

# Effects of land use change on stream water chemistry in three meso-scale catchments in Eastern Amazonia



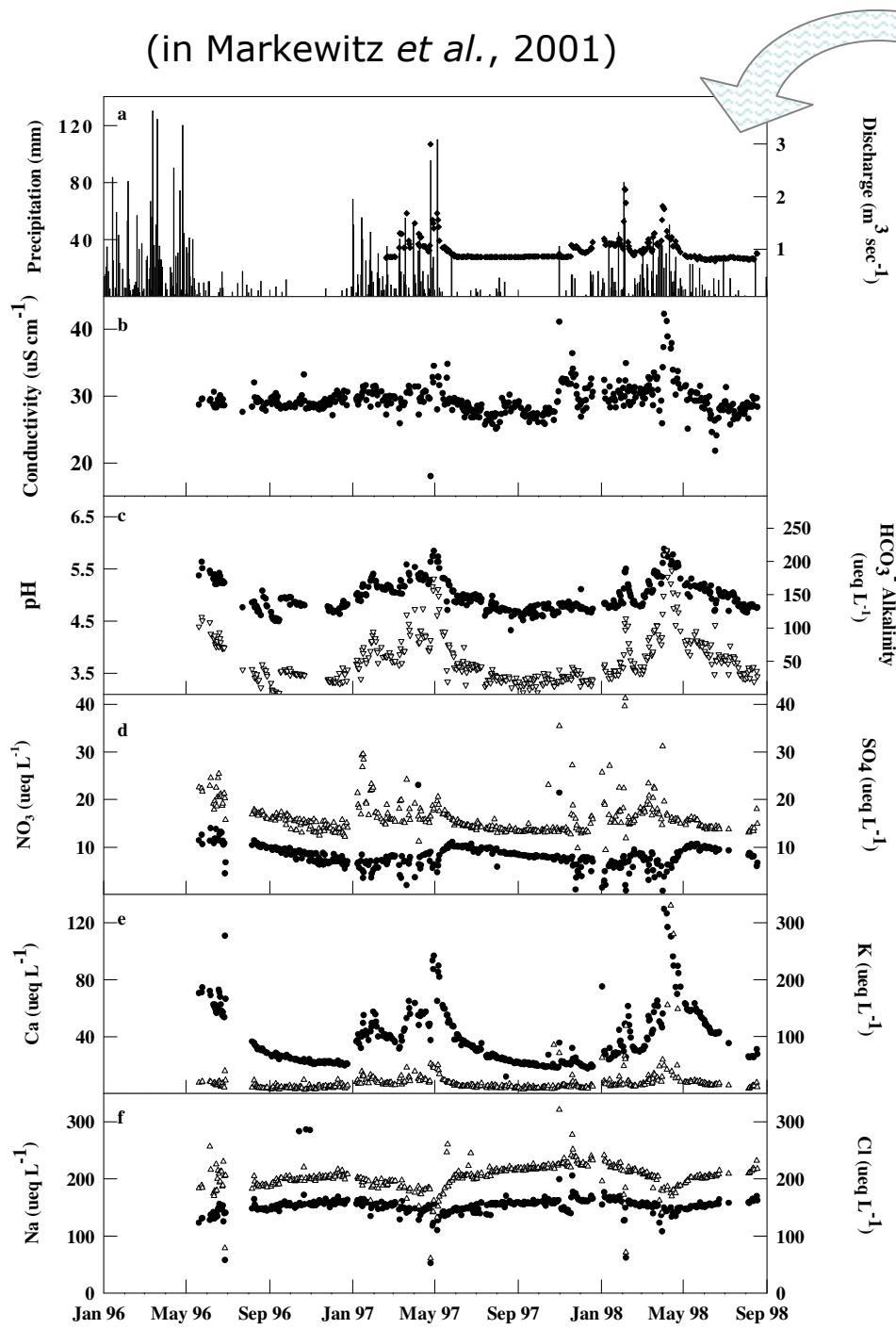
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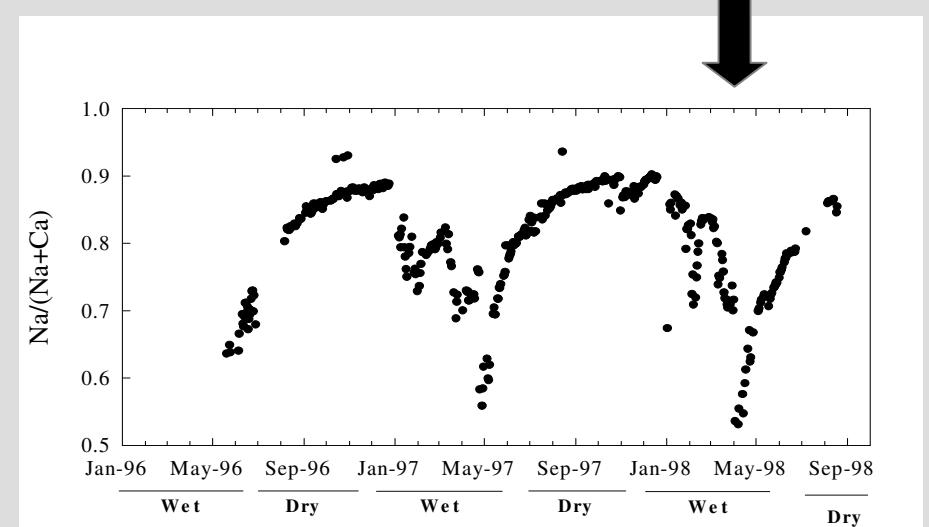
*(ND-02 group, now ND-30 in Phase III = Synthesis of nutrient cycling processes in pastures, secondary forests, and streams)*

(in Markewitz *et al.*, 2001)



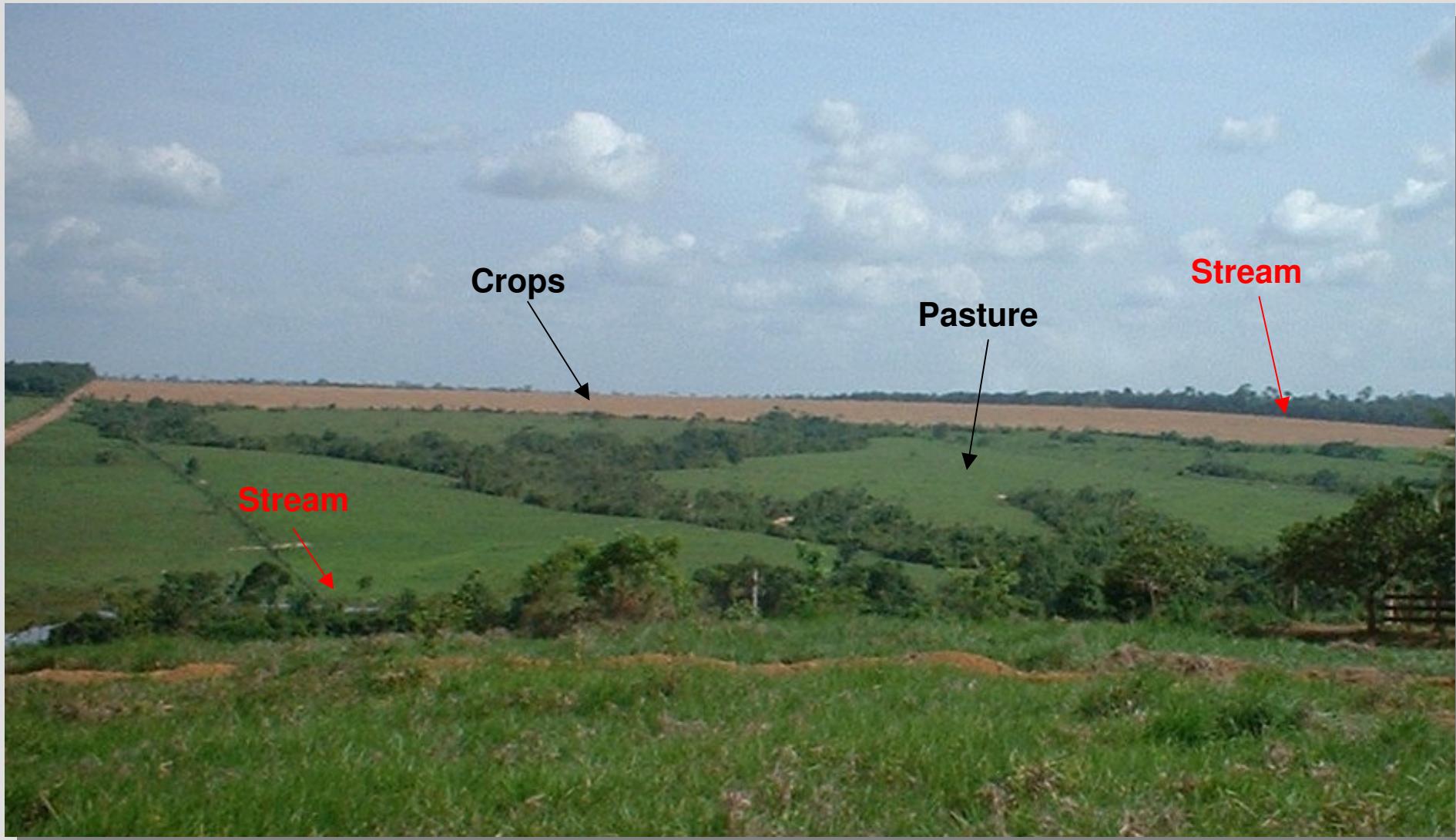
- During higher discharge, higher cations and alkalinity concentrations in stream water (1996-1998).

