Restoring small streams: Effects on aquatic organisms

Revitalisation des petits cours d'eau : Effets sur les organismes aquatiques

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RÉSUMÉ

La perte de biodiversité dans les écosystèmes aquatiques, y compris les petits cours d'eau, est une préoccupation croissante à l'échelle mondiale. En Suisse, la canalisation, les barrières physiques et la détérioration de la qualité de l'eau sont les principaux facteurs de déclin de la biodiversité dans les rivières et les ruisseaux. Les projets de revitalisation visent généralement à améliorer l'abondance et la diversité des organismes aquatiques en mettant en œuvre différents types de mesures, notamment en améliorant les structures abiotiques. Toutefois, les études font état de résultats contradictoires quant à l'efficacité de la revitalisation des cours d'eau en termes d'amélioration des communautés biotiques. Pour étudier ces incohérences, nous avons effectué des relevés standardisés sur 22 projets de revitalisation de petits cours d'eau suisses et de tronçons de contrôle canalisés. En utilisant une comparaison inter-projets, nous avons examiné les données biotiques (macrophytes, poissons, macroinvertébrés et végétation riveraine) ainsi que les paramètres abiotiques (complexité de l'habitat, température et géodonnées du bassin versant). Les analyses préliminaires d'un sous-échantillon de projets (n=16) suggèrent un effet positif global de la revitalisation des rivières, mais avec une variation significative entre les indicateurs individuels. Nos résultats contribueront à une meilleure compréhension de l'efficacité de la revitalisation pour conserver la biodiversité bleue-verte dans les petits cours d'eau.

ABSTRACT

The loss of biodiversity in aquatic ecosystems, including small streams, is a growing concern globally. In Switzerland, key drivers of biodiversity decline in rivers and streams include channelization, physical barriers, and deteriorating water quality. Restoration projects usually aim to enhance the abundance and diversity of aquatic organisms by implementing different types of measure, in particular by improving abiotic structures. However, studies report inconsistent findings regarding the effectiveness of river restoration in enhancing biotic communities. To explore these inconsistencies, we conducted a standardized survey of 22 restoration projects in small Swiss streams and channelized control reaches. Using a cross-project comparison, we examined biotic data (macrophytes, fishes, macroinvertebrates, and riparian vegetation) alongside abiotic parameters (habitat complexity, temperature, and catchment geodata). Preliminary analyses of a subset of projects (n=16) suggest an overall positive effect of river restoration, but with significant variation between individual indicators. Our findings will contribute to a better understanding of the efficacy of restoration to conserve blue-green biodiversity in small streams.

KEYWORDS

Stream restoration, cross-project comparison, outcome evaluation, aquatic organisms, restored vs. control reach

Revitalisation de cours d'eau, comparaison inter-projets, contrôle des effets, organismes aquatiques, tronçon revitalisé vs. tronçon contrôle

1 OUTCOME EVALUATION IN SMALL STREAMS RESOTRATION IN SWITZERLAND

1.1 CONTEXT

The loss of biodiversity in aquatic ecosystems, particularly in small streams, is driven by multiple factors. In Switzerland, key pressures include channelization, the construction of physical barriers, and declining water quality (FOEN, 2022). River restoration is often hypothesized to enhance the richness and abundance of aquatic organisms by improving abiotic conditions. This concept, referred to as the "Field of Dreams Myth", posits that improving habitat structure will automatically lead to increased biodiversity (i.e., "if you build it, they will come"; Hildebrand et al., 2005). While many studies demonstrate significant improvements in abiotic conditions following restoration, evidence for the recovery of aquatic communities remain inconsistent (e.g. Haase et al., 2013). Disentangling the effects of restoration is challenging due to a lack of comprehensive biotic and abiotic data collected using standardized methodologies, limited cross-project comparability, and insufficient statistically robust conclusions.

