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Taking an interdisciplinary perspective to disentangle complex effects of restoring ecological continuity in riverine socio-ecosystems

Une perspective interdisciplinaire sur les effets complexes de la restauration de la continuité écologique dans les socio-écosystèmes fluviaux

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RÉSUMÉ

La réglementation environnementale, à l'échelle européenne comme à l'échelle nationale, détermine des objectifs écologiques pour la gestion des rivières. Elle incite les acteurs publics en France à mettre en place une politique ambitieuse de restauration des cours d'eau. Or, les rivières ne peuvent aujourd'hui être dissociées des nombreux usages anthropiques dont elles font l'objet. Cela rend nécessaire de les envisager dans des perspectives multiples et d'intégrer les connaissances de plusieurs disciplines pour comprendre et éventuellement prédire les effets d'un projet de restauration sur les différents compartiments de ces socio-écosystèmes. Nous nous sommes focalisés sur la restauration de la continuité écologique, enjeu d'un débat public très animé en France, et avons réalisé une analyse interdisciplinaire d'un corpus bibliographique large. L'étude poursuit deux objectifs principaux : 1) identifier les limites des connaissances scientifiques actuelles sur les effets de la restauration de la continuité écologique des rivières; 2) identifier les points de vigilance qui pourraient être déterminants pour la trajectoire prise par le socio-écosystème fluvial suite à un projet de restauration. Sans viser une synthèse exhaustive, ce travail propose une perspective interdisciplinaire sur le sujet et encourage les chercheurs et les praticiens travaillant sur la restauration des cours d'eau à s'approprier la complexité des socio-écosystèmes que forment les rivières, de façon à gagner en assurance face aux inévitables incertitudes associées au choix de restaurer, ou de ne pas restaurer.

ABSTRACT

Environmental legislation at the national and international level established clear ecological objectives for river management, which incite public agencies in France to develop an ambitious program of river restoration. The fact that today's rivers are central to a row of human uses, imposes considering them in multiple perspectives and integrating knowledge from a number of disciplines when willing to understand and eventually predict the effects of a restoration project on different compartments of these socio-ecosystems. We focused on the river continuity restoration, a subject of an animated ongoing public debate in France and conducted an interdisciplinary analysis of a selected body of literature, with the goals of 1) identifying the limits of our existing knowledge on the effects of river continuity restoration; 2) identifying crucial aspects of restoration projects which may become

determinant for the trajectory of the restored riverine ecosystems. Not aiming to be an exhaustive synthesis, this work aims to propose an interdisciplinary perspective on the subject and encourage both researchers and managers dealing with river restoration to embrace the complexity of riverine socio-ecosystems and be more comfortable with inevitable uncertainties when choosing whether to restore.

KEYWORDS

River continuity restauration, socio-ecosystem, uncertainty, multidisciplinary approach, stakeholder involvement

1 RIVER CONTINUITY RESTORATION IN FRANCE

European and national legislation requires public agencies managing river bodies to put in place policies of river restoration with the goal of bringing rivers impacted by anthropogenic activities to a good ecological status. Restoration of ecological continuity belongs to key objectives of such policies. It covers a diversity of spatial dimensions (longitudinal, lateral, vertical connectivity), fluxes (water, sediments, organisms), and also a diversity of possible technical approaches (from dam, weir and dike removal to installation of fish passes or construction of bypass channels). While primarily guided by ecological goals, river restoration inevitably affects socio-economic issues related to rivers, notably risk management (e.g. flood and pollution control), the diversity of their uses (e.g. hydropower production, navigation, tourism), and perception of rivers by local population (e.g. emotional attachment to specific landscapes) (Dany, 2016). An animated public debate emerged in France around the topic of river continuity restoration in the last years. It has revealed an urgent need to clarify the terms of the debate and provide elements of scientific evidence to the stakeholders involved in the decision-making process. Importantly, this concerns knowledge produced both by natural sciences (ecology, geomorphology, physics) and social sciences (social geography, sociology, economy), which have increasingly followed the topic in the last years (Barraud & Germaine, 2017). Our goal here was to take an interdisciplinary perspective on the subject in a literature review aiming to 1) assess the degree of existing scientific knowledge on physical, ecological and social processes affected by river continuity restoration as well as the sources of associated uncertainties, and 2) identify crucial points to be taken into account at different steps of restoration projects.

