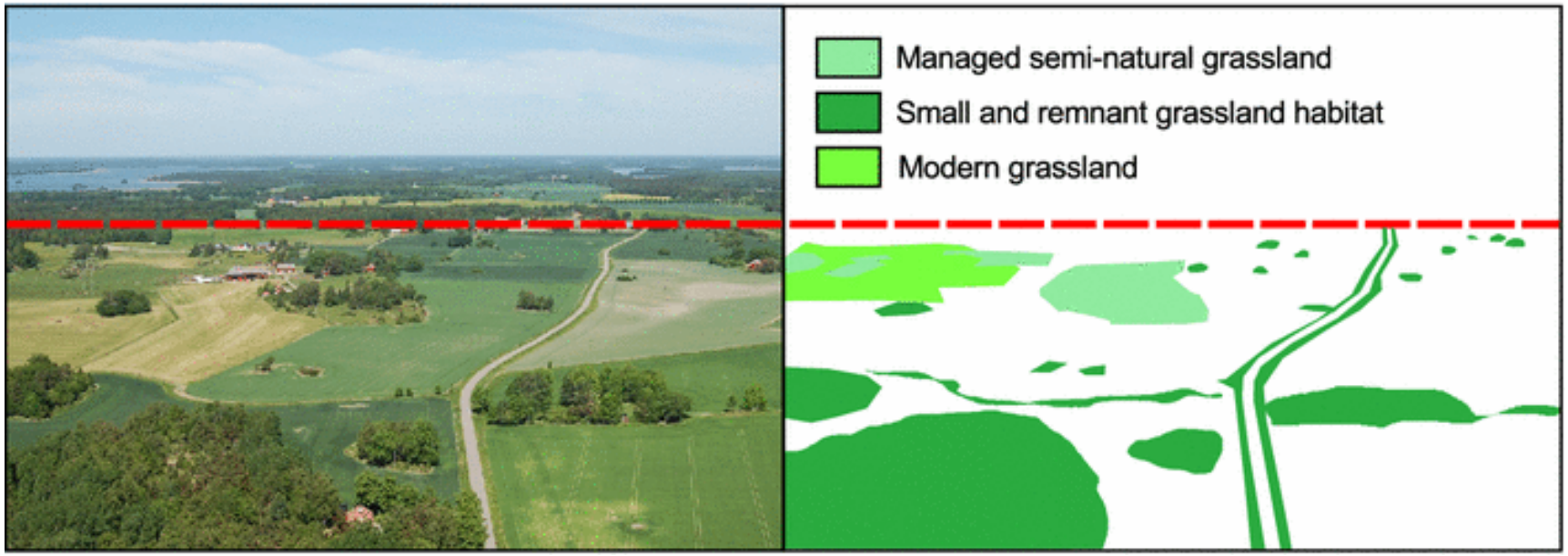
From individual movement to landscape and population connectivity

Bernardo Brandão Niebuhr
bernardo.brandao@nina.no

Animal Movement PhD-course, SLU
Ekenäs Herrgård
4-8 September, 2023

Landscape connectivity

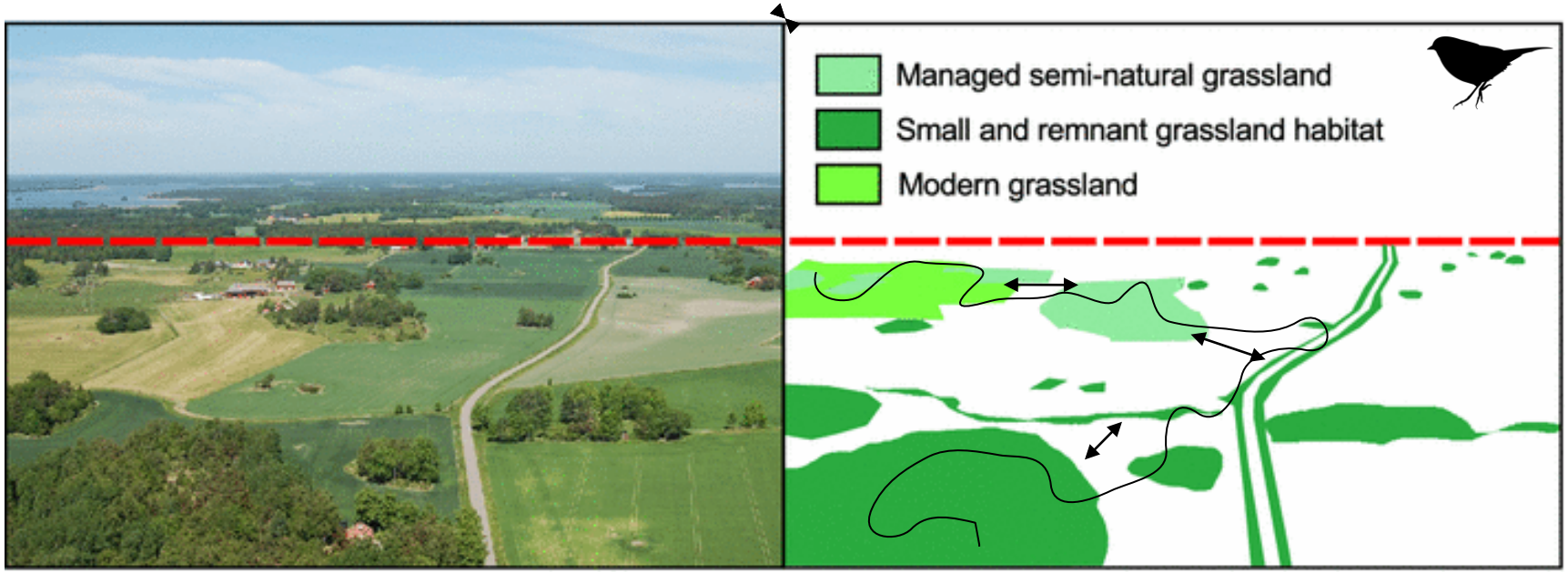
- Structural connectivity
- Functional connectivity



Auffret et al. 2015

Landscape connectivity

- Structural connectivity
- Functional connectivity

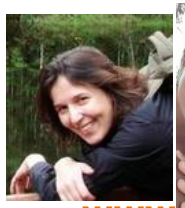


Auffret et al. 2015

Population dynamics

Movement ecology meets road ecology:
Landscape connectivity in face of an expanding road network




Bernardo Niebuhr, Fernando Ascensão,
Andreia Moraes, Brenda Alexandre, Assis,
Milene Alves-Eigenheer, Marcio de Morais-Jr,
Andreia Martins, Ademilson Oliveira, Elisamã Moraes,
Maria Lucia Lorini, Carlos Ramon Ruiz-Miranda,
Laurence Culot, Milton Cezar Ribeiro



Golden Lion Tamarins

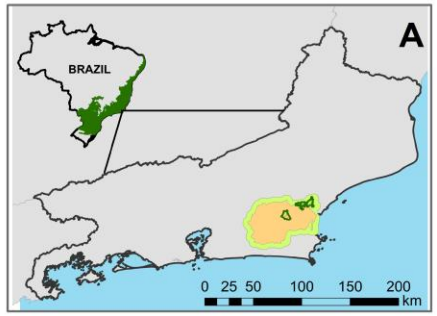
Leontopithecus rosalia

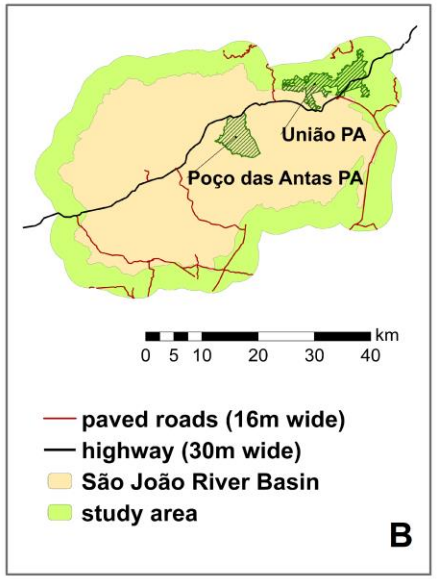
- Callitrichidae
- Monogamic and cohesive groups
- Arboreal
- Forest dependance
- Endangered
- 30 years of continuous research

