Os Aproveitamentos Hidráulicos em Portugal: que perspectivas de futuro?
Associação Portuguesa de Recursos Hídricos, LNEC, 18 Janeiro 2017, 17:30-18:00

Caudais ecológicos: novas abordagens holísticas

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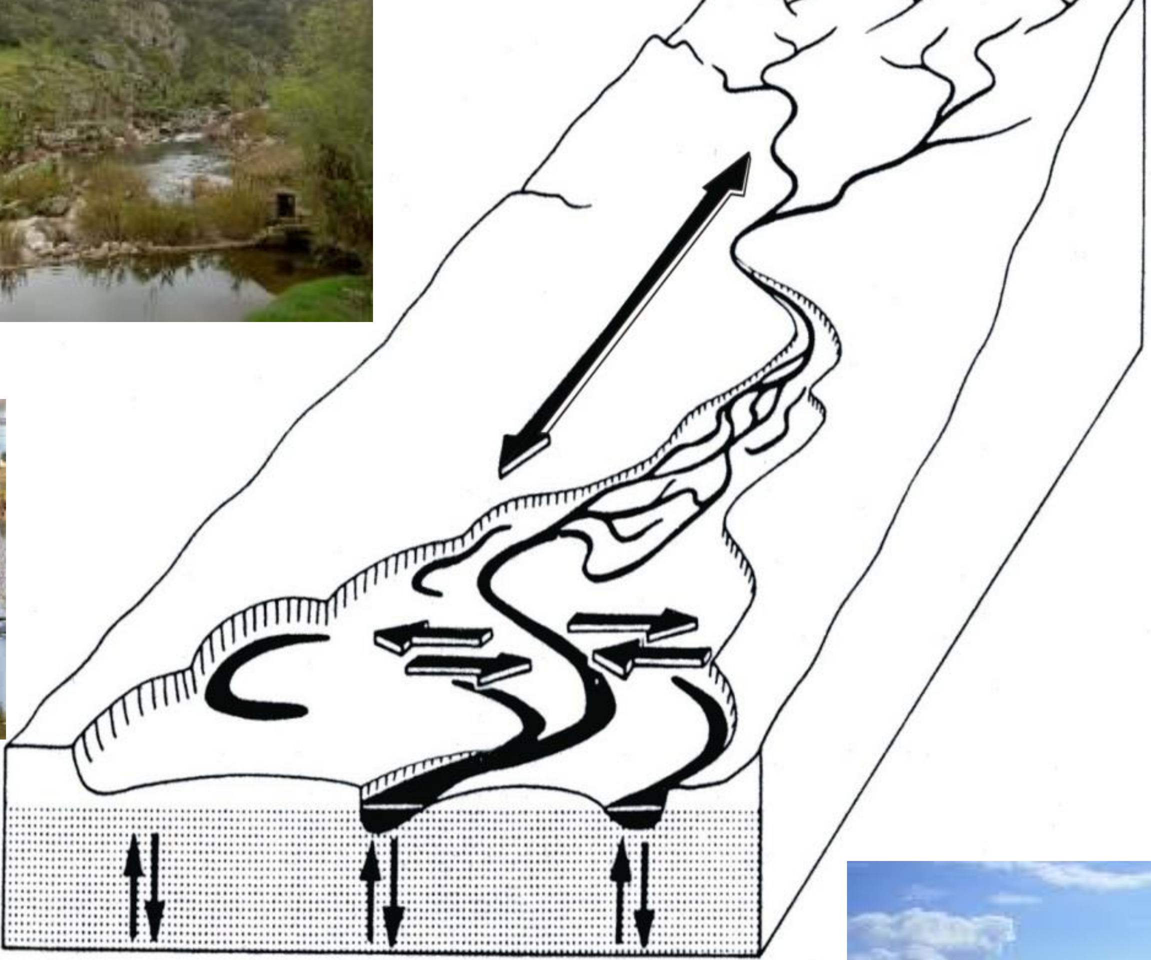
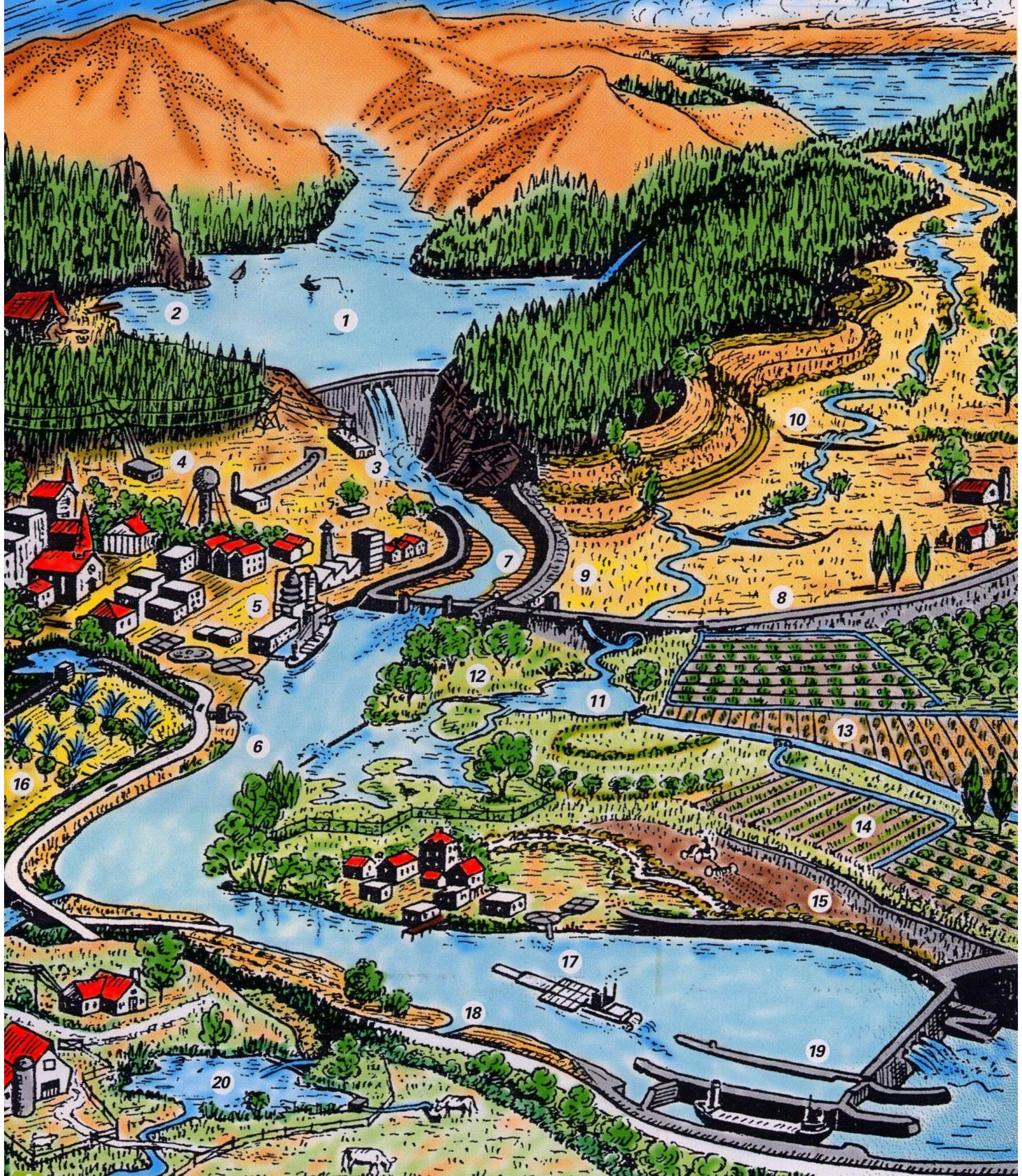


LONGITUDINAL, LATERAL AND VERTICAL DIMENSIONS

Ward 1989; Gregory et al. 1991; Petts and Amoros 1996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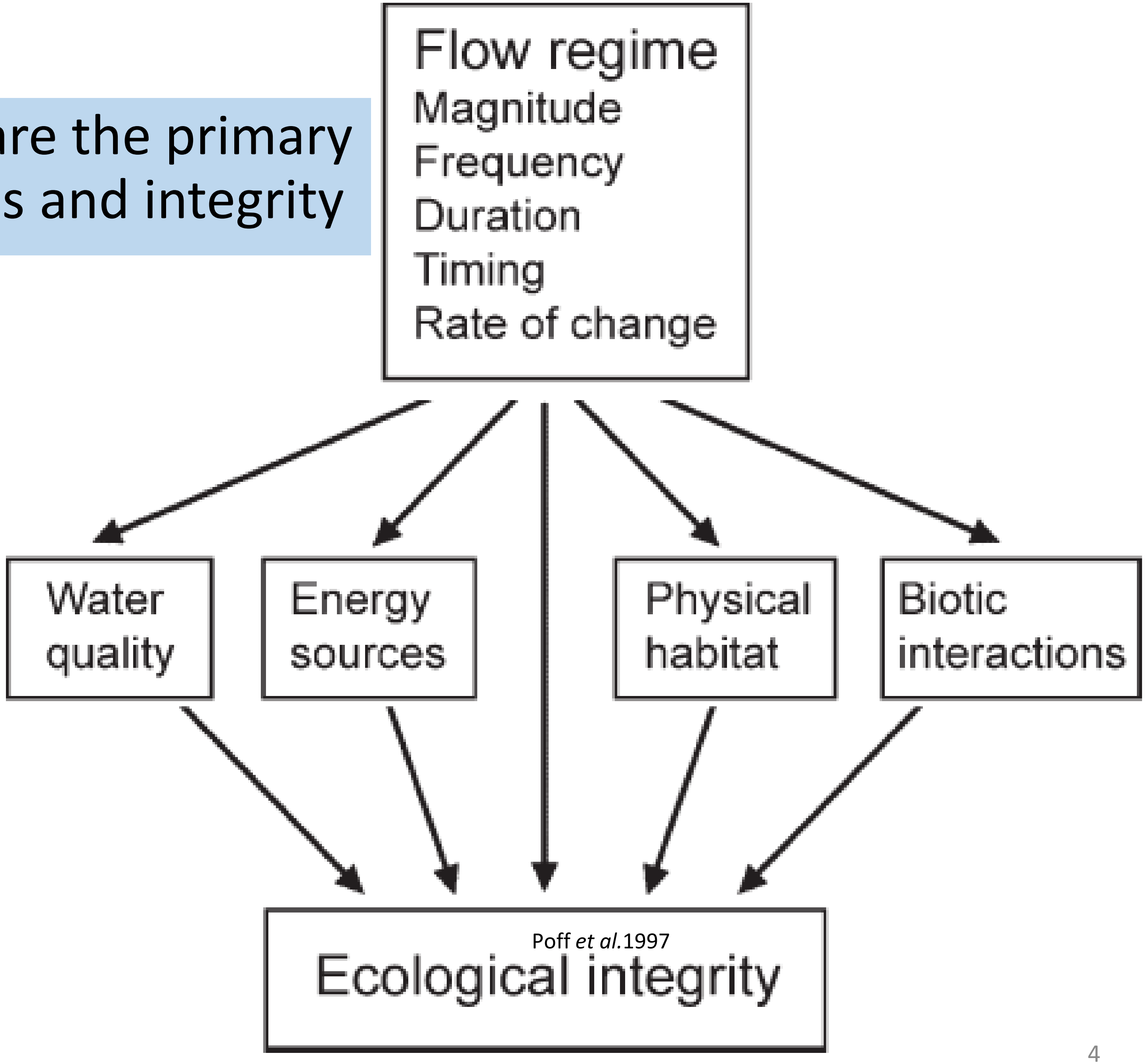
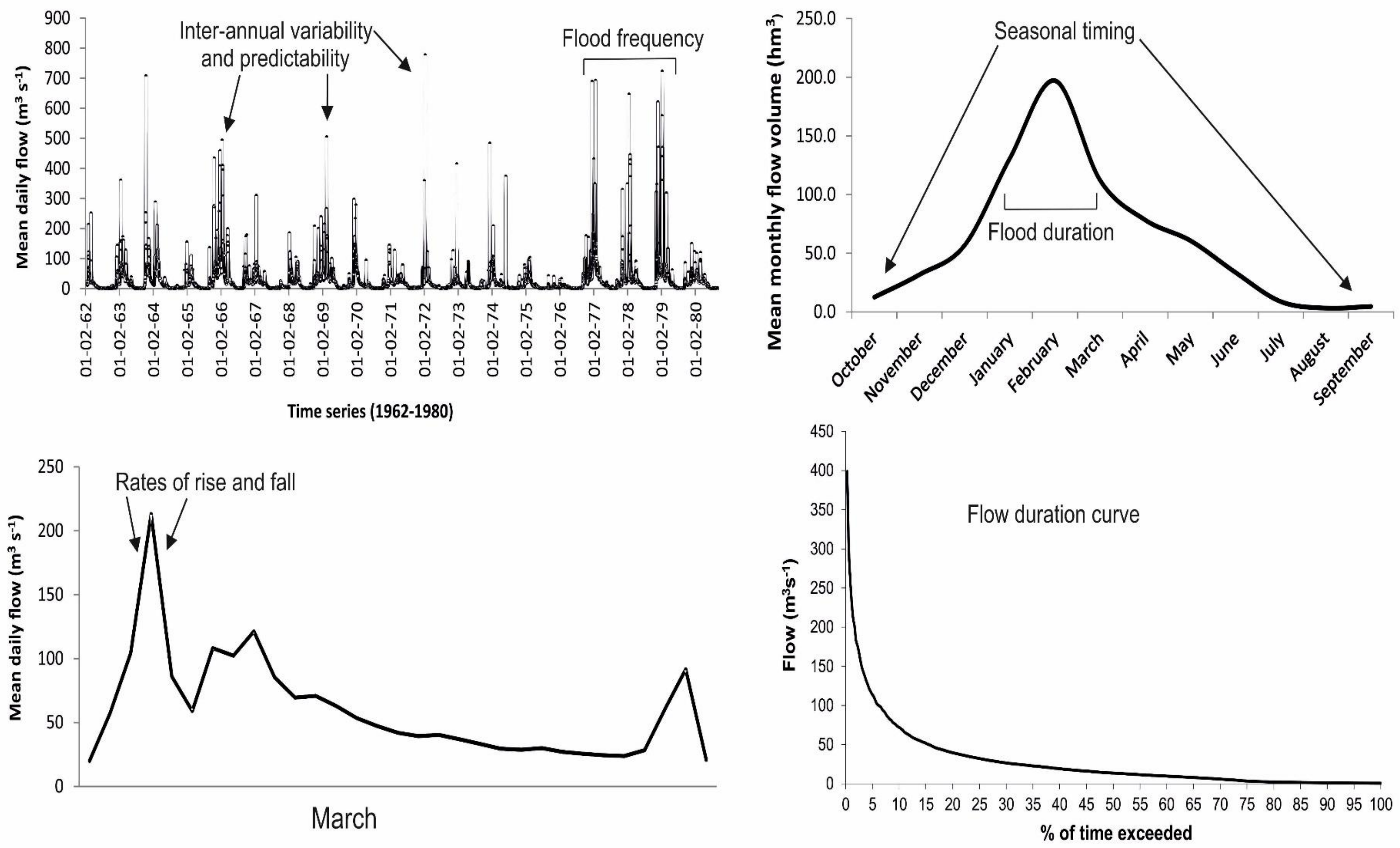
Flow regime components are the primary regulators of river functions and integrity

