Sociogeomorphic river recovery: integrating human and physical processes in rehabilitation

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Key Points

- River recovery occurs via interactions between physical and human processes
- Rehabilitation practices that aim to support and enhance existing recovery processes are most likely to be efficient and effective
- Understanding trajectories of adjustment can help to underpin decision-making
- Sociogeomorphology provides a conceptual framework for understanding relationships between physical and human processes, to support recovery-based river rehabilitation

Abstract

River rehabilitation framed within a recovery-enhancement approach uses an understanding of river morphology, behavior and trajectory as a basis for improving river condition. On-ground rehabilitation activities commonly involve strategic, passive interventions, such as vegetation plantings, targeted weed management and livestock exclusion. However, in addition to the biophysical processes that are driving river recovery, human processes can also enhance or constrain possibilities for recovery. These include direct interactions (e.g. land use change) and indirect interactions (e.g. institutional conditions and relational issues). This paper examines relationships between human and physical (geomorphic) processes in river recovery through the lens of sociogeomorphology, which recognises that physical and social processes are simultaneously produced by – and producing – rivers, with on-ground implications for river recovery. River recovery in a southeast Australian case study is placed in context of its historical and contemporary human-environment interactions, including formal and informal relationships that shape river recovery trajectories. Recognition of relationships between human and physical processes, through a sociogeomorphic perspective, leads to an integrative understanding of the river system, its history and potential future trajectories of river recovery. For river management planning, this presents an opportunity to recognise and enhance existing physical and human recovery processes to achieve the best possible outcomes for river health and the ecosystems they support.

Keywords

Bottom-up approach, catchment management, environmental history, Macdonald River, participation, recovery-based river rehabilitation, recovery potential, trajectories.

Introduction

River rehabilitation can be a very expensive exercise, both in terms of time and money. River managers are under pressure to deliver the best possible environmental and social outcomes with the greatest efficiency. Recovery-based river rehabilitation, which aims to support and enhance existing processes of river recovery, meets the challenges of cost-effective and environmentally appropriate river rehabilitation because management actions do not fight against fluvial processes (Brierley and Fryirs, 2009). For this reason, the concept of recovery-based river rehabilitation has gained widespread popularity (e.g. Beechie et al., 2010).

In order to practice effective recovery-based river rehabilitation, we need to understand the nature of river recovery – both at a general conceptual level and in location-specific terms. This paper proposes that river recovery occurs because of interactions between physical (geomorphic, hydrological, etc.) and human (social, cultural, economic) processes. This means that we need to understand each group of processes not in isolation, but in a way that recognises their relationships with each other. The emerging concept of sociogeomorphology provides a conceptual framework for approaching these relationships and making sense of them for the purposes of supporting holistic recovery-based river rehabilitation. This paper aims to introduce sociogeomorphology and demonstrate its application with reference to a case study, where geomorphic river recovery is occurring and a sociogeomorphic understanding of its trajectory can provide a foundation for decision-making in recovery-based river rehabilitation.

Sociogeomorphology explained

Sociogeomorphology is a way of seeing geomorphic landscapes as the result of interactions between physical and human processes (Ashmore, 2015). Both physical and human processes are critical for explaining how rivers have evolved and how they might adjust in the future. From a sociogeomorphological perspective, the human and physical components make up one socio-natural system, rather than existing in isolation. Human and physical processes, as well as interactions between these processes, drive and/or inhibit river adjustment (Fig. 1). A significant implication of sociogeomorphology for river management is that it demands that human and physical drivers and constraints on river adjustment are considered and understood simultaneously. Therefore, a transdisciplinary approach is required to achieve outcomes that are socially and environmentally desirable (Mould et al., 2018).

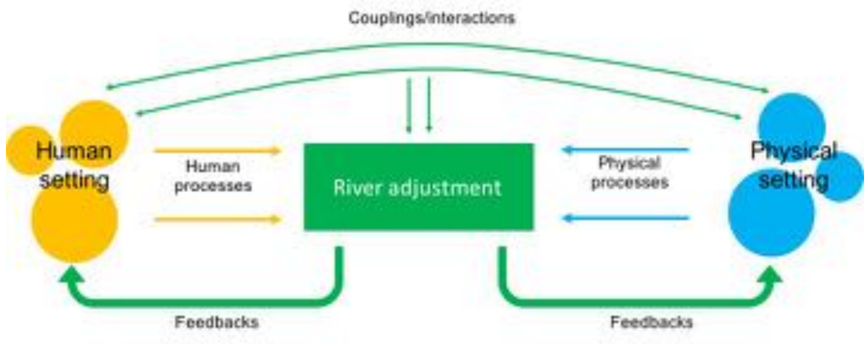

Figure1. A sociogeomorphological conceptualisation of river adjustment, being produced by physical and human processes, interactions between these processes and feedbacks between adjustments and the human/physical setting.

