Introdução à Modelagem de Nicho Ecológico

Maurício Vancine

16/07/2020

Webinar

Tópicos

1. Apresentações
2. Introdução aos Modelos de Nicho Ecológico - *Ecological Niche Models* (ENMs)
3. Nicho Ecológico e Distribuição de Espécies
4. Construção dos ENMs passo a passo
5. Dados de entrada: ocorrências e variáveis ambientais
6. Ajuste dos modelos
7. Avaliação dos modelos
8. Predição dos modelos
9. Aplicações e mais informações
10. Prática no R

1. Apresentações

Maurício Vancine

Ecólogo (2015) | Mestre em Zoologia (2018) | Doutorando em Zoologia (2020-?)

Pesquisa

Ecologia Espacial (Ecologia da Paisagem)
Ecologia Quantitativa (SDM e JSDM)
Ecologia e Conservação de Anfíbios

unesp
UNIVERSIDADE ESTADUAL PAULISTA
"JÚLIO DE MESQUITA FILHO"

Prof. Milton Ribeiro

Prof. Célio Haddad

Maurício Vancine

Ecólogo (2015) | Mestre em Zoologia (2018) | Doutorando em Zoologia (2020-?)

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UNIVERSIDADE ESTADUAL PAULISTA
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Pesquisa
Ecologia Espacial (Ecologia da Paisagem)
Ecologia Quantitativa (SDM e JSDM)
Ecologia e Conservação de Anfíbios

Especialidades
Modelos de Nicho Ecológico (ENMs)
Análise de Dados Ecológicos e Geoespaciais
Open Source [R, QGIS, GRASS GIS, Linux, Libreoffice, ...]

Contato e informações

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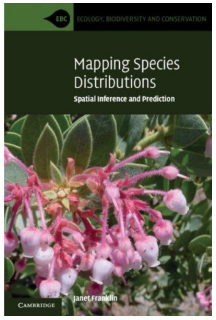
2. Introdução aos Modelos de Nicho Ecológico (ENMs)

Uma abordagem, muitos nomes...

Ecology, 93(7), 2012, pp. 1527–1539

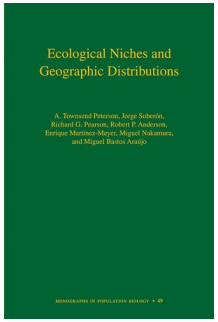
Uses and misuses of bioclimatic envelope modeling

MIGUEL B. ARAÚJO[1,2,3,5] AND A. TOWNSEND PETERSON[4]



Franklin (2009)

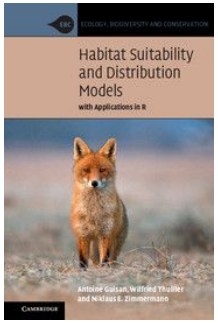
1. **Modelos de Envelopes Climáticos** (*Bioclimatic Envelope Models*)
Estimado um espaço multivariado de variáveis climáticas (envelope)



Peterson et al. (2011)

2. **Modelos de Nicho Ecológico** (*Ecological Niche Models*)
Vincula o envelope à teoria de nicho ecológico (Grinnell e Hutchinson)

3. **Modelos de Adequabilidade de Habitat** (*Habitat Suitability Models*)
Envelope relacionado ao “habitat”, como espaço físico e recursos



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4. **Modelos de Nicho Ecológico** (*Species Distribution Models*)
Modelar a distribuição geográfica das espécies

Uma abordagem, muitos nomes...

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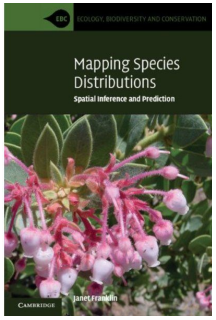

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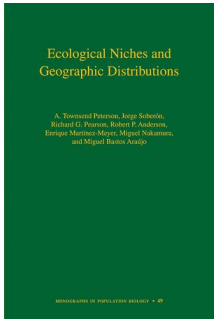

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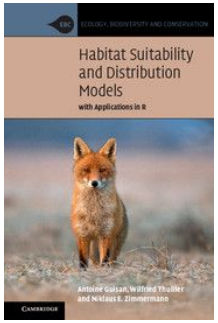

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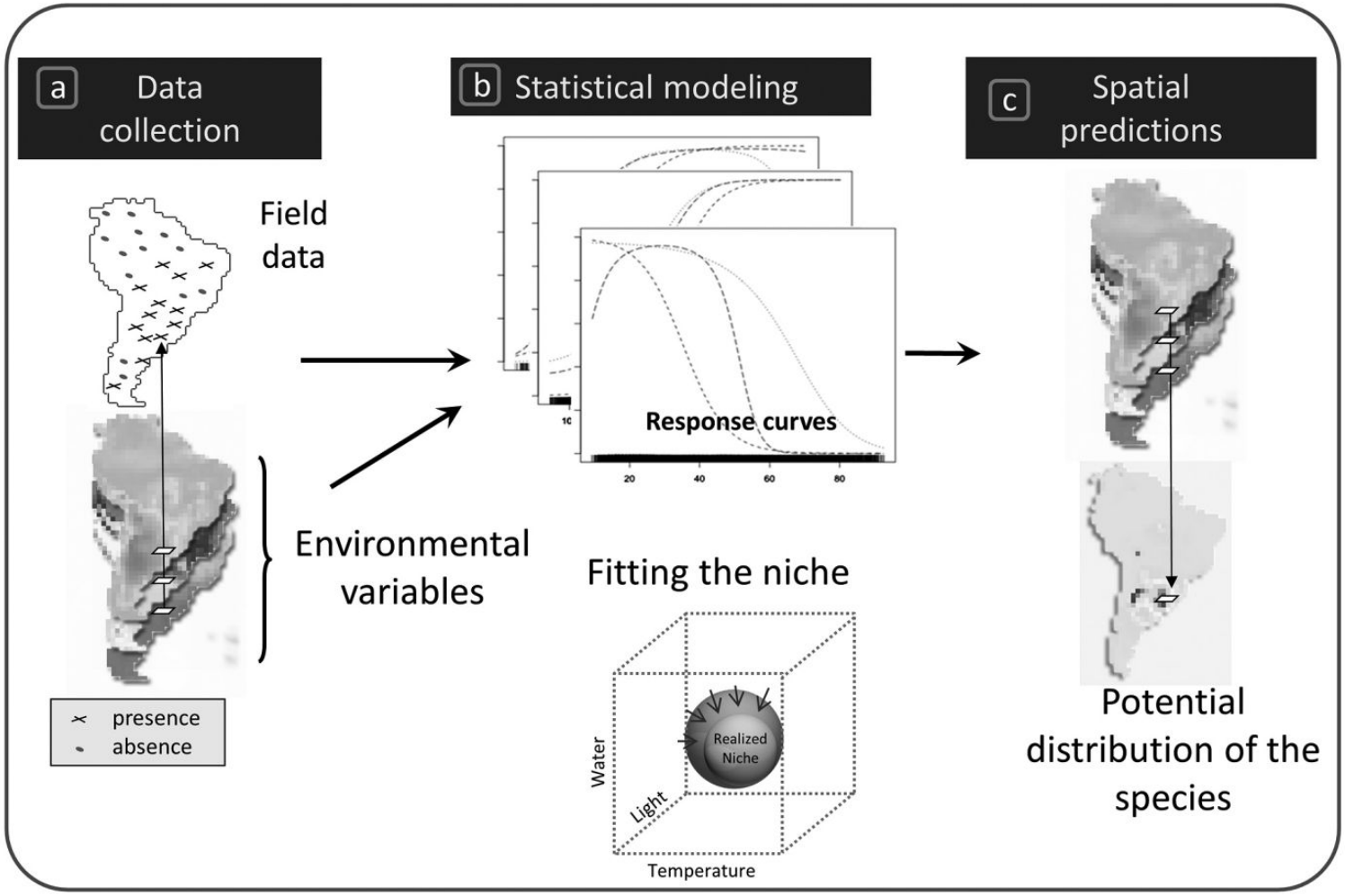
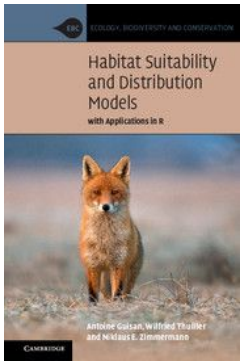
Modelar a distribuição geográfica das espécies

Modelos de Nicho Ecológico (ENMs)

Visão geral

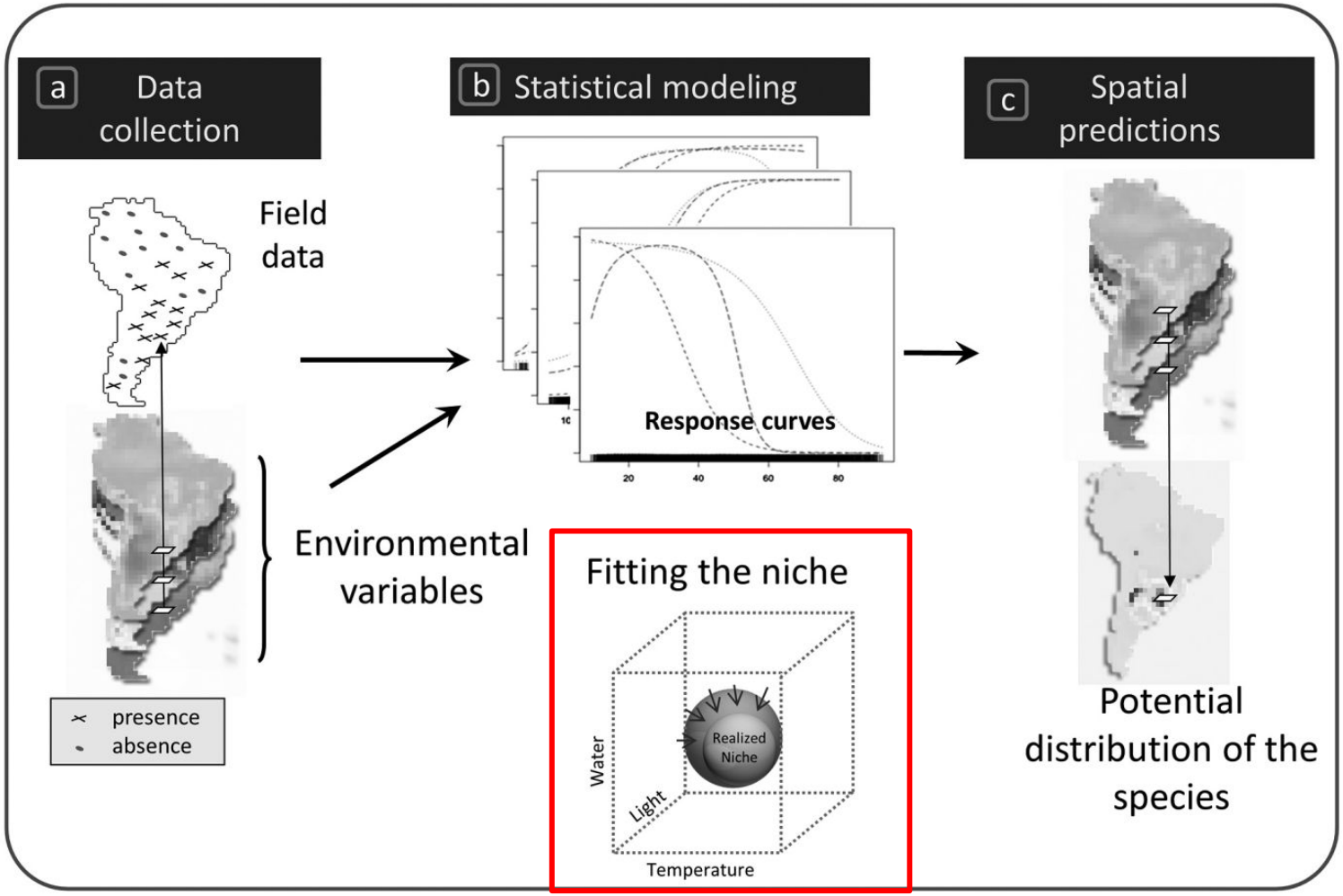


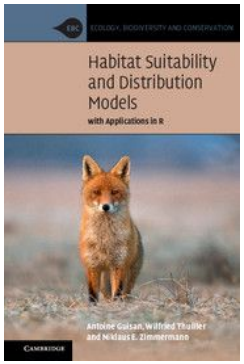


Guisan et al. (2017)

Modelos de Nicho Ecológico (ENMs)

Visão geral





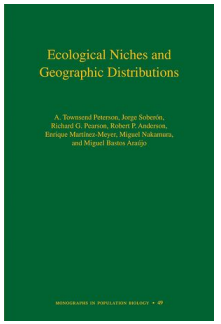
Guisan et al. (2017)

3. Nicho ecológico e distribuição das espécies

O que determina a distribuição de espécies?

Espaço Geográfico (G)

G



Peterson et al. (2011)

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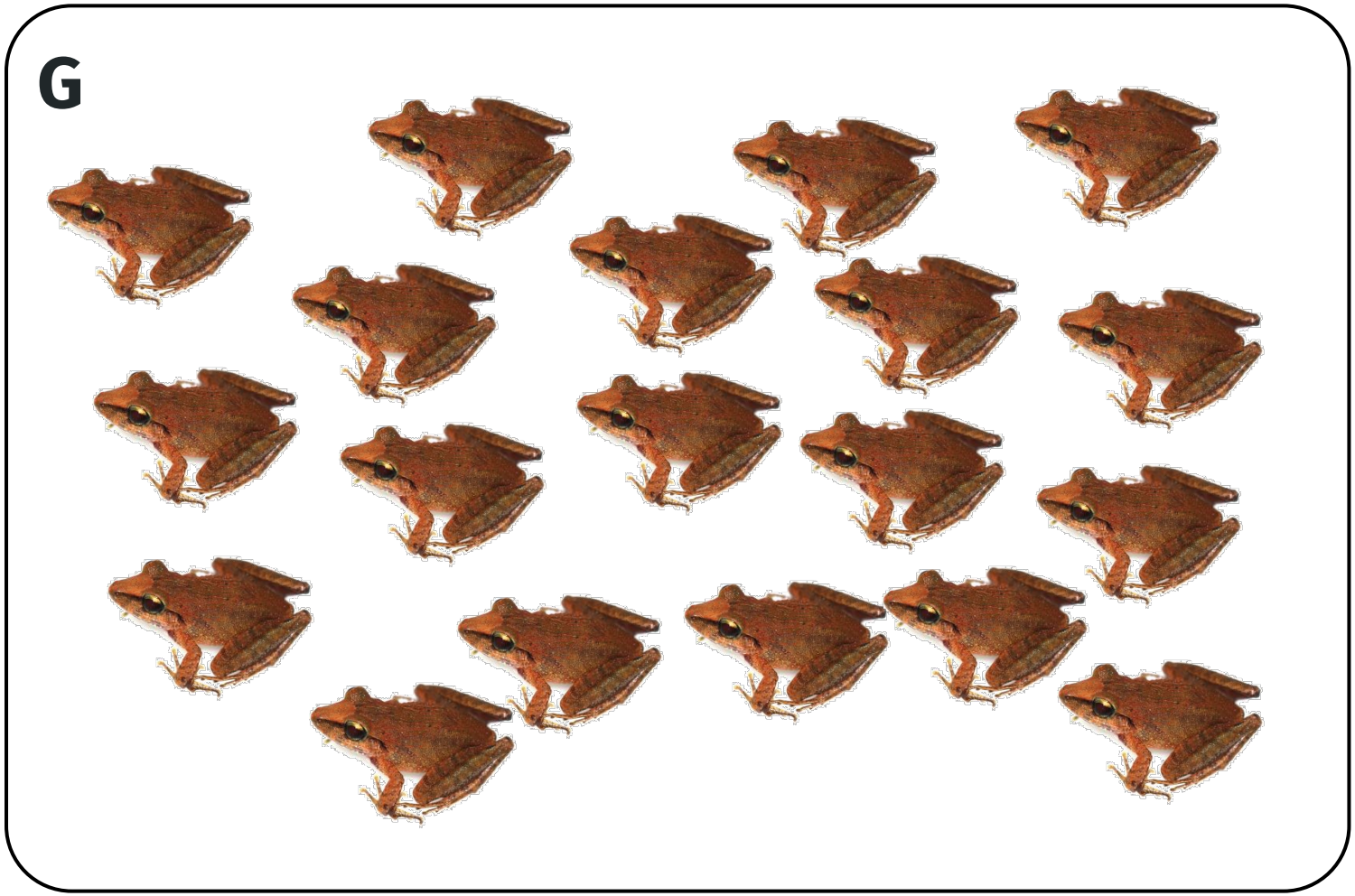
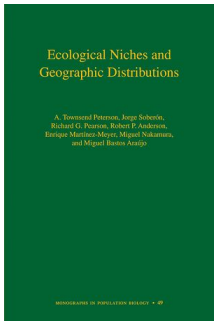
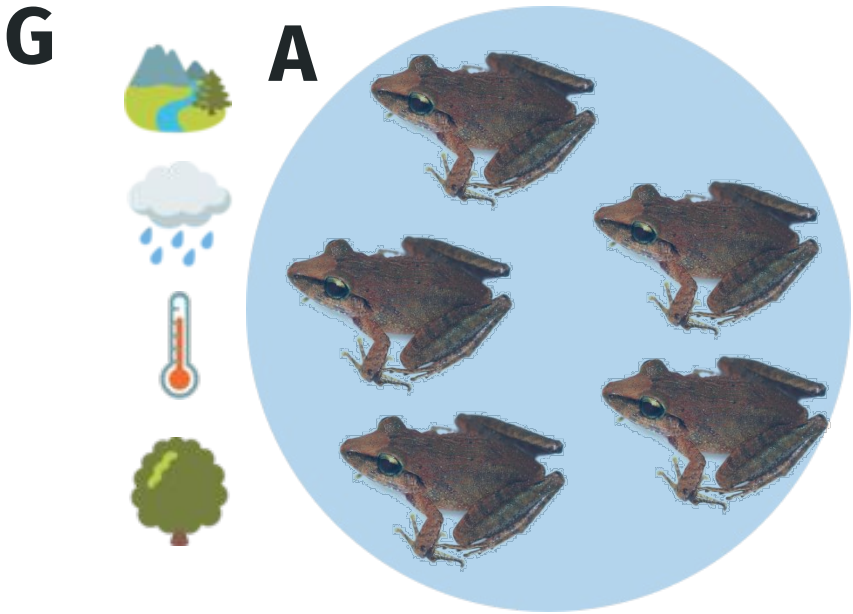


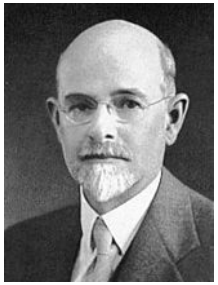


Peterson et al. (2011)

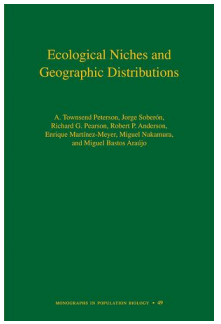
O que determina a distribuição de espécies?

Condições Abióticas (A)





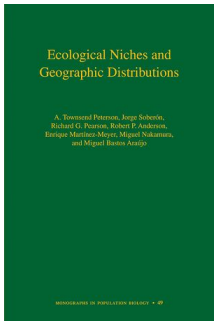
Joseph Grinnell (1917)
Requerimentos ambientais “condições climáticas”



Peterson et al. (2011)

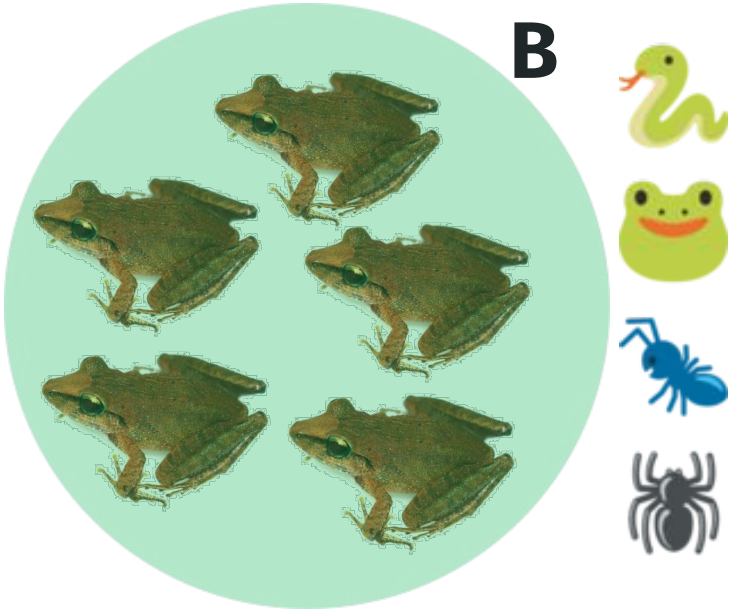
O que determina a distribuição de espécies?

Condições Bióticas (B)



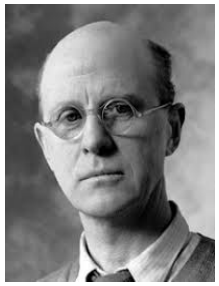
Peterson et al. (2011)

G



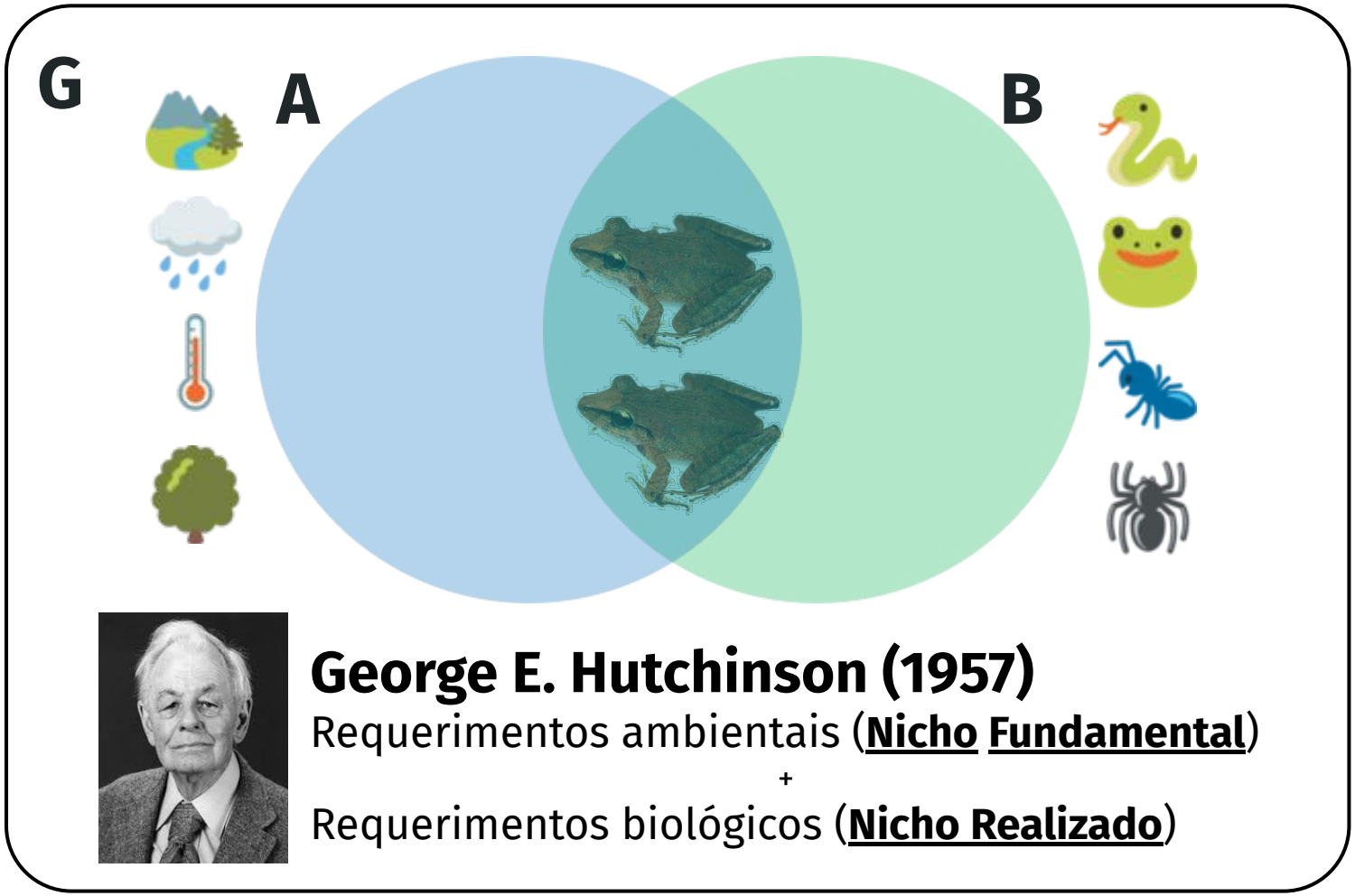
Charles Elton (1927)

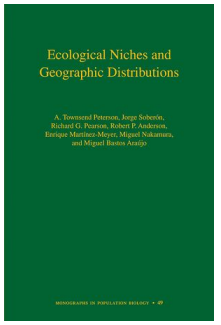
Papel funcional dos organismos “impacto”



O que determina a distribuição de espécies?

Relação entre condições abióticas e bióticas

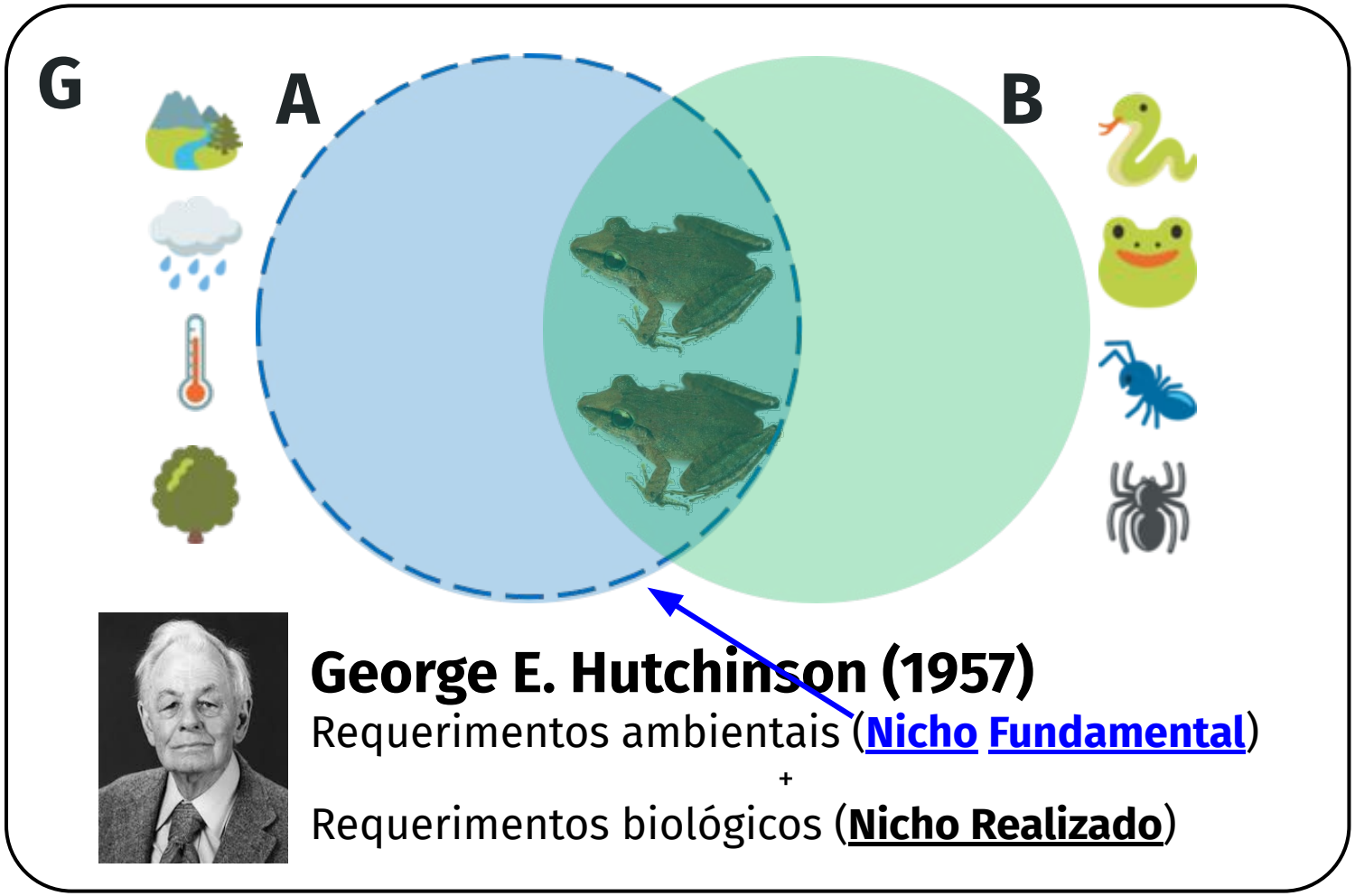




Peterson et al. (2011)

O que determina a distribuição de espécies?

Nicho Fundamental

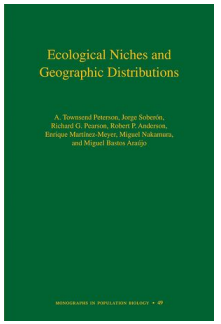


George E. Hutchinson (1957)

Requerimentos ambientais (**Nicho Fundamental**)

+

Requerimentos biológicos (**Nicho Realizado**)



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O que determina a distribuição de espécies?

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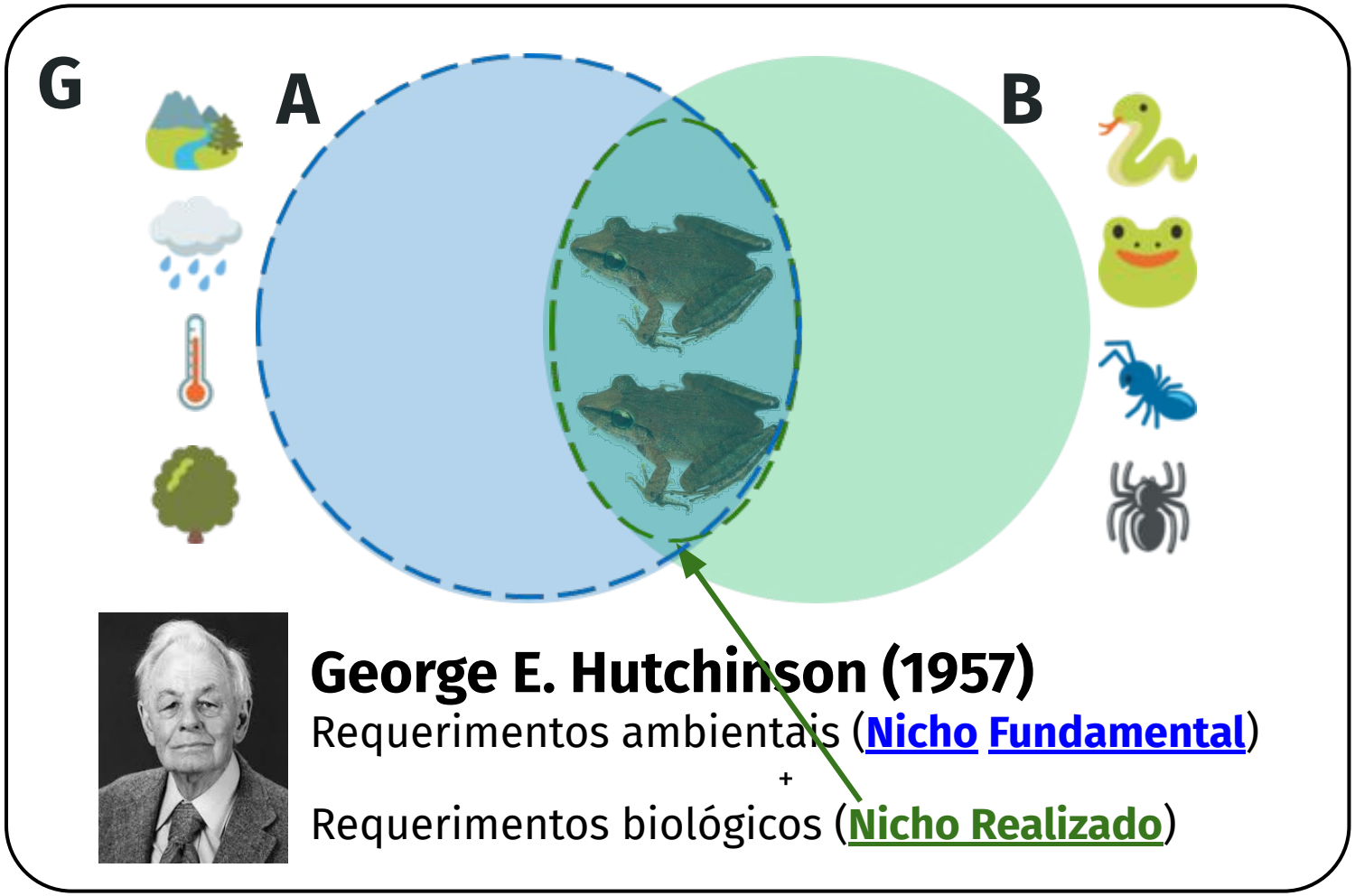

George E. Hutchinson (1957)

Requerimentos ambientais (Nicho Fundamental)

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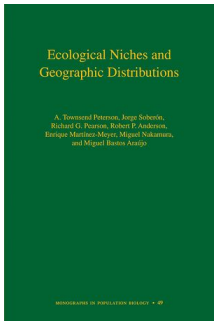
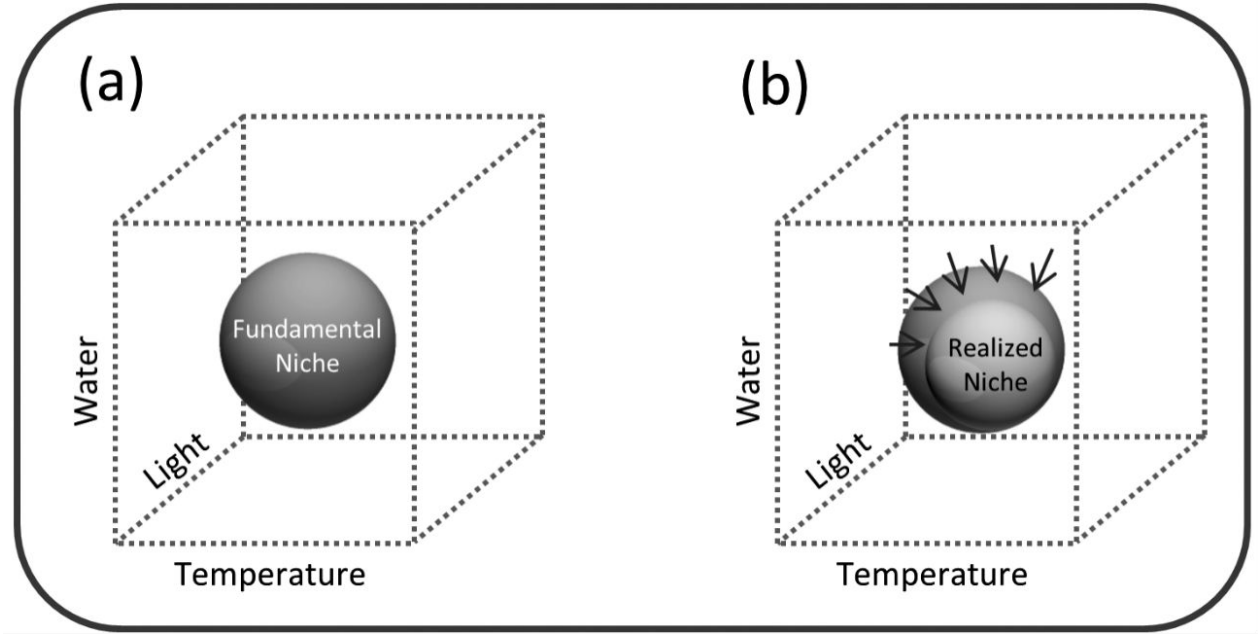
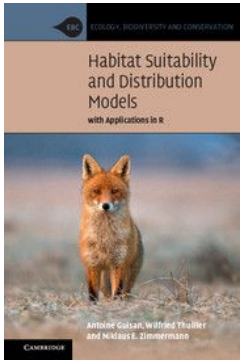


Peterson et al. (2011)

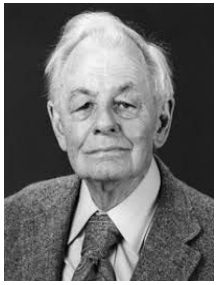
O que determina a distribuição de espécies?

Hipervolume n-dimensional





Guisan et al. (2017)



George E. Hutchinson (1957)

Requerimentos ambientais (**Nicho Fundamental**)

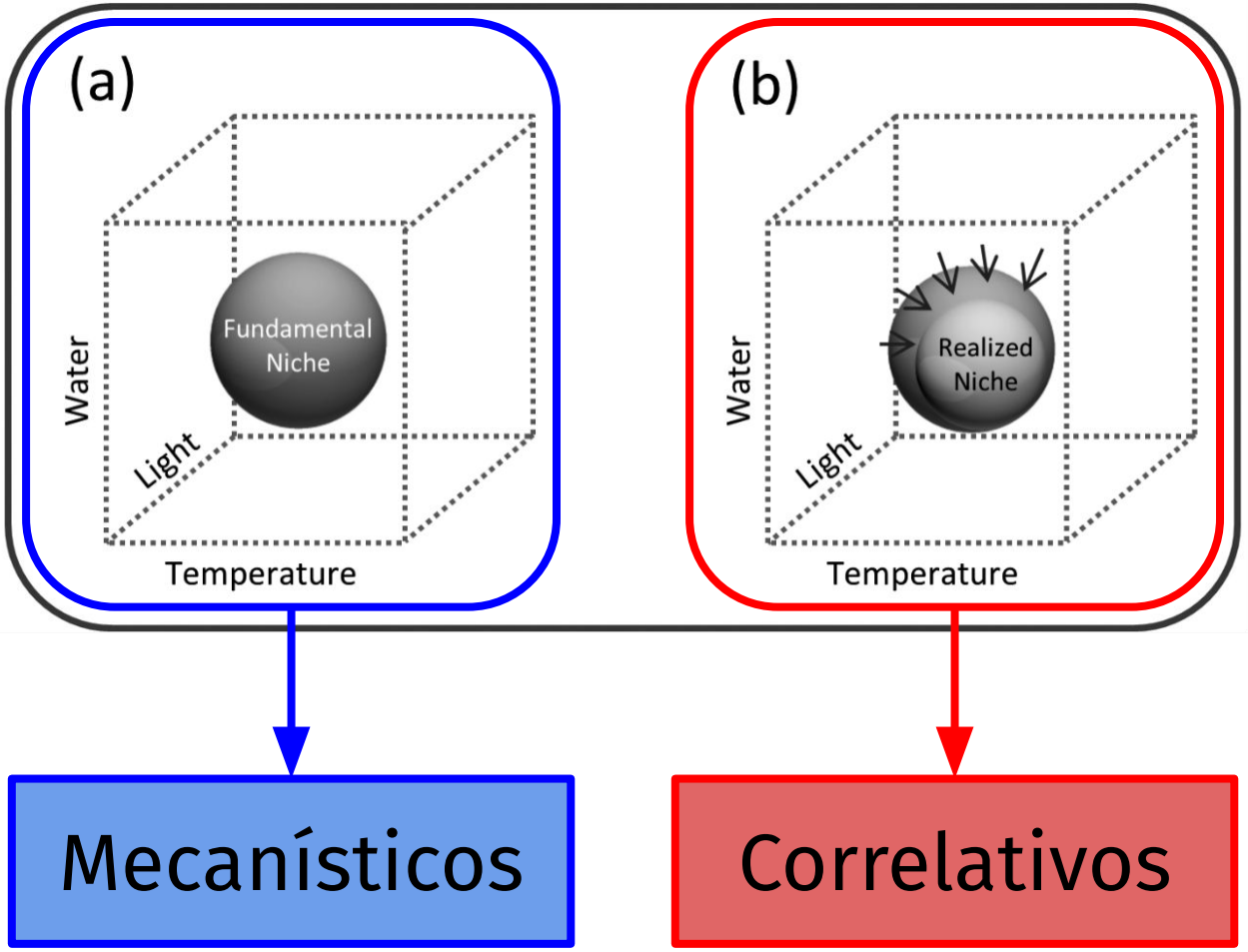
+

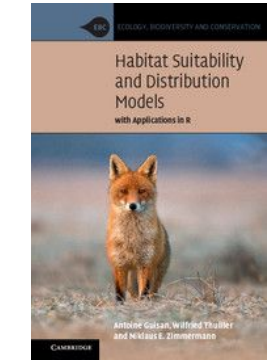
Requerimentos biológicos (**Nicho Realizado**)

Os ENMs estimam o nicho **fundamental** ou **realizado**?

