Australian Government

Department of the Environment, Water, Heritage and the Arts

Assessment of Australia’s Terrestrial Biodiversity 2008

Chapter 3 Aquatic ecosystems

Disclaimer
The then National Land and Water Resources Audit’s Biodiversity Working Group had a major role in providing information and oversighting the preparation of this report. The views it contains are not necessarily those of the Commonwealth or of state and territory governments. The Commonwealth does not accept responsibility in respect of any information or advice given in relation to or as a consequence of anything contained herein.

Cover photographs:
Perth sunset, aquatic ecologists Bendora Reservoir ACT, kangaroo paw: Andrew Tatnell.
Ecologist at New Well SA: Mike Jensen

Editor: Biotext Pty Ltd and Department of the Environment, Water, Heritage and the Arts

Chapter 3

Aquatic ecosystems

Aquatic ecosystems are defined for this Assessment as ecosystems that depend on freshwater inundation most or part of the time. They include rivers, wetlands and estuaries. As there are no national datasets of river health or wetland extent, distribution and health, this chapter will give examples of the progress made in developing methodologies, in collaboration between jurisdictions and in undertaking assessments.

3.1 Key findings

The extent and distribution of wetlands nationally is not known.	Studies identify that only 17 per cent of Australia has comprehensive coverage of the extent and distribution mapping of wetlands.
A wetland mapping methodology has been developed.	A methodology for mapping wetlands, as well as providing information on the extent and distribution of different wetland types, has been developed and implemented on a state-wide basis, by one state.
Selected case studies indicate a decline in the extent of wetlands.	Case studies indicate a decline in the extent of wetlands. This is predominantly due to altered flow regimes through river regulation, increased surface and groundwater abstraction, increased interception of surface water, and land use change.
	These findings are consistent with assessments indicating altered flow regimes have resulted in the loss of 90 per cent of floodplain wetlands in the Murray-Darling Basin.
Wetland health assessment methodologies are being developed.	A wetland health assessment program for state-wide application is being developed by one state. Other states are developing wetland health assessment techniques for potential use.
River health assessment methodologies are improving.	Methods to determine river health have evolved considerably by moving from using only one indicator to incorporating data from several indicators, to provide a more comprehensive and holistic indication of river health.
Most states have implemented independent river health programs.	Most states have implemented independent river health programs. States have developed their own methodologies for data collection and analysis of different indicators, with the exception of the standardised collection and processing methods of AUSRIVAS for macroinvertebrates.
Basin-wide river health assessments have been undertaken.	Jurisdictions have collaborated in developing and implementing river health assessments in the Murray-Darling Basin (MDB) and the Lake Eyre Basin (LEB).
Assessments indicate:	The Sustainable Rivers Audit of the MDB found 13 rivers to be in ‘very poor’ health, seven in ‘poor’ health, two in ‘moderate’ health and one in

- A decline in river health and fish species within the Murray-Darling Basin.

'good' health. Native fish species were found in only 43 per cent of valley zones where they were predicted to occur under reference condition, indicating a decline of native fish in the Basin.

- Intact aquatic ecosystems in the Lake Eyre Basin.

The LEB Rivers Assessment found the rivers and catchments of the LEB to be in generally good condition, with critical aquatic ecosystem processes remaining intact. Intact aquatic ecosystems make the LEB rivers unique compared with other arid river systems in Australia and around the world. The LEB may therefore provide critical aquatic habitat, especially for migratory waterbirds, given the greater impacts seen in other river systems.

3.2 Indicators for assessing aquatic ecosystems

Indicators reported in this chapter are listed in Table 3.1.

Table 3.1 Indicators

Indicator	Current reporting capacity rating
The extent and distribution of wetlands	Moderate for important wetlands nationally Good for some states
Trends in river and wetland health	Poor nationally Good for the Murray-Darling Basin (rivers) Good in some states (rivers) Good at case-study level

3.3 Rivers and wetlands

Summary

The following findings are based on information provided in this chapter and from selected case studies and indicate:

- The current development of a national framework for the identification and classification of high conservation value aquatic ecosystems (HCVAE) may assist capacity to measure biodiversity at the ecosystem and ecological complex level.
- Ongoing research is crucial to underpin improved understanding of aquatic ecosystem function, inter-relationships with other ecosystems and water movement through the landscape. As knowledge increases, so will the need to develop cost-effective and appropriate condition assessment techniques.
- The extent and distribution of wetlands nationally is not known. Studies identify that only 17 per cent of Australia has comprehensive coverage of the extent and distribution mapping of wetlands.

