Species on the move (and gene flow)

January 12 2023

A framework for studying the within-range structure of species with discontinuous distributions under climate change

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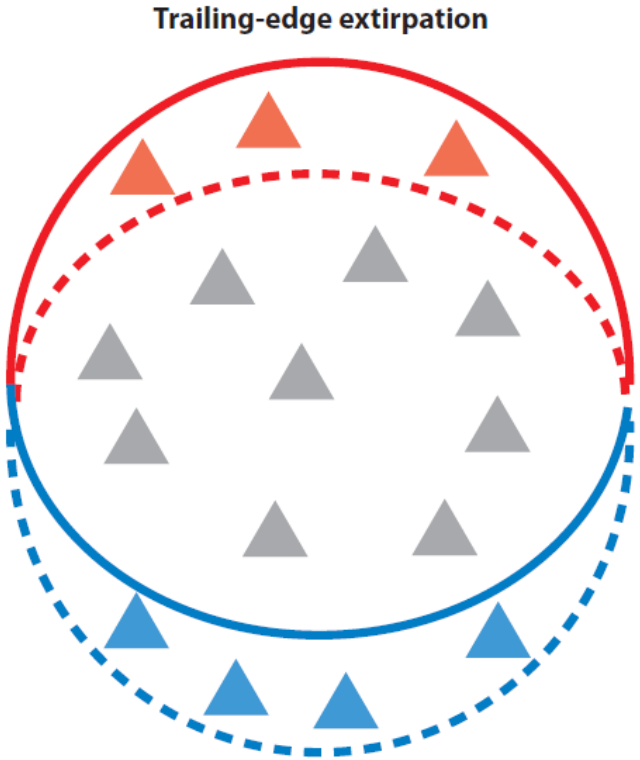
13TH INTERNATIONAL TEMPERATE REEFS SYMPOSIUM

Ifremer

REEHAB

Predicted range changes are often global



As Earth's climate rapidly changes, species must adapt or move.

Range changes are often modelled as if ranges were homogeneous.

Species range before climate change

Species range after climate change

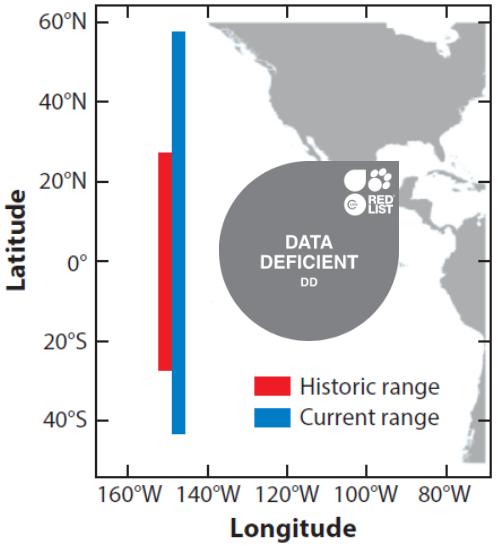
Local population

(Pinsky et al., 2020)

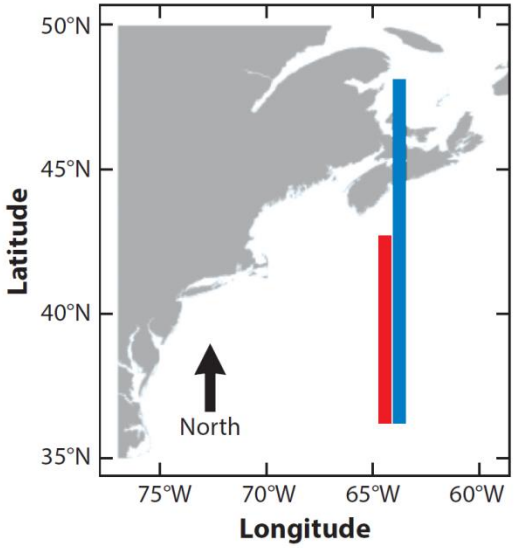
Yet many species have fragmented ranges

Terrestrial species: mountain ranges, roads,…

Humboldt squid
(*Dosidicus gigas*)



American lobster
(*Homarus americanus*)



(Pinsky et al., 2020)

Marine species: hydrographic barriers, lack of suitable substrate, …

Objectives

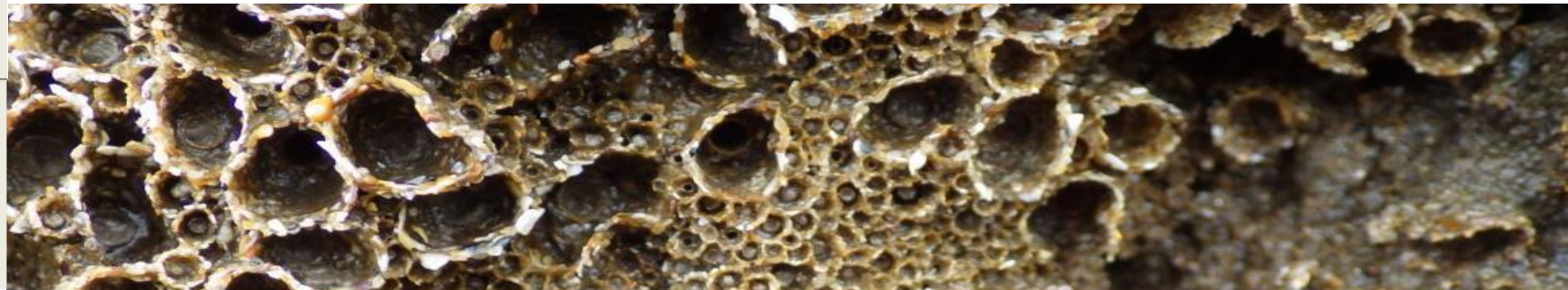
Using an ecosystem engineer with a naturally fragmented distribution

I. Predicted Present & Future scenarios

Range-long species distribution modelling (SDM)

