The variation in frog biodiversity along the forested landscape in Rio de Janeiro State in Brazil



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Amphibians

An animal group disapearing from the planet

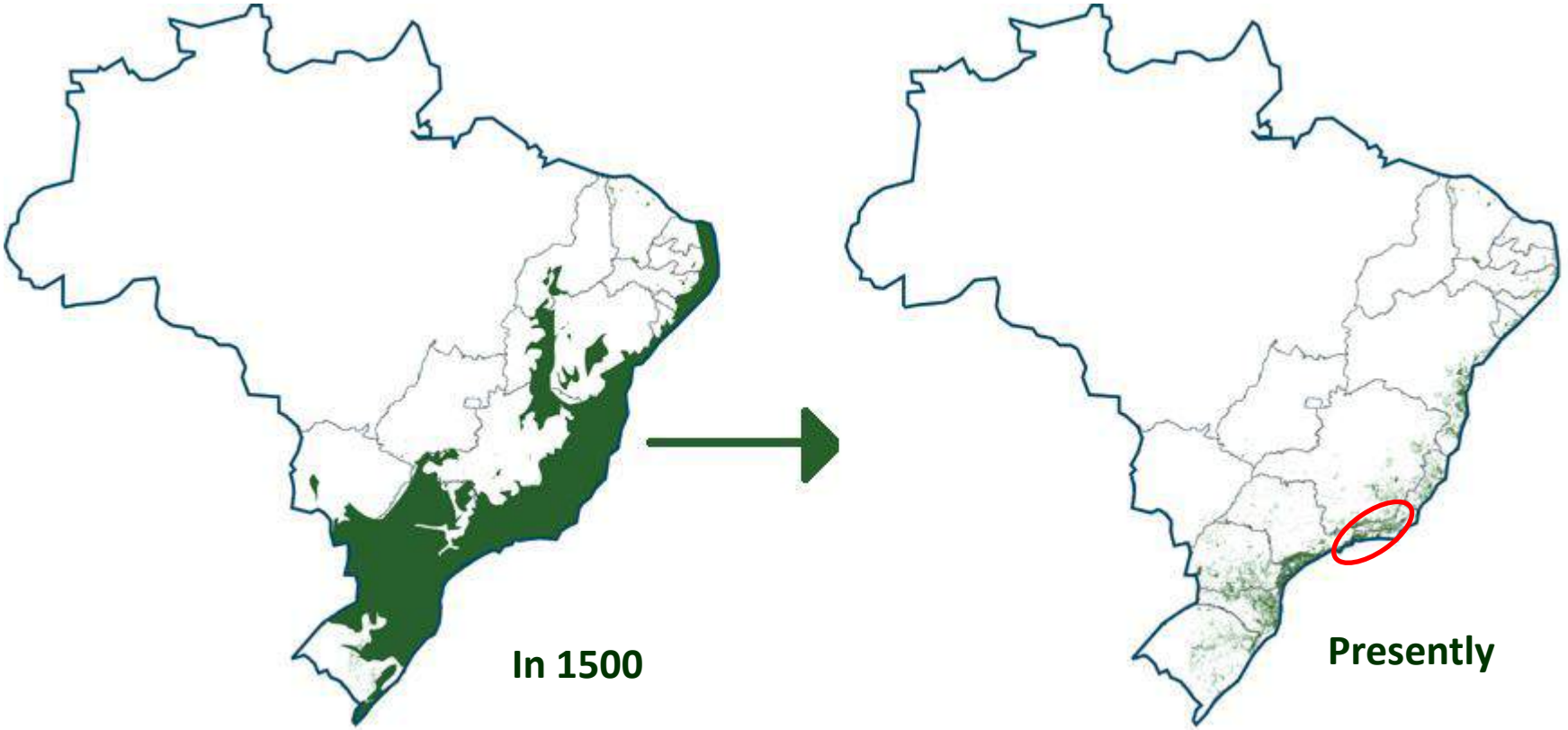
- Strongly susceptible to variations in humidity
- Life cicle involving acquatic part of life for most species
- Habitat destruction
- Chytridiomycosis
- Climatic changes





Brazilian Atlantic Rainforest:

One of the worlds' hotspots



A very species rich Biome for different animal and plant species

Community composition changes along space as habitat characteristics changes

How frog communities varies?

- Biodiversity
- Density
- Similarity

of frogs varies along the forested landscape?

Haddadus binotatus



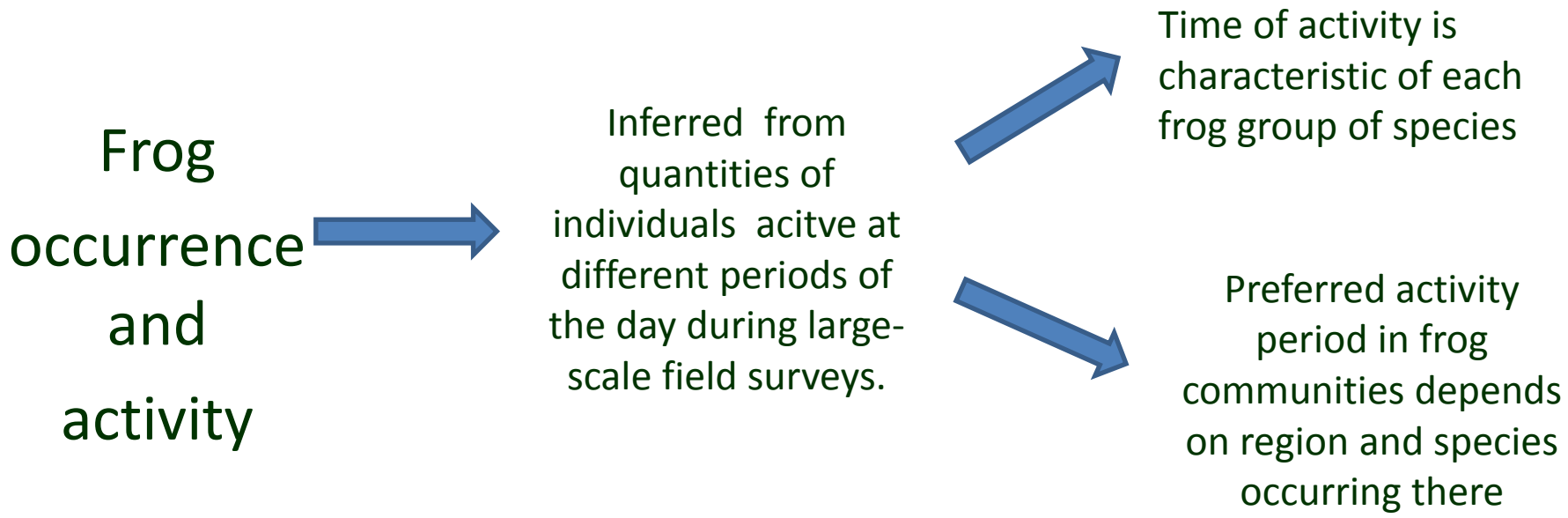
We estimated frog biodiversity based on intensive field surveys sampling frog assemblages in nine Atlantic Rainforest areas covering all regions of the state.