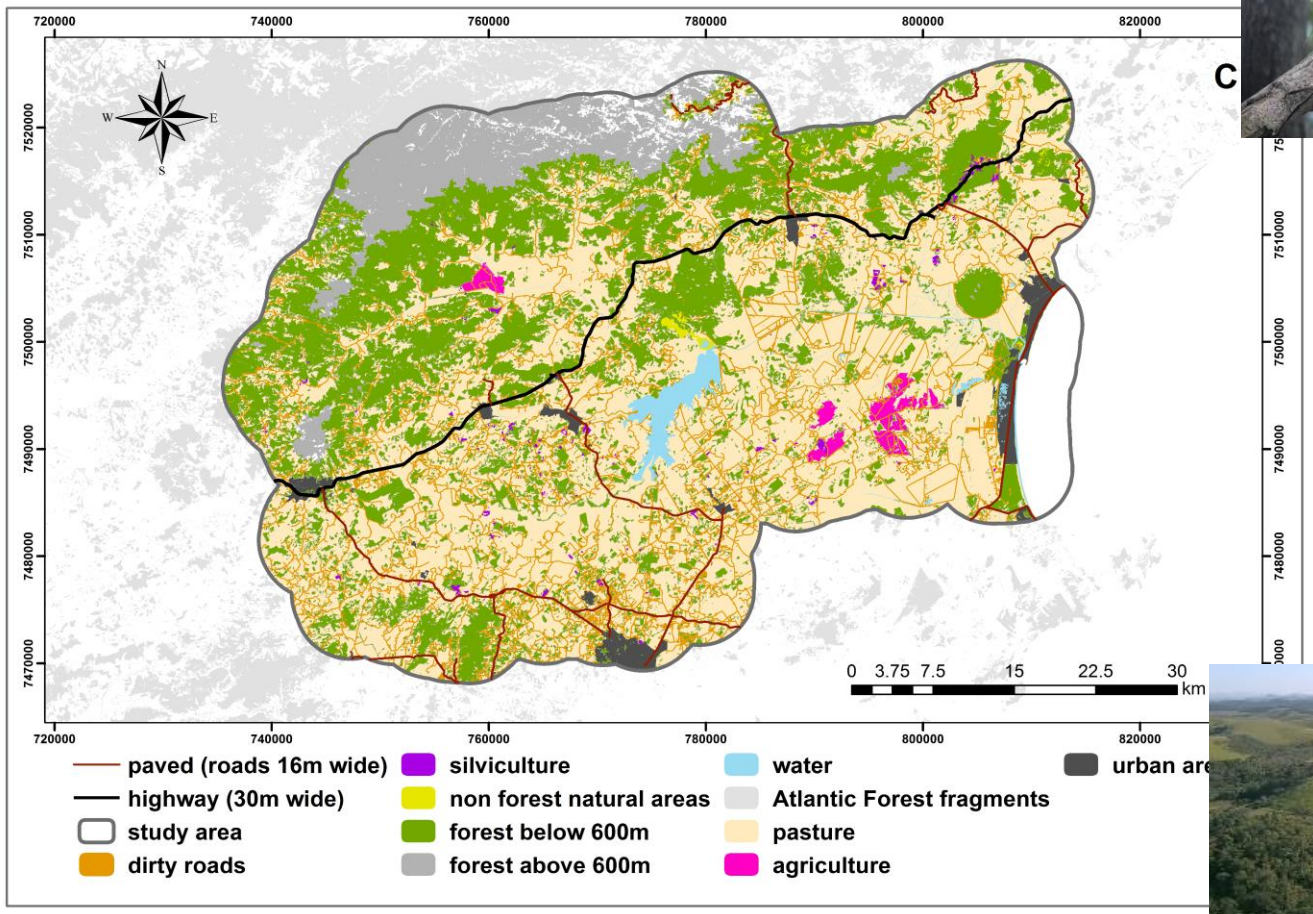
NINA

Golden Lion Tamarins

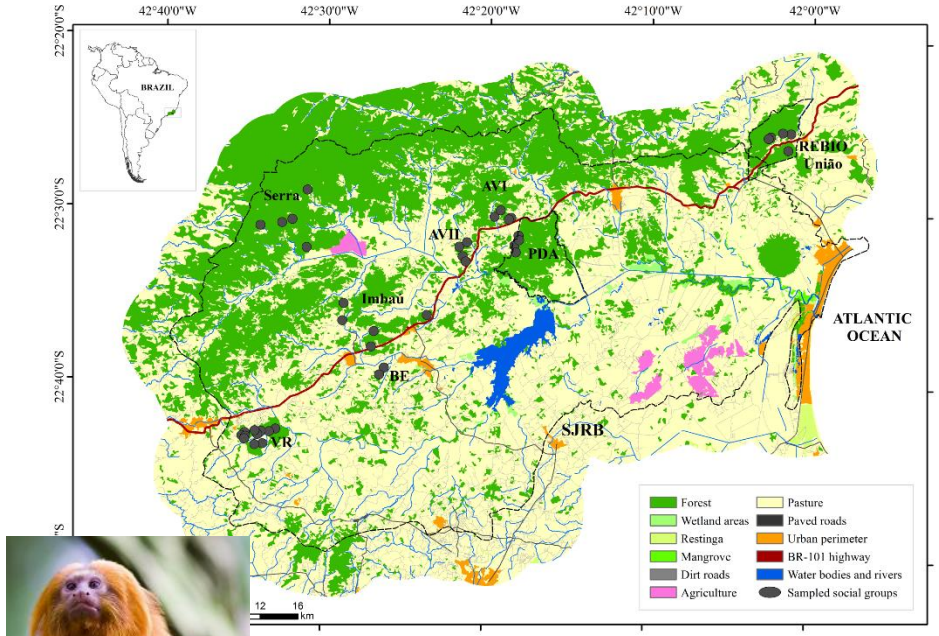
Leontopithecus rosalia

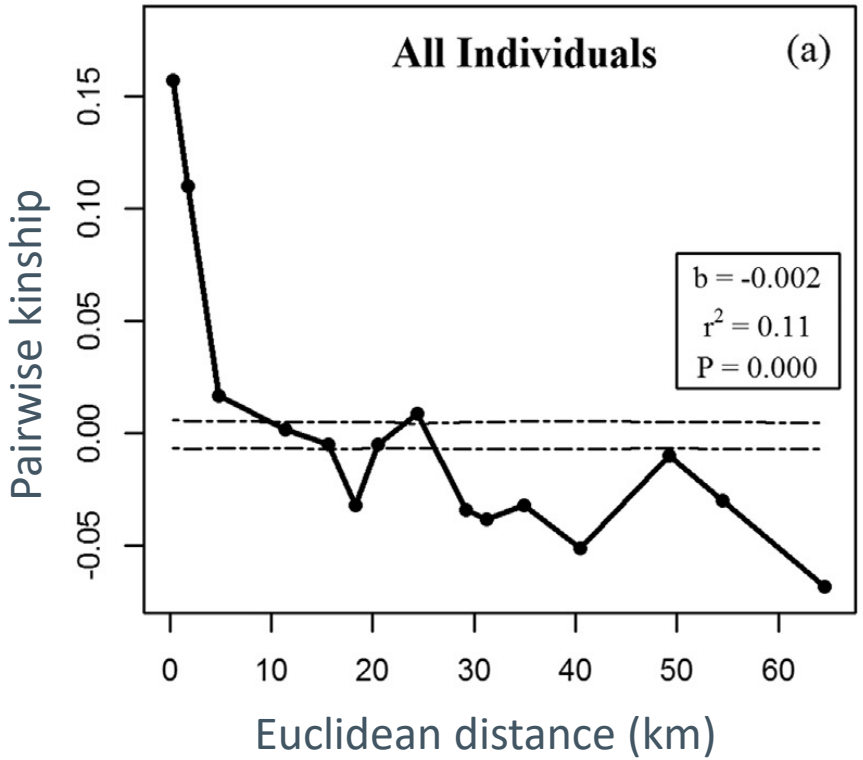






Movement meets roads

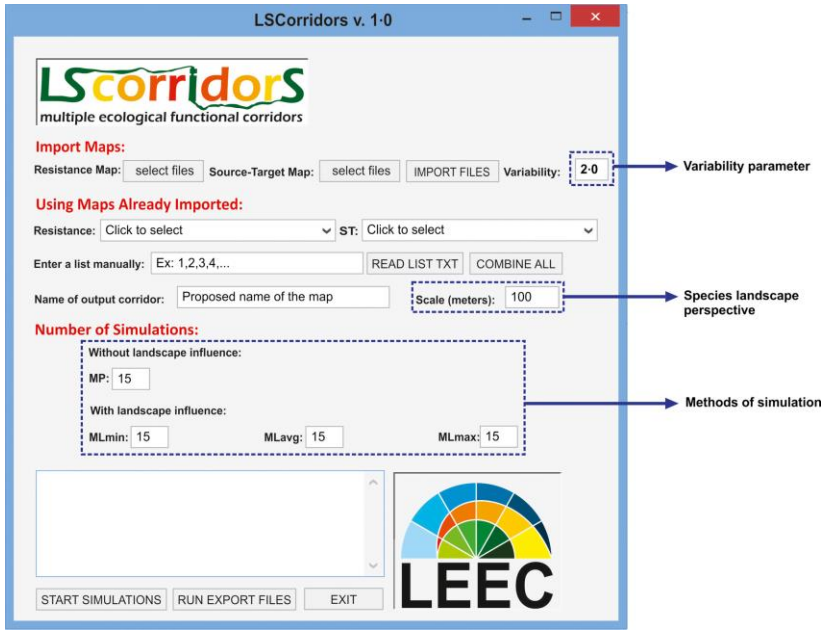




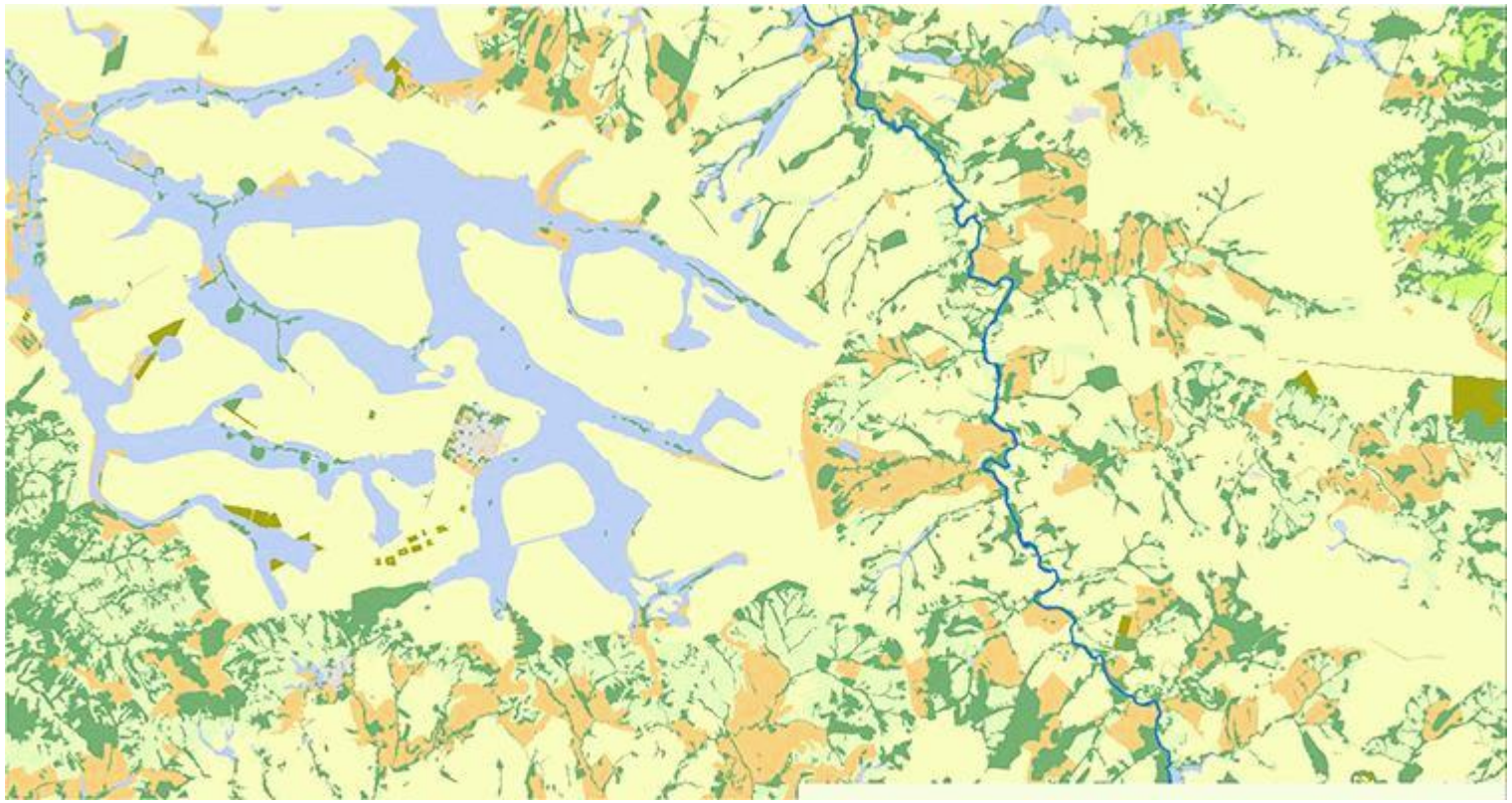
Moraes et al. 2018
Landscape genetics of GLT

