Modelagem de distribuição de espécies

Uma introdução com exemplo no R

Marília Melo Favalesso

31-10-2020

Marília Melo Favalesso

Formação

- Técnica ambiental (CEEP, 2009)
- Bióloga (UFPR, 2014)
- Mestre em Ciências Ambientais (UNIOESTE, 2018)
- Doutoranda em Ecologia (UBA - Argentina, atual)

Projetos

- **GECD** - Grupo de Estudos em Ciência de Dados
- **Soma dos quadrados**
- **Grupo de Estudos em Modelagem de nicho e distribuição de espécies**

Contatos

- ✉️ mariliabioufpr@gmail.com
- 🌎 www.mmfava.com
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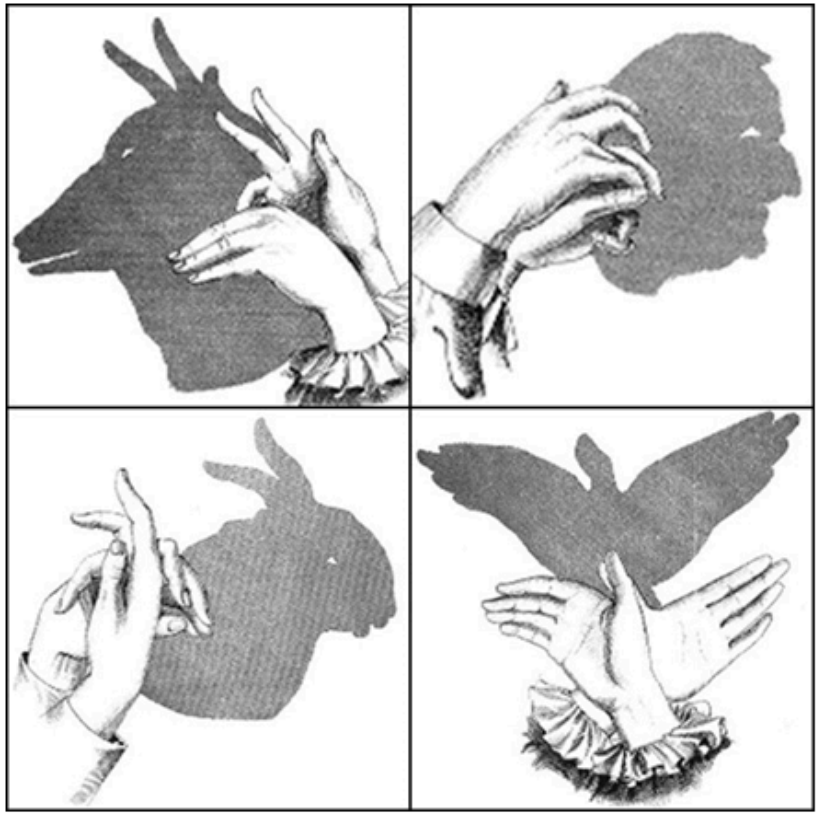
- 💻 Github: mmfava

O que é um modelo?

O que é um modelo?



Modelos de distribuição de espécies

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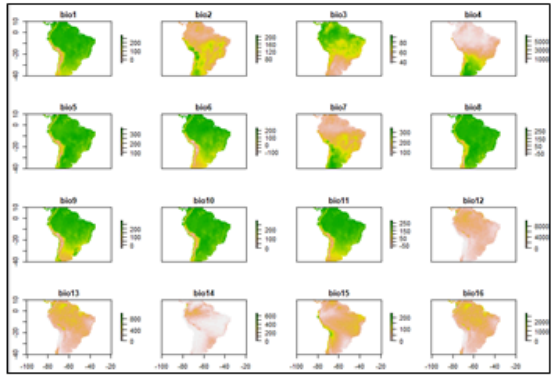

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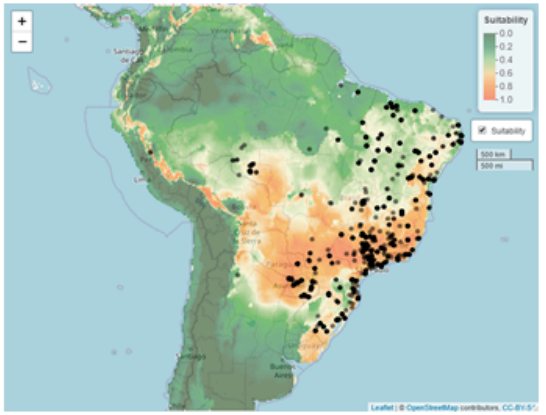
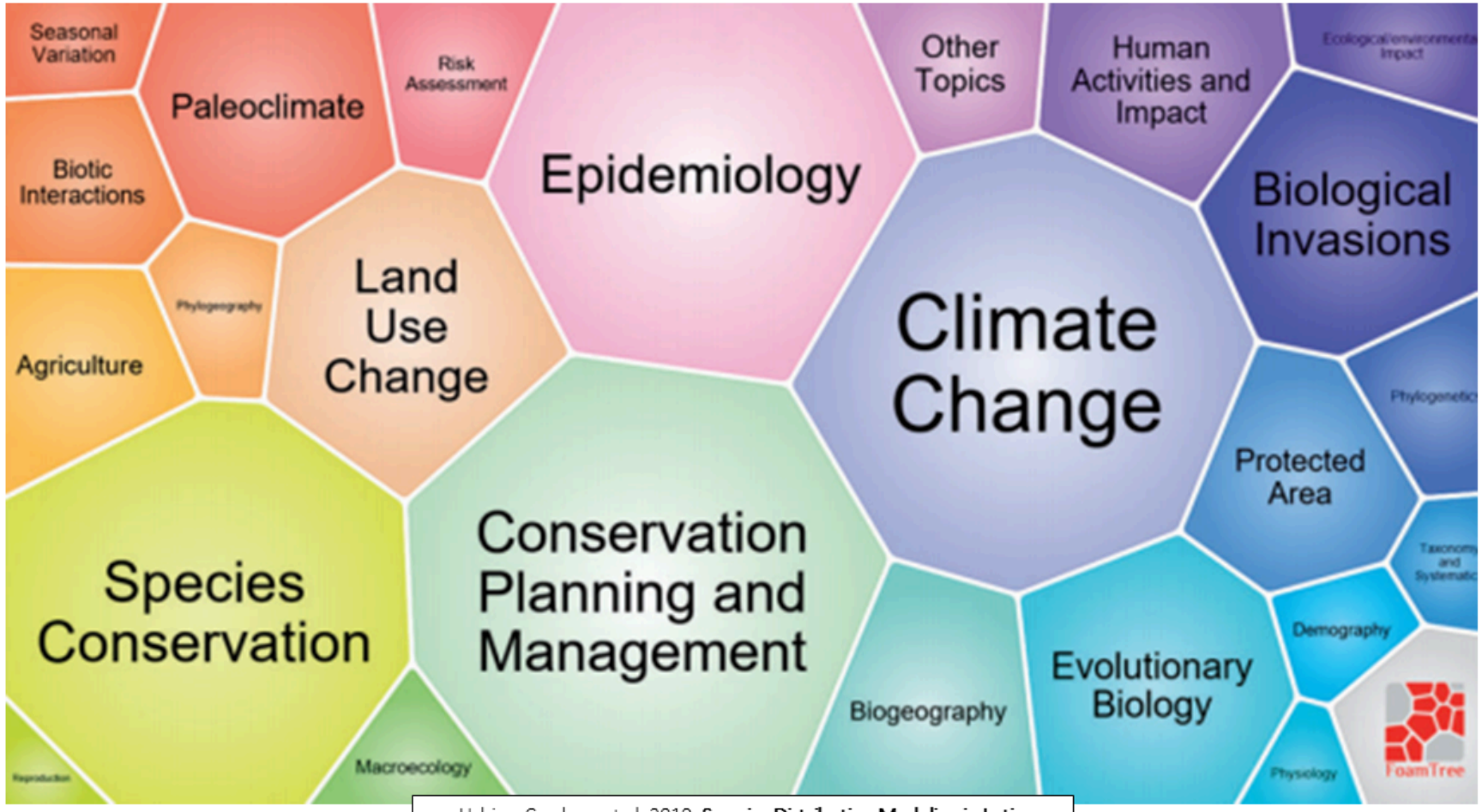


	Nome/s da espécie	Longitude	Latitude
1	Trigona spinipes	-43.16248	-22.953575
2	Trigona spinipes	-47.89580	-15.844967
3	Trigona spinipes	-46.36071	-22.999322
4	Trigona spinipes	-47.85274	-15.670733
5	Trigona spinipes	-47.03776	-22.784671
6	Trigona spinipes	-47.88682	-15.733383
7	Trigona spinipes	-47.86232	-15.768570

bio1	bio2	bio3	bio4	bio5	bio6	bio7	bio8	bio9	bio10	bio11	bio12	bio13	bio14	bio15	bio16	bio17	bio18	bio19
201	102	85	355	263	143	120	199	198	205	197	1611	263	40	55	731	168	316	172
216	100	84	355	278	160	118	214	213	221	212	1452	241	43	54	670	171	261	174
196	98	83	405	257	139	118	194	191	201	191	1872	304	57	52	851	240	318	251
207	96	83	408	267	152	115	205	202	212	202	1961	318	72	50	884	285	305	305
209	103	85	317	271	151	120	206	205	212	205	1469	240	36	56	677	149	284	149
222	101	84	358	284	165	119	220	219	226	218	1335	223	40	56	627	151	238	151
206	99	83	383	268	149	119	203	202	211	202	1650	272	49	55	769	205	272	207
210	97	83	405	271	155	116	208	206	216	206	1783	292	62	53	824	248	270	257
218	107	86	327	281	158	123	215	217	221	214	1435	227	36	55	646	143	374	621
223	105	86	343	286	165	121	220	221	227	219	1285	212	34	57	601	127	250	569
225	102	85	348	286	167	119	222	221	228	221	1249	210	35	59	599	129	222	557
228	100	85	368	289	172	117	225	225	232	224	1257	213	40	60	609	145	200	558
233	97	84	400	293	178	115	230	229	238	229	1301	219	49	58	626	169	184	173
219	111	88	339	284	158	126	216	217	222	214	1587	246	37	53	705	161	413	683
217	108	88	334	280	158	122	214	215	220	213	1465	235	32	57	676	138	388	647
219	105	86	366	282	160	122	216	217	222	214	1329	220	30	60	635	122	248	600
231	102	85	371	293	174	119	227	228	235	226	1125	194	27	64	556	102	201	525
236	100	85	364	297	180	117	233	233	240	232	1062	186	28	65	534	104	170	500
225	113	86	364	293	163	130	222	224	229	220	2065	301	50	47	853	237	554	841
233	113	87	385	300	171	129	229	232	237	227	1823	277	44	50	781	199	473	768
234	111	87	380	300	173	127	230	233	238	228	1609	254	38	53	714	165	408	697
243	109	88	366	306	183	123	239	243	246	237	1343	225	32	59	622	121	312	615
241	106	88	371	302	182	120	237	241	243	235	1207	209	24	64	582	96	278	573
247	103	87	397	308	190	118	243	247	251	241	1020	186	14	69	512	67	223	509
246	101	86	388	306	189	117	242	244	250	240	957	176	14	72	494	65	188	483
247	99	85	389	307	191	116	243	245	251	242	902	168	15	73	477	67	152	459

Por quê **precisamos** modelar a distribuição de espécies?

Passado – Presente - Futuro



Urbina-Cardona et al. 2019. **Species Distribution Modeling in Latin America: A 25-Year Retrospective Review.** Tropical Conservation Science Volume 12: 1–19. doi: 10.1177/1940082919854058.

Austral ECOLOGY A Journal of ecology in the Southern Hemisphere

Austral Ecology (2019) ••, ••–••

Spatial niche modelling of five endemic cacti from the Brazilian Caatinga: Past, present and future

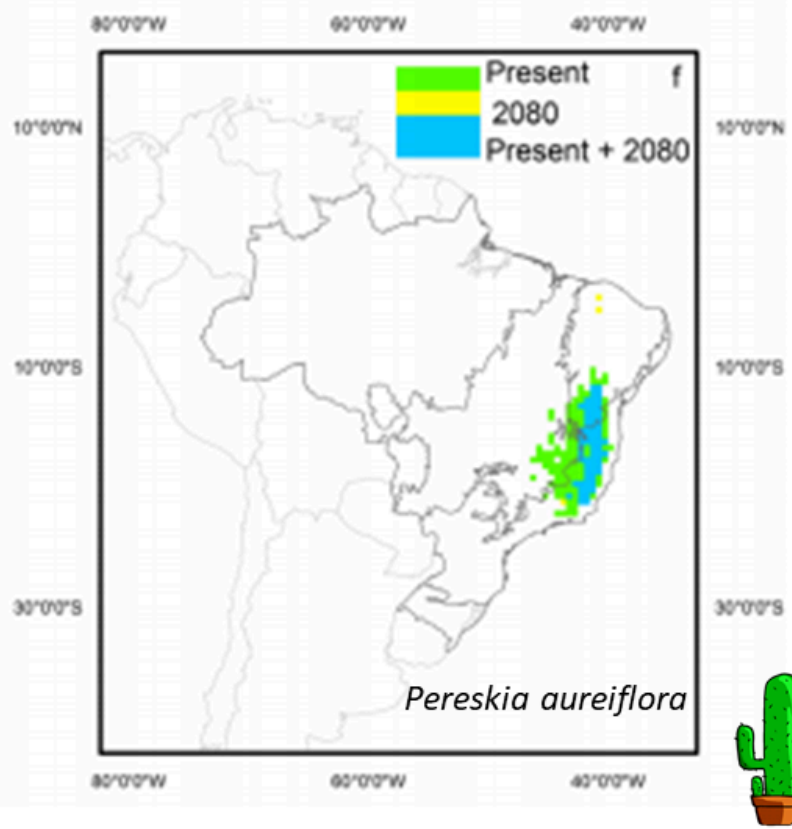
SILVANA DOS SANTOS SIMÕES,[1,2] DANIELA ZAPPI,[3] GRÊNIVEL MOTA DA COSTA,[2] GUILHERME DE OLIVEIRA[2] AND LIDYANNE YURIKO SALEME AONA[2]*

[1]*Programa de mestrado em Recursos Genéticos Vegetais, Universidade Federal do Recôncavo da Bahia – UFRB;* [2]*Centro de Ciências Agrárias, Ambientais e Biológicas, Universidade Federal do Recôncavo da Bahia – UFRB, Rua Rui Barbosa, 710, Centro, Cruz das Almas, 44380-000 (Email: lidyanne.aona@gmail.com); and* [3]*Instituto Tecnológico Vale/Museu Paraense Emilio Goeldi – Coord. Botânica, Belém, Brazil*

Abstract Climate change, together with human activities, impacts on natural and human systems on all continents and poses a major threat to biodiversity, especially in environments with a high rate of endemism and where species are profoundly adapted to specific environmental conditions, as is the case of the seasonally dry tropical forests, noticeably the Caatinga, an exclusively Brazilian biome. The objective of this study was to build spatial niche models of five species of Cactaceae (*Arrojadoa penicillata*, *Brasilicereus phaeacanthus*, *Pereskia aureiflora*, *Stephanocereus leucostele* and *Tacinga inamoena*) endemic to the Caatinga and with different traits, to evaluate the impact of climate change on their geographical distribution. The species records and environmental variable values were overlaid on a grid of 6818 cells with 0.5° spatial resolution. Niche models were obtained for five types of general circulation models between ocean and atmosphere and 12 different ecological models. The ensemble ecological niche model was calculated at present and projected to past (last glacial maximum – LGM, 21 000; and mid-Holocene – Hol, 6000 years ago) and future climate conditions (average of 2080), under the effect of climate change, in the greenhouse gas emission scenario RCP4.5. The distribution pattern of the studied species indicates an area with less environmental suitability in the LGM, followed by an expansion that began in the Hol and continued until the present period. In the future (2080), the models predicted a retraction of areas of environmental suitability, in which *P. aureiflora* and *B. phaeacanthus*, given their more restricted, marginal habitat and woody habit, present a great risk of extinction, whilst *S. leucostele*, *A. penicillata* and *T. inamoena* present a smaller reduction in suitable area, partly reflecting their spreading, less woody habit. Regional conservation actions for Cactaceae species and their habitat need to take these findings into account if we are to ensure the survival of these species.

Key words: Cactaceae, climate change, conservation, forecast modelling, North-eastern Brazil, plant distribution.

Planejamento e gestão de habitat
Conservação
Modelagem passado-presente-futuro



Planejamento e gestão de habitat
Mudanças climáticas
Conservação de espécies

Austral ECOLOGY A Journal of ecology in the Southern Hemisphere

Austral Ecology (2020) ••, ••–••

Extinction threat to neglected *Plinia edulis* exacerbated by climate change, yet likely mitigated by conservation through sustainable use

VALDEIR PEREIRA LIMA,[1,2]* CESAR AUGUSTO MARCHIORO,[3] FERNANDO JONER,[2] HANS TER STEEGE[4,5] AND ILYAS SIDDIQUE[1,2]

[1]*Programa de Pós-Graduação em Recursos Genéticos Vegetais, Centro de Ciências Agrárias, Universidade Federal de Santa Catarina, Florianópolis, 88034-000, Santa Catarina, Brazil (valldeir@gmail.com);* [2]*Departamento de Fitotecnia, Centro de Ciências Agrárias, Universidade de Santa Catarina, Florianópolis, 88034-000, Santa Catarina, Brazil;* [3]*Departamento de Agr Biodiversidade e Florestas, Centro de Ciências Rurais, Universidade Federal de Santa Catarina Curitibanos, Brazil;* [4]*Naturalis Biodiversity Center, Leiden, The Netherlands; and* [5]*Systems Ec Free University, Amsterdam, The Netherlands*

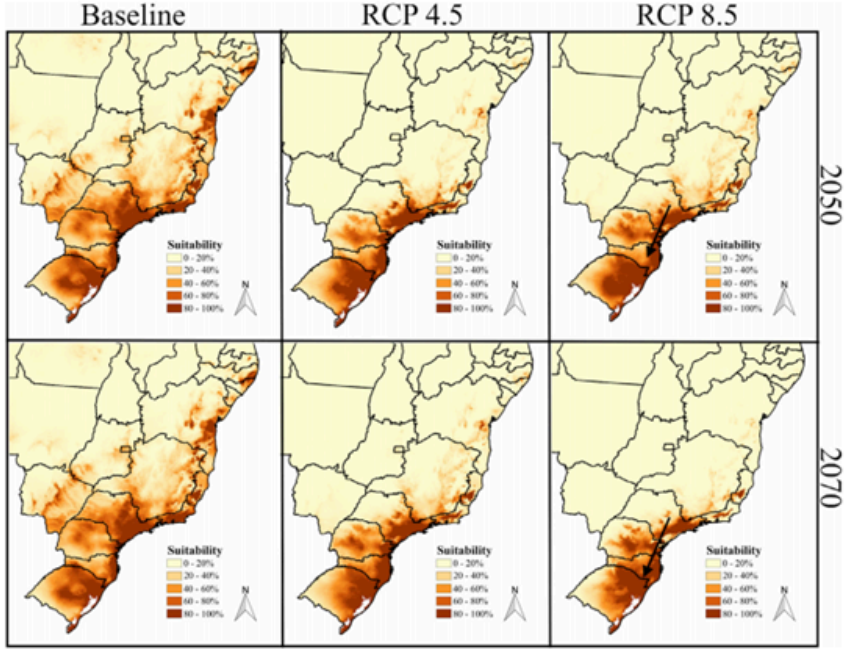


Fig. 1. Current and future climatic suitability for *Plinia edulis* in the Brazilian Atlantic Rainforest. The vector indicates the direction and magnitude of the changes in species core distribution.

Epidemiologia

Acta Tropica 192 (2019) 158–164

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

Potential distribution and ecological conditions of *Lonomia obliqua* Walker 1855 (Saturniidae: Hemileucinae) in Brazil

Marília Melo Favalesso[a,*], Lisete Maria Lorini[b], Maria Elisa Peichoto[a], Ana Tereza Bittencourt Guimarães[c]

[a] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET); Instituto Nacional de Medicina Tropical (INMeT), Puerto Iguazú, Misiones, Argentina
[b] Universidade de Passo Fundo, Passo Fundo, Rio Grande do Sul, Brazil
[c] Universidade Estadual do Oeste do Parand,Cascavel, Parand, Brazil

ARTICLE INFO

Keywords:
Caterpillar
Disease risk
Ecological niche modeling
Species distribution
Venomous insect

ABSTRACT

Lonomia obliqua Walker 1855 (Lepidoptera: Saturniidae) is a species of moth which la
lonomism, a form of envenomation that has been occurring in Brazil since the 1980s.
public health, the geographical distribution and their ecological aspects are unknown
study, we present a potential geographical distribution map for *L. obliqua* in Brazil, b
different Ecology Niche Modelling (ENM) algorithms. A total of 38 occurrence poi
southern/ southeastern regions of Brazil and in the province of Misiones (Argentina
calibration and evaluation of the model. Eight continuous climatic and soil variab
previously calculated for model calibration. The final model-map is composed of a
rithms (Gower, Mahalanobis, MAXENT and SVM), with samples of pseudo-abse
Envelope (BIOCLIM) in quantity equal to the presences. This model-map was binari
Threshold (LPT) and cut only to the Brazilian area. According to this map, the areas
obliqua are restricted between latitudes "12" and "32", and longitudes "39" and "57", w
km². The model-map was also validated with external data from samples of the speci
the state of Rio Grande do Sul (Brazil). From this information, we extracted the va
climate and soil, and with additional variables related to the land use and type of v
tribute to the ecological knowledge of the species. In general, the map and the ecolo
can serve as a tool for public health agents in Brazil to adequately guide preventive

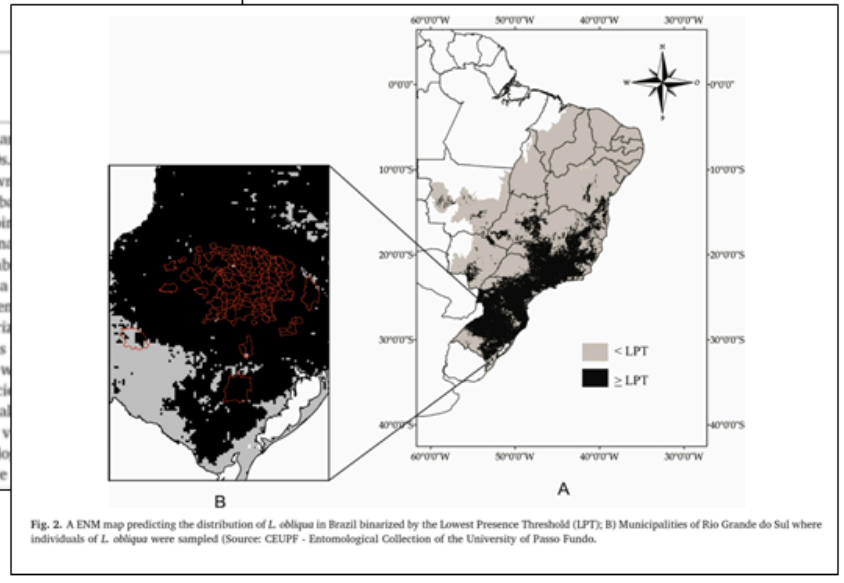


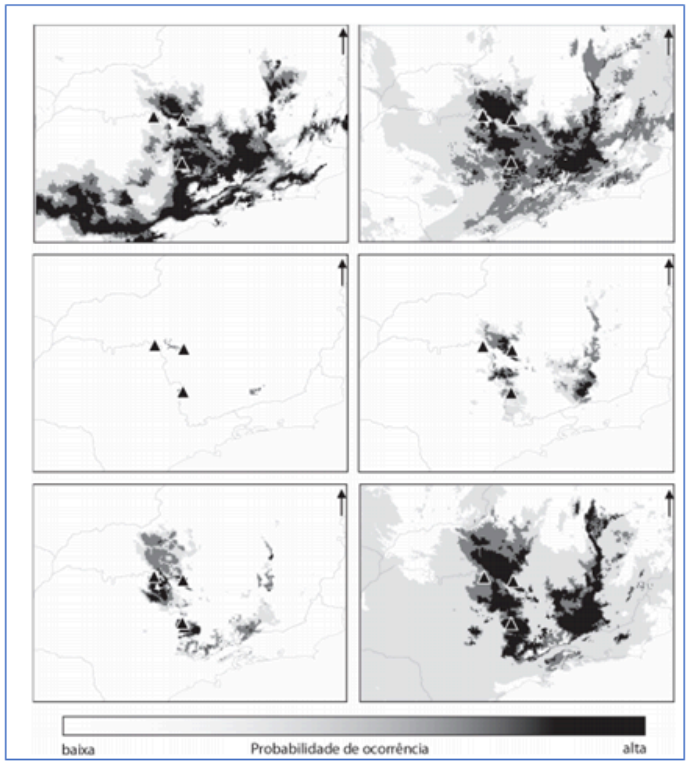
Fig. 2. A ENM map predicting the distribution of *L. obliqua* in Brazil binarized by the Lowest Presence Threshold (LPT); B) Municipalities of Rio Grande do Sul where individuals of *L. obliqua* were sampled (Source: CEUPF - Entomological Collection of the University of Passo Fundo.