Also, humidity is crucial to frogs and explain frogs' occurrence and activity

Tend to restrict activity:

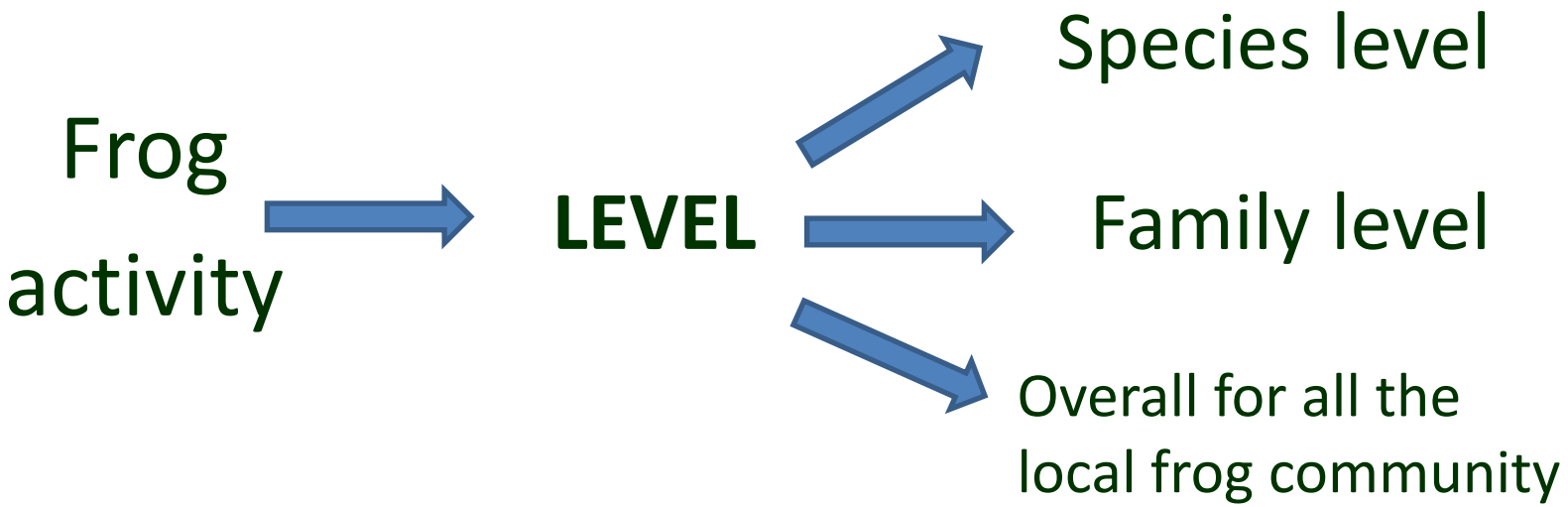
- To favorable areas
- To periods of less risk to desiccation

This resulted in frog activity being species and group specific

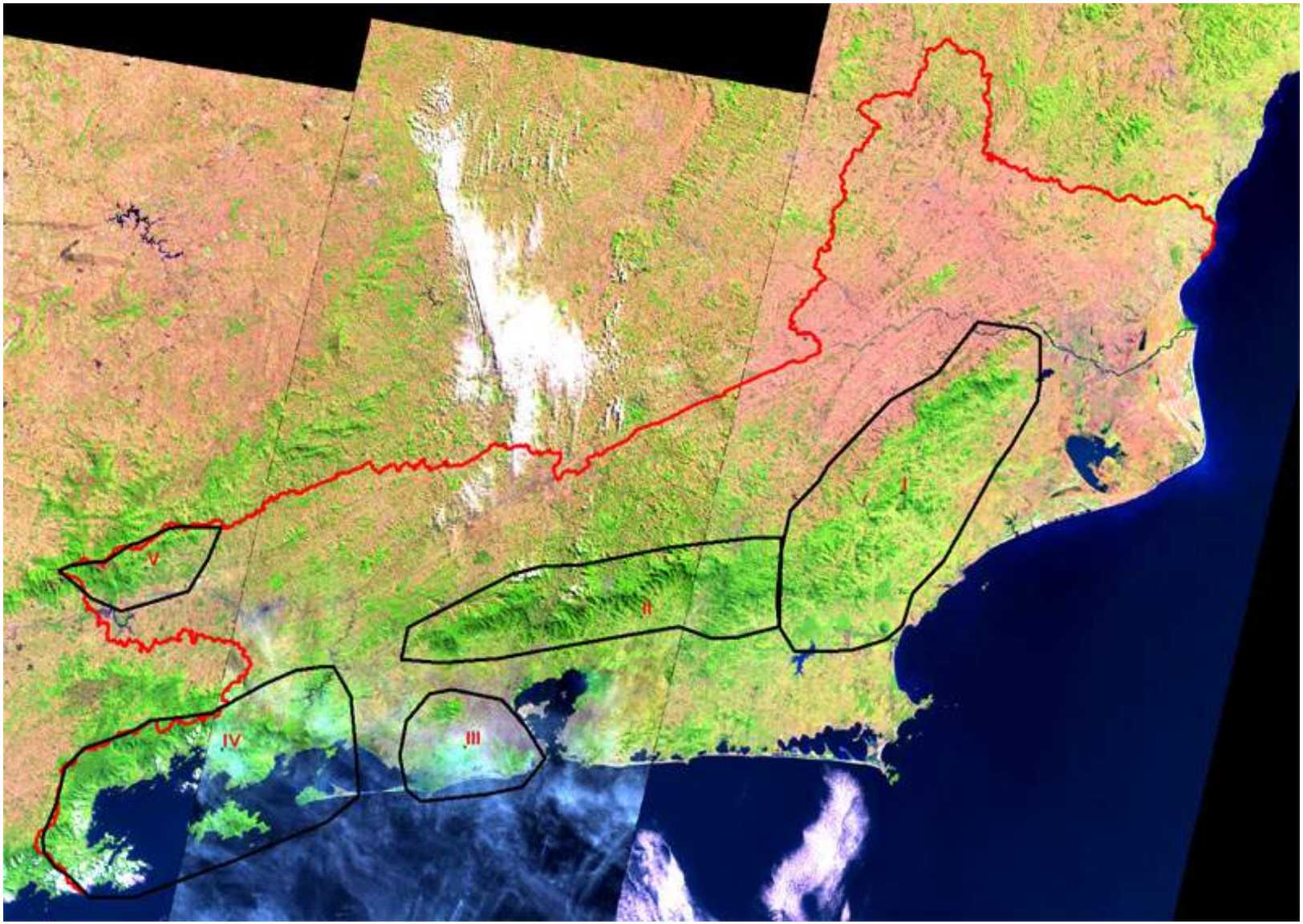


What is the most appropriate period to find, inventory and study amphibians during studies and monitoring?

