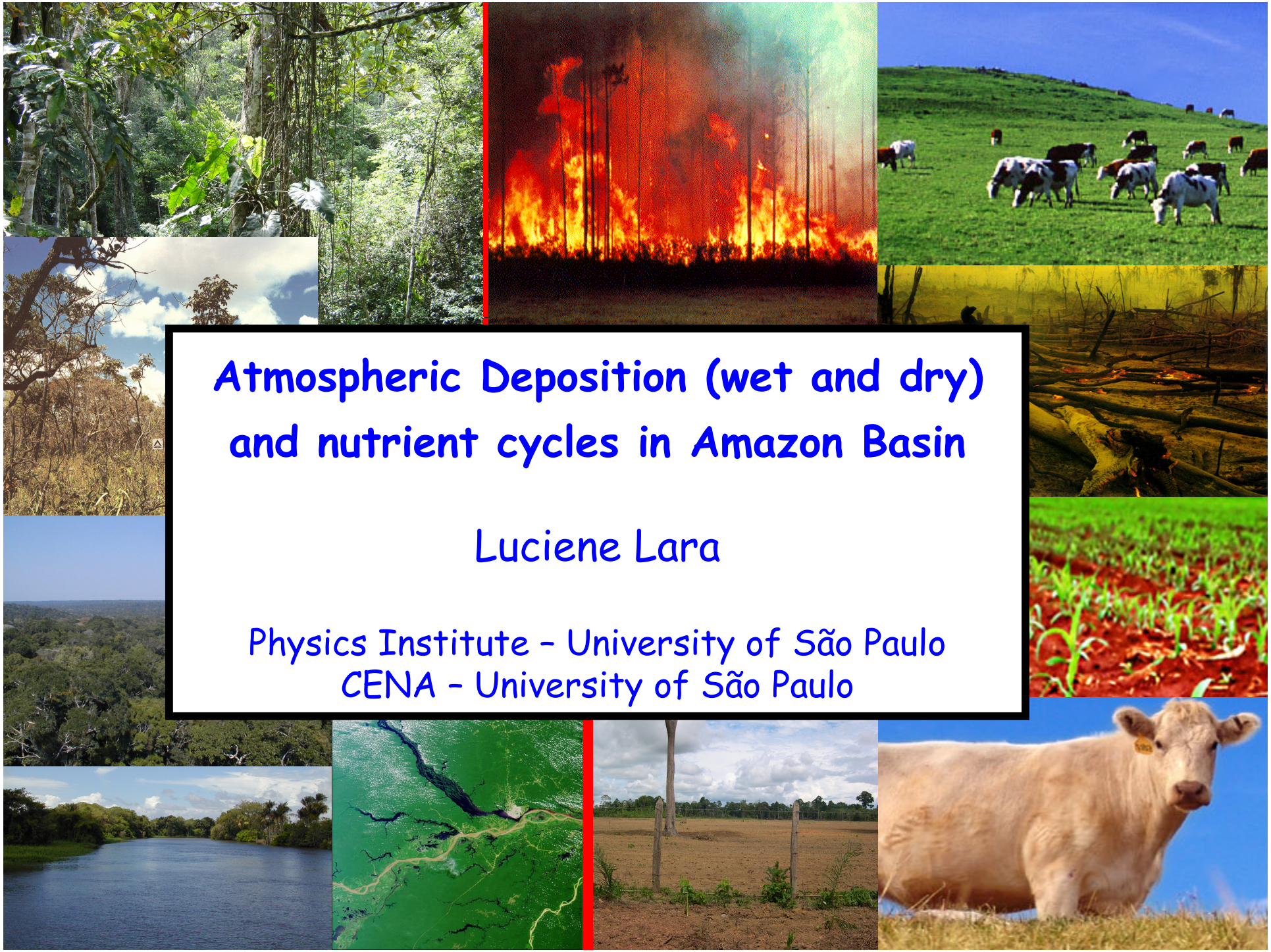

Atmospheric Deposition (wet and dry) and nutrient cycles in Amazon Basin

Luciene Lara

Physics Institute – University of São Paulo
CENA – University of São Paulo

How anthropogenic activities are changing the aerosol, rainwater chemistry and nutrient deposition?


AMAZONIA
LBA


Pristine areas


Disturbed areas


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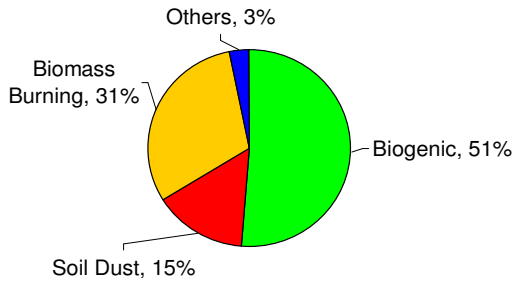
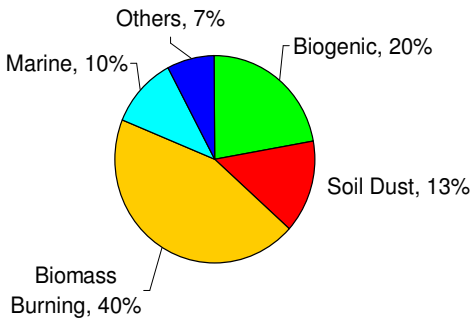
Fine Mode Aerosol Source Apportionment

