

Relações entre espécies e características ambientais

Disciplina: Biodiversidade, Geodiversidade e Paisagem

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Angela Terumi Fushita

Christian Ricardo Ribeiro

2025.1



Objetivos

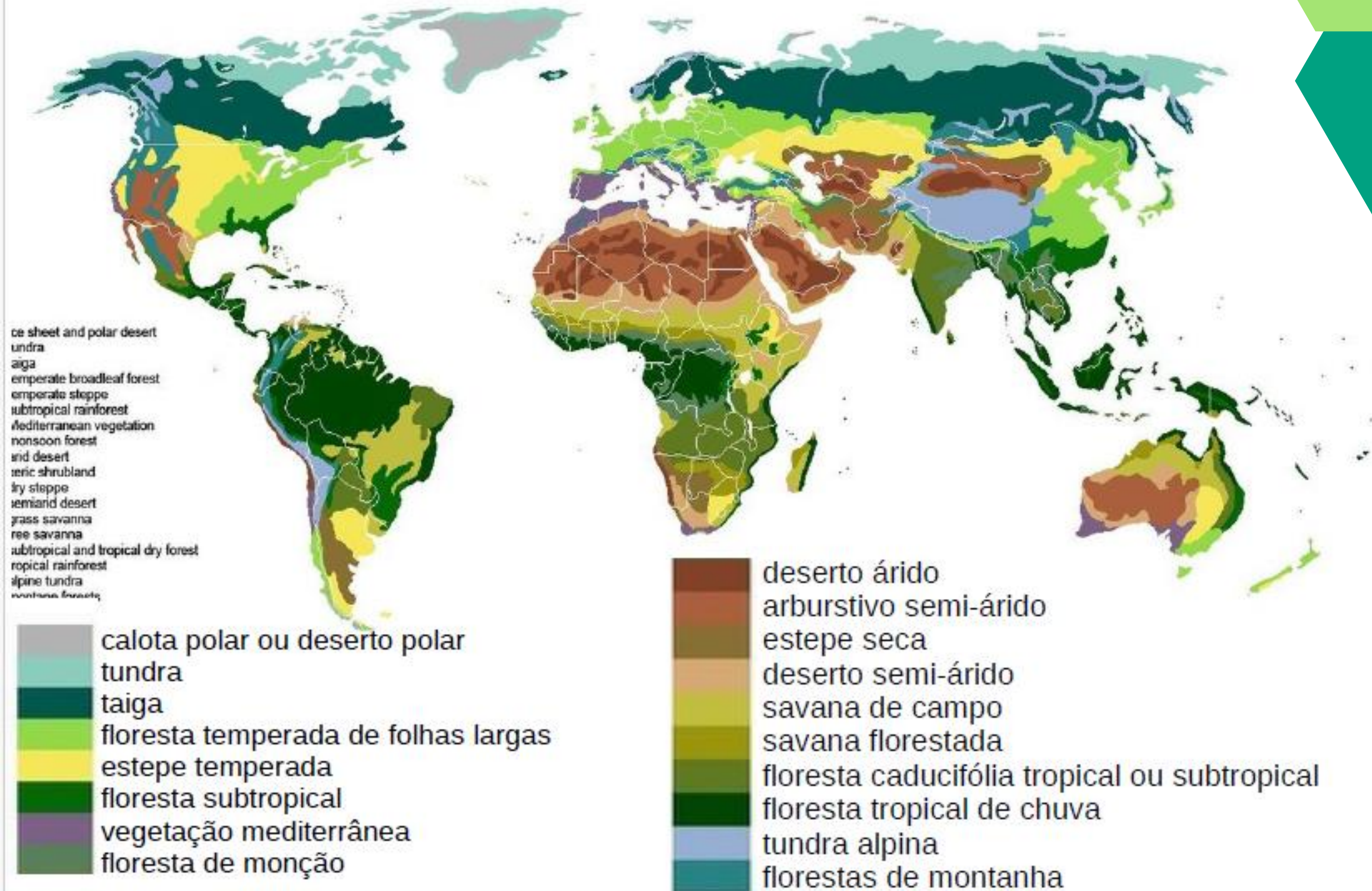
- Entender as relações entre as distribuições de espécies (biodiversidade) com as características dos ambientes
- Compreender os métodos e técnicas para modelagem de distribuição de espécies



Por que entender as relações entre as espécies e as características do meio onde vivem?

- Entendimento do funcionamento dos ecossistemas
- Aptidão agrícola e pecuária.
- Dispersão de pragas, de vetores (animais portadores) de doenças e animais exóticos invasores.
- Impactos das mudanças climáticas na distribuição de espécies nativas, cultivadas e invasoras.
- Planejamento de medidas de restauração de ambientes naturais ou manejados.

Biomas



<https://commons.wikimedia.org/wiki/File:Biomes.jpg>

Nichos como limites e envelopes

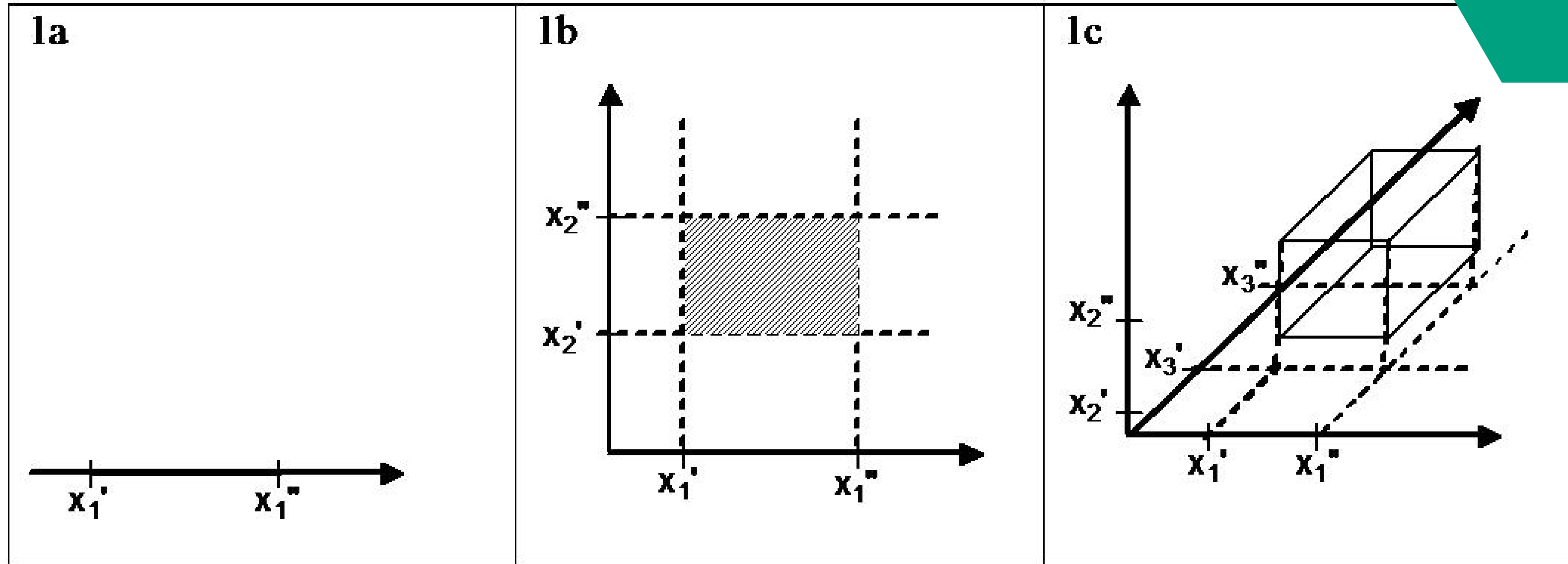
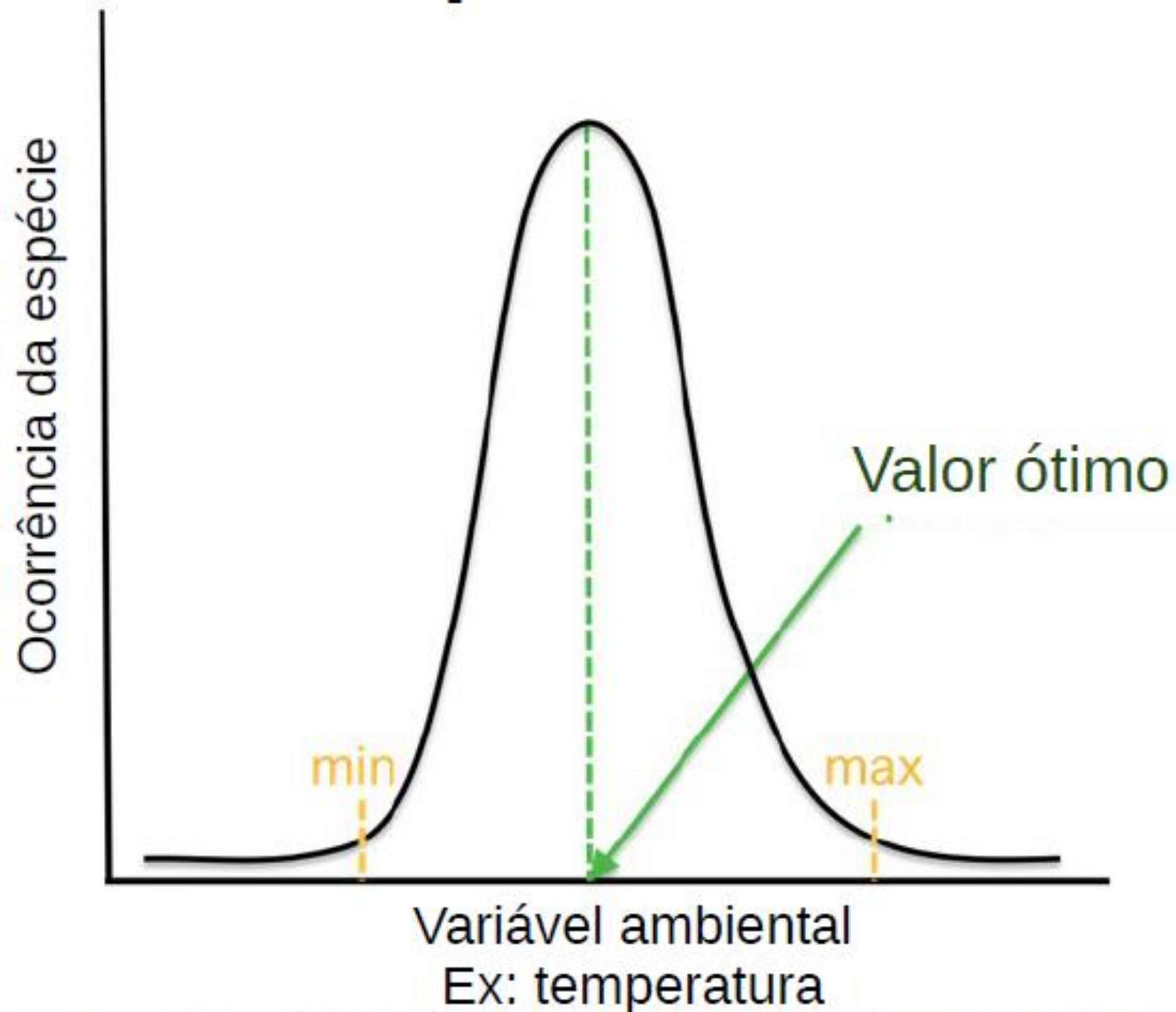
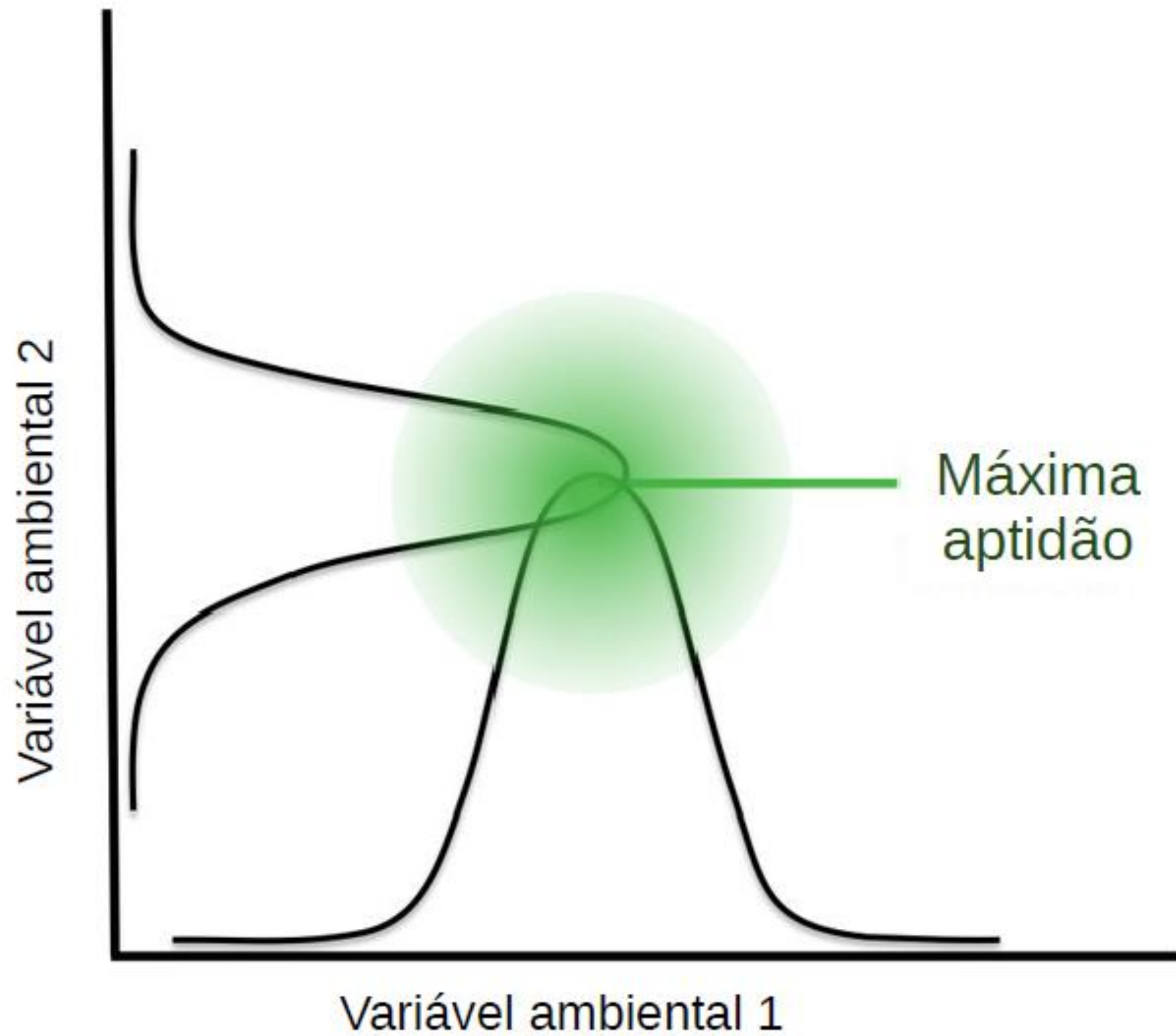
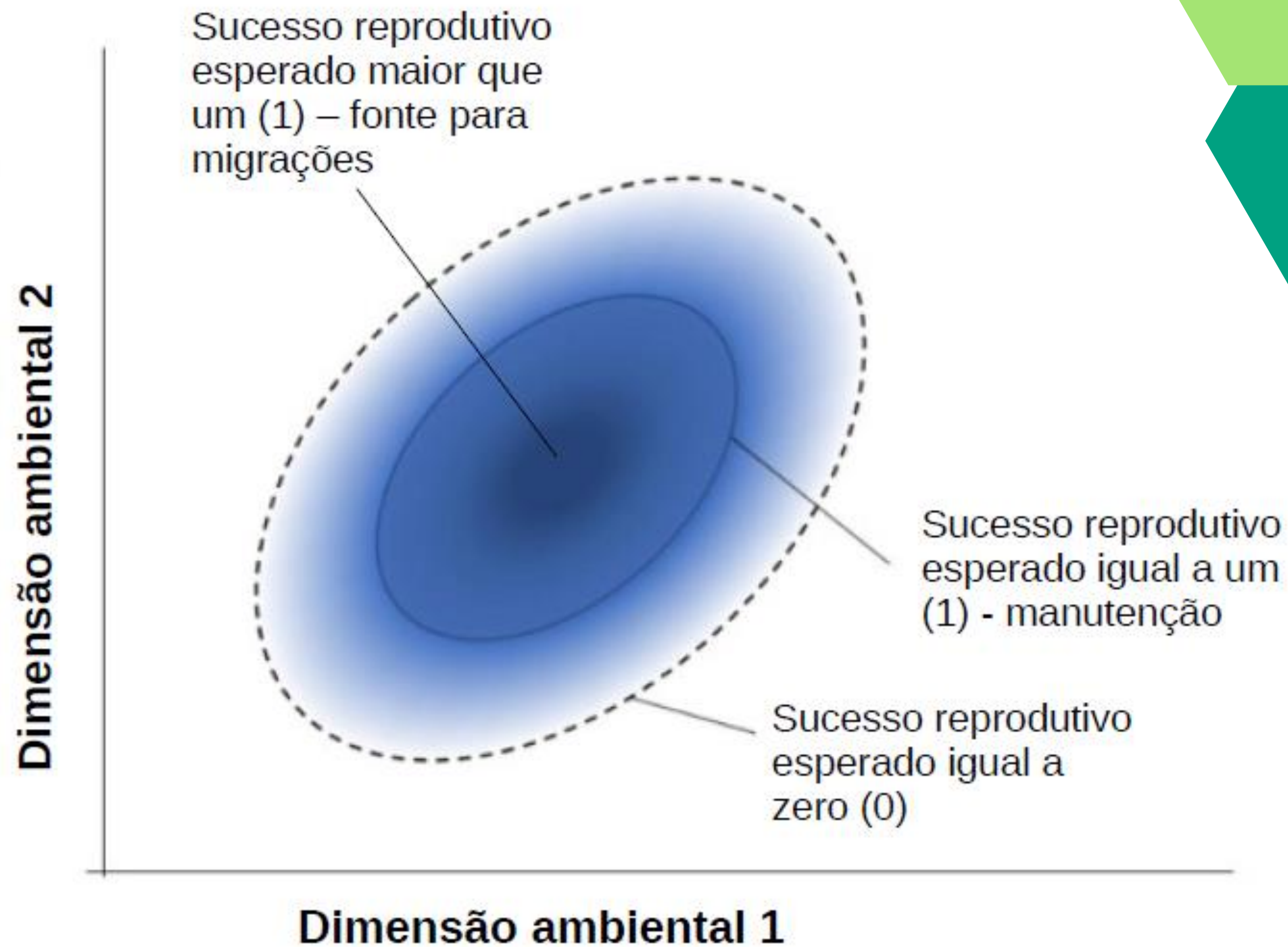


Figura 1: Esquema da definição de nicho ecológico proposta por Hutchinson (1957), para uma (1a), duas (1b) e três (1c) dimensões (variáveis).

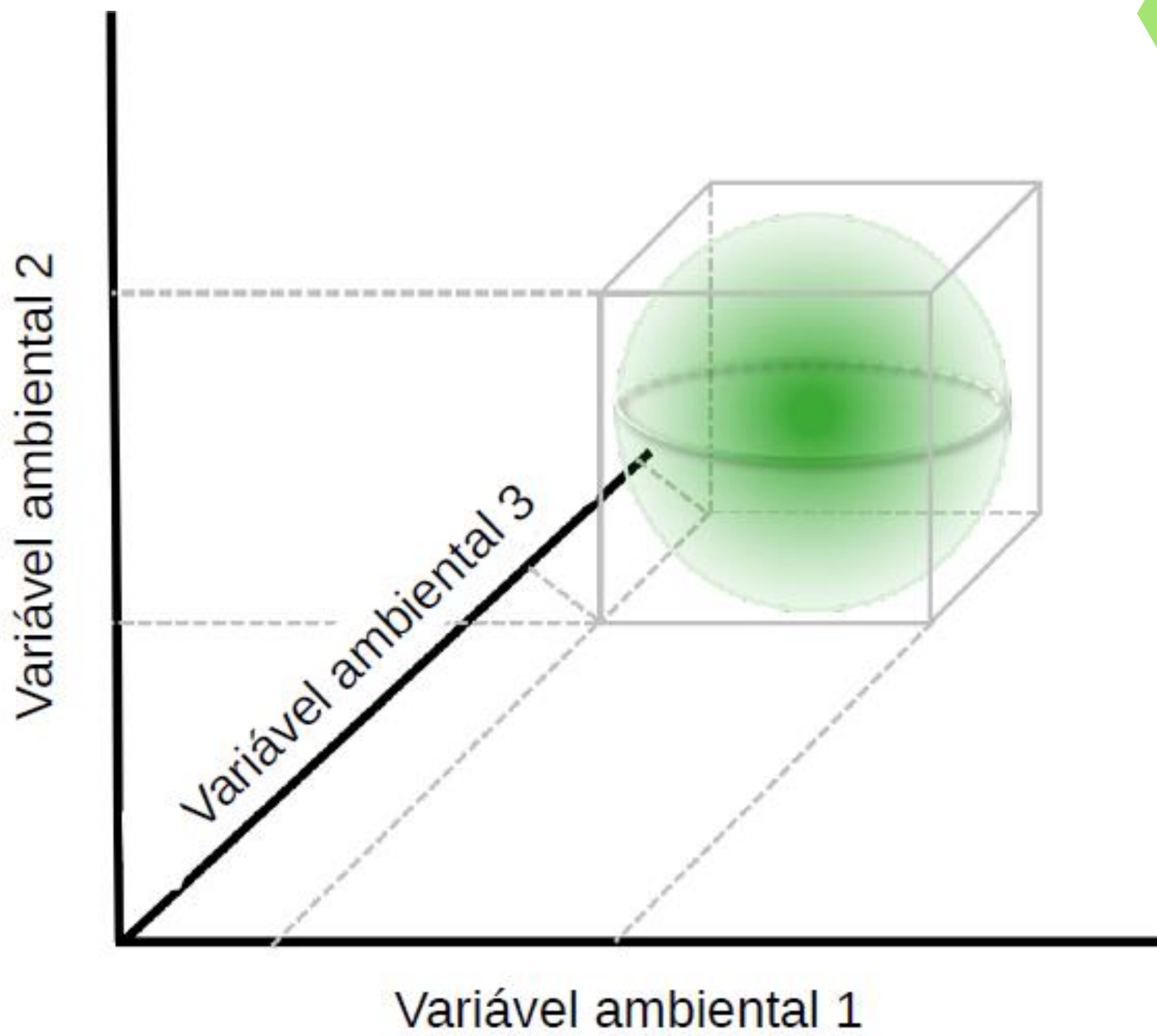
Nichos como graduação de aptidão





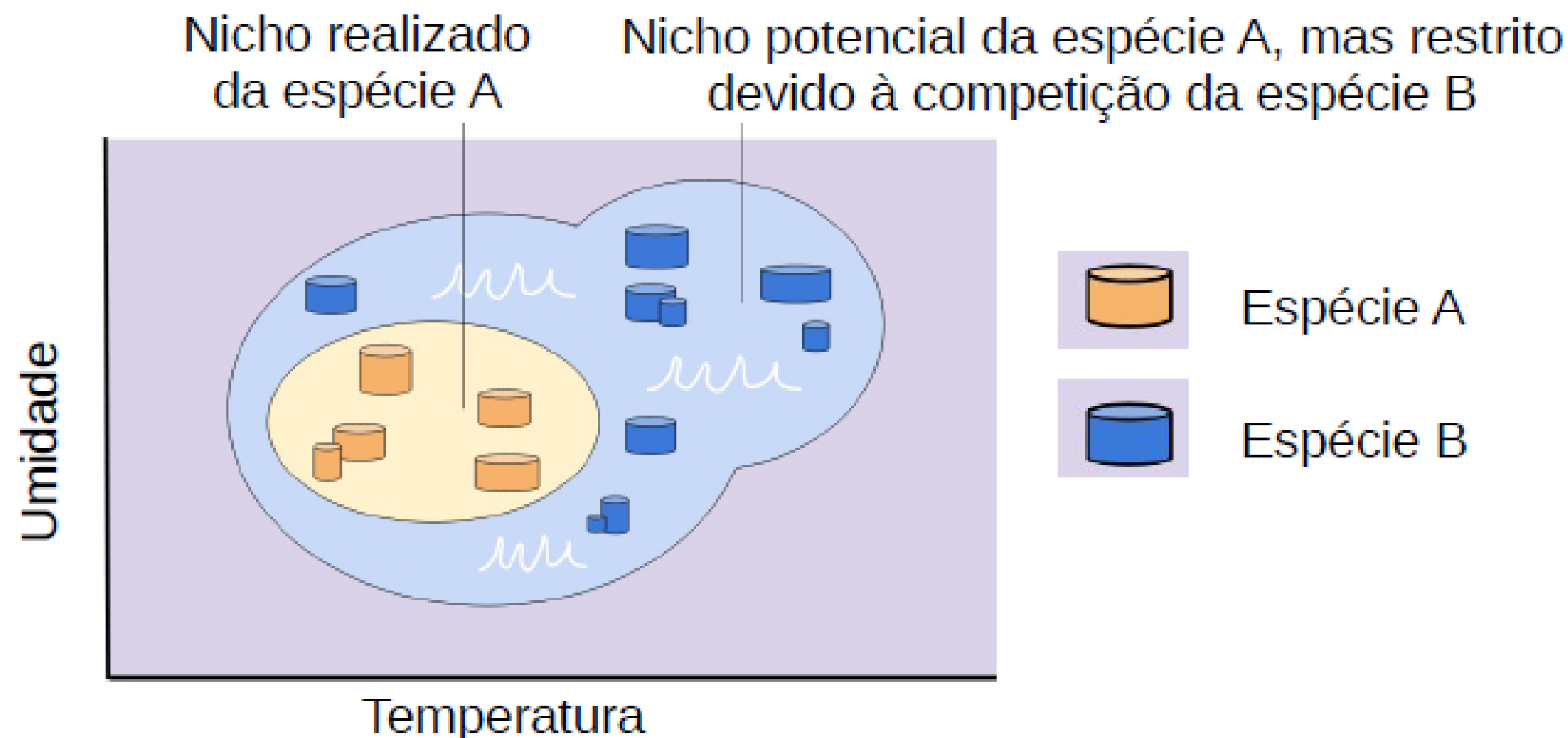


TAKOLA, Elina; SCHIELZETH, Holger. Hutchinson's ecological niche for individuals. *Biology & Philosophy*, v. 37, n. 4, p. 25, 2022.