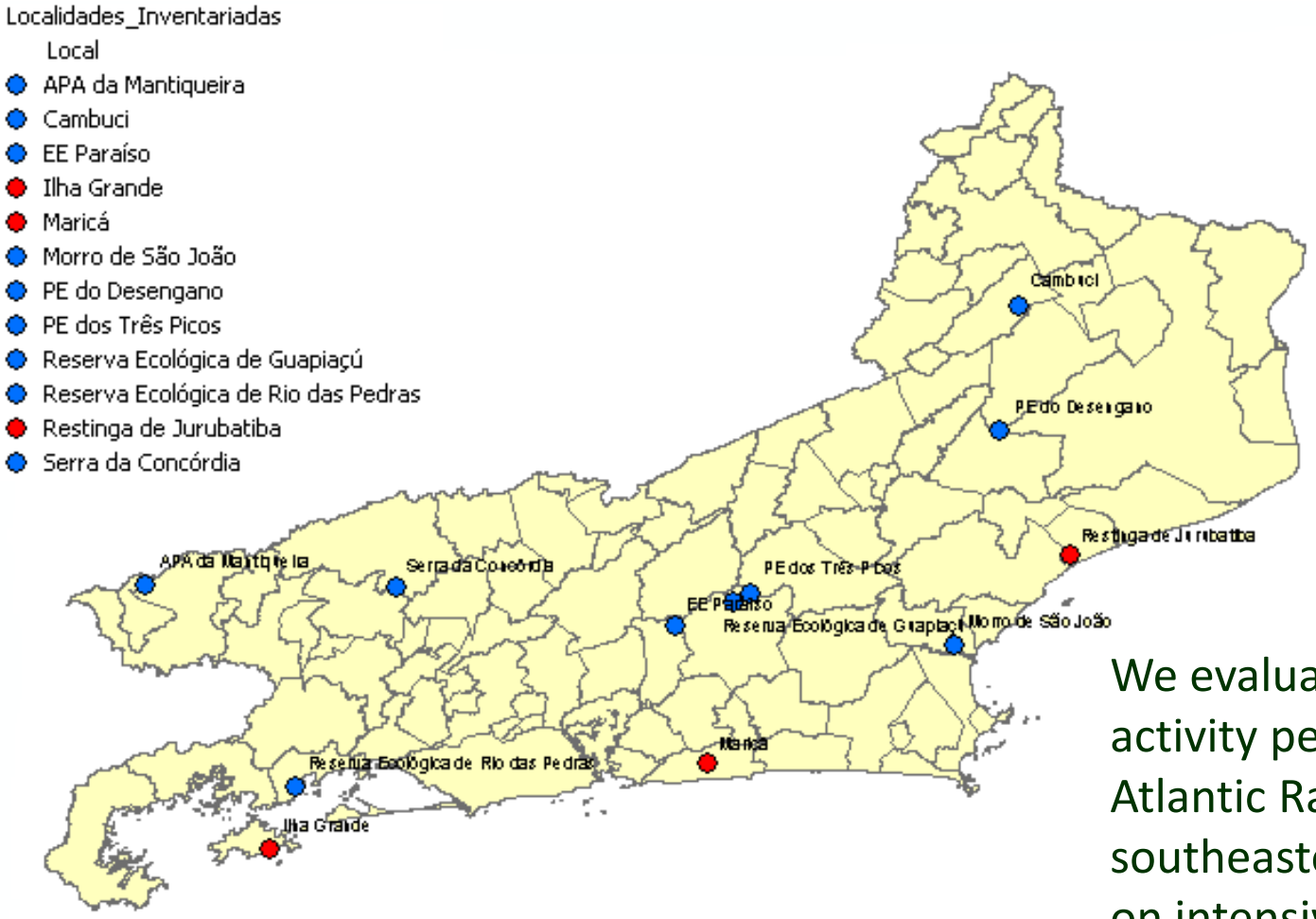
Shoud be studied at each habitat in particular to know activity



We studied frog community composition and activity in the main remnants of forests in the Atlantic Rainforest in Rio de Janeiro state in Brazil



At what period of time are Atlantic Rainforest frogs predominantly active?



We evaluated the preferred activity period in nine Atlantic Rainforest areas in southeastern Brazil, based on intensive field surveys.

Localities studied and sampling effort



Table 1. Number of 30-minutes survey bouts (total = 1409) and sampling time (total = 704.5 h) for three periods (diurnal, crepuscular and nocturnal) of searching for frogs in nine Atlantic rainforest areas of Rio de Janeiro State in Brazil. SPP = Surveys performed in the period; THSP = total of hours of searching in the period.

AREA	Coordinates	Diurnal		Crepuscular		Nocturnal	
		SPP	THSP	SPP	THSP	SPP	THSP
Estação Ecológica Paraíso	22° 26' S, 42° 56' W	89	44.5	50	25	72	36
Reserva Ecológica de Guapiaçu	22° 24' S, 42° 44' W	70	35	70	35	70	35
Serra da Concórdia	22° 22' S, 43° 47' W	40	20	40	20	40	20
Morro São João	22° 31' S, 42° 00' W	40	20	40	20	40	20
Reserva Ecológica Rio das Pedras	22° 59' S, 44° 05' W	50	25	50	25	50	25
APA da Mantiqueira	22° 21' S, 44° 35' W	50	25	50	25	50	25
Parque Estadual do Desengano	21° 52' S, 41° 54' W	48	24	50	25	50	25
Cambuci	21° 29' S, 41° 52' W	50	25	50	25	50	25
Parque Estadual dos Três Picos	22° 25' S, 42° 34' W	50	25	50	25	50	25
Total		487	243.5	450	225	472	236

Sampling of amphibian activity in nine different remnants of the Attlantic Rainforest

At each area:
About ten researchers in fieldwork













Sampling was spread along space to better estimate the general activity of Atlantic Rainforest frogs

At each locality:

we employed similar sampling effort during diurnal, crepuscular and nocturnal searches (totaling 706 sampling hours).