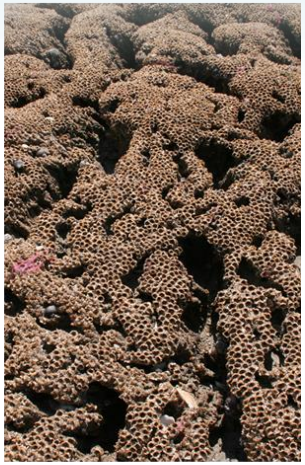
II. Within-range changes

Landscape metrics (LSM) applied to SDM outputs



The intertidal ecosystem engineer - *Sabellaria alveolata*

Ranges from Scotland to Morocco



Turns soft substrate into biogenic reef

High-diversity habitat buffers infauna from environmental extremes

No accurate ‘off-the-shelf’ occurrence dataset

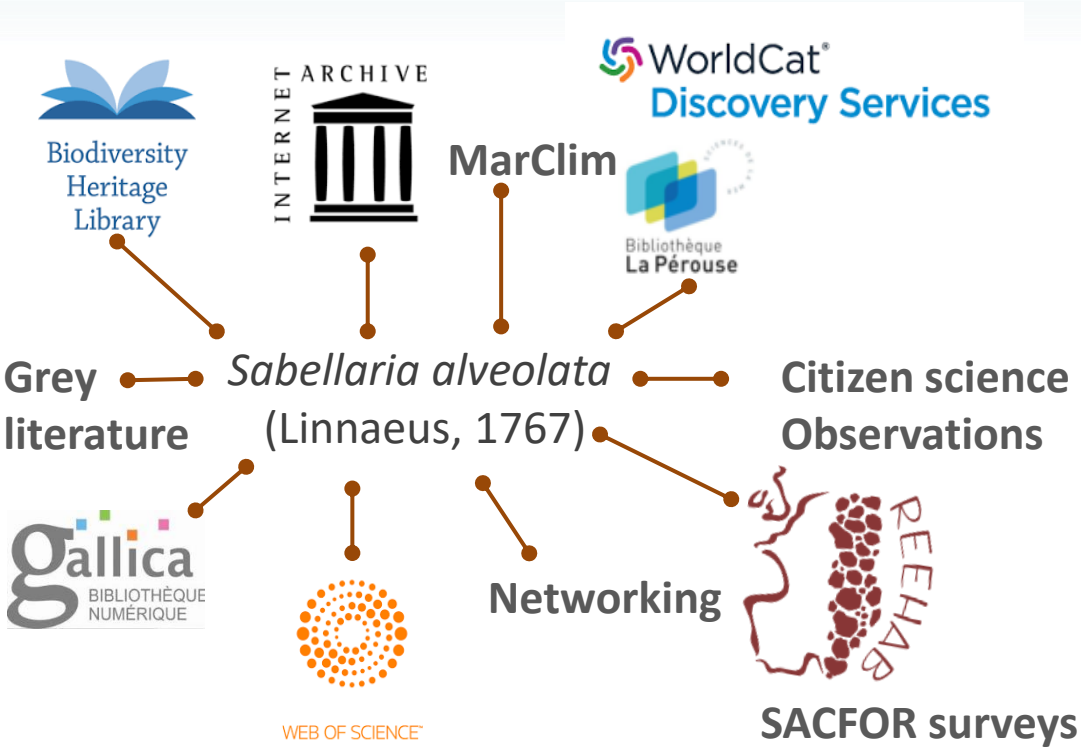
Often SDM papers simply state:

"GBIF data for these x species was downloaded ” OR “we downloaded IUCN geographic range map polygons”

Spatial bias – we know this doesn’t accurately represent *S. alveolata* distribution

accessed on 14-06-2020

S.alveolata Records Search Methods



(Curd et al., 2020; Firth et al., 2021)

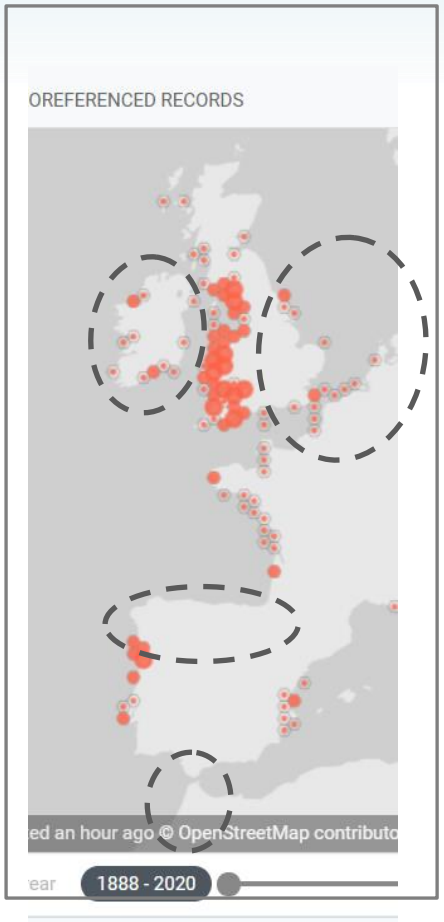
>21,500 occurrence records collated between 1821-2019

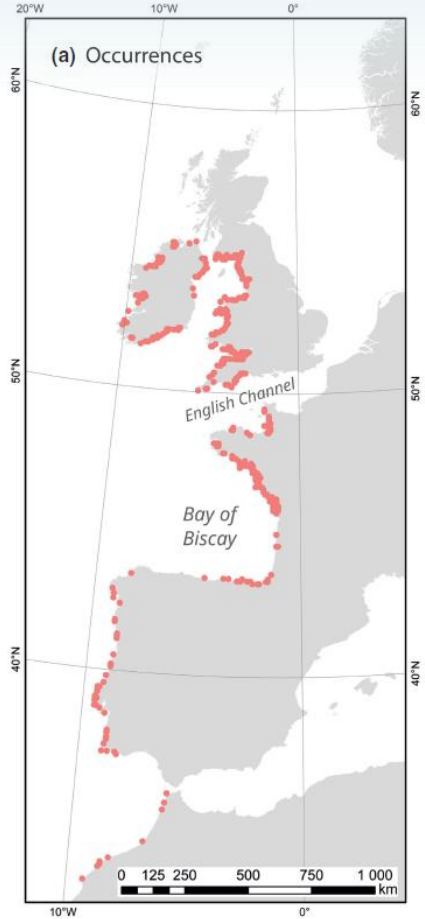
17,425 occurrence records collated between 2000-2019

