Applications and lessons learned report

A report from the Land and Ecosystem Accounts Project

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Source: Suzanne Prober. Lowland streams, irrigation supply channel (picture taken 26/10/19).

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Contents

1 Introduction

This applications and lessons learnt report covers four discrete elements:

- interpretation of results against the User Needs Report
- options for the efficient operationalisation of ecosystem account development, with a particular focus on opportunities for the establishment of basin-scale ecosystem accounts
- recommendations for additional analysis on the account products for GKP to meet the user needs of MDBA
- Suggestions for next steps. This section of the report was originally included in the Accounts report. We have moved this content to the lessons learned report in agreement with DAWE

We understand the intended audience for the applications and lessons learned report includes MDBA, DAWE, the EEA Board and the IJSC. This report has been prepared for this audience and assumes some base understanding of EEA and the application of EEA in Australia.

This report is not intended to be a public facing document. Rather, the document faces the community involved in developing EEA in Australia, and key decision maker groups using the GKP EEA report, and other EEAs. The report aims to provide practical insights to support the efficient and effective development of EEA as part of the LEAP, and efficient and effective development of basin-scale ecosystem accounts.

Lessons in this report are developed from the perspective of the accounts preparation team. The accounts preparation team includes cross-disciplinary expertise in:

- Preparation of environmental-economic accounts in Australia and internationally. The team includes principals that pioneered the United Nations' System of Environmental-Economic Accounting (IDEEA).
- Environmental systems and systems modelling (GHD).
- Environmental economics and valuation (Marsden Jacob Associates).

Our team has a long history of working with Commonwealth and State governments on high-profile issues of national significance, including the Murray-Darling Basin plan. Our work is evidence based, pragmatic, and communicated in plain English.

2 Assess the extent to which the case study met the user needs

The User needs report identified user needs and how accounting information could be applied to use cases. Illustration of user needs and use cases are outlined in Table 1.

2.1 How can we quantify the optimisation of economic, social, cultural and environmental outcomes from Basin Plan implementation?

The SEEA EA standards and guidelines can be relied on to create a 'Coherent set of Environmental-Economic Data' (CEED). The CEED will enable quantification of the economic, social, cultural and environmental outcomes from basin plan implementation by capturing the link between management of environmental assets (the ecosystems and biodiversity depicted in Figure 1) and beneficiaries (depicted on the rights hand side of Figure 1). The CEED achieves this because it is fully coherent across the Core Accounting model.

Benefits received by beneficiaries (Figure 1) encompass the economic, social, cultural and environmental outcomes that the CEED is able to quantify. The CEED can then be used to produce time series, accounts and reports that measure the productivity of the asset and return on any investment.

Assessment of the trade-offs across economic, social, cultural and environmental outcomes can then be made to optimise outcomes in the respective areas. Trade-offs can be assessed in dollar terms, which would require valuation of the individual service, or in quantity alone.

The overarching Basin Plan objectives (chapter 5.02) include optimising social, economic, and environmental outcomes arising from the use of Basin water resources in the national interest. Environmental economic accounting for GKP provides consistent information on ecosystems and their condition (important for the measurement of ecological integrity) and the link between ecosystems and people through ecosystem services.

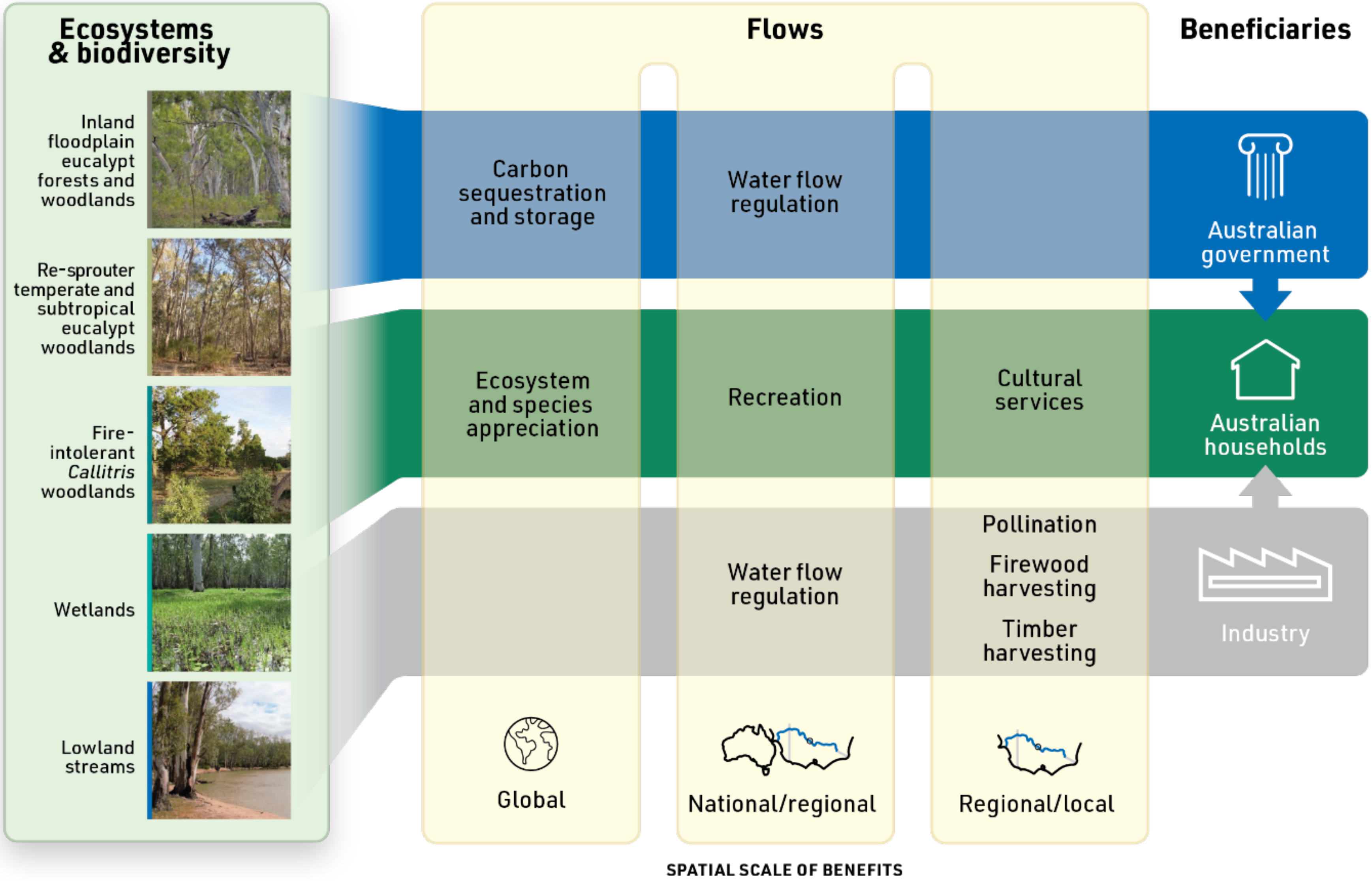
The GKP account information provides a credible basis for condition monitoring and reporting focussed on environmental objectives and outcomes in the GKP, and the social and economic benefits provided by GKP assets in the Basin. Accounts can also contribute to more effective policy development evaluation and decision making through the specific use cases identified in Table 1.

The GKP accounts provide coverage of ecosystem assets, extent and condition, and then systematically link extent and condition to services flows and how these accrue to beneficiaries (Figure 1). Understanding the link between extent and condition and the quantity of service flows and monetary values is an important progression in quantifying impacts of Basin Plan

Table 1: Policy development evaluation and decision making

Policy Challenges	User Need	How the GKP Case Study Could Help	Specific Use Cases	Desired Outcome
How can we quantify the optimisation of social, economic and environmental outcomes from Basin Plan implementation? Lack of information to inform decisions involving trade-offs between social, economic and environmental outcomes. While environmental watering plans mention trade-offs there isn't a framework to operationalise this. ***How is environmental water helping people?*** Lack of social licence, especially with local communities, for environmental watering (and water reform and the MDB Plan more generally) in part due to a lack of understanding of how environmental watering is required to maintain healthy river ecosystems which in turn underpin ecosystem services which provide benefits to the community. ***How can we improve the condition of our ecosystems?*** Continued pressures (e.g. river regulation, drought, climate change, insufficient flows and invasive species) are continuing to negatively impact biodiversity, forest health and ecosystem condition.	Credible and trusted information on the social, economic and environmental benefits of environmental watering (or more broadly water reform and the MDB Plan). Current monitoring and reporting is focused on environmental objectives and outcomes and the social and economic benefits provided by ecosystems dependant on environmental water are not well quantified or communicated.	Use of international statistical guidelines/standards to improve consistency and credibility. Quantify the ecosystem services and social, economic and environmental benefits provided by the GKP to policy development, evaluation and decision making. Examine the relationship between environmental watering, ecosystem condition and delivery of ecosystem services. Quantify the difference (in terms of ecosystem condition, services and benefits) between watered and unwatered sites in the GKP.	Provide information to support more effective **policy development, evaluation and decision making** including: • the five yearly evaluation of the MDB Plan (next due 2020) • annual State of the Basin Reports • Basin-wide Environmental Watering Strategy • Environmental Water Management Plans for Gunbower Forest and for Koondrook-Perricoota • Triple bottom line reporting of NSW Forestry Corporation • Ramsar site reporting Provide information (directly and indirectly) to **educate and increase understanding** of how GKP and environmental watering contributes to the well being of the local community.	Policy and management decisions optimise social, economic and environmental outcomes (link to objectives of the Basin Plan 2012 section 5.02c: *to optimise social, economic and environmental outcomes arising from the use of Basin water resources in the national interest*): The Australian community (especially communities in the MDB) has a better understanding of the environment's contribution (especially the contribution of ecosystems within the MDB that rely on environmental watering) to human wellbeing including the interactions, dependencies and trade-offs between social, economic and environmental outcomes. Improved condition of ecosystem assets and improved sustainability of ecosystem service delivery including timber provisioning.
Technical Challenges	**User Need**	**How the GKP Case Study Could Help**	**Specific Use Cases**	**Desired outcome**
How can we provide consistent credible information on the social and economic benefits of the MDB Plan? ***In a very noisy system, how can we disentangle the impact of environmental watering from natural variation?*** ***How do we harmonise social, economic and environmental data and information and fill the resulting knowledge gaps?*** ***How do we scale up or replicate information collected at sites to the whole of the MDB so we can manage environmental watering for the whole system rather than at a site level? Can this be done in a way that can accommodate local diversity in environmental, social and economic conditions?***	Demonstration of a technically feasible, credible and consistent way to provide information on social and economic benefits. A better understanding of natural variation in the system and credible methods to disentangle the impact of environmental watering from natural variation. Credible methods which integrate environmental with social and economic data and values to inform transition to a balanced and healthy MDB Credible methods which enable scaling up information from site to Basin scale.	The value of an ecosystem accounting approach is clearly demonstrated. Develop state and transition models which quantify the range of natural variation (by quantifying a dynamic reference state) and thresholds for transitions to alternative or modified states. Use these models to underpin accounts which: • Examine the relationship between environmental watering, ecosystem condition and delivery of ecosystem services. • Quantify the difference (in terms of condition, services and benefits) between watered and unwatered sites in the GKP. Test methods which can be scaled from site to Basin and/or applied consistently (replicated at multiple sites) Basin wide.	Enable leaders within the MDBA to **evaluate the usefulness of an ecosystem accounting approach** and make informed decisions about further investment in ecosystem accounts for MDB. **Evaluate the usefulness of methods** with potential for application as part of MDBA's transition to a whole of Basin 'systems approach' including managing for resilience and managing for thresholds.	Adoption of ecosystem accounting approach by MDBA to complement their existing monitoring and reporting systems. Adoption of elements of the ecosystem accounting method to underpin a whole of Basin triple bottom line 'systems approach' within the MDBA.

