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Integrating Transport Infrastructure with Living Landscapes
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Université Lyon 3 - Manufacture des Tabacs
Road permeability assessment for ungulates - from science to practise

Andreas Seiler (SLU), Mattias Olsson (Enviroplanning), Mats Lindkvist (Transport Administration), J-O Helldin (Calluna)
• **Barrier effect:**
  • knowledge base
  • assignment of potential barriers

• **Existing measures:**
  • existing potential passages
  • passage efficacy

• **Identification of deficiencies**
• **Ranking of mitigation needs**
• **Pragmatic – strategic approach**
Barriers ...
Barriers …
Barriers …
Barriers … ???
Barrier effect

Physical hindrances

Avoidance and repellence

Animals intending to cross

Successful crossing

Accidents
Fencing

- 50-80% reduction of ungulate-vehicle collision – if well done …
- Barrier effect of a fenced road > 90%
- Effect is species dependent

⇒ by default, fenced roads must be regarded as effective barriers
Physical hindrances - Fences

- about 30% of major roads are fenced (speed, traffic volume)
- standard reduction in accidents: 80% moose, 60% deer, 55% roe deer, 50% wildboar
  - resulting barrier effect = 2 x
- factors affecting efficacy:
  - length
  - endings and openings
  - gates
  - stability
  - ...

BUT: fenced roads SHOULD be considered as potential barriers
Snow-tracking studies revealed declined crossing rates = increased avoidance in ungulates as traffic volume increased

Avoidance

- Traffic volume vs. Repellence / Avoidance

Cars per average day vs. Tracks ratio (R/R+C)

Railways
- Moose
- Roe deer

Trains per average day vs. Tracks ratio (R/R+C)

Roads
- Moose
- Roe deer

Seiler & Olsson, unpublished
Olsson & Seiler, unpublished
Mortality

- Non-linear effect of traffic volume and speed on ungulate-vehicle collisions

Seiler 2004
Combined barrier model for moose

Percent animals attempting to cross vs. Traffic volume

- Small effect
- Mortality
- Barrier

redrawn from Seiler 2003, Helldin et al. 2010
Animal response types

Johansen et al. 2016
Criteria for potential barriers

Step 1. Identification of potential barriers

Public roads and rails

Traffic volume
- > 4000 cars per day
- > 80 trains per day

Standard
- International highway > 2000 adt
- Main railroad > 50 tadt

Design
- with fences, central barriers, ...
  - more than 1 lane

Speed limits
- road: > 100 km/h
- rail: > 150 km/h

Bundeling
- roads > 2000 at or railways > 50 at
  parallel for 4 km with < 1 km distance

Upgrading
- see STA Capacity plan 2012

Land use
- > 300m outside urban areas

Potential barrier for ungulates

Potential barriers = roads that animals are not able / not allowed to cross
Railroad barriers

Trains / day

- < 65
- 65 - 120
- 120 - 200
- > 200

Marktäcke

- Kalfjäll
- Öppen mark
- Sankmark
- Skogsmark
- Vattenyta
- Tätort
- Länsgräns

VANDRINGSHINDER OCH BROAR
enligt Bristanalysen Klövillet 2014

Datum: 2012-07-03
Skala (A3): 1:6,000,000

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Road bridges and tunnels

prim. function of passage

- Vatten
- Land
- Tunneltak
- GC, djur
- Enskild väg
- Allmän väg
- Järnväg

Potentiella barriärer

- Järnväg
- Väg

Landarea

- Landyta
- Vattenyta
- Tätort
- Länsgrens

VANDRINGSHINDER OCH BROAR

enligt Bristanalysen Klövilt 2014

Datum: 2012-07-03
Skala: 1:5,000,000

© Lantmäteriet, dnr 109/2010/2667
Potentiella barriärer

Alla broar

Effektivitet för älg

- < 5%
- 5-25%
- 25-50%
- 50-75%
- 75-100%

Övriga järnvägar

Övriga vägar

Länsgräns

Tätorter

POTENTIELLA PASSAGE

enligt Basismaterialen Klövvi 2015
Passage efficacy 1(2)
Efficacy of “bridges”

- Passage size (with/length) is crucial factor, given sufficient height > 3m
Efficacy of “bridges”

- Effect of passage width and passage height on passage usage by ungulates.
  Passage height > 3m.
Potential passages

Phase 2
Identification of potential passages

Bridge database

at potential barriers

Main purpose

Railroad
- traffic < 80 ADT

Public road
- traffic < 1000 ADT

Private road, path
- all

Animals
- all

Valley, landscape
- all

Water
- dry passage > 2m

Visual evaluation

Efficacy model
\[ E = f \left( \frac{B}{L} \right) \]

Efficacy of potential passage for ungulates

not feasible for wildlife
Passage efficacy 1(2)

Oh my Love, I would go 500 miles for you!