NINA

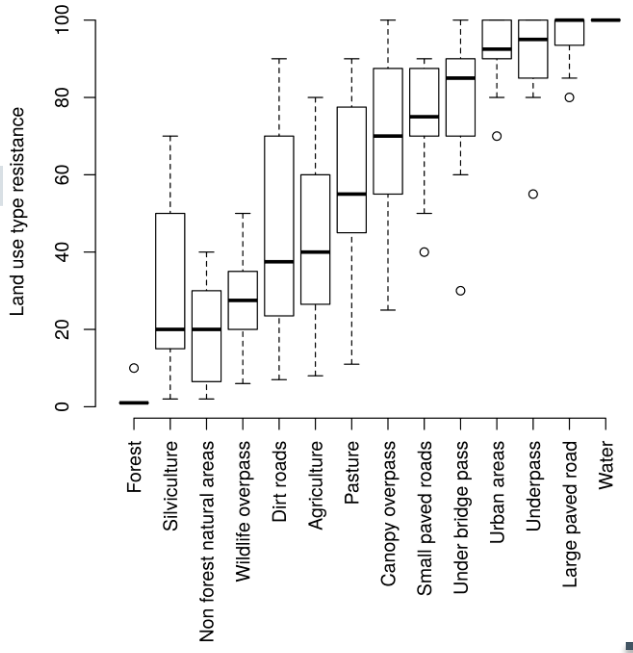
Movement meets roads



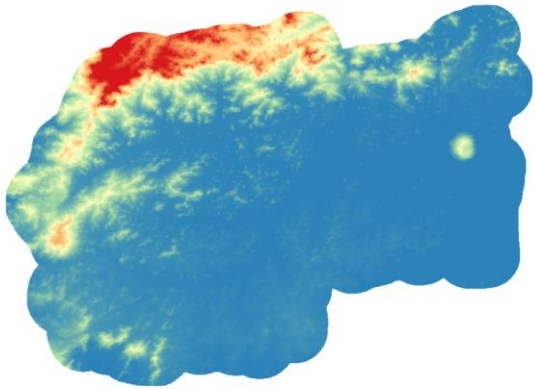
Ribeiro et al. 2017

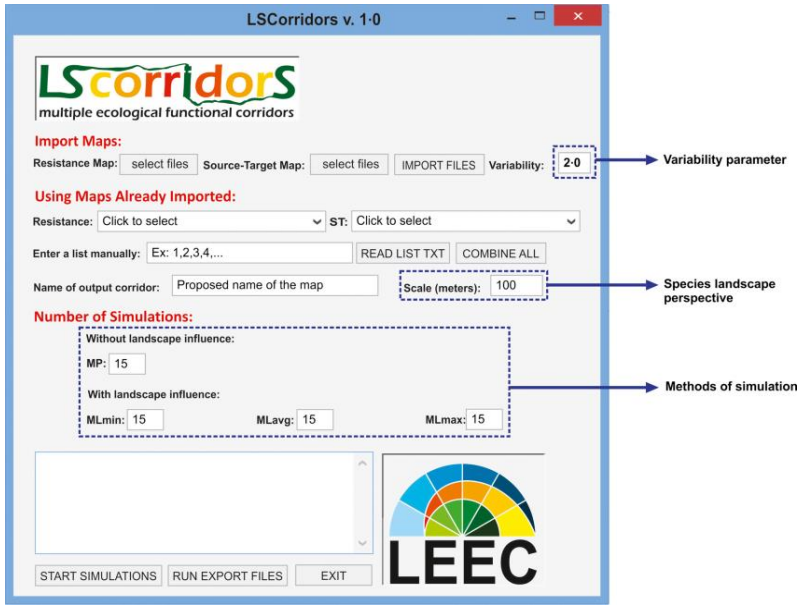


Expert knowledge



Elevation +

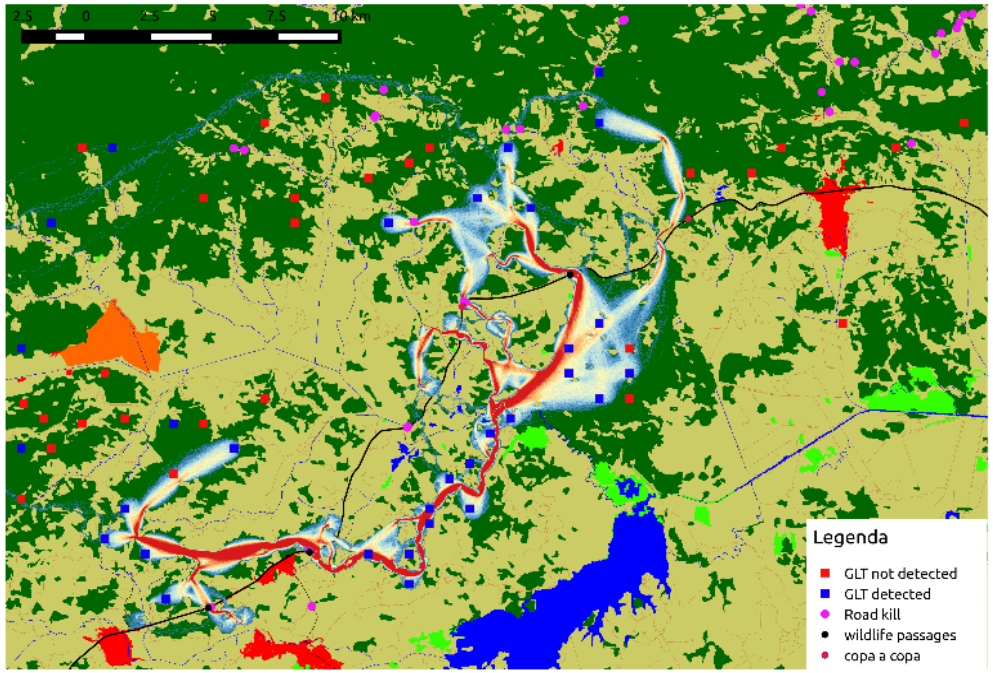


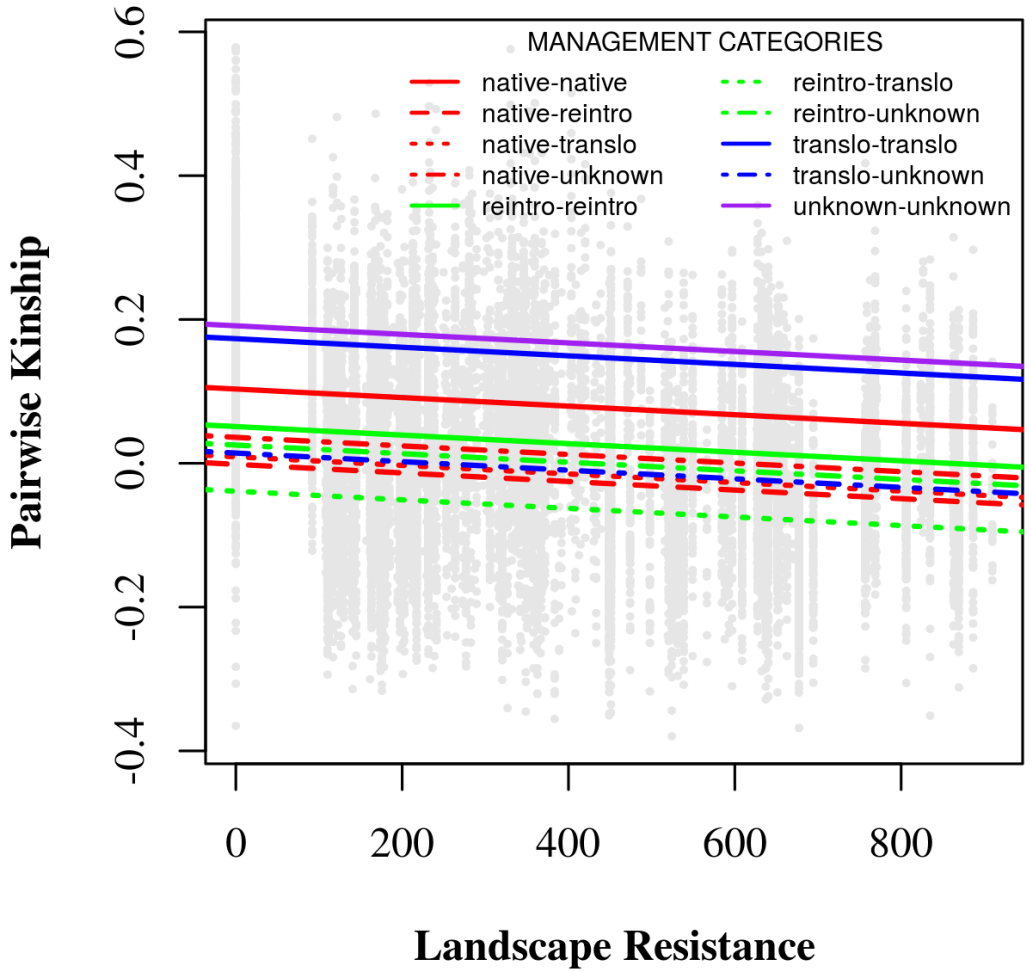


Movement meets roads

NINA

Movement meets roads

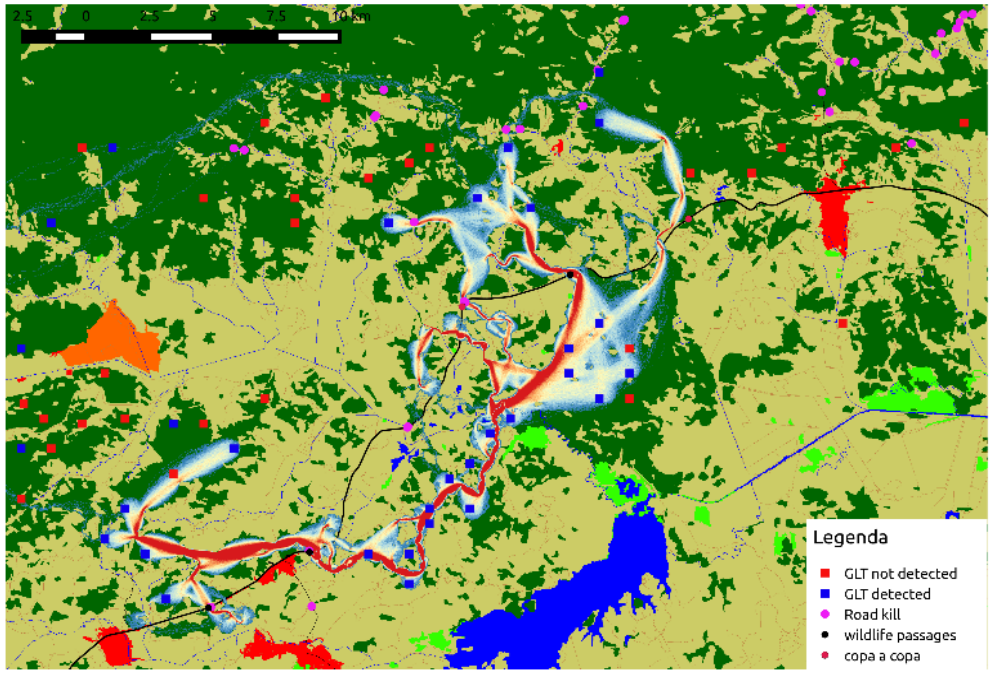


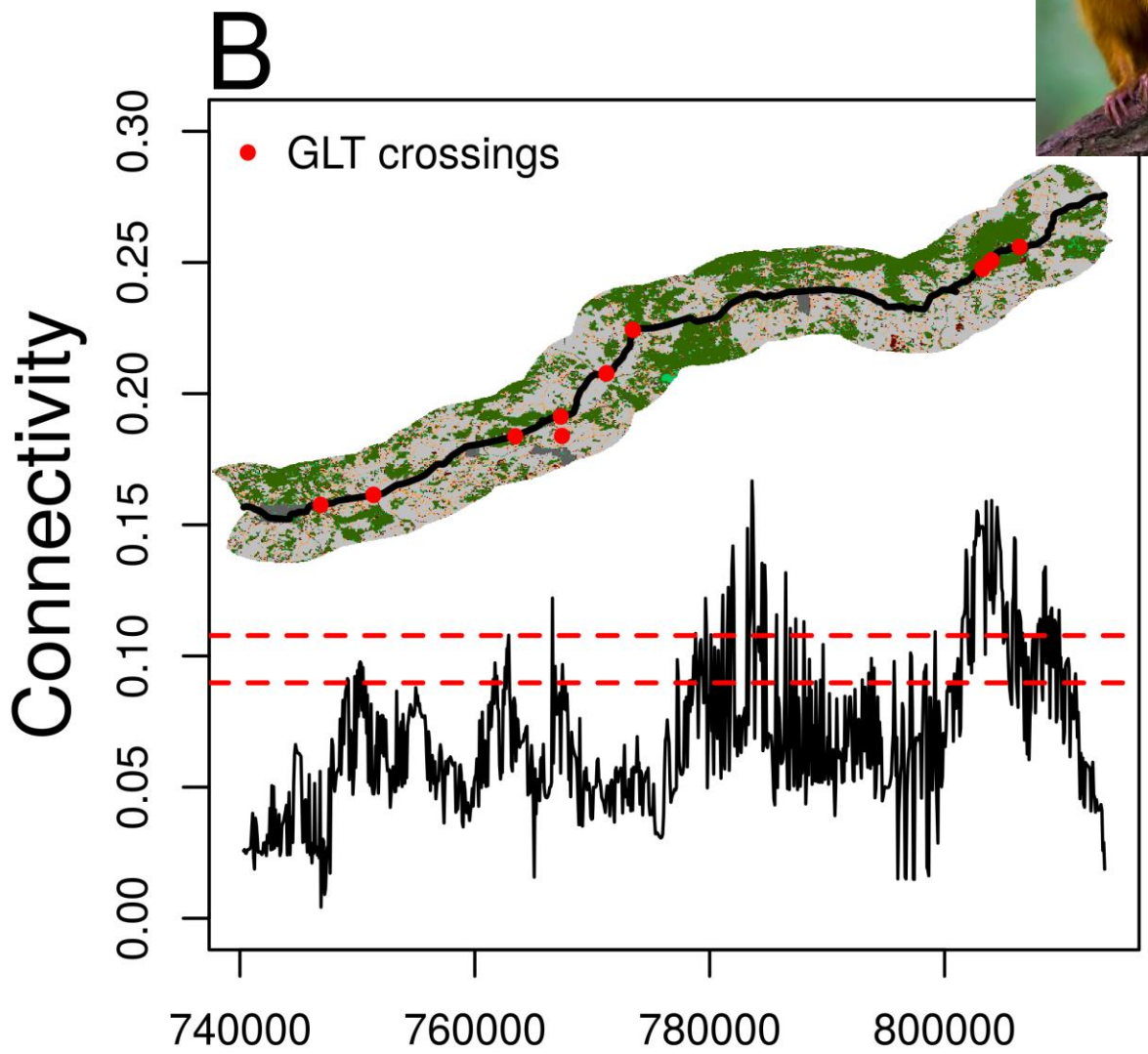