One observation record per raster cell

Presence selected over absence

363 spatially thinned presence records

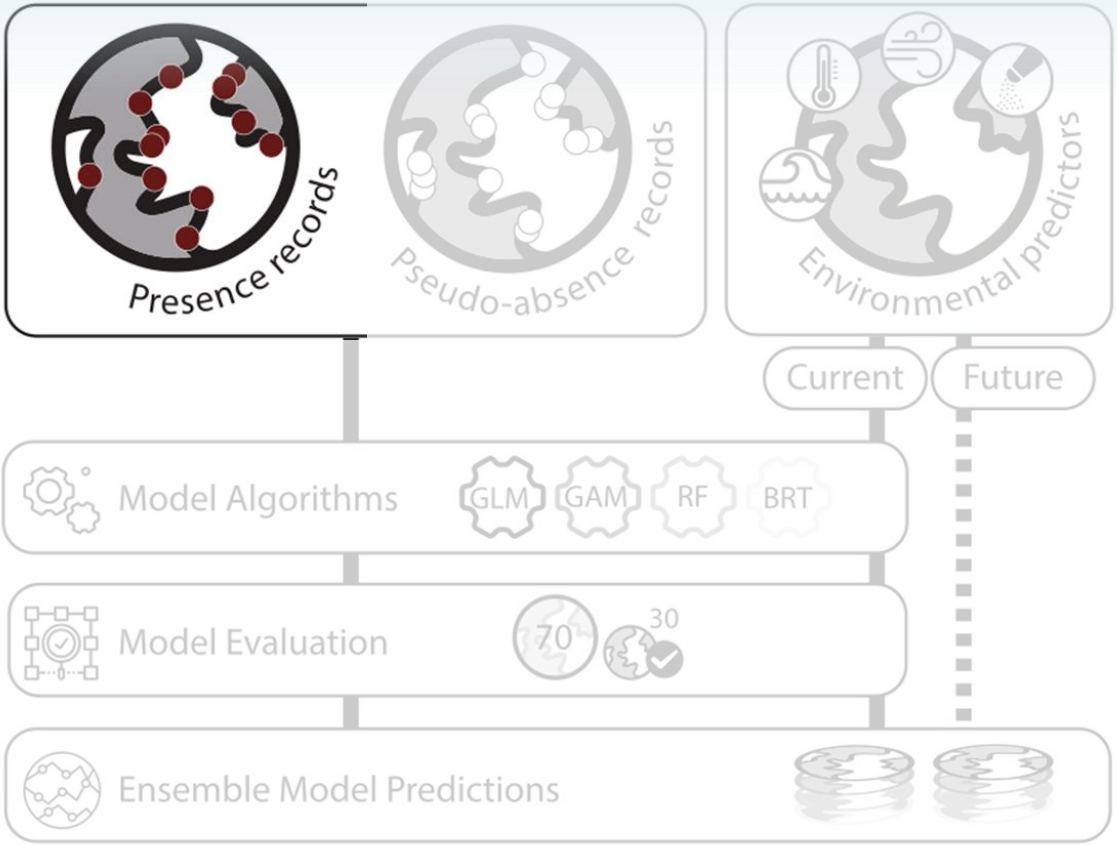




1.pixel^{-1}
2000-2019
1 pixel = 25km²

Lambert azimuthal **equal-area** projection

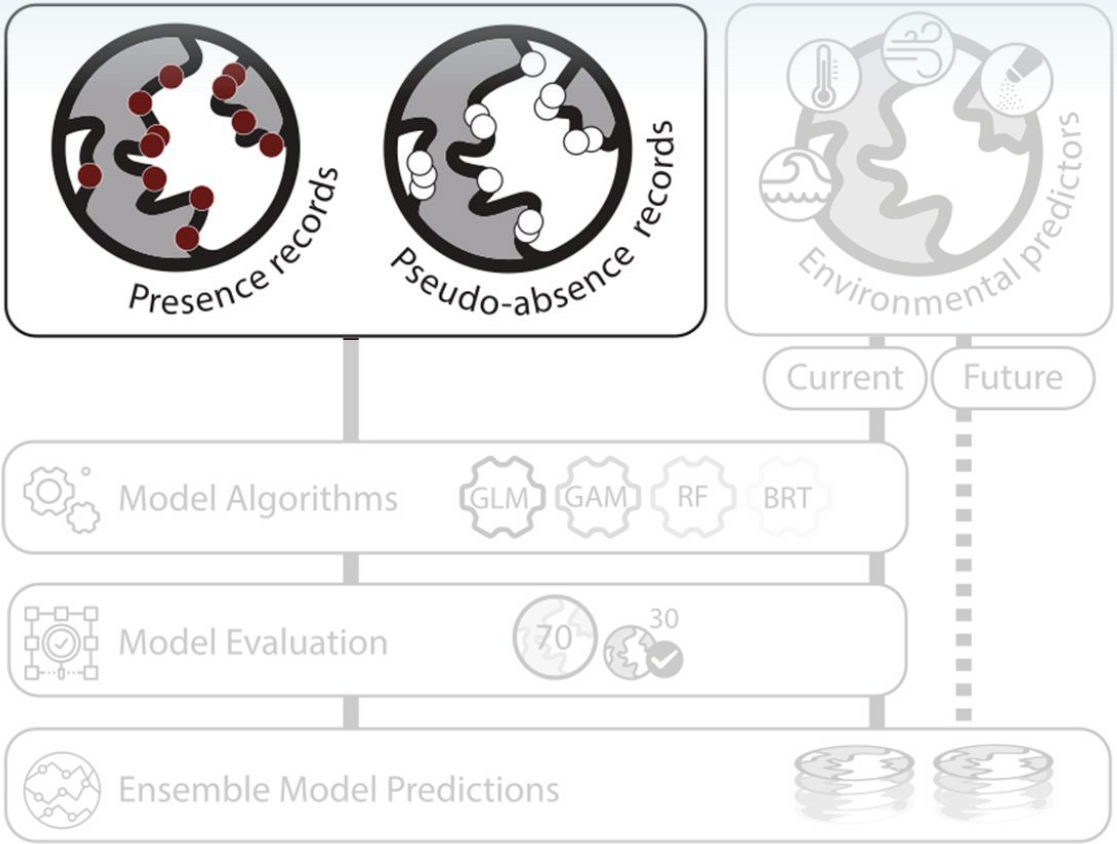
Model building and evaluation



363
Presence Records

Using the biomod2: package in R (Thuiller et al., 2009)