1.2 THE NATIONAL OUTCOME EVALUATION

In this study, we analyse data collected as part of the national outcome evaluation for river restoration in Switzerland (FOEN, 2019). This evaluation framework, implemented in 2020, employs standardized methods for the collection of both biotic and abiotic data, ensuring consistency and comparability across projects. The dataset includes 22 small stream restoration projects, each surveyed using identical survey protocols and compared to corresponding control reaches to evaluate restoration effects. The restoration projects are at least 4 years old.

This contribution focuses on a cross-project analysis integrating data from multiple sources (Figure 1). Standardised data derived from the national outcome evaluation cover habitat complexity, water temperature, macrophytes, macroinvertebrates, fish, and riparian vegetation. Additionally, we incorporate standardised data from the implementation control provided by the Swiss government. The implementation control offers information on the river restoration projects, such as the year of implementation, project specific characteristics or restoration measures undertaken. Furthermore, geospatial information on catchment characteristics is included, derived from available geodata. These geodata encompass variables such as the number of barriers located upstream or downstream of the restoration site, land-use composition within the catchment, and nutrient concentrations (e.g., nitrates and phosphates). In the analysis, data from the implementation control and geospatial variables are treated as explanatory variables to evaluate the effectiveness of the river restoration efforts. This multi-source approach aims to provide a comprehensive understanding of the factors influencing restoration outcomes.

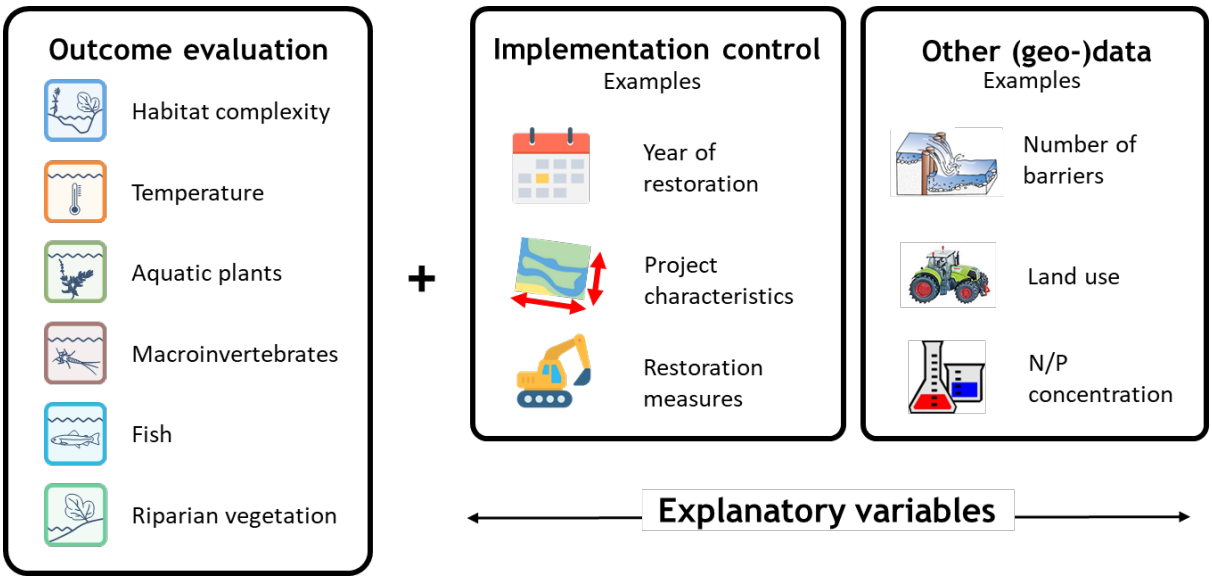

Figure 1. Sources of the different data used for the cross-project analysis.