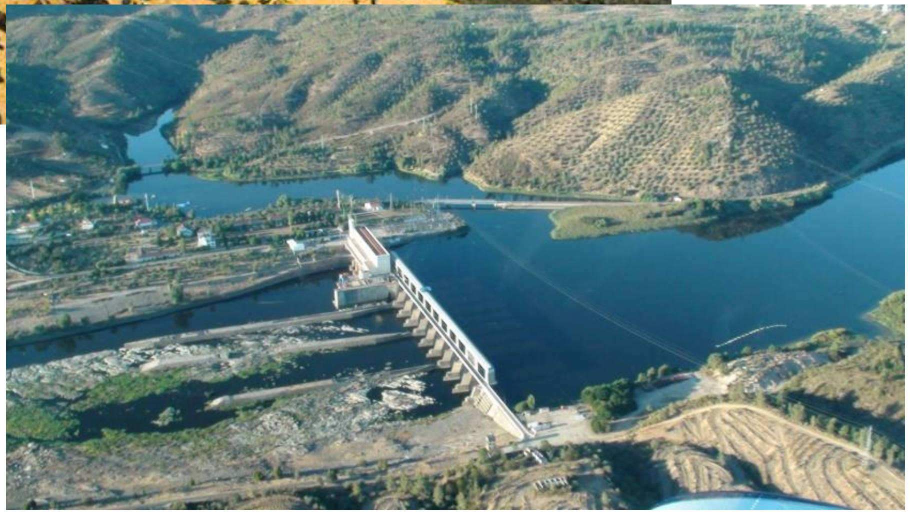


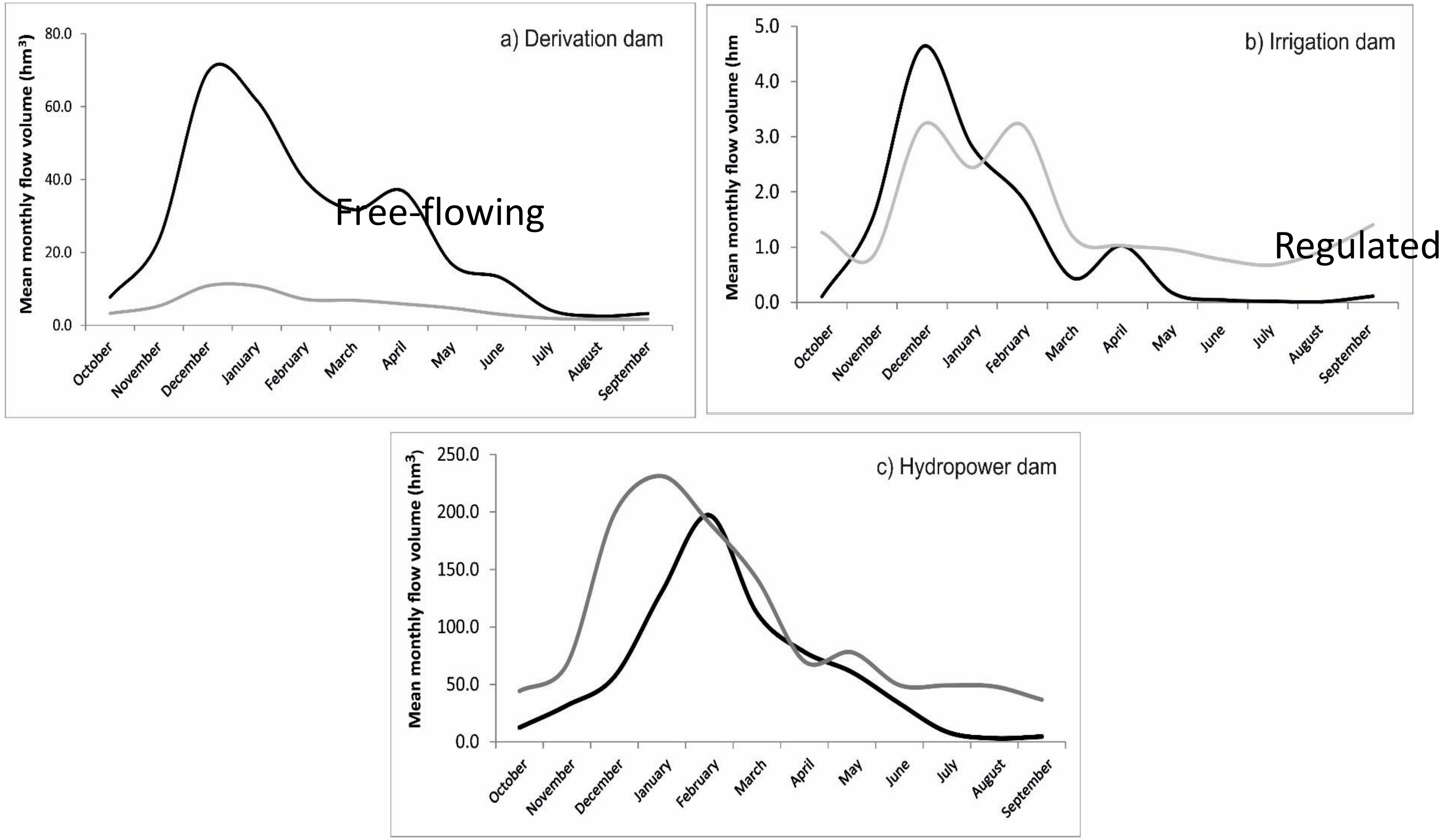
Poff *et al.*1997



Hydrograph of River Vouga, central west region of the Iberian Peninsula, Portugal, illustrating the terms associated with the main facets of streamflow regime. Data provided by the Portuguese Environmental Agency (APA/INAG) (SNIRH, 2012).

LARGE BARRIERS AND FLOW REGIME ALTERATIONS

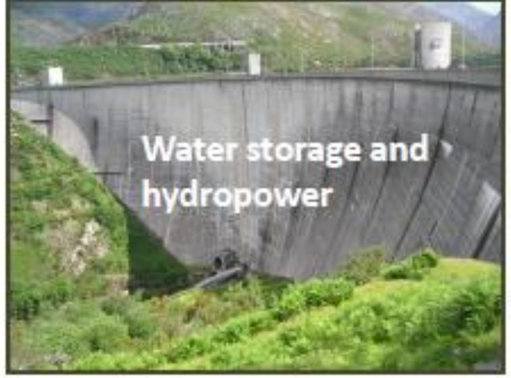


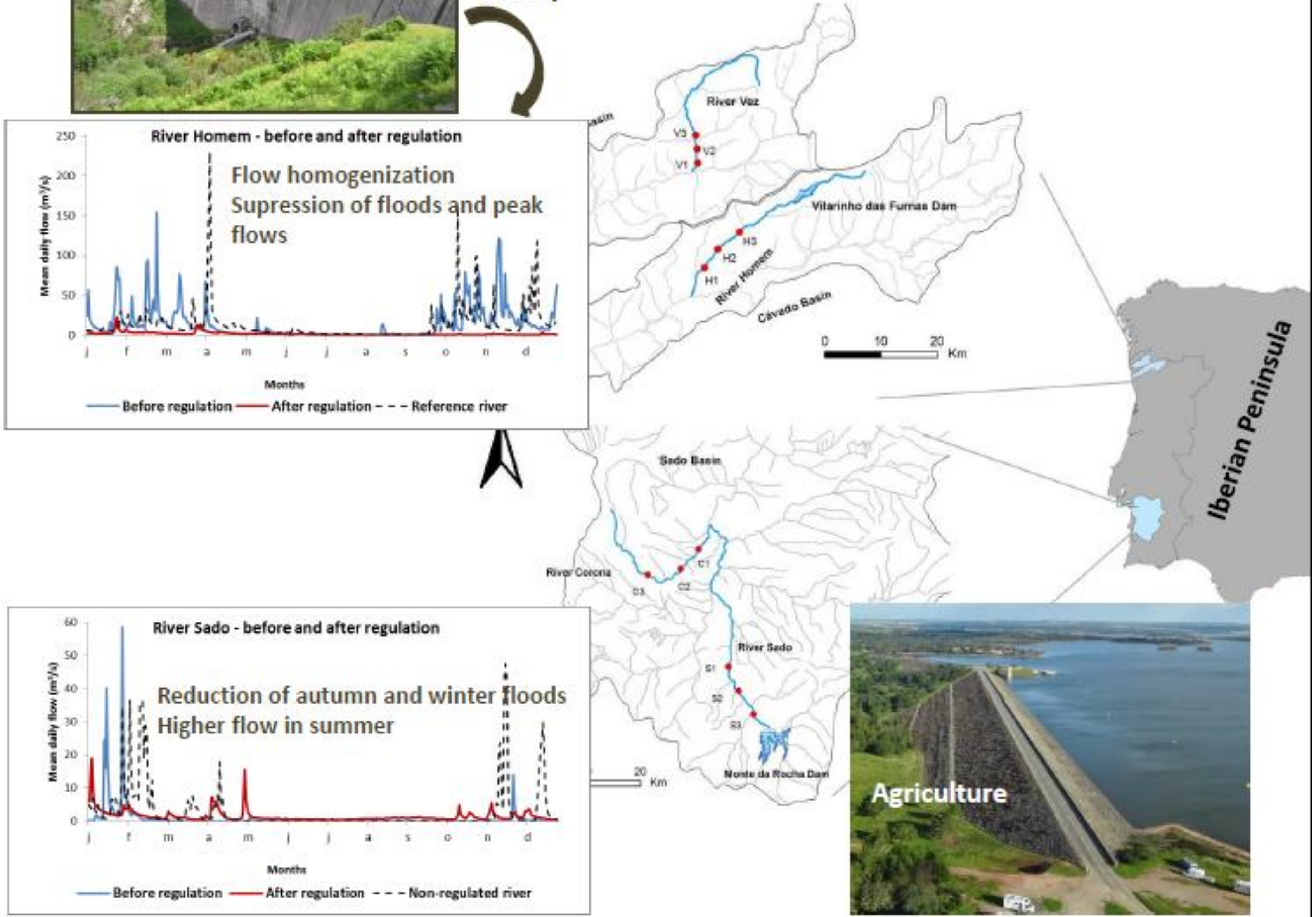


Hydrograms representing the changes in the intra-annual variation of monthly streamflow volume (hm^3) caused by three different types of dams operating for a) water derivation, b) water storage for summer irrigation and c) hydropower production, in the Portuguese territory. Grey line represents the regulated watercourse while black line represents the correspondent free-flowing river, from the same region and with the same original characteristics. Flow data was provided by the Portuguese Environmental Agency (APA/INAG) (SNIRH, 2012) and by EDP (Energias de Portugal).

PARALEL EXPERIMENTAL DESIGN: one regulated and one near-natural; one permanent and one intermittent

minimum evidence of human disturbance (flow regulation aside)

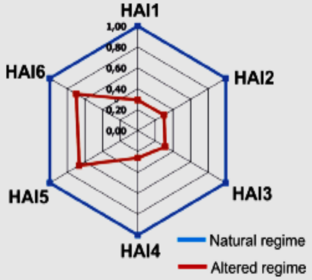


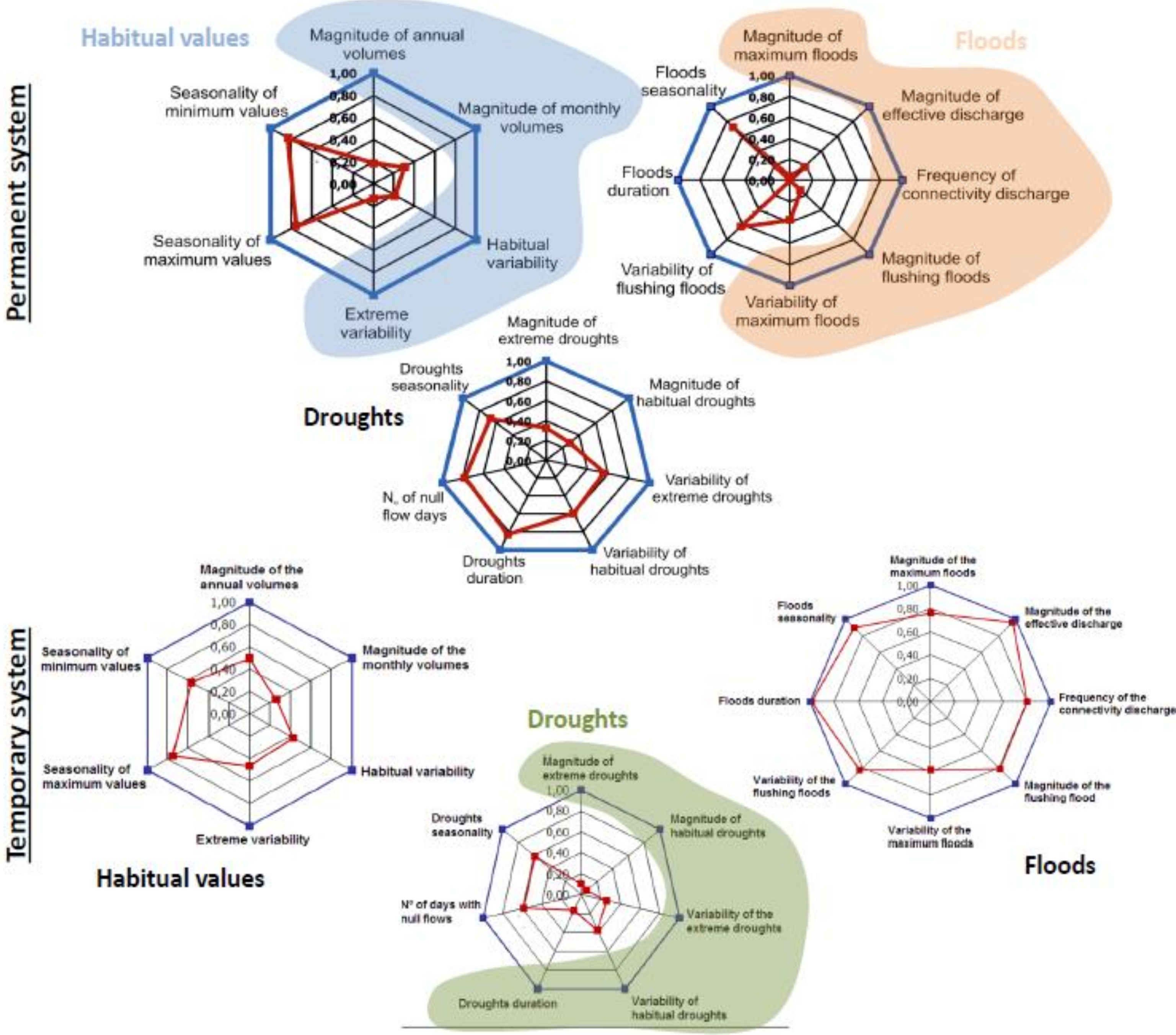


Hydrological Alteration Indicators - HAI
(IAHRIS 2.2; Santa-Maria & Yuste, 2010).