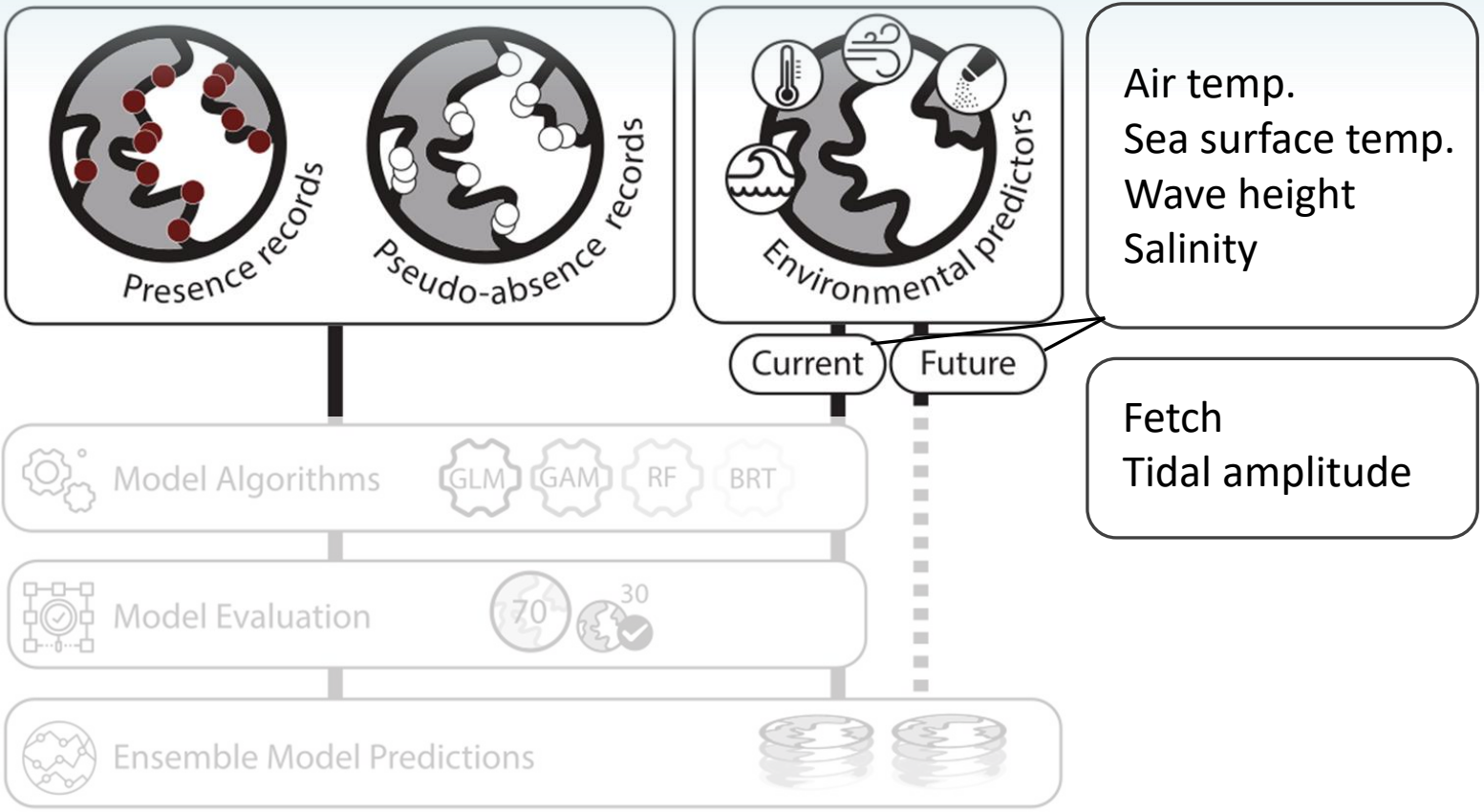
Model building and evaluation



Ten datasets of randomly generated pseudo-absences
363 records

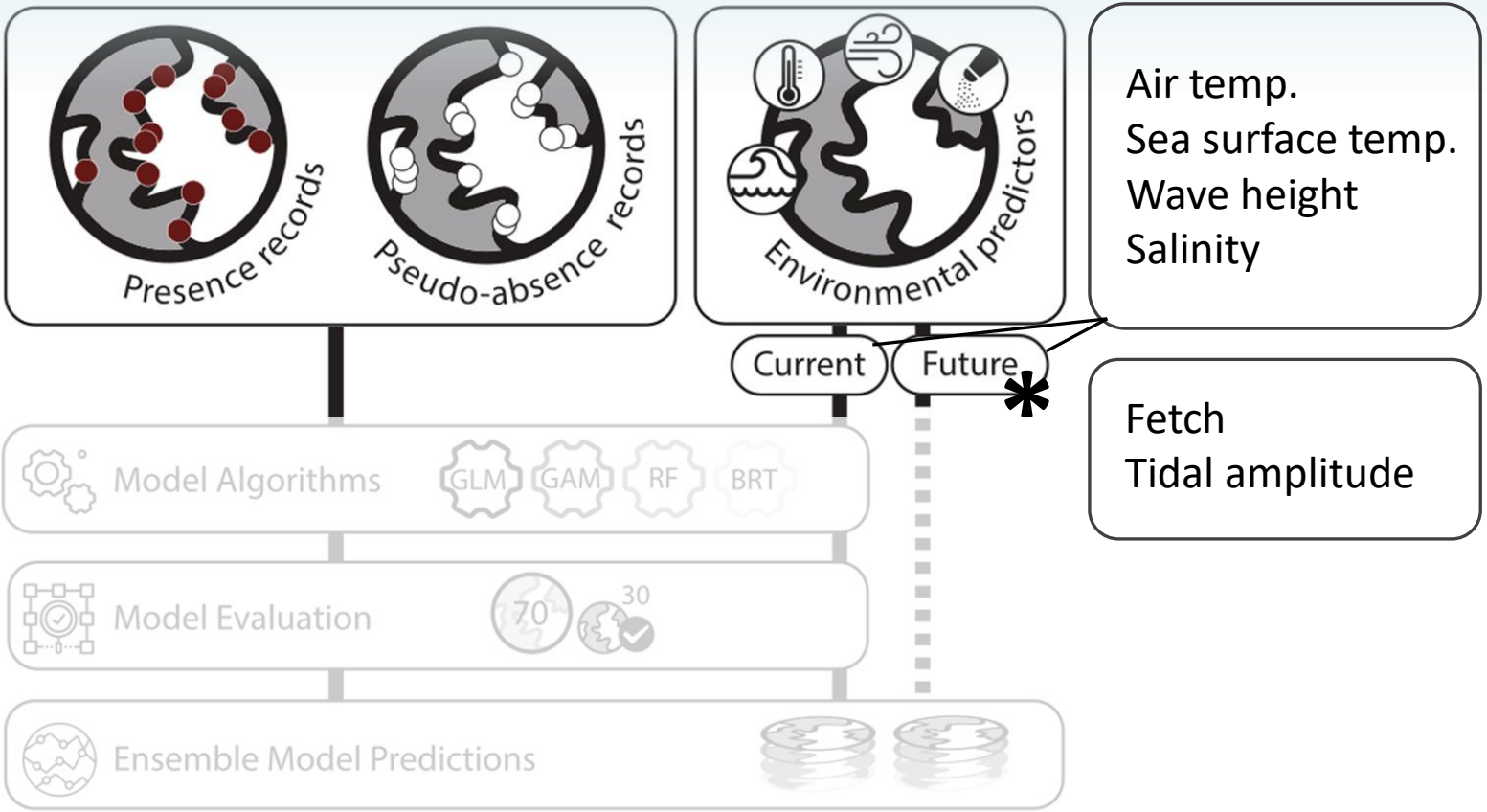
Using the biomod2: package in R (Thuiller et al., 2009)

Model building and evaluation



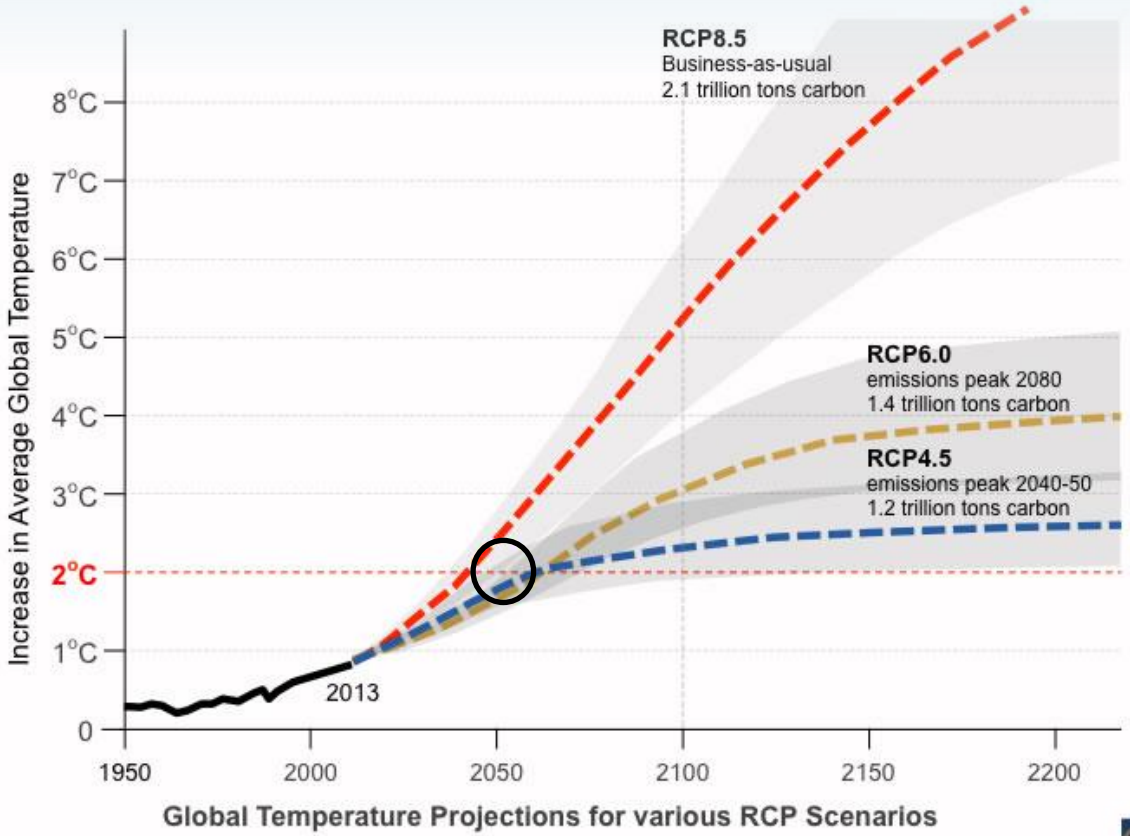
Using the biomod2: package in R (Thuiller et al., 2009)

