Designing a climate change resilient landscape connectivity network from a multi-species perspective

Dr Carlos Bedson

With Natural England colleagues

Ben Payne

Danielle Greaves

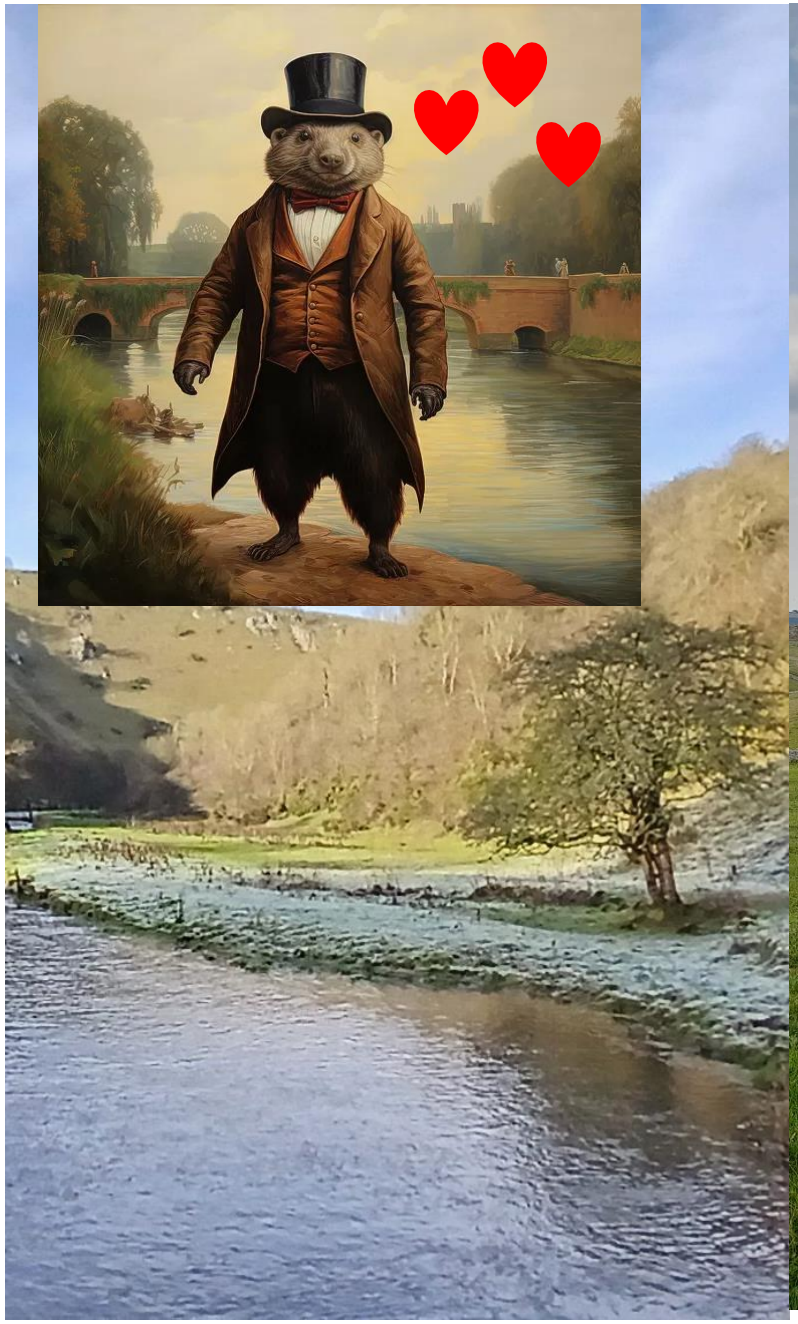
Heather White

Humphrey Crick

And

Chris Sutherland (University of St Andrews)

A water vole connectivity love story...

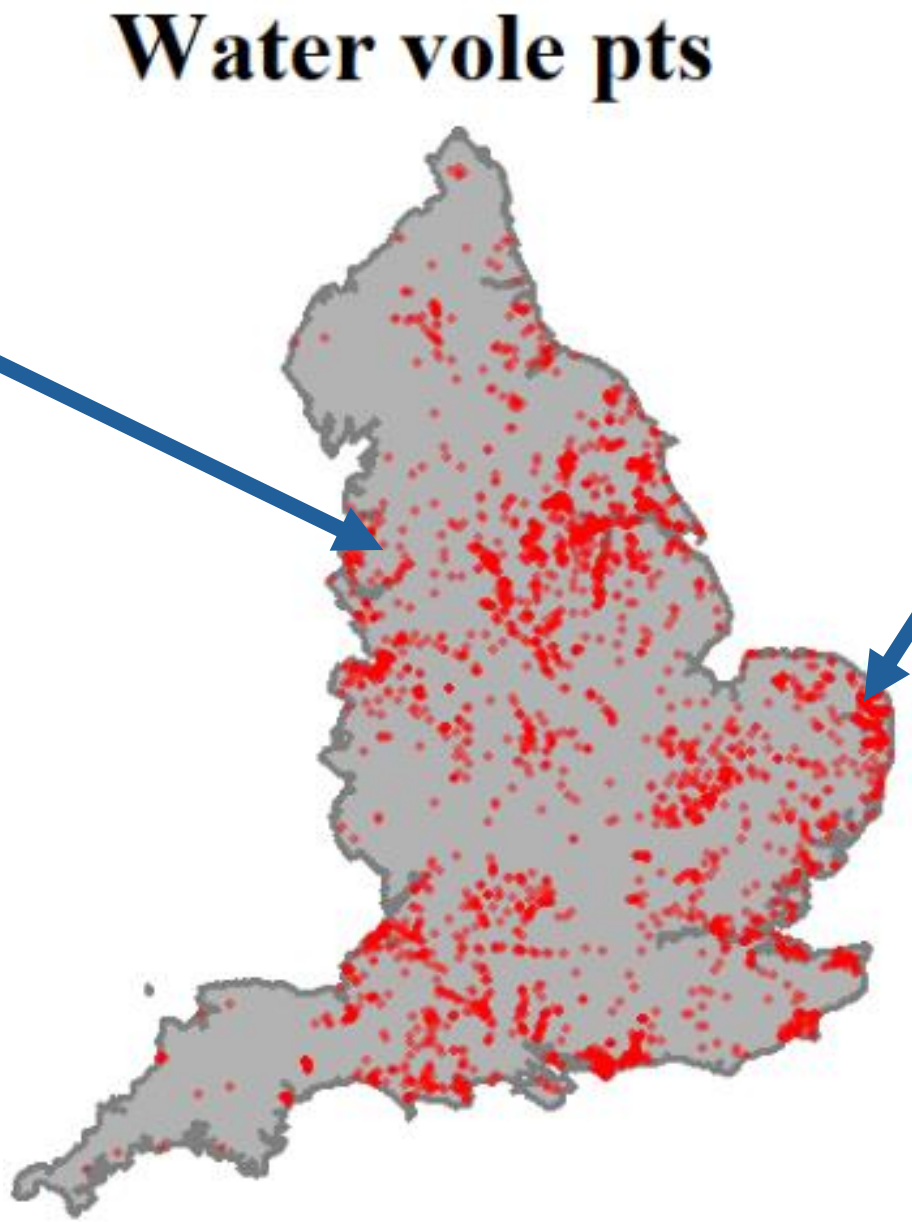


Against a background of human activity…

NBN Atlas informing water vole connectivity

I need to know the suitable places where I can find another water vole

Species distribution models



I need to know how to move between the suitable places

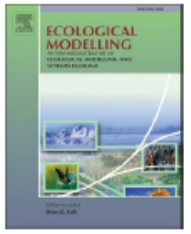
Circuit theory

Species distribution models

Contents lists available at ScienceDirect

Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel



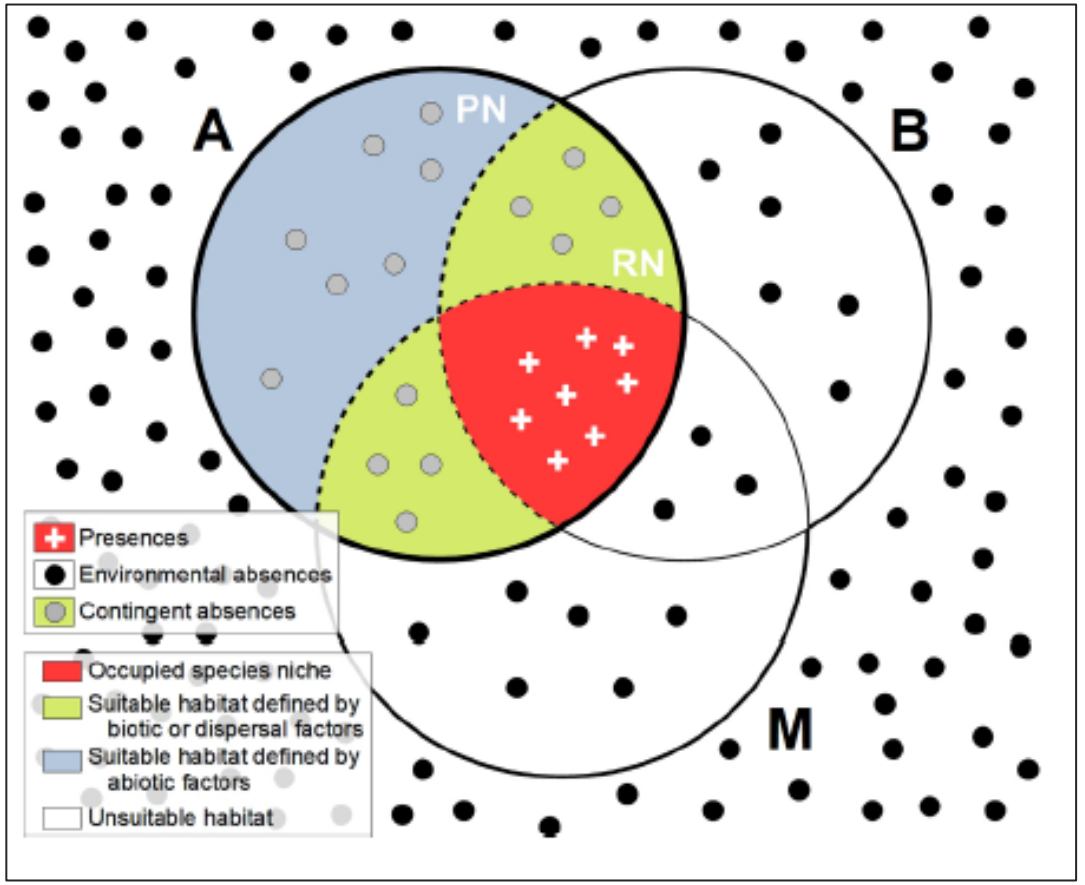
Check for updates

Want to model a species niche? A step-by-step guideline on correlative ecological niche modelling

