5. Wetlands

Key Findings

- Three NRM regions provided information for wetland condition accounts, based on data collected for specific management-focussed programs.
- There are currently different wetland classification methods in use in Australia. Some are based on ecological processes, others on hydrological processes.
- SEQ catchments used a simple measure of wetland condition based on expert assessment. In Victoria, it was possible to compare between two regions because they both used a common assessment methodology (Index of Wetland Condition).
- The use of a national wetland classification system based on hydrological and ecosystem processes, such as that proposed by the Framework for the Assessment of River and Wetland Health provides the foundation for an accounting standard. If adopted by all regions, this system will enable a national comparison of wetland condition and allow for consideration of differing objectives that communities might hold for the management of these resources.

Introduction

Wetlands are among the most degraded of all Australian ecosystems. They are significantly affected by land use change, salinisation, changed water regimes and changed water quality (DEWHA 2009). In response to these concerns, several states have developed wetland assessment methodologies but few are implemented on a state-wide basis (DEWHA 2009). There is currently no national wetland assessment method.

The Framework for the Assessment of River and Wetland Health (FARWH) was developed to provide a national approach to wetland condition assessment. It was applied to over 30,000 wetlands in five surface water management areas in NSW: Hunter, Karuah, Manning, Murrumbidgee and Murray (OEH & DPC 2011). The results of the FARWH trials were not used by the regions in the environmental accounts trial. However, with further testing in other states, FARWH could provide the basis for wetland condition accounts for national policy and investment purposes.

Wetlands are recognised as an asset in the regional strategic plans of 77% of NRM regions (GHD 2012) (see **Supplementary Material 7**). Four regions submitted wetlands accounts for the environmental accounts trial: Queensland Murray-Darling Committee, SEQ Catchments, North Central CMA, and Corangamite CMA. These regions provided information on the condition of wetlands, using multiple indicators describing the quantity and quality of wetlands. There are two main sources for identification of Australian wetlands. The Directory of Important Wetlands provides an inventory of 900 wetlands across Australia determined important through a range of criteria, including social significance and rarity (Environment Australia 2001), while the Ramsar list of wetlands includes 65 representative, rare or unique important wetlands that are of international significance.

Comparison of Approaches

Classification of Assets

A number of different wetland classifications are used in Australia. The Aquatic Ecosystems Task Group (2012) uses the Cowardin *et al.* classification of wetlands: marine, estuarine, riverine, lacustrine, palustrine (Cowardin *et al.* 1979). This chapter presents approaches for lacustrine and palustrine wetlands only.

Lacustrine (lake) wetlands are defined as being situated in a topographic depression or dammed river channel, having sparse vegetation coverage (<30%) and with the total area exceeding 8 hectares (Aquatic Ecosystems Task Group 2012). Palustrine systems, typically described as swamps, bogs, marshes and prairies, are dominated by trees, shrubs, persistent emergent vegetation, mosses and lichens covering over 30% of wetland area (Aquatic Ecosystems Task Group 2012).

Victoria uses Corrick's classification system which defines wetlands based on water depth, water permanence and salinity (DSE 2006). Part of South Australia utilises a system developed by Semeniuk and Semeniuk (1995) which extends Cowardin (Cowardin *et al.* 1979) by including geological characteristics.

Wetlands assets submitted for the environmental accounts trial used two of these classification systems. QMDC and SEQ Catchments utilised the standard Cowardin system, whereas the two Victorian regions (Corangamite and North Central) utilised Corrick's classification (**Table 32**). Additionally, North Central provided accounts for individual wetlands.

The FARWH trials did not use any of these standard classification systems. Instead, wetlands were classified, based on their intrinsic characteristics, into five types in the Hunter, Karuah and Manning Surface Water Management Areas, seven types in the Murrumbidgee and five types in the Murray.

Table 32: Classification systems for wetlands assets used in the environmental accounts. Number of classes are shown in parentheses.

Region	Classification used
QMDC	Cowardin 1979 (3)
SEQ	Cowardin 1979 (2)
North Central	Corrick's Classes (6); Individual wetlands (33)
Corangamite	Corrick's Classes (6)

Selection of Indicators

There are a number of state-based programs that provide indicators for wetland condition, including Index of Wetland Condition in Victoria (State of Victoria 2012), AquaBAMM in parts of Queensland (Queensland Government 2013) and in South Australia (Scholz and Fee 2008).

