Spatial analysis of enforcement for reducing deforestation in Brazilian Amazon

an exploratory study in Pará state

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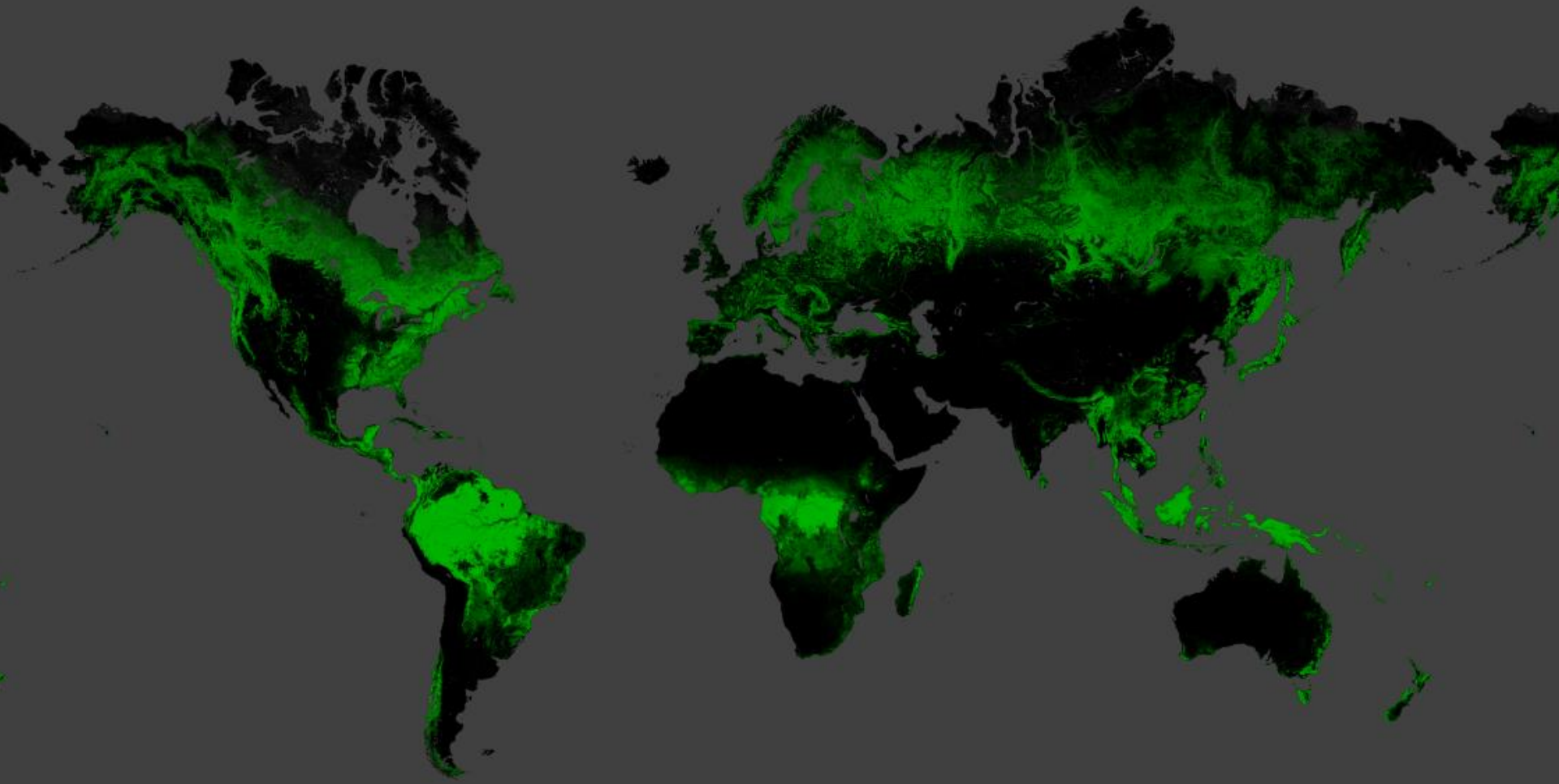
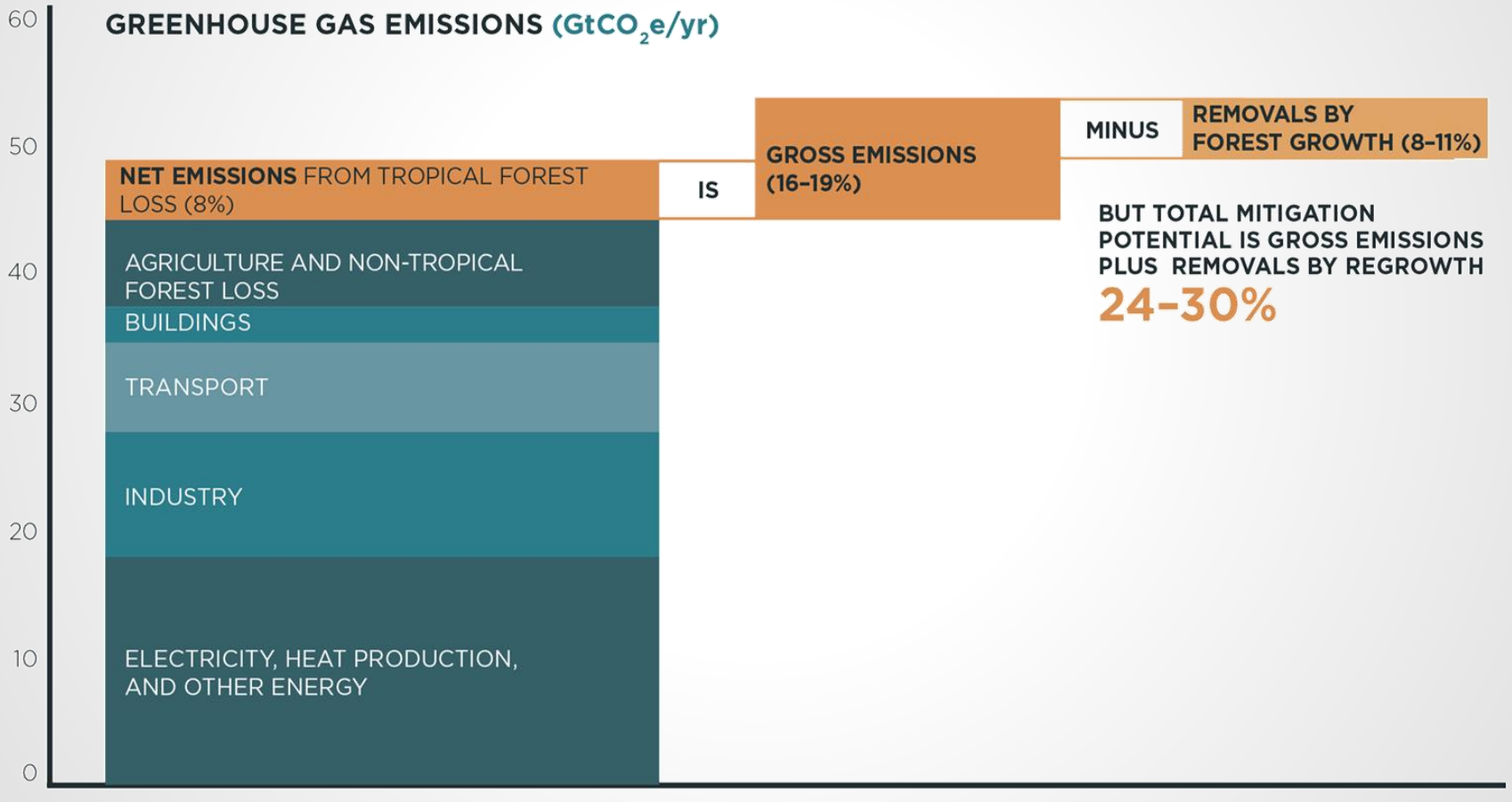
BEERS, Bergen
May 2017

