Ecological status and dynamics: pressures-impacts relationships

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Why focusing on ecological status?

Legal framework

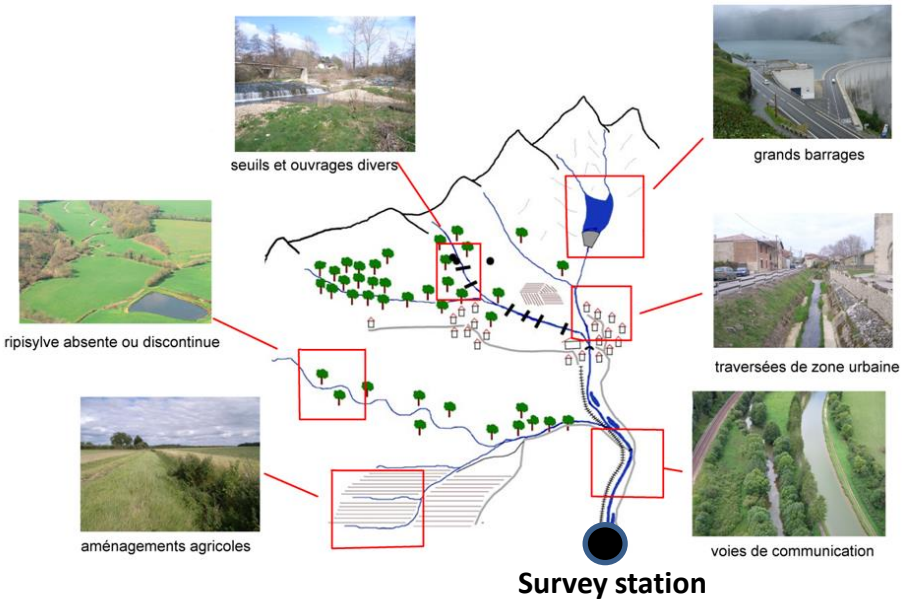
- Water Framework Directive, 2000 – art. 1 (a): a framework which « prevents further deterioration and protects and enhances the status of aquatic ecosystems »
- WFD defines a « good chemical status » (concentration normes) and a « good ecological status » (quality of structure and functioning for aquatic ecosystems)

- Return to good status in 2015 (2022 now)
- Elimination of the toxics

- Thus, a political need for tools assessing these status
  - Measurement scale : 11.500 surface waterbodies
  - 4 biological components: fish, macroinvertebrates, macrophytes, diatoms

Why focusing on ecological status?

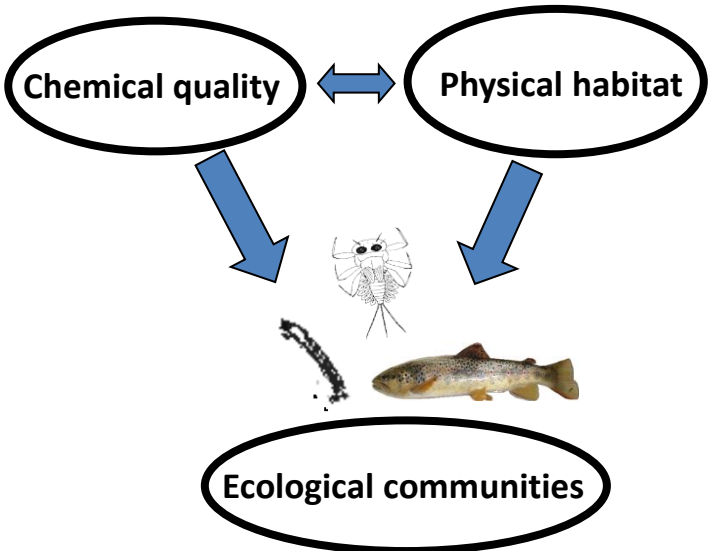
A measure of ecological functioning, under multiple stresses



Basin scale land-use

Ecological structures and processes are hierarchically organised (Frissell, 1986)

Local determinants



Pollution

- Organic
- Nutrients
- Toxics

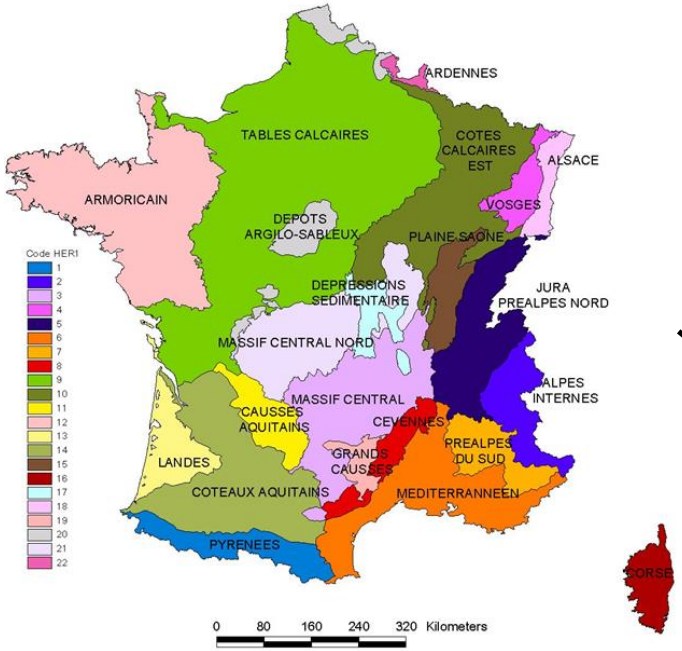
Physical alterations

- Flow regulation
- Chenalization
- Artificialization
- Slow flowings (dams)

