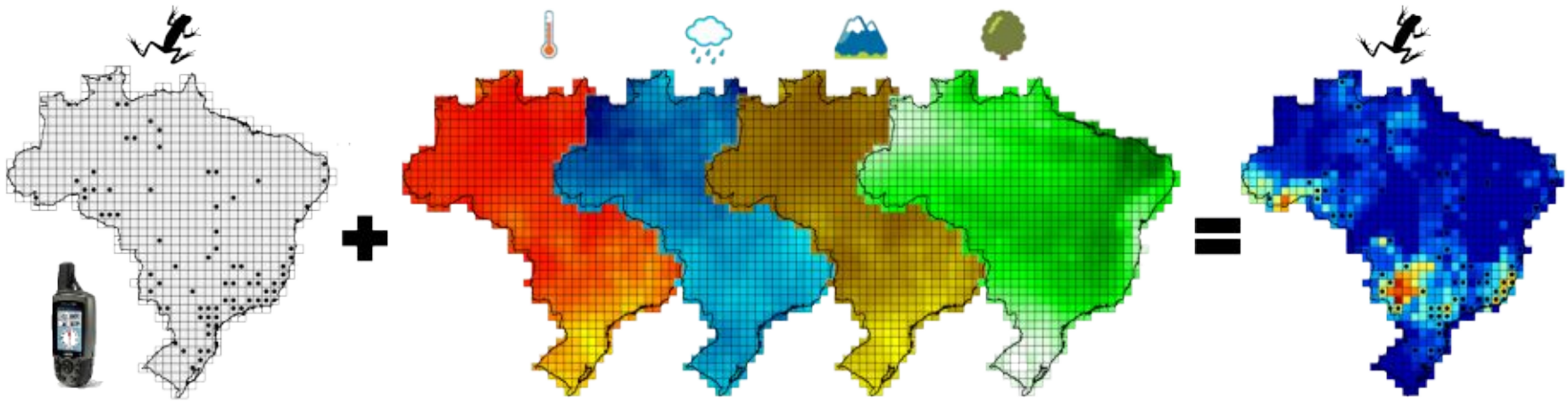
Modelos de Distribuição de Espécies: uma visão geral



Maurício Vancine

05/03/2020

Grupo de Genética e Genômica da Conservação
APTA

USP
ESALQ

Palestra

Tópicos

1. Apresentações
2. Introdução aos Modelos de Distribuição de Espécies - *Species Distribution Models* (SDMs)
3. Nicho Ecológico e Distribuição das Espécies
4. Construção dos SDMs 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

1. Apresentações

Maurício Vancine

Ecólogo (2015) | Mestre em Zoologia (2018) | Doutorado em Ecologia (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"

Especialidades

Modelos de Distribuição de Espécies (SDMs)
Análise de Dados Ecológicos e Geoespaciais
Open source [R, QGIS, GRASS GIS, Linux, Libreoffice, ...]

Contato e informações

mauricio.vancine@gmail.com
@mauriciovancine
mauriciovancine.netlify.com

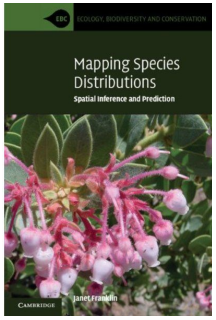
2. Introdução aos Modelos de Distribuição de Espécies (SDMs)

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)

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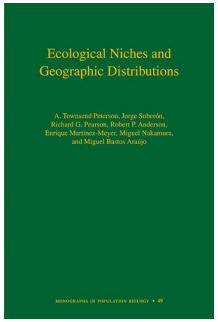
Estimado um espaço multivariado de variáveis climáticas (envelope)



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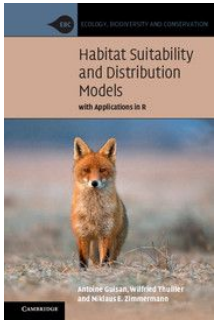
3. **Modelos de Adequabilidade de Habitat** (*Habitat Suitability Models*)
Envelope relacionado ao “habitat”, como espaço físico e recursos



Guisan et al. (2017)

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

Uma abordagem, muitos nomes...

Ecology, 93(7), 2012, pp. 1527–1539

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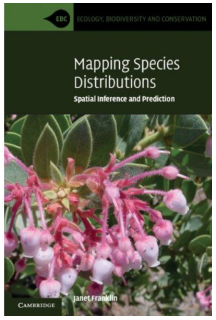

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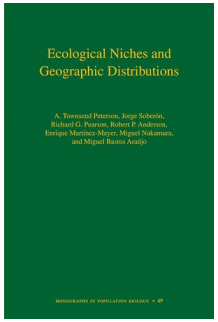

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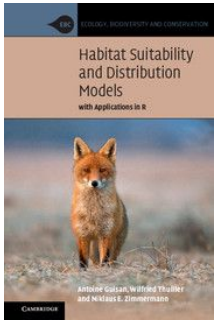
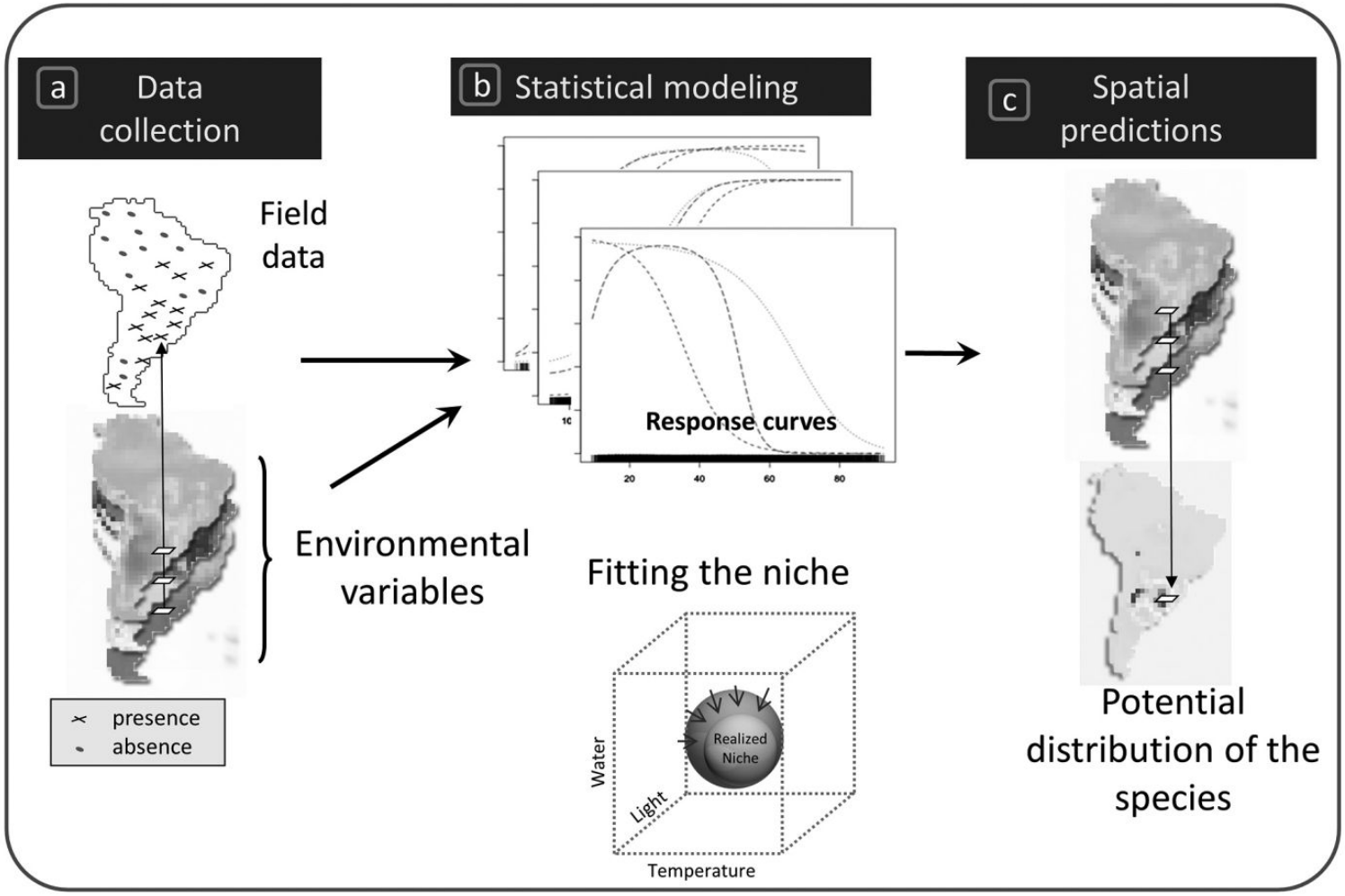
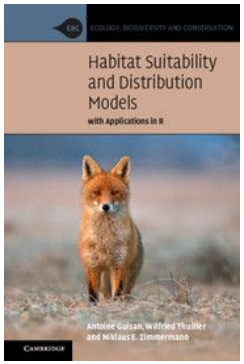


Guisan et al. (2017)

Modelos de Distribuição de Espécies (SDMs)

Visão geral

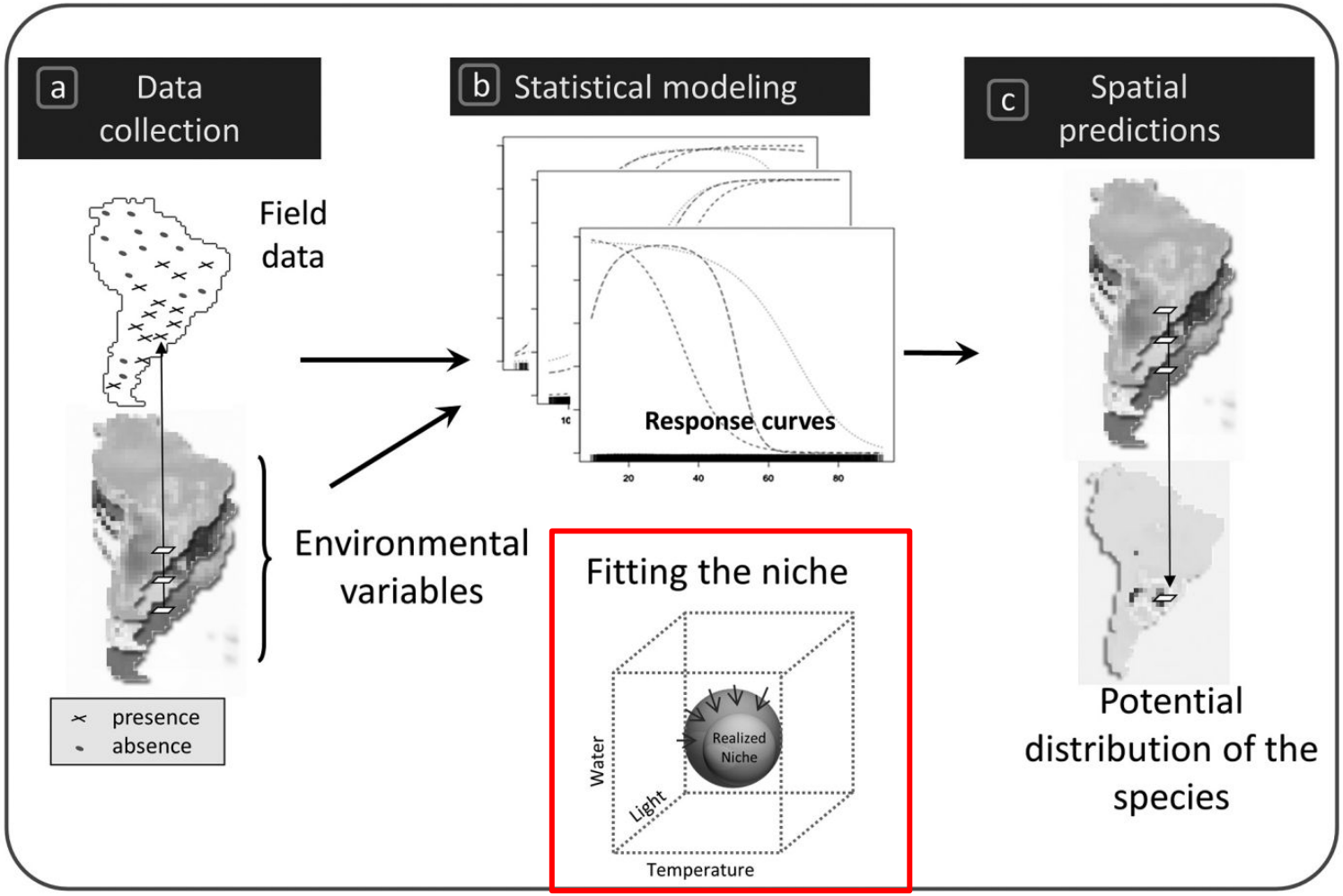


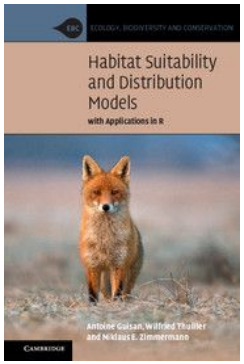


Guisan et al. (2017)

Modelos de Distribuição de Espécies (SDMs)

Visão geral





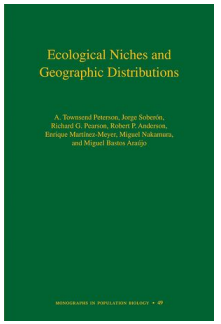
Guisan et al. (2017)

3. Nicho ecológico e distribuição das espécies

O que determina a distribuição das espécies?

Espaço Geográfico (G)

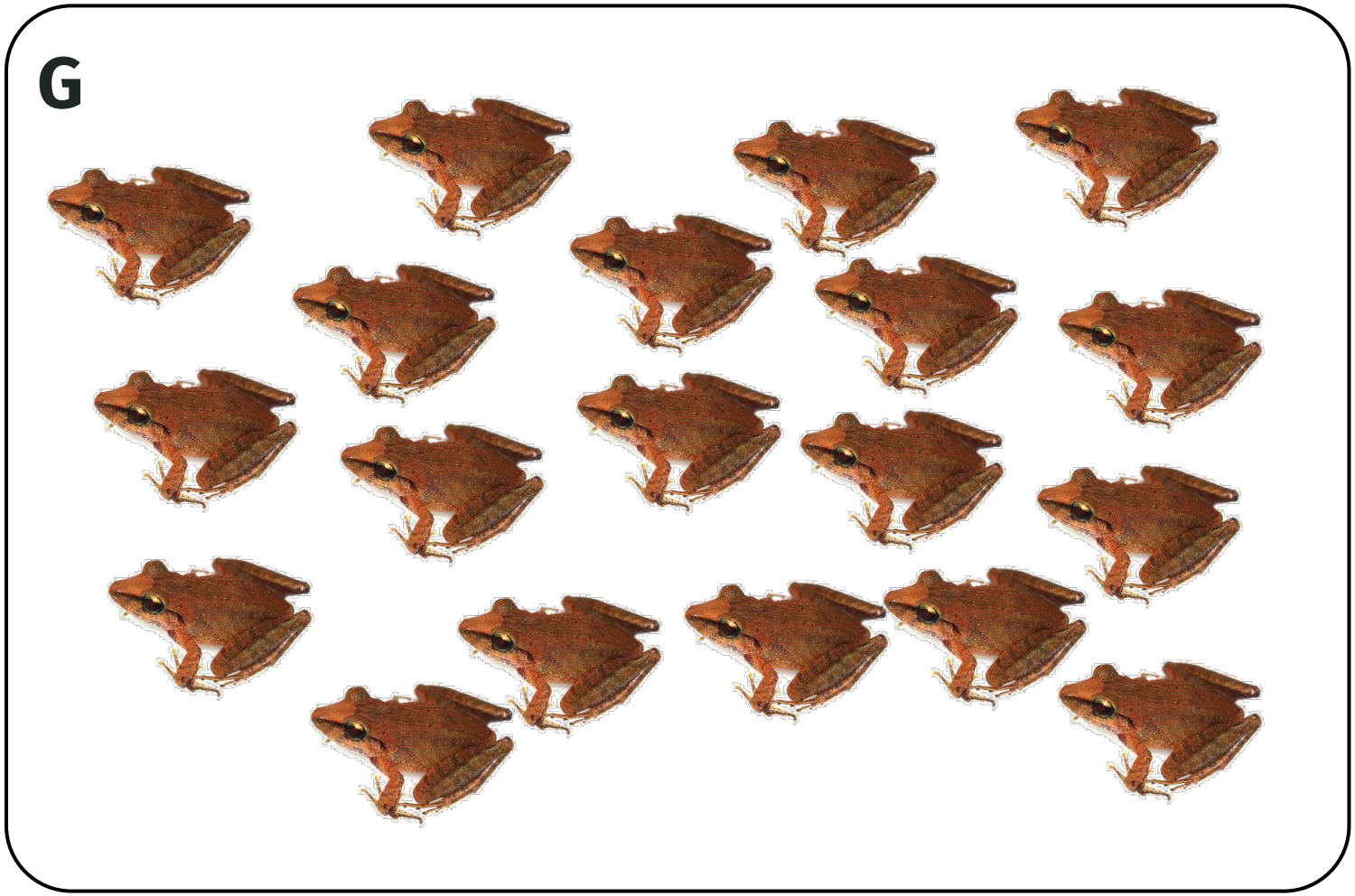
G

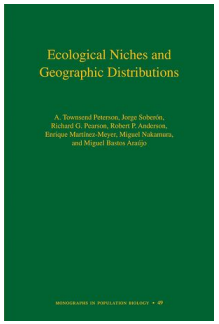


Peterson et al. (2011)

O que determina a distribuição das espécies?

Espaço Geográfico (G)

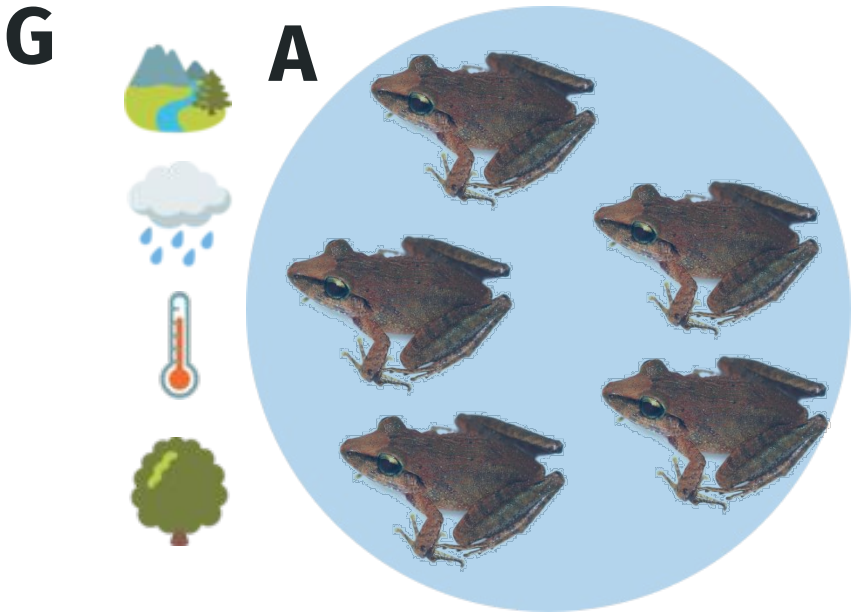


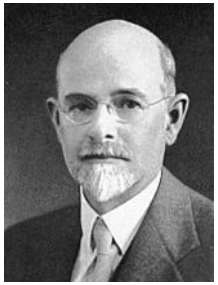


Peterson et al. (2011)

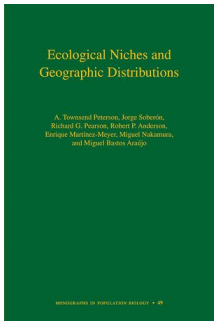
O que determina a distribuição das espécies?

Condições Abióticas (A)





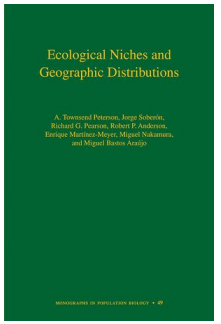
Joseph Grinnell (1917)
Requerimentos ambientais “condições climáticas”



Peterson et al. (2011)

O que determina a distribuição das espécies?

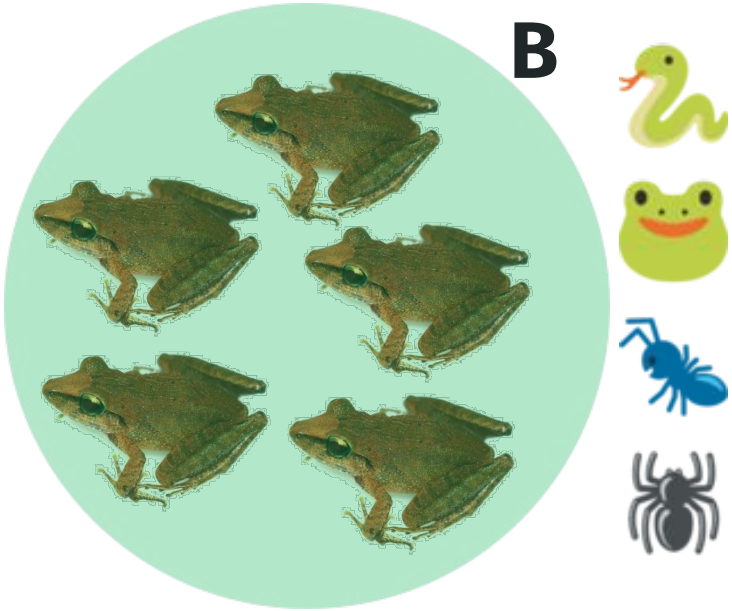
Condições Bióticas (B)



Peterson et al. (2011)

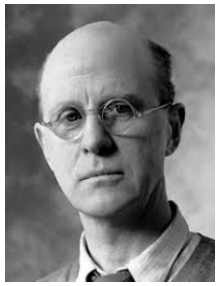
G

B



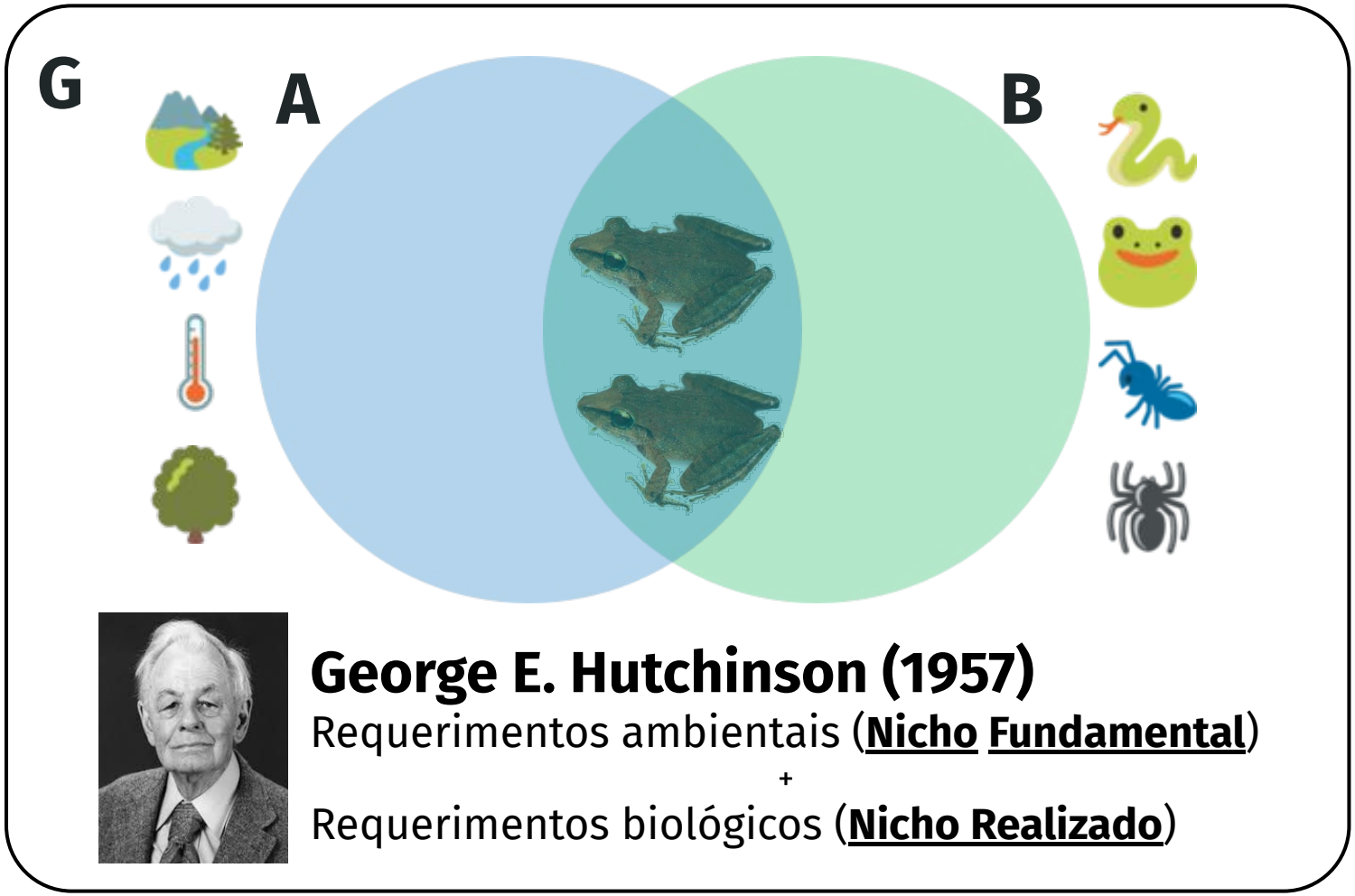
Charles Elton (1927)

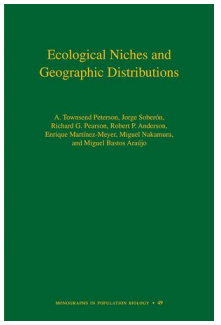
Papel funcional dos organismos “impacto”



O que determina a distribuição das espécies?

Relação entre condições abióticas e bióticas

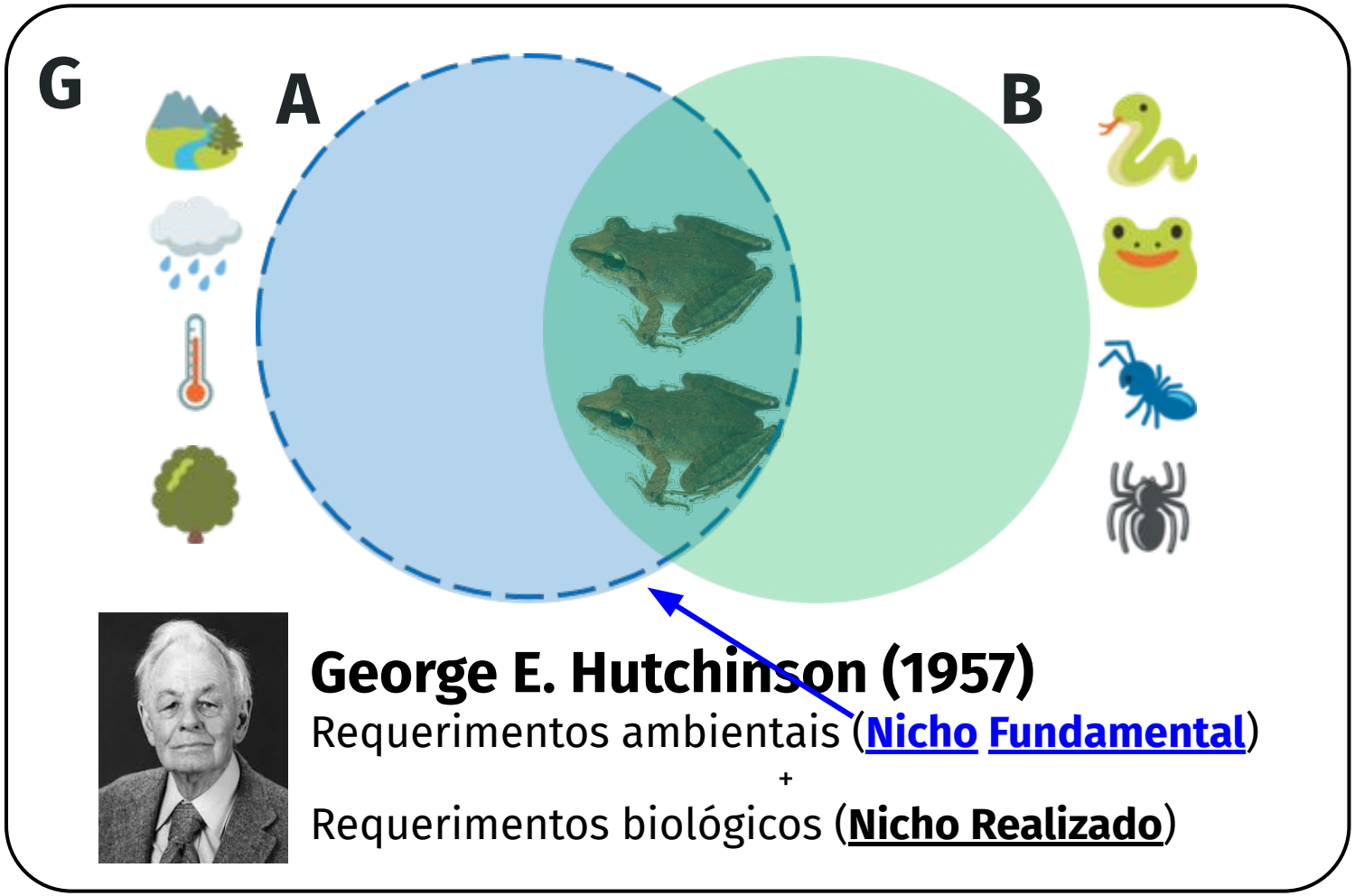




Peterson et al. (2011)

O que determina a distribuição das espécies?

Nicho Fundamental

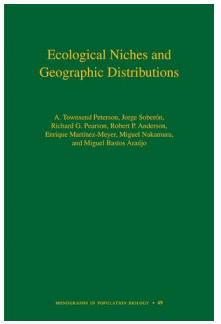


George E. Hutchinson (1957)

Requerimentos ambientais (**Nicho Fundamental**)

+

Requerimentos biológicos (**Nicho Realizado**)



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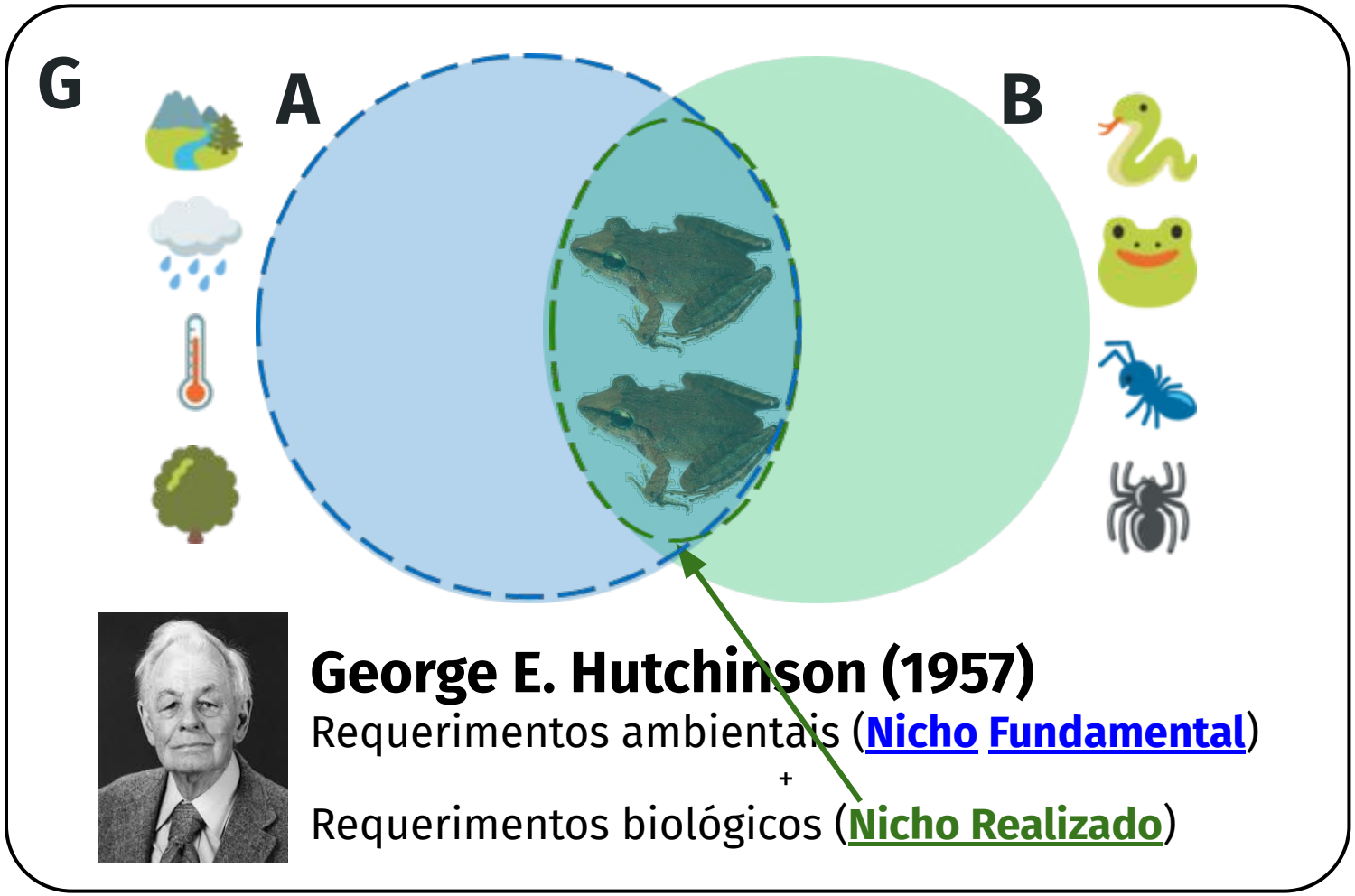
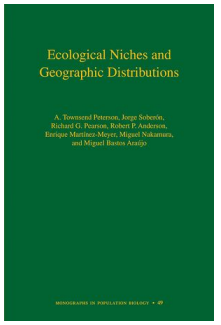
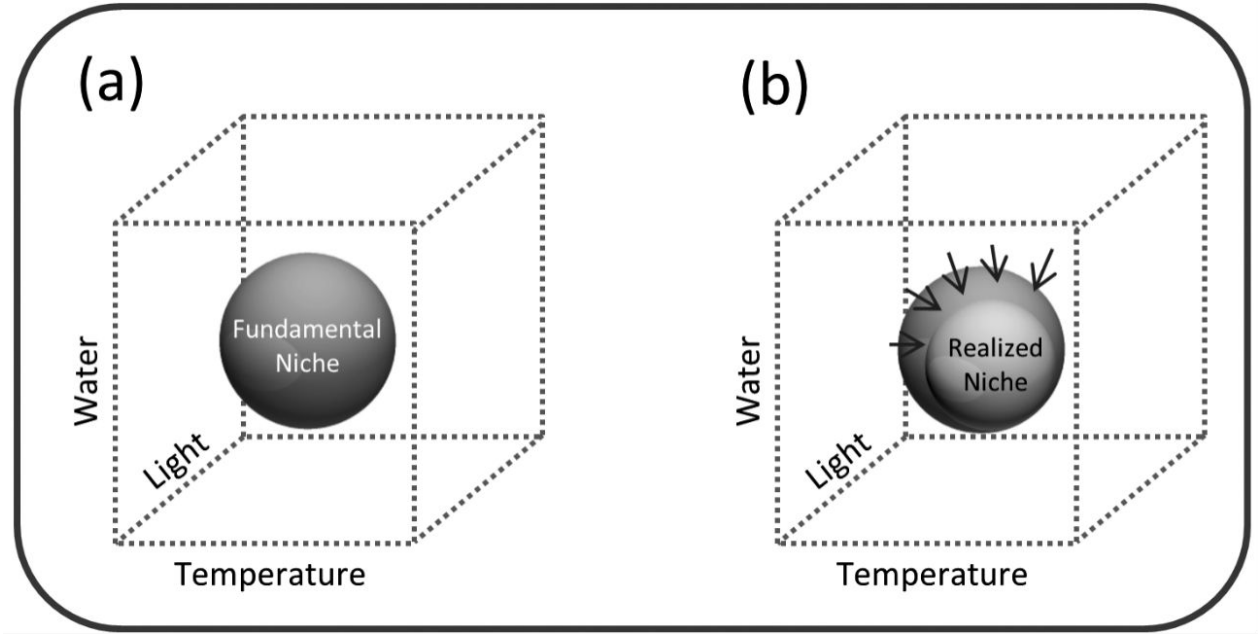


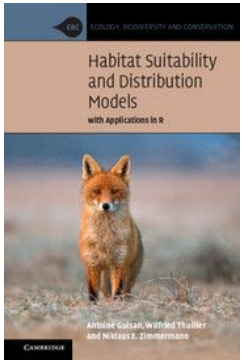


Peterson et al. (2011)

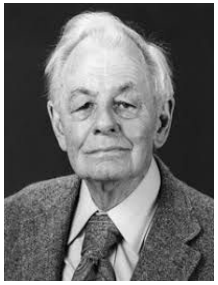
O que determina a distribuição das espécies?

Hipervolume n-dimensional





Guisan et al. (2017)



George E. Hutchinson (1957)

Requerimentos ambientais (**Nicho Fundamental**)

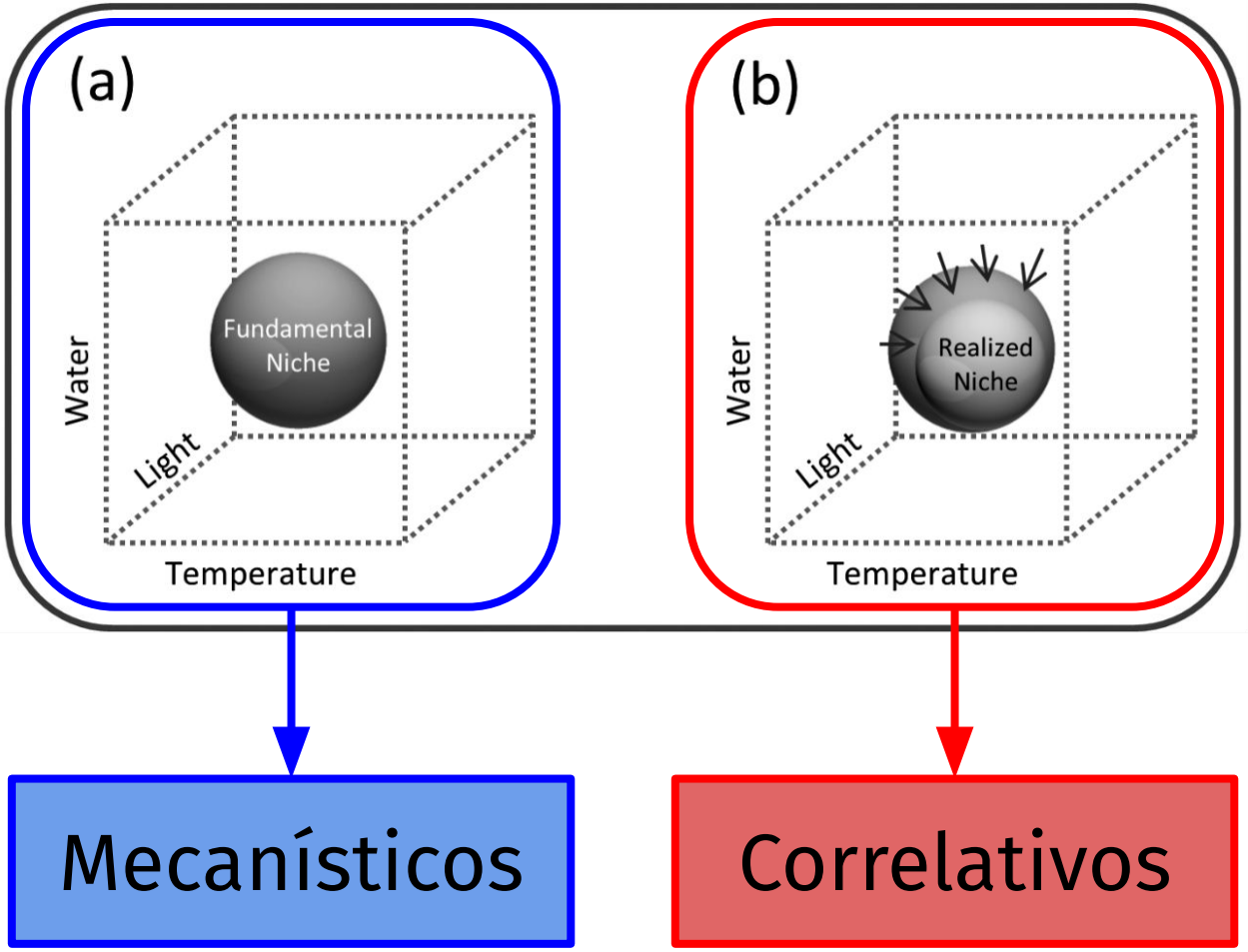
+

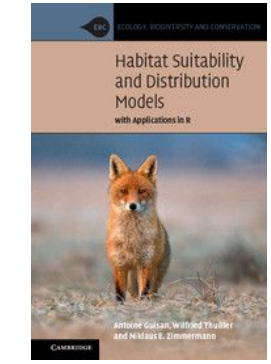
Requerimentos biológicos (**Nicho Realizado**)

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

Nicho fundamental e realizado

Modelos mecanísticos e correlativos

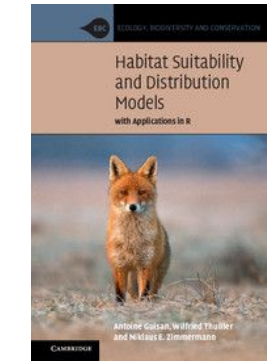




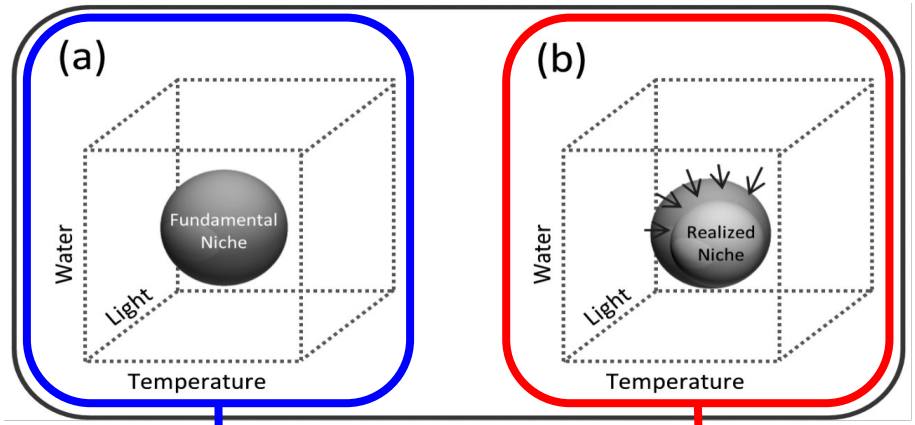
Guisan et al. (2017)

Nicho fundamental e realizado

Modelos mecanísticos e correlativos

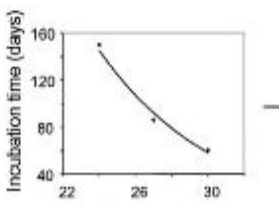


Guisan et al. (2017)

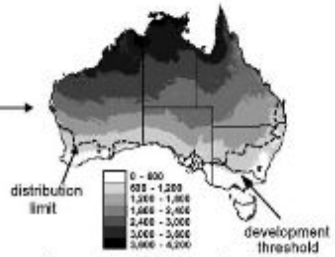


Mecanísticos

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



Heteronotia egg development

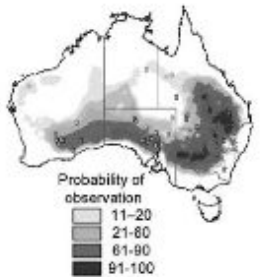


Degree days for egg development in soil

Correlativos

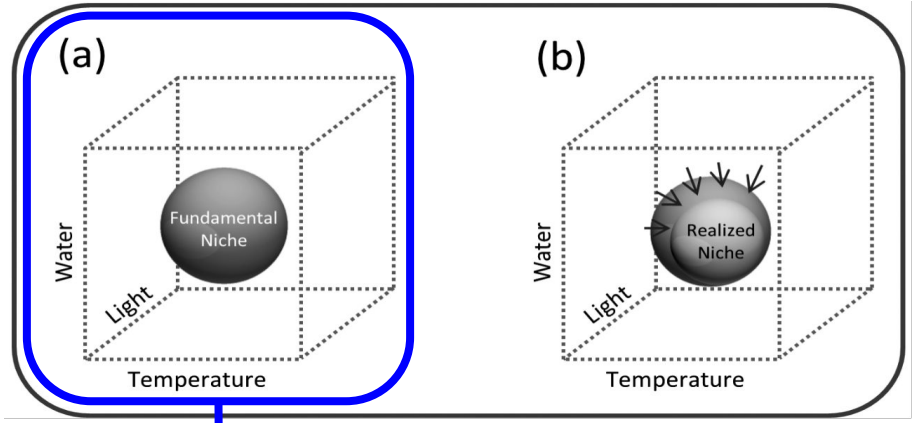
GIS data
Distribution data (presence/absence)
→ Correlative habitat model → Predicted distribution (probability of occurrence)

Heteronotia (EA6 lineage) presence/absence

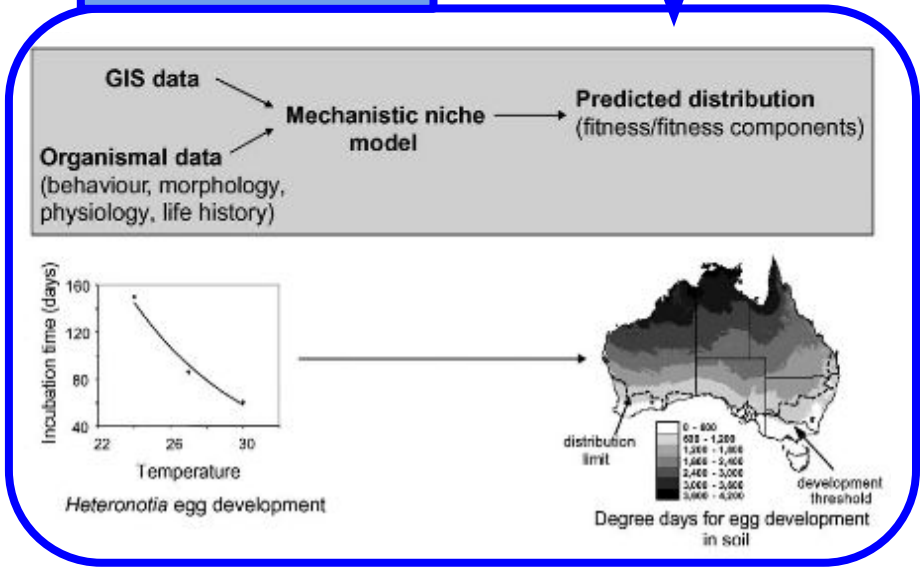


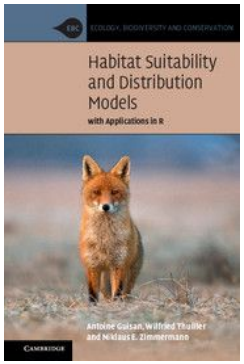
Nicho fundamental

Modelos mecanísticos



Mecanísticos





Guisan et al. (2017)

Como determinar o **nicho fundamental** de uma espécie?

Como determinar o nicho fundamental

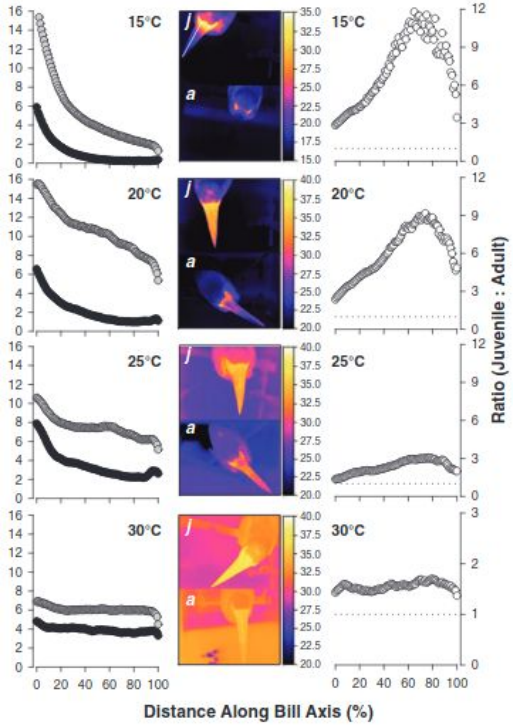
Experimentos fisiológicos e traços funcionais

REPORT

Heat Exchange from the Toucan Bill Reveals a Controllable Vascular Thermal Radiator

Glenn J. Tattersall[1,3], Denis V. Andrade[2,3], Augusto S. Abe[2,3]
+ See all authors and affiliations

Science 24 Jul 2009:
Vol. 325, Issue 5939, pp. 468-470
DOI: 10.1126/science.1175553



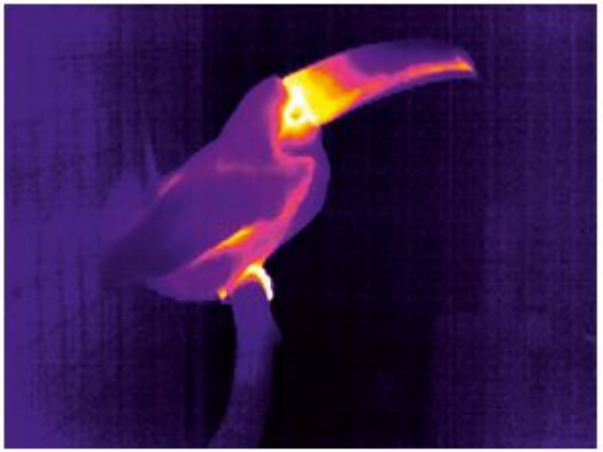


Imagem térmica mostra onde o calor se concentra *(em amarelo)*

THIAGO FILADELPHO

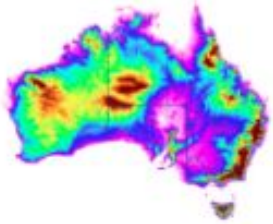
Modelos mecanísticos

Ecology Letters, (2009) **12**: 334–350 doi: 10.1111/j.1461-0248.2008.01277.x

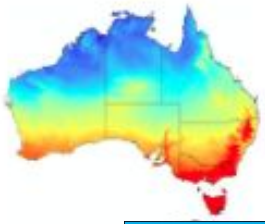
REVIEW AND SYNTHESIS

Mechanistic niche modelling: combining physiological and spatial data to predict species'

Michael Kearney[1]* and Warren Porter[2]

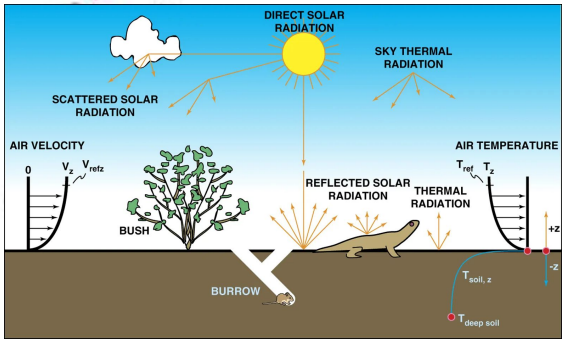


GIS Data In
climate
terrain
shading etc.



monthly/daily data

Microclimate Model



hourly microclimate per day/month

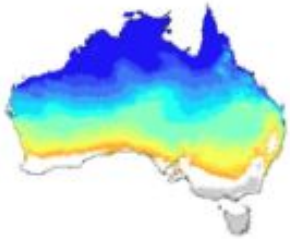
Organism/ Object Data
size/shape, reflectivity, diet, behaviour, performance curves etc.