ANNUAL ALTERATIONS OF THE FLOW REGIME

$$HAIn = \frac{Value\ of\ parameter\ n\ in\ Altered\ Regime}{Value\ of\ parameter\ n\ in\ Natural\ Regime}$$





HYDROPEAKING > ECOPEAKING

CAUDAIS ANUAIS

CAUDAIS DIÁRIOS

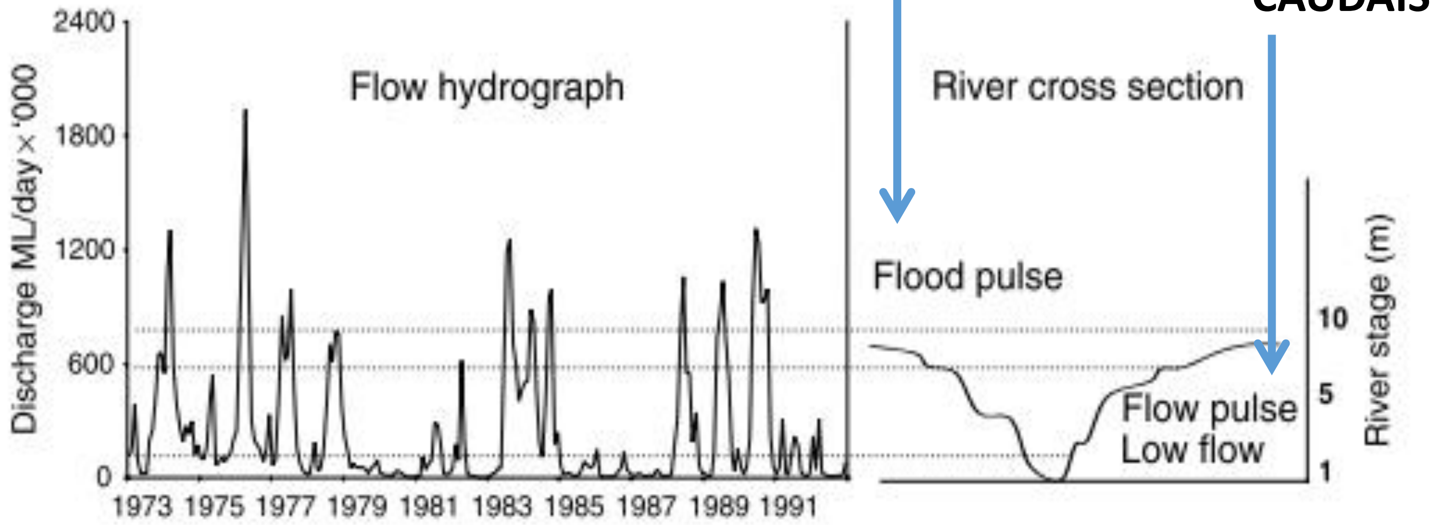


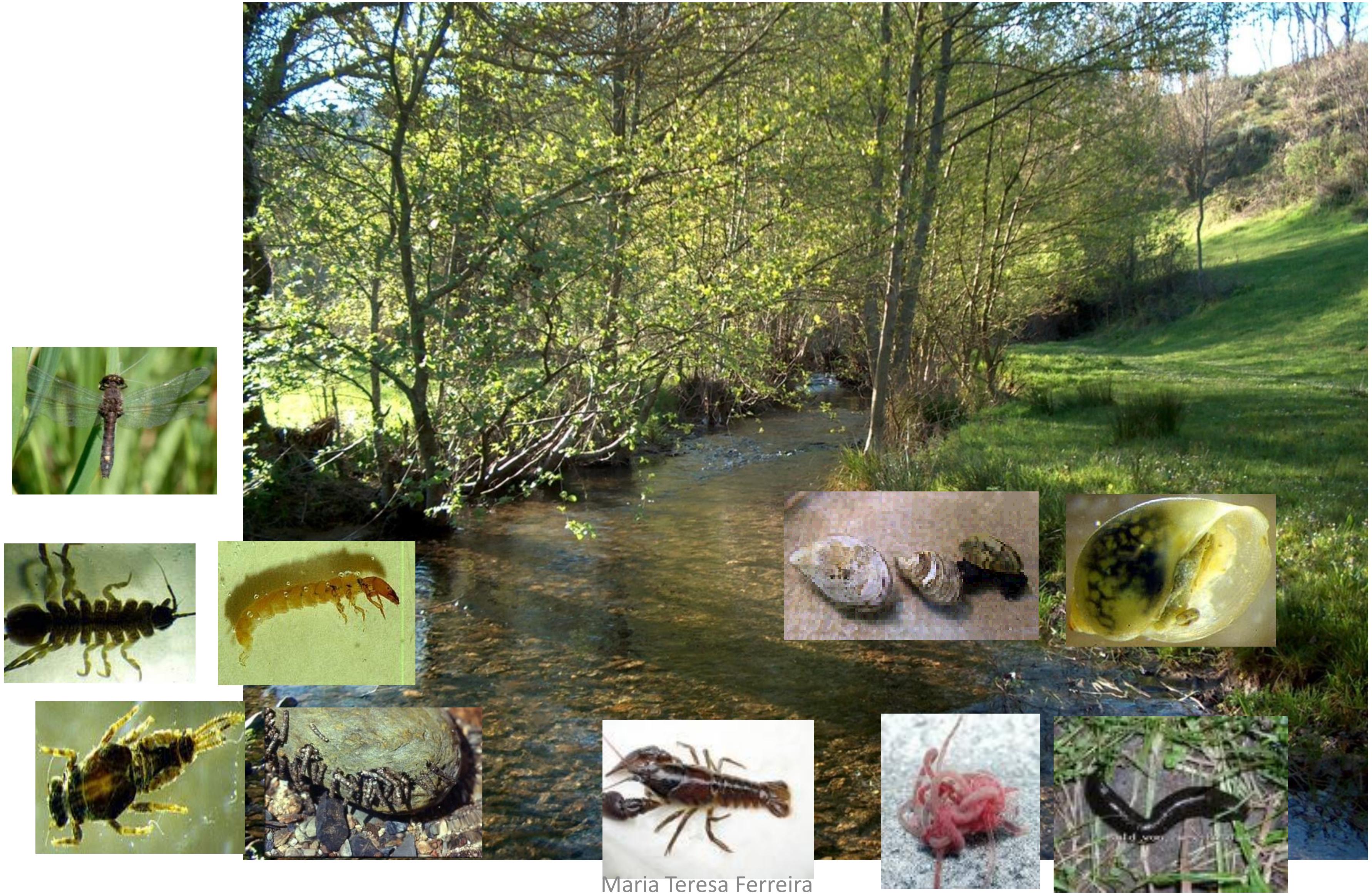
FIGURE 2.1 River hydrograph and river channel cross section illustrating low flow, flow pulse, and flood pulse for the Darling River at Bourke, southeastern Australia.

O regime hidrológico dá forma a cada rio

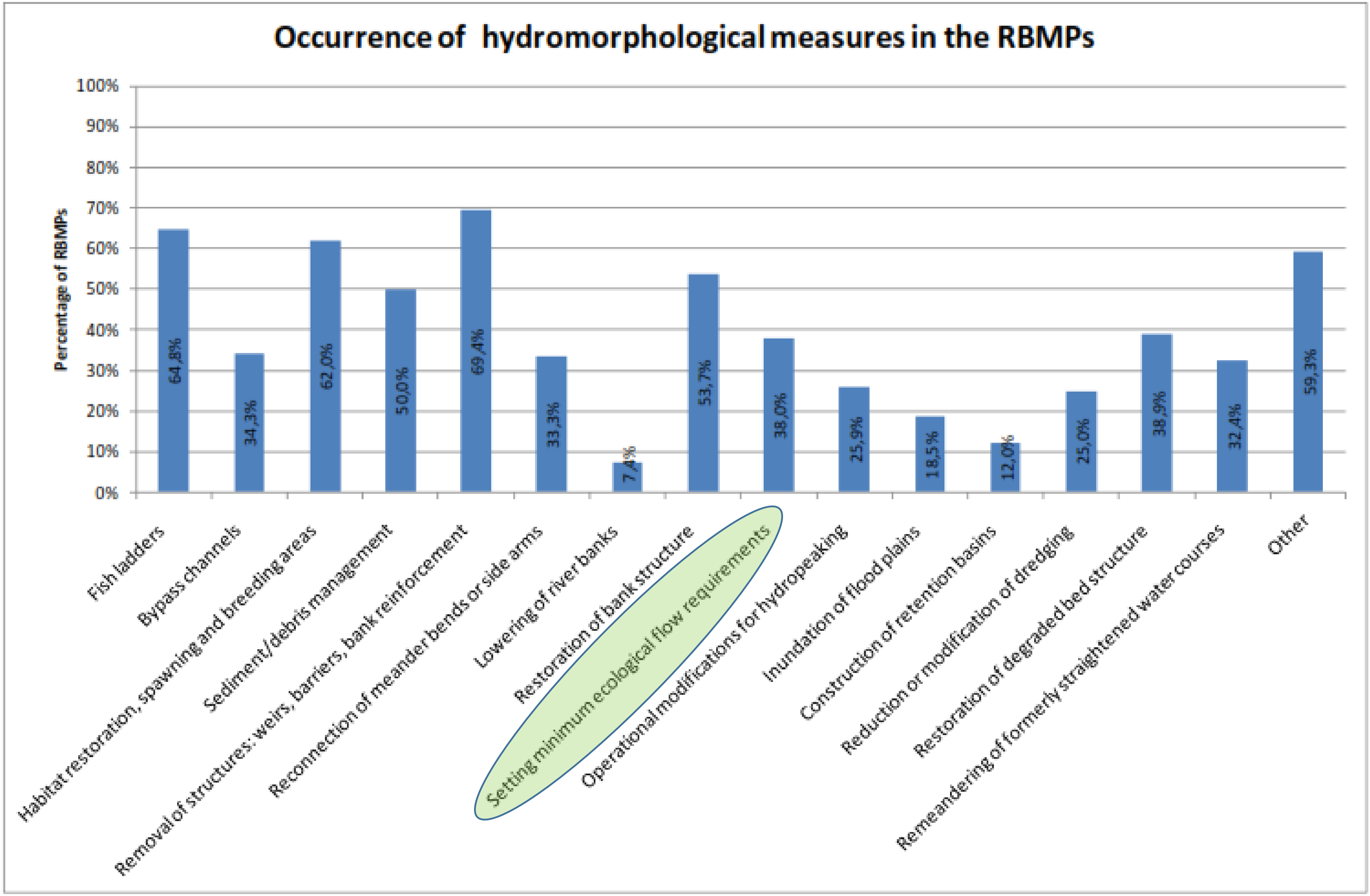
DAILY ALTERATIONS OF THE FLOW REGIME

HYDROPEAKING > ECOPEAKING

INVERTEBRATES CAN BE USED TO DEFINE HYDROPEAKING RAMPING AND VARIATION



Maria Teresa Ferreira



Occurrence of hydromorphological measures in the RBMPs
Percentage of RBMPs
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
64,8%
34,3%
62,0%
50,0%
69,4%
33,3%
7,4%
53,7%
38,0%
25,9%
18,5%
12,0%
25,0%
38,9%
32,4%
59,3%
Fish ladders
Bypass channels
Habitat restoration, spawning and breeding areas
Sediment/debris management
Removal of structures: weirs, barriers, bank reinforcement
Reconnection of meander bends or side arms
Lowering of river banks
Restoration of bank structure
Setting minimum ecological flow requirements
Operational modifications for hydropeaking
Inundation of flood plains
Construction of retention basins
Reduction or modification of dredging
Restoration of degraded bed structure
Remeandering of formerly straightened water courses
Other

CAUDAL ECOLÓGICO

Caudal mínimo a manter no curso de água, que permita assegurar a conservação e manutenção dos ecossistemas aquáticos naturais, a produção das espécies com interesse desportivo ou comercial, a conservação e manutenção dos ecossistemas ripícolas, e aspetos estéticos ou de interesse científico ou cultural.

REGIME DE CAUDAIS ECOLÓGICOS

Um regime de caudais ecológicos é constituído por valores de caudal que variam ao longo do ano (em geral de mês para mês) para atender às necessidades das espécies (ou comunidades), sendo flexível em função das condições hidrológicas naturais que se verificam em cada ano, em particular em anos secos.

