
Transport infrastructure of the 21st century:
connecting people and wildlife
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IENE 2016 - International Conference on Ecology and Transportation

Integrating Transport Infrastructure with Living Landscapes

30th August to 2nd September 2016

Lyon - France

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)

Foto: Niklas Luuks

Content

- **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 …

TRIEKOL

Barriers …

TRIEKOL

Barriers …

TRIEKOL

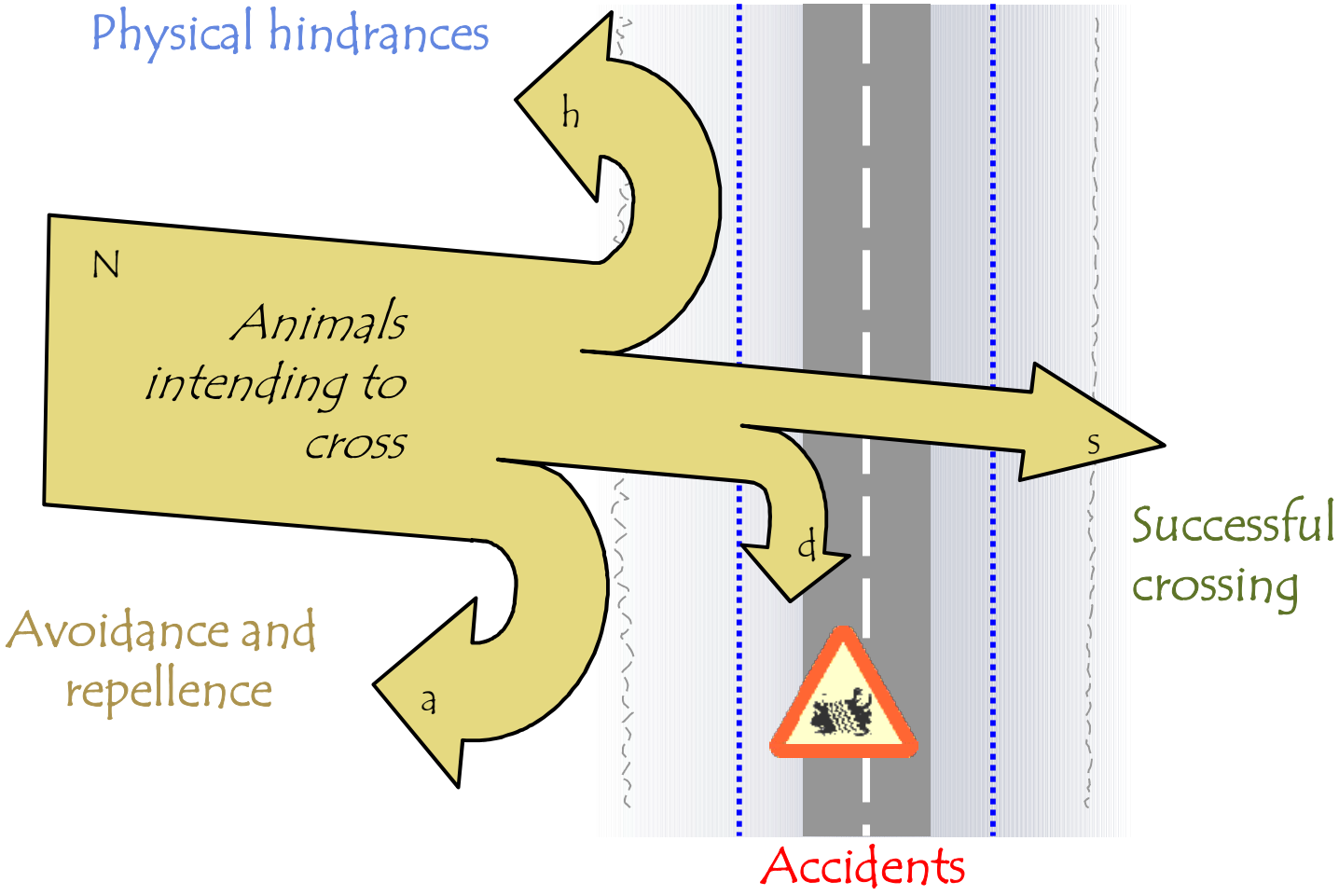
Barriers … ?

TRIEKOL

Barriers … ???

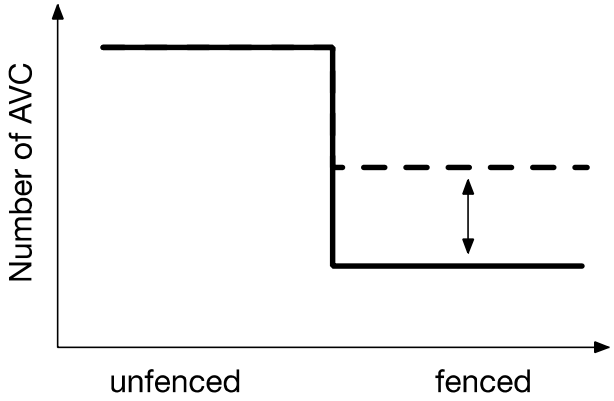
TRIEKOL

Barrier effect



Fencing

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



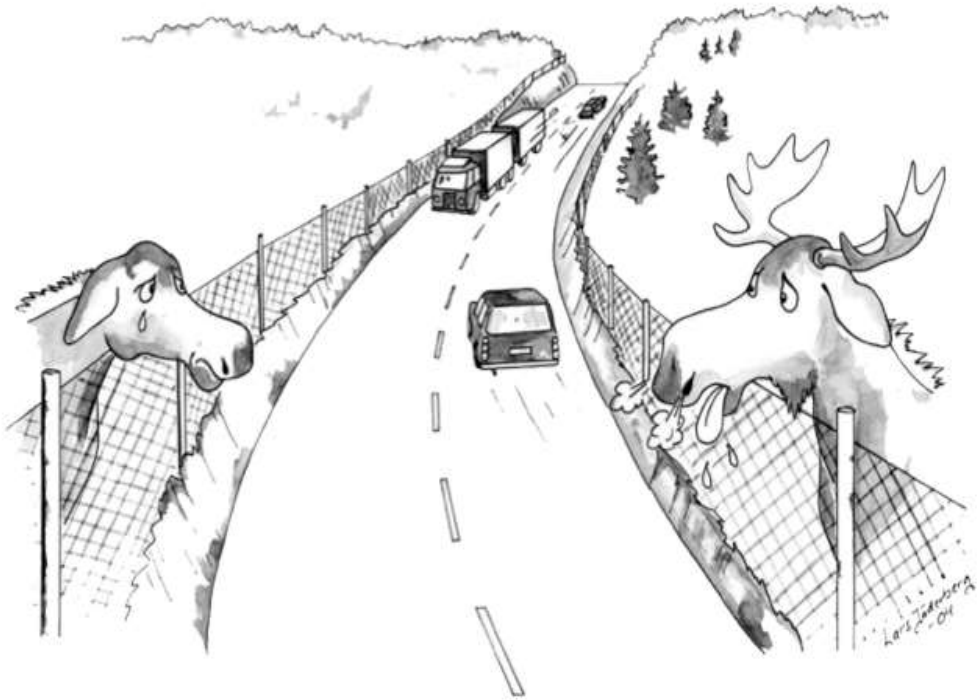


Illustration: Lars Jäderberg

➔ **by default, fenced roads must be regarded as effective barriers**

TRIEKOL

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
  - …

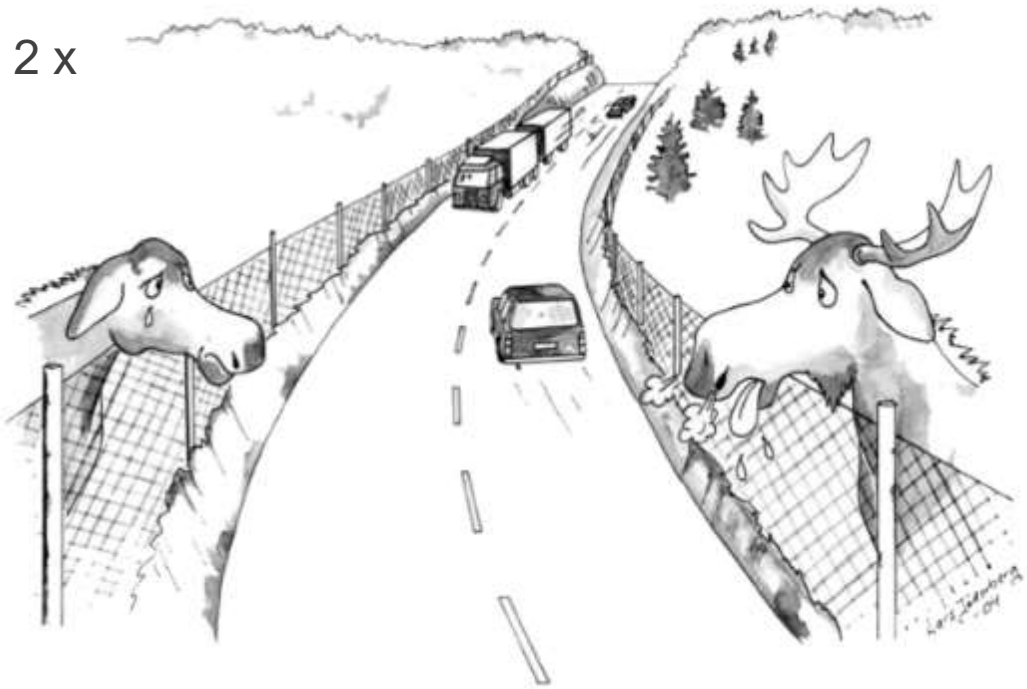


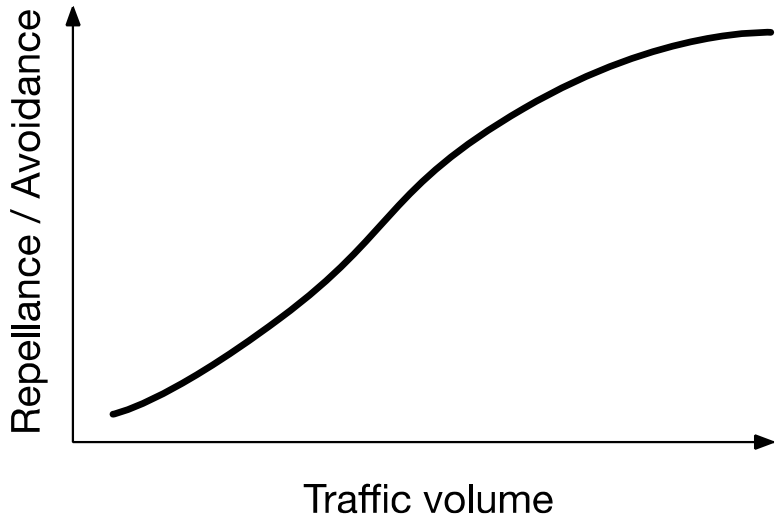
Illustration: Lars Jäderberg

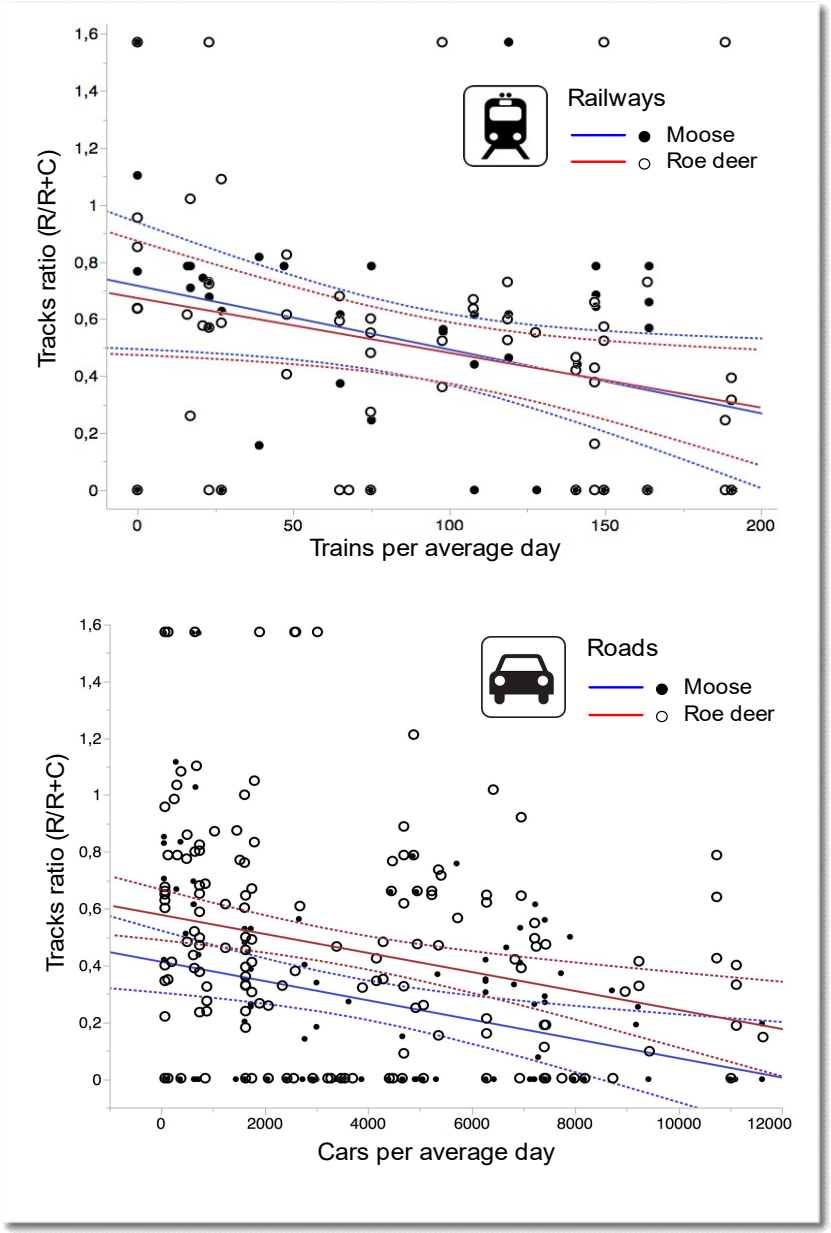
BUT: fenced roads SHOULD be considered as potential barriers

TRIEKOL

Avoidance

- Snow-tracking studies revealed declined crossing rates = increased avoidance in ungulates as traffic volume increased

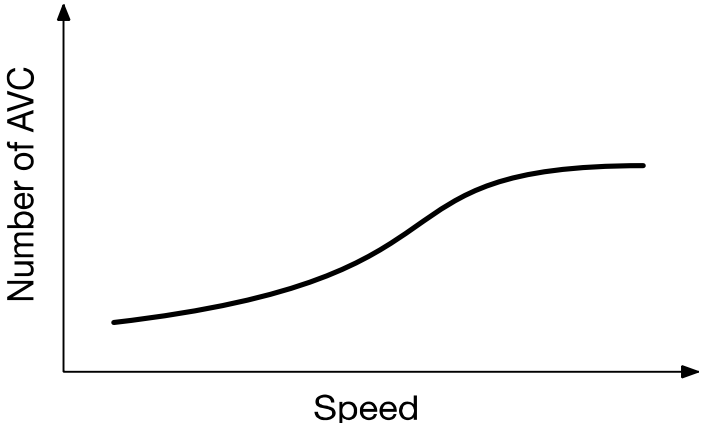


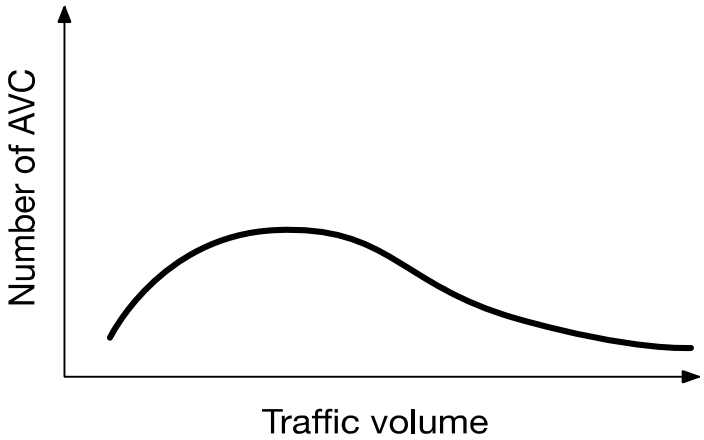


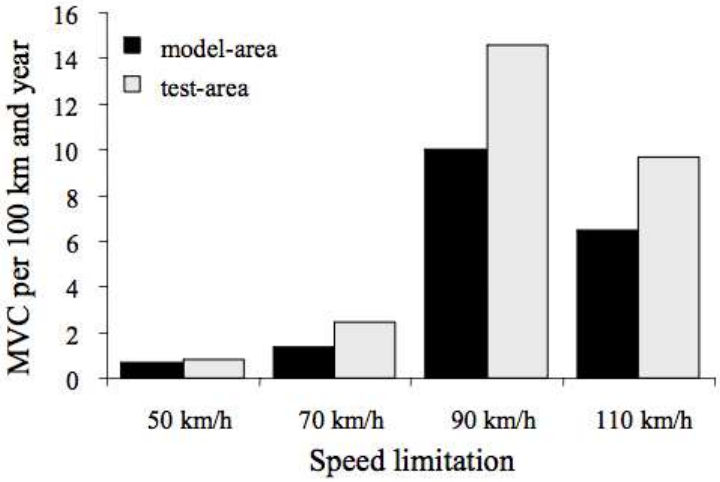
Seiler & Olsson, unpublished
Olsson & Seiler, unpublished

