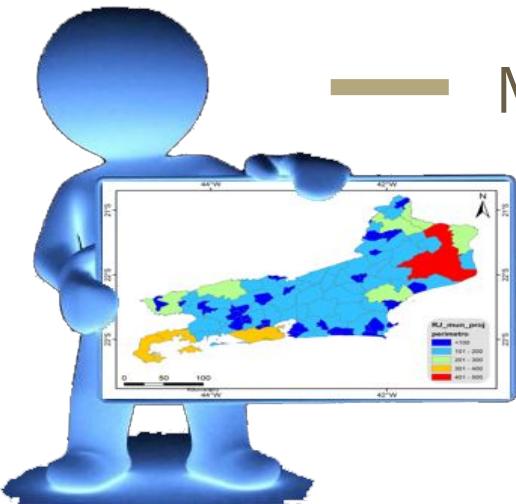


# Cartografia & Saúde: Análise geoespacial como ferramenta aplicada na parasitologia

— Modelagem de Nicho Ecológico —



Diogo S. B. Rocha

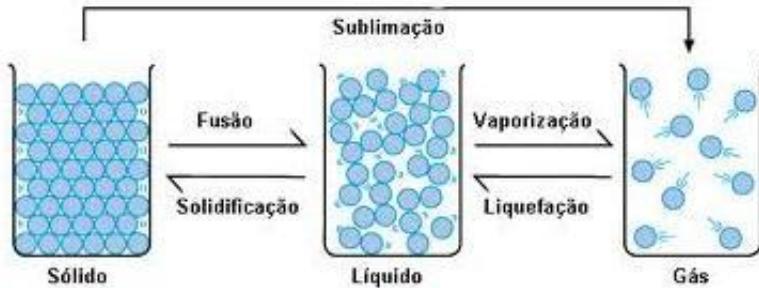
Fiocruz - 2021



INSTITUTO  
INTERNACIONAL PARA  
SUSTENTABILIDADE  
  
INTERNATIONAL  
INSTITUTE FOR  
SUSTAINABILITY

# O que são Modelos?

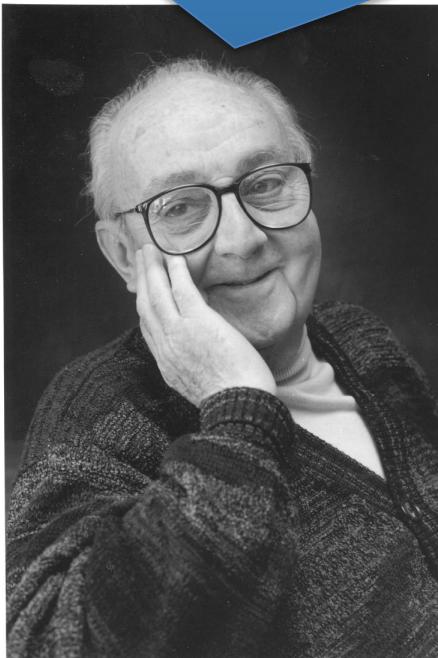
Uma simplificação com um propósito !



$$f(x) = ax + b$$



**Todos os modelos estão errados,  
mas alguns são úteis**



George E. P. Box  
18 October 1919 – 28 March 2013

# Relação entre altitude e temperatura

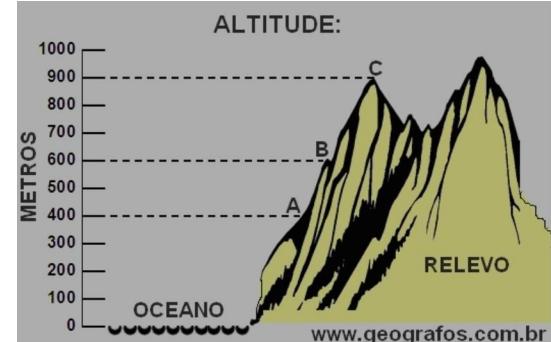
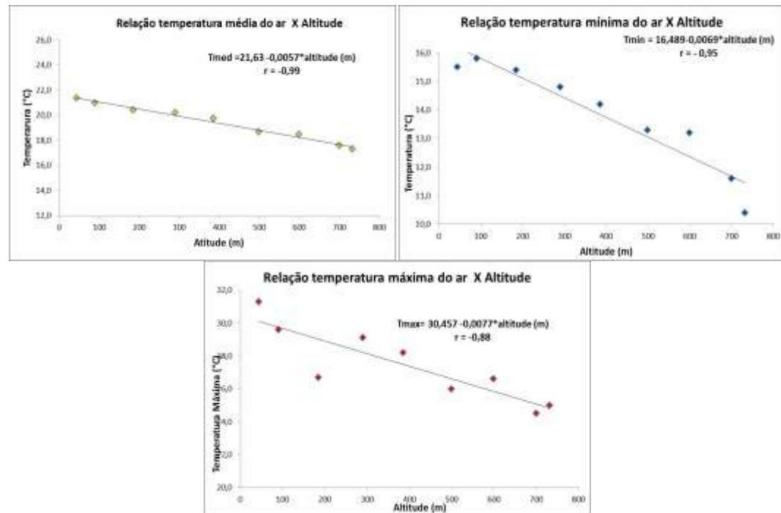
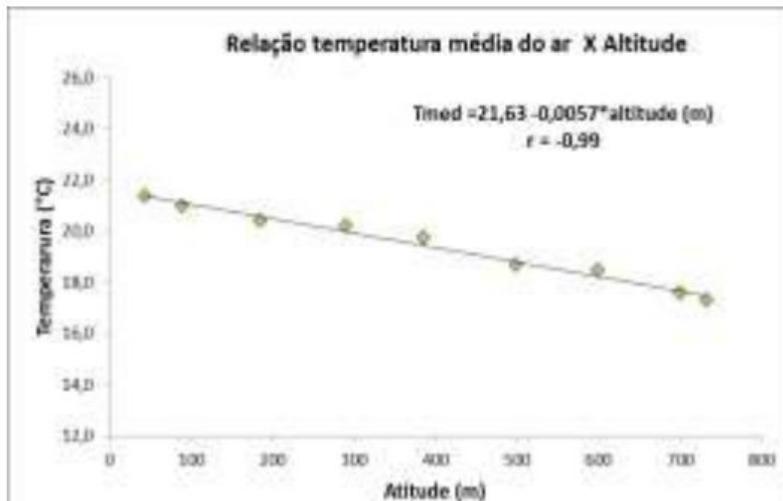
$$T = T_0 + ah$$

Temperatura

Altitude

Temperatura de referência

Variação da temperatura



Santos, D. D., de Moraes, S. L., & Galvani, E. (2016). Variação da temperatura do ar média, mínima e máxima no perfil topoclimático da Trilha Caminhos do Mar (SP). REVISTA EQUADOR, 5(5), 01-19.

# Introdução à Modelagem de Nicho Ecológico

**Parte 1:** Distribuição geográfica e os conceitos de nicho envolvidos na modelagem

**Parte 2:** Distribuição no espaço geográfico x Distribuição no espaço ambiental

**Parte 3:** O processo de modelagem: mapa conceitual e premissas adotadas

# Distribuição geográfica

# Distribuição de espécies



*Panthera onca*

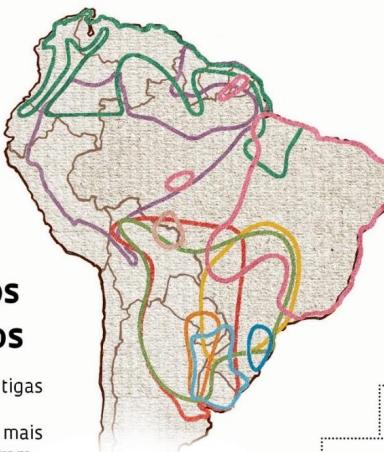


■ Atual ■ Original

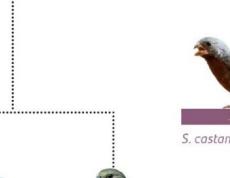
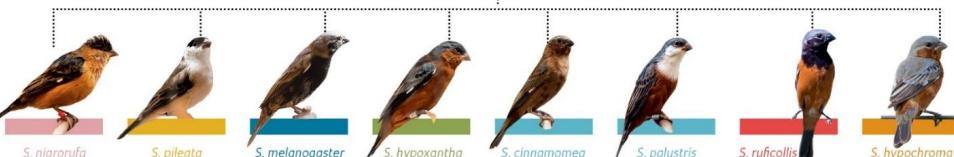
## Hábitat dos caboclinhos

As espécies mais antigas vivem no norte da América do Sul e as mais recentes se espalham pelo centro-sul

FONTE: CAMPANHA E SILVEIRA  
FOTOS: FERNANDO MEDOLACO  
INFOGRÁFICO: ANA PAULA CAMPOS  
ILUSTRAÇÃO: SANDRO CASTELLI

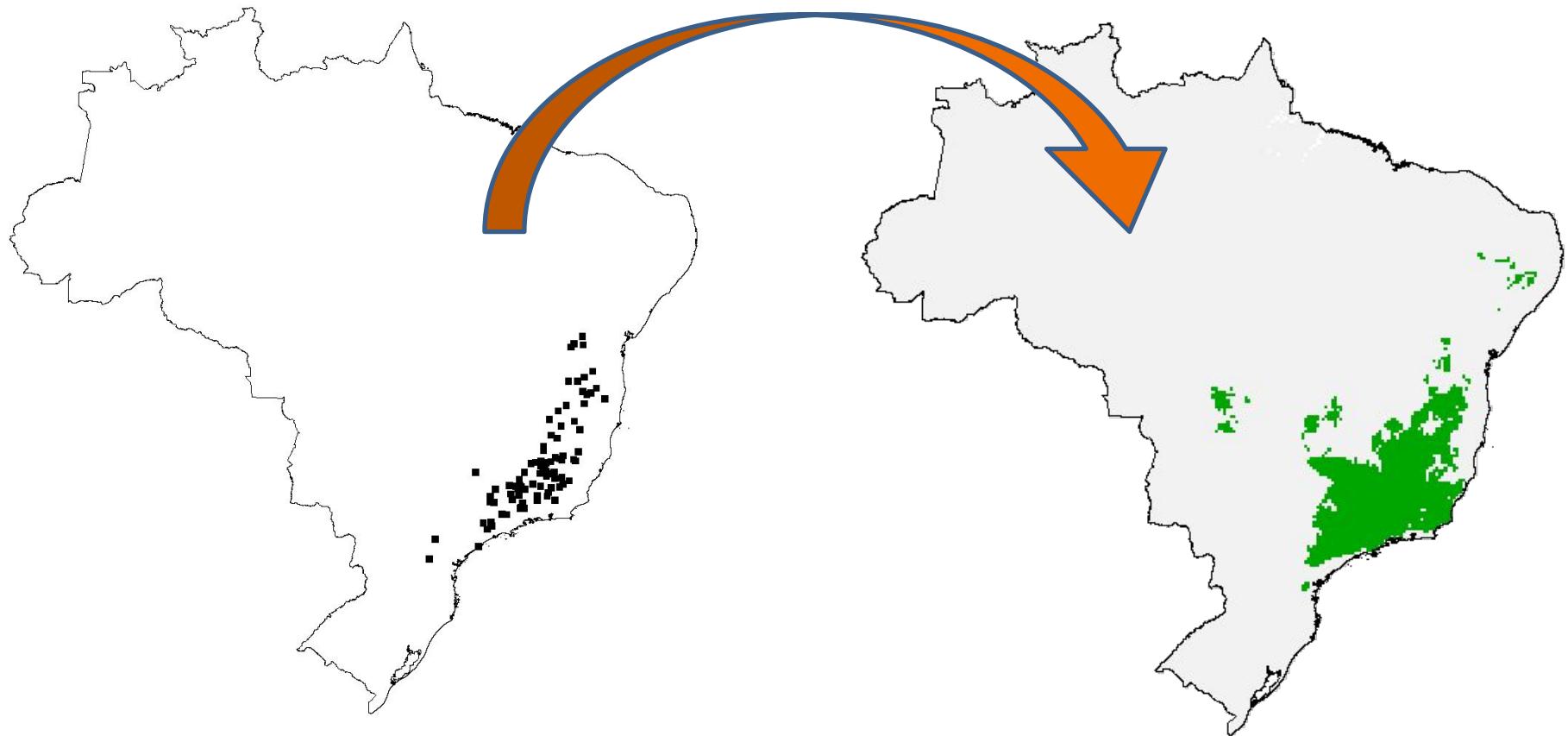


As relações filogenéticas entre as 11 espécies do gênero *Sporophila*. A espécie que primeiramente divergiu das demais é a *S. castaneiventris*