Introduction



INTRODUCTION



Source: Pan *et al.*, (2009); Baccini *et al.*, (2012), IPCC WGIII

Center for Global Development


5.3
mi km²


40%
of global forests

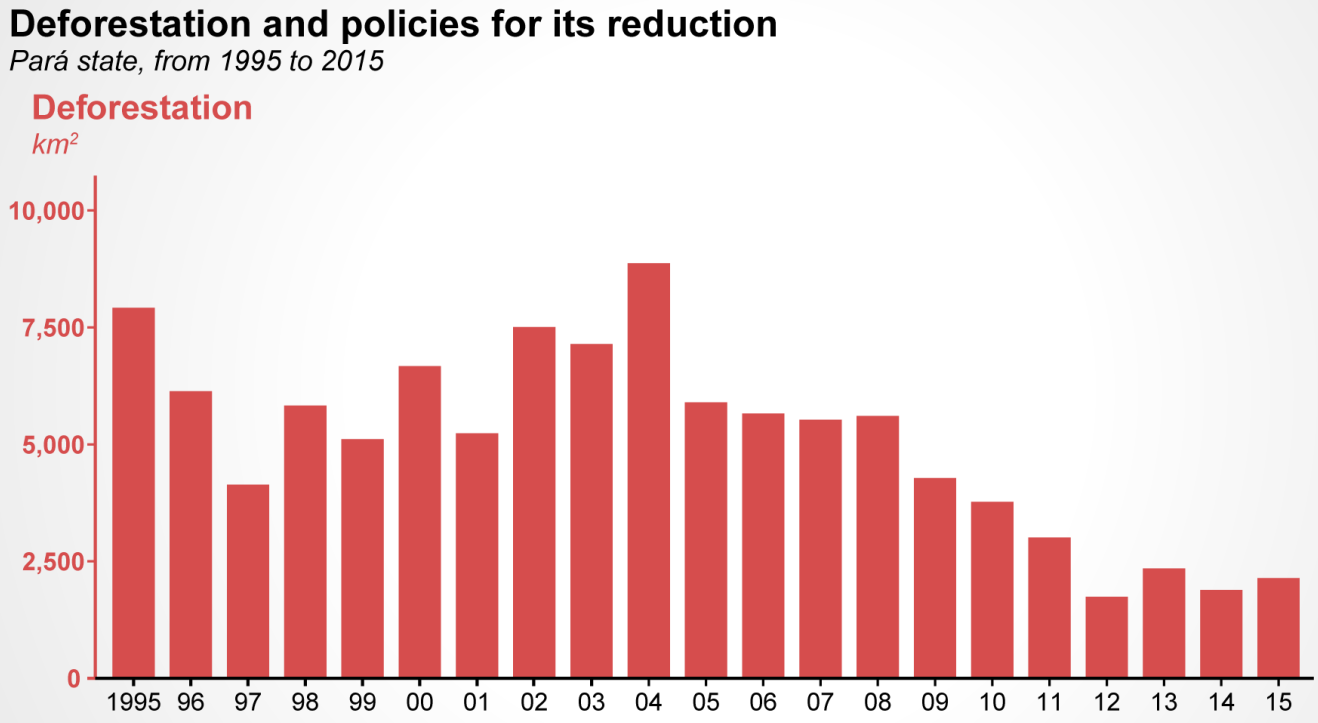
Introduction

Income

Food

Health

INTRODUCTION



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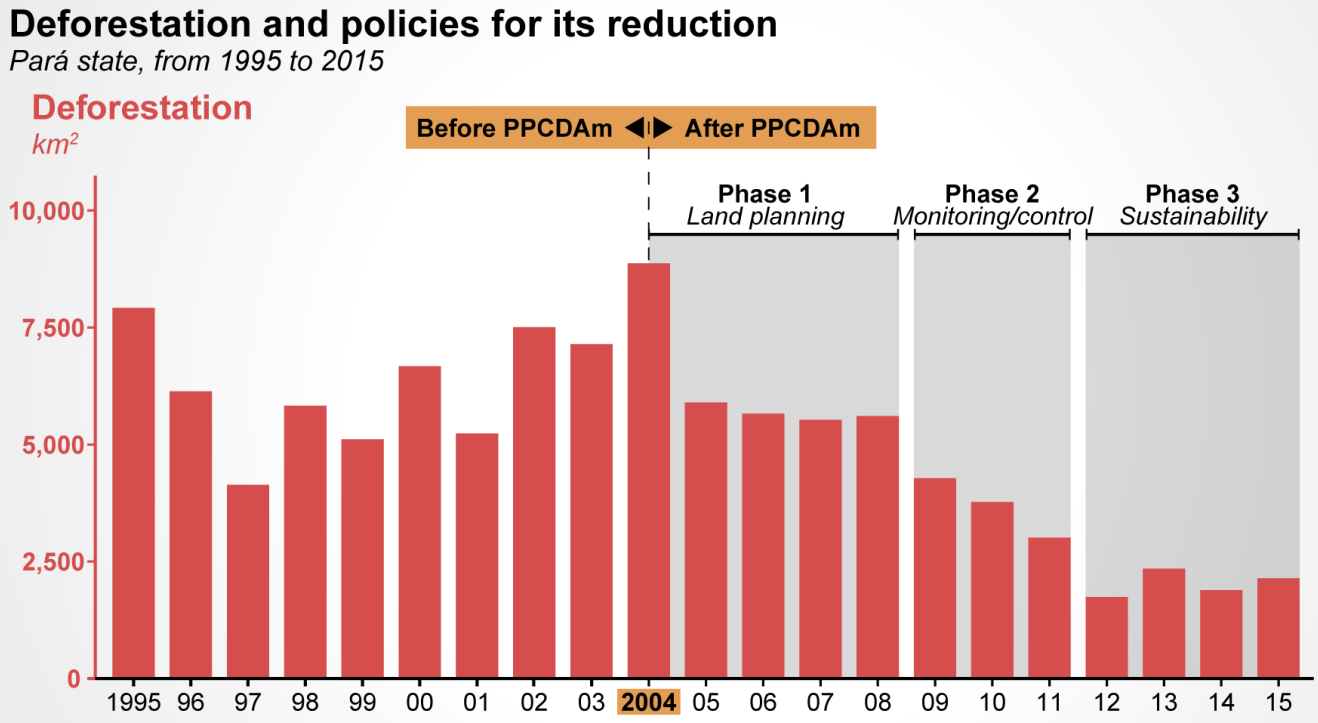

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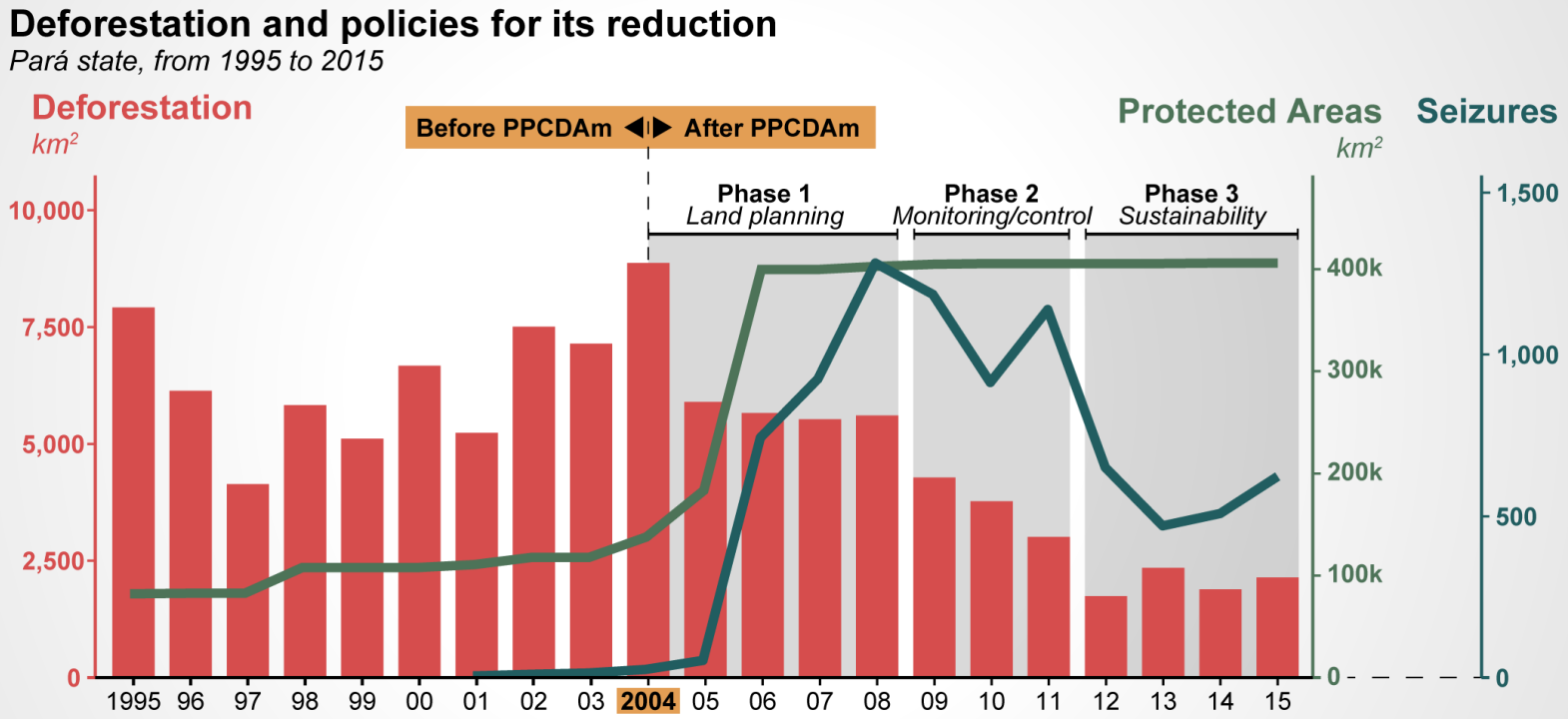

Sources: National Institute for Space Research, INPE (2016);
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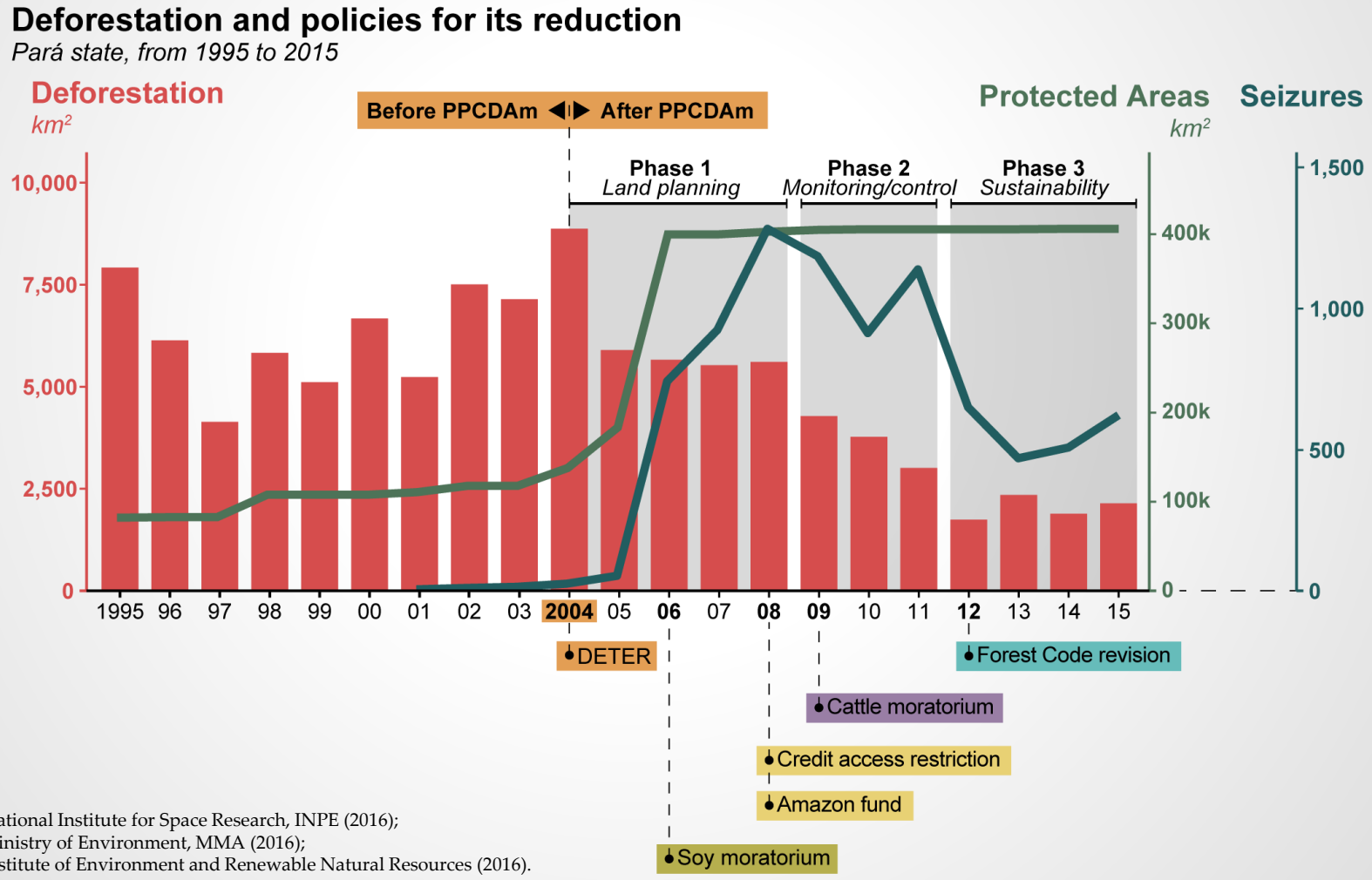

Sources: National Institute for Space Research, INPE (2016);
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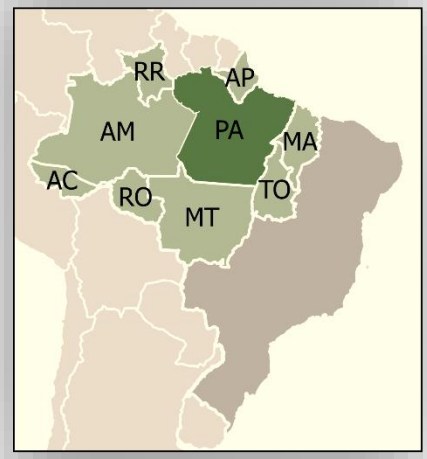
QUESTIONS

1. Do the long-term dynamics of **law enforcement** spatially match the **deforestation hot spots**?
2. Are law enforcement actions driven by the presence of Protected Areas (APs)?

OBJECTIVES

To develop an exploratory analysis of the **space-time patterns** of **seizures related to deforestation** from **2004 to 2015** for the **state of Pará**.