Nicho fundamental e realizado

Modelos mecanísticos e correlativos

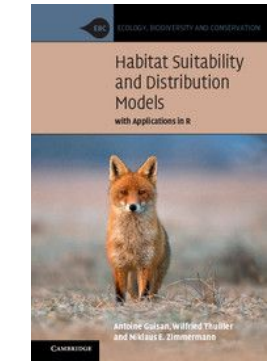




Guisan et al. (2017)

Nicho fundamental e realizado

Modelos mecanísticos e correlativos



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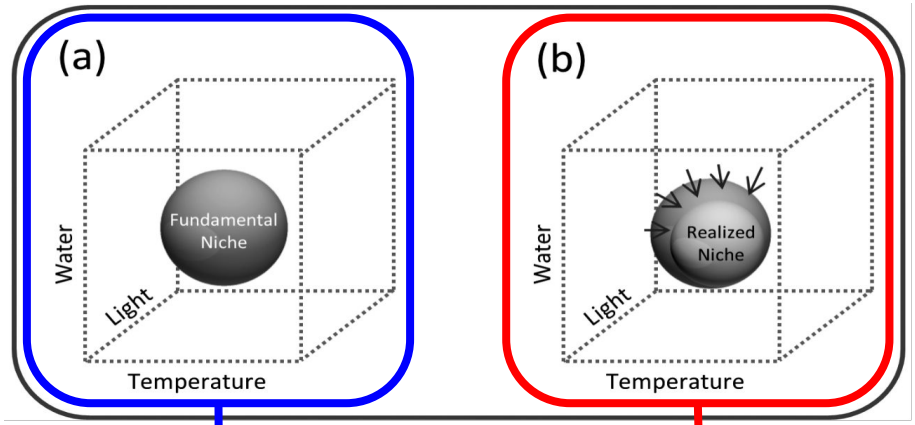
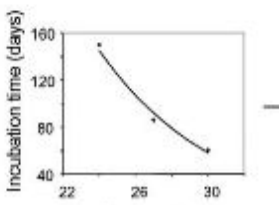
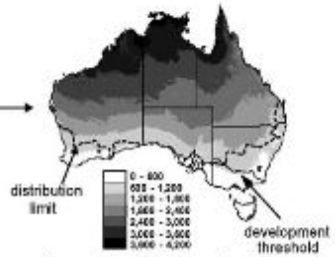


Mecanísticos

GIS data
Organismal data (behaviour, morphology, physiology, life history)
→ Mechanistic niche model → Predicted distribution (fitness/fitness components)



Heteronotia egg development

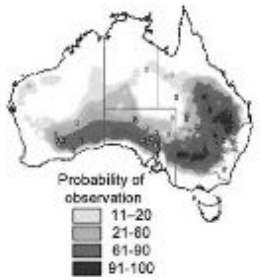


Degree days for egg development in soil

Correlativos

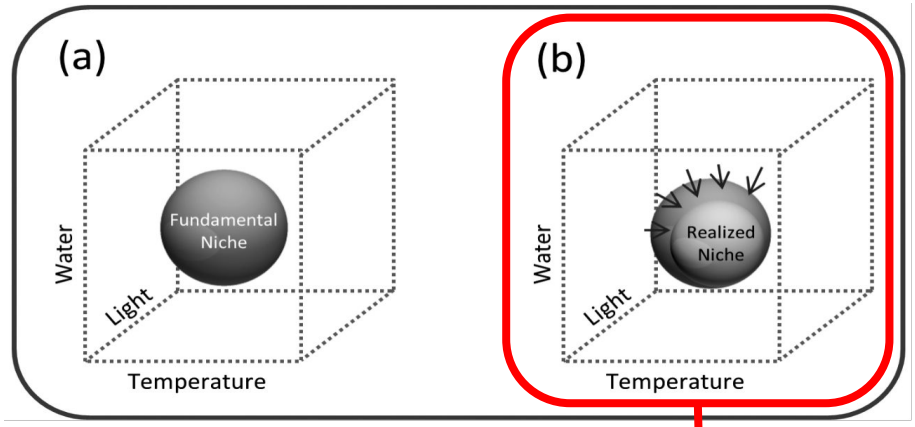
GIS data
Distribution data (presence/absence)
→ Correlative habitat model → Predicted distribution (probability of occurrence)

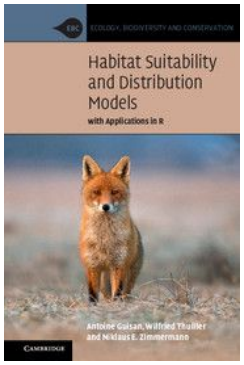
Heteronotia (EA6 lineage) presence/absence



Nicho realizado

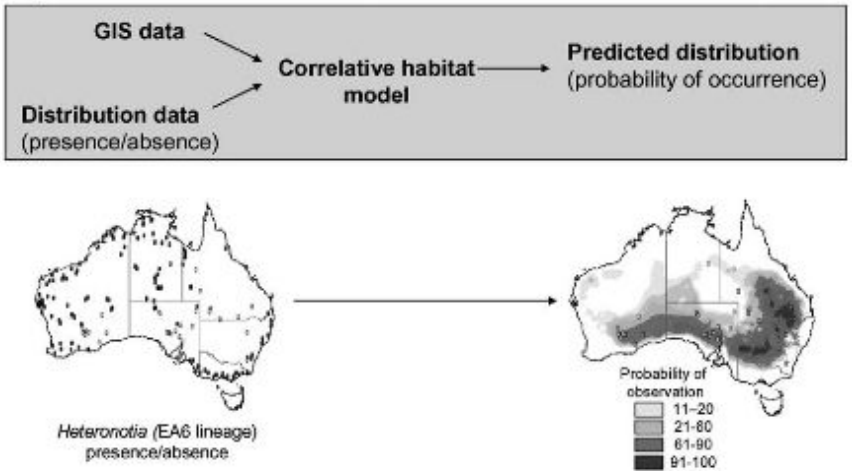
Modelos correlativos





Guisan et al. (2017)

Correlativos

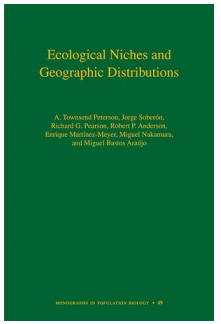


Modelos correlativos

Ocorrências

Espaço geográfico (G)

Jackson & Overpack (2000)



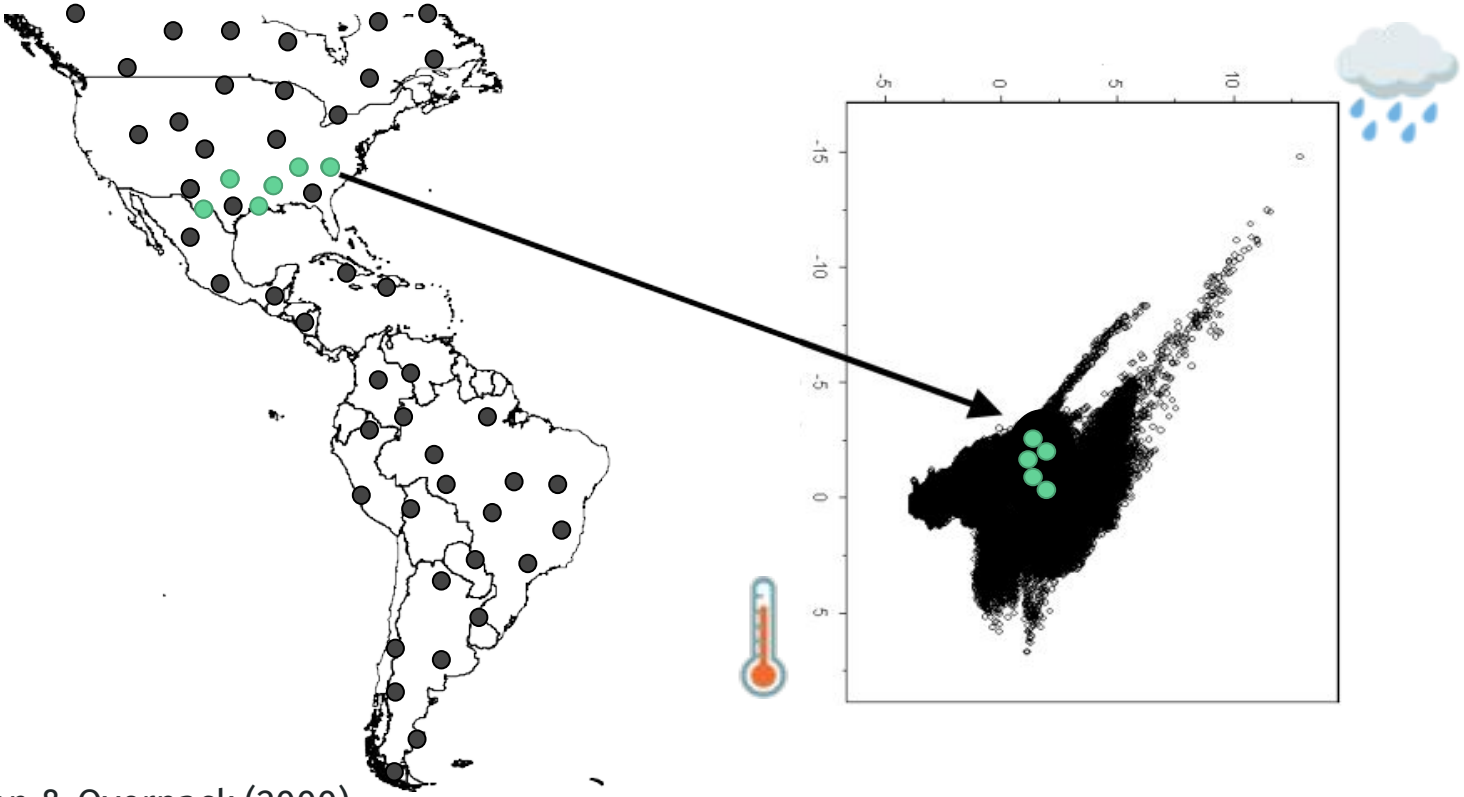
Peterson et al. (2011)

Modelos correlativos

Condições ambientais

Espaço geográfico (G)

Espaço ambiental (E)



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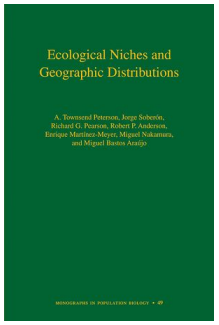
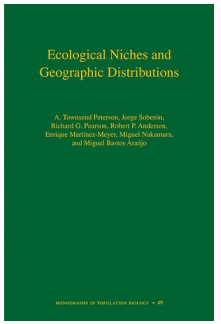


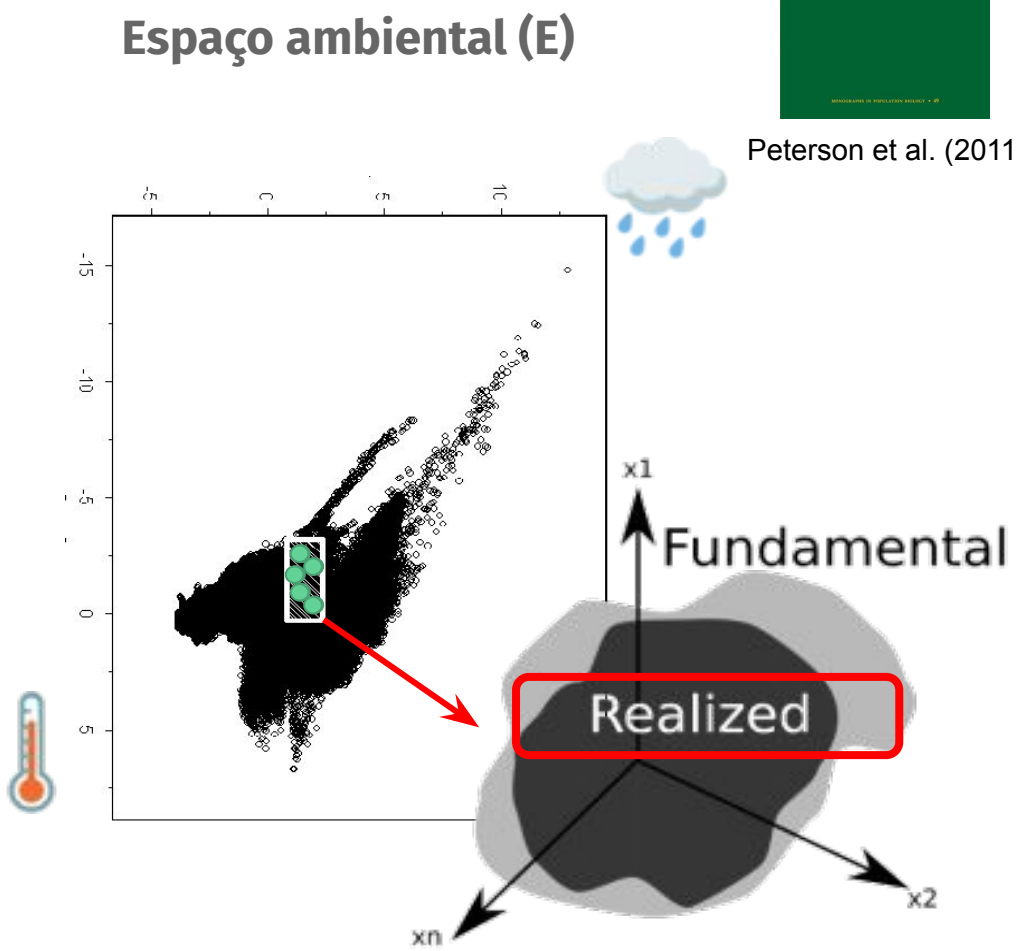
Peterson et al. (2011)

Modelos correlativos

Estimativa do nicho realizado



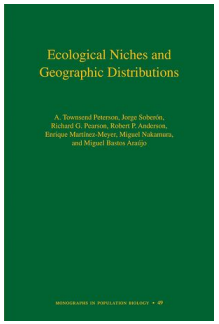
Peterson et al. (2011)



Jackson & Overpack (2000)

Modelos correlativos

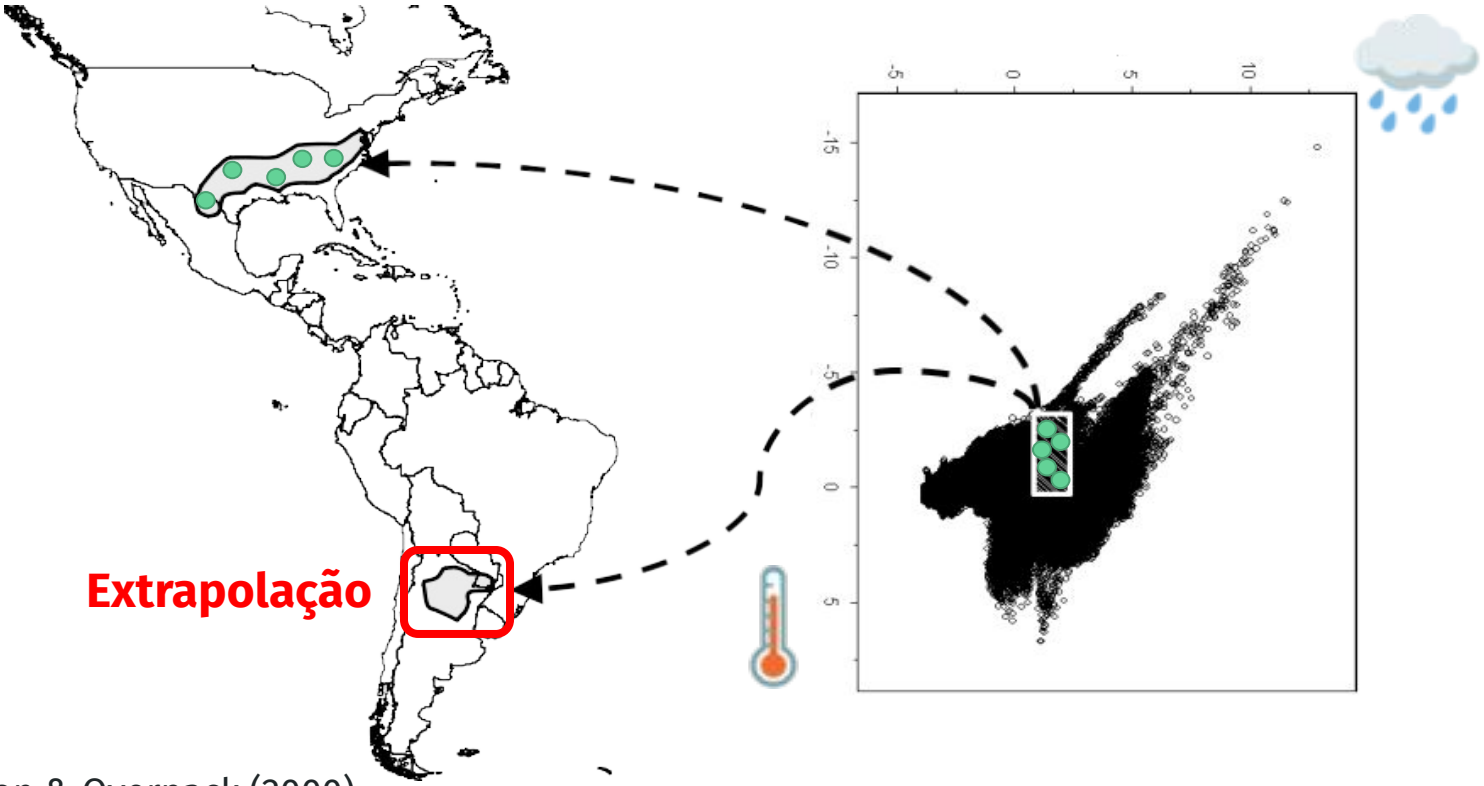
Predição do nicho realizado estimado



Peterson et al. (2011)

Espaço geográfico (G)

Espaço ambiental (E)

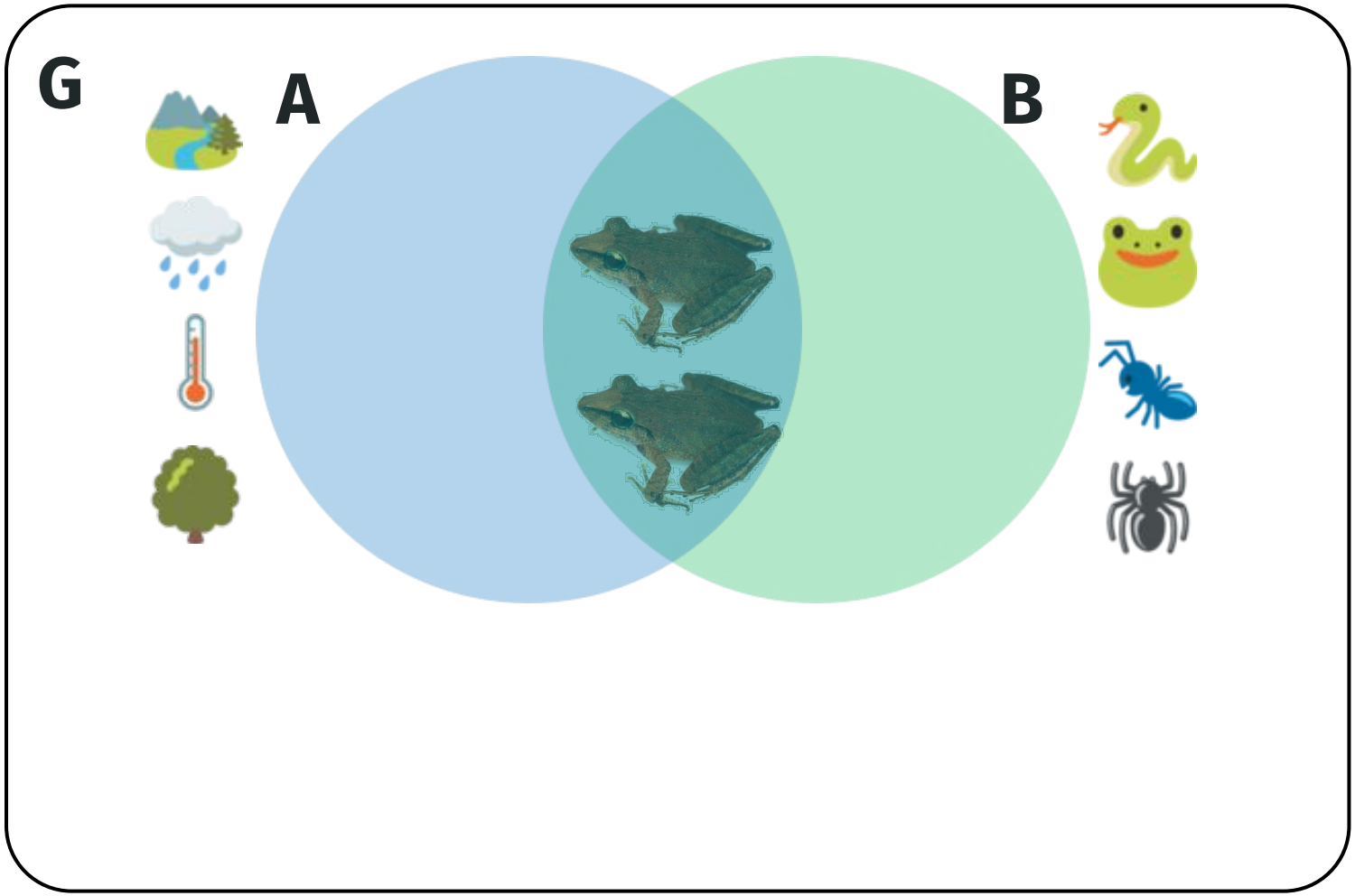


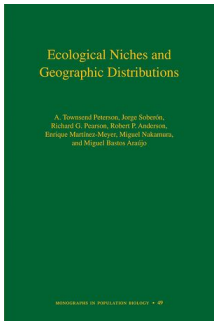
Jackson & Overpack (2000)

E como contornar essa **extrapolação**?

O que determina a distribuição de espécies?

Nicho Ecológico

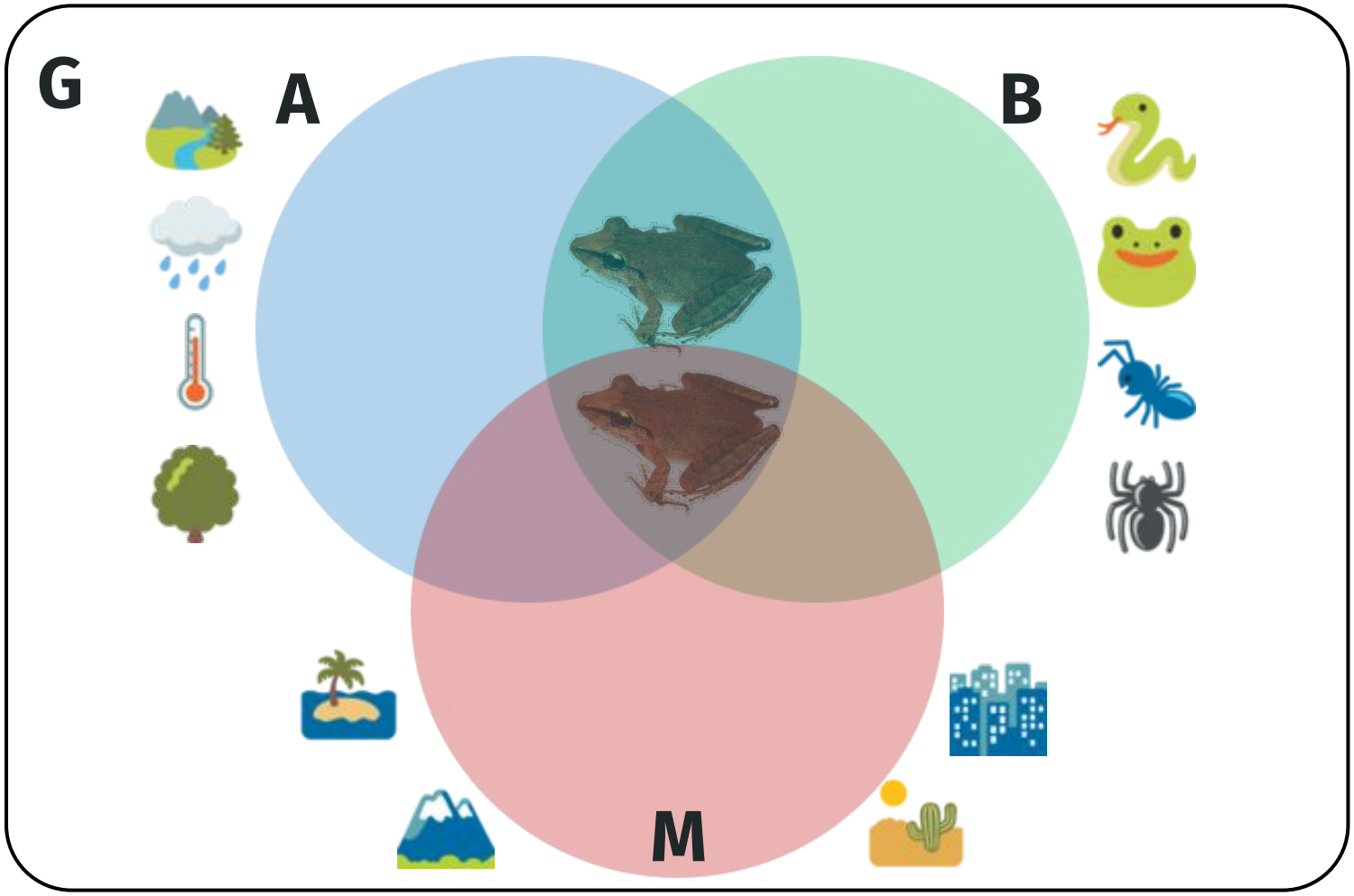


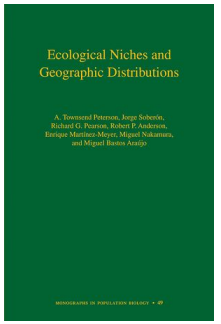


Peterson et al. (2011)

O que determina a distribuição de espécies?

Nicho Ecológico limitado pelo **movimento**





Peterson et al. (2011)

A teoria dos modelos...

O que determina a distribuição das espécies?

Teoria

$$\frac{1}{x_i^j}\frac{dx_i^j}{dt} = r_i(\vec{e}^{\,j}) - \varphi_i^j(\vec{x}^{\,j};\vec{R}_i^{\,j}) + \psi^j(\vec{x};\mathbf{T})$$

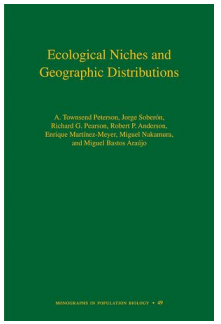
G

Ambiente
(fatores abióticos)

Interações
Bióticas

Movimento

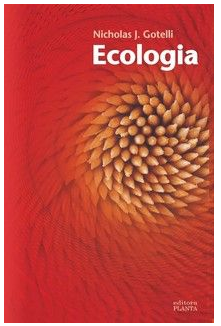
i = espécie
j = **célula do raster**
x = densidade
t = tempo
r = cresc. da pop.
e = vetor de cond. amb.
φ = termo de regulação
R = interação com outras esp.
T = matriz de transição (cap. de mov.)
Ψ = termo de movimento



Peterson et al. (2011)

O que determina a distribuição das espécies?

Ecologia de Populações



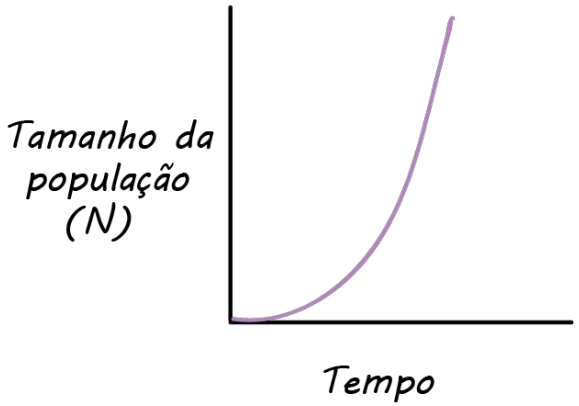
Gotelli (2007)

$$\frac{dN}{dt} = rN$$

Crescimento exponencial

A taxa de crescimento per capita (r) não muda, mesmo se a população aumentar muito.

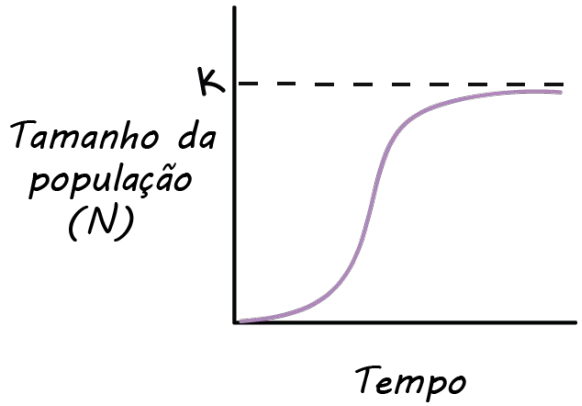
$$\frac{dN}{dt} = r_{máx}N$$



Crescimento logístico

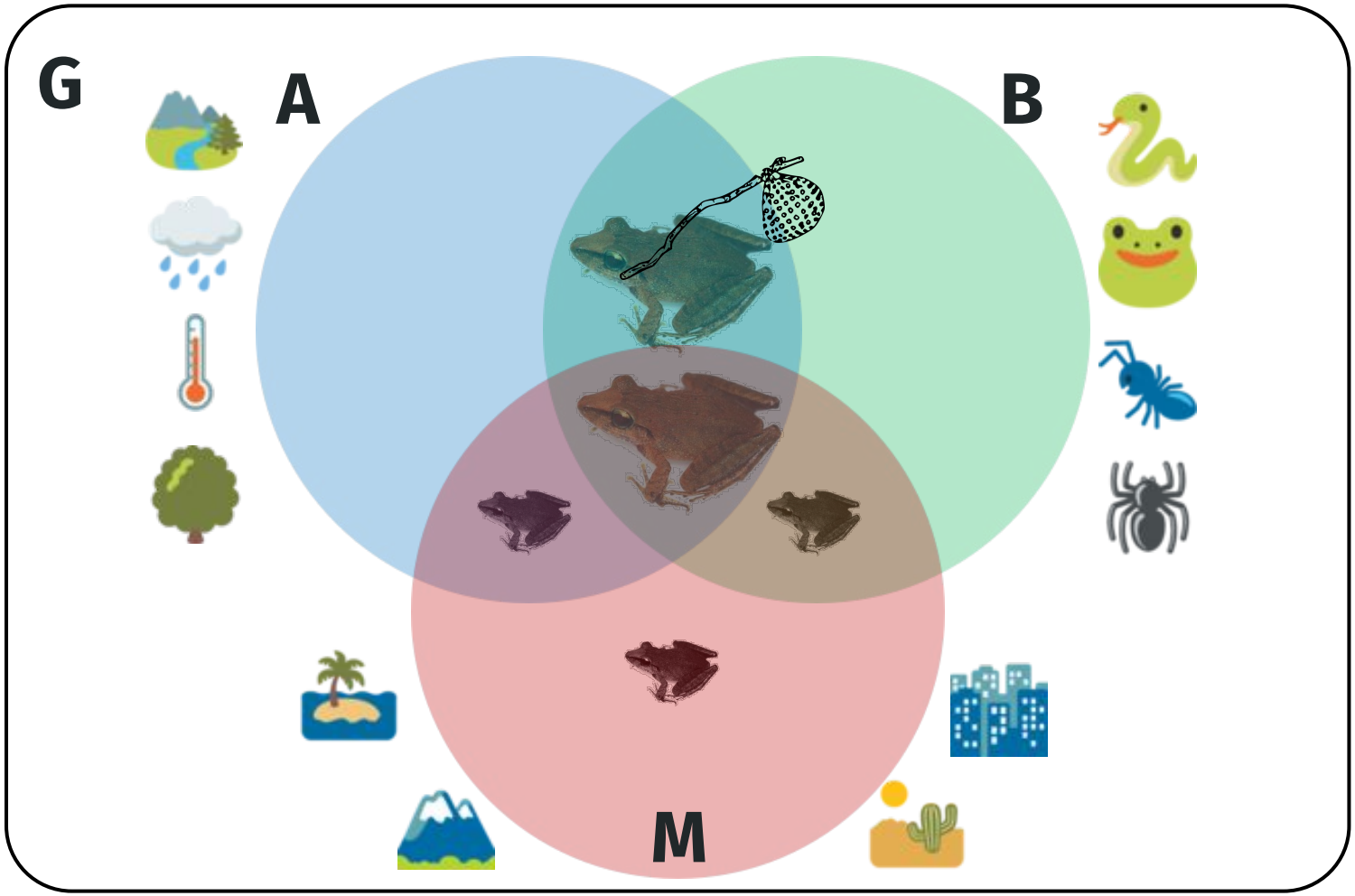
A taxa de crescimento per capita (r) diminui à medida que a população se aproxima de seu tamanho máximo.

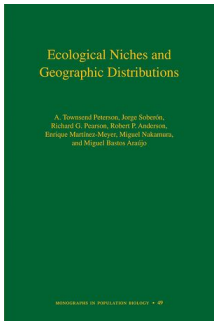
$$\frac{dN}{dt} = r_{máx}\left(\frac{K-N}{K}\right)N$$



O que determina a distribuição de espécies?

Populações fonte e ralo (*source-sink*)





Peterson et al. (2011)

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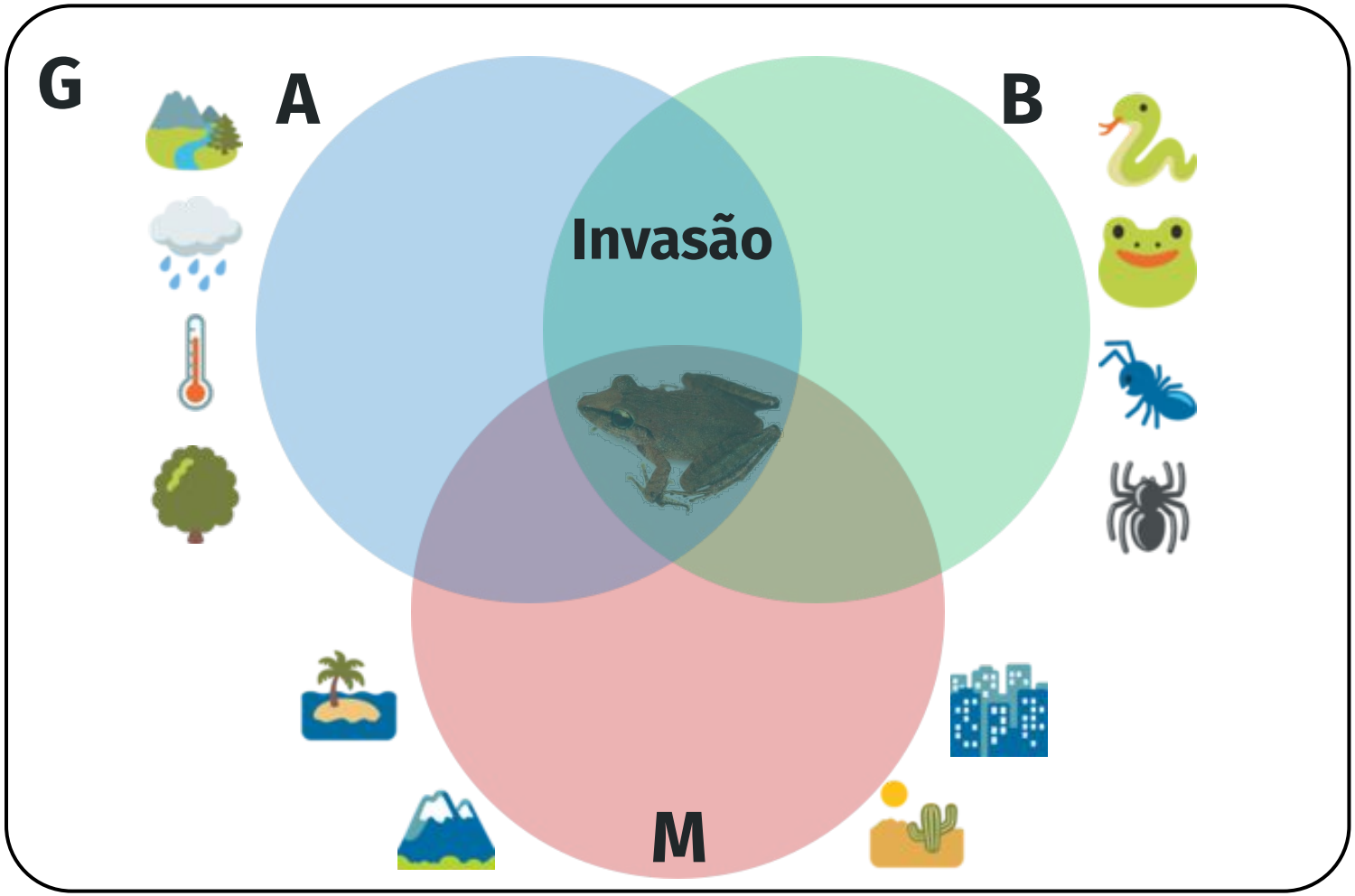

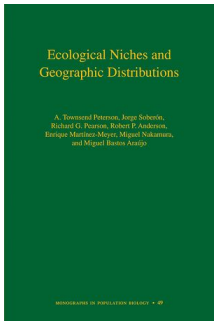

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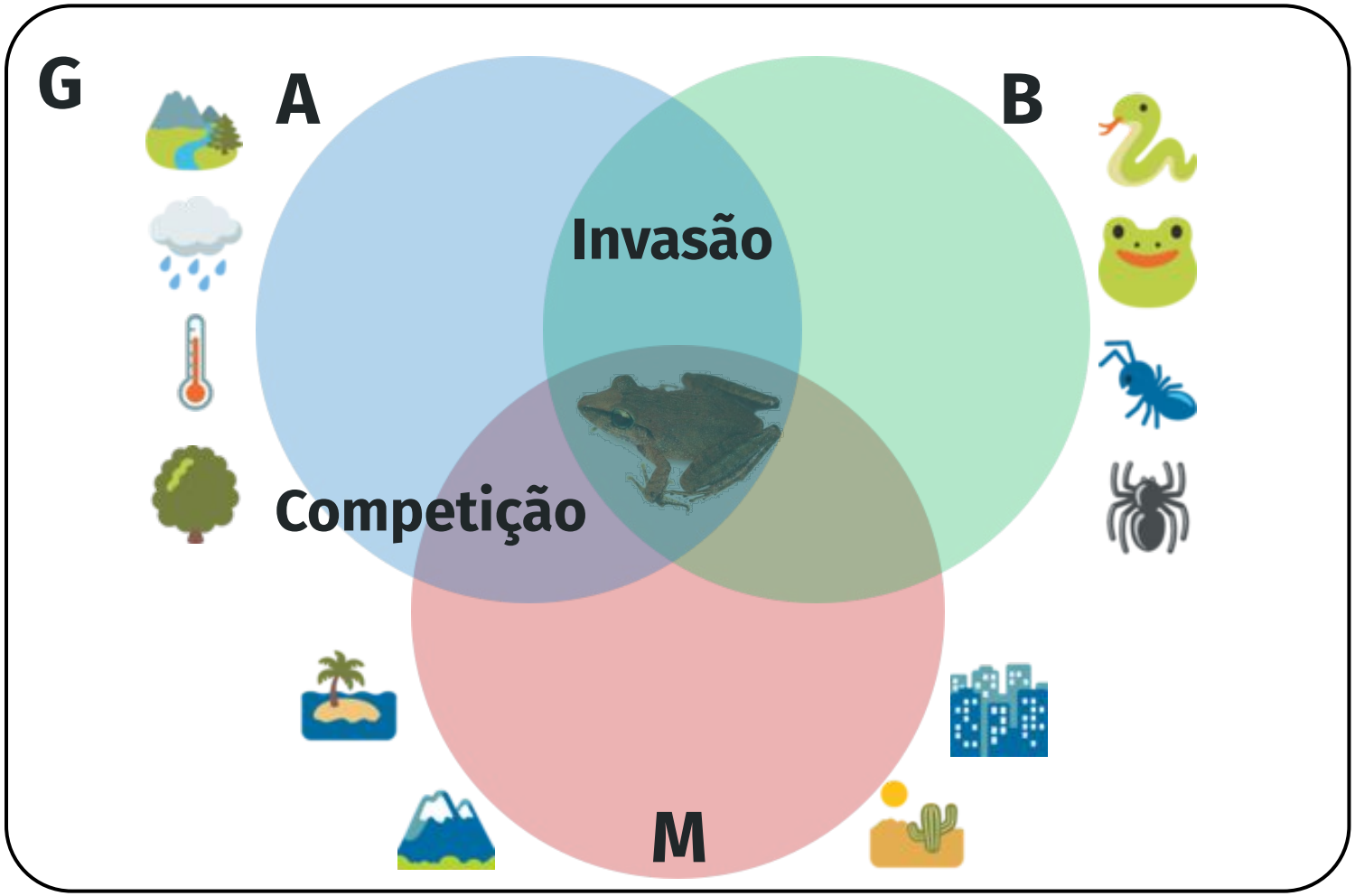

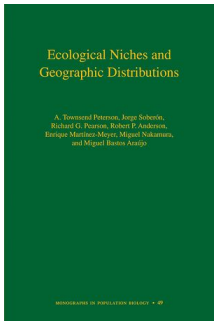

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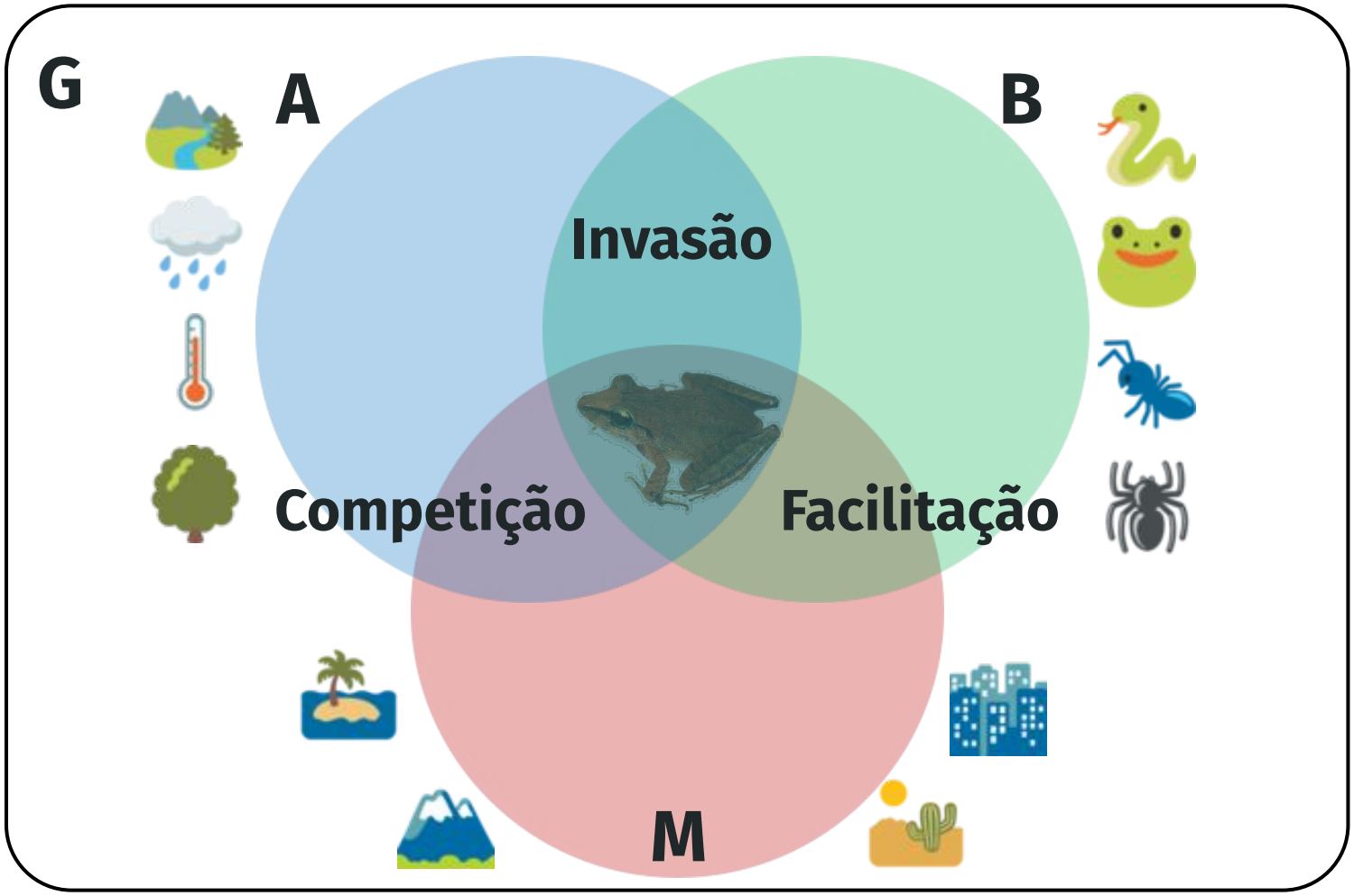

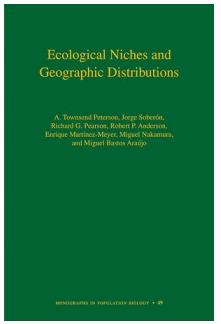

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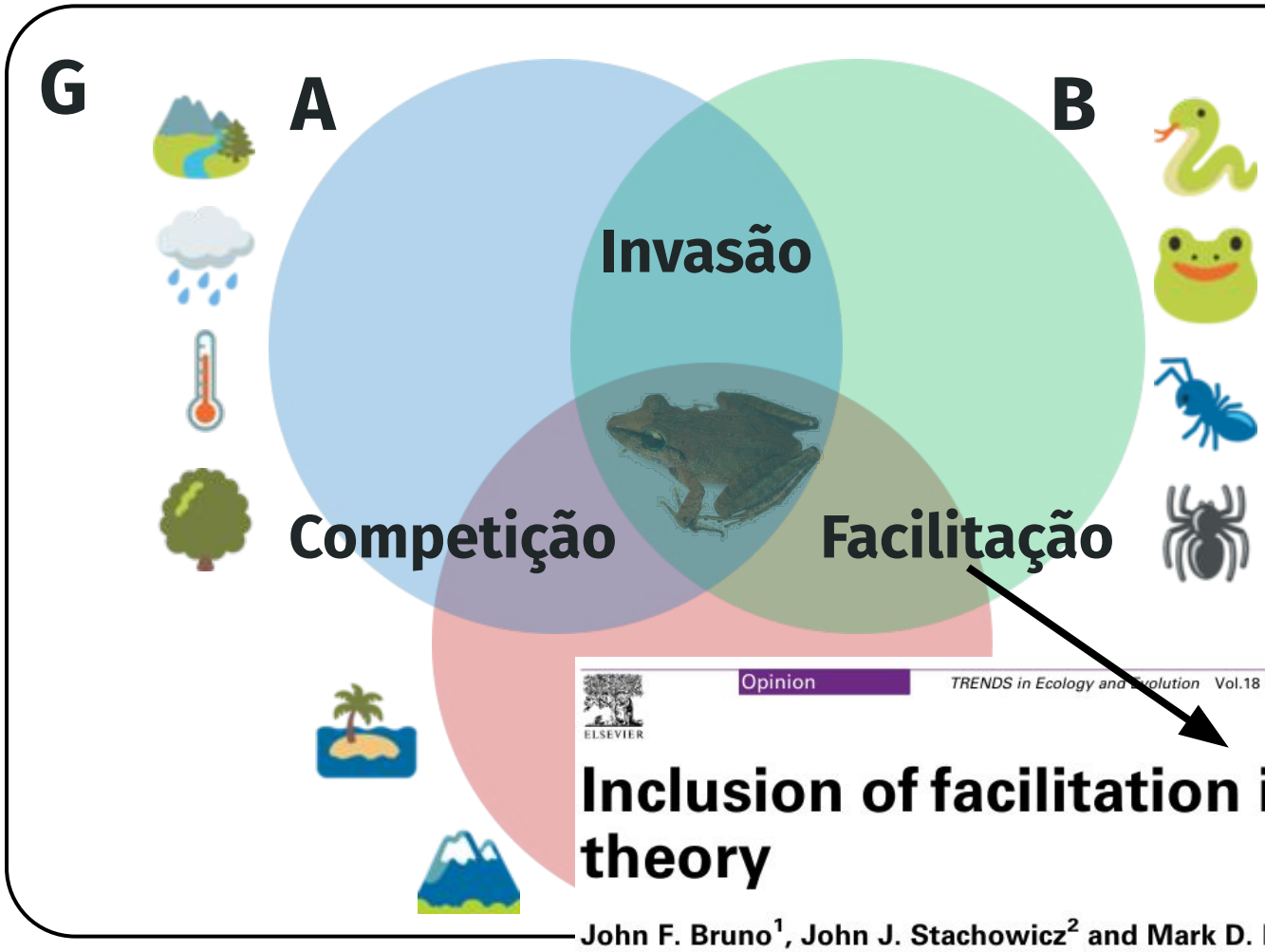
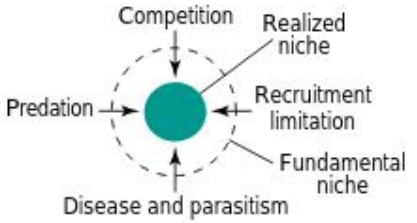
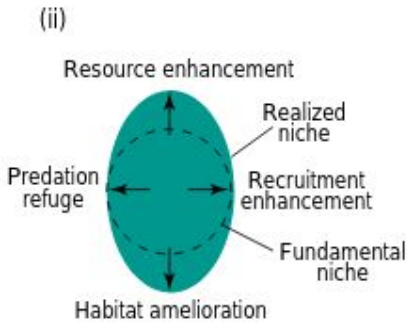






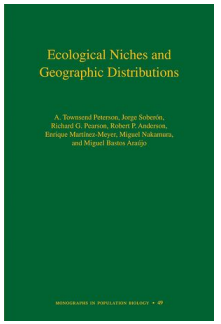
Opinion TRENDS in Ecology and Evolution Vol.18 No.3 March 2003 119

Inclusion of facilitation into ecological theory

John F. Bruno[1], John J. Stachowicz[2] and Mark D. Bertness[3]

O que determina a distribuição de espécies?