A river in recovery

The Macdonald River in southeast Australia (Fig. 2) was impacted by a series of catastrophic floods between 1949 and 1955, during which the channel was significantly widened and the eroded material deposited as a sand slug (Erskine, 1986; Henry, 1977). Subsequent floods in 1977 and 1978 reworked and added to the sand slug (Erskine and Melville, 1983). The over-widening and over-supply of sediment produced a loss of geomorphic complexity. The primary source of excess sediment was bank erosion, made possible by the rapid sequencing of floods and a particular land use history.

Environmental history was reconstructed using documentary evidence and oral testimony from local residents (Fig. 2). Since early settlement by the British in approximately 1810, floodplains have been cleared for cropping, followed by grazing. Grazing (predominantly cattle) extended to the water's edge and was intensive due to the limited availability of fertile land in this partly-confined valley. Population data and historical accounts suggest that from the outset, farming was family-scale and could not support large numbers of people. Impacts of the 1950s and 1970s floods further reduced floodplain size and buried farmland under excess sediment, putting pressure on farmers. This combined with broader scale economic changes in industrial agriculture and food markets from the 1960s to render farming in the Macdonald Valley largely unviable beyond subsistence.

The decline of farming as a means of maintaining livelihood made land available to 'tree-changers' and lifestyle land uses. Analysis of aerial photographs shows that vegetation cover increased significantly between 1953 and present-day, both in-channel and in the riparian zone (Fig. 3a-d). This was possible because of removal of grazing pressure since incomes no longer relied directly on the land. In-channel vegetation stabilised a proportion of sediment, which formed benches along the sides of the low-flow channel. Benches are step-like geomorphic units set within the greater channel zone, storing sediment and constraining the low-flow channel and considered a geomorphic recovery feature (see Erskine and Livingstone, 1999; Rustomji, 2008; Fryirs et al., in press.). Aerial photographs reveal that the proportion of the channel covered by benches vs bars (unstabilised sediment) increased significantly since 1953 (Fig. 3a-b). More recently, further vegetative stabilisation of benches and resultant reduction in channel cross-sectional area has allowed scouring and reworking of the low-flow channel. This is evident in the re-emergence of pools and riffles, as well as incision and re-definition of the low-flow channel (Fig. 3a-d), another sign of geomorphic recovery (Fryirs et al., in press). Residents note that this increase in geomorphic complexity was particularly noticeable since the 2007 'Pasha Bulker' storm and associated flooding (local residents pers. comm., 2017).