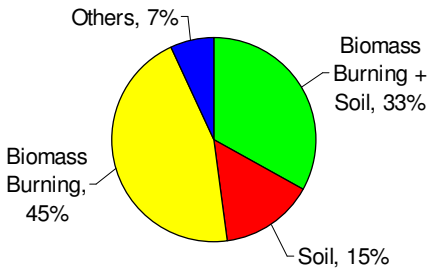
$PM_{2.5}$ Wet Season



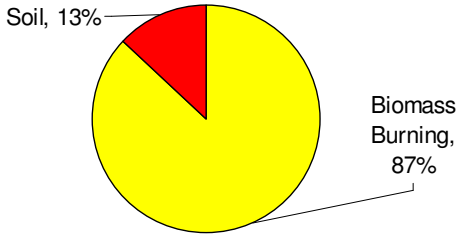
$PM_{2.5}$ Dry Season



$PM_{2.5}$ Wet Season

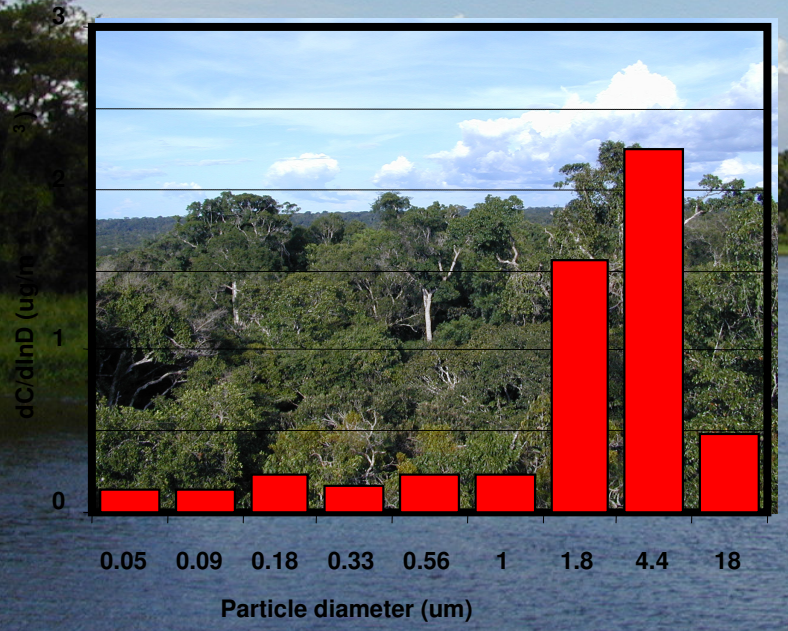


$PM_{2.5}$ Dry Season

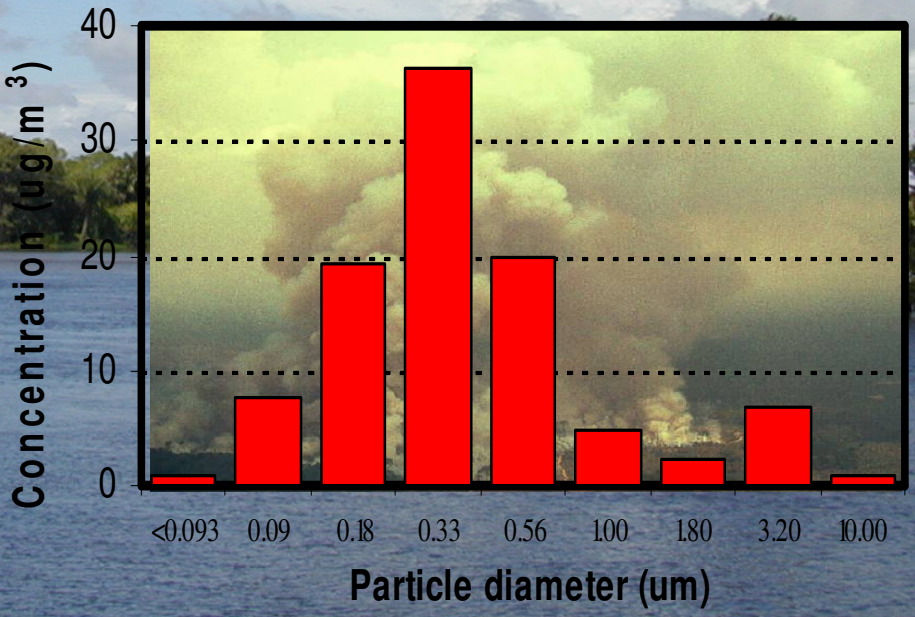


Aerosol size distribution in Amazonia

Balbina

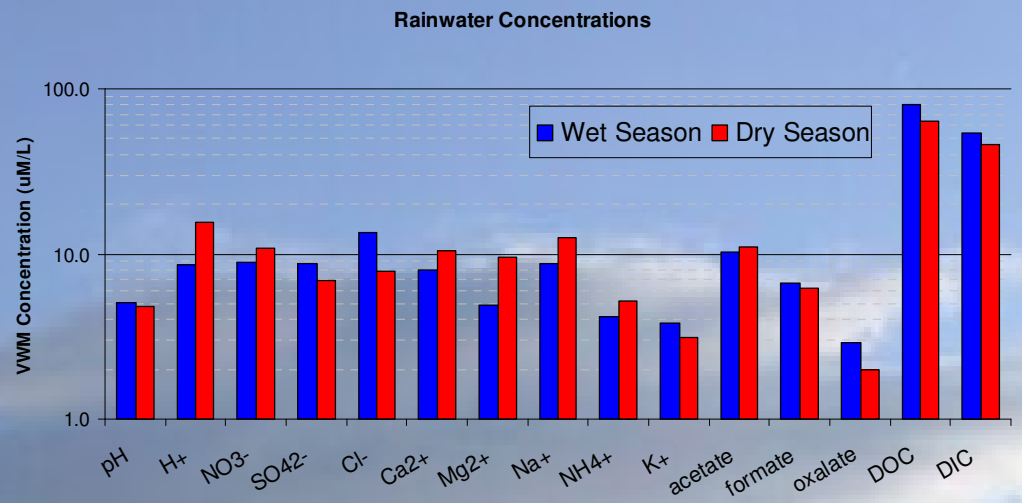


Rondonia

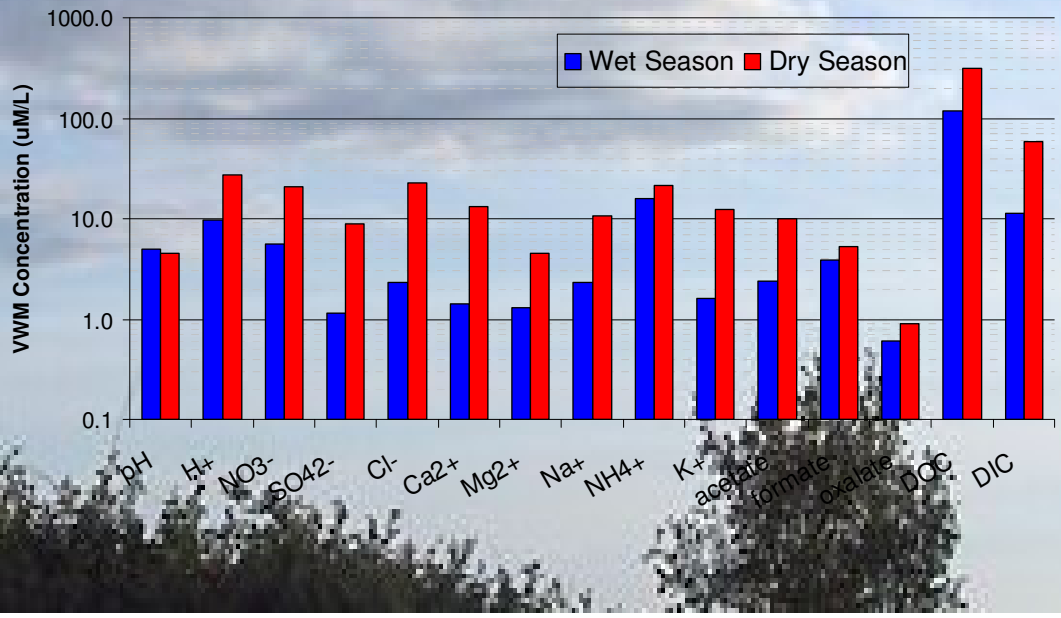


Rainwater chemical composition in Amazonia

Balbina



Rondonia



Main sources of rainwater in Central Amazon

	Biogenic Marine	Organic acidity	BIO 1	BIO 2	BIO 3	COM
Na^+	**0.89**	0.29	0.15	0.24	0.10	*0.97*
Cl^-	**0.87**	0.35	0.14	0.14	0.06	*0.92*
$SO4^{2-}$	**0.85**	0.34	0.28	0.15	0.12	*0.95*
K^+	**0.83**	0.17	**0.38**	0.13	0.13	*0.90*
Mg^{2+}	**0.79**	0.48	0.20	0.25	0.18	*0.98*
Ca^{2+}	**0.76**	0.48	0.20	0.22	0.15	*0.92*
NO_3^-	**0.69**	**0.56**	0.26	0.15	0.24	*0.94*
CH_3COO^-	0.37	**0.84**	0.16	0.11	0.10	*0.89*
H^+	**0.57**	**0.76**	0.12	0.08	0.13	*0.94*
$C_2O_4^{2-}$	0.34	**0.52**	**0.52**	0.35	0.16	*0.80*
NH_4^+	0.30	0.15	**0.91**	0.07	0.04	*0.94*
PO_3^{4-}	0.26	0.13	0.10	**0.94**	0.06	*0.98*
$C_6H_5O_7^{3-}$	0.17	0.14	0.06	0.06	**0.97**	*1.00*
Variance (%)	41	21	12	10	9	

Sea salt aerosols and biogenic emissions

Acidity from biogenic emissions

Biogenic Emissions

Main sources of rainwater in Rondonia

	Biogenic Marine	Organic acidity	Biomass burning	H_2SO_4 acidity	COM
Na^+	**0.88**	0.17	0.37	0.10	*0.94*
Ca^{++}	**0.87**	0.31	0.01	0.15	*0.88*
Cl^-	**0.70**	0.18	**0.55**	0.32	*0.92*
DOC	0.15	**0.94**	0.16	0.01	*0.92*
Mg^{++}	0.35	**0.84**	0.20	0.18	*0.89*
NO_3^-	0.17	0.21	**0.87**	0.13	*0.85*
K^+	**0.58**	0.14	**0.64**	0.23	*0.82*
H^+	0.18	**0.54**	**0.60**	**0.46**	*0.89*
SO_4^{--}	0.21	0.10	0.21	**0.93**	*0.97*
Variance (%)	29	23	23	15	