Study area



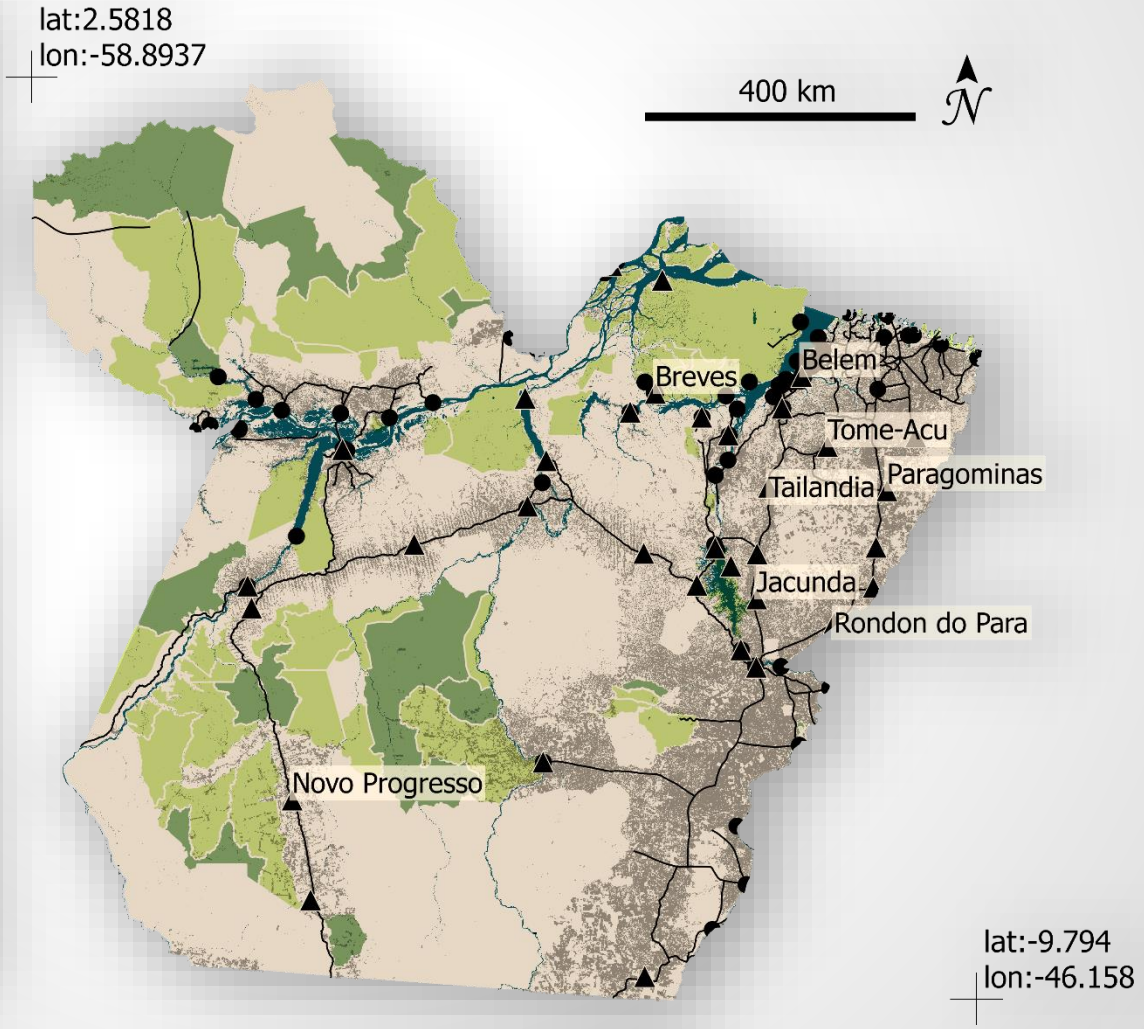
Legend

- Logging locations
- Ports
- Roads
- Water
- Deforestation

Protected Areas

- Strictly Protected
- Sustainable Use

GCS: SIRGAS 2000



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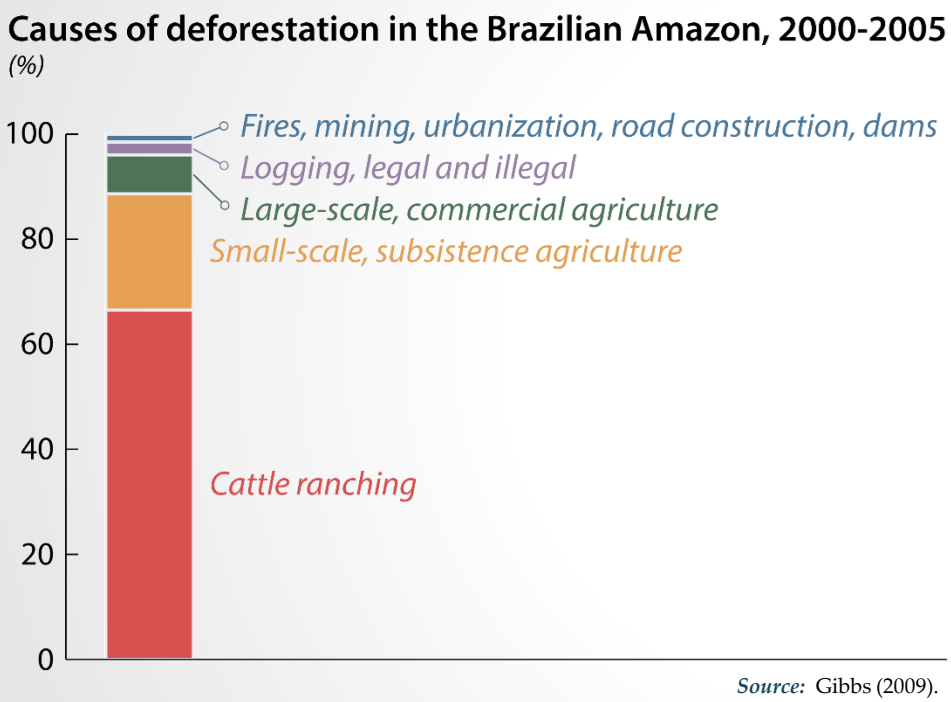


Source: Gibbs (2009).

Methodology

Data

Seizures

Brazilian Institute of Environment and Renewable Natural Resources

- Selection seizures related to illegal deforestation – wood, tools and transportation
- n = 8,523 seizures > but only 1,520 with consistent spatial information

Period

2004 ⟶ 2015

Methodology

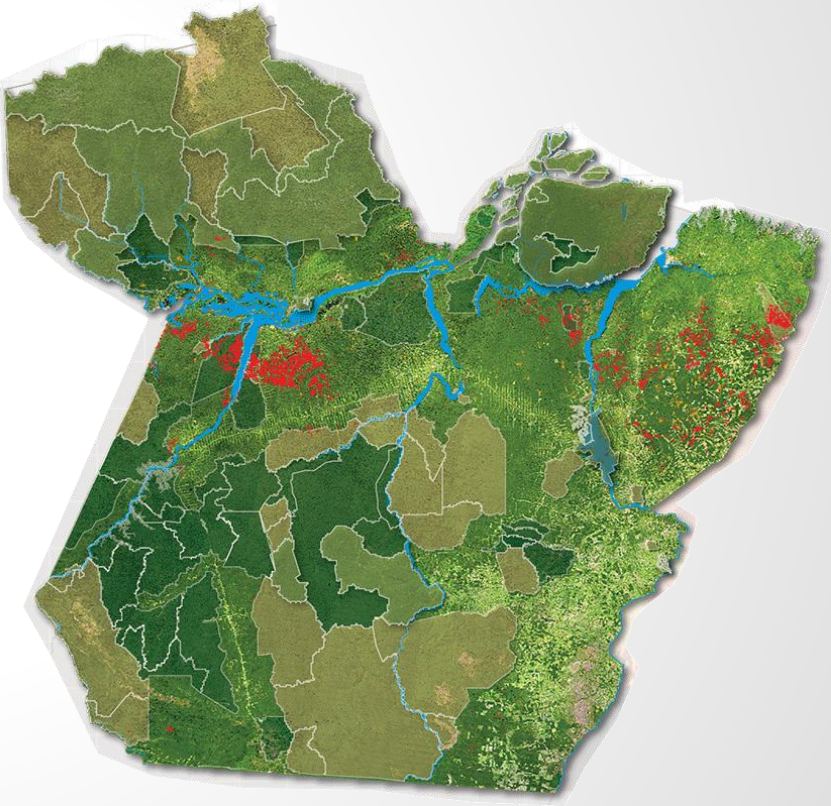
Data

Deforestation

National Institute for Space Research

- Near Real Time Deforestation Detection project (**DETER**)
- Spatial resolution of **250 m**;
- Related to forest **clear-cutting**, forest degradation – preparatory to deforestation –, fire scars and logging

Deter



Source: INPE (2015)

Period

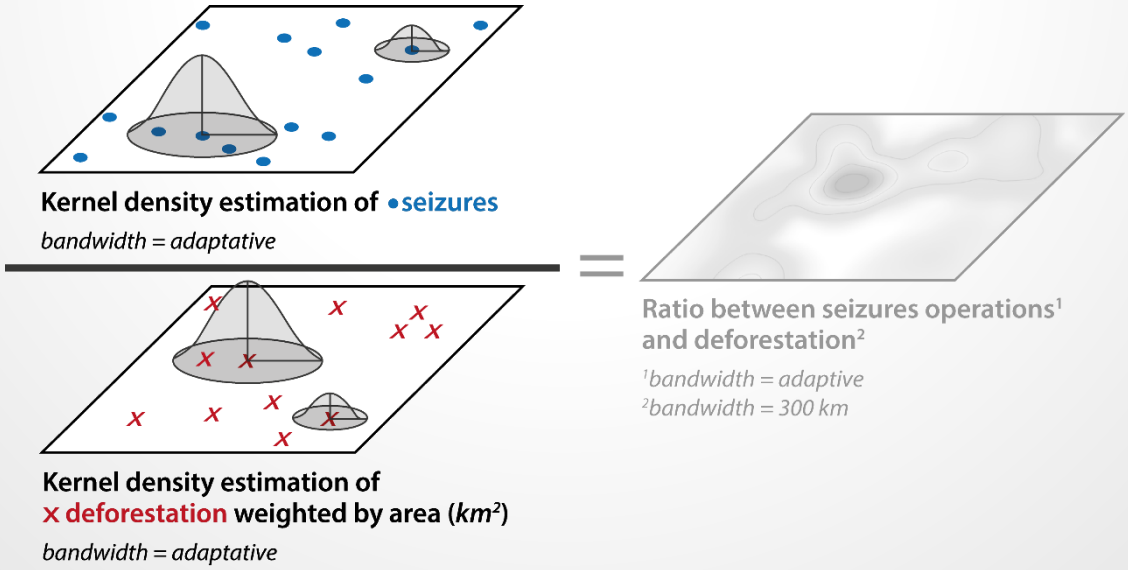
2004 ⟶ 2015

METHODOLOGY

1. KERNEL DENSITY ESTIMATION

$$\hat{f}(x,y) = \frac{1}{nh^2}\sum_{i=1}^{n} K\left(\frac{d_{i,(x,y)}}{h}\right)$$

- $\hat{f}(x,y)$ = density
- n = total number of event points
- h = bandwidth
- $d_{i,(x,y)}$ = distance between event point i and location (x,y)
- K = density function (quartic)