- A methodology for mapping wetlands, as well as providing information on the extent and distribution of different wetland types, has been developed and is starting to be implemented on a state-wide basis.
- The selected case studies, identified in Table 3.2, indicate a decline in the extent of wetlands, due to altered flow regimes through river regulation, increased surface and groundwater abstraction, increased interception of surface water, and land use change. For example:
  - Less than 6 per cent of pre-European wetland extent remains in the upper south-east (with less than 10 per cent of this estimated to be intact), and 18.3 per cent remains in the lower south-east of South Australia.
  - More than 50 per cent of the southern Macquarie Marshes area and 40-50 per cent of the northern marshes area has been lost since the 1960s. This has resulted in a well-documented decline in the waterbird population (Kingsford 2000).

High conservation value aquatic ecosystems

The world's biodiversity is decreasing (Pimm and Brooks 2000) and this is affecting organisms associated with inland aquatic ecosystems more than other major groups (e.g. terrestrial, marine). Relative to scale, inland water systems are species-rich and levels of endemism of freshwater species are particularly high (World Resources Institute 2005).

There has been considerable progress towards identifying and managing Australia's aquatic ecosystems since 2002. Through the National Water Initiative (NWI) (2004), Australia's blueprint for water reform, parties have agreed to identify high conservation value aquatic ecosystems (HCVAE) within water sharing plans, and to manage hydrological systems to maintain HCVAE values (NWI clause 25x).

The unprecedented combination of increasing demands for water abstraction, the effects of climate variability including extreme events, and the threat of further climate change are compounding existing pressures on aquatic ecosystems. Governments will be increasingly challenged to sustainably manage water resources. The identification of HCVAE will enhance governments' ability to protect and maintain critical aquatic assets and biodiversity, and to monitor the effects of climate change. The threats to and pressures on aquatic ecosystems are examined in Chapter 5.

The Australian Government is working with the multi-jurisdictional Aquatic Ecosystems Task Group to develop a national framework for the identification and classification of Australia's HCVAE. Through this process, a broader, more detailed Australian National Aquatic Ecosystem Classification Scheme is also being developed. An HCVAE may be, for example, a mound spring in an arid landscape or a system encompassing a complex of coastal wetlands, groundwater, rivers and estuaries. The draft National HCVAE Framework will shortly undergo trials in a number of Drainage Divisions.

The HCVAE approach may assist capacity to assess biodiversity at the ecosystem and ecological complex level, and is consistent with the national definition of biodiversity as stated in the consultation draft of *Australia's Biodiversity Conservation Strategy 2010-2020*:

> **Biodiversity** (biological diversity) – variability among living organisms from all sources (including terrestrial, aquatic, marine and other ecosystems and ecological complexes of which they are a part), which includes genetic diversity, species diversity and ecosystem diversity (National Biodiversity Strategy Review Task Group 2009).

The move to identifying and classifying HCVAE in this manner reflects the need to progress beyond an understanding of key ecological components and structure, and the biological, physical and chemical make-up of particular sites. In order to maintain ecological character and high conservation values, it will be necessary to understand the way HCVAE function, their ecological processes and how different components interact within and between the ecological and hydrological systems on which they are dependent.

Current river health monitoring programs are generally confined to assessing in-stream and riparian zone health, but the inclusion of methods to identify changes in river, wetland and floodplain condition on a landscape scale will give an indication of system condition. All jurisdictions agree that ongoing research is crucial to underpin improved understanding of aquatic ecosystem function, inter-relationships with other ecosystems and water movement through the landscape. As knowledge increases, so will the need to develop cost-effective and appropriate condition assessment techniques.

3.3.1 The extent and distribution of wetlands

Trends in the extent and distribution of Australia's wetlands will be an important indicator of the impact of climate change. In the absence of information on wetland health, wetland extent and distribution provide key surrogates. However, the data and information systems used to assess wetland extent and condition, and to provide primary wetland data, are fragmented and often limited. They operate at national, state and territory levels, and have been established at different times, to varying degrees of completeness and scale, and for a range of purposes. (National Land and Water Resources Audit 2008)

A review of wetland mapping undertaken by the National Land and Water Resources Audit (Auricht & Watkins 2008), acknowledges that despite the considerable investment and mapping work undertaken previously, there are significant gaps in the baseline data on the extent and distribution of Australia's wetlands. The review highlights that only 17 per cent of Australia has comprehensive coverage of extent and distribution mapping, and the quality of other available wetland datasets is inconsistent and has limited application beyond the regional or site scale. More recent mapping work conducted under the Queensland Wetland Program, as outlined in case study 3.1, has increased this figure.