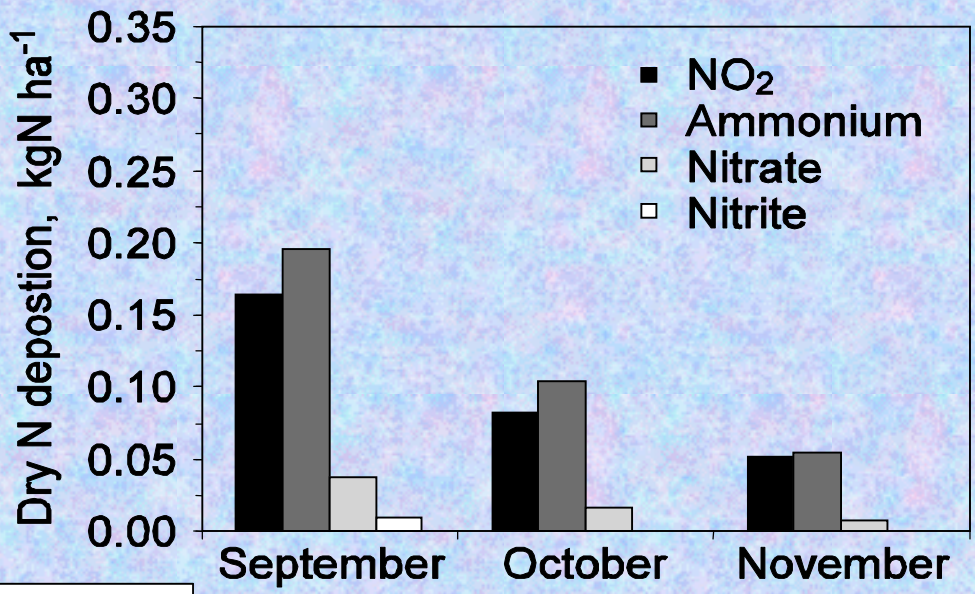
Inorganic acidity

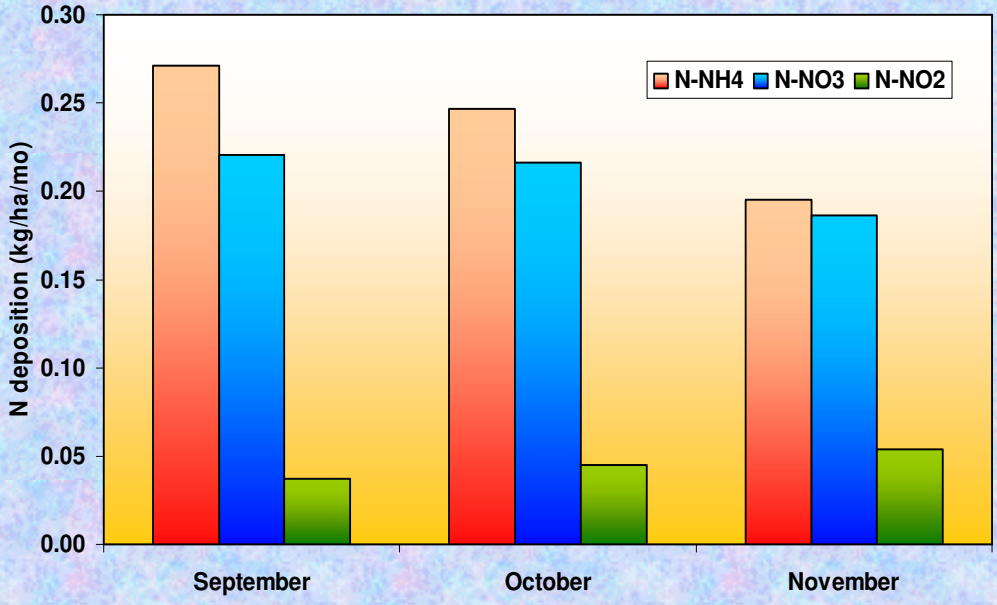
N wet deposition ($kg.N.ha^{-1}.yr^{-1}$)

N wet deposition – kg $N.ha^{-1}.yr^{-1}$	
Balbina *	2.9
Central Amazon**	2.8
Pristine Atlantic Forest *	3.2
Rondônia *	5.7
Disturbed Atlantic Forest***	5.6

