Characterising condition for non-woody vegetation in floodplain-wetland systems

Commonwealth Environmental Water Holder’s Science Program: Flow Monitoring, Evaluation and Research Program (Flow-MER)

December 2024

Australian Government
Commonwealth Environmental Water Holder

FLOW Monitoring Evaluation Research

Acknowledgement of Country

The project team and the Commonwealth Environmental Water Holder (CEWH) respectfully acknowledge the Traditional Custodians of the land on which this work was conducted, their Elders past and present, their Nations of the Murray–Darling Basin, and their cultural, social, environmental, spiritual and economic connection to their lands and waters.

Citation

Campbell C, Dyer F and Thomas JE (2024) Characterising condition for non-woody vegetation in floodplain-wetland systems. Flow-MER Program. Commonwealth Environmental Water Holder: Flow Monitoring, Evaluation and Research Program, Department of Climate Change, Energy, the Environment and Water, Canberra, Australia. 18pp.

Acknowledgement of contributors

We acknowledge the Commonwealth Environmental Water Holder via the Flow-MER program for supporting this research. This research was undertaken as a PhD and was funded by an Australian Government (PhD) Research Training Program scholarship and top-up funding via the Flow-MER program. Cherie acknowledges and thanks her supervisors Fiona Dyer, Ross Thompson and Samantha Capon for the time and energy invested throughout her PhD. We acknowledge the support of the Flow-MER team, in particular the Basin-scale vegetation team (Tanya Doody, Fiona Dyer, Will Higgisson, Alica Tschierschke) and vegetation leads from each of the Selected Areas (Fiona Dyer, Skye Wassens, Jason Nicol, Mark Southwell, Robyn Watts, Kay Morris). The data used in the case study in section 2.6 was collected as part of the Flow-MER and Long-Term Intervention Monitoring (LTIM) projects and we acknowledge the people involved in making that possible. The case study also drew on work undertaken by the Flow-MER Basin-scale vegetation team (of which Cherie and Fiona were a part), including the allocation of functional groups to plant species and the development of hydrological groups, and we thank Will Higgisson and Alica Tschierschke for their involvement in these. We acknowledge support from the Flow-MER program more broadly. The vast variety of support provided has been critical to conduct this research project and preparation of this report.

Ethics

The surveys conducted as part of this research were approved under University of Canberra ethics permit 4636.

Document submission history

Date	Content
December 2023	Primary material provided by C Campbell
October 2024	Draft prepared from primary material
December 2024	Report approved for publication

Cover photograph

Sneeze weed (*Centipeda cunninghammi*). Photo credit: University of Canberra.

SUMMARY

An important part of evaluation is understanding ‘what is good’. Defining what is ‘good’ requires understanding what environmental water management is aiming to achieve and why – for example, the objectives, and the functions and values supported, as well as how outcomes will be assessed, such as condition, resilience or thresholds to evaluate ‘success’ against. This research explored the notion of ‘success’ and ‘what is good’ and aimed to rethink the way condition is used to envisage, evaluate and communicate non-woody vegetation outcomes from environmental flows. The resulting structured framework for characterising condition, using both ecological data and societal values, provides practical guidance for water managers to inform condition benchmarks, watering objectives and choice of monitoring metrics. Outcomes have fed into the Flow-MER evaluation of vegetation and are more broadly applicable to monitoring and evaluation of non-woody vegetation outcomes from environmental watering or other management activities.

Research aim

Basin-scale monitoring and research projects have provided insights into just how diverse, unique, and complex wetland and floodplain plant communities are at a landscape scale. Given the unique species-level responses of non-woody vegetation, research was needed to seek patterns in non-woody vegetation responses that can inform predictions for future water management. The challenge was to develop a Basin-scale process for evaluating non-woody vegetation outcomes that incorporates diversity and variability of responses, has clear links to the functions and values supported, and can predict expected outcomes in unmonitored areas.

The aim of this research was to rethink the way condition is used to envisage, evaluate and communicate non-woody vegetation outcomes from environmental flows.

Approach and methods

This project was completed as a PhD (Campbell 2024) titled *What is good? Characterising condition for non-woody vegetation in floodplain-wetland systems.*

The project developed a framework for characterising the condition of non-woody wetland and floodplain vegetation. A combination of expert opinion, societal values, ecological data, literature and conceptual understanding was used to rethink the way condition is used to measure and evaluate vegetation responses to environmental water.

Key messages

- Condition is a social–ecological construct.
- Components of condition cover hierarchical biodiversity, social-ecological functions and values, and resilience.
- Management requires more than just water.
- Multiple lines of evidence should inform a data-driven narrative around vegetation condition at scales such as the Murray–Darling Basin.