Figure 1: Ecosystem service flows and beneficiaries



implementation, and the economic, social, cultural and environmental services and values in the Basin. Importantly, the GKP accounts extend beyond what was previously known about the economic and social flows of GKP services and their values, providing a more comprehensive and robust understanding of the contribution of GKP assets to services like carbon sequestration, recreation, timber harvesting and apiary services. Understanding these services and their relative values provides one basis for being able to understand value trade-offs in the context of Basin water management.

The evidence in the GKP accounts can be combined with annual monitoring of GKP by States under the Living Murray program and through the annual report cards for Gunbower and the Koondrook-Perricoota report card and TLM icon site long-term condition reporting. GKP accounting outputs can be used to extend values and outcomes in the report cards proper, or they can be complimentary to these accounts.

Many of the methods established in GKP are scalable to other locations and key environmental asset sites in the Basin. Doing this provides a consistent basis for understanding values and trade-offs and integrating with other monitoring and reporting across the Basin.

2.2 How is environmental water helping people? In a very noisy system, how can we disentangle the impact of environmental watering from natural variation?

In their current form, the GKP account shows that environmental water is helping people by contributing to outcomes that are reported in aggregate in the GKP accounts.

The current GKP pilot accounts do not account for the marginal contribution of Basin Plan implementation actions on social, environmental, and economic outcomes. GKP accounts can be extended in future work to be able to identify with greater clarity how environmental flows and other Basin Plan implementation actions contribute to GKP asset conditions and outcomes compared to other flows and actions. Key points here are:

- The current GKP accounts are prepared for 2010 and 2015. The accounts report has documented the environmental watering events between 2010 and 2015 for Gunbower and Koondrook Perricoota.
- The environmental watering regime in Gunbower has progressively increased from 2008 to 2019 (Table 2 and Figure 2). Monitoring of ecosystem responses to watering events identified improvements in tree health, waterbird, breeding, fish movement and recruitment, maintenance of permanent wetlands (chapter 2.3). In comparison the Koondrook-Perricoota forest monitoring identified limited responses largely due to the very limited environmental watering between 2010 and 2015.
- Use of the AusEcomodel state and transition models (Richards et al 2021) documents changes between ecosystem states over long time periods (50 years). To understand the benefit of natural or environmental watering events requires understanding and monitoring of the expected responses of the ecosystems to individual and multiple year watering events (Bennetts and Sim 2020). Monitoring of Gunbower forest wetland, River Red Gum and Black

and Grey Box communities identified changes from environmental watering for key vegetation indicators was higher after they were recently inundated with environmental water, than when naturally inundated, retained ponded water, or dry.

- Application of this monitoring data to ecosystem accounts requires development of conceptual models that define predicted responses to natural and environmental watering events. These models would complement the state and transition models effectively defining the changes represented by arrows in the AusEcomodels.
- Disentangling the environmental watering events compared to natural events requires detailed forest inundation mapping to be available aligned with ecosystem extent and condition. This, combined with conceptual models of the ecosystem responses would provide a basis for incorporation in accounts.
- At this point, GKP accounts do not show the marginal contribution of environmental flows to ecosystem asset condition, extent, or how services and their monetary values are attributable to flows and other implementation actions.
- One reason GKP accounts do not show this is because accounts are snapshot in time of total values, they do not intend to model the marginal contribution. Marginal contribution could be derived through application of conceptual model of response of system to environmental flows, duration and timing. This was not prepared in the current accounts, which focussed on preparing the core accounts.
- Marginal contribution would need to specify a without watering case and a with watering case. Figure 2 shows the with watering case includes watering and TLM works and measures. For pre 2010 and 2015, the contribution of environmental flows and TLM are likely small compared and combined with the impacts of natural flow events. This is because (1) flow and work contributions are relatively small, and the first event occurred in 2014 (for Koondrook Perricoota) and (2) ecological timeframes are long.
- Understanding the marginal contribution would involve monitoring where environmental water reaches and conceptual models and monitoring of similar areas that did not receive environmental watering. This would need to be undertaken over multiple years, not single year events.
- Parts of this work, including environmental flows maps of the 2015 watering Gunbower watering event, are completed for GKP. Conceptual models of ecosystems states and expressions supporting ecosystem extent and condition works are now also established for GKP. But the link between watering events and ecosystem extent and condition is not coupled in a way that provides for robust evidence-based assessment for the development of accounts. In other words, because the models are conceptual no statistical relationships have been derived to support the underlying concepts.
- Linking and empirical evidencing would require local-scale hydrological information and development of empirical conceptual models. It would also require local-scale hydrological information (water accounts) to included in the local accounts. Consistent monitoring of ecosystem characteristics is also required, to understand change in them, and their effect on ecosystem services and benefits. Greater on-ground validation of conceptual models is another aspect that would be required.

Figure 2: e-water and river flows 2004-20

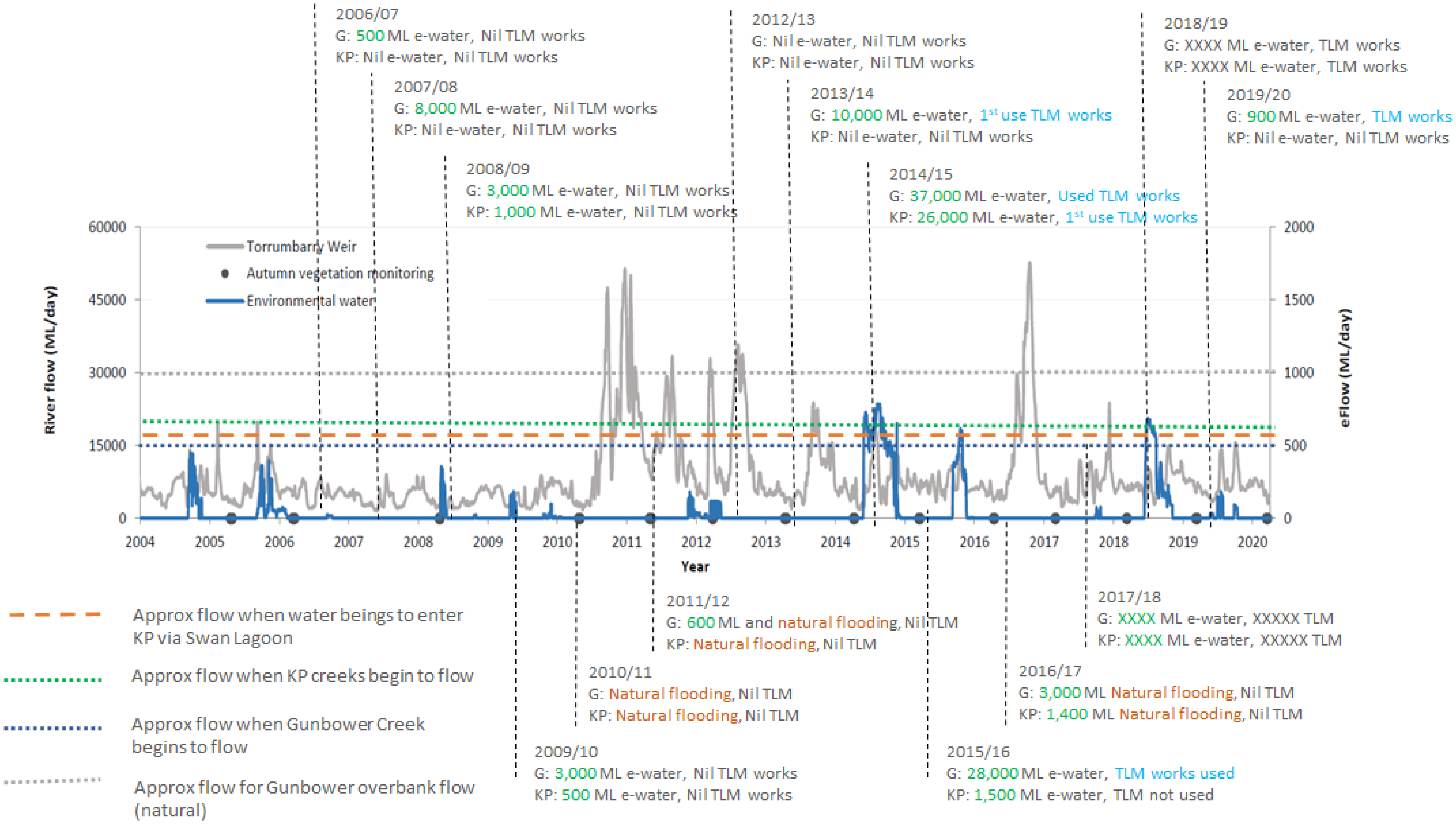


Table 2 Summary of environmental watering events and objectives for Gunbower and Koondrook-Perricoota forests from 2011 to 2016.