Mortality

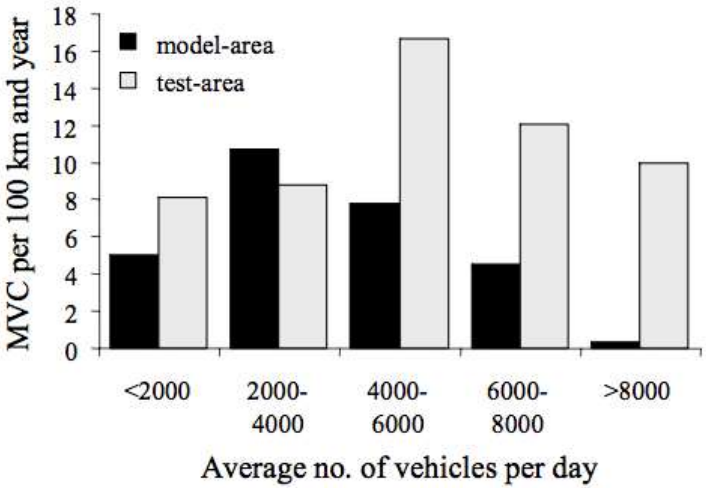
- Non-linear effect of traffic volume and speed on ungulate-vehicle collisions







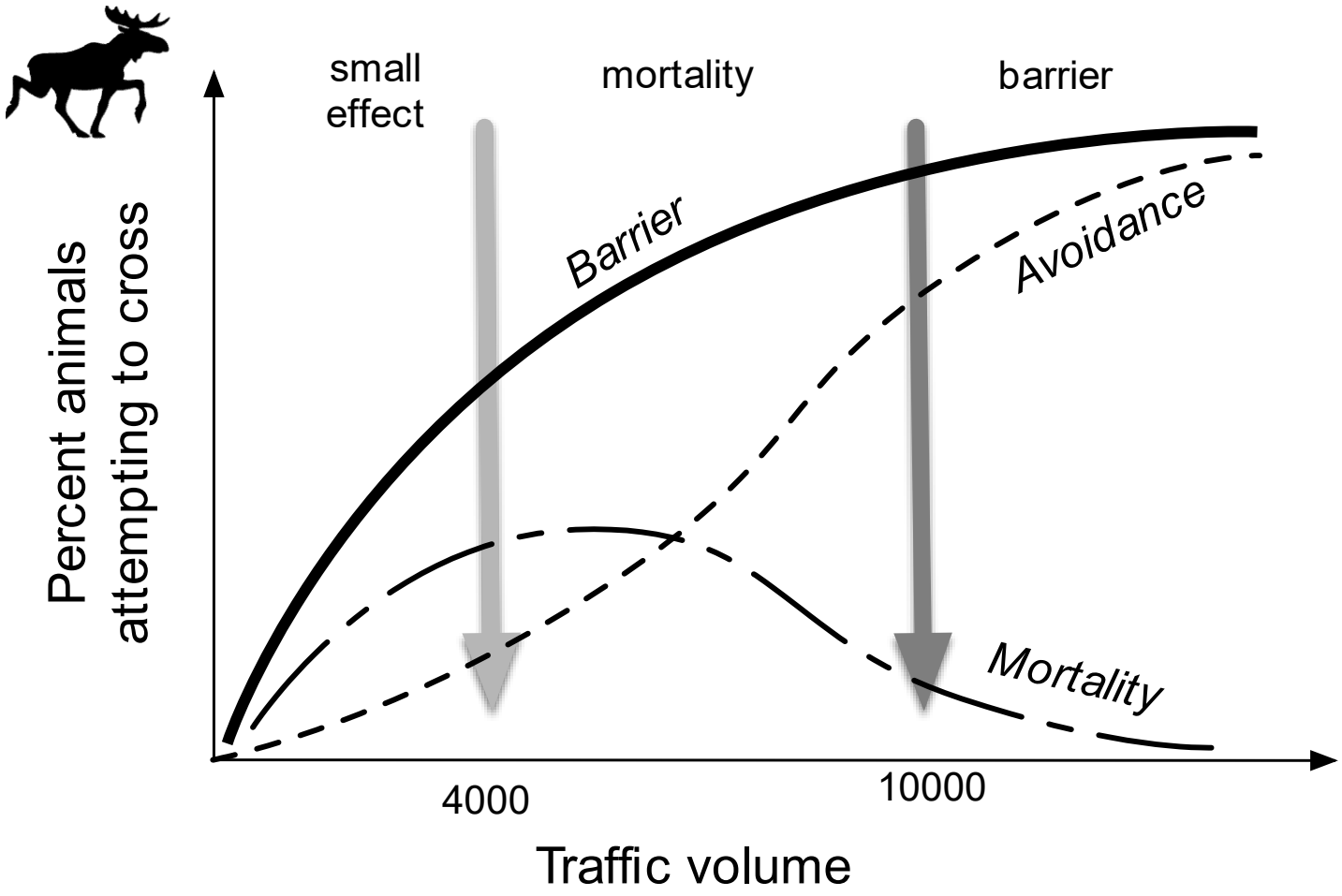
A)



B)

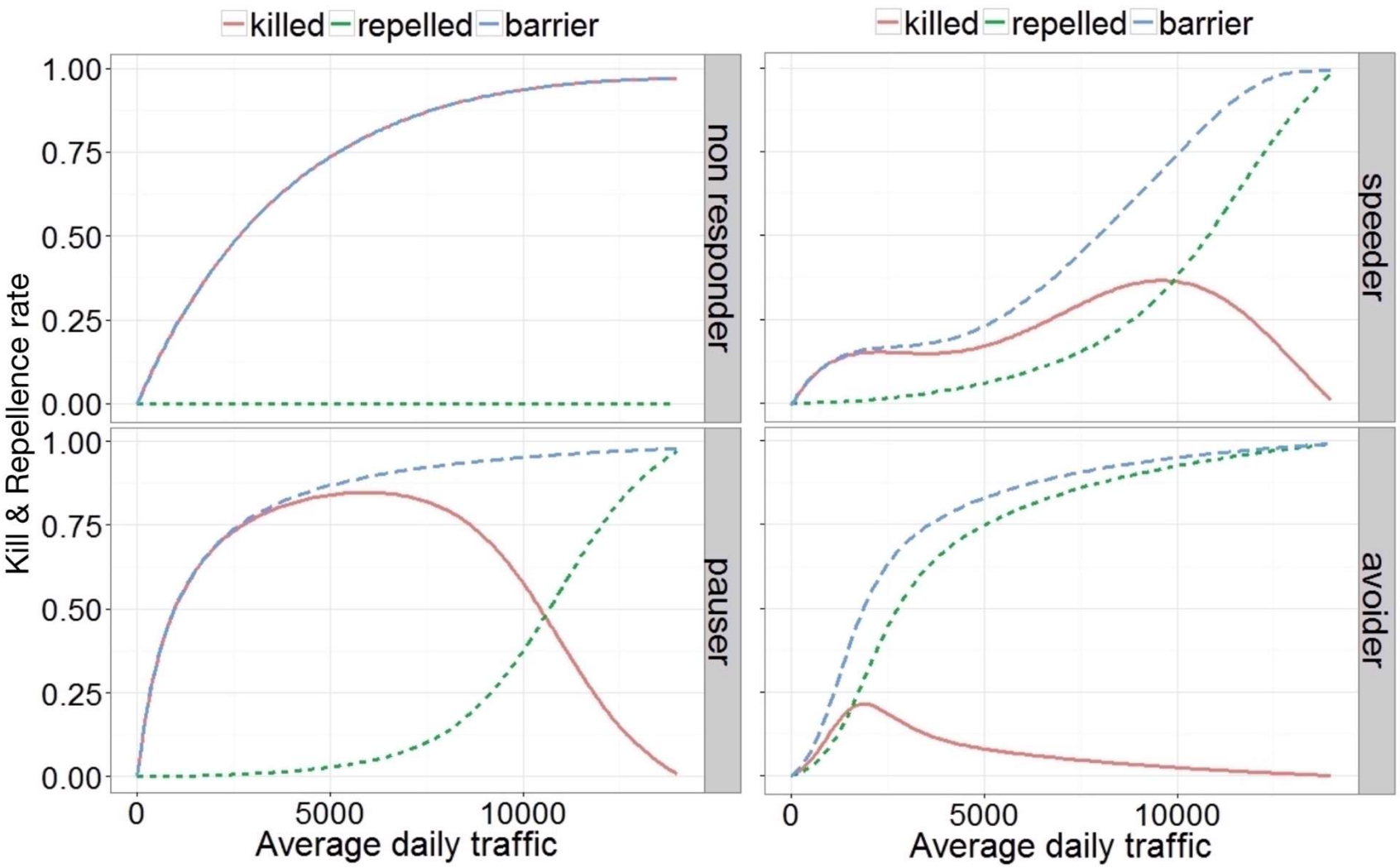
Seiler 2004

Combined barrier model for moose



redrawn from Seiler 2003, Helldin et al. 2010

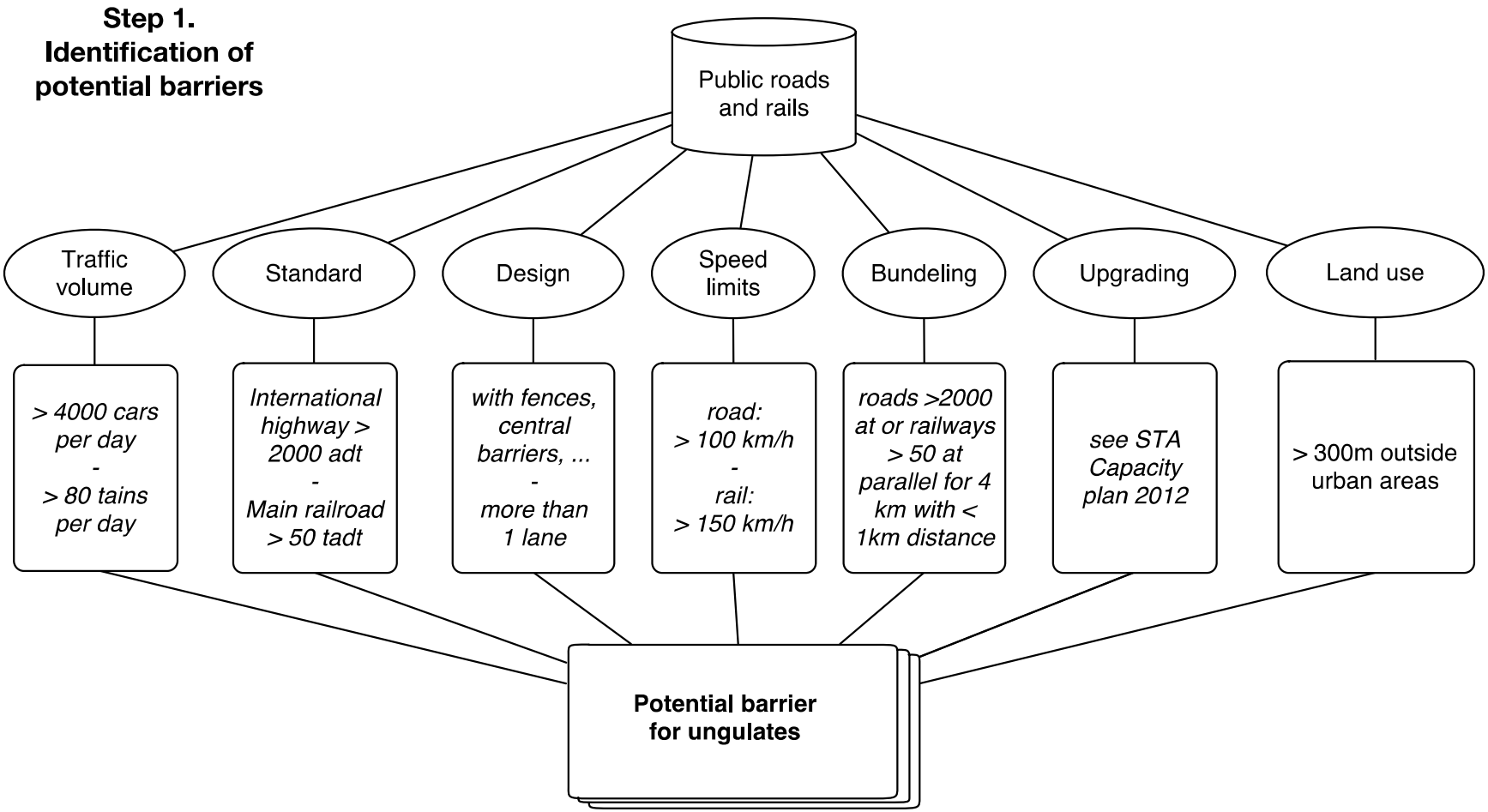
Animal response types



Johansen et al. 2016

TRIEKOL

Criteria for potential barriers



Potential barriers =

roads that animals **are not able / not allowed** to cross

TRIEKOL

Road barriers

Vehicles / day

- < 1000
- 1000-4000
- 4000-10000
- > 10000

Marktäcke

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

VANDRINGSHINDER OCH BROAR

enligt Bristanalysen Klövvilt 2014

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

0 35 70 140 km

N

Railroad barriers

Trains / day

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

Marktäcke

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

VANDRINGSHINDER OCH BROAR

enligt Bristanalysen Klövvilt 2014

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0 35 70 140 km

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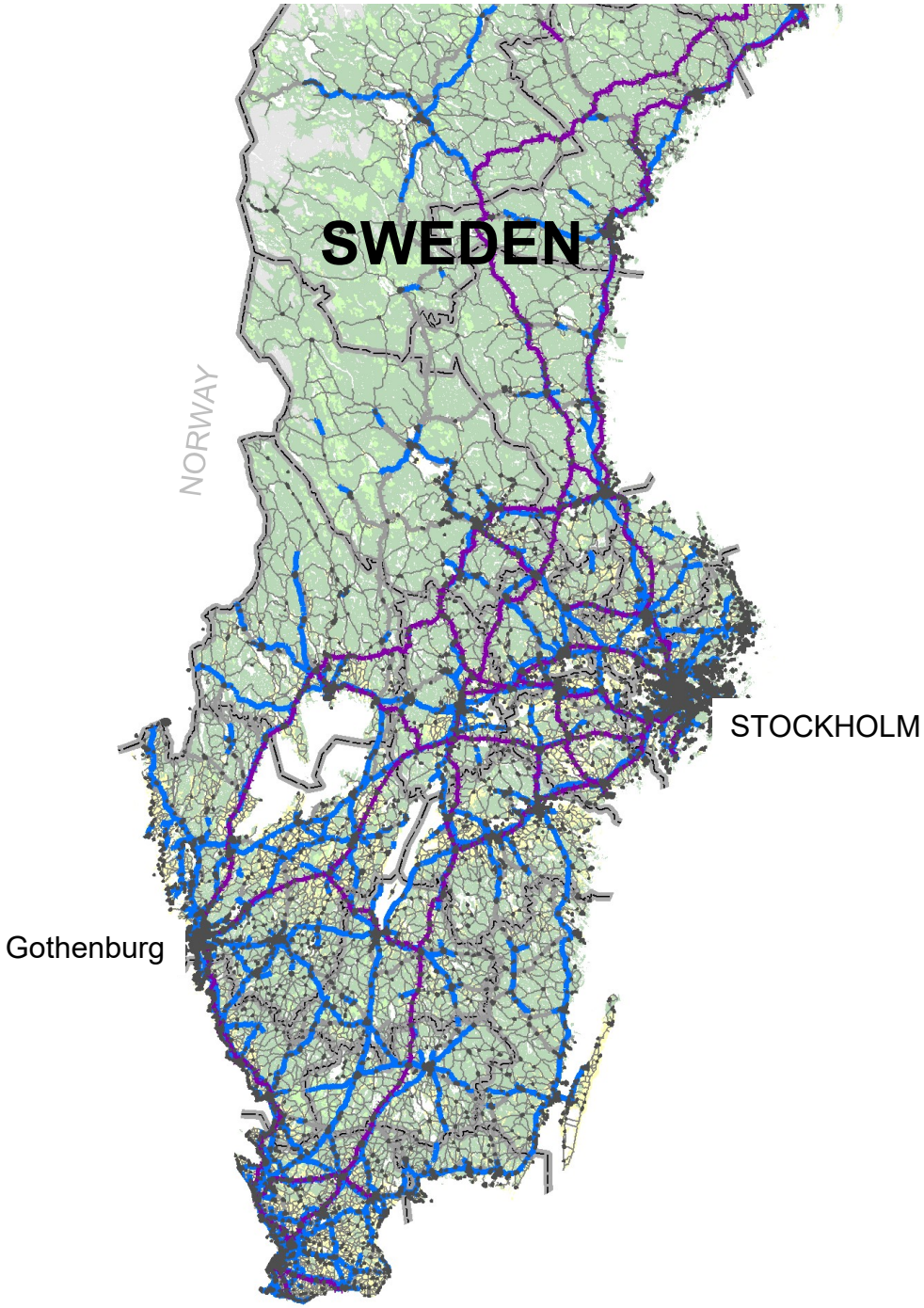