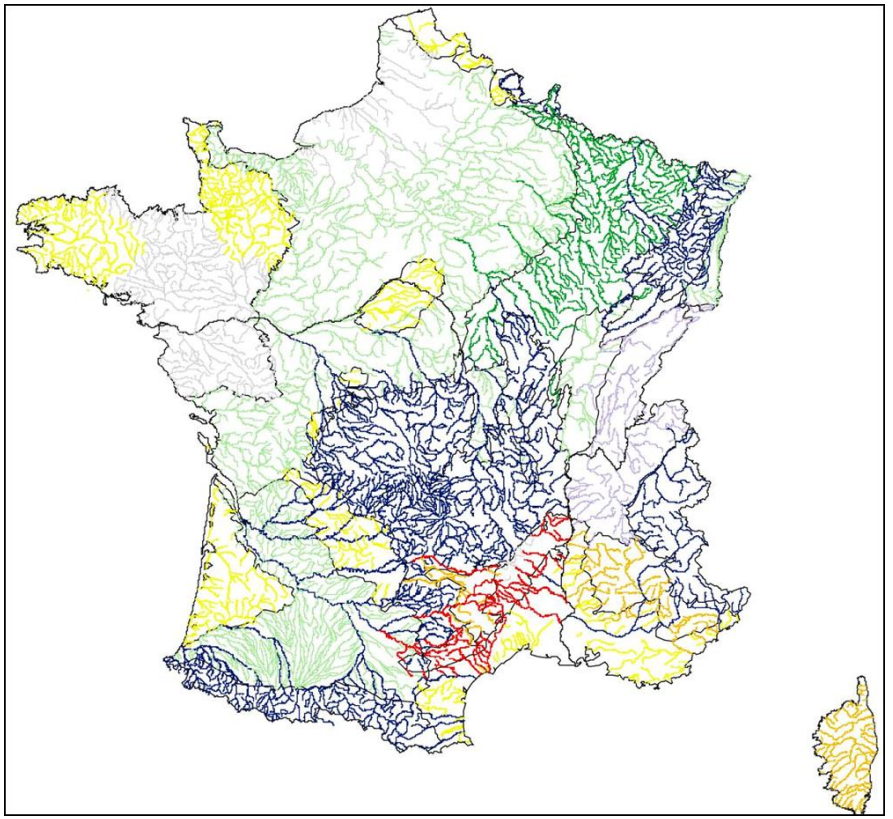
Strategy of France

1/ National typology of functioning

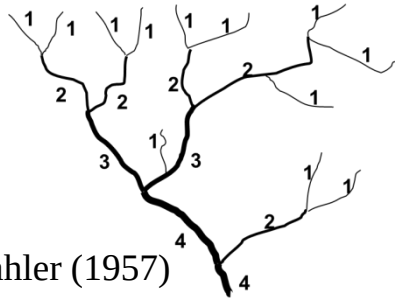
Hydroecoregions



Wasson, et al. (2002)



Strahler ranks



Strahler (1957)

Strategy of France

2/ Definition of a reference

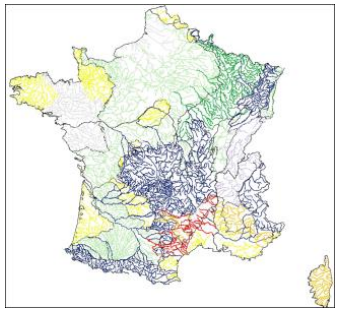
- Selection of :
  - well functioning rivers (natural processes)
  - with their natural biodiversity
  - Low human impacts
    - ✓ Very located
    - ✓ Hardly observed / in the range of natural variability
    - ✓ No human toxics

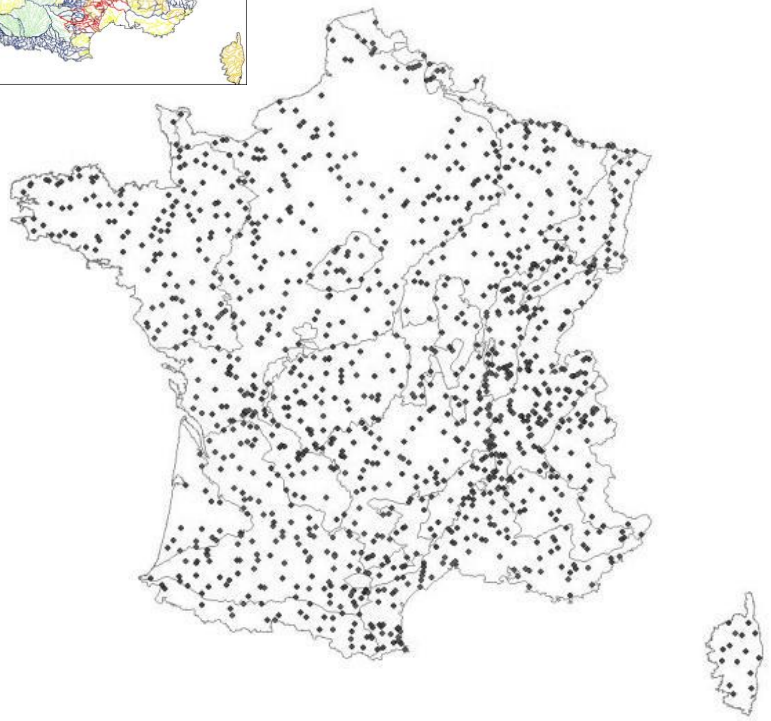
- Used to assess the 4 biological components under unimpacted conditions:
  - Macro invertebrates
  - Diatoms
  - Fish
  - Macrophytes

Strategy of France

3/ A survey network

National typology





1500 stations

Homogeneously distributed among the national types

Ecological components

- macroinvertebrates (1 a year)
- diatoms (1 a year)
- macrophytes (1 every 6 years)
- fish (1 every 2 years)

General Physico-chemicals

- dissolved oxygen
- O_2 saturation rate
- BDO5
- ammonium
- nitrites
- nitrates
- total phosphorous
- orthophosphates
- dissolved organic carbon
- …

