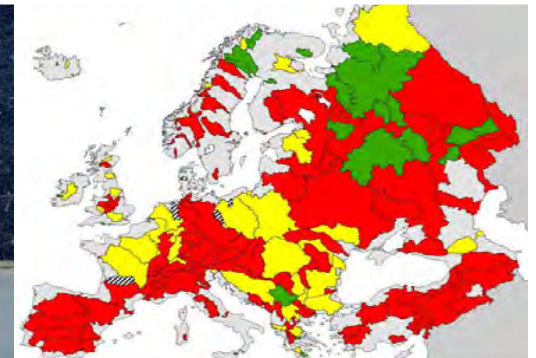
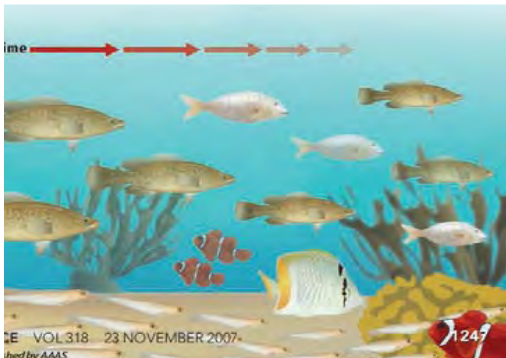


Hydrogeomorphic-ecologic linkages and feedbacks in dynamic fluvial systems

Klement Tockner
(www.igb-berlin.de)







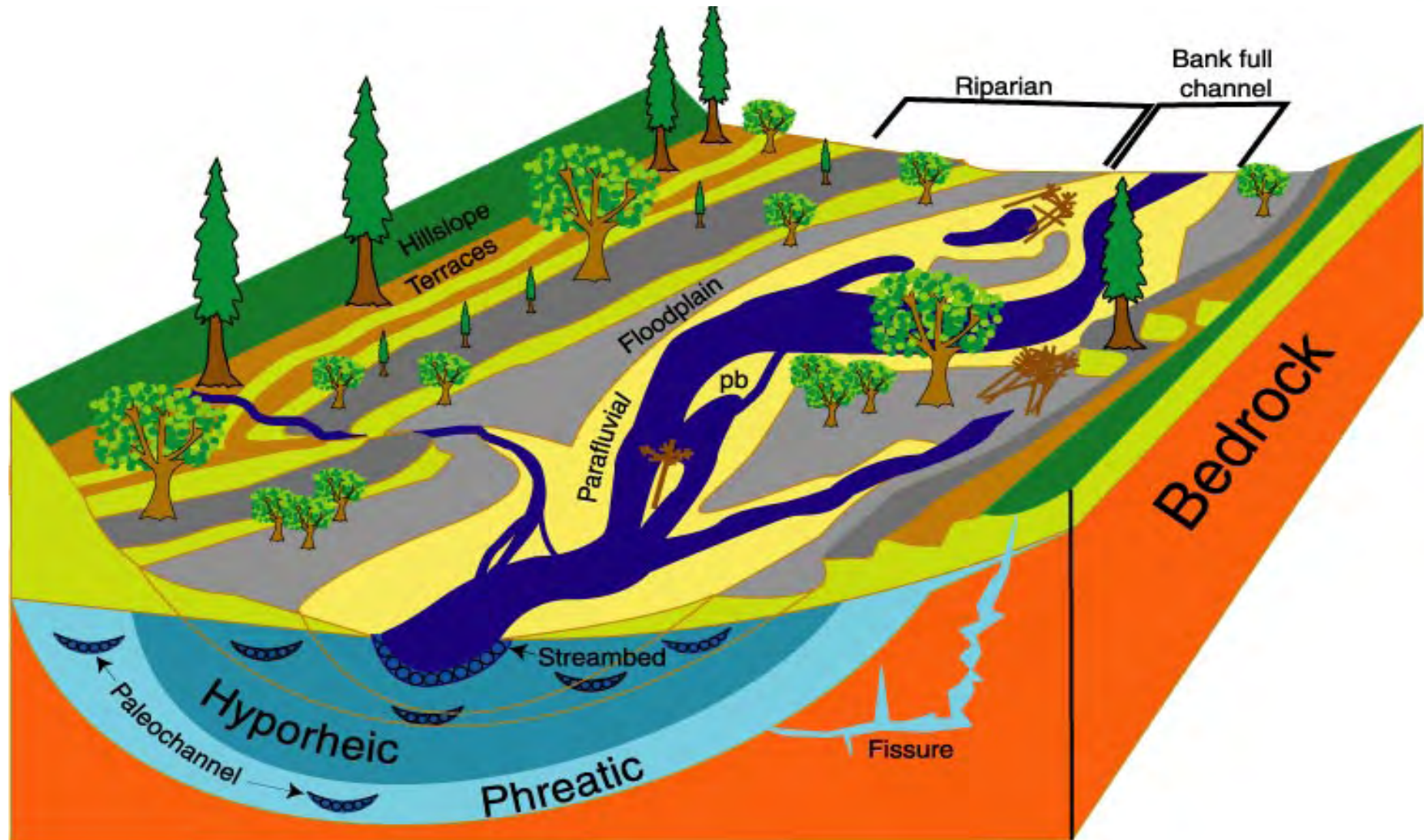
(Elbe River during flooding. Photo: Schwartz)

Unique Ecosystems

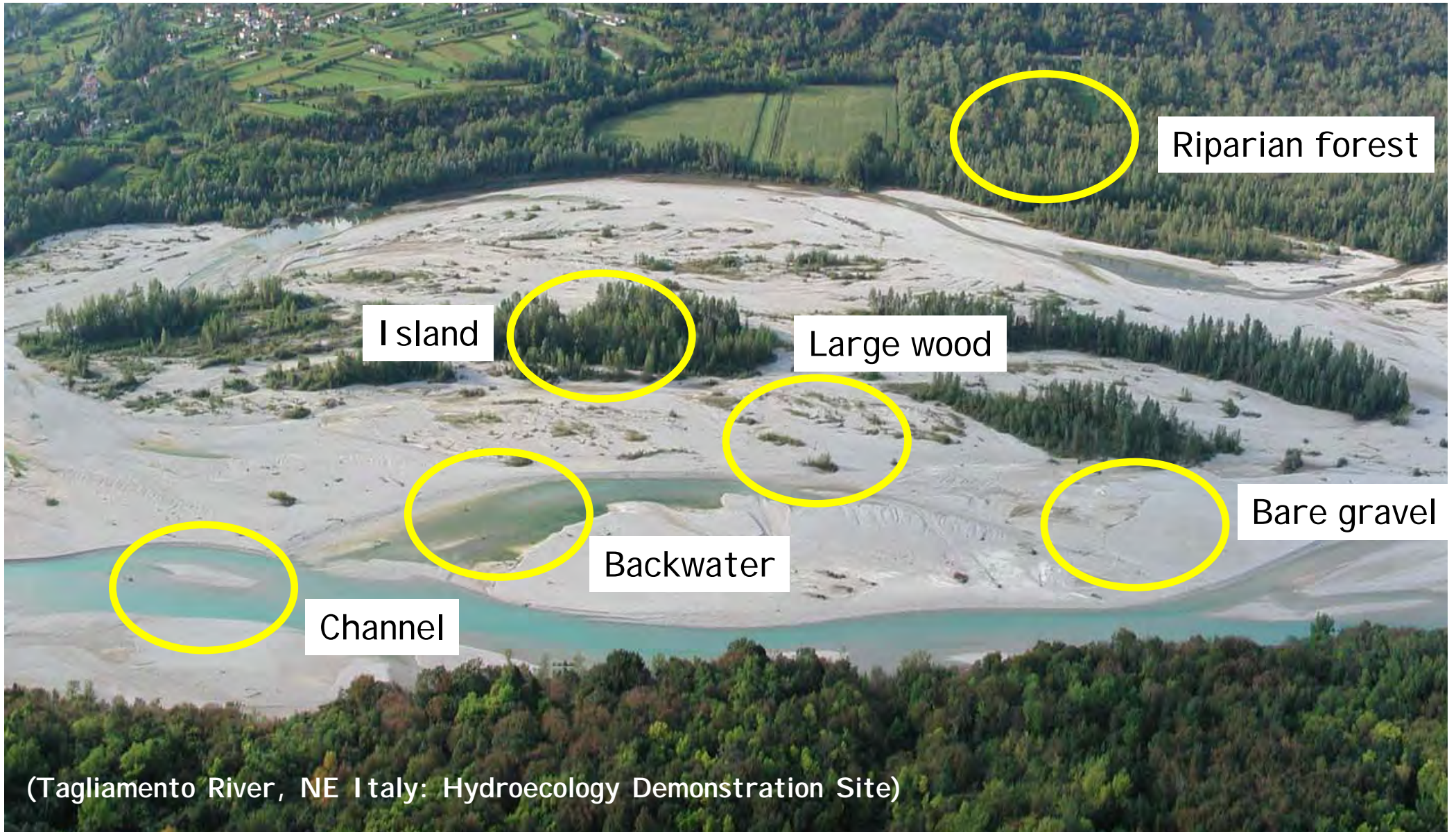
- Topographic lowest point of the landscape
- Mosaic or linear features in a terrestrial matrix
- Expanding and contracting ecosystems
- Rapid successional processes
- Strong linkages to terrestrial and groundwater systems
- Hot-spots of productivity and biodiversity



Riverine floodplain: Entire valley bottom that is capable of flooding, including the channel network
(after Stanford et al. 2005)



Floodplains as habitat mosaics



Structure
meets
function



Habitat-specific sediment respiration rates (Tagliamento)

Habitat Type	Respiration (g C m ⁻² yr ⁻¹)
Pond	162
Channel	212
Gravel	142
Large Wood	503
Vegatated Island	1138
Riparian Forest	994
Floodplain* (t C yr⁻¹)	863

* Total Area: 1.83 km²

Sensitivity of sediment respiration to environmental change

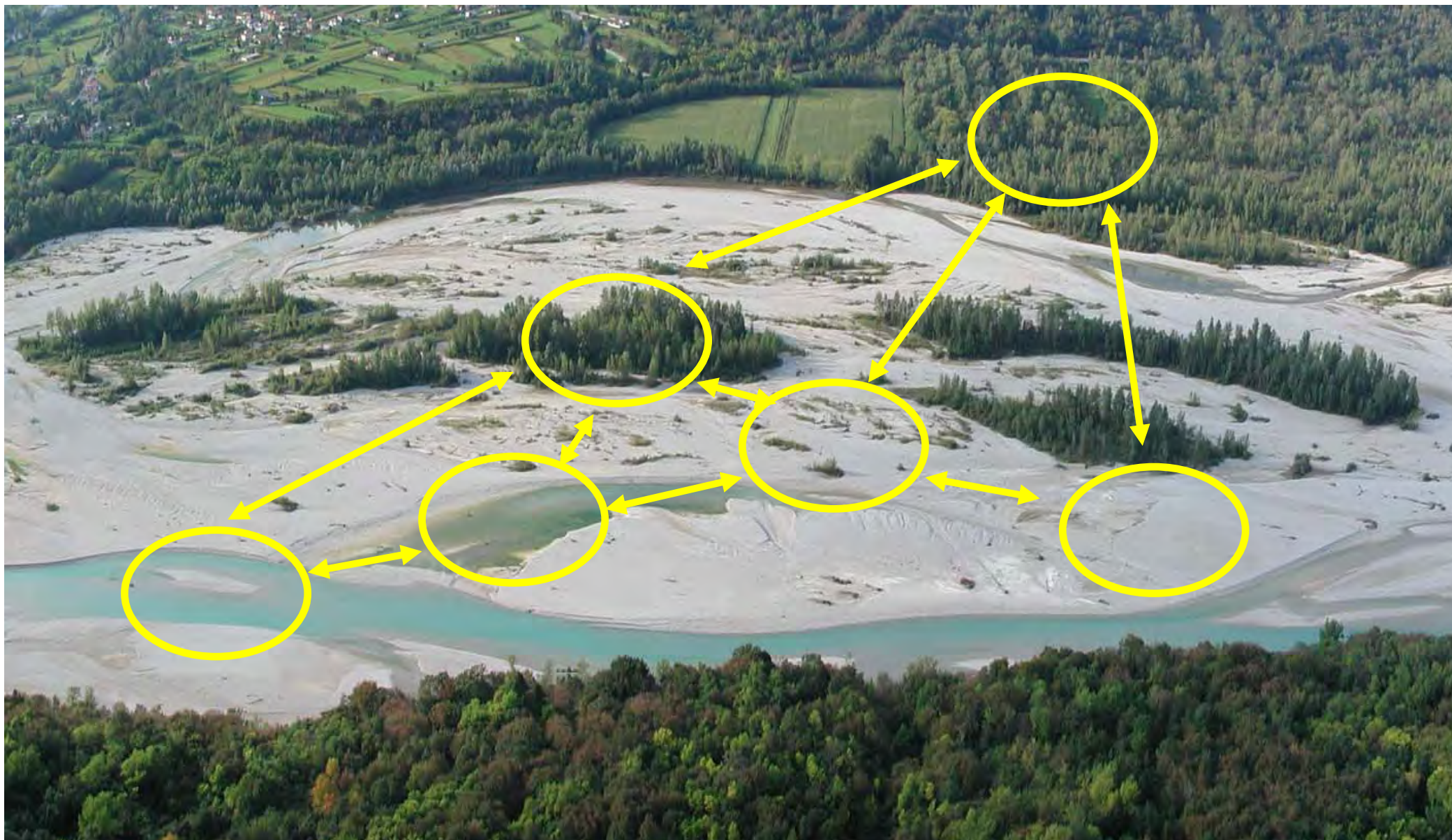
Habitat Type	Respiration (g C m ⁻² yr ⁻¹)	+2° C
Pond	162	+06%
Channel	212	+08%
Gravel	142	+14%
Large Wood	503	+20%
Vegatated Island	1138	+14%
Riparian Forest	994	+31%
Floodplain* (t C yr⁻¹)	863	+20%