	Gunbower Forest			Koondrook-Perricoota Forest		
Year	**Volume (ML)**	**Area (ha)**	**Objective / response**	**Volume (ML)**	**Area (ha)**	**Objective / response**
2011–12	645	350	Maintain wetland water levels, waterbird breeding event	0	0	NA
2012–13	0	0	NA	0	0	NA
2013–14	19,257	ND	Recovery of native fish species	0	0	NA
2014–15	37,400	3,800	Redgum watering, wetland filling, fish movement between channel and floodplain	26,400	4,000	Understorey, semi-aquatic and aquatic vegetation growth. Reduced encroachment of terrestrial vegetation
2015–16	28,692	2,692	Mass small-bodied fish recruitment, recovery wetland vegetation and floodplain eucalypts	1,600	ND	Flooding of Pollack Swamp
Total	**85,994**	**6,842**	**NA**	**28,000**	**4,000**	**NA**

ND = not determined; NA = not applicable.
Source: MDBA (2014, 2015, 2016), NCCMA (2013), VEWH (2012, 2013, 2014, 2015, 2016)

2.3 How can we improve the condition of our ecosystems?

The condition of ecosystems is understood in terms of ecological integrity, as discussed in the GKP accounts reports.

The conceptual models (state and transition models) produced in this project provide one way to understand how condition is influenced by different drivers. These models can be used as one approach to understanding different mechanisms by which condition can be influenced.

The public summary report details how integrated models of GKP ecosystems and the core ecosystem accounting framework can enable an exploration of trade-offs and benefits of different management actions, related to silviculture and river regulation, on ecosystem condition, and the supply of ecosystem services. The example is based on timber harvesting coupes logged in 2015 in Gunbower Forest. The Experimental accounts report (McLeod et al. 2021a) includes the full application example.

Figure 3 shows how inland floodplain eucalypt forests and woodlands extent and condition shift in response to selective logging activities, salinisation from excess irrigation and other factors. Figure 4 shows what each ecosystem state in Figure 3 looks like in GKP. Table 3 shows how stocks and flows of ecosystem services from the inland floodplain are likely to change for each ecosystem state. It also shows the ecosystem condition index (ecological integrity) of each state in timber harvesting coupes in Gunbower in 2015. Carbon sequestration and storage estimates for 2015 with and without logging are also shown.

MDBA site condition monitoring of Gunbower forest and Koondrook Perricoota monitored ecosystem responses to environmental watering with condition indices for vegetation, waterbirds and fish improving following watering events (MDBA 2018). Long term monitoring of wetlands and vegetation in Gunbower forest is able to demonstrate the changes in indices with and without watering concluding indicators was higher after they were recently inundated with environmental water, than when naturally inundated, retained ponded water, or dry (Bennetts and Lim 2020).

The application shows that timber removed from the invaded mature floodplain eucalypt forests and woodlands state (State C) in 2015 in Gunbower Forest could drive a transition to the reduced tree canopy over invaded understorey state (State B). This shift would lead to a 0.12 decline in ecosystem condition (ecological integrity) and a 53% reduction in carbon storage and sequestration and reduction in future harvest volumes for timber and firewood.

Similarly, a shift from the reduced canopy over invaded understorey state (State B) to the invaded mature floodplain eucalypt forests and woodlands state (State C) after cessation of logging would, over a period of 50-100 years lead to a potential increase in carbon storage and sequestration of 2,272 and 463 tonnes, respectively.

This example highlights how the use of ecosystem accounts, combined with conceptual models of ecosystem drivers, can be used to understand trade-offs in the supply of different ecosystem services and how changing ecosystem condition will change flows of services to beneficiaries.

It also highlights the need for conceptual models to define changes in vegetation and other ecosystem attributes as a result of environmental watering (single and multiple years). These models can be used to inform condition changes at shorter time scales and support quantification of ecosystem services. However, these models are conceptual and no statistical relationships have been derived to support the underlying concepts.

Figure 3 State and transition model of the inland floodplain eucalypt forests and woodlands ecosystem type at GKP.

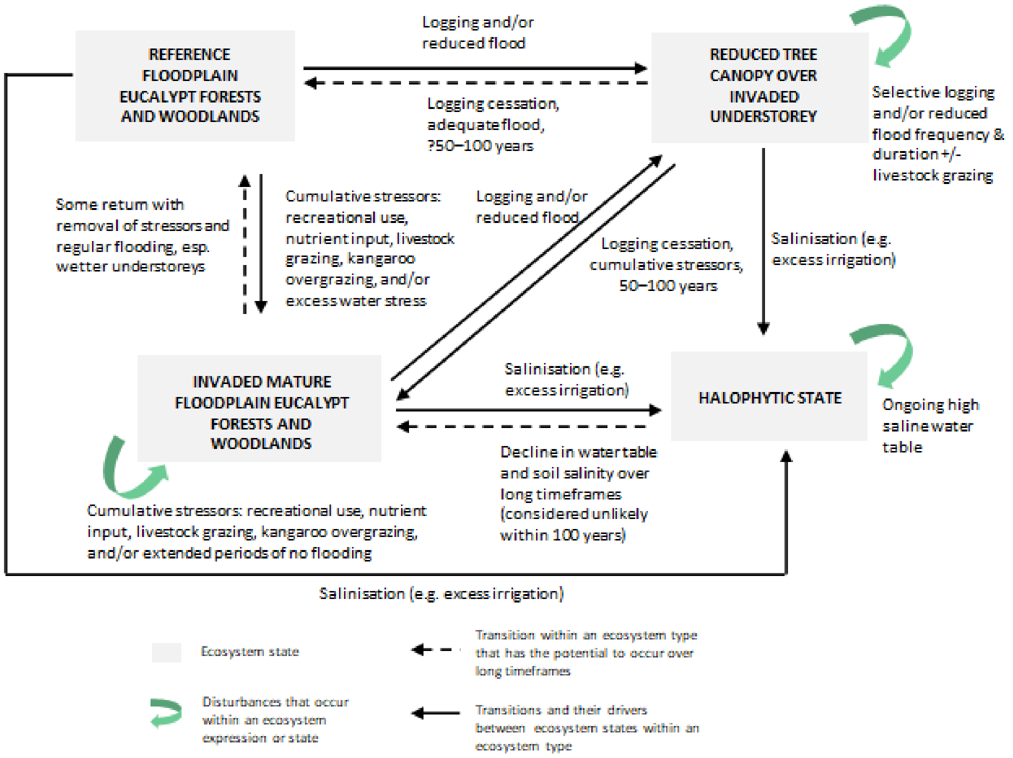


Figure 4 Images of each ecosystem state in the inland floodplain eucalypt forest and woodlands ecosystem type, including A) reference state; B) reduced tree canopy over invaded understorey state; C) invaded mature floodplain eucalypt forests and woodlands state; D) halophytic modified state.

Source: S. Prober & P. McInerney

Table 3 Extent, condition and flow of ecosystem services for each ecosystem state in the 'inland floodplain eucalypt forests and woodlands' ecosystem type, based on values calculated for 2015 for a timber harvesting coupe at Gunbower Forest

	Reduced tree canopy over invaded understorey	Invaded mature floodplain eucalypt forests and woodlands	Halophytic state	Reduced tree canopy/ invaded mature
Area ha	7	51	1	47
Ecosystem condition index	0.46	0.58	0.16	0.50
Timber (tonnes)	45	333	0	308
Firewood (tonnes)	224	1663	0	1538
Carbon sequestered no logging (tonnes carbon)	435	822	3	834
Carbon sequestered post timber harvest (tonnes carbon)	359	678	2.2	687
Carbon stored no logging (tonnes carbon)	2140	4038	16	4098
Carbon stored post timber harvest (tonnes carbon)	1766	3336	13	3381

Note: Carbon sequestration and storage reductions post logging are based on estimated proportion of total above ground biomass removed due to logging occurring in the defined coupe areas. Estimates do not include projected increased sequestration from vegetation regeneration.

Between December 2011 and 2015 the Gunbower forest ecosystem was supported by regular environmental watering events from Living Murray and Victorian Environmental Water Holder allocations (Table 2). In Gunbower forests the watering events resulted in vegetation responses for the 'wetlands' and 'inland eucalypt forests and woodlands' ecosystem type. Responses were also seen for fish, waterbirds and maintenance of ecosystems (Table 2) (VEWH 2016).