* Lara et al., 2004; 2005 , ** Williams et al., 1997, *** Lara et al., 2001

Dry and wet deposition of N in a transition dry – wet season in Rondonia



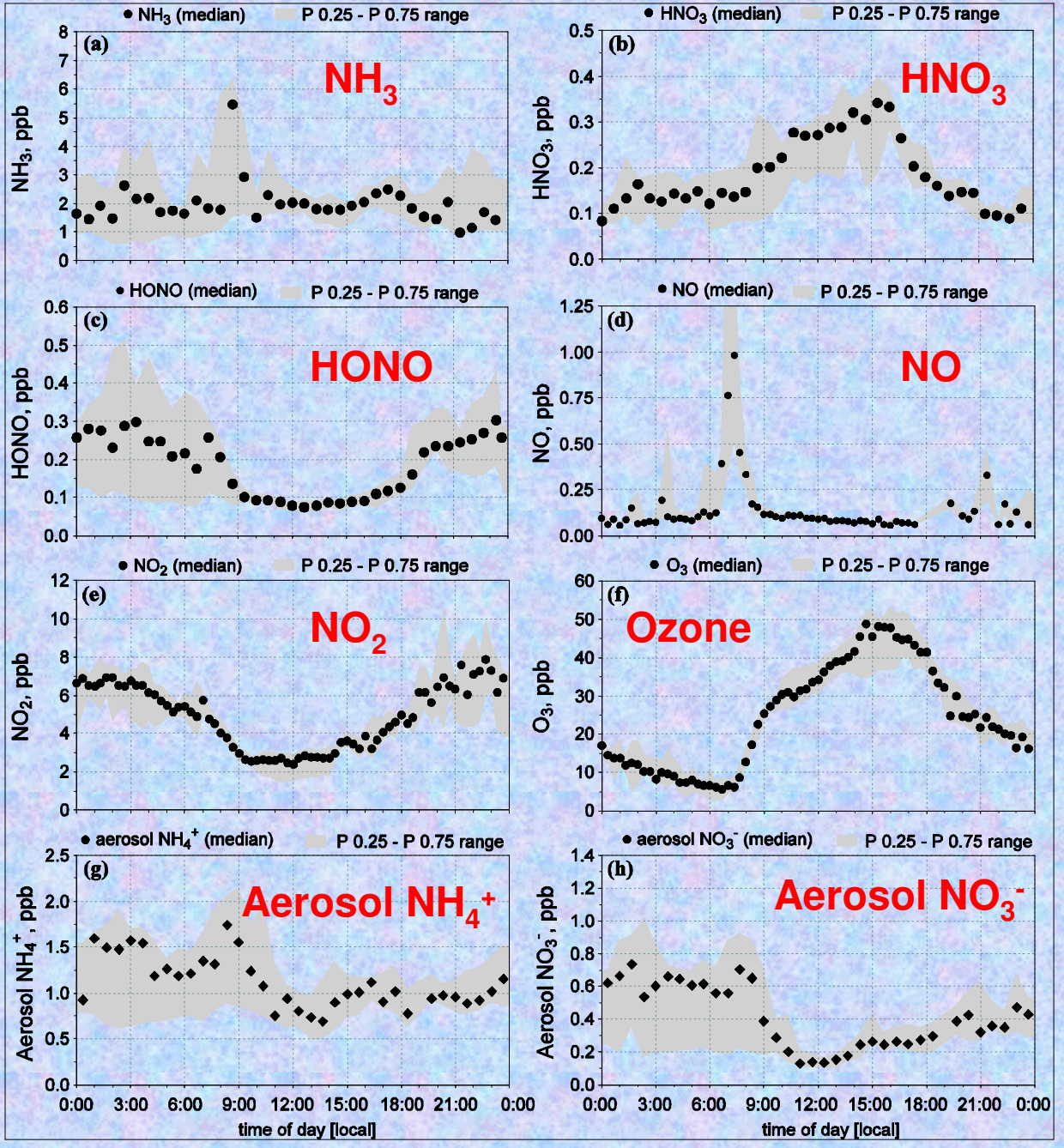


Trebbs et al., 2006; Lara et al., 2006

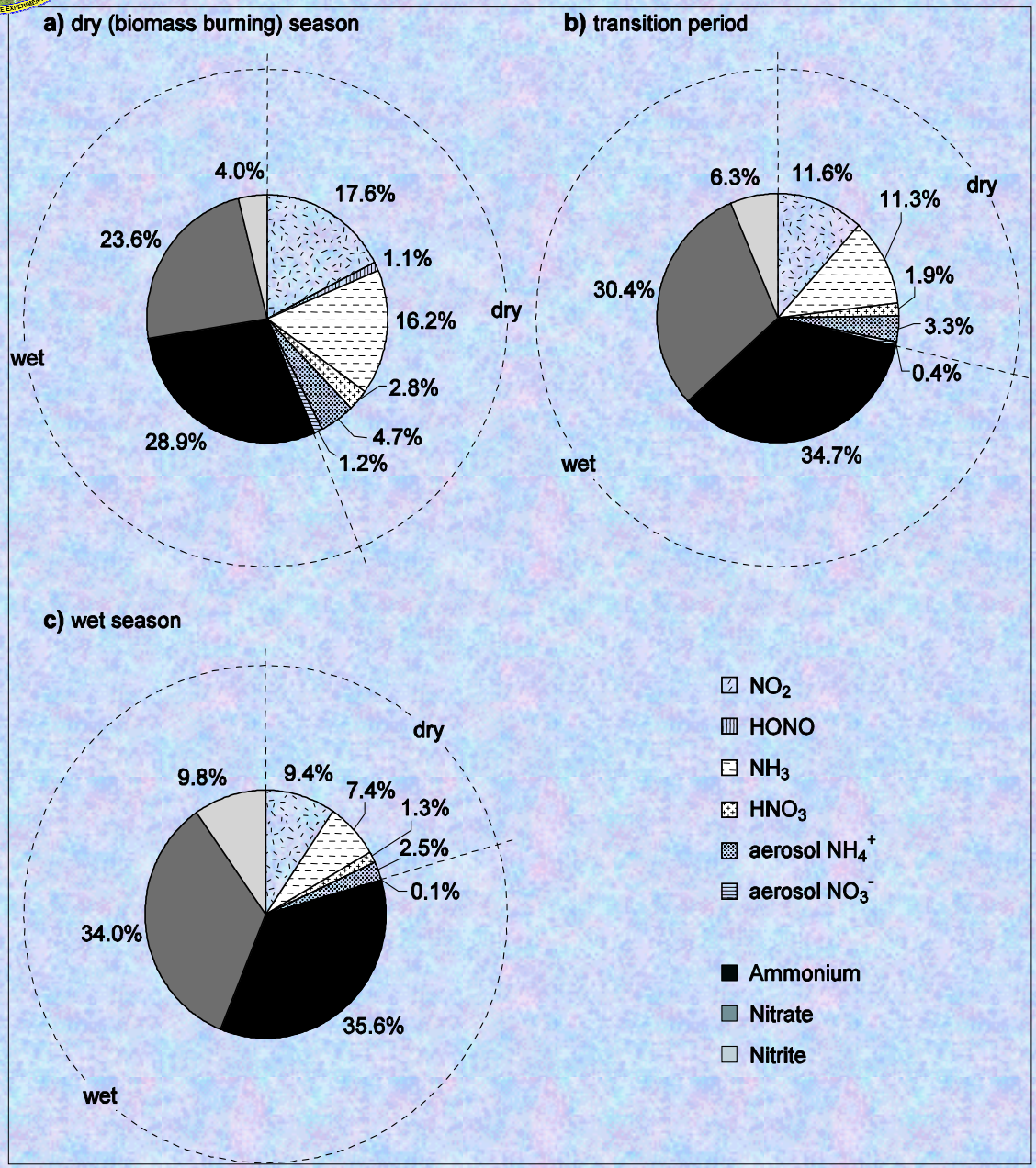
Diurnal variability of nitrogen compounds in Amazonia

Diurnal variation of: (a) NH_3, (b) HNO_3, (c) HONO, (d) NO, (e) NO2, (f) O_3, (g) aerosol NH4+ (PM 2.5) e (h) aerosol NO3– (PM 2.5). Measurements at the dry-wet season transition in Rondonia.

Trebbs et al., 2006



N total deposition in Rondonia, Amazonia



- N dry deposition ranges from 22 to 42 %.

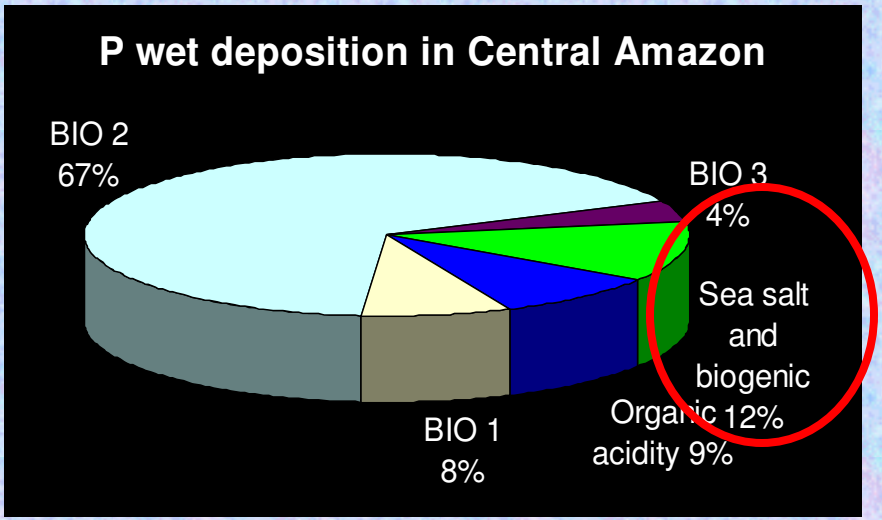
-N wet deposition is dominant even during dry season.