Moraes et al. 2018
Landscape genetics of GLT

NINA

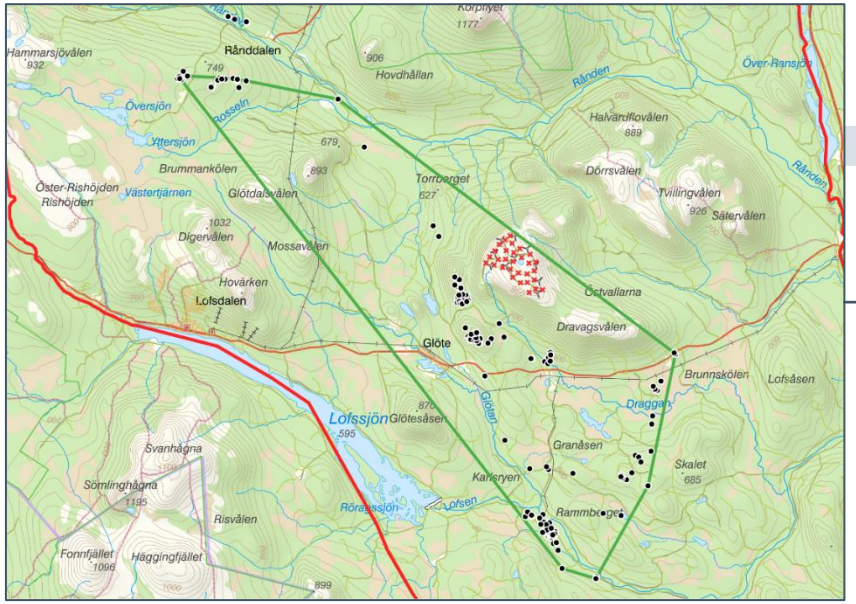
Movement meets roads



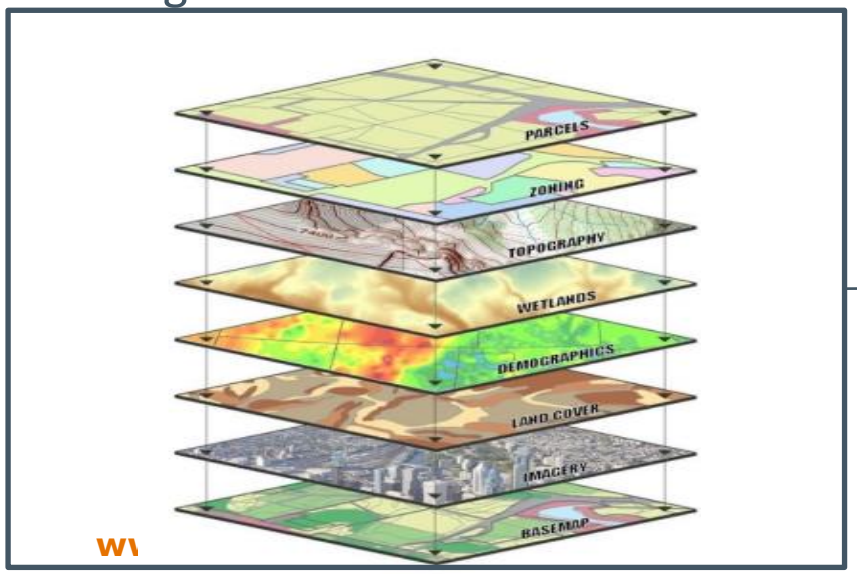


IA

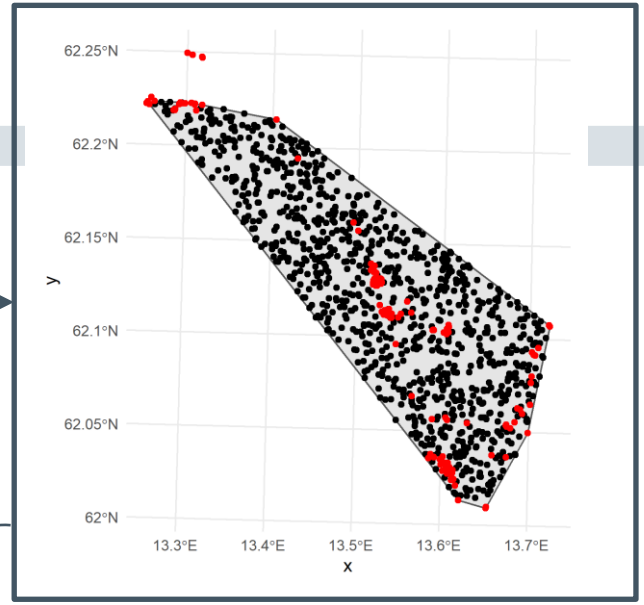
a. Animal movement (GPS) data



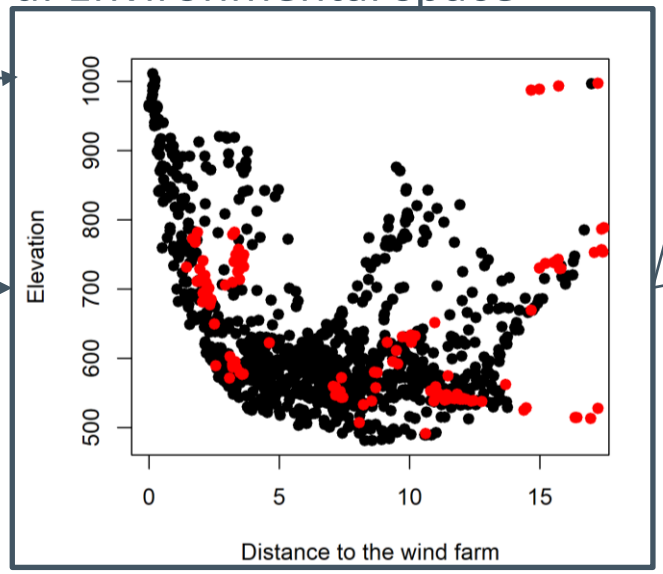
b. Background data



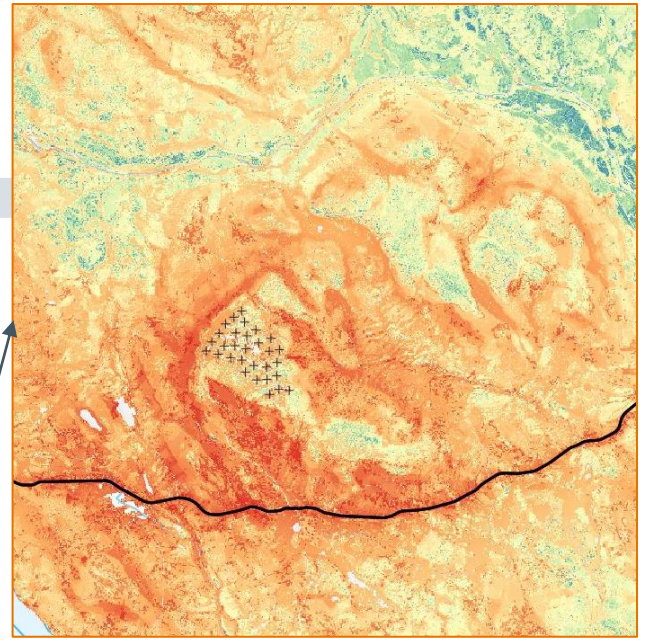
c. Use-availability design on geographical space