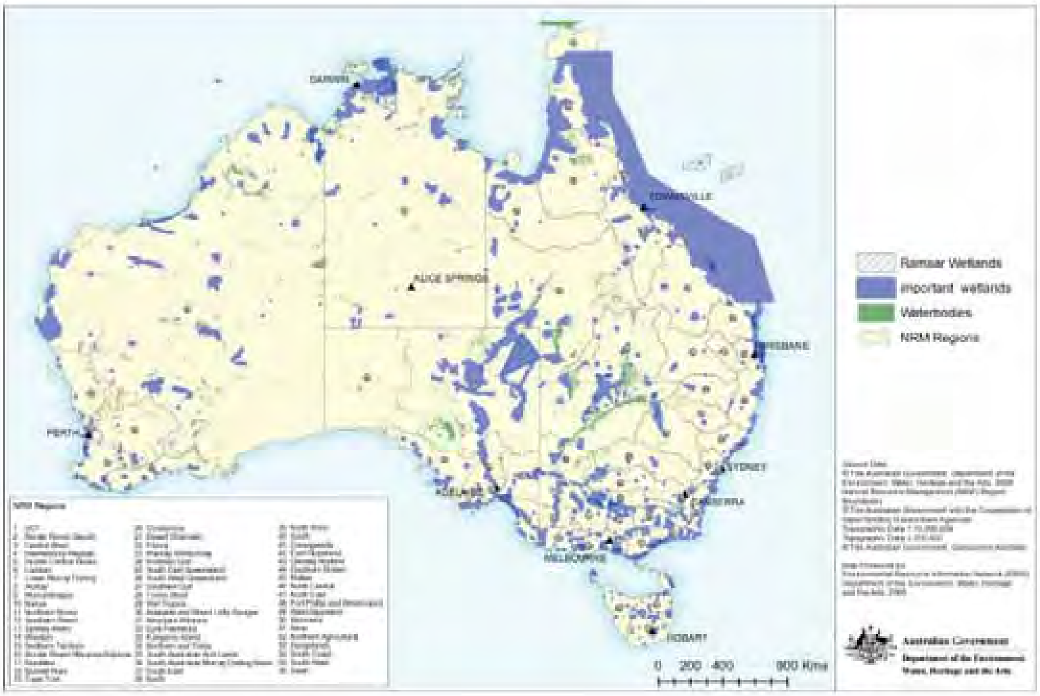
Wetland mapping undertaken in south-east South Australia, as outlined in case study 3.2, indicates that less than 6 per cent of pre-European wetland extent remains in the upper south-east (with less than 10 per cent of this estimated to be intact), and 18.3 per cent remains in the lower south-east of South Australia.

Altered flow regimes have resulted in the loss of 90 per cent of floodplain wetlands in the Murray-Darling Basin (Beeton *et al* 2006). The case studies in this report identify that wetlands in Australia are among the most degraded of all ecological systems. The Macquarie Marshes, part of which is designated under the Ramsar Convention, are one of the largest semi-arid floodplain wetlands in south-eastern Australia (case study 3.3 refers). They provide the largest nesting site in Australia for colonial nesting waterbirds. Thirty-four species listed in the New South Wales *Threatened Species and Conservation Act 1995,* are known to occur in the marshes, and this includes the brolga, Australasian bittern, blue-billed duck, magpie goose, freckled duck and painted snipe. More than 50 per cent of the southern marshes area and 40-50 per cent of the northern marshes area has been lost since the 1960s. This has resulted in a well-documented decline in the waterbird population (Kingsford 2000).

The Directory of Important Wetlands (DIWA) (Environment Australia 2001) provides some information on 851 wetlands of national significance, including 56 Ramsar designated wetlands, as identified in Figure 3.1. Australia has added a further nine sites to the Ramsar estate since the last edition of the DIWA. There has been progress in obtaining information on Australia’s Ramsar wetlands since 2002. Ecological Character Descriptions are being written for all 65 Ramsar sites and as part of this exercise, the Ramsar Information Sheets are being updated. A Ramsar “Rolling Review” of sites is proposed to collect baseline data and identify data gaps.

The Ramsar Convention provides a framework for national and international action for the conservation and wise use of wetlands and their resources. All Parties to the Ramsar Convention are urged to give their highest priority to the compilation of a comprehensive national inventory of wetlands (Ramsar Convention Secretariat 2007). The development of a web-based National Wetlands Inventory would provide a national information infrastructure for wetlands. It could be the principal source of nationally collated data and information, and link to state systems. It could contain, for example, the ecological character description including environmental/biodiversity values, location, extent, distribution, condition, water needs and the threats and pressures to particular wetlands.

