Soil erosion evaluation and multitemporal analysis in two Brazilian basins

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FRAMEWORK

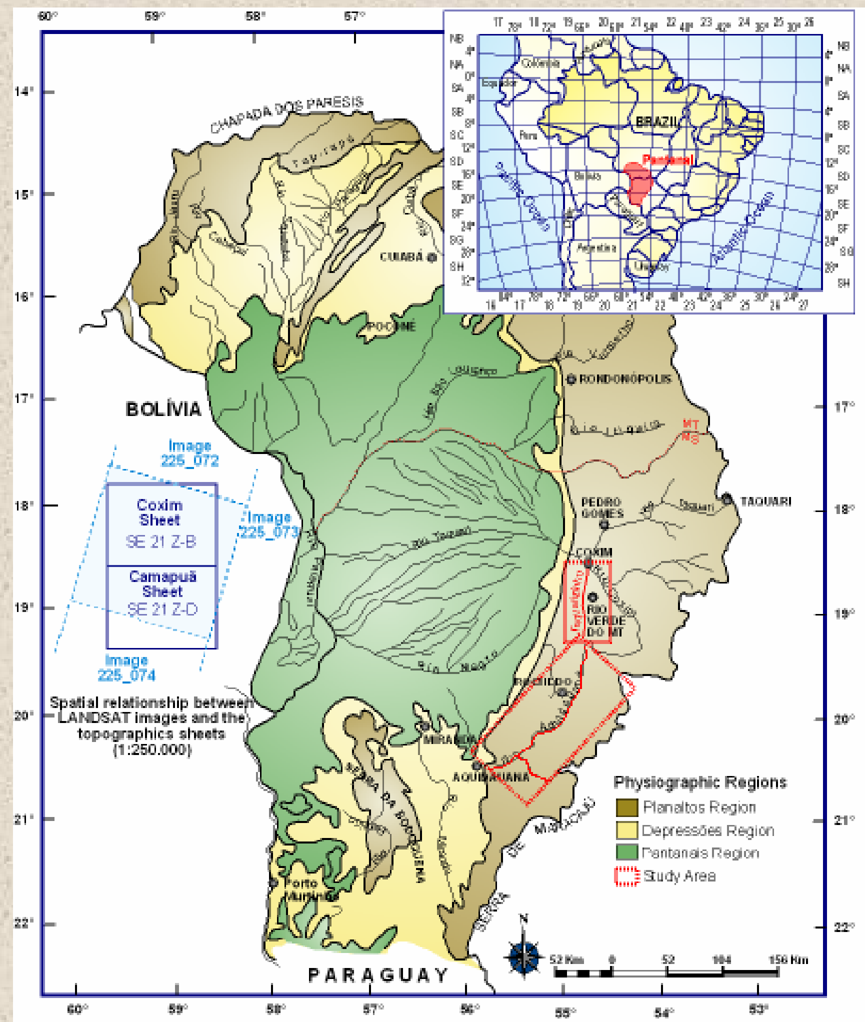
INCO-DC Project: “Geo - environmental dynamics of Pantanal - Chaco: multitemporal study and previsional modelling”

Partners:

University of Siena (Coordinator - Italy)
ENEA Pisa (Italy)
National Zootechnical Station (Portugal)
University of Curitiba (Brazil)
National University of Asuncion (Paraguay)

THE PROBLEM

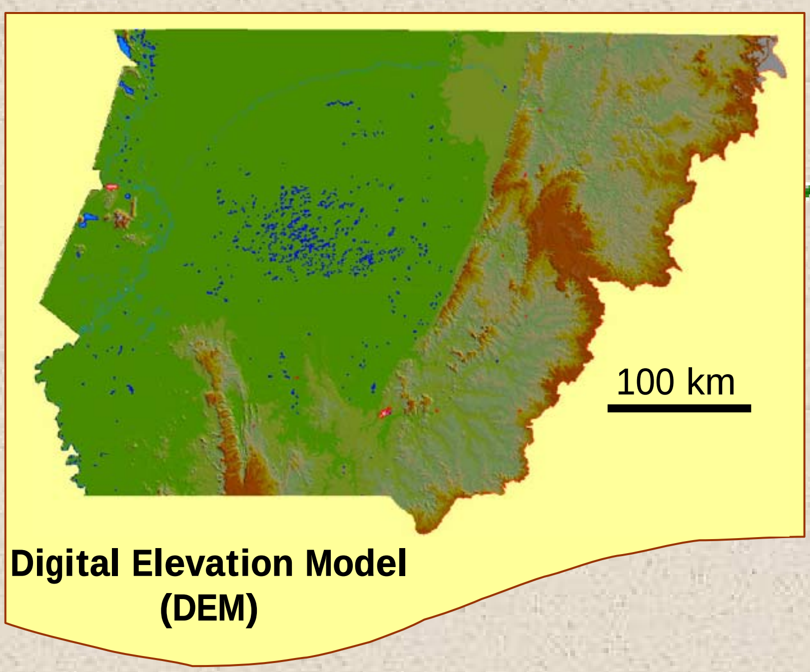
LOCALIZAZION



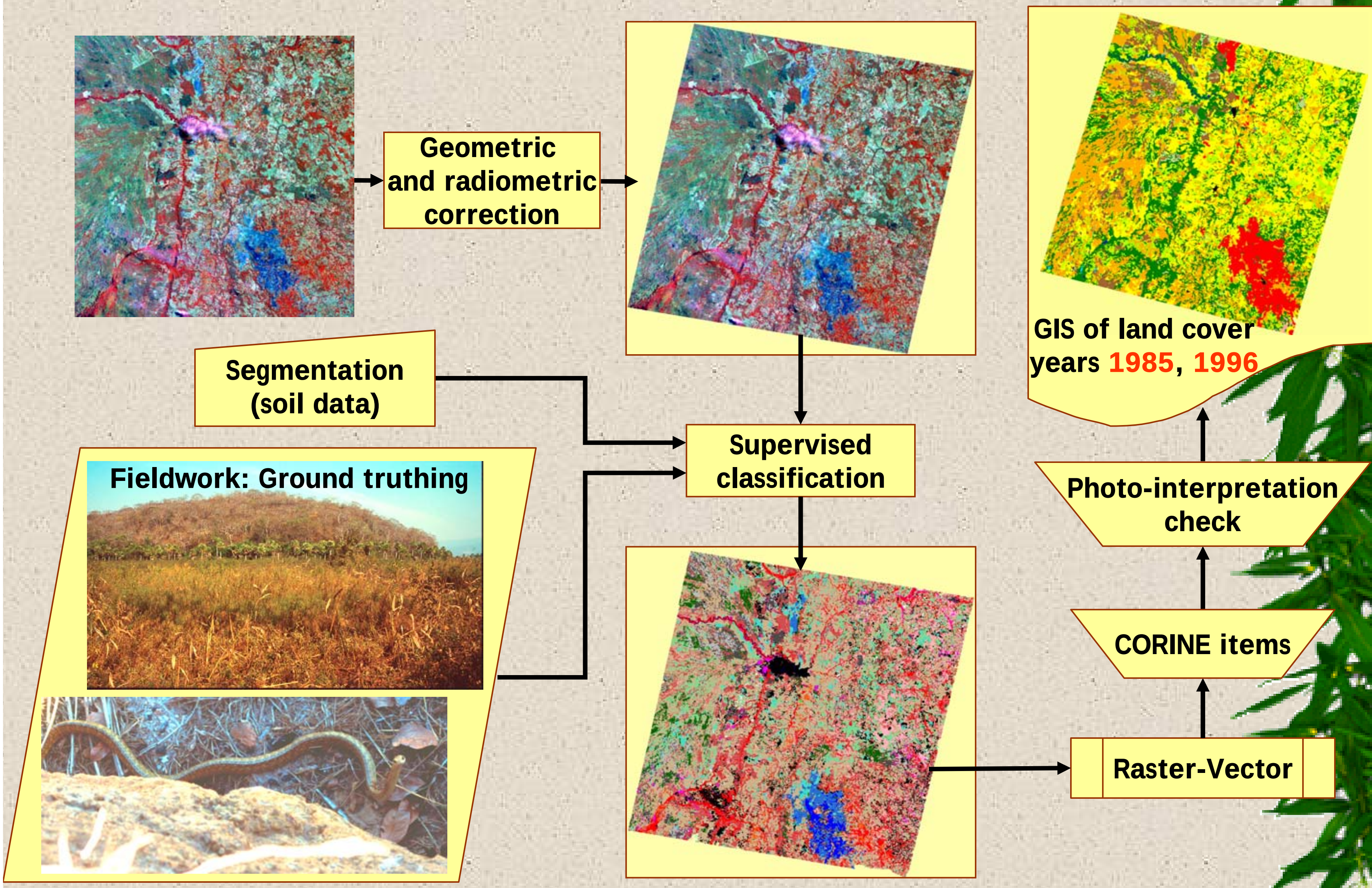
The Pantanal is one of the widest wetlands of the world (it extends approximately 120.000 Km², across the Mato Grosso and Mato Grosso do Sul Brasilian states)