Organism/Object Models

monthly/daily/hourly

GIS Data Out
survival, growth, reproduction, etc.

Potential Distribution



Kearney & Porter (2009)

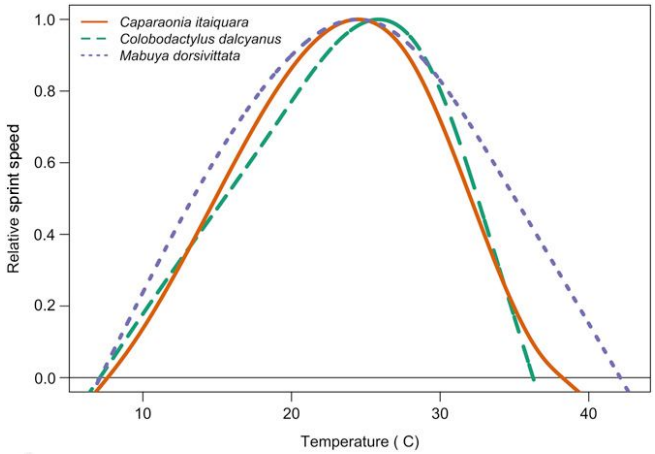
Modelos mecanísticos

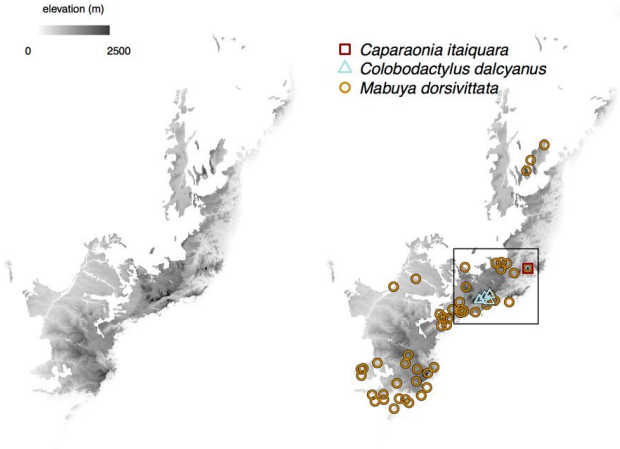
Experimentos fisiológicos e traços funcionais

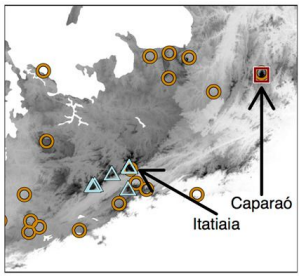
Thermophysiology, microclimates, and species distributions of lizards in the mountains of the Brazilian Atlantic Forest

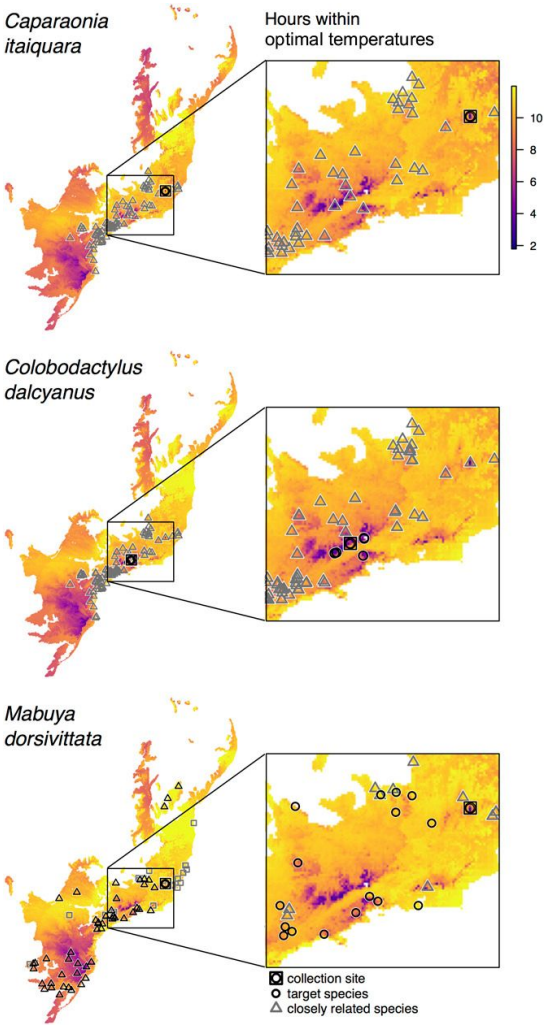
Maria L. Strangas ✉, Carlos A. Navas, Miguel T. Rodrigues, Ana C. Carnaval

Caparaonia itaiquara



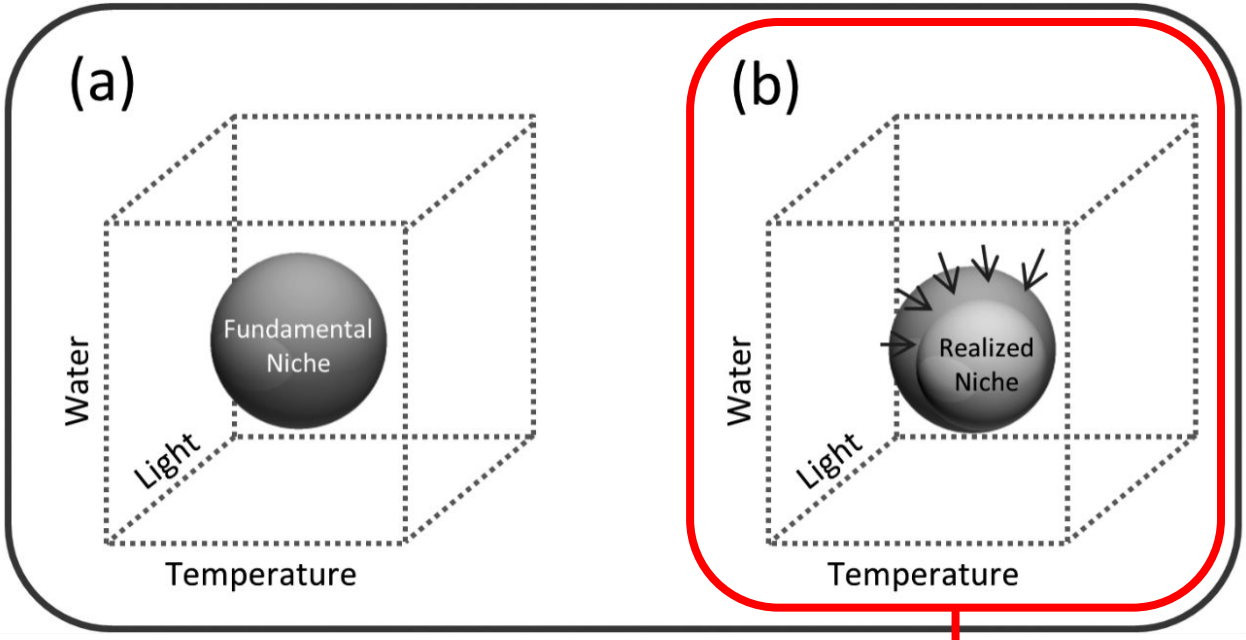




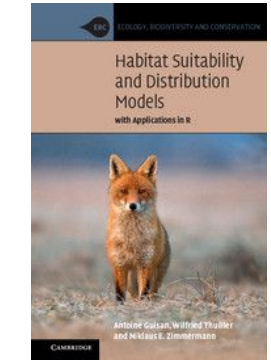


Nicho realizado

Modelos correlativos



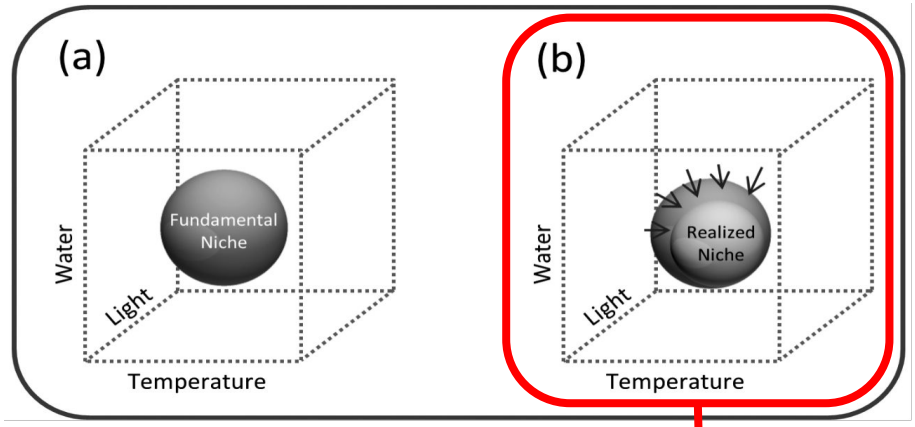
Correlativos

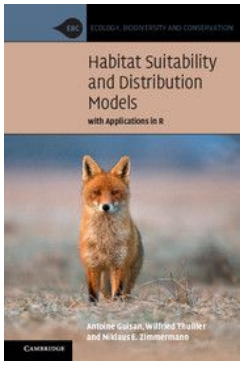


Guisan et al. (2017)

Nicho realizado

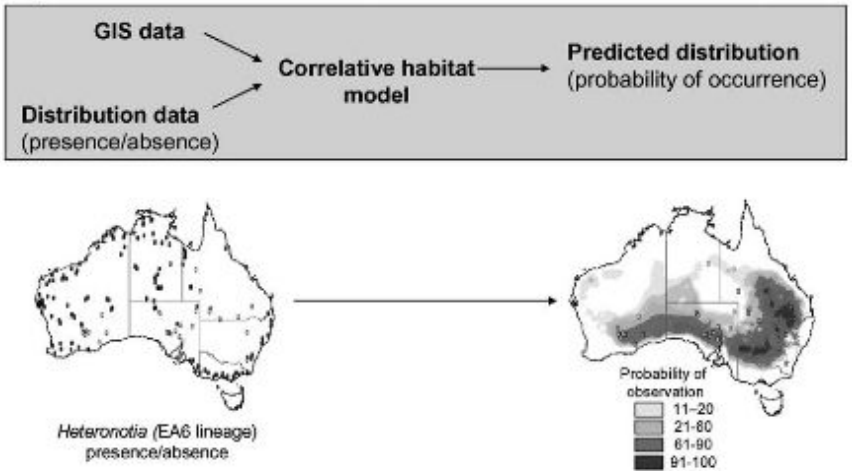
Modelos correlativos





Guisan et al. (2017)

Correlativos

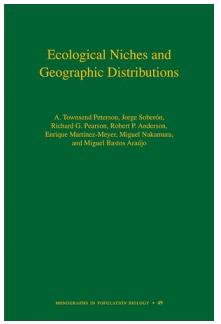


Modelos correlativos

Ocorrências

Espaço geográfico (G)

Jackson & Overpack (2000)



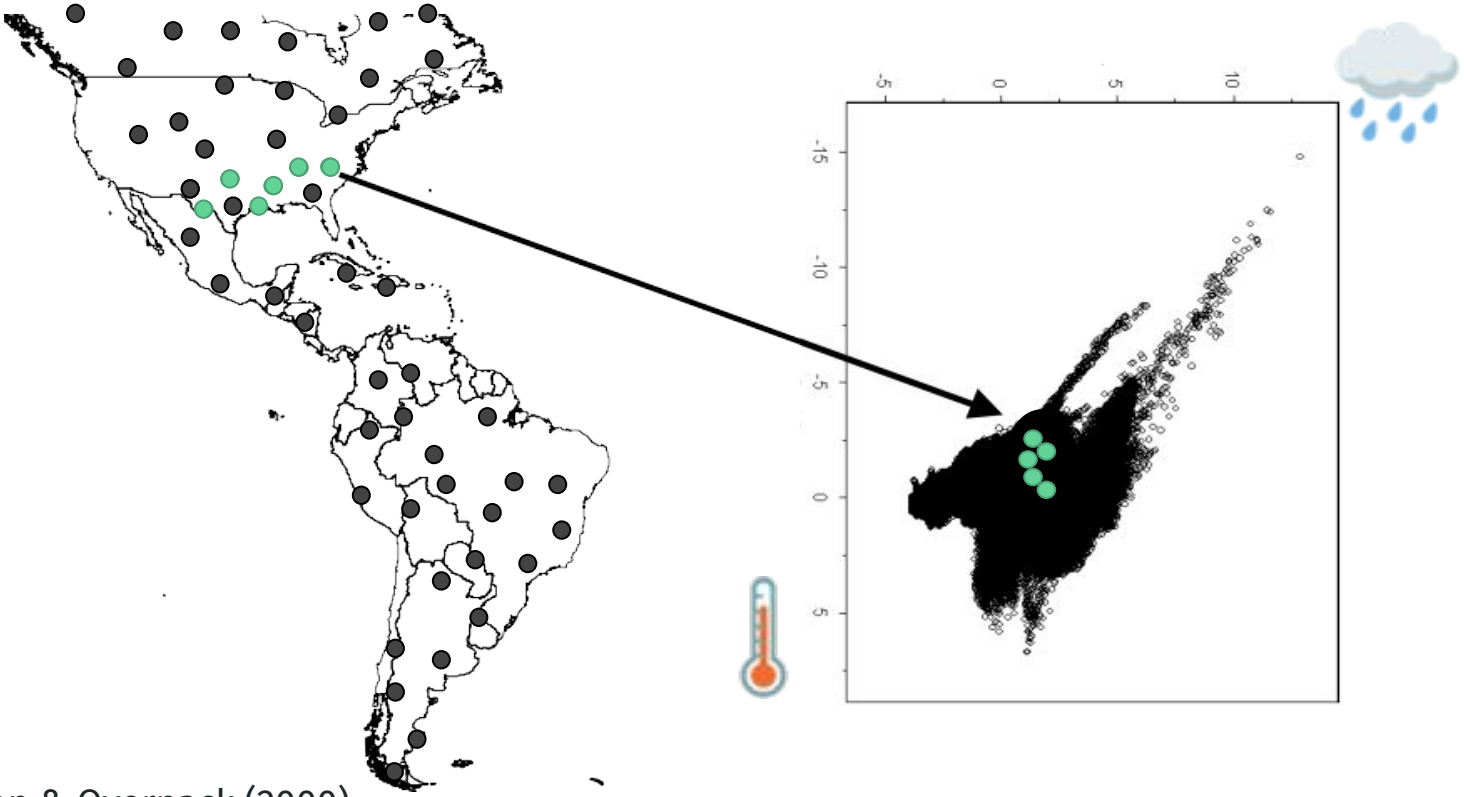
Peterson et al. (2011)

Modelos correlativos

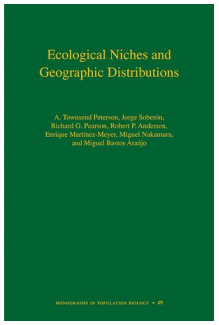
Condições ambientais

Espaço geográfico (G)

Espaço ambiental (E)



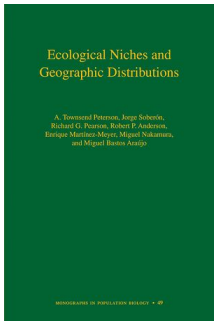
Jackson & Overpack (2000)



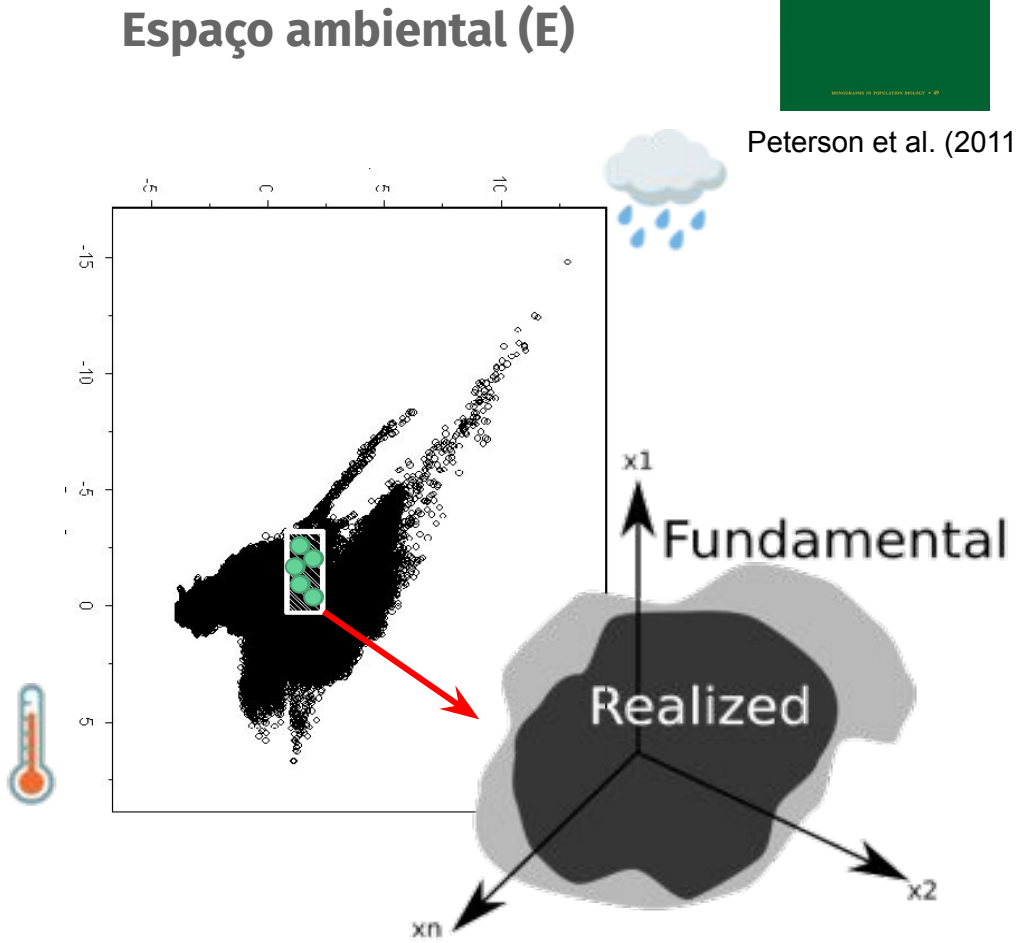
Peterson et al. (2011)

Modelos correlativos

Estimativa do nicho realizado



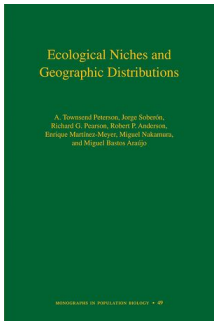
Peterson et al. (2011)



Jackson & Overpack (2000)

Modelos correlativos

Predição do nicho realizado estimado



Peterson et al. (2011)

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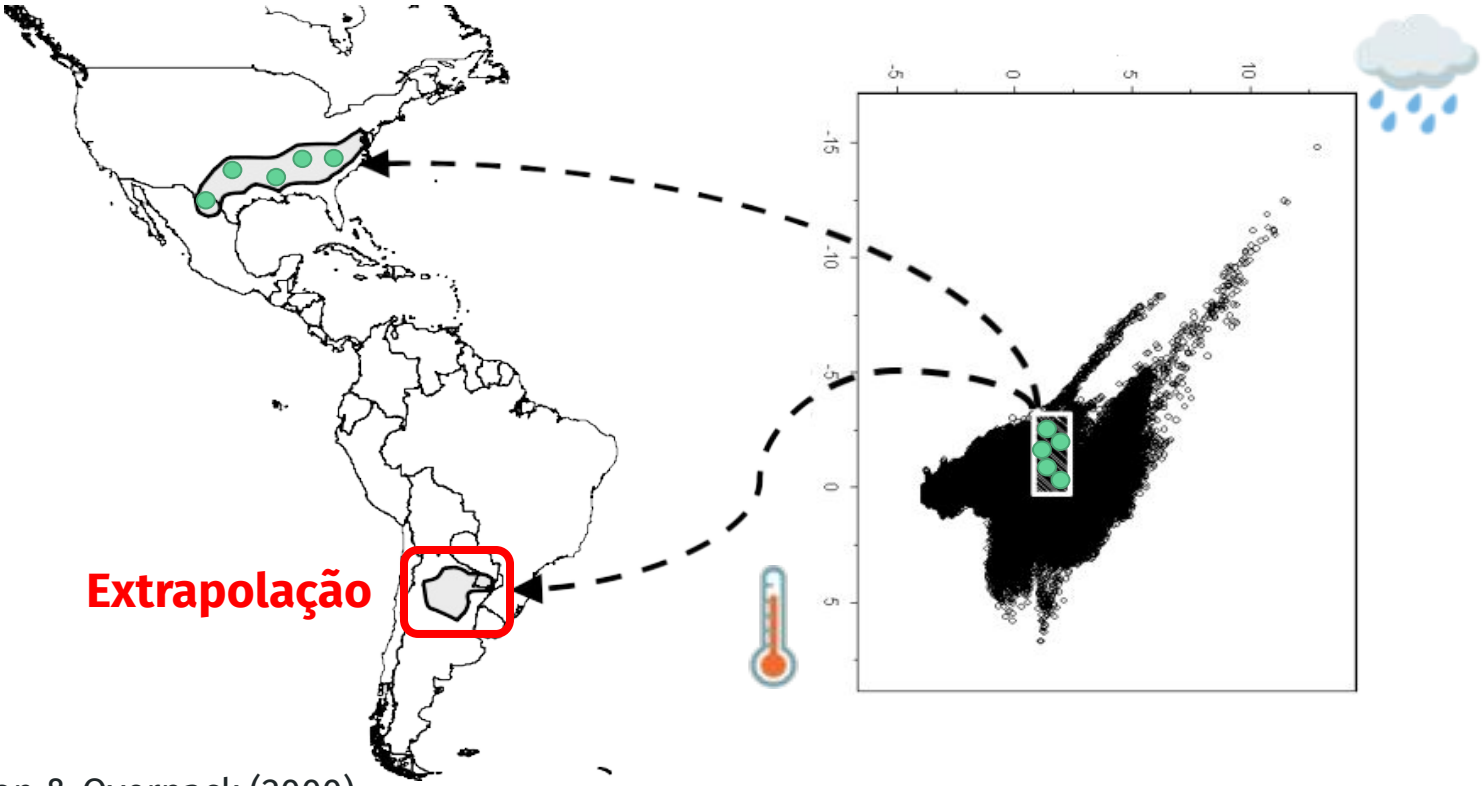
Espaço ambiental (E)

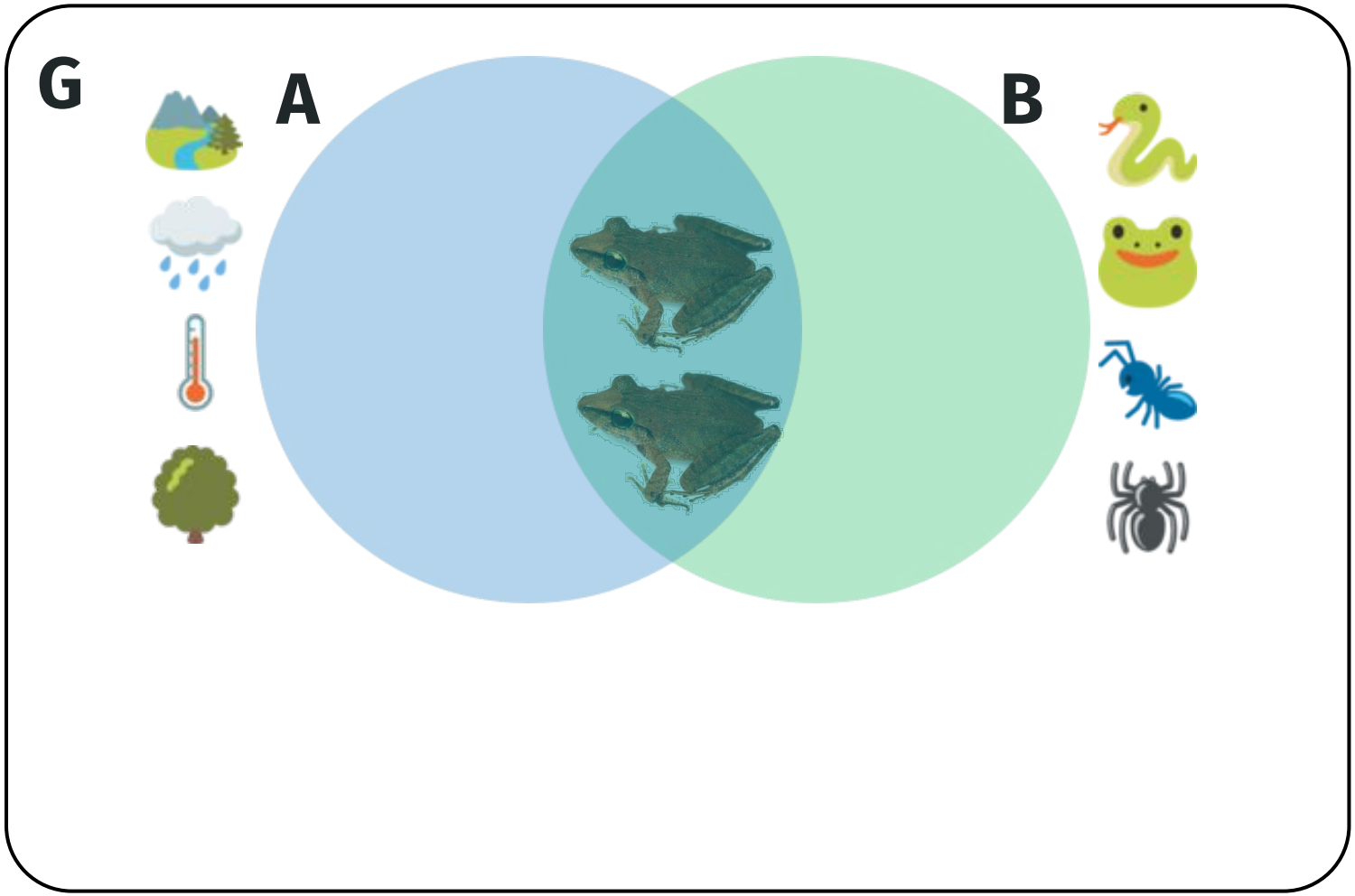


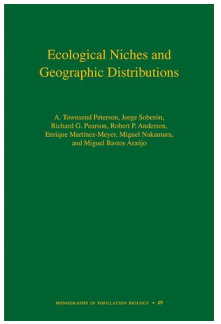
Jackson & Overpack (2000)

E como contornar essa **extrapolação**?

O que determina a distribuição das espécies?

Nicho Ecológico

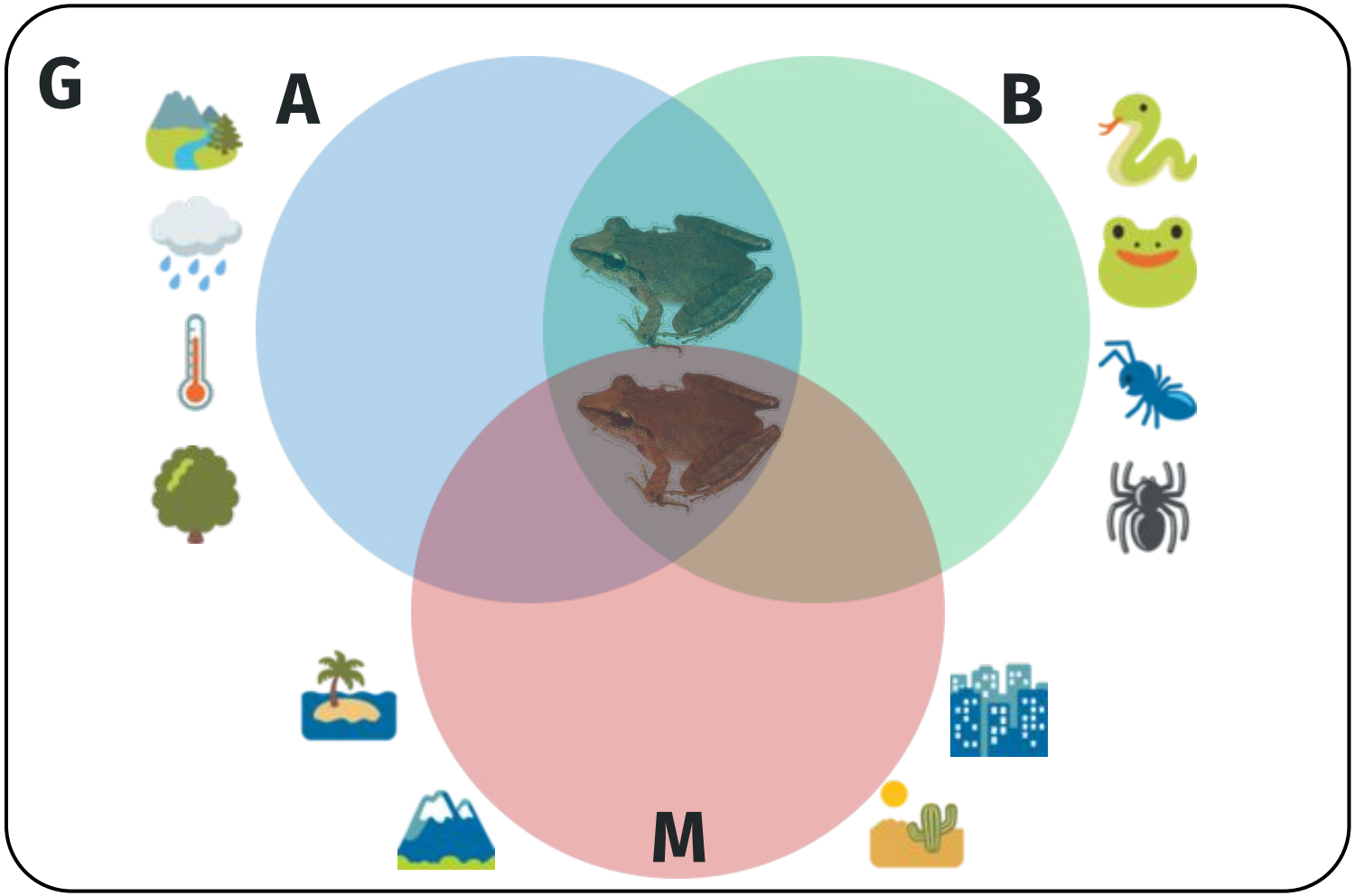


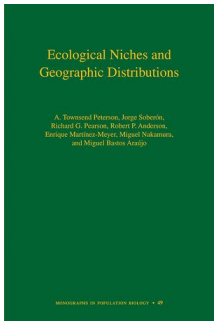


Peterson et al. (2011)

O que determina a distribuição das espécies?

Nicho Ecológico limitado pelo **movimento**

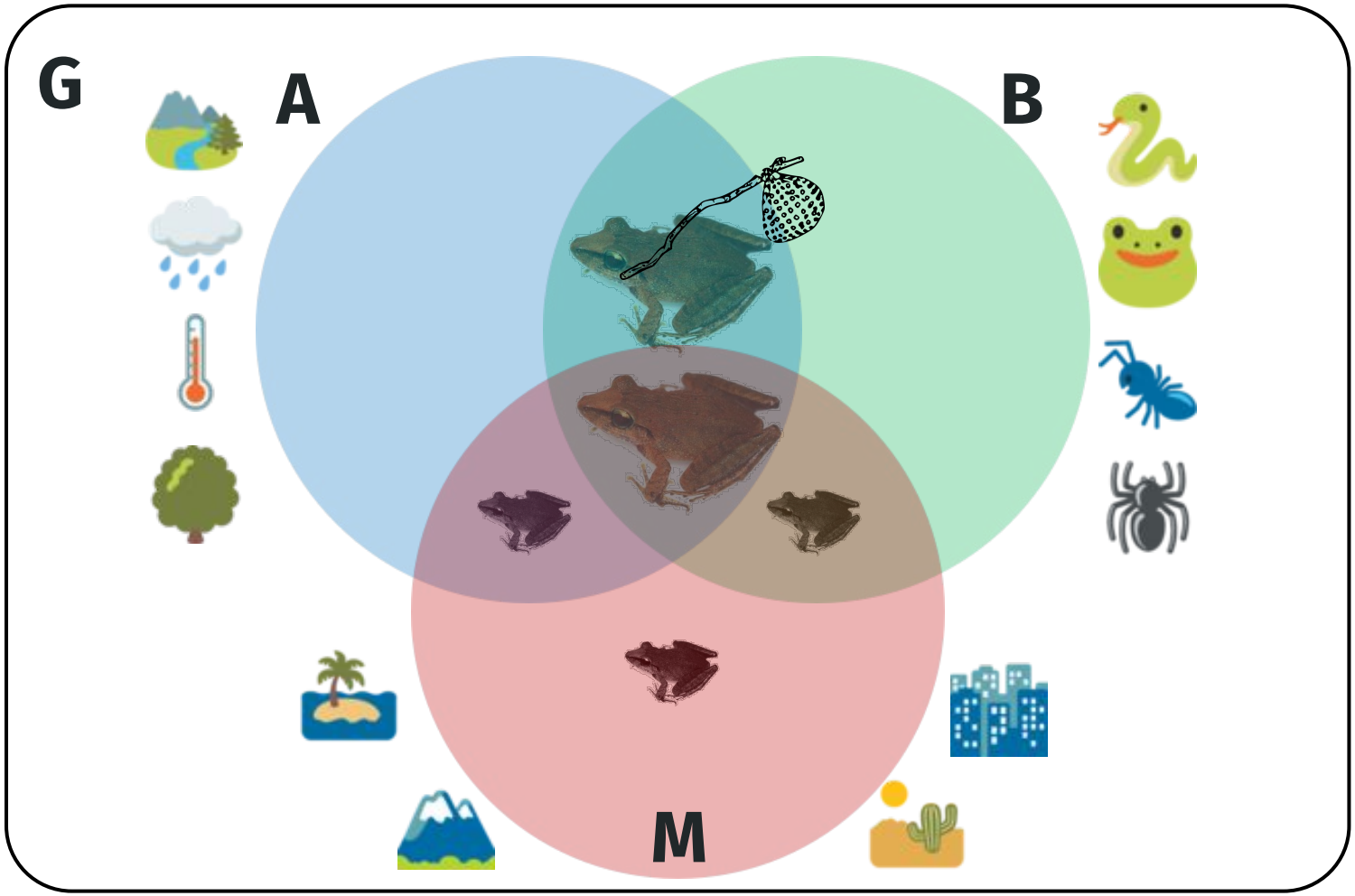


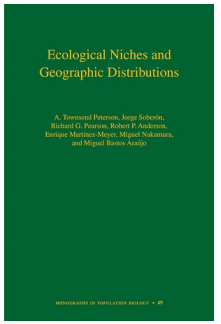


Peterson et al. (2011)

O que determina a distribuição das espécies?

Populações fonte e ralo (*source-sink*)





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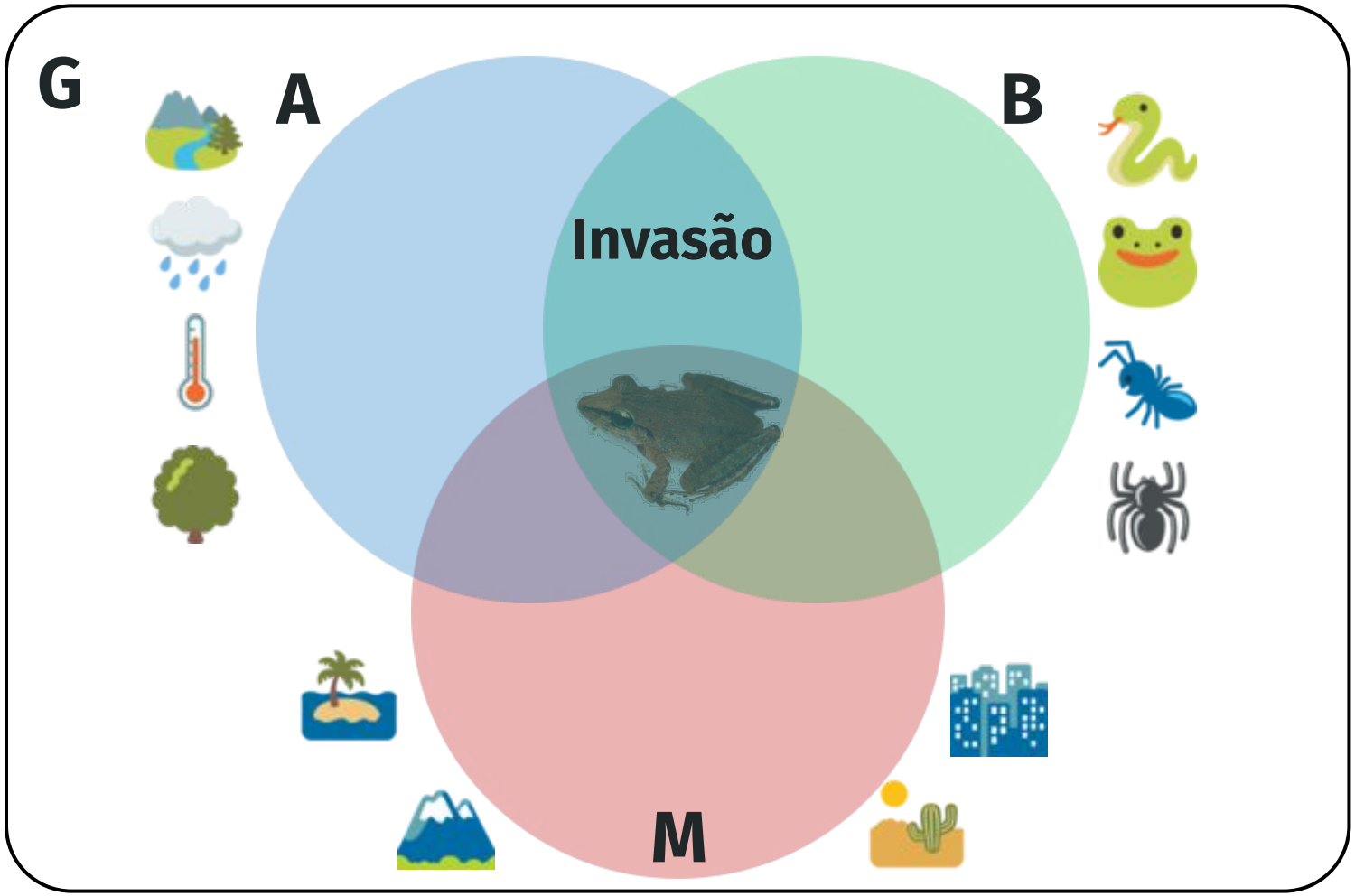

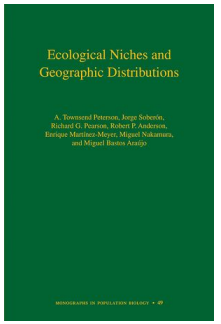

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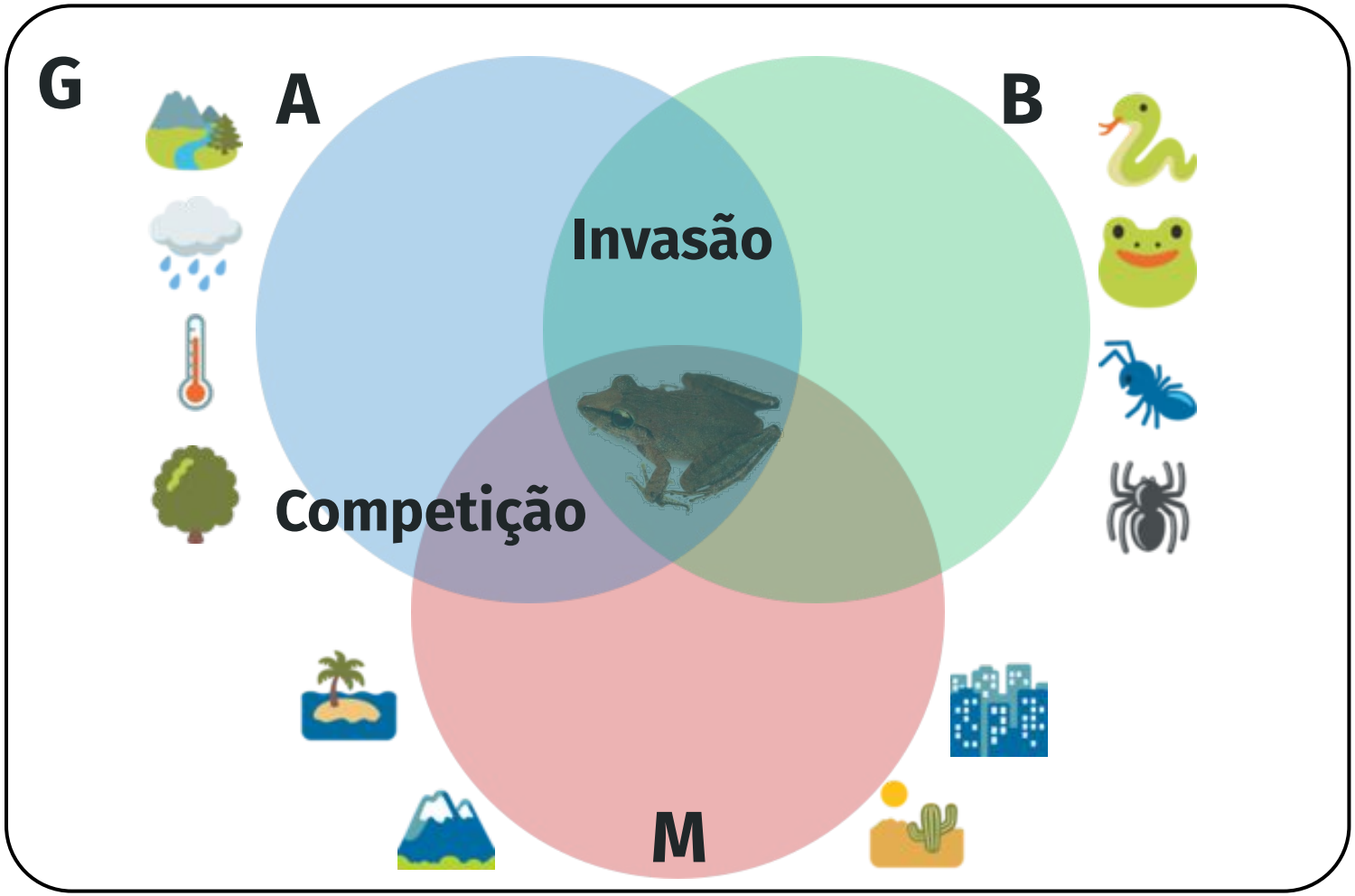

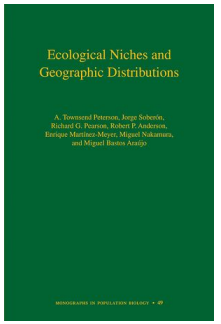

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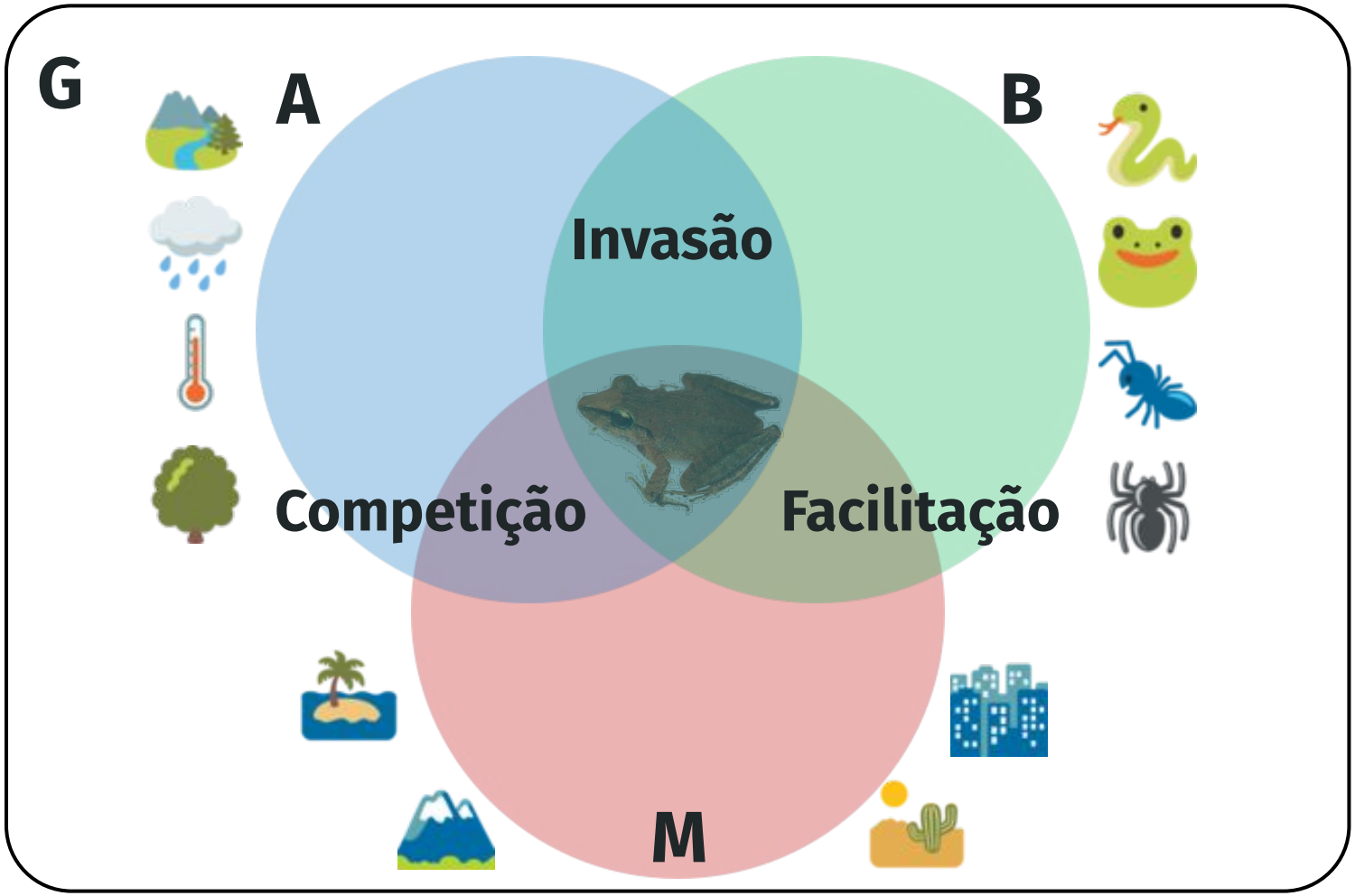

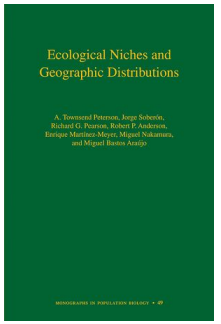

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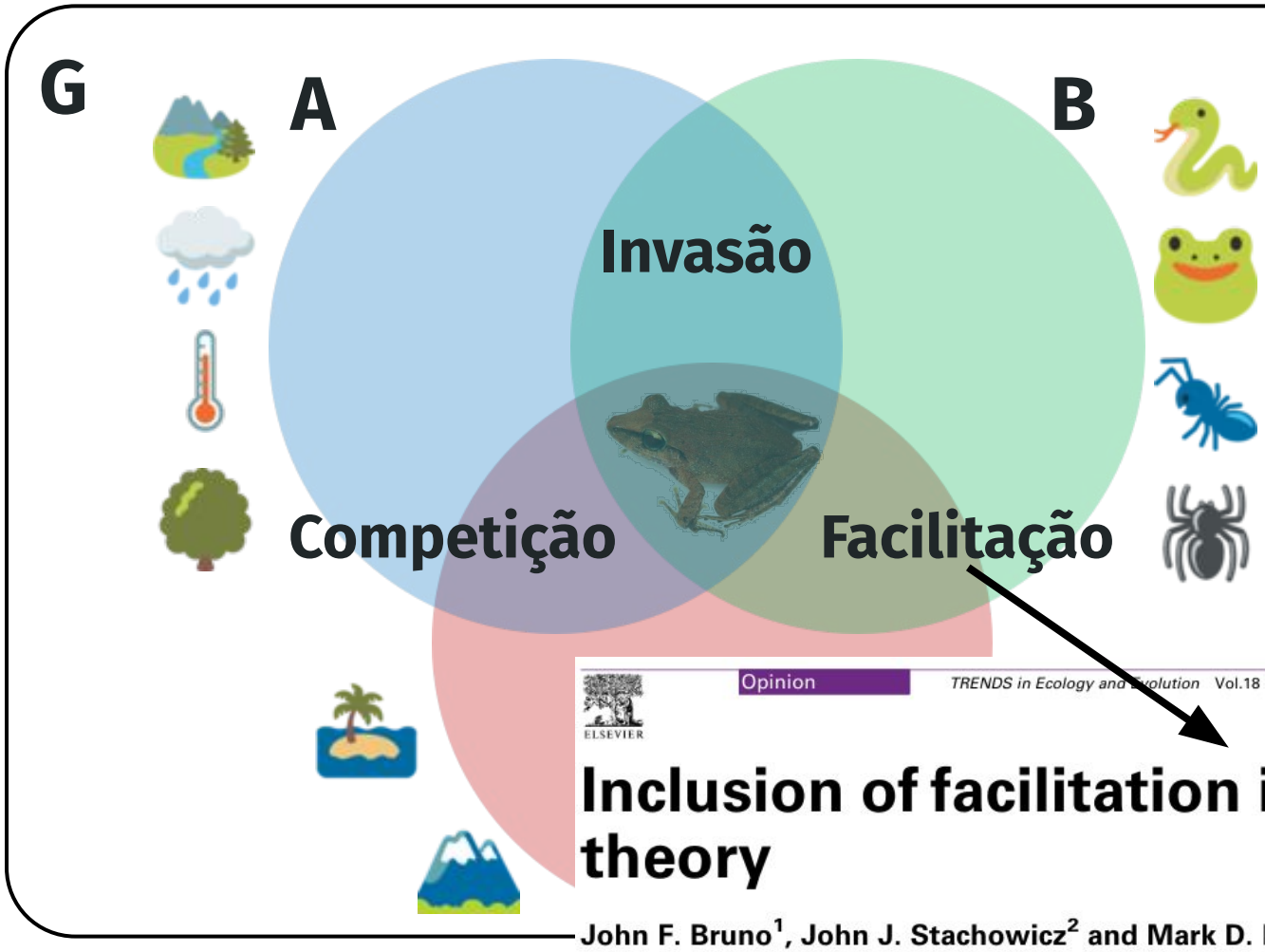

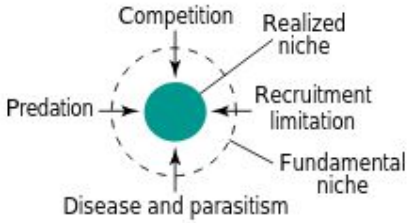

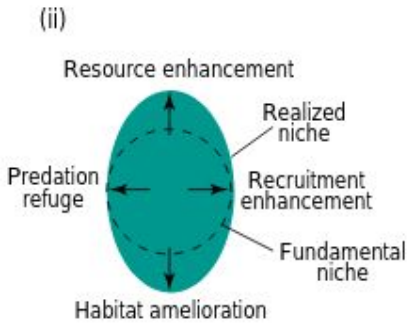

Opinion TRENDS in Ecology and Evolution Vol.18 No.3 March 2003 119

Inclusion of facilitation into ecological theory

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

O que determina a distribuição das espécies?