- **Toxics**

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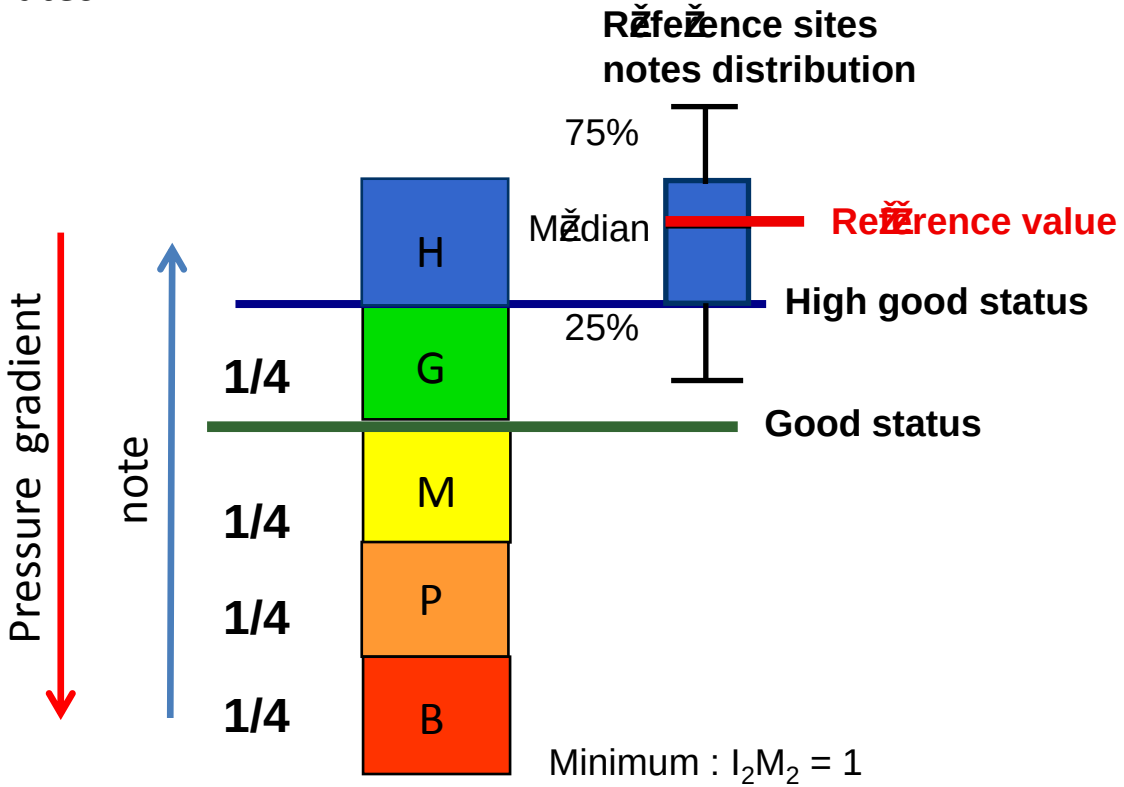
4/ Biotic indices (Example of the macroinvertebrates indice I2M2)

- Measure of the ecological status
  - From a field survey, provide a note that is transcipted to a status class

- Macro-invertebrates
- Fish
- Diatoms
- Macrophytes



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5/ Pressure-Impacts methodologies

They are developed to:

1/ understand how biotic indices respond to anthropogenic disturbances, so that

2/ we can assign a status to each unsurveyed waterbody, and

3/ assess how to achieve WFD goals

Strategy of France

5/ Pressure-Impacts methodologies: explicative goal

- 1/ To understand how biotic indices respond to anthropogenic disturbances

Land-cover pressures, hydromorphological alterations et physico-chimical pressures have been linked with:

- **macrophytes** (Feld 2013),
- **diatoms** (Dahm et al. 2013, Villeneuve 2015),
- **fishes** (Kristensen et al. 2012; Marzin et al. 2012; Feld 2013; Marzin et al. 2013; Dahm et al. 2013, Villeneuve 2015),
- **macro-invertebrates** (Sponseller et al. 2001; Donohue et al. 2006; Wasson et al. 2010; Marzin et al. 2012; Feld 2013; Sundermann et al. 2013; Dahm et al. 2013, Villeneuve 2015),

These studies show that:

- **each kind of pressure has a significant effect on each biological index**
- **links between pressures and biological indices could be scale dependant** (watershed, reach and riparian buffer have a strong structuring effect on ecological functionning)

Strategy of France

5/ Pressure-Impacts methodologies: explicative goal

- 1/ To understand how biotic indices respond to anthropogenic disturbances

1500 sites

Macro-Invertebrates Muti-metric Index (I_2M_2)

Mondy et al.,2012.

Average of 2008-2009 values

PLS Regression

Basin scale

Reach scale

Site scale

Land Cover and Hydromorphology

- Land cover (watershed percentage)
- Alteration risk of solid flows
- Alteration risk of liquid flows

Hydromorphological alterations

- Alteration risk at floodplain level (roads, forest corridors, dykes, urban zones)
- Alteration risk at riverbed level (roads, forest corridors, dykes, urban zones)
- Alteration risk of structure and functioning (dams, ponds, straightening, width anomalies)

Physico-chemical parameters

- dissolved oxygen
- BOD
- Ammonium
- Nitrite
- Nitrate
- Total Phosphorus
- Suspended matter