* Total Area: 1.83 km²

(Doering *et al.* Ecosystems. in revision)



Floodplains as interacting habitat mosaics



Concave and convex islands

(*sensu* Karaus, Alder & Tockner. 2005. Wetlands)



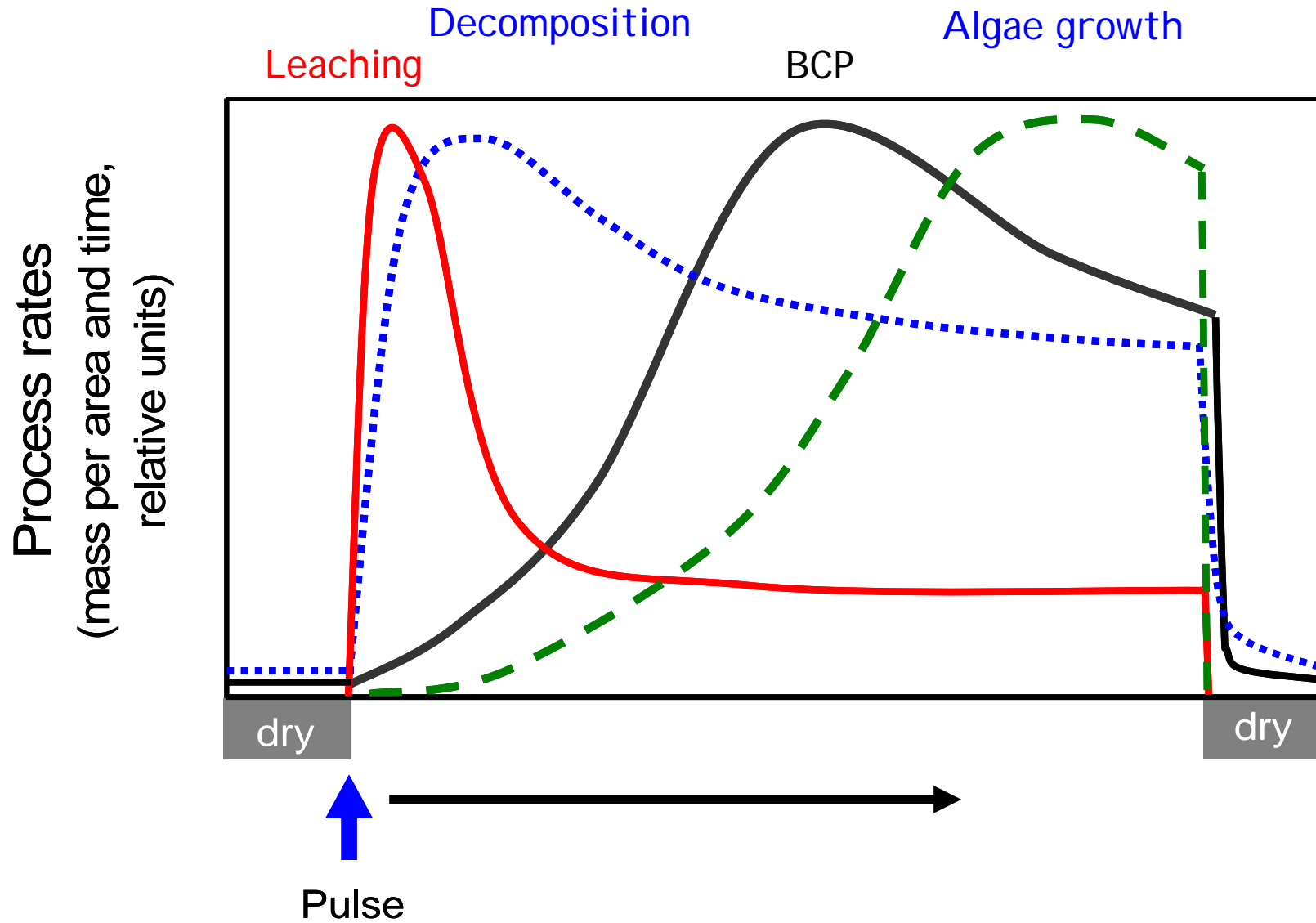


(Tagliamento River, NE Italy:
Hydroecology Demonstration Site)





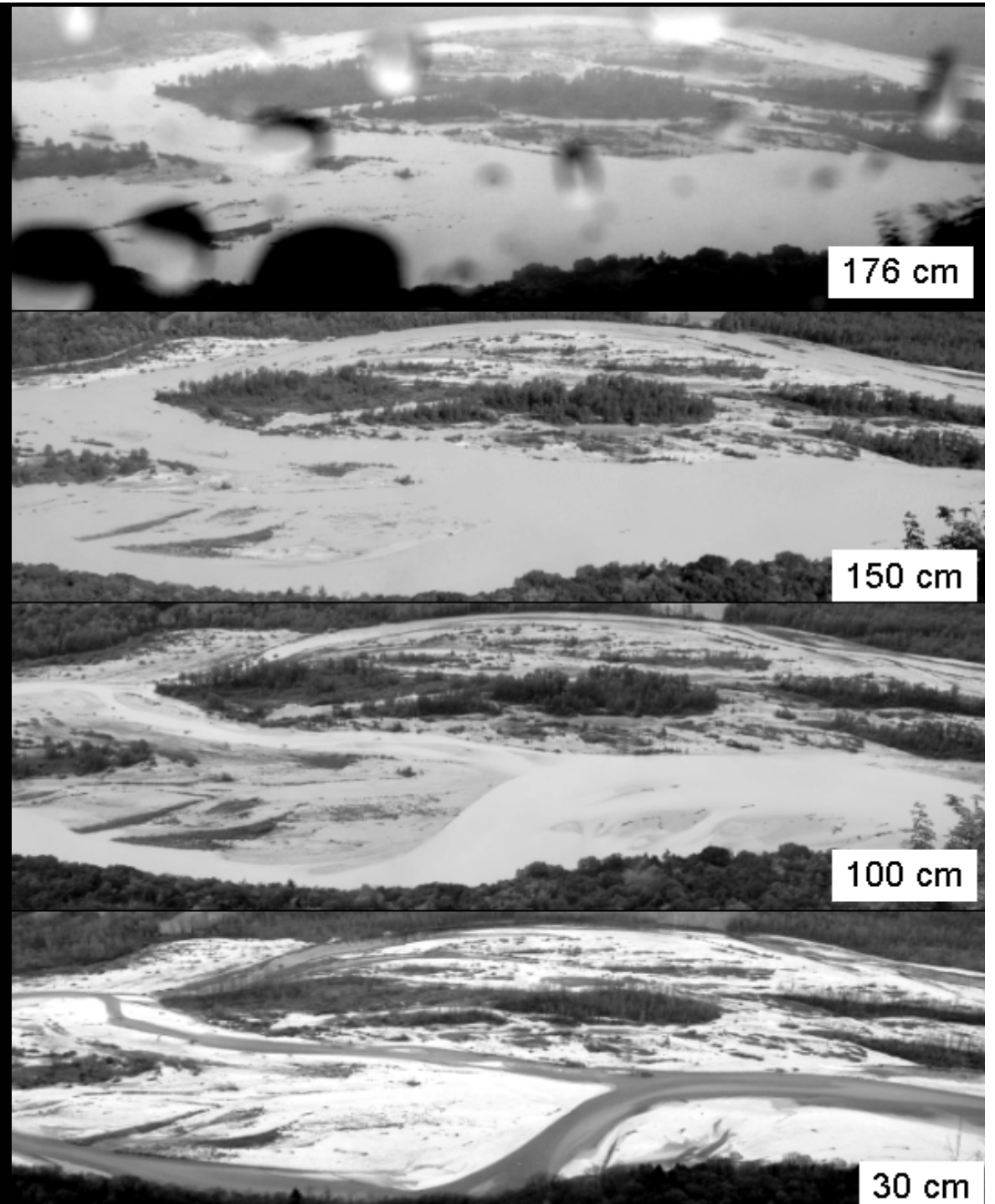
Response of ecosystem processes to resource pulses



Floating organic matter is a key vector for mass dispersal of terrestrial organisms

