IUCN NCUK River Restoration and Biodiversity Project: Phase 3 Monitoring Protocol Workshop

The IUCN river restoration and biodiversity project has been established to demonstrate and promote the benefits for biodiversity of best practice river restoration across the United Kingdom (UK) and the Republic of Ireland (RoI). The project is led by SNH under the auspices of the IUCN's UK National Committee (IUCN NCUK) and has a steering group comprising representatives of the UK and RoI's nature conservation and environment protection agencies, the Freshwater Biological Association, the River Restoration Centre, and the IUCN NCUK. Phases 1 and 2 reviewed river restoration in the UK and RoI. Phase 2 culminated in a report, *River Restoration and Biodiversity: Nature-based Solutions for restoring the Rivers of the UK and the Republic of Ireland*, the recommendations of which include gathering evidence of the benefits for biodiversity of restoring rivers by investing in flagship restoration sites. As part of Phase 3, the steering group wishes to develop a best practice monitoring protocol to enable practitioners to gather and analyse meaningful data, using scientific rigour, to appraise restoration success.

On 30–31 October 2018, representatives of the UK and RoI's nature conservation and environment protection agencies joined practitioners and researchers to discuss monitoring best practice.

The aim of the workshop:

To explore best practice and incorporate academic knowledge to inform an operational monitoring protocol for appraising the benefits for biodiversity of successful restoration. The discussions focussed on what would complement existing guidance, and what we already know (the givens).

The givens:

1. We are focused on techniques that restore natural processes.
2. We are not re-writing existing guidance, e.g. PRAGMO.
3. We need to monitor and evaluate to assess and demonstrate project outputs or effectiveness and to allow an adaptive management approach and identify the need for further restoration works.
4. Effective monitoring is needed to improve our overall scientific understanding of the benefits of restoration.
5. Monitoring needs to be part of an integrated project planning process.
6. Monitoring should have SMART objectives that are linked to project goals, objectives, and predicted outcomes.
7. Monitoring should be integrated and include both environmental/habitat and biota assessments.
8. Fixed point photography should always be done.
9. Monitoring should follow a Before-After-Control-Impact (BACI) design.
10. We need to share the results of the appraisals, e.g. via the RiverWiki, an online tool used for sharing information on river restoration projects across Europe.

Following an introduction by workshop chair Phil Boon, the different components we may want to consider in an appraisal were discussed. The key points noted for each follow.

Hydromorphology:

- Consultations with geomorphologists are key.
- The use of new and novel techniques such as LIDAR, drones, and remote sensing could help. These need to be tested to understand how they will be useful for monitoring habitats for biodiversity—this project provides a great opportunity to do this.
- We need to assess physical changes and how these relate to ecological change, so we need sequential monitoring from physical change to ecological response. Timescales are important.

- Ultimately we need to know how we change the availability of habitats and their occupancy.

Invertebrates:

- Surber samples are recommended using a stratified random approach by river section, e.g. 3 random samples collected per 100 m of river, with no subjective decision made about longitudinal and cross-section sample location or habitat and recording environmental variables.
- Alternative methods will be needed.
- Collecting information for 3 years before restoration and 3 years after (longer if possible, perhaps 7–10 years) is recommended.
- Additional controls (positive and negative) can help when pre-restoration data is limited.
- Two seasons of sampling is recommended, but each sampling season should be limited to a specific sampling window of one month.
- Species or mixed level identification is needed. The level of identification for Diptera needs to be established.
- eDNA and agency data could help to establish the species pool which will help understand colonisation potential.
- Modelling approaches to data analysis are advocated. In addition to considering indicator species we need to consider their functional role as this may indicate the presence of unique habitats or change (trajectory of change). We need to link the biological changes back to the habitat composition.

Diatoms/periphyton/bio-films:

- Potentially of interest since the communities respond quickly and are linked to patterns of hydraulic habitats.
- We need to seek expert advice about their usefulness for assessing river restoration, and appropriate techniques.
- Bentho torches could be used to assess primary production or for daily measurements of benthic algae standing crop.
- Outside high energy systems, macrophytes would be the lead primary production indicators.

