PROCESSO BIOGEOGRÁFICO NATURA 2000
REGIÃO BIOGEOGRÁFICA MACARONÉSICA

BIOGEOGRAPHICAL PROCESS NATURA 2000 - MACARONESIAN REGION

DEFINITION OF COHERENCE FOR NATURA 2000 NETWORK

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NATURA 2000

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GOBIERNO DE ESPAÑA
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IS NATURA 2000 NETWORK A NETWORK?

Catchpole, R. *Ecological Coherence Definitions in Policy and Practice - Final Report. Contract Report to Scottish Natural Heritage, No. 41102*; Aspen International: Leeds, 2013

IS NATURA 2000 NETWORK A NETWORK?

A NETWORK SHOULD BE COHERENT

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IS NATURA 2000 NETWORK A NETWORK?

↓

A NETWORK SHOULD BE COHERENT

↓

WHAT IS COHERENCE?

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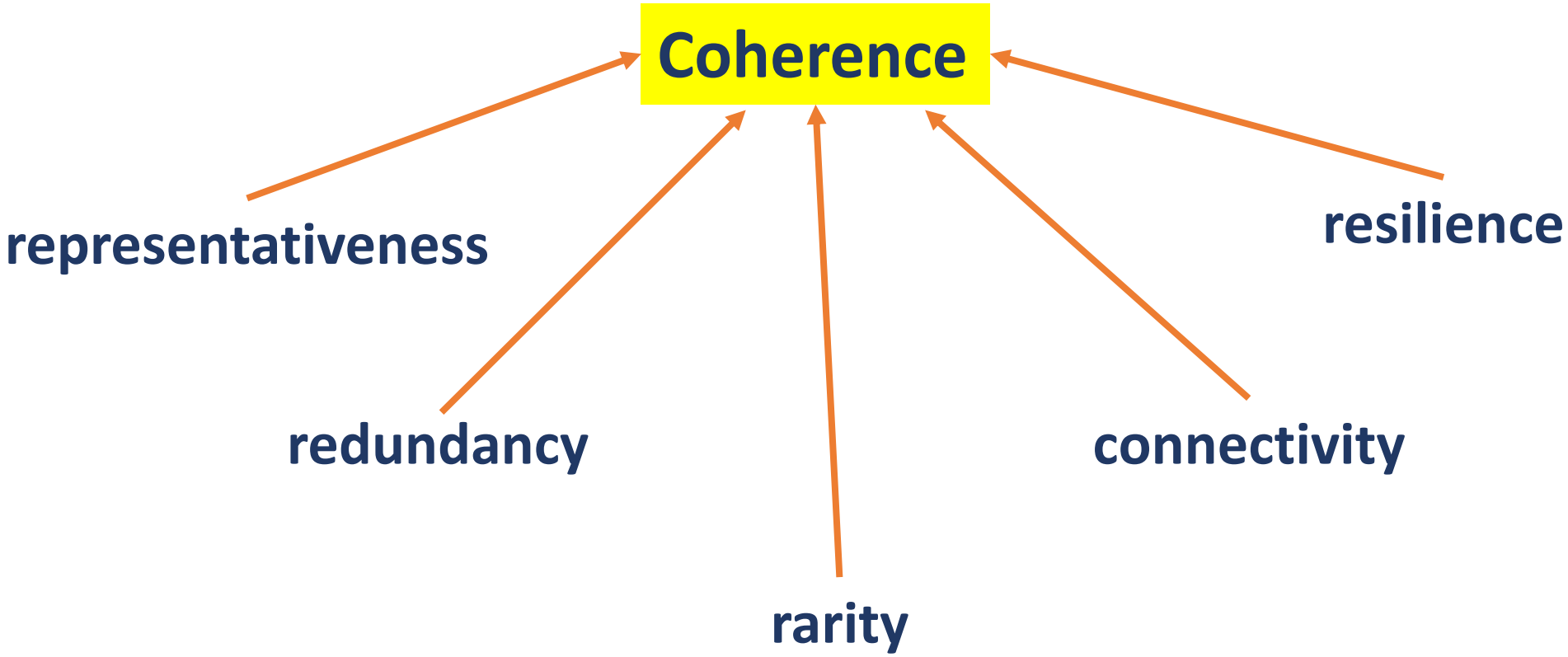
COHERENCE: OPERATIONAL DEFINITION

At the scale of the Natura 2000 Network, coherence is achieved when:

- the full range of variation in valued features is **represented**;
- **replication** of specific features occurs at different sites over a wide geographic area;
- **dispersal**, migration and genetic exchange of individuals is possible between relevant sites;
- all critical areas for **rare**, highly threatened and endemic species are included;
- and the network is **resilient** to disturbance or damage caused by natural and anthropogenic factors.

Catchpole, R. *Ecological Coherence Definitions in Policy and Practice - Final Report. Contract Report to Scottish Natural Heritage, No. 41102*; Aspen International: Leeds, 2013

Coherence is a system meta-property:



COHERENCE: OPERATIONAL DEFINITION

A network is coherent when there is environmental & biota variability and replication, connectivity across the network, resilience to perturbances, and includes all threatened, endemic, and rare species.

HOW TO MEASURE COHERENCE

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REPRESENTATIVENESS: ENVIRONMENT & BIOTA

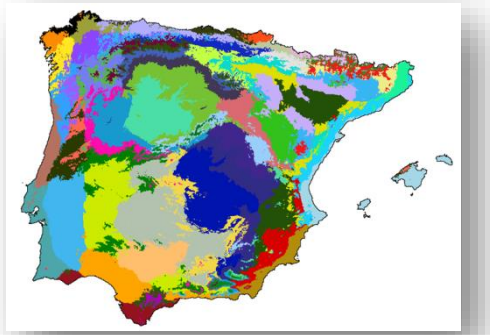
- **Network capacity to reproduce the features of a territory: representative sample**
  - **ENVIRONMENT**
    - Oriented to represent ranges of variation of ecosystem natural drivers
    - Requires hierarchical arrangement of land classes
    - Essential to support resilience
  - **BIOTA**
    - Oriented to contain target groups of biota: habitats, species
    - Commonly based on target thresholds
    - Concerns to common, rare and endemic biota