Registros de ocorrência

Mapa de distribuição potencial



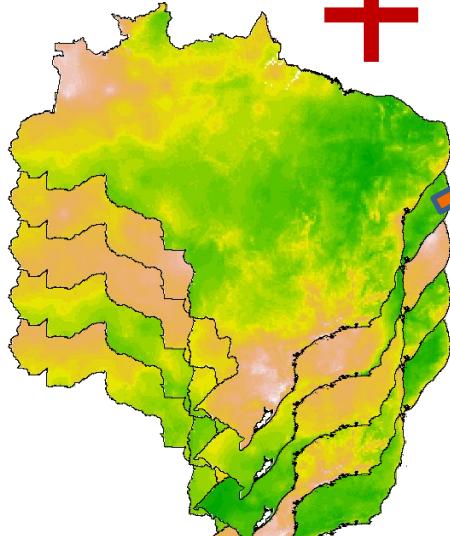
# Introdução Modelagem

Registros de ocorrência



Dados de entrada

Variáveis preditoras



Precipitação

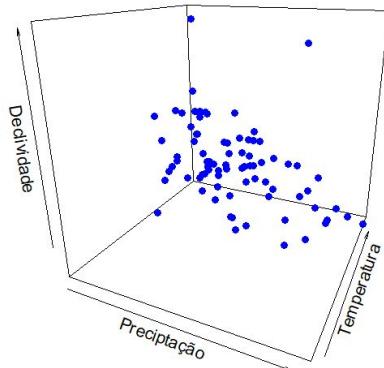
Temperatura

Topografia

Variável X

Variável Y

Algoritmos de modelagem  
(Bioclim, GLM, GAM, ANN, GARP,  
MAXEnt, etc.)



Mapa de distribuição potencial



## Conceitos de nicho envolvidos na modelagem

O termo *nicho* apareceu primeiramente nos trabalhos de Grinnell (1917, 1924) cujo foco está na distribuição geográfica dos indivíduos de uma espécie como uma resposta às variáveis ambientais (temperatura, precipitação, elevação etc.).

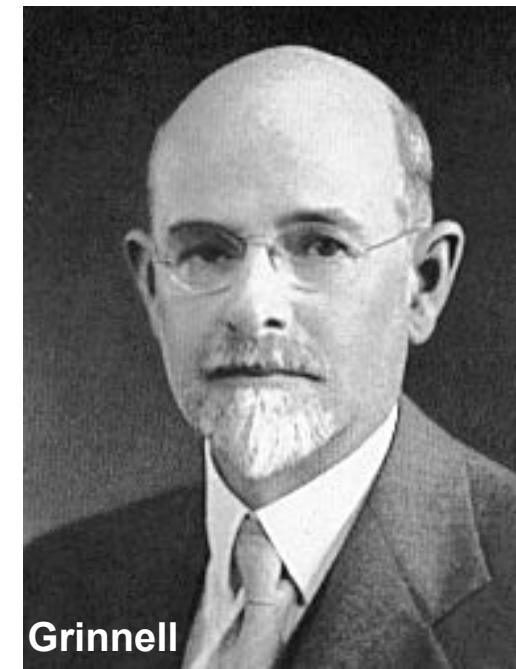
THE NICHE-RELATIONSHIPS OF THE CALIFORNIA  
THRASHER.<sup>1</sup>

BY JOSEPH GRINNELL.

THE California Thrasher (*Toxostoma redivivum*) is one of the several distinct bird types which characterize the so-called "Californian Fauna." Its range is notably restricted, even more so than that of the Wren-Tit. Only at the south does the California Thrasher occur beyond the limits of the state of California, and in that direction only as far as the San Pedro Martir Mountains and

---

<sup>1</sup> Contribution from the Museum of Vertebrate Zoölogy of the University of California.



Grinnell

# Evolução do Conceito de nicho em Ecologia

Elton (1927) muda o foco e coloca o nicho como uma resposta da interação entre espécies.

The image shows the front page of the journal 'ECOLOGY LETTERS'. At the top, it says 'ECOLOGY LETTERS'. Below that, it says 'Ecology Letters, (2010) 13: 1310–1324' and 'doi: 10.1111/j.1461-0248.2010.01515.x'. There are two main article sections: 'REVIEW AND SYNTHESIS' and 'IDEA AND PERSPECTIVE'. The 'REVIEW AND SYNTHESIS' section is titled 'Niche conservatism as an emerging principle in ecology and conservation biology'. The 'IDEA AND PERSPECTIVE' section is titled 'Grinnellian and Eltonian niches and geographic distributions of species'.

*Ecology Letters, (2007) 10: 1115–1123 doi: 10.1111/j.1461-0248.2007.01107.x*

**IDEA AND PERSPECTIVE**

**Grinnellian and Eltonian niches and geographic distributions of species**

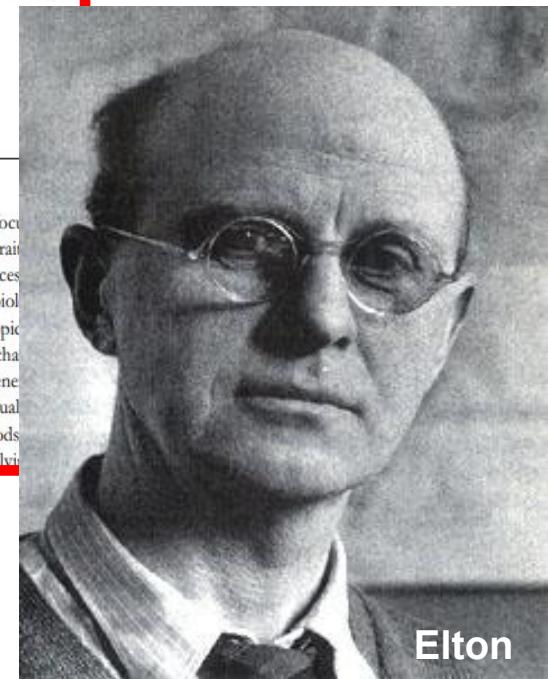
**Abstract**

In the recent past, availability of large data sets of species presences has increased by orders of magnitude. This, together with developments in geographical information systems and statistical methods, has enabled scientists to calculate, for thousands of species, the environmental conditions of their distributional areas. The profiles thus obtained are obviously related to niche concepts in the Grinnell tradition, and separated from those in Elton's tradition. I argue that it is useful to define Grinnellian and Eltonian niches on the basis of the types of variables used to calculate them, the natural spatial scale at which they can be measured, and the dispersal of the individuals over the environment. I use set theory notation and analogies derived from population ecology theory to obtain formal definitions of areas of distribution and several types of niches. This brings clarity to several practical and fundamental questions in macroecology and biogeography.

Jorge Soberón\*

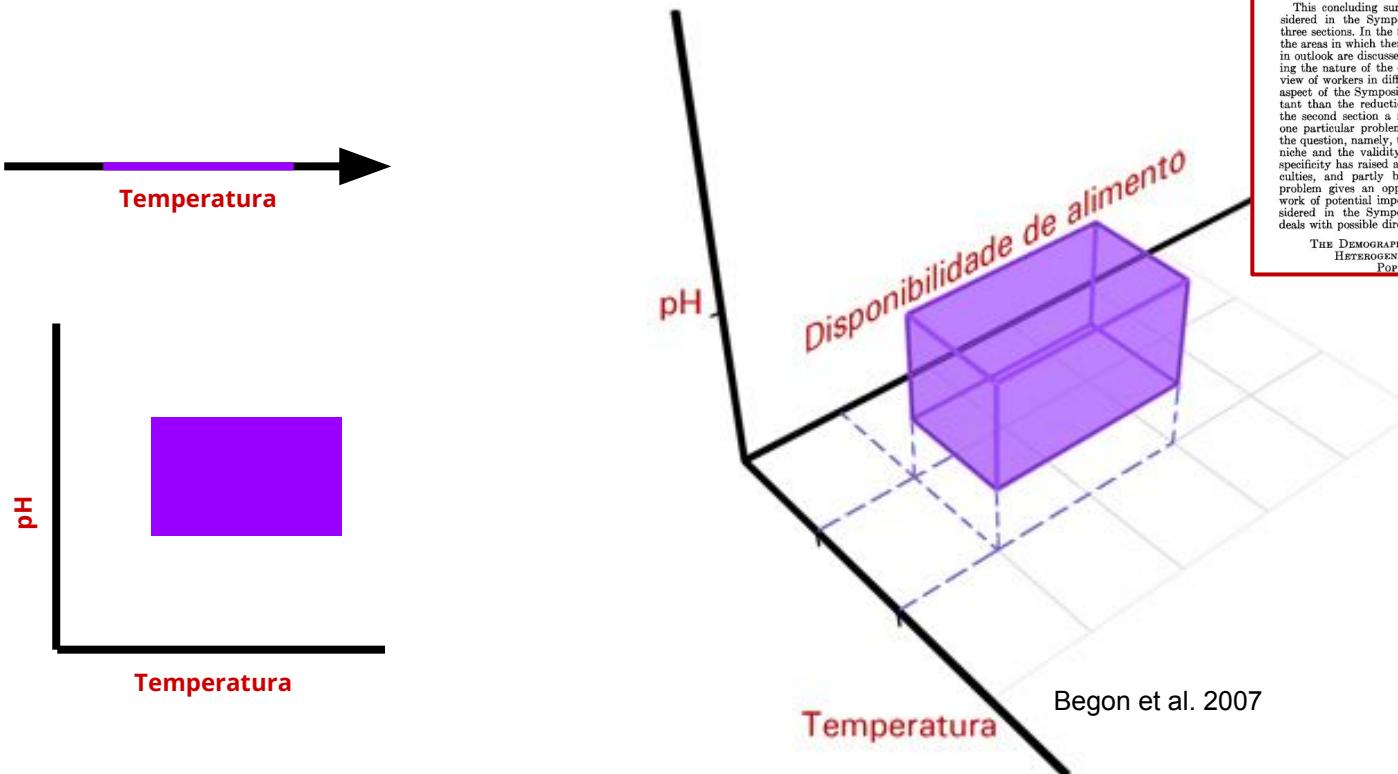
Biodiversity Research Center  
and Museum of Natural History,  
University of Kansas Dyche Hall,  
1345 Jayhawk Blvd, Lawrence,  
KS 66045, USA

\*Correspondence: E-mail:  
jsoberon@ku.edu



Elton

Hutchinson (1957) define o termo *nicho* como a soma de todos os fatores ambientais (bióticos e abióticos) que agem em um determinado organismo, definido como um hipervolume com n dimensões.