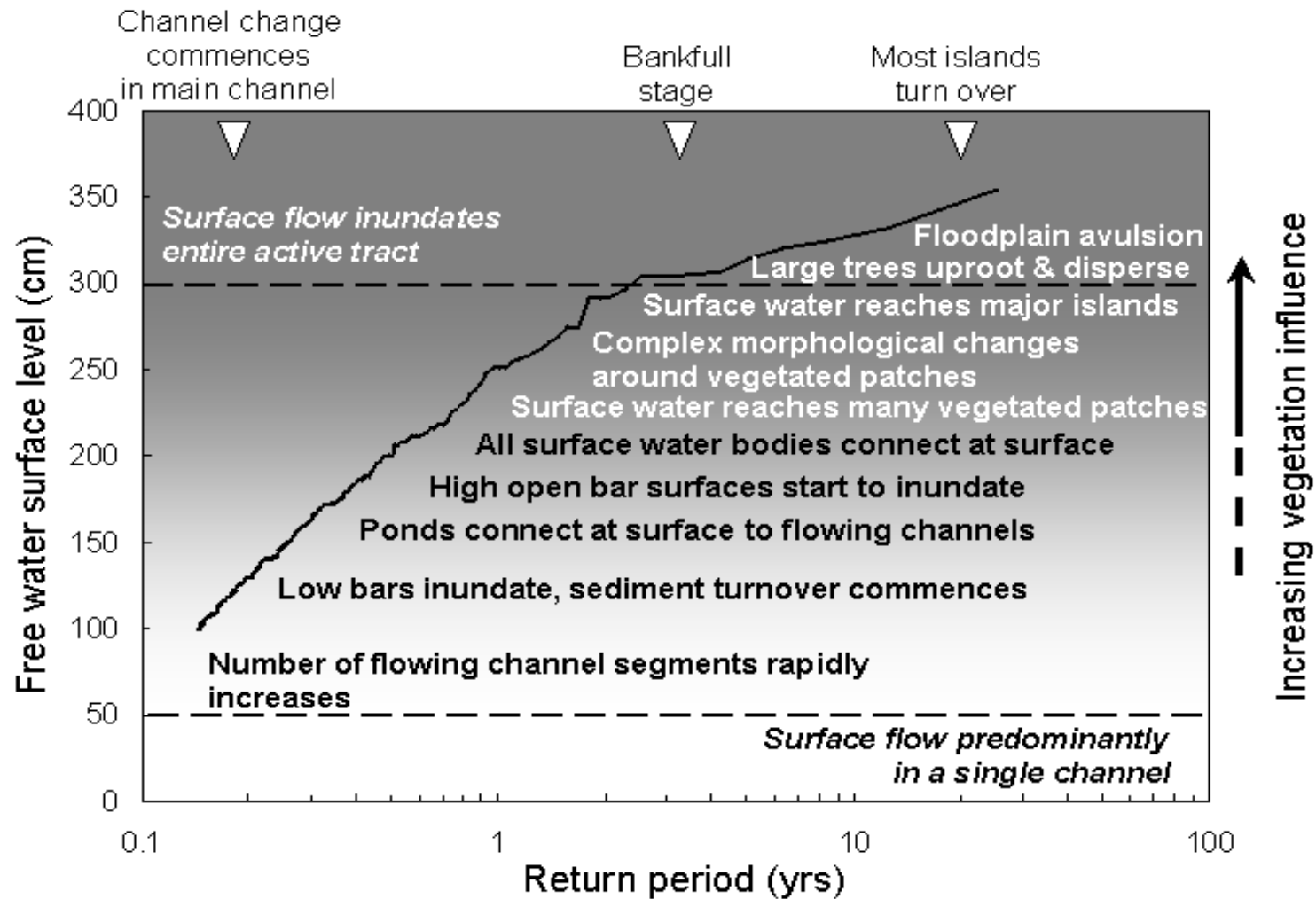


Spatio-temporal dynamics of linked aquatic-terrestrial landscapes



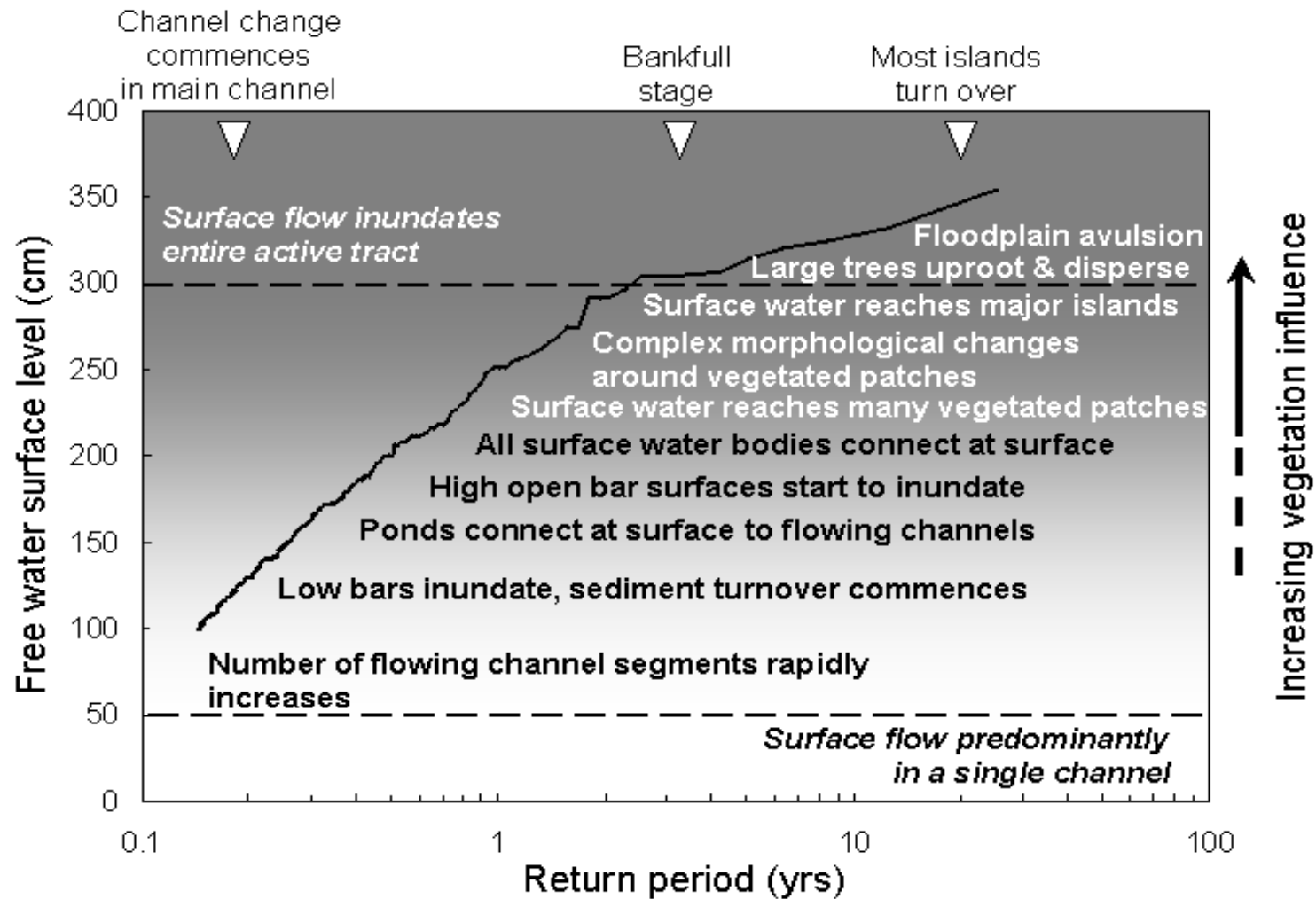
(Photos: Bertoldi *et al.* RRA. 2009)

Hydrogeomorphic thresholds in riverine floodplains



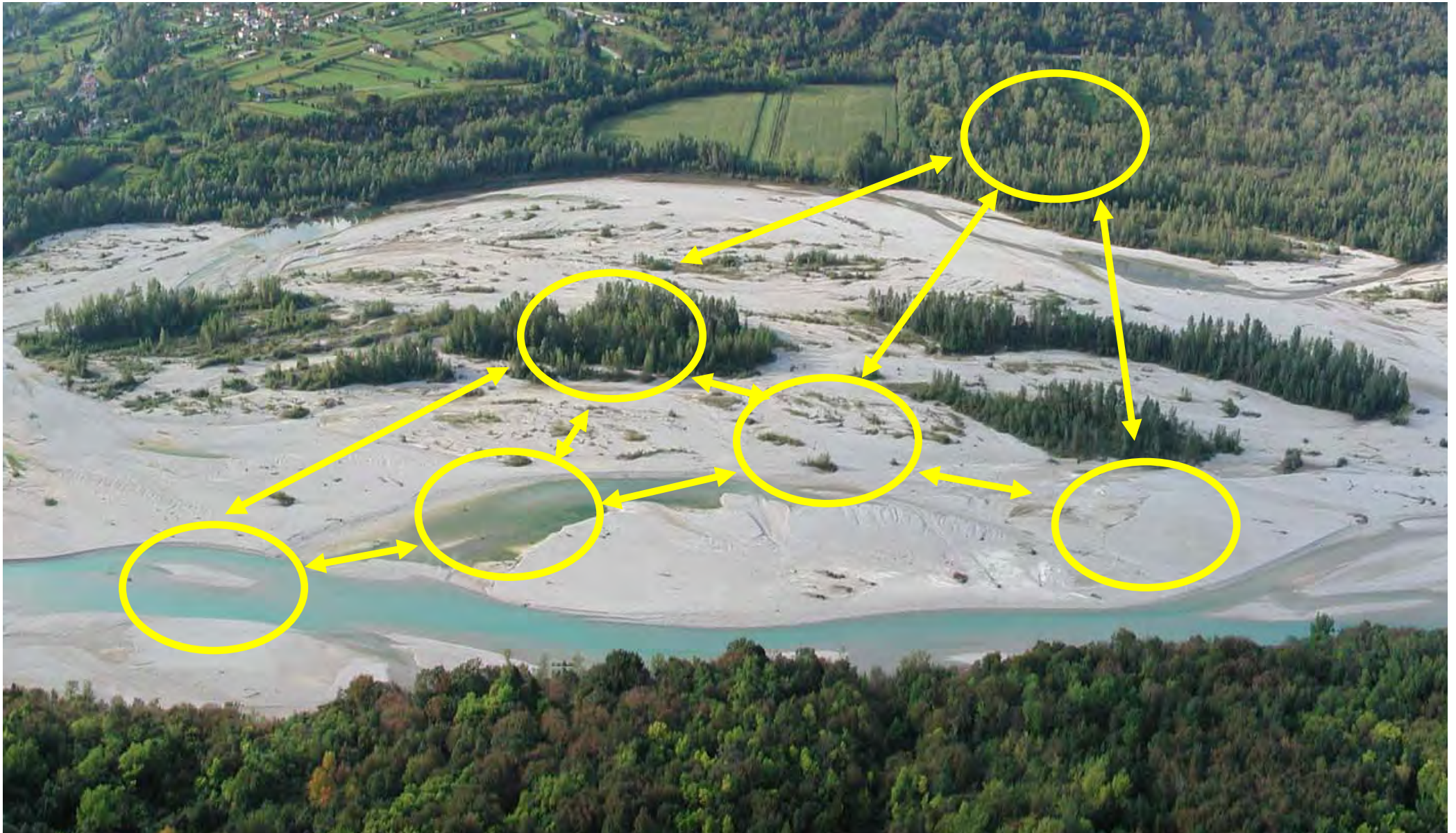
(Bertoldi *et al.* 2009. RRA)

Do ecological thresholds match hydrogeomorphic thresholds in riverine floodplains?

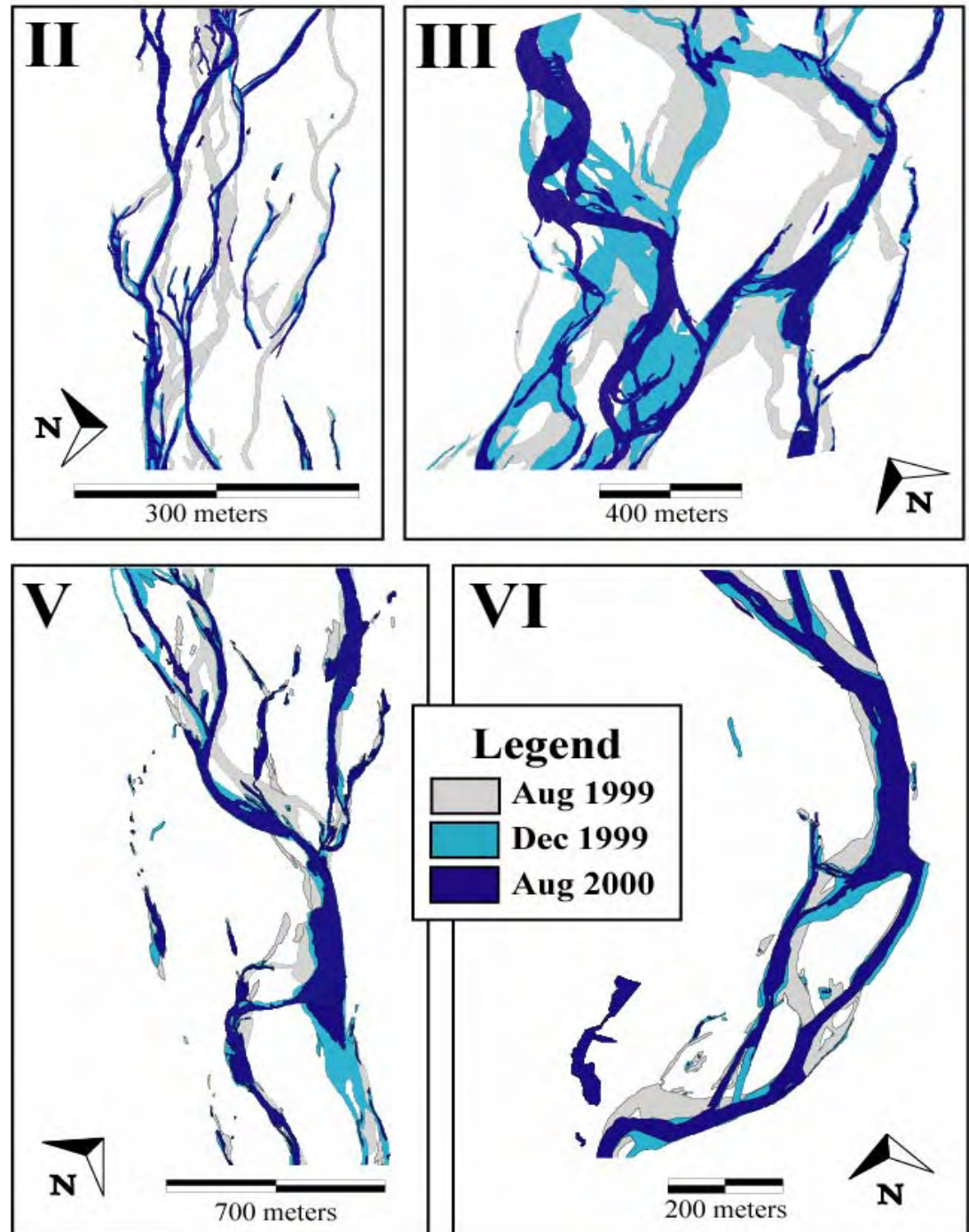


(Bertoldi *et al.* 2009. RRA)

