Grey and Red squirrel Least Cost Pathway in Kielder Forest

A Machine Learning and GIS-Based approach

LIFE14 NAT/UK/000467

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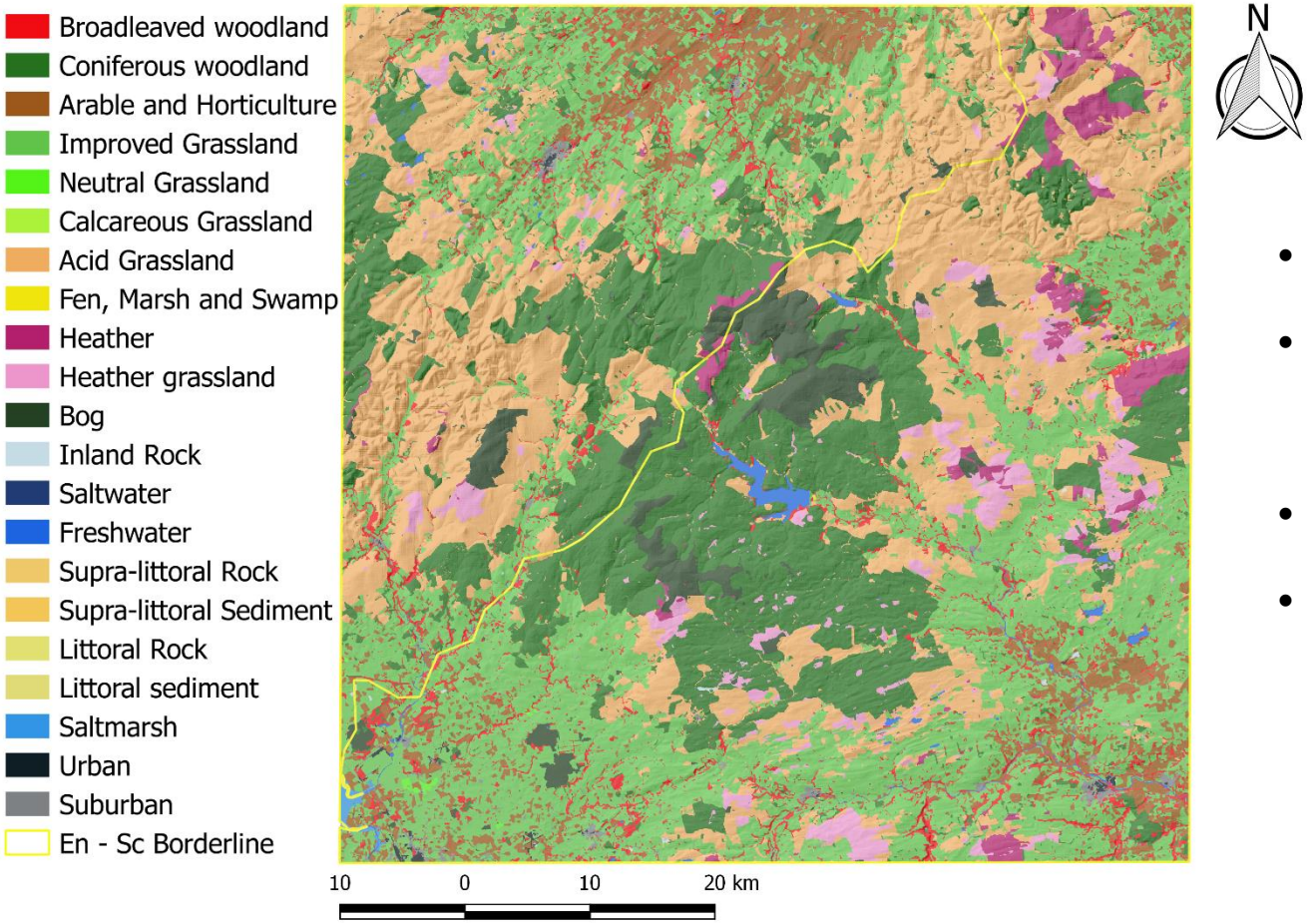
Study area: Kielder Forest

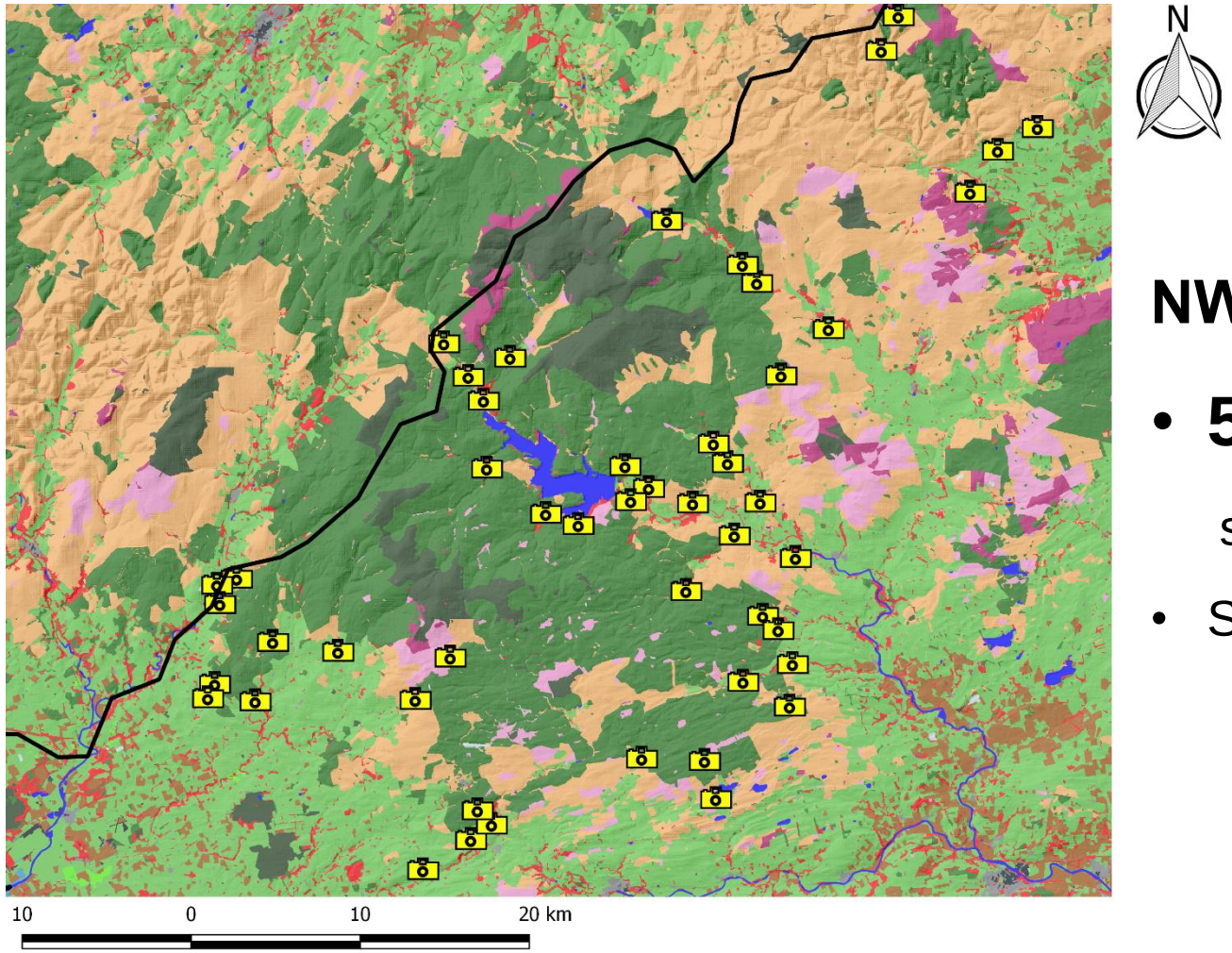
Land Cover Map 2015



- **LCM 2015** classification at 25m resolution
- Largest Human-made woodland complex in England

  ca. 80% Conifer: mainly Sitka and Norway Spruce
- High landscape fragmentation and hetereogeneity
- **Patchy landscape**

Camera Traps Network



NWT's Early Warning Detection System

- **50** Camera Traps across Kielder Forest since 2012
- Spacing configuration **based on Expert – Opinion**

Aims of the study

- Identify the **most likely routes of movements of grey and red squirrels** across North England landscape and across South of Scotland, by developing Least Cost Pathways models (LCPs)
- Evaluate the **spatial configuration** of the camera traps network in order to figure out how well the monitoring programme is working and if chances are needed
- Identify **key areas** that might me **safeguarded from invasions**
- Identify **areas** where red squirrel **conservation efforts should be focused**
- Provide maps and tools useful to inform the management strategy
- Better understanding of the landscape use for grey and red squirrels

Analytical Process

Habitat Suitability Analysis

- **MaxEnt** 3.4.1 (Phillips *et al.*, 2006)

Least Cost Pathways Models

- **UNICOR** (Landguth *et al.*, 2011)

GIS Post Processing

- **QGIS**

Maps

- **QGIS**

Machine Learning tools

GIS processing tools

Habitat Suitability Analysis

What it is?