#### Concluding Remarks

G. EVELYN HUTCHINSON  
*Yale University, New Haven, Connecticut*

This concluding survey<sup>1</sup> of the problems considered in the Symposium naturally falls into three sections. In the first brief section certain of the areas in which there is considerable difference in outlook are discussed with a view to ascertaining the nature of the differences in the points of view of workers in different parts of the field; no aspect of this question can be regarded as final, and it may lead to the reduction of areas of dispute. In the second section a rather detailed analysis of one particular problem is given, partly because the question, namely, the nature of the ecological niche and the validity of the principle of niche specificity has raised and continues to raise difficulties, and partly because discussion of this problem gives an opportunity to refer to new work of potential importance not otherwise considered in the Symposium. The third section deals with possible directions for future research.

THE DEMOGRAPHIC SYMPOSIUM AS A HETEROGENEOUS UNSTABLE POPULATION

The human demographer by virtue of his position as a slow breeding participant observer, and also because he is usually called on to predict for practical purposes what will happen in the immediate future, is inevitably interested in what may be called the microdemography of man. The significant quantities are mainly seen in third derivative rates, such as those of natality and mortality, and the rates of change of such rates. These latter to the animal demographer might appear as random fluctuations which he can hardly hope to analyse in his experiments. What the animal demographer is mainly concerned with is the macrodemographic problem of the integral curve and its first derivatives. He is accustomed to dealing with a numerically stable system, where the latter is negative, a situation that is so rare in human populations that it seems to be definitely pathological to the human demographer. Only when anthropology and archaeology enter the field of human demography does something comparable to animal demography, with its broad, if sometimes insufficiently supported conclusions,



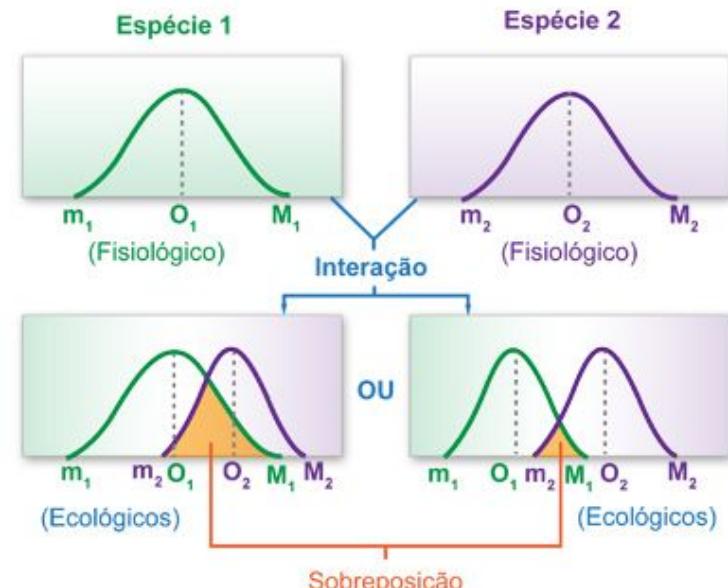
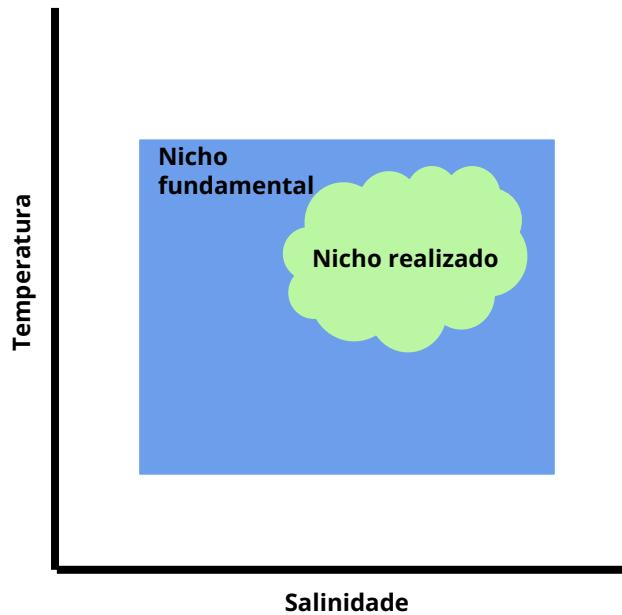
Hutchinson

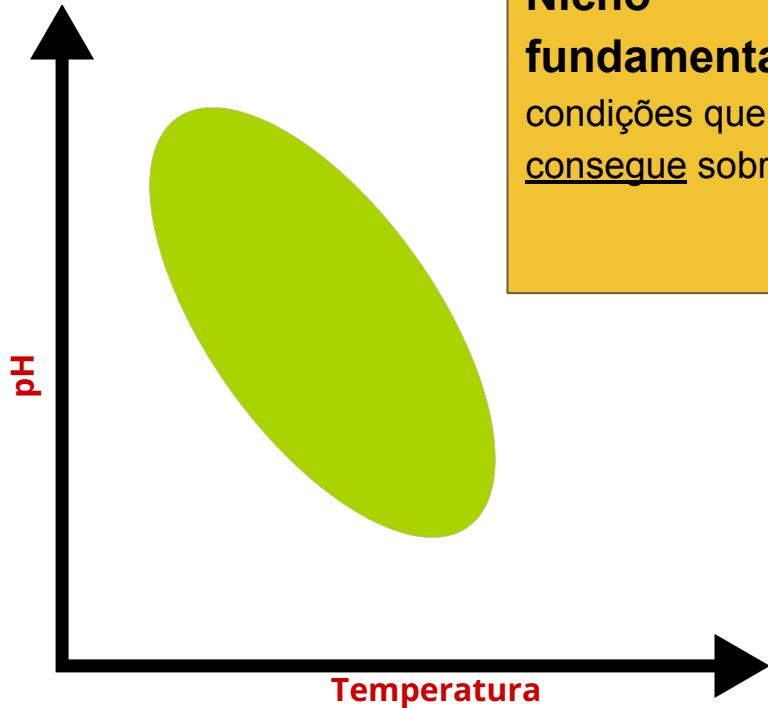
Begon et al. 2007

# Conceito de nicho em Ecologia

## Terminologias de Hutchinson

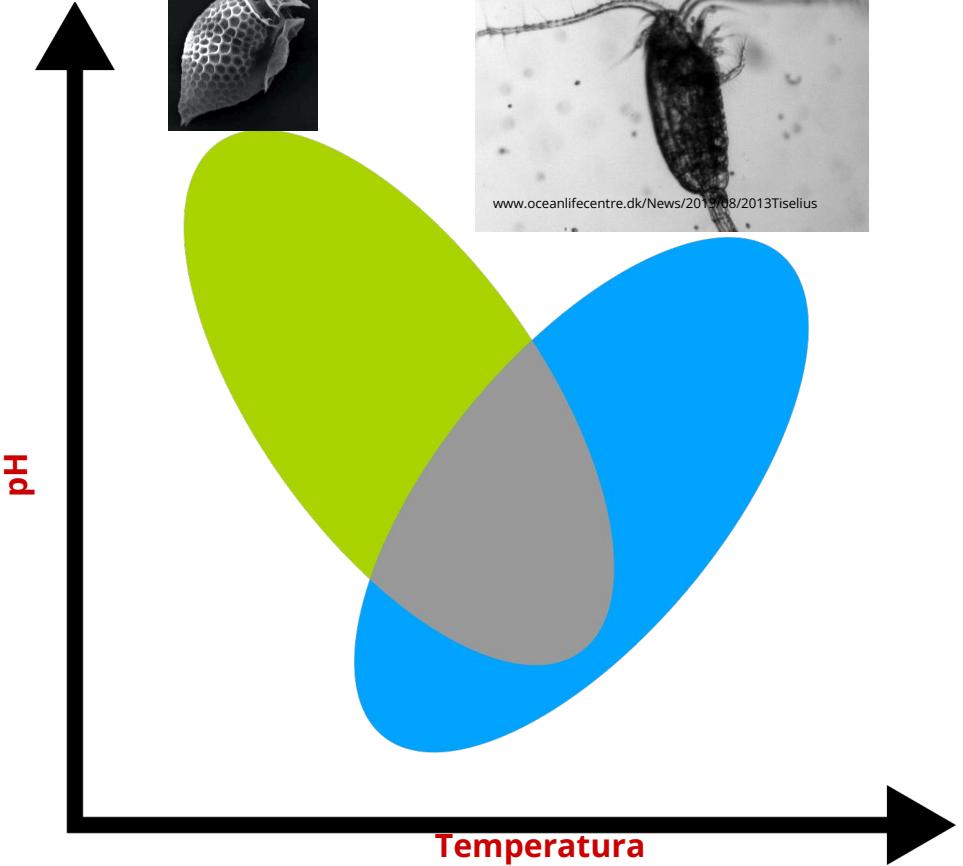
- **Nicho Fundamental:** conjunto de ótimos fisiológicos.
- **Nicho Realizado:** conjunto de ótimos ecológicos.





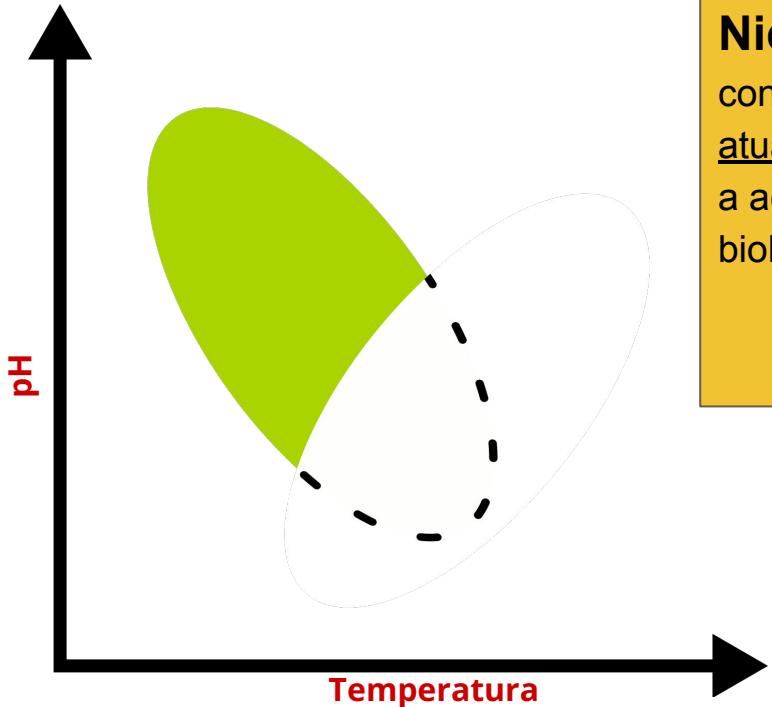
**Nicho  
fundamental:**

condições que a espécie  
consegue sobreviver



## Nicho realizado:

condições que a espécie atualmente vive, considerando a ação das interações biológicas



## Nicho realizado:

condições que a espécie atualmente vive, considerando a ação das interações biológicas

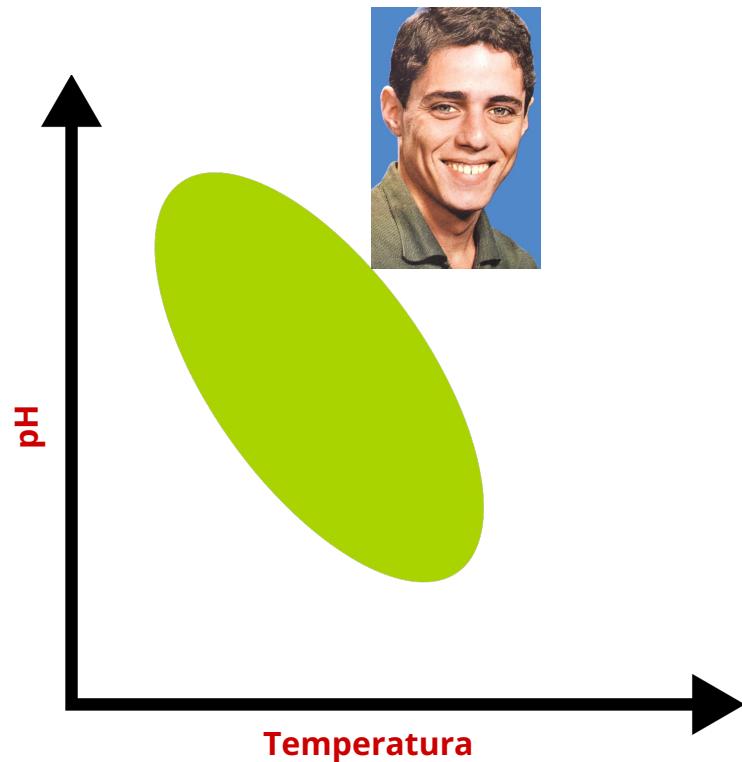
# Nicho Fundamental

vs.

