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EVIDENCE-BASED CONSERVATION OF THE NORTHERN VICTORIAN FLOODPLAINS

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ABSTRACT: The floodplain wetlands of northern Victoria are crucial for conservation of biodiversity and the livelihoods of people. Extensive ecosystem degradation and recent extreme floods and droughts have highlighted the urgent need for more sustainable management. We draw on expertise in ecology, hydrology, climatology and governance to synthesise key knowledge and options for enhanced conservation of the floodplains. A key finding is the need for more flexible mechanisms for delivering water to the diverse array of wetlands. A key option is 'relaxing constraints' that involves agreements with selected landholders to enable pulses of environmental water to fill river channels and safely spill onto low-lying floodplain wetlands. This should improve conservation of biodiversity, better manage flood risk and support a diverse range of local agricultural and recreational industries. These options may aid Victorians to find better ways of managing the rich lands, waters and biota of the floodplains in the southern part of the Murray–Darling Basin.

Keywords: conservation, environmental flows, floodplains, freshwater biodiversity, Murray–Darling Basin, river, Victoria, wetlands

WHY NORTHERN VICTORIAN FLOODPLAINS?

Rivers, creeks and wetlands play a vital role in sustaining healthy communities and economies. In the Murray–Darling Basin (hereafter the 'Basin'), wetlands — primarily floodplain wetlands — cover 6.2 million hectares or 5.87 % of the area (Kingsford et al. 2004). These low-lying lands have rich soils and waterbodies that are replenished by floods. These fertile floodplains are the traditional lands of many Indigenous nations and sustain important habitats for populations of plant and animal species that are of great cultural significance. The floodplains also underpin valuable agricultural industries. However, exploitation of land and water has led to extensive environmental degradation that impacts people and biodiversity (Pittock et al. 2010; Holland et al. 2015).

The widespread floods that devastated residents across northern Victoria in 2011 and 2022 contrast starkly with the desiccated ecosystems seen in the prolonged and severe Millennium Drought (1997–2010), one of five major droughts since Federation (1901). These extreme events illustrate the importance of managing the northern Victorian floodplains as sustainably as possible to benefit people and nature within the context of a rapidly changing climate.

This paper provides a concise review of options for conservation of the northern Victorian floodplains based on advice from 12 experts consulted by the Royal Society of Victoria and Wentworth Group of Concerned Scientists. It is intended as an initial contribution to deliberations on the proposed Victorian Constraints Measures Program and other governance programs of river management. The Royal Society of Victoria proposes further discussion of the science that may inform better floodplain management in 2023. This review starts with defining the floodplains, provides perspectives on current management, considers ecological values and the changing hydrology, before concluding by considering future prospects.

First, we acknowledge the Indigenous Traditional Owners of these wetlands. For tens of thousands of years they managed these lands and waters sustainably. We look forward to a time when a focus on better river management provides enhanced livelihoods and culture, and renewed partnerships between Indigenous and non-Indigenous Australians.

DEFINING THE FLOODPLAINS

The floodplains of northern Victoria lie on the Quaternary alluvial sediments on the Riverine Plains in the Murray

Basin, and are contiguous with those in New South Wales (NSW) (VEAC 2006). The geomorphology ranges from constrained upper floodplains to lunette-fringed lakes and meander belts of the open river system associated with the Murray River and its tributaries. In Victoria, the floodplains include those of rivers such as the Loddon, Avoca and Campaspe, Goulburn and Murray. In 2006, the Victorian Environmental Assessment Council defined an area of 1,216,000 hectares as representing the former extent of forests of River Red Gum (*Eucalyptus camaldulensis*; a key floodplain tree species) and associated ecosystems, from Lake Hume to the South Australian border. While much of this land has been cleared for agriculture, the area included 269,000 hectares of public land that was largely under native vegetation (VEAC 2006).