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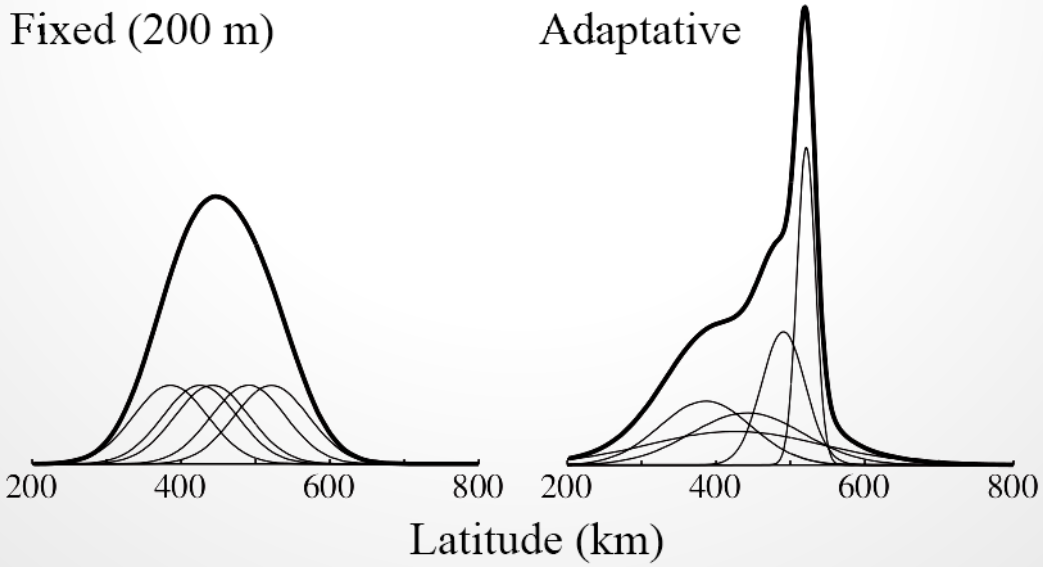


METHODOLOGY

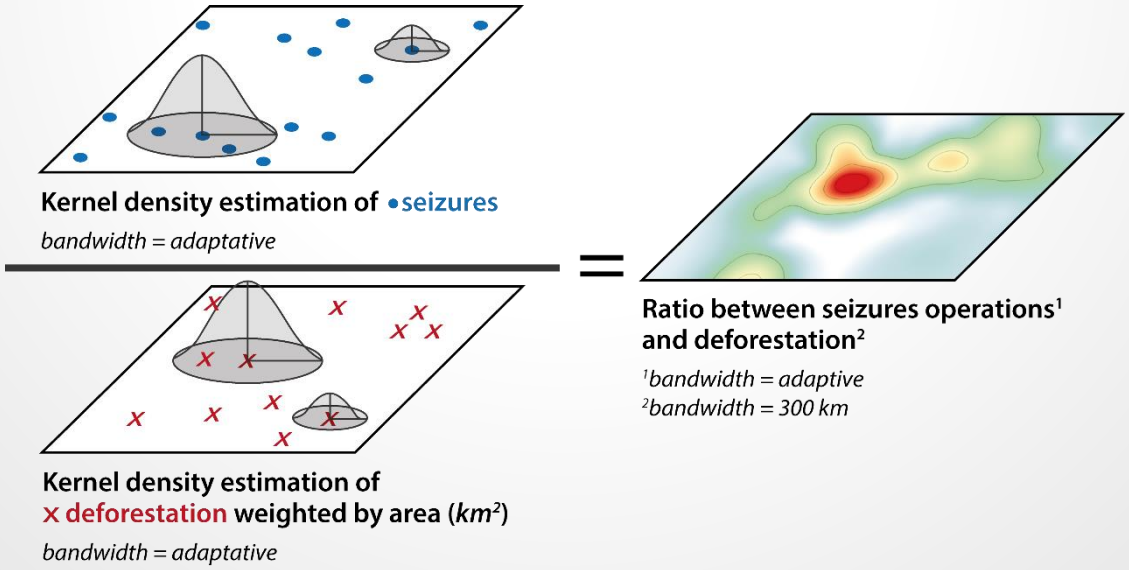
1. KERNEL DENSITY ESTIMATION

$$\hat{r}(x,y) = \frac{c}{p}$$

$\hat{r}(x,y)$ = indication of the enforcement risk
c = density of **seizures**
p = density of **deforestation**

- We "over-smoothed" the density of the deforestation

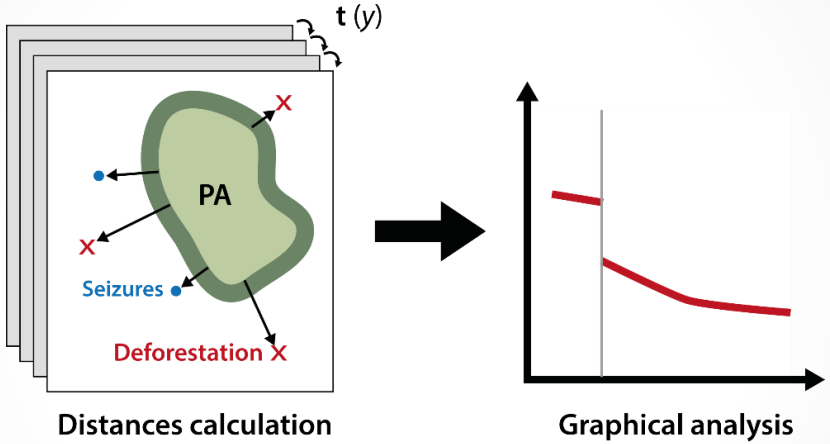
Gatrell et al. (1996)



METHODOLOGY

2. DISTANCES ANALYSIS

- Analysis of the spatial patterns of law enforcement with the presence of Protected Areas



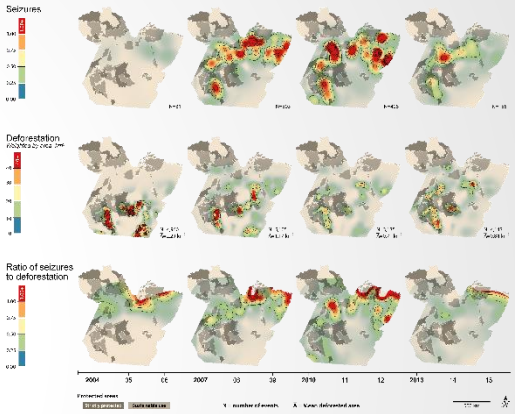
- Different institutional arrangements { jurisdiction: **federal** or **state**; management group: **SP** or **SU**

- $\hat{e}(d,j,g) = \dfrac{seizures_{d,j,g}}{deforestation_{d,j,g}}$ { $\hat{e}(d,j,g)$ = density; d = distance to protected area; h = jurisdiction; g = group

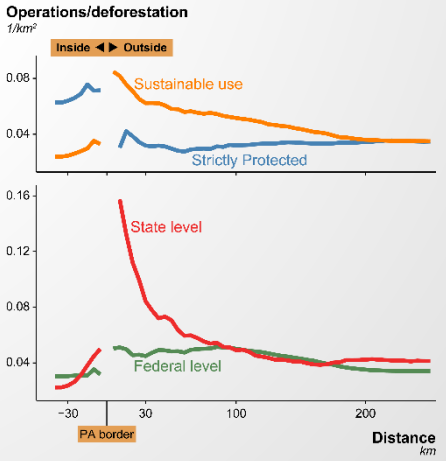
Results

1. Kernel density estimation maps:

exploratory spatial analysis of seizures



2. Relating law enforcement with the presence of PAs



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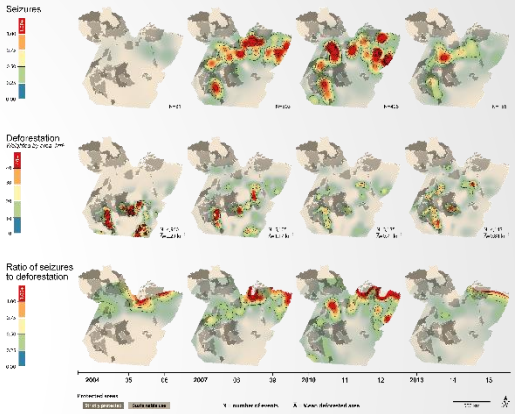

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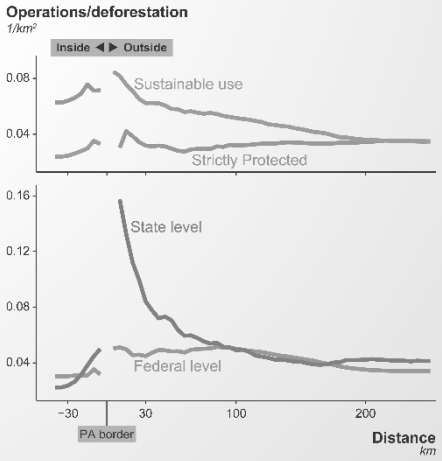

