

A large herd of Norwegian wild reindeer is captured in motion, running through a snowy, hazy landscape. The reindeer are in various stages of running, with some in the foreground and others receding into the distance. The background is a dense, misty forest, creating a sense of a busy, natural environment. The reindeer have varying antler sizes and fur colors, ranging from light brown to dark brown.

## Norwegian wild reindeer: understanding impacts in a busy landscape

Olav Strand, Manuella Panzacchi, Bram Van Moorter, Roy Andersen, Vegard Gundersen, Anders Mossing, Lena Rømtveit;

Norwegian wild reindeer center / Norwegian institute for nature research

## Wild reindeer in Norway – mountain living herds



- 23 different management units in southern Norway
- Prior to development app 3 major distribution areas
- Harvested for the last 9- 10 000 years
- Few animals left at the beginning of the 1900's- hunting banned in two periods

At present, 25- 30 000 animals on a total range of app. 35 000 km<sup>2</sup>

### Development in the 1900's

Roads

Railroad

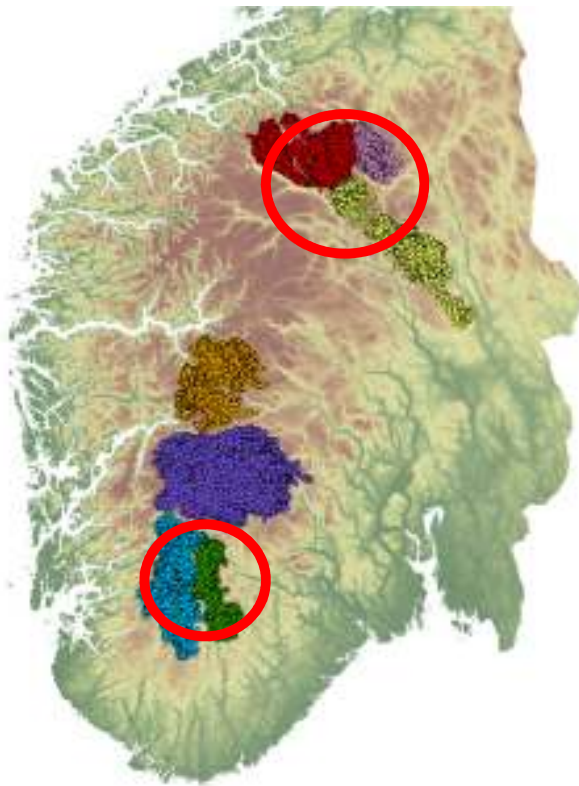
Hydroelectric power (and more roads in remote areas)

Rural – more urban populations

Summer farms – cabins – secondary homes

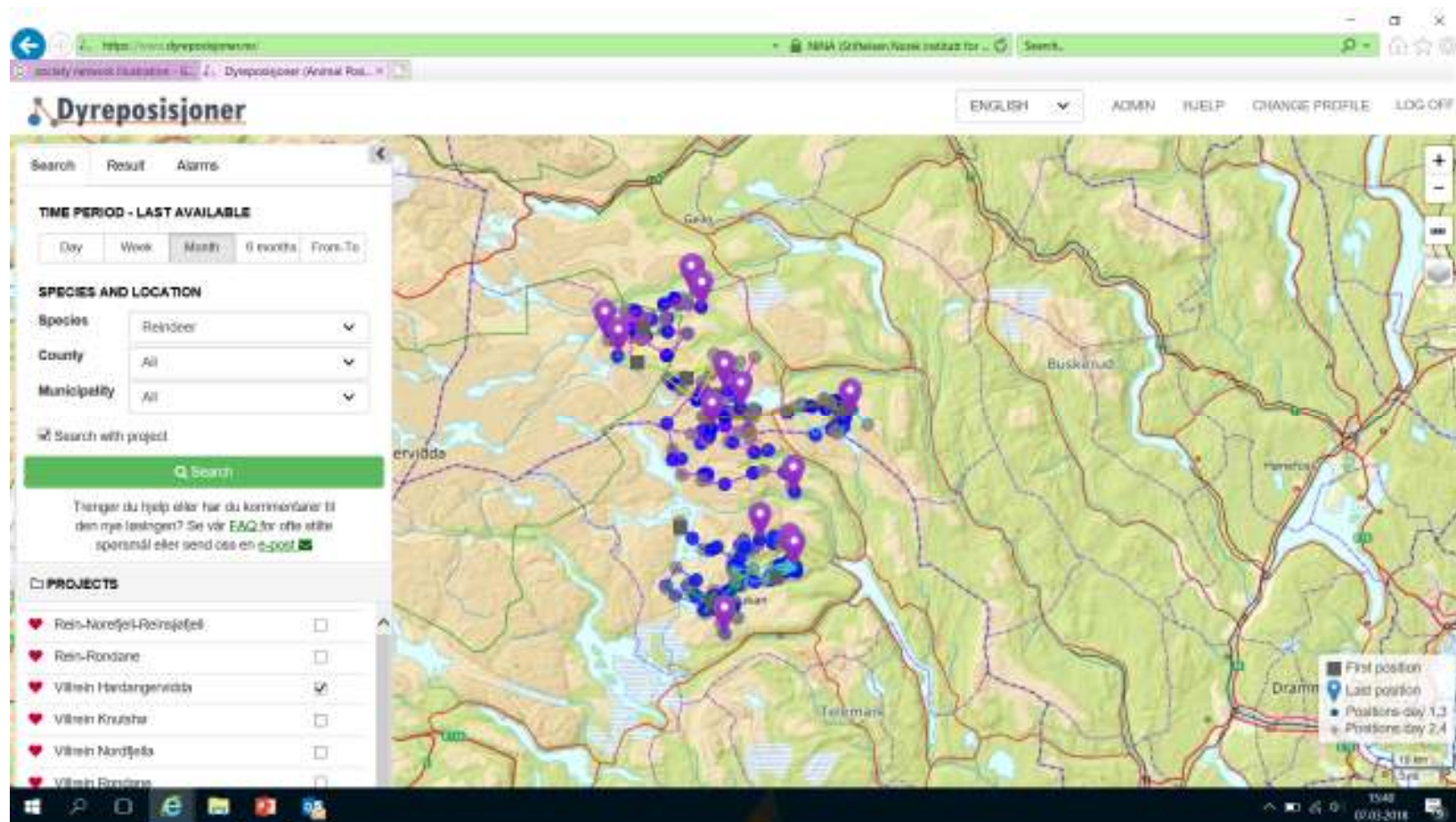
Subsistence – recreational use (selfie time)

## Studies of reindeer responses to disturbance and infrastructure



- 1995- 2000: series of papers using monitoring data- «density» of reindeer and wear of lichen pastures vs distance to infrastructure
- 2001: Starting to collar reindeer with GPS-collars in Hardangervidda (still running)
- 2007-2008: expanding the studies to 8 new populations
- App 400+ reindeer collared since 2001 (app 800 animal years) – GPS –fix every 3 hours.
- Each project (management areas) has had a steering board with all major stakeholders represented
  - Developed project plans
  - Economy
  - Identification of areas with conflicts between reindeer / people-development (**focal areas**)
  - Lately also worked with possible mitigation / sett off measures

# Distribution of data: open online database Dyreposisjoner.no





## Focusing on landscapes means upscaling

Upscaling from population and harvest management to landscape conservation

Less knowledge, we need better understanding of anthropogenic effects

Challenges since we are dealing with large areas, huge datasets, more complicated models etc

More stakeholders

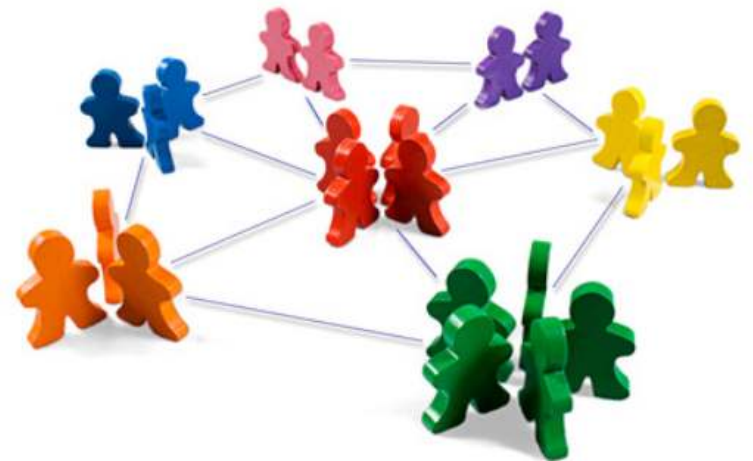
Divers stakeholders

Different cultures and knowledge platforms

Moving from a small happy green family to the Norwegian society

Different responsibilities

Laws and regulations



## Research directions

Local  
studies/  
disturbance  
levels

Pre- post  
development  
by using  
pitfalls and  
GPS data

Habitat  
selection  
models -  
optimal  
niche

Quantifying  
barriers to  
movement

Effects at the  
population  
level



## Research directions: local studies

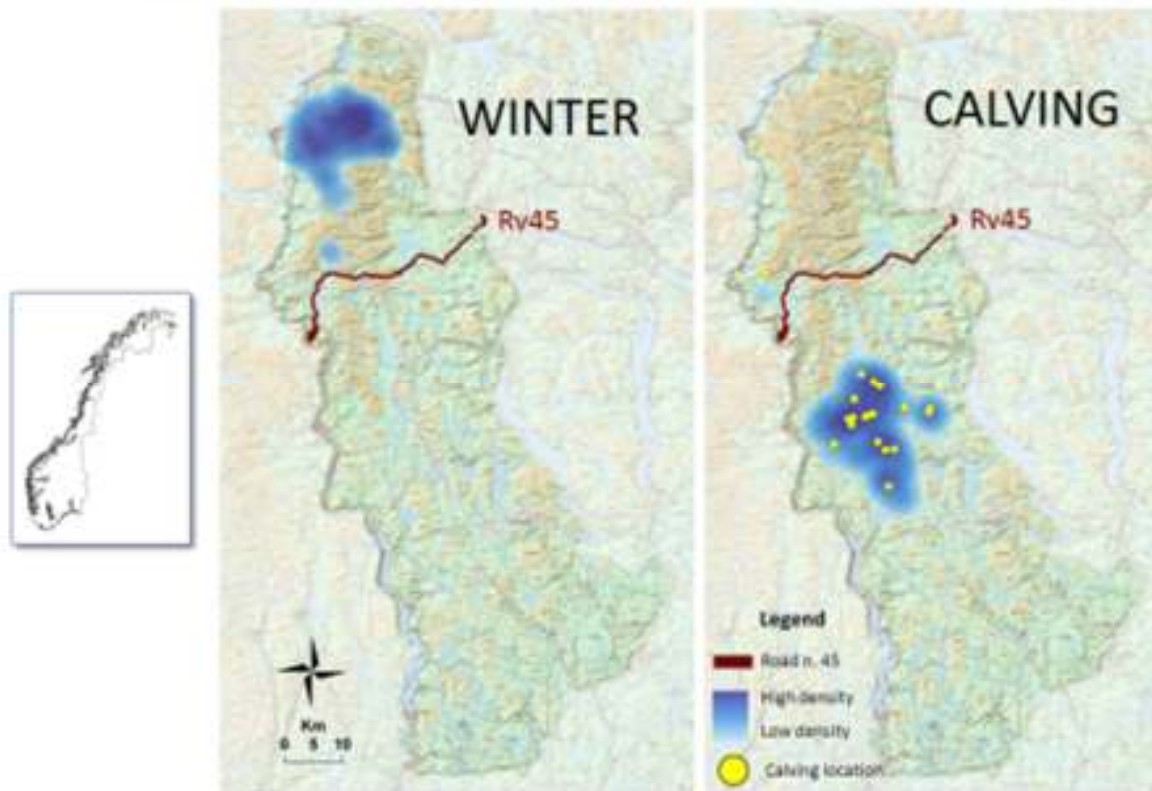
**Rangifer**, 33, Special Issue No. 21, 2013: 15–26

