

Braided rivers and landscape-scale perspective

Holly Harris

Floodplains are some of the most globally threatened ecosystems. These landscapes are dynamic environments that comprise both river and land where water periodically flows during high flow or flood events. Braided rivers are a specific subset of gravel-bed rivers and their associated floodplains which are naturally rare worldwide, although relatively common in New Zealand. These rivers are highly dynamic rivers which form in areas where steep gradients combine with flashy flows, an abundant supply of bedload-calibre material, and erodible banks to create extensive gravel-based floodplains. Notably, braided river floodplains are characterized by heterogeneous channels in longitudinal, lateral, vertical and temporal dimensions (Tockner et al., 2006; Figure 1). In New Zealand, these landscapes are subject to a myriad of homogenising land-use changes such as encroachment, weed invasion, development and water abstraction.

Barren, or high ecological value?

Traditionally, braided rivers were thought of as ecologically barren from an aquatic perspective. The major channels in the central gravel plain are home to a few invertebrate species such as *Deleatidium* mayflies and little chironomid midges. From a river management perspective, these rivers provide gravel resources and pose high flood risk, with little ecological value in the major channels. However, to an ecologist, braided rivers are a nexus of ecological diversity, dynamic changing environments that serve not only as their own special landscape but also and a corridor for migratory birds, fish, and, in the northern hemisphere, megafauna such as bears and moose.

We only glean this perspective by considering the whole braided river landscape. For example, we found the major channels of Te Awa-a-Takatamira | the Cass River, in Tekapo, have low invertebrate diversity (mean = 10 taxa). However, other channels in the braidplain, such as the minor-channels (mean = 17 taxa), mid-channel (mean = 16 taxa), and lateral springs (mean = 22 taxa), contribute different species to the overall landscape diversity (river total = 70 taxa). Each of these channel types has different hydrology, flow disturbance histories, and temperatures, which suit different invertebrate species, thus greatly increasing total biodiversity. Te Awa-a-Takatamira is not unique in this regard; Gray et al. (2006) found the greatest amount of biodiversity in lateral channels of braided rivers across New Zealand. These channels would not exist without the dynamic back and forth of the major channel and flow variability over time creating space for springs to emerge and old channels to shrink and become hydrologically separate. Additionally, over 500 (and over 1000 on the Tasman) recognisably different invertebrate species, including many native bees (Figure 1), have been identified in the native vegetated landscapes that form after flood disturbances in the gravel parts of the river (with 25-30% unique species between rivers; T Murray pers coms). Thus, it is the whole landscape and the variability within it that facilitates high biodiversity.



Figure 1. Native raoulia mats and their associated communities are often overlooked, yet contribute considerably to landscape biodiversity, aesthetics value, and resource availability. These communities require the reworking of gravel from moving river channels and floods, in the absence of invasive weeds, to flourish. Photo credit: AR McIntosh

Contributions of heterogeneity to regional stability and resilience

We found that the natural variability of braided rivers also contributes to ecological resilience and stability. At a local scale, sampling invertebrate community biomass in one area such as a major channel may seem variable and vulnerable to floods. However, when biomass from multiple channels across the landscape is aggregated to calculate regional variability, asynchrony between channel types dampens overall variability, creating a more stable system. This dampening effect is even more pronounced in species such as fish, which can move around the landscape to take advantage of favourable conditions in local areas (Figure 2). The fewer distinct local channels that exist within the river, the more variable and unstable the aquatic system becomes. Therefore, landscape simplification will increase variability, and thus decrease stability, by turning multi-channel braided rivers into rivers with a single thread and deep, fast flowing water.