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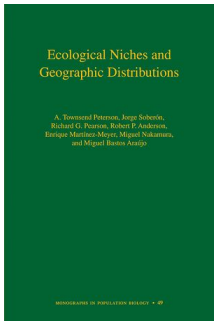
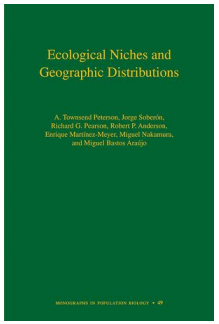


Peterson et al. (2011)

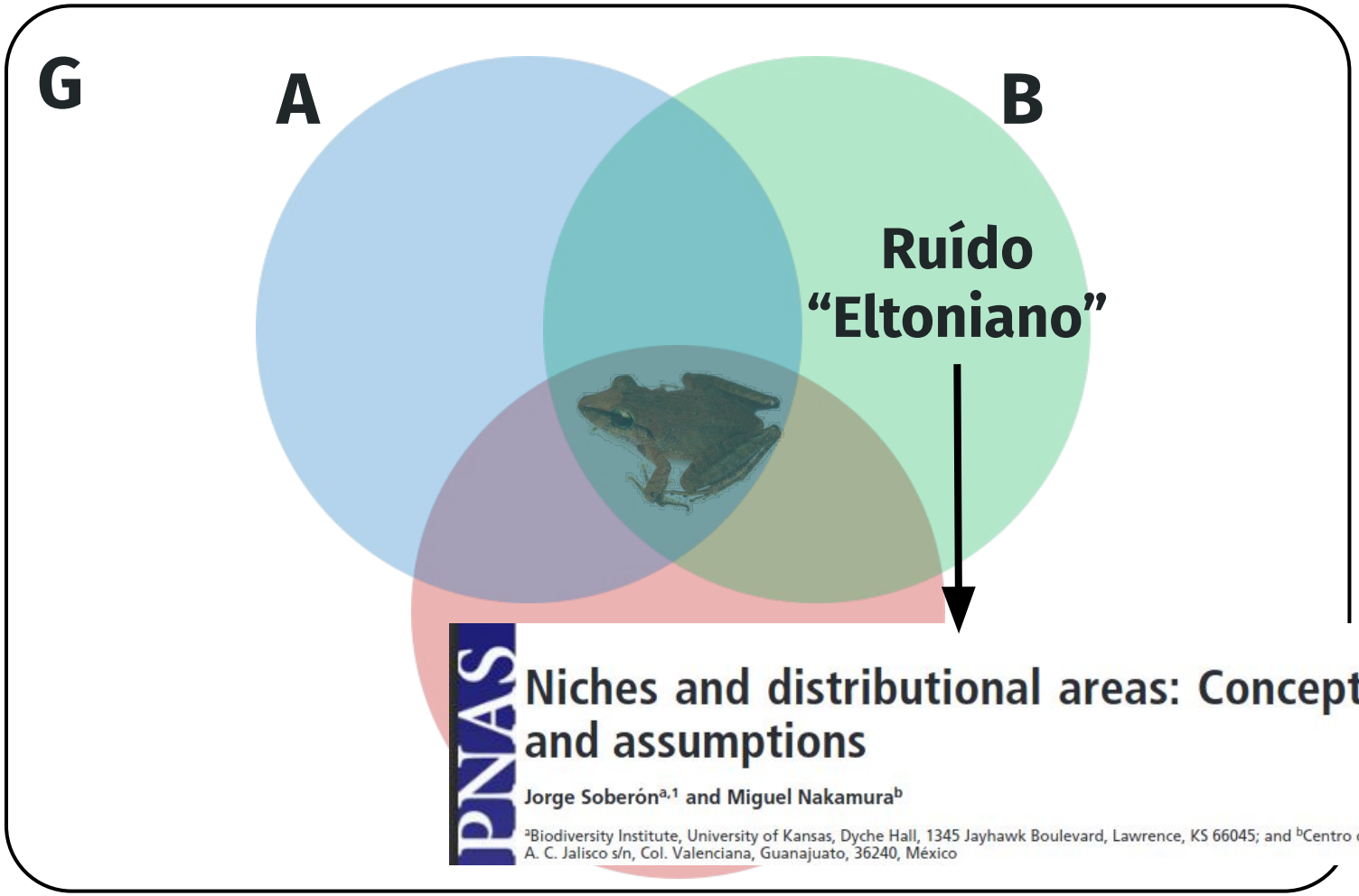
E as **interações bióticas**?

O que determina a distribuição das espécies?

Interações bióticas “ignoradas”



Peterson et al. (2011)



PNAS

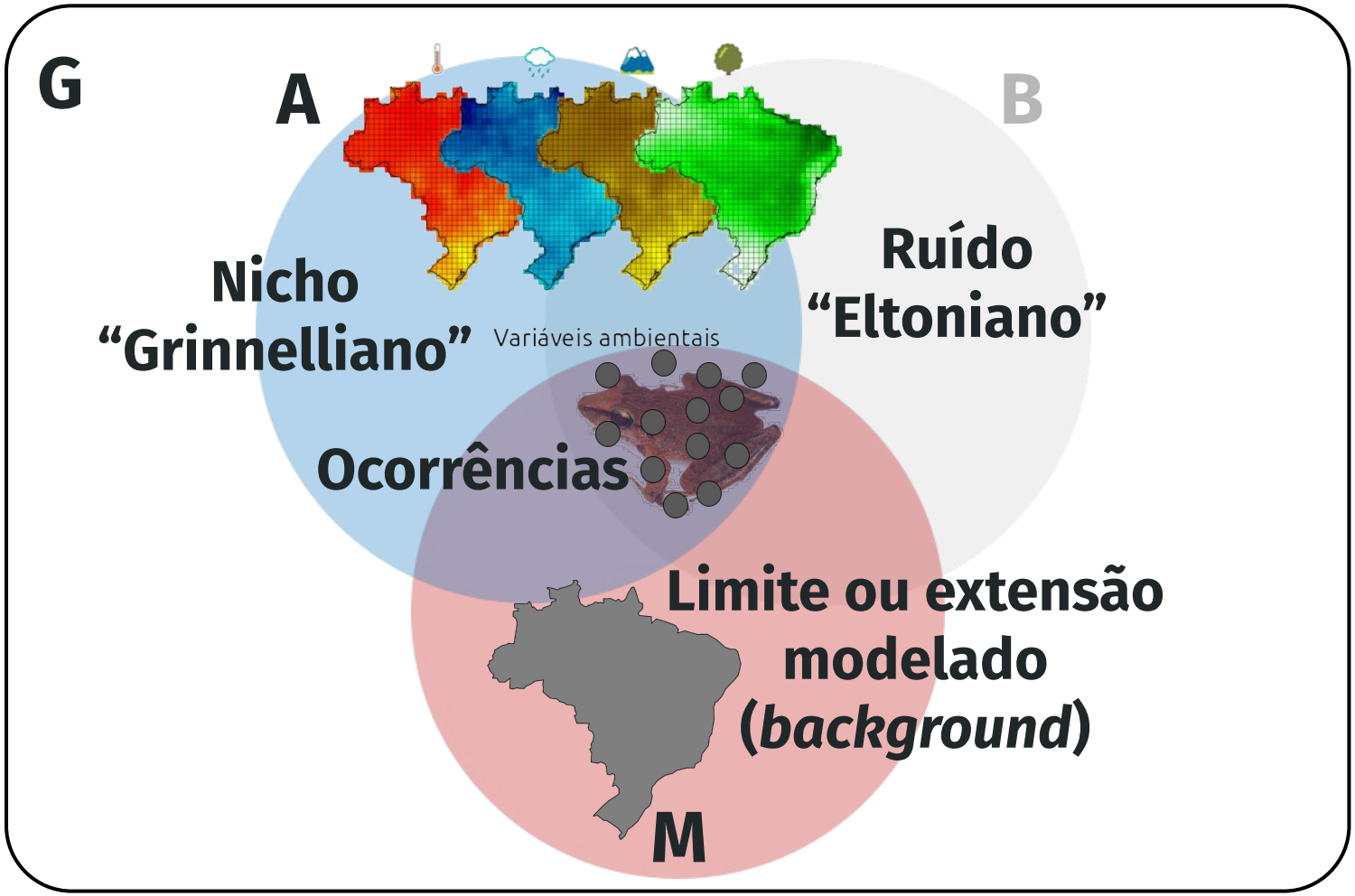
Niches and distributional areas: Concepts, methods, and assumptions

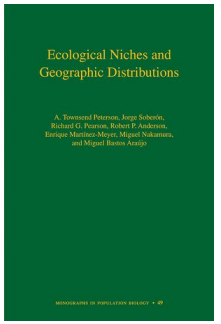
Jorge Soberón[a,1] and Miguel Nakamura[b]

[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 das espécies?

Estimativa do nicho Grinnelliano realizado





Peterson et al. (2011)

Área em desenvolvimento

Como inserir as interações bióticas nos SDMs?

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

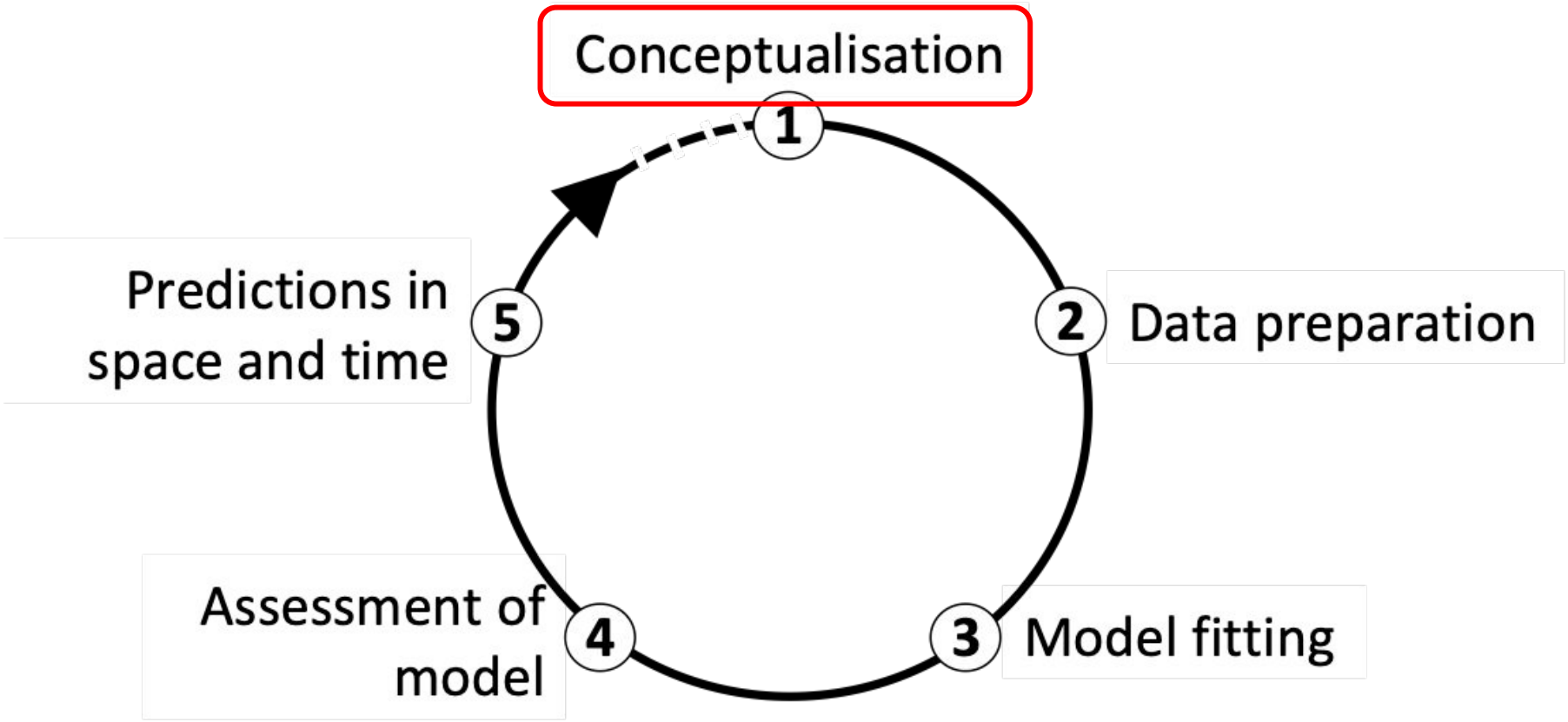
Daniel P. Bebber, Sarah J. Gurr

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

4. SDM passo a passo

SDM passo a passo

Estrutura dos SDMs



Conceitualização

Perguntas associadas à distribuição das espécies

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

Conceitualização

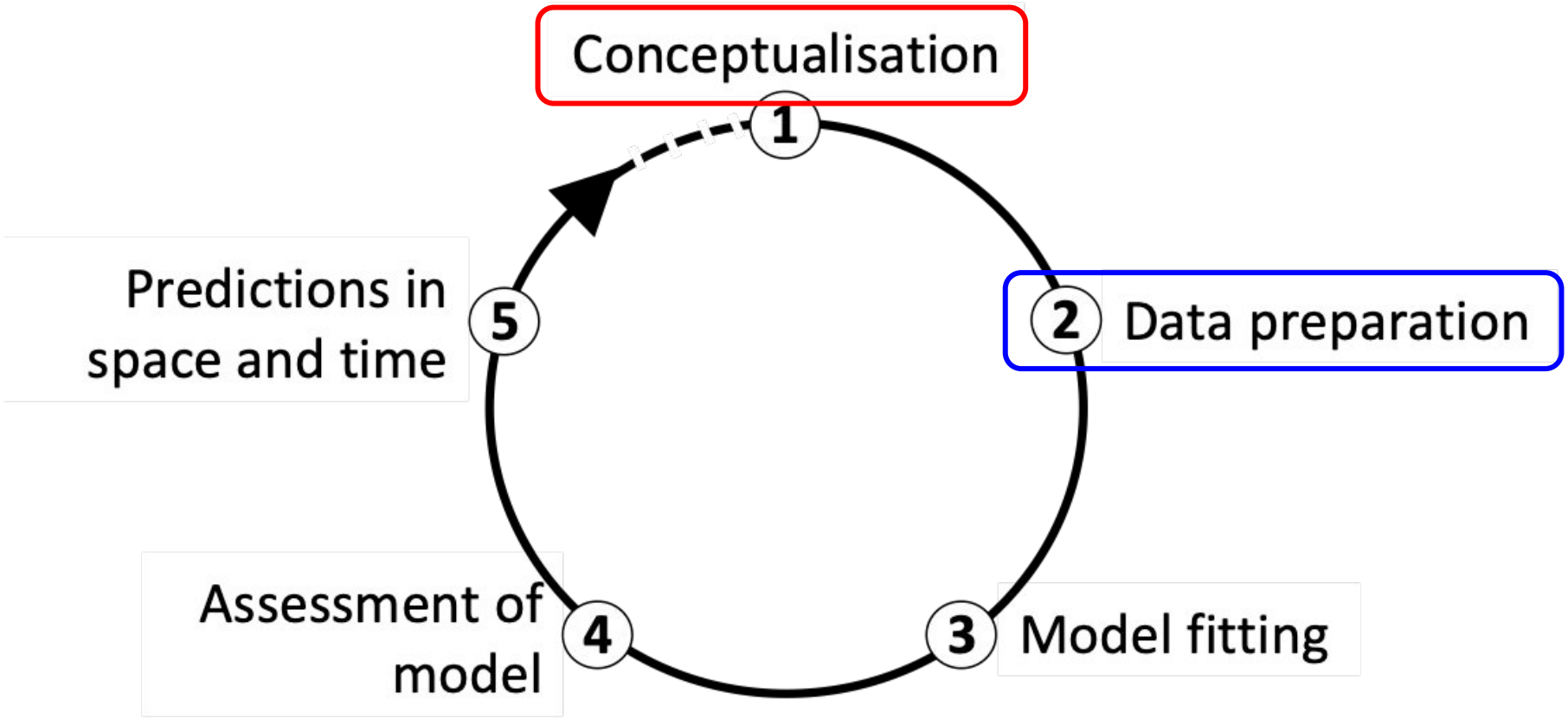
Perguntas associadas à distribuição das espécies

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

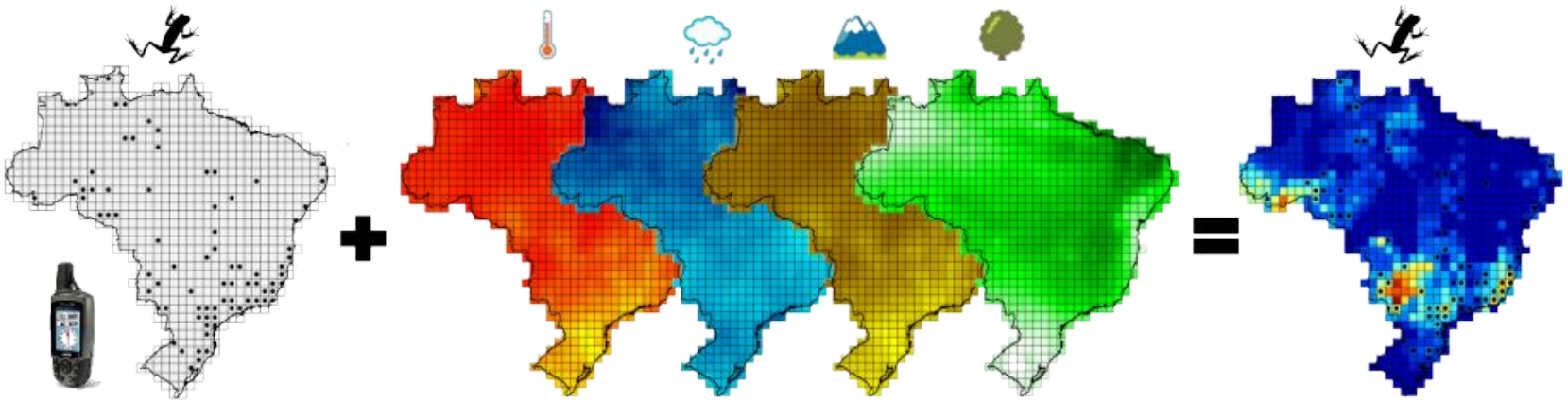
SDM passo a passo

Estrutura dos SDMs



Modelos de Distribuição de Espécies (SDMs)

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

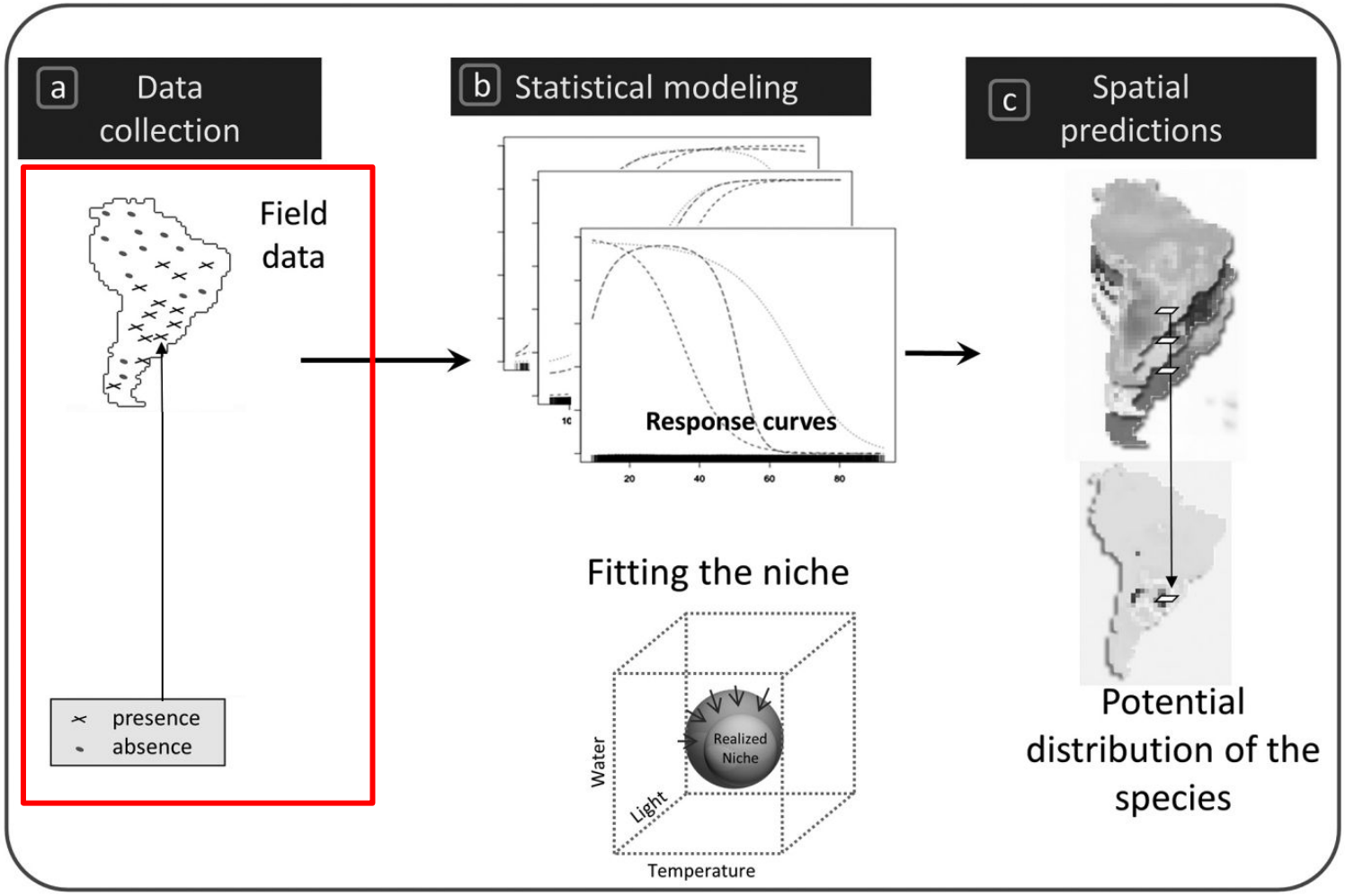
Adequabilidade

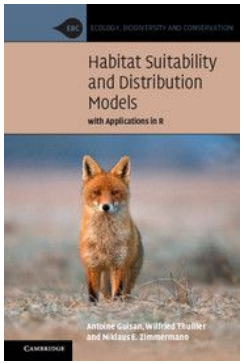
valores
0
até
1

5. Dados de entrada: ocorrências e variáveis

Ocorrências

Visão geral





Guisan et al. (2017)

Ocorrências

Fontes

1. Coletas em campo

Ocorrências

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2. Literatura (artigos, data papers, ...)

Ocorrências

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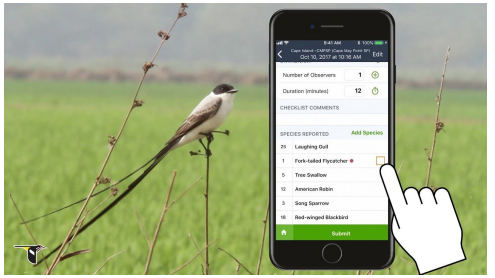

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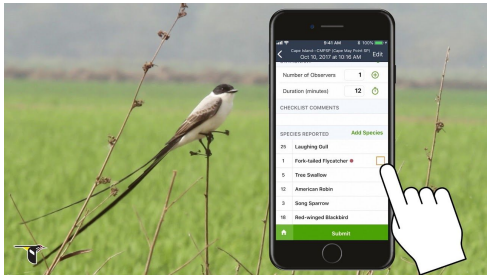

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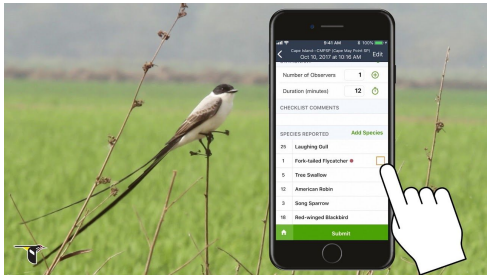
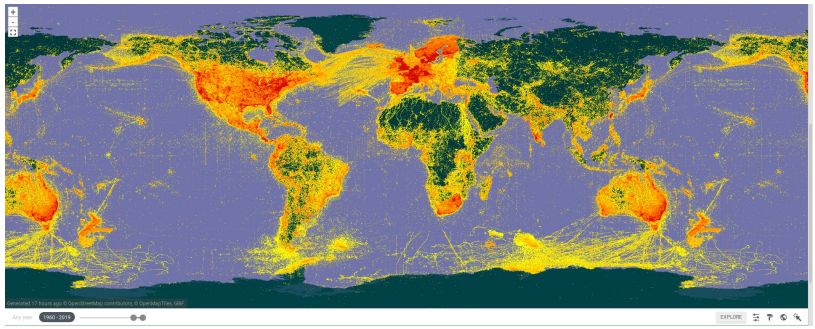
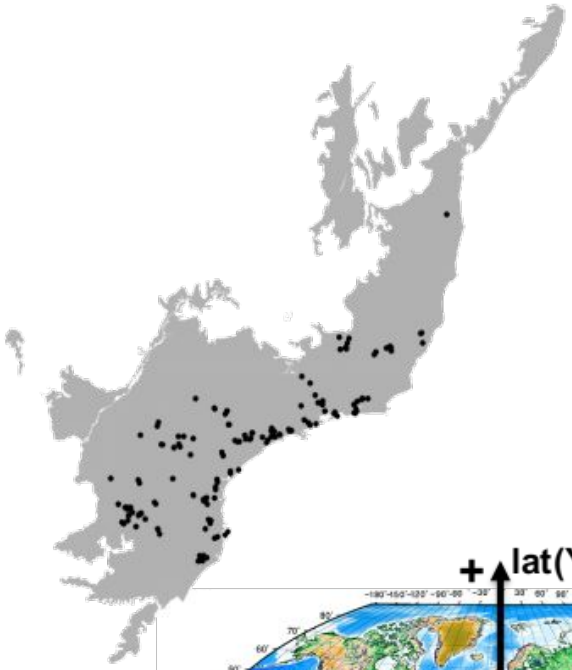
5. Banco de dados (GBIF, SpeciesLink, ...)



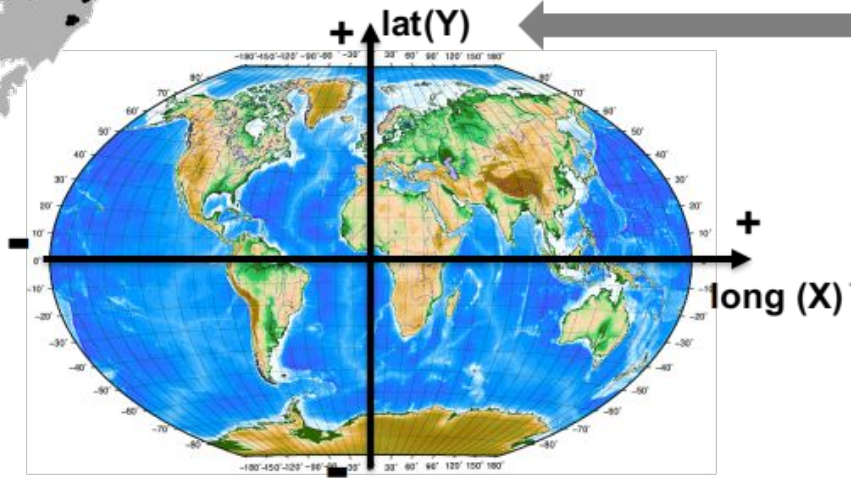


Ocorrências

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



Ocorrências

Pressupostos

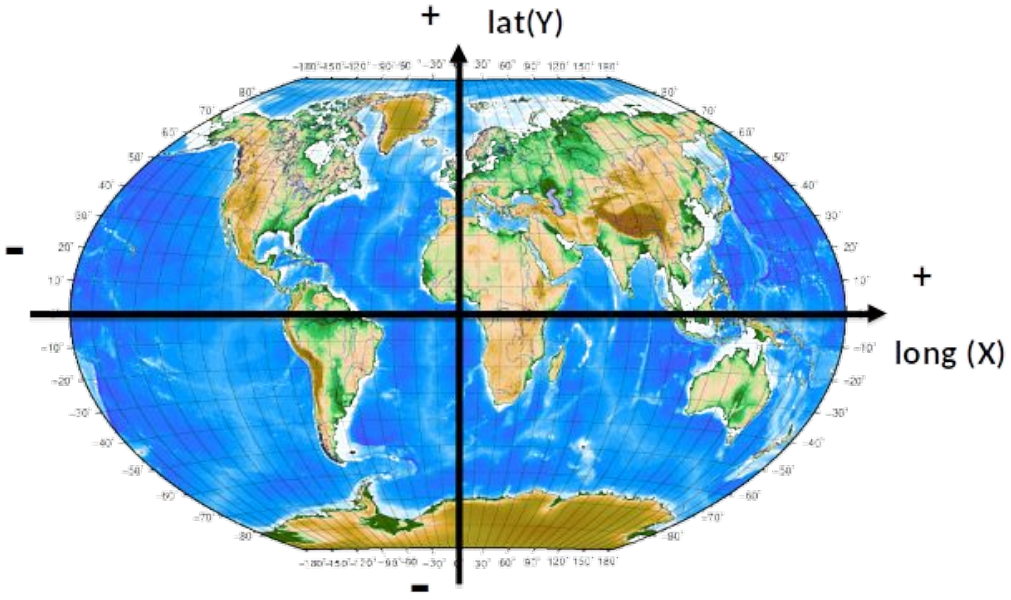
Ocorrências

Sistemas referência de coordenadas (SRC)

Geográficas (graus)

1. <u>Graus, minutos e segundos</u>
   Longitude: 42°42’42”O
   Latitude: 23°23’23”S

2. <u>Graus decimais</u>
   Longitude: -42.71167
   Latitude: -23.38972

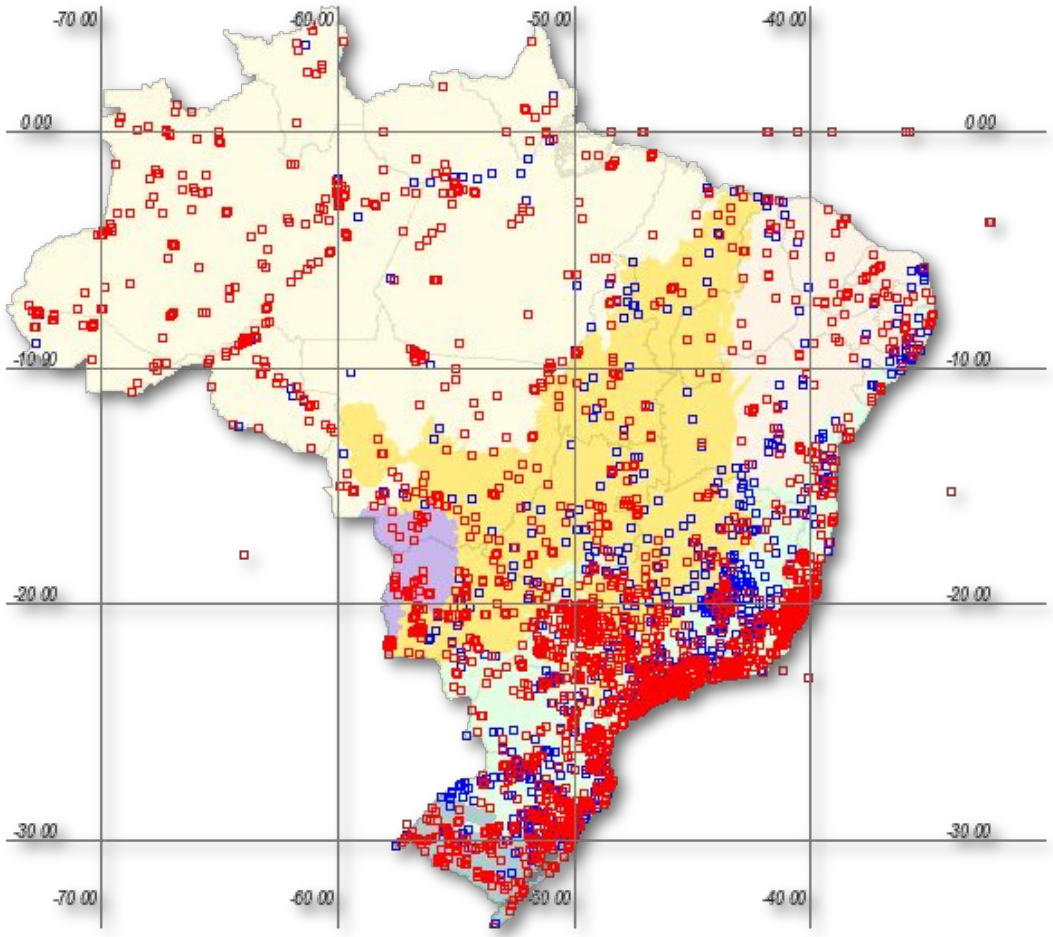


Converção: 23 + (23/60) + (23/3600)

Desafios:
Viés de amostragem

Ocorrências

Viés de amostragem

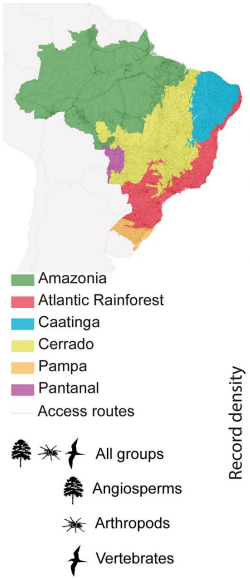


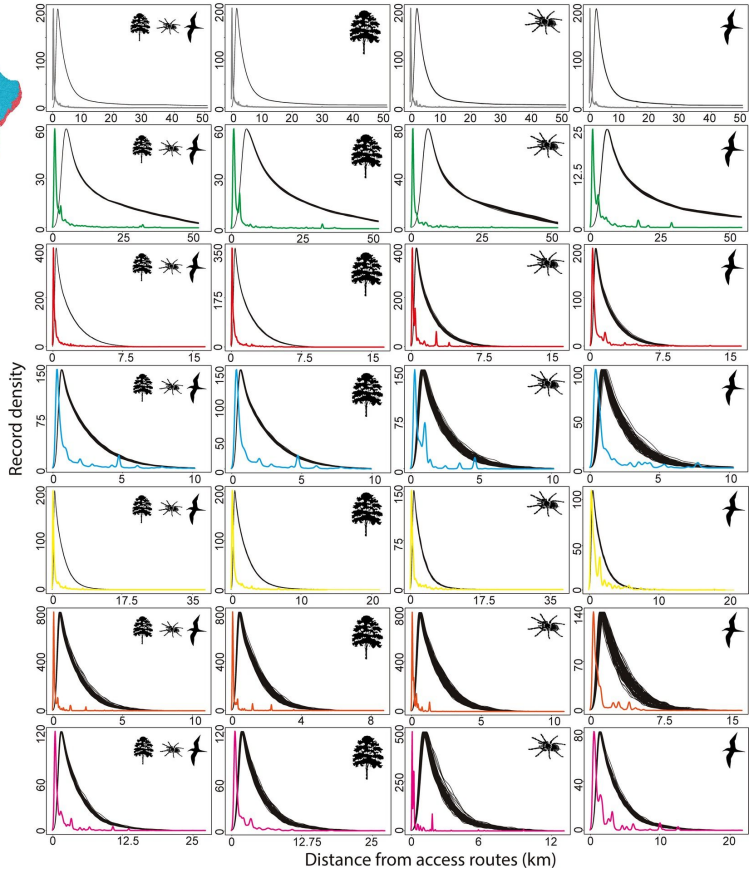
Boana faber

speciesLink

Ocorrências

Viés de amostragem



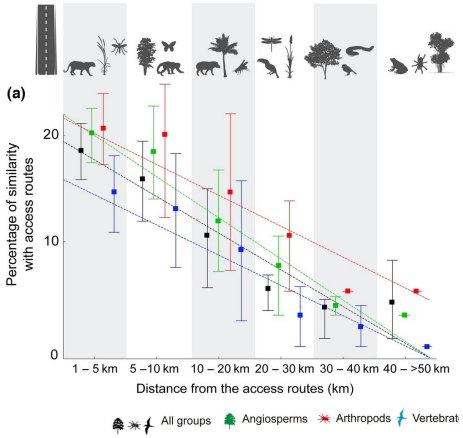


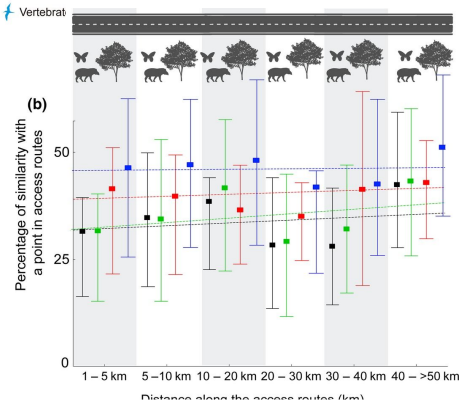
Diversity and Distributions, (Diversity Distrib.) (2016) **22**, 1232–1244

BIODIVERSITY RESEARCH

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

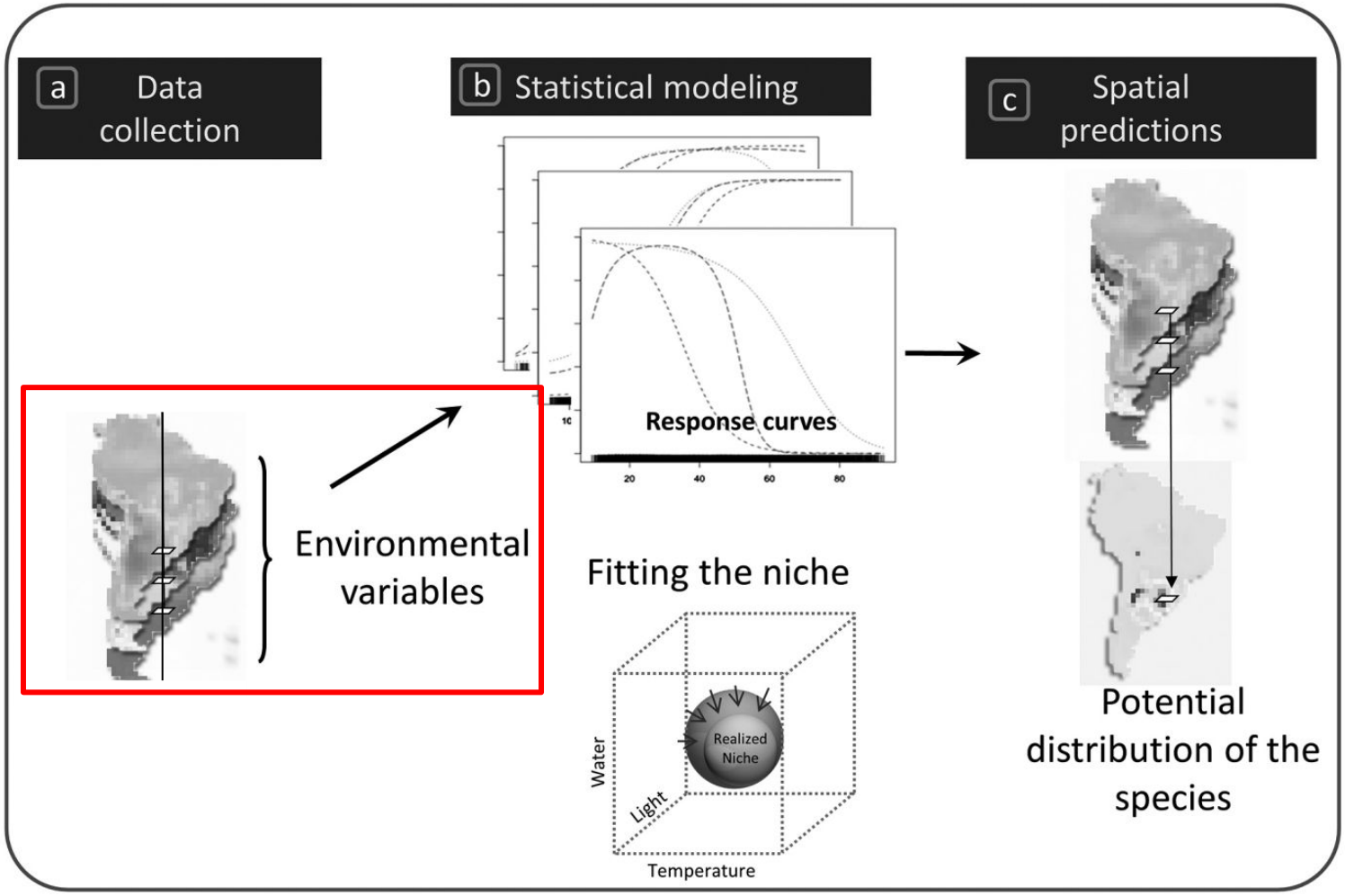
Ubirajara Oliveira[1,2*], Adriano Pereira Paglia[3], Antonio D. Brescovit[4], Claudio J. B. de Carvalho[5], Daniel Paiva Silva[6], Daniella T. Rezende[7], Felipe Sá Fortes Leite[8], João Aguiar Nogueira Batista[9], João Paulo Peixoto Pena Barbosa[4], João Renato Stehmann[9], John S. Ascher[10], Marcelo 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]

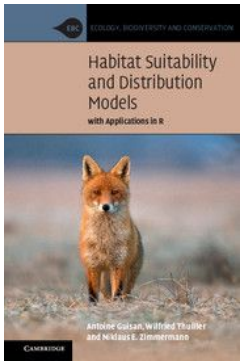




Variáveis ambientais

Visão geral

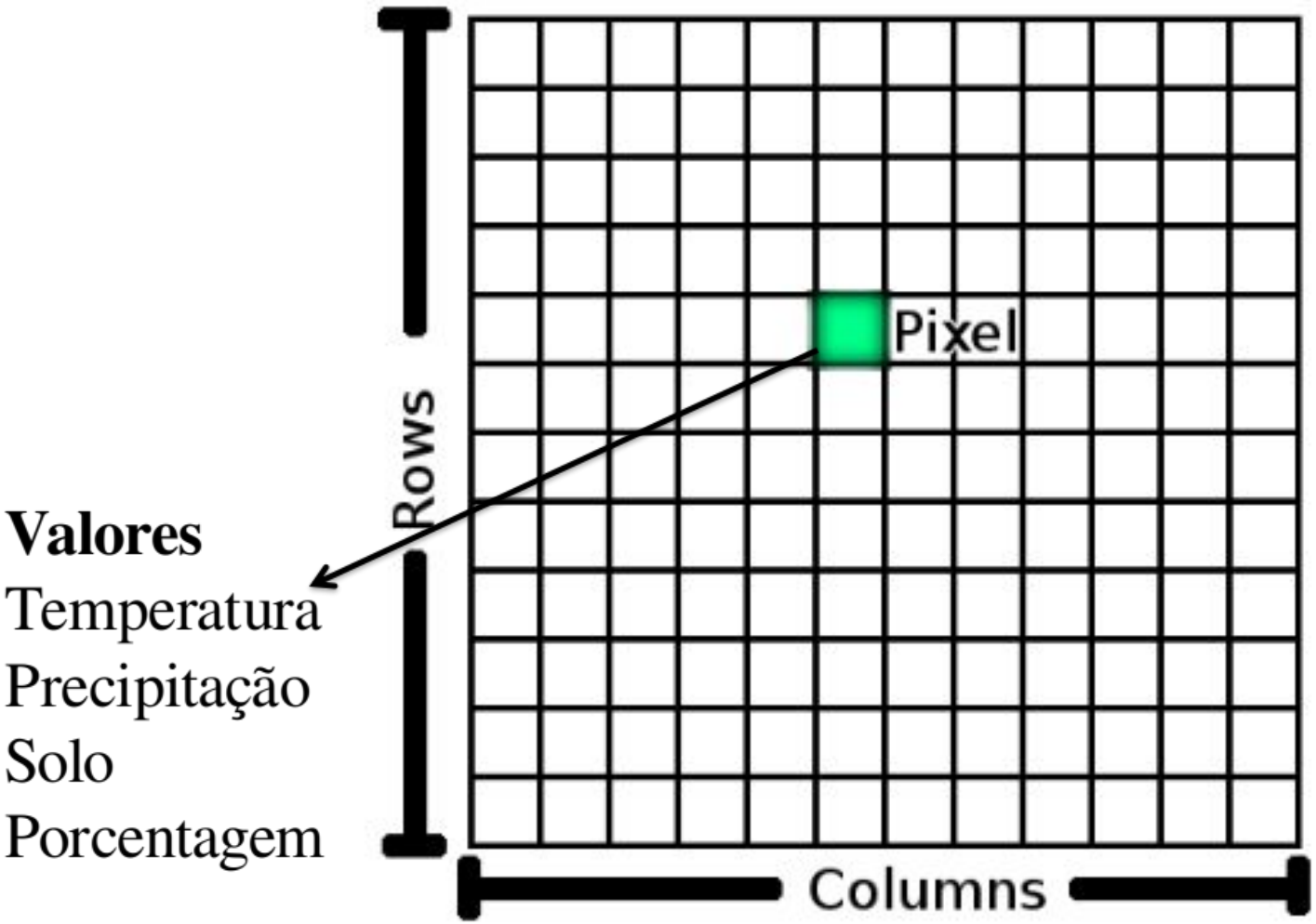




Guisan et al. (2017)

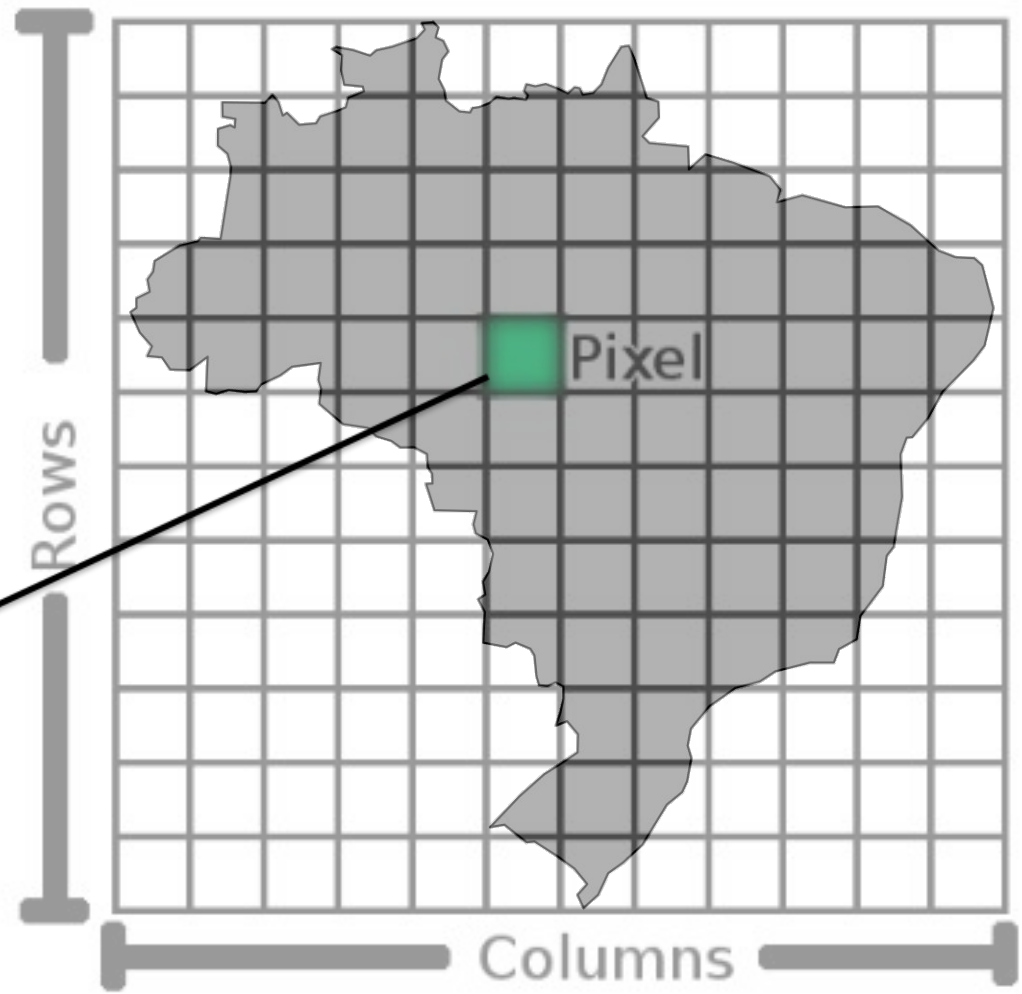
Variáveis ambientais

Raster - Extensão e resolução



Variáveis ambientais

Raster - Extensão e resolução

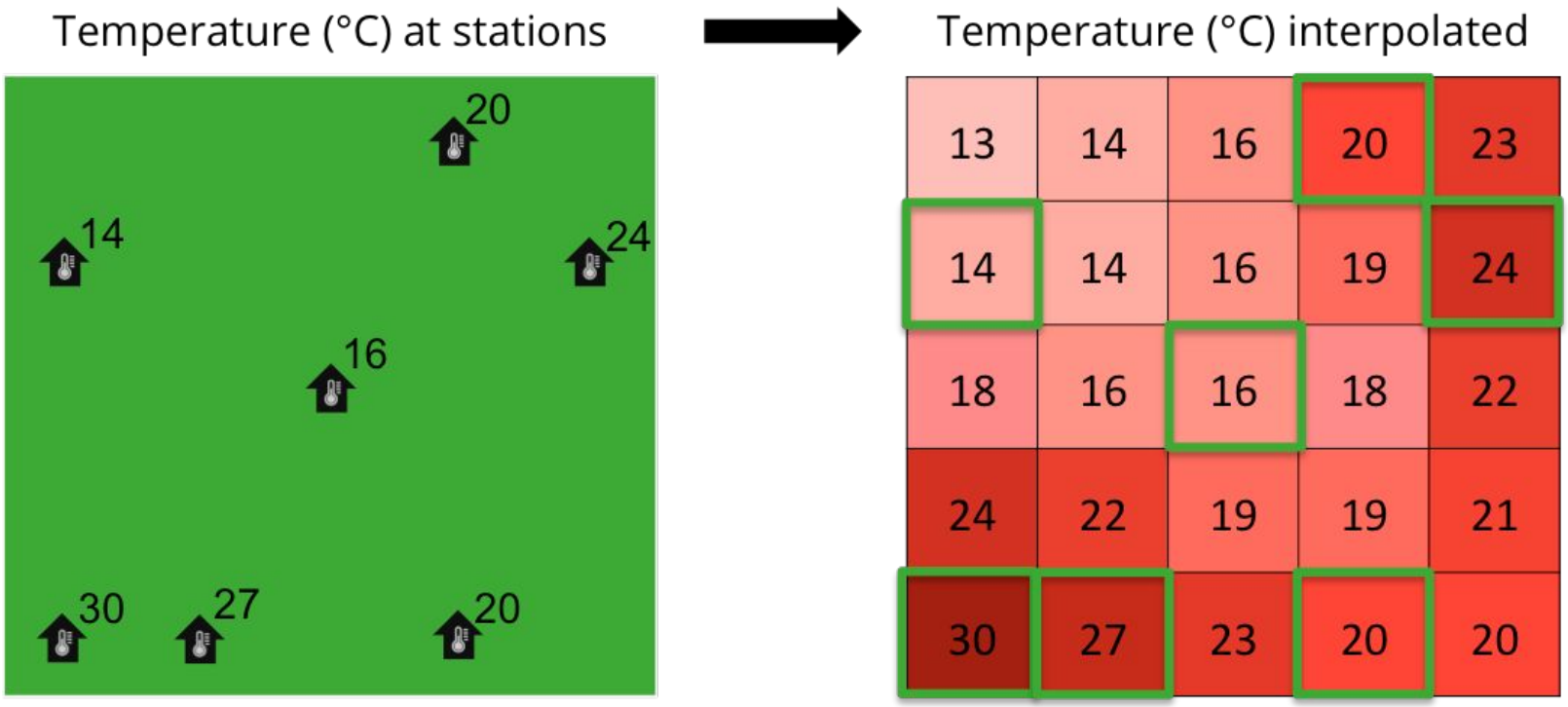


Valores
Temperatura
Precipitação
Solo
Porcentagem

Variáveis ambientais

Raster - Interpolação

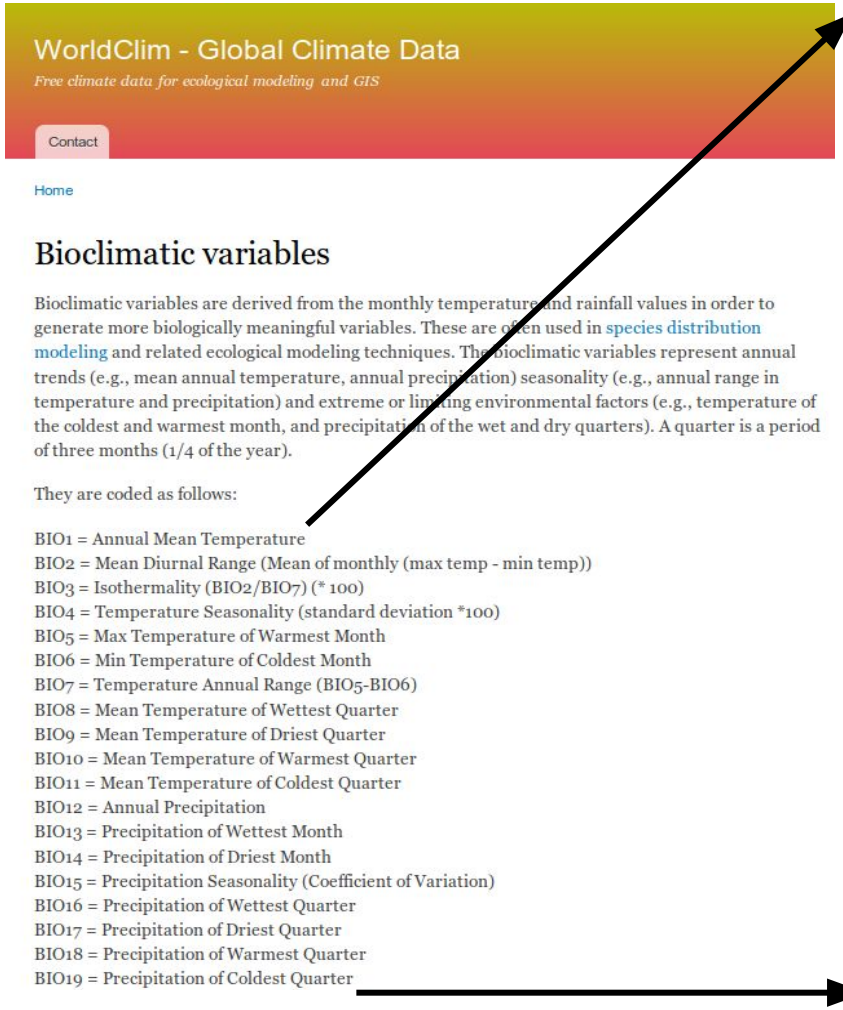
https://support.bccvl.org.au/support/home