-  $\text{Na}/(\text{Na}+\text{Ca})$  ratio close to 1 during low discharge = weathering less important as cation source.



\* First points to be answered:  
This pattern also occurs in other catchments? Is this an effect of land use change?

## Landscape in Transformation: from Pastures to Croplands



\* Other question to be answered: what are the effects of these land use change to stream water chemistry?

## Cattle ranches...



**... now are farms with large crop fields of soybean, maize and rice.**



**Three meso-scale catchments in Paragominas (upstream areas from the further downstream sample stations) :**

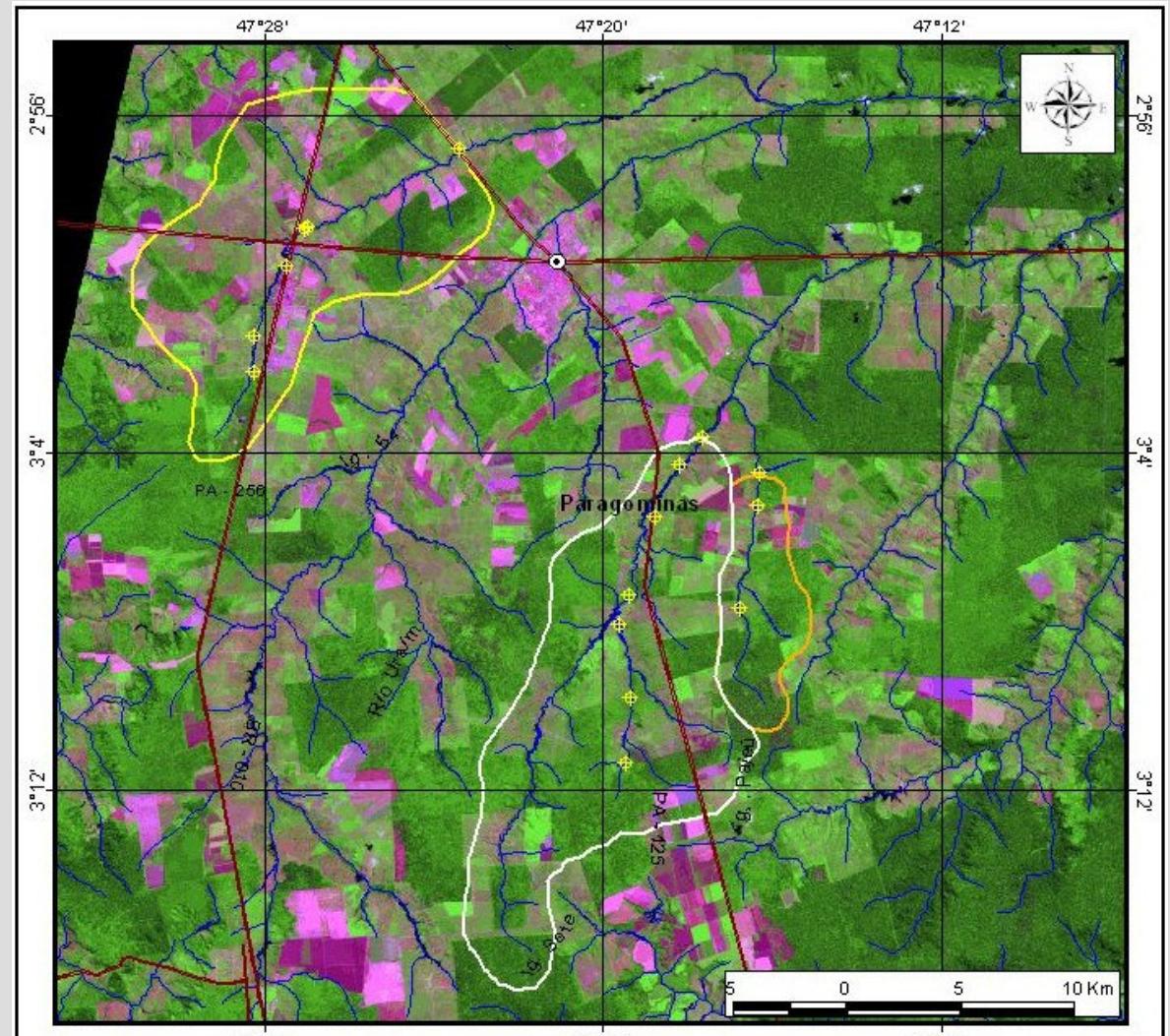
> Igarapé Cinquenta e Quatro (~ 14,000 ha)

> Igarapé do Sete (~ 16,000 ha)

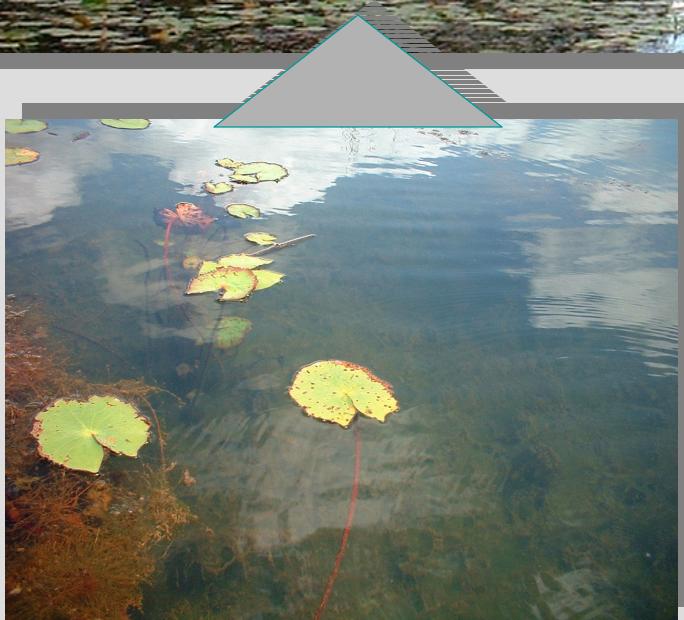
> Igarapé Pajeú (~ 3,200 ha)

