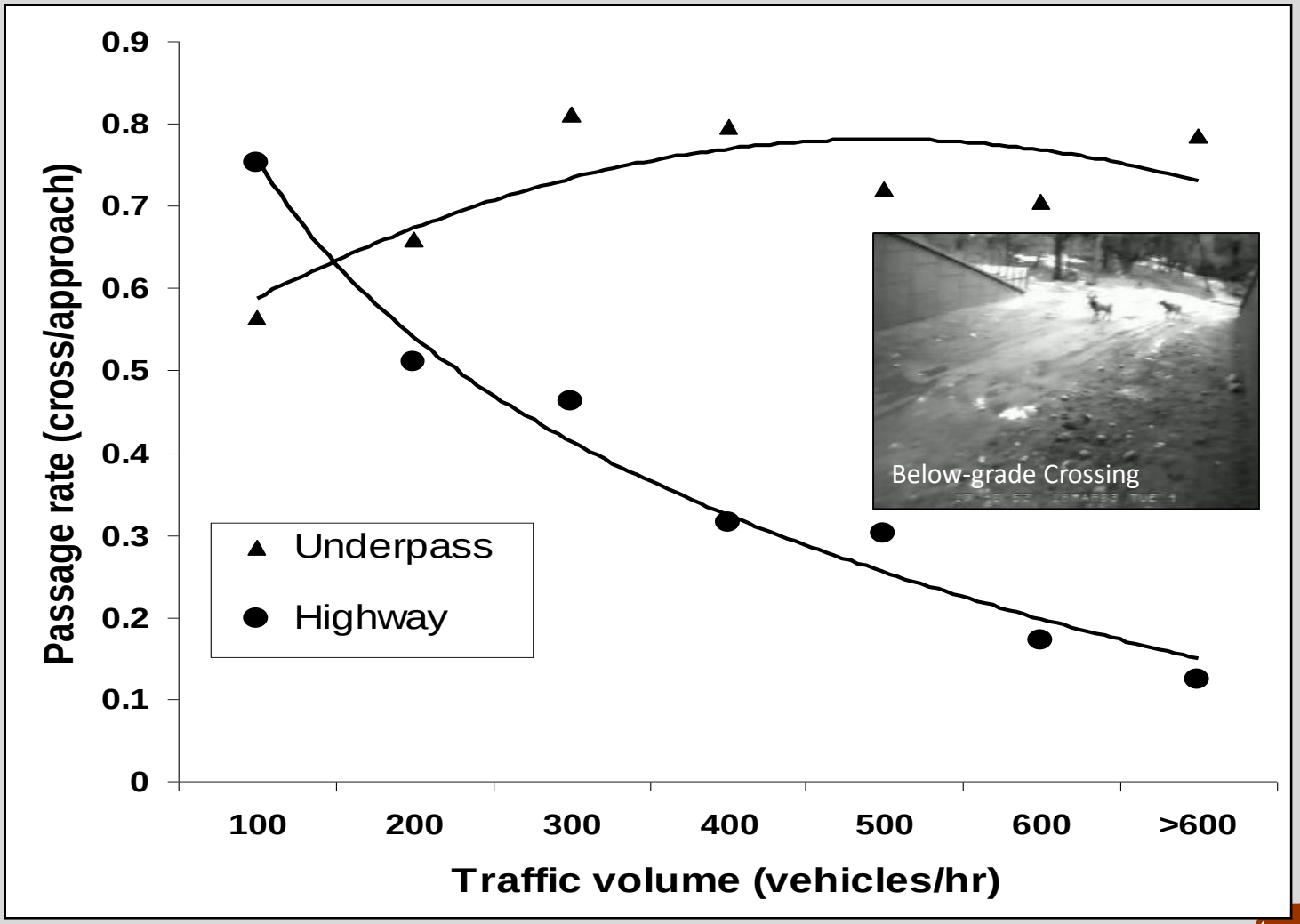
INFLUENCE OF TRAFFIC VOLUME

At-Grade Crossing Passage Rate (GPS-collared elk)



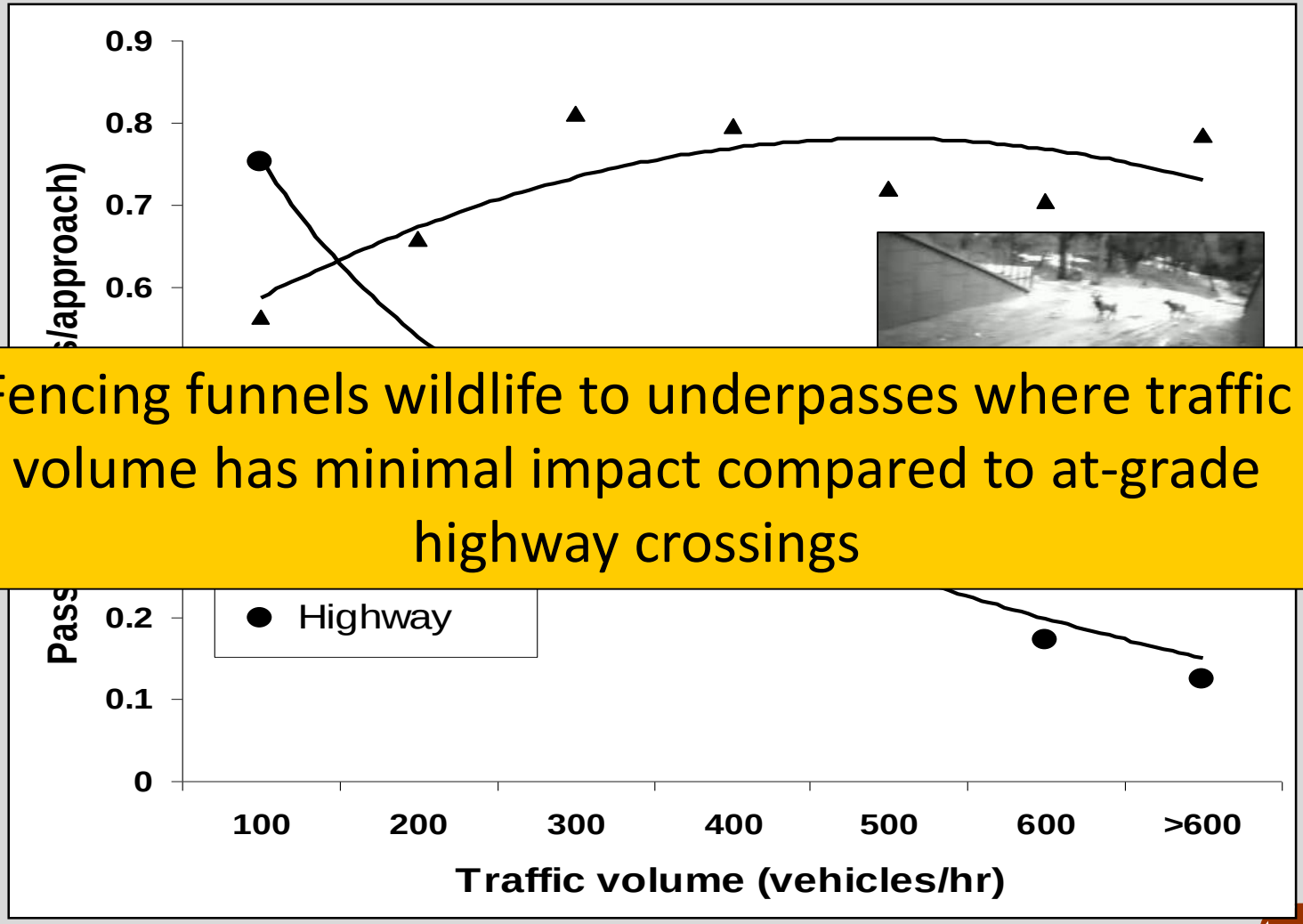
INFLUENCE OF TRAFFIC VOLUME

Below-Grade Underpass Crossing Passage Rate (Elk)



