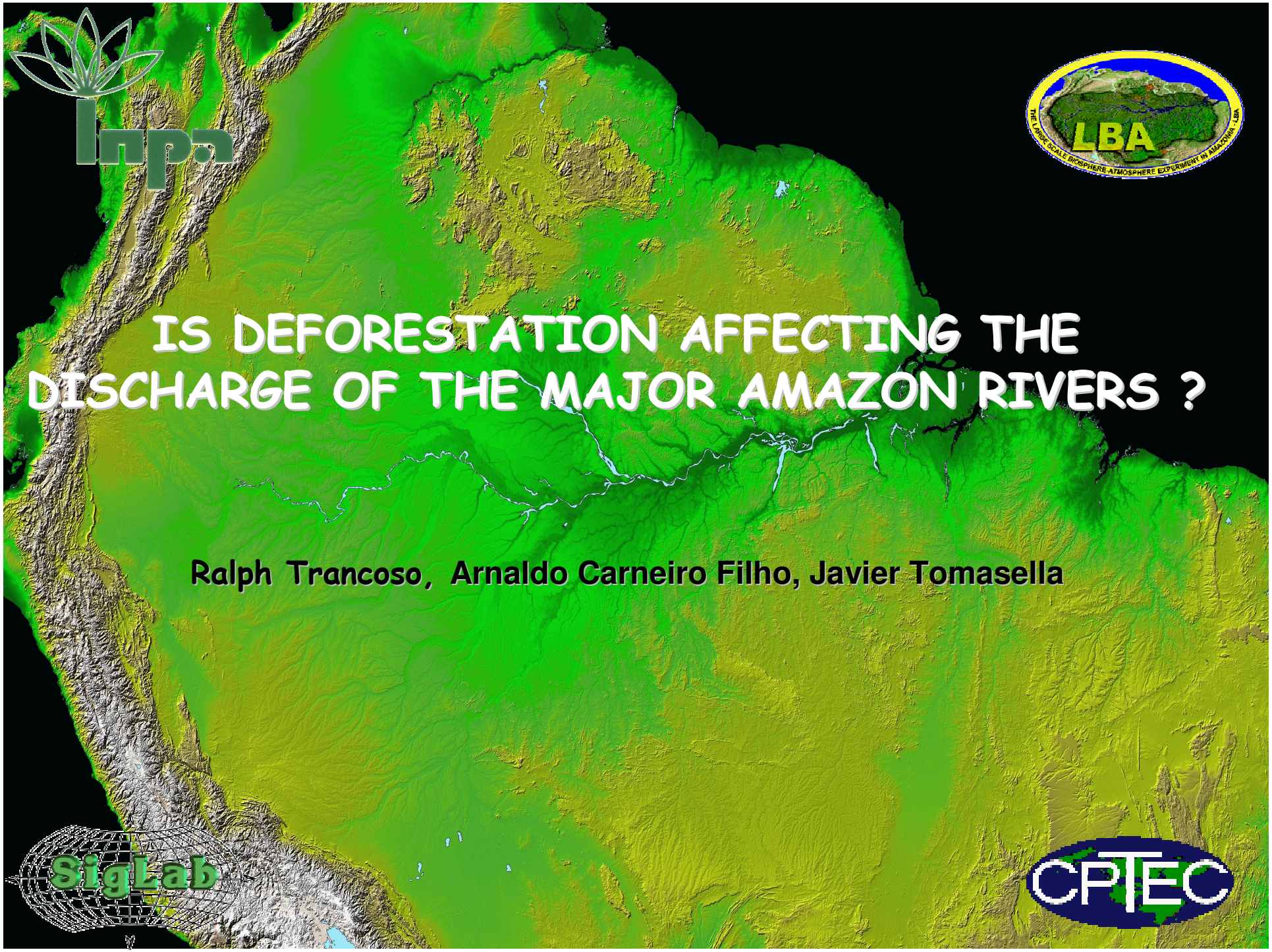
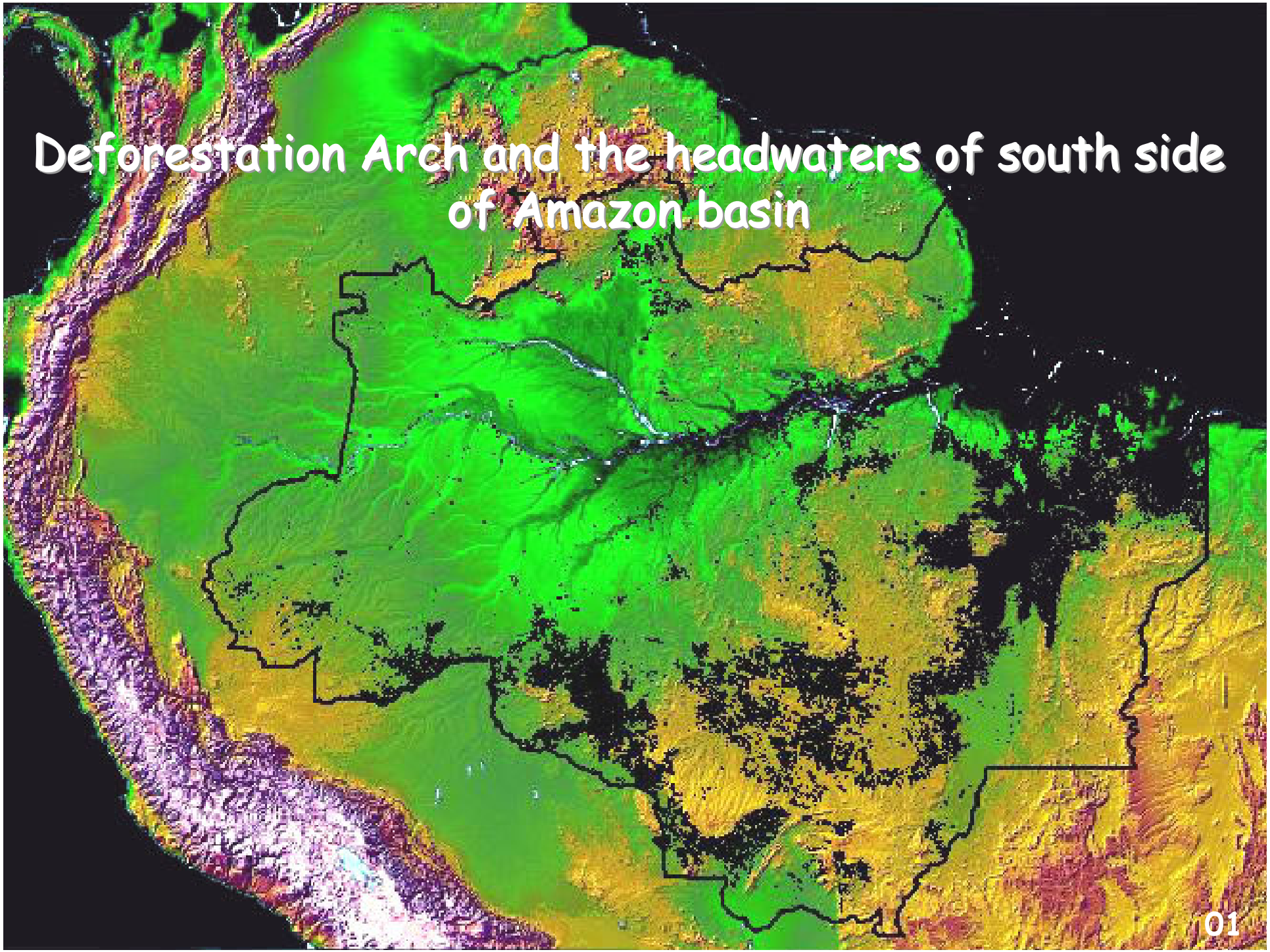
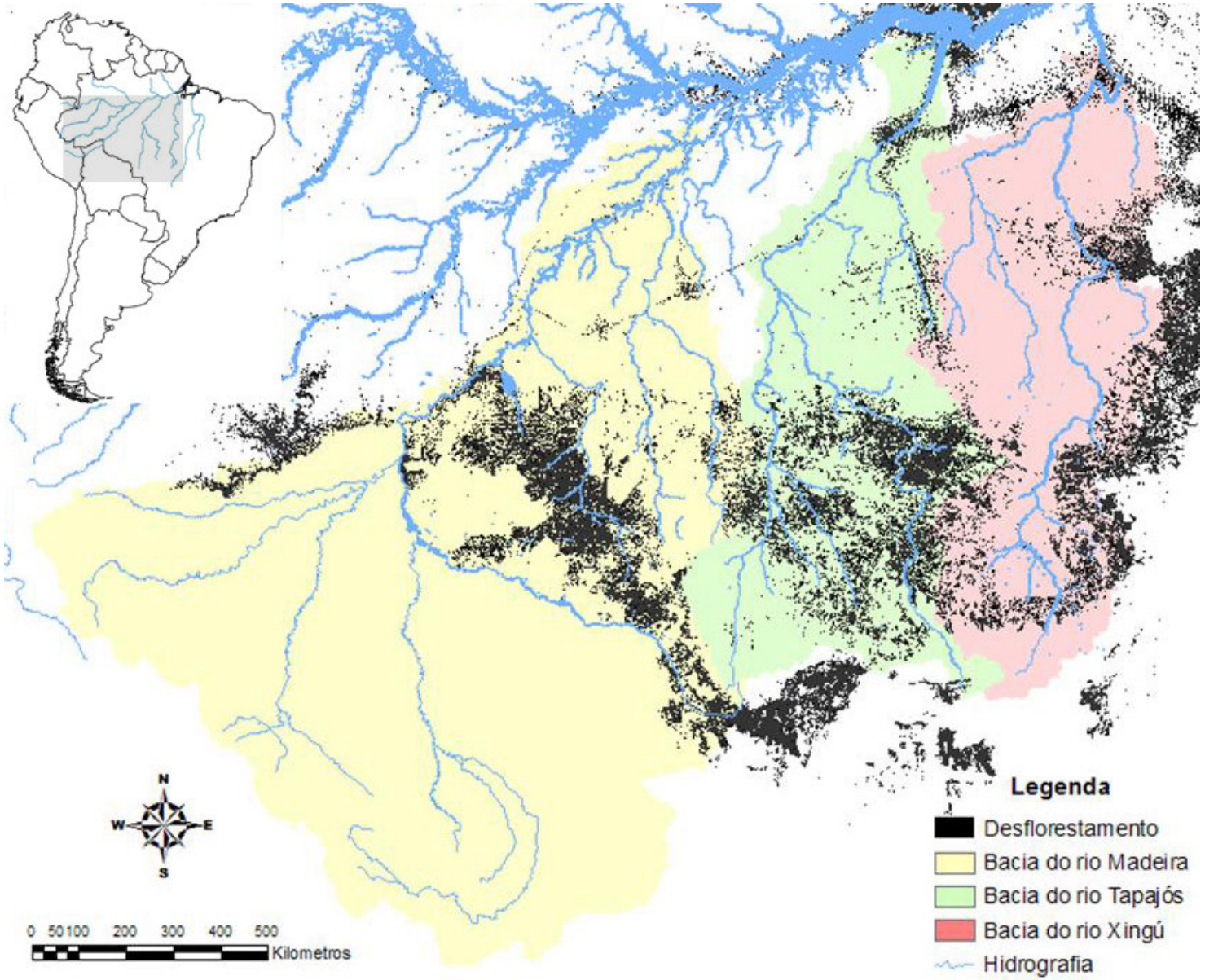