Neftalí Sillero [a,*], Salvador Arenas-Castro [a,b], Urtzi Enriquez-Urzelai [c,d], Cândida Gomes Vale [e], Diana Sousa-Guedes [a], Fernando Martínez-Freiría [c], Raimundo Real [f], A.Márcia Barbosa [a]

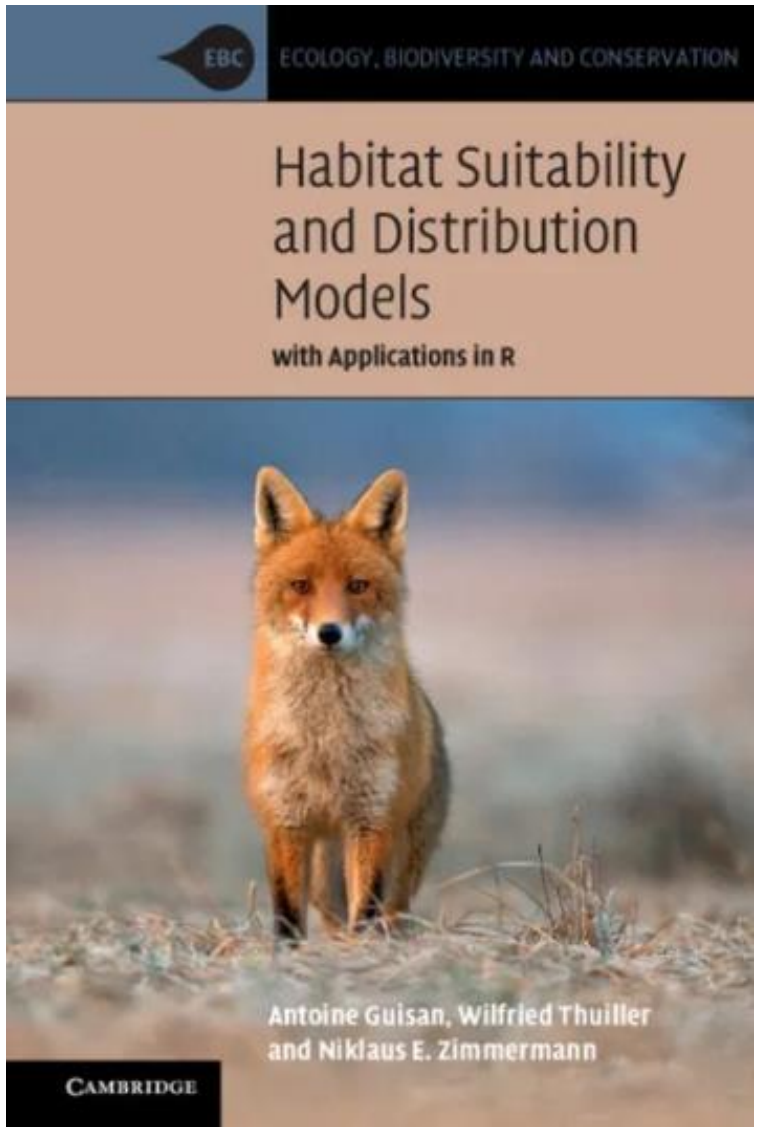
[a] CICGE - Centro de Investigação em Ciências Geo-Espaciais, Alameda do Monte da Virgem, 4430-146 Vila Nova de Gaia, Portugal

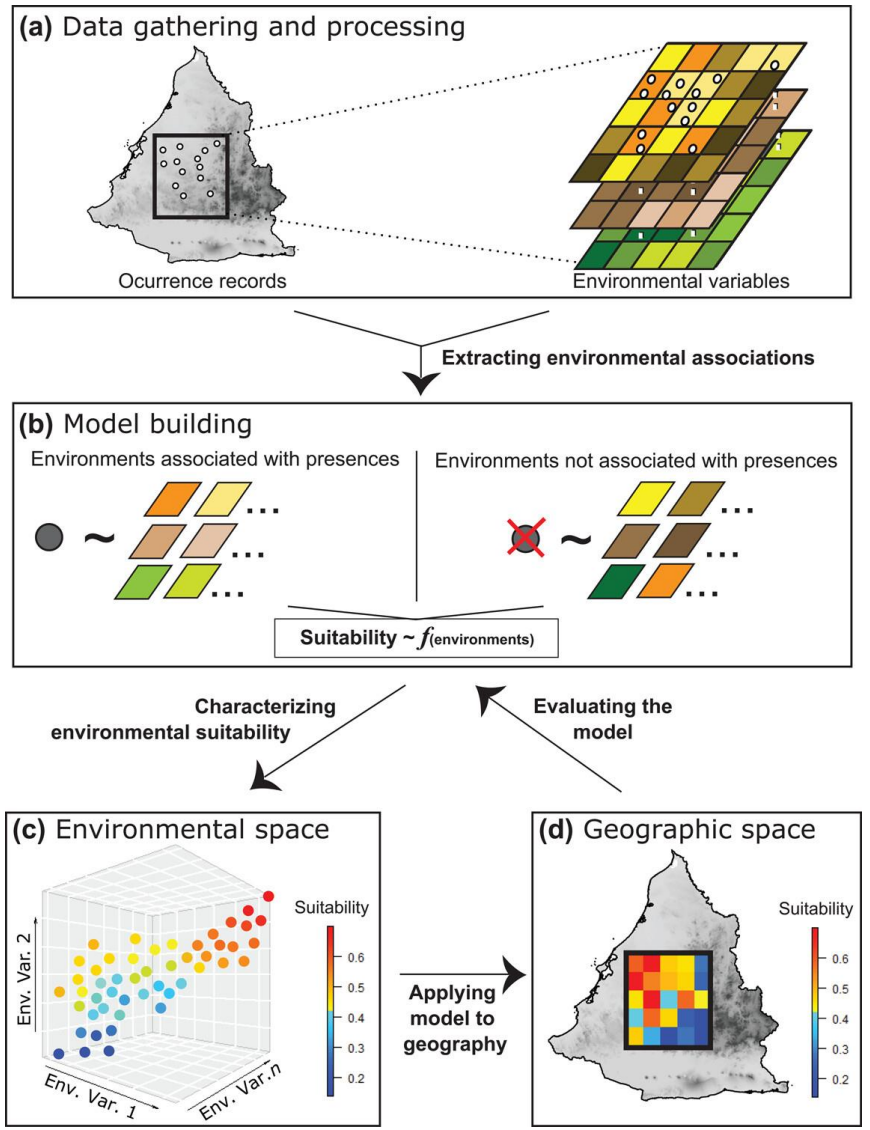
- SDM species distribution model;
- HSM habitat suitability model;
- ENM ecological niche model;
- RSF resource selection function



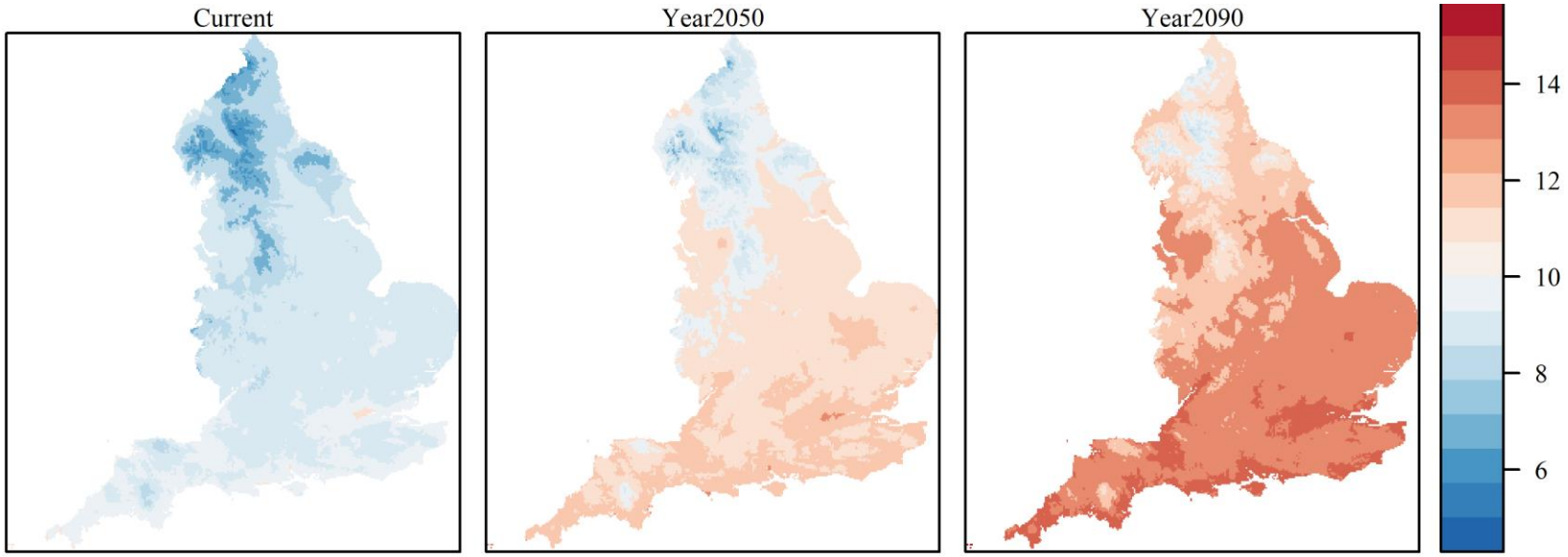
Species Distribution Models with R package “Biomod2”

