HABITAT FUNCTIONALITY METRIC:

Quantifying the total impact of habitat loss & fragmentation on mobile species, in large continuous landscapes

Bram Van Moorter, Ilkka Kivimaki, Robin Devooght, Manuela Panzacchi, Marco Saerens

NINA Norwegian Institute for Nature Research

UCL Université catholique de Louvain

A! Aalto University

The Research Council of Norway

ANTHROPOGENIC LAND USE

main threat to
biodiversity worldwide

HABITAT LOSS

FRAGMENTATION

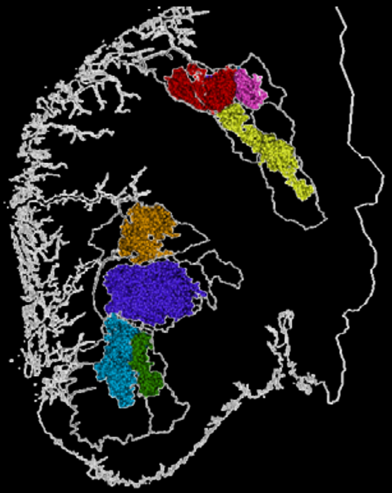
The total impact of land use is determined by the *magnitude, location & spatial configuration of* both habitat loss and fragmentation

good but non-accessible habitat is lost to the species

BACKGROUND WORK IN MOVEMENT ECOLOGY (IN A NUTSHELL)

1 - QUANTIFYING SUITABLE HABITAT / HABITAT LOSS

GPS data

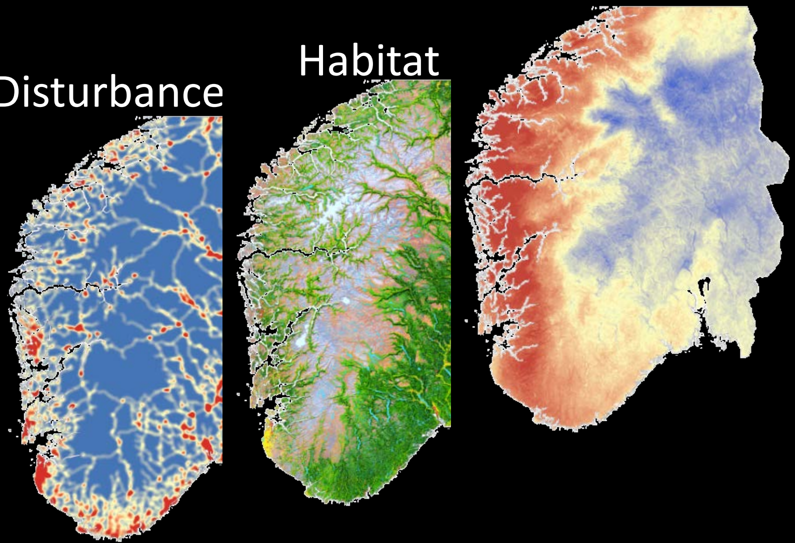


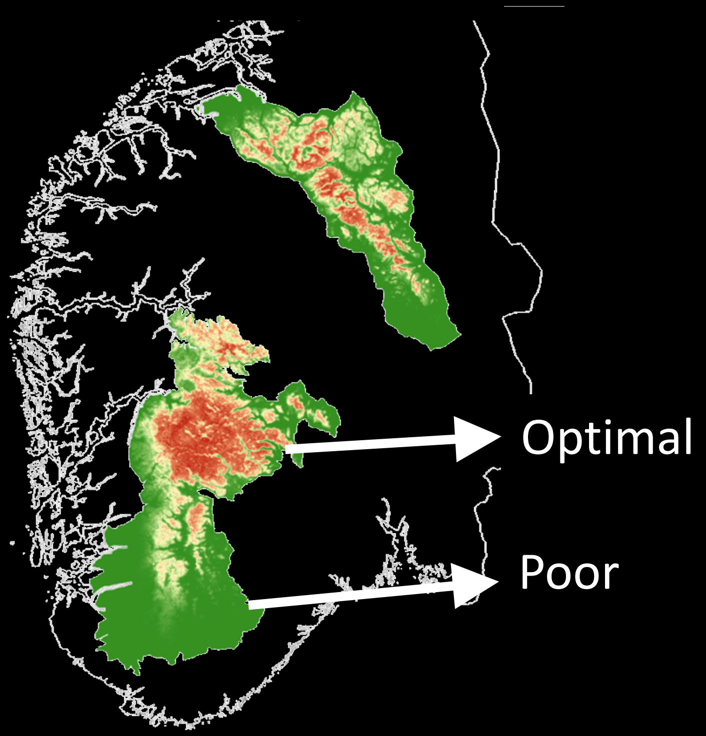
Compare used to available habitat
at each location using methods such as
RSPF - Resource Selection Probability Functions

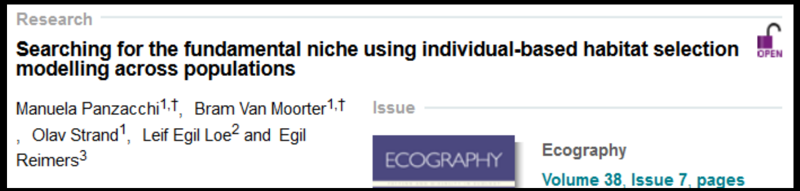
Disturbance

Habitat

Climate






Research

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

Manuela Panzacchi[1,†], Bram Van Moorter[1,†], Olav Strand[1], Leif Egil Loe[2] and Egil Reimers[3]