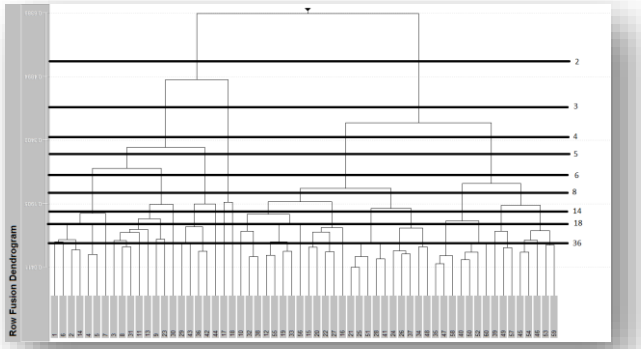
REPRESENTATIVENESS: ENVIRONMENTAL HIERARCHICAL CLASSIFICATION

PROCESSO BIOGEOGRÁFICO NATURA 2000
REGIÃO BIOGEOGRÁFICA MACARONÉSICA

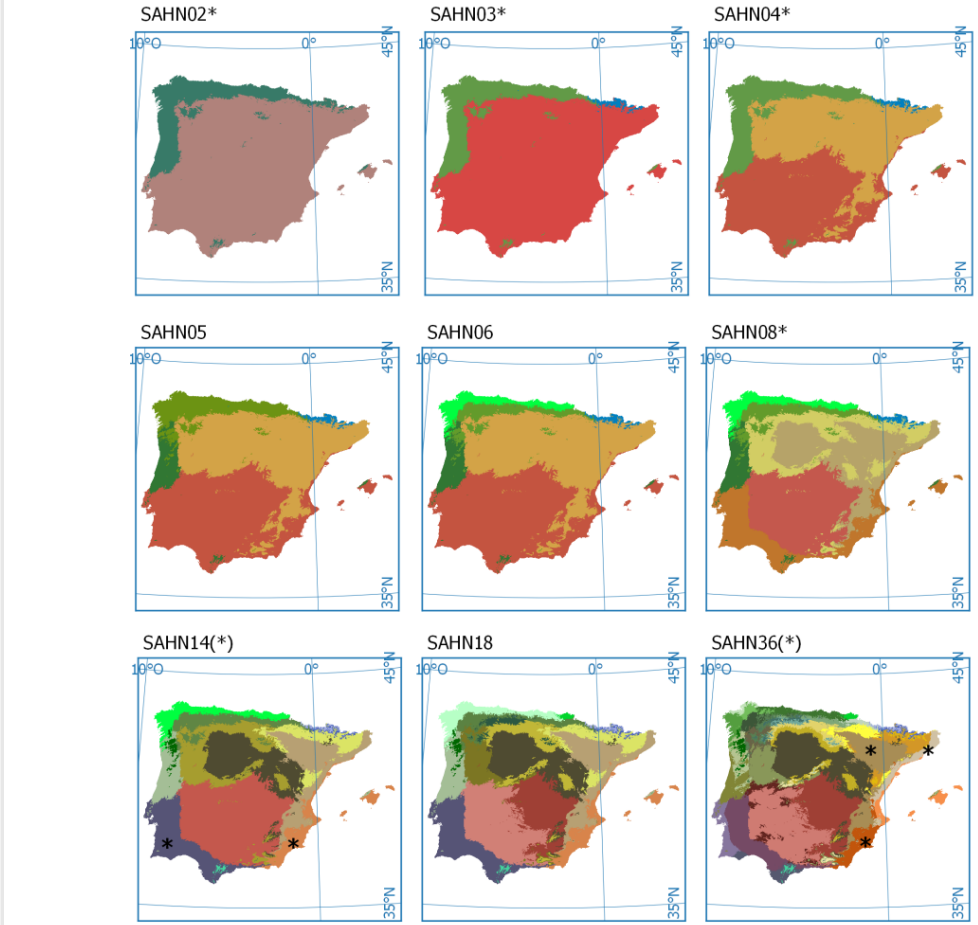
climate surfaces 1981-2010

19 bioclimatic variables (*Bioclim*, *WorldClim*)





Climatic regionalization of the Iberian Peninsula



del Barrio G, Sanjuán M E, Martínez-Valderrama J & Ruiz A. 2019. *Descripción y ensayo de un procedimiento de regionalización climática del territorio. Serie "Metodologías para el seguimiento del estado de conservación de los tipos de hábitat"*. Ministerio para la Transición Ecológica. Madrid. 42 pp. NIPO: 638-19-088-X. http://hdl.handle.net/10261/207348

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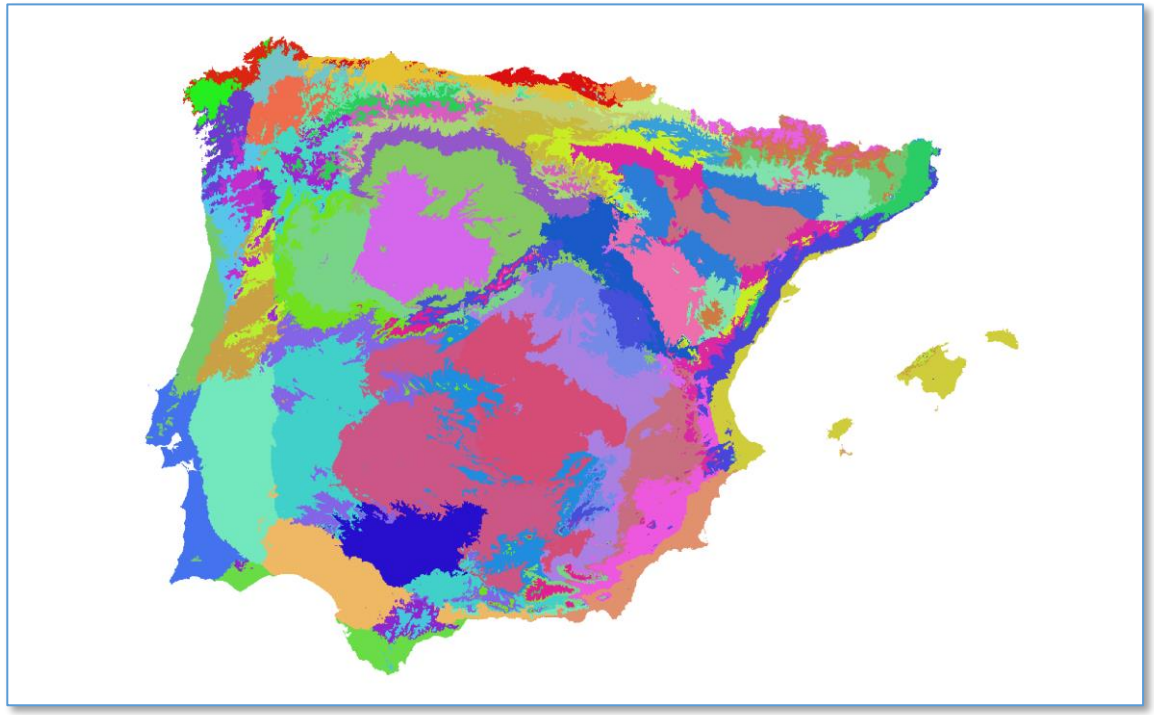
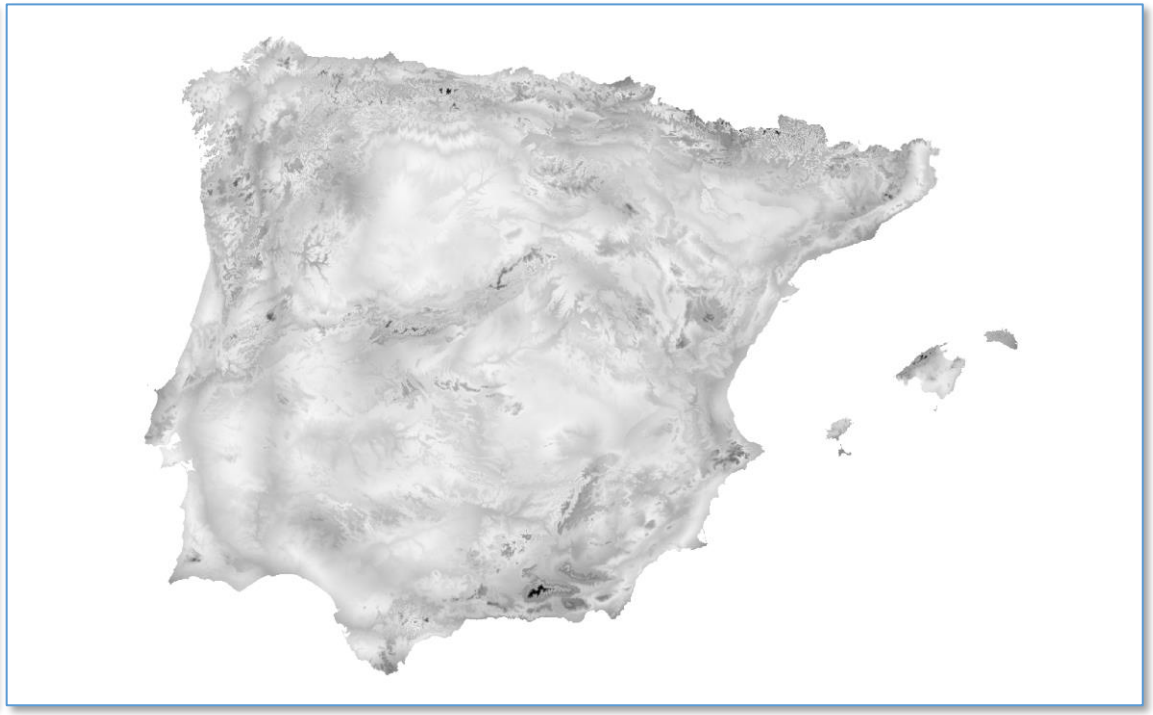
REPRESENTATIVENESS: SIMILARITY BETWEEN CLASSES





- Representativeness in N2K:
  - How many regional classes are represented in each SAC
  - How many SACs are represented in each regional class

SAC: Special Area of Conservation

REPRESENTATIVENESS: ENVIRONMENT & BIOTA

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REPRESENTATIVENESS: THRESHOLDS FOR HABITATS AND SPECIES

As done in Spain at the N2K planning stage:

Habitat type	Representation threshold in N2K
Very rare (prioritary or not)	100%
Rare and prioritary	80%
Non rare and prioritary	50%
Rare and non prioritary	50%
Non rare and non prioritary	10%

[Very rare – Rare – Non rare ← 33%, 66% percentiles of distribution size]

Criteria suggested by the European Topic Centre on Biological Diversity (ETC/BD):

Representation assessment	Representation threshold in N2K
Well represented	> 60%
Require detailed analyses	< 20%
Require discussion case by case	20% – 60%

Orella, J.C *et al*, 1998. La lista nacional de lugares de la Directiva Habitats 92/43/CEE. Metodología y proceso de elaboración. *Ecología*, 12: 3-65.