Ischnocnema octavioi

Different environments sampled inside the areas to reach the most wide array of species living there





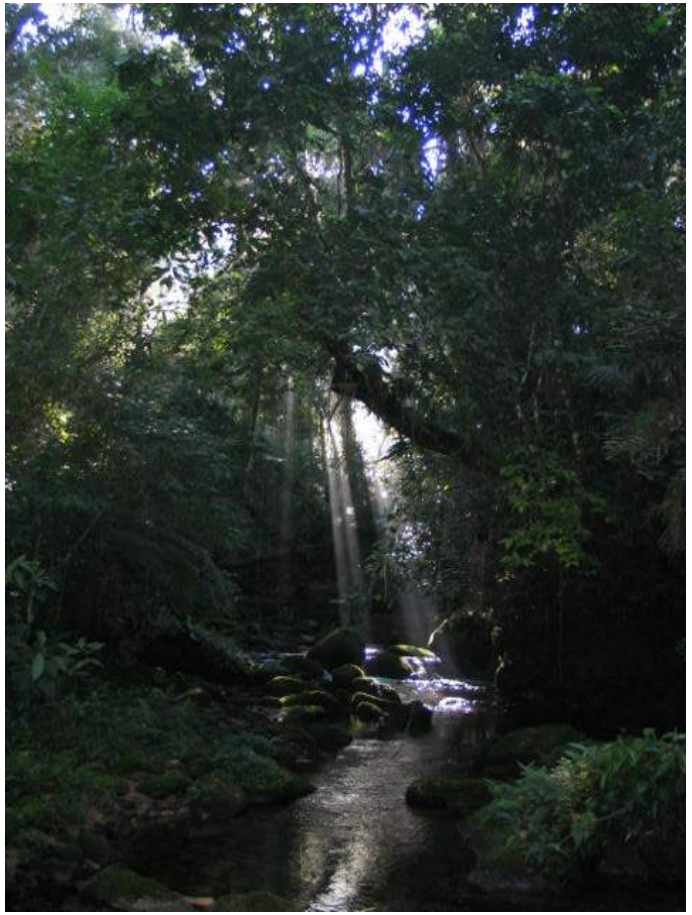
Ombrofilous forests (Selva)



Disturbed and regeneration areas (Hábitats perturbados y en áreas de regeneración)



Inselbergs



Riparian forests and streams (bosques ribereños y arroyos)

To efficiently sampling frog activity: Different methods, different periods of day

Systematic sampling at different times of day

Increases the chance of finding species with different activity periods

Sampling

Diurnal period (09:00 -1600hs)

Crepuscular period (17:30 -18:30hs)

Nocturnal period (19:00 – 22:00 hs)

Metodology



Active search limited by time:

- 150 transects of 30 minuts duration totaling 75 hours of sampling
- 50 diurnal transects, 50 crepusculars e 50 nocturnals





The lleaf-litter layer of forest ground:

An environment where complex processes recicle nutrients to new forest growth



Complex anuran community sensible to alterations in the structure and micro climate of leaf-litter



Interactions with micro, meso and macroorganisms which promote the break of the material and further remineralization in mechanic and chemichal processes.



Leaf-litter amphibians have crucial function in the top-down control on the density of preys with na important role in the regulation of nutrient dynamics in the forests

Metodology – sampling leaf-litter forest frogs

(muestreo de ranas de la hojarasca forestale)

- **Sampling:** established 30 plots of 5 x 5 m (25 m2) on forest floor which were distant at least 100 m among them



- Total of 750 m2 of forest leaf-litter floor sampled

- Researchers carefully searched for frogs inside each plot in a systematic way



- Frog Density expressed in termos of no. Ind/100m2 of forest floor= standardized for leaf litter frogs in the world

Metodology – sampling frogs using pit-fall traps

(Cubos enterrados en el suelo del bosque)



- 3 pit-fall systems opened during 11 days at each area
- Each system composed by 30 buckets of 30 litters distant 5 m apart from the next
- Totalling 90 buckets passively sampling terrestyrial frogs
- Buckets checked separately during the day and in crepuscular and nocturnal periods







Representative specimens of each species of frogs were processed in the field for reference of its occurrence in each area









Results

Frog species richness in the areas

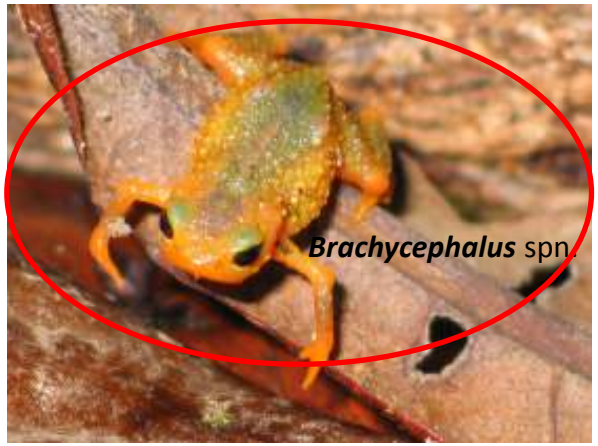
We found a total of **69 frog** species

Higher richness of frog species at dusk and night



- **Nocturnal** (median = 12, range = 6 to 19 frog species)
- **Crepuscular** (median = 8, range = 3 to 14 species)
- **Diurnal** (median = 4, range = 1 to 6

Species richness differed significantly among sampling periods (ANOVA: $F_{2,21} = 7.395$; $p < 0.005$), with differences being significant between diurnal and nocturnal periods ($p < 0.005$).


Brachycephalus spn.


Ischnocnema octavioi


Ischnocnema parva

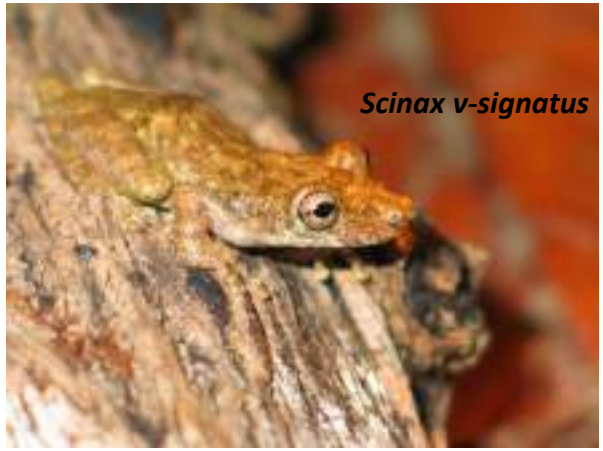

Proceratophrys melanopogon


Haddadus binotatus


Phasmahyla guttata


Rhinella icterica


Scinax flavoguttatus


Scinax v-signatus

Results – Frog abundances

817 individual frogs found in the nine areas surveyed

The abundances were species-specific and characteristic of each frog group of species



Brachycephalus spn.

Results – Frog abundances

Abundances differed at different periods of day

Higher number of individual frogs at dusk and night for most species.