Relationship between the occurrence record of a target species and the environment

Habitat Suitability Index : from **0** (*unsuitable habitat*) to **1** (*high suitable, optimal habitat*)

How?

MaxEnt Algorithm: Allow to compute a habitat suitability model using ***presence only data***, demographic parameter (dispersal) and the ***environmental variables*** of the place where the species has been recorded

Why MaxEnt?

Widely used and well-accepted **presence – only** modelling process

Data prepared in QGIS environment at a resolution of 25m

INPUT DATA

Red and Grey squirrel occurrence records

- RSNE annual monitoring system (2013 – 2018) - England
- NBN Atlas (2014 – 2018) - Scotland

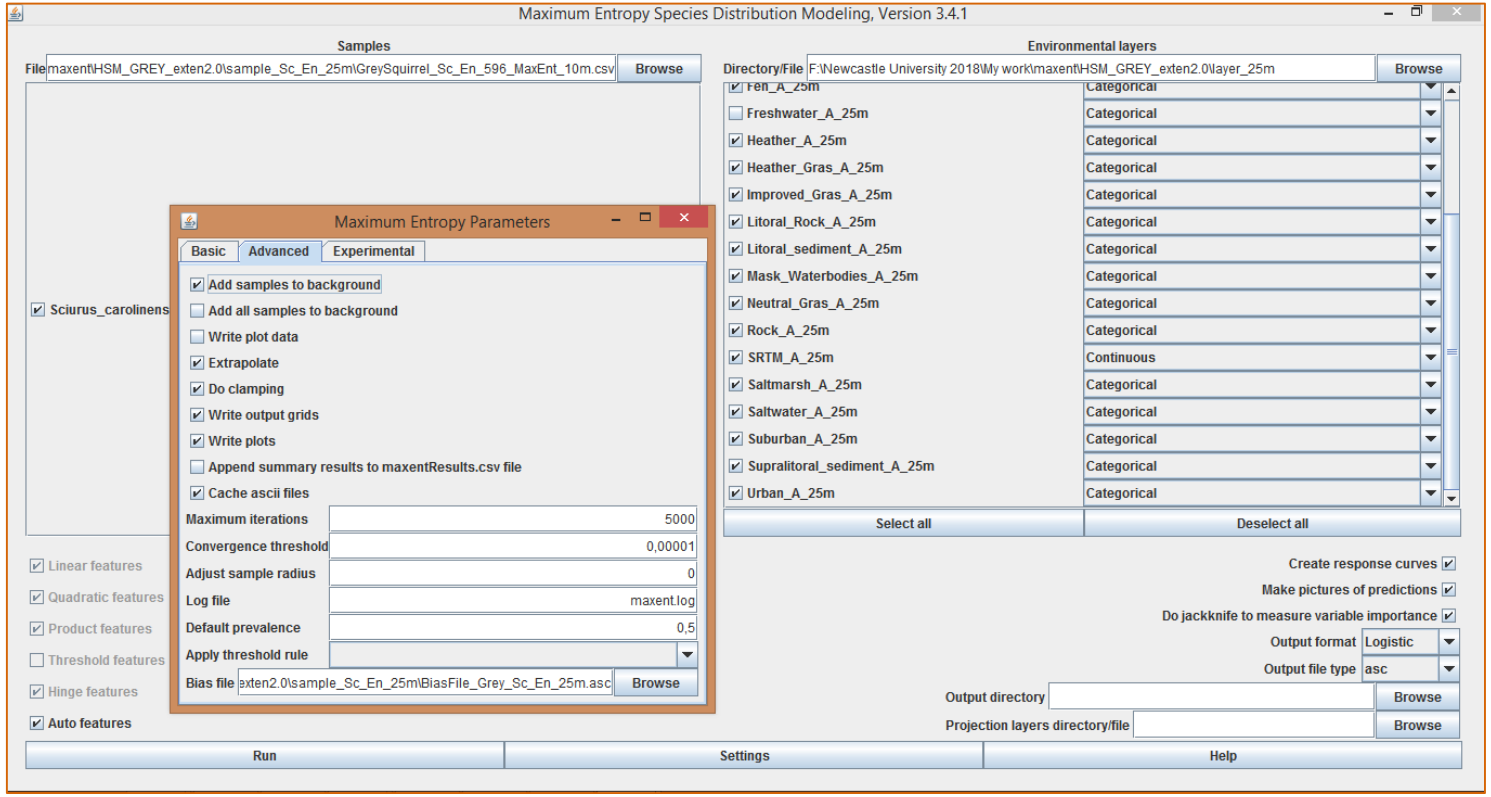
Environmental variable

- Land Cover Map 2015
- SRTM Altitude layer

Demographic parameter

- Dispersal

MaxEnt 3.4.1

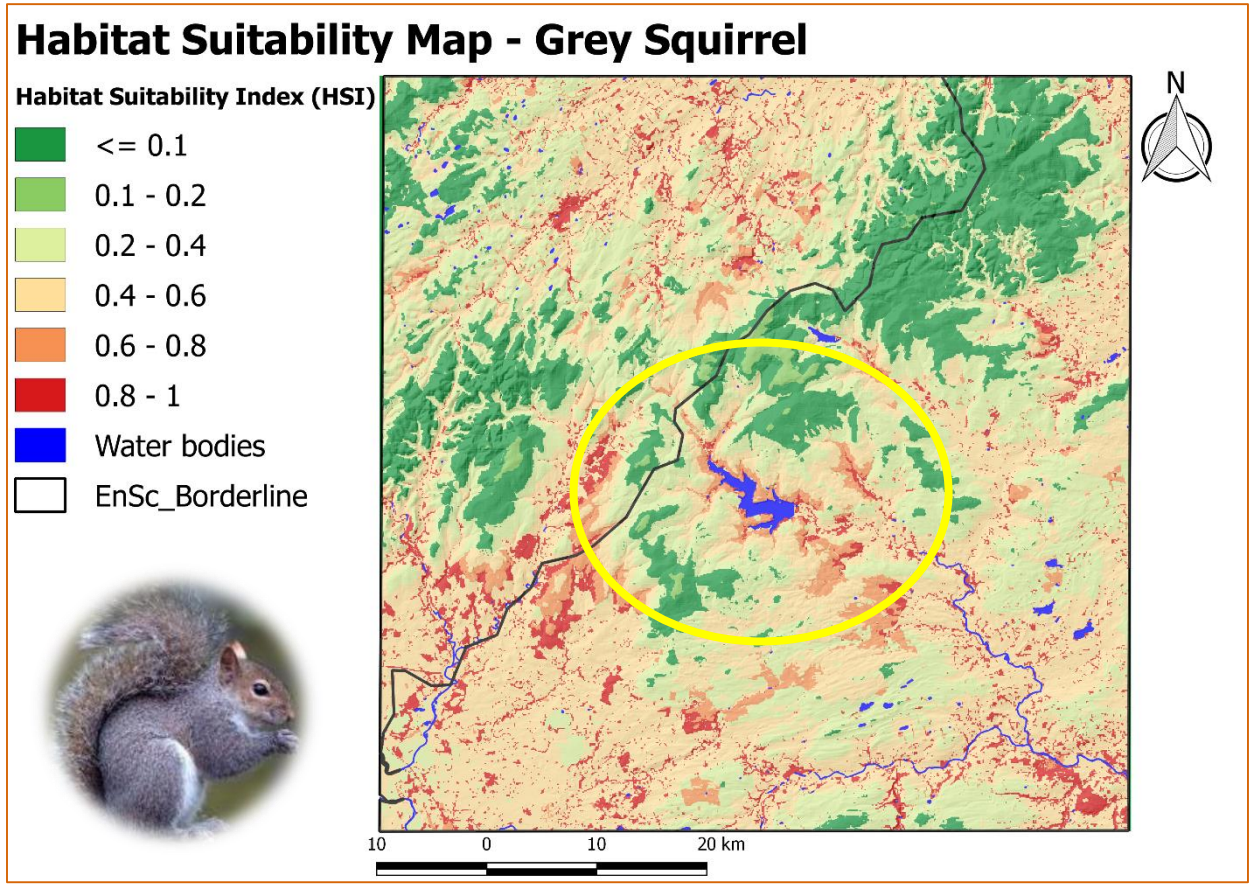


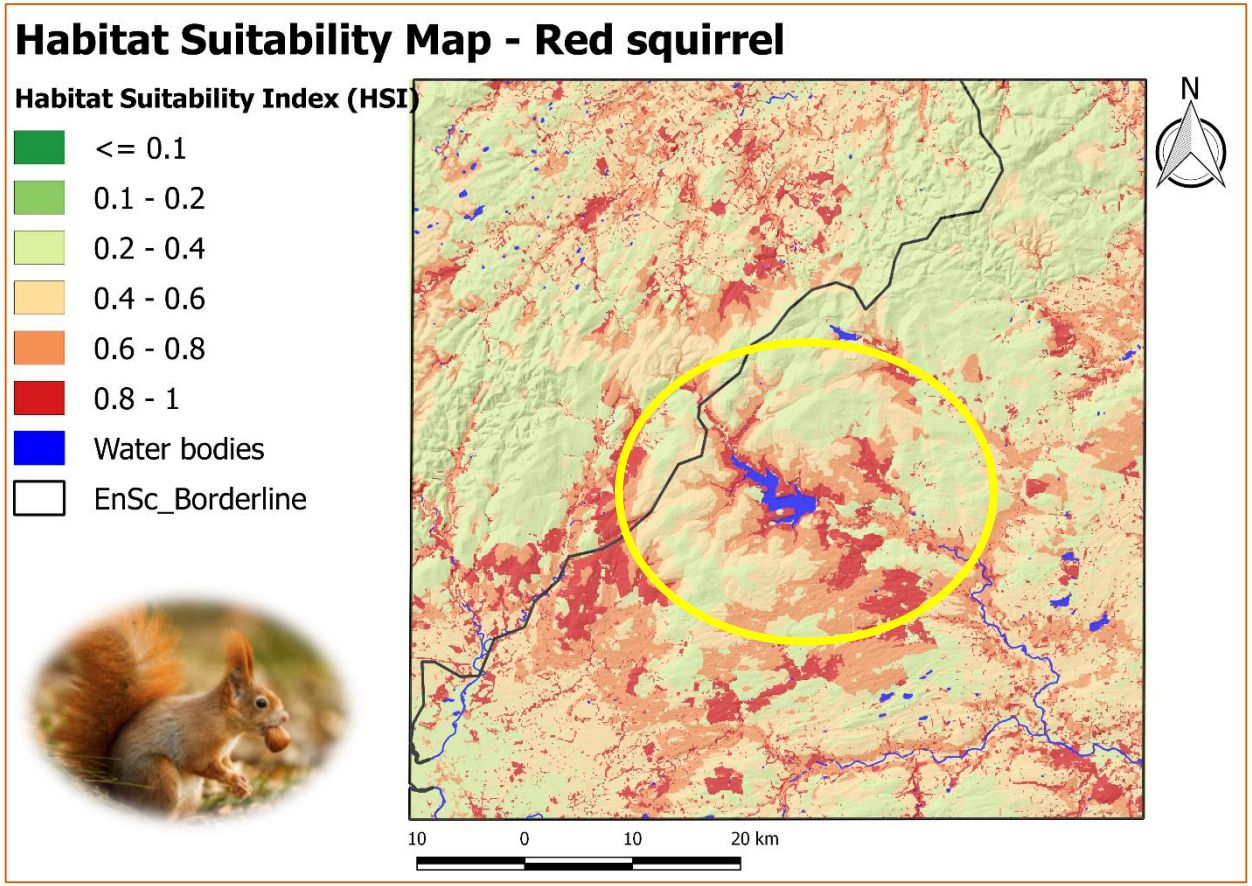
- Occurrence records
- Environmental variables
- Background data default (10.000 points)
- Number of Maximum Interaction 5000
- Bias File (Sampling bias correction)
- **Logistic Output**

HSIndex = probability of presence

(under some circumstances)

MaxEnt Outcomes





Least Cost Pathway

What it is?

Least Cost Pathway models are tools to identify the most likely used routes of a species between presence points across the landscape

Widely used as **landscape connectivity** tool, for mapping **ecological corridors** and to predict animal movements

UNICOR (Universal Corridor Network Simulator)

What it is?

Species connectivity and corridor identification tool (Landguth *et al.*, 2011)

What it does?

Compute a **single path** or **all the shorter paths** between points on a landscape, to create a **connectivity graph** which can be used to highlight:

- Least Cost Pathways
- Bottleneck
- Areas of high connectivity
- Ecological barriers

UNICOR (Universal Corridor Network Simulator)

How it works?

UNICOR requires two input files:

1. Species **presence points** (nodes) – Start and End points between paths
2. Landscape **Resistance surface**

Is a cost-surface where each pixel is given a weight (**resistance value**) which represents the “cost” of movement across that pixel

UNICOR (Universal Corridor Network Simulator)

How to get the Resistance Surface?

Habitat Suitability Index **inversely linked** to the landscape Resistance

Reciprocal Cubic Function of the Habitat Suitability Index for each pixel of the Habitat Suitability map

Higher habitat suitability values implies lower landscape resistance values and lower habitat suitability values refers to higher resistance values