A road in the middle of one of the last wild reindeer migration routes in Norway: crossing behaviour and threats to conservation

*Tilnærming 3:*

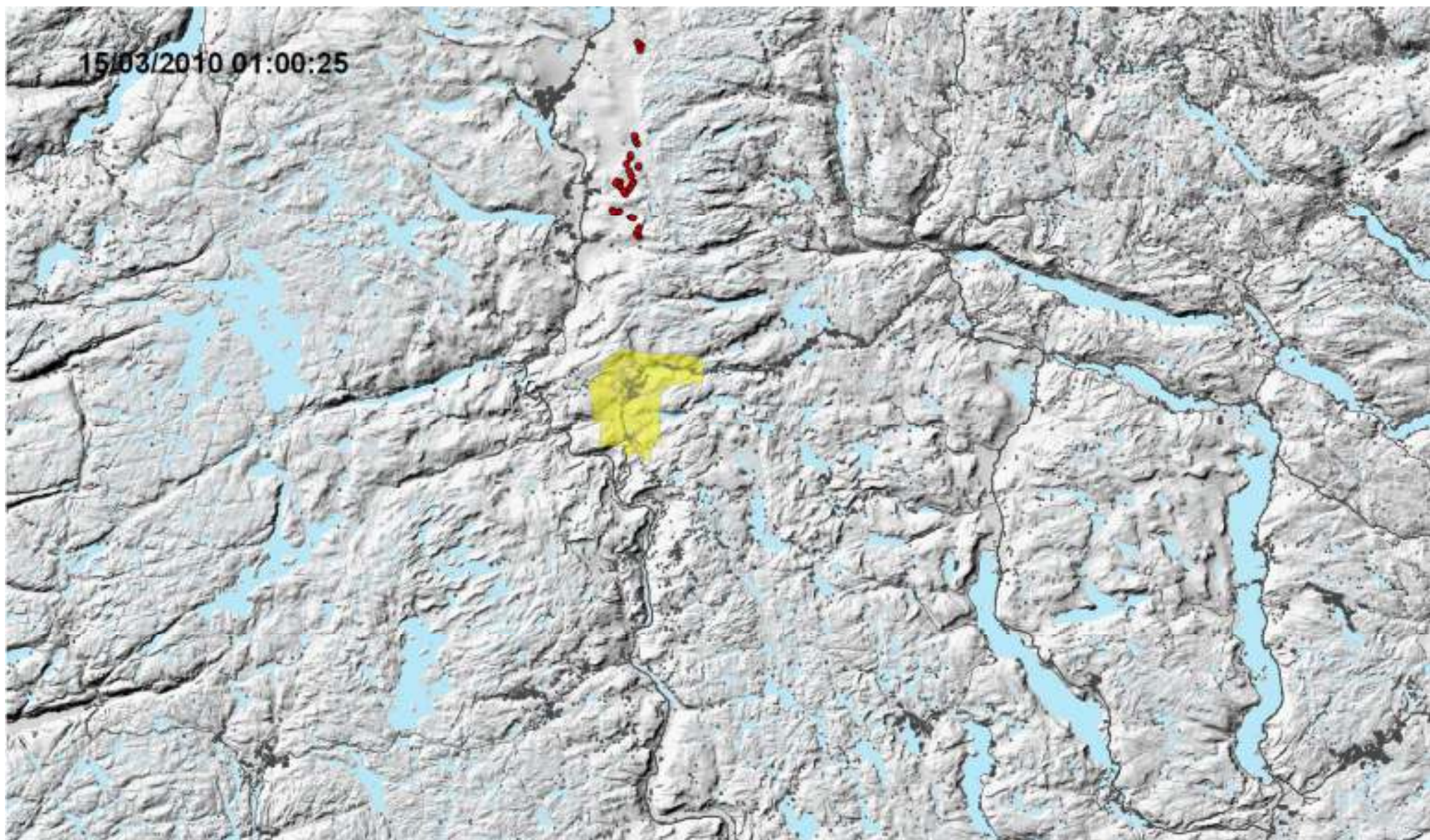
Case study: Setesdal Austhei

Manuela Panzacchi<sup>1</sup>, Bram Van Moorter<sup>1</sup> & Olav Strand<sup>1</sup>

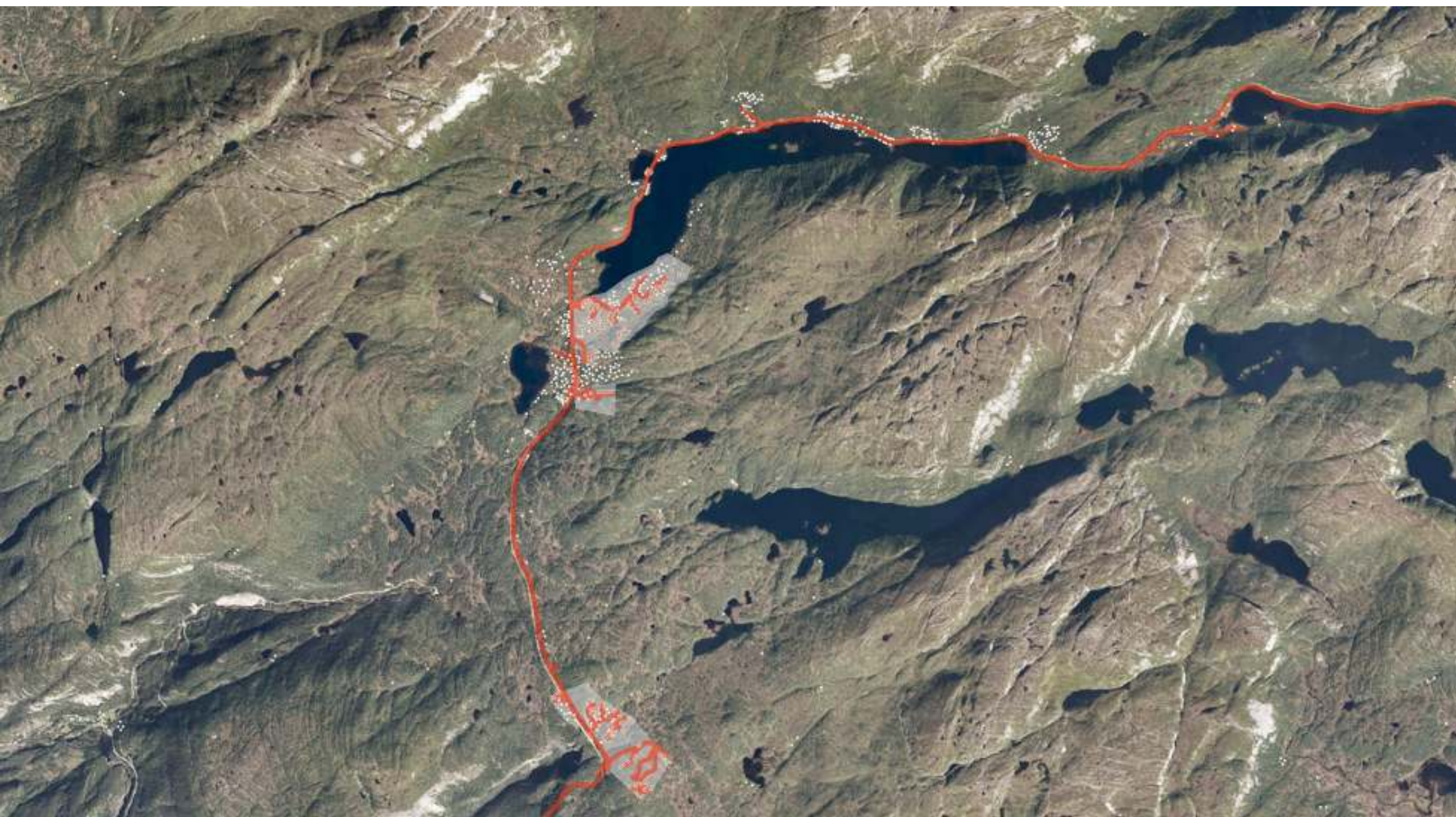




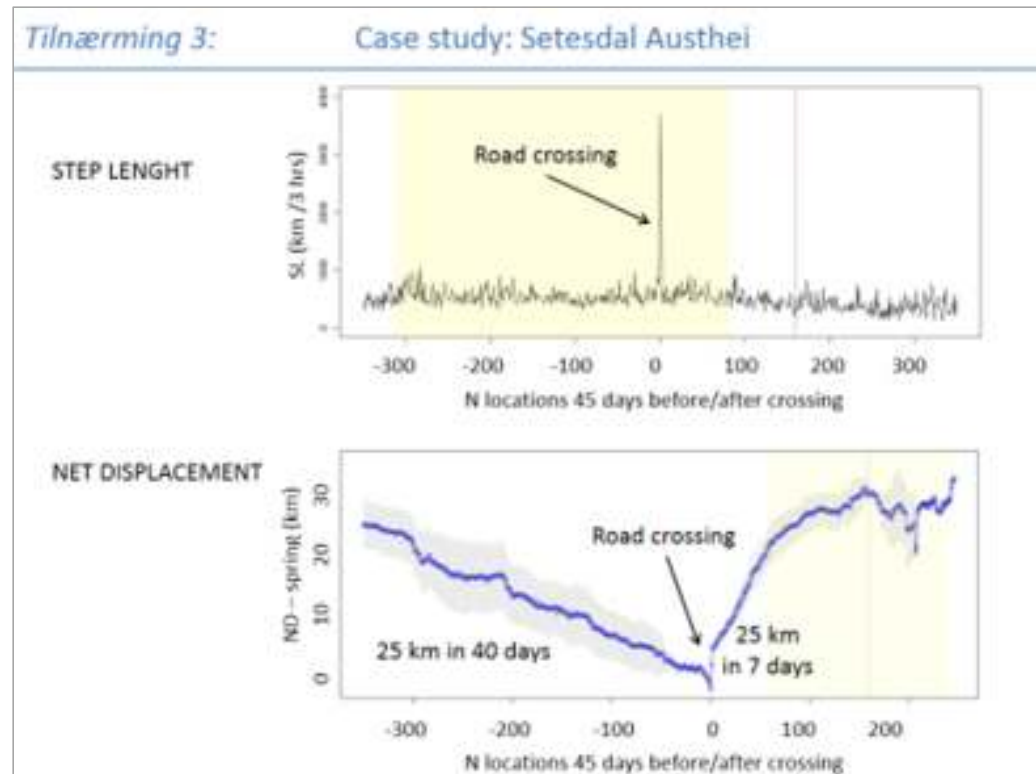
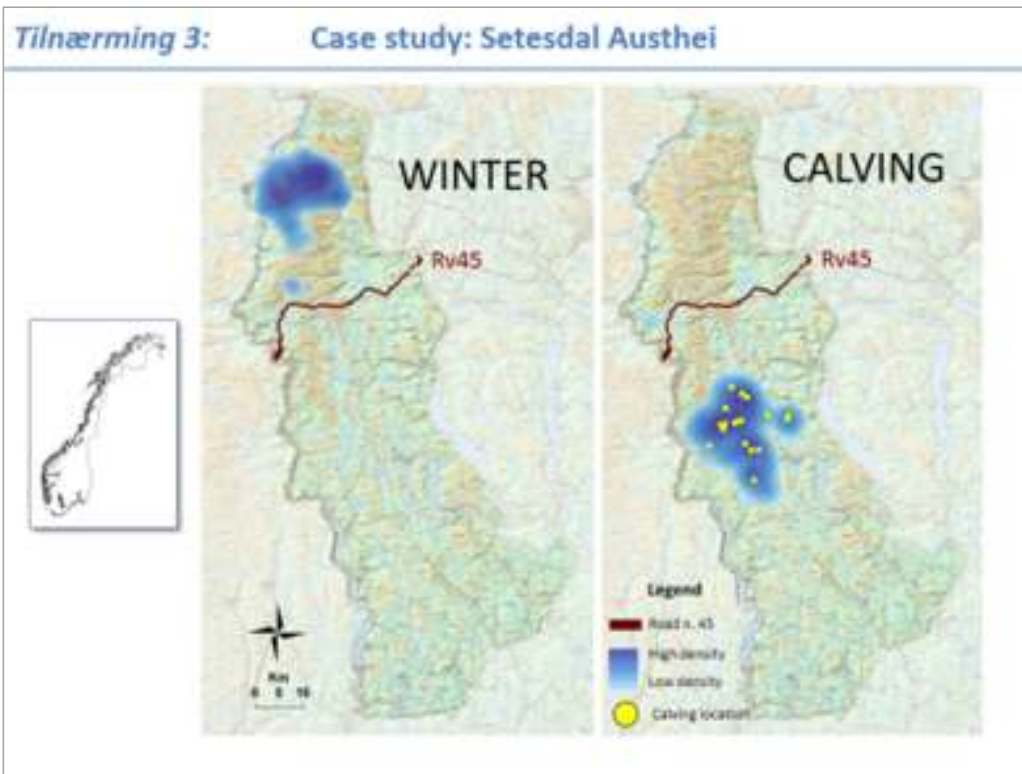
15/03/2010 01:00:25