Potential barriers

Type of barrier

- Railroad
- Road
- Other infrastrutcure

Marktäcke

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

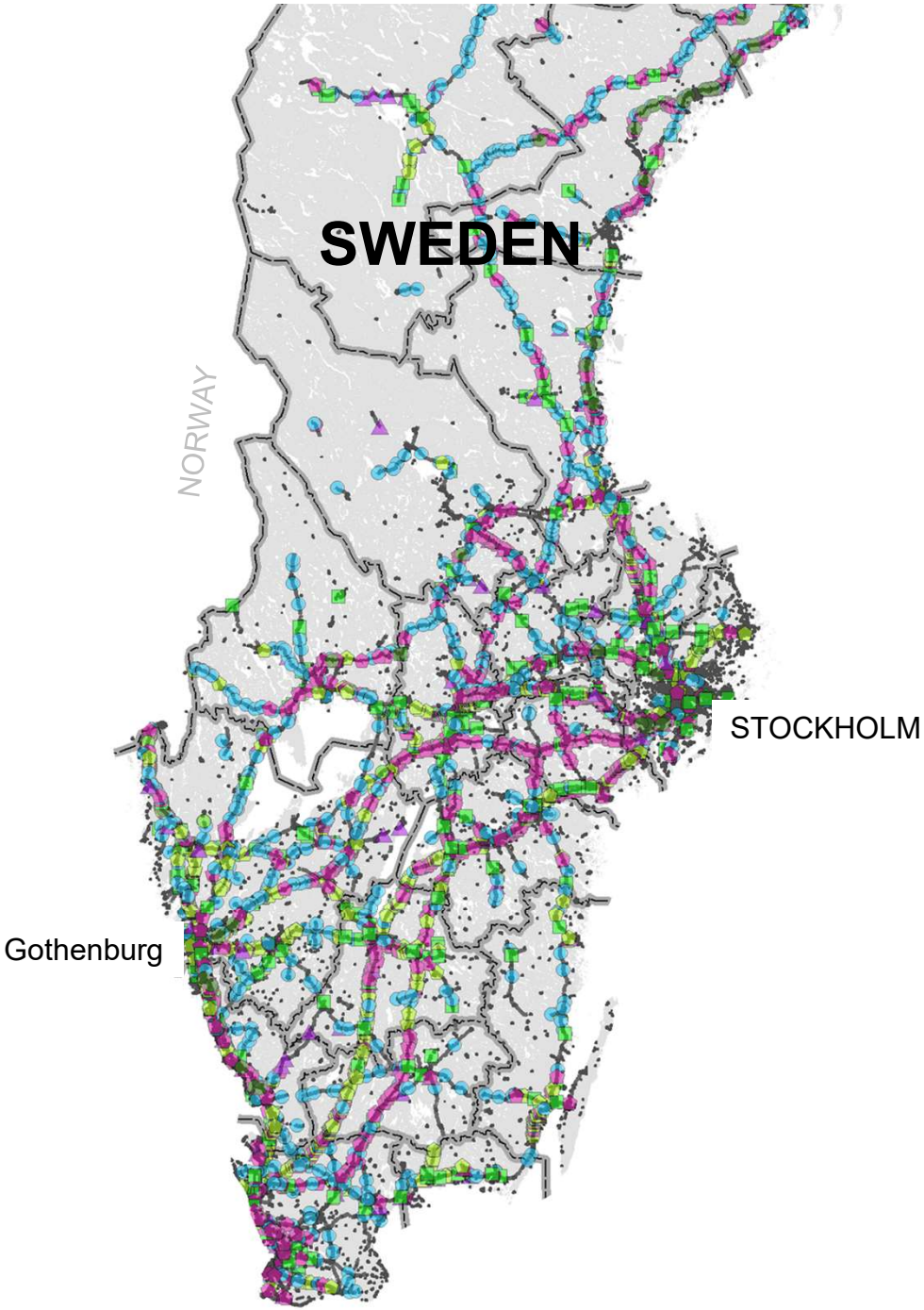
VANDRINGSHINDER OCH BROAR

enligt Bristanalysen Klövvilt 2014

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

0 35 70 140 km

N



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
- Länsgräns

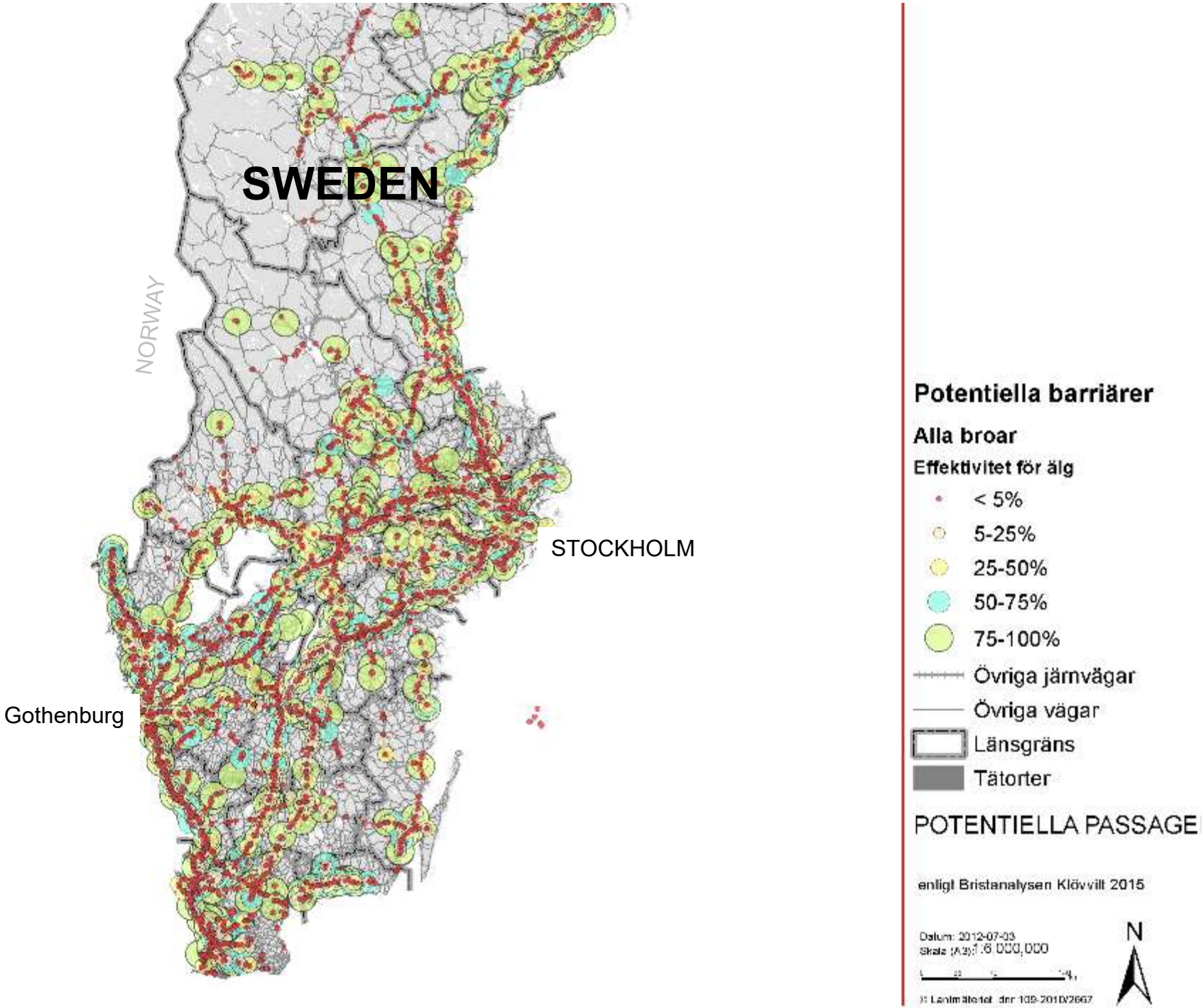
VANDRINGSHINDER OCH BROAR

enligt Bristanalysen Klövvilt 2014

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

0 35 70 140 km

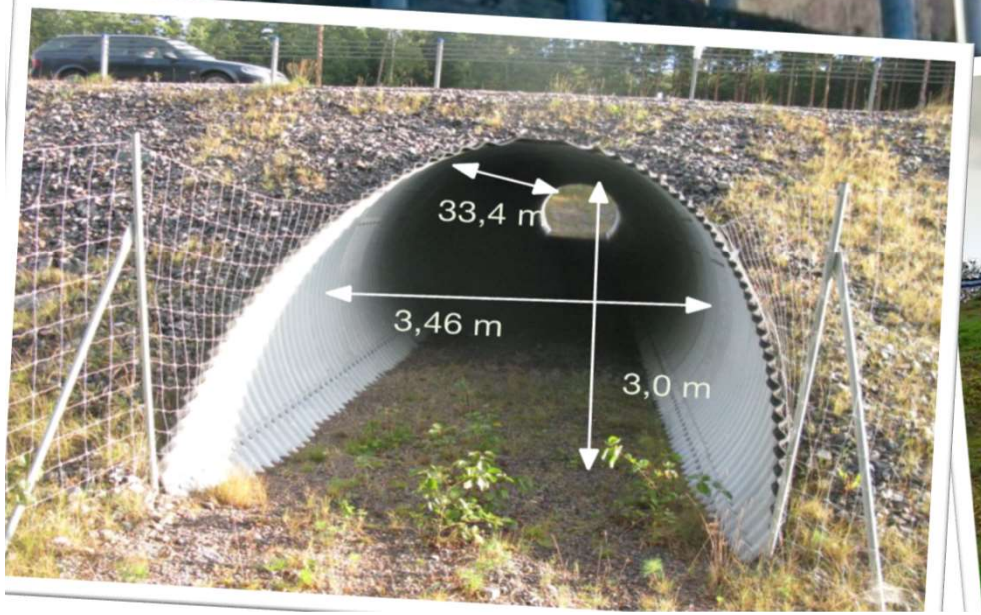
N


SWEDEN
NORWAY
STOCKHOLM
Gothenburg
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 Bristanalysen Klövvilt 2015
Datum: 2012-07-03
Skala (A3):1:6 000,000
N


27 m + 27 m

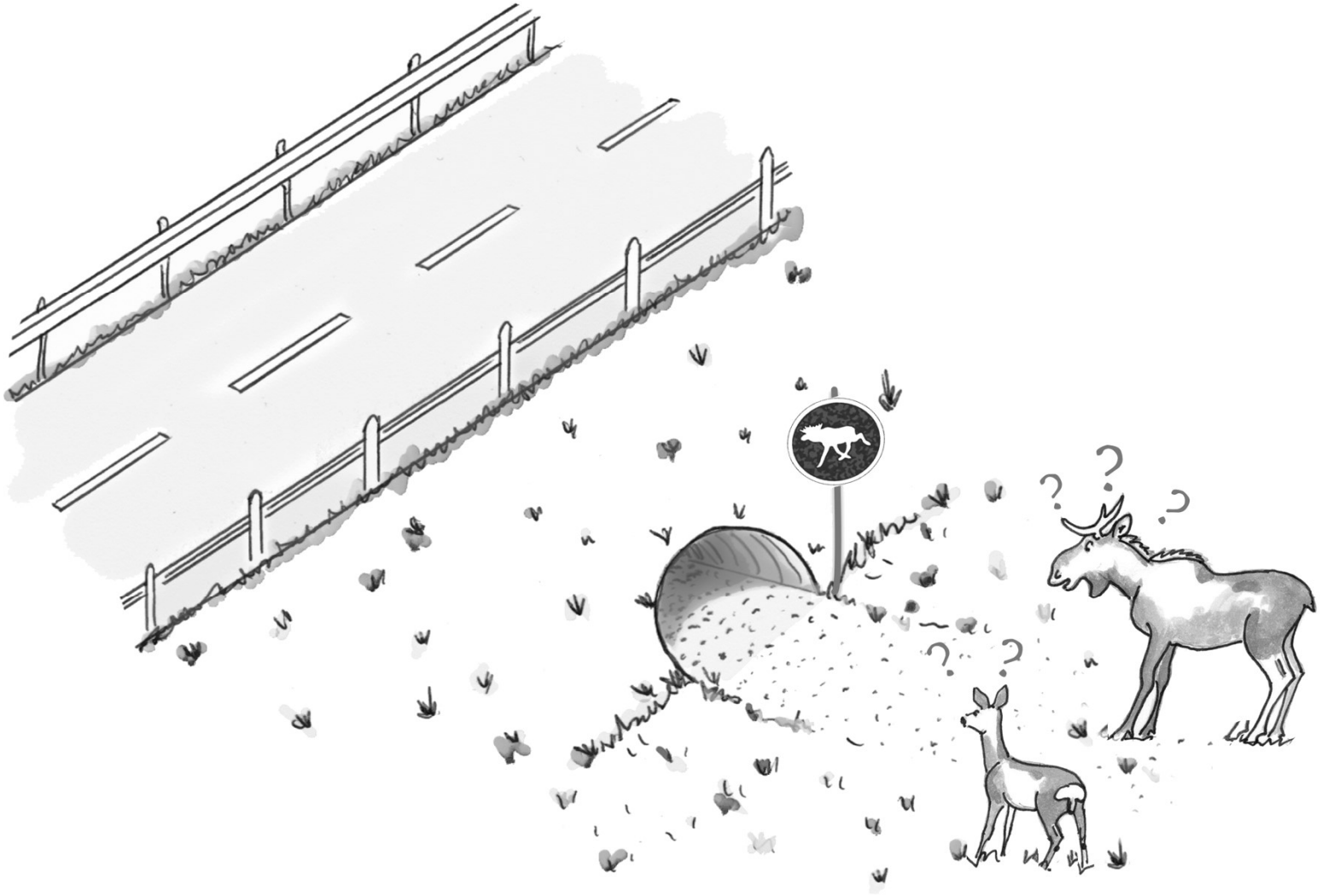

6 m


ca 16 m
ca 14 m
10 + 10 m
> 4,5 m


33,4 m
3,46 m
3,0 m


10,5 m
> 4,5 m
27 m

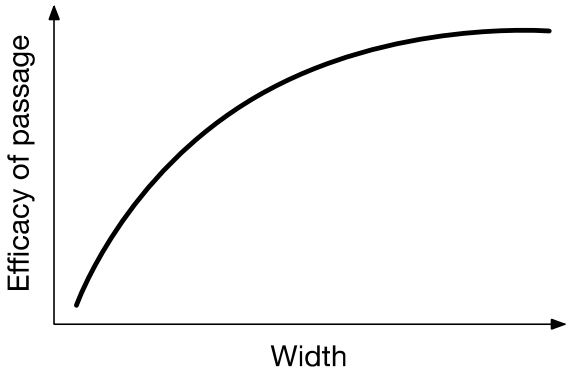
Passage efficacy 1(2)