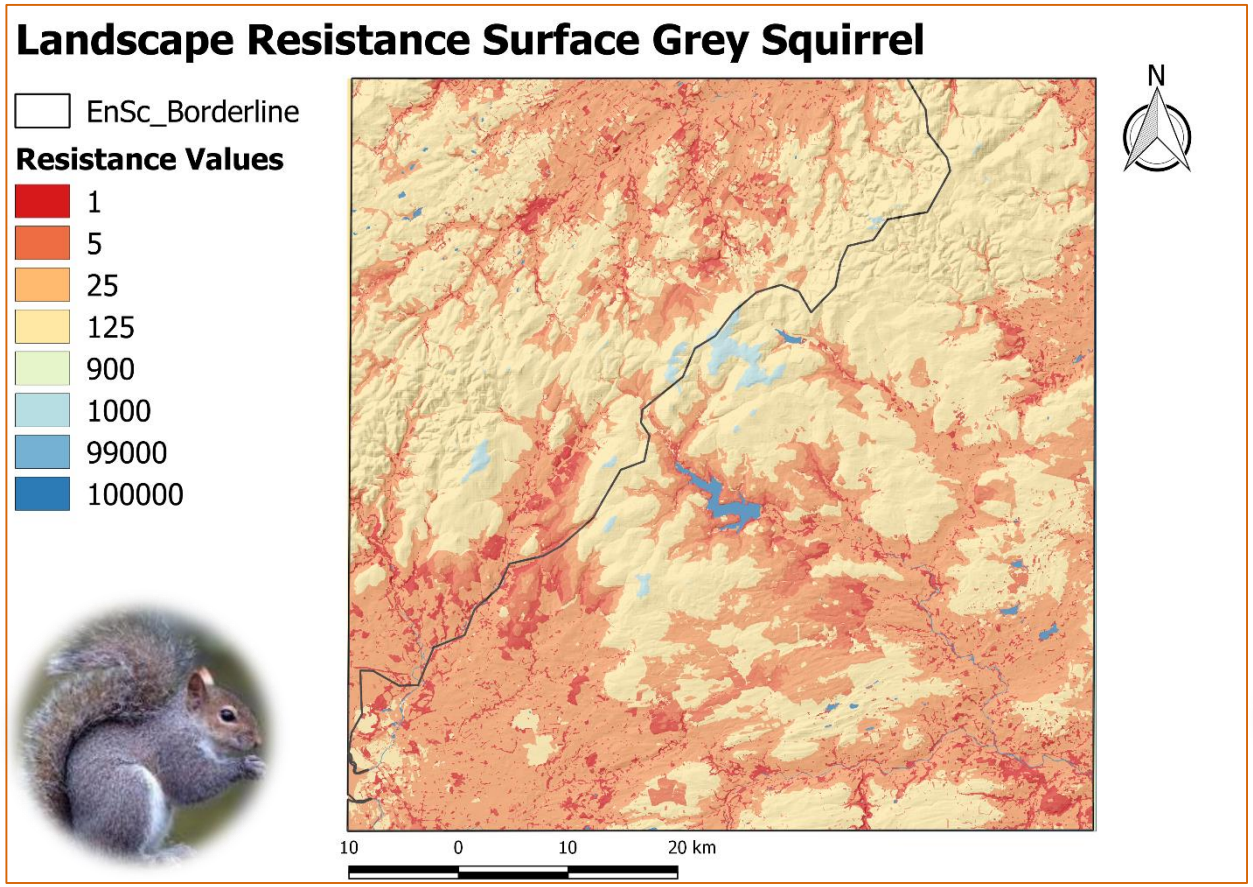
UNICOR Outcomes

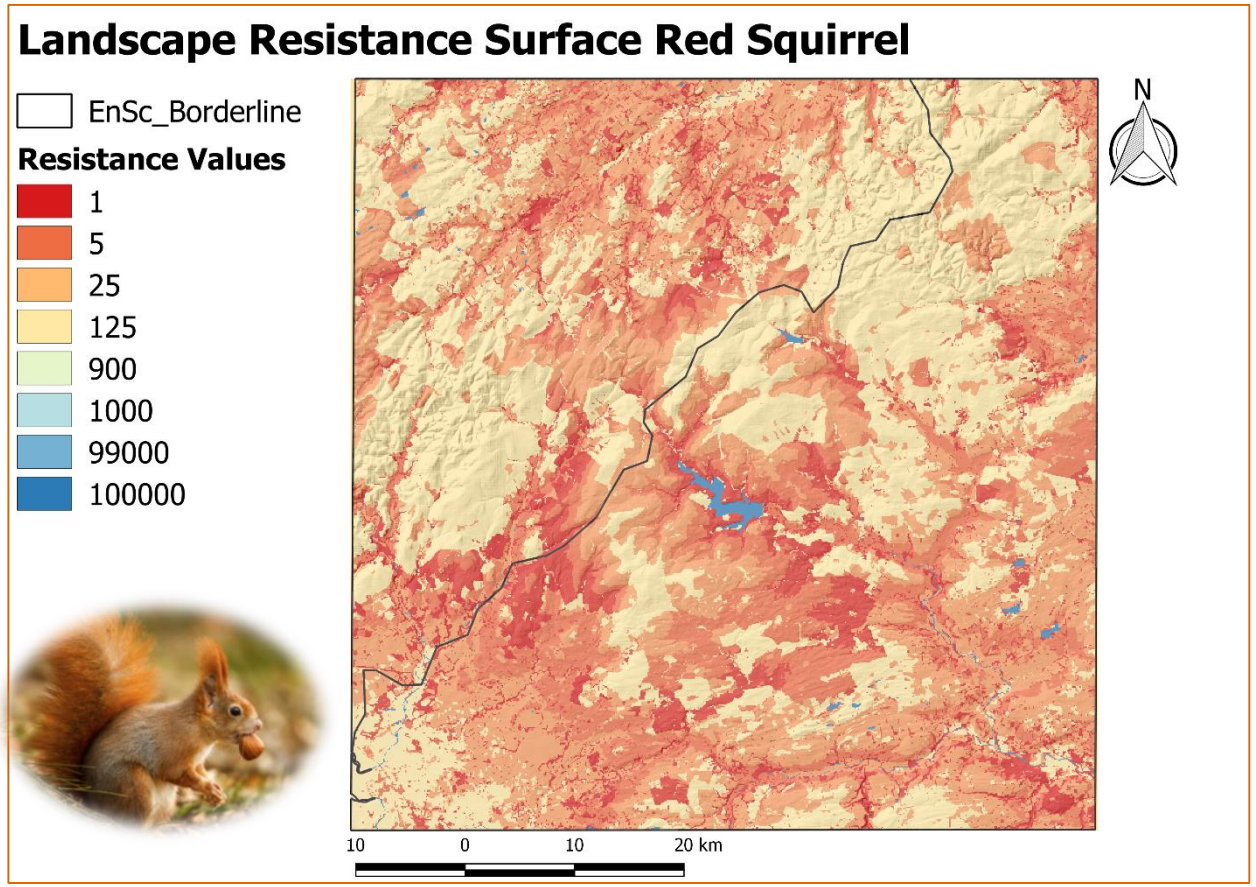
Connectivity network composed of multiple paths in which each represent a **likely corridor of movement with different strength depending on the cost of moving** within the landscape across the resistance surface

QGIS Post Processing:

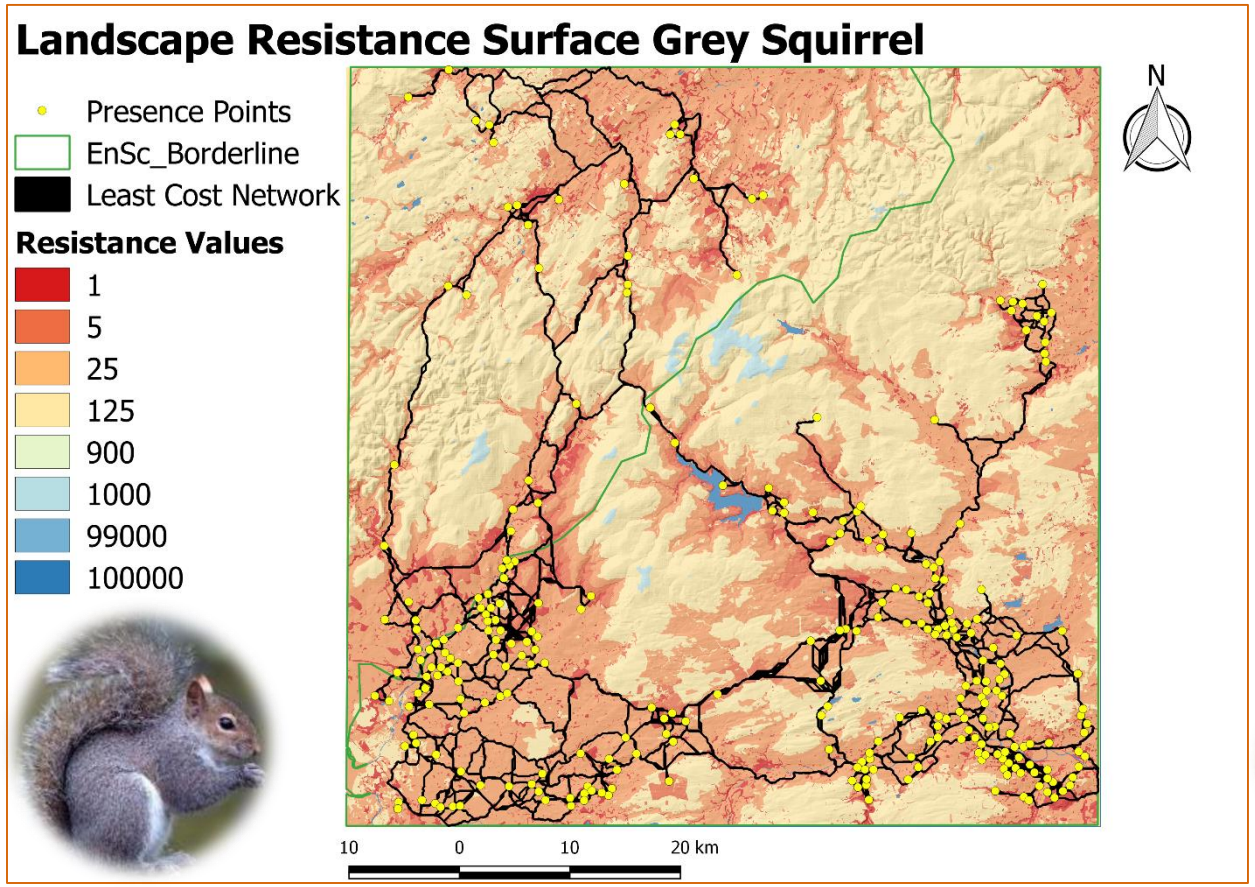
- The whole connectivity network over the Resistance surface
- The main and strongest connections
- Bottlenecks and areas of high connectivity – (Connectivity Density)
- Early warning detection system over the Least Cost Pathways map