**Field campaigns from April/2003 to October/2005, from headwaters in remnant mature forests, through pastures, secondary forests, and crop fields.**

**Upstream-downstream patterns in stream chemical concentrations were assessed with regression analysis relative to percent watershed area in each land use.**



## **Remnant forests at headwaters of do Sete and Pajeú streams**



**at Igarapé 54 headwater  
forest extremely explored**





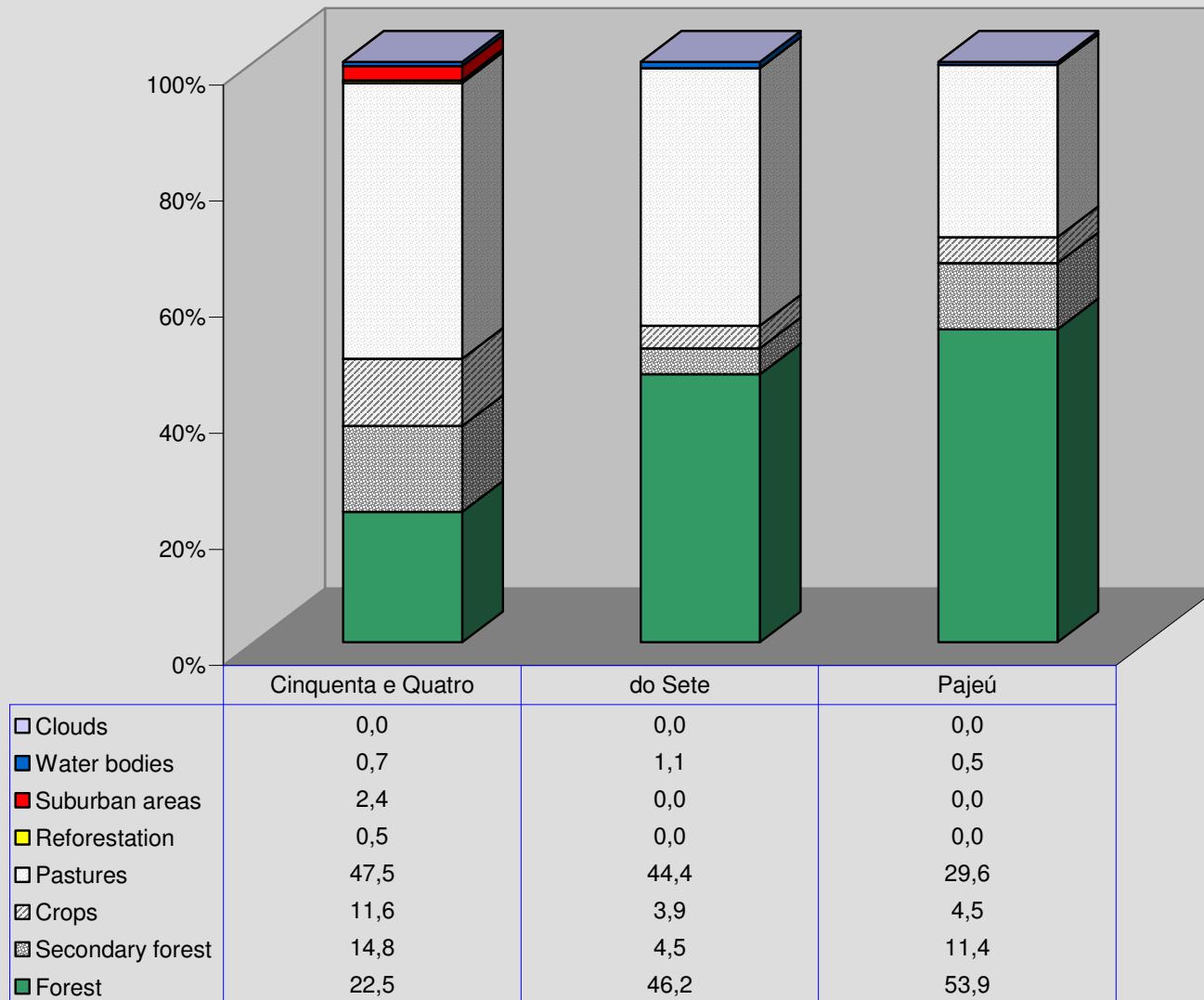
**A very typical streamwater use:  
water supply and electricity  
for the farms**

## Two distinct downstream patterns



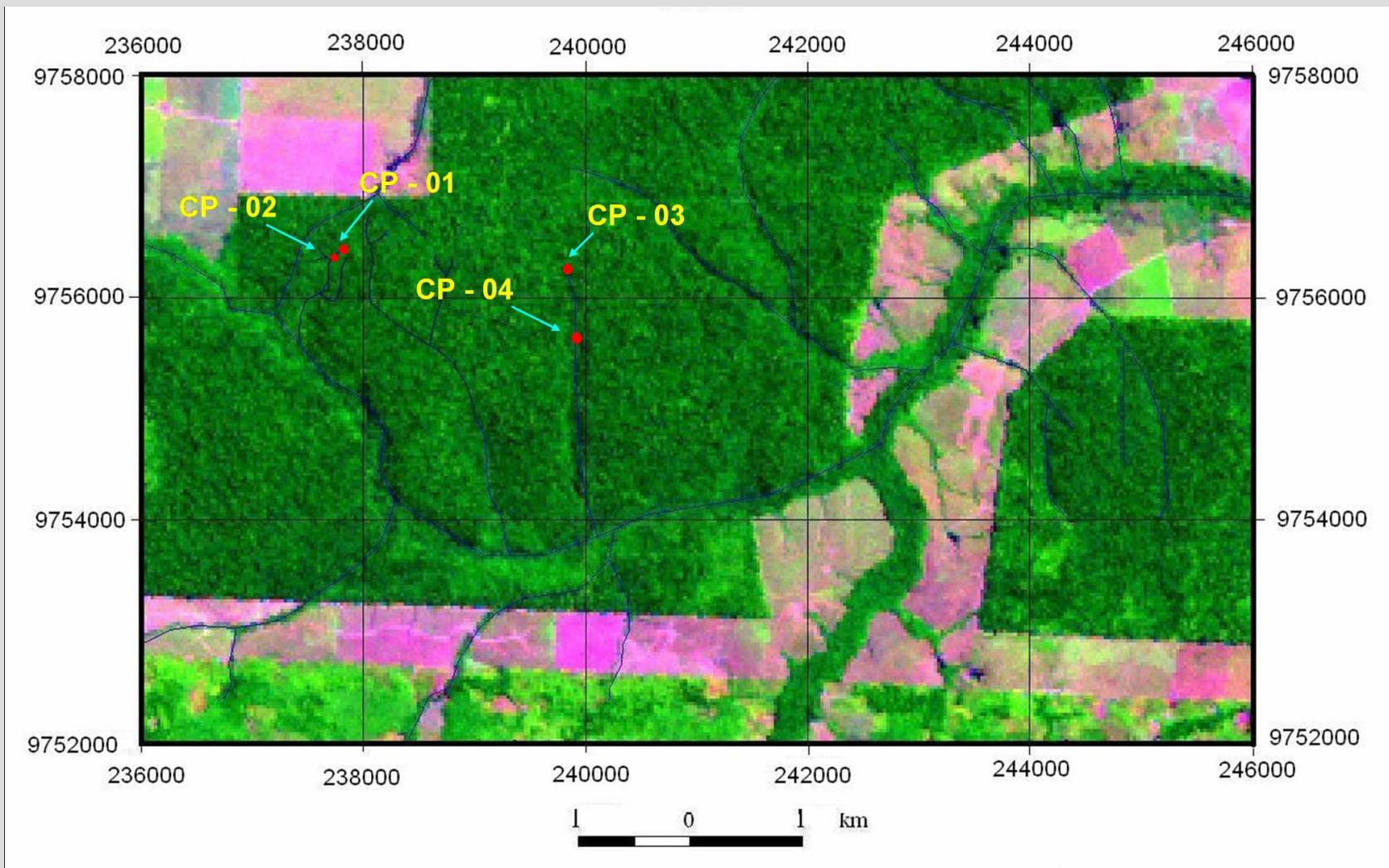
\* Other question to be answered: how dams affect stream water chemistry?

