Distribution of South American river dolphins in protected and transformed areas in the Amazon and Orinoco river basins

Mosquera Guerra Federico, Trujillo Fernando, Oliveira-da-Costa Marcelo, Marmontel Miriam, Van Damme Paul A, Franco Nicole, Mantilla-Meluk Hugo, Carvajal-Castro Juan David, Cordova Leslie, Caballero Susana, Armenteras-Pascual Dolors.

Context

The dolphins of genus *Inia* (family Iniidae) are cetaceans who have evolved through complex geomorphological processes of isolation in clear water systems of the Amazon basin, Iténez-Mamoré, Tocantis-Araguaia and Orinoco.

The genus *Sotalia* (family Delfinidae) shows a sympatric distribution in the Amazon with *Inia g geoffrensis* and Sotalia sp con *Inia g humboldtiana* in the delta of the Orinoco.

Instituto de Desenvolvimento Sustentável Mamirauá

FAUNAGUA

omacha

Context

DE GRUYTER DOI 10.1515/mammalia-2013-0112 — Mammalia 2014; 78(4): 481–486

Claryana Costa Araújo* and Vera Maria Ferreira da Silva

Spatial distribution of river dolphins, *Inia geoffrensis* (Iniidae), in the Araguaia River (central Brazil)

Abstract: This study aimed to characterize the distribution of botos, *Inia geoffrensis*, along a 530 km stretch in the middle reaches of the Araguaia River (central Brazil). Data collection was conducted in May (lowering water season) and September (dry season) of 2009. The location and group size of botos were recorded, and the relative density was calculated. The river was divided into nine areas according to geomorphological features; these areas were later grouped into two (low and high) levels of sediment input. The study area was categorized into six types of shoreline habitats: vegetated bank, non-vegetated bank, beach, confluence, bay, and island. A total of 195 sightings (239 botos) were recorded, with the highest density of sightings found in habitats in which tributaries entered the Araguaia River (confluence) followed by the bay habitat. The group size varied from one to three individuals, and single individuals were predominant. The segment with high sediment input also had a higher density of botos compared with the low-sediment segment. Botos-preferred habitats and human activities have a great overlap in Araguaia River. Restrictions of certain human activities, and tourism management would reduce both the intentional and accidental harm of botos in the Araguaia River.

Keywords: group size; Iniidae; population; South America.

***Corresponding author: Claryana Costa Araújo,** Applied Ecology and Conservation Lab, Federal University of Goiás, 74001-970 Goiânia, Goiás, Brazil, e-mail: araujoclaryana@gmail.com; and Boto Araguaia Project, 74310-040 Goiânia, Goiás, Brazil
Vera Maria Ferreira da Silva: Aquatic Mammals Lab, National Institute of Amazonian Research, 69080-97 Manaus, Amazonas, Brazil

Introduction

Various factors affect the distribution of cetacean species, such as evolutionary, demographical, ecological, and anthropogenic factors (Forcada 2009). The occurrence of prey, predators, and competitors, as well as water temperature and water depth are some commonly studied ecological and environmental factors that appear to be related to cetacean distribution. Furthermore, anthropogenic effects such as pollution and environmental degradation may also be important determinants of the distribution and occurrence of species (Forcada 2009).

The boto, *Inia geoffrensis* (de Blainville, 1817), is widely distributed in the Amazon, Orinoco, and Araguaia-Tocantins river basins (Best and da Silva 1989, 1993, Martin and da Silva 2004). These basins undergo dramatic seasonal changes. During the rainy season, botos explore the *igapó*, or flooded forest, habitat that emerges, whereas during the lowering water and dry seasons, they concentrate in main river channels (Martin and da Silva 2004). The seasonal changes in the water level are the major influences affecting the distribution and occurrence of botos. Variations in the physiochemical characteristics (such as pH and quantity of suspended sediment) of the water do not seem to affect the presence of botos, but can influence boto density indirectly through their effect on prey abundance (da Silva 1994).

Studies conducted in the Amazonian region indicate that *Inia geoffrensis* appears to occur preferentially in specific habitats, with highest concentrations being found at the confluences of rivers and lakes. The most plausible explanation for the observed preferences would be that the food resources in these sites are more available and abundant (Magnusson et al. 1980, Meade and Koehnken 1991, Vidal et al. 1997, Leatherwood et al. 2000, Martin et al. 2004).

Heavy anthropogenic pressures on the river environment (especially deforestation of riparian forest and construction of dams) have been recognized as one of the main factors that can influence the distribution and occurrence of botos and consequently increase their vulnerability to extinction (Reeves et al. 2000, 2008, Galetti et al. 2010). Until 2008, this species was classified by the International Union for Conservation of Nature as Vulnerable; however, it was recently reclassified and categorized as Data Deficient. This reclassification was mainly because, despite considerable knowledge about its biology in some regions, more data on density and

MOMENTOS DE CIENCIA Universidad de la AMAZONIA
Mom. Cien. 2015. 12 (2). pp: 121-125 ISSN 1692-5491

Nota corta

Modelación de nicho y aspectos biogeográfícos del género *Sotalia* (Cetartiodactyla: Delphinidae) en los ríos Amazonas y Orinoco, Colombia

Juan David Carvajal-Castro[1], Tatiana Velásquez-Roa[1], Hugo Mantilla-Meluk[1], Fernando Trujillo[2*] y Federico Mosquera-Guerra[2]

[1]Programa de Biología, Universidad del Quindío. Armenia, Colombia.
[2]Fundación Omacha, Bogotá D.C. Colombia.

Autor para Correspondencia*:
fernando@omacha.org

Recibido 05 de julio de 2015.
Aceptado 25 de diciembre 2015.

Resumen
El género *Sotalia* (Cetartiodactyla: Delphinidae) esta compuesto de dos especies, basados en morfología craneal y evidencia genética. La primera *Sotalia fluviatilis* (continental) corresponde a individuos distribuidos en la cuenca del río Amazonas y *Sotalia guianensis* (Orinoco y Océano Atlántico) presentes en las costas de Océano Atlántico en Centro y Sur América, incluido el delta del río Orinoco y el Lago Maracaibo en Venezuela. Las individuos establecidos en el medio y bajo Orinoco, corresponden a individuos que presentan 600.000 años de divergencia genética de las poblaciones costeras correspondientes a *S. guianensis*. El tucuxi, *S. fluviatilis* es simpatrico con *Inia geoffrensis* para la cuenca del río Amazonas. Se caracterizaron ecológicamente los avistamientos realizados para el género *Sotalia* en las cuencas de los ríos Amazonas y Orinoco y el efecto de su interconectividad sobre los patrones biogeográficos a través del modelamiento del nicho ecológico (nicho climático) en aras de establecer la distribución potencial del género *Sotalia* empleando el algoritmo de Máxima Entropía (MaxEnt) y sistemas de información geográfica junto con variables ecográficas e hidrográficas, asociadas a los sistemas acuáticos habitados por estas especies de cetáceos. Los resultados sugieren que la especies *S. fluviatilis* y *S. guianensis* presentan limitaciones a su distribución generado por los raudales como Córdoba en el río Caquetá (Amazonas) y Maipures y Atures en el río Orinoco (Venezuela). Finalmente, se resalta la importancia de este tipo de investigaciones, que emplean aproximaciones ecológicas para inferir las distribuciones potenciales de estas especies en los sistemas acuáticos de la Amazonia y Orinoquia.
Palabras clave: MaxEnt; modelamiento; Sotalia sp; Sistemas de Información Geográfica.

MOMENTOS DE CIENCIA Universidad de la AMAZONIA
Mom. Cien. 2015. 12 (2). pp: 121-125 ISSN 1692-5491

Nota corta

Modelación de nicho y aspectos biogeográfícos del género *Sotalia* (Cetartiodactyla: Delphinidae) en los ríos Amazonas y Orinoco, Colombia

Juan David Carvajal-Castro[1], Tatiana Velásquez-Roa[1], Hugo Mantilla-Meluk[1], Fernando Trujillo[2*] y Federico Mosquera-Guerra[2]

[1]Programa de Biología, Universidad del Quindío. Armenia, Colombia.
[2]Fundación Omacha, Bogotá D.C. Colombia.

Autor para Correspondencia*:
fernando@omacha.org

Recibido 05 de julio de 2015.
Aceptado 25 de diciembre 2015.

Resumen
El género *Sotalia* (Cetartiodactyla: Delphinidae) esta compuesto de dos especies, basados en morfología craneal y evidencia genética. La primera *Sotalia fluviatilis* (continental) corresponde a individuos distribuidos en la cuenca del río Amazonas y *Sotalia guianensis* (Orinoco y Océano Atlántico) presentes en las costas de Océano Atlántico en Centro y Sur América, incluido el delta del río Orinoco y el Lago Maracaibo en Venezuela. Las individuos establecidos en el medio y bajo Orinoco, corresponden a individuos que presentan 600.000 años de divergencia genética de las poblaciones costeras correspondientes a *S. guianensis*. El tucuxi, *S. fluviatilis* es simpatrico con *Inia geoffrensis* para la cuenca del río Amazonas. Se caracterizaron ecológicamente los avistamientos realizados para el género *Sotalia* en las cuencas de los ríos Amazonas y Orinoco y el efecto de su interconectividad sobre los patrones biogeográficos a través del modelamiento del nicho ecológico (nicho climático) en aras de establecer la distribución potencial del género *Sotalia* empleando el algoritmo de Máxima Entropía (MaxEnt) y sistemas de información geográfica junto con variables ecográficas e hidrográficas, asociadas a los sistemas acuáticos habitados por estas especies de cetáceos. Los resultados sugieren que la especies *S. fluviatilis* y *S. guianensis* presentan limitaciones a su distribución generado por los raudales como Córdoba en el río Caquetá (Amazonas) y Maipures y Atures en el río Orinoco (Venezuela). Finalmente, se resalta la importancia de este tipo de investigaciones, que emplean aproximaciones ecológicas para inferir las distribuciones potenciales de estas especies en los sistemas acuáticos de la Amazonia y Orinoquia.
Palabras clave: MaxEnt; modelamiento; Sotalia sp; Sistemas de Información Geográfica.

Ecología en Bolivia 47(2): 134-142. Septiembre de 2012. ISSN 1605-2528.

Distribución y estado poblacional del bufeo boliviano (*Inia boliviensis*) en cuatro ríos tributarios de la subcuenca del Río Mamoré

Distribution and population status of the Bolivian river dolphin (*Inia boliviensis*) in four tributary rivers of the Mamore River sub basin

Enzo Aliaga-Rossel[1*,2], Luis Guizada[1,2], Amber S. Beerman[3], Alex Alcocer[2,4] & Consuelo Morales[2]

[1]Instituto de Ecología, Universidad Mayor de San Andrés, Casilla 10077 – Correo Central,La Paz, Bolivia
Email: ealiagar@hotmail.com *Autor de correspondencia
[2]Asociación FAUNAGUA, Avenida Max Fernández final s/n (Arocagua), Sacaba, Cochabamba, Bolivia
[3]Wageningen University, Department of Aquatic Ecology and Water Quality. P.O. Box 47, Wageningen, Holanda
[4]Universidad Autónoma Gabriel René Moreno, Km. 9 Norte, Santa Cruz, Bolivia

WWF
Instituto de Desenvolvimento Sustentável Mamirauá
FAUNAGUA
omacha

Material and Methods

Distribution Predictive Models

33K records with georreference
(21K observations y 12K tags)

+

18 bioclimatic variables
Worldclim (Hijmans et al., 2005)