Annual N total deposition: 7 kgN/ha/yr

Phosphorous Wet deposition in Amazon Basin

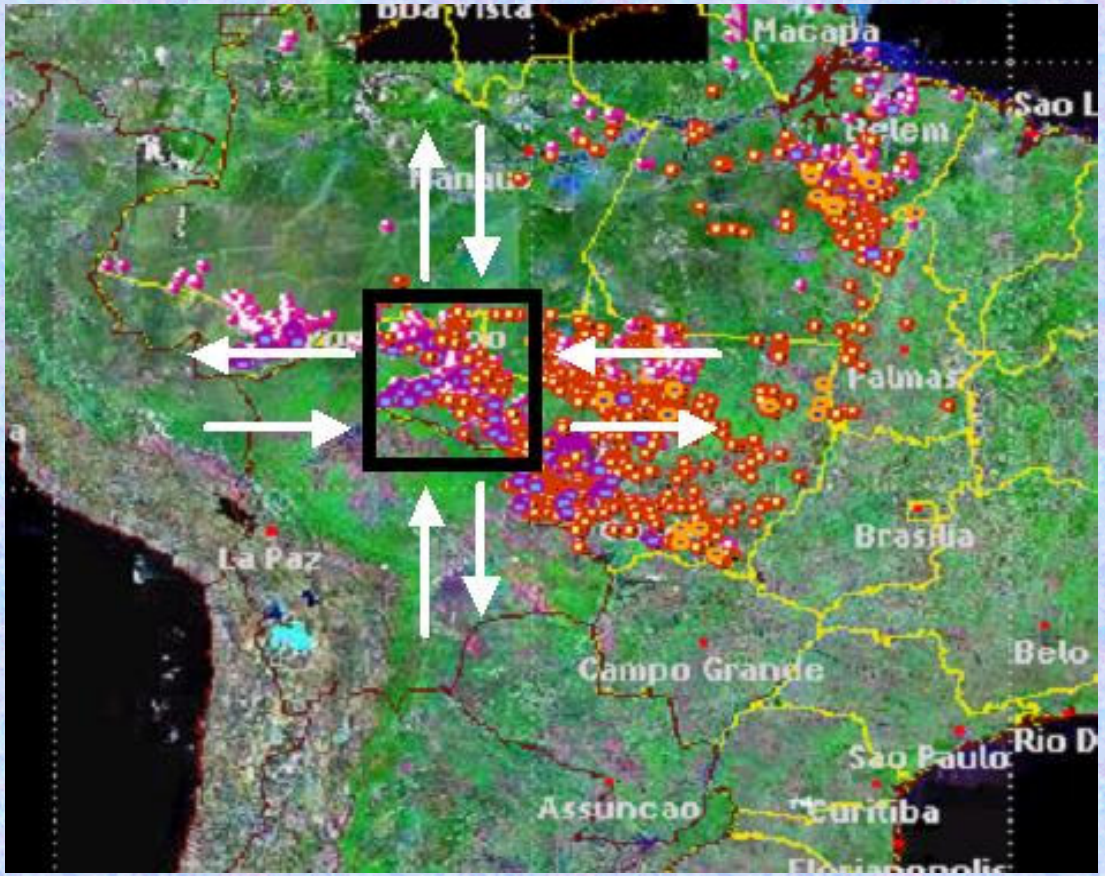
	K	Mg	Ca	P
Saldo do fluxo em Rondônia setembro	1.3E+09	2.8E+08	2.4E+07	3.2E+07
Saldo do fluxo em Rondônia outubro	8.3E+08	1.8E+08	1.6E+07	2.1E+07
Extrapolação para a Amazônia	3.0E+10	6.6E+09	5.7E+08	**7.6E+08**
Porcentagem da ciclagem	4.6%	2.1%	0.1%	**85%**

Íon	Deposition (kg)
K	$6.5\ 10^{8}$
Mg	$3.1\ 10^{8}$
Ca	$4.6\ 108^{18}$
P (PO_4^{3-})	$9.0\ 10^{5}$



Pauliquevis thesis, 2005

Exportation of nutrients trough biomass burning: Special case - P

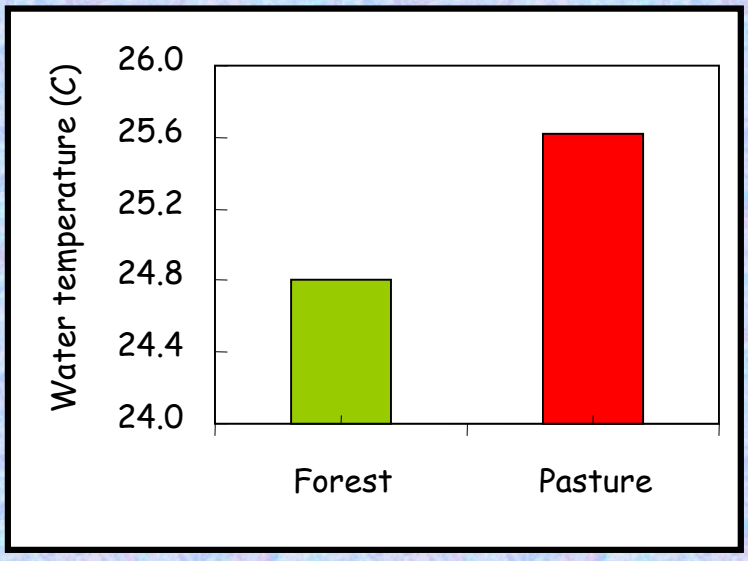


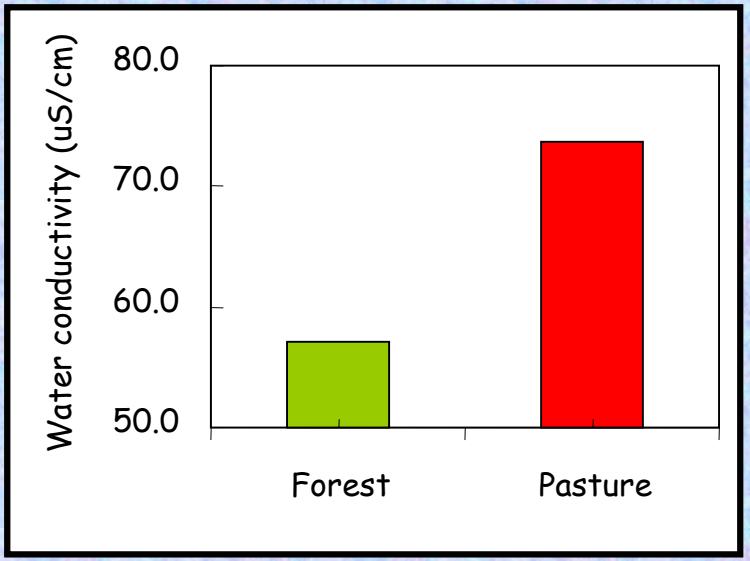
Synthesis of values of phosphorus wet deposition and the corresponding exported amount. One can see that the deposited and exported quantities are quite similar. However, considering only the deposition due to long range transport of phosphorus, the exportation of phosphorus is about 10 times higher.

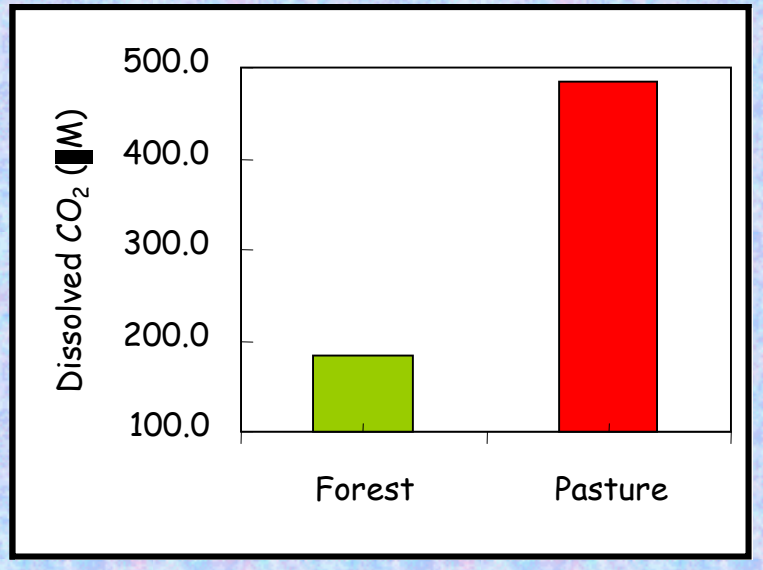
Total measured wet deposition of phosphorus ($mg/m^2/year$)	0.16
Integrated deposition in whole Amazonia (g/yr)	$9.0\ 10^8$
Phosphorus deposition only due to long range transport (g/yr)	$1.1\ 10^8$
Particulate phosphorus exportation - whole Amazonia (g)	$7.3\ 10^8$

