Spatial variability of the deforestation along the Amazon River main stem floodplain

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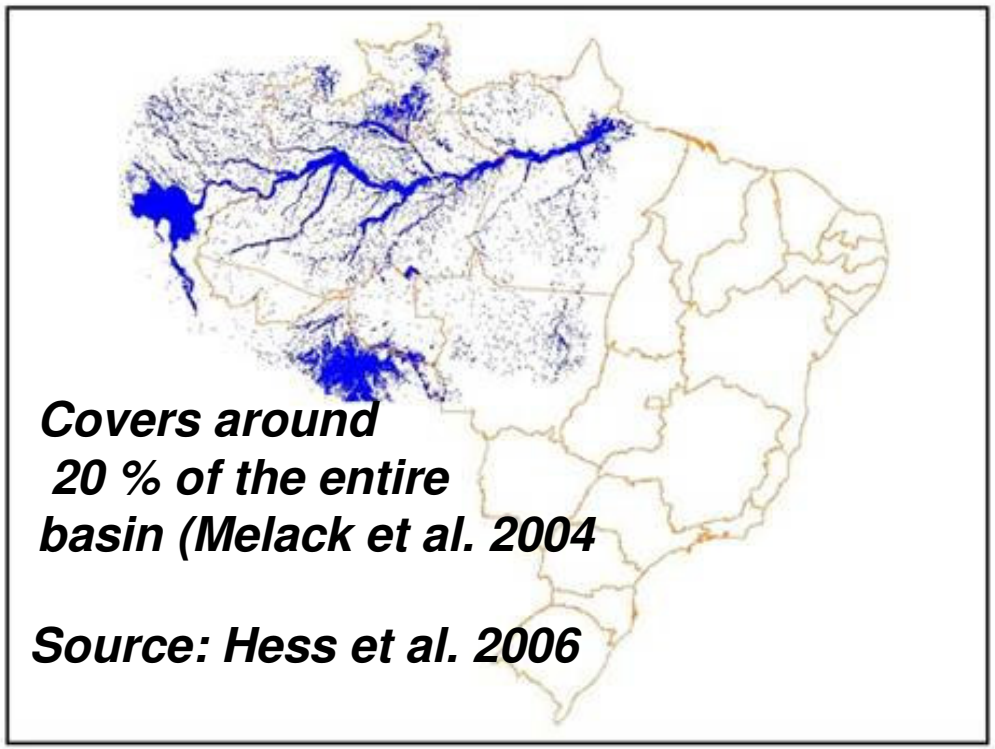
Why focus in land use changes in the wetland?

- *wetland represents 20 % of the Amazon region (Melack et al. 2004).*
- *it may affect the role of wetlands and rivers in carbon transport and release by changing the carbon pools*
- *it may affect water quality and biodiversity not only in the wetland*

Amazon Basin Wetland



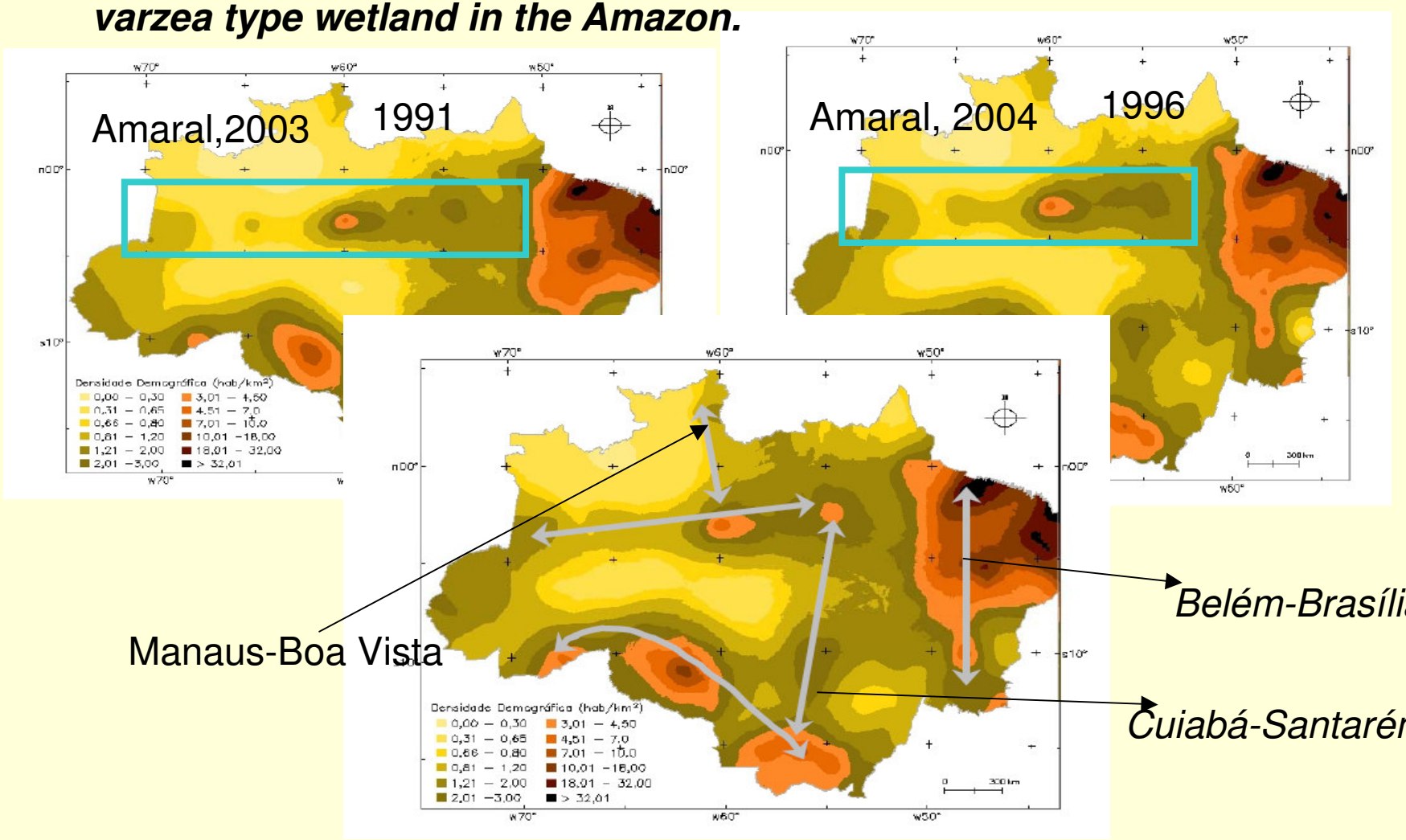
Covers around 20 % of the entire basin (Melack et al. 2004

Source: Hess et al. 2006

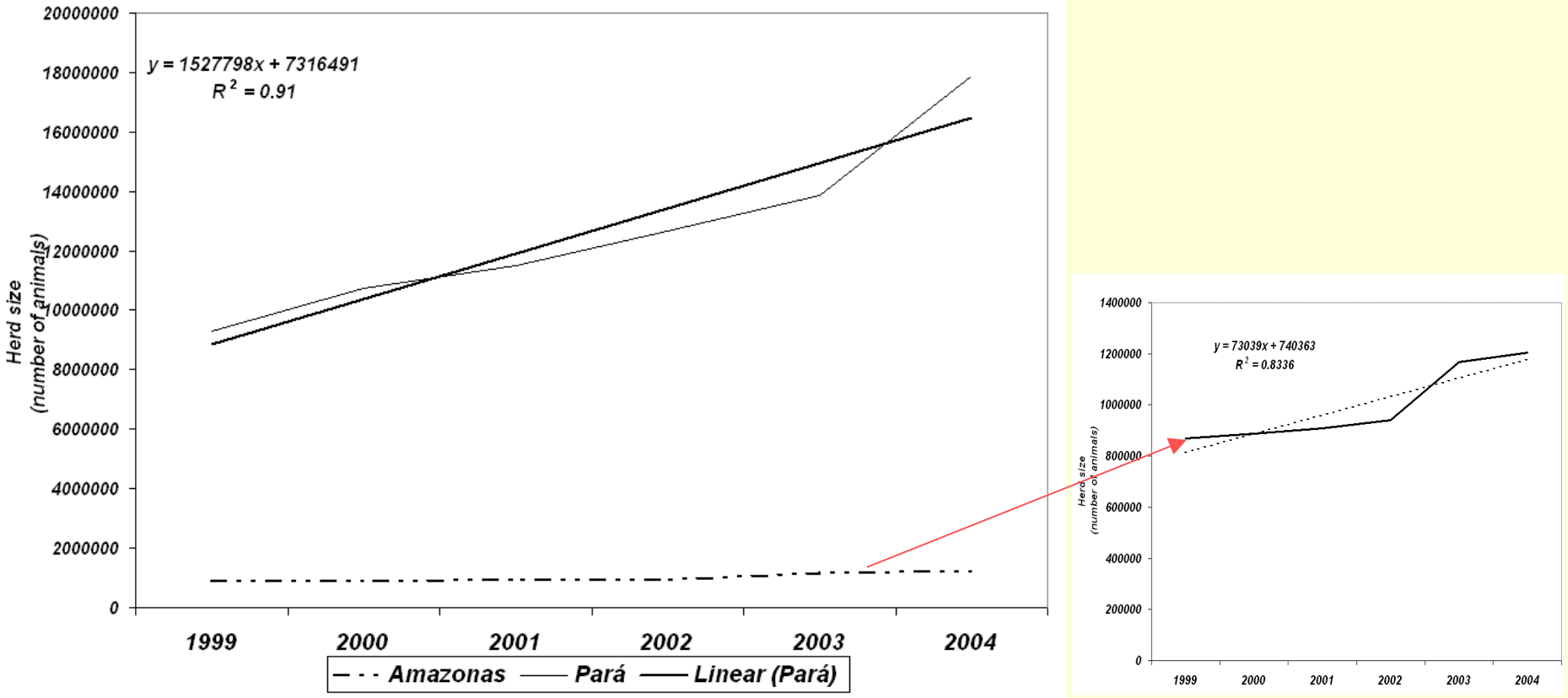
- ***Is a globally significant source of atmospheric methane (Melack et al.2004)***
  - ***Length of inundation controls vegetation composition (Piedade et al. 2001)***

Vegetative cover varies as a function of hydrologic regime, solute and sediment content of waters (Klinge et al. 1990; Junk, 1997)

Growing human pressure on the Amazon River floodplain – the richest varzea type wetland in the Amazon.