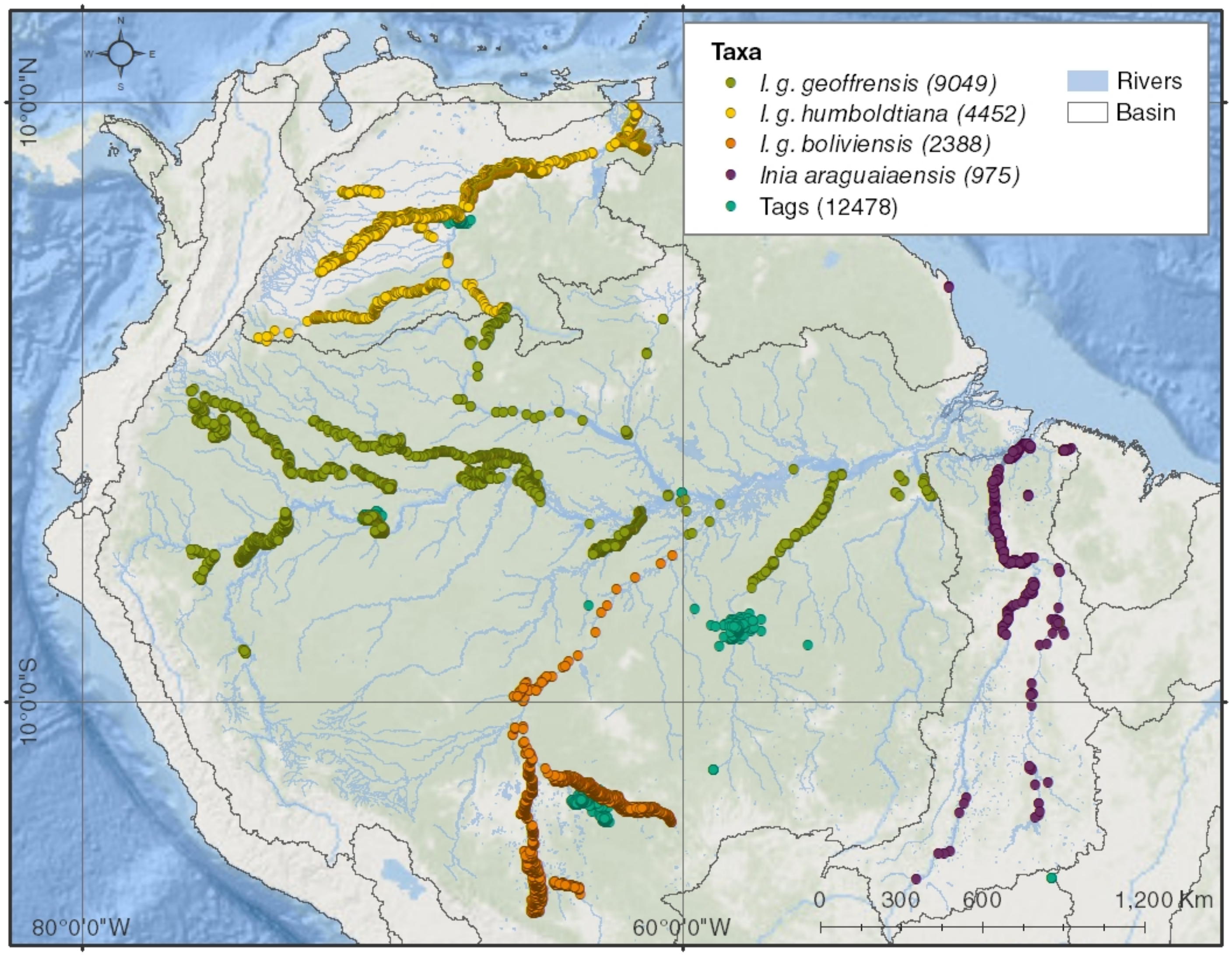
Where are more these conditions

0.1	0.1	0.1	0.1
0.2	0.1	0.2	0.1
0.3	0.1	0.3	0.3
0.4	0.1	0.1	0.4

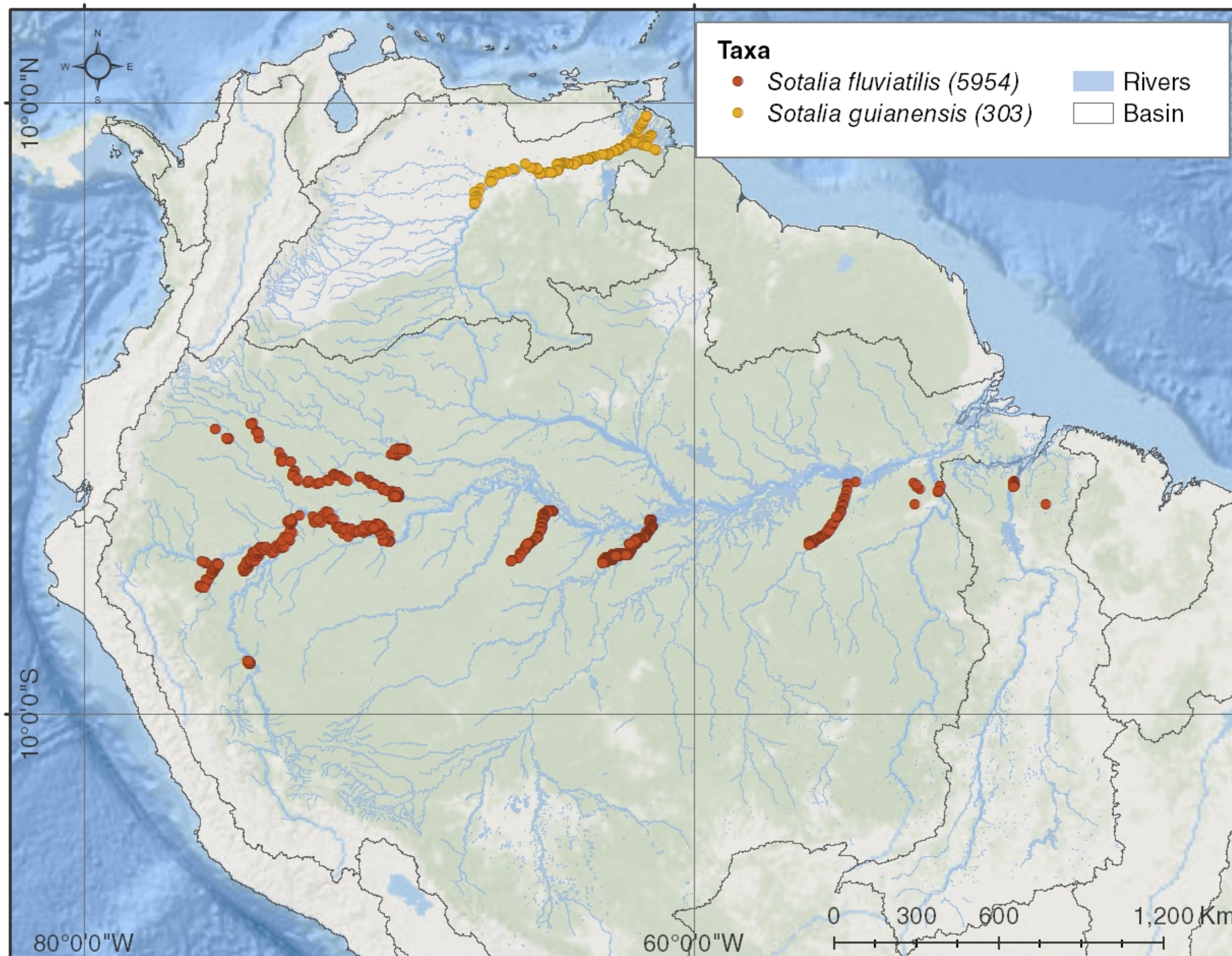
Instituto de Desenvolvimento Sustentável Mamirauá

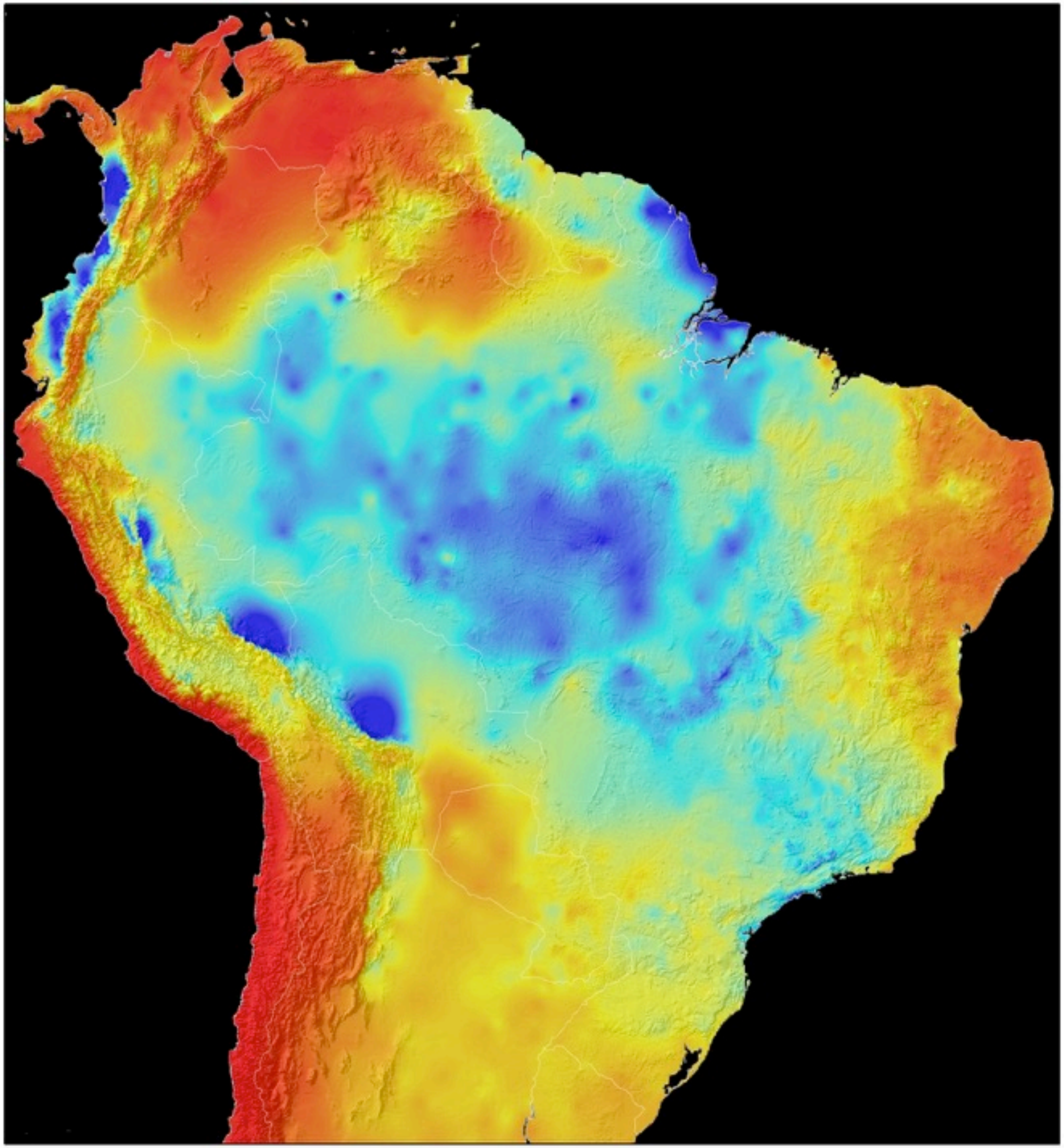
(Phillips *et al.*, 2004, 2006, 2008)