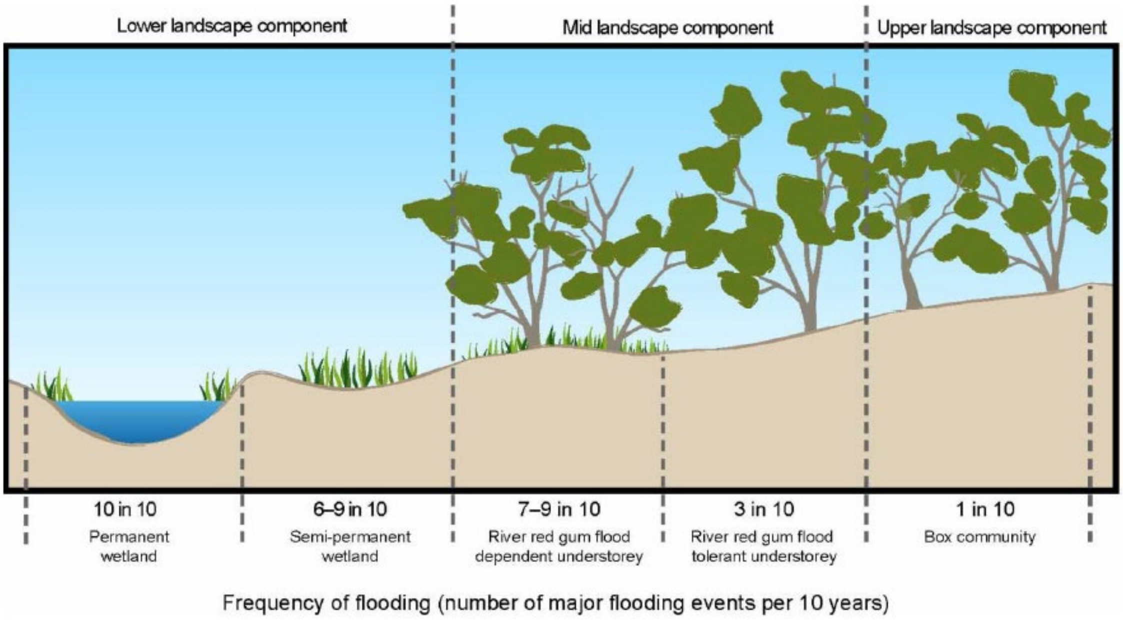
Environmental watering in Koondrook-Perricoota forest has been limited to the end of the accounting period. Watering events in 2013−14 were delayed during construction of environmental watering structures. Monitoring of watering events in 2014−15 identified positive responses of floodplain and wetland vegetation, improved tree health and reduced encroachment of floodplain vegetation into wetlands (MDBA 2016) (Table 2). Allocations for Koondrook-Perricoota include NSW licensed environmental water, Living Murray, Commonwealth Environmental Water and environmental water allowance accrued under water sharing plans.

Environmental water requirements for GKP floodplains and wetlands vary depending on their location in the landscape, with increased frequency and duration of flooding required for wetlands and floodplain-dependent understorey vegetation (Figure 5). Duration of inundation varies from 7 to 12 months for wetlands, 1 to 8 months for flood-dependent understorey vegetation and less for communities higher in the landscape (Ecological Associates, 2009). An example is the 2015 watering event where Gunbower wetlands were watered using a VEWH allocation of 28,692 ML over a ten-week period. The watering event, inundated 2,692 ha of floodplain communities: 183 ha wetlands (90% of wetlands in the forest); 2,090 ha 'invaded mature floodplain eucalypt forests and woodlands' modified state; and 419 ha of other modified states in the 'inland floodplain eucalypt forests and woodlands' ecosystem type (Figure 6). The majority of this water was retained in the landscape, with approximately 700 ML released into the River Murray via Shillinglaws regulator during the final 4 weeks. Post-event monitoring identified improved growth of river red gums, aquatic plant growth and mass recruitment of small-bodied fish (VEWH 2016). Monitoring of the progressive filling of wetlands and inundation of inland floodplain eucalypt forests and woodlands over the ten-week period is illustrated in Figure 6.

MDBA site condition monitoring of Gunbower forest has detected positive ecosystem responses to environmental watering with condition indices for vegetation, waterbirds and fish improving between 2010 and 2015 (MDBA 2018). Site condition monitoring of Koondrook Perricoota has identified indices for vegetation, waterbirds and fish that are significantly lower than Gunbower and have not changed through the same time period (MDBA 2018).

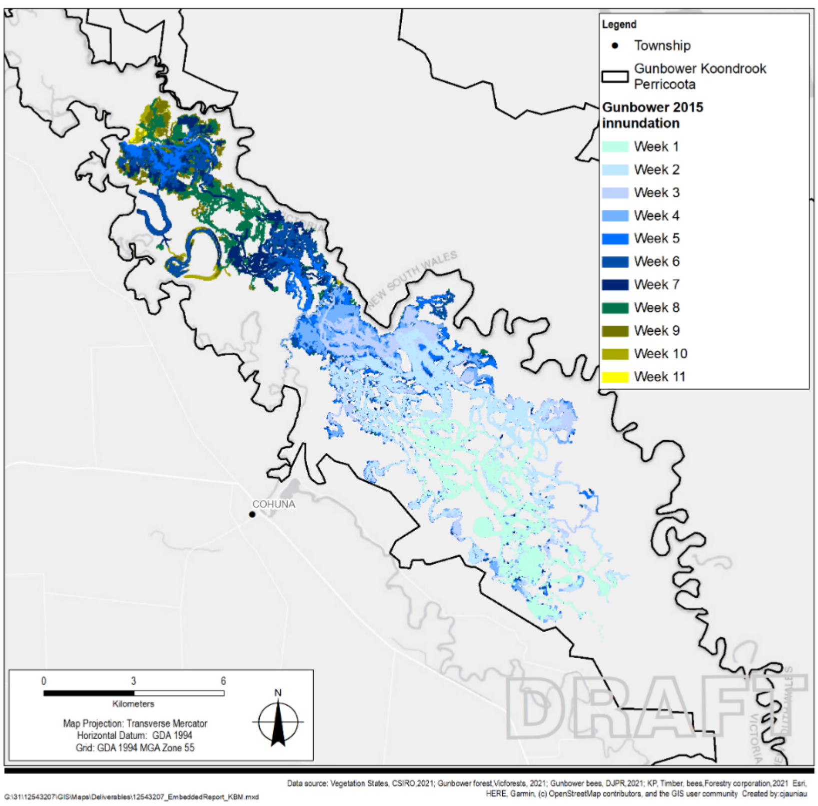
Both natural flooding between 2011 and 2013 as well as environmental watering events have contributed to meeting environmental watering objectives for maintaining and improving ecological processes and communities in Gunbower forest (VEWH 2013, 2014, 2015). However, the benefits from – and ecological responses to – the most extensive environmental watering events in 2014–15 and 2015–16 were not able to be assessed in this case study because of the time lag in the expected ecological responses, which will occur in the years outside the accounting period. For example, watering prior to 2015 has not been sufficient to support apiary services and honey production, which was established through discussions with apiarists who reported zero supply in 2010 and 2015.

Figure 5 GKP frequency of environmental watering required for wetlands and floodplain vegetation



Note: The River Red Gum flood dependent and flood tolerant understories, and the Box community, are vegetation types that fall within the ‘inland floodplain eucalypt woodlands and forests’ ecosystem type. The permanent and semi-permanent wetlands are included in the ‘wetlands’ ecosystem type. Source: (Ecological Associates 2009).

Figure 6 Gunbower 2015–16 environmental watering event, showing progressive inundation of ‘wetlands’ and ‘inland floodplain eucalypt forests and woodlands’ ecosystem types.



2.4 How can we provide consistent credible information on the social and economic benefits of the MDB Plan? How do we harmonise social, cultural, economic and environmental data and information and fill the resulting knowledge gaps?

The Productivity Commission's national water reform and December 2018 Basin reviews (Productivity Commission, 2017, 2018) identify that Commonwealth and Basin State governments must collectively do more to make credible information available and accessible to Basin communities about the beneficial impacts of enhanced environmental and working river outcomes. A lack of credible evidence showing how these enhanced outcomes support Basin communities reduces confidence that the costs of environmental water recovery is worthwhile.

As discussed above, environmental economic accounts provide a framework for providing credible and consistent information on environmental assets, their extent, condition and the services these assets provide. They also provide a framework for showing how extent, condition and services change over time due to planned and unplanned actions.

At scale, the environmental economic accounting framework and conceptual models could be used as one consistent basis for credible evidence showing how enhanced outcomes support Basin communities, and to provide understanding of whether the costs of environmental water recovery and other Basin Plan reforms are worthwhile.

To do this, analysis would need to:

- Include water accounts.
- Extend conceptual models to be able to credibly estimate how ecosystem extent and condition changes through states and conditions as a result of Basin Plan implementation activities such as environmental watering and works and measures.
- Scale to other key environmental asset sites in the Basin, and other key sites of community interest / contention.

This would get assessment part of the way. To be able to comprehensively understand the benefits, costs and distribution of benefits and costs of Basin Plan water reforms going forward, future analysis would also need, at a minimum:

- **To continue to evaluate the emerging impacts of on-farm and off-farm infrastructure modernisation and the flow on impacts of water recovery.** The Seftons Review report and work completed for the 2020 Basin Plan review, identified on-farm and off-farm modernisation has provided benefits for participating irrigators. It has also had some positive flow-on effects for regional communities through economic stimulus. However, no comprehensive benefit-cost analysis has been undertaken to confirm that the public benefits of these measures have exceeded the costs to taxpayers.
- **To continue to evaluate the emerging impacts of other Basin water reforms focussing on communities of interest.** In our view, the main way this can be done well is through comprehensive and large-scale surveying of irrigators, irrigator value chain, and broader

community members over time. Large-scale repeated surveying using consistent survey questions would allow the MDBA to evaluate how Basin Plan reforms have impacted the same people and communities over time, and to parse out the contribution of Basin Plan reforms versus other factors impacting on people and communities. We are aware this panel survey approach has been proposed to successive State and Federal Governments multiple times since the early 2000s as a much-needed way to evidence national water reform impacts. To date, successive Governments have chosen not to make this investment to support better knowledge of the impacts of national water reform.