IS DEFORESTATION AFFECTING THE
DISCHARGE OF THE MAJOR AMAZON RIVERS ?
Ralph Trancoso, Arnaldo Carneiro Filho, Javier Tomasella
inpa
LBA
SigLab
CPTEC


Deforestation Arch and the headwaters of south side of Amazon basin

Study Area: Watersheds with higher deforested areas. Xingu, Tapajós and Madeira River Basins



River stations choice (Precipitation and Streamflow)

1 – Into these three river basins (Madeira, Tapajós e Xingu)

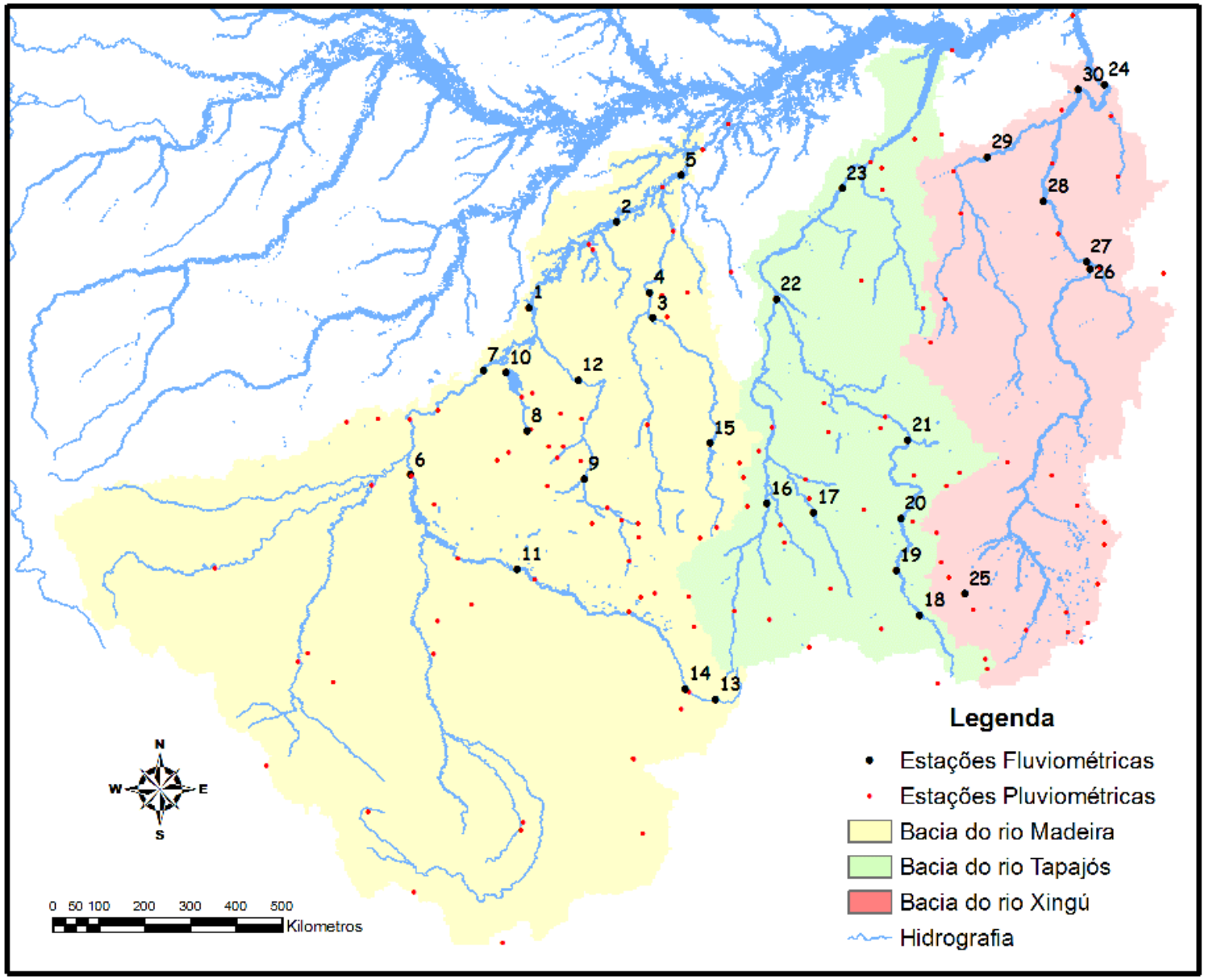
2 – Hydrological series with more than 25 years of continuous data

3 - Remove stations with gaps major than 5 years continuous.

