FACTSHEET

5. Monitoring of hydromorphological restoration: open problems and perspectives

Despite the relatively high number of hydromorphological restoration schemes implemented in the last decades, consistent evidence of the effects and benefits of restoration is still limited. As a result, long-term physical and ecological effects of restoration projects appear still highly uncertain.

Part of this is due to the fact that project monitoring and assessment are still carried out in a minority of cases and, more in general, there is still a lack of planning. But even where the monitoring effort has been strong, several reviews underline that results remain to a significant extent ambiguous, due to the several critical gaps in the implemented approaches.

MAIN GAPS and OPEN PROBLEMS

1. **Lack of an explicit identification of the physical and ecological objectives** of the restoration scheme; even in case of quantitative monitoring it is thus not possible to assess whether the project was successful or not. In relation to ecological objectives this is often related to a lack of reference conditions (however, in several cases these may be very difficult or even impossible to identify) and of suitable biological metrics (e.g. diversity/taxonomic richness are often misleading evaluation criteria).
2. **The main drivers** affecting the variables/quality elements to be assessed and the cause-effect relationships linking them **are not always explicitly defined**; thus the changes in some relevant factors are often not monitored and at the end it is unsure whether the observed effects are actually a consequence of the restoration project or rather of external factors.
3. The range of **natural variability** of the variables/quality elements to be monitored **is usually unknown** and not taken into consideration in the monitoring plan; **monitoring results are often statistically too weak.**
4. **The spatial and temporal scales of the processes involved** (therefore the needed spatial and temporal scales of monitoring activities) **are often neglected**; this applies both to physical processes and to recovery of biological communities. In addition, often the scale of the restoration projects is too small if compared to the scale of the key fluvial processes that should be tackled.
6. **Control sites are often not included** in the monitoring scheme.
7. **Monitoring pre- project** implementation is often **neglected** and only post- project implementation is performed, not allowing a pre-post comparison.

PERSPECTIVES

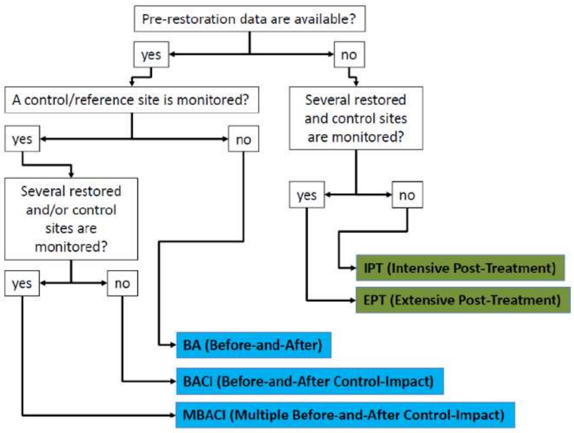

Figure 1 – Classification of different monitoring schemes (adapted from Roni et al., 2013)

Much more ambitious monitoring programs exploring longer spatial and temporal scales are needed to statistically isolate restoration effects from other forcings/controls and to go beyond case study applications (e.g. MBACI and EPT, see Fig. 1 and the box).

While planning these programmes, these key steps should be considered:

1. A clear and explicit **identification of project objectives**, as well as of **cause and effect relationships** and **boundary factors.**
2. Definition of the **key questions** and of the **hypotheses** to be tested.
3. Designing of the monitoring scheme based on a **robust**

statistical approach by properly considering the comparability/ interdependence between Control and Test, the constancy of the system / assumptions in time, the number of replicates, the intrinsic spatial and temporal variation of the processes, etc.

4. To select **parameters and metrics** sensitive to the implemented actions and suitable to respond to the key questions. These parameters ideally should be: of a different nature (physical/biological), not redundant, easy to measure, with reduced costs and quick answers, based on recognized methods (if possible) and with low intrinsic variability.

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EXAMPLE: monitoring plan restoration site Kleblach-Lind (Drava River)

- ***Objectives*** — *Restoring river morphology, reconnecting adjacent areas of the former floodplains, achieving good ecological status (WFD)*
- ***Monitoring approach*** — *Habitats:*
    - *Before-After (BA)*

  Morphology:
    - *Survey at high spatial resolution (for creation of digital elevation model): BA-design*
    - *Cross section surveys: MBACI*
- ***Parameters*** — *Habitats: key species, habitat variety (stagnant shallow zones, riffle areas, gravel and sand bars)*
  Morphology: sediment budget, bed elevation
- ***Spatial / temporal scale*** — *Habitats: three-year post-treatment program, repeated monitoring afterwards*
  Morphology:
    - *5 cross section surveys between 1991 and 2016: first tachymetric survey, then echosounder*
    - *9 surveys at high spatial resolution between 2001 and 2011, resumption of monitoring activities in HyMoCARES (2018 and 2019, side channel only in 2017): combination of echosounder in the main channel, tachymetric survey in the side channel, UAV photogrammetry in HyMoCARES*
- ***Data analysis*** — *DEM of difference, sediment budget analysis, cross section analysis (HyMoCARES HyMoLink, Chevo)*

Figure 2 – Monitoring plan of the restoration site Kleblach-Lind at the Drava river