Hydrogeomorphic processes that create and maintain an interacting habitat mosaic

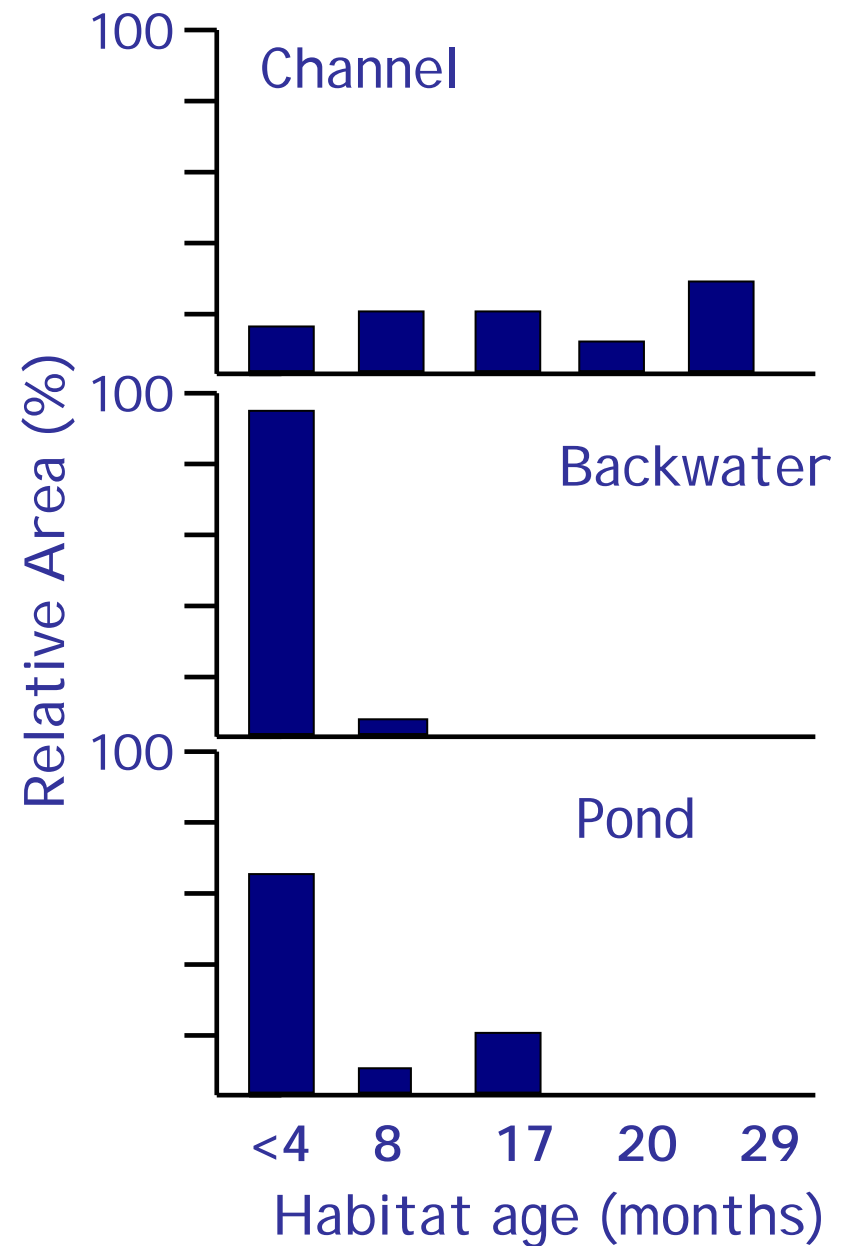
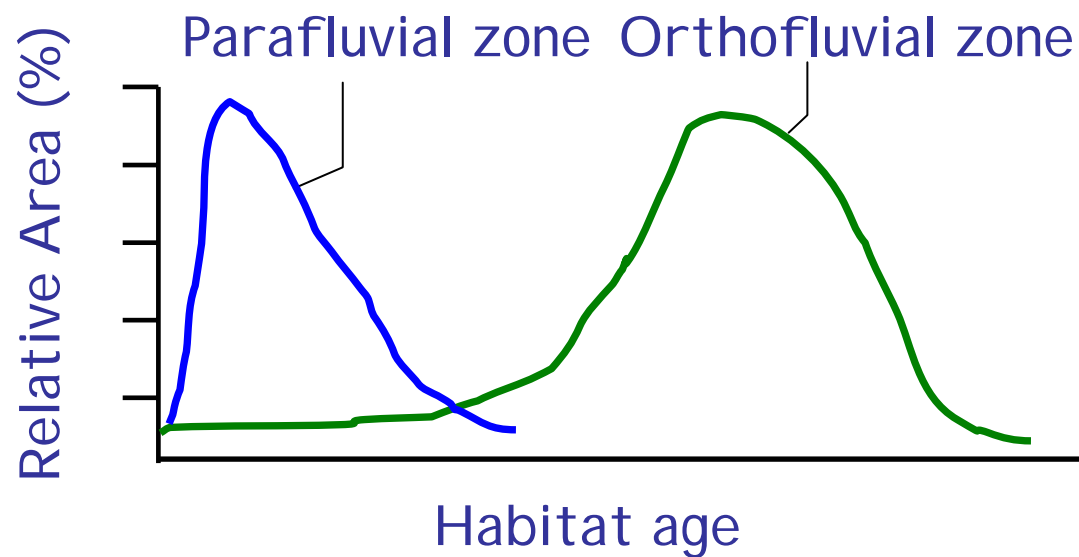


Floodplains: Shifting habitat mosaics



(Arscott, Tockner & Ward. 2002. Ecosystems)

Age distribution of aquatic habitats



Upper Danube Valley

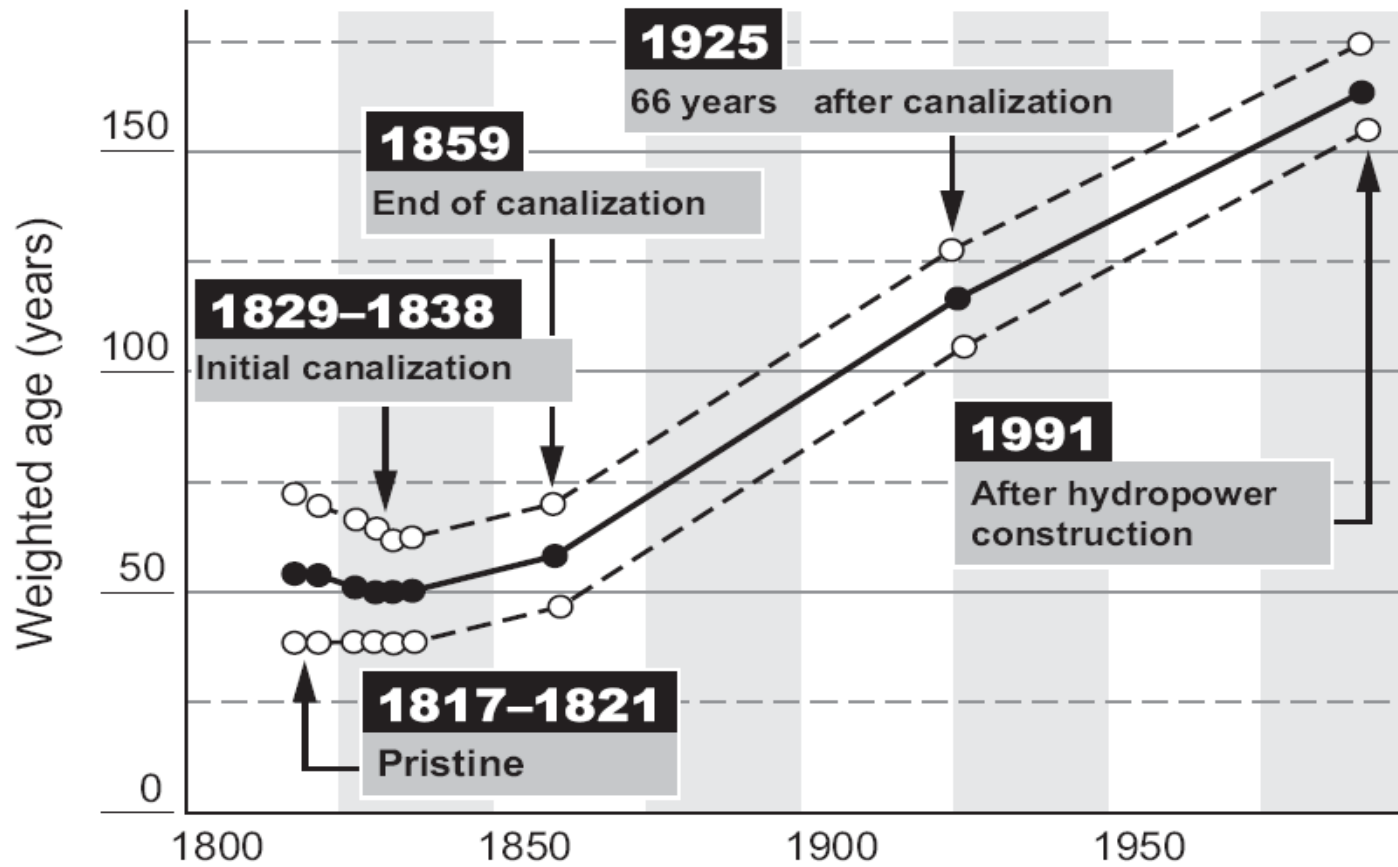


Landscape development of a Danubian floodplain

(after Hohensinner *et al.* 2005)