Increased presence of humans reflected in the increase in cattle raising

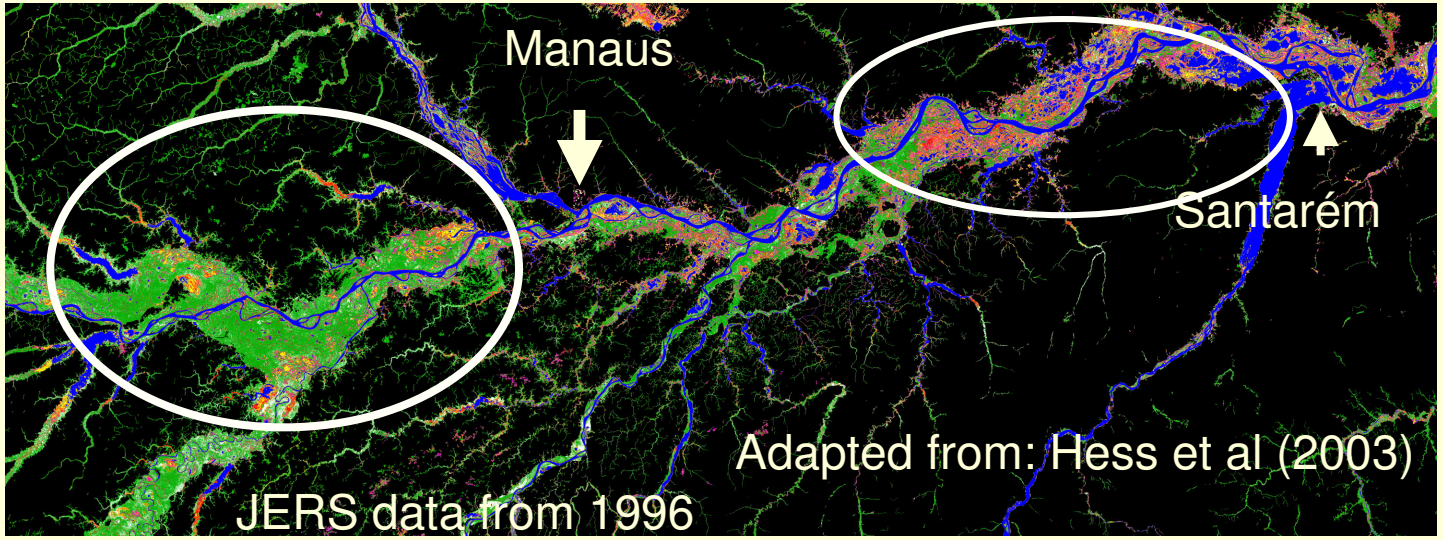


Source: IBGE, 2000

Background

- *It is well documented that the floodplain is being intensively used for cattle in both Pará and Amazonas states,*
- *It is still missing information on the spatial variability of this occupation.*
- *The impact of cattle ranching on floodplain ecology may increase as the proportion of wetland within a given region increases.*
- *There are striking differences in the baseline algae primary productivity expressed as chlorophyll concentration from measurements reviewed in literature (Maleck and Forsberg, 2001) and measurements made in Curuai Lake (Barbosa, 2005) and extrapolated to theParintins- Almeirim reaches (Novo et al. 2006).*

How to tell differences between natural and human induced patterns in the land cover?



Water

Bare or herbaceous

Forest

Shrub

What is the question?

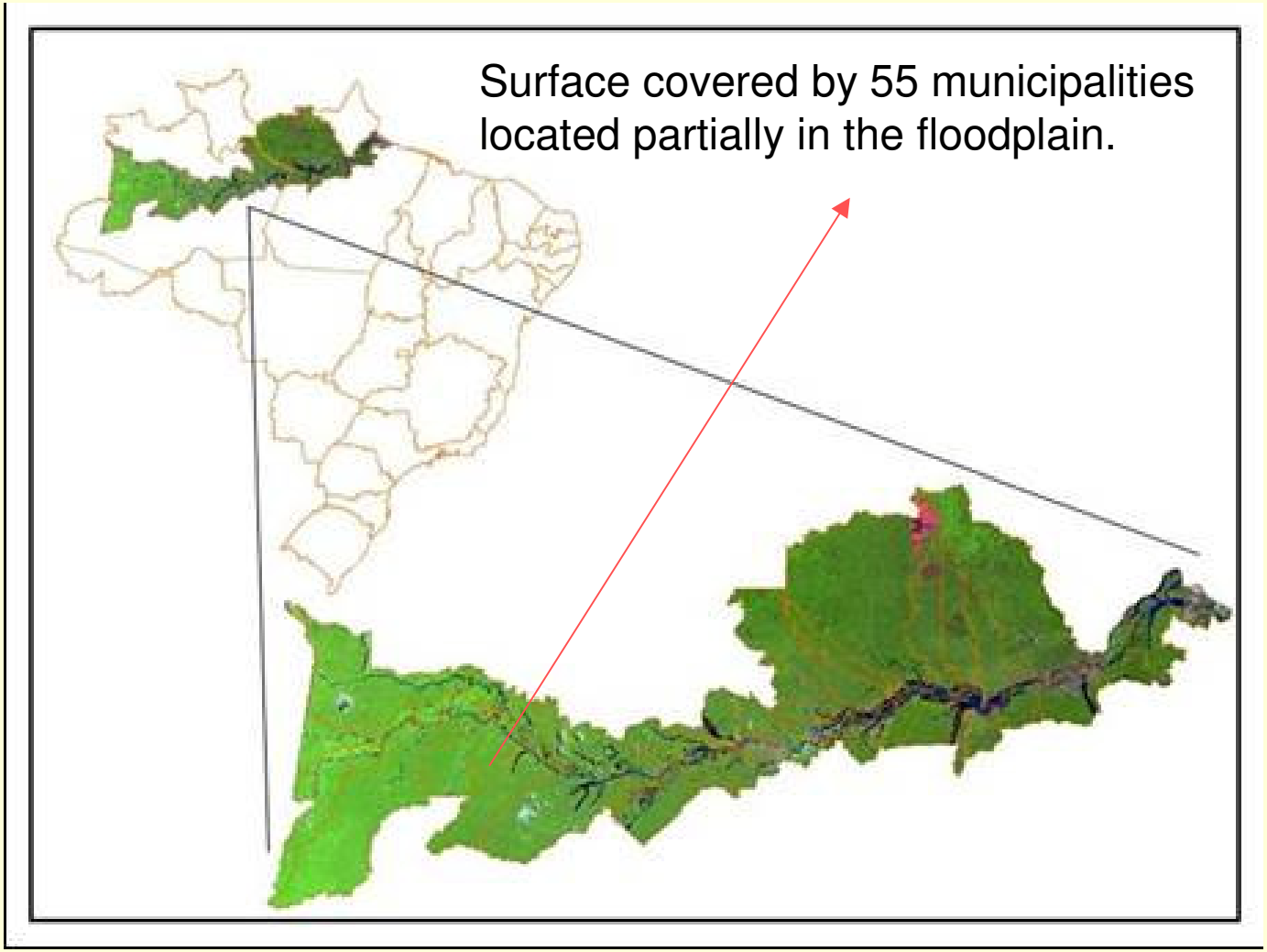
- *Are those differences in primary productivity natural?*

- *Are they connected to cattle ranching in the floodplain?*

Methodology

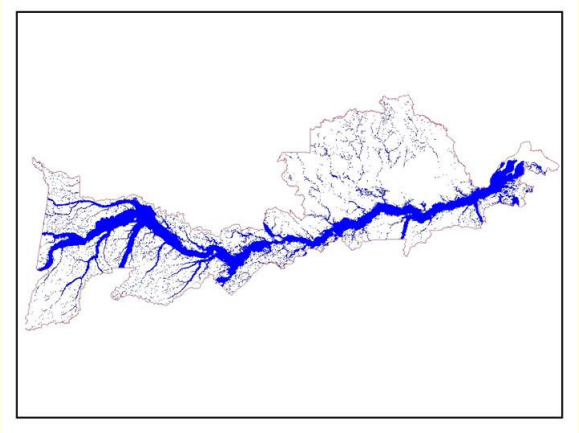
- *In order to answer those questions the following data were quantified:*
  - *proportion of wetland for each municipality in the Amazonas (37) and Para (18) States using the non-validated Amazon wetland mask;*
  - *the deforested area for each municipality using the digital deforestation data base provided by PRODES project;*
  - *the deforested area within a 2 km buffer from the Amazon River bank, assuming that the floodplain is mainly used for owners living nearby the river banks.*
  - *Herd size (number of heads) per municipality (IBGE, 2002);*
  - *Population (inhabitants) per municipality (2004);*
  - *Distance from the market centers (Manaus and Belém);*
  - *Eutrophic Lake Area (index derived from MODIS images - 2002)*

STUDY AREA

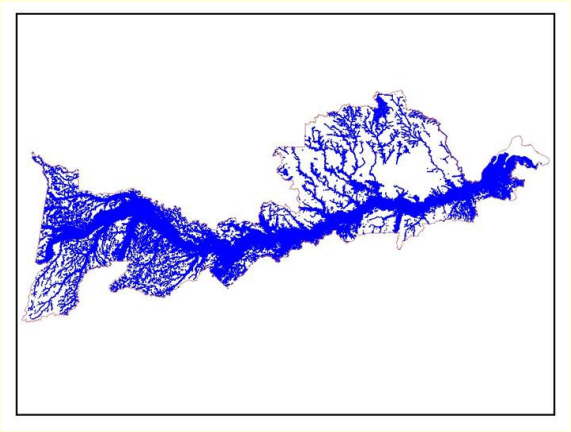

Surface covered by 55 municipalities
located partially in the floodplain.

Steps to obtain the data

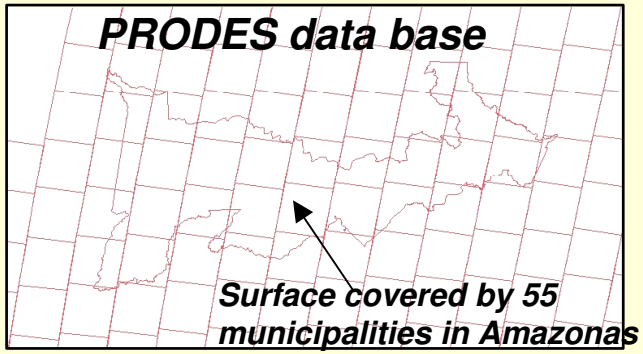
1- Overlay the wetland mask on the municipality map