The indicators used for wetlands accounts by the regions are provided in **Table 33**. Quality indicators include measures of biota, soil moisture, water quality, and other parameters. Wetland assessment is well developed in Victoria, through the Index of Wetland Condition (State of Victoria 2005). A variety of indicators are used to form this index, including water quality, biotic elements (vegetation and aquatic biota), and hydrology.

Table 33: Indicators for wetlands assets

Region	Assessment Program	Indicators of Condition
SEQ Catchments	Expert assessments of condition (data sourced from (DERM 2009) and (QDSITIA 2008))	*Extent* [area of vegetation associations identified with each wetland type ('remnant'+'regrowth')]; *Quality*: comprising expert assessments against three indicators: *Structural Integrity, Species Richness and Regenerative Capacity.*
QMDC (for all of the regions in the QMD Basin)	Queensland State of the Environment 2011 (data sourced from DERM (2009) and Wilson and Pennay (2011)	*Extent* [area of wetland systems]
North Central and Corangamite	Index of Wetland Condition (State of Victoria 2005)	*Physical Form* [assessment of the reduction in wetland area] *Biota* [vegetation condition using Habitat Hectares scoring method] *Wetland catchment* [an assessment of the buffer size and quality; and intensity of adjacent land use] *Water properties* [nutrient richness score is derived from observation and expert opinion] *Hydrology* [scored through a series of five steps identifying the water source and changes to the regime] *Soils* [derived from observation and recording against a set list of disturbances and their severity]

Estimation of Reference Benchmarks

Reference benchmarks for the Index of Wetland Condition are based upon modelling to estimate pre-European conditions (State of Victoria 2005). Queensland regions used estimates of pre-clearing of wetland extent (DERM 2009). FARWH used modelled estimates of pre-European conditions (Alluvium Consulting 2011).

Data Sources and Analysis

The Index of Wetland Condition database, maintained by the Victorian department, contains details of 1,310 wetland assessments conducted from 2009-2012. This dataset provides the results of two large-scale statewide assessments; the 2009-10 assessment that assessed approximately 600 of Victoria's high-value wetlands, and the 2010-11 assessment that assessed approximately 450 representative wetlands (Papas and Moloney 2012). The database also contains the assessment results for wetlands included in various Wetland Tenders that have occurred from 2010-2012, including sites within the Corangamite and North Central regions. Although a large number of wetlands have not been included in the database, the Victorian NRM regions assumed that assessed wetlands are representative of all wetlands of that type in their regions. They have noted that this is likely to overestimate the average condition of wetlands due to the apparent over-representation of high-value wetlands in the two regions (McCristal *et al.* 2014).

The Queensland Herbarium's Aqua BAMM program was scheduled to conduct wetland condition assessments in the NRM regions, including SEQ Catchments and Queensland Murray-Darling, but these data were not available at the time of the trial. As a result, Queensland Murray-Darling used data on wetland extent from the Queensland State of the Environment report (EHP 2012). SEQ Catchments applied an expert assessment method used for their native vegetation account, whereby an expert panel assessed wetlands based on the quality of wetland-specific native vegetation. Both Queensland regions sourced data from the Queensland wetlands mapping database (Table 33)

Indicator Condition Scores

Indicator condition scores were calculated for wetlands indicators, as described in Table 34. Where extent is used as an indicator, the metric is determined by comparing the current measure of area to the reference measure, yielding an indicator condition score. Quality indicators include biota, wetland catchment, water properties, hydrology and soils. Quality indicator condition scores may either be derived by comparing current measures with reference measures where these data are available, or be given an assigned score based on expert advice.

Table 34: Methods for calculating indicator condition scores in wetlands assessment programs used in the regional environmental accounts trial

Region	Method for calculating indicator condition scores
SEQ Catchments	Extent: distance-to-reference; Quality: Scores for remnant and regrowth of each regional ecosystem were calculated using a weighted average across the three indicators of Structural Integrity (27%); Species Richness (18%) and Regenerative Capacity (55%) (Thackway 2013)
QMDC (for all regions within the QMD Basin)	Extent: distance-to-reference
North Central CMA	Each sub-index – biota, wetland catchment, water properties, hydrology and soils – is scored out of 20.
Corangamite CMA	Each sub-index – biota, wetland catchment, water properties, hydrology and soils – is scored out of 20.