Model building and evaluation

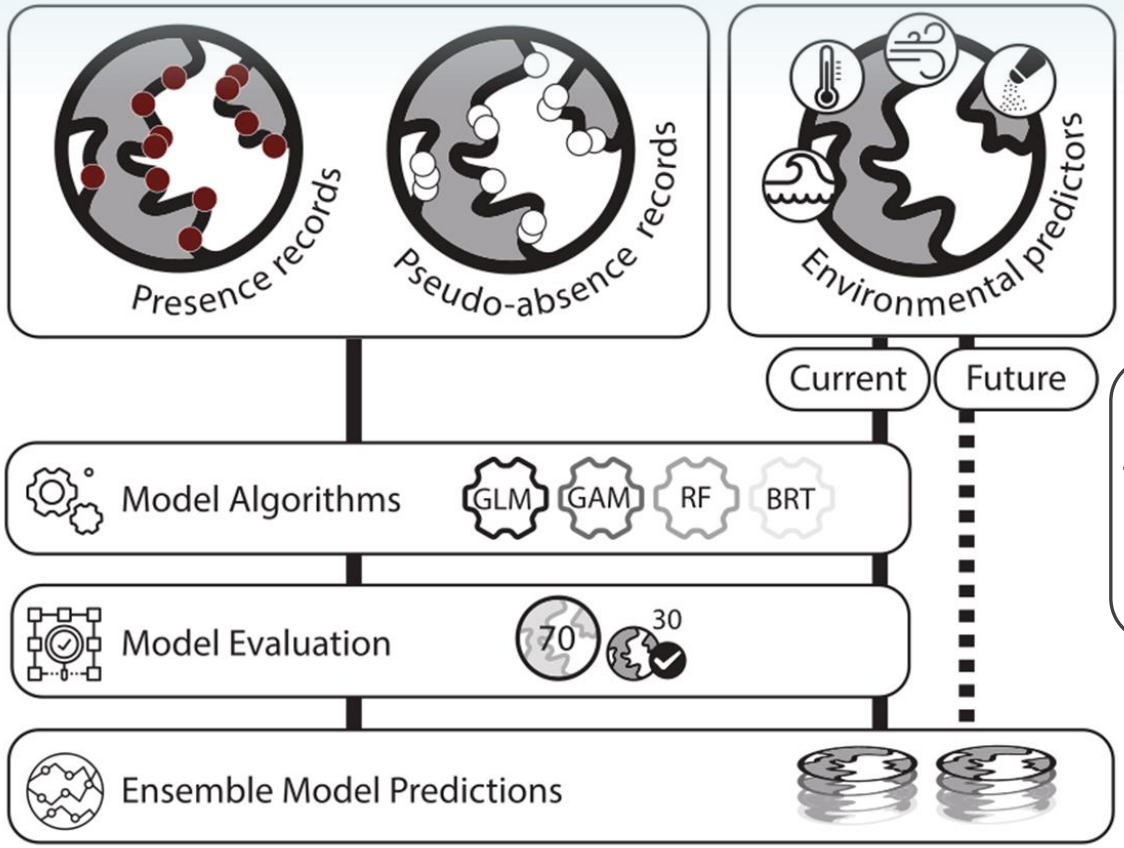


Using the biomod2: package in R (Thuiller et al., 2009)

Future = RCP 4.5 in 2050



Ensemble Model Predictions of Present Distribution Performed Well

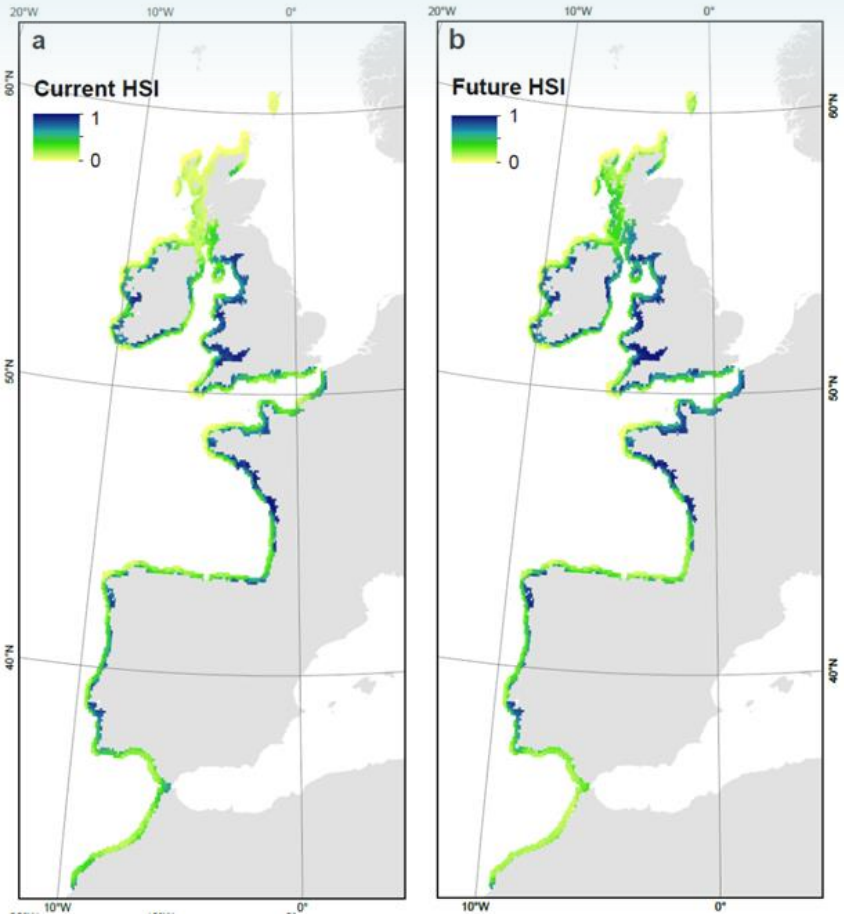


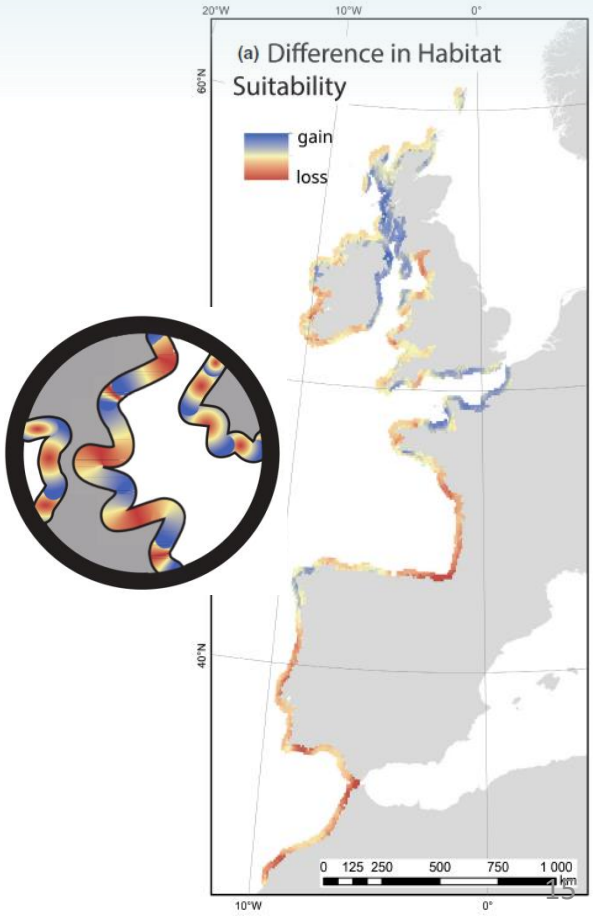
400 models
4 algorithms
* 10 cross-validations
* 10 Pa samplings