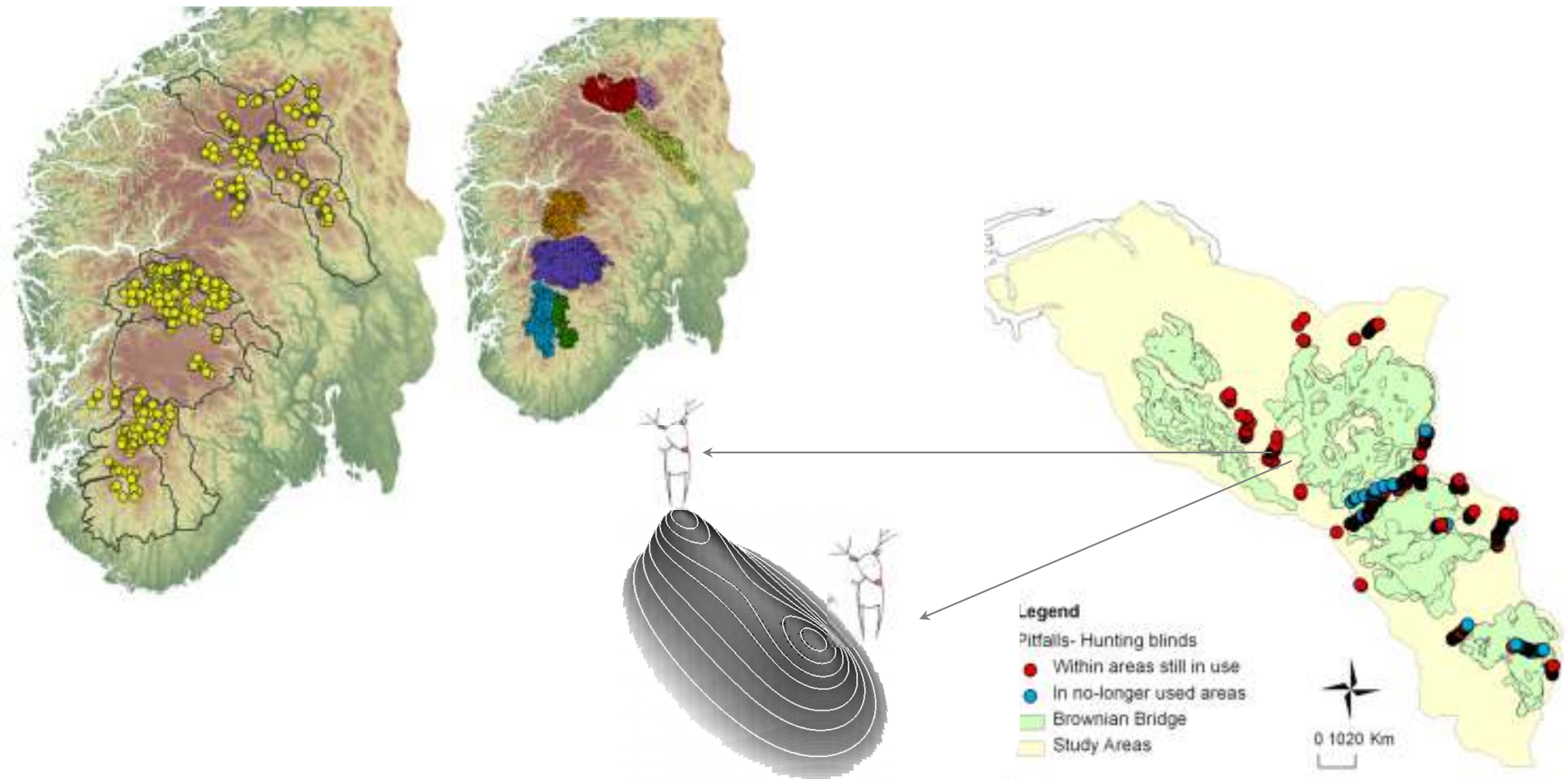


## Research directions



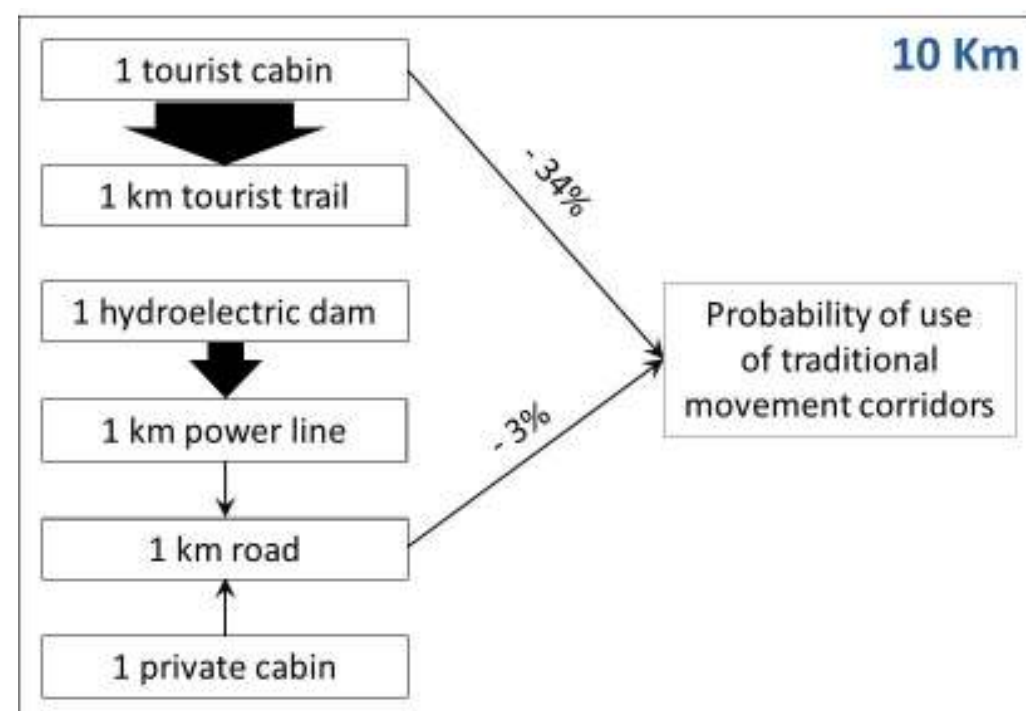
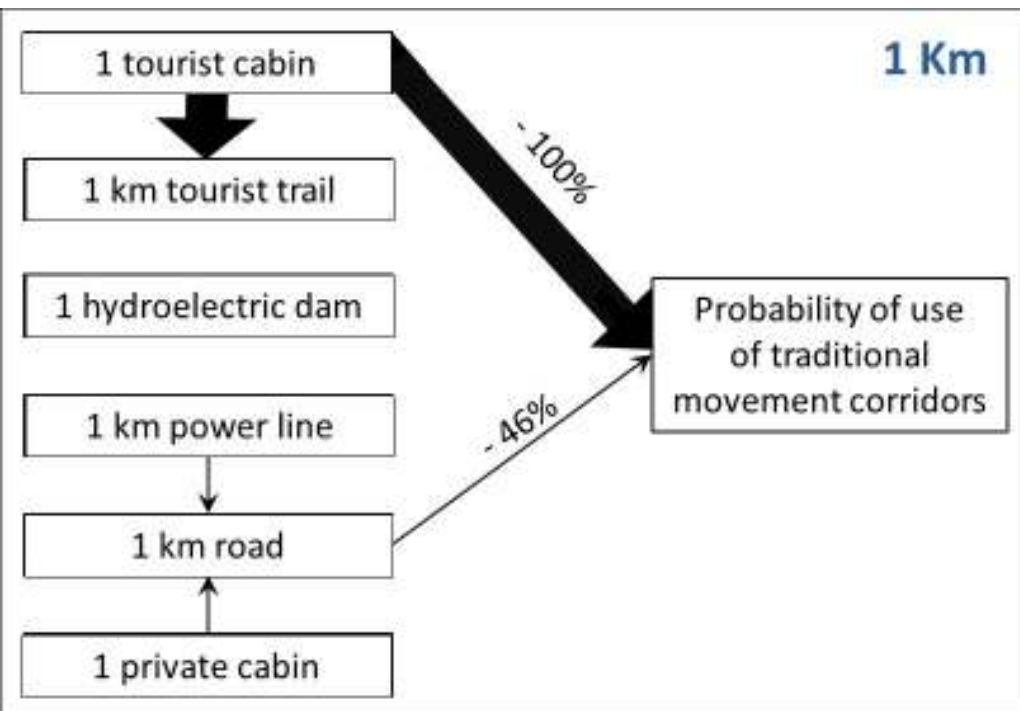


