Insights into the demand side of the socio-ecological system from a pressure-oriented, freshwater view – *experiences from the FP7 MARS project*

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This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 603378.

MARS PROJECT

Managing Aquatic ecosystems and water Resources under multiple Stress

Multiple stressors, ecological status and ecosystem services

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How is this all related?

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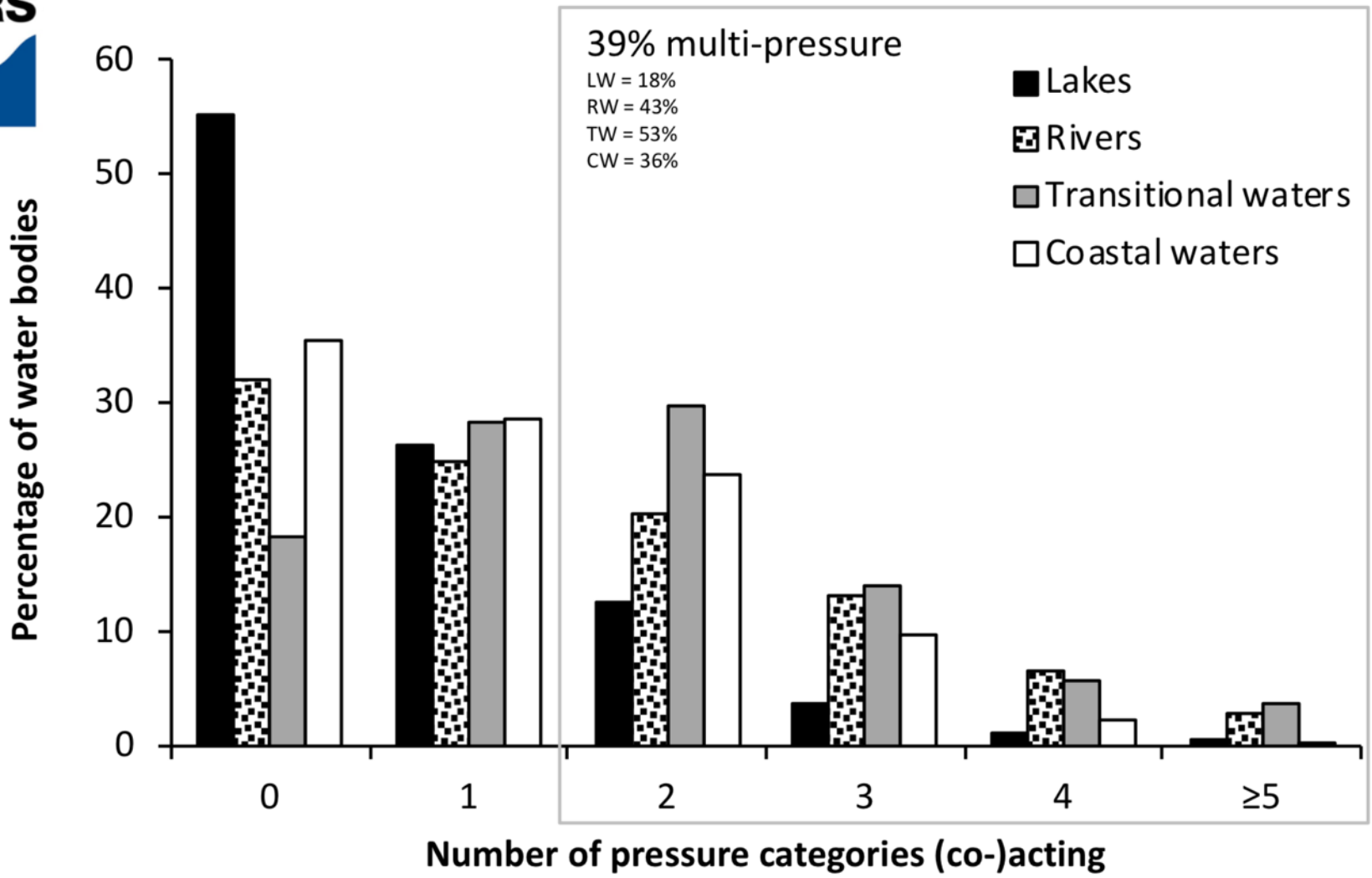
Content

- Multiple stressors acting on European surface waters
- Relationships between ecological status and ecosystem services (ESS)