Author: Wilfried Thuiller (100,722 citations)
Laboratoire d'Ecologie Alpine, CNRS, Univ. Grenoble Alpes, France

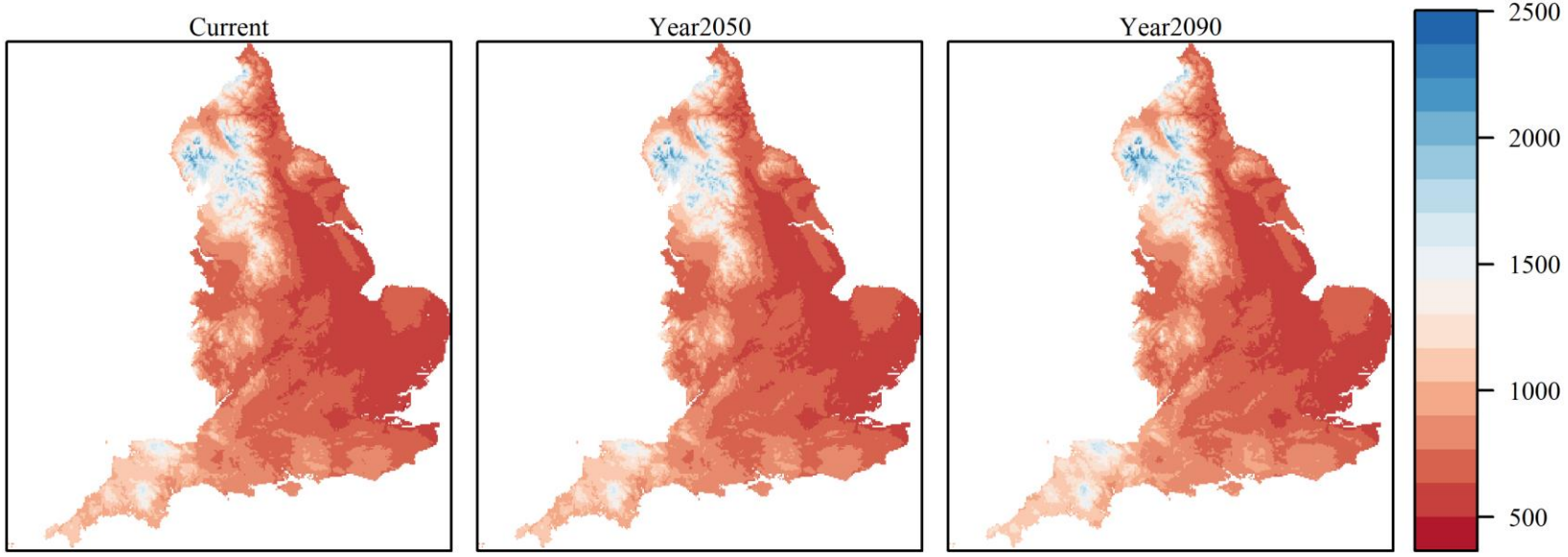




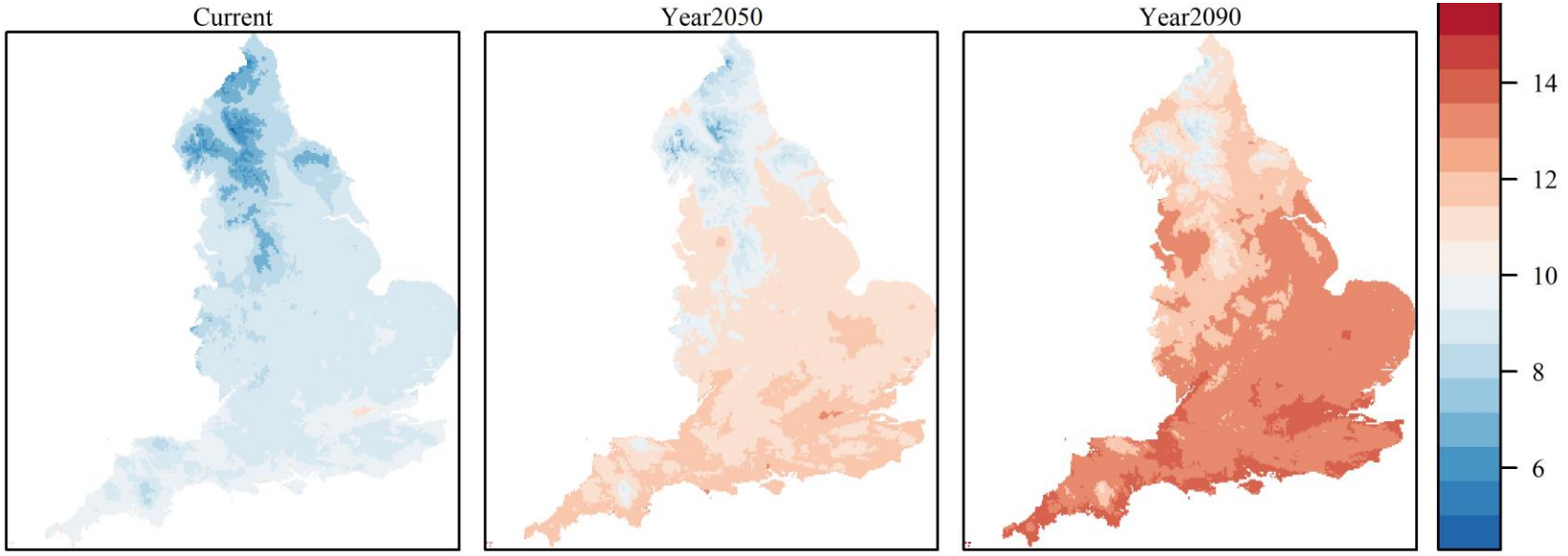
Predictor: BIO 1 Annual mean temperature C°



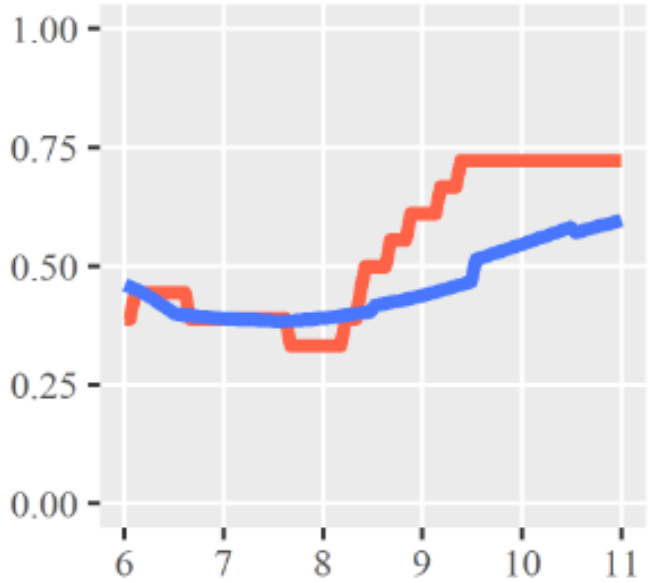
Predictor: BIO 12 Annual precipitation (mm)



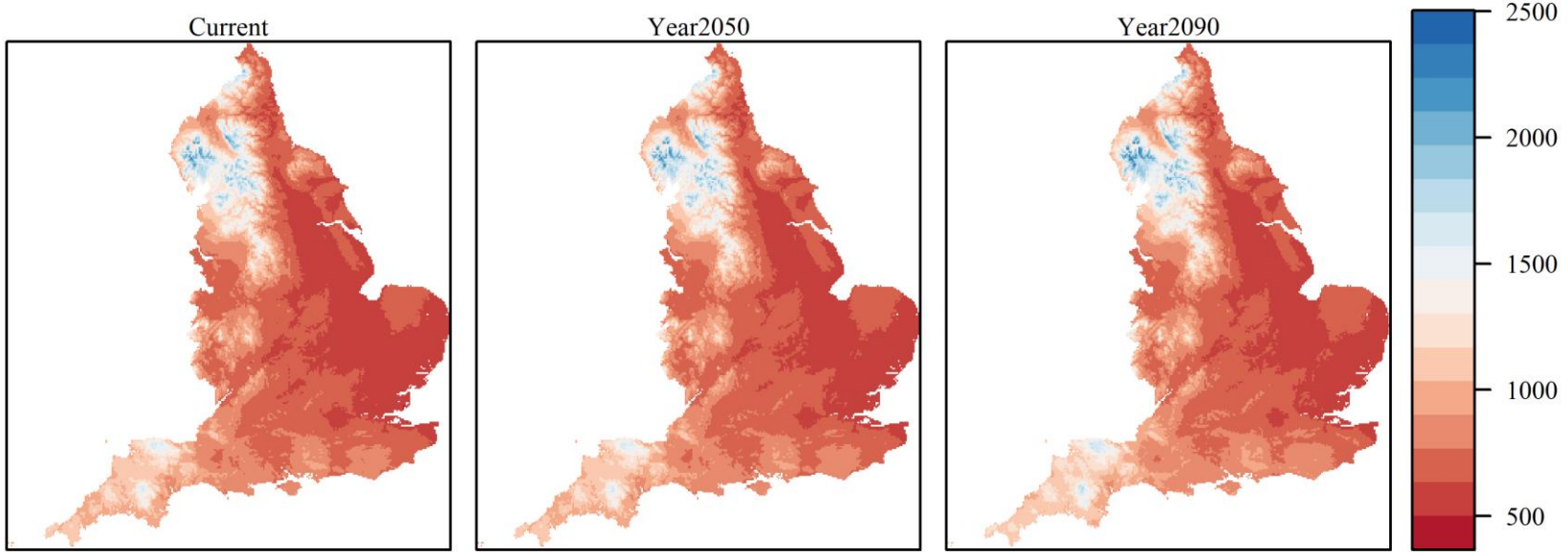
Predictor: BIO 1 Annual mean temperature C°