Indicator condition scores are available in the spreadsheets online (NRM Regions Australia). Examples of indicators are shown for the North Central CMA in Victoria (Table 35).

Table 35: Measures and indicator condition scores for wetlands classified by six Corrick's classes in North Central CMA, Victoria.

Class (Corrick's Class)	Indicator	Reference Benchmark	2006		
			Measure	ICS	Econd
Total					*63*
Deep freshwater marsh					*71*
	Wetland Catchment	20	15	74	
	Physical Form	20	19	94	
	Hydrology	20	8	40	
	Water Properties	20	15	76	
	Soils	20	15	77	
	Biota	20	9	43	
Freshwater meadow					*57*
	Wetland Catchment	20	8	39	
	Physical Form	20	17	87	
	Hydrology	20	12	59	
	Water Properties	20	15	76	
	Soils	20	14	72	
	Biota	20	12	62	
Permanent open freshwater					*58*
	Wetland Catchment	20	9	46	
	Physical Form	20	20	100	
	Hydrology	20	5	25	
	Water Properties	20	17	85	
	Soils	20	16	79	
	Biota	20	10	49	
Permanent saline					*62*
	Wetland Catchment	20	12	60	
	Physical Form	20	20	100	
	Hydrology	20	2	9	
	Water Properties	20	13	67	
	Soils	20	20	99	
	Biota	20	14	70	
Semi-permanent saline					*60*
	Wetland Catchment	20	12	58	
	Physical Form	20	17	87	
	Hydrology	20	6	29	
	Water Properties	20	14	68	
	Soils	20	17	85	
	Biota	20	9	47	
Shallow freshwater marsh					*60*
	Wetland Catchment	20	9	46	
	Physical Form	20	18	90	
	Hydrology	20	9	45	
	Water Properties	20	17	83	
	Soils	20	17	83	
	Biota	20	12	60	

Environmental Condition Index (*Econd*)

Calculating an *Econd* was not possible for Queensland Murray-Darling's account without a quality measure. Consequently, results for Queensland Murray-Darling will not be discussed here. The Index of Wetland Condition, which contributes to the North Central and Corangamite accounts, calculates an index based on weighted subindices. SEQ applied an equation, whereby *Econd* = Quantity x Quality (Table 36).

Table 36: Methods for aggregating to the *Econd* for wetlands assets, environmental accounts.

Region	Method of creating asset *Econds*	Method for aggregating asset *Econds* to region
SEQ Catchments	*Econd* = Quantity x Quality indicator condition scores	Sum of spatially weighted asset *Econds*: $Econd_r = \sum_{c=1}^{c_{max}} Econd_c \times \frac{A_c}{A_r}$ where the *Econd* for all wetlands in a region *r* is the sum of all *Econds* after they are multiplied by the fraction of the total wetland area *A* covered by wetland class *c*
North Central CMA	Weighted sub-index scores are summed, scaled and averaged to yield a class score. Weighting given as follows: Biota (0.73), Wetland Catchment (0.26), Water Properties (0.47), Hydrology (0.31), Physical Form (0.08), Soils (0.07)	Sum of spatially weighted asset *Econds* (see equation above).
Corangamite CMA	Weighted sub-index scores are summed, scaled and averaged to yield a class score. Weighting given as follows: Biota (0.73), Wetland Catchment (0.26), Water Properties (0.47), Hydrology (0.31), Physical Form (0.08), Soils (0.07)	Sum of spatially weighted asset *Econds* (see equation above).

Econds were available for one time period only across SEQ Catchments, North Central and Corangamite CMAs (2006). Corangamite CMA scored highest, followed by North Central and SEQ Catchments (Table 37). *Econds* are shown for North Central CMA where two asset accounts were constructed using different classification systems: one for individual wetland assets and one for the Corrick's classification (Figure 33). *Econds* from Corangamite and North Central (Corrick's class) were comparable as they used the same classification, methodology and indicators. However, the Victorian and Queensland *Econds* were not comparable because of the substantial differences in wetland classification, indicator selection and aggregation methods.