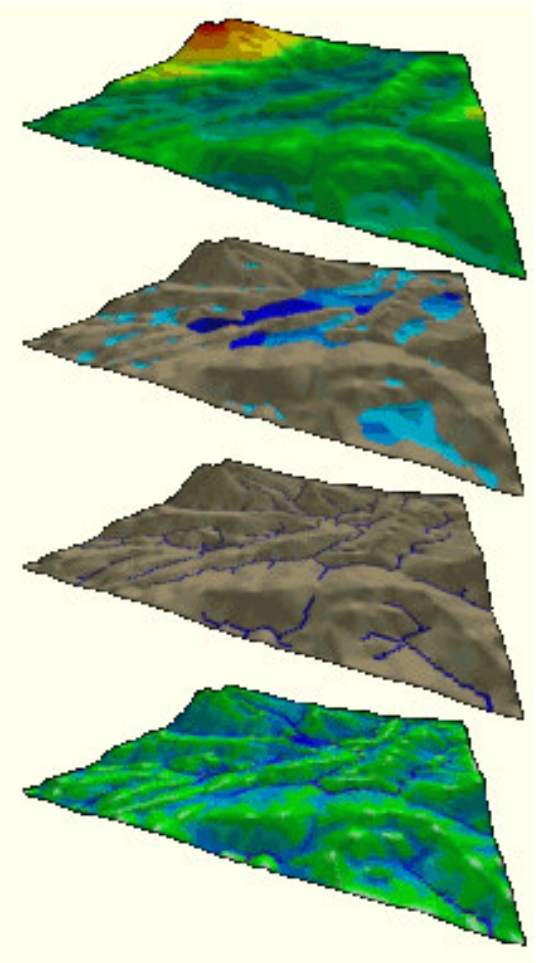
12988 acessos registrados desde 1/02/2005

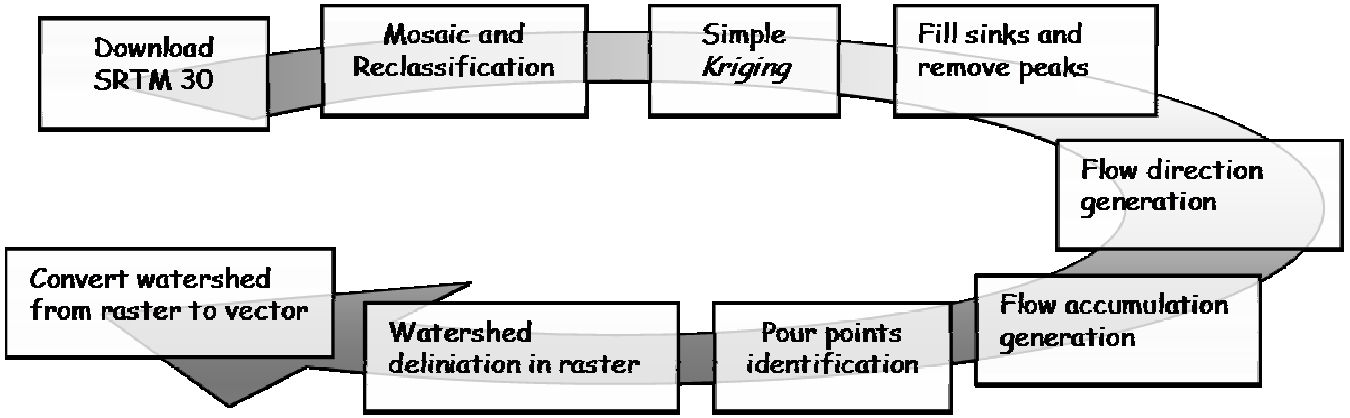
(BURN & HAG ELNUR, 2002)

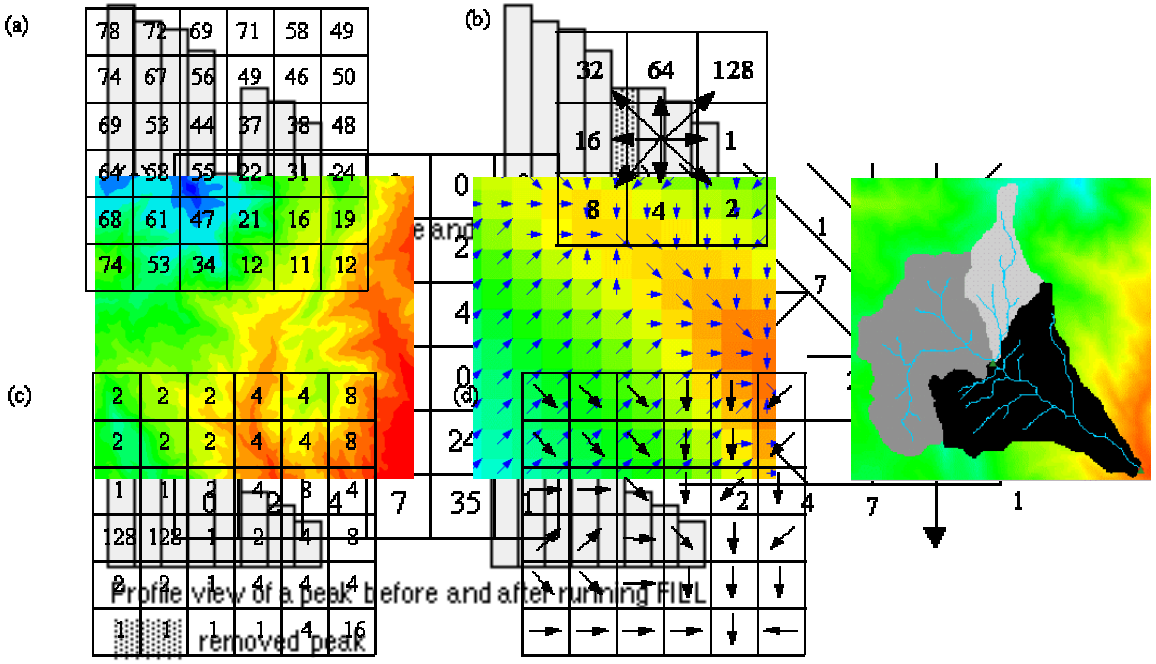
Hydrological data bank: Hidroweb (ANA)
30 River Discharge Stations and 140 Raingauges Stations