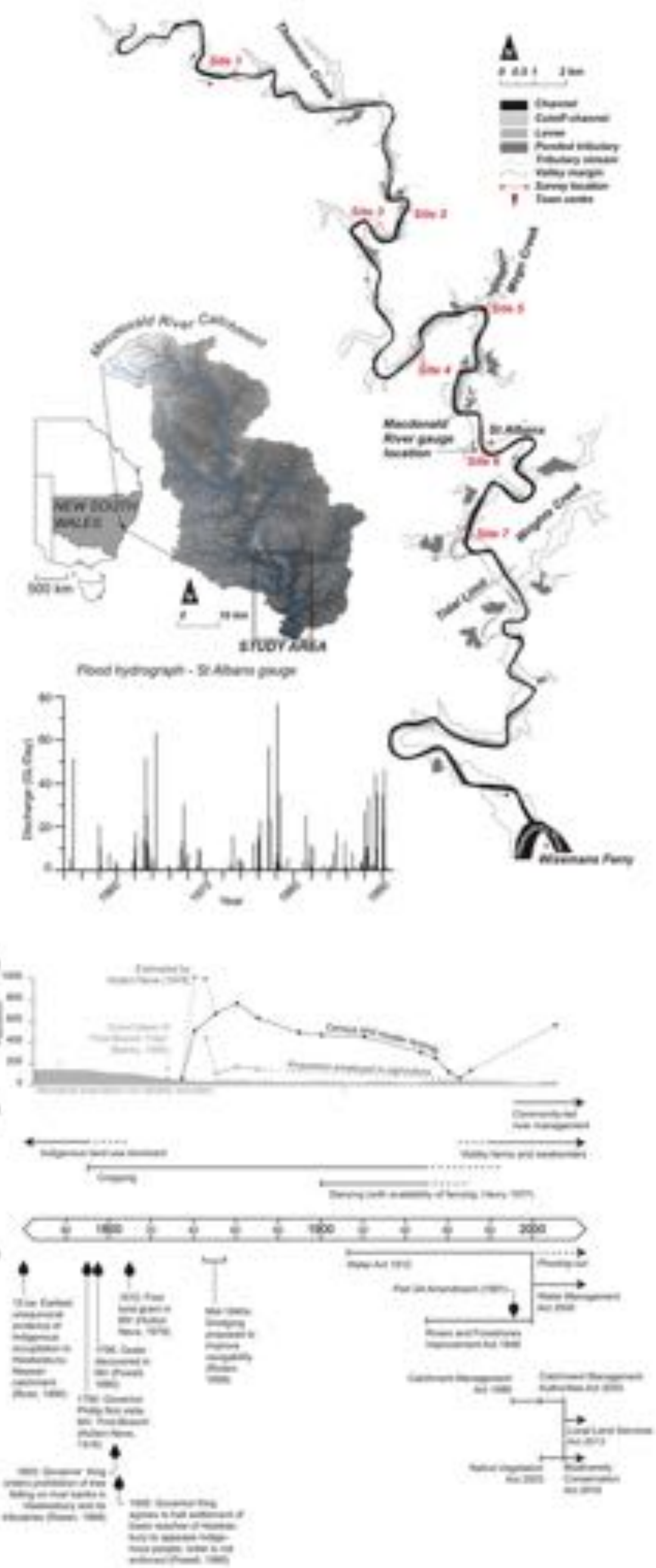

Figure2. Geomorphic map of the Macdonald River, flood hydrograph and summary of environmental history. Figure modified from Mould and Fryirs (2018).