Material and Methods



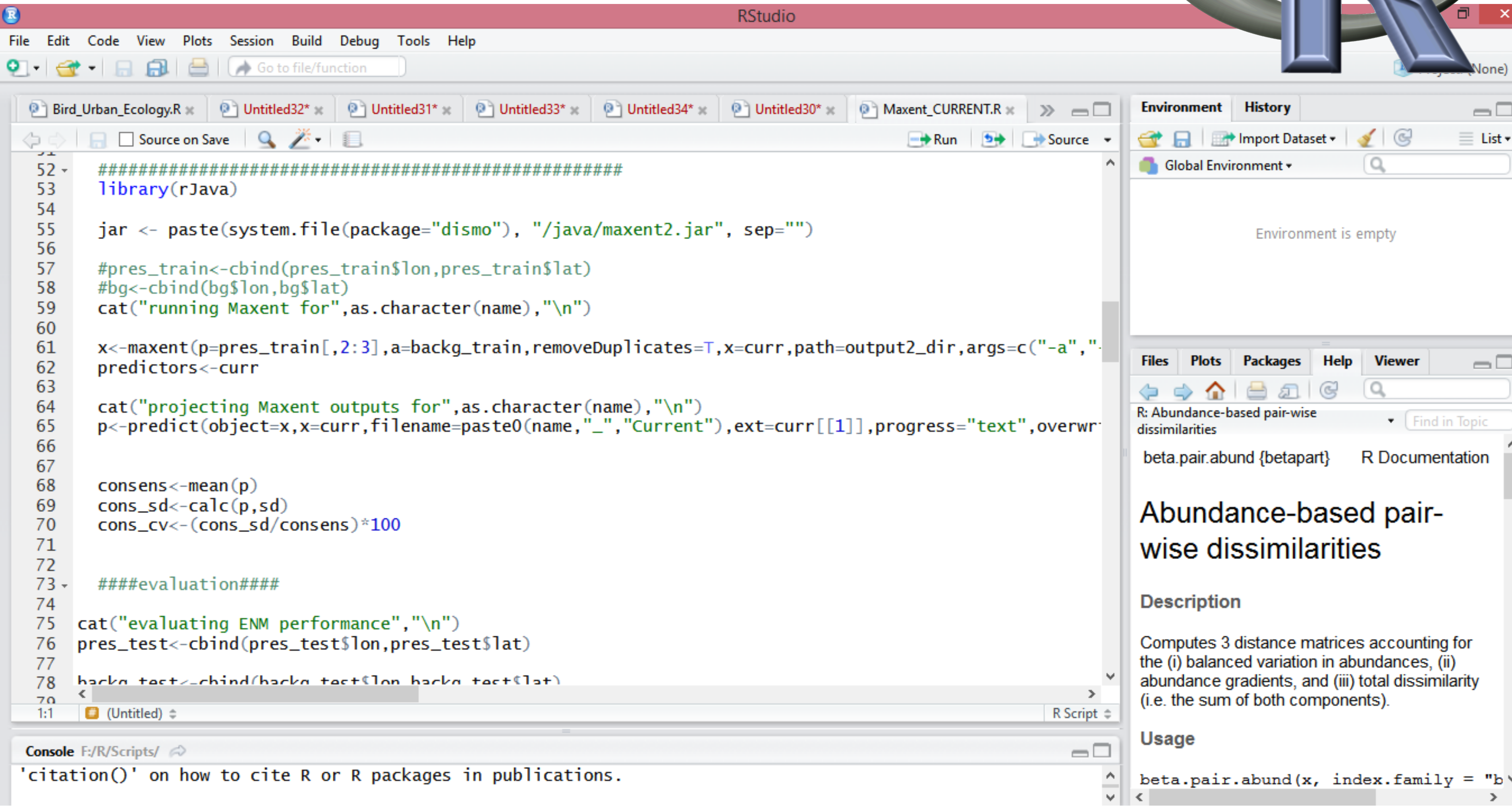
Material and Methods





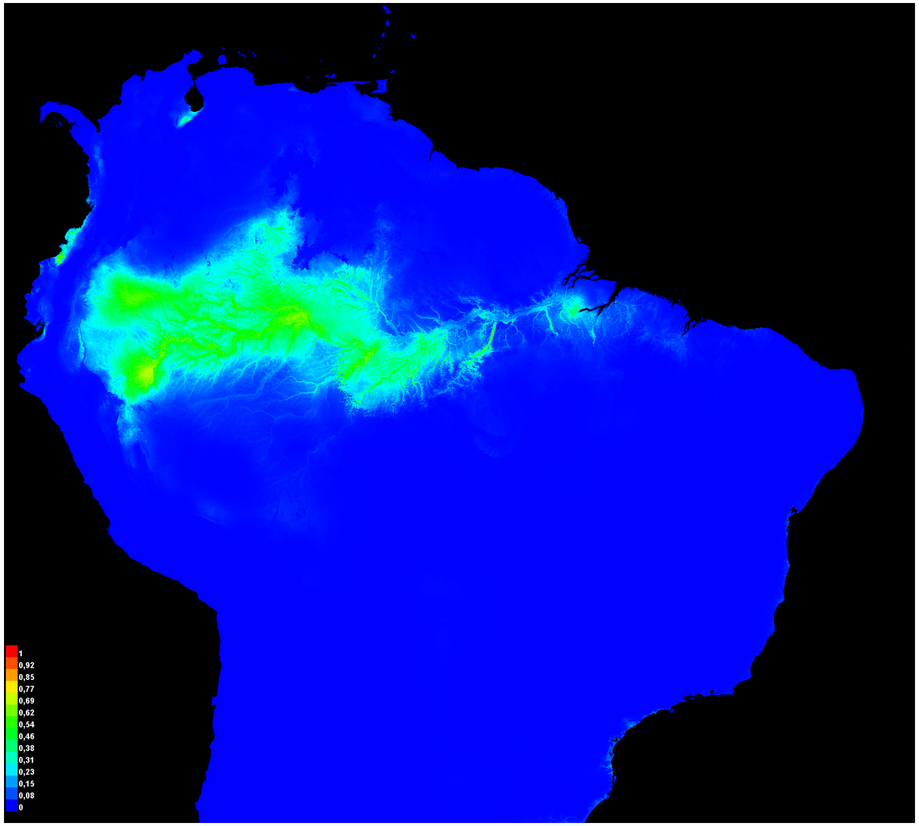
Variables	Description
Elevation	Height in meters above sea level
Bio 1	Annual average temperature
Bio 2	Average daytime range (Mean of the month (Max Temp - Min Temp))
Bio 3	Isothermality ((Bio 2/Bio 7) * 100)
Bio 4	Seasonality of temperature (Standard deviation * 100)
Bio 5	Maximum temperatura of the hottest month
Bio 6	Minimum temperature of the coldest month
Bio 7	Annual temperature range (Bio 5 - Bio 6)
Bio 8	Average temperature of the wettest quarter
Bio 9	Average temperature of the driest quarter
Bio 10	Average temperature of the warmest quarter
Bio 11	Average temperature of the coldest quarter
Bio 12	Annual rainfall
Bio 13	Precipitation of the wettest month
Bio 14	Precipitation of the driest month
Bio 15	Seasonality of precipitation (Coefficient of variation)
Bio 16	Precipitation of the wettest quarter
Bio 17	Precipitation of the driest quarter

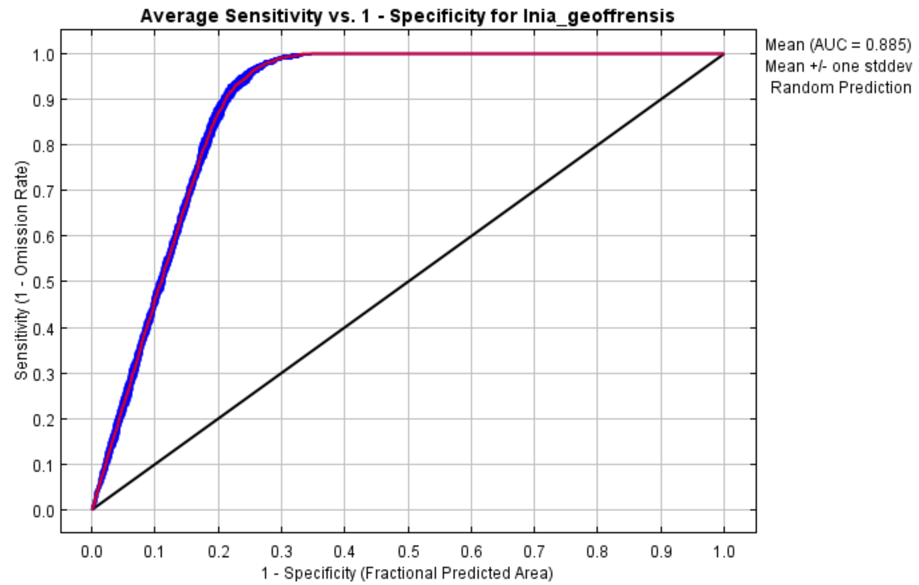
Material and Methods



Instituto de Desenvolvimento Sustentável Mamirauá

Results





Inia g geoffrensis

AUC: 0,8852 High

No random

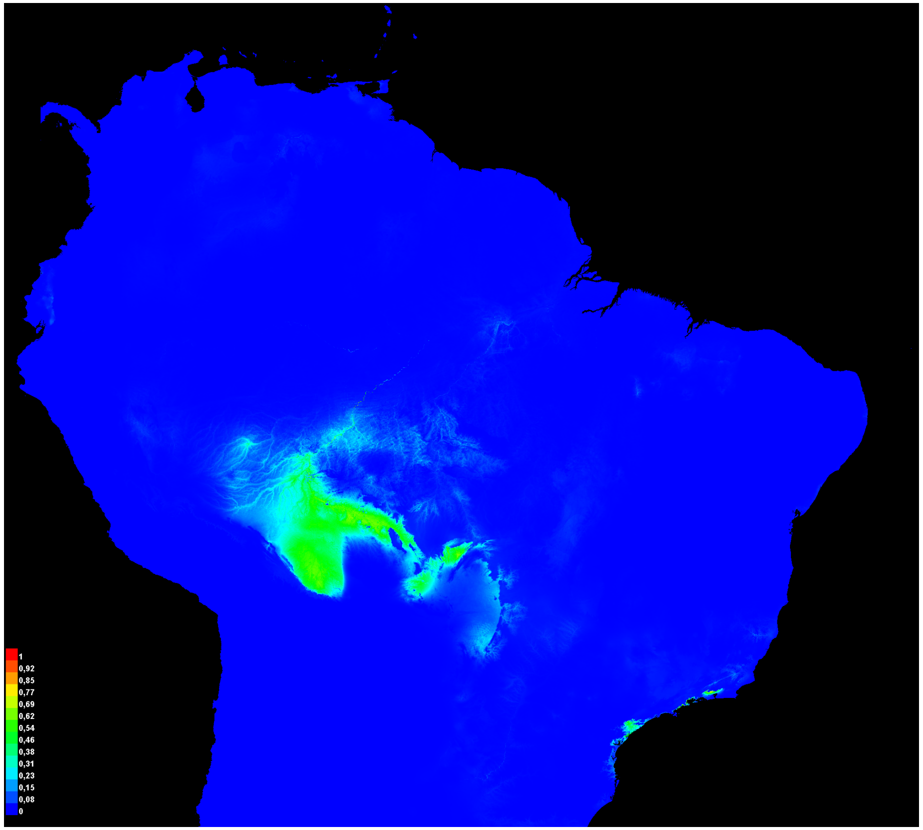
Instituto de Desenvolvimento Sustentável Mamirauá