Land cover GIS and DEM realisation

- In Brazil topographic maps provide land cover data based on aerial photos acquired from 1964 to 1966.
- The GIS of the following themes could be built:
  - – land cover (1966)
  - – elevation
  - – hydrography
  - – roads

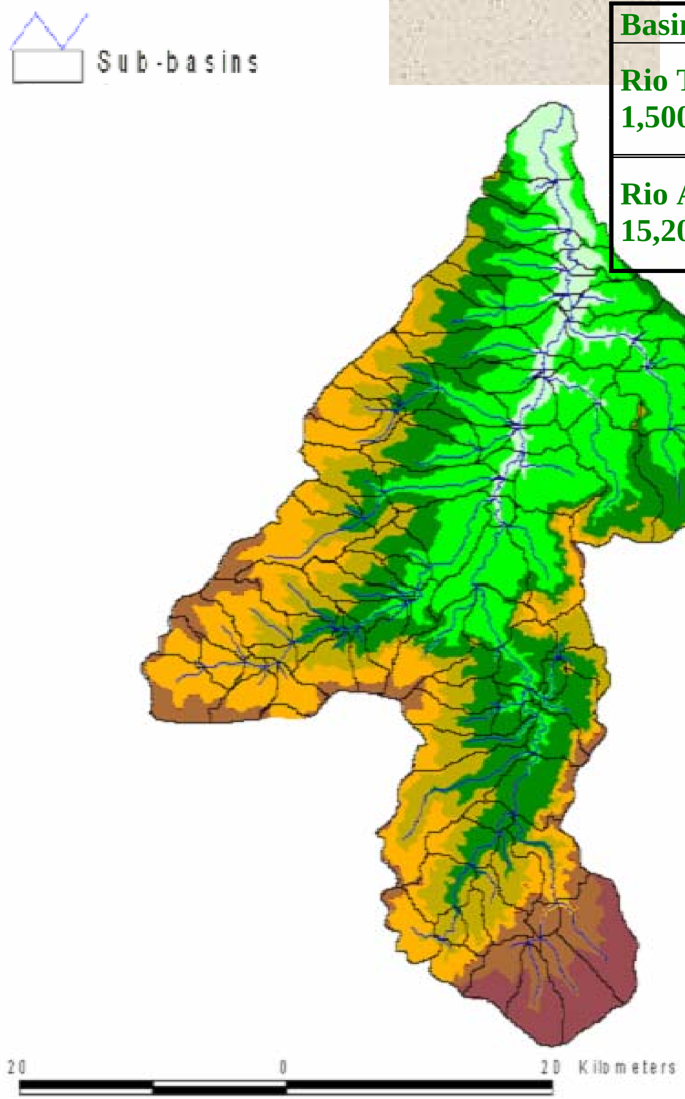


Land cover GIS realisation

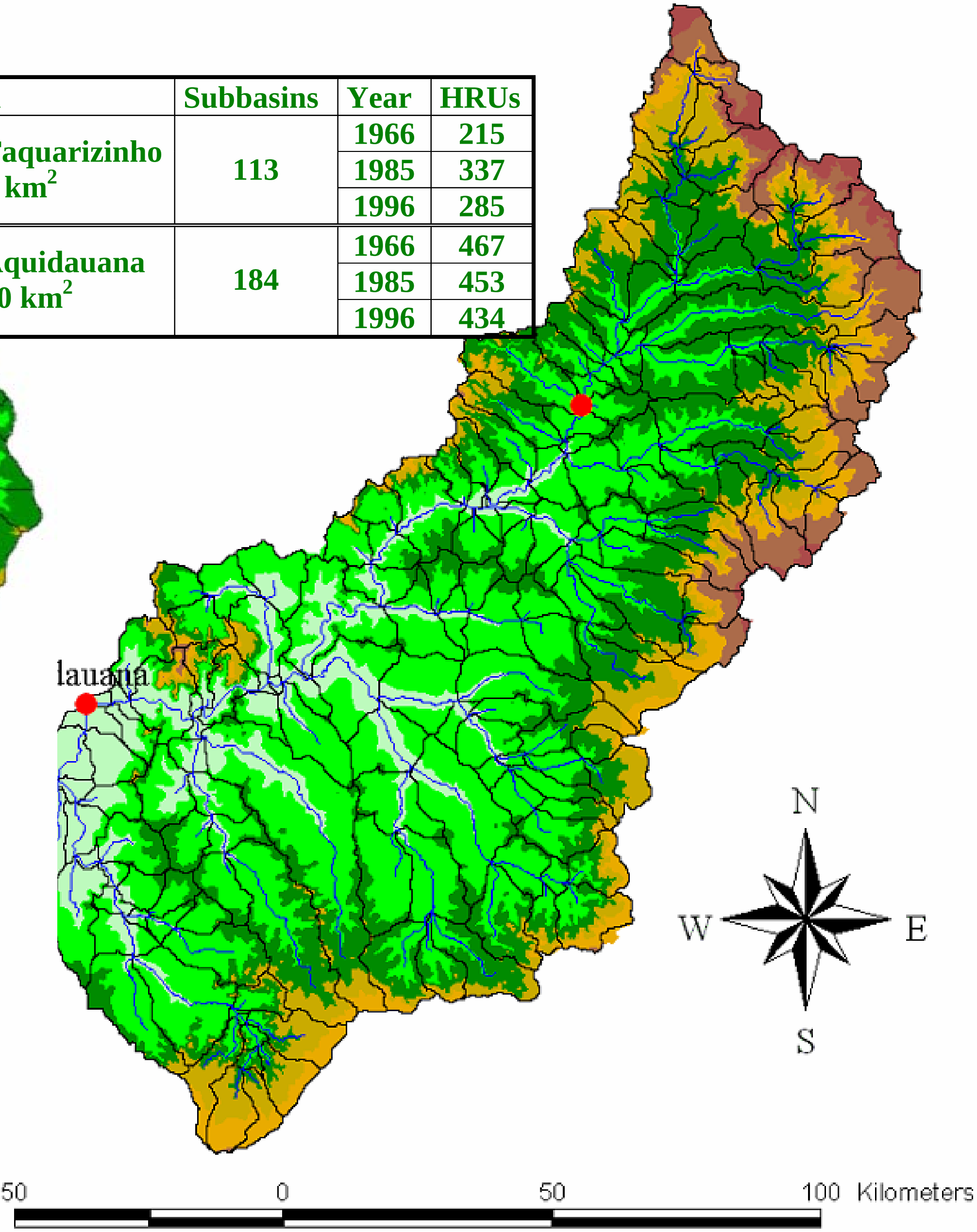


from Landsat TM5 images (years 1985 and 1996)

