Pan American Health Organization

Regional Office of the World Health Organization

NC STATE UNIVERSITY

Mapping hotspot of infectious diseases in the animal-human-ecosystem interface

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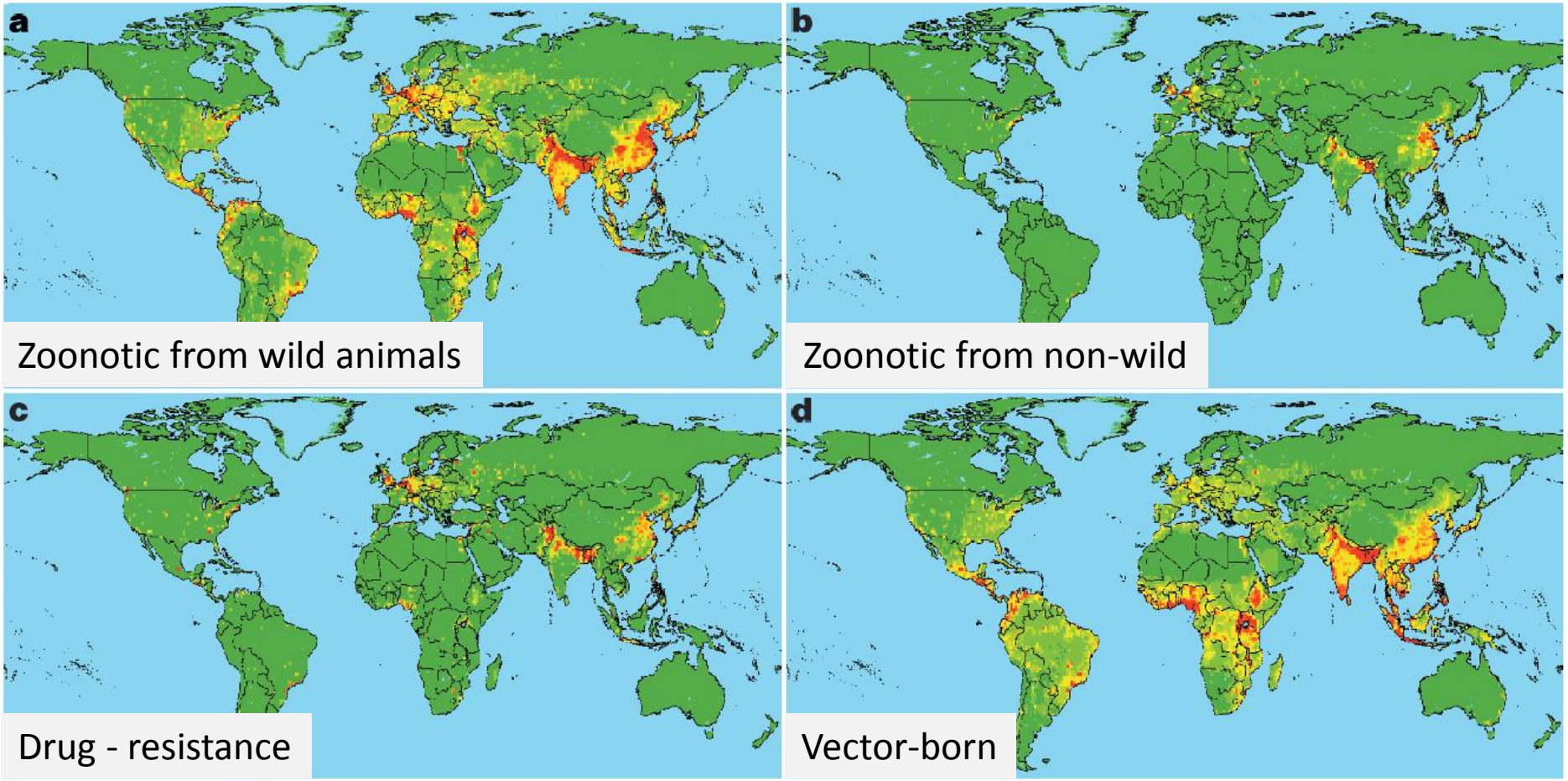
Emerging infection diseases (EIDs) in the interface

All based in GLM-Relative risk

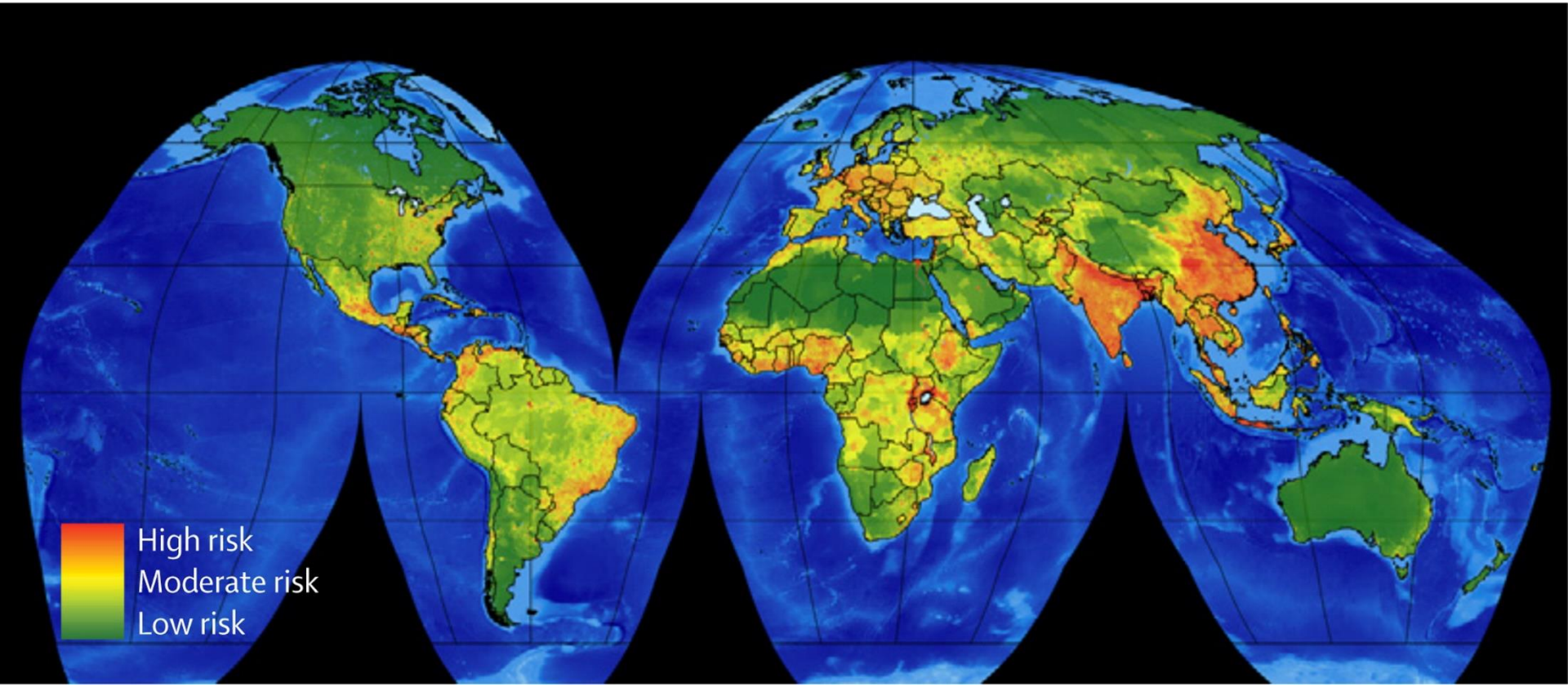


Jones, KE, Patel, N, Levy, M et al. Global trends in emerging infectious diseases. *Nature*. 2008; **451**: 990–994

2008

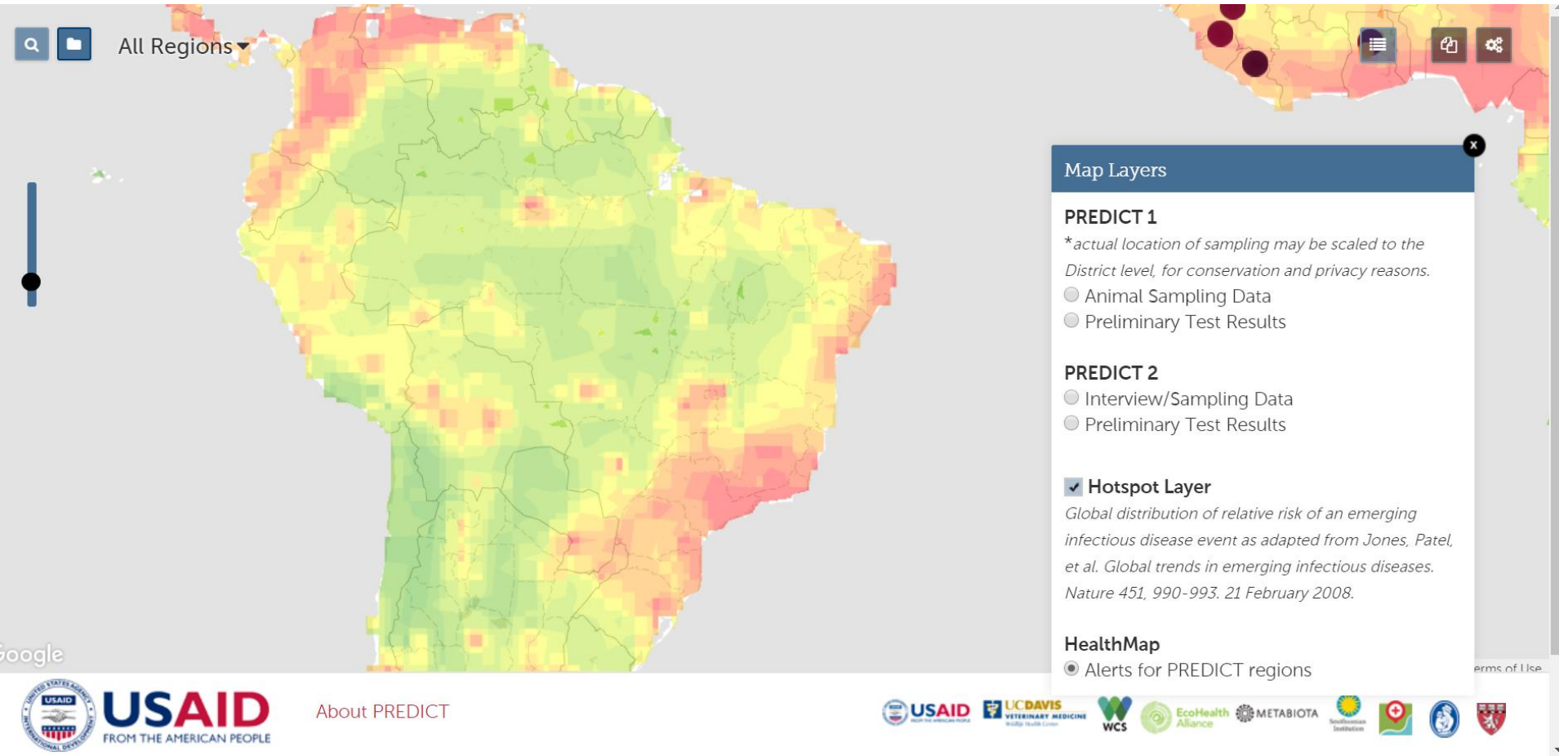
Emerging infection diseases (EIDs) in the interface

Infections emerging from wildlife-ENM



Morse, S.S.M et al. 2012- The lancet

2012



http://data.predict.global/

Near real time

Bolivia
PREDICT

USAID | PREDICT

Avian Influenza, HIV/AIDS, SARS, and Influenza H1N1: these diseases are not just infamous for...

LEARN MORE >

PREDICT

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Avian Influenza, HIV/AIDS, SARS, and Influenza H1N1: these diseases are not just infamous for...

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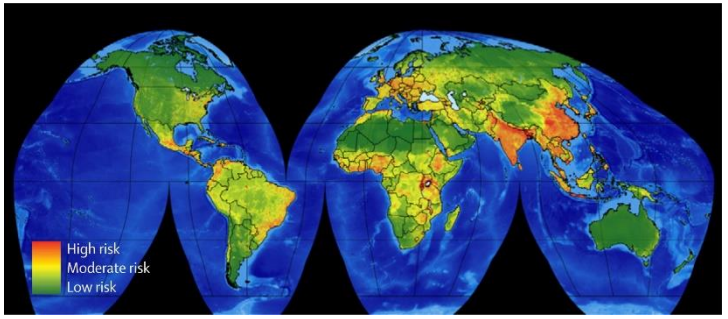


EcoHealth Alliance, 2017

Current

Emerging diseases in the interface

Infectious hazards and epidemics:

- 70% of infectious hazard threats to PH are in the interface with animals (Taylor, 2001).
- New strains:

✓Ebola virus;

✓Human immunodeficiency virus (HIV);

✓BSE;

✓Severe acute respiratory syndrome (SARS);

✓Influenza A (H5N1) with a pandemic potential;

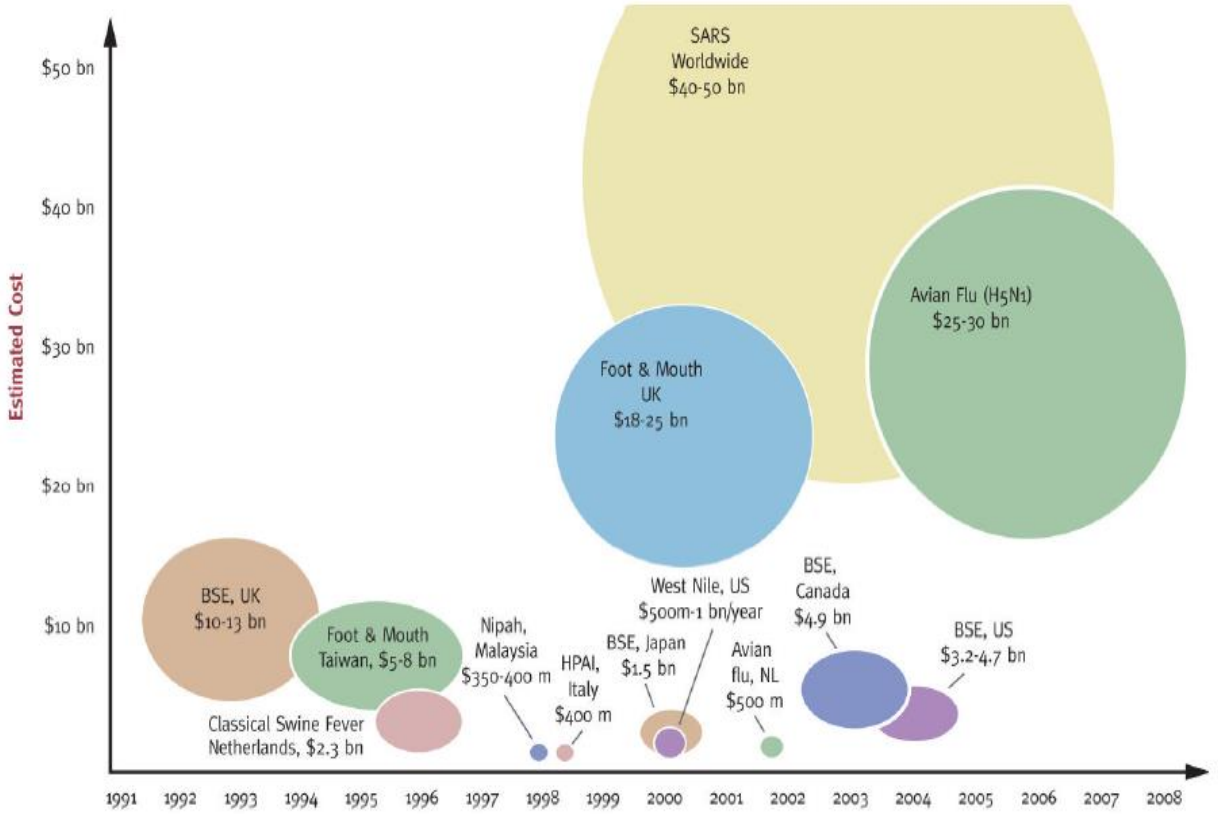
✓Novel A(H1N1) influenza virus;

✓MERS.

- Re emerging of well know infectious hazards that still persist and continue producing outbreaks **(yellow fever, plague).**

Economic impact example of some infectious diseases

FIGURE 8: Economic Impact of Selected Infectious Diseases



Figures are estimates and are presented as relative size.

Over $ 125 billion in economic losses were estimated considering the broader economic cost of some diseases that hit people and animals globally, 1995-2008 (Newcomb, 2008)

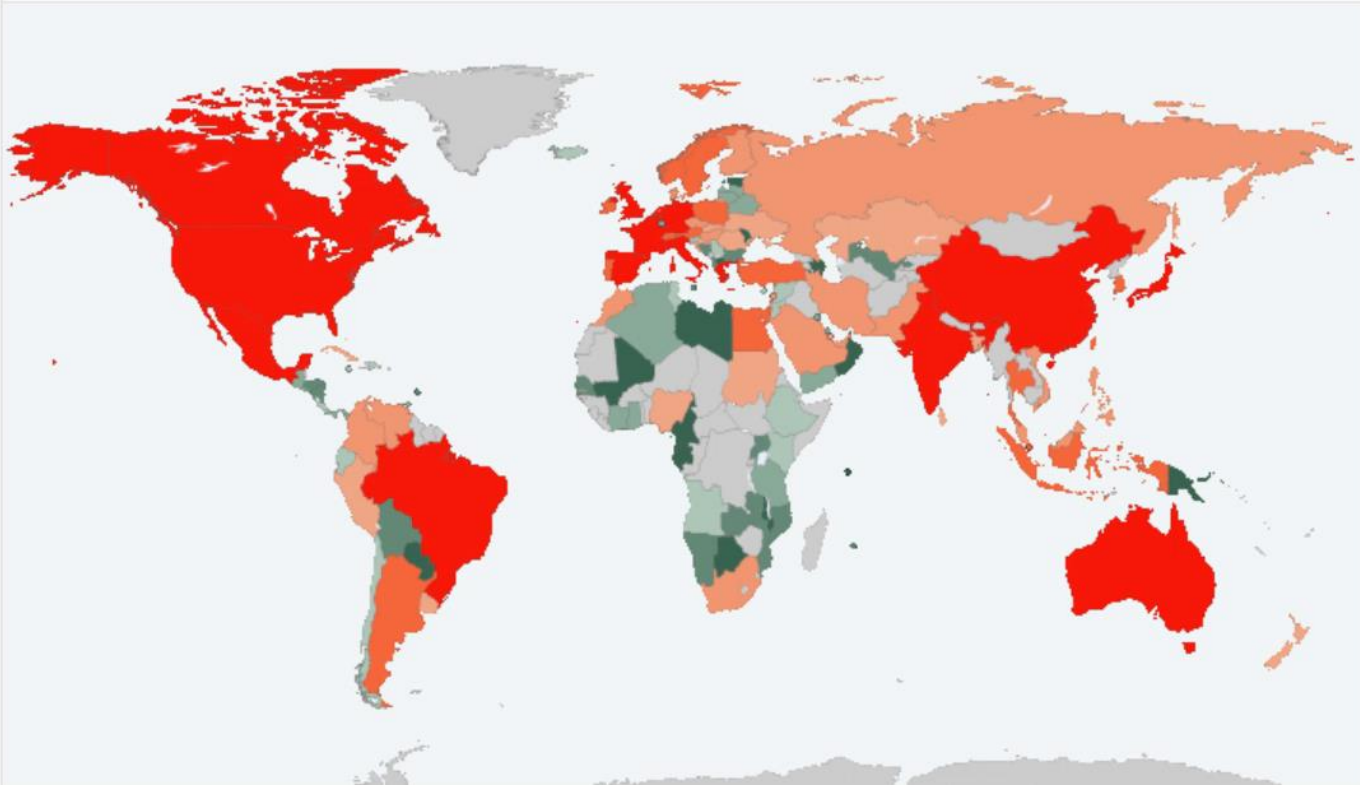
https://www.nationaldebtclocks.org/

$ 060,243,400,765,548

CURRENT GLOBAL PUBLIC DEBT

Total public debt

Higher debt — Lower debt



COMPARE COUNTRY DEBT

Choose a country...

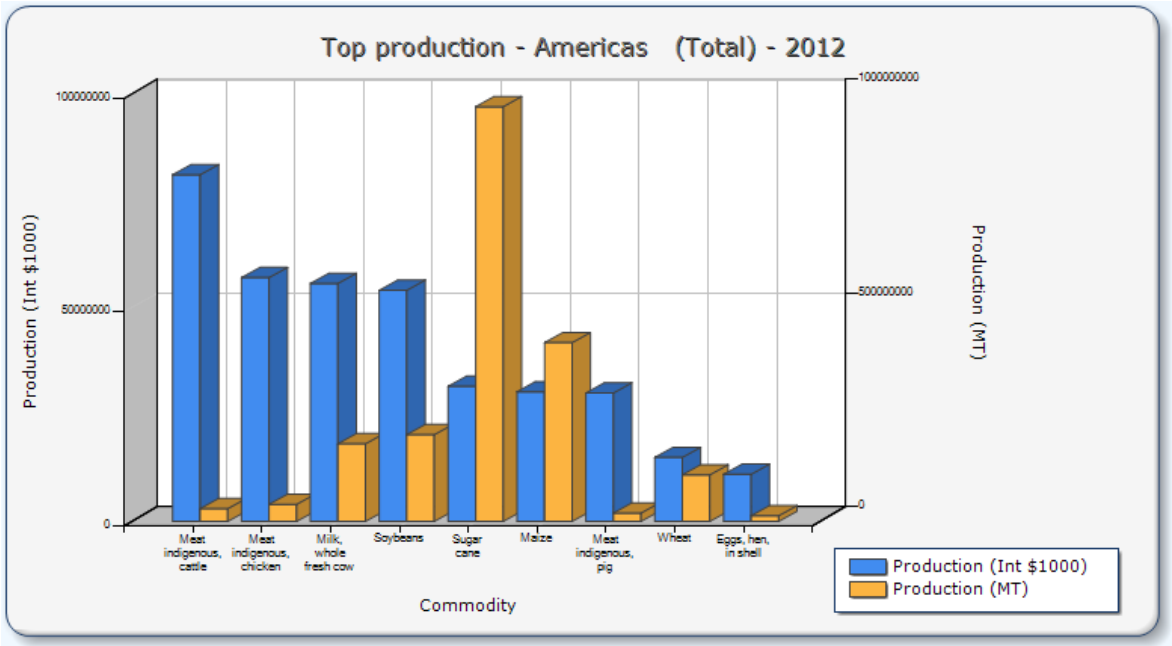
Choose a country...

Choose a country...

Current global world

Trade, tourism and global economy:

- Food production as a commodity for many countries.