- **To close significant gaps in understanding the beneficial impacts of enhanced environmental and working river outcomes, as discussed above.** Commonwealth and Basin State governments must collectively do more to make credible information available and accessible to Basin communities about the beneficial impacts of enhanced environmental and working river outcomes. A lack of credible evidence showing how these enhanced outcomes support Basin communities reduces confidence that the costs of environmental water recovery are worthwhile. EEA river operations and other evidence, plus working with communities to integrate this into daily lives, is also an important part of the process.

3 Recommendations for additional analysis on the account products to meet user needs

This chapter summarises key recommendations for additional analysis on the account products for GKP to meet the user needs of MDBA. This is **not** further evolving the accounts nor scaling them up to Basin or national scale. Rather this is taking the accounts as they are and analysing them further (including by comparison with other datasets or in conjunction with other methods). This analysis could be undertaken by the LEAP team, or by someone else.

The first step in the process requires defining who users are and what their end needs are. For example, are the end users local or current decision makers who have framed user need questions?

Our additional analysis recommendations in this chapter reflect an assumption that the objective is to "how do we answer the user need questions" (Table 1) that have not been answered by the GKP work to date. A core question here is what the impact of environmental flows and other works and measures are on beneficial and other outcomes for communities, economies and environment.

3.1 General Recommendations

- Complete 2020 accounts to provide a longer time series. A longer time series will allow assessment of how slow changing systems respond ecologically to environmental watering events in the proceeding years.
- Work with First Nations people to integrate Indigenous ecological knowledge into the accounts or establish how Indigenous-led expert elicitation can be developed into parallel conceptual models.
- Prepare water accounts for 2010, 2015, 2020.
- Extend conceptual models to flows to illustrate the variable impact of planned and natural events (watering) on extent and condition over short and longer timeframes.
- Extend the development of conceptual models to physical geography to demonstrate the key thresholds for water distribution across the floodplain. This will help define the extent and duration of overbank flows via effluent channels into the study sites.
- Identify expected ecosystem responses to watering events and climate at shorter timescales. Ecosystem response could incorporate events such as waterbird breeding, tree health and flowering events.

3.2 Ecosystem extent and condition

- In the current GKP accounts, extent and condition were evidenced using MDB and site-specific data. The data included remotely sensed information, on-ground monitoring data and expert-elicited data (Richards et al. 2021a, 2021b). Each pixel was classified by ecosystem type, state and expression, at each accounting time point, by comparing the data to the expert-derived rules captured in the dynamic conceptual models of GKP ecosystems.
- The approach to identify the ecosystem type, state and expression for each pixel is limited by the existing data, which was derived from satellite sensors or ground-based monitoring programs. In some cases, these data were not sufficient to easily map ecosystem characteristics that distinguish ecosystem states.
- Further validation of the extent and condition data should be a priority action. Further refinement should be undertaken to improve map accuracy if it is to be used for local decision making and management. This is particularly the case where there is no detection of understory composition using remote sensing. An example of this is additional on-ground validation data (especially for wetlands and lowland streams), to differentiate exotic and native species in the understorey. Filling data gaps for identification of fire-intolerant *Callitris* woodlands and 'grey box grassy woodland with exotic understorey' modified states is another case it is necessary to address.
- Verification work should be done with greater engagement with local experts, significant body of expertise that can be used to return to validate (confirm whether this has happened). This will increase confidence in work.
- The rules for local geographic details in the final workflow may need to be refined to improve mapping accuracy before these ecosystem accounts can be used for local decision making and management. In the current extent map, there was a moderate level of correspondence between observed ecosystem states (from The Living Murray long-term monitoring plots and additional field data collected in 2020) and mapped ecosystem states within the 'wetlands' ecosystem type (accuracy of 58%), but only weaker correspondence between states in the 'inland floodplain eucalypt forests and woodlands' ecosystem type (accuracy of 22 to 33%) (Richards et al. 2021b). However, there were limited validation points for the 'lowland streams' ecosystem states. For example, the Gunbower Creek is absent in some parts of the Gunbower Forest in the map of ecosystem types. This may be due to misclassification of pixels that straddle the boundary of the icon site and obstruction of satellite detection of open water by overhanging vegetation. Additional work could be undertaken to increase the number of validation points available across all five ecosystem types, including lowland streams. Inclusion of Gunbower Creek is an important component of the environmental flow story and environmental watering connections with the floodplain
- The method used here for expert elicitation of condition scores for each ecosystem state was a pilot. Future research should undertake further expert elicitation to validate reference sites used, and generate more locally applicable validation and calibration data, implemented with statistical cross-calibration between experts.
- Methods such as the Habitat Condition Assessment Tool are one potential option for application (White et al. 2019). The HCAS method was developed to overcome limitations in satellite remote sensing of land cover when used for biodiversity assessment. This data

needs to be interpreted correctly in order to estimate the persistence of native species and ecosystems. This interpretation requires consideration of the dynamics and characteristics of ecosystems, over space and time, as has been done in this project, using concepts coherent with AusEcoModels and SEEA EA frameworks. While the resulting HCAS v2.1 dataset provides the current best estimate of habitat condition nationally, additional research could potentially further improve the data and methods (Williams et al. 2021). Examples of how future work could improve the analysis of biodiversity and various ecosystem services is outlined below.

3.3 Biodiversity

- Confidence in biodiversity modelling can be improved by using state-based (ie. Victoria and NSW) biodiversity analysis because it is significantly more mature in both its methods, surveys and field data. Current biodiversity modelling is low confidence.
- The integrated analysis in accts report (Chapter 9) illustrates a bar chart showing the overall changes in biodiversity features from 2010 to 2015, along with other changes in the account. Biophysical & econometric analysis of these changes could be undertaken, including detail from other datasets, to determine whether there is a causal link.

3.4 Ecosystem services

Quantifying ecosystem services for GKP has relied on access to CSIRO datasets produced specifically for the purpose of preparing ecosystem accounts, and existing public and private datasets which are not produced specifically for preparation of ecosystem accounts. Using datasets not specifically produced for ecosystem accounts poses two challenges relating to:

- Data availability may not have all features required to quantify the ecosystem service this could be related to vegetation attributes, flowering times or required timeseries.
- Data held by state agency has been collected but is not made available for the purpose of developing ecosystem accounts.
- CSIRO data sets (extent and condition) provided resolution of changes in condition for ecosystem states. Expert elicited vegetation attributes supported quantification of some services.
- Data for ecosystem services requires finer resolution of key vegetation attributes, forest management practices, watering extent, ecological responses to adequately quantify services and ecosystem capacity.

Both aspects mean that the quantification of ecosystems services are of lower confidence which will impact assessing ecosystem capacity and conflicts between services.

Timber biomass

- Future work should focus on improving the central collection and open access to ecosystem supply data. This analysis collated information on the biomass for timber (sawlog and firewood) provided by the GKP ecosystem from several different sources with varying levels of detail. Data resourcing for use in ecosystem accounting should be organised to assist future calculations. Data sources were variable in relation to detailed site information such as harvest plans, predicted yields and coupe logging volumes and tonnage. As part of forest harvest plans there is significant planning assessments for timber supply data and detailed harvest records for area and species harvested, harvest and transport costs and the stumpage value compared to the mill door value of sawlog timber yielded. This approach will streamline the quantification of yields and calculation of residual rents of ecosystem supply to ensure account accuracy. This will provide managers with an improved understanding of what the ecosystem is providing to different stakeholders and substantially improve their ability to make management decisions.

- Recommendation - Timber harvest plans, yield estimates, harvest records, transport costs etc, are sought through agreement with agencies to provide greater confidence in the quantification and valuation of ecosystem services.

Floral resources

- Access to data was a significant limitation in the analysis of annual floral resources and the resulting honey yield from the GKP ecosystems. No central database of apiarists that place hives in the GKP ecosystem was available from either VIC Forests or NSW Forest Corp. Similarly, no official record of honey yield from the Gunbower, Koondrook or Perricoota forests is maintained. As a result, the flowering events and annual honey yields from the GKP ecosystem relied on reports from individual apiarists that are known to place hives in the area.
- Discussions with apiarists yielded information on flowering times, climate, impact of existing environmental watering in Gunbower and natural events. This is a source of data that is not commonly available and could be more accurately captured in future iterations. Previous work (Karasinski, 2018) surveyed apiarists nationally providing a rare insight into industry experiential knowledge that is rarely documented.
- Government departments and organisations consulted with include, but is not limited to, the Victorian Department of Environment, Land, Water and Planning (DELWP), Vic Forests, Victorian North Eastern Apiary Association (NEAA), New South Wales Apiary Association (NSWAA), NSW Forestry Corp. Future work should track this.

Carbon sequestration and retention

- Additional research can focus on improving the understanding of carbon sequestration rates and storage within the GKP ecosystem and the various ways the of carbon sequestration can be affected. The influence that soil health and soil moisture has on carbon sequestration is a particular point of interest for future research and should be incorporated into the future accounts.
- The analysis of carbon sequestration within GKP relied on contemporary literature and extensive modelling using FullCAM software. It is recognised FullCAM default values for GKP are lower than that identified through ecological monitoring programs. Future calculations can also be assessed through net primary productivity approaches. Understanding the current management regime and volumes of timber harvested will increase confidence in quantification of carbon sequestration and the impacts of timber harvest and forest management regimes.
- Carbon calculations for wetlands were based on average values (Carnell et al 2018) taken from amalgamation of a state-wide survey of Victorian wetlands. Averages are highly

variable and confirmation of values for GKP would require an extensive sampling program to provide greater accuracy of estimates. Wetland storage and sequestration of carbon will vary depending on the wetting and drying regime.