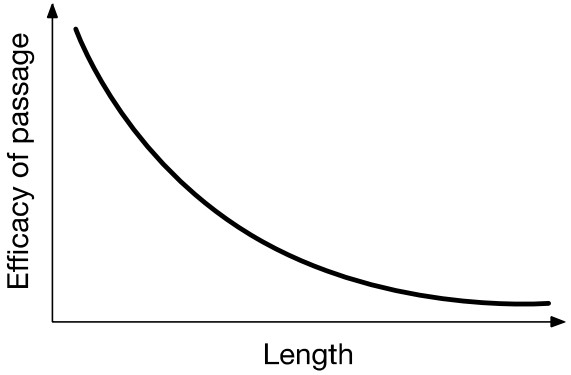


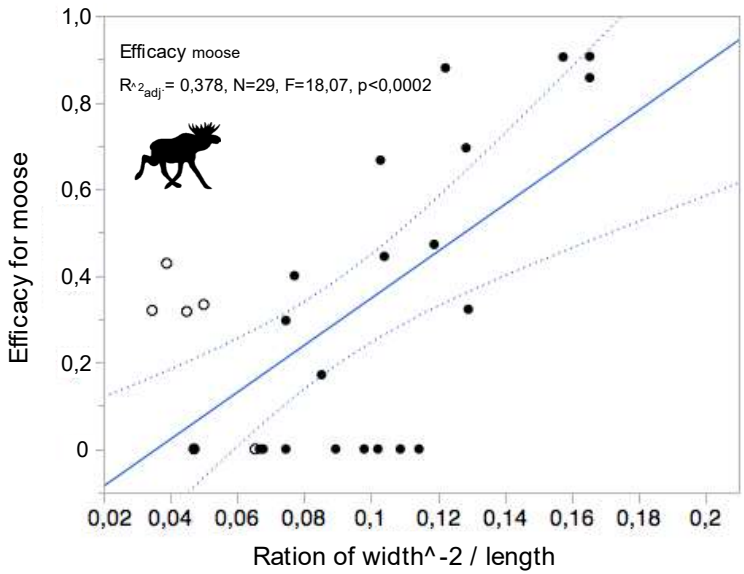
TRIEKOL

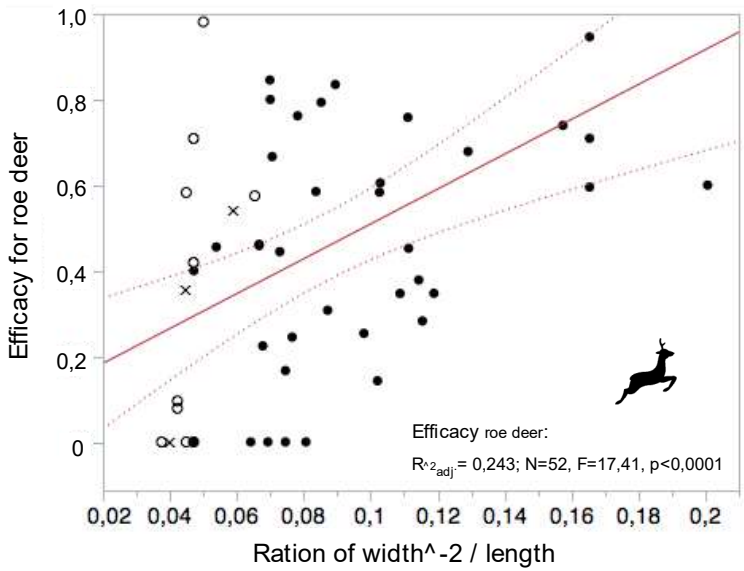
Efficacy of “bridges”

- Passage size (with/length) is crucial factor, given sufficient height > 3m





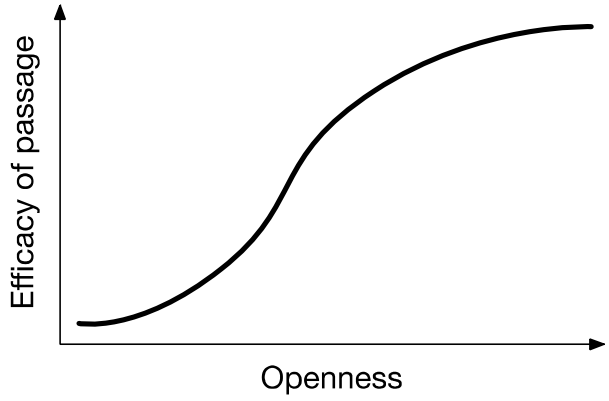


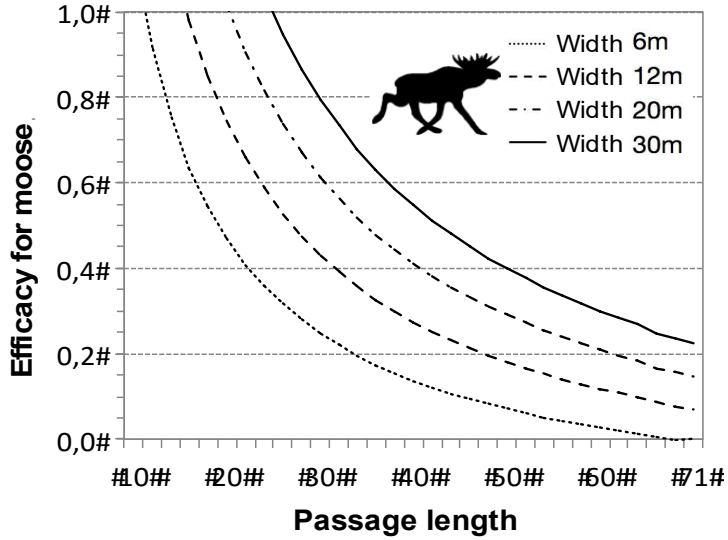


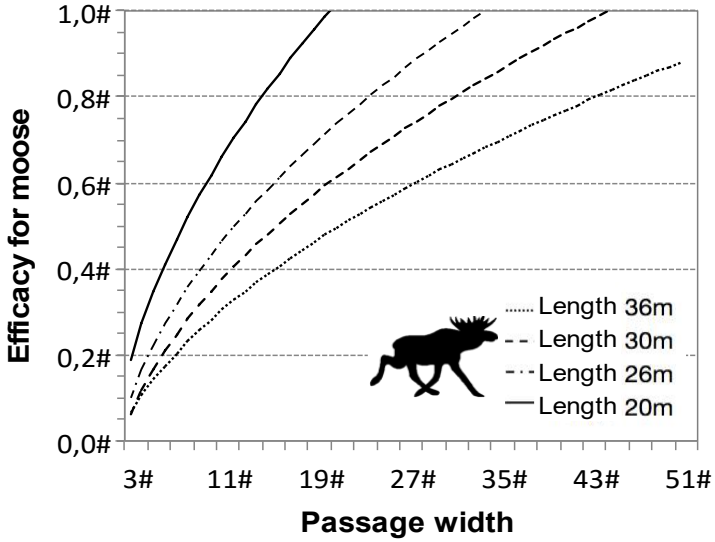
TRIEKOL

Efficacy of “bridges”

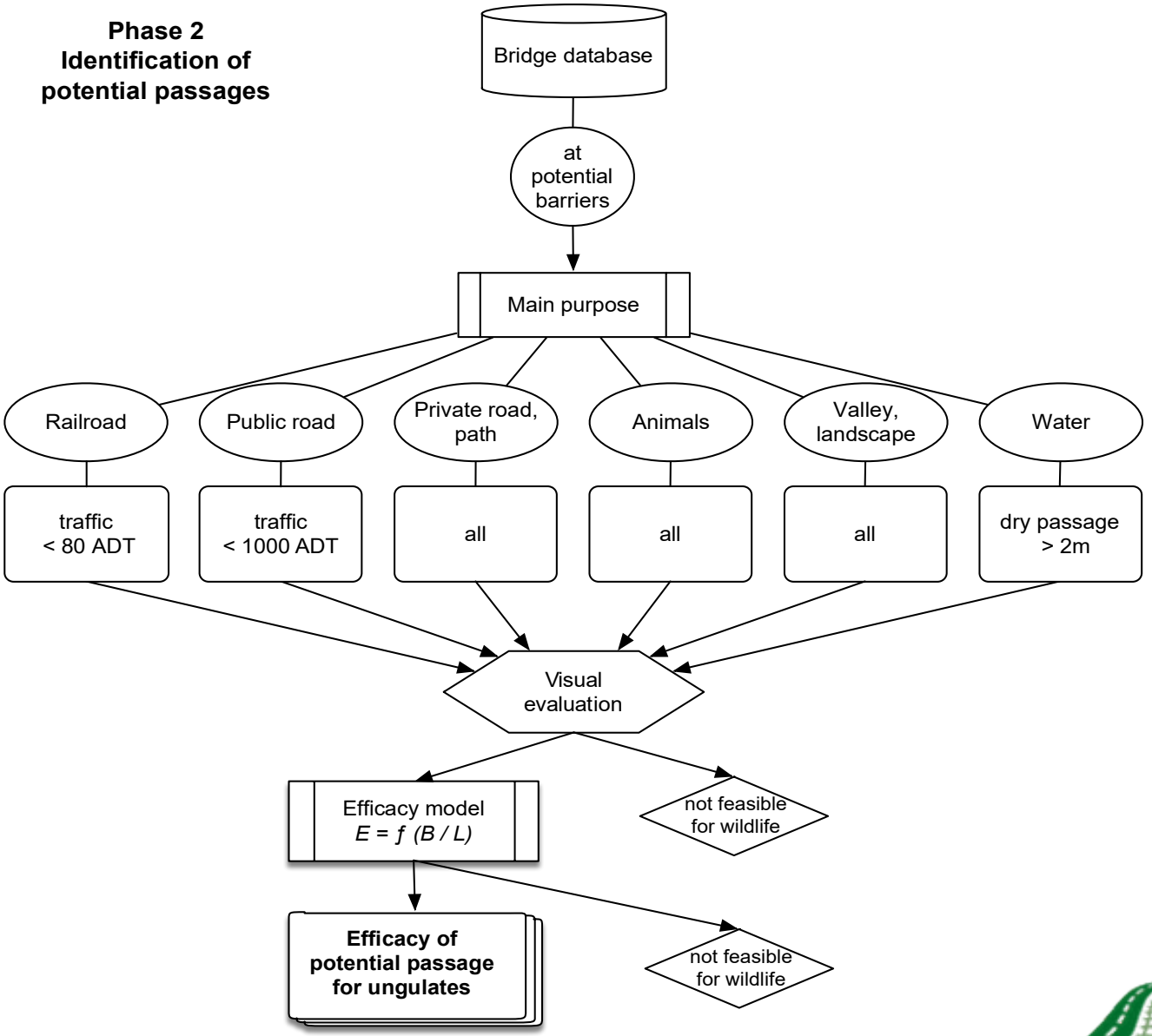
- Effect of
  passage width and
  passage height on
  passage usage
  by ungulates.
  Passage height > 3m.



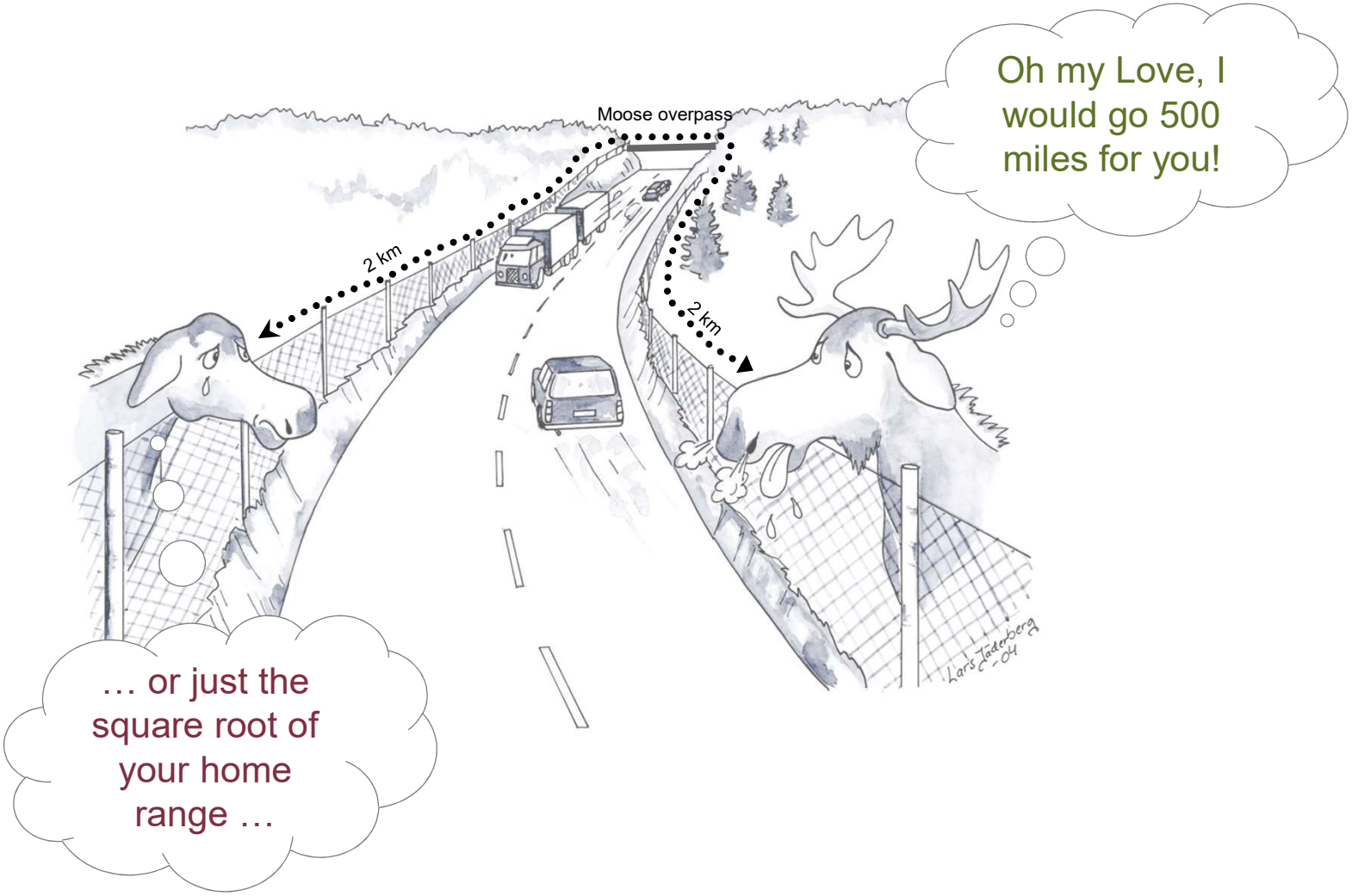




Potential passages



Passage efficacy 1(2)