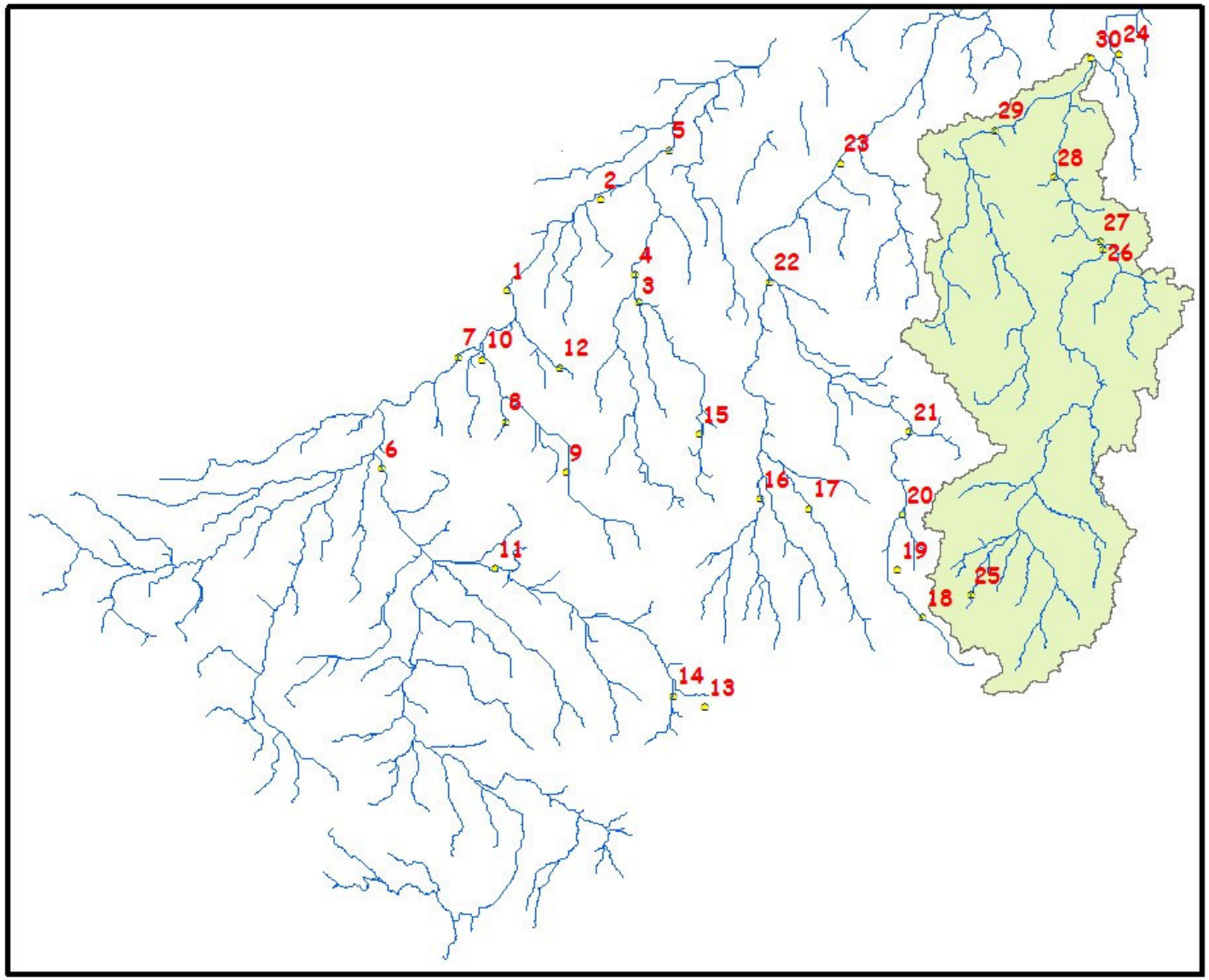
Routine for watersheds deliniation from SRTM 30







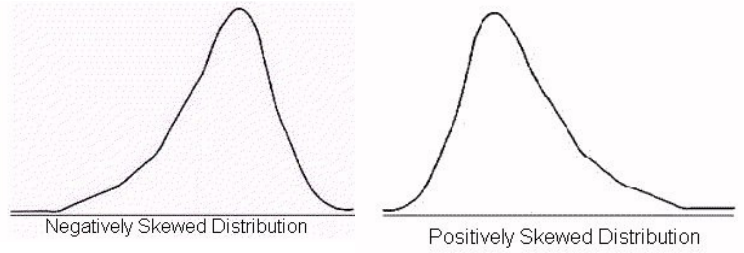
Watersheds deliniation from Digital Elevation Model (SRTM 30)



Trend Analysis of Hydrological Records

→ Historical records for discharge and precipitation since the 70's, when deforestation has begun in Amazon

High Skewness → non-parametric statistical test



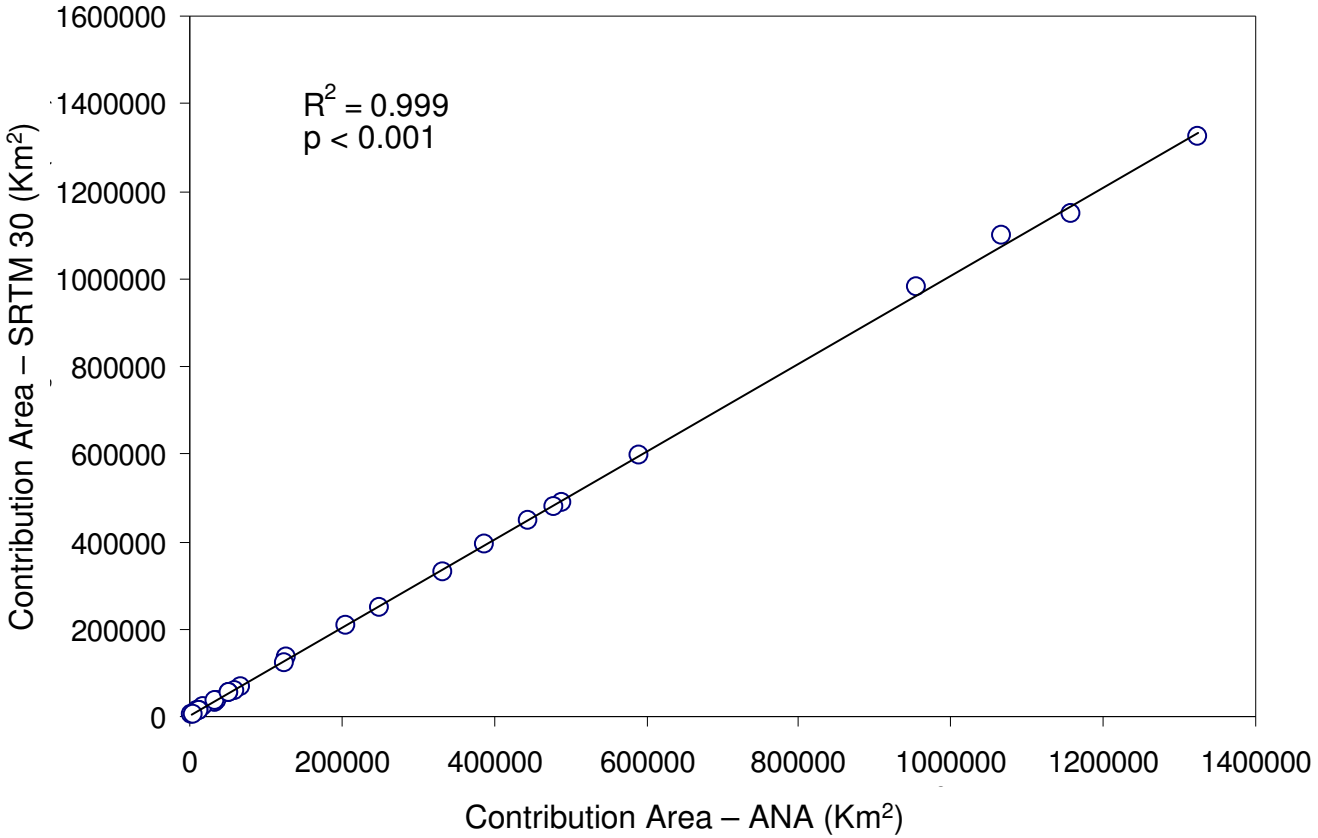
- Seasonal Mann-Kendall (Sk): Detection of Trends
- Sen-Slope estimator: Trends Magnitudes