2 A LITERATURE ANALYSIS INTEGRATING INTERDISCIPLINARY EXPERT KNOWLEDGE

Taking advantage of the French network of interdisciplinary scientific observatories (Zones Ateliers, CNRS), we mobilised for this project a vast group of researchers from different disciplines (geomorphology, ecology, social geography, sociology). Over 20 researchers were involved in several steps of identifying key pieces of literature and key findings in relation to river continuity restoration and its effects in each of the respective domains. An online survey involving these researchers produced a first selection of published literature based on expert knowledge. The latter was then progressively completed and expanded during an interdisciplinary workshop and multiple-stage exchanges on a collective review manuscript elaborated by the core group of the project. Both peer-reviewed scientific publications (meta-analysis, reviews and case studies) and grey literature documenting the effects of individual restoration projects or synthetizing the experience of practitioners in project realisation (e.g. guides published by Water Agencies; Dany 2016) have been included into this analysis.

3 KEY LESSONS LEARNED

Our state of knowledge in environmental sciences provides us with a row of highly performant tools, which enhance our capacity to assess the initial state of the river when considering a possible restoration, as well as predict and quantify the effects of a specific restoration project. For instance, hydraulic modelling allows us to have spatially explicit data on hydraulic habitats and reliably predict their evolution following different scenarios of restoration. Food web modelling allows us to take into

account the complexity of trophic interactions and predict the effects of restoration projects (e.g. dam removal) on the entire food web network and its single components. Population genetic tools open the door to quantifying the effects of connectivity interruption on gene flow between populations and the degree of effective organism dispersal following restoration of continuity. New visualization tools allow for producing images of future landscapes illustrating the effects of different restoration scenarios and providing an important basis for discussion among stakeholders.

In spite of this, a certain level of uncertainty is inevitably associated with every restoration project. Part of it is related to a very strong context-dependency of each specific project: the knowns and the unknowns of environmental and social factors that may have either positive or negative effects on the identified objectives of the project. Pollution legacy, presence or absence of source populations of target species, land use in the river basin are all examples of such factors, which may strongly constrain the ecological responses of river continuity restoration (Foley et al. 2017). Similarly, present and past local socio-economic situation, local and regional activity of certain interest groups (e.g. environmentally active NGOs, fishermen, hydropower producers) as well as presence of local charismatic figures involved in the debate may strongly influence public acceptance of each scenario taken into consideration. Another source of uncertainty is related to the timescale of response of each considered response variable and the sensitivity of each variable to natural stochastic processes (e.g. yearly variations in climatic conditions, occurrence of major floods, etc.). Several decades may be necessary for aquatic communities to find a novel equilibrium. The choice of the restoration measure itself may be a source of additional uncertainty. For instance, installation of fish passes compared to full removal of a barrier is associated with an increased uncertainty in respect to the effect of the operation on the passage of different species and their different life stages.

The scarcity of high quality and long-term data following restoration projects as well as the scarcity of projects, where both environmental and social effects of restoration are documented with rigor, limit our capacity to advance our knowledge on restoration effects. We thus insist on the crucial importance of long-term monitoring that has to start well before the restoration project itself and needs to be associated with rigorous data standardization, storage and management.

One of key conclusions of this work lies in the importance of creating a common river culture among the stakeholders concerned by a potential restoration project as well as across different research disciplines concerned by the topic of river restoration. Even though the drivers of a restoration project may originate from processes completely detached from local context (e.g. obligations by international environmental regulations, concerns of species conservation on a national or regional level etc), restoration of river continuity always concerns a specific territory with a specific ecological and social context, and has to be considered in the context of the long-term trajectory of this specific socio-ecosystem. Identification of key stakeholders concerned by a potential project of restoration and their continuous involvement into discussion appear indispensable to address the goals of territorial development and the potential place of river restoration within this development. This brings us to a the key question on how to balance large scale river management policies in terms of river restoration and conservation with local scale development strategies.

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