2 EXPECTED RESULTS

Based on preliminary analyses from 16 projects, we expect the following results:

- ***For macrophytes**, a higher number of species but a lower total coverage in the restored sites compared to the control reaches*: Restoring bank morphology and widening are two common restoration measures in small streams that open new niches with sparse shading and slower velocities for new macrophyte species to colonize. The overall cover is expected to be low, because hydro-morphological processes are rarely restored in restoration projects in small streams, which can mean that these pioneer habitats disappear on the long term due to riparian vegetation growth (Lorenz et al., 2012; Kail et al. 2015).
- ***For macroinvertebrates**, a slight but insignificant increase in abundance and species richness in the restored sites compared to the control reaches:* Instream measures can have a positive effect on the species richness, but many macroinvertebrate taxa are very sensitive to water quality, which is not directly influenced by restoration measures (Haase et al., 2013). The sites analyzed in this project are mostly found at mid-elevation on the Swiss plateau, which is intensively used for agriculture, often leading to poor water quality.
- ***For fish,** a higher biomass but no increase in species number in the restored sites compared to the control reaches*: The increase in structural complexity (e.g. placement of woody debris) is expected to increase the availability of cover and food for fish thereby leading to an increase in biomass. But a significant increase of the species number might depend more on the availability of a source population in the catchment and the ability of the individuals to reach the restoration site (Stoll et al. 2012), which we expected to be limited on the Swiss plateau.
- ***For riparian vegetation,** an increase in number and cover of target species, but also neophytes in the restored sites compared to the control reaches*: For each restoration project, at least three riparian vegetation species (both target species and neophytes) were chosen by the project manager to be monitored in the restored and the corresponding control reach. Therefore, statements about overall species richness are limited. Nonetheless, restoring the riverbanks is often part of restoration measures, giving the riparian vegetation more space to expand (Lorenz et al. 2018).

These preliminary analyses need further and more comprehensive treatment to confirm or dismiss the hypotheses and to disentangle the causes. Results will be published in a scientific report in summer 2025.

LIST OF REFERENCES

FOEN – Federal Office for the environment (Hrsg.) (2022): *Gewässer in der Schweiz. Zustand und Massnahmen*. Bundesamt für Umwelt, Bern. Umwelt-Zustand Nr. 2207: 90 S.

Haase, P., Hering, D., Jähnig, S. C., Lorenz, A. W., and Sundermann, A. (2013). *The impact of hydromorphological restoration on river ecological status: a comparison of fish, benthic invertebrates, and macrophytes*. Hydrobiologia Vol. 704 Issue 1 Pages 475-488. https://doi.org/10.1007/s10750-012-1255-1

Hilderbrand, R. H., Watts, A. C., & Randle, A. M. (2005). *The myths of restoration ecology*. Ecology and Society, 10(1). http://www.jstor.org/stable/26267738

Lorenz, A. W., Korte, T., Sundermann, A., Januschke, K., and Haase, P. (2012). *Macrophytes respond to reach-scale river restorations*. Journal of Applied Ecology 2012 Vol. 49 Issue 1 Pages 202-212. DOI: https://doi.org/10.1111/j.1365-2664.2011.02082.x

Lorenz, A. W., Haase, P., Januschke, K., Sundermann, A., and Hering, D. (2018). *Revisiting restored river reaches – Assessing change of aquatic and riparian communities after five years*. Science of The Total Environment Vol. 613-614 Pages 1185-1195. DOI: https://doi.org/10.1016/j.scitotenv.2017.09.188

Stoll, S., Sundermann, A., Lorenz, A. W., Kail, J. and Haase, P. (2013). *Small and impoverished regional species pools constrain colonisation of restored river reaches by fishes*. Freshwater Biology (2013) 58, 664–674. https://doi.org/10.1111/fwb.12068

Weber, C., Sprecher, L., Åberg, U., Thomas, G., Baumgartner, S., Haertel-Borer, (2019): *Evaluating the outcome of restoration projects – collaborative learning for the future*. Federal Office for the Environment FOEN, Bern. Factsheets 0-8, on https://www.bafu.admin.ch/outcome-evaluation-resto