INFLUENCE OF TRAFFIC VOLUME

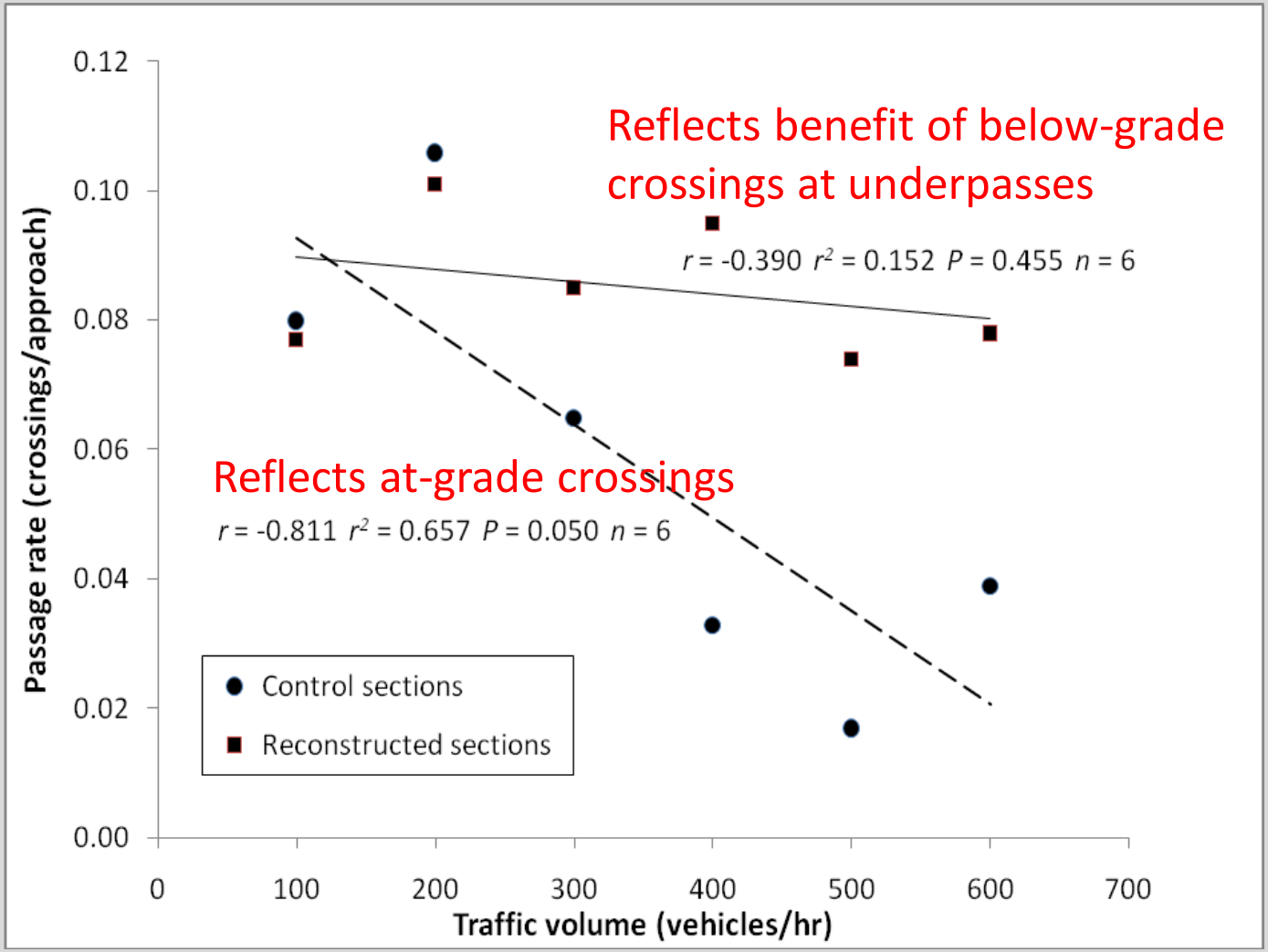
Below-Grade Underpass Crossing Passage Rate (Elk)



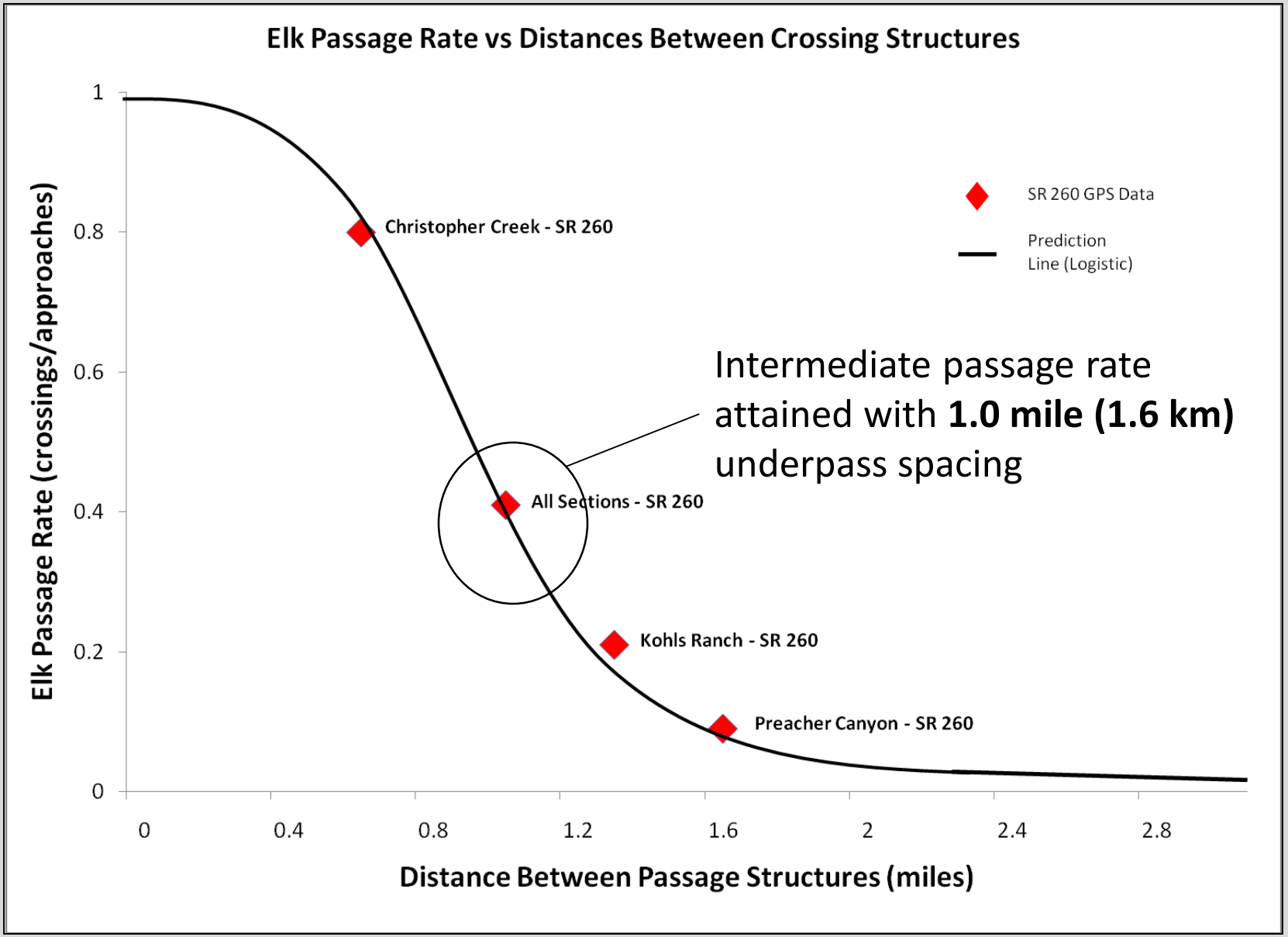
Fencing funnels wildlife to underpasses where traffic volume has minimal impact compared to at-grade highway crossings

INFLUENCE OF TRAFFIC VOLUME

Highway Crossing Passage Rates (White-tailed Deer)



PASSAGE STRUCTURE SPACING IS IMPORTANT



MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

CASE STUDY 1

Location: Quinghai-Tibet Railway/Highway (1,142 km); China

Total of 25 underpasses and 7 at-grade crossings constructed (added 7% to cost of the railway project)

- In 2006, **3,000** migrating Tibetan antelope (EN) counted, of which **98%** passed through underpasses
- Between 2004 and 2007, passage rate increased from 60% to 100% (learning curve)

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

CASE STUDY 2

Location: Quinghai-Tibet Railway/Highway (1,142 km); China

2014-2016 comparison of mammal use of :

- 14 bridges (average passage = 191 crossings/structure)
- 11 box culverts (average passage = 90 crossings/structure)

13 species of mammals

- Tibetan gazelle, Tibetan antelope, Asiatic wild ass, and yak all strongly preferred bridges – **width** had most important influence on passage rates

CASE STUDY

Location: Sixiao Highway, Xishuangbanna Nature Preserve, China (55 km)

New construction:

- 16 underpasses (some viaducts)
- 2 tunnels **NO fencing**

1st-year monitoring:

6 of 28 established Asian elephant travel corridors abandoned

44% of underpasses used by elephants without fencing

Strong correlation (r = 0.84) between elephant use and proximity to established corridors

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Wildlife Overpasses** (for large animals)

Overpasses were once more expensive than underpasses

New guidelines promote cost-effective and functional designs making them more competitive with underpasses

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Wildlife Overpasses** (for large animals)

CASE STUDY

Location: Europe

European countries have led the world in overpass applications for >30 years

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Wildlife Overpasses** (for large animals – and **NOT** so large)

