Multiple stressor impacts on European surface waters: A synthesis resulting from the MARS project

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Project - background and timeline

- FP7 project:
  Managing **A**quatic ecosystems and water **R**esources under multiple **S**tress
- February 2014 – January 2018
- Funding: 9 Mio Euro
- 24 partners
- Currently about 170 paper produced by MARS

Project - objectives

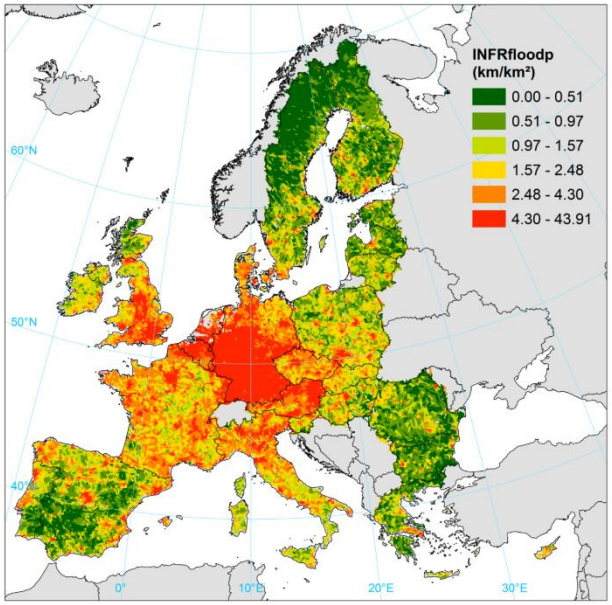
Morphology

Hydrology

Pollution

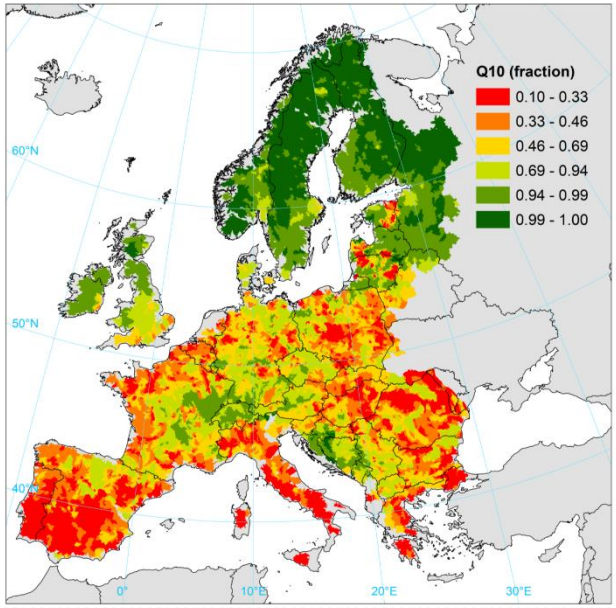
Project - objectives

Morphology



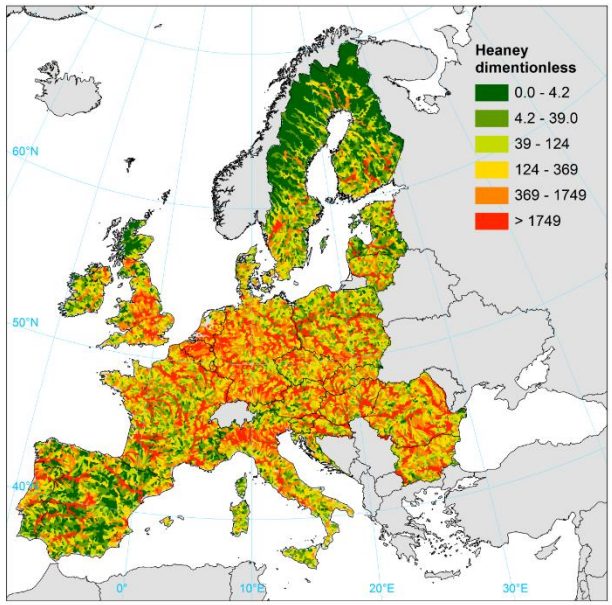
INERfloodp (km/km^2) =
Density of infrastructure
(roads and railways)
in the floodplains (km/km^2)

Hydrology



Q10 fraction =
Ratio between the number of days
the water flow is below the 10%-ile
with and without water abstractions (fraction)

Pollution



Heaney dimensionless =
Relative intensity of the potential
pollution load from urban runoff
(dimensionless), estimated by the
Heaney model