Ecosystem and species appreciation

- Ecosystem and species appreciation is a key area for future development. The approach used for these accounts is not ideal, in that the species level assessments are not suited for account development for species appreciation, because they do not actually measure species or abundance. Moreover, the monetary valuation of services is not directly related to species and their values.
- While the species-level assessments in (Mokany et al., 2021) are intended to identify areas of suitable habitat within the potential extent of occurrence of each species, as noted above they do not indicate where each of the 8 species is expected to occur, or the species abundance that is expected to occur. Mokany et al, (Mokany et al., 2021) note that combined with potential errors in the land cover classification, or in translating land cover categories to habitat suitability, areas of suitable habitat with the potential extent of occurrence may be under- or over-estimated, with the result that the "focal species could vary considerably in terms of both their potential extent of occurrence, as well as the estimated areas of suitable habitat" (Mokany et al., 2021). In practical terms these limitations make it difficult to robustly estimate species abundance in 2010 and 2015 from the simulations.
- Future research should focus on directly estimating focus species. This could be done by working collaboratively with agencies undertaking on- ground fish, bird and other monitoring (Webster, 2017). Using an approach based in on-ground monitoring would allow for scaling up of species data using a robust and evidence-based simulation approach.
- Species should also align with species credits in offsets. These markets are highly imperfect however, and they do not calculate residual rents. More work to develop a more efficient market price for species and credits.
- Recent work has looked to establish the economic value of multiple threatened species and ecological communities in Australia (Gunawardena et al., 2020). If future work in GKP is coordinated, there is an opportunity to link this type of species valuation work with species prevalence assessments. in future work. This would involved (1) estimating WTP for focal species as economic values (2) using simulated exchange approach to derive residual rents suited to accounting.

Ecosystem services for Traditional Owners

- Work with First Nations people to identify whether or how Indigenous ecological knowledge maybe woven or developed into parallel conceptual models via Indigenous-led expert elicitation

Recreation-related services

- The key areas for improvement relate to the recreation survey. For this evaluation, survey respondents were asked about visits to GKP in 2015 and 2010. This requires the ability to accurately recall trip details, which introduces the likelihood of recall error.
- Survey results suggest recall error was an issue for Greater Sydney respondents. The issues with Greater Sydney respondents meant a travel cost model was not estimated in this

evaluation, given the limitations of the Greater Sydney survey results, and the risk that a travel demand model using Greater Sydney recreation counts would be biased. See the technical report for more discussion (Cheesman et al., 2021).

- Recreation is a significant value in the GKP and robust estimates of visitation and use are needed. Given the priority of GKP as an Icon site, recreation at GKP should be more comprehensively monitored in the future. This could involve undertaking systematic annual surveying, with travel cost method applications in mind. The survey developed for the current GKP evaluation could be used as the basis for these future survey evaluations. Respondents should be surveyed about their visits in the last 12 months to minimise recall error bias.
- In Victoria, Parks Victoria completes biennial surveys and face to face interviews known as the Visitor Number Monitor (VNM) as part of their integrated research program [19]. To develop a standard recreation and visitation survey approach in Victoria, DAWE, and Victorian CMAs partner with Parks Victoria to gather information through the VNM.

4 Options for scaling up

This project focussed on applying environmental-economic accounting for the GKP icon site. There are two options for scaling up the current GKP work to the basin scale:

- **Option 1**: Apply the GKP approach at the Basin scale with no refinement
- **Option 2**: Extend and refine the GKP approach, apply at the sub-basin scale (an SDL), and then apply to the basin.

The utility of the accounting system, and the related investment to make the accounting system fit for purpose, depends on the user and the intended purpose of the system. Therefore, an assessment of option 1 and 2 is not divorced from the use case: it is assumed that the purpose of accounting system is to inform current and ongoing watering (environmental and productive) decisions and make assessment of the trade-offs linked to the use of water both locally and at the basin scale.

We recommend option 2 over option 1 and the following sections outline the reasoning for the recommendation. Note, there may be other options however we feel these options are the most realistic and represent real pathways forward.

Option 1 – Basin scale

The approach implemented for the GKP icon site can be scaled up to the basin level. This would require the use of similar datasets and the application of methods used for GKP. The account team do not recommend taking this option. In its current state, the GKP accounting system does not contain the information required to inform watering decisions. The main concern is the ability to draw out insights when combining the current data with data on environmental watering.

Scaling up the GKP approach without addressing the use case will result in an accounting system that is not fit for purpose at the basin scale. This is likely to be an inefficient use of resources and will be a risk to all parties involved, as well as the perceived value of environmental-economic accounting more generally. Furthermore, the effectiveness of the MDBA management strategy may be questioned if the links between water management and environmental, economic and social outcomes have not been made. The current approach requires modification and extension to contain and link appropriately to information on environmental watering.

There are a number of risks associated with applying the GKP approach to the basin.

Extent

- Key waterways were not recognised in the spatial mapping and identification of ecosystems in GKP. A risk related to decision making is that a misrepresentation and non-recognition of water related assets, like small streams, may affect management decisions. There is also a risk that local users of the accounting outputs will identify that the mapping is not reflective of the local features and or landscape.

Condition

- Expert elicitation and HCAS was used to construct estimates of ecosystem condition for GKP. The initial aim of the condition accounting was to produce stage 3 condition accounts, and then information was drawn from a number of sources to populate stage 1 condition accounts. Conceptually there is nothing wrong with this approach, and indeed, it may be more feasible in the short term compared to on ground measurement or using satellite imagery.
- The key issue with the approach to measuring condition is the lack of transparency regarding the intermediate steps in creating the stage 3 condition indicator. The intention of condition accounting in the SEEA is to build up the stage 3 condition indicator from the characteristics measured in stage 1 of the process. This is to ensure that the user of the accounting information understands the characteristics that have been used to assess condition, the values for each of the characteristics, the reference levels to normalise the indicators, and then how the indicators have been aggregated, if at all.
- The three-stage approach to accounting for condition is intended to reduce the risk associated with misinterpretation of condition information. This is not a methodological shortcoming of the approach taken, but a question of process.
- The scaling up of approach taken in GKP to measure condition would require interviewing experts at each of the locations in MDBA. This could be a costly exercise and replication of results could be difficult. There may be some uncertainty in the condition information because of the subjective nature of the approach, and stakeholder confidence could decline.

Services

- Four services, climate regulation, recreation, and timber provisioning (firewood and timber) were measured quantitatively. Other services such as pollination and water flow regulation were either not measured or described qualitatively.
- Methods for estimating the physical quantities of ecosystem services can be applied in other areas. Notwithstanding any improvements to methods performing these methods in other areas would include:
    - timber provisioning – the collection of harvest data for all areas
    - recreation services – collection of additional data specific to the location of interest
    - climate regulation – collection of data to run FullCAM
- Following an approach where the same methods are applied to other areas, data should be collected for the whole basin, and then the methods should be ran. There are economies of scale in running models and compiling accounts at the basin scale, rather than repeating a process multiple times for smaller areas within the basin.
- An alternative approach to applying the GKP methods is to spatially transfer (extrapolate) quantities from GKP to other areas. This is likely to be low cost compared to applying the GKP methods. However, the results of this project are likely to be specific to GKP. There is a high risk that extrapolation across the basin may over or underestimate services or miss services entirely.

- If extrapolation was to be pursued, then there are methodological issues that need to be addressed to ensure there is some accuracy in the approach:
    - Are ecosystems consistent across both areas in terms of their type? For example, carbon quantities can not be extrapolated if the ecosystem type is not consistent across spatial areas
    - Are ecosystems consistent in terms of their characteristics (variation by state and expression). For example, a forest in a relatively poor state, is likely to produce less pollination services than a forest in a good state
    - Are the use of ecosystem services similar across areas? For example, does a longer distance from capital cities affect the consumption of ecosystem services such as recreation?
- It is unlikely that there is enough information to extrapolate ecosystem service quantities with accuracy.
- Methods will need to be developed for the measurement of additional services.

Monetary valuation

- Three broad approaches to the valuation of ecosystem services were applied during the project: resource rent, travel cost method and market prices.
- Methods for estimating the monetary quantities of ecosystem services can be applied in other areas. Performing these methods in other areas could include:
    - timber provisioning – collection of price data. Valuation will depend on the prices used to estimate benefits, and the cost structure of the businesses and the cost of capital. The method used draws on data from the national accounts and can be applied to any area as it is not spatially specific
    - recreation services – collection of data on costs (time, petrol) and travel distance, which will vary based on location of asset supplying the service, relative to the user of the service
    - climate regulation – valuation will be uniform across all locations in Australia.
- Benefit transfer could be used to transfer values from the GKP area to other basin areas. A case by case assessment would be needed to determine the comparability of the GKP site and any additional sites providing services. The type of site, the quality of the site, and the availability of substitutes are all factors that need to be considered. Furthermore, the characteristics of the users of the service would need to be compared across locations.
- There are methods for adjusting estimates where differences exist across study areas. A benefit transfer function could be developed. However, one case study is a small sample size for performing any type of meta-analysis that would capture geographic differences in the qualities of the ecosystem and the users of the ecosystem across the basin. We cannot recommend using benefit transfer to scale up to the basin, without a literature review and appropriate assessment of the comparability of GKP to other sites within the MDB.

Environmental watering

- The GKP accounting system did not cover drivers and pressures of the system. This is linked to perhaps the biggest risk involved in scaling up: the inability to produce information that is relevant to the use case.

In a scenario where the purpose of the accounting system was not to inform specific environmental watering decisions (for example, demonstrating outcomes linked to watering events) and rather as a tool for problem identification (for example, changing trends in extent, condition and services), the GKP approach could be applied.

However, in such a scenario, local scale decision making would be made with relatively high levels of uncertainty and therefore error. The credibility of any local decision made across the basin would be open to scrutiny, as the information would not be fit for purpose. Further, the information set produced would have little connection to local communities and local decision making, thus exposing the MDBA and partners to considerable reputational risk.