- **Nocturnal** (N = 437 individuals or 53.5%)
- **Crepuscular** (N = 267 individuals or 32.7%)
- **Diurnal** (N = 113; 13.8% of individual frogs

Number of individuals per site differed significantly among sampling periods (ANOVA: $F_{2,21} = 10.982$; $p = 0.001$)

Values for the diurnal period being significantly lower than those of the crepuscular ($p < 0.01$) and nocturnal ($p = 0.001$)

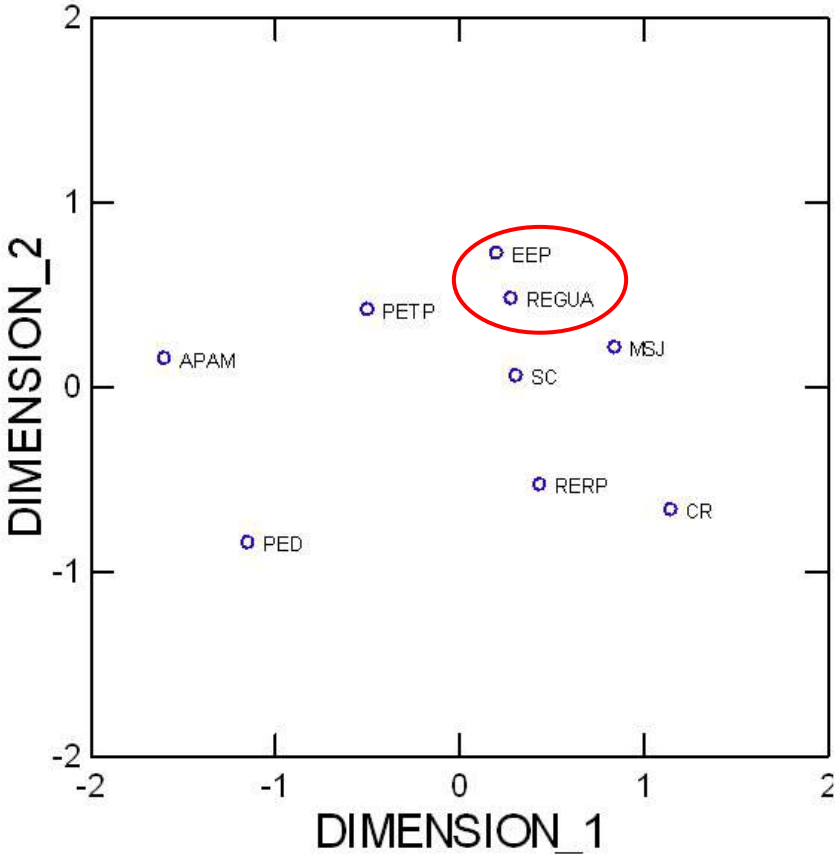
Crepuscular ($p < 0.01$) and nocturnal not differing between themselves ($p = 0.531$).

Results

NMDS analysis showed that higher similarity in frog communities was found

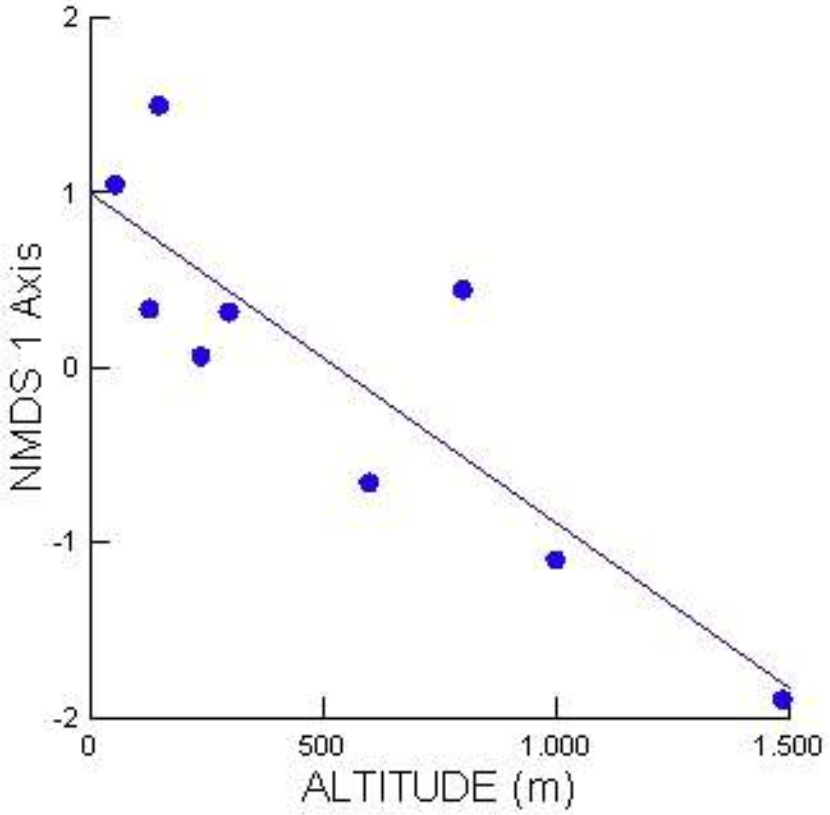
- between Reserva Rio das Pedras (RERP) and Serra Concórdia (SC)
- between EEP and Reserva Guapiaçu (REGUA).

NMDS configuration by Presence/Absence



Results

When configuration is reduced to axis 1 and related to altitudes in the areas ...



Altitude in the areas explain part of the similarities among areas

Activity along the day

The activity was species-specific and characteristic of each frog group of species



Brachycephalus spn.

The activity of Brazilian Atlantic Rainforest Frogs differs consistently among periods of day

Table 2. Richness and abundance of frogs found in three sampling periods (diurnal, crepuscular and nocturnal) in nine Atlantic rainforest areas of Rio de Janeiro State in Brazil. SR = Species richness; SRP = Species richness in the period. The column "Total" indicates the total of individuals found at each locality.

AREA	SR	Diurnal		Crepuscular		Nocturnal		Total
		Individuals (%)	SRP	Individuals (%)	SRP	Individuals (%)	SRP	
Estação Ecológica do Paraiso	21	23 (23.2)	6	24 (24.2)	10	52 (52.5)	17	99
Reserva Ecológica de Guapiaçu	20	11 (9.7)	6	48 (42.1)	11	55 (48.2)	16	114
Serra da Concórdia	13	21 (20.8)	5	45 (44.6)	8	35 (34.6)	6	101
Morro São João	13	16 (22.5)	4	21 (29.6)	7	34 (47.9)	6	71
Reserva Ecológica Rio das Pedras	14	14 (16.3)	4	25 (29.1)	8	47 (54.6)	12	86
APA da Mantiqueira	18	13 (9.8)	2	41 (30.8)	9	79 (59.4)	15	133
Parque Estadual do Desengano	9	4 (10.8)	2	21 (56.7)	4	12 (32.4)	7	37
Cambuci	20	2 (1.7)	1	13 (11.2)	3	101 (87.1)	19	116
Parque Estadual dos Três Picos	17	9 (15.0)	6	29 (48.3)	14	22 (36.7)	7	60
Total	69	113 (13.8)	23	267 (32.7)	38	437 (53.5)	57	817

About 88 % of the activity of the frogs was crepuscular-nocturnal.