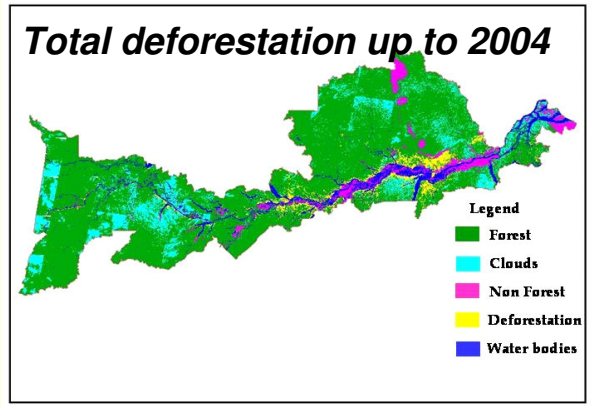
2- build a 2 km buffer-wetaland mask



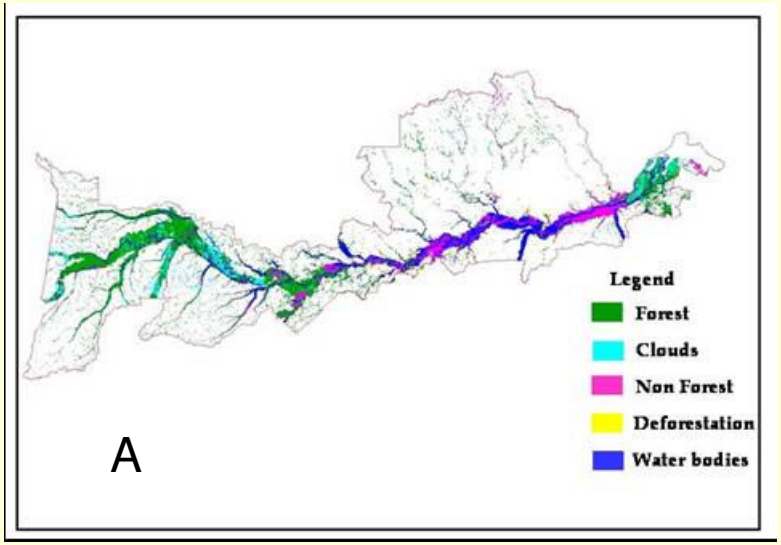
3 -build a mosaic of 60 digital deforestation maps



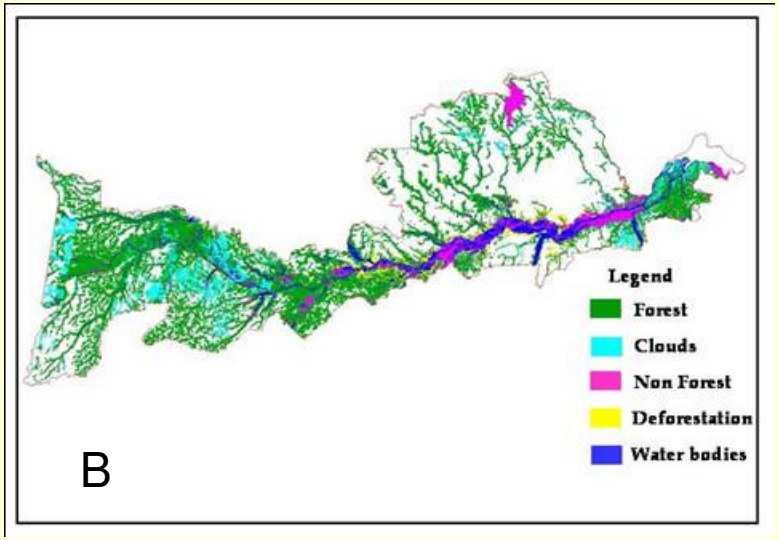
4- build the land cover/deforestation map for the 55 municipalities



wetland deforestation



2 buffer-wetland deforestation



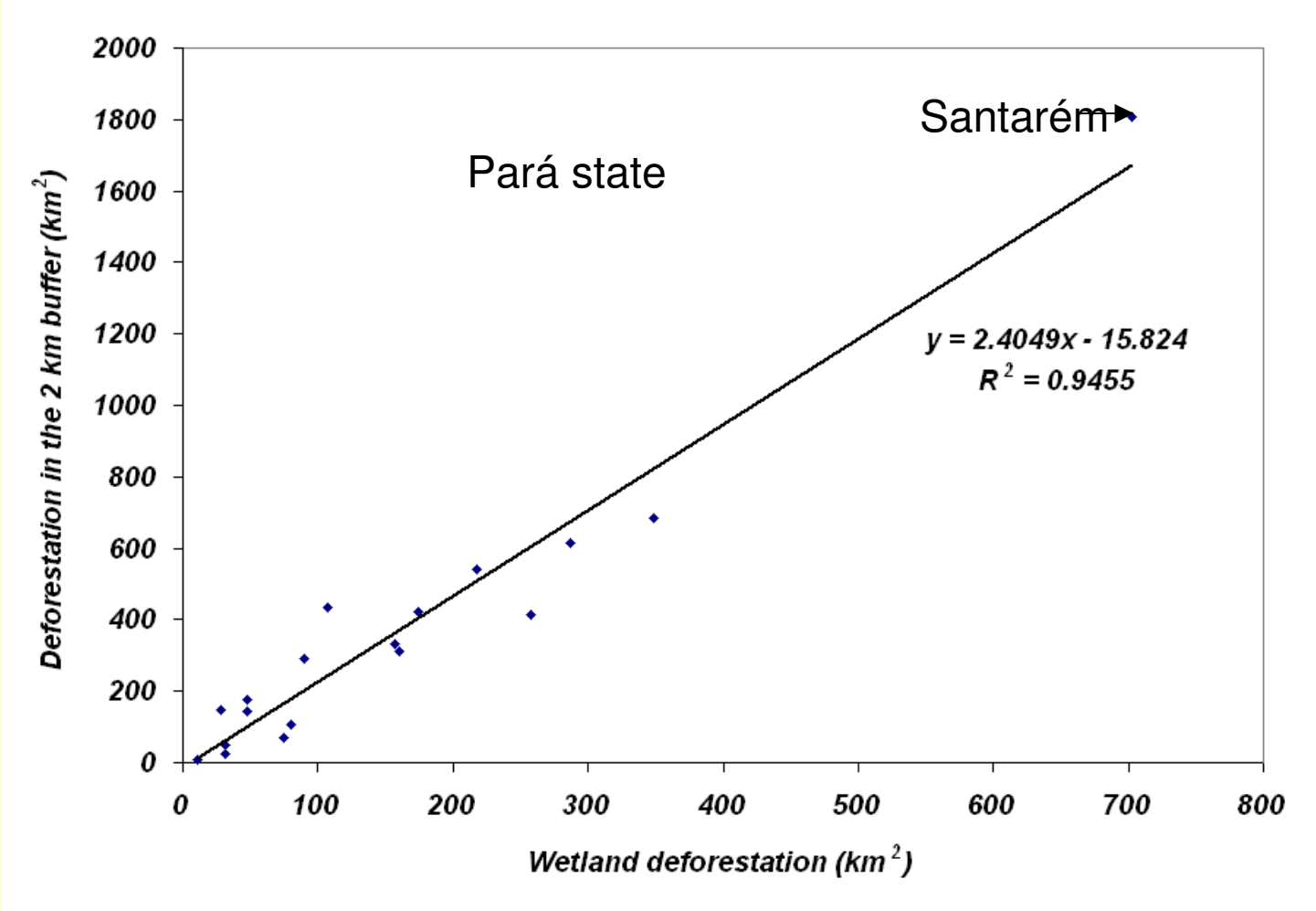
2km Buffer deforestation: deforestation occurring in Terra Firme at the edge of the wetland

Summary – Pará State

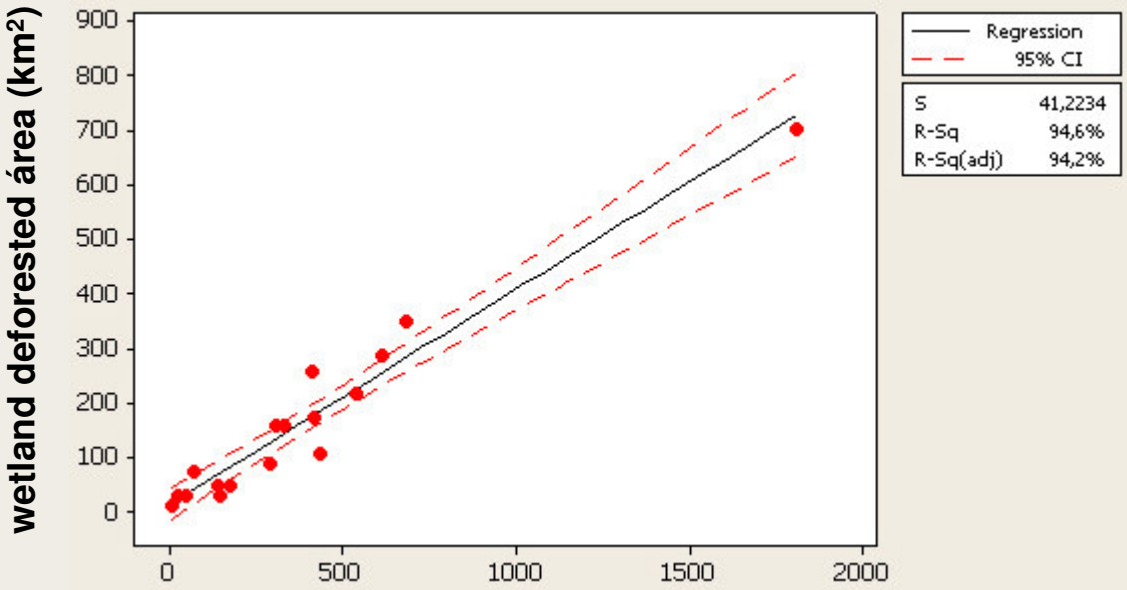
- *18 municipalities occupying wetland in the Amazon River main stem*
- *Total Wetland Area = 43,381 km²*
- *Total Deforestation in the wetland= 2,773km²*
- *Percentage of deforestation=6.4 %*
- *Total 2km buffer deforestation= 8,410 km²*
- *Percentage of buffer deforestation=7.2 %*
- *Total herd size = 894,369*
- *Total Population = 6,189,550*