REGIME DE CAUDAIS ECOLÓGICOS

- Caudais atendendo às necessidades das espécies

- Caudais de limpeza (*flushing flows*) para remoção de materiais finos depositados e manutenção da vegetação pioneira,

- Caudais para manutenção da estrutura do leito e da capacidade de transporte,

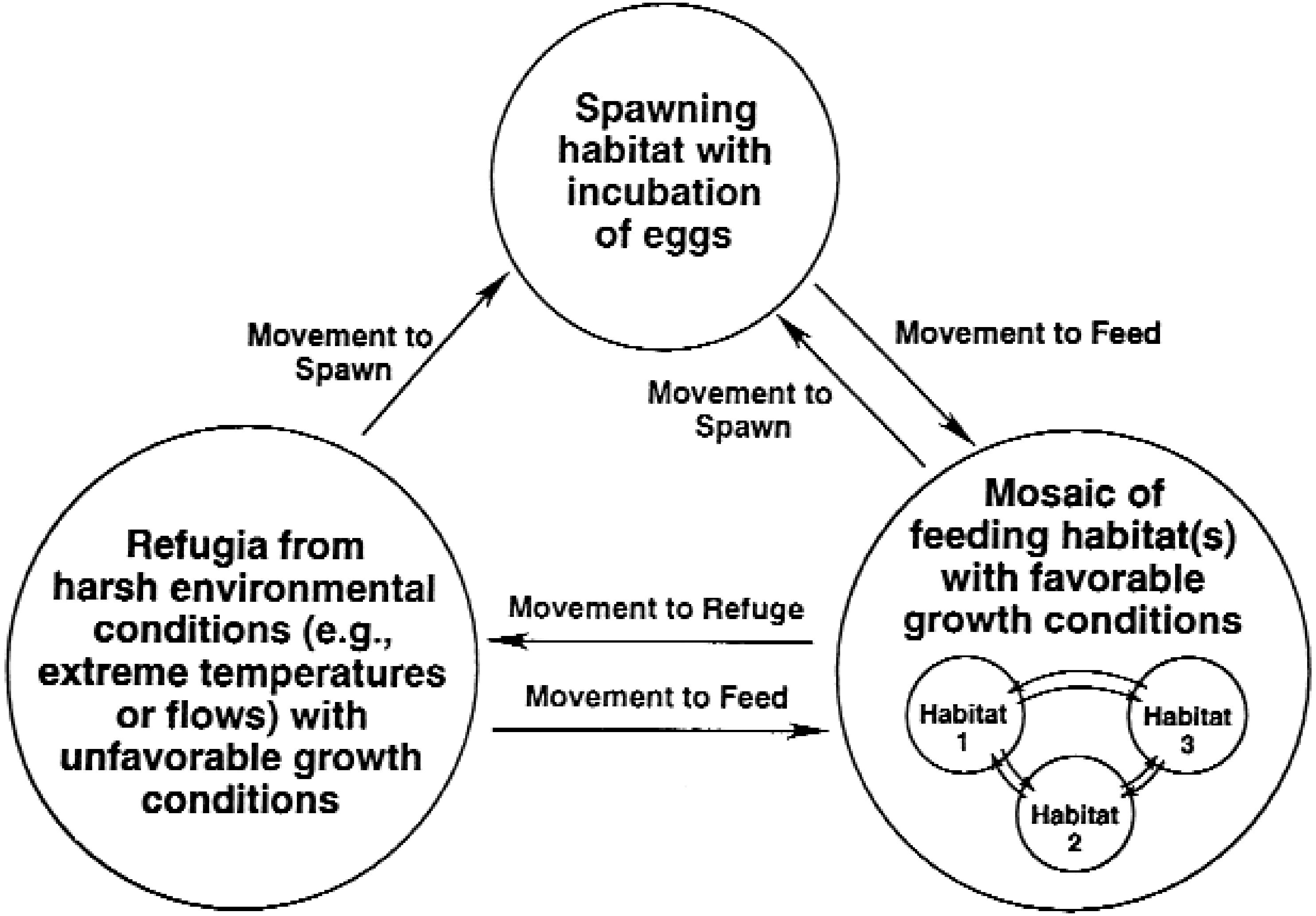
- caudais para manutenção do nível freático (dimensão vertical)

- Caudais para manutenção dos ecossistemas laterais associados (dimensão lateral) - charcos e zonas húmidas

- caudais de manutenção de ecossistemas de estuários.

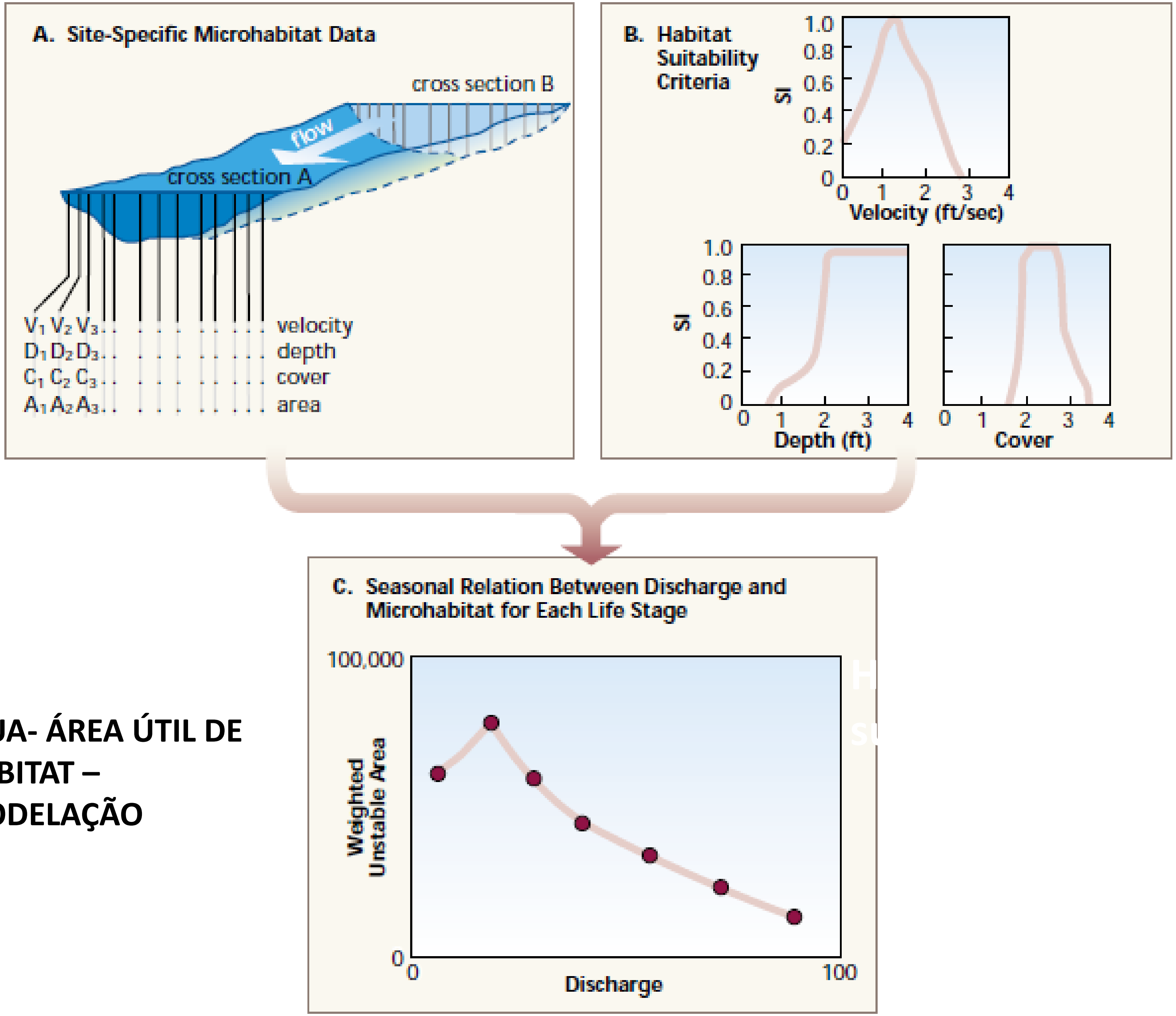
FUTURO: REGIME DE CAUDAIS AMBIENTAIS

Schlosser and Angermeier's (1995) dynamic landscape model of stream fish life history : spatially separated habitats for spawning, feeding and refugia



CARACTERÍSTICAS DE HABITAT – MODELAÇÃO HIDRÁULICA

CURVAS DE USO DE HABITAT PARA AS ESPÉCIES



WUA- ÁREA ÚTIL DE HABITAT – MODELAÇÃO

Variação de caudal (rio Lima- regime natural) e da área útil para a truta de rio

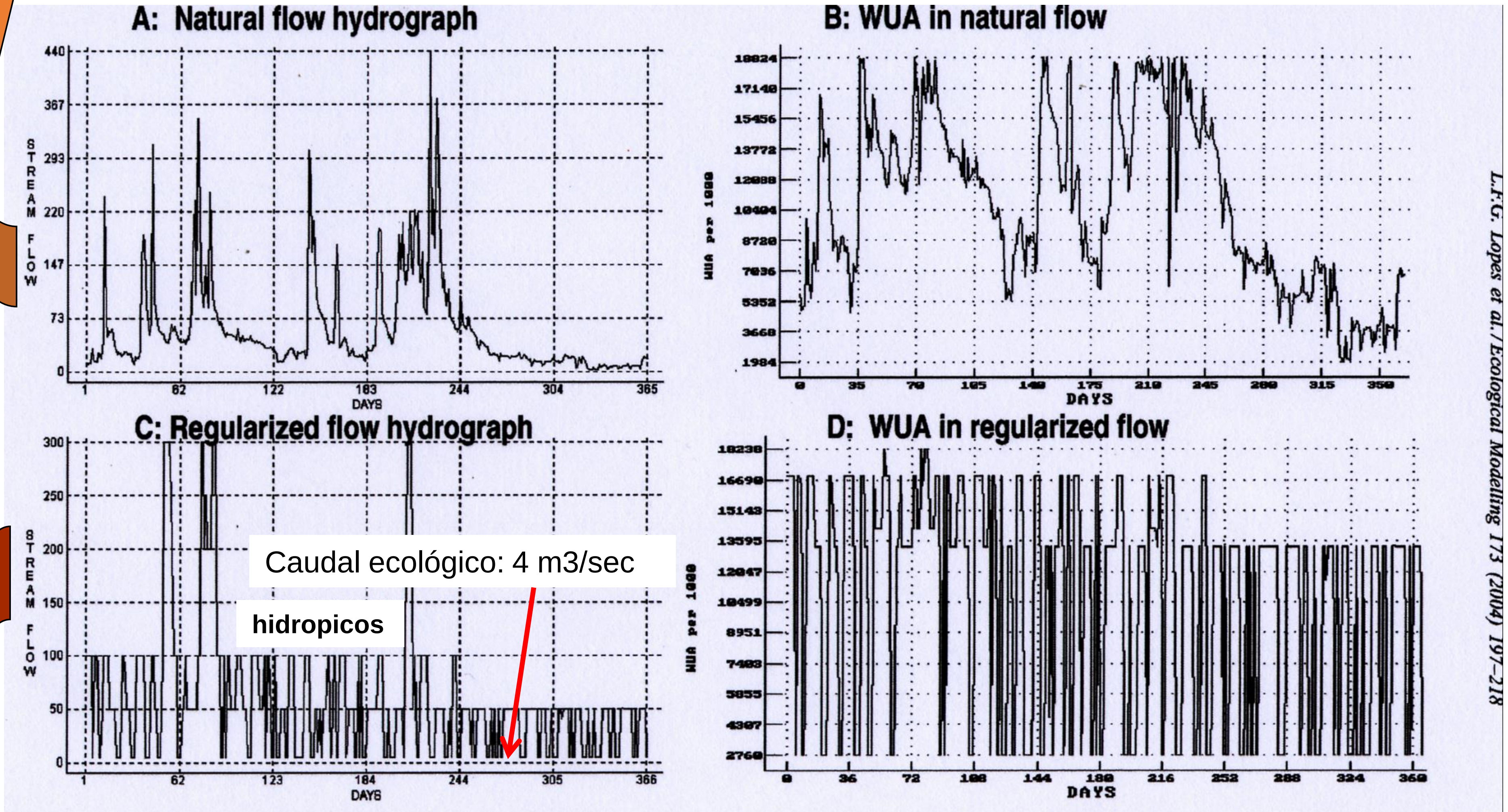
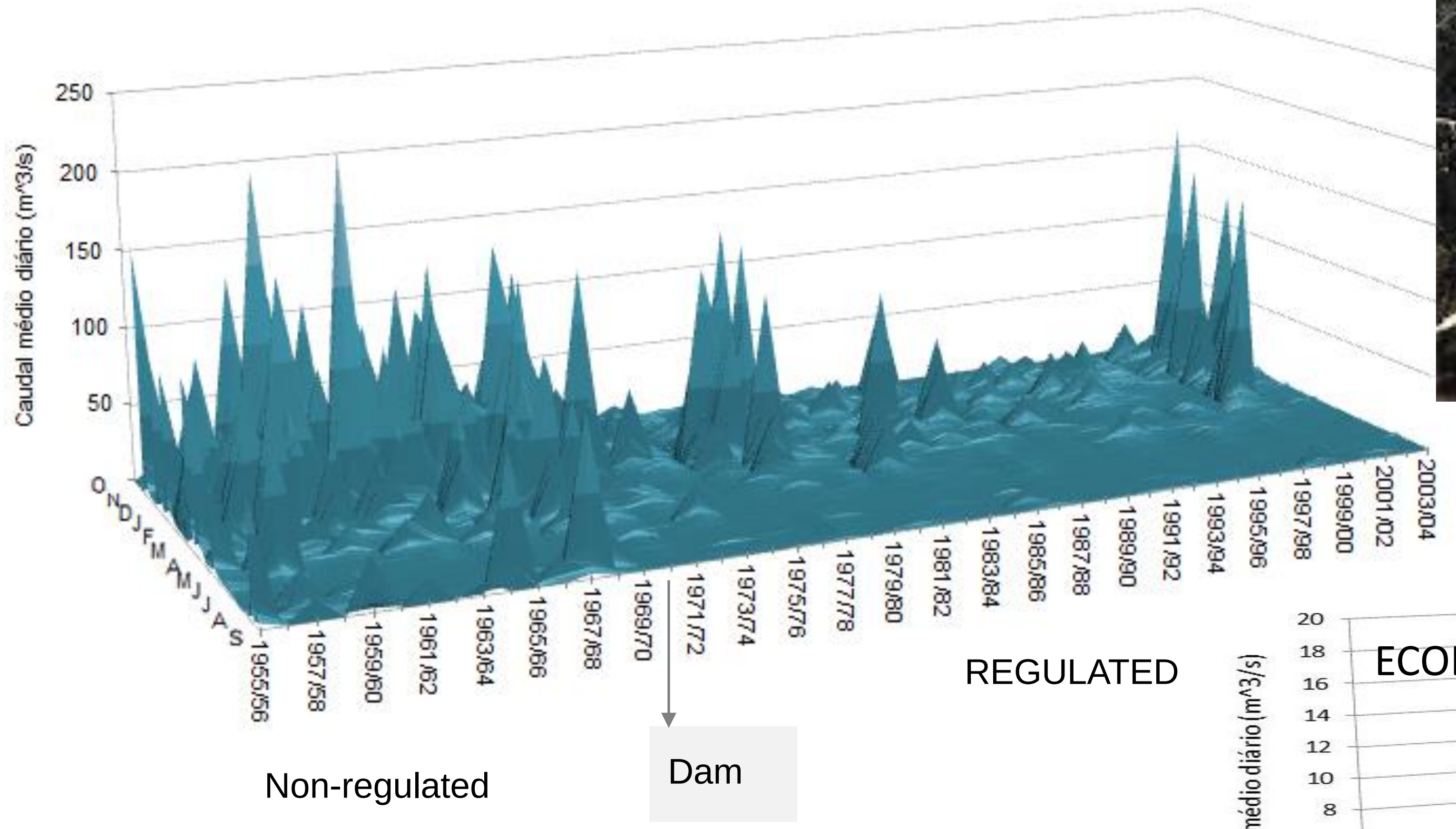
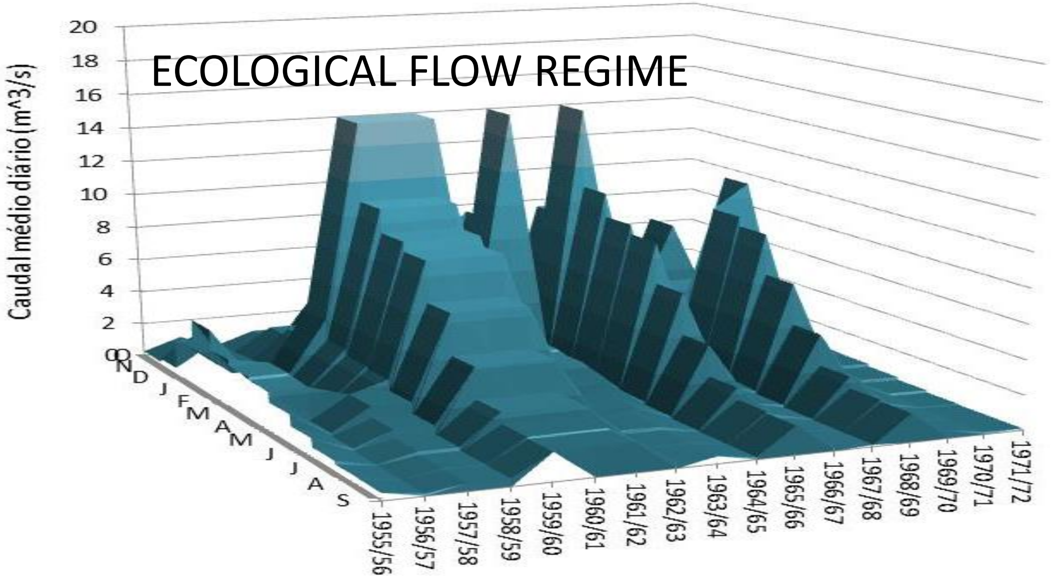