Multiple stressors acting on European surface waters

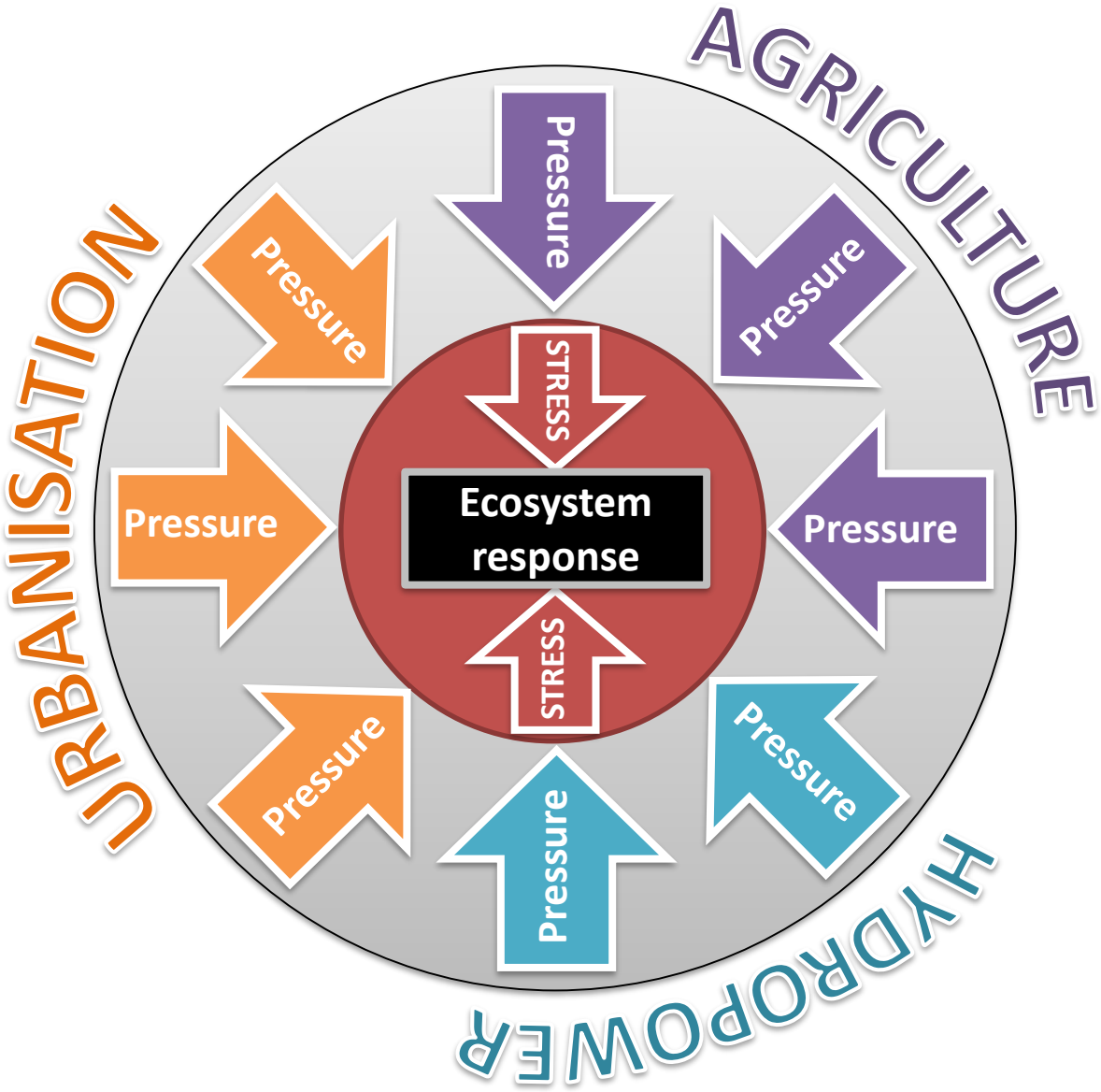
MARS PROJECT



Percentage of water bodies at lakes, rivers, transitional and coastal waters affected by no, one or several significant pressures

Data reported for 103,130 water bodies by 25 EU member states (excl. IE, GR, LT) within the 2nd WFD RBM cycle 2009-2015. Pressure categories cover *point source pollution*, *diffuse pollution**, *water abstraction*, *physical alteration*, *hydrological alteration*, *continuity disruption* and *other pressures* (including *introduced species and diseases* = 1.6%; *exploitation or removal of animals or plants* = 0.6%; *groundwater recharges or alteration* = 0.2%; *litter or fly tipping* < 0.1%). [*excluding atmospheric deposition]

From pressures to stressors



Ecosystem response

Drivers

Pressures

Examples:

Point sources, Diffuse sources

Stressors

directly affecting habitats and biota

Examples:

- *Oxygen depletion*
- *Nutrient enrichment*
- *Siltation*

Effects of multiple stressors in Europe

Multiple stressors

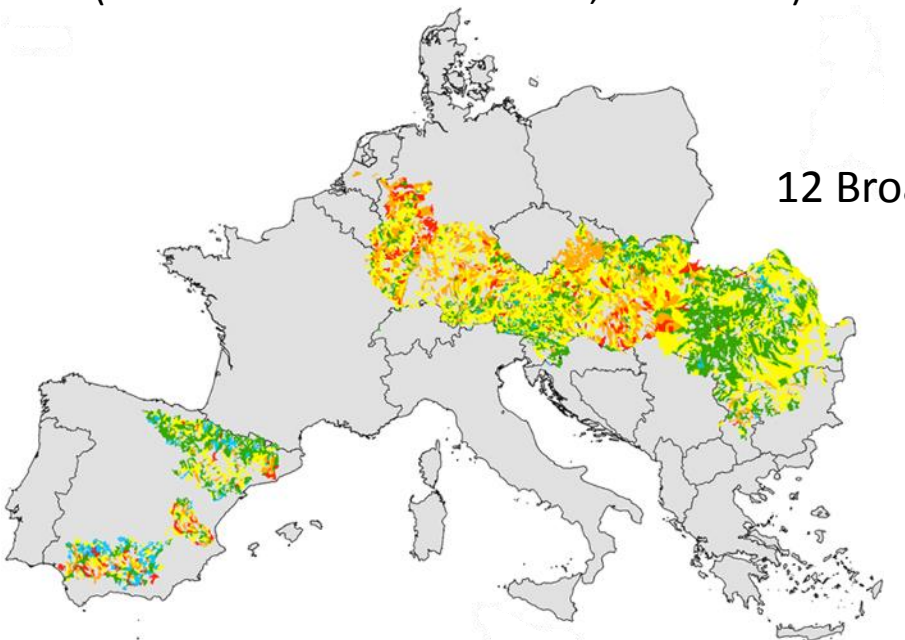
MORPH	HYDRO	NUTR	TOX
Rip. land use	*Mean and base flow*	*Total N and P*	*msPAF*