Summary – Amazonas State

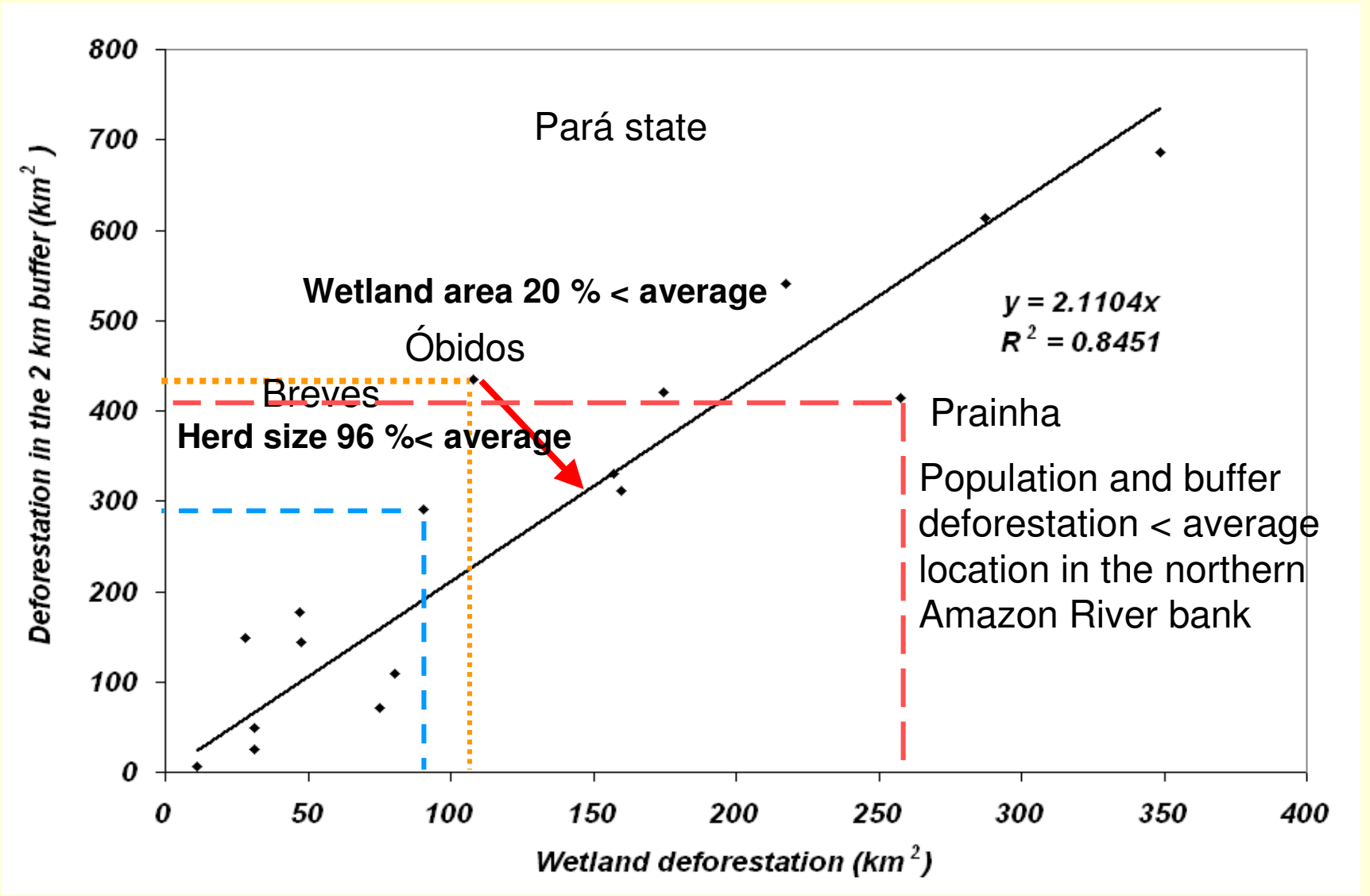
- *37 municipalities occupying wetland in the Amazon River main stem*
- *Total Wetland Area = 107,248*
- *Total Deforestation in the wetland= 5,012*
- *Percentage of deforestation= 4.6 %*
- *Total 2km buffer deforestation= 6,471*
- *Percentage of buffer deforestation= 4.0 %*
- *Total herd size = 590,262*
- *Total Population = 2,582,737*
- *Manaus Population= 1,592,555*
- *70 % of the Population in the Amazon state is in those 37 municipalities*

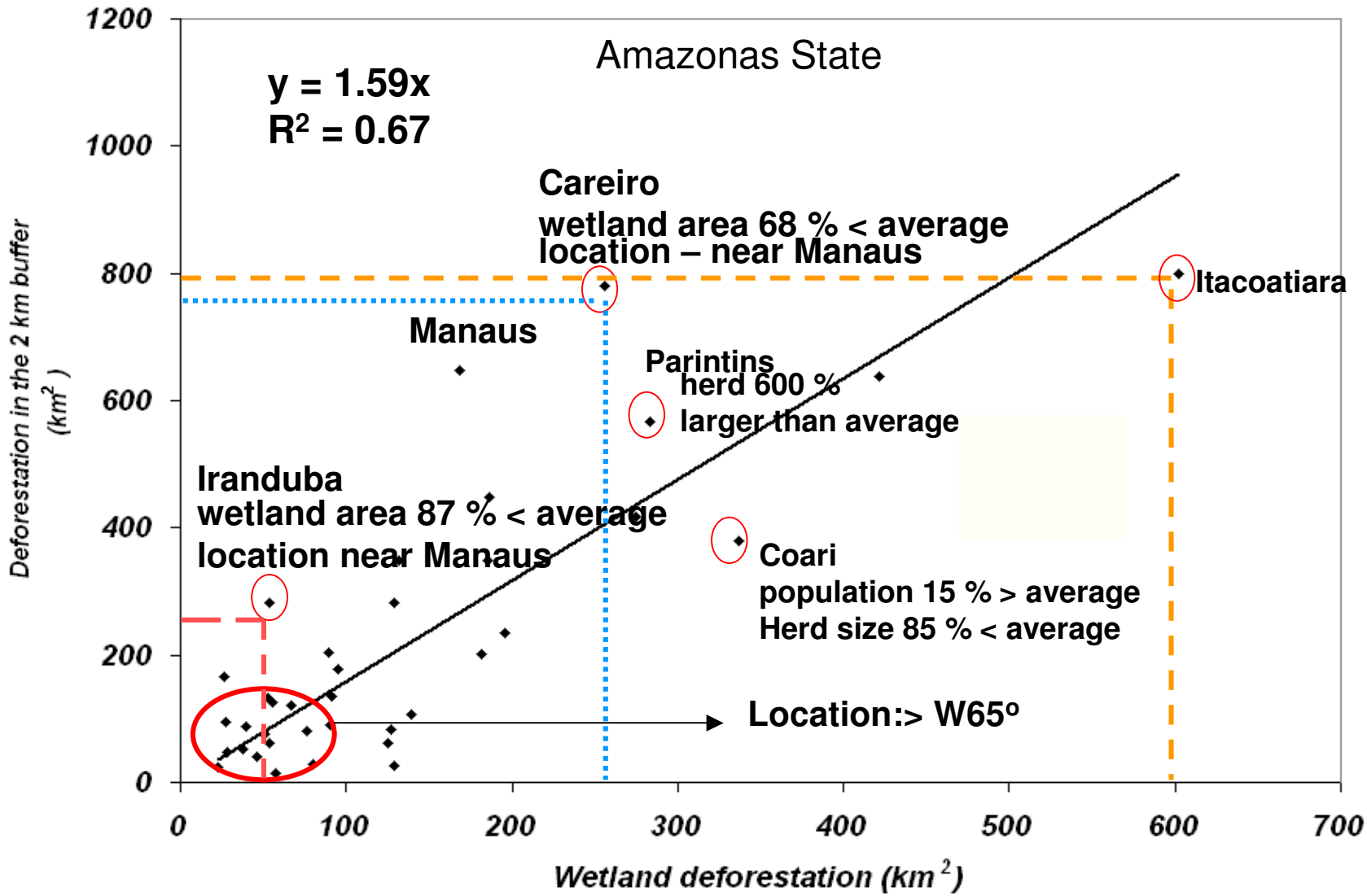

Santarém
Pará state
y = 2.4049x - 15.824
R 2 = 0.9455
Deforestation in the 2 km buffer (km2)
Wetland deforestation (km 2)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
100
200
300
400
500
600
700
800