AUC = 0.91 ± 0.03
TSS = 0.67 ± 0.05

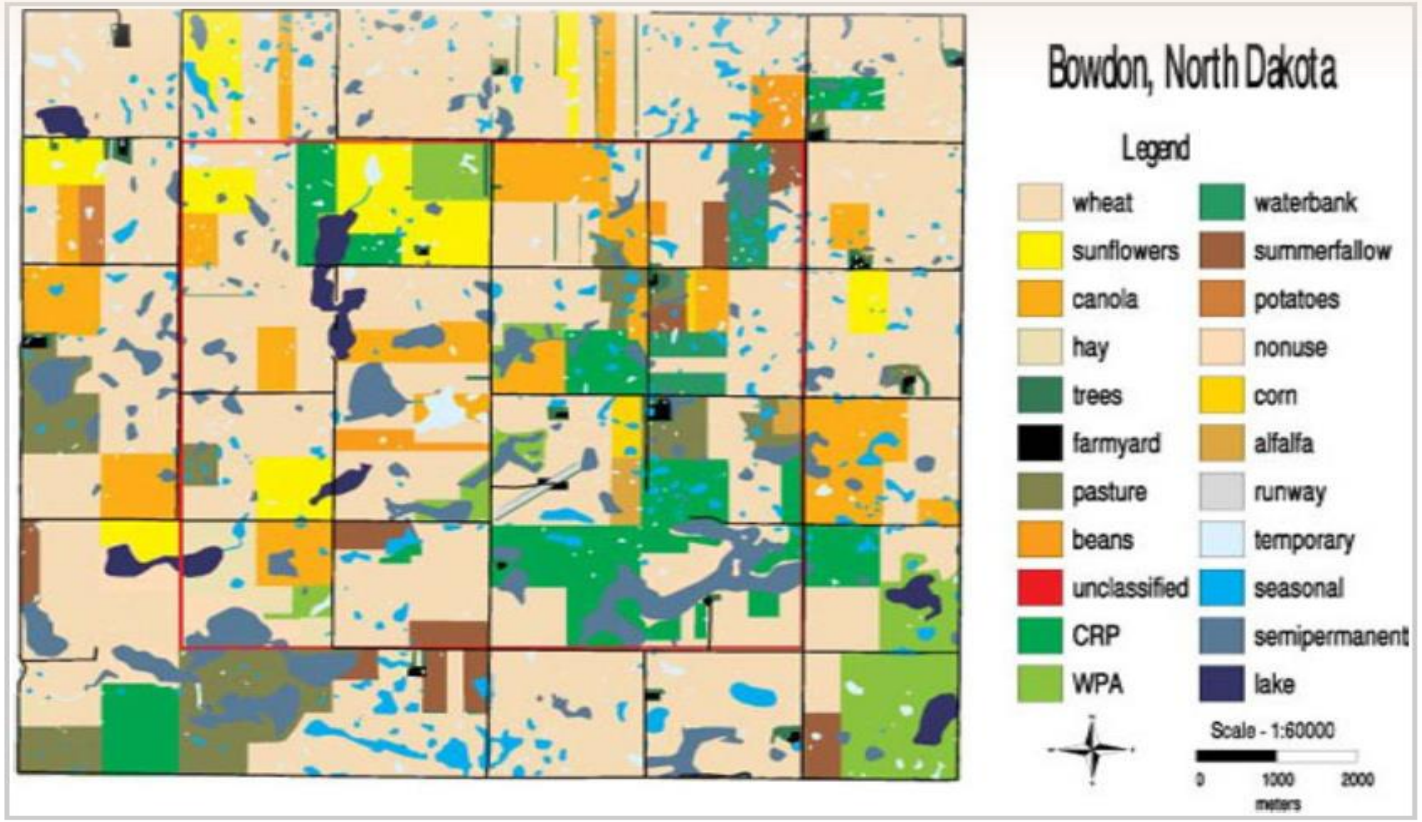
Using the biomod2: package in R (Thuiller et al., 2009)

Current & Future Habitat Suitability Conditions

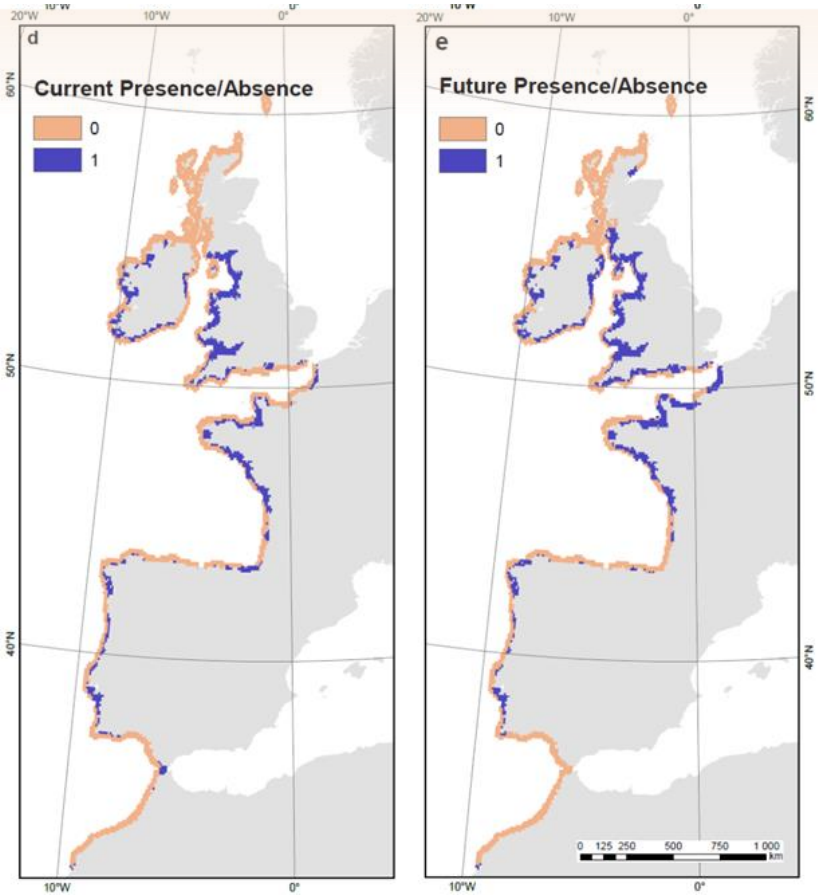




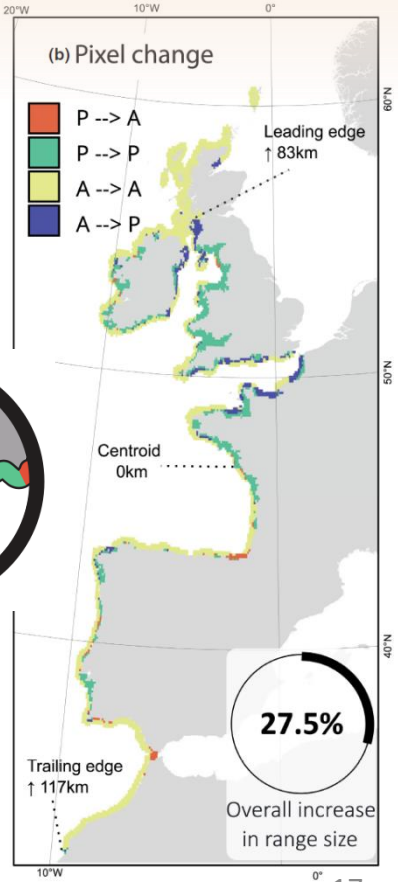
Landscape ecology metrics are usually applied to habitat type maps



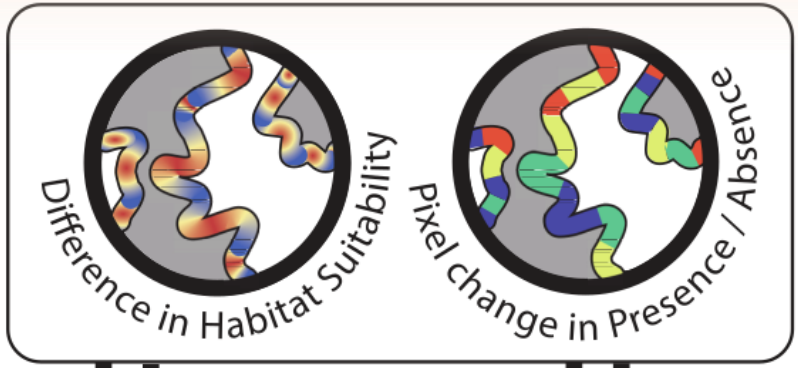
Landscape ecology metrics were applied to binary maps