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

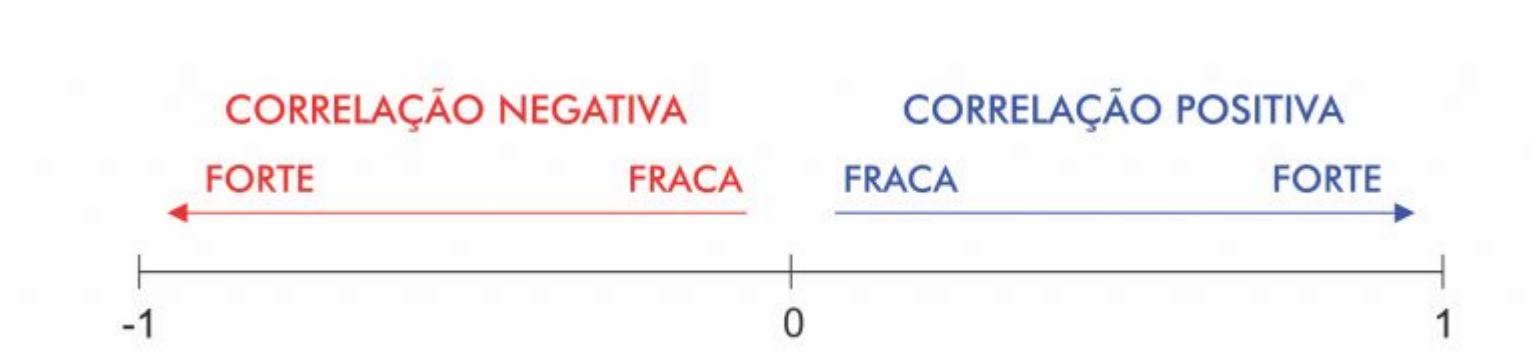
BIO12 = Precipitação Anual
BIO13 = Precipitação do mês mais chuvoso
BIO14 = Precipitação do mês mais seco
BIO15 = Sazonalidade da Precipitação (coeficiente de variação)
BIO16 = Precipitação do trimestre mais chuvoso
BIO17 = Precipitação do trimestre mais seco
BIO18 = Precipitação do trimestre mais quente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

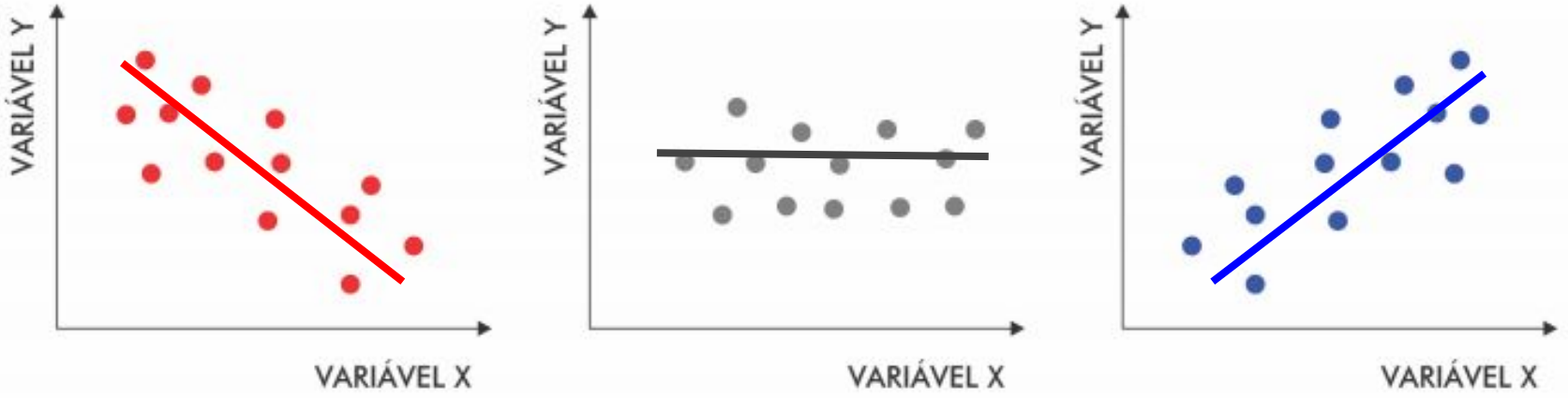
Precipitação

Desafios: Colinearidade

Variáveis ambientais

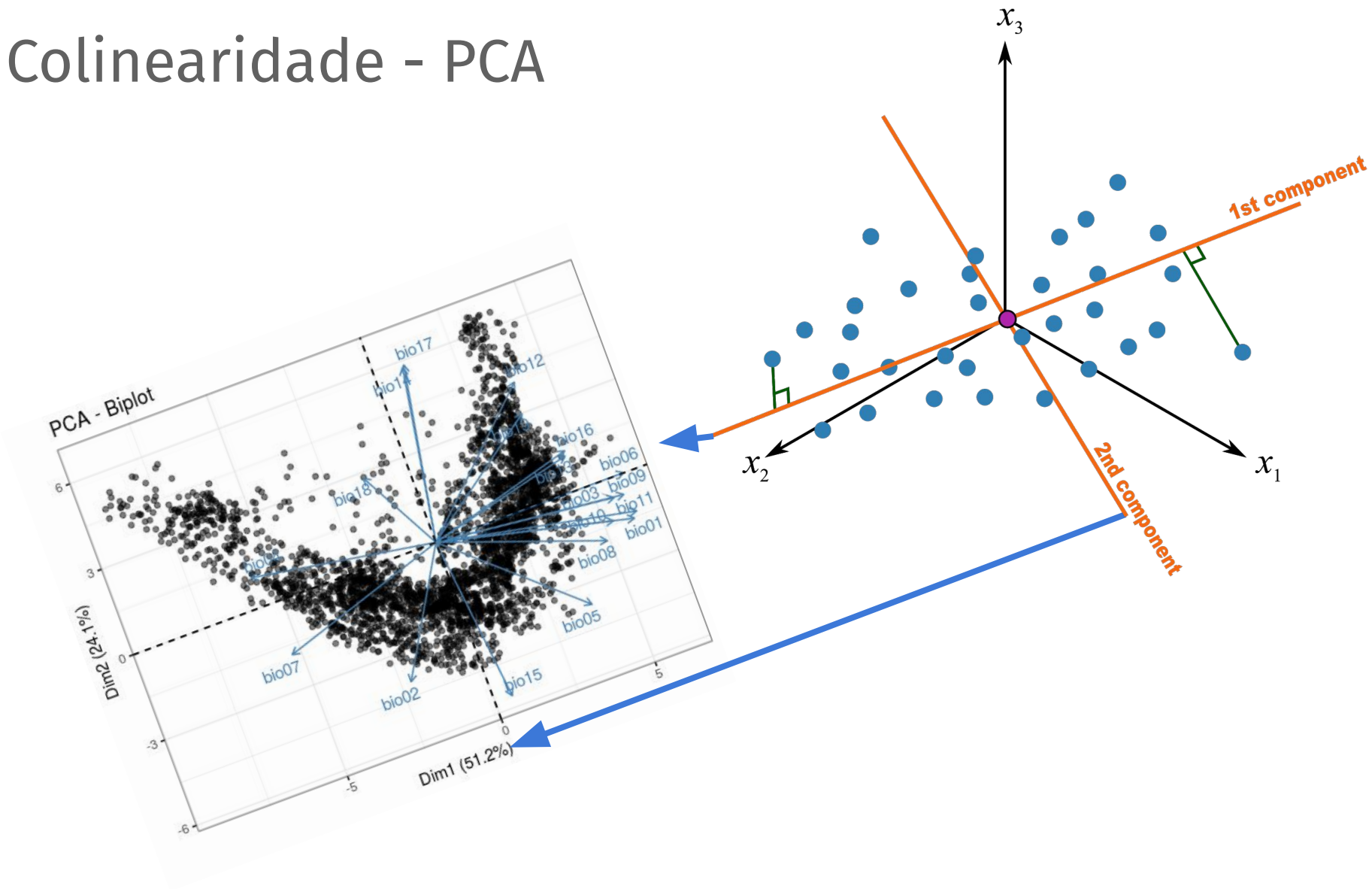
Colinearidade - Correlação





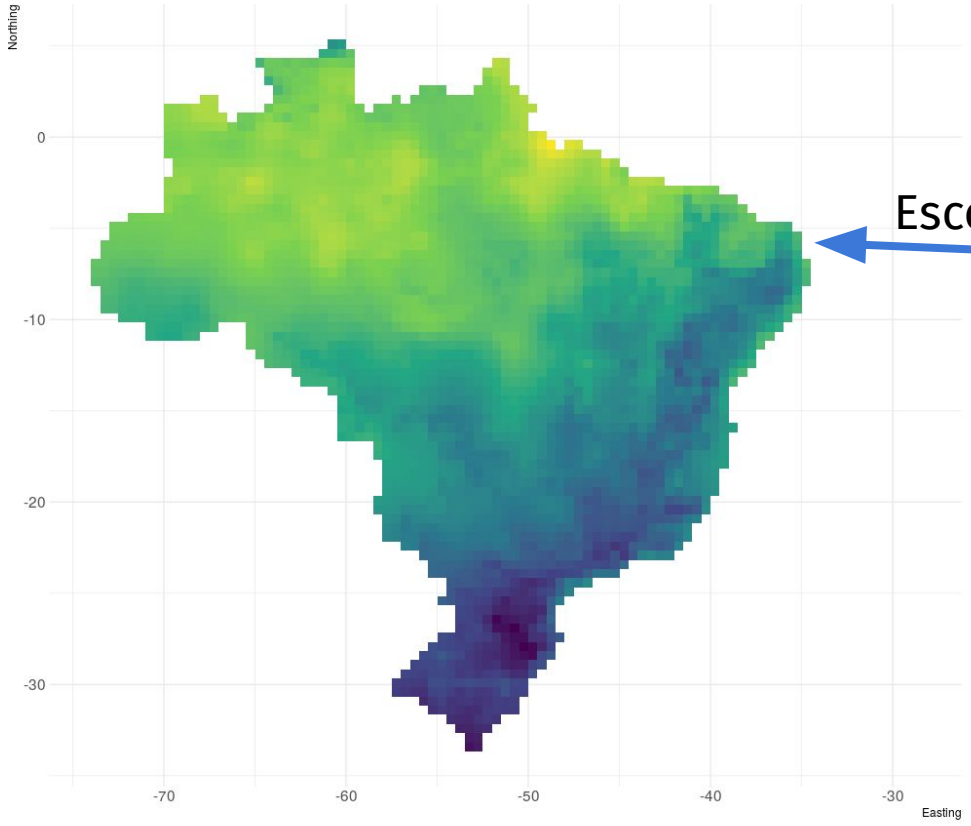
Variáveis ambientais

Colinearidade - PCA

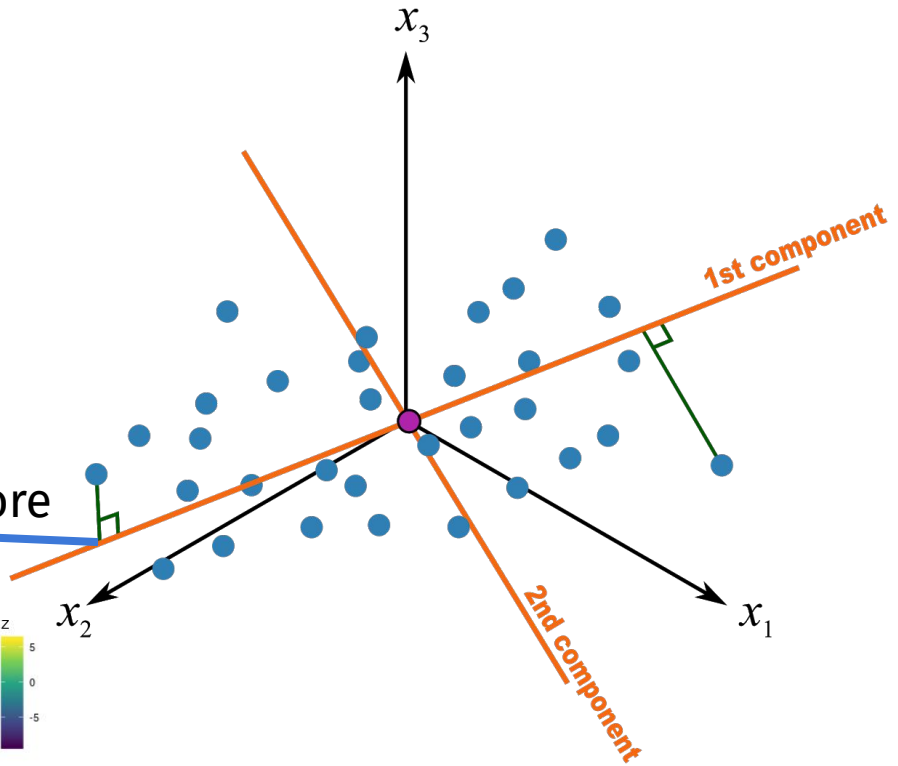


Variáveis ambientais

Colinearidade - PCA

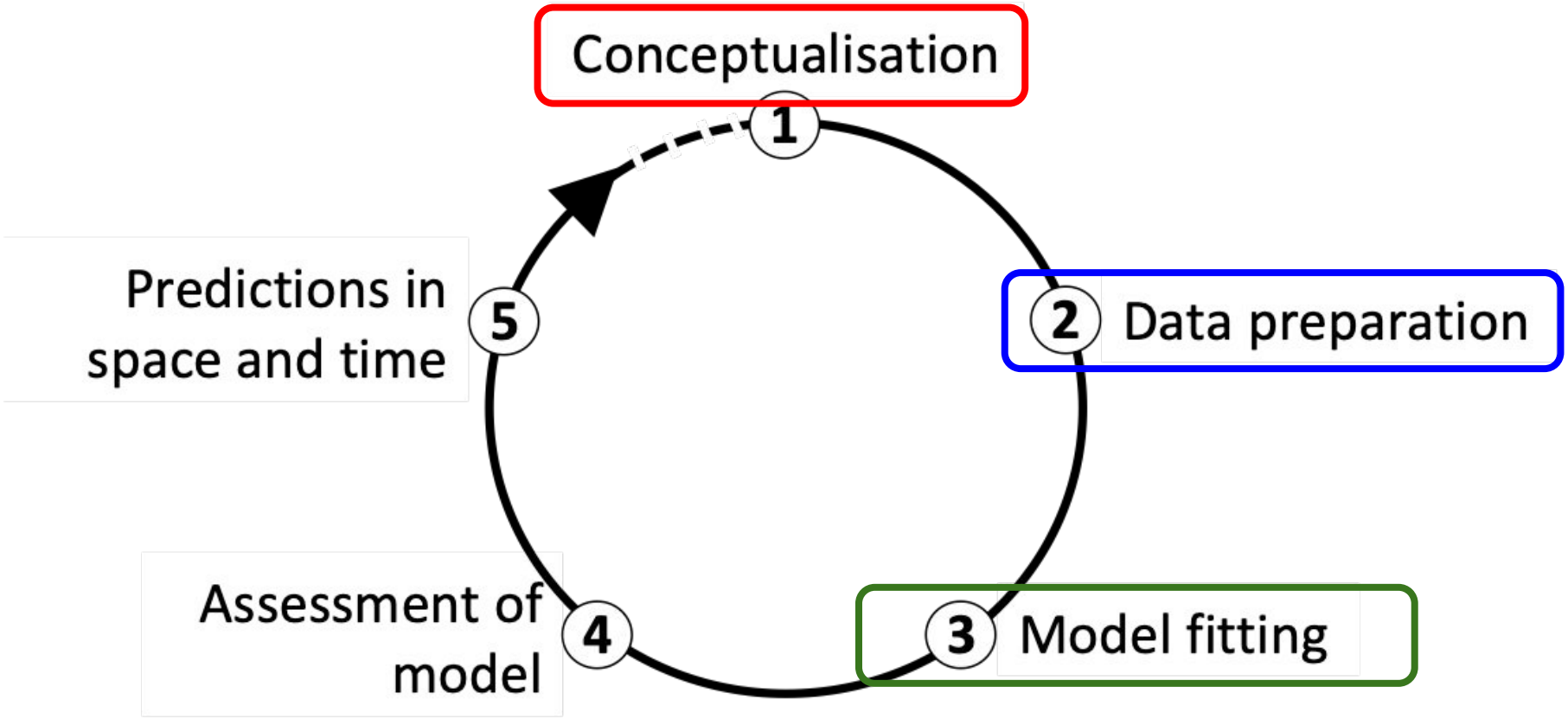


Escore



SDM passo a passo

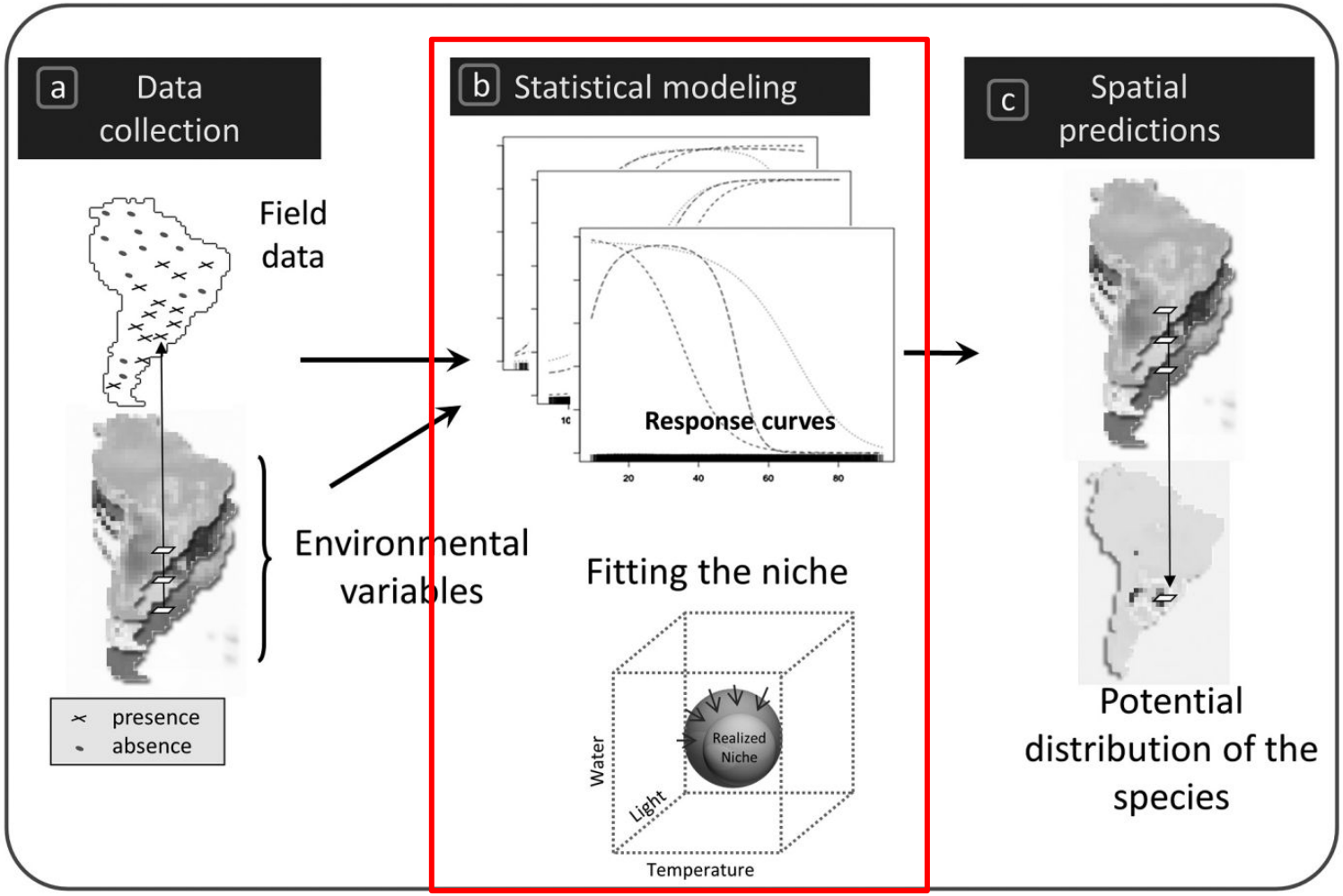
Estrutura dos SDMs

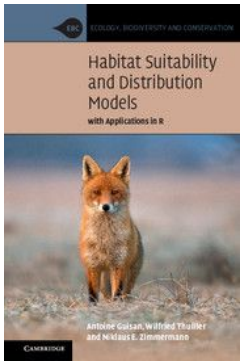


6. Ajuste dos modelos

Ajuste dos SDMs

Algoritmos estimam o nicho realizado





Guisan et al. (2017)

Ajuste dos SDMs

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 SDMs

Mais utilizado - MaxEnt

Lima-Ribeiro &
Diniz-Filho (2013)

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Ajuste dos SDMs

Apenas Presença

Lima-Ribeiro &
Diniz-Filho (2013)

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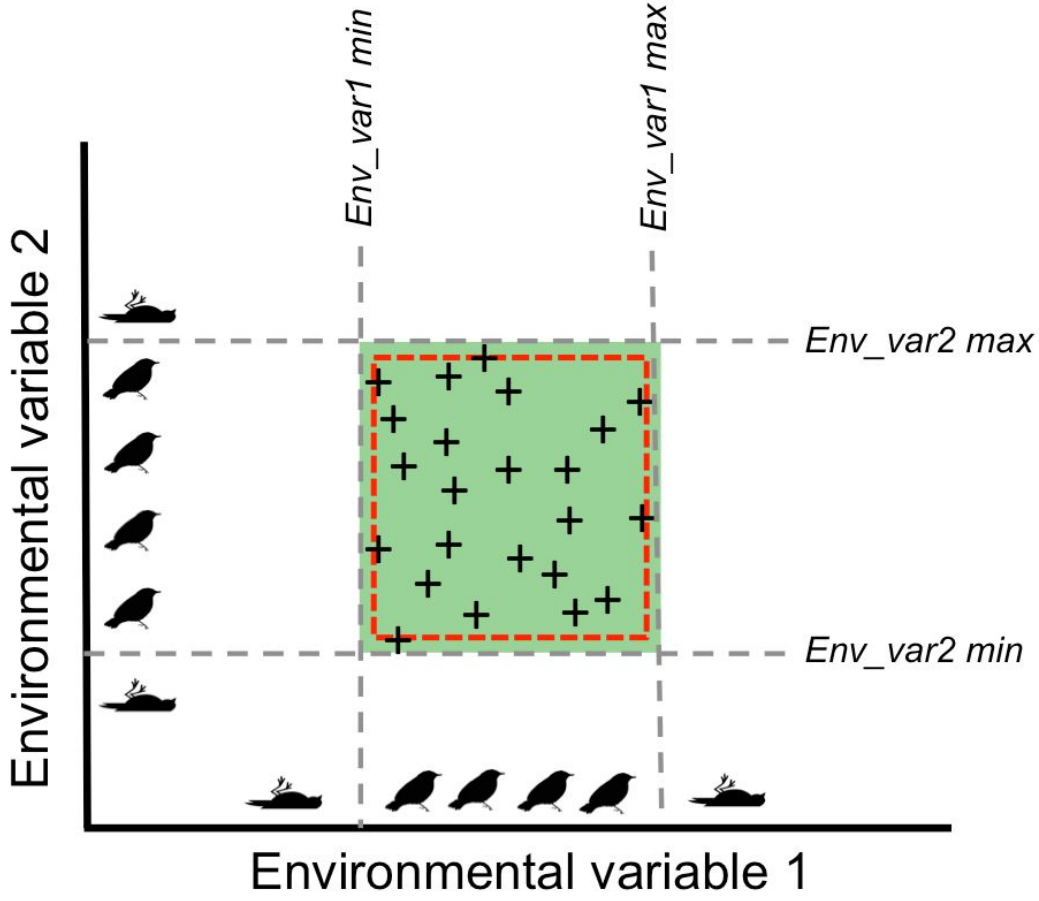
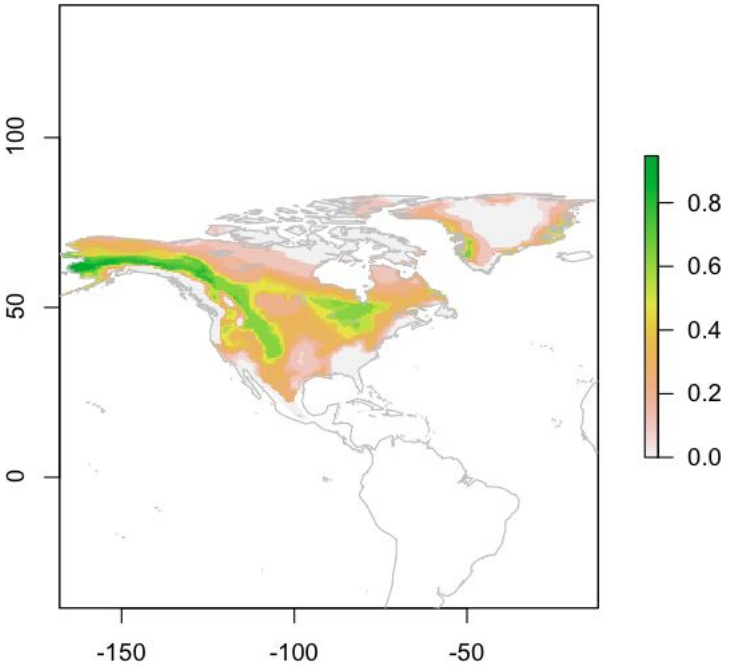
  - ANN (artificial neural networks)

Ajuste dos SDMs

BIOCLIM - Envelope Climático

Lima-Ribeiro &
Diniz-Filho (2013)



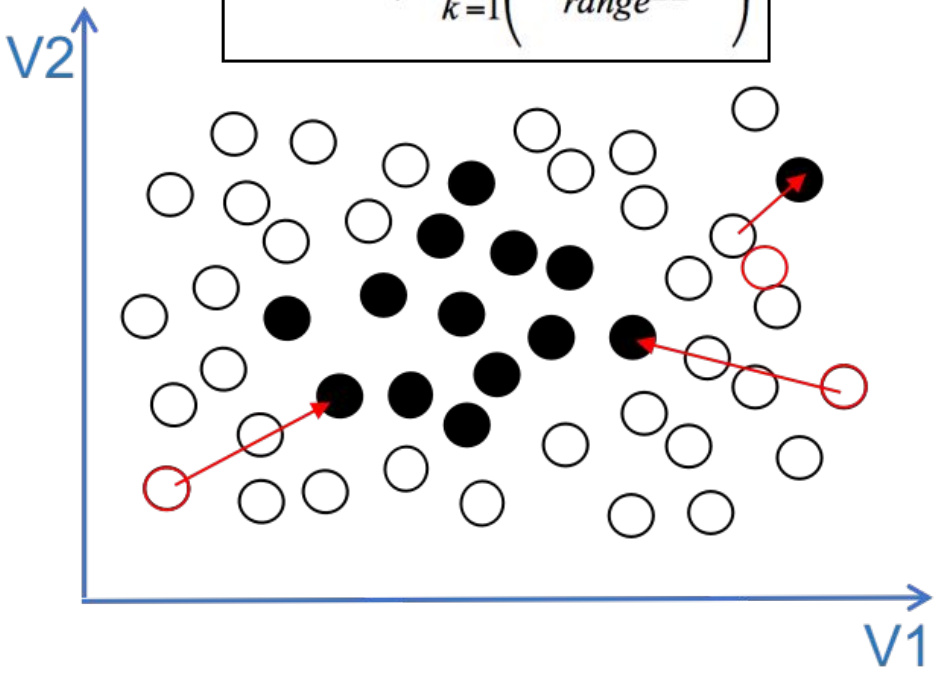


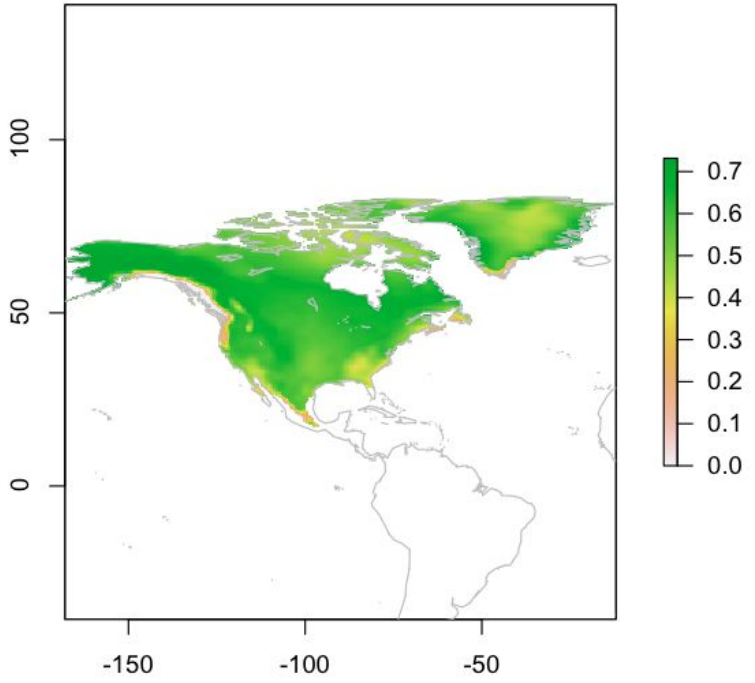
Ajuste dos SDMs

DOMAIN - Distância de Gower

Lima-Ribeiro &
Diniz-Filho (2013)

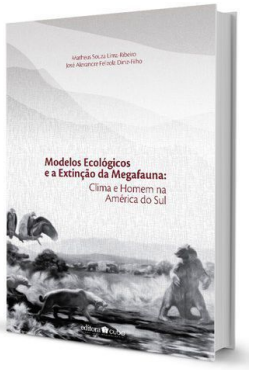
$$d_{AB} = \frac{1}{V}\sum_{k=1}^{V}\left(\frac{\left|A_K - B_K\right|}{range K}\right)$$



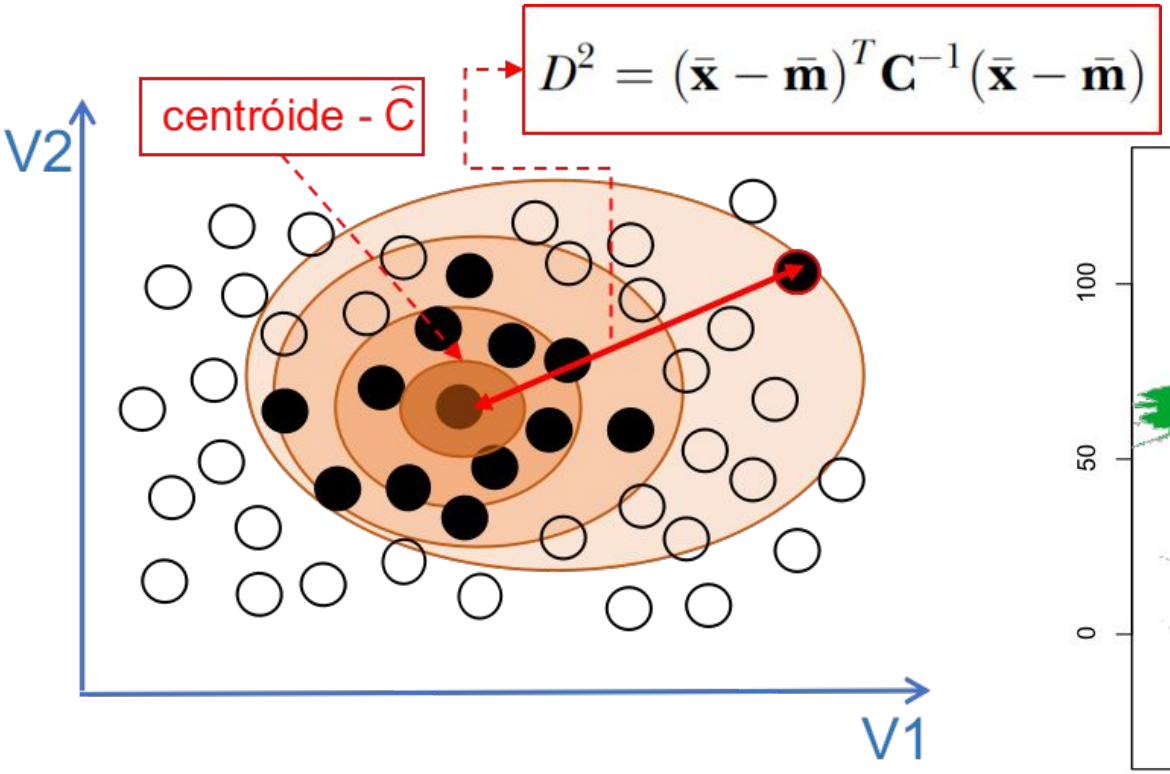


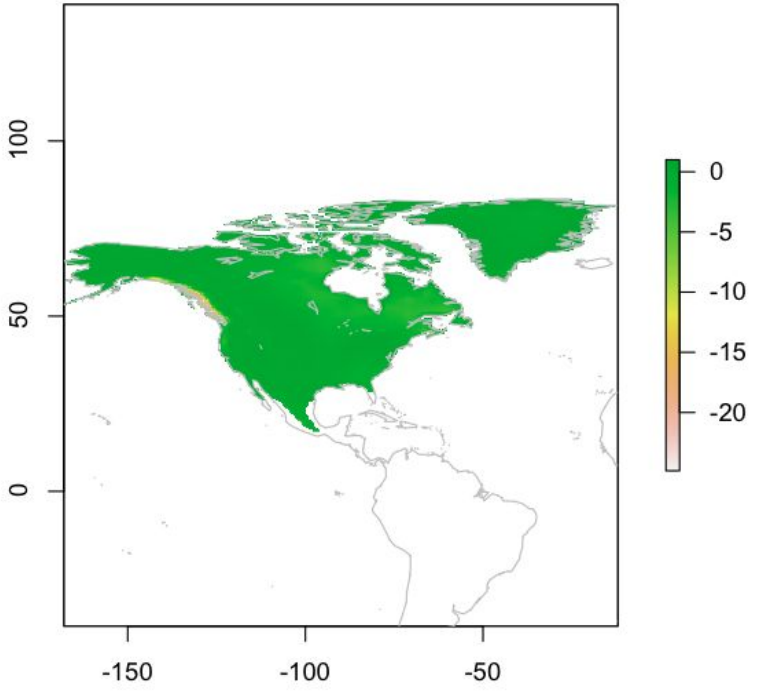
Ajuste dos SDMs

Distância de Mahalanobis



Lima-Ribeiro &
Diniz-Filho (2013)





Ajuste dos SDMs

Presença/Background (plano de fundo)

Lima-Ribeiro &
Diniz-Filho (2013)

Apenas presença

Aquário

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

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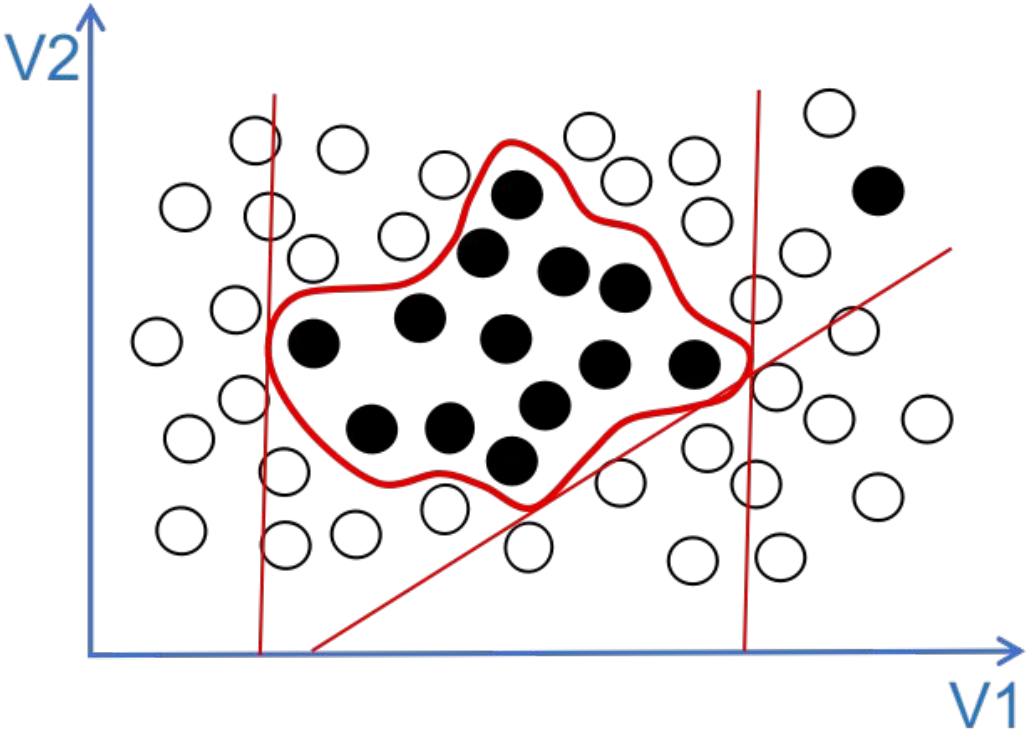
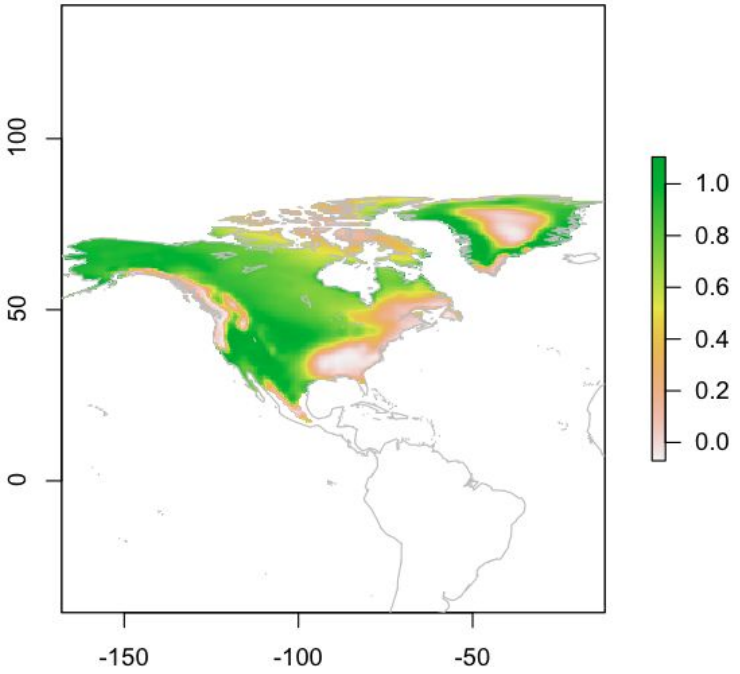
Ajuste dos SDMs

Support Vector Machine (SVM)

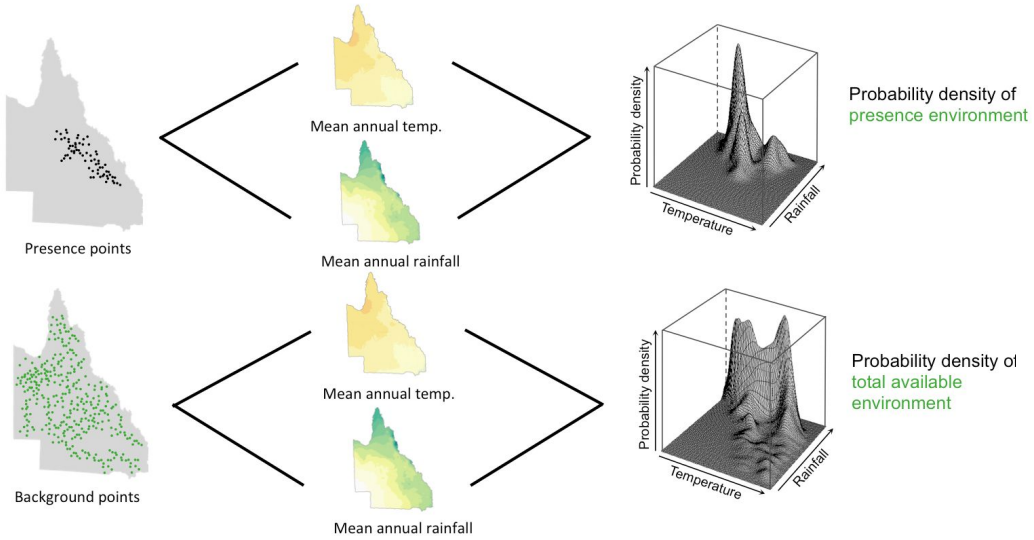
Lima-Ribeiro &
Diniz-Filho (2013)





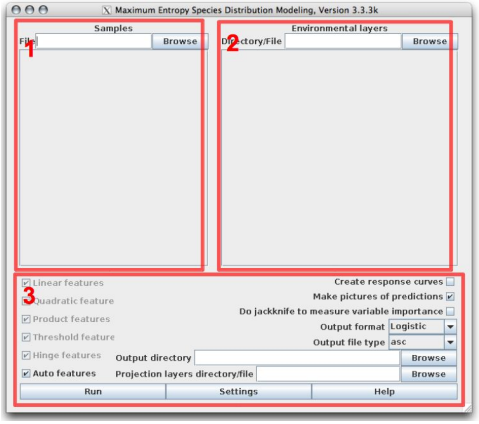
Ajuste dos SDMs

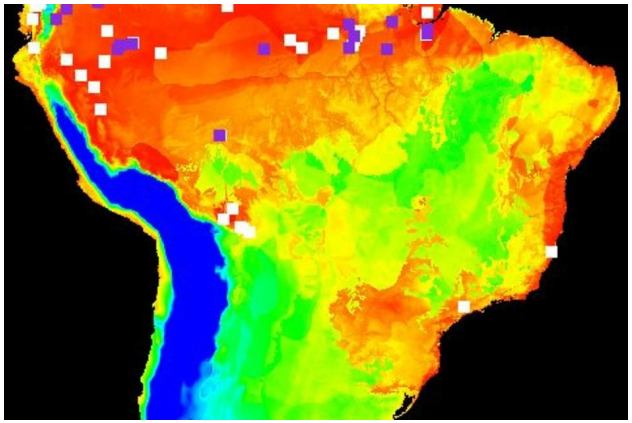
Maximum Entropy (MaxEnt)

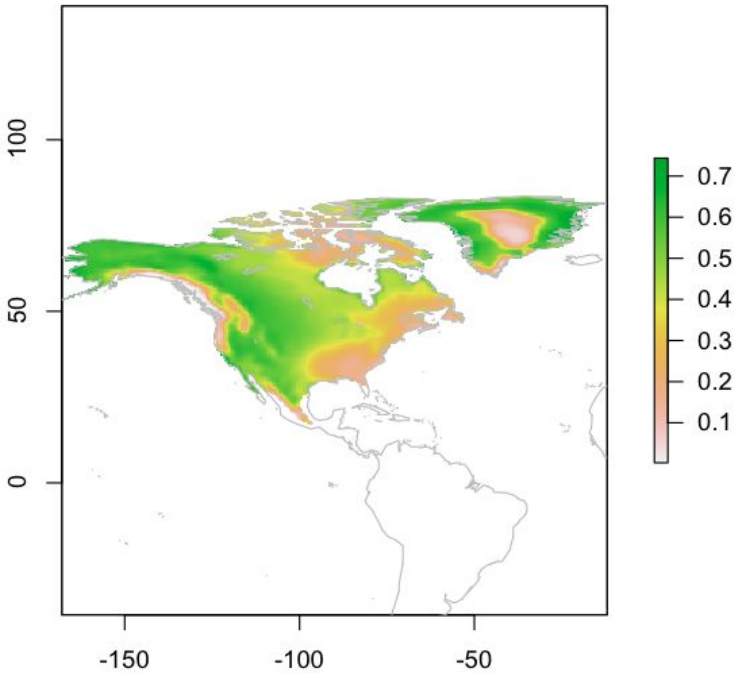


Adapted from Elith et al. (2011) *A statistical explanation of MaxEnt for ecologists*. Diversity and Distributions, 17, 43-57.