Grizzetti B., et al. 2017 Scientific Rep

Project - objectives

1 + 1 = 2 Additive effects of two stressors co-acting

1 + 1 = 3 Synergistic effects of two stressors co-acting

1 + 1 = 1 Antagonistic effects of two stressors co-acting

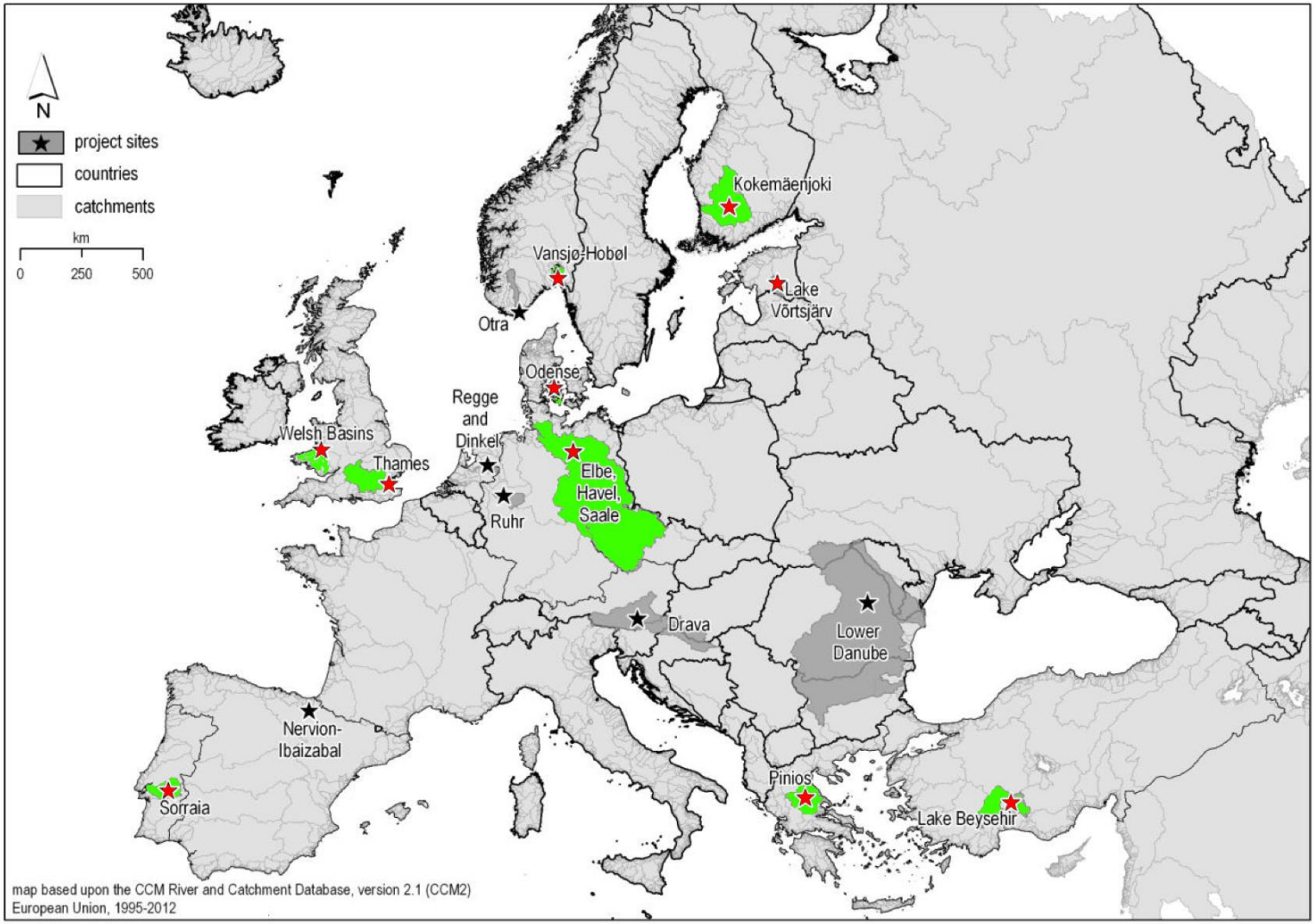
Project - objectives

- How do stressors interact in affecting ecological status and services at the water body, catchment and continental scales?

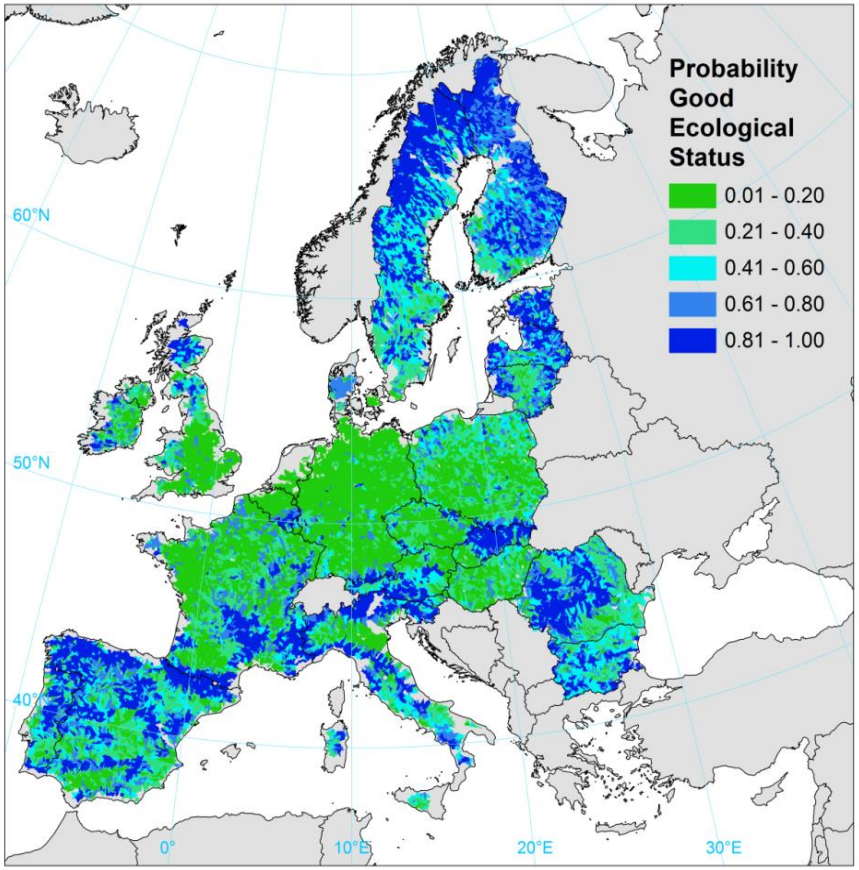
- Despite the multitude of stressors, is there a common ground for restoration activities?

