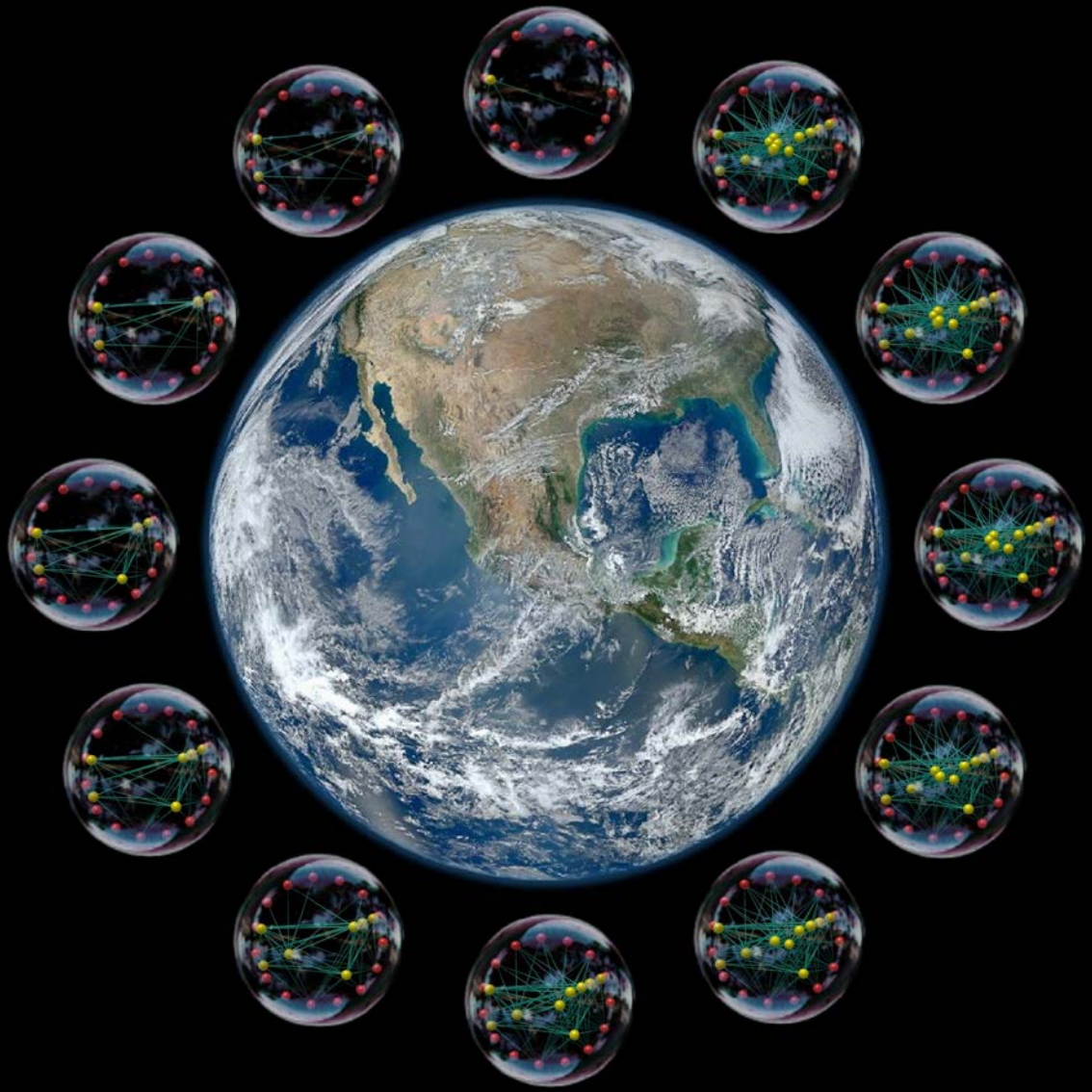
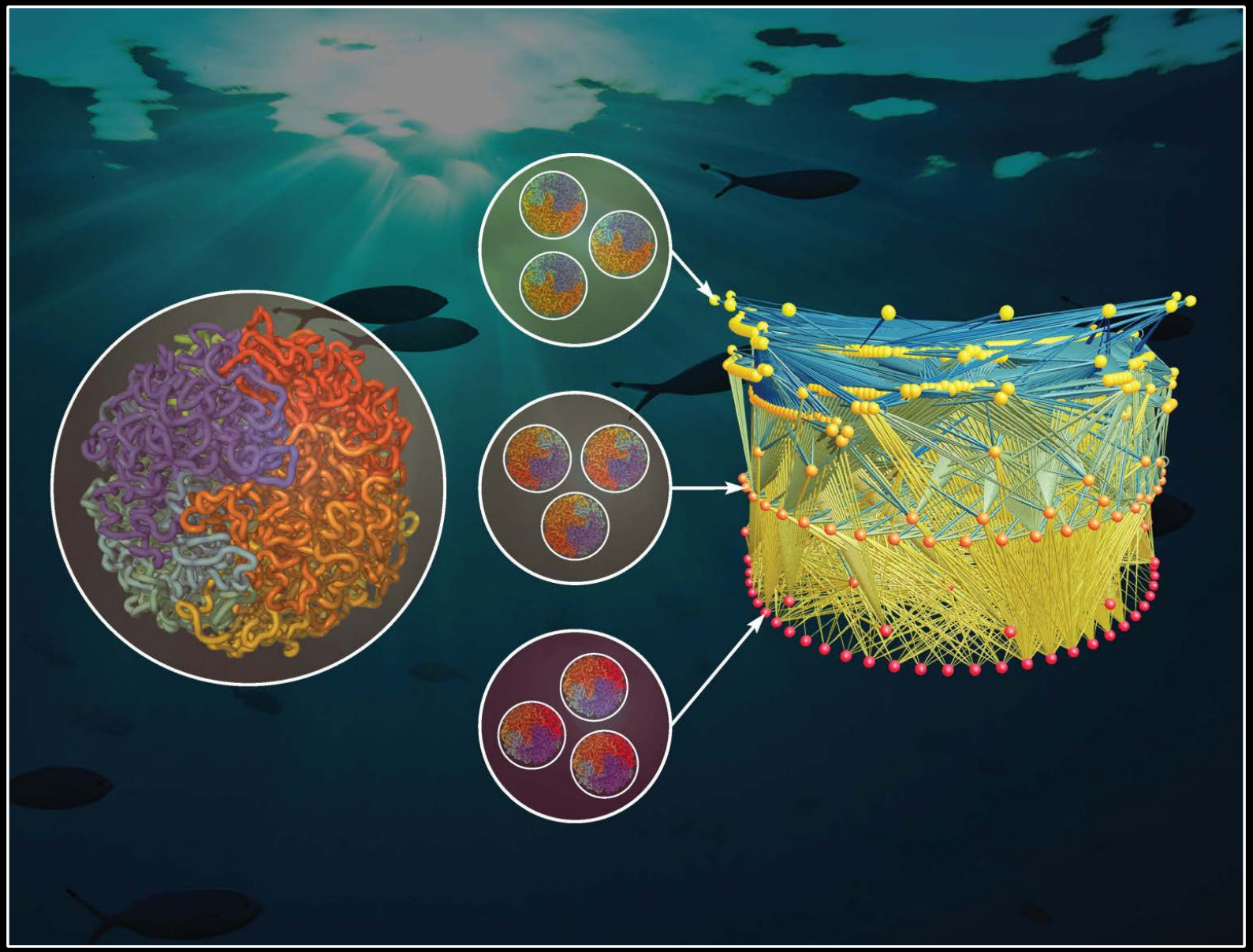
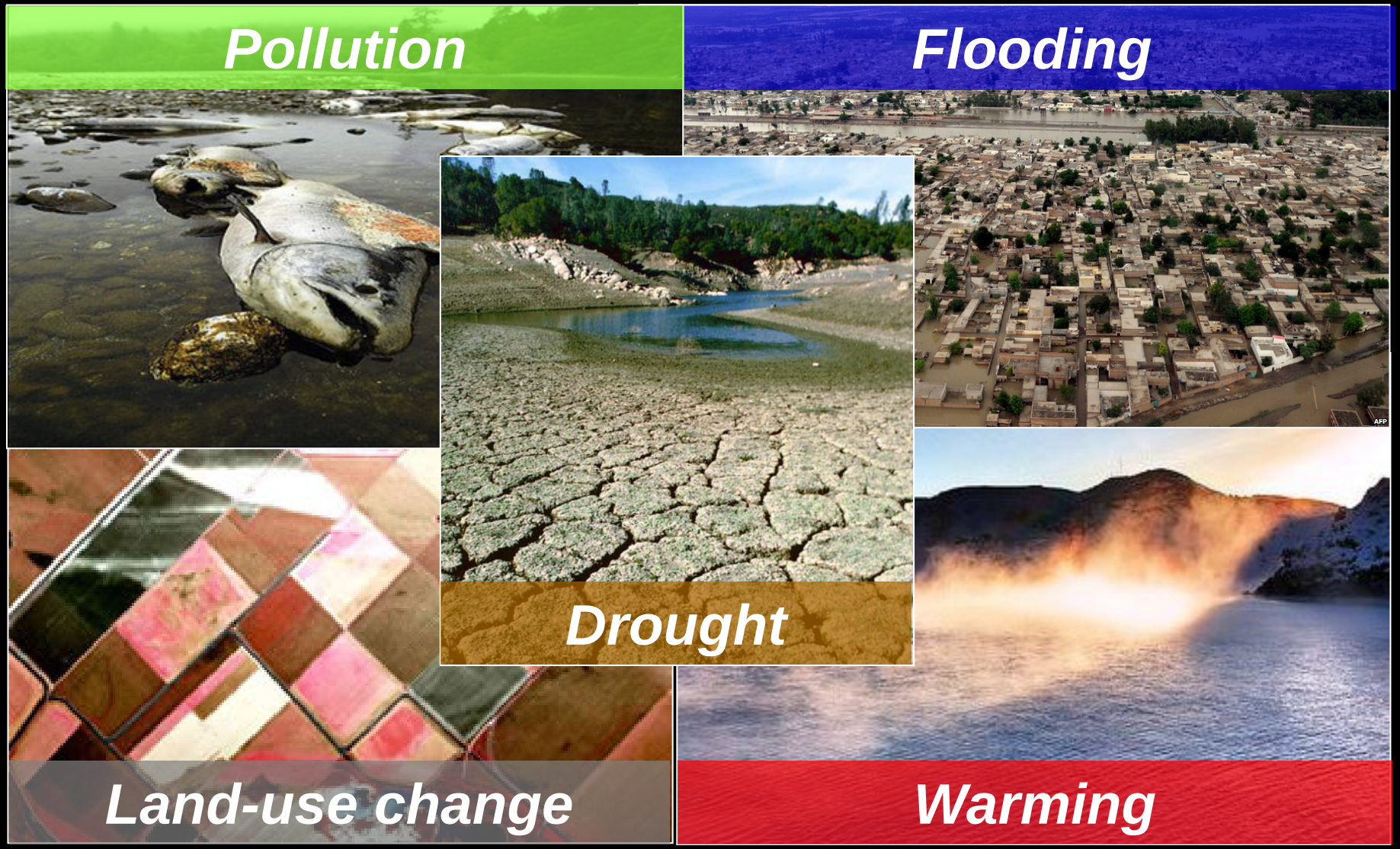
Biodiversity change - a network perspective (Guy Woodward, Imperial College London)