Issue

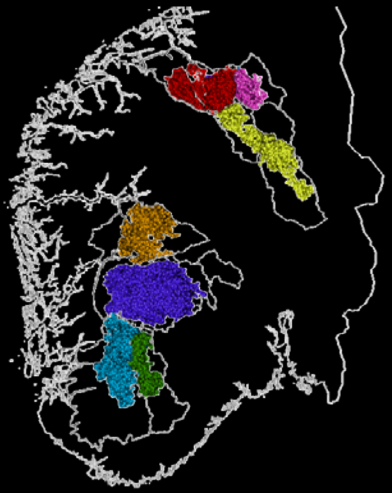
ECOGRAPHY

Ecography
Volume 38, Issue 7, pages

Link between resource selection and population carrying capacity (*in prep*)

2 - QUANTIFYING FINE-SCALE PERMEABILITY TO MOVEMENTS

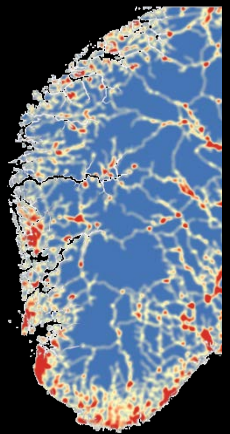
GPS data



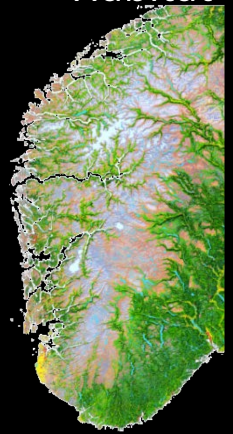
Calculate the probability of traversing each landscape feature with a "step"

SSPF - Step Selection Probability Functions

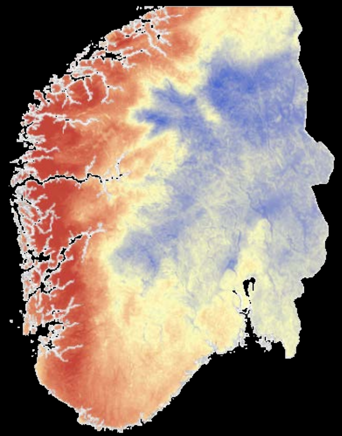
Disturbance

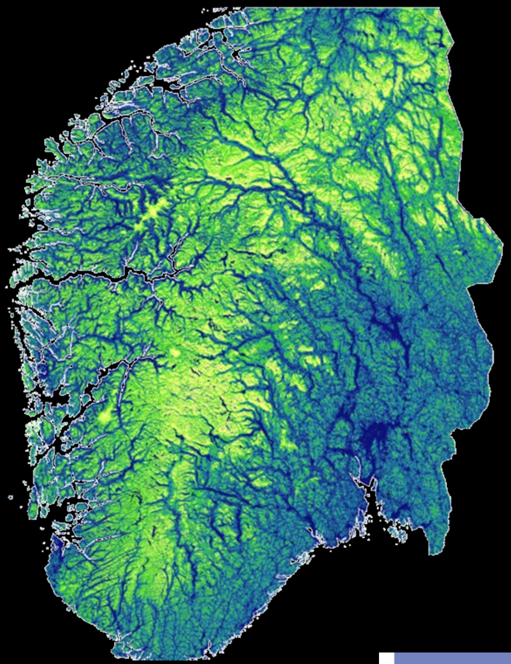


Habitat



Climate





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	*

Barrier *TO STEP*

Easy to traverse


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[1,*], Bram Van Moorter[1], Olav Strand[1], Marco Saerens[2], Ilkka Kivimäki[2], Colleen C. St. Clair[3], Ivar Herfindal[4] and Luigi Boitani[5]