MODELLING

Empirical modelling:
Boosted Regression Trees
analysis

Ecological status

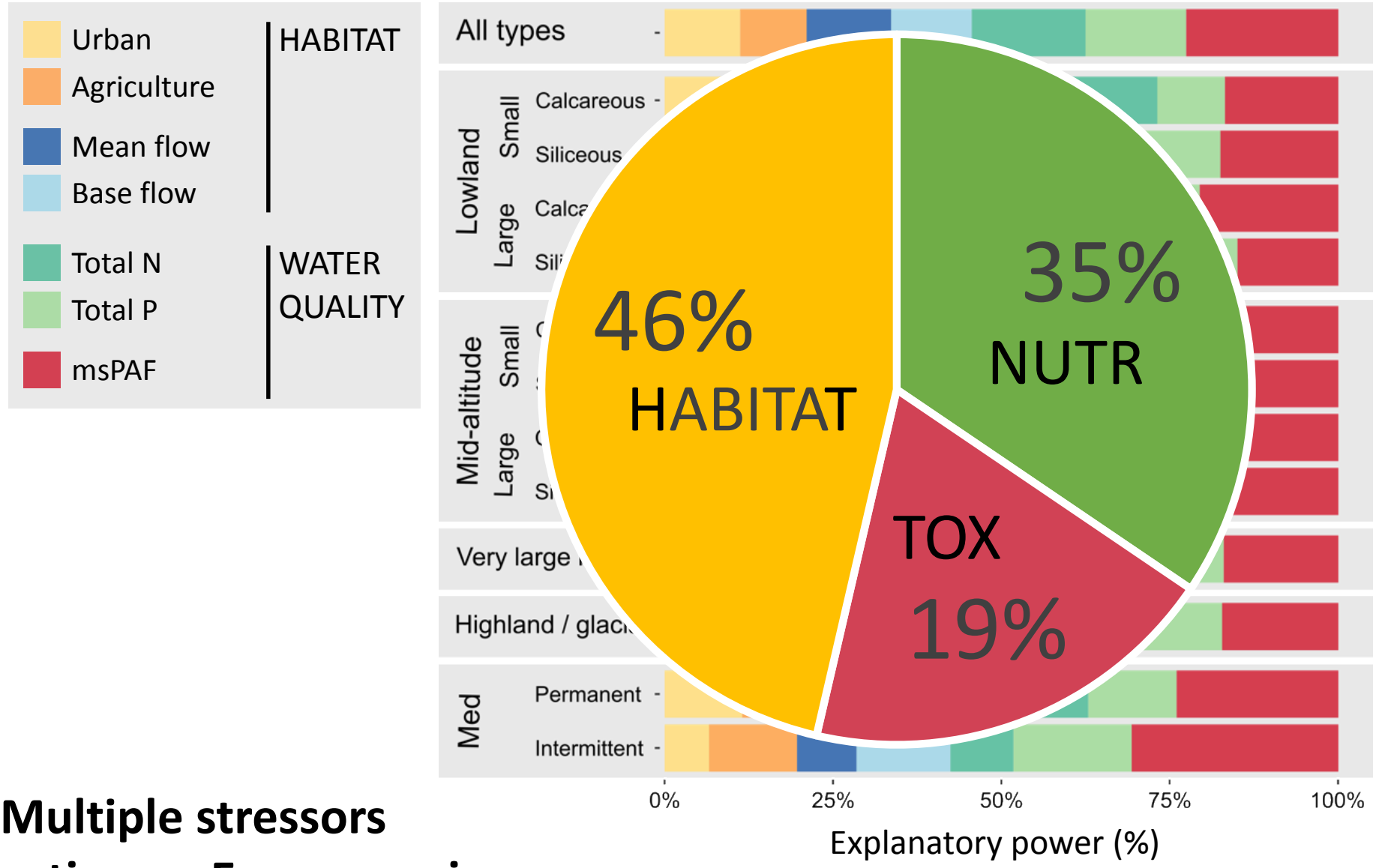
(SOLUTIONS sub-catchments, n > 12.000)



12 Broad River Types

Lemm et al., in prep.

Effects of multiple stressors in Europe



Multiple stressors acting on European rivers

Lemm et al., in prep.

Multiple stressors: *management implications*

What is the (combined) effect of stressors?

Dominance (1 + 0 = 1) or Additive (1 + 1 = 2)

Interactions → *"Ecological surprises"*

Synergistic (1 + 1 = 3) *(e.g. Nutrients & Temperature)*

→ Requires, for instance, more protective nutrient standards.

Antagonistic (1 + 1 = 1) *(e.g. Nutrients & Hydropeaking)*

→ Requires combined stressor mitigation to avoid worsening.