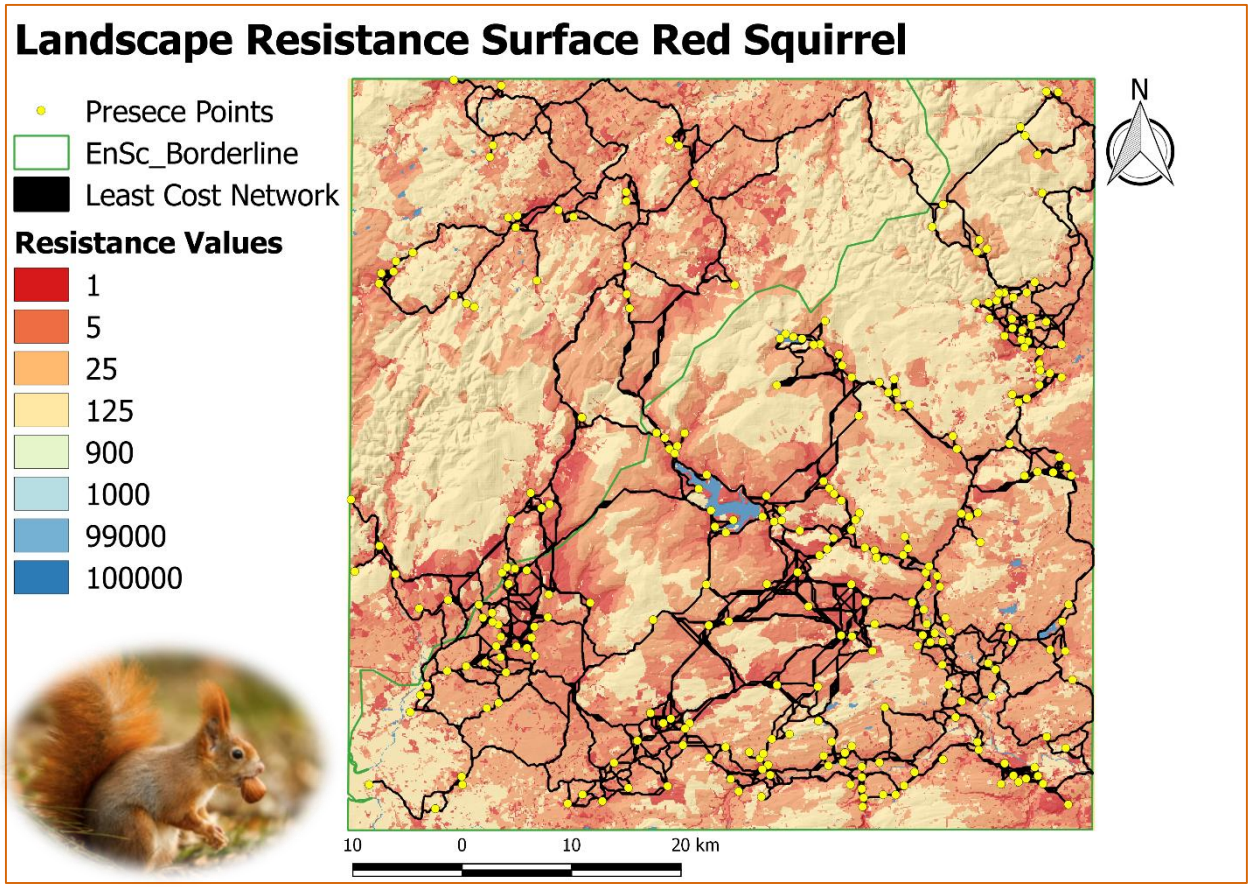
Resistance Surface



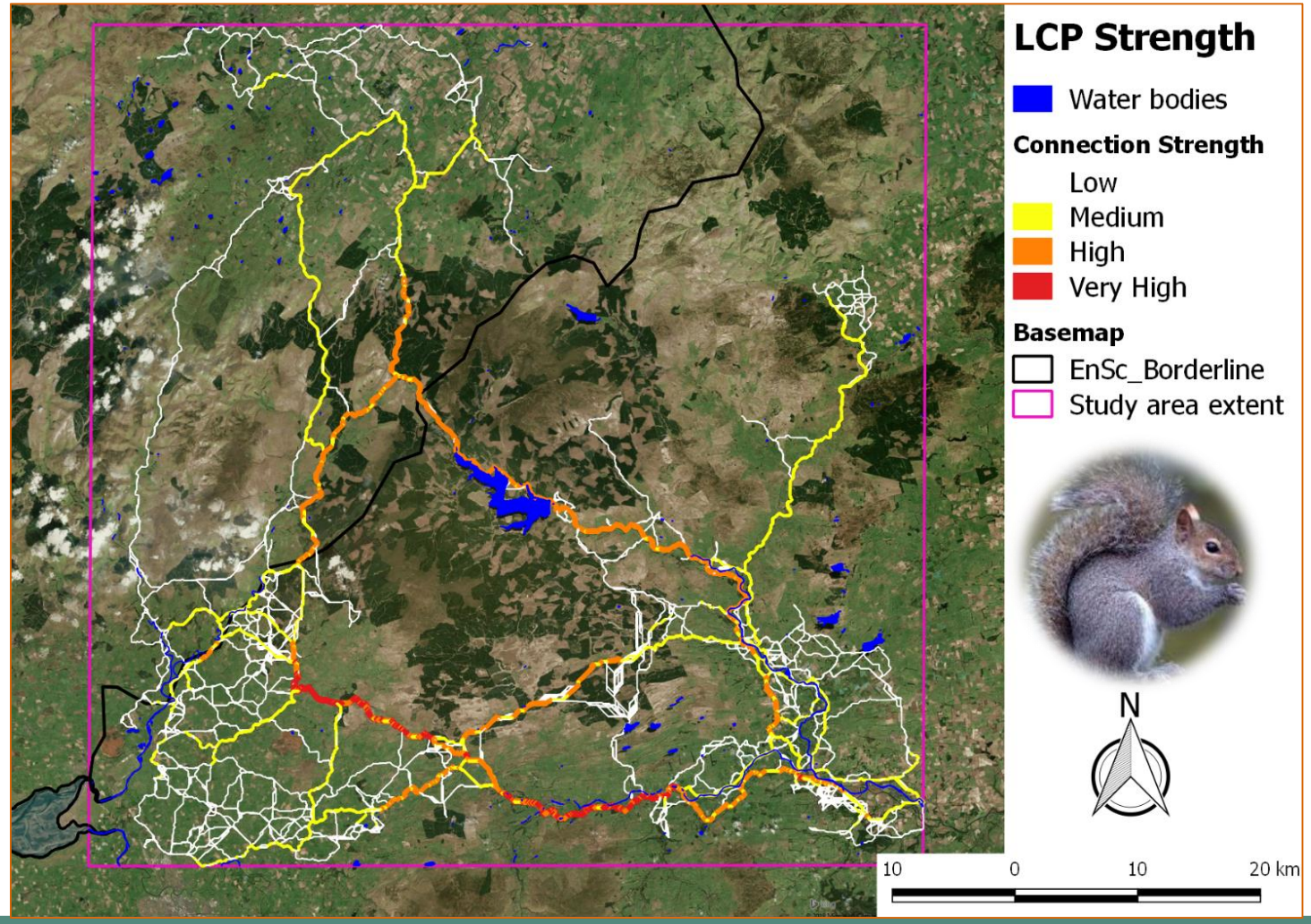


Resistance Surface





Strongest Least Cost connections