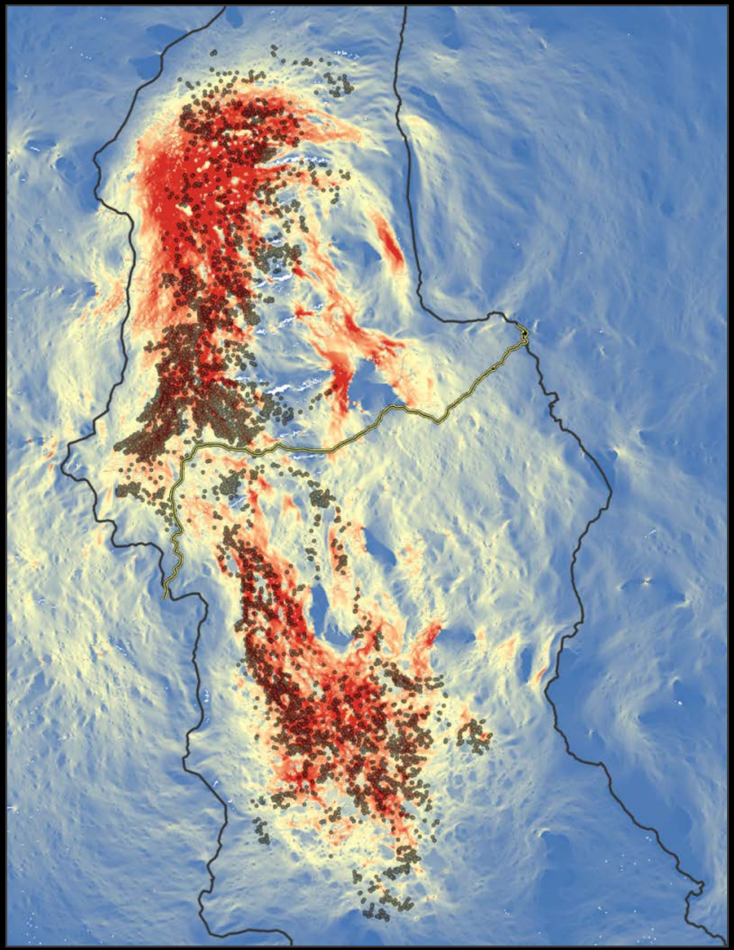
Issue

Journal of Animal Ecology

Early View (Online Version

Record published before

3. IDENTIFY MOVEMENT / MIGRATION CORRIDORS



Highest probability of flow: **CORRIDOR**

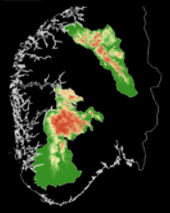
0 P(flow): **BARRIER**

GPS locations

Sensitivity analyses shows that reindeer movement patterns neither fully random nor fully optimal, and this patterns is likely to be widespread among animals

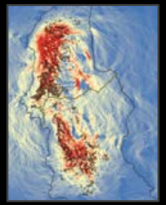
Panzacchi et al, J. Anim. Ecol. 2016

NEED FOR FORMAL INTEGRATION OF DIFFERENT APPROACHES



Habitat quality

Friction to steps



Migration barriers/corridors

These information, separately, are valuable but insufficient to estimate the total impact of anthropogenic land use.

Management actions require a synthetic and spatially explicit representation of the total impact of habitat loss and fragmentation

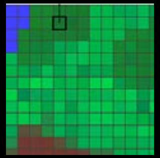
Crucial to identify habitat that is *at the same time* good & accessible – «*Functional habitat*»

good but non-accessible habitat is lost to the species

HABITAT FUNCTIONALITY METRIC

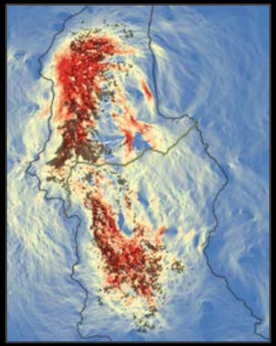
HABITAT FUNCTIONALITY METRIC

Quantifies the same time good & accessible – «Functional habitat»