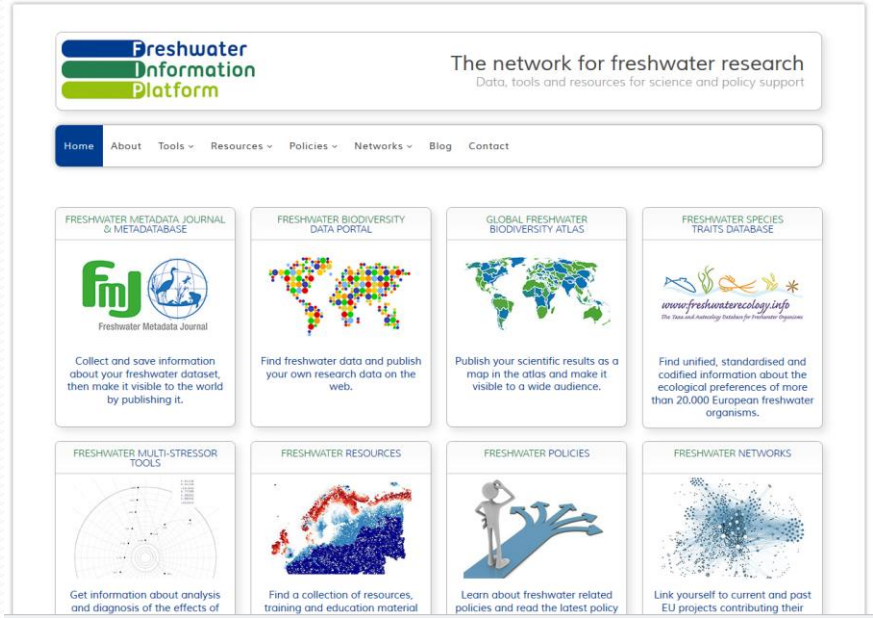
Project – methodology 1: experiments

Project – methodology II: catchment models

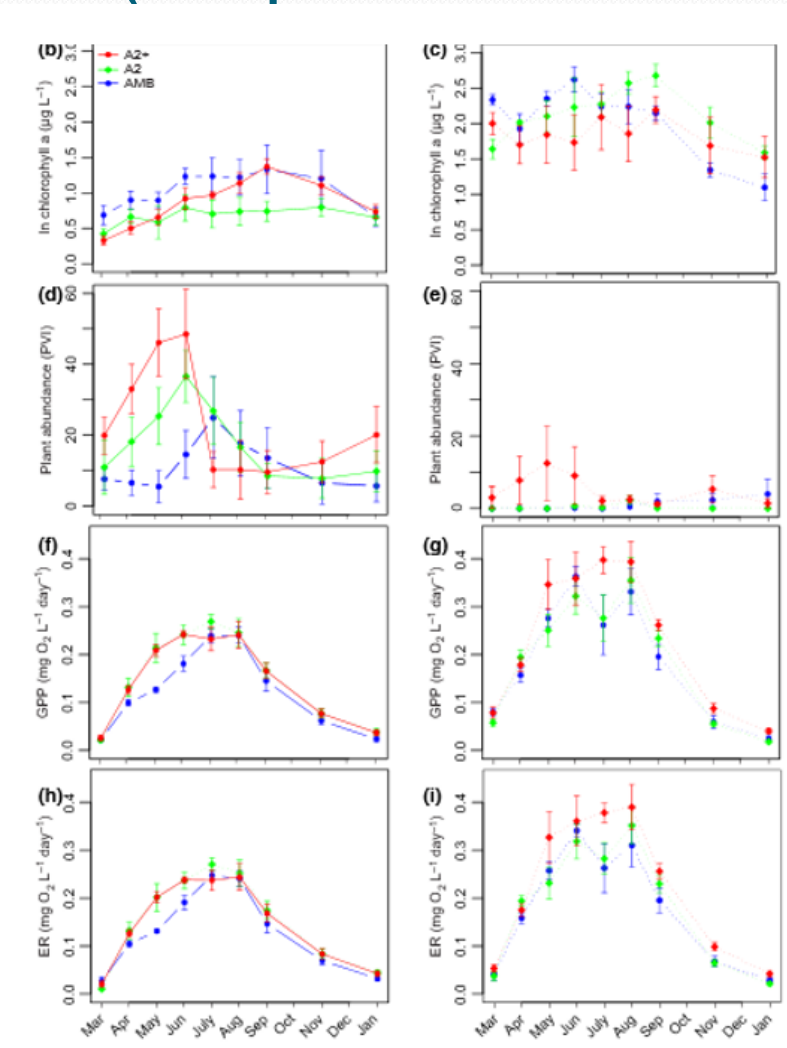


Project – methodology III: Europe-wide analysis and tools





Project - outputs I: example for additive effects (temperature and nutrients add to each other)