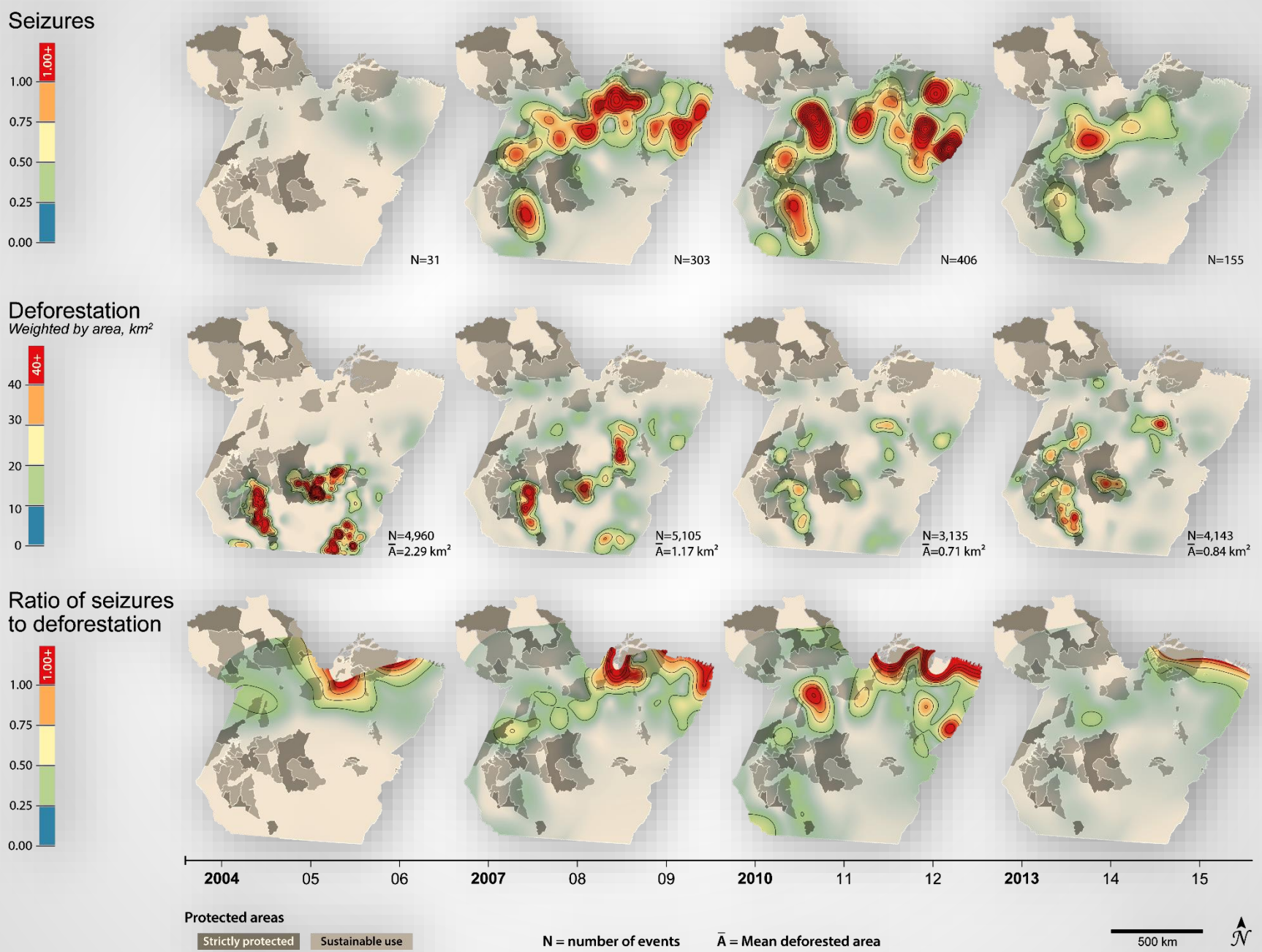
Seizures
1.00+
1.00
0.75
0.50
0.25
0.00
N=31
N=303
N=406
N=155
Deforestation
Weighted by area, km²
40+
40
30
20
10
0
N=4,960
Ā=2.29 km²
N=5,105
Ā=1.17 km²
N=3,135
Ā=0.71 km²
N=4,143
Ā=0.84 km²
Ratio of seizures to deforestation
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2004
05
06
2007
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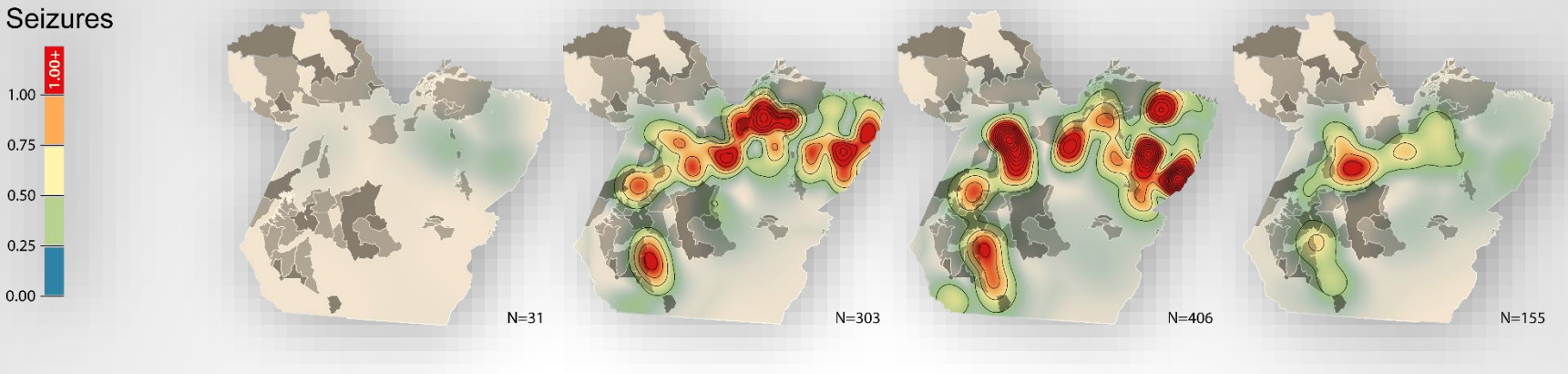
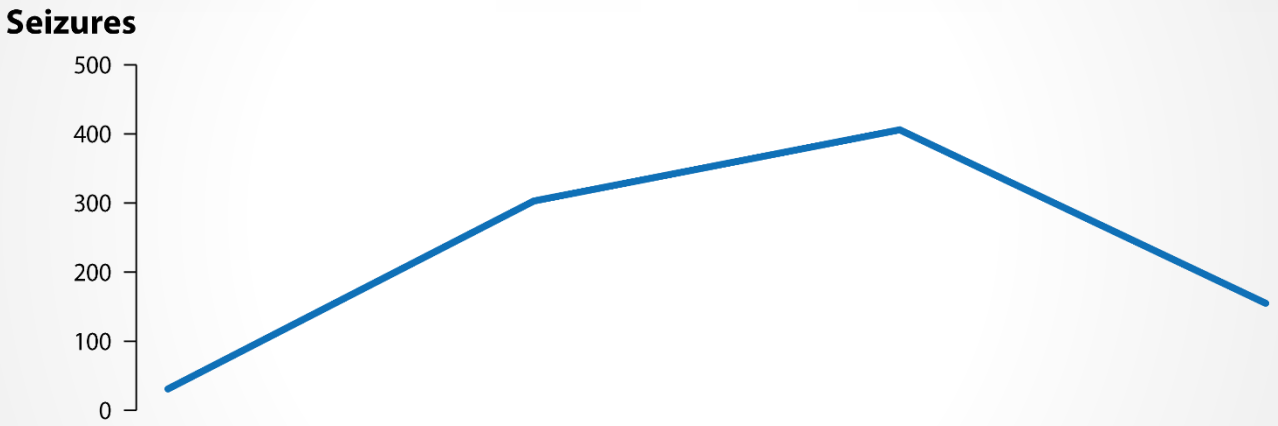
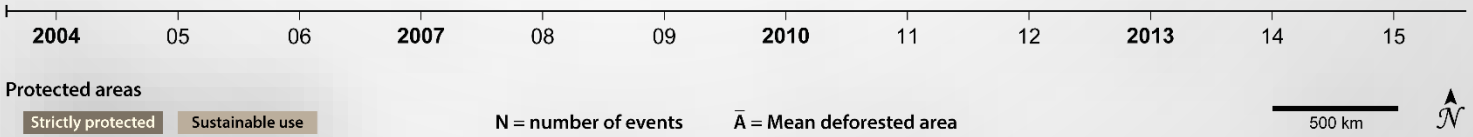
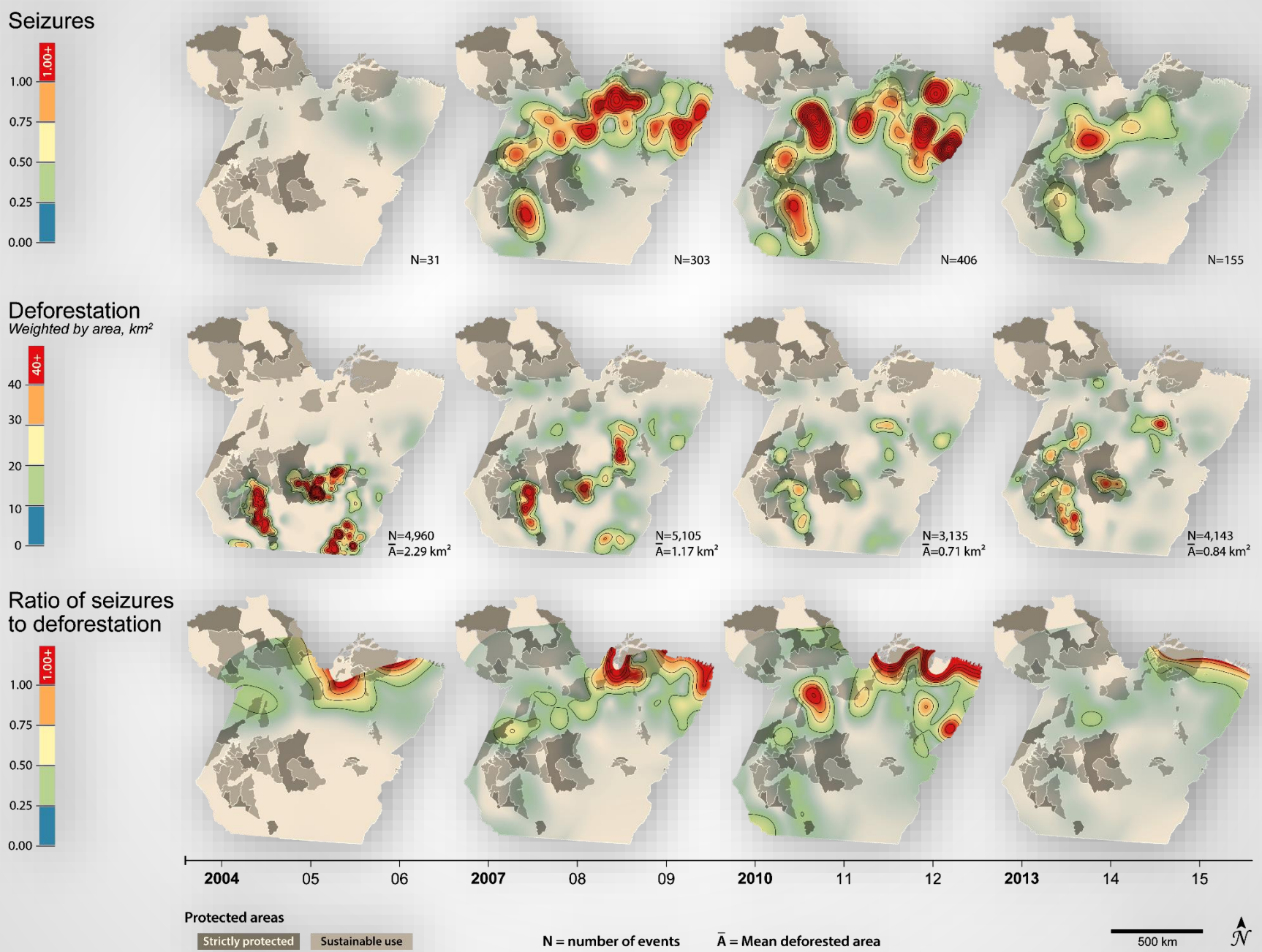
Protected areas
Strictly protected
Sustainable use
N = number of events
Ā = Mean deforested area
500 km
N





- Growth trend and then a slow down
- Evidences that accessibility can be a key factor