$$\sum_s \sum_t Q_s Q_t Prox_{s,t}$$

Prox: opposite of distance (exp. cost) from *Randomized Shortest Path*

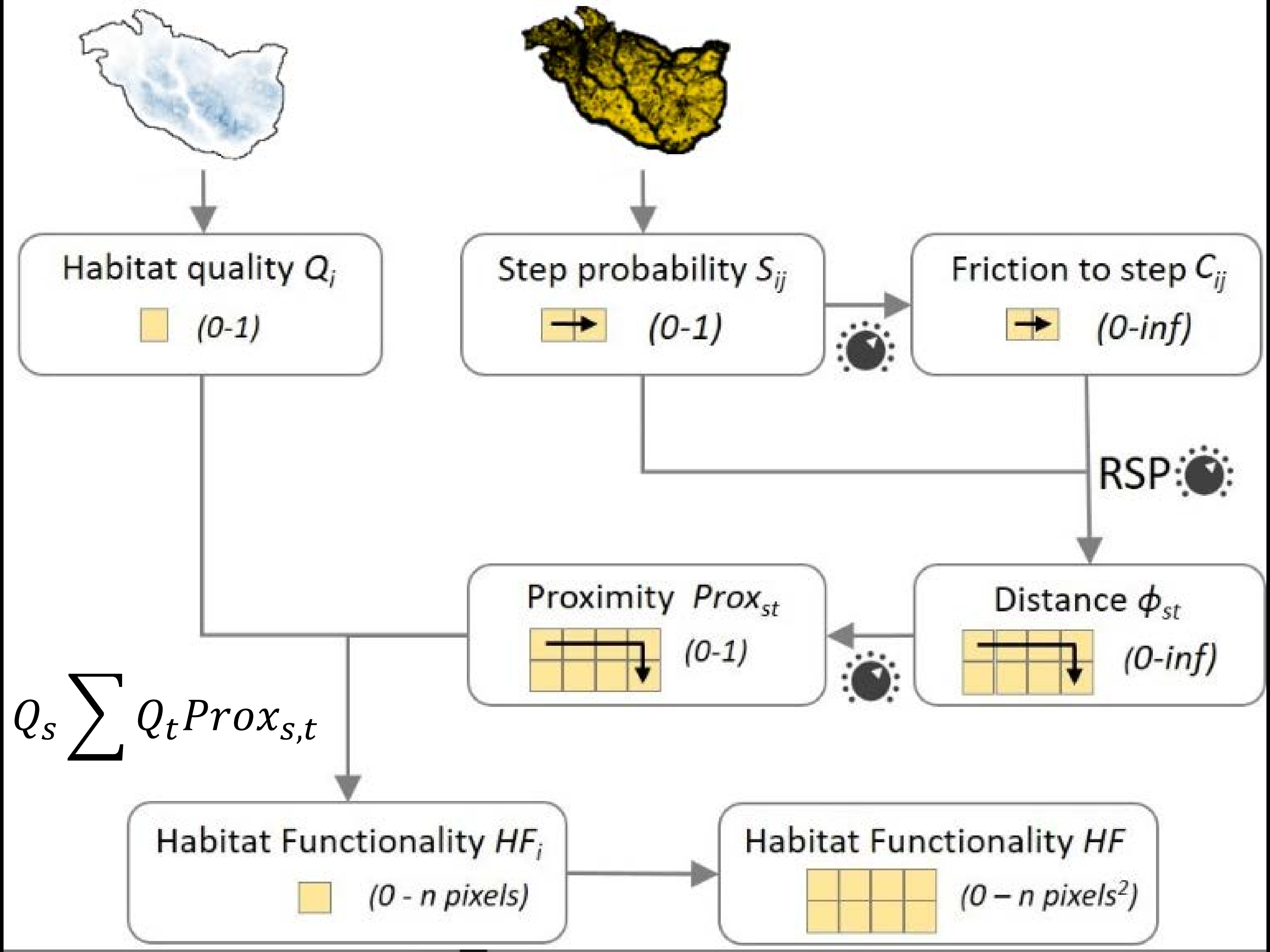


Q: pixel quality

Van Moorter et al. manuscript

HABITAT FUNCTIONALITY - WORKFLOW

inputs



outputs

Van Moorter et al. manuscript

HABITAT FUNCTIONALITY - TUNED TO THE SPECIES' MOVEMENT PATTERNS

HABITAT FUNCTIONALITY - TUNED TO THE SPECIES' MOVEMENT PATTERNS

Step cost to pixel *j*: $c_{i,j}$, which is the opposite of the step probability:

- Inverse: $c_{i,j} = {}^{1}/_{s_{i,j}}$
- Inverse, corrected: $c_{i,j} = {}^{1}/_{s_{i,j}} - 1$
- Logarithmic: $c_{i,j} = -\log(S_{i,j})$

Randomized Shortest Path:

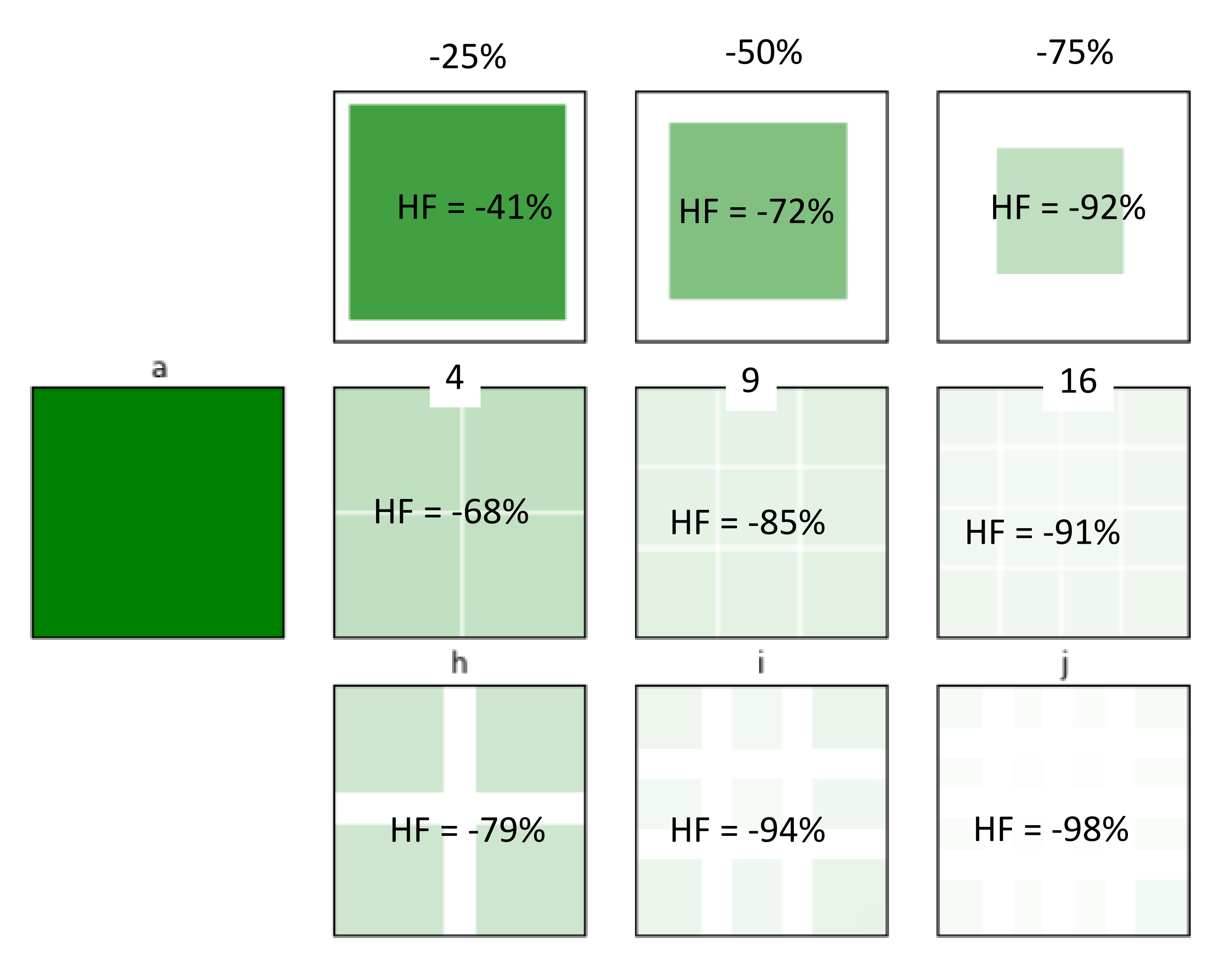
- $\theta \rightarrow 0$ = Random walk, "Circuitscape"
- $\theta \rightarrow \infty$ = Least-Cost Path