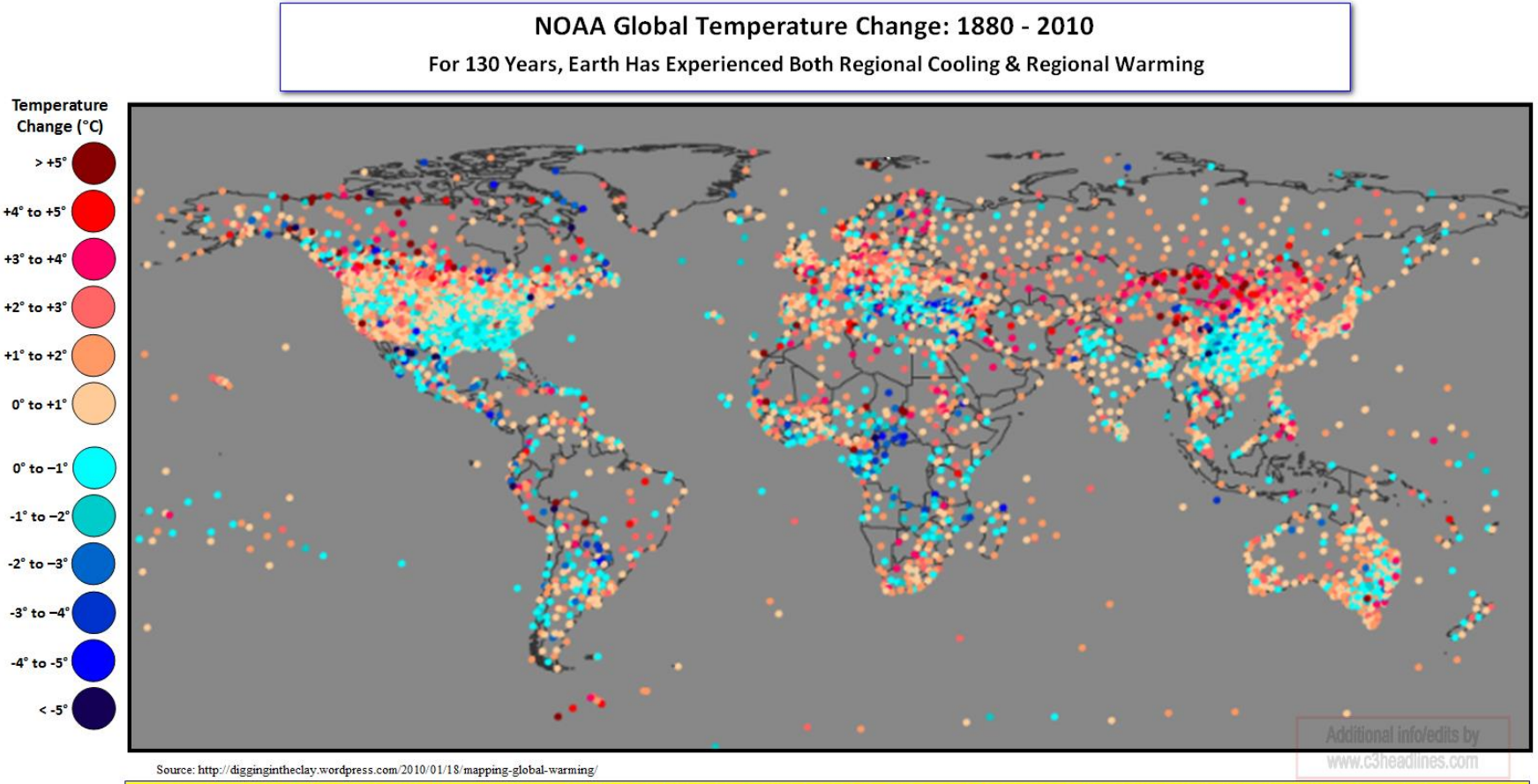
Source: WB

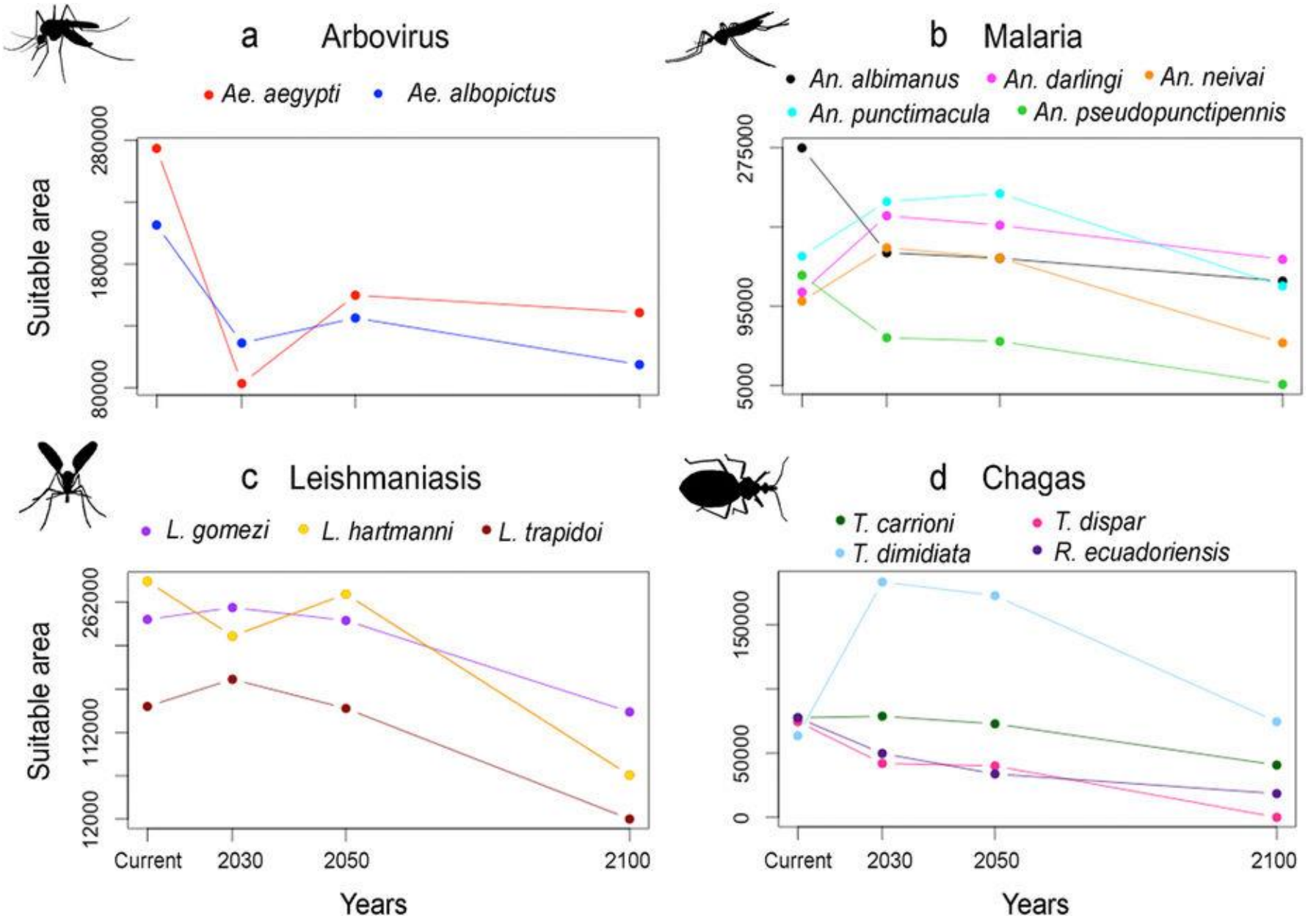
A(H5N1) avian influenza was not detected in the Americas, but there was a 40% drop in the stock of large poultry producers due to the **indirect impact of the global market and consumers** (Newcomb, 2008).

Current global world

Climate change:

- Due to climate change, **extreme weather events**, **temperatures**

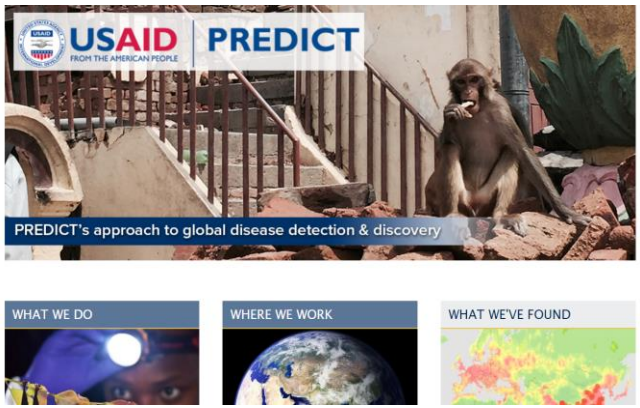


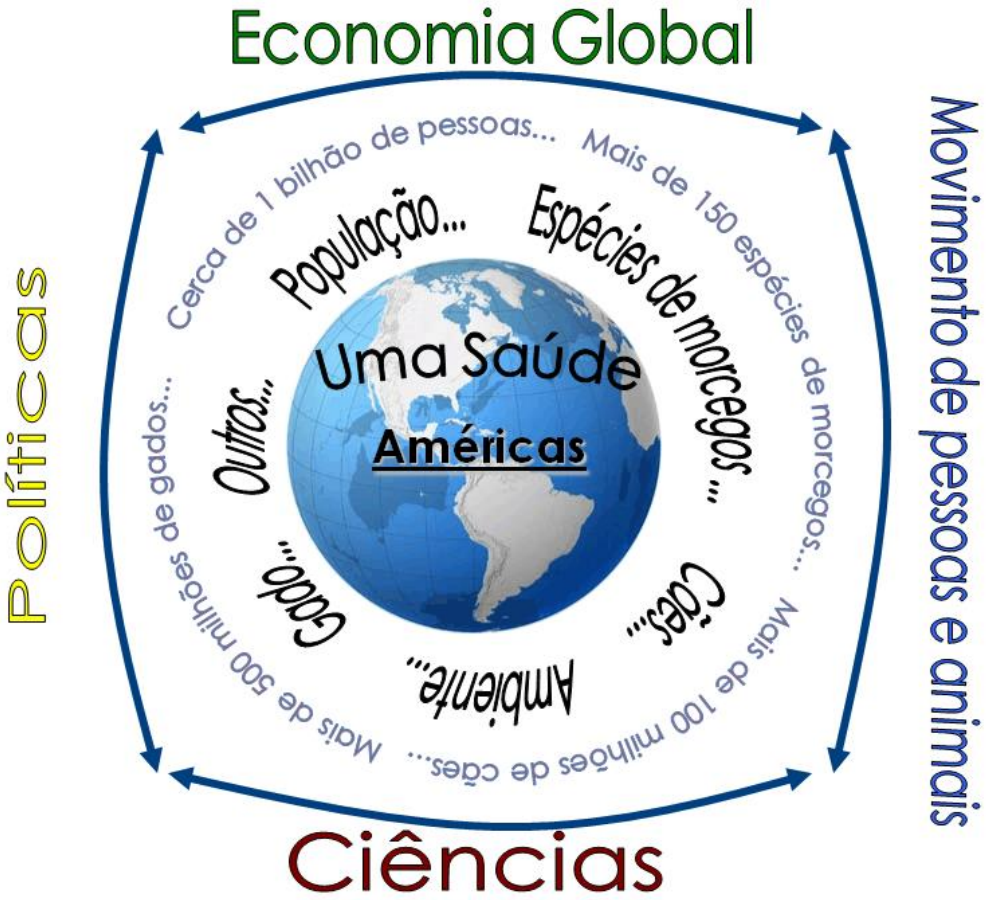


Escobar, E.L. etal. 2016, scientific report

Integrated vison

To respond.. the vision that **humans, animals and the environment are linked** and the collaboration among **multi disciplines is crucial**.





Schneider MC et al, 2014

One Health Concept

- "**OH is a collaboration effort of multidiscipline to attain optimal health for humans and animals while protecting the environment**" (King , 2015)

- Operational definition of the One Health approach, the Stone Mountain Working Group (Rabinowitz, 2013):

❑ It is feasible to integrate efforts in human, animal and environmental to **predict and control certain diseases** in the human -animal- ecosystem interface.

Possible components and integrated actions

Example: **Human Rabies Transmitted by Hematophagous Bats (*Desmodus rotundus)***

HUMAN	ANIMAL	ECOSYSTEM
• Rabies cases in humans can be fatal • Vampire bat bites put individuals at risk for contracting the disease and require attention from the health system	• Infected bats spread rabies to different species • Cattle with rabies have economic loss	• Areas with abundant shelter and food for bats could increase bat population • **Rapid change in productive process/ environment** (deforestation, gold mining, stop raising animals) could change bats feeding habits

Integraded vision

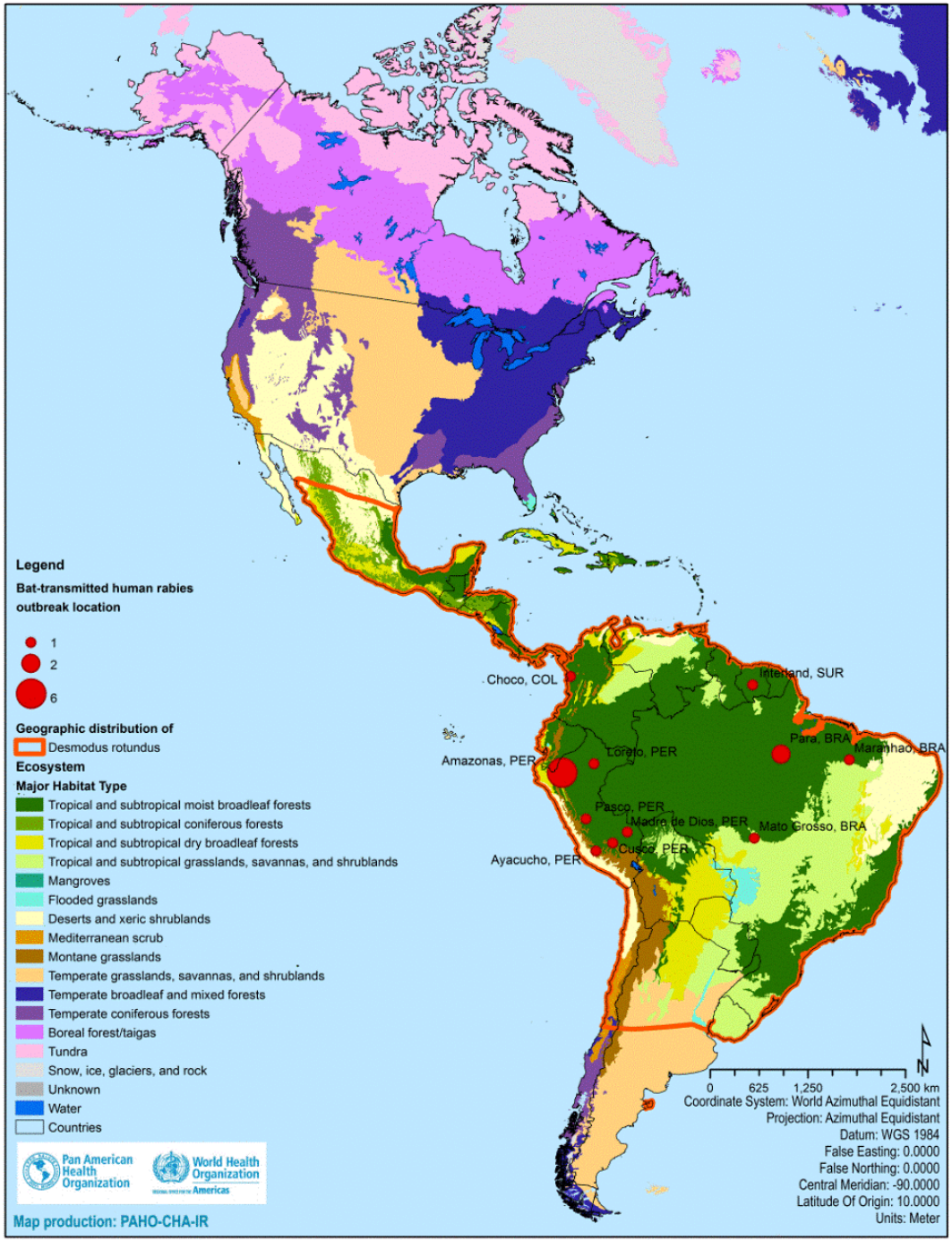


Fig. Outbreaks of human rabies transmitted by vampire bats, region where the *Desmodus rotundus* habiat, over Americas ecossystems

Source: Schneider MC at al. O conceito de “Uma Saúde” e sua aplicação. Revista CFMV, 2014.

Possible integrated actions

Example: **Human Rabies Transmitted by Bats**

- Exchange of information on monitoring at **local level** (human and animal health) rabies cases in humans and in animals
- Tools to **support national authorities in the forecast/identification of risk areas.**
- **Jointly identify areas of social vulnerability** and of difficult access to health services for people being bitten by bats and develop **preventive intersectoral actions before the occurrence of an outbreak**.
- **For risk areas, prepare education materials.**

PLOS | NEGLECTED TROPICAL DISEASES
TENTH ANNIVERSARY

OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

Leptospirosis in Rio Grande do Sul, Brazil: An Ecosystem Approach in the Animal-Human Interface

Maria Cristina Schneider, Patricia Najera, Martha M. Pereira, Gustavo Machado, Celso B. dos Anjos, Rogério O. Rodrigues, Gabriela M. Cavagni, Claudia Muñoz-Zanzi, Luis G. Corbellini, Mariana Leone, Daniel F. Buss, Sylvain Aldighieri, Marcos A. Espinal

Published: November 12, 2015 • https://doi.org/10.1371/

Cases from 2008-2012

Human leptospirosis and ecoregions

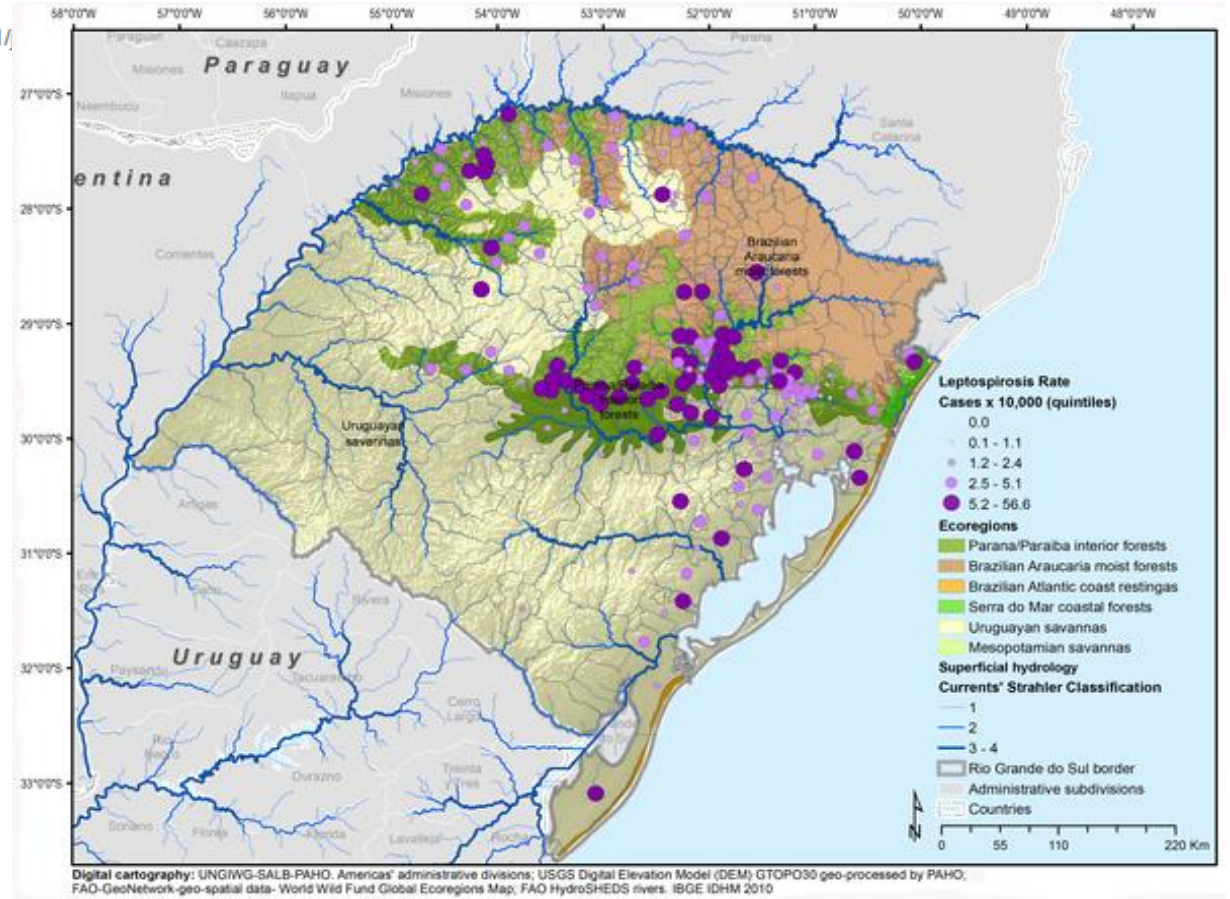
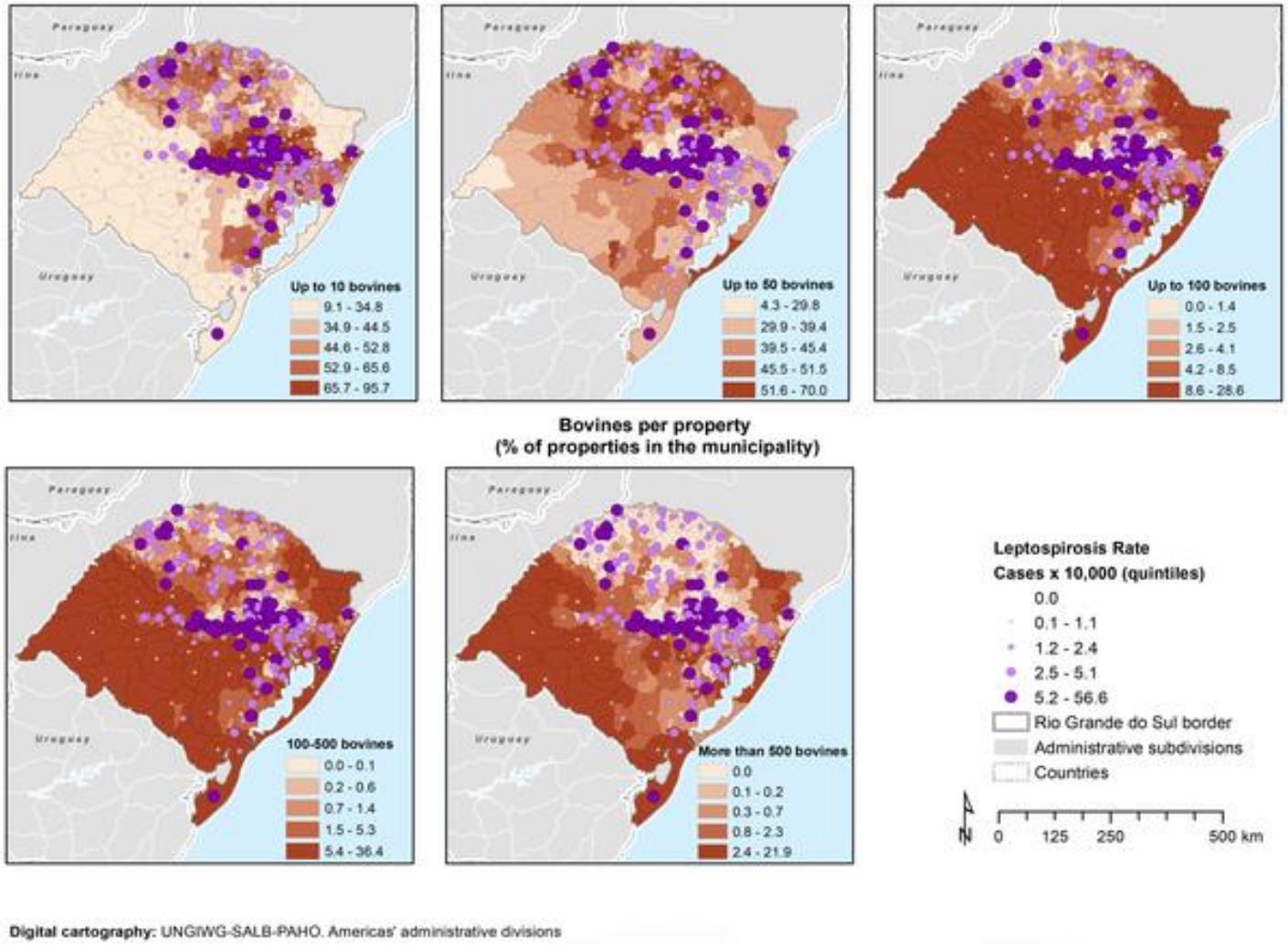


Fig 6. Cumulative incidence for leptospirosis and percentage of properties with up to 10 bovines, by municipality, Rio Grande do Sul, 2008–2012.