Only 12% of frogs were diurnal - usually Hylodidae

At what time of day are the different frog species active in the forest?

Table 3. Sampling frequencies (in absolute numbers and percentages, in parentheses) during diurnal (D), crepuscular (C) and nocturnal (N) periods for 69 frog species sampled in nine Atlantic Rainforest areas in Rio de Janeiro State, southeastern Brazil, with inferred activity trends for each. IDI = Insufficient data (N < 4) to infer on activity of the species.

Species	D	C	N	Total	General activity trend
Brachycephalidae					
Brachycephalus ephippium (Spix, 1824)	1 (100)			1	IDI
Brachycephalus didactylus (Izecksohn, 1971)	1 (25.0)	3 (75.0)		4	Crepuscular
Brachycephalus sp.	1 (50.0)		1 (50.0)	2	IDI
Ischnocnema guentheri (Steindachner, 1864)	3 (6.5)	23 (50.0)	20 (43.5)	46	Crepuscular-nocturnal
Ischnocnema octavioi (Bokermann, 1965)		5 (71.4)	2 (28.6)	7	Crepuscular
Ischnocnema oea (Heyer, 1984)	2 (50.0)		2 (50.0)	4	IDI
Ischnocnema parva (Girard, 1853)	9 (10.5)	56 (65.1)	21 (24.4)	86	Crepuscular
Ischnocnema sp. [gr. *lactea* (Miranda-Ribeiro, 1923)]	3 (14.3)	15 (71.4)	3 (14.3)	21	Crepuscular
Ischnocnema juipoca (Sazima & Cardoso, 1978)			1 (100)	1	IDI
Bufonidae					
Dendrophryniscus brevipollicatus (Jiménez de la Espada, 1871 "1870")		1 (50.0)	1 (50.0)	2	IDI
Rhinella ornata (Spix, 1824)	3 (21.4)	3 (21.4)	8 (57.1)	14	Nocturnal
Rhinella crucifer (Wied-Neuwied, 1821)			1 (100)	1	IDI
Rhinella icterica (Spix, 1824)	2 (16.7)	4 (33.3)	6 (50.0)	12	Nocturnal
Centrolenidae					
Hyalinobatrachium uranoscopum Muller, 1924		3 (100)		3	IDI
Craugastoridae					
Euparkerella brasiliensis (Parker, 1926)	1 (3.8)	14 (53.8)	11 (42.3)	26	Crepuscular-nocturnal
Euparkerella cochranae Izecksohn, 1988		1 (100)		1	IDI
Haddadus binotatus (Spix, 1824)	8 (9.1)	34 (38.6)	46 (52.3)	88	Crepuscular-nocturnal
Cycloramphidae					
Cycloramphus brasiliensis (Steindachner, 1864)		1 (10.0)	9 (90.0)	10	Nocturnal
Odontophrynus americanus (Duméril & Bibron, 1841)			1 (100)	1	IDI
Proceratophrys boiei (Wied-Neuwied, 1825)		6 (40.0)	9 (60.0)	15	Crepuscular-nocturnal
Proceratophrys melanopogon (Miranda-Ribeiro, 1926)	10 (34.5)	14 (48.3)	5 (17.2)	29	Diurnal-crepuscular
Thoropa miliaris (Spix, 1824)	9 (19.6)	16 (34.8)	21 (45.6)	46	Crepuscular-nocturnal
Zachaenus parvulus (Girard, 1853)	1 (33.3)	1 (33.3)	1 (33.3)	3	IDI
Hemiphractidae					
Flectonotus sp.		1 (33.3)	2 (66.7)	3	IDI
Hylidae					
Aplastodiscus arildae (Cruz & Peixoto, 1987 "1985")		2 (100)		2	IDI
Aplastodiscus eugenioi (Carvalho-e-Silva & Carvalho-e-Silva, 2005)		2 (28.6)	5 (71.4)	7	Nocturnal
Aplastodiscus leucopygius (Cruz & Peixoto, 1985 "1984")			4 (100)	4	Nocturnal
Bokermannohyla circumdata (Cope, 1871)		1 (5.5)	17 (94.4)	18	Nocturnal
Bokermannohyla sp. (gr. *circumdata*)		1 (16.7)	5 (83.3)	6	Nocturnal
Dendropsophus decipiens (A. Lutz, 1925)			3 (100)	3	IDI
Dendropsophus elegans (Wied-Neuwied, 1824)			8 (100)	8	Nocturnal
Dendropsophus minutus (Peters, 1872)			25 (100)	25	Nocturnal
Hypsiboas albomarginatus (Spix, 1824)			2 (100)	2	IDI
Hypsiboas faber (Wied-Neuwied, 1821)		3 (13.6)	19 (86.4)	22	Nocturnal
Hypsiboas pardalis (Spix, 1824)			2 (100)	2	IDI
Hypsiboas polytaenius (Cope, 1870 "1869")			9 (100)	9	Nocturnal
Hypsiboas secedens (B. Lutz, 1963)			2 (100)	2	IDI
Hypsiboas semilineatus (Spix, 1824)			15 (100)	15	Nocturnal
Phasmahyla guttata (A. Lutz, 1924)			1 (100)	1	IDI
Phyllomedusa burmeisteri (Boulenger, 1882)		1 (33.3)	2 (66.7)	3	IDI
Scinax albicans (Bokermann, 1967)		2 (25.0)	6 (75.0)	8	Nocturnal
Scinax alter (B. Lutz, 1973)			1 (100)	1	IDI
Scinax angrensis B. Lutz, 1973			14 (100)	14	Nocturnal
Scinax argyreornatus (Miranda-Ribeiro, 1926)	1 (100)			1	IDI
Scinax cardosoi (Carvalho-e-Silva & Peixoto, 1991)			13 (100)	13	Nocturnal
Scinax fuscovarius (A. Lutz, 1925)	2 (10.0)		18 (90.0)	20	Nocturnal
Scinax flavoguttatus (Lutz & Lutz, 1939)		4 (33.3)	8 (66.7)	12	Nocturnal
Scinax humilis (B. Lutz, 1954)			17 (100)	17	Nocturnal
Scinax aff. *perereca* Pombal, Haddad & Kasahara, 1995			5 (100)	5	Nocturnal
Scinax cf. *perpusillus* (A. Lutz & B. Lutz, 1939)			1 (100)	1	IDI
Scinax trapicheiroi (B. Lutz, 1954)			7 (100)	7	Nocturnal
Scinax tupinamba Silva and Alves-Silva, 2008		2 (66.7)	1 (33.3)	3	IDI
Scinax x-signatus (B. Lutz, 1968)		8 (88.9)	1 (11.1)	9	Crepuscular
Scinax aff. *x-signatus* (Spix, 1824)			6 (100)	6	Nocturnal
Hylodidae					
Crossodactylus aeneus Muller, 1924	17 (63.0)	5 (18.5)	5 (18.5)	27	Diurnal
Crossodactylus gaudichaudii (Duméril & Bibron, 1841)	7 (70.0)	2 (20.0)	1 (10.0)	10	Diurnal
Crossodactylus sp.			2 (100)	2	IDI
Hylodes pipilans (Canedo & Pombal, 2007)	3 (75.0)	1 (25.0)		4	Diurnal
Hylodes phyllodes Heyer & Cocroft, 1986	18 (85.7)	2 (9.5)	1 (4.8)	21	Diurnal
Hylodes charadranaetes Heyer & Cocroft, 1986	5 (100)			5	Diurnal
Megaelosia goeldii (Baumann, 1912)		1 (100)		1	IDI
Leptodactylidae					
Adenomera marmorata Steindachner, 1867	1 (2.4)	20 (48.8)	20 (48.8)	41	Crepuscular-nocturnal
Leptodactylus latrans (Linnaeus, 1758)		1 (7.1)	13 (92.9)	14	Nocturnal
Leptodactylus mystacinus (Burmeister, 1861)		1 (100)		1	IDI
Leptodactylus spixii Heyer, 1983			1 (100)	1	IDI

