How to deal with multiple stressors to freshwater biodiversity in the future?

Daniel Hering
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University of Duisburg-Essen

Water categories
according to the Water Framework Directive

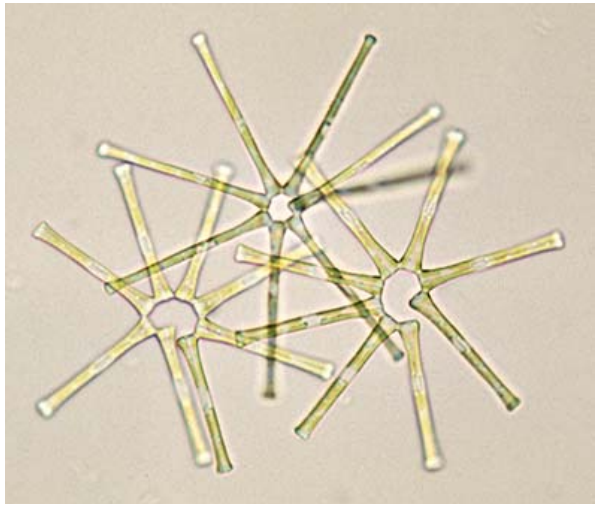
Lakes

Rivers

Transitional Waters

Coastal Waters

“Biological Quality Elements” (BQEs)



Phytoplankton

(Picture: www.microscopy-uk.org.uk)

Macropyhtes, Macroalgae, Angiosperms

(Picture: Klaus van de Weyer)

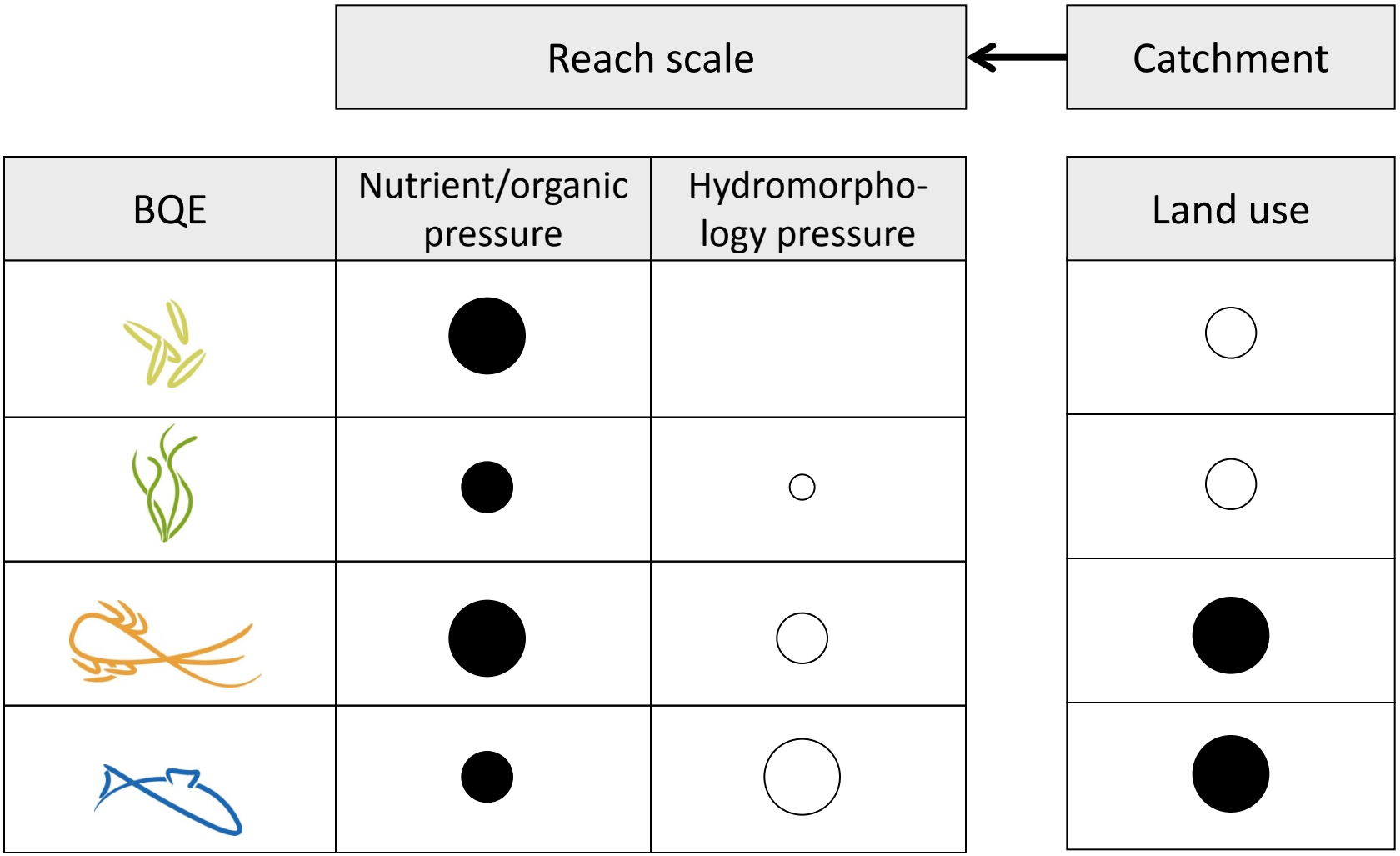
Benthic invertebrates

(Picture: Helmut Schuhmacher)

Fish

(Picture: Bernd Stemmer)

BQE response to stressors: rivers



Hering et al. (2013)
Hydrobiologia 704, 1-9

BQE response to stressors: lakes

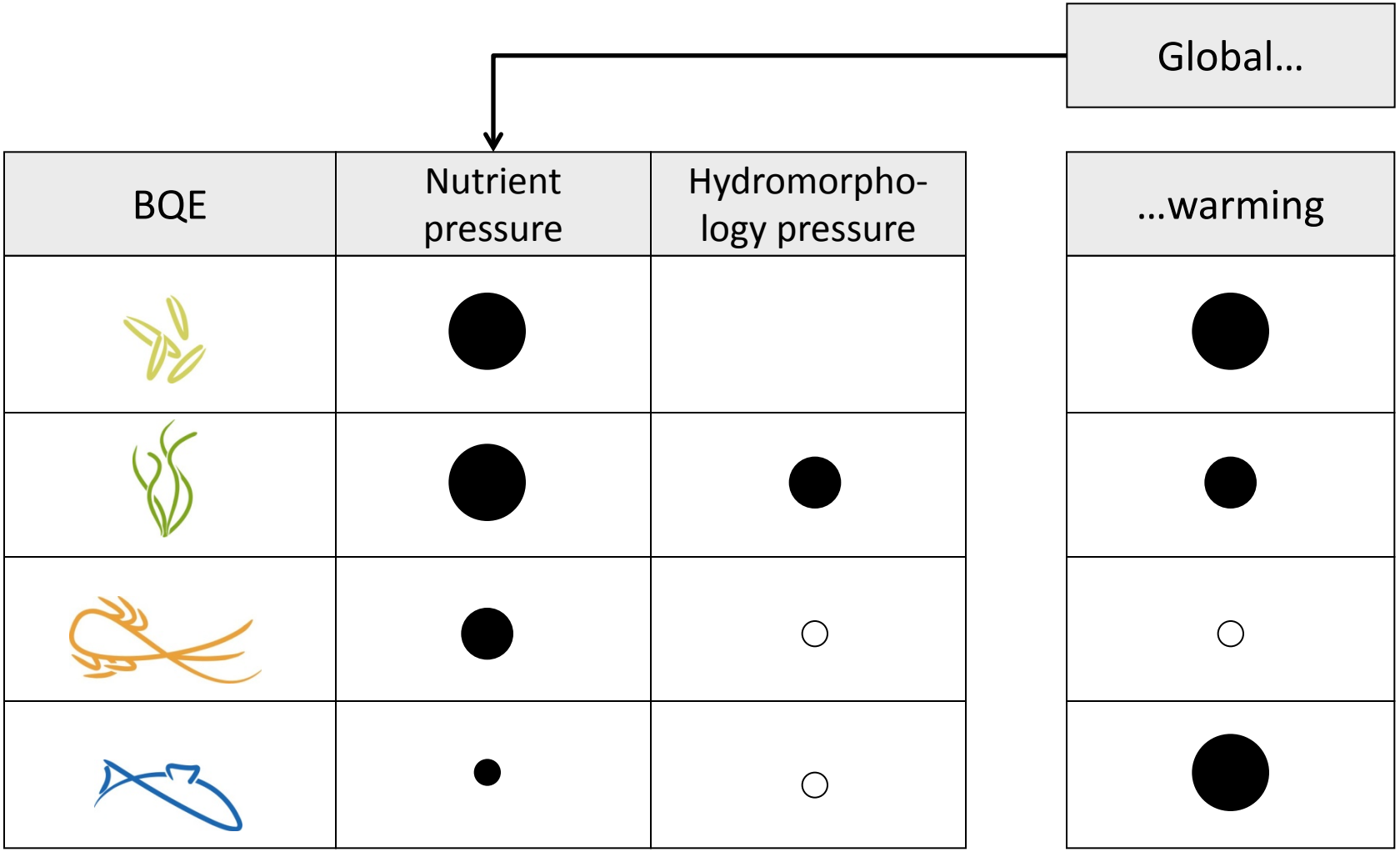
Reach scale ← Catchment

BQE	Nutrient pressure	Hydromorpho-logy pressure	Land use
	●		○
	●	●	○
	●	○	○
	●	○	○