- Monitoring, evaluation and research approaches should focus on assessing impact from environmental water management.

Links to evaluation

This project identified ways to define non-woody vegetation condition to inform evaluation of vegetation outcomes in response to environmental flows, both in Flow-MER and more broadly.

Specifically, outcomes will help inform:

- watering objectives and an overarching vision for the maintenance and recovery of non-woody vegetation
- identifying monitoring indicators and metrics
- definitions of condition and the development of resilience models
- evaluation approaches and a quantifiable definition of success.

Informing adaptive management

Non-woody vegetation can be effectively managed using environmental water in many locations in the Basin. However, there are no clear benchmarks or definitions of success for non-woody vegetation condition that would provide simple targets for monitoring and adaptive management. This research developed condition frameworks which allow an assessment of the effects of environmental watering.

By characterising condition in a structured framework, practical guidance can be given to water managers to help inform the development of benchmarks, watering objectives and monitoring metrics.

Overview of Flow-MER

The Commonwealth Environmental Water Holder (CEWH) invests in monitoring, evaluation and research activities delivered through an integrated program called the Monitoring, Evaluation and Research (Flow-MER) Program. This program builds on work undertaken through the Long-Term Intervention Monitoring (LTIM) and Environmental Water Knowledge and Research (EWKR) Projects (2014–2019) to monitor and evaluate the contribution of Commonwealth water for the environment to environmental outcomes in the Murray–Darling Basin. The Flow-MER Program:

- monitors and evaluates ecological responses to Commonwealth environmental water in 7 Selected Areas and at basin-scale using established metrics and methodologies
- undertakes best-practice science in 7 Selected Areas and at basin-scale to research ecological processes and thus improve capacity to understand and predict how ecosystems respond to water management
- demonstrates outcomes from Commonwealth environmental water and documents these via a regular reporting schedule and engagement and extension activities
- facilitates a regular, timely and effective transfer of relevant knowledge to meet the adaptive management information requirements of Commonwealth environmental water decision-makers.

Up-to-date information on and outcomes from the Flow-MER Program are available from the Flow-MER website.

Flow-MER research

The Flow-MER Program is the primary means by which the CEWH undertakes research to deliver improved methods and a richer evaluation of environmental outcomes from Commonwealth environmental water. Flow-MER research aims to improve basin-scale understanding of the contribution of Commonwealth environmental water within and outside of Selected Areas, develop new approaches to evaluating outcomes, support adaptive management and develop a richer understanding of ecological processes and responses to Commonwealth environmental water.

The Research Plan has evolved from the LTIM and builds on the EWKR research priorities together with a large body of previous work, resulting in 13 research projects: Flow-ecology (BW2), Condition response (E2), Non-woody plants (V1), Woody plants (V2), Fish population models (F1), Fish movement (F2), Waterbirds (E1), Refugia (BW1), Scaling and condition (E3), Bioenergetics (BW3), Visualisation (CC1), Modelling (CC2) and Indigenous engagement (CC3).

This report is the final report from the non-woody plants project (V1) team.

CONTENTS

FIGURES

1 INTRODUCTION

Properly managing environmental water requires knowing 'what is good' in terms of ecosystem condition, so that water managers can know if their actions are achieving desired outcomes (are having 'success'). What 'good' and 'success' look like is not well established for non-woody vegetation, which plays a critical role in water-dependent floodplain-wetland ecosystems in the Murray–Darling Basin.

Non-woody water-dependent vegetation fringes water courses or grows within river channels and wetlands. It includes grasses, sedges, reeds, rushes, herbs, macroalgae and seagrass. Non-woody vegetation is dynamic in space and time, and is a critical component of river-floodplain ecosystems by providing food and habitat for other biodiversity.

The *Basin-wide environmental watering strategy* (MDBA 2019) expected environmental outcomes for non-woody vegetation include maintaining its extent, and maintaining or improving its condition in areas that can be influenced by the delivery of environmental water.

This research aimed to investigate, for non-woody vegetation, **what** is trying to be achieved by environmental water management and **why**, and **how** to know if it is on track. This will help us know whether environmental water management for non-woody vegetation is having 'success' in achieving or maintaining 'good' condition.