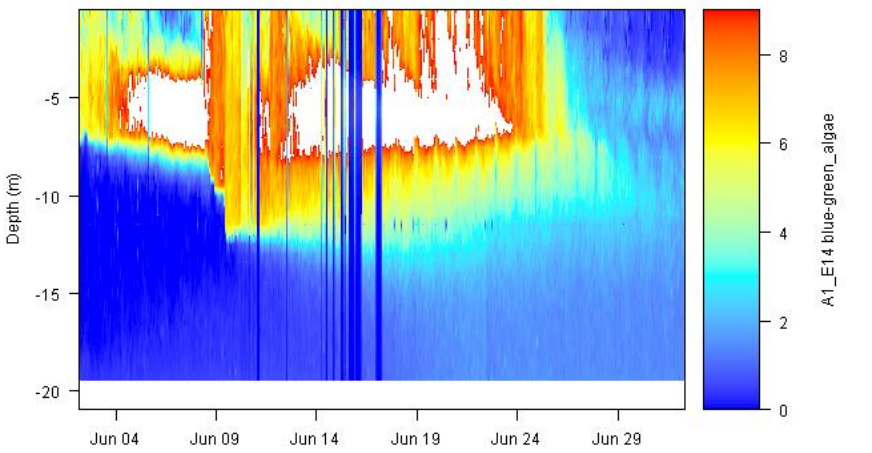
Phytoplankton

Macrophytes

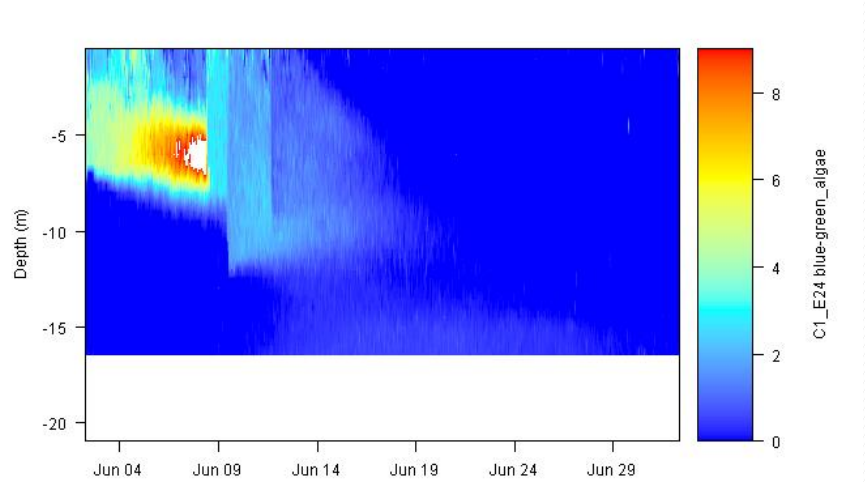
Primary Production

Respiration

Project - outputs II: example for antagonistic effects (Cyanobacteria blooms under nutrient stress)

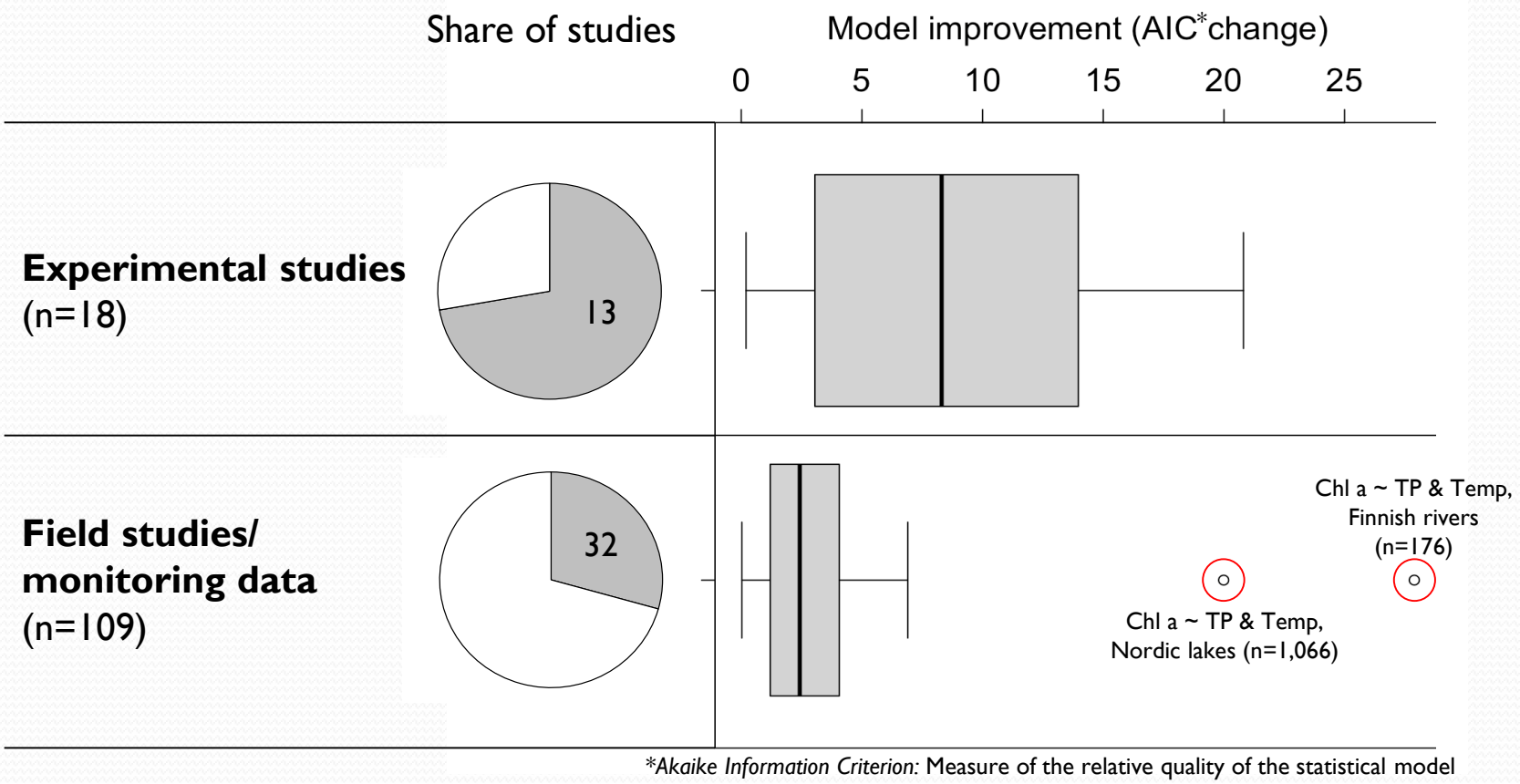


No addition of humic substances



High addition of humic substances

Project – outputs III: multiple stressor synthesis (relevance and strength of interactive effects)