Average of 2008-2009 values

Villeneuve et al, 2015. Ecological indicators

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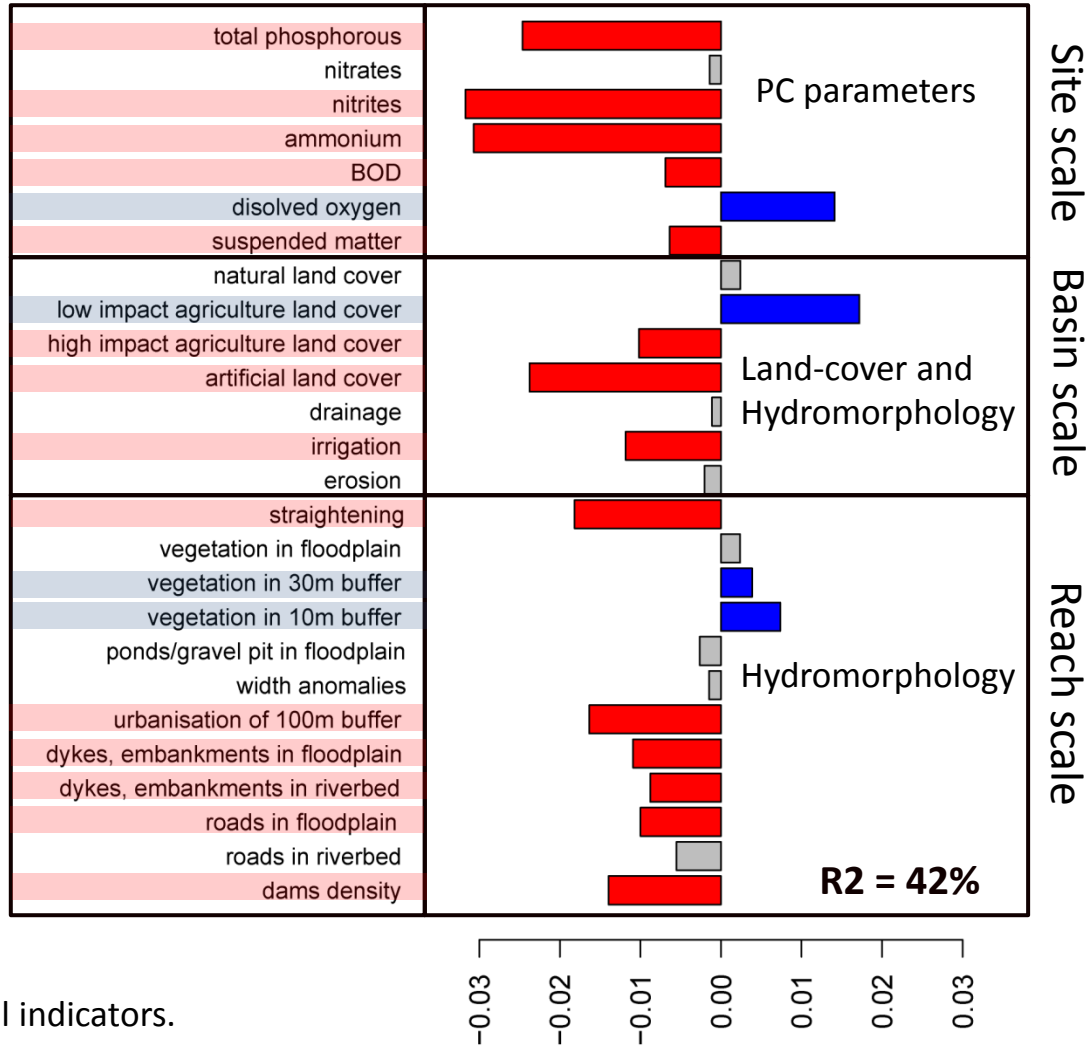
5/ Pressure-Impacts methodologies: explicative goal

- 1/ To understand how biotic indices respond to anthropogenic disturbances

1. Allows to assess the variance of biological indices explained by pressures

2. Allows to assess the relative effect of each predictive variable on biological index



Villeneuve et al, 2015. Ecological indicators.

Strategy of France

5/ Pressure-Impacts methodologies: explicative goal

- 1/ To understand how biotic indices respond to anthropogenic disturbances :Introducing scale hierarchy in pressure-impacts methods

1500 sites

Macro-Invertebrates Muti-metric Index (I_2M_2)

Mondy et al.,2012.

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PLS Regression

Basin scale

Reach scale

Site scale

How are scales linked?

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Villeneuve et al, 2015. Ecological indicators

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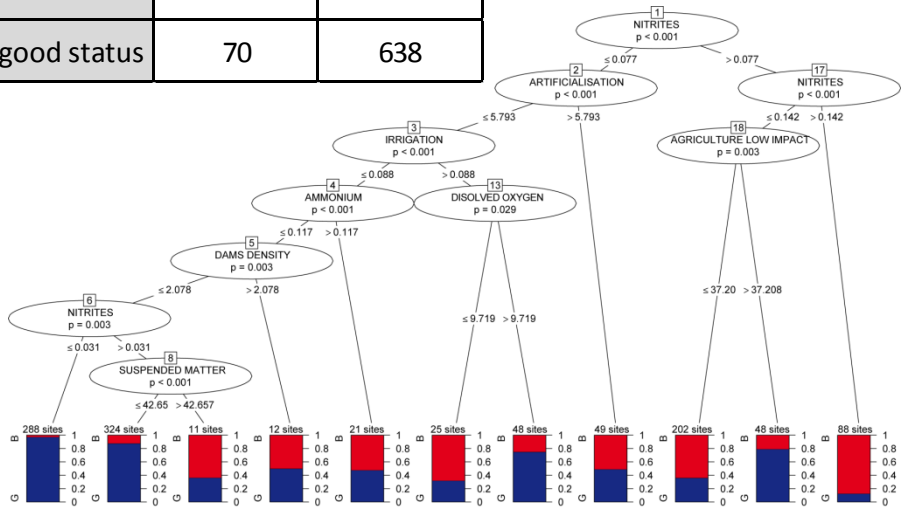
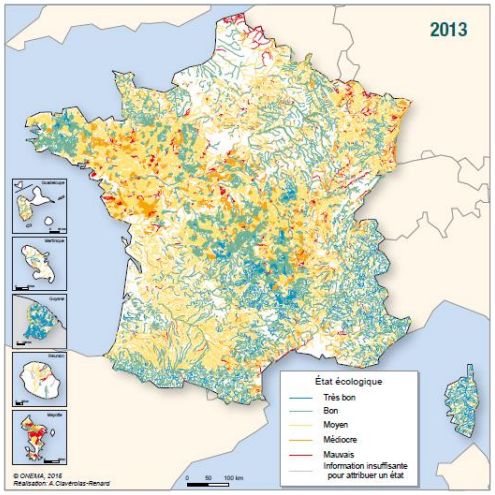
5/ Pressure-Impacts methodologies: predictive goal

- 2/ To help assigning a status to each unsurveyed waterbody

		observed	
		bad status	good status
predicted	bad status	272	136
	good status	70	638





Les Synthèses EauFrance, n°12, Onema

AUC = 0.86 → good predictive efficiency
misclassification rate = 0.19
Sensibility = 0.79 → good capacity to predict bad status
Specificity = 0.82 →good capacity to predict good status