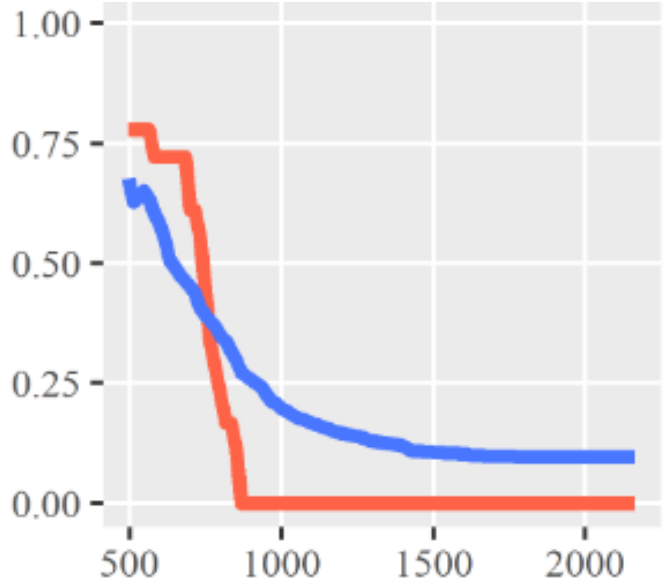
Water vole response



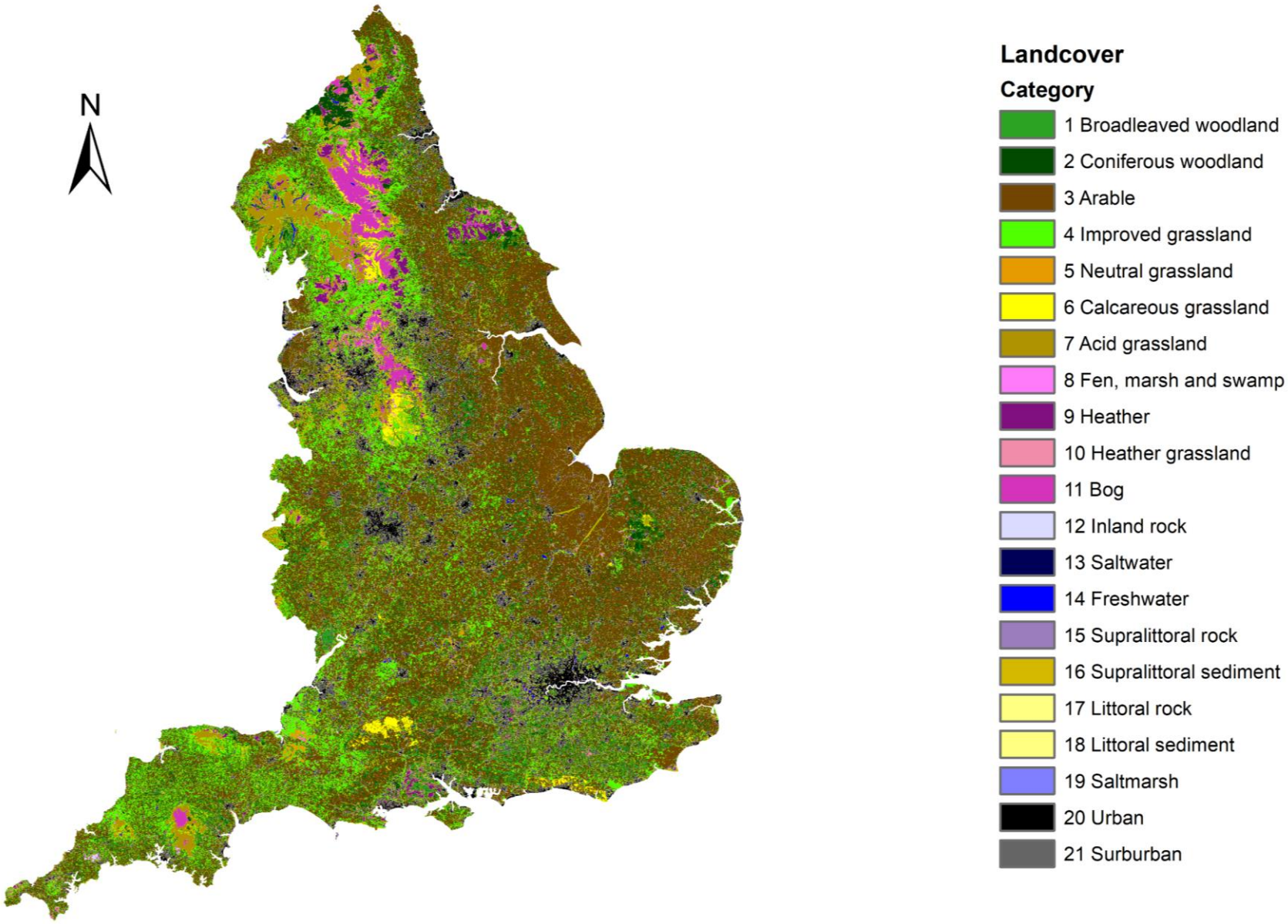
Predictor: BIO 12 Annual precipitation (mm)