● Low uncertainty ○ High uncertainty

Hering et al. (2013)
Hydrobiologia 704, 1-9

BQE response to stressors: lakes



Hering et al. (2013)
Hydrobiologia 704, 1-9

Regional differences in stressors…

Northern Europe

Central Europe

Southern Europe

Lakes

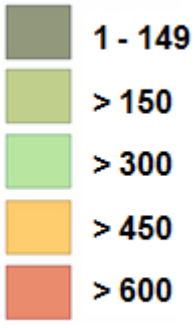
	Currently	Warmer climate
Hydrology		●
Morphology		
Org. pollution		
Eutrophication		●
Acidification	●	
Toxic	●	●
Hydrology	●	●
Morphology	●	
Org. pollution		
Eutrophication	●	●
Acidification		
Toxic		
Temperature		
Hydrology	●	●
Morphology		
Org. pollution		
Eutrophication	●	●
Acidification		
Toxic	●	●

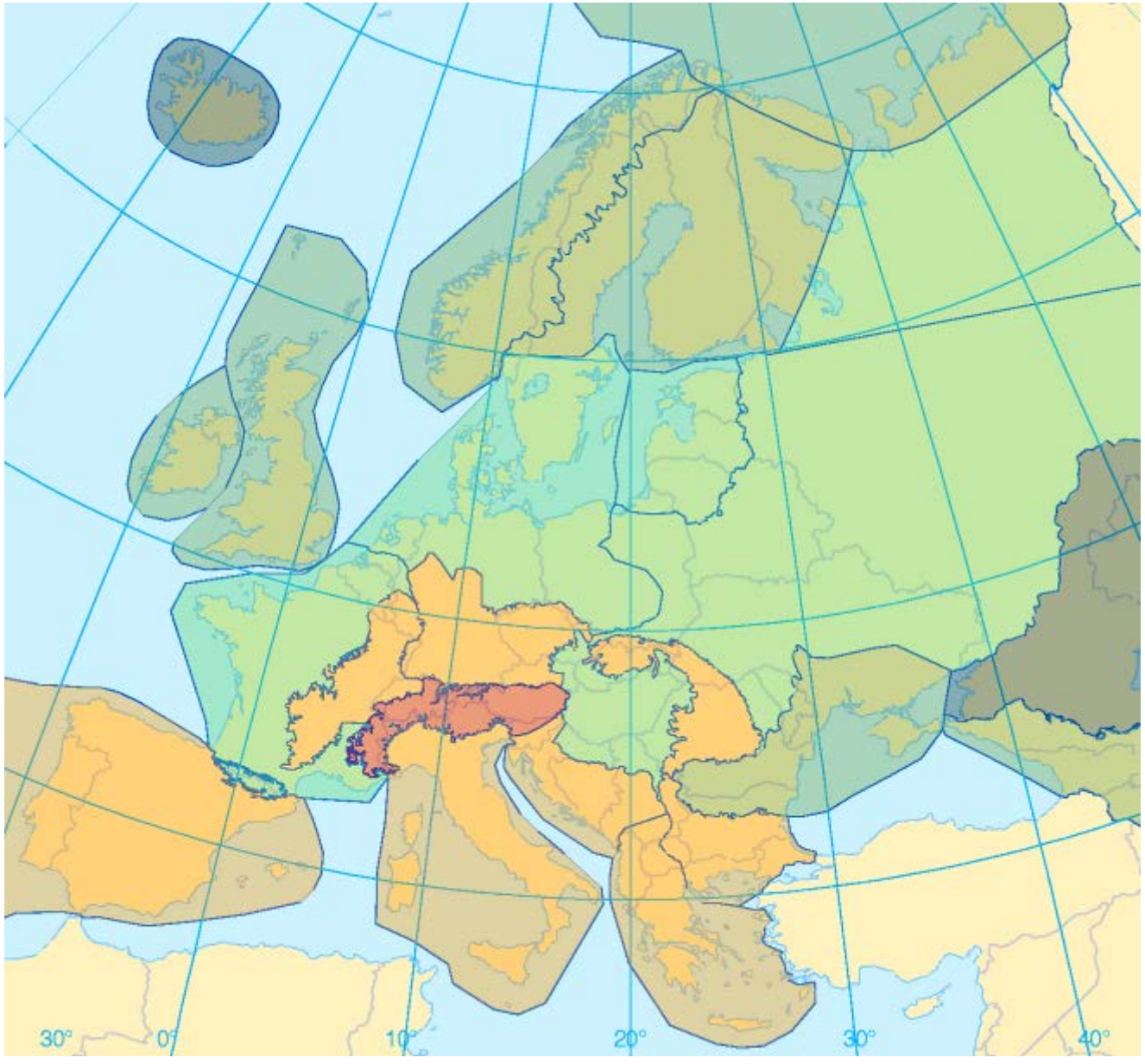
Rivers

	Currently	Warmer climate
Hydrology	●	●
Morphology		
Org. pollution		●
Eutrophication		●
Acidification	●	
Toxic	●	●
Hydrology	●	●
Morphology	●	
Org. pollution	●	
Eutrophication	●	●
Acidification		
Toxic		
Temperature		●
Hydrology	●	●
Morphology	●	
Org. pollution	●	●
Eutrophication	●	●
Acidification		
Toxic	●	●

…and in biodiversity hotspots…

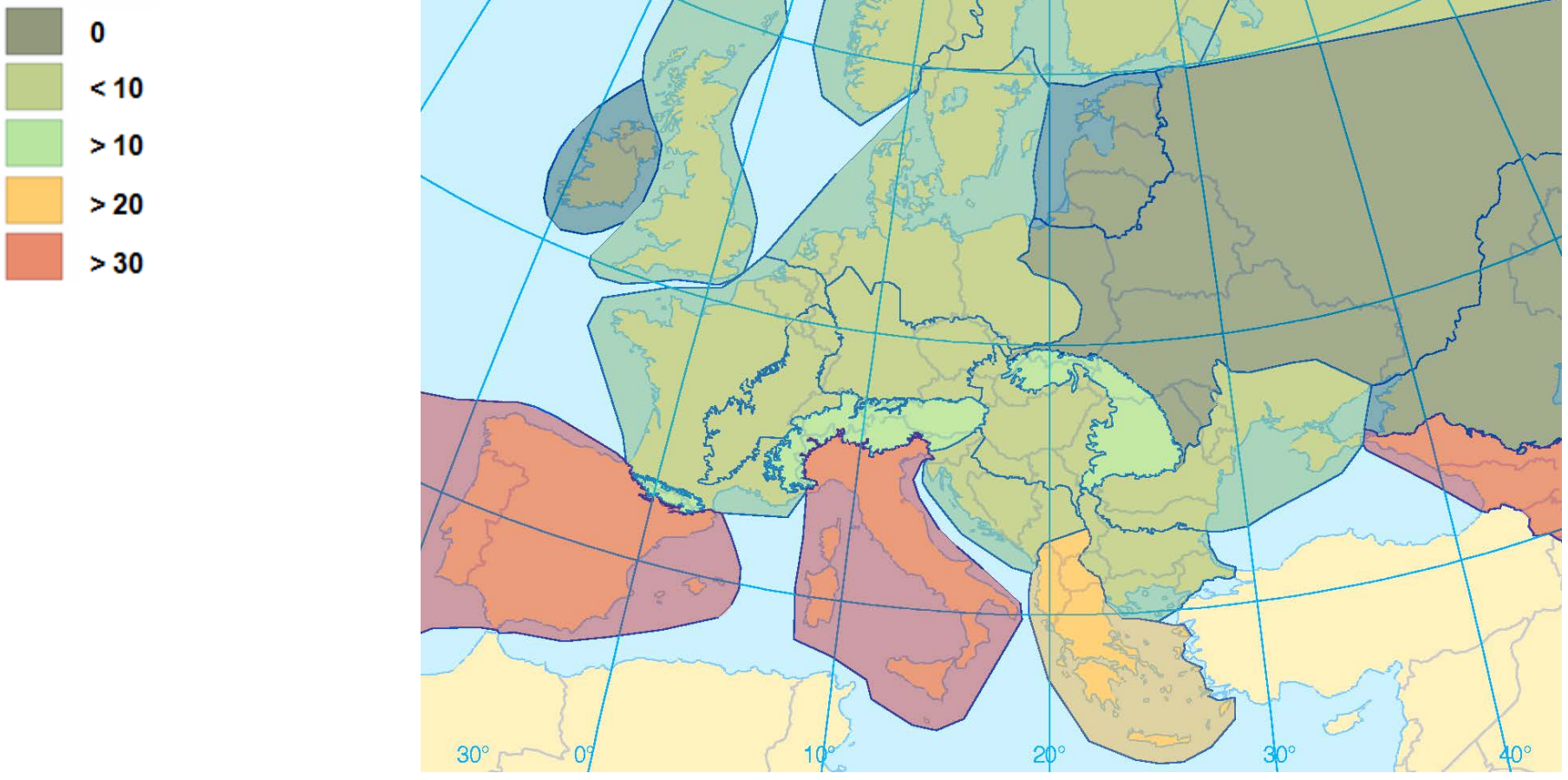
Number of mayfly, stonefly and caddisfly species