## Land use classes percentages in each catchment - Landsat imagery 2004



The main change during the study period (2003-2005) was cropland area increase in Igarapé 54 from 2004 to 2005 (from 11.6% to 21.1%).

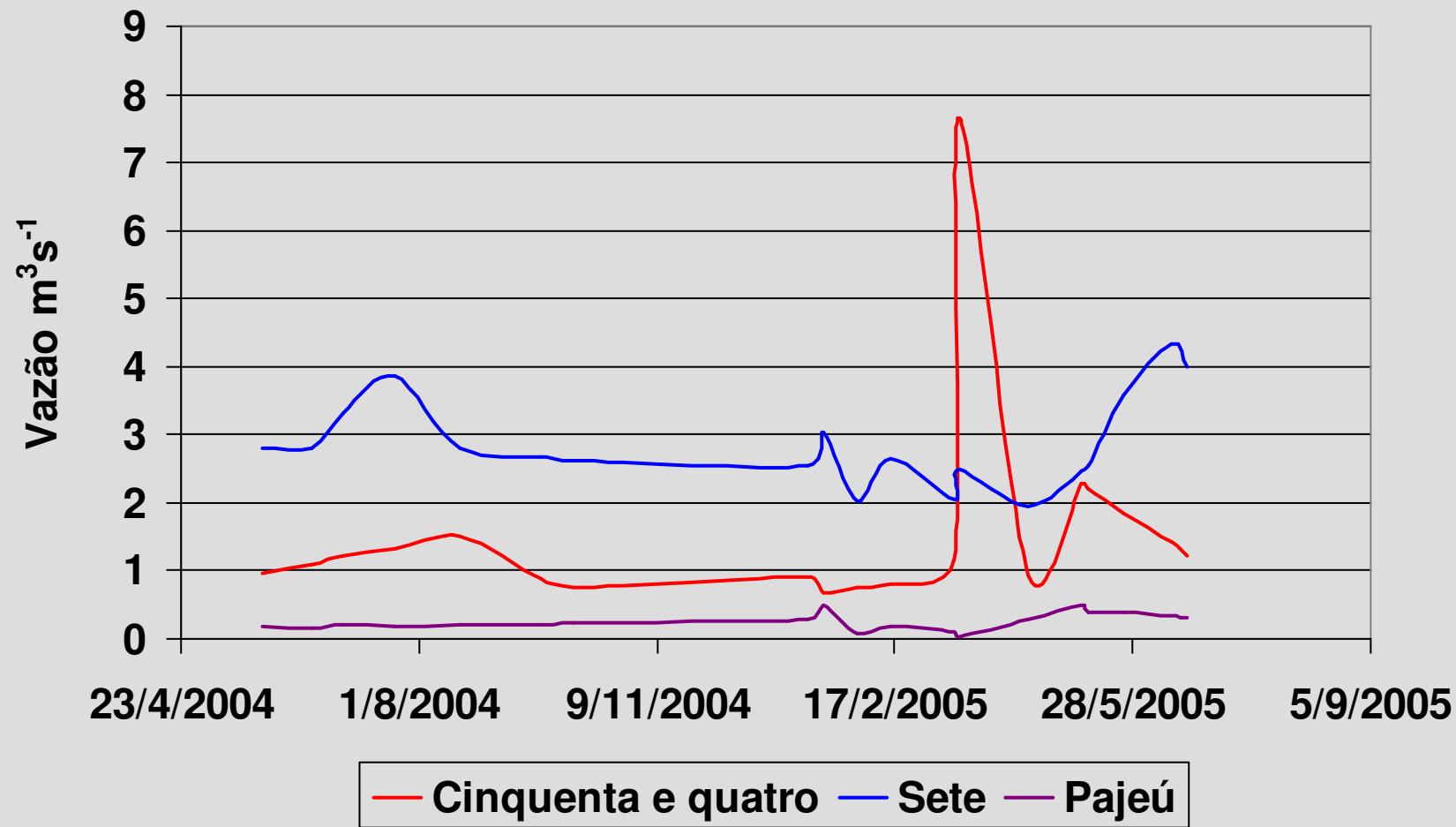
- Two additional streams at whole forested catchments were monitored as control ones and are situated in Capitão Poço county (~ 100 km from the 3 catchments in Paragominas).
- As soils are relatively similar among catchments (predominantly oxisols), we suspect land use conversion is an important factor affecting trends in stream chemistry.



- Field measurements and chemical analyses:
  - current speed (discharge) = *WL14 Global Water* transducer at further downstream station, *General Oceanics* current meter for other stations
  - pH and conductivity = *VWR* pH meter
  - turbidity = *Hanna* turbidimeter
  - alkalinity = end point titration (pH 4.5)
  - dissolved oxygen (OD) and temperature = *Hanna* oxygen meter
  - dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), and organic nitrogen = *Shimadzu TOC-V CSN Analyzer*
  - $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{K}^+$ ,  $\text{Na}^+$ ,  $\text{NH}_4^+$ ,  $\text{NO}_3^-$ ,  $\text{PO}_4^{3-}$ ,  $\text{SO}_4^{2-}$  and  $\text{Cl}^-$  = *DX120 Dionex ion chromatographer*

## Discharge from June/2004 to May/2005

Stream	Mean ( $10^{-6} \text{ m}^3 \text{ s}^{-1} \text{ ha}^{-1}$ )	Minimum ( $10^{-6} \text{ m}^3 \text{ s}^{-1} \text{ ha}^{-1}$ )	Maximum ( $10^{-6} \text{ m}^3 \text{ s}^{-1} \text{ ha}^{-1}$ )
54	<b>121.7</b>	51.4	587.7
do Sete	<b>191.5</b>	129.0	289.0
Pajeú	<b>59.1</b>	3.5	107.9

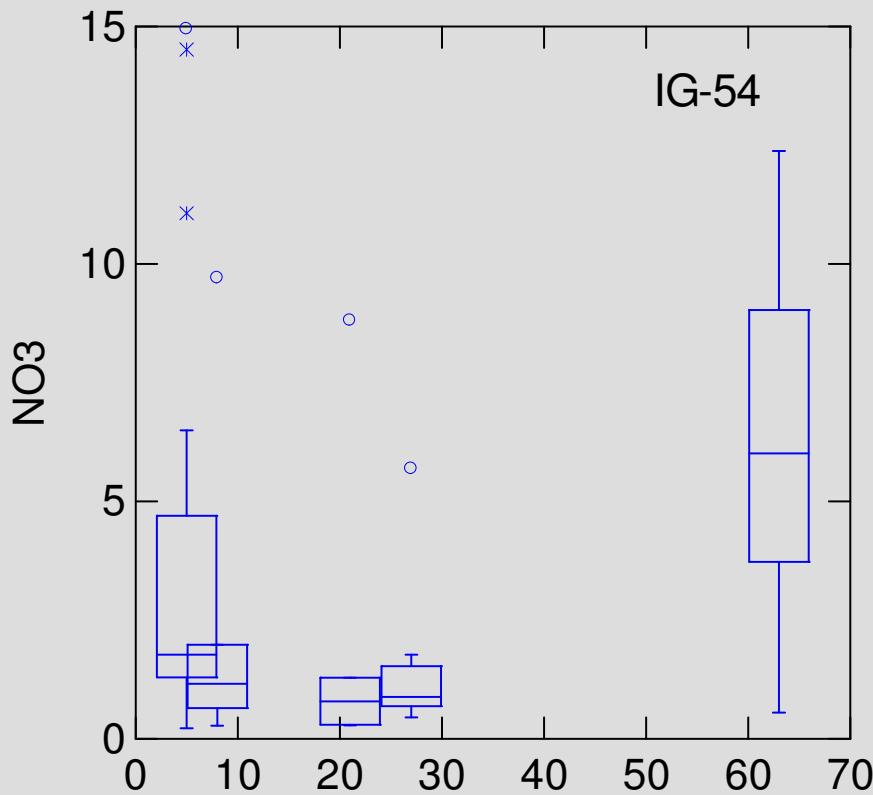


Although Igarapé Cinquenta e Quatro area (14000 ha) is close to Igarapé do Sete area (16000 ha) its discharge is too smaller.