Fig. 9. Temporary habitat series: (A) daily hydrograph in natural regime; (B) daily habitat (WUA) time series for adult brown trout in natural regime; (C) daily hydrograph in regulated regime; (D) daily habitat (WUA) time series for adult brown trout in regulated regime.

Variação de caudal no rio Lima regulado e da área útil para a truta de rio- 1998

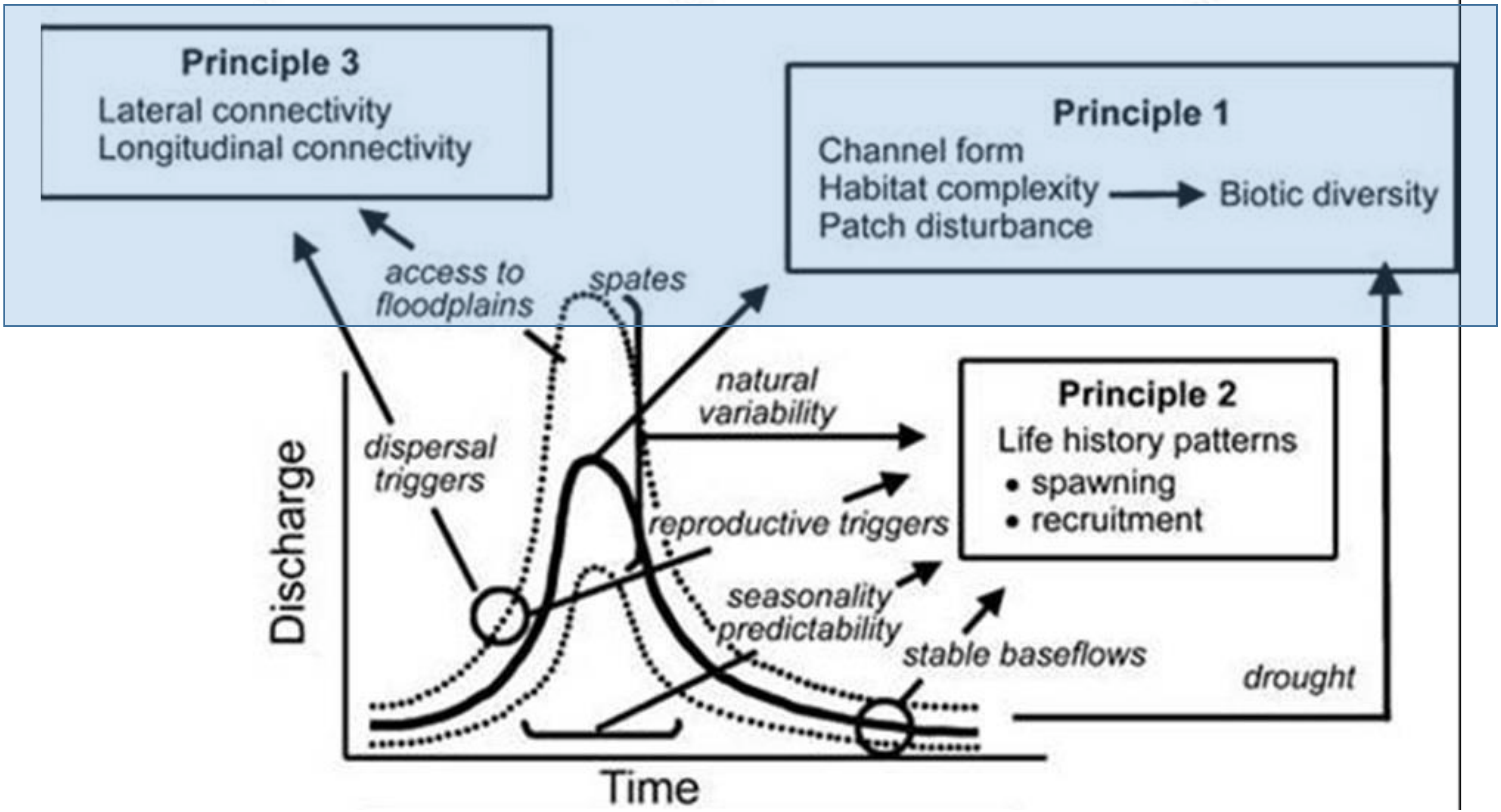
Flow regime components are the primary regulators of river functions and integrity





Vilarinho das Furnas

Aquatic biodiversity and natural flow regimes



Modified by Dudgeon, 2006 from Bunn and Artington, 2002

THE BUILDING BLOCK METHODOLOGY

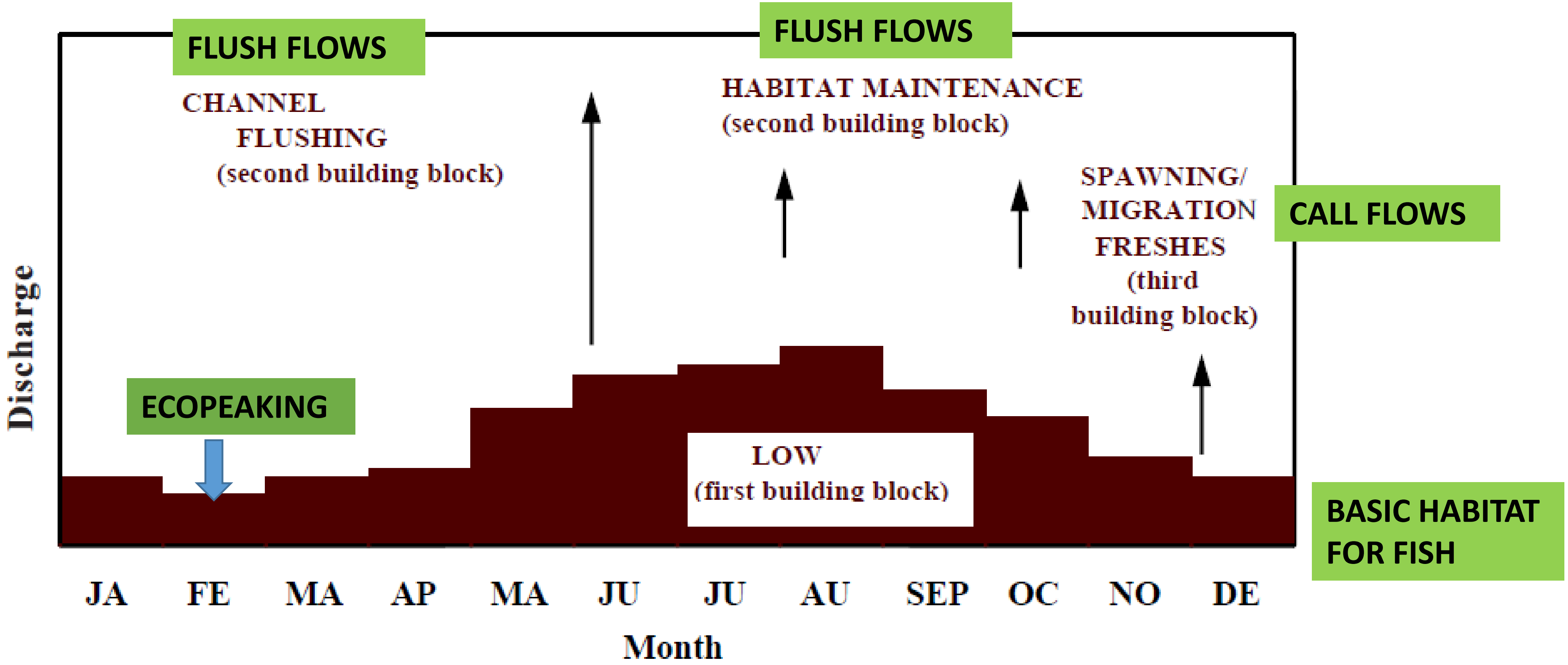
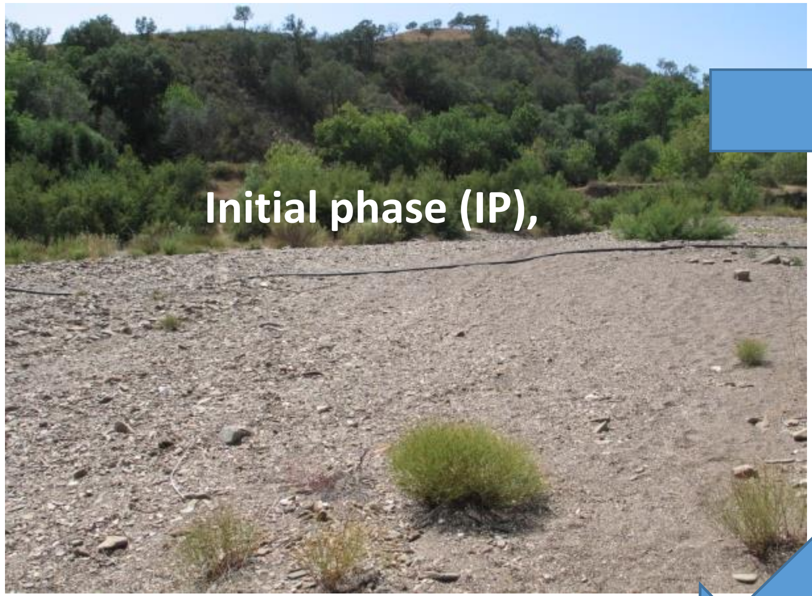
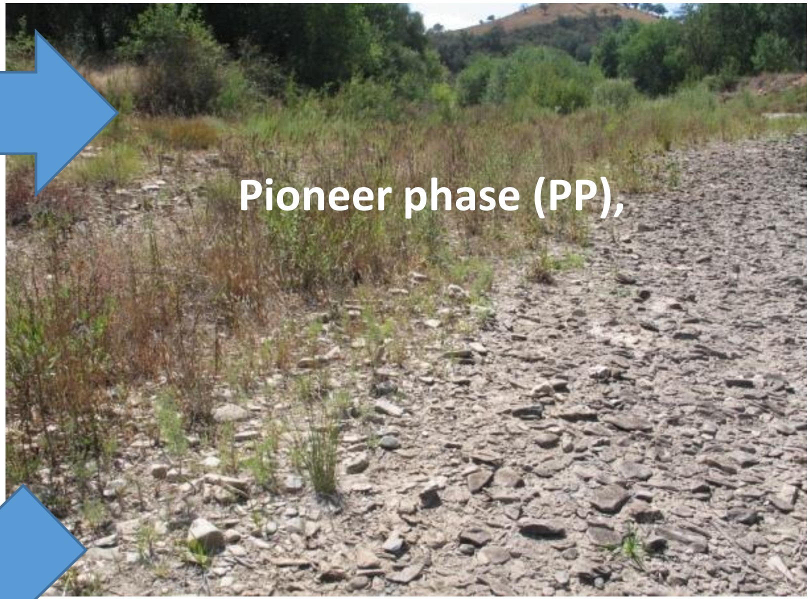