## Research directions: Pre- post development and historic data

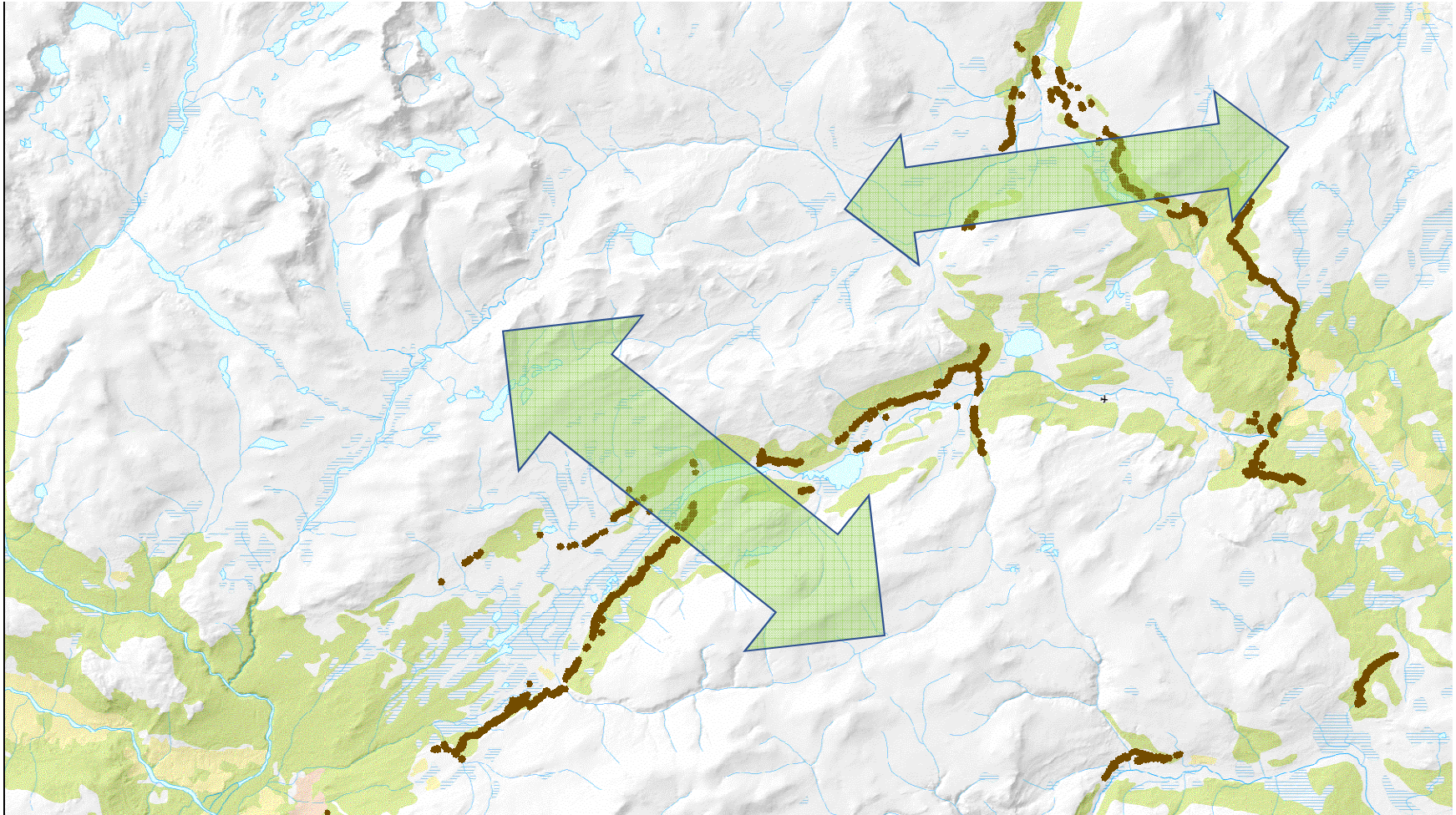




## Research directions

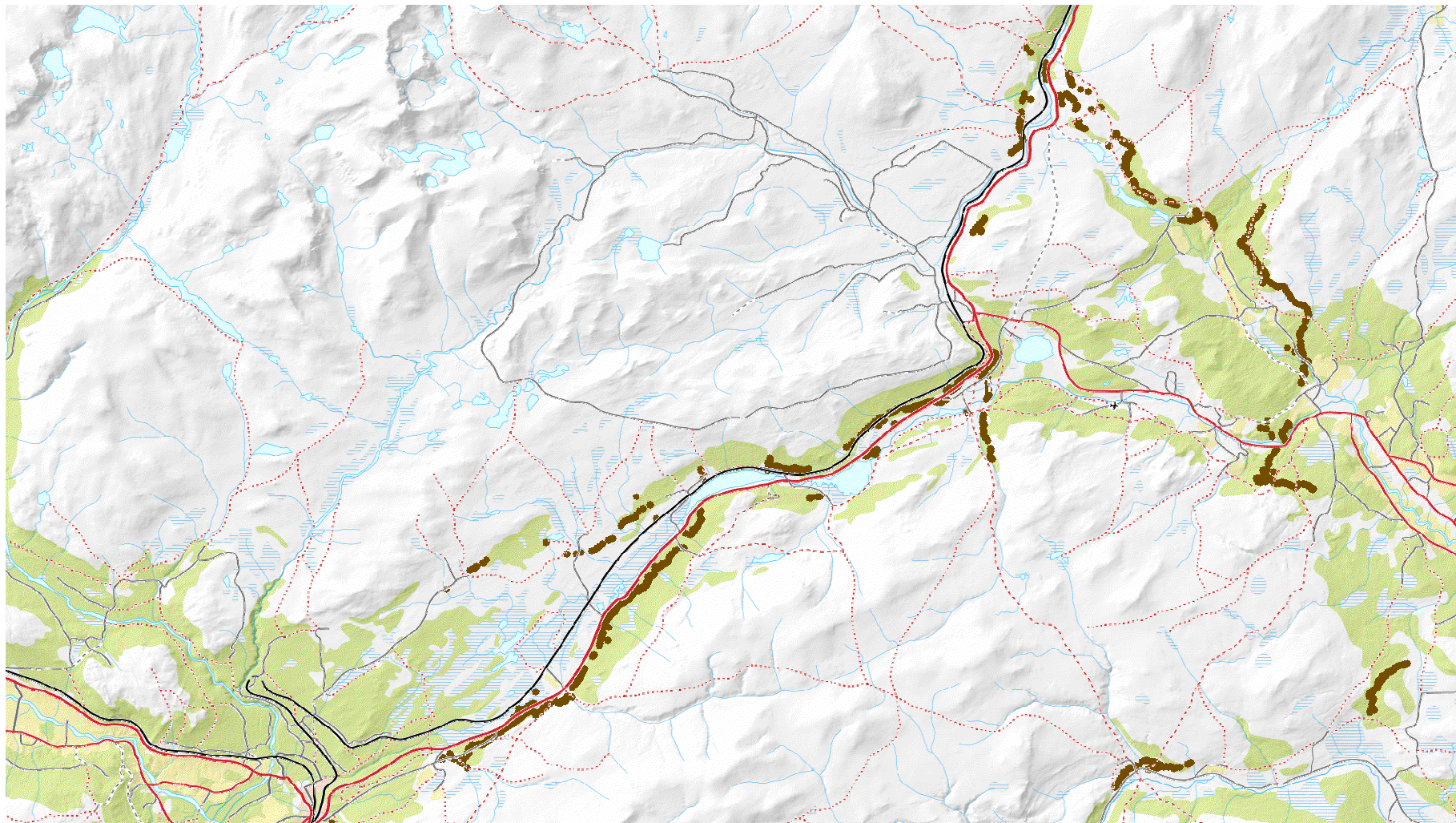


**A closer look – Dovrefjell; before development; app. year 800- 1250 – more than 2000 pitfalls. A reindeer industry directed at large scale seasonal movements**