1.1 Research aims

The aim of this research was to rethink the way condition is used to envisage, evaluate and communicate non-woody vegetation outcomes from environmental flows (Figure 1.1), specifically to:

- conceptualise the components of condition that are integral to adaptively manage non-woody vegetation outcomes to flow in social-ecological systems such as floodplain-wetlands
- better understand the practice of environmental water management for non-woody vegetation outcomes by gathering practitioners' perspectives on outcomes and benefits, influences and risks to achieving outcomes, challenges associated with monitoring and evaluation, and how to improve outcomes in the future
- explore how non-woody vegetation responses to flow have been characterised in the published literature in terms of hierarchical biodiversity, functions and values, and resilience
- better understand community perspectives on the value of non-woody vegetation in river-floodplain environments to inform processes that foster shared understanding and just management of environmental water
- investigate the bounds of resilience for non-woody vegetation communities through variable wet–dry cycles
- synthesise a framing of condition to envisage and evaluate non-woody vegetation outcomes to environmental water to help maintain a range of functions and values.

1.2 About this report

This report is the final report from the non-woody plants project (V1) team. It was conducted as a PhD project (Campbell 2024) published as a suite of journal papers (Campbell et al. 2021; 2022; 2023; 2024).

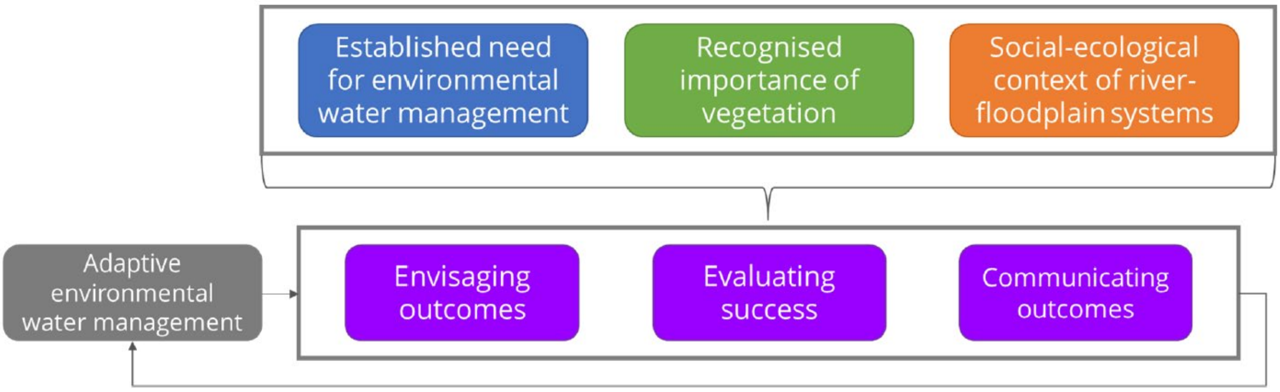

Figure 1.1 Flow diagram outlining the logic underpinning this research (Campbell 2024)
There is i) an established need for environmental water management, ii) a recognised importance of vegetation and iii) a social-ecological context of river-floodplain systems. Collectively, these influence critical aspects of environmental water management such as the way in which i) outcomes are envisaged, ii) success is evaluated and iii) outcomes are communicated. This in turn influences future adaptive environmental water management.