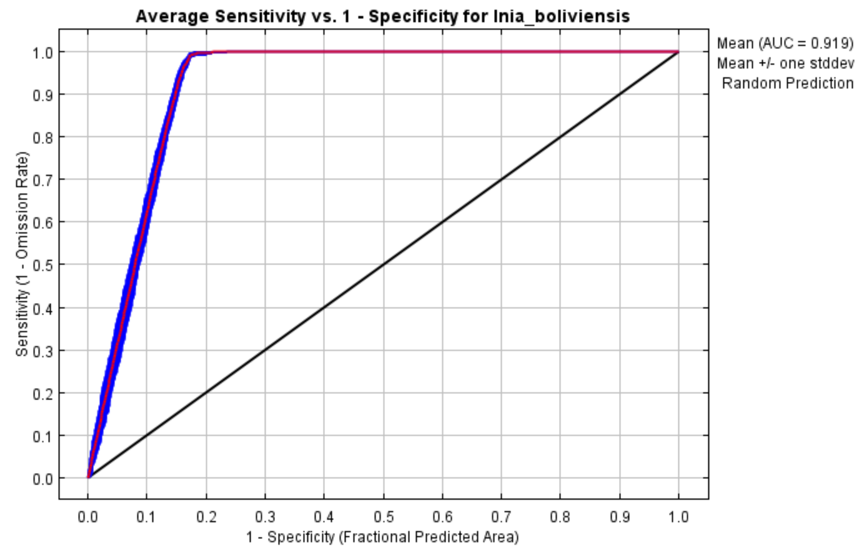
WWF

FAUNAGUA

omacha

Results





Inia g boliviensis

AUC: 0,9189 High

No random

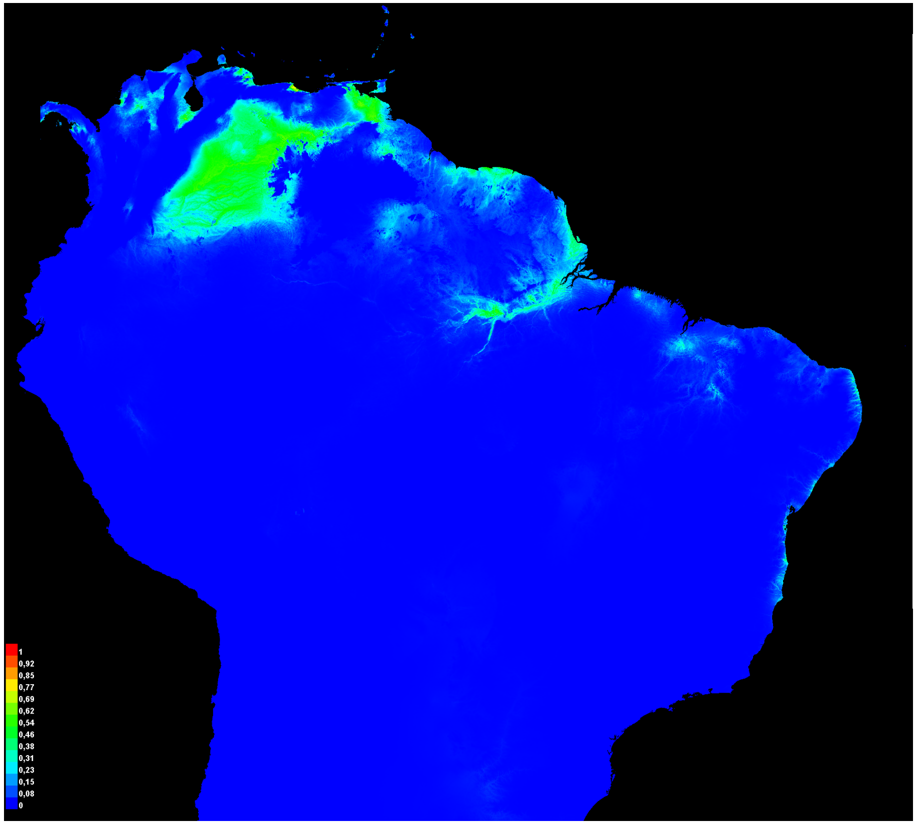
WWF

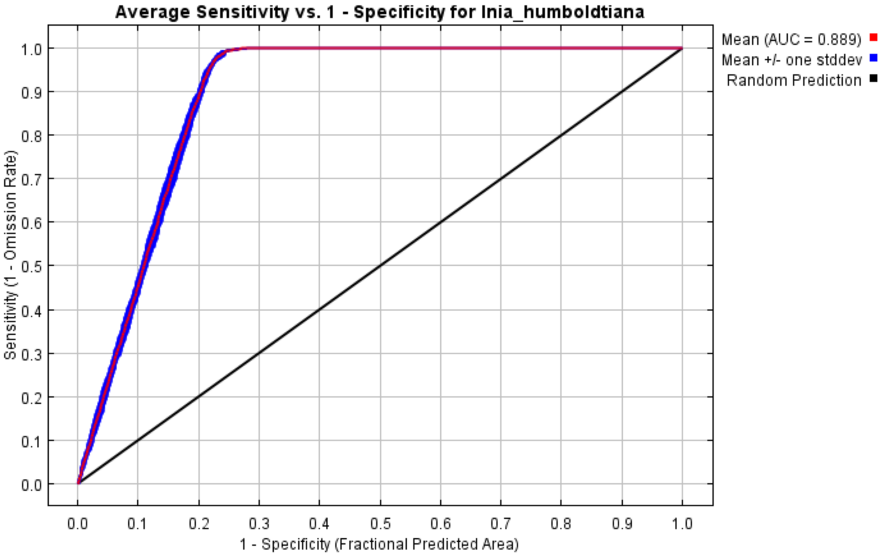
Instituto de Desenvolvimento Sustentável Mamirauá

FAUNAGUA

Fundación omacha

Results





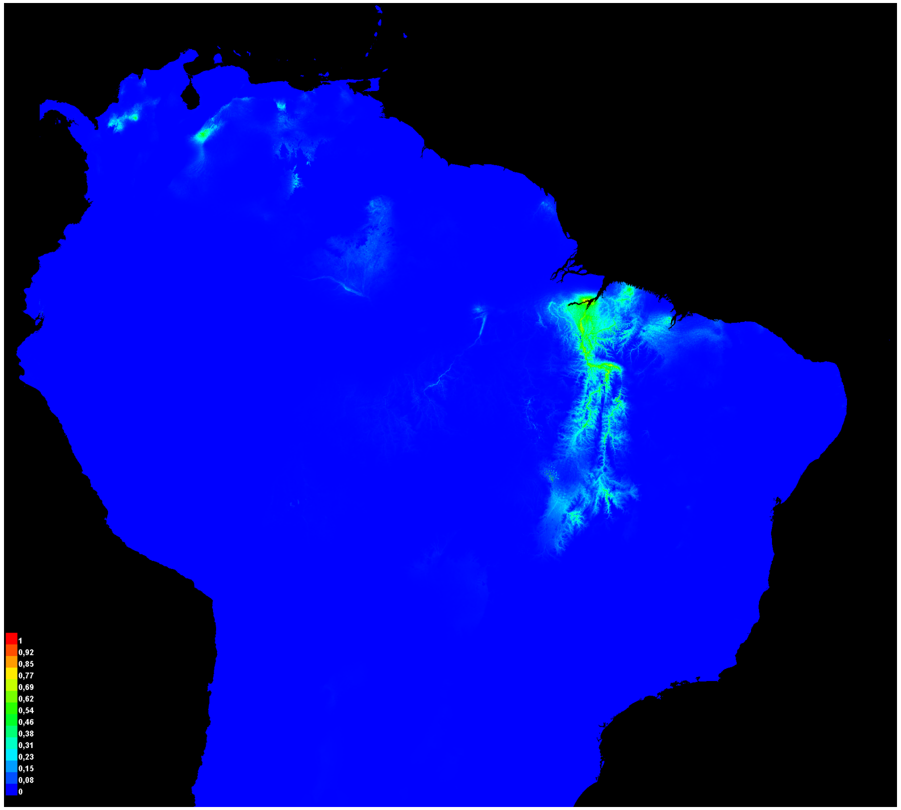
Inia g humboldtiana

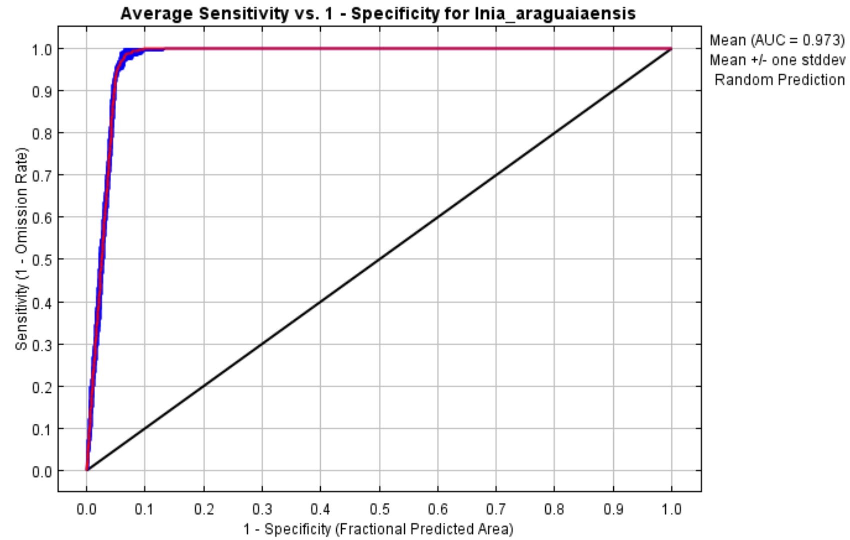
AUC: 0,889 High

No random

Instituto de Desenvolvimento Sustentável Mamirauá

Results





Inia araguaiaensis

AUC: 0,9738 High

No random

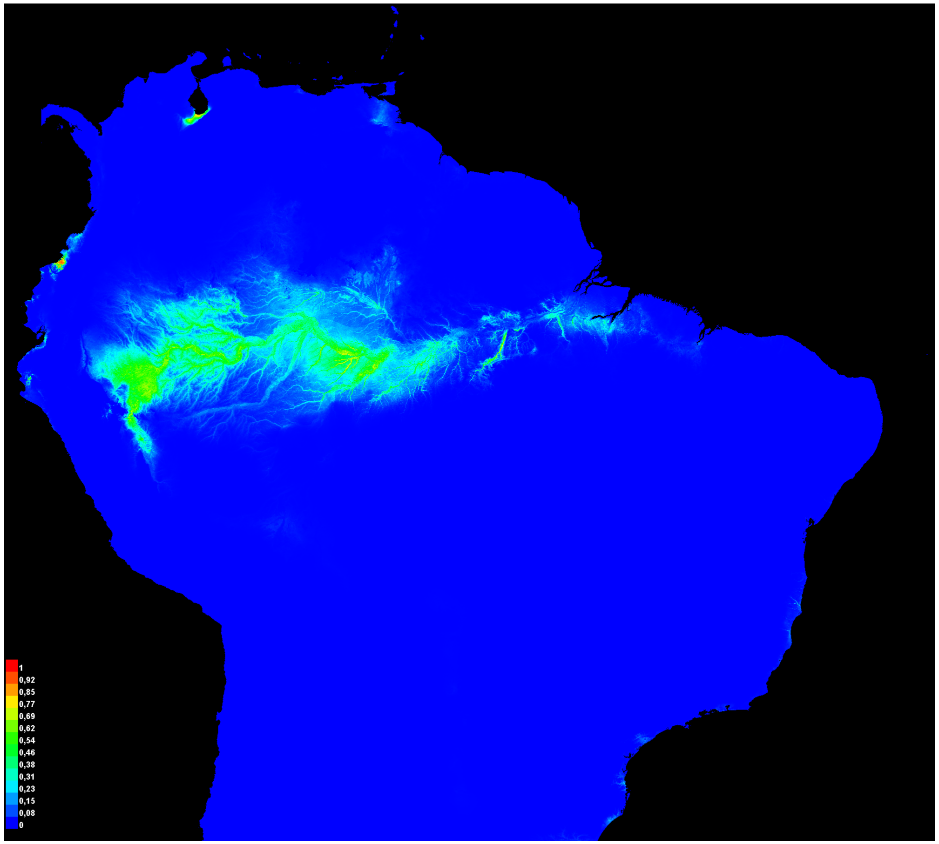
WWF

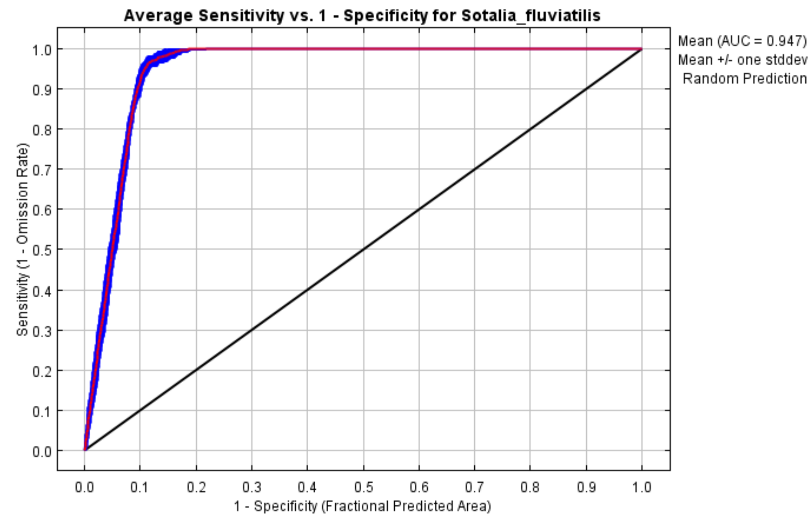
Instituto de Desenvolvimento Sustentável Mamirauá