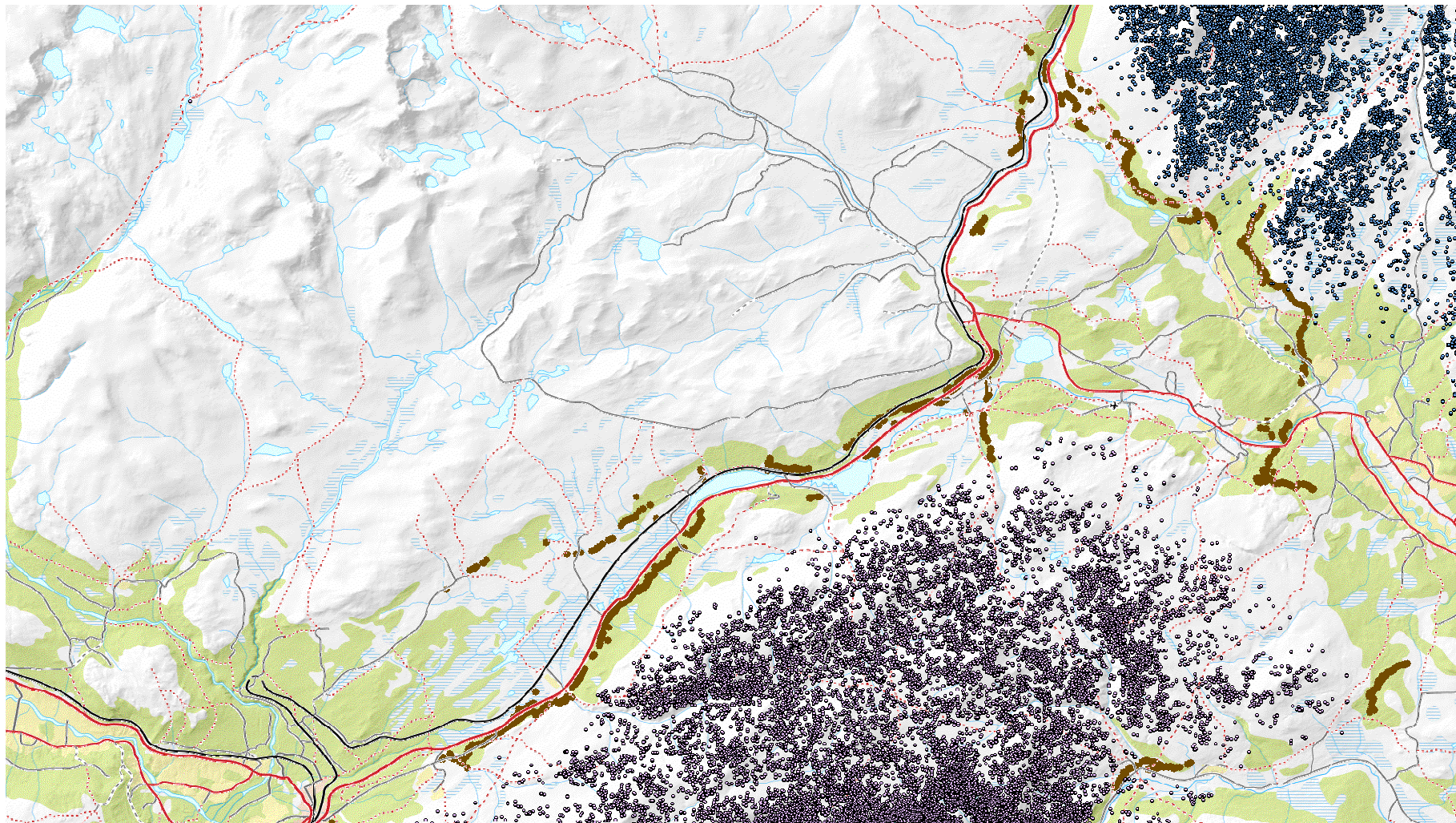


## A closer look – Dovrefjell; with present day infrastructure



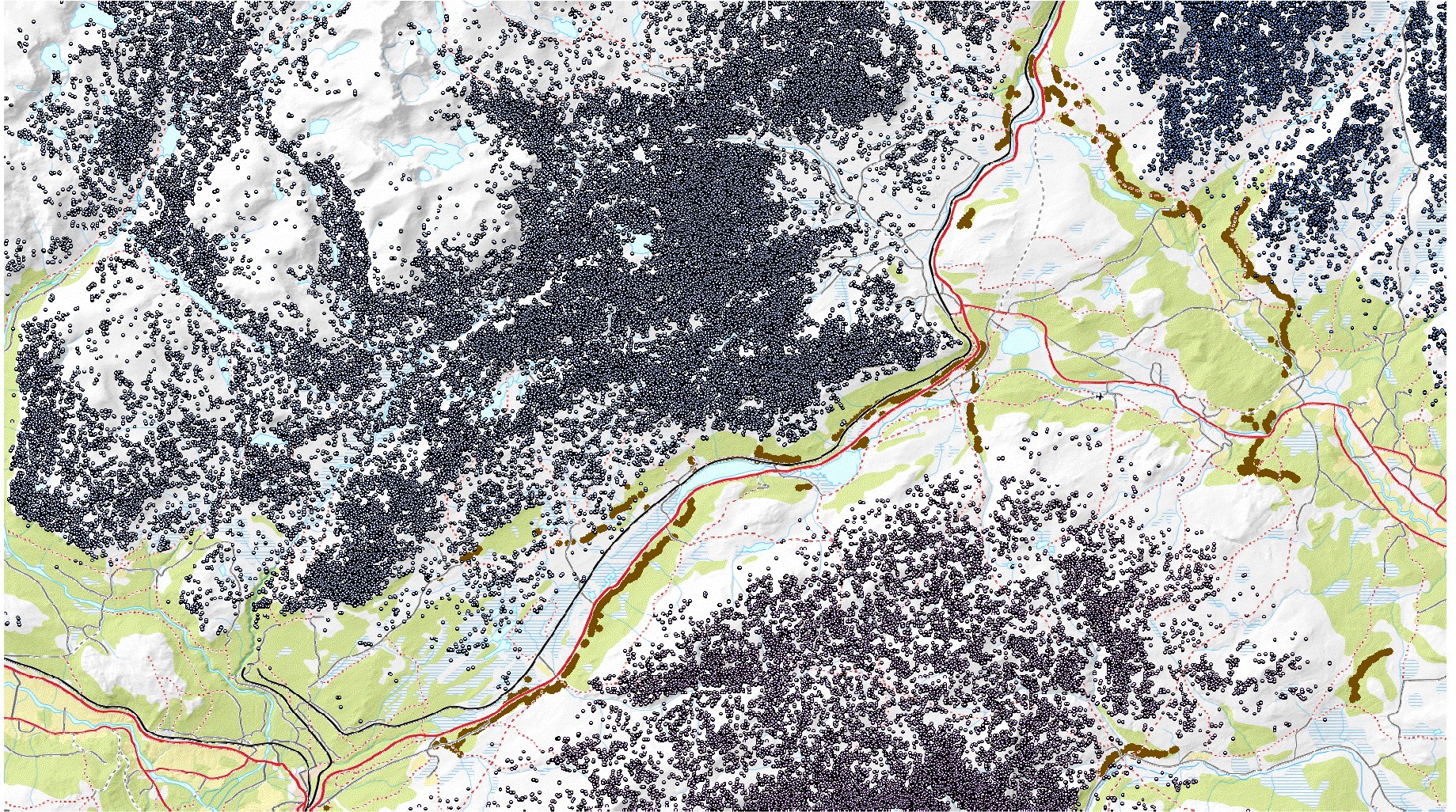


## A closer look – Dovrefjell; GPS data from Rondane and Knutshø



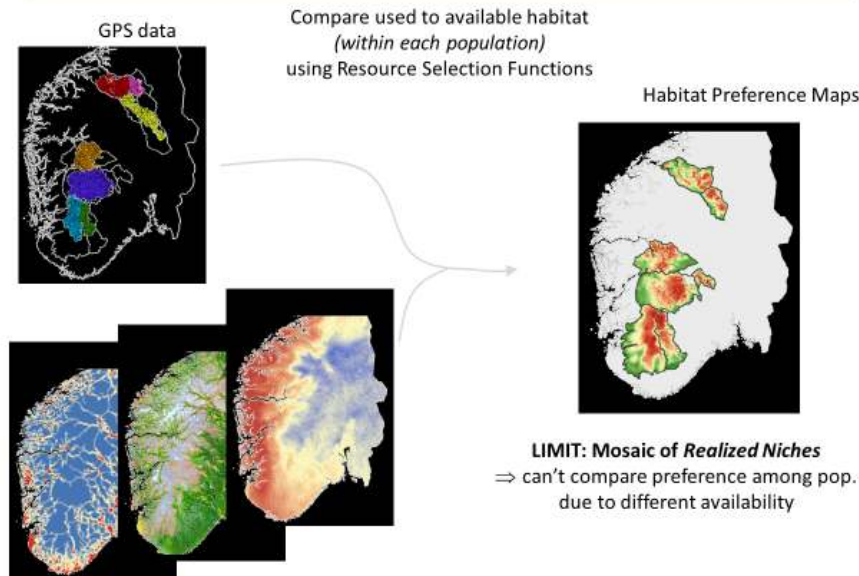


## A closer look – Dovrefjell; all GPS data



# Research directions: habitat quality

## TRADITIONAL HABITAT PREFERENCE MODELLING APPROACH



Research

Searching for the fundamental niche using individual-based habitat selection modelling across populations

Manuela Panzacchi<sup>1,†</sup>, Bram Van Moorter<sup>1,†</sup>,  
Olav Strand<sup>1</sup>, Leif Egil Loe<sup>2</sup> and Egil  
Reimers<sup>3</sup>

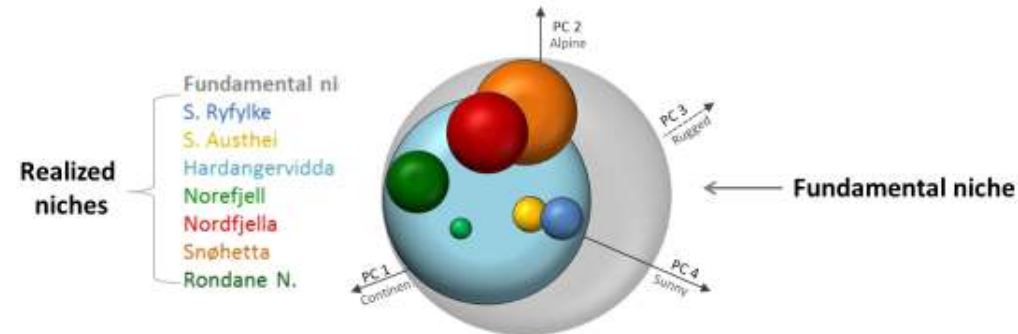
Issue

ECOGRAPHY

Ecography

Volume 38, Issue 7, pages

## HAB MODELLING ACROSS POP: SEARCHING FOR THE FUNDAMENTAL NICHE



- CLR with log-link function. Used points conditioned to available points within available area
- Relevant variables modeled using a Gaussian curve to estimate **NICHE OPTIMUM** (curve mean) and **NICE BREADTH** (variance)

$$\frac{\text{Use}}{\text{Available}} \sim \alpha + \beta_0 \left[ \text{Human disturbance, (different scales)} \right] + \beta_1 \left[ \text{Environmental variable}_1 \right] + \beta_2 \left[ \text{Environmental variable}_2 \right]^2 + \dots + \epsilon$$