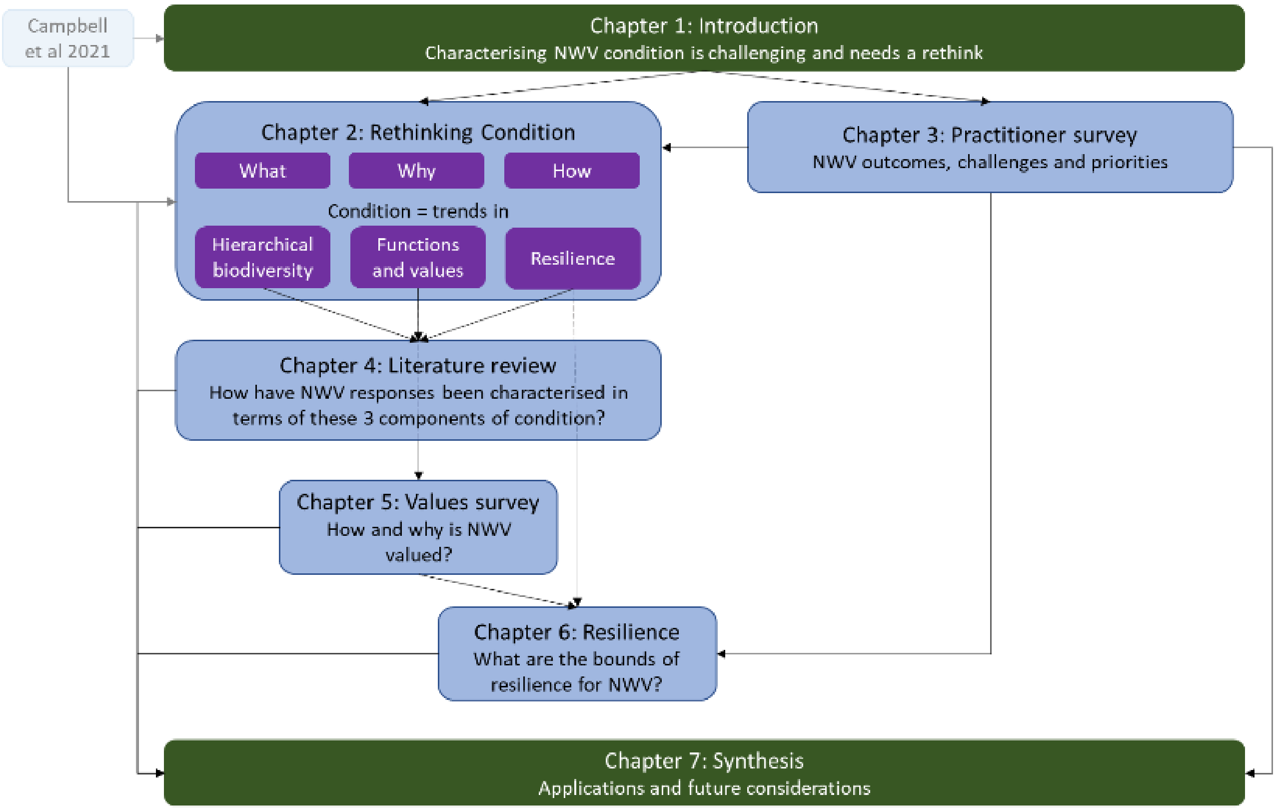

Figure 1.2 Graphical representation of the linkages between chapters of the PhD thesis arising from this project
Thesis chapters 1–6 correspond to sections 2.1–2.6 of this report.

2 APPROACH

This research was conducted as a PhD project (Campbell 2024) and published as a suite of journal papers (Campbell et al. 2021; 2022; 2023; 2024). Each section in this chapter summarises a thesis chapter.

2.1 Blue, green and in-between: objectives and approaches for evaluating wetland flow regimes based on vegetation outcomes

Non-woody water-dependent vegetation is complex, variable and dynamic in space and time, so evaluating its responses to environmental water management can be challenging, even if collecting monitoring data is relatively straightforward.

The peer-reviewed paper that forms the basis of this section (Campbell et al. 2021) resulted from a collaboration of vegetation scientists as part of the Environmental Water Knowledge Research and Long Term Intervention Monitoring projects, and underpins this research project.

Four principles are proposed that can guide the development of management objectives and evaluation approaches to support adaptive management of wetland vegetation in flow-managed systems:

- identify indicators that align to management objectives and ecological functions that support ecological, sociocultural and economic values
- identify appropriate spatiotemporal scales and levels of ecological organisation
- consider temporal context and complexity
- identify non-hydrological modifying factors.

These 4 principles are discussed in more detail below.

Key knowledge needs required to support the implementation of these principles include improving our understanding of ecological, sociocultural and economic values of wetland vegetation and the attributes and functions that support these values.

Identify indicators that align to management objectives and ecological functions that support ecological, sociocultural and economic values

Wetland vegetation, including non-woody vegetation, provides a broad range of ecosystem functions and services. In addition to these ecological values, sociocultural and economic values should also be considered when identifying indicators. Sociocultural values include cultural significance, amenity and recreation. Economic values of wetlands include supporting tourism and fisheries.

Management objectives and indicators should explicitly reflect this broad range of values in order to truly capture management outcomes.

Identify appropriate spatiotemporal scales and levels of ecological organisation

Multiple spatiotemporal scales and levels of ecological organisation should be considered when setting objectives and indicators for wetland vegetation. Spatial scales and levels of ecological organisation range from individual plants to landscapes, and temporal scales range from flow-pulse (days to months) to long-term flow regime (decade(s) to centuries).

Consider temporal context and complexity

Evaluating vegetation condition and responses to environmental flows should reflect a nuanced understanding of temporal flow dynamics. Short-term temporal scales include prevailing and antecedent (recent) flow conditions. Longer-term trajectories of wetland vegetation dynamics, flood history and landscape alteration should also be considered. Future scenarios are a third temporal scale that should be considered when setting environmental watering objectives for wetland vegetation, as projected climatic changes are likely to result in significant changes to wetland vegetation communities.