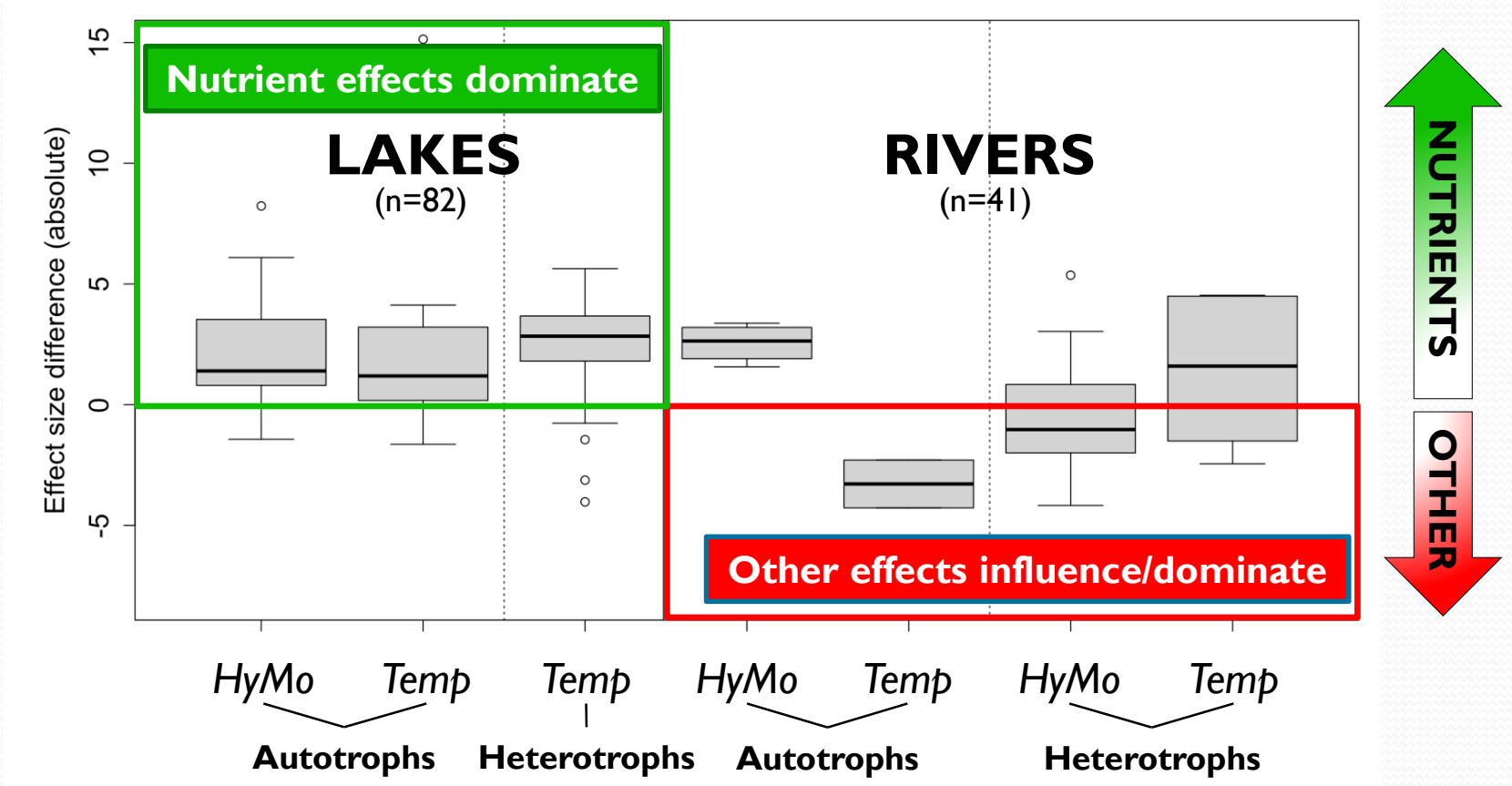


**Akaike Information Criterion:* Measure of the relative quality of the statistical model

Share and strength of paired-stressor interactions

N=127 paired-stressor – impact relationships (data source: *MARS unpubl.*)

Project – outputs III: multiple stressor synthesis (relevance and strength of interactive effects)



Paired-stressor effects (Nutrients and *other*) on lake and river BQEs*

N=123 paired-stressor – impact relationships (data source: *MARS unpubl.*)

* incl. mesocosm experiments

Project - outputs IV: Future scenarios

Storyline 1: '*Techno world*' or '*Economy rules*'

- Fast economic development, increased use of energy
- Policies focus on enhancing trade and economic growth
- Rapid climate change
- SSP5 and climate scenario 8.5 (~ 2°C increase in 2060)

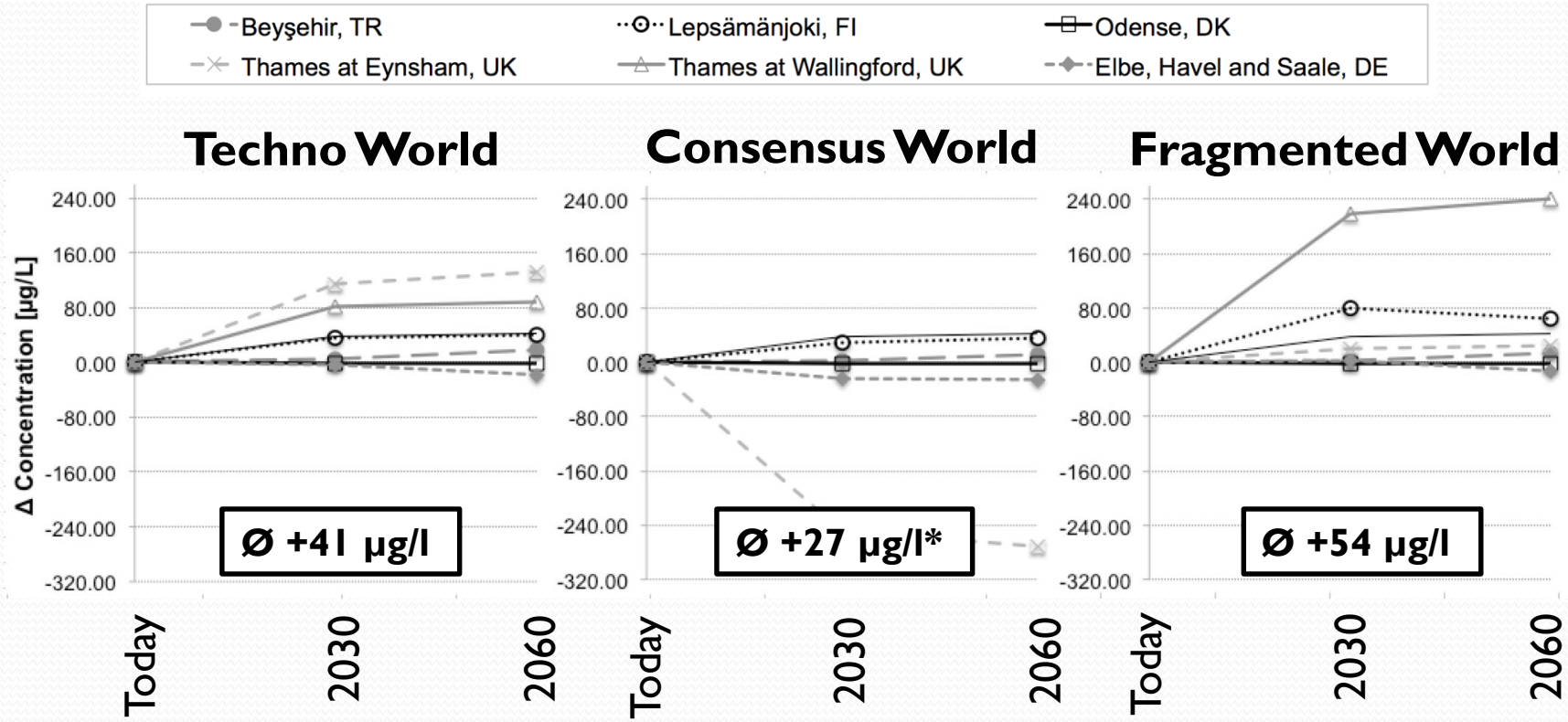
Storyline 2: '*Consensus world*'