Based on vegetation communities, a number of government agencies have defined flow-dependant ecosystems, which require periodic inundation to remain healthy. The Victorian Government uses Ecological Vegetation Classes (DELWP 2022a). The Federal Government uses the interim Australian National Aquatic Ecosystem classification (Brooks et al. 2014), which includes 19 ecosystem types for dominant wetland tree and shrub communities in the Basin, notably River Red Gum (*Eucalyptus camaldulensis*), Black Box (*Eucalyptus largiflorens*) and Lignum (*Muehlenbeckia florulenta*) in the south. Here, we use 'wetlands' to include river channels and floodplains, consistent with the definition of the Ramsar Convention on Wetlands (Ramsar 2009). Compared with the Ramsar Convention, the Victorian and other Australian governments have applied the term 'wetlands' narrowly — only to palustrine and lacustrine wetlands. These inconsistencies limit the use of government wetland classifications in defining floodplains.

The Murray–Darling Basin Authority in its *Basin-wide Environmental Watering Strategy* (EWS) focuses on the 'managed floodplain', namely the area where floodplain vegetation can be actively managed with environmental water (MDBA 2019). The extent of this managed floodplain has been changed and has not been publicly defined for Victoria. Continuing this hydrologically focused approach, in 2013 the Commonwealth, NSW and Victorian governments adopted a *Constraints Management Strategy* (MDBA 2013). Seven river reaches are identified in the strategy, whereby the governments propose to remove levee banks, relocate or protect flood-prone infrastructure and acquire flood easements, as well as ensuring that property owners are compensated for any damage from periodic flooding of private land from managed environmental flow releases from dams (Figure 1).