…particularly endemic species

Number of endemic mayfly, stonefly and caddisfly species



Stressors may act antagonistically…

Abatement of acidification in mining lakes in Germany

Helmut Klapper, Walter Geller, Martin Schultze

Article first published online: 28 JUN 2006

DOI: 10.1111/j.1440-1770.1996.tb00043.x

Issue

Lakes & Reservoirs: Research & Management

Volume 2, Issue 1-2, pages 7–16, March 1996

- Organic matter (pollution) and eutrophication remidiate acidification in open cast lignite mining lakes
- Similar effects are reported for streams: organic pollution can mask acidification

…or synergistically…

Special Issue: Multiple Stressors in Freshwater Ecosystems

Volume 55 Issue s1 - January 2010
Guest Editors: S. J. Ormerod, M. Dobson, A. G. Hildrew and C. R. Townsend

The fundamental importance of freshwaters, the rapid extinction rate of freshwater species and the real sensitivity of freshwater ecosystems to global change together bring an urgent need for renewed scientific focus, resources and evidence to support their management. Against this background, the Freshwater Biological Association in 2008 launched a new series of 'summit' Conferences in Aquatic Biology intended to develop and showcase the application of ecological science to major issues in freshwater ecosystems. The inaugural meeting part-sponsored by the Environment Agency and *Freshwater Biology*, was held in the Association's newly refurbished premises at Windermere. Papers from the first conference on ?Multiple stressors? are now freely available online in *Freshwater Biology*.

Freshwater Biology (2011) doi:10.1111/j.1365-2427.2011.02619.x

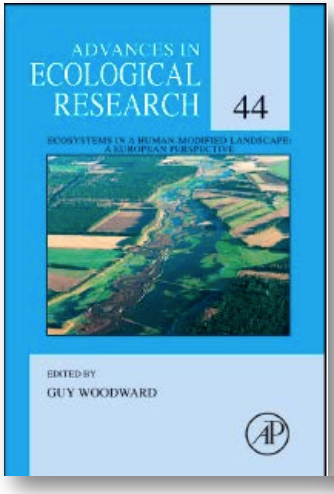
APPLIED ISSUES

Subsidy-stress and multiple-stressor effects along gradients of deposited fine sediment and dissolved nutrients in a regional set of streams and rivers

ANNIKA WAGENHOFF*, COLIN R. TOWNSEND*, NGAIRE PHILLIPS† and CHRISTOPH D. MATTHAEI*
*Department of Zoology, University of Otago, Dunedin, New Zealand
†National Institute of Water and Atmospheric Research, Hamilton, New Zealand

- Fine sediment pollution and nutrient enrichment synergistically determine the response of benthic invertebrates and benthic algae

…or hierarchically

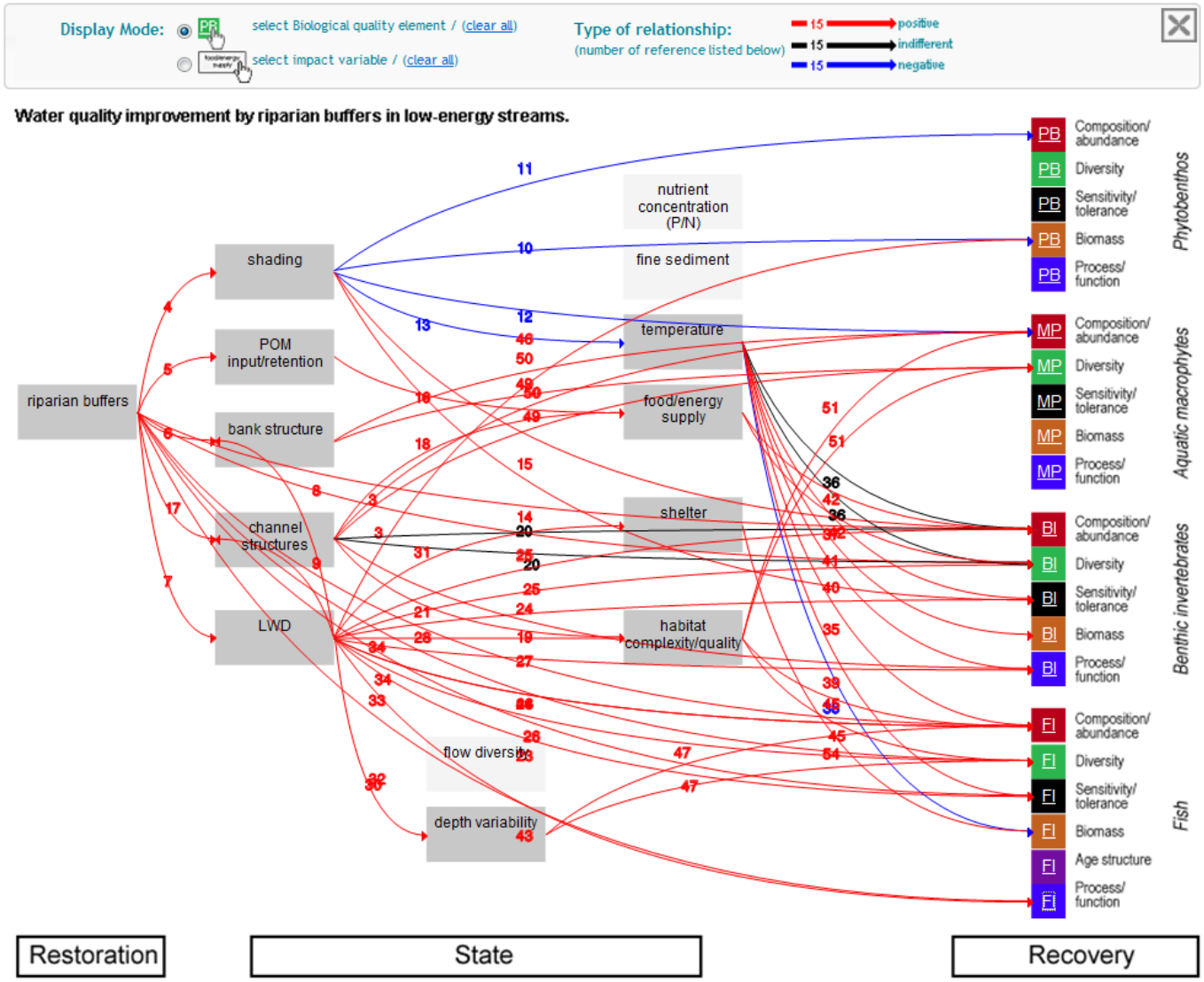


From Natural to Degraded Rivers and Back Again: A Test of Restoration Ecology Theory and Practice