Populações fonte e ralo (*source-sink*)

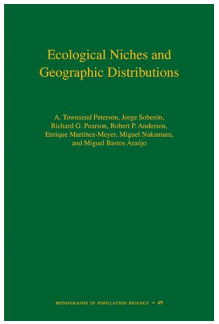


Peterson et al. (2011)

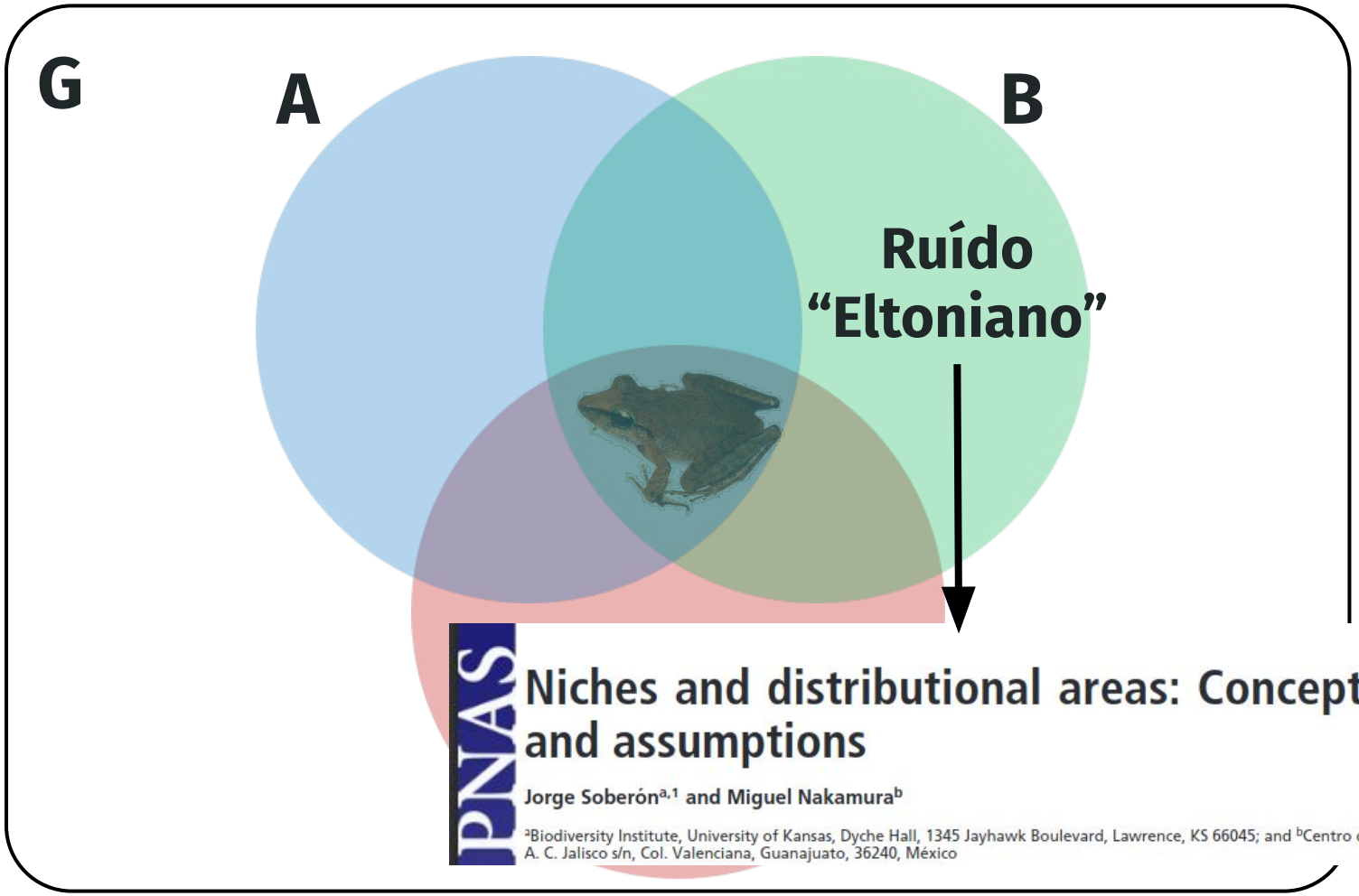
E as **interações bióticas**?

O que determina a distribuição de espécies?

Interações bióticas “ignoradas”



Peterson et al. (2011)



PNAS

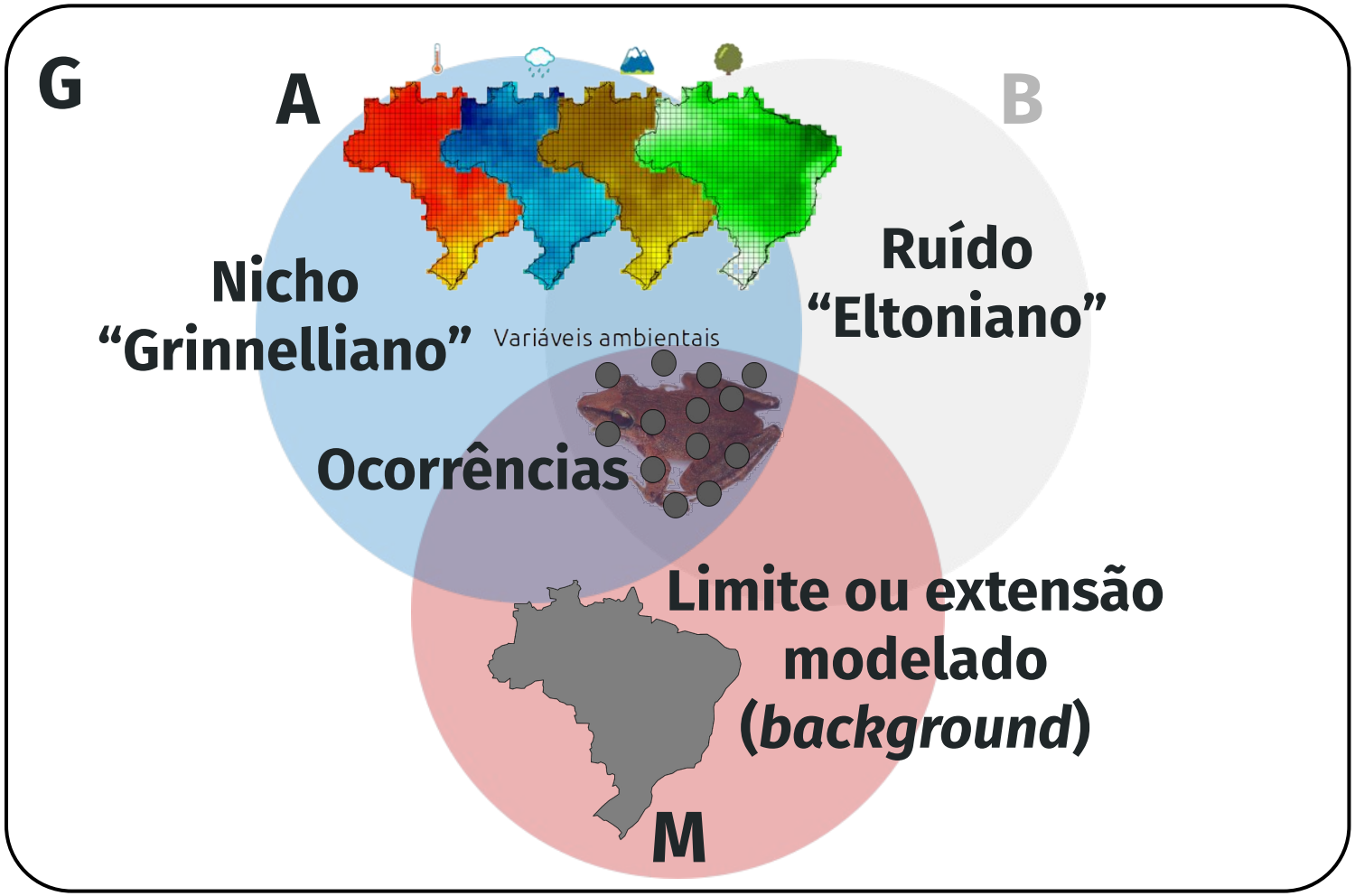
Niches and distributional areas: Concepts, methods, and assumptions

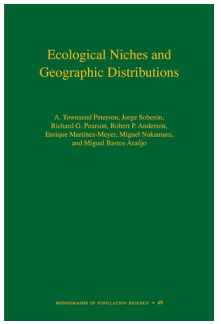
Jorge Soberón[a,1] and Miguel Nakamura[b]

[a]Biodiversity Institute, University of Kansas, Dyche Hall, 1345 Jayhawk Boulevard, Lawrence, KS 66045; and [b]Centro de Investigación en Matemáticas, A. C. Jalisco s/n, Col. Valenciana, Guanajuato, 36240, México

O que determina a distribuição de espécies?

Estimativa do nicho Grinnelliano realizado





Peterson et al. (2011)

Área em desenvolvimento

Como inserir as interações bióticas nos ENMs?

RESEARCH PAPER

WILEY Journal of Biogeography

Using biotic interactions in broad-scale estimates of species' distributions

Iulian Gherghel[1,2,3] | François Brischoux[4] | Monica Papeş[5]

BIOLOGICAL REVIEWS Cambridge Philosophical Society

Open Access

The role of biotic interactions in shaping distributions and realised assemblages of species: implications for species distribution modelling

Mary Susanne Wisz, Julien Pottier, W. Daniel Kissling, Loïc Pellissier, Jonathan Lenoir, Christian F. Damgaard, Carsten F. Dormann, Mads C. Forchhammer, John-Arvid Grytnes ... See all authors

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Journal of Biogeography

Original Article | Full Access

The importance of biotic interactions in species distribution models: a test of the Eltonian noise hypothesis using parrots

Carlos B. de Araújo, Luiz Octavio Marcondes-Machado, Gabriel C. Costa

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Effects of biotic interactions on modeled species' distribution can be masked by environmental gradients

William Godsoe, Janet Franklin, F. Guillaume Blanchet

RESEARCH REVIEWS

WILEY Global Ecology and Biogeography

Biotic interactions in species distribution modelling: 10 questions to guide interpretation and avoid false conclusions

Carsten F. Dormann[1] | Maria Bobrowski[2] | D. Matthias Dehling[3] | David J. Harris[4] | Florian Hartig[1,5] | Heike Lischke[6] | Marco D. Moretti[7] | Jörn Pagel[8] | Stefan Pinkert[9] | Matthias Schleuning[10] | Susanne I. Schmidt[11] | Christine S. Sheppard[8] | Manuel J. Steinbauer[12,13] | Dirk Zeuss[14] | Casper Kraan[15,16]

Biotic interactions and climate in species distribution modelling

Daniel P. Bebber, Sarah J. Gurr

doi: https://doi.org/10.1101/520320

4. SDM passo a passo

SDM passo a passo

Estrutura dos ENMs

ECOGRAPHY

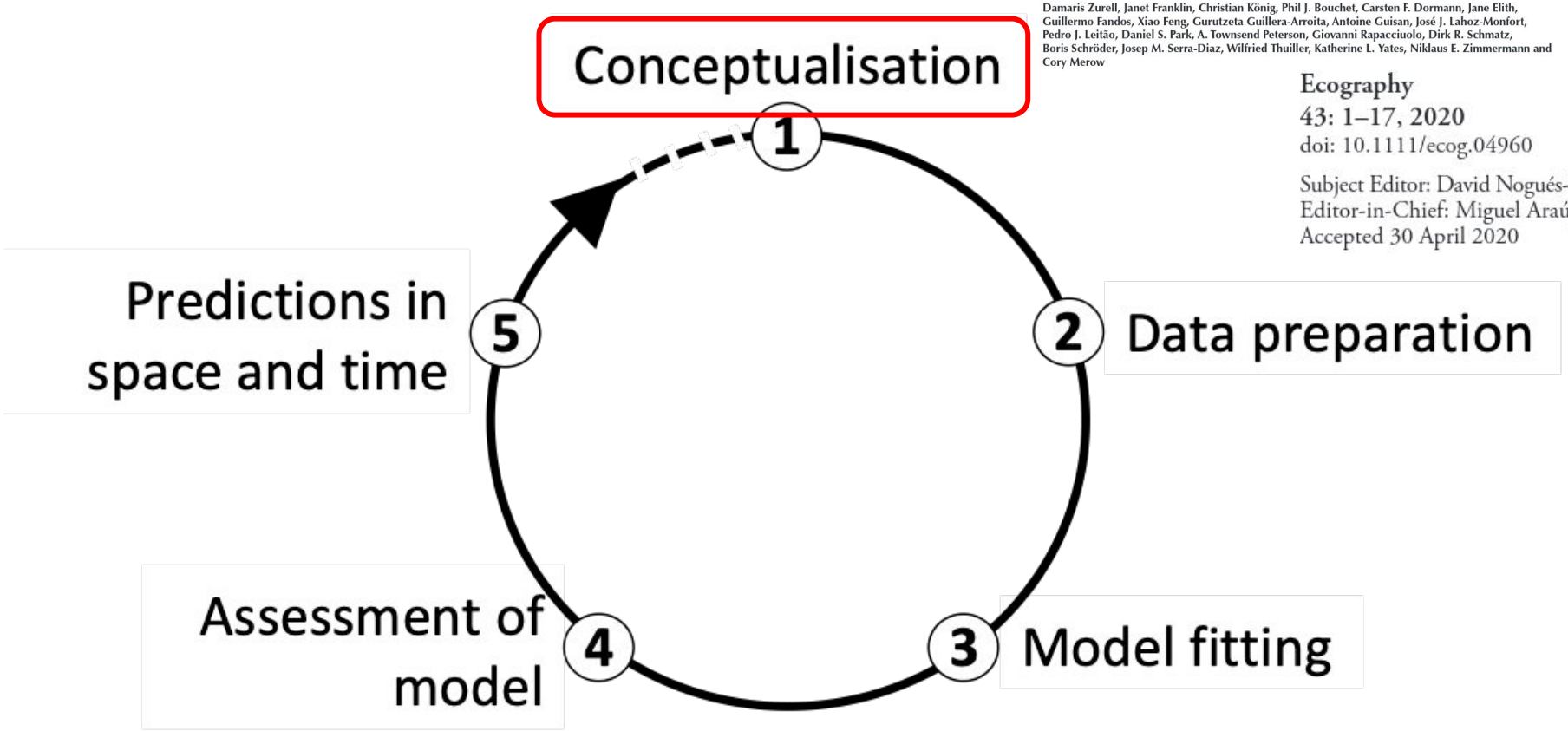
Review and synthesis

A standard protocol for reporting species distribution models

Damaris Zurell, Janet Franklin, Christian König, Phil J. Bouchet, Carsten F. Dormann, Jane Elith, Guillermo Fandos, Xiao Feng, Gurutzeta Guillera-Arroita, Antoine Guisan, José J. Lahoz-Monfort, Pedro J. Leitão, Daniel S. Park, A. Townsend Peterson, Giovanni Rapacciuolo, Dirk R. Schmatz, Boris Schröder, Josep M. Serra-Diaz, Wilfried Thuiller, Katherine L. Yates, Niklaus E. Zimmermann and Cory Merow

Ecography
43: 1–17, 2020
doi: 10.1111/ecog.04960

Subject Editor: David Nogués-Bravo
Editor-in-Chief: Miguel Araújo
Accepted 30 April 2020



https://doi.org/10.1111/ecog.04960

Conceitualização

Perguntas associadas à distribuição das espécies

Teoria -> Perguntas -> Hipóteses ->
Estatística (modelos) -> Respostas

Conceitualização

Perguntas associadas à distribuição das espécies

Teoria -> Perguntas -> Hipóteses ->
Estatística (modelos) -> Respostas

1. Padrões de diversidade
2. Mudanças climáticas (futuro)
3. Mudanças climáticas (passado)
4. Invasão de espécies
5. Transmissão de doenças
6. Interações entre espécies
7. Processos de diversificação
8. Dispersão de espécies
9. Processos de extinção
10. Conservação-evolução do nicho
11. Testar hipóteses filogeográficas
12. Estabelecer refúgios climáticos
13. Estabelecer hotspots
14. Estabelecer áreas protegidas
15. Eficiência das áreas protegidas

SDM passo a passo

Estrutura dos ENMs

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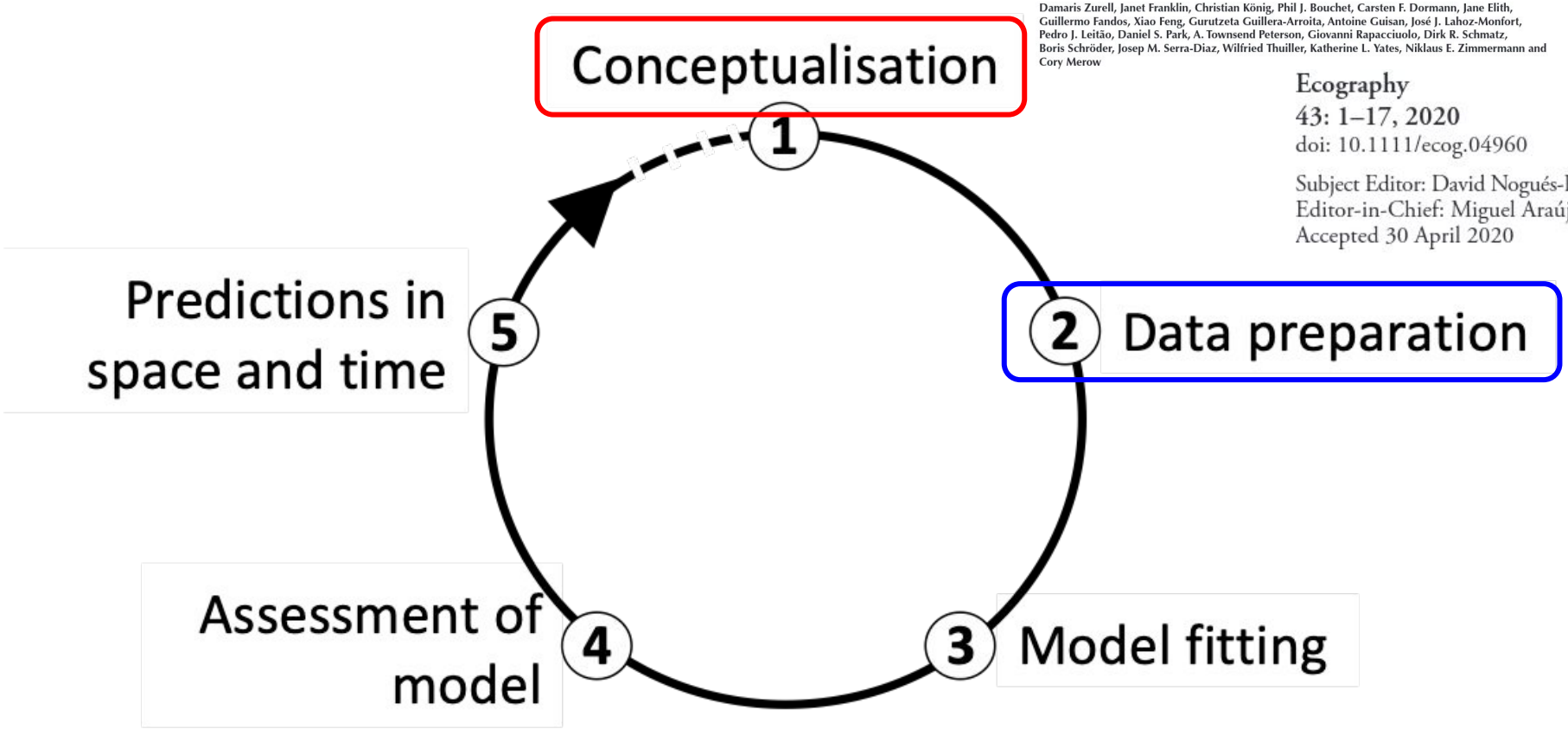
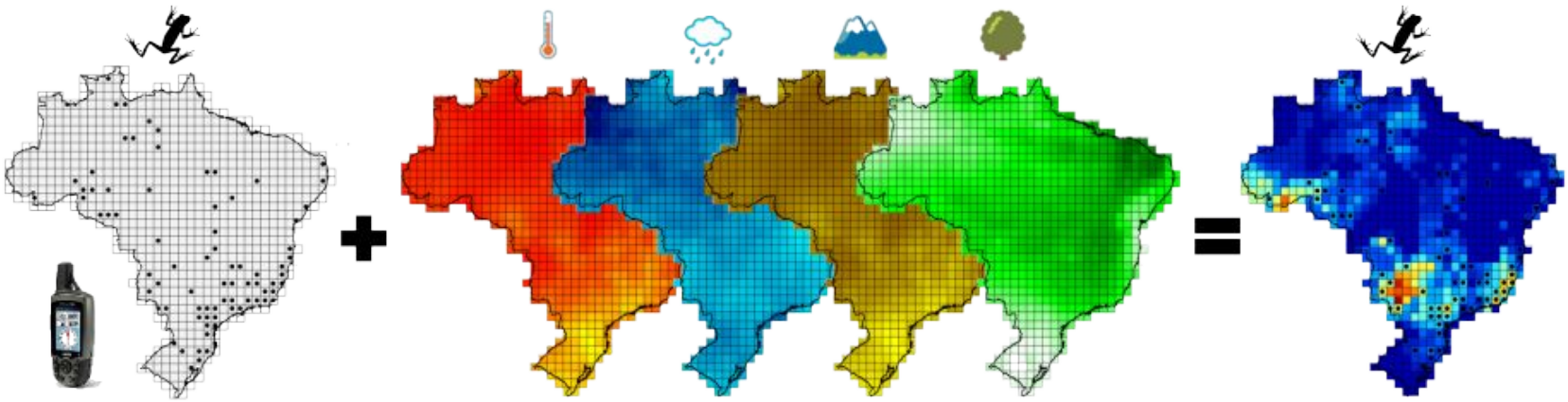


https://doi.org/10.1111/ecog.04960

Modelos de Nicho Ecológico (ENMs)

Preparação dos dados



"Ocorrências"

species	lon	lat
sp1	-40.2	-23.4
sp1	-38.8	-20.3
sp1	-43.3	-19.9

Variáveis ambientais

variaveis
temperatura
precipitação
relevo

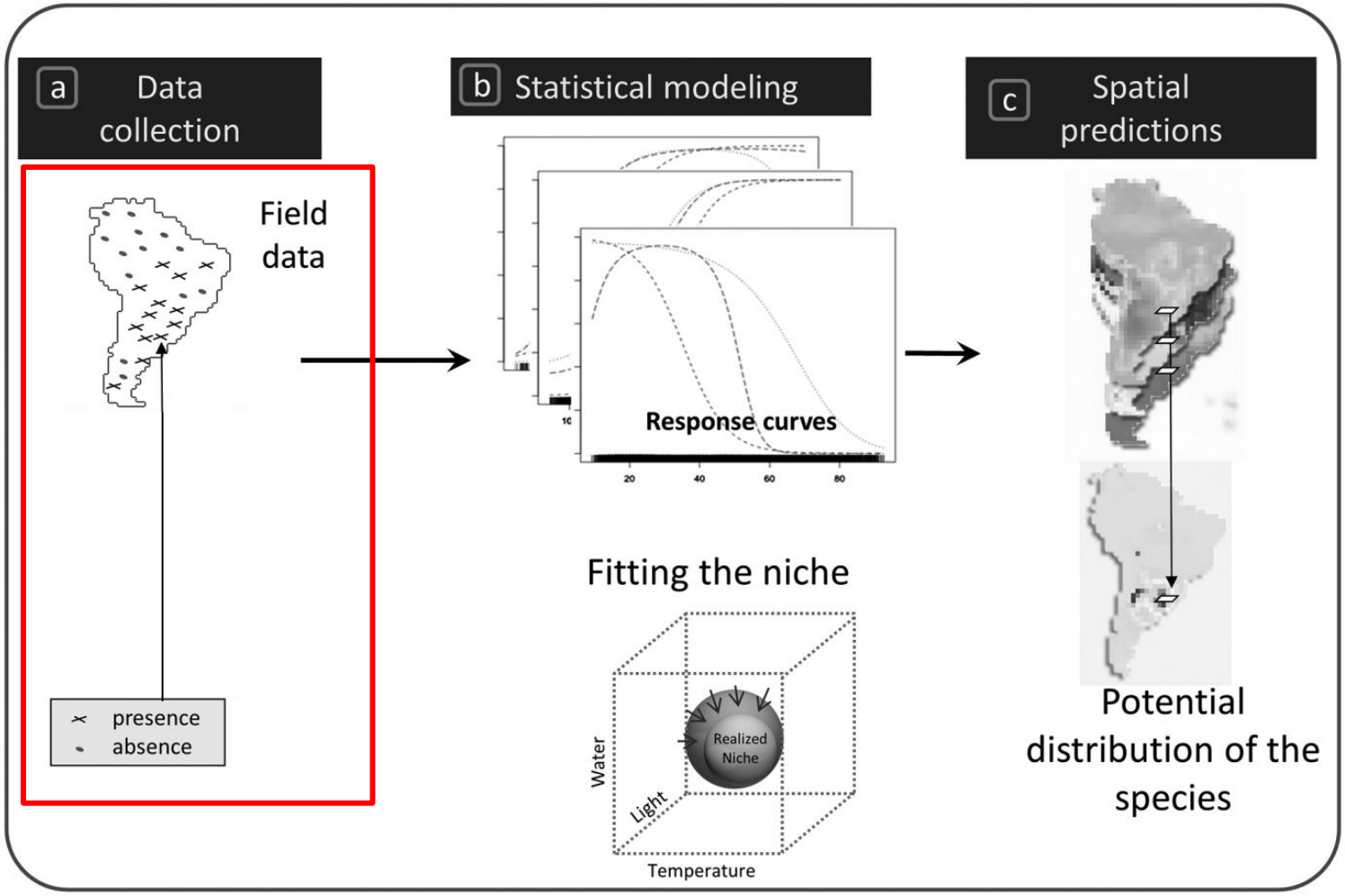
Adequabilidade

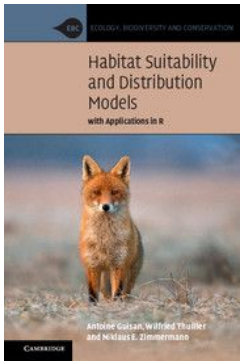
valores
0
até
1

5. Dados de entrada: ocorrências e variáveis

Ocorrências

Visão geral





Guisan et al. (2017)

Ocorrências

Fontes

1. Coletas em campo

Ocorrências

Fontes

1. Coletas em campo
2. Literatura (artigos, data papers, ...)

Ocorrências

Fontes

1. Coletas em campo
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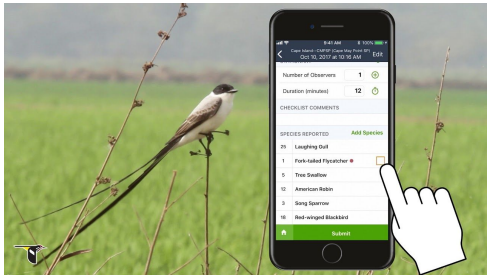

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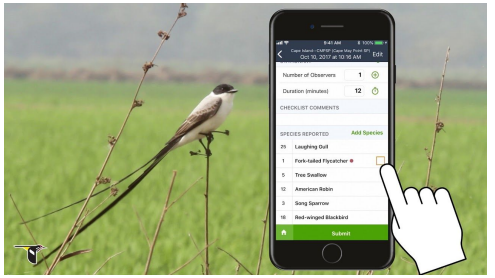

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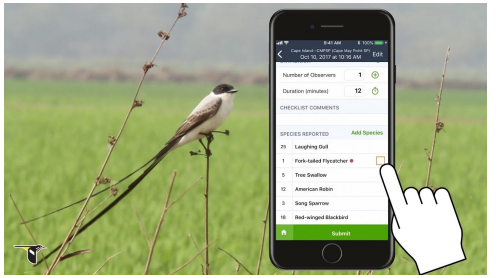
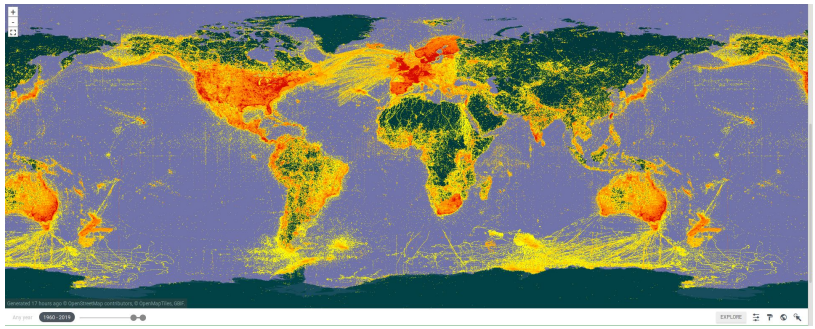
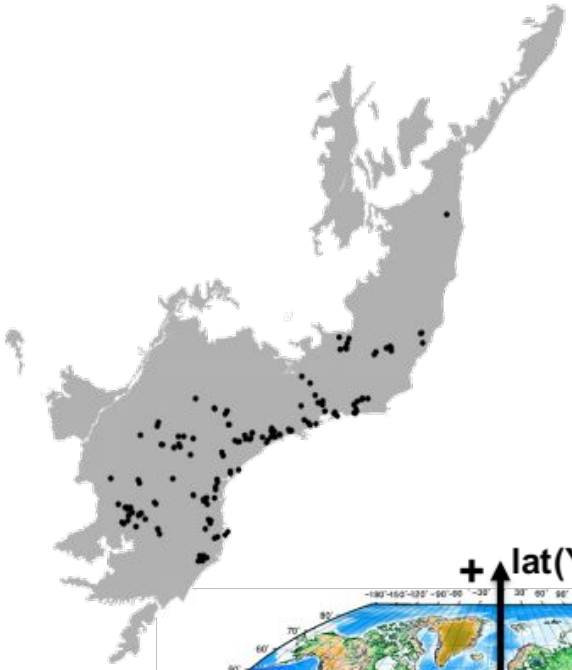
4. Coleções científicas e museus (Museu Nacional, MZUSP, CFHB, ...)
5. Banco de dados (GBIF, SpeciesLink, ...)



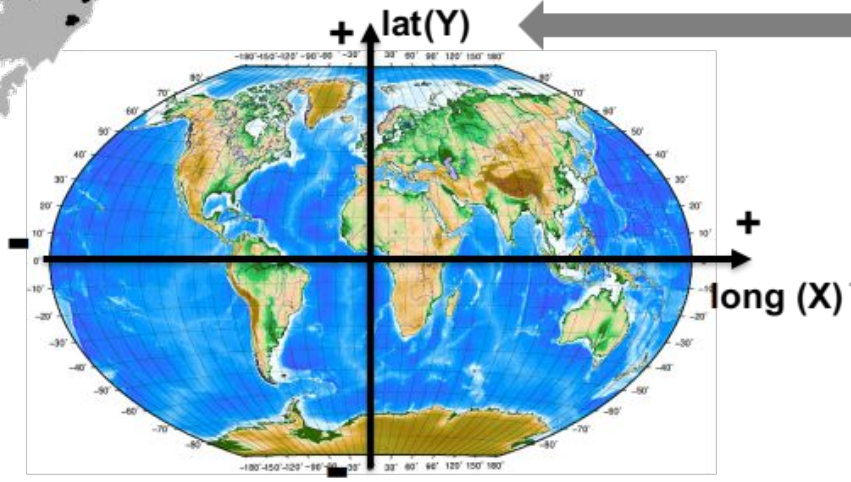


Ocorrências

Formato



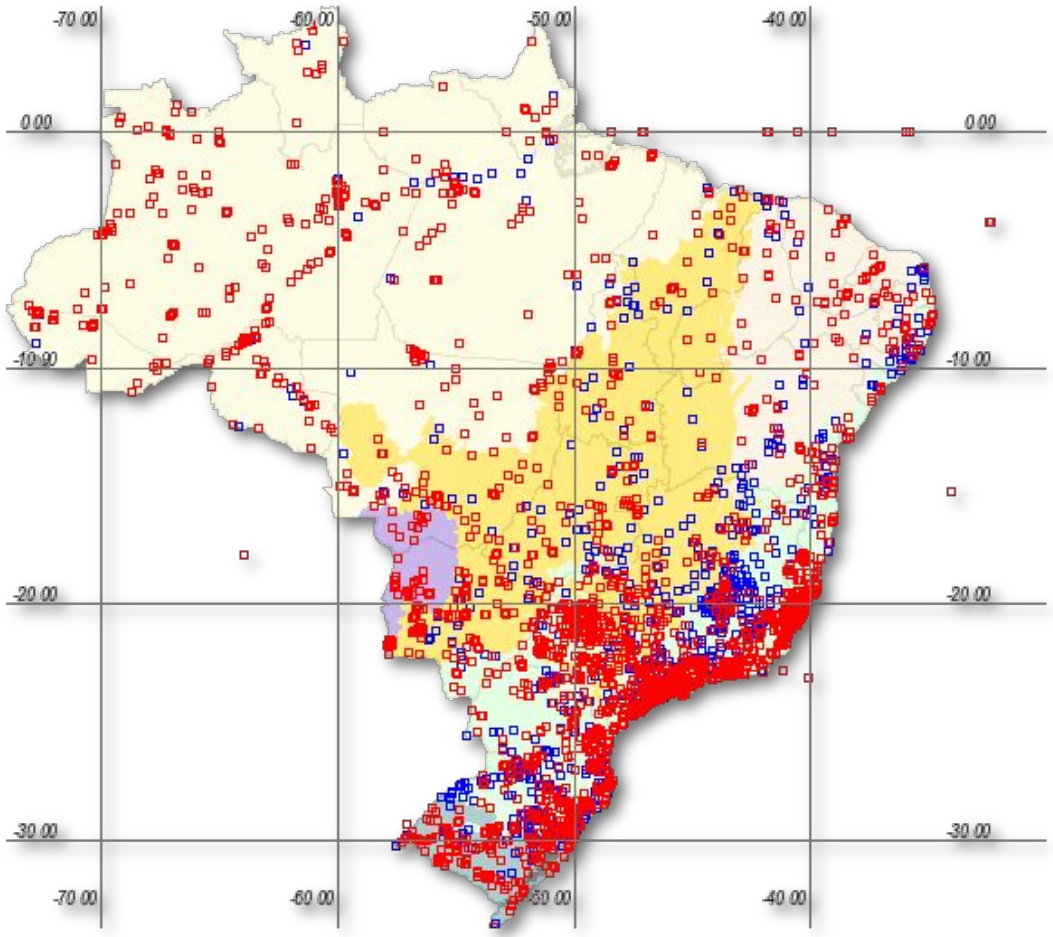
sp	long	lat
vitreorana_uranoscopa	-52.8300	-26.4400
vitreorana_uranoscopa	-52.6836	-27.1253
vitreorana_uranoscopa	-52.5569	-26.5642
vitreorana_uranoscopa	-52.4500	-26.5667
vitreorana_uranoscopa	-52.4489	-27.0689
vitreorana_uranoscopa	-52.4147	-26.8667



Desafios:
Viés de amostragem

Ocorrências

Viés de amostragem

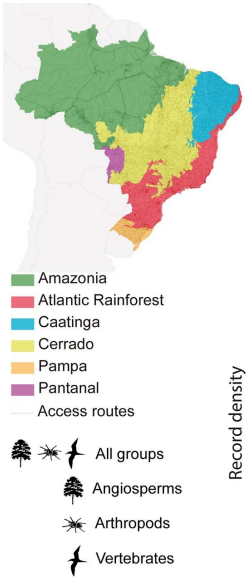


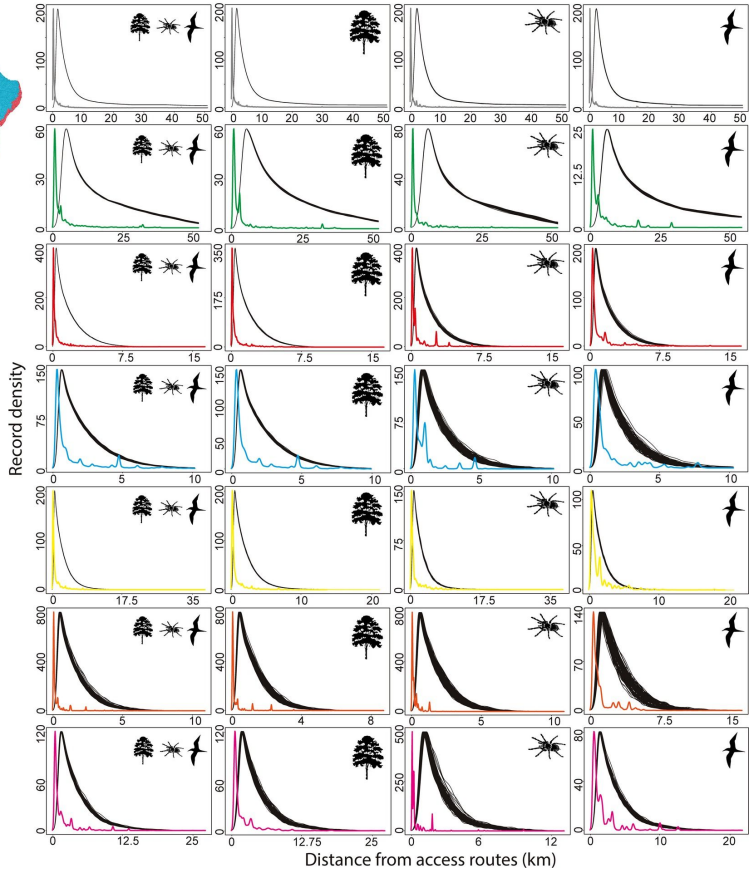
Boana faber

speciesLink

Ocorrências

Viés de amostragem



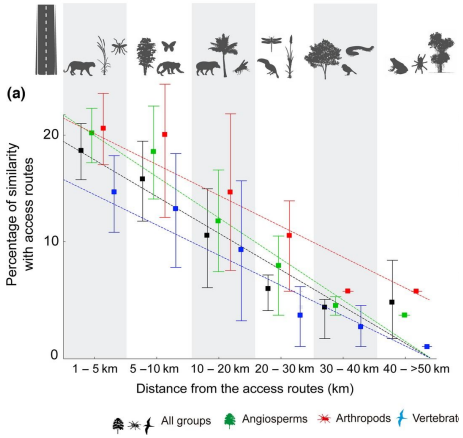


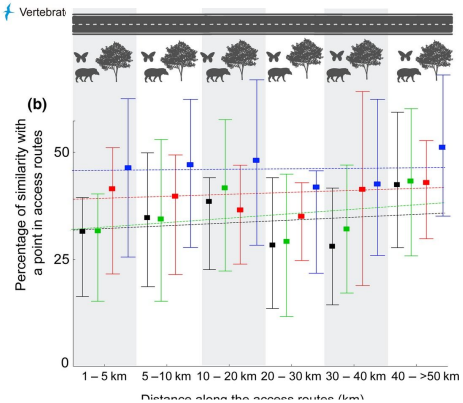
Diversity and Distributions, (Diversity Distrib.) (2016) **22**, 1232–1244