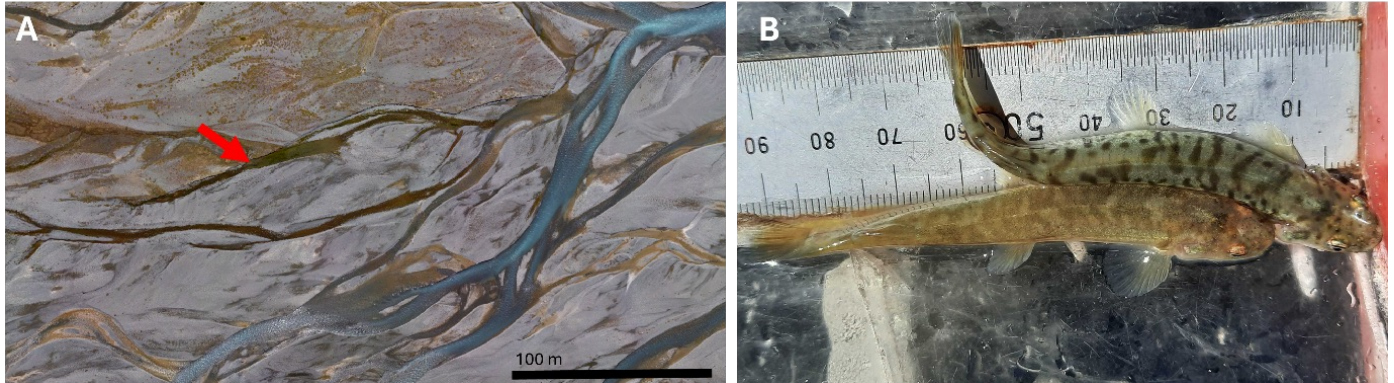


Figure 2. Braided river landscapes comprise many different channels (A) that shift through time, have different physico-chemical properties, and are home to different species assemblages, which are used by mobile species such as kōaro (B). Fish caught in a mid-channel spring (B) location indicated by the red arrow in panel A, display two colourings, one more golden than the other. Kōaro in turbid water turn a pale grey seen in the upper fish (B), thus indicating one fish has recently moved upstream from the turbid main channel shown in panel A. Photo Credit: H Harris

Heterogenous landscapes connected by mobile species

This landscape variability is utilised by mobile species that interact with the landscape on a broader scale. Bird species such as the endangered tarapirohe (*Chilodoniastriatus*) nest on the exposed gravel of the river through the spring and summer, allowing them to take advantage of changing resources within the river landscape. In early nesting season, these terns will use fish from the channels as part of their courtship, then later in the summer will catch skinks from the surrounding tussock grasslands (Gurney, 2022; L alas, 1977; O'Donnell & Monks, 2009; Figure 3). Kāki (*Himantopus novaezelandia*), the world's rarest wading bird, are highly adaptive foragers who will track prey abundance around the landscape following flow variation, feeding in minor channels when taking advantage of catastrophic mayfly drift at the start of a flood before moving to safer parts of the landscape such as back pools and tarns (Pierce, 1986). While these species can take advantage of the broader landscape, they are still river birds and thus are restricted in their ecology to river landscapes and vulnerable to landscape-scale changes.

