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Towards an ecosystem-based approach to environmental risk assessment for freshwater ecosystems

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Context

- **Conventional approaches to ERA** predominantly evaluate the dose-response relationship of **individual stressors** using **a limited range of taxa** as proxies for predicting potential impacts on the freshwater ecosystem.
- The associated uncertainty to account for the inter- and intraspecies extrapolations is addressed with the application of assessment factors, whose magnitude depends only on the availability and number of data points and test species.

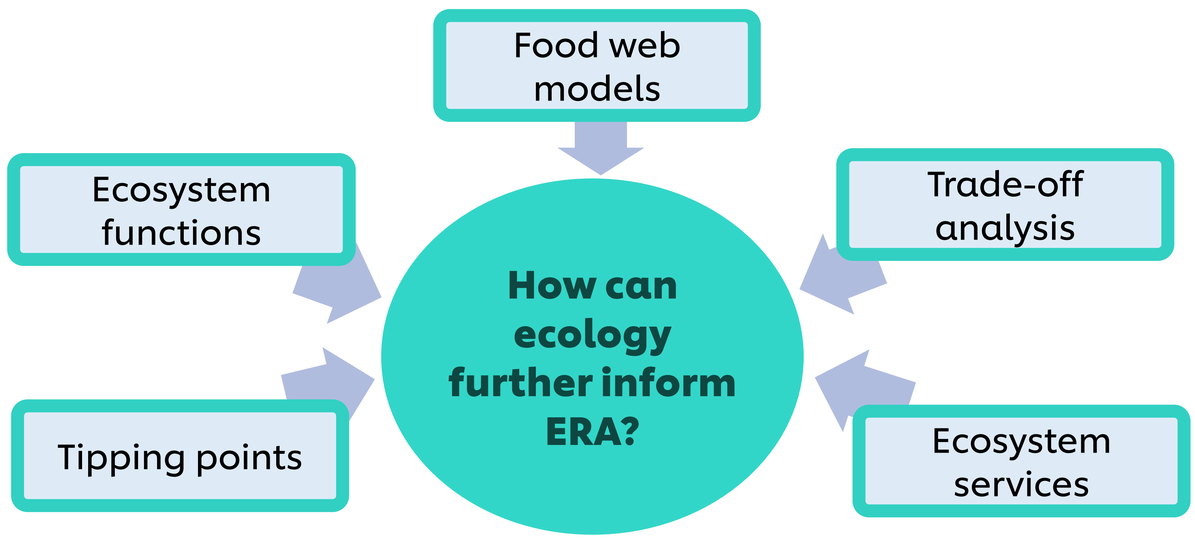
As a result, it does not directly consider all potential impacts of chemicals and their mixtures on the complex processes and interactions occurring in ecosystems.

The challenge

- Varying responses of **different species** to chemical exposure, and **cascading ecological effects** make outcomes difficult to predict at the community and ecosystem levels.
- **Ecosystem-based management** requires consideration of the whole suite of anthropogenic pressures affecting the entire freshwater ecosystem(s), rather than focusing on individual chemical and biological components [a].

Operationalizing an ecosystem-based approach to ERA

Ecology focuses on **interactions** between organisms, their **distributions** and **abundances**, the **functioning** of communities, and the **processes** that affect all these parameters [b].



Recent advancements include understanding **indirect effects**, measuring **functional compensation**, assessing **trade-offs**, and **evaluating ecosystem functions** and **services** delivery, which are yet to be fully explored under an ERA context [c,d].

Conceptual approach moving from the assessment of susceptibility to the valuation of the vulnerability of freshwater ecosystems [e]

Chemical mixtures

Freshwater ecosystem(s) exposed to chemical(s) and other stressors

What are the effects of stressor(s) on whole ecosystems?

SCENARIO

RESEARCH AIM

Molecular traits

Ecosystem functioning and processes

Which are the physiological and ecological traits more relevant to inform species sensitivity given the chemical Mode of Action? What are the critical ecosystem function and services in the freshwater ecosystem of interest?

Indirect effects

Can we leverage on food web modelling and/or experimental set-ups (e.g. artificial ecosystems) to evaluate secondary effects of chemicals based on species interactions?

Resilience

Can we use information on functional compensation/ redundancy/ complementarity (e.g. through biomass changes, analysis of species trade-offs) to assess the potential for ecosystems to cope with and mitigate the stress?

Exposure modelling

Regime shifts

How likely are ecosystems to adapt and either return to steady-state or rather reach new equilibria?
Can we define tipping-points of adversity and understand their role in the definition of a specific protection goal?

TOWARDS ECOSYSTEM-BASED APPROACHES

How can we best model overall impacts of stressors on biodiversity and ecosystem health?

Ensure whole ecosystem health using holistic approaches

OBJECTIVE

PROTECTION GOAL

Conclusions

- ✓ We reviewed approaches currently available supporting **ecosystem-based considerations in ERA**.
- ✓ We presented a **conceptual framework** towards their integrated implementation, highlighting their role in **operationalizing** an ecosystem-based ERA for freshwater ecosystems.

References

[a] Oginah S. A. *et al.*, Linking freshwater ecotoxicity to damage on ecosystem services in life cycle assessment, *Environment International*, 171, 2023, 107705

[b] Andrewartha & Birch (1954). The distribution and abundance of animals. U. of Chicago press.

[c] De Laender F. *et al.* Theoretically exploring direct and indirect chemical effects across ecological and exposure scenarios using mechanistic fate and effects modelling, *Environment International*, 74, 2015, 181-190

[d] Harrison, L. J. *et al.* Functional measures as potential indicators of down-the-drain chemical stress in freshwater ecological risk assessment. *Integrated Environmental Assessment and Management*, 18(5), 2022, 1135-1147

[e] Weißhuhn P. *et al.* Ecosystem Vulnerability Review: Proposal of an Interdisciplinary Ecosystem Assessment Approach. *Environ Manage*. 2018, 61(6):904-915