RESTOLINK Policy Brief

Integrating ecosystem functioning into river restoration assessment

Improving evaluation, diagnosis, and adaptive management

Why this matters

Across Europe, investments in river restoration are increasing. However, authorities and practitioners often lack timely and informative tools to evaluate whether restoration measures are working, why they succeed or fail, and how management should adapt. Current assessments rely largely on structural indicators (e.g. habitat features, species composition), which frequently respond slowly and are increasingly challenged by climate change and shifting ecological baselines. This policy brief draws on conceptual and empirical insights synthesised by RESTOLINK to demonstrate how ecosystem functioning can complement existing assessment approaches and strengthen restoration evaluation and adaptive management.

Key Messages

- Structural indicators alone are no longer sufficient to assess restoration success. They often respond slowly, provide limited diagnostic insight, and are increasingly difficult to interpret under climate change.
- Ecosystem functions offer earlier and more informative signals of restoration outcomes. Core processes such as production, respiration, nutrient uptake, and organic matter decomposition can respond within management-relevant timeframes.
- Functional indicators remain meaningful under environmental change, even when species composition shifts, making them more robust for future-oriented freshwater management.
- A small, targeted set of ecosystem functions is sufficient to complement existing assessments, provided indicators are aligned with management objectives and feasible to measure.
- Integrating ecosystem functioning into current frameworks supports adaptive management, improves diagnosis of limiting stressors, and increases the effectiveness and accountability of restoration investments.

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Policy Context

European and international policy frameworks already recognise ecosystem functioning as a core objective of freshwater management.

EU Water Framework Directive (WFD)

Defines ecological status of freshwaters in terms of both structure and functioning.

EU Biodiversity Strategy for 2030

Calls for restoring freshwater ecosystems and the natural functions of rivers.

Convention on Biological Diversity

Links pollution reduction to the protection of ecosystem function and biodiversity.

Despite these commitments, monitoring and assessment practices remain dominated by structural indicators, creating a persistent gap between policy ambition and implementation.

The Challenge

Current restoration assessment approaches face three interrelated challenges:

Delayed feedback

Structural indicators may take years to respond, reducing their usefulness for evaluating restoration effectiveness within decision-making time-frames.

Limited diagnostic capacity

Changes in species com-position are often difficult to attribute to specific stressors or restoration measures, constraining adaptive management.

Shifting baselines

Climate change, invasive species, and altered catchment conditions mean that historical reference communities may no longer represent realistic or appropriate targets.

Together, these challenges reduce confidence in restoration outcomes and limit opportunities to improve future interventions.

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What the Evidence Shows

Evidence synthesised within RESTOLINK demonstrates that ecosystem functions provide complementary and policy-relevant information alongside traditional structural indicators.

Earlier response to restoration

Key functions such as primary production, ecosystem respiration, nutrient uptake, and organic matter decomposition often respond more rapidly than community-based metrics, enabling earlier evaluation of restoration effects.

Robustness under environmental change

Functional indicators describe how ecosystems operate rather than which species are present. As a result, they remain informative even when species composition changes due to climate or other pressures.

Improved diagnosis of stressors

Many ecosystem functions respond directly to physical and chemical drivers (e.g. nutrients, light, temperature, hydrology), supporting clearer identification of limiting factors and more targeted management responses.

From Science to Practice: Selecting Functional Indicators

RESTOLINK does not propose measuring all ecosystem functions. Evidence indicates that a small, carefully selected core set can provide substantial added value when indicators are chosen according to three criteria.

Alignment with management objectives

Indicators should reflect restoration goals, such as improving water quality, restoring habitat functioning, or enhancing overall ecological health.

Practicality

Measurement approaches must be feasible, cost-effective, and suitable for routine monitoring or targeted evaluations.

Integrative insight

Selected functions should capture key processes across trophic levels and ecosystem compartments.

Candidate functions include **primary production and ecosystem respiration**, **organic matter decomposition**, and **nutrient processing and retention**, supported by basic hydromorphological information. This set is flexible and can be adapted to local contexts and emerging priorities, such as greenhouse gas emissions from rivers.

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Interpreting Functional Outcomes

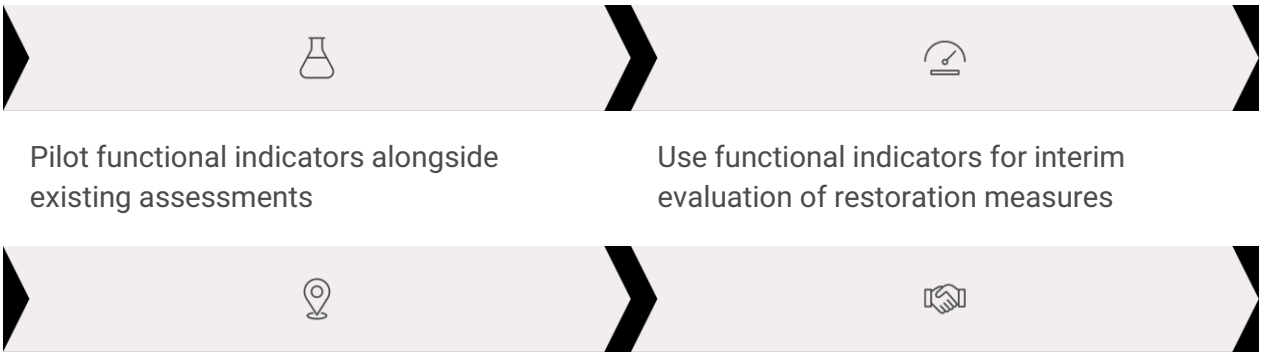
For policy-relevant application, functional indicators require clear interpretation frameworks:

- For specific objectives, functional indicators can provide direct evidence of progress.
- For holistic goals such as ecological health, functional indicators should complement, not replace, structural metrics.
- Reference conditions may require reinterpretation, for example through functional typologies or ranges or rather than strict historical benchmarks.

Explicit treatment of uncertainty and trade-offs enhances transparency and credibility.

Policy and Practice Options

Policy-makers, authorities, and implementing agencies may consider the following options.



Pilot functional indicators alongside existing assessments

Use functional indicators for interim evaluation of restoration measures

Define context-specific expectations for functional responses

Strengthen collaboration between science, policy, and practice to support interpretation and uptake

These options can be integrated into existing monitoring, reporting, and adaptive management frameworks without major restructuring.

What This Enables

Integrating ecosystem functioning into river assessment can:

- Improve evaluation and accountability of restoration investments
- Support adaptive, learning-oriented management
- Increase the robustness of freshwater policy under environmental change

Further Information

Project:

Quantifying restoration success across biomes by linking biodiversity, multifunctionality and hydromorphological heterogeneity (RESTOLINK)

Project website:

https://restolink.weebly.com/

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