CASE STUDY

Location: Bukit Timah Expressway, Singapore

ECO-Link@BKE - Asia's 1st Overpass

Retrofit construction - 2013

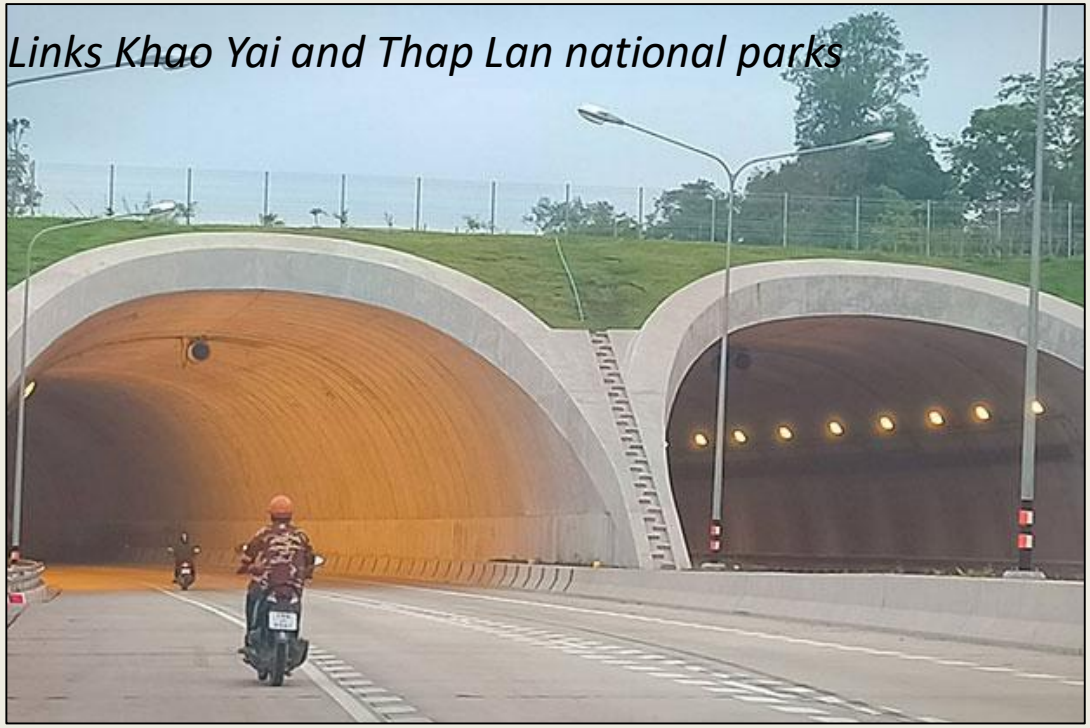
Sunda pangolins - IUCN Critically Endangered

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Wildlife Overpasses** (for large animals)

CASE STUDY

Location: Highway 304, Thailand

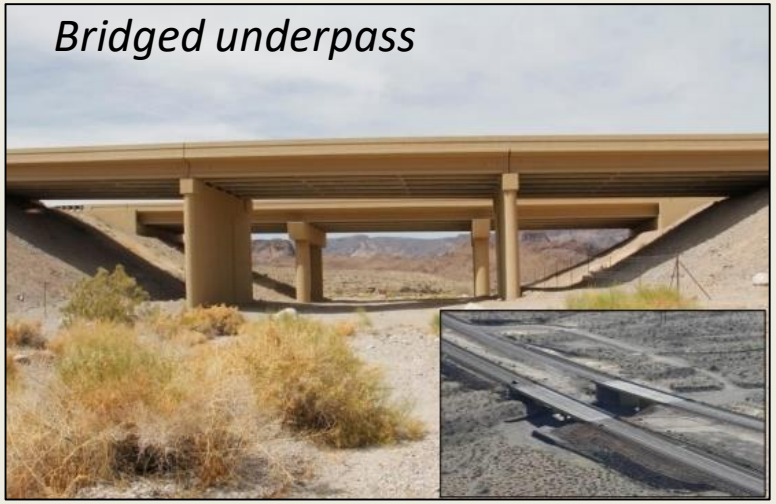


CASE STUDY

Location: US Highway 93 Arizona, USA

Phased reconstruction (30 km) with cameras and GPS telemetry (2011-14)

- 3 overpasses
- 2 large bridged underpasses
- 3 drainage box culverts
- Funnel fencing



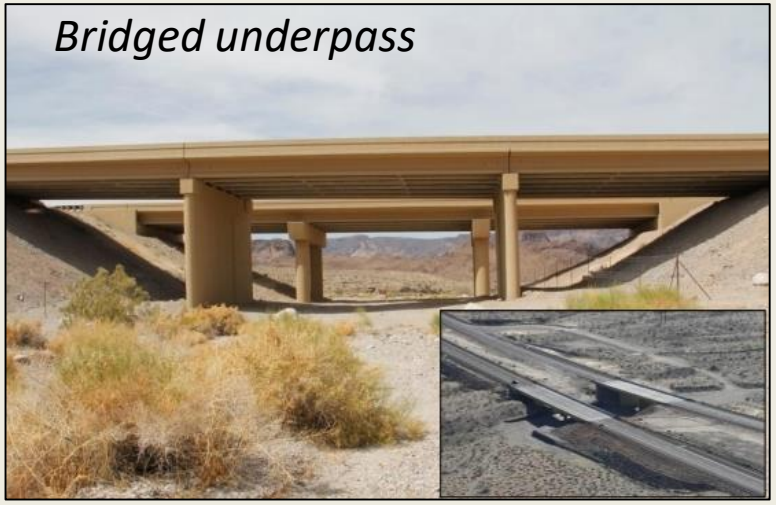
CASE STUDY

Location: US Highway 93 Arizona, USA

Phased reconstruction (30 km) with cameras and GPS telemetry (2011-14)

Bighorn Sheep Use of Passages:

- 3 overpasses **5,862 crossings (90%)**
- 2 underpasses **474 crossings (7%)**
- 3 box culverts **195 crossings (3%)**



CASE STUDY

Location: US Highway 93 Arizona, USA

Phased rec
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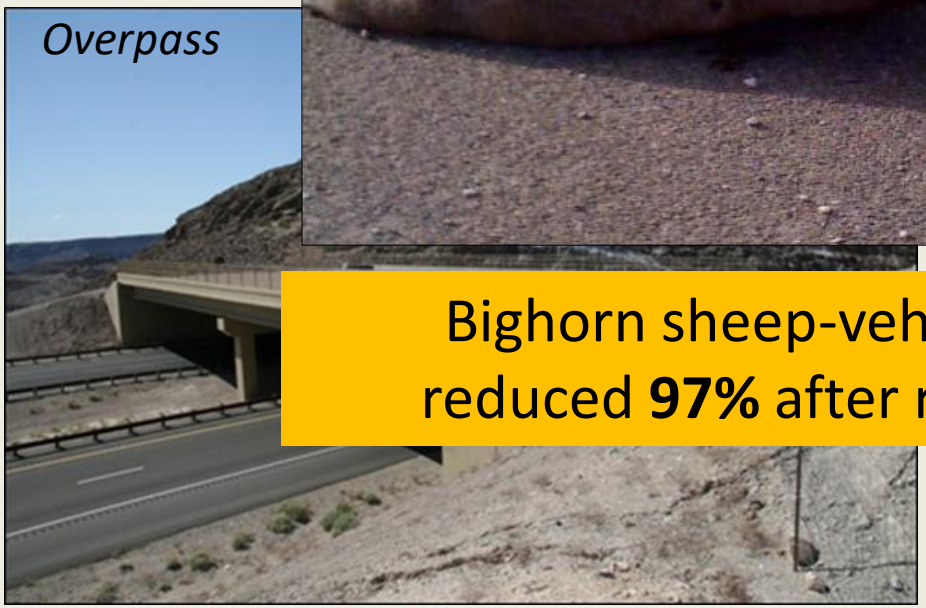
Bighorn Sh

- 3 overpa
- 2 under
- 3 box cu

Desert bighorn sheep)

Culvert

Overpass



Bighorn sheep-vehicle collisions reduced **97%** after reconstruction

Highway Permeability For Bighorn Sheep

- Based on comparison of GPS-collared sheep movements
  - 33 sheep before construction
  - 48 sheep after construction

- Before-construction (2-lane) vs. Year 1 after-construction (4-lane) - **100% increase** in mean passage rates with passage structures and fencing