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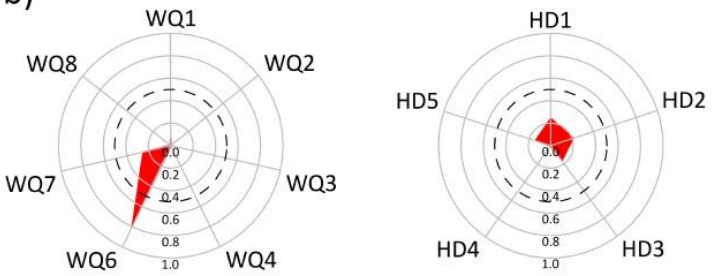
5/ Pressure-Impacts methodologies: WFD goal

- 3/ To assess how to achieve the WFD goals

a)

b)



c)

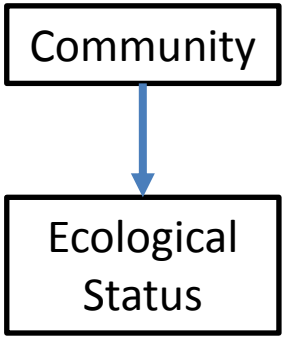
Water Quality pressures	*Habitat Degradation pressures*
WQ1 – Organic matter	*HD1* – Transportation facilities
WQ2 – Nitrogen compounds	*HD2* – Riverine vegetation
WQ3 – Nitrates	*HD3* – Urbanization
WQ4 – Phosphorous compounds	*HD4* – Clogging risk
WQ5 - Suspended matter	*HD5* – Hydrological instability
WQ6 – Acidification	*HD6* – Straightening
WQ7 – Mineral micro-pollutants	
WQ8 – Pesticides	
WQ9 – PAH	
WQ10 – Organic micro-pollutants	

Mondy & Usseglio (2013). Using conditionnal tree frorest and life history traits to assess specific risk of stream degradation under multiple pressure scenario, STOTEN, 461-462, p750-760

Current work

But environment is changing…

- Introducing climate change scenarios



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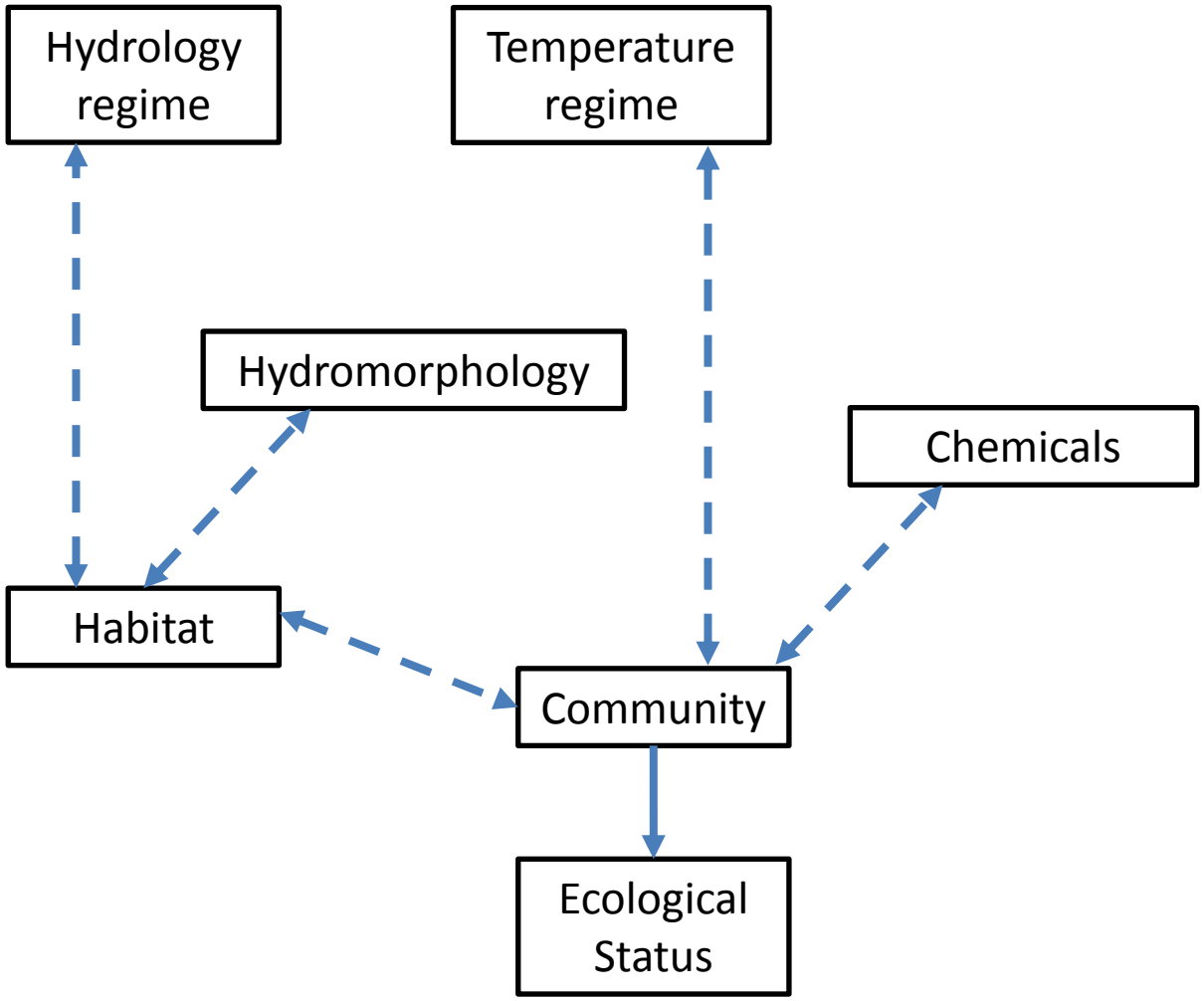