# Nicho Realizado

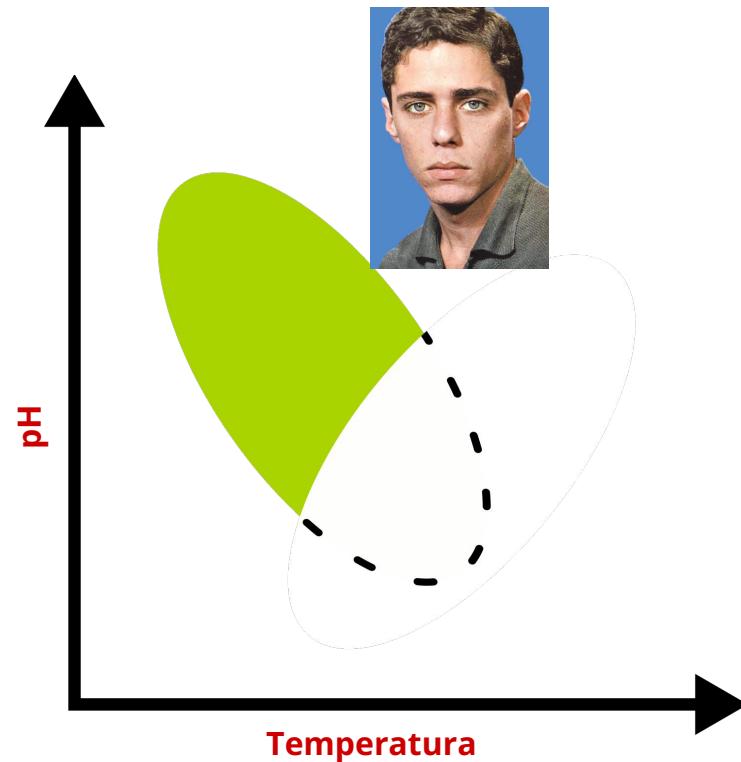
## Fatores abióticos

Salinidade, pH, temperatura,  
nutrientes, luz



## Fatores bióticos

Predação, competição



# Conceito de nicho em Ecologia

Estas definições podem ser separadas em duas classes (Soberón 2007).

1. O nicho Grinnelliano ou nicho não-interativo, é importante para compreender a distribuição geográfica das espécies em escala global/continental.
2. O nicho Eltoniano focaliza interações bióticas e a dinâmica de consumo dos recursos, que na maior parte das vezes ocorre em escala local.

Ecology Letters, (2007) 10: 1115–1123  
doi: 10.1111/j.1461-0248.2007.01107.x

**IDEA AND PERSPECTIVE**

**Grinnellian and Eltonian niches and geographic distributions of species**

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**Jorge Soberón\***  
Biodiversity Research Center  
and Museum of Natural History,  
University of Kansas Dyche Hall,  
1345 Jayhawk Blvd, Lawrence,  
KS 66045, USA

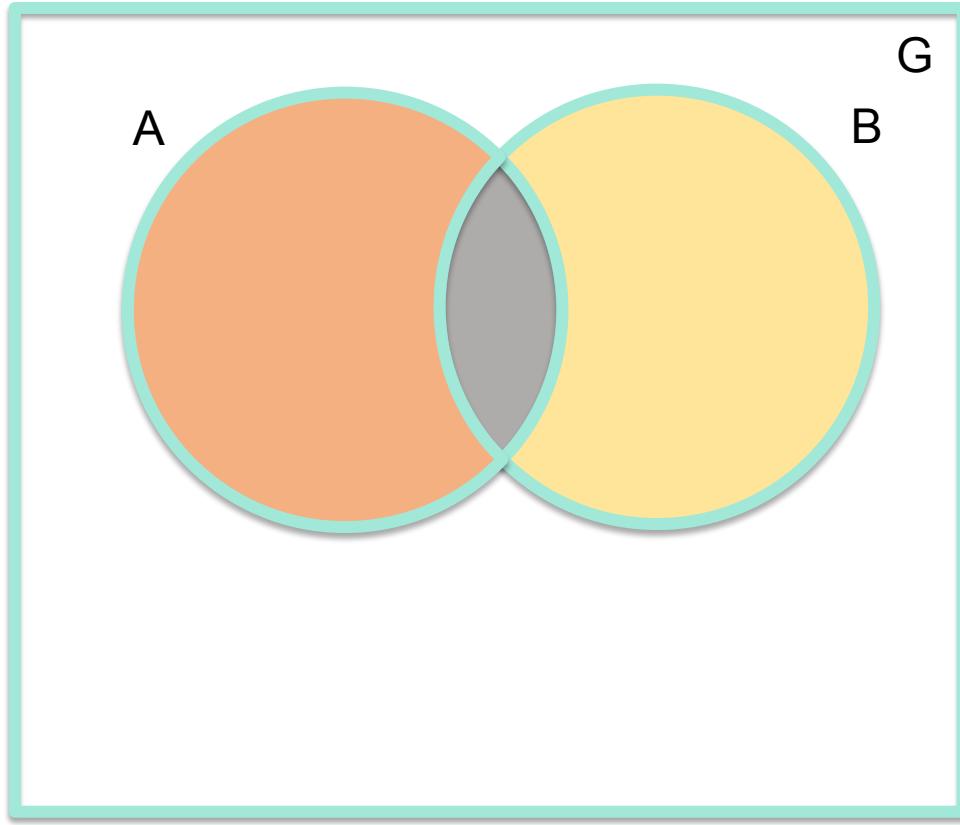
\*Correspondence: E-mail:  
jsoberon@ku.edu

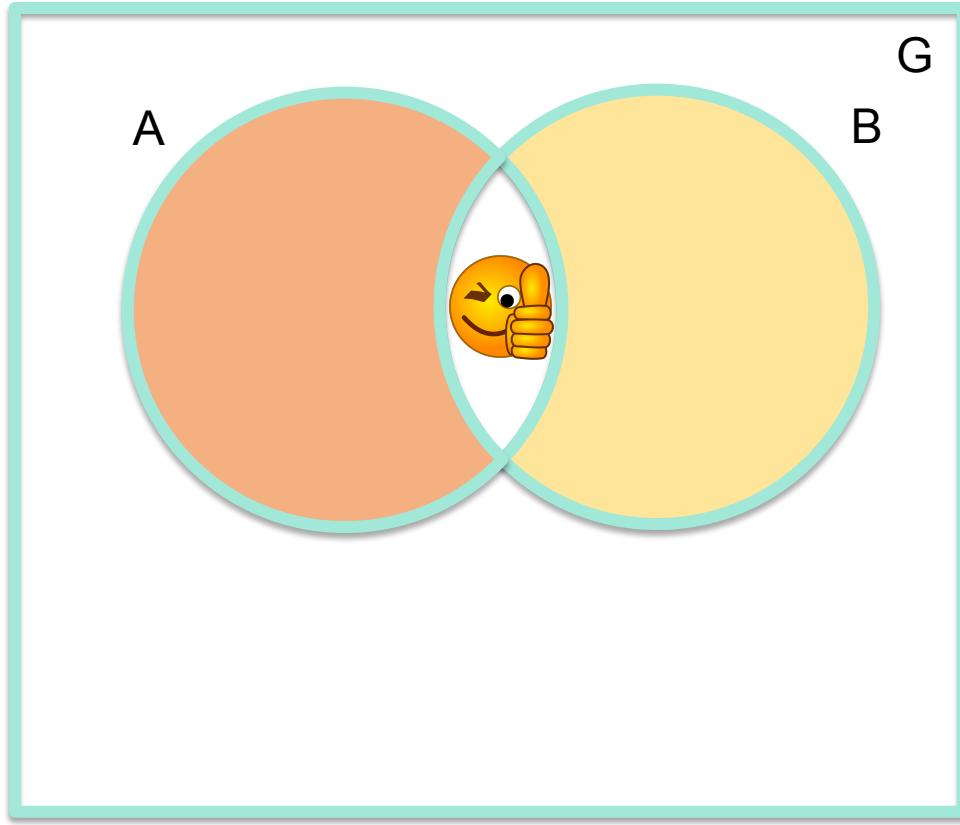
**Abstract**  
In the recent past, availability of large data sets of species presences has increased by orders of magnitude. This, together with developments in geographical information systems and statistical methods, has enabled scientists to calculate, for thousands of species, the environmental conditions of their distributional areas. The profiles thus obtained are obviously related to niche concepts in the Grinnell tradition, and separated from those in Elton's tradition. I argue that it is useful to define Grinnellian and Eltonian niches on the basis of the types of variables used to calculate them, the natural spatial scale at which they can be measured, and the dispersal of the individuals over the environment. I use set theory notation and analogies derived from population ecology theory to obtain formal definitions of areas of distribution and several types of niches. This brings clarity to several practical and fundamental questions in macroecology and biogeography.