Arithmetic means and standard deviation of stream water sampled at output locations. (turbidity in FTU, dissolved oxygen in mg L<sup>-1</sup>, conductivity in µS, and all others in µEq L<sup>-1</sup>)

	Igarapé 54		Igarapé do Sete		Igarapé Pajeú		Pristine stream 1		Pristine stream 2	
	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet
Turbidity	9 (11)	25 (26)	4 (8)	23 (33)	5 (8)	26 (35)	2 (3)	17 (24)	3 (6)	21 (21)
Dissolved Oxygen	5.77 (0.97)	5.05 (1.26)	7.30 (1.14)	5.24 (1.99)	5.82 (1.10)	5.95 (1.83)	4.50 (1.21)	3.98 (1.39)	4.36 (0.91)	3.77 (1.63)
Conductivity	37.9 (9.3)	33.2 (3.1)	31.6 (2.7)	30.6 (8.4)	36.6 (4.3)	39.4 (18.1)	22.6 (2.9)	25.6 (7.3)	20.5 (2.4)	20.3 (2.4)
pH	4.41 (0.23)	4.94 (0.42)	4.50 (0.23)	4.70 (0.44)	4.67 (0.25)	4.85 (0.39)	4.35 (0.21)	4.33 (0.37)	4.36 (0.29)	4.36 (0.30)
Alkalinity	14 (7)	59 (42)	21 (2)	37 (16)	19 (9)	41 (17)	13 (1)	21 (17)	21 (2)	22 (8)
DIC	21.6 (0.5)	0.4 (0.2)	23.8 (2.9)	29.5 (78)	28.8	33.4 (2.3)				
DOC	57.7 (20.0)	2.1 (1.5)	50.6 (32.6)	108.9 (43.9)	63.8 (51.7)	113.3 (33.1)	69.1 (33.8)		112 (20.0)	
DON	8.6 (6.4)	5.0	4.0 (4.5)	10.5 (7.7)	10.3 (6.9)	23.7 (23.0)	16.8 (18.3)		1.4 (0.6)	
NO <sub>3</sub>	4.4 (2.9)	5.2 (5.0)	0.2 (0.2)	0.3 (0.6)	0.4 (0.9)	0.6 (0.7)	5.3 (5.0)	6.8 (5.2)	1.8 (2.3)	2.1 (3.3)
NH <sub>4</sub>	1.8 (2.8)	5.8 (4.6)	2.9 (3.2)	7.4 (4.6)	6.5 (3.6)	6.9 (3.7)	2.6 (3.0)	11.5 (12.2)	2.0 (2.8)	17.6 (36.2)
K	7.1 (2.3)	14.6 (8.5)	6.4 (4.4)	9.1 (5.6)	3.0 (3.8)	6.2 (4.1)	1.5 (1.8)		5.0 (3.4)	
Ca	9.8 (4.4)	13.8 (4.9)	7.0 (5.0)	18.9 (11.3)	10.0 (5.2)	18.0 (12.9)	7.0 (4.4)	8.7 (7.2)	8.7 (5.0)	10.6 (7.9)
Mg	5.4 (2.4)	9.2 (4.9)	5.2 (3.5)	13.0 (7.5)	7.3 (3.2)	51.2 (115.3)	4.1 (4.4)		3.5 (3.5)	
Na	168.8 (64.5)	138.2 (48.5)	134.6 (78.4)	114.2 (57.8)	193.2 (73.5)	122.9 (87.7)	97.6 (64.3)	63.1 (46.1)	106.4 (53.6)	89.7 (91.6)
Cl	208 (85.6)	188.5 (119.8)	131.1 (93.3)	187.1 (134.2)	216.2 (135.6)	229.0 (175.9)	74.1 (37.3)	91.3 (78.4)	82.9 (37.9)	77.6 (35.6)
SO <sub>4</sub>	1.8 (1.1)	2.1 (1.4)	1.4 (1.0)	1.1 (0.6)	1.9 (1.1)	1.3 (1.1)	2.5 (1.2)	2.9 (2.3)	2.4 (1.1)	2.0 (1.4)
PO <sub>4</sub>	0.4 (1.1)	0.1 (0.0)	0.1 (0.0)	0.1 (0.0)	0.2 (0.2)	0.1 (0.0)	0.1 (0.0)	0.1 (0.0)	0.1 (0.0)	0.1 (0.0)

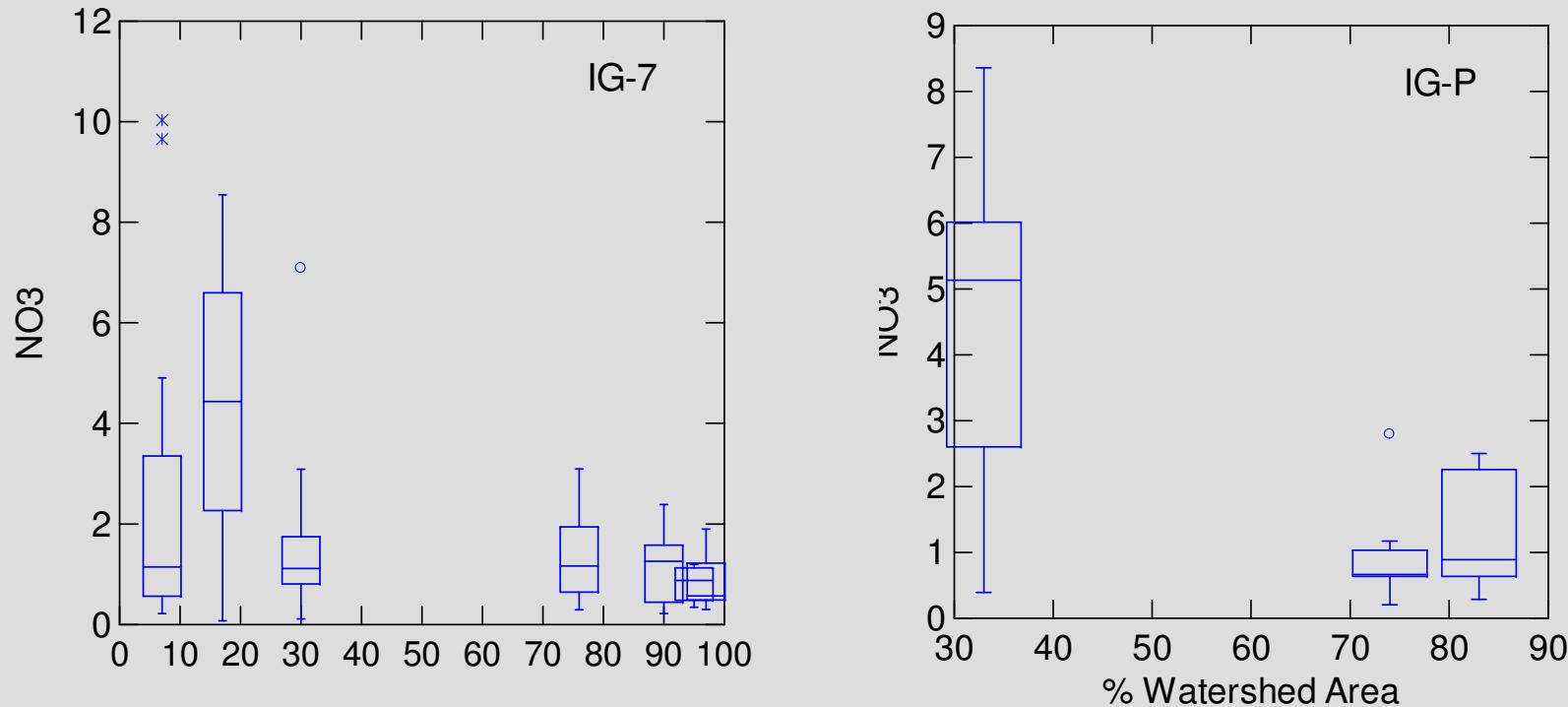
- turbidity increase in wet season in all streams (Do dams help in sedimentation of the suspended particulate matter?)  
alkalinity and cations (Ca, Mg and K) increase in wet season (larger discharge as Markewitz et al. (2001) found previously in Igarapé 54  
nitrate seems to respond to larger cropland percentages in Igarapé 54 as King et al. (2005) found in watersheds of the Coastal Plain of Maryland, USA