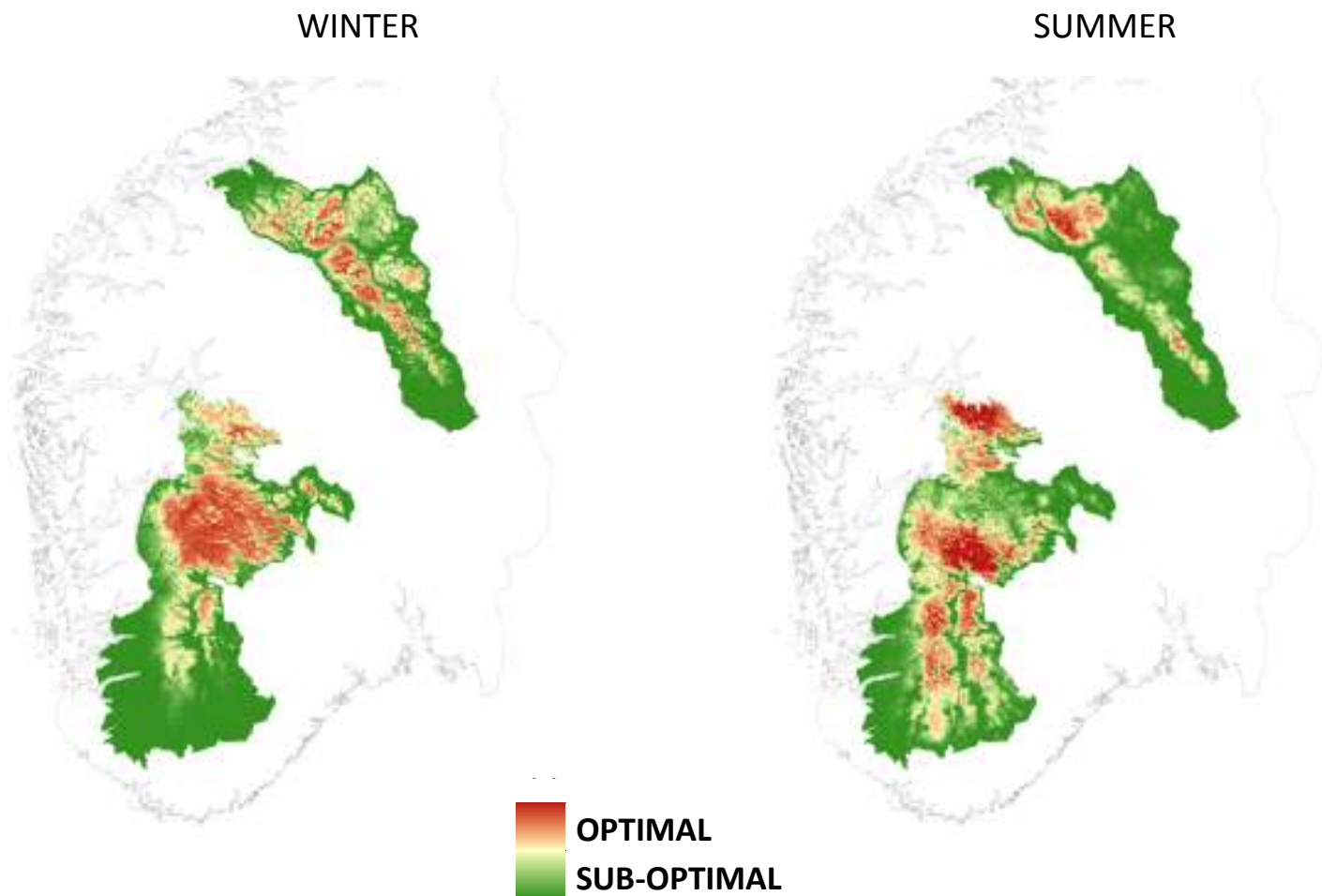
Niche Optimum =  $\beta_1 \sigma^2$

Niche Breadth =  $-1/(2 \beta_2)$



## APPROXIMATION OF THE FUNDAMENTAL NICHE

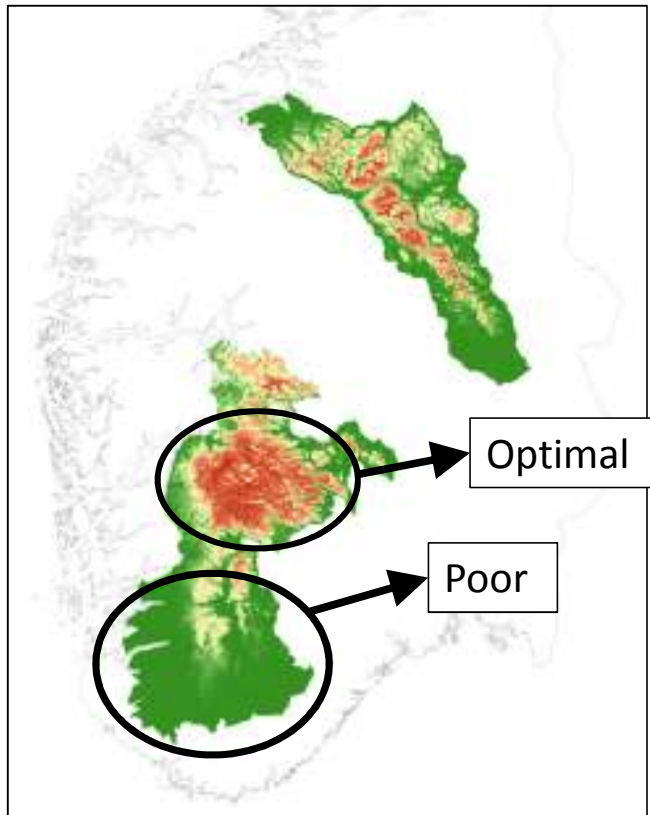
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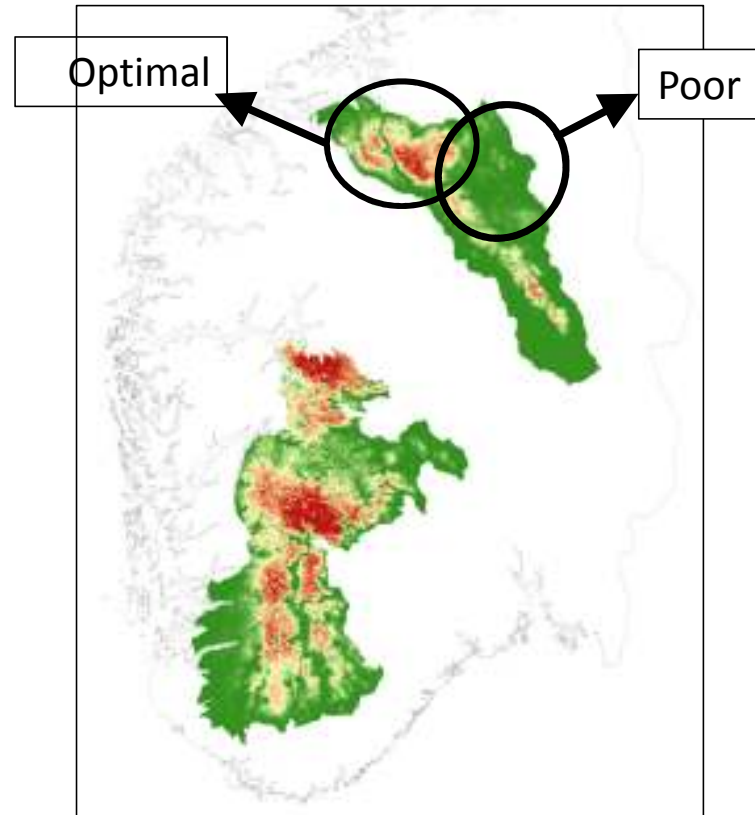
*Panzacchi-Van Moorter et al. Ecography, 2015*

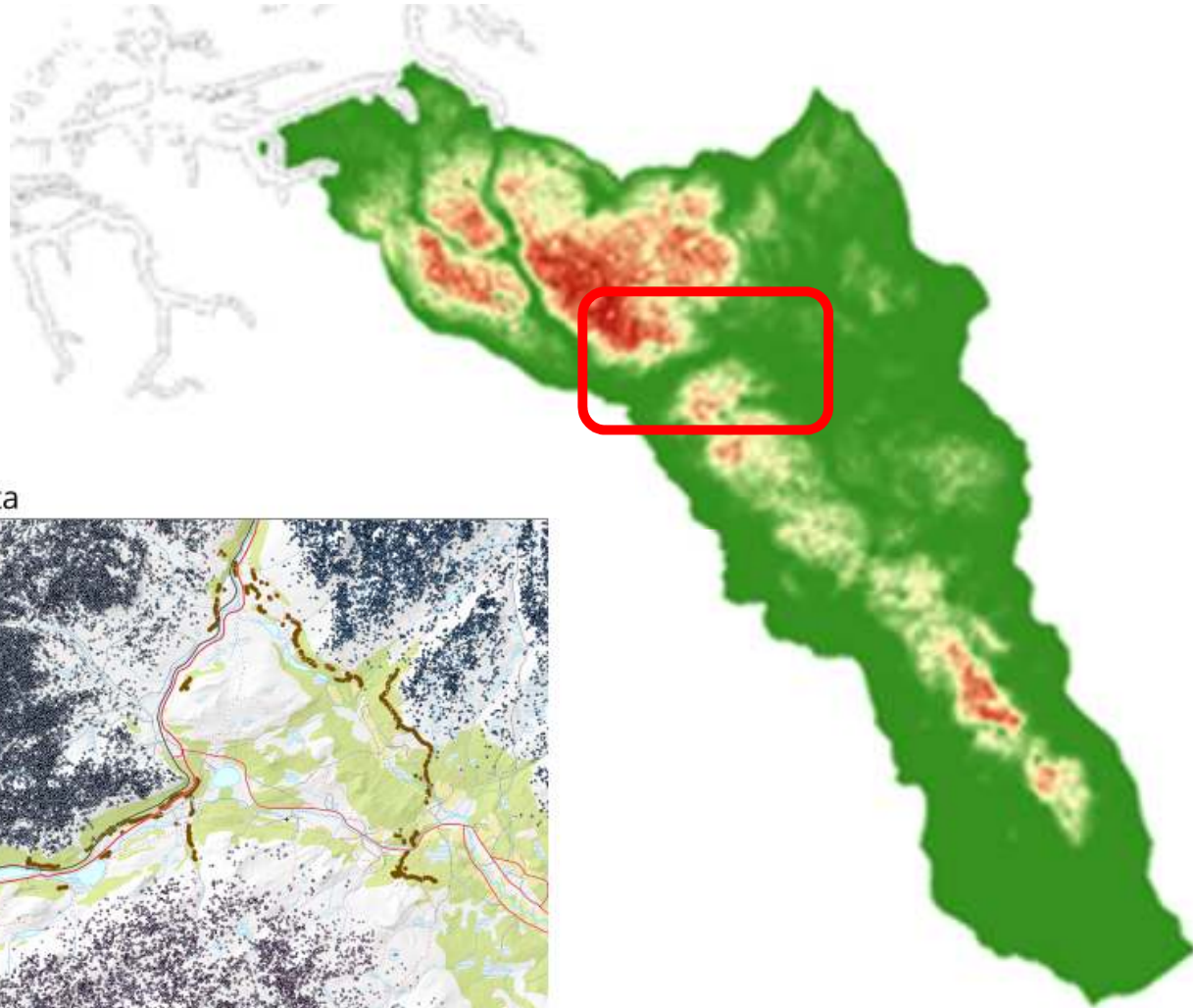
## APPROXIMATION OF THE FUNDAMENTAL NICHE