Proximity is the opposite of the ecological distance (exp. cost):

- Inverse: $Prox_{s,t} = {}^{1}/_{1+d_{s,t}}$
- Exponential: $Prox_{s,t} = \exp(-d_{s,t})$

$$HF = \sum_s \sum_t Q_s Q_t Prox_{s,t} \quad = \sum_s \sum_t a_s a_t p^*_{s,t} = \text{Probability of Connectivity}$$

PERFORMANCE OF HABITAT FUNCTIONALITY ON SIMULATED LANDSCAPES



HABITAT LOSS

FRAGMENTATION

HAB LOSS + FRAGMENTATION

Van Moorter et al. manuscript

HABITAT FUNCTIONALITY - DEMO

- Calculate HF for a reindeer management area - Snøhetta
- Scenario approach: Estimate total impact of two entirely *hypothetical* land development plans on HF

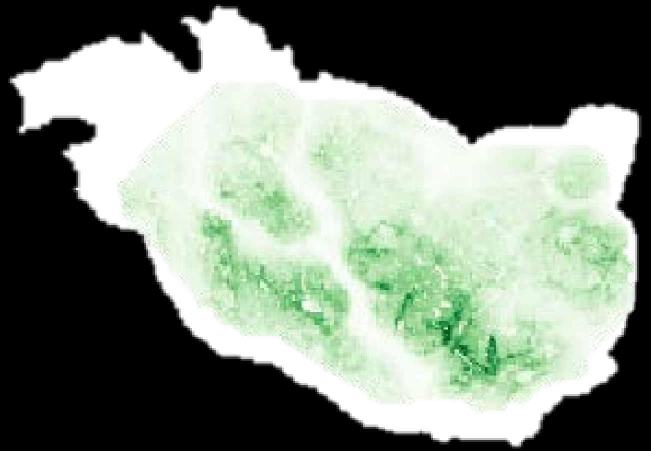
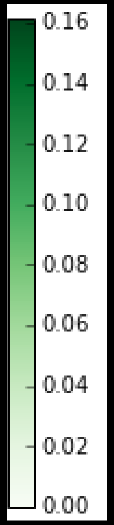
Note: these 2 unrealistic scenarios are used only for the purpose of demonstrating the metric performance, and in the course of the project will be replaced with realistic mitigation measures suggested by a board of local experts

- *Scenario 1*: increased road traffic (increase fragmentation)

- *Scenario 2*: construction of large tourist resort (decrease habitat quality)

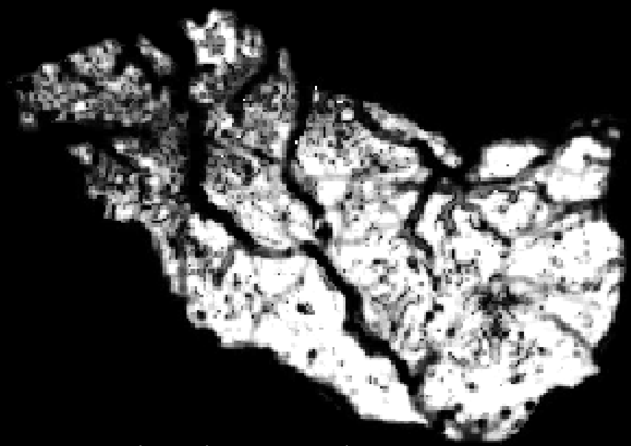
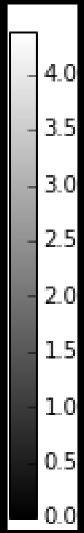
HABITAT FUNCTIONALITY - DEMO