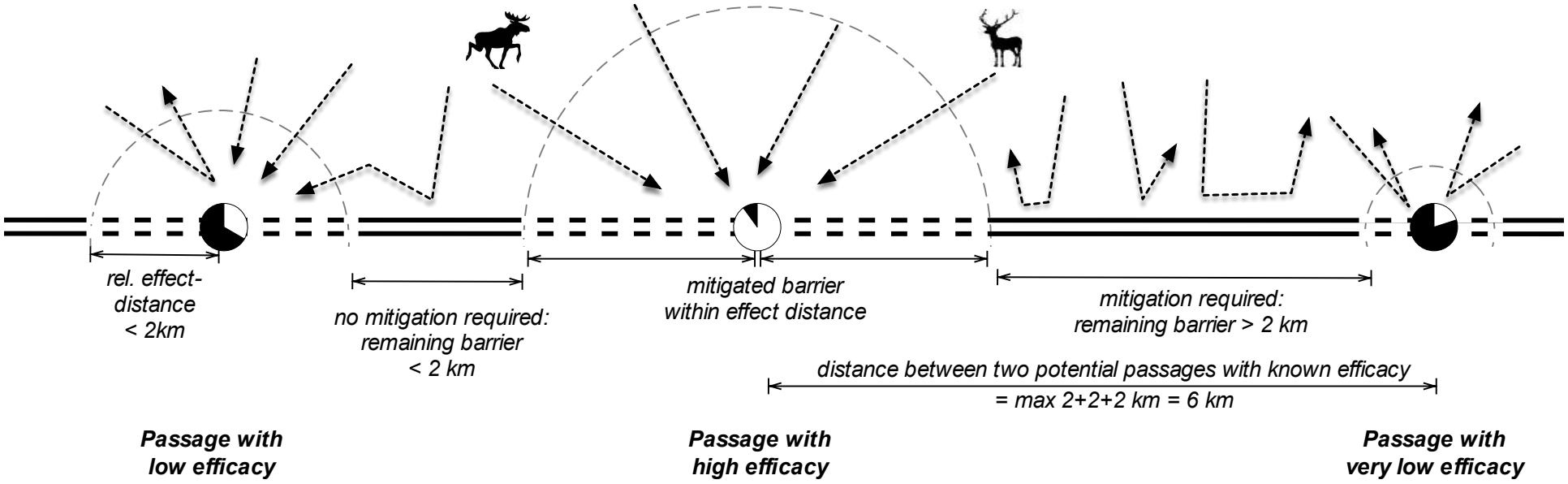
Effective distance

***allometrically scaled** effect distance*
*= passage efficacy E * SQRT(Home range area)*

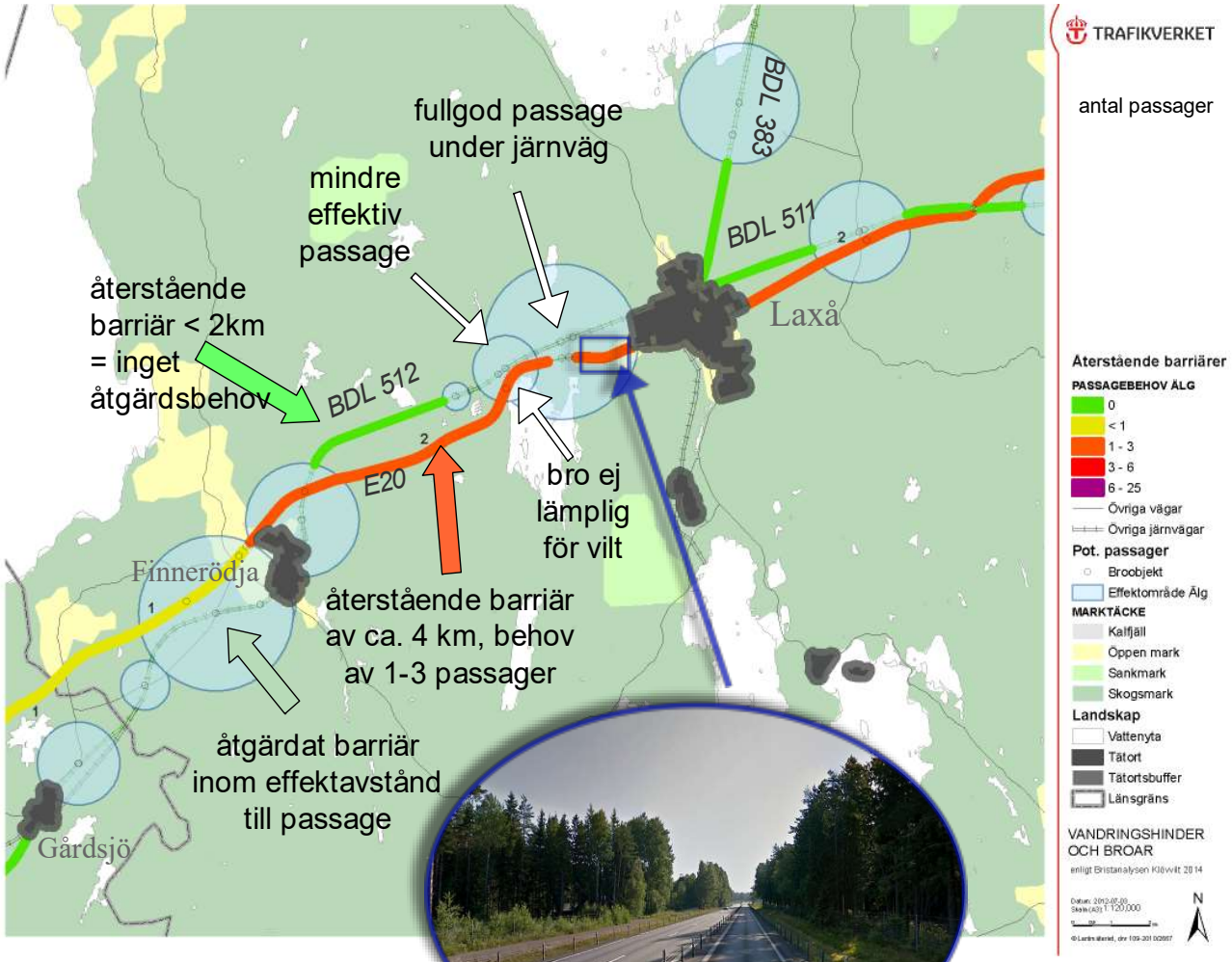
compare Bissonette and Adair 2008

open, high efficacy

closed, low efficacy



➔ Permeability = "proportion of potential barrier without need for further mitigation"

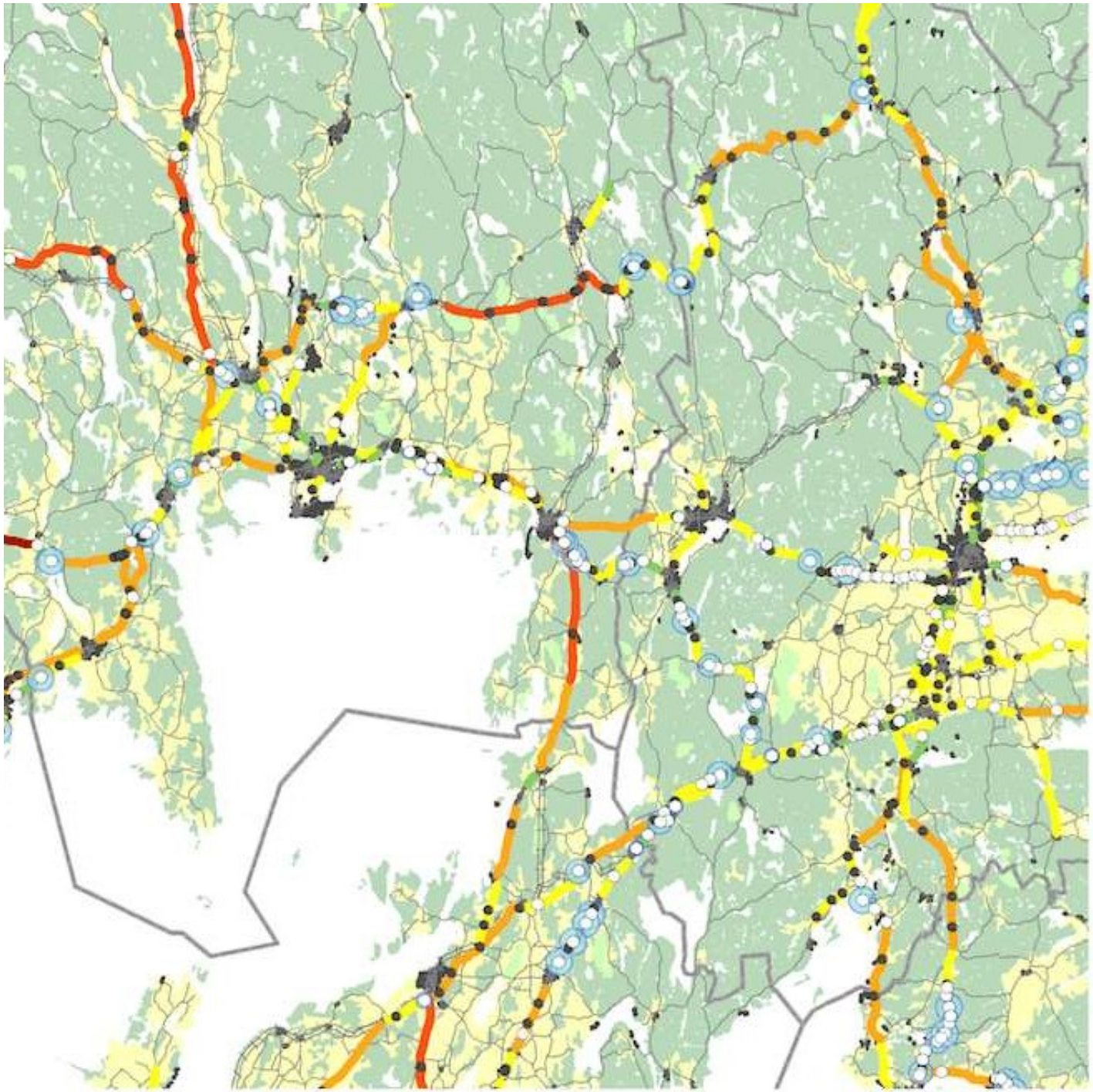


Application example:

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

Foto: Google Maps och Google StreetView 2014.

TRIEKOL



Återstående barriärer

Antal passager (älg)

- 0
- 1 - 4
- 5 - 10
- 11 - 17
- 18 - 30
- Effektområde Älg

Potentiella passager

- olämpliga / exkluderade
- lämpliga / inkluderade
- Övriga vägar
- Övriga järnvägar

MARKTÄCKE

- Kalfjäll
- Öppen mark
- Sankmark
- Skogsmark

Landskap

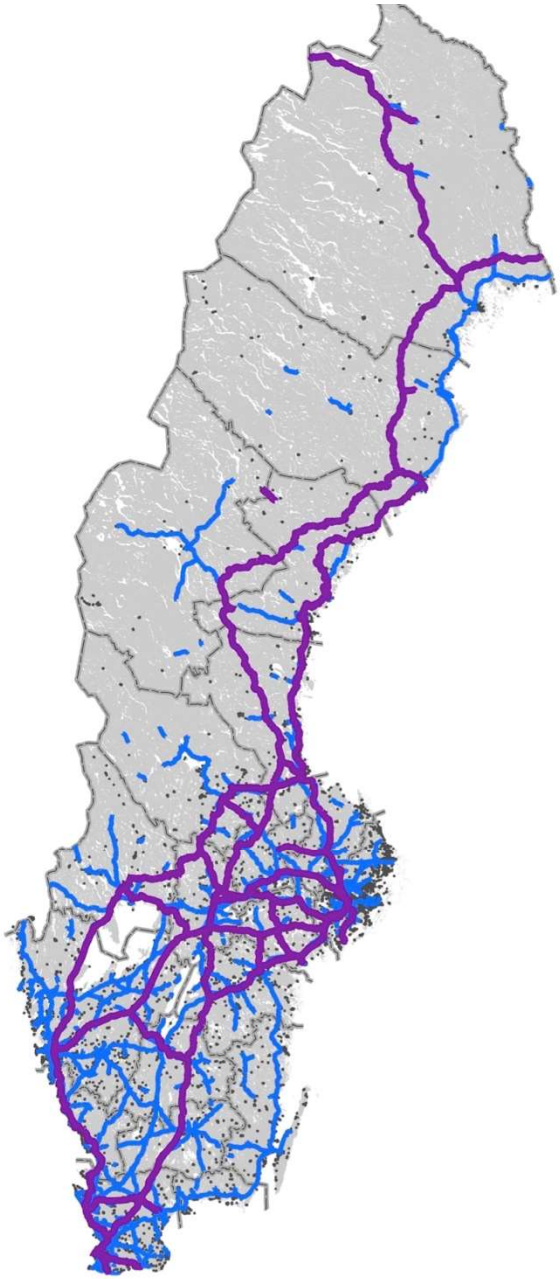
- Vattenyta
- Tätort
- Tätortsbuffer
- Länsgräns

BRISTANALYS
FÖR KLÖVVILT 2015

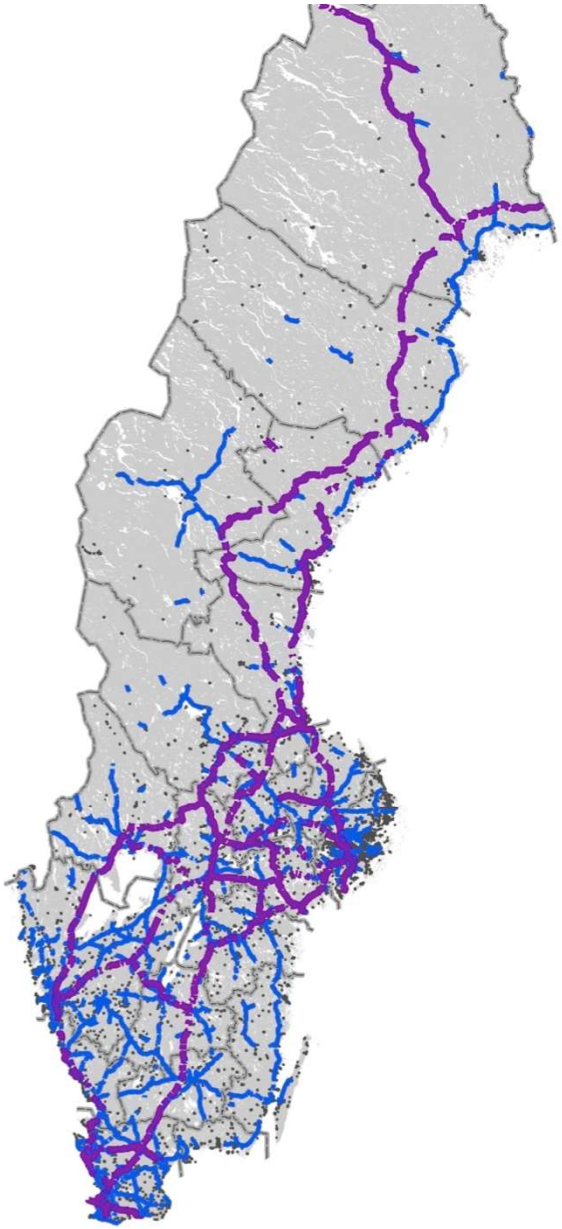
Datum: 2013-07-03
Skala (A3) 1:1.200.000

N

Potential barriers



Remaining barriers
(deficiencies in permeability)