Age diversity change of floodplain habitats

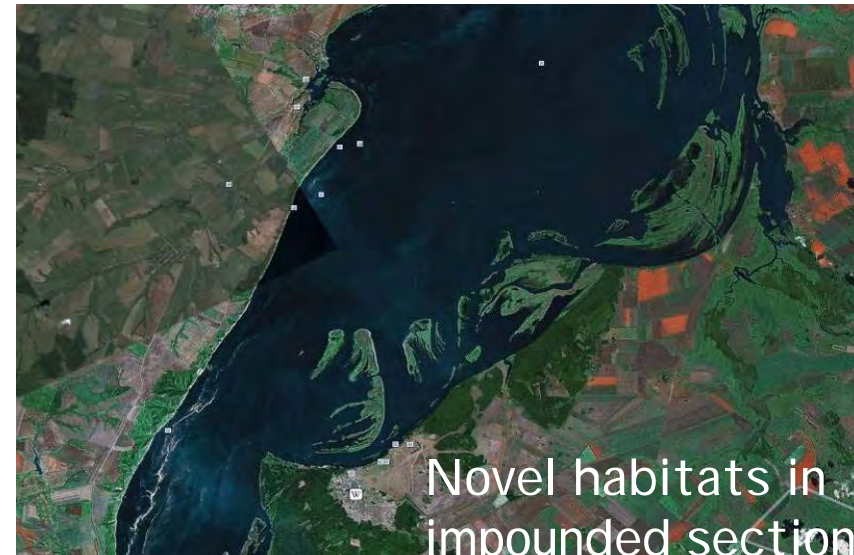
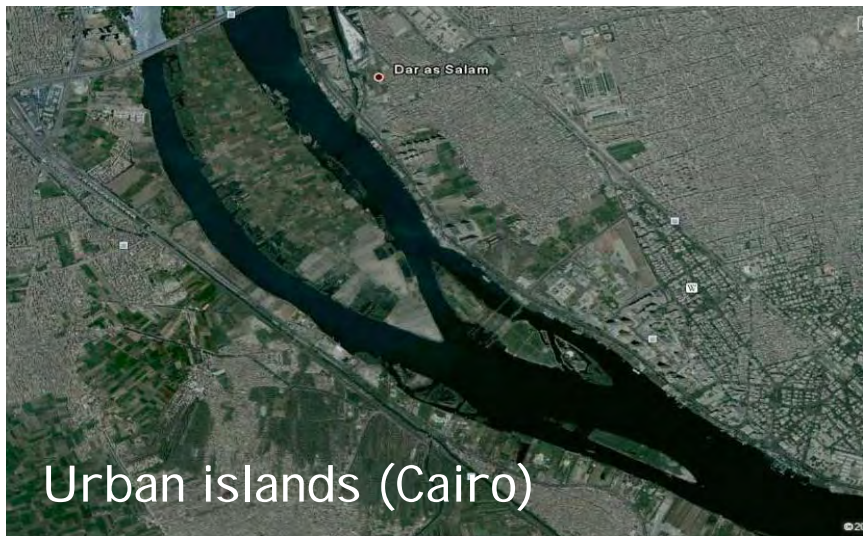


(after Hohensinner *et al.* 2005)

Vegetated islands: key ecological nodes along river corridors



Vegetated islands: key ecological nodes along river corridors



Vegetated islands: key ecological nodes along river corridors

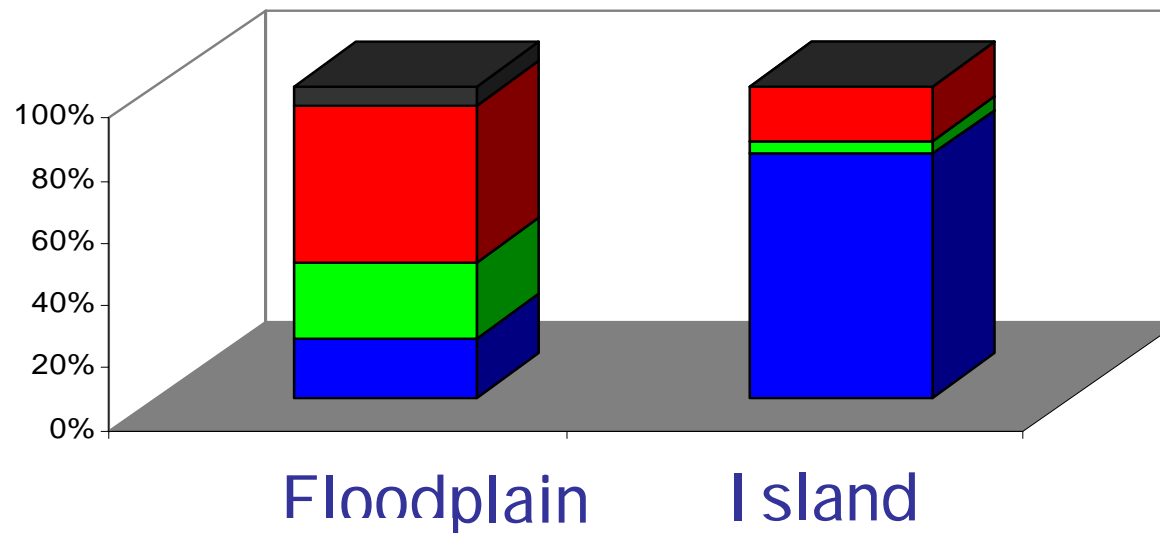
Study area: 12 European rivers (Varzuga to Ebro)

Total: 2771 islands

Islands per 100 km: 8 (Rhine) to 160 (Tagliamento)

Total ecotone length: 7200 km (island area: 1600 km²)

Environmental condition:



(Boesch, Ricaurte & Tockner. unpubl. data)



AP 4480

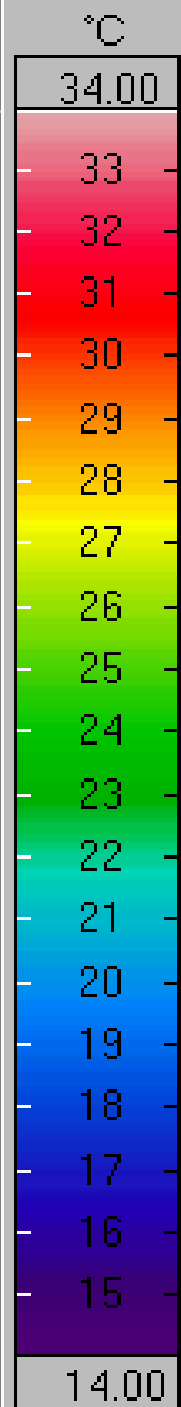
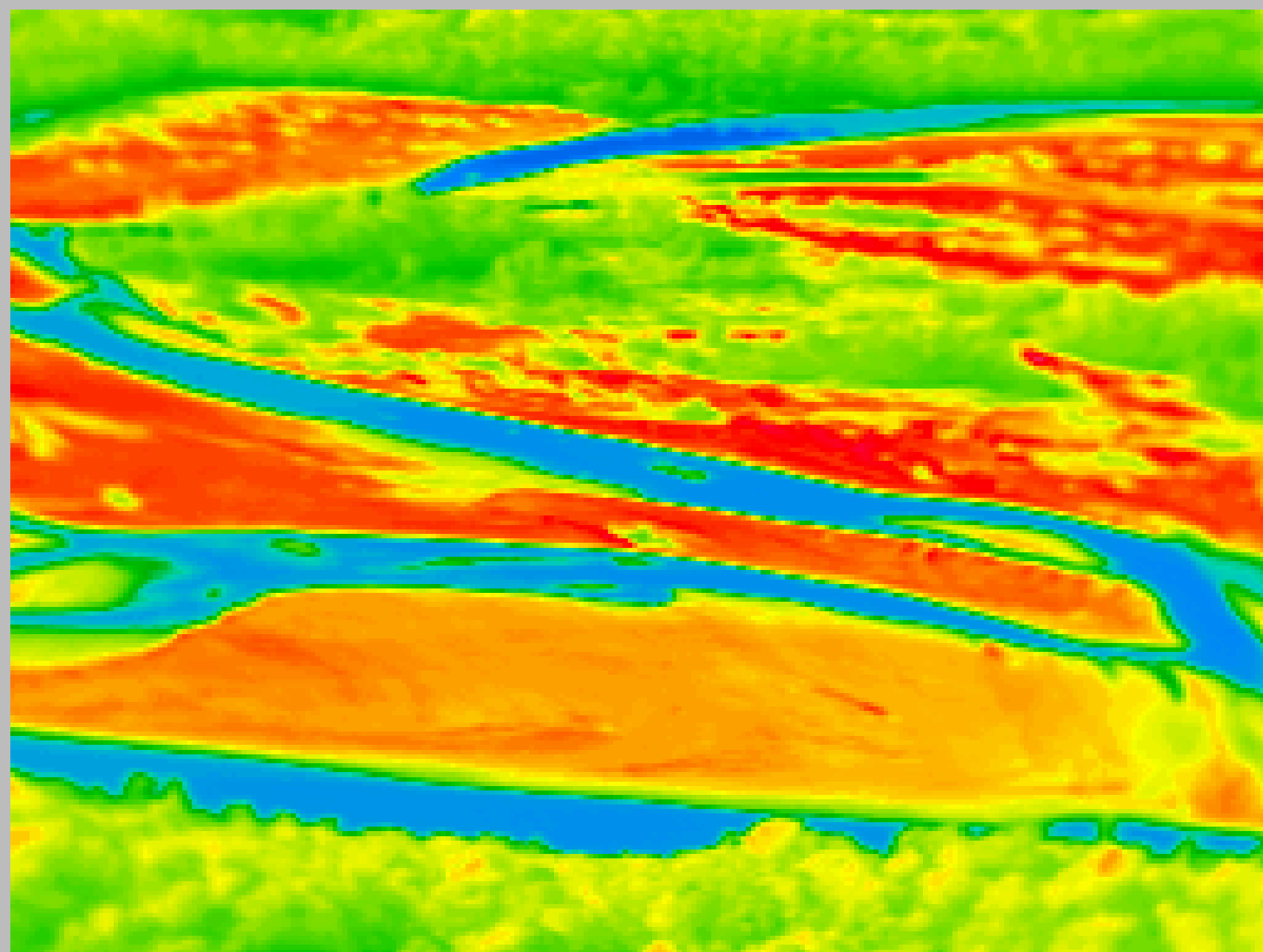
AR 2002

SC 4465

MC 8984

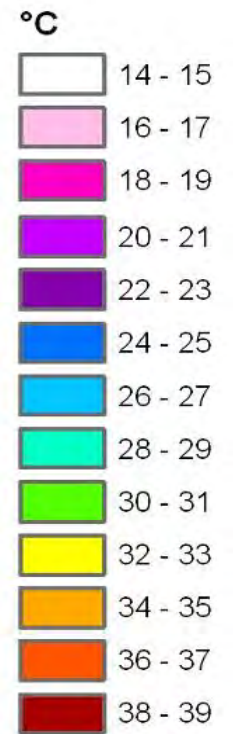
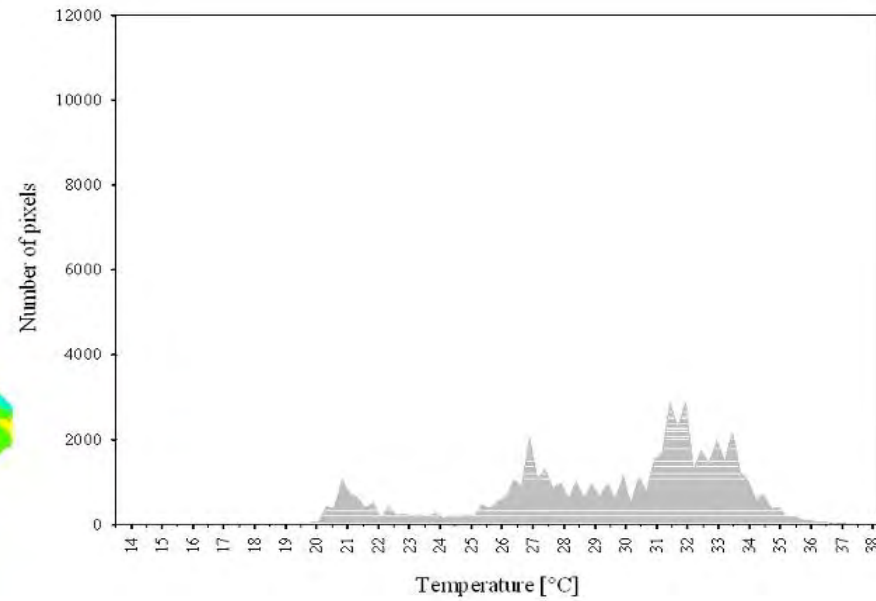
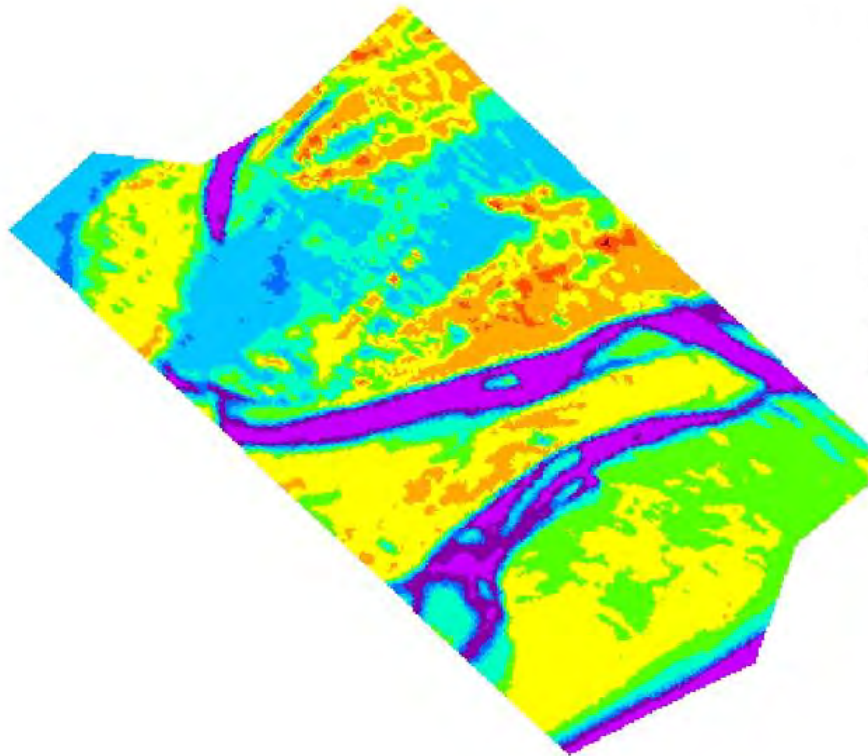
ragogno001.tmp