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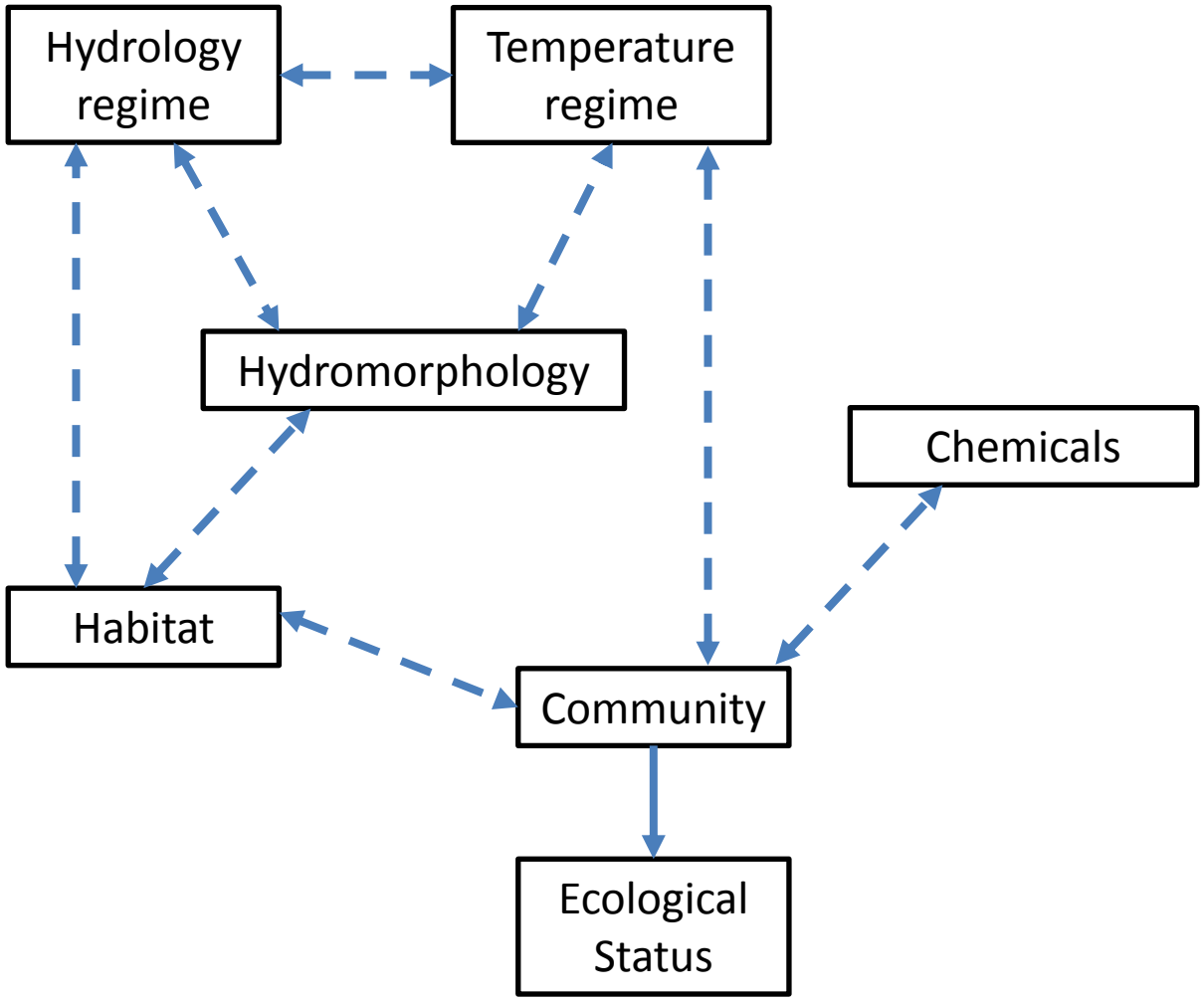

Current work

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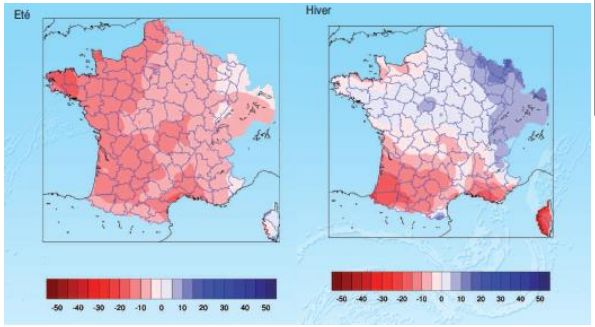
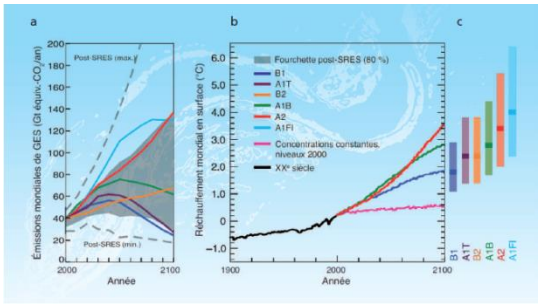
summer **winter**