Nicho fundamental e nicho realizado

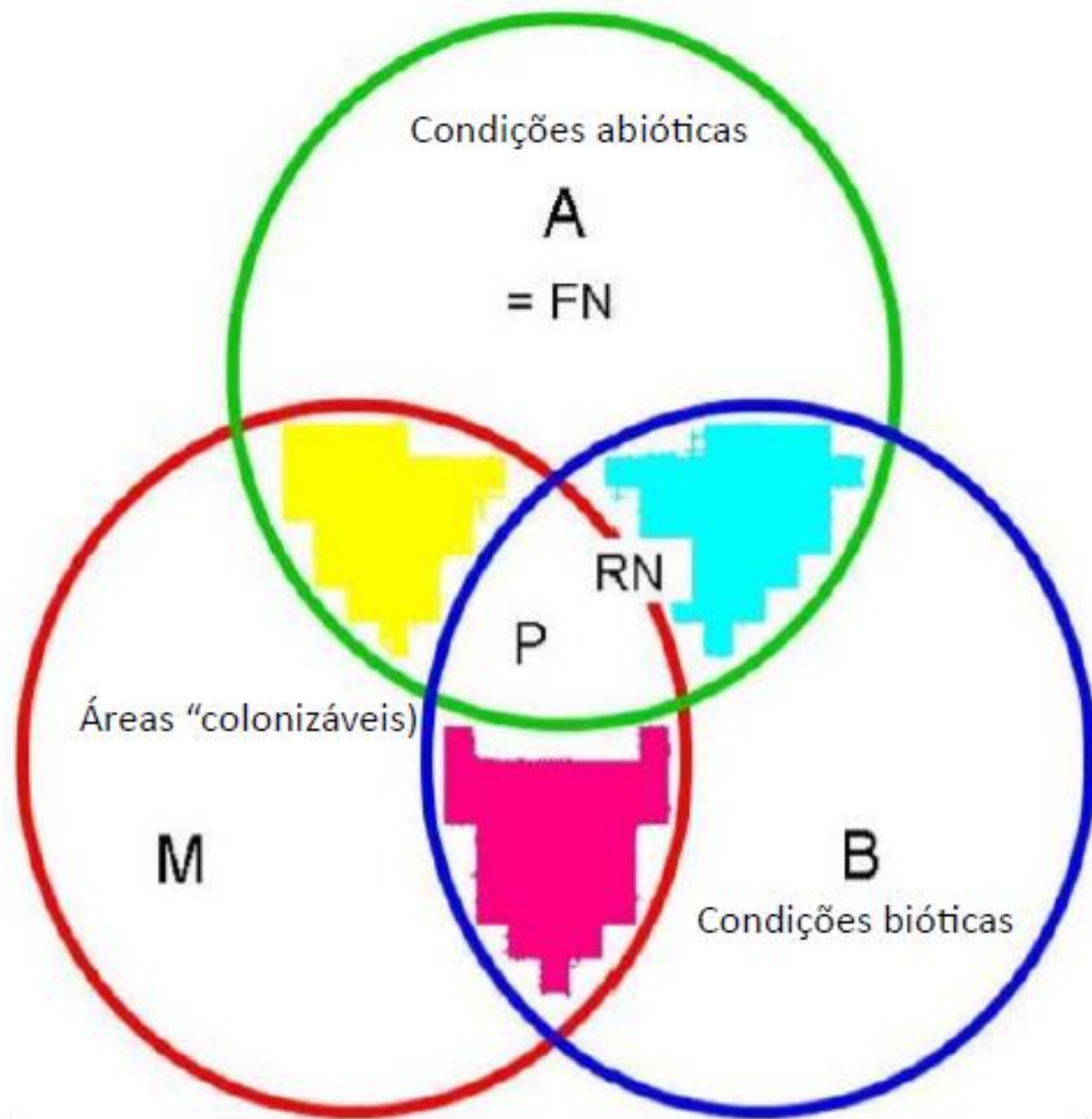
O **nicho fundamental** é representado pelas as condições ambientais nas quais as espécies poderiam viver, se não fossem as restrições impostas pelas relações bióticas, que define o **nicho realizado** (Hutchinson 1957).



Hutchinson GE (1957) Concluding remarks. Cold Spring Harbor Symposia on Quantitative Biology. 22:415–427.

Ho, Taylor. Graph depicting how a realized niche fits within a fundamental niche depending on varying abiotic factors, 2023.

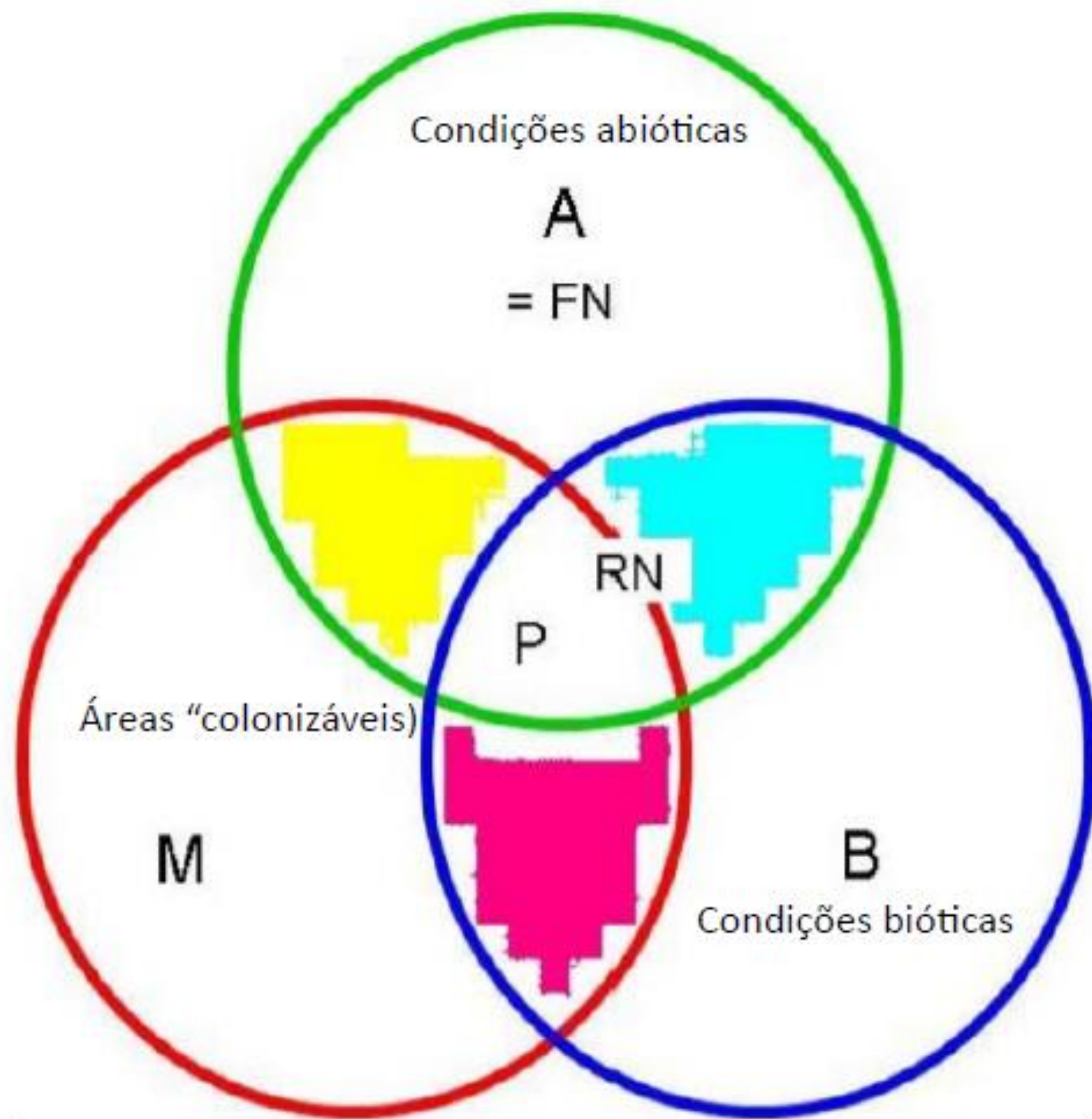
https://en.wikipedia.org/wiki/Ecological_niche#/media/File:Model_of_ecological_niche.svg



E a ação humana, como influenciaria nesses processos?

SOBERON, Jorge; PETERSON, A. Townsend. Interpretation of models of fundamental ecological niches and species' distributional areas. Biodiversity Informatics, 2, 2005, pp. 1-10 .

P = distribuição geográfica (potencial) da espécie



E a ação humana, como influenciaria nesses processos?

SOBERON, Jorge; PETERSON, A. Townsend. Interpretation of models of fundamental ecological niches and species' distributional areas. Biodiversity Informatics, 2, 2005, pp. 1-10 .

P = distribuição geográfica (potencial) da espécie

Modelagem de distribuição de
espécies

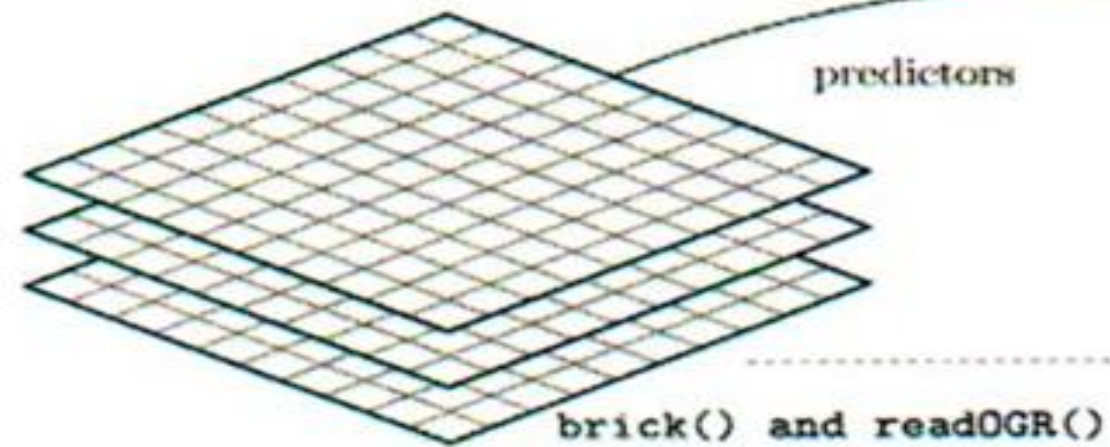


Organizado por Vitor Vieira Vasconcelos

Universidade Federal do ABC
São Bernardo do Campo - SP

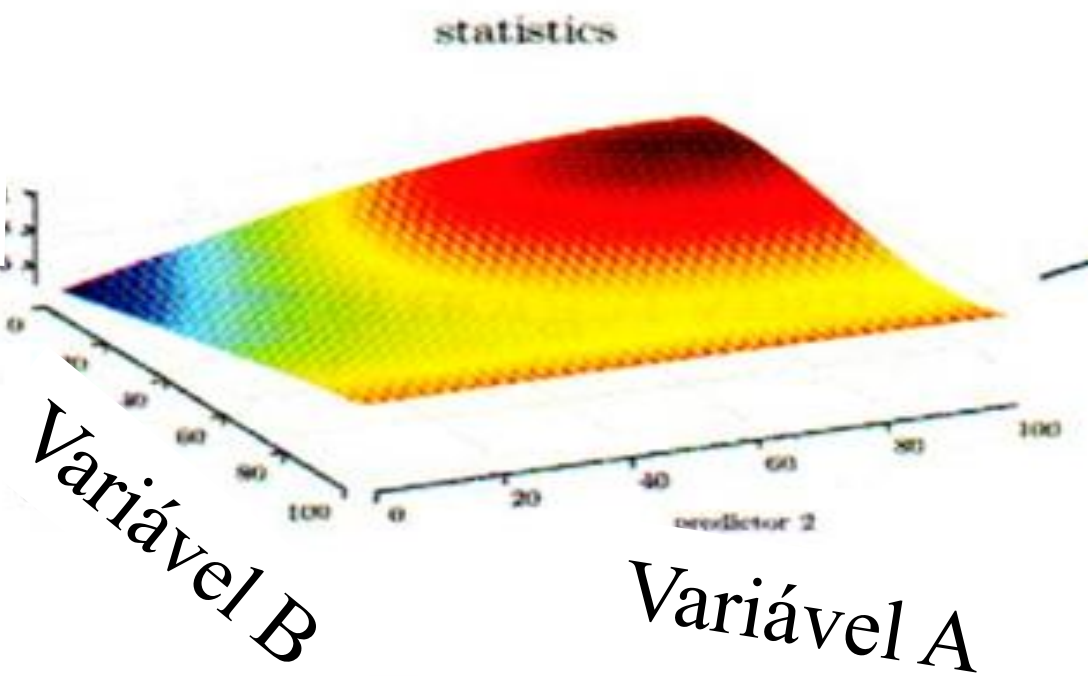
Modelagem de processos pontuais

Ocorrência dos pontos no espaço



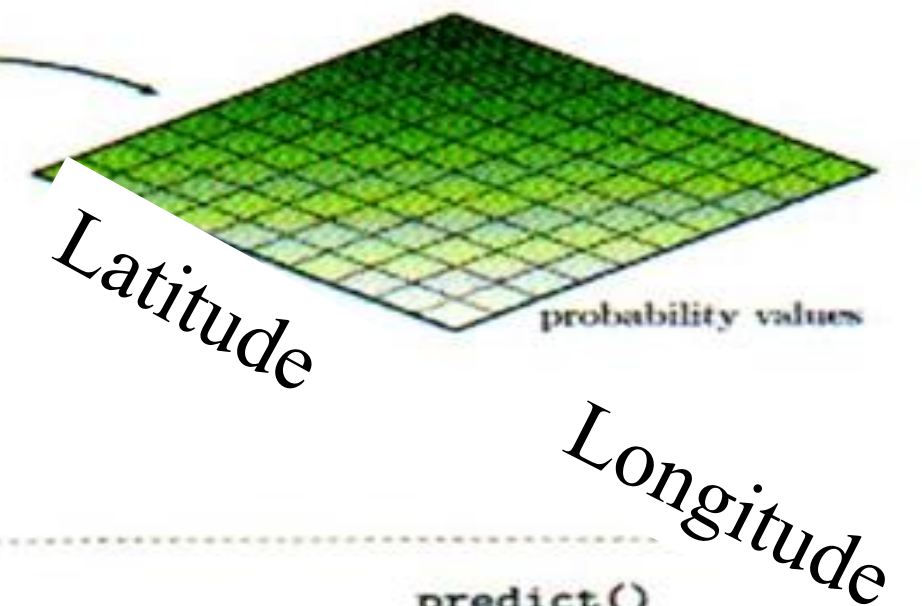
Distribuição espacial das características explicativas

Adequação



Modelo relacionando as variáveis com a ocorrência dos pontos

Cor expressa probabilidade de ocorrência



Mapa com a probabilidade de ocorrência dos pontos

Reineking, B. Et al., Modelling species distributions. In: Wegmann M. et al. (org). Remote sensing and GIS for Ecologists. Pelag. 2016

Modelagem de processos pontuais

Eventos pontuais	Variáveis explicativas	Resultado
Observações de espécies	Características do ambiente (temperatura, umidade, etc.)	Probabilidade de ocorrência de espécies
Ocorrência de deslizamentos de terra	Características dos geossistemas (declividade, rocha, solo, etc.) e de ocupação	Probabilidade de ocorrência de deslizamentos
Ocorrência de queimadas	Características climáticas (temperatura, chuva), sociais (proximidade de rodovias) e de vegetação (biomassa)	Probabilidade de ocorrência de queimadas
Notificações de crimes	Características socioeconômicas (renda, concentração de pessoas, distância a delegacias)	Probabilidade de ocorrência de crimes

Modelagem de processos pontuais

Eventos pontuais	Variáveis explicativas	Resultado
Notificações de casos de dengue	Clima propício para o vetor (temperatura, umidade, etc.), locais de reprodução (lixo acumulado, ferro velho, etc.), porcentagem de casas sem tela nas janelas	Probabilidade de ocorrência da doença

Por que entender as relações entre as espécies e as características do meio onde vivem?

- Entendimento do funcionamento dos ecossistemas
- Aptidão agrícola e pecuária.
- Espalhamento pragas, de vetores (animais portadores) de doenças e animais exóticos invasores.
- Impactos das mudanças climáticas na distribuição de espécies nativas, cultivadas e invasoras.
- Planejamento de medidas de restauração de ambientes naturais ou manejados.

Nichos como limites e envelopes

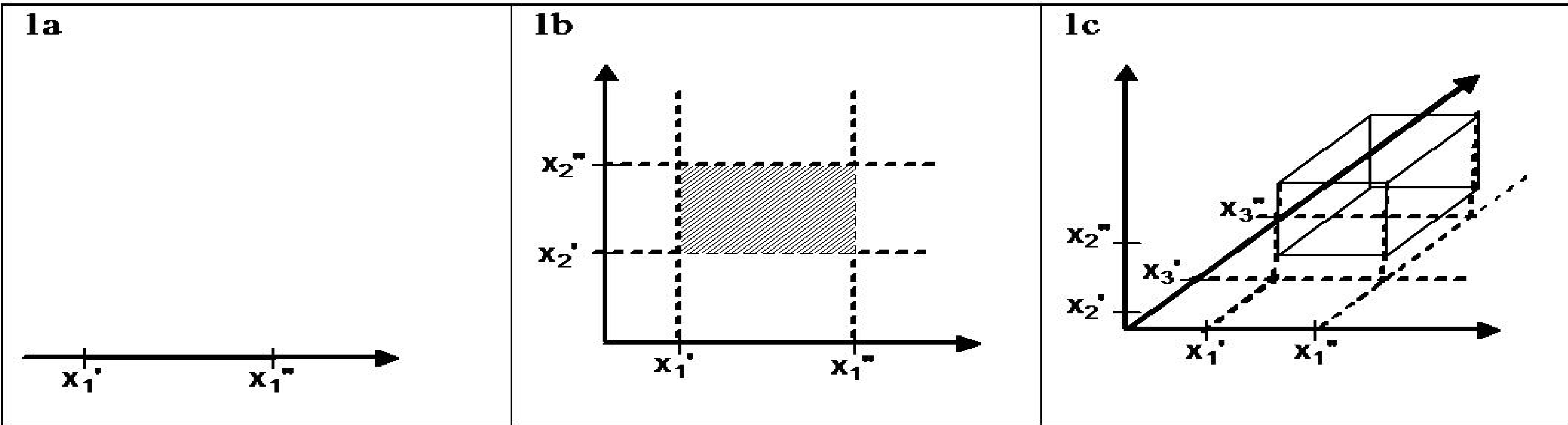
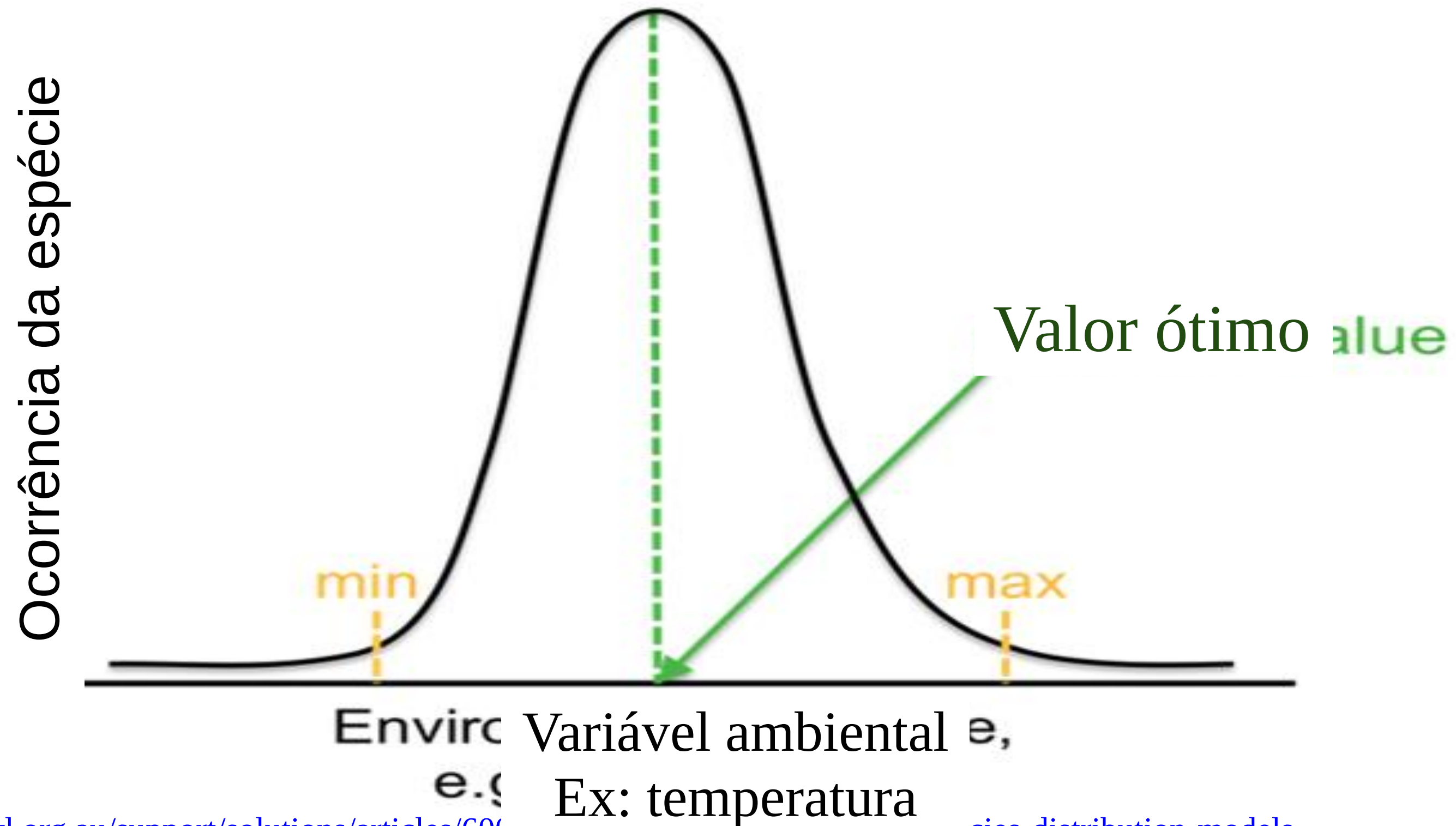
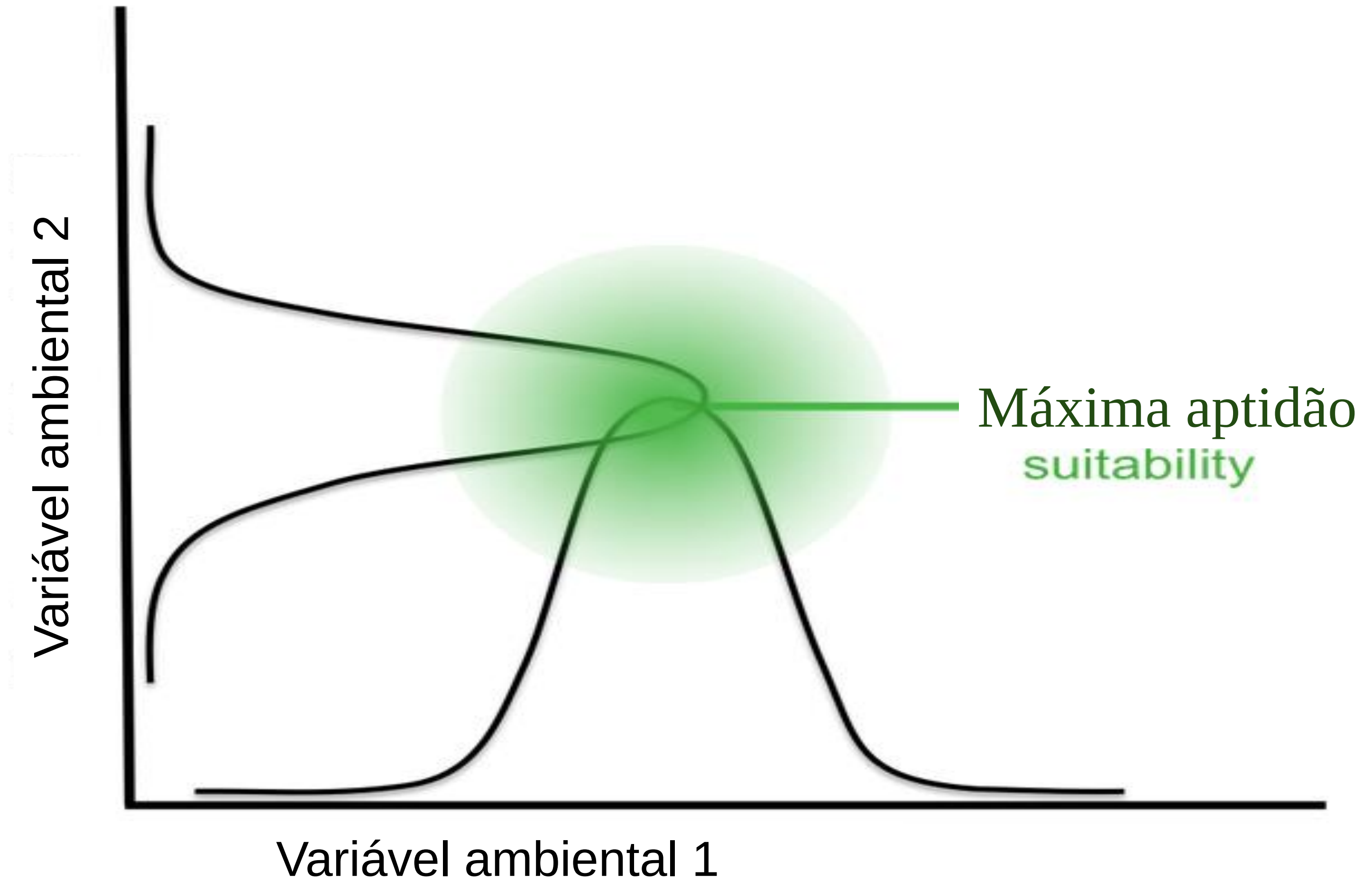
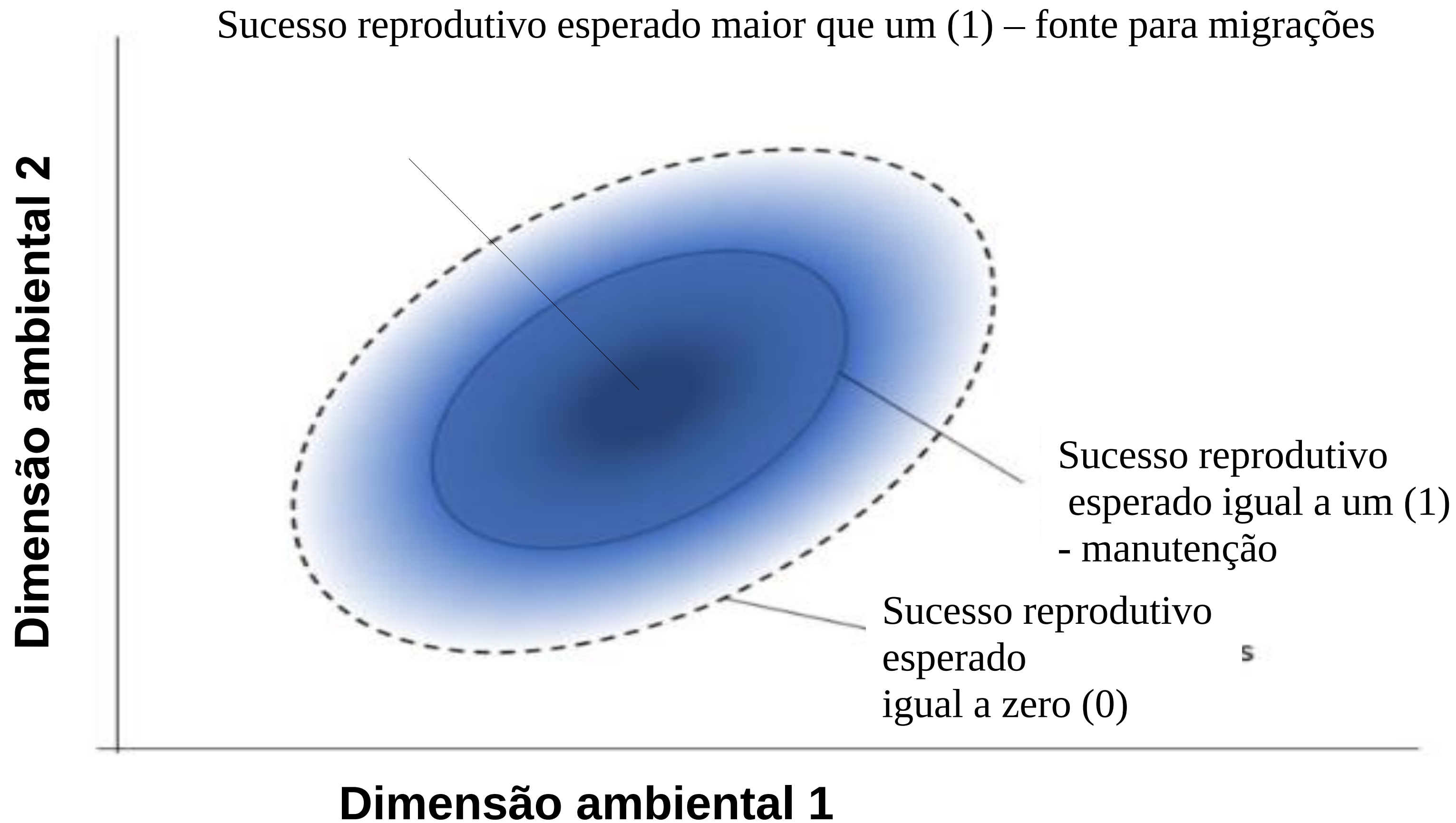


Figura 1: Esquema da definição de nicho ecológico proposta por Hutchinson (1957), para uma (1a), duas (1b) e três (1c) dimensões (variáveis).