Fig. 2. *Example of flow regime built up using building blocks.*

From Acreman and Dunbar, Hydrology and Earth System Sciences, 8(5), *861–876* (2004)

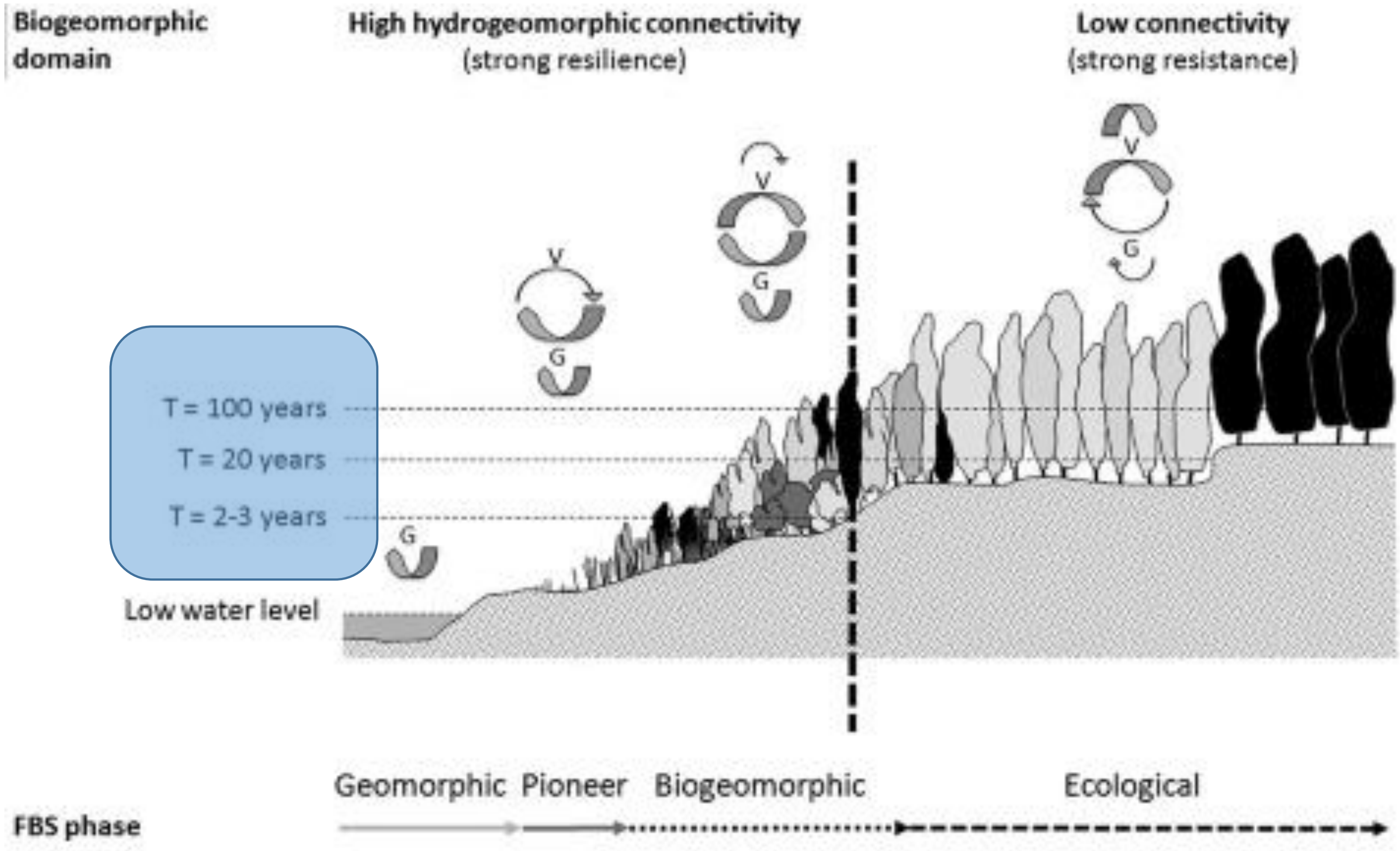

Bosque
maturo
Bosque
estabelecido
pioneiras
Bosque
jovem
recrutamento
MOSAICOS DE ÁRVORES DE IDADES DIFERENTES DEFINIDOS PELO REGIME DAS CHEIAS ANUAIS (variação temporal)





River Odelouca, Southwestern Iberia

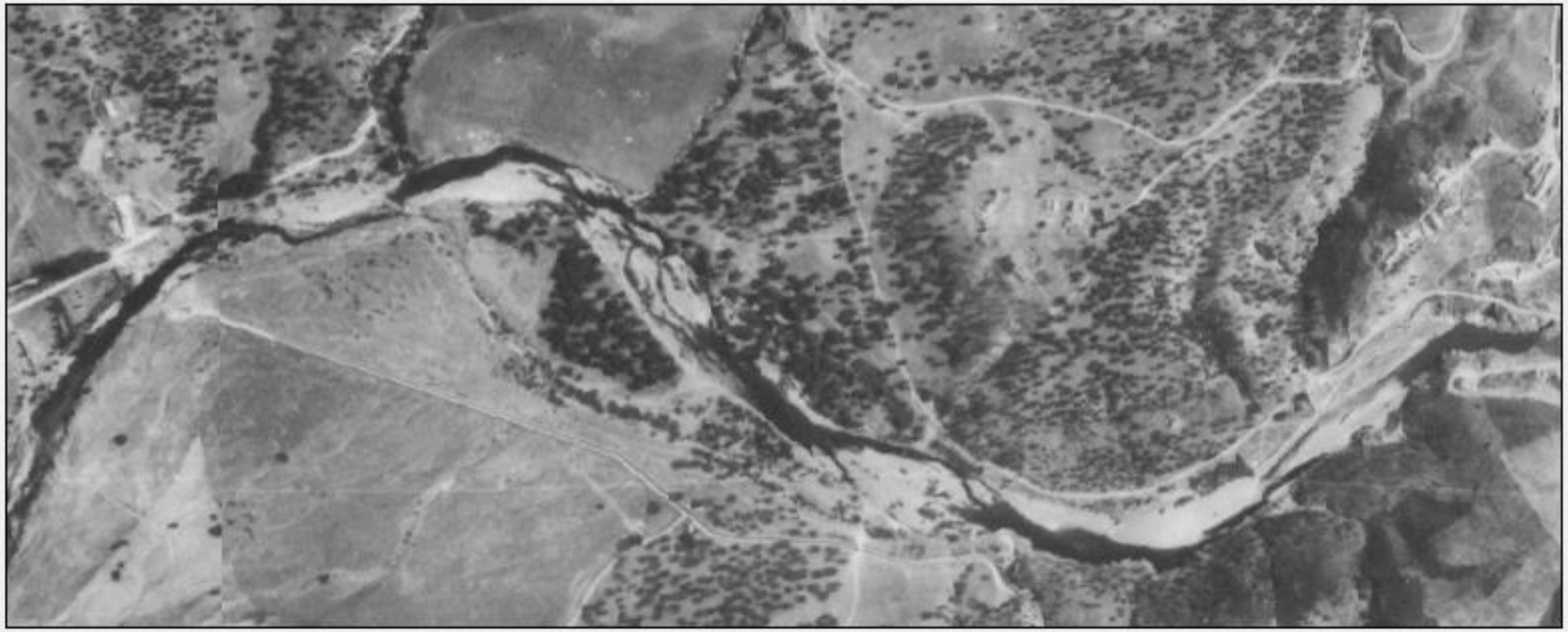
SUCESSÃO RIPÁRIA



Fluvial biogemorphic succession (FBS: Corenblit et al. 2007)
V- vegetation, G- geomorphology

Corenblit, D., NS Davies, J Steiger, MR Gibling and G Bornette. Considering river structure and stability in the light of evolution: feedbacks between riparian vegetation and hydrogeomorphology. Earth Surface Processes and Landform (2014)

MATA RIPÁRIA ANTES DA BARRAGEM



1947
Alcaçovas River downstream of Pego do Altar Dam

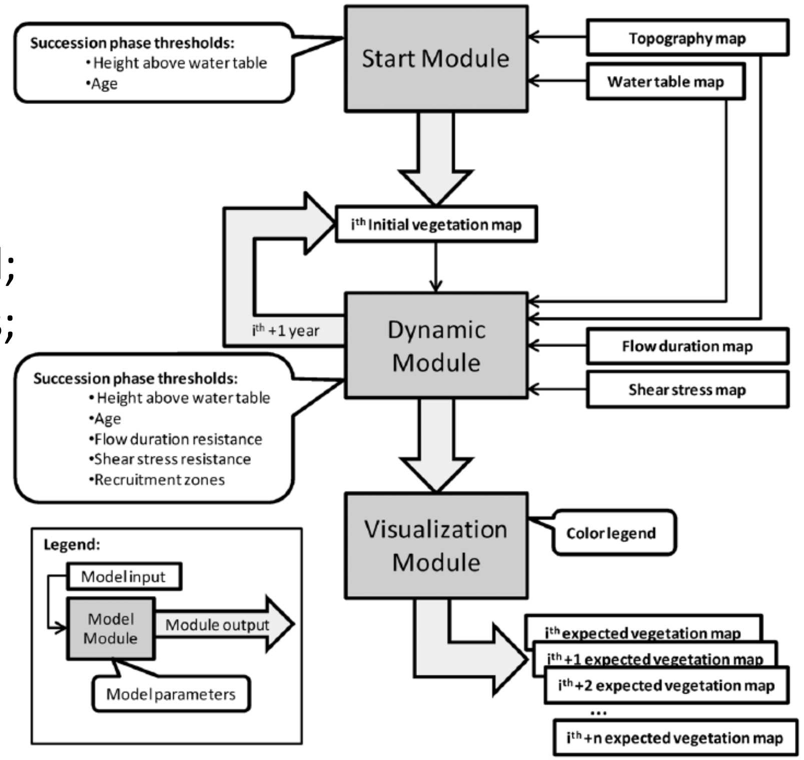
MATA RIPÁRIA DEPOIS DA BARRAGEM

2010
Alcaçovas River downstream of Pego do Altar Dam

FLUSH FLOWS

CASiMiR-vegetation model

- Mathematic, deterministic, dynamic and distributed model;
- Calculation based on the relation between relevant hydrological elements and the response of vegetation to hydrologic change;
- *Output*: vegetation maps by succession phase;
- Possibility of widespread application to watershed;
- Successfully implemented in Mediterranean rivers;



Rivaes *et al.*, 2013

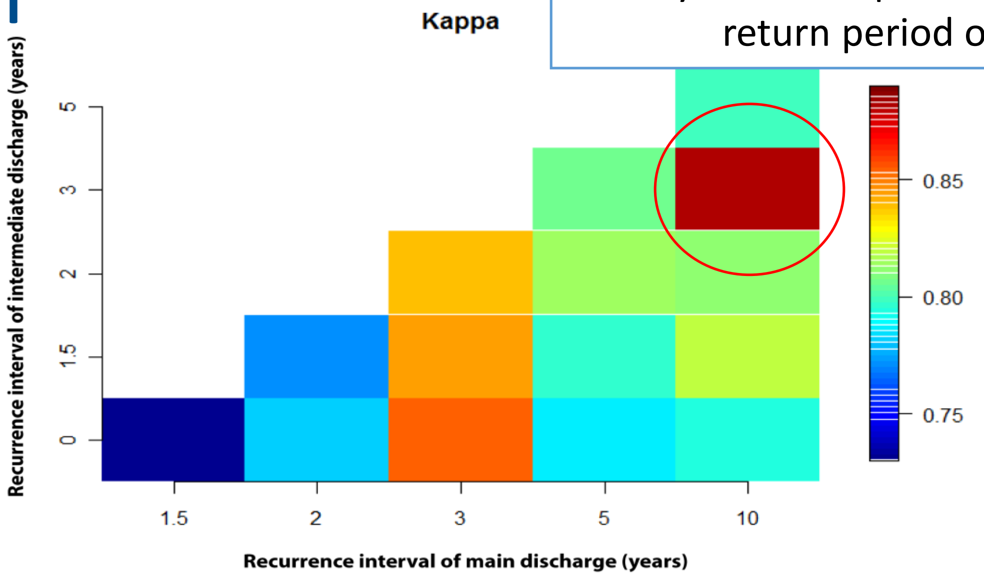
Inputs

- Shear stress of maximum annual discharge;
- Minimum summer water table elevation;
- Ecological succession characterization;
- Age description of succession phases;
- Distance to watertable elevation of succession phases

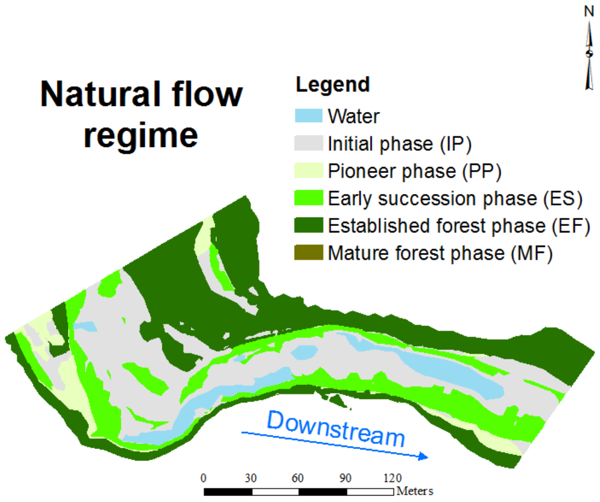
Rivaes R., Rodríguez-González P. M., Albuquerque A., Pinheiro A. N., Egger G., Ferreira M. T. (2013). Riparian vegetation responses to altered flow regimes driven by climate change in Mediterranean rivers. Ecohydrology, 6, 413-424.