Results

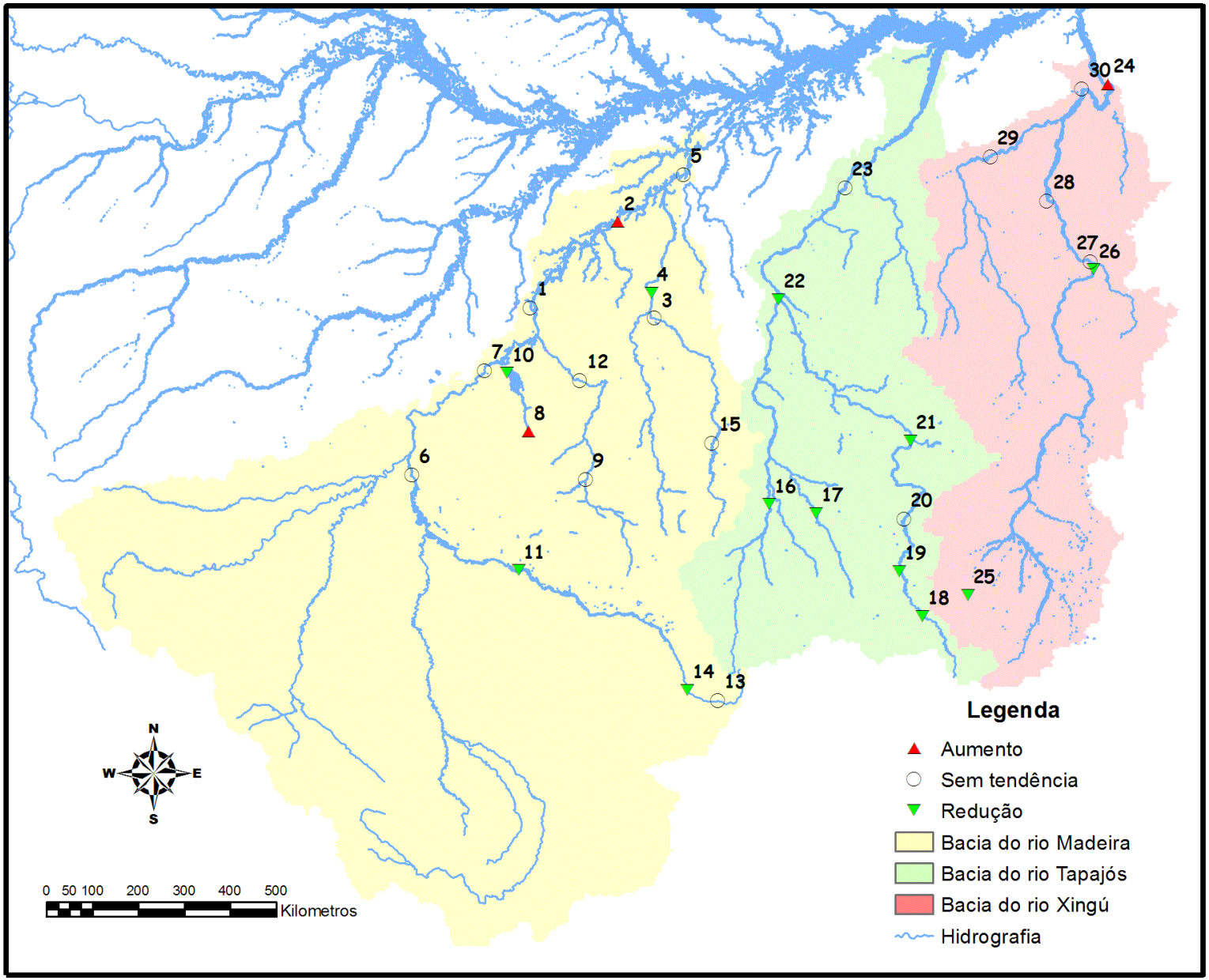
Deforestation levels and physical features on watersheds

ID	*Desfl* (%)	*A* (Km^2)	*Dd* (Km/Km^2)	*F*	*K*	H_m (m)	*ΔH* (m)	*Rr*	*Ir*
1	8.83	1097218.91	5.48	0.53	2.14	629.704	5976	4.17	32766.96
2	8.50	1148486.35	5.54	0.42	2.32	606.229	5995	3.64	33185.61
3	10.71	69885.25	6.29	0.28	1.78	183.437	461	0.92	2901.10
4	9.76	135859.17	6.76	0.37	2.14	199.365	564	0.93	3811.23
5	8.51	1324195.92	5.72	0.42	2.23	549.667	6007	3.37	34330.48
6	5.26	597858.03	4.89	0.52	2.06	560.626	4907	4.56	23980.98
7	4.53	980535.68	5.39	0.59	2.15	679.083	5959	4.60	32107.40
8	60.55	7845.33	4.26	0.40	1.89	239.300	456	3.27	1944.15
9	59.75	32923.92	5.82	0.38	1.71	293.438	443	1.50	2578.20
10	55.02	17773.94	5.39	0.22	2.39	195.862	941	3.35	5075.87
11	18.61	132220.71	4.88	0.41	1.97	288.219	913	1.61	4454.71
12	56.35	60102.83	6.15	0.25	2.53	261.593	535	1.09	3291.37
13	49.89	5911.87	5.42	0.62	1.73	448.315	553	5.67	2999.12
14	26.00	22664.96	3.62	0.50	2.21	322.752	758	3.57	2743.46
15	17.58	15231.99	6.26	0.33	2.16	256.726	352	1.64	2203.79
16	3.82	55543.34	5.72	0.35	1.91	483.639	593	1.48	3392.69
17	27.49	34192.03	7.99	0.24	2.27	390.182	446	1.17	3561.57
18	5.04	11430.87	11.19	0.32	2.28	475.626	453	2.41	5070.67
19	6.99	14225.44	10.56	0.17	2.79	454.952	530	1.84	5598.15
20	28.23	34896.07	9.41	0.23	2.56	404.532	564	1.44	5309.93
21	36.78	53951.20	9.20	0.17	2.18	384.043	698	1.25	6425.09
22	24.25	331823.88	6.36	0.37	2.39	341.172	769	0.82	4891.62
23	21.44	394184.84	6.42	0.31	2.50	315.049	786	0.69	5043.58
24	14.10	479336.83	4.62	0.26	2.51	292.173	788	0.58	3641.58
25	17.24	4779.36	7.54	0.31	1.71	402.027	308	2.47	2322.83
26	19.37	208084.22	6.20	0.23	2.47	333.284	718	0.75	4452.49
27	21.07	250108.39	5.62	0.26	2.62	334.140	723	0.74	4061.66
28	4.85	4409.56	3.06	0.35	1.73	251.688	362	3.22	1106.18
29	3.10	122119.45	3.09	0.29	2.36	289.102	620	0.96	1918.13
30	14.09	445250.62	4.69	0.25	2.59	300.631	780	0.59	3660.66

Comparison between drainage area of large watersheds generated from SRTM and from ANA data base