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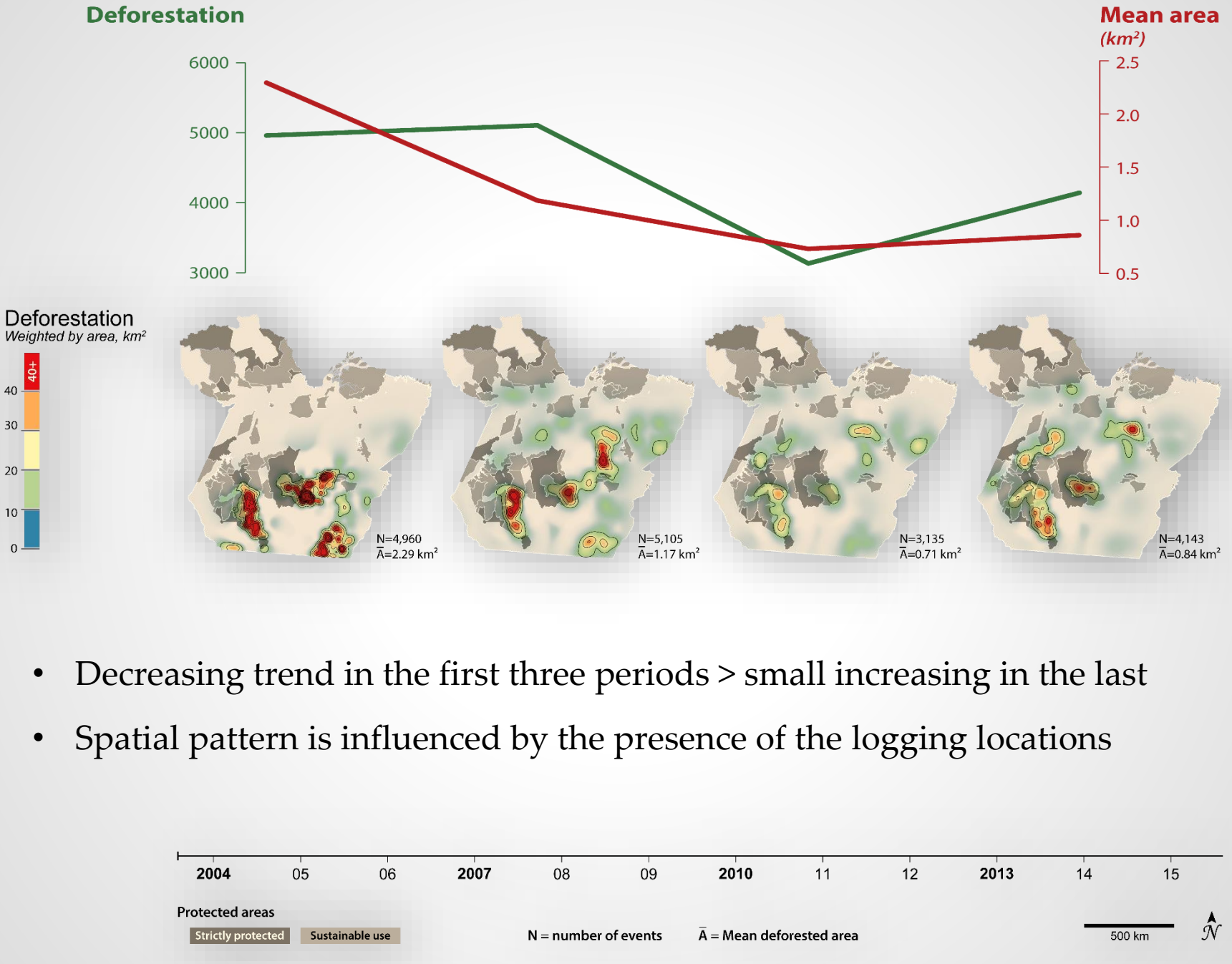
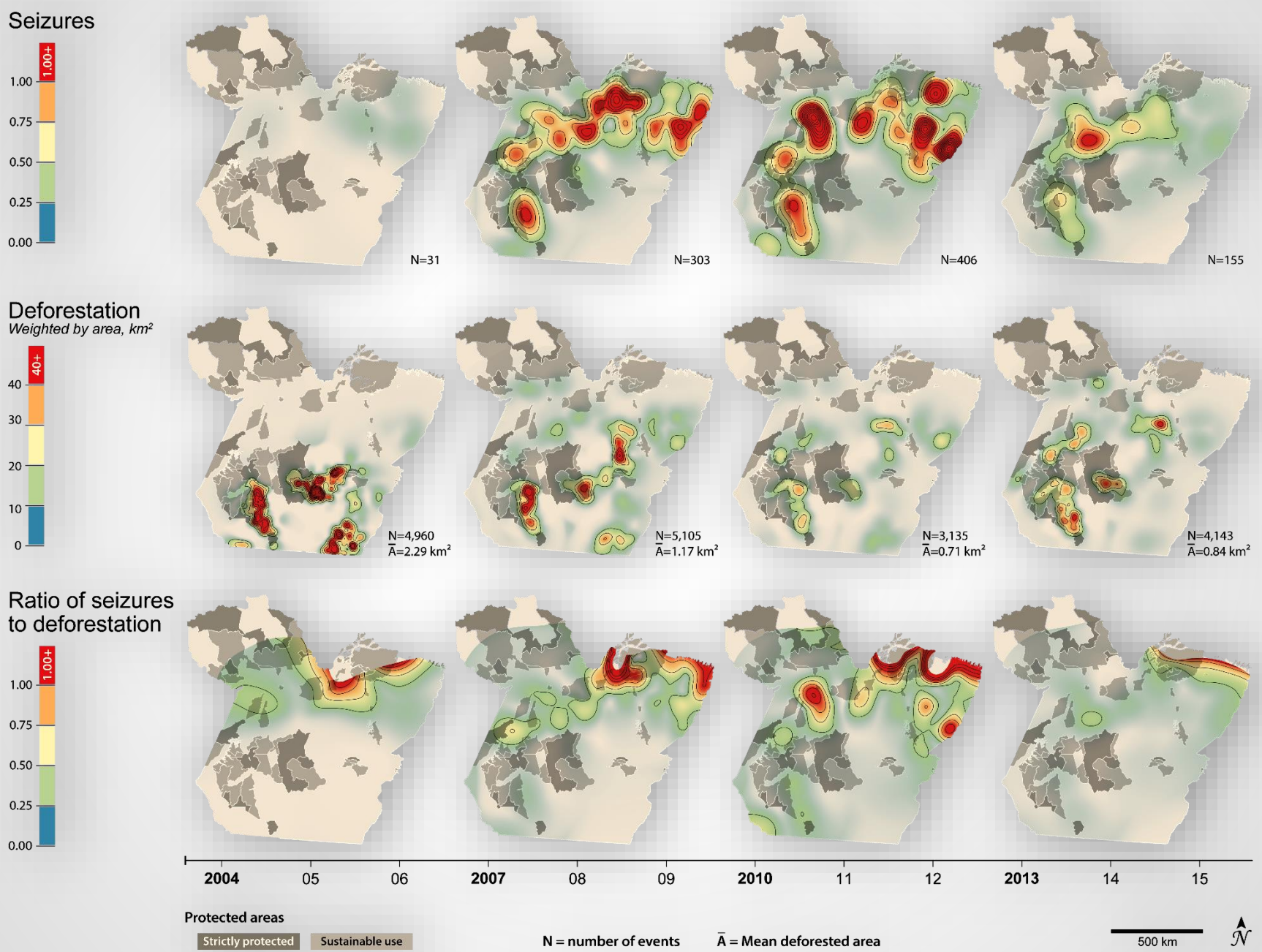


- Decreasing trend in the first three periods > small increasing in the last
- Spatial pattern is influenced by the presence of the logging locations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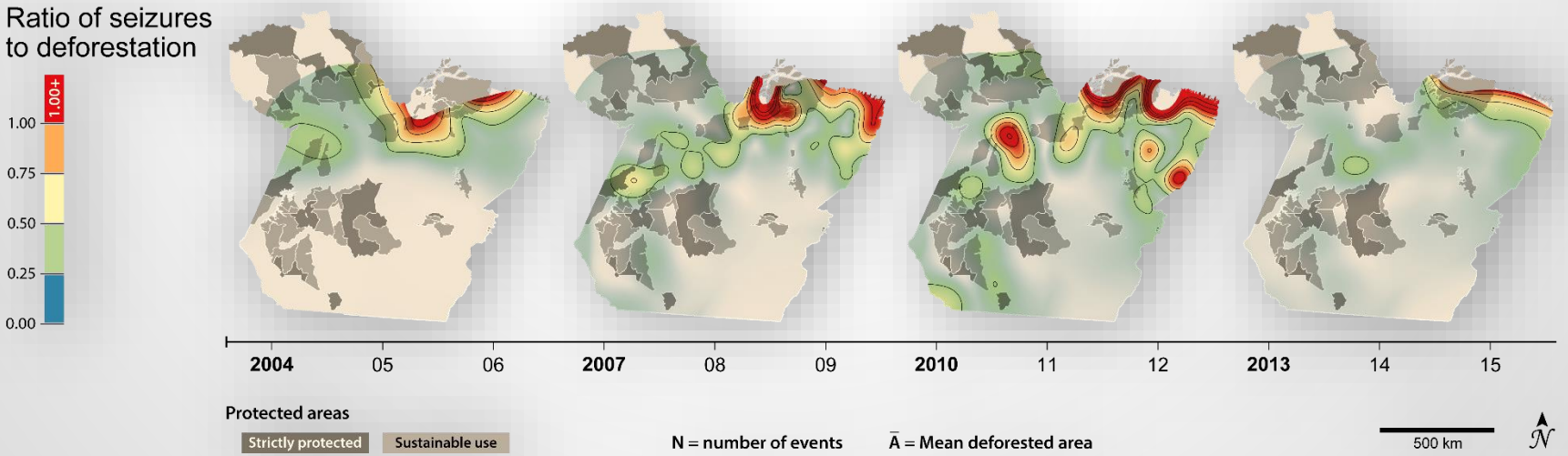
- Relative density of deforestation presented higher values in the **northeast region**, as well as in the **Transamazônica highway and Amazonas river** axis.

- Although **low concentrations of seizures** were observed in Terra do Meio, a **decrease in deforestation density** was observed as well as enforced regions.



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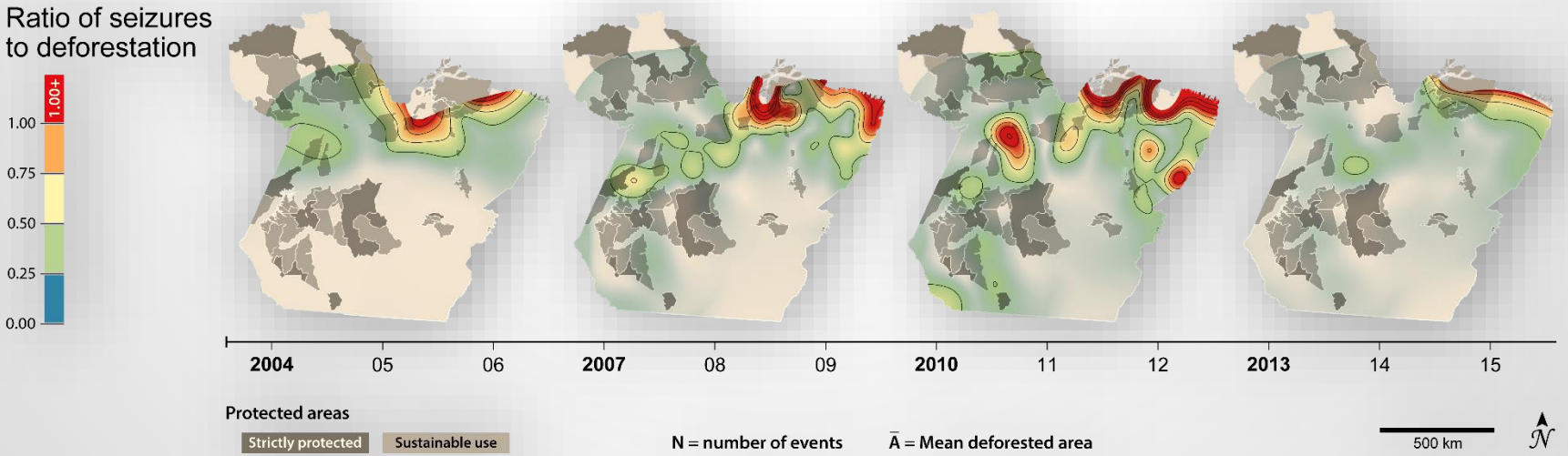

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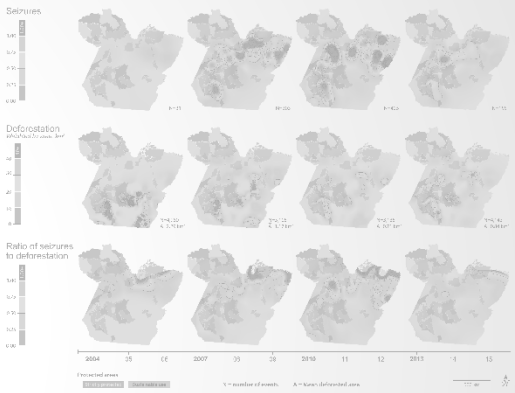