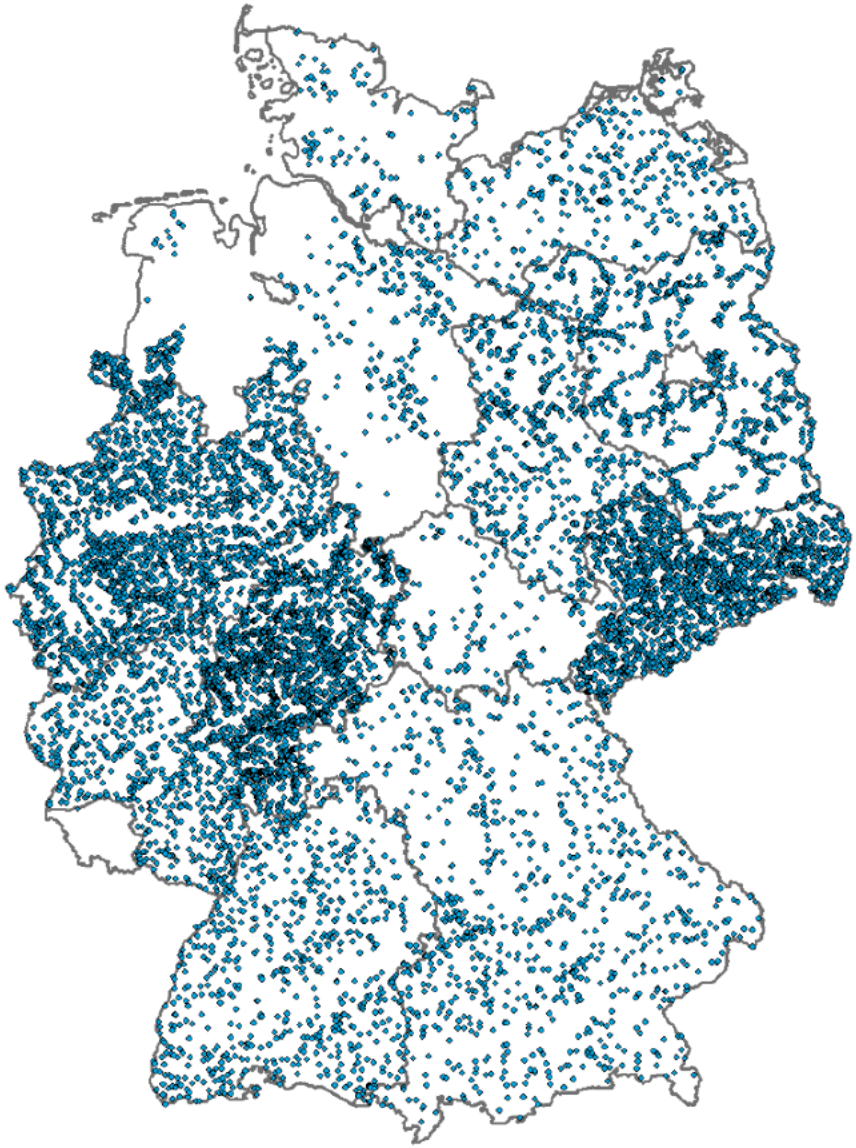
CHRISTIAN K. FELD, SEBASTIAN BIRK, DAVID C. BRADLEY, DANIEL HERING, JOCHEM KAIL, ANAHITA MARZIN, ANDREAS MELCHER, DIRK NEMITZ, MORTEN L. PEDERSEN, FLORIAN PLETTERBAUER, DIDIER PONT, PIET F.M. VERDONSCHOT AND NIKOLAI FRIBERG

- Ongoing pollution counteracts hydromorphological restoration (medium quality superior to matrix quality)

Single stressors with multiple pathways?



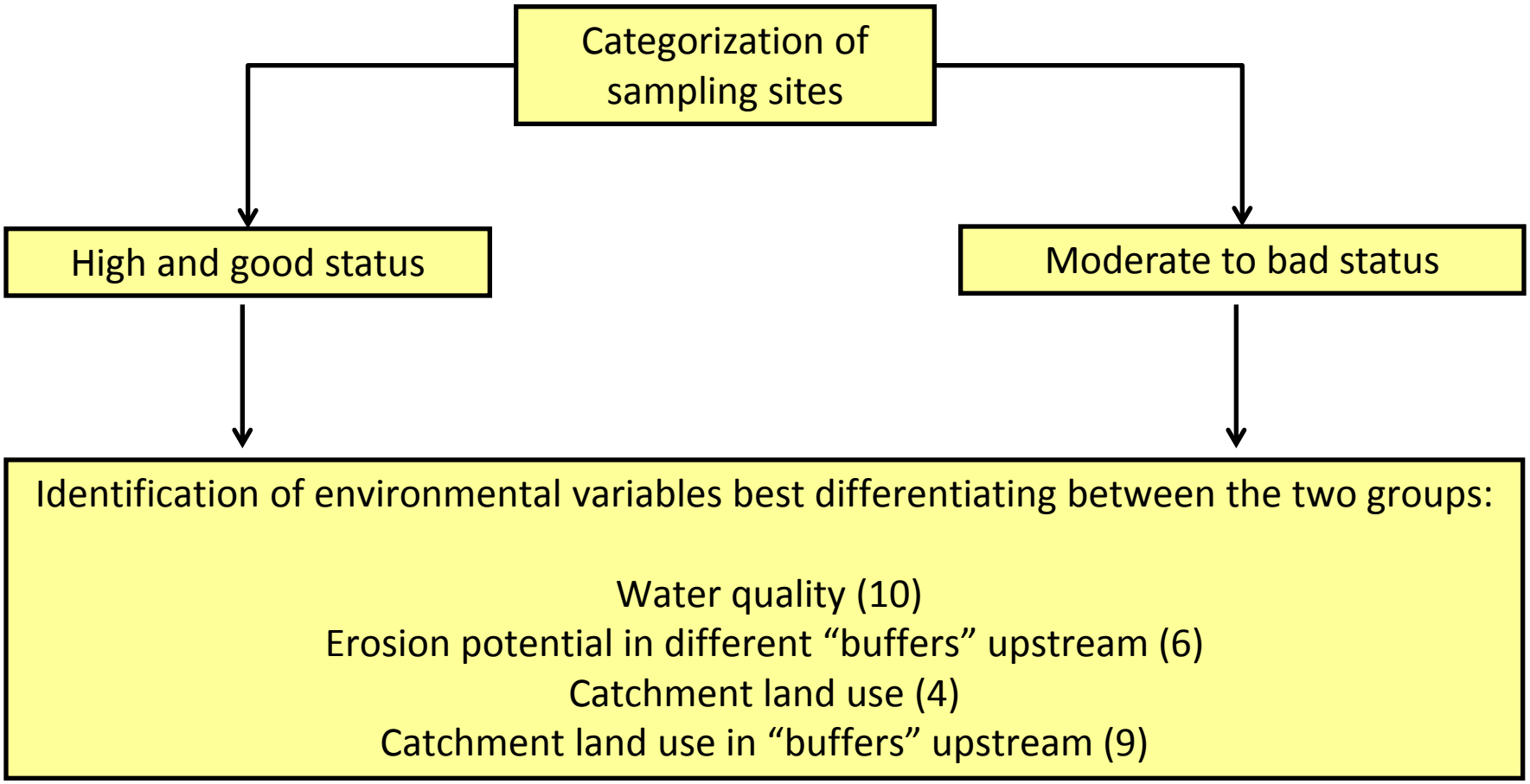
Which stressors are relevant?



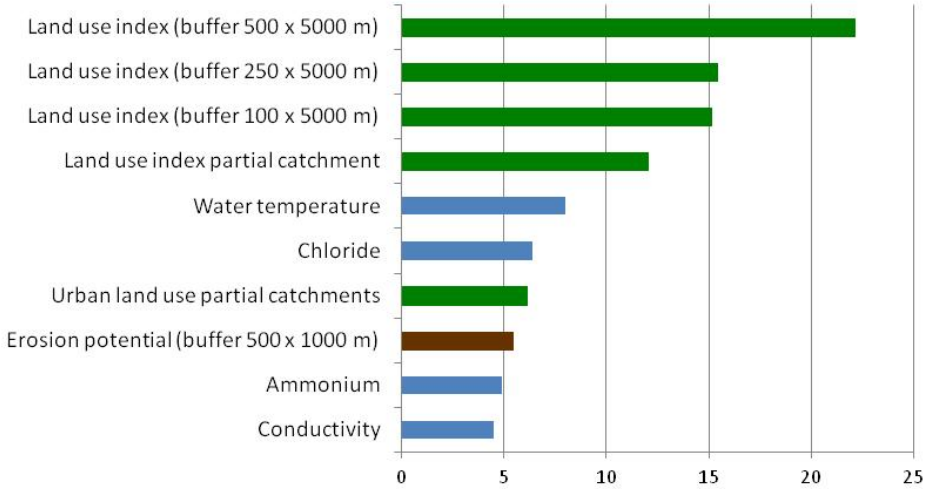
Data bases: 12,000 sampling sites from 12 federal states

Which stressors are relevant?