SWAT INP

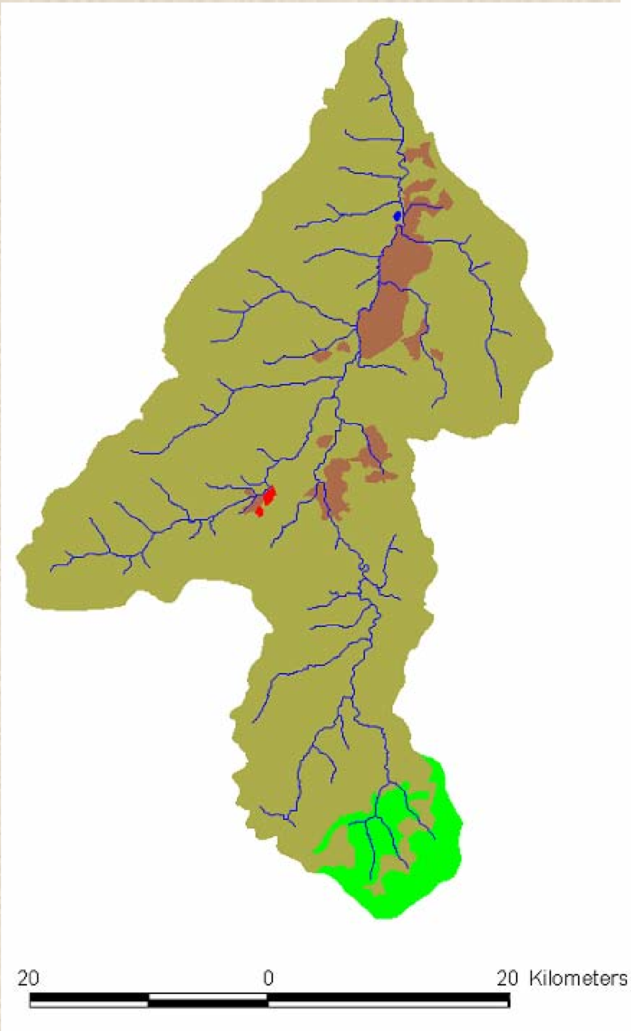


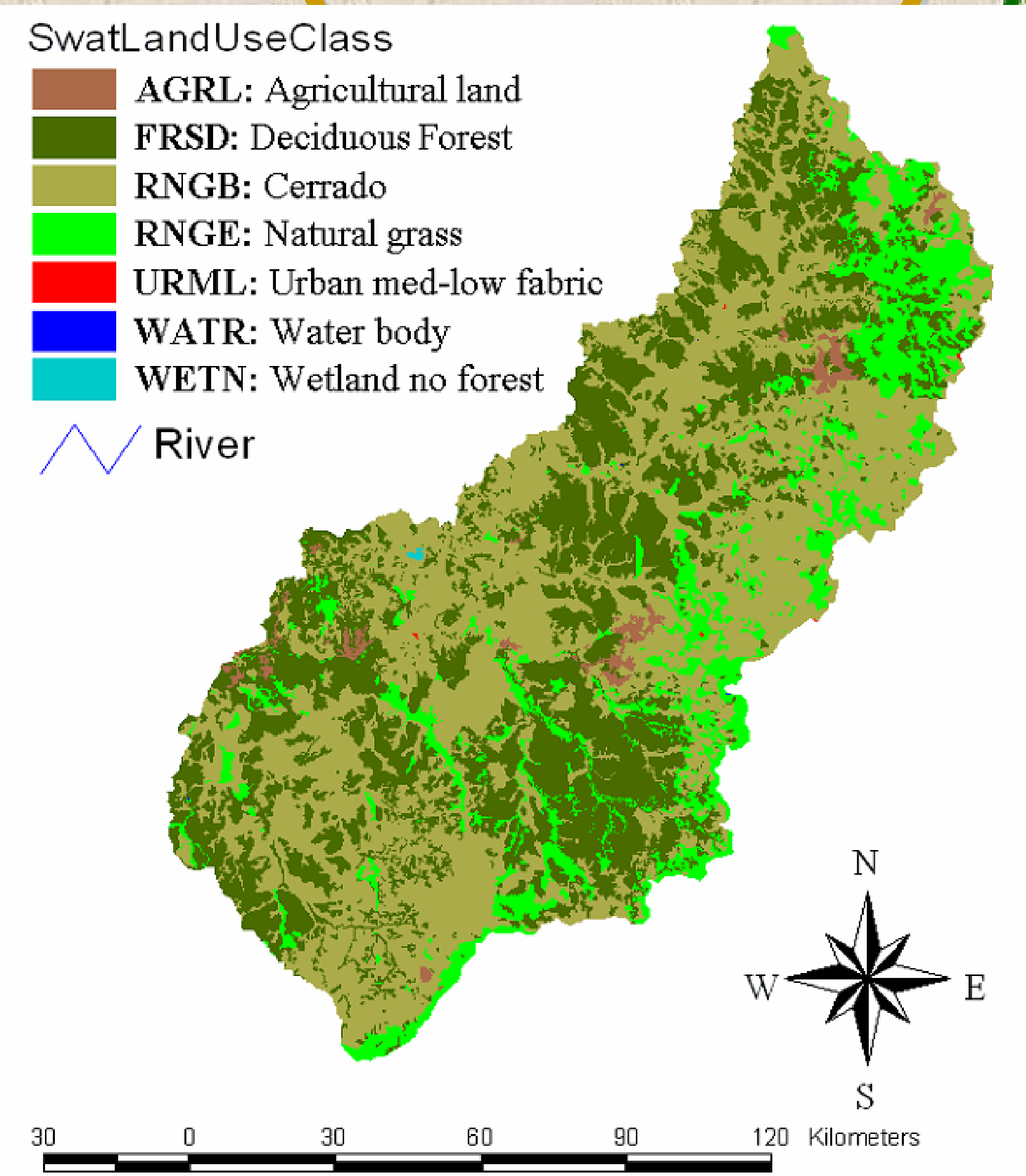
Basin	Subbasins	Year	HRUs
Rio Taquarizinho 1,500 km^2	113	1966	215
		1985	337
		1996	285
Rio Aquidauana 15,200 km^2	184	1966	467
		1985	453
		1996	434



SWAT INPUTS (LANDUSE)