Highway P **ep**

- Based or sheep movements
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  - 48 sh
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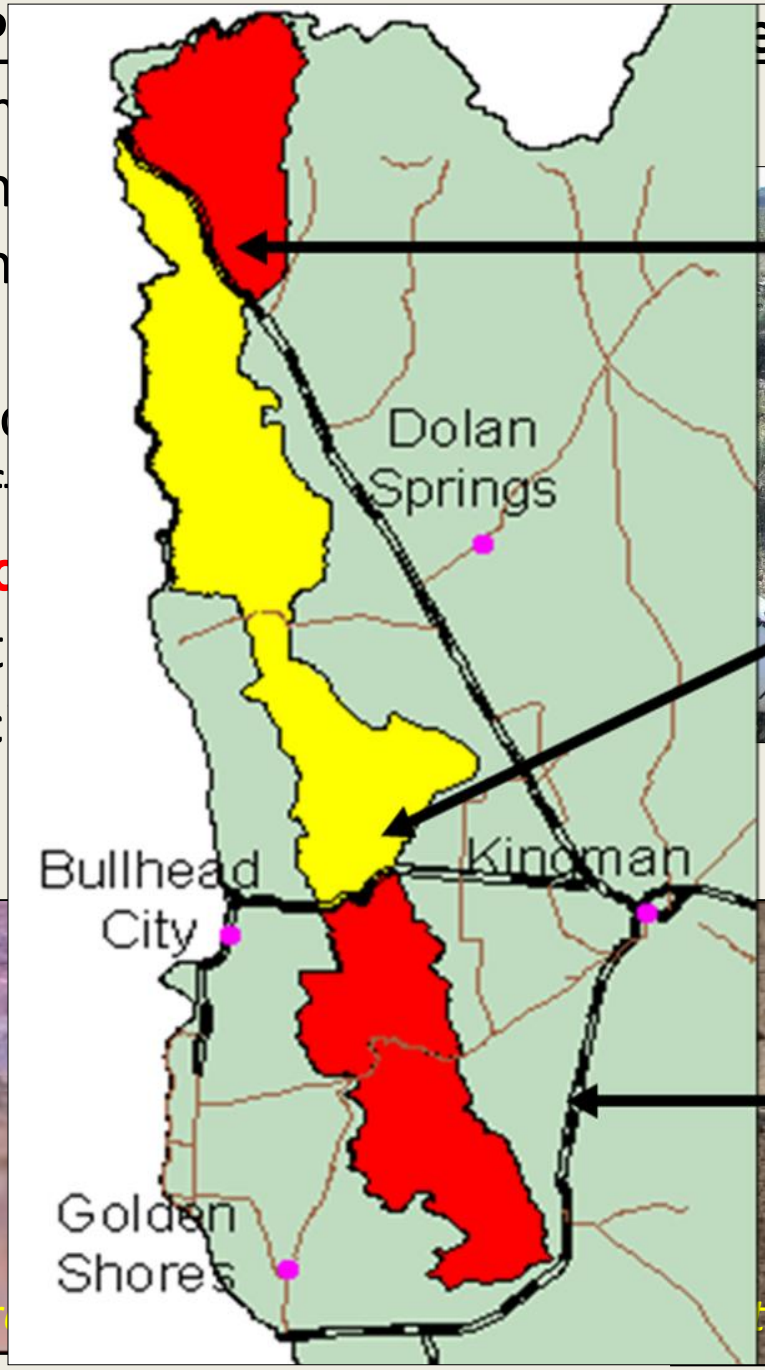

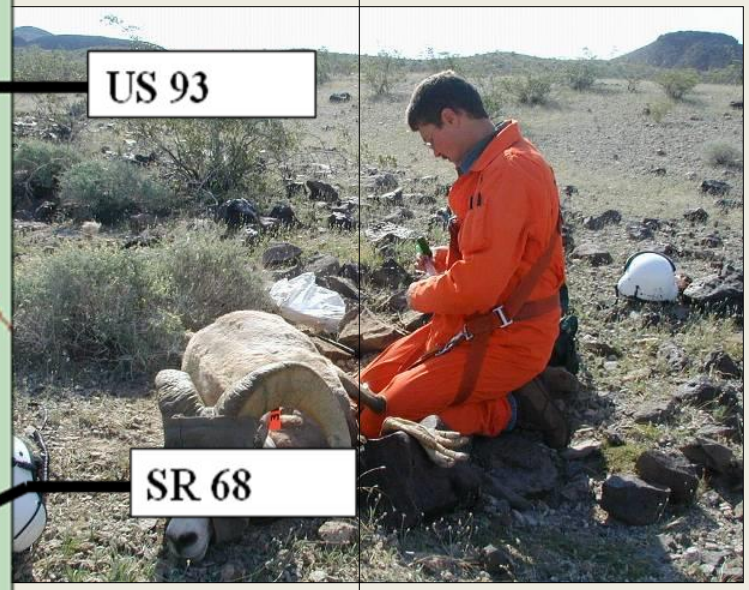

Befor

ter-construction


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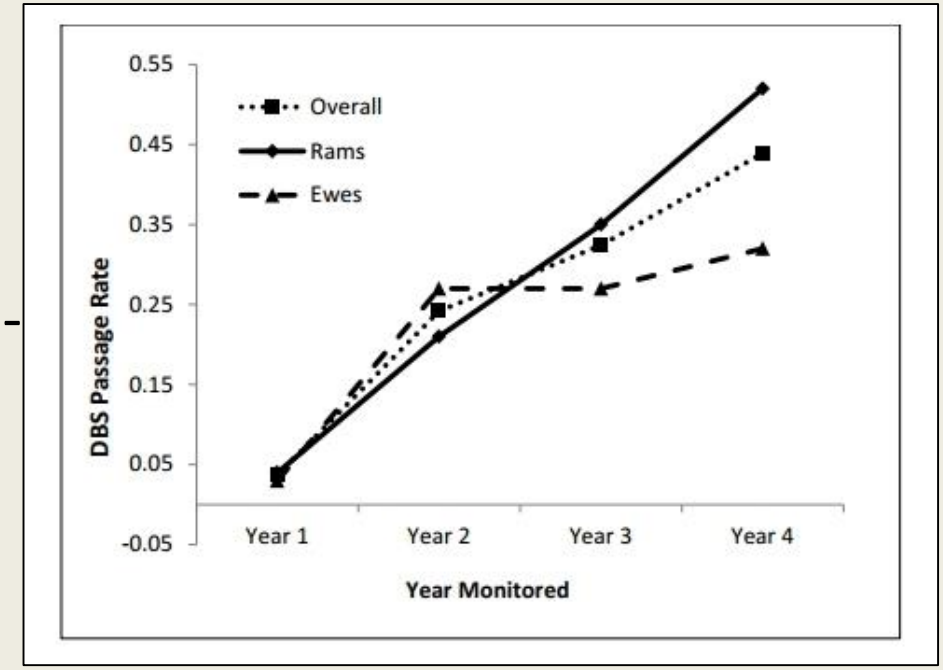
Highway Permeability For Bighorn Sheep

- Based on comparison of GPS-collared sheep movements
  - 33 sheep before construction
  - 48 sheep after construction

- Before-construction (2-lane) vs. Year 4 after-construction (4-lane) - **1,367% increase** in mean passage rates with passages and fencing (reflects learning curve)



CASE STUDY

Location: Trans-Canada Highway, Banff National Park, Alberta, Canada (42 km)

Phased reconstruction:

- 38 underpasses (bridges, metal pipes, culverts)
- 6 overpasses

Overpass/Underpass Comparison

Longest continuous monitoring study in the world (1996–2014)

152,154 crossings of passage structures by 11 large mammals (track counts and cameras):

Ungulates

- Elk 53,251
- Deer 72,857
- Moose 534
- Sheep 4,999

Carnivores

- Black bear 1,663
- Grizzly bear 1,549*
- Cougar 1,627
- Wolf 6,826

*Exhibited most dramatic "*learning curve*":

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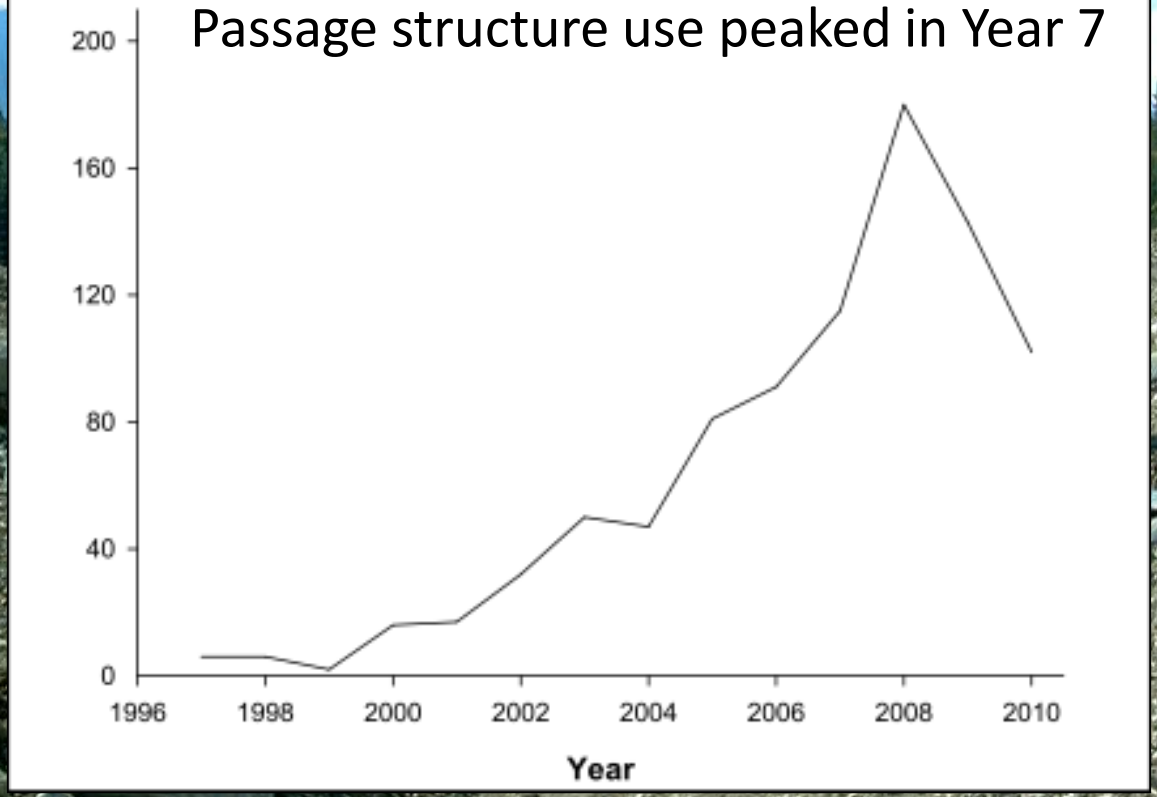
- Wolf 6,826