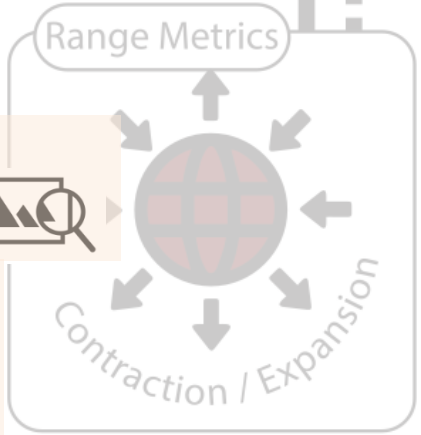


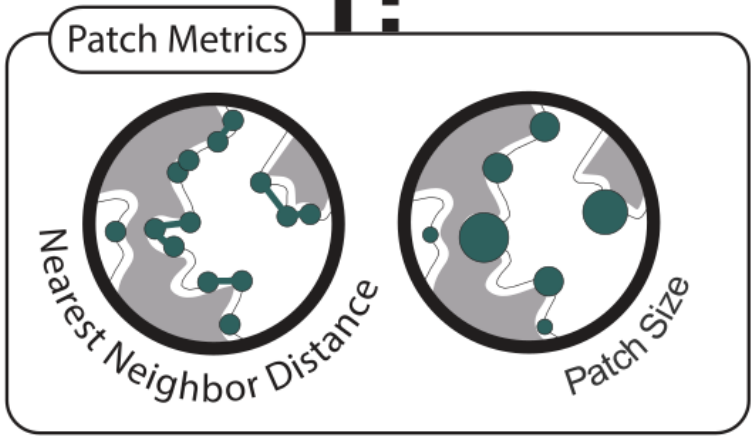
maxTSS threshold of 0.53



Applying landscape metrics to patches of presence/absence





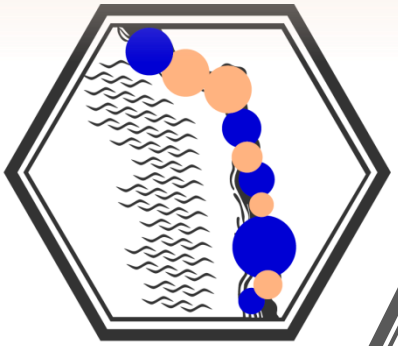


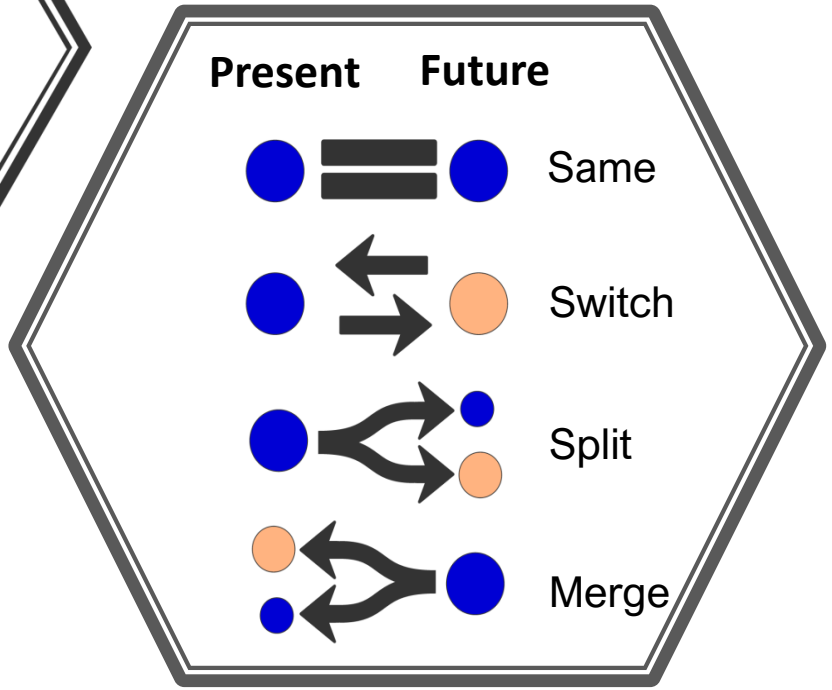
A patch is defined as one isolated, or several adjacent, pixels of the same class

Landscape metrics describe change in patch properties (eg. area, Euclidean distance to the nearest neighbour)

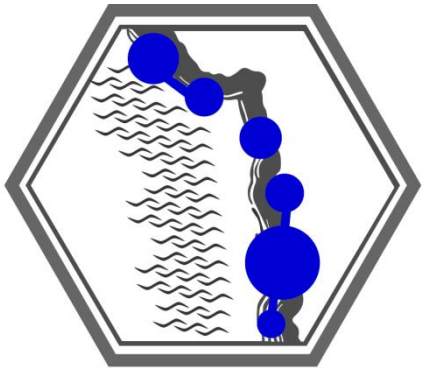
Using the landscapemetrics: package in R (Hesselbarth et al., 2019)

Enhancing within-range model predictive power



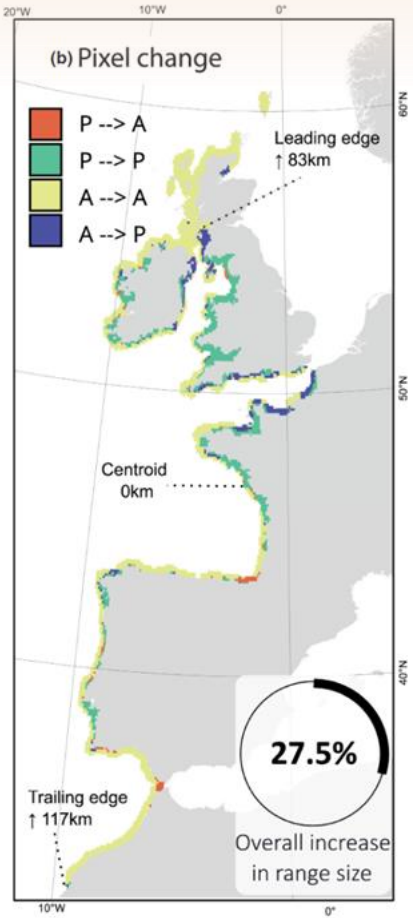


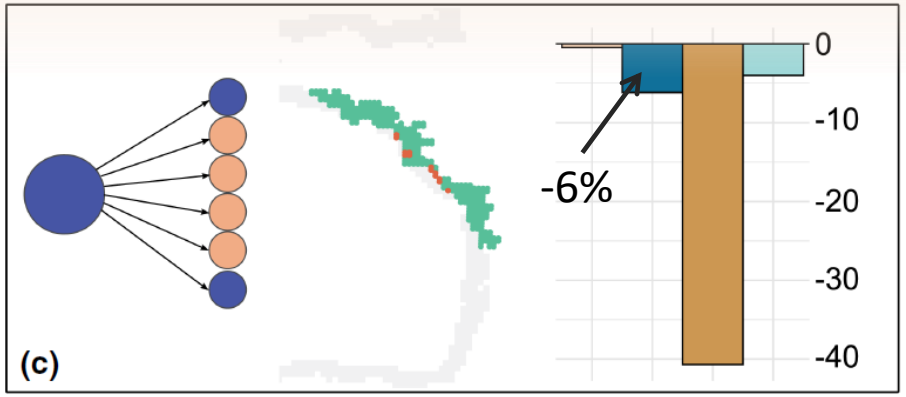
Each pixel retains additional quantitative information (i.e. habitat suitability)