WINTER

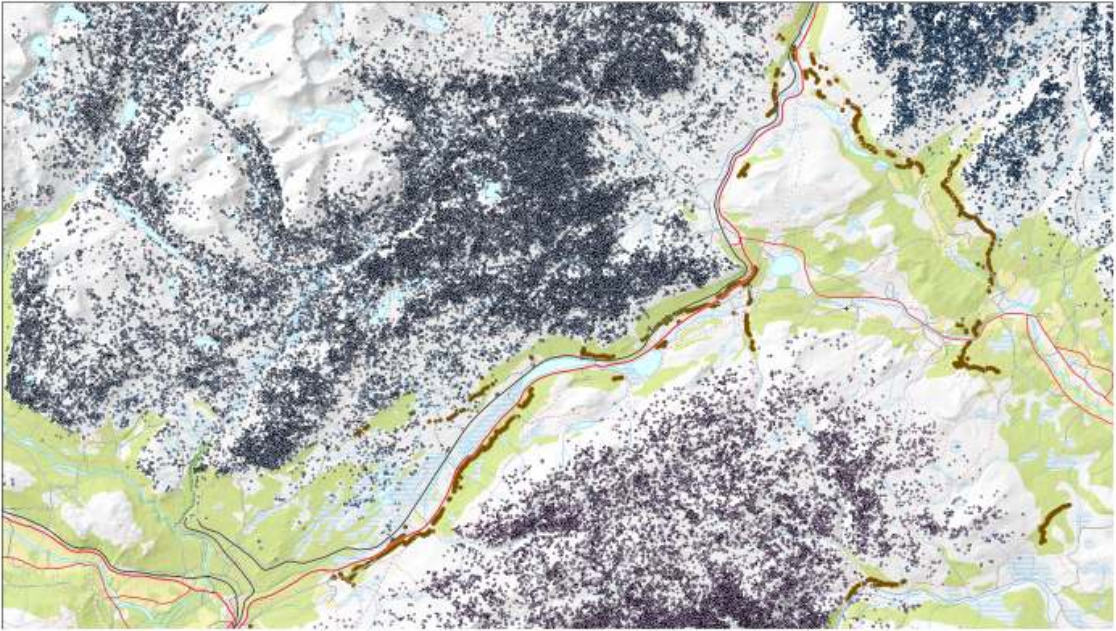


SUMMER



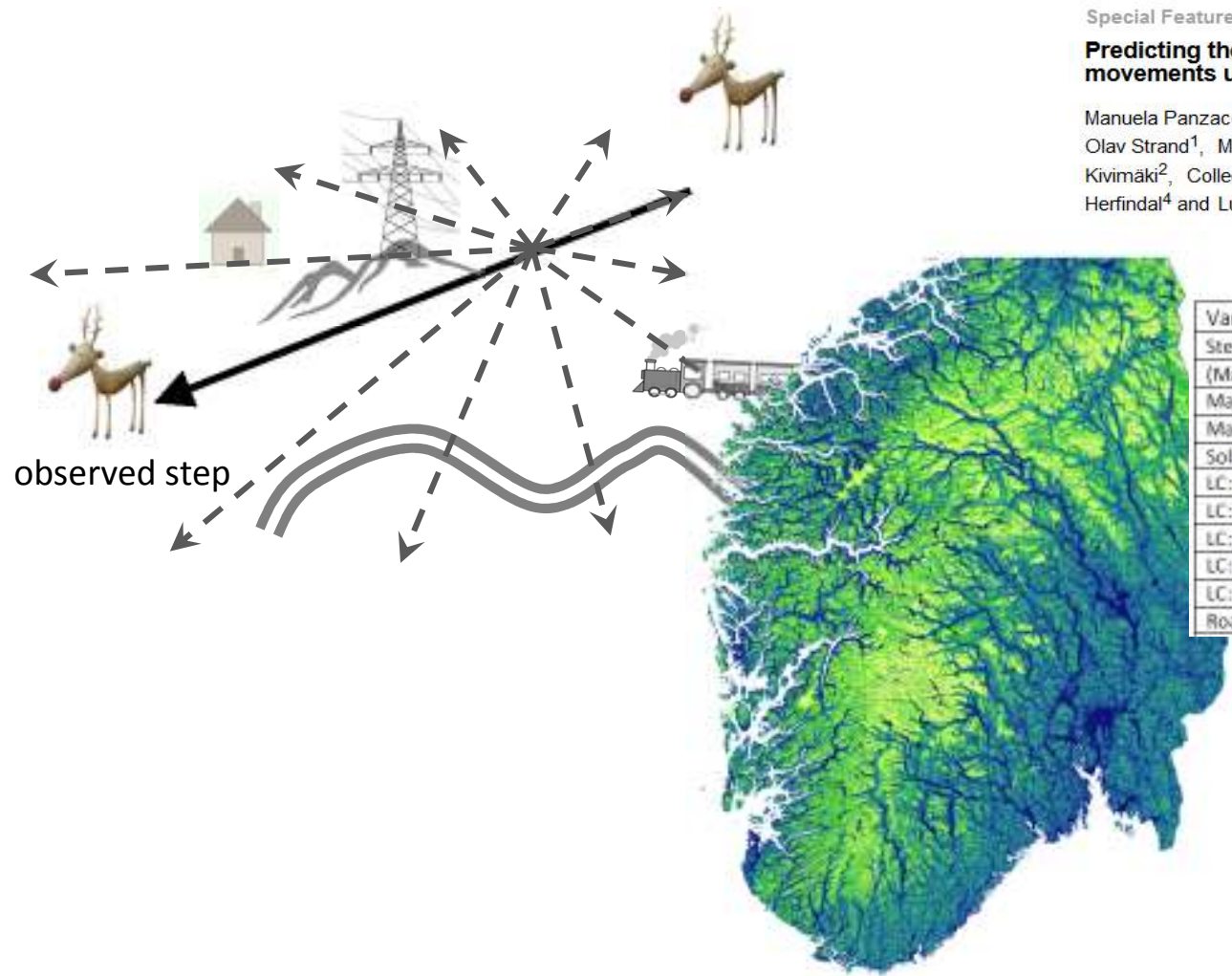


A closer look – Dovrefjell; all GPS data





Research directions; quantification of barriers



Journal of Animal Ecology

Special Feature: Stuck In Motion? Reconnecting Questions And Tools In Movement Ecology

Predicting the *continuum* between corridors and barriers to animal movements using Step Selection Functions and Randomized Shortest Paths

Manuela Panzacchi<sup>1\*</sup>, Bram Van Moorter<sup>1</sup>,  
Olav Strand<sup>1</sup>, Marco Saerens<sup>2</sup>, Ilkka  
Kivimäki<sup>2</sup>, Colleen C. St. Clair<sup>3</sup>, Ivar  
Herfindal<sup>4</sup> and Luigi Boitani<sup>5</sup>

Issue



Journal of Animal Ecology  
Early View (Online Version  
Record published before

| Variables                    | coef       | se(coef)  | z       | p   |
|------------------------------|------------|-----------|---------|-----|
| Step length (corrected)      | -1.142e-03 | 1.171e-05 | -97.500 | *** |
| (Max slope)^2                | -1.165e-03 | 3.559e-05 | -32.732 | *** |
| Max trail density            | -1.538e-01 | 2.338e-02 | -6.581  | *** |
| Max road density             | -5.324e-01 | 1.006e-01 | -5.295  | *** |
| Solar radiation              | 3.978e-01  | 1.051e-02 | 37.832  | *** |
| LC: bog                      | -5.510e-01 | 1.570e-01 | -3.509  | *** |
| LC: mountain not edible veg. | 1.516e-01  | 6.908e-02 | 2.195   | *   |
| LC: mountain edible veg.     | 5.996e-01  | 6.096e-02 | 9.835   | *** |
| LC: non dammed lakes         | -1.431e+00 | 1.268e-01 | -11.288 | *** |
| LC: dammed lakes             | -3.936e+00 | 4.645e-01 | -8.473  | *** |
| Road crossing                | -3.099e-01 | 1.264e-01 | -2.451  | *   |

## RANDOMIZED SHORTEST PATH ALGORITHM

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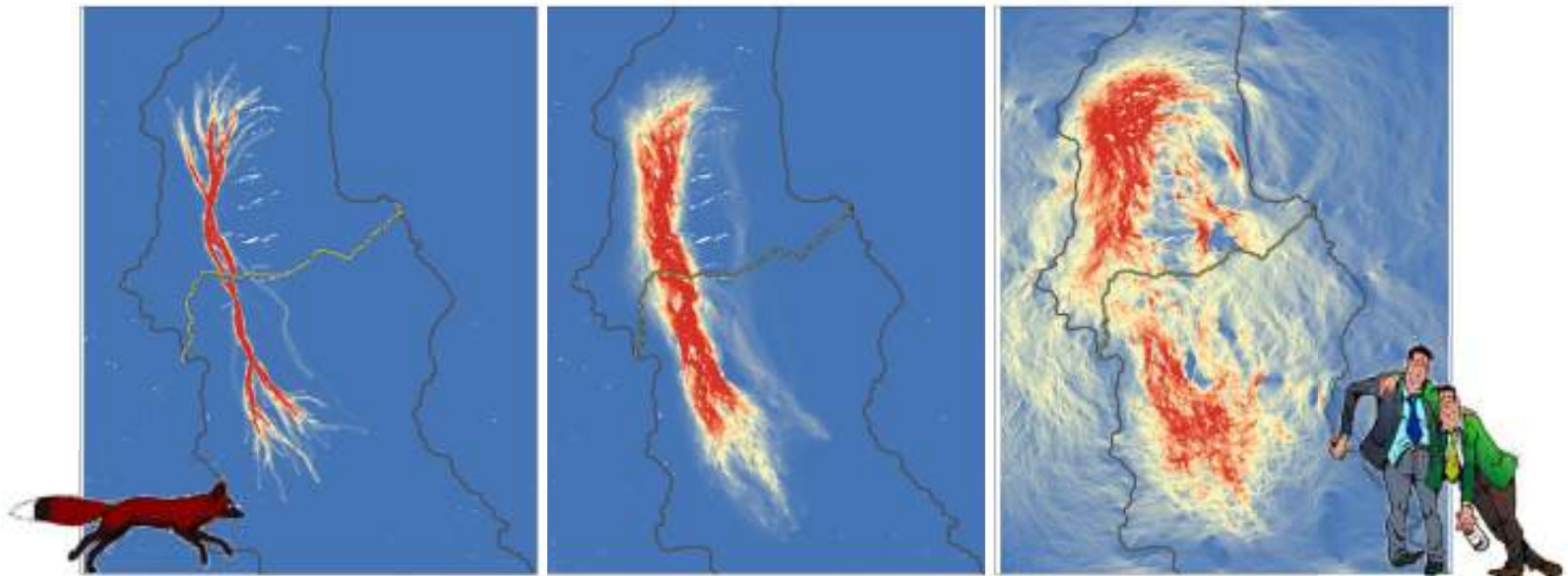
RSP bridges the gap between LCP and random-walk based approaches.

It identifies paths based on a *given degree of randomness* in animal movements (controlled by the parameter  $\Theta$ ):

$\Theta = 20$  (Least Cost Path)

«Something in between»

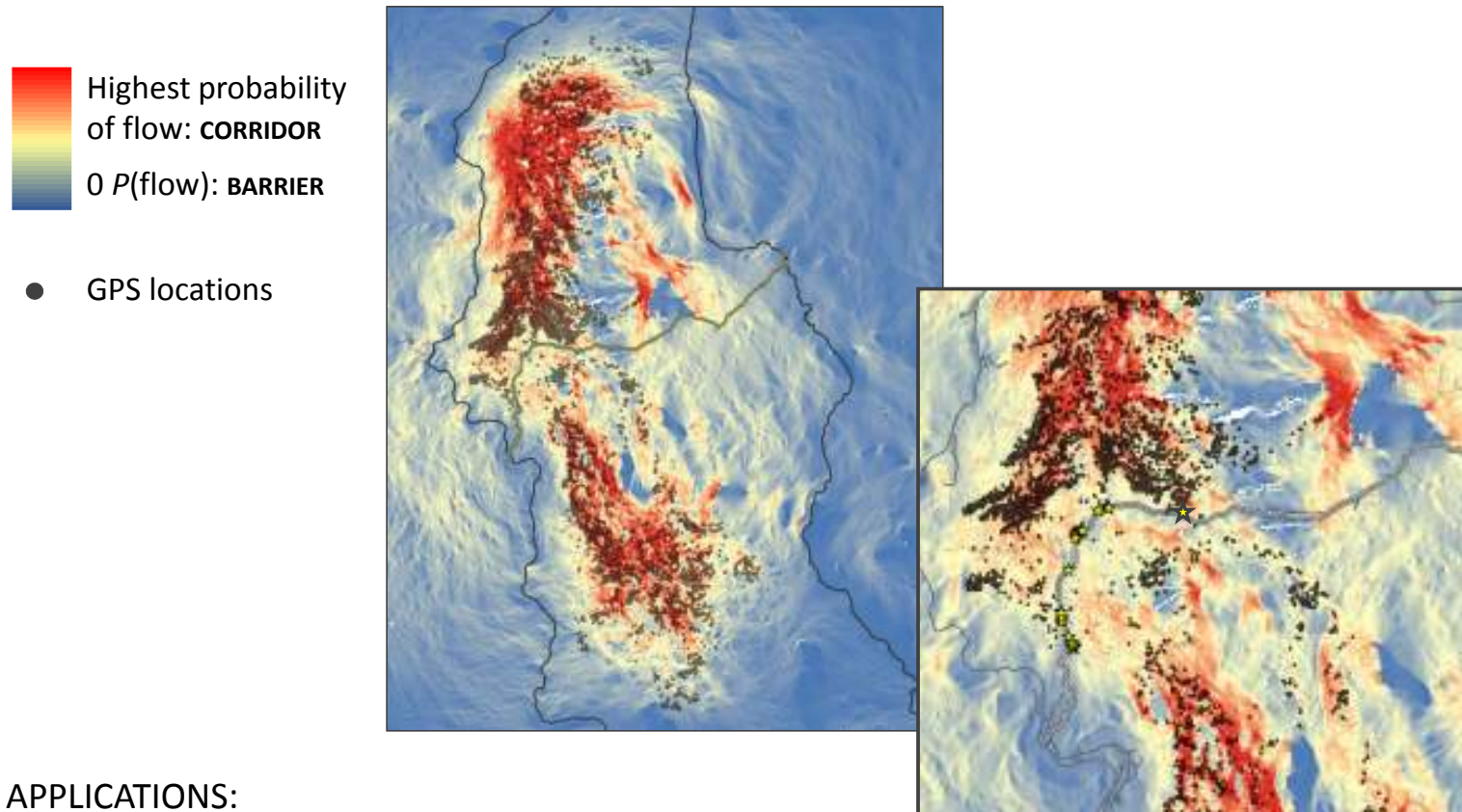
$\Theta = 0$  (Random Walk)



Sensitivity analysis to find  $\Theta$  values that best match the observed reindeer movement pattern

*Panzacchi et al, J. Anim. Ecol. 2015*

## MEET THE BEST PREDICTED CORRIDOR-BARRIER *CONTINUUM*



### APPLICATIONS:

- Support sustainable land planning: forecast changes in movement routes following changes in infrastructure network
- Identify cost-efficient mitigation /defragmentation measures

*Panzacchi et al, J. Anim. Ecol. 2015*



# SUMMARY

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## **ROADS** (10.635 km)

- ⇒ Shape distribution
- ⇒ Strongly avoided in all seasons and areas, up to (RSF, Panzacchi-Van Moorter et al. *Ecography*, 2015)
  - 10-15 km - *public* roads
  - 1 km (winter), 5 km (summer) – *private* roads
- ⇒ Reduce landscape permeability of 44-100% (SSF, Beyer et al 2015)
- ... ..