*Exhibited most dramatic "*learning curve*":

Few grizzly bear crossings (<10%) first 5 years

Passage structure use peaked in Year 7

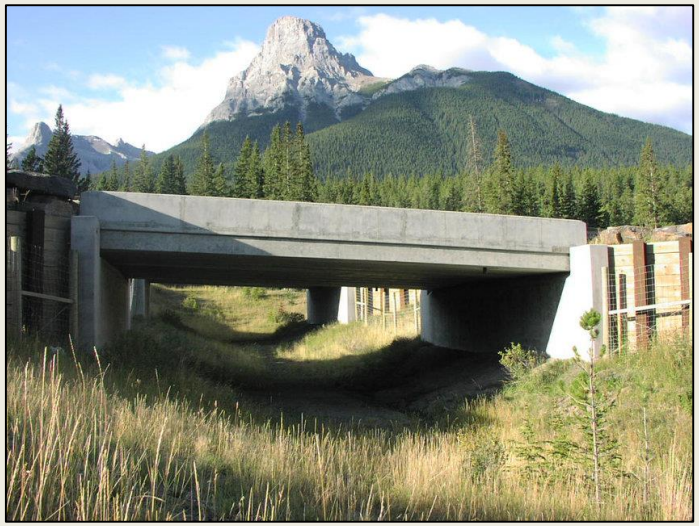


Wildlife-Vehicle Collision Reductions

- Overall – **80%** for all species
- Elk and deer (most frequently crossed through passages) – **96%**
- Carnivores (bears, mountain lion, wolf) – only **18%**

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

Passage Structure *Openness* Influence in Use Differed by Species



MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

Underpass Openness

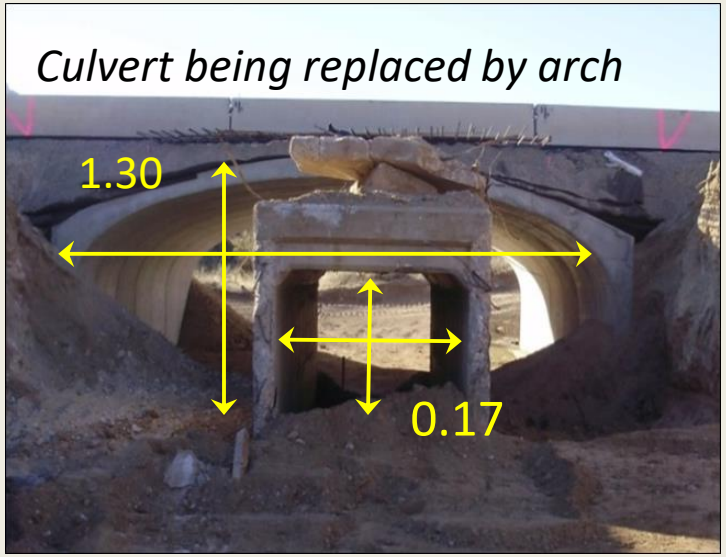
Affects amount of light penetrating underpass and view through and to the other – goal is to avoid "tunnel" effect

Very important to animals to overcome hesitancy to pass through unnatural, confined spaces

Openness Index is a **guide** to design and compare structures:

$$Openess\ Index = \frac{Height \times Width}{Length}$$

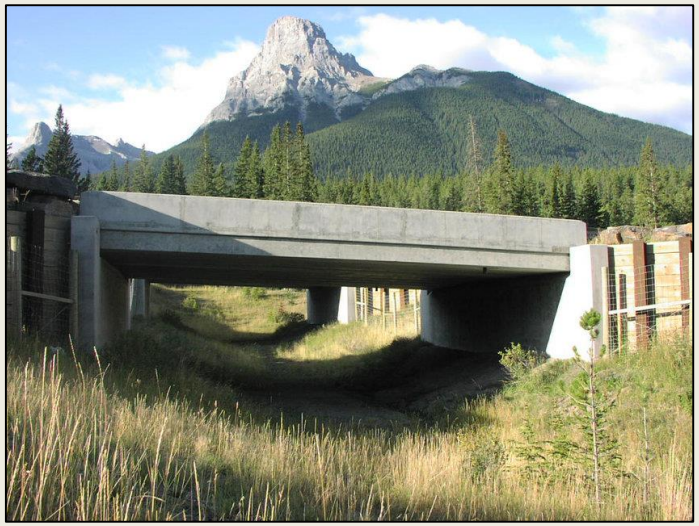
Recommended minimum index for ungulates is 0.8 – 1.0



MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

Passage Structure Openness Influence on Use Differed by Species

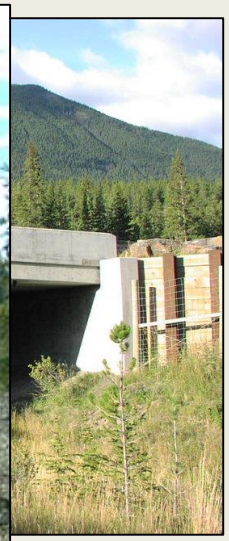
- **Deer, elk, wolf** - preferred structures with **HIGHER** openness (top photo)
- **Black bear and mountain lion** - preferred **LOWER** openness and confined underpasses (lower photo)
- **Grizzly bear** – strong preference for overpasses



MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

Passage
Influence in

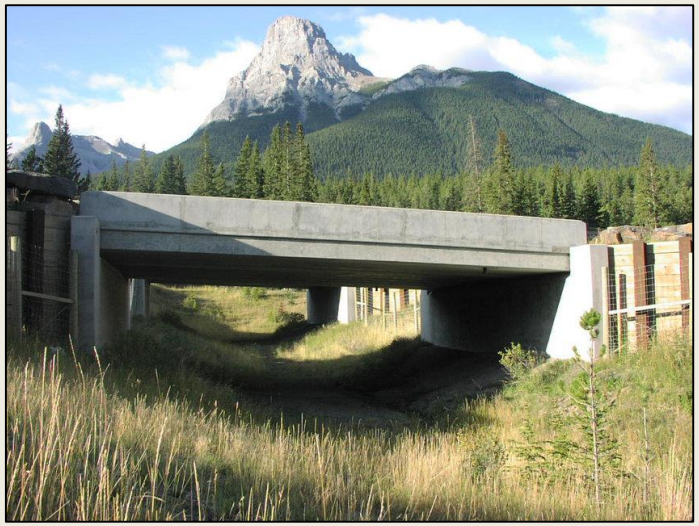
- **Deer, elk,** structures (top photo
- **Black bea** preferred confined u photo)
- **Grizzly be** for overpasses



MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

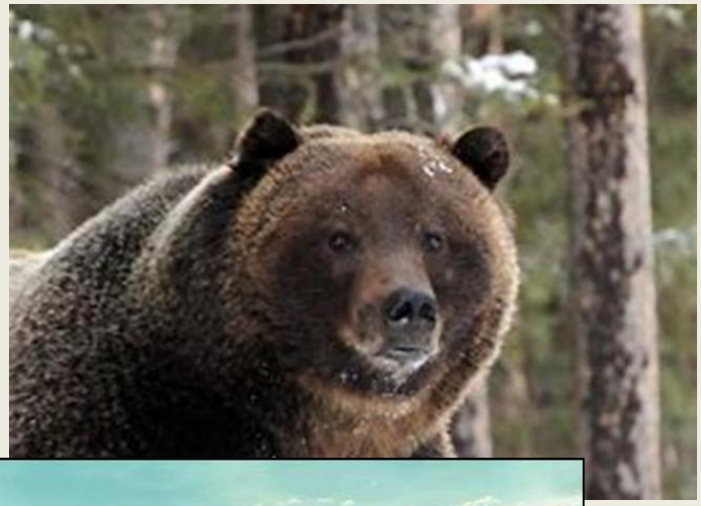
No evidence from this or any other studies that passage structures become "*Prey Traps*" where predators lurk to prey on passing animals.