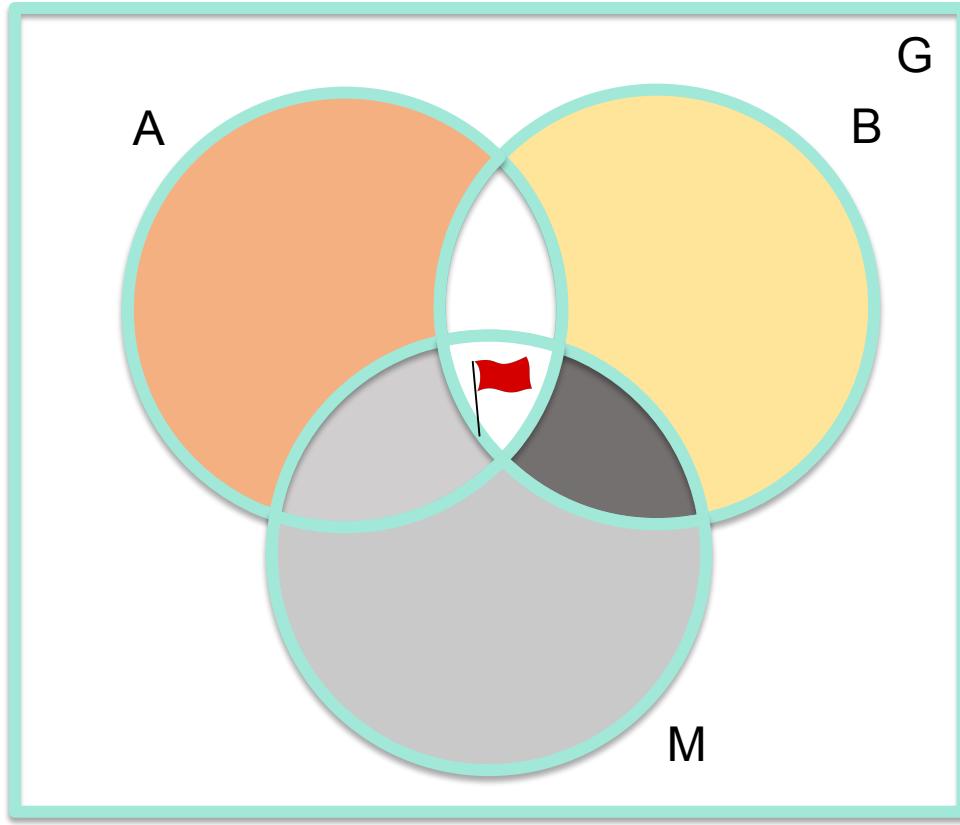
## **Diagrama BAM (Peterson et al. 2011): Fatores que influenciam a distribuição**

A

G







## Diagrama BAM (livro Peterson et al. 2011): Fatores que influenciam a distribuição

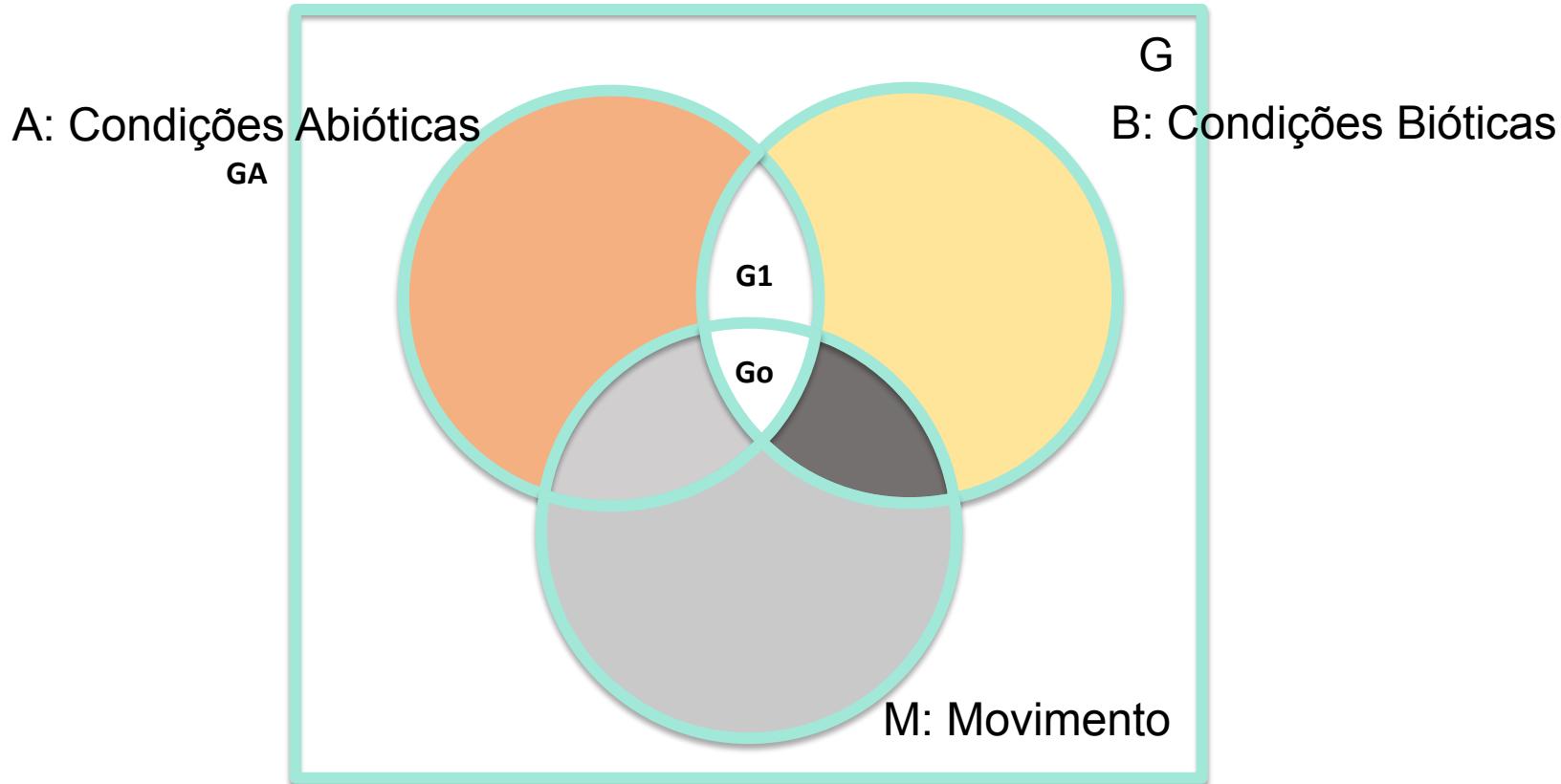
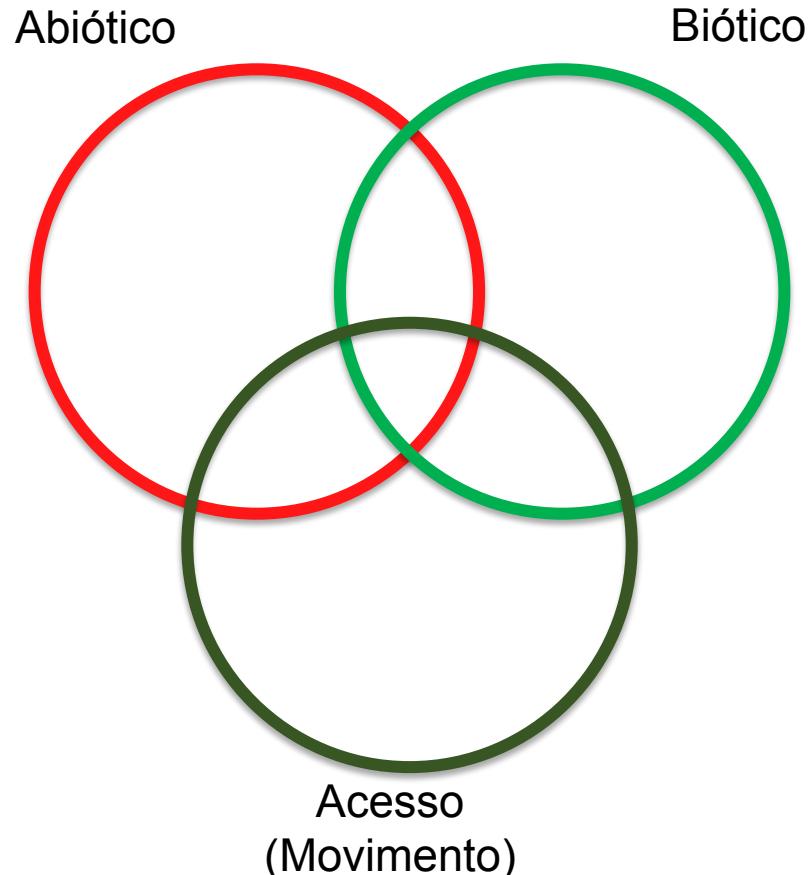
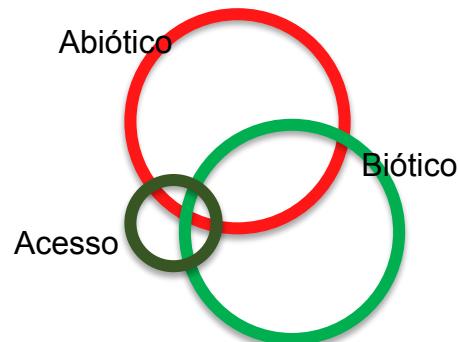
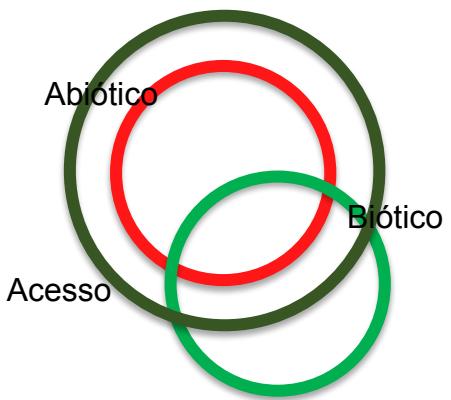
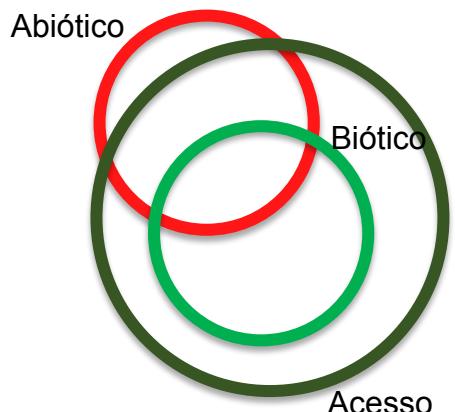
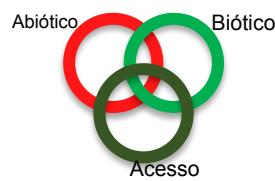
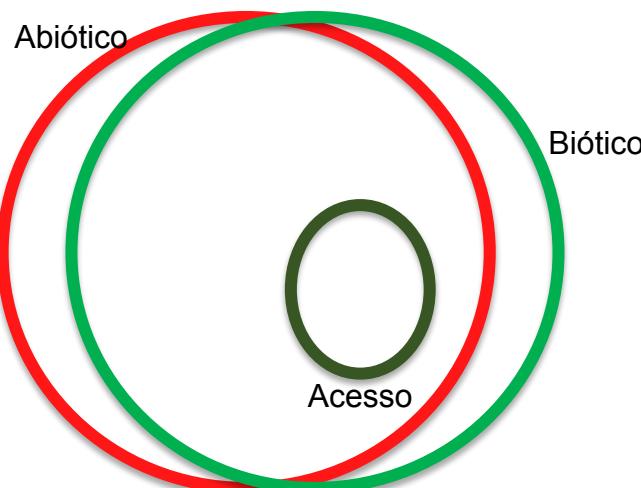
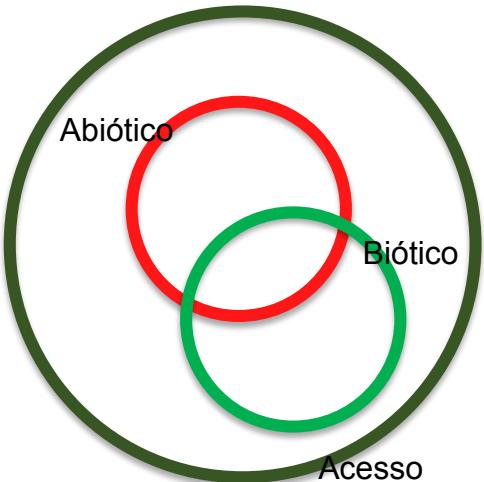


Diagrama representando as interações entre os fatores bióticos (**B**), abióticos (**A**) e de movimento (**M**) que condicionam a ocorrência de uma espécie em um determinado local. **G** representa o espaço geográfico em que a espécie está inserida, **Go** = área efetivamente ocupada; **G1** = área de distribuição potencial e **GA** = toda a área abiótica que a espécie tem condição de ocupar.