Lima-Ribeiro &
Diniz-Filho (2013)

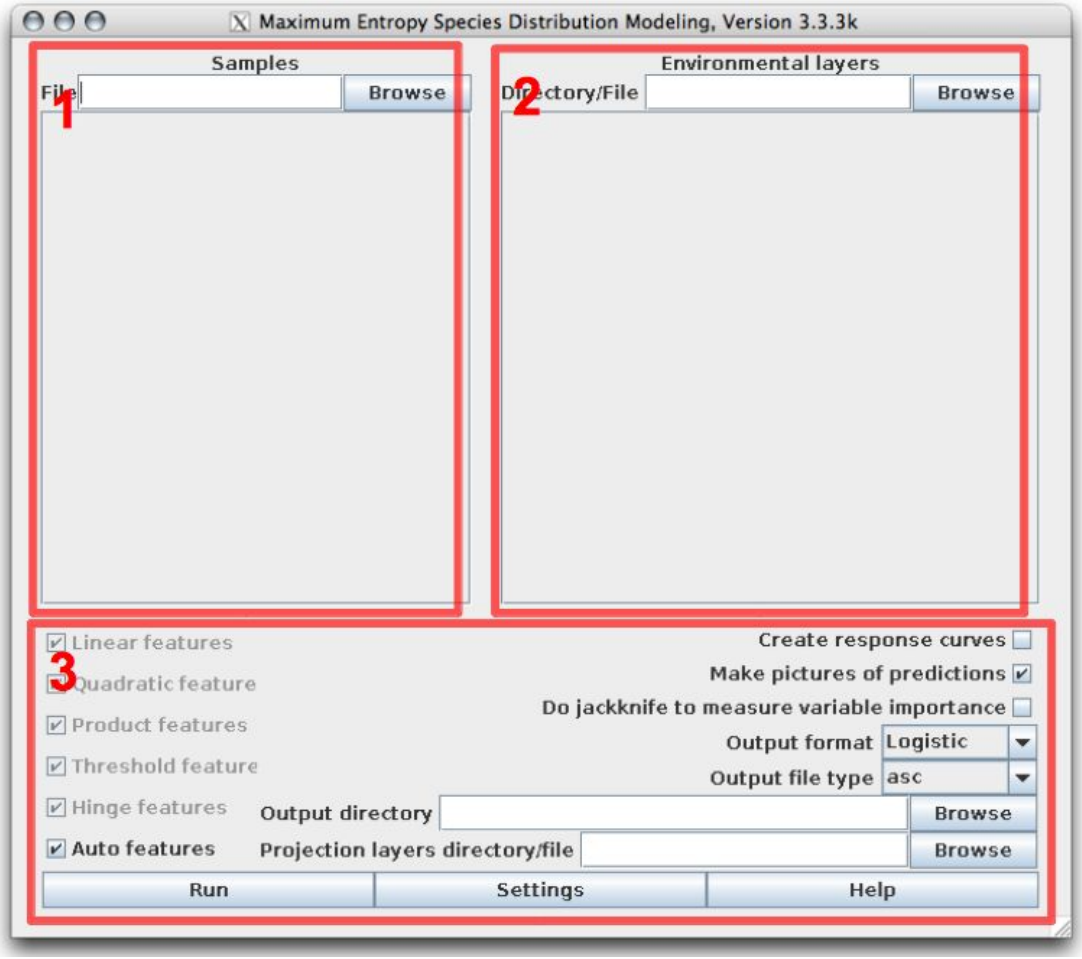


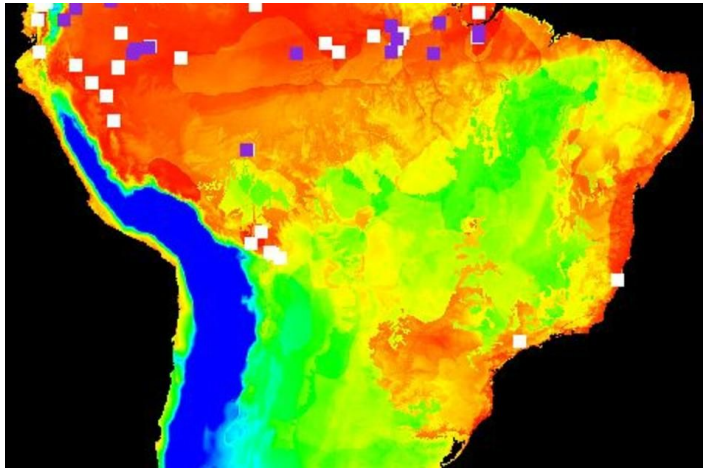


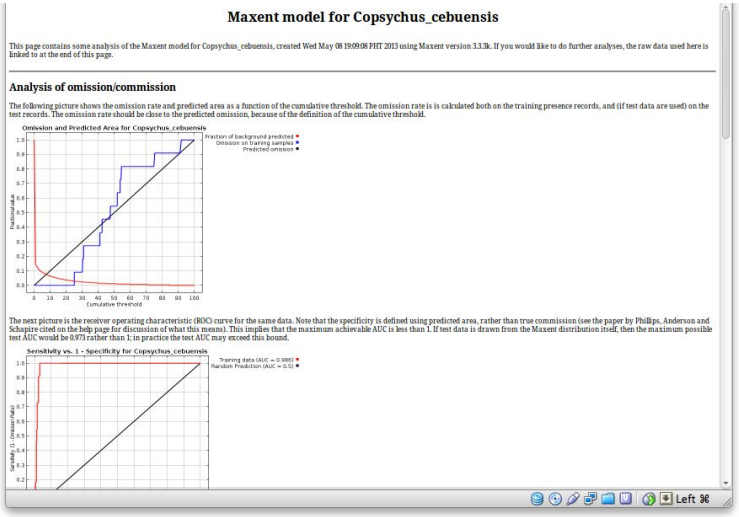


Ajuste dos SDMs

Maximum Entropy (MaxEnt)







Ajuste dos SDMs

Presença e ausência

Lima-Ribeiro &
Diniz-Filho (2013)

Apenas presença

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Onde encontrar dados de ausência?

Ajuste dos SDMs

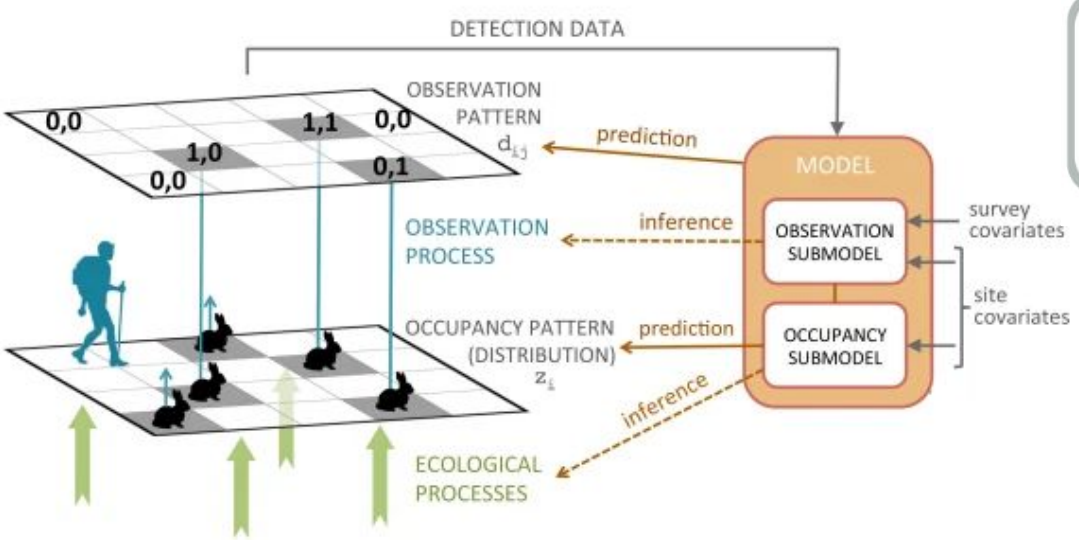
Ausência “real” (modelos de ocupação)

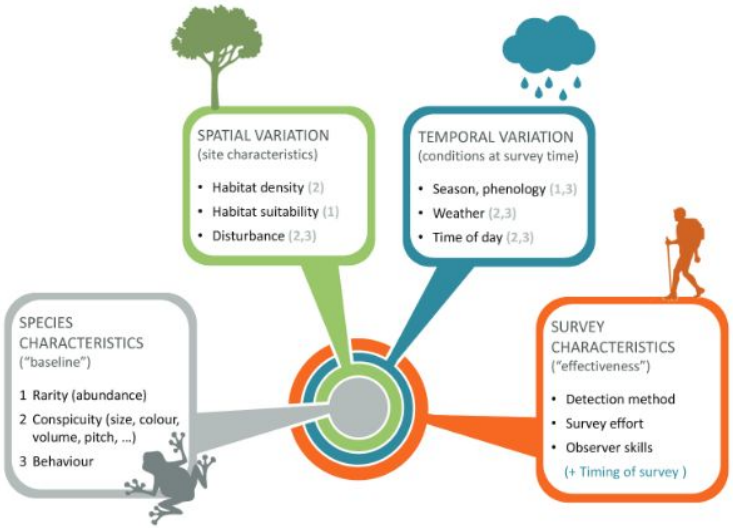
Modelling of species distributions, range dynamics and communities under imperfect detection: advances, challenges and opportunities

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

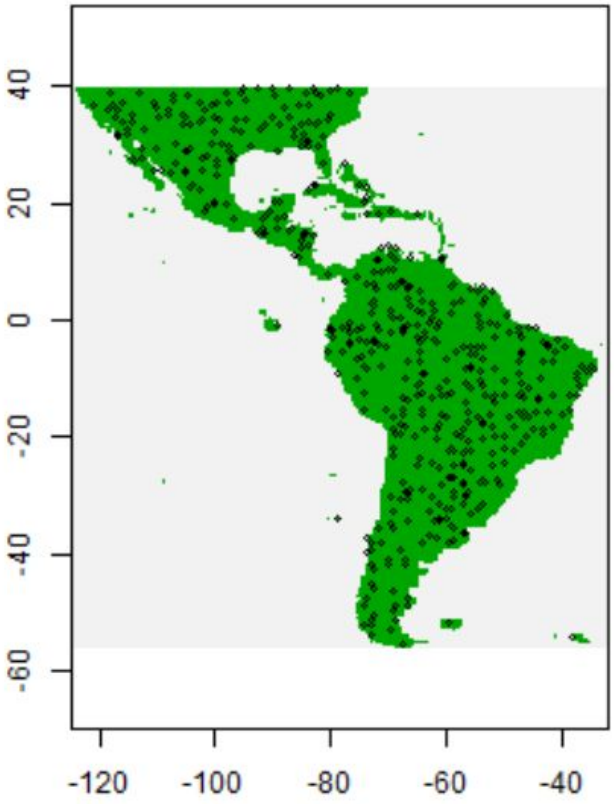


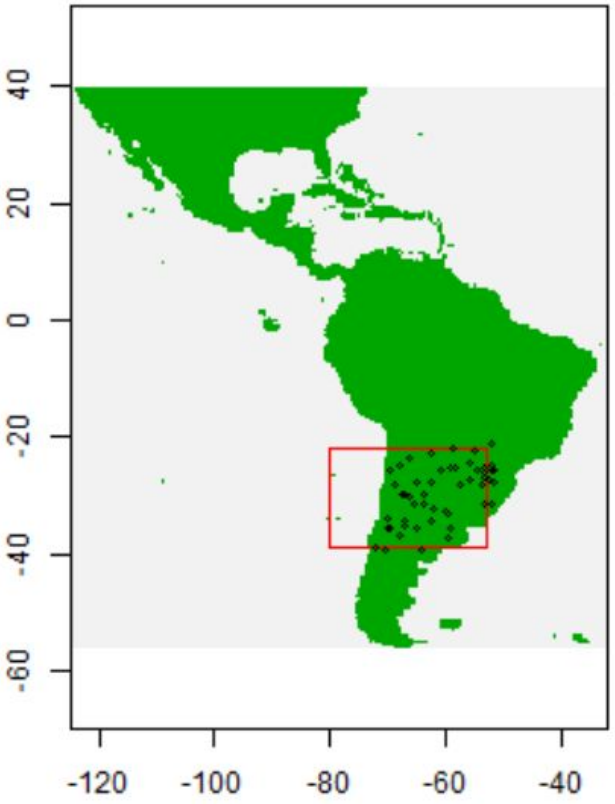


Ajuste dos SDMs

Pseudo-ausência

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





Ajuste dos SDMs

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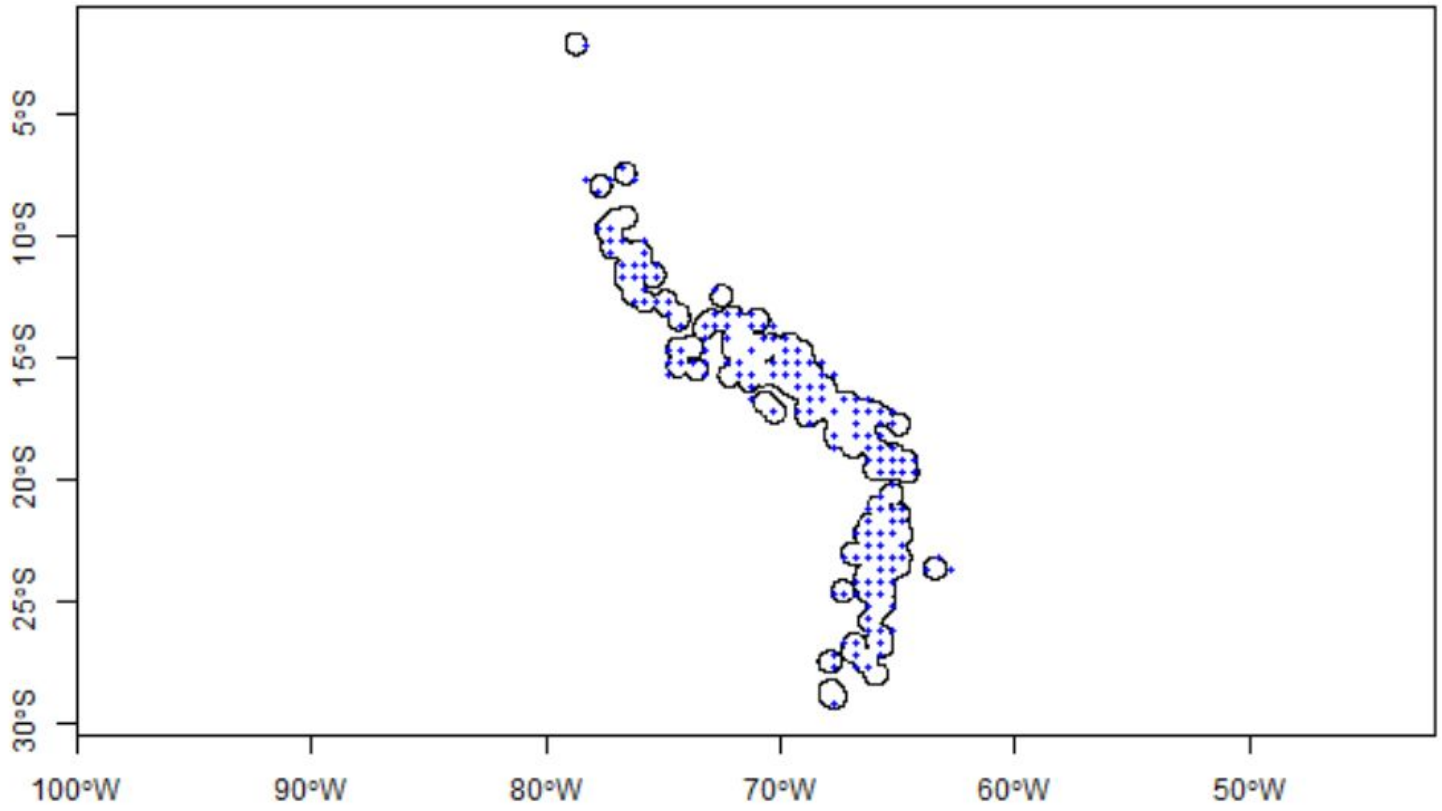
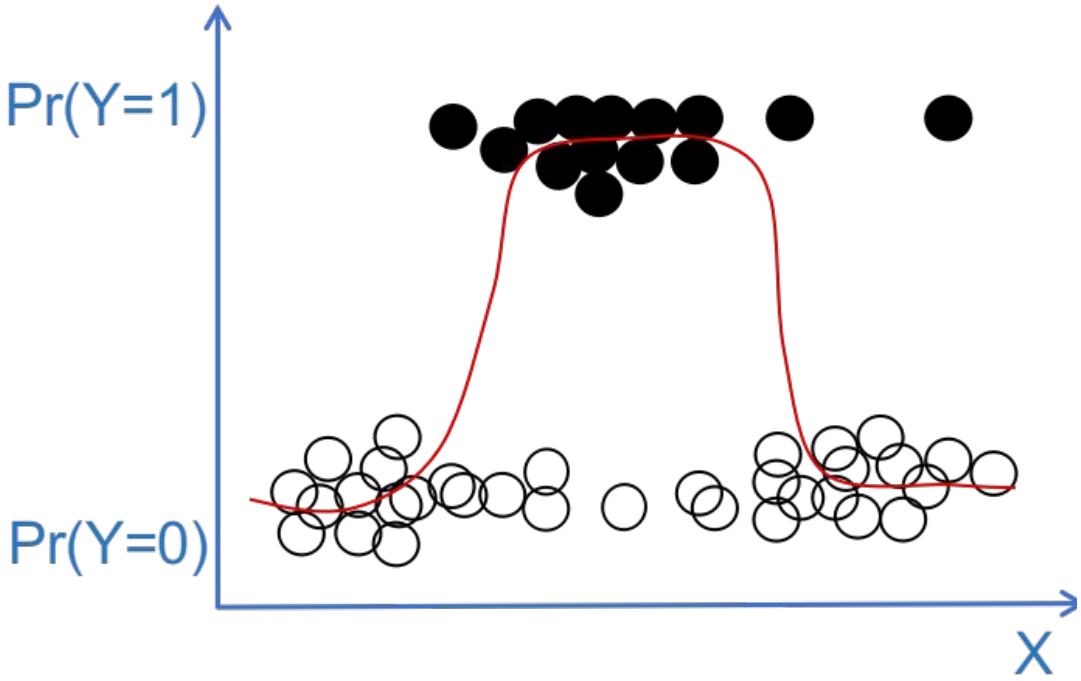
Sorteio de **pontos aleatórios** (com **padrão espacial**) para serem considerados como **ausência verdadeira**

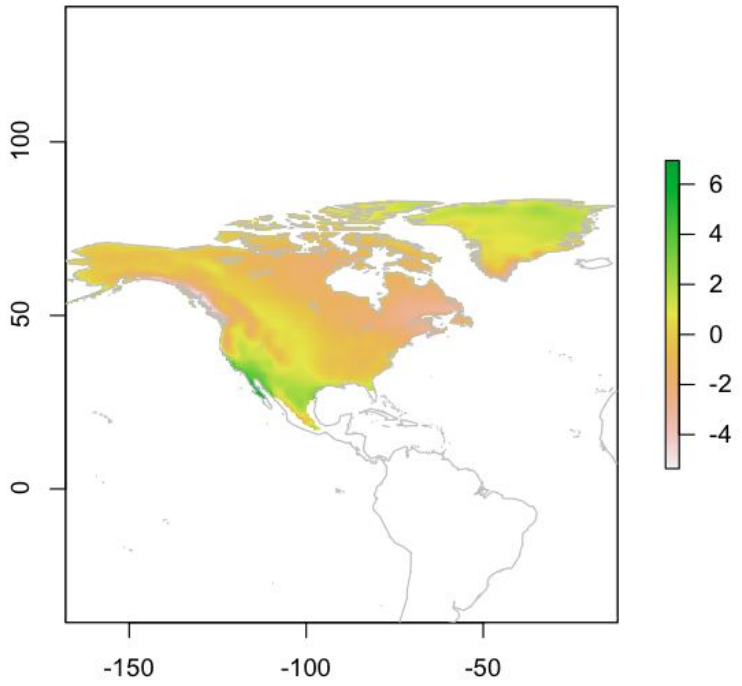


Ajuste dos SDMs

Generalized Linear Models (GLM)

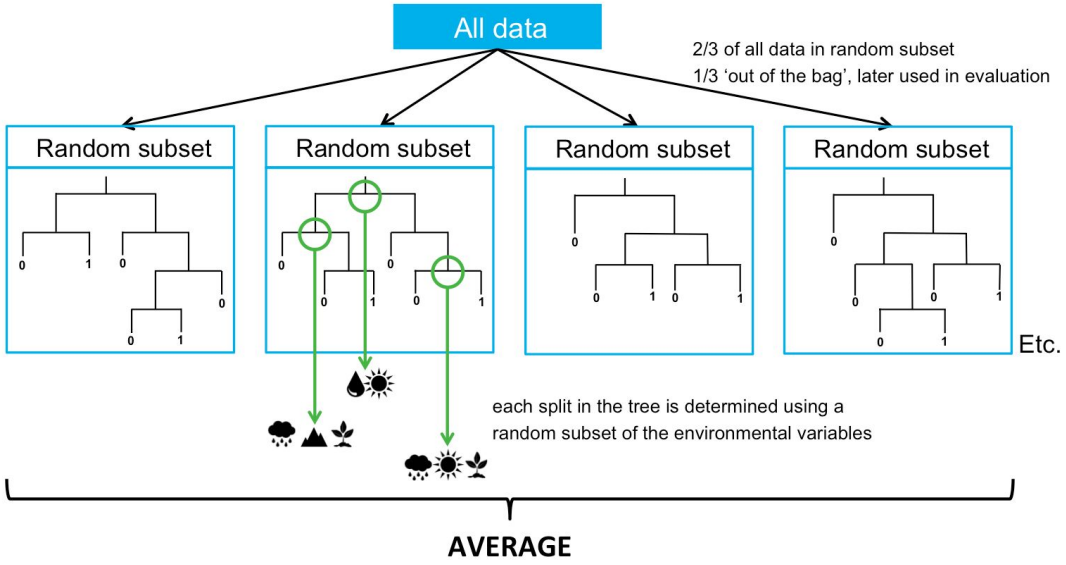
Lima-Ribeiro &
Diniz-Filho (2013)





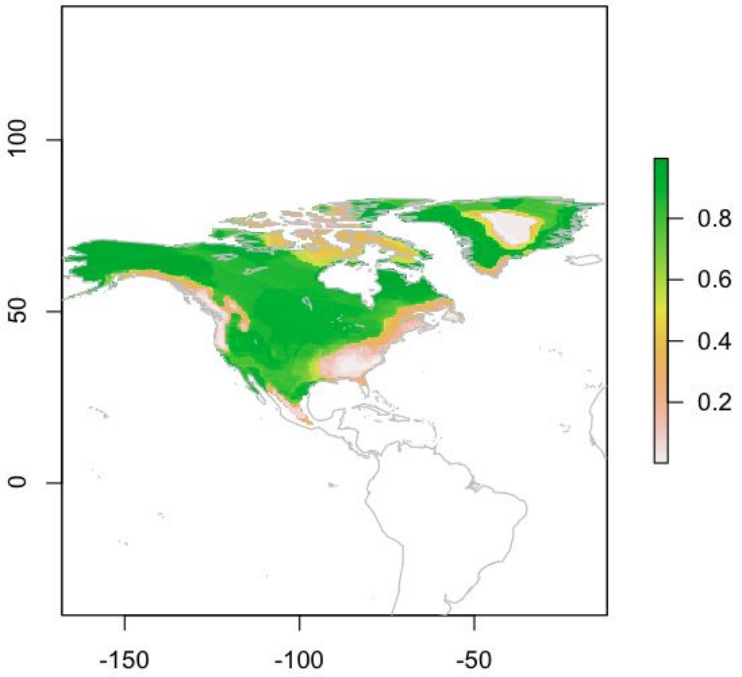
Ajuste dos SDMs

Random Forest



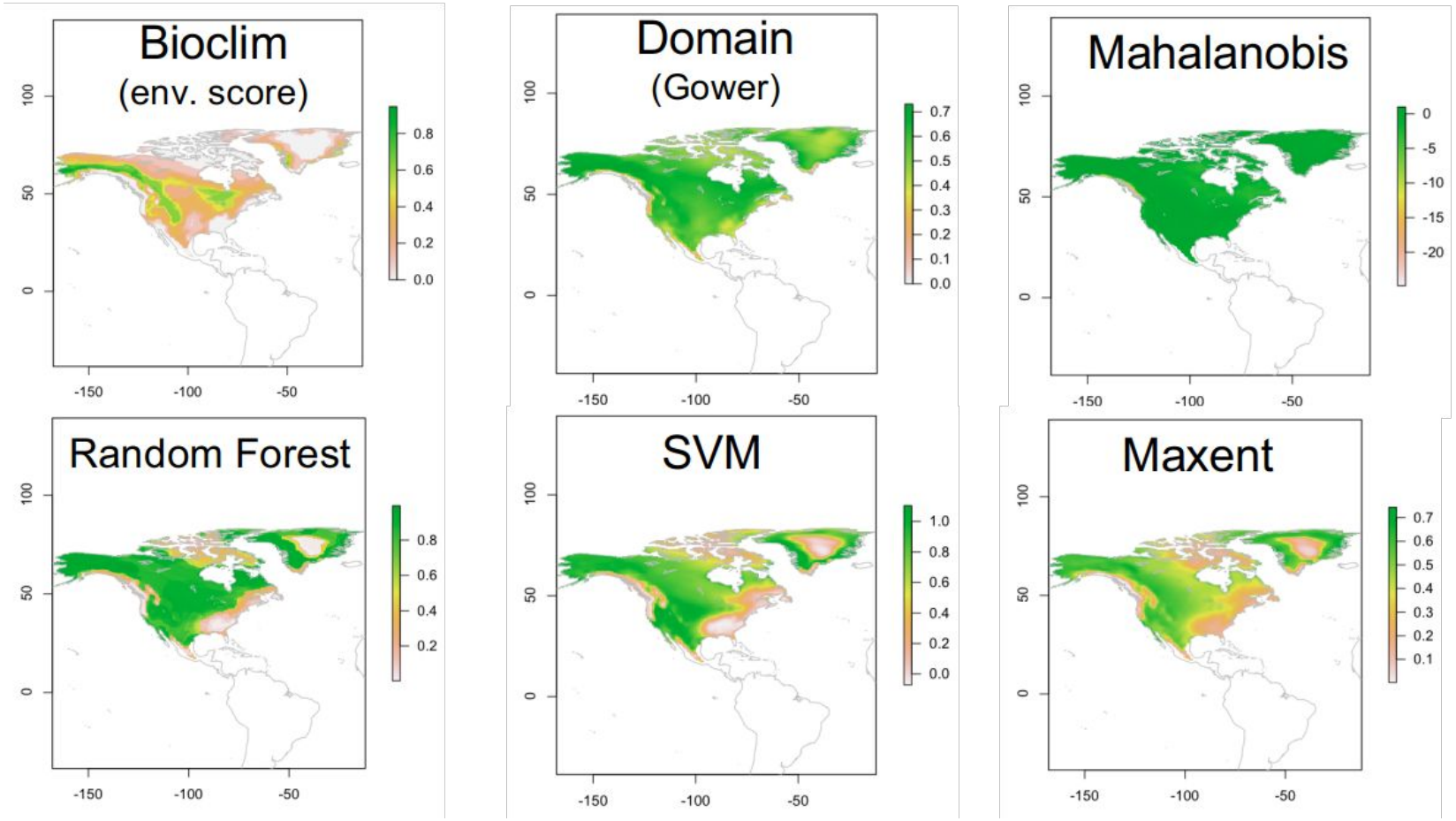
> find the set of predictor variables that produce the strongest classification model

Lima-Ribeiro &
Diniz-Filho (2013)



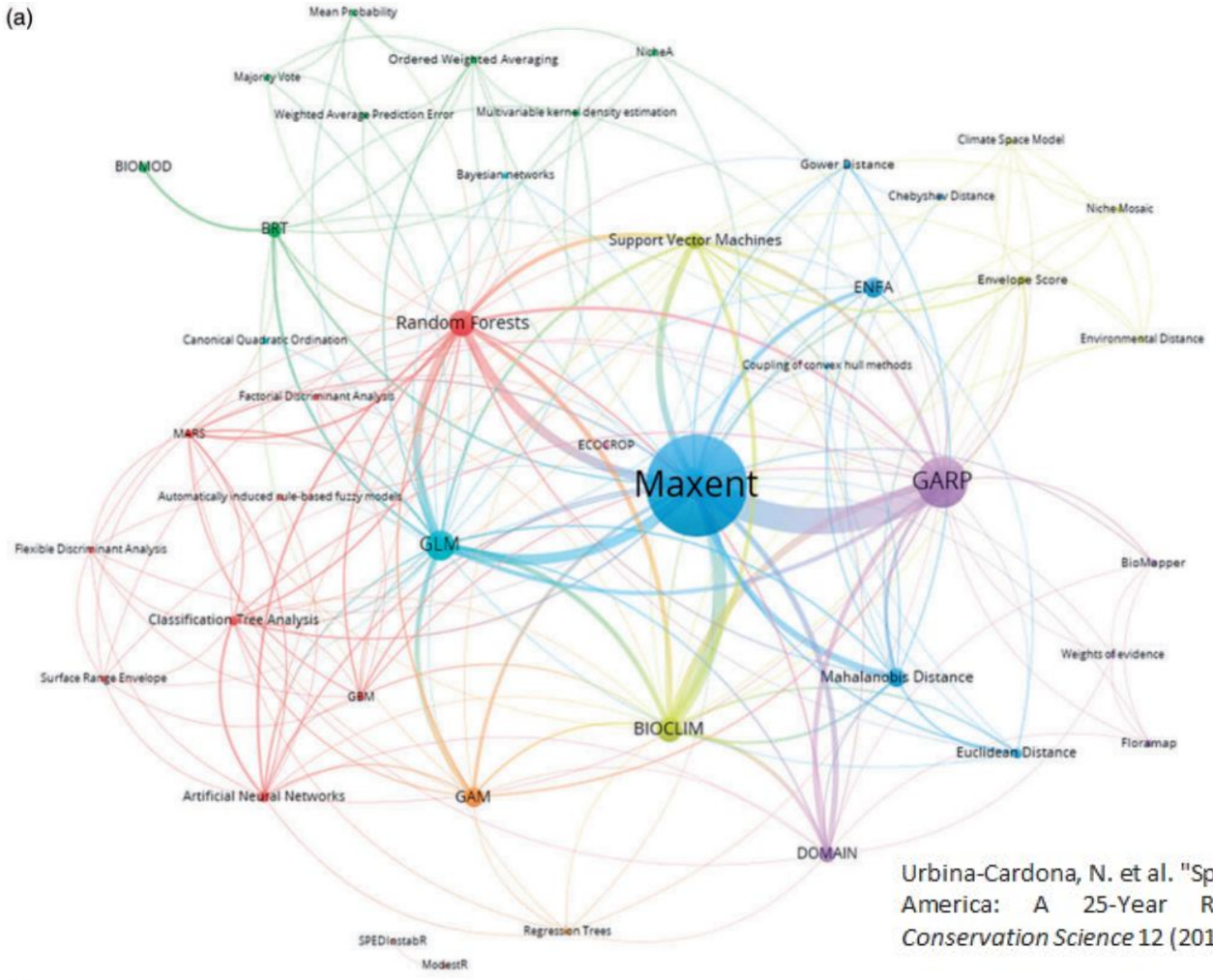
Ajuste dos SDMs

Qual algoritmo usar?



Ajuste dos SDMs

Uso dos algoritmos (Am. Latina - últimos 25 anos)



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

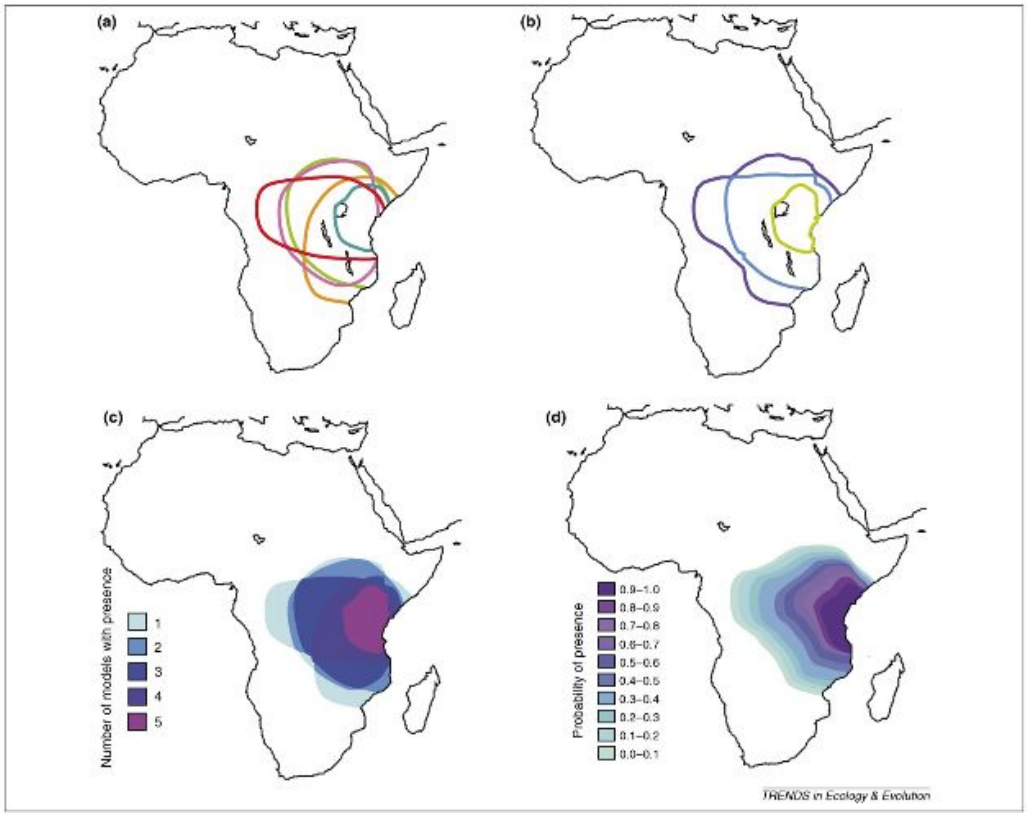
Ajuste dos SDMs

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]



Ajuste dos SDMs

Consenso *(Ensemble)*

Novel methods improve prediction of species' distributions from occurrence data

Jane Elith*, Catherine H. Graham*, Robert P. Anderson, Miroslav Dudík, Simon Ferrier, Antoine Guisan, Robert J. Hijmans, Falk Huettmann, John R. Leathwick, Anthony Lehmann, Jin Li, Lucia G. Lohmann, Bette A. Loiselle, Glenn Manion, Craig Moritz, Miguel Nakamura, Yoshinori Nakazawa, Jacob McC. Overton, A. Townsend Peterson, Steven J. Phillips, Karen Richardson, Ricardo Scachetti-Pereira, Robert E. Schapire, Jorge Soberón, Stephen Williams, Mary S. Wisz and Niklaus E. Zimmermann

ECOGRAPHY 29: 129–151, 2006

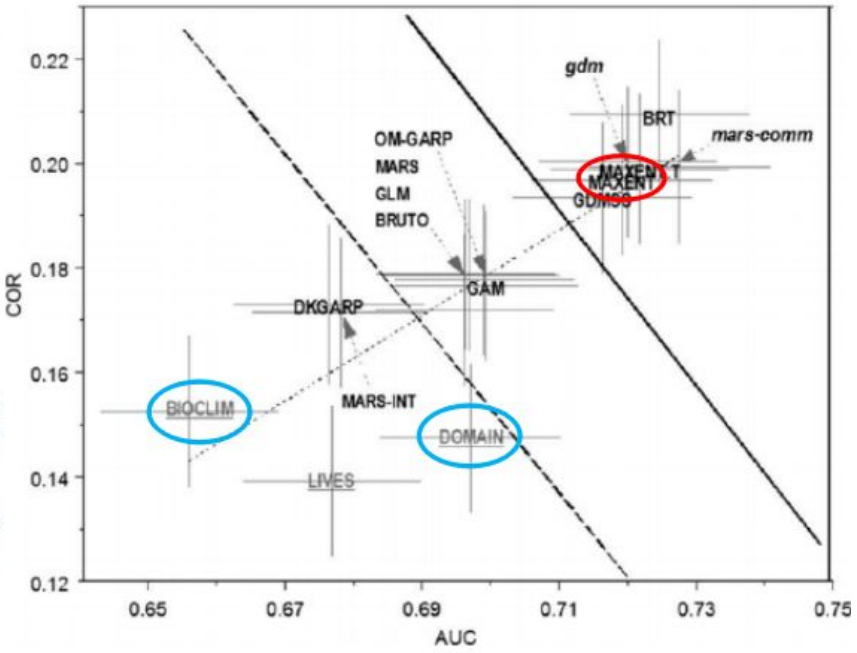


Fig. 3. Mean AUC vs mean correlation (COR) for modelling methods, summarised across all species. The grey bars are standard errors estimated in the GLMM (see Appendix), reflecting variation for an average species in an average region. The labels are broad classifications of the methods: grey underlined = only use presence data, black capitals = use presence and background samples, black lower case italics = community methods.

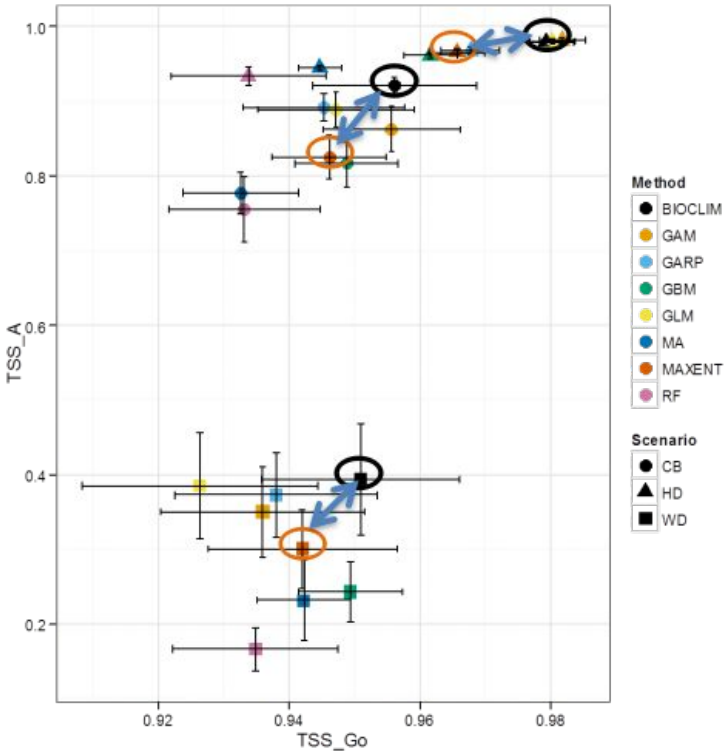
Ajuste dos SDMs

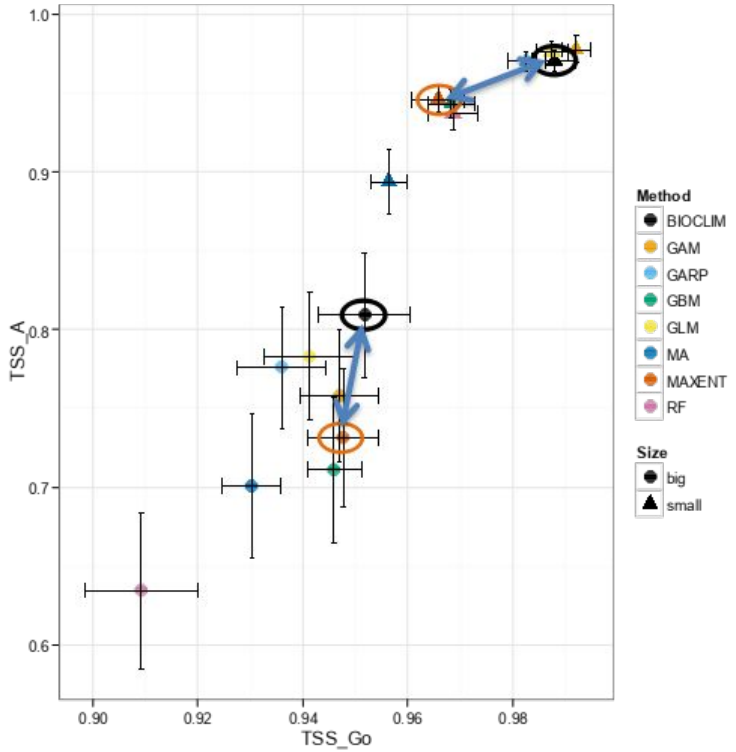
Consenso *(Ensemble)*

Methods in Ecology and Evolution
BRITISH ECOLOGICAL SOCIETY
Research Article | Free Access

No silver bullets in correlative ecological niche modelling: insights from testing among many potential algorithms for niche estimation

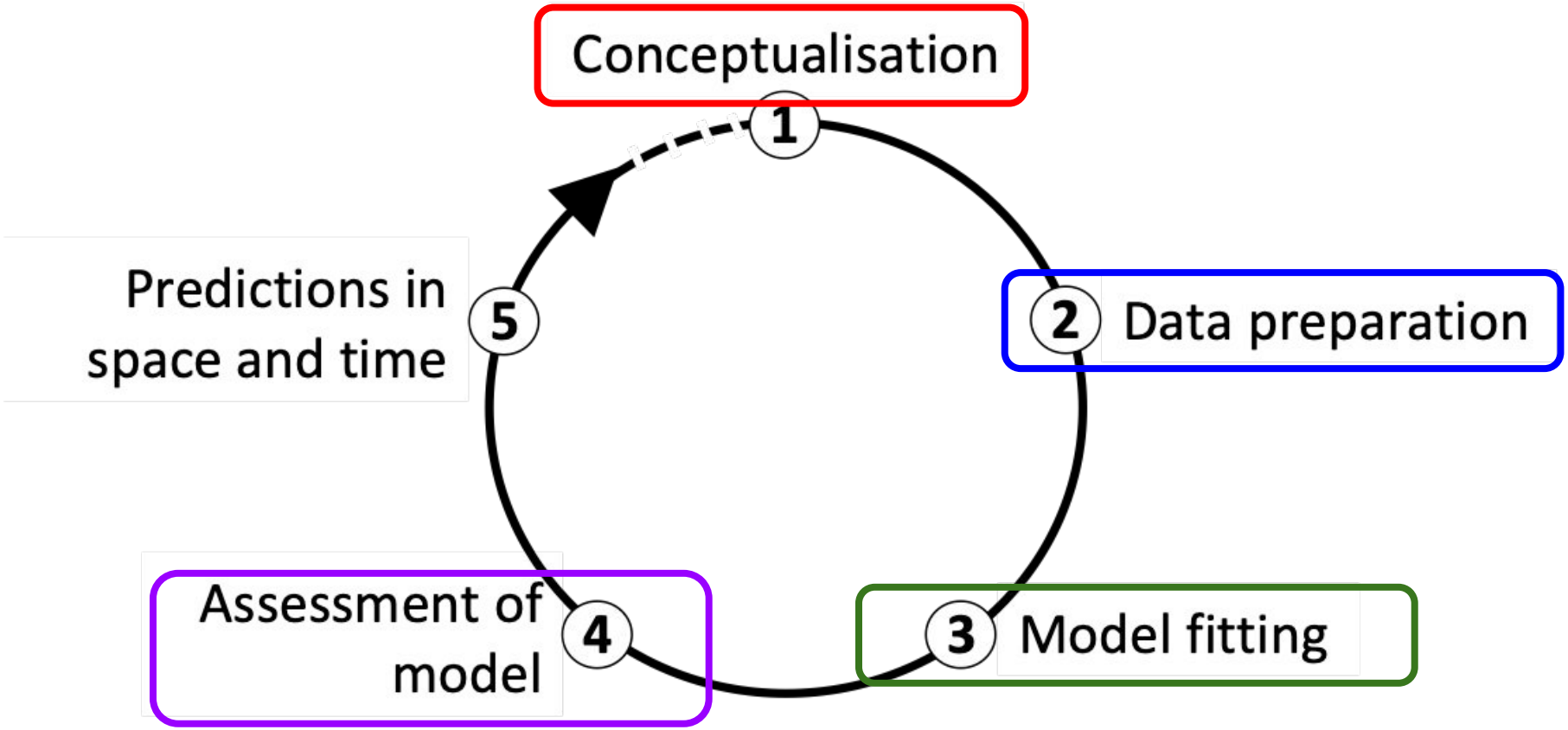
Huijie Qiao, Jorge Soberón, Andrew Townsend Peterson





SDM passo a passo

Estrutura dos SDMs

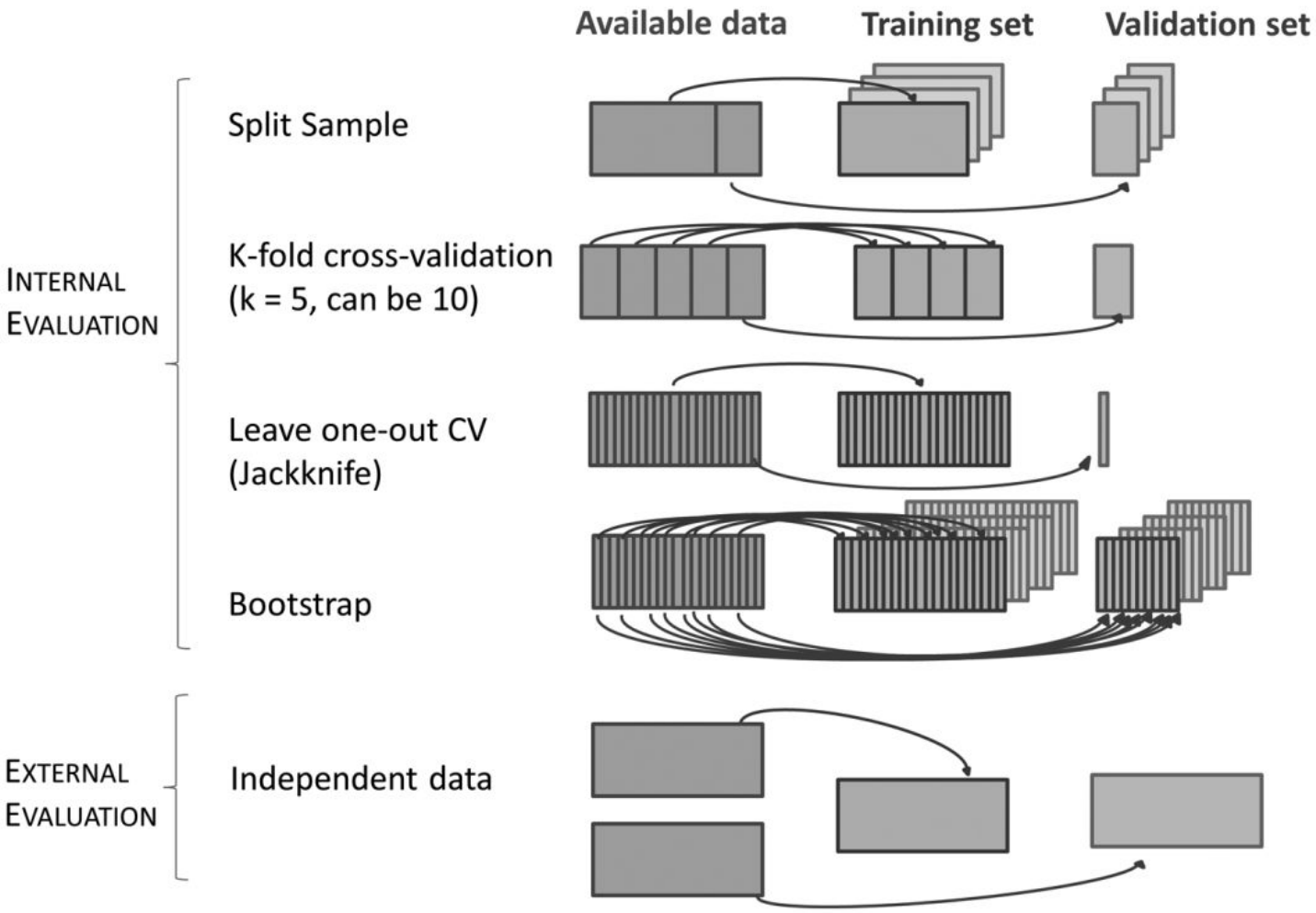


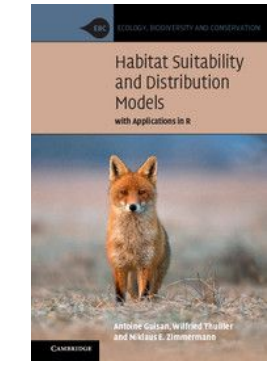
7. Avaliação dos modelos

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

Avaliação dos SDMs

Tipos de avaliação

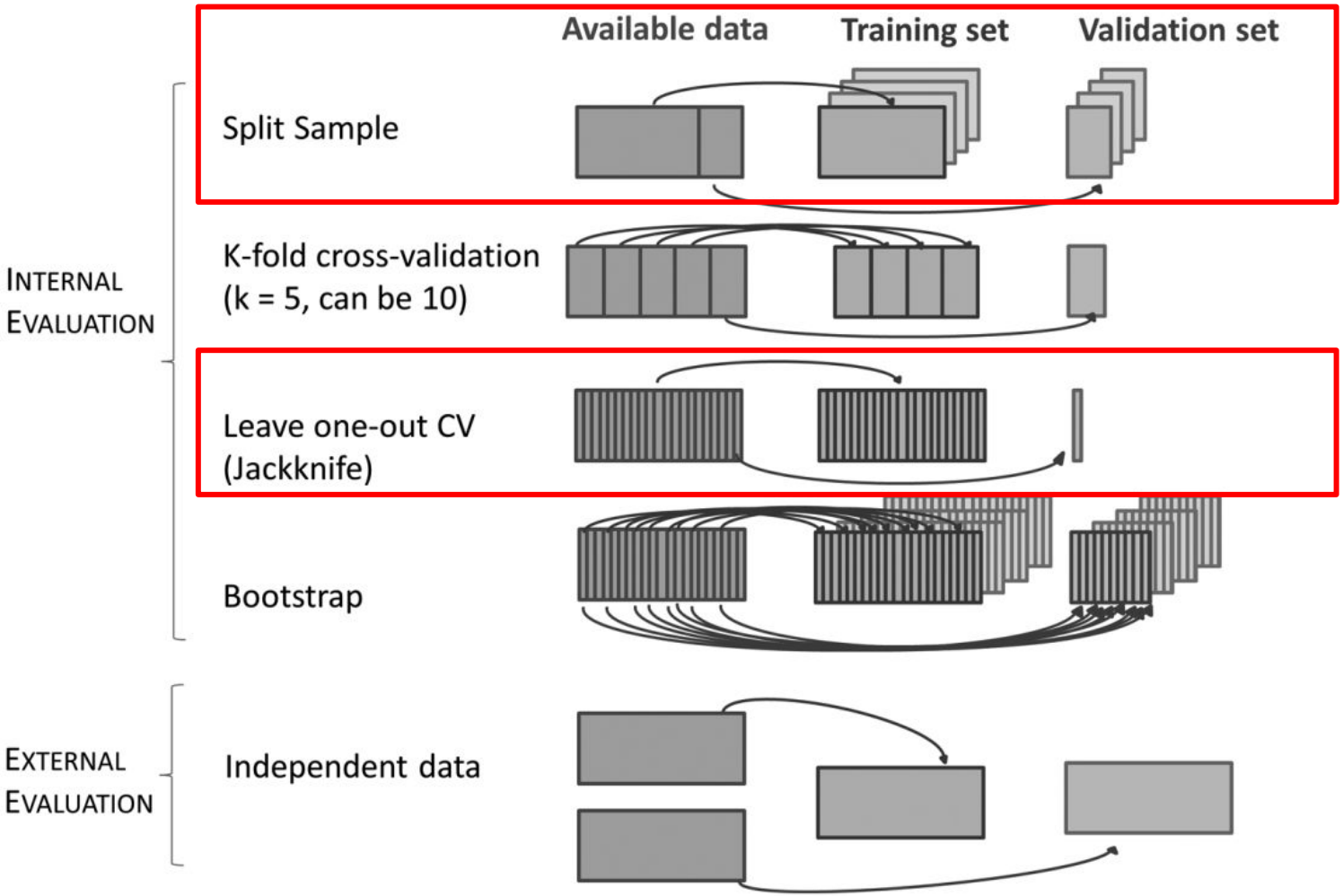


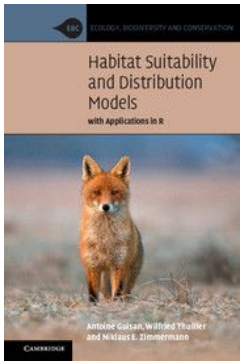


Guisan et al. (2017)