REPRESENTATIVENESS IN MACARONESIA

- **Organization levels, regionalizations and spatial resolutions**
  - Inter-archipelago: climate, 1000 m
  - Intra-archipelago: climate, topo-climate, 250 m
  - Intra-island: topography, 10 – 250 m
- **Scale-dependent representativeness targets**
  - Inter-, intra-archipelago: commonness
  - Intra-archipelago, intra-island: rarity
- **Scale-dependent environmental drivers**
  - Inter-, intra-archipelago: climate
  - Intra-archipelago, intra-island: topography, landforms, lithology

REPRESENTATIVENESS: METRICS

- Extent of each regional climate class within SACs across selected regionalization levels [Inter-, intra-archipelago]
- Extent of each local topography-lithology-landform class within SACs across selected regionalization levels [Intra-archipelago, intra-island]
- Gradient intervals for relevant predictors from the actual distribution of HTCI, and their representation in SACs [Intra-archipelago, intra-island]
- Proportion of the actual distribution of each HTCI and each SCI that is represented in the SAC system [all levels]
- List of relevant ecosystems or species that are not HTCI or SCI

HTCI: habitat types of community interest
SCI: Species of Conservation Interest

REPRESENTATIVENESS: REQUIRED DATA & TOOLS

- **Required data**
  - Climate atlas at 1 – 10 km resolution
  - Digital Elevation Models at 10 – 50 m resolution
  - Digitized maps of other environmental drivers: lithology, landforms
  - Vector coverage of SACs
  - Actual distributions of HTCI and SCI
- **Specific tools**
  - Software for (non-)hierarchical classification (e.g. k-means, CLARA, etc.)
  - R scripting (& packaging) for sharing, repeating, etc.

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OPERATIONAL DEFINITION

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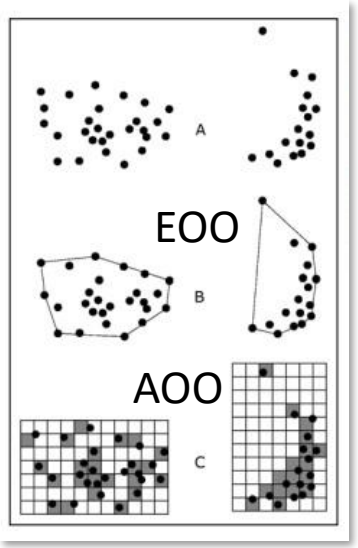
REDUNDANCY

- **Functional**: species performing similar roles (niches) in communities
  - resilience vs. expendability
- **Conservation**: options against catastrophic disturbances
  - IUCN threat category criterion B applied by archipelago:



B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)	Critically Endangered	Endangered	Vulnerable
B1. Extent of occurrence (EOO)	< 100 km²	< 5,000 km²	< 20,000 km²
B2. Area of occupancy (AOO)	< 10 km²	< 500 km²	< 2,000 km²
AND at least 2 of the following 3 conditions:			
(a) Severely fragmented **OR** Number of locations	= 1	≤ 5	≤ 10
(b) Continuing decline observed, estimated, inferred or projected in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** area, extent and/or quality of habitat; **(iv)** number of locations or subpopulations; **(v)** number of mature individuals			
(c) Extreme fluctuations in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** number of locations or subpopulations; **(iv)** number of mature individuals			

Rosenfeld, J.S. (2002), Functional redundancy in ecology and conservation. Oikos, 98: 156-162. https://doi.org/10.1034/j.1600-0706.2002.980116.x
Keith DA, Rodríguez JP, Rodríguez-Clark KM, Nicholson E, Aapala K, et al. (2013) Scientific Foundations for an IUCN Red List of Ecosystems. PLOS ONE 8(5): e62111. https://doi.org/10.1371/journal.pone.0062111

RARITY

- **Rare species**
  - Not redundant with other species
  - Contribute disproportionately to
    - the diversity traits of a region
    - ecosystem functions and associated services
  - High extinction risk: low abundance & narrow distribution
  - Largest effect on community stability when perturbed
- **Rarity depends on**
  - *Geographic restrictiveness*
  - *Functional distinctiveness*
- **Rarity must be assessed not as such, but within a spectrum:**
  - e.g.: *common – average – rare*

Säterberg, T., Jonsson, T., Yearsley, J. *et al.* A potential role for rare species in ecosystem dynamics. *Sci Rep* **9**, 11107 (2019). https://doi.org/10.1038/s41598-019-47541-6

RARITY

Functional distinctiveness

1. Select a set of taxa traits or niche features (e.g. Hutchinson niche after predictive distribution)
2. Ordination of the taxa pool (e.g. PCoA)
3. For each taxon, compute distance to all other taxa (e.g. use PCoA coordinates)

$$D_i = \frac{\sum_{j=1, j \neq i}^{N} d_{ij}}{N - 1}$$

D_i : average functional distance between the species of interest and all the other species of the pool [1 (very different) to 0 (very similar)]
d_{ij} : functional Gower's pairwise distance between species i and j
N : total number of species

Geographic restrictiveness

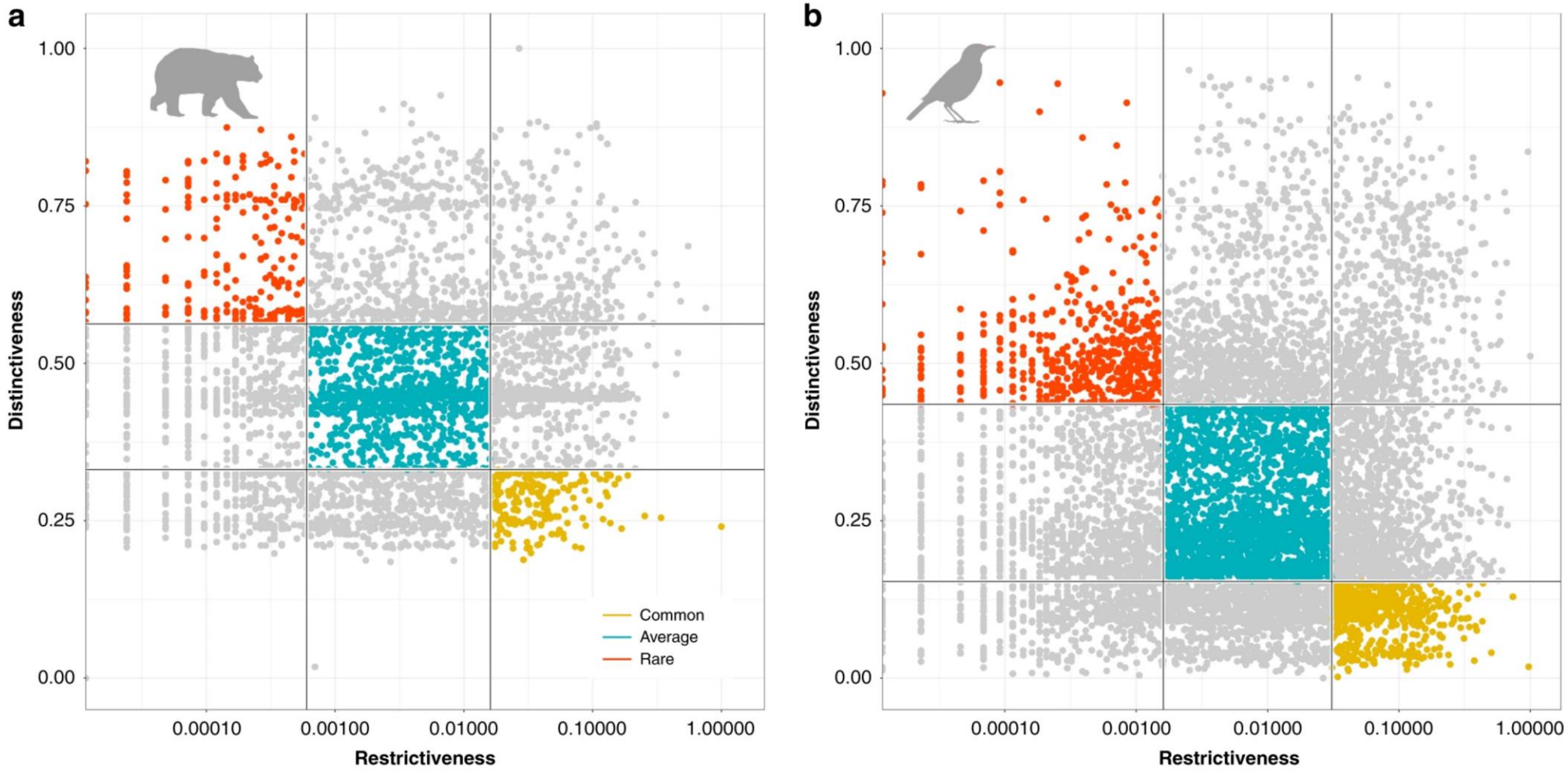
1. Know the distribution area of all taxa in the pool

$$R_i = 1 - \frac{K_i}{K_{tot}}$$

R_i : geographical restrictedness of species i [1 (restricted) to 0 (common)]
K_i : number of cells where species i is present
K_{tot} : total number of cells