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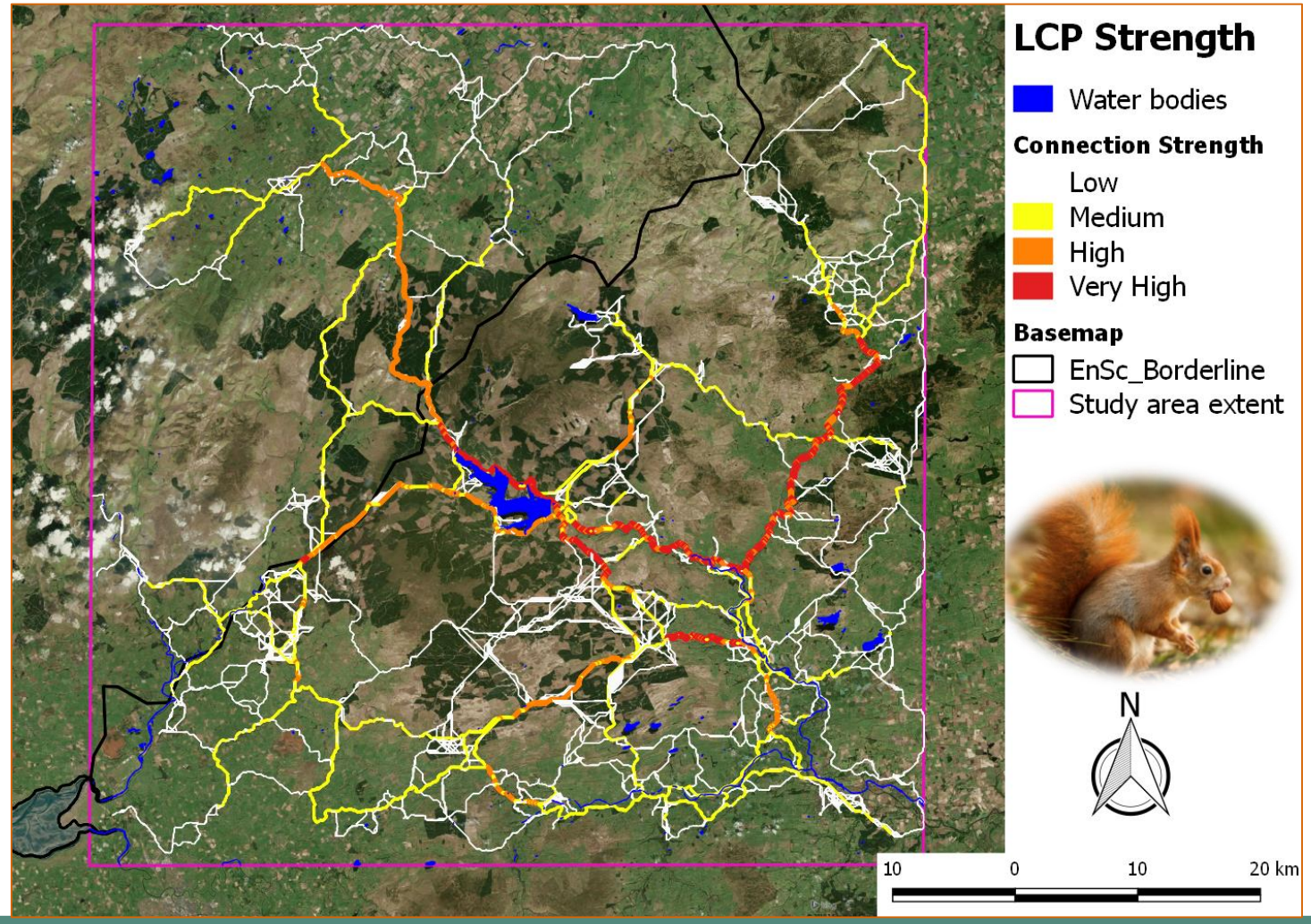
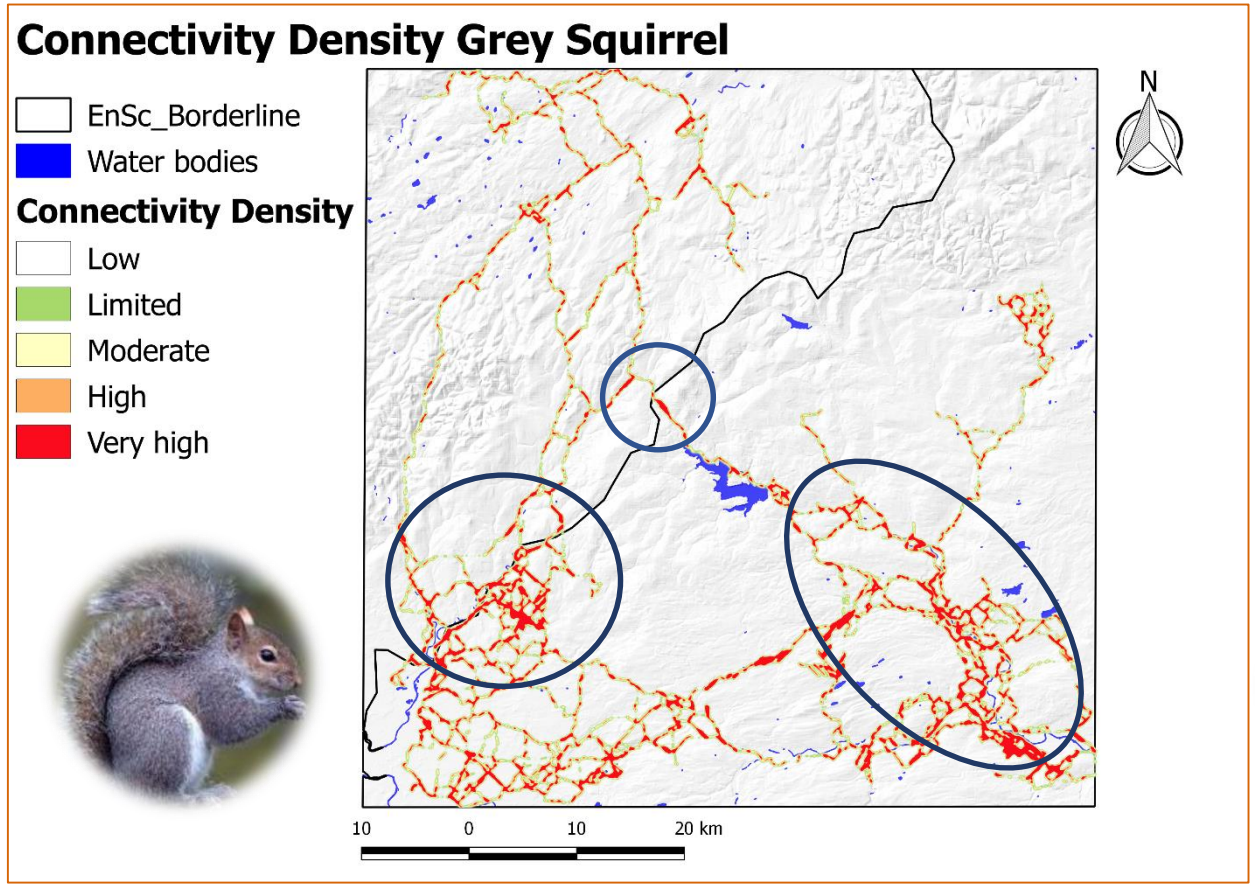
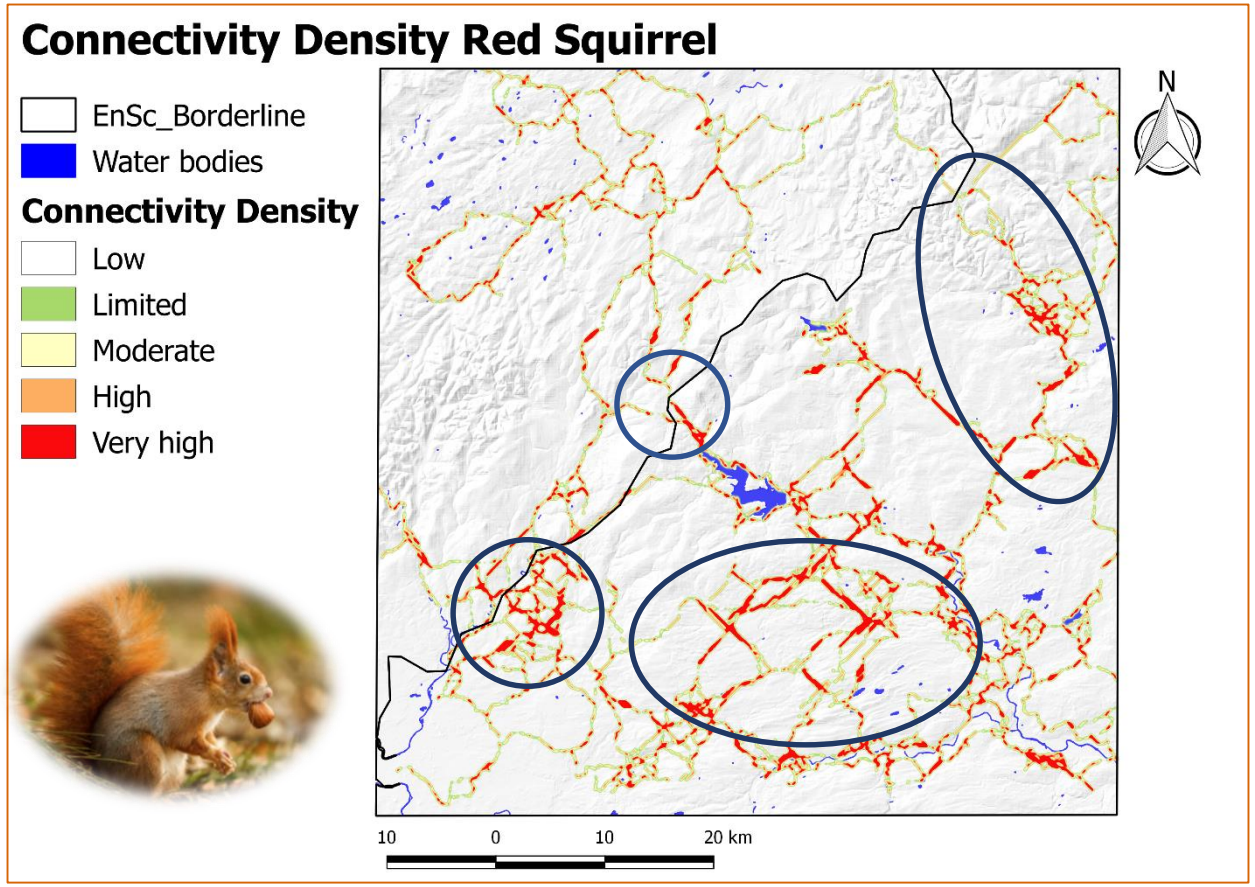