Paired-stressor effects

Ecosystem response

$$f(x) = a \cdot x_1 + b \cdot x_2 + c \cdot x_1 \cdot x_2$$

Stressor 1

Stressor 2

Interaction-term

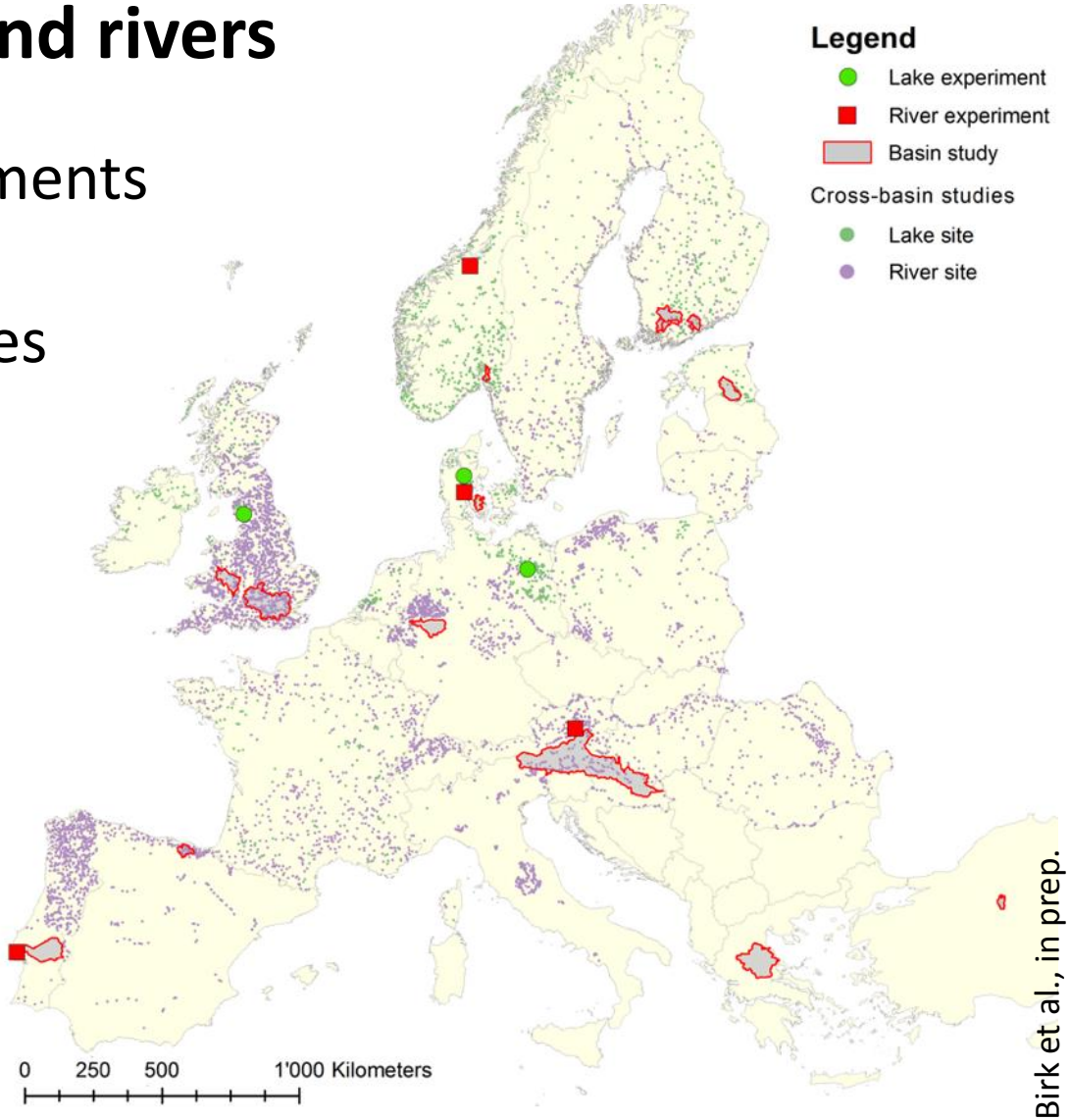
Birk et al., in prep.

Paired-stressor effects: *data basis*

European lakes and rivers

9 mesocosm experiments
13 basin studies
22 cross-basin studies

→ 18.000 samples



Birk et al., in prep.