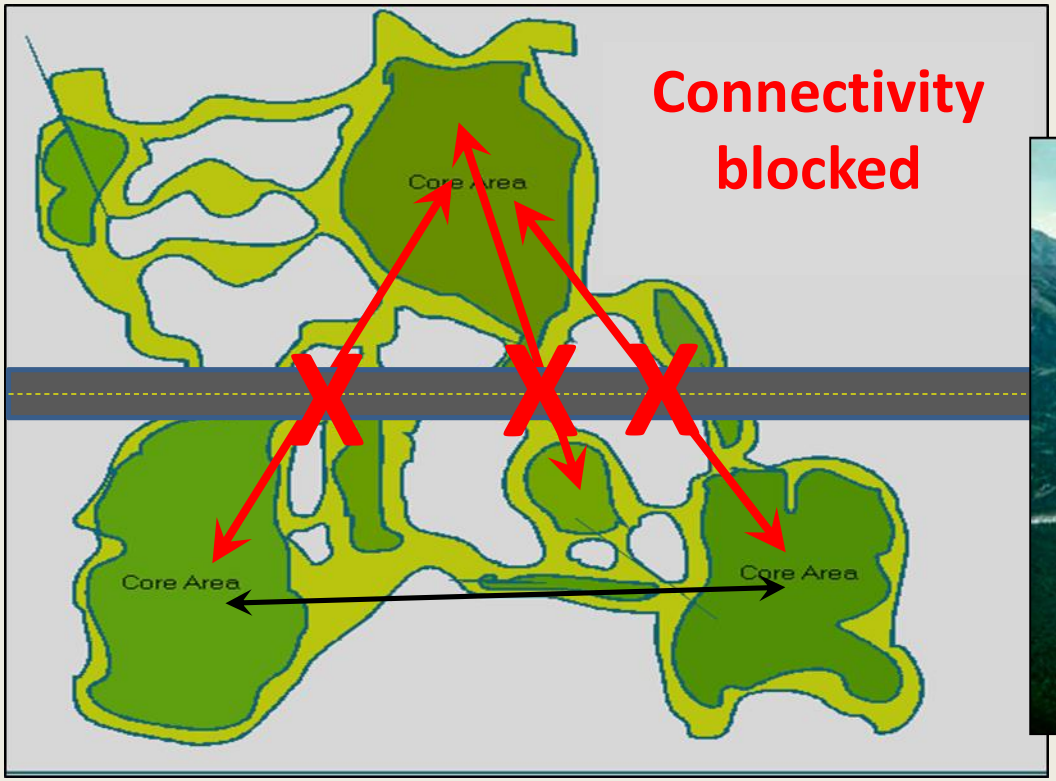
However, differences in use by predator species *may* reflect avoidance strategies.



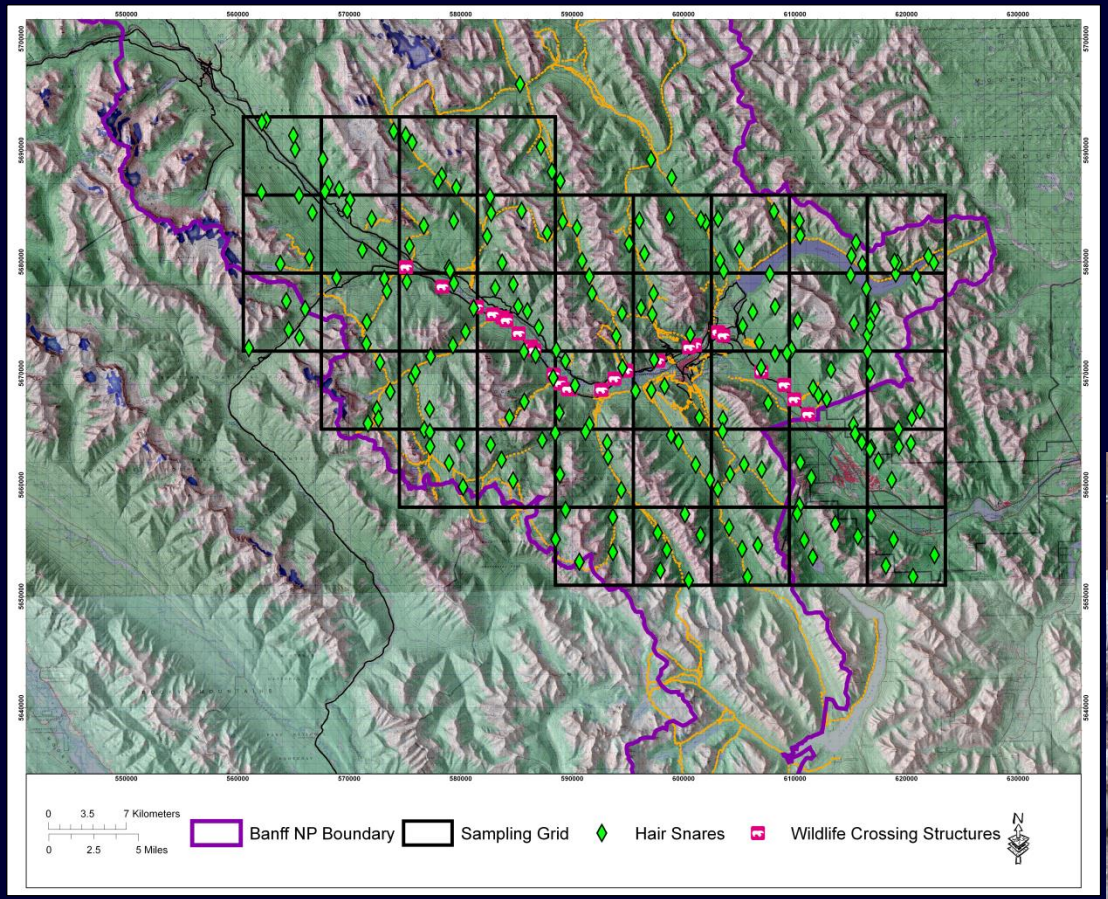
Genetic and Population Benefits of Passages

Grizzly bear populations across western North America were documented as being genetically isolated by highways (Proctor et al. 2012).





DEMOGRAPHIC CONNECTIVITY AND POPULATION-LEVEL BENEFITS



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

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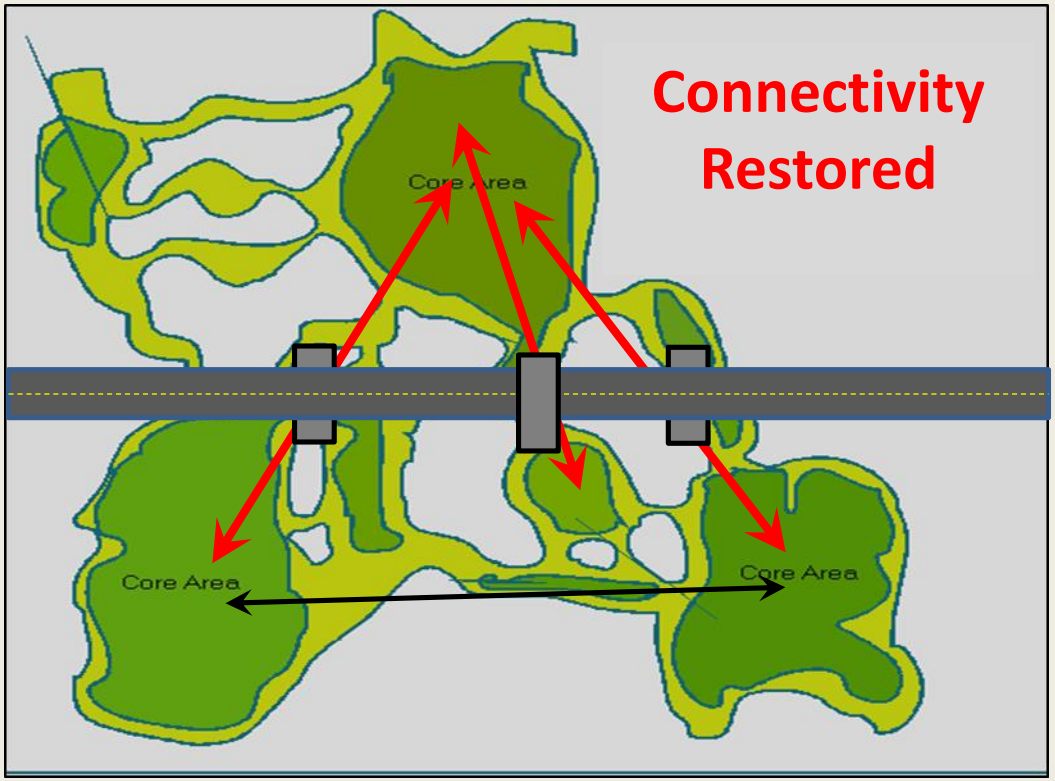


Evidence points to benefits of Banff's passages in promoting sufficient gene flow to prevent genetic isolation within the grizzly bear population (Sawaya et al. 2013).