The biodiversity gap in biomonitoring - genes-to-ecosystems



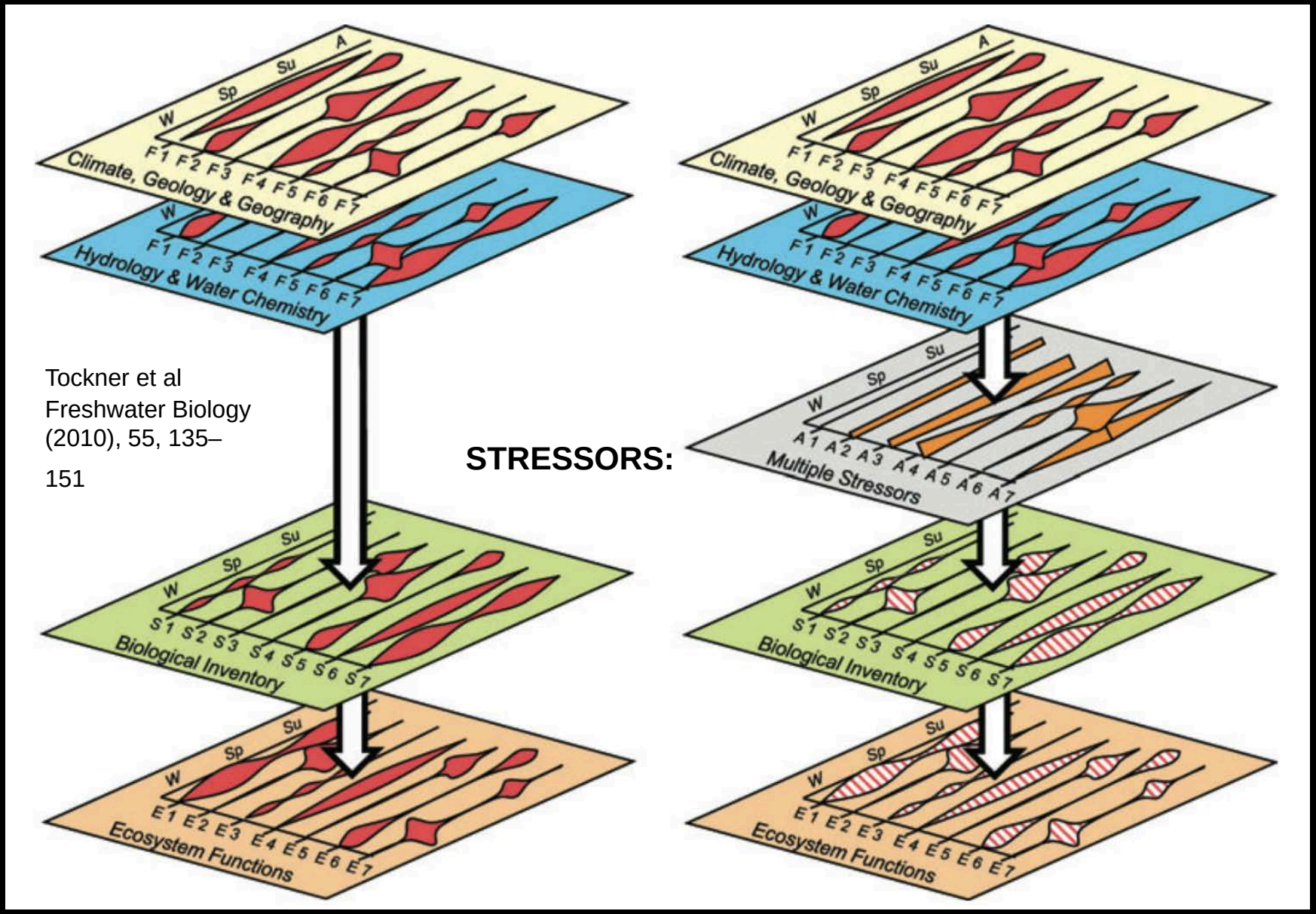
Challenges and opportunities for global biodiversity monitoring: freshwaters are exposed to a cocktail of stressors in the 21st century



National Governmental Biomonitoring Scheme

600 “RIVPACS” reference steam sites - species-level invertebrate data

Global-to-local abiotic and biotic filters reshape ecosystems



Tockner et al
Freshwater Biology
(2010), 55, 135–
151

STRESSORS:

Non-random biodiversity loss in the food web

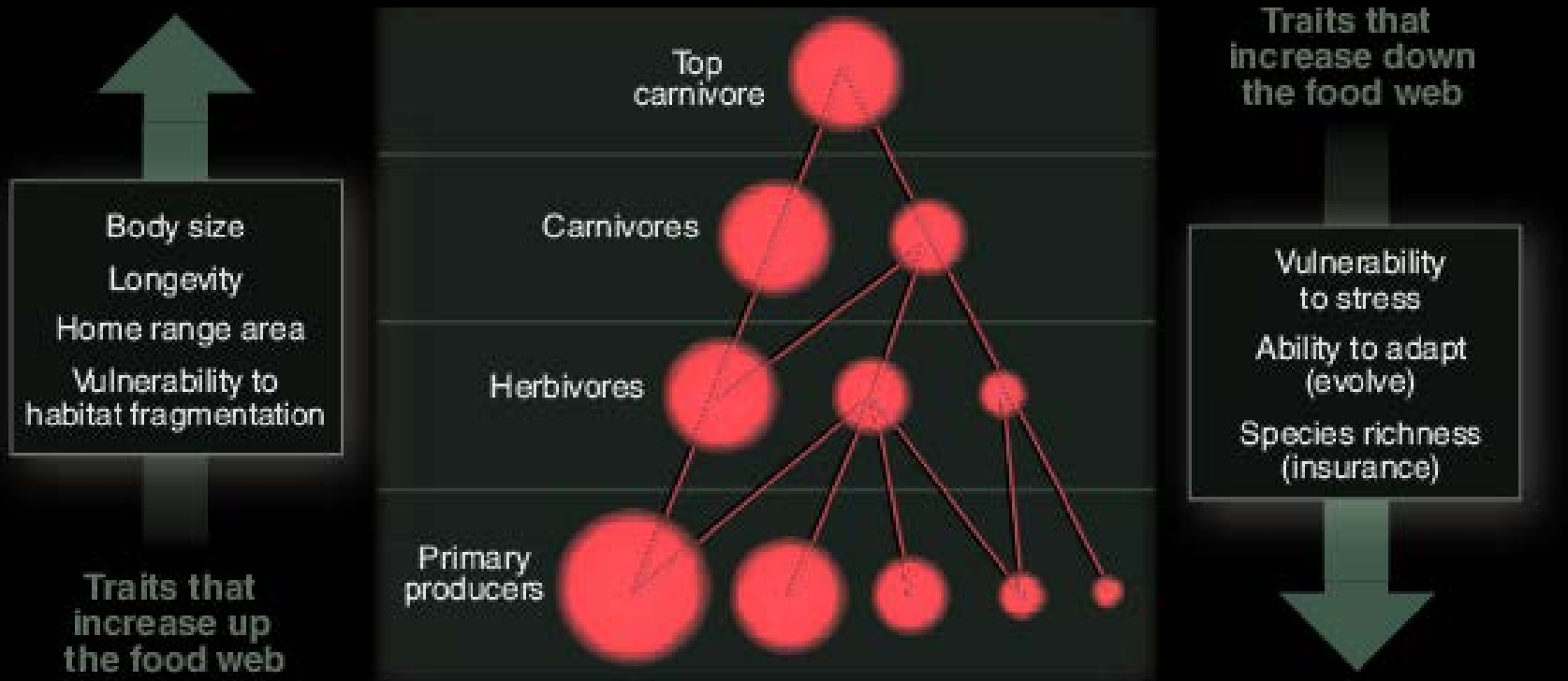
ECOLOGY

SCIENCE VOL 306 12 NOVEMBER 2004

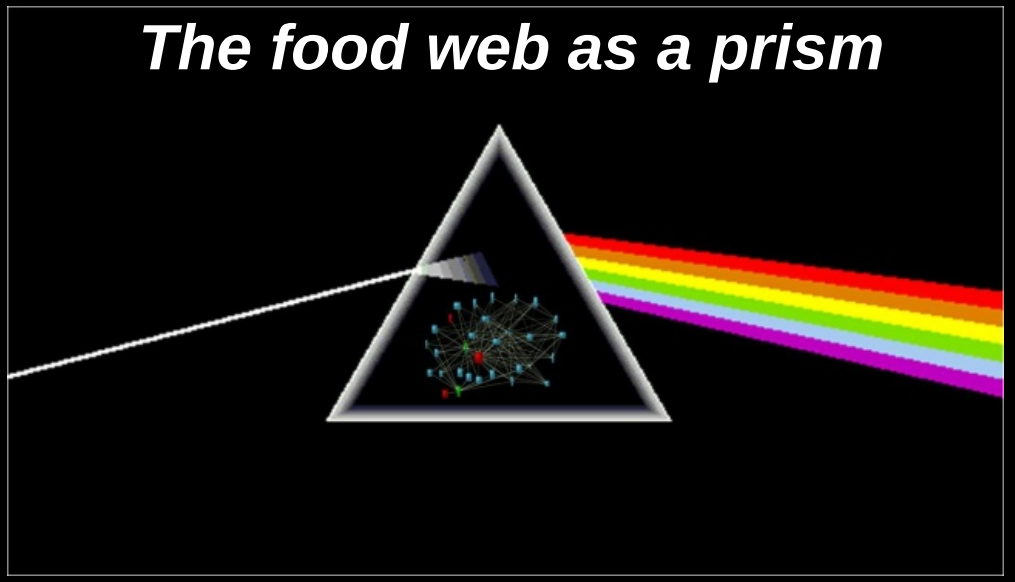
How Extinction Patterns Affect Ecosystems

David Raffaelli

"…effects of biodiversity loss… will depend largely on the order in which species are lost, which in turn is determined by the susceptibilities of ecosystems to different types of stresses"



Biodiversity is far more than just species richness



EXTRINSIC DRIVERS
- nutrients
- pH
- etc.

BIODIVERSITY

SPECIES TRAITS

ABUNDANCE

INTERACTIONS

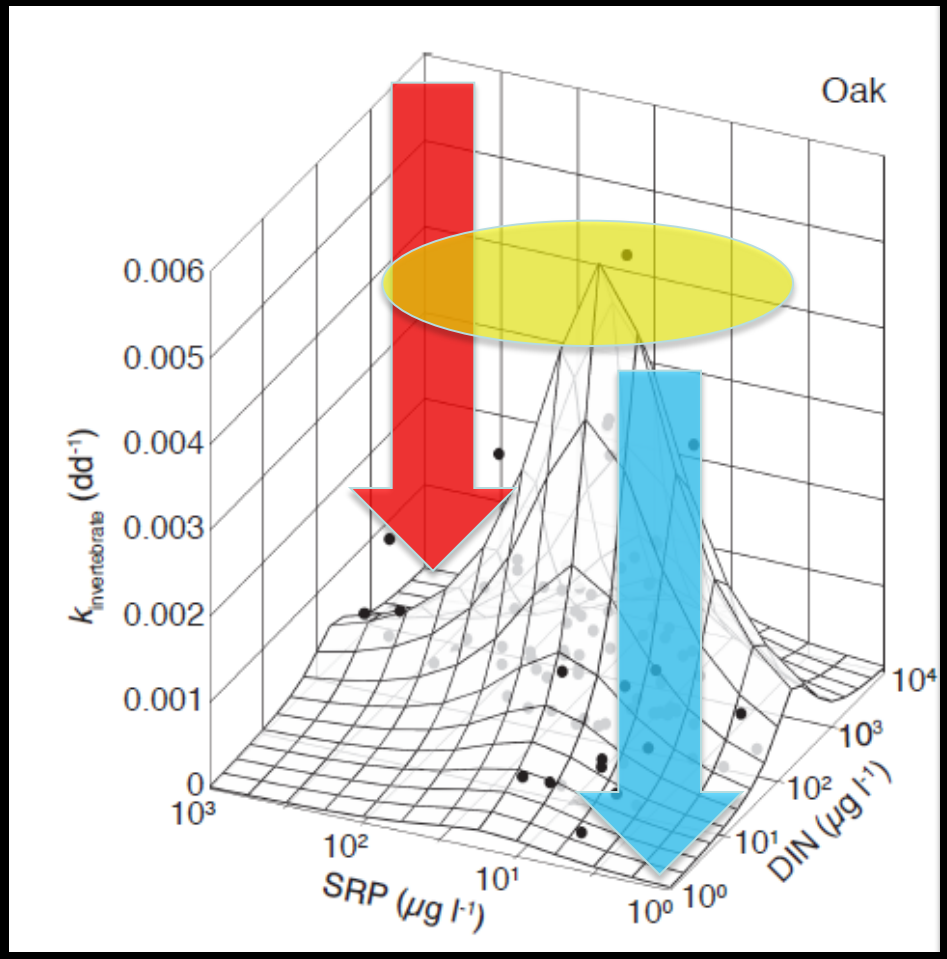
FOOD WEB
- web size
- no. links
- link strength

ECOSYSTEM PROCESSES
- decomposition
- biomass production

ECOSYSTEM GOODS & SERVICES

Provision of drinking water
Climate regulation
Maintenance of viable fisheries

Ecosystem functioning in the "Goldilocks Zone"



Woodward et al (2012) *Science*

Decomposition rates across Europe are constrained by nutrient limitation and toxic effects at either extreme - the "just-right" Goldilocks zone lies in the middle where biodiversity effects are at play