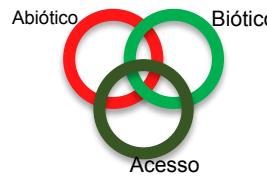
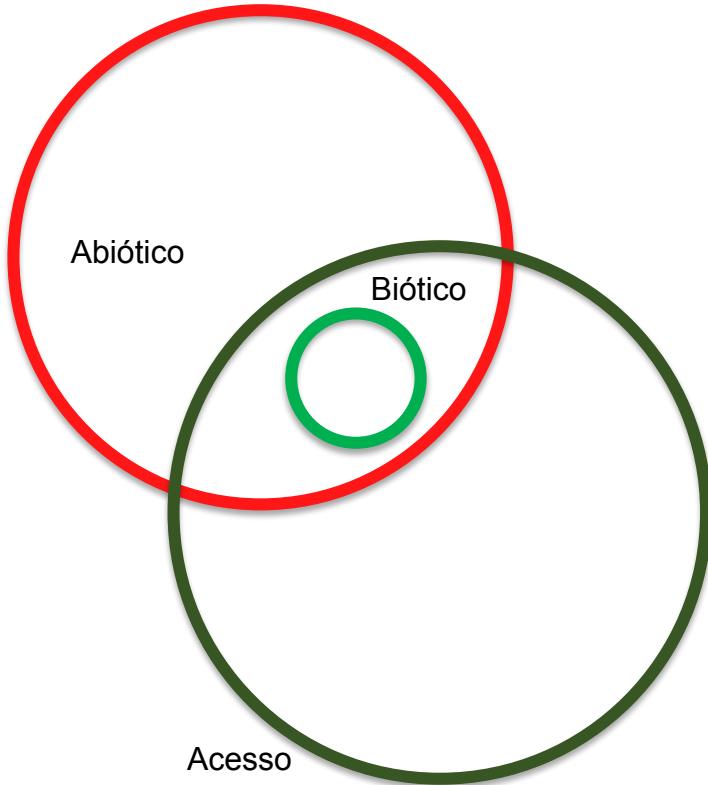
## Configuração clássica do Diagrama BAM



## Configurações possíveis do Diagrama BAM

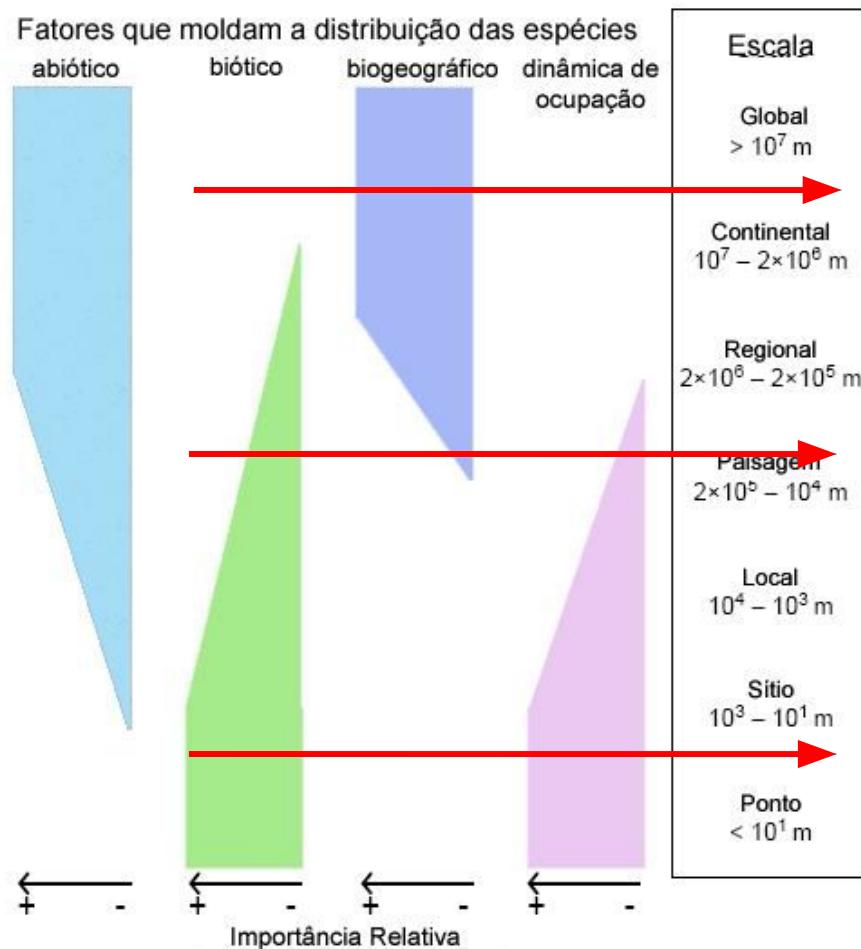


## Configurações possíveis do Diagrama BAM



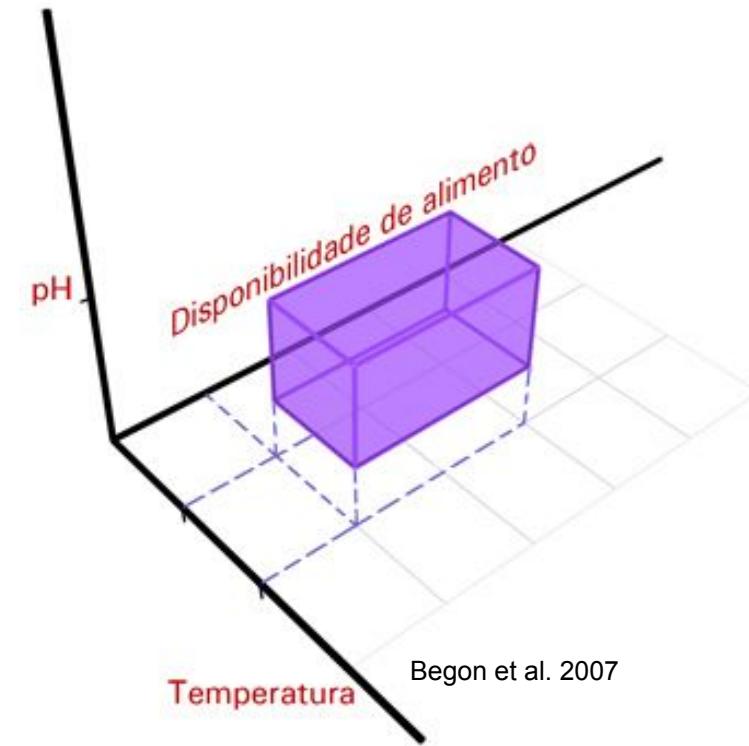
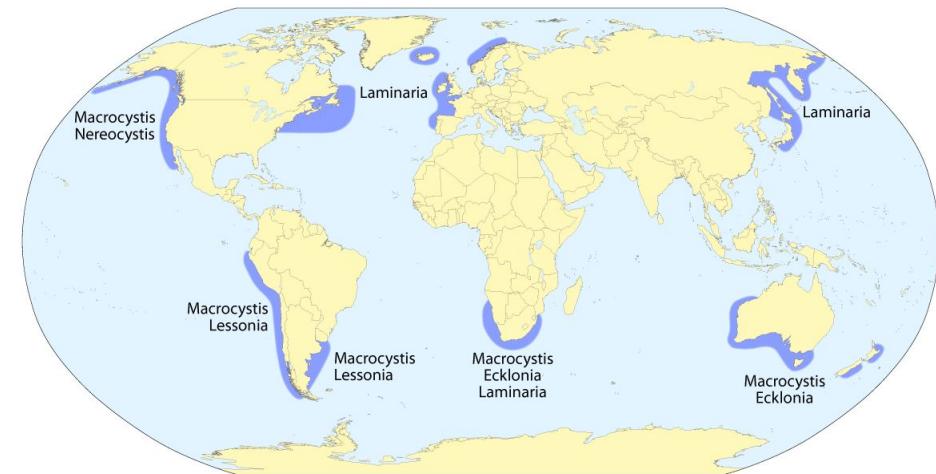
**“Ruído Eltoniano”**  
Os fatores bióticos  
influenciam em  
pequena escala

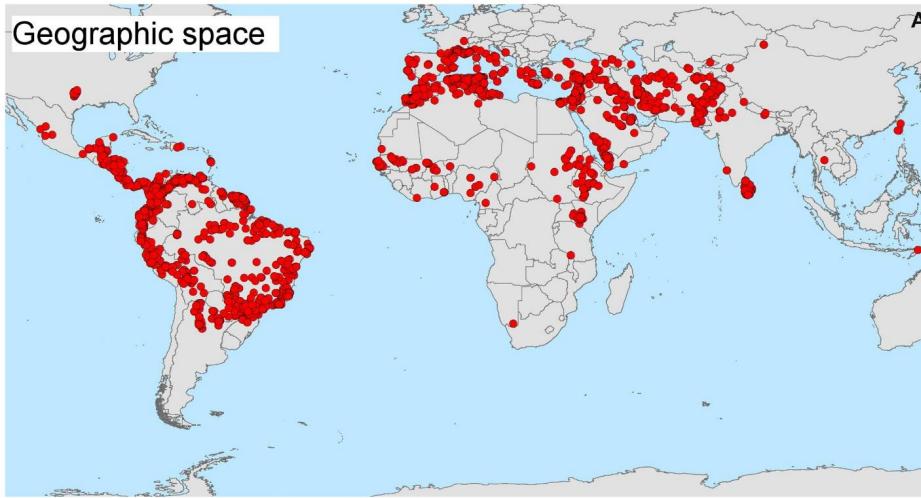
# Importância dos fatores que afetam a distribuição das espécies através da **escala** espacial.



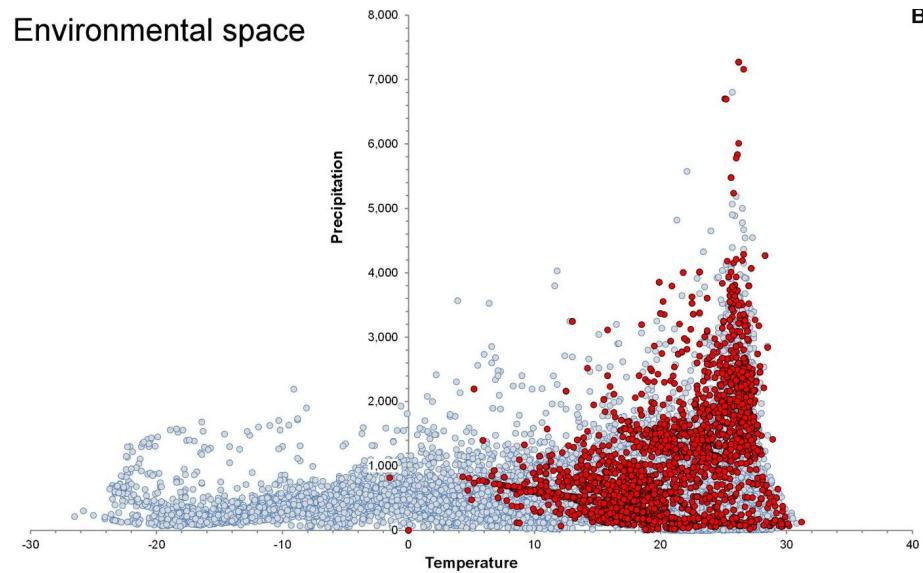
Fonte: modificado de Hortal *et al.*, 2010).