Table 37: *Econds* for wetlands, 2002-2009. The *Econds* are comparable between the two Victorian regions (Corrick's class) but differ from the *Econds* for the SEQ Catchments.

Region	2006
Corangamite (VIC)	77
North Central (VIC) - Corrick's Class	63
North Central (VIC) - Individual wetlands	56
SEQ Catchments (QLD)	33

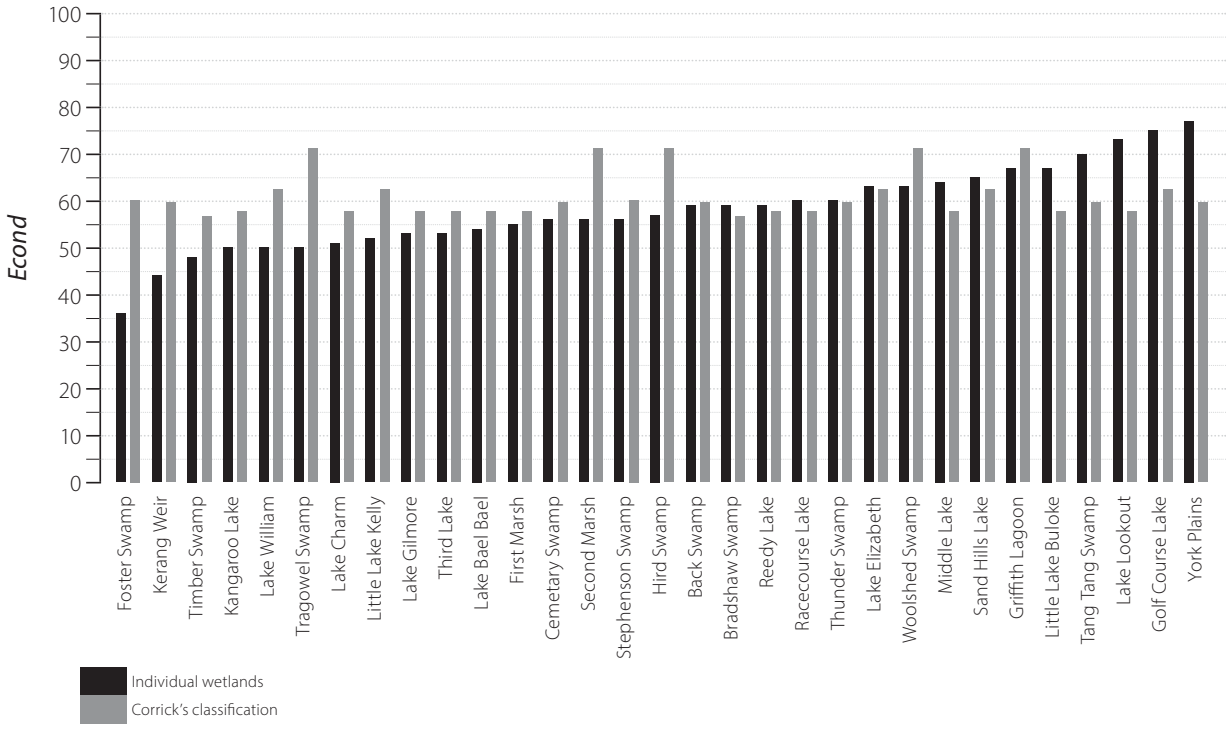

Figure 33: *Econds* in the North Central CMA, Victoria, shown for different wetland classifications systems: individual wetlands and the Corrick's classification.