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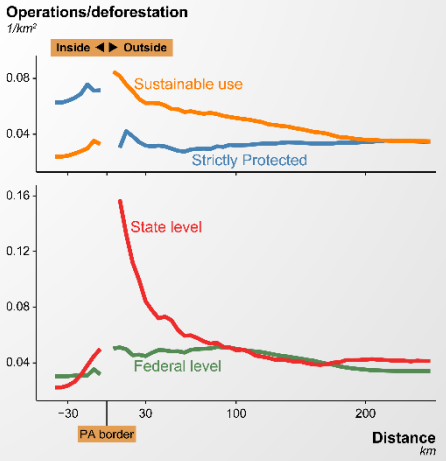
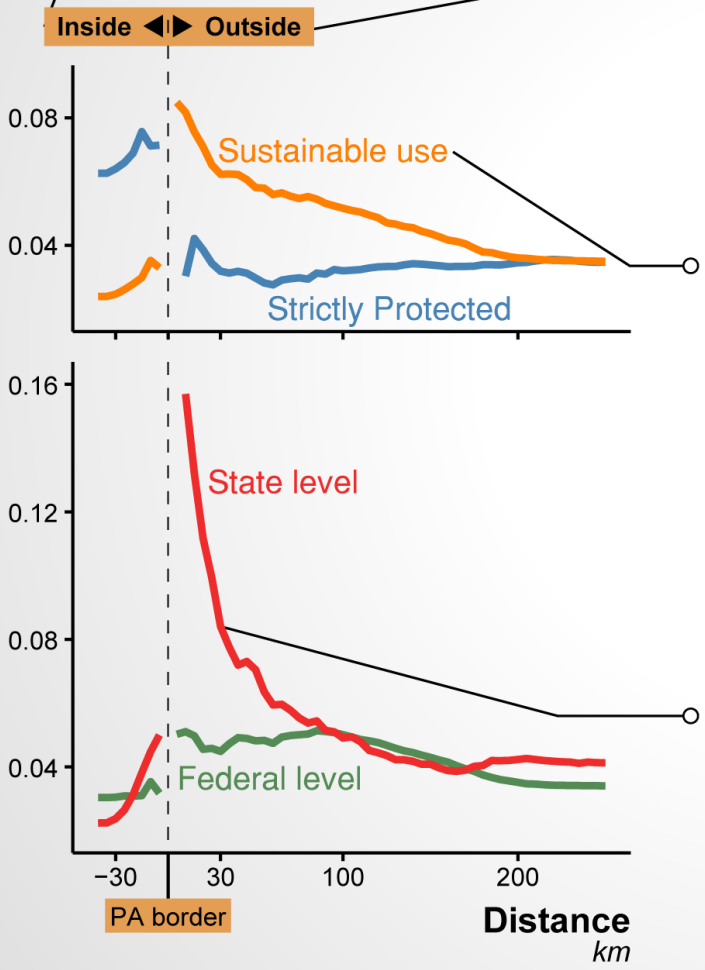


Inside PA's, the management group influences the enforcement efforts – SP areas have a higher enforcement inside than sustainable use areas;



Outside of PAs, the accessibility of the places, and consequently the costs of enforcement, influence more than the level of restriction of the PA;

The enforcement inside SU areas is lower than outside, suggesting that despite legally protected, this areas have no more efforts for enforcement than not PAs;

State PAs present higher values of enforcement than federal ones as the distance to the PA's border decreases;

Concluding remarks

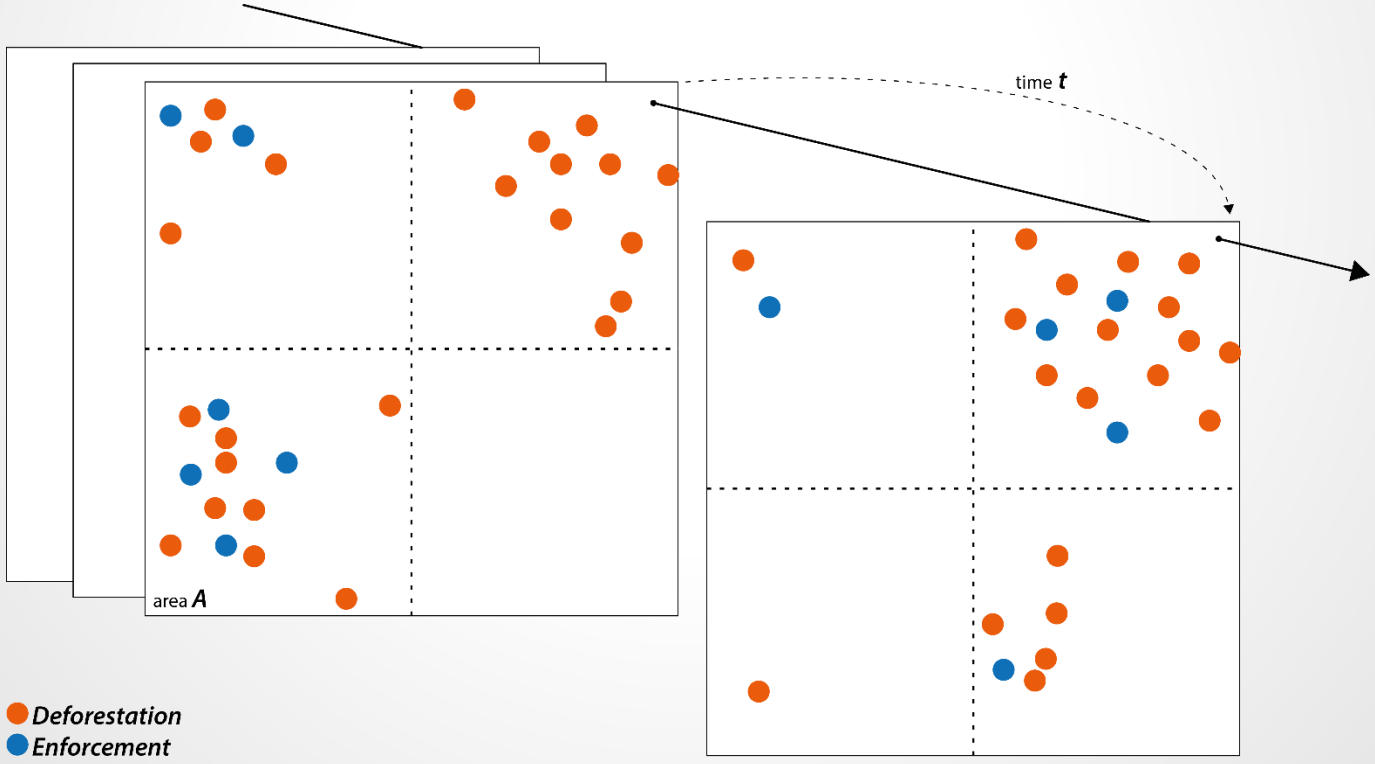
This study is a preliminary analysis that seeks to investigate spatial patterns over time of law enforcement, as well as to investigate its relationships with regulated areas.

- Seizures locations were more correlated to the **proximity to cities and mobility axes** than to deforestation hot spots
- It is not clear whether enforcement is driven by land regulation
- On the one hand, the **management group** influences the level of enforcement inside the PAs. On the other, despite legally protected, **Sustainable Use** areas have no more efforts for enforcement than outside them
- Outside of PAs, the **accessibility** and consequent **costs for enforcement** appears to influence more than the level of restriction of the PA

What comes next?

Questions

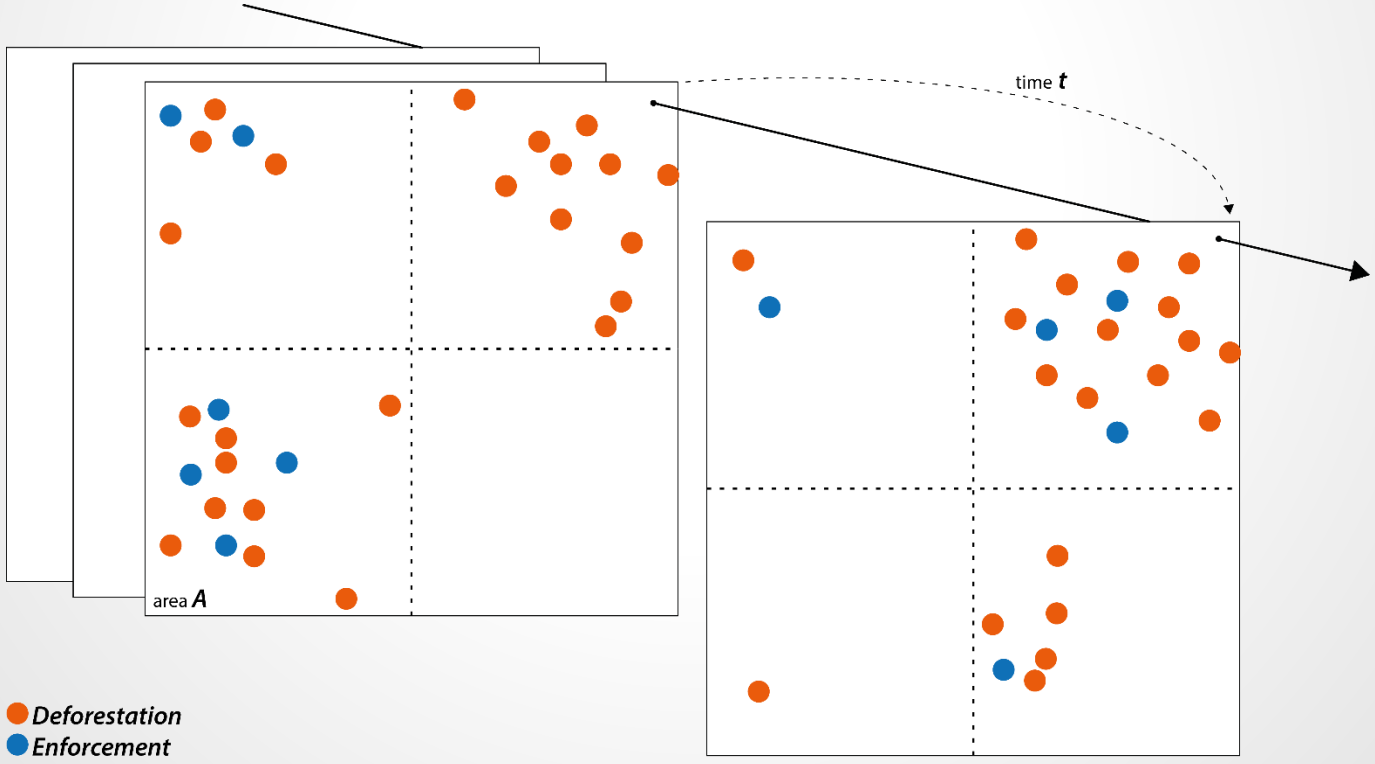
1. Are the location of **deforestation impacted by IBAMA enforcement**?



What comes next?