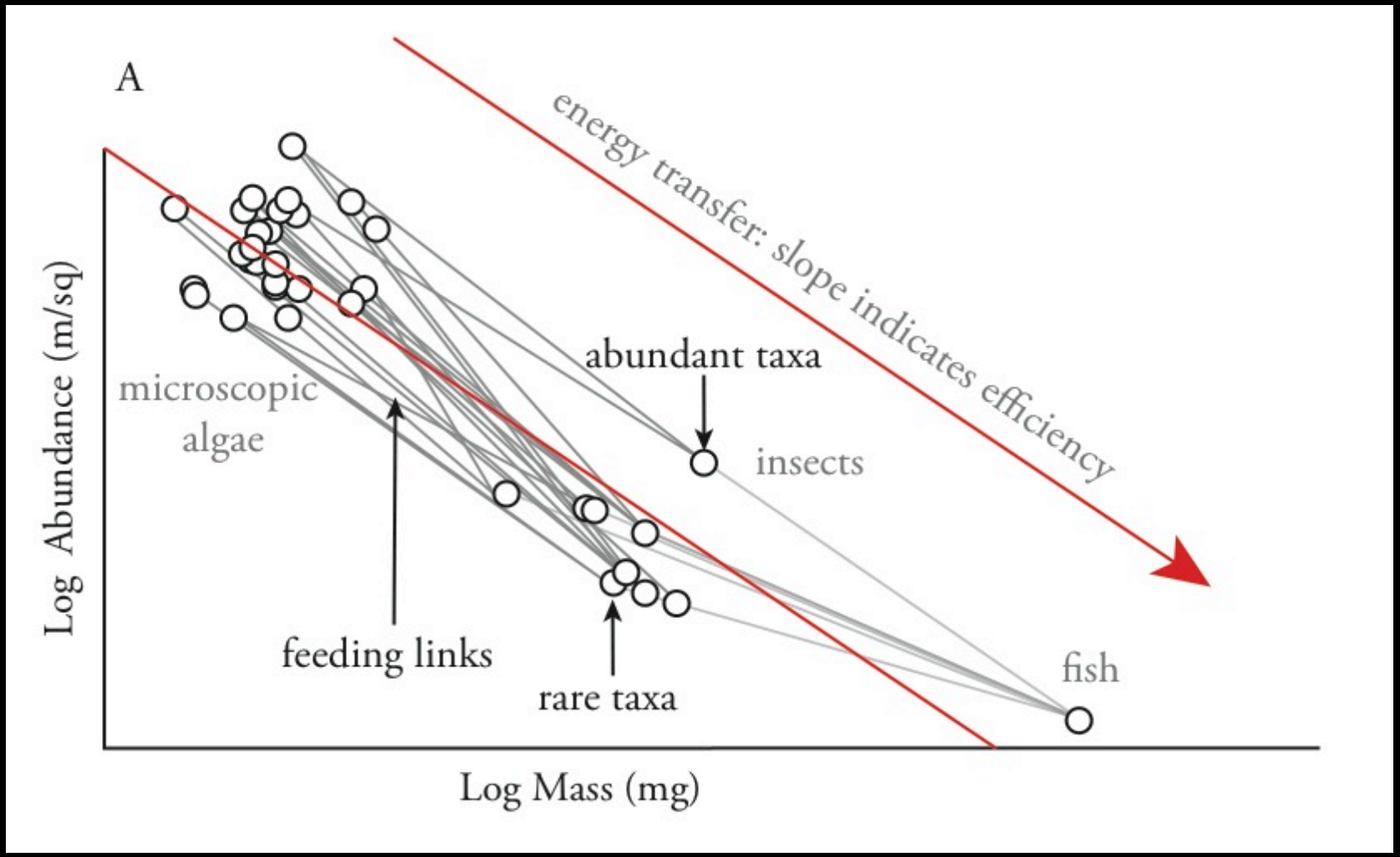
Collecting freshwater food web biomonitoring data (not rocket science)

Stones scrapes: algal community

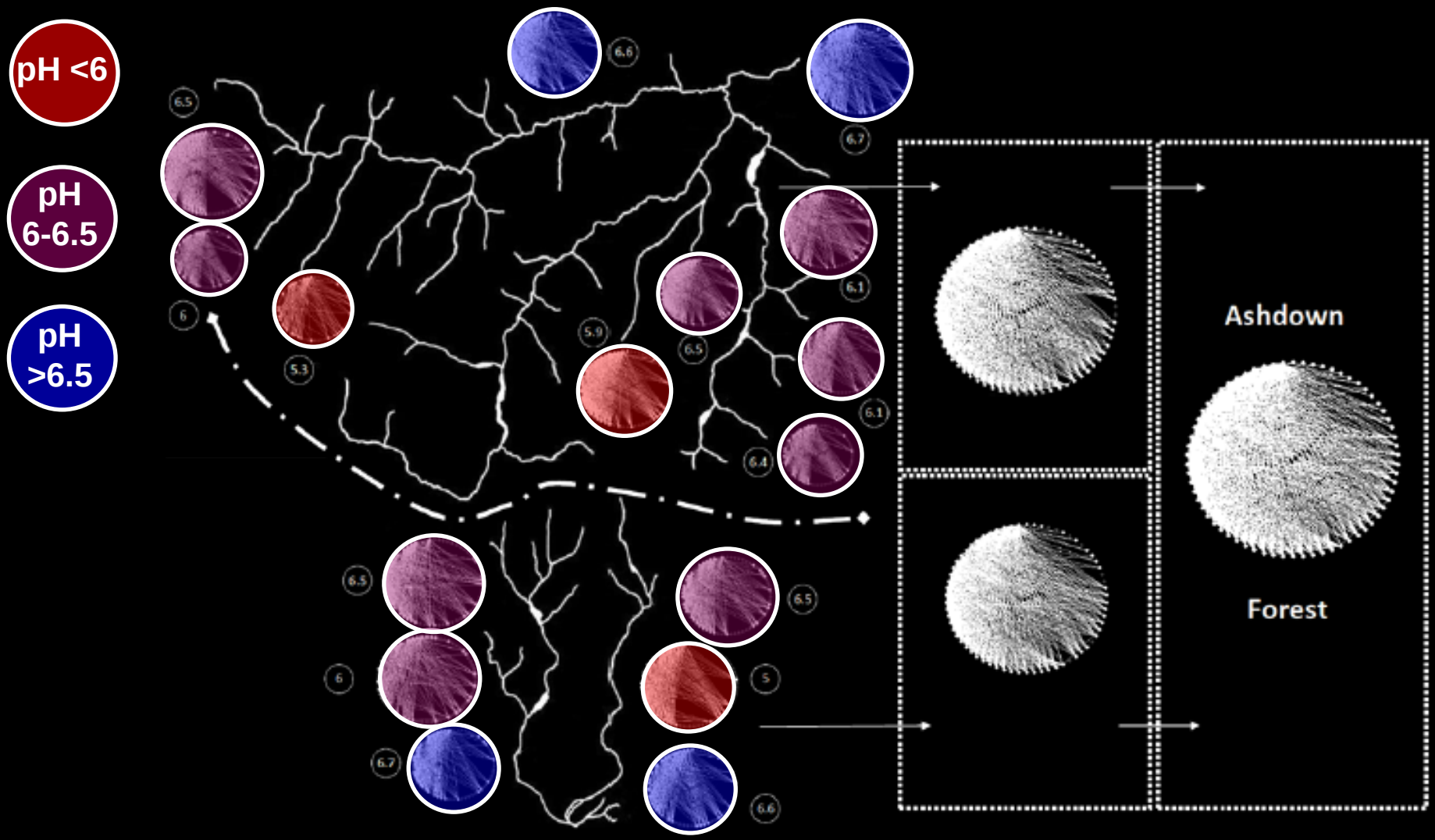
Hess sampler: invertebrates

Electrofishing between stop nets

The food web provides multiple levels of biosensing the environment – and offers a "taxon-free" global approach

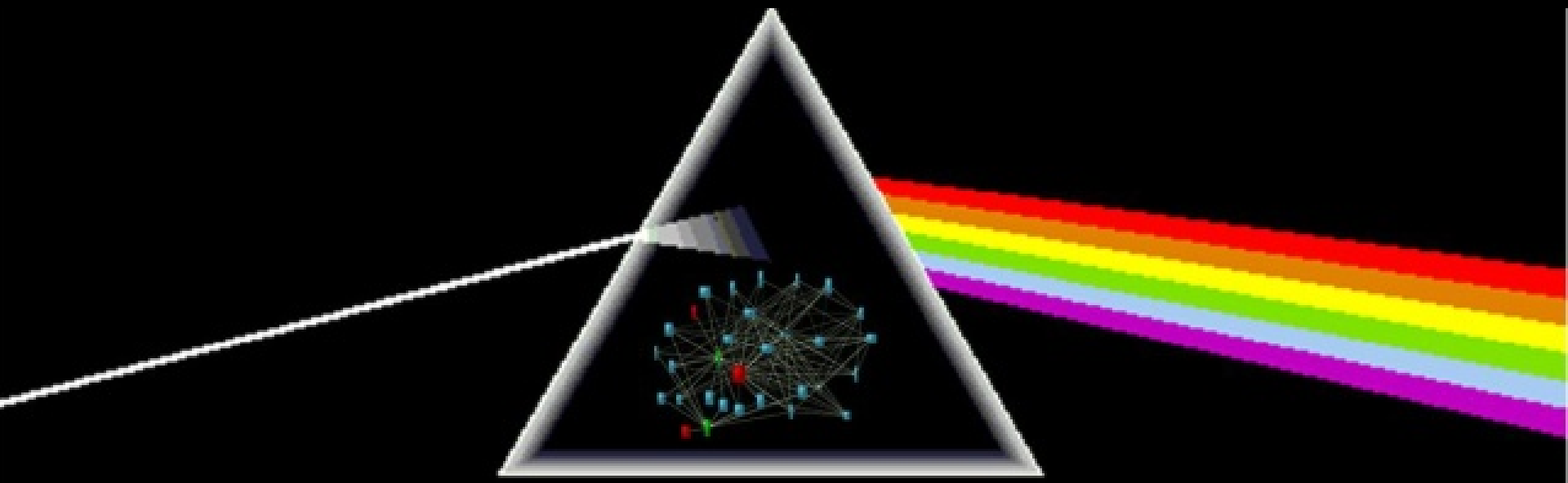


Freshwater food webs are filtered through pH gradients in the landscape



Hagen et al Adv. Ecol. Res. 2012

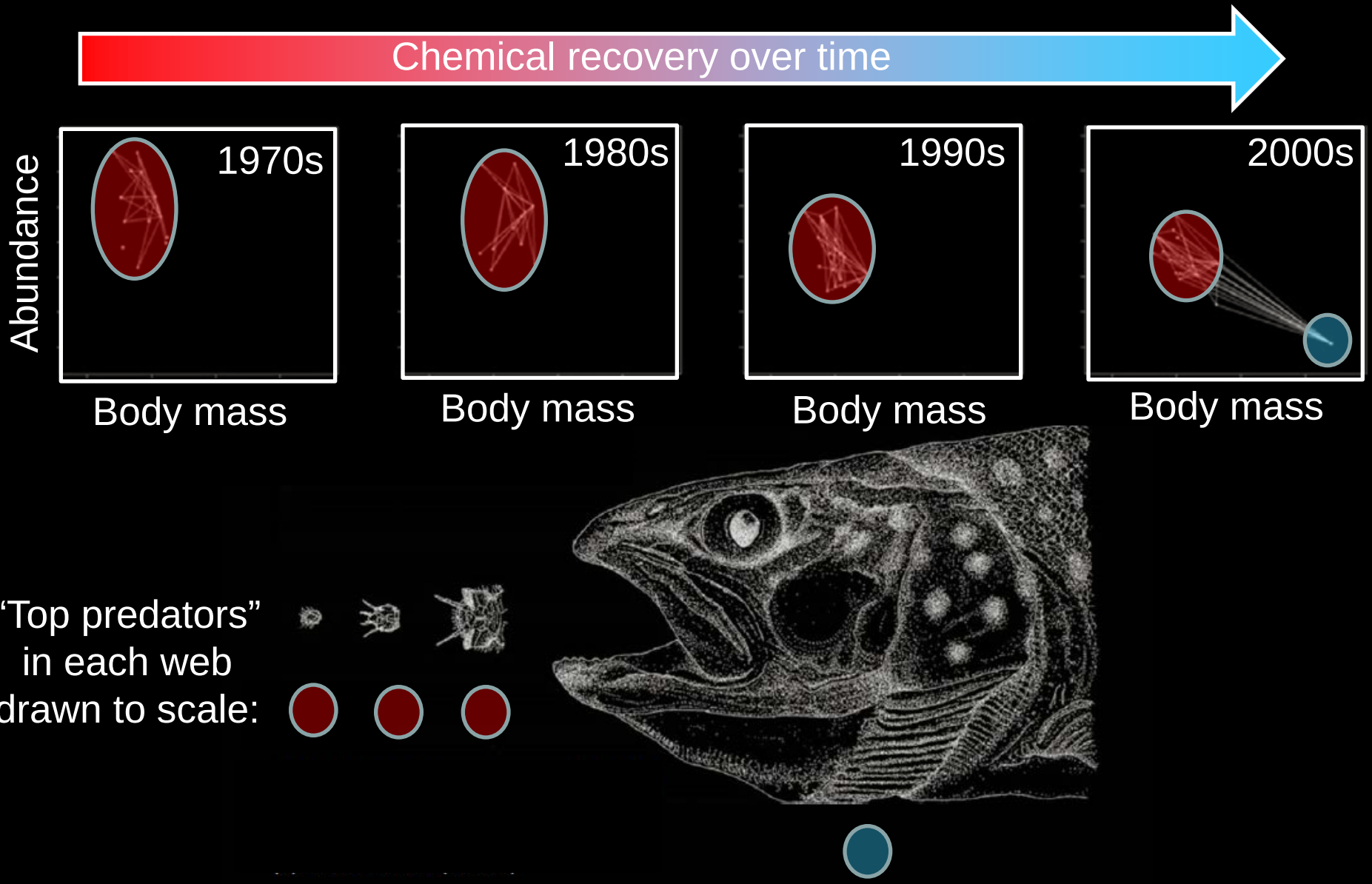
The food web modulates local biodiversity within these templates



“*nothing makes sense unless one thinks in terms of food webs*”

(Referee X)

Case Study: declining invertebrate numbers BUT return of trout as food web recovers from acidification



Biodiversity: what we can measure versus what we do…

Taxonomic diversity (often species richness, *S* – but not the only measure)

Functional diversity - autecological traits

Body mass (*M*), numerical abundance (*N*), biomass (*NxM* = *B*)

Trophic interactions (*C, L, etc*) – synecological traits

Ecosystem functioning

Most studies measure just one or two of these variables, giving an incomplete view – biomonitoring has focussed on S.