## **CABINS** (299 DNT + 42.925 private cabins)

- ⇒ Avoided in all areas (high d), especially in summer (Panzacchi-Van Moorter et al. *Ecography*, 2015)
- ⇒ DNT cabins built along traditional migration corridors pose migration at risk:

## **DNT TRAILS** (7.850 km)

- ⇒ Highly variable effects due to landscape / topography and variation in intensity of use

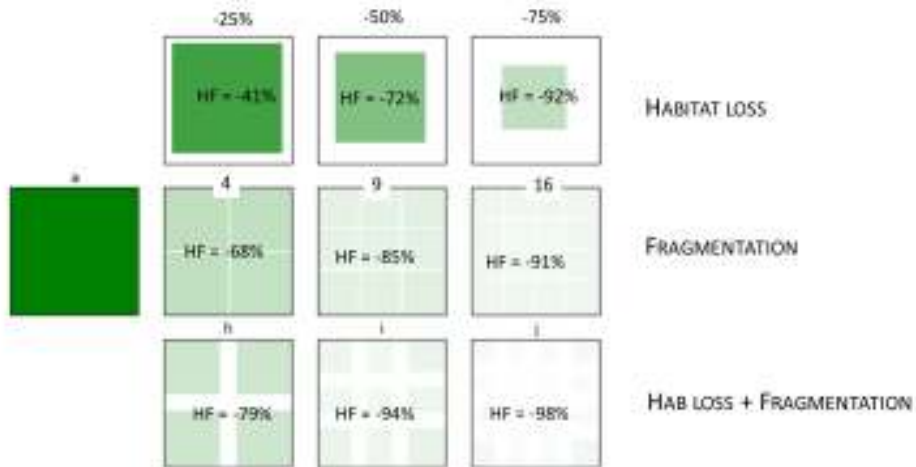
## Ongoing / future work: a index for habitat Functionality

Models to  
aid  
management  
and  
mitigation  
measures

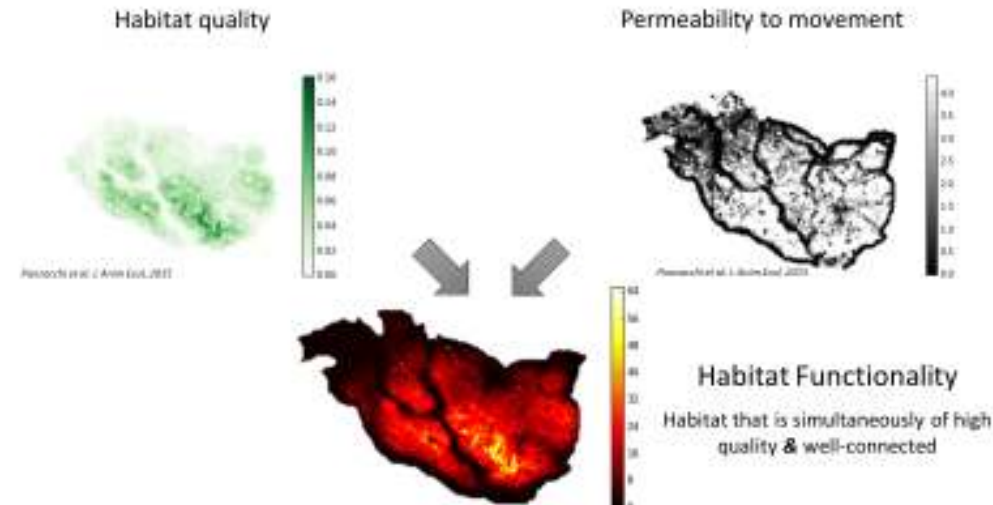
Effects at the  
population  
level  
(demography  
- population  
performance)

Science /  
policy  
interface

### PERFORMANCE OF HABITAT FUNCTIONALITY ON SIMULATED LANDSCAPES



### HABITAT FUNCTIONALITY - DEMO

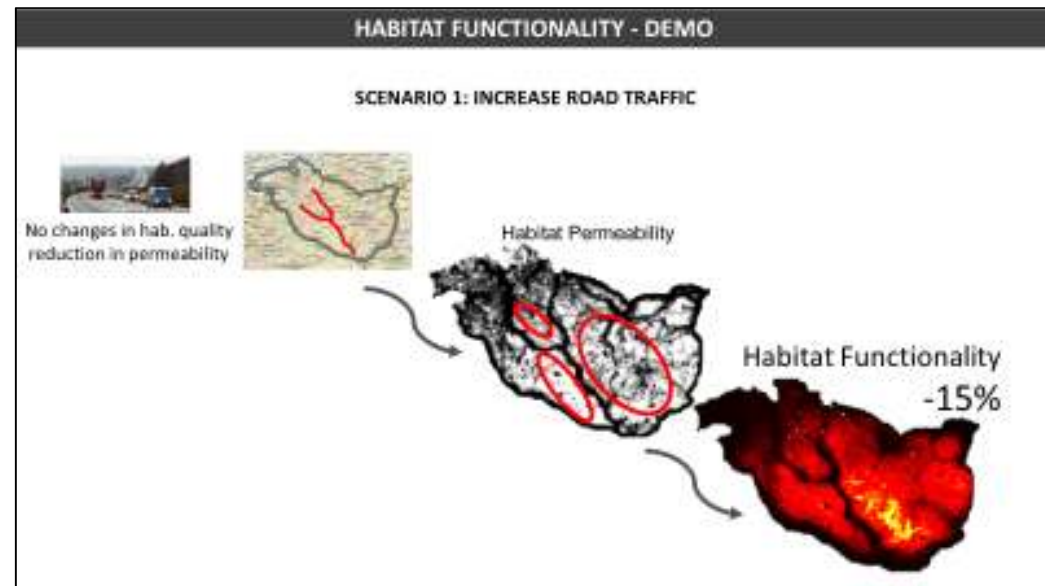
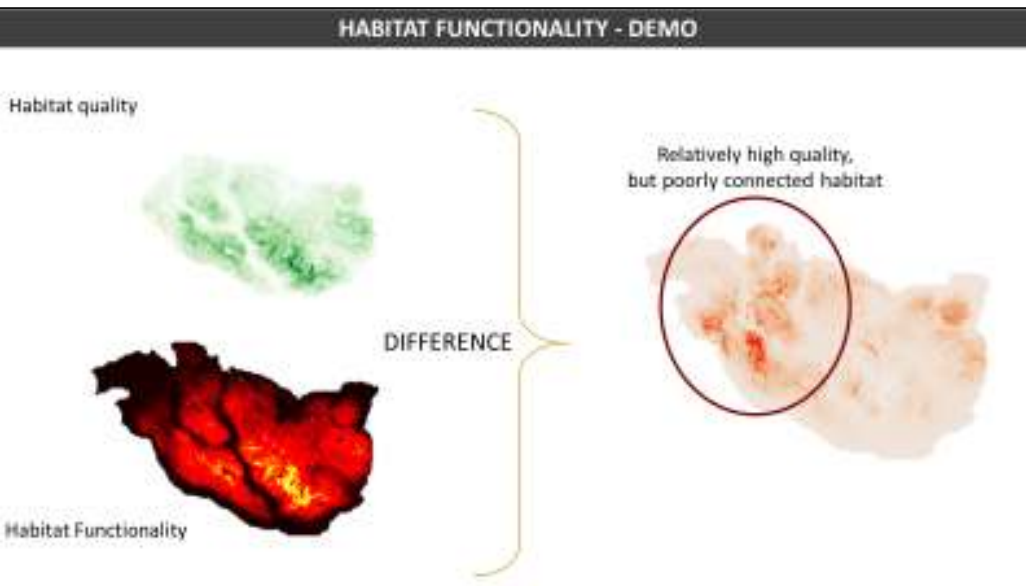


## Ongoing / future work

Models to  
aid  
management  
and  
mitigation  
measures

Effects at the  
population  
level  
(demography  
- population  
performance)

Science /  
policy  
interface





## Ongoing / future work

Models to aid management and mitigation measures

Effects at the population level (demography - population performance)

Science / policy interface

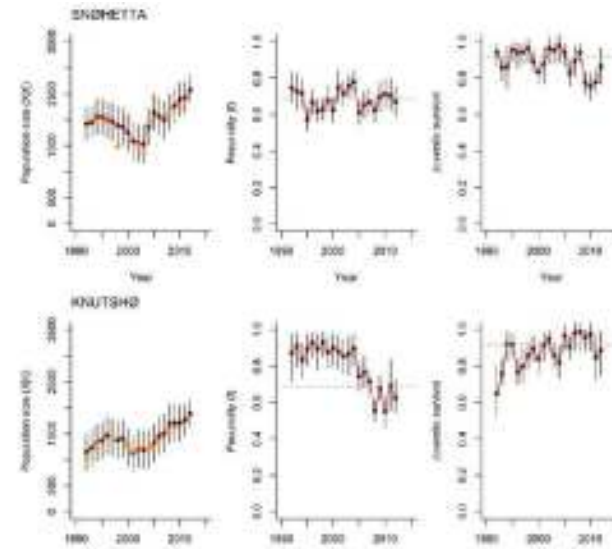
Integrated population models with markov chains to utilize the full assembly and potential of the monitoring data ( app 1980 – present)

Models show that we are getting robust estimates of recruitment and mortality.



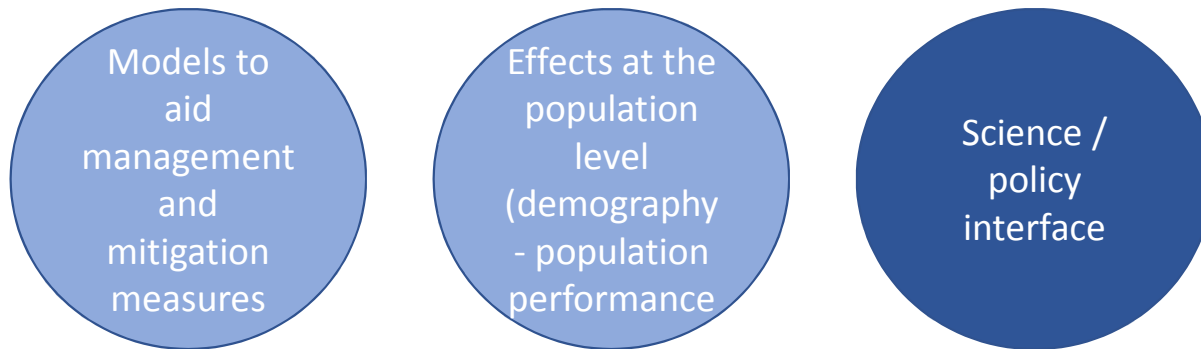
This habitat is fragmented into 5 (6) population units

What are the demographic effects of this development?



Nilsen & Strand (in press) Plus One. *Using hierarchical change in ratio models integrating data from several sources for increased insight into demographic processes: Simulation studies and proof of concept*

## Ongoing / future work



- Online distribution of results and project activities on interactive platforms
- HTML format
- Small “homepages” on article format, but with trans-media content (videos, animations, interactive maps, “infographics”)
- Joint production of content with steering boards and work groups

# Thank you for your attention!