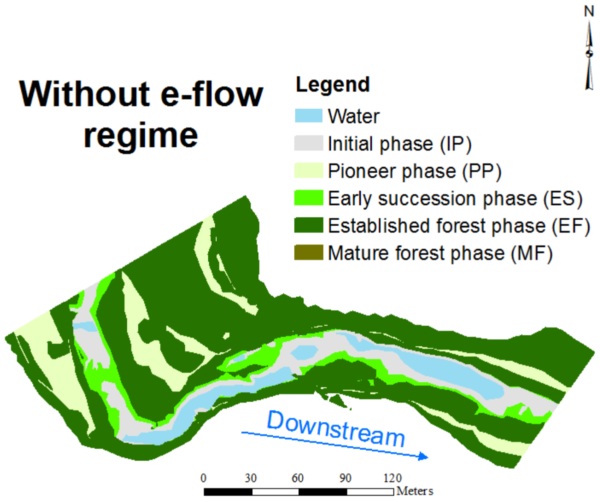
Selection of flush flow regime

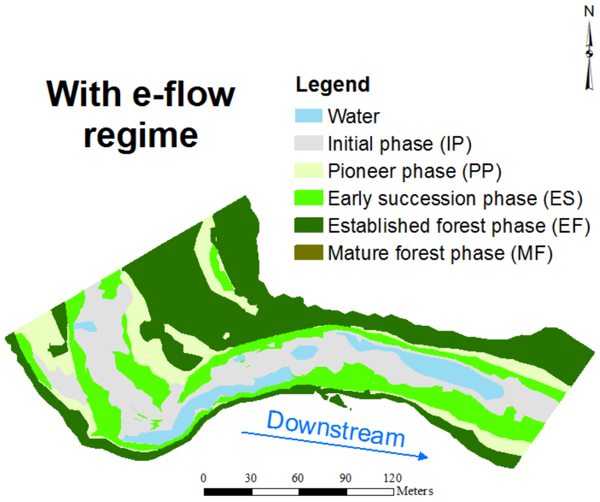
Odelouca



Best regime: Floods with a return period of 10 years interspersed by floods with a return period of 3 years

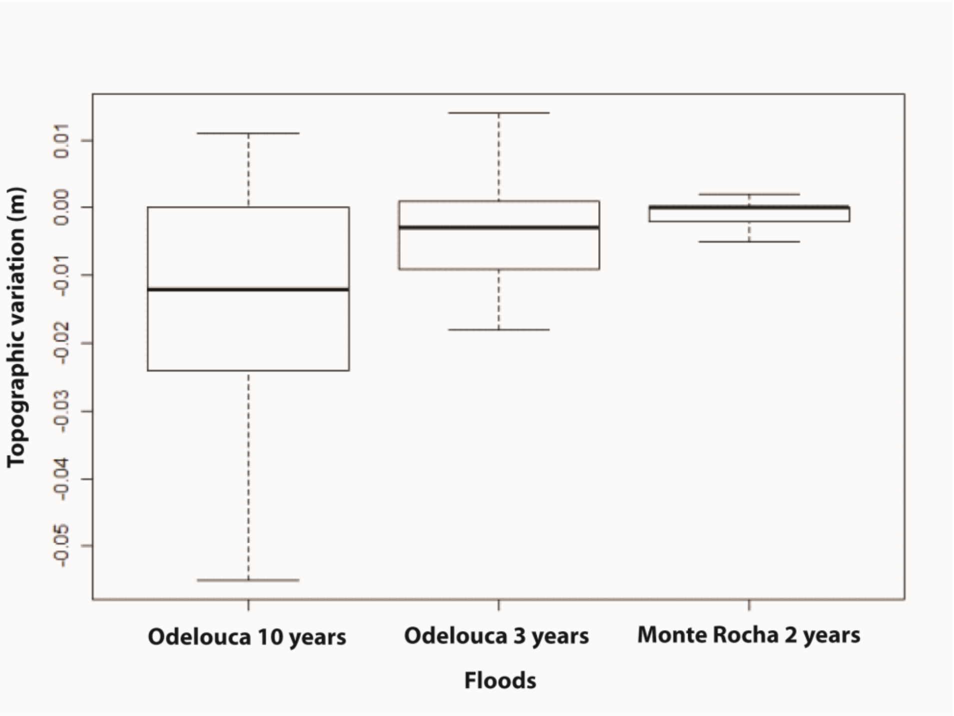






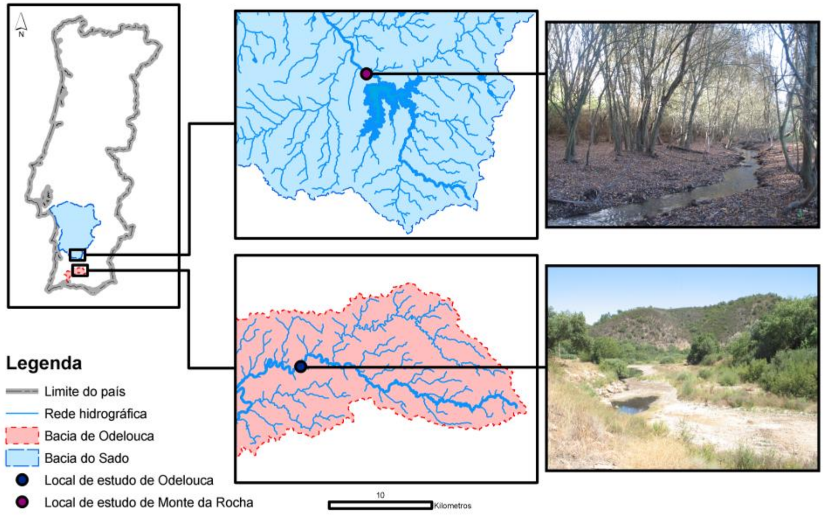
Sediment transport analysis

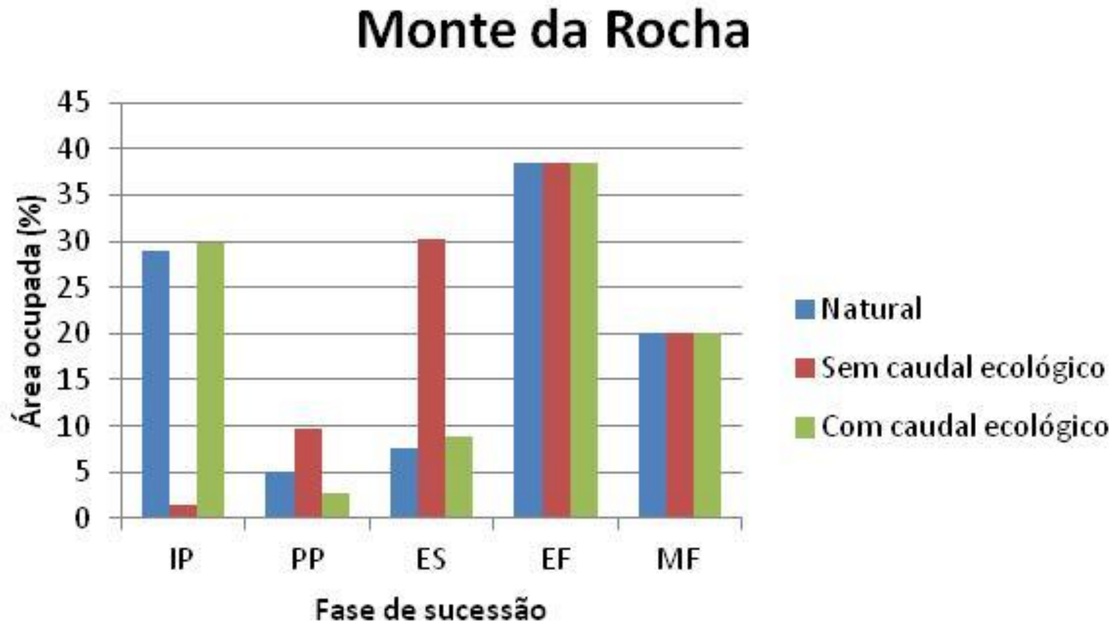
	Odelouca (10-year)	Odelouca (3-year)	Monte da Rocha
N	2014	2017	977
Dominant process	Erosion	Erosion	Erosion
Erosion	68 %	57 %	37 %
Sedimentation	25 %	32 %	17%
Mean topographic change	-32 mm	-22 mm	-4 mm

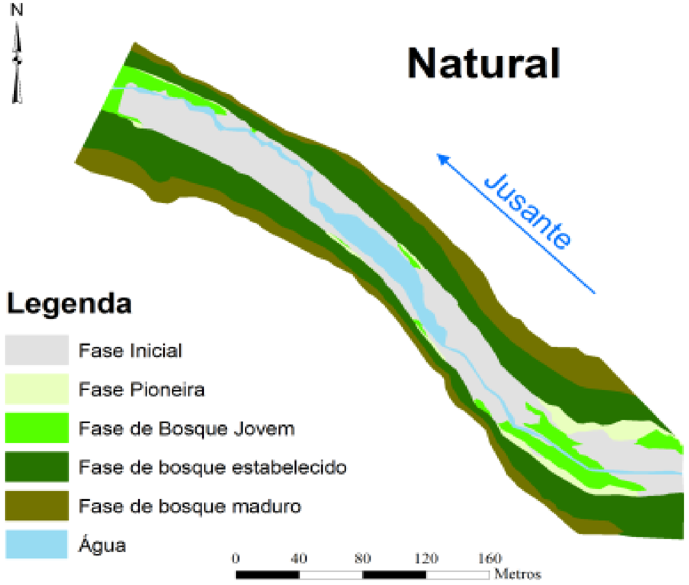


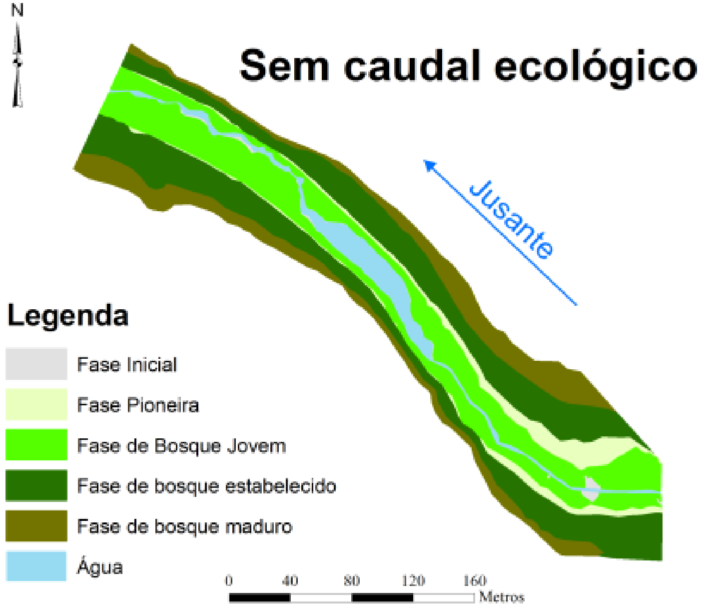
Odelouca dam

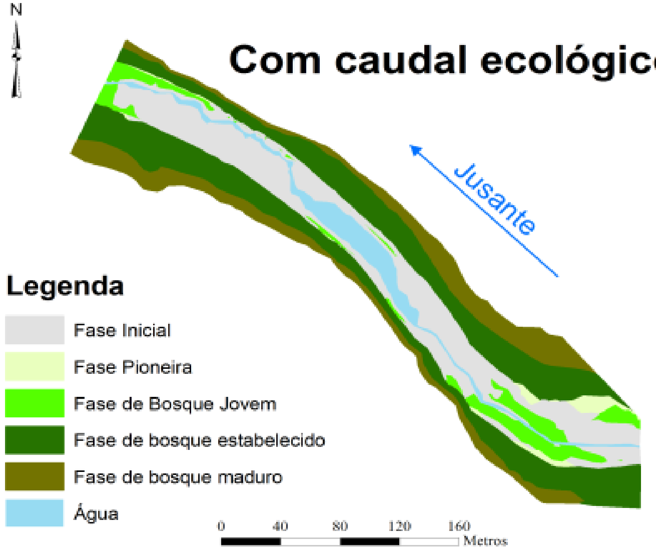
- Maximum discharges necessary for flushing flows: 171 and 290 m^3/s
- Dam spillway
  - Type: Gated shute
  - Maximum discharge capacity: 1400 m^3/s
- Bottom outlet
  - Maximum discharge: 53 m^3/s


Legenda
Limite do país
Rede hidrográfica
Bacia de Odelouca
Bacia do Sado
Local de estudo de Odelouca
Local de estudo de Monte da Rocha
10
Kilometros