Paired-stressor effects: *data basis*

Ecosystem response

Plants

Animals

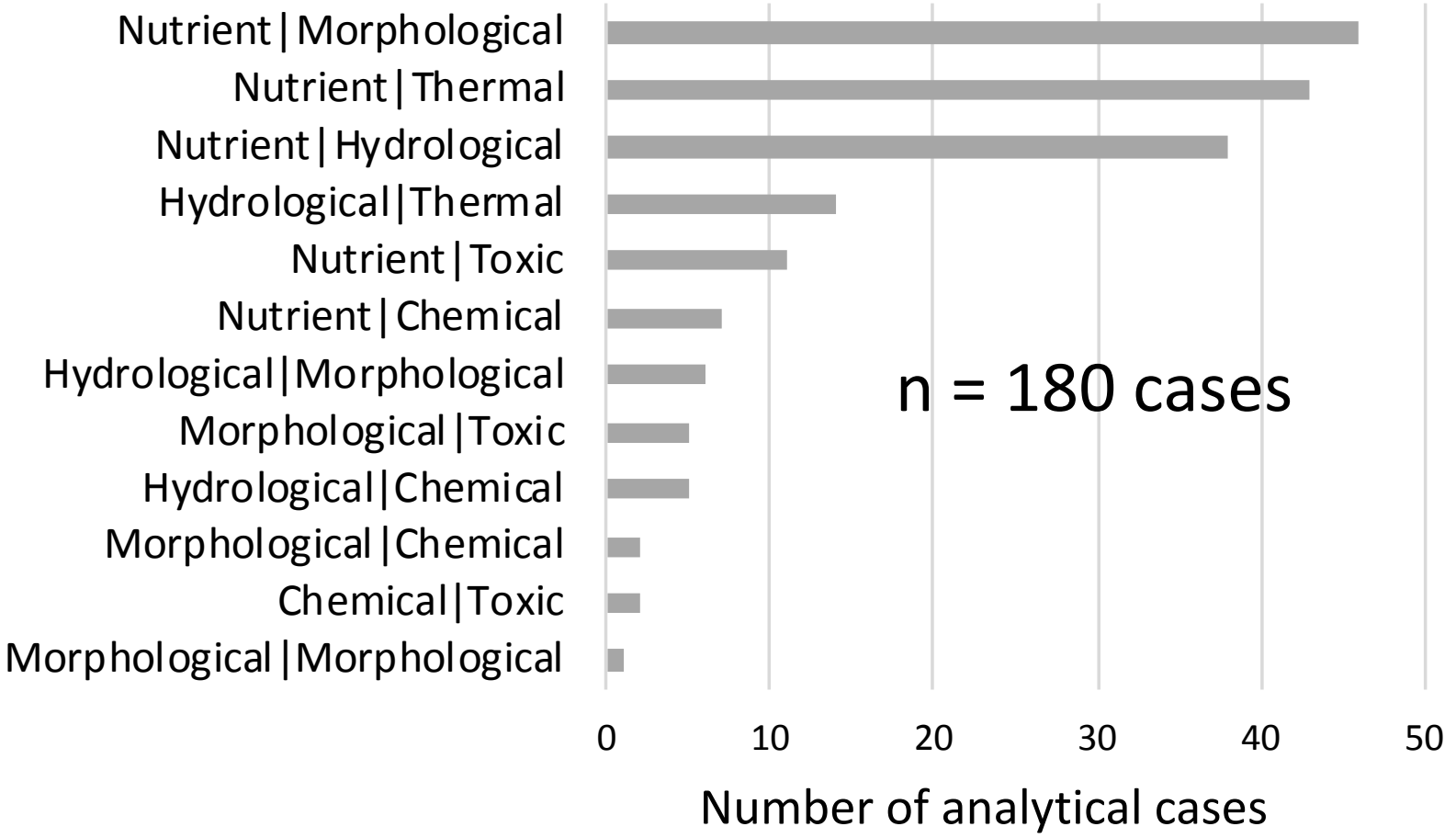
freshwaterecology.info

Bioassessment metrics
(Biodiversity, Functional traits, Functions)

Birk et al., in prep.

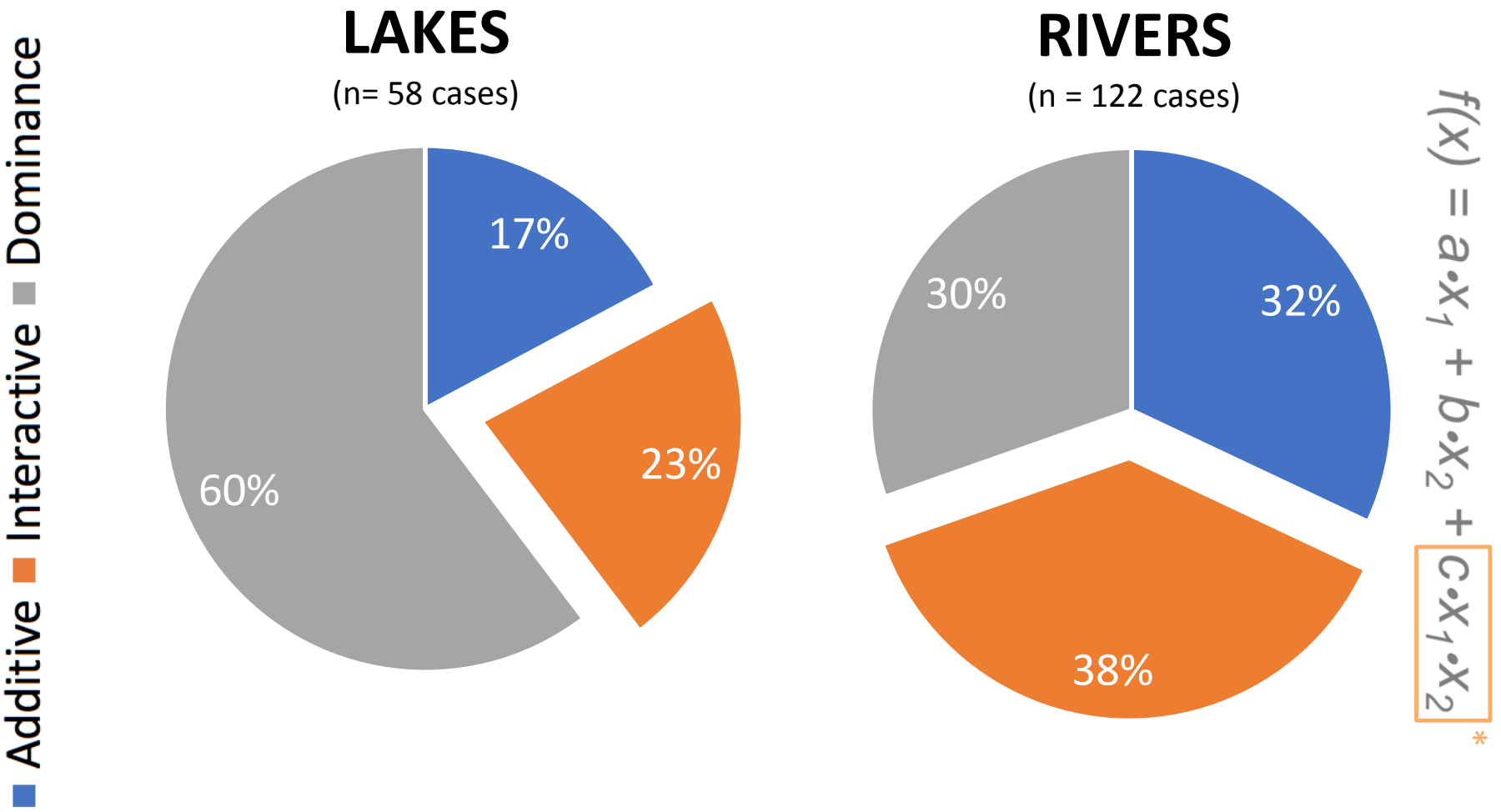
Paired-stressor effects: *data basis*

Stressor pairs



Birk et al., in prep.