New NERC Duress Project spans >400 upland streams…see talk by Isabelle Durance tomorrow

EA catchments:
More than 400 catchments for which large scale data on invertebrates, fish, birds and land use are available for the past 20 years

Historical sites:
A set of 99 sites across upland Wales from which land use and historical invertebrate, fish and bird data are available. Used for resilience analysis

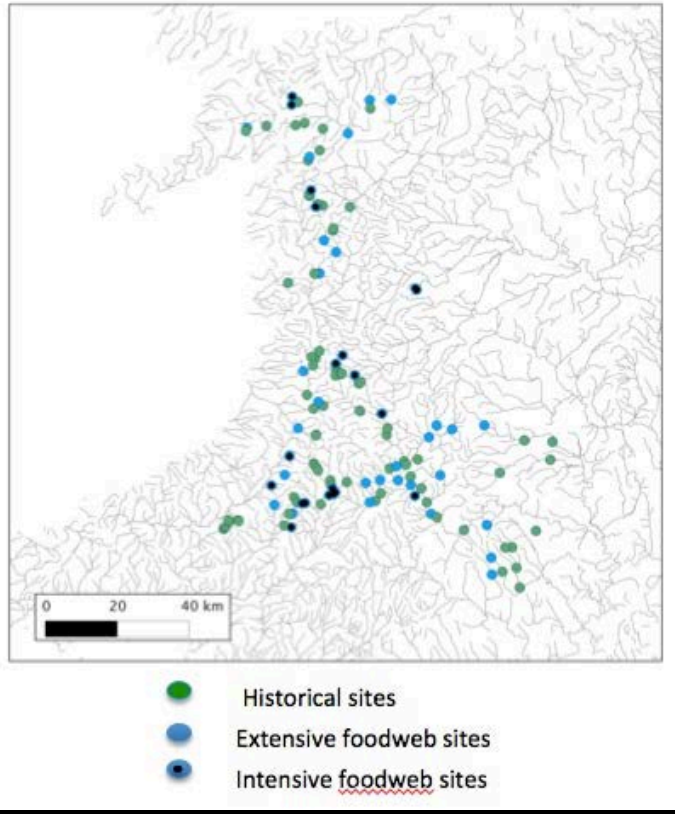
Extensive food web sites:
A subset of 50 sites across upland Wales along a gradient of water quality, land use, altitude where food web, fish and genetic analysis will take place

Intensive food web sites:
A subset of 20 sites where detailed food web and fish population analysis will be performed

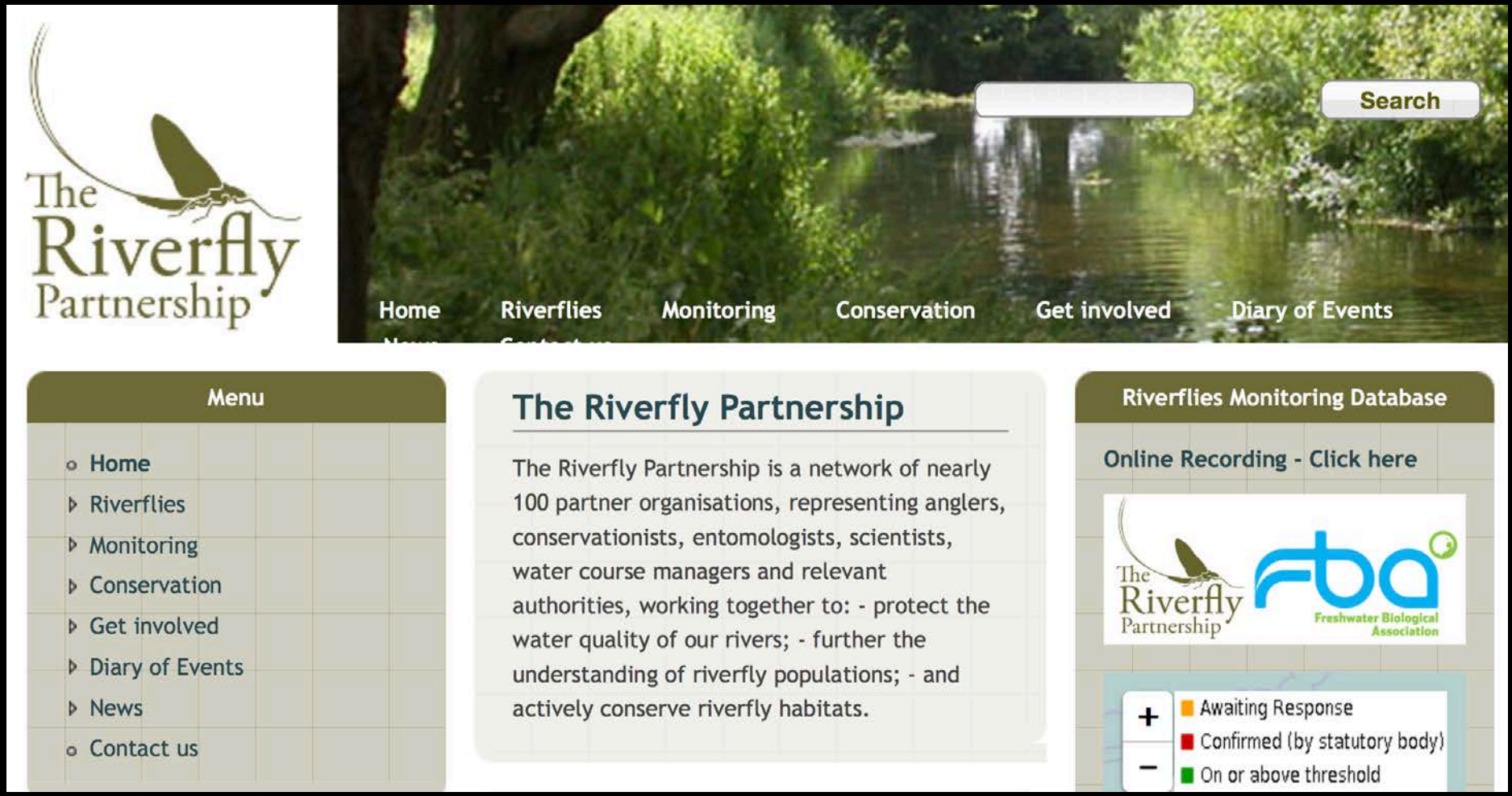
Dynamic sites:
A subset of 8 sites to test the resilience of invertebrate and biofilm communities under different land uses

Experimental sites:
A subset of 6 replicate streams, 3 moorland streams and 3 conifer streams, to test the impact of N, C and litter addition

A multi-scale approach



National Citizen Science Biomonitoring Scheme



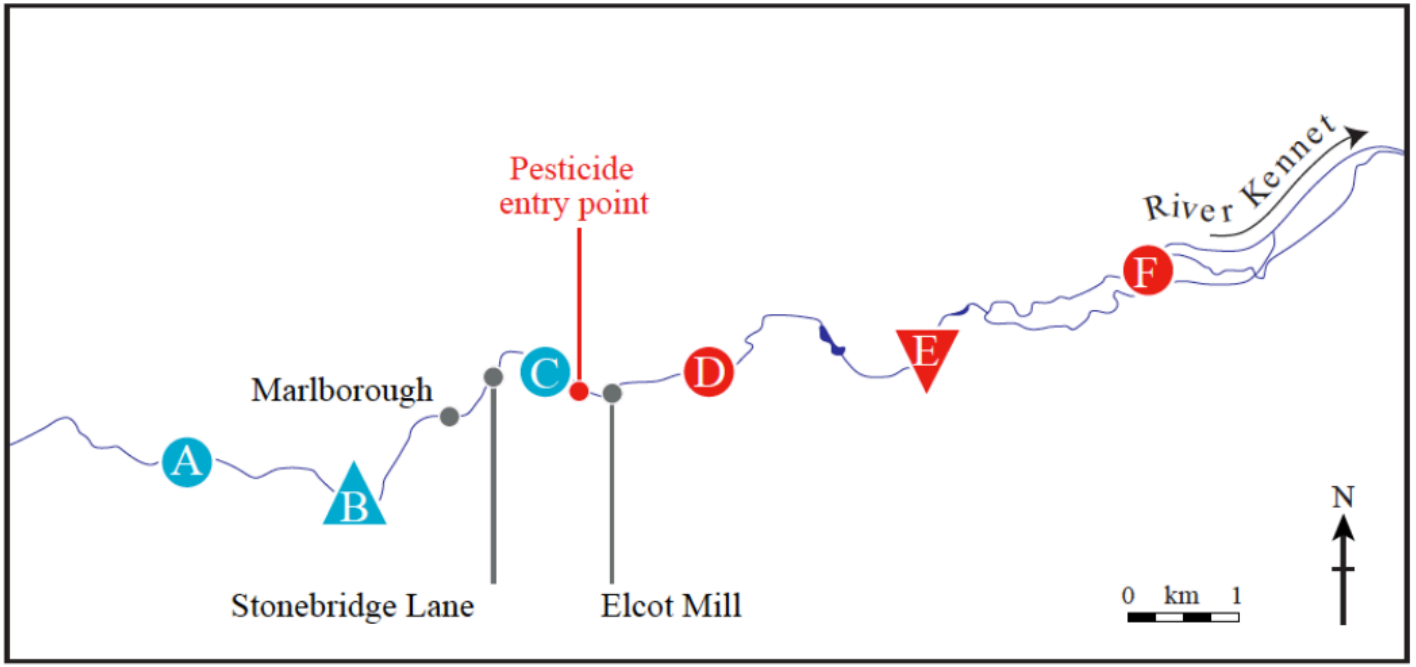
Regional Citizen Science Biomonitoring Scheme

Home

Welcome to Action for the River Kennet

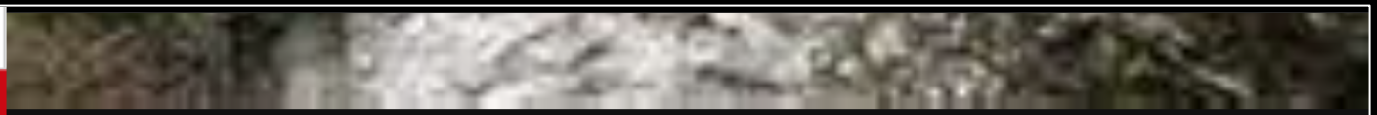
The River Kennet is one of England's most important chalk streams. Some 45 miles long, it is the largest tributary of the Thames and in summer months contributes up to half its flow.