Identify non-hydrological modifying factors

Many non-flow factors can influence how wetland vegetation responds to environmental flows. Some of these non-hydrological factors include shading and litter from mature canopies, sediment regime, grazing, animal disturbance, nutrient inputs, salinity and fire, as well as warmer temperatures with projected climatic changes. Where possible, non-flow factors should be considered when setting management objectives.

2.2 Re-thinking condition: measuring and evaluating wetland vegetation responses to water management

To best evaluate watering outcomes for non-woody vegetation, 'condition' needs to reflect **what** is trying to be achieved by environmental watering, **why** it is trying to be achieved and **how** to know if it is on track. Campbell et al. (2022) conceptualised the components of condition that are integral to adaptively manage non-woody vegetation outcomes to flow in floodplain-wetlands – namely hierarchical biodiversity the 'what'), functions and values (the 'why'), and resilience (Figure 2.1). Monitoring, evaluation and research should reflect these components in a structured framework.

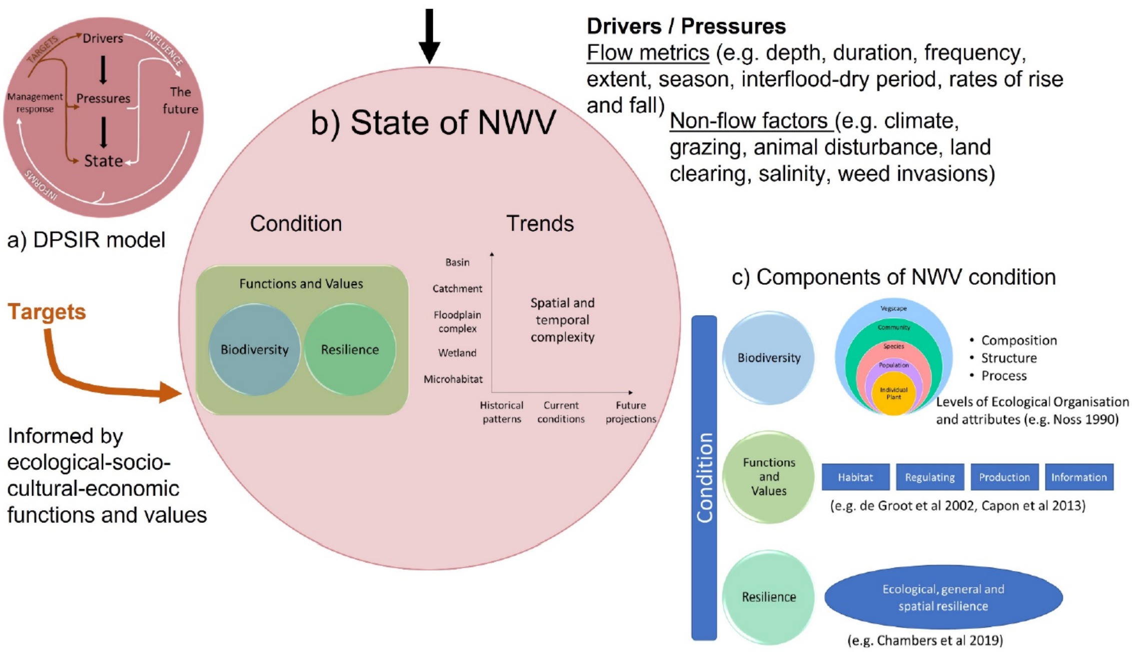

Figure 2.1 Conceptual framework depicting key components in the characterisation of non-woody vegetation (NWV) condition in floodplain-wetland environments

(a) represents the common use of 'state' in driver–pressure–state–impact–response (DPSIR) models and the links with targets and drivers and pressures, (b) depicts the state of non-woody vegetation as condition and trends, where condition incorporates functions, values, biodiversity and resilience, and trends covers both spatial and temporal complexity, and (c) represents the components of non-woody vegetation condition within biodiversity, functions and values and resilience.

Hierarchical biodiversity

Biodiversity exists at multiple levels of ecological organisation and across a range of attributes. Levels of ecological organisation range from the individual plant up to vegscapes (landscapes of multiple vegetation communities or ecosystem types). 'Attributes' refers to the range of vegetation characteristics such as composition (e.g. species richness), structure (e.g. cover) and process (e.g. seed production). Measures of condition should reflect these multiple levels of biodiversity.

Functions and values

Functions and values can be thought of as 'the quality, importance, amount or value of something'. Non-woody vegetation provides numerous ecological, socio-cultural and economic functions and values that might include things like erosion prevention and aesthetic values. Functions and values can be grouped as providing habitat, regulation, production or information. Evaluation of non-woody vegetation condition should align with its functions and values.