Questions

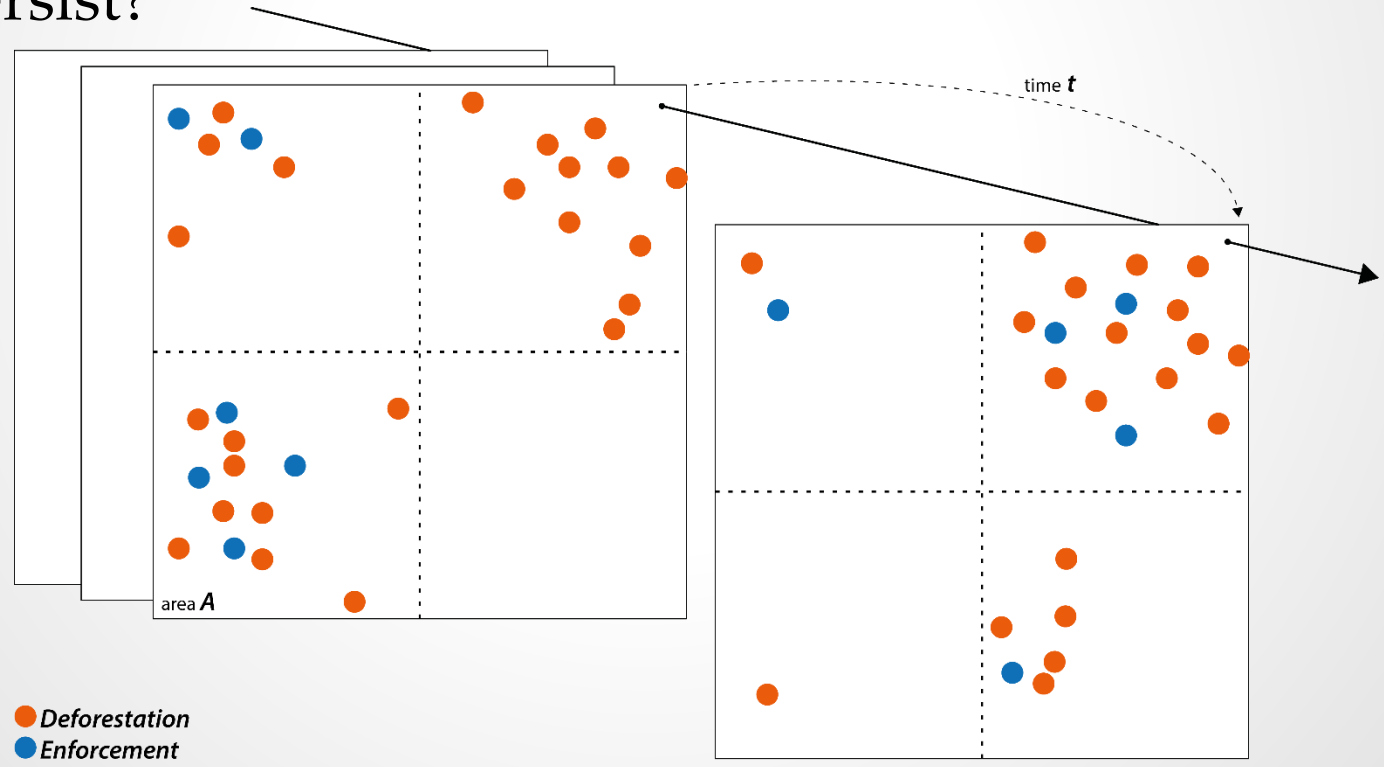
2. Has increased monitoring and control in one region **altered the dynamics** of deforestation elsewhere?



What comes next?

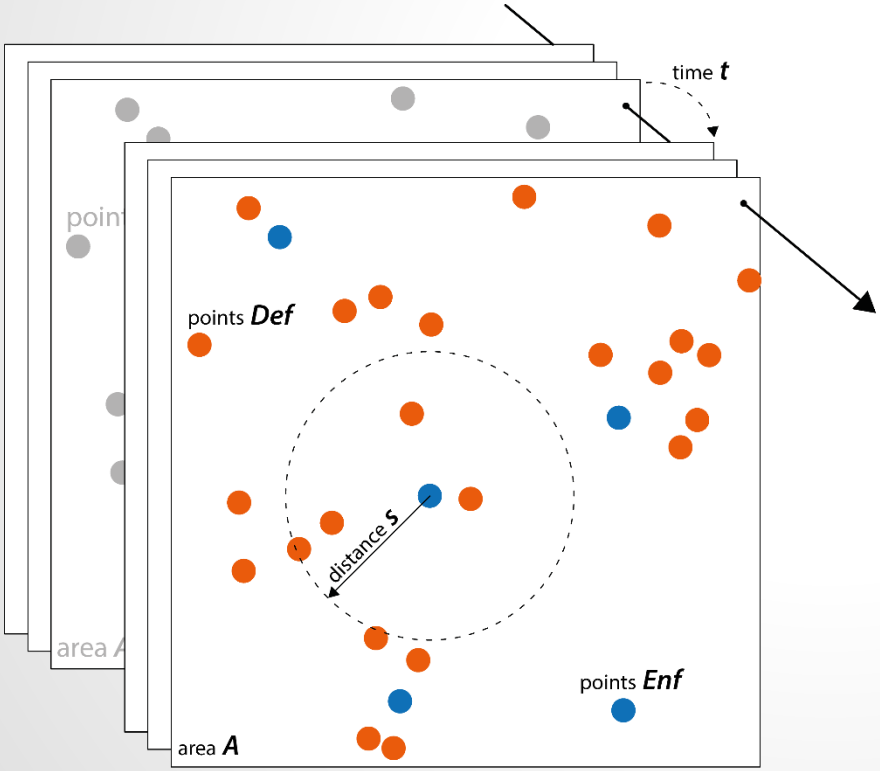
Questions

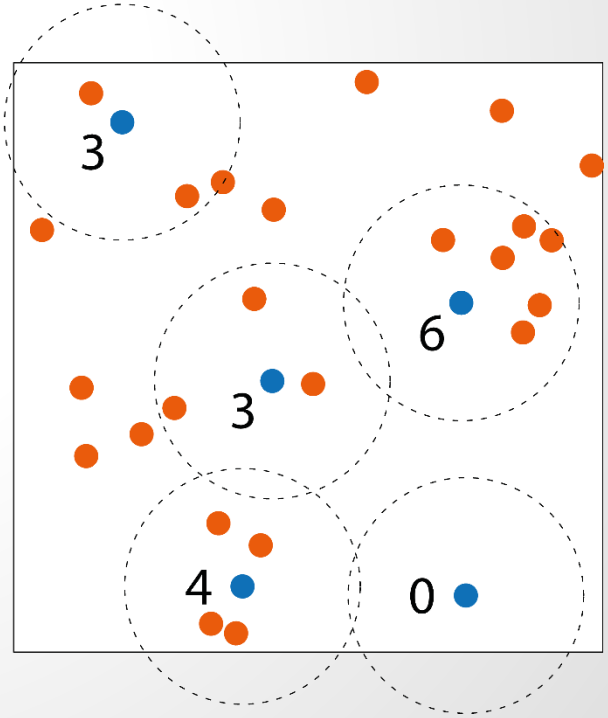
3. What is the **extent** of deforestation inhibition caused by policing? And **how long** does the inhibition persist?



Methodology

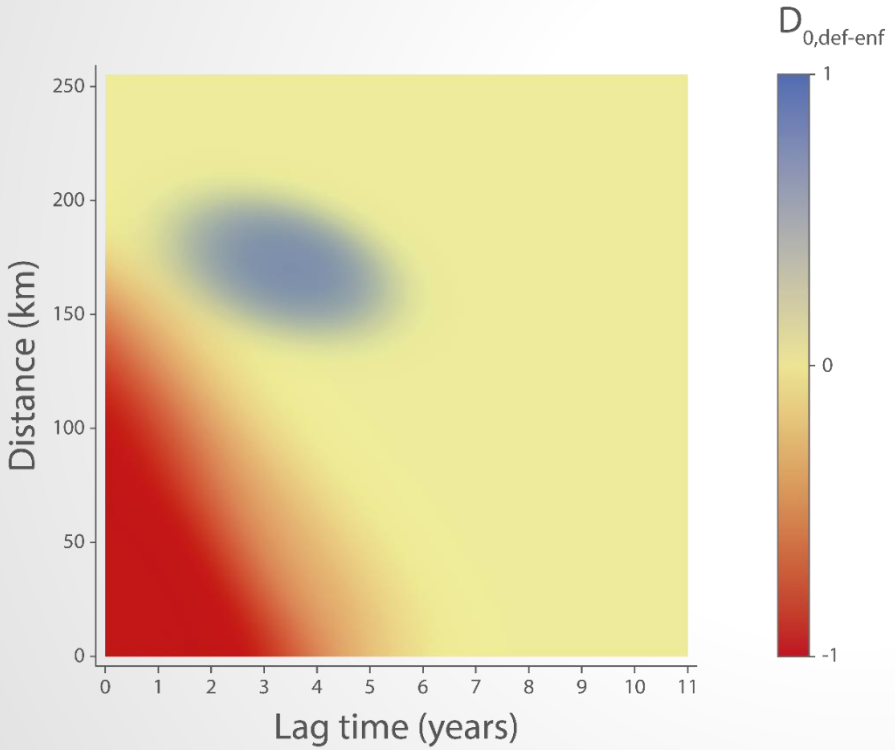
- Spatiotemporal cross K-function (Lynch *et al.*, 2008; Flaxman *et al.*, 2013; Wooditch *et al.*, 2016)





Expected results

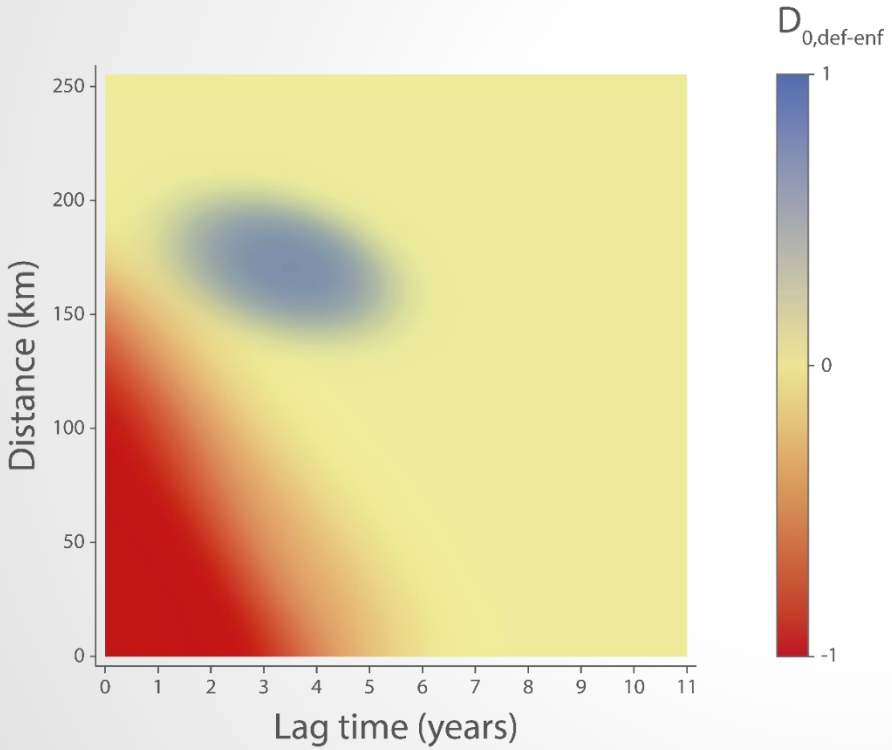
Hypotetical result



Identify the **spatial and temporal relations** between the reduction of deforestation and the investments of governmental actions, specifically the IBAMA policing.

Expected results

Hypotetical result



Contribute to **understanding the "leakage" effects**

NHH

INPE

TREES

Cemaden

Takk!

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