Modelagem do nicho ecológico de *Phyllomedusa ayeaye* (Anura: Hylidae): previsão de novas áreas de ocorrência para uma espécie rara

Ecological modelling of *Phyllomedusa ayeaye* (Anura: Hylidae): prediction of new occurrence areas for a rare species

João G. R. Giovanelli[1,2*]
jgiovanelli@gmail.com
Cybele O. Araujo[3]
cyaraujo@iflorestal.sp.gov.br
Célio F. B. Haddad[2]
haddad@rc.unesp.br
João Alexandrino[2]
jalex@rc.unesp.br

Encontrar espécies raras



Restauração

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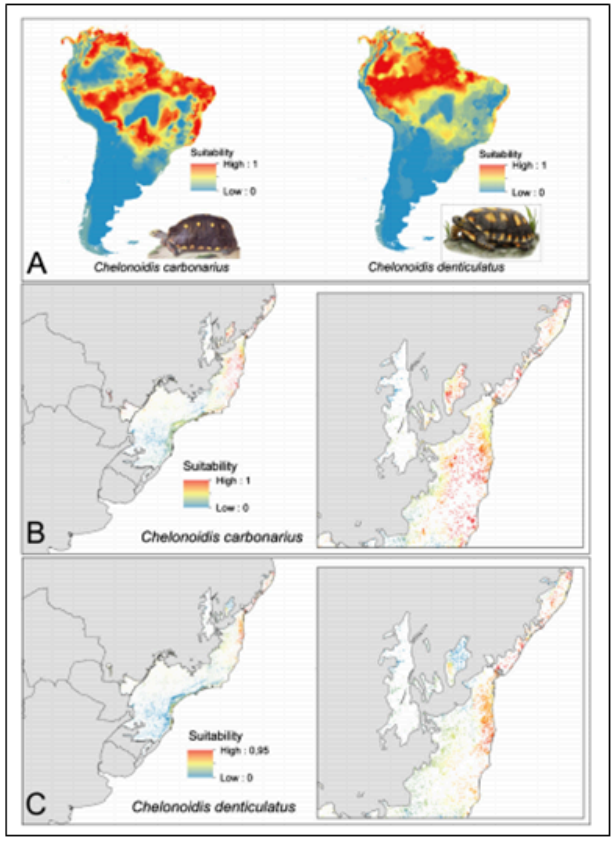
Research Letters

Rewilding defaunated Atlantic Forests with tortoises to restore lost seed dispersal functions

Thadeu Sobral-Souza[a,b,*], Laís Lautenschlager[a], Thais Queiroz Morcatty[c,d], Carolina Bello[a], Dennis Hansen[e], Mauro Galetti[a]

[a] Instituto de Biociências, Departamento de Ecologia, Universidade Estadual Paulista (UNESP), 13506-900 Rio Claro, São Paulo, Brazil
[b] Department of Education, Biological Science Course, Universidade Metropolitana de Santos (UNIMES), Santos, São Paulo, Brazil
[c] Wildlife Conservation Society – Brazil, 69067-005 Manaus, Amazonas, Brazil
[d] Programa de Pós-Graduação em Ecologia, Instituto Nacional de Pesquisas da Amazônia (INPA), 69011-970 Manaus, Amazonas, Brazil
[e] Zoological Museum & Department of Evolutionary Biology and Environmental Studies, University of Zurich, Zurich, Switzerland

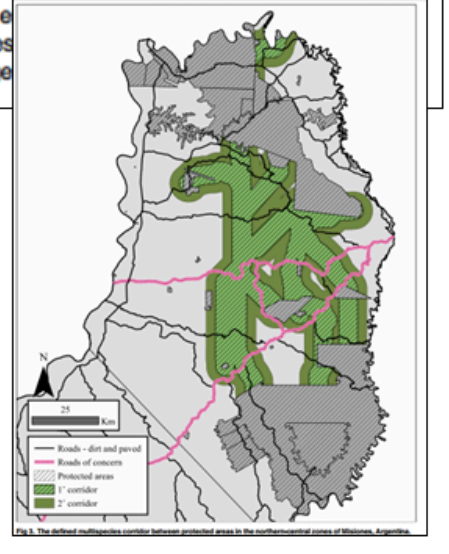


RESEARCH ARTICLE

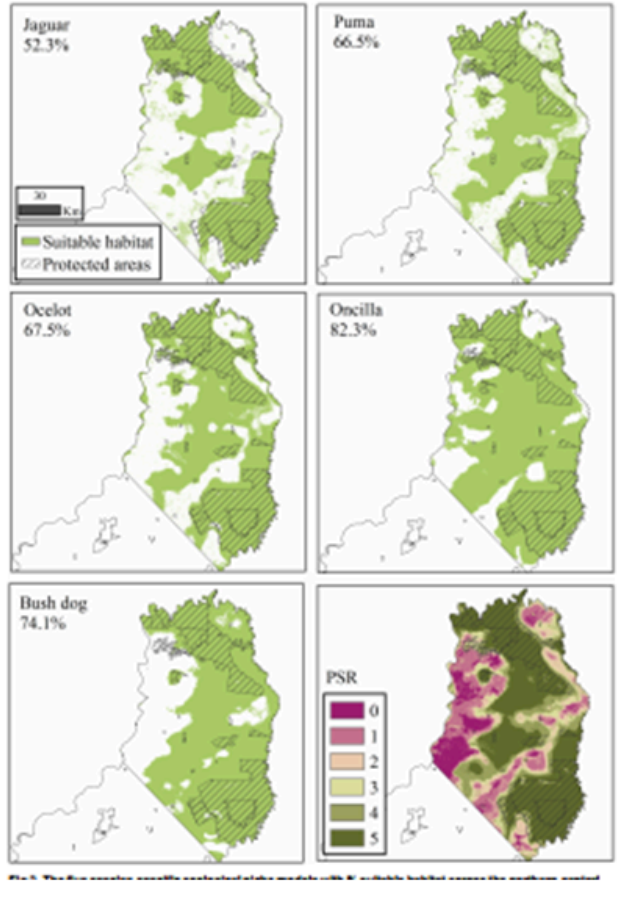
Using niche-modelling and species-specific cost analyses to determine a multispecies corridor in a fragmented landscape

Karen E. DeMatteo[1,2,3]*, Miguel A. Rinas[4☯], Juan Pablo Zurano[5¤a‡], Nicole Selleski[5¤b‡], Rosio G. Schneider[5¤c‡], Carina F. Argüelles[5,6☯]

1 Washington University in St. Louis, Department of Biology & Environmental Studies, St. Louis, Missouri, United States of America, **2** WildCare Institute at the Saint Louis Zoo, St. Louis, Missouri, United States of America, **3** University of Missouri, Division of Biological Sciences, Columbia, Missouri, United States of America, **4** Ministerio de Ecología y Recursos Naturales Renovables, Posadas, Misiones, Argentina, **5** Facultad de Ciencias Exactas, Químicas y Naturales, Departame Misiones (UNaM), Posadas, Misiones, Argentina, **6** Grupo de Inves IBS – Nodo Posadas, UNaM – CONICET, Posadas, Misiones, Arge



Corredor ecológico




Várias utilidades!

Vocês já se perguntaram

“quais fatores estão envolvidos na ocorrência/distribuição de uma espécie?”

Papagaio-do-mar

Fratercula sp. (Alcidae)

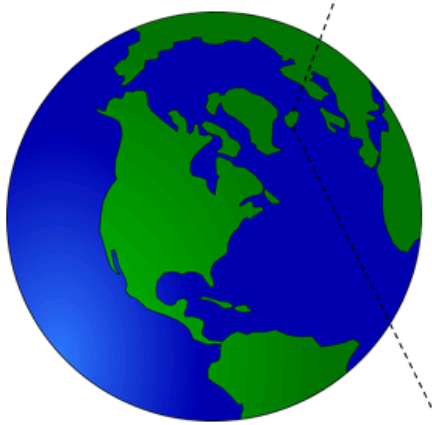
Ordem Charadriiformes

Família Alcidae

Papagaio-do-mar

Fratercula sp. (Alcidae)

iNaturalist.org

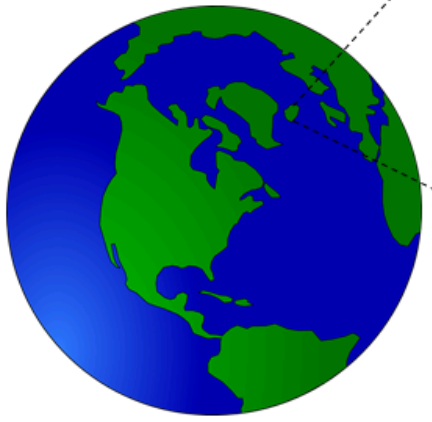


Extensão territorial (exemplo: Islândia)

Papagaio-do-mar
Fratercula sp. (Alcidae)

G

M



Papagaio-do-mar
Fratercula sp. (Alcidae)

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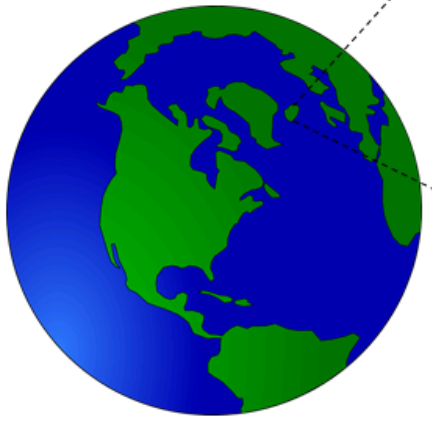
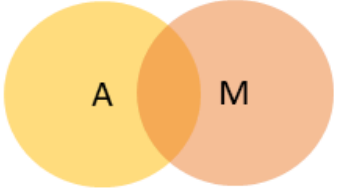



Papagaio-do-mar
Fratercula sp. (Alcidae)
G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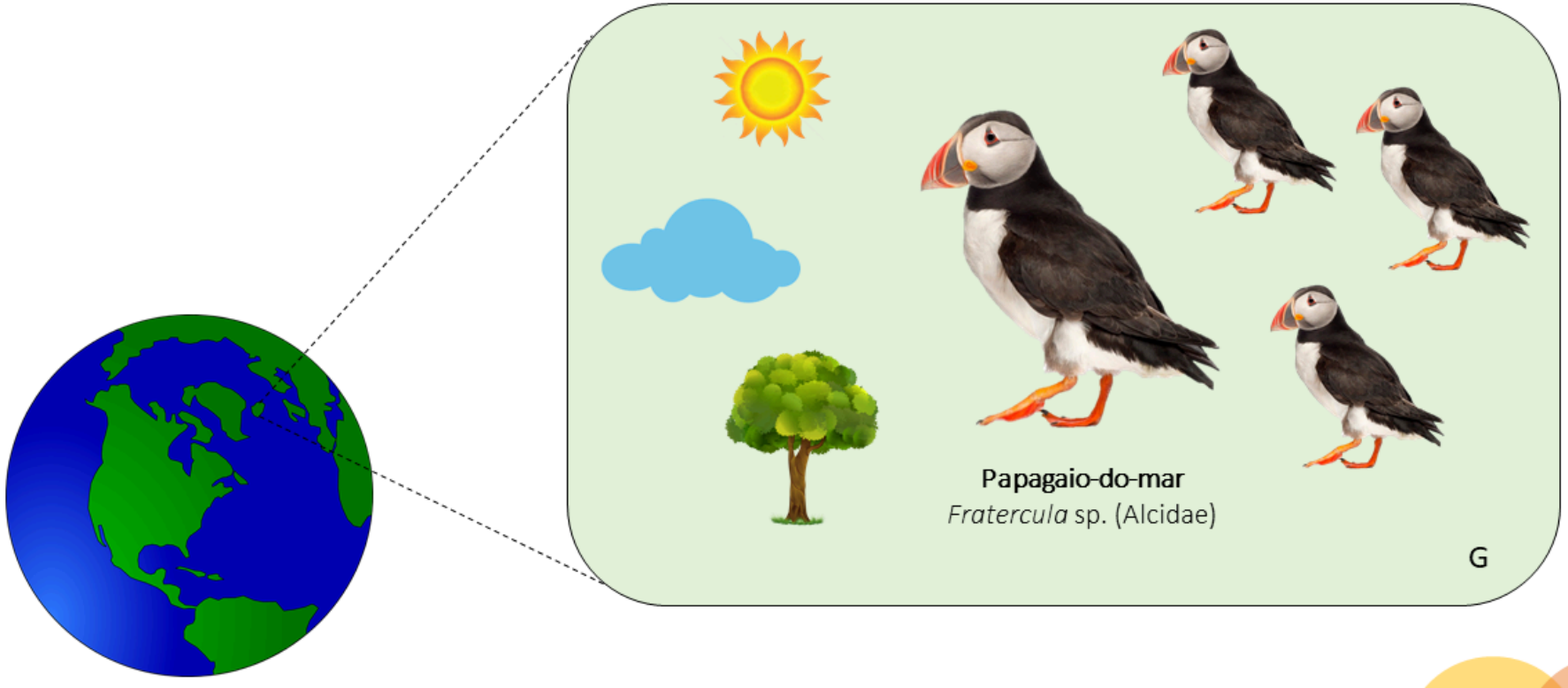
Papagaio-do-mar
Fratercula sp. (Alcidae)
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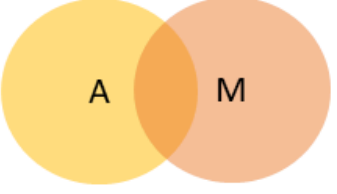
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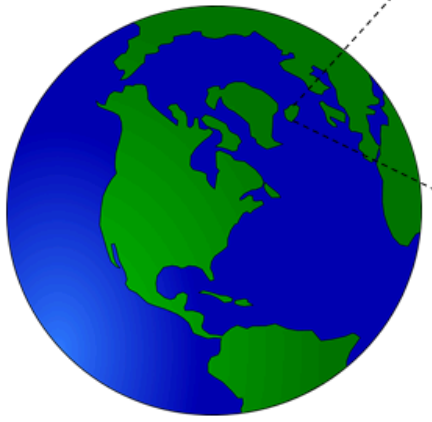

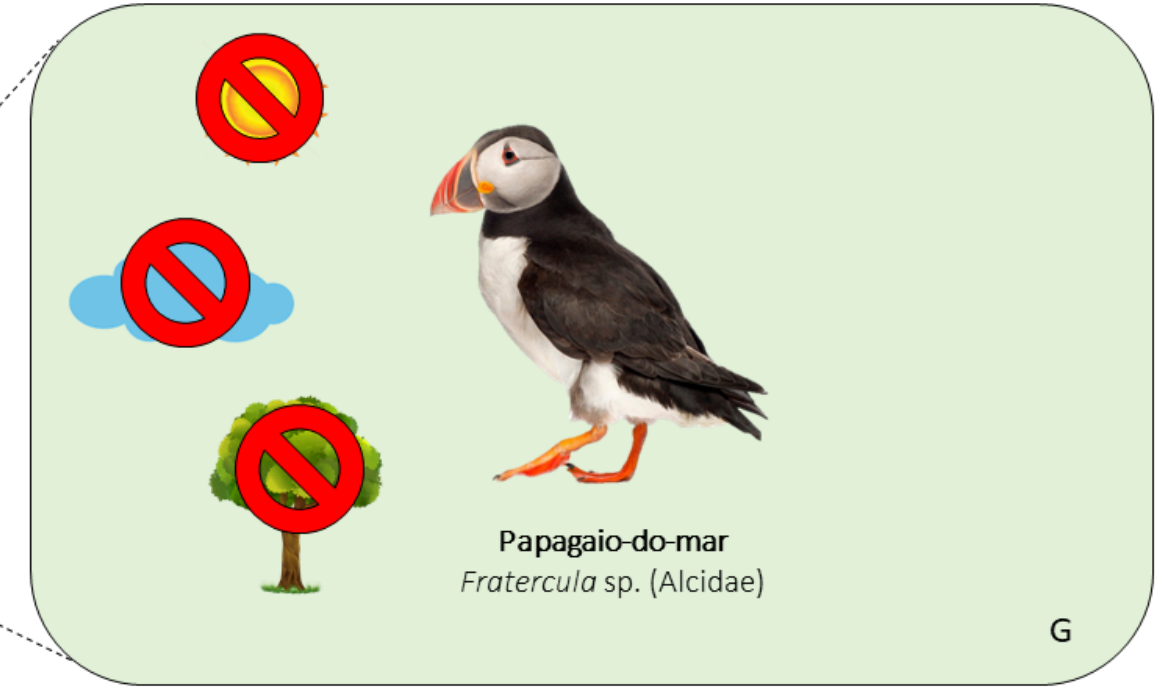
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Fratercula sp. (Alcidae)
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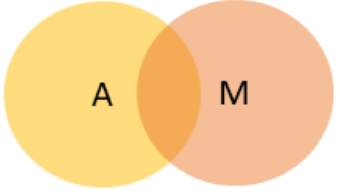
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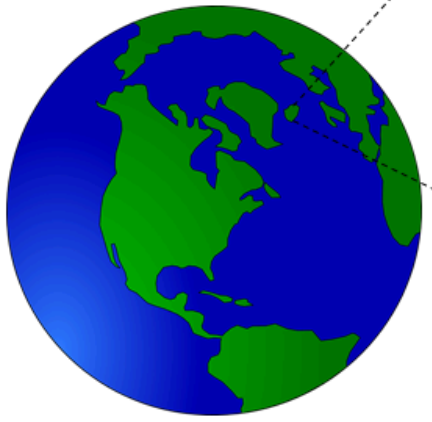

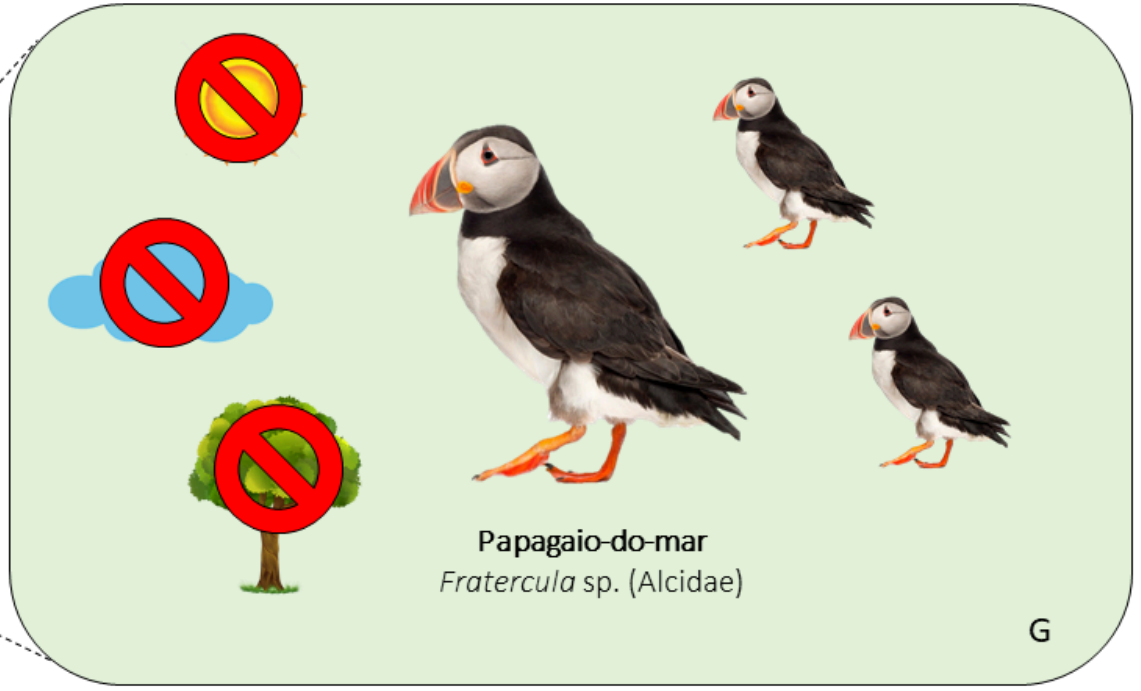
Papagaio-do-mar
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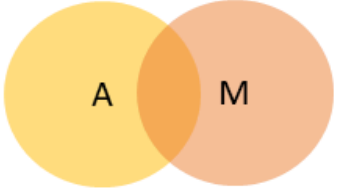
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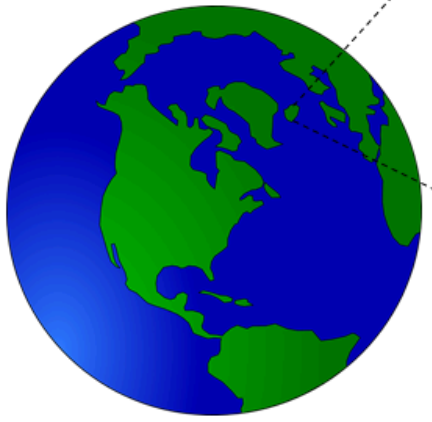

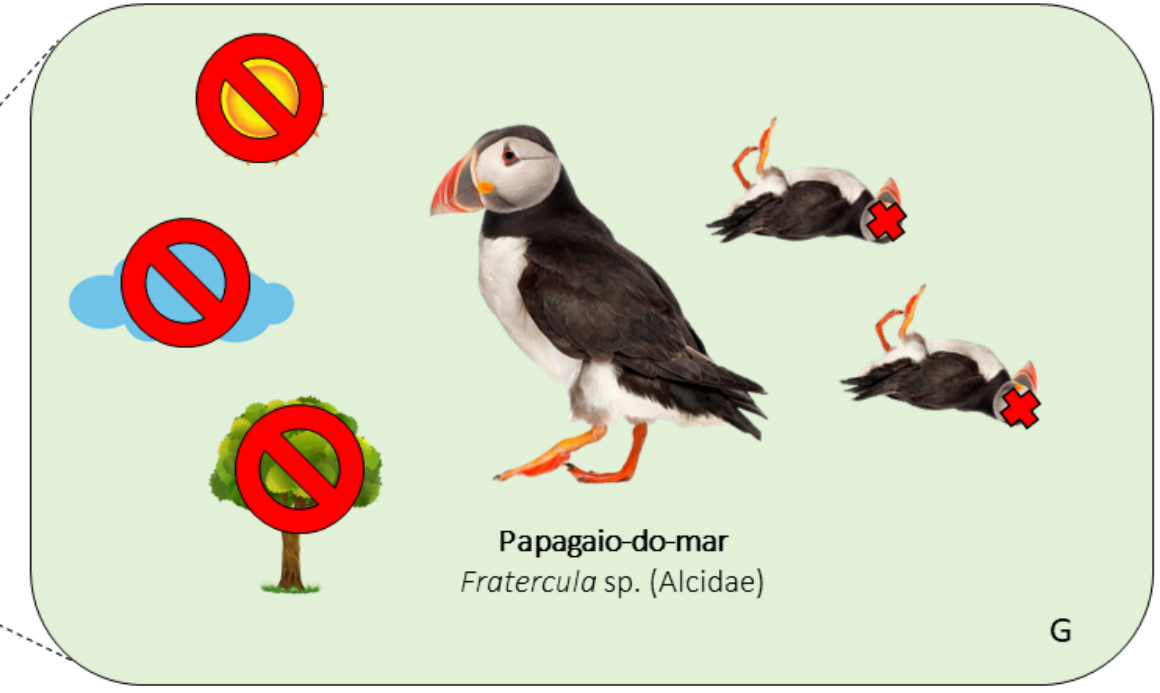
Papagaio-do-mar
Fratercula sp. (Alcidae)
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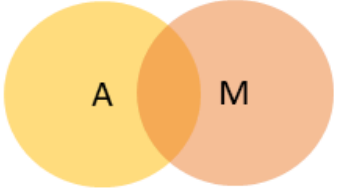
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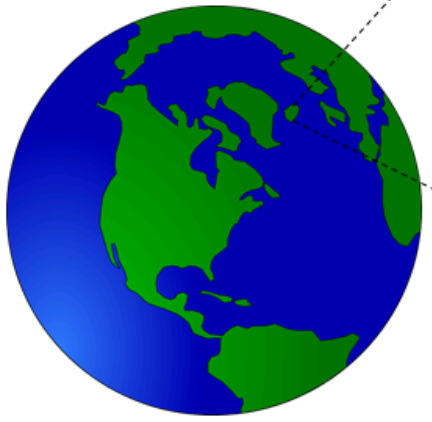
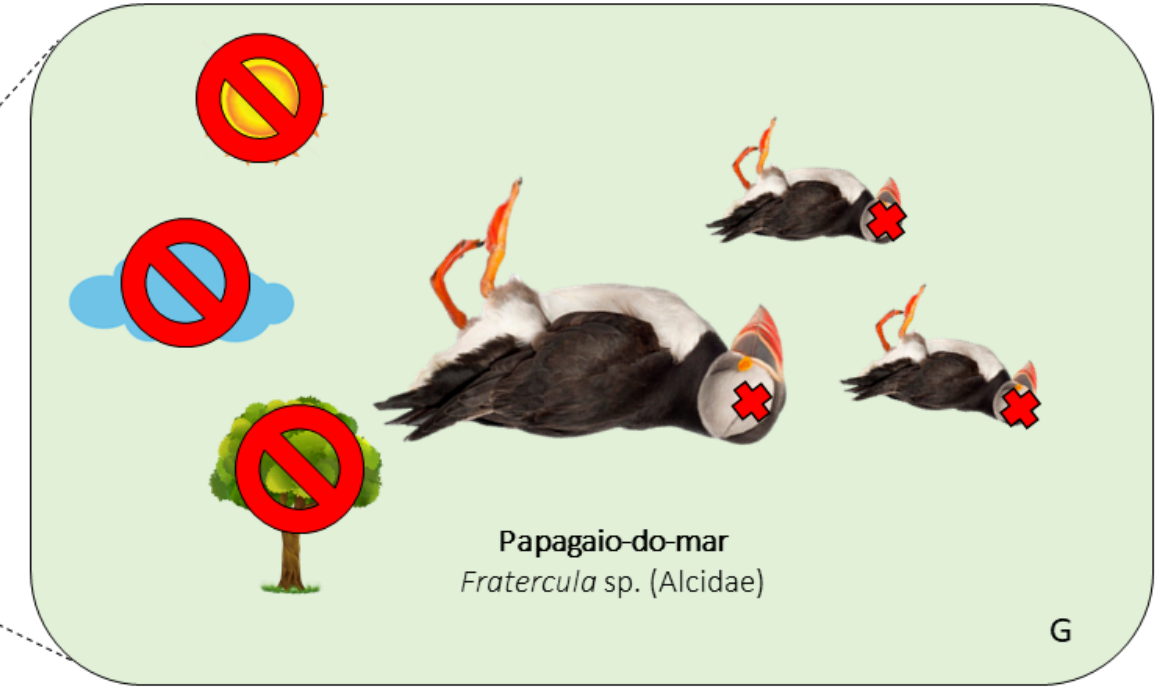
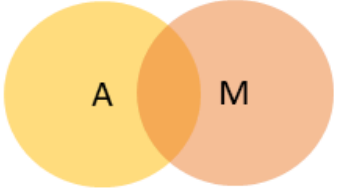
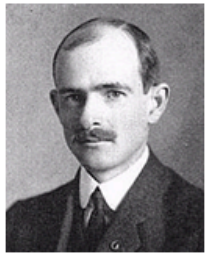