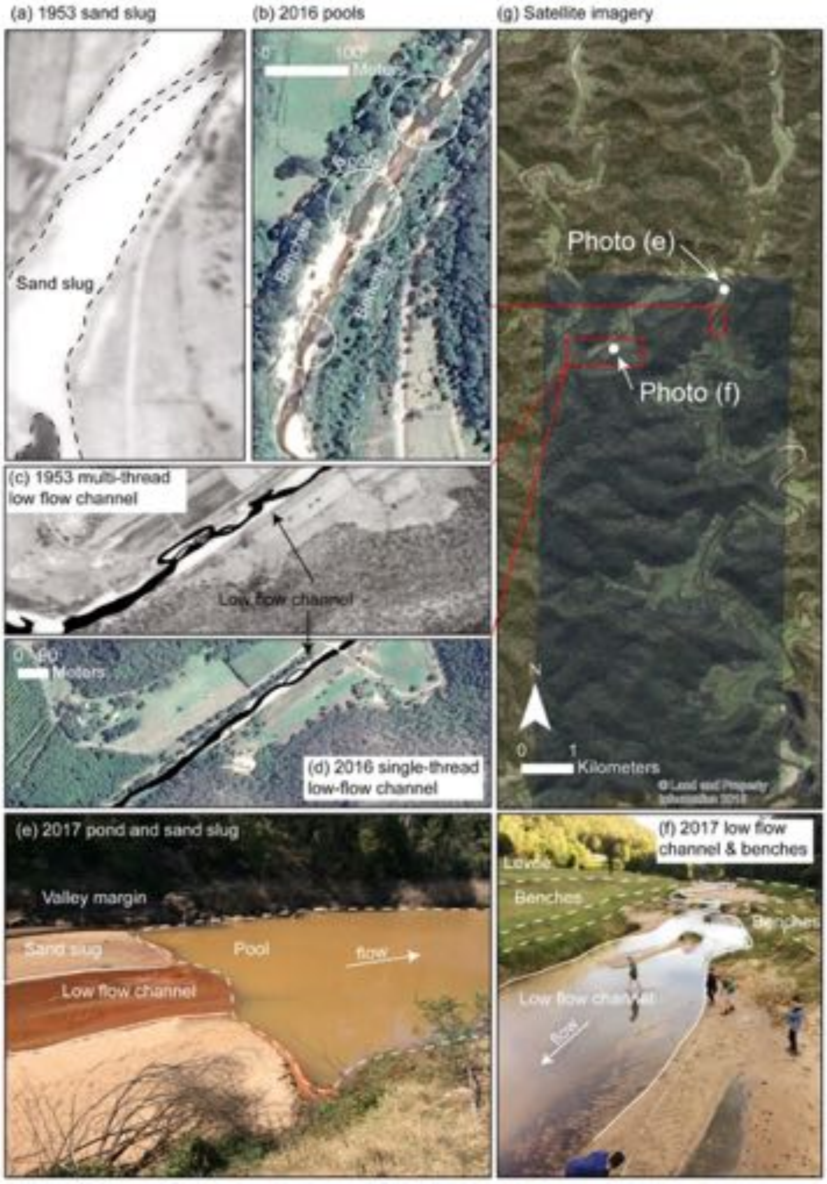

Figure3.Modes of geomorphic recovery, including (a-b) formation of pools, riffles and benches, (c-d) re-definition of low-flow channel and (e-f) ground-level views of pool, sand slug and benches. Figure from Mould and Fryirs (2018).

Sociogeomorphic history and trajectory analysis

Environmental history provides a basis for forecasting, or considering how a river might adjust in the future. Rather than attempting to predict a singular likely outcome, thinking in terms of adjustment trajectories allows for contextualisation of contemporary river condition and the generation of a range of possible future scenarios, consistent with managing for 'moving targets' (Brierley and Fryirs, 2016).The river recovery diagram for the Macdonald River (Fig. 4) illustrates trajectory analysis and its application as a decision support tool. Representations of reaches in different degrees of geomorphic condition are placed along a continuum from 'intact' (top) to 'degraded' (bottom); i.e. (b) is in poorer condition than (a) due to removal of vegetation and in-channel wood, which has allowed for incision. Scenario (a) is based on a pre-European condition whereas (b) is based on aerial photographs from 1941 (before 1950s floods). Scenario (k) represents the most degraded condition, where the channel is incised and over-widened. Reaches showing early signs of geomorphic recovery are critical 'turning points,' from where the river could either degrade or progress along a recovery trajectory (c.f. Brierley and Fryirs, 2005). For example, (c) has begun to store sediment in benches, which are partially stabilised by immature vegetation. If another large flood occurred at this stage, or if there were some other disturbance, the benches would likely be stripped away and the reach would become a (g), (i) or (k). However, if vegetation is allowed to become more established, and if small floods make minor modifications to the low-flow channel, (c) could progress to a (d), which is further recovered with more benches and more mature vegetation. A reach can degrade at any point and move 'down' the diagram but cannot move back 'up'; we cannot turn back the clock. Recovery processes must appear on a trajectory pathway adjacent to the primary pathway; for example, (e) closely resembles (a) from the surface but is structurally different and has a different evolutionary history, so it is on the adjacent recovery pathway. More radical changes in geomorphic structure may result in a 'creation' pathway, where a new river type is formed. This may be as a result of events such as cutoff formation (h) or human modification (j; dredging). In the Macdonald River, all reaches surveyed were a (c) or (d), suggesting that they are all either firmly on a recovery pathway or at a critical point where recovery may take hold. In these situations, ongoing recovery processes should be supported and enhanced, for example by protecting existing riparian and in-channel vegetation and perhaps planting addition vegetation to ensure that bench sediment stores remain secure, to avoid loss of recovery as in (f).