Loiseau, N., Mouquet, N., Casajus, N. *et al.* Global distribution and conservation status of ecologically rare mammal and bird species. *Nat Commun* **11**, 5071 (2020). https://doi.org/10.1038/s41467-020-18779-w

RARITY



Loiseau, N., Mouquet, N., Casajus, N. *et al.* Global distribution and conservation status of ecologically rare mammal and bird species. *Nat Commun* **11**, 5071 (2020). https://doi.org/10.1038/s41467-020-18779-w

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ENDEMISM

- **Endemism**
  - Biogeographical: the whole distribution is included in the study area
  - Phylogenetic: phylogenetic equivalent of species endemism
  - Weighted: species richness inversely weighted by species ranges

Daru, B.H., Farooq, H., Antonelli, A. *et al.* Endemism patterns are scale dependent. *Nat Commun* **11**, 2115 (2020). https://doi.org/10.1038/s41467-020-15921-6

REPRESENTATIVENESS: REQUIRED DATA & TOOLS

- **Required data**
  - Vector coverage of SACs
  - Actual distributions of HTCI and SCI
- **Specific tools**
  - No specific tools required
  - R scripting (& packaging) for sharing, repeating, etc.

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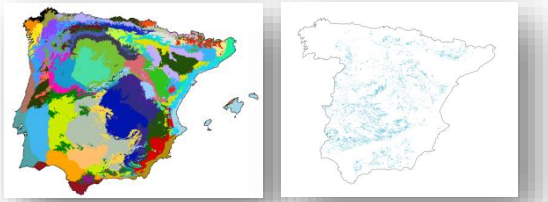
CONNECTIVITY

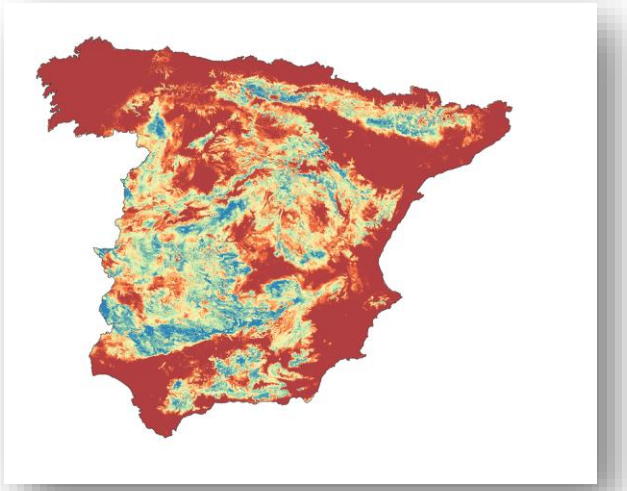
- The ability of a given population to move through a landscape.
- Measurable.
- Central to biodiversity conservation.
- Spatial property extrinsic to the landscape -> result of the **spatial structure of the landscape** and the characteristics of **the taxon ecological niche**.
- Only landscapes where suitability is spatially **heterogeneous**.
- Depends on a **scale of dispersal** -> spatial range where movements of a species can be associated to the distribution of its resources.
- No time dimension.
- Connectivity takes place across the whole landscape -> **Gradient of suitability**.
- Habitat suitability index -> **Ecological niche models**.

CONNECTIVITY: BUILDING A MODEL

Landscape characteristics

Ecological niche





Predictive distribution model:
probability of presence = suitability surface

Friction surface

Observed distribution
Dispersal distance

CONNECTIVITY MODELS: PARAMETERS

Dispersal distance

- Habitat-path model
- Cost is lower in the pixel where the habitat is present -> populations have to be defined to calculate lowest cost routes ('corridors')
- Two pixels are considered to belong to different populations if they exceed the dispersal distance

Friction

- 1/*p:* inverse of the habitat suitability index
- measure of the difficulty of dispersion over the selected territory

ALCOR: Algoritmo para la Conectividad Regional (del Barrio *et al.,* 2006*)*

CONNECTIVITY MODELS

ALCOR: Algoritmo para la Conectividad Regional

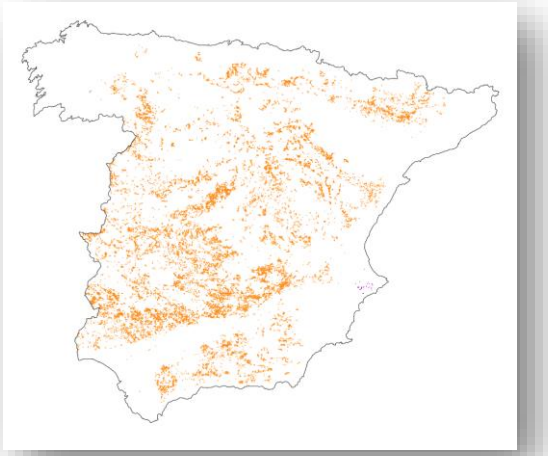
Input data:
- Observed distribution
- Predictive distribution

Parameters:
- Dispersal distance
- Friction definition: 1/p

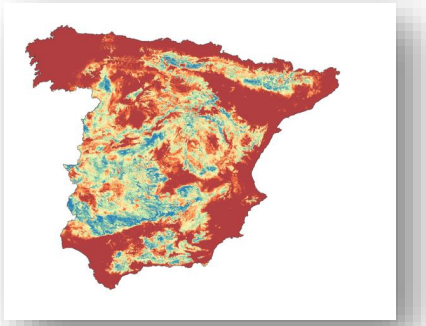
Output data:
- Populations
- Cost Surface
- Minimum cost/maximum connectivity paths ('corridors')

Observed distribution

Distance threshold

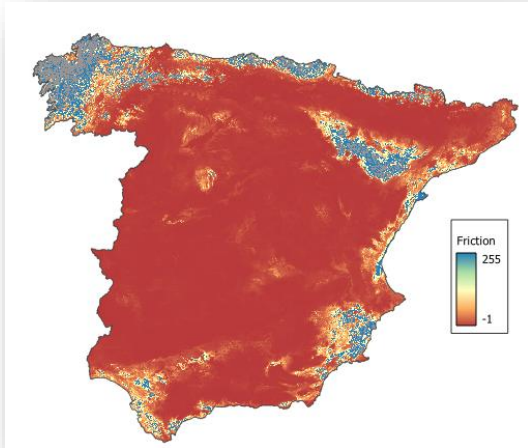


ALCOR defined populations



Predictive distribution model (*p*)

1/*p*



Friction surface (1/*p*)

del Barrio, G., Ruiz, A. 2006. ALCOR: software para estimar la conectividad ecológica. Registro de la Propiedad Intelectual de Almería, solicitud nº AL 61/06. Almería.