Biomonitoring gene-to-ecosystem responses to a catastrophic pesticide spill in a UK river in 2013 – 15km of invertebrate life wiped up



BBC News

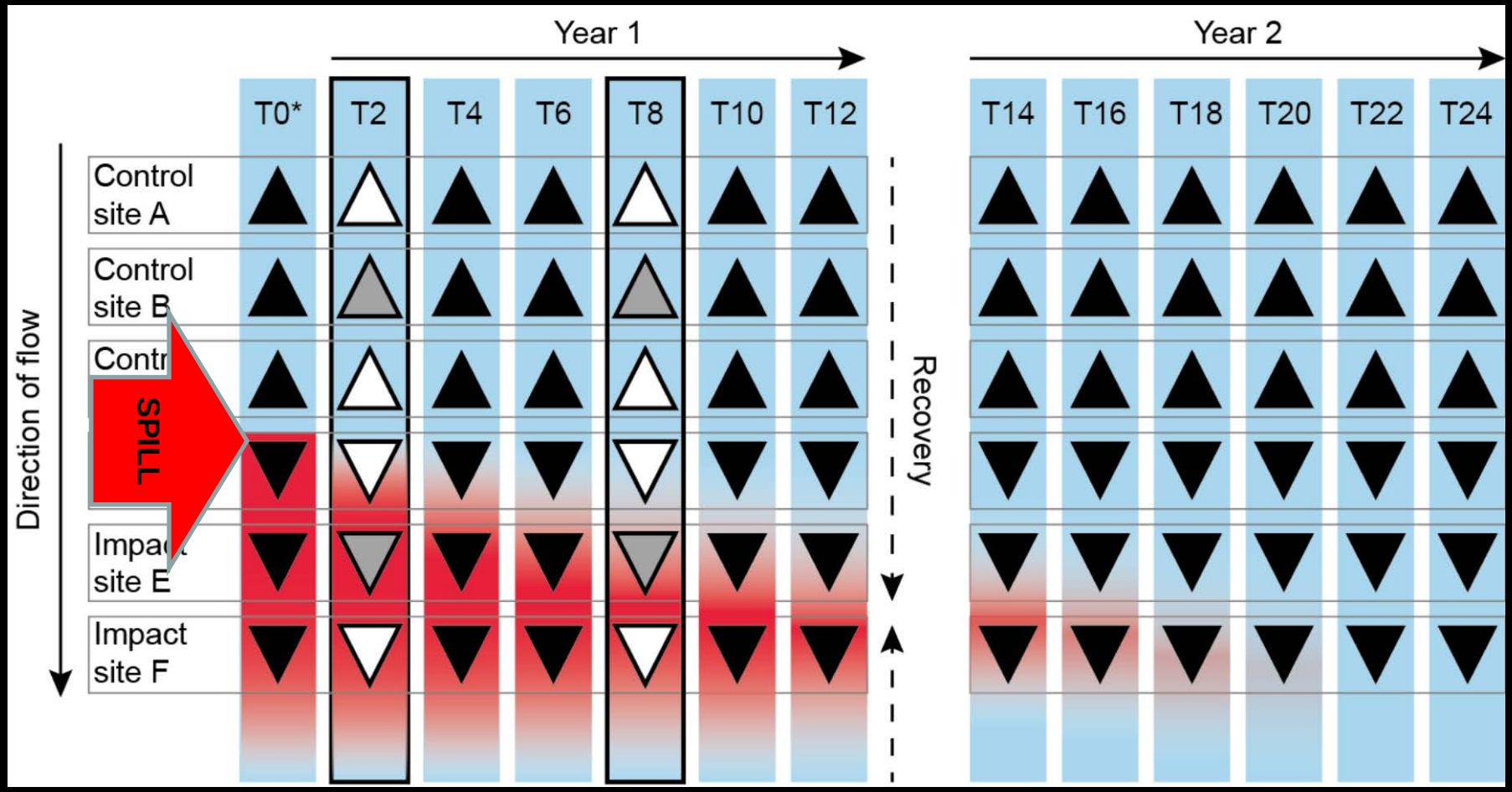
NEWS



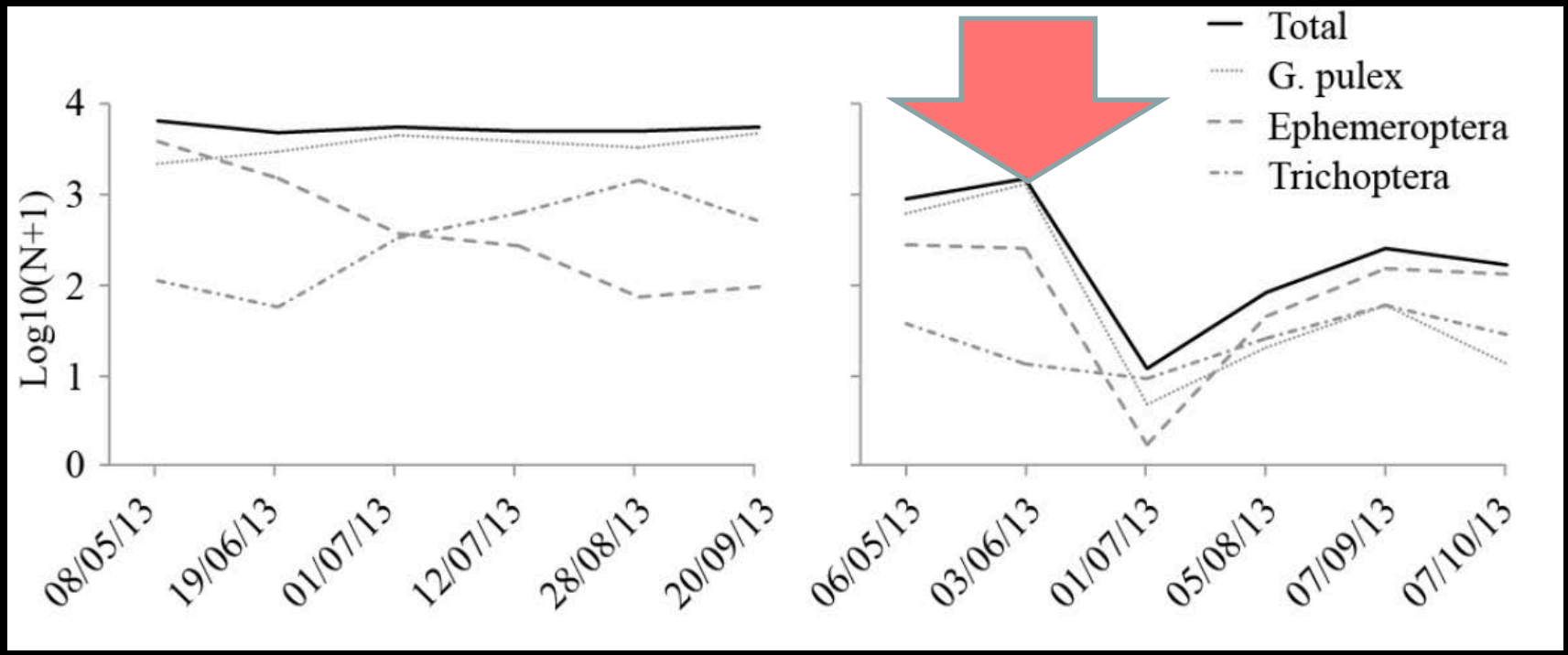
Richard Benyon, also the MP for Newbury, lives near the River Kennet

River Kennet pesticide pollution prompts call for ban

Working with Citizen Scientists to monitor impacts and recovery of biodiversity

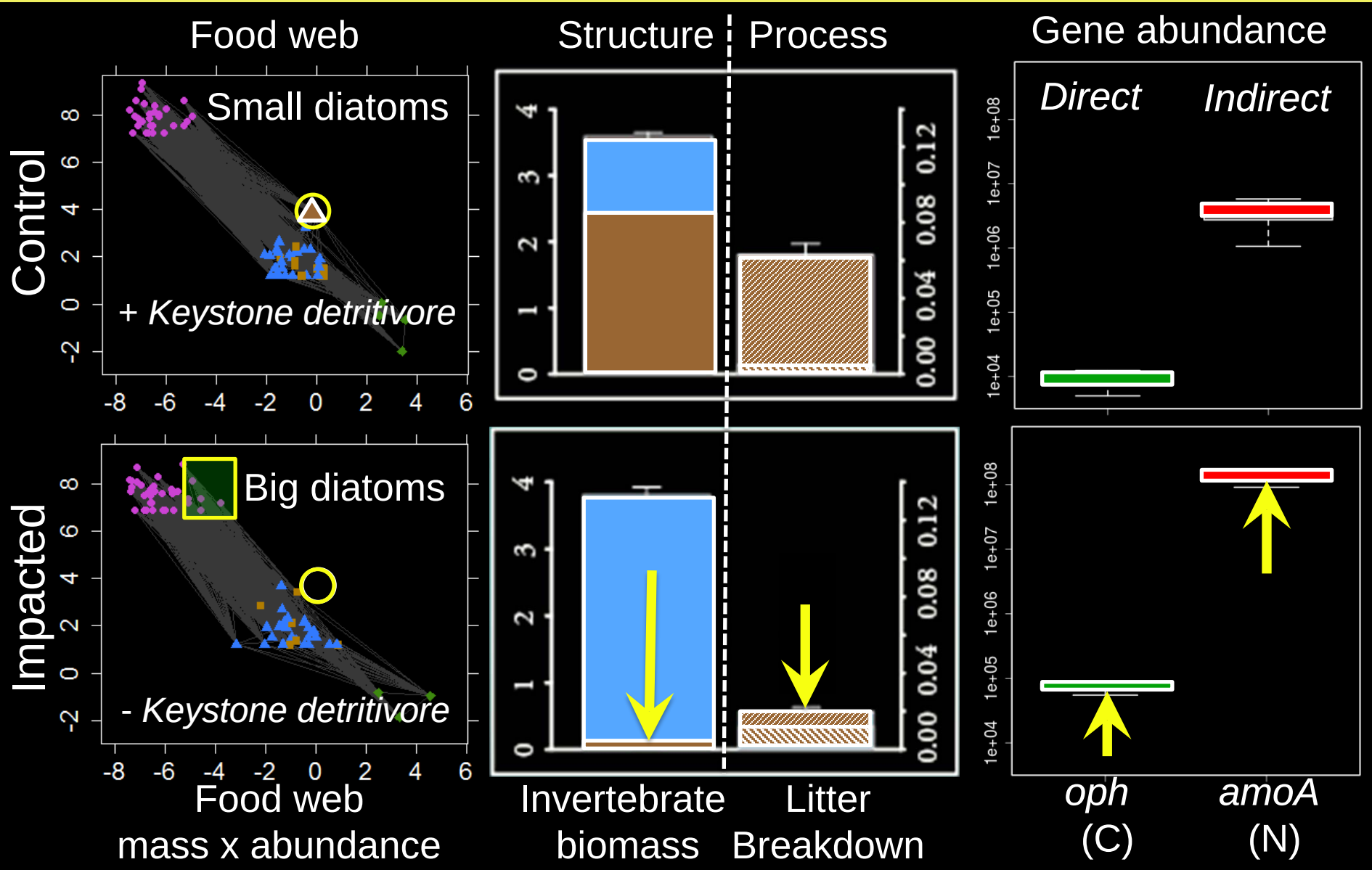


Invertebrate populations crash following a catastrophic pesticide spill (2013)

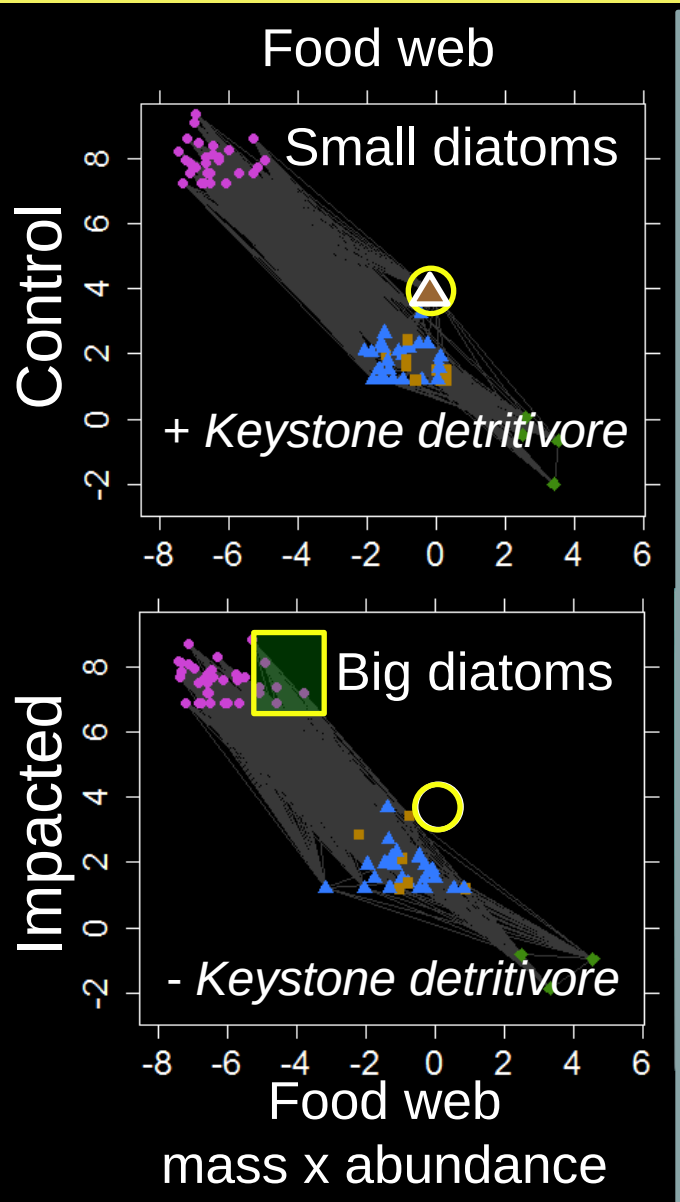


"riverfly" indicators revealed the smoking gun

Gene-to-ecosystem responses



Food web responses – loss of top-down effects



Orders of magnitude increase in diatom cell sizes – as grazers are stripped out of the web

Keystone species (e.g. *Gammarus* shrimps) wiped out as nodes are lost from the network…