Papagaio-do-mar
Fratercula sp. (Alcidae)
G

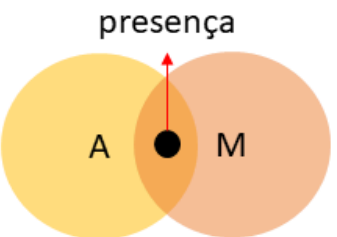

A
M

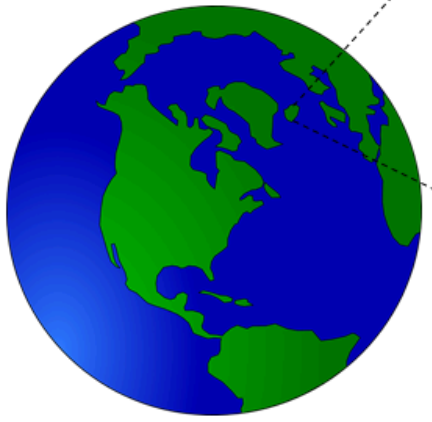


Joseph Grinell (1917, 1928)

Nicho abiótico ou cenopoético

Dualidade entre condições abióticas e distribuição da espécie



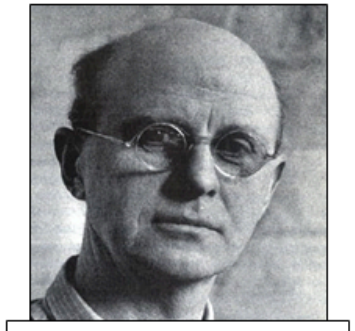


Papagaio-do-mar

Fratercula sp. (Alcidae)

G

B



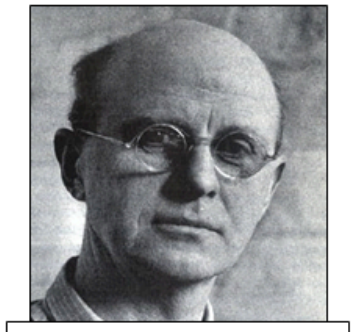
Charles Elton (1927)

Foco no papel funcional da espécie dentro da cadeia trófica (nicho bionômico)

Papagaio-do-mar
Fratercula sp. (Alcidae)

G

B



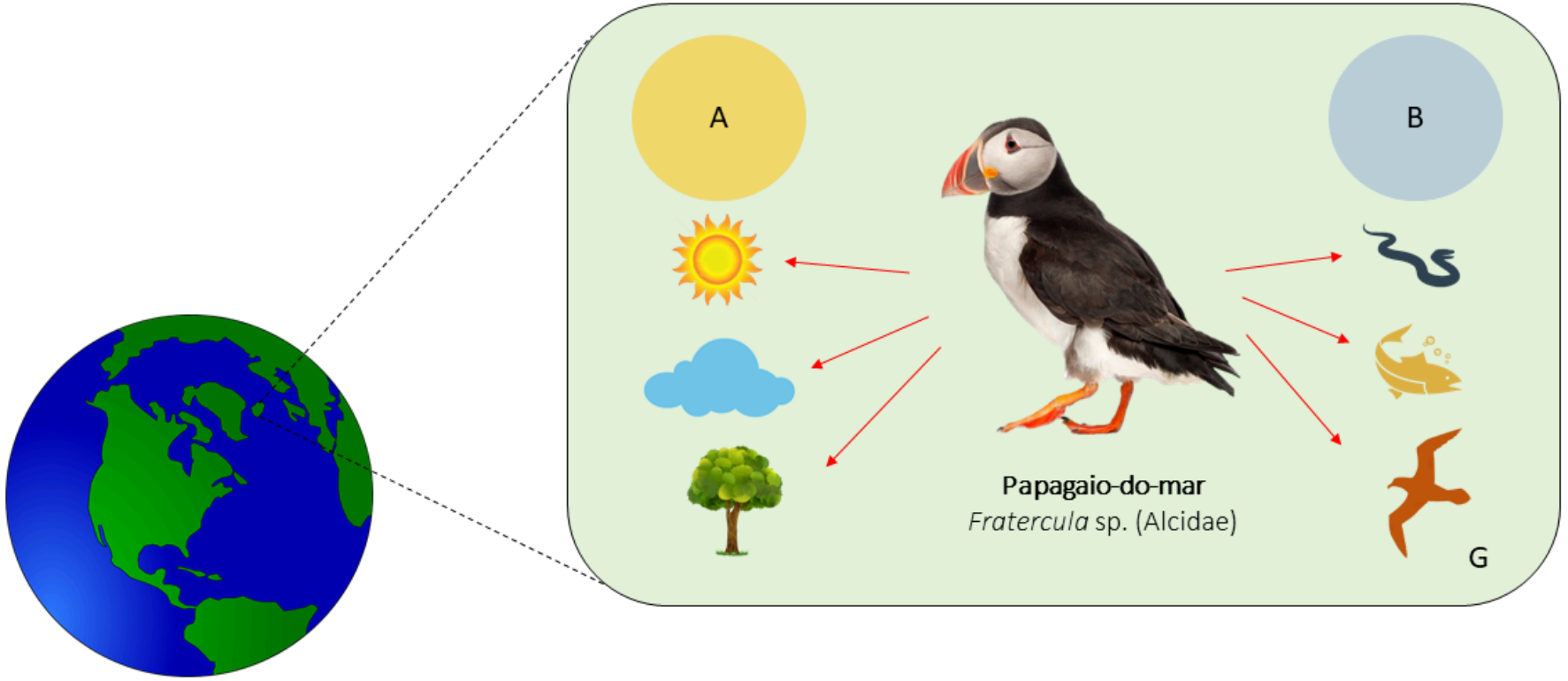
Charles Elton (1927)

Foco no papel funcional da espécie dentro da cadeia trófica (nicho bionômico)

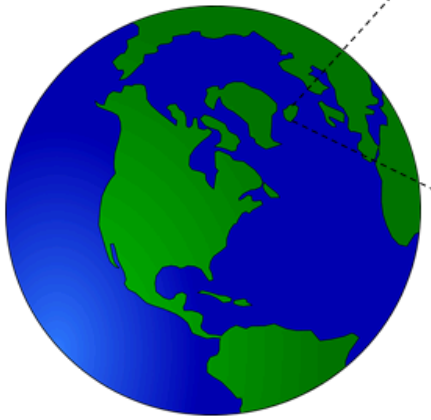
B

- Falou sobre o status funcional de uma espécie em sua comunidade
- Não considerou a questão abiótica
- Nicho como uma propriedade da comunidade biótica e não do seu ocupante

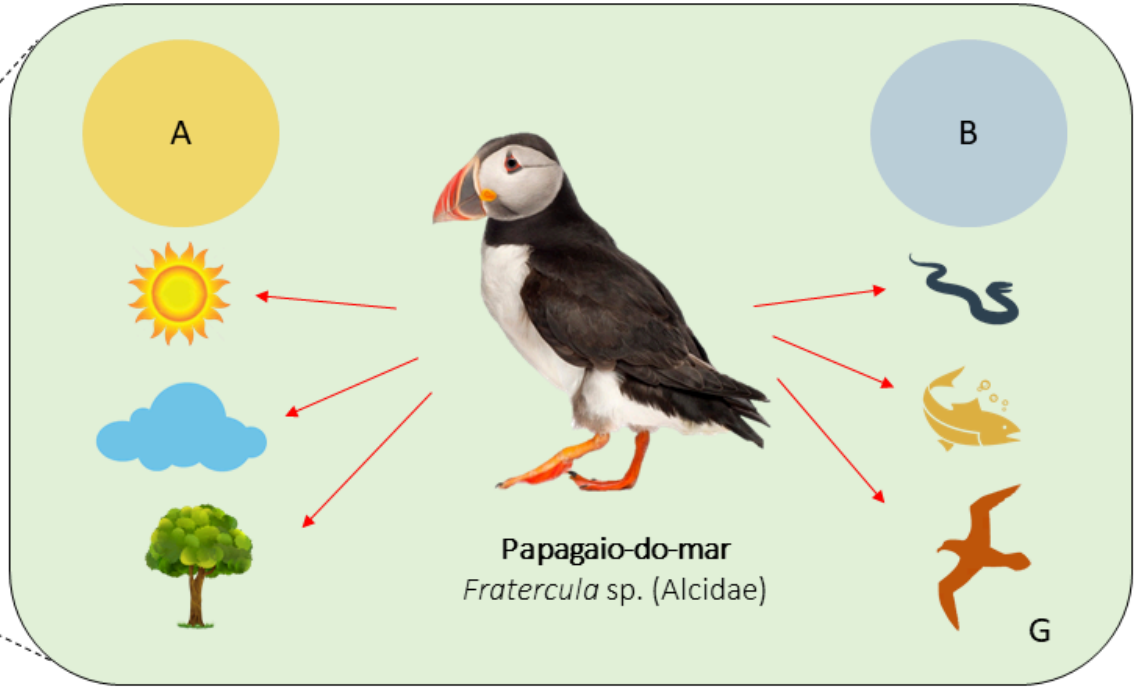
(complementar a Grinell)


A
B
Papagaio-do-mar
Fratercula sp. (Alcidae)
G

Hutchinson (1957)

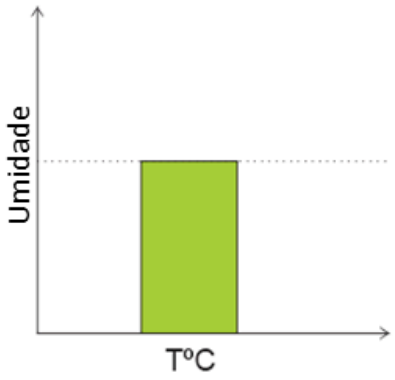


O nicho de uma espécie é **multidimensional**!



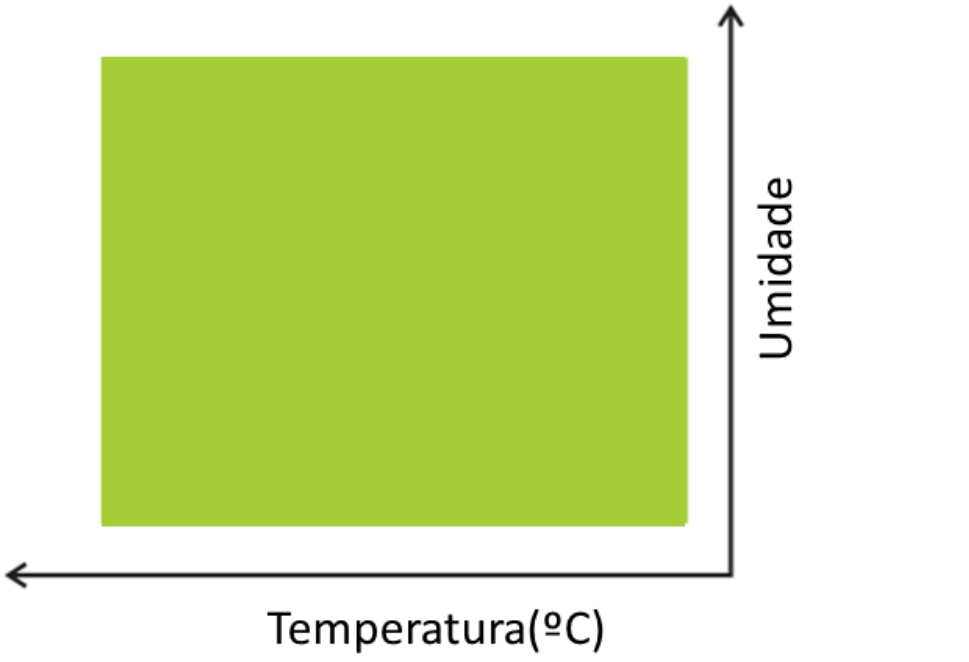
"(...) O nicho é definido por todos os fatores limitantes que interferem na ocorrência de uma dada espécie em um dado local (...)"

"(...) As condições nas quais as espécies poderiam viver são geralmente mais amplas do que as condições onde elas de fato vivem, e isso é devido frequentemente as interações bióticas (...)"

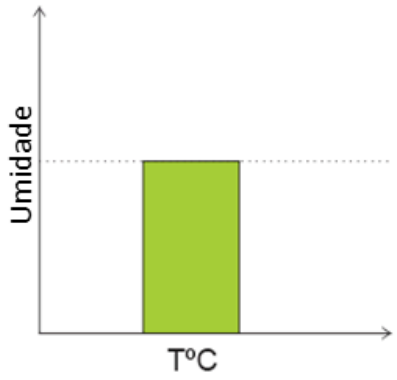


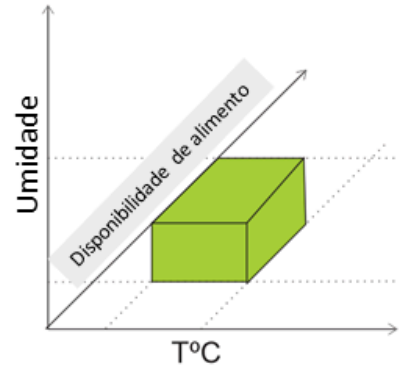
Hutchinson (1957)

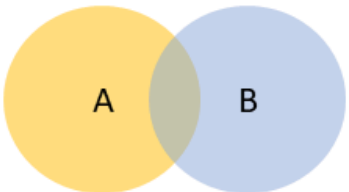
Nicho em dimensões



A

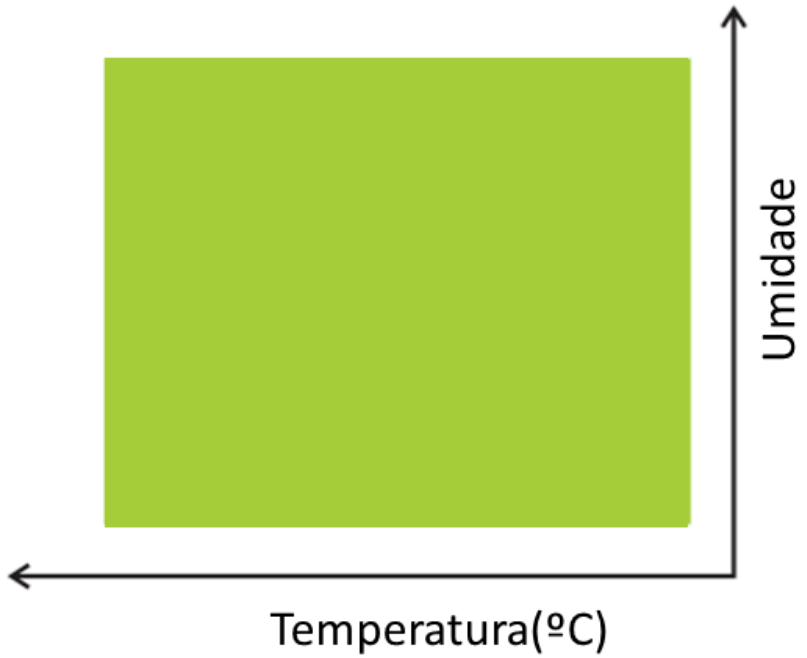


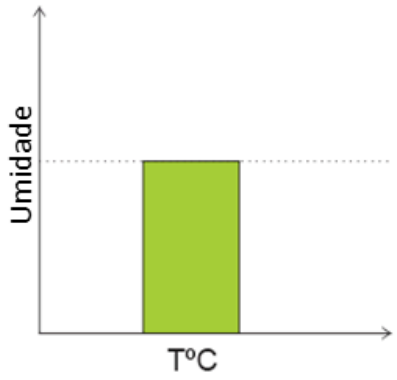


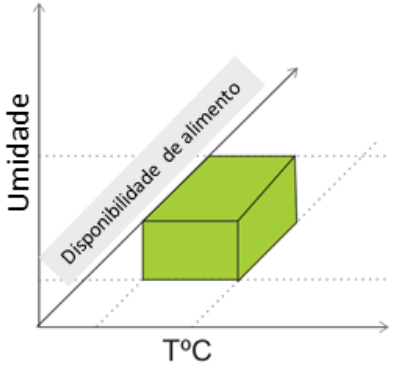


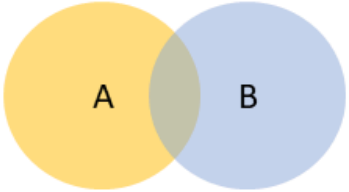
Nicho em dimensões

Hutchinson (1957)



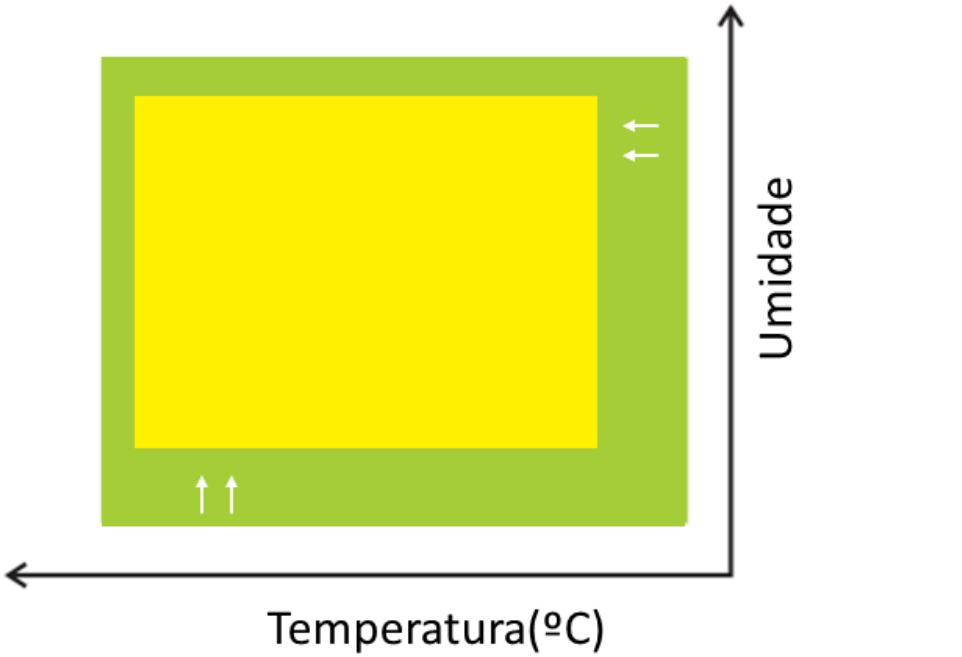


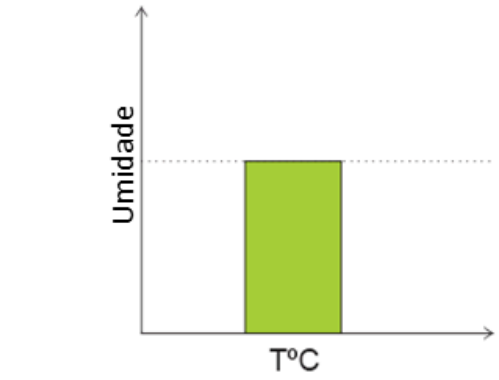


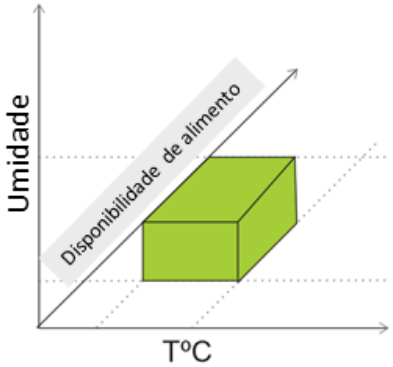


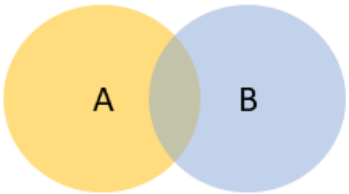
Nicho em dimensões

Hutchinson (1957)



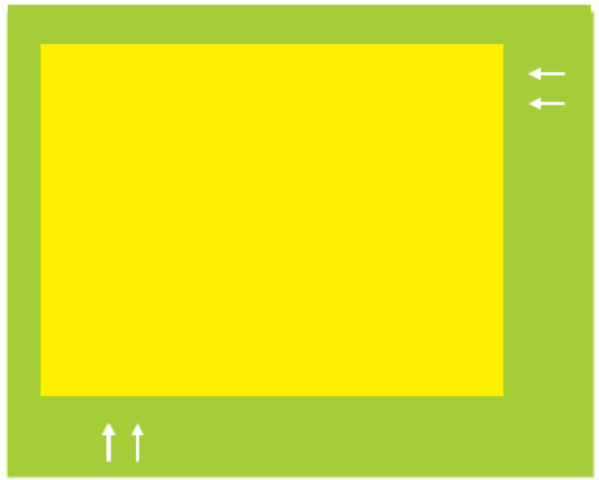


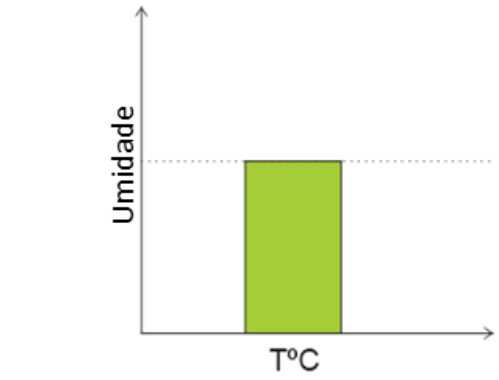


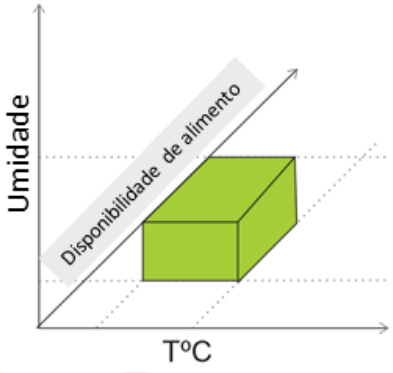


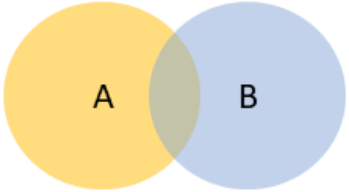
Nicho em dimensões

Hutchinson (1957)