... or just the square root of your home range ...
Effective distance

**allometrically scaled effect distance**

\[
\text{Permeability} = \text{proportion of potential barrier without need for further mitigation}
\]

\[\text{effect distance} = \text{passage efficacy } E \times \sqrt[2\pi]{\text{Home range area}}\]

compare Bissonette and Adair 2008

![Diagram showing the concept of effective distance with open and closed barriers, and mitigation requirements.](image-url)
Application example:

Permeability analysis for highway E20 and railroad between Laxå and Finnerödja.

Foto: Google Maps och Google StreetView 2014.
Potential barriers
(Deficiencies in permeability)

Remaining barriers
(Railroads > 2km, Roads > 2km)
## Remaining barriers per road

<table>
<thead>
<tr>
<th>Roadnr.</th>
<th>Total length of barrier (km)</th>
<th>Length resolved barriers</th>
<th>% resolved barriers</th>
<th>Length remaining barriers</th>
<th>Max length of remaining barrier section</th>
<th>Count barrier sections</th>
<th>Number of passages needed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td>4</td>
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<tr>
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<td>9,5</td>
<td>11,7%</td>
<td>72,0</td>
<td>37,7</td>
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<td>11,5</td>
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<tr>
<td>12</td>
<td>80,1</td>
<td>21,4</td>
<td>26,8%</td>
<td>58,7</td>
<td>28,5</td>
<td>5</td>
<td>10,5</td>
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<tr>
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<td>12,9%</td>
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<td>18,8</td>
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<td>10,5</td>
</tr>
<tr>
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<td>2,0%</td>
<td>60,2</td>
<td>16,8</td>
<td>6</td>
<td>10,5</td>
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<tr>
<td>11</td>
<td>69,4</td>
<td>8,6</td>
<td>12,4%</td>
<td>60,8</td>
<td>39,2</td>
<td>5</td>
<td>10,0</td>
</tr>
<tr>
<td>31</td>
<td>88,2</td>
<td>20,8</td>
<td>23,5%</td>
<td>67,5</td>
<td>24,6</td>
<td>5</td>
<td>10,0</td>
</tr>
</tbody>
</table>
Remaining barriers per county

% potential barrier WITHOUT need for mitigation
## Ranking and prioritization

<table>
<thead>
<tr>
<th>Ranking criteria</th>
<th>Condition, measure, limit values</th>
<th>factor weight</th>
<th>Example road</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td><strong>Length of remaining barrier</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 20 km</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>9-20 km</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4-9 km</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>&lt; 4 km</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Physical barriers (fences, noise walls, etc)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 80% coverage</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>50-80%</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>&lt; 50%</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Traffic volume (ADT)</strong></td>
<td>road &gt; 10 000; rail &gt; 100</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>road &gt; 4 000; rail &gt; 60</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>road &lt; 4 000; rail &lt; 60</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Speed (km/h)</strong></td>
<td>road &gt; 100; rail &gt; 150</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>road 80-100; rail 90-150</td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>road &lt; 80; rail &lt; 90</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Wildlife-vehicle collisions</strong></td>
<td>hotspot (high cost-efficacy)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>hotspot (low cost-efficacy)</td>
<td></td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>no hotspot</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Wildlife corridors</strong></td>
<td>large-scale strategic corridor</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>locally known corridor</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>outside corridors</td>
<td></td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Circuitscape
Landscape connectivity
and prioritization
Remaining barrier
Need for mitigation
High
Intermediate
Low

Landskap
Vattenyta
Tåltort
Tåltortsbuffar
Länsgrens
Konnektivitet
Simulerat flöde
Hög
Lågt

Storskaliga korridorer

Datum: 2017-02-21
Version: 1.0.0
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UVC locations
significant UVC clusters (KDE+)
KDE+ prioritized clusters

Criteria for prioritization:
- UVC every year
- UVC > 5 / km
- Cluster length > 250m
- Cluster strength > 10%

Prioritized for mitigation
detailed StreetView analysis

- gates in fence
- attraction (on the other road side)
- impediment
Cost-benefit of fencing

UVC 2010 - 2014

Benefit KDE

- very high
- high
- existing fences

UVC per km and year

1
2
3
4
5
6
7
10
15
20
25
30
50
60

National roads
County roads
Urban areas

1:750,000
0 5 10 20 Km
Remaining tasks:

- Define a realistic goals for permeability
  - 20%, 50%, 80%, 100% -
  - what is needed – what is attainable?
  - adjust level regionally ?
  - scale dependent ?

- Develop passages at grate
  - cost-efficacy of measures
  - innovative solutions
  - multiple target species

- Develop priority maps for connectivity (strategic wildlife corridors)

- Validate the approach
  - simulation models ?
  - traffic mortality / accidents
National guideline for landscape

- Objectives/Requirements:
  - SMART-goals
  - all infrastructure shall be adapted to landscape
  - no wildlife shall be killed by transport facilities and traffic
  - continuous increase of knowledge through monitoring and research
  - landscape connectivity analysis for all new investment projects required
  - targeted mitigation measures shall be accomplished along existing and new infrastructure
  - ...
  - ...

Thanks!

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