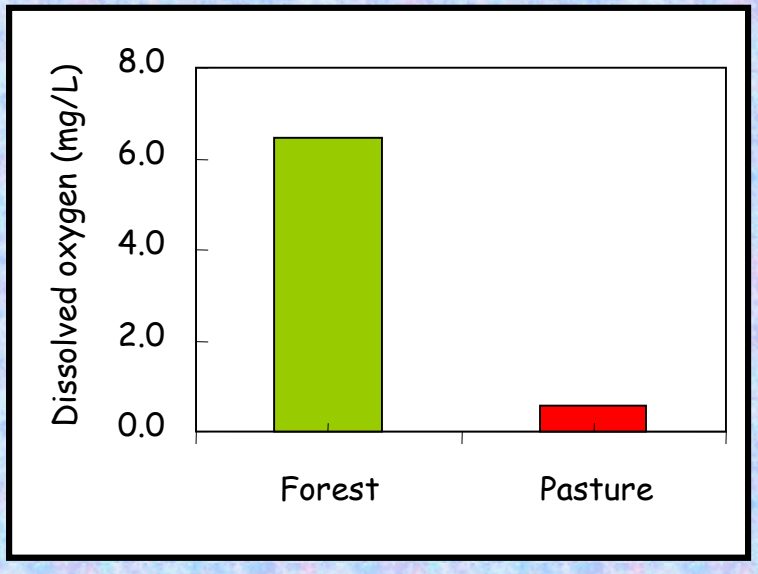
Implications to the ecosystems

Implications to the ecosystems – Rondonia, Amazonia



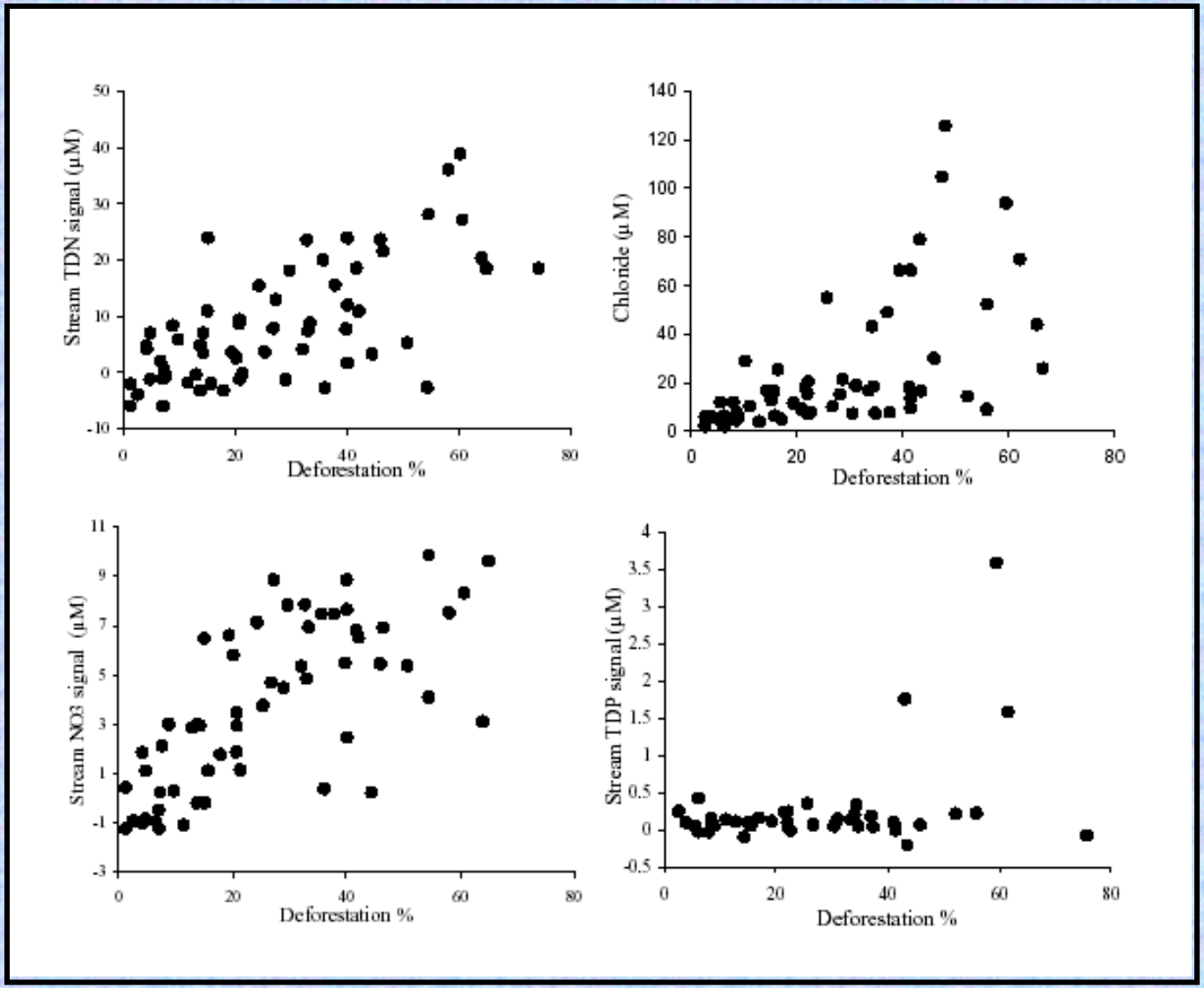




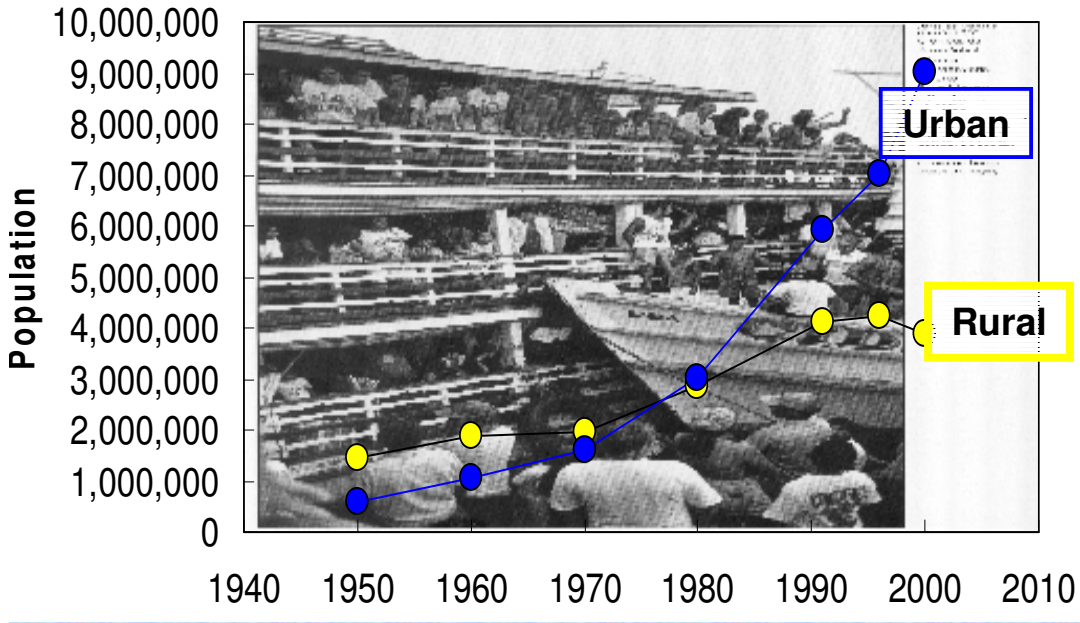


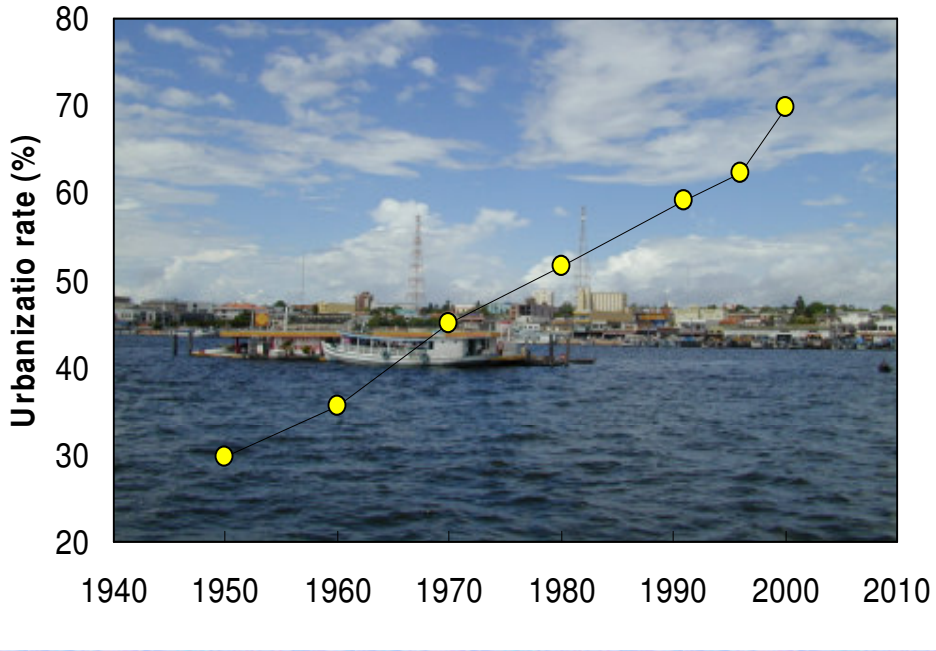
Source: Luis Fernando Charbel thesis