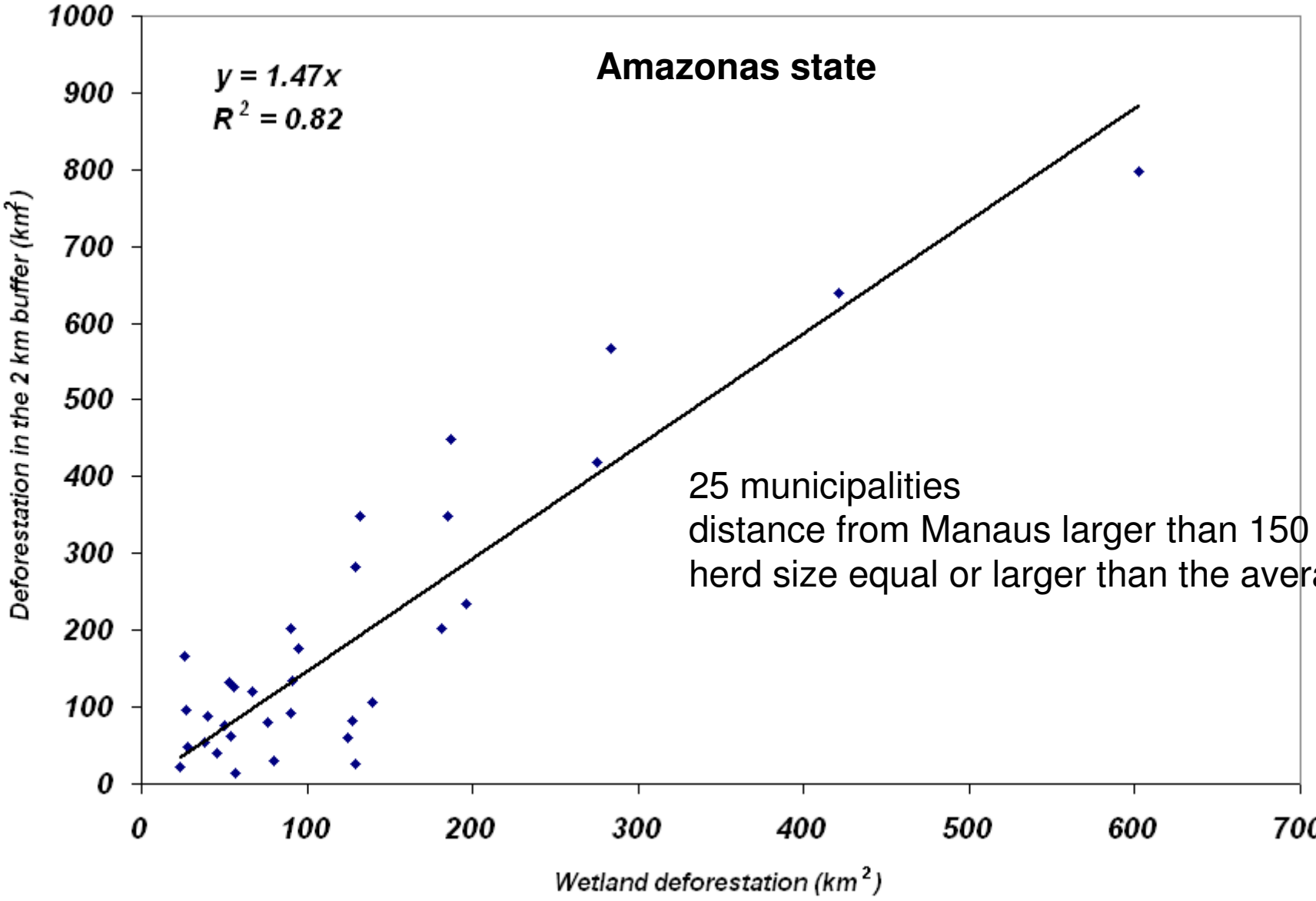
Pará state



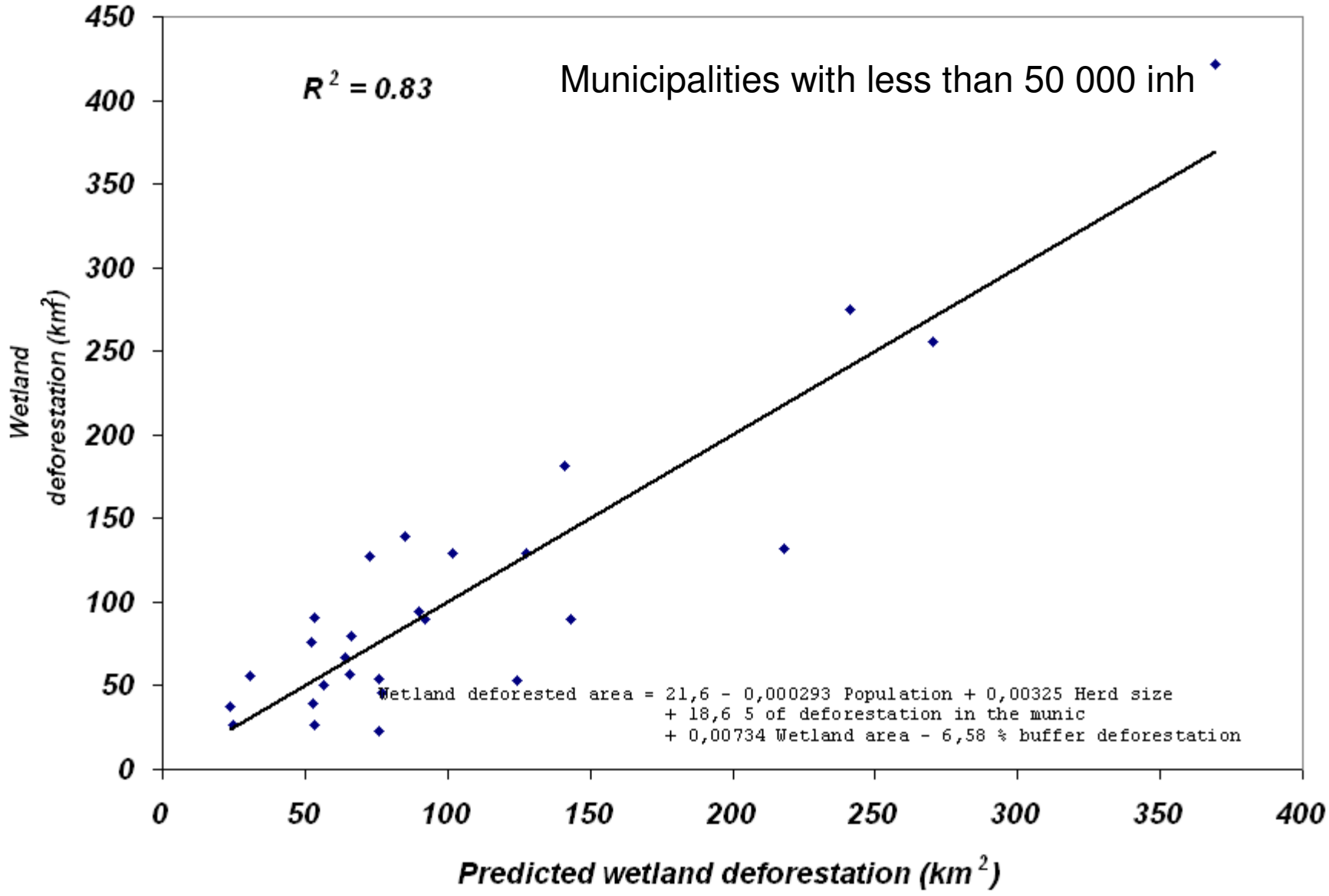
Wetland deforested area = 12.7 + 0.40 buffer deforested area


Pará state
Wetland area 20 % < average
Óbidos
Breves
Herd size 96 %< average
Prainha
Population and buffer deforestation < average location in the northern Amazon River bank
y = 2.1104x
R 2 = 0.8451
Deforestation in the 2 km buffer (km 2)
Wetland deforestation (km 2)
0
100
200
300
400
500
600
700
800
0
50
100
150
200
250
300
350
400

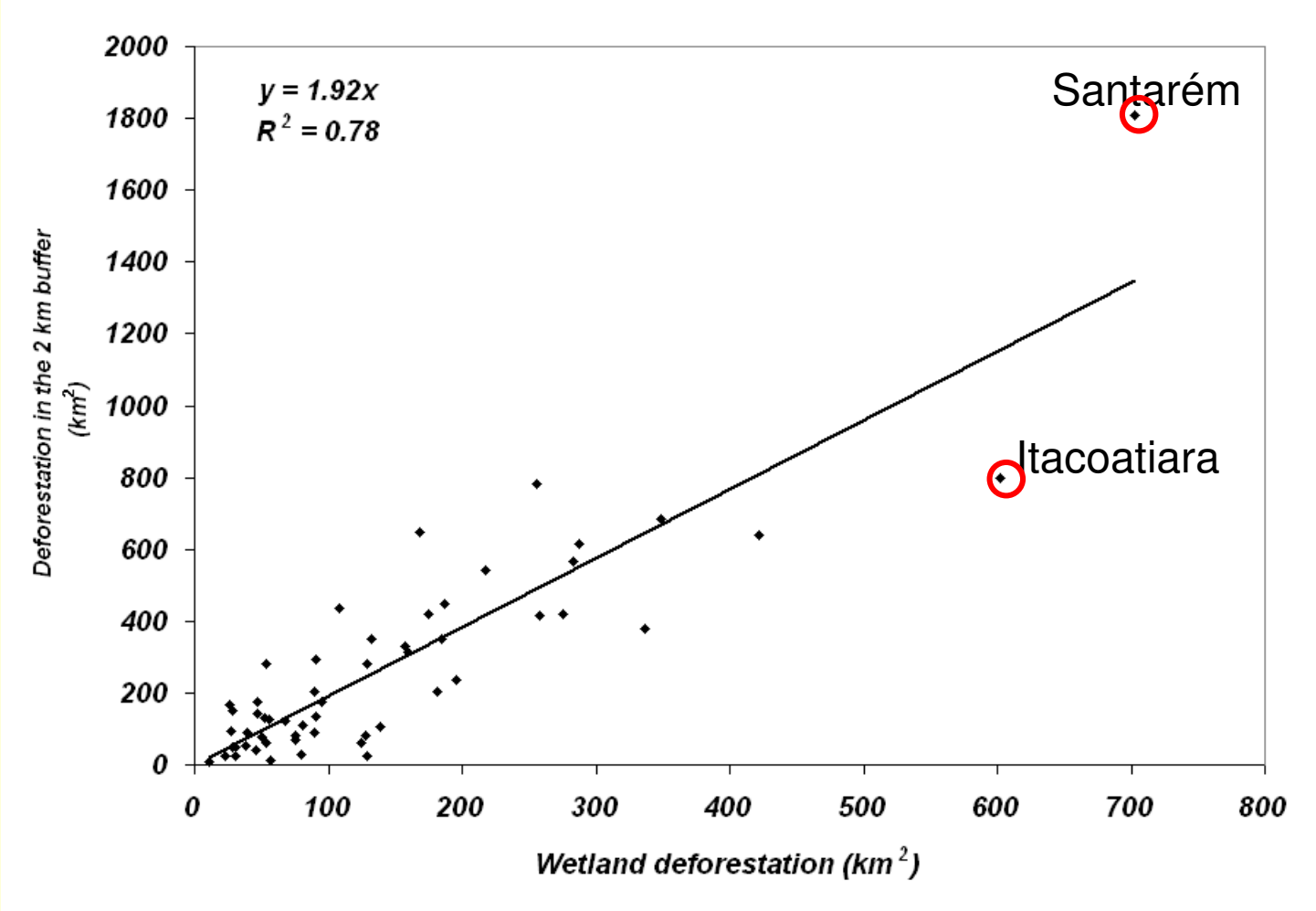

Amazonas State
y = 1.59x
R² = 0.67
Careiro
wetland area 68 % < average
location – near Manaus
Itacoatiara
Manaus
Parintins
herd 600 %
larger than average
Iranduba
wetland area 87 % < average
location near Manaus
Coari
population 15 % > average
Herd size 85 % < average
Location:> W65º
Deforestation in the 2 km buffer (km²)
Wetland deforestation (km²)
0
200
400
600
800
1000
1200
0
100
200
300
400
500
600
700