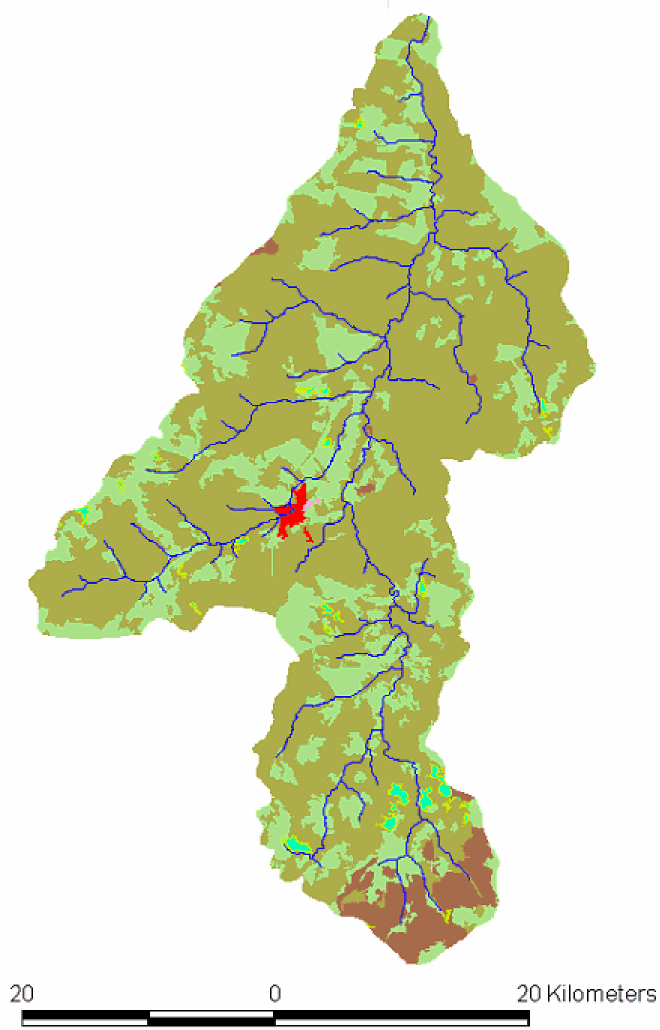
YEAR 1966

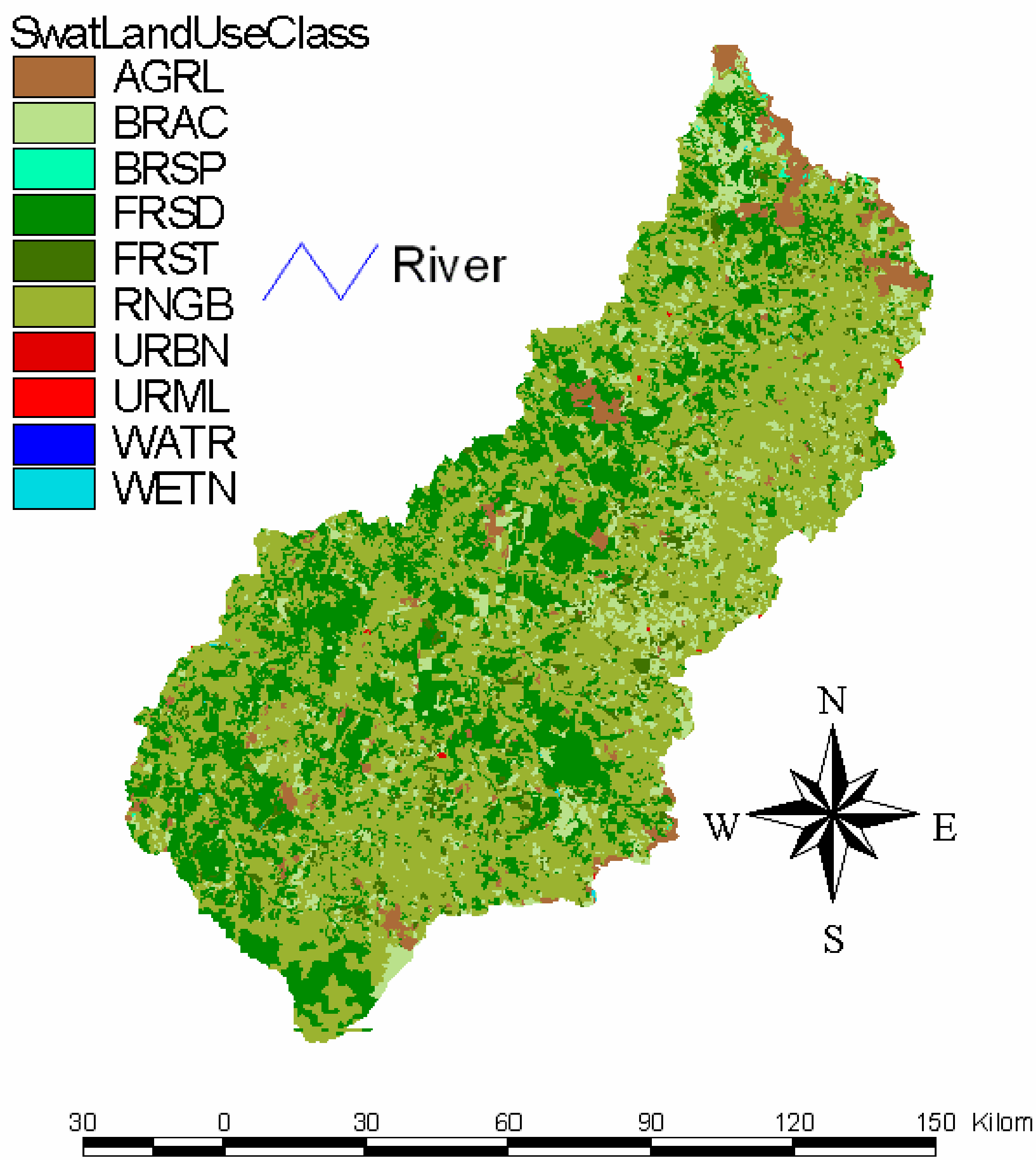




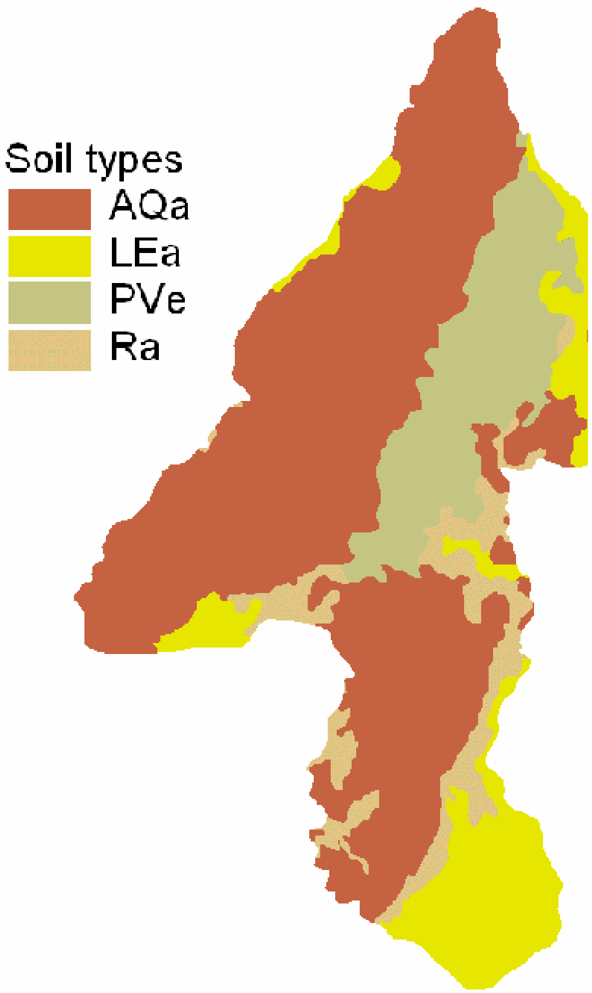
SWAT INPUTS (LANDUSE)

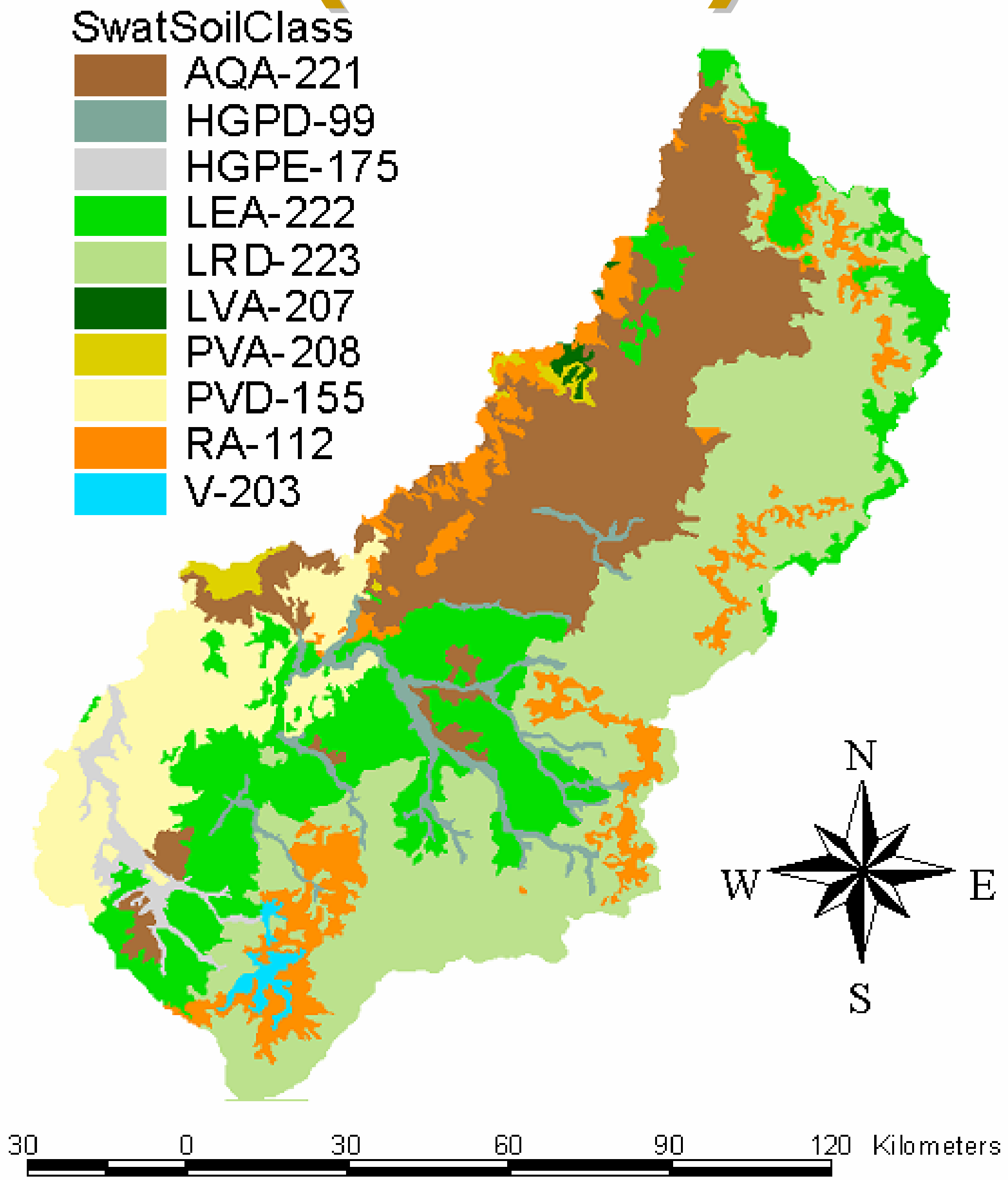
YEAR 1985





SWAT INPUTS (SOILS)





Soils legends

SWAT INPUTS (Agr. manag.)

YEAR 1985 1996

Rotation Soybean – Soybean – Corn (3 years)

Year 1-2

1st March	Pesticide application (insecticide)
20th April	Corn (Soya bean) harvest and kill
1st November	Tillage operation (plowing)
10th November	Fertiliser application
11th and 20th November	Tillage operation (harrowing)
21st November	Soya bean planting
6th and 20th December	Pesticide application (herbicide + insecticide)

Year 3

15th May	Soya bean harvest and kill
20th October	Tillage operation (plowing)
1st November	Fertiliser application
2nd November	Tillage operation (harrowing)
16th November	Fertiliser application
17th November	Tillage operation (harrowing)
18th November	Corn planting
28th November	Pesticide application (herbicide)

SWAT CALIBRATION

Model calibration was performed in three steps:

1. **Run-off and Total stream flow:** Using ANEEL (Agencia Nacional de Energia Eletrica) data

2. **Evapotranspiration:** using PCBAP Project data

3. **Sediments flow:** using literature and PCBAP Project data

SWAT CALIBRATION

<u>**Step 1: Run-off and total streamflow**</u>

a. **Acquisition of total flow data from ANEEL;**
b. **Use of USGS HYSEP software to calculate run-off and base flow from total flow;**
c. **SWAT run and confrontation with HYSEP results;**
d. **Use of Calibration Tool to modify Curve Number, Available Water Capacity and Soil Evaporation compensation factor;**
e. **Iteration of steps c-d until satisfactory match reached for both run-off and total flow.**