Implications to the ecosystems

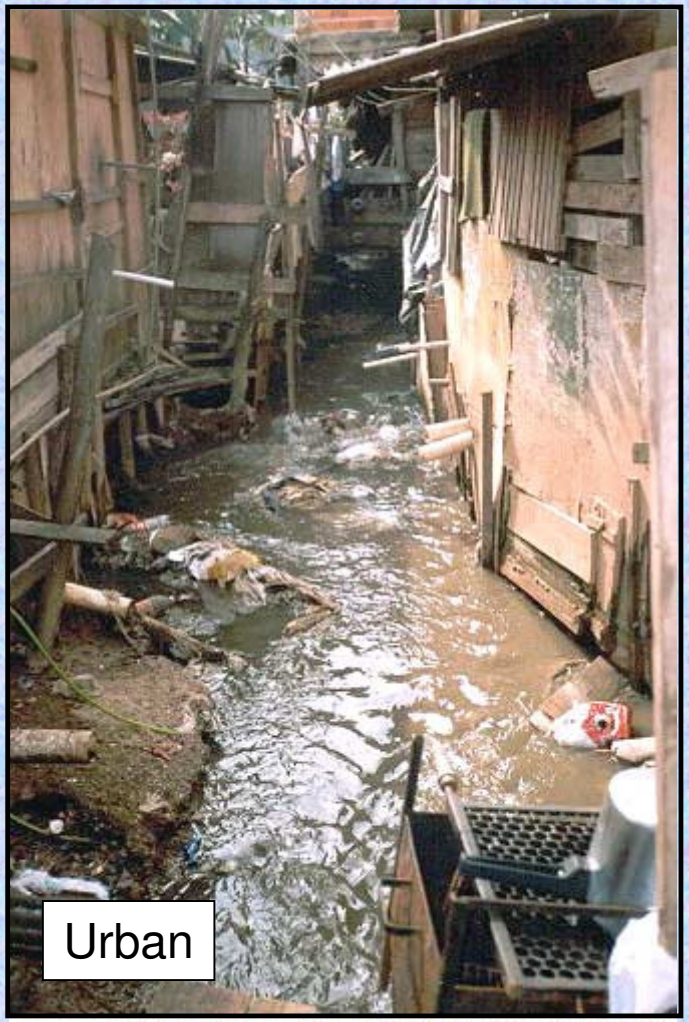


Source: Biggs et al. (2003) – Biogeochemistry

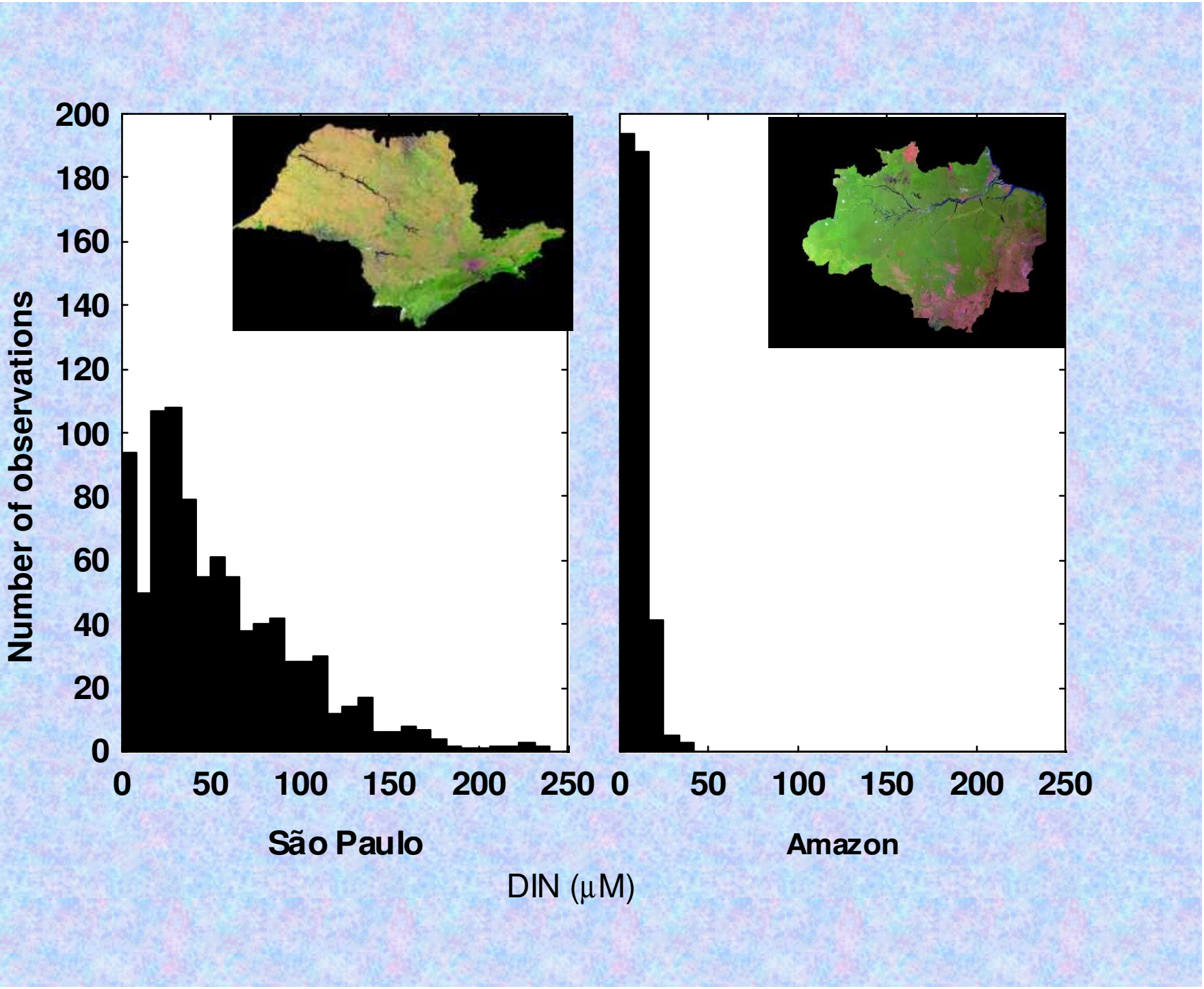

Population
10,000,000
9,000,000
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
1940
1950
1960
1970
1980
1990
2000
2010
Urban
Rural