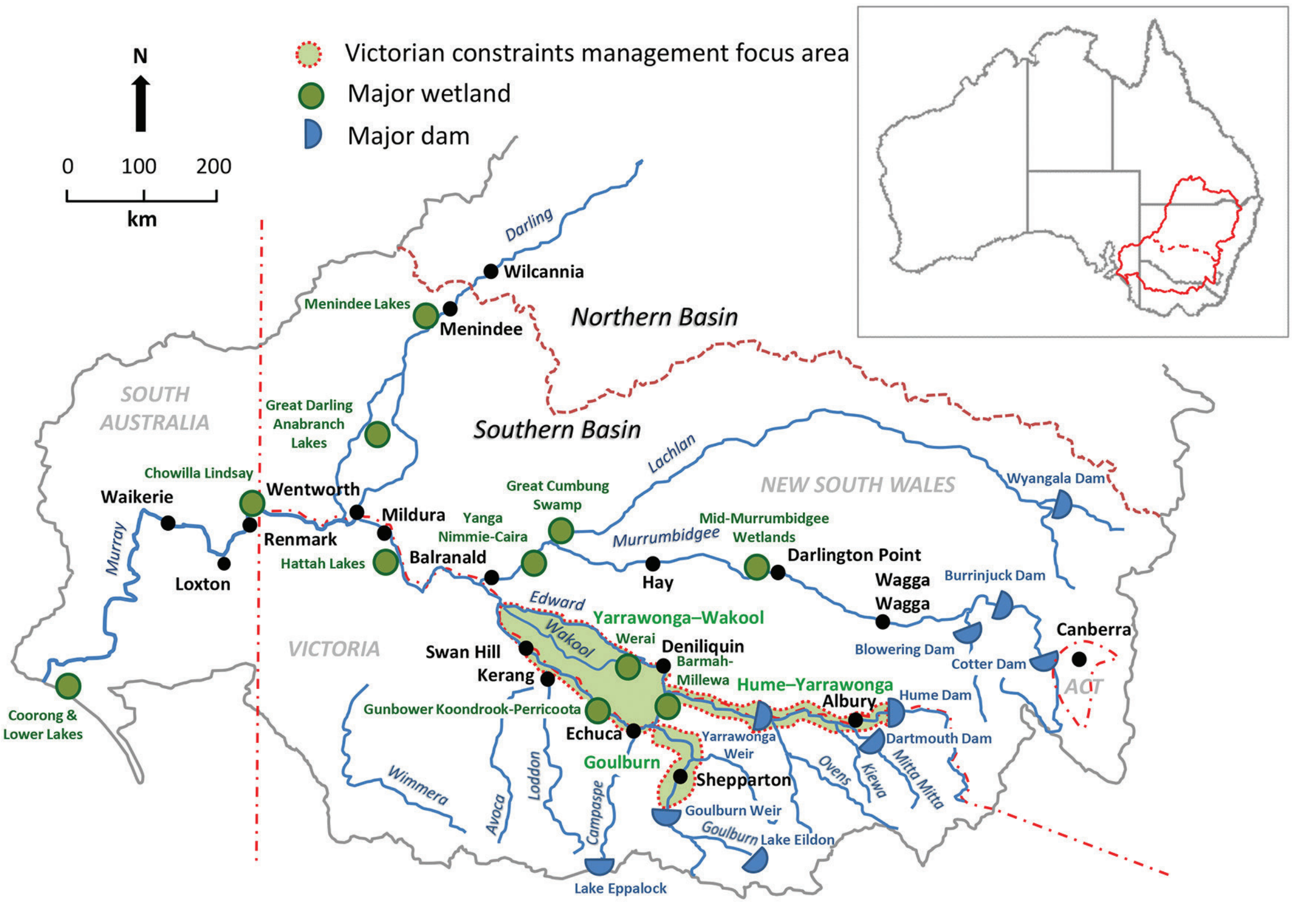

Figure 1: Locations of floodplain management focus areas in Victoria prioritised by the Basin Constraints Management Strategy (2013). © M. Colloff.

The three priority river reaches identified for constraints relaxation in Victoria are: 1) Goulburn River, 2) Hume to Yarrawonga on the River Murray, and 3) Yarrawonga to Wakool Junction on the River Murray. Compared with other Victorian rivers, these river reaches were selected by the governments as having large floodplains downstream of major reservoirs (Eppalock, Eildon, Dartmouth and Hume) from which stored environmental water may be released in a coordinated manner to water extensive areas of wetlands along the full length of the River Murray (Kahan et al. 2020). This would directly enable managed watering of around 375,000 hectares of floodplain wetlands in three states (Victoria, New South Wales and South Australia). For the Goulburn River, constraints relaxation could temporarily inundate 8330 hectares of private land (held by around 560 landholders) and enable watering of 10–12,000 hectares of floodplain wetlands (Kahan et al. 2020). The Victorian statistics are not disaggregated for the two constraints relaxation proposals involving NSW along the River Murray. Much of the following discussion focuses on the Goulburn River as it is wholly in Victoria and is where most information is available. However, this review considers the issues for floodplain management along the Goulburn and Murray rivers in Victoria and recognises their integral ecological connection to wetlands in the other states.

The different and imprecise methods of defining floodplains used in Victoria highlighted above, point to an opportunity to better quantify and manage these wetlands.

PERSPECTIVES ON MANAGING THE FLOODPLAINS

Good floodplain management is vital for both people — human settlements are focused on the rivers — and the conservation of biodiversity (Kahan et al. 2020). The flat floodplains, with comparatively deep and nutrient-rich soils, and diversity of wetlands are focal habitats for flora and fauna (described below) and have benefitted people through timber extraction, farming, grazing and recreation. These biodiversity benefits and ecosystem services are increasingly jeopardised by declining river inflows with climate change and high levels of water regulation and extraction (Alexandra 2021).