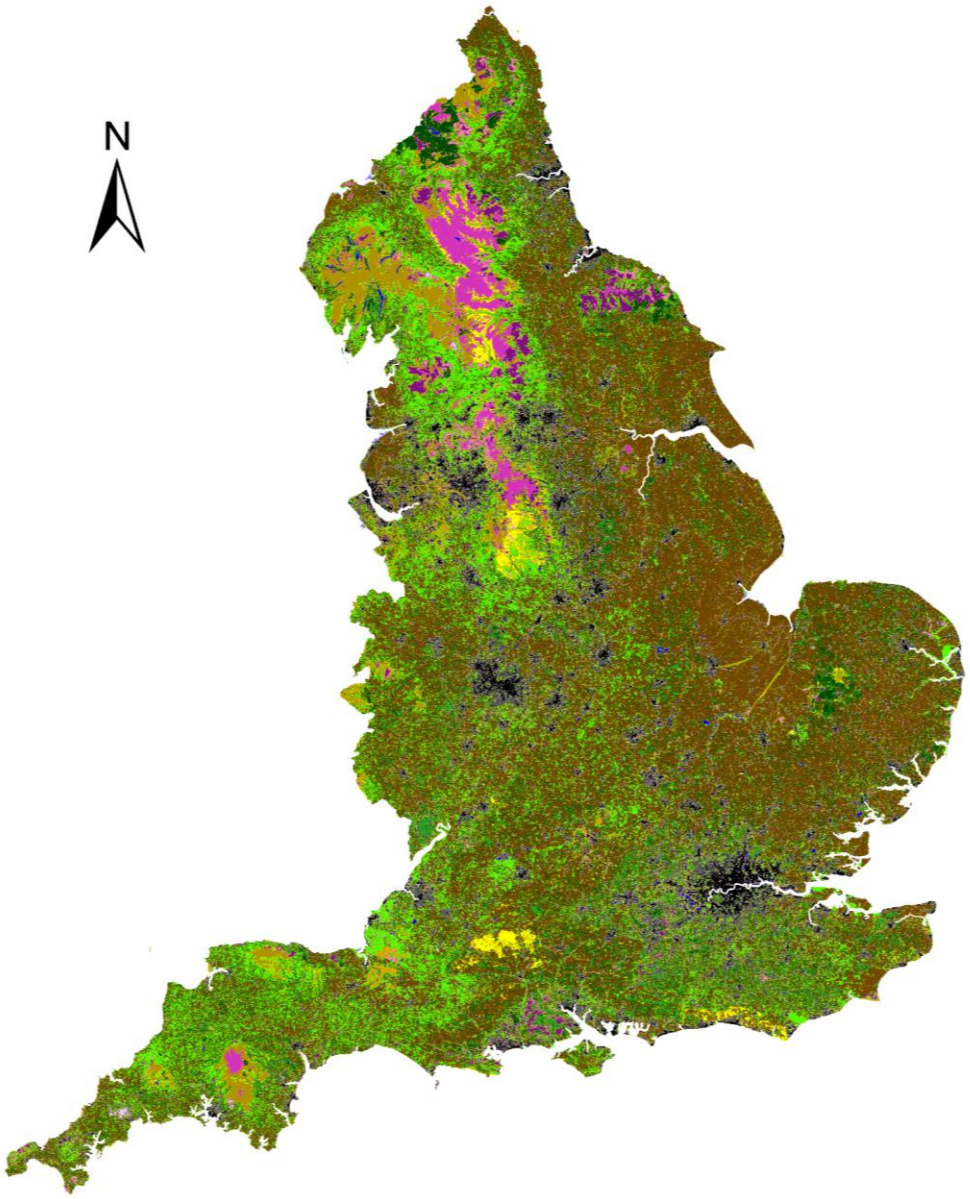
Water vole response



Predictor: Landcover and rivers



Predictor: Landcover and rivers

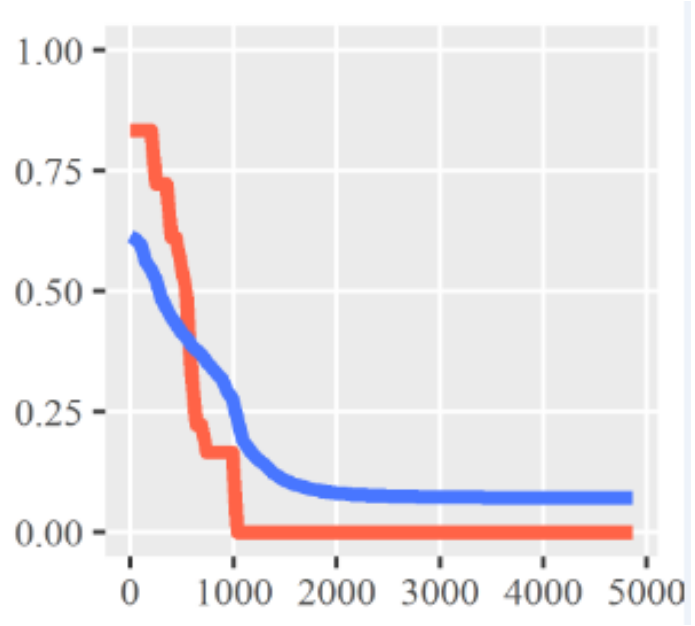


Landcover

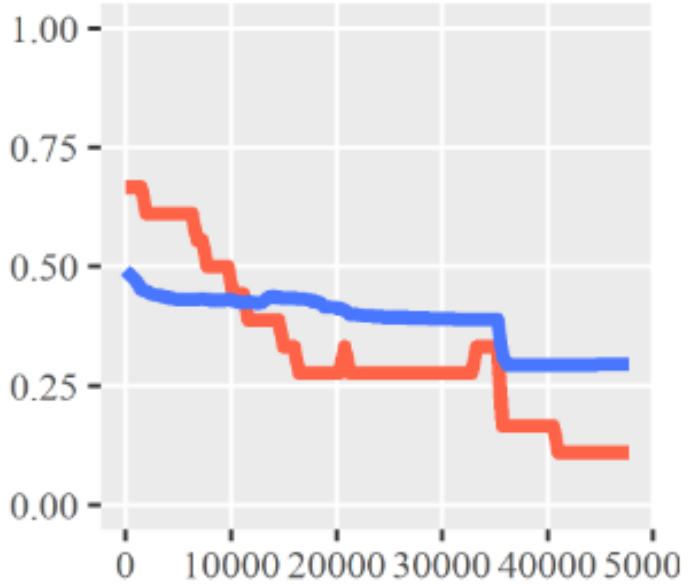
Category

- 1 Broadleaved woodland
- 2 Coniferous woodland
- 3 Arable
- 4 Improved grassland
- 5 Neutral grassland
- 6 Calcareous grassland
- 7 Acid grassland
- 8 Fen, marsh and swamp
- 9 Heather
- 10 Heather grassland
- 11 Bog
- 12 Inland rock
- 13 Saltwater
- 14 Freshwater
- 15 Supralittoral rock
- 16 Supralittoral sediment
- 17 Littoral rock
- 18 Littoral sediment
- 19 Saltmarsh
- 20 Urban
- 21 Surburban

Water vole response to rivers

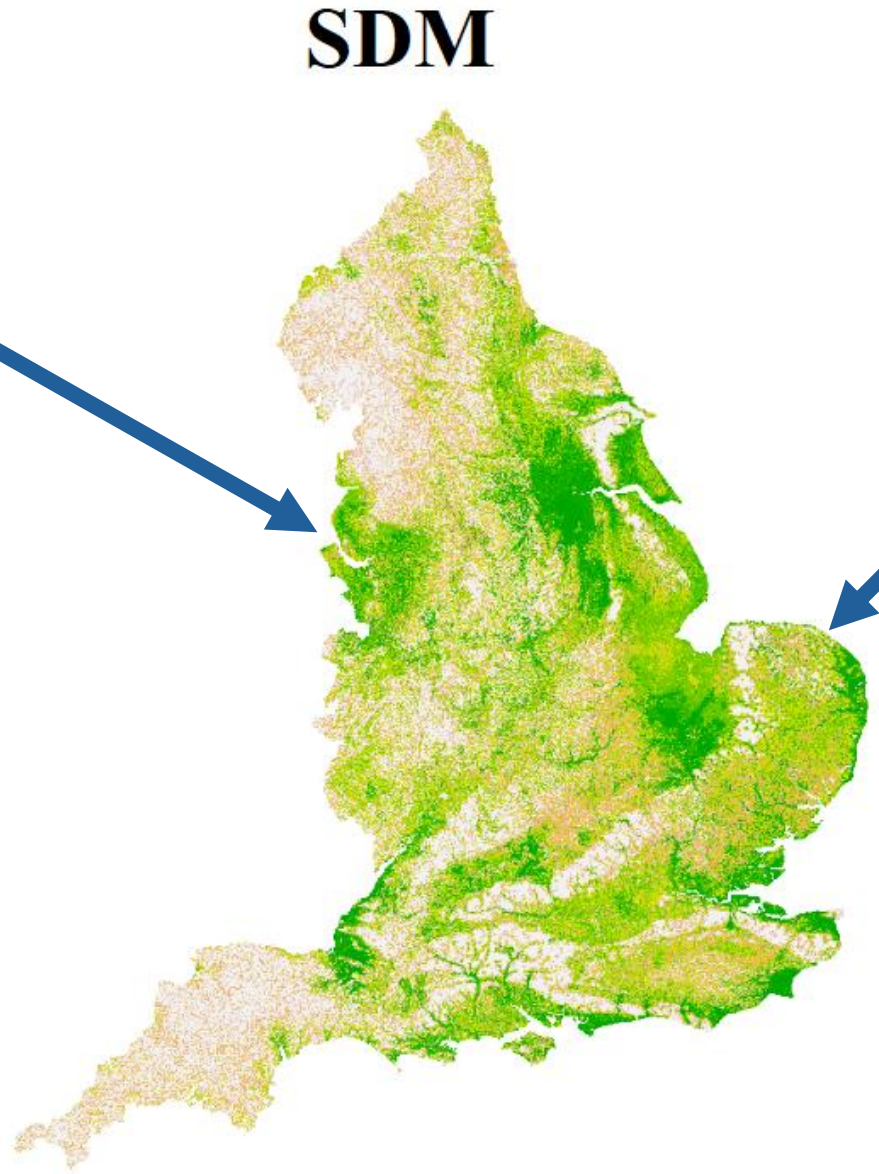


Response to bog / grass / heather



From species distribution models ... towards circuit theory ...

How will I disperse to find connection?



I feel resistant to moving through some areas

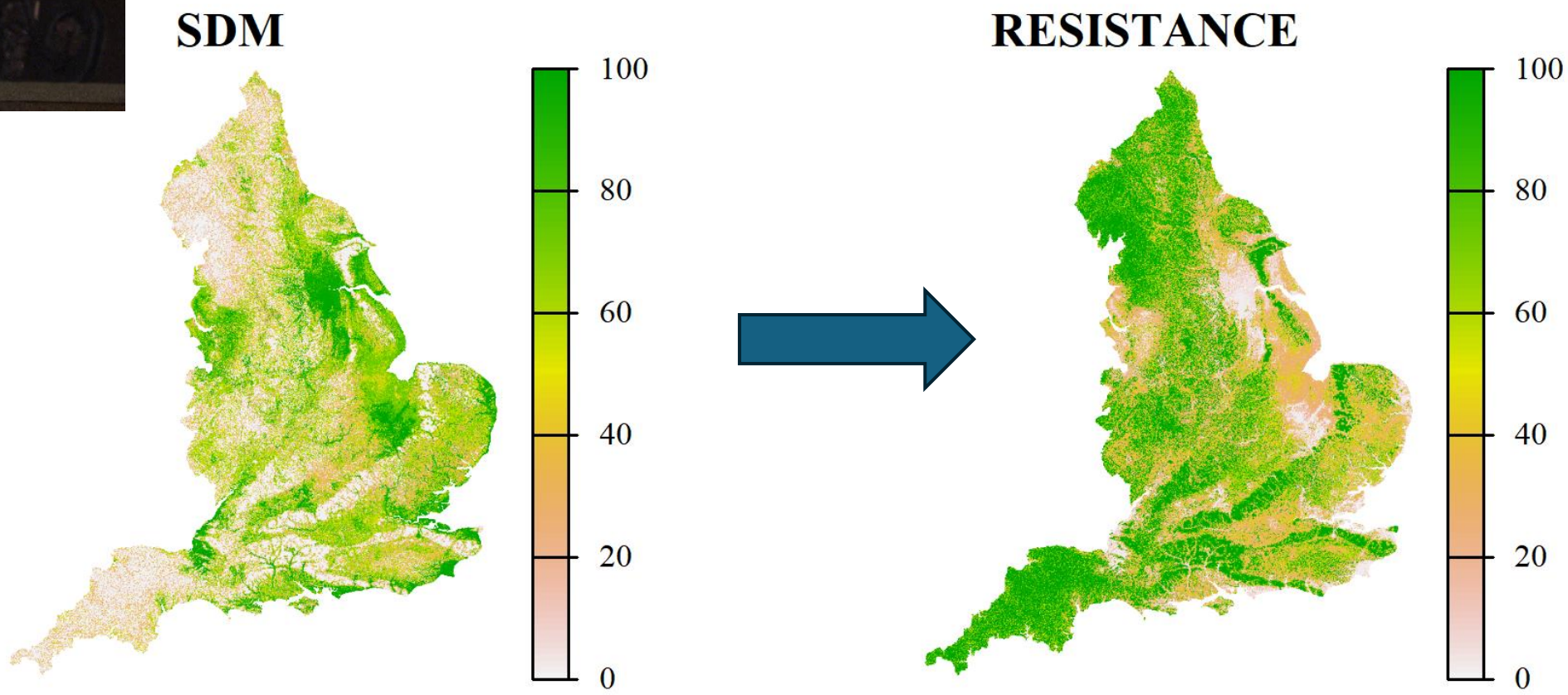
Resistance is ~~futile~~ useful

Landscape Ecol (2012) 27:777–797
DOI 10.1007/s10980-012-9737-0

LANDSCAPE ECOLOGY IN REVIEW

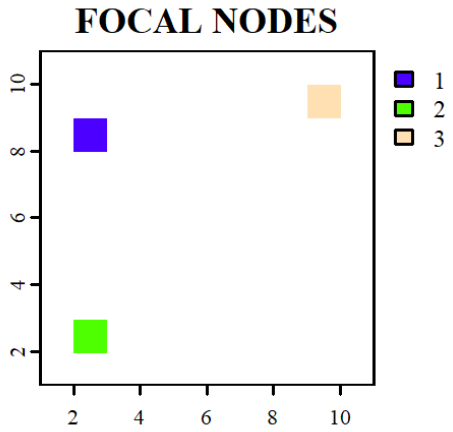
Estimating landscape resistance to movement: a review