# Distribuição no espaço geográfico × Distribuição no espaço ambiental

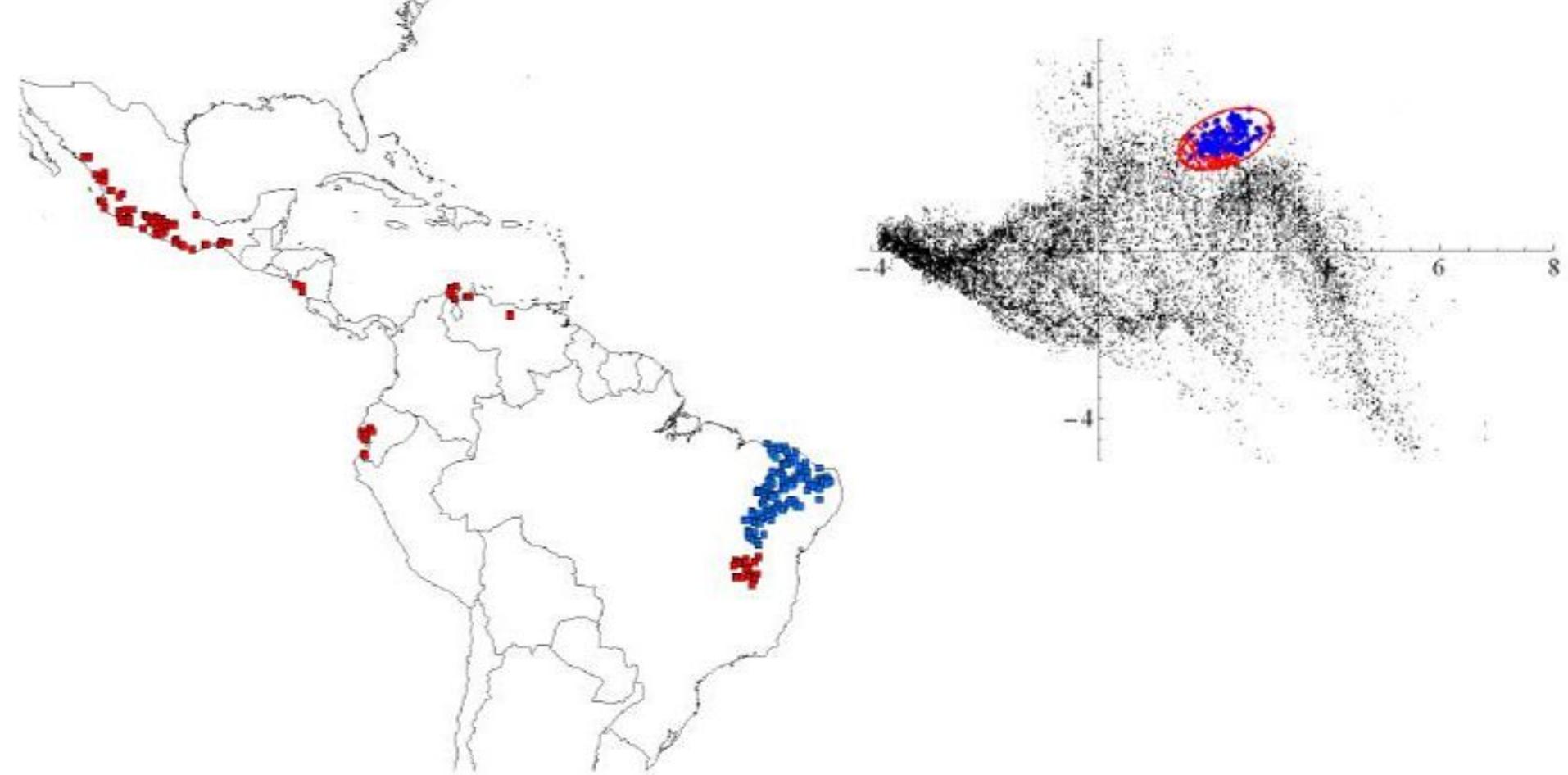




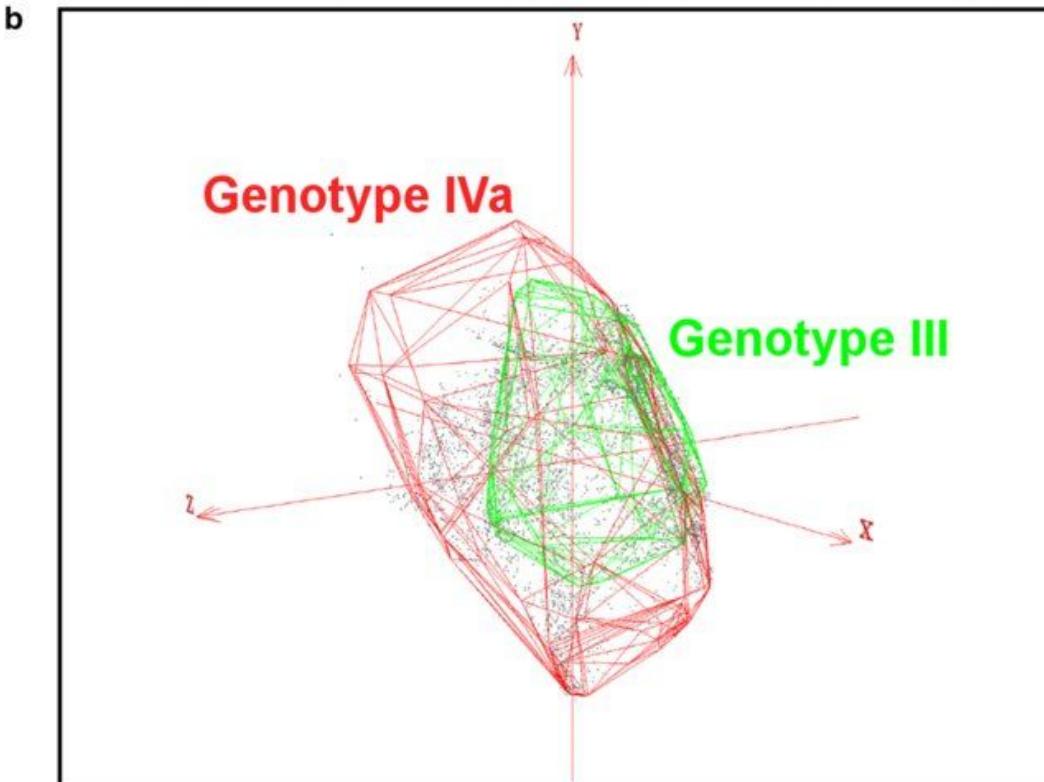
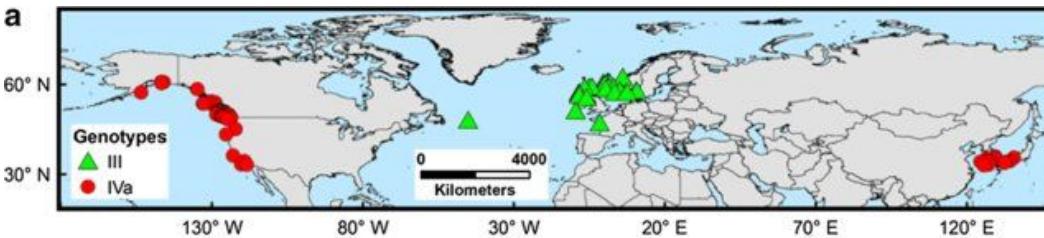
**Environmental space**



**Escobar, L. E., & Craft, M. E. (2016).** Advances and limitations of disease biogeography using ecological niche modeling. *Frontiers in microbiology*, 7, 1174.

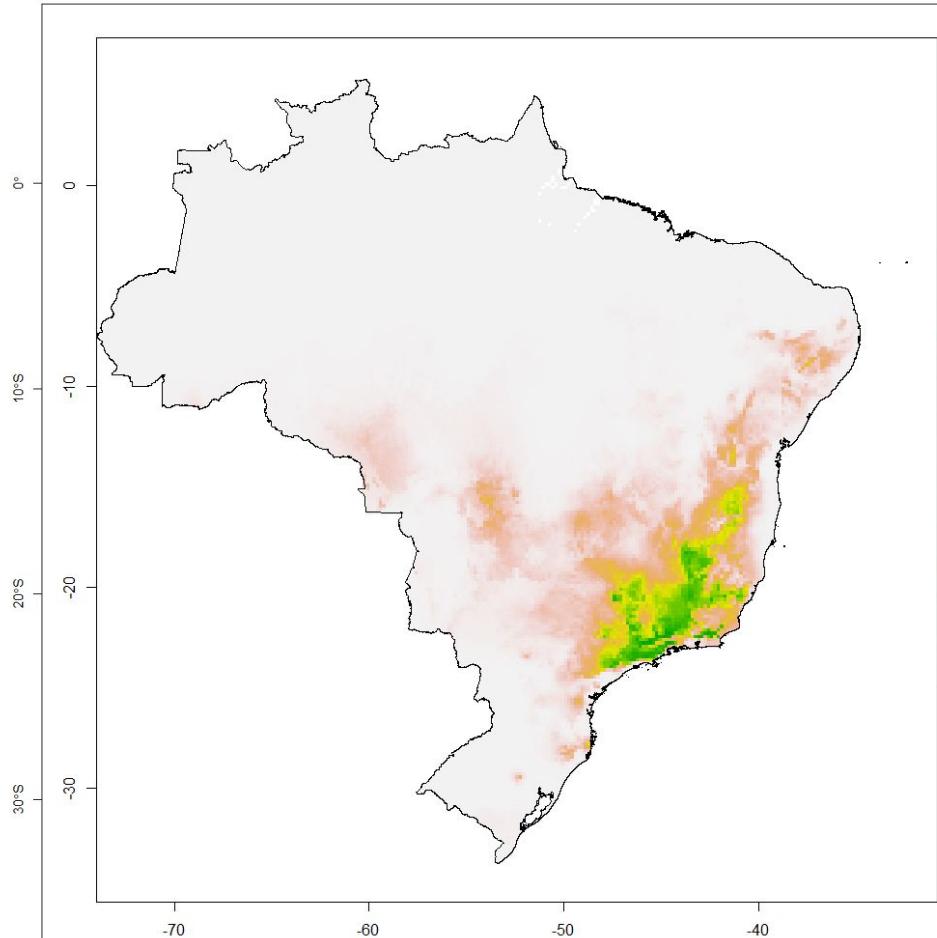
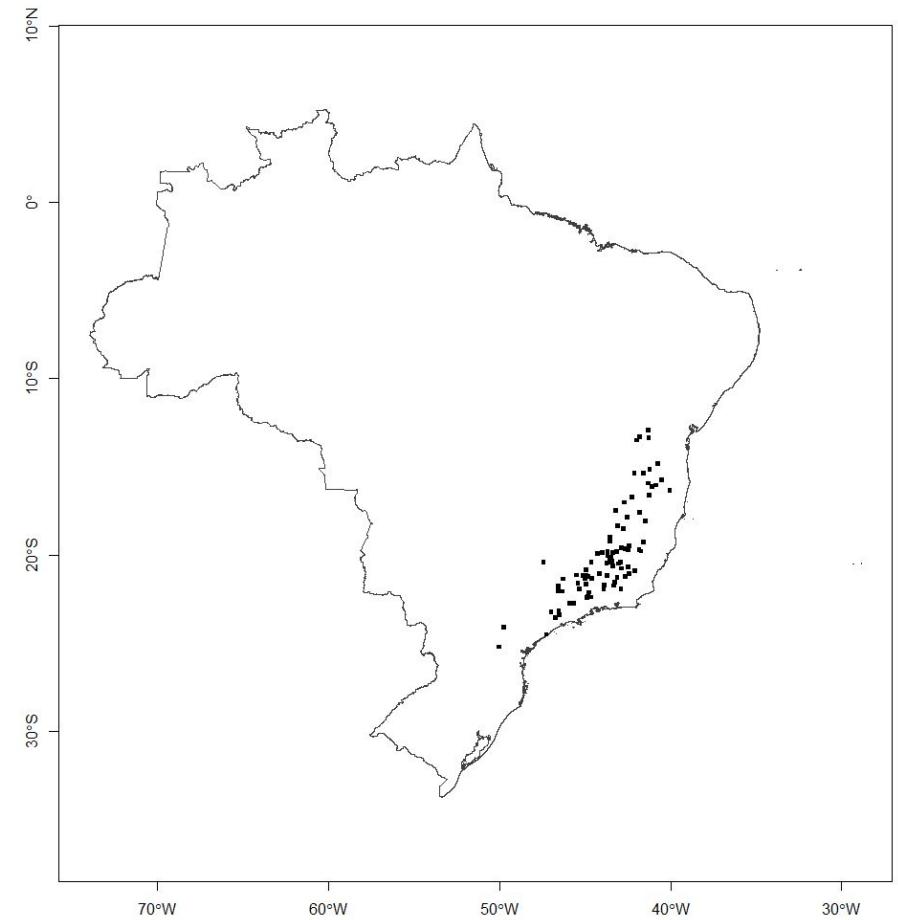


**Soberón, J., & Townsend Peterson, A. (2011).** Ecological niche shifts and environmental space anisotropy: a cautionary note. Revista Mexicana de Biodiversidad, 82(4), 1348-1355.