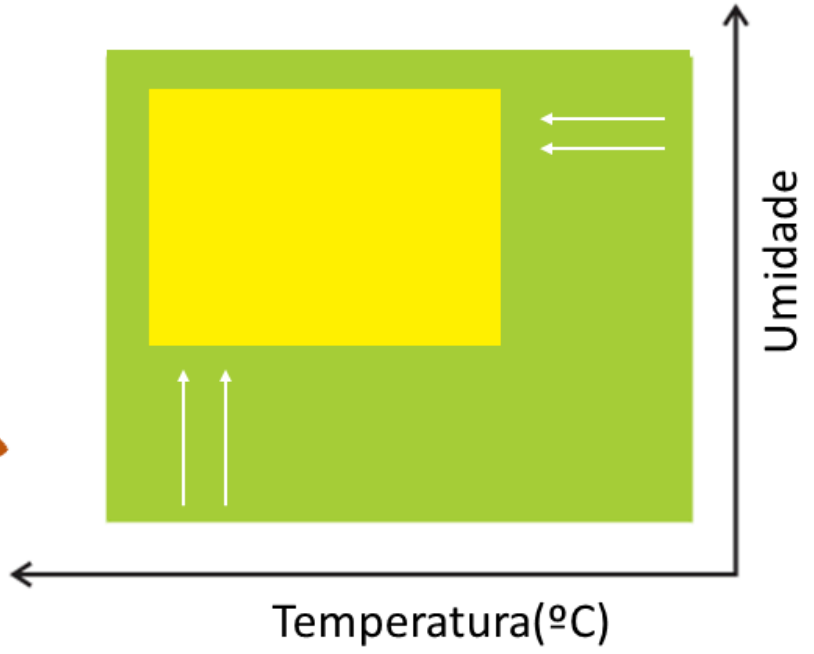


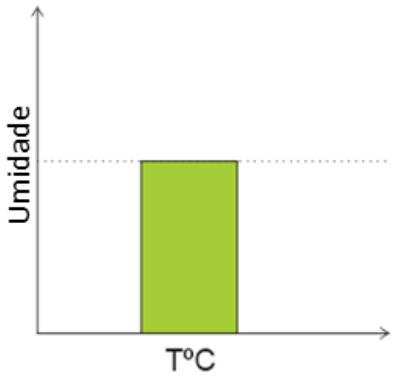


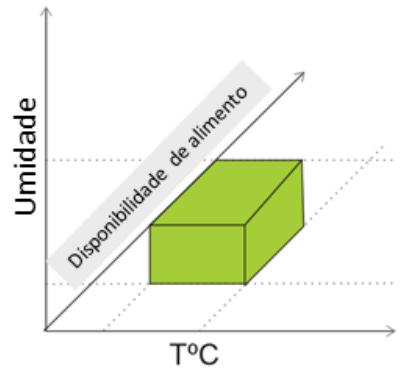


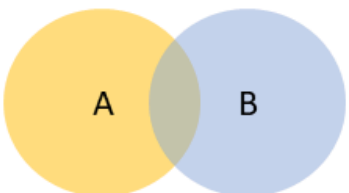
Nicho em dimensões

Hutchinson (1957)



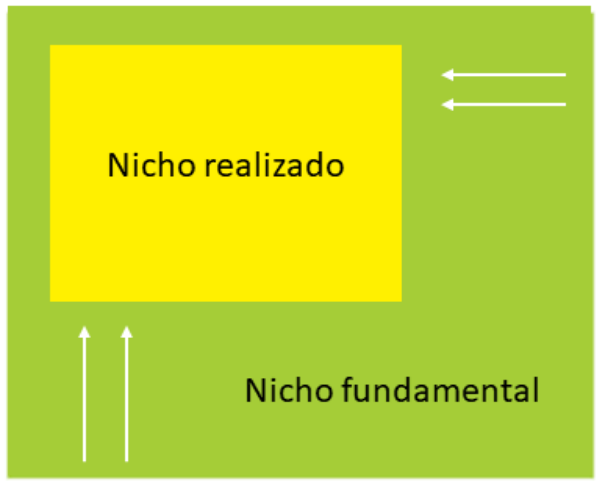






Hutchinson (1957)

Nicho em dimensões



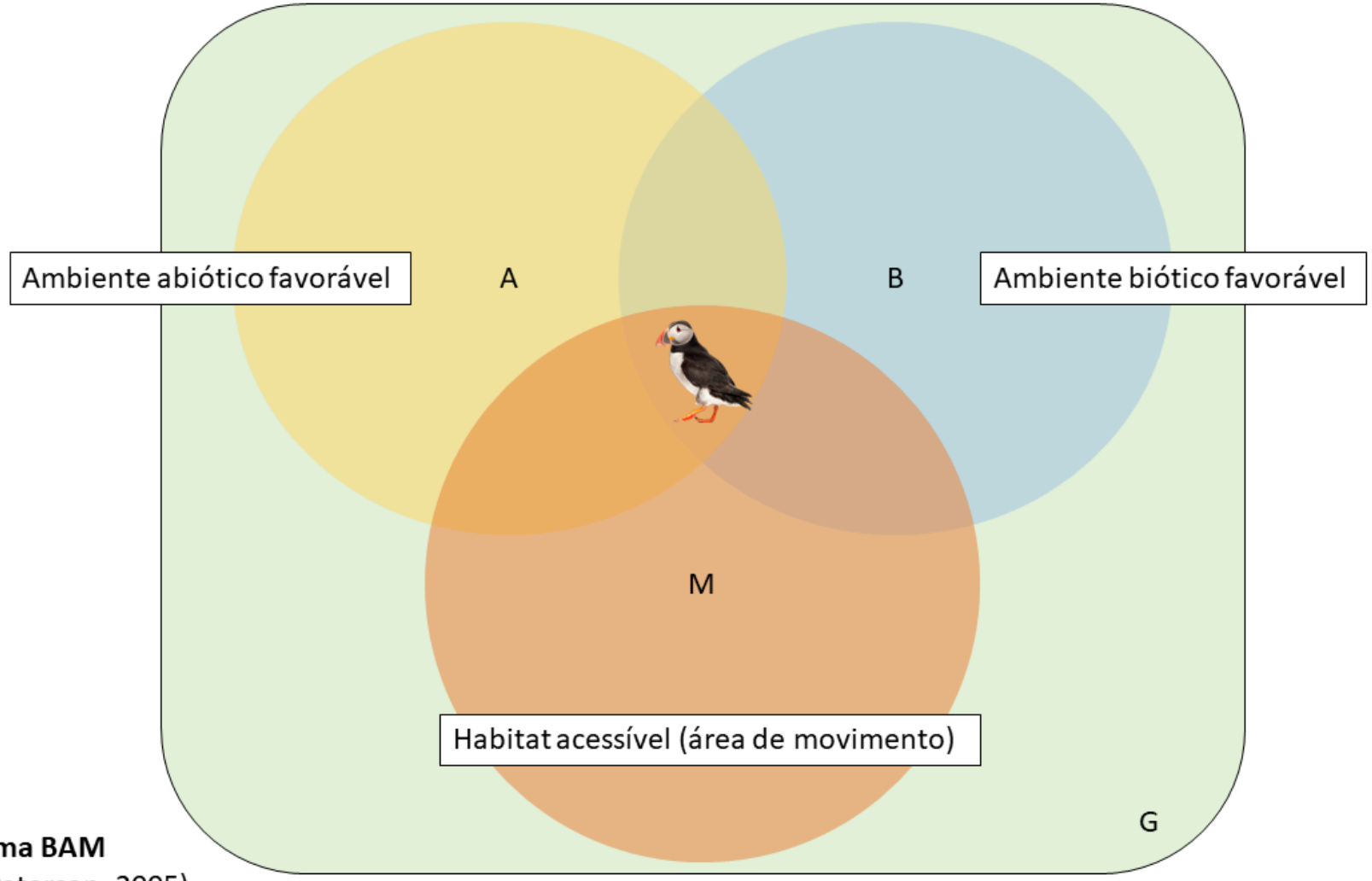


Diagrama BAM
(Soberón & Peterson, 2005)

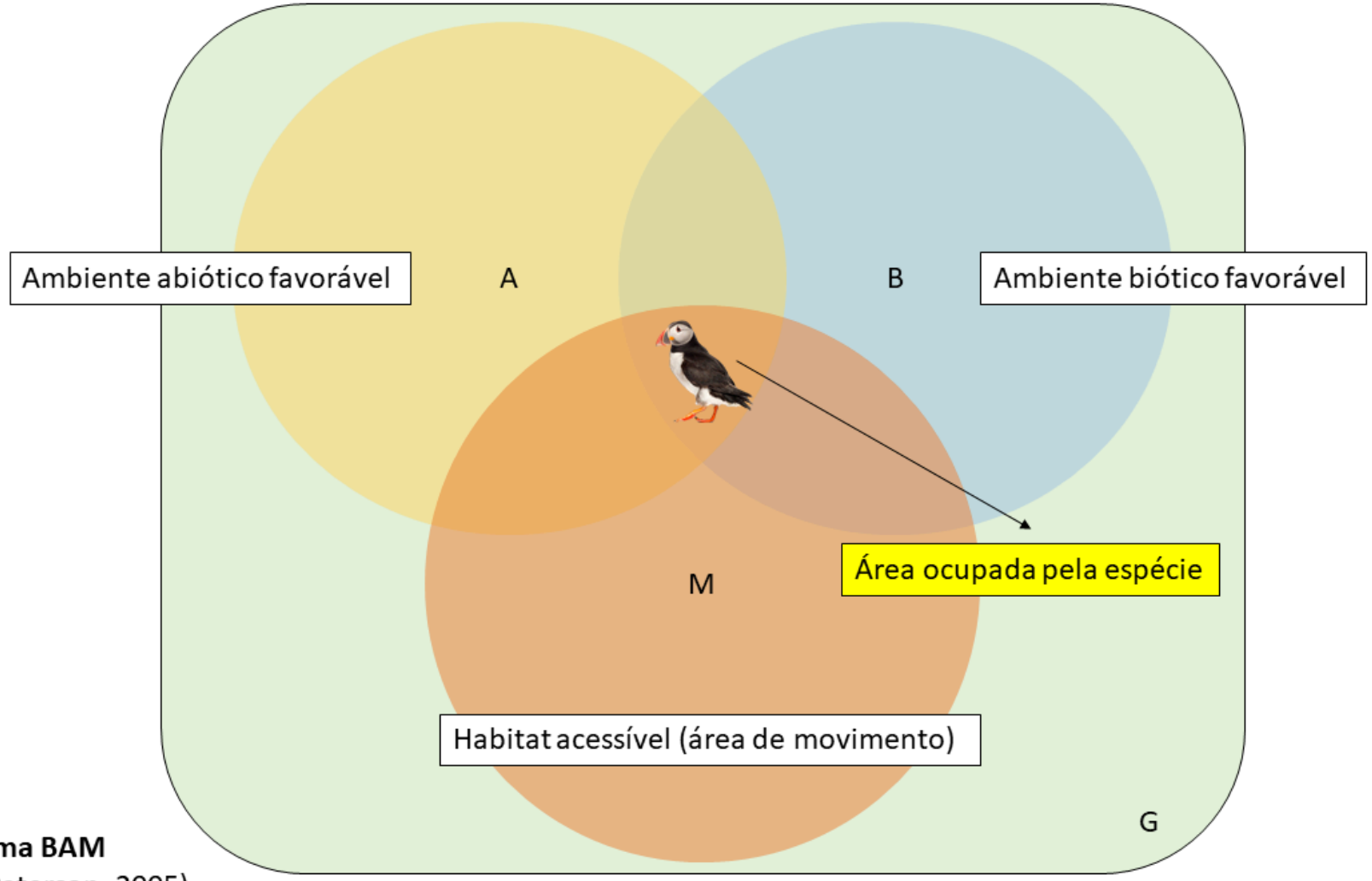


Diagrama BAM
(Soberón & Peterson, 2005)

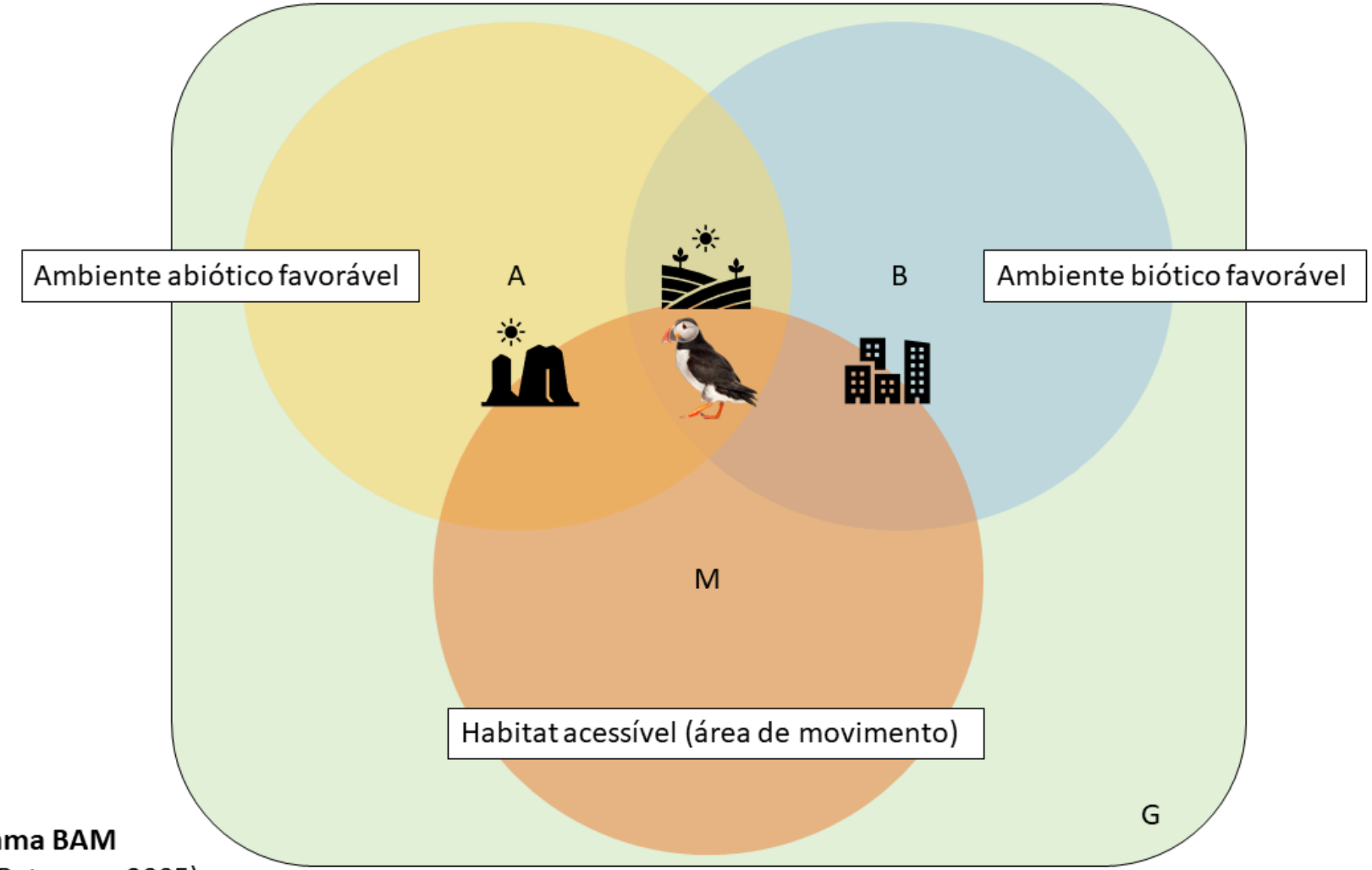


Diagrama BAM
(Soberón & Peterson, 2005)

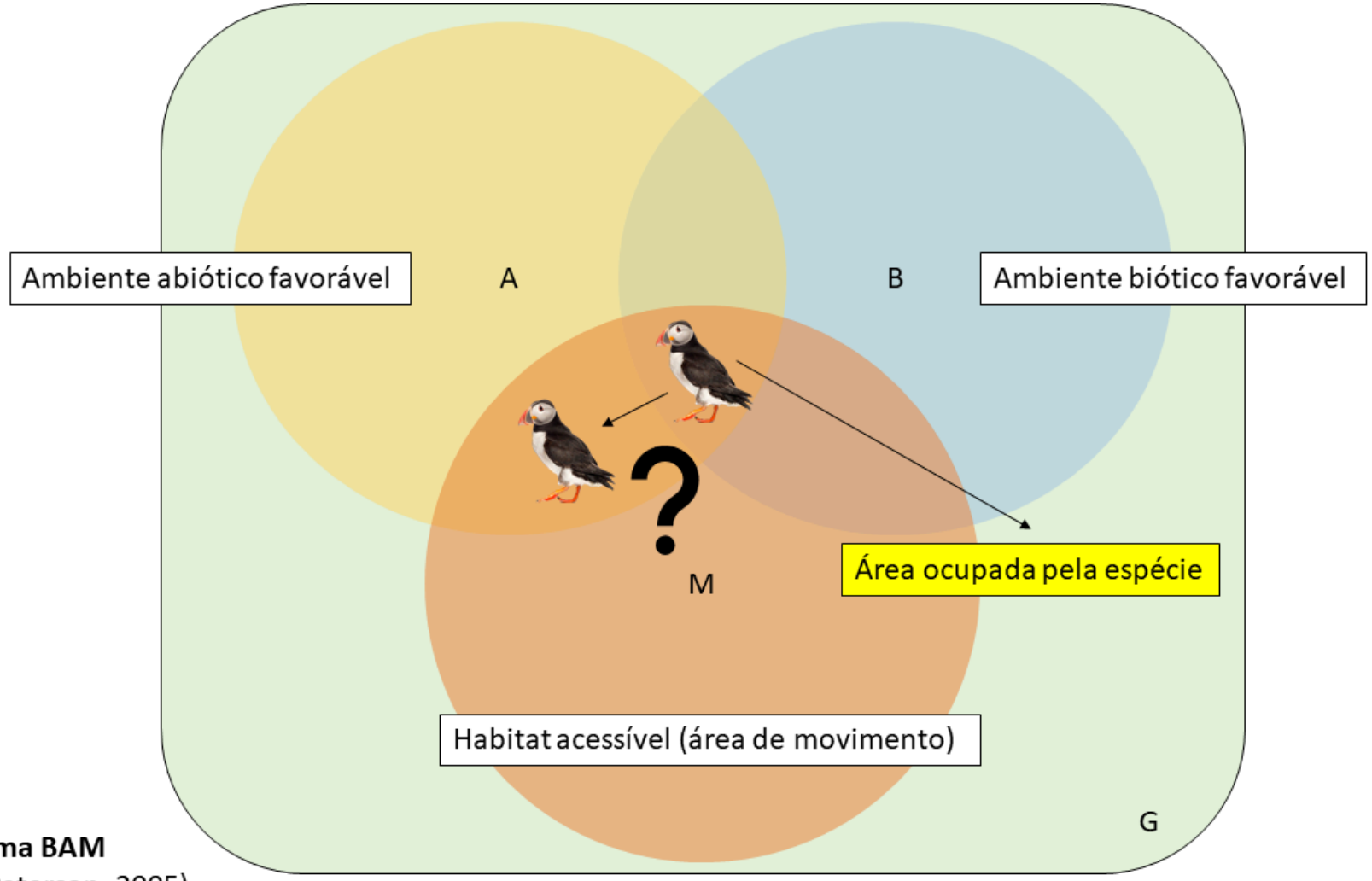


Diagrama BAM
(Soberón & Peterson, 2005)

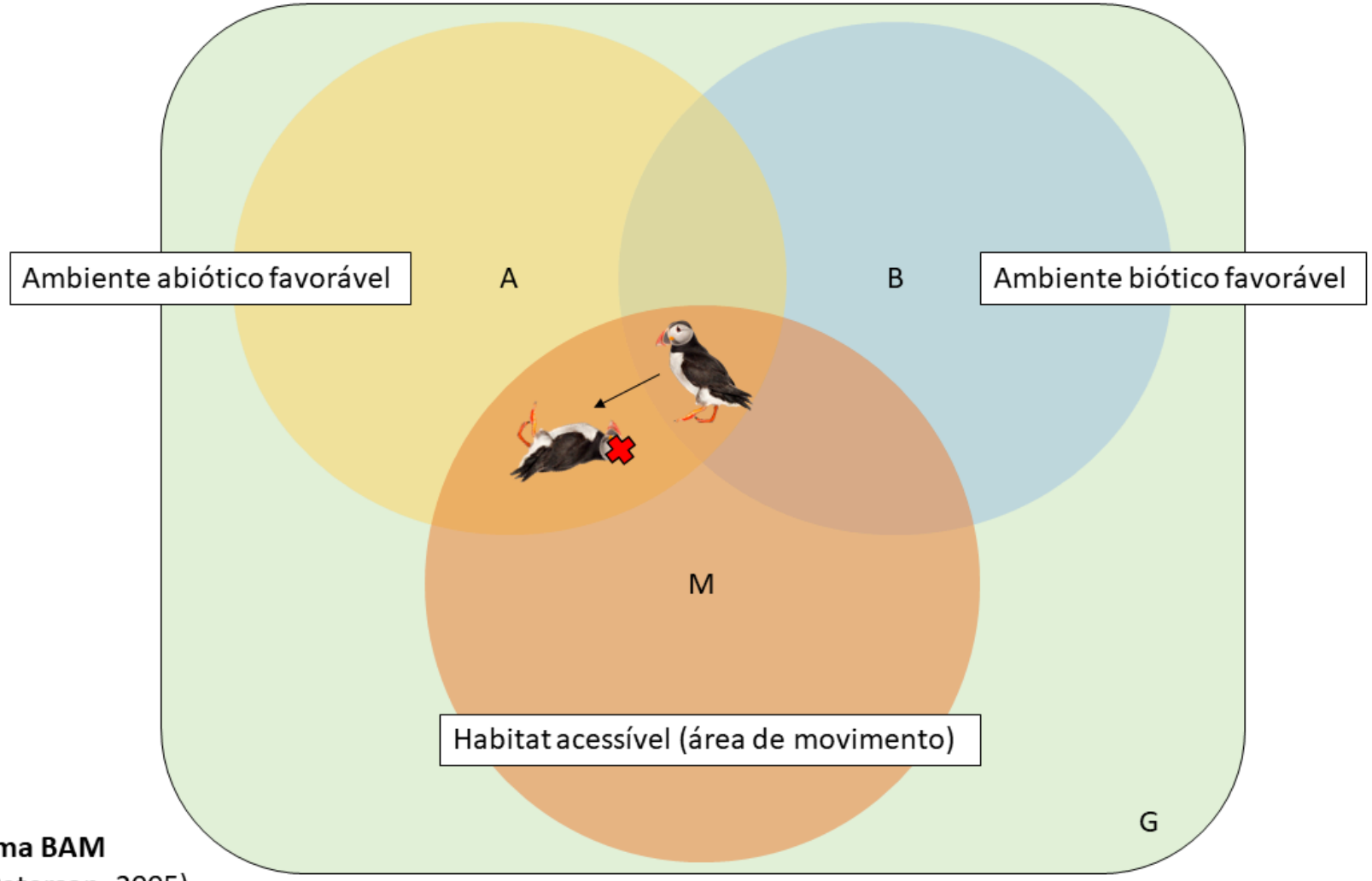
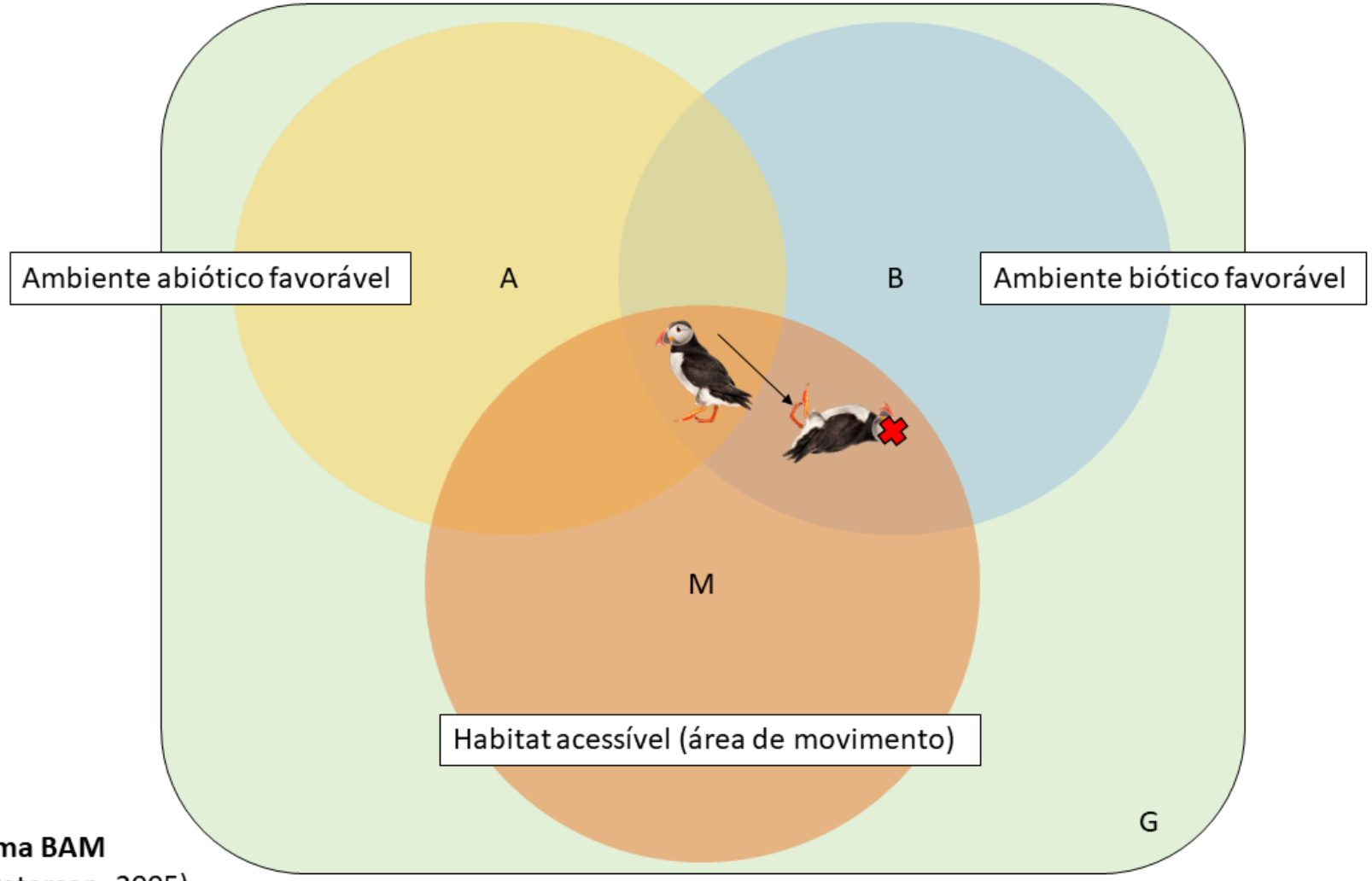