SWAT CALIBRATION

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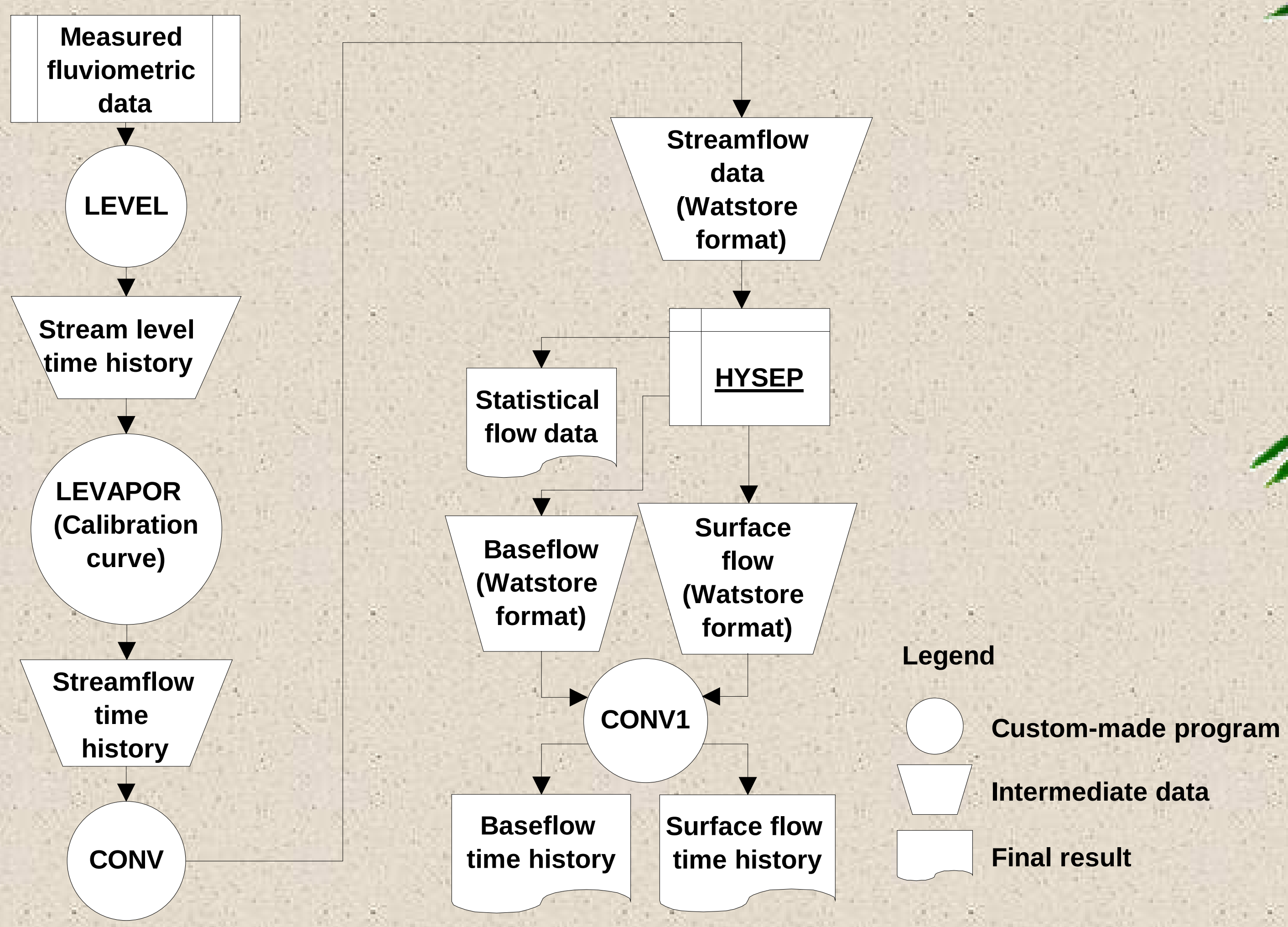
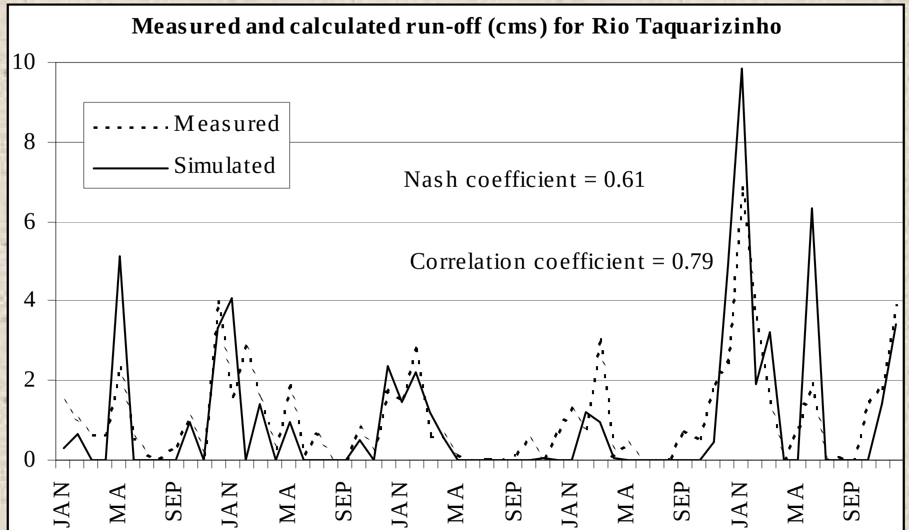
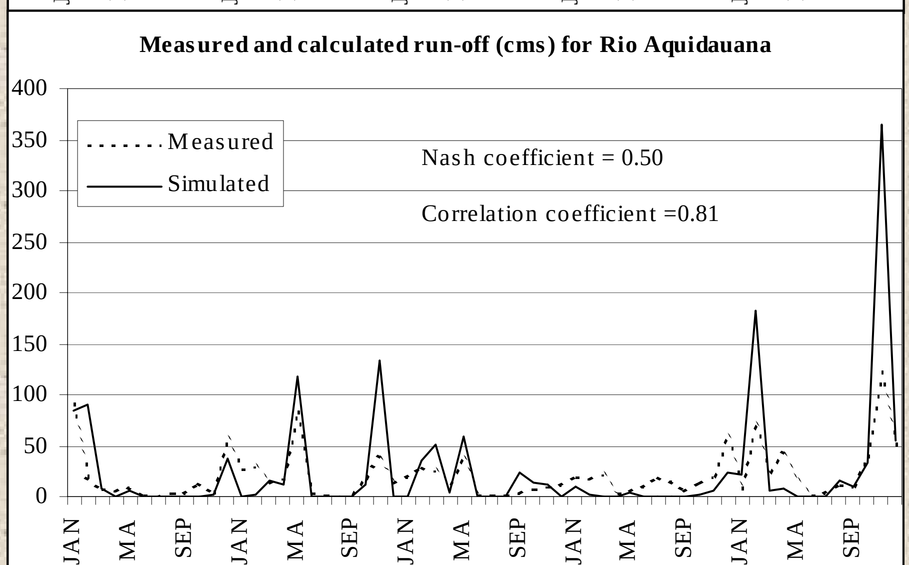