CONNECTIVITY MODELS: OUTPUT

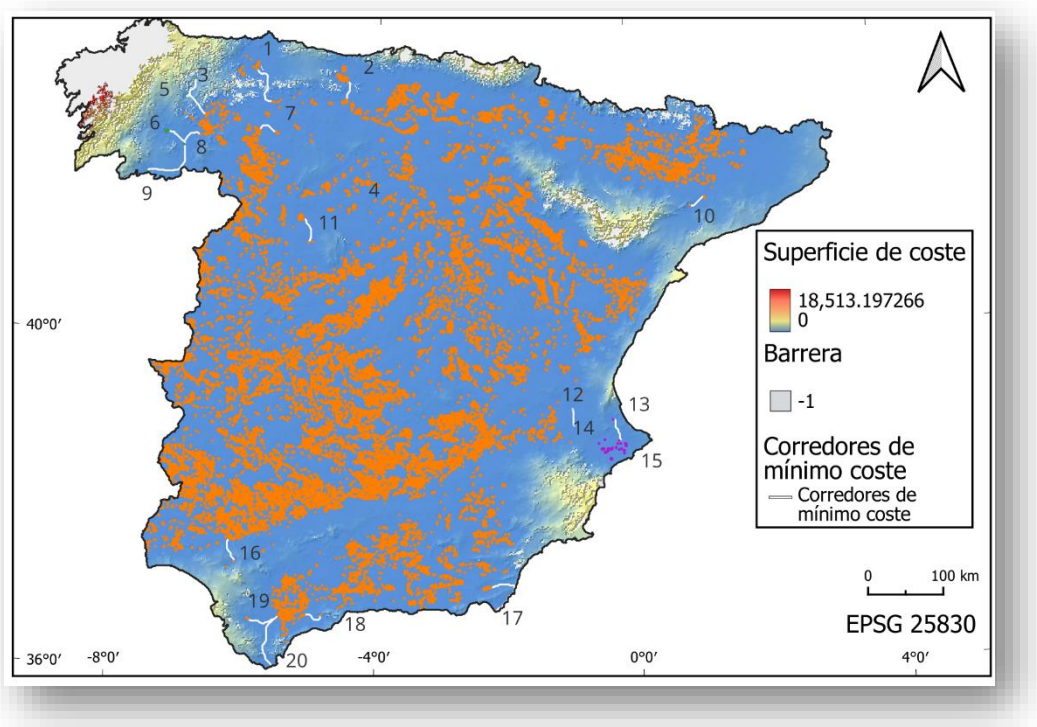
Populations: created by ALCOR based on dispersal distance

Cost surface:

- Cost: friction accumulated by the species as it disperses.

Corridors:

- Calculates the path between a population and its nearest population passing through the pixels of the cost surface that have the lowest values.



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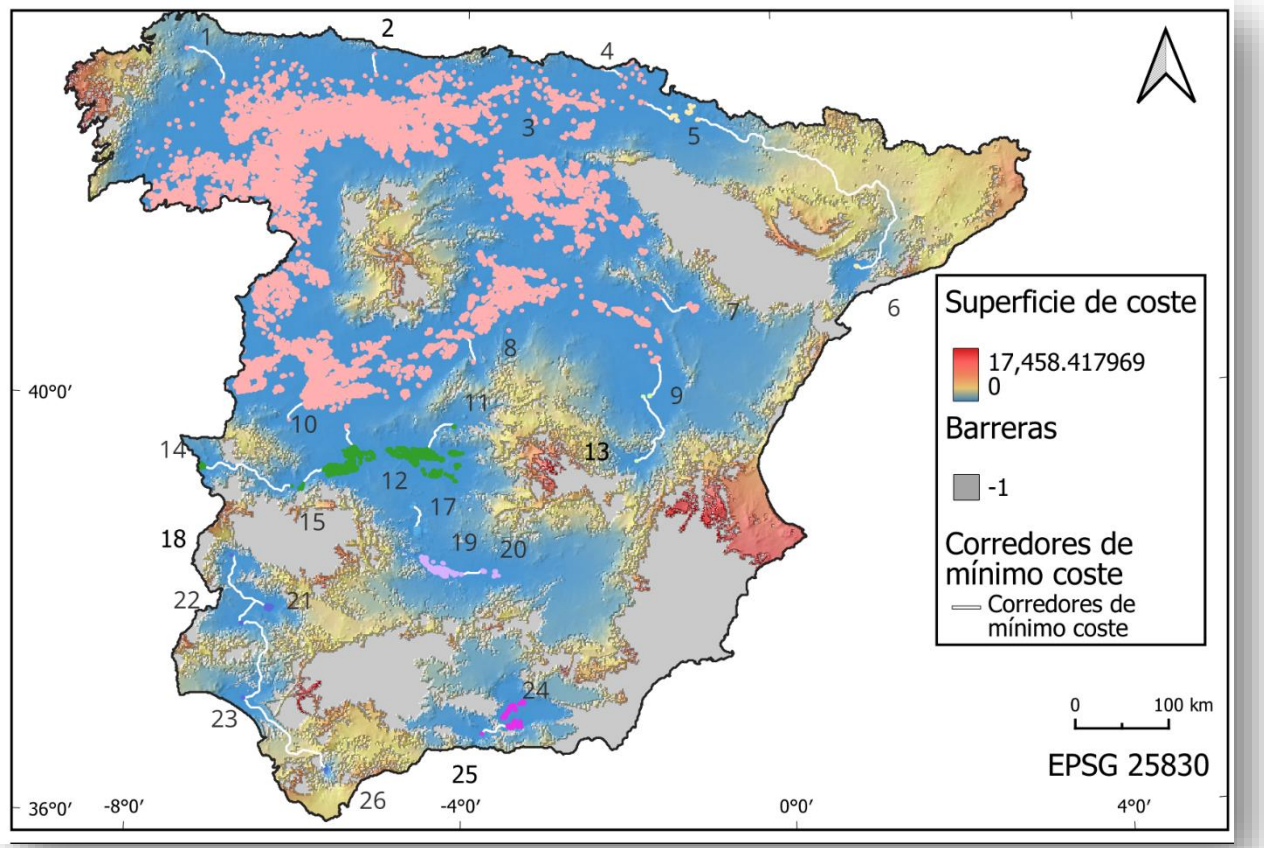
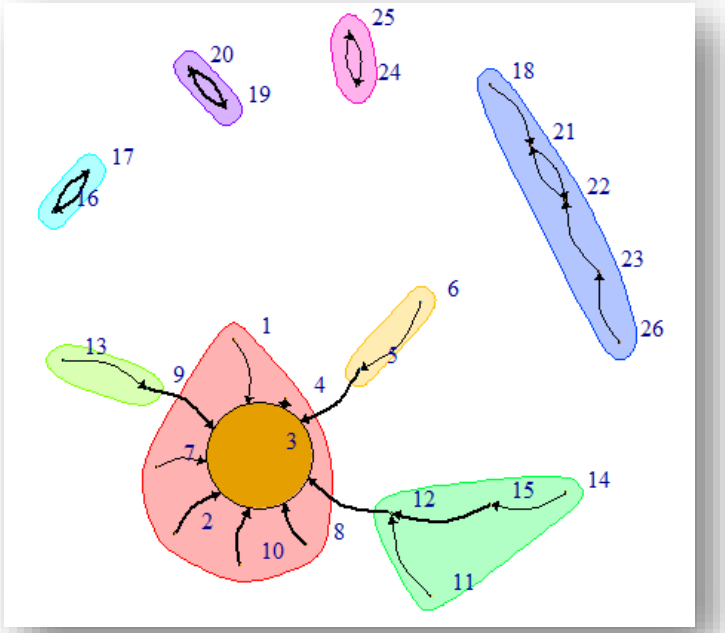
CONNECTIVITY MODELS