Diagrama BAM
(Soberón & Peterson, 2005)



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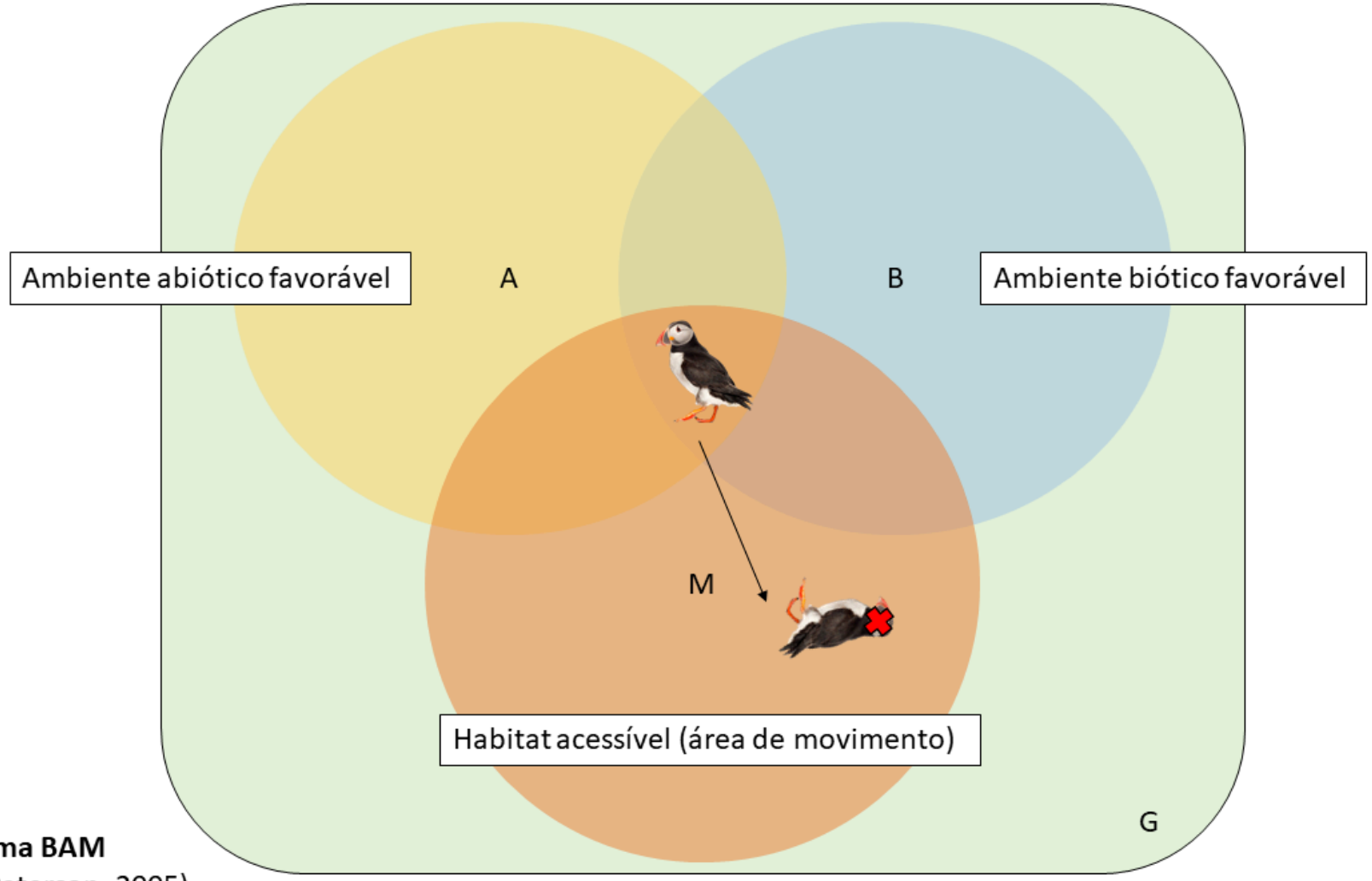


Diagrama BAM
(Soberón & Peterson, 2005)

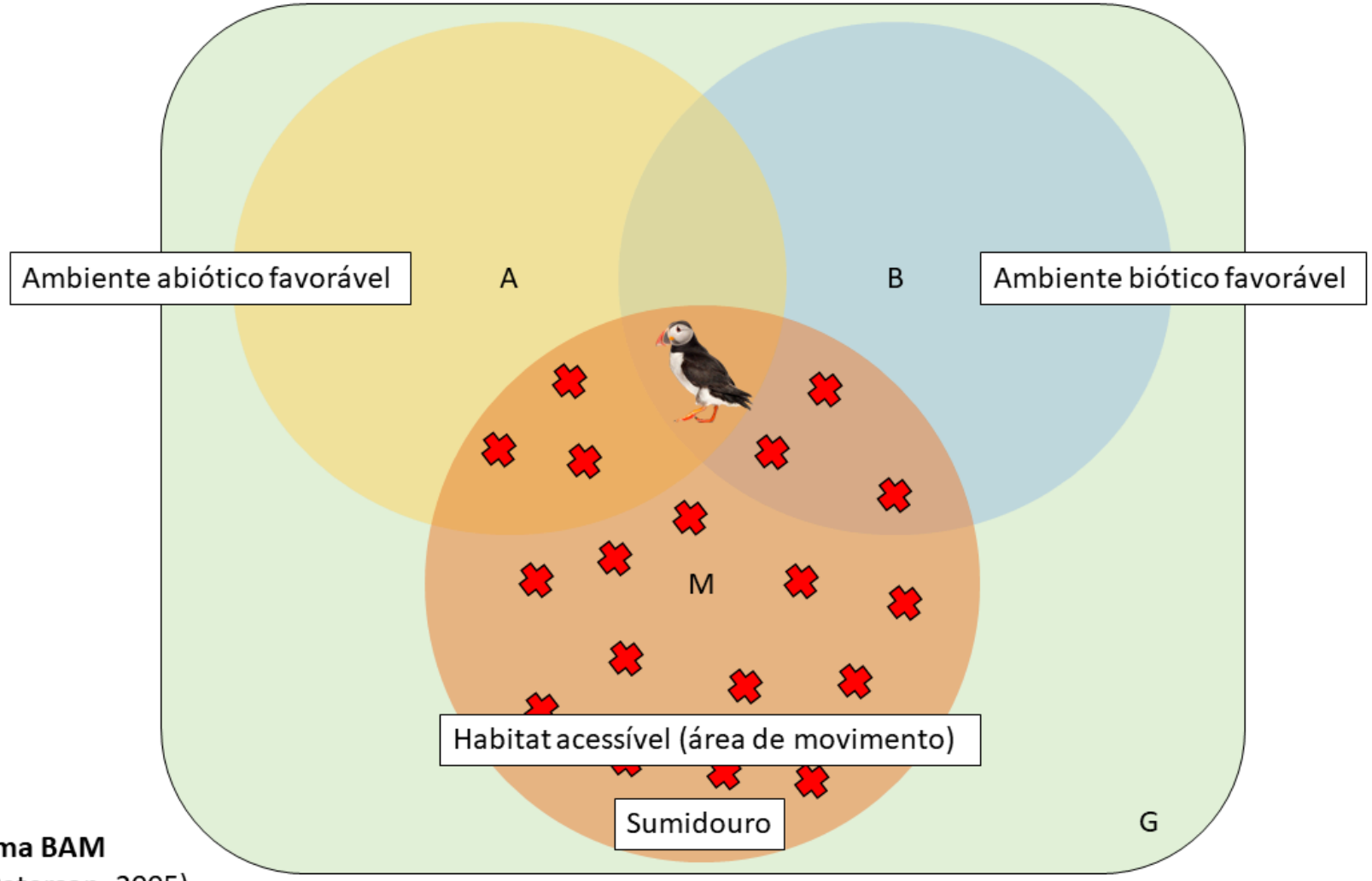


Diagrama BAM
(Soberón & Peterson, 2005)

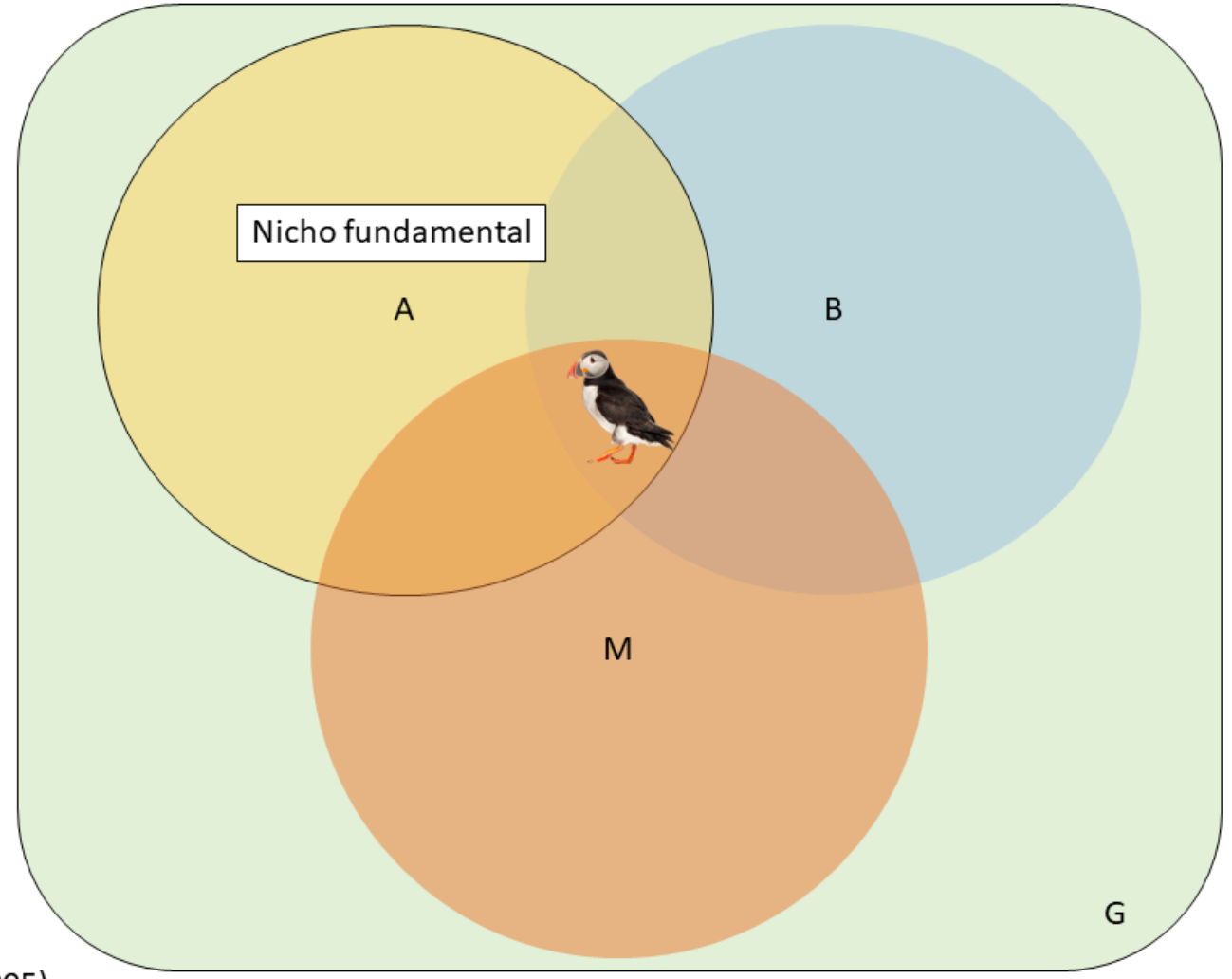


Diagrama BAM
(Soberón & Peterson, 2005)

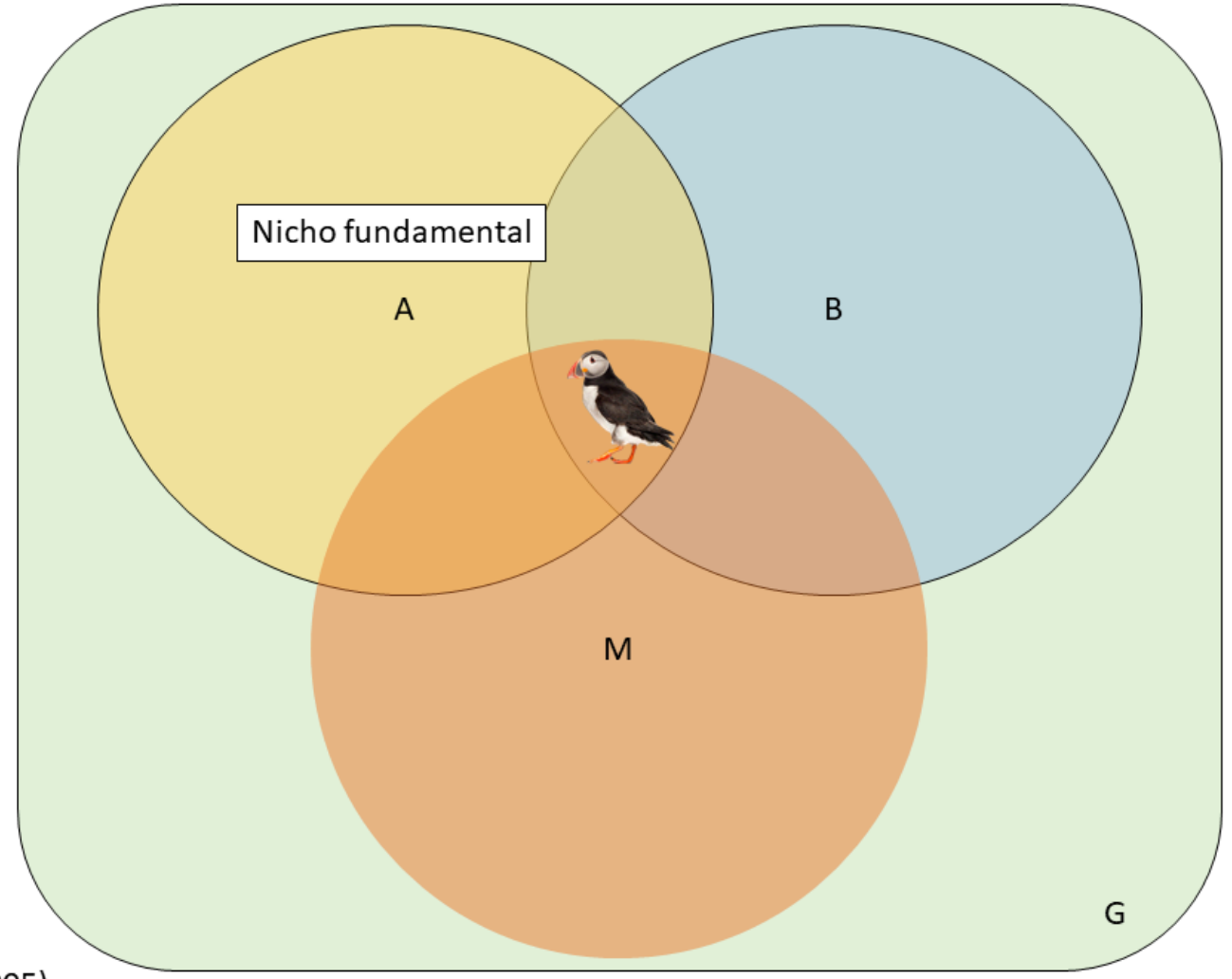


Diagrama BAM
(Soberón & Peterson, 2005)

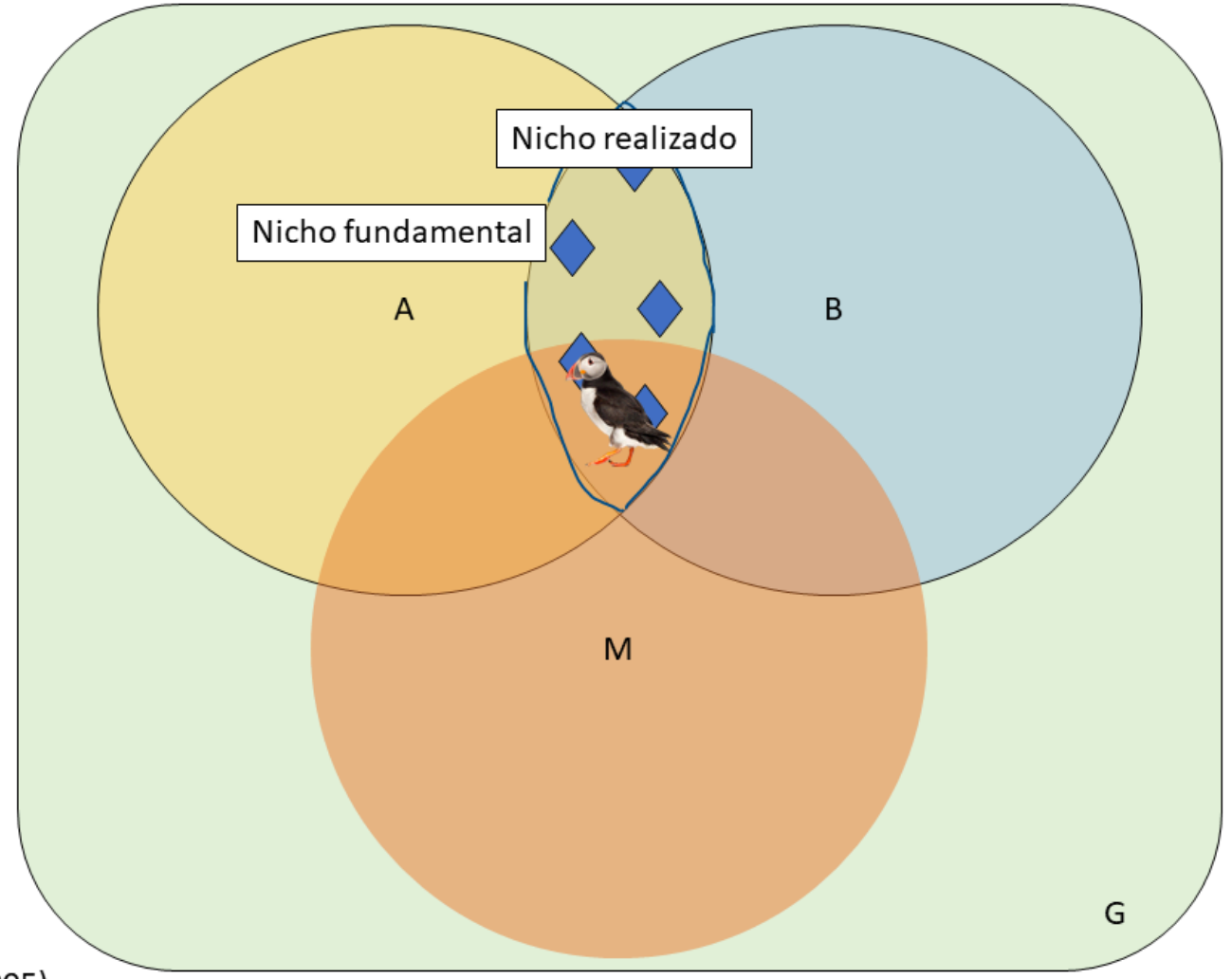


Diagrama BAM
(Soberón & Peterson, 2005)

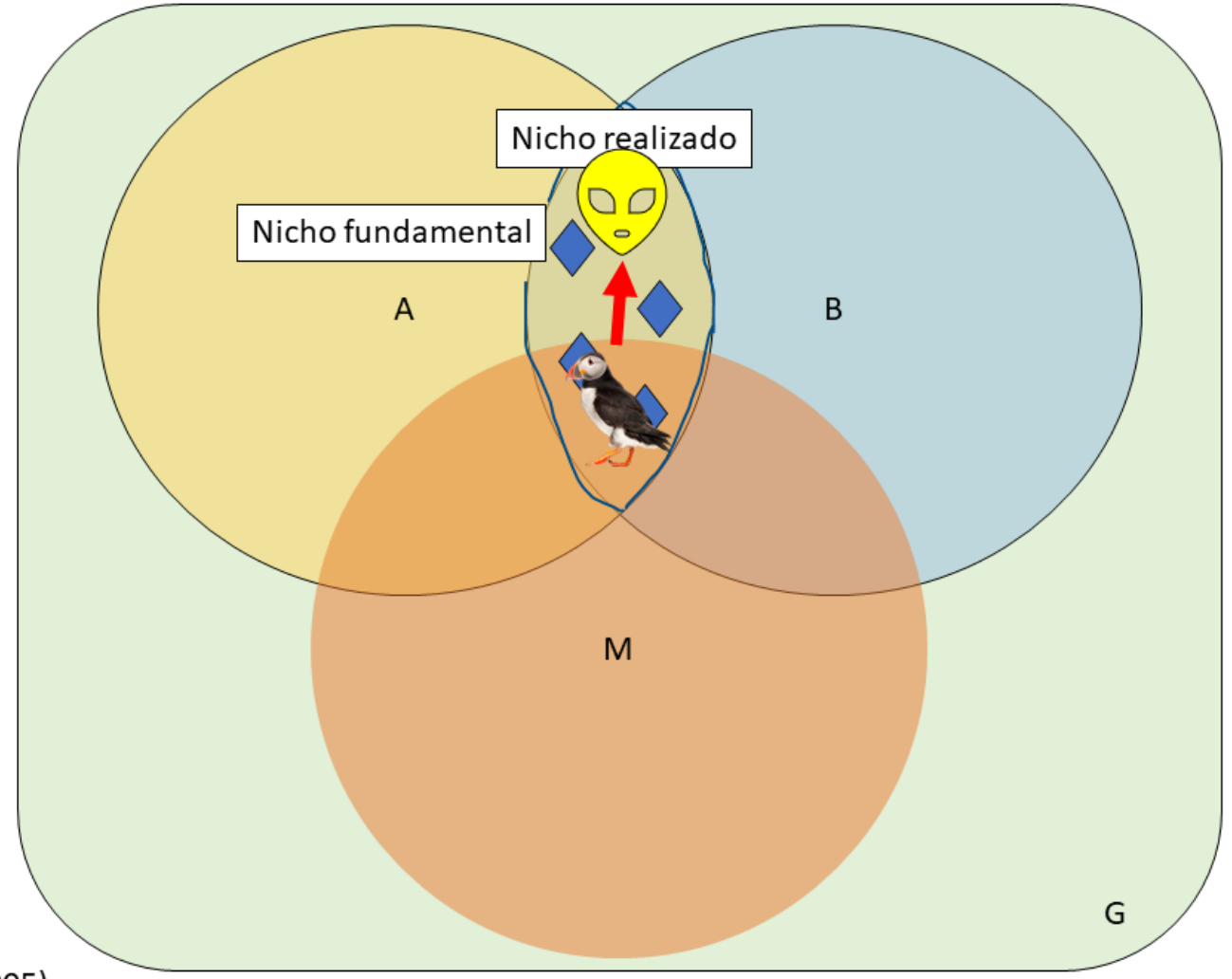
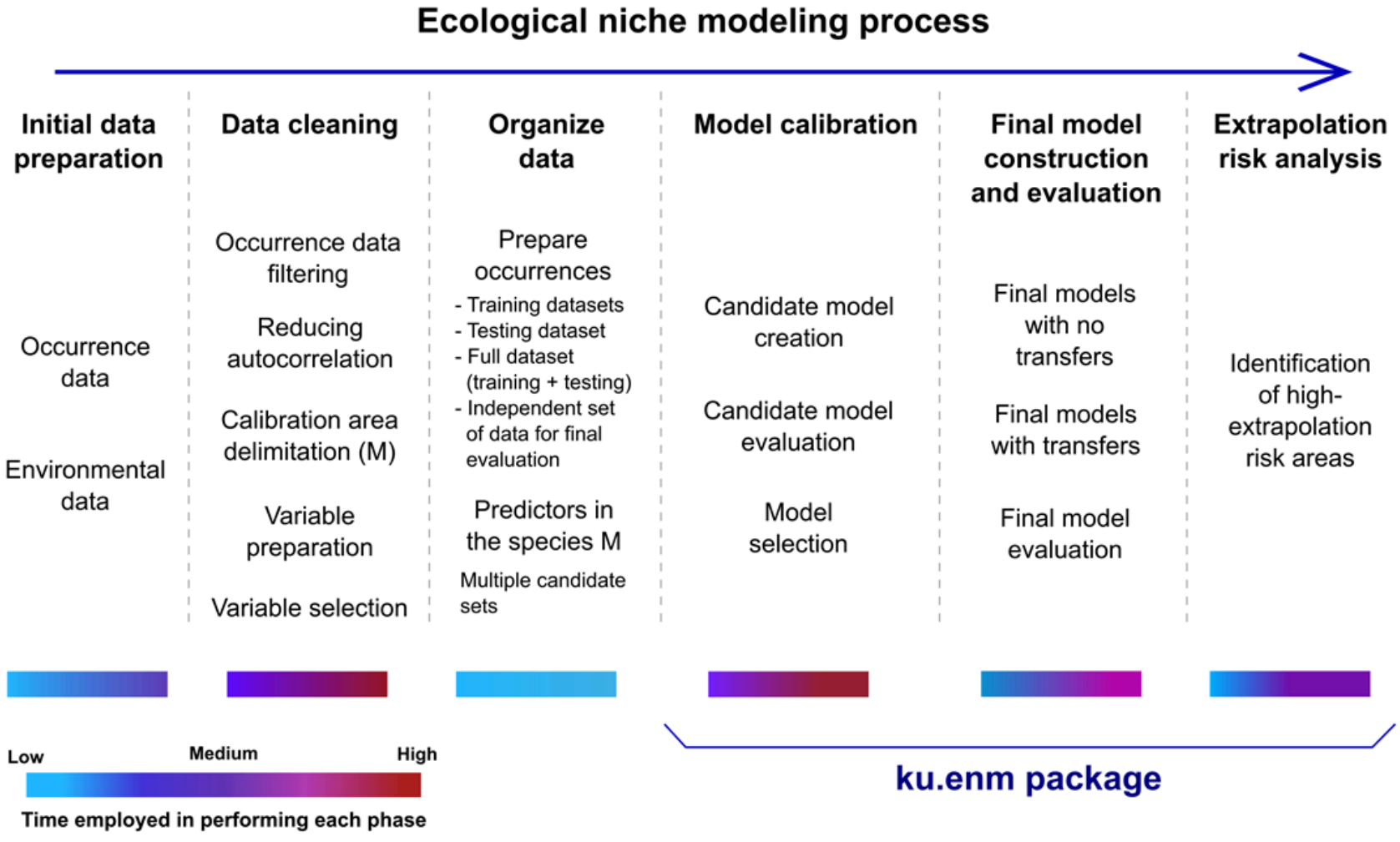
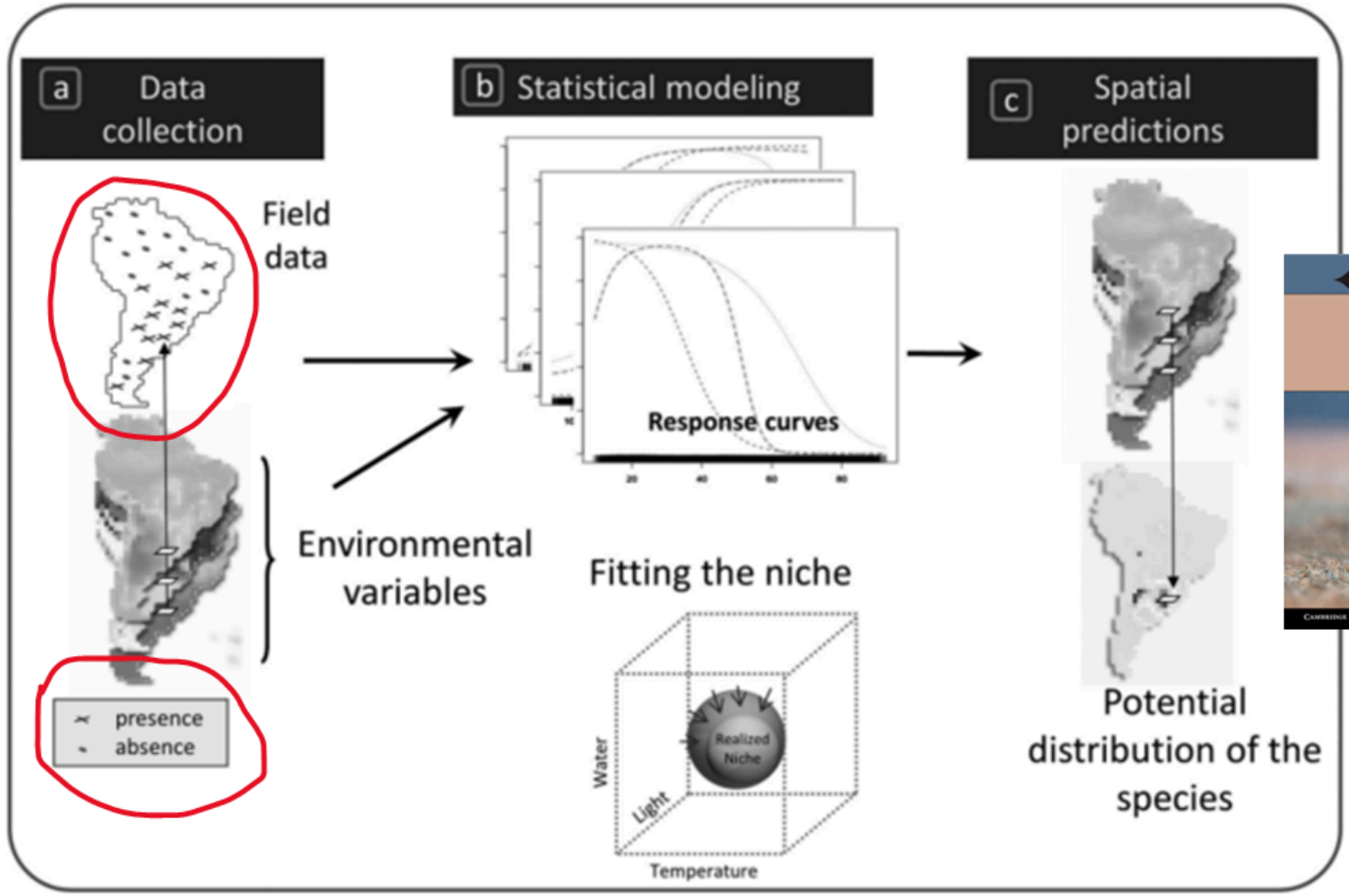
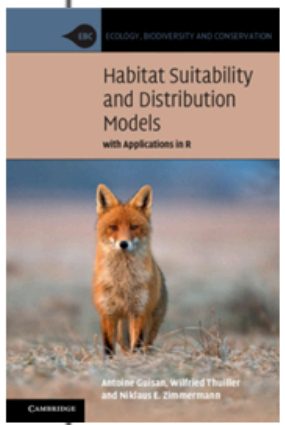