i.e. Patch isolation

Localised extirpation in the current range centre





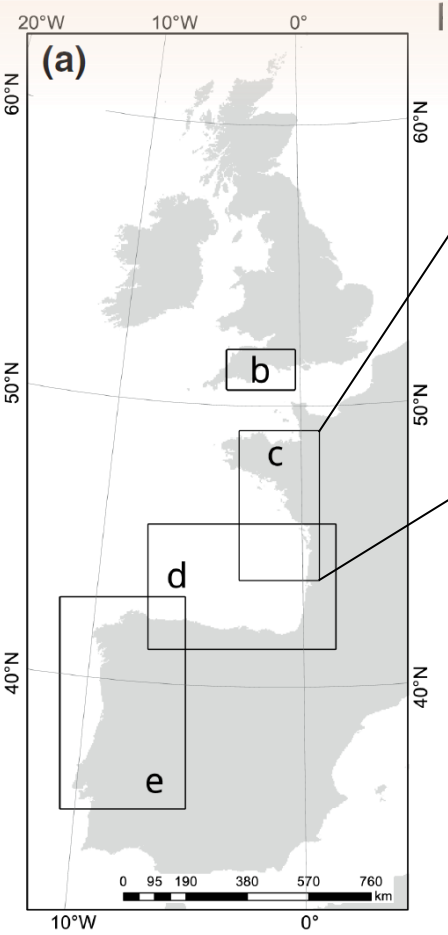
Patch state
- Presence
- Absence

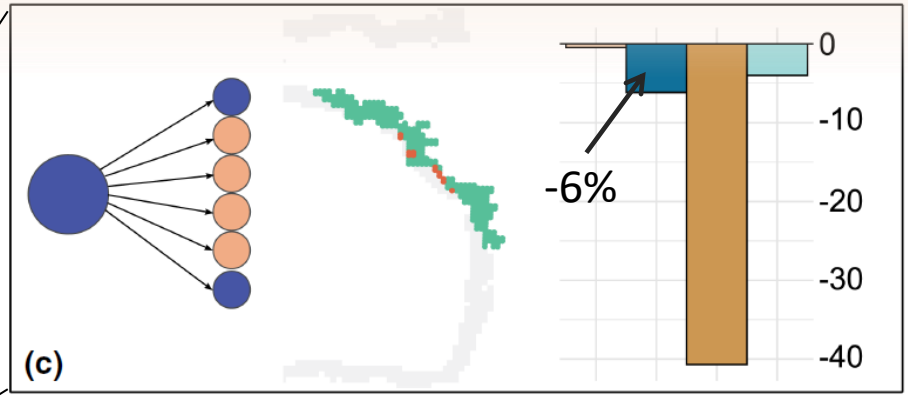
Pixel change
- P --> A
- A --> A
- P --> P
- A --> P

Landscape metrics
- Aggregation index
- Core area landscape %
- Largest patch index
- Total class area (ha)

Predicted extirpations within the centre of a large presence patch

Localised extirpation in the current range centre





Patch state
- Presence
- Absence

Pixel change
- P --> A
- A --> A
- P --> P
- A --> P

Landscape metrics
- Aggregation index
- Core area landscape %
- Largest patch index
- Total class area (ha)

Predicted extirpations within the centre of a large presence patch

Take home messages

Internal range structure metrics are needed to accurately quantify the effects of climate change.

Landscape metrics applied to SDM outputs are a robust, non-data intensive method that can aid with broad-scale spatial planning under climate change.

This method can be applied to any species.

Global Change Biology

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Applying landscape metrics to species distribution model predictions to characterize internal range structure and associated changes

Amelia Curd, Mathieu Chevalier, Mickaël Vasquez, Aurélien Boyé, Louise B. Firth, Martin P. Marzloff, Lucy M. Bricheno, Michael T. Burrows, Laura E. Bush, Céline Cordier, Andrew J. Davies, J. A. Mattias Green, Stephen J. Hawkins, Fernando P. Lima, Claudia Meneghesso, Nova Mieszkowska, Rui Seabra, Stanislas F. Dubois
... See fewer authors

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Amelia Curd and Mathieu Chevalier should be considered joint first authors.

Thank You

Baie de Douarnenez, February 2020

Credit : S. Dubois

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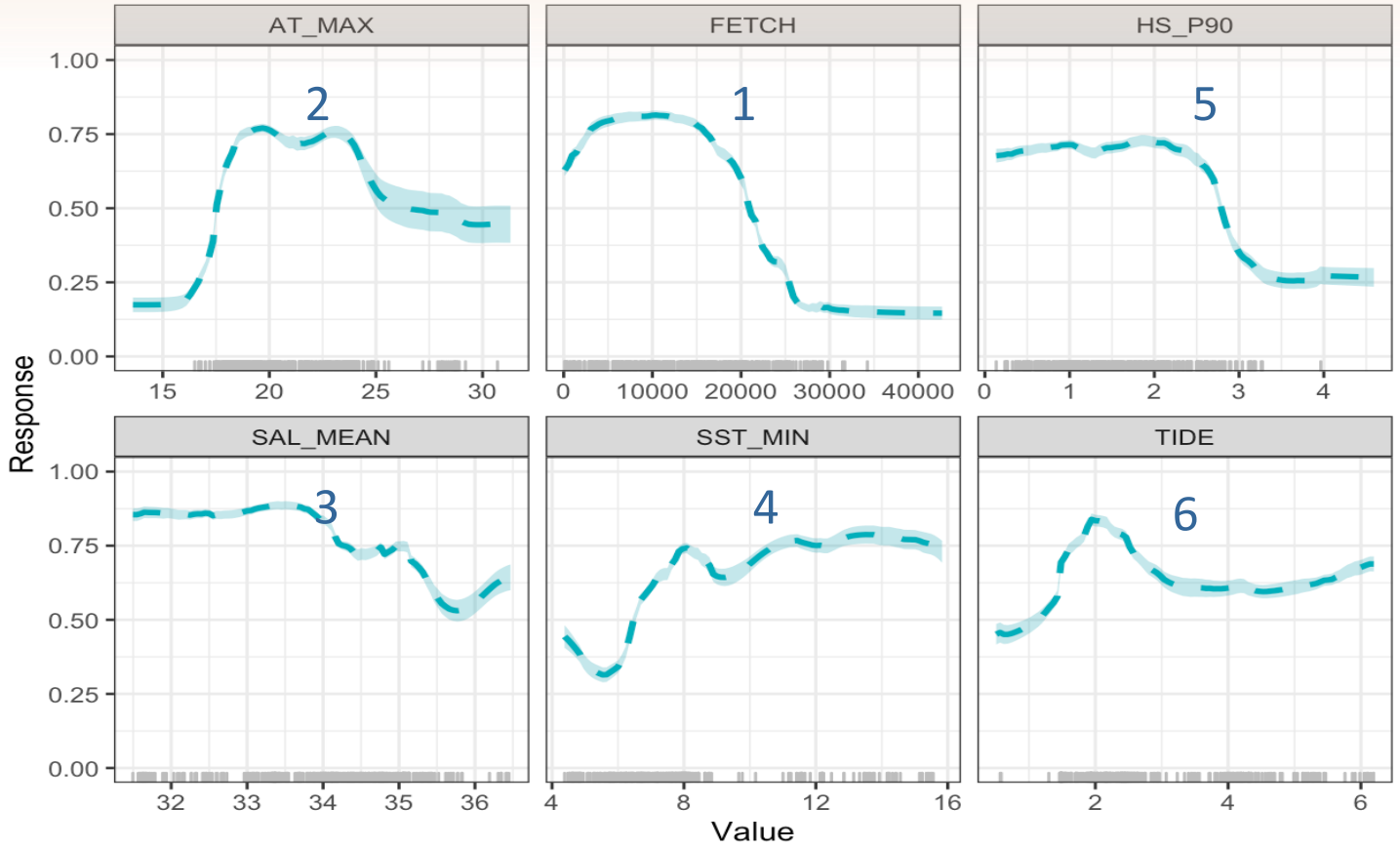
Variable response curves



Mean habitat suitability tips mid-range