CASE STUDY

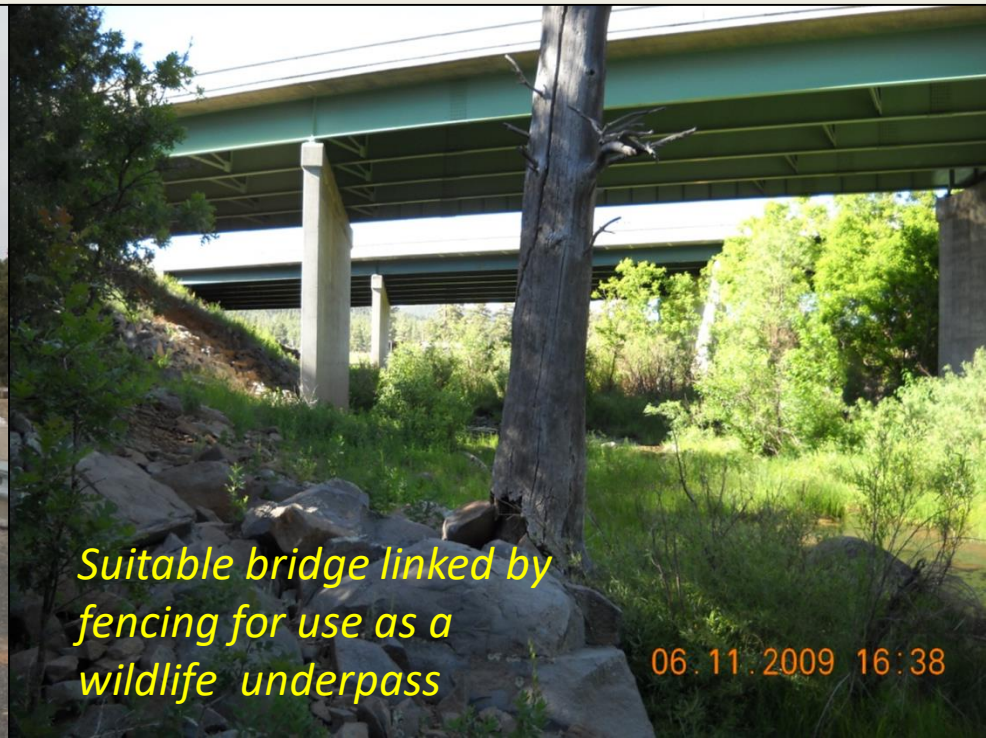
Location: Interstate 17, Arizona, USA

Retrofit with fencing only to link **existing suitable structures** (9 km):

- 2 large bridges
- 2 modified traffic interchanges

Raised right-of-way funnel fence

Interchange modified to accommodate wildlife use as dual-use overpass



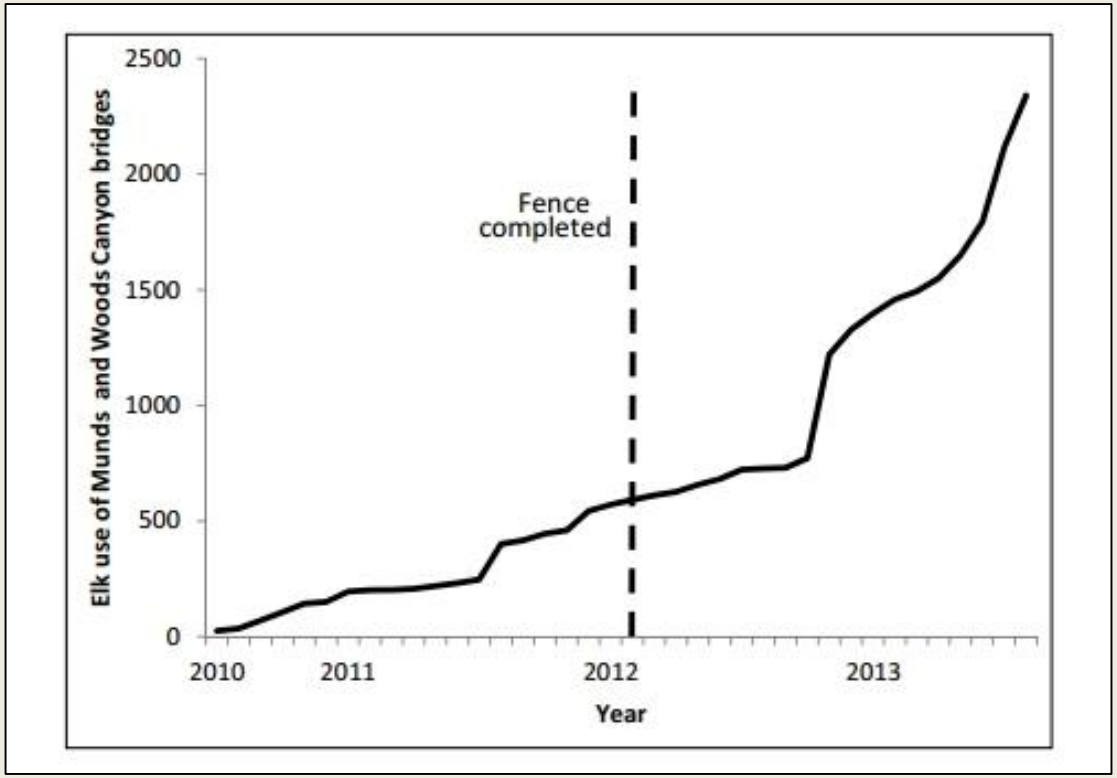
Suitable bridge linked by fencing for use as a wildlife underpass

Monitoring 2012–2014:

- 14 species recorded
- **2,340** elk crossings at existing structures
- **217% increase** in use of existing structures (right)

Elk-Vehicle Collisions:

- **97%** reduction
- Benefits > Cost - 4 years



CASE STUDY

Location: US Highway 30, Wyoming, USA (21 km)

Retrofit with "drop-in" underpasses and fencing (**no suitable existing structures**):

- 7 large pre-cast box culverts

Monitoring 2008–2010:

- **49,146** mule deer crossings
- Elk, moose, and other species also crossed

<u>Deer-Vehicle Collisions</u>:

- 81% reduction
- Benefits > Cost - 6 years

<u>Passage Rate</u>:

- Year 1 - 54%
- Year 3 – **92%**
- Learning curve (+70%)

CASE STUDY

Location: US Highway 191, Wyoming, USA (20 km)

Retrofit with "drop-in" passage structures and fencing:

- 6 underpasses (single-span bridges)
- 2 overpasses

Cost = $6.4 million USD

Crossing monitoring 2012–2015 (cameras):

- **40,251** mule deer
- **19,900** pronghorn

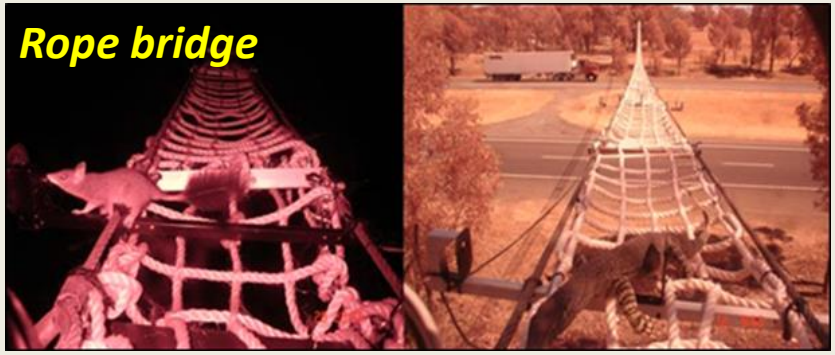
Strong preference differences for crossing

<u>Wildlife-Vehicle Collisions</u>:

- Mule deer - 79% reduction
- Pronghorn - 100% reduction
- Benefits > Cost -**11 years**

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Wildlife Overpasses** (for smaller and arboreal animals)



MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

- **Wildlife Overpasses** (for smaller and arboreal animals)

CASE STUDY

Location: Diani Beach Road, Kenya

- 28 canopy bridges installed in 1997 along 10 km to address primate-vehicle collisions for 4 species
- By 2011, bridges averaged **800 crossings/day** by 3 species (no baboons used bridges)
- Location near suitable habitat and continuous forest canopy approaches influenced use rates

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

CASE STUDY

Location: New East-West Highway, Bhutan

Four (4) arch underpasses with average **Openness Index = 5.5** were readily and regularly used by Asian elephants and 4 other IUCN-listed species soon after construction during a year of monitoring