Resilience

Resilience can be ecological, spatial or general in nature, and incorporates current and projected changes to flow, climate, and other non-flow stressors and drivers. An example of ecological resilience might be the composition, abundance and viability of seed banks at individual locations. An example of spatial resilience might be landscape distribution and configuration of community types with different levels of ecological resilience. Frameworks to evaluate condition should incorporate monitoring and managing for resilience.

2.3 Beyond a 'just add water' perspective: environmental water management for vegetation outcomes

Environmental water managers operate within complex social-ecological systems. To better understand this complexity, we surveyed managers to better understand their practice of environmental water management for non-woody vegetation (Campbell et al. 2023). This gathered perspectives on outcomes and benefits, influences and risks, challenges associated with monitoring and evaluation, and how to improve outcomes in the future. The survey captured knowledge and expert opinion from practitioners in environmental water management. Survey responses identified 6 key themes:

- flow regimes
- vegetation attributes
- non-flow drivers
- management-governance considerations
- functions and values
- monitoring, evaluation and research.

Key findings from this research include:

- Flow is important for vegetation, but management requires more than just water.
- Integrated land-water management is needed to limited impacts of non-flow drivers.
- Constraints need to be addressed to improve vegetation outcomes to flow regimes.
- Practitioners perceive vegetation management in holistic and interconnected ways.
- Building societal understanding of environmental water management is important.

These diverse themes – and the holistic and interconnected perceptions of environmental water management by its practitioners – highlight the need for ‘more than just water’ when it comes to the restoration and management of non-woody vegetation. The survey identified the need for more integrated land–water governance and management to address the impacts of non-flow drivers, such as pest species, land-use change, and climate change, along with a need to tackle physical, operational and social constraints to improve outcomes to environmental flow management.

2.4 Branching out: patterns and perspective in environmental water management for non-woody vegetation outcomes

This part of the research aimed to explore how the responses of non-woody vegetation to flow have been characterised in the published literature and to discuss how learnings can be applied to adaptive management of environmental flows for non-woody vegetation outcomes. This review identified a diverse range of response metrics, associated flow components and co-variates that have been used to describe non-woody vegetation responses to flow across multiple levels of ecological organisation and across a range of different spatial and temporal scales.

Key findings from this review:

- Patterns observed in vegetation responses in floodplain-wetland systems are varied.
- Studies have covered a wide variety of vegetation, flow and covariate metrics.
- Studies have covered multiple levels of ecological organisation, spatial scale and temporal complexity.
- For discrete components of vegetation, we advocate a ‘theory of change’ to articulate expected outcomes in response to a suite of conditions, including a description of ‘unacceptable’ departure from expected outcomes.
- When synthesising outcomes across broad spatial scales, such as the Murray–Darling Basin, and across multiple vegetation components (e.g. species, communities, landscape mosaics), we advocate a structured narrative to position information into a broader context.
- Moving from scientific interest to informing management requires a shift from observing patterns of change to providing perspectives.
- Translating observed patterns into perspectives that inform management decisions and actions would be a helpful progression in the science–management interface.

2.5 More than a service: values of rivers, wetlands and floodplains are informed by both function and feeling

How people value rivers, wetlands and floodplains influences their attitudes, beliefs and behaviours towards these ecosystems, and can shape policy and management interventions. Better understanding why people value rivers, wetlands and floodplains and their key ecosystem components, such as vegetation, helps to determine what factors underpin the social legitimacy required for effective management of these systems. A peer-reviewed publication describes this research, which sought to ascertain community perspectives on the value of non-woody vegetation in river-floodplain systems via an online survey (Campbell et al. 2024).

- Participants valued non-woody vegetation for its provision of a range of ecosystem functions and services, with a strong emphasis on ecological aspects such as regulation functions, habitat provision, and biodiversity.

- The inclusion of a question framed to focus on stories or narratives resulted in a different emphasis. The responses to this question indicated that non-woody vegetation – and rivers, wetlands and floodplains – were valued for the way they made people feel through lived experiences such as recreational activities, personal interactions with natural, educational and research experiences.
- Storytelling has an important role in navigating complex natural resource management challenges and ascertaining a deeper understanding of values that moves beyond provision of function to feeling.
- Improved understanding of the diverse ways people value and interact with river-floodplain systems will help to develop narratives and forms of engagement that foster shared understanding, empathy and collaboration.