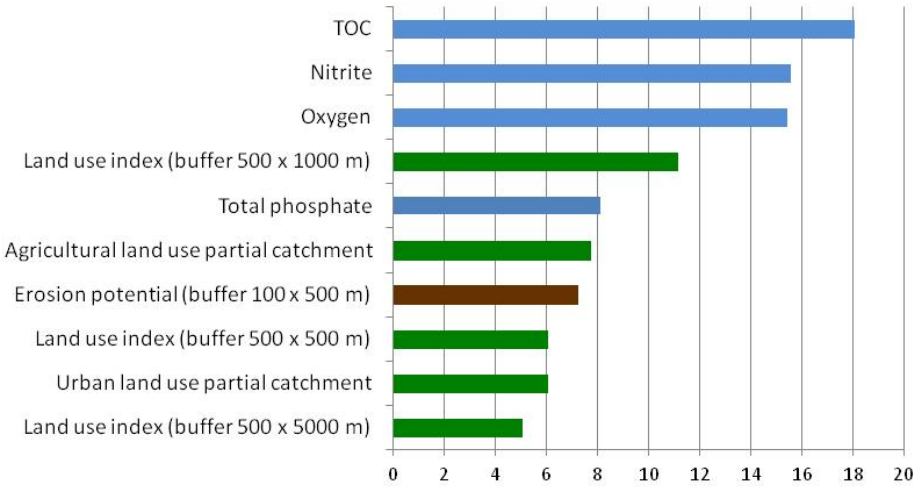
Boosted Regression Trees



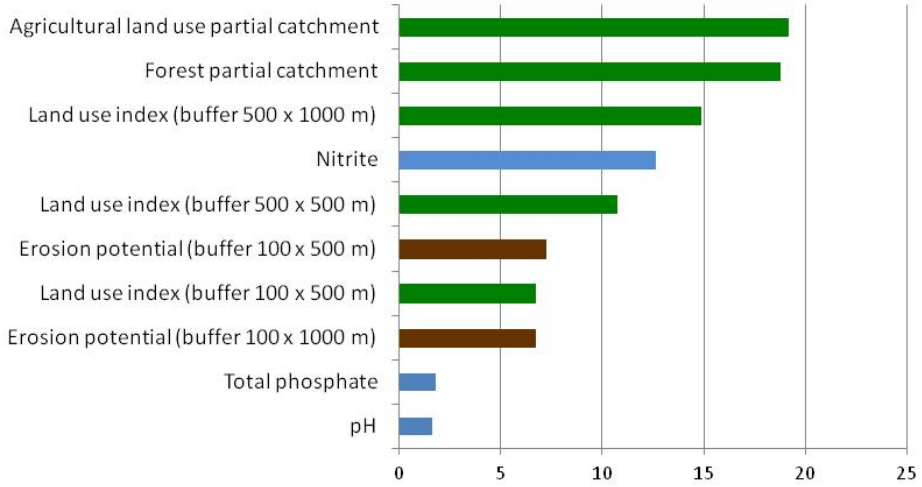
Benthic invertebrates: Relevance of parameters



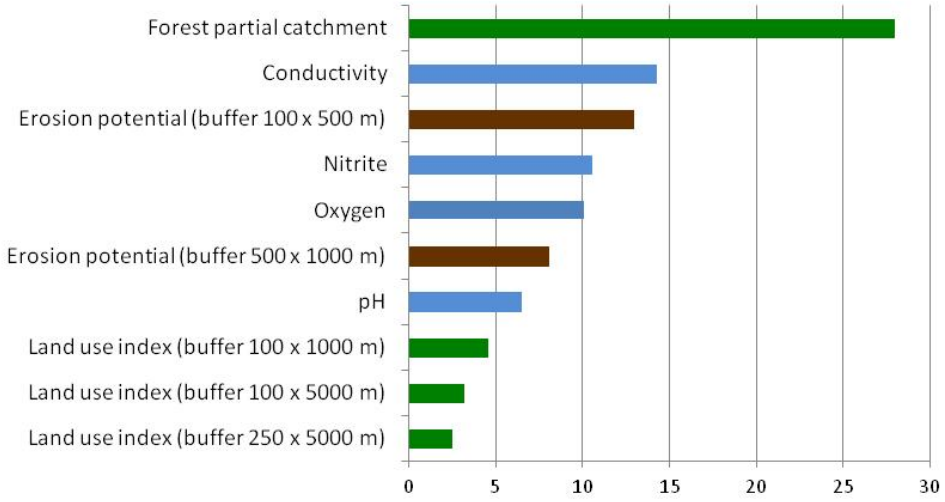
Small mountain streams



Mountain rivers



Small lowland streams

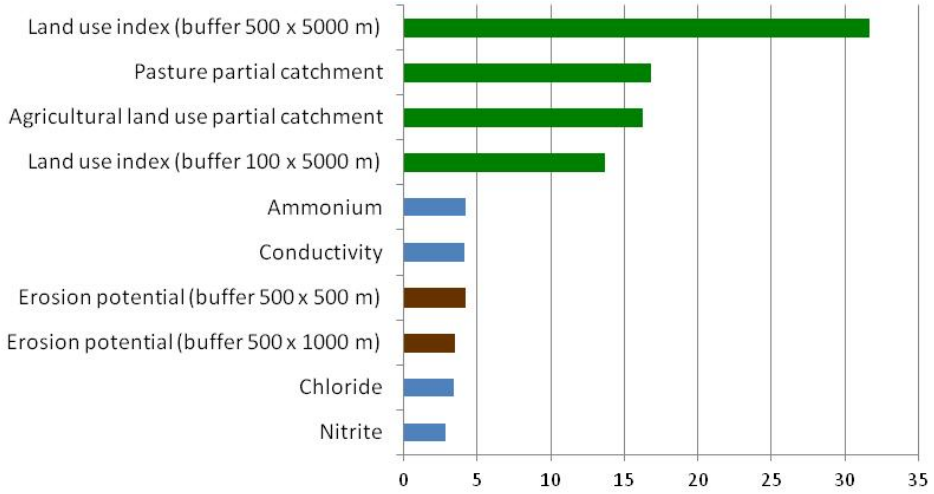


Lowland rivers

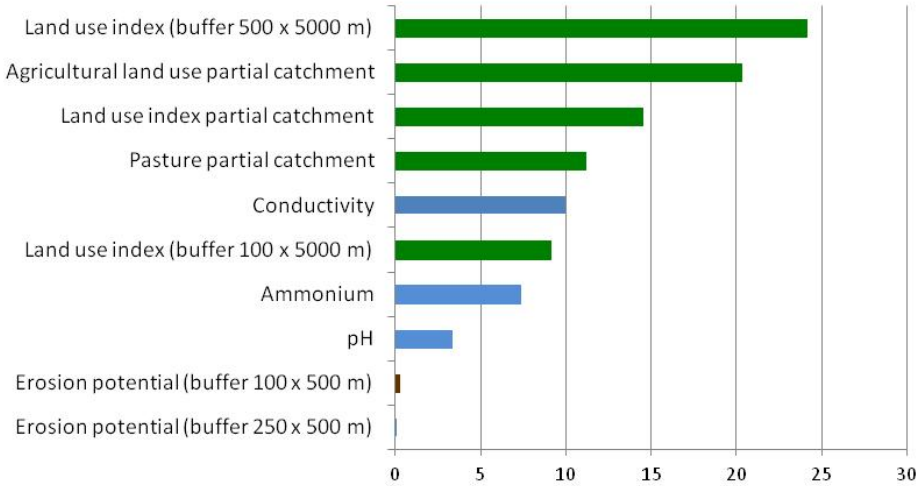
Water quality Land use in buffers Erosion potential