The process of integrating basin scale information on extent, condition and services, with newly constructed information on environmental watering, is risky. The coherence of different data sources and methods should be assessed at a local scale before investing in scaling up a system designed to inform watering decisions. There is a high probability that the process of integrating the components of the accounting system would not work or additional work would be required to organise information of extent, condition and services to enable integration with information on environmental watering. It is recommended that this is explored at a granular spatial scale before scaling up.

Option 2 – SDL to Basin scale

The GKP project showed that while progress has been made, the accounting system in its current form cannot be utilised to determine the impact of environmental watering, which is the priority use case. The account team recommend building on the learnings from the GKP project and extending the accounting system to the sub basin level, and then rolling out this approach at the basin scale.

We suggest applying environmental-economic accounting at the surface water Sustainable Diversion Limit (SDL) resource units scale, which represent the maximum long-term average quantities of water that can be taken for consumption in any one year, (i.e. the long-term average annual limit) and include all users of water. Given that the approach taken at the SDL scale is appropriate for the application in mind, the implementation of basin scale environmental-economic accounting will consist of an aggregation of all SDL units. A staged approach, which focusses on one SDL before scaling up to the basin level, will minimise the risks in design and application whilst still maintaining local and regional relevance. Compared to the option of scaling up to the basin scale immediately, an intermediate step at the SDL scale is likely to be slightly more costly in the short term. However, it will lower cost in the long term (of having a system that is not interoperable) and reduces the risk of having a system that does not deliver on the use case.

Application at an SDL unit (for example Murrumbidgee) will enable a number of diverse ecosystems to be considered (beyond those in GKP) and will provide the opportunity to put more emphasis on the cultural needs of First Nations people, the needs of Basin communities and economic activities including agriculture. SDL units are also consistent with the geographical area for which water entitlements are provided and are an important factor when thinking about the purchases of environmental water (investment in nature) and associated government policies.

The benefits of an approach to basin level scaling via an SDL include the following:

- The accounting system can be extended to contain the information necessary for environmental watering decisions and can be tested by the MDBA. It is recommended that the SDL watering decisions are considered in the context of basin level water allocation decisions so basin scale application can be achieved with minimal effort.
- Contrast a new process (see section 4.3) with the process taken to develop an accounting system in GKP. It is likely that undertaking a new process will increase the utility of the accounting system when scaling up, for example by ensuring better coherence between condition and services, and reduce the costs / problems associated with rolling out a fit for purpose accounting system at the basin scale.
- Broadening the scope of the accounting system to include water accounting. Water accounts must be linked to ecosystem accounts – this has been missed in the current GKP study. We recommend the water accounts are undertaken through an ecosystem lens thus producing ecosystem-based water accounts, which goes beyond simple (traditional) water balance accounts.
- Refinement of the current conceptual models used in GKP. This should also consider temporal scale of changes to ecosystems by defining how they are more likely to respond over shorter five-year timeframes.
- Testing and refinement of methods
    - The method for measuring ecosystem extent could be tested at different locations and ecosystem types could be refined for local decision making. Additional consideration needs to be given to state (jurisdictional) level approaches to ecosystem classification and condition assessment methods. Further, as part of an assessment of state based ecosystem approaches a concordance could be developed to ensure it is applicable across the basin.
    - Refinement of ecosystem condition measurement to better capture core condition variables and indicators for each ecosystem type and state, and ensure coherence between said condition variables and estimates of ecosystem services. There is a need to determine a list of key characteristics for each ecosystem type and build up stage 1, stage 2, and stage 3 condition measurements following that approach.

There are a number of additional considerations for the purpose of assessing watering events that can be explored at the SDL unit level. These include designing the accounting information set to:

- Capture additional ecosystem services across a range of ecosystem types, noting that this is dependent on the question being asked. The implicit assumption in the recommended extension of the scope of ecosystem services is that they are affected by watering (watering affects condition, which affects services):

    - Agriculture – allocation of water
        - provisioning – crop provisioning services, grazed biomass provisioning services, livestock provisioning services
        - regulating – soil and sediment retention services
    - Natural ecosystem types – environmental watering
        - provisioning – hunting
        - regulating – rainfall pattern regulation services, water purification services, soil and sediment retention services
- Better represent the relationship between extent and condition and the provision of services. Ecosystem characteristics can be mapped to the estimation of extent, condition and services transparently.
- Capture a periodic account of water at an appropriate grid (say 100 metre grid), where each cell is balanced and recorded at a monthly interval. This is the key feature of how water accounting would be different to other approaches.
- The 100-metre grid can be aggregated and reported across different spatial areas (SDL, sub catchment, catchment, basin).
- Information in the water account would include:
    - Environmental water (human induced)
    - Natural water (rainfall etc)
    - Water balance within ecosystems (transpiration, evaporation, groundwater recharge and discharge etc.)
- Ecosystem accounts need to be at the appropriate time scale to match the water accounts
- Understand historical trends in the decline (or improvement) of ecosystem extent, condition and services (potentially need to develop backwards looking scenarios)

Perform additional analysis to:

- Determine ecosystem services that have been depleted over time
- Determine the relationship between extent and condition and the decrease in service provision
- Determine the locations where ecosystem services could be enhanced and the ecosystem services that are at risk of being depleted
- Determine the amount of water that is required to mitigate the risk of ecosystem decline or collapse (by assessing thresholds) or rehabilitate the ecosystem, such that the ecosystems function at a level that provides benefits
- Develop scenarios where different levels of environmental water is provided and linked to restoration and degradation trajectories
- Analyse the benefits and costs associated with different options and scenarios.

- Set up a program to monitor health of the ecosystems relative to thresholds. Note that the thresholds may change across time as drivers such as climate change affect ecosystem assets.

Process

The learnings from the GKP project can be used to refine the process for developing fit for purpose information. The entry point for accounting is to understand the use case (see Figure 6 - e.g. the impact of watering) and then to produce information that can support that use case. A common misconception about environmental economic accounting is that the purpose is to produce accounts (stock and flow accounts and supply and use tables). Indeed, the true purpose of accounting is to produce a coherent set of data that can be used in a number of applications (for example, scenario analysis, or producing an extent account for problem identification). Taking an example from financial accounting, the wider public normally see the profit and loss statement, or the balance sheet, but these are only one of many outputs from a system of financial data. Financial projections and other applications draw on data from the accounting system.

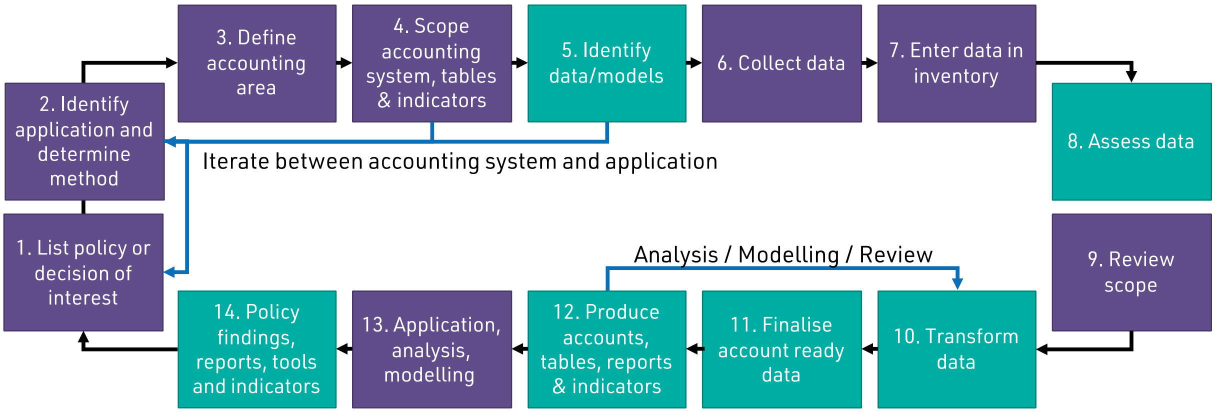
The idea of an environmental economic accounting system is new relative to financial accounting systems, which have been refined by businesses over time to meet particular needs. Iteration has been performed by the business community over multiple decades to design fit for purpose financial accounting systems. Our overarching recommendation is that additional design and iteration is needed to refine the accounting system for the intended application.

We recommend spending additional time considering the design of the accounting system (see steps 1 to 5 in Figure 6):

- Understanding policy question – what information is needed to address the policy question e.g. impact of environmental watering.
- Identify and designing the application - informing the characteristics of the information required for the application. For example, for the evaluation of the impact of environmental watering there is a need to capture information at a monthly interval, understand short term responses to environmental watering etc.
- Understand components of the accounting system that are needed to answer the question / underpin the application. For example, data on the stocks and flows of water and ecosystem based water balances are needed to deliver on the application. Take a coordinated approach to designing the accounting system, including ecologists and economists – noting that the components of the accounting system need to join together.
- Perform initial sense check / manage expectations around the role of accounting with respect to the application – for example, will accounting be able to deliver the information for the application? This is largely dependent on the existing data that is available. What are the pain points, in terms of the data that is available?

The user needs dictate the data and information that must be gathered or developed (though using existing data to meet user needs is also an important consideration to achieve coherence with other programs of work and resource efficiency - e.g. recouping previous investments in data and methods). Iteration through the initial stages of design are imperative if the accounting system is to be relevant for decision making. Indeed, all stages of the accounting process (including design, data collection, transformation, compilation and application) are interdependent, so an integrated design process is necessary at the beginning of the project.