TRAFIKVERKET

Potentiella barriärer

Permeabilitetsbrister

- Railroads > 2km
- Roads > 2km
- Landyta

KATEGORI

- Vattenyta

Landskap

- Vattenyta
- Tätort
- Tätortsbuffer
- Länsgräns

BRISTANALYS FÖR KLÖVVILT 2014

Datum: 2012-07-03
Skala (A3): 1:8,000,000

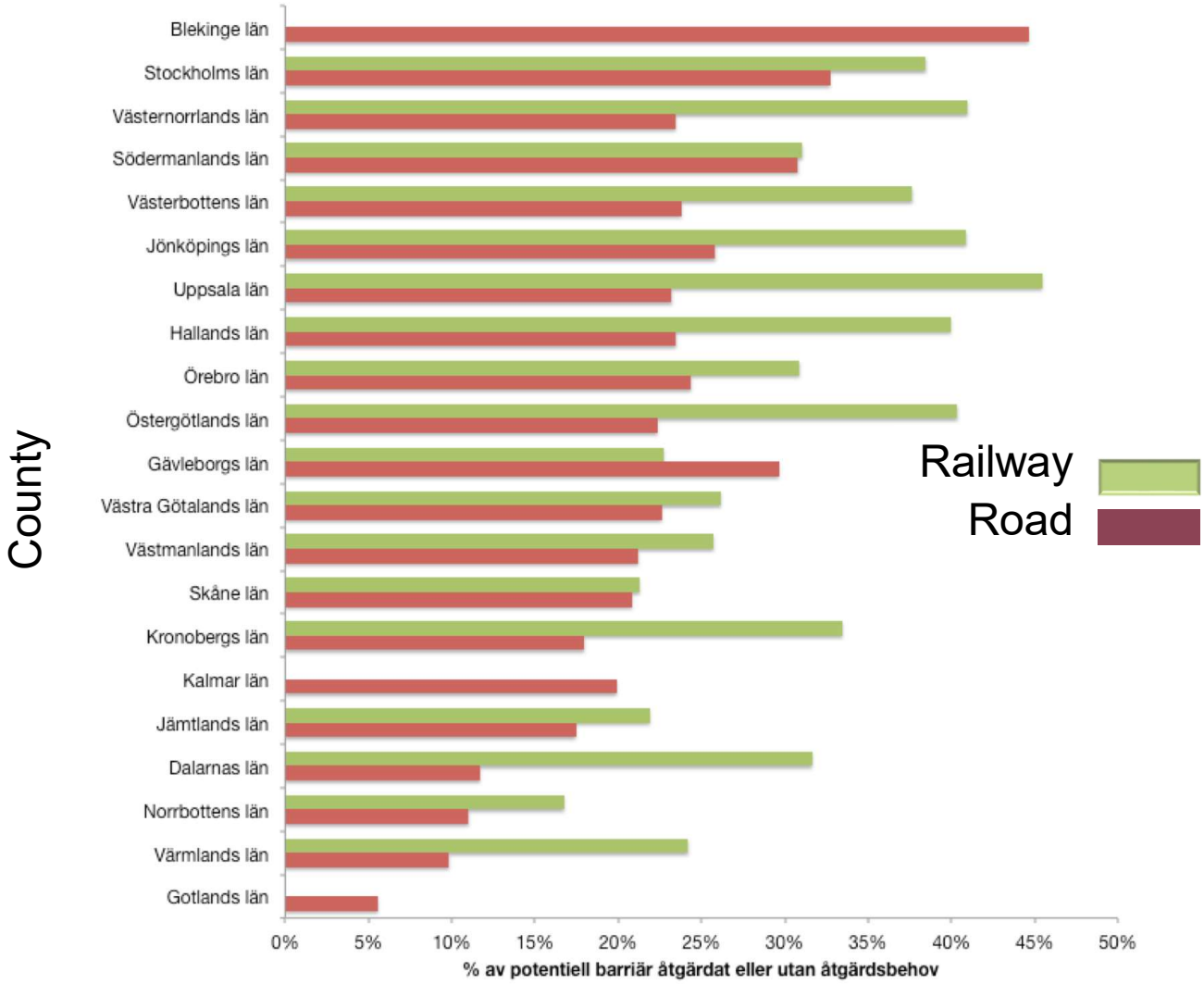
0 35 70 140 km

N

Remaining barriers per road

Roadnr.	Total length of barrier (km)	Length resolved barriers	% resolved barriers	Length remaining barriers	Max length of reminaing barrier section	Count barrier sections	Number of passages needed
4	1 536,2	717,7	46,7%	818,5	65,7	100	139,0
45	526,3	55,3	10,5%	471,0	102,1	28	77,0
22	479,9	138,5	28,9%	341,3	58,3	25	55,5
18	463,8	222,3	47,9%	241,4	47,3	31	41,0
23	261,2	18,2	7,0%	243,0	48,5	12	41,0
26	264,0	17,8	6,8%	246,2	32,0	14	40,5
6	470,6	270,3	57,4%	200,2	16,8	48	39,0
20	360,9	135,5	37,6%	225,3	34,5	27	38,0
14	231,9	15,0	6,5%	216,9	69,1	11	36,5
50	224,0	35,1	15,7%	188,9	46,2	19	32,0
25	186,3	16,4	8,8%	169,9	39,0	11	29,5
70	211,2	29,9	14,1%	181,3	46,9	15	29,0
10	155,1	-	0,0%	155,1	65,6	5	26,5
27	175,3	25,3	14,4%	150,0	40,2	6	25,0
55	153,1	9,9	6,4%	143,3	35,7	12	22,5
56	123,4	10,6	8,6%	112,7	38,2	10	18,5
40	146,2	65,3	44,6%	80,9	27,9	11	14,0
44	102,6	24,8	24,2%	77,8	40,2	7	13,5
13	90,2	6,9	7,6%	83,3	32,7	5	13,0
61	88,7	7,2	8,2%	81,4	42,3	6	12,5
80	81,2	6,4	7,9%	74,8	27,0	6	12,5
21	87,3	15,4	17,6%	71,9	41,6	4	11,5
52	71,5	0,7	0,9%	70,8	24,1	7	11,5
66	81,5	9,5	11,7%	72,0	37,7	5	11,5
12	80,1	21,4	26,8%	58,7	28,5	5	10,5
41	73,3	9,4	12,9%	63,9	18,8	5	10,5
47	61,4	1,2	2,0%	60,2	16,8	6	10,5
11	69,4	8,6	12,4%	60,8	39,2	5	10,0
31	88,2	20,8	23,5%	67,5	24,6	5	10,0

Remaining barriers per county

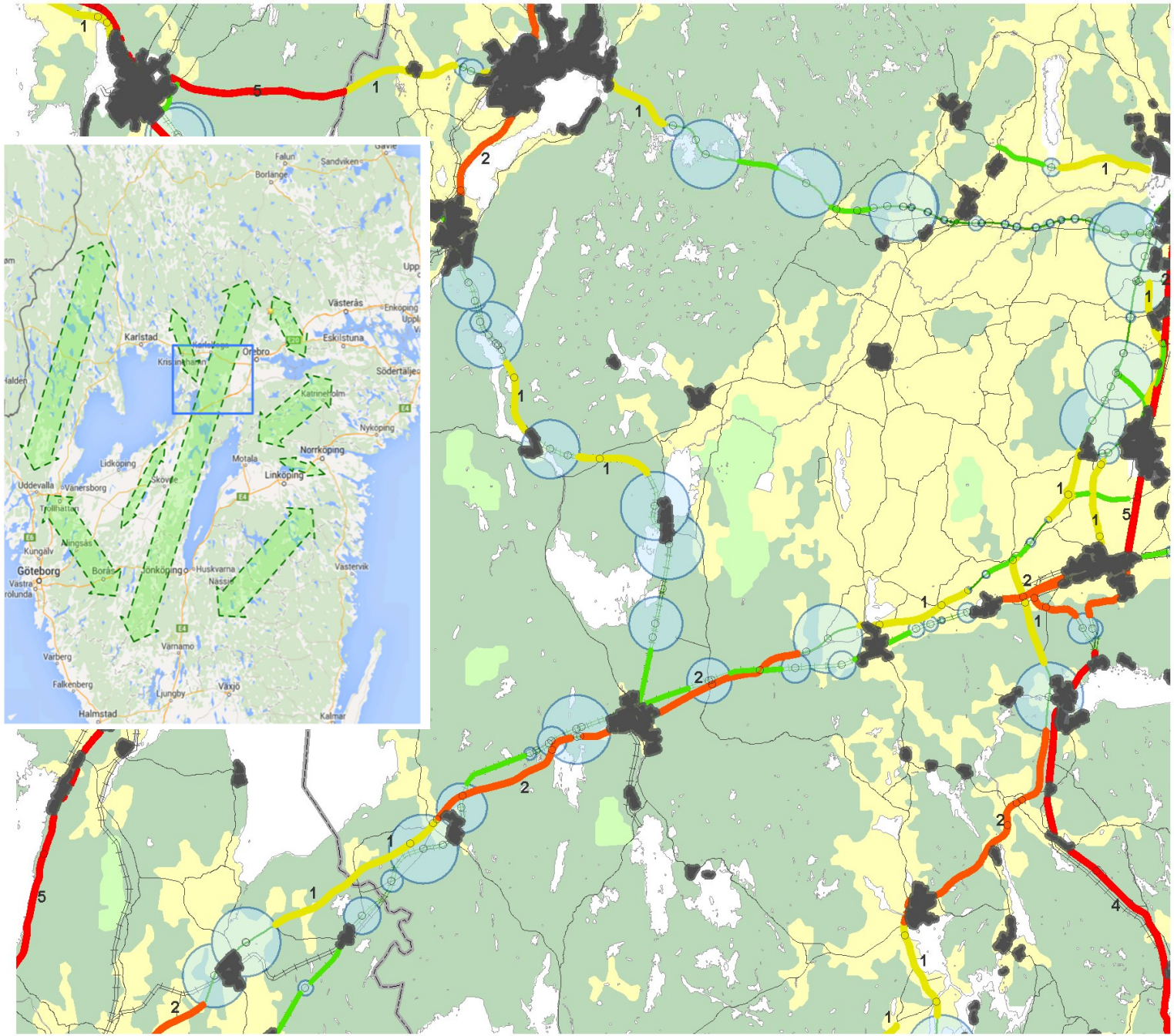


% potential barrier WITHOUT need for mitigation

TRIEKOL

Ranking and prioritization

Ranking critera	Condition, measure, limit values	factor weight	Example road		
			A	*B*	*C*
Length of remaining barrier					
	> 20 km	3			
	9-20 km	2		*2*	
	4-9 km	1	*1*		*1*
	< 4 km	0			
Physical barriers (fences, noise walls, etc)					
	> 80% coverage	3	*3*		
	50-80%	2			*2*
	< 50%	1		*1*	
Trafic volume (ADT)					
	road > 10 000; rail > 100	4	*4*		
	road > 4 000; rail > 60	2		*2*	
	road < 4 000; rail < 60	0			*0*
Speed (km/h)					
	road > 100; rail > 150	3		*3*	
	road 80-100; rail 90-150	2	*2*		
	road < 80; rail < 90	0			*1*
Wildlife-vehicle collisions					
	hotspot (high cost-efficacy)	4	*4*		
	hotspot (low cost-efficacy)	3		*3*	
	no hotspot	1			*1*
Wildlife corridors					
	large-scale strategic corridor	5	*5*		
	locally known corridor	3		*3*	
	outside corridors	0			*0*