2.00x Emis:1.00 Range:-60.0..219.9 °C Zoom:1.4/1.4 Date:31.08.2005-17:45:55



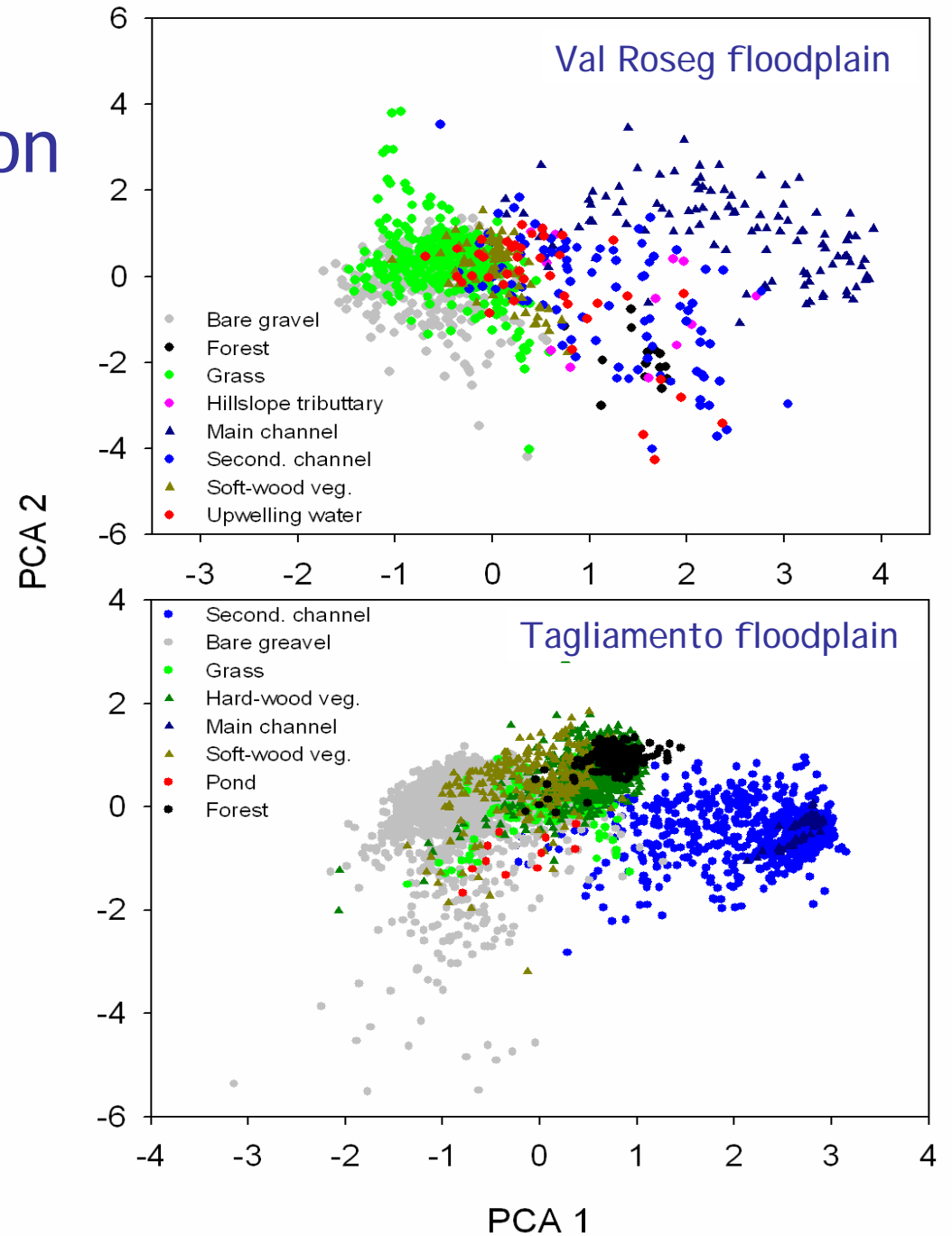
Thermal patch dynamics at the floodplain scale

16:00 h



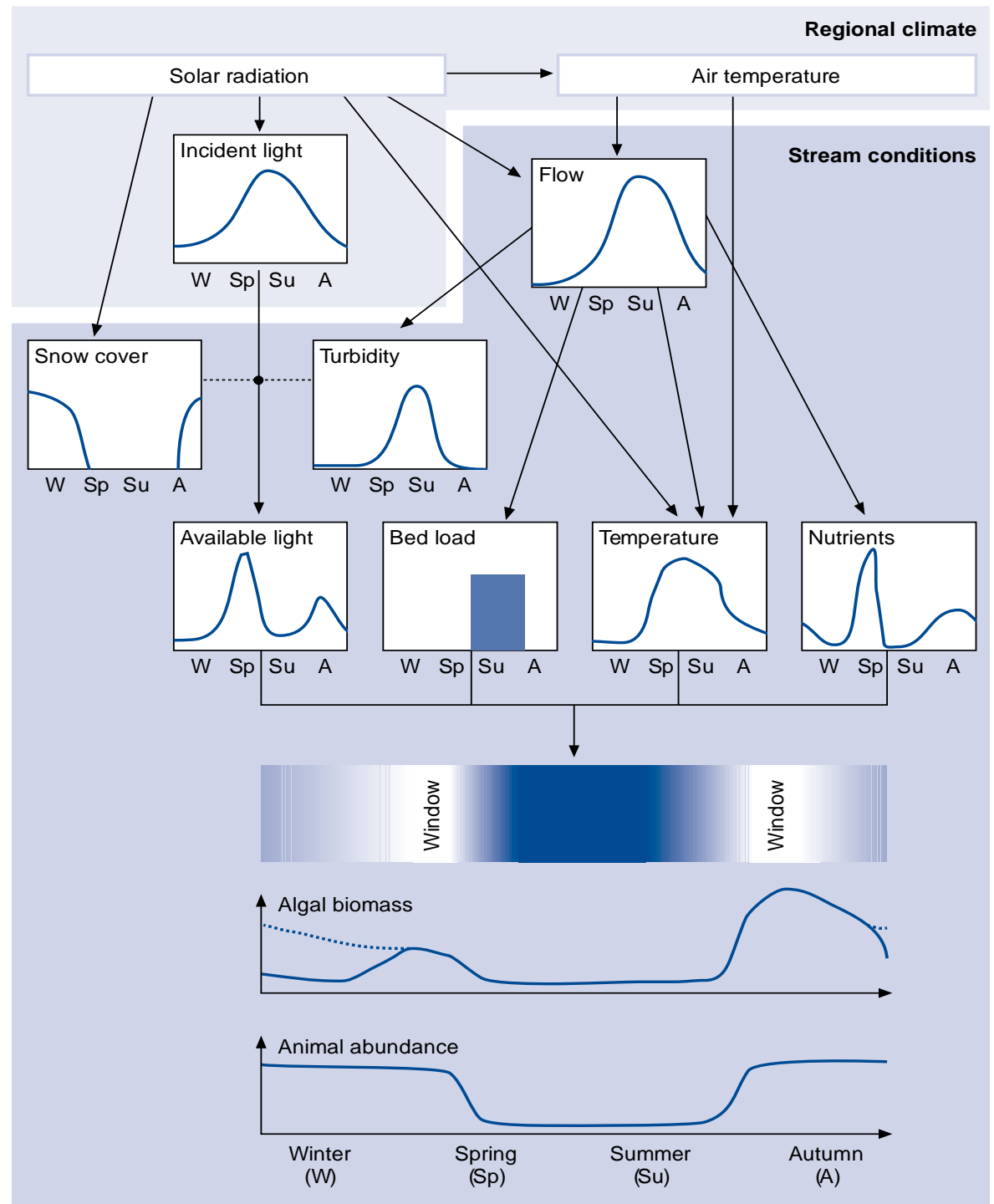
Thermal characterization of floodplain elements

(Tonolla, Acuna, Uehlinger, Frank & Tockner, unpubl.)

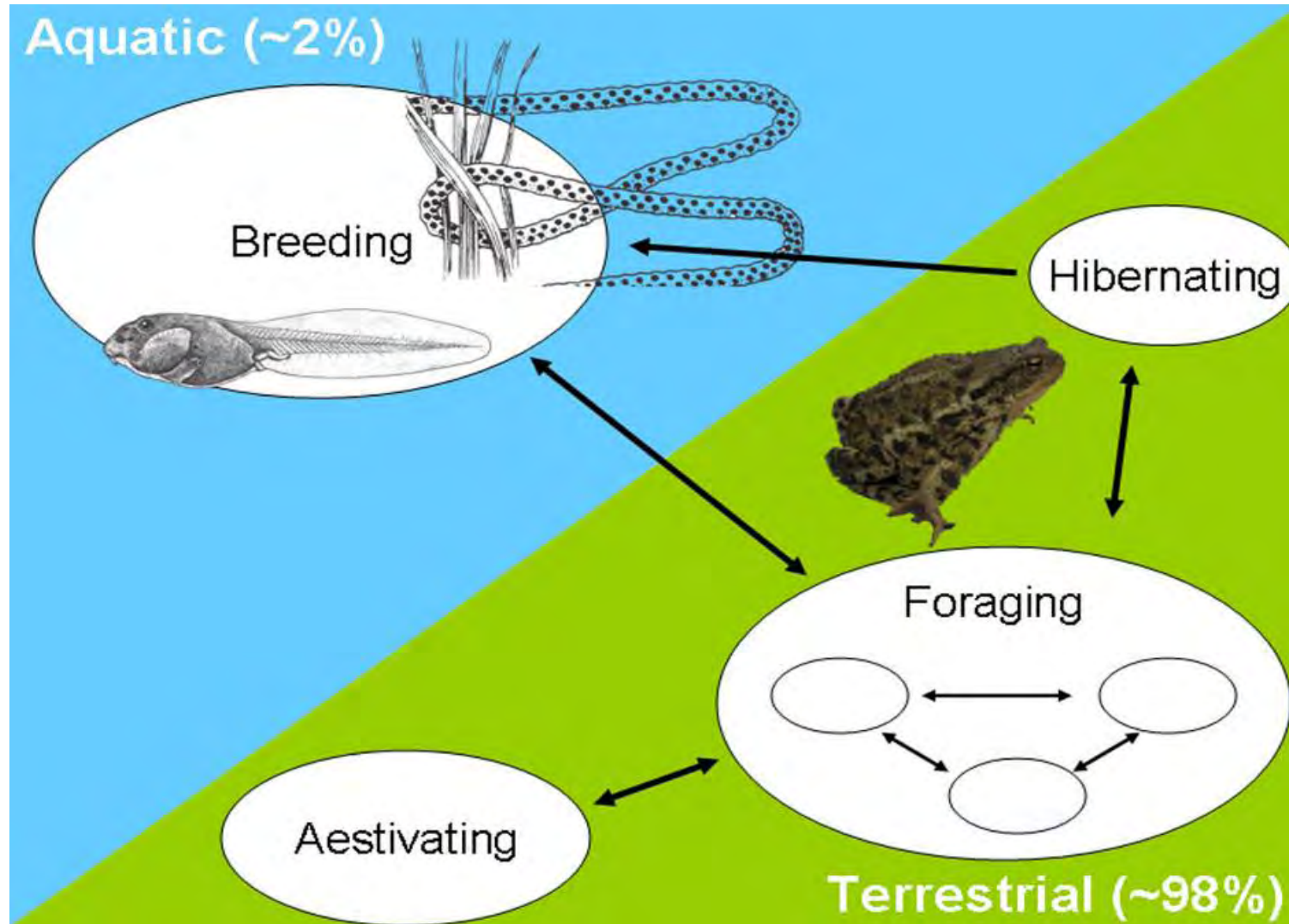


Interacting pulses in
dynamic floodplains
create:
**Windows of ecological
opportunity**