Diagrama BAM
(Soberón & Peterson, 2005)

Métodos

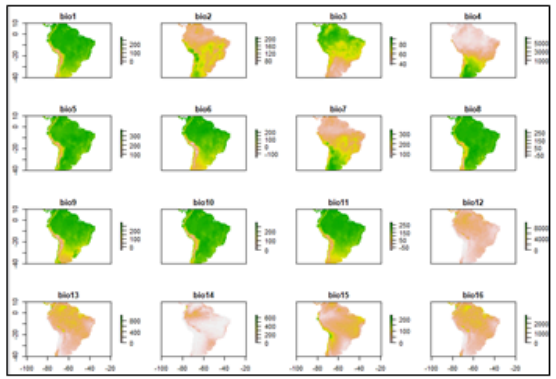

Ecological niche modeling process
Initial data preparation
Occurrence data
Environmental data
Data cleaning
Occurrence data filtering
Reducing autocorrelation
Calibration area delimitation (M)
Variable preparation
Variable selection
Organize data
Prepare occurrences
- Training datasets
- Testing dataset
- Full dataset (training + testing)
- Independent set of data for final evaluation
Predictors in the species M
Multiple candidate sets
Model calibration
Candidate model creation
Candidate model evaluation
Model selection
Final model construction and evaluation
Final models with no transfers
Final models with transfers
Final model evaluation
Extrapolation risk analysis
Identification of high-extrapolation risk areas
Low
Medium
High
Time employed in performing each phase
ku.enm package


a Data collection
b Statistical modeling
c Spatial predictions
Field data
Environmental variables
presence
absence
Response curves
Fitting the niche
Realized Niche
Water
Light
Temperature
Potential distribution of the species


Habitat Suitability and Distribution Models
with Applications in R
Antoine Guisan, Wilfried Thuiller and Niklaus E. Zimmermann
CAMBRIDGE

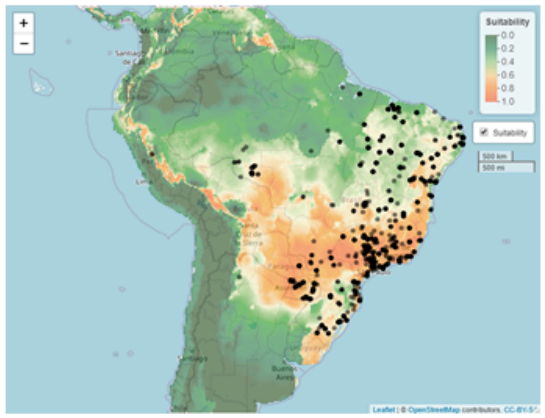
O que são modelos de distribuição de espécies?

~



=

Modelo/s!



	Nome/s da espécie	Longitude	Latitude
1	Trigona spinipes	-43.16248	-22.953575
2	Trigona spinipes	-47.89580	-15.844967
3	Trigona spinipes	-46.36071	-22.999322
4	Trigona spinipes	-47.85274	-15.670733
5	Trigona spinipes	-47.03776	-22.784671
6	Trigona spinipes	-47.88682	-15.733383
7	Trigona spinipes	-47.86232	-15.768570

bio1	bio2	bio3	bio4	bio5	bio6	bio7	bio8	bio9	bio10	bio11	bio12	bio13	bio14	bio15	bio16	bio17	bio18	bio19
201	102	85	355	263	143	120	199	198	205	197	1611	263	40	55	731	168	316	172
216	100	84	355	278	160	118	214	213	221	212	1452	241	43	54	670	171	261	174
196	98	83	405	257	139	118	194	191	201	191	1872	304	57	52	851	240	318	251
207	96	83	408	267	152	115	205	202	212	202	1961	318	72	50	884	285	305	305
209	103	85	317	271	151	120	206	205	212	205	1469	240	36	56	677	149	284	149
222	101	84	358	284	165	119	220	219	226	218	1335	223	40	56	627	151	238	151
206	99	83	383	268	149	119	203	202	211	202	1650	272	49	55	769	205	272	207
210	97	83	405	271	155	116	208	206	216	206	1783	292	62	53	824	248	270	257
218	107	86	327	281	158	123	215	217	221	214	1435	227	36	55	646	143	374	621
223	105	86	343	286	165	121	220	221	227	219	1285	212	34	57	601	127	250	569
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219	111	88	339	284	158	126	216	217	222	214	1587	246	37	53	705	161	413	683
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225	113	86	364	293	163	130	222	224	229	220	2065	301	50	47	853	237	554	841
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234	111	87	380	300	173	127	230	233	238	228	1609	254	38	53	714	165	408	697
243	109	88	366	306	183	123	239	243	246	237	1343	225	32	59	622	121	312	615
241	106	88	371	302	182	120	237	241	243	235	1207	209	24	64	582	96	278	573
247	103	87	397	308	190	118	243	247	251	241	1020	186	14	69	512	67	223	509
246	101	86	388	306	189	117	242	244	250	240	957	176	14	72	494	65	188	483
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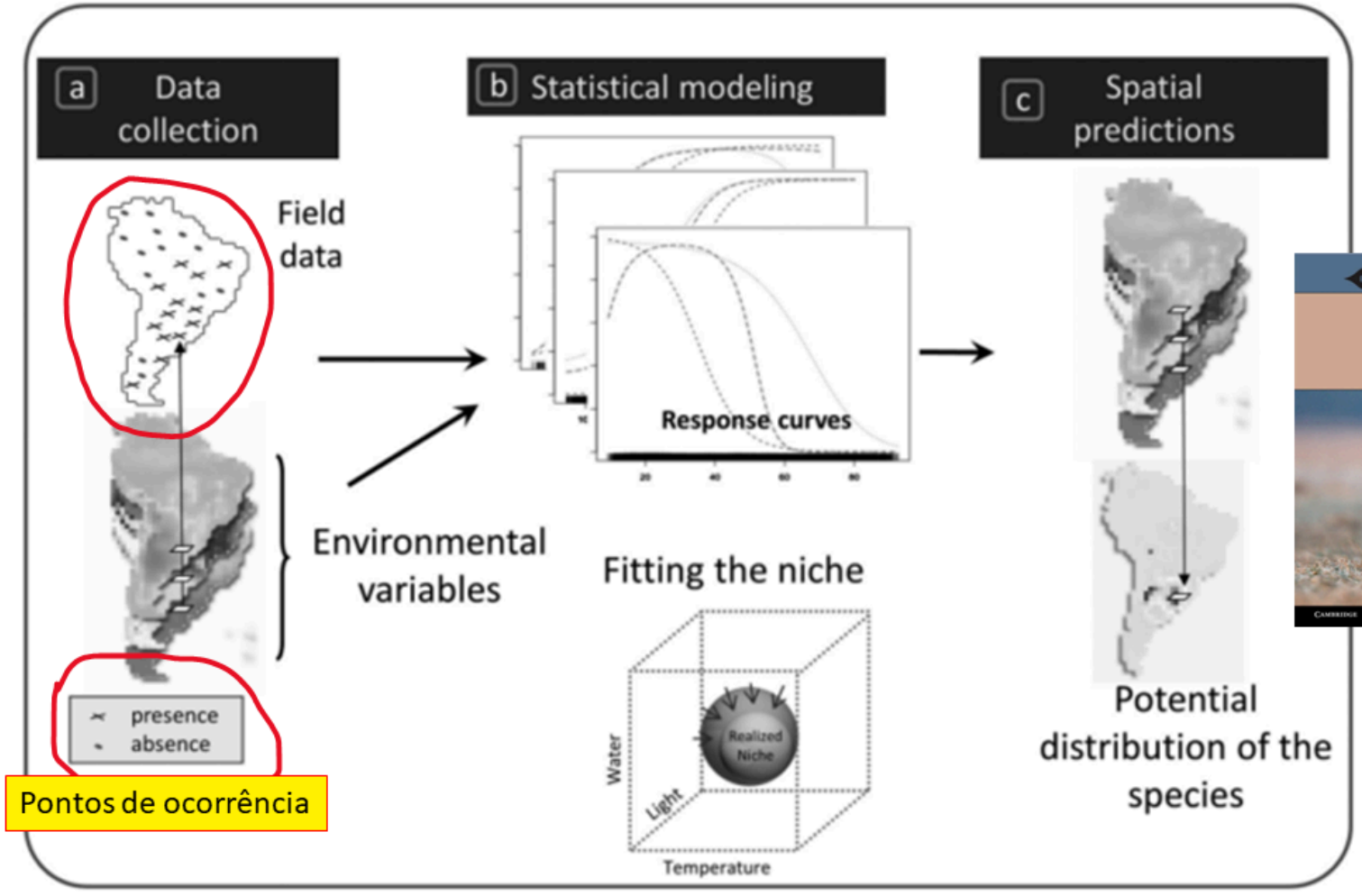
a Data collection
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Field data
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Response curves
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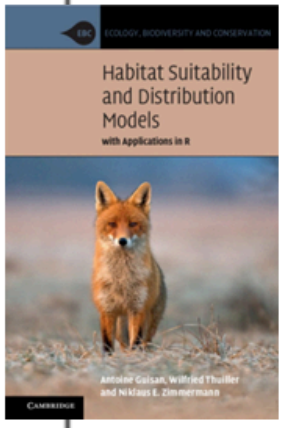
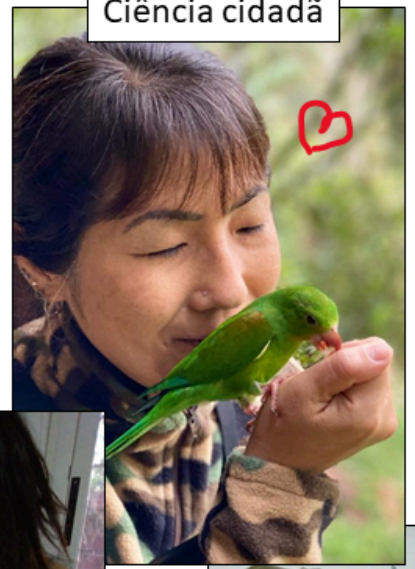
Realized Niche
Potential distribution of the species

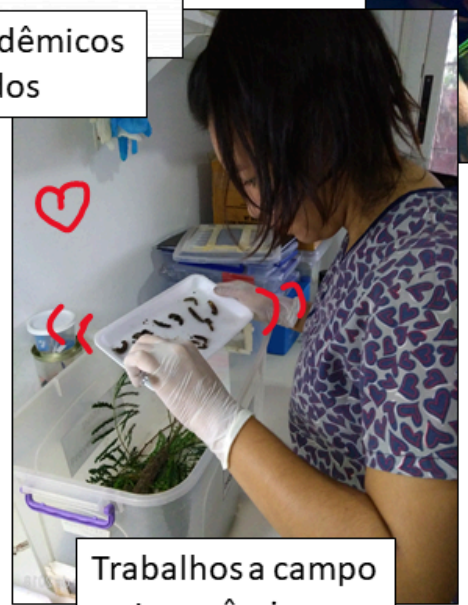

Habitat Suitability and Distribution Models
with Applications in R
Antoine Guisan, Wilfried Thuiller and Niklaus E. Zimmermann
CAMBRIDGE

Pontos de ocorrência

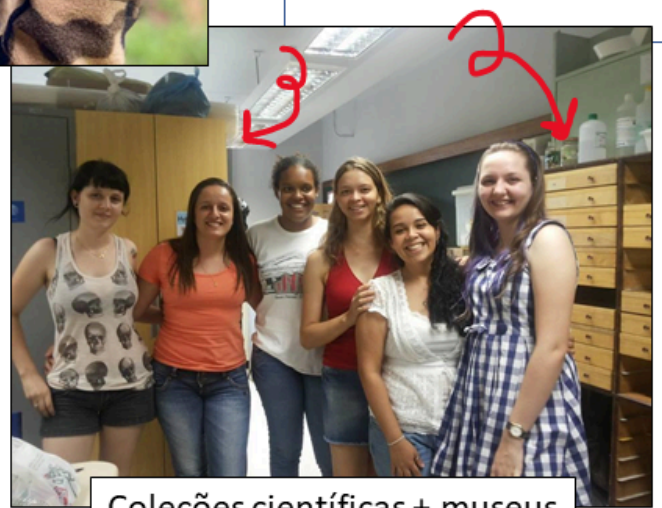
Trabalhos acadêmicos publicados

Ciência cidadã





Trabalhos a campo taxonômicos



Coleções científicas + museus

speciesLink

GBIF Global Biodiversity Information Facility

Banco de dados

Ciência cidadã

WIKIAVES

RELATO DE EVENTOS PREDATÓRIOS EM *Lonomia* spp. (Saturniidae: Hemileucinae)

Marília Melo Favalesso[1], Luciana Chiyo[2], Milena Casafús[1], Ana Tereza Bittencourt Guimarães[3] & Maria Elisa Peichoto[1]*

[1] "Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)", "Instituto Nacional de Medicina Tropical (INMeT)" - ANLIS "Dr. Carlos G Malbrán", Grupo de Investigación en Biotoxinología (GrinBiTox), Almafuerte y Ámbar s/n, Código Postal: 3370, Puerto Iguazú (Misiones), Argentina.

[2] Centro de Controle de Zoonoses, Av. Maceió, nº 1511, CEP: 85869-675, Foz do Iguaçu,PR, Brasil.

[3] Universidade Estadual do Oeste do Paraná, Centro de Ciências Biológicas e da Saúde, Rua Universitária, nº 2069, CEP: 85819-110, Cascavel, PR, Brasil.

E-mails: biologist.mmf@gmail.com (*corresponding author), milecasafus@gmail.com, mepeichoto@yahoo.com.ar, anatbguimaraes@gmail.com

Resumo: *Lonomia*
devido a ocorrênc
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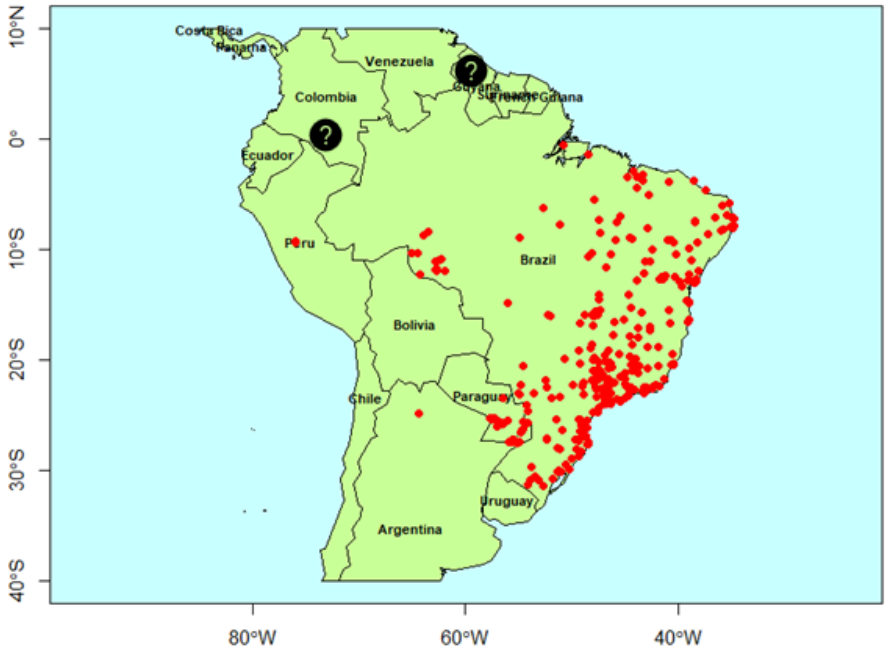
de predação de sua
1817, e o segundo p

Palavras-chave: In

Pontos de ocorrência



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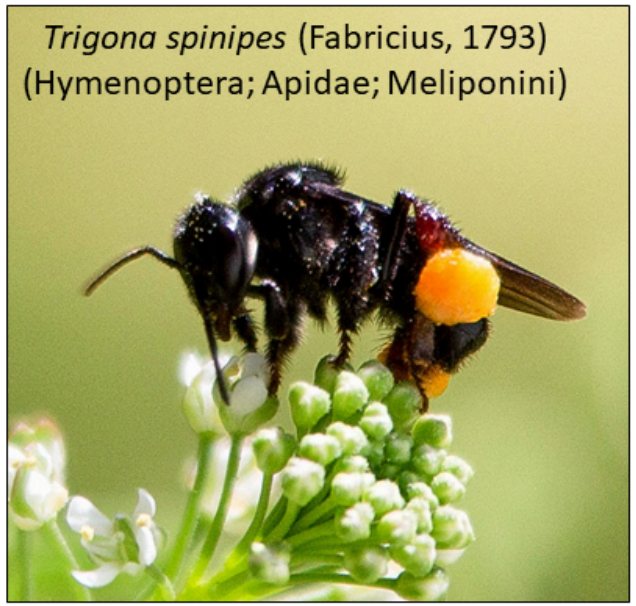


Região neotropical (http://moure.cria.org.br/catalogue):
1. Argentina (Misiones); 2. Brazil; 3. Colombia; 4. Guyana; 5. Paraguay; 6. Peru (Madre de Dios)

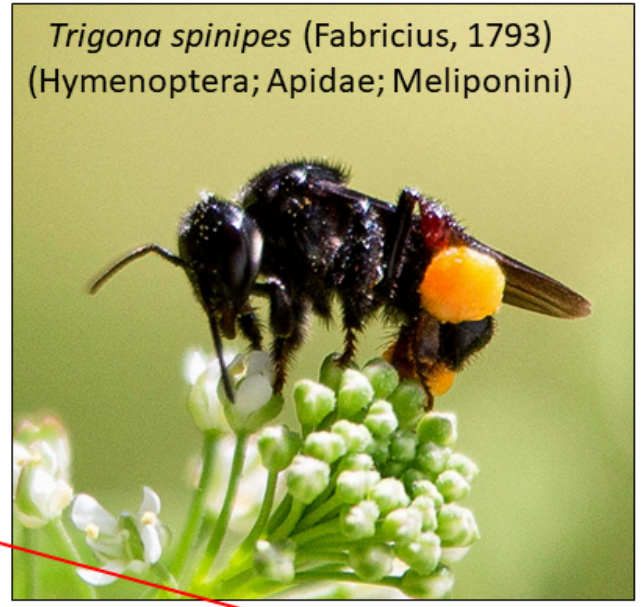
Pontos de ocorrência

Necessário complementar as presenças!

Dependência de esforço amostral!

GBIF Global Biodiversity Information Facility

Trigona spinipes (Fabricius, 1793)
(Hymenoptera; Apidae; Meliponini)



Região neotropical (http://moure.cria.org.br/catalogue):
1. Argentina (Misiones); 2. Brazil; 3. Colombia; 4. Guyana; 5. Paraguay; 6. Peru (Madre de Dios)

Pontos de ocorrência

GBIF Global Biodiversity Information Facility

	Nome/s da espécie	Longitude	Latitude
1	Trigona spinipes	-43.16248	-22.953575
2	Trigona spinipes	-47.89580	-15.844967
3	Trigona spinipes	-46.36071	-22.999322
4	Trigona spinipes	-47.85274	-15.670733
5	Trigona spinipes	-47.03776	-22.784671
6	Trigona spinipes	-47.88682	-15.733383
7	Trigona spinipes	-47.86232	-15.768570
8	Trigona spinipes	-47.83692	-15.736069
9	Trigona spinipes	-47.86270	-15.768679
10	Trigona spinipes	-43.69141	-20.523639
11	Trigona spinipes	-46.69120	-23.603072
12	Trigona spinipes	-47.83721	-15.736163
13	Trigona spinipes	-47.75991	-22.436066
14	Trigona spinipes	-49.27125	-25.452969
15	Trigona spinipes	-47.83723	-15.735802
16	Trigona spinipes	-47.85682	-15.671995
17	Trigona spinipes	-47.85250	-15.670943
18	Trigona spinipes	-47.87907	-15.779194

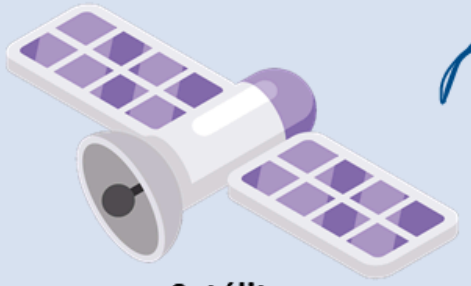
Importante revisar os dados!