Precipitations tendancies



Greenhouse gas

Surf. Temperature

Hydrology regime

Temperature regime

Hydromorphology

Chemicals

Habitat

Community

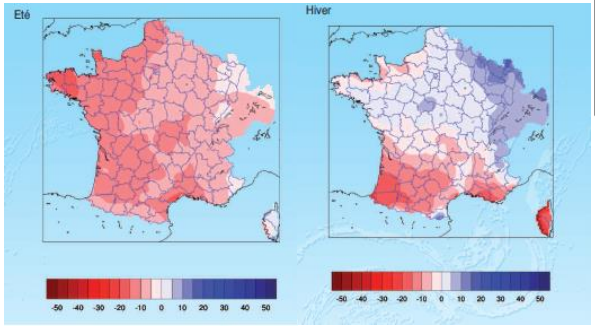
Ecological Status

Current work

But environment is changing…

- Introducing climate change scenarios

summer **winter**



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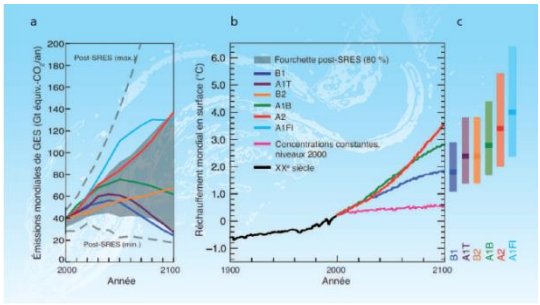
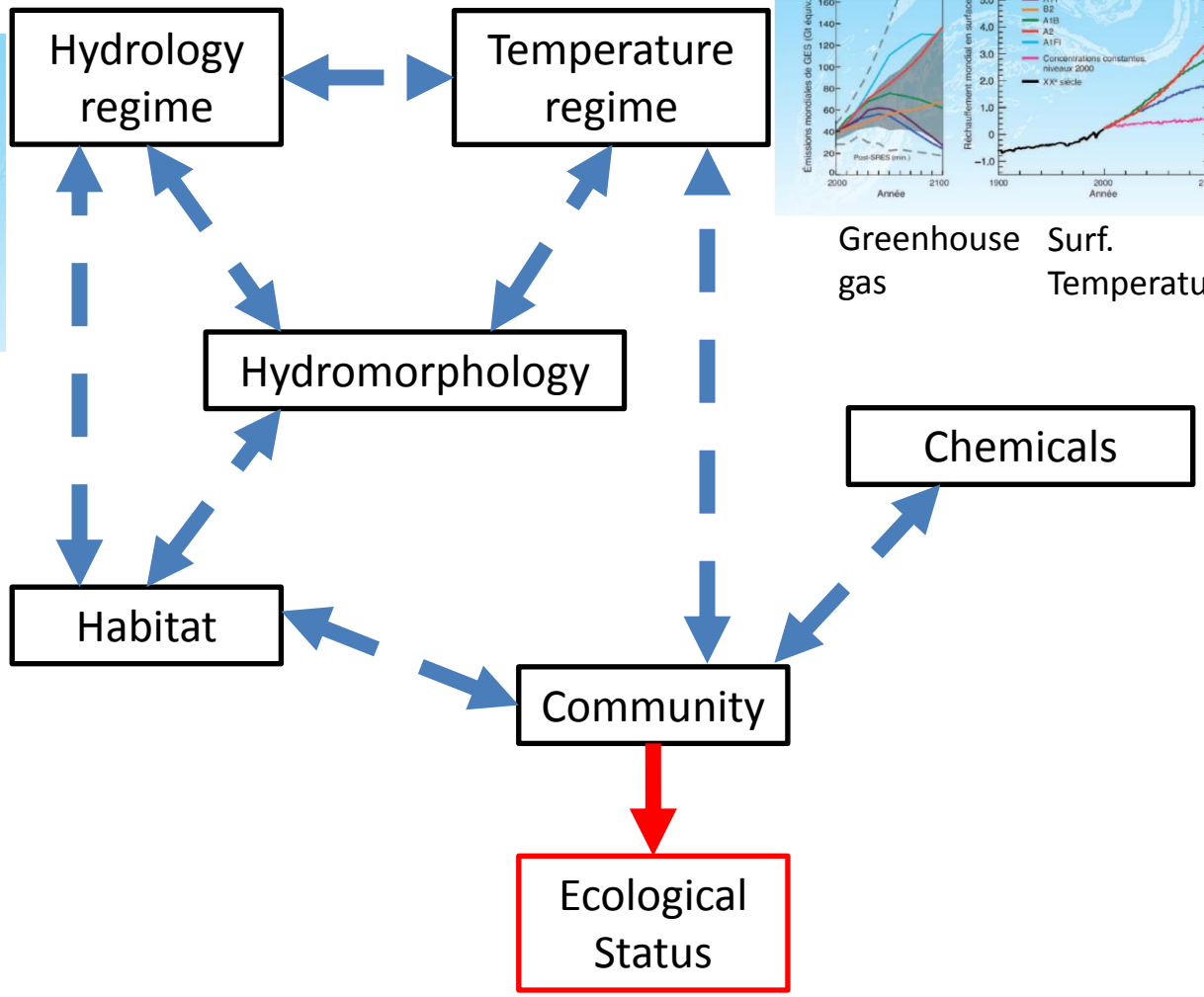