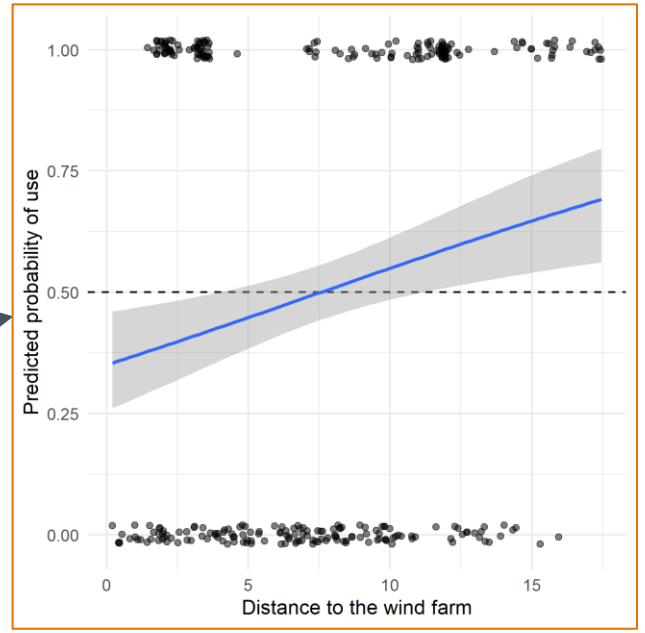


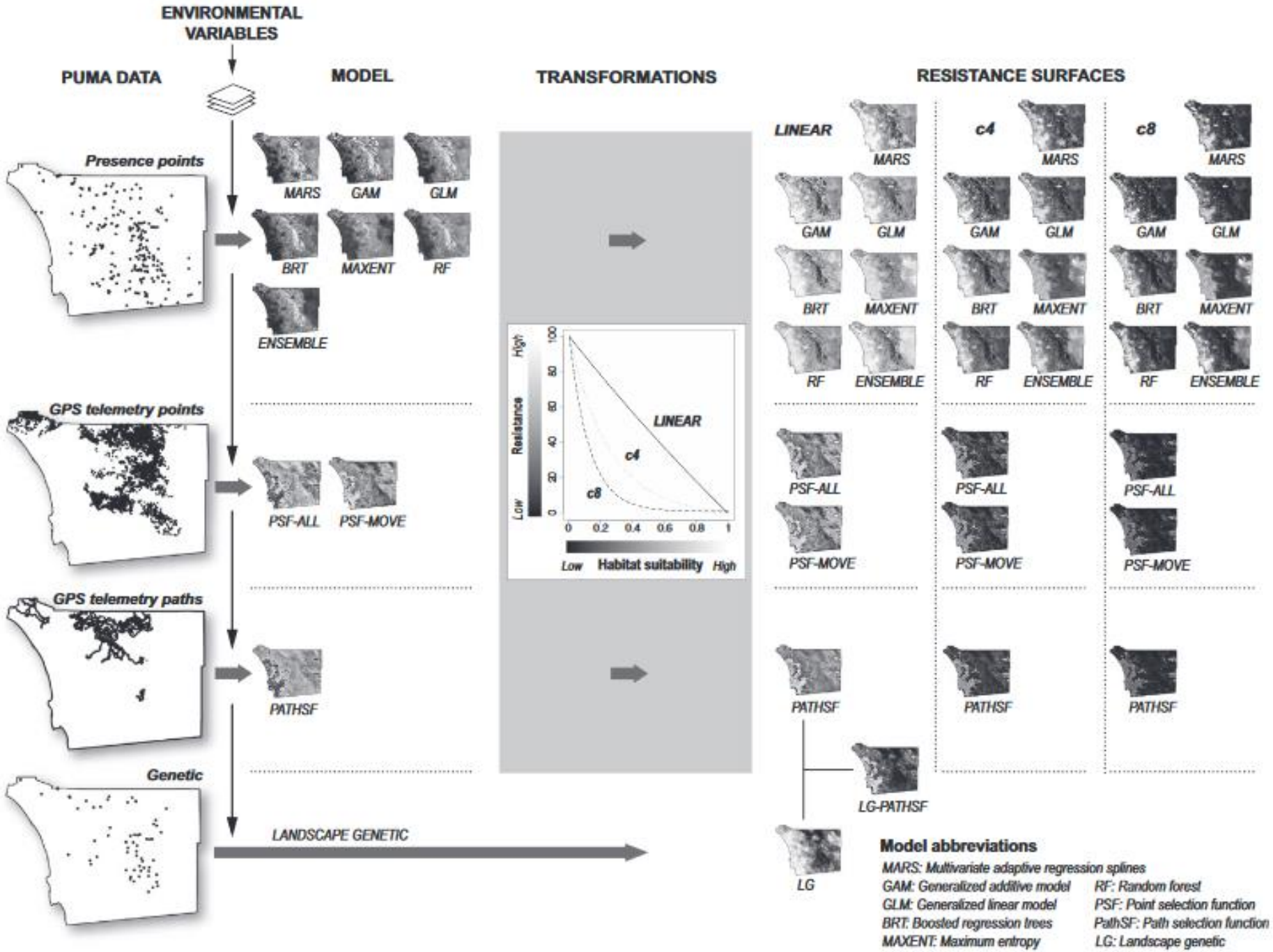
d. Environmental space



e. Predicted probability of use



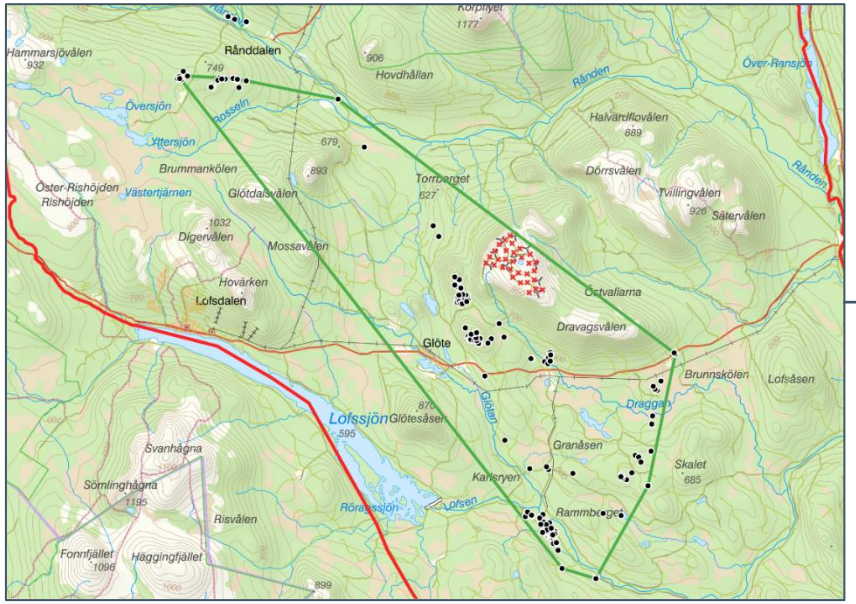




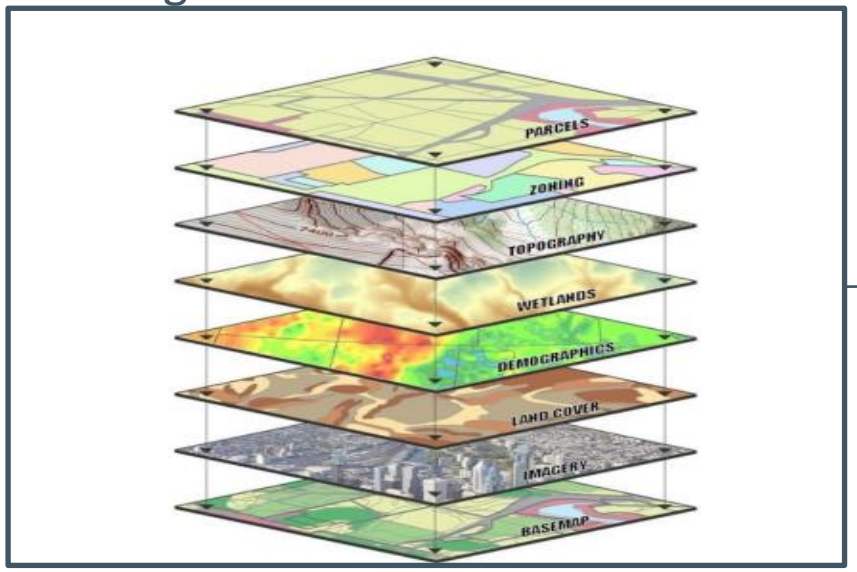
Zeller et al. 2018

NINA

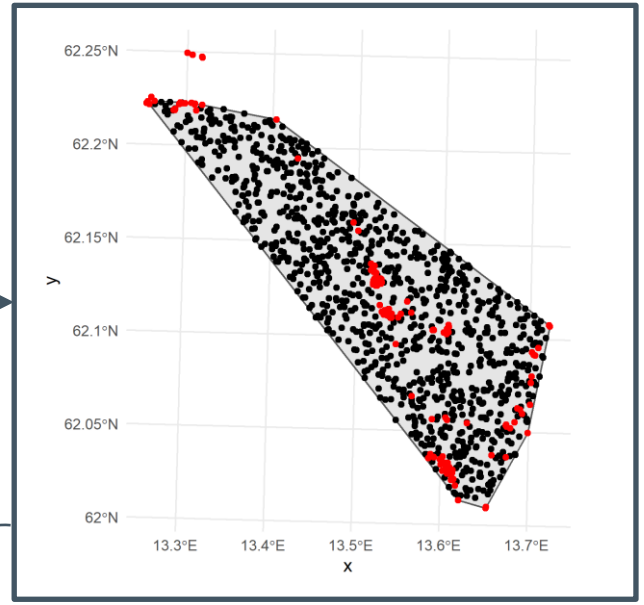
a. Animal movement (GPS) data



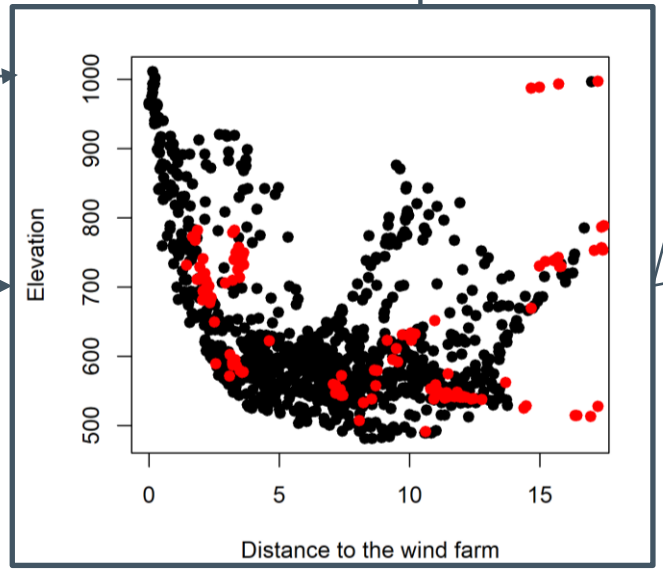
b. Background data



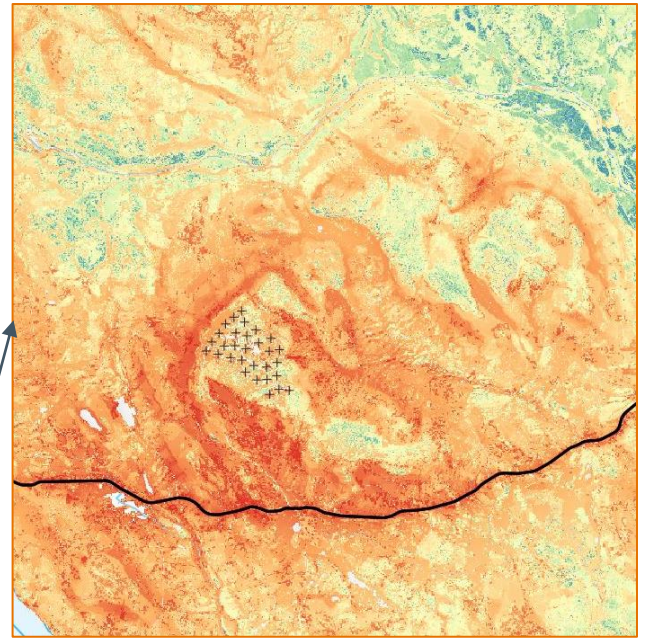
c. Use-availability design on geographical space

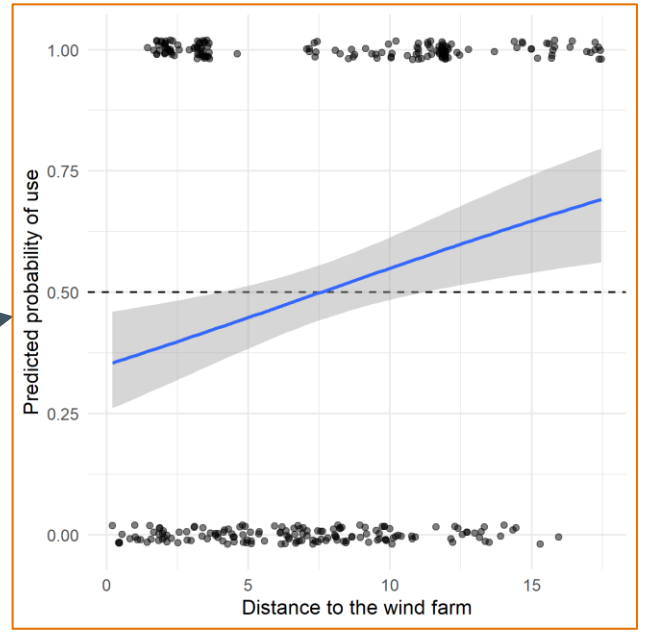


d. Environmental space



e. Predicted probability of use





Habitat functionality: beyond Habitat suitability

PIXEL FOCUS (ENVIRONMENTAL SPACE)

DATA

Species	Habitat	Climate - weather	Land use & infrastructures	Biotic interactions
• Locations	• Vegetation	• T, precipitation	• Road, railway, forestry	• Competition
• Movements	• Topography	• Icing	• Renewable energy	• Predation
• Life history	• Trophic res..	• Extreme events...	• Tourism..	• Parasites..

HABITAT QUALITY

Panzacchi et al 2022
Van Moorter et al 2021
Van Moorter et al 2023a,b

Habitat functionality: beyond Habitat suitability

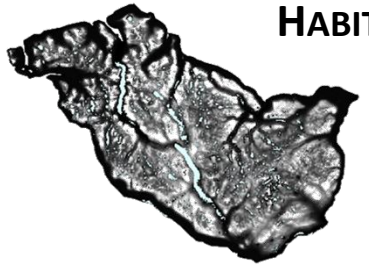
PIXEL FOCUS (ENVIRONMENTAL SPACE)

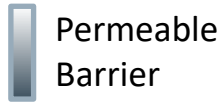
DATA

Species	Habitat	Climate - weather	Land use & infrastructures	Biotic interactions
• Locations	• Vegetation	• T, precipitation	• Road, railway, forestry	• Competition
• Movements	• Topography	• Icing	• Renewable energy	• Predation
• Life history	• Trophic res..	• Extreme events...	• Tourism..	• Parasites..