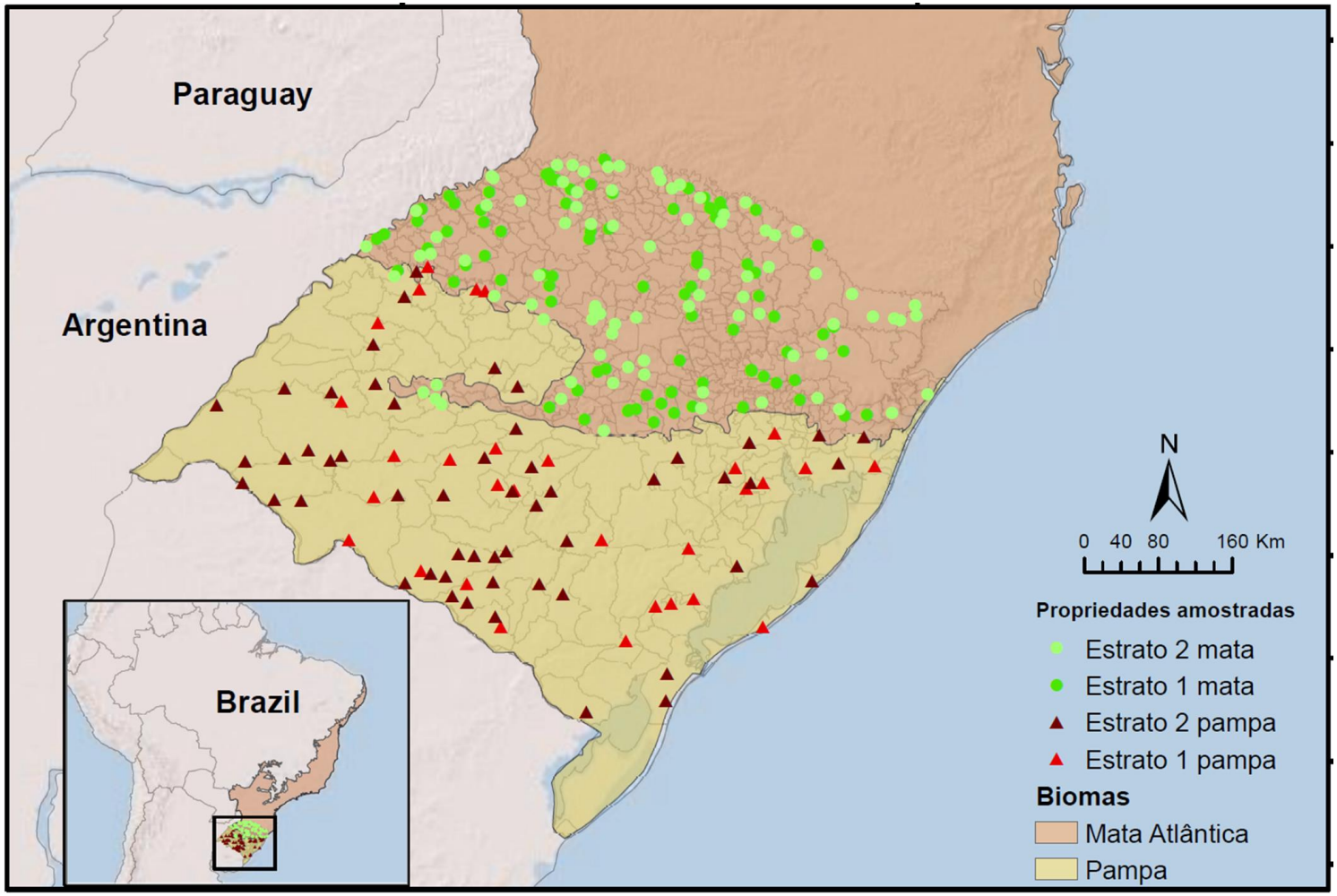
Human leptospirosis and % of properties with up to 10 bovines



Schneider MC, Najera P, Pereira MM, Machado G, dos Anjos CB, et al. (2015) Leptospirosis in Rio Grande do Sul, Brazil: An Ecosystem Approach in the Animal-Human Interface. PLOS Neglected Tropical Diseases 9(11): e0004095. https://doi.org/10.1371/journal.pntd.0004095
http://journals.plos.org/plosntds/article?id=10.1371/journal.pntd.0004095

Possible integrated actions

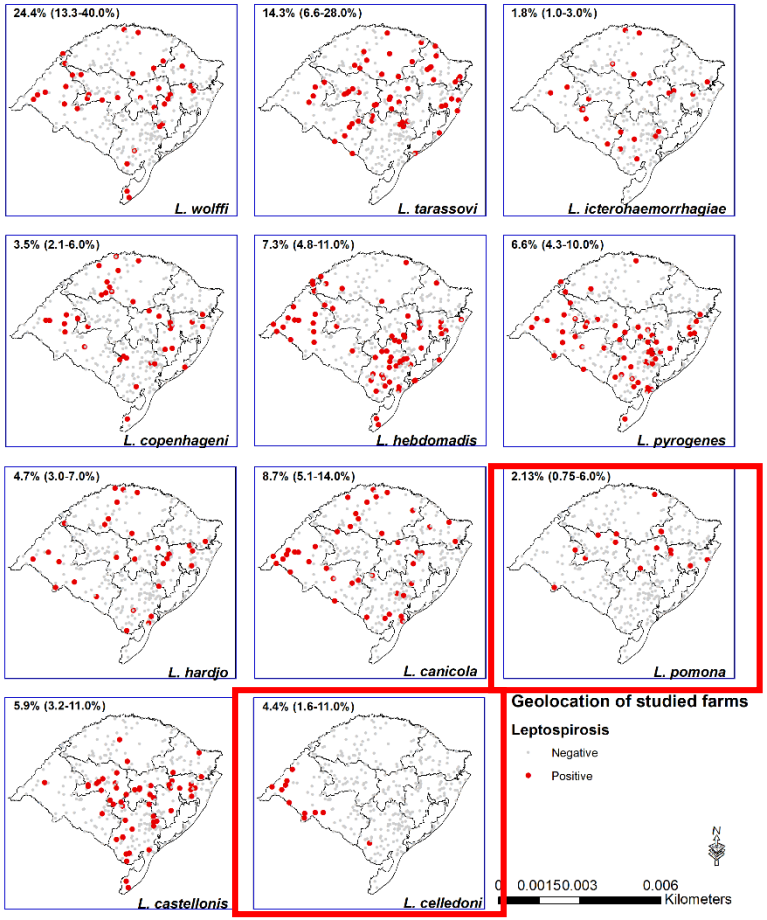
Second phase --cattle distribution

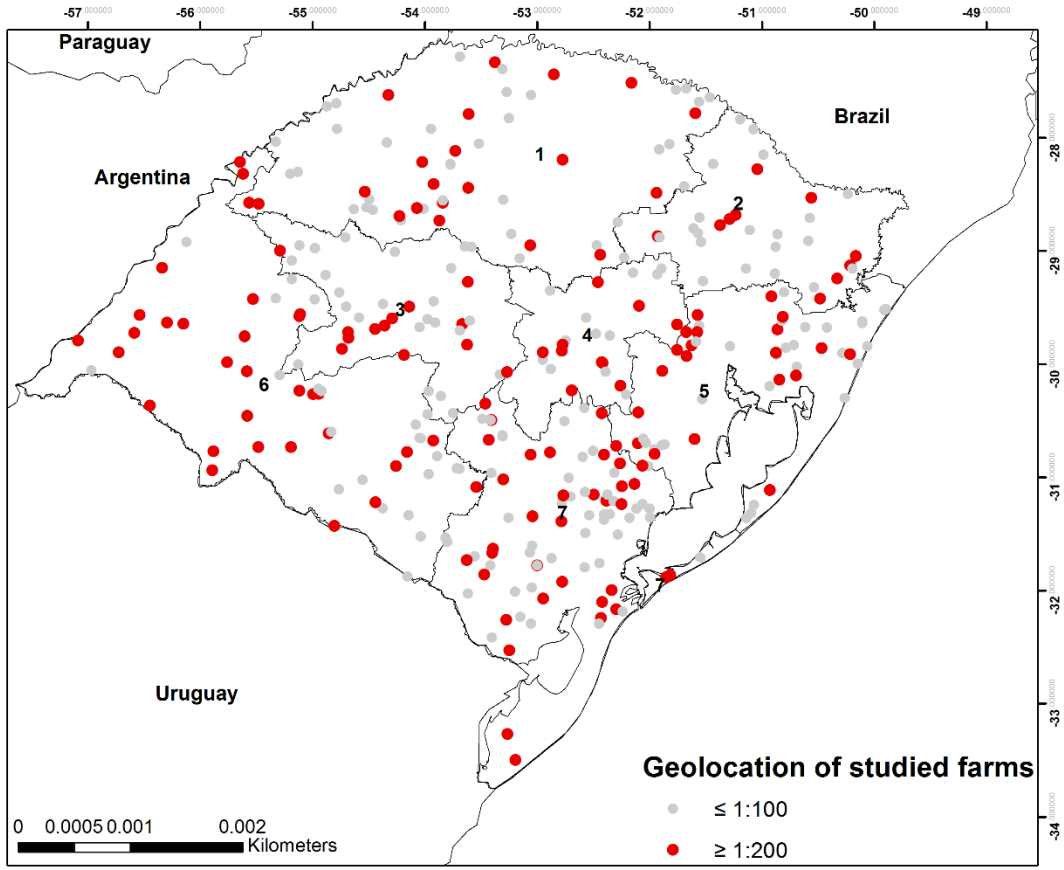


Data not published-APOIO SEAPI-RS- FUNDESA

Possible integrated actions

Equine distribution





Machado, G. etal. data not published- APOIO SEAPI-RS- FUNDESA

Possible new studies for Brazil using integrated vision

Mapping Rabies hotspot by Hematophagous Bats

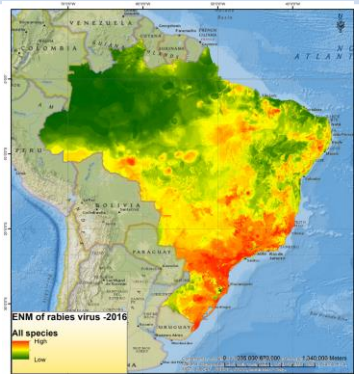
Possible transdisciplinary research team:

- MAPA
- SVS/MS
- PAHO
- Universities
- Others

Possible components using One Health operational definition

Human Rabies Transmitted by Hematophagous Bats (*Desmodus rotundus)*

HUMAN	ANIMAL	ECOSYSTEM
• Rabies cases in humans can be fatal • Vampire bat bites put individuals at risk for contracting the disease and require attention from the health system	• Infected bats spread rabies to different species • Cattle with rabies have economic loss	• Areas with abiotic conditions.



Future studies

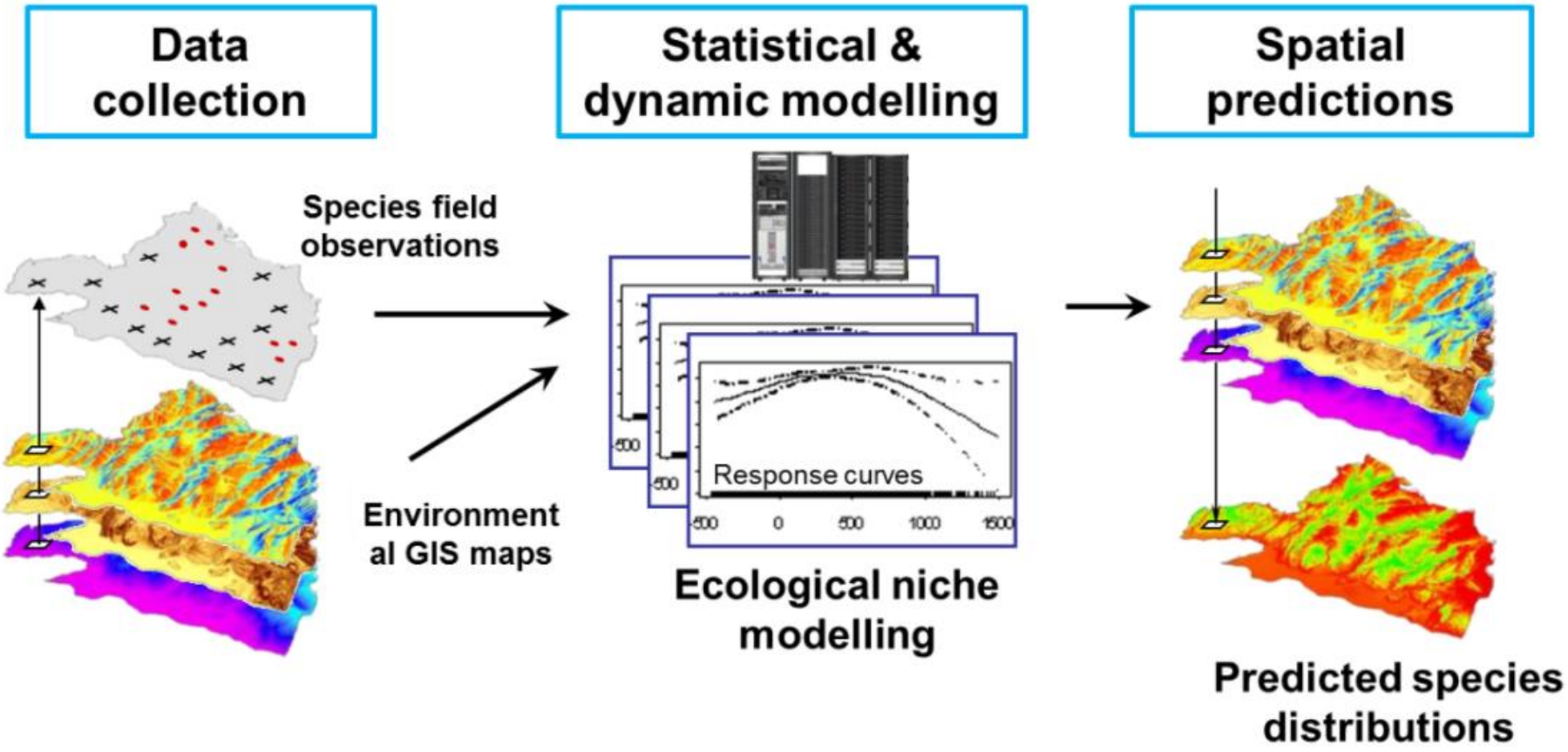
General objective

Analyze the distribution of rabies transmitted by hematophagous bats (*Desmodus rotundus*) in Brazil and explore possible drivers using the One Health approach.

Research questions

- **Are there area of high suitability** for Rabies in Brazil

Ecological Niche modeling-ENM
Species distribution modelling

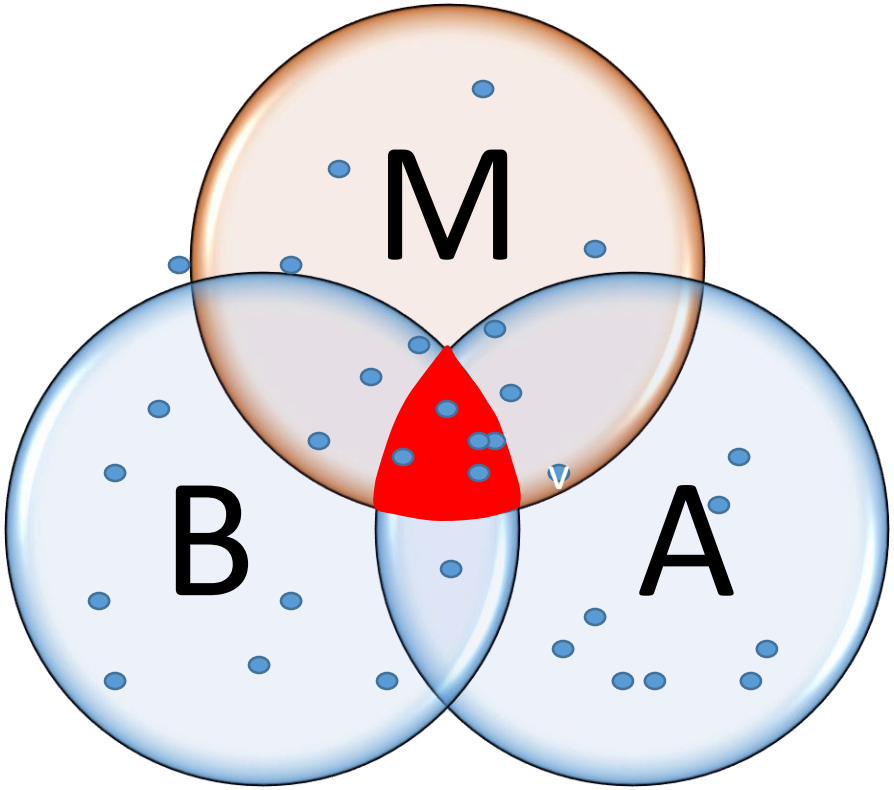


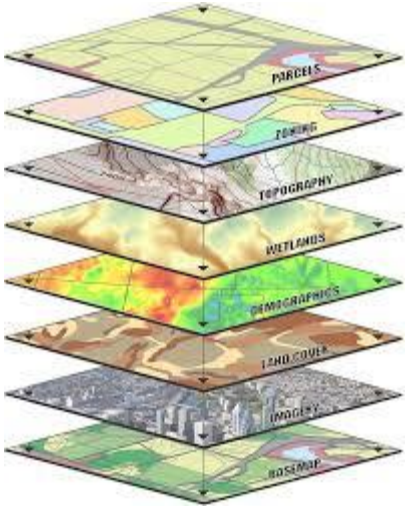
Antoine Guisan

BAM framework-terminology (Peterson et al., 2011)

G

Accessible to dispersal (Movements)





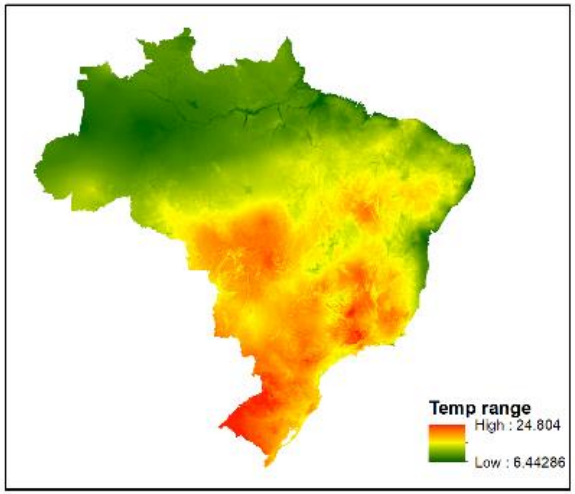
Favorable biotic environment (Biotic)

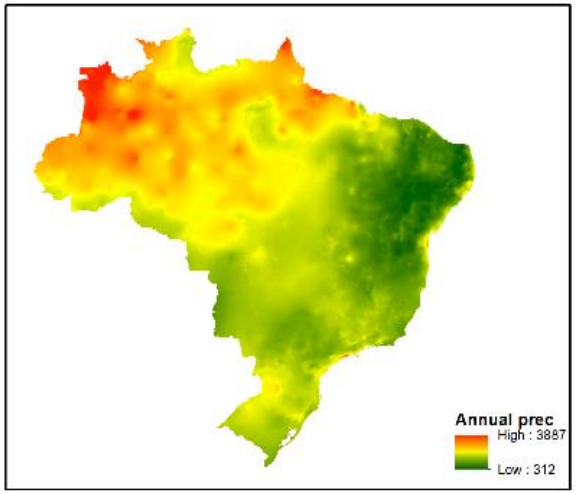
Physiological requirements (Abiotic)

Preliminary results

Environmental variables :

1. Temperature
2. Precipitation
3. Solar radiation





...