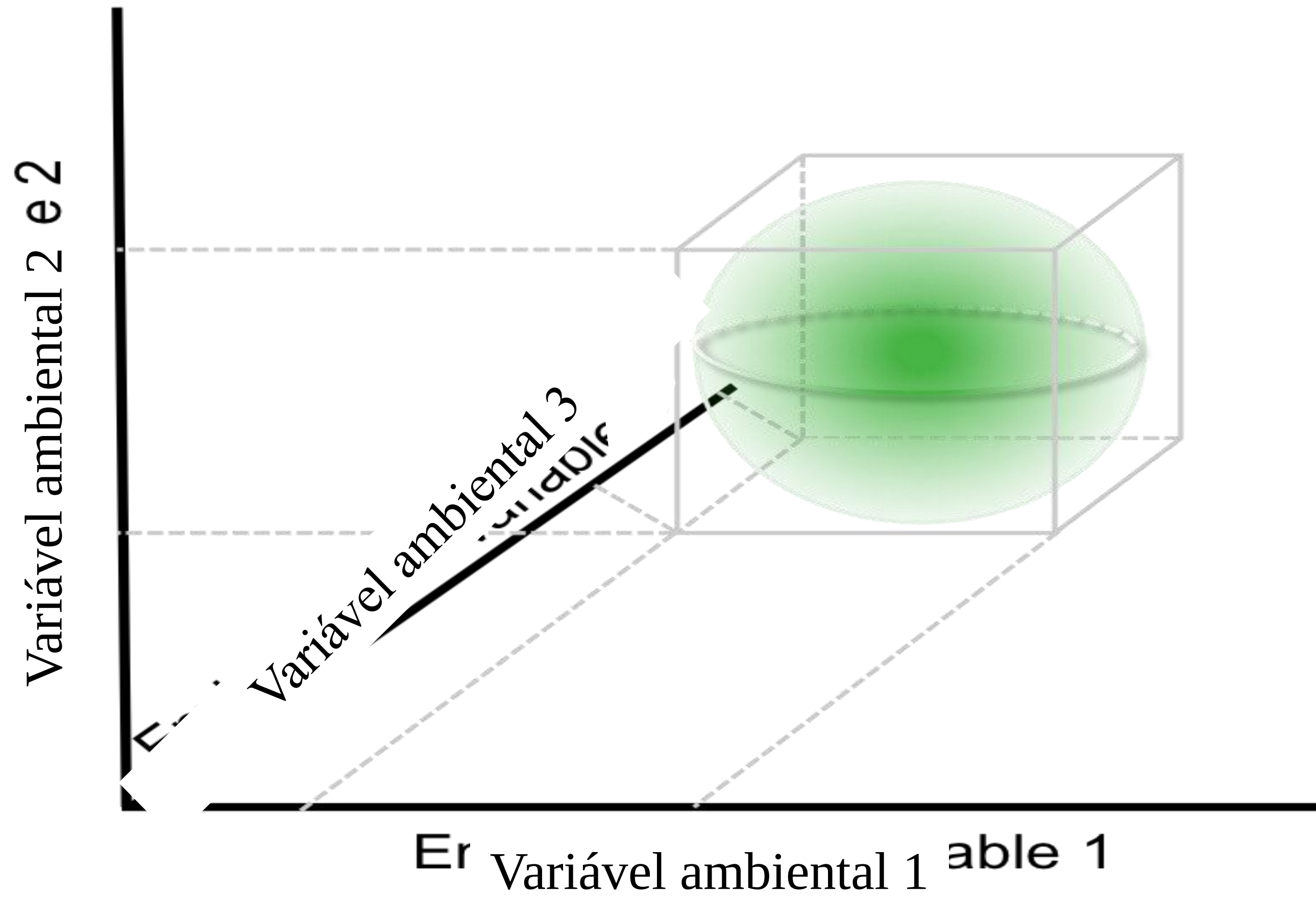
Nichos como graduação de aptidão



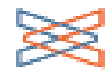




TAKOLA, Elina; SCHIELZETH, Holger. Hutchinson's ecological niche for individuals. Biology & Philosophy, v. 37, n. 4, p. 25, 2022.



<https://posit.co/download/rstudio-desktop/>



posit

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PRICING

1: Install R

RStudio requires R 3.3.0+. Choose a version of R that matches your computer's operating system.

DOWNLOAD AND INSTALL R

2: Install RStudio

DOWNLOAD RSTUDIO DESKTOP FOR WINDOWS

Size: 215.66 MB | [SHA-256: D3C03C42](#) | Version: 2023.12.1+402 | Released: 2024-01-29

<https://cran.r-project.org/bin/windows/base/>

R-4.3.2 for Windows

[Download R-4.3.2 for Windows](#) (79 megabytes, 64 bit)

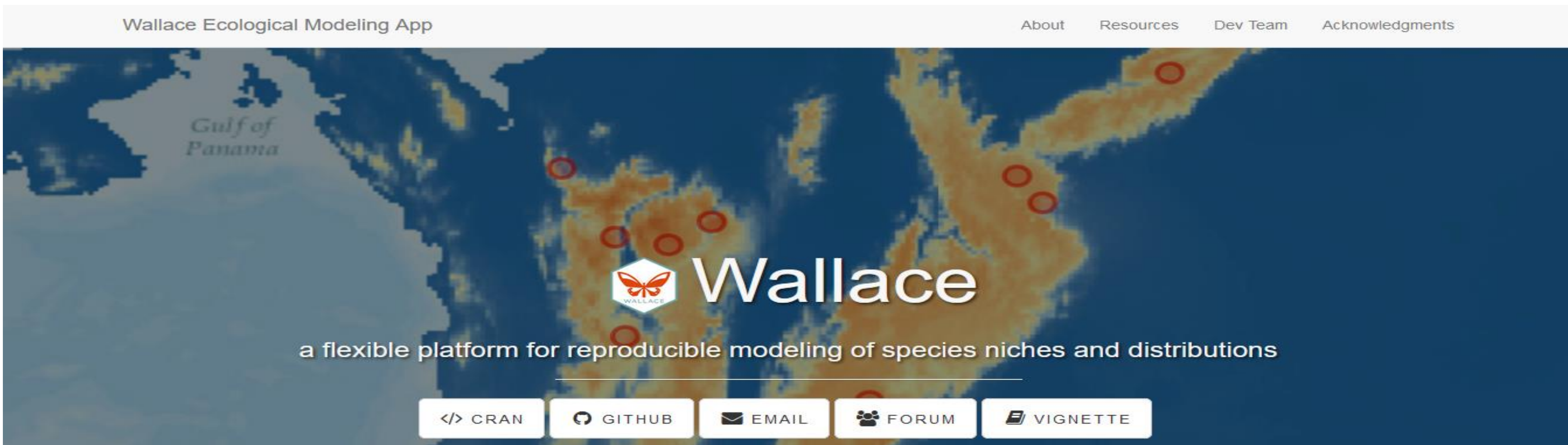
[README on the Windows binary distribution](#)

[New features in this version](#)

Wallace

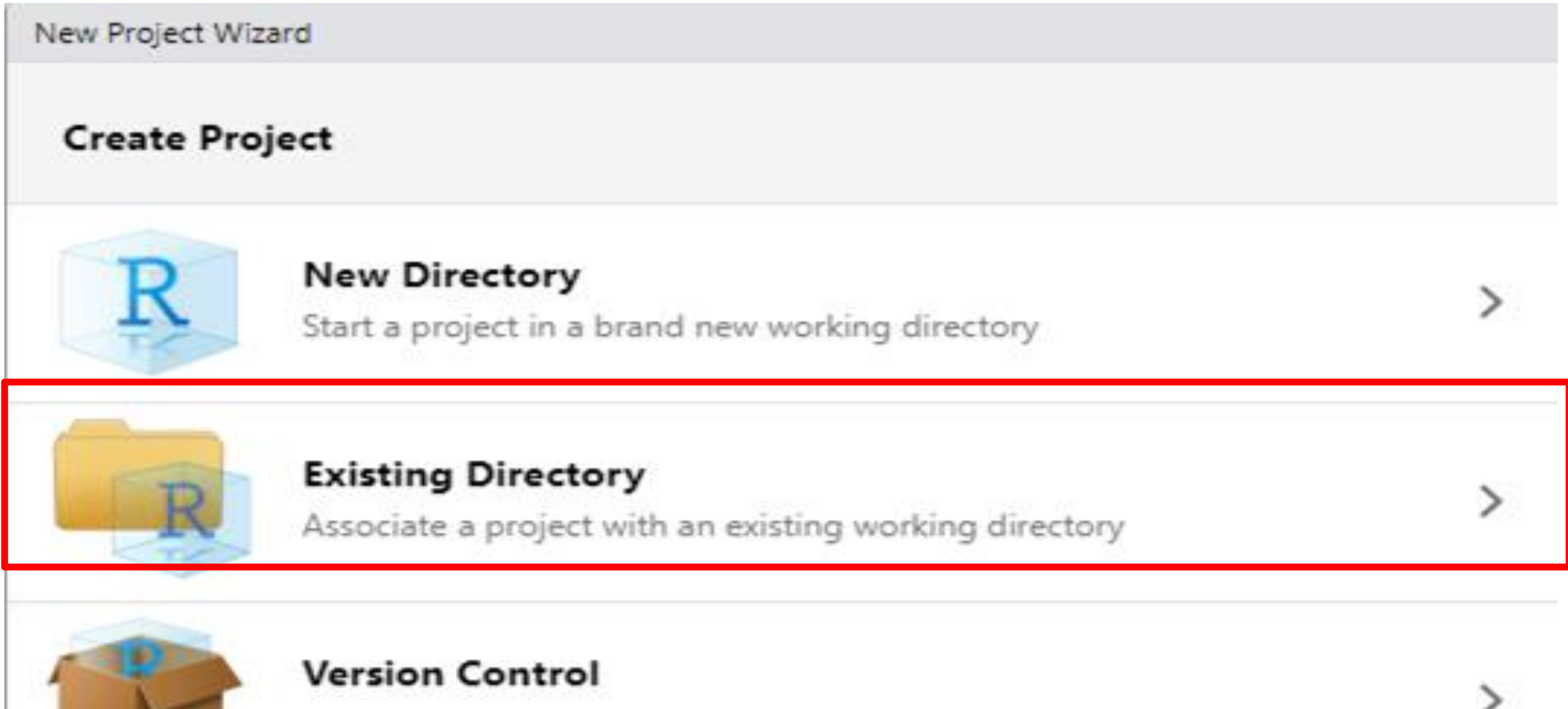
Interface gráfica para modelagem de distribuição e espécies

<https://wallaceecomod.github.io/>

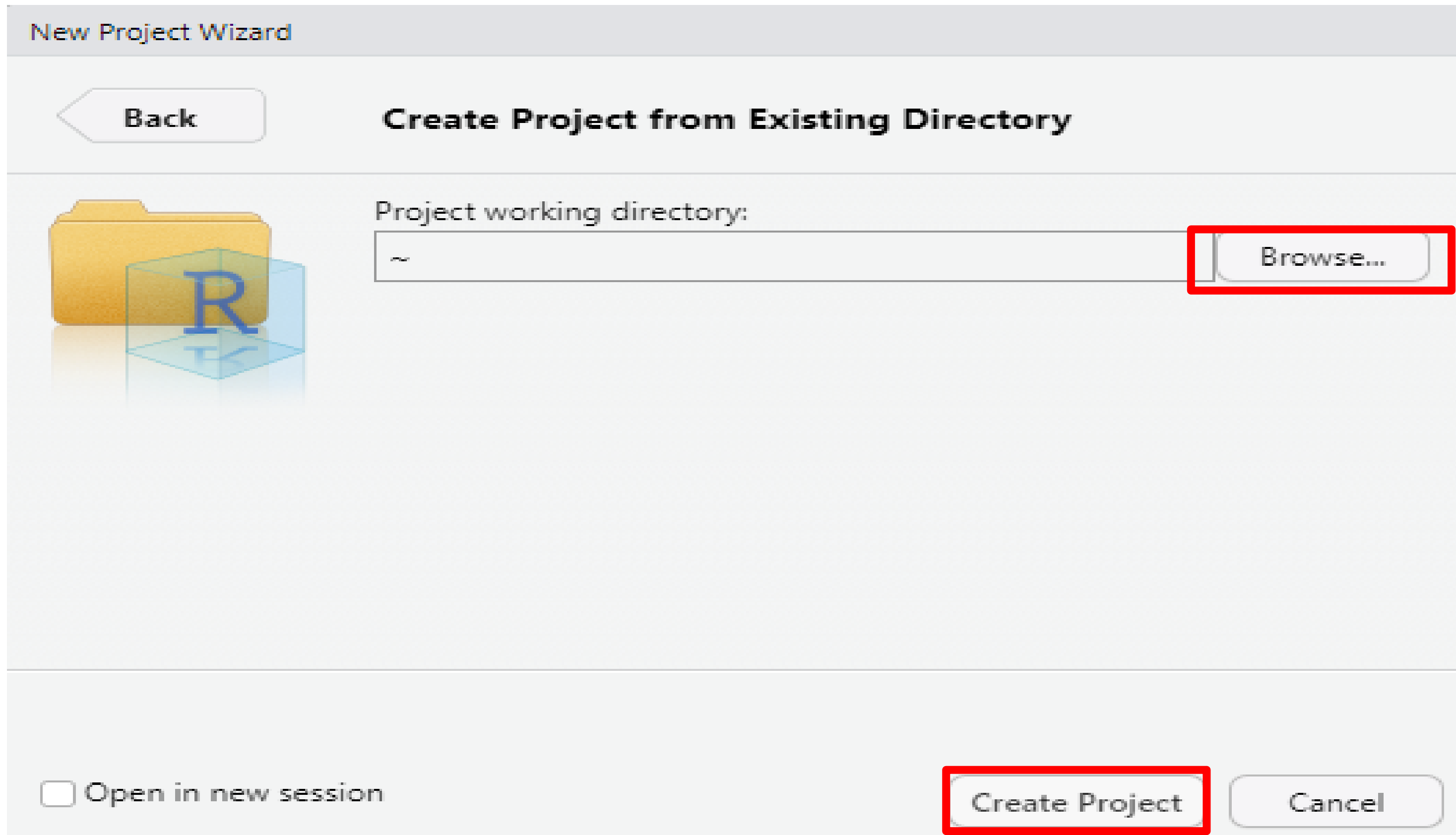


- Copiar o arquivo de aula para uma pasta
- Script para chamar abrir a interface gráfica Wallace, dentro do RStudio
 - wallace.R

- Create project -> Existing directory



- Escolha a pasta onde colocou o arquivo de aula
- Create project



Interface do RStudio

The image shows the RStudio interface with the following components and labels:

- Scripts:** The main editor window on the left, titled 'wallace.R', containing R code for installing and running the 'wallace' package.
- Objetos:** The Environment pane on the right, which is currently empty, indicating no objects are loaded in the global environment.
- Resultados:** The Console pane at the bottom left, showing the standard R startup message and a prompt for user input.
- Arquivos:** The Files pane on the bottom right, displaying the project's file structure, including the .Rhistory file, the Rproj file, and the current script wallace.R.

```
1 # Install wallace from CRAN
2 install.packages("wallace")
3 install.packages("markdown")
4
5 # OR install wallace from GitHub
6 install.packages("remotes")
7 remotes::install_github("wallaceEcoMod/wallace")
8
9 # THEN load wallace
10 library(wallace)
11 # AND Run wallace
12 run_wallace()
```

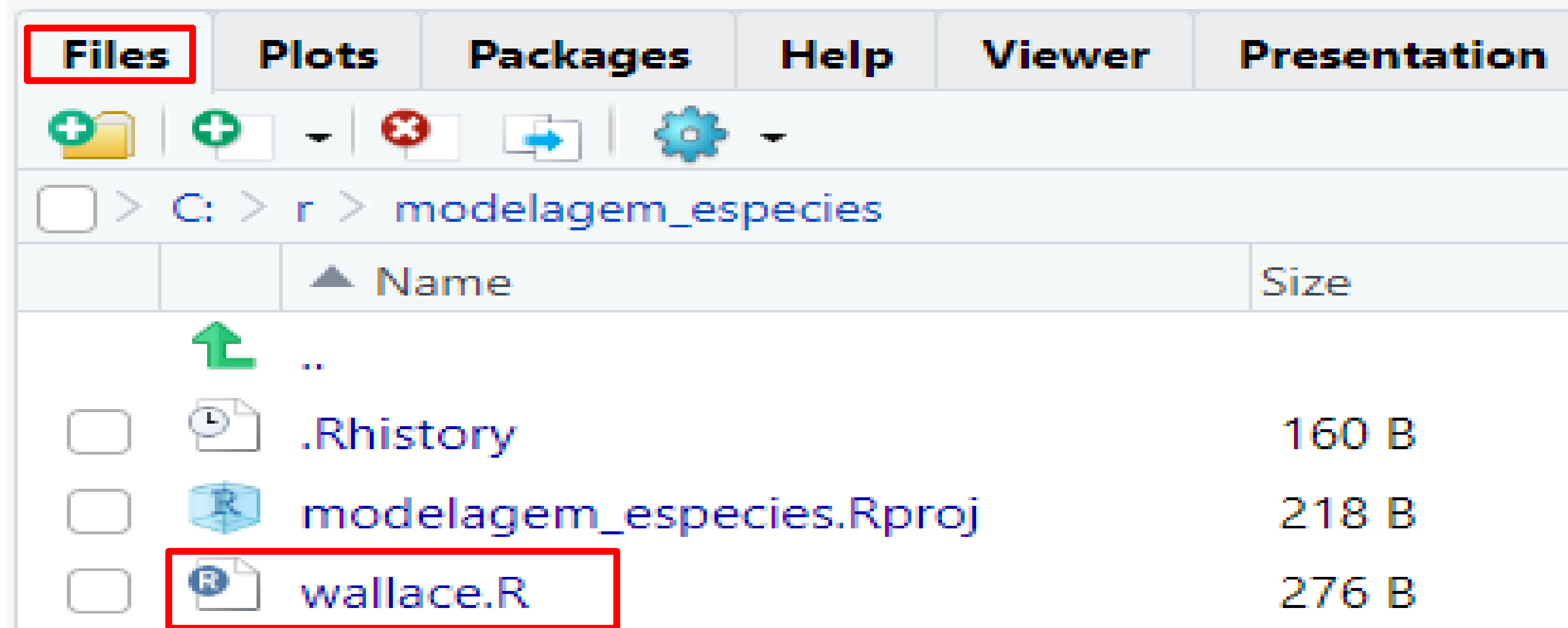
R 4.3.2 · C:/r/modelagem_especies/

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.
Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

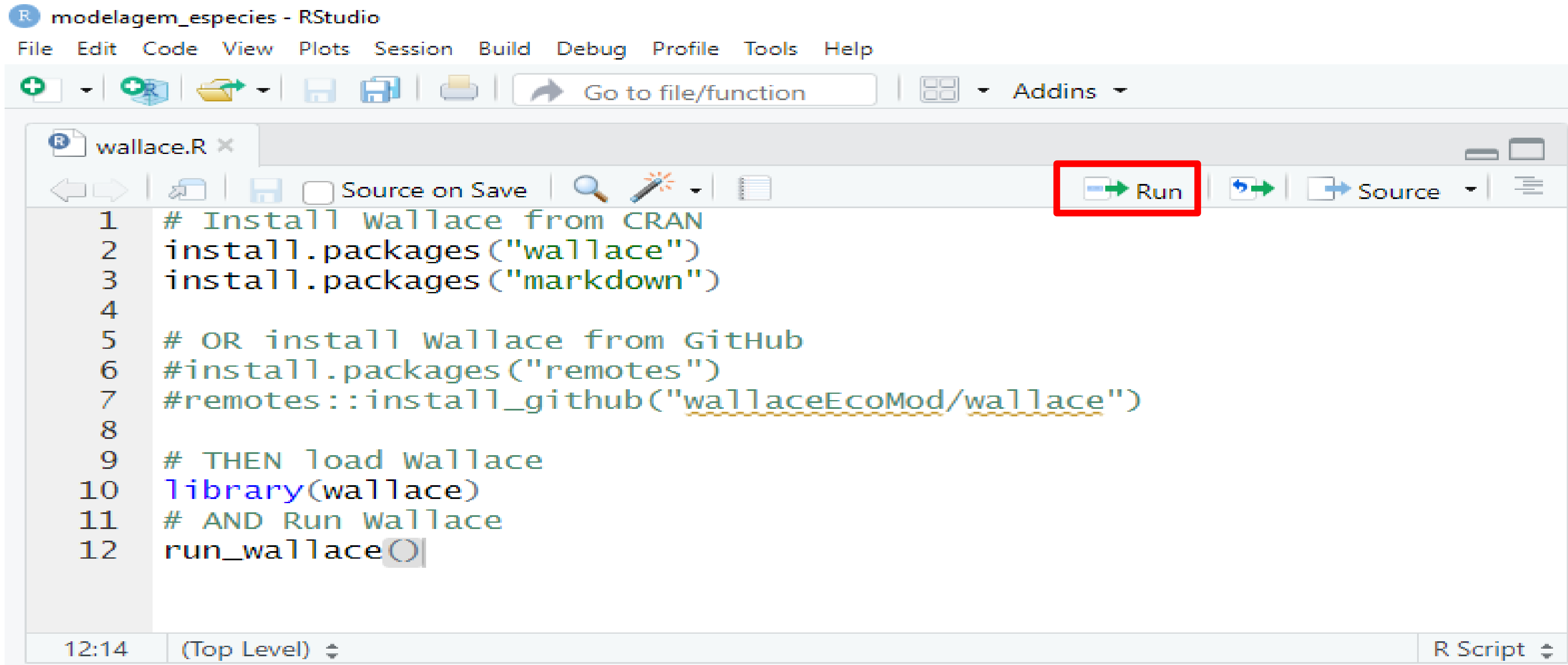
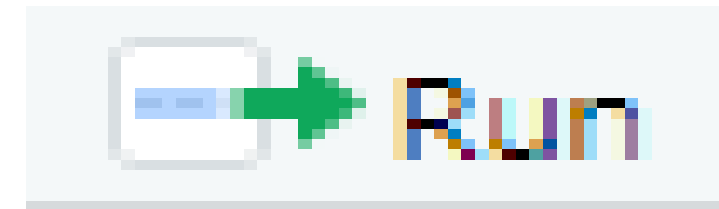
> |

Name	Size	Modified
..		
.Rhistory	160 B	Mar 6, 2024, 1:09 A
modelagem_especies.Rproj	218 B	Mar 10, 2024, 3:58
wallace.R	276 B	Mar 10, 2024, 3:58

- Na janela inferior direita, escolha a aba “Files”
- Clique no script “wallace.R”



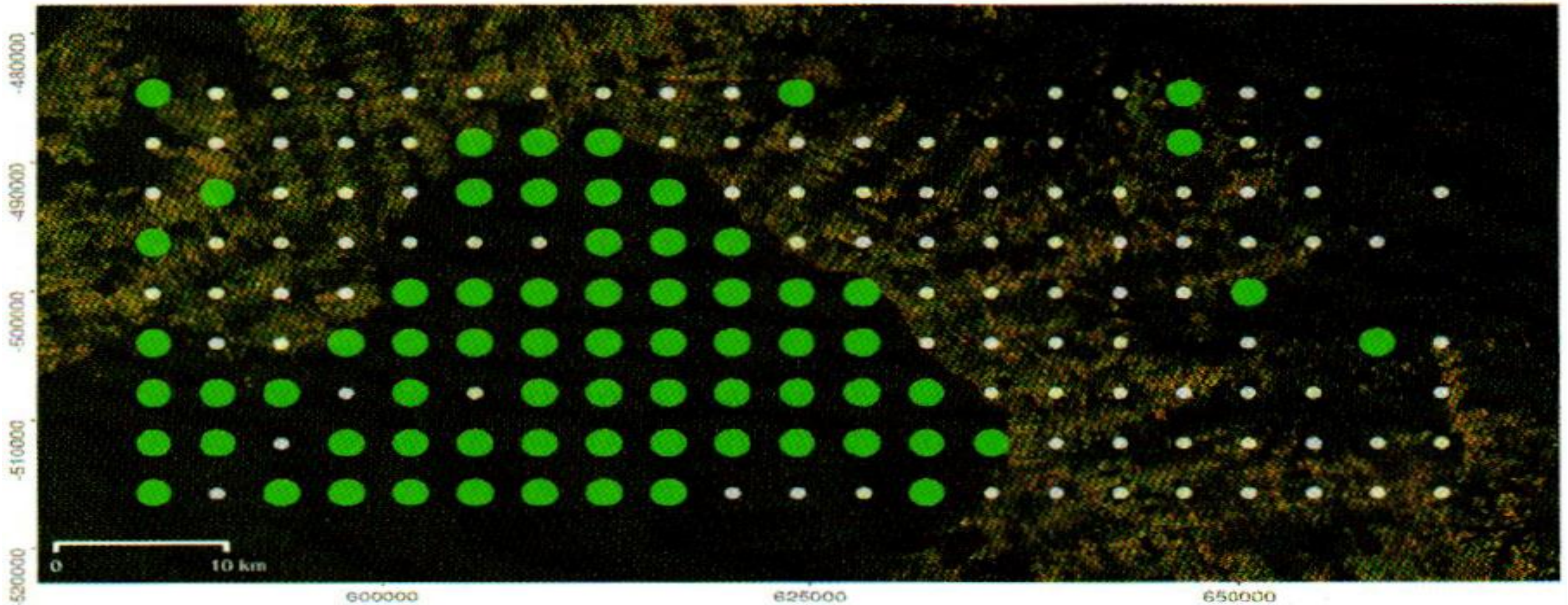
•Clique no botão “Run”