Habitat quality

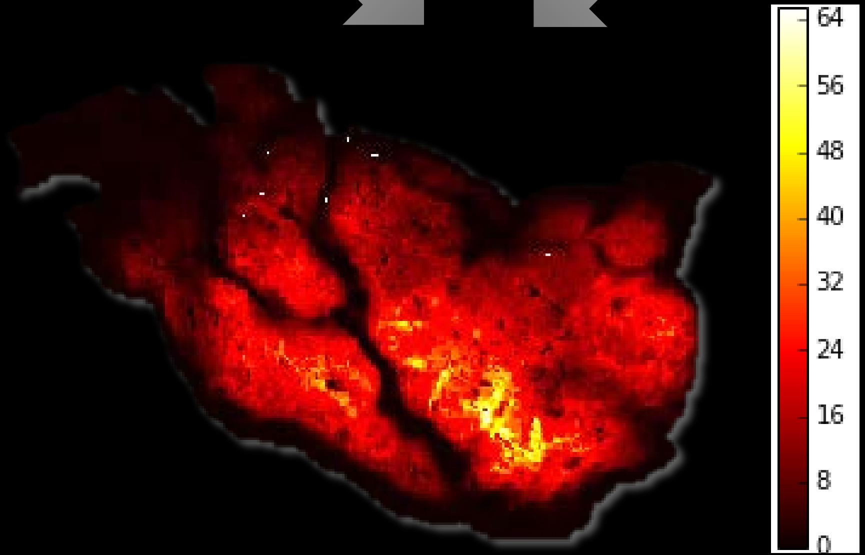



Panzacchi et al. J. Anim Ecol, 2015

Permeability to movement

Panzacchi et al. J. Anim Ecol, 2015



Habitat Functionality

Habitat that is simultaneously of high quality **&** well-connected

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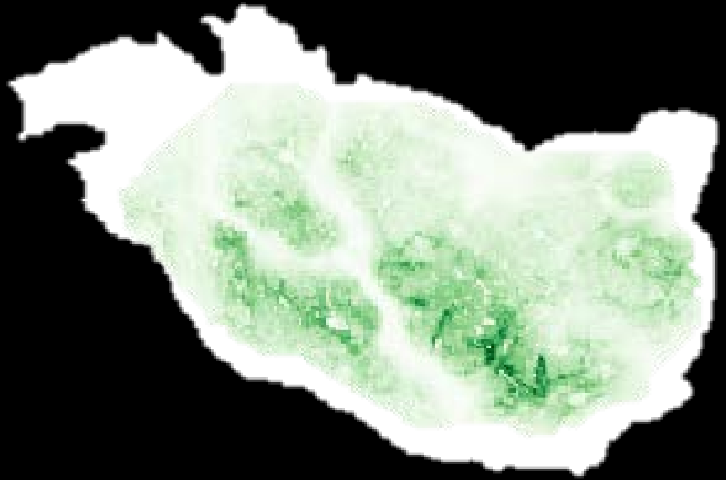
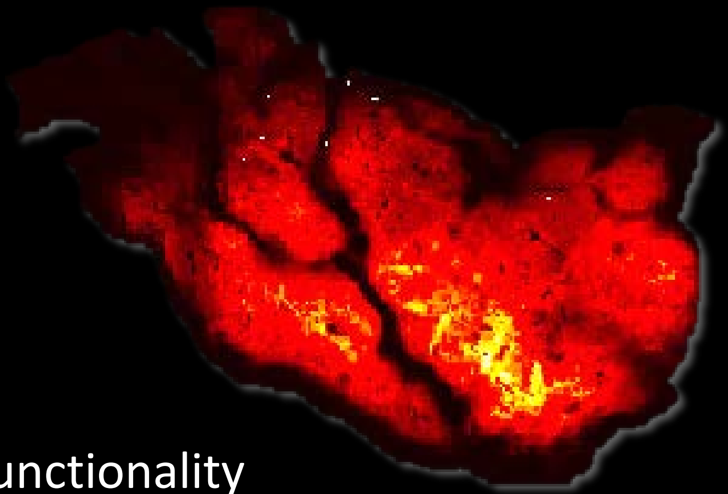
HABITAT FUNCTIONALITY - DEMO