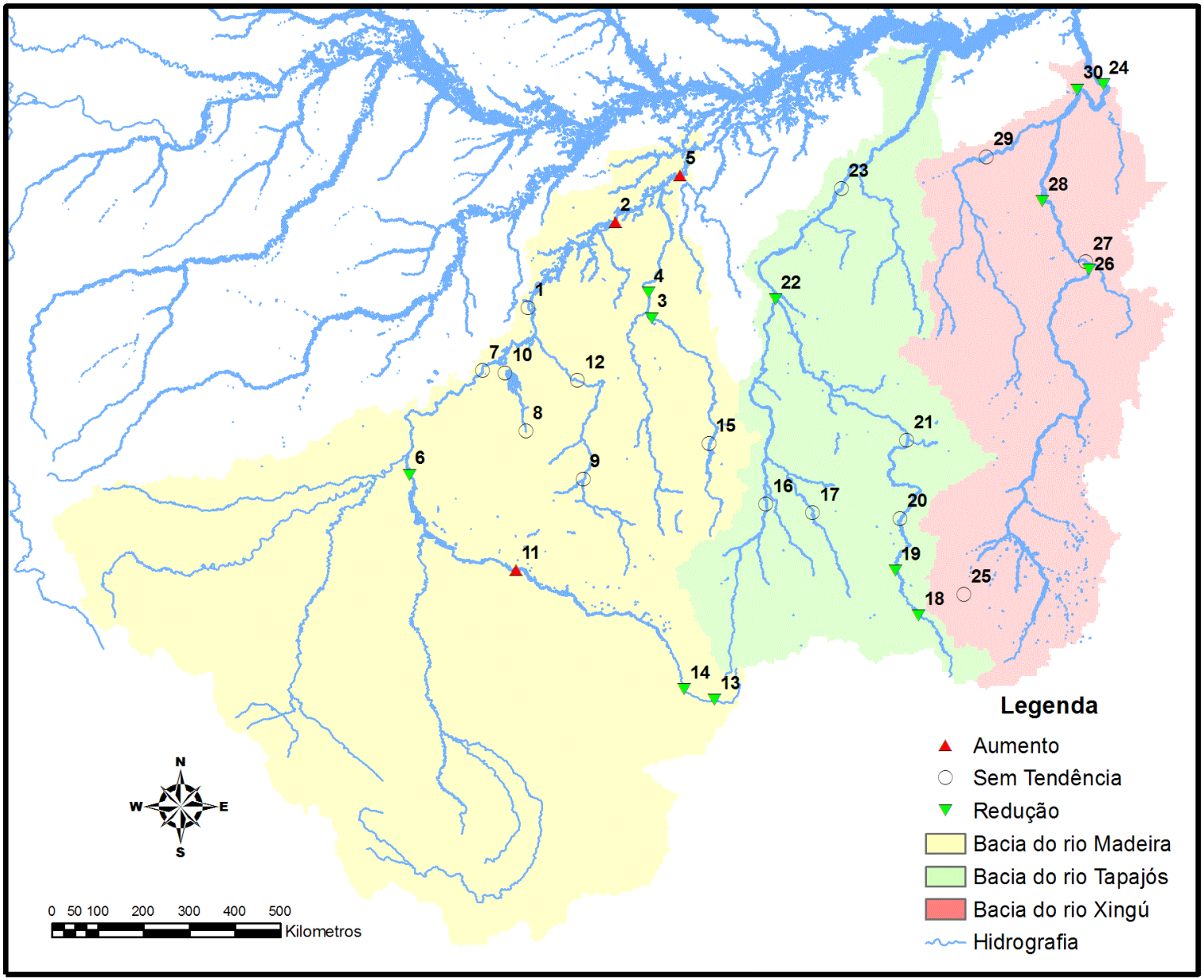
Trends in **Streamflow**
40% of decrease of river gauge stations



Trends magnitudes on **streamflow**

Number	Name	S_k	P	Slope (mm.year^{-1})
2	Manicoré	2.927	0.003	80.22
4	Prainha Velha	-2.403	0.016	-48.25
8	Ariquemes	1.994	0.046	23.34
10	Samuel	-2.244	0.025	-3.51
11	Guaporé	-3.356	0.001	-0.39
14	Vila Bela da Sant. Trindade	-1.930	0.054	-26.19
16	Fontanilhas	-2.945	0.003	-40.75
17	Porto dos Gaúchos	-2.319	0.020	-45.34
18	Porto Roncador	-1.856	0.063	-27.14
19	Teles Pires	-2.129	0.033	-67.33
21	Indeco	-2.028	0.043	-39.89
22	Barra do São Manuel - jusante	-2.415	0.016	-61.02
24	Belo Monte	2.437	0.015	6.79
25	Fazenda Itaguaçu	-1.796	0.073	-45.19
26	Boa Sorte	-2.742	0.006	-75.00

Trends in **Precipitation**
40% of decrease of representative rainfall stations



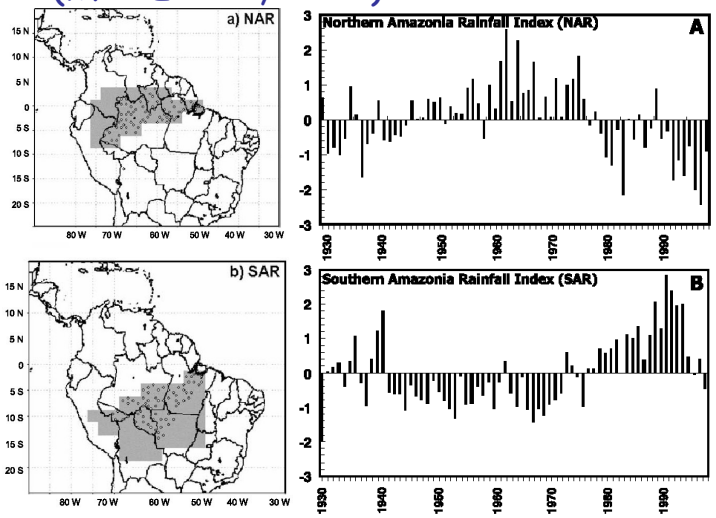
Trends magnitudes on **precipitation**

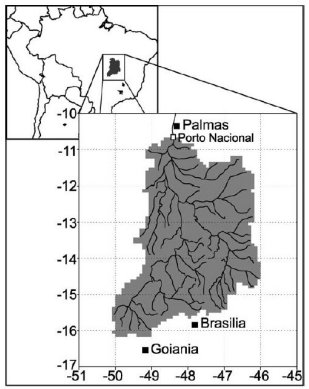
Number	Name	S_k	P	Slope (mm.year^{-1})
2	Manicoré	3.398	0.001	14.94
3	Boca do Guariba	-1.864	0.062	-15.78
4	Prainha Velha	-3.860	0.000	-30.86
5	Fazenda Vista Alegre	2.788	0.005	12.48
6	Guajara-mirim	-2.456	0.014	-7.93
11	Guaporé	2.076	0.038	8.14
13	Pontes e Lacerda	-3.223	0.001	-13.47
14	Vila Bela da Sant. Trindade	-3.140	0.002	-16.09
18	Porto Roncador	-1.899	0.058	-7.21
19	Teles Pires	-2.315	0.021	-8.75
22	Barra do São Manuel - jusante	-1.823	0.068	-5.70
24	Belo Monte	-2.216	0.027	-9.01
26	Boa Sorte	-2.827	0.005	-17.77
28	Belo Horizonte	-4.060	0.000	-27.28
30	Altamira	-2.949	0.003	-10.80

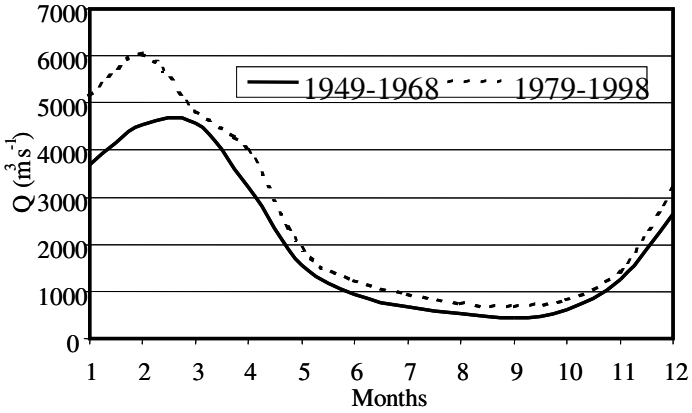
Which is the cause of decrease trends in the streamflow in some of the major tributaries of the Amazon?

Is it Deforestation, natural variability of rainfall or climate change?