- Economy and population grow at the same pace as now
- Environmental policies enforced by the government
- SSP2 and climate scenario 4.5 (~ 1.4°C increase in 2060)

Storyline 3: '*Fragmented world*'

- Unequal development of different countries
- No more international trade agreements
- Environmental protection done by rich countries at local scale
- SSP3 and climate scenario 8.5 (~ 2°C increase in 2060)

Project - outputs IV: Future scenarios
Water quality (Total Phosphorus)

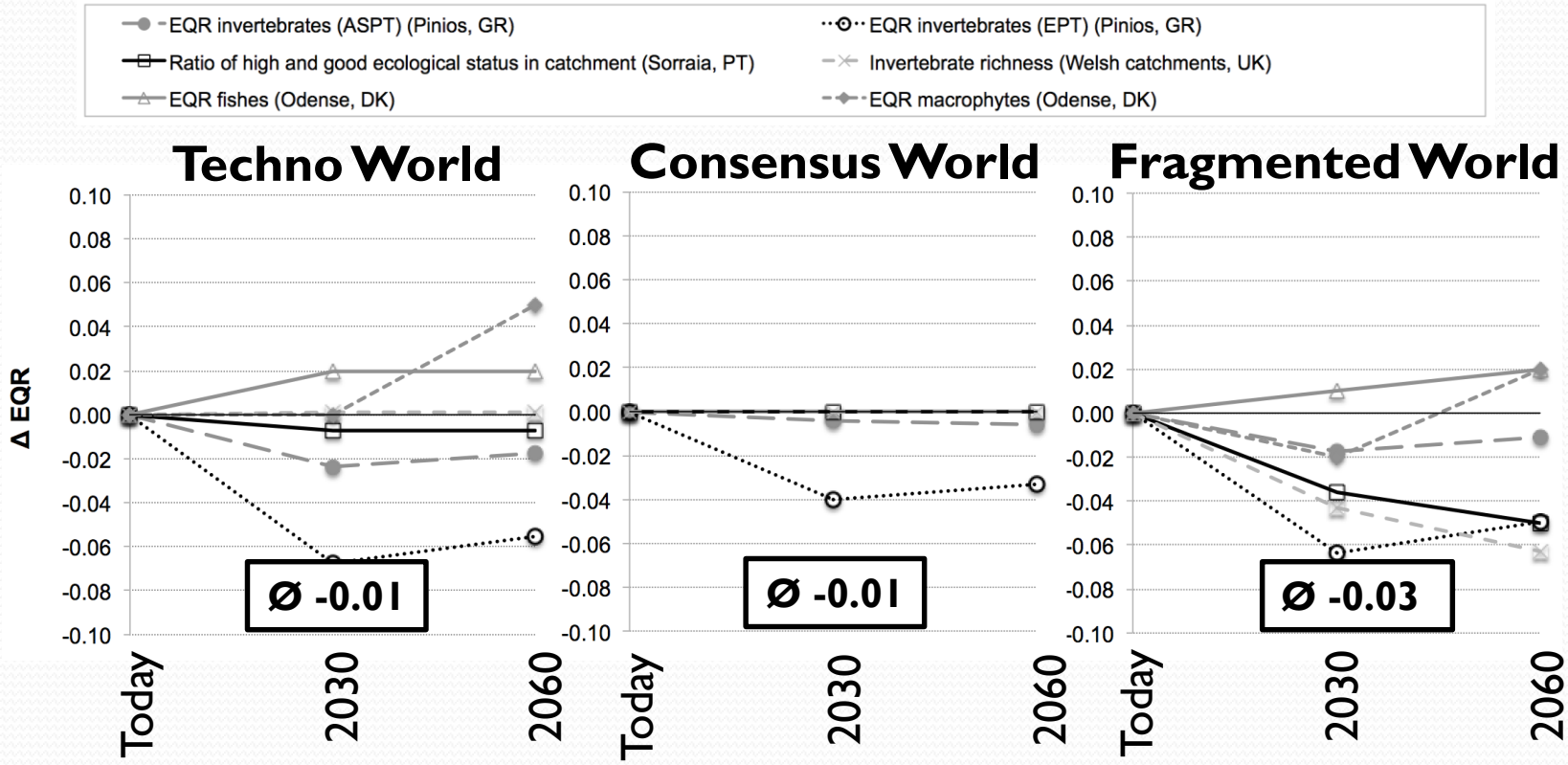


Relative change in Total Phosphorus concentrations

for the future scenarios across six case-studies

* excluding Thames at Eynsham

Project - outputs IV: Future scenarios
Ecological Quality Ratios



Relative change in Ecological Quality Ratios

for the future scenarios across six case-studies

Project - outputs V:
Multiple stressors acting at European rivers

Multiple stressors
(modelled in MARS and SOLUTIONS)