Analysis by Andrea Sundermann, Senckenberg Institute

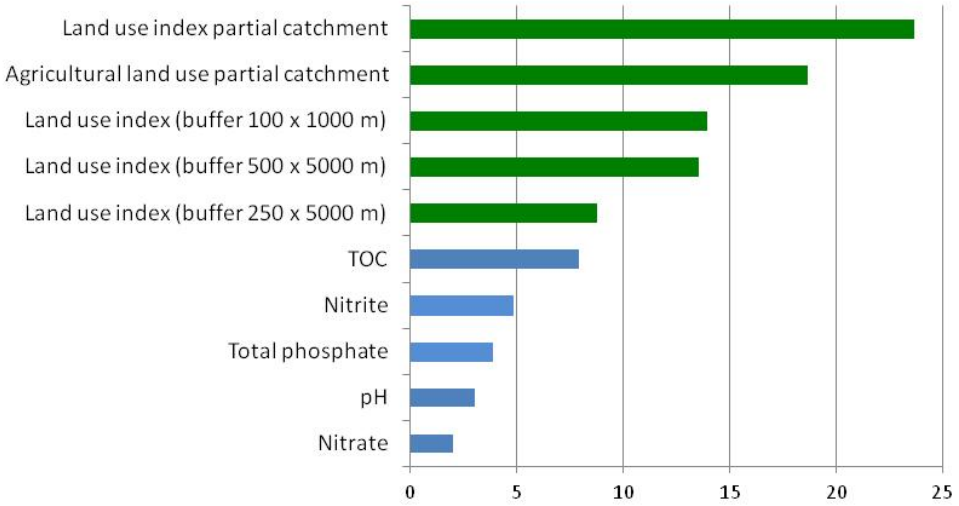
Fish, macropyhtes: Relevance of parameters



Fish: Rhithral zones



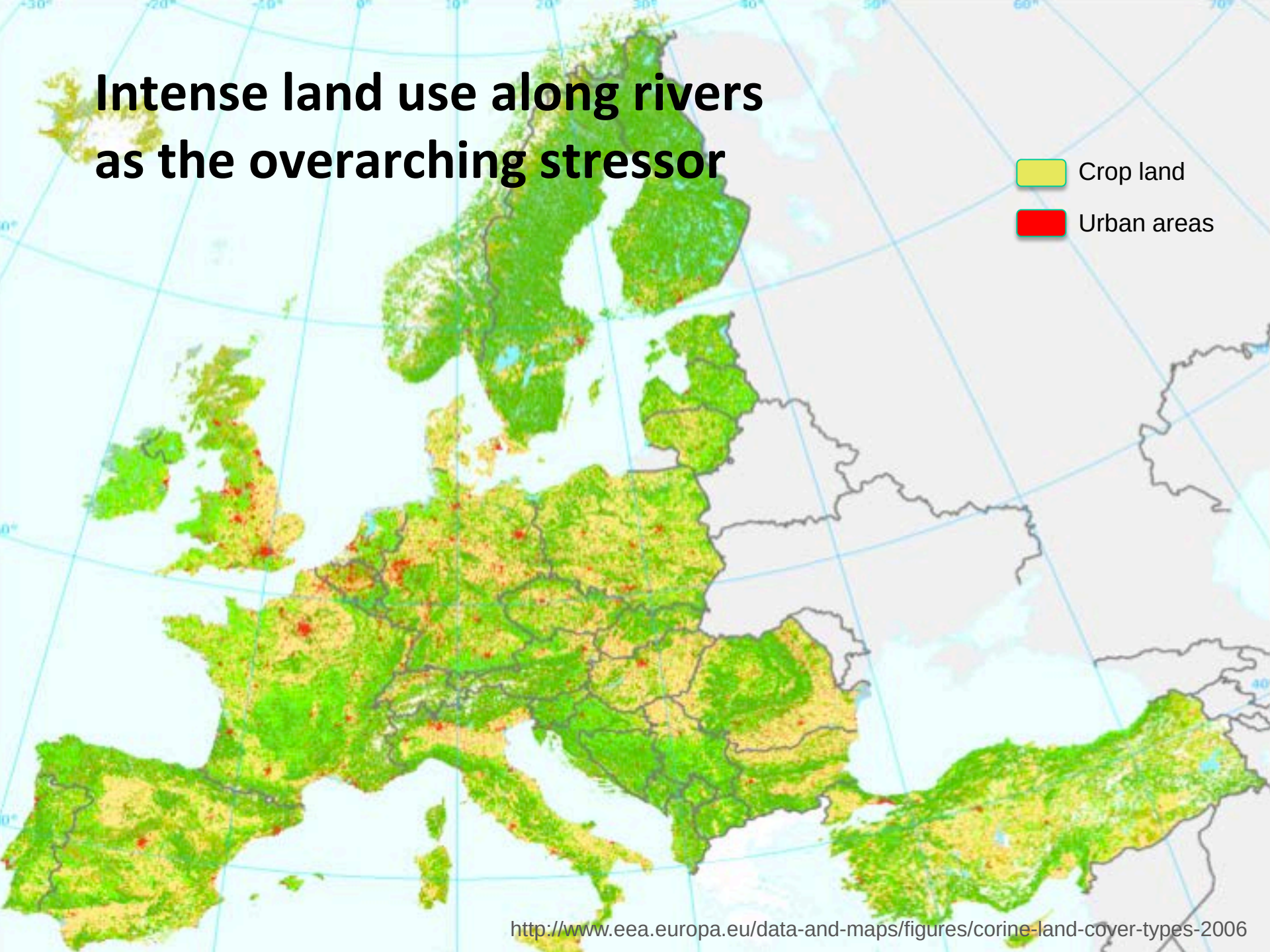
Macrophytes: Rhithral zones (carbonatic)



Macrophytes: Potamal zones, mountains

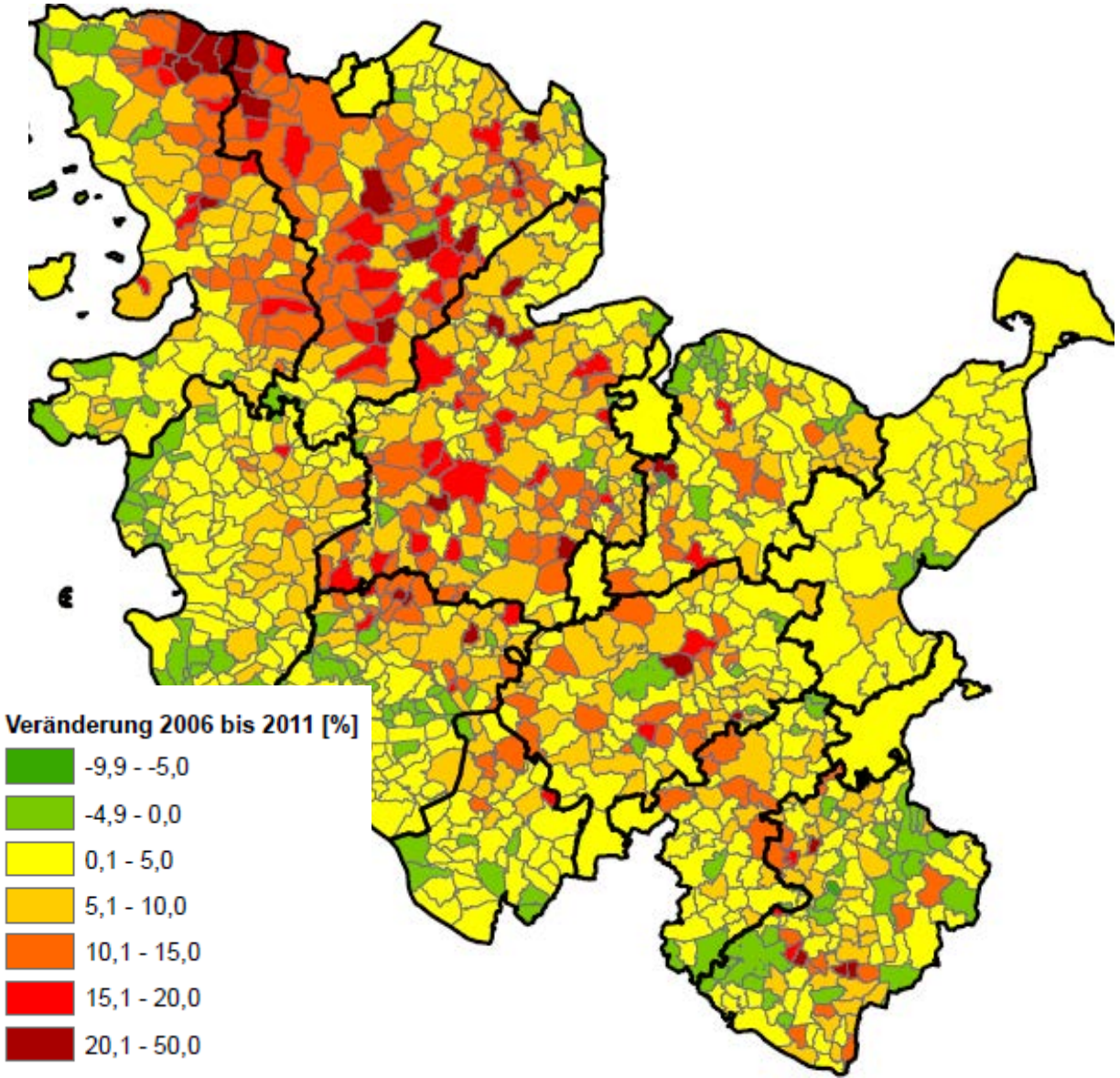
Water quality Land use in buffers Erosion potential