### Downstream increase in nitrate concentration

Nitrate concentrations ( $\mu\text{eq}$ ) in *Igarapé 54* (IG-54) plotted according to the percentage of the drainage area upstream of each sampling stations. The total catchment area is 21,702 ha.

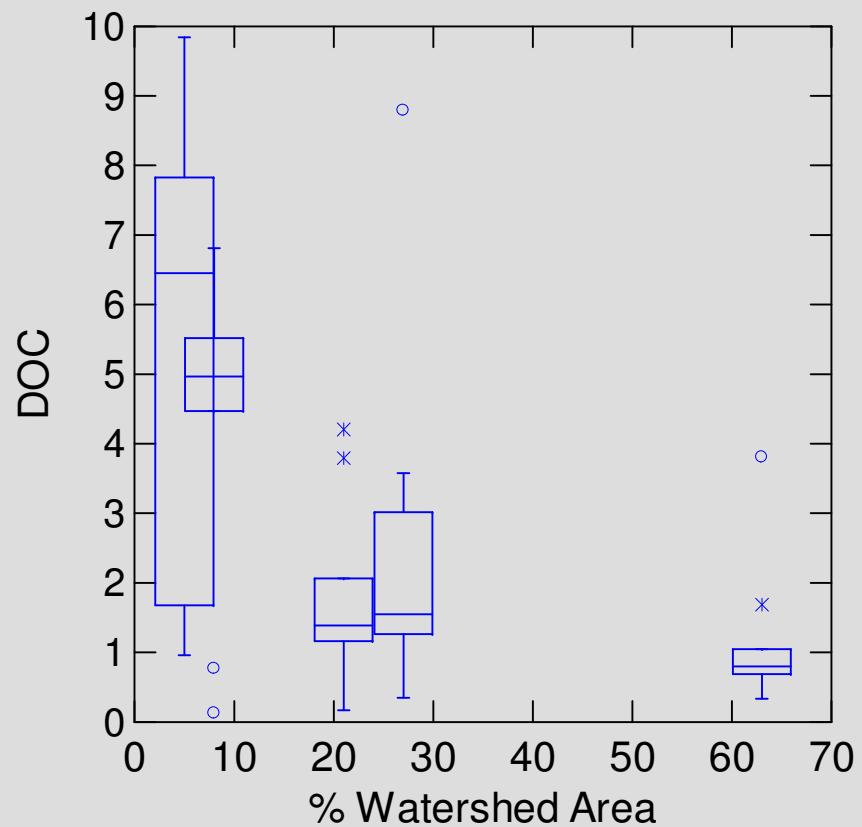
The length of the boxes shows the range within which the central 50% of values fall and the line in the boxes indicates the median value. The whiskers extend across the range of the values that fall within  $1.5 * \text{hspread}$  where  $\text{hspread}$  is the absolute value between the first and third quartile. Values between  $1.5$  and  $3 * \text{hspread}$  are plotted with asterisks while values outside this range are plotted with empty circles.



### Downstream decrease in nitrate concentration

Nitrate concentrations ( $\mu\text{eq}$ ) in Igarapé do Sete (IG-7) and Igarapé Pajeú (IG-P), plotted according to the percentage of the drainage area upstream of each sampling stations. The total catchment areas are respectively: 16,694 ha and 3,925 ha.

*The length of the boxes shows the range within which the central 50% of values fall and the line in the boxes indicates the median value. The whiskers extend across the range of the values that fall within  $1.5 * \text{hspread}$  where hspread is the absolute value between the first and third quartile. Values between  $1.5$  and  $3 * \text{hspread}$  are plotted with asterisks while values outside this range are plotted with empty circles.*