Invertebrate biomass

Litter Breakdown

oph (C)

amoA (N)

Structure & function
- impacts on "brown pathways" in the food web

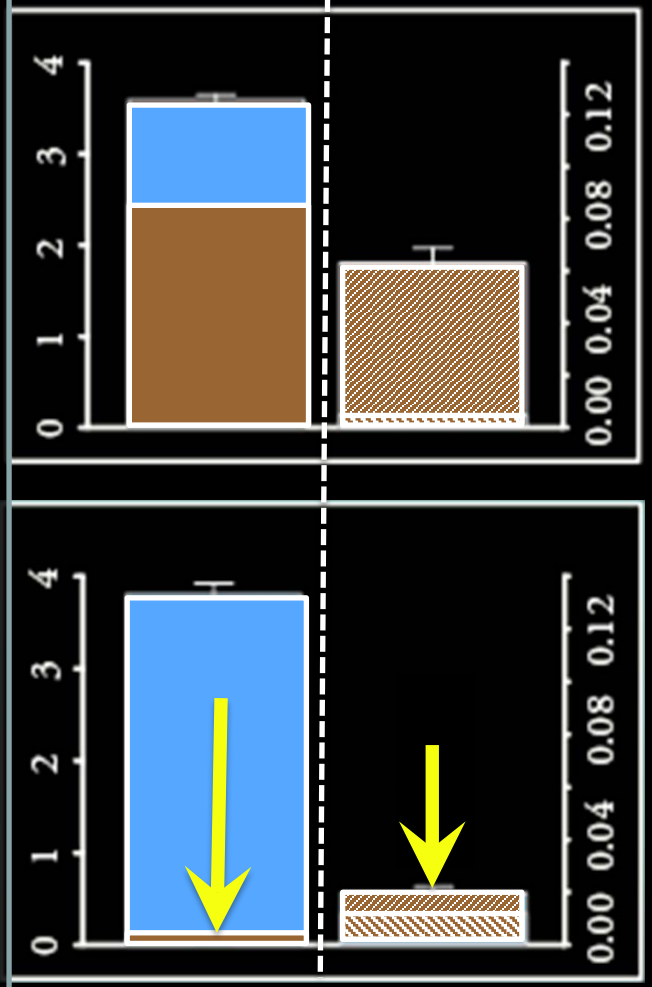
Food web

Compensatory response as community shifts towards dominance by small taxa as large keystone species are lost……

Food web

mass x abundance

Structure | Process

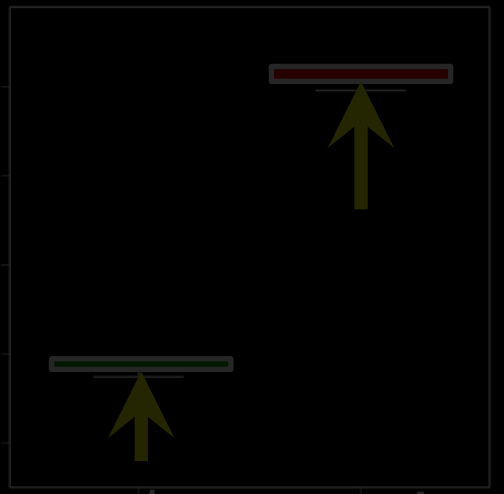


Invertebrate biomass

Litter Breakdown

Gene abundance

Microbial processes dominate detrital processing in absence of large detritivores….

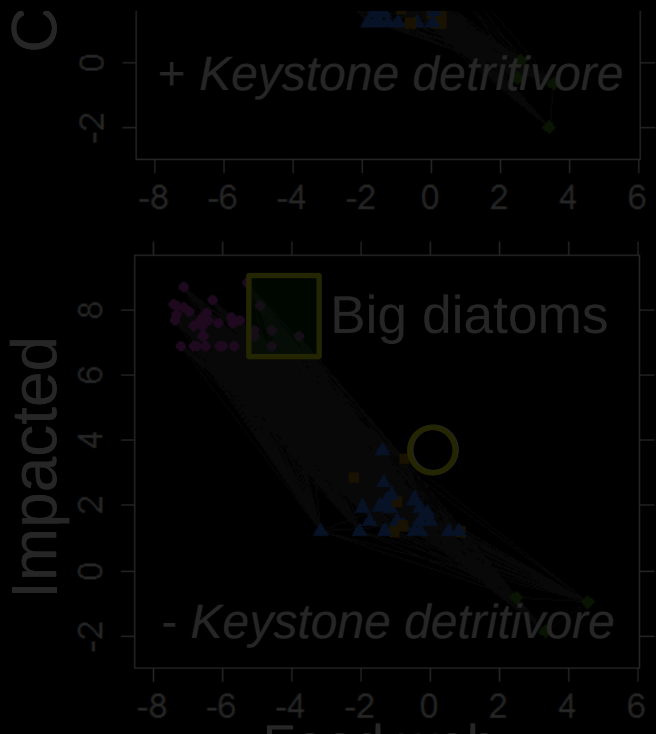


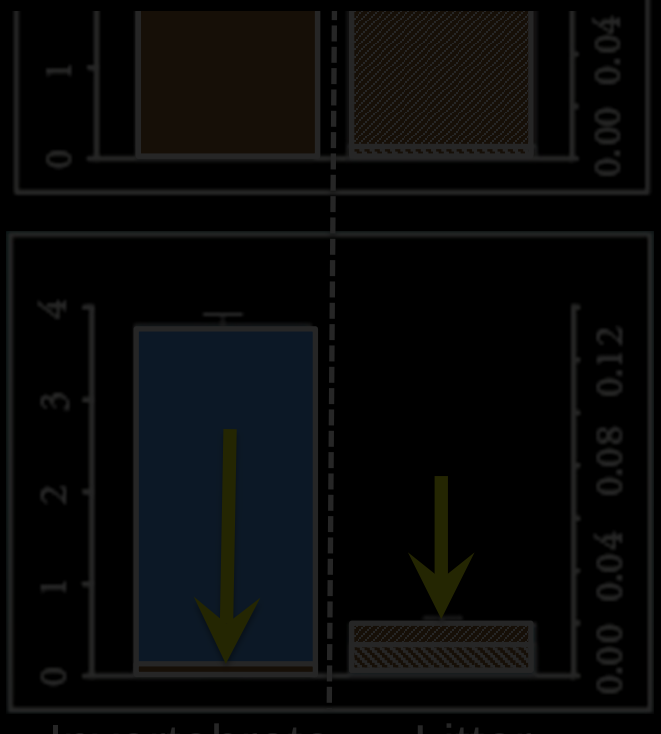
oph (C)

amoA (N)

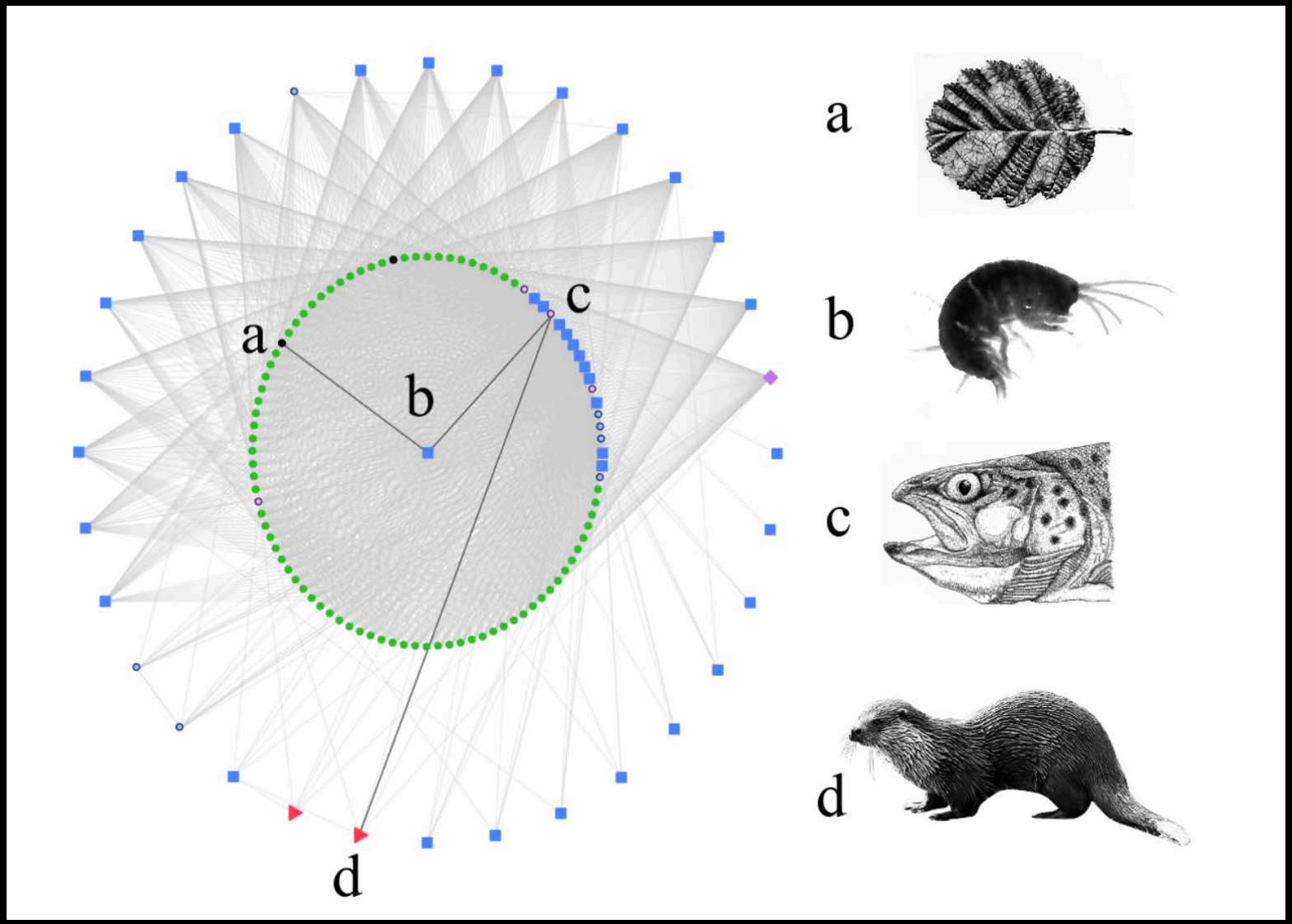
Gene-to-ecosystem responses

Abundance of microbial functional genes associated with processing pesticide (direct effect) and with decomposing animal carcasses (indirect effect) increase

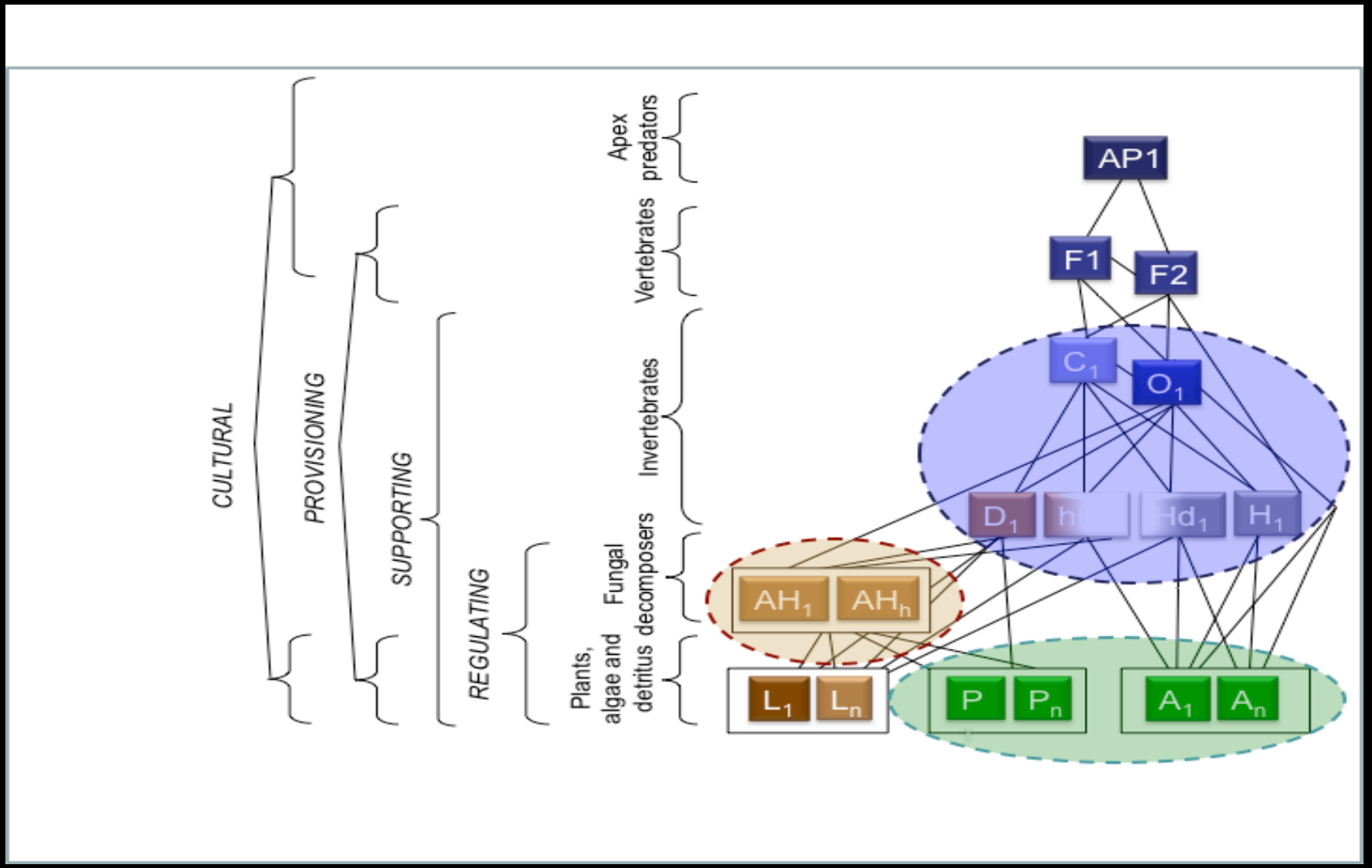




It's a small world – perturbations can ripple rapidly through the system – focusing on one portion misses the bigger picture



Biomonitoring Society's Faustian Pact: trading ecosystem services with agrochemical-based food production?