Modelos de levantamento de campo

Ideal: ocorrência vs. não ocorrência, sistemático

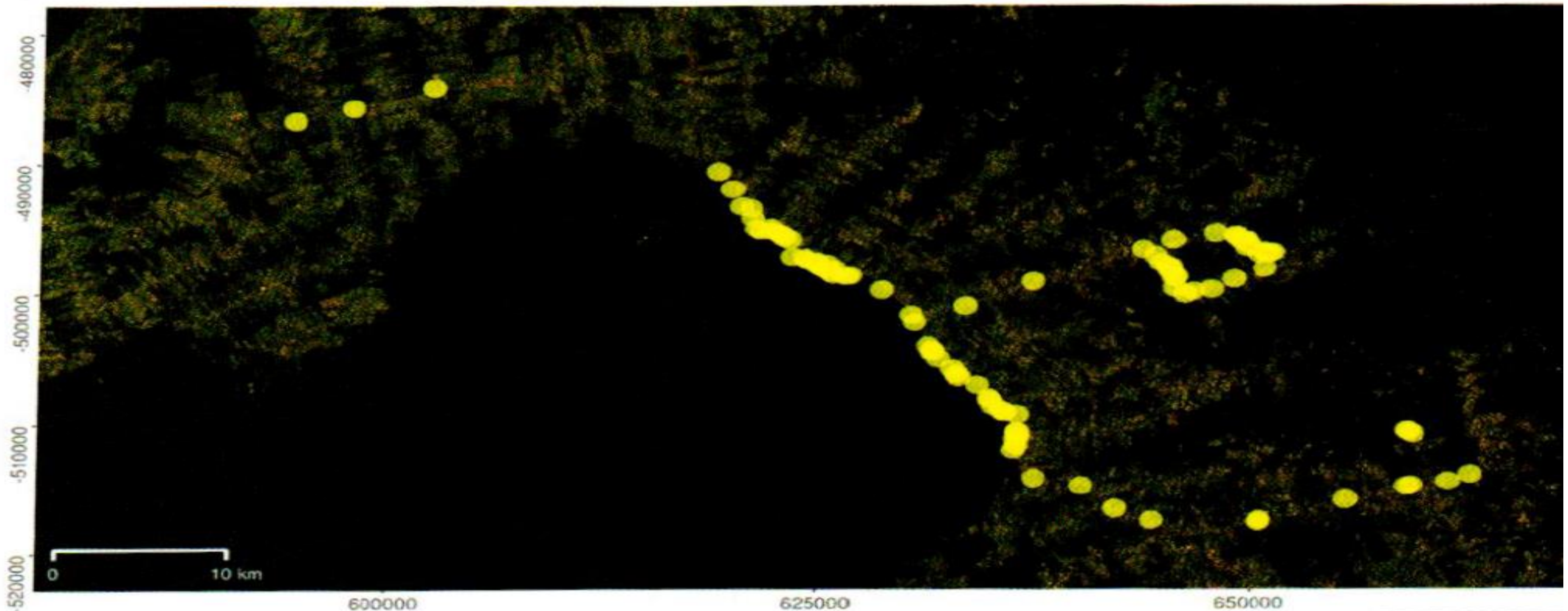
○ Não
● Sim



Reineking, B. Et al., Modelling species distributions. In: Wegmann M. et al. (org).
Remote sensing and GIS for Ecologists. Pelag. 2016

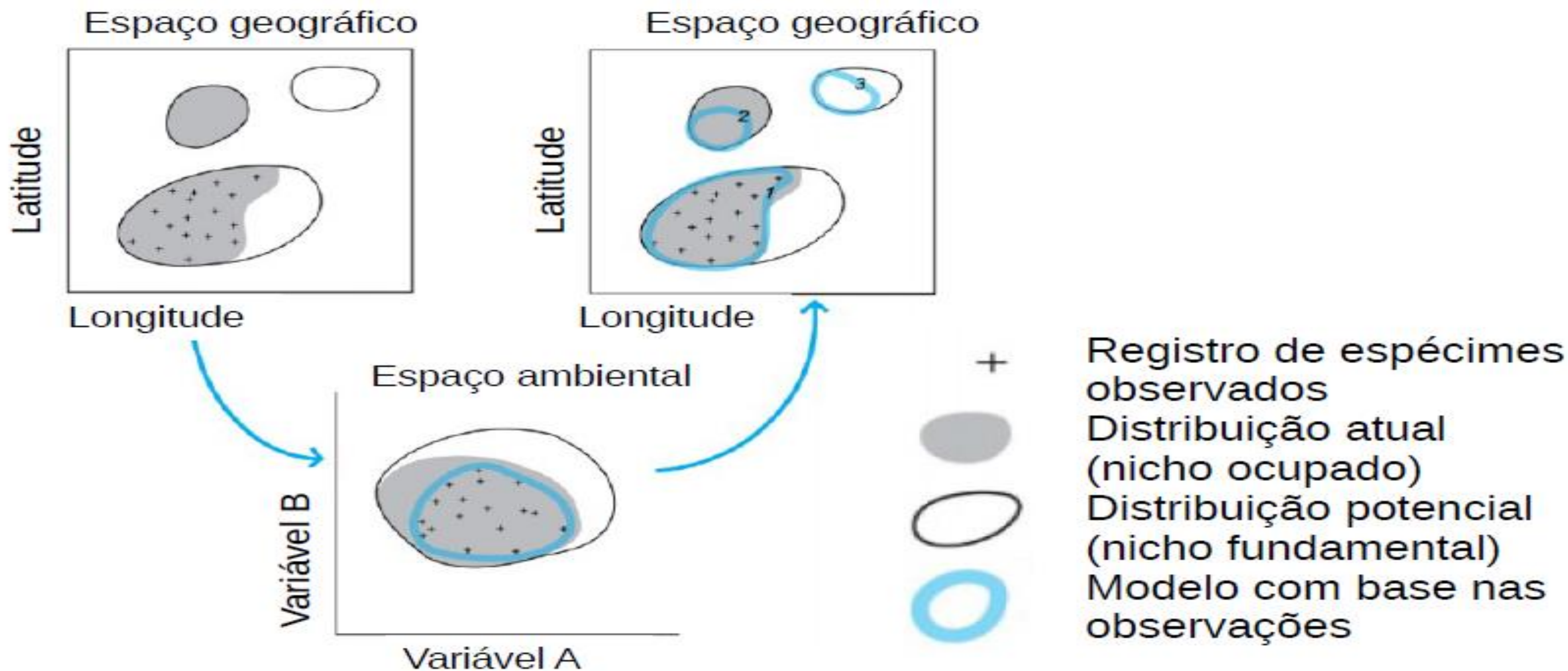
Modelos de levantamento de campo

Usual: somente ocorrência, em locais de fácil acesso



Reineking, B. Et al., Modelling species distributions. In: Wegmann M. et al. (org).
Remote sensing and GIS for Ecologists. Pelag. 2016

Distribuição no espaço geográfico x espaço ambiental



Pearson, R. G. (2007). Species' distribution modeling for conservation educators and practitioners. Synthesis. American Museum of Natural History, 50, 54-89.

GBIF – Global Biodiversity Information Facility

<https://www.gbif.org/>



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GBIF | Global Biodiversity Information Facility

Free and open access to biodiversity data

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What is GBIF?

About GBIF Brazil

Modelagem de Espécie Invasora

- Javali (*Sus scrofa*)
- Altamente adaptável a diversos ambientes
- Destroi ecossistemas nativos, plantações e criações de porcos



ZANI, L. S. Modelagem de distribuição potencial do *Sus scrofa* (linnaeus, 1758) javali em território brasileiro. Dissertação de Mestrado. UFABC, 2024.

Tela Inicial

[Intro](#)[Occ Data](#)[Env Data](#)[Process Occs](#)[Process Envs](#)[Env Space](#)[Partition Occs](#)[Model](#)[Visualize](#)[Transfer](#)[Reproduce](#)[Support](#)

WORKFLOW

Wallace (v2.1.2) currently includes ten components, or steps of a possible workflow. Each component includes two or more modules, which are possible analyses for that step.

Components:

1. Obtain Occurrence Data

- Query Present Database
- User-specified Occurrences

2. Obtain Environmental Data

- WorldClim
- EcoClimate
- User-specified Environmental Data

3. Process Occurrence Data

- Select Occurrences on Map
- Remove Occurrences by ID
- Spatial Thin

4. Process Environmental Data

- Select Study Region by Extent
- Draw Study Region
- User-specified Study Region

5. Characterize Environmental Space

- Environmental Ordination

[About](#)[Team](#)[How To Use](#)[Load Prior Session](#)

What is *Wallace*?

Welcome to *Wallace*, a flexible application for reproducible ecological modeling, built for community expansion. The current version of *Wallace* (v2.1.2) steps the user through a full niche/distribution modeling analysis, from data acquisition to visualizing results.

The application is written in [R](#) with the web app development package [shiny](#). Please find the stable version of *Wallace* on [CRAN](#), and the development version on [Github](#). We also maintain a *Wallace* [website](#) that has some basic info, links, and will be updated with tutorial materials in the near future.

Wallace is designed to facilitate spatial biodiversity research, and currently concentrates on modeling species niches and distributions using occurrence datasets and environmental predictor variables. These models provide an estimate of the species' response to environmental conditions, and can be used to generate maps that indicate suitable areas for the species (i.e. its potential geographic distribution; Guisan & Thuiller 2005; Elith & Leathwick 2009; Franklin 2010a; Peterson et al. 2011). This research area has grown tremendously over the past two decades, with applications to pressing environmental issues such as conservation biology (Franklin 2010b), invasive species (Ficetola et al. 2007), zoonotic diseases (González et al. 2010), and climate-change impacts (Kearney et al. 2010).

Also, for more detail, please see our initial publication in *Methods in Ecology and Evolution* and our follow-up in *Ecography*.

Kass J. M., Vilela B., Aiello-Lammens M. E., Muscarella R., Merow C., Anderson R. P. (2018). *Wallace*: A flexible platform for reproducible modeling of species niches and distributions built for community expansion. *Methods in Ecology and Evolution*, 9(4): 1151-1156. DOI: [10.1111/2041-210X.12945](#)

Kass, J.M., Pinilla-Buitrago, G.E, Paz, A., Johnson, B.A., Grisales-Betancur, V., Meenan, S.I., Attali, D., Broennimann, O., Galante, P.J., Maitner, B.S., Owens, H.L., Varela, S., Aiello-Lammens, M.E., Merow, C., Blair, M.E., Anderson R.P. (2022). *wallace 2*: a shiny app for modeling species niches and distributions redesigned to facilitate expansion via module contributions. *Ecography*, 2023(3): e06547. DOI: [10.1111/ecog.06547](#).



[Intro](#)[Occ Data](#)[Env Data](#)[Process Occs](#)[Process](#)

Aba: Occ data (Ocorrências)

Módulo:
"Query database"

Base de dados: GBIF

Nome científico da espécie:
Sus scrofa

Máximo número de ocorrências:
300

Component: Obtain Occurrence Data ?

Modules Available:

☒ Query Database (Present)

☐ User-specified

Module: Query Database (Present) ?

R packages: *BIEN*, *spocc*

Choose Database

☒ GBIF ☐ VertNet ☐ BIEN

☐ Keep only occurrences with uncertainty values

☐ Include Data Source Citations

Enter species scientific name

Sus scrofa

Set maximum number of occurrences

300



Query Database

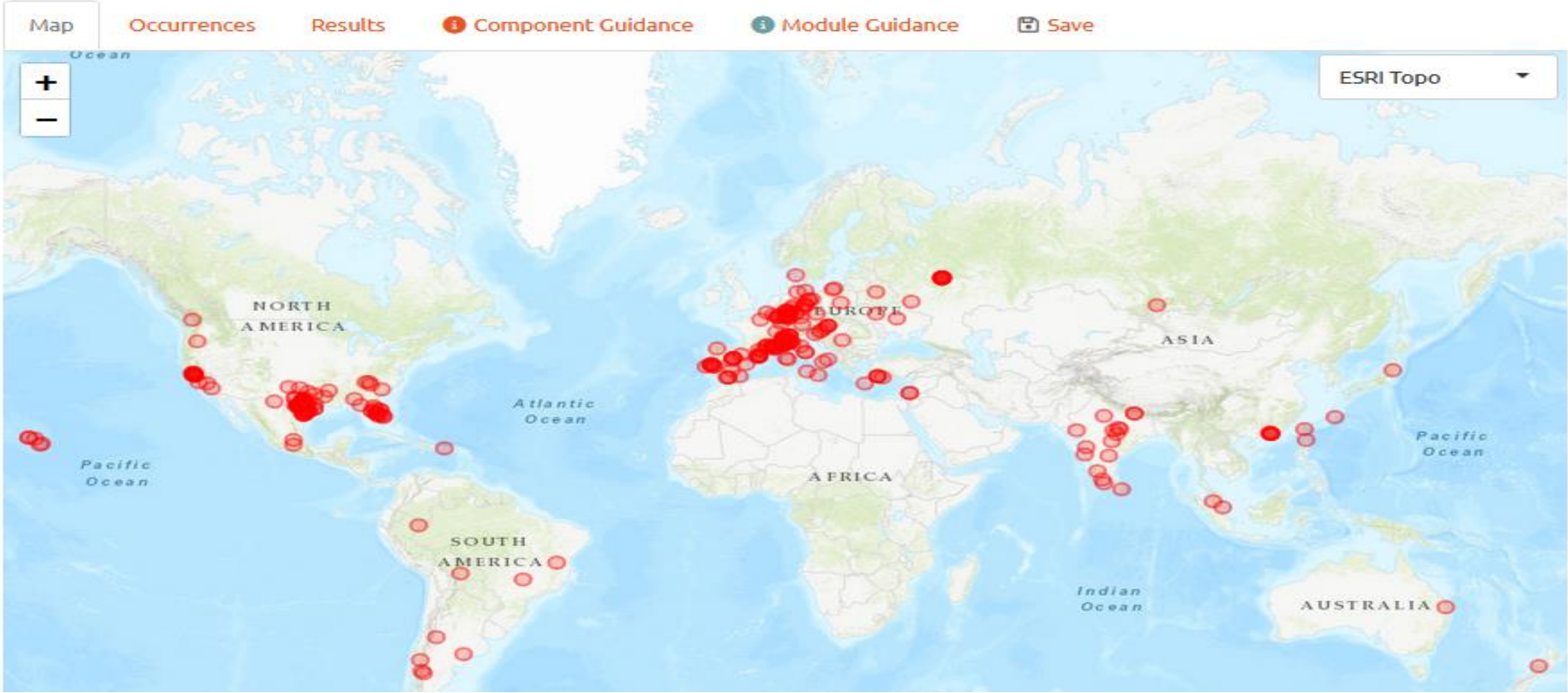
Species menu

Sus_scrofa

Log window

Please find messages for the user in this log window.

> **Sus scrofa** | Total gbif records returned [300] out of [373827] total (limit 300). Records without coordinates removed [1]. Duplicated records removed [11]. Remaining records [288].



•Aba “Occurrence”

•Observe as coordenadas, países, ano, tipo e instituição

Map

Occurrences

Results

Component Guidance

Module Guidance

Save

Show

10

▼

entries

Search:

occID	scientific_name	longitude	latitude	country	state_province	locality	year	record_type	catalog_number	institution_code
1	Sus scrofa Linnaeus, 1758	10.23	56.85	Denmark			2024	HUMAN_OBSERVATION	Arter_099e732a-1622-40b6-a0d3-b10201190bc5	MST-and-NHMD
2	Sus scrofa Linnaeus, 1758	13.17	52.57	Germany			2024	HUMAN_OBSERVATION	1463b494-d855-5376-aa12-20375cf69298	https:// artenfinder.net
3	Sus scrofa Linnaeus, 1758	2.17	42.75	France	Languedoc-Roussillon		2024	HUMAN_OBSERVATION	195454565	iNaturalist
4	Sus scrofa Linnaeus, 1758	27.72	53.97	Belarus	Minsk		2024	HUMAN_OBSERVATION	195466145	iNaturalist
5	Sus scrofa Linnaeus, 1758	-95.26	29.07	United States of America	Texas		2024	HUMAN_OBSERVATION	195524959	iNaturalist
6	Sus scrofa domesticus Linnaeus, 1758	-121.63	37.67	United States of America	California		2024	HUMAN_OBSERVATION	195530288	iNaturalist
7	Sus scrofa Linnaeus, 1758	8.23	40.94	Italy	Sardegna		2024	HUMAN_OBSERVATION	195551470	iNaturalist
8	Sus scrofa Linnaeus, 1758	-99.61	31.68	United States of America	Texas		2024	HUMAN_OBSERVATION	195570096	iNaturalist
9	Sus scrofa domesticus Linnaeus, 1758	-42.22	-14.5	Brazil	Bahia		2024	HUMAN_OBSERVATION	195582870	iNaturalist

Note: To save your session code or metadata, use the Reproduce component

Save Session

By saving your session into an RDS file, you can resume working on it at a later time or you can share the file with a collaborator.

 Save Session

Download Data

Download data/results from analyses from currently selected module

Download original
occurrence data

 CSV file

Download current table

 CSV file

Download all data

 CSV file

Variáveis comumente utilizadas para modelagem de distribuição de espécies

- Clima (temperatura, precipitação)
- Médias anuais
- Sazonalidade
- Topografia
- Elevação
- Declividade
- Curvatura
- Solos
- Classes de solo
- Textura (arenoso, siltiloso, argiloso)
- Nutrientes

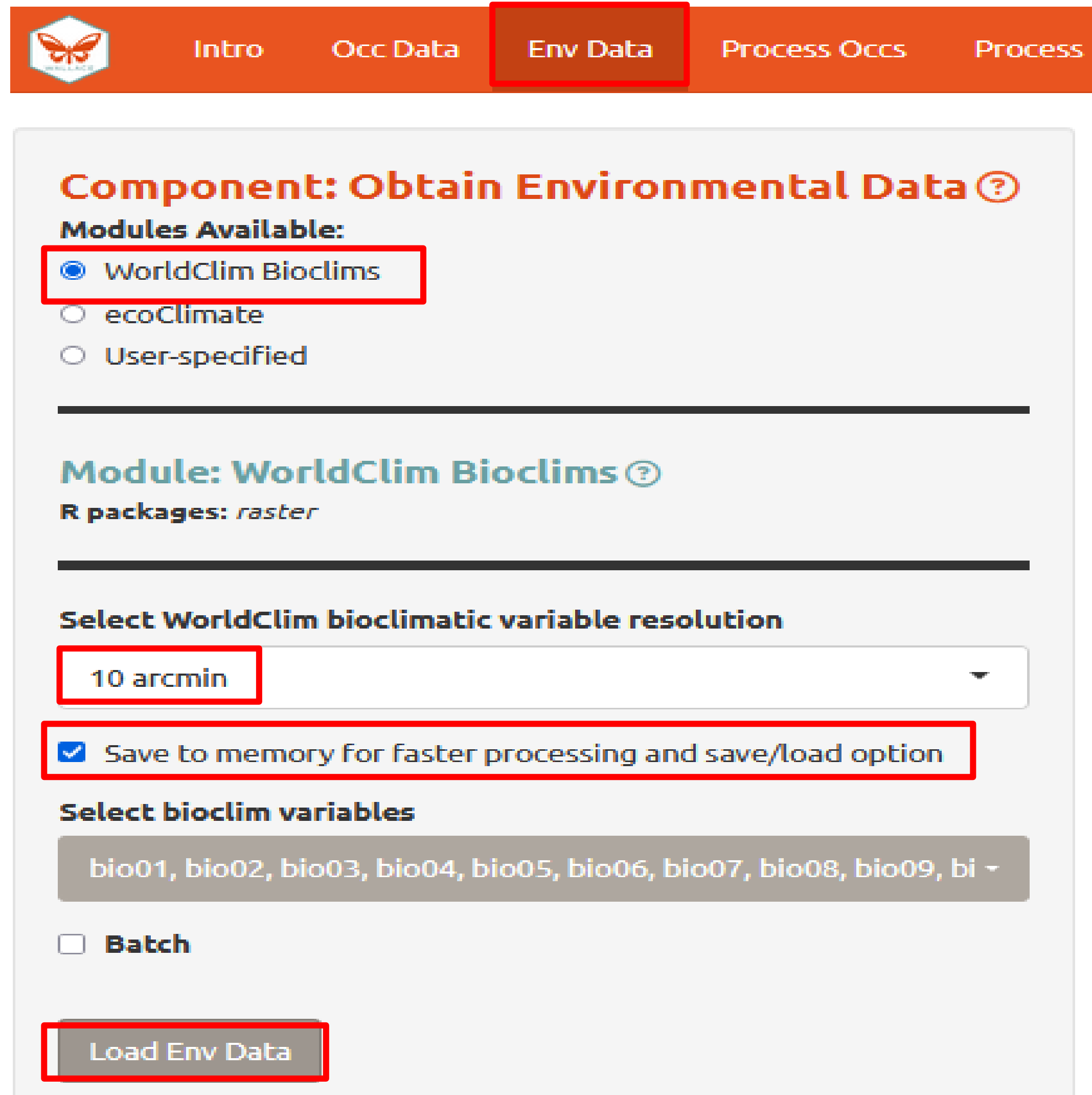
Variáveis comumente utilizadas para modelagem de distribuição de espécies

- Pressões antrópicas
 - Ocupação do solo
 - Densidade humana ou de vias de locomoção
 - Desmatamento
 - Poluição do ar, água ou solo

Variáveis comumente utilizadas para modelagem de distribuição de espécies

- Tipo de vegetação, para prever animais
- Predador e presa
- Competição
- Ocorrências de outras espécies

- Aba “EnvData”
 - Dados ambientais
- Módulo:
 - WorldClim Bioclimes
- Resolução
 - 10 arcmin
- Marque:
 - “Save to memory for faster processing and save/load option”



The screenshot shows the 'Env Data' tab selected in a top navigation bar. The main content area is titled 'Component: Obtain Environmental Data' with a help icon. Under 'Modules Available', 'WorldClim Bioclimes' is selected with a radio button. Below this, 'Module: WorldClim Bioclimes' is shown with the R package 'raster'. A dropdown menu for 'Select WorldClim bioclimatic variable resolution' is set to '10 arcmin'. A checkbox for 'Save to memory for faster processing and save/load option' is checked. Under 'Select bioclim variables', a list of variables (bio01 to bio09) is displayed. A 'Batch' checkbox is unchecked. At the bottom, a 'Load Env Data' button is visible.

Component: Obtain Environmental Data ?

Modules Available:

- ☒ WorldClim Bioclimes
- ☐ ecoClimate
- ☐ User-specified

Module: WorldClim Bioclimes ?

R packages: raster

Select WorldClim bioclimatic variable resolution

10 arcmin

☒ Save to memory for faster processing and save/load option

Select bioclim variables

bio01, bio02, bio03, bio04, bio05, bio06, bio07, bio08, bio09, bi -

☐ Batch

Load Env Data

WorldClim

<https://worldclim.org/>

Variáveis climáticas:

Histórico

Presente

Projeções climáticas

WorldClim

Maps, graphs, tables, and data of the global climate

Download



Variáveis bioclimáticas

BIO1 = Temperatura média anual

BIO2 = Amplitude térmica diurna (Média mensal (max temp - min temp))

BIO3 = Isotermalidade (BIO2/BIO7) ($\times 100$)

BIO4 = Sazonalidade da temperatura (desvio padrão $\times 100$)

BIO5 = Temperatura máxima do mês mais quente

BIO6 = Temperatura mínima do mês mais frio

BIO7 = Amplitude térmica anual (BIO5-BIO6)

BIO8 = Temperatura média do quadrimestre mais úmido

BIO9 = Temperatura média do quadrimestre mais seco

BIO10 = Temperatura média do quadrimestre mais quente

BIO11 = Temperatura média do quadrimestre mais frio

BIO12 = Precipitação anual

BIO13 = Precipitação do mês mais úmido

BIO14 = Precipitação do mês mais seco

BIO15 = Sazonalidade da precipitação (coeficiente de variação)

BIO16 = Precipitação do quadrimestre mais úmido

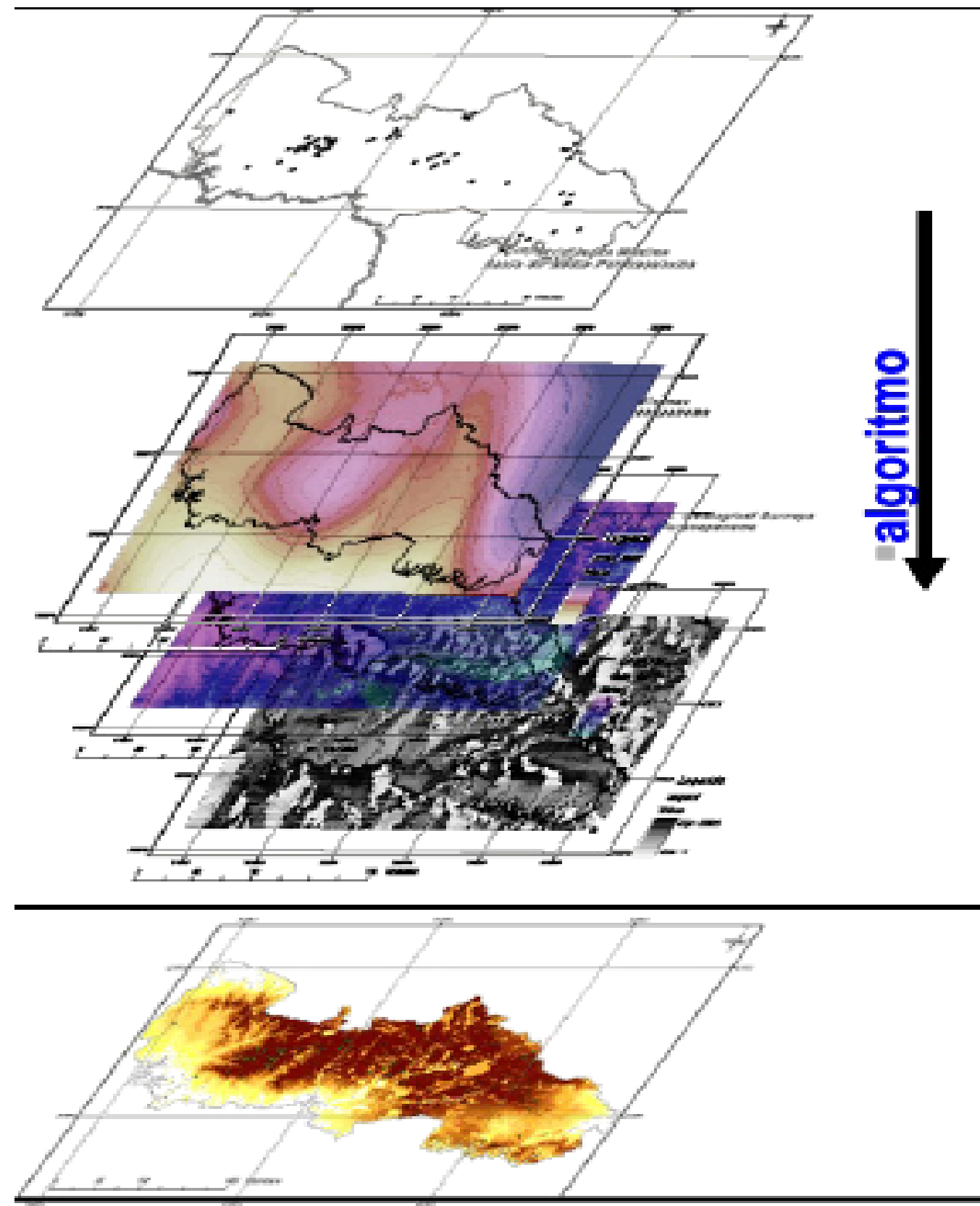
BIO17 = Precipitação do quadrimestre mais seco

BIO18 = Precipitação do quadrimestre mais quente

BIO19 = Precipitação do quadrimestre mais frio

Booth, T. H., Nix, H. A., Busby, J. R., & Hutchinson, M. F. (2014). BIOCLIM: the first species distribution modelling package, its early applications and relevance to most current MAXENT studies. *Diversity and Distributions*, 20(1), 1-9.