This research highlights the important role of storytelling in navigating complex natural resource management challenges and ascertaining a deeper understanding of values that moves beyond provision of function to feeling. Improved understanding of the diverse ways people value and interact with river-floodplain systems will help develop narratives and forms of engagement that foster shared understanding, empathy and collaboration. Appreciation of plural values such as the provision of functions and services along with the role of emotional connections and lived experience will likely increase lasting engagement of the general public with management to protect and restore river-floodplain systems.

2.6 Managing for non-stationarity in floodplain-wetland systems: a case study using non-woody vegetation responses

Resilience is the ability to resist or recover from disturbances, including natural disturbances such as wetting and drying. A resilient vegetation community will have the ability to resist or recover (i.e. a level of condition) that is adequate to maintain defined functions and values (Figure 2.2). The resilience or condition state also has implication for the environmental flow regime that managers may seek to implement (Figure 2.2).

Conceptual resilience response models were developed for 5 broad non-woody vegetation types: submerged benthic herbfields, tall reed beds, sedge-rushlands, aquatic grasslands, and ephemeral herbfields. Vegetation responses – considering composition, structure and processes – were hypothesised for different hydrostates (i.e. wetting, wet, drying, dry) under ‘exemplar’ (typical), drier and wetter hydrological scenarios. These conceptual models were applied to case studies using understorey vegetation data from the Flow-MER program. For broad non-woody vegetation types, these resilience models help define expected outcomes (e.g. what are the characteristics of a functioning reed bed?), bounds of resilience (e.g. when is a reed bed no longer a reed bed?) and restoration goals (e.g. how do we reinstate a reed bed?).

Using Flow-MER data collected from floodplain-wetlands in the Murray–Darling Basin, we developed a case study to explore the validity of our hypotheses. We believe our conceptual framing can help frame resilience and articulate a theory of change for non-woody vegetation communities in floodplain-wetland systems in response to changes in wet–dry cycles.

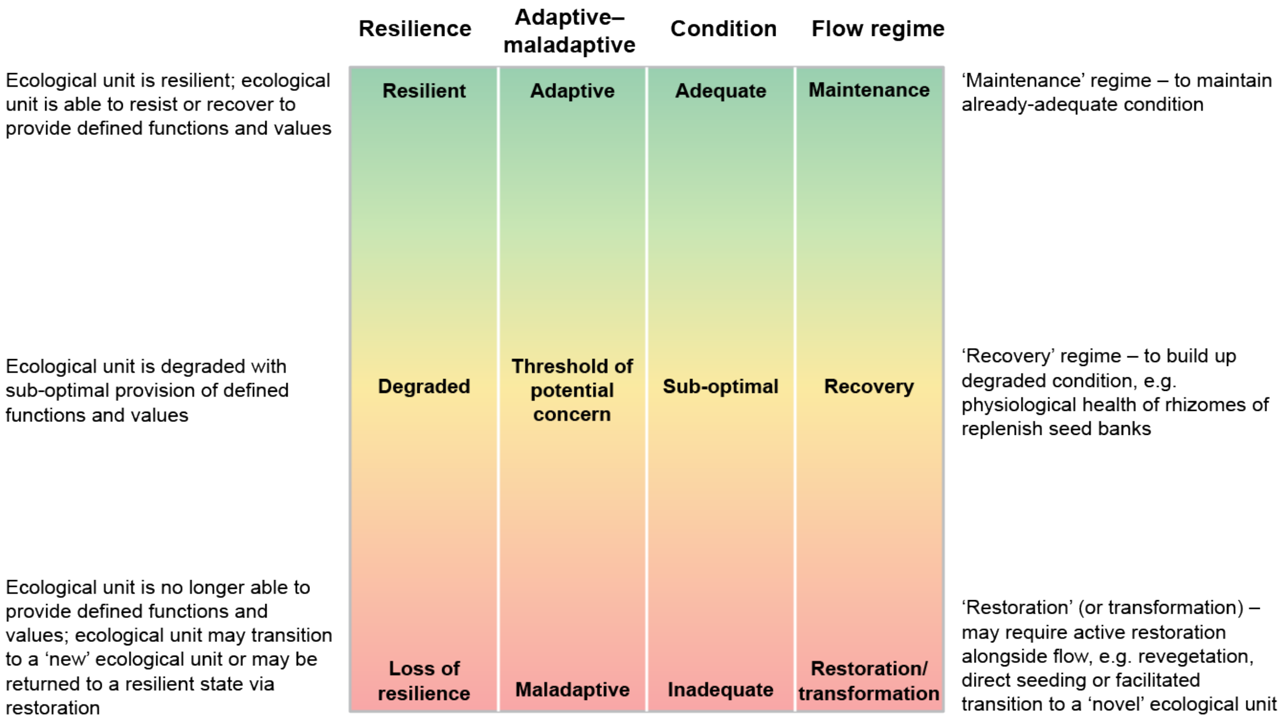

Figure 2.2 Relationship between resilience, adaptive-maladaptive space and condition

The upper (green) end of the scale represents a high degree of resilience with condition adequate to maintain defined functions and values. The lower (red) end of the scale represents a loss of resilience with a level of condition that is inadequate to maintain defined functions and values. Diagram created by C. Campbell.