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

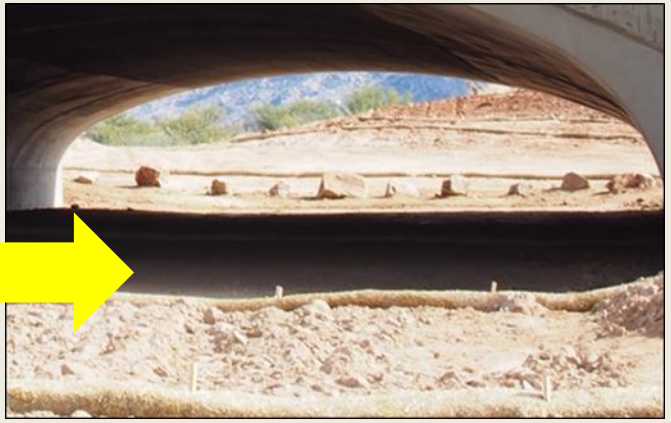
Wildlife Approaches to (and through) Passage Structures

- One the **most overlooked** areas of implementation – can totally render a costly structure unusable and ineffective
- Animals *must* be able to see through underpasses – **unimpeded visibility**

UNACCEPTABLE

Impeded visibility

Slope had to be excavated



ACCEPTABLE

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

Wildlife Approaches to (and through) Passage Structures

- Animals *must* have **suitable substrate** to approach and pass through structures *without* impediments to passage such as rock rip-rap

UNACCEPTABLE

Rip-rap at culvert approach

UNACCEPTABLE

Drainage boulders at underpass mouth

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

Learning from Our Mistakes:

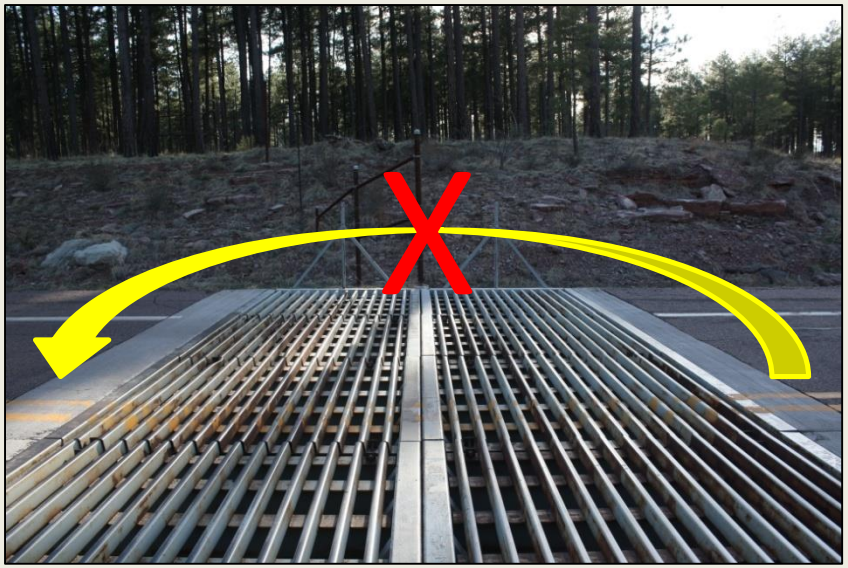
Importance of close project coordination and monitoring during design *and* construction

Double-wide cattle guard applications to prevent deer, elk and sheep from jumping into fenced SR 260 corridor

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

Learning from Our Mistakes: Importance of close project coordination during design and construction

Double-wide cattle guard applications to prevent deer, elk and sheep from jumping into fenced SR 260 corridor



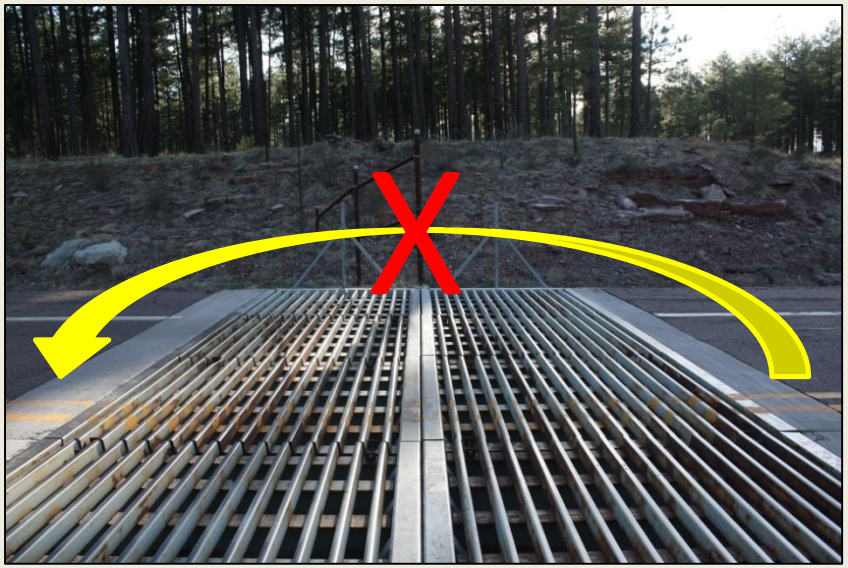
CORRECT

(animals cannot jump across both guards)

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

Learning from Our Mistakes: Importance of close project coordination during design and construction

Double-wide cattle guard applications to prevent deer, elk and sheep from jumping into fenced SR 260 corridor



CORRECT

(animals cannot jump across both guards)

WRONG!

(with landing pad to facilitate jumping)

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Learning from Our Mistakes: Importance of close project coordination during design and construction

Double-wide cattle guard applications to prevent deer, elk and sheep from jumping into fenced SR 260 corridor

CORRECT

(animals cannot jump across both guards)

WRONG!

(with landing pad to facilitate jumping)

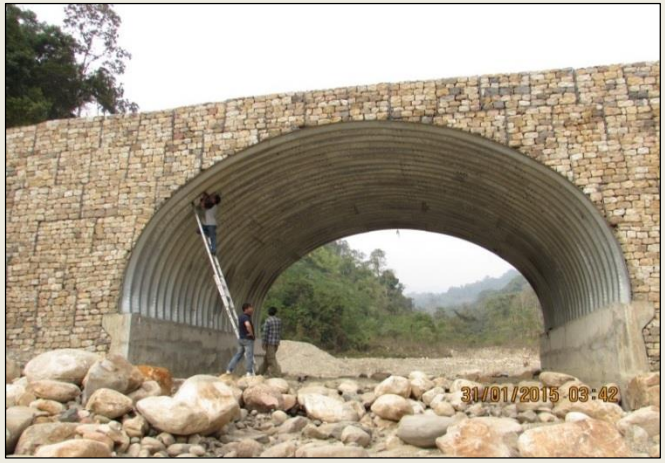
WE ONLY GET ONE CHANCE TO GET IT RIGHT!

IMPORTANCE OF PROJECT MONITORING

Post-Construction Monitoring

Vital to assessing:

- Effectiveness of wildlife passage structures
- Need for corrective modifications to green infrastructure
- Wildlife collision incidence - need for additional fencing
- Changes in wildlife species occurrence due to project – compare to Biodiversity Baseline



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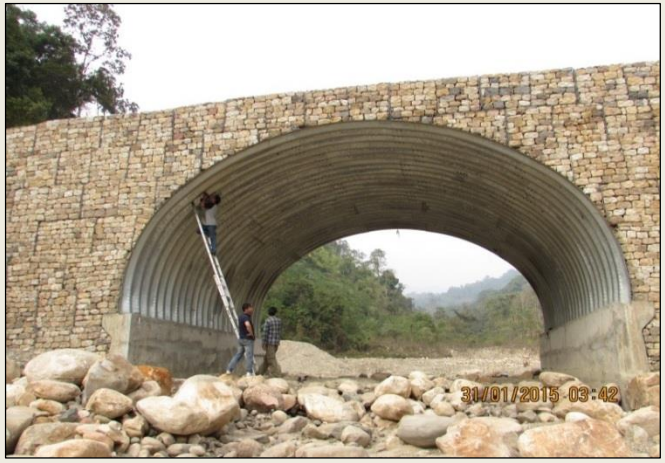
Post-Construction Monitoring

Vital to assessing:

- Effe
- Ne
- Wildlife collision incidence - need for additional fencing
- Changes in wildlife species occurrence due to project – compare to Biodiversity Baseline

Long-term (4+ years) best to address learning curve for most species



CONCLUSIONS

Green infrastructure has been conclusively shown to:

- Reduce wildlife-vehicle collisions
- Improve highway permeability
- Promote landscape connectivity
- Reduce genetic isolation

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Green infrastructure can effectively help *balance* economic development (transport infrastructure) with biodiversity and environmental conservation

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- Promote landscape connectivity
- Reduce genetic isolation

Increasingly cost-effective designs are available, especially for retrofitting of existing highways

Green infrastructure can effectively help *balance* economic development (transport infrastructure) with biodiversity and environmental conservation

Monitoring is *critical* to successful applications (4 years+ best)


THANK YOU

MINIMIZING IMPACT TO LANDSCAPE/WILDLIFE CONNECTIVITY

Learning from Our Mistakes

Underpass Openness

CASE STUDY

Location: Uttaranchal, India

Culvert "underpass" modified for Asian elephants reported as having minimal use, creating doubt as to whether underpasses will work for elephants

The dimensions of this "underpass" tunnel:

5 m wide × 5 m high × **111 m long**

Openness Index = 0.22