Analyzing each species separately

Higher number of individuals at dusk and night for most species.



15 species (21.7%) during both the crepuscular and nocturnal surveys

24 species (34.8%) were found only at night

15 (21.7%) were found during all three periods

Comparing to other areas

- **Our study - The crepuscular together with the nocturnal periods - about 88% of the individuals recorded.**

- Rocha et al. (2000) in Atlantic forest area - 71% (nine species) during nocturnal sampling

- Menin et al. (2008) in Central Amazonia (total of 30 species recorded) - 73% (25 species) at night.

- Summers (2002) similar values in a Panamanian forest (77 %)

Families and activity

- Hylids were predominantly nocturnal
- Terrestrial direct-developers [comprising the Terrarana *sensu* Hedges et al. (2008) and represented here by the families Brachycephalidae and Craugastoridae] tend to have crepuscular-nocturnal activity.
- Nocturnal or crepuscular-nocturnal activity for the Leptodactylidae, Bufonidae and Cycloramphidae
- Only species of the family Hylodidae can be considered as diurnal in our study.

Family Hylodidae

Genus *Hylodes* and *Crossodactylus*

All species exclusively diurnal

Life essencially restrict to streams and rivulets inside forests



Hylodes phyllodes

Hylodes fredi



Constitute species particularlly vulnerable to extinction



Hylodes nasus

Real Area of ocupation (AO) too much smaller than supposed

Present method of threaten risk evaluation (IUCN) is still generalized to all species

Overestimate the real Area of ocupation (AO) of these species restrict to streamswhich is too much smaller!



Crossodactylus gaudichaudii

Conservation of amphibians

The importance of considering the efetcive Ocupation Area (AO) for species of life restricted to streams and rivulets as the area of the hidric system

Conservation Biology

Diversity

Underestimation of Extinction Threat to Stream-Dwelling Amphibians due to Lack of Consideration of Narrow Area of Occupancy

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Introduction

Researchers worldwide have reported several amphibian species declines in the last 30 years, most of them in Latin America (e.g., García-Rodríguez et al. 2012) and Australia (e.g., Hero et al. 2005). The 2 main threats responsible for these declines are habitat loss and the fungus *Batrachochytrium dendrobatidis* (Bd) (Alford & Richards 1999). The physical separation between terrestrial and breeding habitats (i.e., habitat split) may be the primary factor promoting extirpations in fragmented landscapes of amphibian forest species that have an aquatic larval phase (Becker et al. 2007). Additionally, several amphibian species have declined even in well-preserved forest areas, possibly because of action of Bd (Rhusstein & Wake 1998; Lips et al. 2008). Because species associated with streams seem to be more susceptible to Bd infection (Lips 1998), the joint action of habitat split and Bd may explain why most amphibian declines have occurred in forest species with aquatic larvae (Lips et al. 2004; Hero et al. 2005).

Atlantic Forest Stream-Dwelling Amphibians

The Atlantic Forest of Brazil is still a center of great diversity and endemism for amphibian species (Becker et al. Stream-dwelling amphibians (SDAs) in the Atlantic Forest are closely associated with flowing water in forested areas during their entire life cycle (Almeida-Gomes et al. 2007; Haddad et al. 2008) and include all species of the genera *Crossodactylus*, *Hylodes*, *Megaelosia*, and most species of *Cycloramphus* (Haddad et al. 2008). These species tend to be more affected by the loss of riparian forest because all their life stages (eggs, tadpoles, and adults) are strictly associated with small areas of a specific type. Given the situation of the Atlantic Forest and habitat requirements of SDAs, it is reasonable to expect that some of them would be classified as threatened. Surprisingly, none of the 55 SDAs endemic to this biome (Frost 2013) are listed as threatened on red lists of either the International Union for Conservation of Nature (IUCN) or Brazil (Morais et al. 2012). Of the 55 SDAs evaluated by IUCN, 35 (66.0%) are listed as data deficient (DD), 15 (28.3%) as least concern (LC), and 3 (5.7%) as near threatened (NT) (IUCN 2012) (Supporting Information). We argue that SDAs may be highly vulnerable to extinction and require reassessment of their conservation status through a new approach for estimating area of occupancy (AOO).

Key Factor of AOO

Most SDAs have very small geographic distributions, and

Table 1. EOO, AOO, percentage of AOO relative to EOO, and current and proposed IUCN status of 2 endemic stream-dwelling amphibian species endemic to state of Rio de Janeiro in Brazil.

Anura: Hylodidae	*EOO (km²)*	*AOO -R1/R2/R3[a] (km²)*	*AOO/EOO (R1/R2/R3)[a] (%)*	*C/P IUCN status[b]*	*IUCN criteria[c]*
H. charadranaetes	5209.21	53.80/108.24/182.05	1.0/2.1/3.5	DD/EN	EN B2ab(iii)
H. pipilans	4151.91	37.76/75.78/127.07	0.9/1.8/3.1	DD/EN	EN B1ab(iii)+2ab(iii)

[a]Abbreviations: R1, R2, and R3 are the widths of riparian zones of 15, 30, and 50 m, respectively, used to estimate the AOO.
[b]Abbreviations: C, current IUCN status; P, proposed IUCN status; DD, data deficient; EN, endangered.
[c]Criterion b(iii) based on approximately 14% forest loss recorded in the state of the Rio de Janeiro between 1990 and 2005.