A natural experiment in Iceland - isolating the effects of temperature in multiple food webs

Geothermal catchment

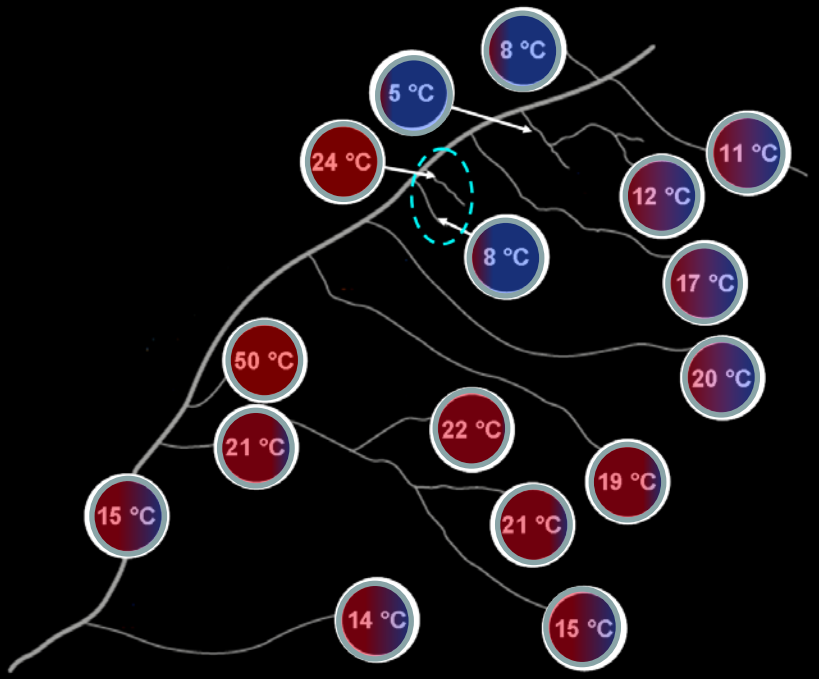
15 streams - 2m-2km apart

Linked to main river

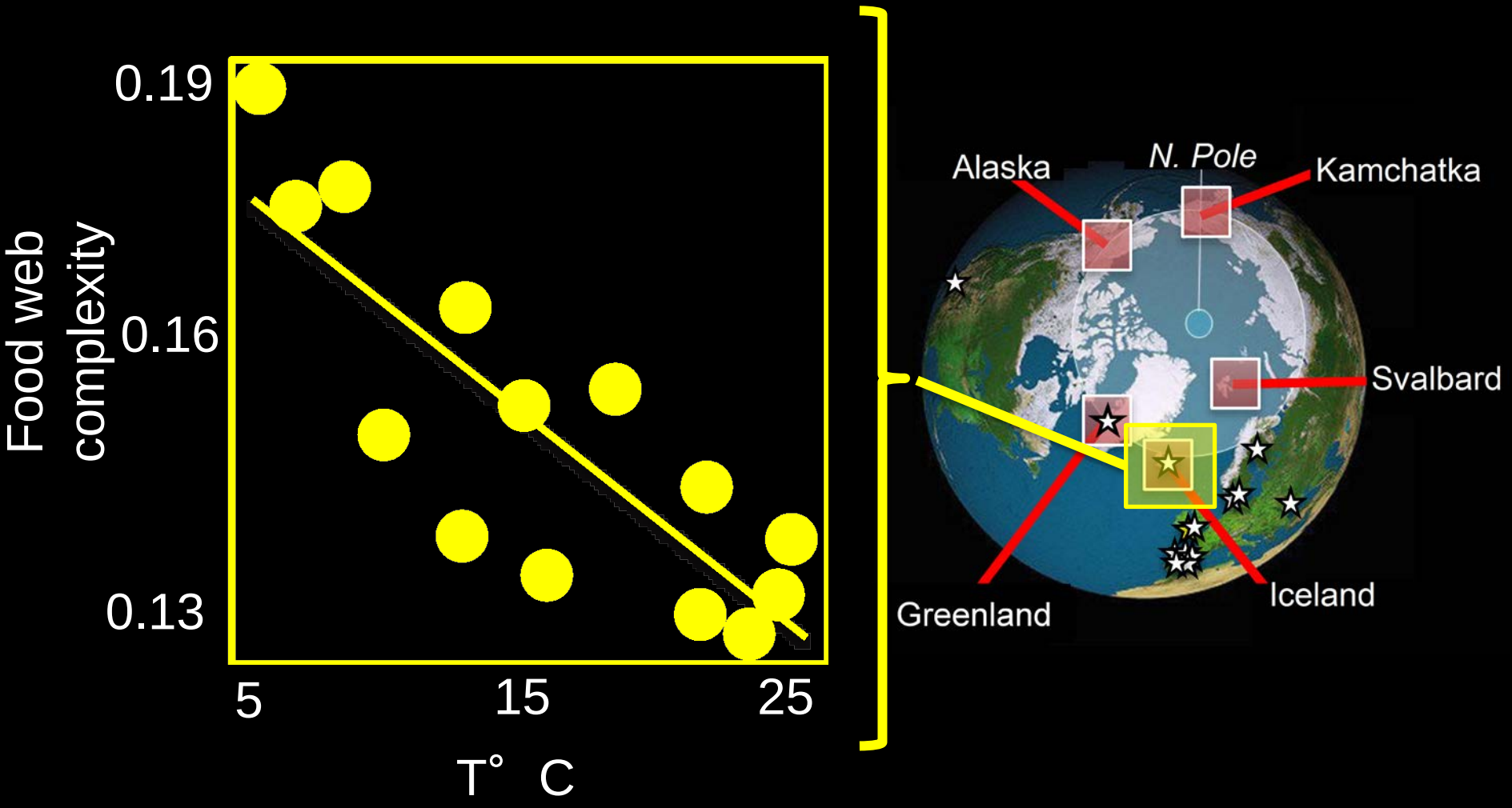
Alike in phyisico-chemistry

No dispersal constraints

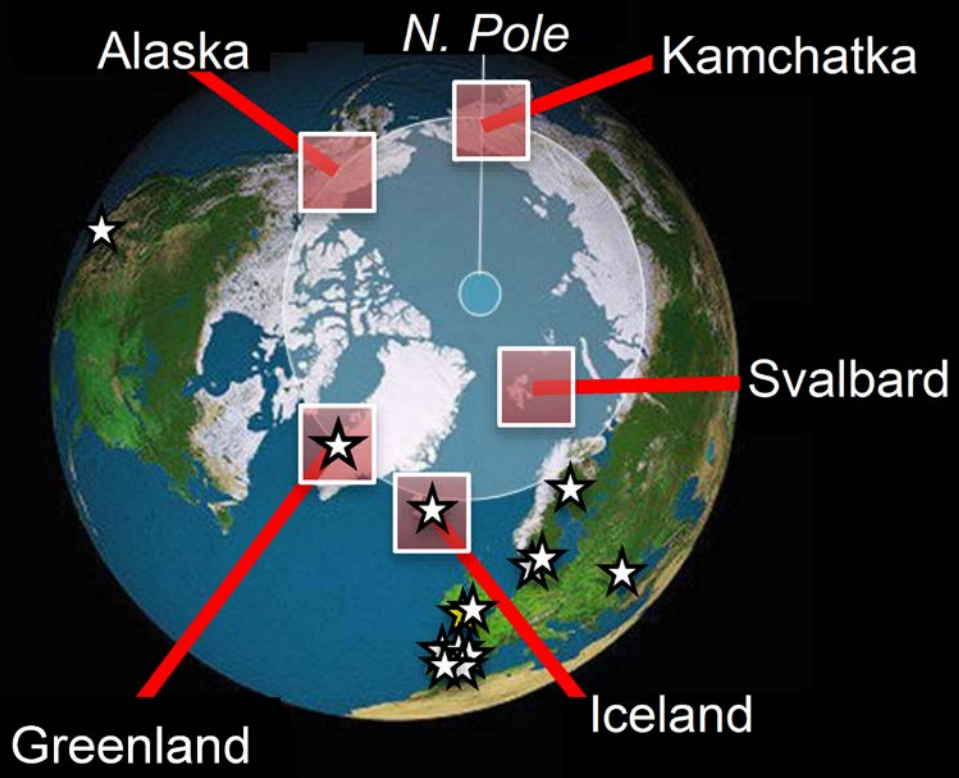
5-25˚ C thermal gradient



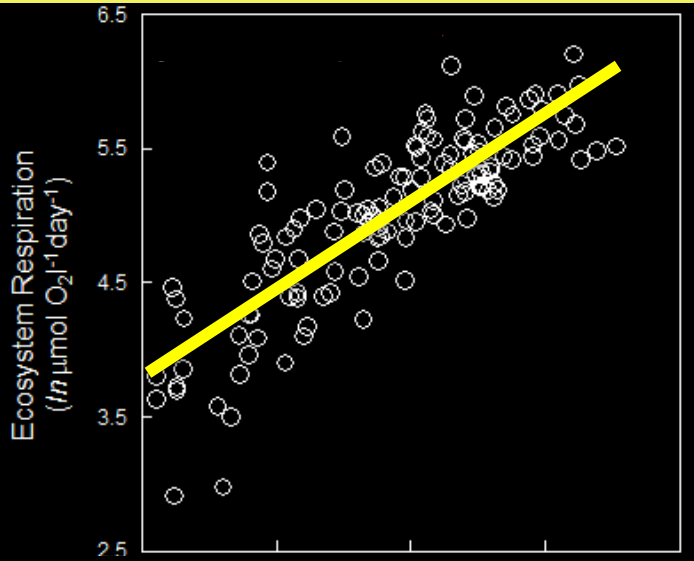
Global food web responses: does network complexity decline with warming?