SWAT CALIBRATION

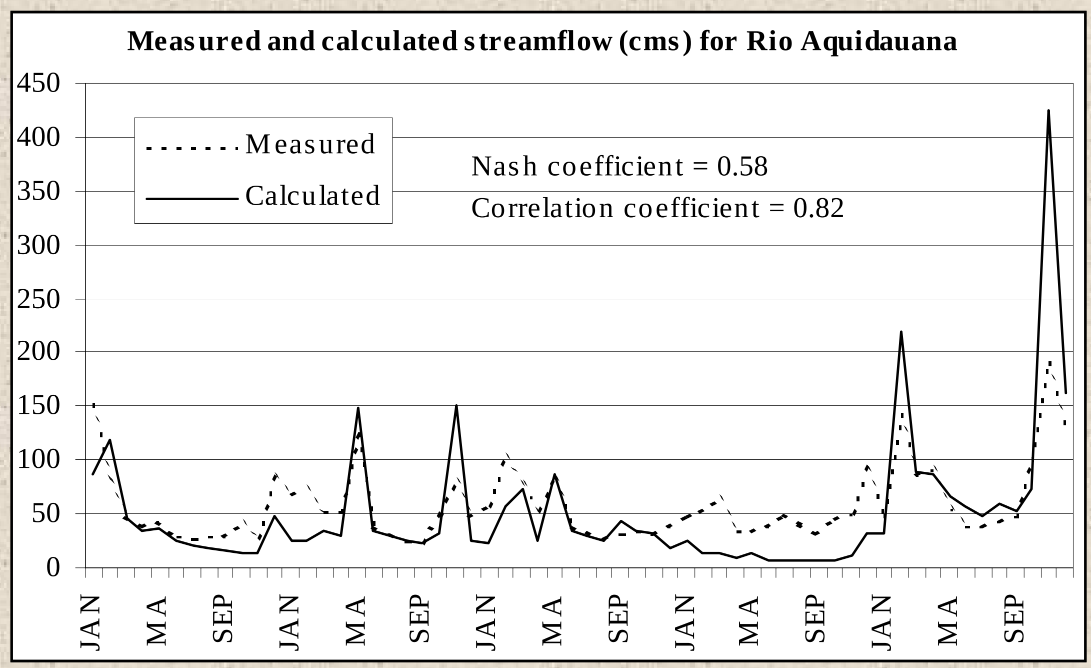




RUNOFF RESULTS

SWAT CALIBRATION

T O T A L S T R E A M F L O W



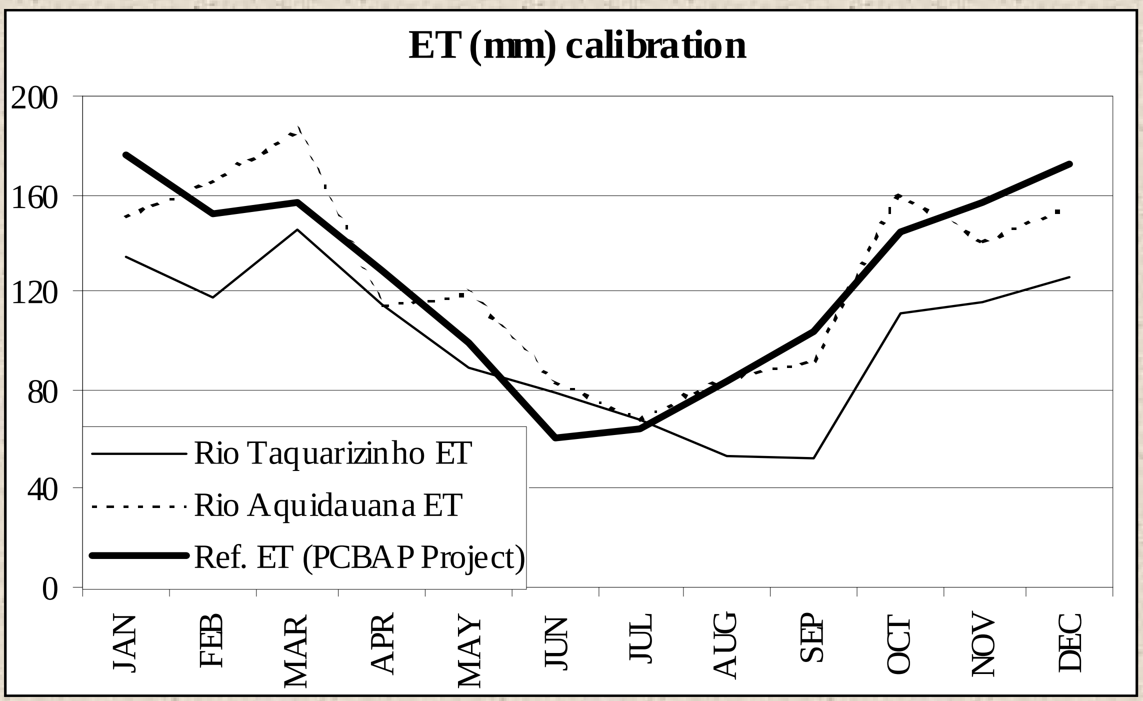
SWAT CALIBRATION

Step 3: Evapotranspiration

- **Performed in order to optimize the water balance;**
- **Modified parameters: groundwater “revap” coefficient (also influences run-off) and threshold depth in the shallow aquifer for “revap” to occur;**
- **Confrontation data coming from PCBAP Project.**

SWAT CALIBRATION

Step 3: Evapotranspiration (results)



Correlation factors (R^2): 0.85 for Rio Taquarizinho and
0.90 for Rio Aquidauana

SWAT CALIBRATION

Step 4: Sediment flow

- **Rio Taquarizinho: Confrontation data was computed from literature measurements of sediment flow on similar watersheds.**
- **Rio Aquidauana: Confrontation data came from PCBAP monthly averages.**
- **Modified parameters: factors used to calculate the sediment reentrainment in channel routing phase (linear and exponential parameters).**