Recovery seen in the Macdonald has come about largely through unintentional human processes in combination with physical processes; however, its firm position on a trajectory of recovery is supported by more deliberate and organised social and political processes. Initially, it was the reduction of grazing pressure as farming became unviable that allowed vegetation to recover (likely largely from existing seedbank; cf. O'Donnell et al., 2015). With vegetative protection of the low-flow channel margins, deposition was possible in the form of benches and this was not un-done by grazing because many of the newer residents with lifestyle properties did not directly manage the in-channel vegetation (although this is not true of all landowners; local residents pers. comm., 2017). The Macdonald's unofficial name, 'The Forgotten Valley' reflects a history of being 'left alone' by authorities, for better or worse. While this meant that essential services were late in arriving to the valley, it also meant that the Macdonald avoided many of the hard engineering river management works characteristic of the NSW Rivers and Foreshores Improvement Act (Fig. 2c; see for comparison the history of rivers in the Hunter Catchment as in Spink et al., 2010).More recently, many landowners have participated in programs aimed at improving the condition of the riparian zone and this has been supported by Local Council and NSW Local Land Services (LLS; and Catchment Management Authority prior to restructuring). Residents formed the Macdonald Valley Association (MVA) in the early 1990s to organise support for services such as road maintenance and rubbish collection. However, the MVA later developed capabilities to apply for – and successfully manage – significant external grants to manage invasive weeds. The MVA also successfully petitioned for a dedicated catchment officer in the Catchment Management Authority to support their work and provide training in management techniques. This catchment officer continues to be employed by LLS and the valley benefits from a strong ongoing relationship. Strong participation in – and ownership of – passive river rehabilitation programs in the community has also been driven from the bottom-up by a small number of particularly dedicated and capable residents, who have taken on formal and informal roles to promote and organise their work and to support others in theirs. These social and political conditions contribute to the high likelihood of geomorphic recovery continuing in the Macdonald River, which reduces the likely geomorphic impacts of future large magnitude floods.

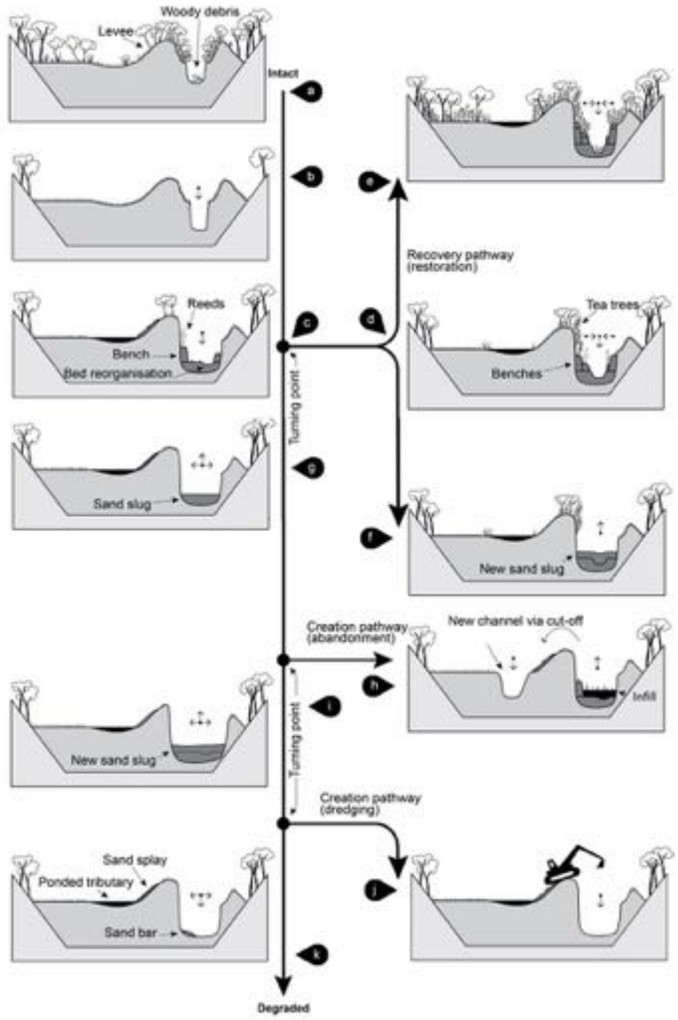

Figure4.River recovery diagram. Figure modified from Mould and Fryirs (2018).

Conclusions: recognising human and physical linkages

Recovery-based river rehabilitation requires a solid basis of knowledge around the nature of river recovery and the location of critical factors that drive or inhibit recovery from taking place. The Macdonald River case study illustrates a ‘good news story’ where recovery is successfully taking place and being supported by appropriate management (also see Fryirs et al., in press. and this volume). For river recovery, human processes and settings are just as important as the physical, both in recognising and explaining ‘unintentional’ recovery and in planning strategic approaches to river management (as in trajectory analysis). Sociogeomorphology provides a useful framing for developing the knowledge required for each of these tasks, ensuring that the focus of research is directly engaged with the human-and-physical systems in which river recovery takes place.

Acknowledgments

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