Nutrients

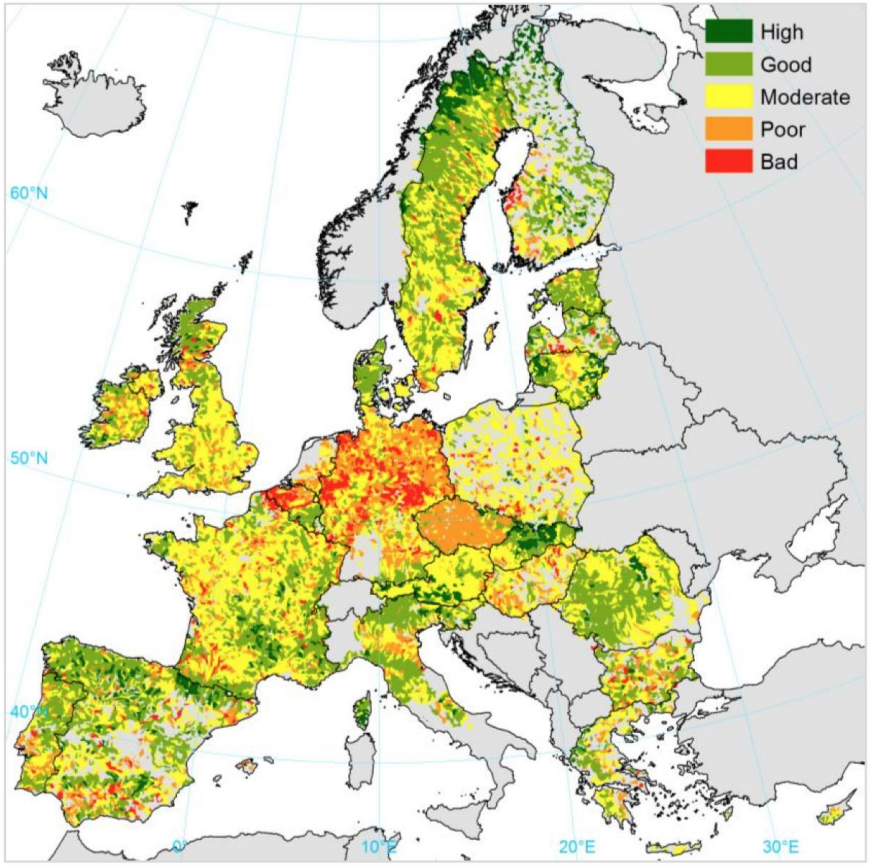
Hydrological alteration

Riparian land use

Toxics

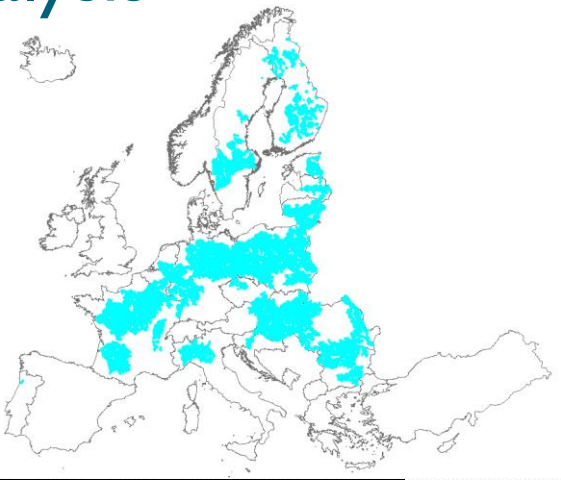
MODELLING

Ecological status
(2nd RBMP)