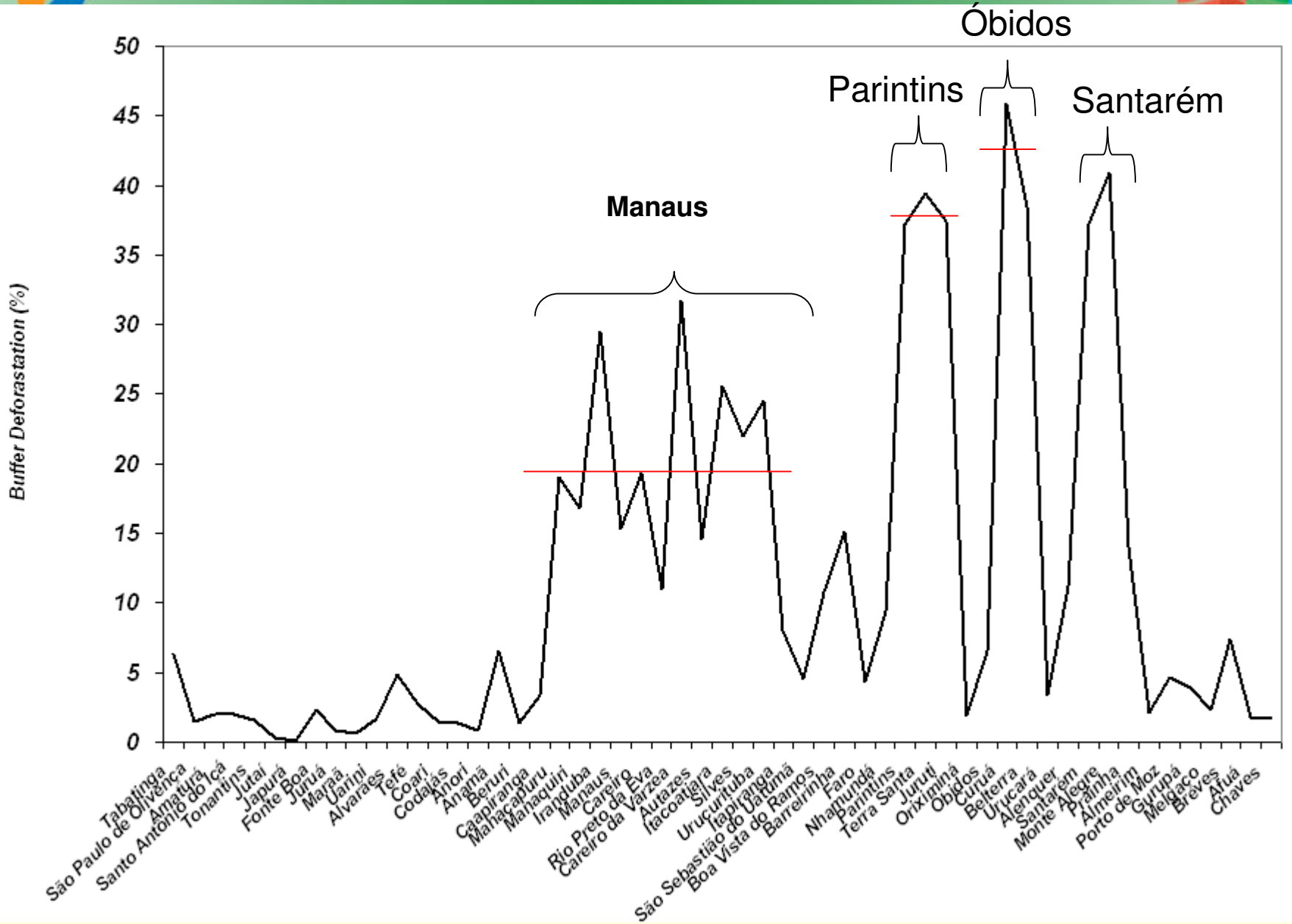


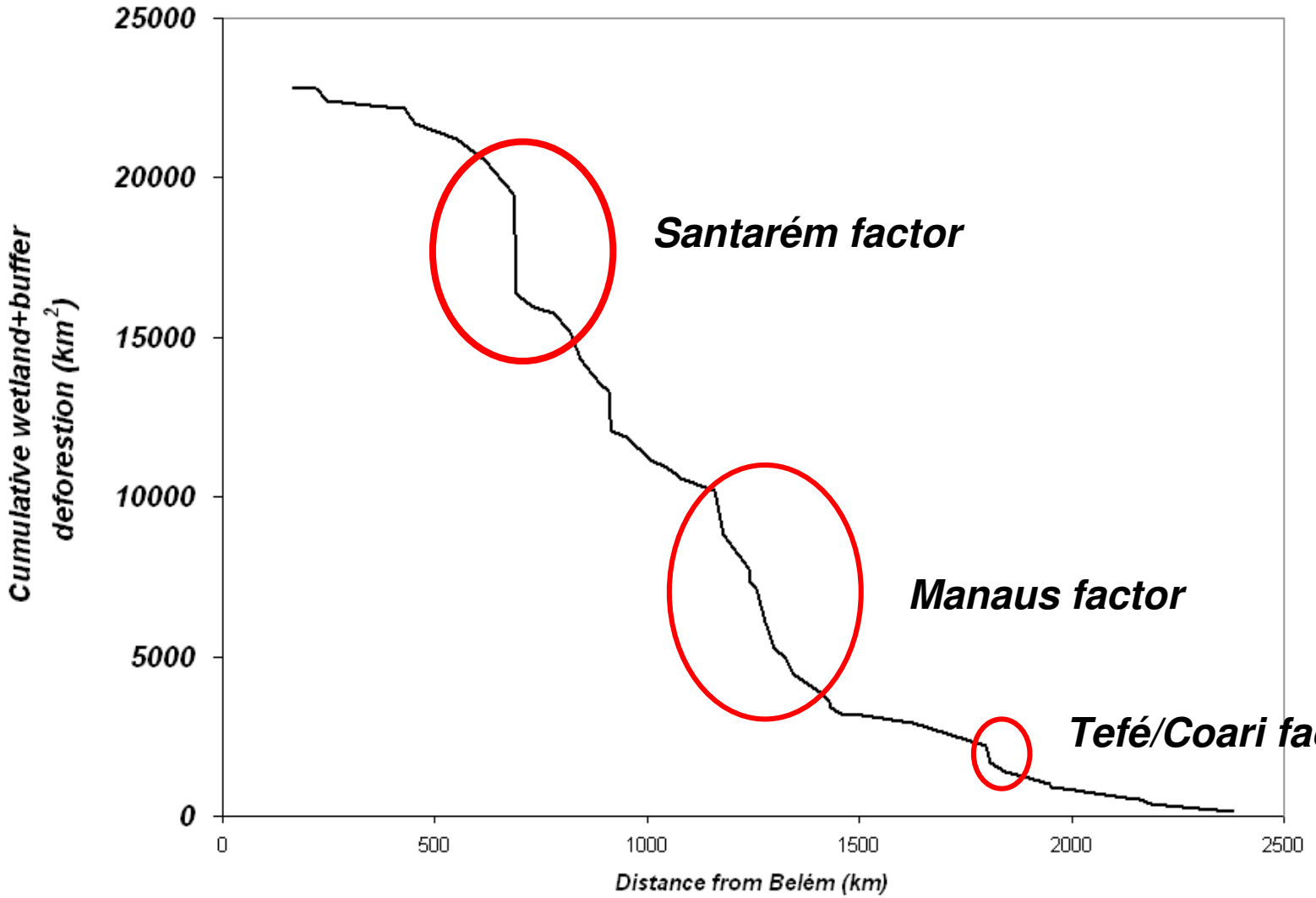
25 municipalities
distance from Manaus larger than 150 km
herd size equal or larger than the average


$R^2 = 0.83$
Municipalities with less than 50 000 inh
Wetland deforested area = 21,6 - 0,000293 Population + 0,00325 Herd size
+ 18,6 5 of deforestation in the munic
+ 0,00734 Wetland area - 6,58 % buffer deforestation
Wetland deforestation (km^2)
Predicted wetland deforestation (km^2)
0
50
100
150
200
250
300
350
400
450

55 municipalities along the Amazon River main stem floodplain



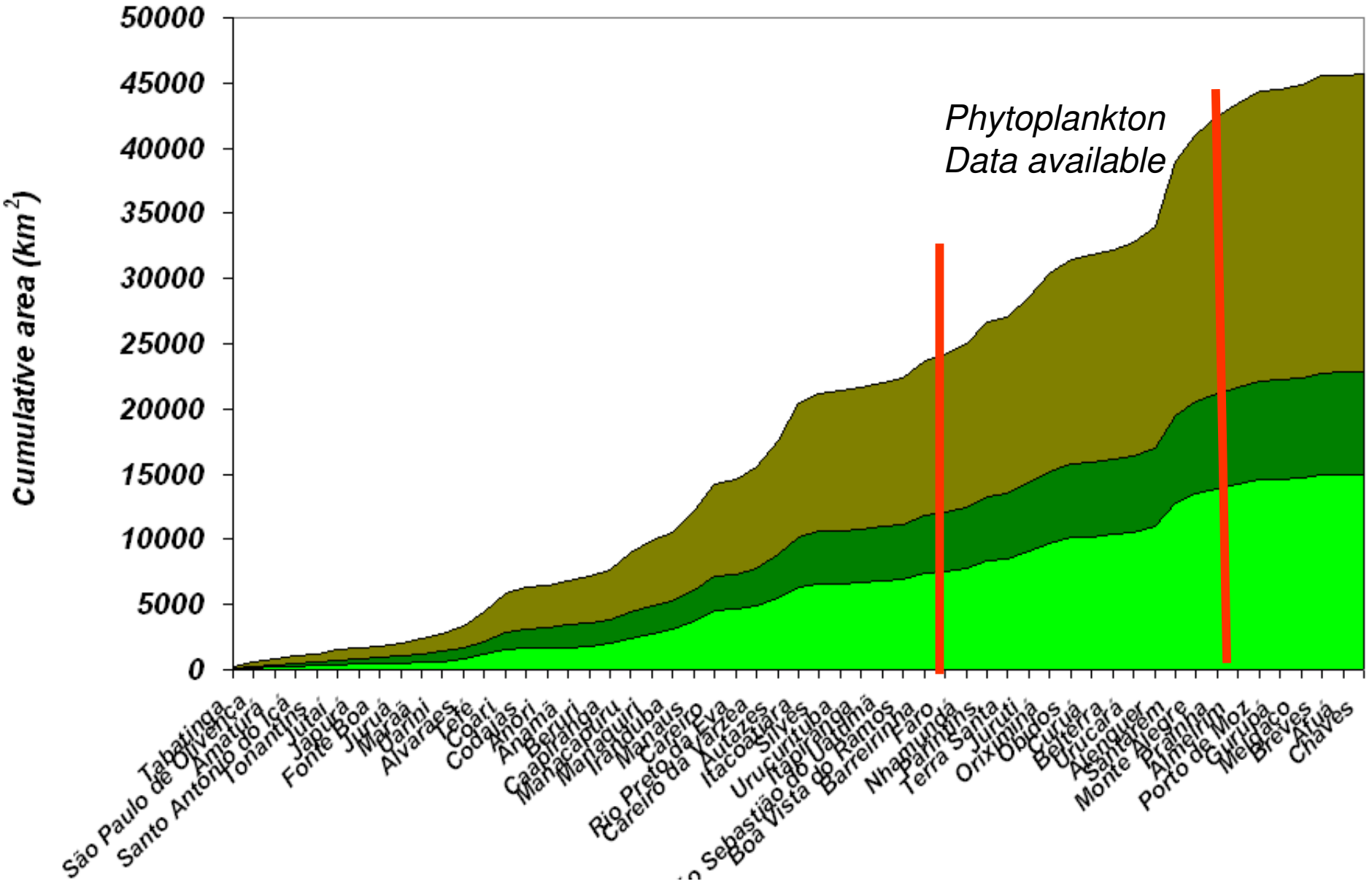

Óbidos
Parintins
Santarém
Manaus
Buffer Deforastation (%)
50
45
40
35
30
25
20
15
10
5
0
Tabatinga
São Paulo de Olivença
Amaturá
Santo Antônio do Içá
Tonantins
Jutaí
Japurá
Fonte Boa
Juruá
Maraã
Uarini
Alvarães
Tefé
Coari
Codajás
Anori
Anamã
Beruri
Caapiranga
Manaquiri
Iranduba
Manaus
Careiro
Rio Preto da Eva
Careiro da Várzea
Autazes
Itacoatiara
Silves
Urucurituba
Itapiranga
São Sebastião do Uatumã
Boa Vista do Ramos
Barreirinha
Faro
Nhamundá
Parintins
Terra Santa
Juruti
Oriximiná
Óbidos
Curuá
Belterra
Urucará
Alenquer
Santarém
Monte Alegre
Prainha
Almeirim
Porto de Moz
Gurupá
Melgaço
Breves
Afuá
Chaves