Figure 7 Suggested accounting process

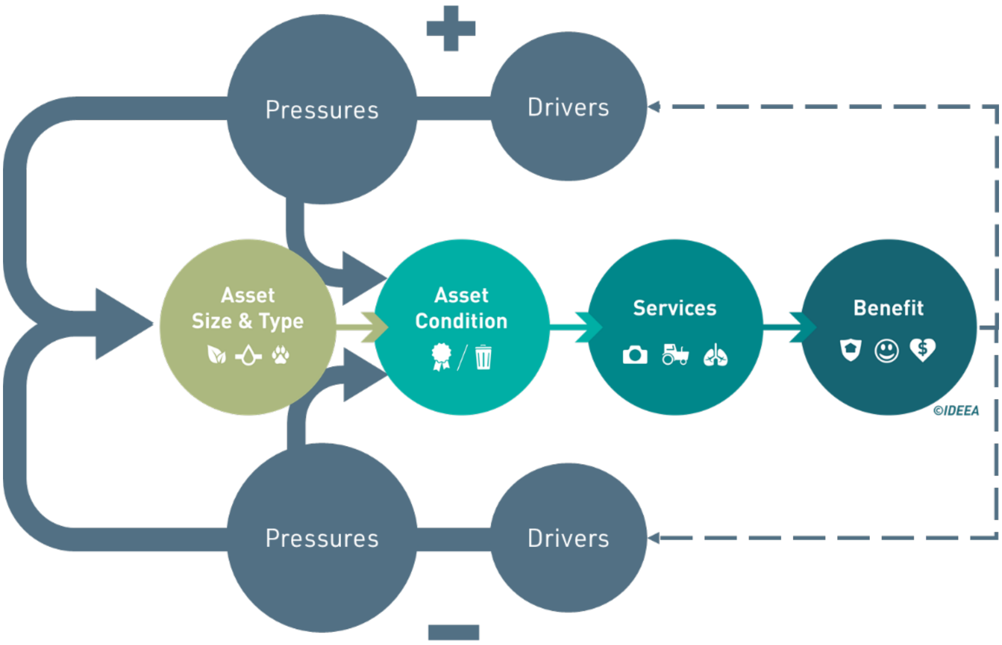


Source: IDEEA Group

Taking a more technical perspective, it is essential to work backwards from the use case to determine the components that need to be included in the accounting system. This is beyond the core accounting framework and includes pressures and drivers (see Figure 7), which are likely to be covered in other components of the SEEA framework including environmental transactions, and environmental stocks and flows). In the case of evaluating the impact of environmental watering in GKP we need:

- a response variable, ecosystem service quantities
- a treatment variable (environmental watering)
- a number of control variables which account for other drivers and pressures (or positive effects) that are likely to affect the response variable
- a pathway for relating environmental watering to ecosystem services (through changes to ecosystem extent and condition)

Figure 8 Identifying components of the accounting system



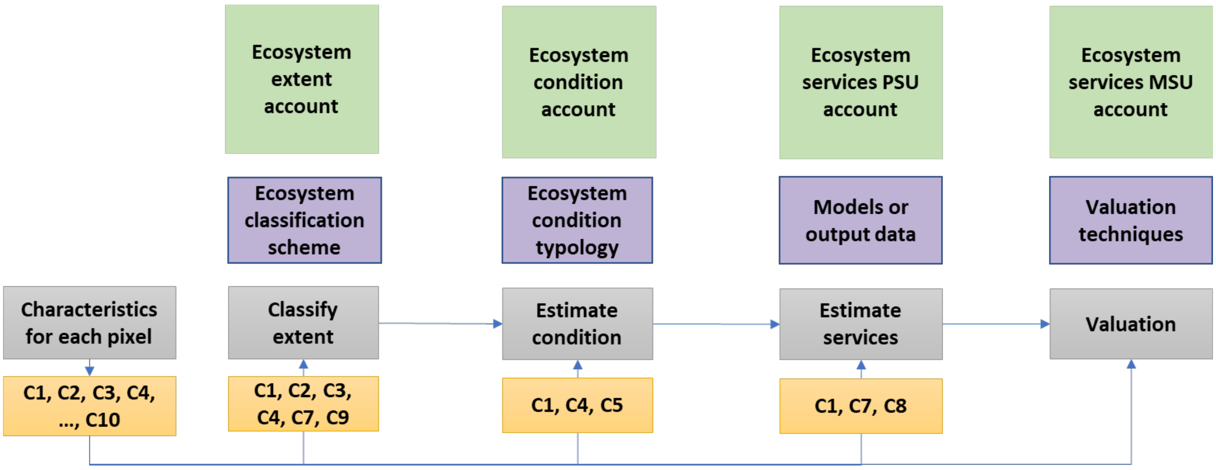
Source: IDEEA Group

We recommend that the process of identifying the concepts that need to be measured begins with ecosystem services and benefits, and then aligning ecosystem services and benefits to decision makers and stakeholder priorities.

Next, we suggest developing conceptual models that link ecosystem services to some management action or pressure (in this case environmental watering). It will be necessary to link environmental watering with an ecological response and a change in ecosystem services. The state and transition models used in GKP define changes to ecosystem states and expressions and their responses which may occur over longer timeframe. Future projects would benefit from conceptual models that define ecosystem responses over a shorter timeframe such as breeding and recruitment, flowering.

Having defined the concepts, we next think about the data requirements to measure those concepts. Because coherence is central to this approach, there is a need to develop a set of characteristics that are applicable and relevant across ecosystem condition and services. This is the essence of the SEEA – coherence across the different measurement domains. The identification of key characteristics can also reduce the amount of time spent collecting data that may not be required (Figure 8).

Figure 9 Linking ecosystem characteristics across the core framework



Source: IDEEA Group

The measurement of ecosystem services requires the identification of core ecosystem characteristics for the ecosystem services to be coherent with extent and condition. For those ecosystem services that are being modelled, it is likely that a suite of characteristics will be required as an input. For ecosystem service quantities that are observed, the use of characteristics will depend on the scale at which the ecosystems services are recorded. For example, timber provisioning services recorded at plot level, can be reported immediately. However, if the tonnes of biomass harvested (say 100,000 tonnes) is recorded for the catchment, a suite of characteristics will be needed to apportion the 100,000 tonnes in a consistent manner across the spatial area. Coherence between condition and services is important for understanding notions of return on investment, and should be prioritised in all projects.

We recommend considering methods and data collection for ecosystem services at the beginning of the project. This will help guide information collection for extent and condition that can be meaningfully linked to services. Collect data and prepare methods, noting any deviation from inclusion of characteristics in methods. Assess methods as Tier 1, Tier 2 and Tier 3 methods.

We recommend a two-year program of work to scale up the GKP approach to the basin. The two-year program of work will be a blending of the process described and the approach described in option 2.

- Month 1 to 6: Iterating over step 1 to 5 in Figure 6 to prepare accounting system for the use case in one SDL.
- Month 7 to 12: Developing the required information base for one SDL, and implementing the method developed during month 1 to 6 to perform the application (6 months),
- Month 13 to 24: Roll out approach across the basin

National considerations

A key challenge for future work is putting in place arrangements that can support both the private and public sector in adopting environmental-economic accounting. Establishing an Australian Natural Capital Accounting Community of Practice (ANCA-CP) would be an efficient and effective way to coordinate the production of accounts and facilitate capacity building and knowledge transfer. The ANCA-CP should have a strong working relationship with relevant

Commonwealth, state and local institutions, academia and business and should impart authority to the information that is produced and the methods that are used. The ANCA-CP could recommend changes to institutional arrangements so there is coherence in the data collected and the concepts underpinning the methods, enabling the data to be integrated more readily. Membership of the ANCA-CP should include Environment departments, Treasury, Local Government, Catchment Management Authorities, ABS, CSIRO, GA, State and Territory Government, business, academia, private sector expertise and sectoral representation.

The ANCA-CP can generate economies of scale in knowledge that members can use. It can also facilitate the ongoing development of standards for data collection, method development, transformation and integration. Establishing standard data quality assessment processes and technical advisory groups would be a part of this.

Collaboration across all sectors (government, private, academia, community organisations) is important to encourage standardisation, coherence and sharing across the many diverse and ongoing data collection efforts. Some key data streams that could benefit from being guided by an accounting approach include scientific research and development; business sustainability reporting; and environmental impact assessments. Standardising the collection and development of ecological data will improve the coherence with economic data at a both the local and national level, such as that collected by the State Government environmental agencies and Australian Bureau of Statistics.

This ANCA-CP would ideally convene an ongoing committee for data providers and users to agree and endorse key data streams and how they are collected, developed and maintained. This ensures agreement on the approach, improves likelihood of broad uptake of the data streams (improving coherence), and supports translations and concordances where (for example) states need to use related but different state data that differs from national data.

The ANCA-CP could determine a number of work programs across different areas, including:

- a broad evaluation of methods and data sources for natural capital accounting to support consistent national approaches to accounting
- Develop a data management plan and process for other accounting projects, including a template that lists all datasets and related metadata, supported by a data infrastructure that enables future accounting teams to share data and track provenance and licensing.
- Develop a toolkit of resources to support SEEA implementation to reduce barriers to entry
- Consolidate an essential set of ecosystem characteristics most likely to support assessment across extent, condition, biodiversity, services and valuation to streamline account compilation and reduce cost
- articulate principles of ‘ideal’ data and methods to provide benchmarks / aspirational goals for future projects
- define criteria to assess maturity of data and methods to support investment in accounting over time
- A systematic reporting of uncertainty beyond that currently contained in the ABS data quality framework should be developed to ensure consistency in reporting and comparability of results
- Develop institutional buy in by linking to other programs - for example State of the Environment, Convention on Biological Diversity, Sustainable Development Goals, environmental development approvals, environmental stewardship, bushfire analytics,

National Environmental Prediction System, national soil policy, Nature Strategy, environmental standards recommended in the Samuels review of the Environment Protection and Biodiversity Conservation Act 1999, National Environmental Science Program, Natural Capital Investment Initiative

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