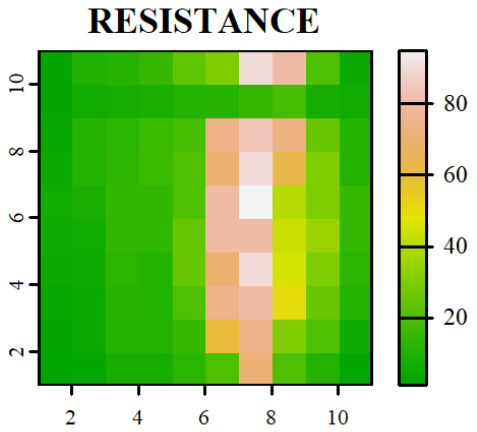
Katherine A. Zeller · Kevin McGarigal · Andrew R. Whiteley

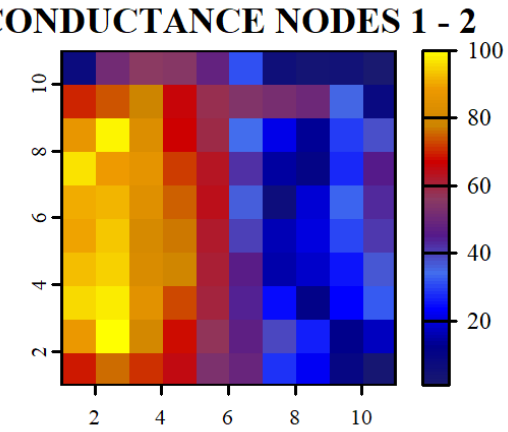


CIRCUITSCAPE.ORG

julia

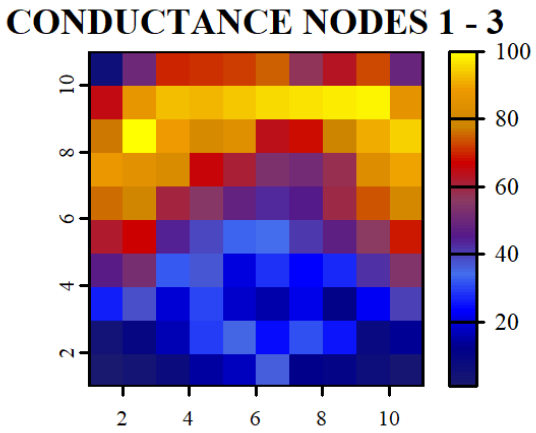


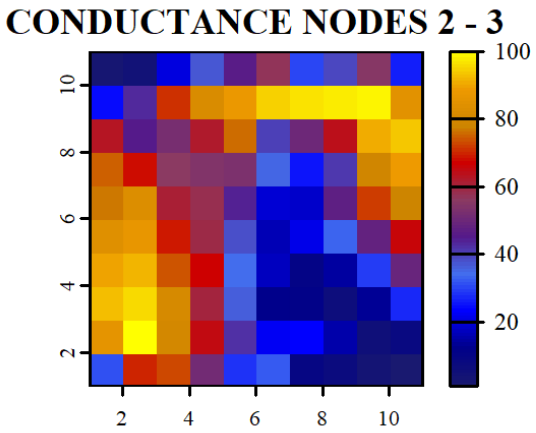


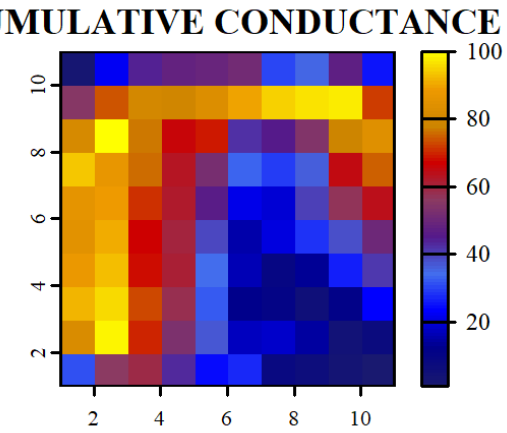


Circuitscape

Circuit theory



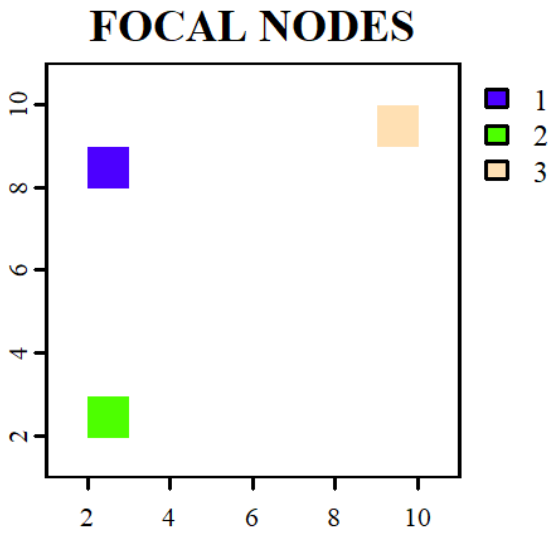


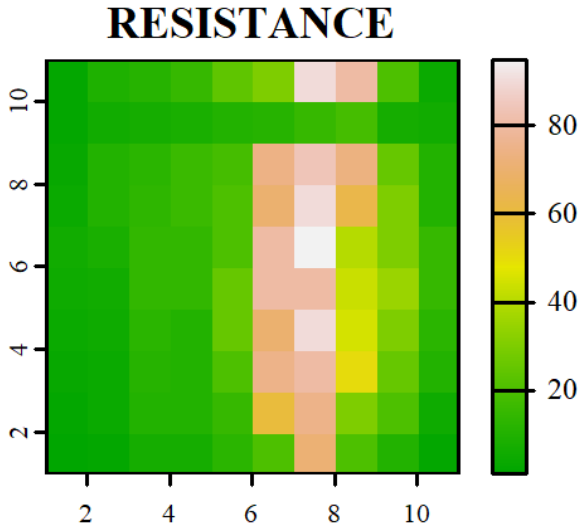


Random walk of animal dispersing through resistance surface

McRae et al. 2008
Using circuit theory to model connectivity in ecology, evolution and conservation
(2,188 citations; 20,000+ downloads)

Calculate





julia

EXAMPLE.FOCAL.NODES.R

File Edit View

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yllcorner         1
cellsize          1
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-9999   1     -9999 -9999  -9999  -9999  -9999  -9999  -9999 -9999
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Ln 1, Col 1 | 816 characters | 100% | Windows (CRLF) | UTF-8