Intense land use along rivers as the overarching stressor



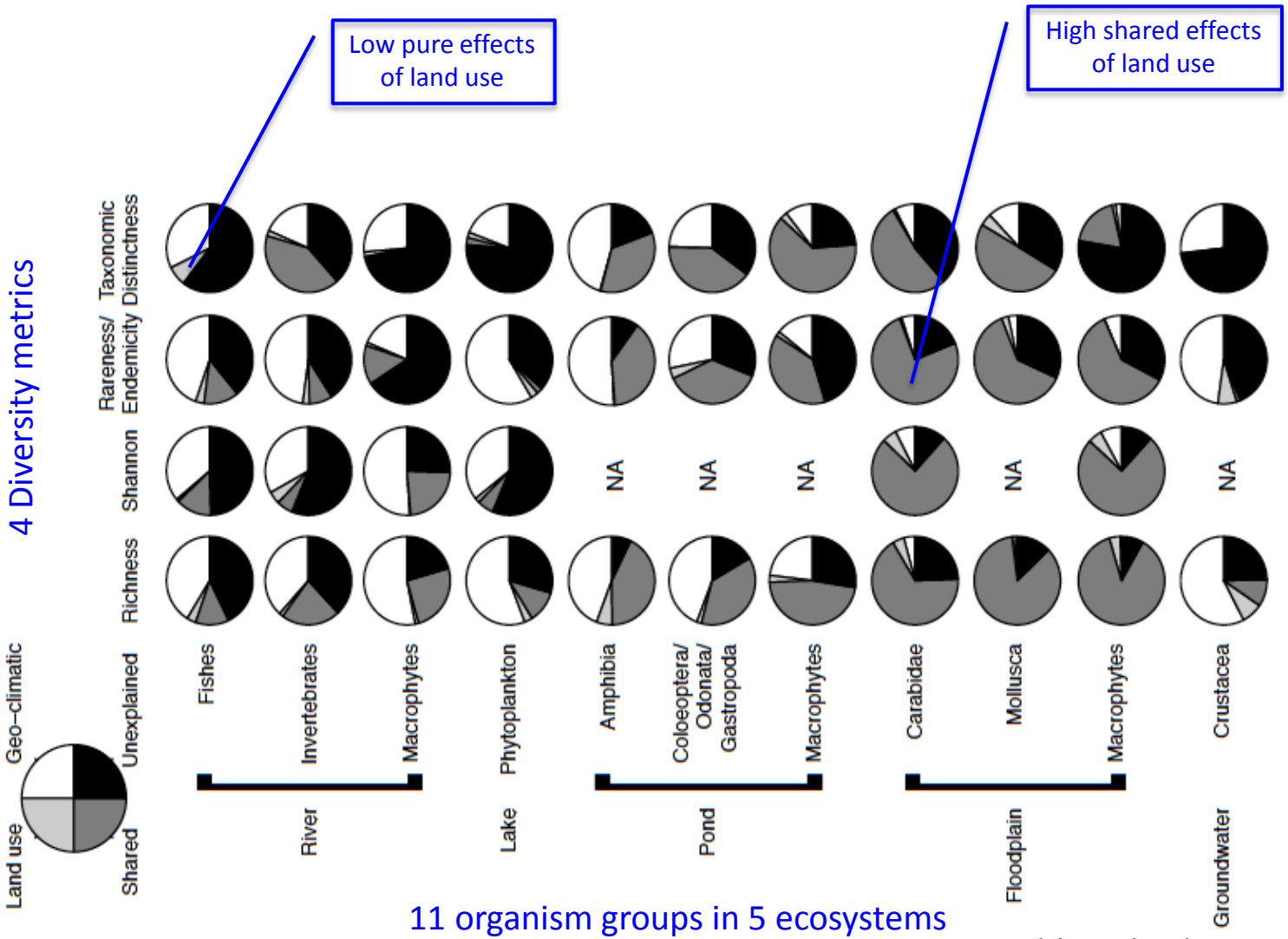
http://www.eea.europa.eu/data-and-maps/figures/corine-land-cover-types-2006

And it is getting more intense!



Change in the share of maize fields from 2006 to 2011 in Schleswig-Holstein

Intense land use homogenises biodiversity in most aquatic ecosystems



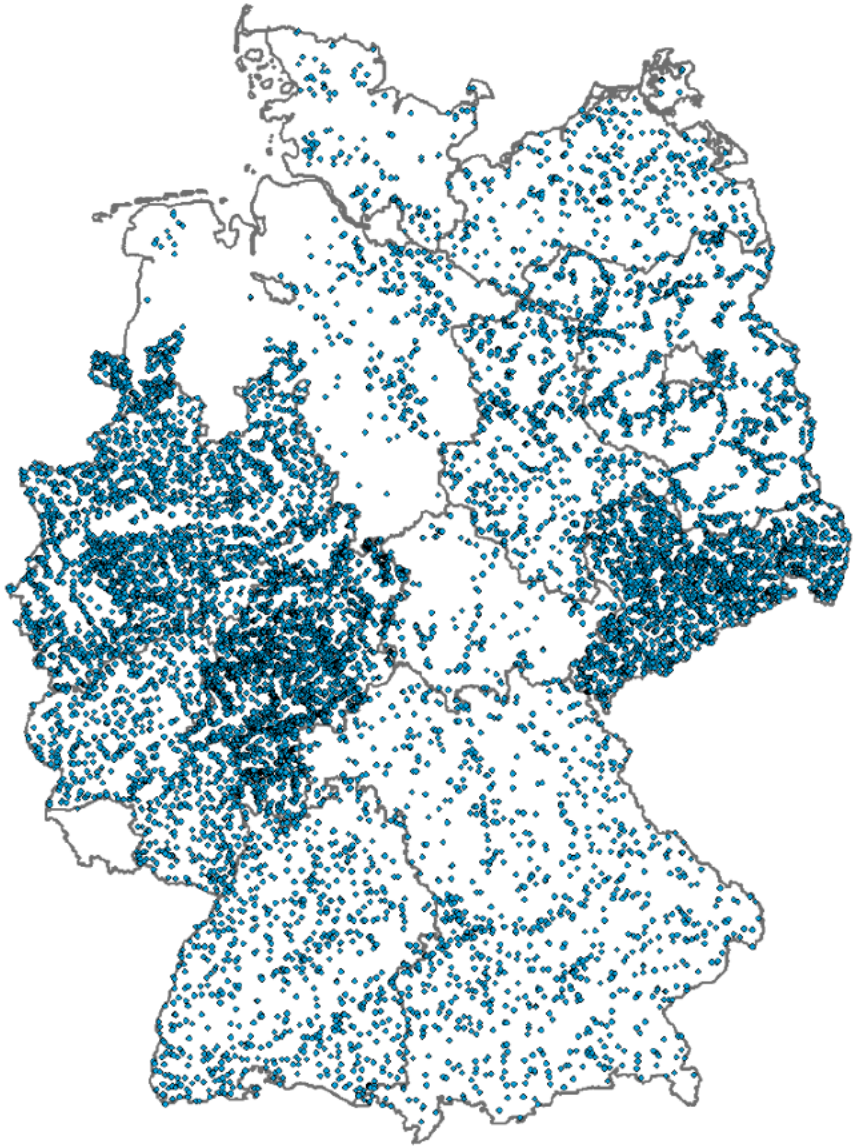
Feld et al., almost submitted

What's about recovery?