Habitat quality



DIFFERENCE



Habitat Functionality

Relatively high quality,
but poorly connected habitat

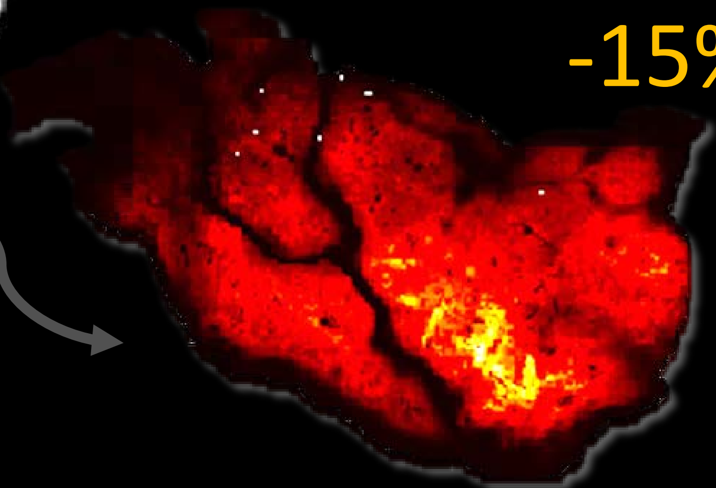
HABITAT FUNCTIONALITY - DEMO

SCENARIO 1: INCREASE ROAD TRAFFIC

No changes in hab. quality
reduction in permeability

Habitat Permeability

Habitat Functionality
-15%



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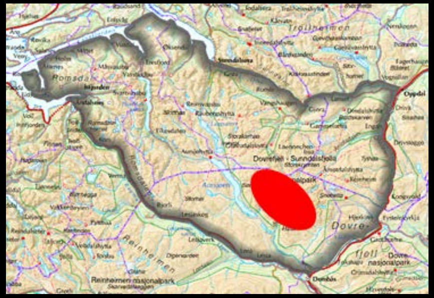
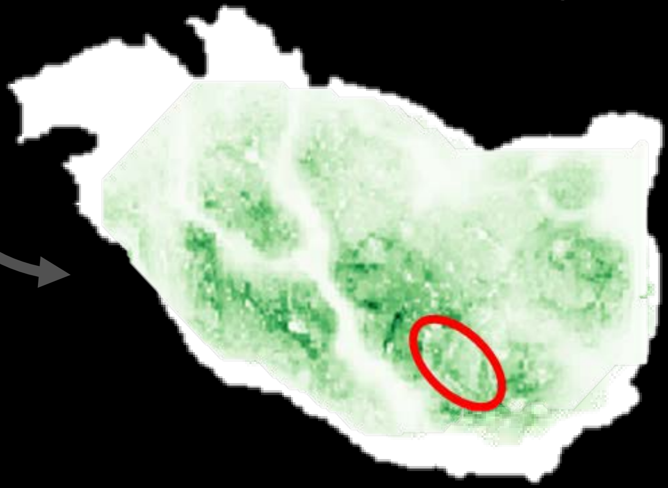
SCENARIO 2: BUILD A TOURIST RESORT

Local reduction in habitat quality

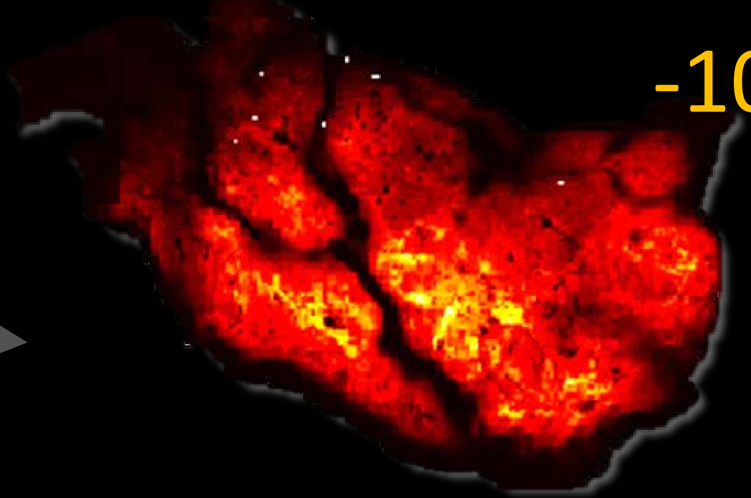


Habitat Quality



Habitat Functionality:

-10%



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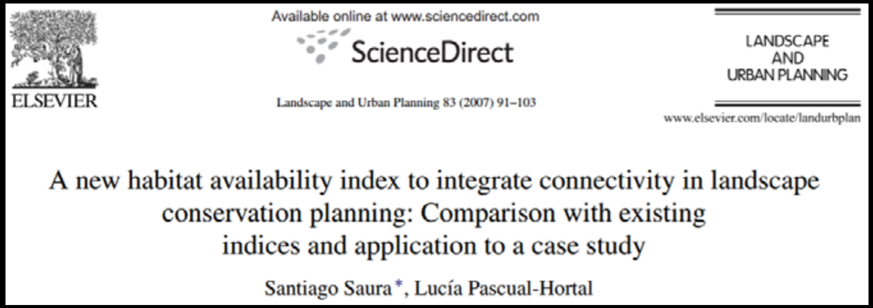
A SIMILAR METRIC WAS DEVELOPED IN 2007 AND IS WIDELY USED FOR CONSERVATION PLANNING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ELSEVIER

LANDSCAPE AND URBAN PLANNING

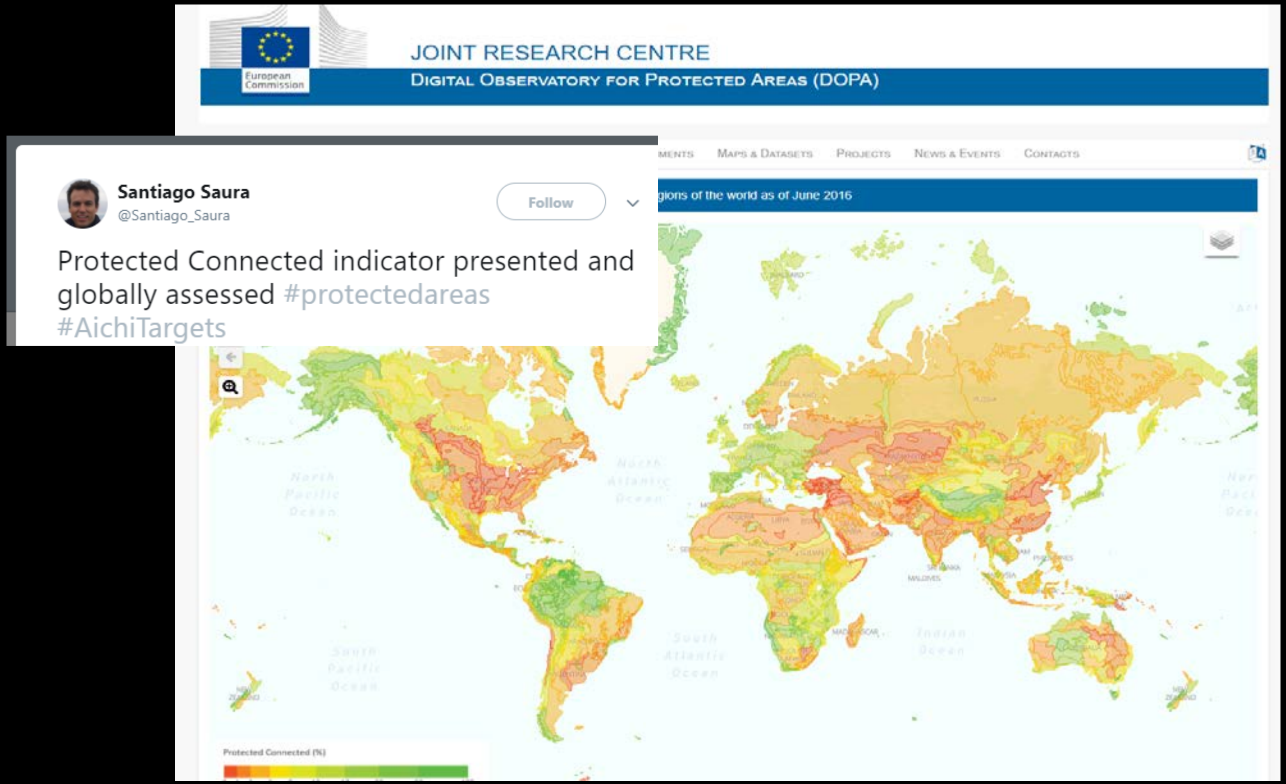
Landscape and Urban Planning 83 (2007) 91–103