Exemplo de tabela de dados, com os valores ambientais adicionados, utilizada no procedimento de modelagem



(Siqueira, 2014)

	pa	bio1	bio12	bio16	bio17	bio5	bio6	bio7	bio8
1	1	183	988	374	110	323	66	257	240
2	1	226	1395	455	177	327	126	202	265
3	1	192	2160	833	267	262	107	155	219
4	1	191	1200	516	140	276	91	186	220
5	1	209	1330	501	190	300	103	197	237
6	1	205	1354	541	165	296	99	197	233
7	1	208	1403	539	180	296	104	193	236
8	1	222	1444	697	30	291	139	152	226
9	1	229	1217	580	111	309	146	163	243
10	1	186	1934	550	444	289	87	201	187
11	1	199	1436	779	46	284	97	186	218
12	1	257	1267	568	52	333	156	177	269
13	1	194	1919	533	443	295	99	197	208
14	1	165	2041	575	460	271	50	221	168
15	1	195	1449	750	61	281	79	201	219
16	1	197	1500	720	97	281	96	185	223
17	1	188	1530	724	101	272	98	174	213
18	1	223	1475	583	153	302	144	158	250
19	1	196	1484	741	90	273	86	186	218
20	1	258	2691	1077	276	317	215	102	259
21	1	262	3406	1242	238	309	219	90	252
22	1	202	2026	611	426	275	140	135	202
23	1	236	1072	476	46	306	162	145	235
24	1	236	1072	476	46	306	162	145	235
25	1	225	2622	1183	84	295	164	131	222
26	1	192	2160	833	267	262	107	155	219
27	1	136	1746	578	312	200	78	122	131
28	1	267	1912	851	54	322	223	99	262
29	1	167	3159	1168	312	224	111	113	166
30	1	167	3159	1168	312	224	111	113	166
31	1	261	3561	1376	315	321	216	105	258
32	1	236	1072	476	46	306	162	145	235
33	1	216	3185	1063	443	277	160	117	212
34	1	259	2876	1119	163	315	214	101	253
35	1	267	1912	851	54	322	223	99	262
36	1	262	2483	933	229	329	201	127	256
37	1	258	2691	1077	276	317	215	102	259
38	1	167	3159	1168	312	224	111	113	166
39	1	258	2691	1077	276	317	215	102	259
40	1	202	1751	530	337	315	79	236	232
41	1	265	2109	865	195	325	221	105	265
42	1	261	3561	1376	315	321	216	105	258
43	1	167	3159	1168	312	224	111	113	166
44	1	167	3159	1168	312	224	111	113	166
45	1	228	3218	1418	153	303	161	141	225



**Please, check Log window for
more information**

OK

- Ocorrências removidas porque estavam na mesma célula (pixel) da base do WorldClim

Log window

```
bio05, bio06, bio07, bio08, bio09, bio10, bio11, bio12, bio13,  
bio14, bio15, bio16, bio17, bio18, bio19 at 10 arcmin resolution.  
> ! WARNING : Sus scrofa | Removed 63 localities that shared the  
same grid cell. occIDs: 34, 42, 52, 58, 70, 71, 75, 93, 94, 95, 99,  
100, 103, 105, 106, 109, 138, 139, 140, 142, 143, 148, 149, 151,
```

Aba:
“Occurrences”

Restaram 225 ocorrências

Map

Occurrences

Results

Component Guidance

Module Guidance

Save

Show

10

entries

occID	scientific_name	longitude	latitude	country	state_province	locality
1	Sus scrofa Linnaeus, 1758	10.23	56.85	Denmark		
2	Sus scrofa Linnaeus, 1758	13.17	52.57	Germany		
3	Sus scrofa Linnaeus, 1758	2.17	42.75	France	Languedoc-Roussillon	
4	Sus scrofa Linnaeus, 1758	27.72	53.97	Belarus	Minsk	
5	Sus scrofa Linnaeus, 1758	-95.26	29.07	United States of America	Texas	
6	Sus scrofa domesticus Linnaeus, 1758	-121.63	37.67	United States of America	California	
7	Sus scrofa Linnaeus, 1758	8.23	40.94	Italy	Sardegna	
8	Sus scrofa Linnaeus, 1758	-99.61	31.68	United States of America	Texas	
9	Sus scrofa domesticus Linnaeus, 1758	-42.22	-14.5	Brazil	Bahia	
10	Sus scrofa Linnaeus, 1758	8.47	45.91	Italy	Piemonte	

<

Showing 1 to 10 of 225 entries

- ABA “Save”

Map

Occurrences

Results

 Component Guidance

 Module Guidance

 Save

Note: To save your session code or metadata, use the Reproduce component

Save Session

By saving your session into an RDS file, you can resume working on it at a later time or you can share the file with a collaborator.

 Save Session

Download Data

Download data/results from analyses from currently selected module

Download environmental
variables (Select
download file type)

GeoTIFF ▼

 ZIP file

- Aba: Process Occs
- Selezione “Spatial thin”
- Distância: 5km

IntroOcc DataEnv DataProcess Occs

Component: Process Occurrence Data

?

Modules Available:

☐ Select Occurrences On Map

☐ Remove Occurrences By ID

☒ Spatial Thin

Module: Spatial Thin ?

R packages: *spThin*

The minimum distance between occurrence locations (nearest neighbor distance) in km for resulting thinned dataset. Ideally based on species biology (e.g., home-range size).

Thinning distance (km)

5

☐ Batch

Thin Occurrences

Log window

157, 169, 177, 179, 181, 186, 191, 192, 193, 196, 199, 202, 206,
208, 212, 224, 225, 226, 228, 229, 234, 236, 242, 243, 244, 245,
246, 257, 262, 263, 270, 271, 274, 275, 283, 294, 299, 300.

> ***Sus scrofa*** | Worldclim variables ready to use.

> ***Sus scrofa*** | Total records thinned (5 km) to 220 localities

Fontes de incerteza para modelagem de processos pontuais

- Previsão para fora da área de estudo ou para locais com características diferentes das amostradas
 - Ex: expansão potencial de espécies invasoras, vetores de doença, plantios agrícolas
- Previsões para outros períodos de tempo (passado, futuro)
 - Ex: efeito de mudanças climáticas

- As relações seriam as mesmas?
- Outras variáveis e processos ambientais e sociais seriam relevantes?
- As projeções são confiáveis?

- Aba “Process Envs”
- Marque
“Select Study Region”
- Extensão:
 - “Minimum convex polygon”
- Buffer:
 - 1 km

IntroOcc DataEnv DataProcess OccsProcess Envs

Component: Process Environmental Data ?
Modules Available:

- ☒ Select Study Region
- ☐ Draw Study Region
- ☐ User-specified Study Region

Module: Select Study Region by Extent ?
R packages: *sp, sf*

Step 1: Choose Background Extent
Background Extents:

- ☐ bounding box
- ☒ minimum convex polygon
- ☐ point buffers

Study region buffer distance (degree)

☐ Batch

Select

Map

Occurrences

Results

 Component Guidance

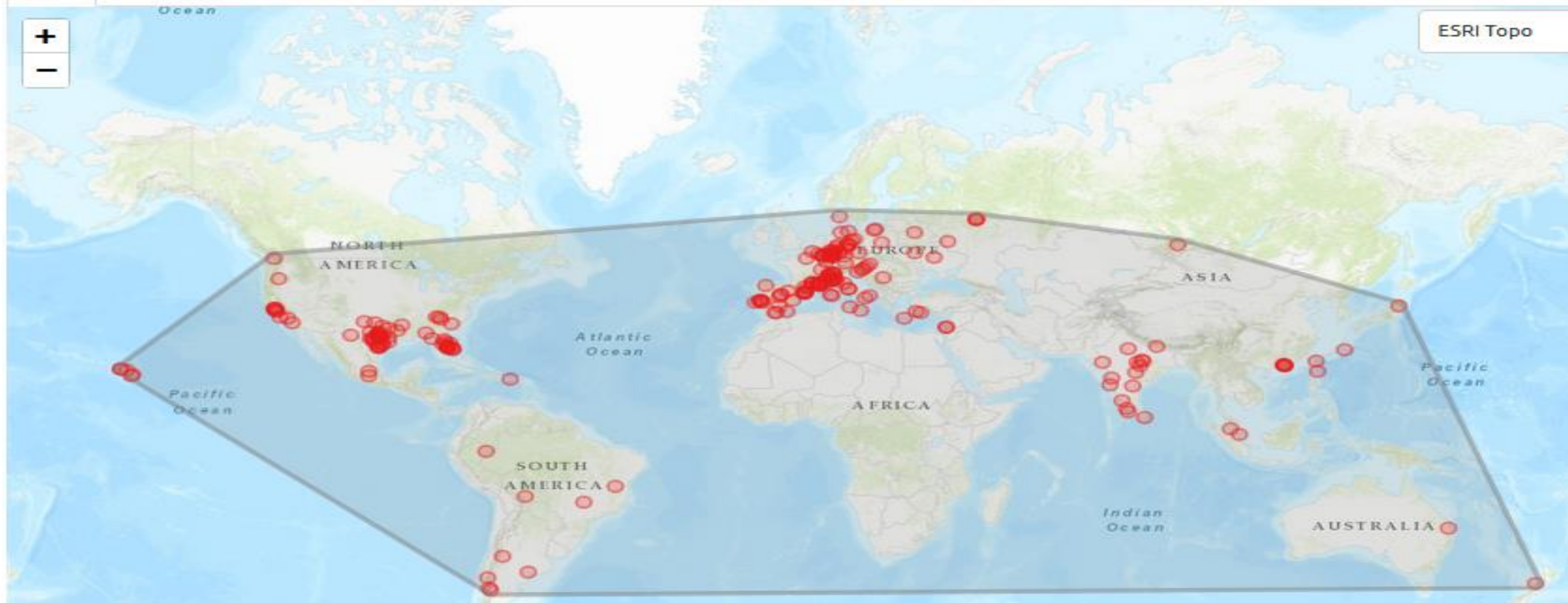
 Module Guidance

 Save

+

-

ESRI Topo



- Amostragem aleatória de pontos para comparação:
 - 220, igual ao número de ocorrências

Step 2: *Sample Background Points*

Mask predictor rasters by background extent and sample background points

No. of background points

220

☐ **Batch**

Sample

Note: To save your session code or metadata, use the Reproduce component

Save Session

By saving your session into an RDS file, you can resume working on it at a later time or you can share the file

 The current session data is large, which means the downloaded file may be large and the download might

 Save Session

Download Data

Download data/results from analyses from currently selected module

Download shapefile of
background extent

 ZIP file

Download predictor rasters
masked to background
extent (Select download file
type)

GeoTIFF

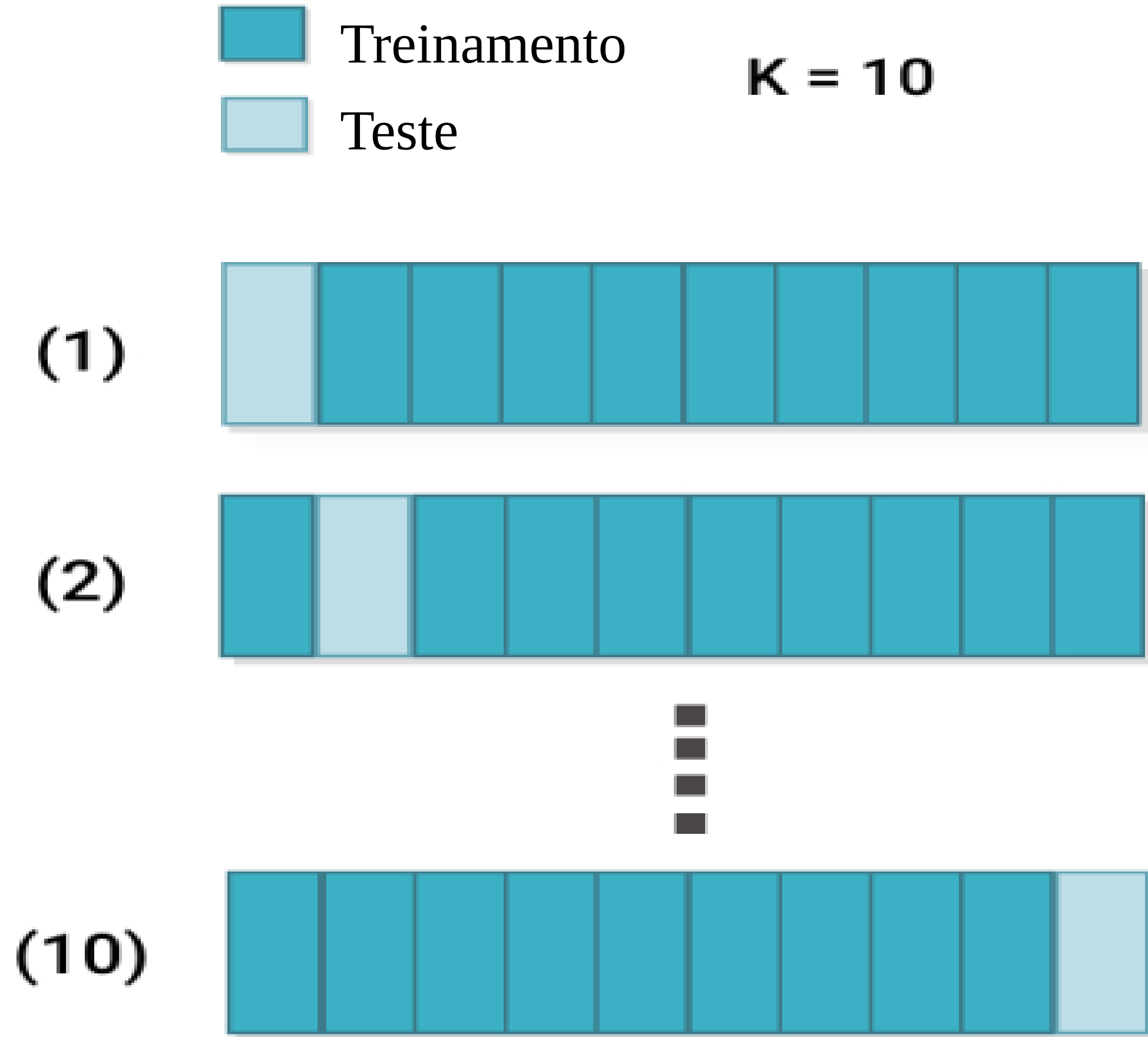


 ZIP file

Download sample
background points

 CSV file

Validação cruzada

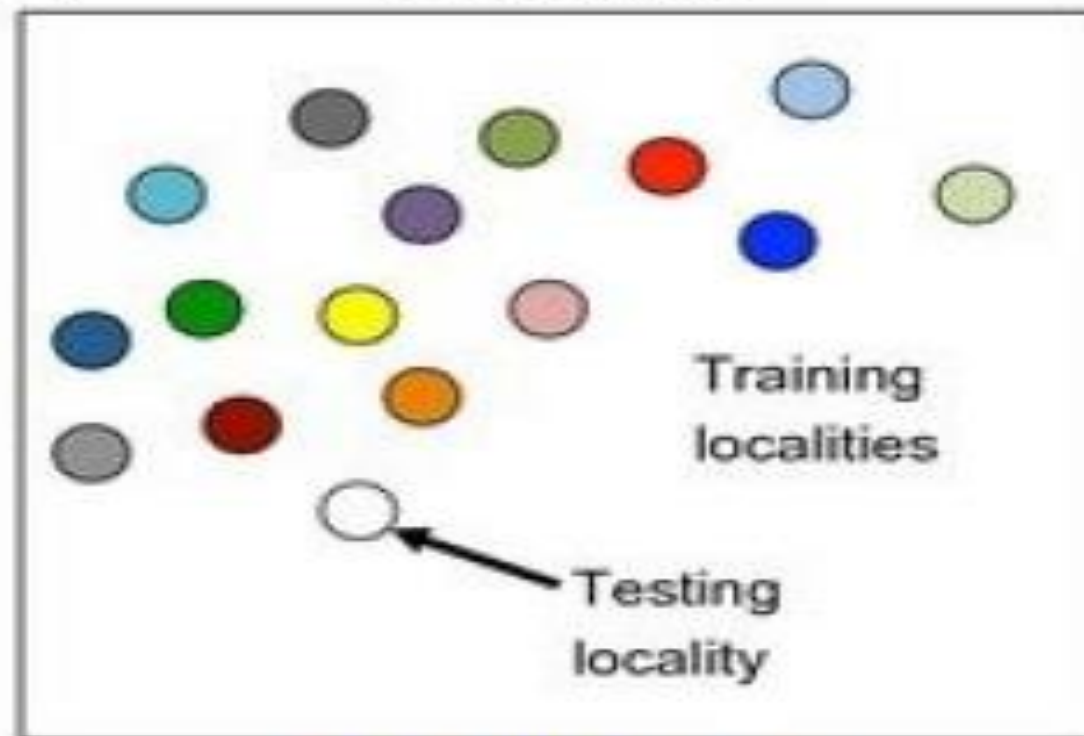


Métodos de particionamento

Aleatório

'n-1 jackknife'

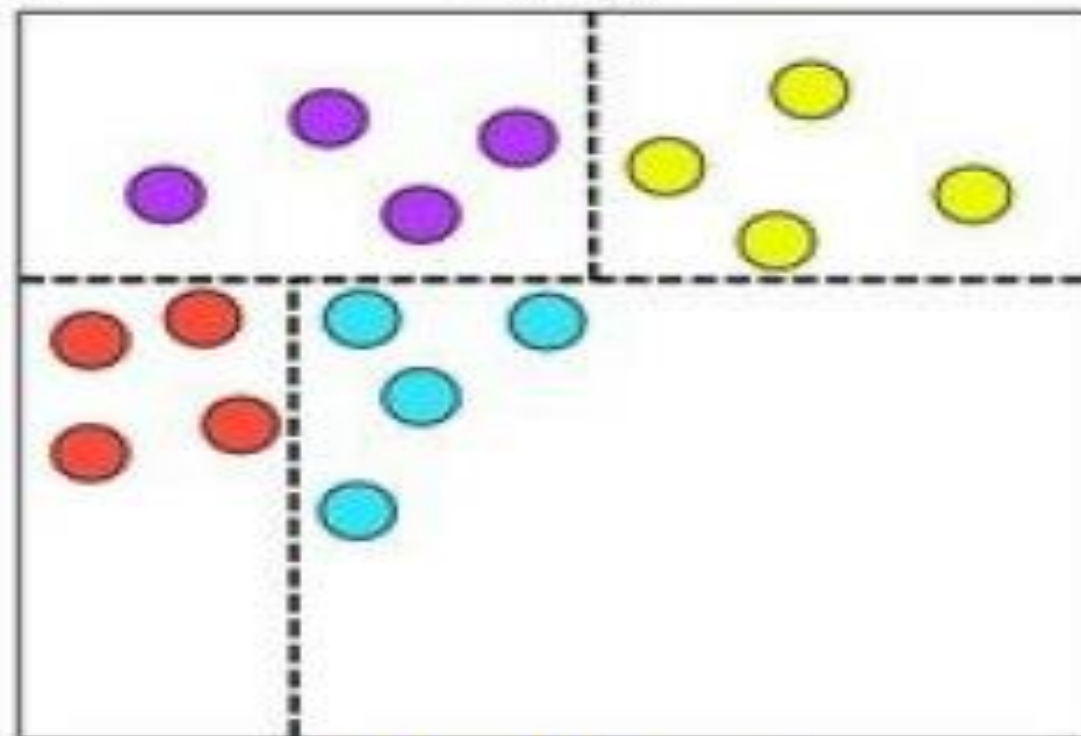
(a)



Agrupamento espacial

(b)

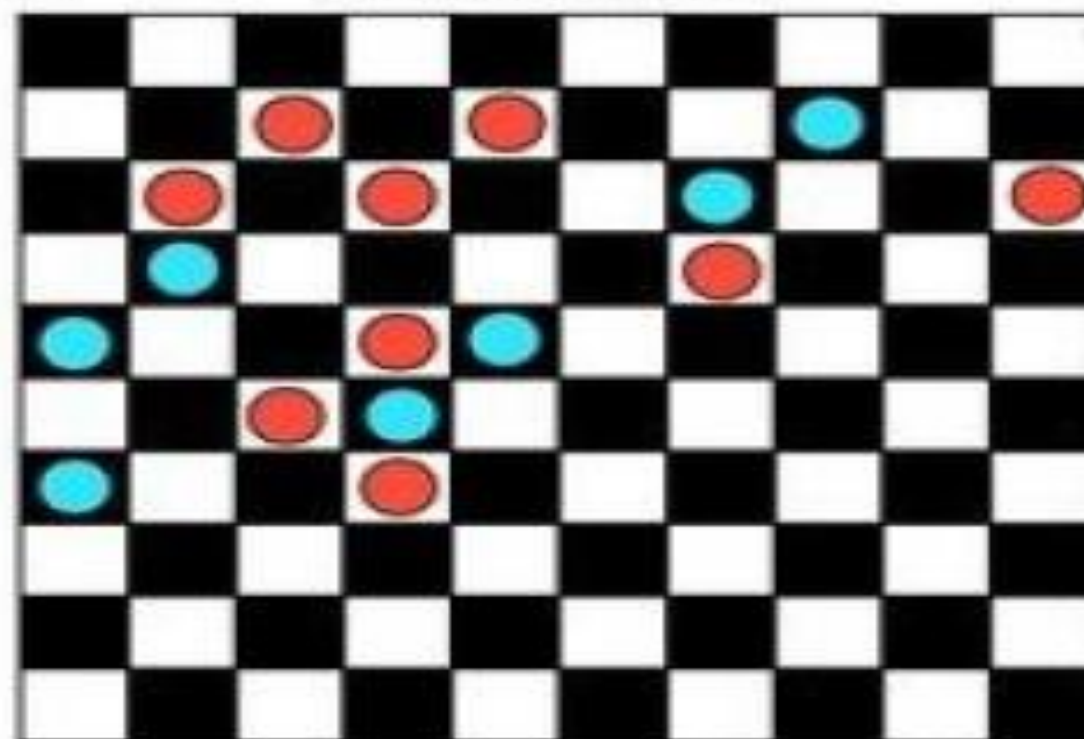
'Block'



Tabuleiro 1

'Checkerboard1'

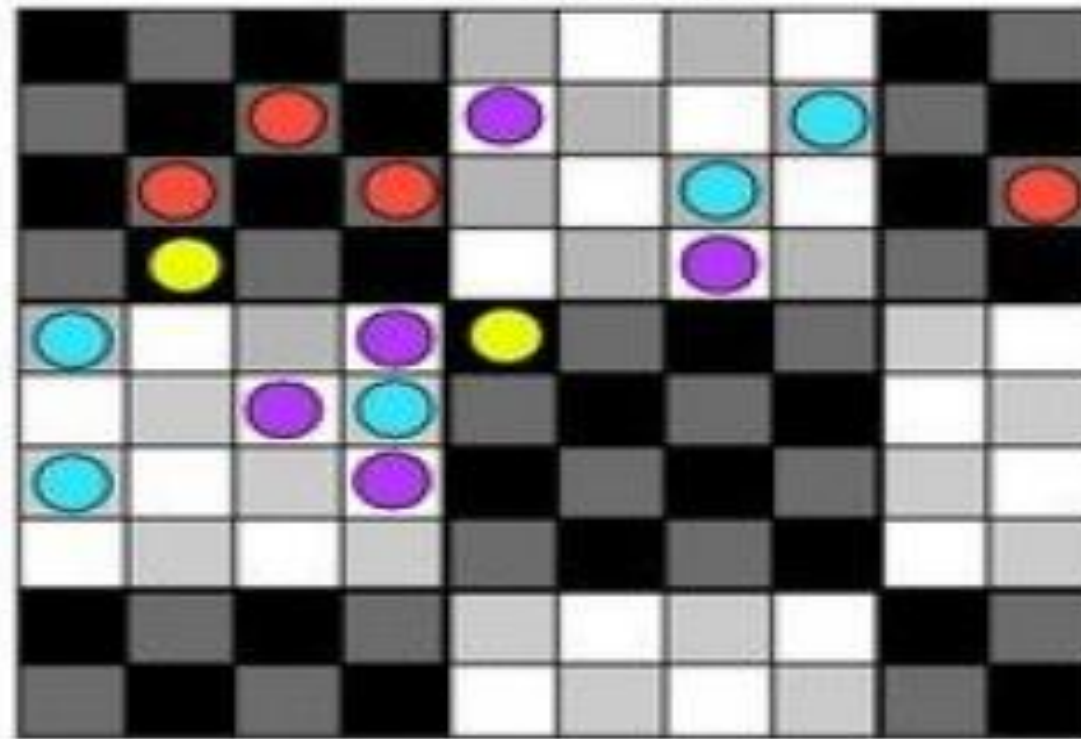
(c)



Tabuleiro 2

'Checkerboard2'

(d)



Muscarella, R. et al. (2014). ENM eval: An R package for conducting spatially independent evaluations and estimating optimal model complexity for Maxent ecological niche models. *Methods in ecology and evolution*, 5(11), 1198-1205.

[Intro](#)[Occ Data](#)[Env Data](#)[Process Occs](#)[Process Envs](#)[Env Space](#)[Partition Occs](#)

Component: Partition Occurrence Data ?

Modules Available:

- ☐ Non-spatial Partition
- ☒ Spatial Partition

Module: Spatial Partition ?