BIODIVERSITY RESEARCH

The strong influence of collection bias on biodiversity knowledge shortfalls of Brazilian terrestrial biodiversity

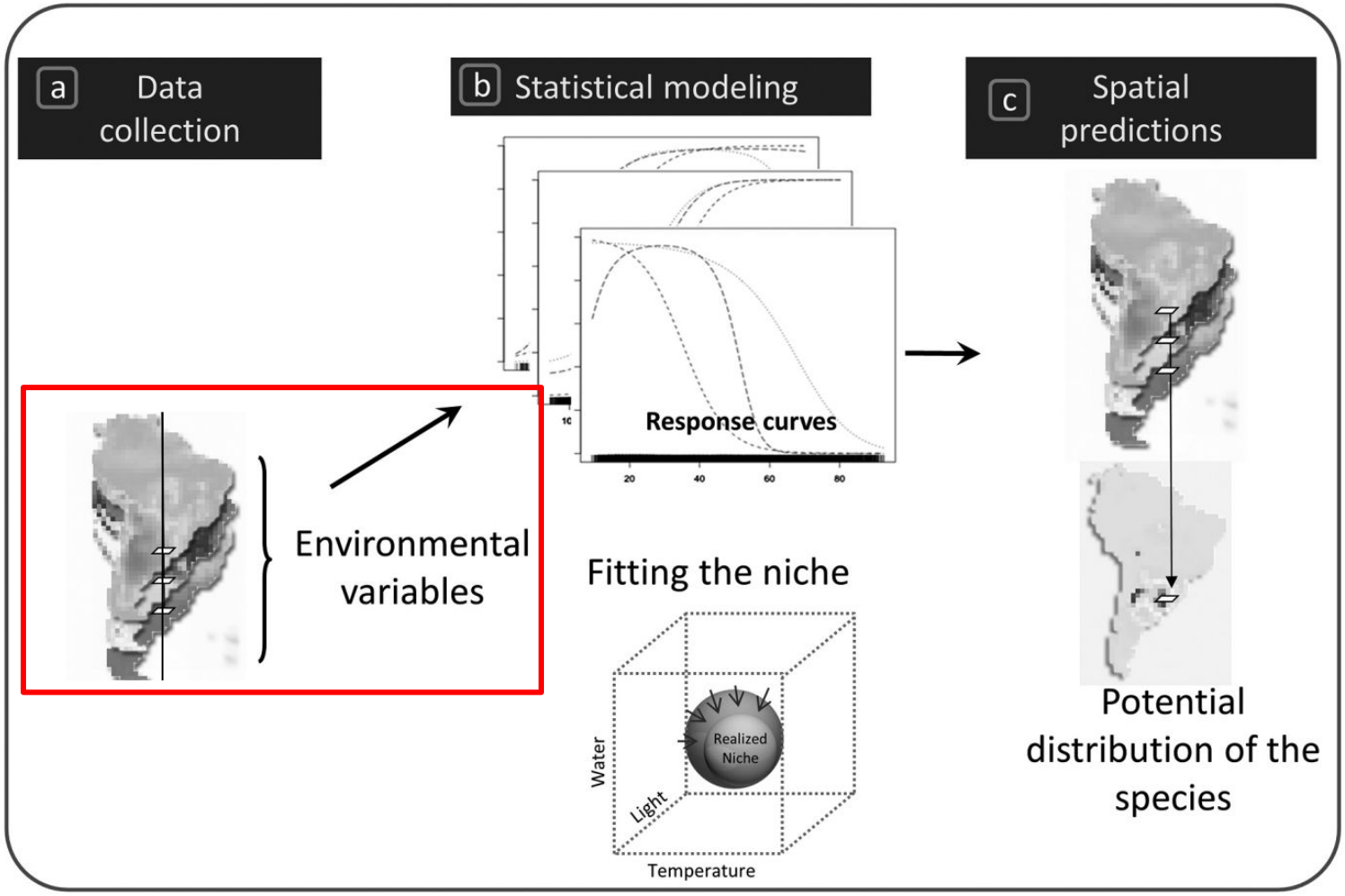
Ubirajara Oliveira[1,2*], Adriano Pereira Paglia[3], Antonio D. Brescovit[4], Claudio J. B. de Carvalho[5], Daniel Paiva Silva[6], Daniella T. Rezende[7], Felipe Sá Fortes Leite[8], João Aguiar Nogueira Batista[9], João Paulo Peixoto Pena Barbosa[4], João Renato Stehmann[9], John S. Ascher[10], Marcelo Ferreira de Vasconcelos[11,12], Paulo De Marco Jr[13], Peter Löwenberg-Neto[14], Priscila Guimarães Dias[15], Viviane Gianluppi Ferro[13] and Adalberto J. Santos[2]

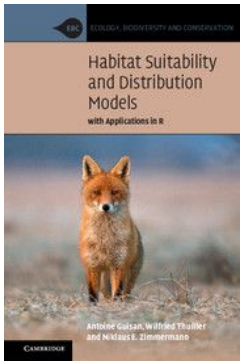




Variáveis ambientais

Visão geral

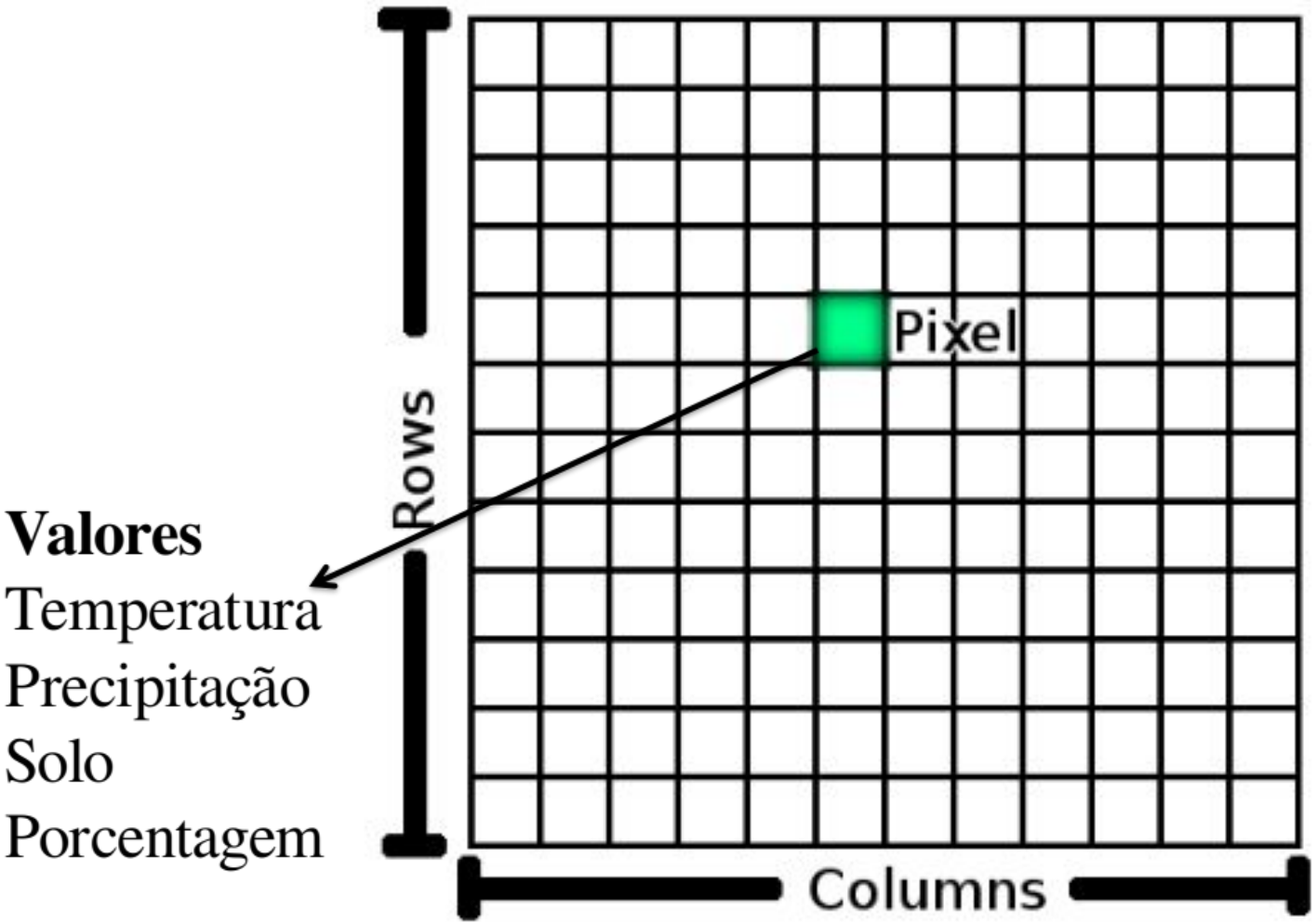




Guisan et al. (2017)

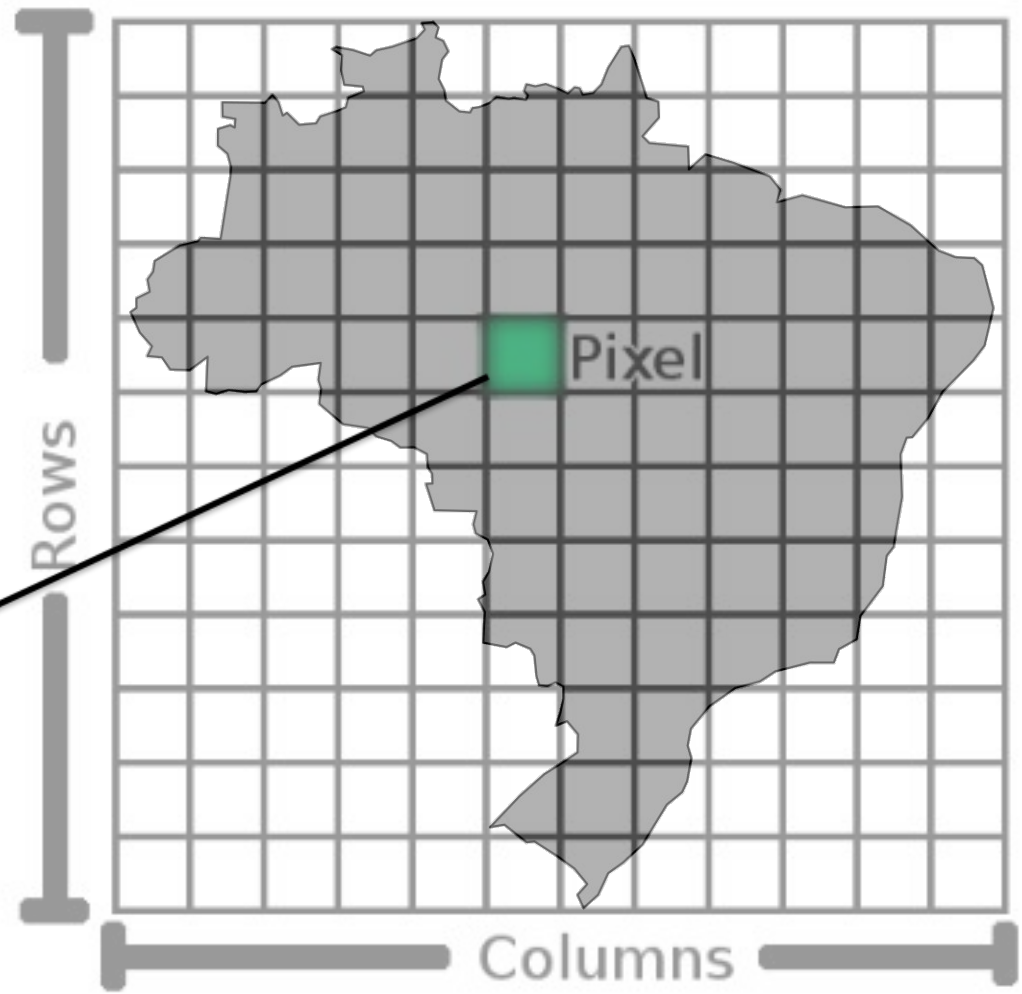
Variáveis ambientais

Raster - Extensão e resolução



Variáveis ambientais

Raster - Extensão e resolução

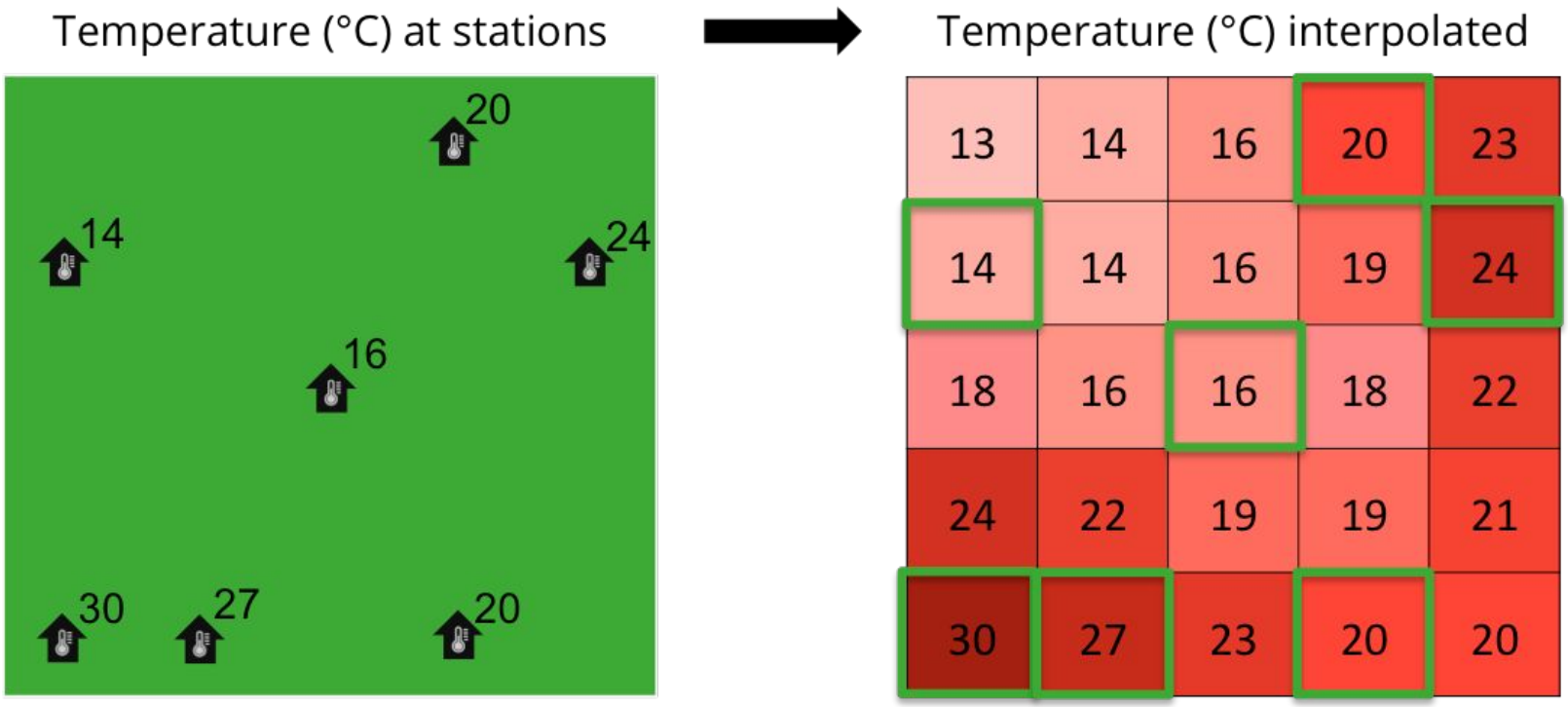


Valores
Temperatura
Precipitação
Solo
Porcentagem

Variáveis ambientais

Raster - Interpolação

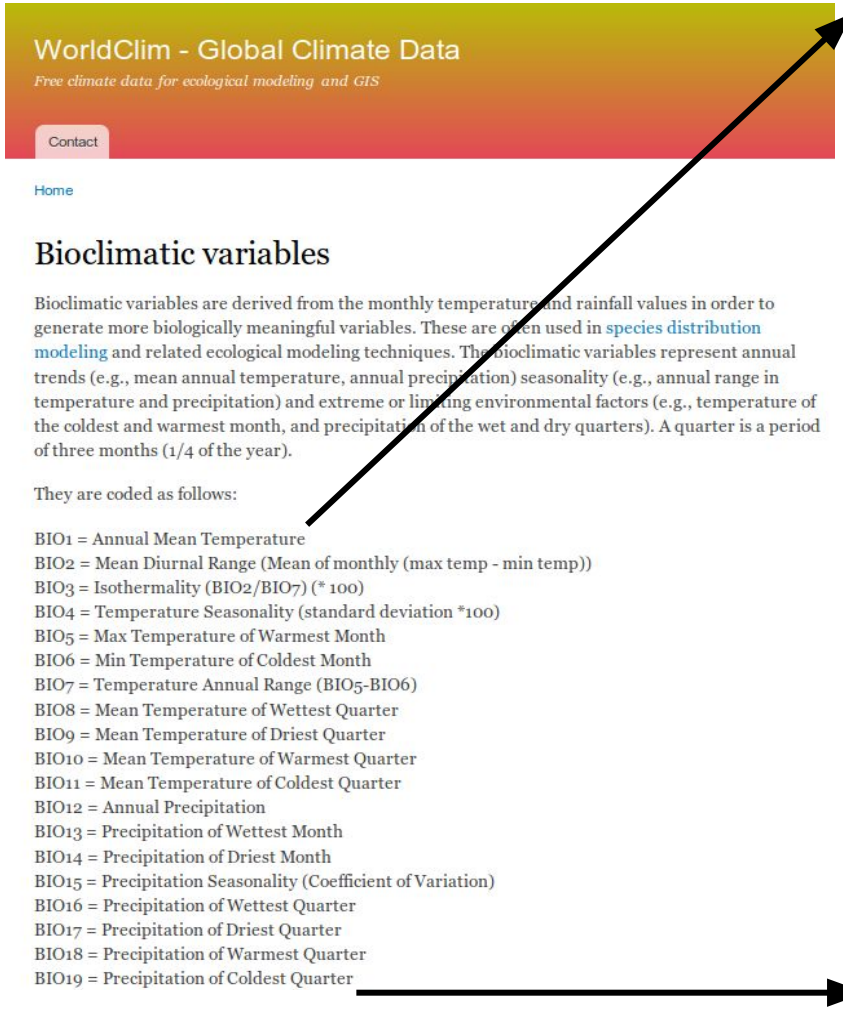
https://support.bccvl.org.au/support/home



Adapted from http://planet.botany.uwc.ac.za/nisl/GIS/spatial/chap_1_11.h

Variáveis ambientais

WorldClim - Bioclimáticas



BIO01 = Temperatura média anual
BIO02 = Variação Diurna Média de Temperatura (Média mensal (Tmax-Tmin))
BIO03 = Isotermalidade ((BIO2/BIO7) (* 100))
BIO04 = Sazonalidade da Temperatura (desvio padrão * 100)
BIO05 = Temperatura máxima do mês mais quente
BIO06 = Temperatura mínima do mês mais frio
BIO07 = Amplitude térmica anual (BIO5-BIO6)
BIO08 = Temperatura média do trimestre mais úmido
BIO09 = Temperatura média do trimestre mais seco
BIO10 = Temperatura média do trimestre mais quente
BIO11 = Temperatura média do trimestre mais frio

Temperatura

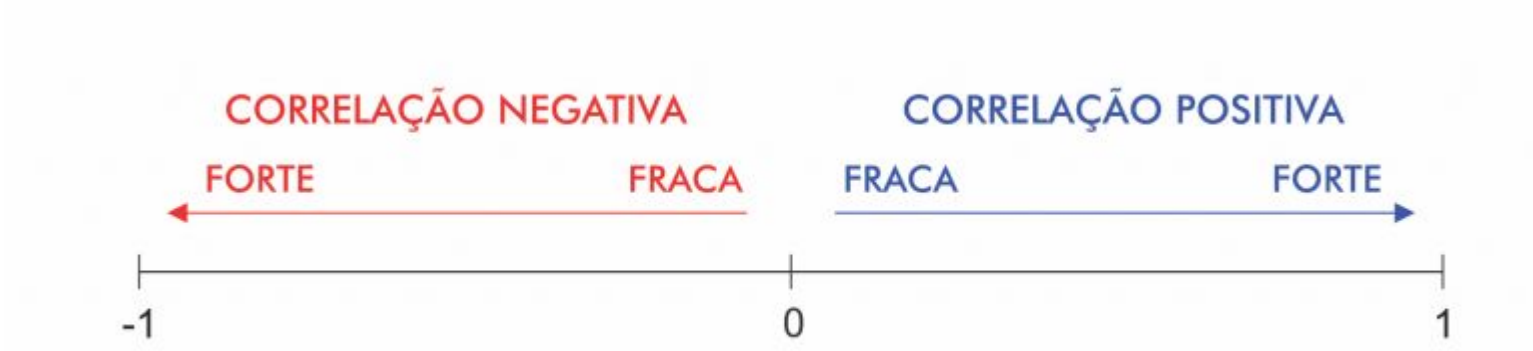
BIO12 = Precipitação Anual
BIO13 = Precipitação do mês mais chuvoso
BIO14 = Precipitação do mês mais seco
BIO15 = Sazonalidade da Precipitação (coeficiente de variação)
BIO16 = Precipitação do trimestre mais chuvoso
BIO17 = Precipitação do trimestre mais seco
BIO18 = Precipitação do trimestre mais quente
BIO19 = Precipitação do trimestre mais frio

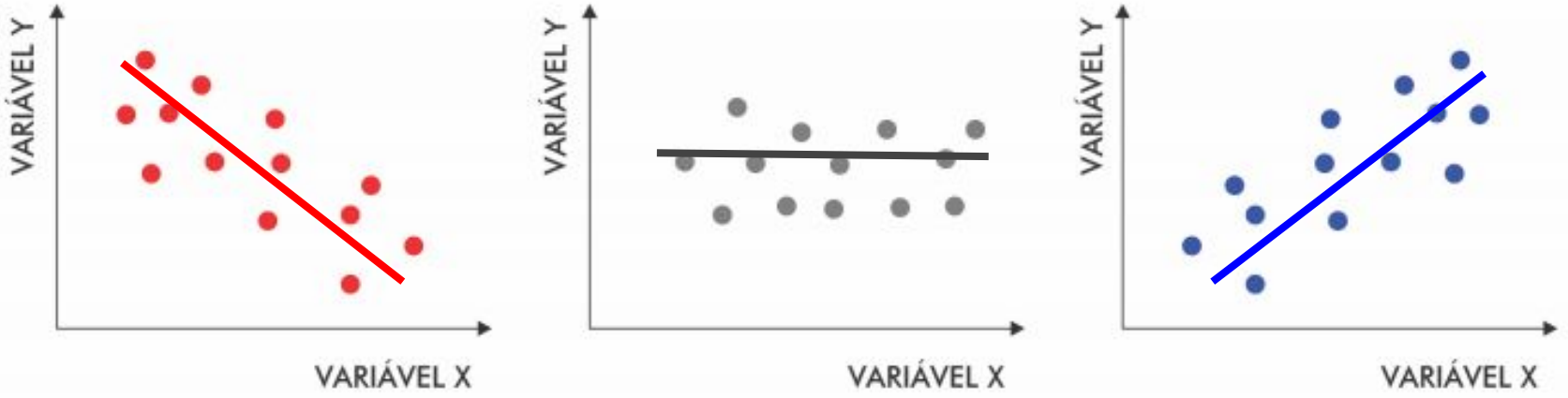
Precipitação

Desafios: Colinearidade

Variáveis ambientais

Colinearidade - Correlação





SDM passo a passo

Estrutura dos ENMs

ECOGRAPHY

Review and synthesis

A standard protocol for reporting species distribution models

Damaris Zurell, Janet Franklin, Christian König, Phil J. Bouchet, Carsten F. Dormann, Jane Elith, Guillermo Fandos, Xiao Feng, Gurutzeta Guillera-Arroita, Antoine Guisan, José J. Lahoz-Monfort, Pedro J. Leitão, Daniel S. Park, A. Townsend Peterson, Giovanni Rapacciuolo, Dirk R. Schmatz, Boris Schröder, Josep M. Serra-Diaz, Wilfried Thuiller, Katherine L. Yates, Niklaus E. Zimmermann and Cory Merow

Ecography
43: 1–17, 2020
doi: 10.1111/ecog.04960

Subject Editor: David Nogués-Bravo
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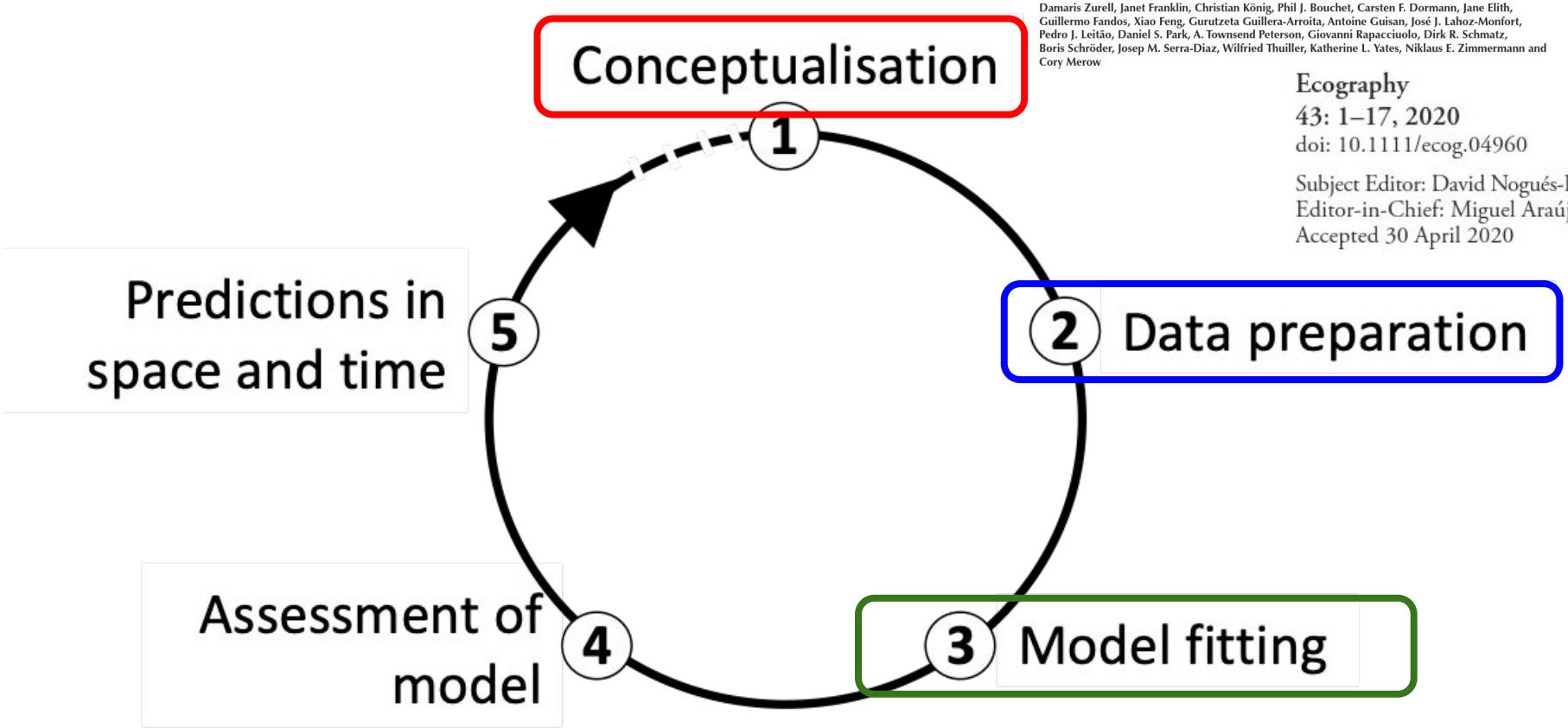
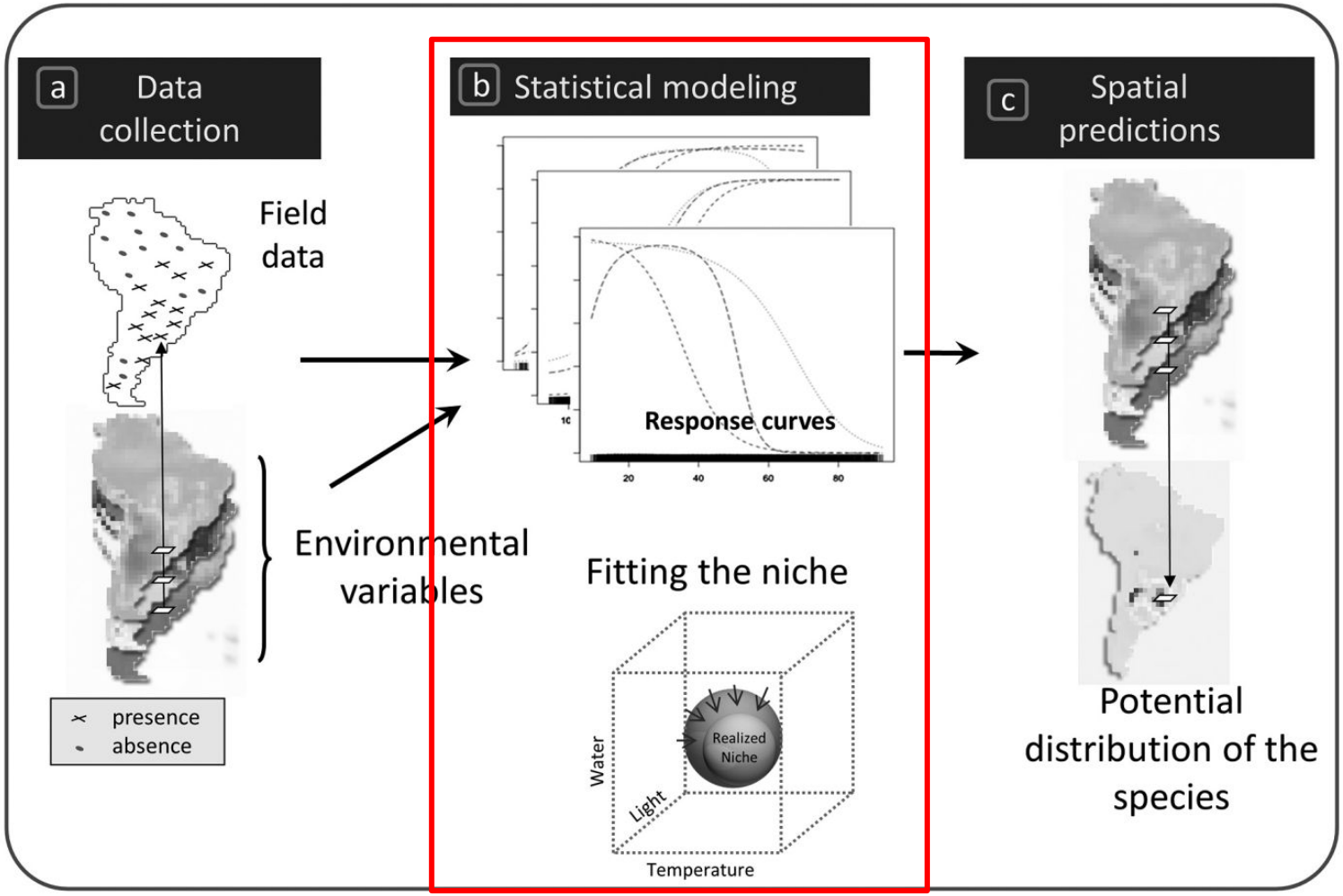
Accepted 30 April 2020

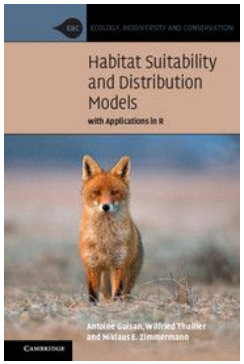


6. Ajuste dos modelos

Ajuste dos ENMs

Algoritmos estimam o nicho realizado





Guisan et al. (2017)

Ajuste dos ENMs

Muitos tipos de algoritmos

Lima-Ribeiro &
Diniz-Filho (2013)

Apenas presença

Aquário

- Bioclim
- Dist. Euclidiana
- Dist. Mahalanobis
- Domain (dist. Gower)
- ENFA (ecological niche factor analysis)

Presença/Background

- GARP (genetic algoritm for rule-set production)
- Maxent (maximum entropy)
- SVM (support vector machine)

Aprendizado de Máquina
(*machine learning*)
"cofre"

Presença/Ausência

Estatístico ("turbina")

- GLMz (generalized linear model)
- GAM (generalized additive model)
- FDA (flexible discriminant analysis)
- MARS (multivariate adaptive reg. splines)

- BRT (boosted regression trees)
  - GBM (gradient boosting machine)
- CART (classification and regression trees)
- RDNFOR (random forest)
- NNET (neural networks)
  - ANN (artificial neural networks)

Ajuste dos ENMs

Mais utilizado - MaxEnt

Lima-Ribeiro &
Diniz-Filho (2013)

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Ajuste dos ENMs

Apenas Presença

Lima-Ribeiro &
Diniz-Filho (2013)

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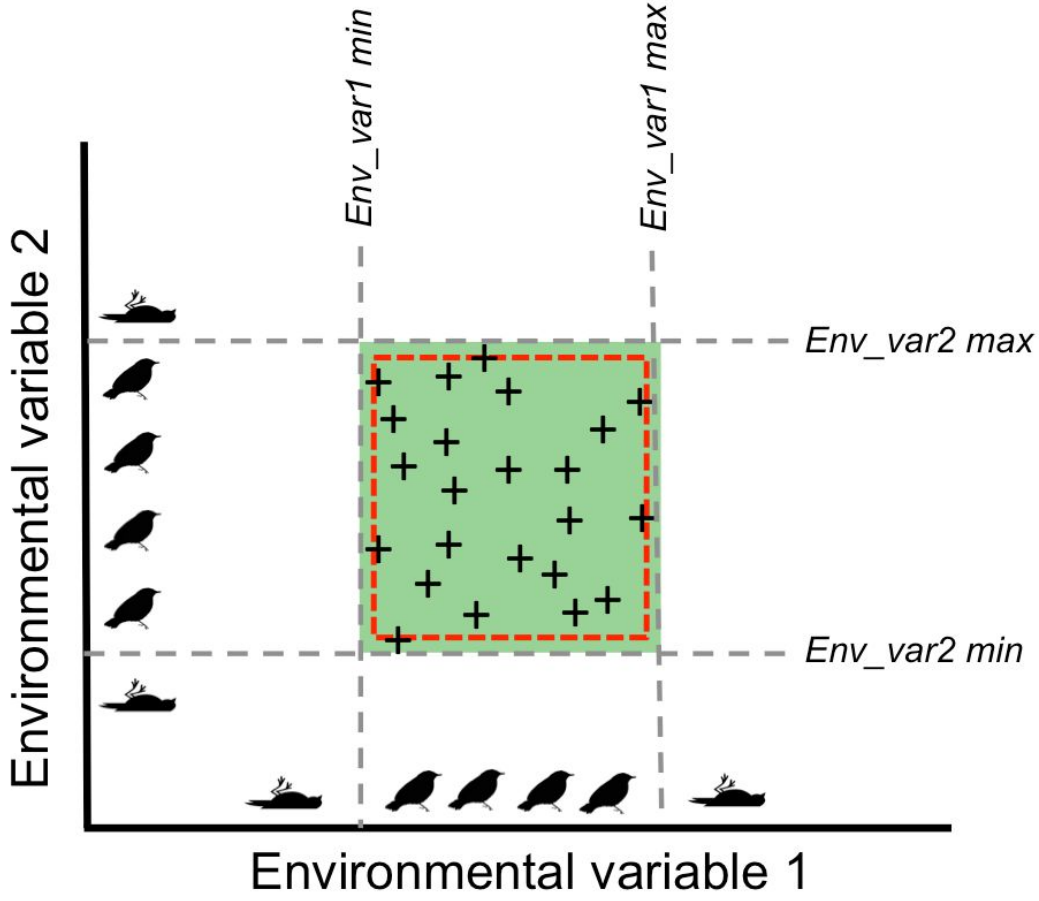
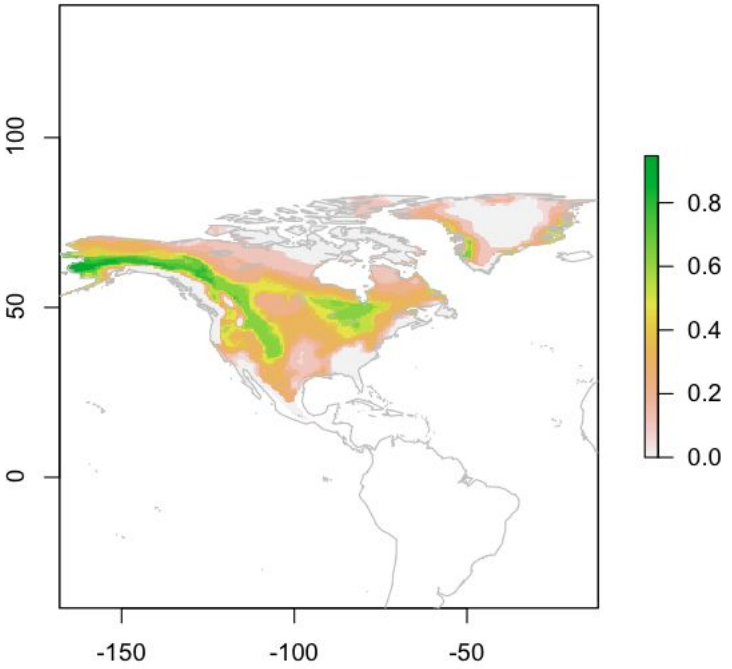
  - ANN (artificial neural networks)

Ajuste dos ENMs

BIOCLIM - Envelope Climático

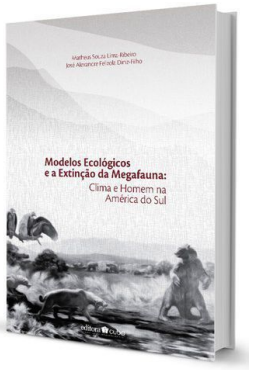
Lima-Ribeiro &
Diniz-Filho (2013)





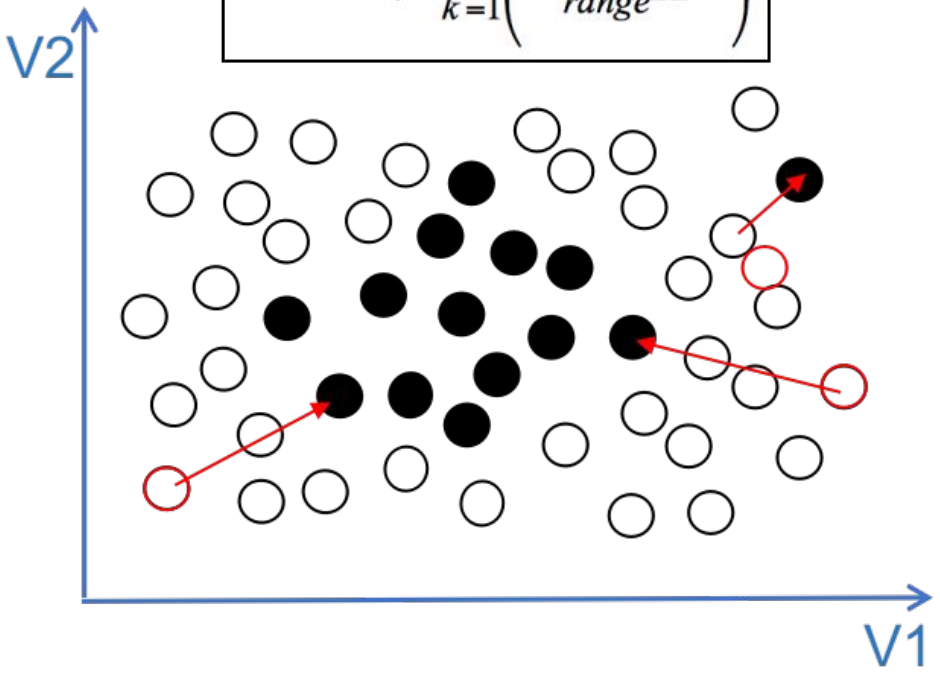
Ajuste dos ENMs

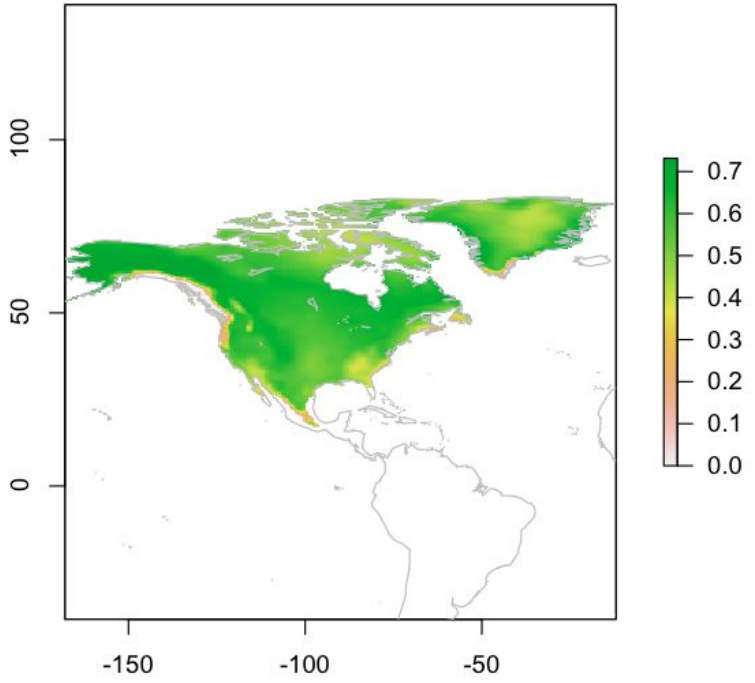
DOMAIN - Distância de Gower



Lima-Ribeiro &
Diniz-Filho (2013)

$$d_{AB} = \frac{1}{V}\sum_{k=1}^{V}\left(\frac{\left|A_K - B_K\right|}{range K}\right)$$