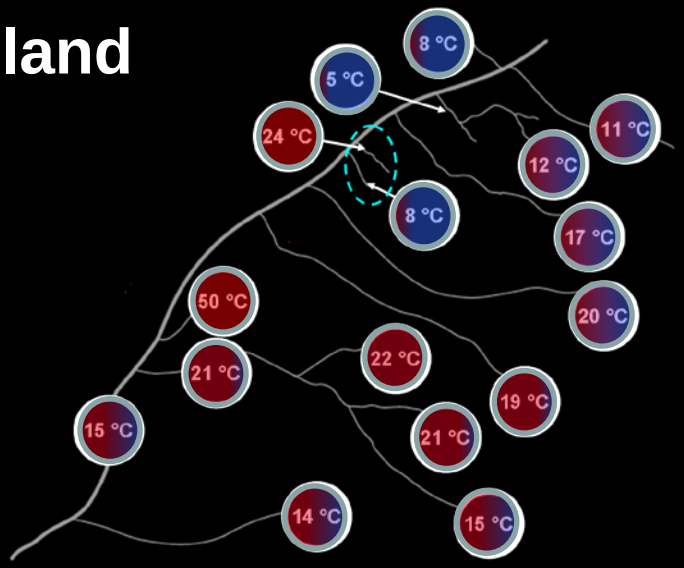
Global sentinel systems – combining field experiments and surveys

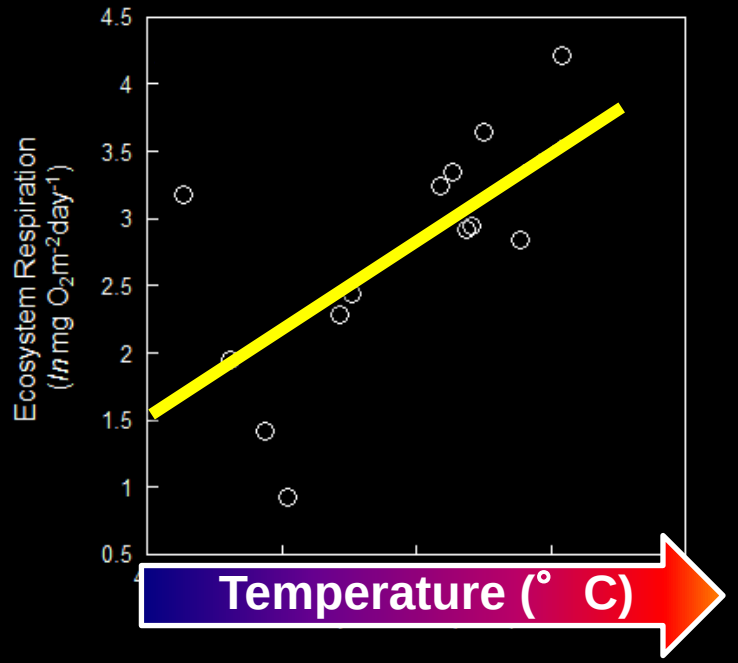


Combining surveys and experiments for biomonitoring? ecosystem respiration in Iceland streams & UK mesocosms



Iceland

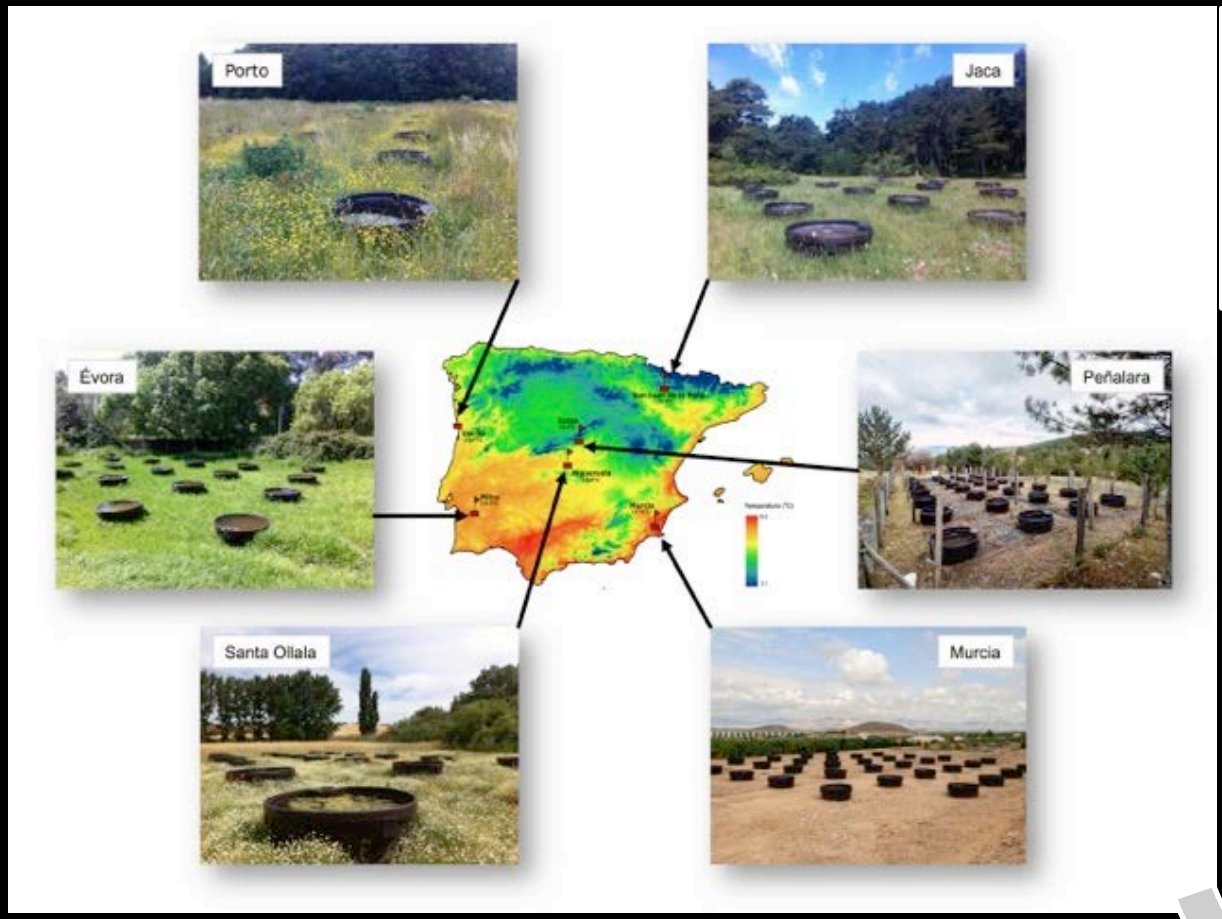


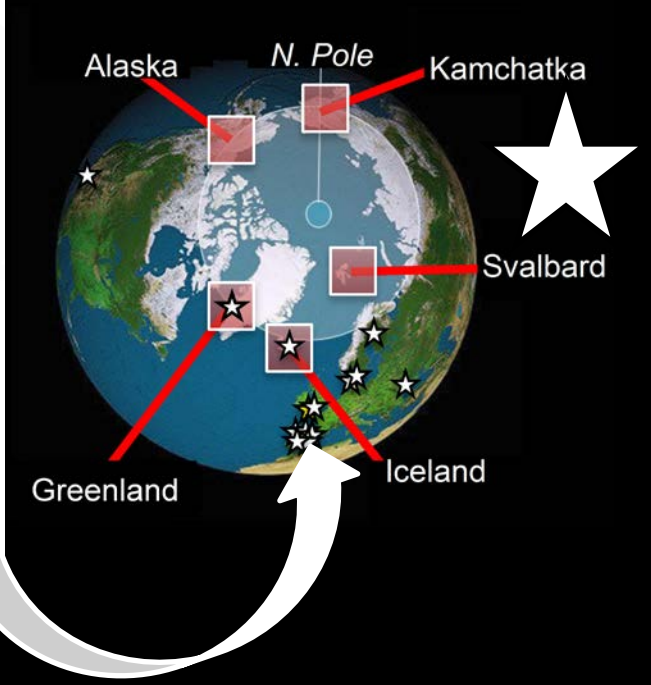


Friberg et al (2011) Adv Ecol Res

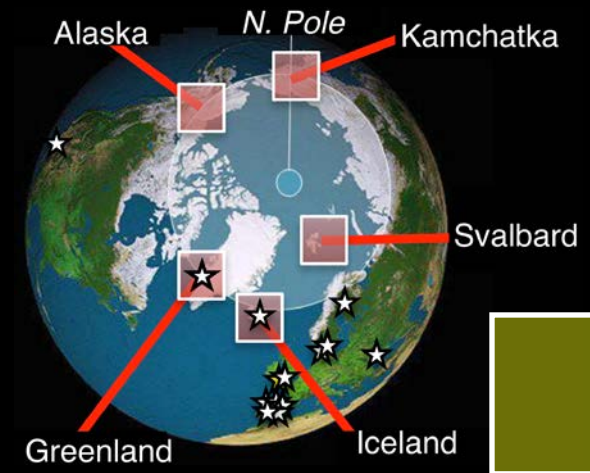
Global biomonitoring via field mesocosm experiments

Biomonitoring data from comparable field experiments (n >400)



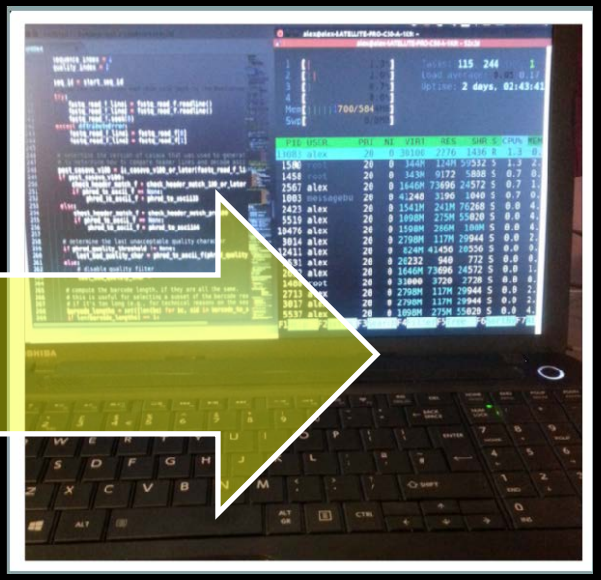


New Challenges and Opportunities: eDNA, Ecoinformatics and Metasystematics



Sampling

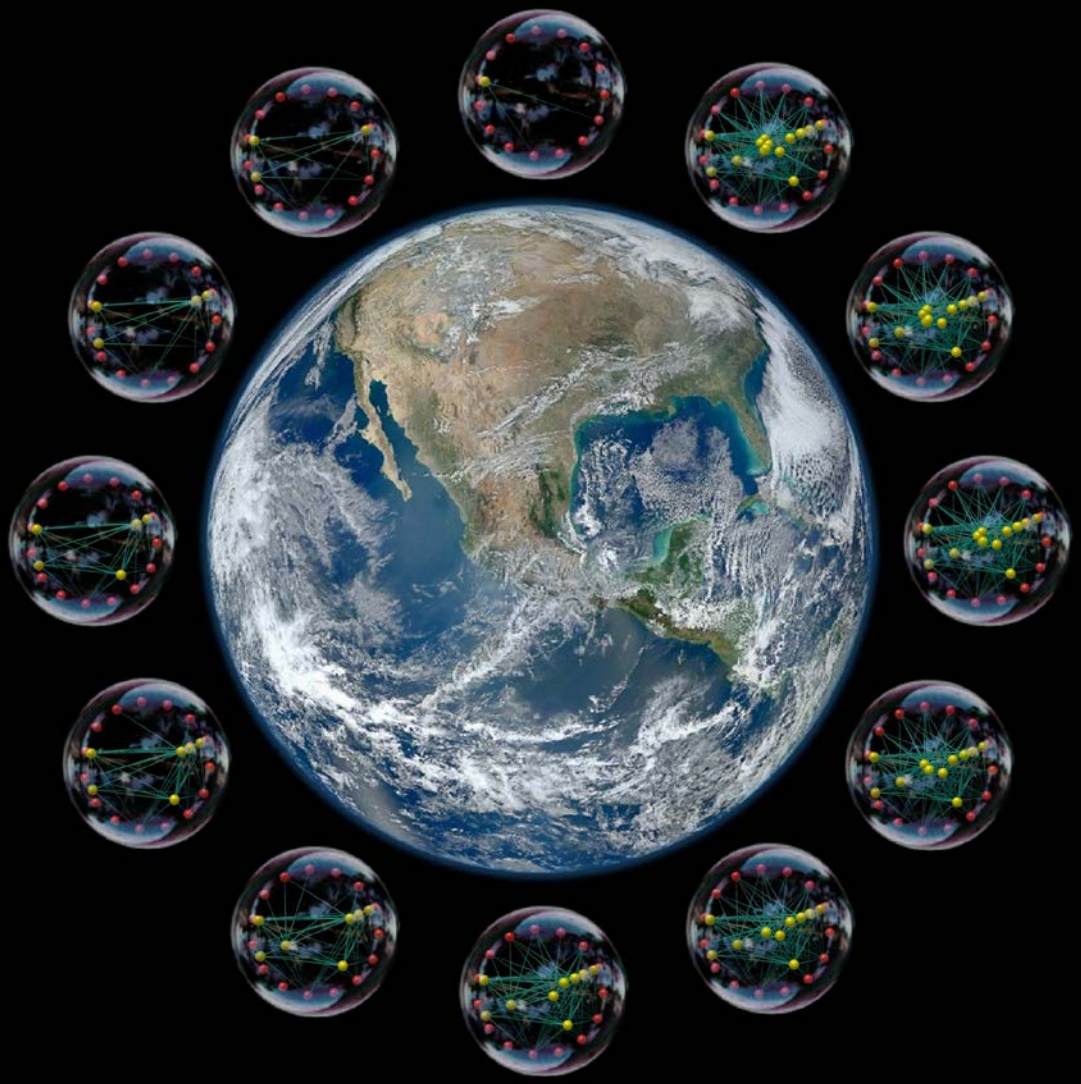
NGS targets functional & phylogenetic marker genes



Bioinformatics assigns taxonomy & function.

Ecoinformatics integrates NGS with ecological data

New Directions: The CELLDEX Cotton Strip Club Experiment (2015-16) – setting a global baseline



>30 countries…100s of sites…

Decomposition rates + NGS samples

Problems and solutions for biodiversity biomonitoring?

Multiple stressors
Multiple levels
Multiple scales (time, space)
Structure-function
Cause-effect
Molecular tools
Direct-remote sensing
Citizen Science
Big Data
Standardisation, integration
Co-ordination
– more bang per buck