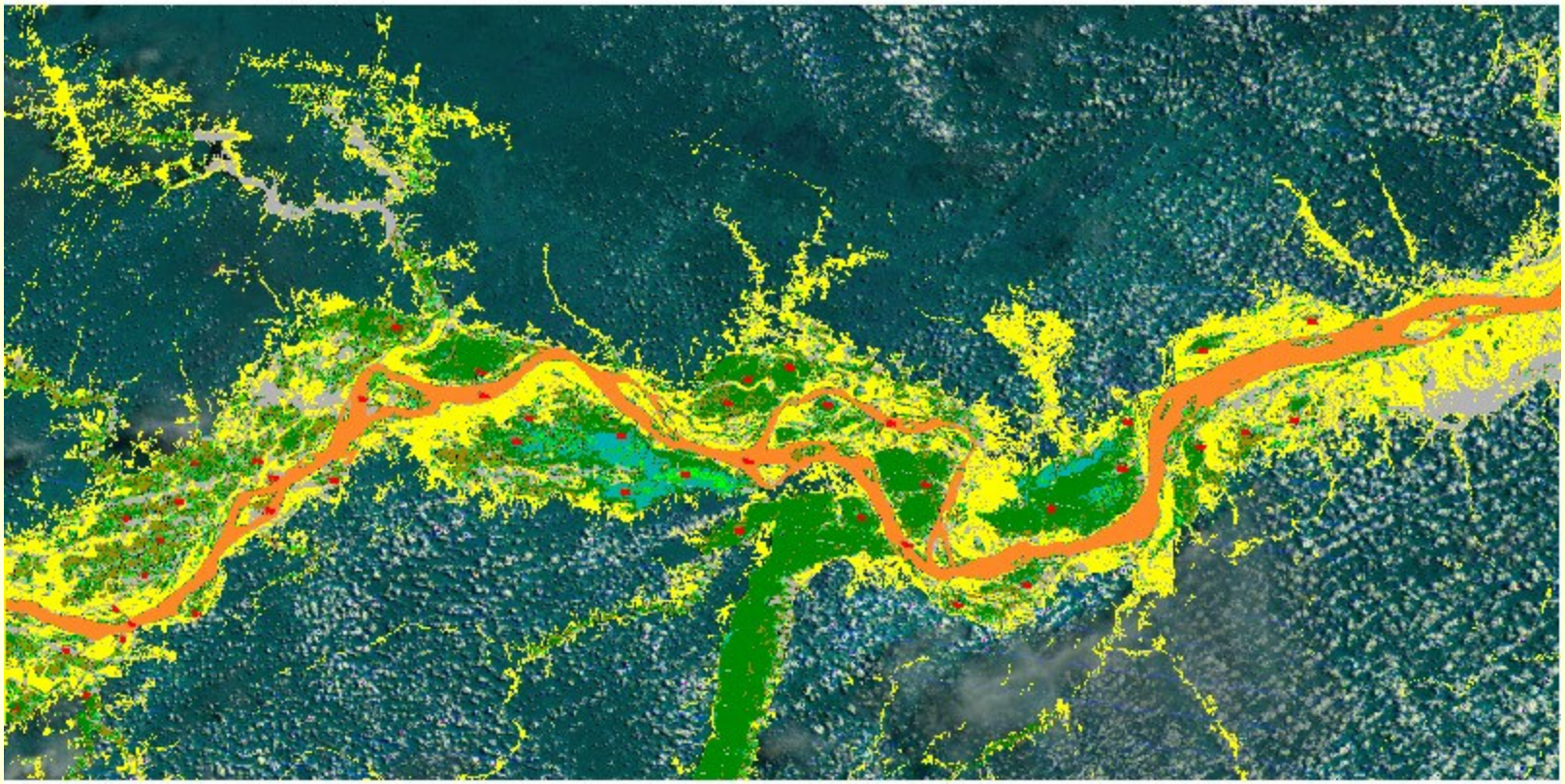

25000
20000
15000
10000
5000
0
Cumulative wetland+buffer deforestion (km²)
0
500
1000
1500
2000
2500
Distance from Belém (km)
Santarém factor
Manaus factor
Tefé/Coari factor

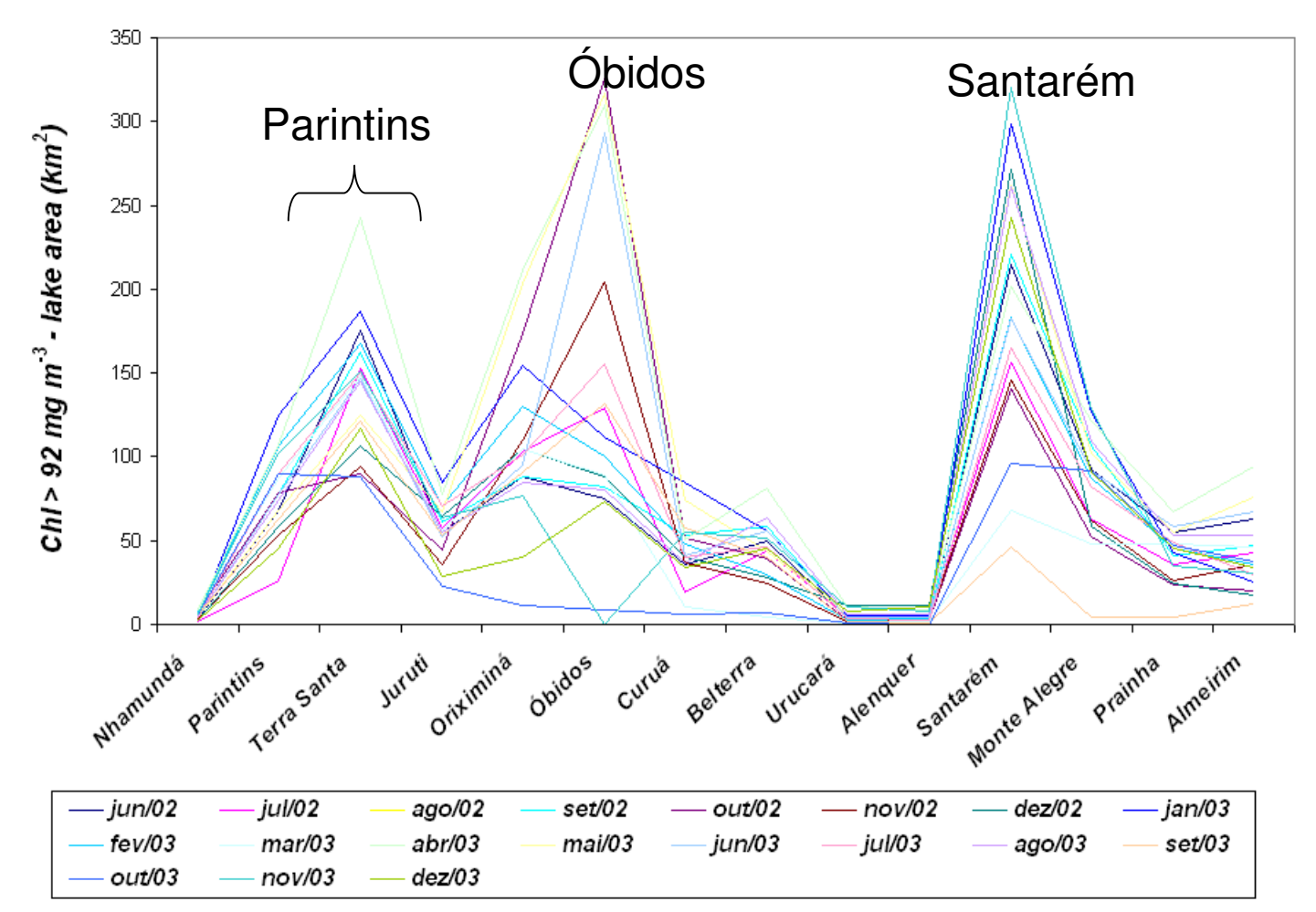
- *What are the consequences of deforestation, cattle ranching, increased human pressure on:*

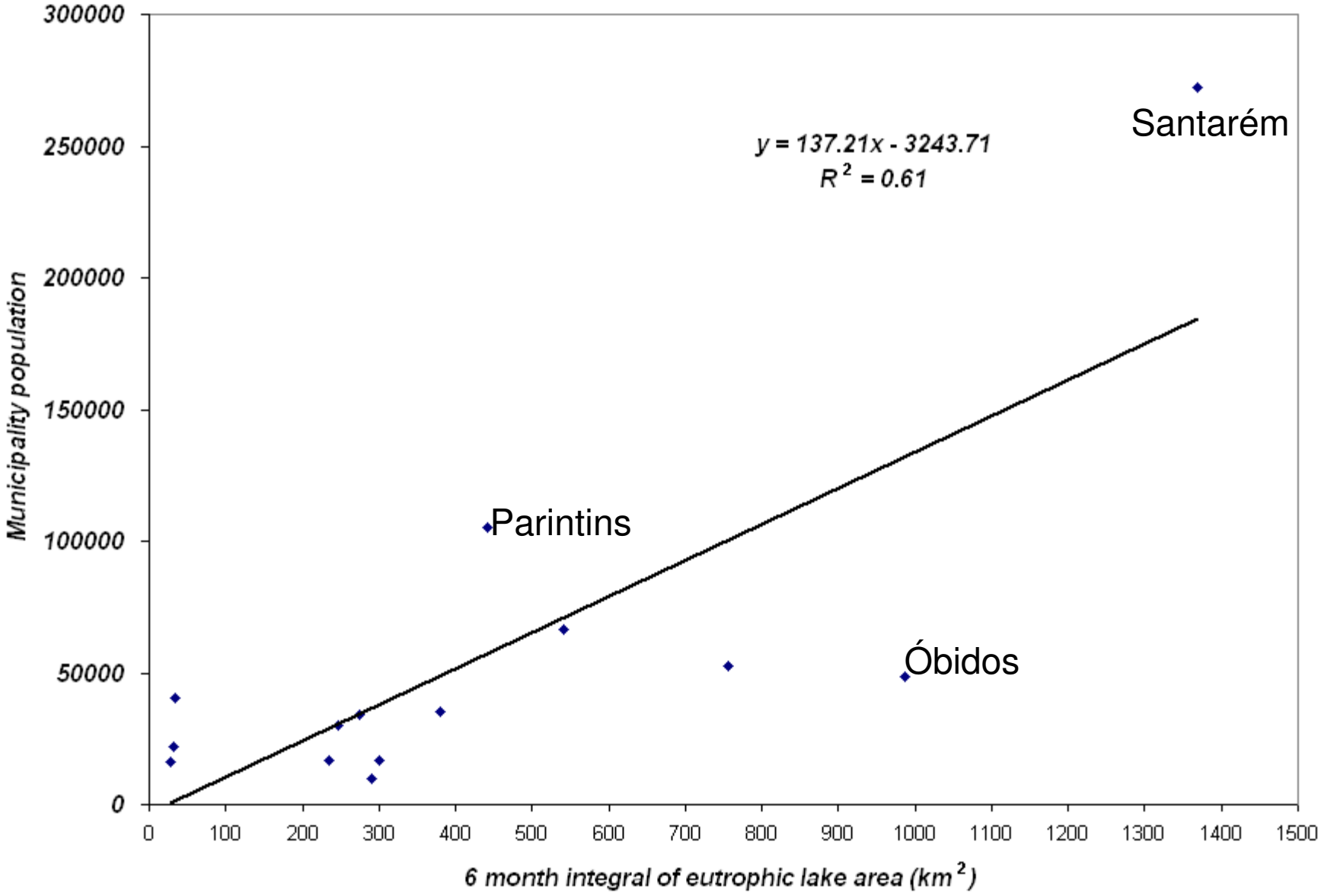
- *algae primary productivity – chl concentration in lake*