R packages: *ENMeval*

Options Available:

Checkerboard 2 (k = 4)

Aggregation Factor

2

☐ Batch

Partition

Species menu

Sus_scrofa

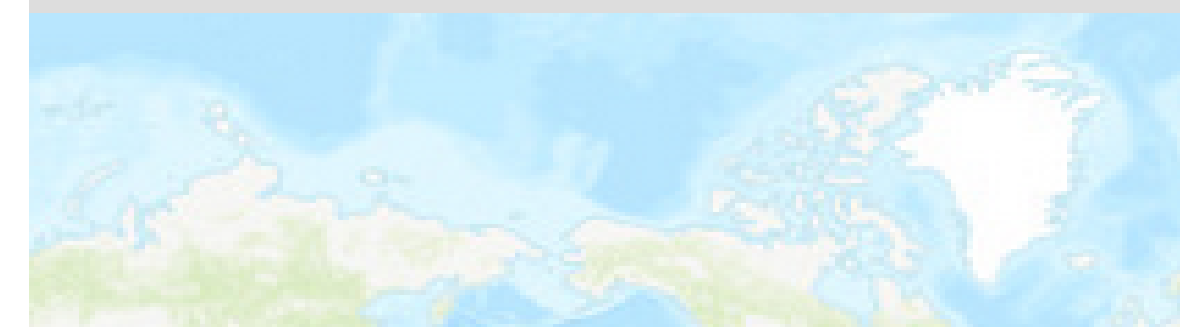
Map

Occurrences

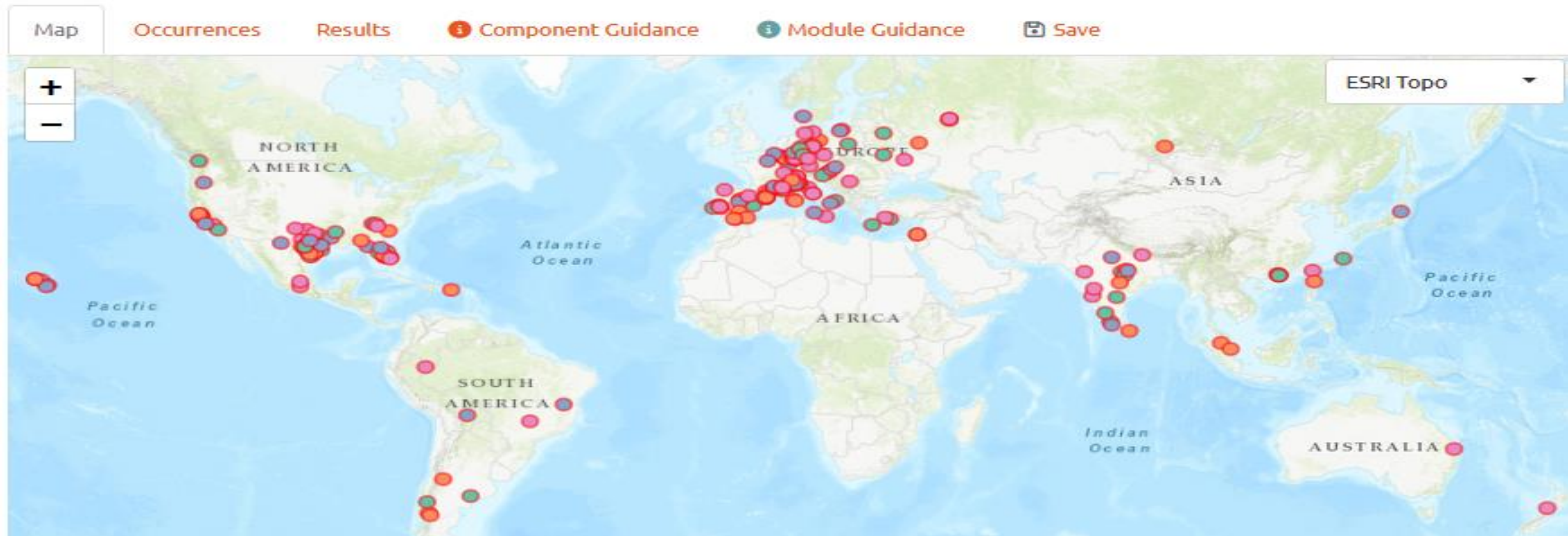
Results

+

-

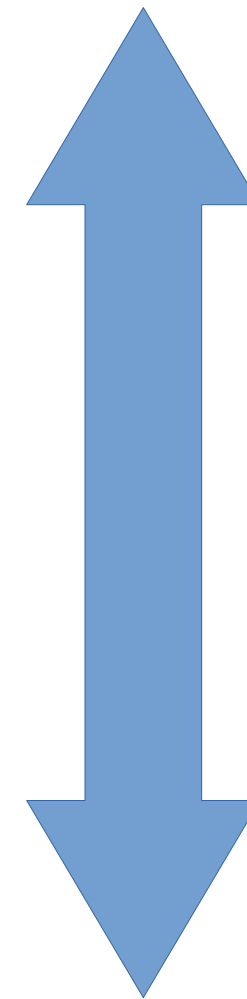


Cada um dos 4 grupos (cores) será usado para calibrar o modelo, e os 3 outros serão usados para validação



Modelos de processos pontuais

- Envelopes
- Regressão linear
- Regressão não-linear
- Aprendizado de máquinas



Mais simples

Pior ajuste

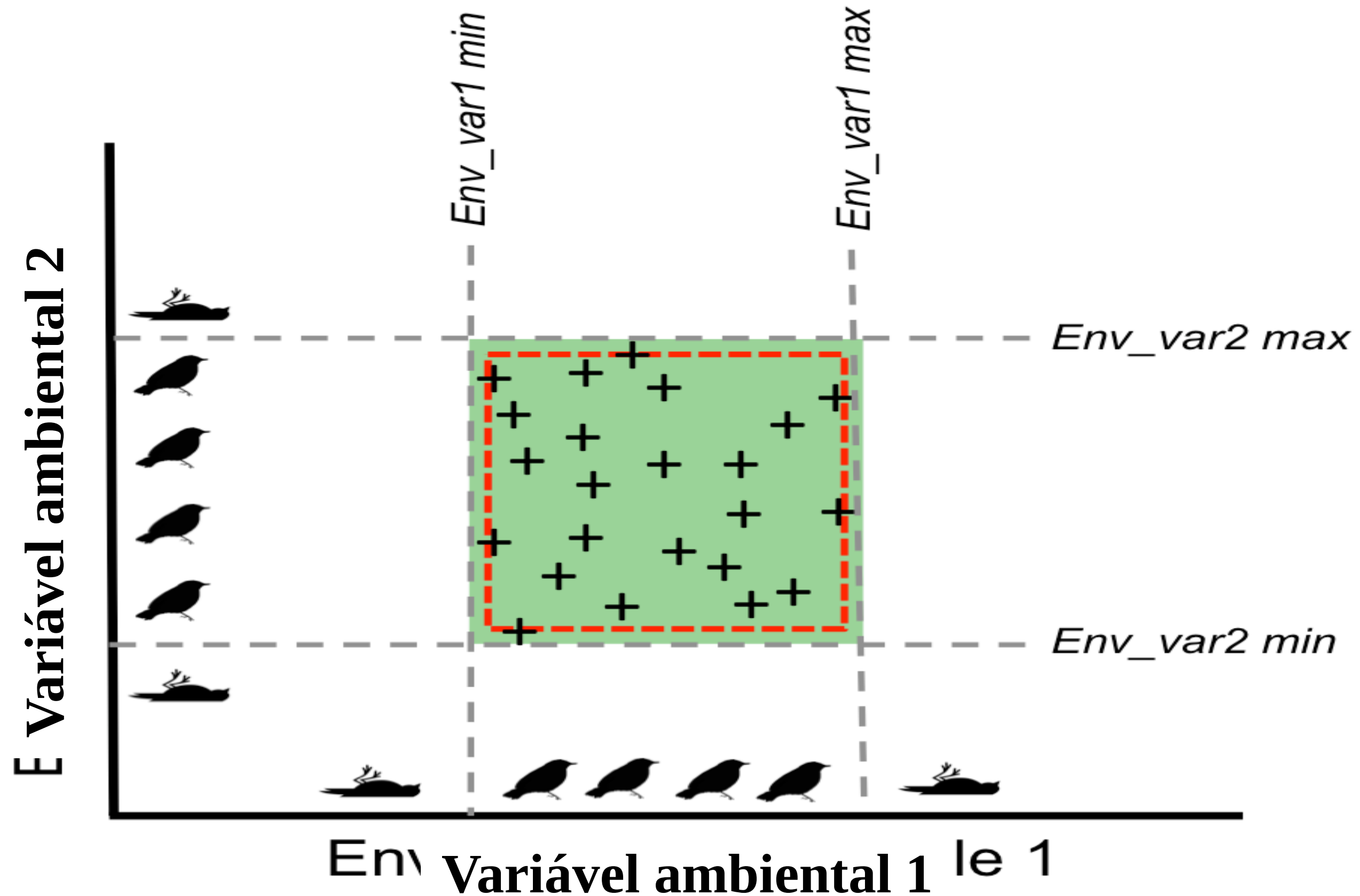
Extrapolação mais confiável

Mais complexos

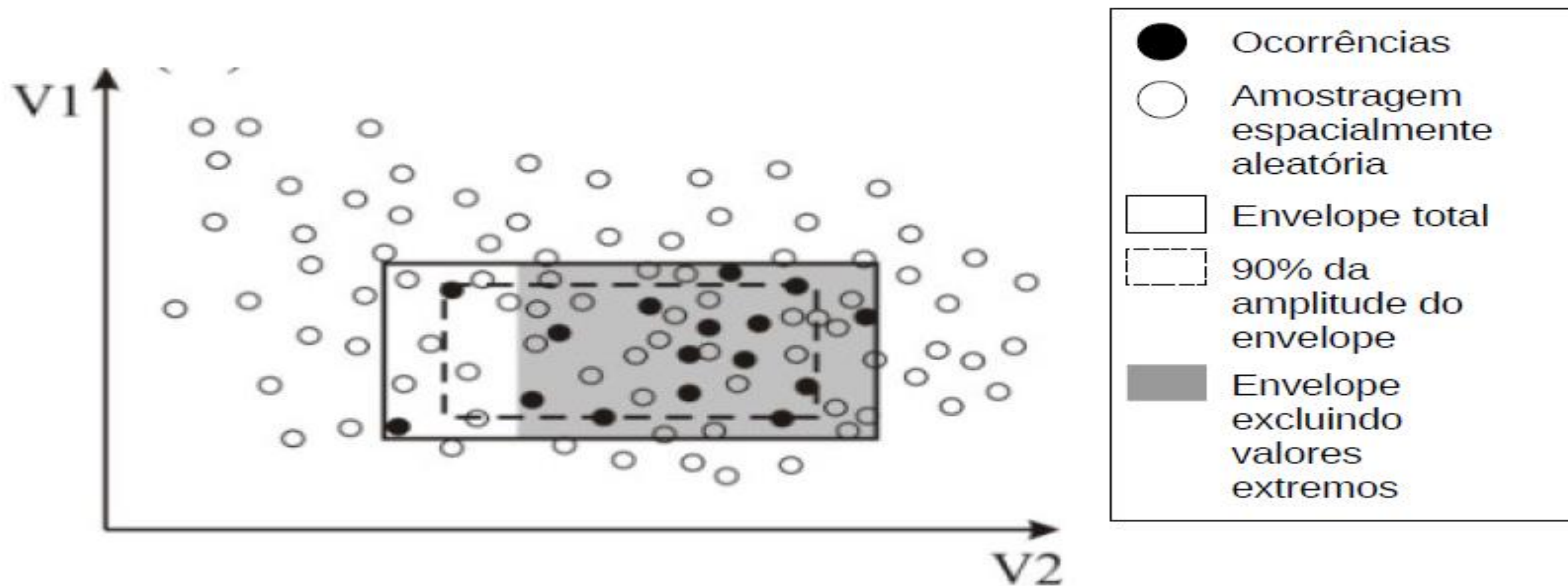
Melhor ajuste

Extrapolação menos confiável

Envelope



BIOCLIM (Método de Envelope)



Lima-Ribeiro, M. D. S., & Diniz-Filho, J. A. F. (2012). Modelando a distribuição geográfica das espécies no passado: uma abordagem promissora em paleoecologia. *Revista Brasileira de Paleontologia*, 15(3), 371-385.

- Aba “Model”
- Modelo: BIOCLIM (Envelope)



IntroOcc DataEnv DataProcess OccsProcess EnvsEnv SpacePartition OccsModel

Component: Build and Evaluate Niche Model

Modules Available:

☐ Maxent

☒ BIOCLIM

Module: BIOCLIM

R packages: *ENMeval, dismo*

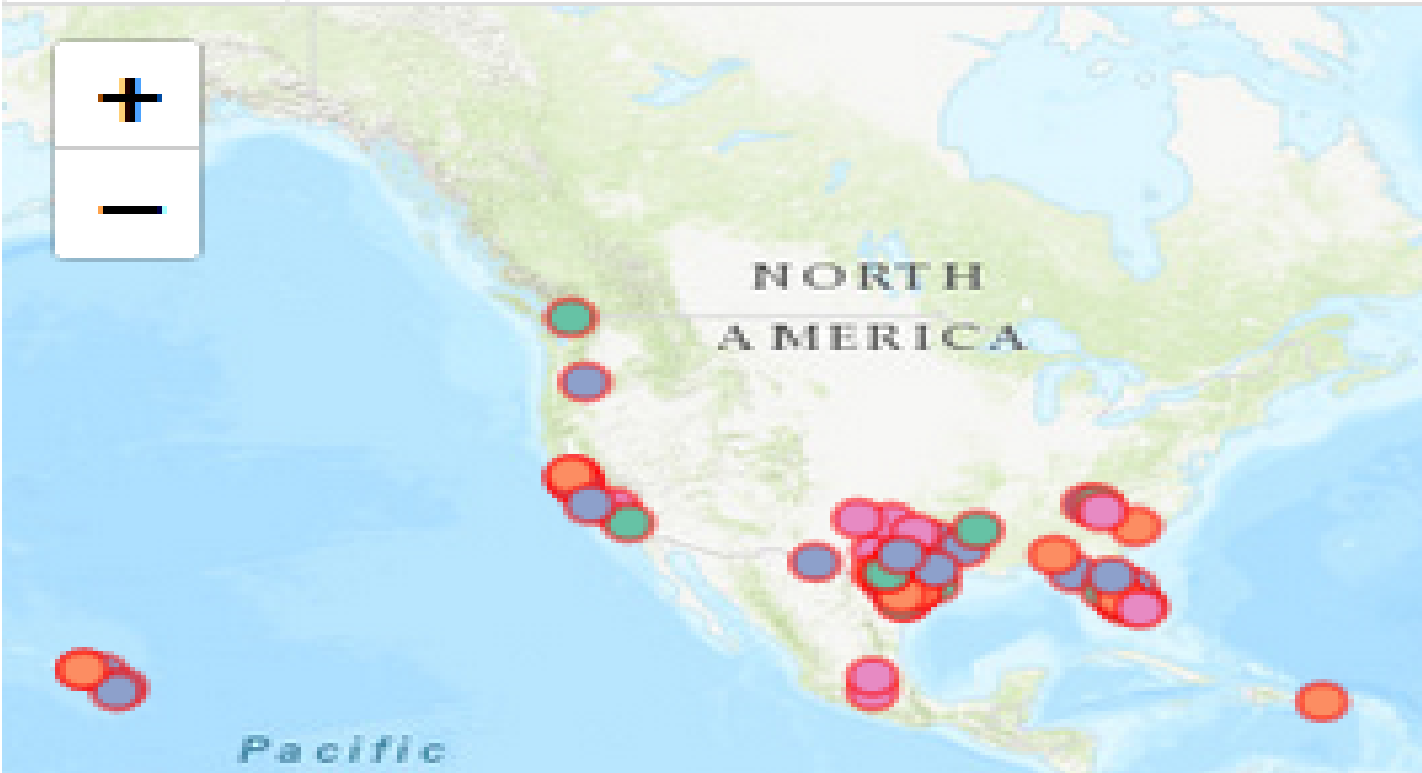
☐ Batch

Run

Species menu

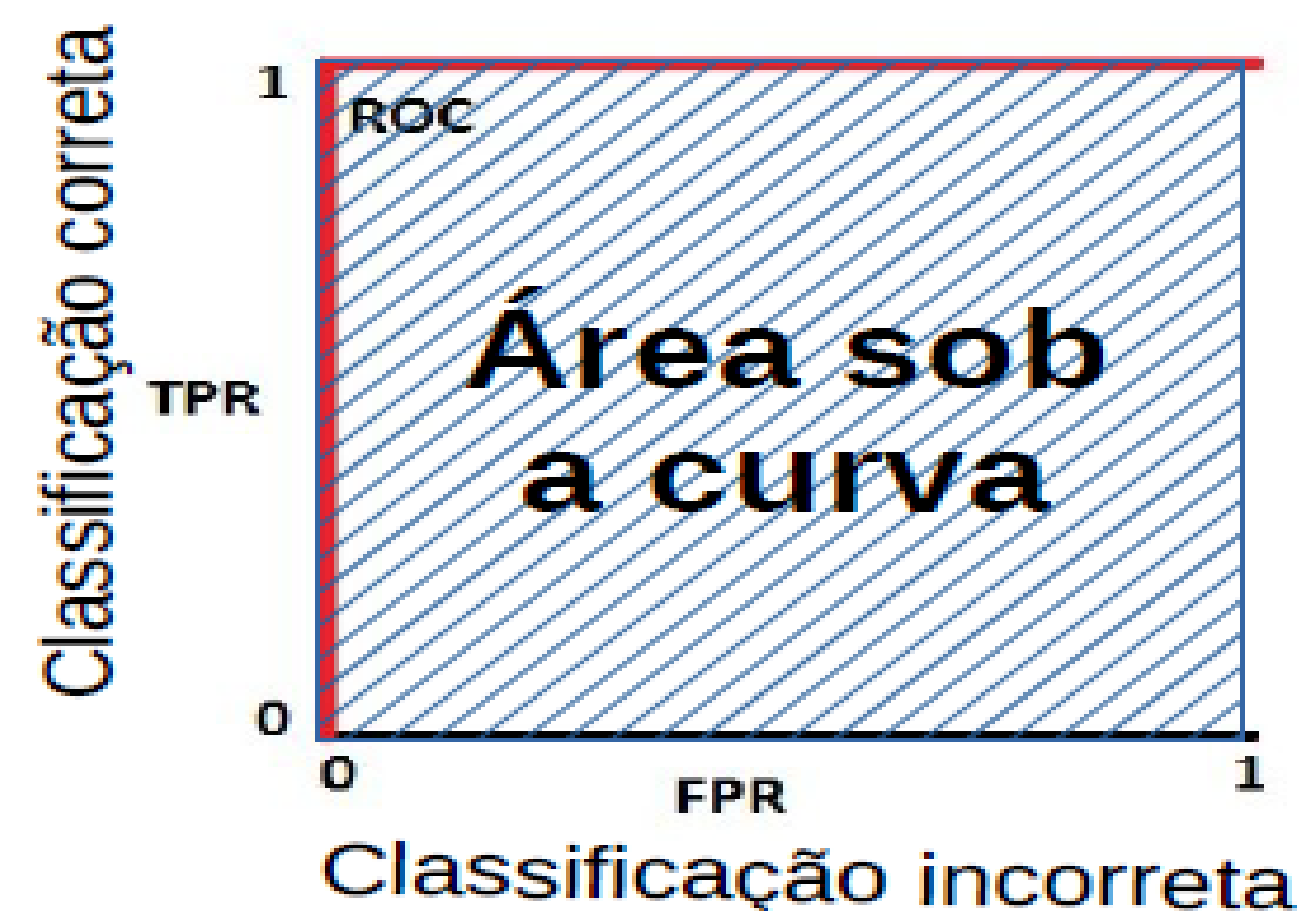
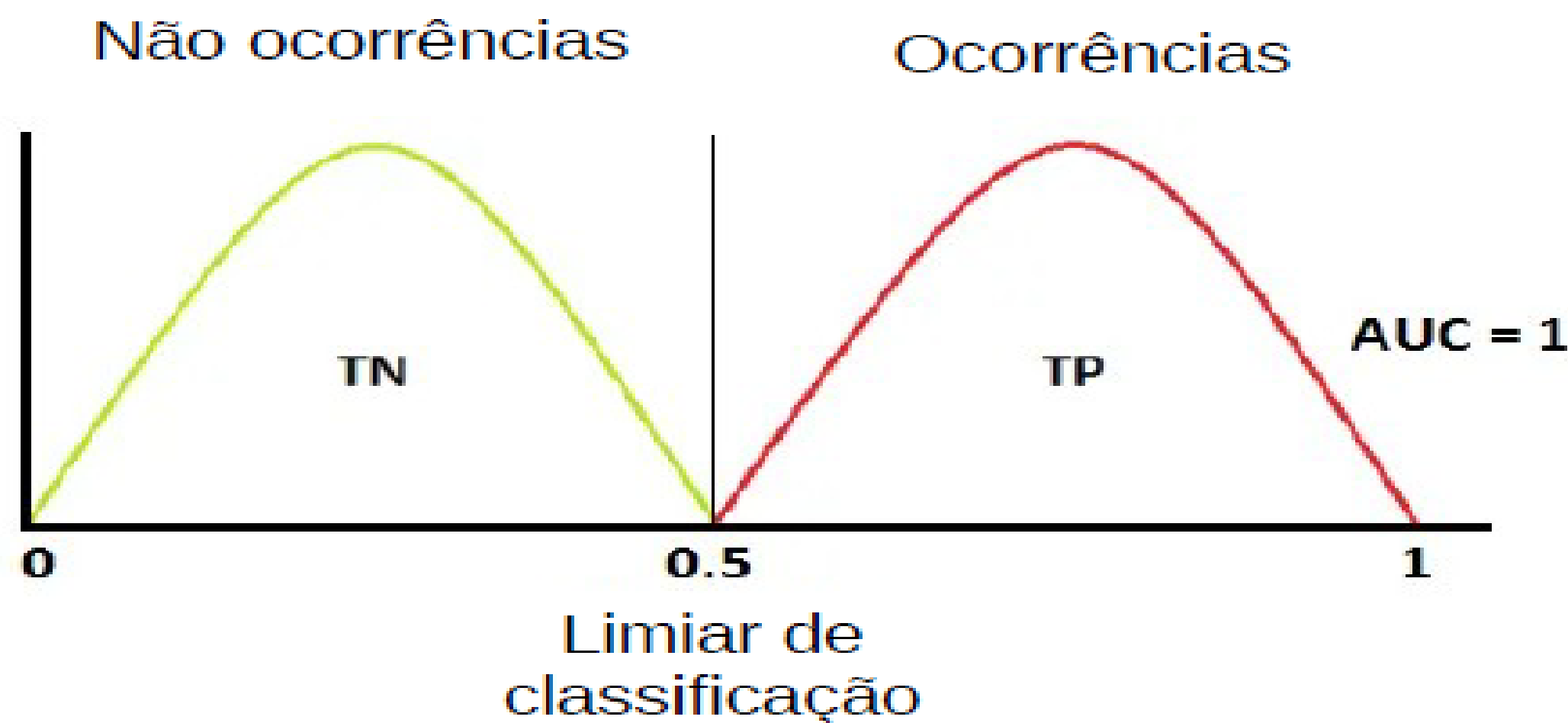
Sus_scrofa

MapOccurrencesResults



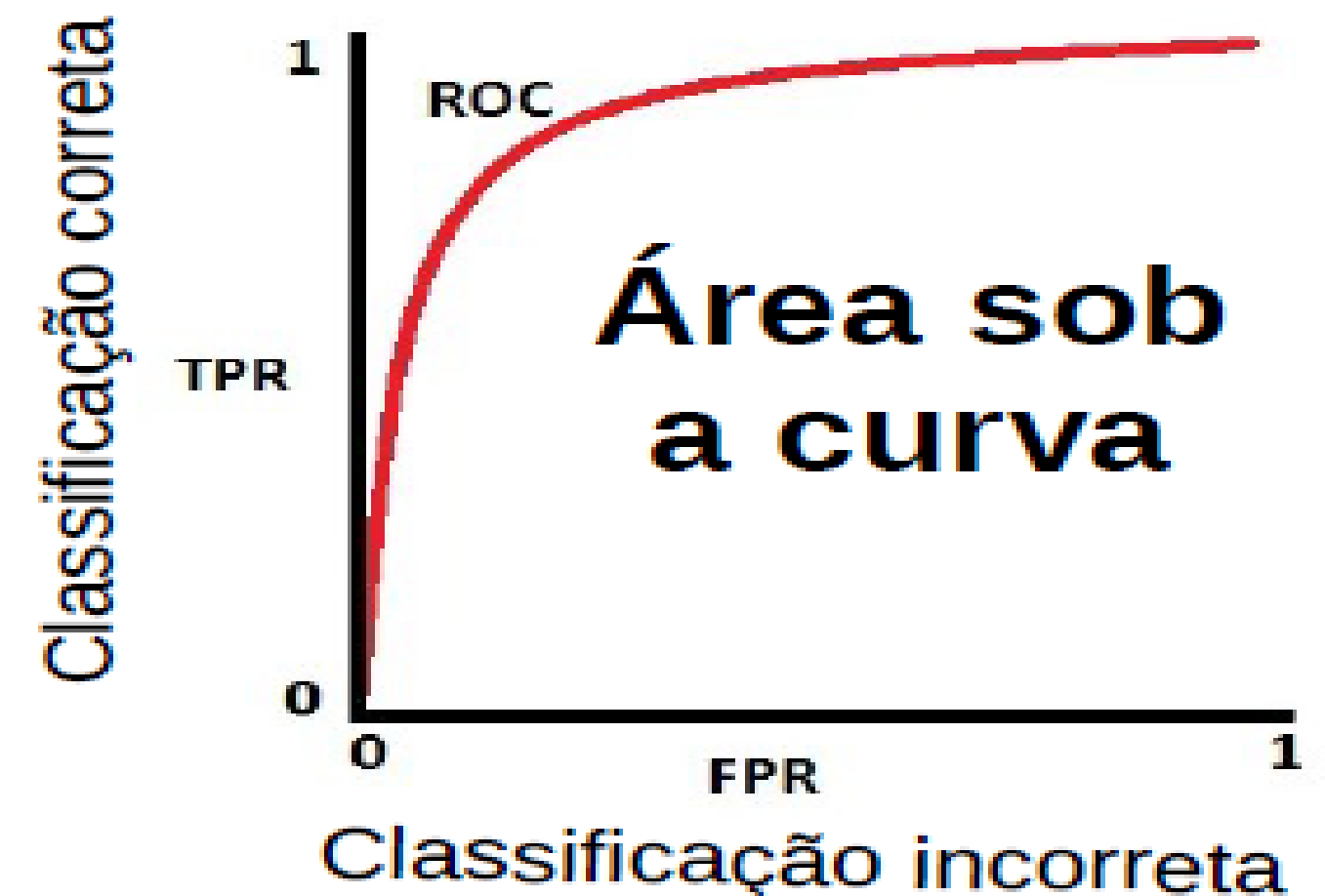
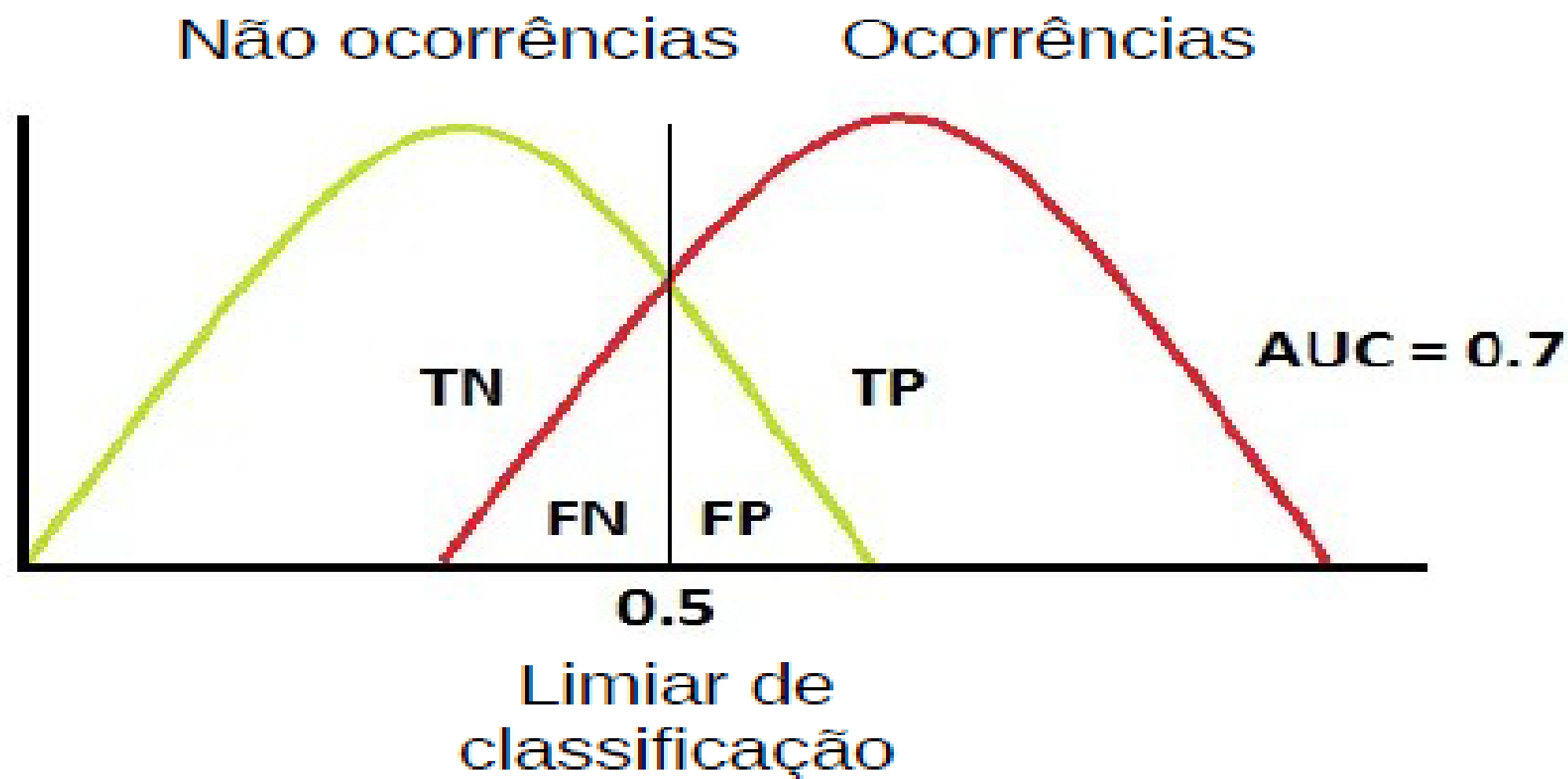
Area sob a curva (AUC – Area Under Curve)