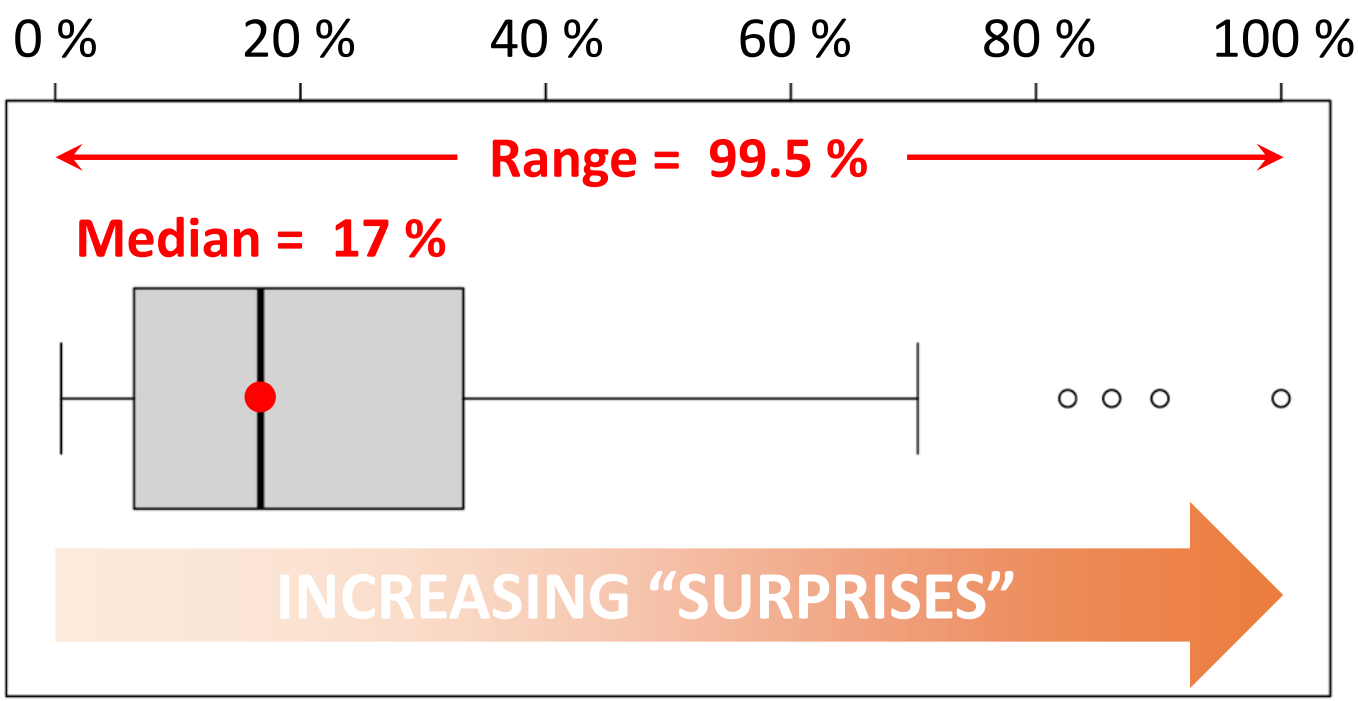
Paired-stressor effects: *interactions*



Share of interactions across lakes and rivers

Birk et al., in prep.

Paired-stressor effects: *interactions*



$$f(x) = a \cdot x_1 + b \cdot x_2 + \boxed{c \cdot x_1 \cdot x_2}^{*}$$

Interaction strength

Change in models' explanatory power due to interaction effects (n = 59 cases)

Birk et al., in prep.

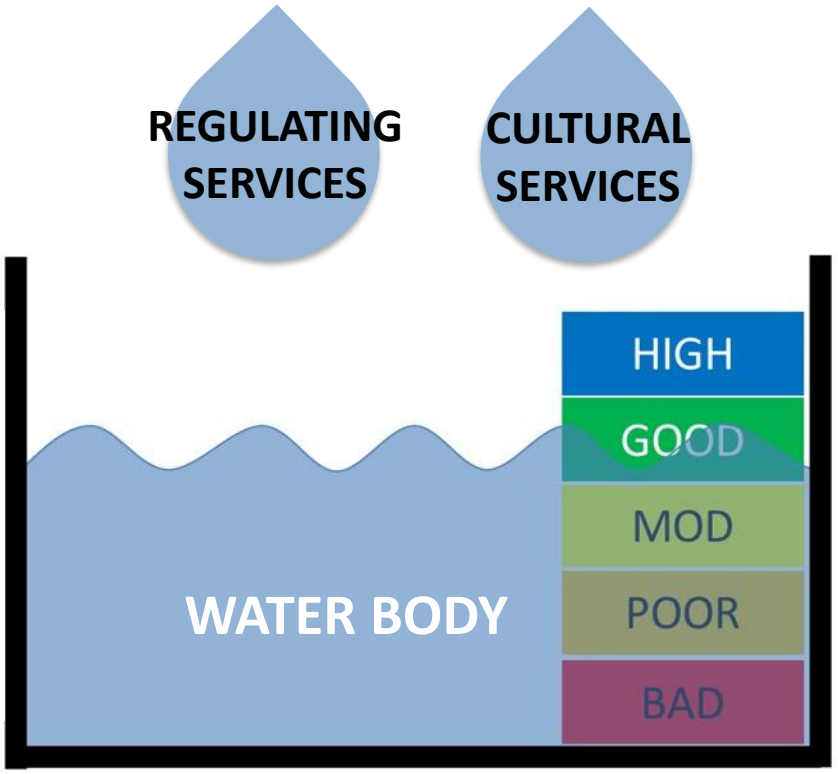
Multiple stressors: *summary*

Multiple stressors are acting on European surface waters, with highly case-specific ecological impacts.