Avaliação dos SDMs

Tipos de avaliação

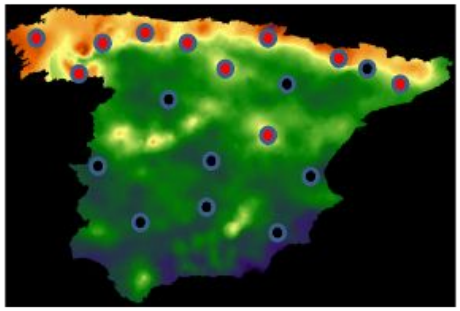


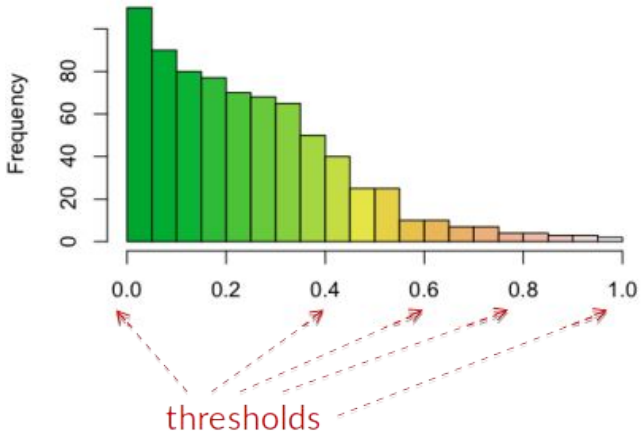


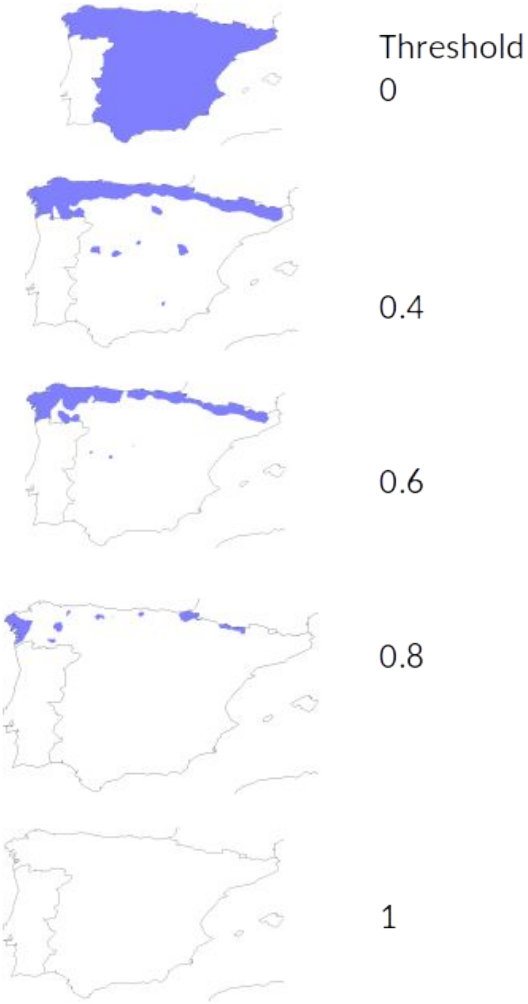
Guisan et al. (2017)

Avaliação dos SDMs

Limiares (*Thresholds*)

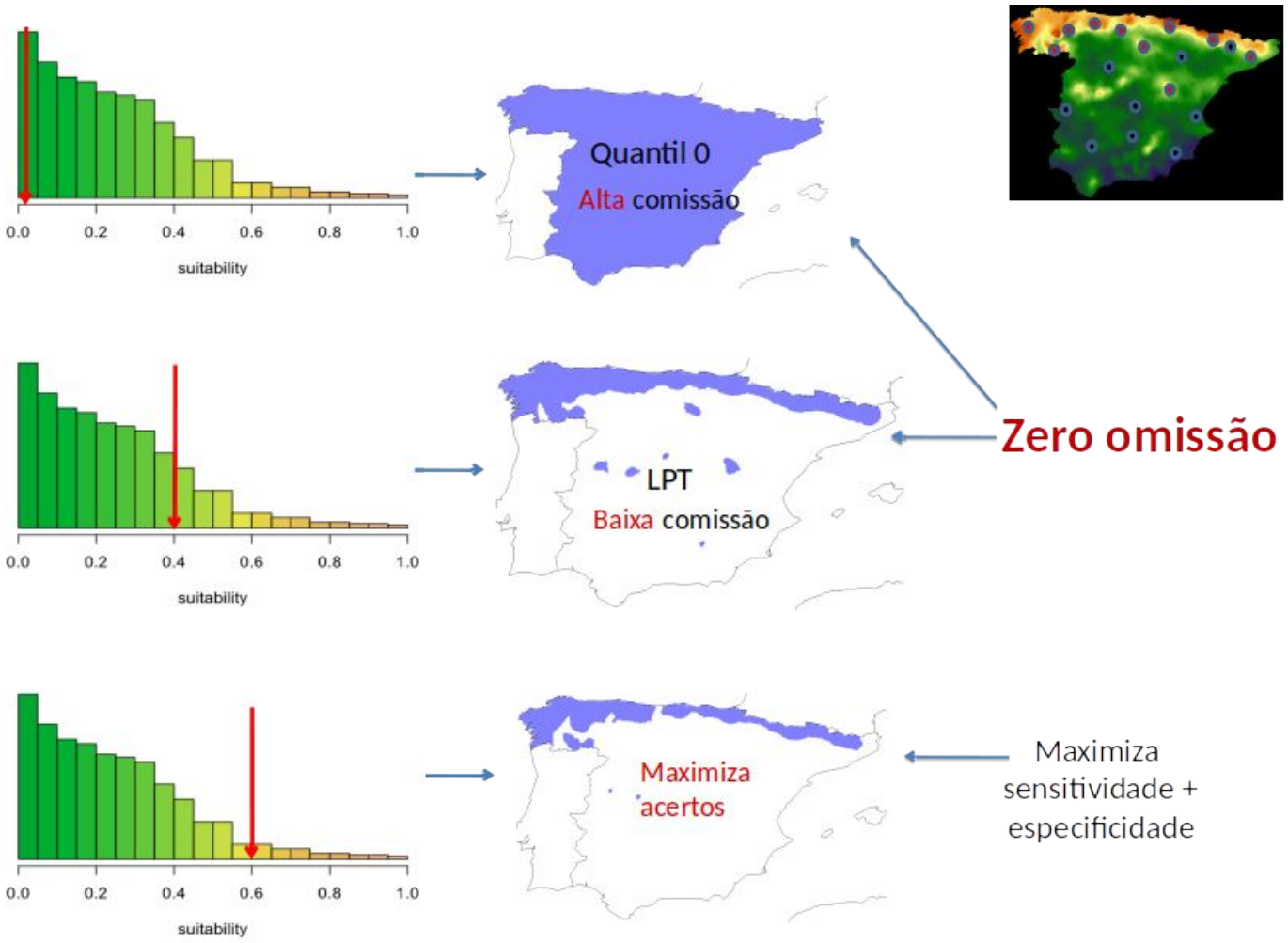






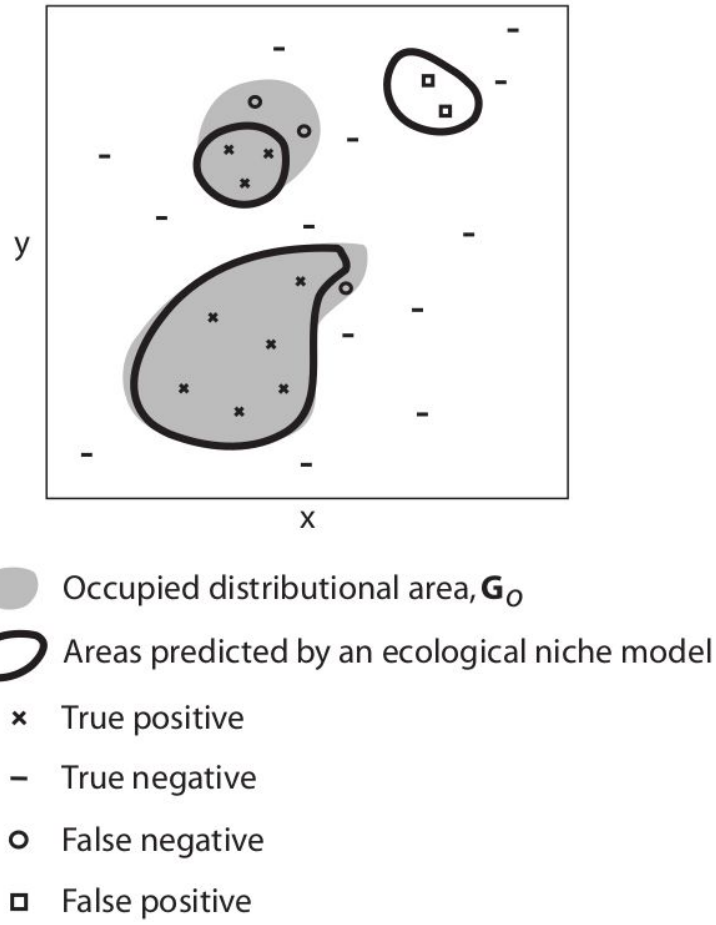
Avaliação dos SDMs

Limiares (*Thresholds*)



Avaliação dos SDMs

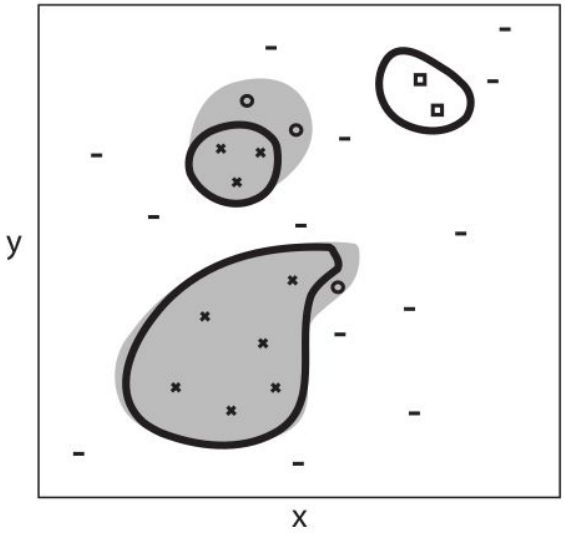
Matriz de confusão



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

Avaliação dos SDMs

Matriz de confusão

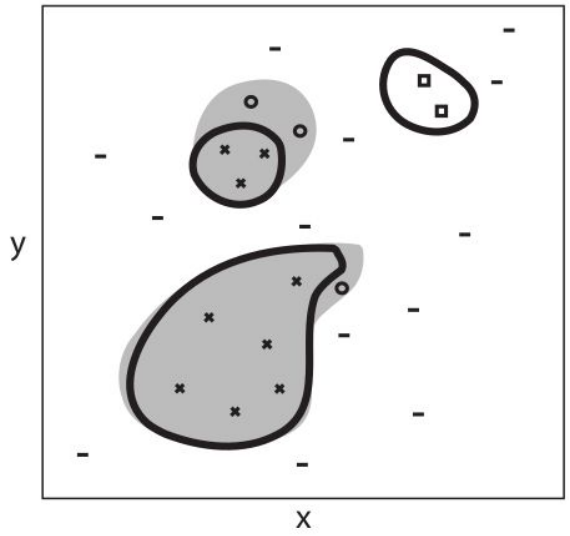


		Observation: Present	Observation: Absent
Prediction	Present	True positive	False positive
Prediction	Absent	False negative	True negative

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

Avaliação dos SDMs

Matriz de confusão



Occupied distributional area, G_O

Areas predicted by an ecological niche model

× True positive

– True negative

o False negative

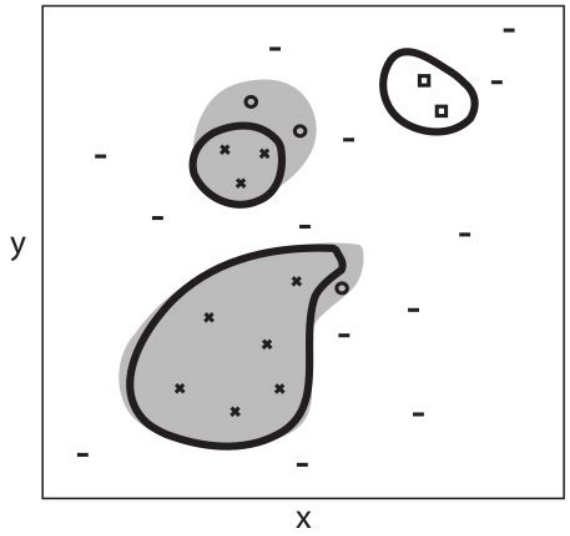
□ False positive

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

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

Avaliação dos SDMs

Matriz de confusão



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Occupied distributional area, G_O

Areas predicted by an ecological niche model

× True positive

– True negative

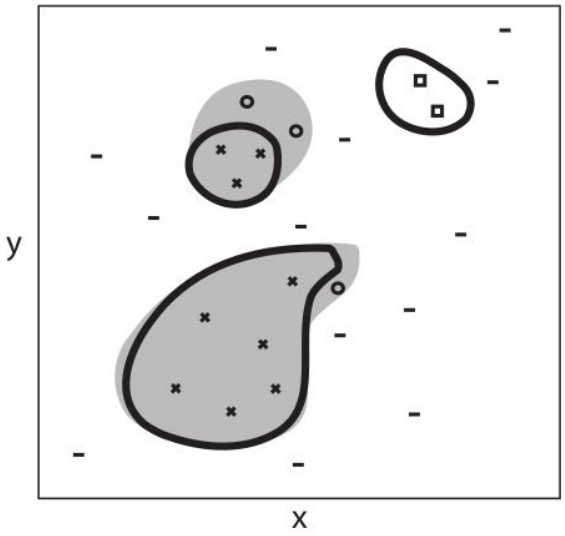
o False negative

□ False positive

<u>Ocorrência</u> que o modelo previu como **<u>ausência (erro de omissão)</u>**

Avaliação dos SDMs

Matriz de confusão



		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

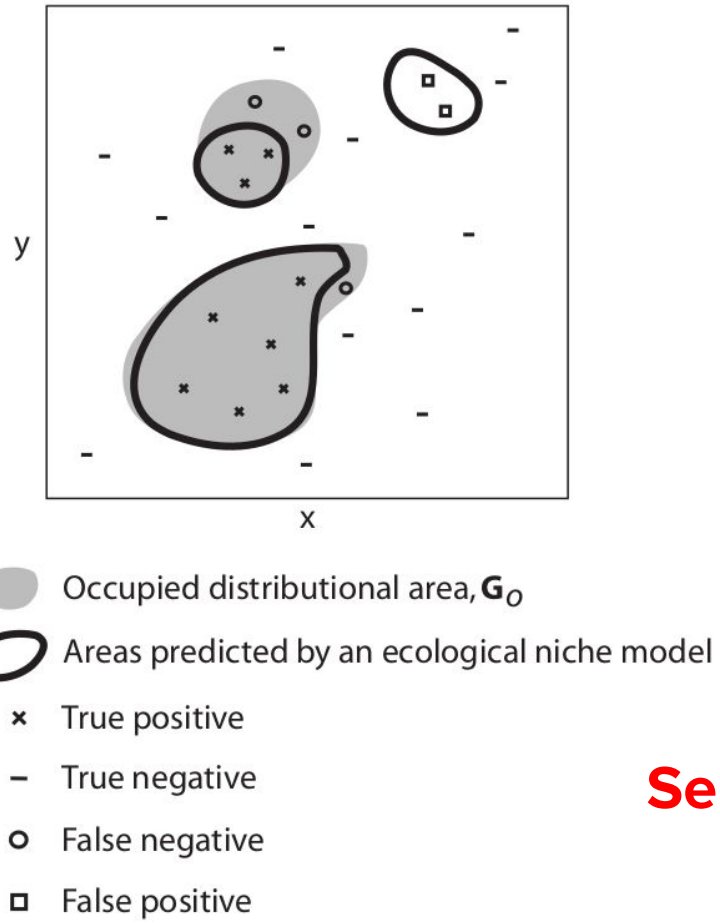
o False negative

□ False positive

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

Avaliação dos SDMs

Matriz de confusão

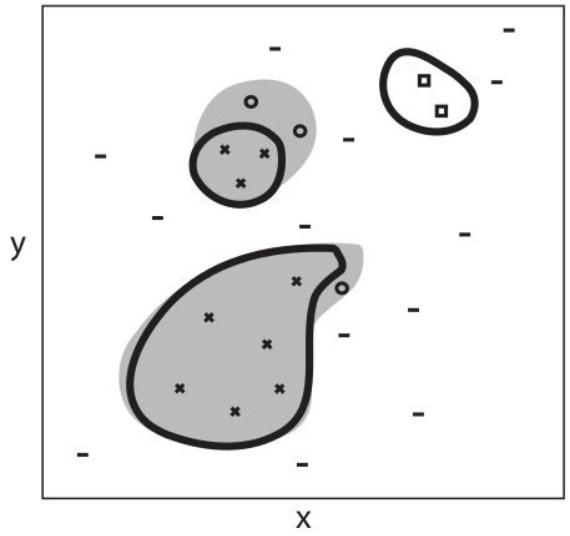


		Observation: Present	Observation: Absent
Prediction	Present	True positive	False positive
Prediction	Absent	False negative	True negative

Sensitividade: presenças corretas / total de presenças

Avaliação dos SDMs

Matriz de confusão



Occupied distributional area, G_O

Areas predicted by an ecological niche model

× True positive

– True negative

o False negative

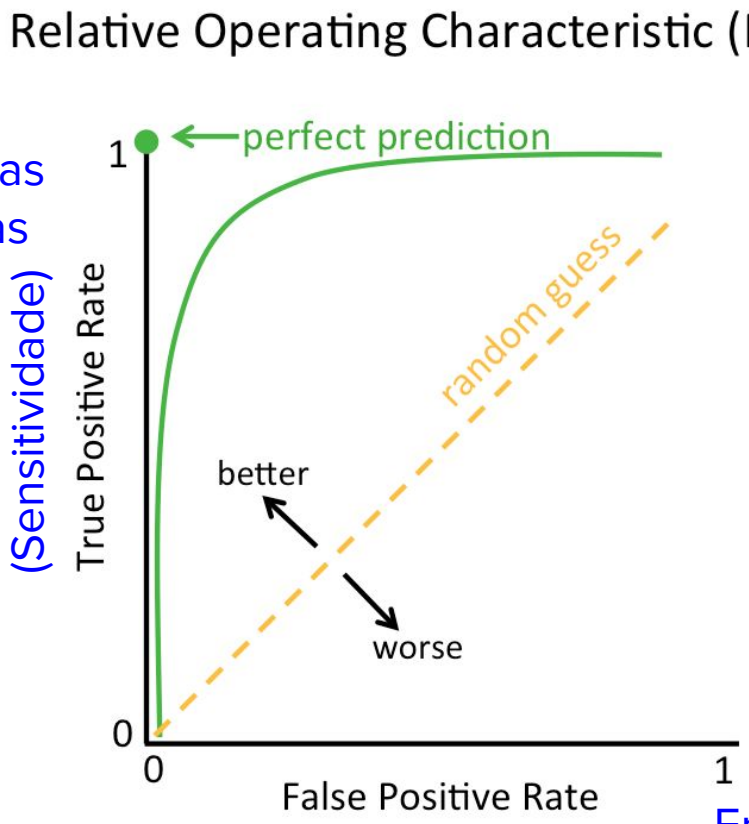
□ False positive

		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 SDMs

Curva ROC e AUC



Acertos das presenças (Sensitividade)

(Especificidade - 1) Erro das ausências

AUC = area under the curve

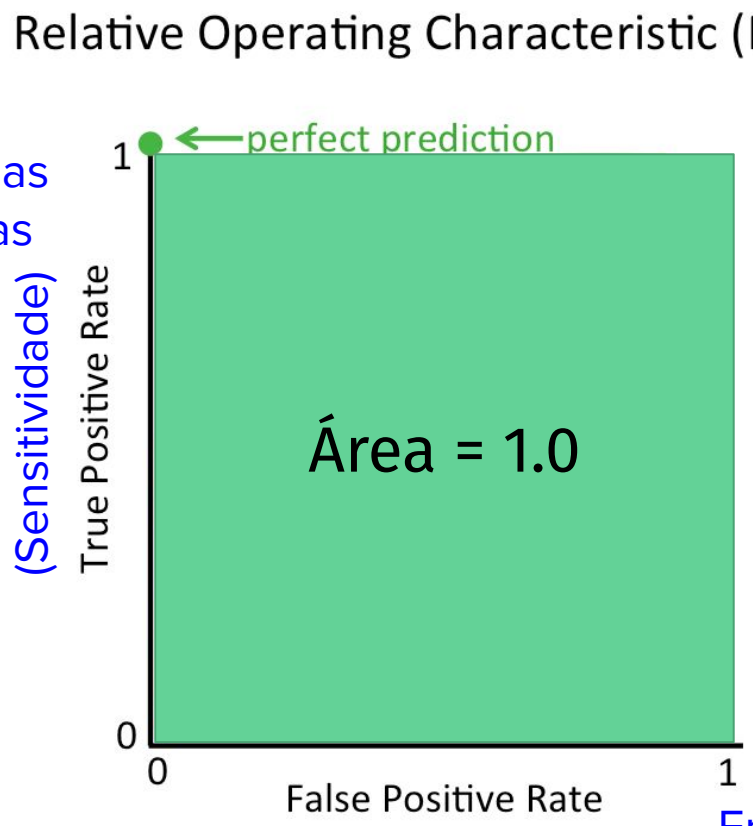
0.5-0.7 = poor model performance

0.7-0.9 = moderate

> 0.9 = excellent

Avaliação dos SDMs

Curva ROC e AUC



Acertos das presenças (Sensitividade)

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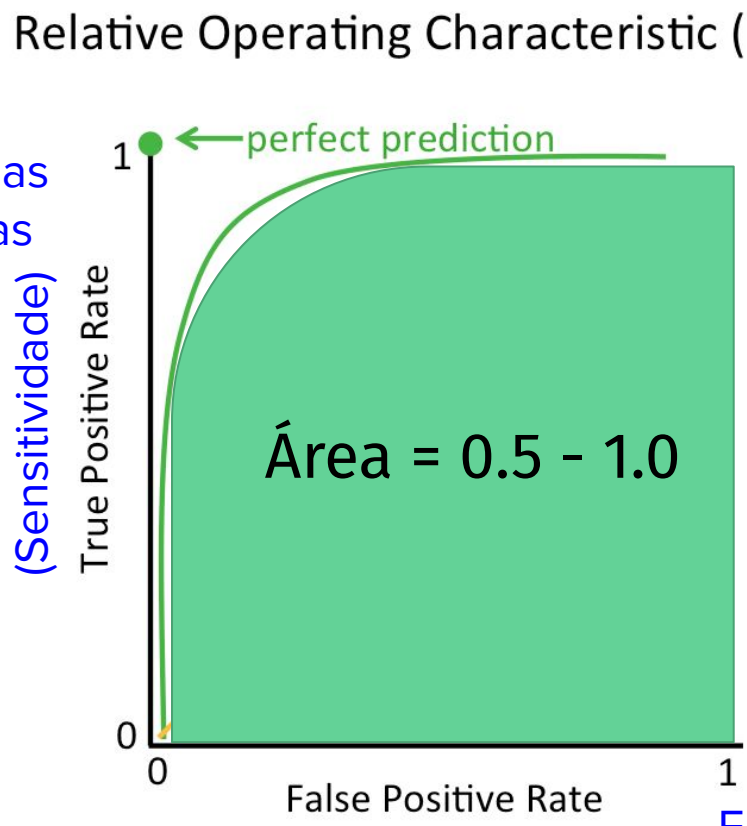
(Especificidade - 1) Erro das ausências

Avaliação dos SDMs

Curva ROC e AUC



Acertos das presenças

Erro das ausências

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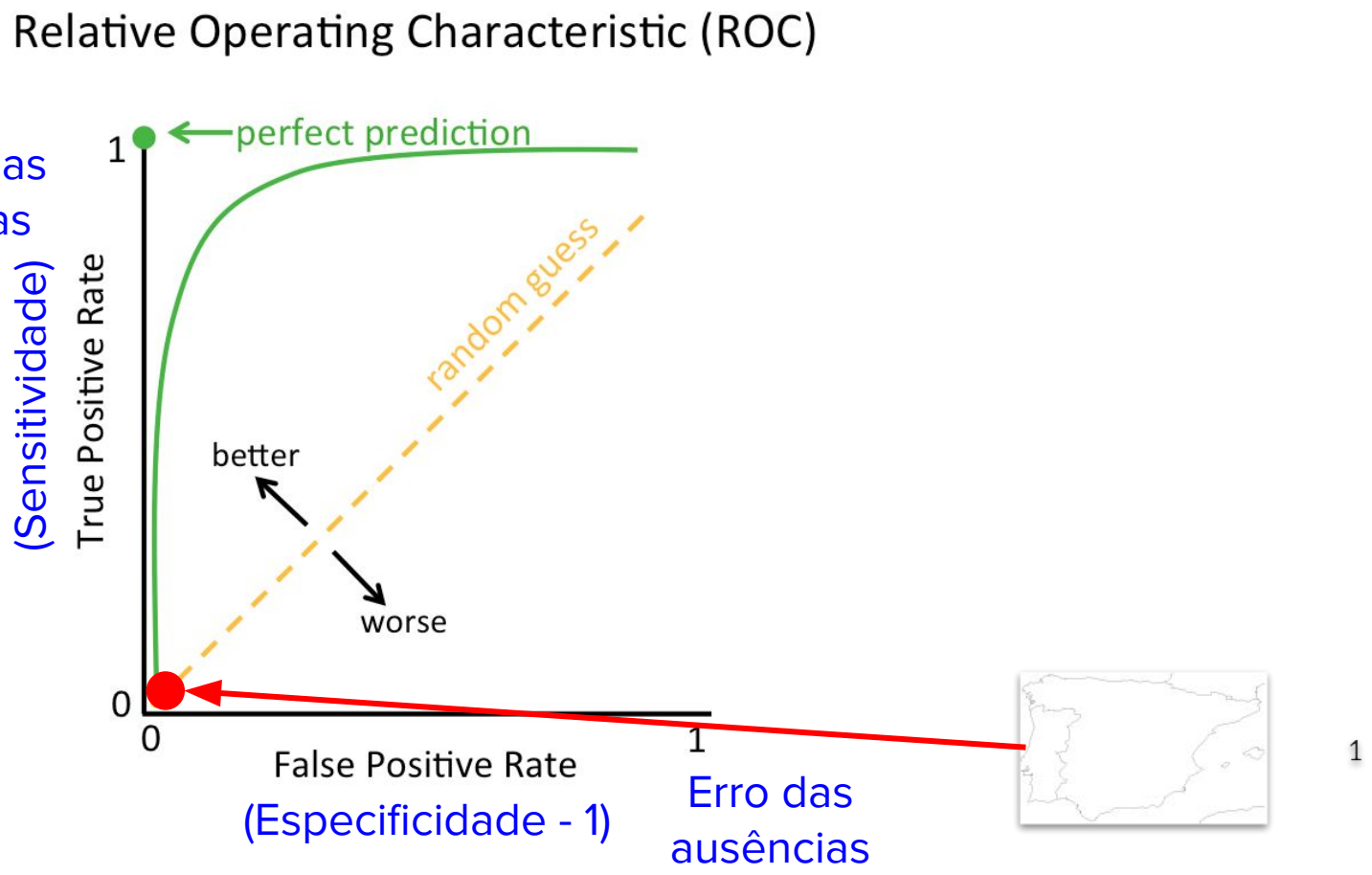
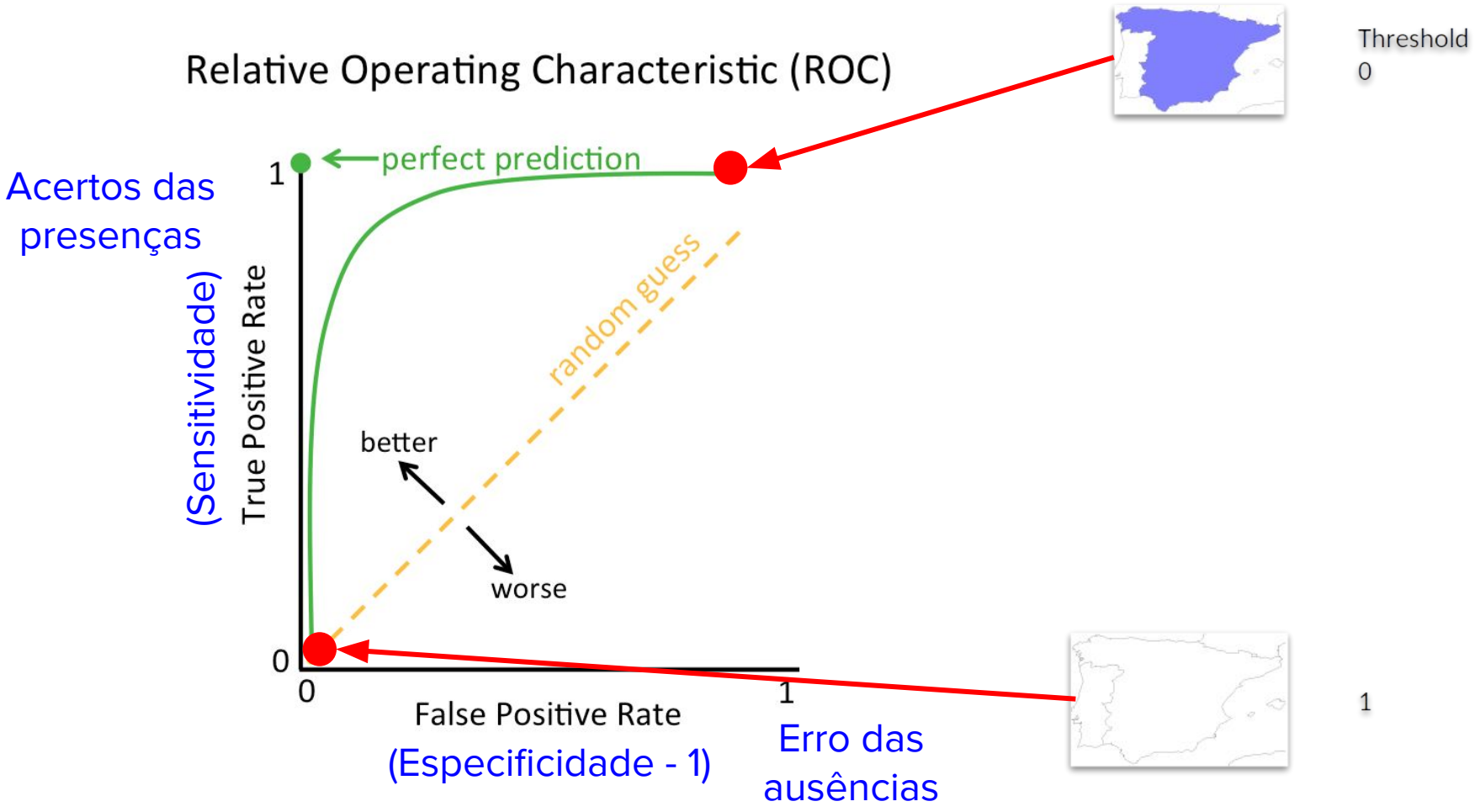
Avaliação dos SDMs

Curva ROC e AUC



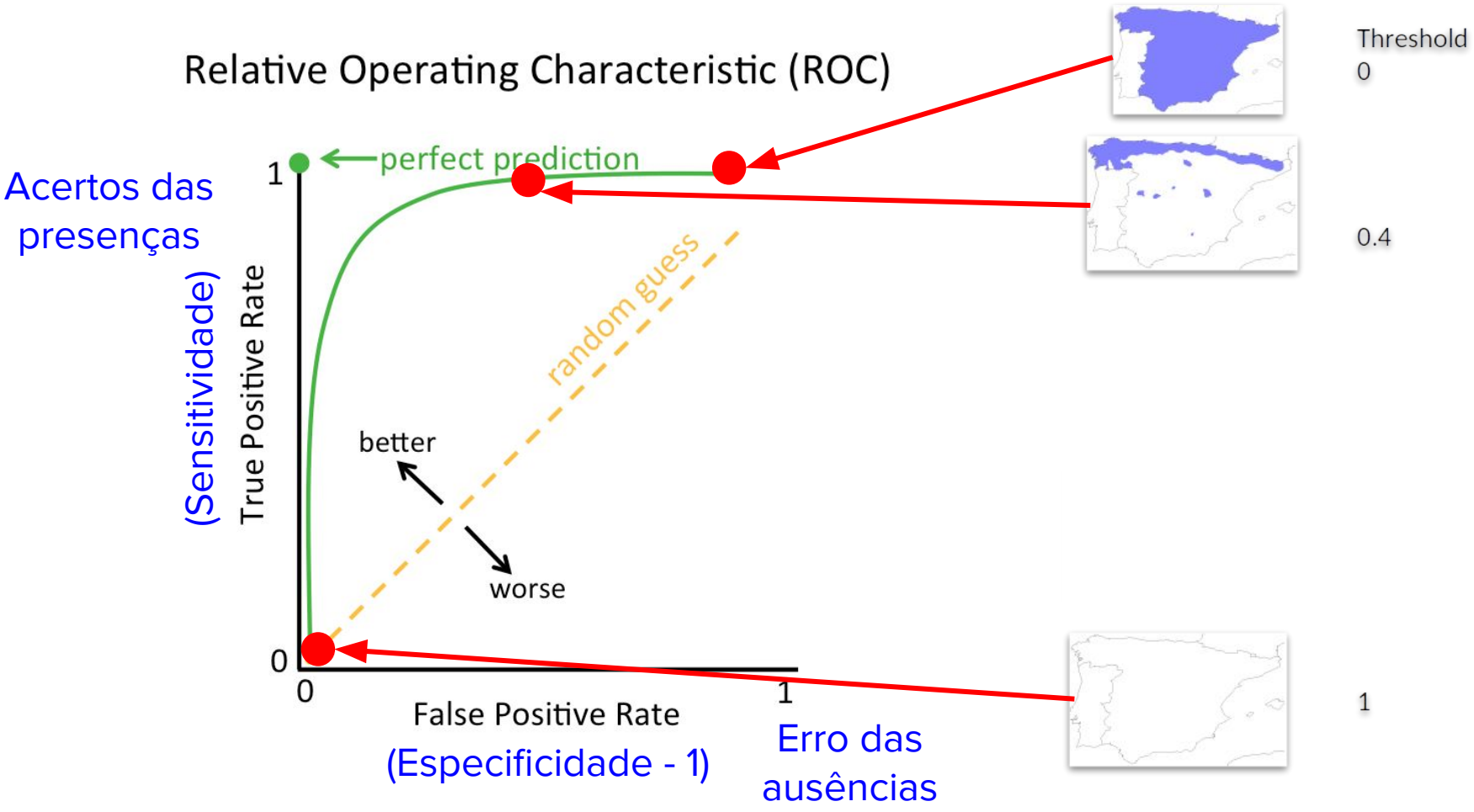
Avaliação dos SDMs

Curva ROC e AUC



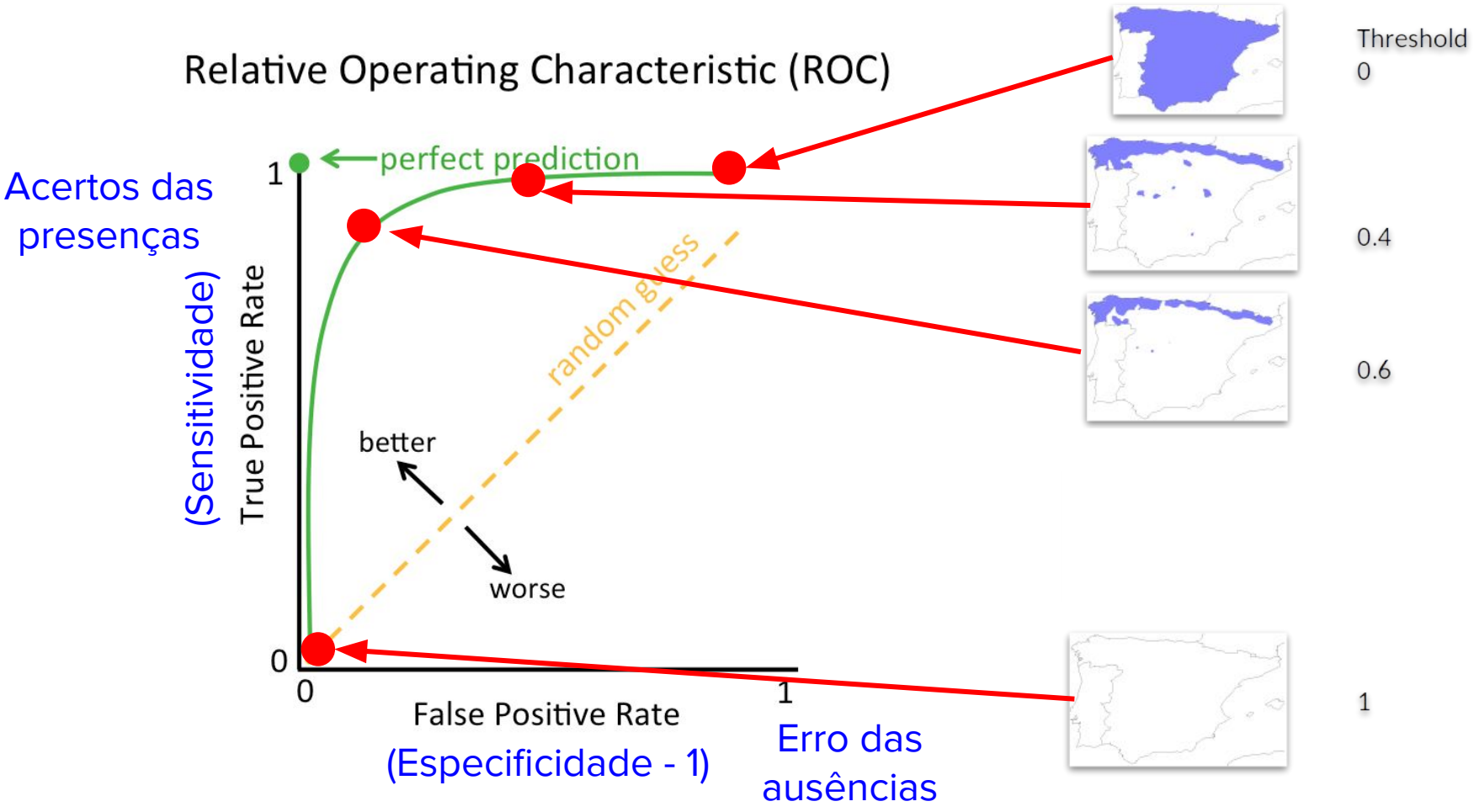
Avaliação dos SDMs

Curva ROC e AUC



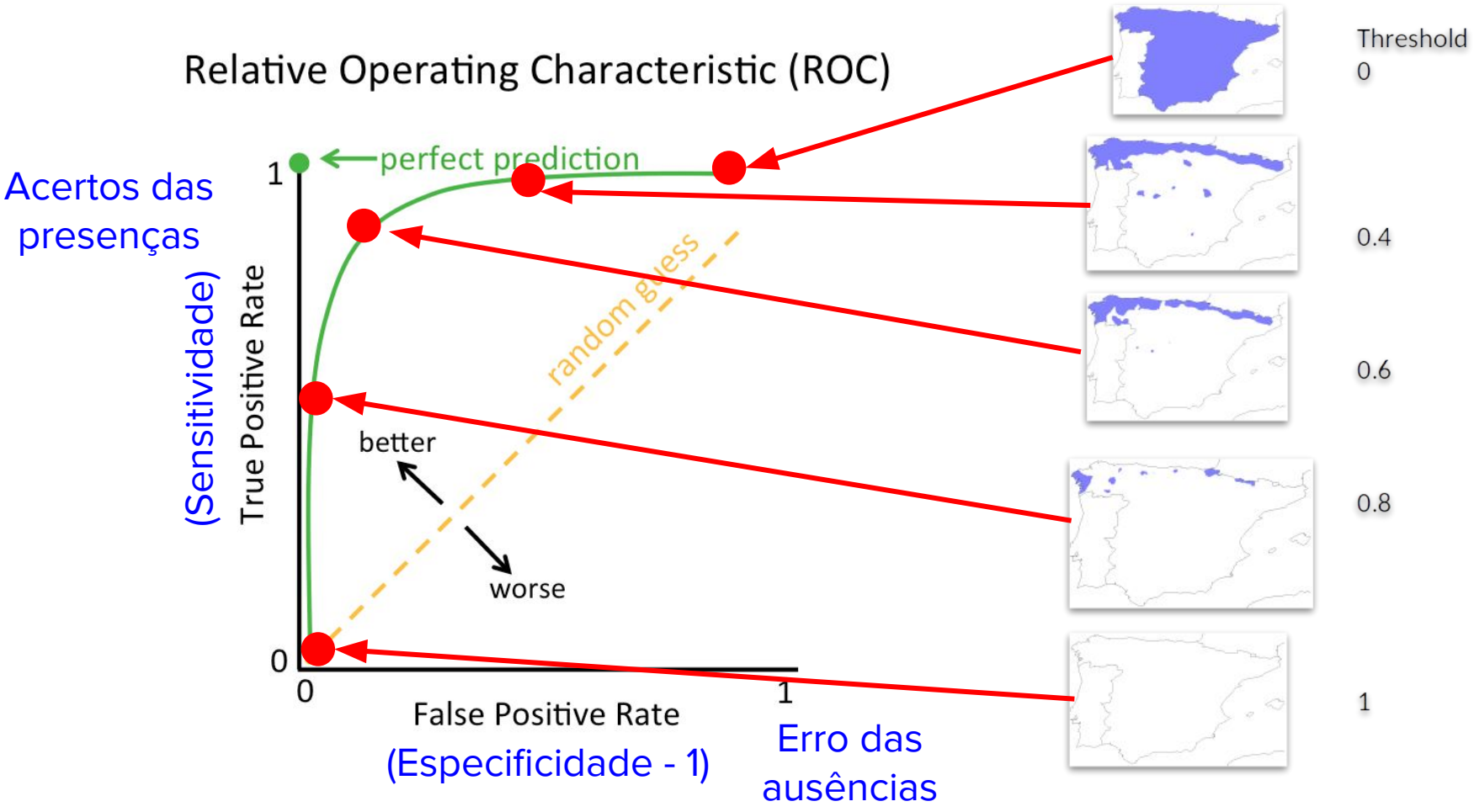
Avaliação dos SDMs

Curva ROC e AUC



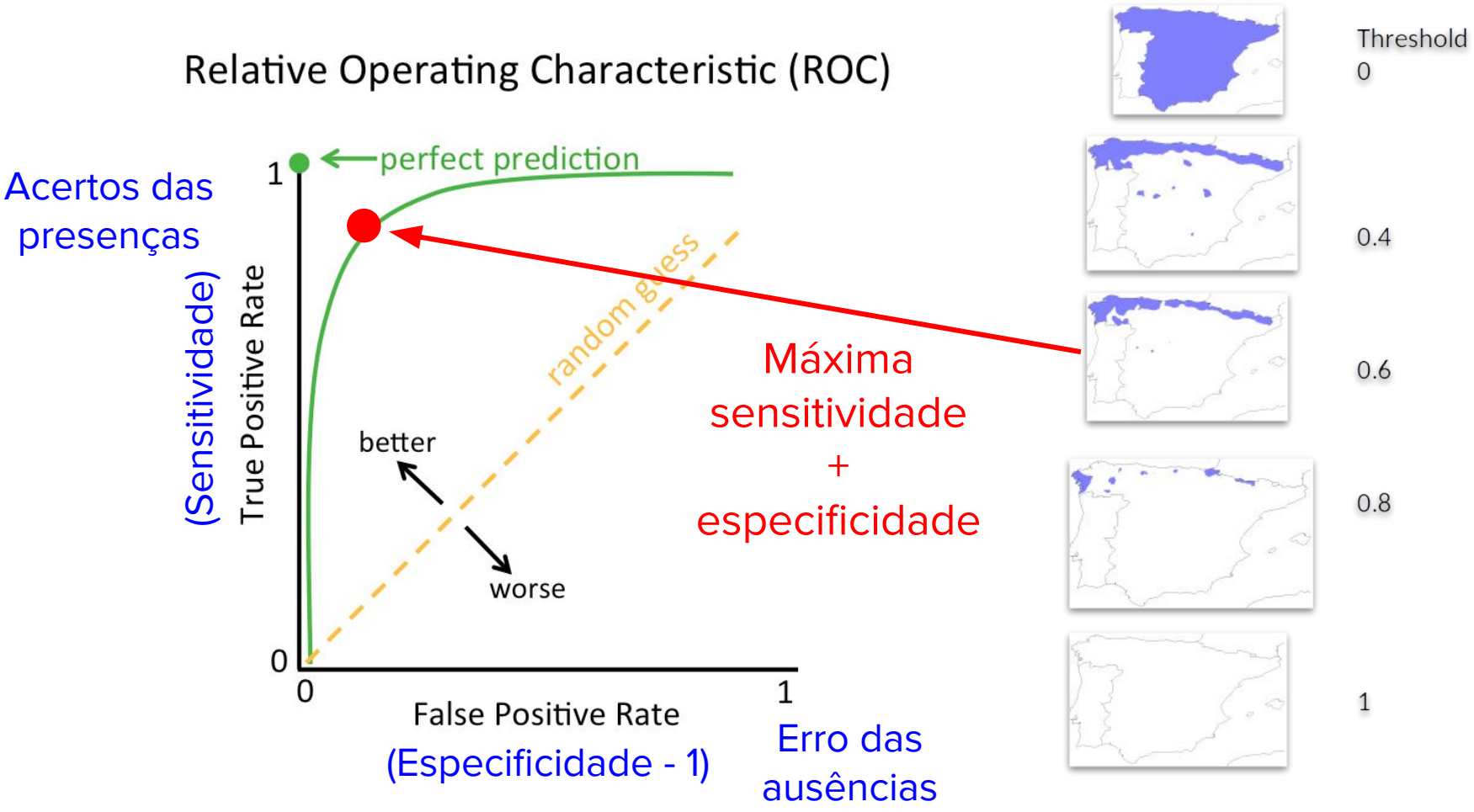
Avaliação dos SDMs

Curva ROC e AUC



Avaliação dos SDMs

Curva ROC e AUC



Avaliação dos SDMs

TSS (*True skill statistic*)

Número de sucessos menos o número de sucessos aleatórios

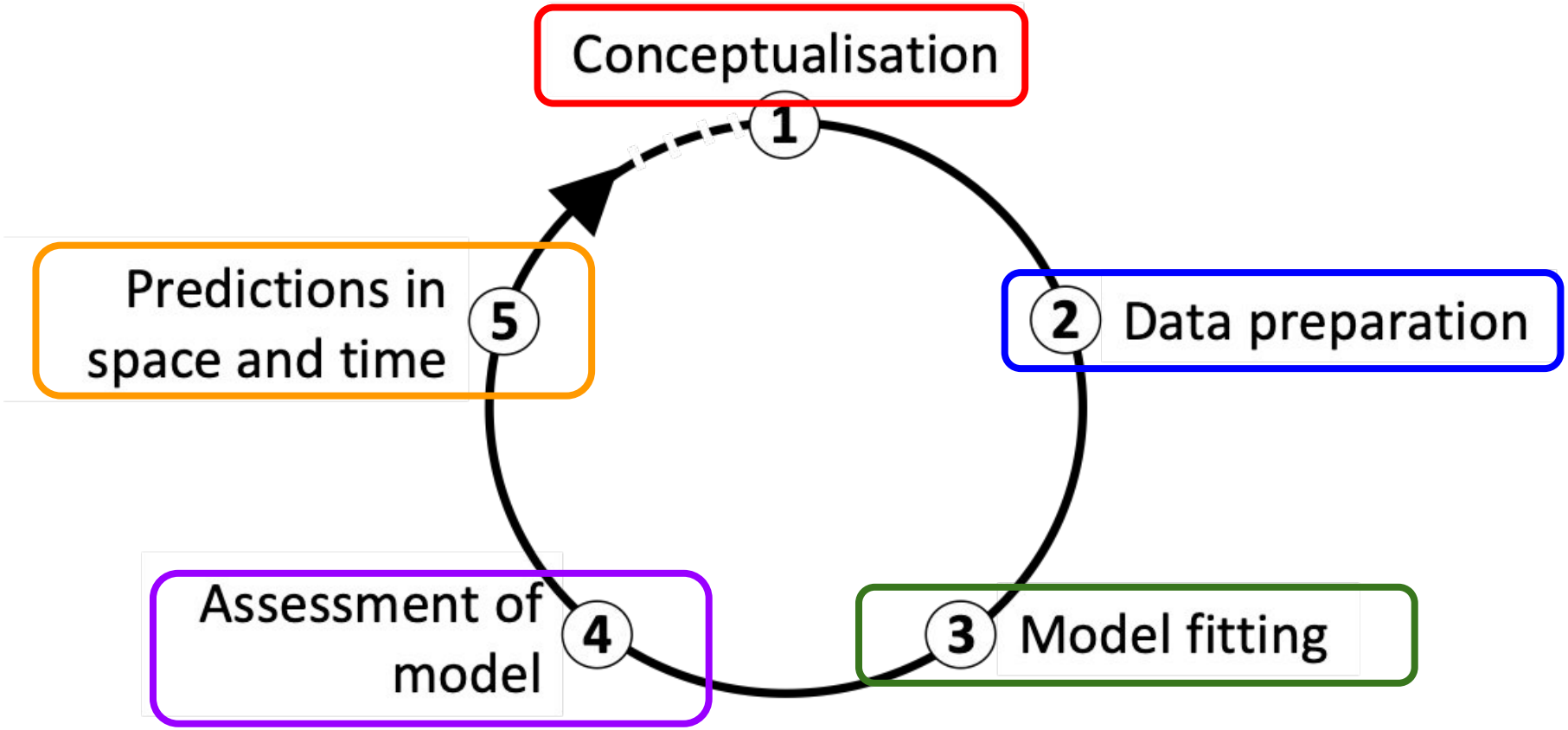
Varia de -1 to 1. Valores próximos a 0 modelos não diferentes do aleatórios

Depende de um valor de corte (threshold)

TSS = sensitividade + especificidade - 1

SDM passo a passo

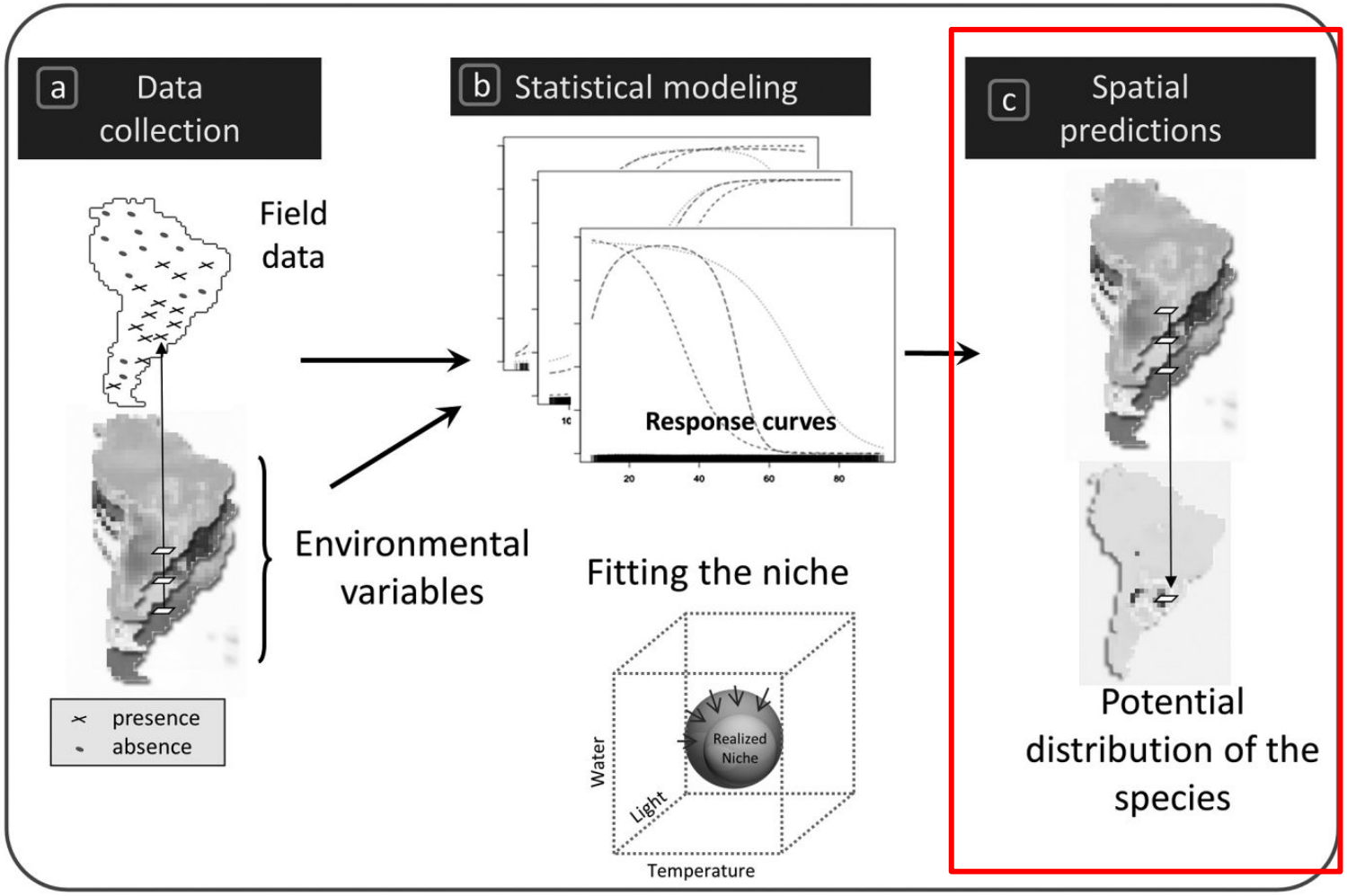
Estrutura dos SDMs

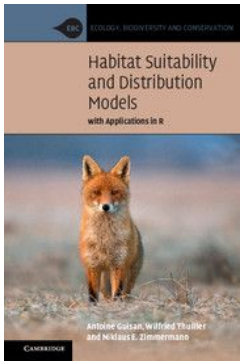


8. Predições no espaço e no tempo

Modelos de Distribuição de Espécies (SDMs)