Identificação perfeita de



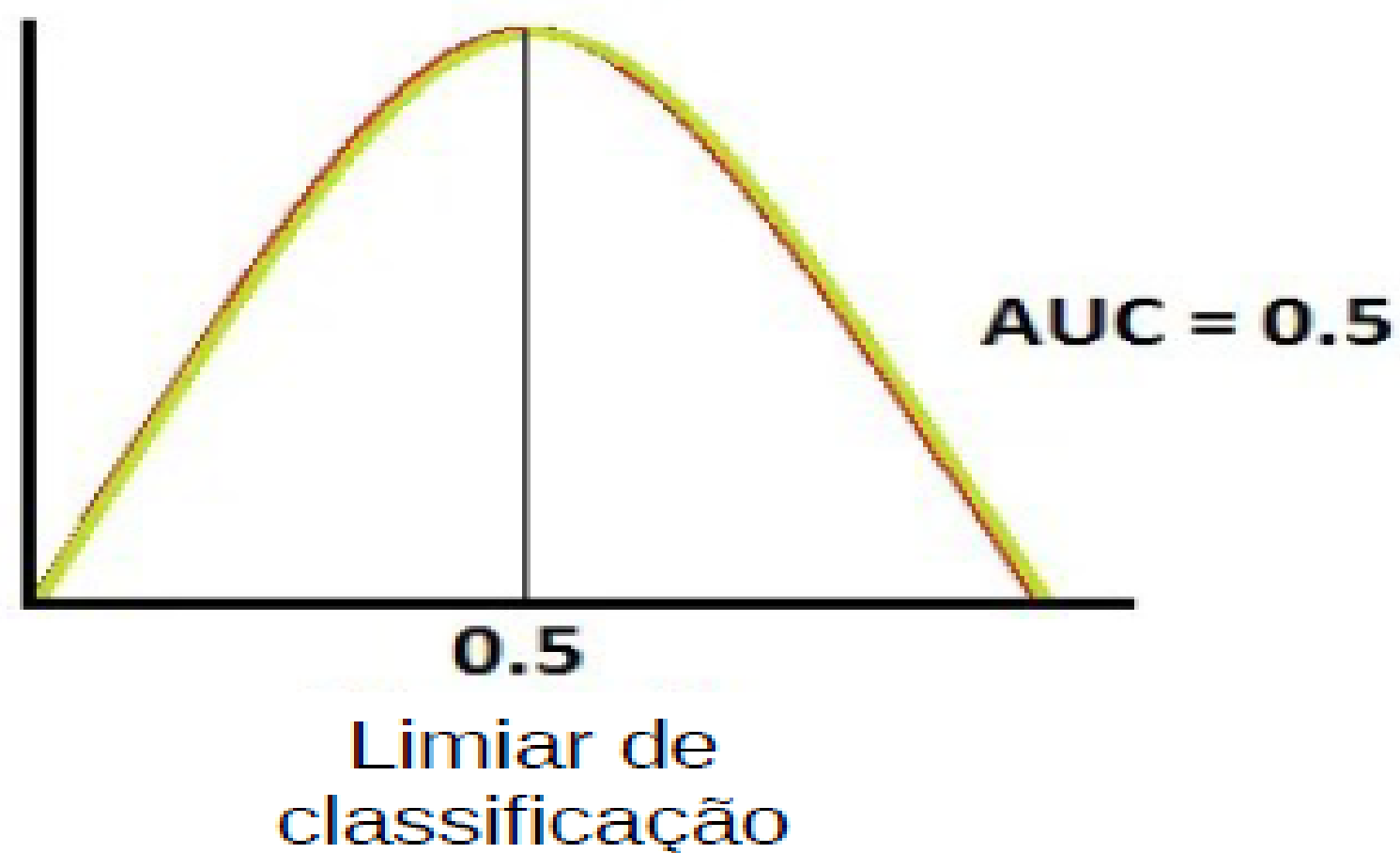
Area sob a curva (AUC – Area Under Curve)

Identificação parcial de



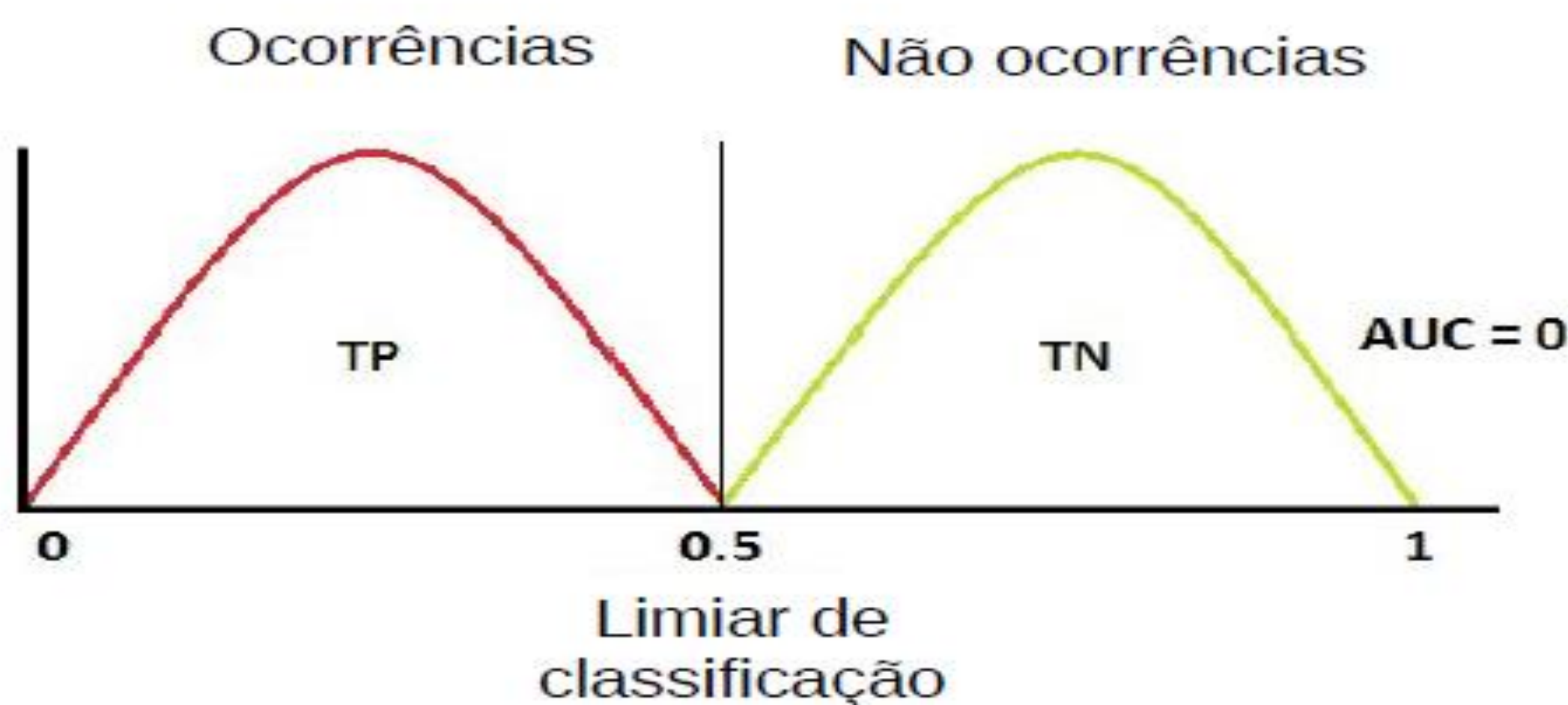
Area sob a curva (AUC – Area Under Curve)

Identificação aleatória



Area sob a curva (AUC – Area Under Curve)

Identificação inversa de



- Aba “Results”
- Qualidade da calibração: auc.train
- Qualidade da validação: auc.val.avg

Species menu

Sus_scrofa

Select model:

bioclim

Log window

370536 total po
> **Sus scrofa** | C
with aggregatio
> **Sus scrofa** | E
results.

Map

Occurrences

Results

Component Guidance

Modu

Evaluation statistics: full model and partition averages

	auc.train	cbi.train	auc.diff.avg	auc.diff.sd	auc.val.avg
1	0.878	0.746	0.036	0.034	0.836

- ABA “Visualize”
- Selezione: “Bioclim Envelope Plots”

IntroOcc DataEnv DataProcess OccsProcess EnvsEnv SpacePartition OccsModel**Visualize**

Component: Visualize Model Results ⓘ
Modules Available:

- ☐ Map Prediction
- ☐ Maxent Evaluation Plots
- ☐ Response Curves
- ☒ BIOCLIM Envelope Plots

Species menu

Select model:

☒ Map☒ Occurrences☐ Re

•Alterando os eixos, observam-se as combinações entre cada variável

•Verde = Observações

•Vermelho = amostragem aleatória

● BIOCLIM Envelope Plots

Module: BIOCLIM Envelope Plots ?

R packages: *dismo*

Pick a bioclimatic variable number for each axis

Axis 1

1

Axis 2

2

Set threshold

0.9

Module Developers: *Jamie M. Kass, Robert Muscarella, Bruno Vilela, Robert P. Anderson*

dismo references

Species Distribution Modeling

Package Developers: Robert J. Hijmans, Steven Phillips, John Leathwick and Jane Elith

[CRAN](#) | [documentation](#)

Map

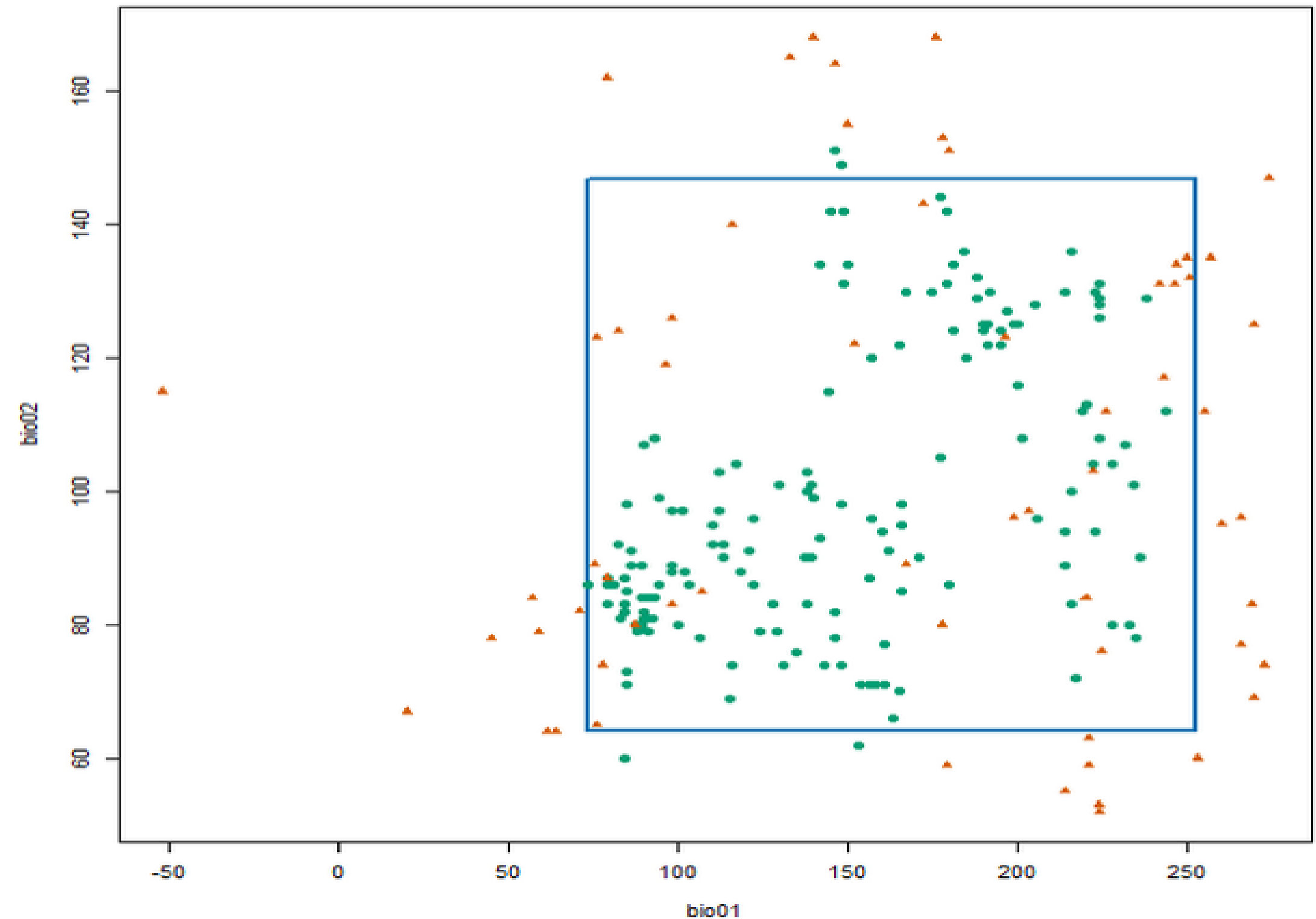
Occurrences

Results

i Component Guidance

i Module Guidance

 Save



- Selezione: “Map Prediction”
- Plot

Component: Visualize Model Results



Modules Available:

☒ Map Prediction

☐ Maxent Evaluation Plots

☐ Response Curves

☐ BIOCLIM Envelope Plots

Module: Map Prediction ?

R packages: *dismo*

Set threshold

No threshold



Plot

- Vermelho: maior probabilidade
- Azul: menor probabilidade

Species menu

Sus_scrofa

Select model:

bioclim

Log window

> **Sus scrofa** | Occurrences partitioned by checkerboard 2 method with aggregation factor 2.
> **Sus scrofa** | BIOCLIM ran successfully and output evaluation results.
> **Sus scrofa** | BIOCLIM model prediction plotted.

Map

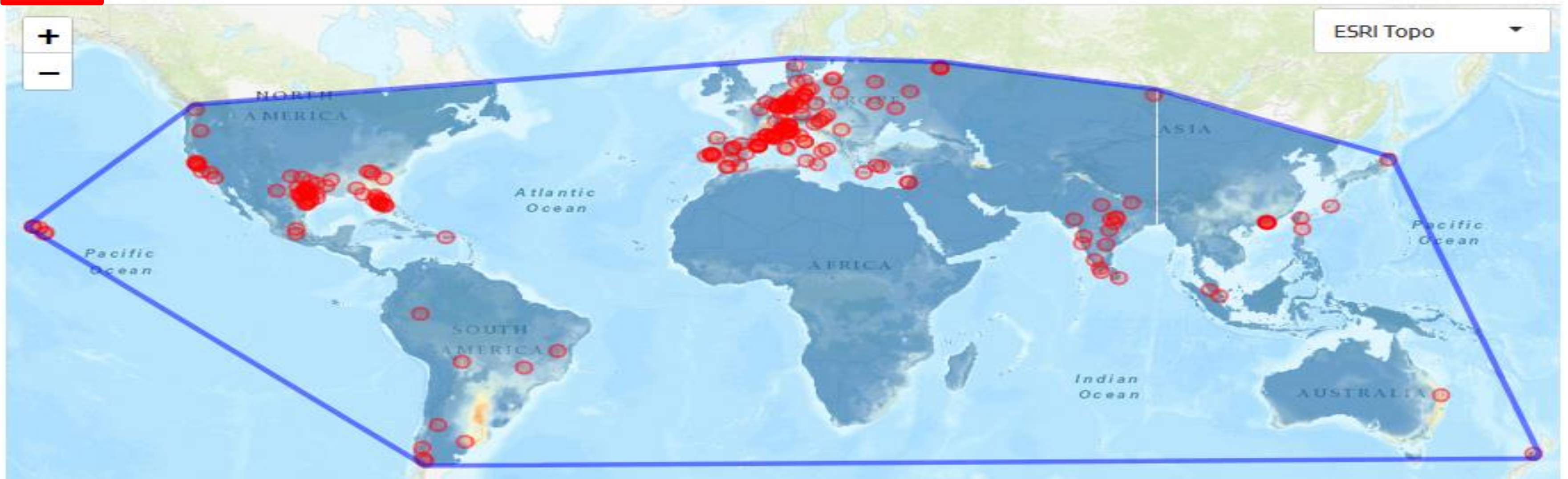
Occurrences

Results

Component Guidance

Module Guidance

Save



- Aba: Transfer
- “Transfer to new Time
- Região de estudo: “Same extent”
- Create

IntroOcc DataEnv DataProcess OccsProcess EnvsEnv SpacePartition OccsModelVisualizeTransfer

Component: Model Transfer ?

Modules Available:

- ☐ Transfer to New Extent
- ☒ Transfer to New Time
- ☐ Transfer to User Environments
- ☐ Calculate Environmental Similarity

Module: Transfer to New Time ?

R packages: *dismo*

Step 1: Choose Study Region

Select method

Same extent

You will use the same extent

Create

Species menu

Sus_scrofa

Select model:

bioclim

MapOccurrencesResultsComponent Guide



- Base das variáveis de mudança climática:
- WordClim
- Período: 2070
- Modelo climático: ACCESS1-0
- Cenário RCP: 4.5 (tendencial)

Step 2: Transfer

Transfer model to extent (red)

Select source of variables

☒ WorldClim ☐ ecoClimate

Select time period

2070

Select global circulation model

ACCESS1-0

Select RCP

4.5

Set threshold

No threshold

Transfer

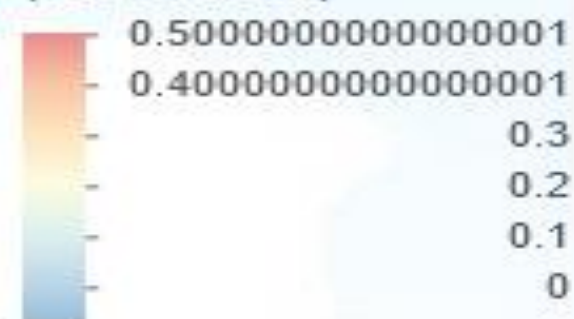
Map Occurrences Results **Component Guidance** Module Guidance Save



ESRI Topo



Predicted Suitability
(Transferred)



Component: Model Transfer ?

Modules Available:

- ☐ Transfer to New Extent
- ☐ Transfer to New Time
- ☐ Transfer to User Environments
- ☒ Calculate Environmental Similarity

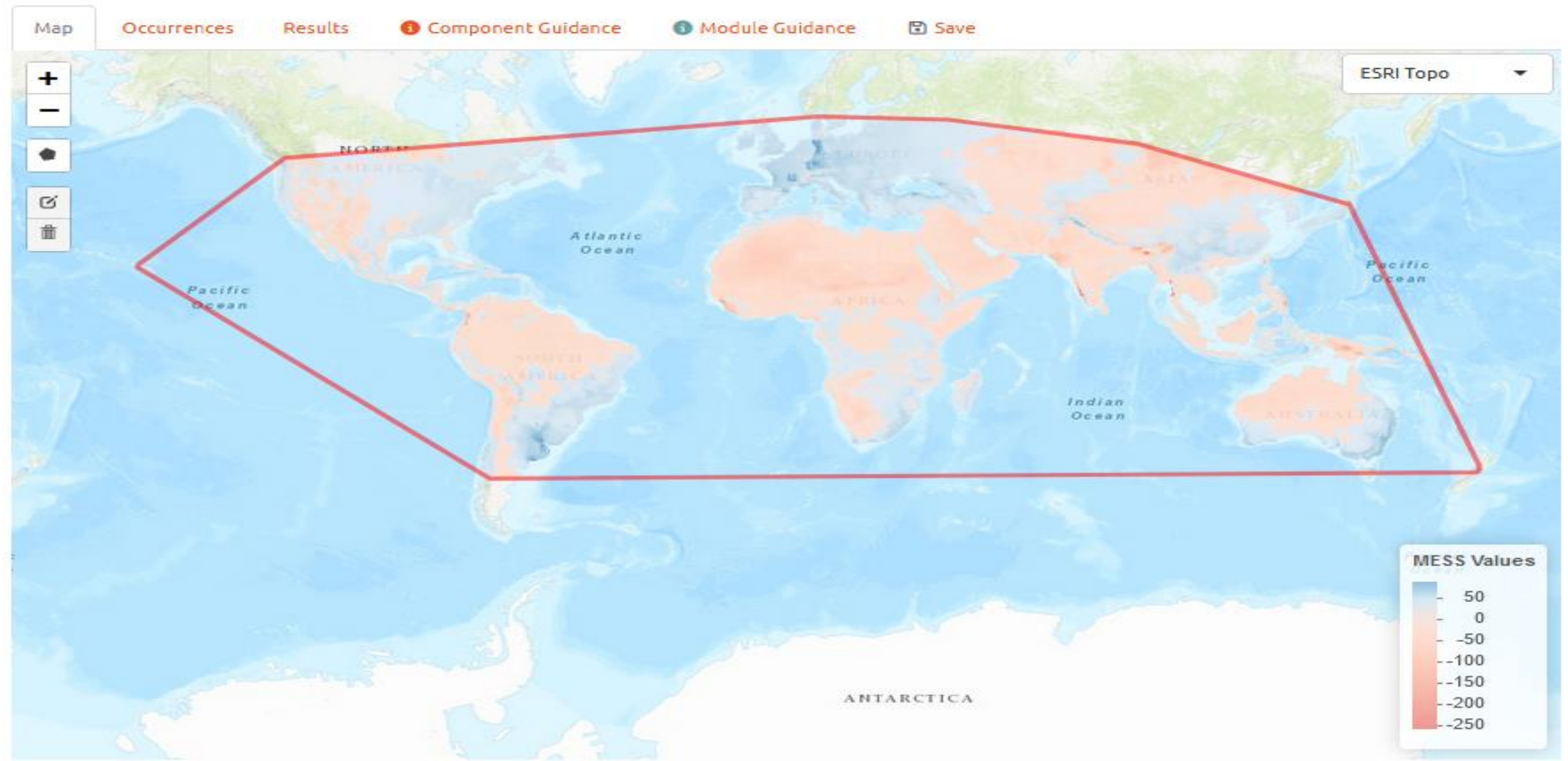
Module: Calculate Environmental Similarity ?

R packages: *dismo*

Calculate MESS for current extent

Calculate MESS

- Azul: maior similaridade
- Vermelho: maior mudança



Note: To save your session code or metadata, use the Reproduce component

Save Session

By saving your session into an RDS file, you can resume working on it at a later time or you can share the file with a collaborator.

⚠ The current session data is large, which means the downloaded file may be large and the download might take a long time.

 Save Session

Download Data

Download data/results from analyses from currently selected module

Download shapefile of extent of transfer

 ZIP file

Download environmental variables of transfer (Select download file type)

GeoTIFF ▼

 ZIP file

Download transfer (Select download file type**)

GeoTIFF ▼

 Transfer file

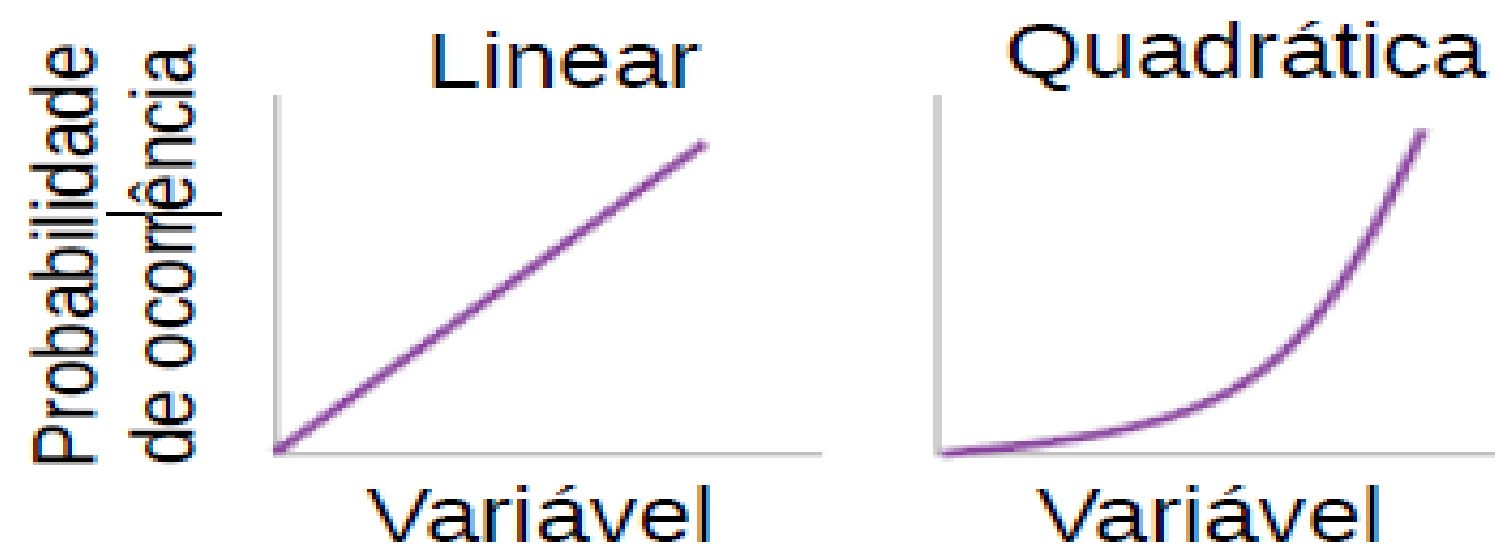
Download MESS (Select download file type**)

GeoTIFF ▼

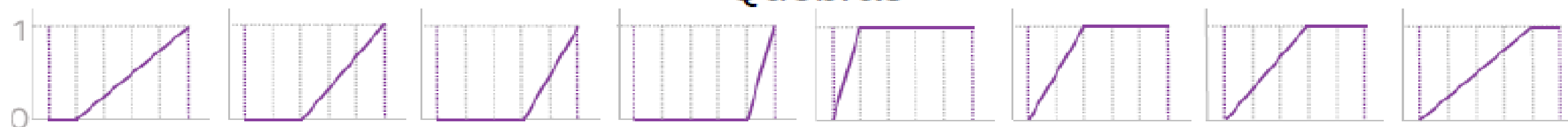
 MESS file

Maxent

- Testa várias combinações de influências de variáveis.
- Compara: Previsão X Penalidade de complexidade
- Relações: lineares, quadráticas, quebras, produtos



Quebras



Produto: Probabilidade de ocorrência = Variável A x Variável B

[Intro](#)[Occ Data](#)[Env Data](#)[Process Occs](#)[Process Envs](#)[Env Space](#)[Partition Occs](#)[Model](#)

Component: Build and Evaluate Niche Model[?]