FAUNAGUA

Fundación Omacha

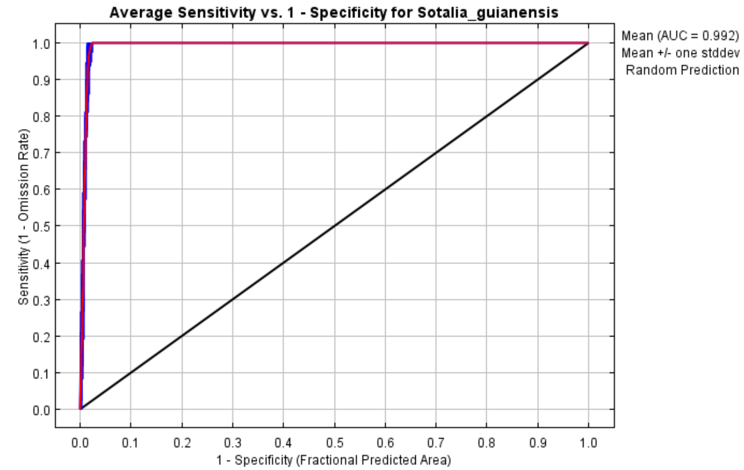
Results





Sotalia fluviatilis
AUC: 0,948 High
No random

Results



Sotalia guianensis

AUC: 0,993 High

No random

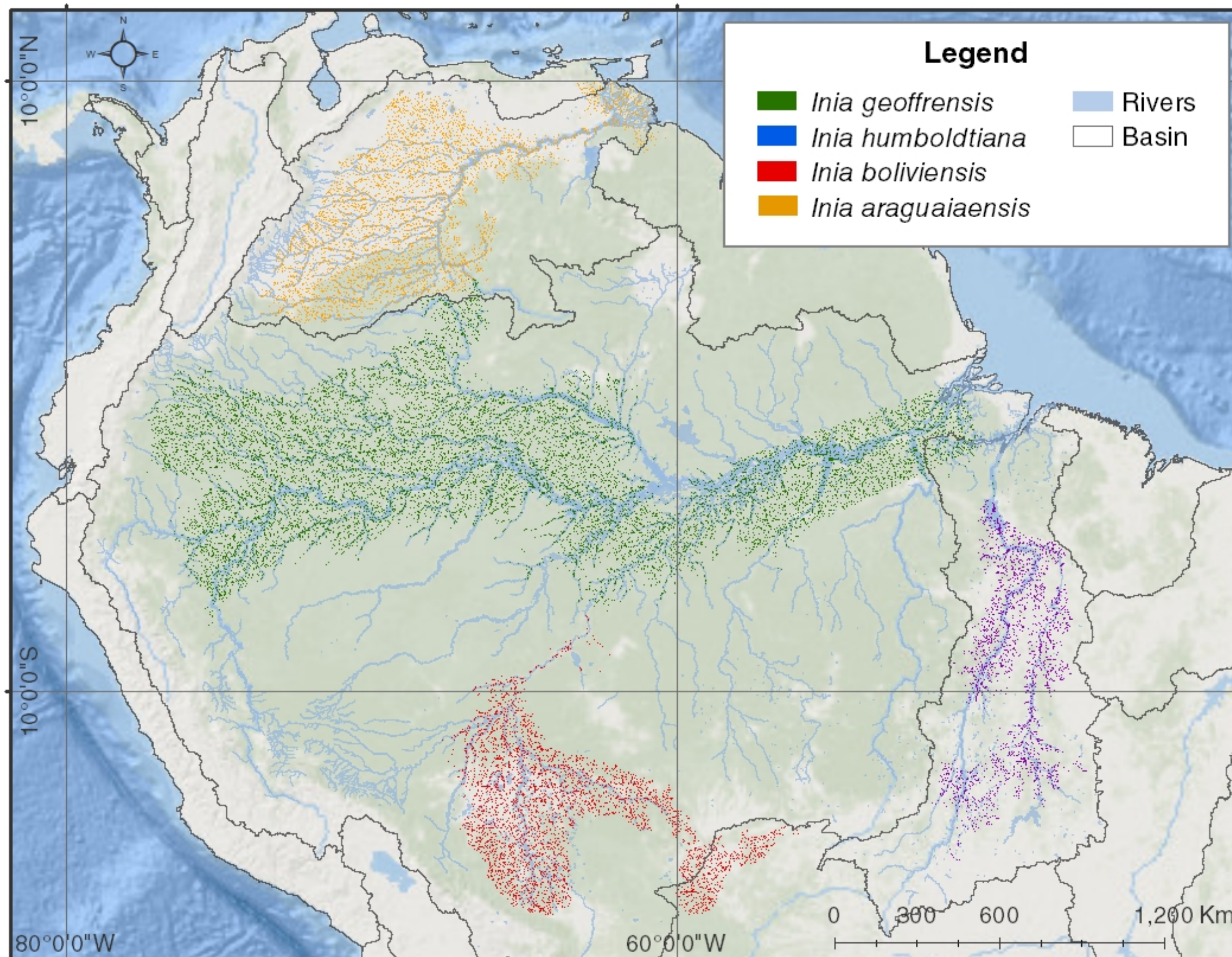
WWF

Instituto de Desenvolvimento Sustentável Mamirauá

FAUNAGUA

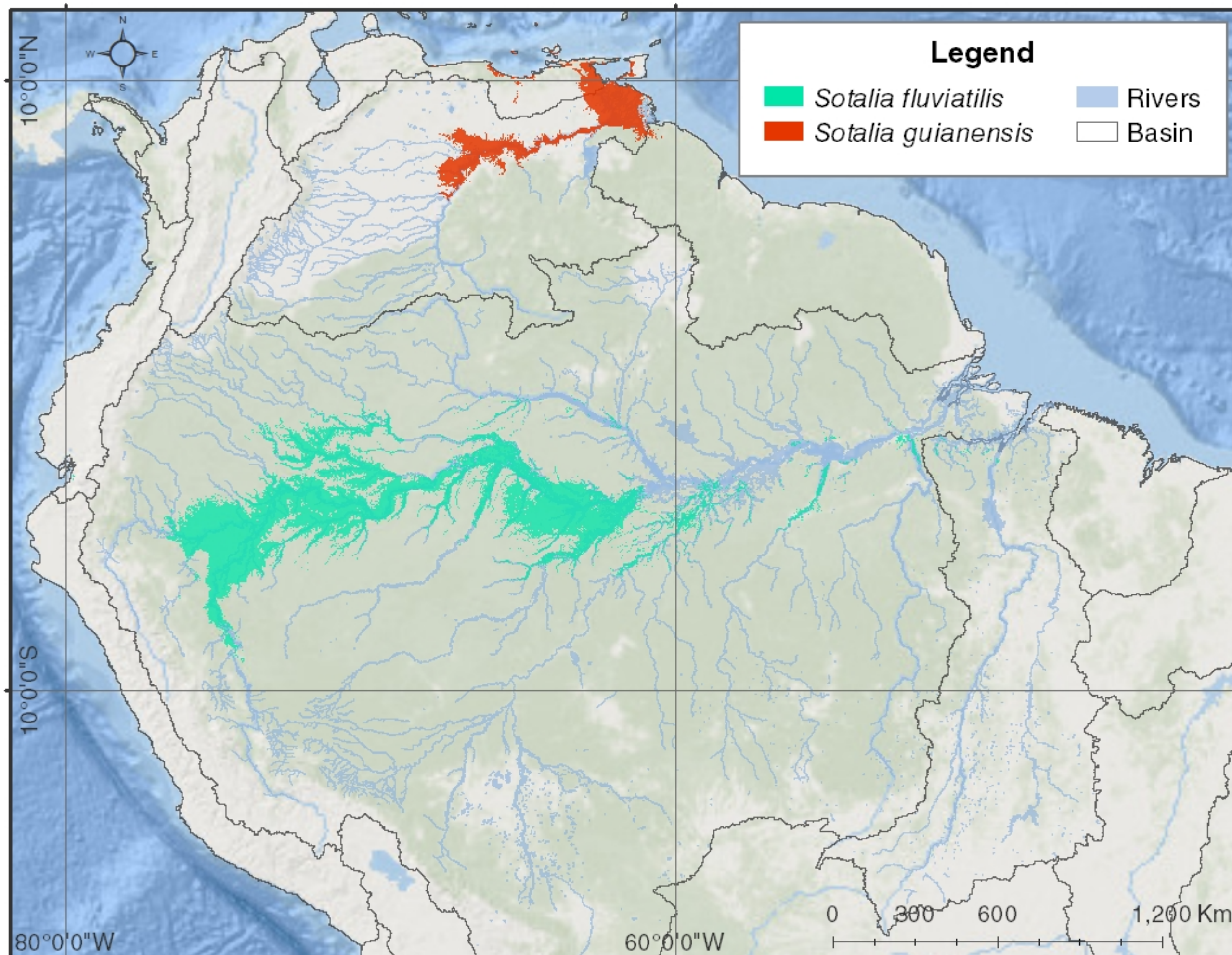
Fundación omacha

Results



Instituto de Desenvolvimento Sustentável Mamirauá

Results



Instituto de Desenvolvimento Sustentável Mamirauá

FAUNAGUA

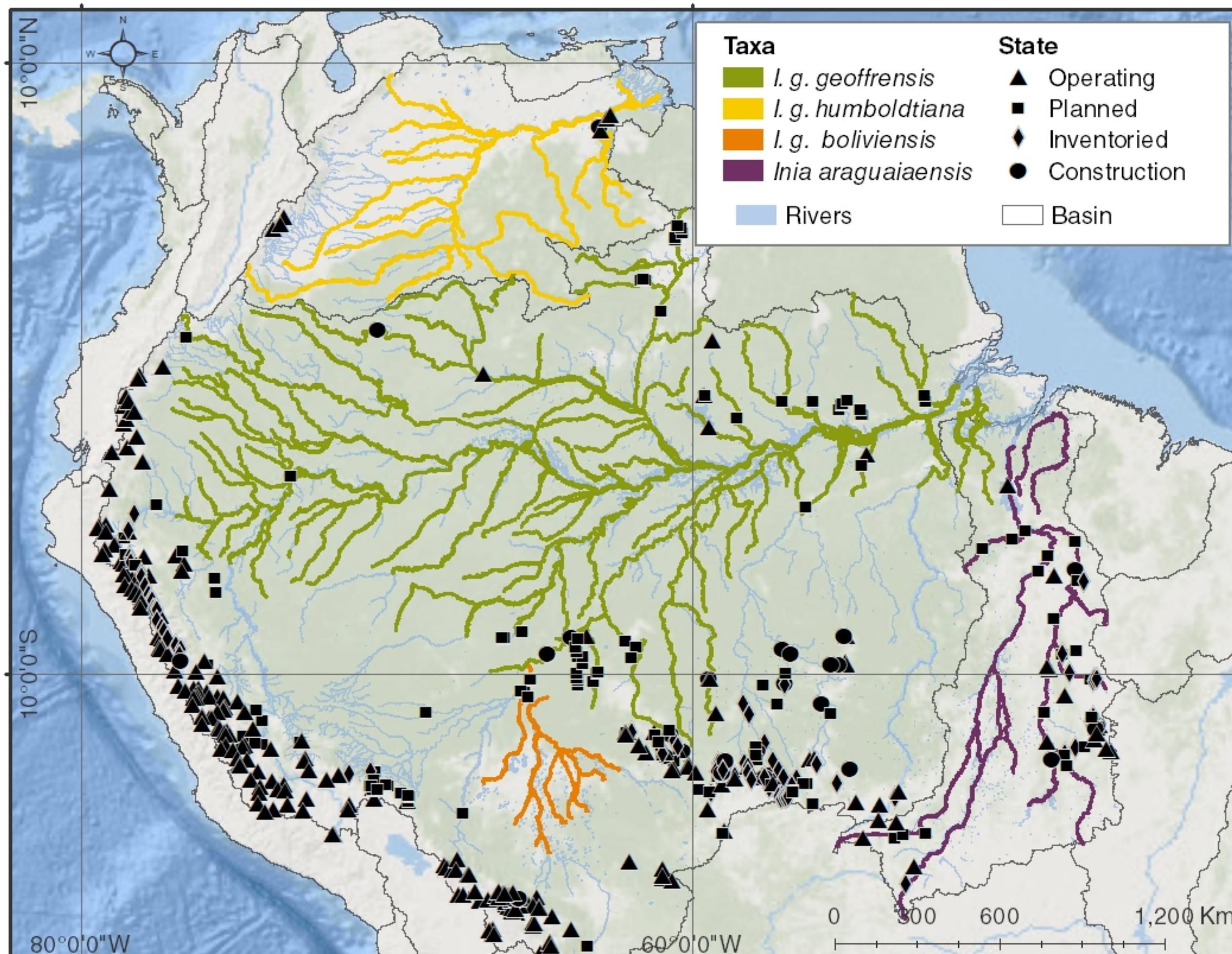
omacha

Results

Species	Total area potential distribution km²	Areas transformed by hydroelectric plants in different phases km²		
		Operation	Constrution	Planning
I. g. geoffrensis	468.717	77.077 (16.4%)	68.995 (14.7%)	139.981 (29.9%)
I. g. humboldtiana	114.962	26.348 (22.9%)	6.302 (5.5%)	
I.g. boliviensis	76.597			1.482 (1.9%)
I. araguaiaensis	76.182	41.853 (54.9%)	16.005 (21%)	36.281 (47.6%)
Sotalia fluviatilis	356.716	77.077 (21.6%)	68.995 (19.3%)	139.981 (39.2%)
Sotalia guianensis	17.473	2.704 (15.5%)	2.555 (14.6%)	