Predições (espaço e no tempo)

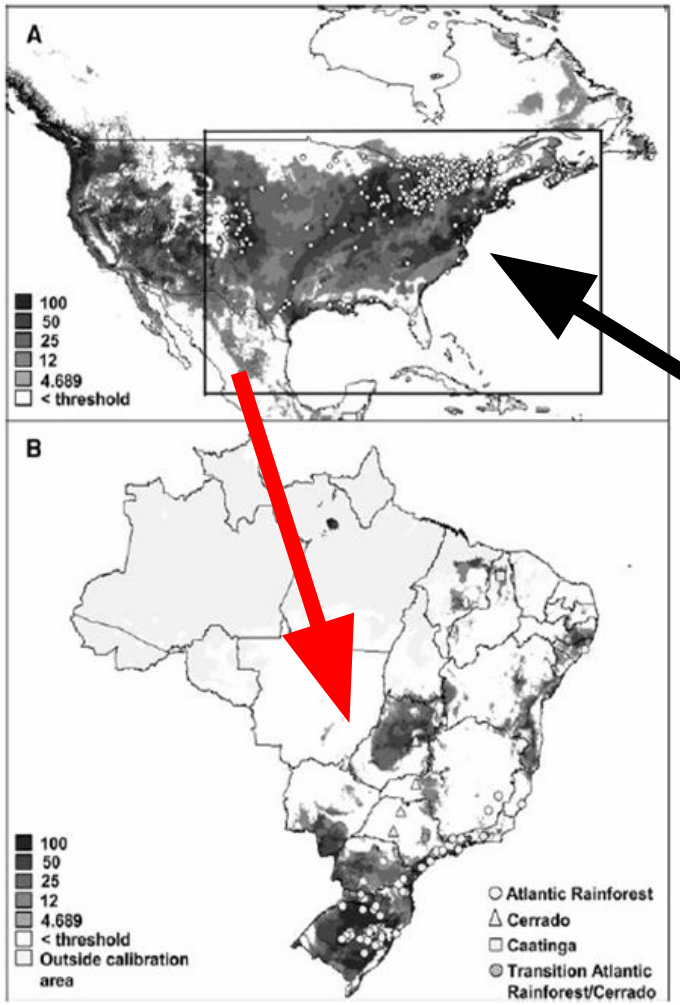




Guisan et al. (2017)

Modelos de Distribuição de Espécies (SDMs)

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

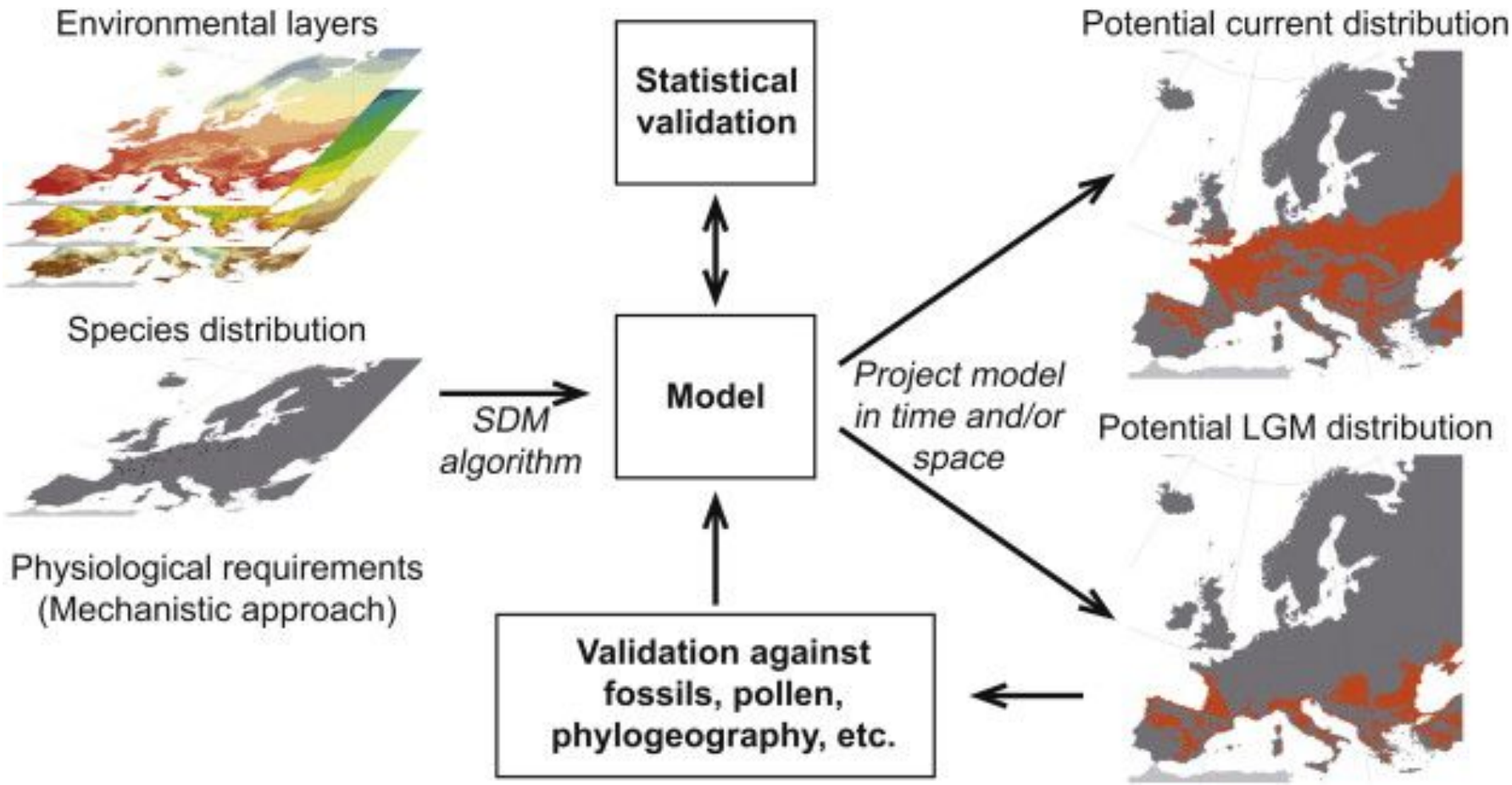
João G. R. Giovanelli · Célio F. B. Haddad · João Alexandrino

Foto: Carl D. Howe

Giovanelli et al., 2008. Biological Invasions

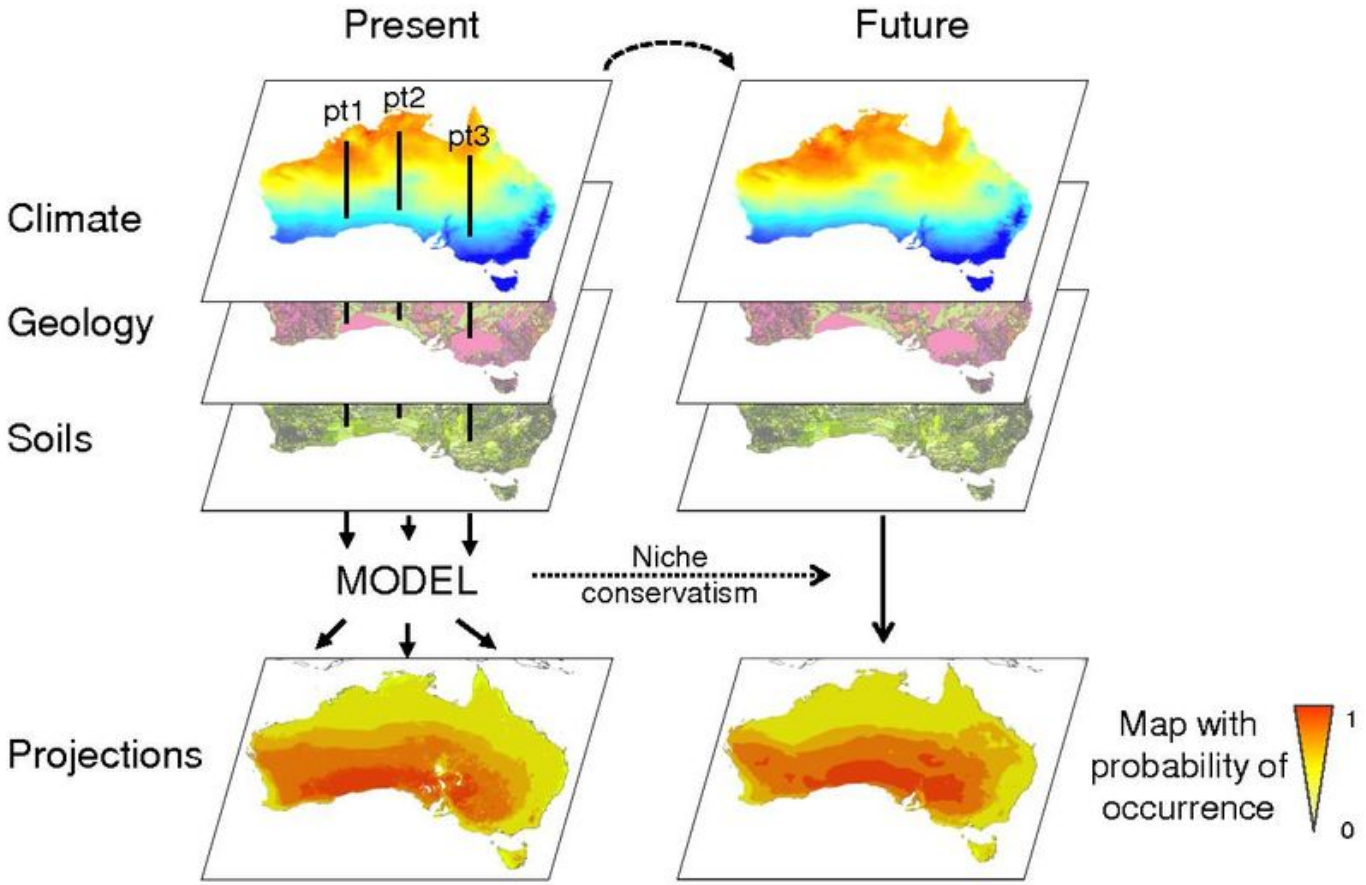
Modelos de Distribuição de Espécies (SDMs)

Tempo - passado



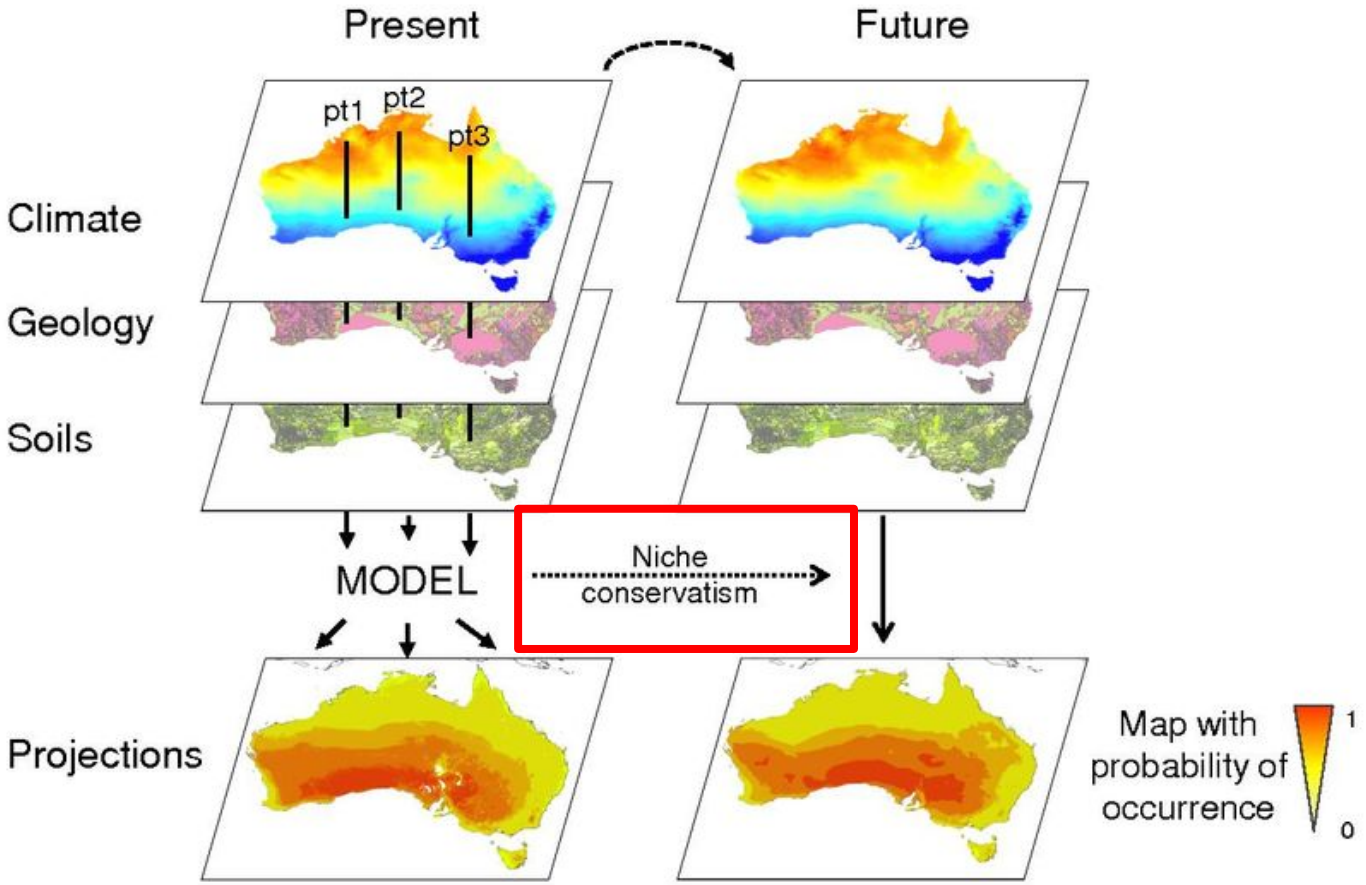
Modelos de Distribuição de Espécies (SDMs)

Tempo - futuro



Modelos de Distribuição de Espécies (SDMs)

Tempo - futuro

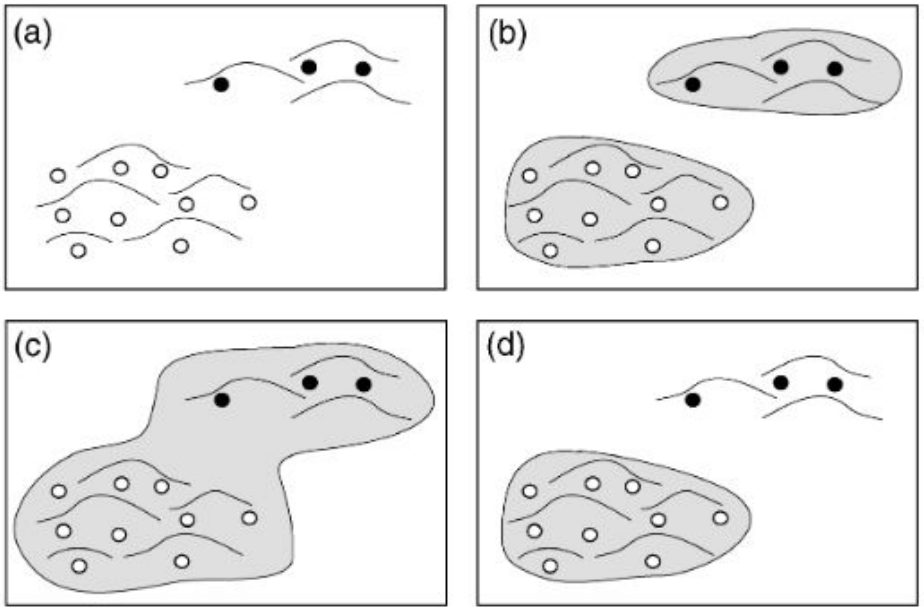


Modelos de Distribuição de Espécies (SDMs)

Premissa - Conservação de nicho

NICHE CONSERVATISM: Integrating Evolution, Ecology, and Conservation Biology

John J. Wiens and Catherine H. Graham
Department of Ecology and Evolution, Stony Brook University, Stony Brook, New York 11794-5245; email: wiensj@life.bio.sunysb.edu, cgraham@life.bio.sunysb.edu



Modelos de Distribuição de Espécies (SDMs)

Premissa - Conservação de nicho

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John J. Wiens and Catherine H. Graham
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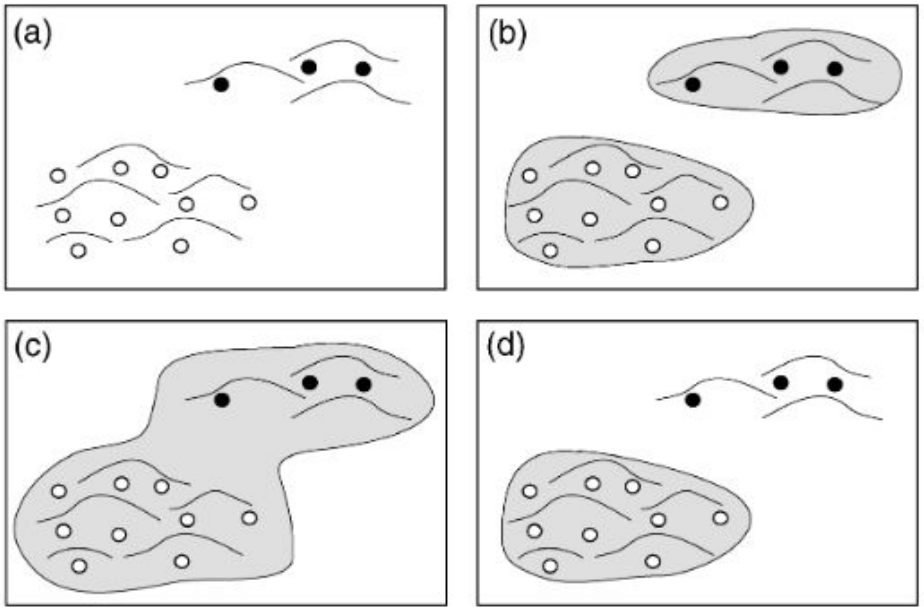


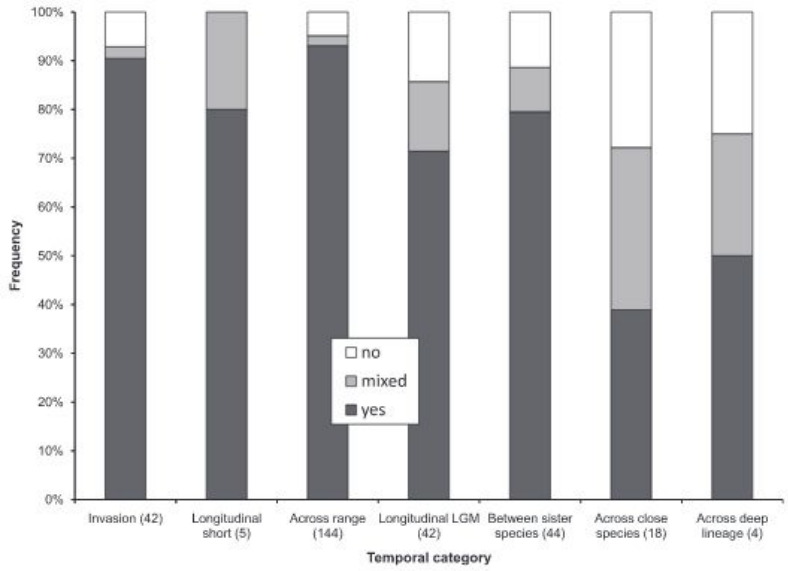
Journal of Biogeography

SYNTHESIS | Free Access

Ecological niche conservatism: a time-structured review of evidence

A. Townsend Peterson

First published:17 March 2011 | https://doi.org/10.1111/j.1365-2699.2010.02456.x | Citations: 325



Modelos de Distribuição de Espécies (SDMs)

Premissa - Conservação de nicho

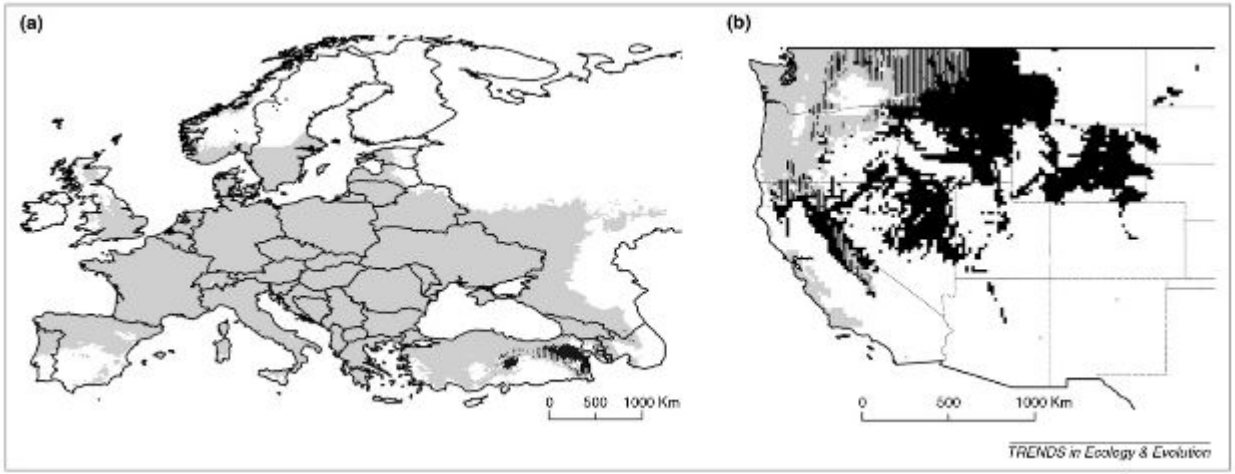
Review

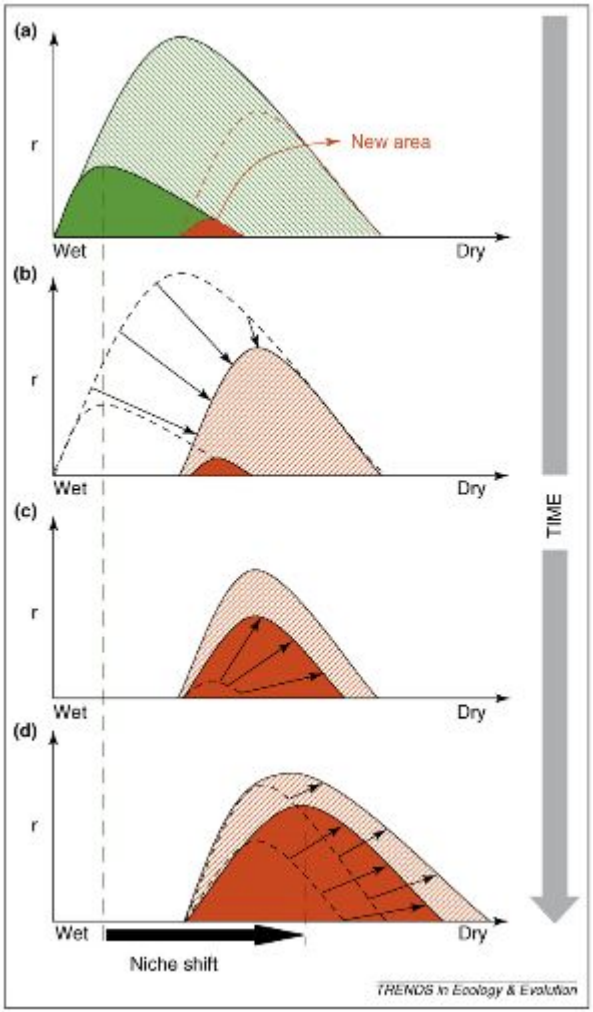
Cell PRESS

Niche dynamics in space and time

Peter B. Pearman*, Antoine Guisan*, Olivier Broennimann and Christophe F. Randin

University of Lausanne, Department of Ecology and Evolution, CH-1015 Lausanne, Switzerland