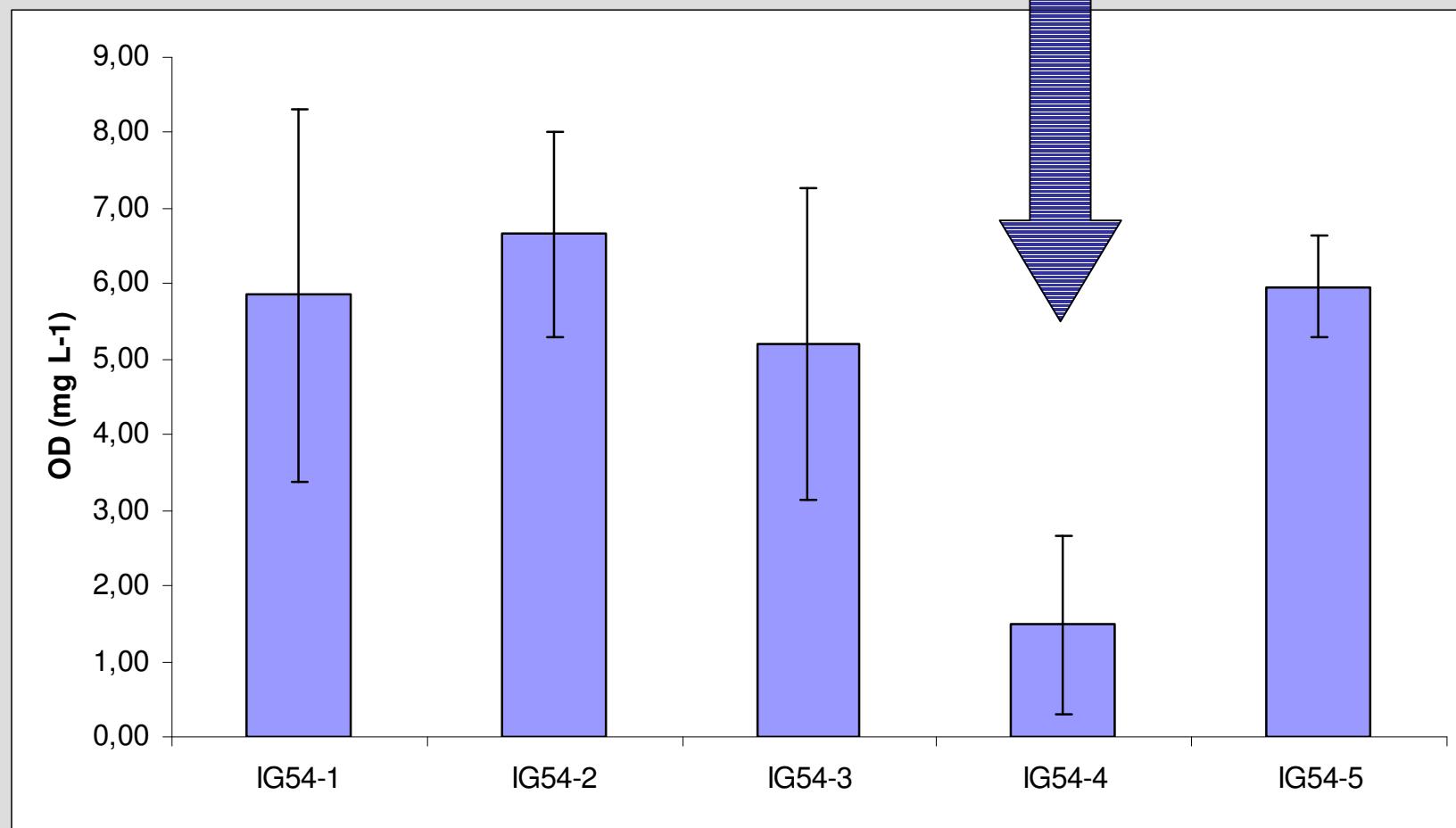


We also observed same pattern for DOC (decreasing downstream in Igarapé 54). Headwater areas are really the main source of organic matter, and consequently for the mineralization processes generating inorganic nitrogen. So any addition of nitrogen must come from antropic sources, here mainly related with agriculture practices.

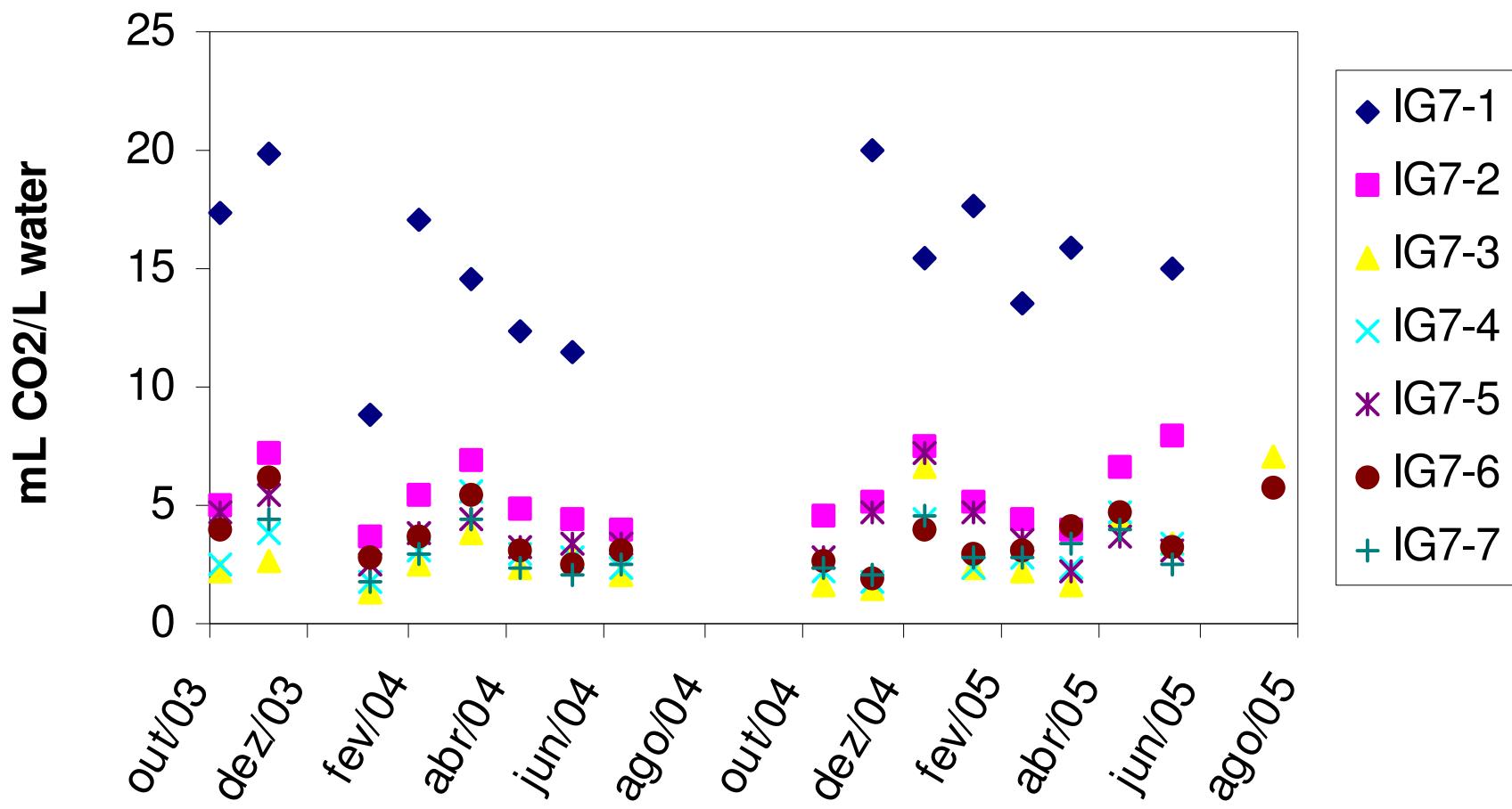
### Downstream increase in DOC concentration

Dissolved organic carbon (DOC) concentrations ( $\text{mg L}^{-1}$ ) in Igarapé 54 plotted according to the percentage of the drainage area upstream of each sampling stations. The total catchment area is 21,702ha.