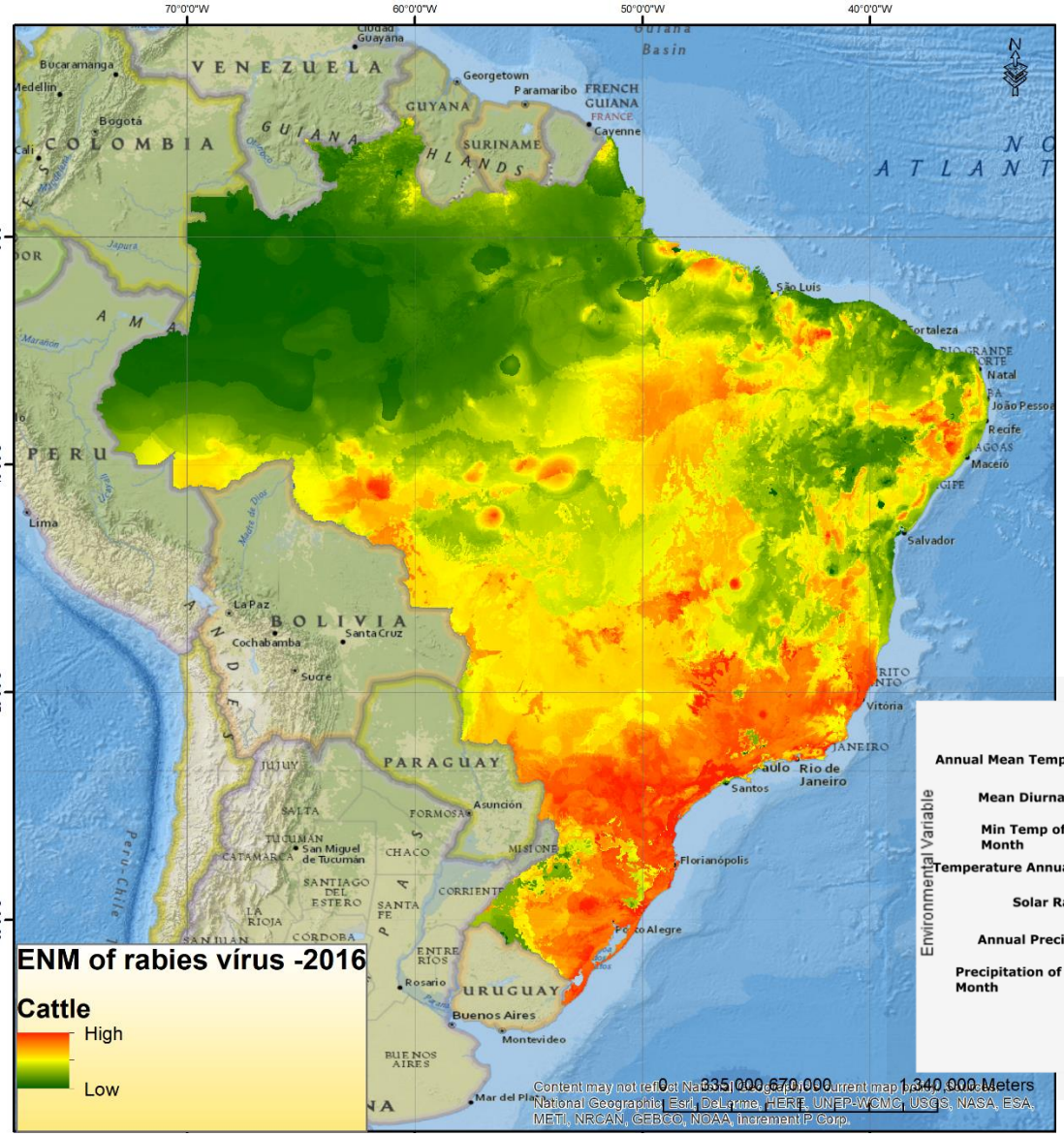
Y=Geolocation (Long e Lat)

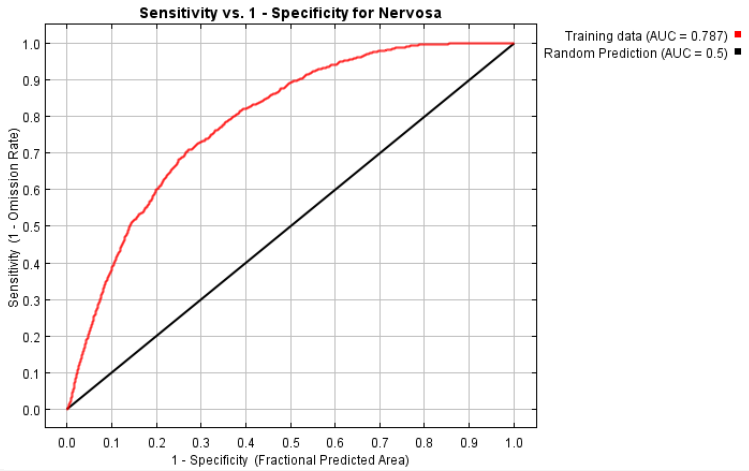
MAPA data not published

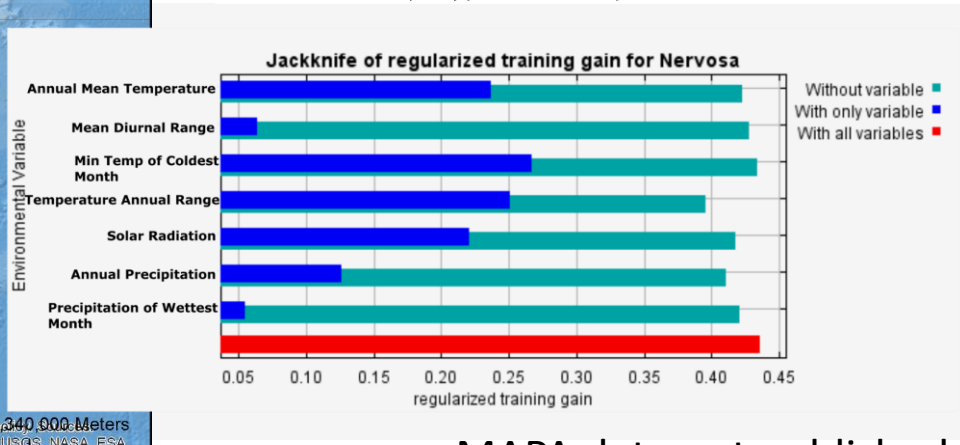
Preliminary results

Environmental variables :

1. Temperature
2. Precipitation
3. Solar radiation

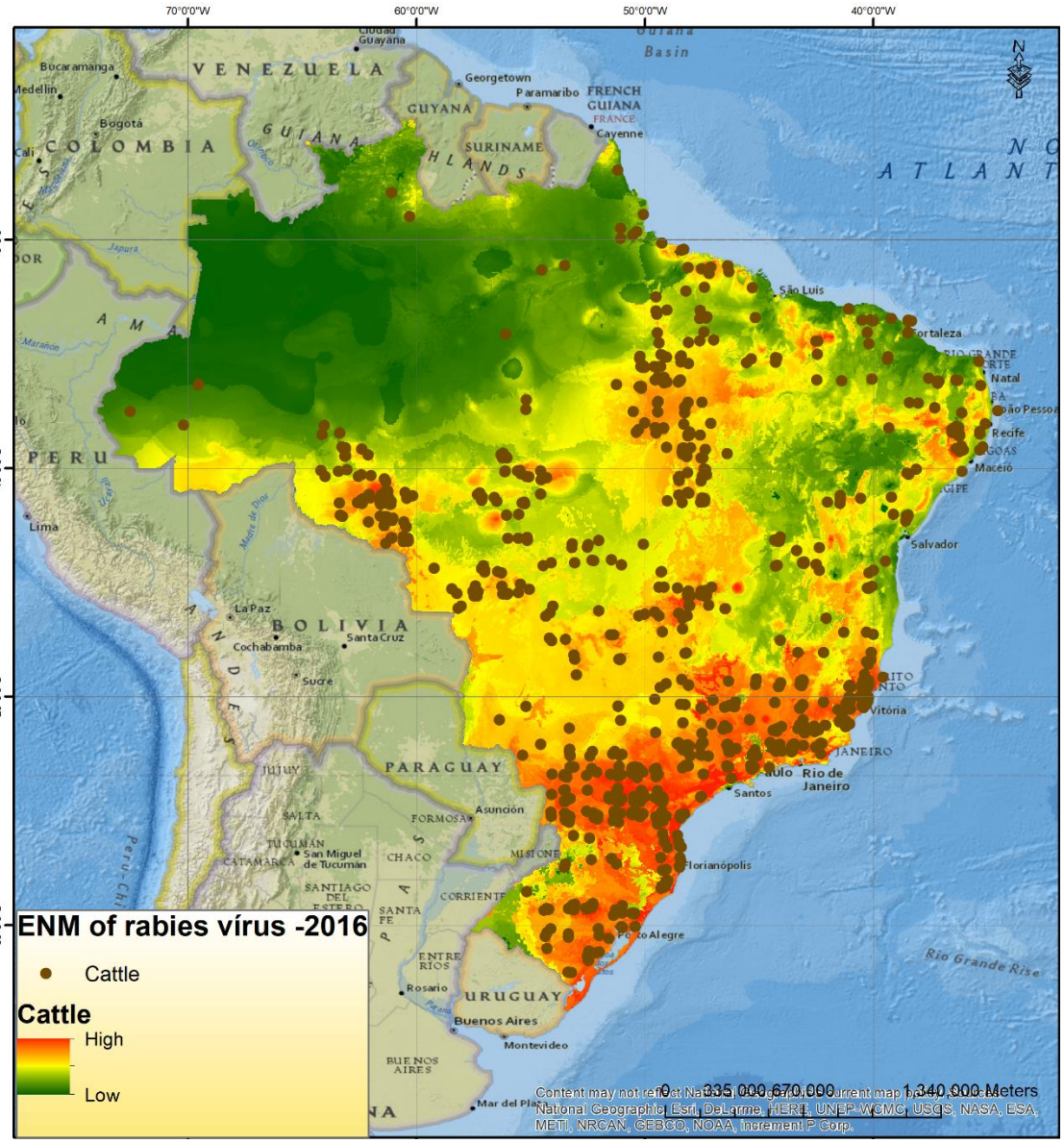






MAPA data not published

Preliminary results



Environmental variables :

1. Temperature
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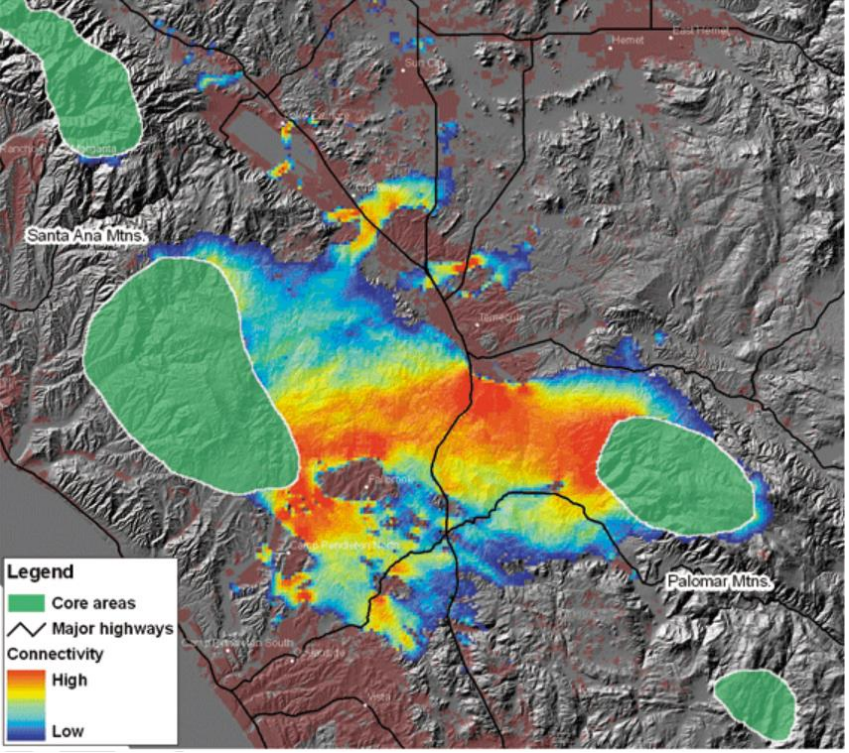
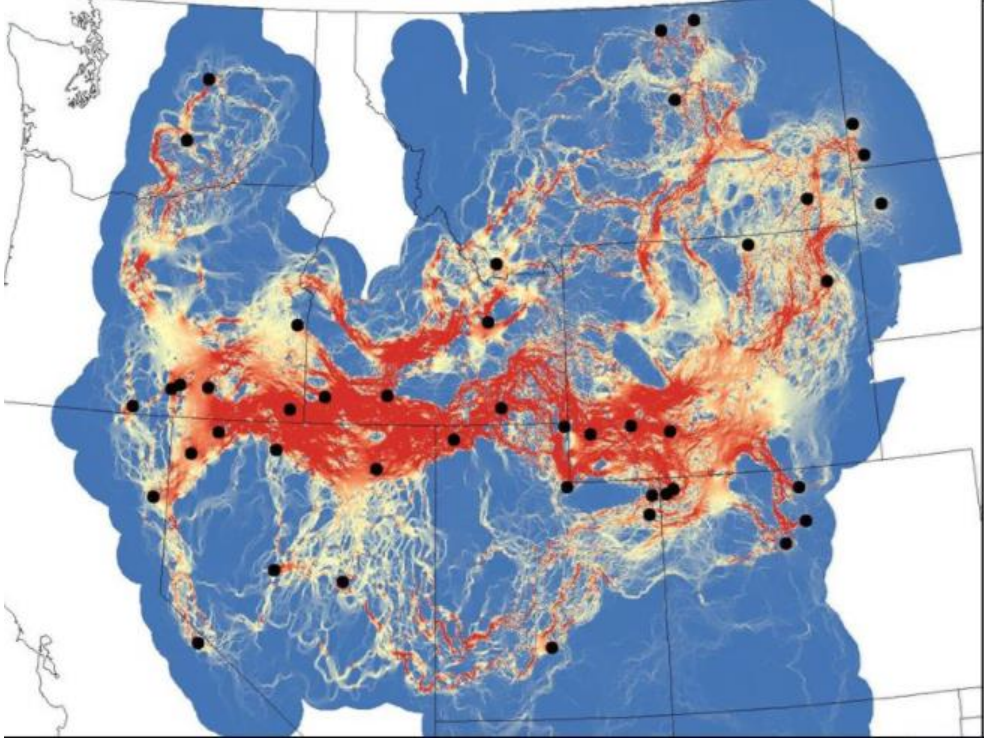
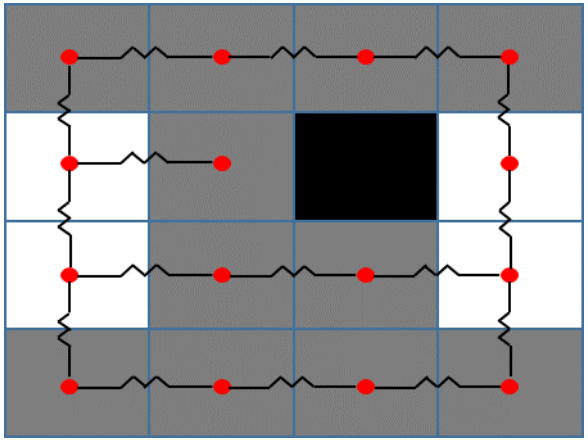


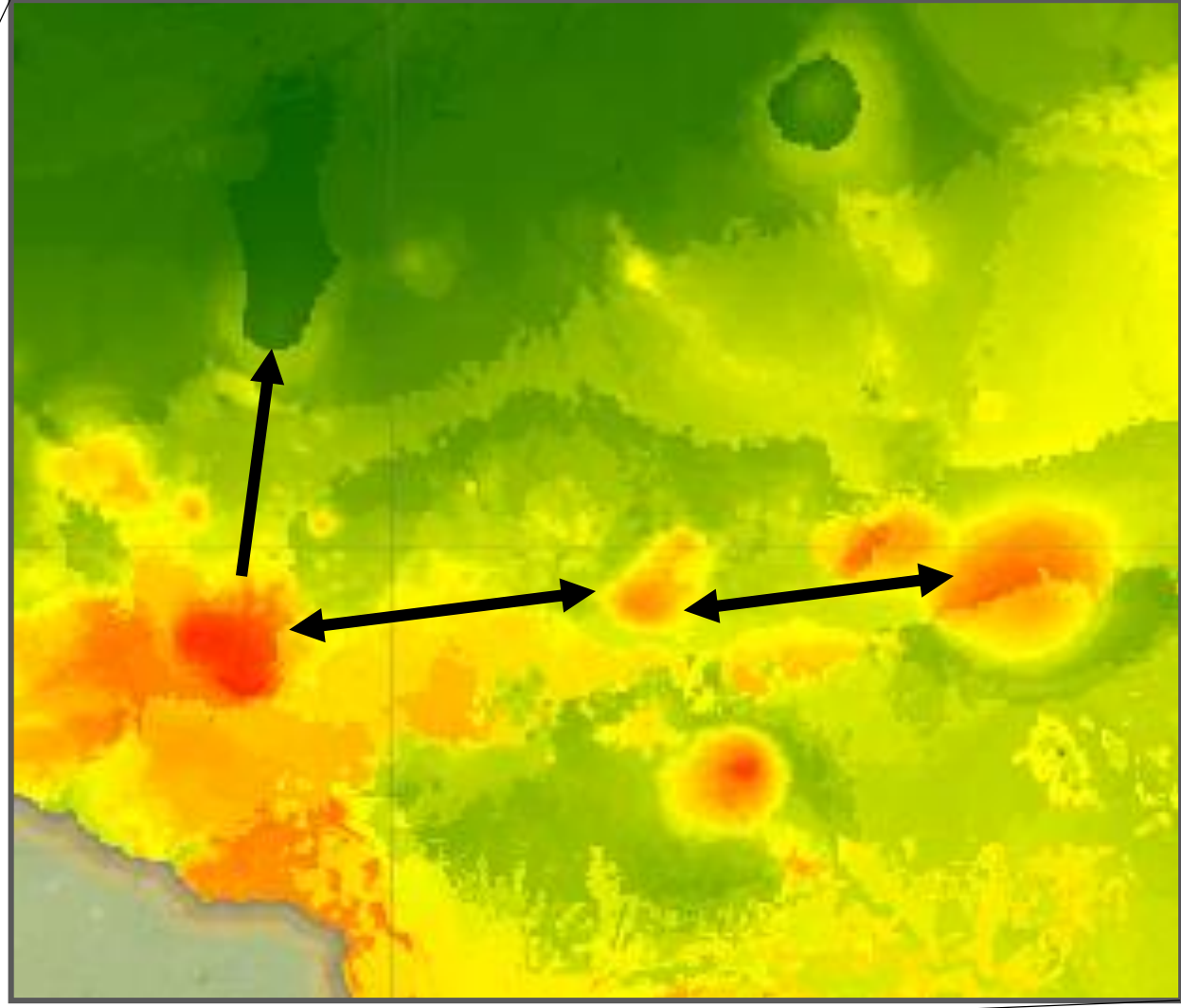
Steve Reinhardt and Viral Shah

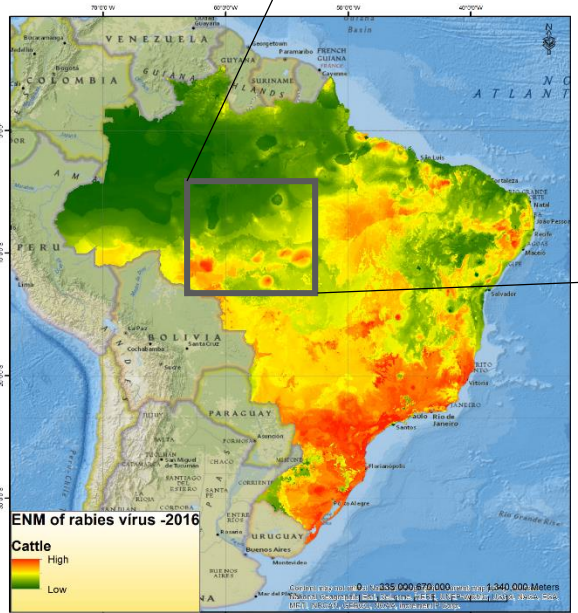


Brad, eta. 2017



Circuit theory to predict ecological connectivity connectivity across fragmented landscapes





Forecast of Rabies spread based on circuit theory will provide a **best-justified veterinary surveillance** by bringing epidemiological reports, landscape data, and ecological niche modeling

Human health

- Incorporate case reports by human health systems,
- Reinforce treatment and vaccination is available in these hot-sports
- Inform the local, regional authorities
- …

Sobe para dois número de mortos por raiva humana na mesma família, no AM

De acordo com Susam, mortes são primeiras em decorrência de raiva humana desde 2002.

Por G1 AM

02/12/2017 17h18 · Atualizado há 19 horas

Conclusion

Inclusion of multiple and diverse disciplines to shift the world's **currently reactive approach** (once a disease is spreading in populations) toward a **proactive**, **predictive approach for emerging infectious disease prevention and timely control**.

Contact

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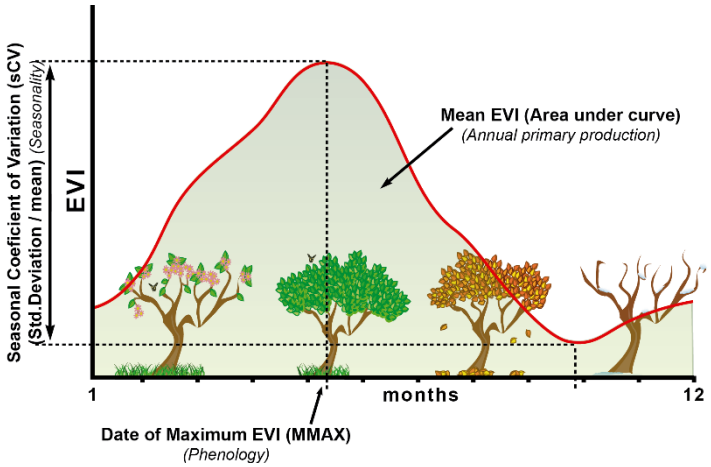
Raleigh NC 27607

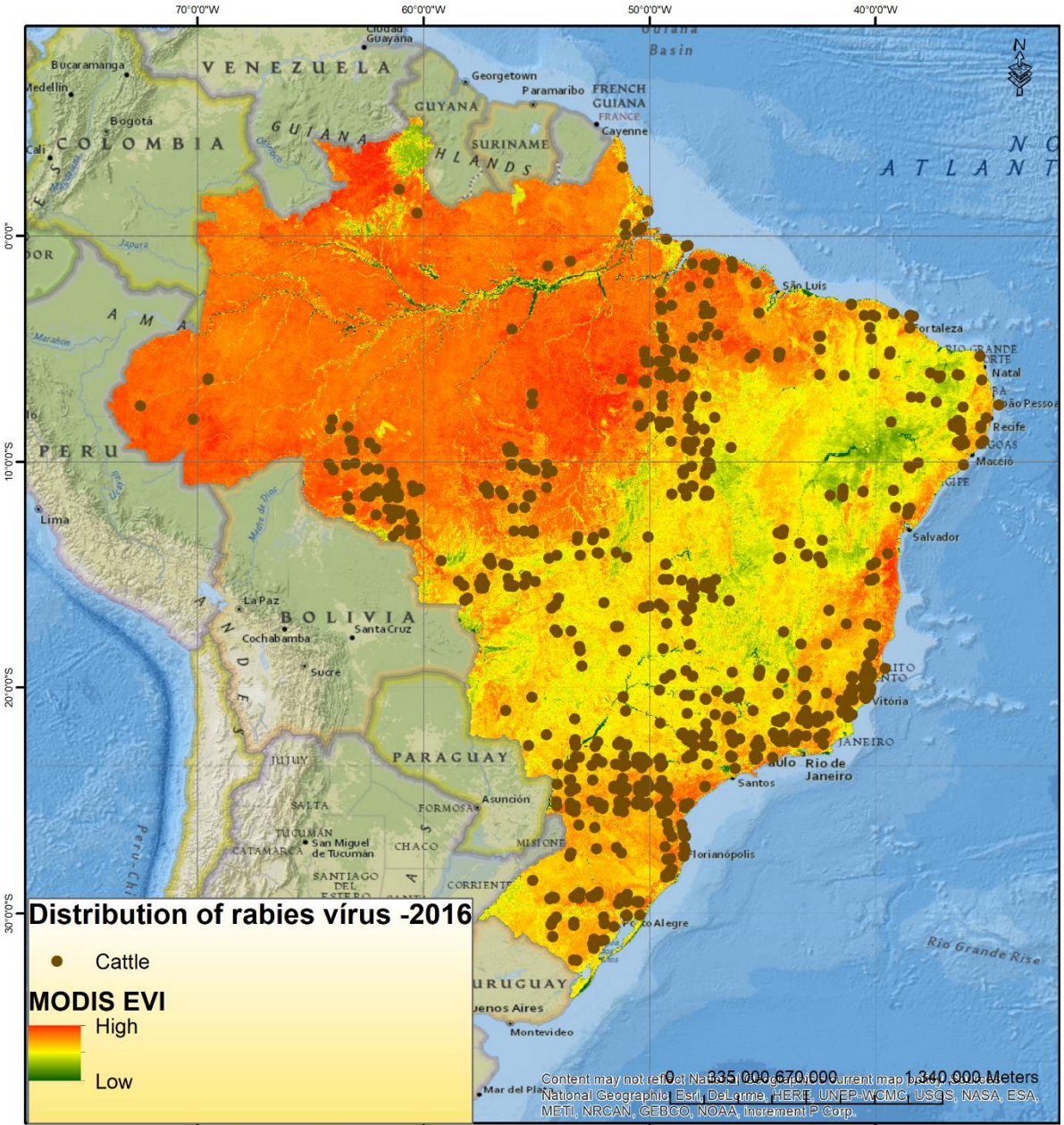
gmachad@ncsu.edu

Possible Integrated Actions

Human Rabies Transmitted by Bats

- Exchange of information on monitoring at local level (health and agriculture) rabies cases in humans and in animals (evidence of presence of the virus), and bats bites (demonstrate the risk of occurring an outbreak.
- Tools to support national authorities in the forecast/identification of risk areas.
- **In areas of greater risk**, task other sectors to report the events such as mining and deforestations to support prediction the increase of the bats bites.
- Jointly identify areas of social vulnerability and of difficult access to health services for people being bitten by bats and develop preventive intersectoral actions before the occurrence of an outbreak.
- **For risk areas, prepare education materials**.
- As well joint intersectorial training, orienting coordinated surveillance, research of possible outbreaks, and actions of prevention and control.





