RIVER SYMPOSIUM

A Tool for Establishing Environmental Flows and Access Rules in Unregulated Rivers in Central Brazil

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Introduction

- An environmental flow (EF) is the water regime provided to maintain ecosystems & their benefits where competing water uses exist
- To establish EF, one needs to consider environmental, economic, social and cultural values in relation to the entire system (Dyson et al, 2003)
- Although the Brazilian legislation has provisions for minimum flows in rivers, they only consider the hydrologic (statistical) aspect

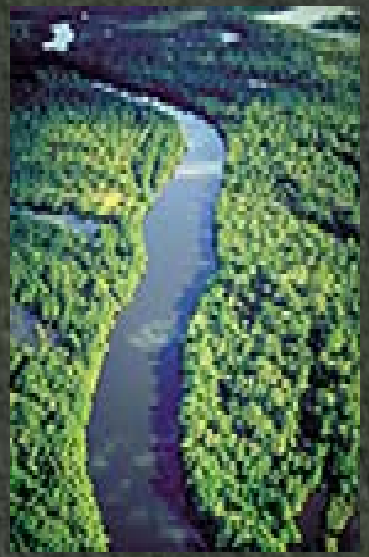
Objectives

- To develop / adapt a suitable methodology for the establishment of environmental flows and water management rules for unregulated rivers in Central Brazil
- To apply it to the Pipiripau river

Methodology (1)

- NSW's (2006) philosophy:
  - ✓Give greater protection to areas of higher instream value (Rutherford, 2000)
  - ✓Allow greater extraction in areas where extraction brings greater economic & social benefits
  - ✓Allow for more intensive management in areas where both instream & extraction values are high

Methodology (2)



- P_{ef} is a function of:
  - ✓ The hydrologic stress (Hs) of the catchment
  - ✓ The economic dependence (Ed) of the extraction
  - ✓ The instream value, Iv (ecologic & cultural)
- A regional panel, representing the different sectors & stakeholders, calculates the Pef

Methodology: Hydrologic Stress

H_s = f (Water use intensity (Wu);
Climate change vulnerability (Vc))

Water Use Intensity (Wu):

Level	Wu (% of Qav)
Low	Wu <20%
Medium	20%≤ Wu ≤50%
High	Wu ≥50%

Methodology: Hydrologic Stress

Vulnerability C.C. = f (Climate Variability (Var); Non-stationarity (Ns))

Climate Variability (Var)

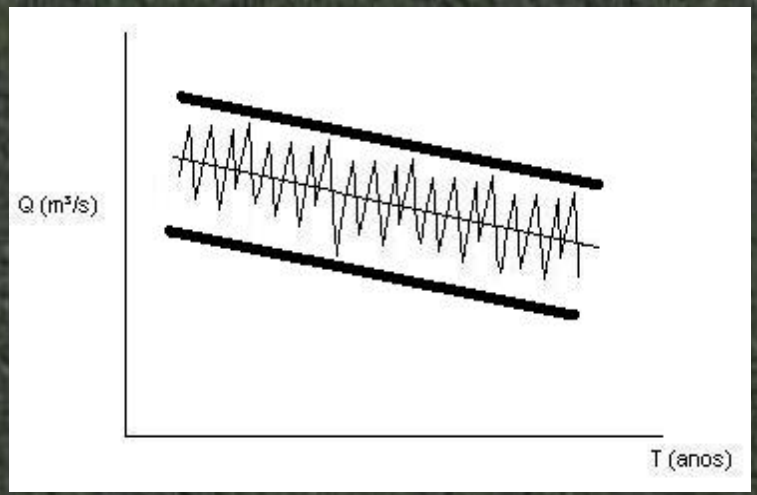
Var.	C.V. (%)
Low	C.V.< 15%
Medium	15%≤ C.V.≤30%
High	C.V.≥ 30%

Non-stationarity (Ns)

