Resilience and River Restoration: what it is and is not

La résilience fluviale : ce qu'elle est et ce qu'elle n'est pas

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RÉSUMÉ

La résilience est devenue un mot à la mode dans la science fluviale. Cette popularité a donné lieu à des interprétations et à des utilisations parfois incorrectes, qui nuisent à son rôle dans l'étude et la gestion des rivières en tant que systèmes naturels-humains complexes et couplés. La résilience des rivières est la capacité de ces systèmes couplés à faire face aux perturbations/facteurs de stress et à continuer de fonctionner à peu près de la même manière. La résilience est une mesure de la mesure dans laquelle une rivière peut changer avant de franchir un point de basculement vers un état alternatif, dans lequel elle a tendance à rester. La résilience n'est pas la capacité de rebondir. C'est la capacité d'absorber, de s'adapter et de se transformer, tout en faisant face aux perturbations – il s'agit de changer pour ne pas être changé. Cette présentation fournira des exemples illustrant les capacités d'absorption, d'adaptation et de transformation qui sont les éléments clés de la résilience des rivières, qui doivent être comprises si nous voulons restaurer la fonction de nos corridors fluviaux.

ABSTRACT

Resilience has become a buzzword in river science. This popularity has resulted in interpretations and use that are sometimes incorrect, which detracts from its role in the study and management of rivers as complex, coupled natural – human systems. River resilience is the ability of these coupled systems to cope with disturbances / stressors and to keep functioning in much the same way. Resilience is a measure of how much a river can change before it crosses a tipping point into some alternate state, which it tends to stay in. Resilience is not the ability to bounce back. It is the ability to absorb, adapt and transform, while coping with disturbance – it's about changing in order not to be changed. This presentation will provide examples that illustrate the absorbing, adapting and transforming capacities that are the key components of river resilience, which must be understood if we are to restore function in our riverine landscapes.

KEYWORDS

Resilience capacities, absorption, adaptation, transformation, rivers as coupled systems

Capacités de résilience, absorption, adaptation, transformation, les rivières comme systèmes couplés

1 DEFINING RESILIENCE IN THE CONTEXT OF RIVER RESTORATION

The concept of resilience acknowledges societies' ability to live and develop with dynamic environments (Thoms and Fuller, 2024). Riverine landscapes are among the most dynamic of ecosystems, globally. River channel behaviour has often been conceptualised as being in some form of equilibrium, implying balance and steady-state process regimes, resulting in the misunderstanding by society that rivers can be tamed, stabilised and controlled. However, riverine landscapes are disturbance-driven systems. Disturbance is inherent to geomorphological and ecological function and a key driver of river ecosystem health. Without the disturbance of floods, most geomorphic work (erosion, sediment transport) would not happen. Given the recognition of the need to prepare for anticipated and unanticipated disturbances, there has been an increasing application of resilience as a guiding principle in understanding riverine landscapes, including their restoration.

Resilience is a popular concept within scientific and popular discourse (Walker and Cooper 2011). However, inconsistent use and multiple meanings of the term has been a source of confusion. Commonly, resilience is incorrectly referred to as the ability to bounce-back (Walker, 2020). The multiple meanings of resilience have one thing in common: the ability to deal with perturbations/shocks/disturbances, and to keep functioning. Thus, resilience is the ability to absorb, adapt and reorganise, or transform, while coping with disturbance, i.e. the ability to change in order not to change (Walker, 2020). In river restoration, resilience refers to the ability to persist in the face of disturbances that emanate either internally or externally and occur naturally or from anthropogenic activities in order provide a range of ecosystem services. The fundamental difference between bounce-back resilience and the resilience of restored riverine landscapes is the latter rejects the existence of a single stable equilibrium. A restored, resilient riverine landscape responds to disturbance (s) by changing the relative distribution of biophysical and social structures and their interactions.

The conceptualisation of resilience has expanded from the ability to absorb a disturbance (s) to include adaptiveness and transformation. The ability to absorb former underpins a predominantly biophysical view of resilient riverine landscapes, while the capacity to adapt is the ability to learn, combine experience and knowledge, and adjust to changing external drivers and internal process to continue functioning. The capacity to create a fundamentally new riverine landscape, is to transform because existing structures, functions and feedbacks are untenable, socially. Hence, the restored riverine landscape no longer retains its prior identity, being metamorphosed to a different regime or state. In this situation, there are also fundamental adjustments to the social component of the riverine landscape. Transforming riverine landscapes involves institutional change, innovation, behavioural shifts, new knowledge, and cultural change, all challenge our values, beliefs, and assumptions about rivers (cf. Berkes, 2023).

Recognition of resilience as a combination of three 'resilience capacities' promotes different responses in the restoration of riverine landscapes. Absorbing capacity leads to the persistence of the system with little overall change, and commonly the focus is the biophysical dynamics of riverine landscapes at various scales. Adaptive capacity leads to adaptation via incremental adjustments in the coupled natural – human system to enable continued use of ecosystem services provided by riverine landscapes. Transformative capacity is the capacity to create a new system i.e., those actions leading to transforming into an alternate regime or system. All three capacities are important and overlap to a degree. Viewing resilience as a capacity and not an outcome or endpoint, emphasizes the ability to actively develop and implement strategies, and modify responses for the continued sustainability of riverine landscapes (cf., Thoms et al. 2024). Depending on the context of river restoration, i.e., biophysical, social, or coupled, there is a continuum of resilience capacities and responses to achieving sustainability in riverine landscapes. The following sections apply these three capacities to river restoration.