www.elsevier.com/locate/landurbplan

A new habitat availability index to integrate connectivity in landscape conservation planning: Comparison with existing indices and application to a case study

Santiago Saura*, Lucía Pascual-Hortal

Very large number of publications



CONEFOR

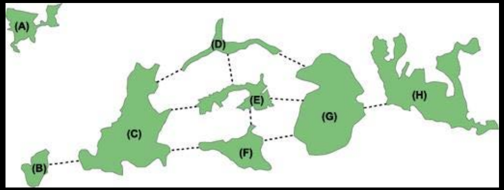
Free software

The "**Probability of Connectivity**", PC, is a powerful tool for strategic conservation planning, adopted in a variety of studies, conservation and management plans all over the world, and in official reports by the European Commission and the European Environment Agency. Recently, PC has been suggested for the assessment of the Aichi Target 11 within the strategic Plan for Biodiversity 2011–2020, which aims at the expansion of well-connected protected areas at the global scale

A SIMILAR METRIC WAS DEVELOPED IN 2007 AND IS WIDELY USED FOR CONSERVATION PLANNING

“Probability of Connectivity” (Saura & Pascual-Hortal 2007):

- Widely used in landscape ecology
- Simple representation of landscapes – habitat patches (e.g. protected areas) connected by links, in a “non-habitat” matrix
- Simple representation of animal movements – least cost path
- Not too efficient algorithms – difficult to compute on large, continuous landscapes



p*: highest probability path (Least Cost Path)

$$\sum_{s}\sum_{t} a_s a_t p^{*}_{s,t}$$

a: patch attribute (e.g. size, quality)

HABITAT FUNCTIONALITY

- *Habitat Functionality* is a generalization of the *Probability of Connectivity*
- In addition, Habitat Functionality formally integrates advances in:
  - movement ecology:
    - Pixel quality & transition probability can be estimated directly from data (SSPF, RSPF)
    - Sophisticated representation of animal movements – RSP
  - computer science:
    - Sophisticated, efficient algorithm – easy to compute on large, high-resolution landscapes
    - RSP

=> Ongoing collaboration to explore potential for formal integration of the two metrics

TAKE HOME MESSAGES

HF quantifies jointly, efficiently and realistically the total impact of two major drivers of biodiversity loss – i.e. habitat loss and fragmentation – on mobile species:

- high-quality, continuous landscapes are always classified as the most functional

- both habitat loss and fragmentation lead to reduction in HF; their combined effect is larger than each one independently

- space does matter: the impact of habitat / connectivity loss is highly dependent on their geographic locations

- isolated, good habitat locations have low HF, and contribute little to the HF of other locations

- poor quality locations have little HF, *but may contribute greatly to the functionality of other areas* by providing connectivity. This is an important difference with respect to previous studies, as movement corridors are not necessarily characterized by optimal habitat (e.g. road overpasses)

APPLICATIONS: assess or forecast the total impact of existing or planned anthropogenic development / mitigation options

Given these properties, HF may represent an appropriate alternative to traditional metrics in studies aiming at identifying with great accuracy areas to be prioritized for conservation of mobile species, or sustainable land development options

Thank you!

http://www.nina.no/english/Research/Projects/Renewable-Reindeer

The Research Council of Norway
NINA Norwegian Institute for Nature Research
MILJØ-DIREKTORATET
Norges vassdrags- og energidirektorat NVE
Sira-Kvina KRAFTSELSKAP
UCL Université catholique de Louvain
Villreinrådet i Norge
Norsk VILLREINSENTER
UNIVERSITY of GUELPH
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bc3 BASQUE CENTRE FOR CLIMATE CHANGE Klima Aldaketa Ikergai
Aalto University School of Science and Technology
Siri Bøthun Naturforvaltning