Connectivity Density Analysis

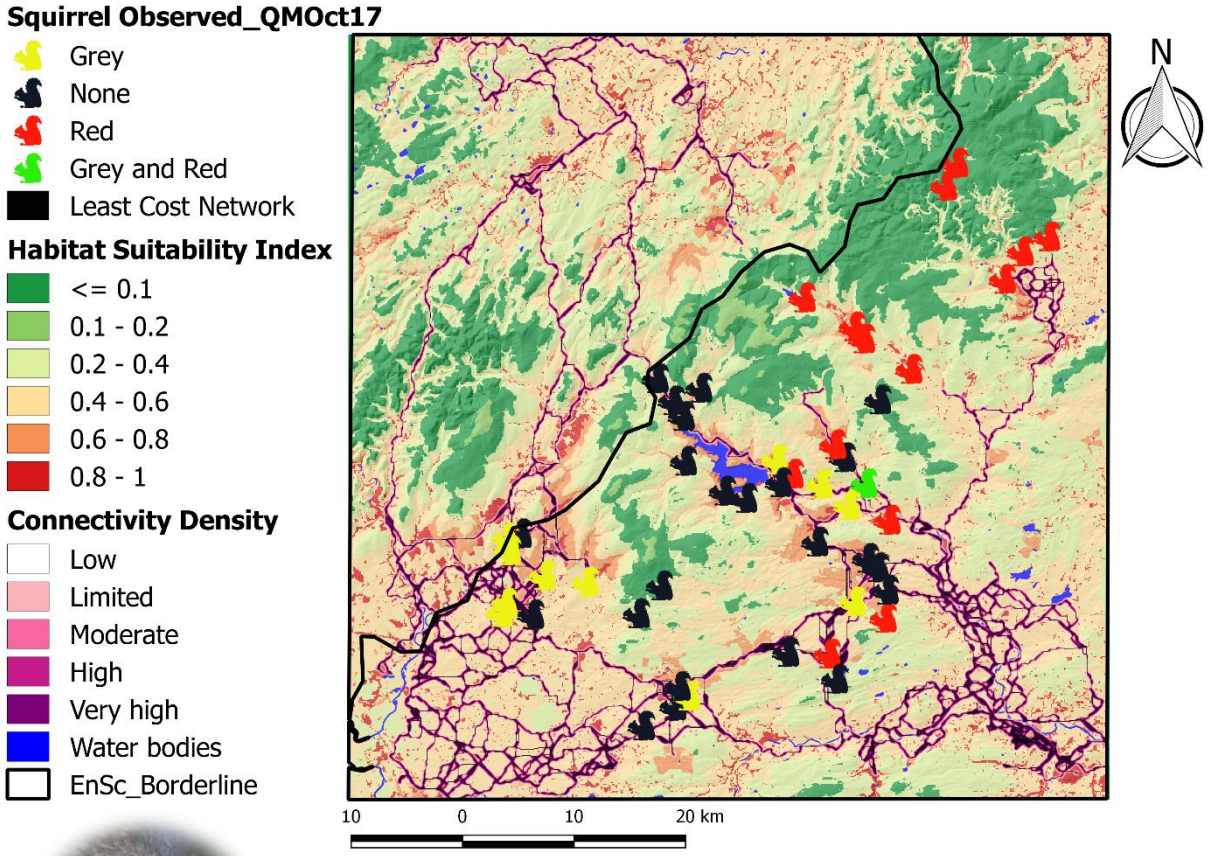
- **Bottlenecks**
- **Areas of High Connectivity**