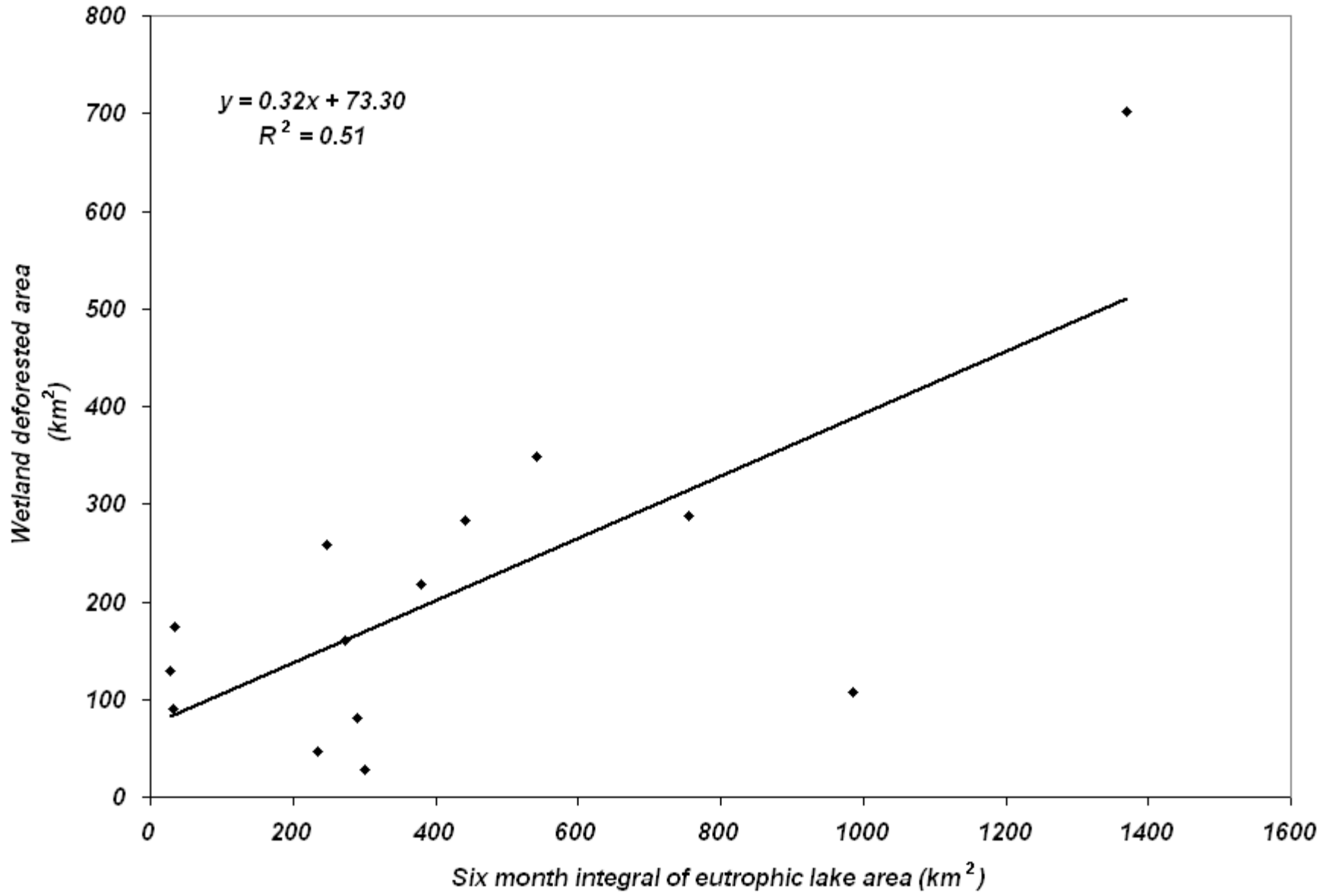
- *Water quality – lake eutrophication resulting from huge inputs of nutrients*

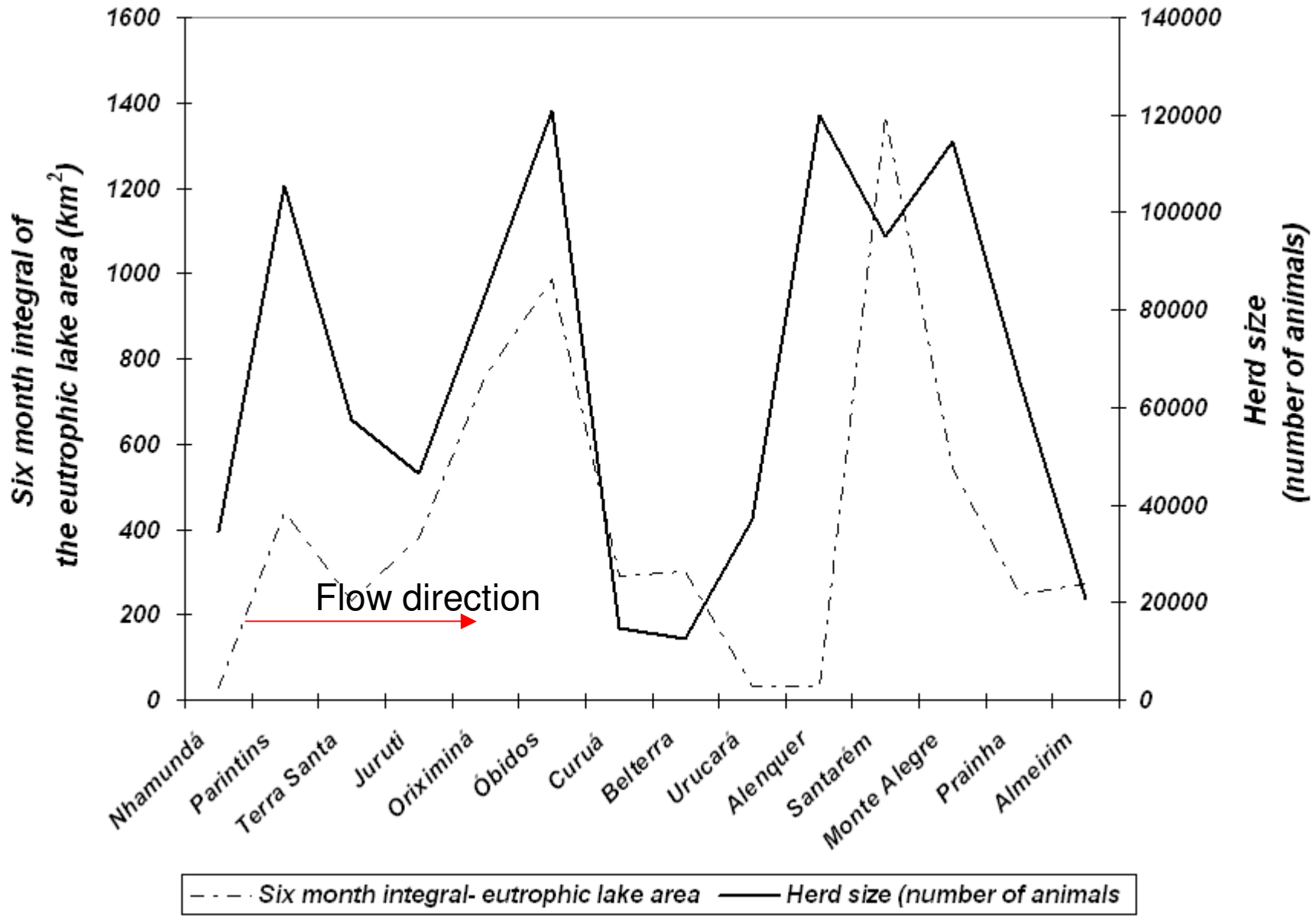

Cumulative area (km²)
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
Phytoplankton
Data available
Tabatinga
São Paulo de Olivença
Amaturá
Santo Antônio do Içá
Tonantins
Jutaí
Japurá
Fonte Boa
Juruá
Maraã
Carauari
Alvarães
Tefé
Coari
Codajás
Anori
Anamã
Beruri
Caapiranga
Manacapuru
Manaquiri
Iranduba
Manaus
Careiro
Rio Preto da Eva
Careiro da Várzea
Autazes
Itacoatiara
Silves
Urucurituba
Itapiranga
São Sebastião do Uatumã
Boa Vista do Ramos
Barreirinha
Paro
Nhamundá
Parintins
Terra Santa
Juruti
Oriximiná
Óbidos
Curuá
Belterra
Urucará
Alenquer
Santarém
Monte Alegre
Prainha
Almeirim
Porto de Moz
Gurupá
Melgaço
Breves
Afuá
Chaves


CLORO_A_<20
CLORO_B_20a56
CLORO_C_56a92
CLORO_D_92a110
CLORO_E_>110


Parintins
Óbidos
Santarém
Chl > 92 mg m-3 - lake area (km2)
350
300
250
200
150
100
50
0
Nhamundá
Parintins
Terra Santa
Juruti
Oriximiná
Óbidos
Curuá
Belterra
Urucará
Alenquer
Santarém
Monte Alegre
Prainha
Almeirim
jun/02
jul/02
ago/02
set/02
out/02
nov/02
dez/02
jan/03
fev/03
mar/03
abr/03
mai/03
jun/03
jul/03
ago/03
set/03
out/03
nov/03
dez/03


y = 137.21x - 3243.71
R 2 = 0.61
Santarém
Parintins
Óbidos
Municipality population
6 month integral of eutrophic lake area (km 2)
300000
250000
200000
150000
100000
50000
0
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500


y = 0.32x + 73.30
R 2 = 0.51
Wetland deforested area (km2)
Six month integral of eutrophic lake area (km 2)
0
100
200
300
400
500
600
700
800
0
200
400
600
800
1000
1200
1400
1600


1600
1400
1200
1000
800
600
400
200
0
Six month integral of the eutrophic lake area (km²)
140000
120000
100000
80000
60000
40000
20000
0
Herd size (number of animals)
Flow direction
Nhamundá
Parintins
Terra Santa
Juruti
Oriximiná
Óbidos
Curuá
Belterra
Urucará
Alenquer
Santarém
Monte Alegre
Prainha
Almeirim
Six month integral- eutrophic lake area
Herd size (number of animals

Final considerations

- *Deforestation area in the Amazon River floodplain presents distinct patterns.*
- *Pará state- the deforestation is clearly underestimated because PRODES started after considerable deforestation had took place.*
- *Amazonia state - deforestation is more closely connected to the presence of cattle ranching in the floodplain.*
- *In spite of the limited samples on chlorophyll concentration, the results suggests a clear connection between cattle ranching and the occurrence of large areas of eutrophic water*