Connectivity network

Connectivity model for 111MN_32_Melojares *Quercus pyrenaica*

CONNECTIVITY: REQUIRED DATA & TOOLS

- **Required data**
  - Vector coverage of SACs
  - Actual distributions of HTCI and SCI
- **Specific tools**
  - ALCOR / Circuitscape
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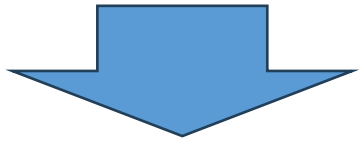
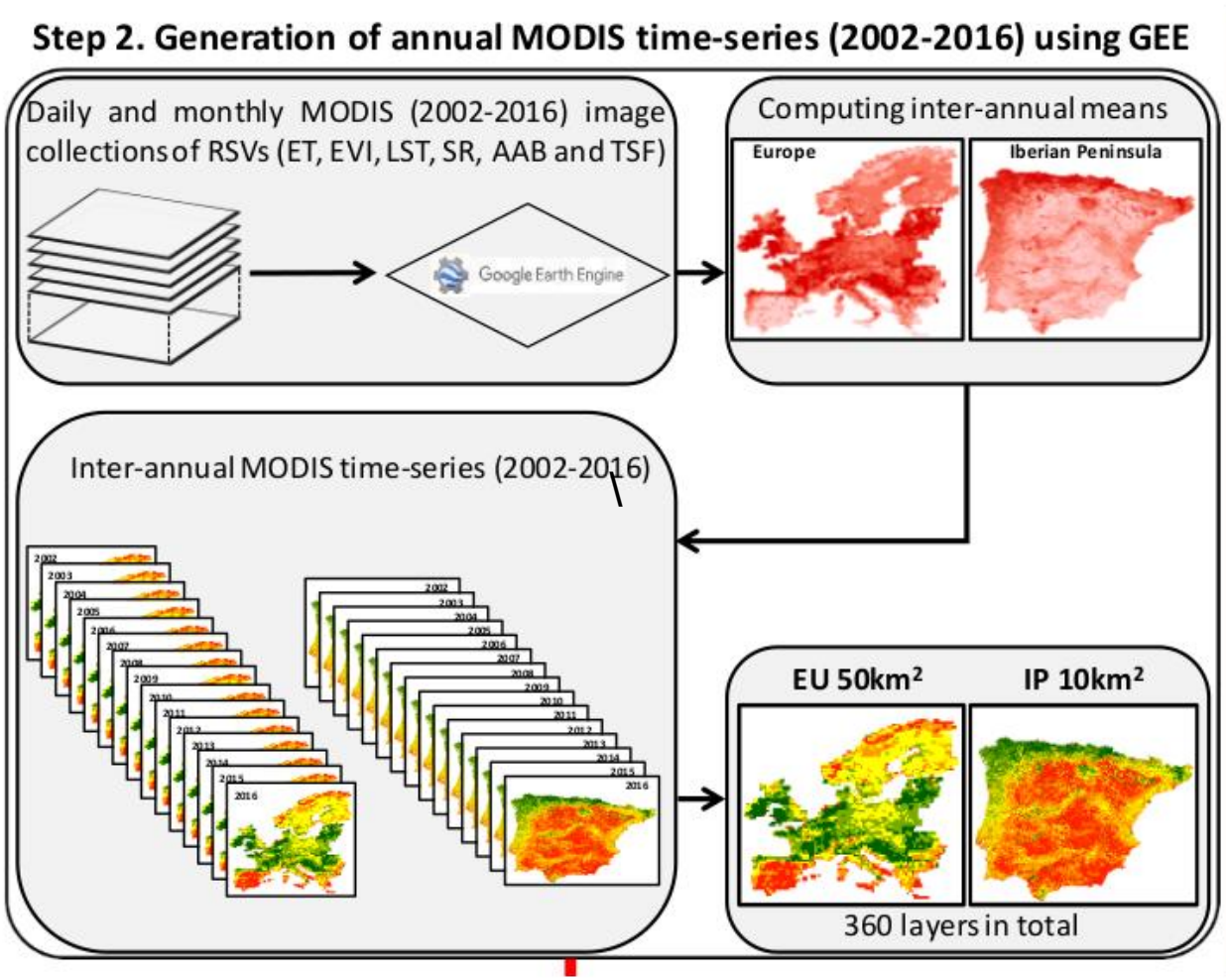
RESILIENCE

- Network capacity to resist natural and human perturbations
  - Difficult to measure
  - We can measure perturbations at ecosystem level
  - We can measure perturbations at habitat level
  - Habitat → specific for each species
  - Perturbations can affect the species in different ways
  - We need a standard method, easy to apply



Salvador Arenas-Castro & Neftalí Sillero (2021): Cross-Scale Monitoring of Habitat Suitability Changes Using Satellite Time Series and Ecological Niche Models. Science of The Total Environment 784: 147172. https://doi.org/10.1016/j.scitotenv.2021.147172.

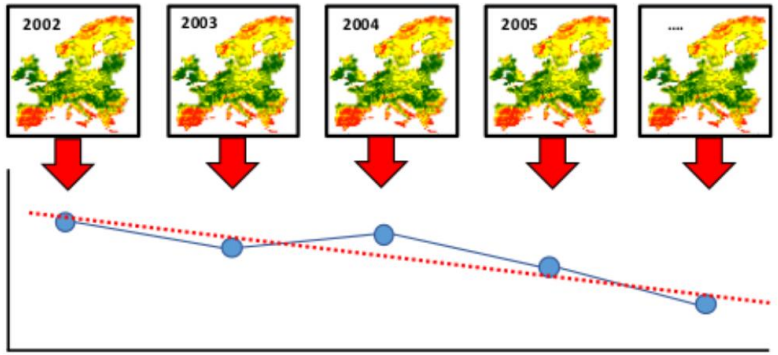
TEMPORAL SERIES OF SATELLITE IMAGES TO FEED ENMS



MAXENT MODELS

OVER TIME

HABITAT SUITABILITY TRENDS



EXEMPLE OF VARIABLES

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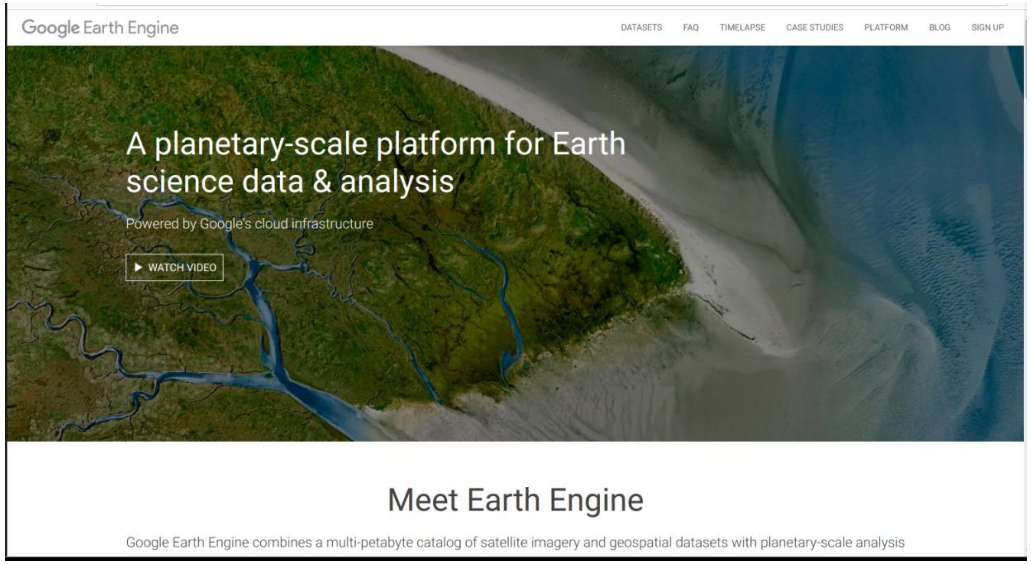
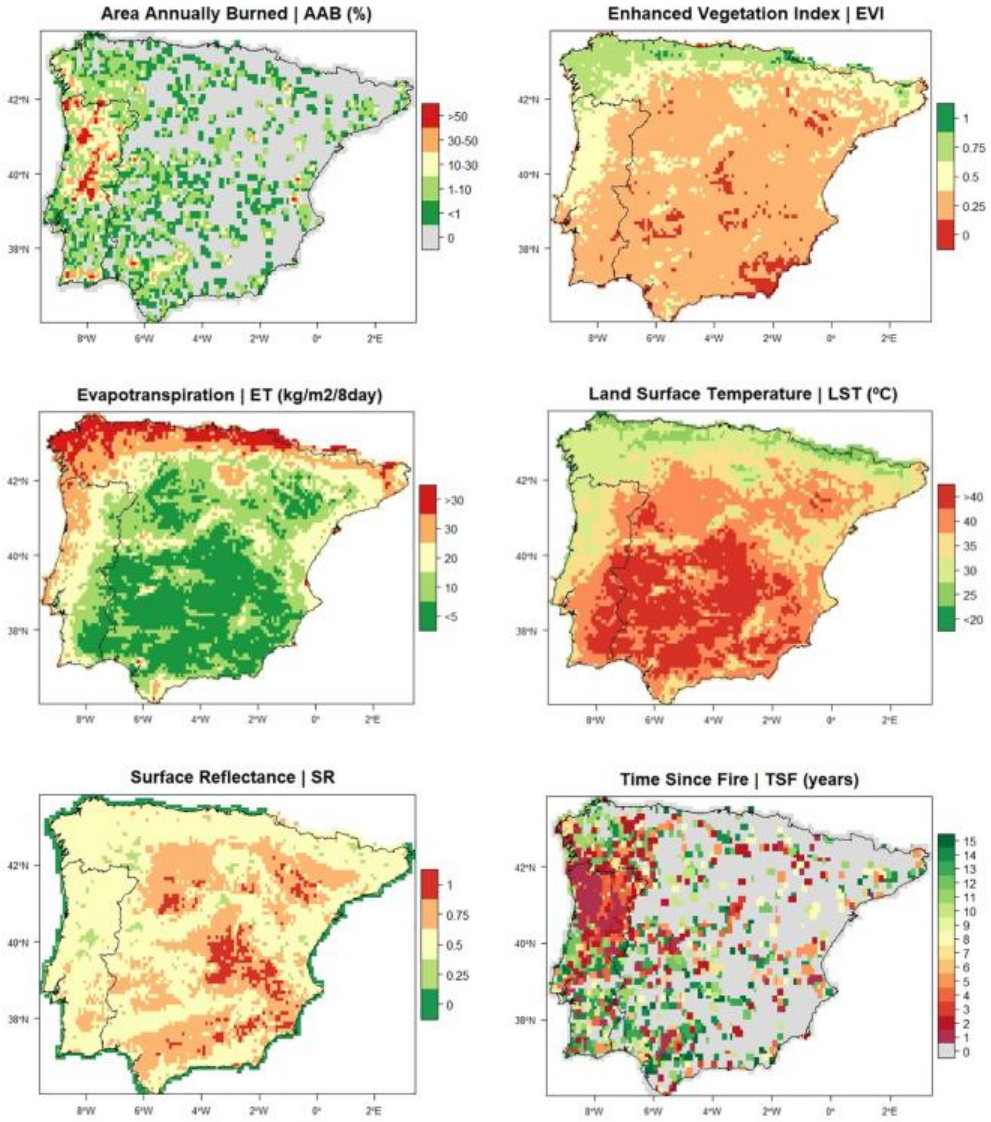
REGIÃO BIOGEOGRÁFICA MACARONÉSICA