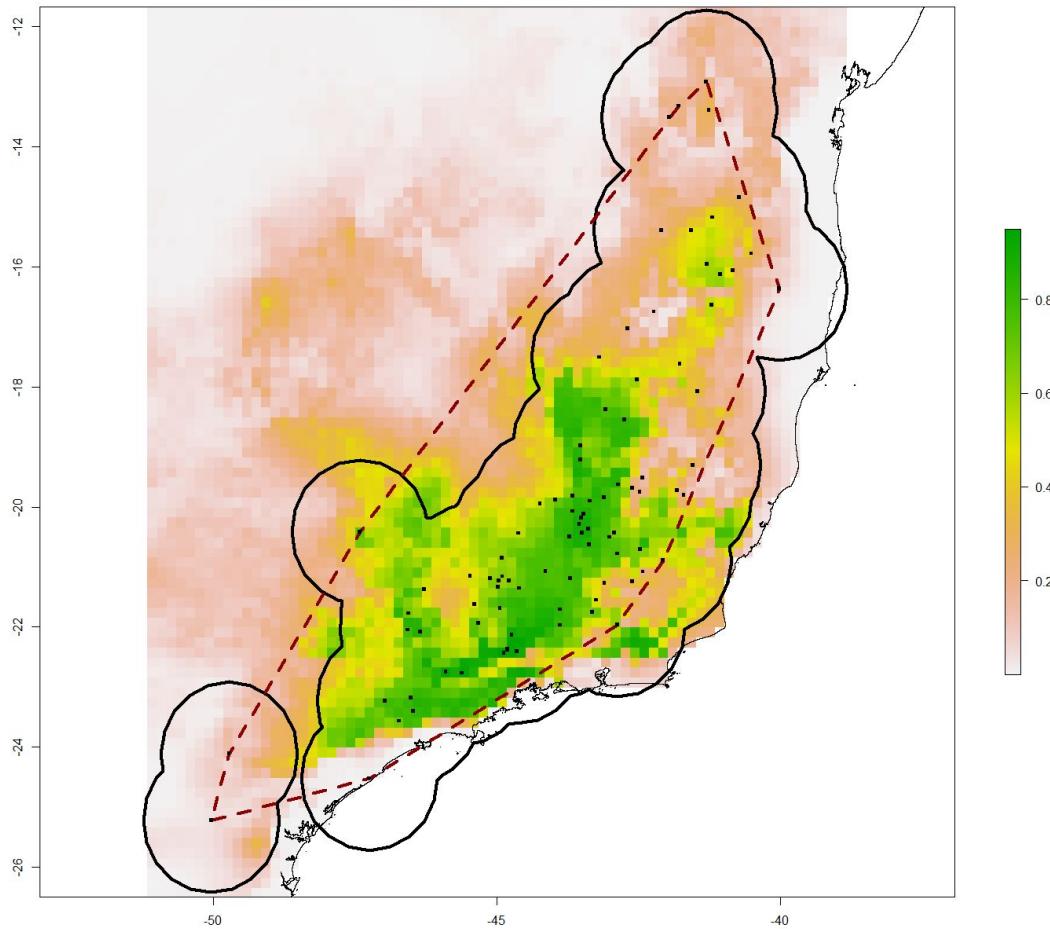


**Escobar, L. E., Escobar-Dodero, J., & Phelps, N. B. (2018).**  
Infectious disease in fish: global risk of viral hemorrhagic septicemia virus. *Reviews in Fish Biology and Fisheries*, 28(3), 637-655.

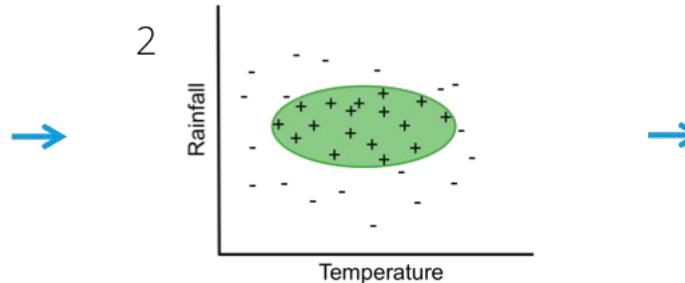
# Distribuição de espécies



# Distribuição de espécies



## Environmental space models

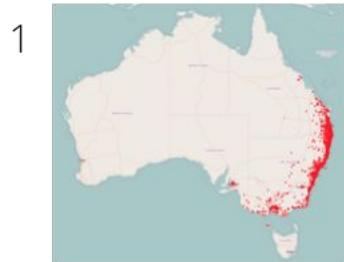


Geographical space

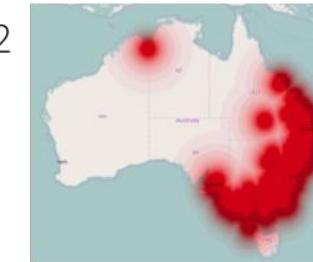
Environmental space

Geographical space

## Geographical space models



No environmental variables



Geographical space

Geographical space

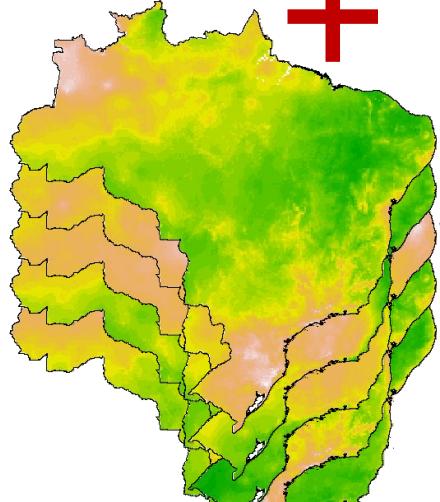
# Modelagem

Registros de ocorrência



Dados de entrada

Variáveis preditoras



Precipitação

Temperatura

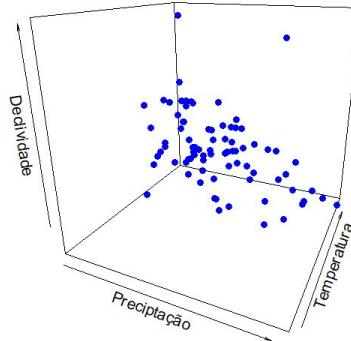
Topografia

Variável X

Variável Y

Algoritmos de modelagem

(Bioclim, GLM, GAM, ANN,  
MAXEnt, etc.)

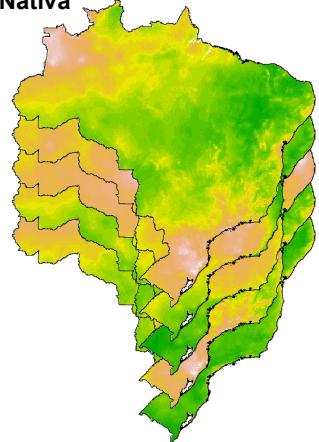


Mapa de distribuição potencial

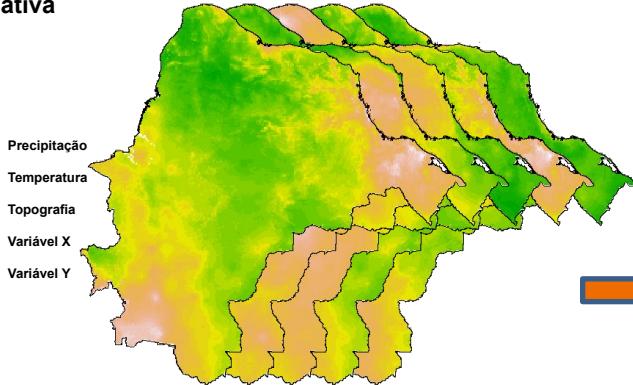


# Modelagem de nicho ecológico no espaço

Região Nativa

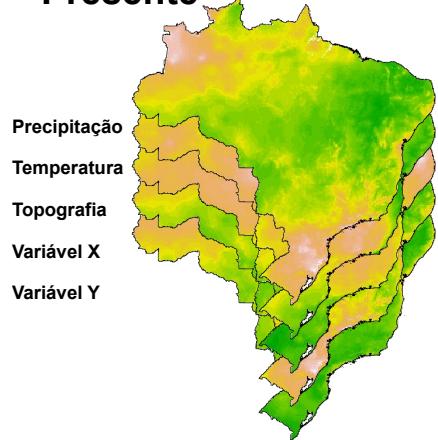


Região Alternativa

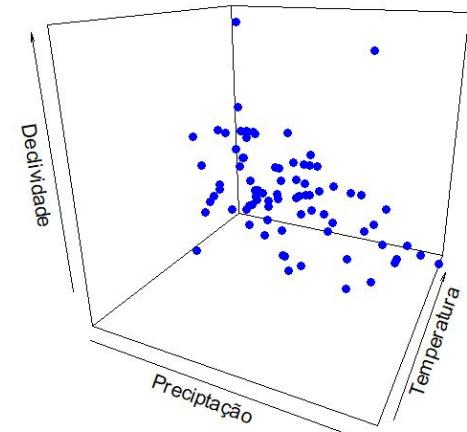
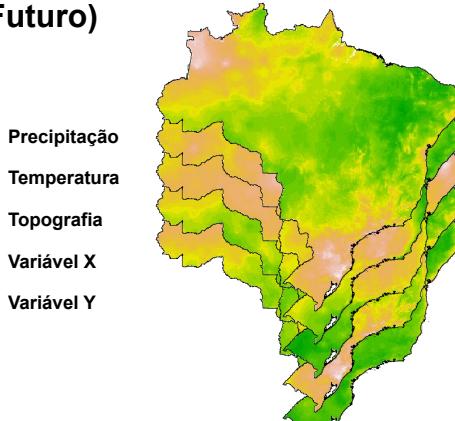


# Modelagem de nicho ecológico no tempo

Presente



Cenário Climático alternativo  
(e.g. Passado, Futuro)



# Premissas básicas da modelagem de nicho

- 1) Equilíbrio: Uma relação de equilíbrio entre a espécie e as condições ambientais que ocupam. É dita que uma espécie está em equilíbrio com as características físicas do ambiente em que ocorrem quando a espécie ocupa todas as áreas **possíveis** de serem ocupadas.
- 2) Suficiência amostral: A amostragem do espaço geográfico (registros de ocorrência da espécie) deve carregar uma boa amostra do espaço ambiental ocupado pela espécie.
- 3) Conservação do nicho: a propensão das espécies em manter as características referente ao nicho que ocupa ao longo de uma escala de tempo evolutivo.

# **Garbage in Garbage OUT**