TRAFIKVERKET

Remaining barriers

- 0
- < 1
- 1 - 3
- 3 - 6
- 6 - 25

min. number of passages required

- Övriga vägar
- Övriga järnvägar

Pot. passager

- Broobjekt
- Effektområde Älg

MARKTÄCKE

- Kalfjäll
- Öppen mark
- Sankmark
- Skogsmark

Landskap

- Vattenyta
- Tätort
- Tätortsbuffer
- Länsgräns

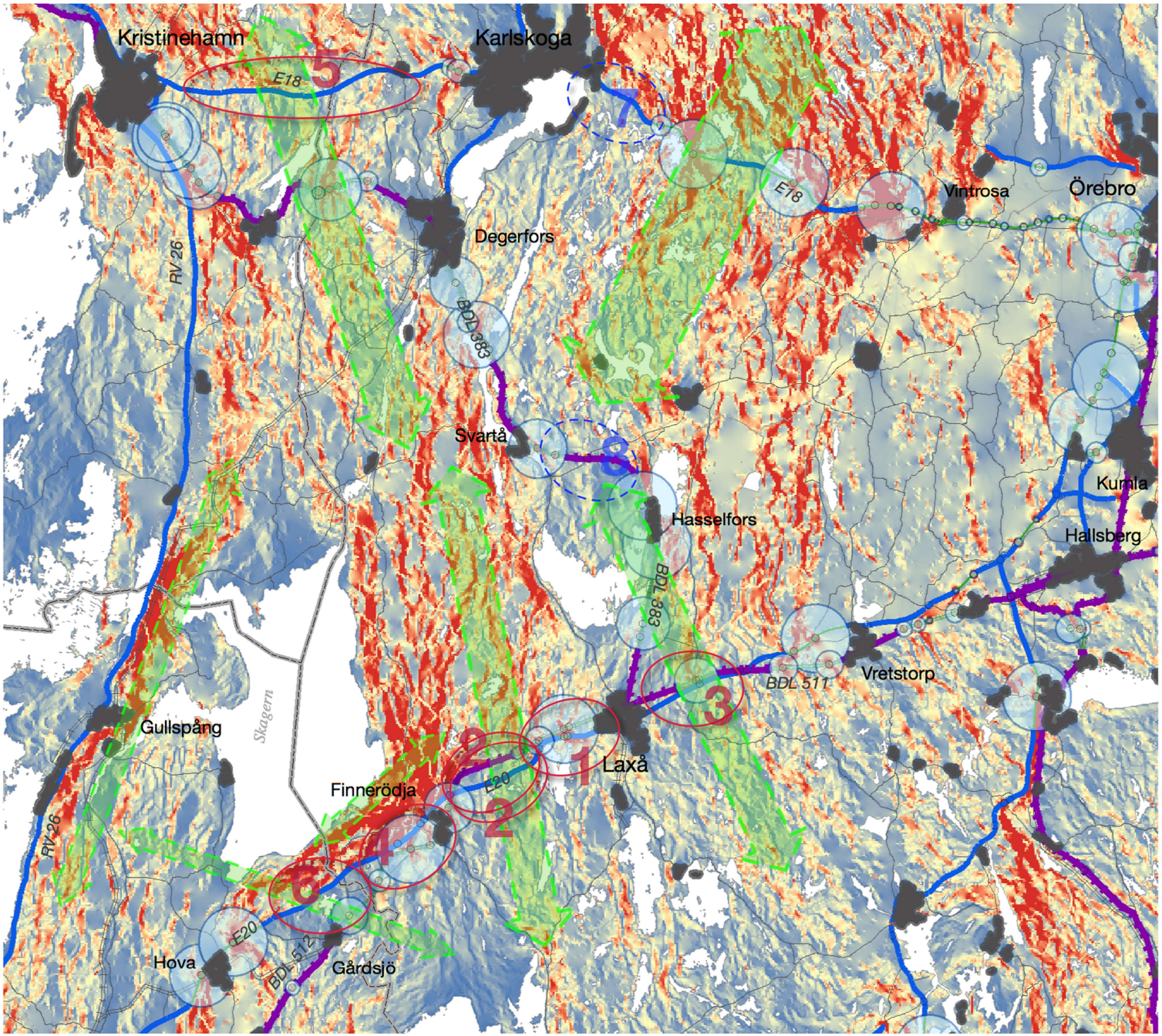
VANDRINGSHINDER OCH BROAR

enligt Bristanalysen Klövvilt 2014

Datum: 2012-07-03
Skala (A3): 1:300,000

0 1,25 2,5 5 km

N



TRAFIKVERKET

Landscape connectivity and prioritization

Need for mitigation

- 2 High
- Intermediate
- Low

Remaining barrier

- Järnväg > 2km
- Väg >2km
- Övriga vägar
- Övriga järnvägar

Pot. passager

- Broobjekt
- Effektområde Älg

Landskap

- Vattenyta
- Tätort
- Tätortsbuffer
- Länsgräns

Konnektivitet

Simulerat flöde

Högt

Lågt

Circuitscape

Storskaliga korridorer

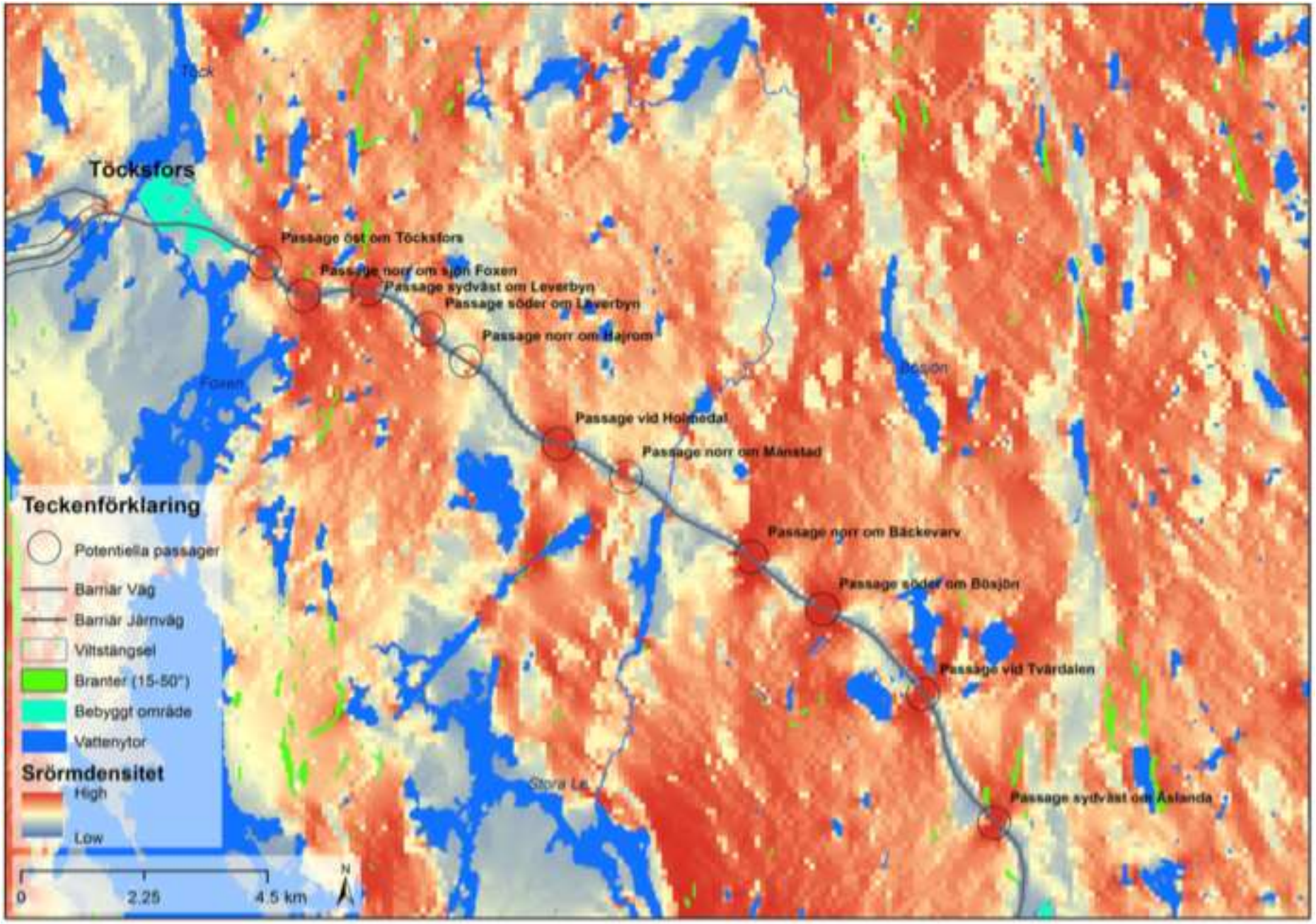
enligt Bristanalysen Klövvilt 2014

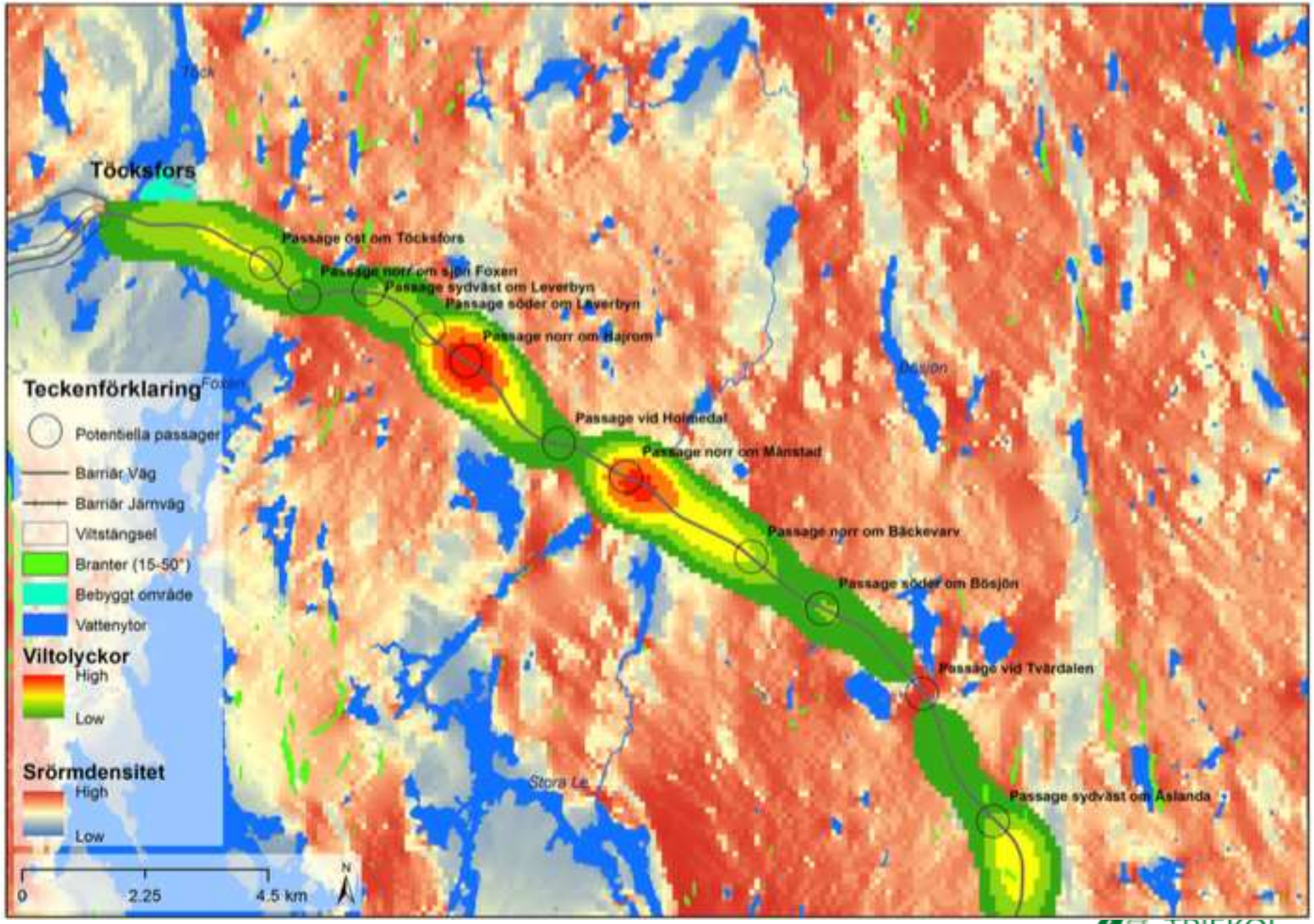
Datum: 2012-07-03
Skala (A3): 1:300,000

0 12,5 25 50 km

© Lantmäteriet, dnr 109-2010/2667

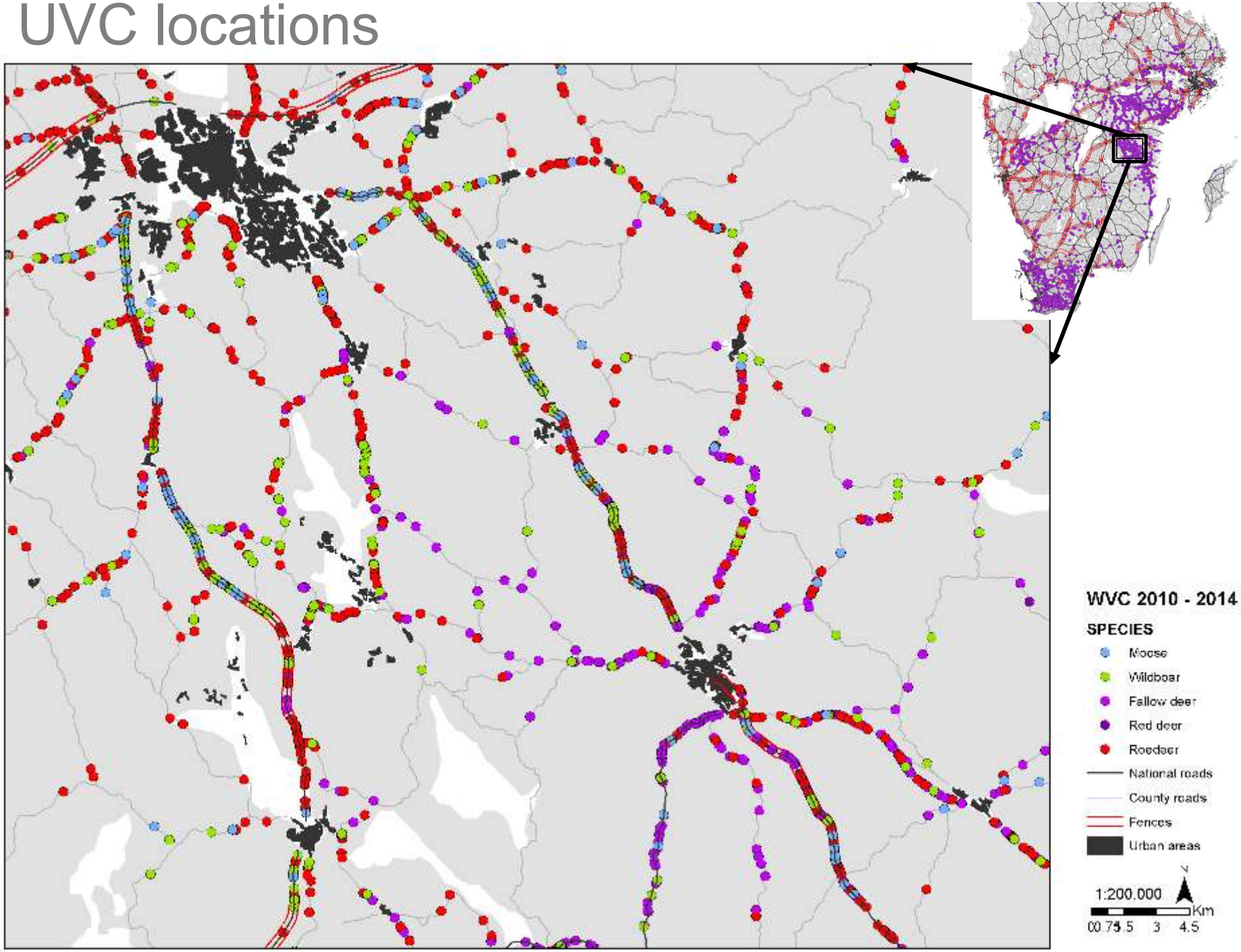
N


Töcksfors
Passage öst om Töcksfors
Passage norr om sjön Foxen
Passage sydväst om Leverbyn
Passage söder om Leverbyn
Passage norr om Bajrom
Foxen
Passage vid Holmedal
Passage norr om Månstad
Passage norr om Bäckevarv
Passage söder om Bösjön
Passage vid Tvärdalen
Passage sydväst om Åslanda
Teckenförklaring
Potentiella passager
Barriär Väg
Barriär Järnväg
Viltstängsel
Branter (15-50°)
Bebyggt område
Vattenytor
Strömdensitet
High
Low
0
2.25
4.5 km
N

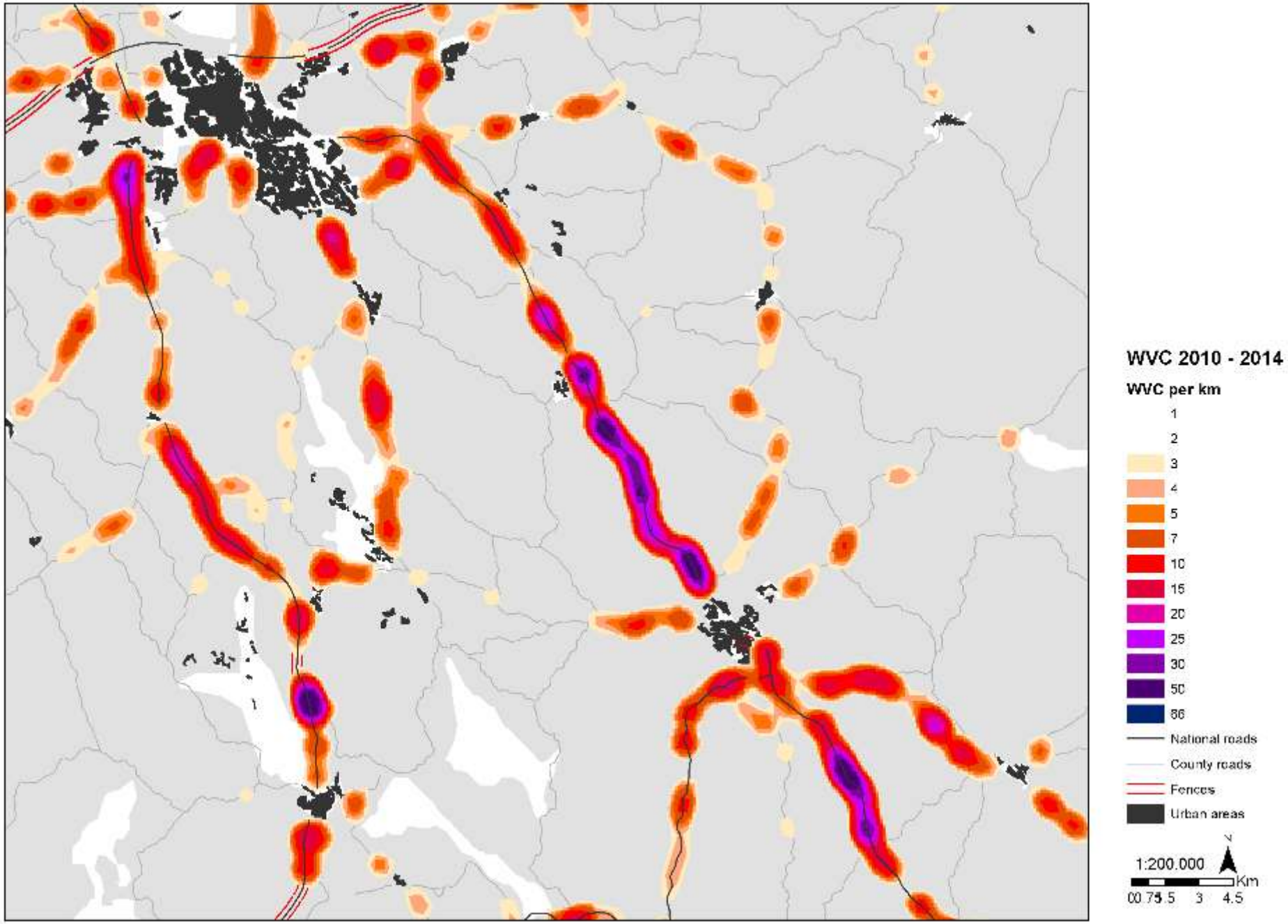

Töcksfors
Passage öst om Töcksfors
Passage norr om sjön Foxen
Passage sydväst om Leverbyn
Passage söder om Leverbyn
Passage norr om Bäprom
Passage vid Holmedal
Passage norr om Månstad
Passage norr om Bäckevarv
Passage söder om Bösjön
Passage vid Tvärdalen
Passage sydväst om Åslanda
Stora Le
Teckenförklaring
Potentiella passager
Barriär Väg
Barriär Järnväg
Viltstängsel
Branter (15-50°)
Bebyggt område
Vattenytor
Viltolyckor
High
Low
Srörmdensitet
High
Low
0
2.25
4.5 km
N