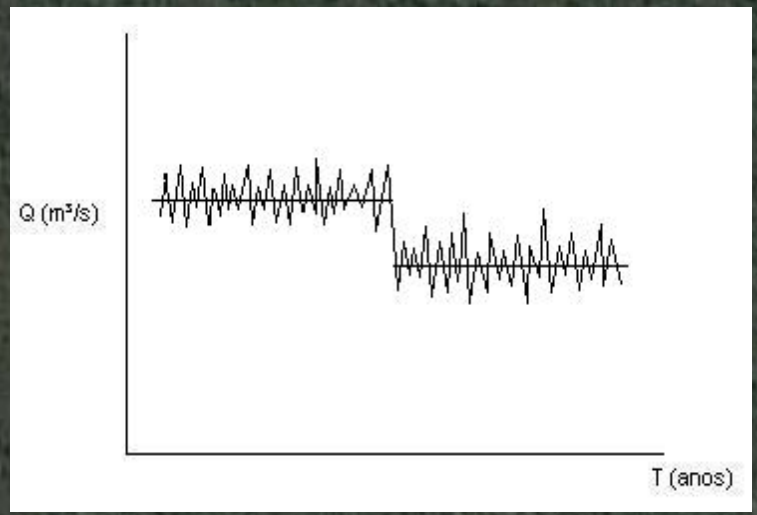
Ns	Salas' tc
Low	tc < 0,9 t
Medium	0,9t ≤ tc ≤1,1t
High	tc ≥ 1,1 t

Methodology: Hydrologic Stress

Climate Variability (Var)



Non-stationarity (Ns)



Methodology: Hydrologic Stress

Non-stationarity

Clim. Var.

	Low	Medium	High
Low	1	2	3
Medium	2	4	6
High	3	6	9

Score	Vuln. CC
1 - 2	Low
3 - 4	Medium
6 - 9	High

Methodology: Hydrologic Stress

Water-use Intensity

Vuln. C.C

	Low	Medium	High
Low	1	2	3
Medium	2	4	6
High	3	6	9

Score	Hs
1 - 2	Low (1)
3 - 4	Medium (2)
6 - 9	High (3)

Methodology: Econ. Dependency

Econ. Dependency = f (Econ. value of extraction;
Potential of water demand mgt.)

Econ. Value Extraction: Irrigation

Level	Value (Ir) (US$/m3)
Low	Ir < 0,2
Medium	0,2≤Ir ≤0,6
High	Ir > 0,6

Econ. Value Extraction: Urban

Level	Tariff (Ur) (US$/m3)
Low	Ur < 0,2
Medium	0,2≤Ur ≤0,6
High	Ur > 0,6

Methodology: Econ. Dependency

Econ. Dependency = f (**Econ. value of extraction**; Potential of water demand mgt.)

Econ. Value Extraction: Irrigation

Econ. Value Extraction: Urban	Low	Medium	High
Low	1	2	3
Medium	2	4	6
High	3	6	9

Methodology: Econ. Dependency

Econ. Dependency = f (Econ. value of extraction; **Potential of water demand mgt.**)

Potential of improving irrigation efficiency

Pot. of reducing urban water losses	Low	Medium	High
Low	1	2	3
Medium	2	4	6
High	3	6	9

Methodology: Econ. Dependency

Score	Ev
1-2	Low
3-4	Medium
6-9	High

Score	P.D.M.
1-2	Low
3-4	Medium
6-9	High

Economic Value of Extraction

Pot. of water demand mgt.	High	Medium	Low
Low	1	2	3
Medium	2	4	6
High	3	6	9

Methodology: Econ. Dependency

Economic Dependency:

Score	Ed
1-2	High (1)
3-4	Medium (2)
6-9	Low (3)

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Methodology: Instream Value

Instream Value = f (Sensitivity to flow reduction;
Riparian integrity; Diversity; Rarity;
Special features; Non-extract. values)

Parameters	Low (1)	Medium (2)	High (3)
Gradient of river reach			
Perimeter to area ratio			
Water aspect			
Fish movement			
Integrity of riparian veg.			
Fish diversity			
Diversity of macro-inv.			