Increasing water scarcity caused by excessive irrigation diversions resulted in Basin governments capping water entitlements in 1995 at 1994 levels of extraction. At the same time, those governments agreed that water should be allocated for the environment in order to conserve wetlands and their biodiversity on a continual basis. On the Goulburn and Murray rivers, there have been two basic approaches to conserving wetlands with environmental water (Pittock 2016), namely 'environmental works and measures' and environmental flows. Beginning in 2002 as the Millennium Drought deepened, the Victorian and Commonwealth governments invested in engineering projects to inundate key floodplain wetlands with less water than would be required to generate overbank flows. These projects involved extracting water from the rivers using canals and pumps to pond the water in wetlands behind levees, stop banks and new weirs. Projects at Hattah Lakes and Gunbower Forest under The Living Murray Program are examples of these (MDBA 2011). A new tranche of nine such 'environmental works and measures' projects are now proposed, called the Victorian Murray Floodplain Restoration Project, that is part of the Sustainable Diversion Limit Adjustment Mechanism at the Basin scale.

These engineering projects have been extensively criticised on a number of grounds (Bender et al. 2022; Bond et al. 2014; Lyons et al. 2022; Pittock et al. 2013). The ecological outcomes are not the same as from natural inundations and some negative ecological impacts are likely. The projects are designed to provide water for targeted high-value wetlands and parts of the upper floodplain that have been deprived of their natural flows, but that is a negative consequence of diminishing the volume of environmental water in the river system. The justification for these projects has changed from being drought refuges for freshwater fauna, to floodplain restoration, to saving water for agriculture. These are expensive projects focused on small areas of the floodplain and they have large conservation opportunity costs. A monitoring system has been implemented, but it remains to be seen how adaptive management will be achieved.

Globally, provision of managed environmental flows has been adopted as a method of best practice for conserving rivers and their floodplains (Arthington et al. 2018; Tharme 2003). Environmental flows have been delivered to Victorian floodplain wetlands over the last two decades with some positive ecological responses (King et al. 2010; Ward & Colloff 2010). However, constraints on releasing larger flows that may inundate private land have limited the ability of managers to better conserve many floodplain wetlands (Stewardson & Guarino 2018). Indeed, in the past eight years, river managers have advised one of us (Pittock) of an informal Victorian Government policy of not allowing managed overbank flows along the Goulburn River, to the detriment of its 13,000 hectares of floodplain wetlands. Further, Victorian managers' inability to deliver environmental flows overbank has contributed to persistently high and unnatural in-channel flows in the Goulburn River that have had negative environmental impacts (DELWP 2022b).

Since the enactment of the *Water Act* 2007 (Commonwealth) the total volume of water that has been reallocated to support the health of the rivers and wetlands in the Basin has grown to 3053 GL/year on average (MDBA 2021). This equates to 22% of the 13,623 GL/year historically allocated for irrigation or 9% of average surface water inflow of 32,800 GL/year (MDBA 2010). However, it is important to note that a volume of only 1900 GL/year is actually released as environmental flows by the Commonwealth (Chen et al. 2021). At the same time environmental water management has been evolving from site- to system-scale across the Southern-connected Basin. This has highlighted that environmental outcomes would be greatly improved through the relaxation of constraints that would enable managed releases of water to fill river channels and spill out onto the floodplains to sustain the wetland ecosystems and generate benefits for people (Kahan et al. 2020). However, the agreements with landowners to implement the *Constraints Management Strategy* have yet to be obtained in New South Wales and Victoria.

The kinds of interventions proposed in the Basin to relax constraints for more effective environmental-flow delivery are undertaken in other countries to reduce the impacts of flooding on society. These floodplain restoration programs are known variously as 'nature-based solutions' and 'ecosystem-based adaptation' and 'managed retreat' in programs for climate-change adaptation and disaster-risk reduction. Jurisdictions as diverse as China, the European Union and the United States of America have extensive floodplain restoration programs (Wenger et al. 2013). In those countries, floodplain land has usually changed from agricultural use to nature conservation and tourism, and this has generated considerable social and economic benefits (Opperman et al. 2009; Pittock 2009).