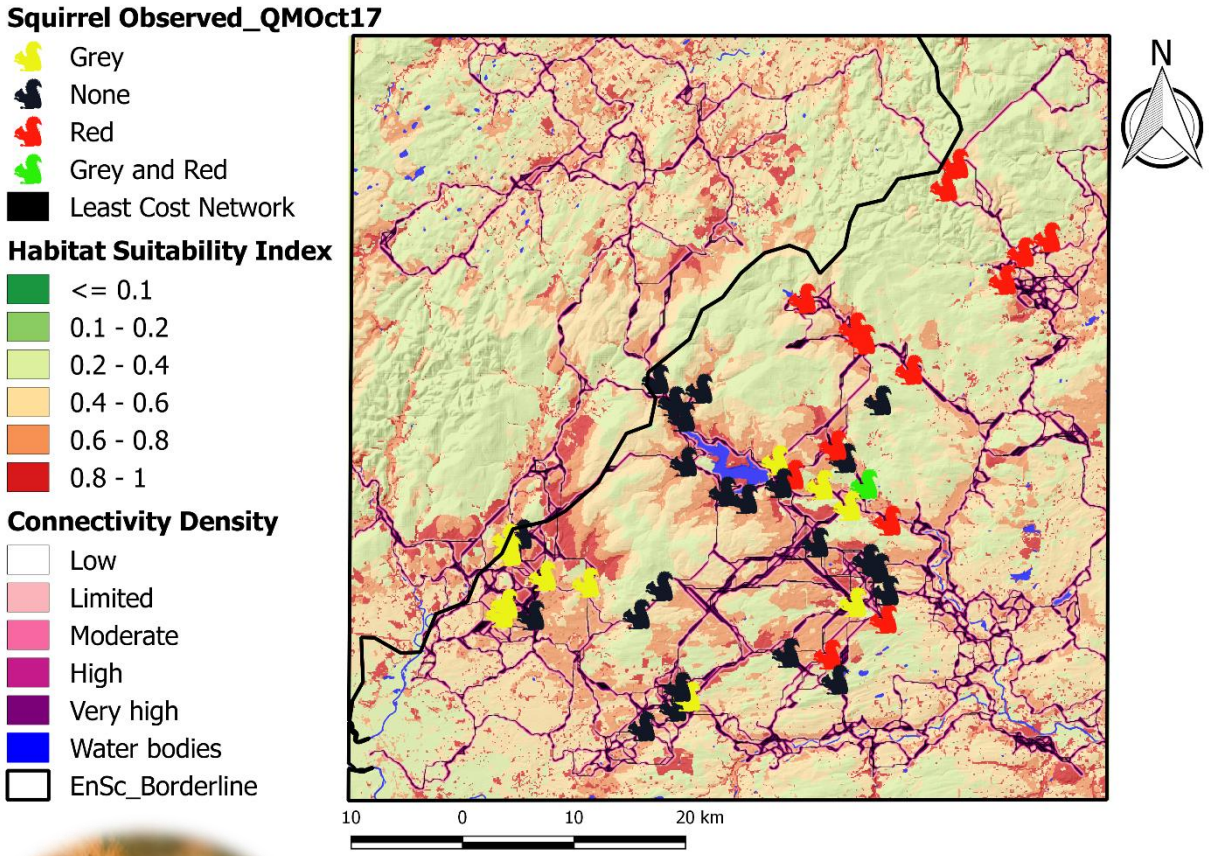
Connectivity Density Analysis





Early Warning Detection System





Squirrel Observed_QMOct17

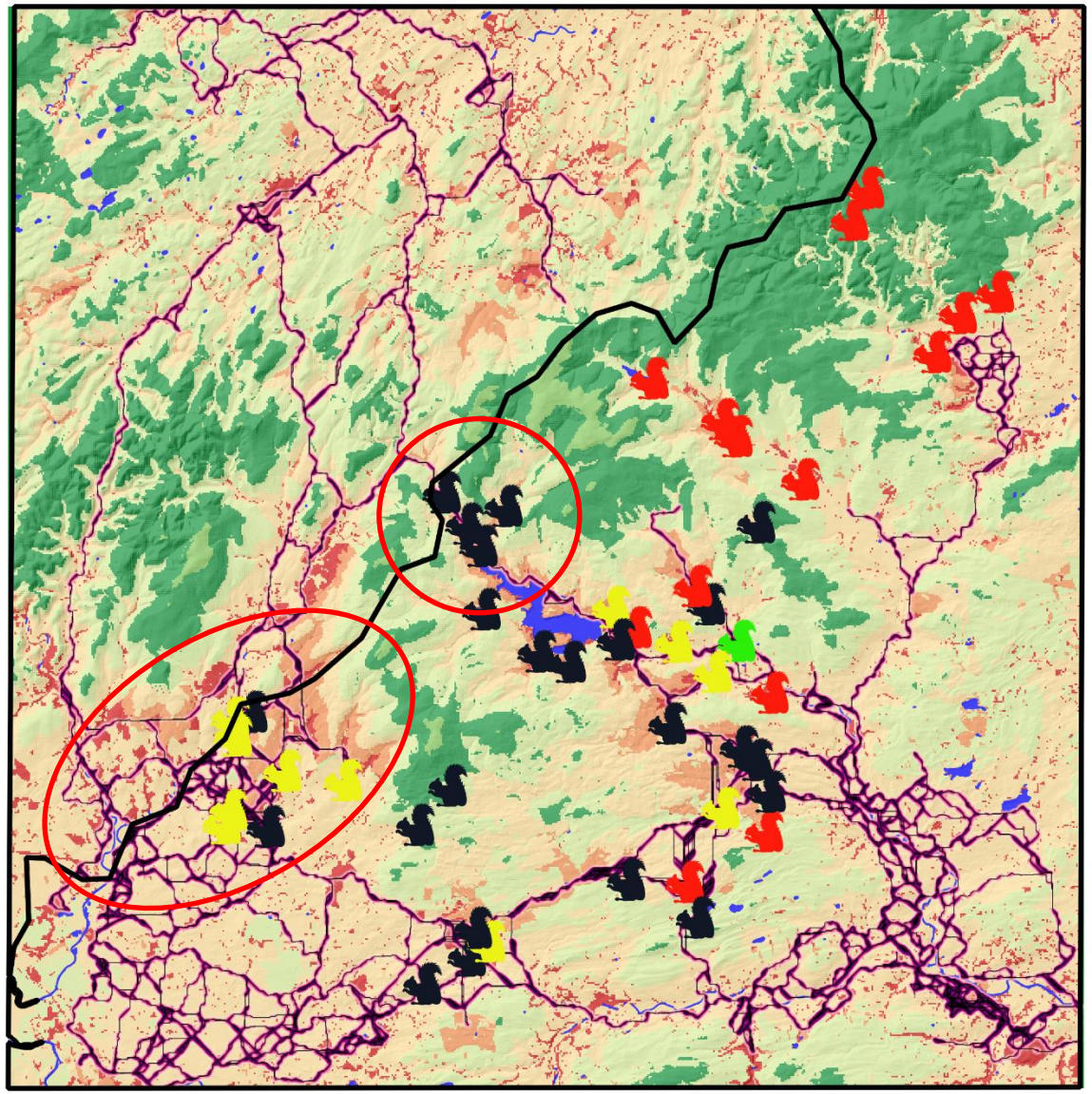
- Grey
- None
- Red
- Grey and Red
- Least Cost Network

Habitat Suitability Index

- <= 0.1
- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1

Connectivity Density

- Low
- Limited
- Moderate
- High
- Very high
- Water bodies
- EnSc_Borderline



Red Squirrels UNITED

Life

HERITAGE FUND

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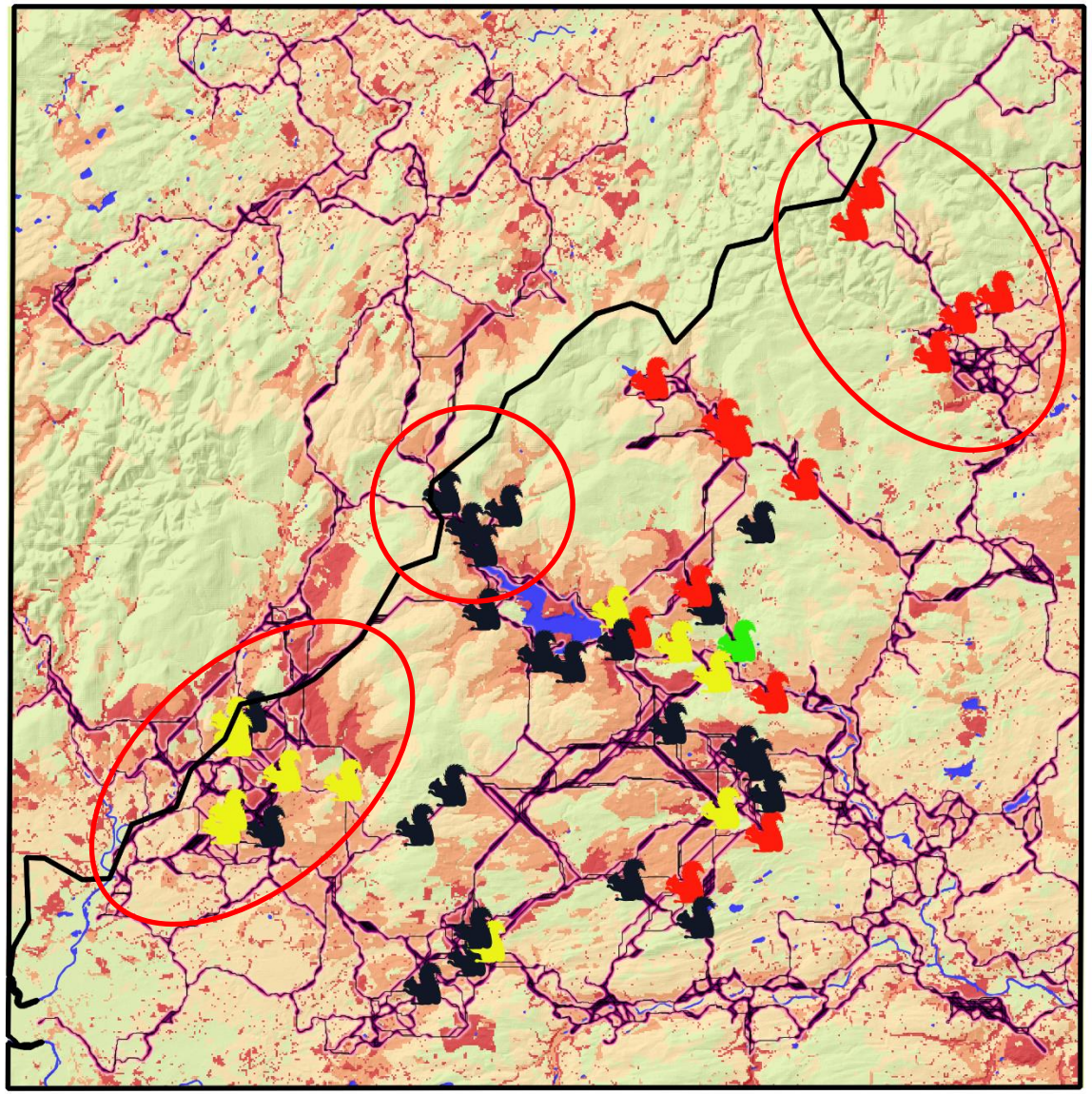

10 0 10 20 km

N

Red Squirrels UNITED

Life

HERITAGE FUND

Conclusion

1. Kielder Forest is an optimal habitat for red squirrel, but it is still well permeable to grey squirrel invasions
2. Landscape around Kielder Forest is well connected and the strongest connections for grey squirrel follows the two main river valleys
3. Areas of high connectivity density shows where control / monitoring efforts should be focused in preventing and detecting new invasions at an early stage
4. Three areas of high importance on the borderline with the South of Scotland that need to be defended from invasions coming from the North
5. Camera traps network falls into the predicted corridors used by squirrels
6. The Machine Learning approach gave value to the Expert-Opinion based approach in evaluating the spatial configuration of the detection system
7. Maps and tools useful to practitioners to improve the monitoring system
8. Driving the making-decision process to address the best monitoring strategy
9. Surveys into the main block of woodland in Kielder Forest may be useful to improve the model
10. A strict collaboration between English and Scottish partners is highly recommended

Acknowledgments

Modelling Evidence and Policy at Newcastle University

Red Squirrel Northern England

Saving Scotland's Red Squirrel

RSU Knowledge Fair 2019

Thank you!

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