HABITAT QUALITY

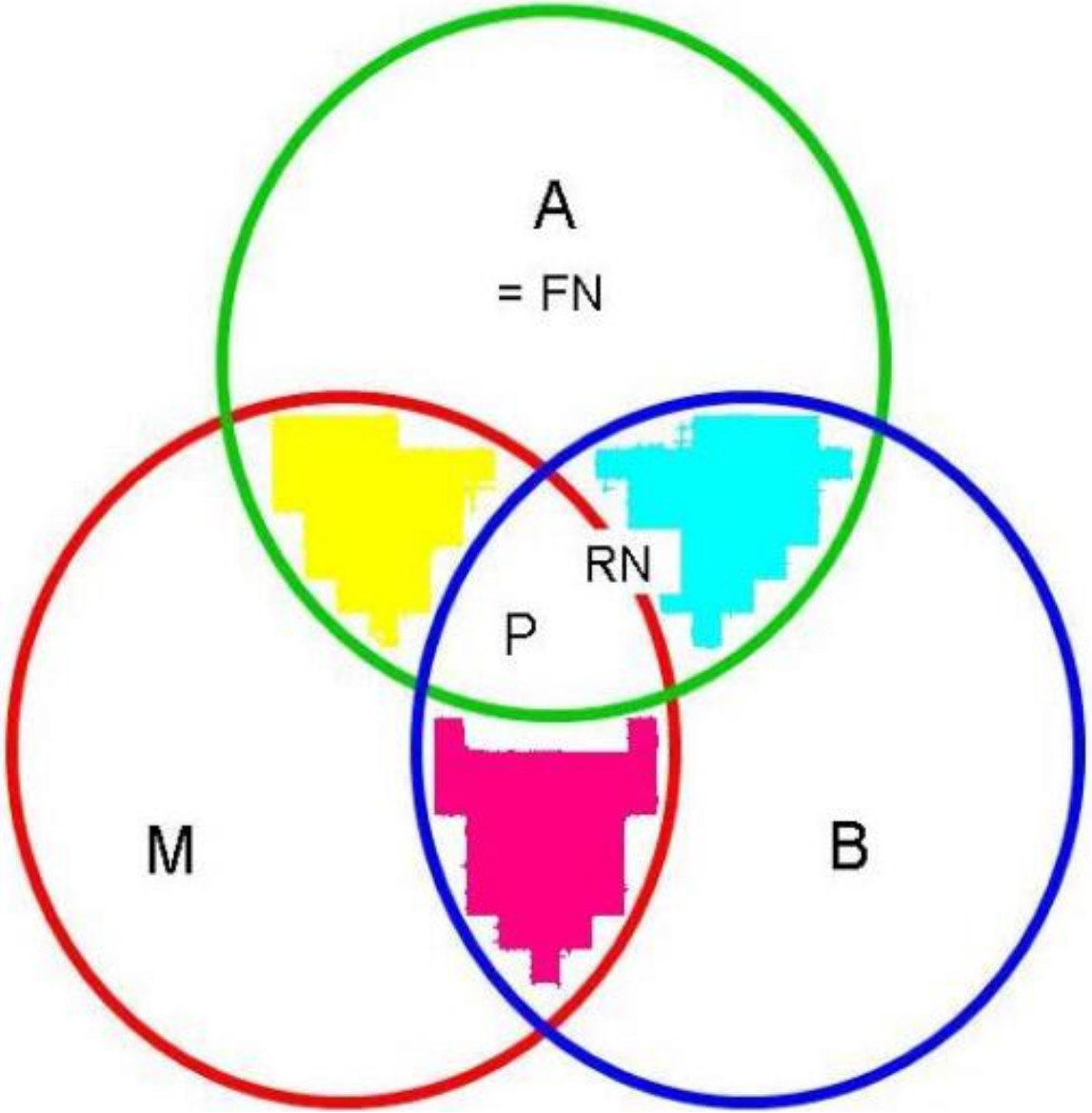
HABITAT PERMEABILITY



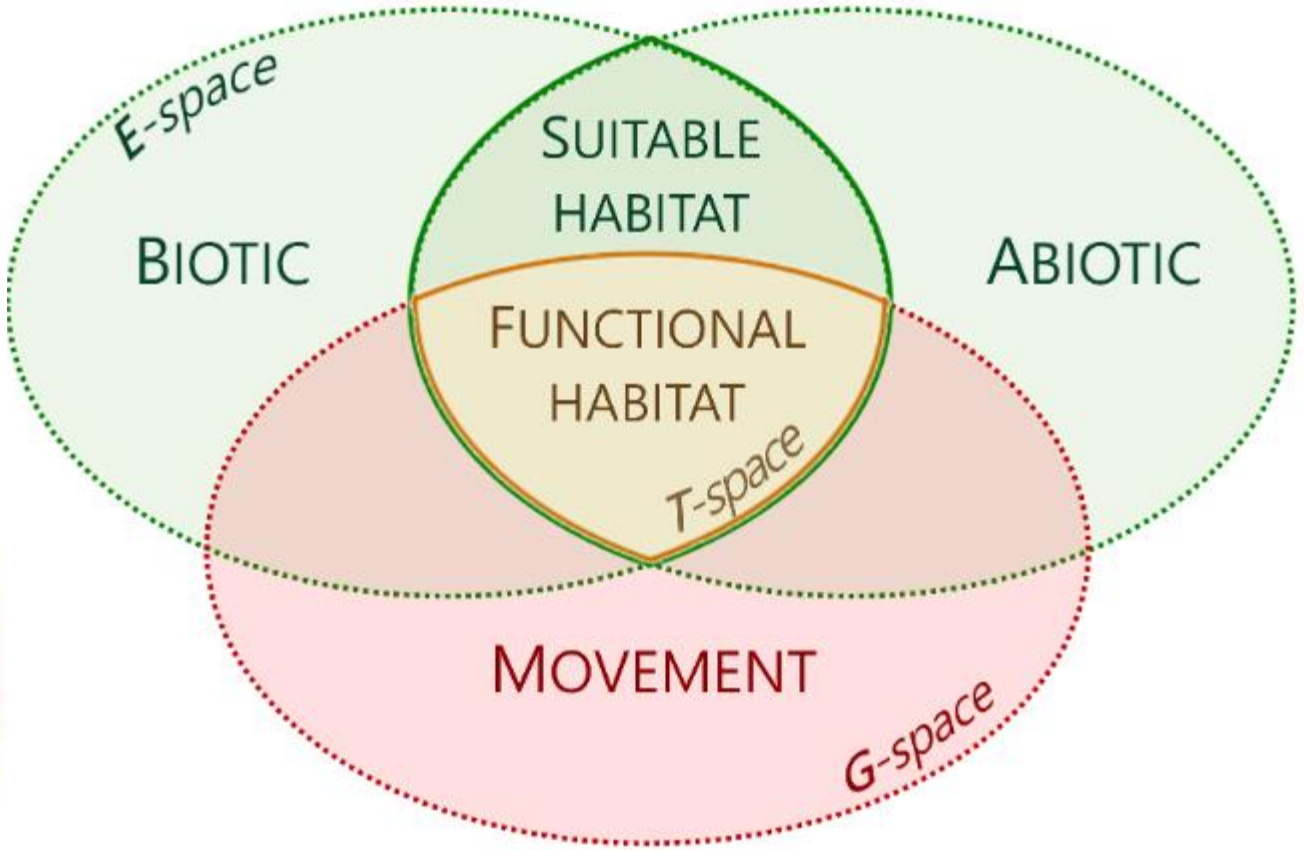


Panzacchi et al 2022
Van Moorter et al 2021
Van Moorter et al 2023a,b

Habitat functionality: beyond Habitat suitability



Soberón & Peterson 2005



Van Moorter et al 2023b

HABITAT FUNCTIONALITY: BEYOND HABITAT SUITABILITY

PIXEL FOCUS (ENVIRONMENTAL SPACE)

DATA

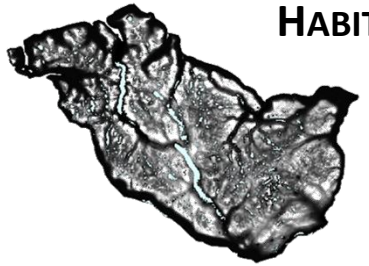
SPECIES	HABITAT	CLIMATE - WEATHER	LAND USE & INFRASTRUCTURES	BIOTIC INTERACTIONS
• Locations	• Vegetation	• T, precipitation	• Road, railway, forestry	• Competition
• Movements	• Topography	• Icing	• Renewable energy	• Predation
• Life history	• Trophic res..	• Extreme events...	• Tourism..	• Parasites..

HABITAT QUALITY

Preferred

Avoided

HABITAT PERMEABILITY

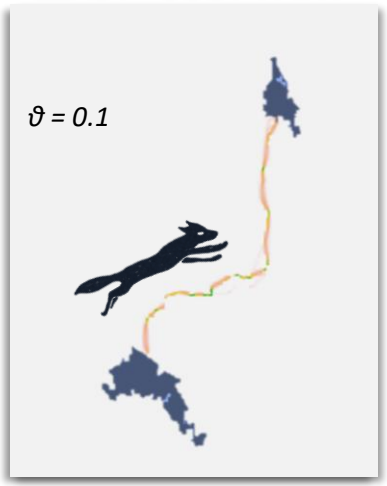


Permeable

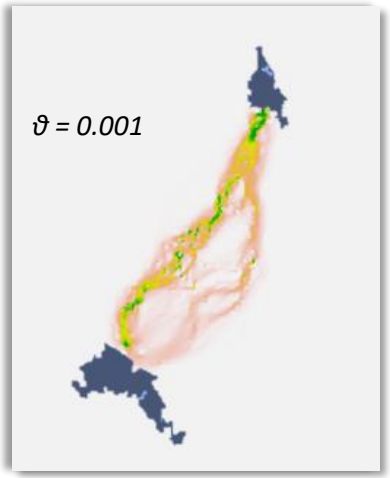
Barrier

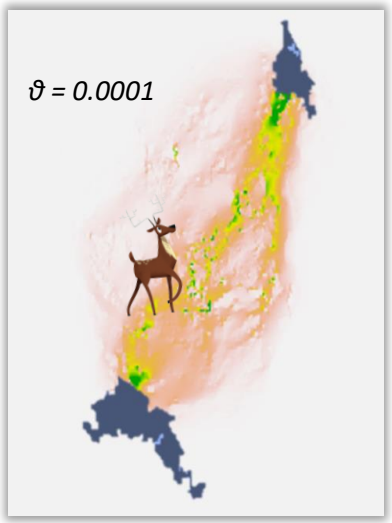
ConScape

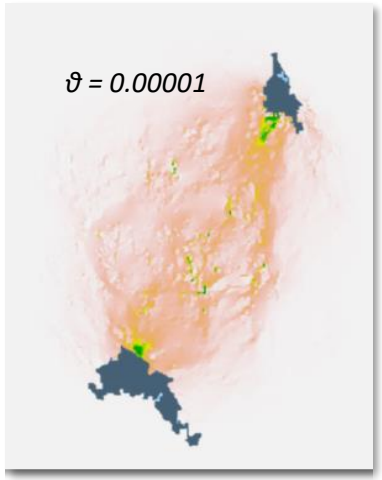
LEAST- COST PATH



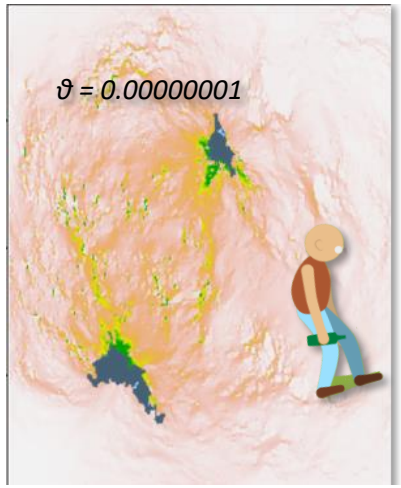
RANDOMIZED SHORTEST PATH







RANDOM WALK



Panzacchi et al 2022
Van Moorter et al 2021
Van Moorter et al 2023a,b

HABITAT FUNCTIONALITY: BEYOND HABITAT SUITABILITY

PIXEL FOCUS (ENVIRONMENTAL SPACE)

LANDSCAPE FOCUS (GEOGRAPHIC SPACE)

DATA

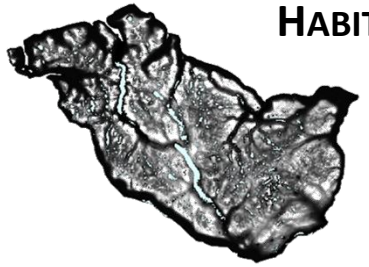
SPECIES	HABITAT	CLIMATE - WEATHER	LAND USE & INFRASTRUCTURES	BIOTIC INTERACTIONS
• Locations	• Vegetation	• T, precipitation	• Road, railway, forestry	• Competition
• Movements	• Topography	• Icing	• Renewable energy	• Predation
• Life history	• Trophic res..	• Extreme events...	• Tourism..	• Parasites..