Rio Taquarizinho

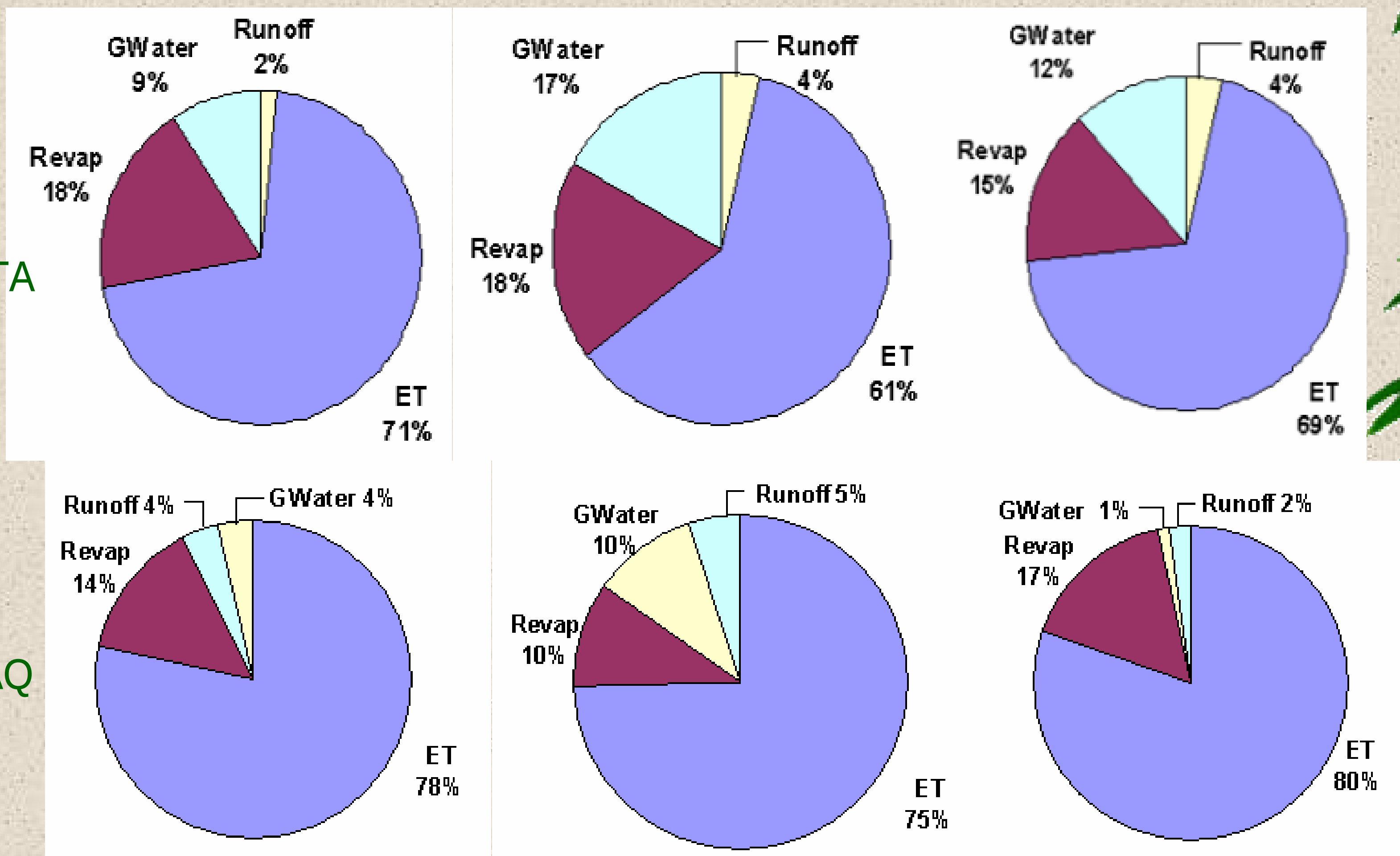
Rio Aquidauana

SIMULATIONS RESULTS

1966 1985 1996

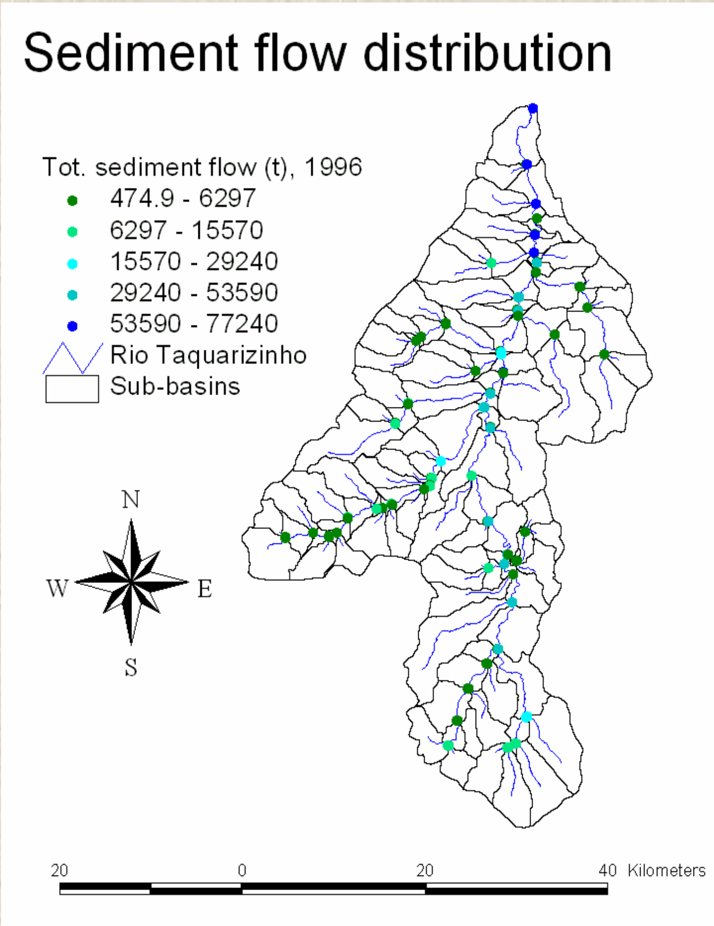
TA

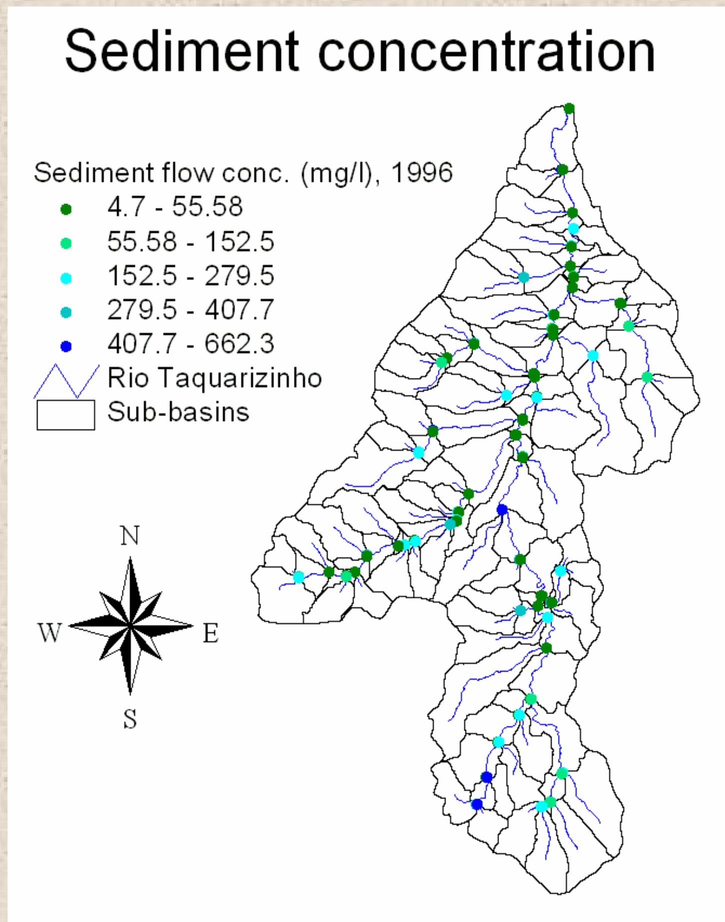
AQ



HYDROLOGIC BALANCE

SIMULATIONS RESULTS





MULTITEMPORAL ANALYSIS

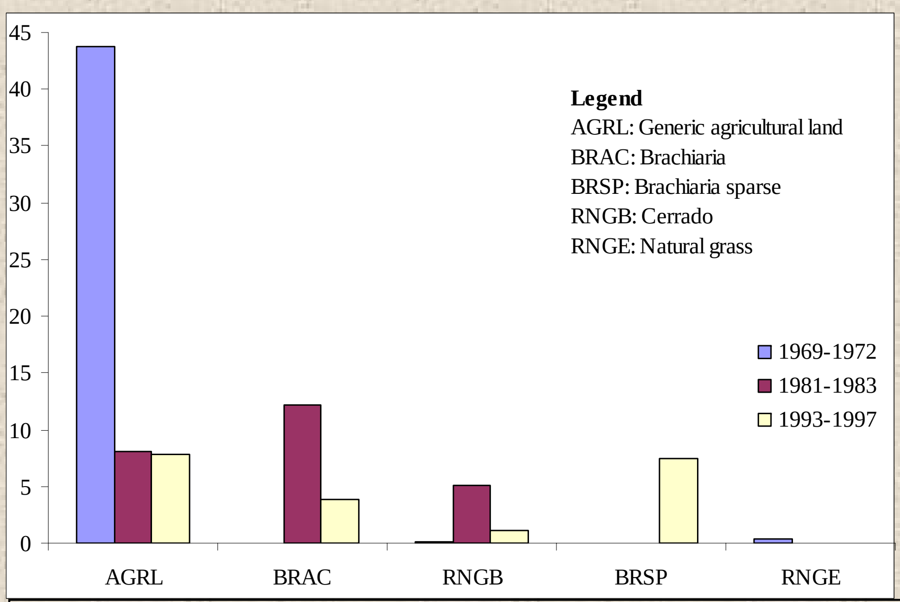
Target: to investigate some of the links between human-induced land use modifications and the soil erosion trend.

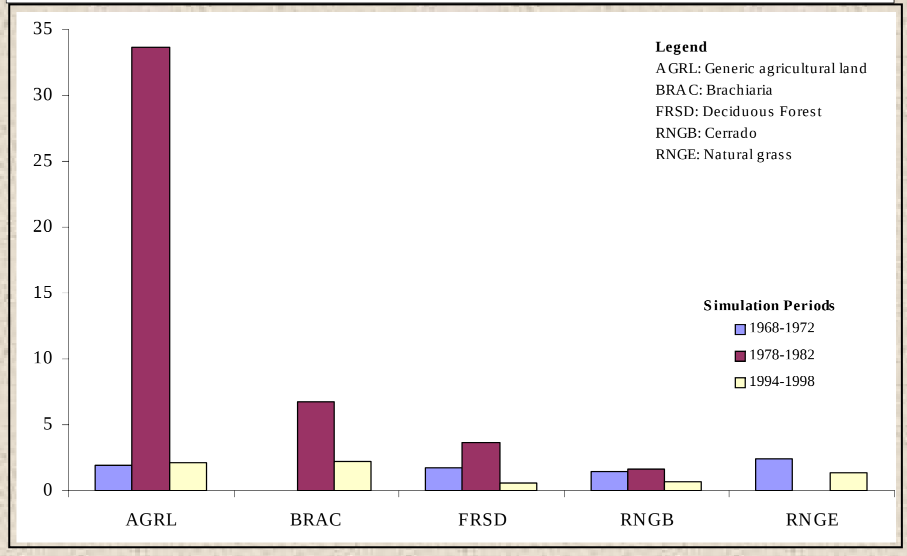
Limitations: it is not always easy to compare the results of different simulation periods, since also natural phenomena play an important role. For example the greater amounts of the runoff and the soil loss in the 1978-1982 period (see Tab) is strictly linked to the total amount of rainfall in this period. A comparison of parameters (runoff, revap, evapo-transpiration, total soil loss) don't give useful elements for a multitemporal analysis because they are also influenced by the rainfall.