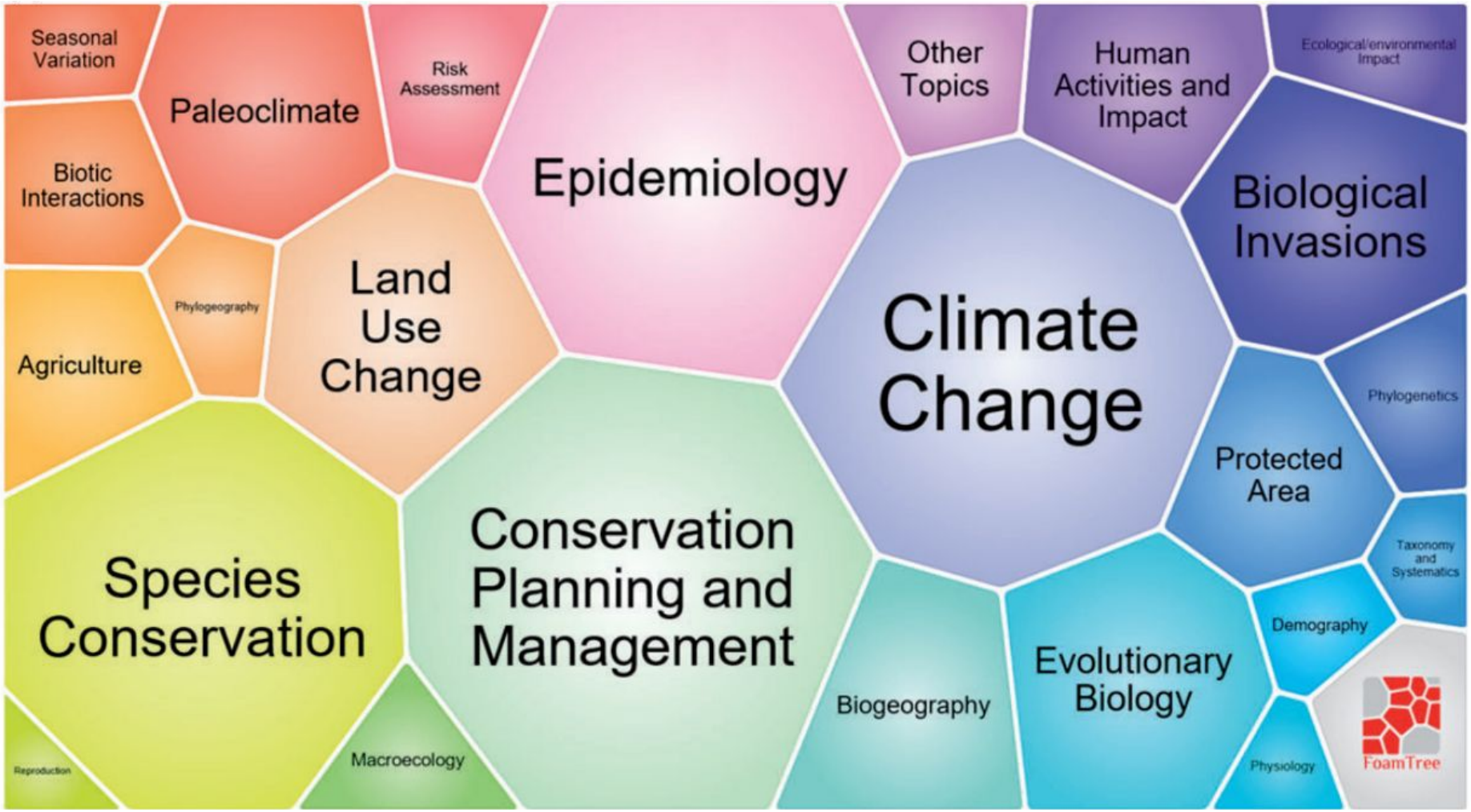


9. Aplicações e mais informações

Aplicações

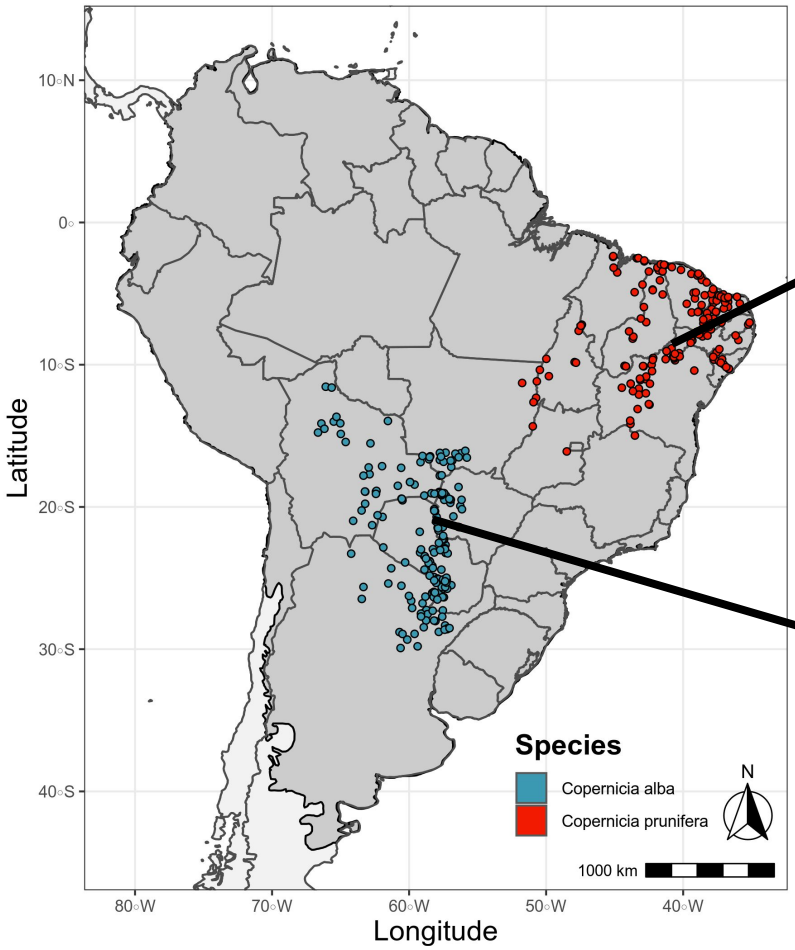
Áreas de aplicação

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



Aplicações

Mudanças climáticas sobre carnaúbas

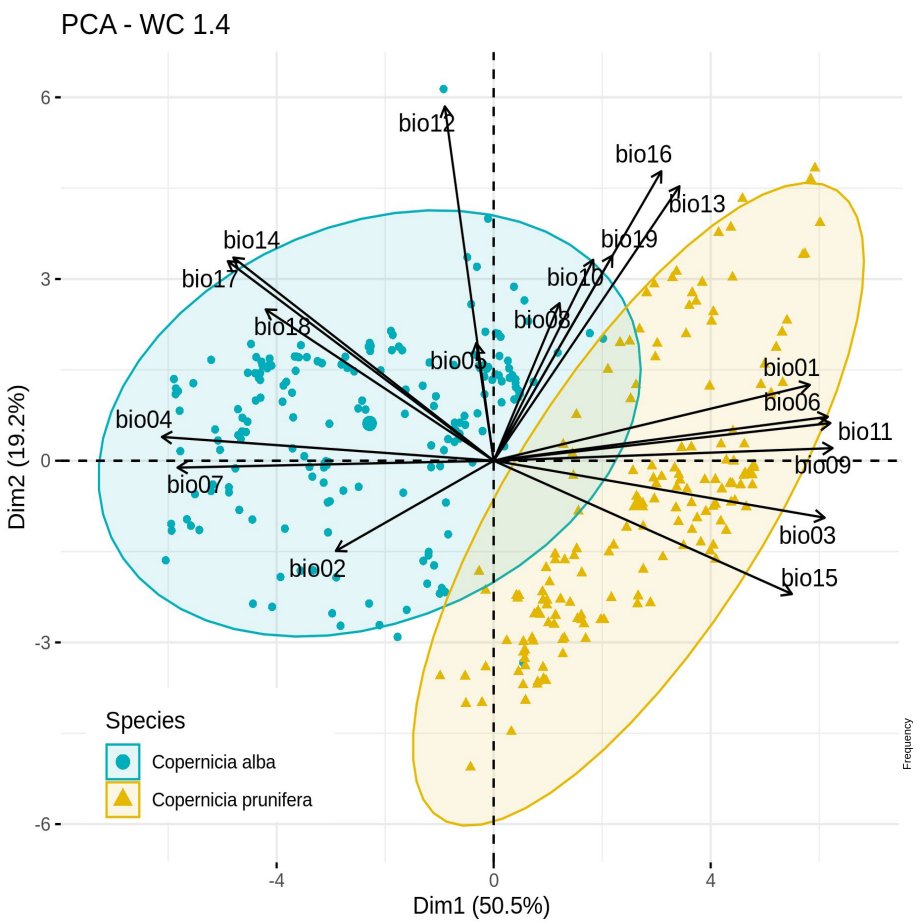


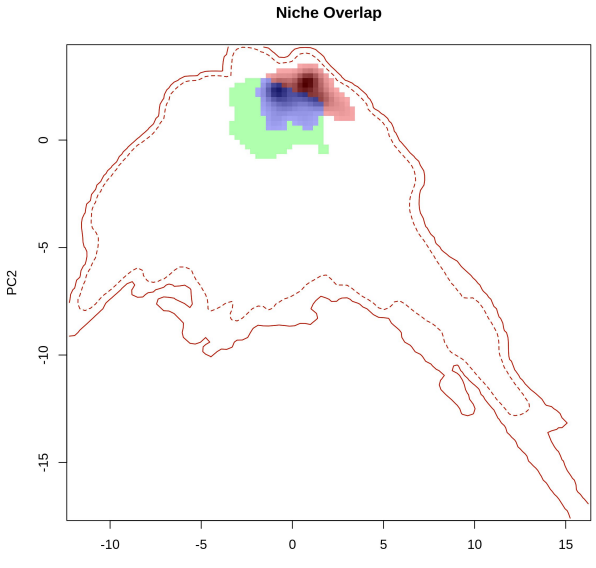
Copernicia prunifera

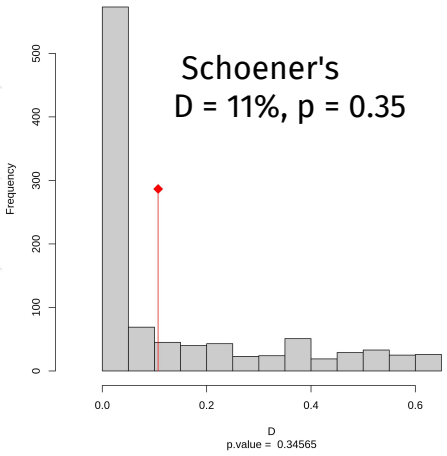
Copernicia alba

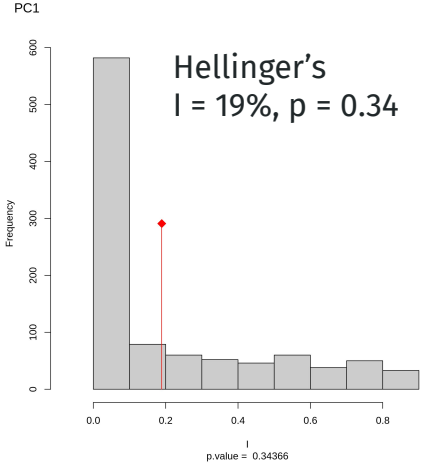
Aplicações

Mudanças climáticas sobre carnaúbas



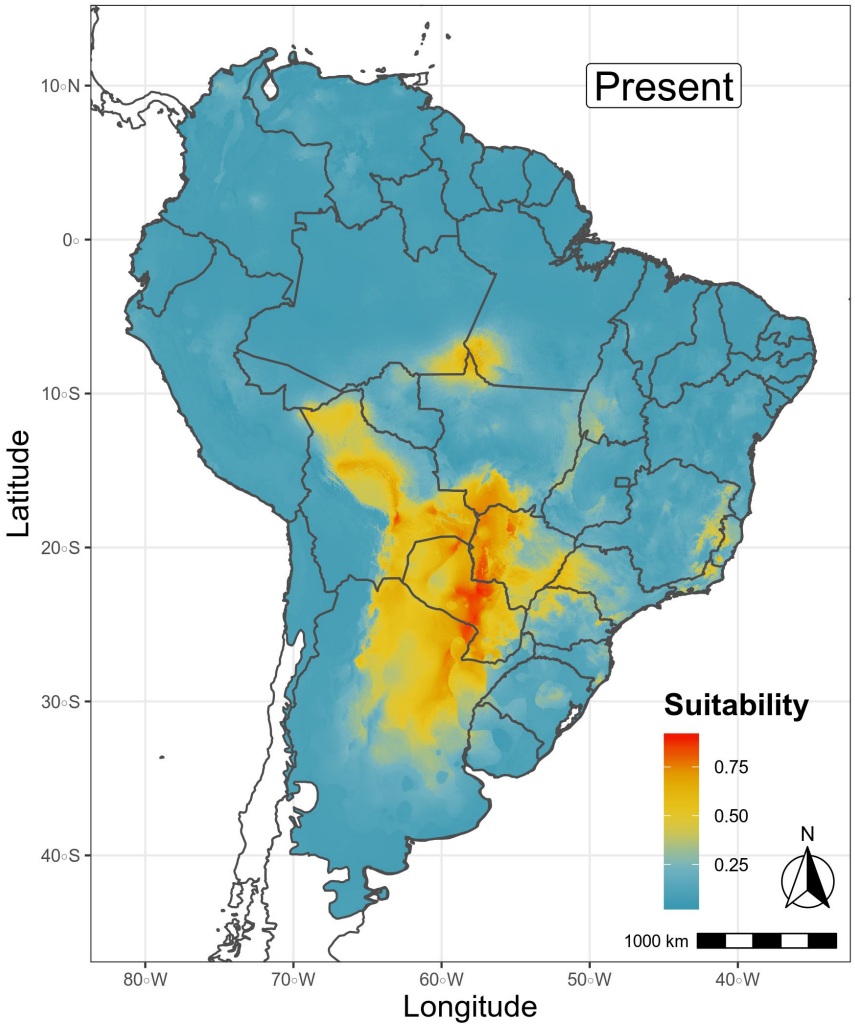


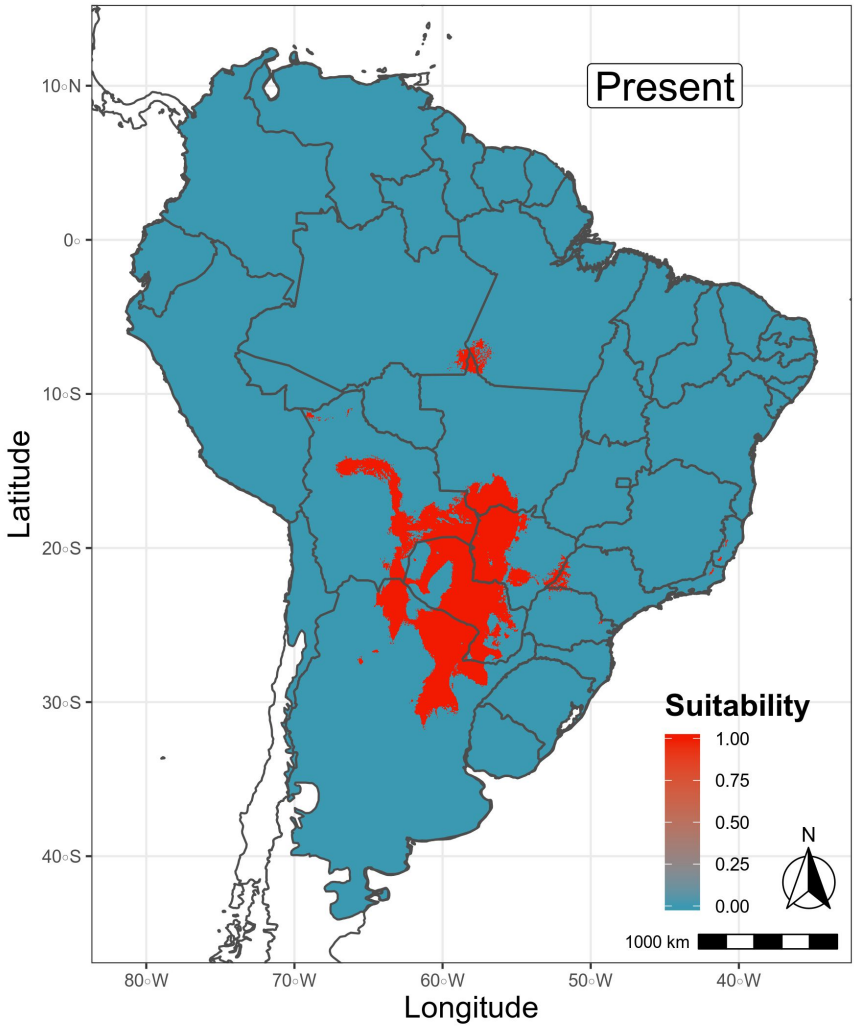




Aplicações

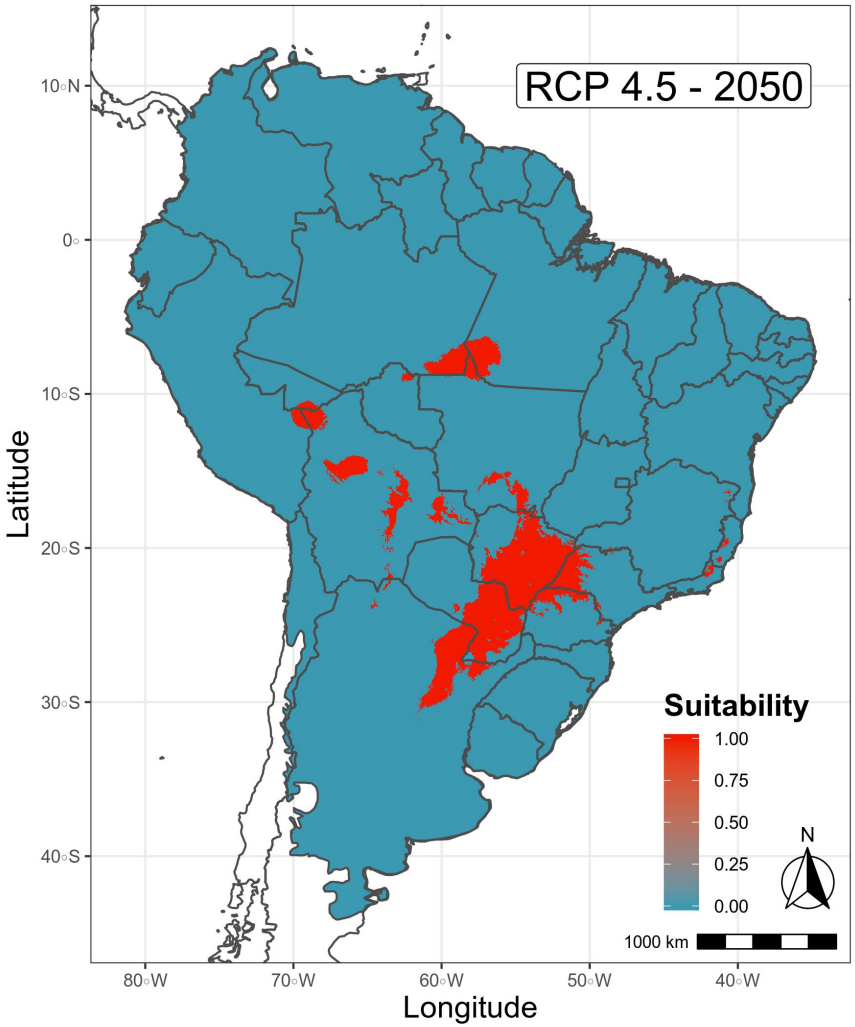
Copernicia alba

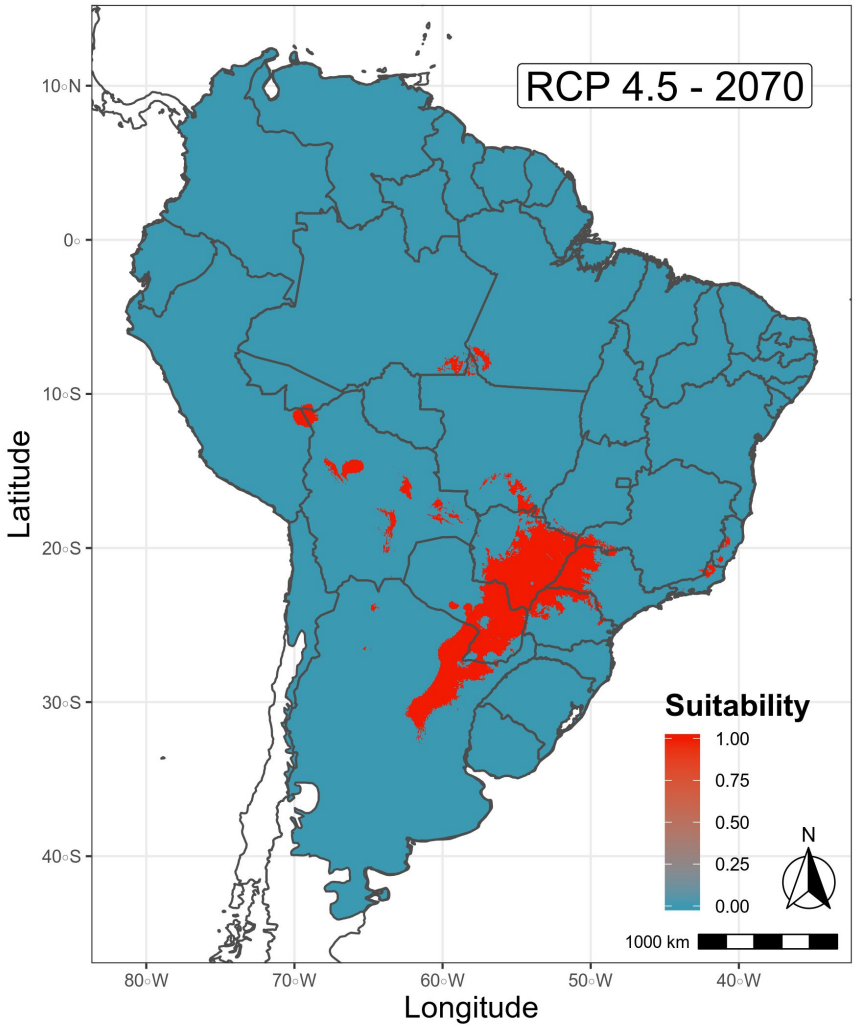




Aplicações

Copernicia alba





Aplicações

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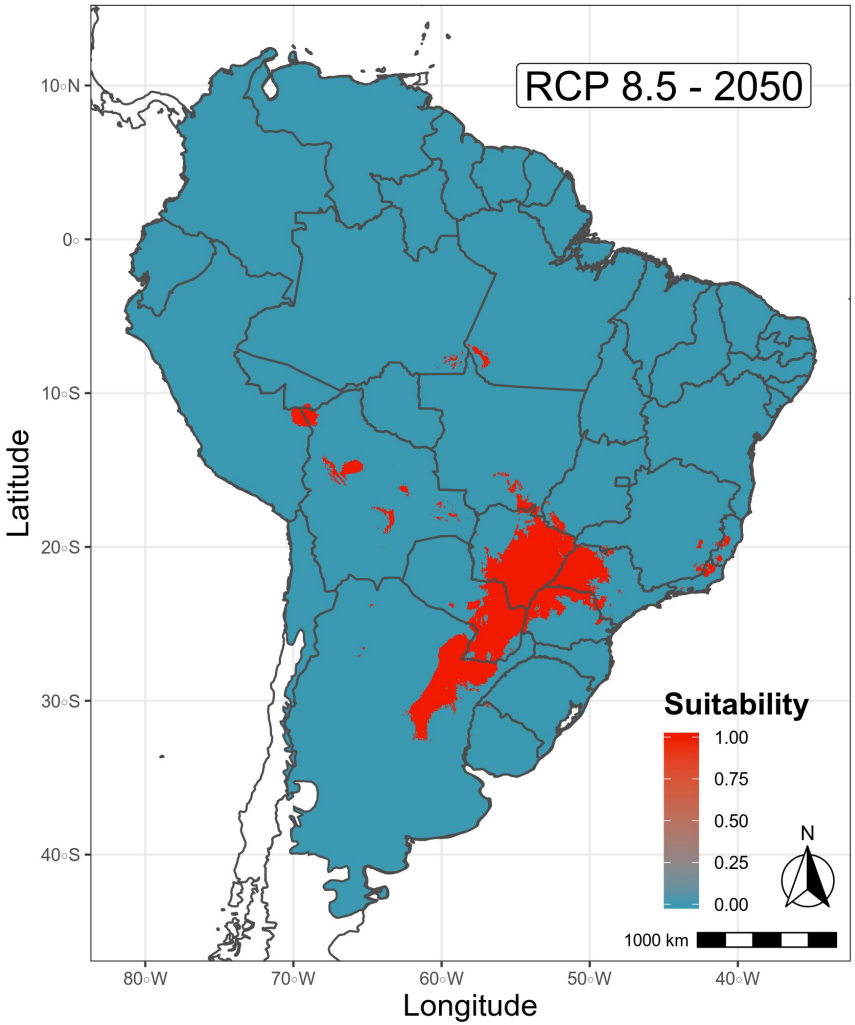
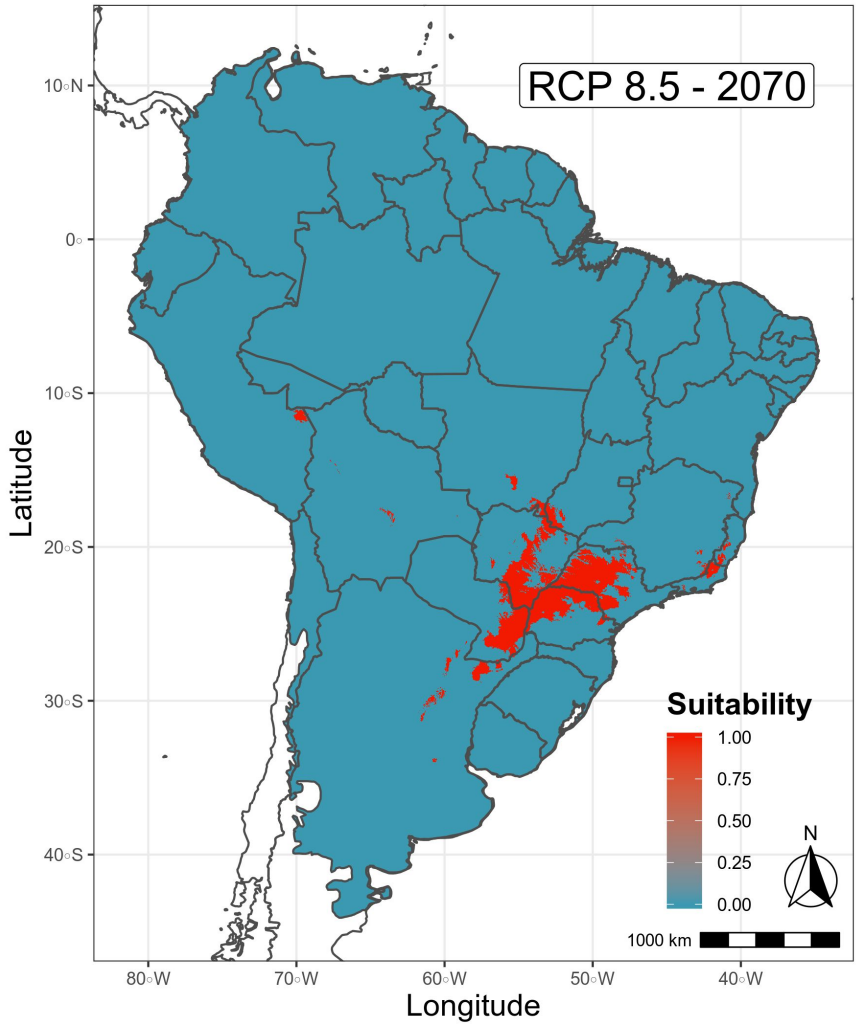
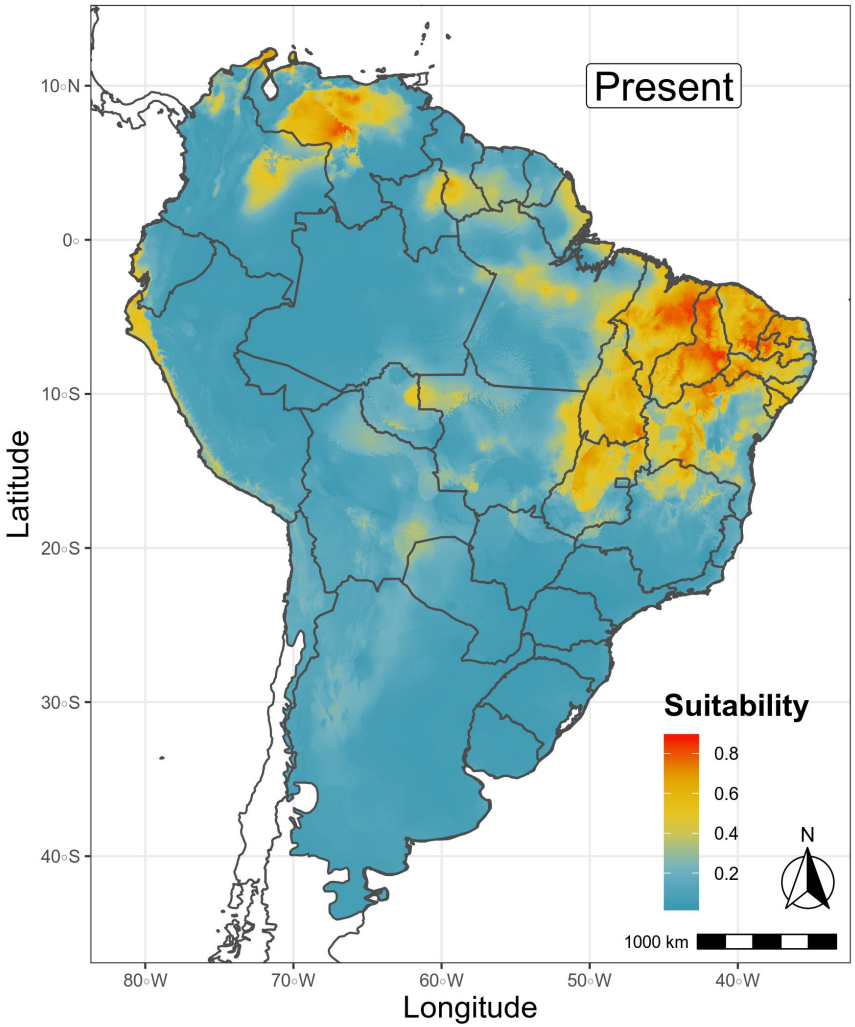
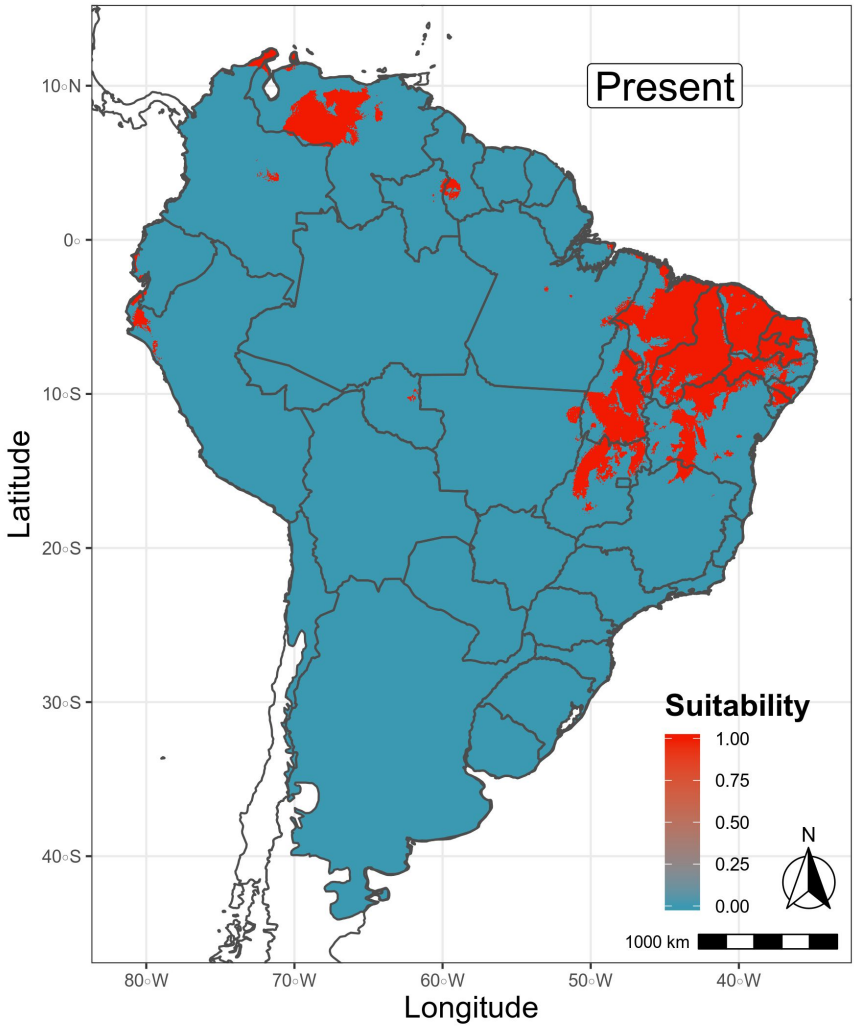




Aplicações

Copernicia prunifera





Aplicações

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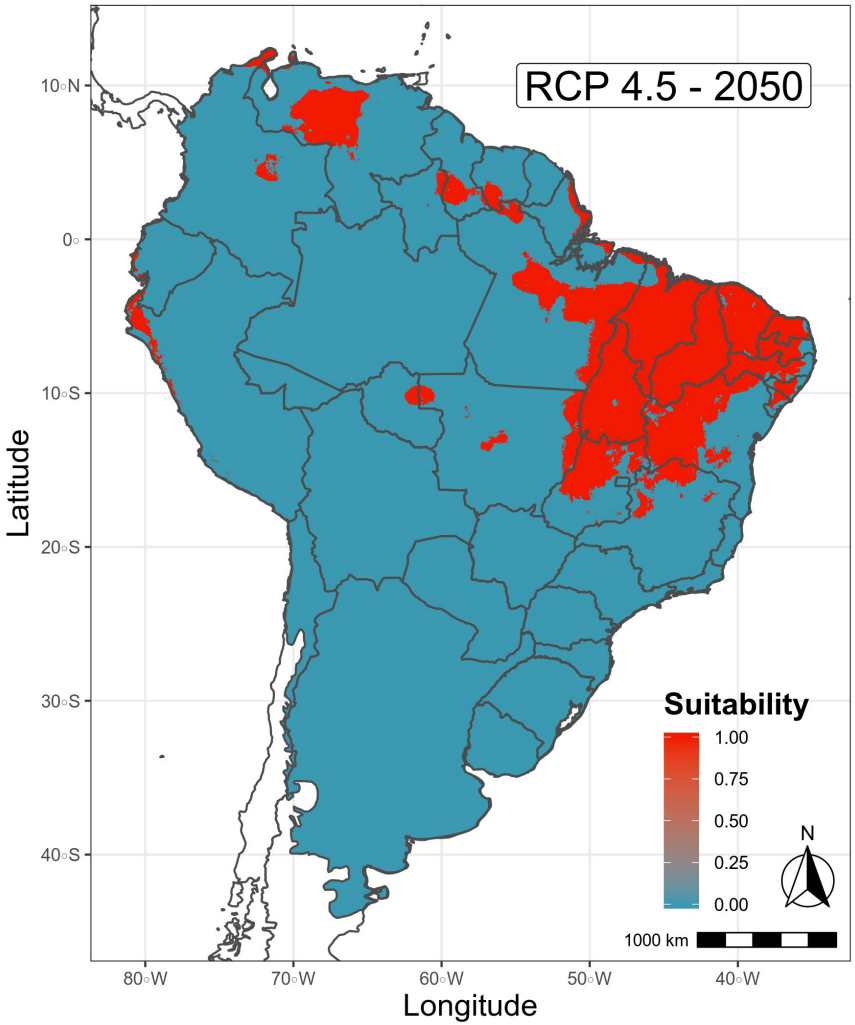

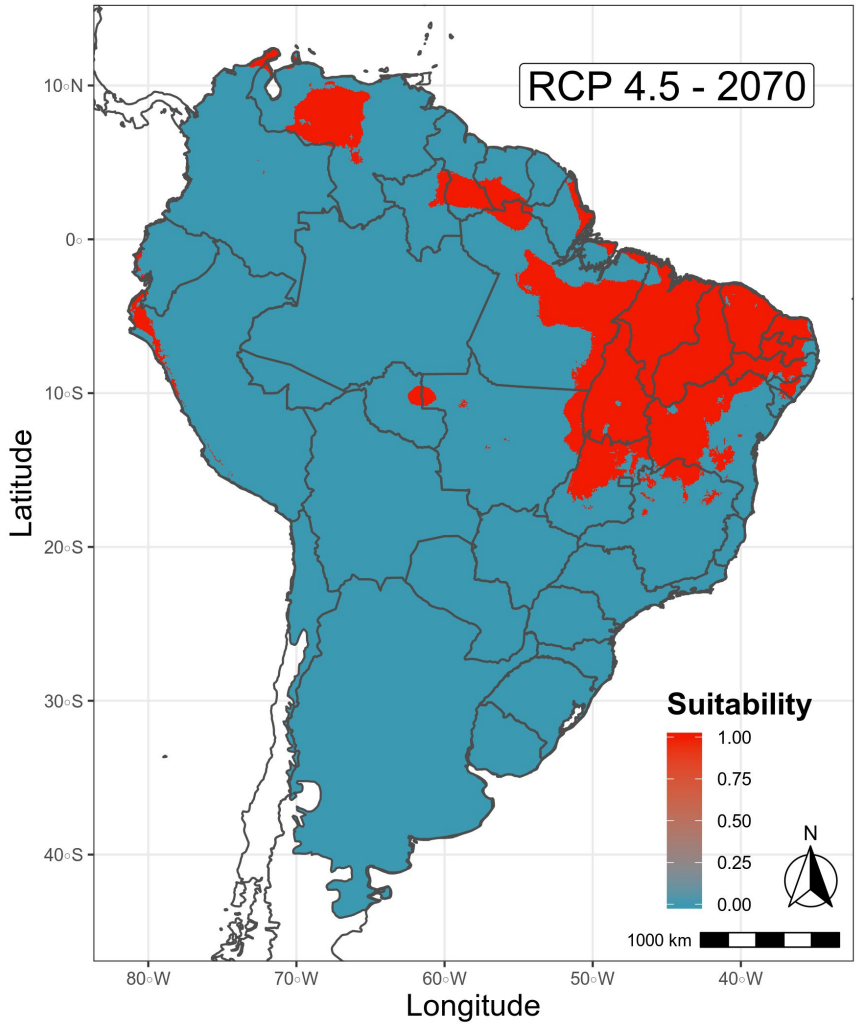

Aplicações

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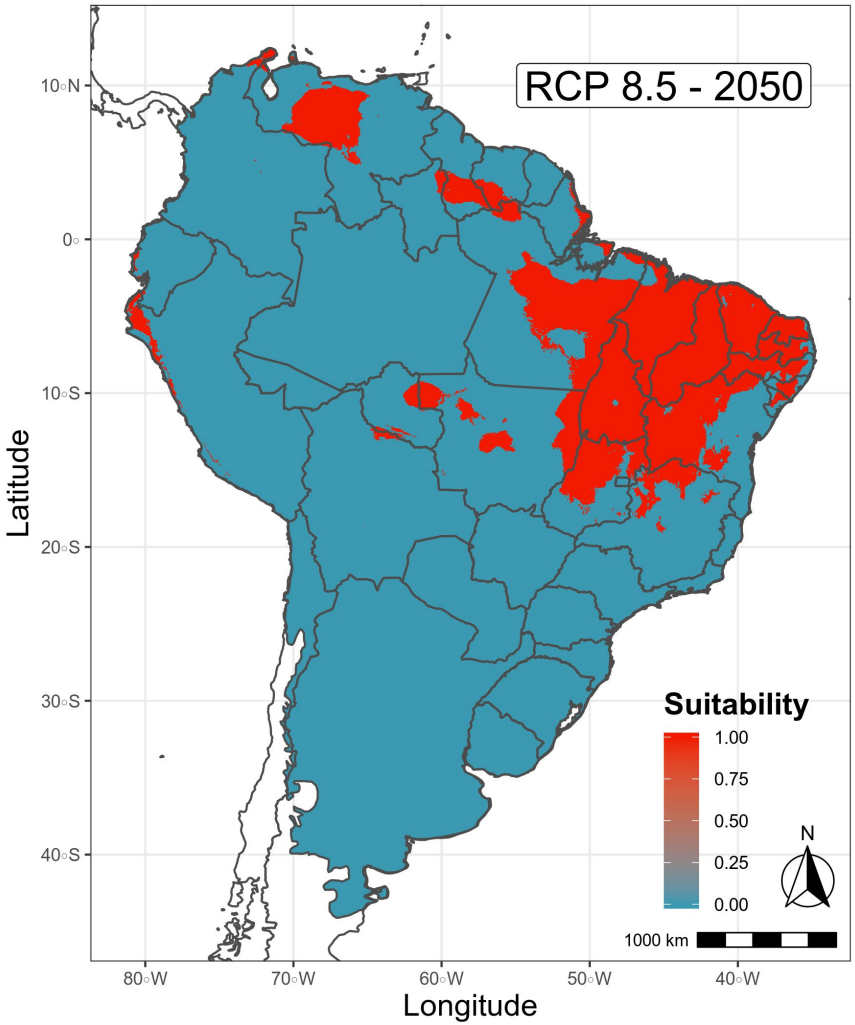

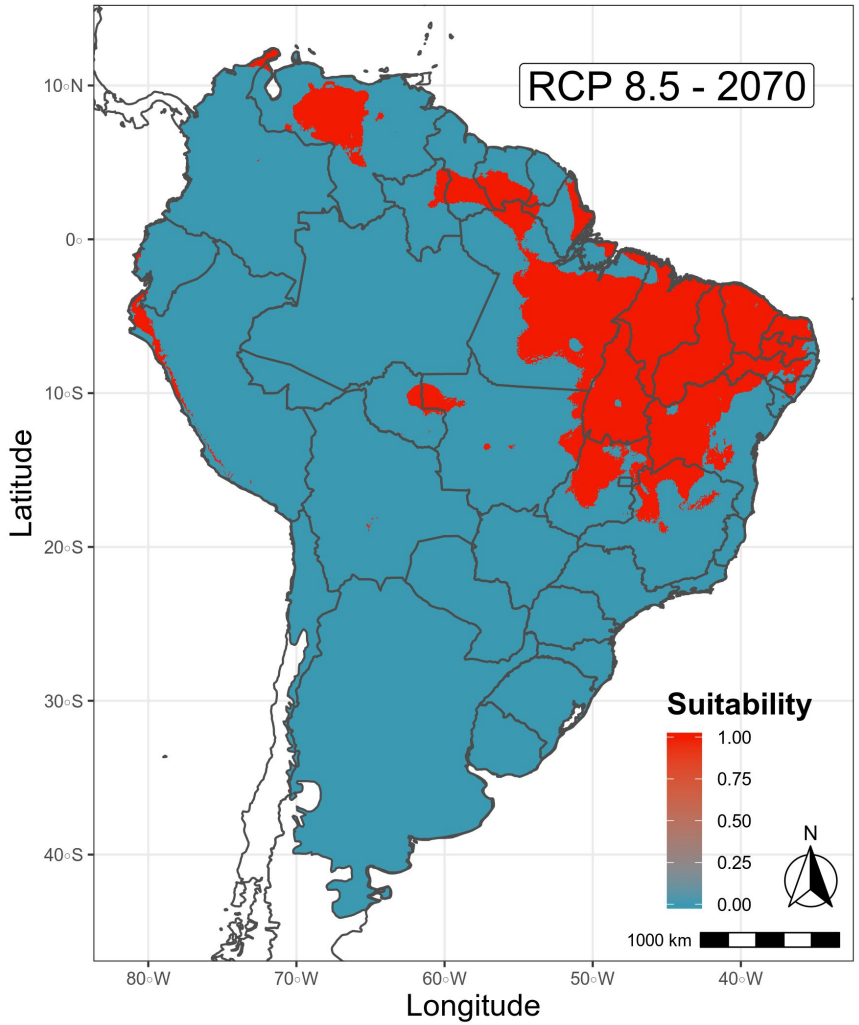

Aplicações

Mineração sobre anuros e aves na Serra Espinhaço

ABECO
ASSOCIAÇÃO BRASILEIRA DE CIÊNCIA ECOLÓGICA E CONSERVAÇÃO

Perspectives in ecology and conservation

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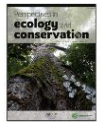
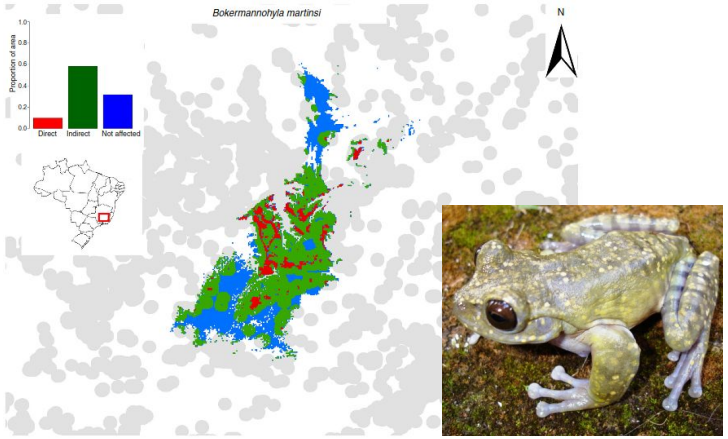
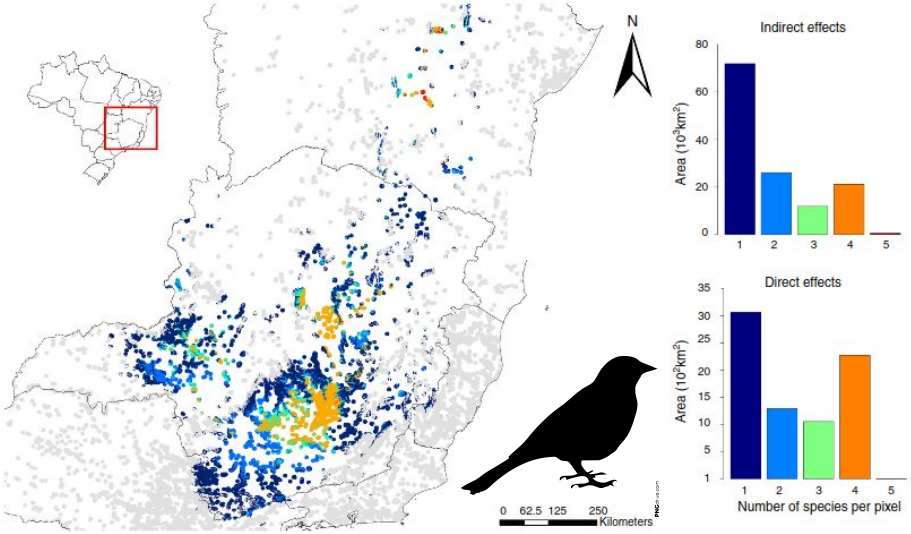


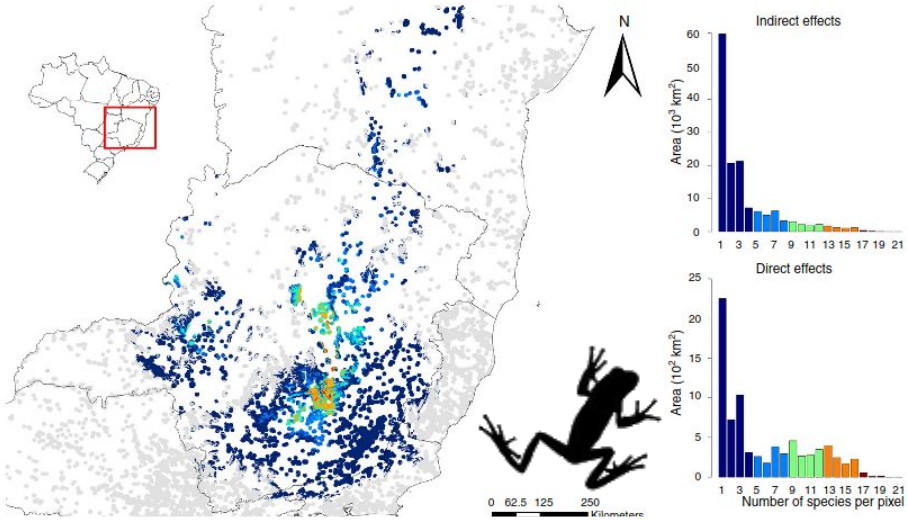
Impacts of mining activities on the potential geographic distribution of eastern Brazil mountaintop endemic species

João Carlos de Castro Pena[a,b,*,1], Fernando Goulart[c], G. Wilson Fernandes[d,e], Diego Hoffmann[f], Felipe S.F. Leite[g], Natália Britto dos Santos[b], Britaldo Soares-Filho[c], Thadeu Sobral-Souza[h,i], Maurício Humberto Vancine[h], Marcos Rodrigues[a]



Bokermannohyla martinsi





Aplicações

Eficiência das áreas protegidas da AM e MA

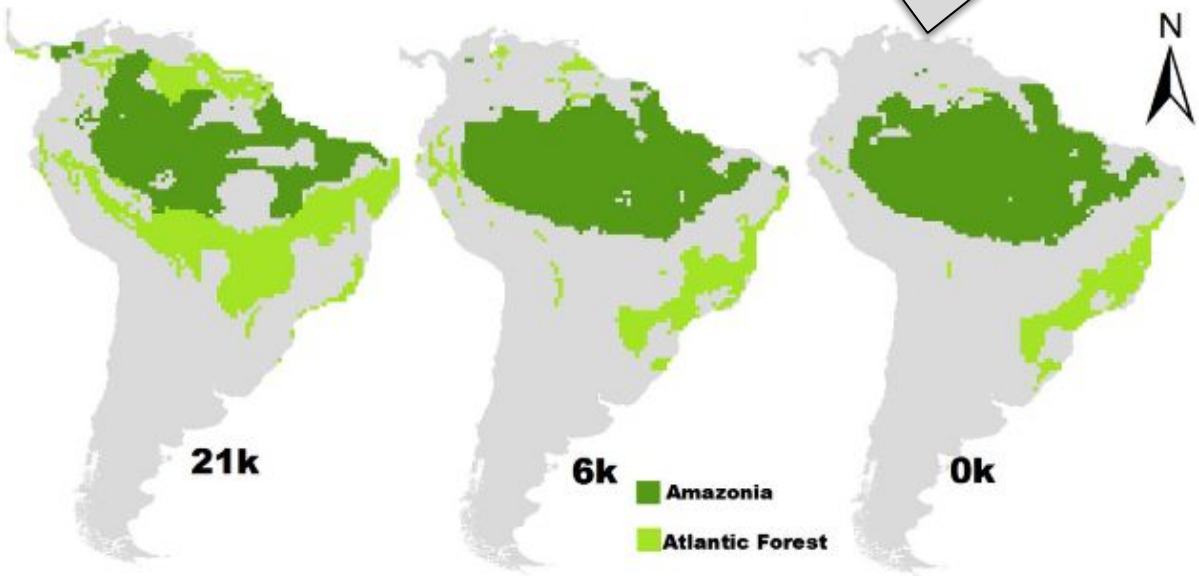
Contents lists available at ScienceDirect

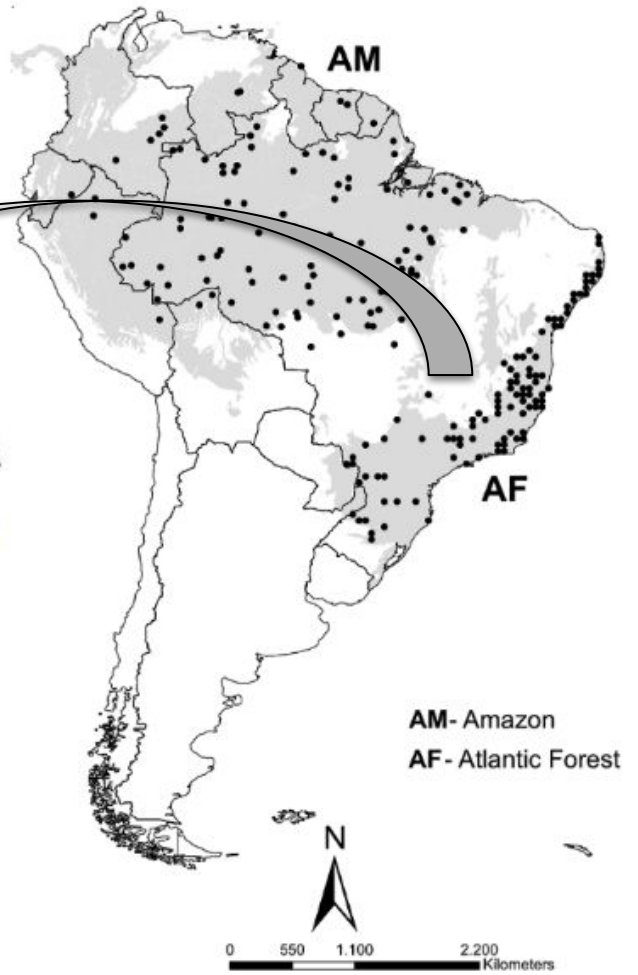
Acta Oecologica

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

Efficiency of protected areas in Amazon and Atlantic Forest conservation: A spatio-temporal view

Thadeu Sobral-Souza[a,b,*], Maurício Humberto Vancine[a], Milton Cezar Ribeiro[a], Matheus S. Lima-Ribeiro[c]





Aplicações

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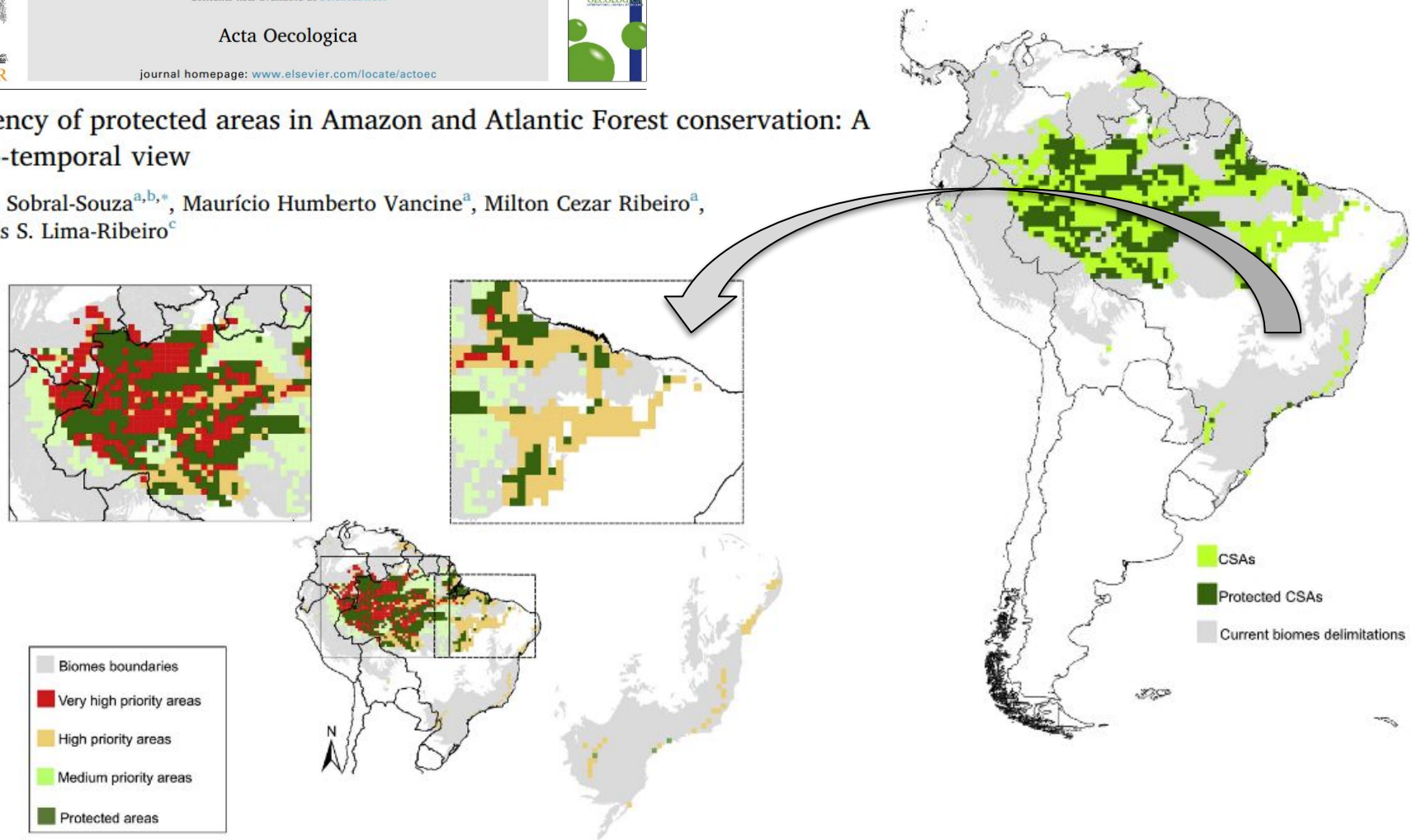


Aplicações

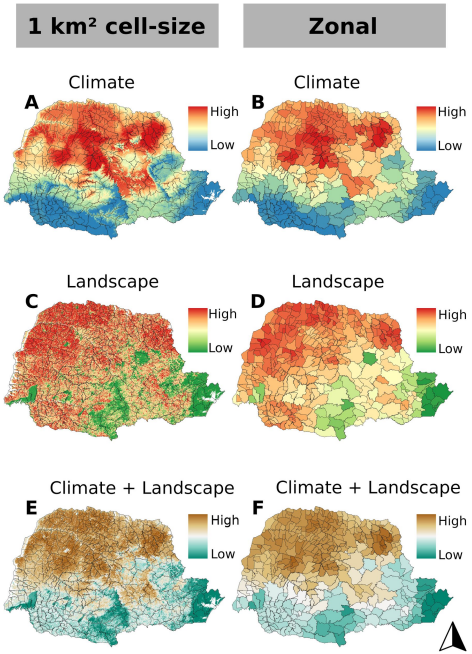
Áreas de transmissão *Trypanosoma cruzi* no PR

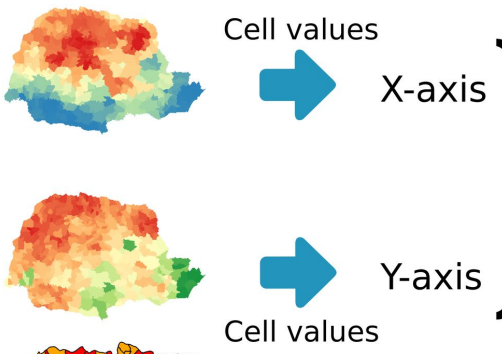
PLOS | NEGLECTED TROPICAL DISEASES

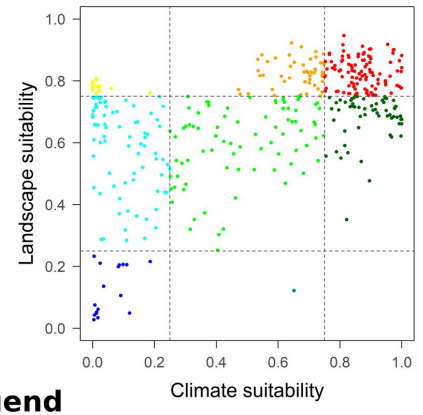
RESEARCH ARTICLE

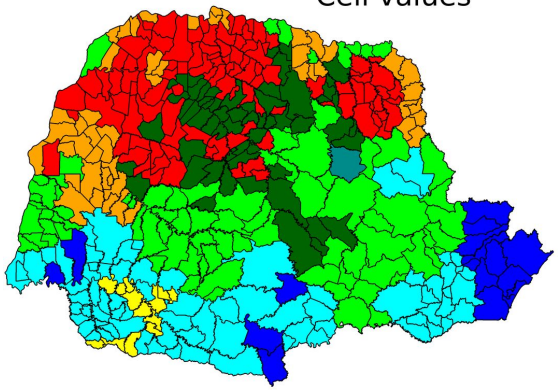
Spatial prediction of risk areas for vector transmission of *Trypanosoma cruzi* in the State of Paraná, southern Brazil

Andréia Mantovani Ferro e Silva[1], Thadeu Sobral-Souza[2], Maurício Humberto Vancine[2], Renata Lara Muylaert[2], Ana Paula de Abreu[1], Sandra Marisa Pelloso[1,3], Maria Dalva de Barros Carvalho[1,4], Luciano de Andrade[1,4], Milton Cezar Ribeiro[2], Max Jean de Ornelas Toledo[1,5]*









Legend

- High climate and high landscape suitability
- High climate and medium landscape suitability
- Medium climate and high landscape suitability
- Medium climate and medium landscape suitability
- Medium climate and low landscape suitability
- Low climate and high landscape suitability
- Low climate and mediumhigh landscape suitability
- Low climate and low landscape suitability

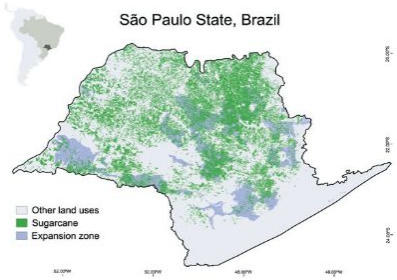
Aplicações

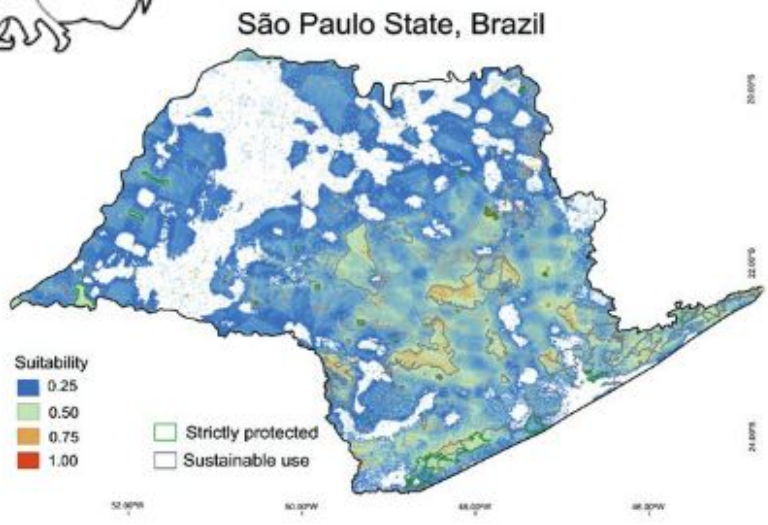
Expansão da cana sobre o tamanduá em SP

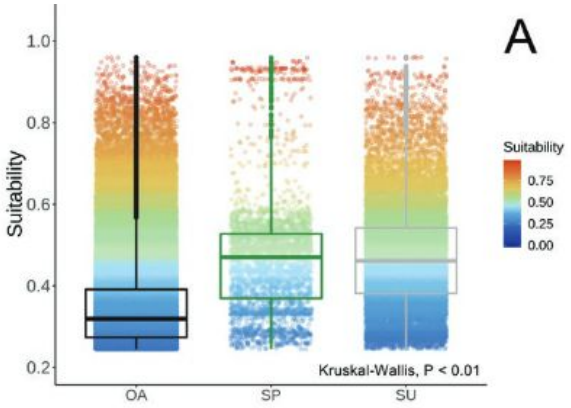
Journal of Mammalogy, XX(X):1–10, 2019
DOI:10.1093/jmammal/gyz042

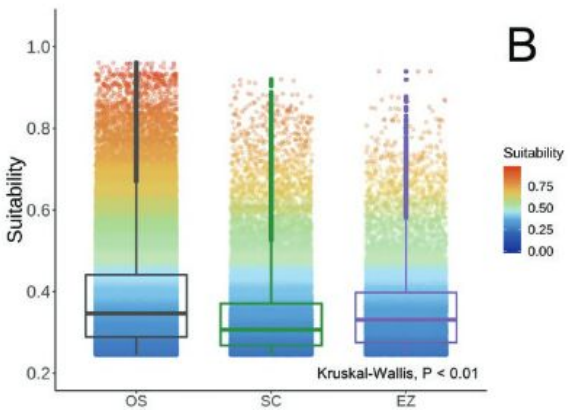
Land-use changes and the expansion of biofuel crops threaten the giant anteater in southeastern Brazil

Alessandra Bertassoni,* Rômulo Theodoro Costa, Jéssica Abonizio Gouvea, Rita de Cassia Bianchi, John Wesley Ribeiro, Maurício Humberto Vancine, and Milton Cezar Ribeiro



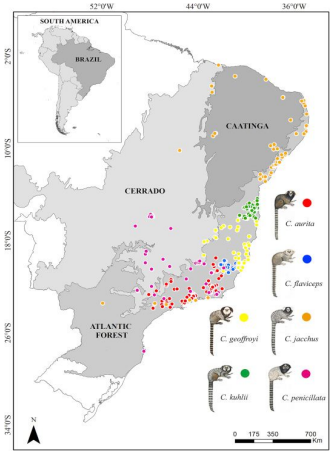


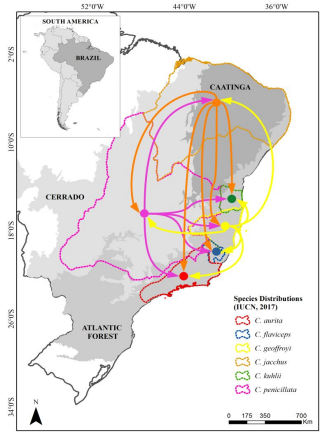




Aplicações

Zonas de hibridização potencial de saguis



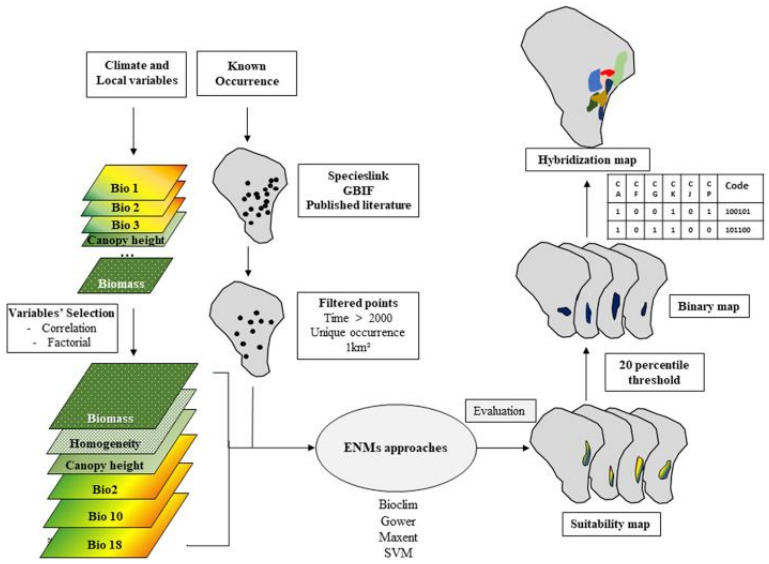


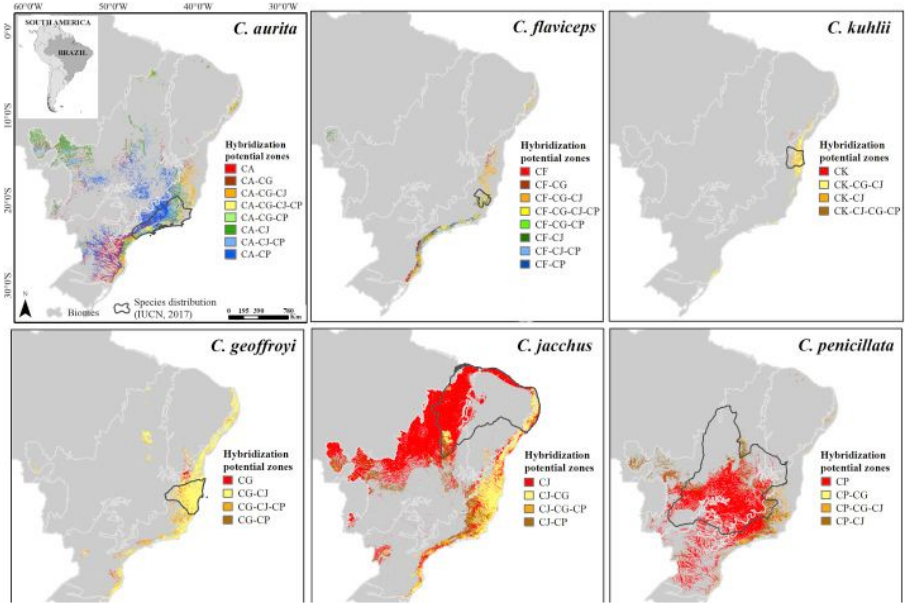
ELSEVIER

Global Ecology and Conservation
Volume 20, October 2019, e00706

Predicting the potential hybridization zones between native and invasive marmosets within Neotropical biodiversity hotspots

Andreia Magro Moraes [a], Maurício Humberto Vancine [b], Andreza Magro Moraes [c], Carlos Leandro de Oliveira Cordeiro [d, e], Míriam Plaza Pinto [f], Adriana Almeida Lima [f], Laurence Culot [g], Thiago Sanna Freire Silva [e], Rosane Garcia Collevatti [h], Milton Cezar Ribeiro [a], Thadeu Sobral-Souza [i]





Aplicações

Efeitos sobre riqueza de borboletas

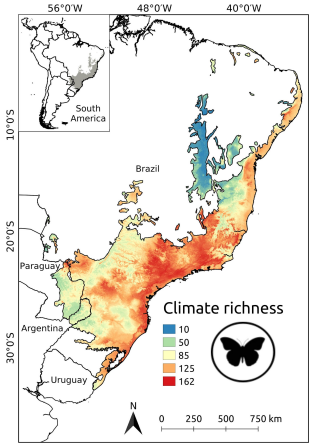
Diversity and Distributions Open Access — A Journal of Conservation Biogeography

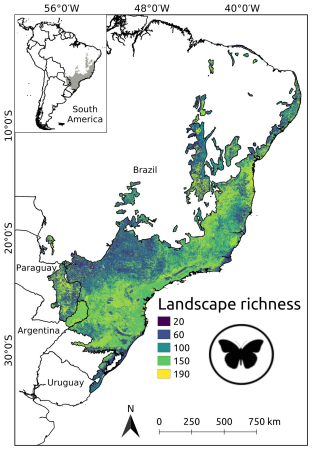
BIODIVERSITY RESEARCH | Open Access

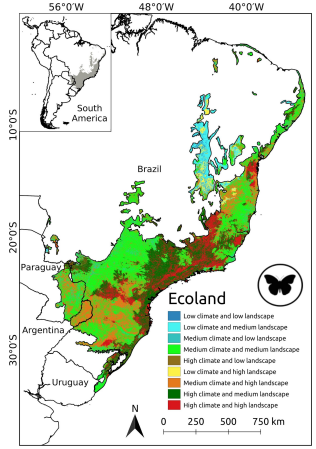
Effects of landscape modification on species richness patterns of fruit-feeding butterflies in Brazilian Atlantic Forest

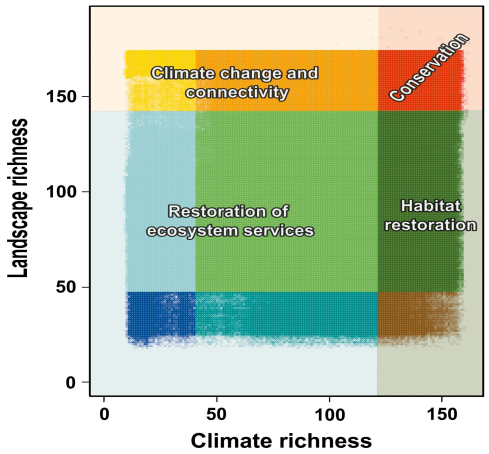
Jessie P. Santos, Thadeu Sobral-Souza, Keith S. Brown Jr, Maurício Humberto Vancine, Milton C. Ribeiro, André V. L. Freitas

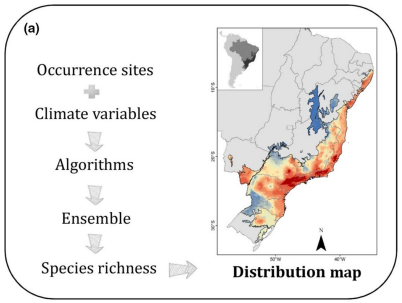
First published: 19 November 2019 | https://doi.org/10.1111/ddi.13007

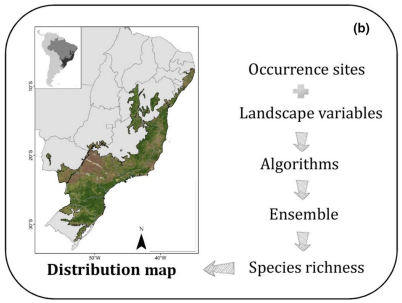


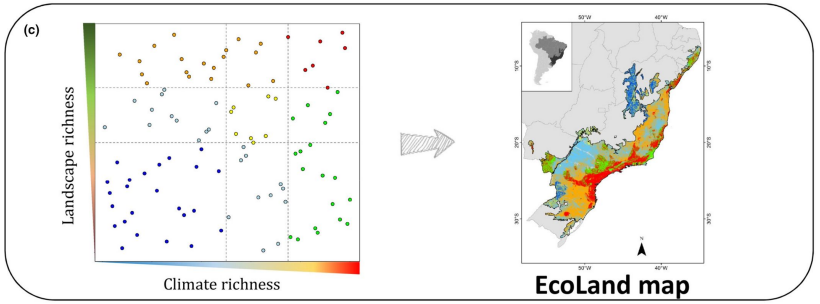






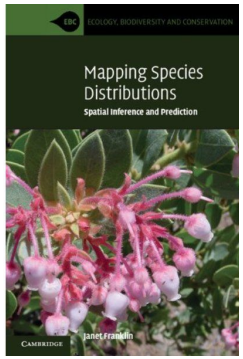




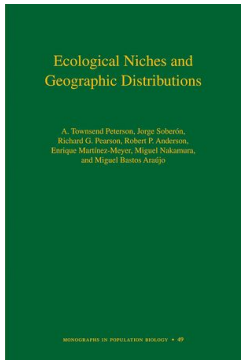


Mais informações

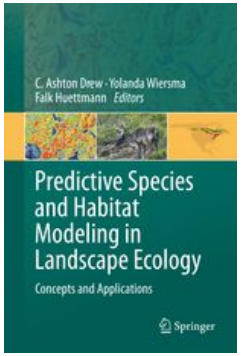
Livros



Franklin (2009)

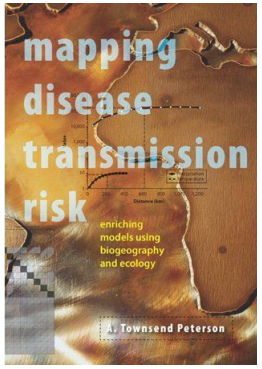


Peterson et al. (2011)

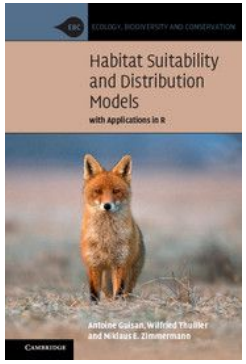


Drew et al. (2011)

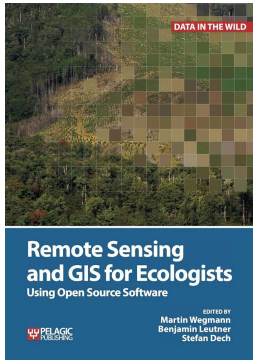
Lima-Ribeiro & Diniz-Filho (2013)



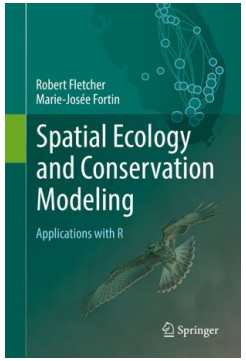
Peterson (2014)



Guisan et al. (2017)



Wegmann et al. (2016)
Cap. 13



Fletcher and Fortin (2018)
Cap. 07

Muito obrigado!

Modelos de Distribuição de Espécies: uma visão geral

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