Turning to the Victorian floodplains, the Goulburn Valley Environment Group (J. Pettigrew, pers. comm. 26 September 2022) has highlighted that increased scientific understanding of the flow requirements of flow-dependent ecosystems has not been matched by changes in the delivery of environmental water due to the continuation of constraints on release of managed flows. They argue that the necessary relaxation of flow constraints will require state governments to implement mechanisms for compulsory acquisition of flood easements, 'without which there is little or no prospect of gaining landholder cooperation and final approvals' to enable inundation of low-lying private land.

To achieve the objectives of the Murray–Darling Basin Plan's EWS, it is essential to overcome the constraints on flows and adaptively manage environmental water using approaches that are supported by the community. Changing current management practices is complex. Involving the community in participatory approaches for planning, implementation, monitoring, learning and reflection on flow trials is necessary in order to increase support for environmental flows and improve environmental outcomes. As an example, a trial in the Edward–Kolety–Wakool system (NSW) demonstrated how water managers and the community can work together to plan and implement flow trials that perform better than established river-management practices (Allan & Watts 2022).

ECOLOGICAL NEEDS OF FLOODPLAIN FLORA AND FAUNA

River Murray floodplain wetlands have been extensively altered by human activities since the 1840s. The iconic River Red Gum floodplain forests and other wetlands now represent hybrid or novel ecosystems: they have departed so substantially from their historical structure and function as to defy conservation efforts aimed at restoration to an earlier reference condition (Colloff 2014). Although the ecosystems have changed, the water requirements of their component biota remain the same; environmental water policy and management must deliver water in a way that is responsive to these needs (Chen et al. 2020; Figure 2).

Environmental watering must meet the needs not only of wetland vegetation communities, but also fauna, such as waterbirds and fish. Fish are important ecologically and provide a range of values that can be protected or restored by ensuring connectivity between in-channel and off-channel fish habitats (Koehn & Lintermans 2012). Ecological cues for a range of important life-cycle events are also dependent on particular environmental flow thresholds, with relaxed flow constraints having the potential to provide floodplain habitats, induce spawning, support recruitment and thus considerably increase fish populations. Modelling of relaxed constraints in the mid-Murray River has indicated that populations of Golden Perch (*Macquaria ambigua*), a wide-ranging flow-responding species, could be increased by up to 39% with flows of 45,000 ML/d allowed at Yarrawonga (Todd et al. 2022). Waterbirds are similarly dependent on wetland habitats and environmental flow events, but their mobility means that they are less dependent on direct connectivity, although this may not be the case for their food sources. Ephemeral wetlands unconnected to river channels can be the most productive habitats for waterbirds when they fill with water, supporting high densities of invertebrates that form the main food for the majority of waterbird species. Due to diet and habitat differences between species, environmental flows to different types of wetlands will benefit different groups of waterbird species (Loyn et al. 2002, 2017; Bino et al. 2020). This poses challenges for water management about how and where to deliver water for the best outcomes.

Figure 2: Managed inundation is needed to maintain the health of red gum forest ecosystems on the floodplain, Barmah National Park, September 2022. © J. Pittock.

CHANGING HYDROLOGY

The Goulburn and Murray rivers are among the most regulated in the Basin and globally, with infrastructure used to maximise water reserves and minimise flood damage to downstream communities, typically by constraining river flows to be within-bank whenever possible. This has caused floodplain ecosystem stress with widespread negative environmental consequences (Kahan et al. 2020).

The impacts of these operational constraints are likely to be exacerbated by climate change. The median climate change projection indicates a 20% reduction in mean annual runoff in the Murray–Darling Basin under 2°C global average warming (Prosser et al. 2021). Though variability is expected to remain high, drought will be more frequent and severe, and high flow events are likely to become 25% less frequent in the southern Basin (Chiew et al. 2022). This means less frequent overbank flows from rainfall events that generate high inflows, and reduced opportunities to 'piggy-back' environmental water on top of high unregulated flows to induce overbank flooding (MDBA 2022).