Ajuste dos ENMs

Presença/Background (plano de fundo)

Lima-Ribeiro &
Diniz-Filho (2013)

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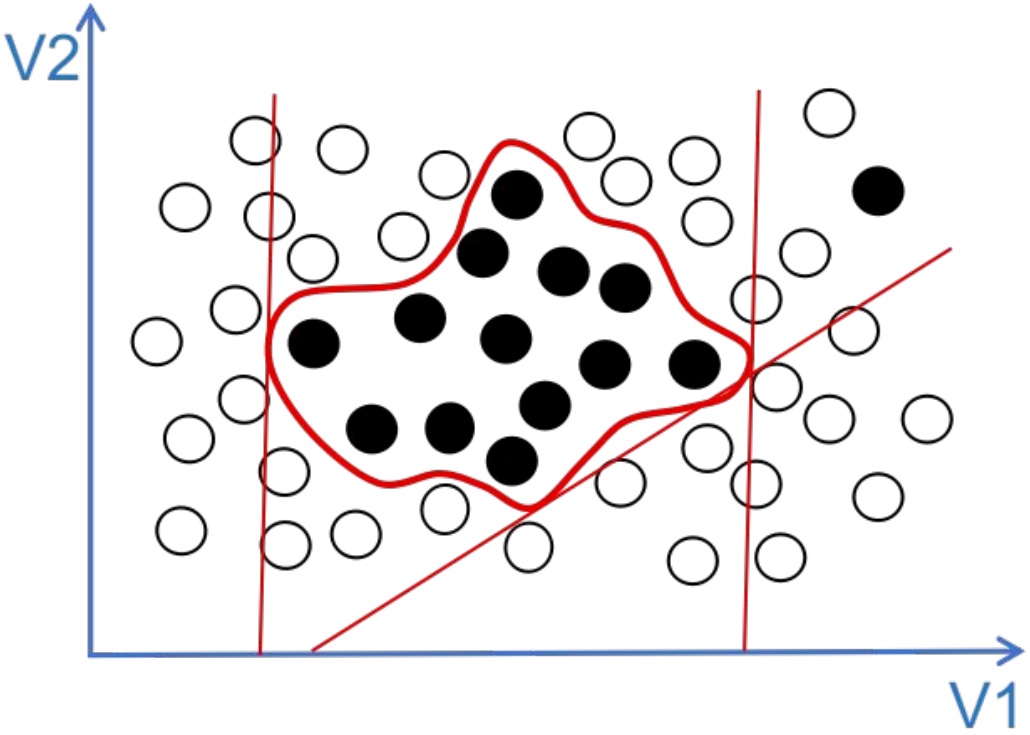
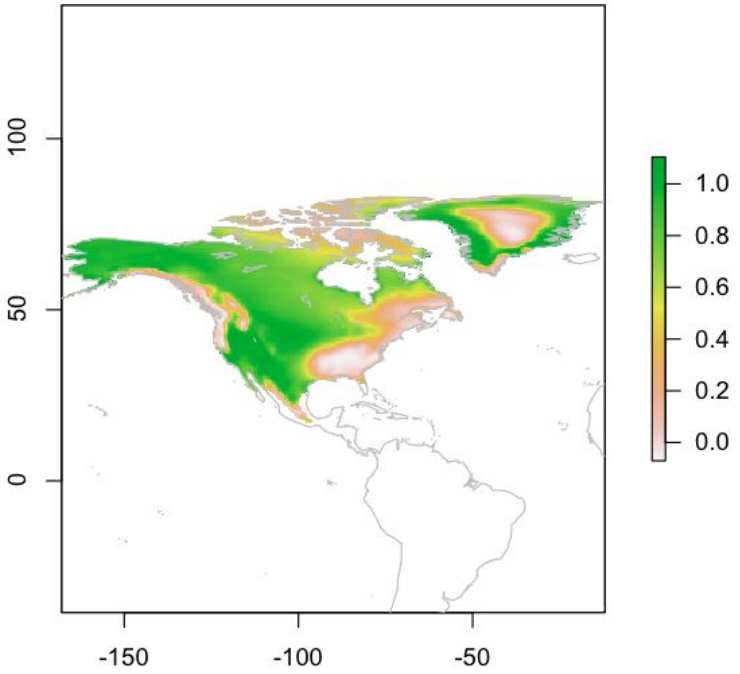
Ajuste dos ENMs

Support Vector Machine (SVM)

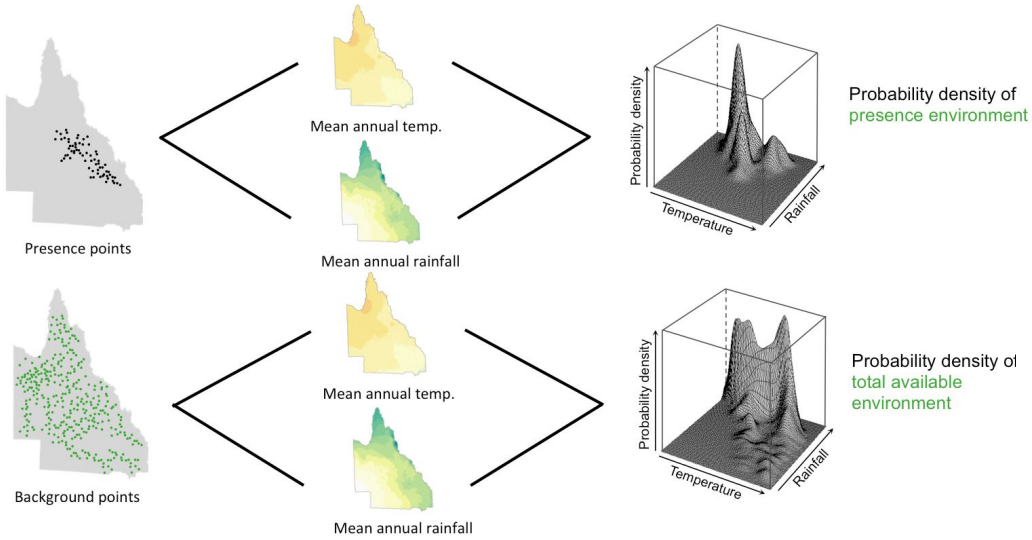
Lima-Ribeiro &
Diniz-Filho (2013)



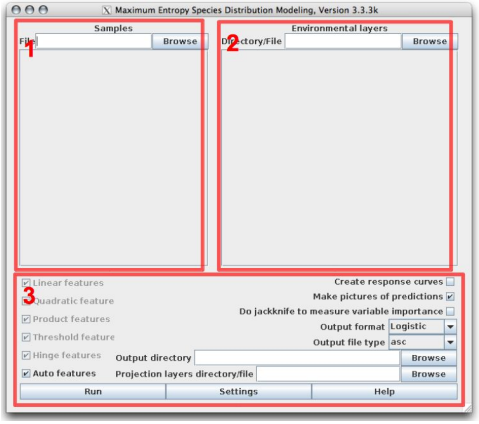


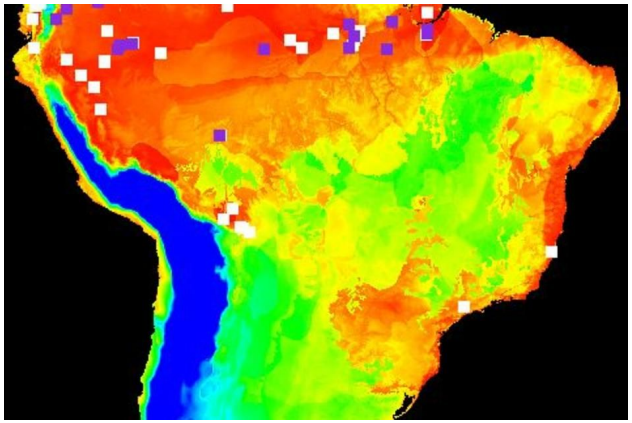
Ajuste dos ENMs

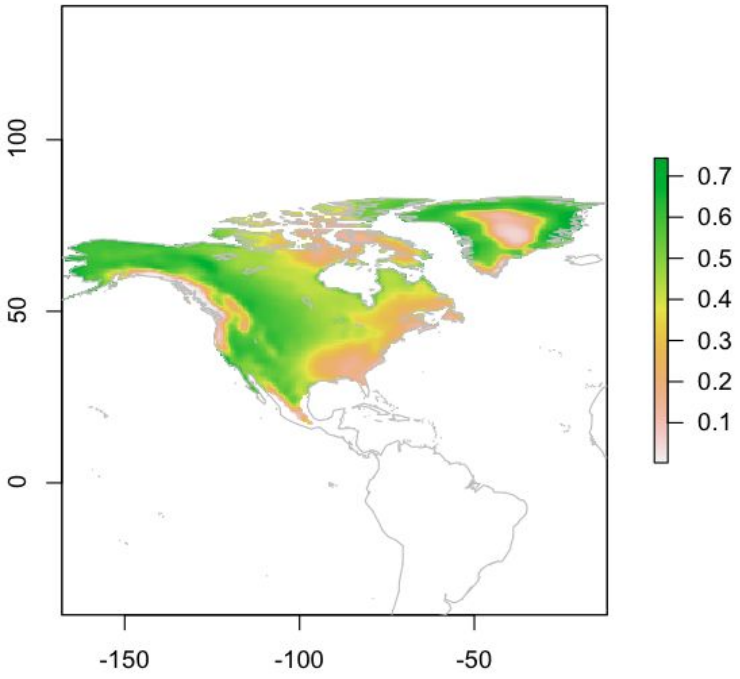
Maximum Entropy (MaxEnt)



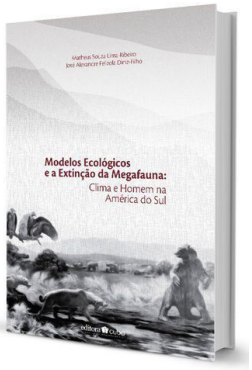
Adapted from Elith et al. (2011) *A statistical explanation of MaxEnt for ecologists*. Diversity and Distributions, 17, 43-57.





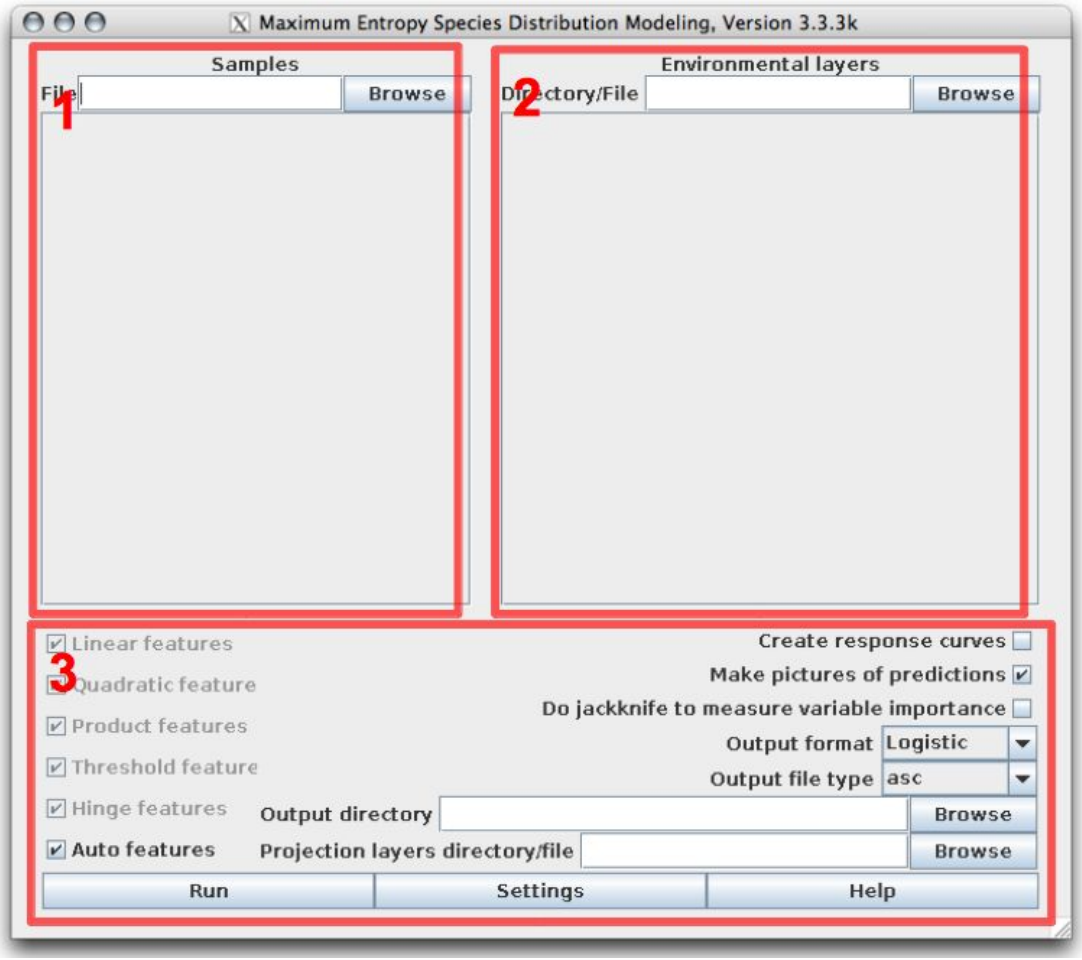


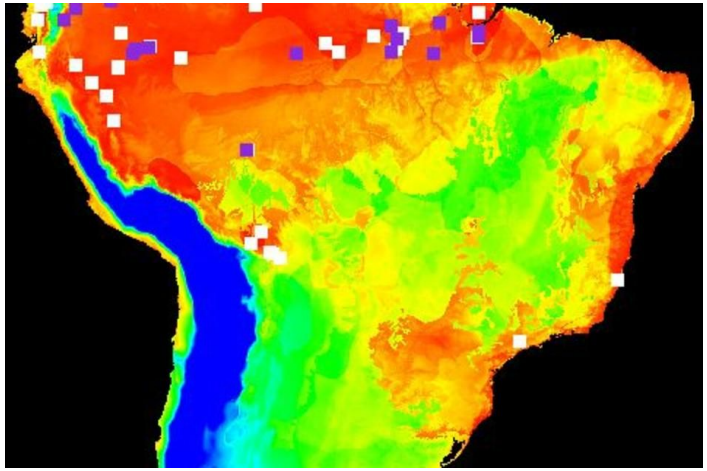
Lima-Ribeiro &
Diniz-Filho (2013)

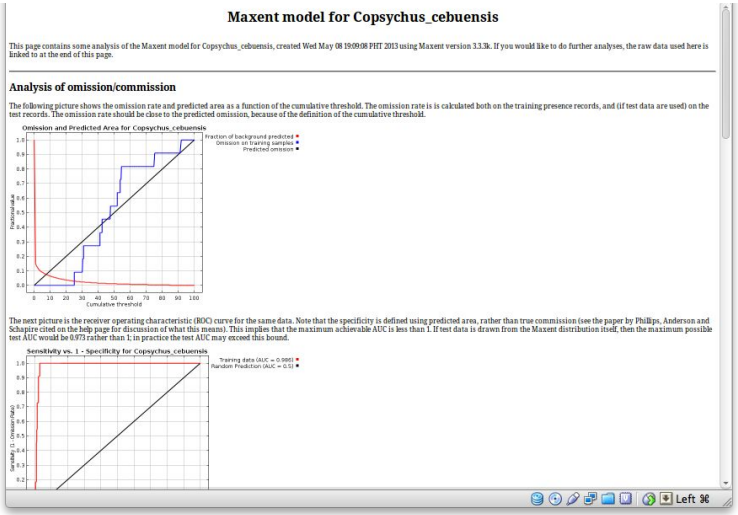


Ajuste dos ENMs

Maximum Entropy (MaxEnt)







Ajuste dos ENMs

Presença e ausência

Lima-Ribeiro &
Diniz-Filho (2013)

Apenas presença

Aquário

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Onde encontrar dados de ausência?

Ajuste dos ENMs

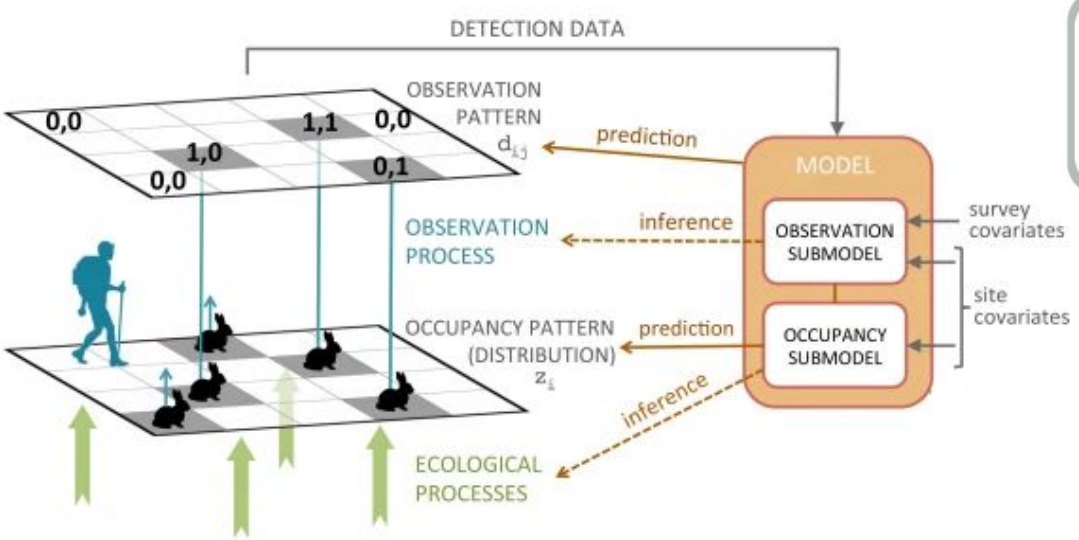
Ausência “real” (modelos de ocupação)

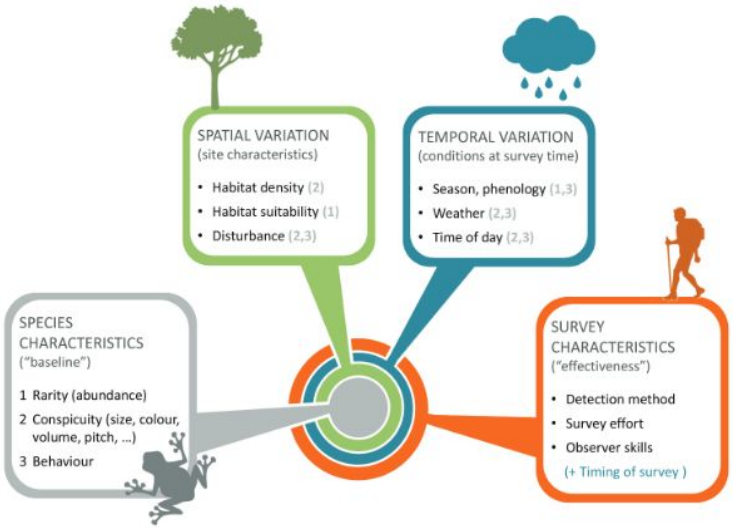
Modelling of species distributions, range dynamics and communities under imperfect detection: advances, challenges and opportunities

Gurutzeta Guillera-Arroita

Ecography 40: 281–295, 2017
doi: 10.1111/ecog.02445

Subject Editor: Miguel Araújo. Editor-in-Chief: Miguel Araújo. Accepted 15 June 2016

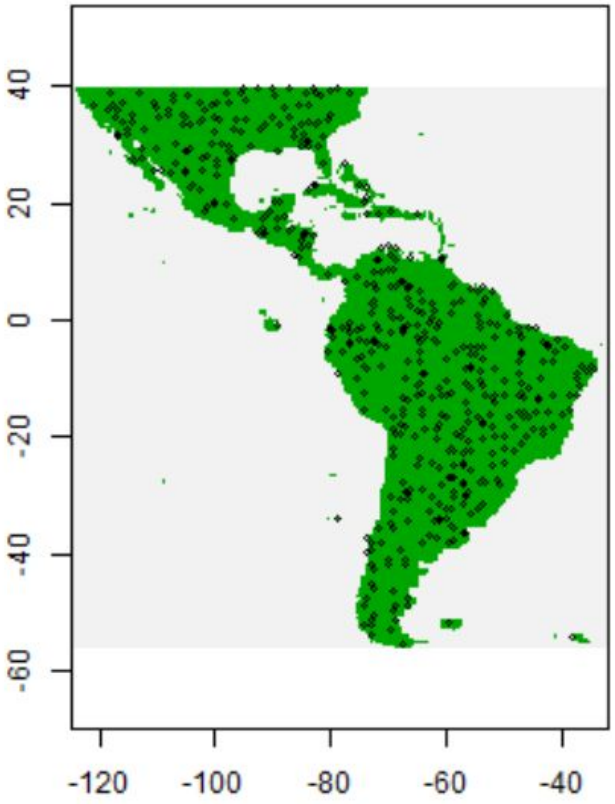


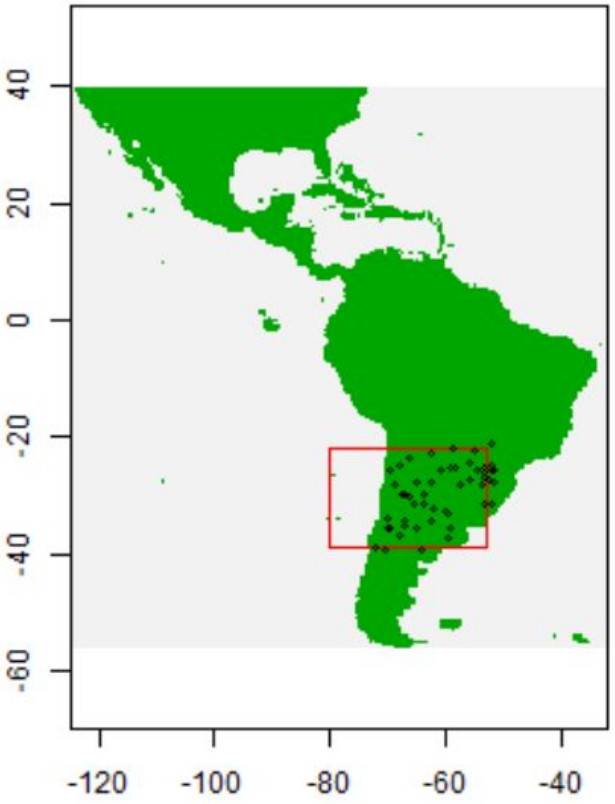


Ajuste dos ENMs

Pseudo-ausência

Sorteio de **pontos aleatórios** (sem **padrão espacial**) para serem considerados como **ausência verdadeira**

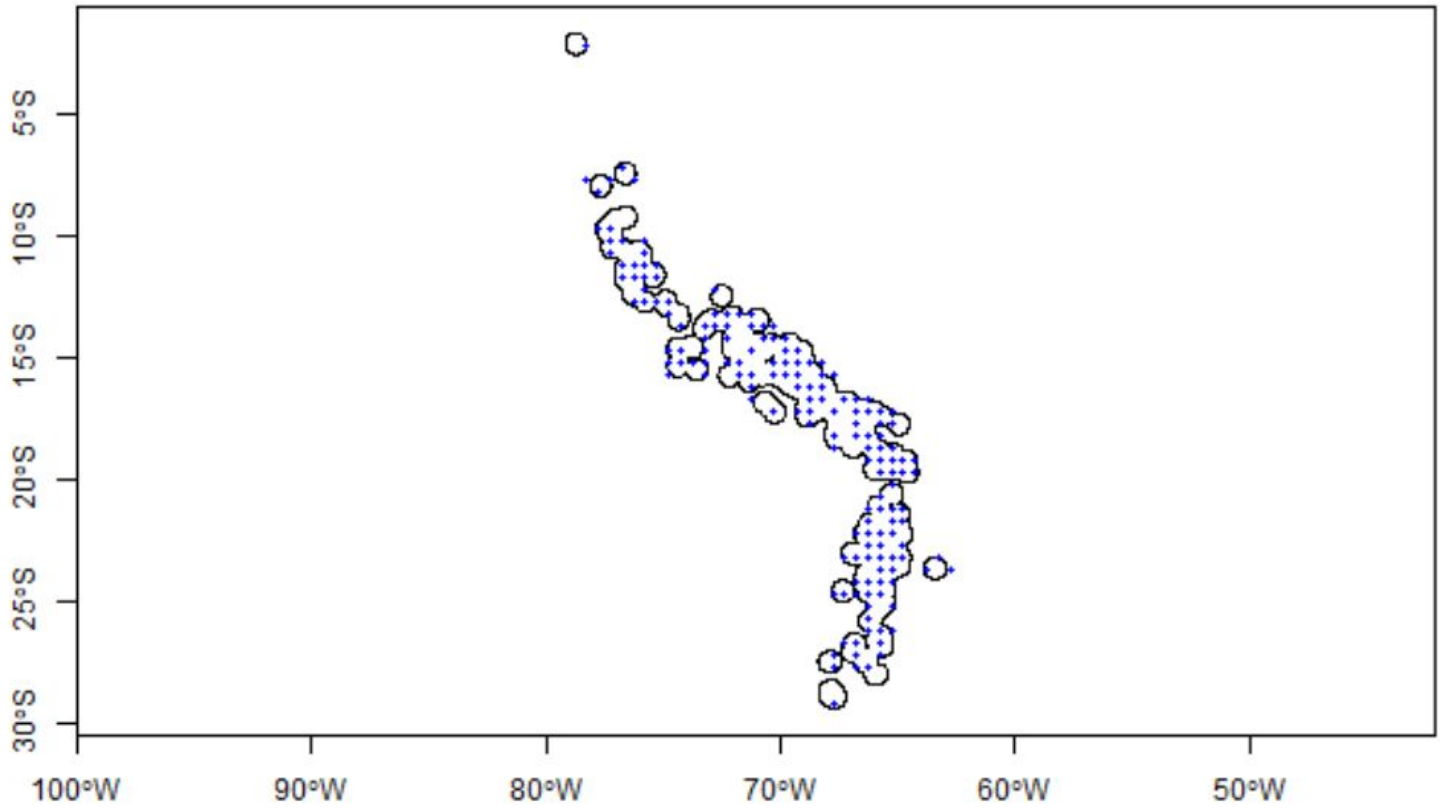




Ajuste dos ENMs

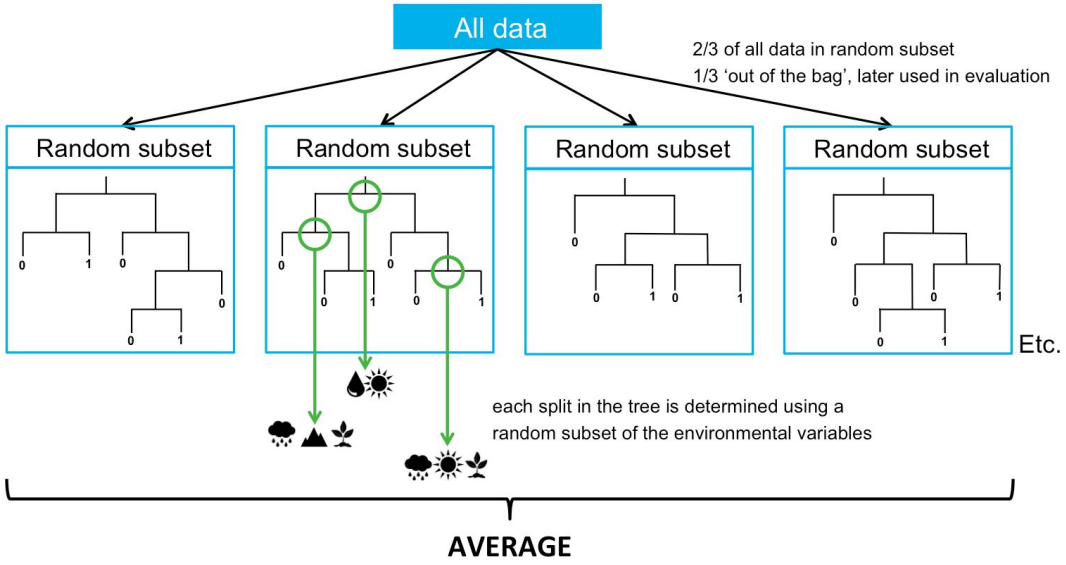
Pseudo-ausência

Sorteio de **pontos aleatórios** (com **padrão espacial**) para serem considerados como **ausência verdadeira**



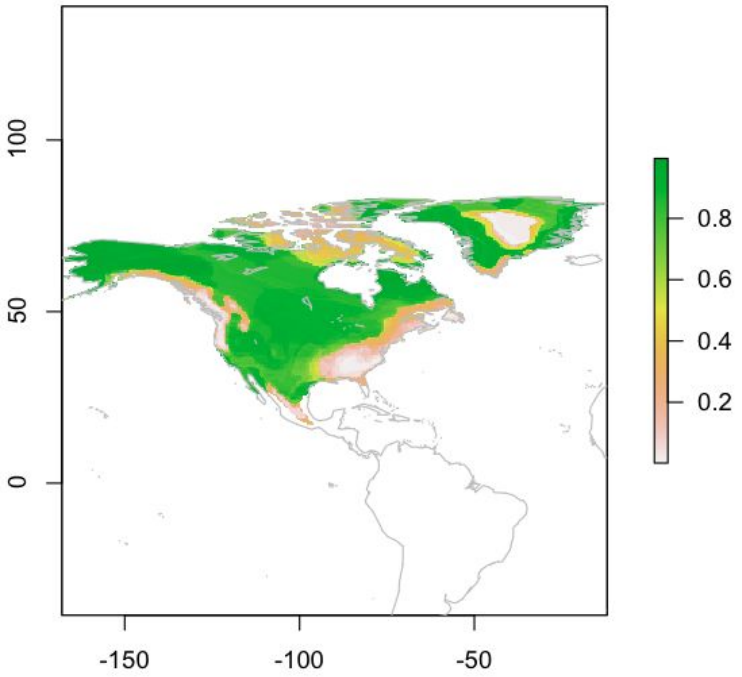
Ajuste dos ENMs

Random Forest



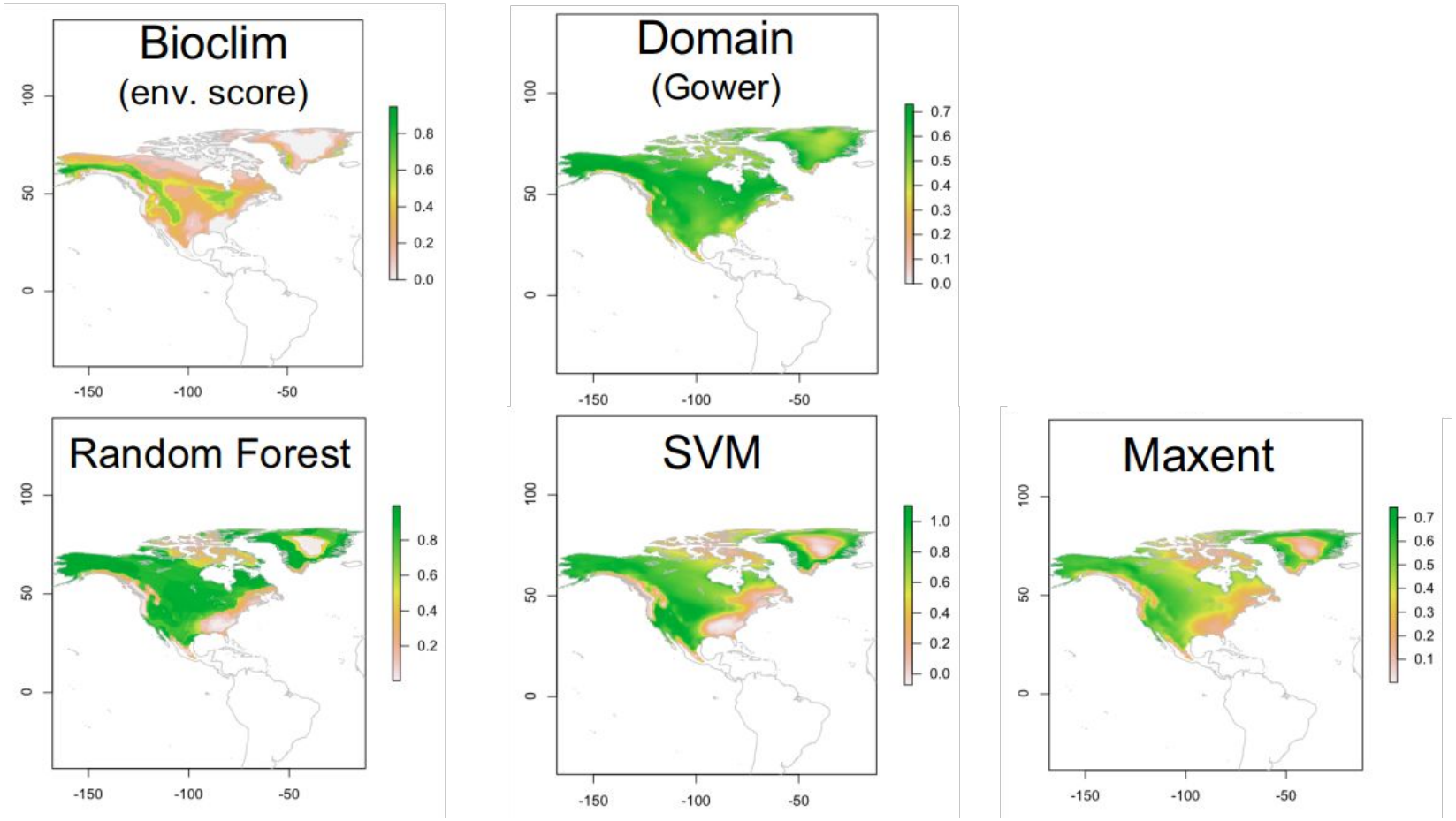
> find the set of predictor variables that produce the strongest classification model

Lima-Ribeiro &
Diniz-Filho (2013)



Ajuste dos ENMs

Qual algoritmo usar?



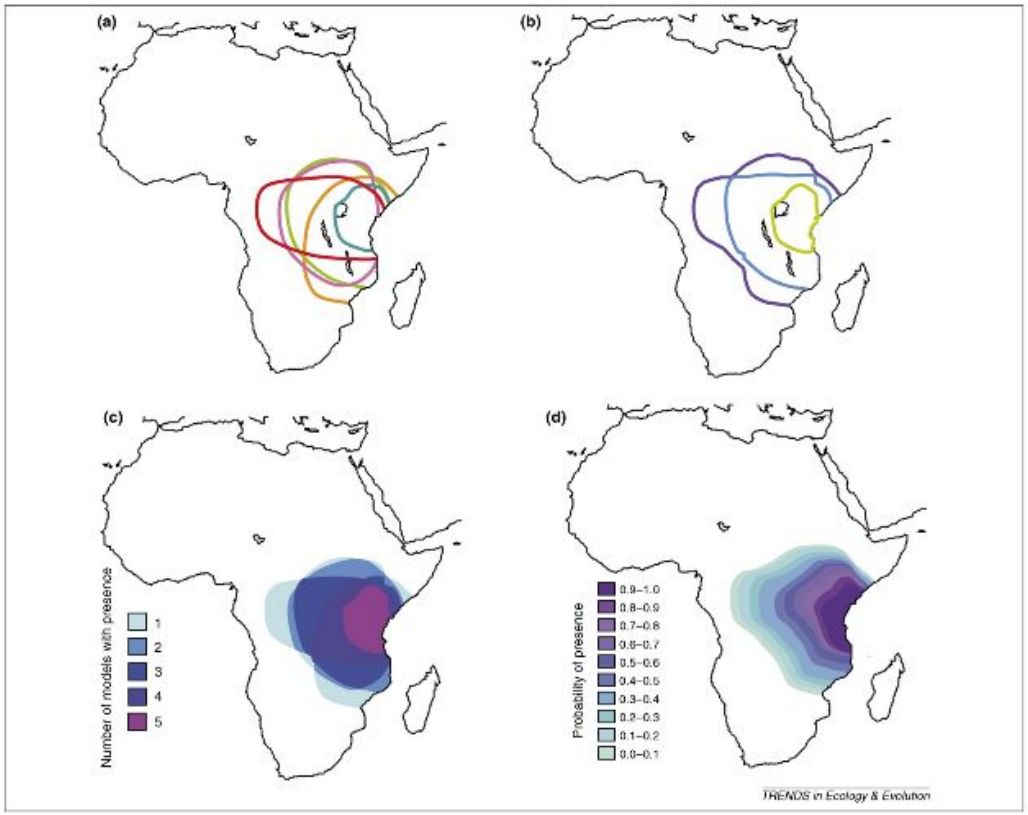
Ajuste dos ENMs

Consenso *(Ensemble)*

Review TRENDS in Ecology and Evolution Vol.22 No.1

Ensemble forecasting of species distributions

Miguel B. Araújo[1] and Mark New[2]



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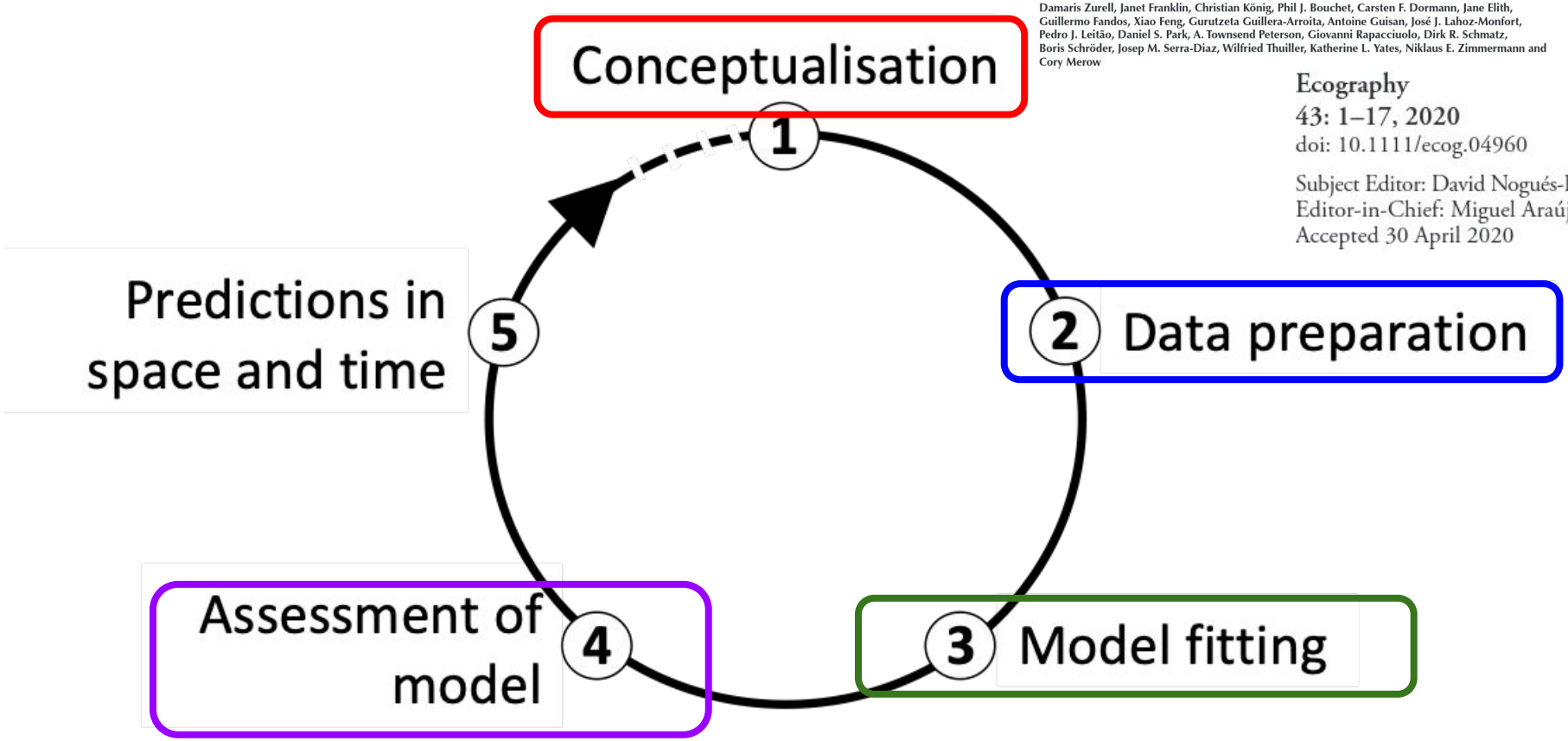
Subject Editor: David Nogués-Bravo
Editor-in-Chief: Miguel Araújo
Accepted 30 April 2020



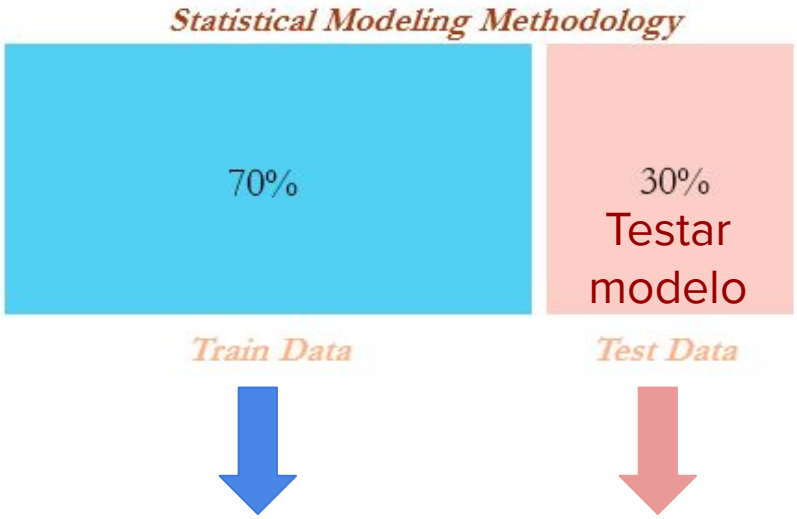
https://doi.org/10.1111/ecog.04960

7. Avaliação dos modelos

Como saber se meu modelo se **aproxima da realidade**?