Presença: Locais que sabemos que a espécie habita (georreferenciados)

Ausência: Locais onde a espécie não foi amostrada

Pseudo-ausência
Locais que hipotetizamos que a espécie não-ocorre

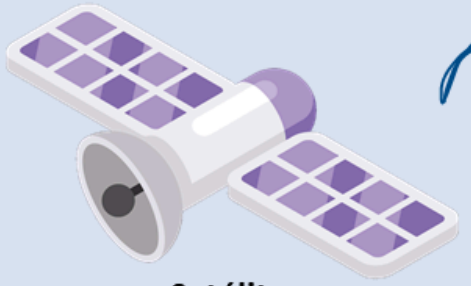
Background
Área M



Satélite

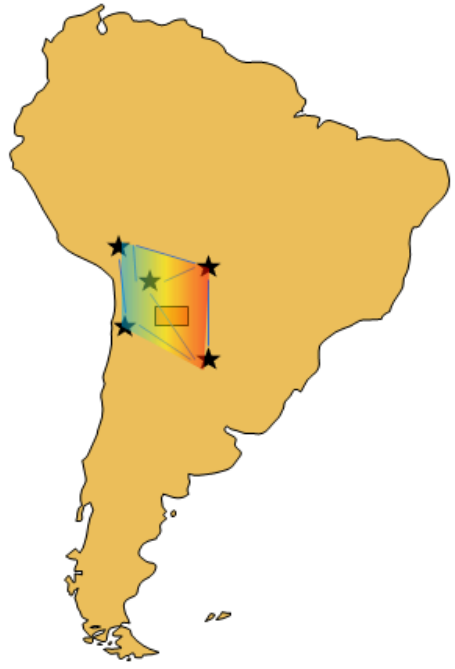
Interpolação
(Estações meteorológicas)

Variáveis bioclimáticas

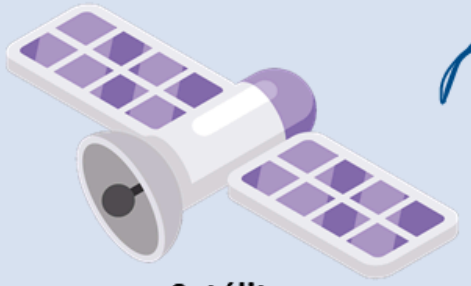


Satélite

Interpolação
(Estações meteorológicas)



Variáveis bioclimáticas

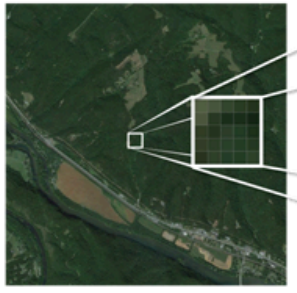


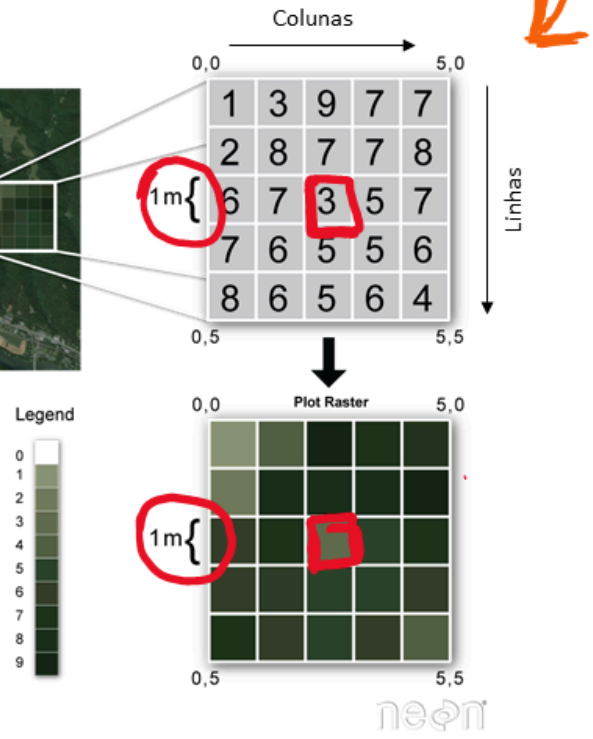
Satélite

Interpolação
(Estações meteorológicas)

Variáveis climáticas

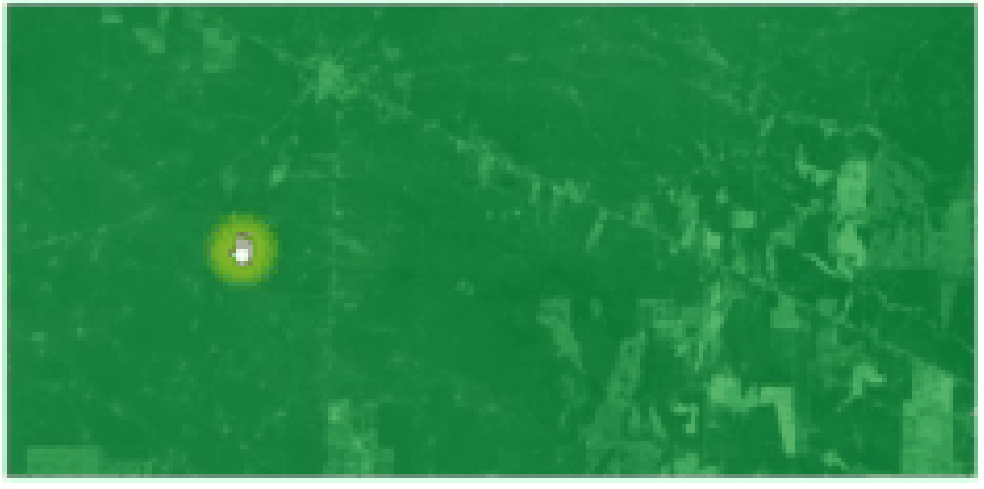
Métricas da paisagem

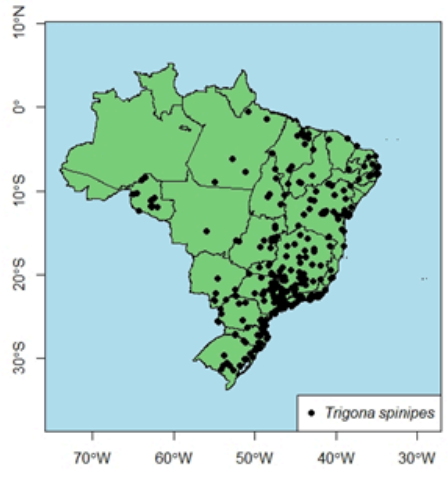


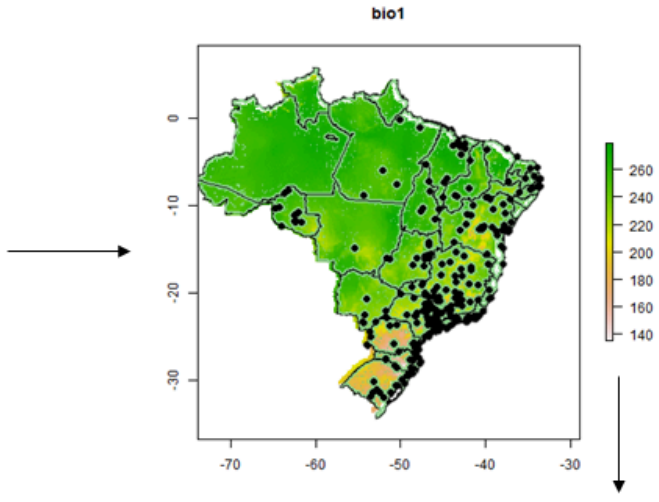


Variáveis bioclimáticas

Raster







	bio1	bio2	bio3	bio4	bio5	bio6	bio7	bio8	bio9	bio10	bio11	bio12	bio13	bio14	bio15	bio16	bio17	bio18	bio19	pres_aus
352	201	102	85	355	263	143	120	199	198	205	197	1611	263	40	55	731	168	316	172	0
353	216	100	84	355	278	160	118	214	213	221	212	1452	241	43	54	670	171	261	174	1
354	196	98	83	405	257	139	118	194	191	201	191	1872	304	57	52	851	240	318	251	1
355	207	96	83	408	267	152	115	205	202	212	202	1961	318	72	50	884	285	305	305	1
623	209	103	85	317	271	151	120	206	205	212	205	1469	240	36	56	677	149	284	149	1
624	222	101	84	358	284	165	119	220	219	226	218	1335	223	40	56	627	151	238	151	0
625	206	99	83	383	268	149	119	203	202	211	202	1650	272	49	55	769	205	272	207	0
626	210	97	83	405	271	155	116	208	206	216	206	1783	292	62	53	824	248	270	257	0
893	218	107	86	327	281	158	123	215	217	221	214	1435	227	36	55	646	143	374	621	1
894	223	105	86	343	286	165	121	220	221	227	219	1285	212	34	57	601	127	250	569	1
895	225	102	85	348	286	167	119	222	221	228	221	1249	210	35	59	599	129	222	557	1
896	228	100	85	368	289	172	117	225	225	232	224	1257	213	40	60	609	145	200	558	1
897	233	97	84	400	293	178	115	230	229	238	229	1301	219	49	58	626	169	184	173	0
1163	219	111	88	339	284	158	126	216	217	222	214	1587	246	37	53	705	161	413	683	1
1164	217	108	88	334	280	158	122	214	215	220	213	1465	235	32	57	676	138	388	647	0
1165	219	105	86	366	282	160	122	216	217	222	214	1329	220	30	60	635	122	248	600	0
1166	231	102	85	371	293	174	119	227	228	235	226	1125	194	27	64	556	102	201	525	1
1167	236	100	85	364	297	180	117	233	233	240	232	1062	186	28	65	534	104	170	500	0
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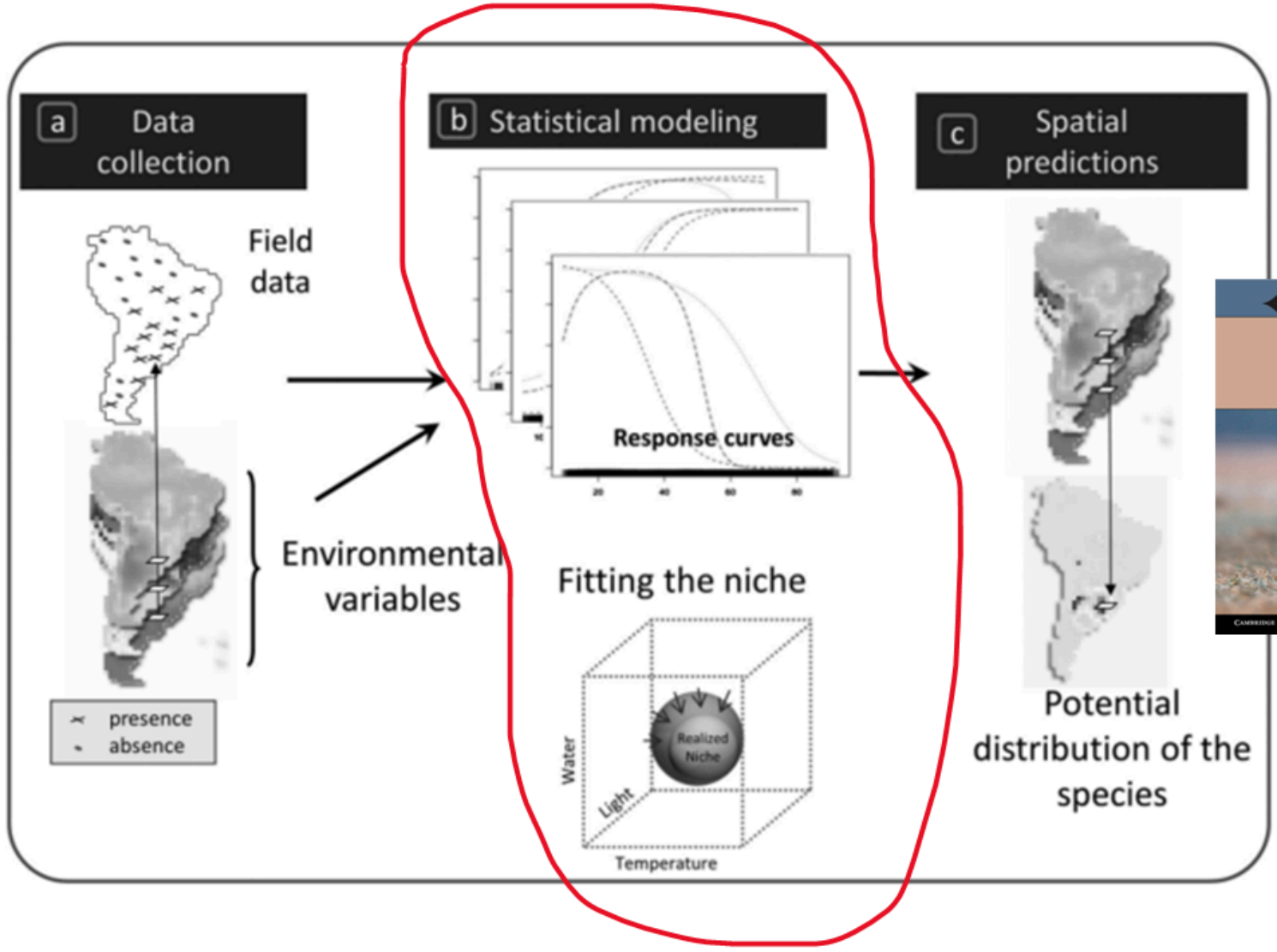
1437	246	101	86	388	306	189	117	242	244	250	240	957	176	14	72	494	65	188	483	1
1438	247	99	85	389	307	191	116	243	245	251	242	902	168	15	73	477	67	152	459	0

Pres-Aus. ~ bio1 + bio2 (...)

Preparo dos dados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Response curves
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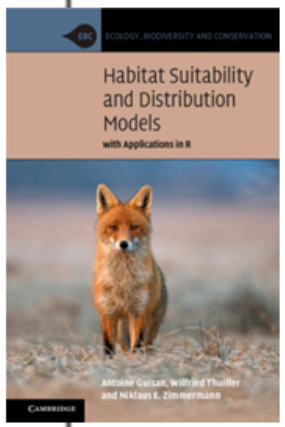
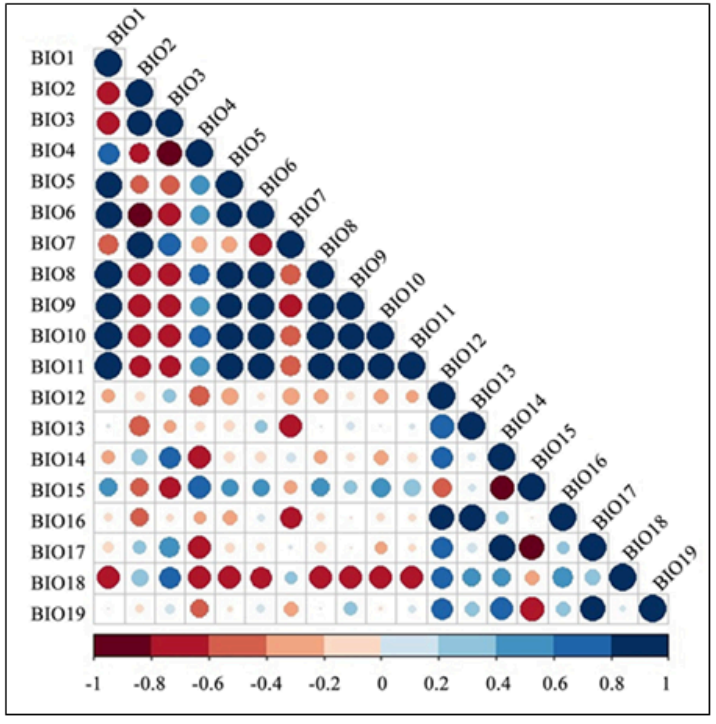
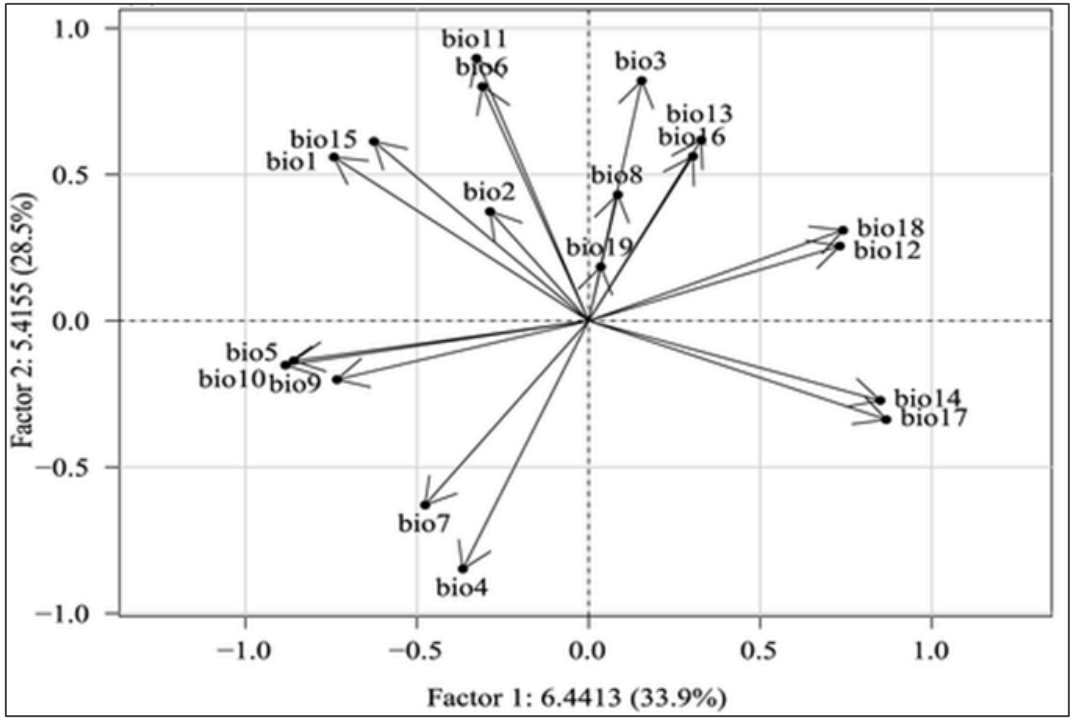
Potential distribution of the species


Habitat Suitability and Distribution Models
with Applications in R
Antoine Guisan, Wilfried Thuiller and Niklaus E. Zimmermann
CAMBRIDGE

Não esquecer de avaliar a **colinearidade**!



Correlação



PCA

Tipos de algoritmos

Envelope

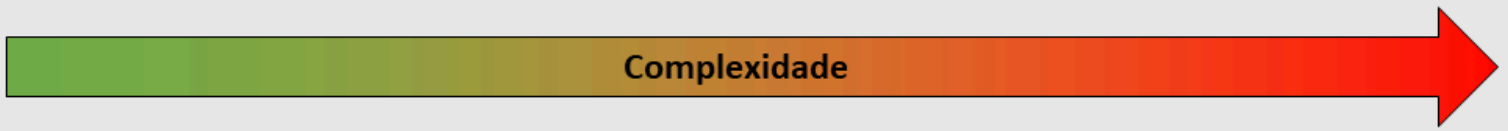
Distâncias

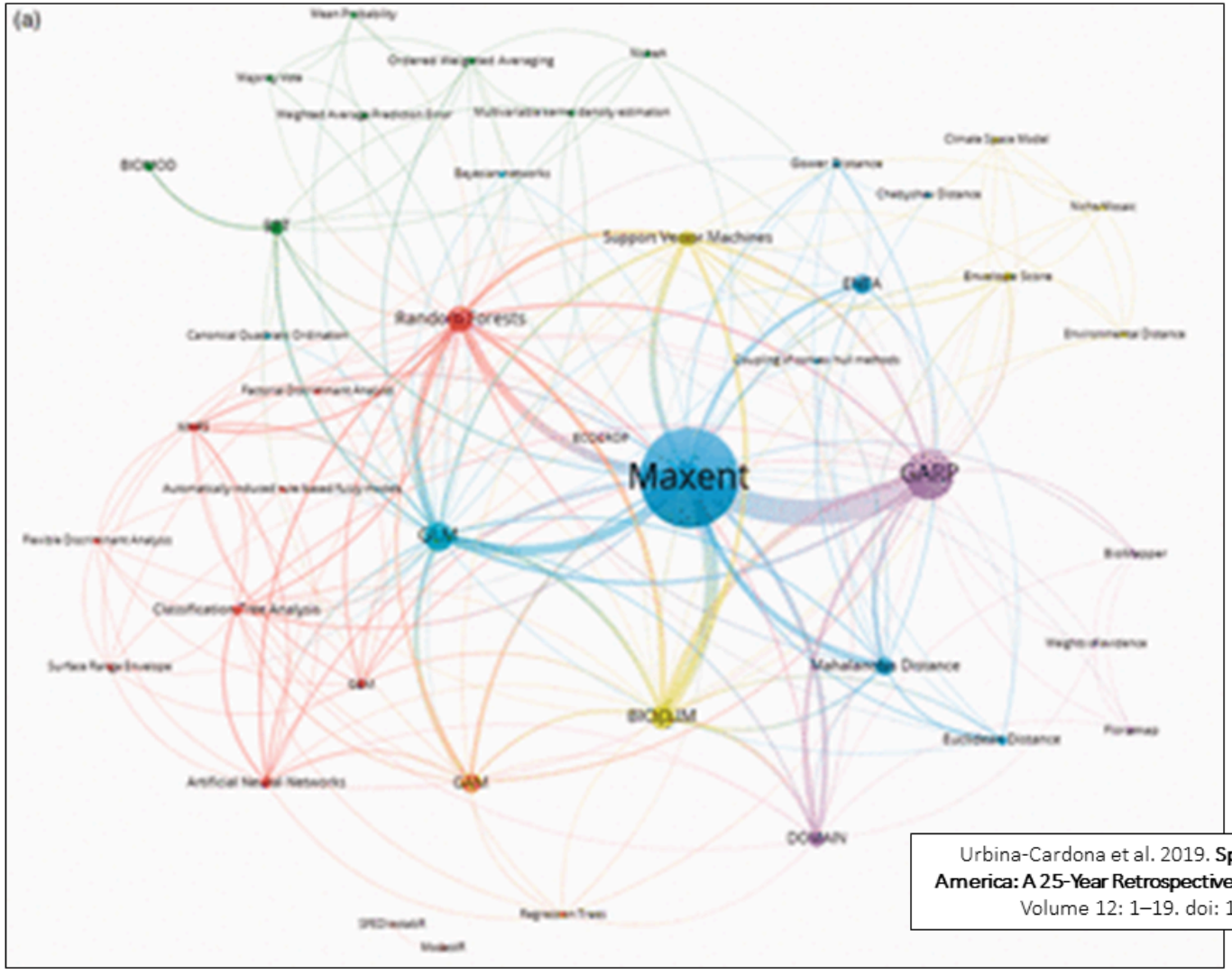
(Apenas presença)

Regressivos

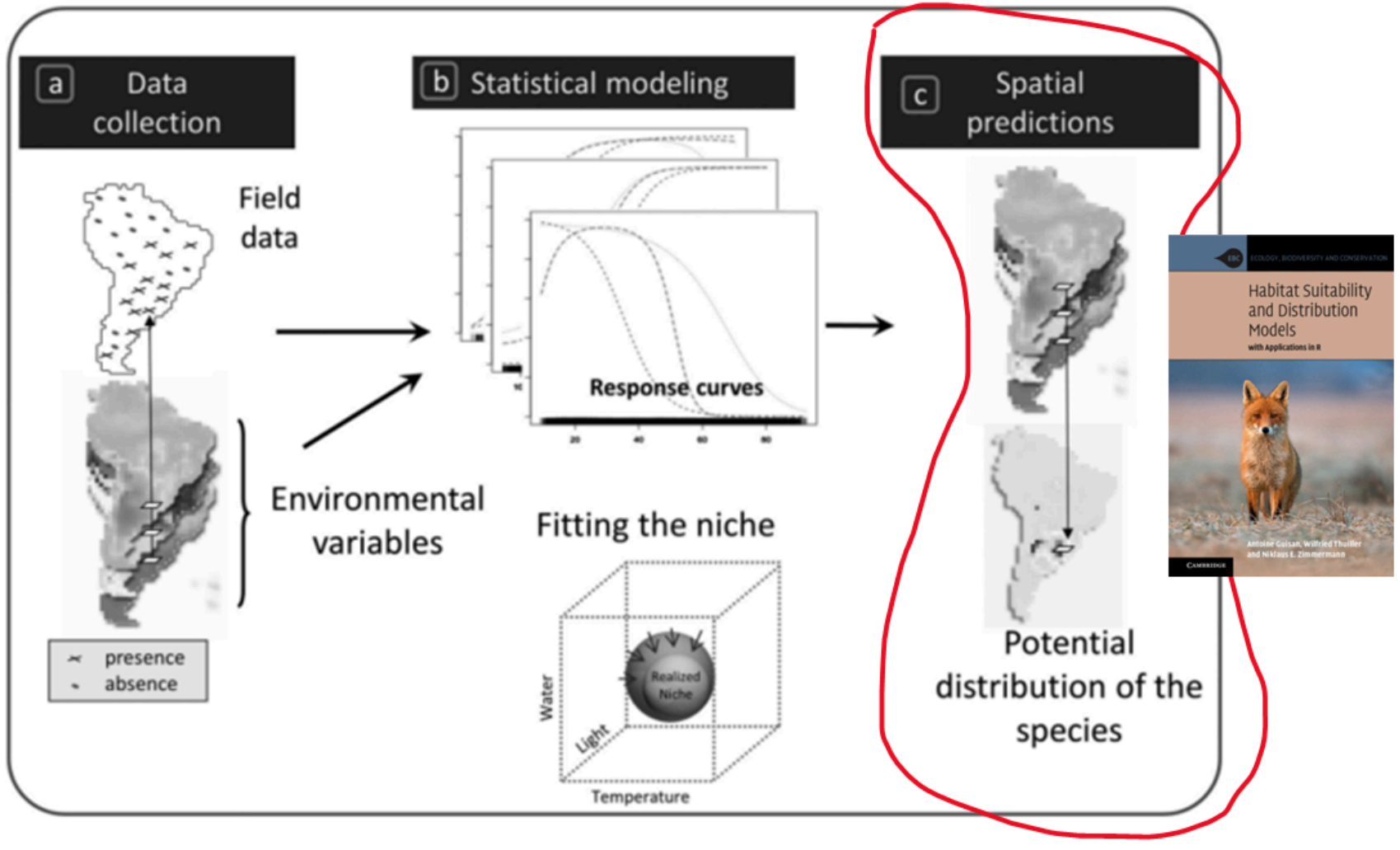
Aprendizado de máquina

Presença/background
Presença/Pseudo-ausência
Presença/ausência





Urbina-Cardona et al. 2019. **Species Distribution Modeling in Latin America: A 25-Year Retrospective Review.** Tropical Conservation Science Volume 12: 1–19. doi: 10.1177/1940082919854058.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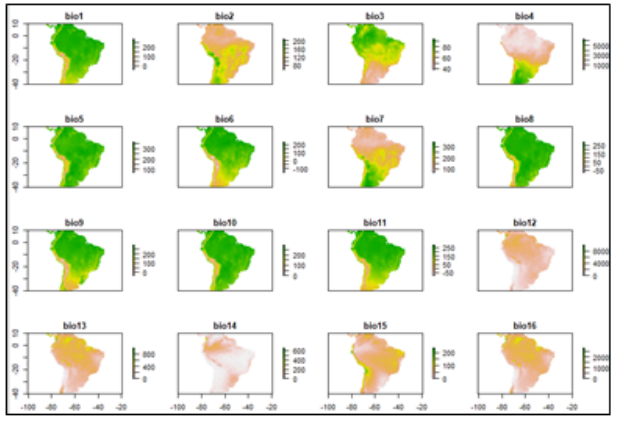

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Modelo/s!