Project - outputs V:
Boosted regression tree analysis

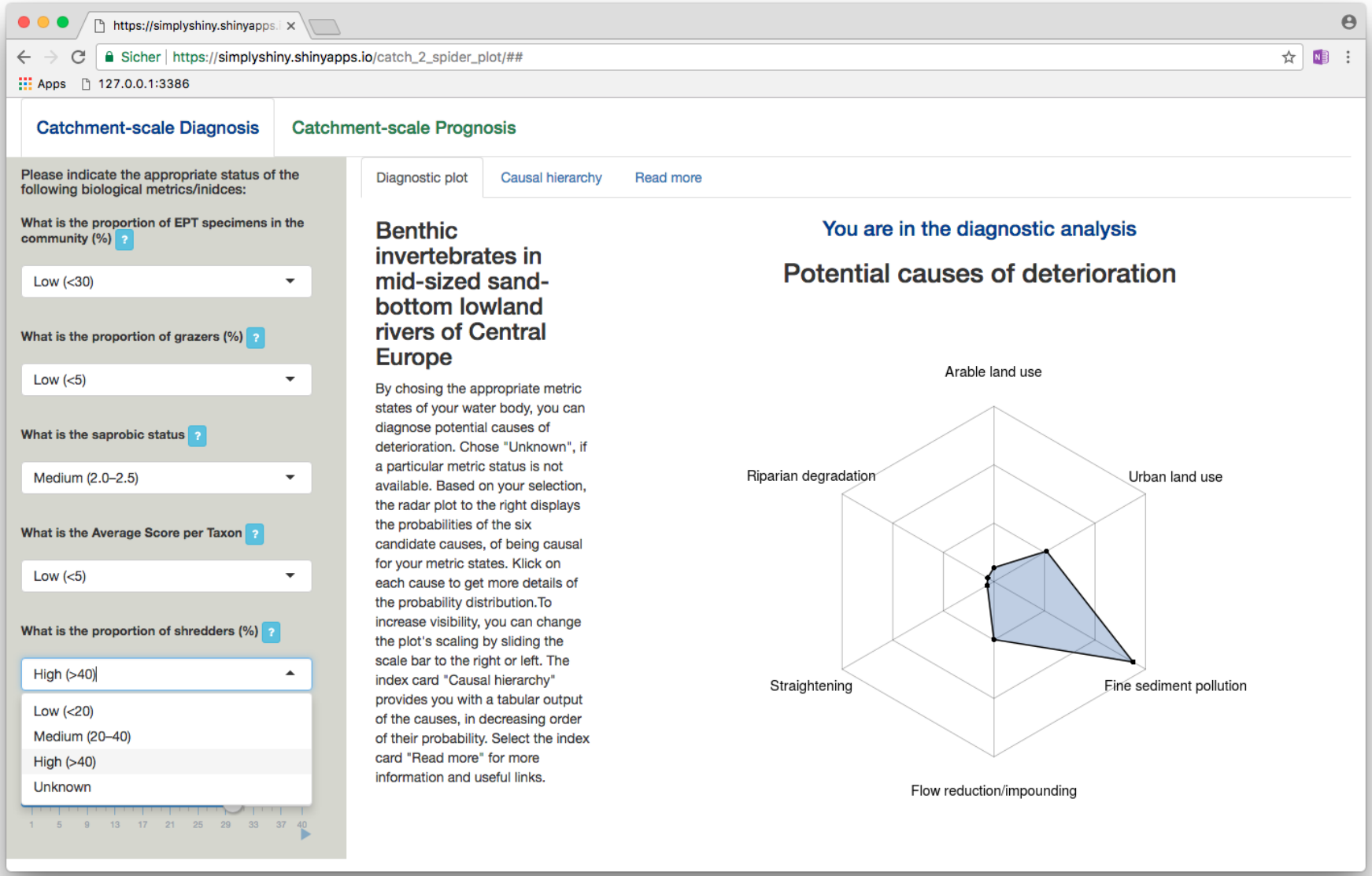
PRELIMINARY ANALYSIS



Lowland streams and rivers
N = 7,331
Variance explained: 64 %

Variable	Group	Relative influence (%)
Dissolved inorganic nitrogen	Nutrients	19.2
msPAF	Toxics	16.9
Total phosphorus	Nutrients	14.5
Mean annual flow	Hydrology	13.0
%Agriculture	Riparian land use	11.6
%Urban	Riparian land use	10.5
High pulse duration	Hydrology	7.4
Low pulse duration	Hydrology	6.9

Project - outputs VI: Diagnostic Tool



Project - outputs (general)

Freshwater Information Platform

The network for freshwater research

Data, tools and resources for science and policy support

Home | About | Tools | Resources | Policies | Networks | Blog | Contact

FRESHWATER METADATA JOURNAL & METADATABASE

Freshwater Metadata Journal

Collect and save information about your freshwater dataset, then make it visible to the world by publishing it.

FRESHWATER BIODIVERSITY DATA PORTAL

Find freshwater data and publish your own research data on the web.

GLOBAL FRESHWATER BIODIVERSITY ATLAS

Publish your scientific results as a map in the atlas and make it visible to a wide audience.

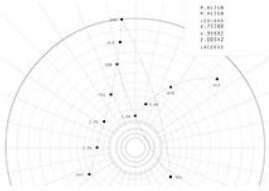
FRESHWATER SPECIES TRAITS DATABASE

www.freshwaterecology.info

The Taxa and Autecology Database for Freshwater Organisms

Find unified, standardised and codified information about the ecological preferences of more than 20.000 European freshwater organisms.

FRESHWATER MULTI-STRESSOR TOOLS



Get information about analysis and diagnosis of the effects of

FRESHWATER RESOURCES

Find a collection of resources, training and education material

FRESHWATER POLICIES

Learn about freshwater related policies and read the latest policy

FRESHWATER NETWORKS

Link yourself to current and past EU projects contributing their

RDI gaps for the future

- *Capitalising on the data source on stressor-impact-relationships:*
  → Disentangling the causes of multiple-stressor effects
- *Capitalising on the Europe-wide data source on various stressors and ecological status:*
  → Modelling the effects of multiple stressors on functions and services
  → Including additional stressors (e.g. invasive species)
- *Capitalising on the tools produced by MARS:*
  → Generating diagnostic tools for additional water categories and types
  → Including measures into the diagnostic tools

Link to SRIA themes

- Strongly addressed by MARS
- Partly addressed by MARS
- Not addressed by MARS

Needs identified by SRIA	MARS contributions
1.1.1. Developing approaches for assessing the ecological functioning of ecosystems	Particularly from experimental approaches
1.1.2. Developing and testing methodologies for the valuation of ecosystem services	Only indirectly
1.1.3. Establishing multiple pressure-impact-response relationships in aquatic, riparian and groundwater-dependent Ecosystems	Many…
1.1.4. Integrating ecosystem services into management of water resources	Europe-wide and catchment modelling of several ecosystem services
1.1.5 Adapting and integrating our water / ecosystem management, planning and governance systems with better environmental data and information	Diagnostic tools

Link to SRIA themes

- Strongly addressed by MARS
- Partly addressed by MARS
- Not addressed by MARS

Needs identified by SRIA	MARS contributions
1.2.1. Restoring morphology continuity and hydraulic connectivity	Case studies in catchments
1.2.2. Managing the risks caused by invasive species and options for remediation	Not directly addressed
1.2.3. Understanding and managing ecological flows	Hydrological models and predictions (catchments and Europe-wide)
1.2.4. Integrated eco-technological solutions for the remediation and mitigation of degraded water bodies and aquatic ecosystems	Diagnostic tools

Link to SRIA themes

- Strongly addressed by MARS
- Partly addressed by MARS
- Not addressed by MARS

Needs identified by SRIA	MARS contributions
1.3.1. Understanding the causes of drought/scarcity; predicting drought events and water scarcity and developing adaptation measures	Europe-wide and catchment hydrological models
1.3.2. Developing innovative (or improved) tools for adaptation to hydroclimatic extreme events, especially floods	Not directly addressed
1.3.3. Improving water management to mitigate the harmful impacts of extreme events (extreme weather events, impaired water quality)	Not directly addressed

Project - contact details

- www.mars-project.eu
- www.freshwaterblog.net
- www.freshwaterplatform.eu