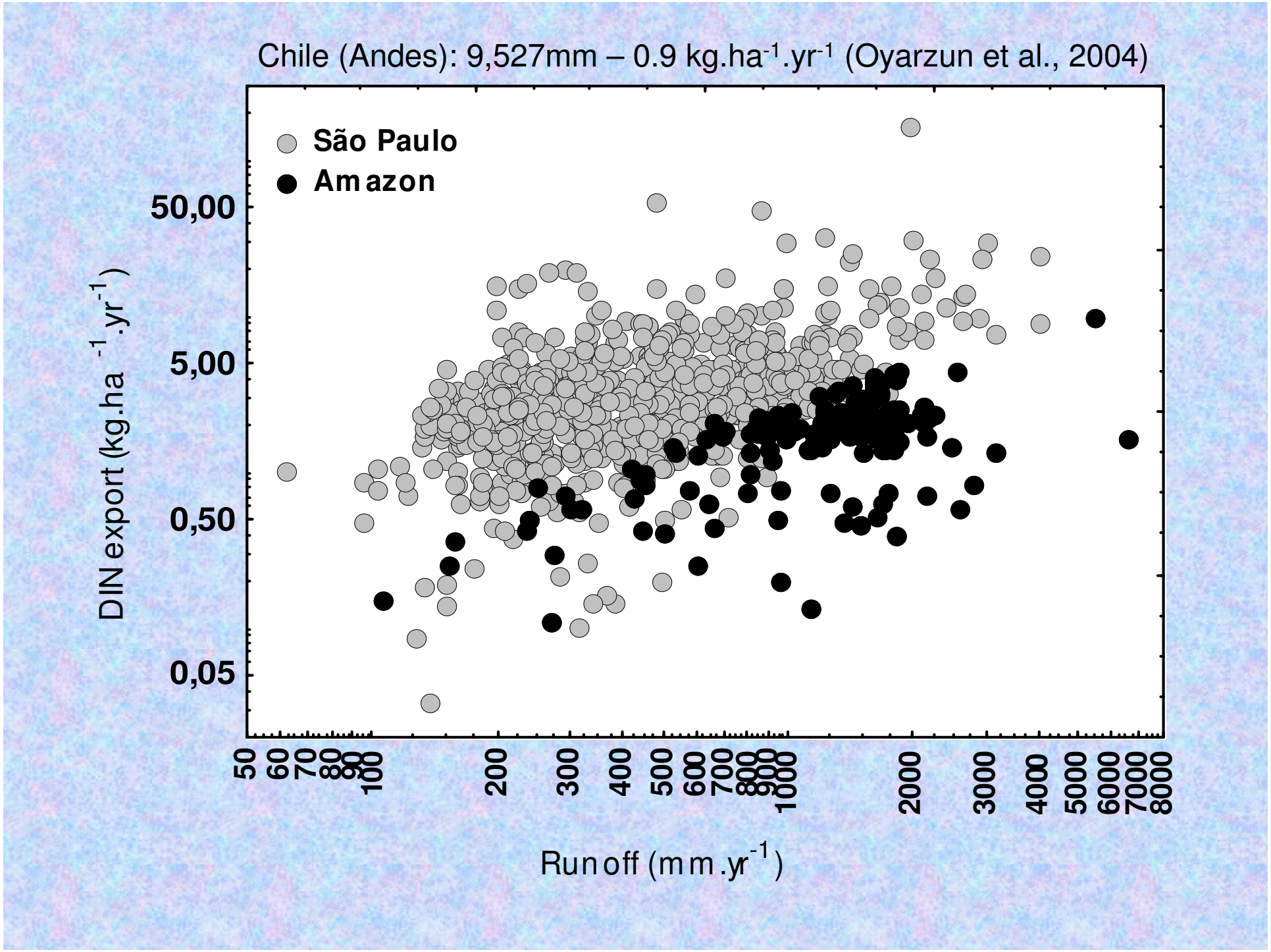

Urbanizatio rate (%)
80
70
60
50
40
30
20
1940
1950
1960
1970
1980
1990
2000
2010

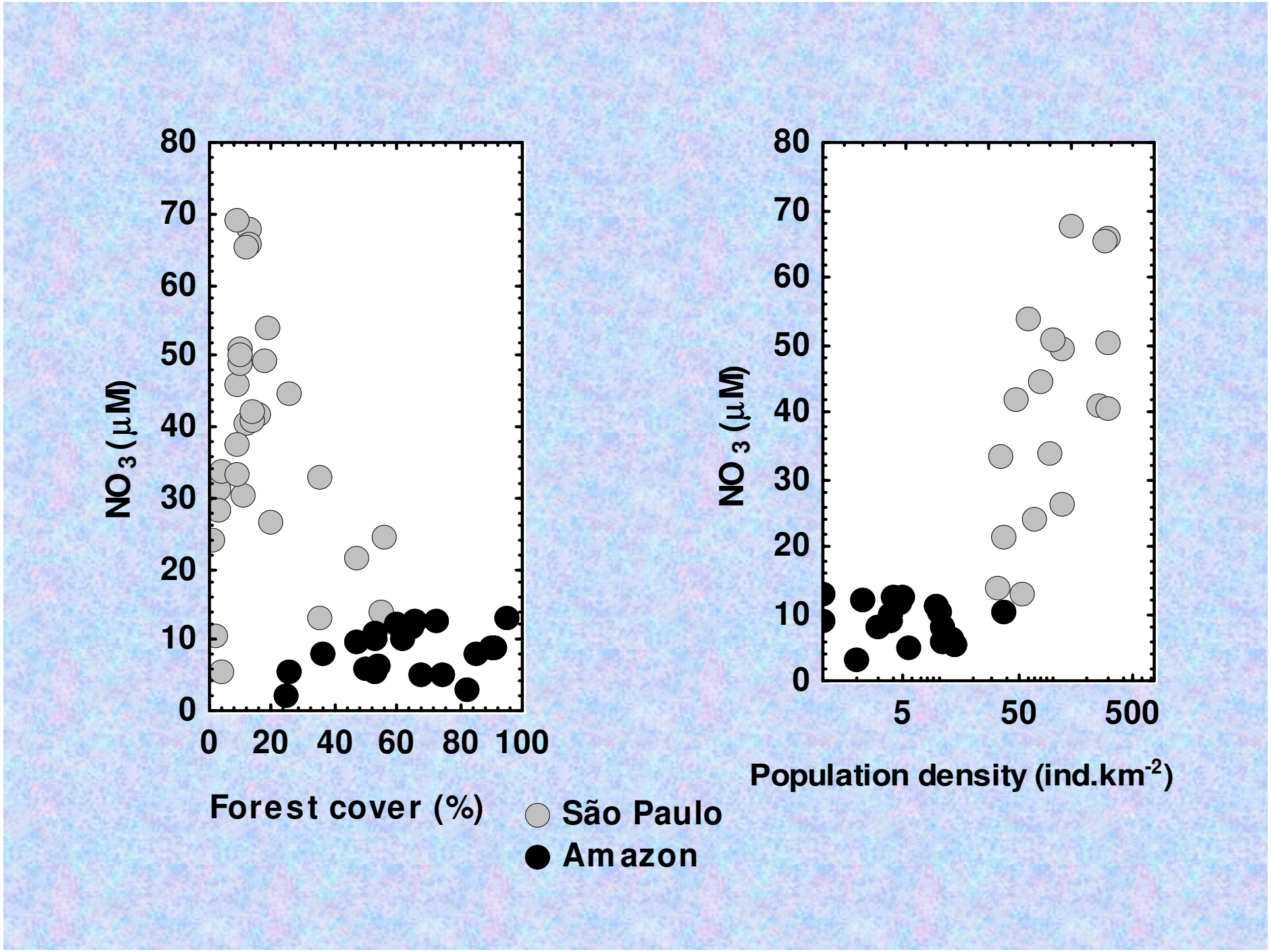
State of São Paulo – streams and creeks



Atlas Ambiental do Município de São Paulo


Number of observations
200
180
160
140
120
100
80
60
40
20
0
0
50
100
150
200
250
São Paulo
0
50
100
150
200
250
Amazon
DIN (μM)


Chile (Andes): 9,527mm – 0.9 kg.ha-1.yr-1 (Oyarzun et al., 2004)
São Paulo
Amazon
50,00
5,00
0,50
0,05
DIN export (kg.ha-1.yr-1)
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000
2000
3000
4000
5000
6000
7000
8000
Runoff (mm.yr-1)


80
70
60
50
40
30
20
10
0
NO_3 (µM)
0
20
40
60
80
100
Forest cover (%)
São Paulo
Amazon
80
70
60
50
40
30
20
10
0
NO_3 (µM)
5
50
500
Population density (ind.km^{-2})

Conclusions:

Land-use changes ---- changes in atmospheric deposition

1. **Link between atmospheric deposition and terrestrial and aquatic systems**

2. **Changes in the dynamics of the streams**

3. **"Signs" of urbanization and pasture have been seen in rivers in Rondonia, but most of that are still unknown.**

Important implications to the regional cycles

Wet Removal of fine particulate mode

PM2.5 deposited on the surface/Atlantic ocean