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201	102	85	355	263	143	120	199	198	205	197	1611	263	40	55	731	168	316	172
216	100	84	355	278	160	118	214	213	221	212	1452	241	43	54	670	171	261	174
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207	96	83	408	267	152	115	205	202	212	202	1961	318	72	50	884	285	305	305
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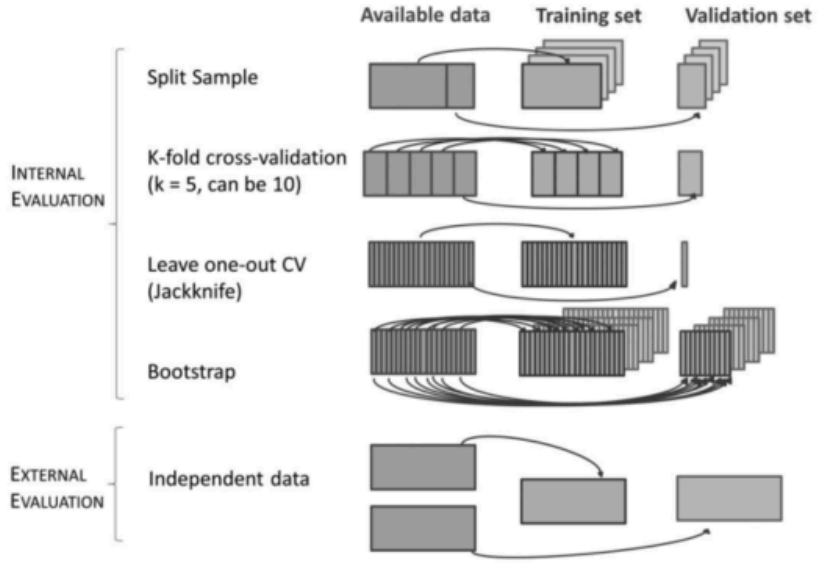
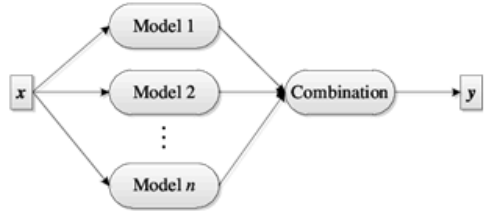
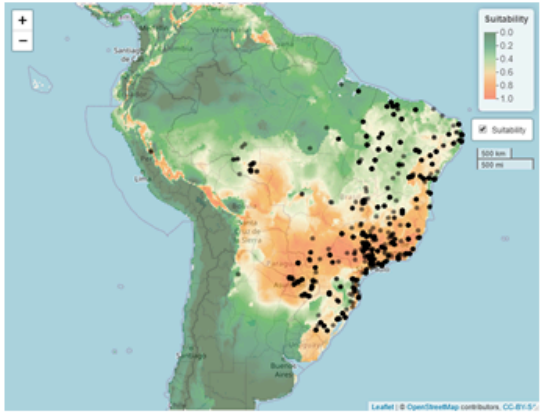
225	113	86	364	293	163	130	222	224	229	220	2065	301	50	47	853	237	554	841
233	113	87	385	300	171	129	229	232	237	227	1823	277	44	50	781	199	473	768
234	111	87	380	300	173	127	230	233	238	228	1609	254	38	53	714	165	408	697
243	109	88	366	306	183	123	239	243	246	237	1343	225	32	59	622	121	312	615
241	106	88	371	302	182	120	237	241	243	235	1207	209	24	64	582	96	278	573
247	103	87	397	308	190	118	243	247	251	241	1020	186	14	69	512	67	223	509
246	101	86	388	306	189	117	242	244	250	240	957	176	14	72	494	65	188	483
247	99	85	389	307	191	116	243	245	251	242	902	168	15	73	477	67	152	459

Avaliação

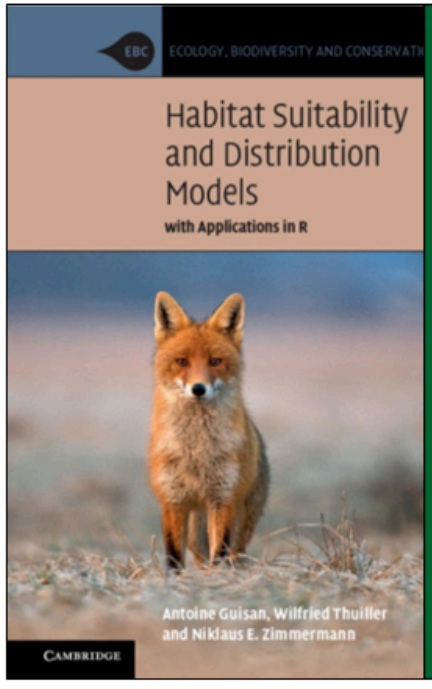


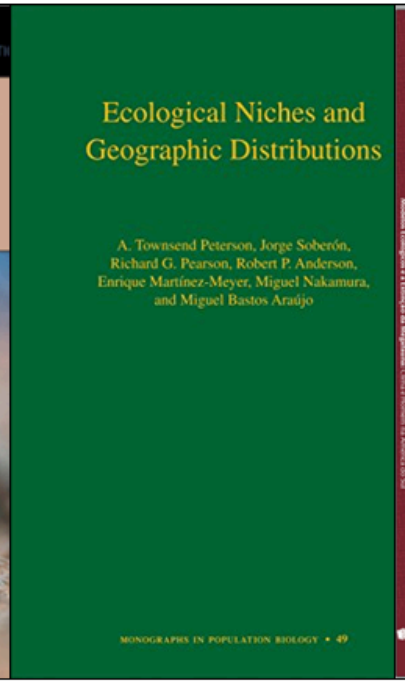
Ensemble

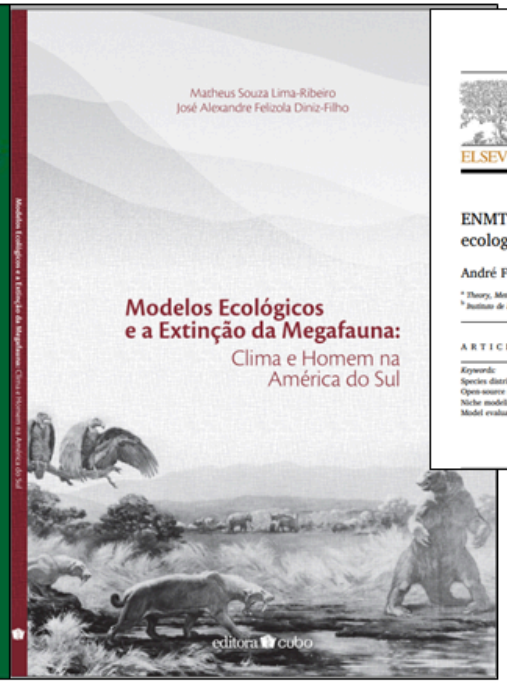


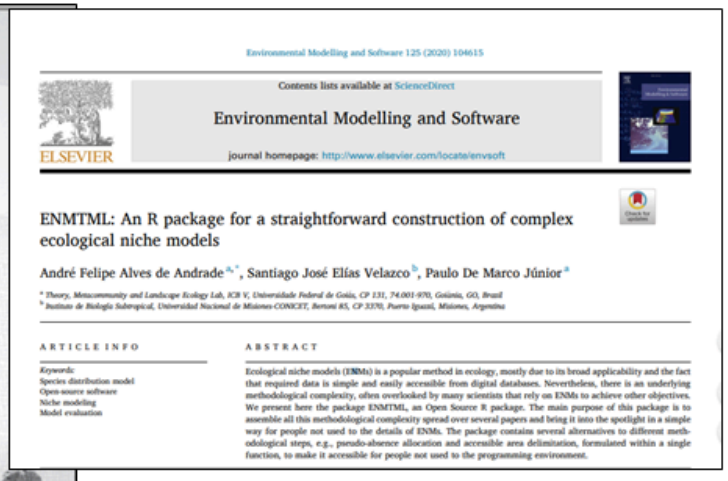


Literatura!









Grupo de estudos:
https://t.me/nichemodel

Pacotes no R

Quais algoritmos você costuma utilizar em seus trabalhos de ENM/SDM? Separar por ';', ex: MAXENT; GLM; Random Forest (...)	Você faz as análises em R?	Se você faz as análises em R, qual pacote você costuma utilizar? Separar por ";".
MAXENT	As vezes	dismo
Random Forest, GAM, Gaussian Process, Support Vector Machine, Maxent	Sim	dismo, ENMTML, dplyr, raster, rgdal, ggplot2
Maxent; Random Forest; SVM; Maximum Likelihood; Bayesian-Gaussian; GLM; GAM	Sim	ENMTML
Maxent;RDF;SVM;GAU;GAM	Sim	enmtml
MAXENT; Gaussian Model; Generalized Linear Models; Random Forest; Generalized Additive Models; Support Vector Machines;	As vezes	São muitos: os principais ENMTML e vegan
BIOCLIM; Gower; Mahalanobis; ENFA; GLM; GAM; MAXENT; Random Forest; SVM	Sim	tidyverse; spocc; CoordinateCleaner; taxize; rnaturalearth; geobr; corrr; caret; ecospat; sf; raster; rgdal; dismo; e1071; randomForest; rJava
Maxent	Sim	dismo; kuenm; SDMtune; ENMTools

Modelagem de distribuição de espécies com o R

Exemplo com *Trigona spinipses* na América do Sul

Pacotes:

```
## Instalar o pacote ENTML
devtools::install_github("andrefaa/ENMTML")

## Carregar os pacotes
install.packages(maptools) # pacote para abrir mapas diretamente no R
install.packages(raster) # para trabalhar com rasters
install.packages(dismo) # função gbif - download de ocorrências de espécies.
install.packages(tidyverse) # trabalhar com as planilhas
install.packages(ENMTML) # pacote para modelagem de nicho
install.packages(leaflet) # pacote para mapas interativos - usaremos nos resultados
```

Modelagem de distribuição de espécies com o R

Dados de ocorrência do GBIF

- Vamos baixar dados de ocorrência de *T. spinipes* do database GBIF.

```
# - Vamos usar a função "gbif()" para fazer o download dos dados.
pontos = dismo::gbif('Trigona', # gênero da espécie
                species = "Trigona spinipes", # nome completo da espécie
                sp = TRUE, # Retornar como um SpatialPointsDataFrame?
                removeZeros = TRUE, # Remover linhas com dados de latitude e/ou logitude faltantes
                download = TRUE) # Para realizar o dowload dos registros

# - Colocar o nome "data" na guia de valores (que são as datas de amostragem).
names(pontos) = "data"
```

Modelagem de distribuição de espécies com o R

Salvar os dados de ocorrência para utilizar com o pacote ENMTML

- O arquivo precisa ser salvo em .TXT (separado por tabulação)!
- Precisamos apenas de três colunas em nossa tabela:
  - 1o nome da espécie
  - 2o longitude
  - 3o latitude

```
library(tidyverse)

# Primeiro vamos gerar um objeto com o endereço do nosso diretório de trabalho:
d_ex = file.path('C:/Users/mmfav/Dropbox/nichemod')
d_ex
```

```
## [1] "C:/Users/mmfav/Dropbox/nichemod"
```

```
# Extrair as informações dos pontos para uma tabela:
tabela = as.data.frame(pontos)

tabela = as.data.frame(pontos) %>% # transformar os dados em data.frame
```

Modelagem de distribuição de espécies com o R

Dados de ocorrência do GBIF

```
knitr::kable(x = head(pontos), format = "html")
```

data	lon	lat
2021-04-08	-46.99378	-22.94122
2021-04-08	-46.63464	-23.45814
2021-04-08	-48.45403	-22.86630
2021-04-08	-46.57087	-23.73215
2021-04-08	-46.92160	-23.28016
2021-04-08	-44.87107	-23.15217

Modelagem de distribuição de espécies com o R

Área de projeção do modelo

- Polígono do mapamundi

```
library(maptools)
data("wrld_simpl")
```

- Recortando o mapa para uma extensão mais próxima dos pontos de ocorrência (background).

1 - Olhar a saída de 'pontos' e ver a dimensão geográfica dele

```
pontos
```

```
## class       : SpatialPointsDataFrame
## features    : 12496
## extent      : -75.9972, -34.7965, -31.395, -0.519111  (xmin, xmax, ymin, ymax)
## crs         : NA
## variables   : 1
## names       :  data
## min values  : 18725
## max values  : 18725
```

Modelagem de distribuição de espécies com o R

Área de projeção do modelo

3 - Recortar o mapa mundi para a extensão selecionada.

```
map = raster::crop(wrld_simpl, ext)
```

Modelagem de distribuição de espécies com o R

Background

```
plot(map, # nosso limite territorial - America do sul
     axes = T, # Pedir para incluir os eixos das coordenadas
     lwd = 1.8, # Grossura da linha do mapa
     col = "#CCFF99", # colorir os países de verde
     bg = "#CCFFFF") # cor do background da imagem em azul


# Plotar o nome dos países no mapa
text(map$LON, map$LAT, map$NAME, cex = 0.7, font = 2)

# Os pontos de ocorrência da nossa espécie
points(pontos, # chamar o poligono de pontos
       pch = 20, # estilo dos pontos de ocorrência
       col = 'red', # na cor vermelha
       cex = 1.5) # tamanho de 1.5
```

Modelagem de distribuição de espécies com o R

Dados biogeoclimáticos

- Chamar os dados para o R com a função `getData()`.
- Vamos usar os dados da plataforma wordclim.

```
# diretório de trabalho
setwd('C:/Users/mmfav/Dropbox/nichemod')

# download data
r = raster::getData("worldclim", # banco de dados
            var = "bio", # var. biogeoclimáticas
            res = 10) # resolução = 10m
```

- Recortar os rasters pela extensão da América do sul

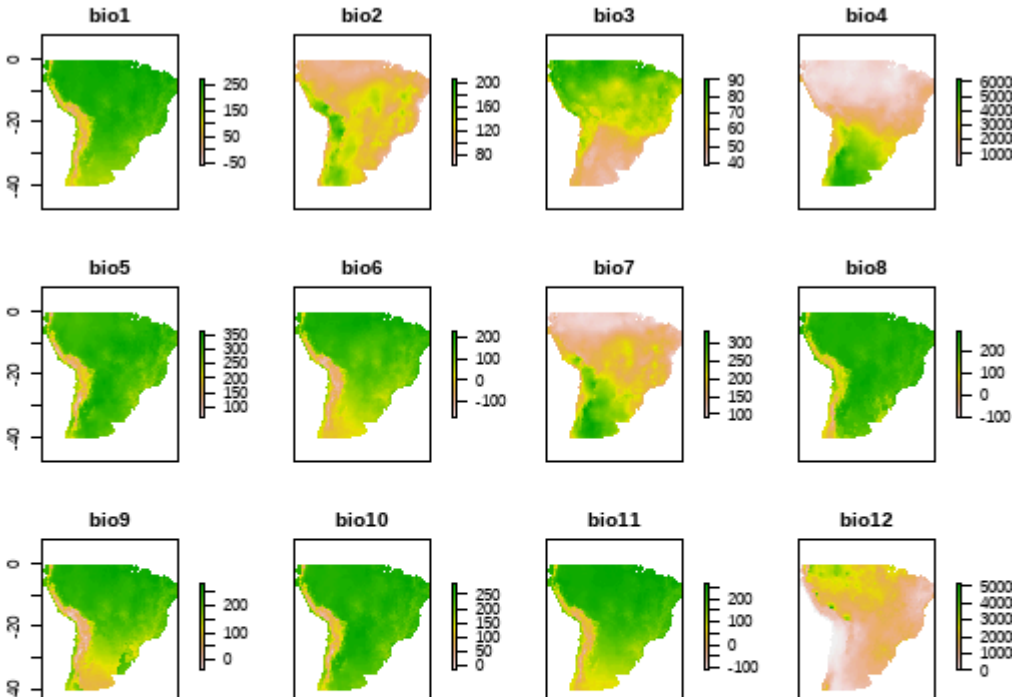
```
rr = raster::crop(raster::mask(r, map), map)
```

Modelagem de distribuição de espécies com o R

Dados biogeoclimáticos

- Visualizar as variáveis biogeoclimáticas

```
plot(rr)
```



Modelagem de distribuição de espécies com o R

Dados biogeoclimáticos

- Salvando os dados bioclimáticos em um diretório próprio

```
# Criar um diretório chamado 'env':
dir.create(paste0(d_ex, '/env'))

# Para salvar cada um dos rasters individualmente no repositório:
for(i in names(rr)){ # para cada raster em 'rr'...
  raster::writeRaster(rr[[i]], paste0(file.path(d_ex, 'env'), "/", i, '.tif'), overwrite = T)
}
```

Modelagem de distribuição de espécies com o R

Modelando a distribuição com o pacote ENMTML

- Criar uma pasta/diretório para salvar os resultados do(s) modelo(s)

```
dir.create(paste0(d_ex, '/resultados'))
```

- Vamos criar objetos com os endereços dos diretórios. Vamos usar os objetos na função `ENMTML()`.

```
# endereço das variáveis climáticas
d_env = file.path("C:/Users/mmfav/Dropbox/nichemod/env")

# endereço dos pontos de ocorrência
d_occ = "C:/Users/mmfav/Dropbox/nichemod/occ/occ.txt"
```

Modelagem de distribuição de espécies com o R

Modelando a distribuição com o pacote ENMTML

```
ENMTML::ENMTML(
  pred_dir = d_env, # Endereço para o diretório das variáveis
  proj_dir = NULL, # Quando trabalhamos com projeções - diferentes locais no espaço ou tempo
  # result_dir = res, # Pasta para salvar as saídas/resultados
  occ_file = d_occ, # Pasta onde estão nossos pontos de ocorrência
  sp = 'species', # coluna que contêm o nome das espécies
  x = 'x', # coluna que corresponde a longitude
  y = 'y', # coluna que corresponde a latitude
  min_occ = 10, # Número minimo de ocorrências para cada espécie
  thin_occ = NULL, # Inserimos os métodos de filtragem de ocorrências dados redundantes
  eval_occ = NULL, # Tabela com dados de ocorrência para validação dos dados
  colin_var = c(method='PEARSON', threshold='0.7'), # Onde inserimos os métodos para evitar a col
  imp_var = FALSE, # Calcula a importância das variáveis em curvas de resposta
  sp_accessible_area = NULL, # Método de restrição de área acessível para as espécies
  pseudoabs_method = c(method = 'RND'), # Método de seleção de pseudo-ausências aleatório
```

Modelagem de distribuição de espécies com o R

Visualização dos resultados

- Vamos plotar os resultados usando o pacote "leaflet"

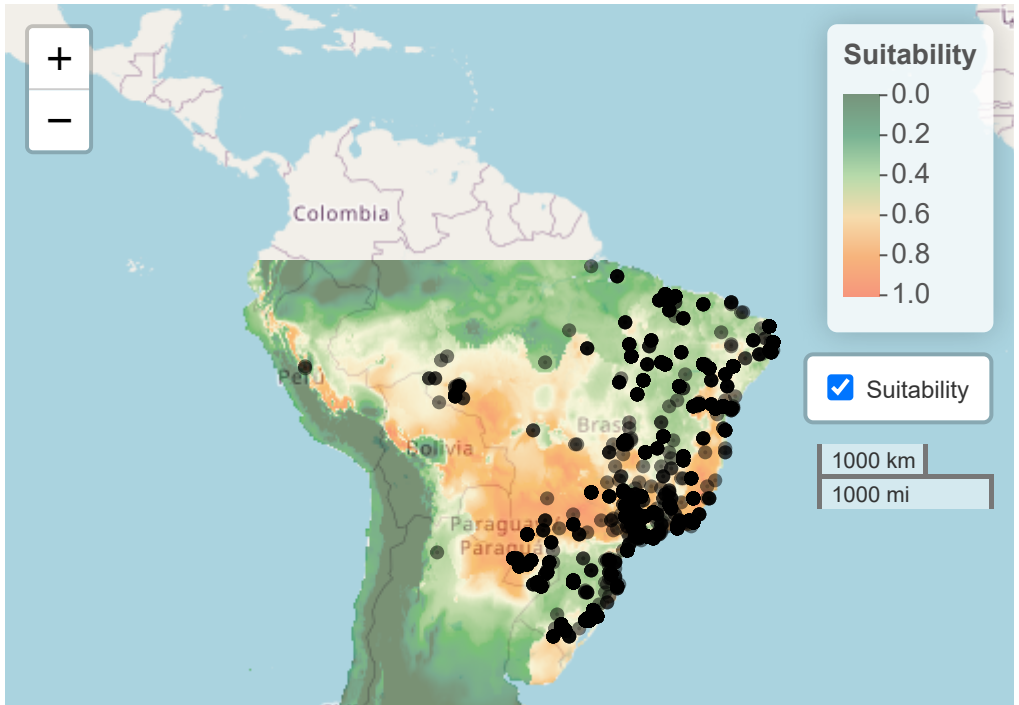
```
library(tidyverse)
library(leaflet)
library(raster)
# Abrir o resultado em objeto chamado 'res'
res = paste0(d_ex, '/Result/Ensemble/PCA/Trigona_spinipes.tif') %>% raster()

# Fazer uma palheta de cores variando de verde até vermelho; para a legenda de 'suitability'.
pal = colorNumeric(c("#003300", "#006633", "#009300", "#FFFFCC",
                     "#FF9900", "#FF6600", "#FF3300"), values(res),
                   na.color = "transparent")

# Plotar em mapa interativo com LEAFLET
map = leaflet(pontos) %>% # Usaremos a função 'leaflet' para produzir os mapas e já chamaremos os p
  addTiles() %>% # add um mapa de fundo
  addRasterImage(res, # adicionar o raster 'res' (com nossos resultados)
                 col = pal, opacity = 0.5, group = "Suitability") %>% # com cor = pal, transparênci
```

Modelagem de distribuição de espécies com o R

Visualização dos resultados

- Vamos plotar os resultados usando o pacote "leaflet".

```
map
```



Agradecimentos

R-Ladies BH 💙

Grupo de Estudos "Niche Group" 💛

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