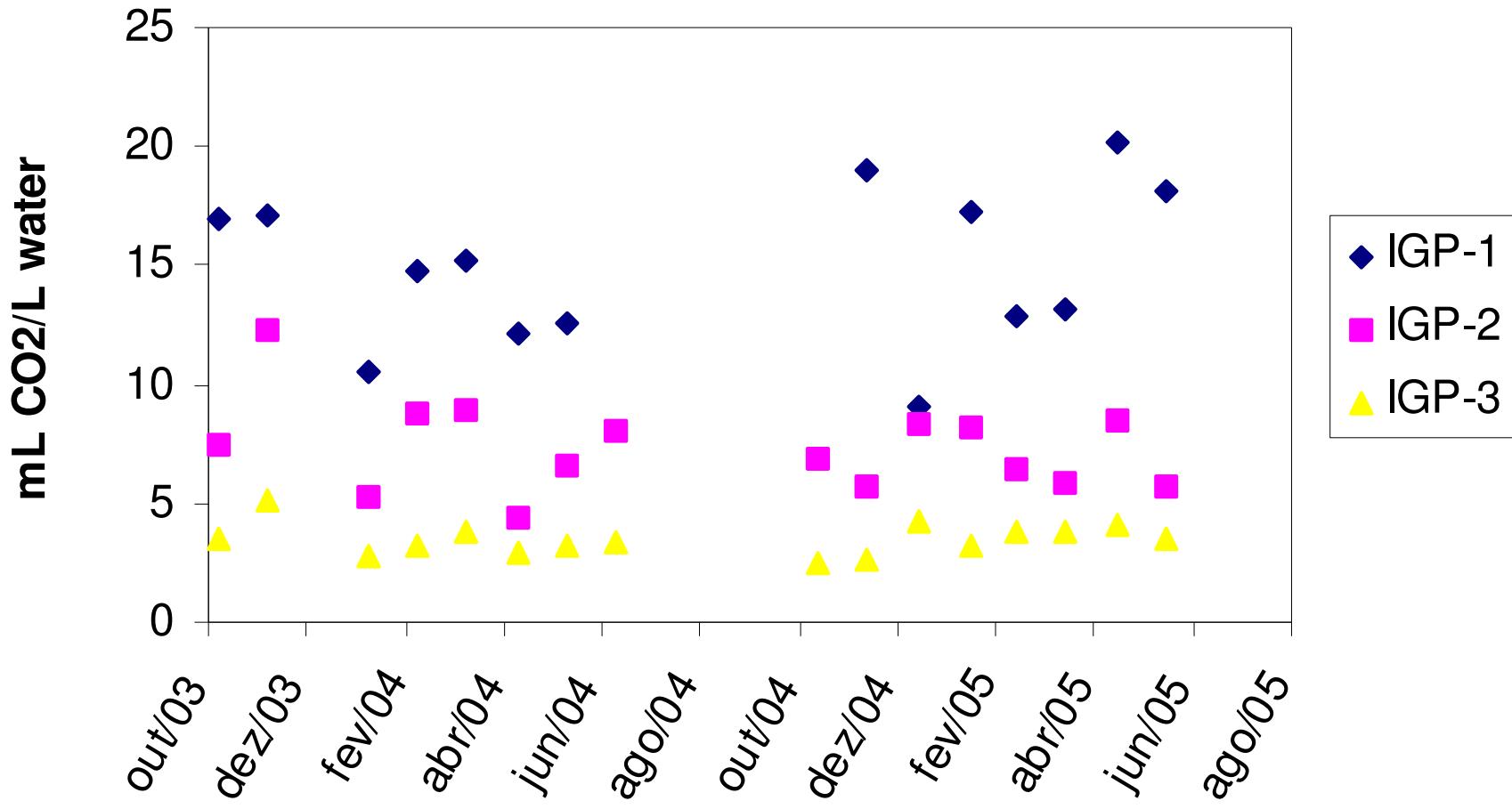
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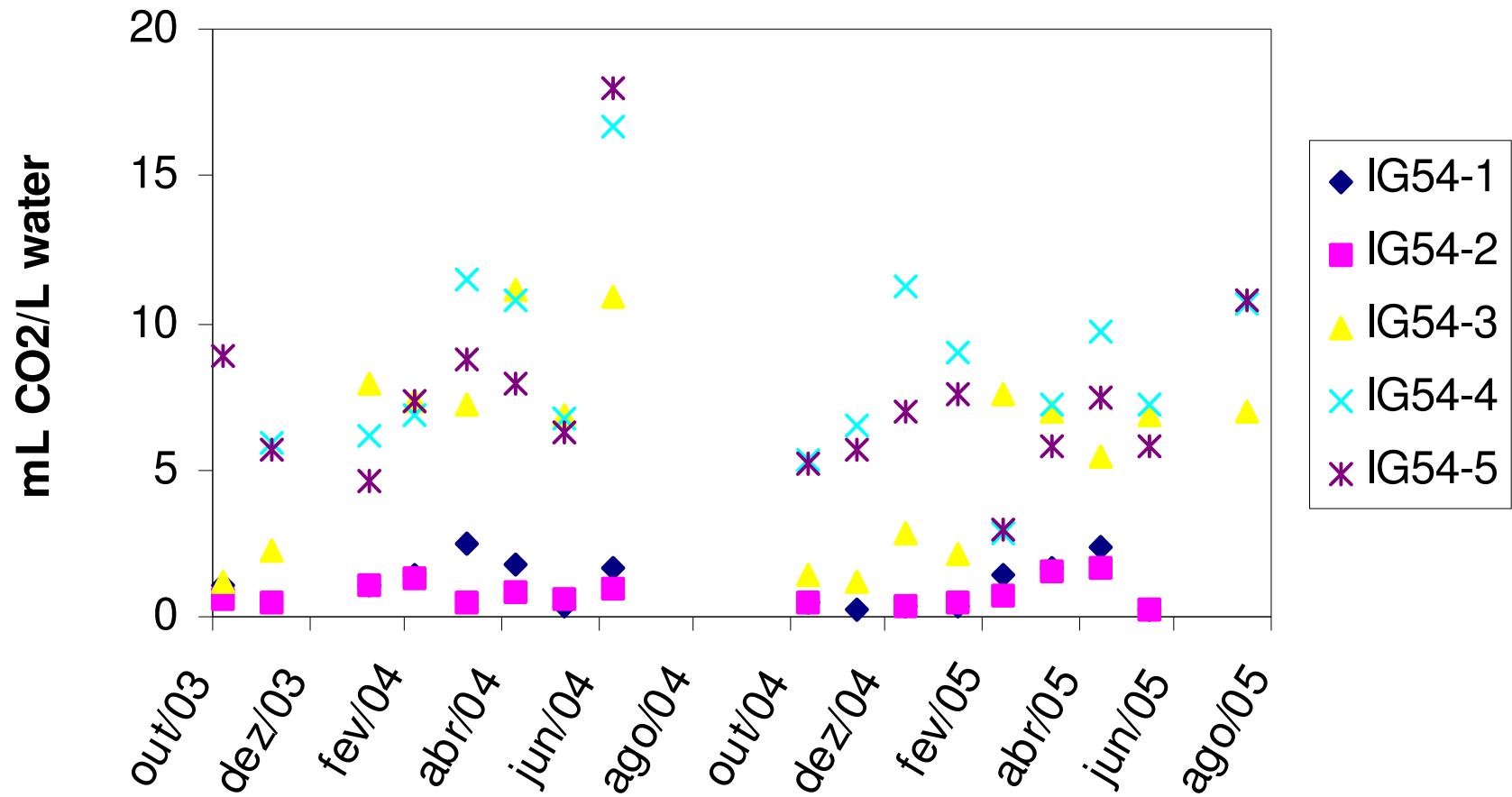
**Dissolved oxygen decrease in station 4 of the Igarapé 54, located downstream cropland  
(mean and standard deviation from June/2003 to May/2005)**



Higher  $\text{CO}_2$  at headwaters of Igarapé do Sete (IG7-1)



**Higher  $\text{CO}_2$  at headwaters of Igarapé Pajeú (IGP-1)**



$\text{CO}_2$  in Igarapé 54 (IG54-1 = too much explored forest at headwaters) do not present the same pattern.

## **Next steps:**

- After conclude a detailed soil survey compare soils of each portion of the catchments with stream water composition
- Nitrate analysis regarding to fertilizer inputs which will be calculated after knowing the extension of croplands and each fertilizer amount used.
- Consider nutrient concentrations upstream and downstream reservoirs
- Finish analysis of temporal concentration patterns
- Make mass balance of each element in each catchment
- Do comparison in other parts early study in the world or tropics and specific discussion of process that are contributing to change relative to land use.

- Additional supports:

*Agrobacias Amazônicas* - Bacias Hidrográficas sob Sistemas de Produção Agropecuária Convencional e Conservacionista na Amazônia: hidrologia, fluxos de nutrientes e carbono, e potencial de contaminação por agrotóxicos (Coord. Ricardo Figueiredo - EMBRAPA / MP2)

*Aguamor* - Água na Amazônia Oriental: relações entre uso da terra e conservação de recursos hídricos. (Coord. Ricardo Figueiredo - CT-Hidro/CNPq)

Análise da Dinâmica do Uso da Terra e Zoneamento Agroecológico em Microbacias Hidrográficas no Nordeste do Estado do Pará, Utilizando Geotecnologias na Integração de Dados (Coord. Orlando Watrin - EMBRAPA / MP3)

Grupo de Estudos e Pesquisa em Modelagem Hidrológica na Amazônia: interpretação de processos hidrológicos e desenvolvimento de ferramentas para a gestão de bacias. (Coord. Marysol Schuler - PROSET/CT-Amazônia/CNPq)

*Projeto MilênioLBA2* - Integração de abordagens do ambiente, uso da terra e dinâmica social na Amazônia: as relações homem-ambiente e o desafio da sustentabilidade. (Coord. Paulo Artaxo – Coord. Subgrupo 1 - Biogeoquímica Aquática – Alex Krusche e Ricardo Figueiredo - MCT/CNPq, Edital Institutos do Milênio 2005-2008)