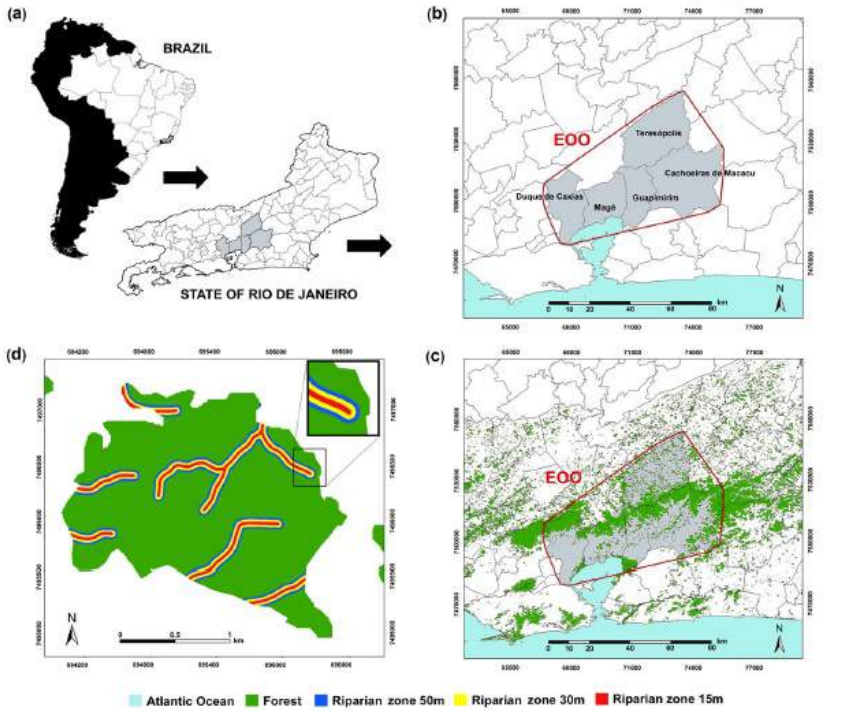
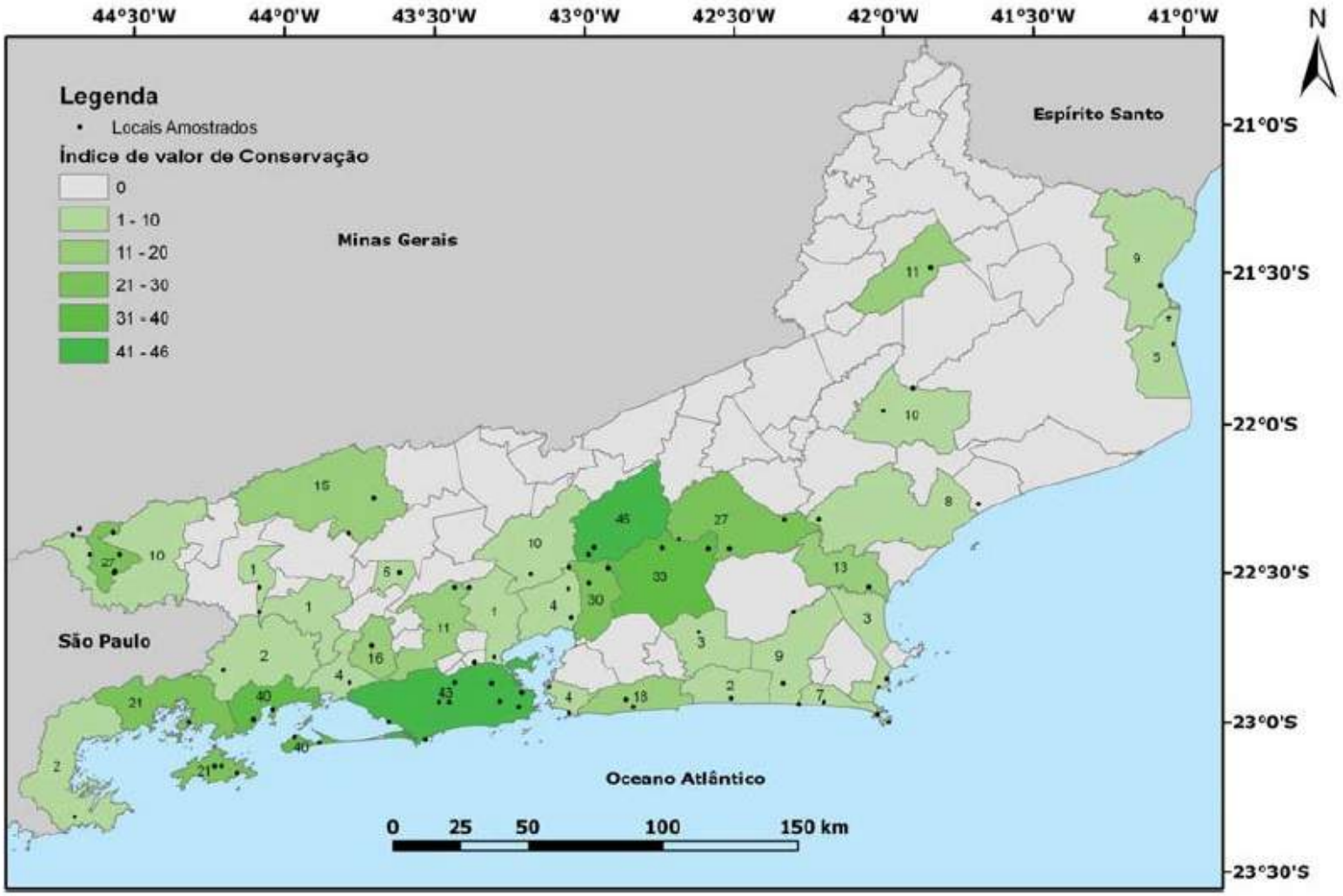


Figure 1. (a) Range of H. pipilans *in the state of Rio de Janeiro, (b) EOO polygon, (c) forested area within EOO polygon, and (d) enlarged area in a forest fragment showing the riparian zones (15, 30, and 50 m out from the edge of rivers and streams) used to estimate AOO.*

Almeida Gomes, Rocha and Vieira , 2014 , Conservation Biology 28 (2) : 616-619

Anurans of Atlantic Rainforets

Where are endemics and threatened species?



Regions of Rio de Janeiro State with concentration of endemic and threatened frog

General conclusions

- Our study evidences a trend for a conspicuous change in biodiversity of frogs along the forested landscape in Rio de Janeiro

- most of such change may be explained based on geographic distance among areas possibly reflecting also structural and altitudinal differences among areas.

General conclusions

Our results indicated the need of conservation efforts on amphibian species, especially:

- To those frog-rich areas of the state.
- Those with life restrict to streams in the forest



DECOL













Thanks!

Gracias!







All students from the Laboratório de Ecologia de Vertebrados