(Uehlinger, Tockner & Malard 2003)



Organisms with complex life cycles link aquatic-terrestrial systems



(modified after Semlitsch 2003)

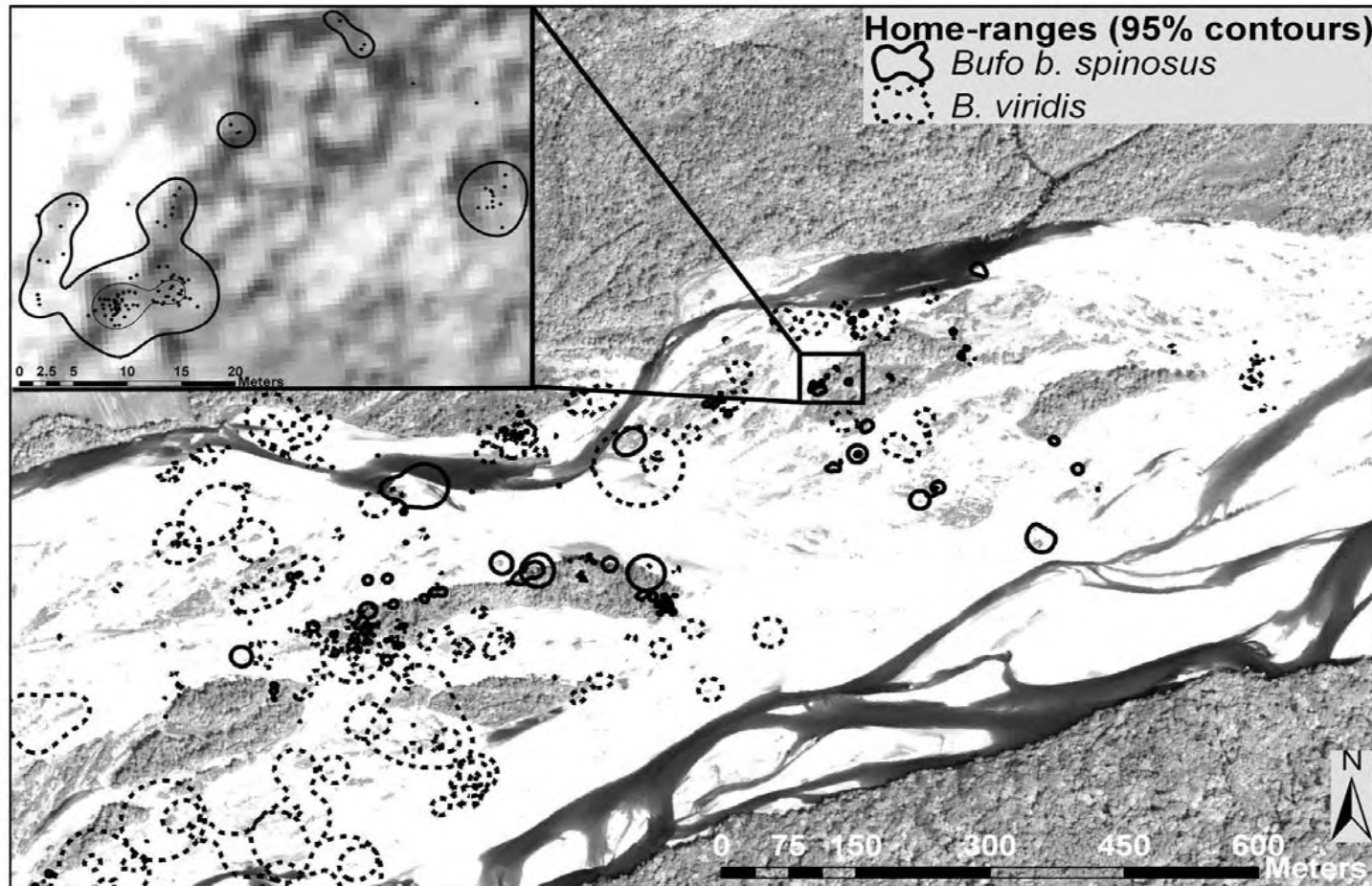
Amphibians: Complex life cycles in dynamic ecosystems



Green toad (*B. viridis*)

(Photo: L. Indermaur)

B. viridis & *B. b. bufo*: Home range size selection

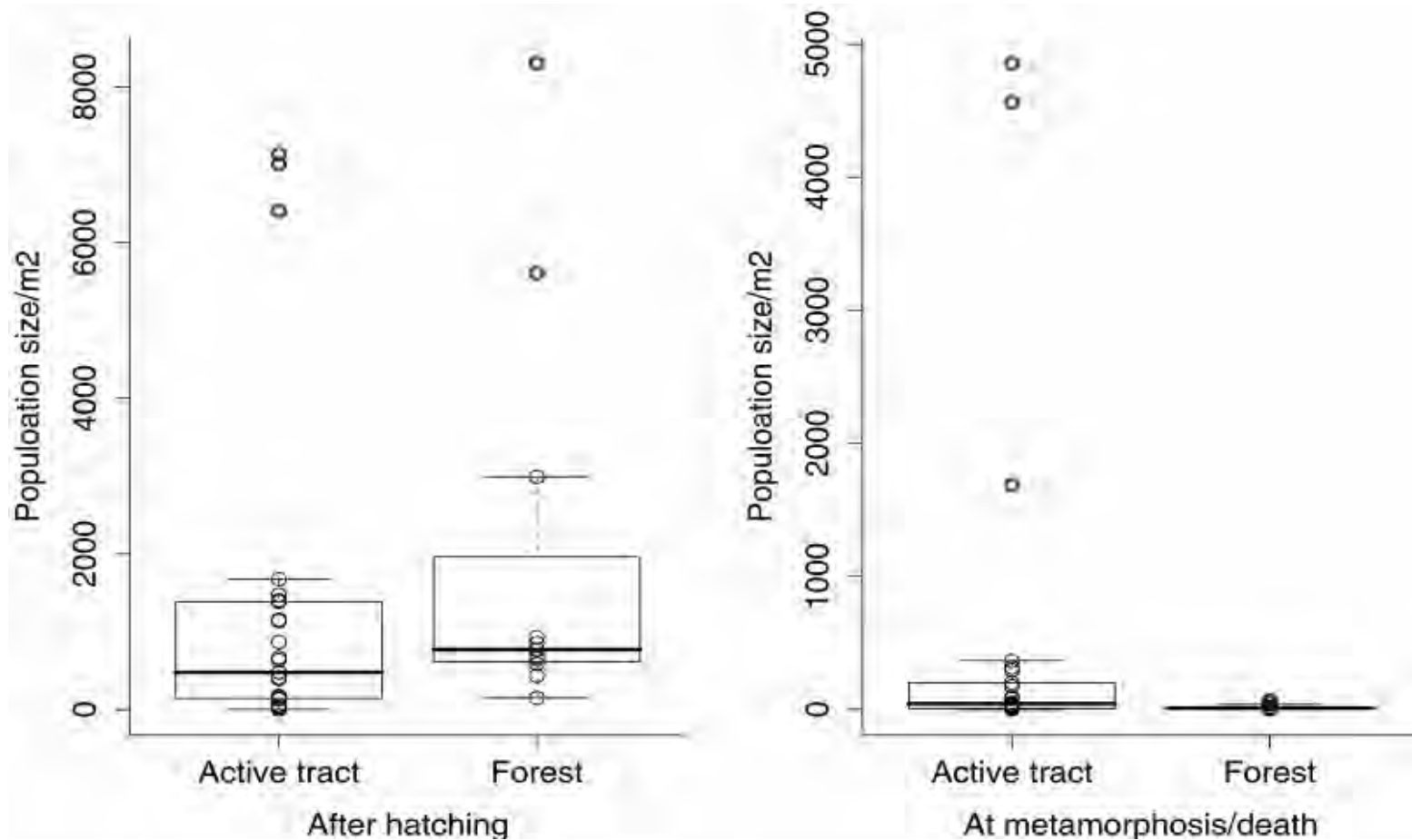


Indermaur, Schmidt, Tockner. 2008. *AmphibiaReptilia*.

Indermaur, Wehrle, Gehring, Naef-Daenzer, Tockner. 2009. *American Naturalist*.

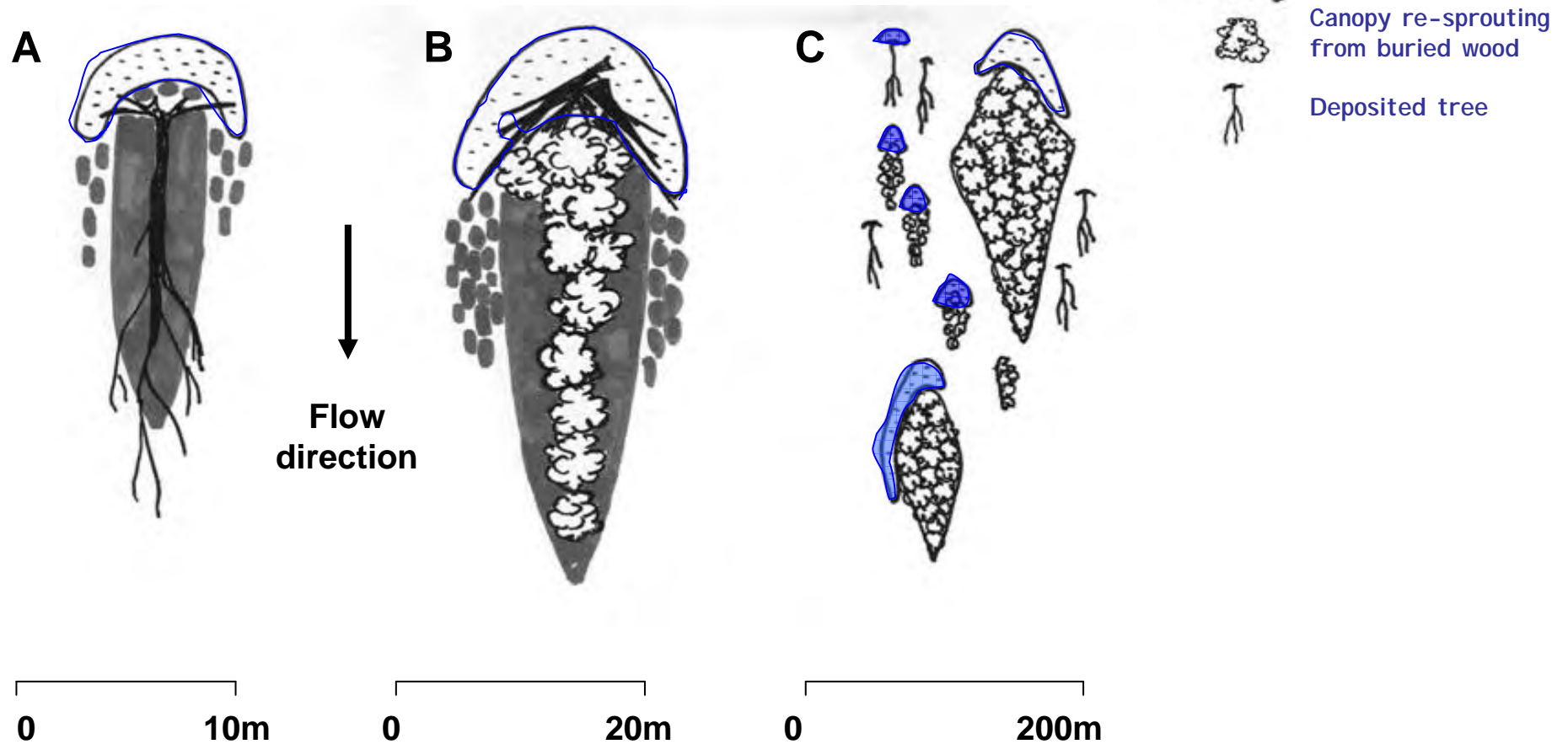
Indermaur, Winzeler, Schmidt, Tockner, Schaub. *Ecology*. Accepted.