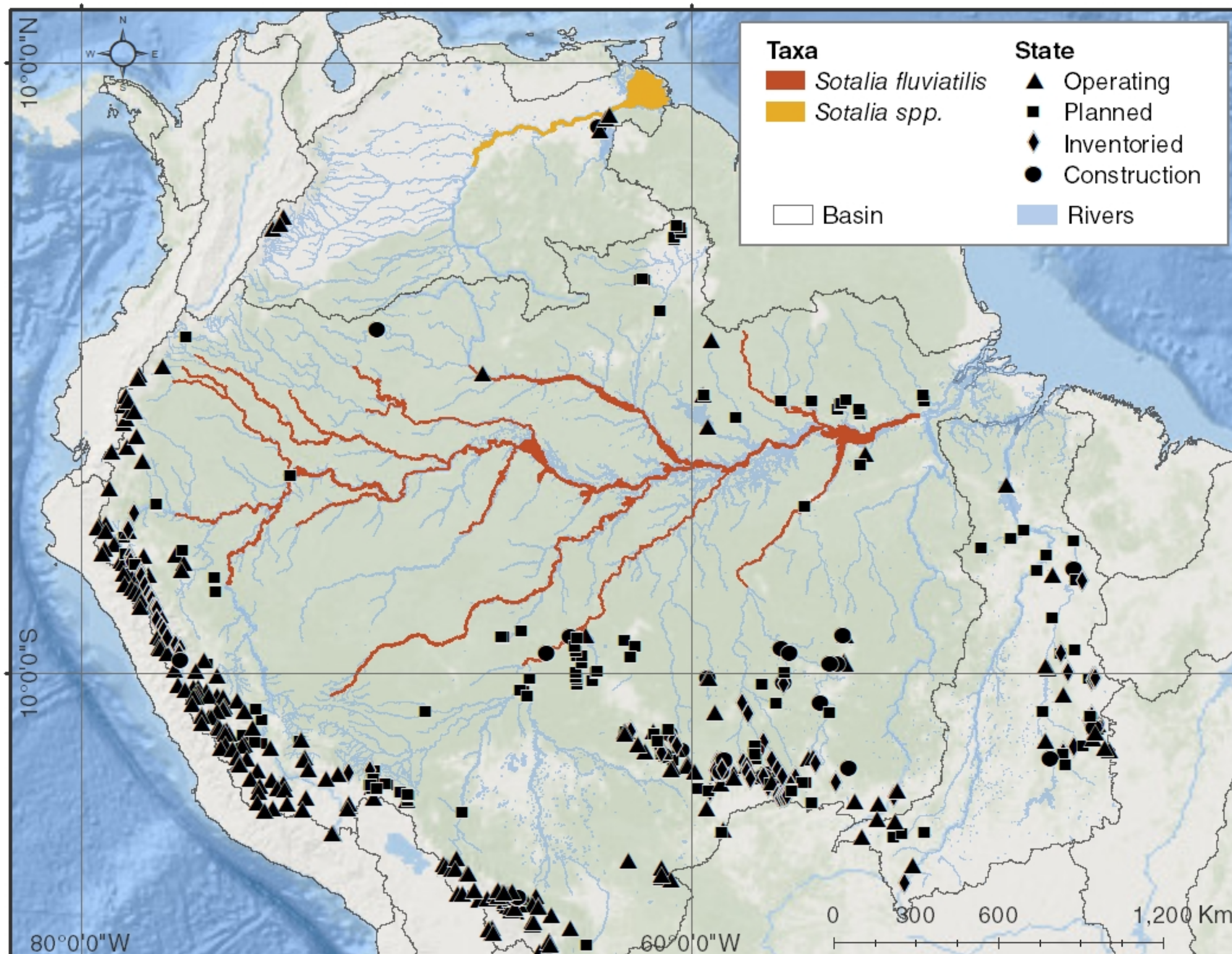
Table. Representativeness of transformed areas by hydroelectric plants in the distribution of South American river dolphins (*Inia* and *Sotalia*).

Results



Taxa
I. g. geoffrensis
I. g. humboldtiana
I. g. boliviensis
Inia araguaiaensis
Rivers
State
Operating
Planned
Inventoried
Construction
Basin
10°0'0"N
10°0'0"S
80°0'0"W
60°0'0"W
0
300
600
1,200 Km

Results



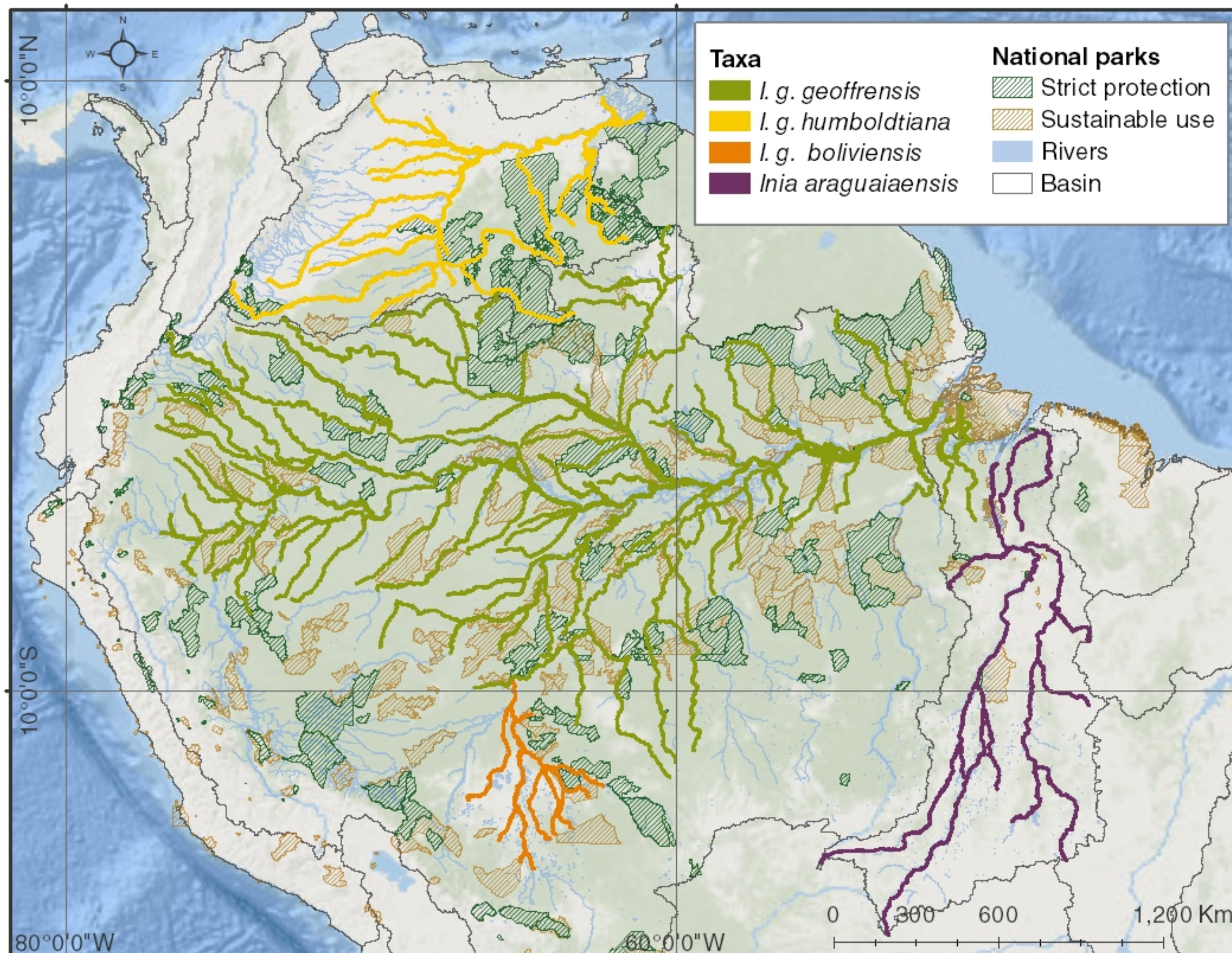
Instituto de Desenvolvimento Sustentável Mamirauá

Results

Species	Total area potential distribution	Areas of aquatic ecosystems in conservation km^2						Total area in Conservation km^2
		Brasil	Bolivia	Colombia	Ecuador	Peru	Venezuela	
I.g.geoffrensis	468.717	69.324		5.839	2.900	11.455	397	89.915 (19,2%)
I.g.humboldtiana	114.962			2.151			10.634	12.785 (11,1%)
I.g.boliviensis	76.597	5.892	12.494					18.386 (24,0%)
I. araguaiaensis	76.182	11.503						11.503 (15,1%)
S. fluviatilis	356.716	54.892		2.637	2.900	7.726		68.155 (19,1%)
S. guianensis	17.473						4.630	4.630 (26.5%)