Rio Aquidauana

MULTITEMPORAL ANALYSIS

SPEC. SOIL LOSS t/ha

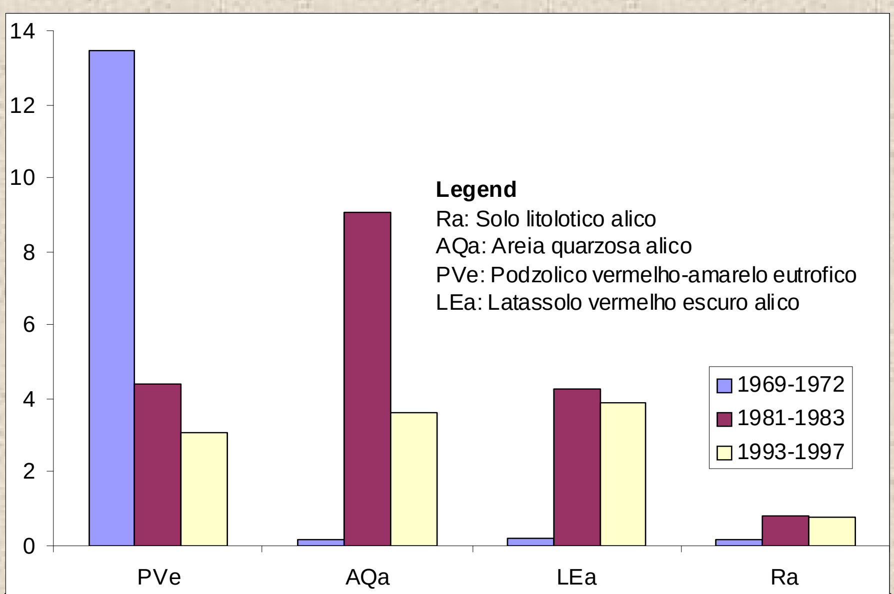


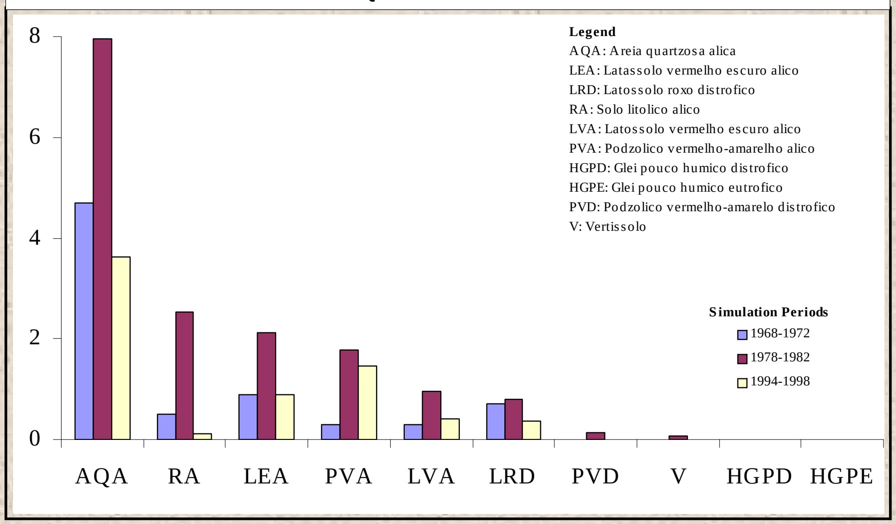


MULTITEMPORAL ANALYSIS

SPEC. SOIL LOSS

t/ha





MULTITEMPORAL ANALYSIS

		Landuse Scenarios		
		1966	**1985**	**1996**
"Anthropised" Land Uses	Surface (ha)	7,160	43,020	103,210
	Total soil loss (t)	309,672	488,774	467,705
	Specific soil loss (t/ha)	43.25	11.36	4.53
"Natural" Land Uses	Surface (ha)	141,860	106,000	45,810
	Total soil loss (t)	18,686	542,471	31,693
	Specific soil loss (t/ha)	0.13	5.12	0.69
"Anthropised" Land Uses	Surface (ha)	3,014	48,222	572,846
	Total soil loss (t)	5,632	908,297	1,167,524
	Specific soil loss (t/ha)	1.87	18.8	2.21
"Natural" Land Uses	Surface (ha)	1,570,742	1,525,479	1,046,741
	Total soil loss (t)	2,472,388	3,315,230	656,492
	Specific soil loss (t/ha)	1.57	2.17	0.63

Rio Taquarizinho

Rio Aquidauana

MULTITEMPORAL ANALYSIS

Rio Taquarizinho: Conclusions.

- **A significant decrease of "Cerrado" from 89% (1969-1972) to 31% (1993-1997) of the total basin area.**
- **The deforested areas became mainly pasture areas (Brachiaria grass). In the 1969-1972 period the Brachiaria grass doesn't appear, so the pasture areas were codified as natural grass.**
- **The extension of the agricultural areas is relatively small, about 5% of the total basin, with no significant variation in the three simulation periods. The relevant differences in specific soil loss for the 1969-1972 period are caused by the differences in soil type and management for the agricultural activities as regards to the other periods (crops rotation in place of single crop).**
- **In the period 1993-1997 the land use BRSP takes into account the pasture areas where Brachiaria is less dense either because they are neglected or because the soils are not suitable for an optimal growing of the grass: both situations cause an increase of soil loss, with values comparable with agricultural landuse.**

MULTITEMPORAL ANALYSIS

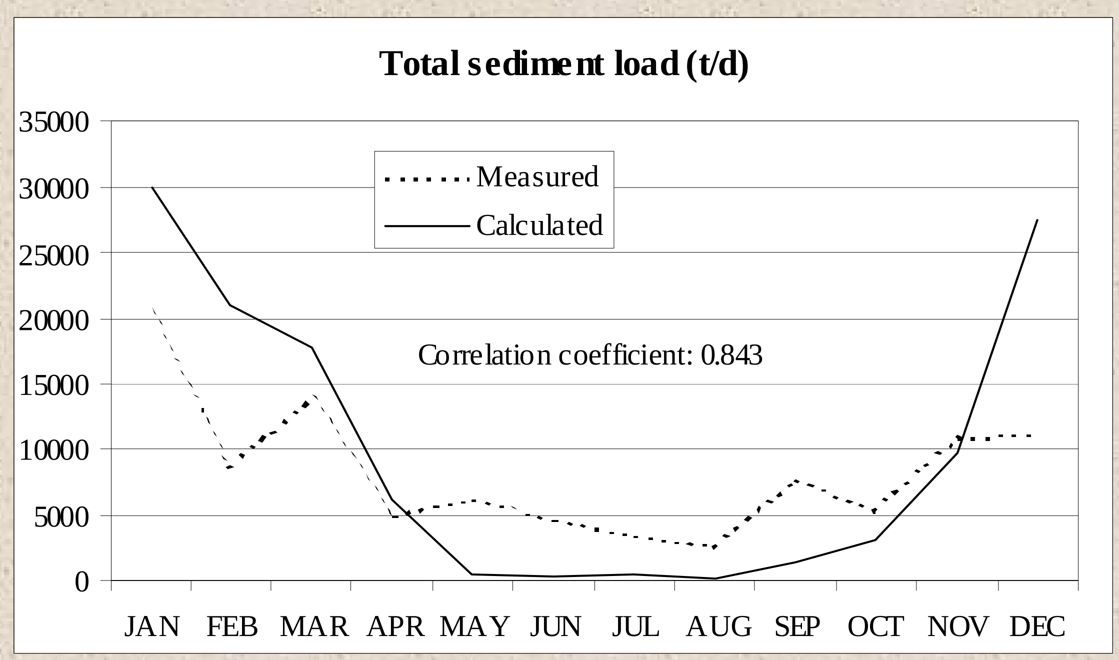
Rio Aquidauana: Conlusions

- **A significant decrease of “Cerrado” from 72% (1978-1982) to 55% (1994-1998) of the total basin area.**
- **A significant decrease of “Deciduous forest” from 34% (1968-1972) to 10% (1994-1998) of the total basin area.**
- **The deforested areas became mainly pasture areas (Brachiaria grass). In the period 1968-1972 the pasture areas were natural grass.**
- **The extension of the agricultural areas (AGRL) is relatively small. It varies from about 0.2% of the total basin area in the 1968-1972 period, to about 6% of the total basin area in the 1994-1998 period.**

SWAT CALIBRATION

Step 4: Sediment flow

Rio Aquidauana results



SWAT CALIBRATION

Step 4: Sediment flow

Rio Taquarizinho procedure:

a. Acquisition of literature data on sediments loads and stream flows in Rio Taquarì streams (period 1995-1997);

b. Calculation of coefficients a and b of the correlation between *suspended* sediments loads (Q_s, t/d) and stream flow (P, m^3/s): $\ln Q_s = a + b \cdot \ln P$ using the above data;

c. Evaluation of mean annual Rio Taquarizinho water flow at outlet by means of the conservation of the specific flow measured at an intermediate gauge station; calculation of mean annual *suspended* sediment flow by the previous correlation (point b.);

d. Evaluation of mean annual *total* sediment load from the ratios "total load / Suspended load" taken from literature data at point a;

e. Confrontation with SWAT results;

SWAT INPUTS (SOILS)

Legend Rio Aquidauana:

AQa – Quartzose alic sandstone (22.5%)
PVa – Yellow-red podzolic alic (0.9%)
PVd – Yellow-red podzolic distrophic (9.8%)
LEa – Dark red alic latosol (18.8%)
LRd – Red distrophic latosol (32.6%)
LVa – Yellow-red alic latosol (0.3)
HGPd – Little humic “glei” distrophic (3.4%)
HGPe – Little humic “glei” eutrophic (1.7%)
Ra – Litholic alic (9.3%)
V – Vertisol (0.7)

Legend Rio Taquarizinho:

AQa – Quartzose alic sandstone (61%)
LEa – Dark red alic latosol (16%)
PVe – Yellow-red podzolic eutrophic (15%)
Ra – Litholic alic (8%)

Note:
Alic = rich of Al

MULTITEMPORAL ANALYSIS

Parameters	Simulation periods 1968-1972	1978-1982	1994-1998	1978-1982 l.u. 1996
Rainfall (mm)	**1,264.9**	**1,528.0**	**994.8**	**1,528.0**
Runoff (mm)	**50.48**	**80.98**	**26.70**	**87.75**
Total soil loss (t/y)	**67,000**	**118,000**	**44,000**	**143,600**
Tot. stream flow (mm)	**106.32**	**253.07**	**40.51**	**248.4**

Rio Aquidauana