HABITAT QUALITY

Preferred

Avoided

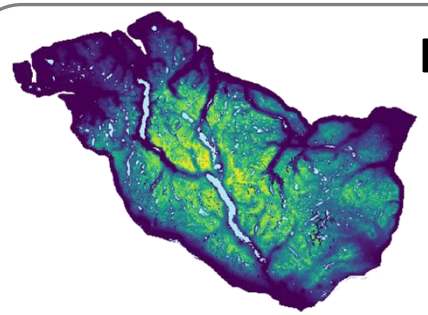
HABITAT PERMEABILITY



Permeable

Barrier

HABITAT FUNCTIONALITY



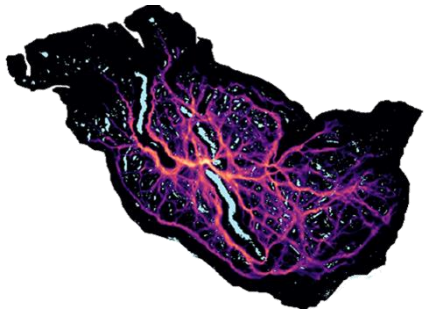
High (preferred and well connected)

Low (low quality &/or inaccessible)

MOVEMENT FLOW

High (movement hub, "traffic-jam")

Low

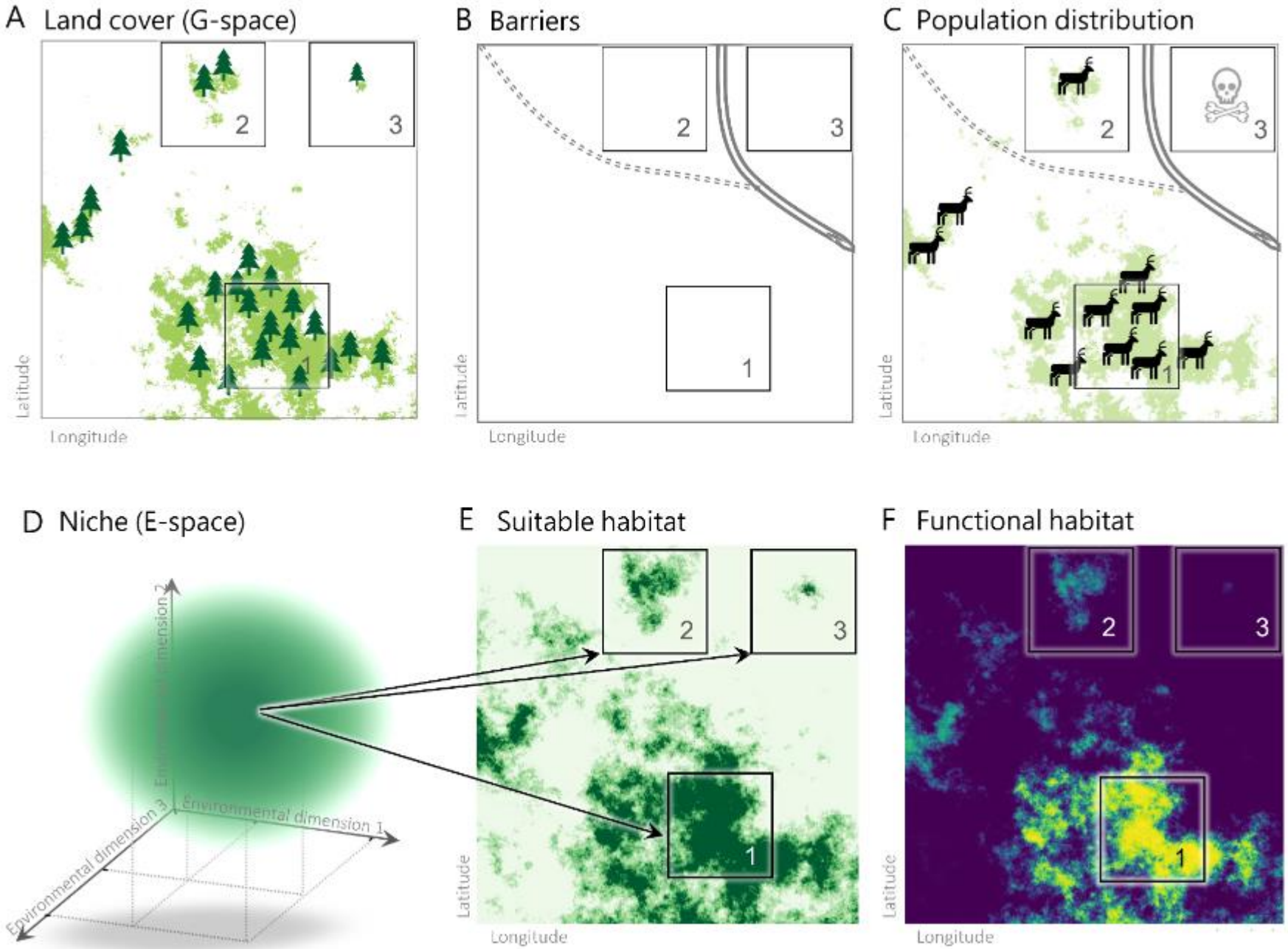


AID SUSTAINABLE LAND PLANNIG:

- *Scenario analyses:* quantify impact of changes in the landscape/climate
- Identify priority areas for conservation (zonation)

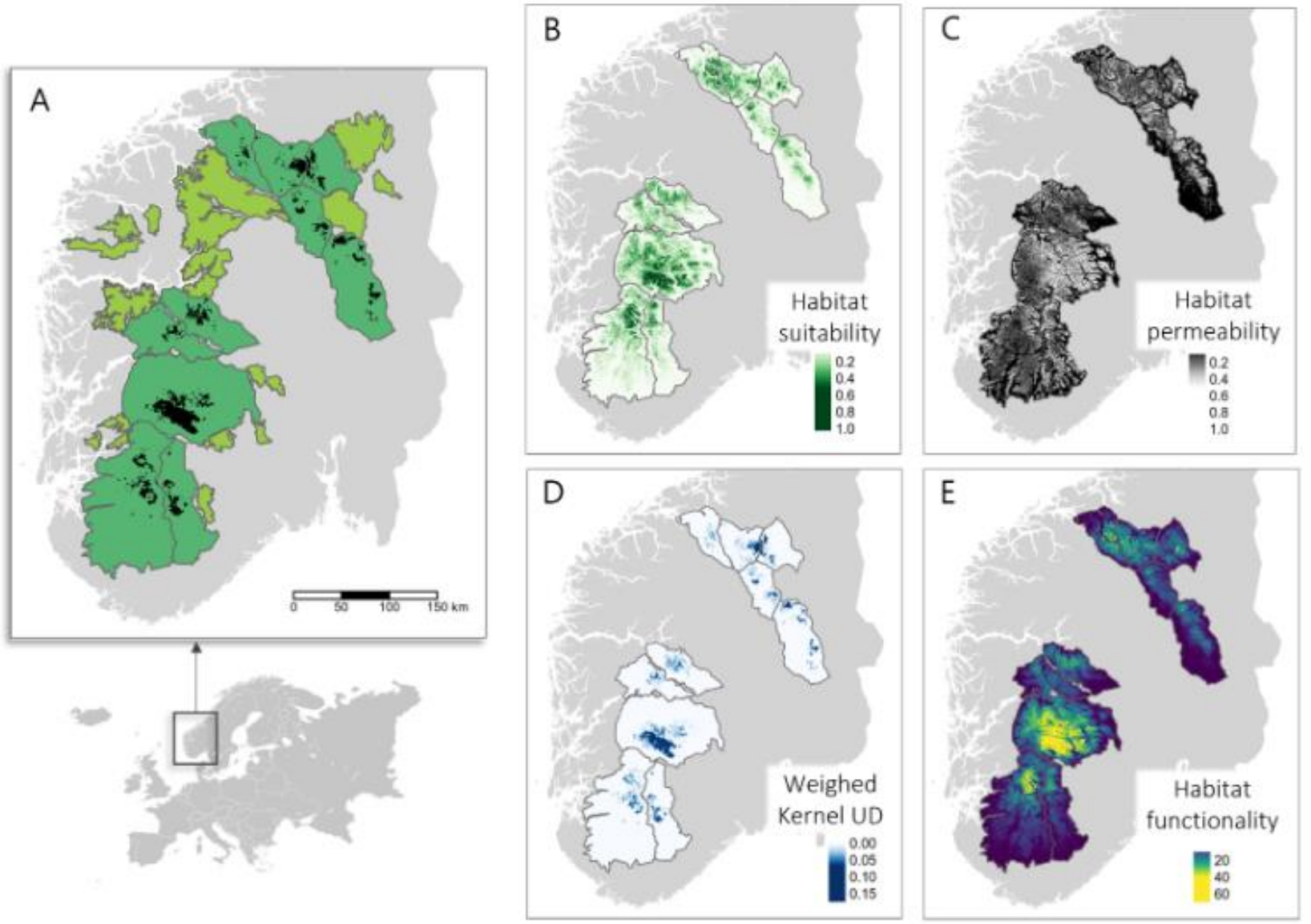
Panzacchi et al 2022
Van Moorter et al 2021
Van Moorter et al 2023a,b

Habitat functionality: beyond Habitat suitability



Van Moorter et al 2023b

Habitat functionality: beyond Habitat suitability



Van Moorter et al 2023b

Connectivity modeling tools

- R: leastcostpath package
- GRASS GIS/Python: LSCorridors
- Julia:
  - Circuitscape
  - ConScape

Literature

- Auffret, A. G., Plue, J., & Cousins, S. A. O. (2015). The spatial and temporal components of functional connectivity in fragmented landscapes. AMBIO, 44(1), 51–59. https://doi.org/10.1007/s13280-014-0588-6
- Ribeiro, J. W., Silveira dos Santos, J., Dodonov, P., Martello, F., Brandão Niebuhr, B., & Ribeiro, M. C. (2017). LandScape Corridors (LSCorridors): A new software package for modelling ecological corridors based on landscape patterns and species requirements. Methods in Ecology and Evolution, 8(11), 1425–1432. https://doi.org/10.1111/2041-210X.12750
- Moraes, A. M., Ruiz-Miranda, C. R., Galetti Jr., P. M., Niebuhr, B. B., Alexandre, B. R., Muylaert, R. L., Grativol, A. D., Ribeiro, J. W., Ferreira, A. N., & Ribeiro, M. C. (2018). Landscape resistance influences effective dispersal of endangered golden lion tamarins within the Atlantic Forest. Biological Conservation, 224, 178–187. https://doi.org/10.1016/j.biocon.2018.05.023
- Zeller, K. A., Jennings, M. K., Vickers, T. W., Ernest, H. B., Cushman, S. A., & Boyce, W. M. (2018). Are all data types and connectivity models created equal? Validating common connectivity approaches with dispersal data. *Diversity and Distributions*, *24*(7), 868–879. https://doi.org/10.1111/ddi.12742
- Van Moorter, B., Kivimäki, I., Panzacchi, M., & Saerens, M. (2021). Defining and quantifying effective connectivity of landscapes for species' movements. Ecography, 44(6), 870–884. https://doi.org/10.1111/ecog.05351
- Van Moorter, B., Kivimäki, I., Noack, A., Devooght, R., Panzacchi, M., Hall, K. R., Leleux, P., & Saerens, M. (2023). Accelerating advances in landscape connectivity modelling with the ConScape library. Methods in Ecology and Evolution, 14(1), 133–145. https://doi.org/10.1111/2041-210X.13850
- Van Moorter, B., Kivimäki, I., Panzacchi, M., Saura, S., Brandão Niebuhr, B., Strand, O., & Saerens, M. (2023). Habitat functionality: Integrating environmental and geographic space in niche modeling for conservation planning. Ecology, n/a(n/a), e4105. https://doi.org/10.1002/ecy.4105

NINA

Cooperation and expertise for a sustainable future

Bernardo Brandão Niebuhr
bernardo.brandao@nina.no

NINA