MAPA data not published

- Schneider MC. Rabia humana transmitida por murciélago hematófago en Brasil: modelo de transmisión
- **Schneider MC at al. Rabies transmitted by vampire bats to humans: An emerging zoonotic disease in Latin America? *Pan Am J Public Health* 25(3), 2009.**
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Our studies with integrated vison

Int. J. Environ. Res. Public Health **2012**, *9*(11), 3883-3910; doi:10.3390/ijerph9113883

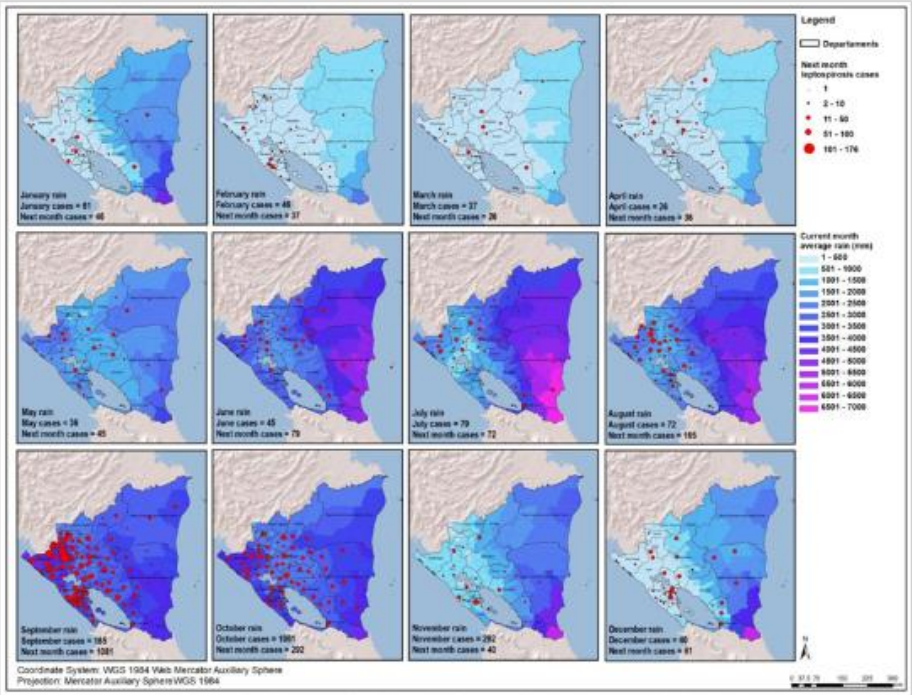
Open Access

Article

Leptospirosis Outbreaks in Nicaragua: Identifying Critical Areas and Exploring Drivers for Evidence-Based Planning

Maria Cristina Schneider [1,*], Patricia Nájera [1], Sylvain Aldighieri [1], Jorge Bacallao [2], Aida Soto [3], Wilmer Marquiño [3], Lesbia Altamirano [3], Carlos Saenz [4], Jesus Marin [4], Eduardo Jimenez [4], Matthew Moynihan [1] and Marcos Espinal [1]

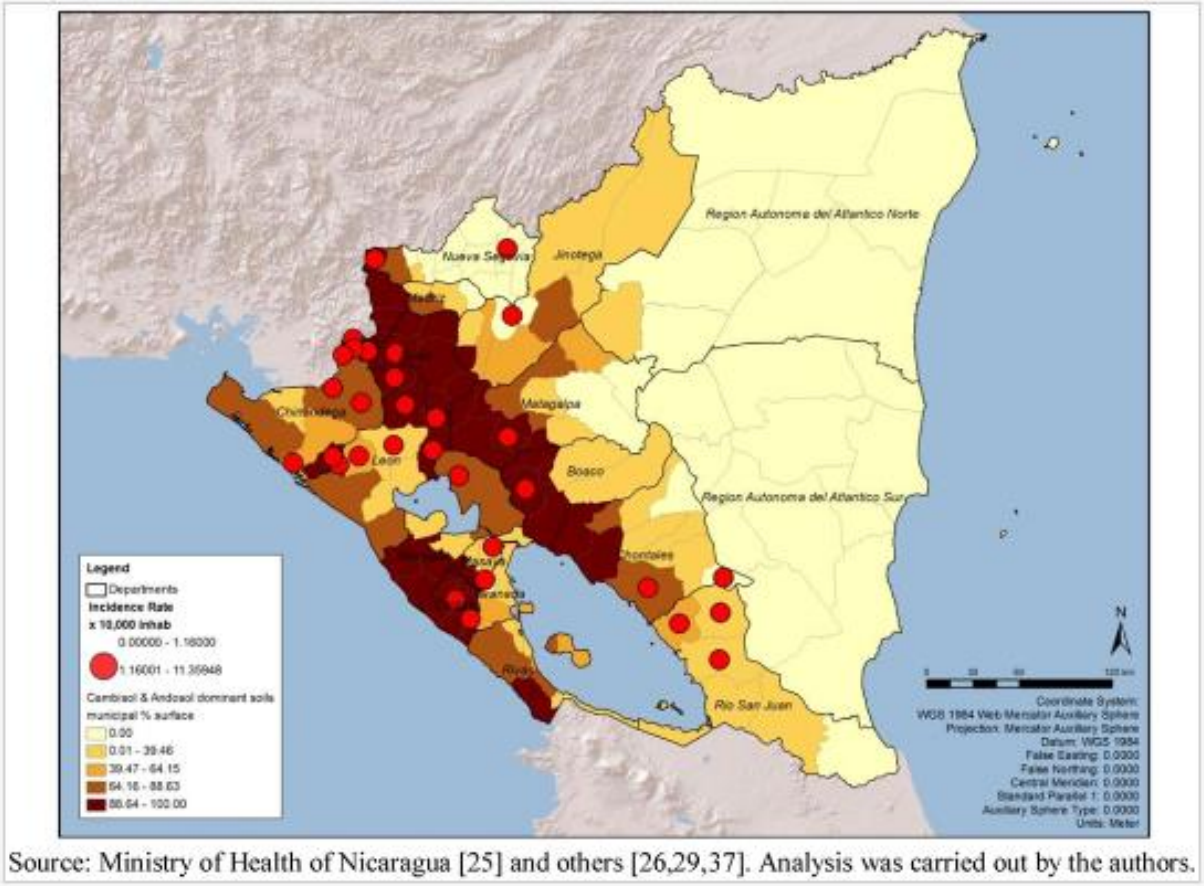
Human leptospirosis cases and rain



Source: Ministry of Health of Nicaragua [25] and others [26,31,37]. Analysis was carried out by the authors.

Our studies with integrated vison

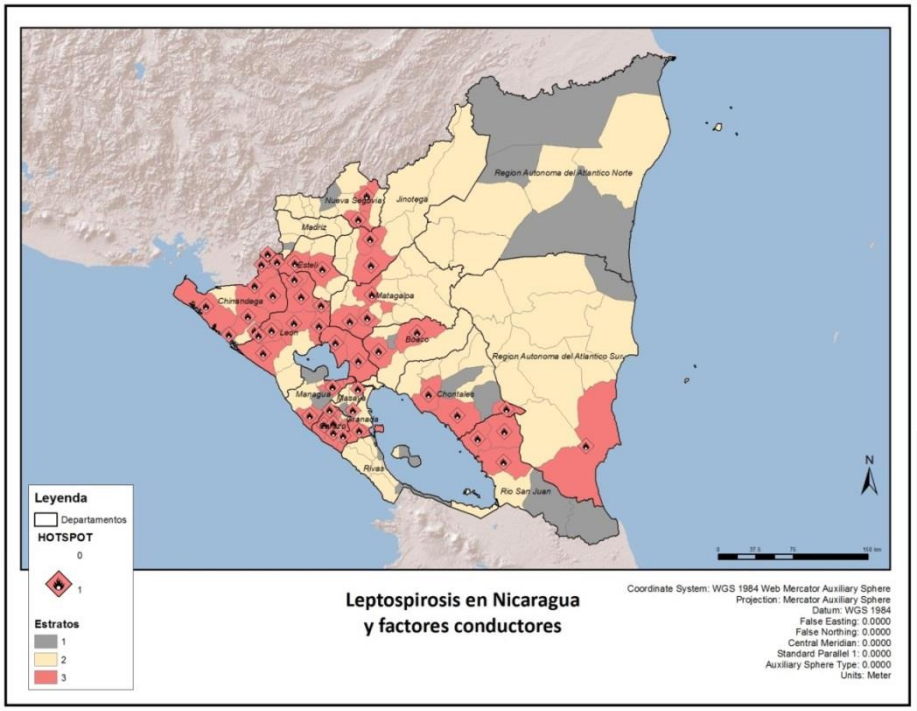
Figure 4. Critical areas for leptospirosis define by incidence rate and percentage of soil with Cambisol and Andosol, by municipality, Nicaragua, 2004–2010.



Source: Ministry of Health of Nicaragua [25] and others [26,29,37]. Analysis was carried out by the authors.

Human leptospirosis critical areas and soil

Our studies with integrated vison



Risk stratification of human leptospirosis

Phone alert

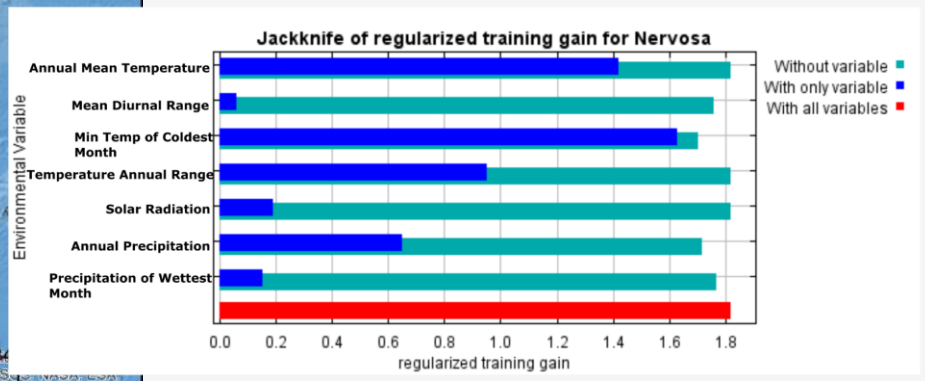
Figure 9. Example of possible use of this information for planning to prevent and respond to leptospirosis outbreaks in the case of Nicaragua.

Month Dept/Municipality	Previous Months	July	August	September	October
León/Achuapa (Critical Area)	Training of outbreak alert and response team	Training about rodent populations	Training of health personnel Control of rodent populations	Population information	Alert for leptospirosis
León/Nagarote (Endemic)	Training of outbreak alert and response team	Training for surveillance	Surveillance	Surveillance	Surveillance

Preliminary results

Variáveis ambientais :

1. Temperatura
2. Precipitação
3. Radiação solar

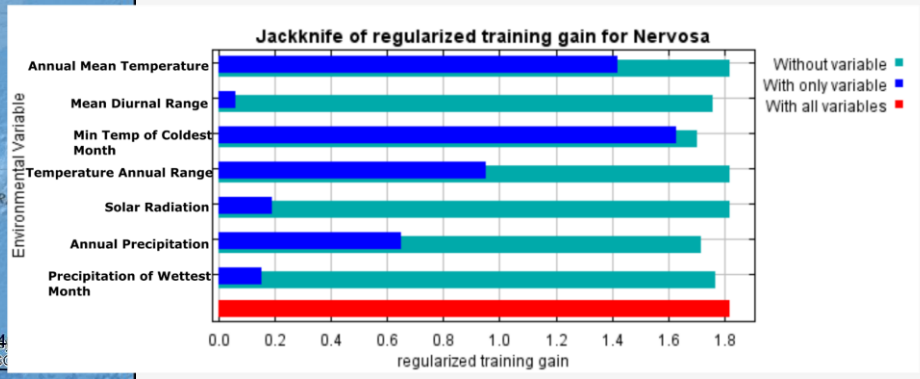


MAPA data not published

Preliminary results

Variáveis ambientais :

1. Temperatura
2. Precipitação
3. Radiação solar



Possible components and integration Actions

Example: **Leptospirosis**

HUMAN	ANIMAL	ECOSYSTEM
• Human cases • People expose to urine of infected animals (indirect contaminated water/mud, or direct) • Occupational hazard • Recreational hazard • Fatal if untreated	• Can be found in rodents, cattle, pigs, horses, dogs and wild animals • Spread through the urine of infected animals	• Temperate or tropical climates • Ecoregions • Flooding areas • Higher precipitations • Certain type of soil

Photos: O. Chaves, G. Moreno

Possible integrated actions

Example: **Leptospirosis**

- **Predict risk areas** - collaboration between animal and human health authorities-reinforcing surveillance (**including circulating serovars**); and with the of environment sector identification of **flood prone areas** and the greater precipitation period.
- Elaborate an intersectoral plan and action coordinates **for rodent control before rainy periods**, orientation of health professionals and of the population at risk of outbreaks etc.
- **For risk areas, prepare education/ information materials**; as well as joint trainings for different sectors and levels.
- OH approach on research of **possible drivers and coordinated actions of prevent or respond to outbreaks**.

Photos: G. Moreno

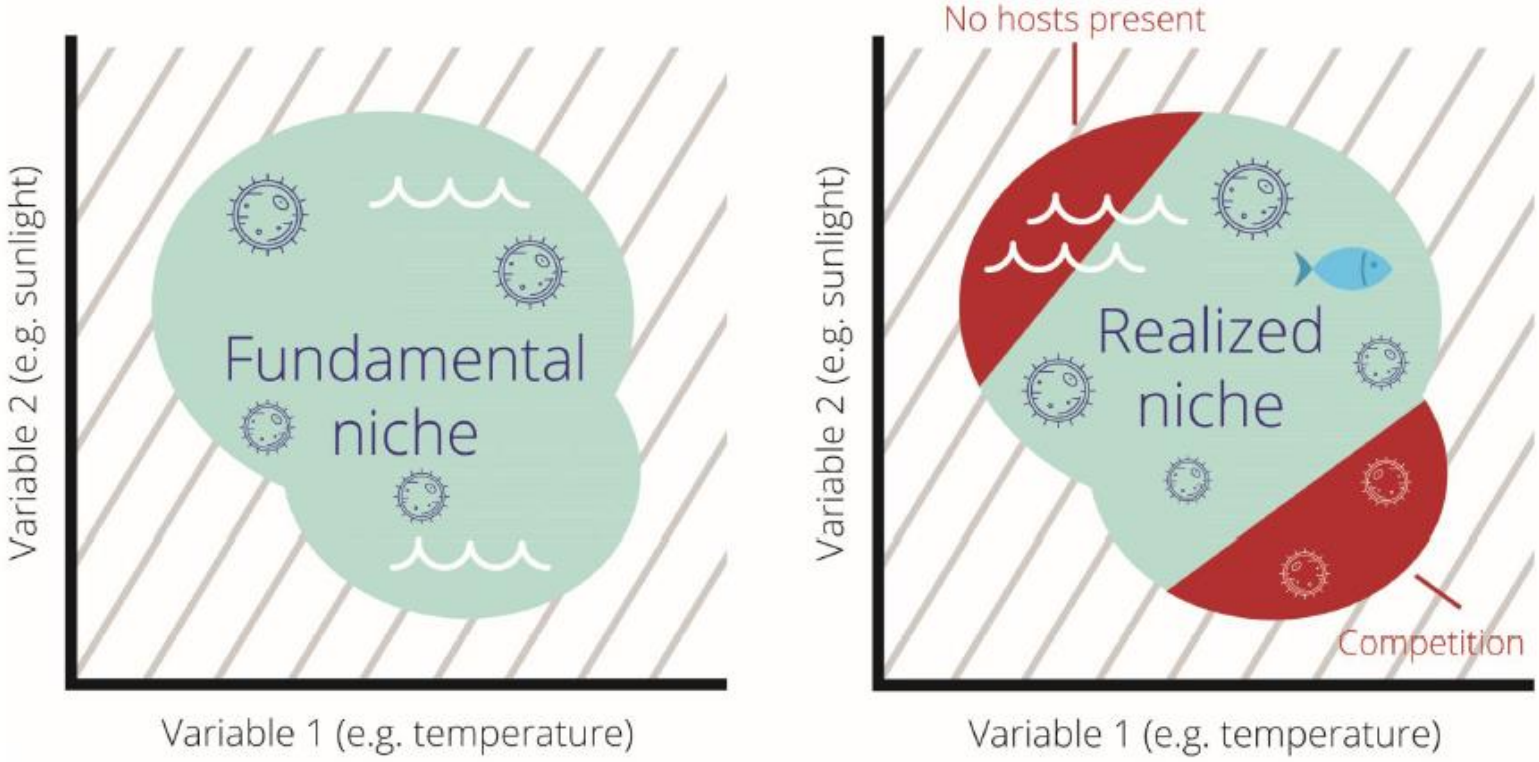
- Center for One Health Research, COHERE, Checklist for One Health Epidemiological
- Reporting of Evidence, http://deohs.washington.edu/cohr/cohere (accessed
- 02.06.16).

What is an ecological niche?

Background: Considers all abiotic factors such as pH, sunlight, moisture, salinity, and temperature

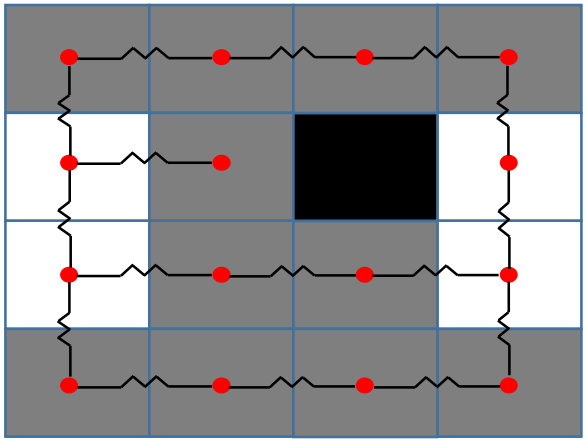
Fundamental niche: The total range of environmental conditions that a species could theoretically tolerate.

Realized niche: A portion of the fundamental niche which takes into account the biotic factors such as food availability, hosts, and competitive exclusion. This is where a species will actually be found.



Escobar LE*, Qiao H, Lee C, Phelps NBD. Novel methods in disease biogeography: A case study with heterosporosis. *Frontiers in Veterinary Science*. In press.

Circuitscape Works



Rabies in domestic and wild animals in Brazil

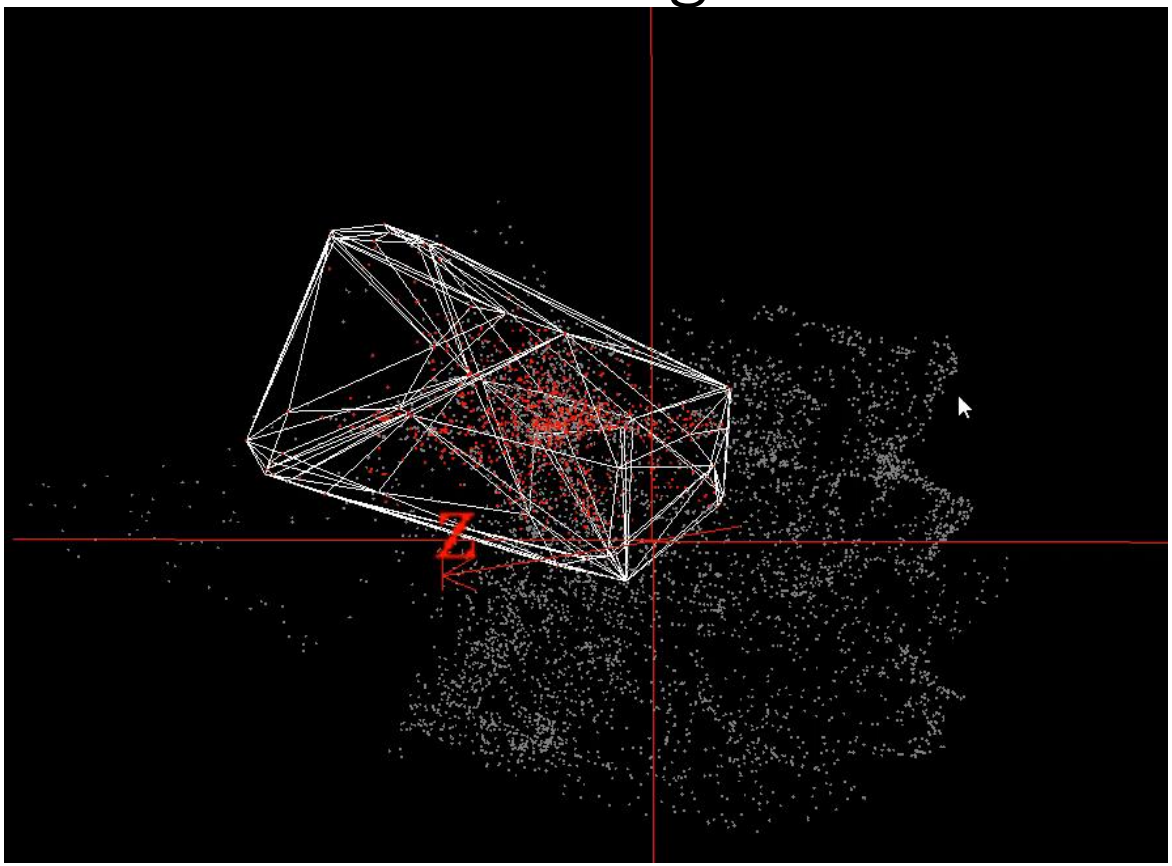
Objective

Analyze the distribution of rabies in Brazil and explore possible drivers using the One Health approach.

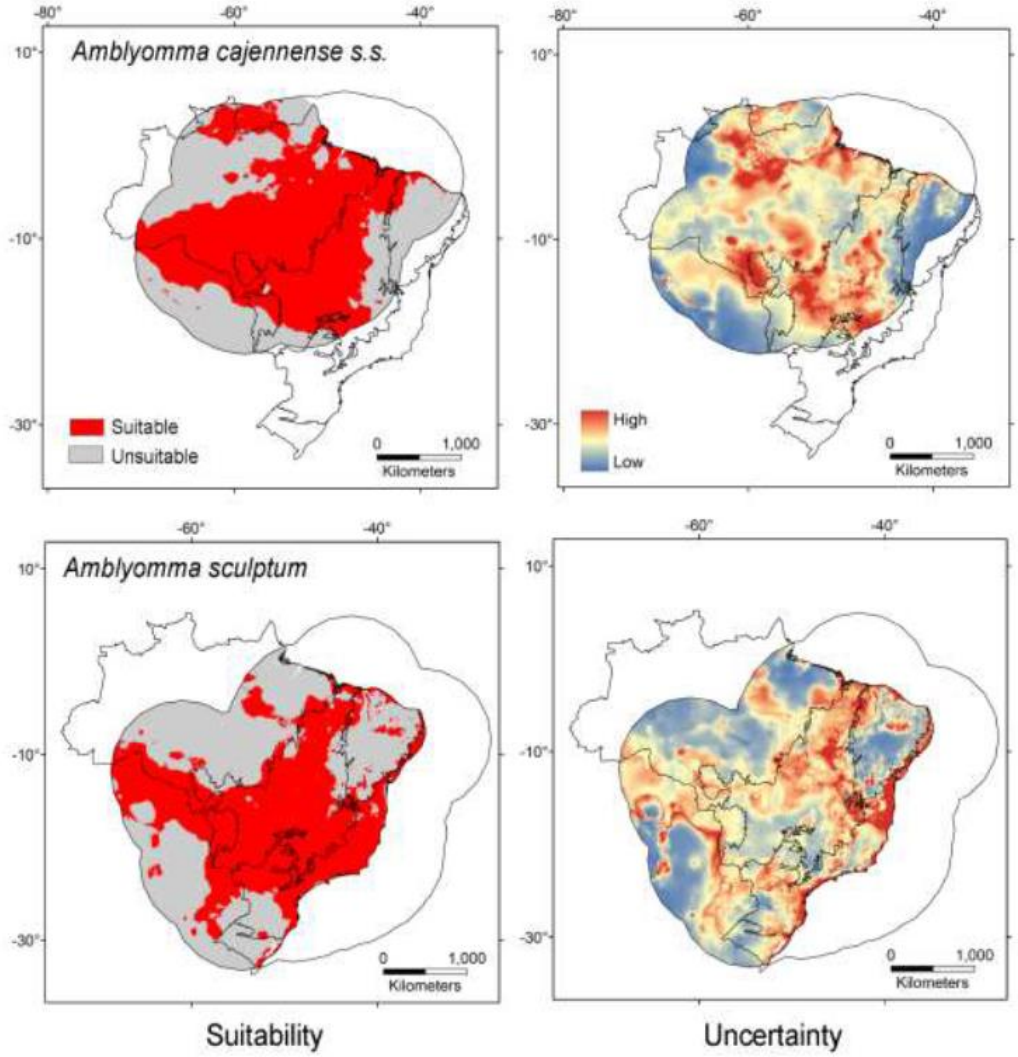
Methodology

- Ecological type of study - Aggregated data by municipality (second administrative level subdivisions
- Bovine rabies cases reported to MAPA 2000 to 2016 (17 years)
- Bovine cases by municipality was used as the outcome variable and eight geo-environmental factors were used as independent variables
- Spatial analysis was performed to identify and examine natural settings per municipality
- Subsequently, a multivariable logistic regression model was built.