- Evapotranspiration
- Enhanced Vegetation Index
- Land Surface Temperature
- Surface Reflectance
- Area Annually Burned
- Time-Since Fire





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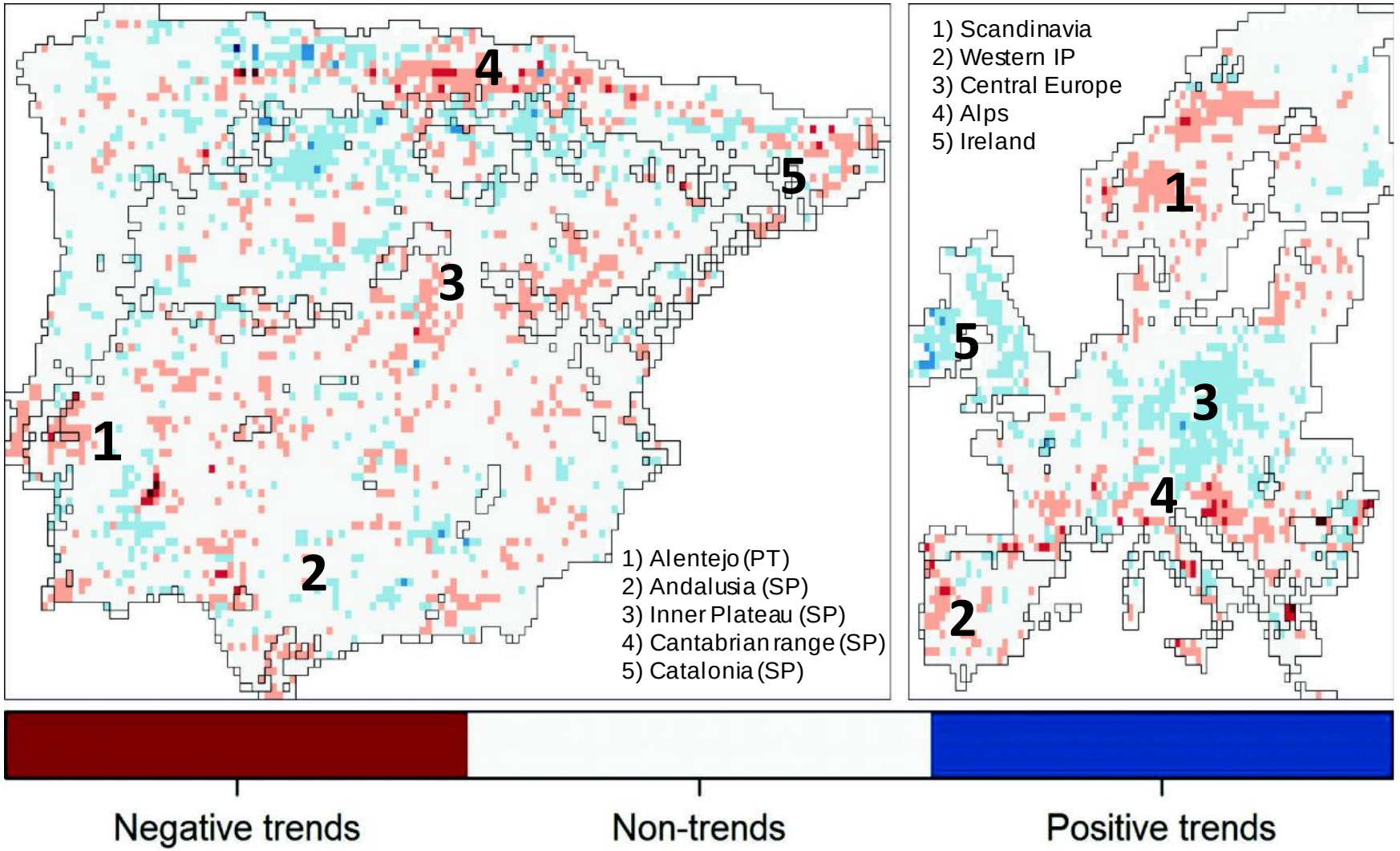
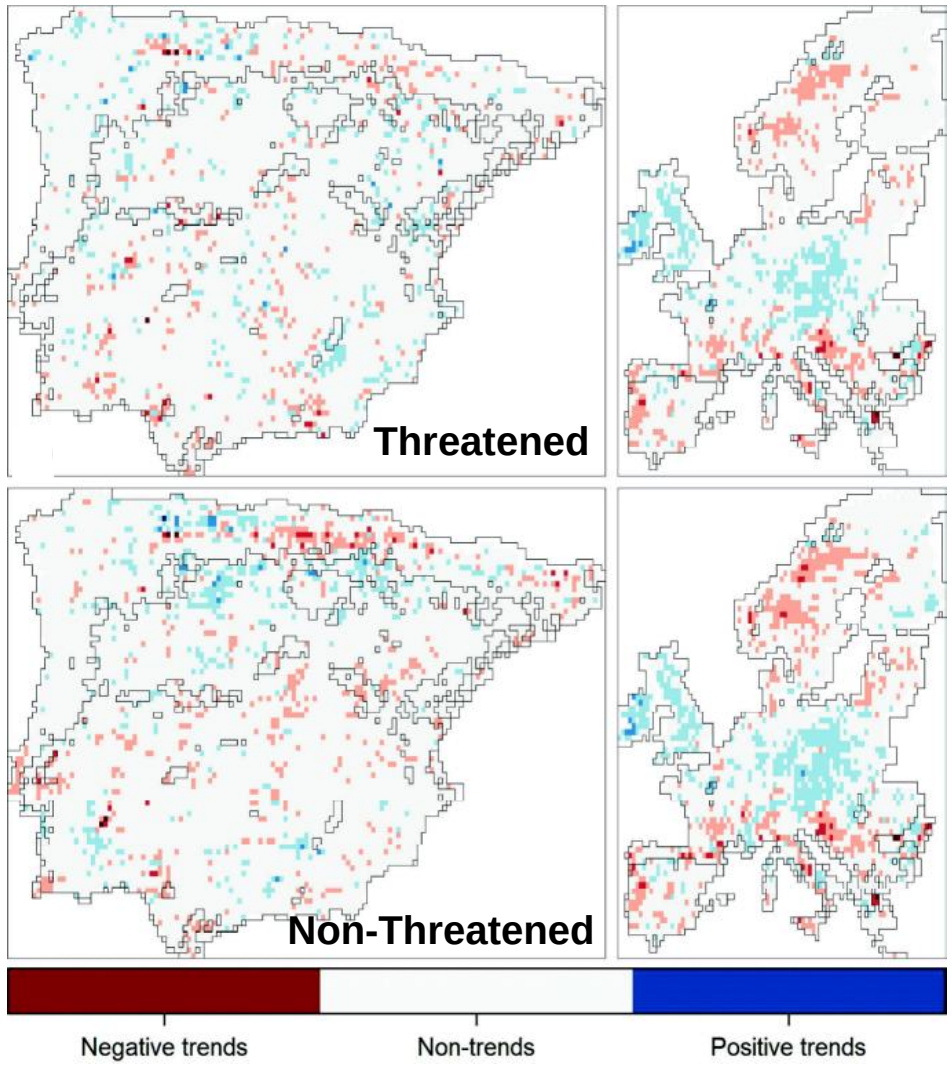
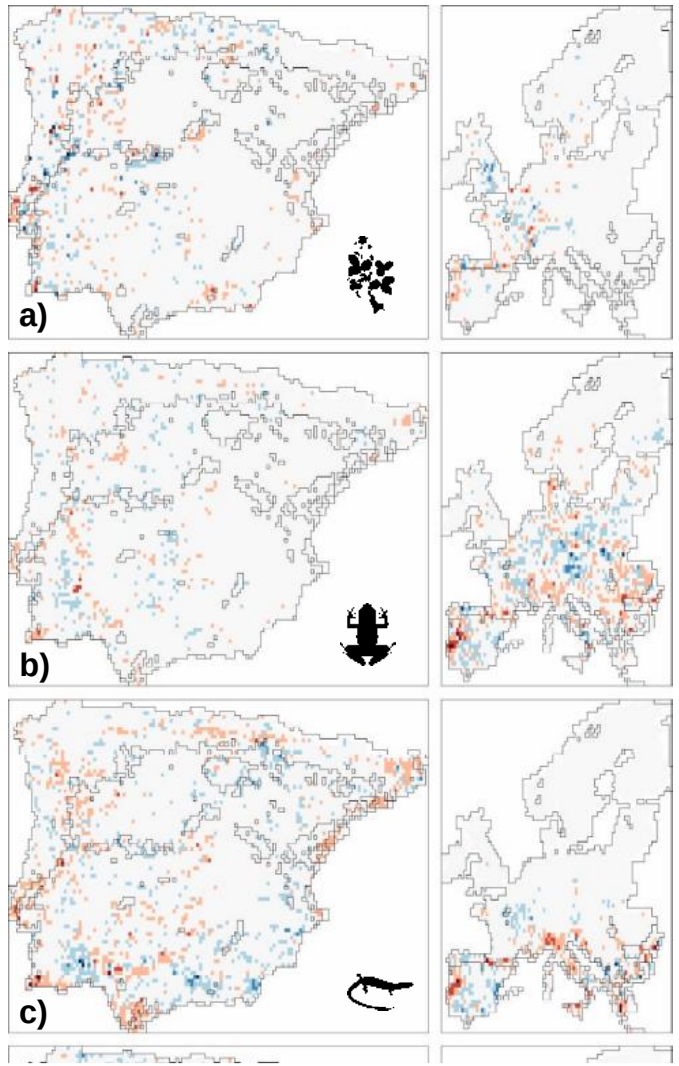
ALL SPECIES TOGETHER