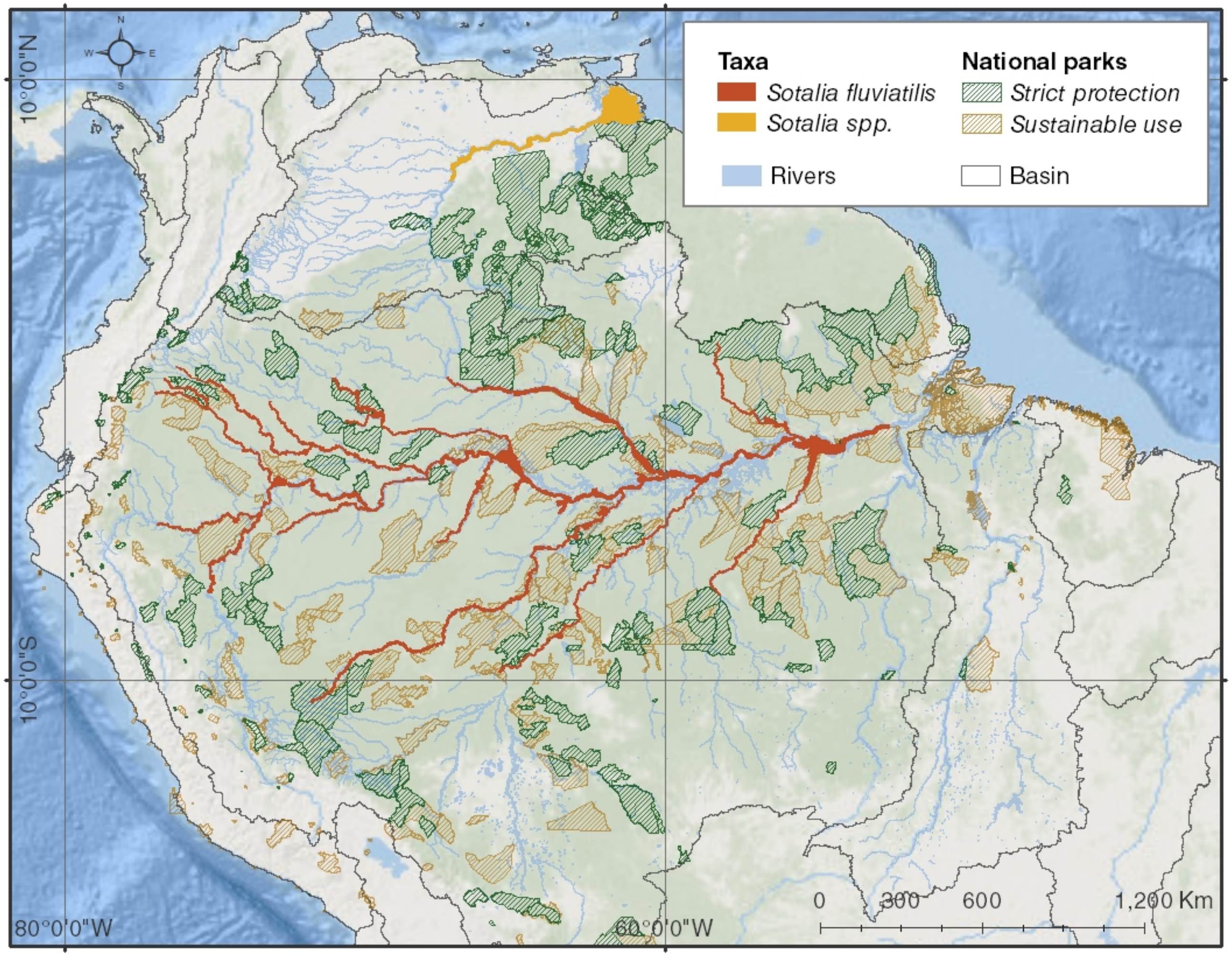
Table . Representativeness of protected areas in the distribution of South American river dolphins (*Inia* and *Sotalia*).

Results



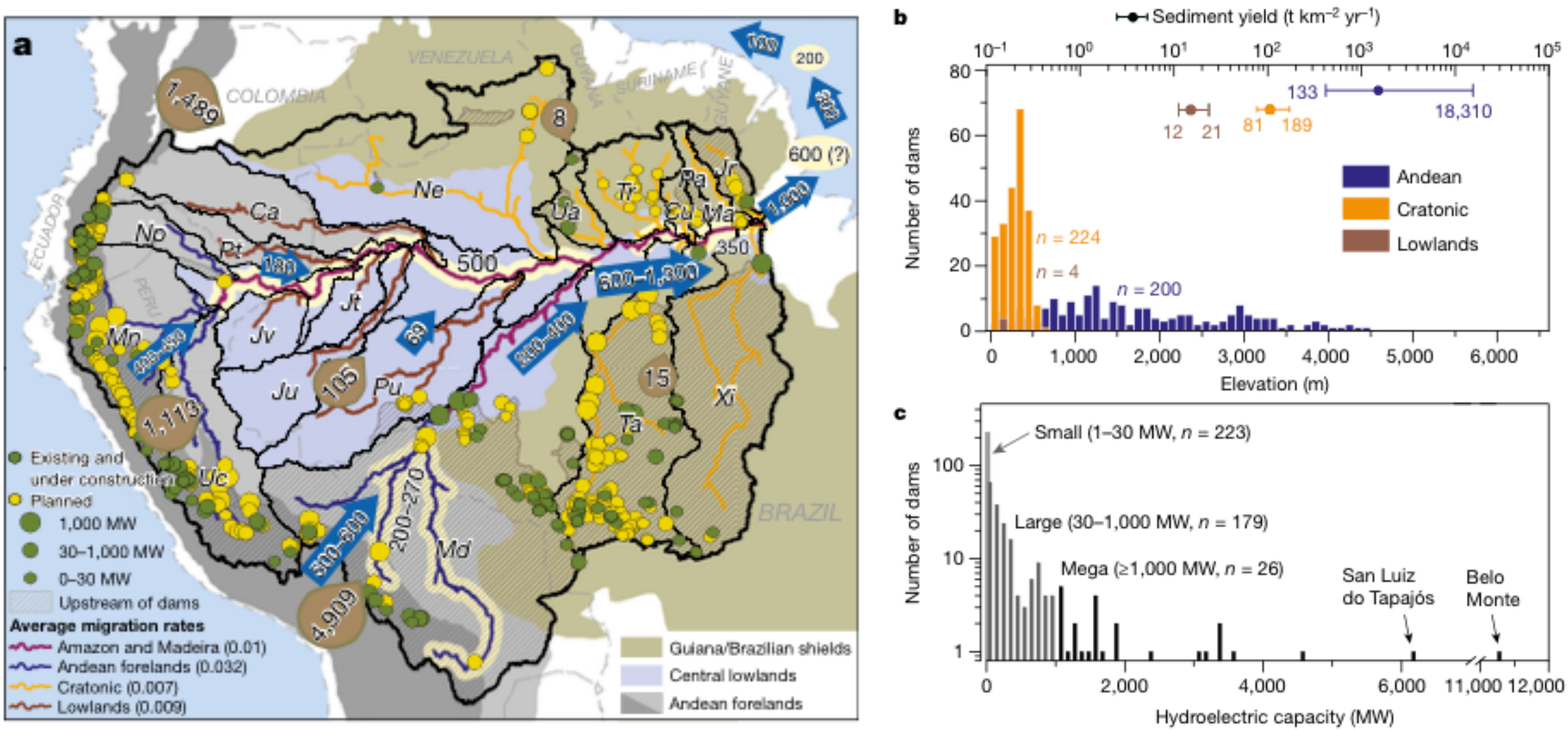
Taxa
I. g. geoffrensis
I. g. humboldtiana
I. g. boliviensis
Inia araguaiaensis
National parks
Strict protection
Sustainable use
Rivers
Basin
10°0'0"N
10°0'0"S
80°0'0"W
60°0'0"W
0 300 600 1,200 Km

Results



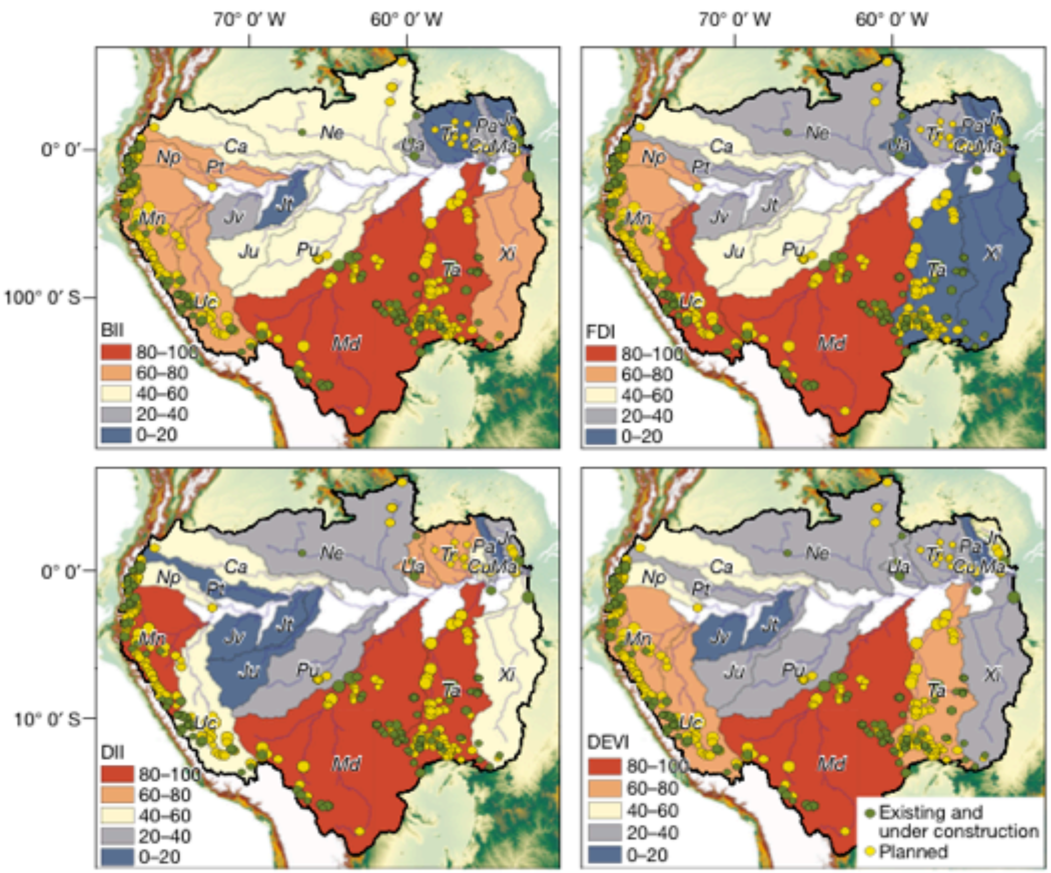
Instituto de Desenvolvimento Sustentável Mamirauá