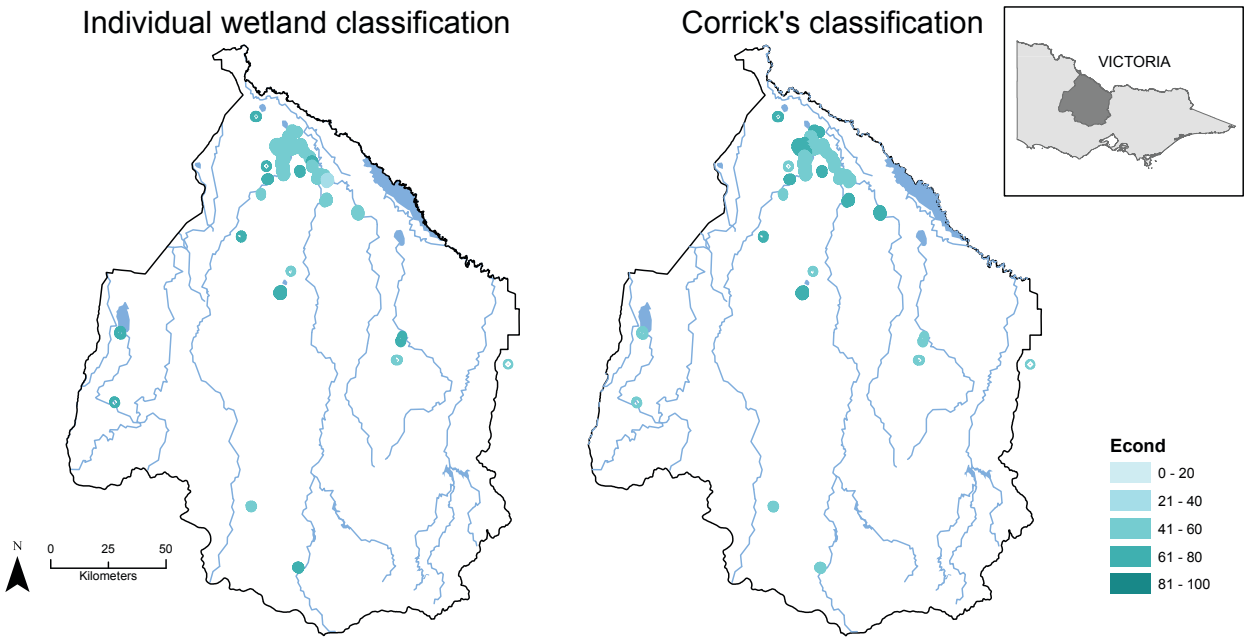

Figure 34: *Econd* maps for individual wetlands and their corresponding Corrick's classification in North Central CMA, VIC.

Regions

The results (**Table 38**) for both the Corangamite and North Central CMA wetlands are taken from the relevant Index of Wetland Condition reports (DSE 2006; North Central CMA n.d.; State of Victoria 2005). These accounts show some significant changes from reference. In the Corangamite region the condition of shallow and deep freshwater marshes was likely to be affected by agriculture and urban development which was estimated to have reduced the area of marshes to 30% and 67% respectively since 1788 (Sheldon 2005).

North Central provided an account for individual wetlands sampled in the region through the Index of Wetland Condition assessment program. Of these 32 sampled wetlands, 18 are listed in the national Directory of Important Wetlands and 16 are Ramsar-listed. Because all wetlands were assessed using a common method, the individual wetland scores are comparable within this region. Of those in the national Directory of Important Wetlands, 12% achieved *Econds* between 60-80, 40% achieved between 40-60, and 3% scored between 20-40. Those wetlands that are Ramsar-listed show similar results, although only 3% achieved *Econds* between 60-80.

In North Central, the total area of wetlands has decreased by 30,000 Ha, while there has been a shift in wetland type with freshwater meadows declining by 34,000 Ha and permanent open freshwater wetlands increasing by 14,000 Ha. Data were collected during a dry period and this may have influenced the overall decline. An increase in open freshwater wetlands has occurred, at least partially, because of an increase in their use as storage basins for irrigation supply and as outfalls from irrigation activities. Some of the decline in freshwater meadows results from conversion to open freshwater bodies as well as land clearing and drainage (North Central CMA n.d.).

Because both Victorian regions were assessed using the same method, *Econds* from the two regions can be compared. **Table 38** shows that, with the exception of semi-permanent saline wetlands, all types of wetlands are in better condition in Corangamite than they are in North Central region (**Figure 35** and **Figure 36**)

Table 38: *Econds* for six wetland classes in Corangamite and North Central CMA's

Class	Corangamite CMA	North Central CMA
Deep freshwater marsh	80	71
Freshwater meadow	72	57
Permanent open freshwater	81	58
Permanent saline	79	62
Semi-permanent saline	70	60
Shallow freshwater marsh	70	60
Region	77	63