Effective water management is challenged by interaction effects which can evoke “ecological surprises”.

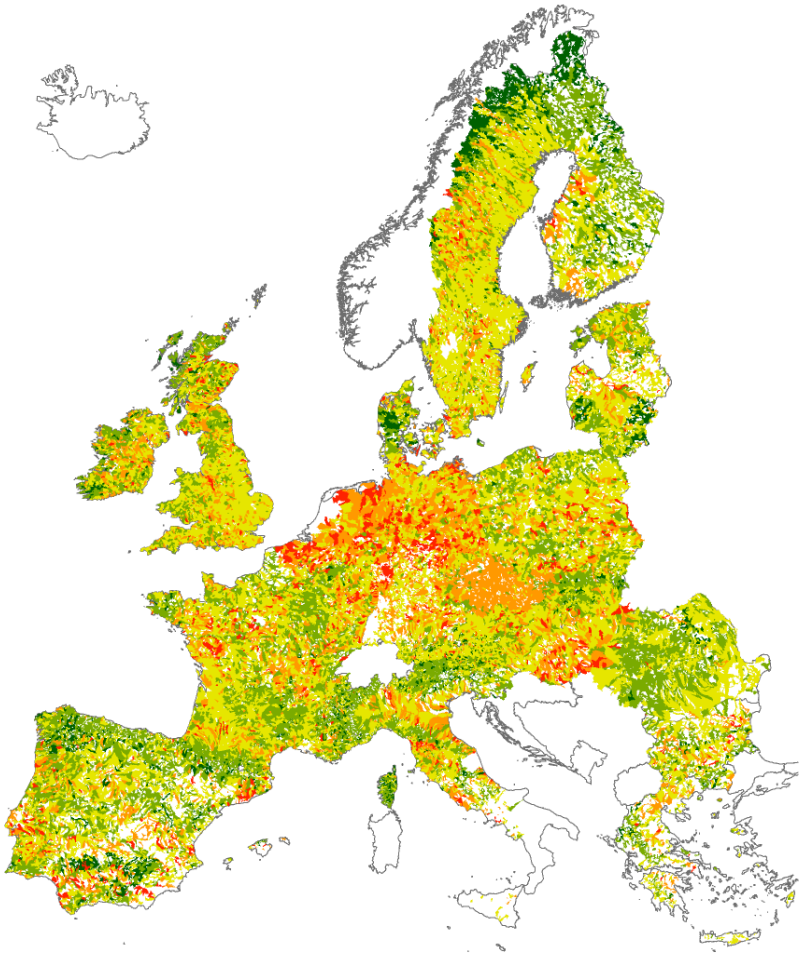
Relationships between ecological status and ecosystem services (ESS)

Ecological status ~ ESS: *general assumption*



'Tapping' and 'replenishing' types of ecosystem services

Ecological status ~ ESS: *empirical proof*



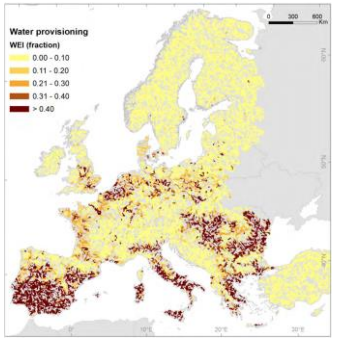
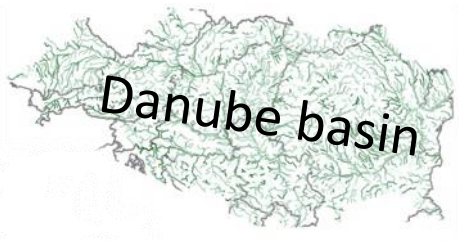
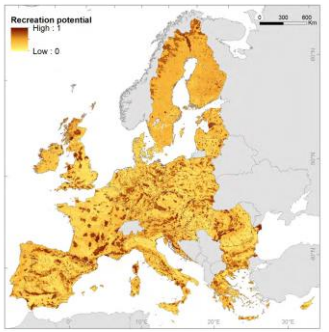
HIGH
GOOD
MOD
POOR
BAD

Ecological status

River Basin Management Planning
of the European Water Framework Directive

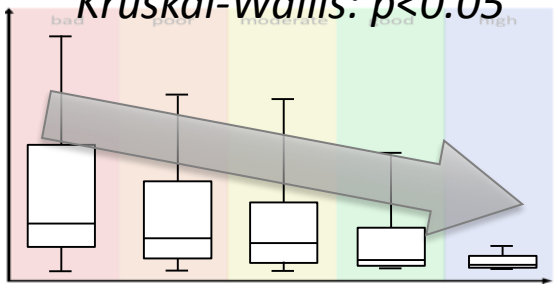
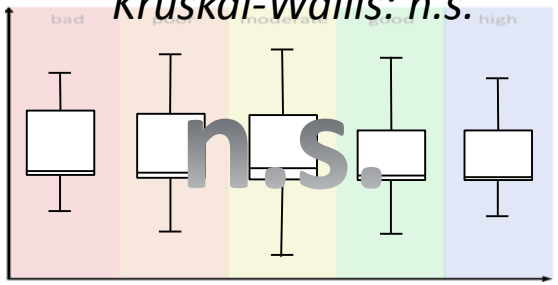
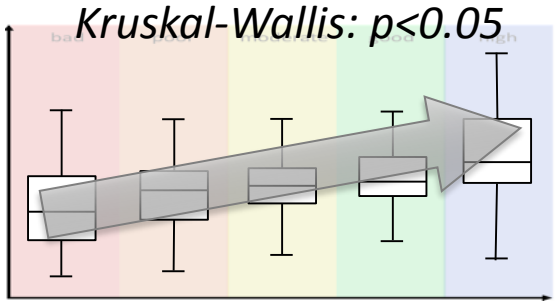
Grizzetti et al., 2017