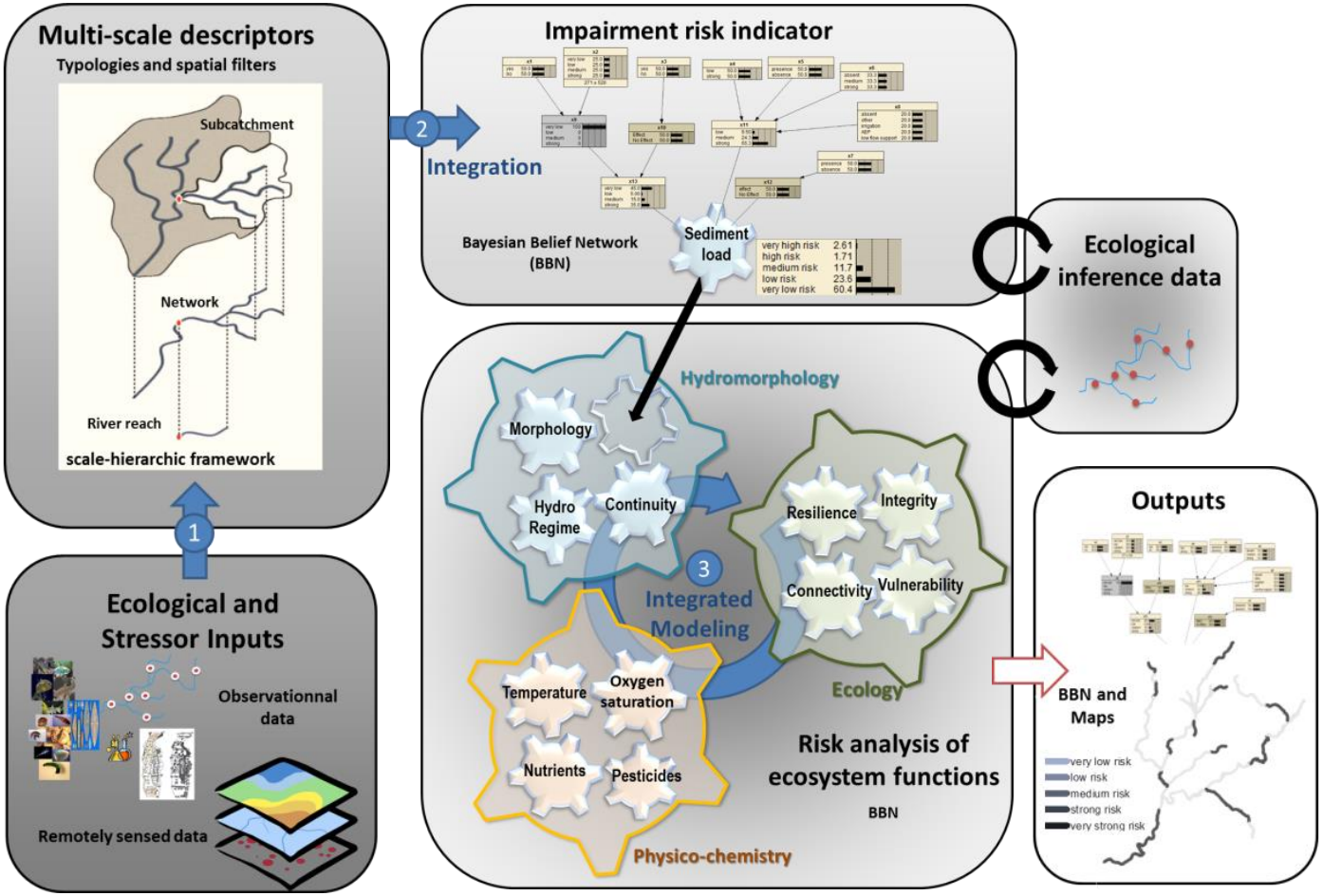
Greenhouse gas

Surf. Temperature



Current work

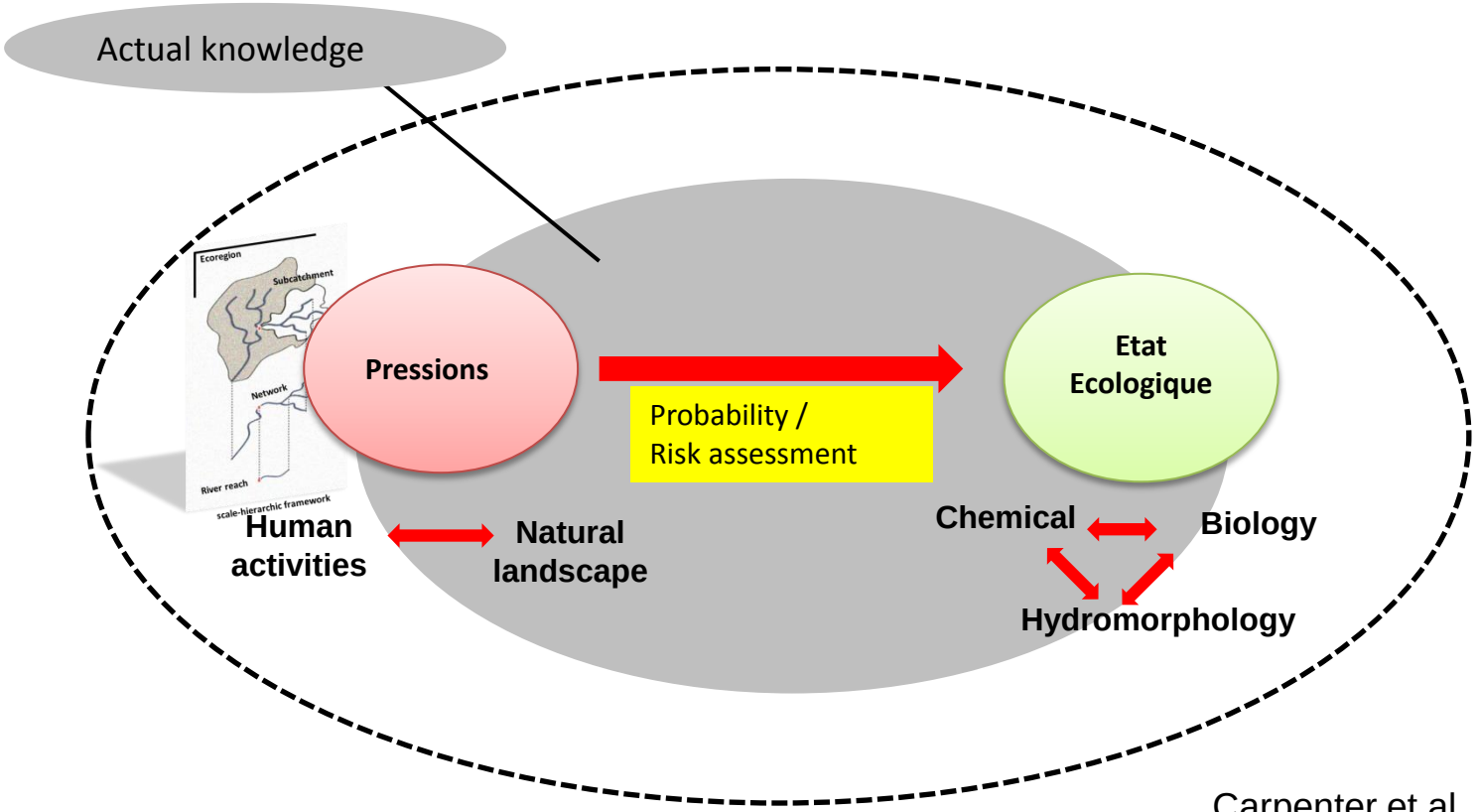
Towards an integrated modeling of river ecological functioning



Van Looy, et al. (2015). Unravelling river system impairments in stream networks with an integrated risk approach. Environmental Management, 55(6):1343-1353

Conclusion

- To guaranty rivers a sufficient freedom of functioning
  - Adaptation / Resilience
- Knowledge is still under development
- Methods to help managers deciding in an uncertain context
  - Risk methodologies



Carpenter et al., 2006

Thanks for you attention!

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