EXAMPLE.RESISTANCE.RAS

File Edit View

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cellsize       1
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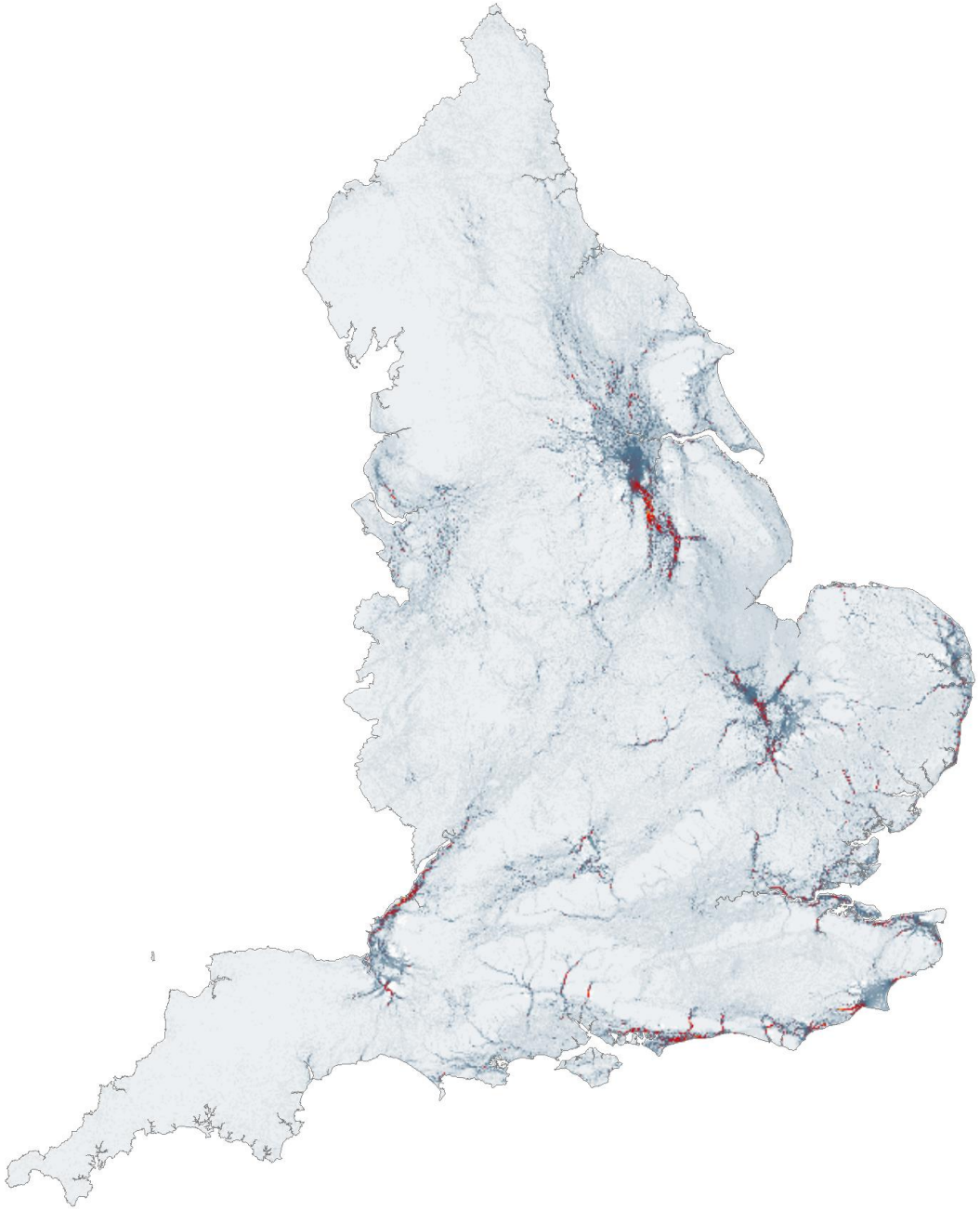
4    10  13    16  20   70   90  63    30    10
6    8   14    14  20   80   95  40    30    15
5    6   14    14  25   80   80  43    35    15
4    5   12    10  25   70   90  45    30    12
3    4   11    10  20   75   80  50    25    10
2    4   10    10  15   60   75   30   20     5
1    2   7      7  12   20   71   20   10     2
```

Ln 16, Col · | 581 characters | 100% | Unix (LF) | UTF-

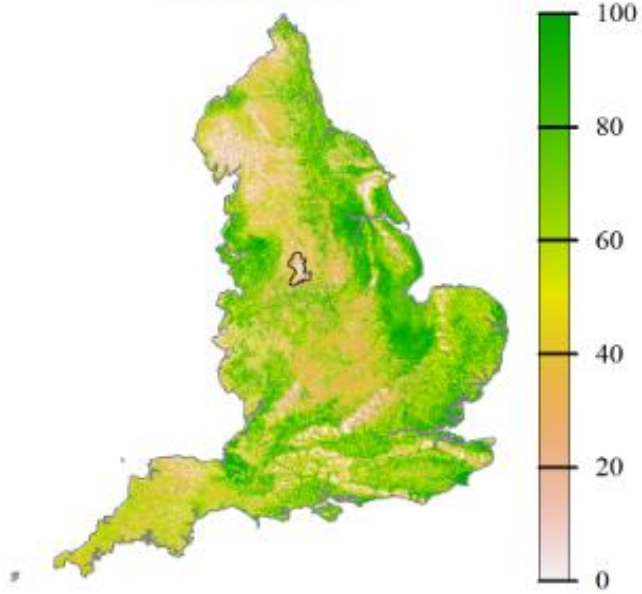
And so the water voles could find each other at last...



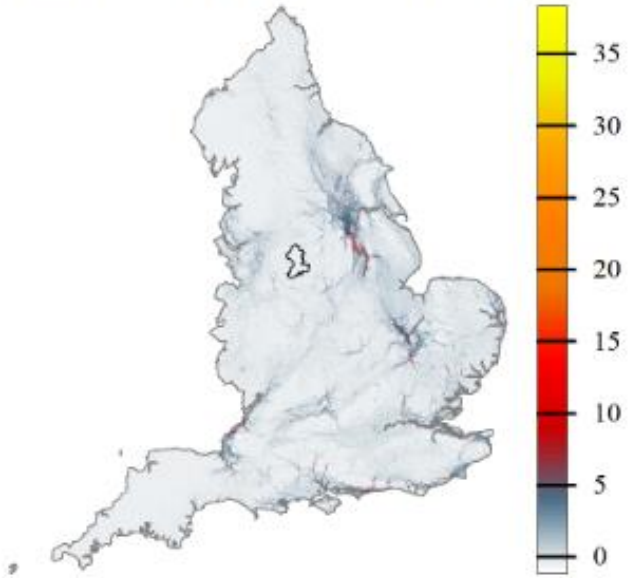
WATER.VOLE CURRENT SDM

2050 SDM

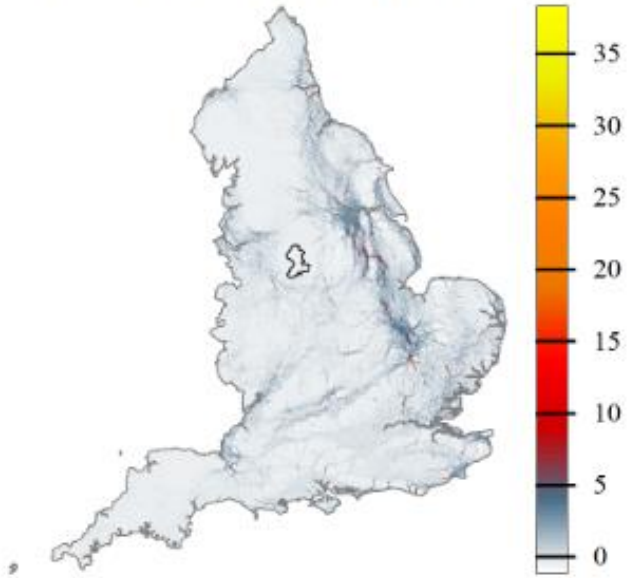
2090 SDM



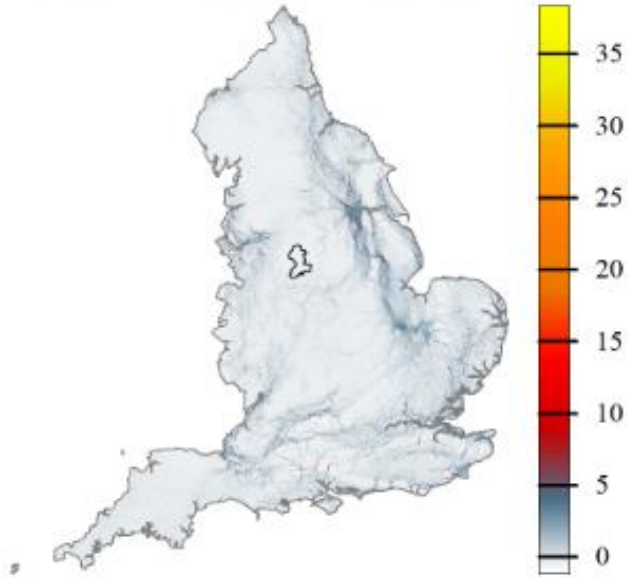
CURRENT CONNECTIVITY



2050 CONNECTIVITY



2090 CONNECTIVITY



Vulnerable butterflies, birds, mammals & a reptile

Chalk carpet moth

Dingy skipper

Northern brown argus

White letter hairstreak

Curlew

Dipper

Marsh tit

Twite

Willow tit

Hazel dormouse

Hedgehog

Leisler's bat

Otter

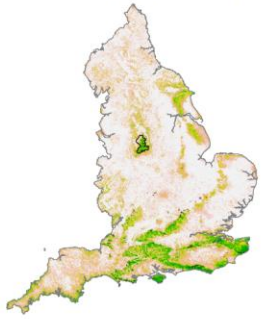
Water vole

Adder

Photos with thanks: British Trust for Ornithology, Butterfly Conservation, The Mammal Society, The People's Trust for Endangered Species

Winner – Chalk carpet moth

CHALK.CARPET CURRENT SDM



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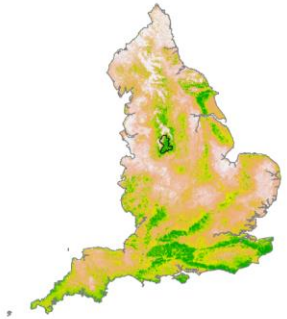

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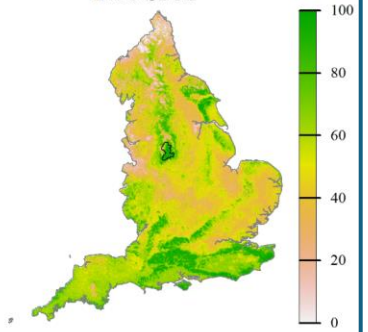

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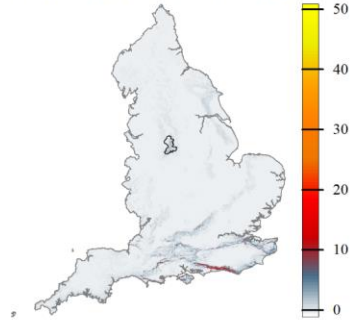

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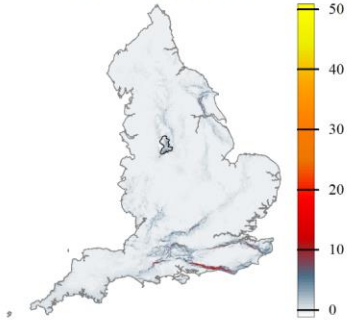

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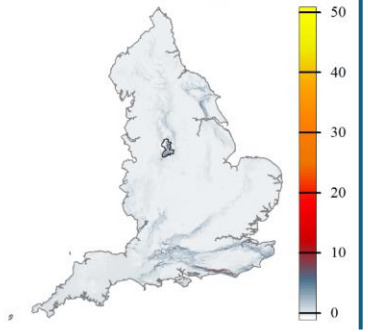
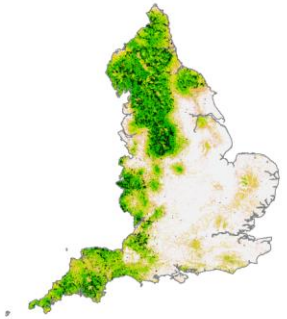
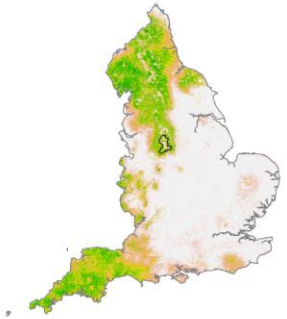


Loser – Dipper

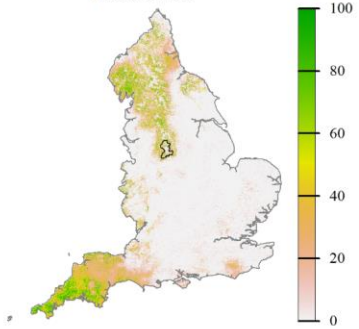
DIPPER CURRENT SDM



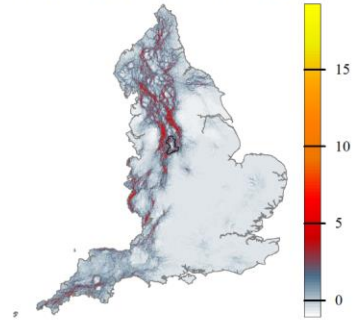
2050 SDM



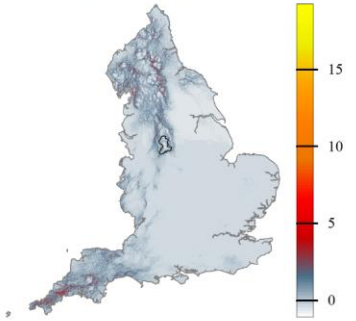
2090 SDM



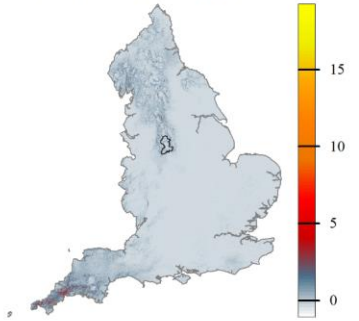
CURRENT CONNECTIVITY



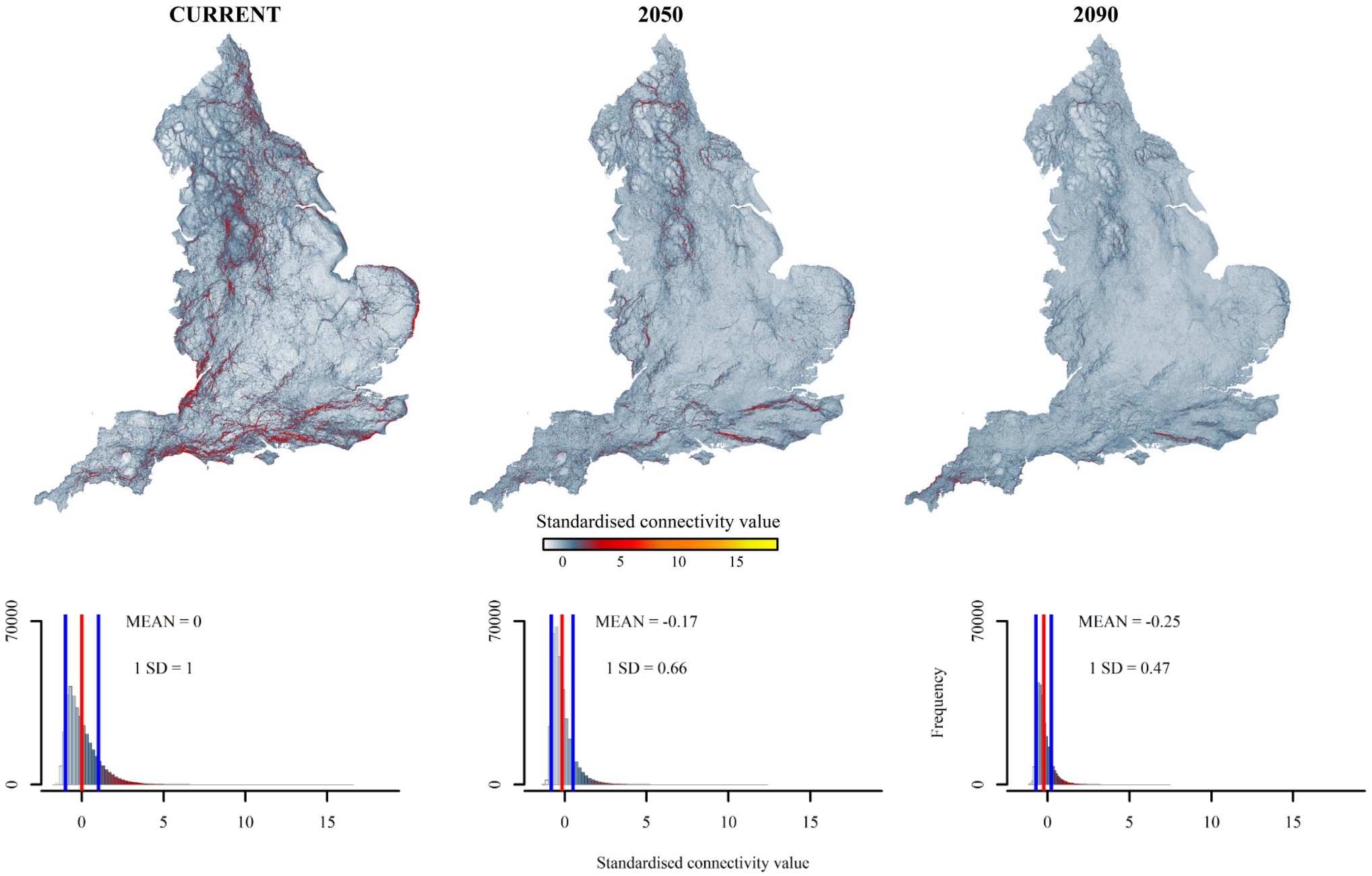
2050 CONNECTIVITY



2090 CONNECTIVITY

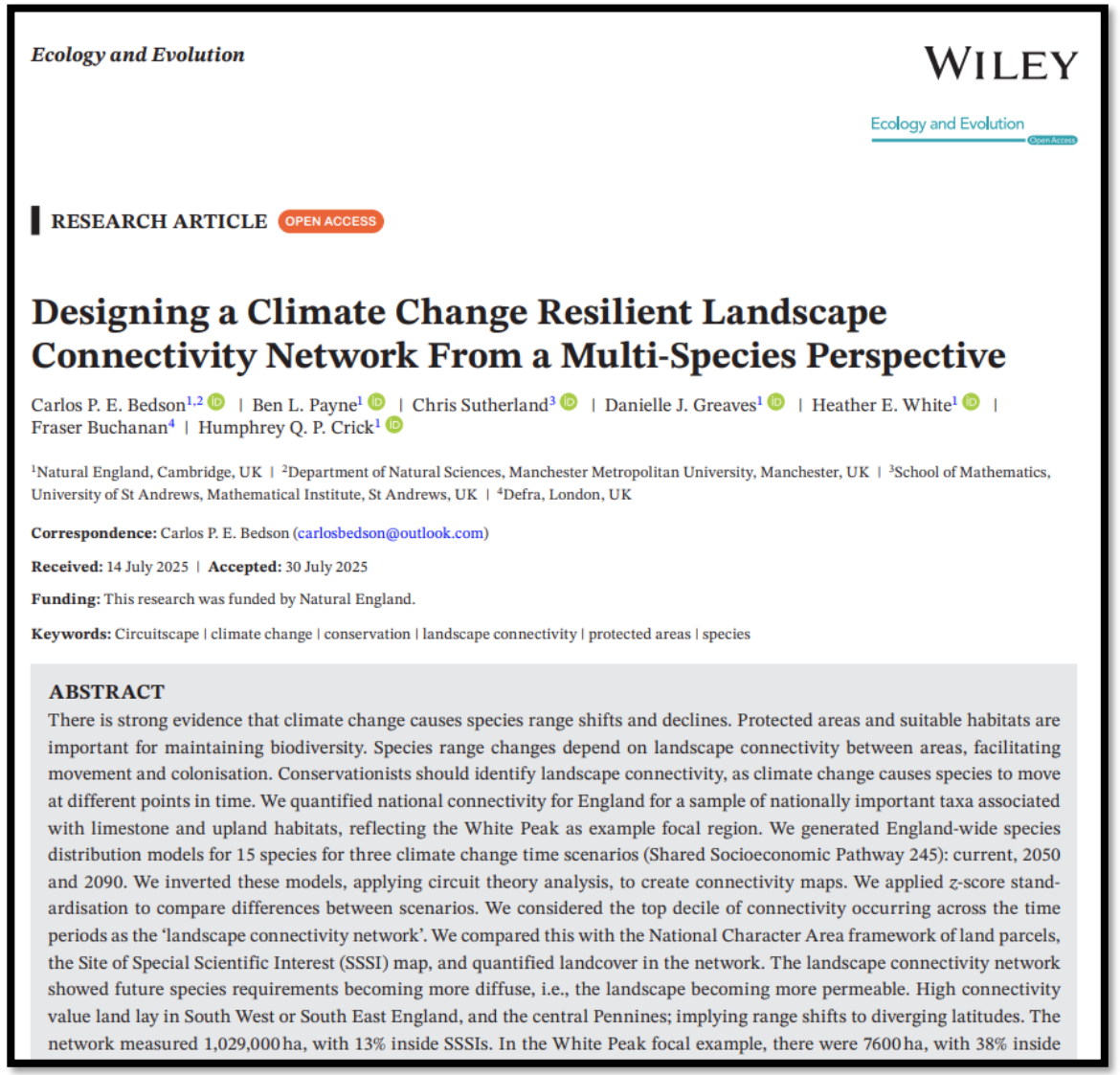


Increasingly permeable landscape connectivity



Application of landscape connectivity design

- Supporting favourable conservation status