Ecological status ~ ESS: *empirical proof*

ESS category	Indicator	Spatial data
Water provisioning	*Water Exploitation Index (-)*	
Regulating services: *Erosion prevention*	*Sediment Removal Efficiency (+)*	
Cultural services: *Recreation*	*Recreation Potential Index (+)*	

Grizzetti et al., 2017

Ecological status ~ ESS: *empirical proof*

ESS category	Indicator	Ecological status
Water provisioning	*Water Exploitation Index (-)*	*Kruskal-Wallis: p<0.05* 
Regulating services: *Erosion prevention*	*Sediment Removal Efficiency (+)*	*Kruskal-Wallis: n.s.* 
Cultural services: *Recreation*	*Recreation Potential Index (+)*	*Kruskal-Wallis: p<0.05* 

Grizzetti et al., 2017

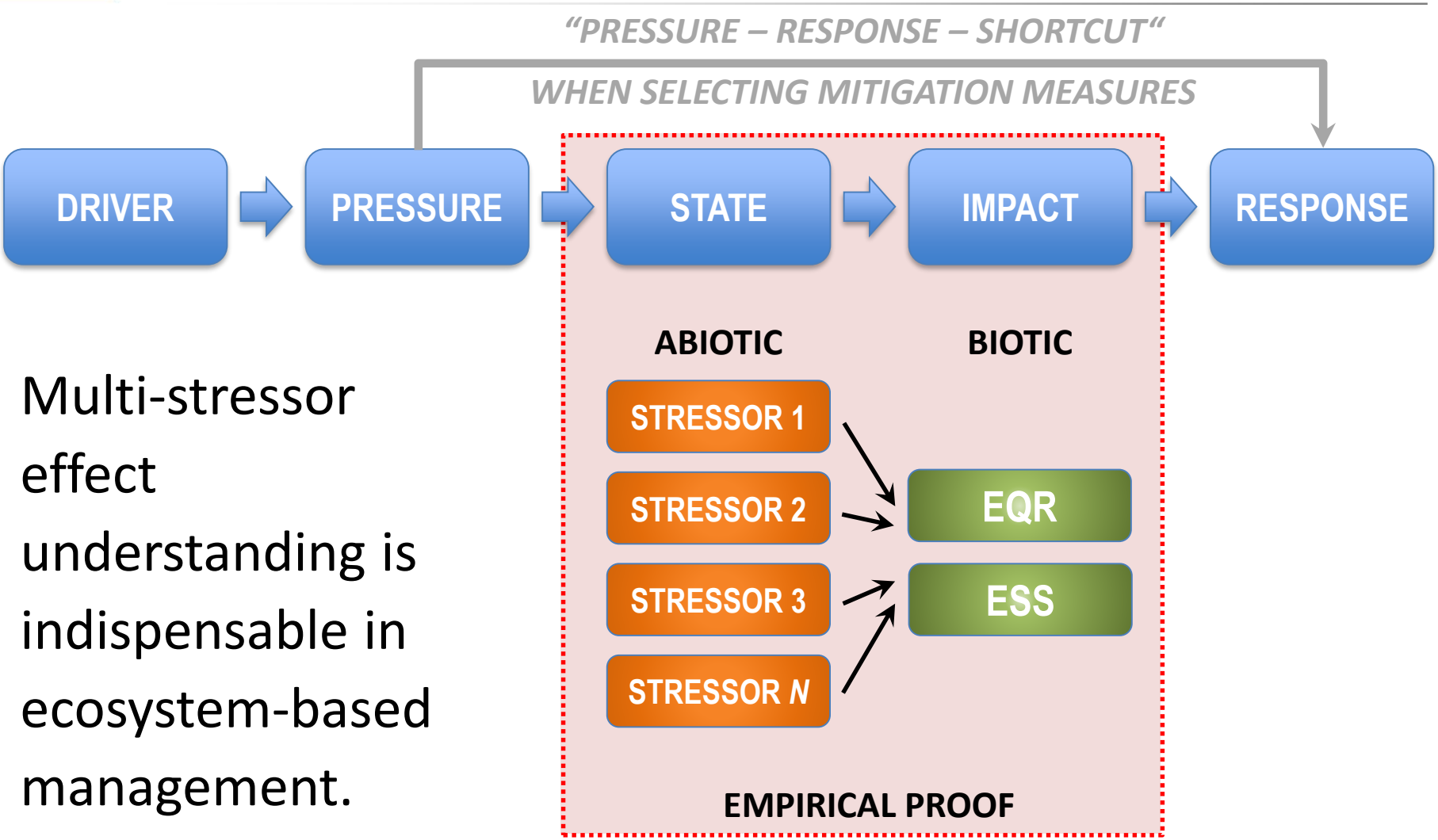
Ecological status ~ ESS: *summary*

Rough-scale evidence (not always) supports assumed relationships between ecological status and provision of different ESS.

Synergies and conflicts between ecological status and ESS yet to be further evaluated at operational scales (e.g. water body, sub-basins).

Conclusions

Conclusions



Multi-stressor effect understanding is indispensable in ecosystem-based management.