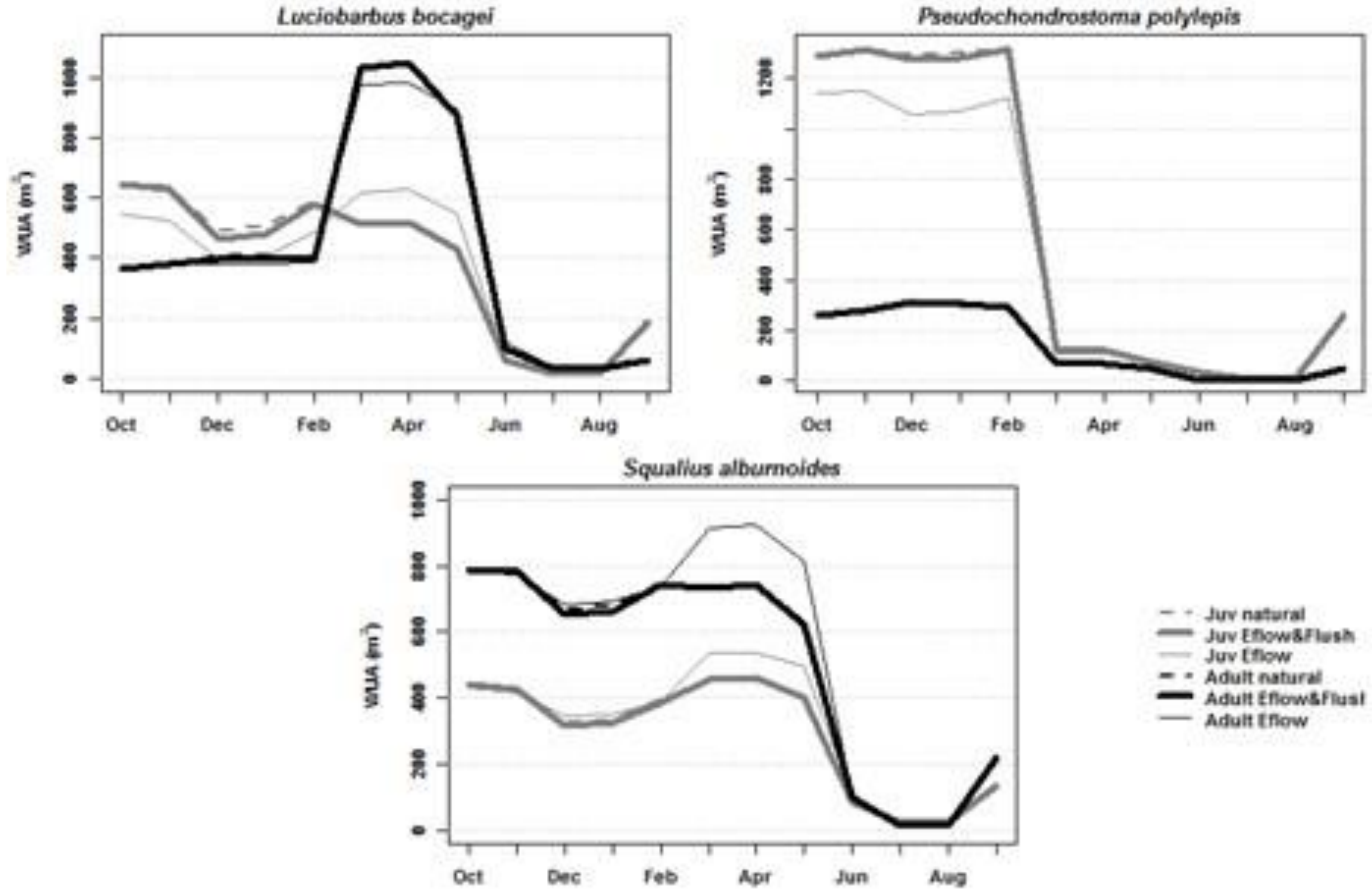

Monte da Rocha
45
40
35
30
25
20
15
10
5
0
Área ocupada (%)
IP
PP
ES
EF
MF
Fase de sucessão
Natural
Sem caudal ecológico
Com caudal ecológico


N
Natural
Jusante
Legenda
Fase Inicial
Fase Pioneira
Fase de Bosque Jovem
Fase de bosque estabelecido
Fase de bosque maduro
Água
0
40
80
120
160
Metros

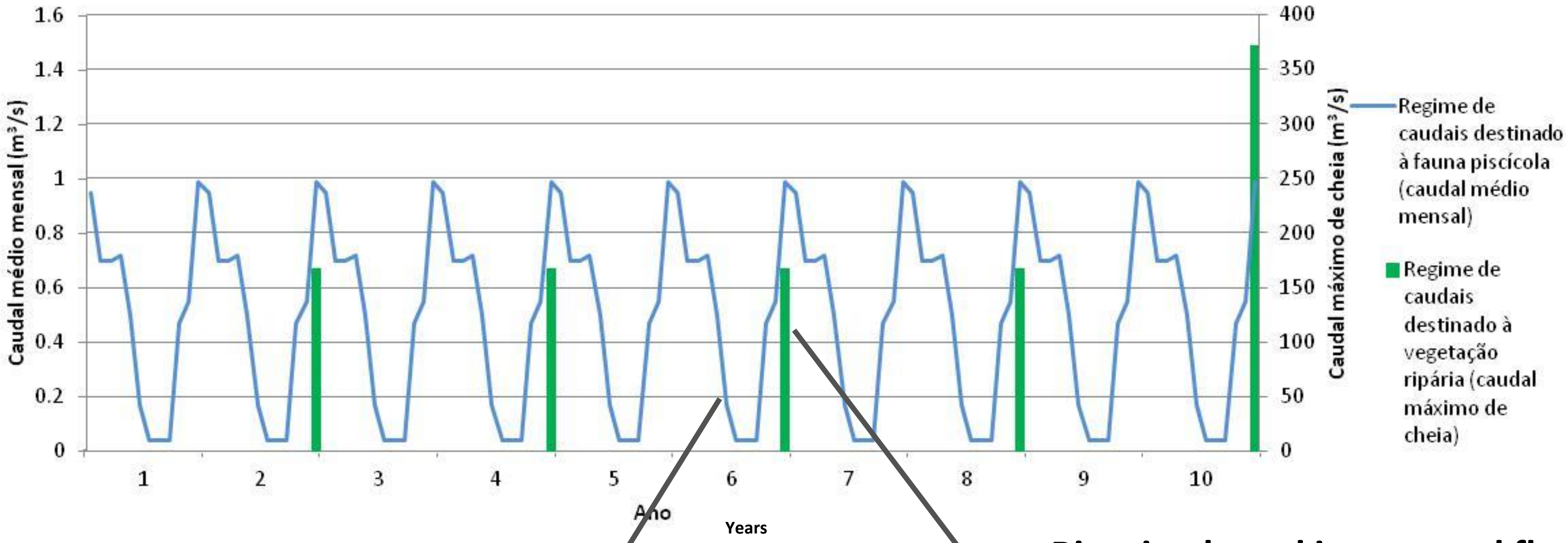

N
Sem caudal ecológico
Jusante
Legenda
Fase Inicial
Fase Pioneira
Fase de Bosque Jovem
Fase de bosque estabelecido
Fase de bosque maduro
Água
0
40
80
120
160
Metros


N
Com caudal ecológico
Jusante
Legenda
Fase Inicial
Fase Pioneira
Fase de Bosque Jovem
Fase de bosque estabelecido
Fase de bosque maduro
Água
0
40
80
120
160
Metros

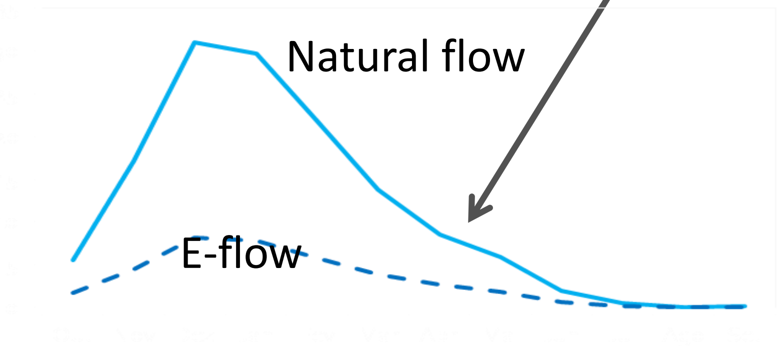
Combinando eflows and flushflows – river Ocreza



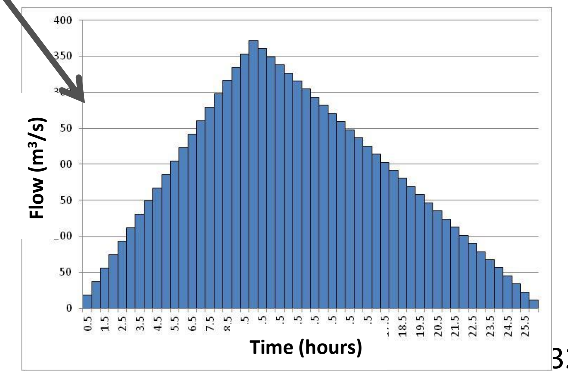
Flush flows using riparian modelling

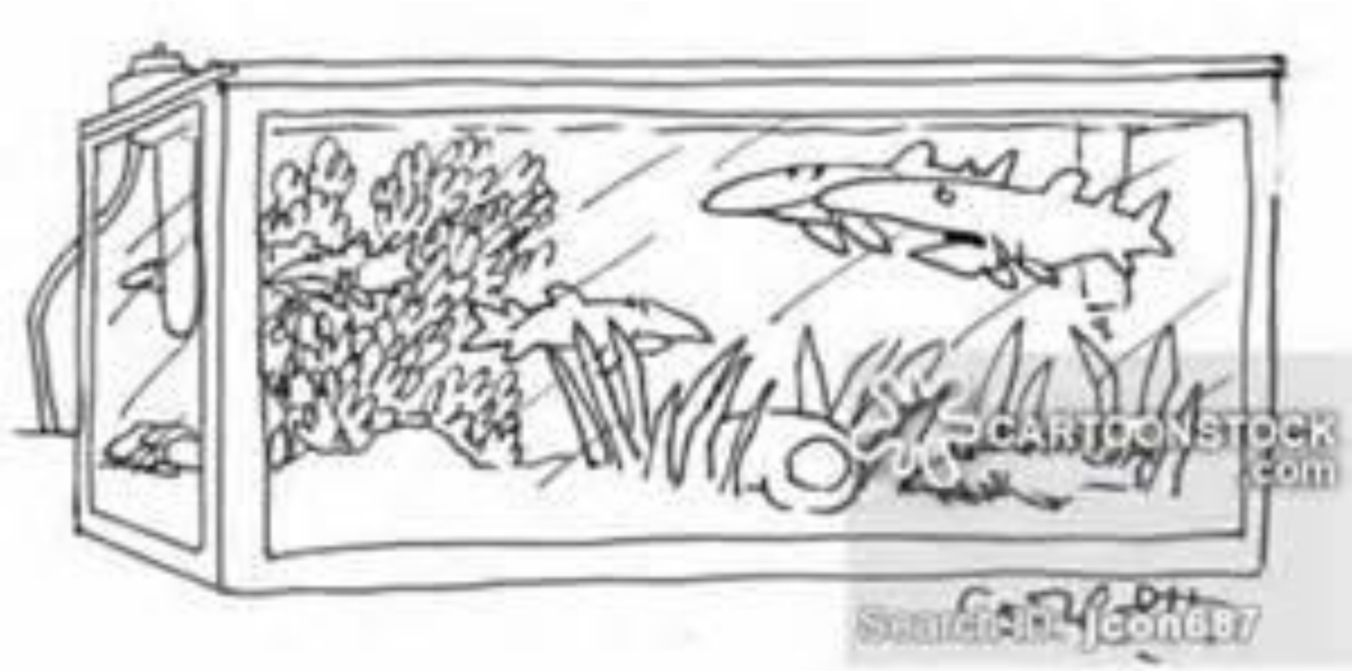


Fish based intra-annual eflow



Riparian based inter-anual flush flows

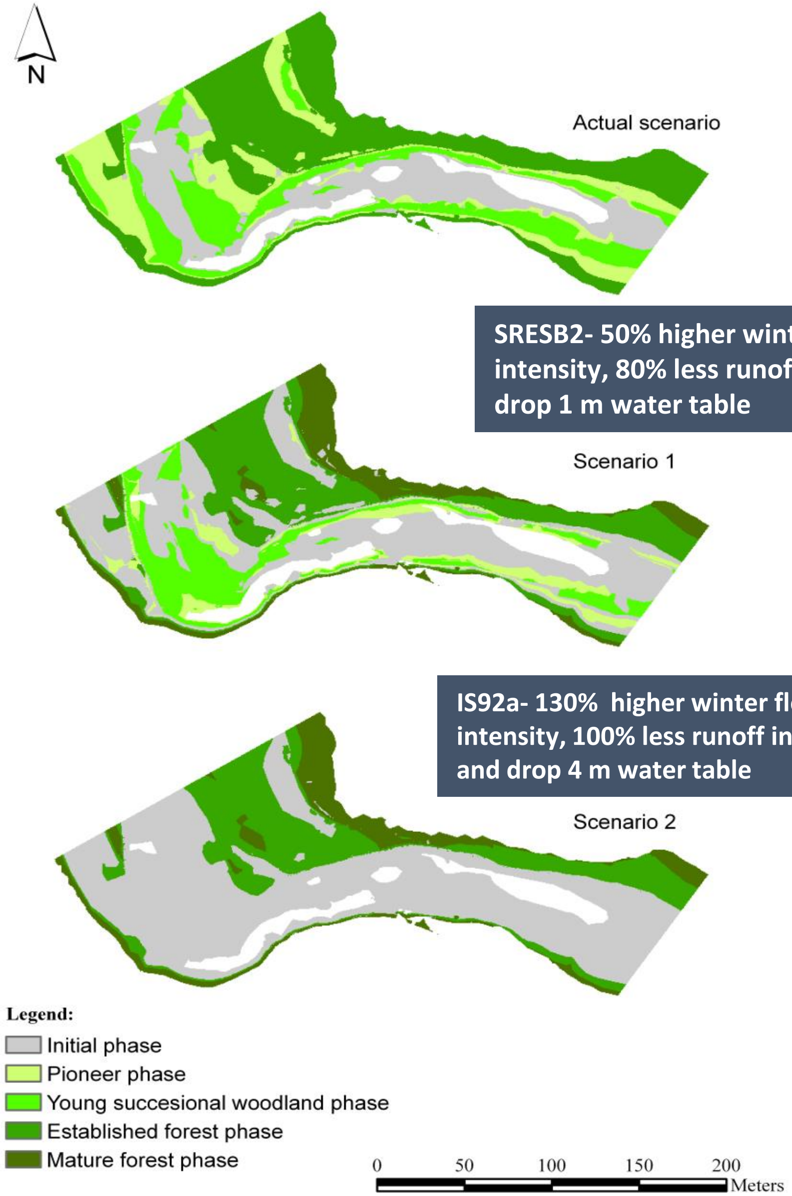




"GO WITH WHAT FLOW? WE LIVE IN AN AQUARIUM!"

Expected succession phase areas for the considered climate change scenarios 2090

- **River bank devegetation and upland forest spreading inwards the river**
- **Area balance: pioneer, young and juvenile patches decrease, while mature and terrestrial patches increase**



SRESB2- 50% higher winter flood intensity, 80% less runoff in summer and drop 1 m water table

IS92a- 130% higher winter flood intensity, 100% less runoff in summer and drop 4 m water table