Nicho realizado na região sul do Brazil



Projeções ao anos de 2020???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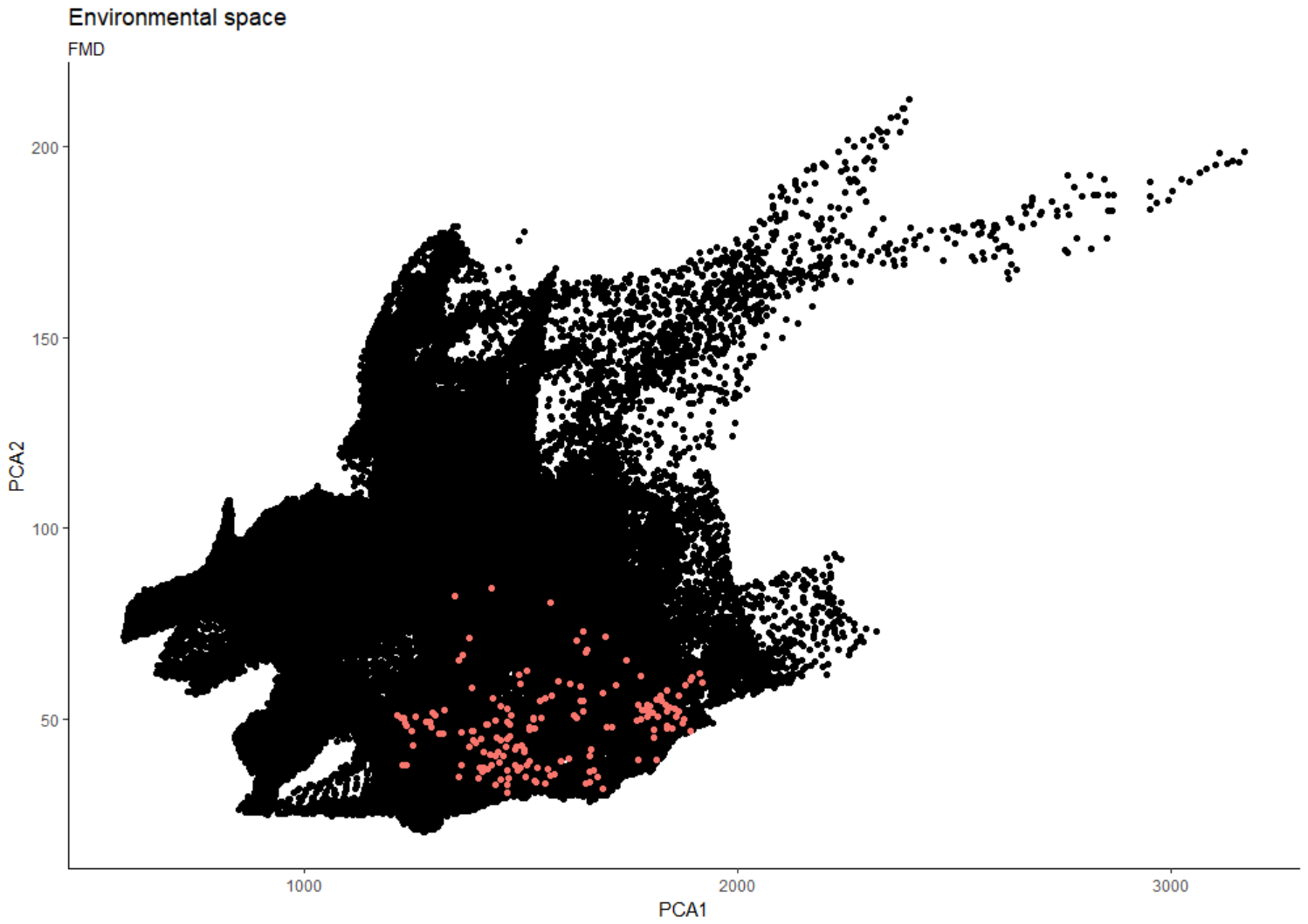
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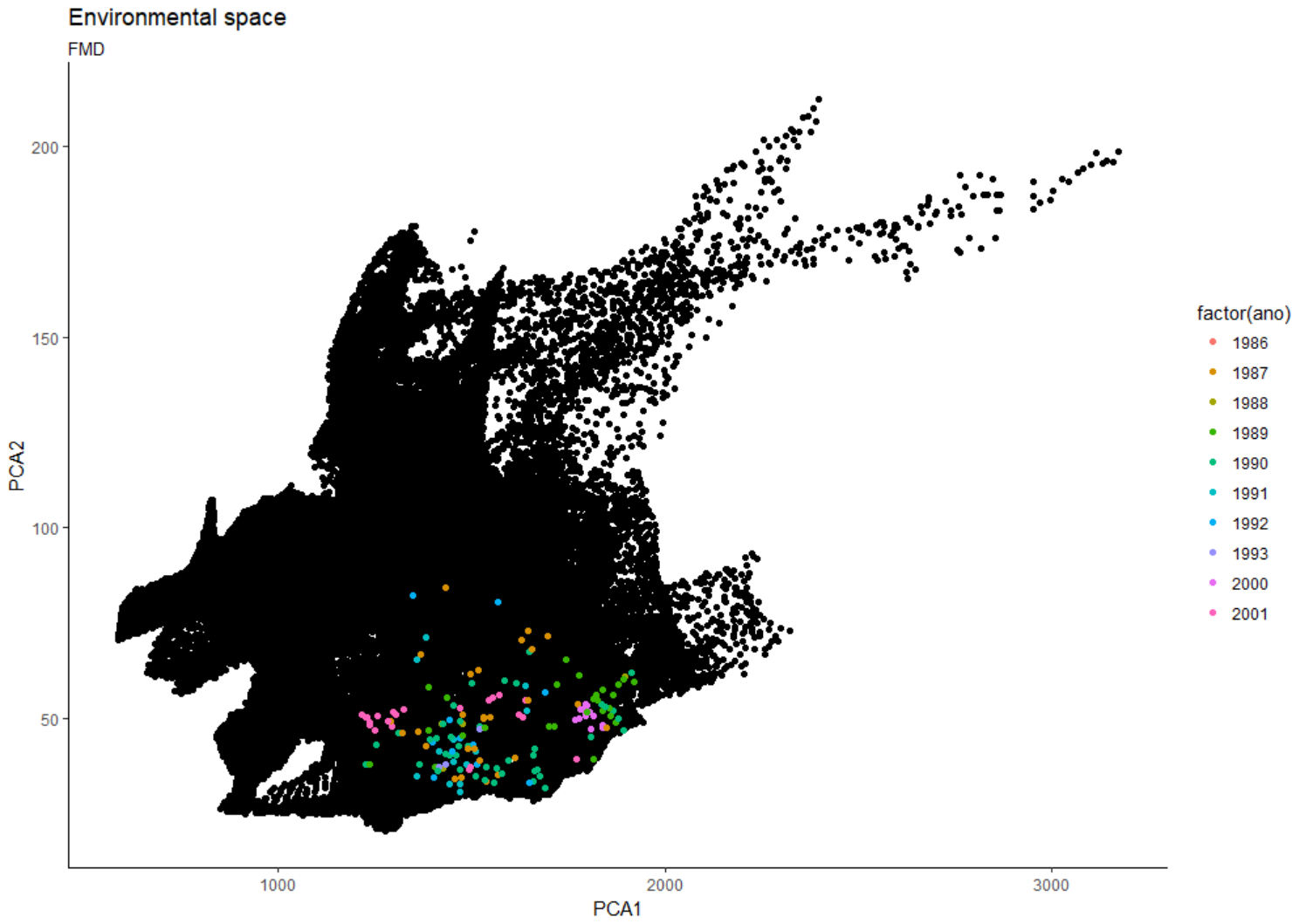
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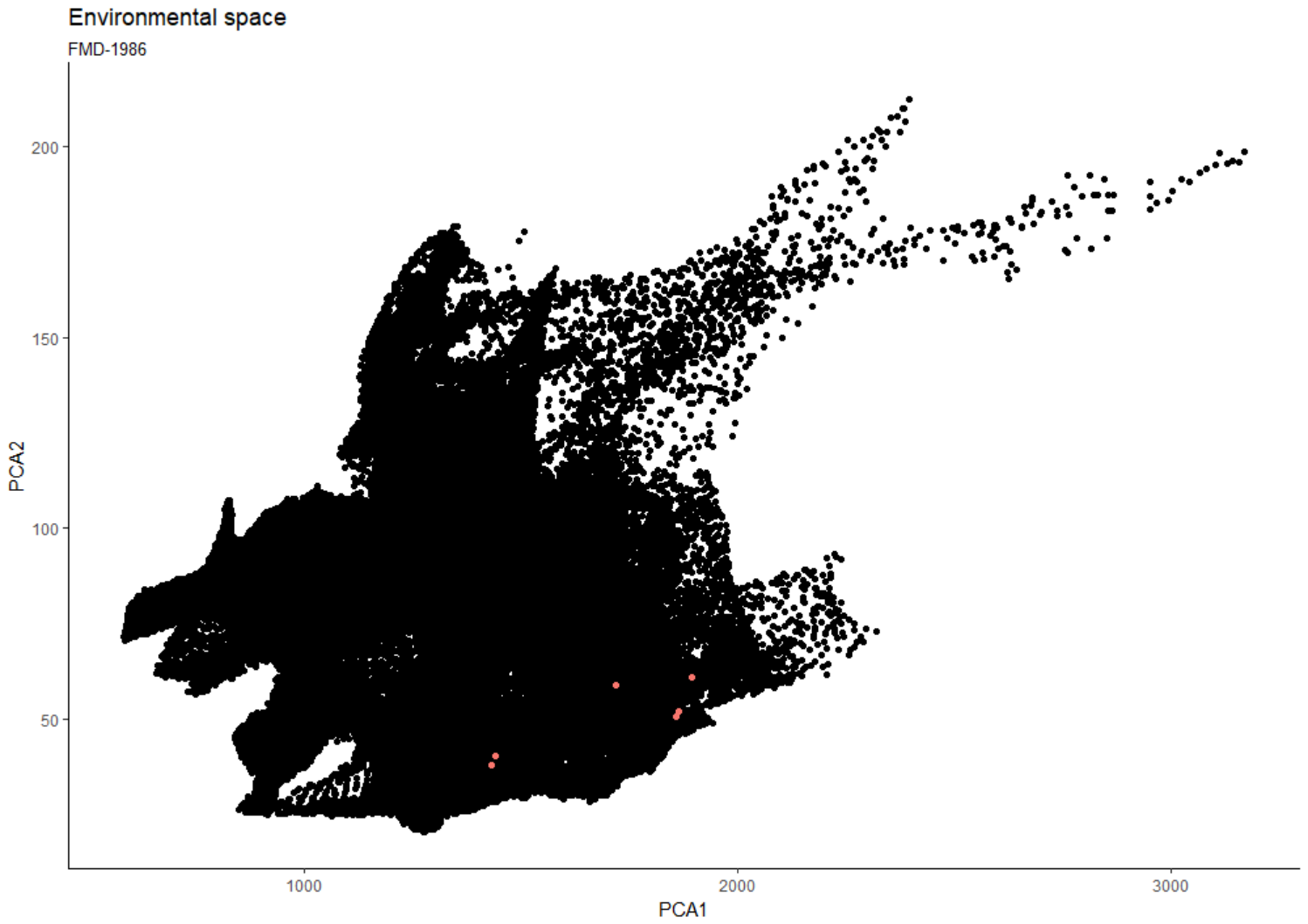
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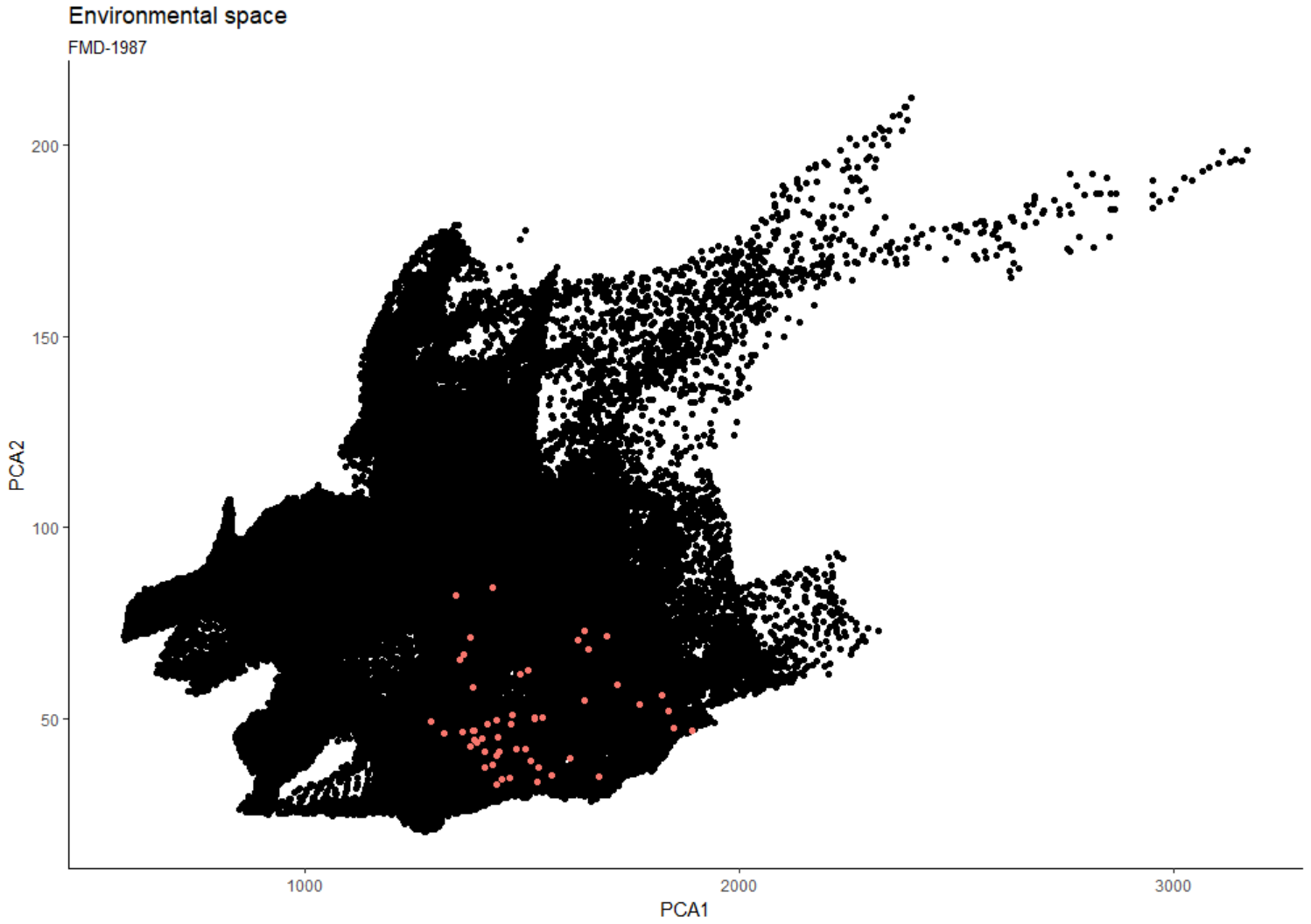
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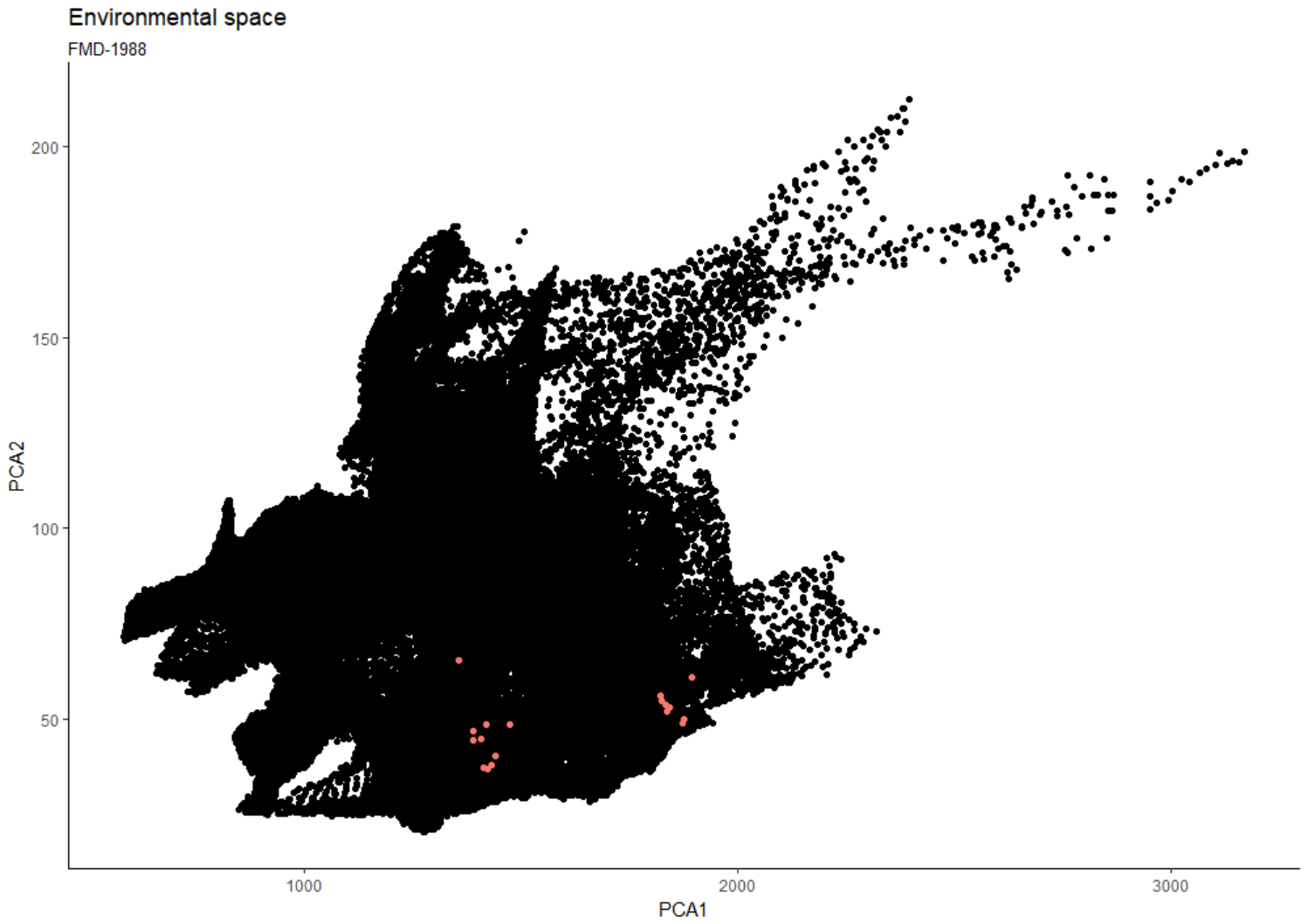
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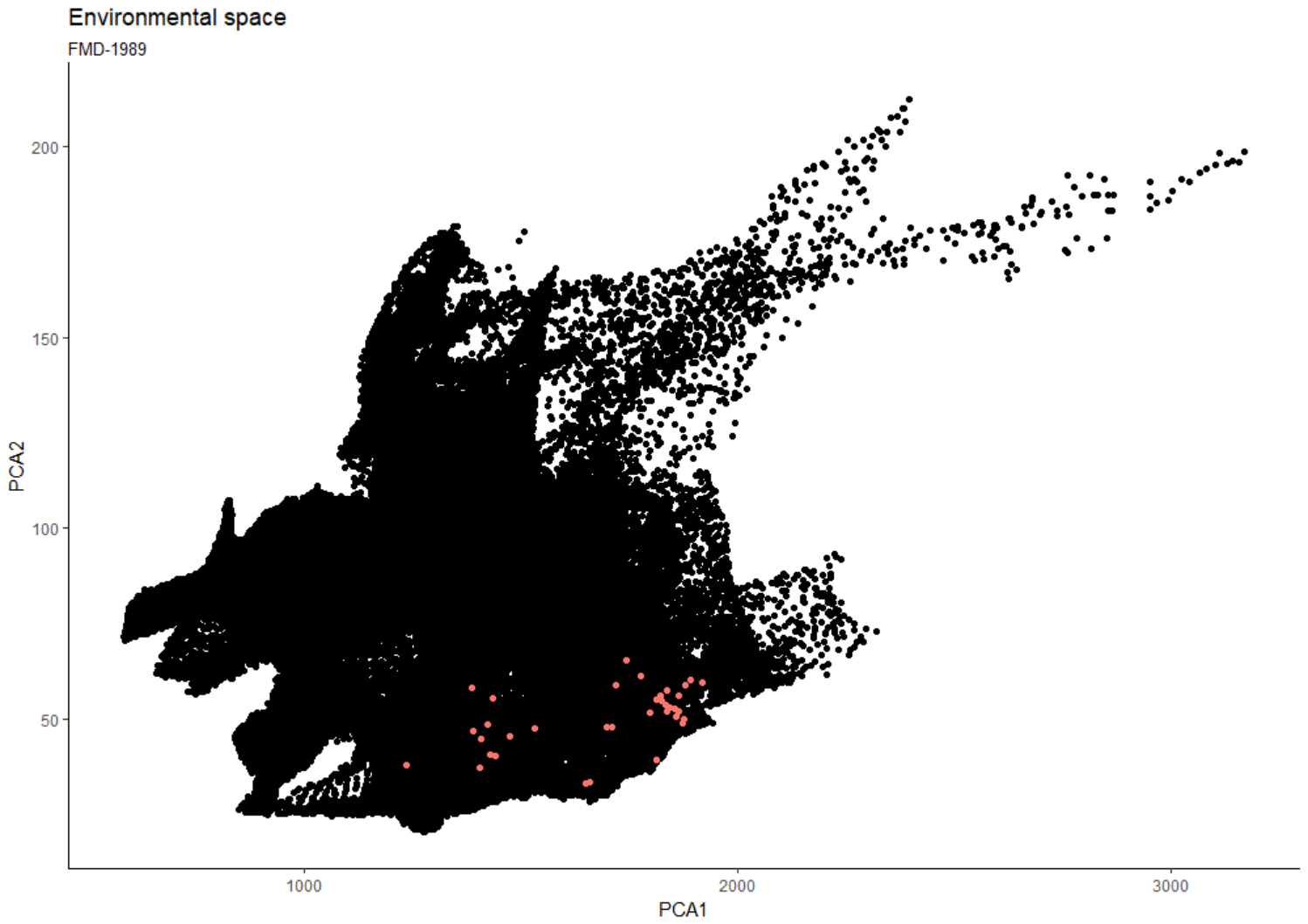
Environmental space
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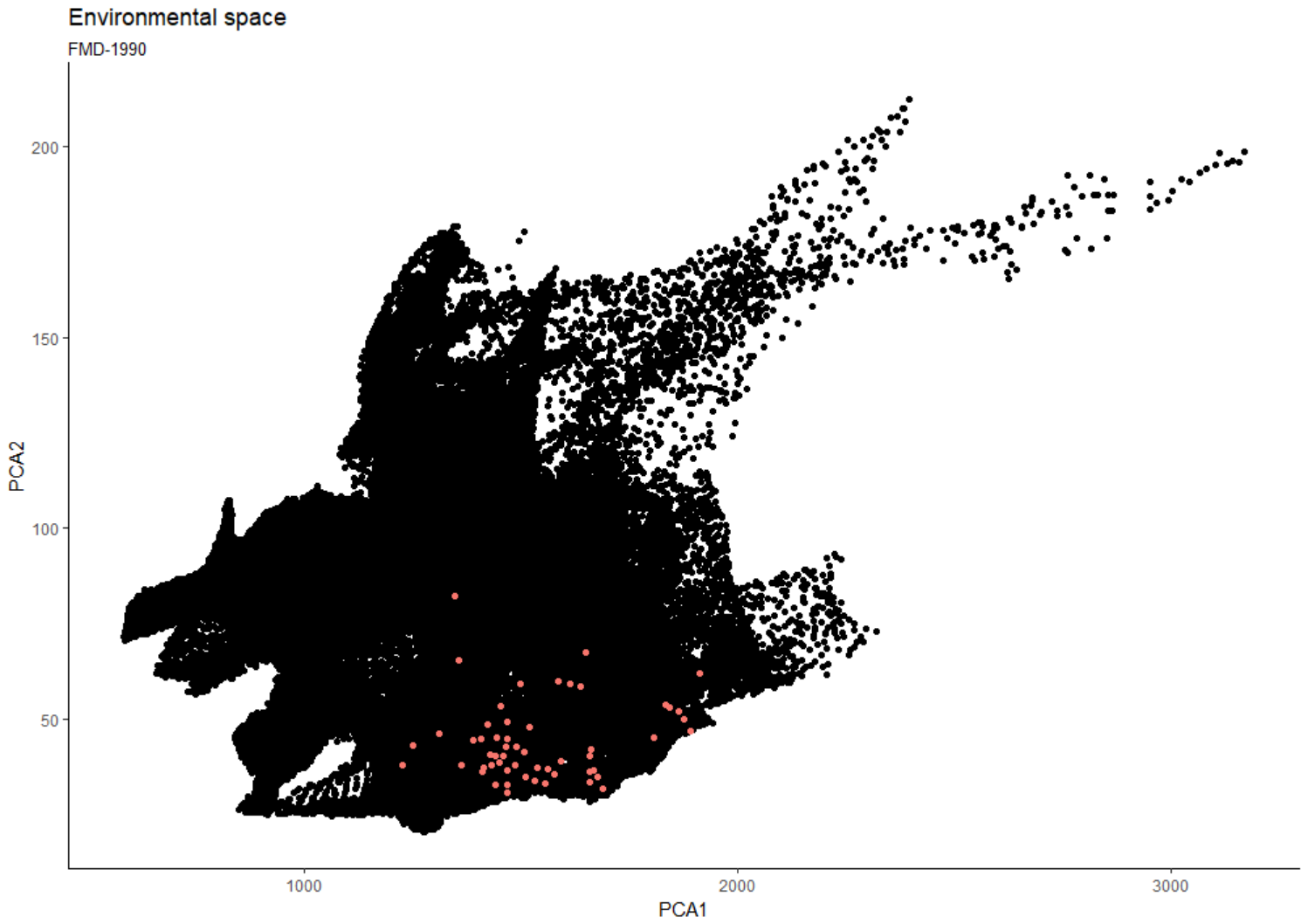
Environmental space