Avaliação dos ENMs

Partição dos dados em **treino** e **teste**



ATENÇÃO!!!

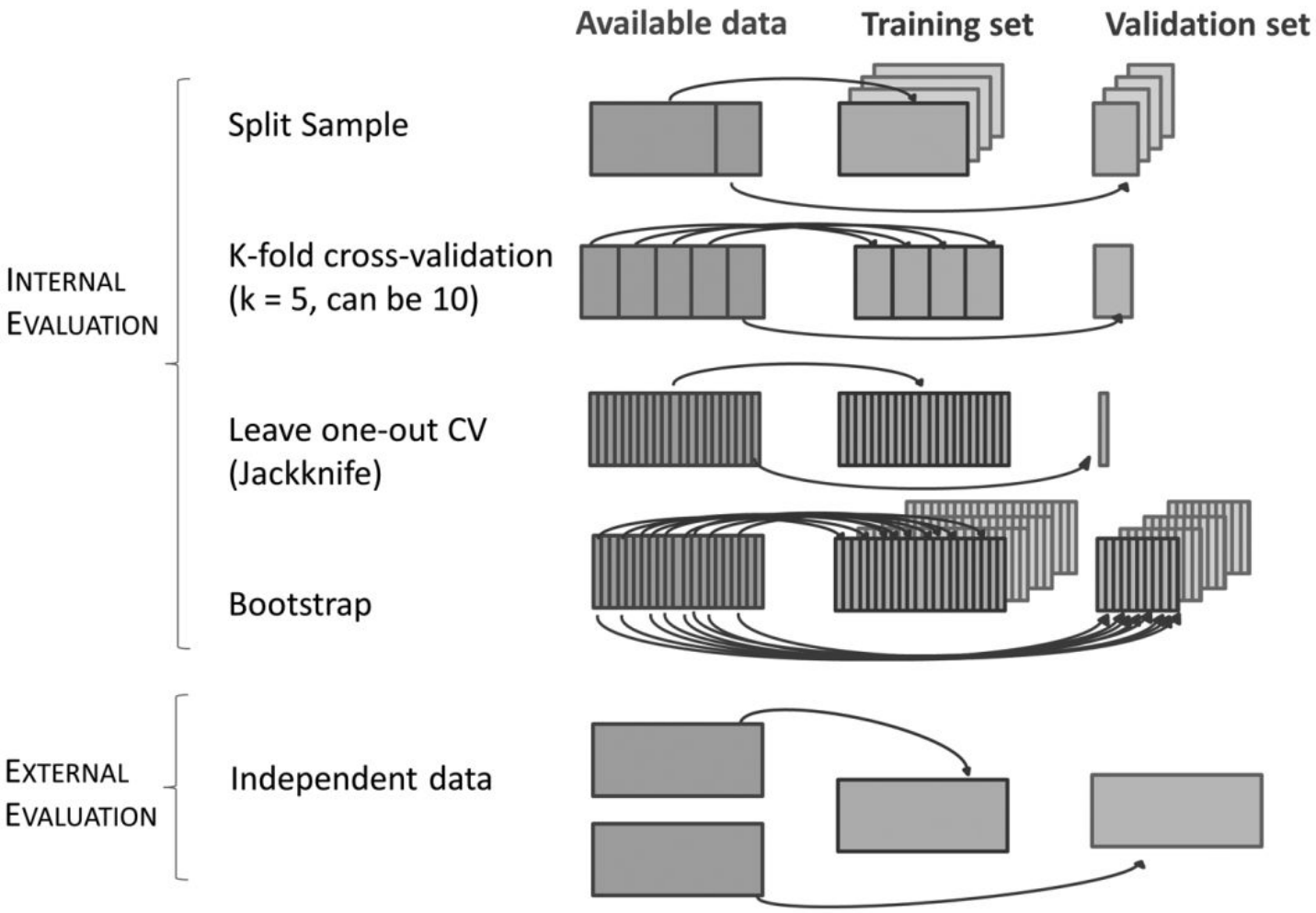
Presenças
e
Pseudo-ausências

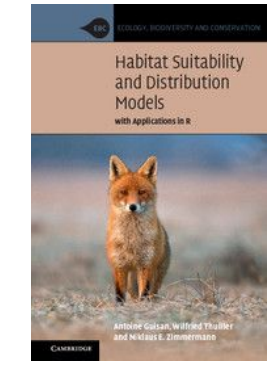
"Ocorrências"

species	lon	lat	
sp1	-40.2	-23.4	Treino
sp1	-38.8	-20.3	Teste
sp1	-43.3	-19.9	Treino

Avaliação dos ENMs

Tipos de avaliação

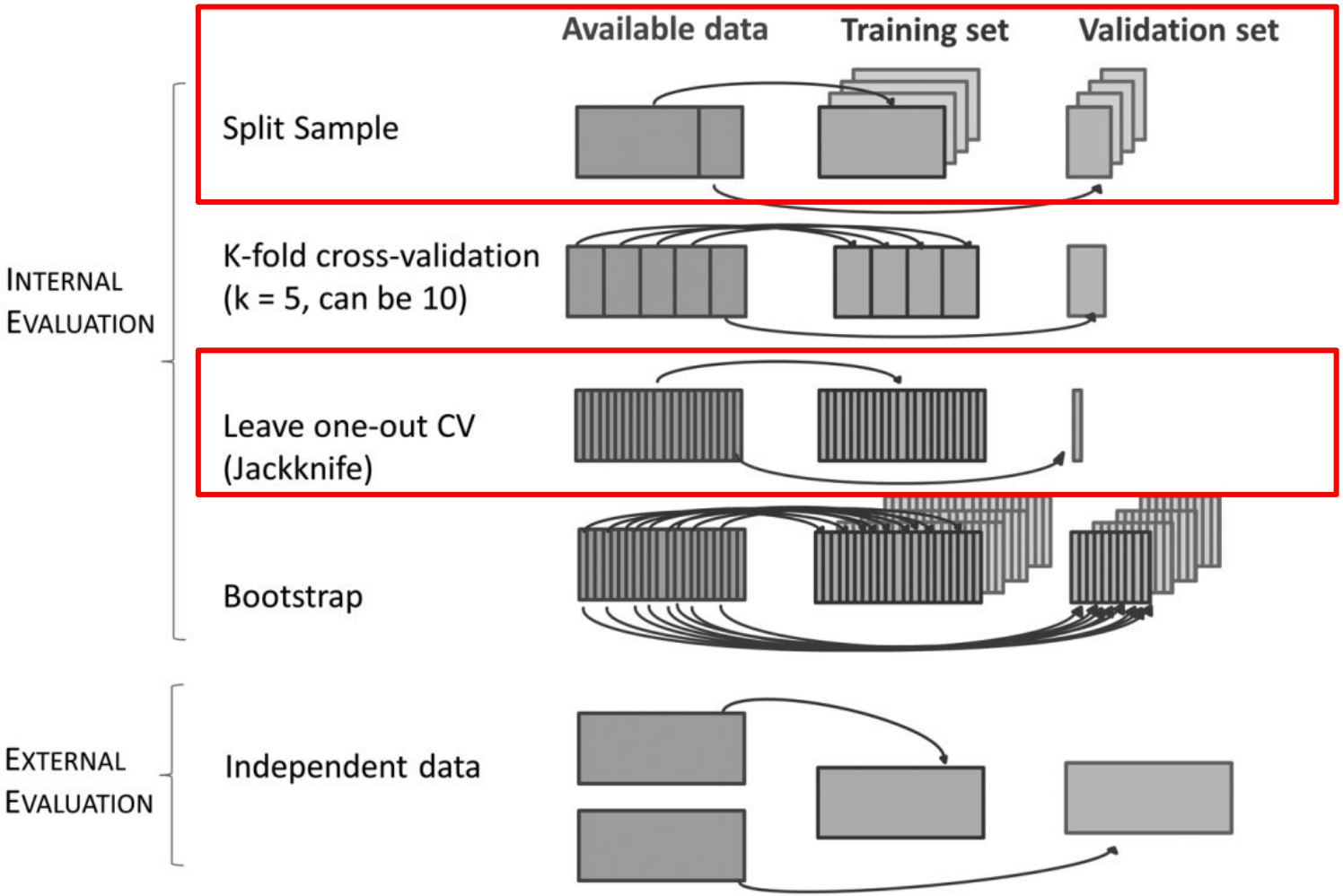


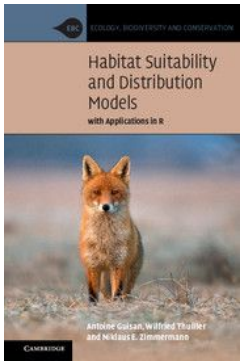


Guisan et al. (2017)

Avaliação dos ENMs

Tipos de avaliação

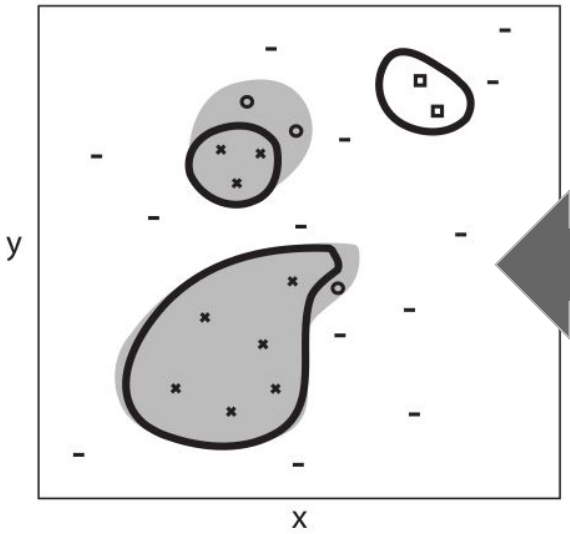


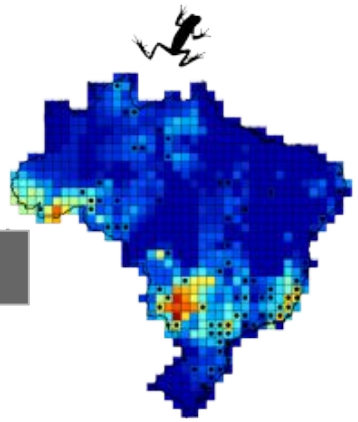


Guisan et al. (2017)

Avaliação dos ENMs

Como saber se o modelo acerta a realidade?





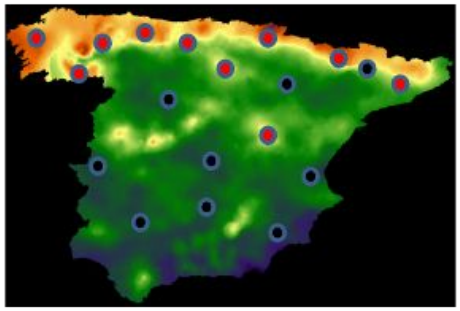
Adequabilidade

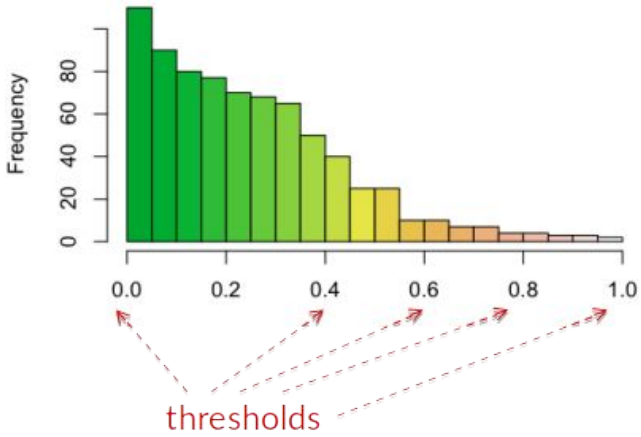
valores
0
até
1

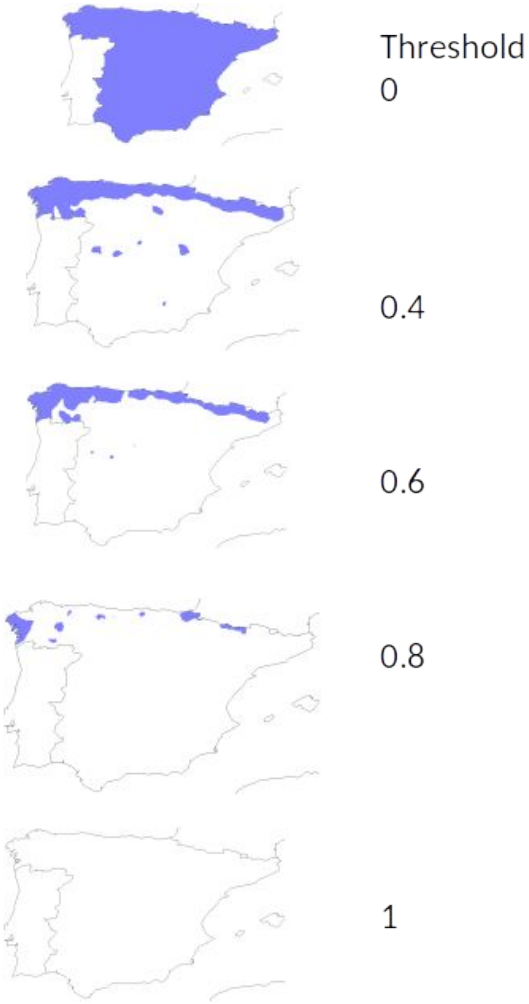
- Occupied distributional area, G_O
- Areas predicted by an ecological niche model
- × True positive
- – True negative
- o False negative
- □ False positive

Avaliação dos ENMs

Limiares (*Thresholds*) - transformar em 1 e 0

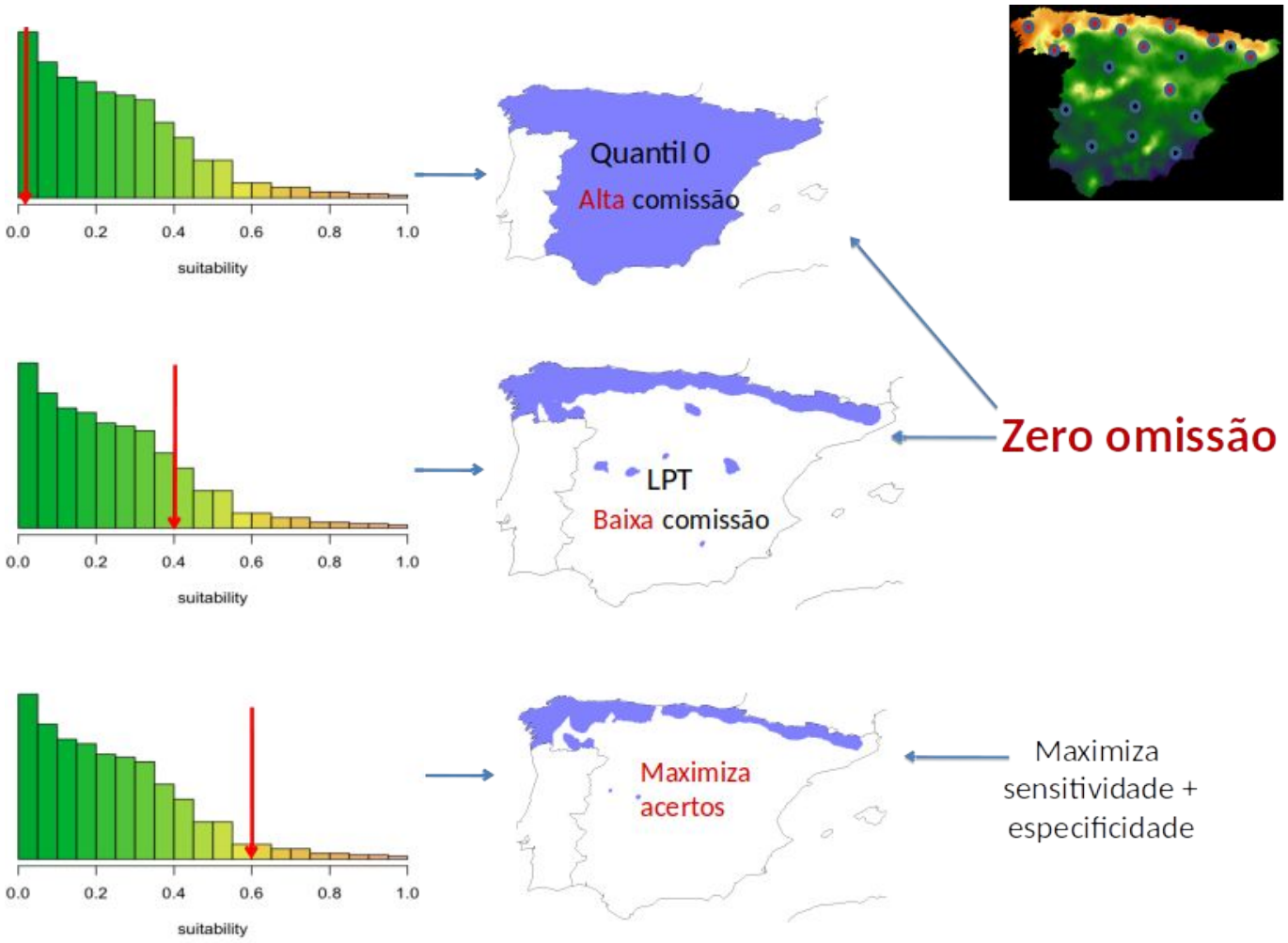






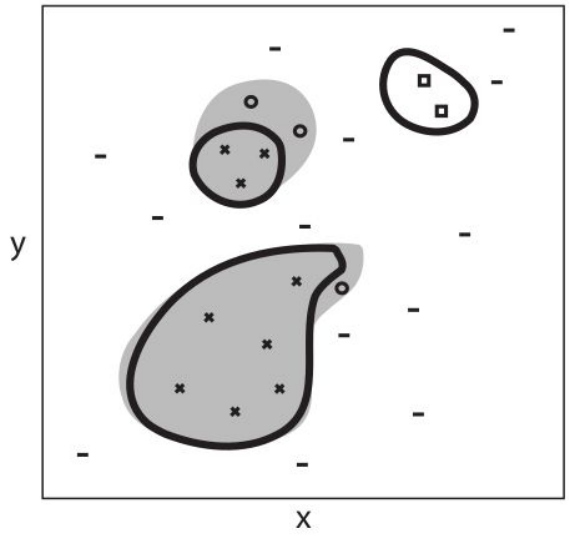
Avaliação dos ENMs

Limiares (*Thresholds*)



Avaliação dos ENMs

Matriz de confusão - para os **dados de teste**



Occupied distributional area, $\mathbf{G}_O$

Areas predicted by an ecological niche model

× True positive

– True negative

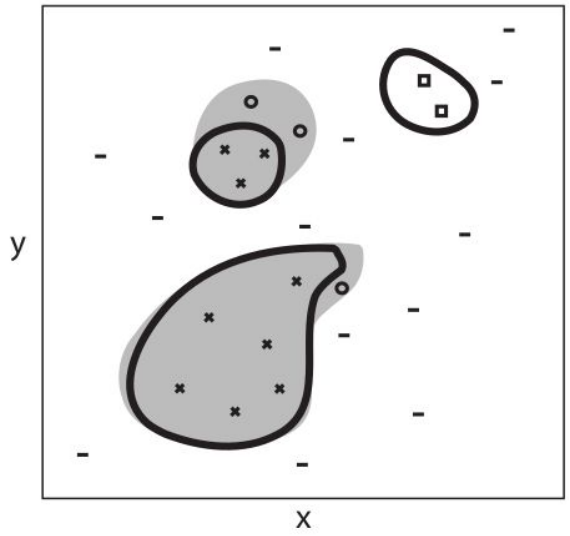
o False negative

□ False positive

		Observation	
		Present	Absent
Prediction	Present	True positive	False positive
	Absent	False negative	True negative

Avaliação dos ENMs

Matriz de confusão - para os **dados de teste**



		Observation: Present	Observation: Absent
Prediction	Present	X True positive	False positive
Prediction	Absent	False negative	True negative

Occupied distributional area, G_O

Areas predicted by an ecological niche model

× True positive

– True negative

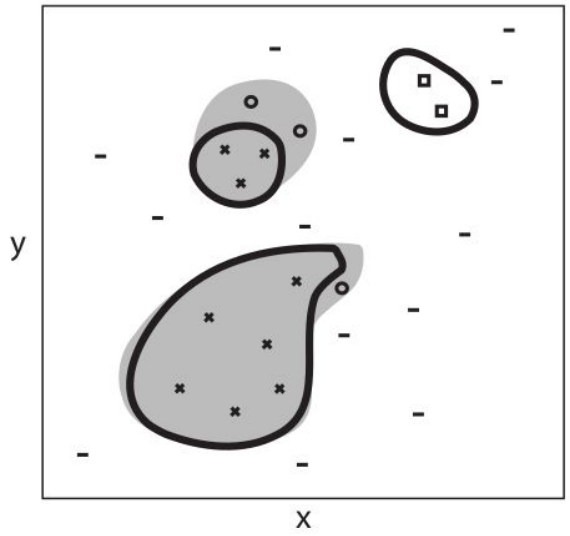
o False negative

□ False positive

Ocorrência que o modelo previu como **presença (acerto)**

Avaliação dos ENMs

Matriz de confusão - para os **dados de teste**



		Observation	
		Present	Absent
Prediction	Present	True positive	False positive
	Absent	False negative	True negative

Occupied distributional area, G_O

Areas predicted by an ecological niche model

× True positive

– True negative

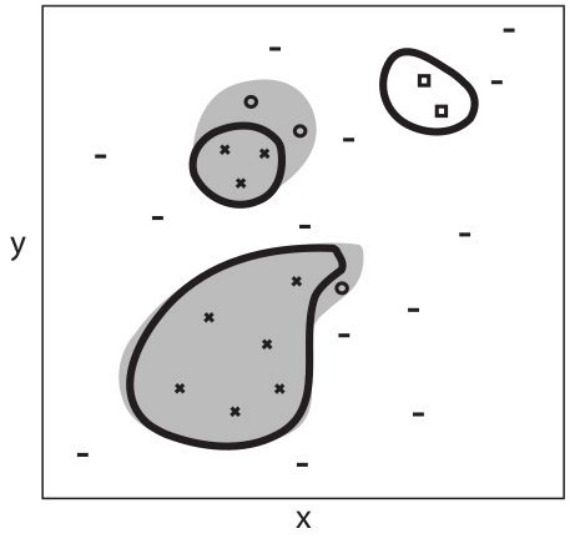
o False negative

□ False positive

Pseudo-ausência que o modelo previu como **ausência (acerto)**

Avaliação dos ENMs

Matriz de confusão - para os **dados de teste**



		Observation: Present	Observation: Absent
Prediction	Present	True positive	False positive
Prediction	Absent	False negative	True negative

Occupied distributional area, G_O

Areas predicted by an ecological niche model

× True positive

– True negative

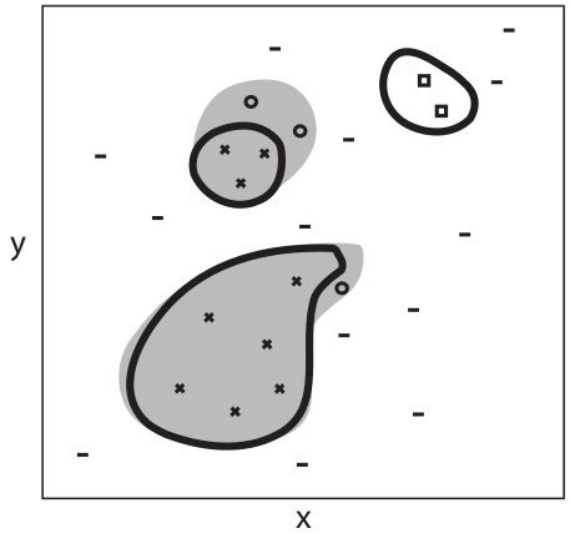
o False negative

□ False positive

Ocorrência que o modelo previu como **ausência (erro de omissão)**

Avaliação dos ENMs

Matriz de confusão - para os **dados de teste**



		Observation: Present	Observation: Absent
Prediction	Present	True positive	False positive
Prediction	Absent	False negative	True negative

Occupied distributional area, G_O

Areas predicted by an ecological niche model

× True positive

– True negative

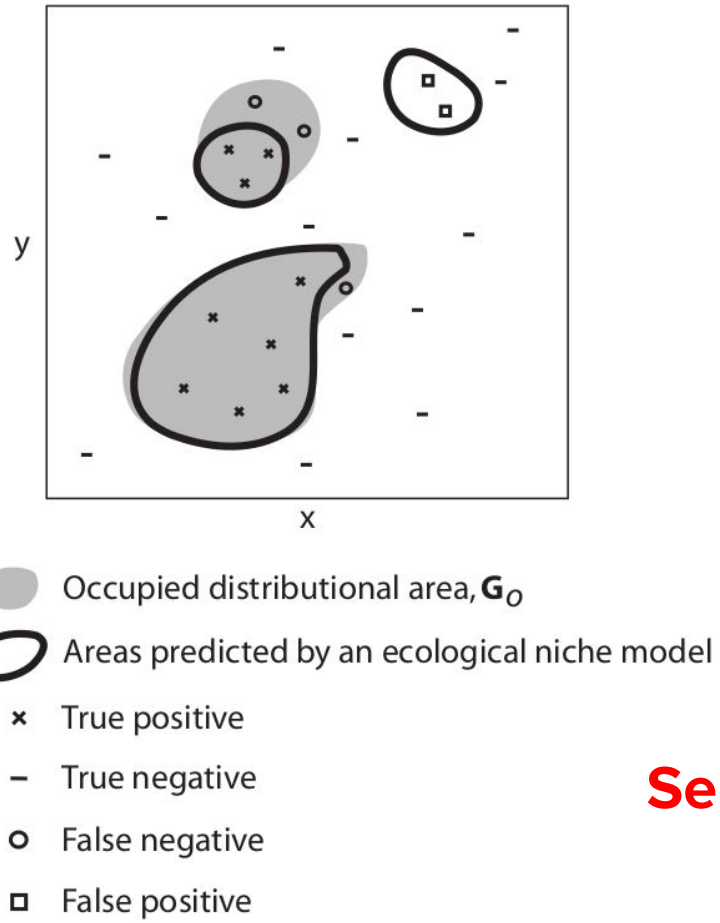
o False negative

□ False positive

Pseudo-ausência que o modelo previu como **presença (erro de comissão)**

Avaliação dos ENMs

Matriz de confusão - para os **dados de teste**

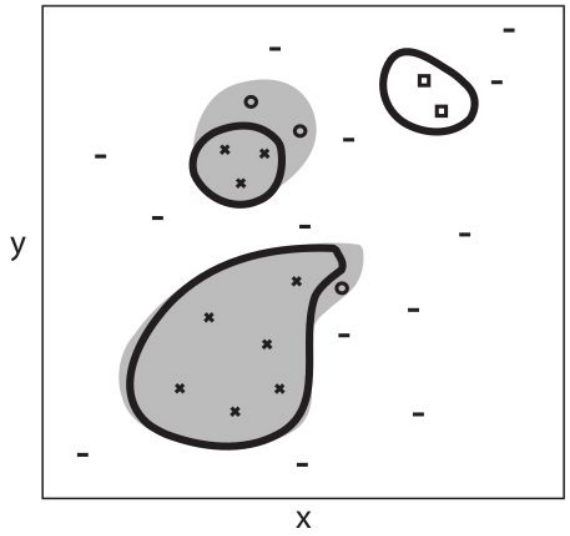


		Observation: Present	Observation: Absent
Prediction	Present	True positive	False positive
Prediction	Absent	False negative	True negative

Sensitividade: presenças corretas / total de presenças

Avaliação dos ENMs

Matriz de confusão - para os **dados de teste**



Occupied distributional area, G_O

Areas predicted by an ecological niche model

× True positive

– True negative

o False negative

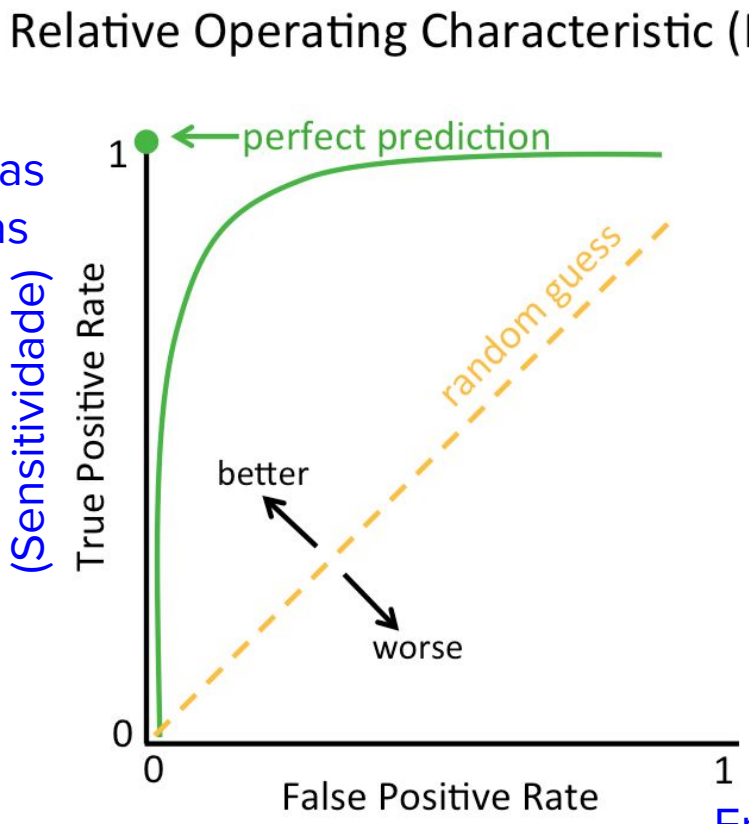
□ False positive

		Observation: Present	Observation: Absent
Prediction	Present	True positive	False positive
Prediction	Absent	False negative	True negative

Especificidade: pseudo-ausências corretas / total de pseudo-ausências

Avaliação dos ENMs

Curva ROC



Acertos das presenças

(Sensitividade)

(Especificidade - 1)