Modules Available:

☒ Maxent☐ BIOCLIM

Module: Maxent[?]

R packages: *ENMeval*, *dismo*, *maxnet*

(**NOTE** : see module guidance for troubleshooting tips if you are experiencing problems.)

Select algorithm

☒ maxnet ☐ maxent.jar

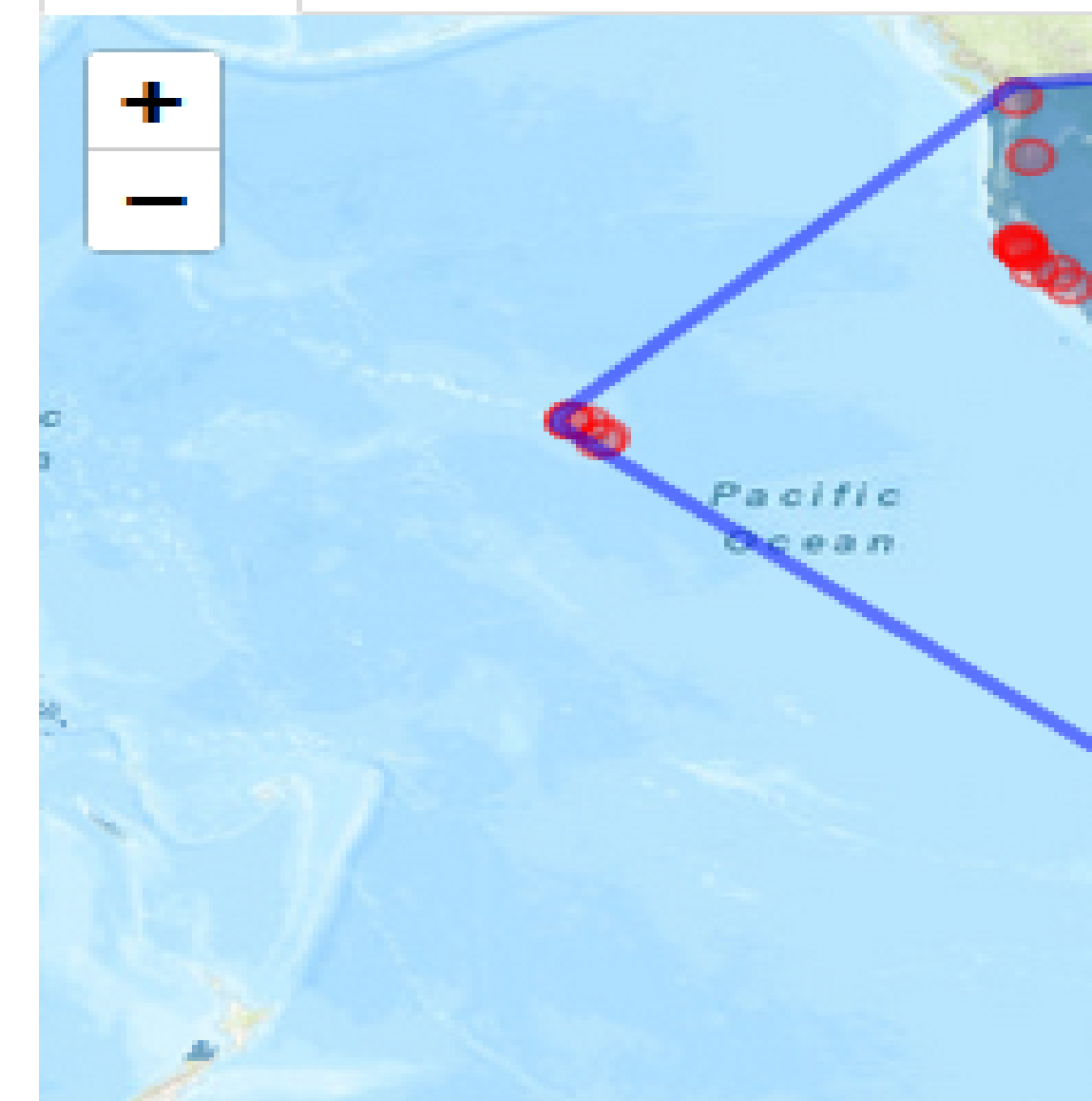
Select feature classes *(flexibility of modeled response)*

key: L inear, Q uadratic, H inge, P roduct

☐ L ☒ LQ ☐ H ☐ LQH ☐ LQHP

Species menu

Select model:

[Map](#)[Occurrences](#)[Results](#)

- Está usando variáveis categóricas?
 - Não
- Clamping (não extrapolar para valores de variáveis além dos registrados para as espécies)
 - Sim
- Processamento paralelo:
 - Sim (deixe o número de processadores [cores] como automaticamente – varia para cada computador)

Select regularization multipliers (*penalty against complexity*)

0.5 1 2 10

0.5 1.5 2.5 3.5 4.5 5.5 6.5 7.5 8.5 9.5 10

Multiplier step value

1

Are you using a categorical variable?

NO

Clamping?

TRUE

Parallel?

TRUE

Specify the number of cores (max. 4)

3

☐ Batch

Run

Atividade

- Compare os modelos Maxent e Bioclim quanto a:
 - Validação da qualidade do modelo.
 - Mapa de predição
 - Projeção para mudanças climáticas
 - Mapa de similaridade ambiental da projeção

- Aba “Results”
- Qualidade da calibração: auc.train
- Qualidade da validação: auc.val.avg

Species menu

Sus_scrofa

Select model:

fc.LQ_rm.1

Log window

GCM ACCESS1-0 under RCP 4.5.
> **Sus scrofa** | Generated MESS map.
> **Sus scrofa** | Maxent ran successfully and output results for 2 models (Regularization multiplier v
Feature classes: [LQ]), using maxnet with clamp

Map Occurrences **Results** ⓘ Component Guidance ⓘ Module Guidance 📁 Save

Evaluation Lambdas

Evaluation statistics: full model and partition averages

	fc	rm	tune.args	auc.train	cbi.train	auc.diff.avg	auc.diff.sd	auc.val.avg
1	LQ	1	fc.LQ_rm.1	0.9	0.925	0.033	0.012	0.876
2	LQ	2	fc.LQ_rm.2	0.893	0.941	0.033	0.019	0.871

- Aba “Lambdas”
- Coeficientes (influência) das variáveis

Map

Occurrences

Results

 Component Guidance

 Module Guidance

Evaluation

Lambdas

Maxent Lambdas File

bio05	bio08	bio09	bio13	bio17
7.058144e-04	3.952946e-03	-1.304549e-04	3.037027e-03	5.250937e-04
bio18	bio19	I(bio02^2)	I(bio03^2)	I(bio04^2)
-5.391945e-04	2.400944e-03	-8.206660e-06	-2.882603e-04	-1.814565e-08
I(bio07^2)	I(bio08^2)	I(bio11^2)	I(bio12^2)	I(bio15^2)
-5.036809e-08	-3.286015e-06	-2.623125e-05	-1.217354e-07	-3.695331e-05
I(bio17^2)	I(bio19^2)			
2.840267e-06	-2.215379e-06			

Variáveis bioclimáticas

BIO1 = Temperatura média anual

BIO2 = Amplitude térmica diurna (Média mensal (max temp - min temp))

BIO3 = Isotermalidade (BIO2/BIO7) ($\times 100$)

BIO4 = Sazonalidade da temperatura (desvio padrão $\times 100$)

BIO5 = Temperatura máxima do mês mais quente

BIO6 = Temperatura mínima do mês mais frio

BIO7 = Amplitude térmica anual (BIO5-BIO6)

BIO8 = Temperatura média do quadrimestre mais úmido

BIO9 = Temperatura média do quadrimestre mais seco

BIO10 = Temperatura média do quadrimestre mais quente

BIO11 = Temperatura média do quadrimestre mais frio

BIO12 = Precipitação anual

BIO13 = Precipitação do mês mais úmido

BIO14 = Precipitação do mês mais seco

BIO15 = Sazonalidade da precipitação (coeficiente de variação)

BIO16 = Precipitação do quadrimestre mais úmido

BIO17 = Precipitação do quadrimestre mais seco

BIO18 = Precipitação do quadrimestre mais quente

BIO19 = Precipitação do quadrimestre mais frio

Booth, T. H., Nix, H. A., Busby, J. R., & Hutchinson, M. F. (2014). BIOCLIM: the first species distribution modelling package, its early applications and relevance to most current MAXENT studies. *Diversity and Distributions*, 20(1), 1-9.

- Aba “Visualize”
- Response curves
- Variável: bio05 (Temperatura máxima do mês mais quente)



Intro

Occ Data

Env Data

Process Occs

Process Envs

Env Space

Pa

Component: Visualize Model Results ?

Modules Available:

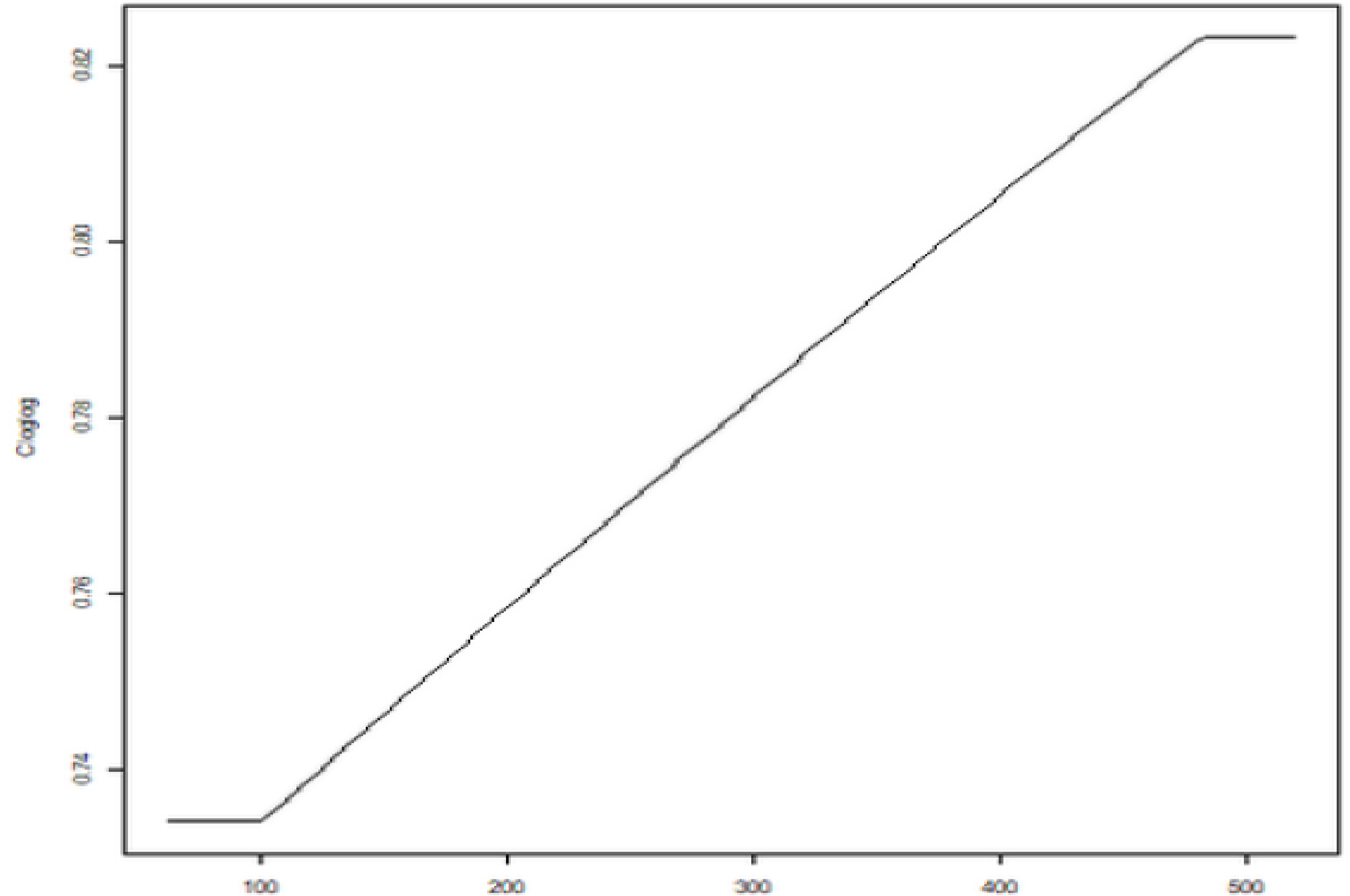
☐ Map Prediction

☐ Maxent Evaluation Plots

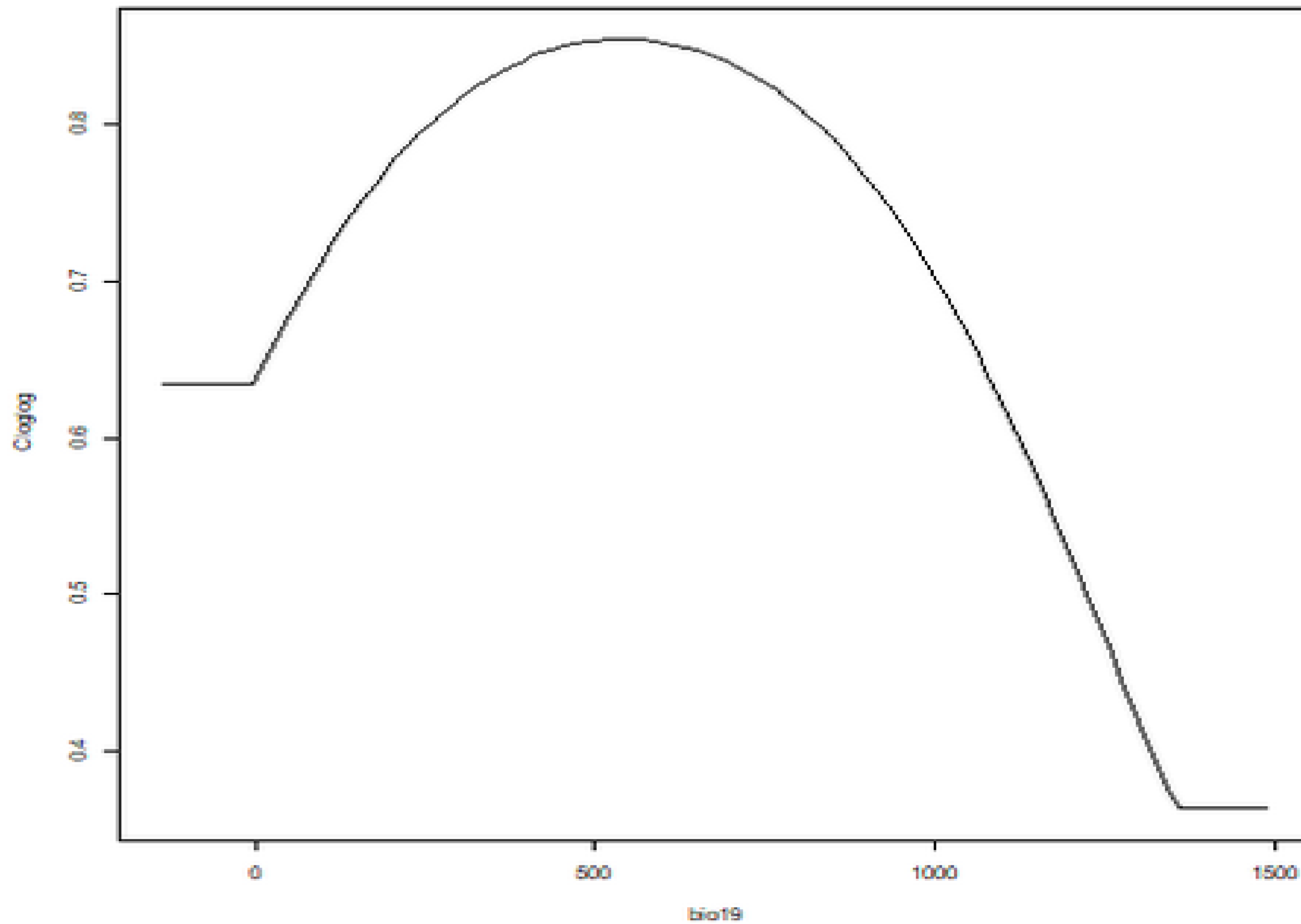
☒ Response Curves

☐ BIOCLIM Envelope Plots

- Abo
“Results”

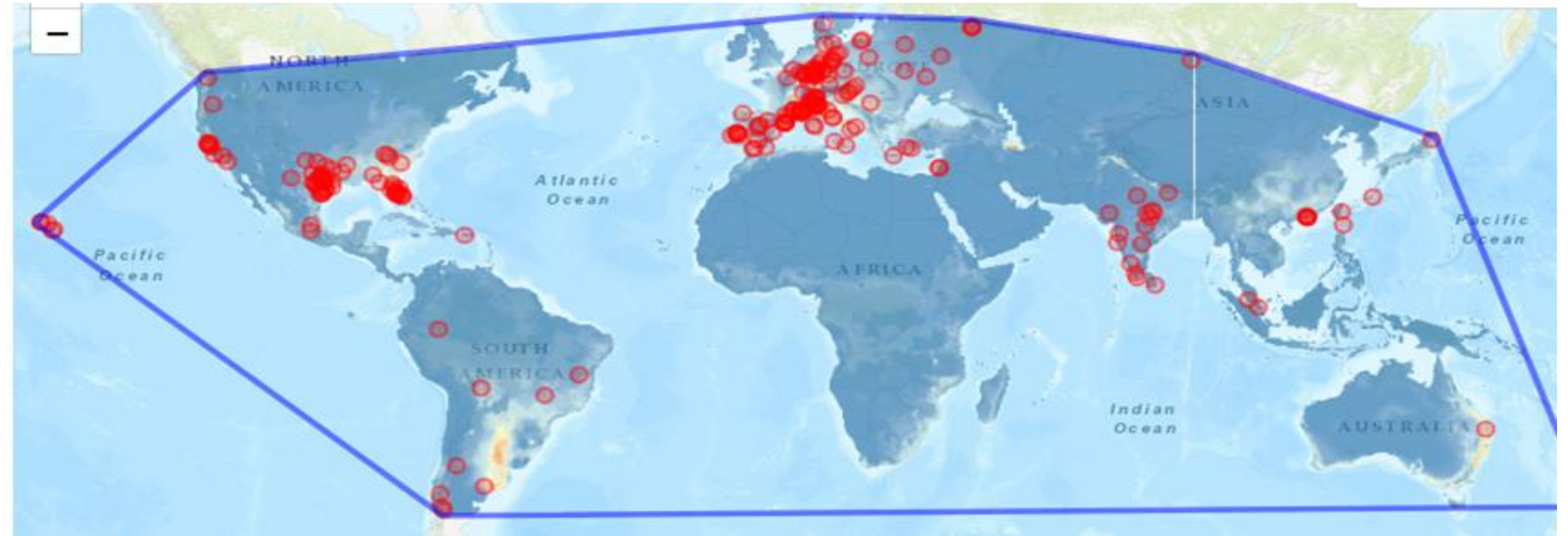


- Altere para “bio19” (precipitação no quadrimestre mais frio)



- Visualize o mapa de predição do Maxent
 - O padrão espacial está diferente do mapa do BioClim?

BioClim

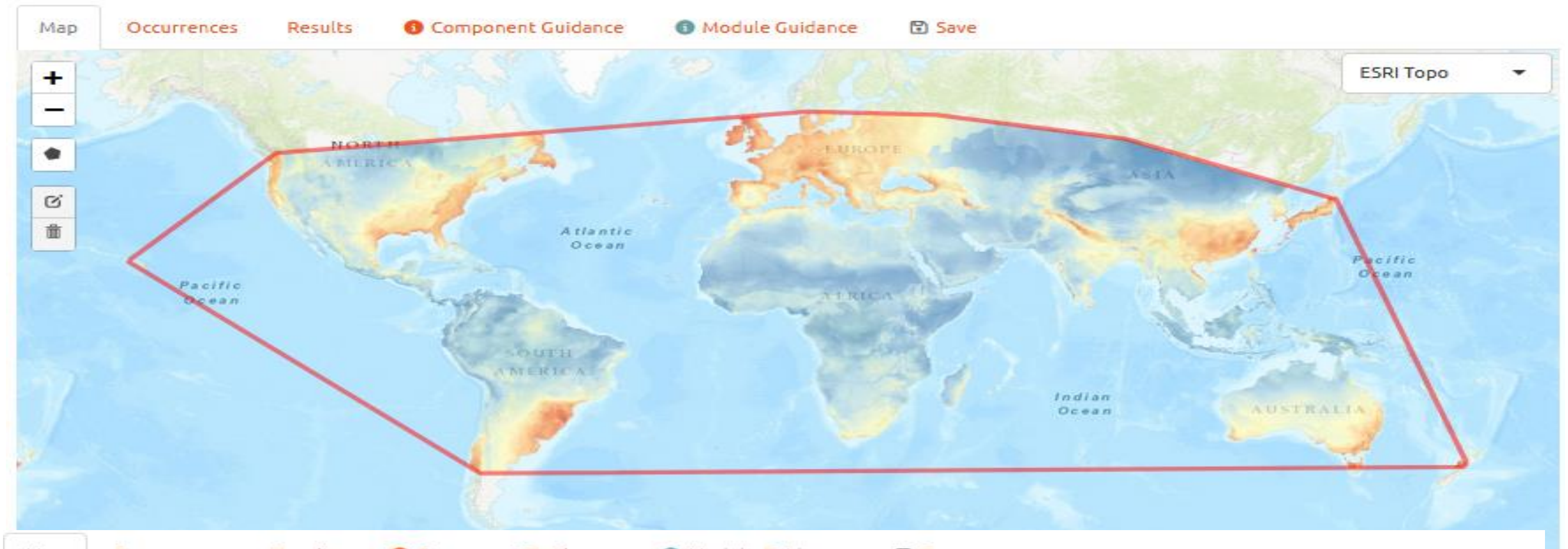


Maxent

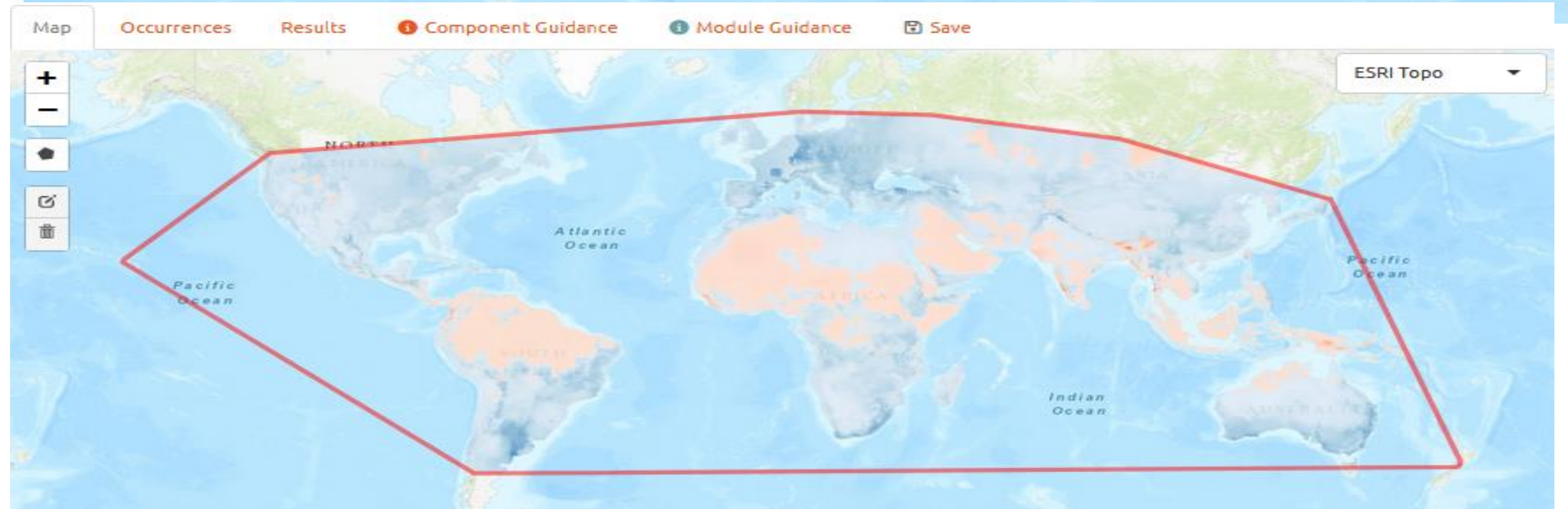


- Faça a predição do Maxent para o futuro
- Visualize o mapa de similaridade ambiental da predição

Predição



Similaridade
ambiental



- ABA “Reproduce”
- Escolha “Session code”
- Download

IntroOcc DataEnv DataProcess OccsProcess EnvsEnv SpacePartition OccsModelVisualizeTransferReproduce

Component: Reproduce

Modules Available:

- ☒ Session Code
- ☐ Metadata
- ☐ Reference Packages

Module: Download Session Code

R packages: *rmarkdown*, *knitr*

Select download file type

Rmd

 Download Session Code

Module: Session Code

BACKGROUND

Over the decade of the 2010s, scientific practice increasingly the area of modeling species niches/distributions has advanced community-driven standards (see Fitzpatrick et al. 2021 for an et al. 2019), standardized metadata frameworks (RMMS, Metadata reporting (ODMAP, Zurell et al. 2020). These tools facilitate the model, indicating whether it meets minimal standards for application leveraging *EMLeval 2.0* and *rangeModelMetadata*, Wallace now uses also form the basis of ODMAP reporting) and allows the user Wallace promotes documentation and downstream assessment information that includes sources of input data, methodological Module: Download Session Code) is a file that can be re-run in and dependent packages). Many intermediate and advanced i Additionally, Wallace now provides citations of the particular Reference Packages).

Via the Session Code module, the user can download files that executable code that can reproduce them). This functionality

```
1 Wallace Session 2024-03-10
2 =====
3
4 Please find below the R code history from your *Wallace* v2.1.2 session.
5
6 You can reproduce your session results by running this R Markdown file
7 in RStudio.
8
9 Each code block is called a "chunk", and you can run them either
10 one-by-one or all at once by choosing an option in the "Run" menu at the
11 top-right corner of the "Source" pane in RStudio.
12
13 For more detailed information see http://rmarkdown.rstudio.com).
14
15 ### Package installation
16
17 Wallace uses the following R packages that must be installed and loaded
18 before starting.
19
20 ```{r}
21 library(spocc)
22 library(spThin)
23 library(dismo)
24 library(sf)
25 library(ENMeval)
26 library(wallace)
27 ```
28
29 The *Wallace* session code .Rmd file is composed of a chain of module
30 functions that are internal to *Wallace*. Each of these functions
31 corresponds to a single module that the user ran during the session. To
32 see the internal code for these module functions, click on the links in
33 the .Rmd file. Users are encouraged to write custom code in the .Rmd
34 directly to modify their analysis, and even modify the module function
35 code to further customize. To see the source code for any module
36 function, just type its name into the R console and press Return.
```