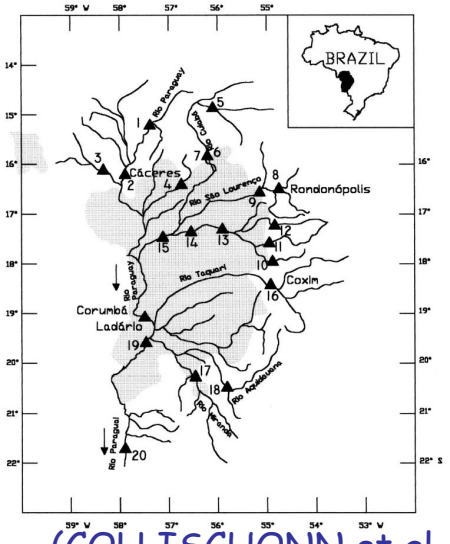
(MARENGO, 2004)



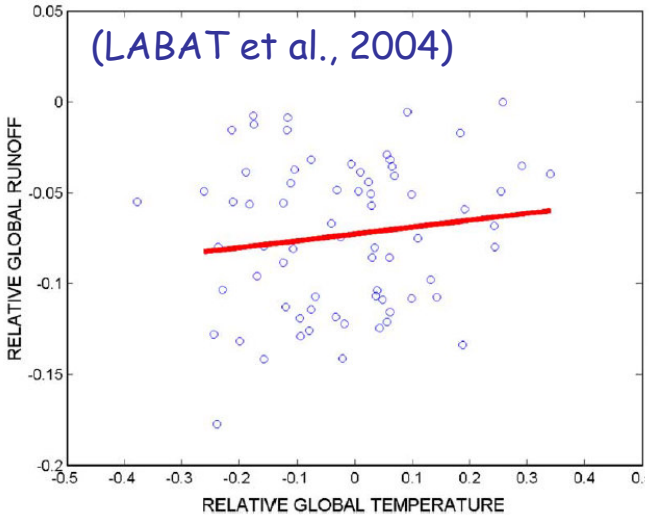




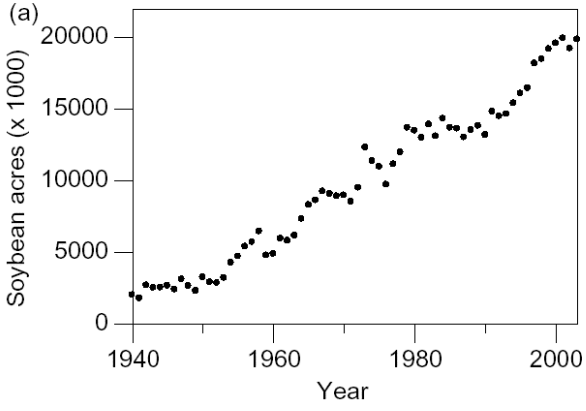
(COSTA et al., 2004)



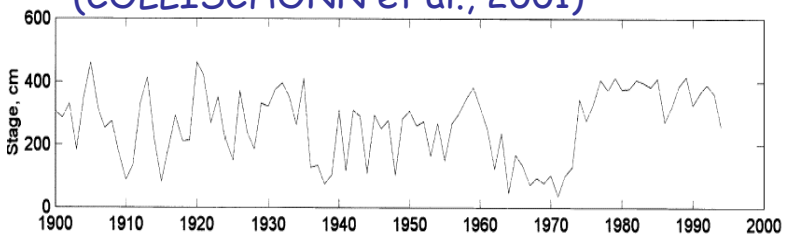
(LABAT et al., 2004)



(ZHANG & SCHILLING, 2006)

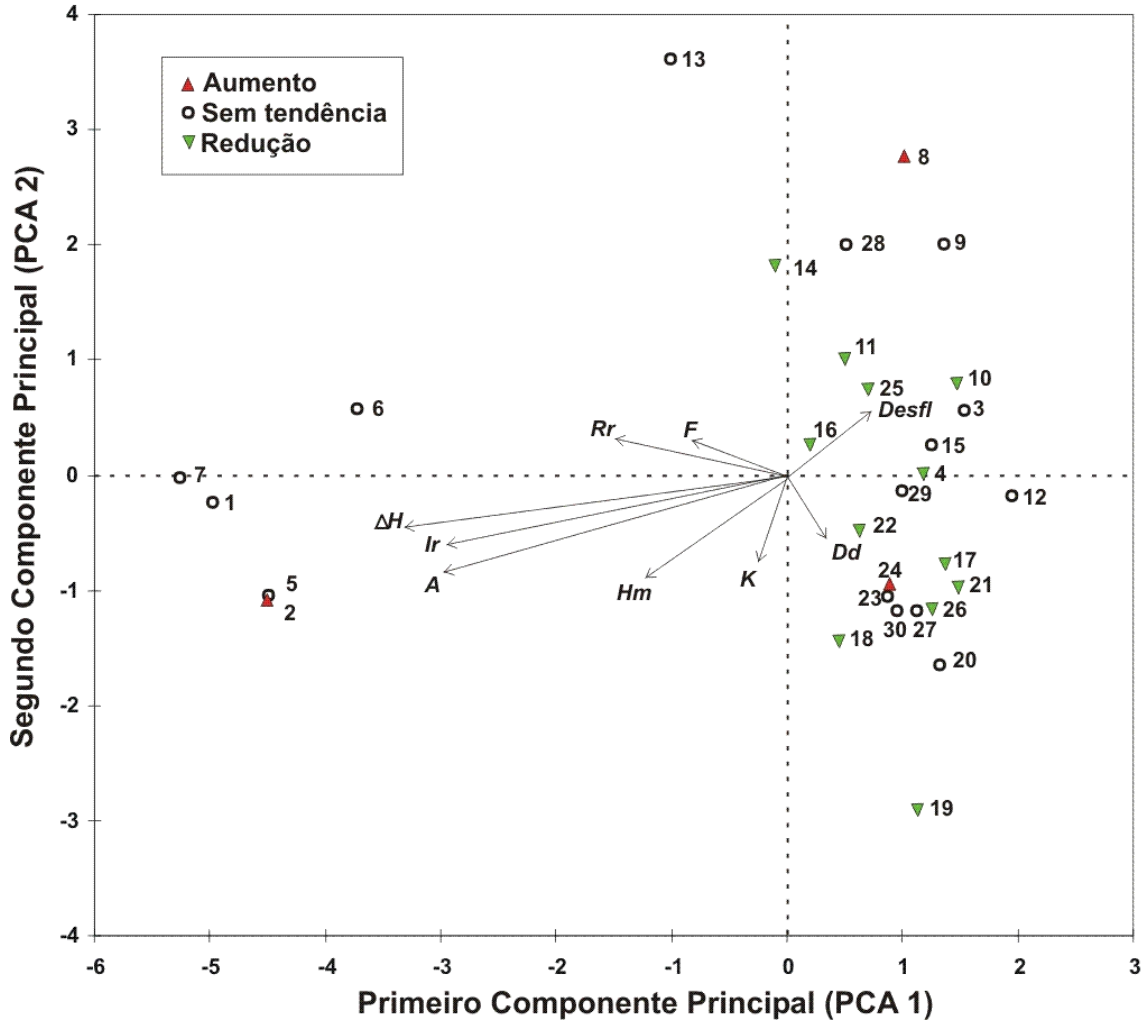


(COLLISCHONN et al., 2001)



Simple regression between slopes of trends on discharge and deforestation levels pointed out no significant relationship between these variables (R^2=0.08; p=0.12)

Principally Component Analysis revealed that the decrease of streamflow is restricted to watersheds with low altitude