Erro das ausências

AUC = area under the curve

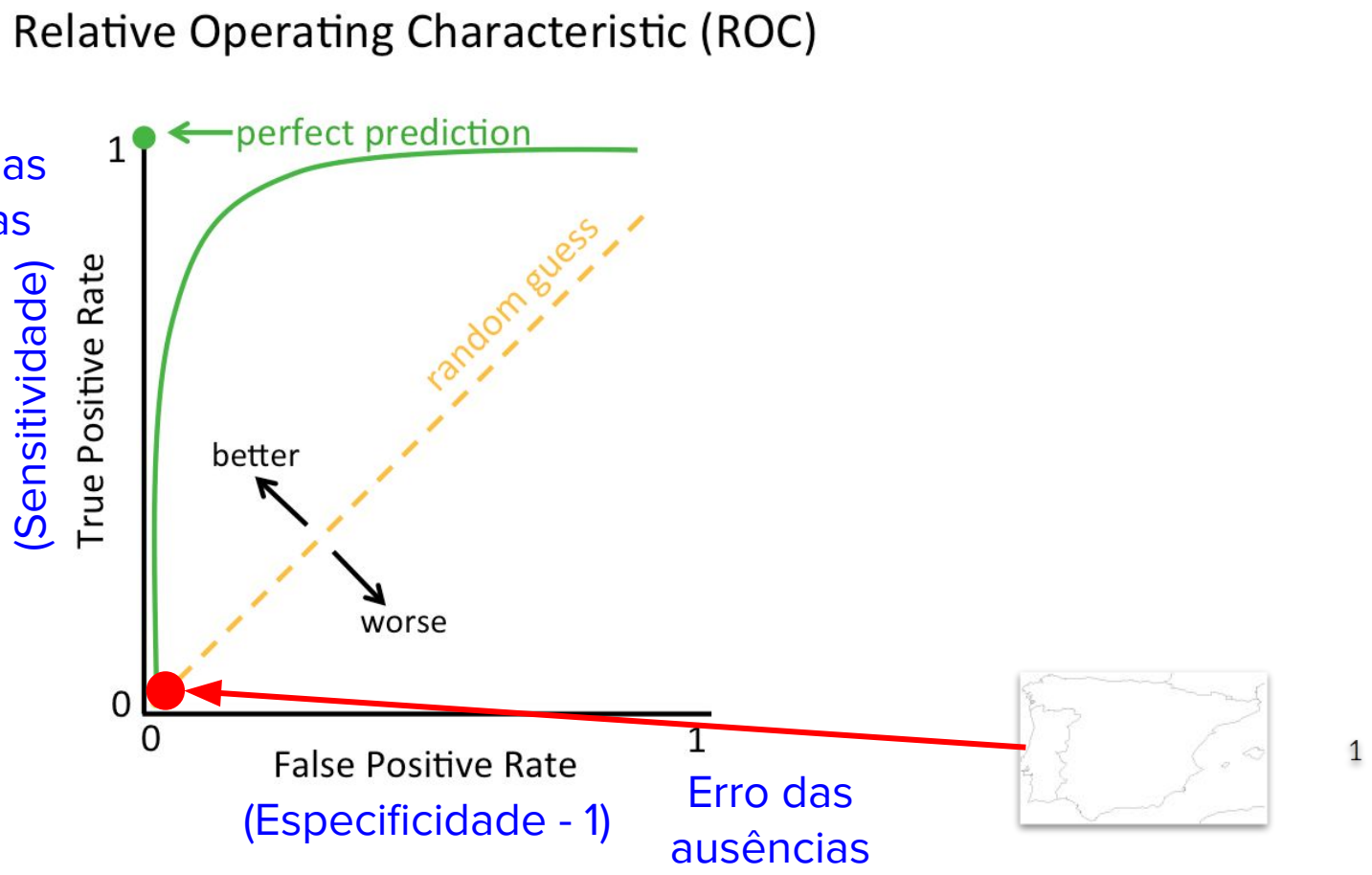
0.5-0.7 = poor model performance

0.7-0.9 = moderate

> 0.9 = excellent

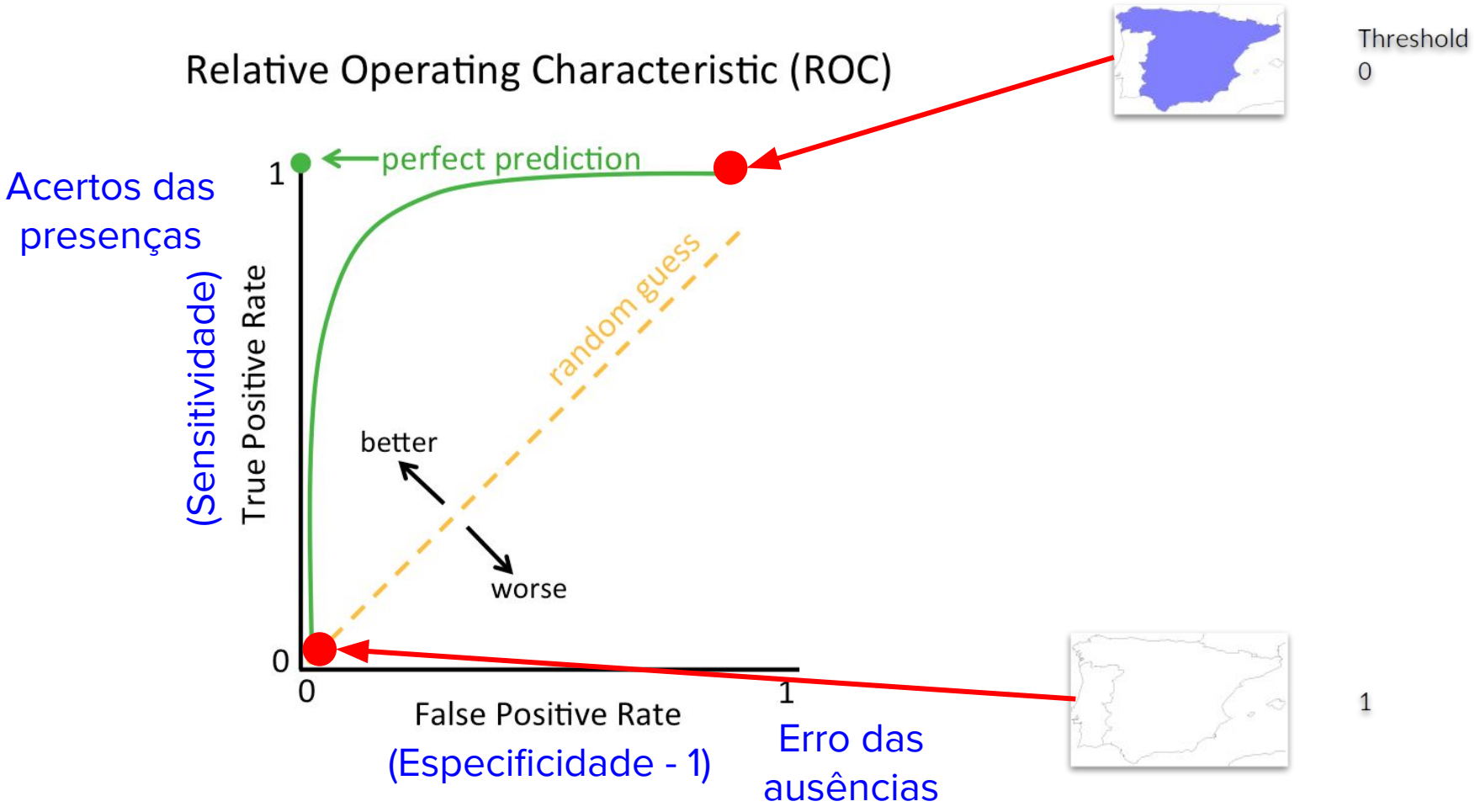
Avaliação dos ENMs

Curva ROC



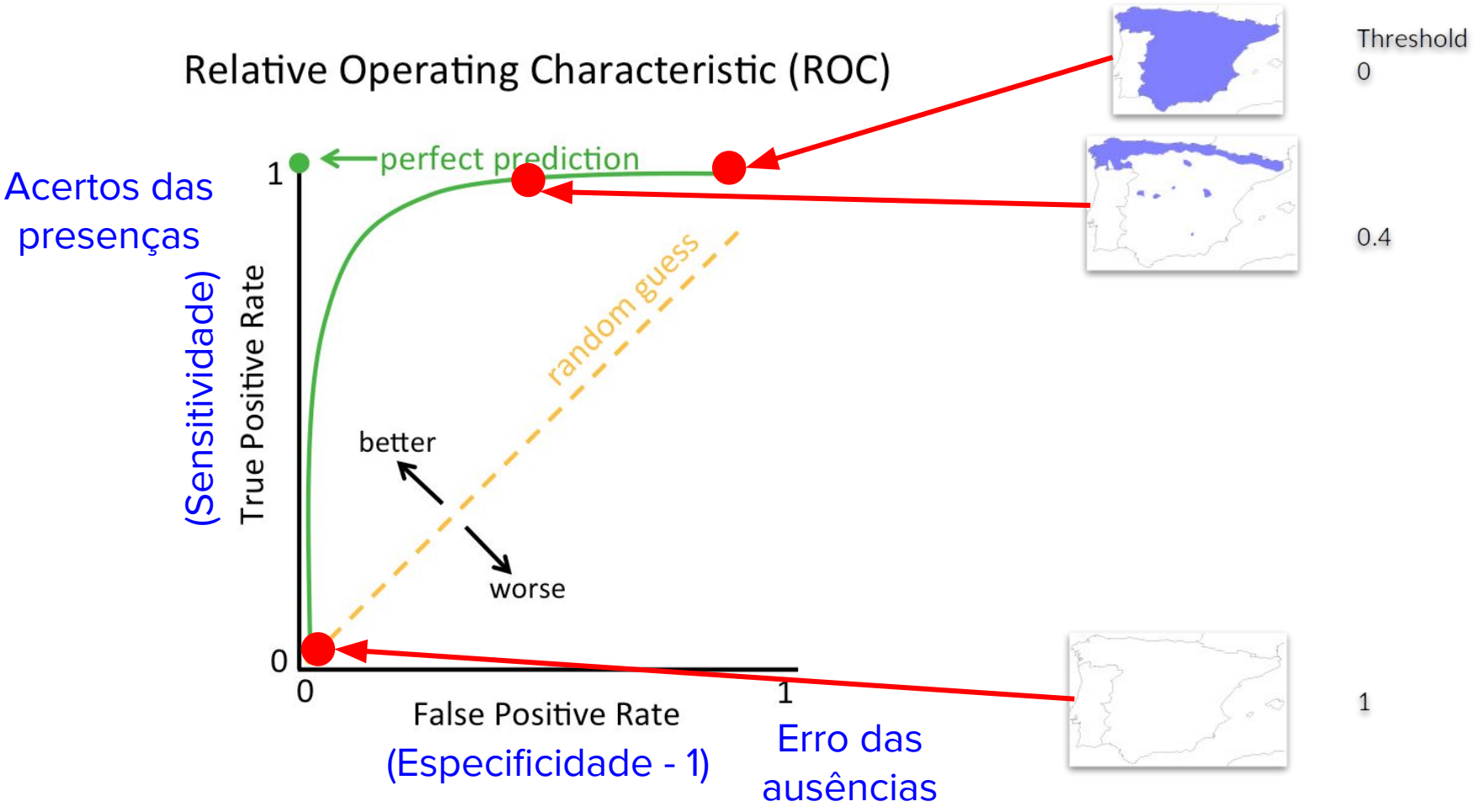
Avaliação dos ENMs

Curva ROC



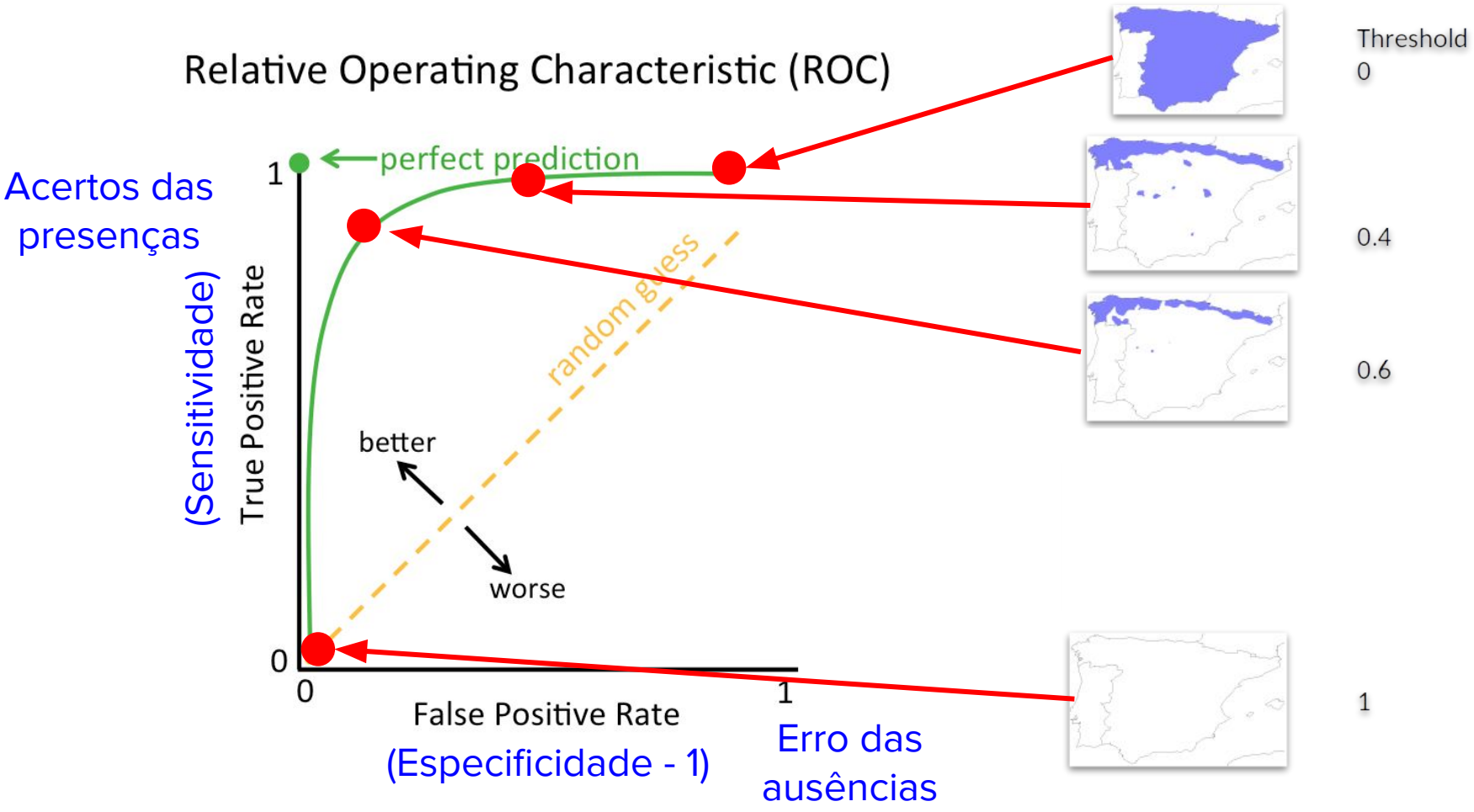
Avaliação dos ENMs

Curva ROC



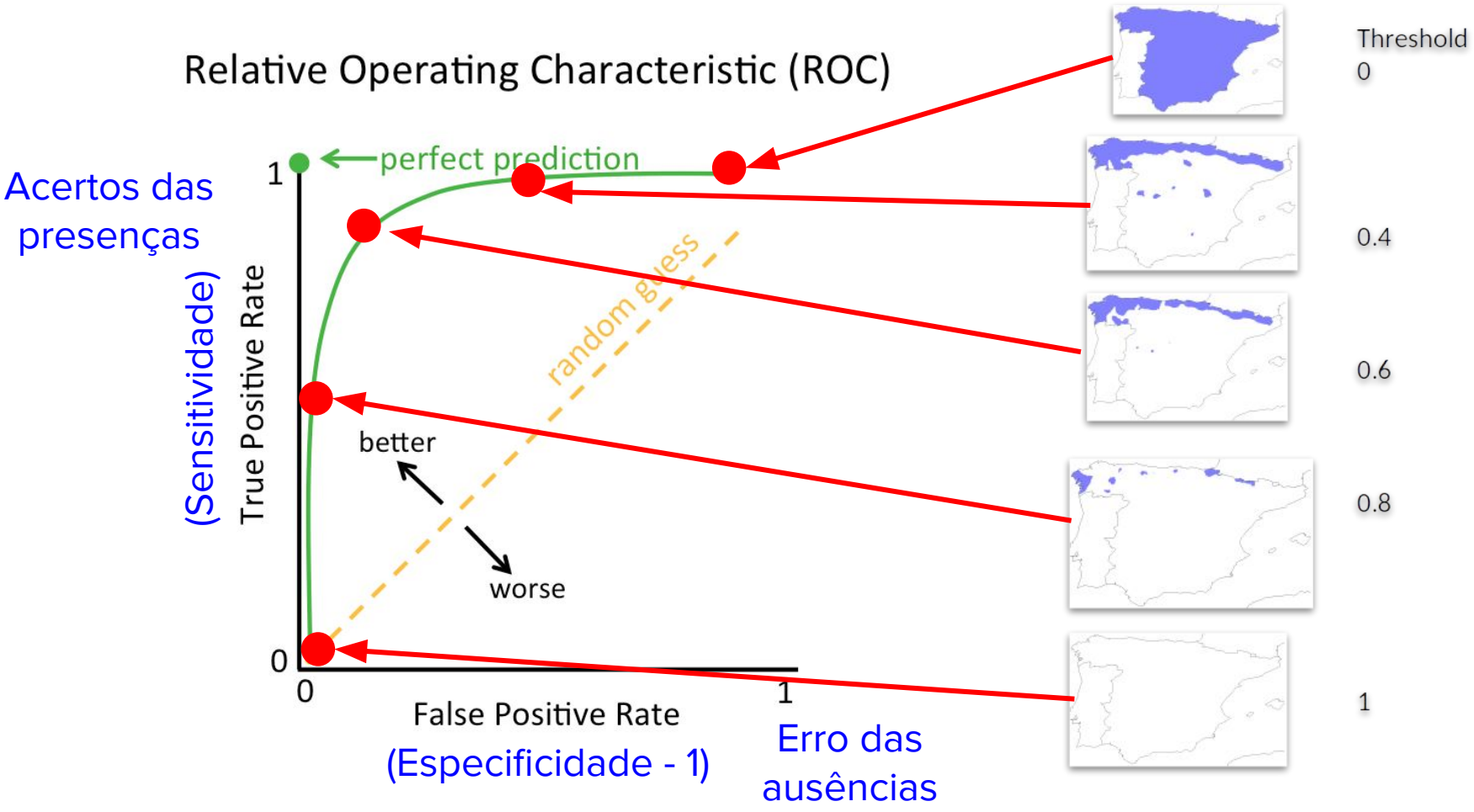
Avaliação dos ENMs

Curva ROC



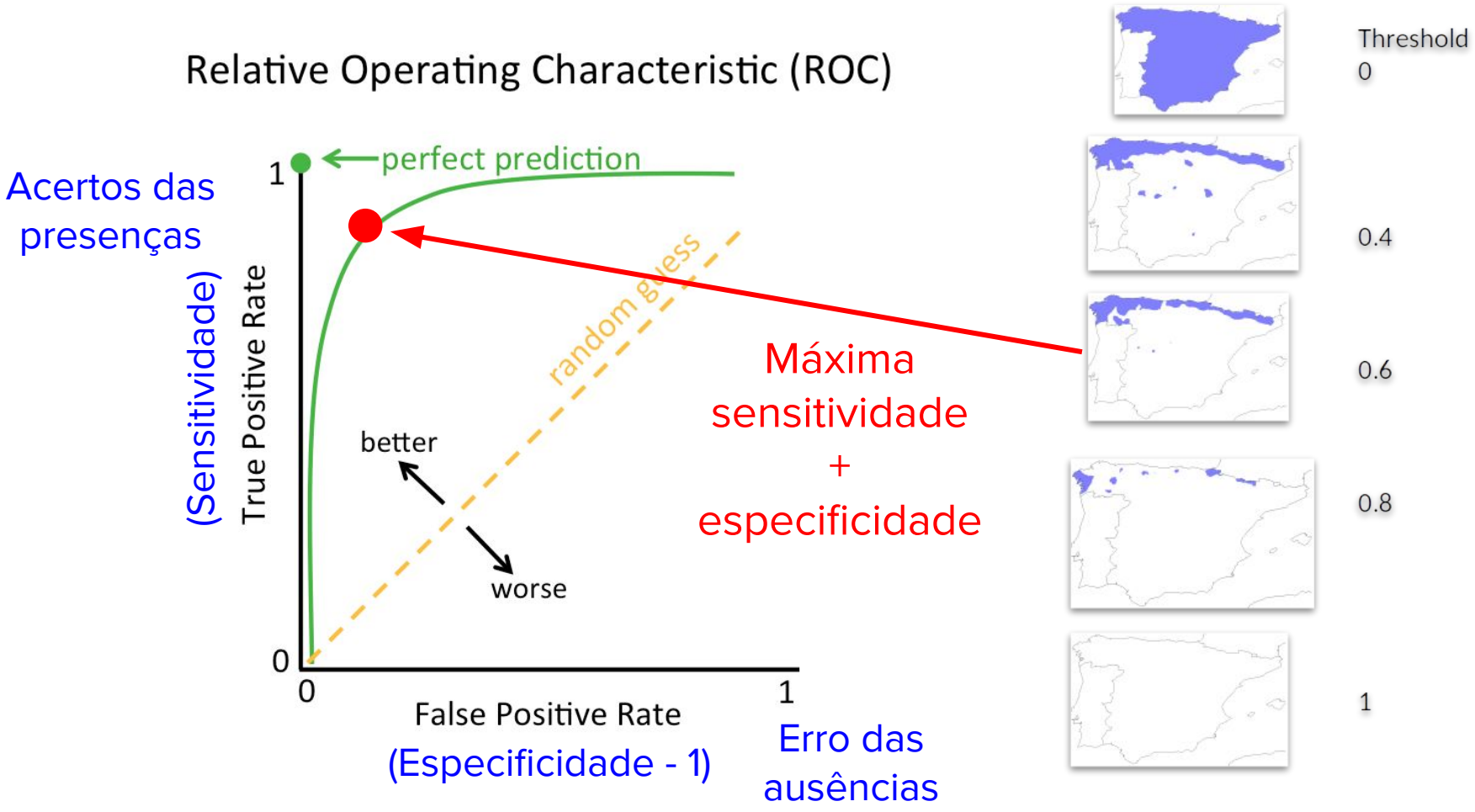
Avaliação dos ENMs

Curva ROC



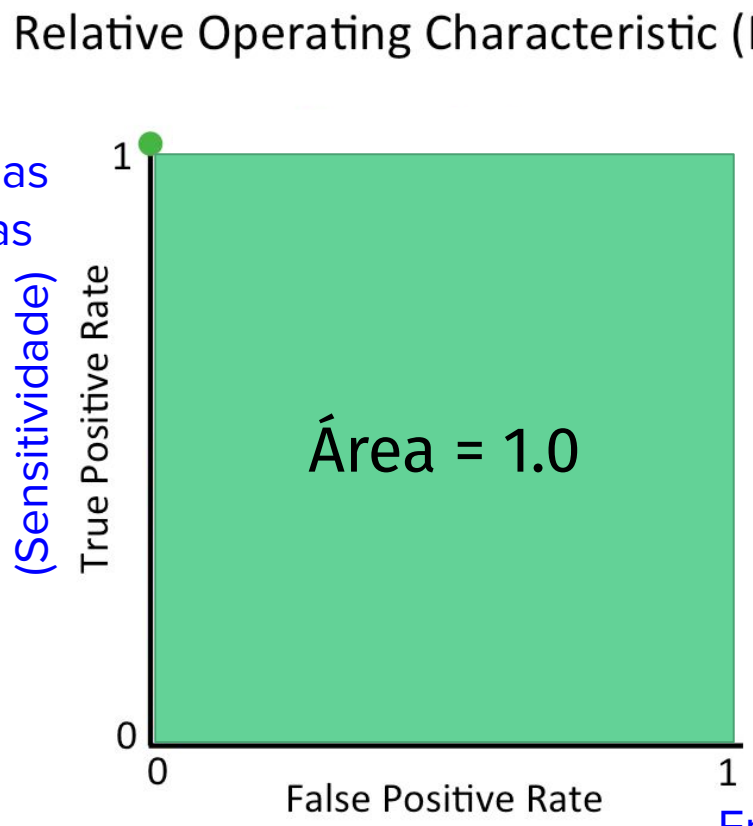
Avaliação dos ENMs

Curva ROC



Avaliação dos ENMs

AUC

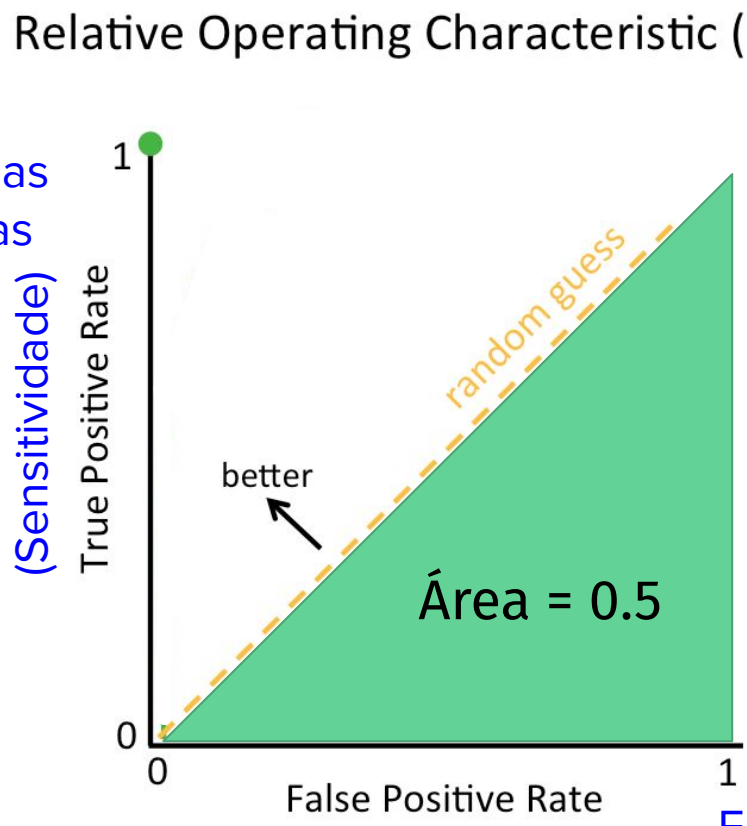


AUC = area under the curve

0.5-0.7 = poor model performance
0.7-0.9 = moderate
> 0.9 = excellent

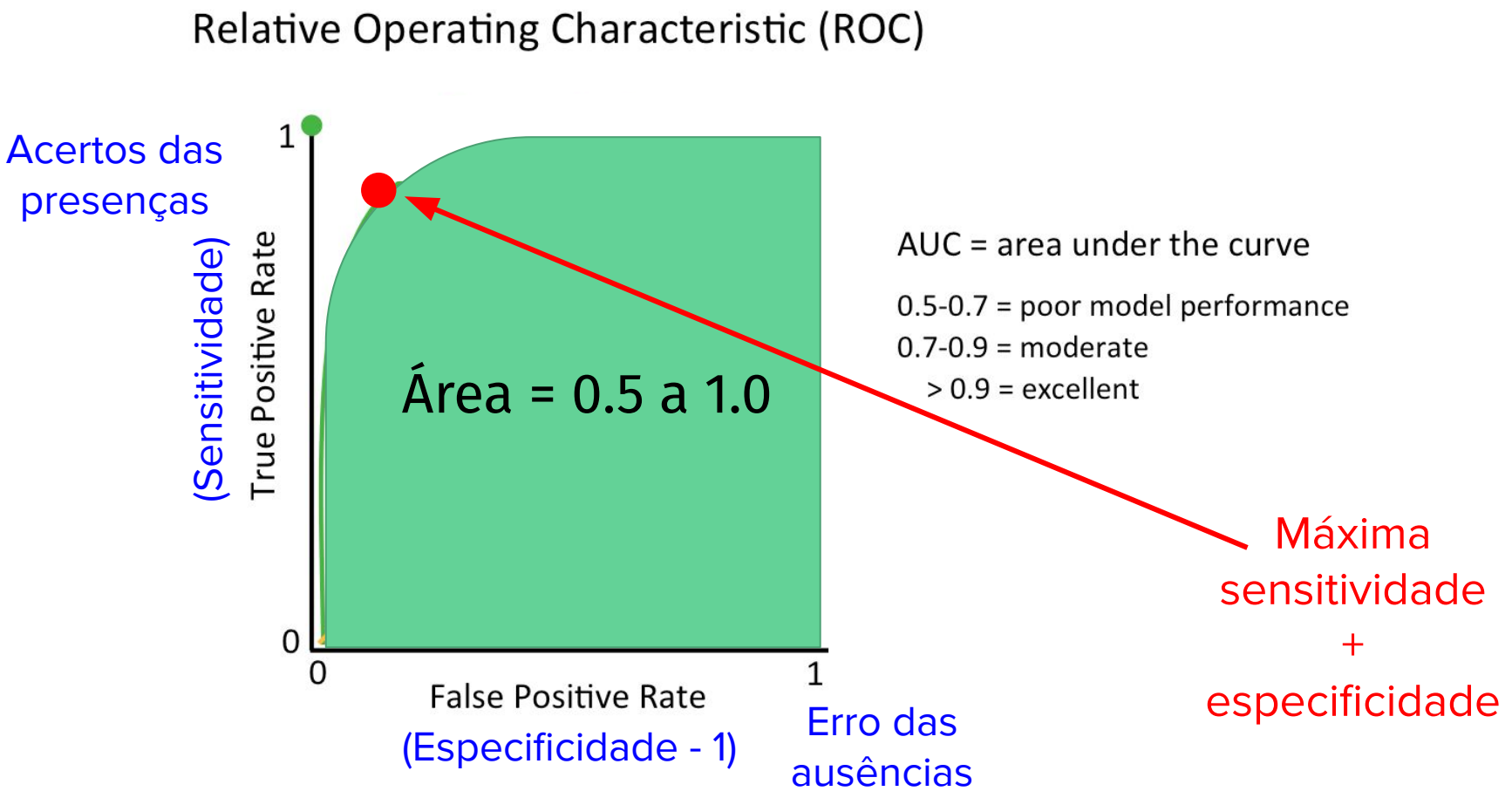
Avaliação dos ENMs

AUC



Avaliação dos ENMs

AUC



Avaliação dos ENMs

TSS (*True skill statistic*)

Número de sucessos menos o número de sucessos aleatórios

Varia de -1 to 1. Valores próximos a 0 modelos não diferentes do aleatórios

Depende de um valor de corte (*threshold*)

TSS = sensitividade + especificidade - 1

SDM passo a passo

Estrutura dos ENMs

ECOGRAPHY

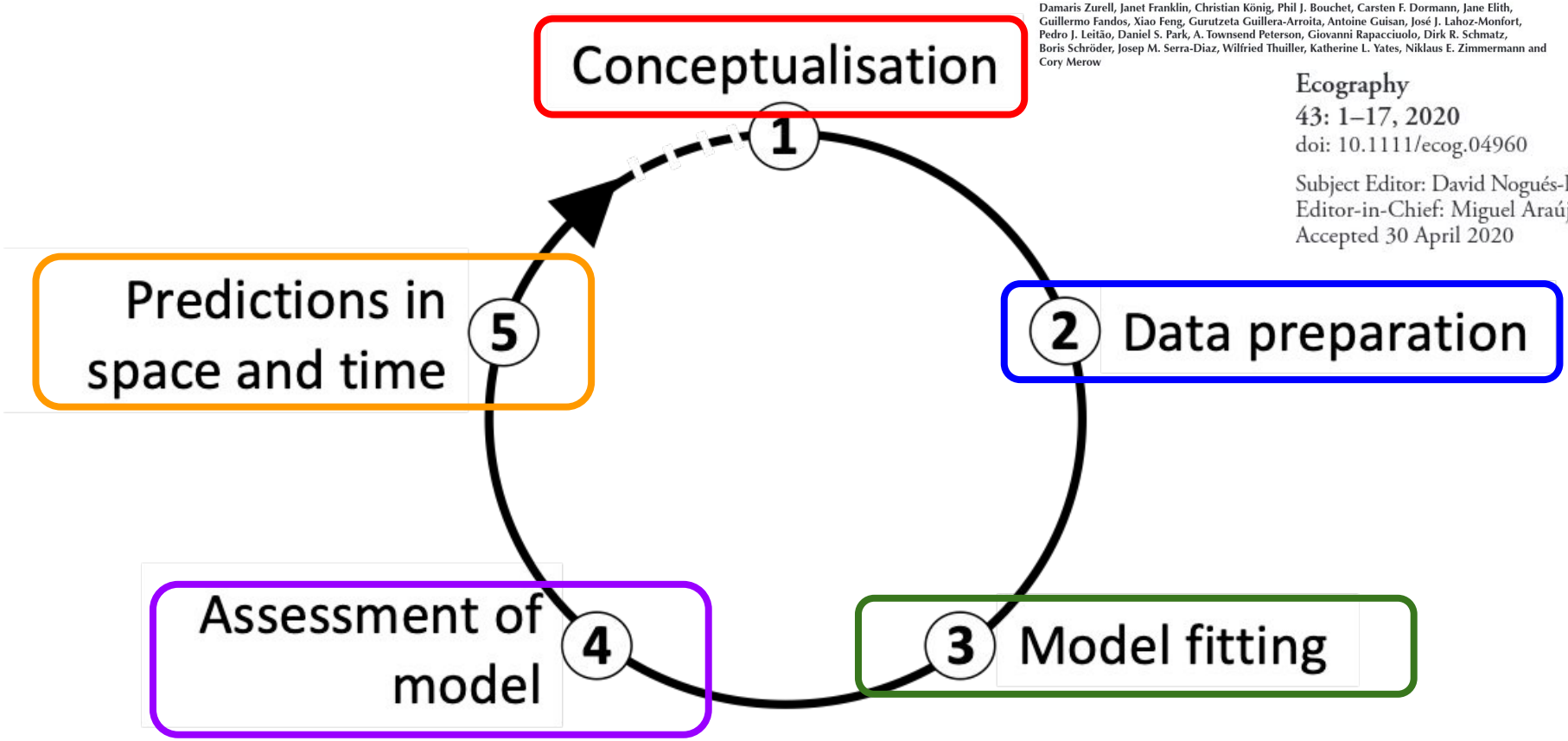
Review and synthesis

A standard protocol for reporting species distribution models

Damaris Zurell, Janet Franklin, Christian König, Phil J. Bouchet, Carsten F. Dormann, Jane Elith, Guillermo Fandos, Xiao Feng, Gurutzeta Guillera-Arroita, Antoine Guisan, José J. Lahoz-Monfort, Pedro J. Leitão, Daniel S. Park, A. Townsend Peterson, Giovanni Rapacciuolo, Dirk R. Schmatz, Boris Schröder, Josep M. Serra-Diaz, Wilfried Thuiller, Katherine L. Yates, Niklaus E. Zimmermann and Cory Merow

Ecography
43: 1–17, 2020
doi: 10.1111/ecog.04960

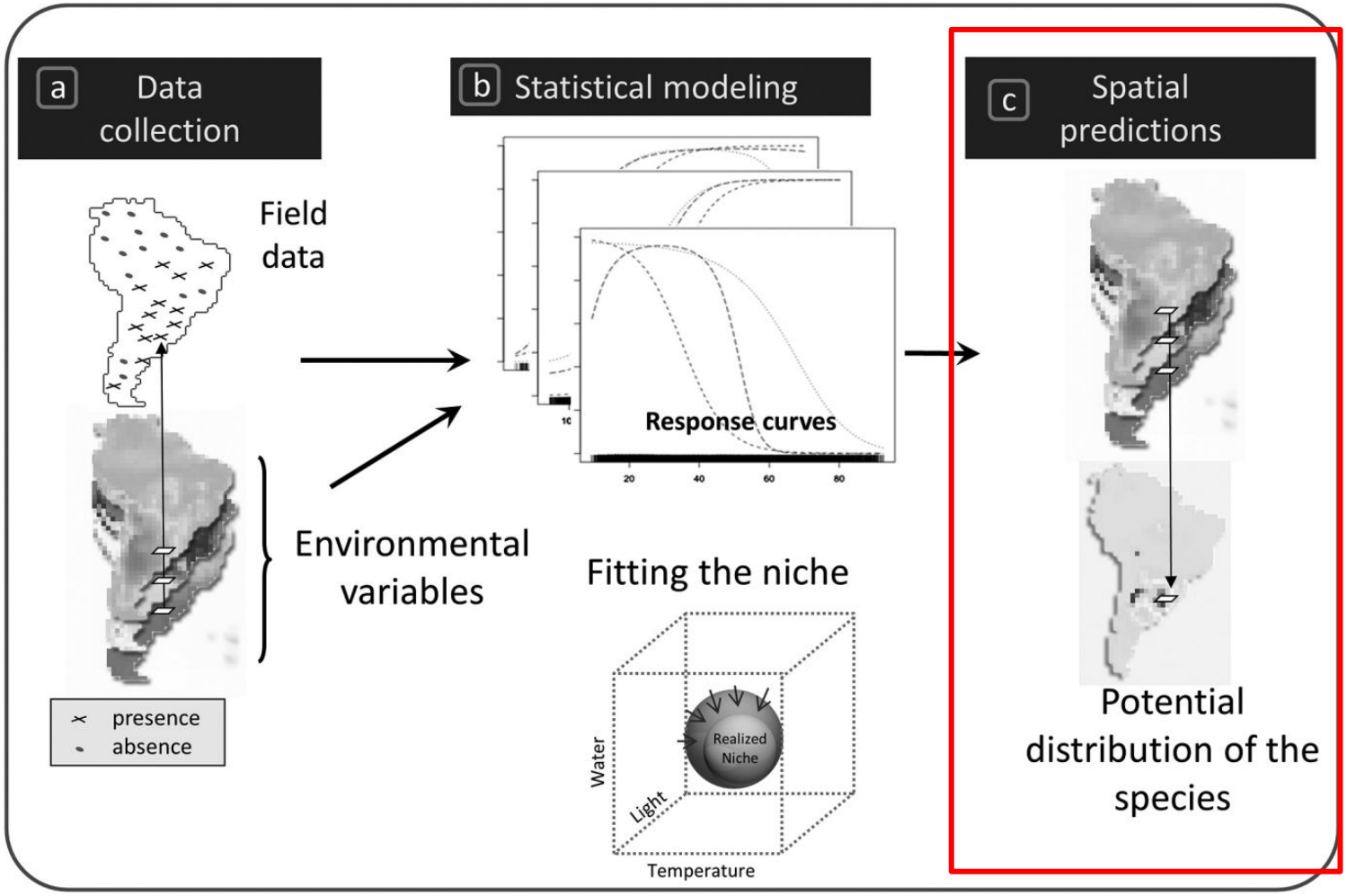
Subject Editor: David Nogués-Bravo
Editor-in-Chief: Miguel Araújo
Accepted 30 April 2020

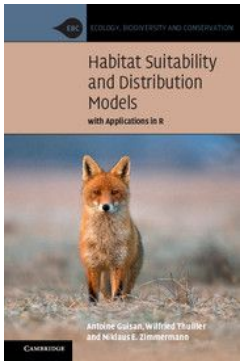


8. Predições no espaço e no tempo

Predições no espaço e no tempo

Predições (espaço e no tempo)

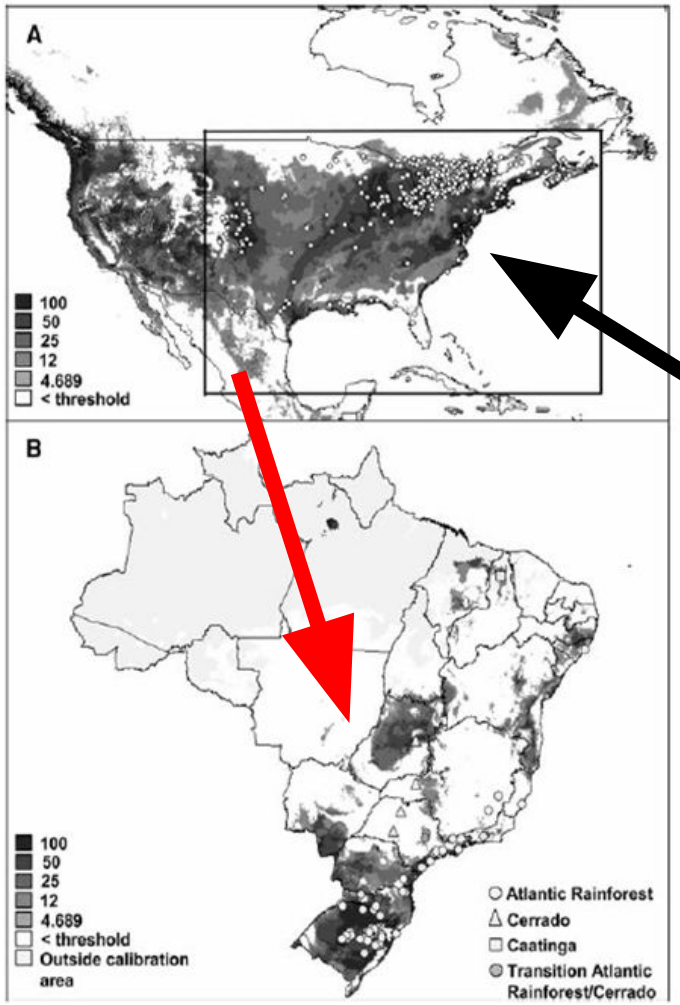




Guisan et al. (2017)

Predições no espaço e no tempo

Espaço - Espécies invasoras



Biol Invasions
DOI 10.1007/s10530-007-9154-5

ORIGINAL PAPER

Predicting the potential distribution of the alien invasive American bullfrog (*Lithobates catesbeianus*) in Brazil

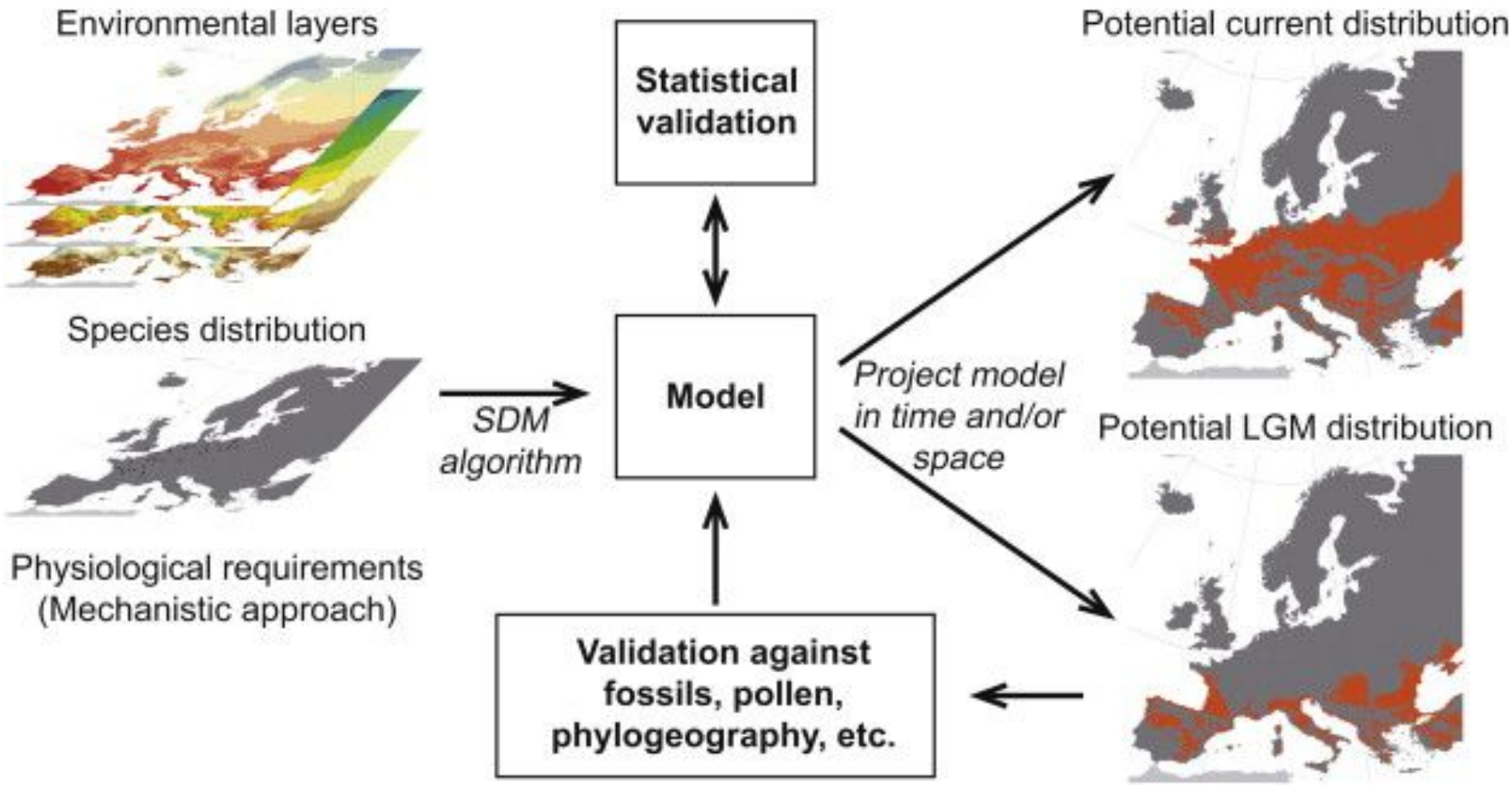
João G. R. Giovanelli · Célio F. B. Haddad · João Alexandrino

Foto: Carl D. Howe

Giovanelli et al., 2008. Biological Invasions

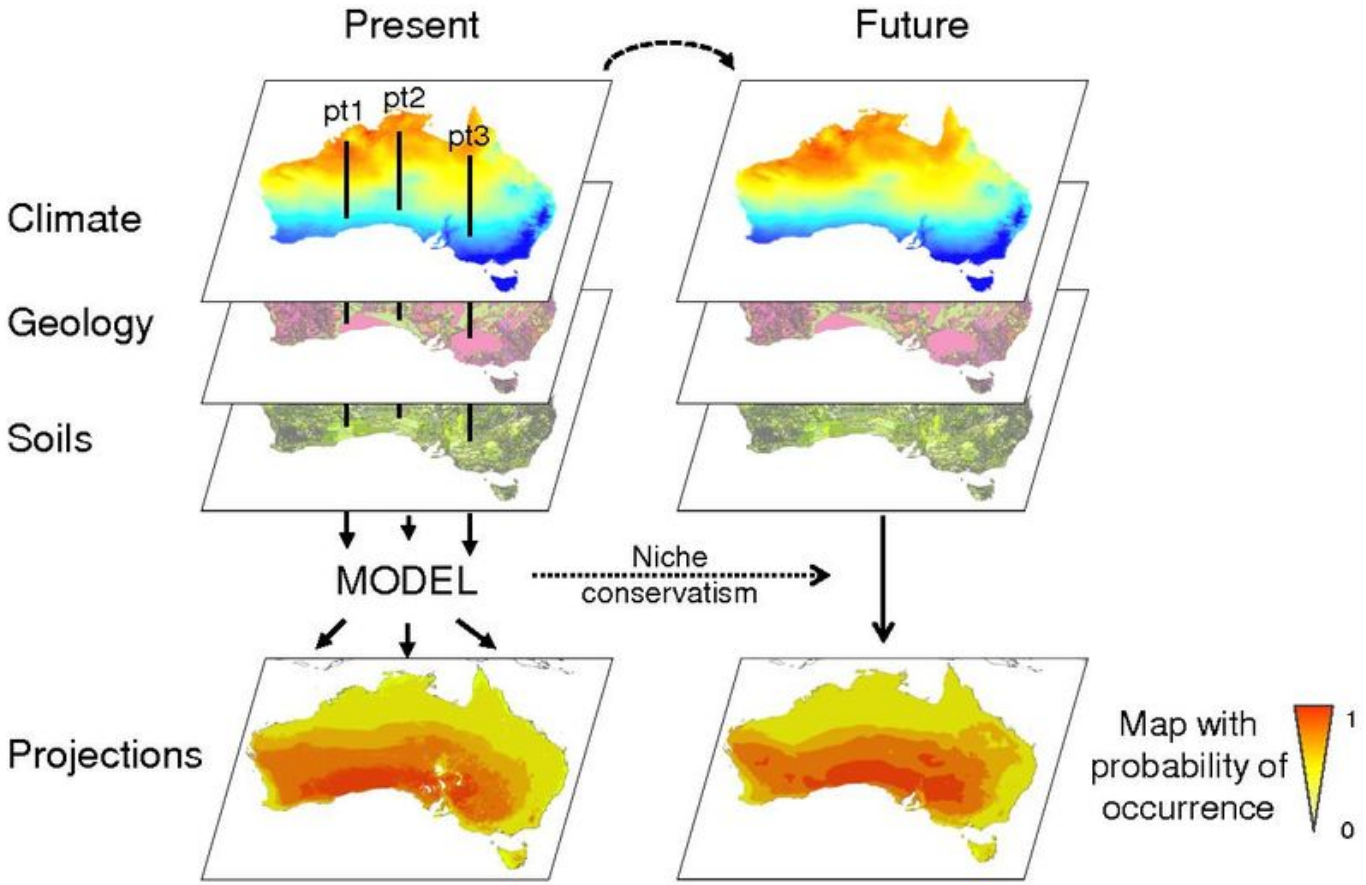
Predições no espaço e no tempo

Tempo - passado



Predições no espaço e no tempo

Tempo - futuro

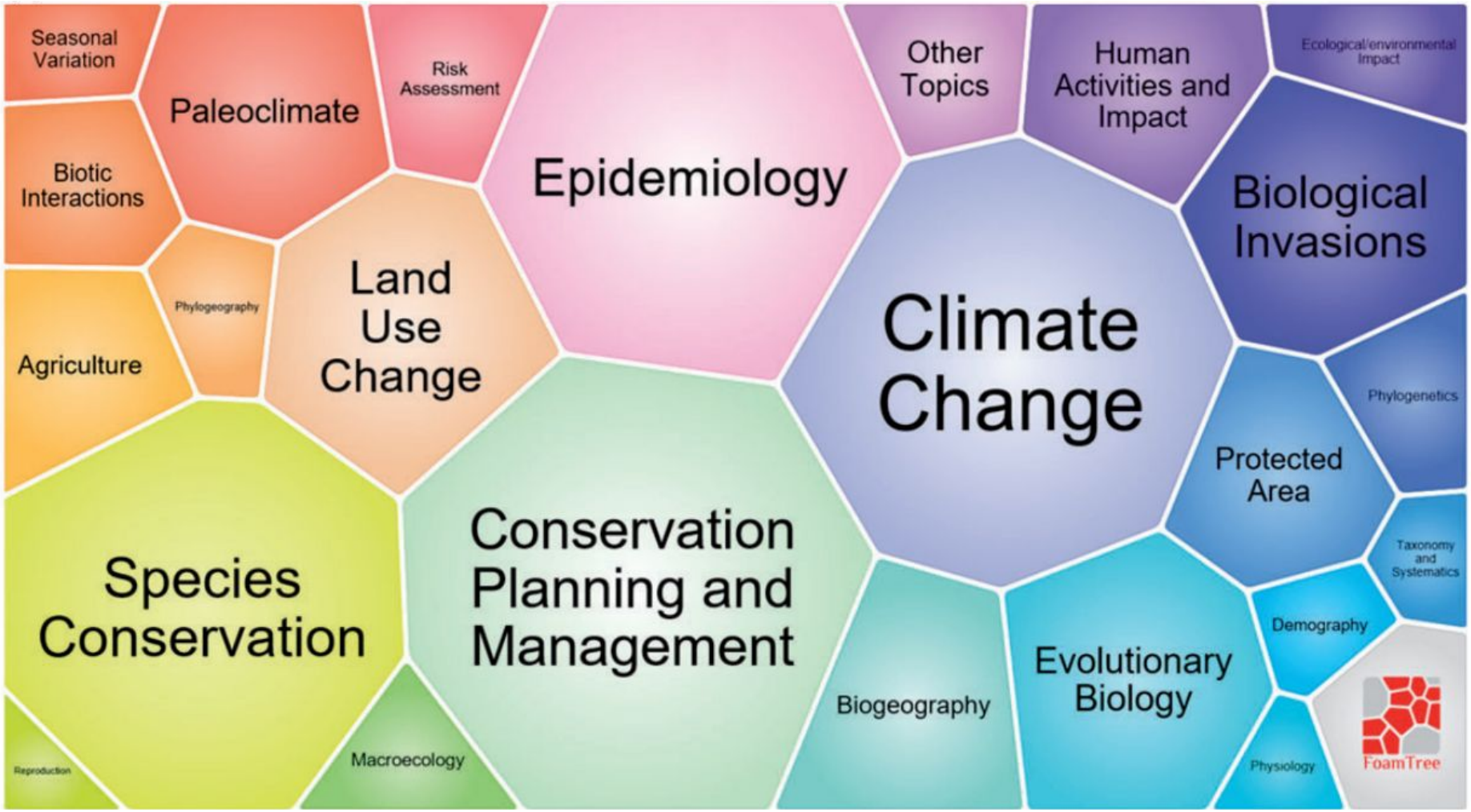


9. Aplicações e mais informações

Aplicações

Áreas de aplicação

Urbina-Cardona, N. et al. "Species Distribution Modeling in Latin America: A 25-Year Retrospective Review." *Tropical Conservation Science* 12 (2019).