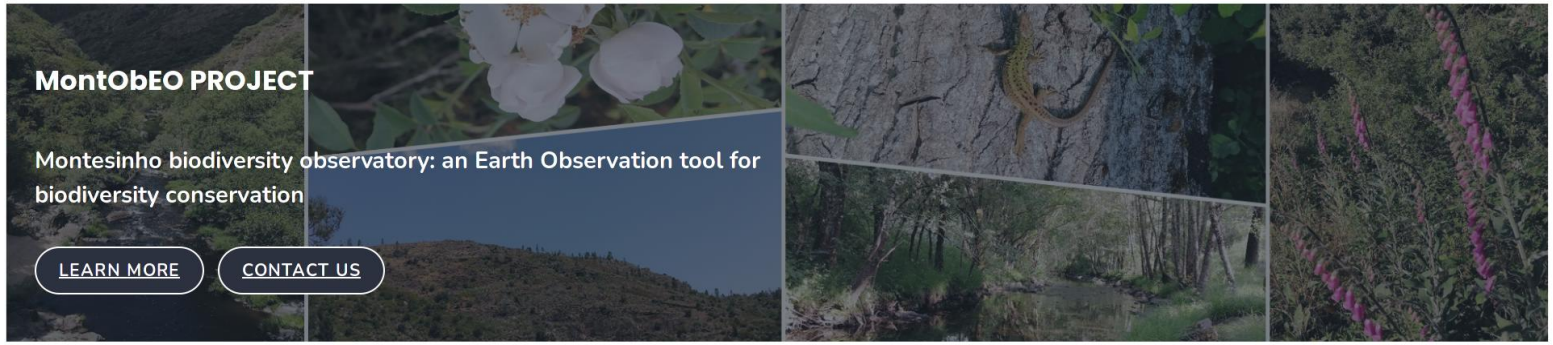


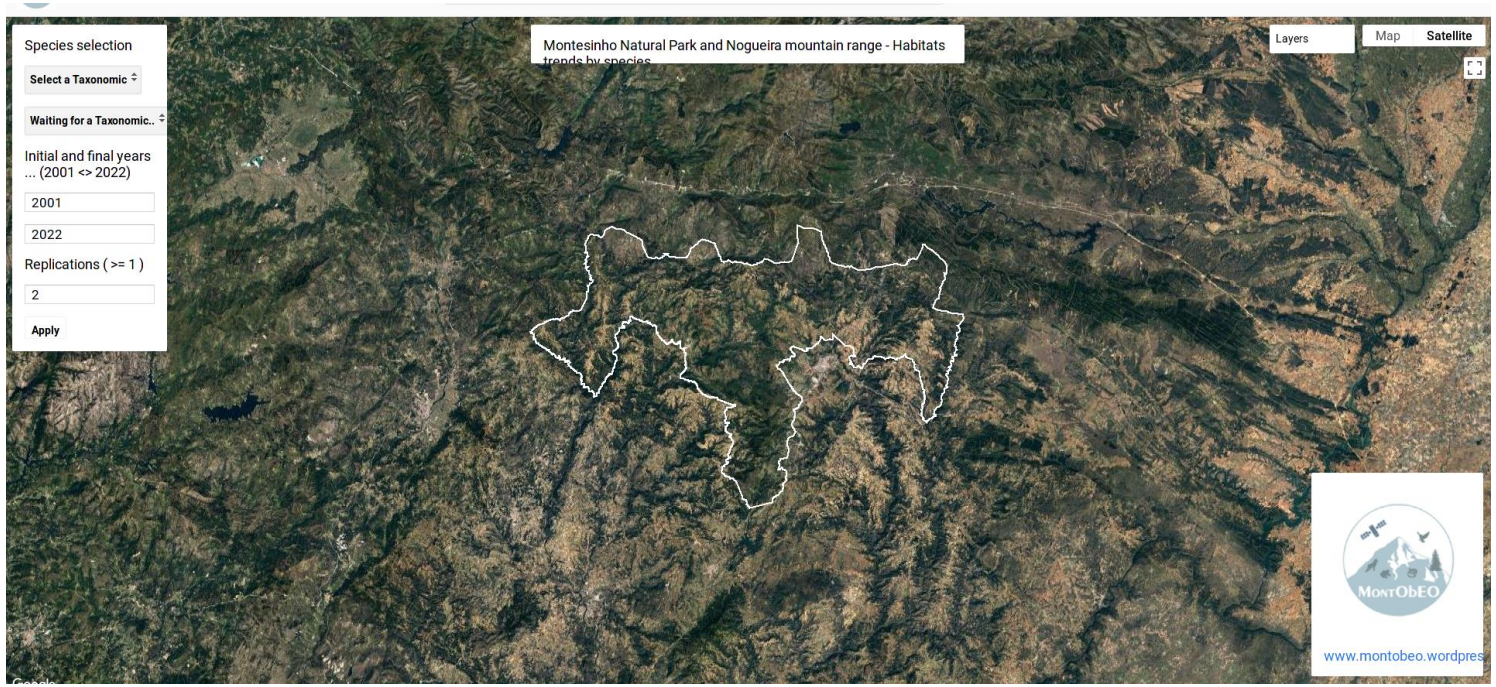
SPECIES FUNCTIONAL GROUPS OR INDIVIDUAL SPECIES





MONTOBEO PROJECT → GEE App





PROCESSO BIOGEOGRÁFICO NATURA 2000
REGIÃO BIOGEOGRÁFICA MACARONÉSICA

NATURA 2000

GOBIERNO DE ESPAÑA
MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA Y EL RETO DEMOGRÁFICO

RESILIENCE: REQUIRED DATA & TOOLS

- **Required data**
  - Vector coverage of SACs
  - Actual distributions of HTCI and SCI
  - Temporal series of remote sensing variables
- **Specific tools**
  - Google Earth Engine

HTCI: habitat types of community interest
SCI: Species of Conservation Interest

Thanks for your attention!
Muito obrigado!
¡Muchas gracias!