Methodology: Instream Value

Parameters (cont'd)	Low (1)	Medium (2)	High (3)
Threatened species			
Ecologic refuge			
Ecol. representativeness			
Tourism potential			
Fishing potential			
Sum	(12-36)		

Sum	Iv
12-19	Low
20-27	Medium
28-36	High

Methodology: Potential for Environm. Flow (Pef)

Score	Hs
1-2	Low (1)
3-4	Medium (2)
6-9	High (3)

Score	Ed
1-2	High (1)
3-4	Medium (2)
6-9	Low (3)

Score	Iv
1-2	Low (1)
3-4	Medium (2)
6-9	High (3)

Pef = Hs x Ed x Iv

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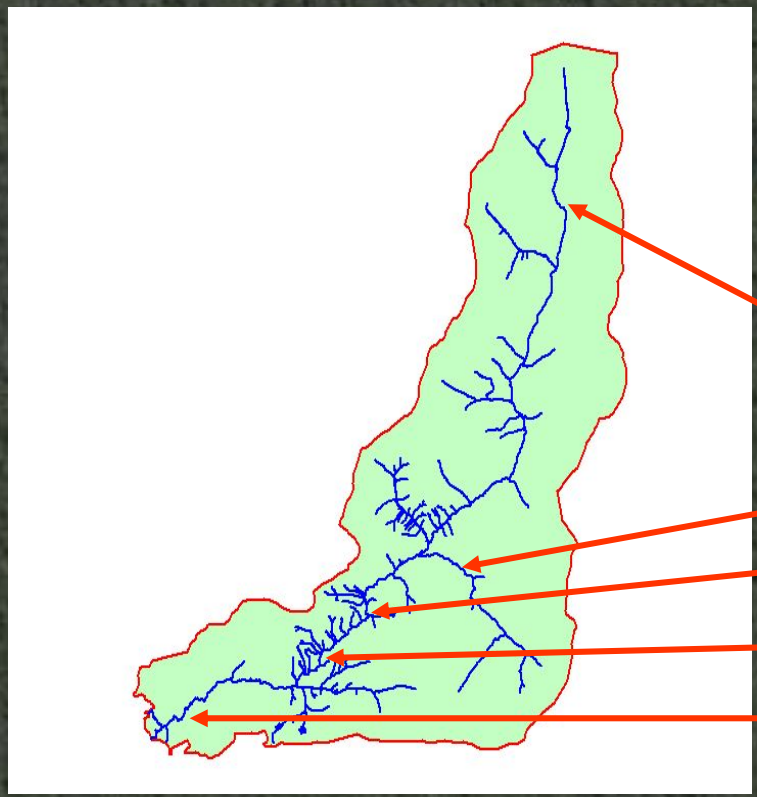
Methodology: Potential for Environ. Flow

P_{ef}	Level	Suggested Actions
1-3	Low	▪ Enforcement of the legal restr. flow limits
		▪ Incentive for the water use rationalization
		▪ Incentive for environmental education
4-12	Medium	▪ Increase at least 25% the restriction flow
		▪ Enforcement of the new restriction flows
		▪ Incentive for the water use rationalization
		▪ Restriction for new water licenses
		▪ Water charging, payment for env. services
18-27	High	▪ Increase at least 50% the restriction flow
		▪ Enforcement of the new restriction flows
		▪ Cap for new water licenses
		▪ Restriction to groundwater licensing
		▪ Water charging, payment for env. services

Methodology: Application of the P_{ef} to the Pipiripau River

- Basin area: 230 km^2
- River length: 36 km
- Original cover: savanna & gallery forest
- Population: 150,000
- SVAP score: 8.2 out of 10
- Existing water-use conflict: urban vs. irrigation
- Selected points for Pef: 05

Methodology: Application of the P_{ef} to the Pipiripau River



- Legal restriction flow: 30% of Q95%
- Stream network divided in 5 reaches / points
- Present restriction flows (environmental) are:

-Section 1: 0.43 m^3/s

-Section 2: 0.16 m^3/s

-Section 3: 0.94 m^3/s

-Section 4: 0.60 m^3/s

-Section 5: 0.38 m^3/s

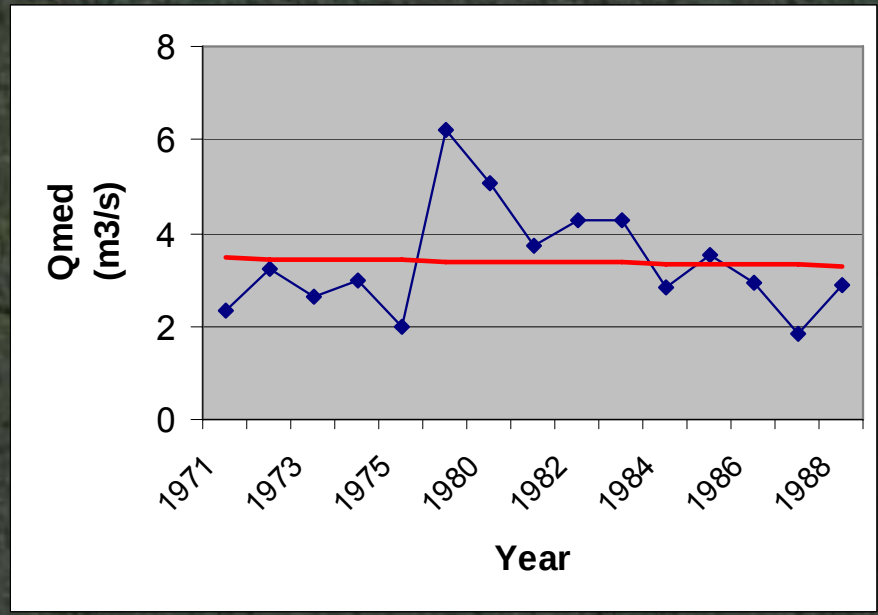
Results: Hydrologic Stress

Clim. Variability

Var	C.V.
High	34.9%

Non-stationarity

Ns	tc
Low	0.31



	Low	Medium	High
Low	1	2	3
Medium	2	4	6
High	3	6	9

Vuln. to Clim. Change

Score	Vc
3	Medium

Results: Hydrologic Stress

Water-use Intensity

Wu	%Qav
Medium	27.1

Vuln. to Clim. Change

	Low	Medium	High
Low	1	2	3
Medium	2	**4**	6
High	3	6	9

Hydrol. Stress

Score	Hs
4	Medium (2)

Results: Economic Dependency

Water Value: Irrigation

Level	Value (Ir) (US$/m3)
Medium	Ir = 0.35

Water Value: Urban

Level	Value (Ur) (US$/m3)
Medium	Ur = 0.54

Water Value: Irrigation

Water Value: Urban

	Low	Med	High
Low	1	2	3
Med	2	**4**	6
High	3	6	9

Ec.Value of Extr.

Score	Level
4	**Med**

Results: Econ. Dependency

Potential for Water Demand Management

Potential of improving irrigation efficiency

Pot. of reducing urban water losses

	Low	**Medium**	High
Low	1	2	3
Medium	2	**4**	6
High	3	6	9

Score	**PDM**
4	**Medium**

Results: Econ. Dependency

Economic Value of Extraction

Pot. of water demand mgt.	Low	**Medium**	High
Low	1	2	3
Medium	2	**4**	6
High	3	6	9

Score	**Ed**
4	**Med. (2)**

Results: Instream Value

Parameters	Low (1)	Medium (2)	High (3)
Gradient of river reach			
Perimeter to area ratio			
Water aspect			
Fish movement			
Integrity of riparian veg.			
Fish diversity			
Macro-invert. diversity			
Threatened species			

Results: Instream Value

Parameters (cont'd)	Low (1)	Medium (2)	High (3)
Ecologic refuge			
Ecol. representativeness			
Tourism potential			
Fishing potential			
Total	**28**		

Score	Iv
28	High (3)

Results: Potential for Environm. Flow

Pef = Hs x Ed x Iv

= Med (2) x Med (2) x High (3)

= 12 (Medium)

P_{ef}	Level	Suggested Actions
4-12	Medium	▪ Increase at least 25% the restriction flow
		▪ Enforcement of the new restriction flows
		▪ Incentive for the water use rationalization
		▪ Restriction for new water licenses
		▪ Water charging, payment for env. services

Future…

- Testing
- Convincement
- Implementation
- Validation…

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Thank You