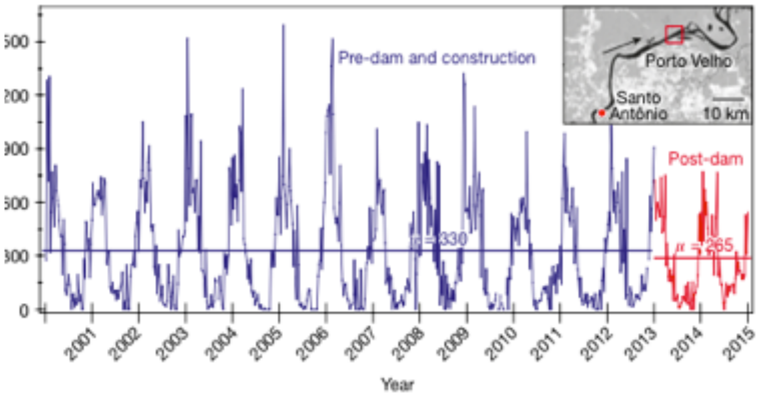
Discussion



Latrubesse et al. 2017

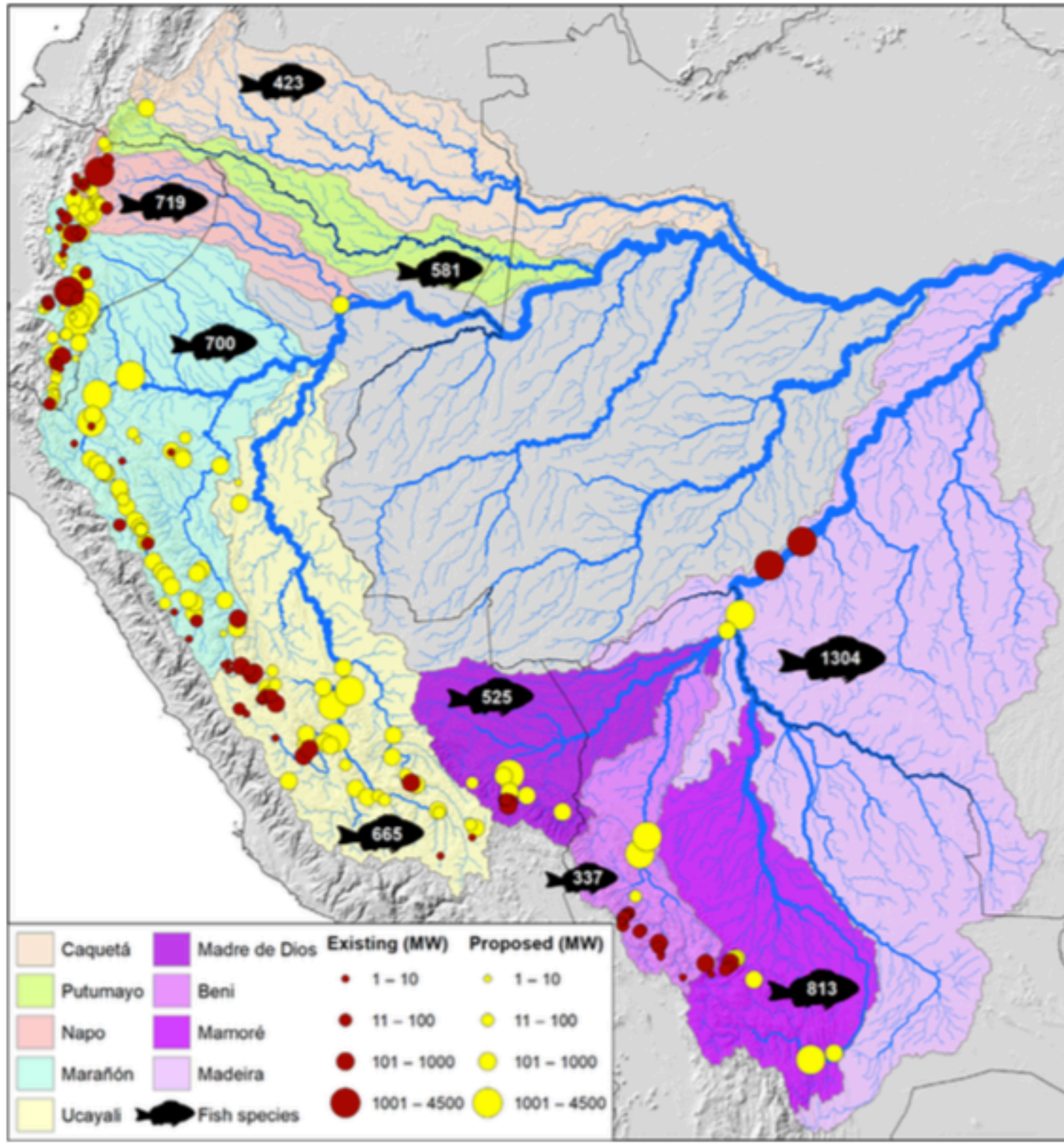
Discussion





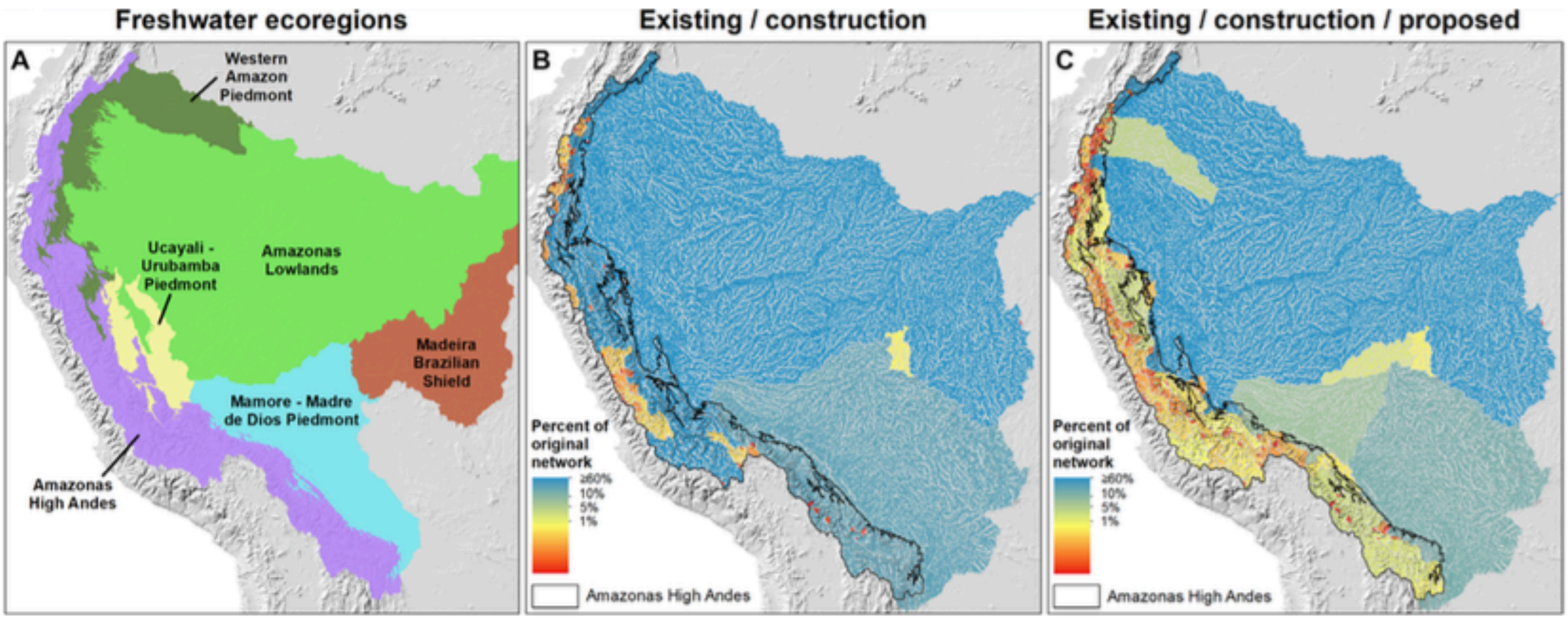
Latrubesse et al. 2017

Discussion



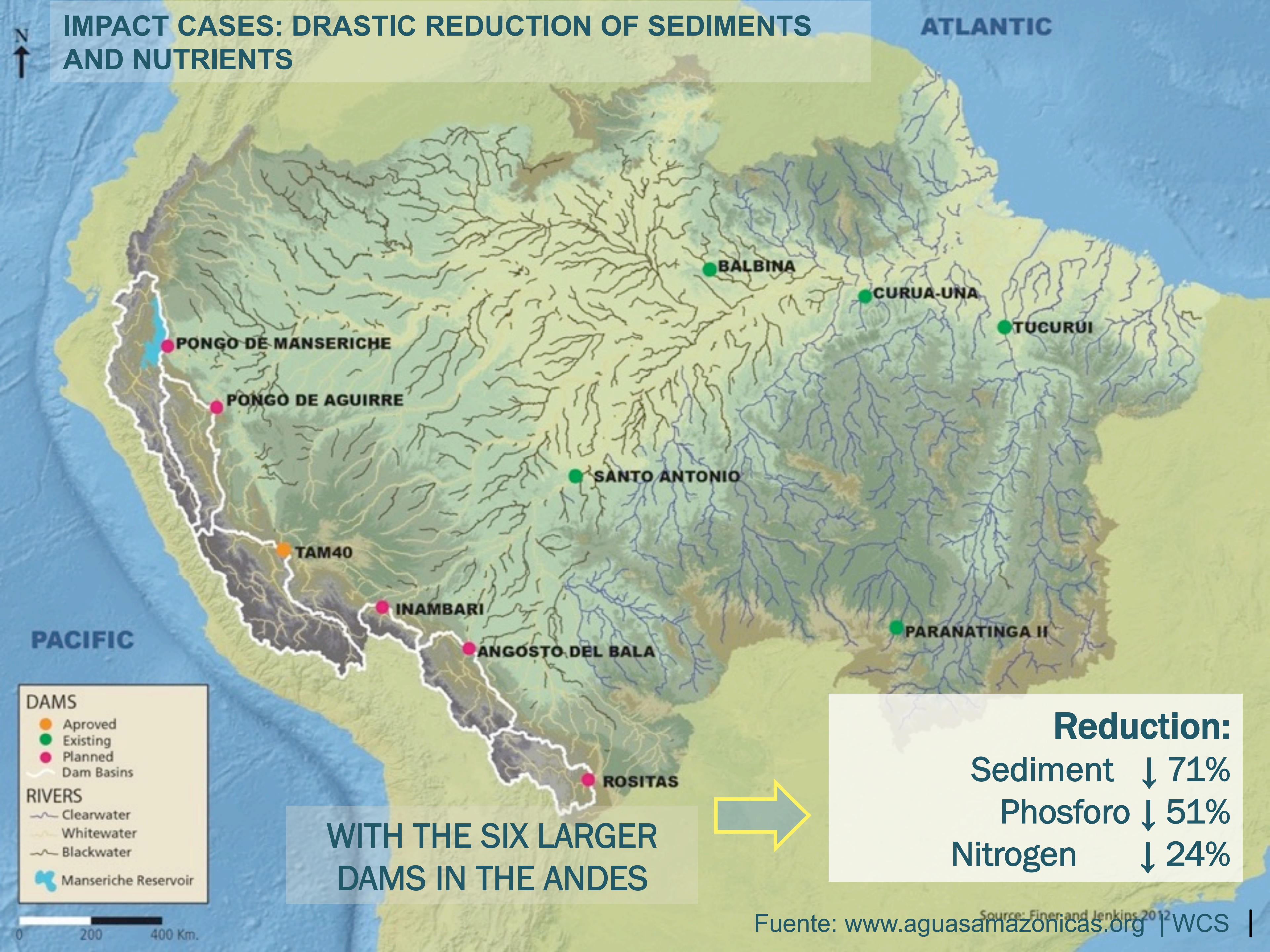
Andersson et al. 2018

Discussion



Andersson et al. 2018

IMPACT CASES: DRASTIC REDUCTION OF SEDIMENTS AND NUTRIENTS



WITH THE SIX LARGER DAMS IN THE ANDES

Reduction:

Sediment ↓ 71%

Phosforo ↓ 51%

Nitrogen ↓ 24%

Fuente: www.aguasamazonicas.org | WCS

Conclusions

It´s obvious the low representation of protected areas in the distribution of the river dolphins in South America.

The standardization of model methods (idoneidad, multiscales and simulations) gives a huge potential of the understanding tools in biogeographic aspects and the conservation that allows the construction of robust applied information, allowing fundamentals for the management and decisions takers.

The negative impacts of dams have to be analyzed from the impact on the movement of the river dolphins like a physical barrier to the migration that can be understood with the resistance models giving coefficients.

Acknowledgments

This research was conducted as part of the South America River Dolphins Conservation Programme, sponsored by the Whitley Fund for Nature, Foundation Segré, and Colciencias through the National Doctorate Scholarship 785. It is part of the strategic plan set by the South American River Dolphin Initiative, supported by WWF offices in Brazil, Colombia, Peru, Ecuador and Bolivia. Special gratitude goes to Saulo Usma, Diego Amorocho, Daphne Willems, Lila Sainz, Jorge Rivas, Jose Luis Mena, and Karina Berg from the WWF network. The authors would also like to express their gratitude to the fishing communities, and the local and national authorities who participated and gave their aid and attention to the strandings and the process of capture of river dolphins during the satellite tracking programme, aiming to study the ecology of movement in the Amazon and Orinoquia river basins.

WWF

omacha

Instituto de Desenvolvimento Sustentável Mamirauá

PRO DELPHINUS PERU

FAUNAGUA

Instituto de Desenvolvimento Sustentável Mamirauá

FAUNAGUA

Thanks for your attention