Diferentes respostas às mudanças climáticas de duas palmeiras de buritis na América do Sul

Perspectives in Ecology and Conservation

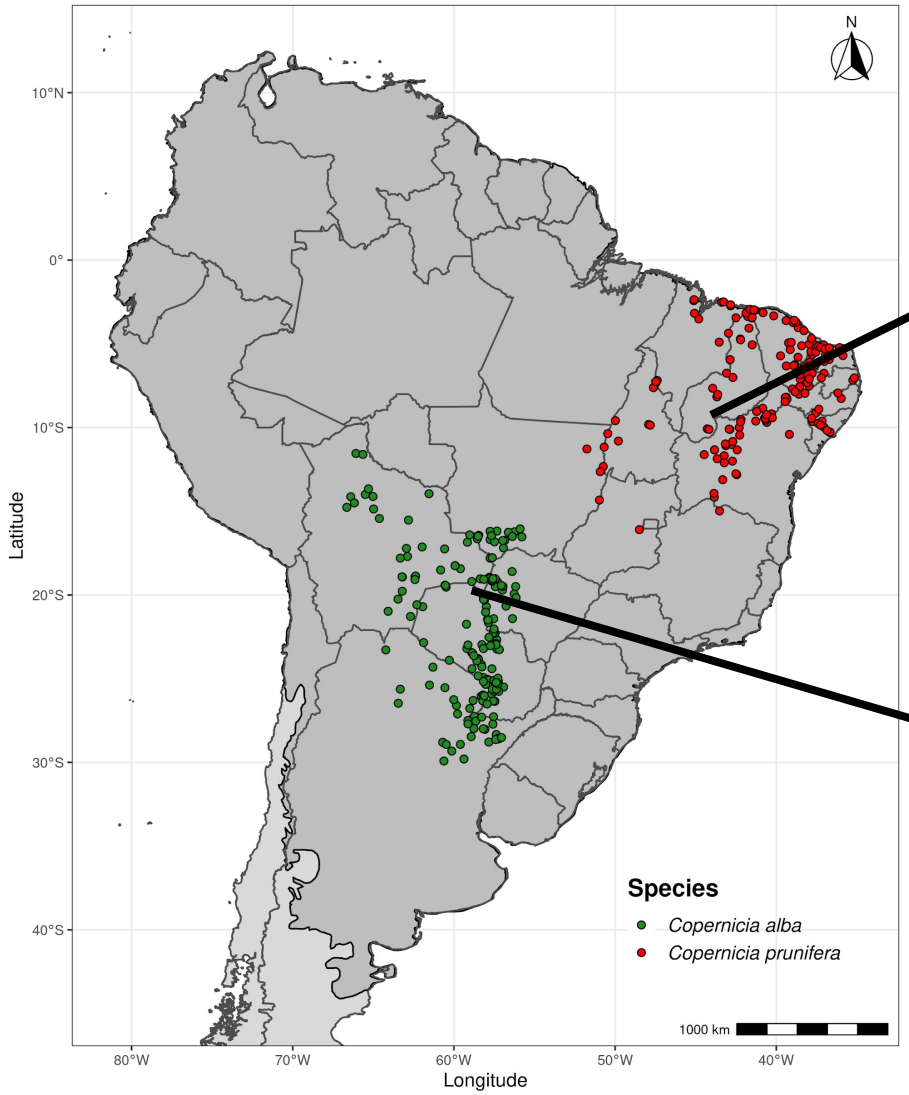
Marcones Ferreira Costa

Maurício H. Vancine

Maria Imaculada Zucchi

07/07/2019

Ocorrências e limite

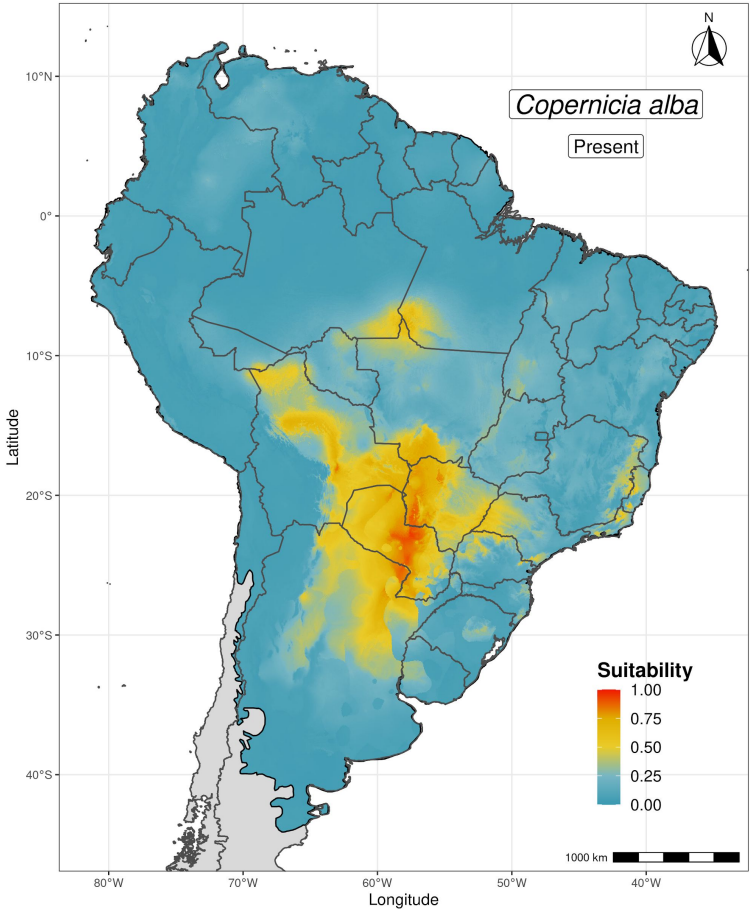


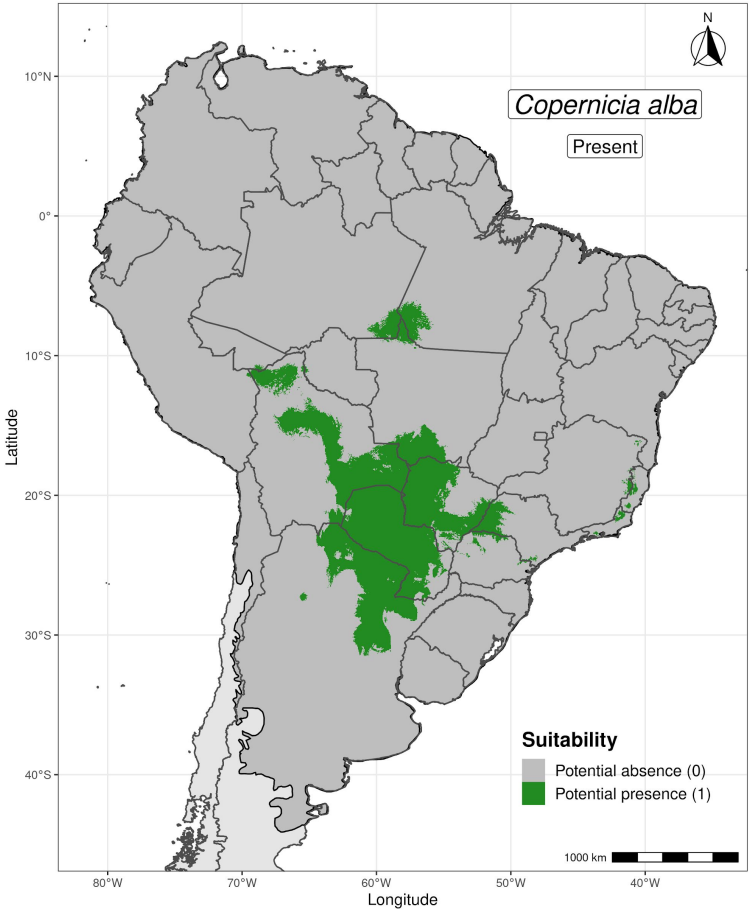
Copernicia prunifera

Copernicia alba

ENMs - Presente

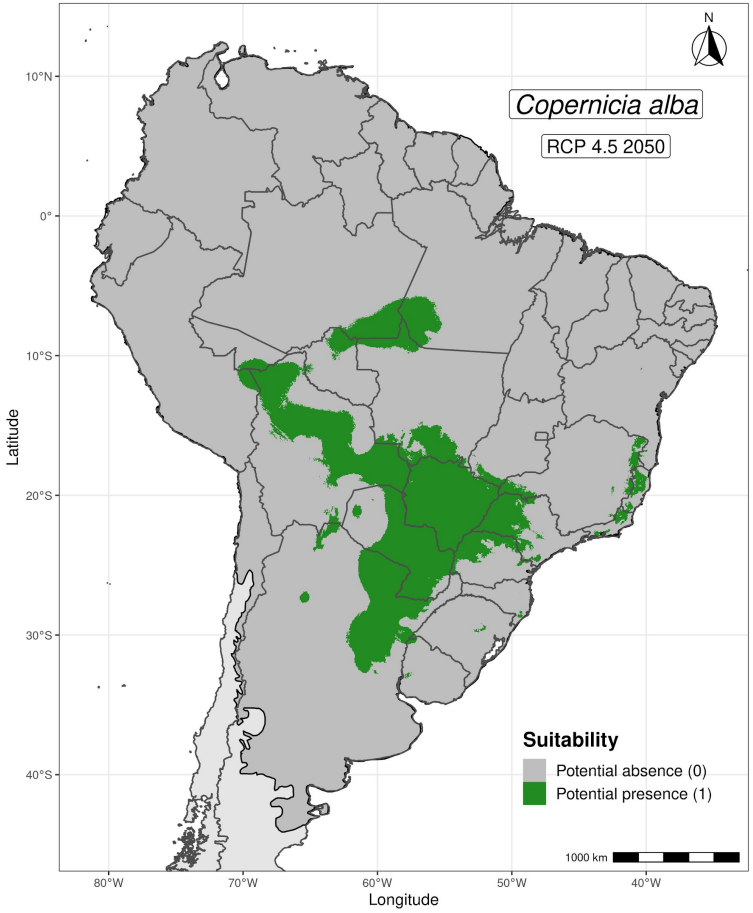
Copernicia alba

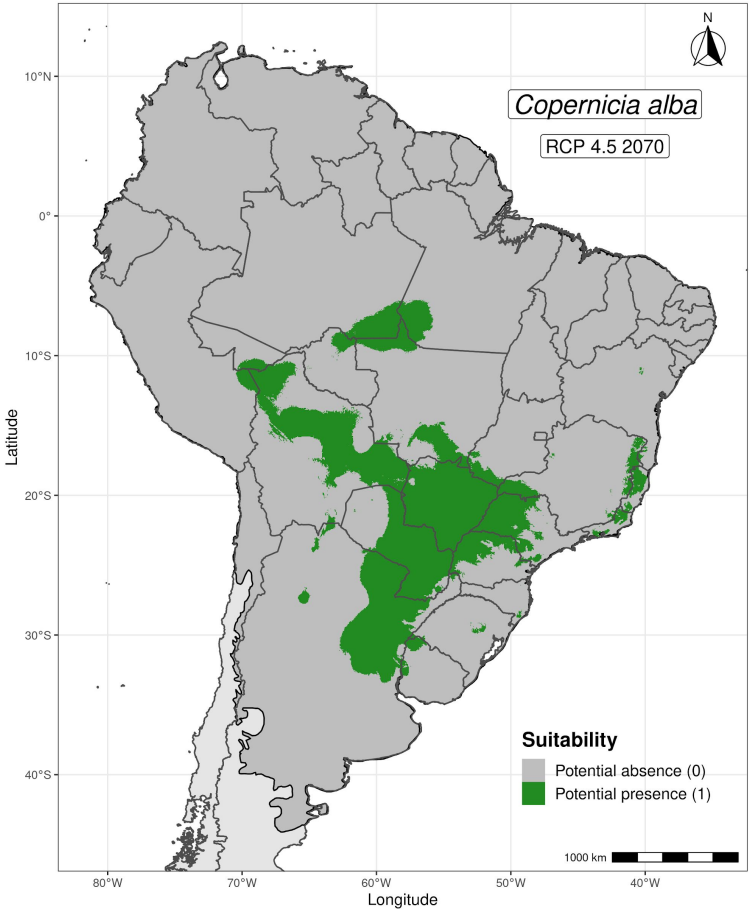




ENMs - Cenário otimista (RCP 4.5)

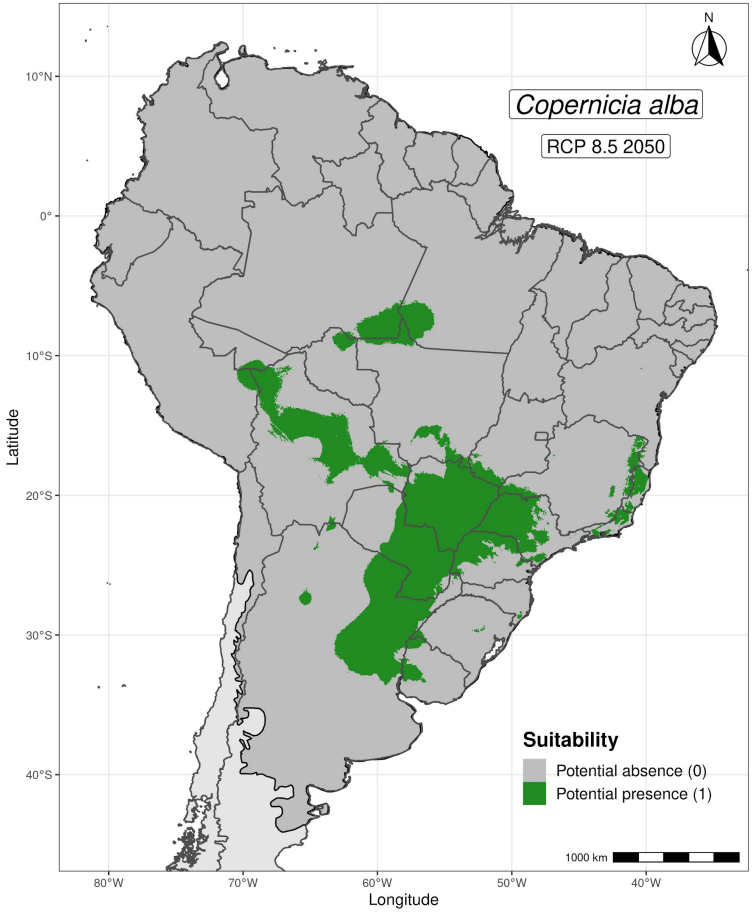
Copernicia alba

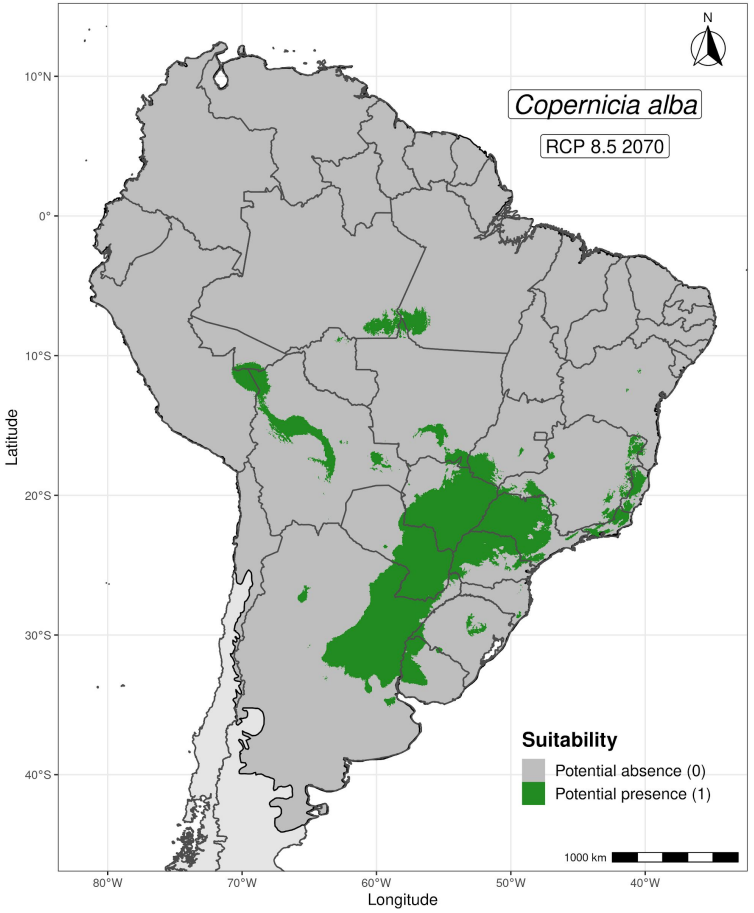




ENMs - Cenário pessimista (RCP 8.5)

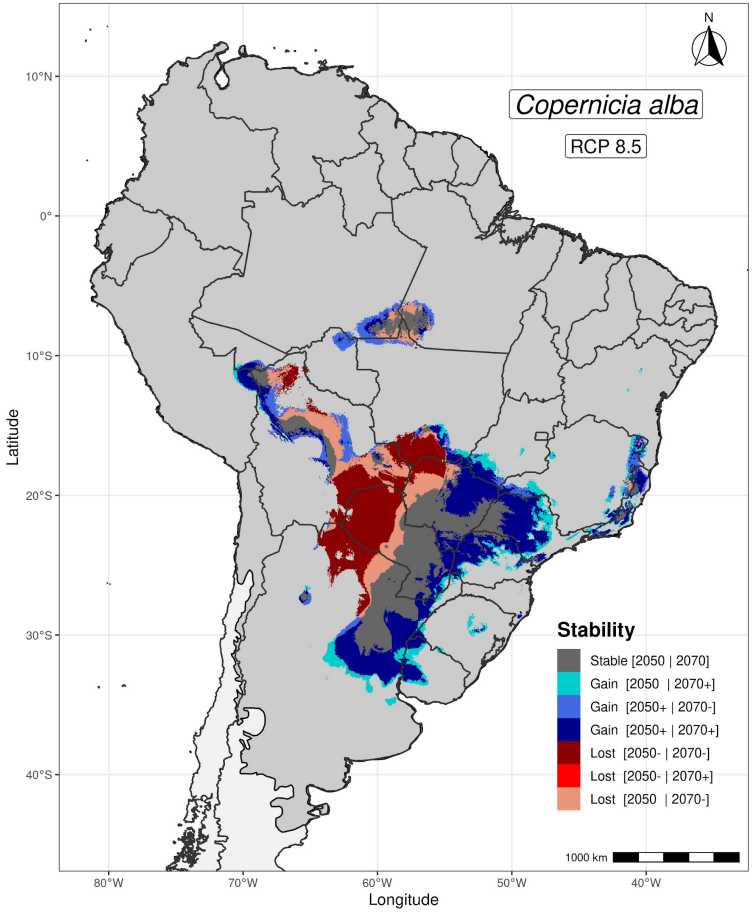
Copernicia alba

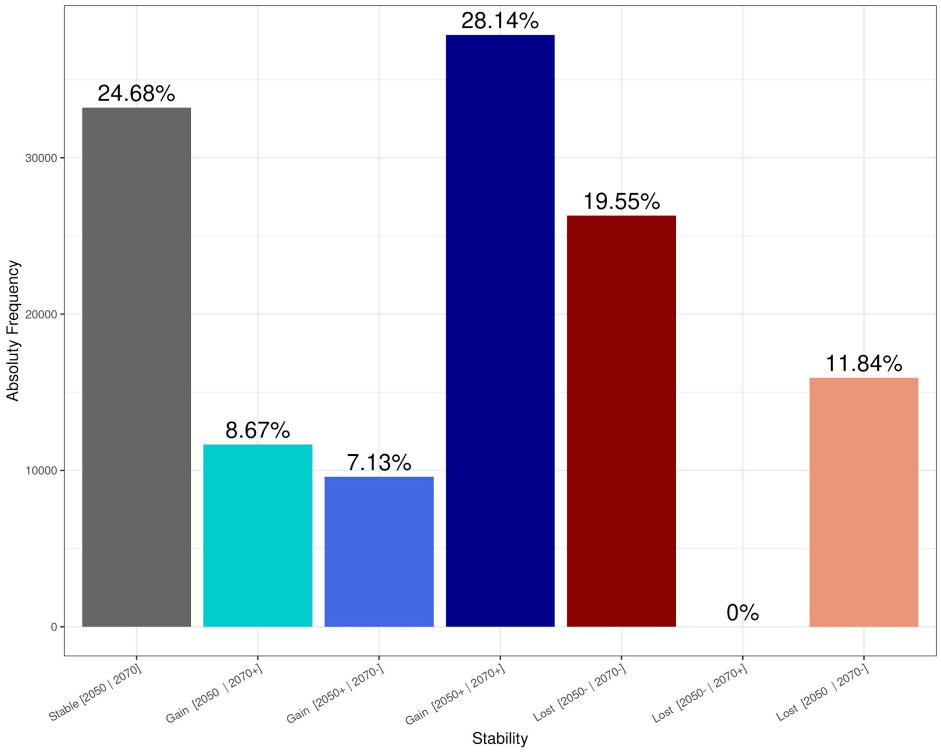




ENMs - Estabilidade (RCP 8.5)

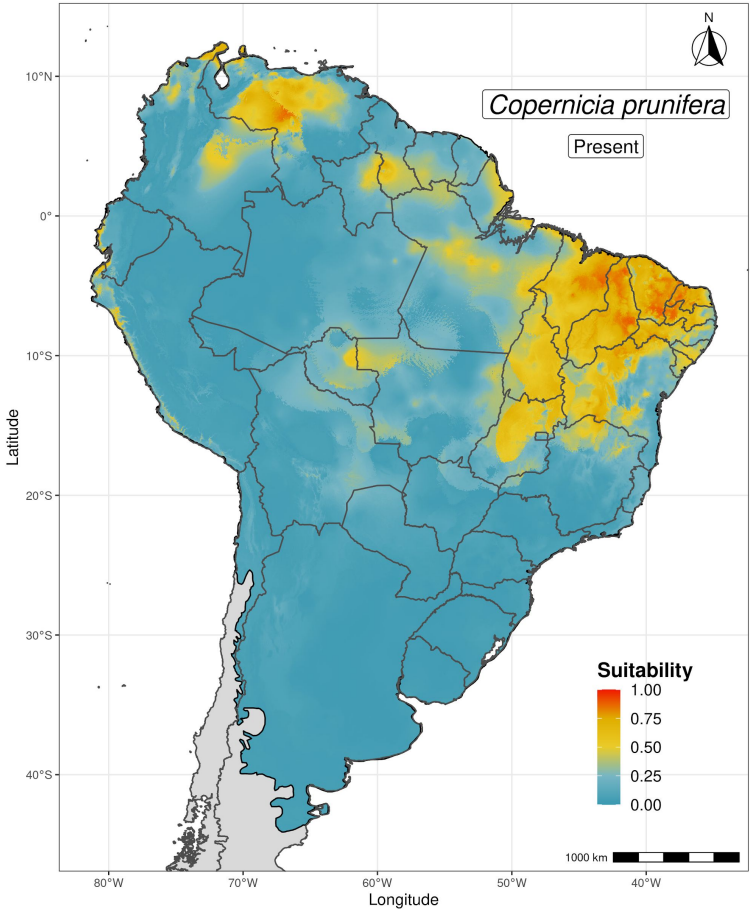
Copernicia alba

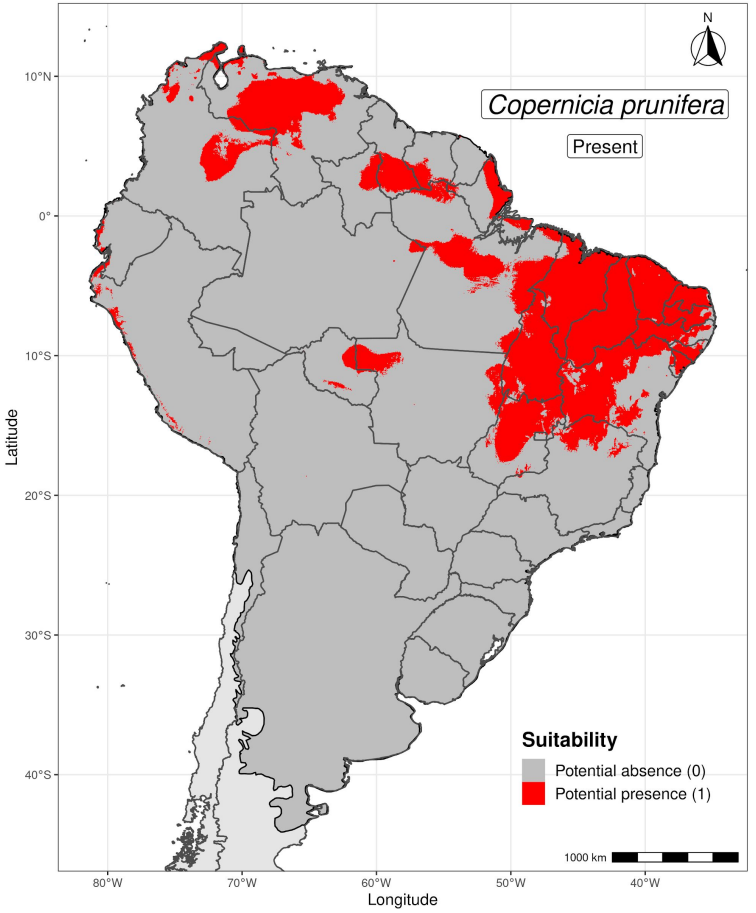




ENMs - Presente

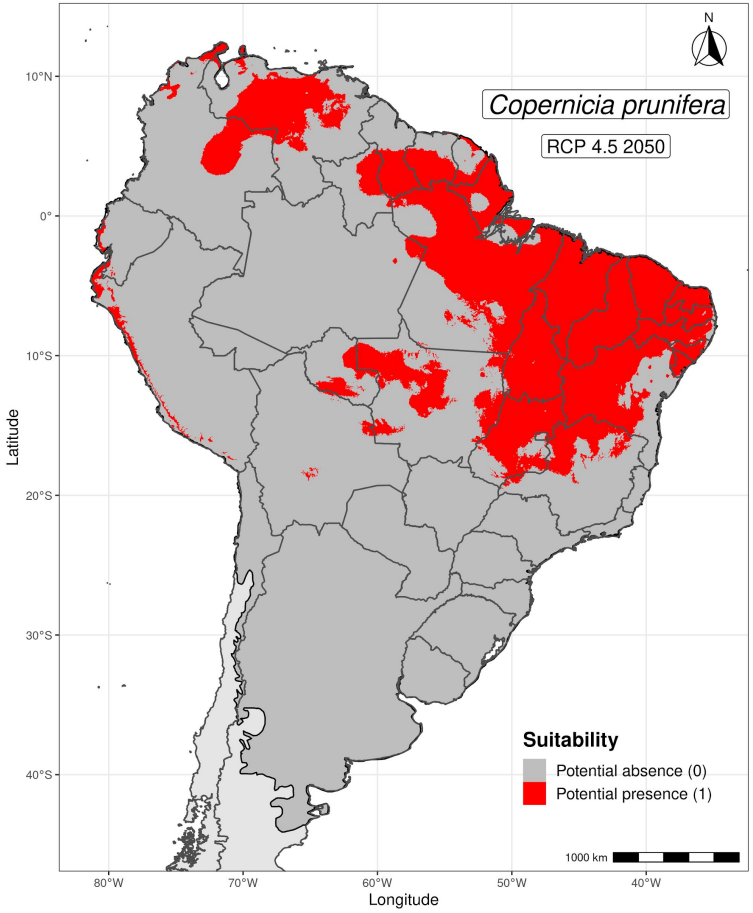
Copernicia prunifera

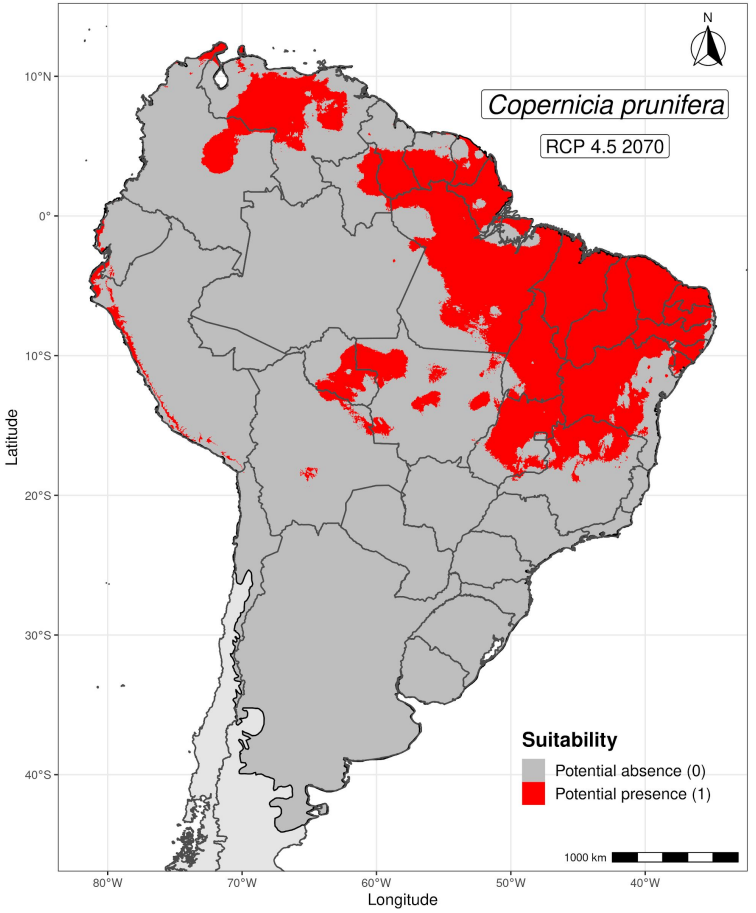




ENMs - Cenário otimista (RCP 4.5)

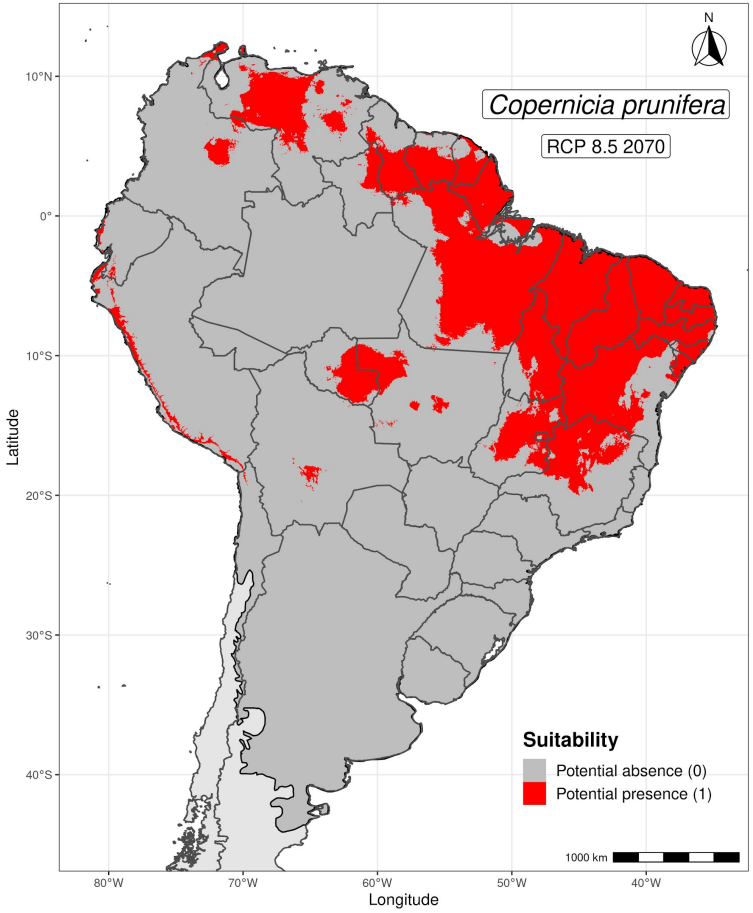
Copernicia prunifera

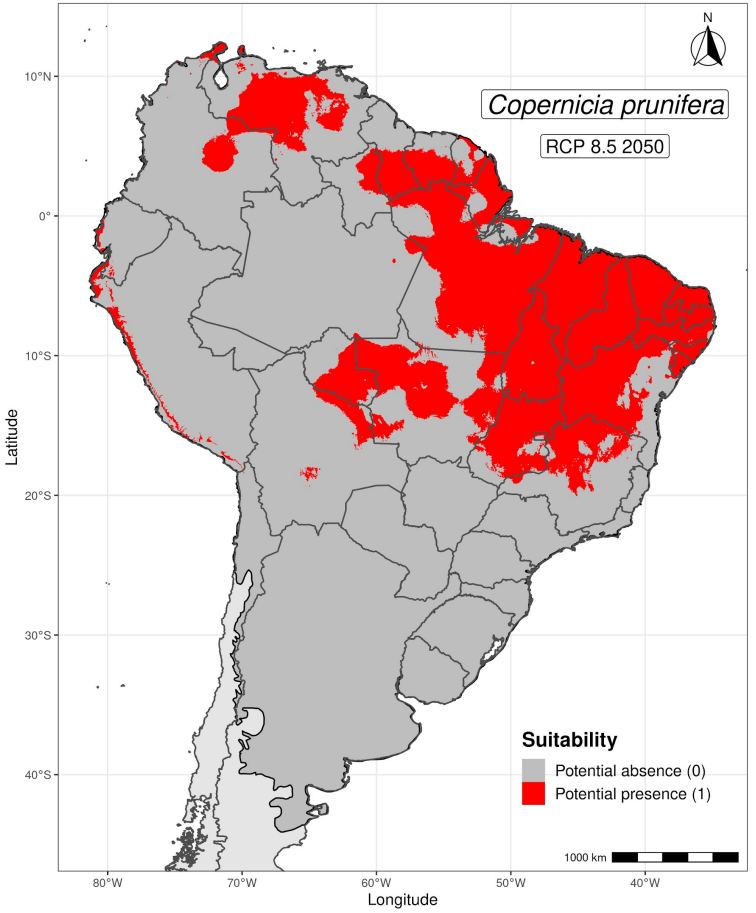




ENMs - Cenário pessimista (RCP 8.5)

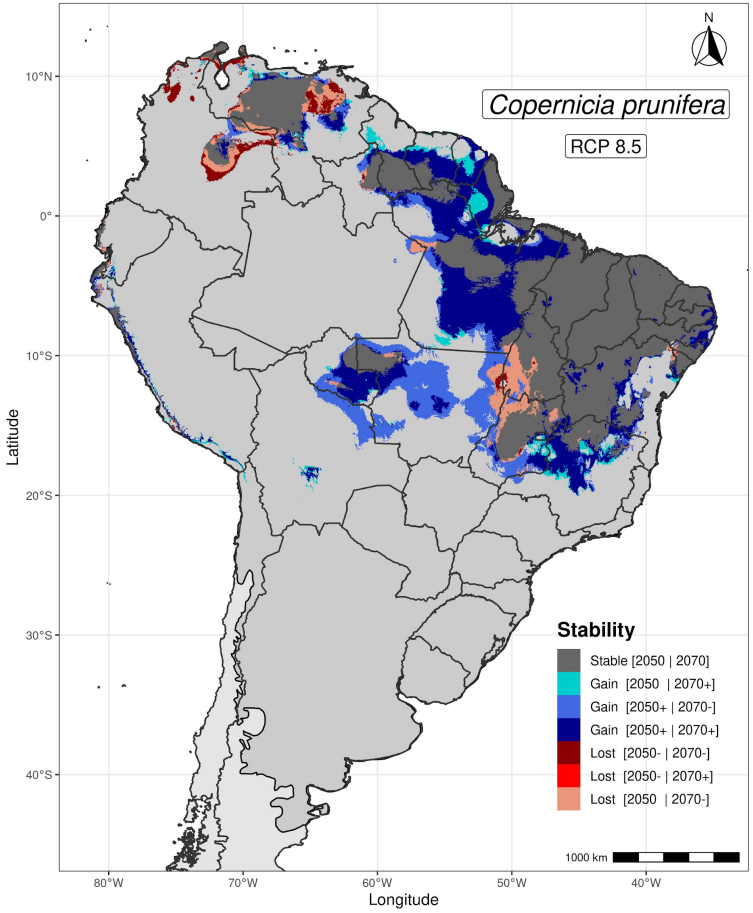
Copernicia prunifera

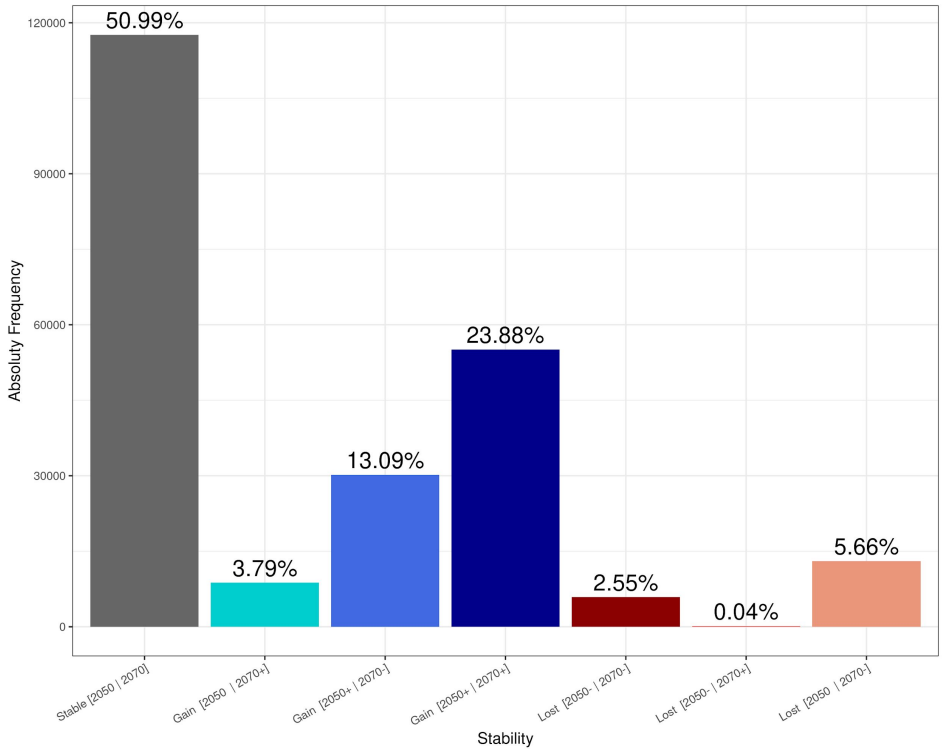




ENMs - Estabilidade (RCP 8.5)

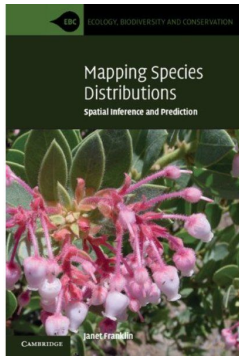
Copernicia prunifera



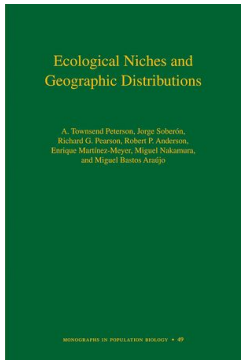


Mais informações

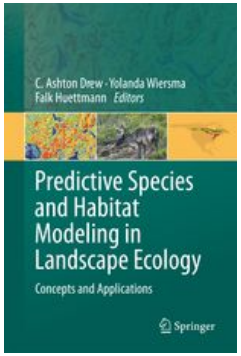
Livros



Franklin (2009)

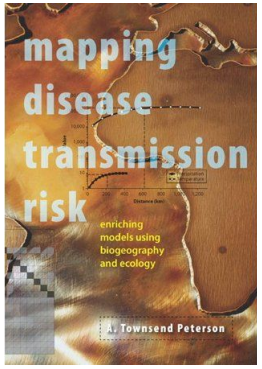


Peterson et al. (2011)

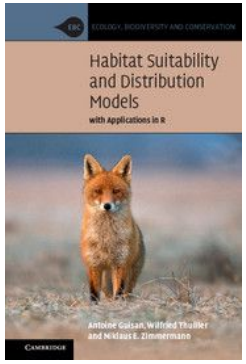


Drew et al. (2011)

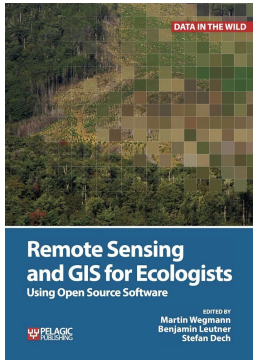
Lima-Ribeiro & Diniz-Filho (2013)



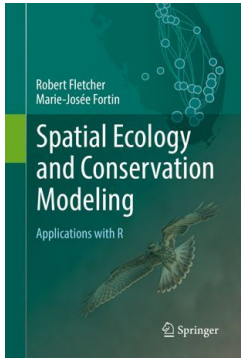
Peterson (2014)



Guisan et al. (2017)



Wegmann et al. (2016)
Cap. 13

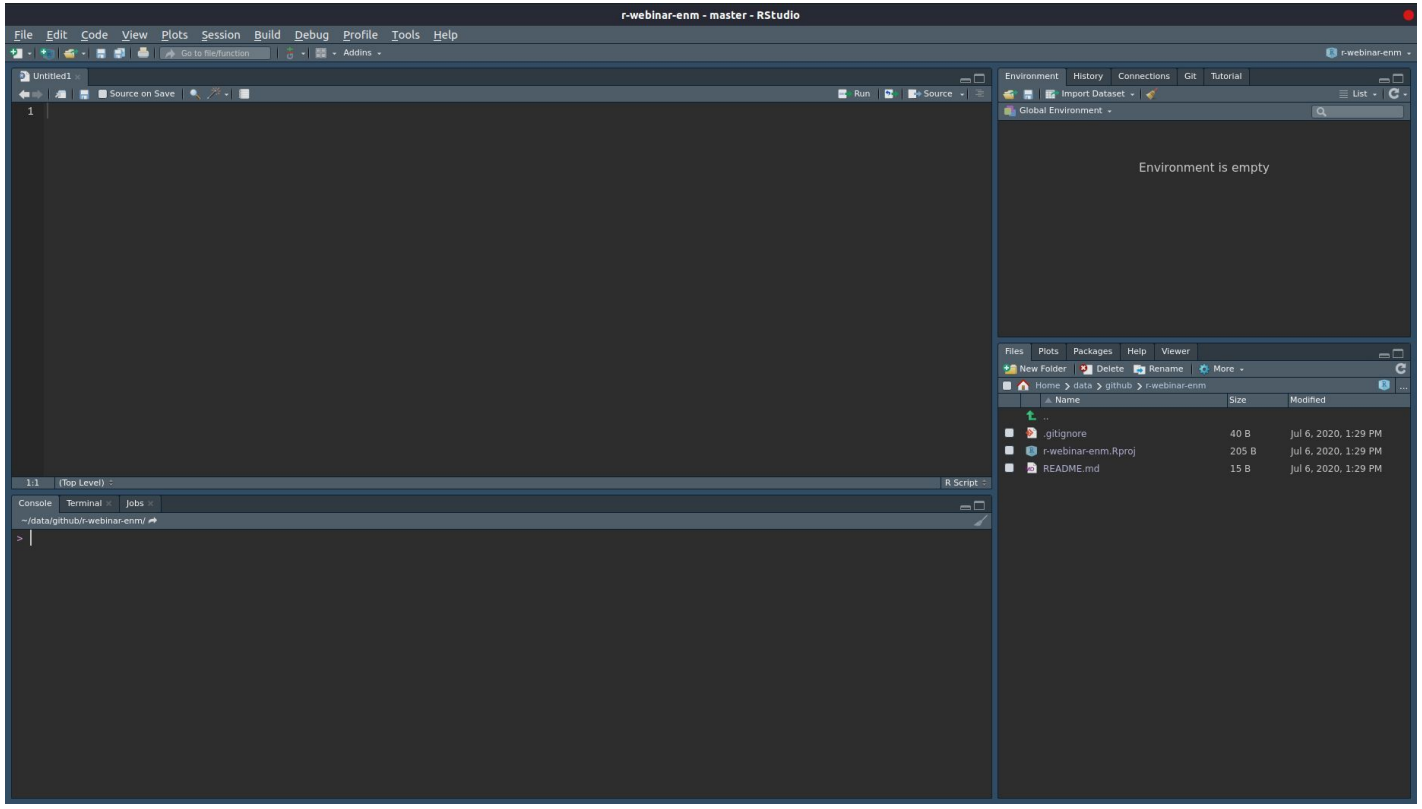


Fletcher and Fortin (2018)
Cap. 07

Prática

R

https://github.com/mauriciovancine/r-webinar-enm



Muito obrigado!

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