B. bufo: Population size after hatching and metamorphosis



(data: L. Indermaur *et al.* submitted)

Vegetated islands as key ecological nodes along river corridors



Pulsed linkages and feedbacks



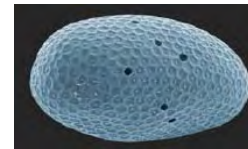
Tisza River: *Palingenia longicauda*



(Photo: C. Elpers)



Larvae



Egg

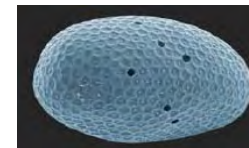
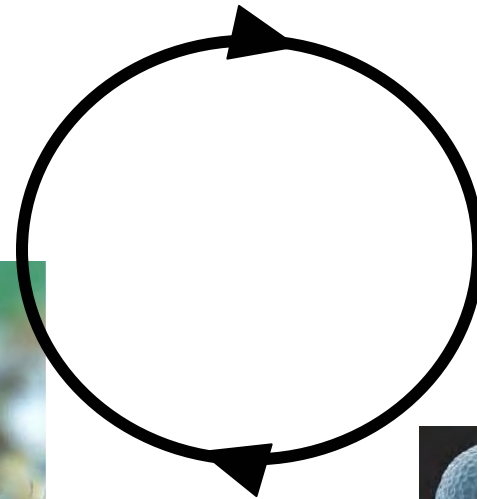
Water

Few days



Land/Air

Several months



Egg

Water

Emergence
Dispersal
Mating
Oviposition



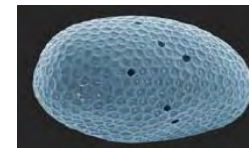
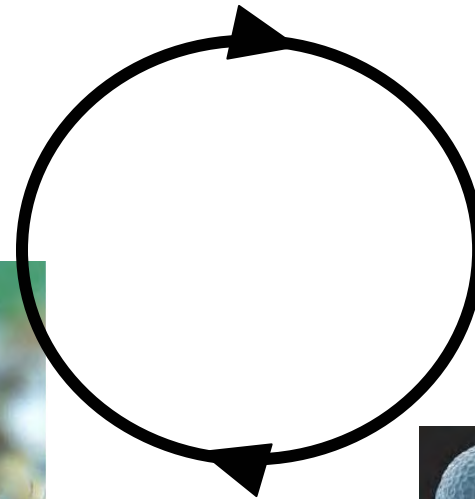
Imago

Land/Air

Growth



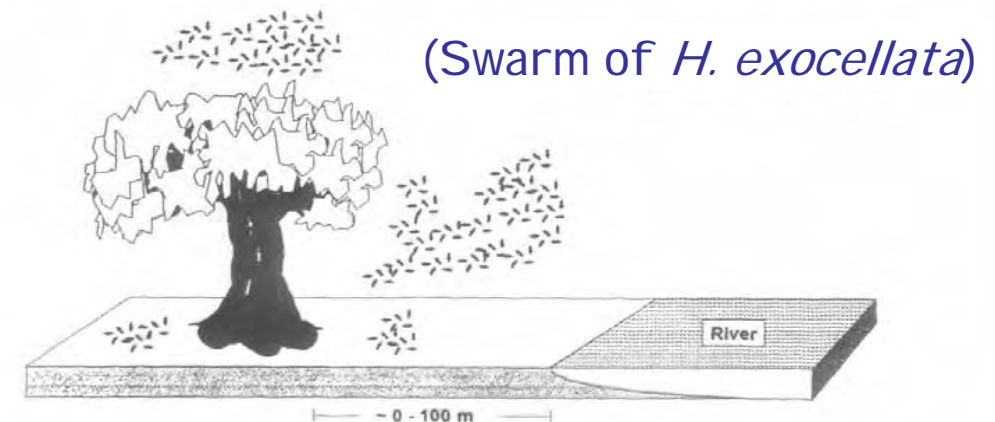
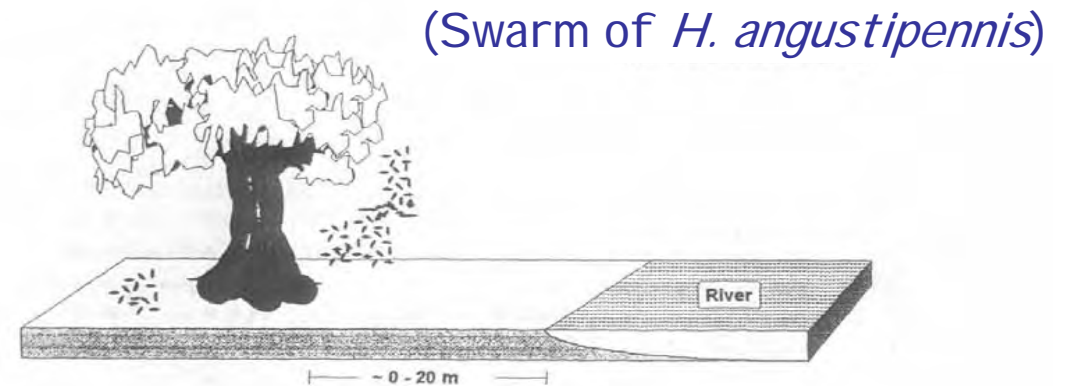
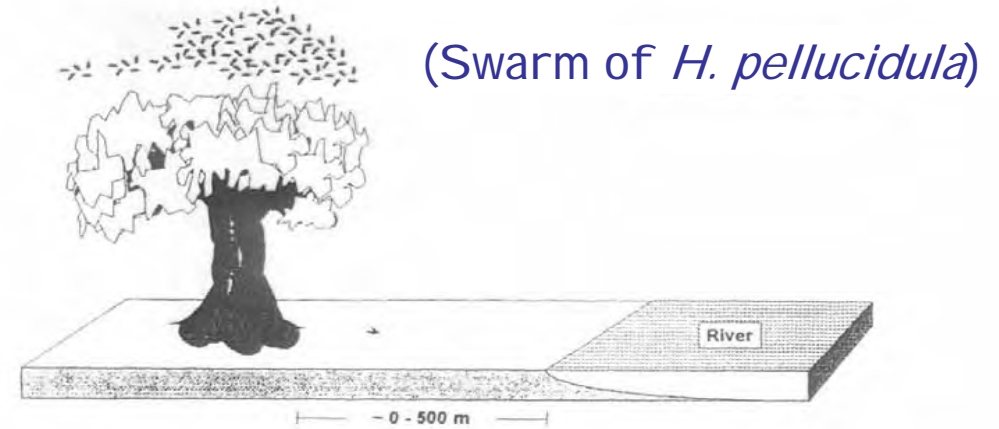
Larvae



Egg

Water

Comparison of the swarming behaviour of three *Hydropsyche* species



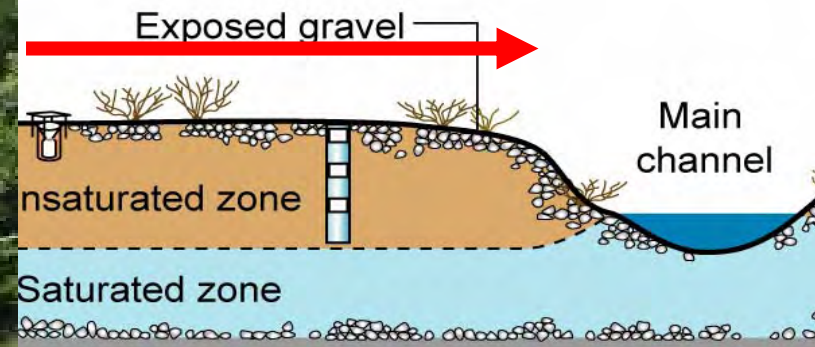
(Engels *et al.* 1996)

Floodplains: Multiple interactive layers



nt

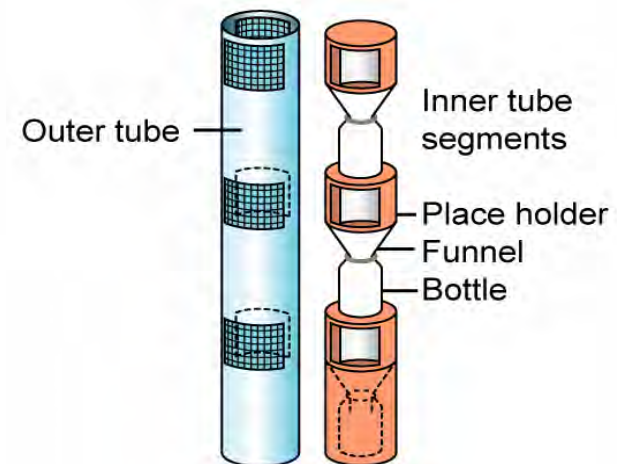
Lateral gradient



nce

Sedimentscape

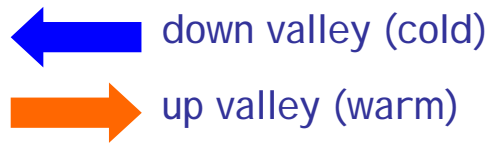
Funnel
Bottle
Outer tube



(after Langhans & Tockner. In prep.)

Conceptual model of the airscape along a river corridor

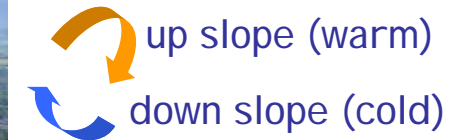
Primary air flow:



unidirectional primary flows can be formed by diurnal meteorological cycles



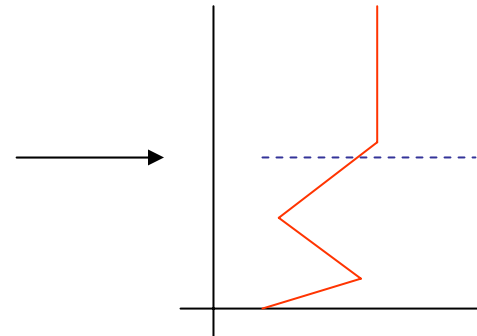
Secondary flow:



secondary flows can develop because of

Micro-structure of air flow:

effects of complex roughness distribution (water, sediments, vegetation)



complex internal boundary layers, wakes, and mixing layers

Summary - questions

Is „age“ diversity (habitats, surface and subsurface waters) a good proxy of coupled hydrogeomorphic-ecological conditions, representing a succession gradient?

How can we effectively link hydrogeomorphic and ecological thresholds, processes and feedbacks?

Are vegetated islands key hydrogeomorphic and ecological nodes along river corridors? (instream riparian zones that increase aquatic and terrestrial habitat complexity)

How do various pulses (e.g. flow, sediment, thermal, resource etc. pulses) interact, and how are these pulses transferred across aquatic-terrestrial boundaries?

Do (should) we ignore some of the most important areas and/or processes along riverine corridors (e.g., ignoring the airscape, role of floating organic matter)?