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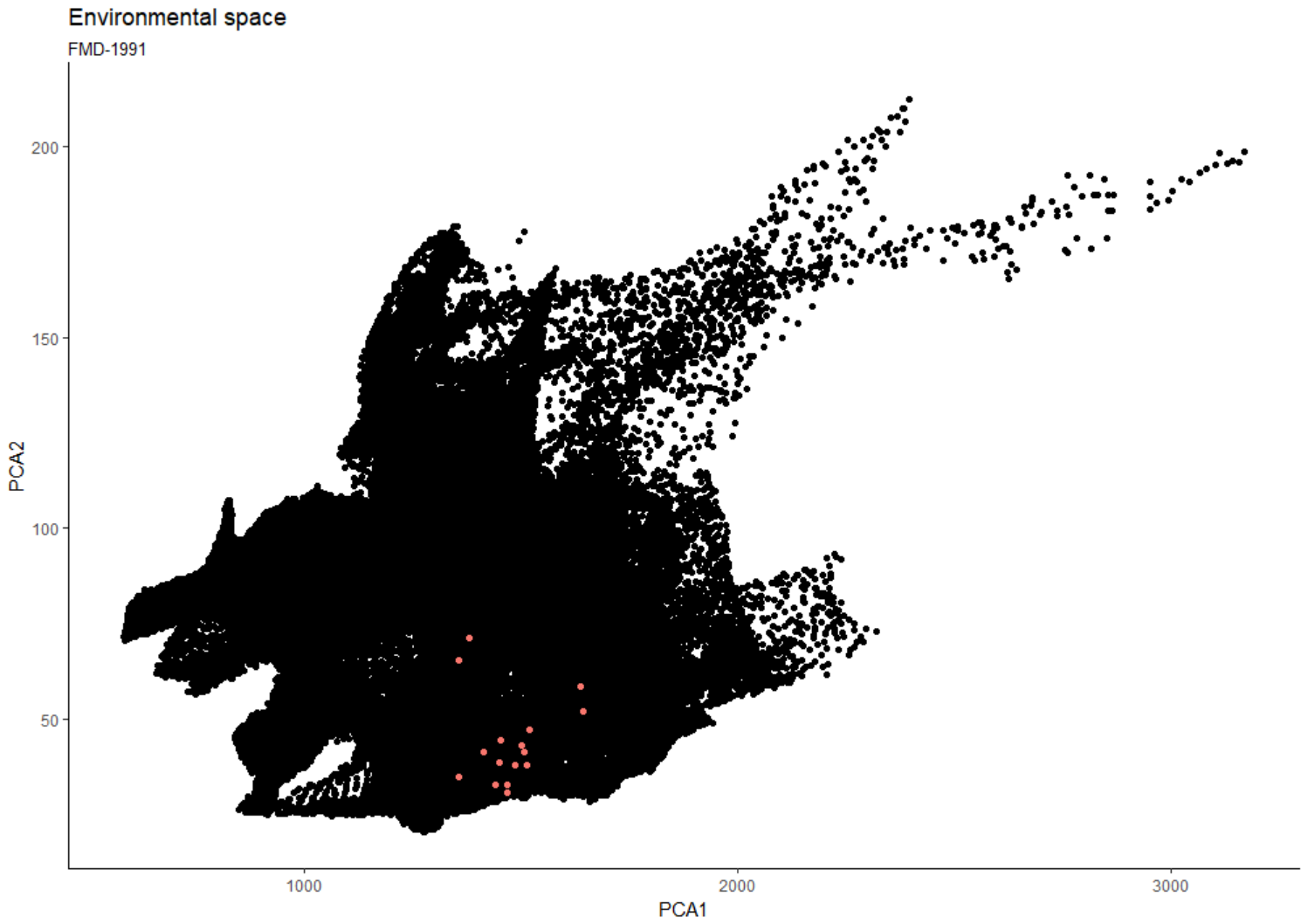
Environmental space
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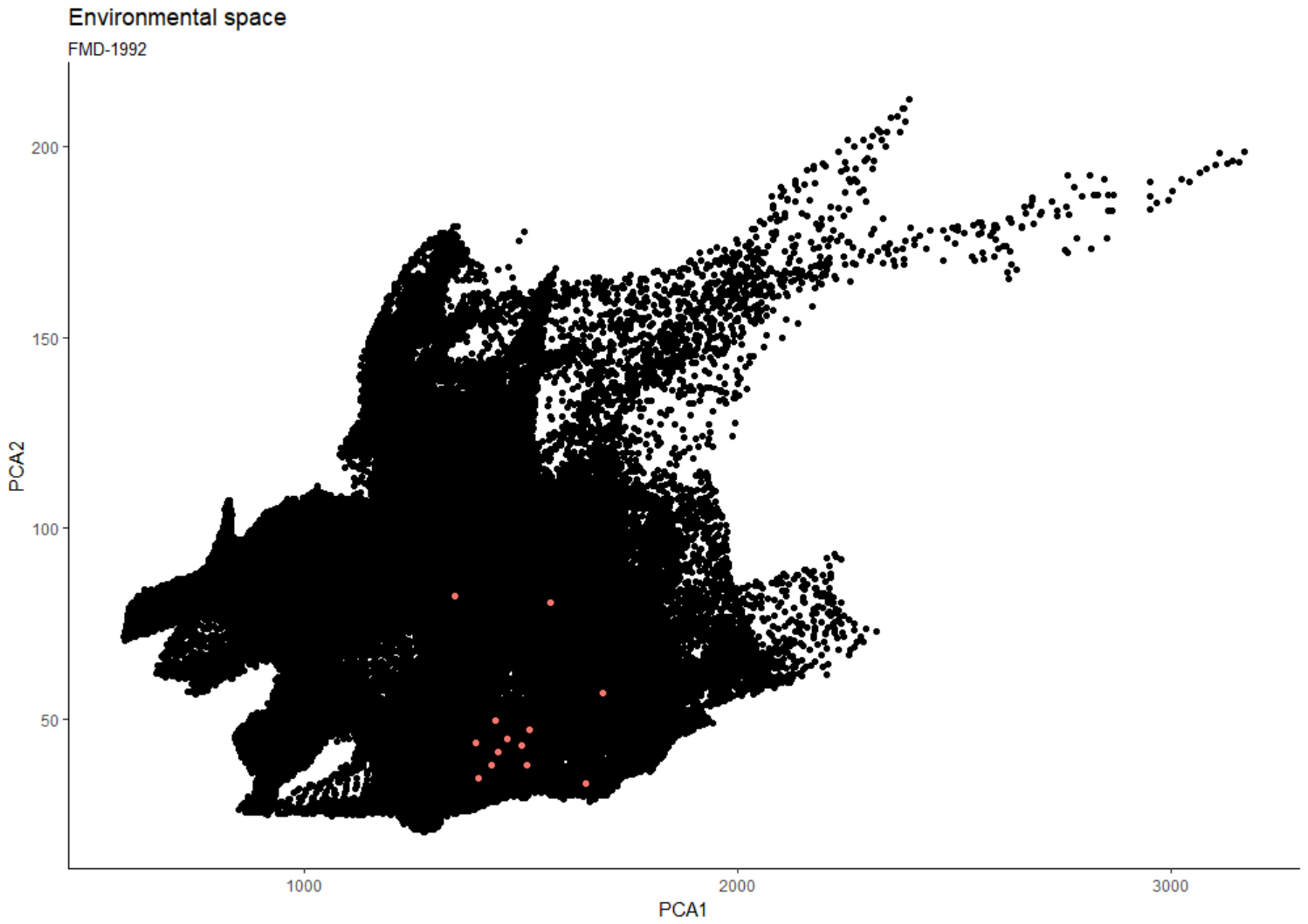
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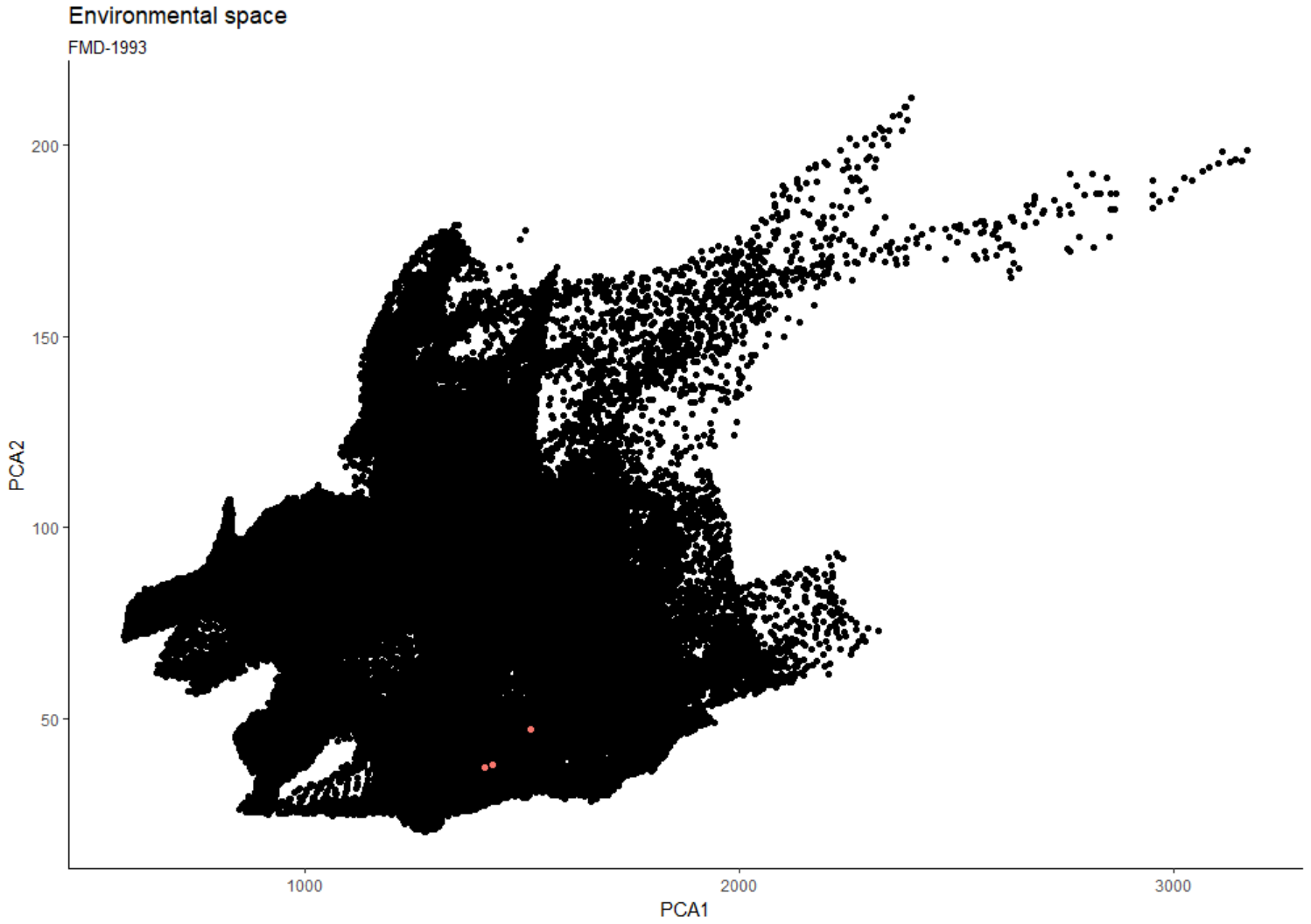
Environmental space
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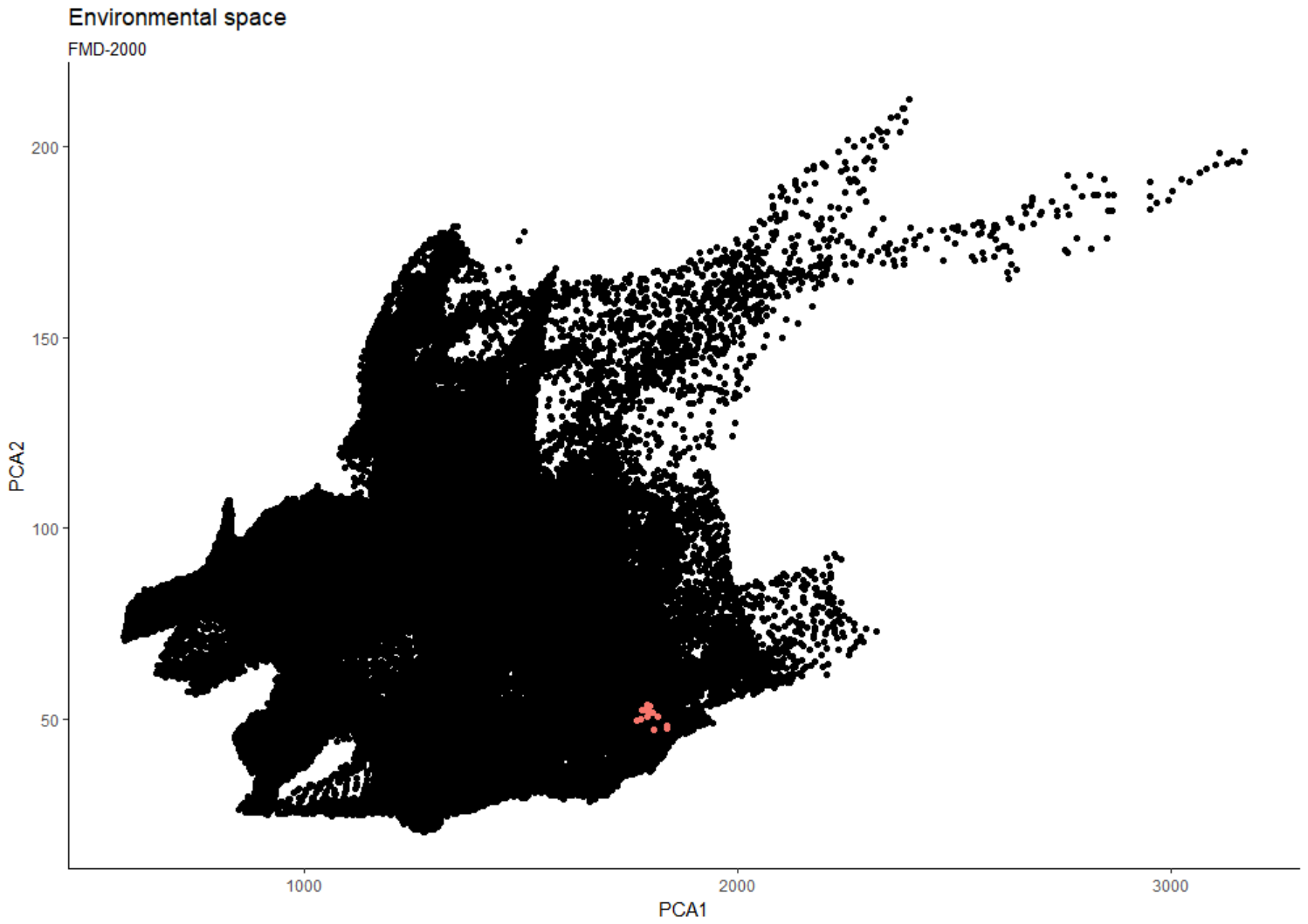
Environmental space
FMD-2000
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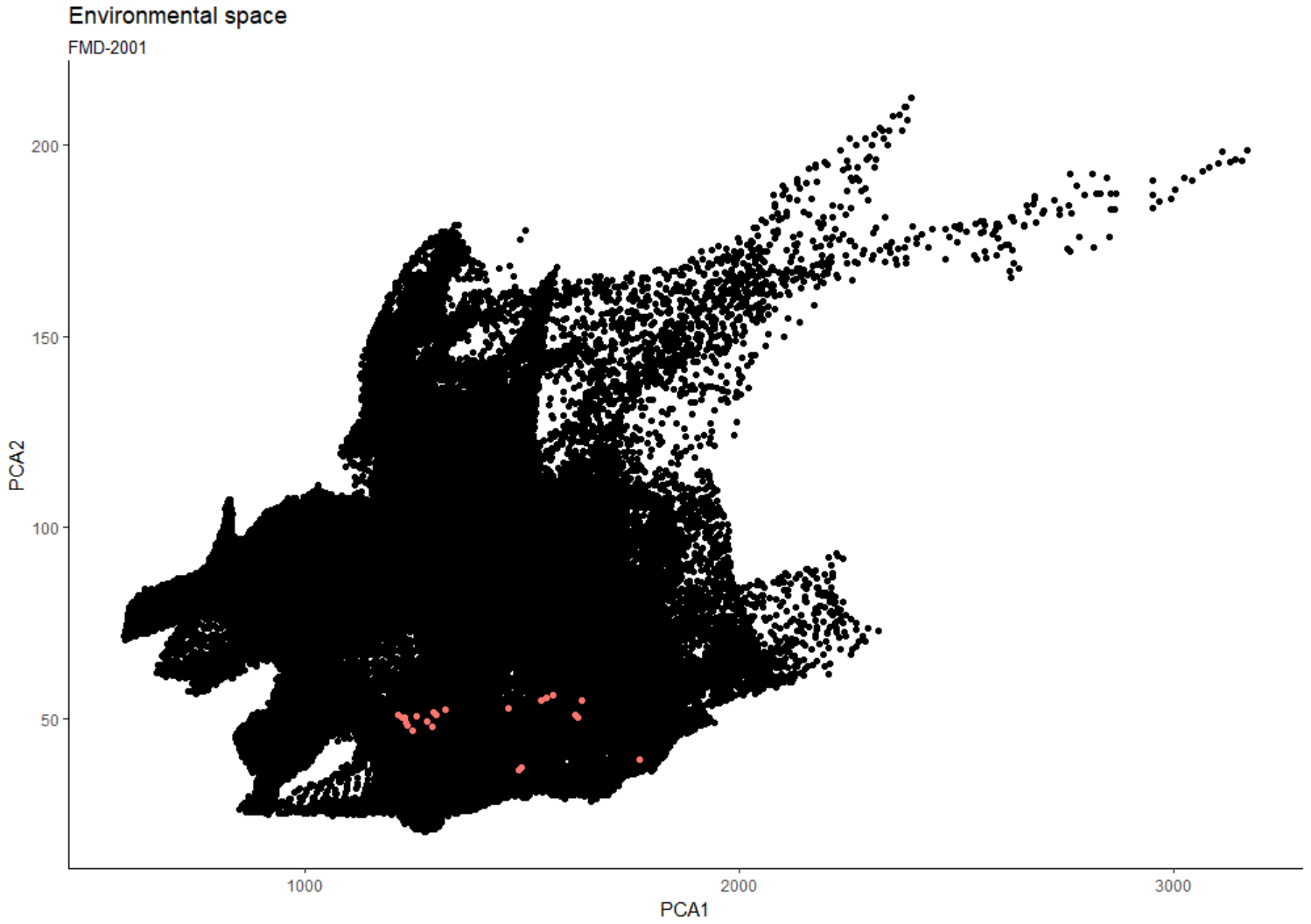
Environmental space
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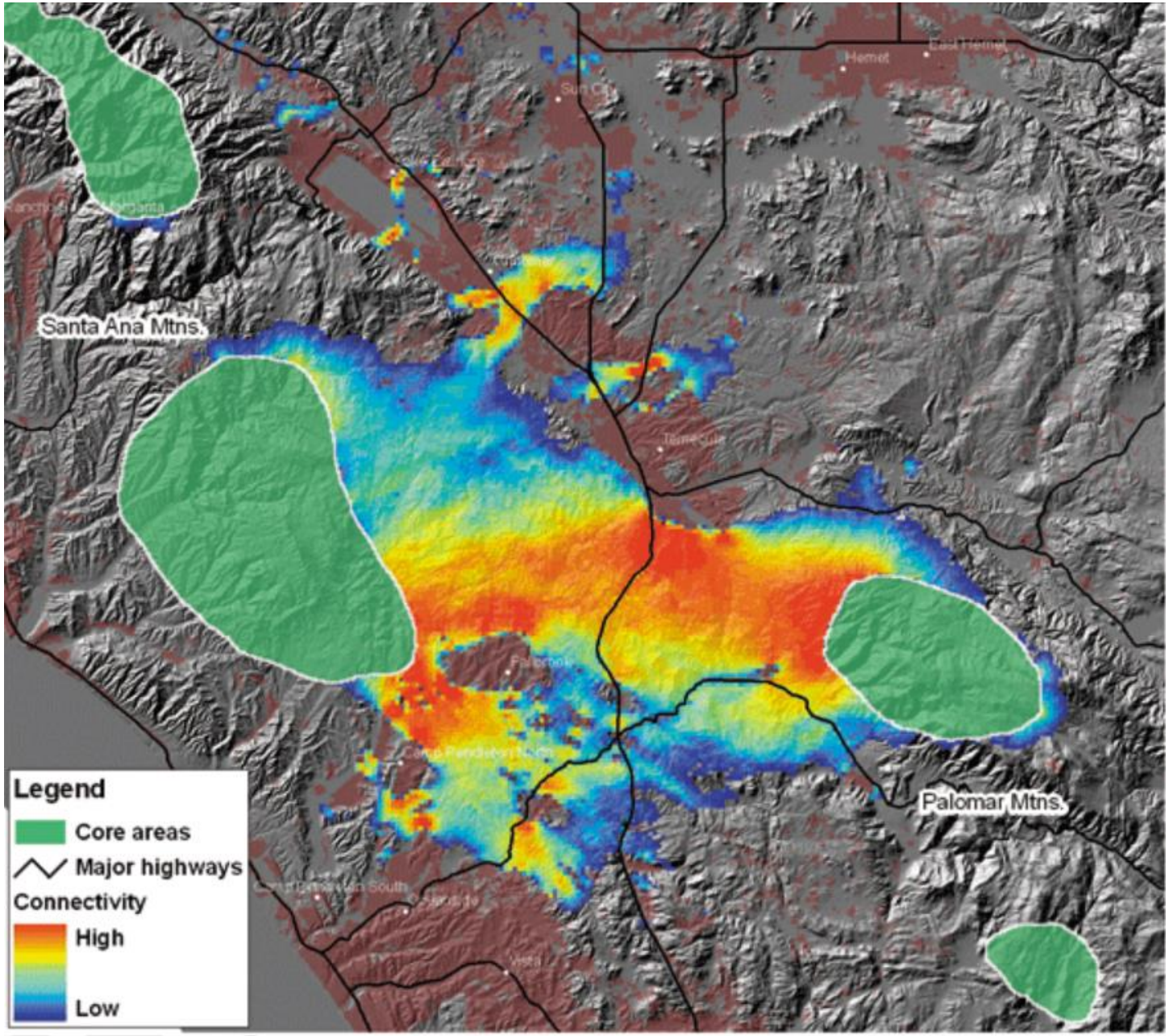
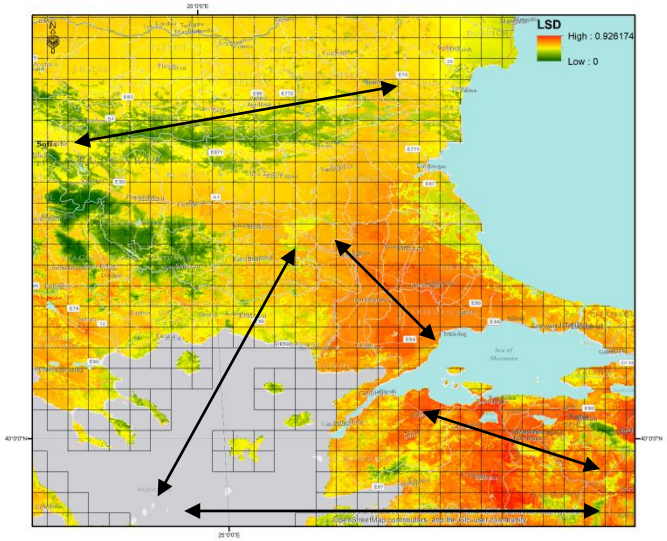
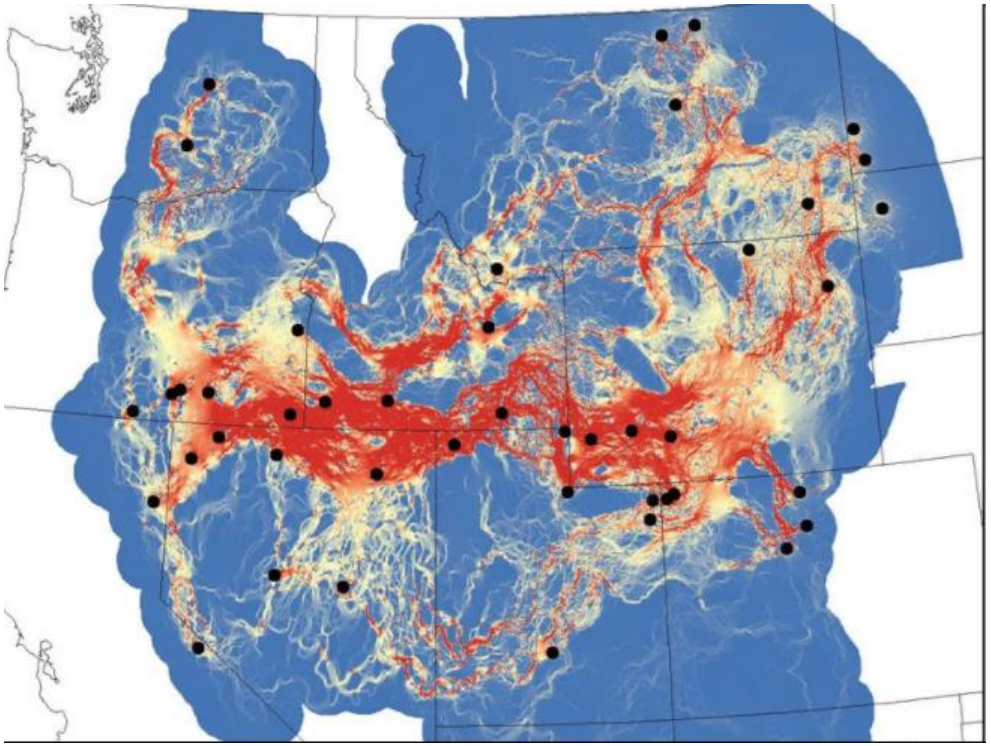
Circuit theory to predict connectivity