TRIEKOL

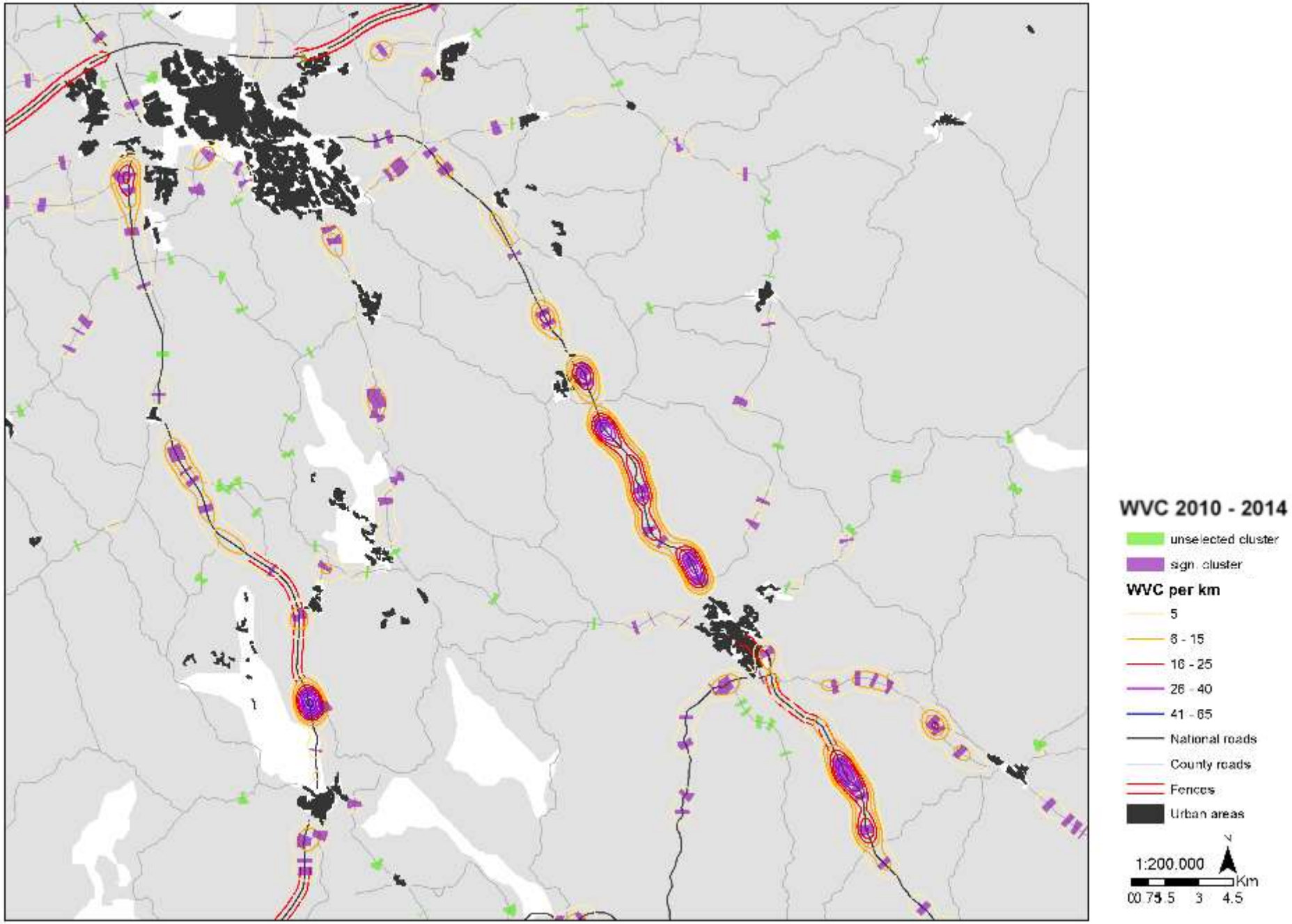
UVC locations



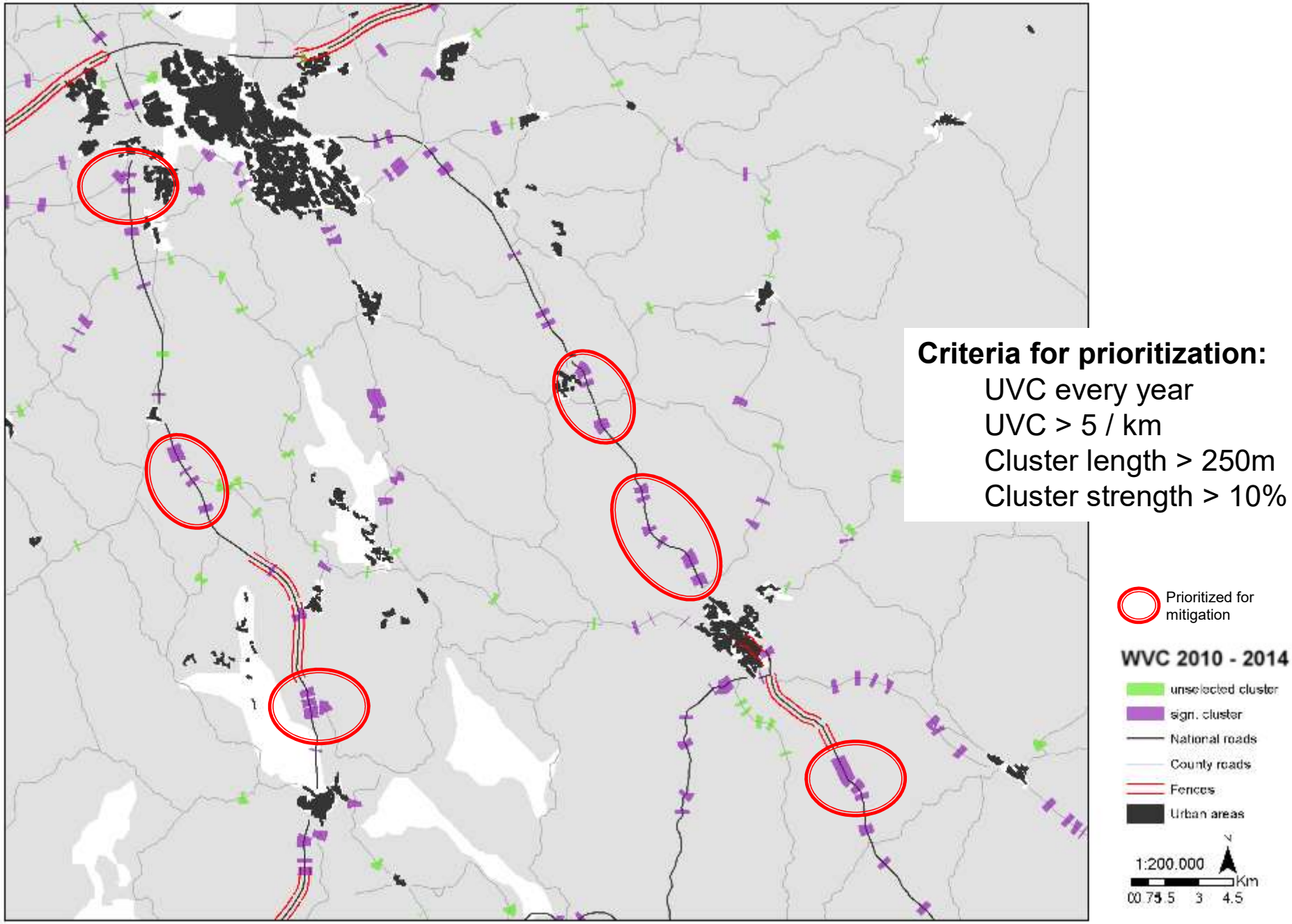
UVC densities



significant UVC clusters (KDE+)



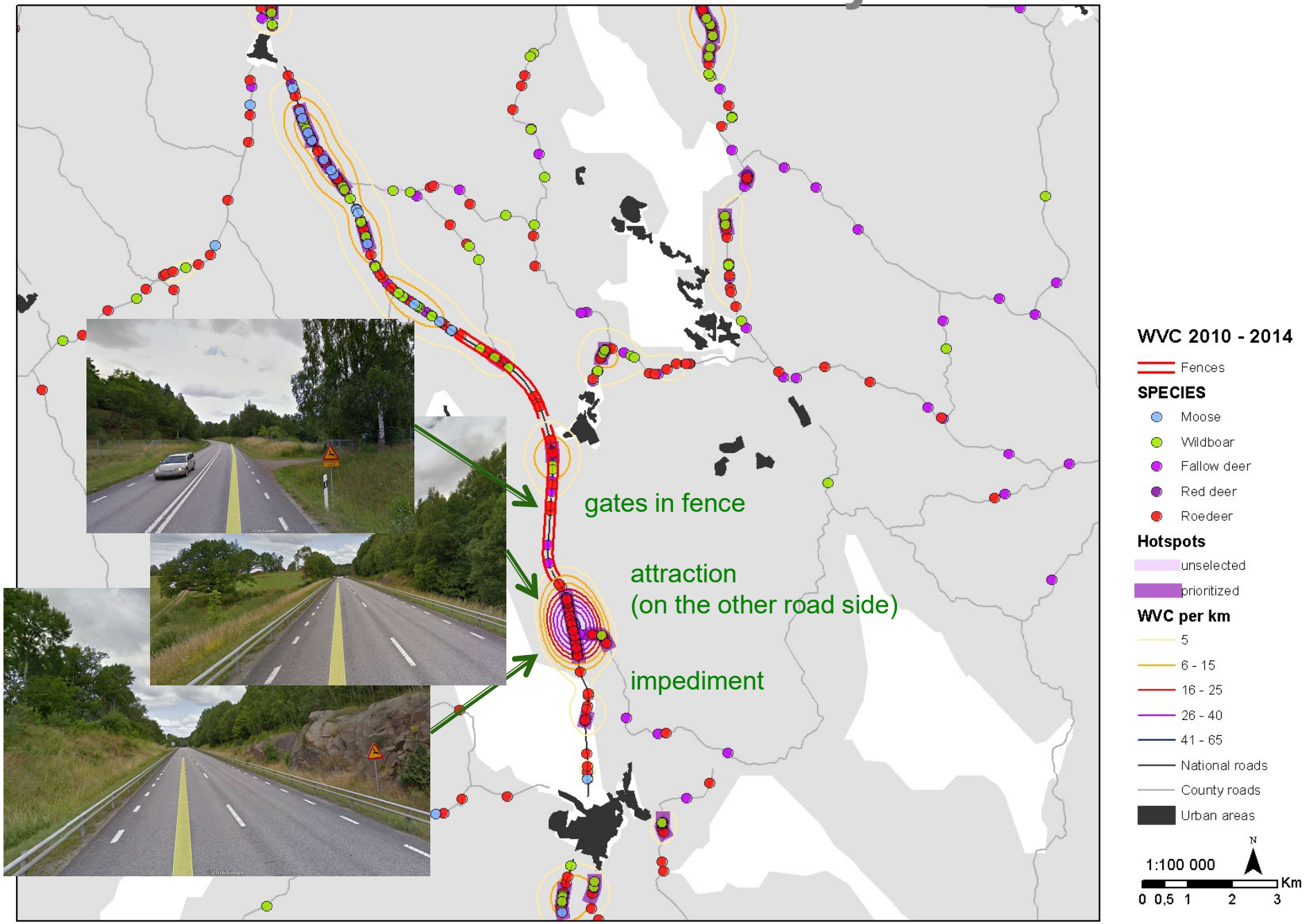
KDE+ prioritized clusters



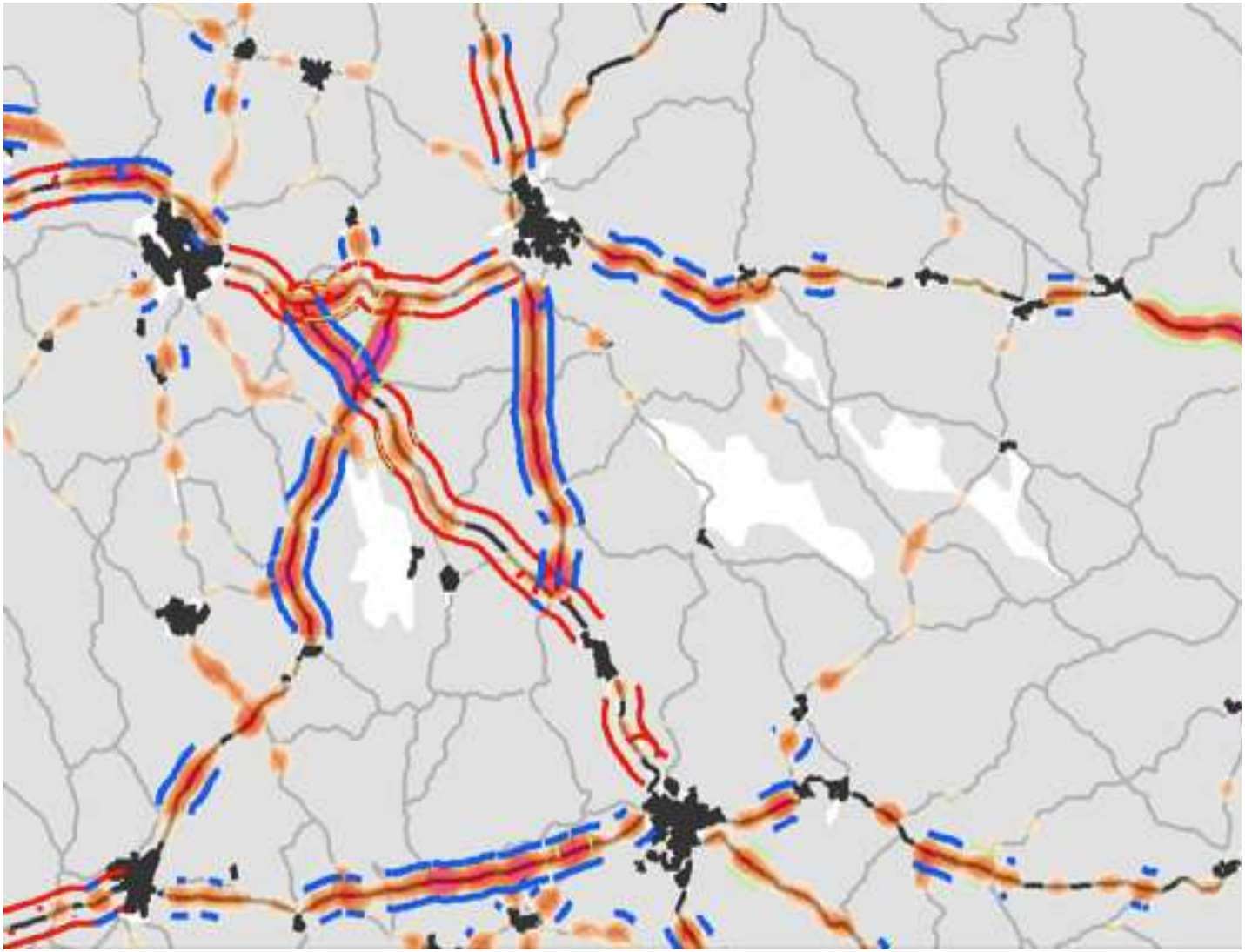
Criteria for prioritization:

UVC every year
UVC > 5 / km
Cluster length > 250m
Cluster strength > 10%

detailed StreetView analysis



Cost-benefit of fencing



UVC 2010 - 2014

Benefit KDE

- very high
- high
- existing fences

UVC per km and year

- 1
- 2
- 3
- 4
- 5
- 7
- 10
- 15
- 20
- 25
- 30
- 50
- 66
- National roads
- County roads
- Urban areas

N

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

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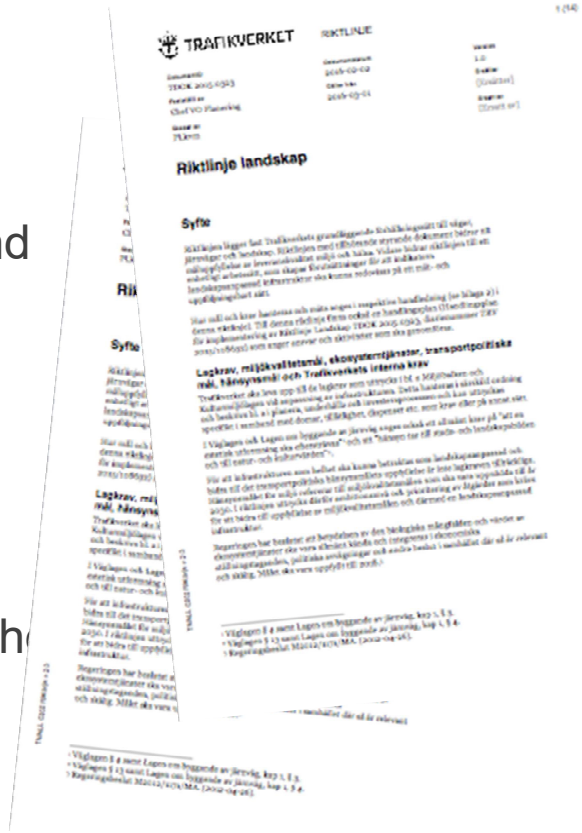
National guideline for landscape

- 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 accomplish along existing and new infrastructure
  - …
  - …


TRAFIKVERKET RIKTLINJE

Riktlinje landskap

Syfte

Lagkrav, miljökvalitetsmål, ekosystemtjänster, transportpolitiska mål, hänsynsmål och Trafikverkets interna krav

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TRAFIKVERKET 2015. Landscape guideline (In Swedish: Riktlinje landskap) *Swedish Transport Administration (Trafikverket),* TDOK 2015-0323.

Thanks!

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