3 Conclusions and recommendations

River-floodplain systems are social-ecological systems, therefore defining ‘what is good’, with the aim of evaluating condition, must include social and ecological components. This research presents a framing of non-woody vegetation condition that considers hierarchical biodiversity, social-ecological functions and values, and resilience. Managing water for non-woody vegetation outcomes requires more than just water. In addition, given the diversity and hierarchical structure of non-woody vegetation, evaluating outcomes at levels of governance such as the Basin requires a structured narrative to frame findings from multiple projects. Evaluating non-woody vegetation outcomes should place stronger emphasis on the impact of environmental water management and to what degree outcomes are likely to represent resilience. Conceptual models developed by this research help define resilience and articulate a theory of change for non-woody vegetation communities in floodplain-wetland systems in response to changes in wet–dry cycles. Constraints to environmental water management remain a major challenge to achieving non-woody vegetation outcomes that will require social-ecological solutions.

3.1 Contribution to Flow-MER objectives

This project identified ways to define non-woody vegetation condition to inform evaluation of vegetation outcomes in response to environmental flows, both in Flow-MER and more broadly.

Specifically, outcomes will help inform:

- watering objectives and an overarching vision for the maintenance and recovery of non-woody vegetation
- identifying monitoring indicators and metrics
- definitions of condition and the development of resilience models
- evaluation approaches and a quantifiable definition of success.

Non-woody vegetation can be effectively managed using environmental water in many locations in the Basin. However, there are no clear benchmarks or definitions of success for non-woody vegetation condition that would provide simple targets for monitoring and adaptive management. This research developed condition frameworks which allow an assessment of the effects of environmental watering.

By characterising condition in a structured framework, practical guidance can be given to water managers to help inform the development of benchmarks, watering objectives and monitoring metrics.

3.2 Outputs

Four journal papers were published during the research project. These are listed in References under Campbell et al. 2021, 2022, 2023, 2024).

3.3 Next steps

Opportunities for further research include:

- investigating interactions between multiple drivers and the role of integrated land–water management

- continuing to address constraints to management
- strengthening the ecological understanding underpinning a theory of change
- widening the breadth of perspectives that inform functions and values
- exploring the role of storytelling and narratives in environmental water management
- defining ‘acceptable’ characteristics and identifying metrics and thresholds
- undertaking a broader range of case studies and further investigate resilience model hypotheses and assumptions.

REFERENCES

Campbell CJ, James CS, Morris K, Nicol JM, Thomas RF, Nielsen DL, Gehrig SL, Palmer GJ, Wassens S, Dyer F, Southwell M, Watts RJ, Bond NR, Capon SJ (2021) Blue, green and in-between: objectives and approaches for evaluating wetland flow regimes based on vegetation outcomes. Marine and Freshwater Research 73, 1212–1224, doi:10.1071/MF20338.

Campbell CJ, Thompson RM, Capon SJ, Dyer FJ (2022) Rethinking condition: measuring and evaluating wetland vegetation responses to water management. Frontiers in Environmental Science 9, doi: 10.3389/fenvs.2021.801250.

Campbell CJ, Lovett S, Capon SJ, Thompson RM, Dyer FJ (2023) Beyond a 'just add water' perspective: environmental water management for vegetation outcomes. Journal of Environmental Management 348, 119499, doi:10.1016/j.jenvman.2023.119499.

Campbell CJ, Lovett S, Capon SJ, Thompson RM, Dyer FJ (2024) More than a service: values of rivers, wetlands and floodplains are informed by both function and feeling. Environmental Management 73, 130–143, doi:10.1007/s00267-023-01900-2.

Campbell CJ (2024) 'What is good?' Characterising condition for non-woody vegetation in floodplain-wetland systems, PhD thesis, University of Canberra.

MDBA (Murray–Darling Basin Authority) (2019) *Basin-wide environmental watering strategy*, Report no. 42/19, MDBA, Canberra, ACT.

https://flow-mer.org.au

Partners

Collaborators