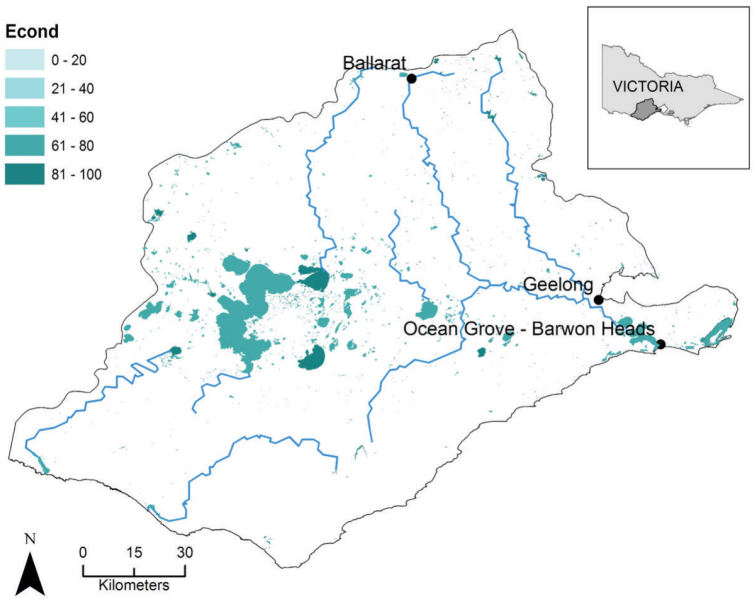

Figure 35: Wetland condition scores mapped for Corangamite CMA, Victoria.

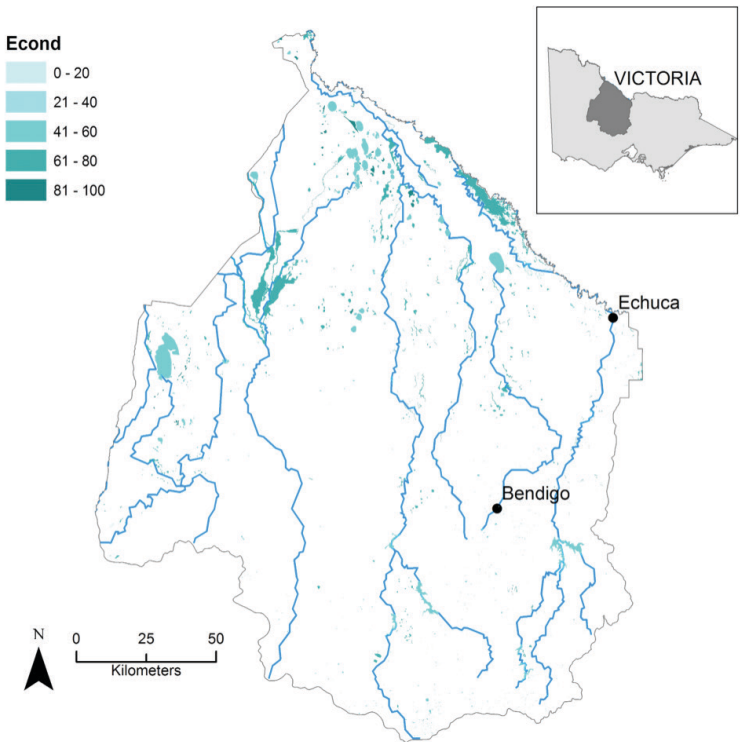

Figure 36: Wetland condition scores mapped for North Central CMA, Victoria.

Table 39 shows the wetlands account including indicator condition scores and *Econds* for SEQ Catchments. While not comparable with wetlands accounts from Victoria, they provide an example of how expert assessment can be used to determine the best estimate of wetland condition for this particular region.

Table 39: Wetlands account, SEQ Catchments. See online spreadsheets for calculation of *Econd*.

Class	Indicator (unit)	ICS	*Econd*
Total			33
Palustrine and saltmarsh wetlands			39
	Extent (Ha)	49	
	Composition (index)	79	
Riverine wetlands			19
	Extent (Ha)	49	
	Composition (index)	38	
Lacustrine wetlands			n/a
	Extent (Ha)	88	
	Composition (index)	n/a	