Steve Reinhardt and Viral Shah

Circuit theory to forecast connections

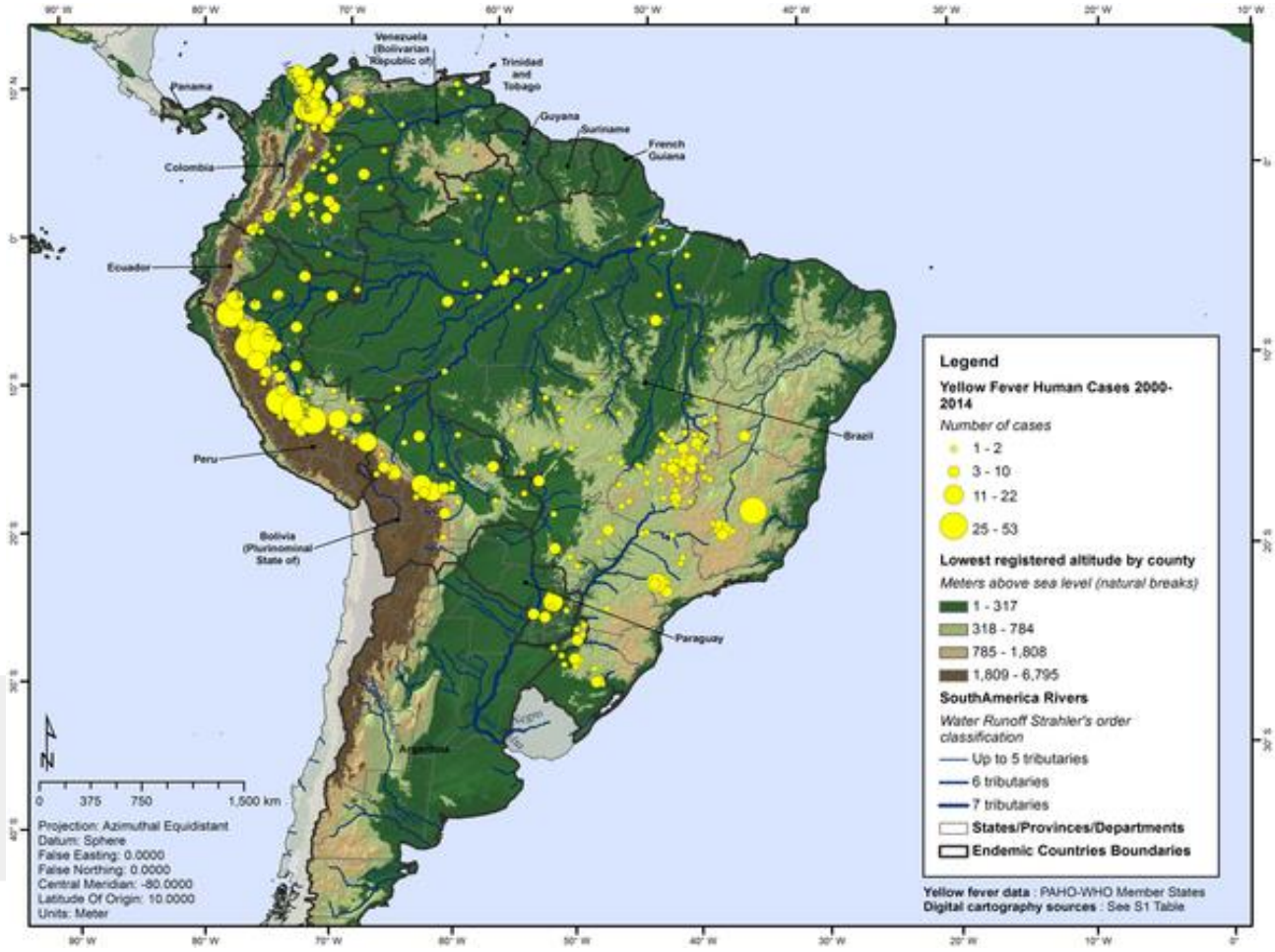




Brad, eta. 2017

Circuit theory to predict ecological connectivity

Our studies with integrated vison



PLOS | NEGLECTED TROPICAL DISEASES
TENTH ANNIVERSARY

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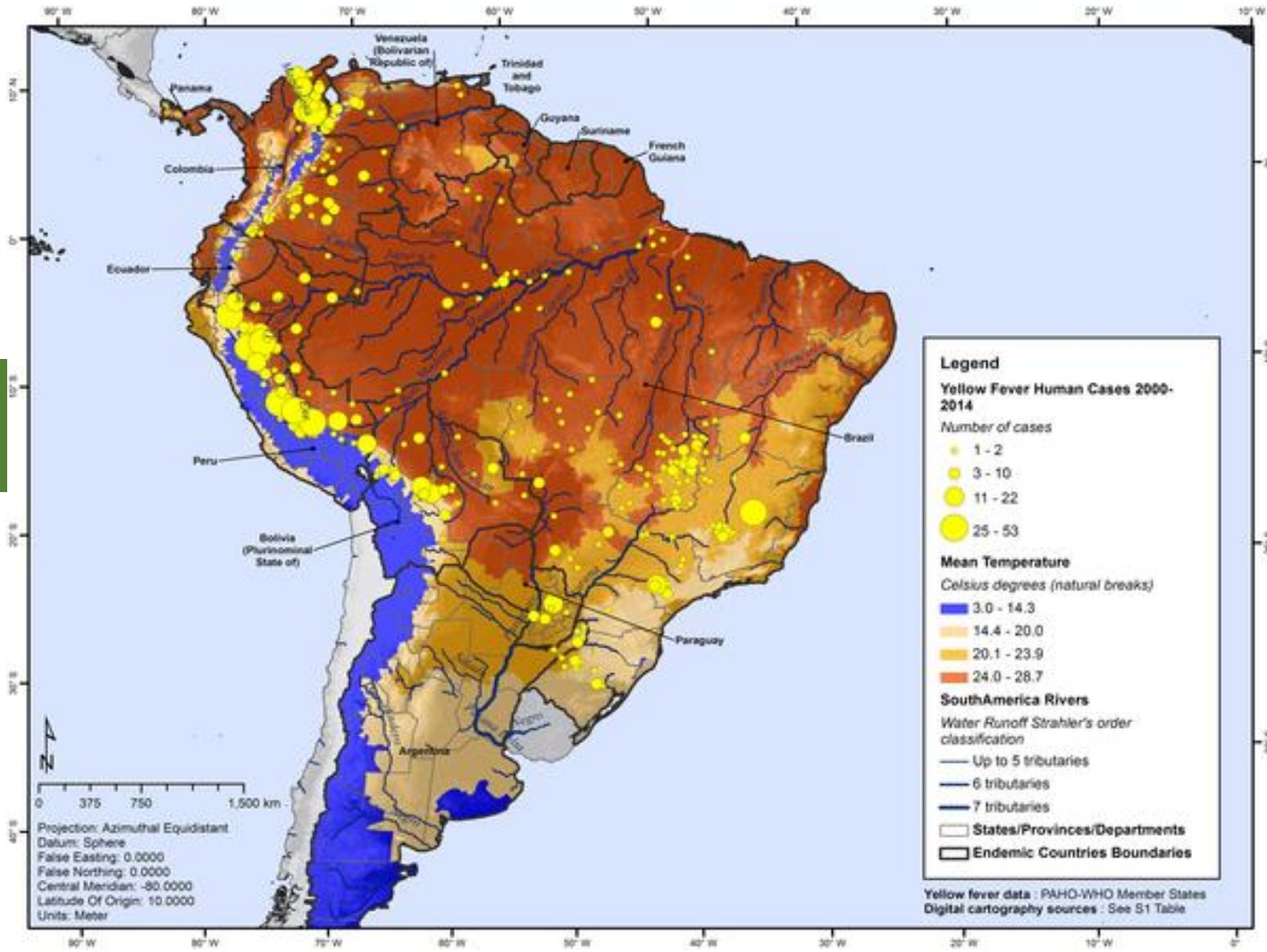
RESEARCH ARTICLE

Geographic patterns and environmental factors associated with human yellow fever presence in the Americas

Fig 3. Mean temperature by county and geographic distribution of yellow fever, Americas, 2000–2014.

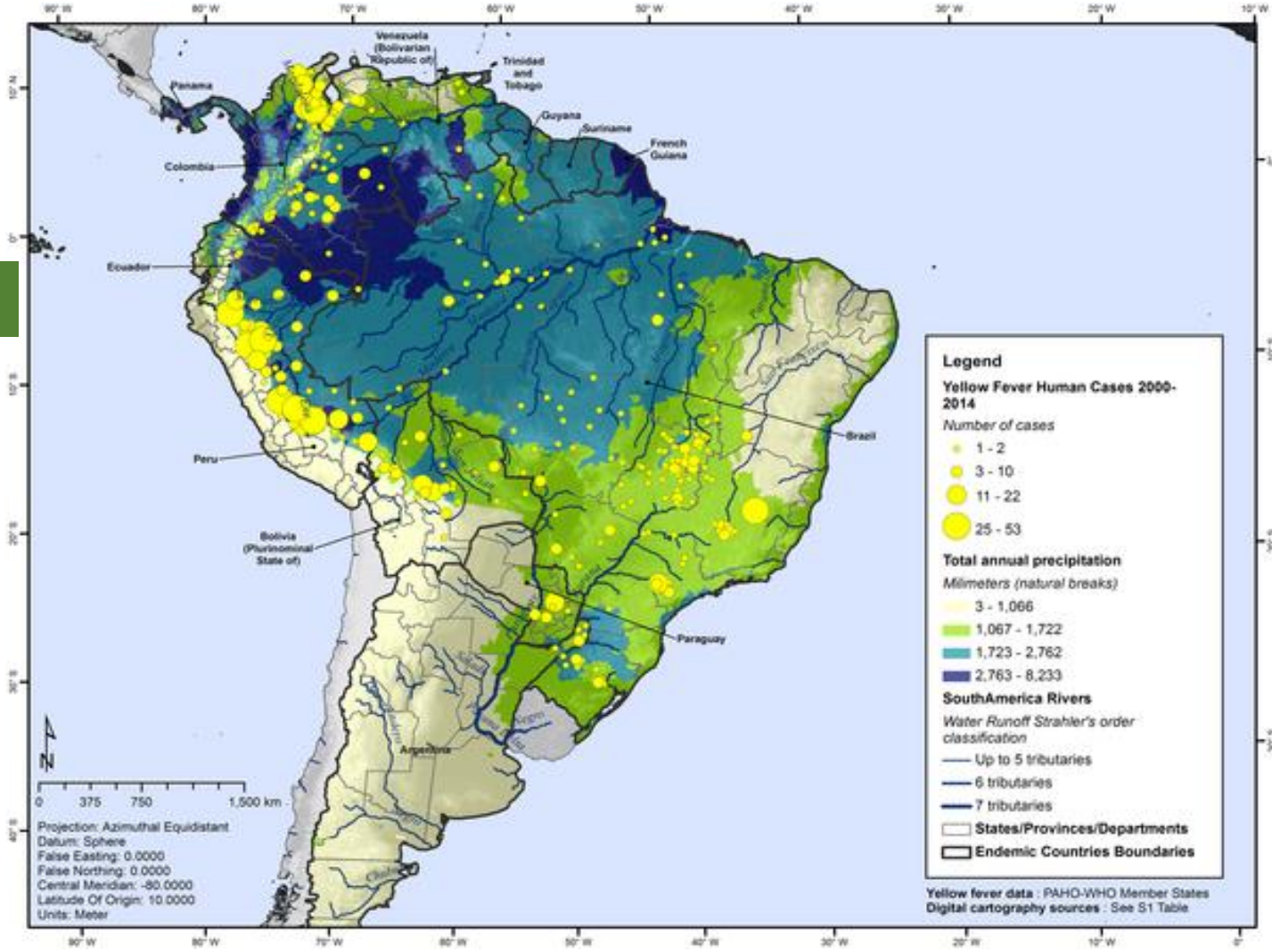
Yellow fever and temperature



Hamrick PN, Aldighieri S, Machado G, Leonel DG, Vilca LM, et al. (2017) Geographic patterns and environmental factors associated with human yellow fever presence in the Americas. PLOS Neglected Tropical Diseases 11(9): e0005897. https://doi.org/10.1371/journal.pntd.0005897
http://journals.plos.org/plosntds/article?id=10.1371/journal.pntd.0005897

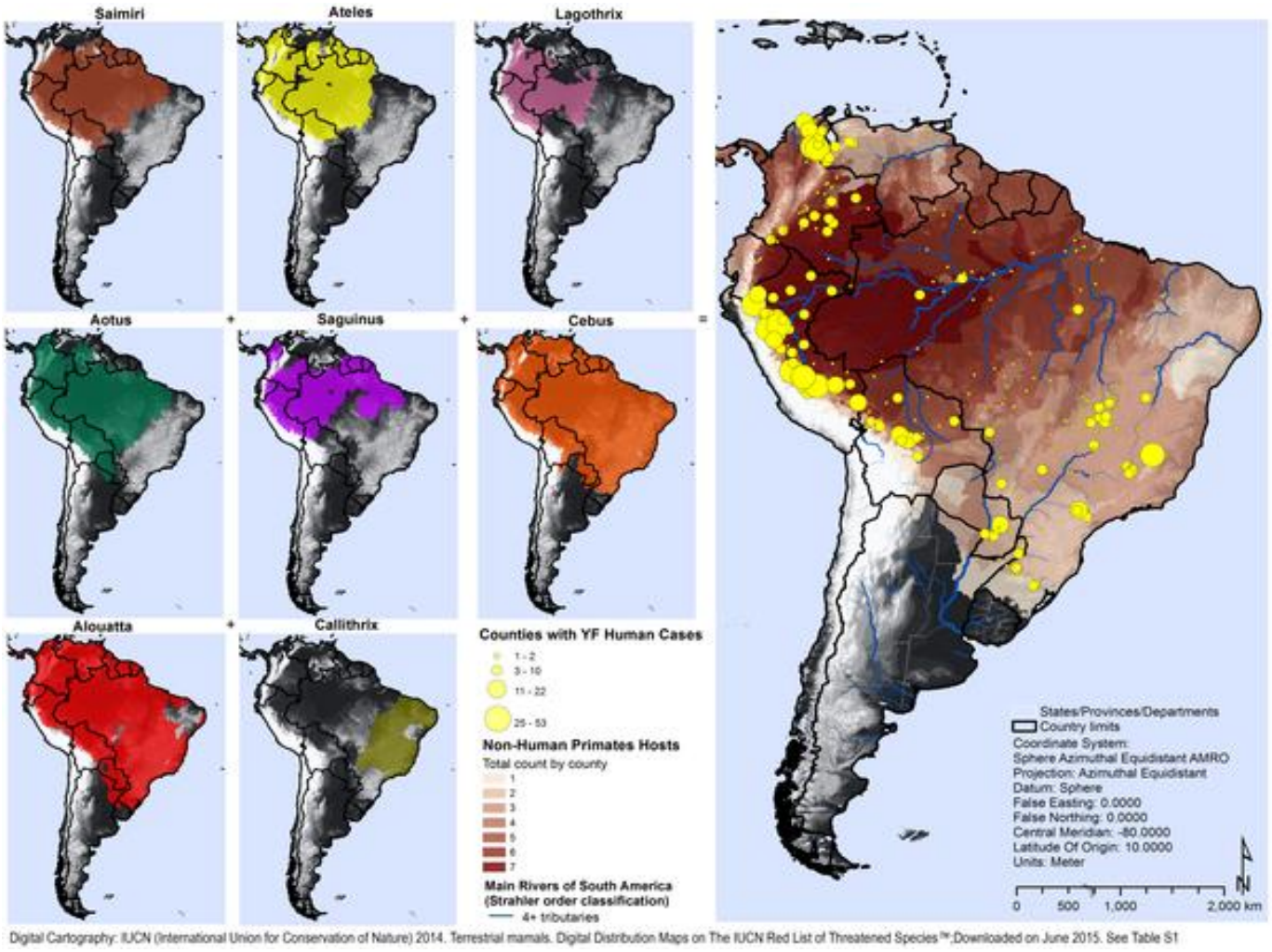
Fig 4. Total annual rainfall by county and geographic distribution of yellow fever, Americas, 2000–2014.

Yellow fever and rain



Hamrick PN, Aldighieri S, Machado G, Leonel DG, Vilca LM, et al. (2017) Geographic patterns and environmental factors associated with human yellow fever presence in the Americas. PLOS Neglected Tropical Diseases 11(9): e0005897. https://doi.org/10.1371/journal.pntd.0005897
http://journals.plos.org/plosntds/article?id=10.1371/journal.pntd.0005897

Fig 5. Number of NHP genera of potential YFV hosts by county and geographic distribution of YF, Americas, 2000–2014.



Yellow fever and non-human primates

Hamrick PN, Aldighieri S, Machado G, Leonel DG, Vilca LM, et al. (2017) Geographic patterns and environmental factors associated with human yellow fever presence in the Americas. PLOS Neglected Tropical Diseases 11(9): e0005897. https://doi.org/10.1371/journal.pntd.0005897
http://journals.plos.org/plosntds/article?id=10.1371/journal.pntd.0005897