A - Area

Hm - Average altitude

ΔH - Altitud variation

Ir - Roughness index

Rr - Relief ratio

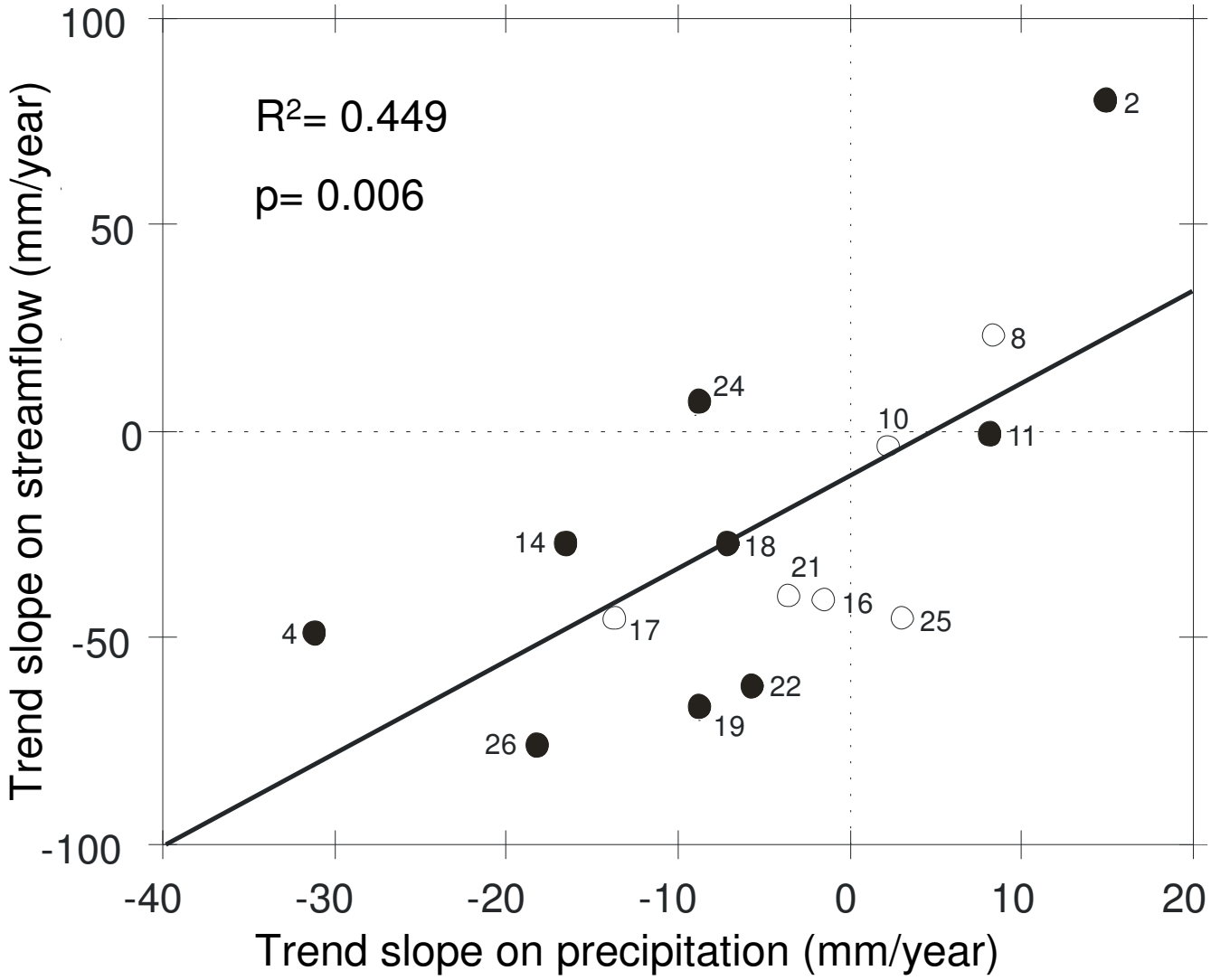
Dd - Drainage density

F - Form factor

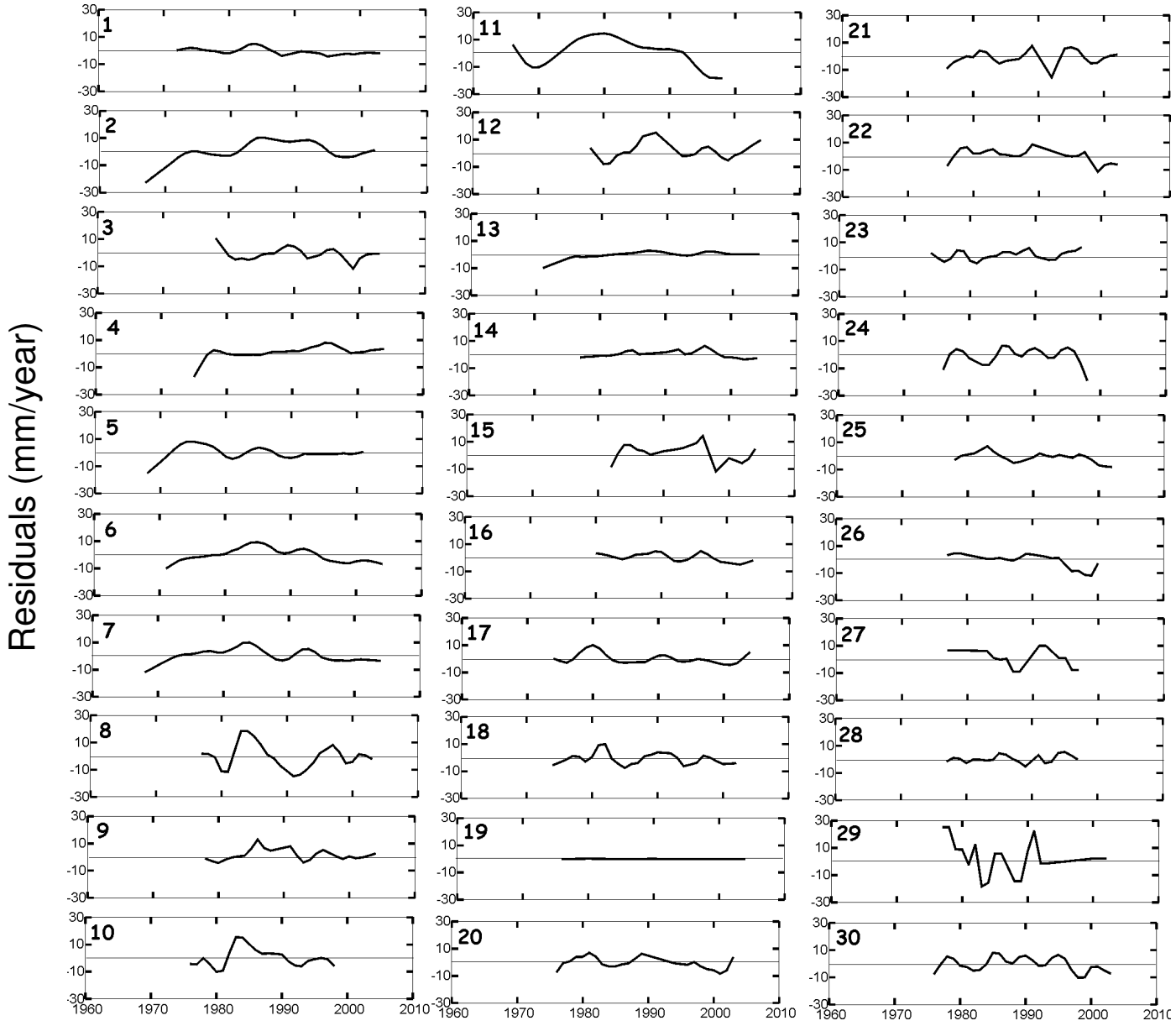
K - Form index

Desfl - Deforestation

Simple regression between trend slopes of discharge and precipitation indicated a direct relationship between these variables



Residuals from streamflow-precipitation relationship showed no trend on most of the watersheds. When precipitation effect is removed, trends are neutralized.



Conclusions

● Watersheds show different **deforestation levels** (3,1 a 60,55%). The most deforested are situated on Madeira river basin, state of Rondônia, on Jamari (8 e 10) and Ji-Paraná (9 e 12) basins.

● **Annual trends** found out on discharge and precipitation showed high spatial variability. However, they were **predominantly reduction** (40%), mainly on Tapajós river basin.

● Even in watersheds with more than a half deforested area, there is no evidence of increase on streamflow.

● **Trends magnitudes** obtained by Sen-slope estimator were quite diversified for **streamflow** and **precipitation**.

● Streamflow decrease found in these three basins are related to precipitation decrease. When precipitation effect were removed, trends are neutralized.

● Although streamflow decreases are related to reduction on precipitation, We can't conclude that deforestation process is the cause of precipitation reduction. Even as if precipitation reduction are due natural variability or climate change.

Acknowledgments

CAPES