- Provide links between isolated areas
- Movement pathways, when routes blocked by building
- Help climate-change range shifting butterflies
- Protect riverine pinch points for otter, water vole, dipper
- Validating and mitigate roadkill locations
- Relocate water vole or hazel dormouse
- Create brushy habitat for willow and marsh tit
- Rescue adder “island populations”



Ecology and Evolution

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RESEARCH ARTICLE OPEN ACCESS

Designing a Climate Change Resilient Landscape Connectivity Network From a Multi-Species Perspective

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Keywords: Circuitscape | climate change | conservation | landscape connectivity | protected areas | species

ABSTRACT

There is strong evidence that climate change causes species range shifts and declines. Protected areas and suitable habitats are important for maintaining biodiversity. Species range changes depend on landscape connectivity between areas, facilitating movement and colonisation. Conservationists should identify landscape connectivity, as climate change causes species to move at different points in time. We quantified national connectivity for England for a sample of nationally important taxa associated with limestone and upland habitats, reflecting the White Peak as example focal region. We generated England-wide species distribution models for 15 species for three climate change time scenarios (Shared Socioeconomic Pathway 245): current, 2050 and 2090. We inverted these models, applying circuit theory analysis, to create connectivity maps. We applied *z*-score standardisation to compare differences between scenarios. We considered the top decile of connectivity occurring across the time periods as the ‘landscape connectivity network’. We compared this with the National Character Area framework of land parcels, the Site of Special Scientific Interest (SSSI) map, and quantified landcover in the network. The landscape connectivity network showed future species requirements becoming more diffuse, i.e., the landscape becoming more permeable. High connectivity value land lay in South West or South East England, and the central Pennines; implying range shifts to diverging latitudes. The network measured 1,029,000 ha, with 13% inside SSSIs. In the White Peak focal example, there were 7600 ha, with 38% inside

Connectivity models ... helping animals find each other ... everywhere

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