- Restoration will eventually not be successful without changes in riparian land use

- Time lags of 10-20 years to be expected once restoration has been performed, as recolonisation is needed

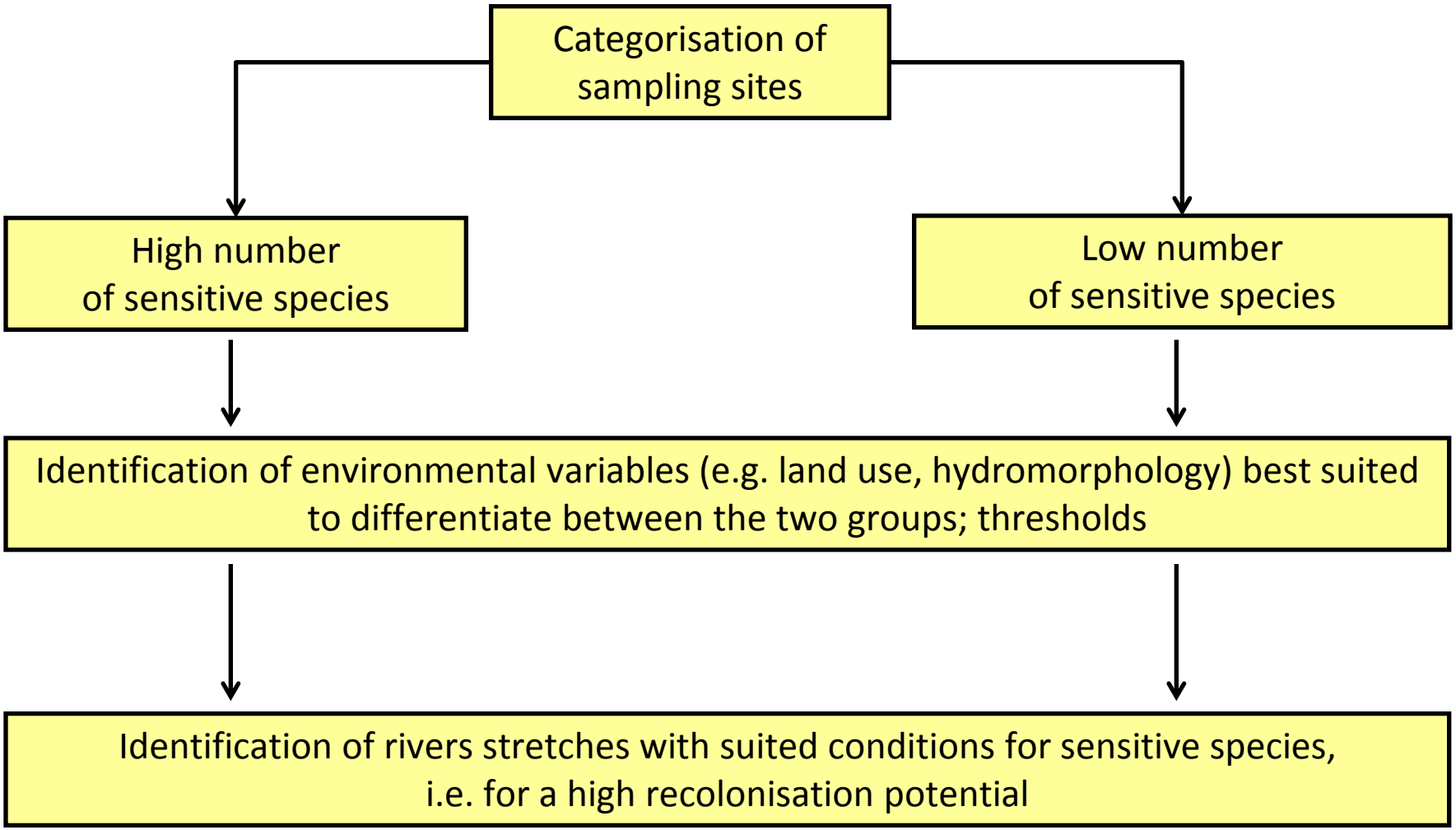
Modelling recolonisation potential



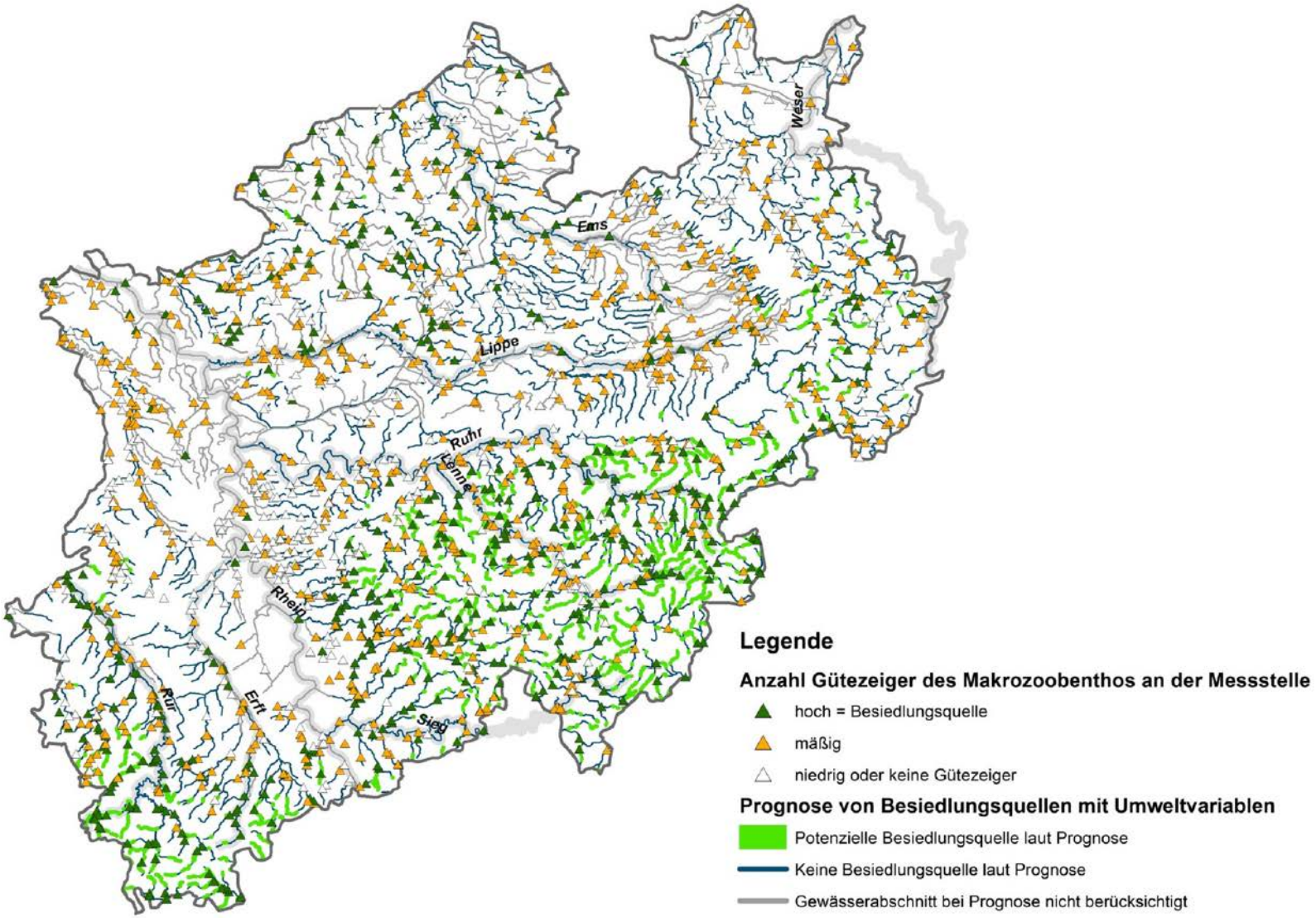
Data bases: 12,000 sampling sites from 12 federal states

Modelling recolonisation potential

Methode: Boosted Regression Trees



Modelling recolonisation potential



Conclusions

- At a first glance: Big mess of multiple interacting stressors causing complex cause-effect-chains

- At a second glance: Most currently important stressors are related to intense land use in riparian zones

- Riparian restoration as a relatively cost-effective option, but:

  - It requires struggle with agriculture
  - Effects will greatly differ regionally, due to different recolonisation potential

Picture by Matthias Brunke