Fish:

- What to monitor depends on the type of river and intervention used and scale applied.
- We need to know what habitats are changing, what species or life stages are likely to be affected and whether they are using the habitats. But we also need to know whether fish are moving in or their populations are increasing.
- It may be better to monitor communities or assemblages.
- Monitoring periods should be 5–10 years but exactly how long will depend on the objectives and scheme, e.g. changes in response to barrier removal may be relatively quick.
- Control sites need to be well chosen. Additional control sites can help when there is limited baseline data.
- Other pressures and catchment context need to be understood—historical data or eDNA may help. It is important to understand the context of the hydrological regime.
- Lots of potential assessment methods, e.g. tagging, camera traps—link to habitat utilisation.

Vegetation community:

- We need to consider in-stream, riparian, and wetland response.
- For in-stream vegetation we could follow the Danish WFD approach (4 transects of sequential quadrats, bank top to bank top across the channel). This could be nested within our standard WFD/LEAFACS survey.
- Summer surveys (June–August) within a 4 week window.
- Three years pre-restoration monitoring and 3–5 years post recommended.

- Antecedent flow data and shading information is important.
- Drones, remote sensing, and aerial photography can be used to help assess riparian and wetland changes.
- NVC can be used for wetlands and riparian vegetation, but stem diameter/density also needs to be recorded since this can influence sediment trapping and conveyance.
- Community based modelling with predictive qualities can also be used.

Other vertebrates:

- We need to think about the provision of natural habitat for key species rather than *constructed* habitats.
- Whether to monitor habitat use depends on scheme specific objectives and the potential presence of specific species.
- RSPB, BTO, BCT, etc. will be able to provide advice on species of interest, e.g. birds that use gravel bars, etc.
- BTO surveys for monitoring response to river engineering are available.

Food webs:

- Food web concepts link structure and function to ecological processes and are linked to resilience.
- It would be beneficial to look at one or more schemes in greater detail with research funding.
- Understanding food webs may be key to improving the evidence base and will help to highlight the value of naturally functioning river systems.
- eDNA could be used to assess community and food web changes.
- Could we use this approach to show that ecological processes are more resilient and therefore restoration has been beneficial?

General discussions:

Multi-taxa assemblages:

- Can we find redundancy in the sampling, e.g. will fish and invertebrates give the same signal?
- The project will need to assess all groups, but future approaches could take a targeted approach. This would form part of the recommendations of the projects.

Modelling/Theoretical frameworks:

- Our theory is that naturally functioning ecosystems provide the best mosaic of river types for promoting ecological resilience.
- We could base our project on a resilience framework (See Donohue *et al.*, 2013, on the dimensionality of ecological stability https://doi.org/10.1111/ele.12086). The framework has not previously been applied to rivers. It considers systems in 5 dimensions and how this breaks down when the system is simplified.
- How can restoration measures help increase resilience to climate change?

Continuous monitoring:

- Could be valuable for understanding changes. This is especially useful for hydrology, water quality, and temperature. Time lapse photographs.

Attendee List:

Name	Organisation
Natalie Angelopoulos	University of Hull
Phil Boon*	Freshwater Biological Association
Jennifer Dodd	Edinburgh Napier University
Anna Doeser	Scottish Environment Protection Agency
Judy England*	Environment Agency
Andy Gill	PANGALIA Environmental
Martin Janes*	River Restoration Centre
Chris Mainstone	Natural England
Mattie O'Hare	Centre for Ecology & Hydrology
Graham Rutt	Natural Resources Wales
Roger Sweeting	Freshwater Biological Association
Angus Tree*	Scottish Natural Heritage
Mary Toland*	Northern Ireland Environment Agency
Jenny Wheeldon*	Natural England
Martin Wilkes	Coventry University
Nigel Willby	University of Stirling

*Steering Group member