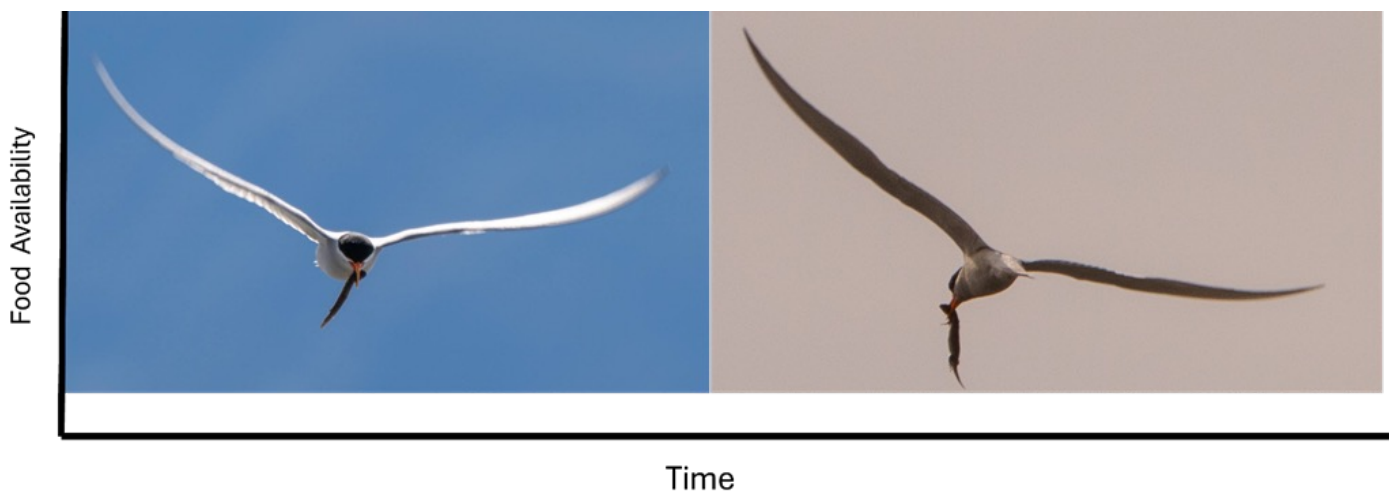


Figure 3. A tarapirohe (black-fronted tern) can integrate food sources spatially across a braided river landscape using fish from the major channels, particularly through spring, and catching skinks in the surrounding grasslands formed from old river bed movement. Photo credit: AR McIntosh

Landscape simplification

Landscape simplification will reduce the ecological resilience of braided rivers. Processes such as weed invasion reduce the braiding of channels and create negative feedback loops where water is channelised and channel movement becomes less likely (Gray et al., 2016; Stecca et al., 2019; Figure 3). These processes are compounded by slow legal recognition of the unique nature of braided river beds, and ad hoc flood protection works that reduce the ability for channel dynamism (Brower et al., 2024). Additionally, with increasing extreme flow events in parts of the country, homogenising floods will become more common and further destabilise braided river communities. Thus, there are many processes that will reduce heterogeneity in braided rivers. This is particularly true when management strategies do not apply broad-scale approaches that consider landscape contexts.

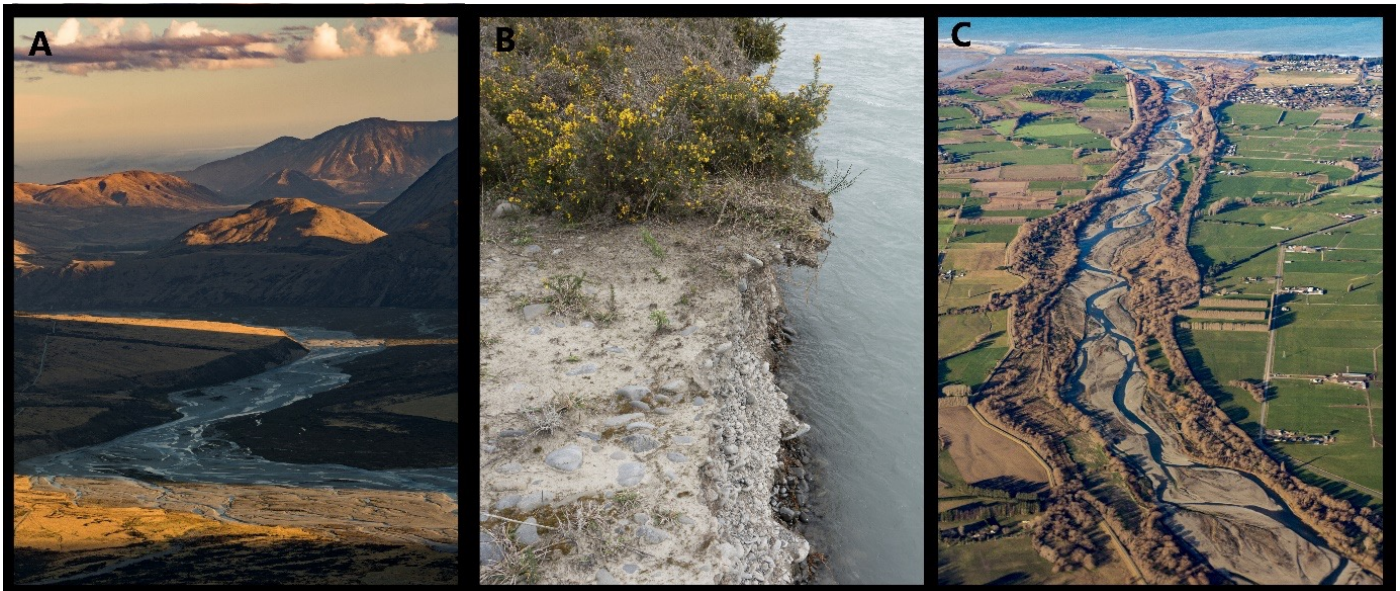


Figure 4. The Waimakariri river near its start in the Southern Alps runs free (A), but lowland weed and sediment entrapment (B), along with land acquisition and stop banks (artificial levees), can restrict braided river paths (C), causing a loss of heterogeneity and associated inherent resilience. Figure reproduced from Harris et al. 2023 “Multiscale ecological resilience in braided rivers” in “Resilience in Riverine landscapes”