Discussion

An agreed, national wetland classification is important for establishing reference conditions and for comparing the condition of wetlands of similar types. A key challenge for environmental asset accounting is to reach agreement on a classification that is nationally applicable and ecologically meaningful (Nevill 2003). For example, the Corrick's classification system, as used in Victoria, appears to align with the list of wetland types in the Directory of Important Wetlands (Larmour 2001). However, it is not clear how Corrick's classification relates to Cowardin's (1979) hierarchy, the minimum suggested classification for Australian wetlands (Aquatic Ecosystems Task Group 2012). The applicability of the Corrick's classification to wetlands outside of Victoria also requires further testing. There are advantages to the Semeniuk classification system (used in South Australia and builds on the Cowardin system) as it links with landscape processes

(Semeniuk and Semeniuk 1995). There is potential for remote sensing to differentiate geomorphic- based wetland types more easily than a system based on water regime and quality (Scholz and Fee 2008). A pathway for a national wetland classification system has been provided by the Aquatic Ecosystems Task Group (2012) and it is recommended that for future wetlands accounts, this national system be introduced.

Australia, despite multiple assessment programs (DEWHA 2009; NLWRA 2002; 2008), still does not have an adequate picture of decline in extent of wetlands across the country (DEWHA 2009). Nevertheless, it is clear from existing state and regional assessments that there has been a loss of wetland numbers and extent since European settlement (State of the Environment Committee 2011).

Each of the trial regions applied a pre-European reference benchmark to the accounts. The two Victorian regions derived these benchmarks from modelling, while the two Queensland regions derived their benchmarks from expert judgement. However, the pre-European extent and condition of wetlands is still not well established, and more detailed modelling will improve reference benchmarks, particularly taking account of the highly dynamic nature of wetlands and natural changes in climate, geomorphologic processes and other drivers. In future wetland accounts, there is potential to use a more appropriate reference benchmark that accounts for natural changes in wetland condition (see 'dynamic reference condition' in Soil Chapter).

Methods for calculating an overall *Econd* varied from the simple multiplying of quantity and quality in SEQ Catchments to the more sophisticated mechanisms used in North Central and Corangamite CMAs. The methods for combining the components will need to be standardised, possibly using FARWH methods, if a nationally consistent picture of wetland condition is to be established.

The FARWH trials in NSW made considerable progress towards a procedure for broadscale wetland assessment that could be applied nationally. The lessons from the FARWH trials echo many of the findings discussed here. There needs to be further development of methods for mapping the extent of wetlands within a study area, identifying reference wetlands which are as close to pre-development conditions as possible, and agreeing on ecologically meaningful wetland typologies. The FARWH trials demonstrated the value of measures of condition defined by groups of indicators that allow for management to deal with particular wetland issues. Future work on wetlands accounts should consider the FARWH framework as a potential method for approaching national-level accounting.

Data used in the wetlands accounts have, for the most part, been supplied and analysed by state agency personnel. Maintaining the link between regional needs and state agency expertise will be integral to the future success of regional environmental accounts.

Conclusions

Monitoring and reporting on the condition of Australian wetlands is much less advanced than for rivers, yet management of wetlands and their functions will almost certainly be an important component of future sustainable management of our national water resources. The Index of Wetland Condition, as used in Victoria, is the most mature state-based wetland assessment program, but the methods are not designed for use across Australia. While Queensland has developed a database of wetlands, it is not currently available across the entire state.

Econds from the two Victorian wetlands regional assessments can be compared since each used the same method, but they cannot be easily compared with *Econds* from other states. No national comparison has been made at this stage. It would be valuable for FARWH trials, as undertaken in NSW, to be conducted in Victoria to provide a method for integrating the Index of Wetland Condition into a national system. Because wetland assessment methods are either non-existent or embryonic in most regions, there is an opportunity to build the FARWH principles into wetland monitoring programs and so avoid the difficulties (found with river monitoring programs) of reconciling a plethora of disparate programs.

Although the programs used in the regional trial provide measures of wetland condition, these measures are yet to offer a measure of trend. Updating datasets is critical to understanding changes in the condition of wetlands within these regions.

Wetlands assessments in SEQ Catchments offered a relatively simple assessment method at minimal cost using existing data. This contrasted with the more intensive sampling and other measurement requirements involved in both the FARWH and Index of Wetland Condition assessments. Considerations should be given to further use of the SEQ approach to construct a wetland account where resources are limited. As management of wetlands becomes more interventionist, measurements required to monitor efficacy of wetland management may also contribute to cost-effective condition monitoring at the regional scale.

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