Focusing purely on increasing the volume of environmental water is insufficient to restore the diversity of wetlands across the Murray–Darling Basin. While wetlands at the floodplain margin are now infrequently inundated due to regulation and constraints, many wetlands near the main river channels are experiencing increased frequency and duration of inundation. To restore the ecological complexity and diversity of wetlands other measures are also needed, such as the control of weeds and pests, long-term management of nutrients, turbidity and sediment accretion, and the reinstatement of flow variability, including periodic drying, that structured the past diversity (Gell et al. 2019; Gell & Reid 2016).

FUTURE PROSPECTS

Victorians have three options for managing their floodplains along the Goulburn and Murray rivers:

1) Doing nothing, which would result in the continuing decline and loss of extensive areas of floodplain wetlands which would be watered too infrequently between unregulated flood events
2) Expanding environmental works and measures projects, which would be expensive to build and maintain, would enable watering of only a minority of the total floodplain area and could have a number of negative, unintended environmental outcomes
3) Relaxing constraints, which while having a high upfront cost, would maximise conservation of the area of wetlands with limited water. Constraints relaxation

would also provide many co-benefits, including reducing flood risks to human communities.

The delivery of the strategy for managing constraints in NSW and Victoria has focused on negotiating with landholders for the purchase of about 3300 flood easements. This would cost about $864 million (2016 estimates) in federal funding for local infrastructure upgrades and easement purchases (Kahan et al. 2020). Reconstruction following the extensive 2022 floods may provide some opportunities to improve this rebuilding of infrastructure, contributing to relaxed constraints and reducing future flood risks.

Currently, the Victorian Government proposes that easement sales should be voluntary; however, individual landowners may then block the delivery of environmental flows. With this in mind we propose that the governments consider three options which may better engage landholders and ensure their participation in the wider efforts to relax constraints and provide more options for managing floodplain wetlands:

1) Broaden the options open to landholders, including having time-limited easements or voluntary land purchases
2) Include an adjustment mechanism and a trust fund to quickly respond to and manage any unexpected outcomes for private landholders after initial implementation
3) Negotiate a deadline for agreements after which time compulsory acquisition of easements is undertaken.

The allocation of environmental water — under a relaxation of constraints on managed water flows onto northern Victorian floodplains — could have profound benefits for the provision of ecosystem services from the re-watered wetlands (Kahan et al. 2020). We urge more action by managers to identify these benefits and the beneficiaries. The benefits include reducing impacts of floods, recharging aquifers, reducing salinity, increasing fish populations, increasing shallow marsh habitat for waterbirds, growing timber and pasture, and supporting recreational industries. Information on the benefits that can accrue to landholders from ecosystem services derived from flooding is needed and can be used to demonstrate how the benefits can be enhanced under different flow scenarios. Operationally, those landholders who may be adversely affected by the relaxation of constraints can be recognised and supported, including with subsidies or compensation, and other practical steps to rapidly minimise any adverse impacts that may occur.

The overdue implementation of the Basin *Constraints Management Strategy* needs to be addressed — it is an important component of the Basin Plan and could be used to overcome identified limitations in other operational activities. Insights from science and governance research combined with participatory decision-making processes may assist communities in northern Victoria and governments to decide how best to enhance floodplain management for people and for nature. We see knowledge from research and from communities along the rivers as an essential part of making informed decisions for effectively managing constraints on flows in order to achieve the goal of restoring the floodplains and ensuring a sustainable social–ecological outcome.

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Conflicts of interest

Kate Auty, C. Max Finlayson, Kate Lyons, John Koehn and Richard Loyn declare no conflicts of interest. Jamie Pittock is a member and Matt Colloff is an associate member of the Wentworth Group of Concerned Scientists.

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