Looking forward

Management strategies are changing. Removing stop banks in some areas has become a reasonable approach to increasing long-term social resilience to flooding and will have the added benefit of increasing ecological resilience if weed invasion is avoided. Mismatches between the scale of species interaction with the landscape and conservation strategies are starting to be recognised and tactics changed accordingly. Increasing the lateral components of floodplains, such as grassland, swamp, and spring areas may create nutrient buffers from runoff whilst additionally contributing to river refuge sites and increasing biodiversity. However, these are complex issues and cohesive planning and communication between a broad array of people responsible for land management and use will be necessary to find success across social, ecological, and economic outcomes for braided river landscapes.

Acknowledgements

Holly Harris is a PhD candidate at the Te Whare Wānanga o Waitaha | University of Canterbury (UC) working with Angus McIntosh and Jono Tonkin of UC's Freshwater Ecology Research Group and Tara Murray of Te Papa Atawhai | Department of Conservation. Her work has been funded by a UC Aho Hīnātore Scholarship and the Environment Canterbury/Department of Conservation Braided Rivers Regional Initiatives fund. The fieldwork for this project was conducted on Te Awa-a-Takatamira, in the rohe of Arowhenua Rūnanga. Ethics approval was given by the Department of Conservation (AEC404 and AEC406), and the University of Canterbury Animal Ethics committee (2021/16R). Thanks also to DOC for the use of their bird sampling protocol, and to the many field assistants who volunteered their time, company, and ideas. to Jenny Ladley and UC for the use of Mt John Field Station, and Glenmore station for access to the upper river and surrounding land for sampling.

References

- Brower, A., Hoyle, J., Gray, D., Buelow, F., Calkin, A., Fuller, I., Gabrielsson, R., Grove, P., Brierley, G., Louie, A. J. S., Rogers, J., Shulmeister, J., Uetz, K., Worthington, S., & Vosloo, R. (2024). *New Zealand's braided rivers: The land the law forgot*. *Earth Surface Processes and Landforms*, 49(1), 10–14. doi.org/10.1002/esp.5728
- Gray, Hicks, M., & Greenwood, M. (2016). *Advances in geomorphology and aquatic ecology of braided rivers*. In *Advances in New Zealand Freshwater Science*. Wellington, NZ.
- Gurney, F. (2022). *Breeding movements and post-breeding dispersal of Black-fronted terns/Tarapirohe (Chlidonias albobstriatus) in the Mackenzie Basin* [Masters, Lincoln University]. Lincoln University Research Repository.
- Lalas, C. (1977). *Food and feeding behaviour of the Black-fronted tern, Chlidonias hybrida albobstriatus*. [Doctoral Thesis, University of Otago]. Otago University Research Repository.
- O'Donnell, C., & Monks, J. (2009). *Predation of lizards by black-fronted terns (Sterna albobstriata)*. *Notornis*, 56, 167–168.
- Pierce, R. J. (1986). *Foraging responses of stilts (Himantopus spp.: Aves) to changes in behaviour and abundance of their riverbed prey*. *New Zealand Journal of Marine and Freshwater Research*, 20(1), 17–28.
- Stecca, G., Zolezzi, G., Hicks, D. M., & Surian, N. (2019). *Reduced braiding of rivers in human-modified landscapes: Converging trajectories and diversity of causes*. *Earth-Science Reviews*, 188, 291–311. doi.org/10.1016/j.earscirev.2018.10.016
- Tockner, K., Paetzold, A., Karaus, U., Claret, C., & Zettel, J. (2006). *Ecology of braided rivers*. In *Braided Rivers: Process, Deposits, Ecology and Management*.