2. RESTORING RESILIENCE CAPACITIES

2.1 Absorbing capacity and river restoration

The capacity to absorb disturbances and retain the same identity, structure, function, and feedback has been the dominant biophysical view of resilient riverine landscapes that underpins river restoration. Based on the concepts of thresholds, tipping points, alternate stable states at different scales and trajectories of change it enables the management and intervention of rivers by incorporating uncertainty and variability. Traditionally, river restoration has focused on recovery via various pathways to a prior state. Resilience thinking challenges the traditional restoration paradigm of returning to 'normal' conditions in several ways. Crossing a tipping point into

a new regime has three important implications for river restoration. First, the change is irreversible and restoring to a prior state is often not possible. Second, rivers attain a different identity in the new regime therefore foundational structures, functions and interactions will need to be identified and managed and not assumed. Third, the ability of river ecosystems to absorb further disturbances is reduced, i.e., the absorbing capacity of rivers decreases. Recognising the importance and understanding tipping points is essential for not only what to restore but also why to undertake river restoration.

Restoration strategies focused on enhancing the absorbing capacity of rivers reduces the risk of future flips. Rivers are complex adaptive systems governed by many variables operating at multiple scales, system trajectories are driven by a small set of controlling variables (Folke et al., 2004) and identifying these are important for what to restore. Heterogeneity, the spatial variance of different biophysical structures and functions across a riverine landscape, is important for enhancing the absorbing capacity of rivers. A positive relationship between biophysical heterogeneity and the ability to absorb disturbance(s) is supported by interdisciplinary river studies. Building biophysical heterogeneity in rivers must be a priority for restoration strategies to reduce the likelihood of further exceeding a tipping point.

An example of absorbative capacity is provided by large wood restoration in the Barwon-Darling River, Australia. The reintroduction of large wood provides habitat and by association changed native fish community dynamics.

2.2 Adaptive capacity and river restoration

The ability to adapt requires an understanding of the dynamics of riverine landscapes and also being proactive to respond to events that occur infrequently and unpredictably that increase the level of uncertainty. Rapid changes that characterize the Anthropocene riverine landscapes require the capacity to anticipate, plan, act and build adaptive capacity to deal with uncertainty.

Adaptive capacity is about enabling riverine landscapes to adapt to change (Thoms et al., 2018). Resilient riverine landscapes must have sufficient capacity to adapt to forecast (and actual) change. The nature and trajectory of change in a system must be understood. Recently there have been calls in New Zealand to ‘reanimate Aotearoa’s strangled rivers’, where confinement between engineered flood and erosion protection has ‘strangled’ rivers, locked them in place and frozen them in time (Brierley et al., 2023). A proposed solution to this problem is to give the river more room, in line with thinking elsewhere. These approaches allow for anticipated increasingly dynamic range of river behaviour. We can anticipate channel expansion, migration and avulsion in New Zealand’s laterally active gravelly rivers by understanding floodplain morphologies and channel trajectories.

This is illustrated in the Waipoua river corridor. Adaptation would provide room for the river in reaches that have been laterally constrained, to re-engage with the floodplain and return the river to a dynamically-adjusting system from its homogenised state.

2.3 Transformative capacity and river restoration

The possibility for organizations, communities, and riverine landscapes to undergo significant transformations in the face of adversity, crises, or changes goes beyond absorbing and adapting to disturbance(s) (Thoms et al., 2024). Transformative capacity changes thinking, behaviours, structures, processes and incorporates different knowledges to enhance river resilience in a rapidly changing and uncertain world. Using different knowledge sources not only expands the range of information to understand a problem, but also changes perceptions of the problem and the approaches to making improved decisions. The process of bringing many different knowledge sources together to understand, define and implement strategic activities is a gap in the restoration of riverine landscapes.

The restoration of riverine landscapes must recognize that knowledge is a social process and a set of outcomes. Knowledge systems are those interconnected components that create meaning about reality that humans construct and adapt over time (Reid et al., 2006). Knowledge systems reflect a knowledge-practice-belief nexus, where meaning emerges from actors constructing symbols, artifacts, competencies, and norms to enact ‘what we know’ and ‘how we know it’. Restoring riverine landscapes can improve with multiple types of knowledge to deal with future uncertainties in response to natural and human disturbances.

The inclusion of indigenous values, knowledge and perspectives in river restoration is in its infancy (Moggridge et al., 2024). Poor understanding of what is required to achieve indigenous engagement, limited confidence and resources to engage, and cultural differences add to the complexity of integrating indigenous cultural views on

both the dynamics of riverine landscapes and how and why to restore riverine landscapes (Thoms and Fuller, 2024). Frameworks and methods exist to integrate multiple sources of information into a single decision-making process for river restoration, but many do not allow decisions to be made based on integrative knowledge (Berkes, 2023). Enhancing indigenous knowledge in decision-making processes for river restoration requires articulation of local values, ethics, knowledge, and reality. This provides a philosophical base that is causative and directly influences the governance, policy, rules and guidelines for restoring rivers (Allan et al., 2024).

An illustration of the use of indigenous knowledges is provided through a case study of the Waikato River, New Zealand. Te ao Māori approaches have transformed river restoration in the Waikato River.

3 SUMMARY

Applying resilience thinking to river restoration is based on the fundamental premise that river ecosystems, society and their economies must be managed as linked natural – human systems. There are benefits to restoring riverine landscapes through a resilience lens. Resilience is about coping with and adapting to change and developing longer-term capacities under conditions of uncertainty. Conceptualising resilience as a capacity emphasizes the need to actively develop and implement river restoration strategies and modify them for their continued sustainability. Enhancing the ability of rivers to absorb future disturbance requires restoration to focus on building redundancy while enhancing adaptative capacity is more focused on incremental adjustments in the coupled natural – human system to enable continued use of the services provided by riverine landscapes. Transformative capacity is the capacity to create a coupled river system and those restoration actions must leading to transforming into an alternate regime or system. All three resilience capacities are important.

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