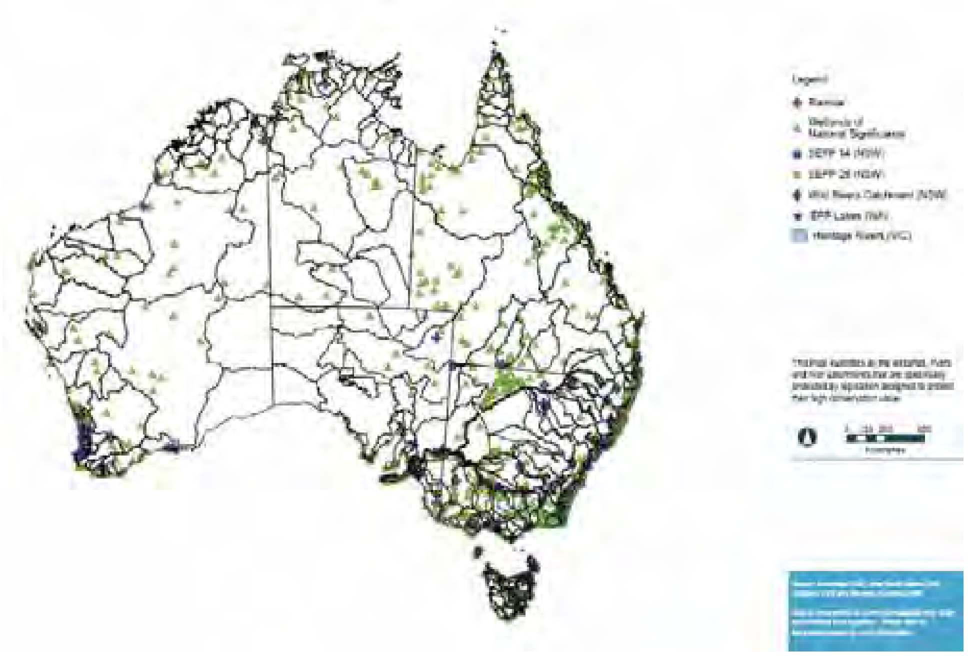
Figure 3.1 Nationally important wetlands



3.3.2 Protected wetlands, rivers and catchments

Legislative protection is provided for wetlands, rivers and river catchments identified in Figure 3.2. These areas include international, national and state listed wetlands, rivers and catchments. The identified sites do not give an indication of river or wetland health, or spatial extent. It is not known whether the protection afforded these sites has had any demonstrable effect on their condition.

Figure 3.2 Location of protected wetlands, rivers and river catchments



EPP = Environmental Protection Policies (WA) ; SEPP = State Environmental Planning Policies (NSW) Source: National Water Commission 2005

Table 3.2 Case studies of wetland mapping and distribution

Case study	Jurisdiction
3.1 Wetland mapping in Queensland	Queensland
3.2 Wetland ecosystem extent and condition in the south-east region of South Australia	South Australia
3.3 Monitoring of wetland extent and condition over time—Macquarie Marshes and coastal wetlands in NSW	New South Wales

Case study 3.1 Wetland mapping in Queensland (Butler 2008)

Queensland has a comparatively advanced system for mapping wetlands that integrates data from a number of sources and provides information on the extent and distribution of different types of wetlands. The Queensland mapping protocol has been recommended as a basis for developing a national mapping protocol.

Wetlands in Queensland

Wetlands can be transitional environments. They can be boundaries between land and water, and can occur in marine and estuarine environments, as well as inland. Wetlands can be geographically diverse and can be highly dynamic, which can make them challenging for classification and mapping. Classification and mapping is therefore a key component of the Queensland Wetlands Program (QWP). Wetlands include rivers, creeks, estuaries, dams, springs, lakes, lagoons, billabongs and swamps, as well as coastal bays and marine areas (to 6 m depth). Inundation by water is essential, but it need not be permanent. The QWP definition uses species reliant on wet conditions and characteristics of wetland substrates as indicators, to help people decide whether an area is a wetland or not. Floodplains are perhaps the most contentious natural landforms for wetland mapping and classification. Under the Queensland definition some parts of floodplains (for example, floodplain depressions), that support plants or animals dependent on wet conditions or have wetland soil characteristics, are wetlands, while others are not.

The QWP makes the completed mapping and a wide range of other wetland-related information available through the Queensland 'Wetland*Info*' website (http://www.epa.qld.gov.au/wetlandinfo/site/index.html). Figure 3.3 provides a status map of Queensland wetland mapping and classification, and an example of a map.

Methodology

Mapping involves sophisticated digital interpretation of satellite image sequences. It also draws on numerous other data sources, including other wetland mapping, topographic mapping, regional ecosystem mapping and spring surveys. Wetlands are classified primarily into the following major ecological systems: marine, estuarine, riverine, palustrine (swamps, bogs and fens), lacustrine (lakes, including dams) and underground/karst. Each wetland is also assigned 'modifiers' that relate to water regime (frequency of inundation), salinity, and local hydrology and its disturbance. The modifiers are useful as descriptors of wetland habitats and values. Further methodologies for inventory, conceptual models and subsequent condition assessment are being developed (http://www.epa.qld.gov.au/wetlandinfo/site/SupportTools.html).

The classification and modifiers applied in Queensland's wetland mapping focus on key features that can contribute regional-scale information on many wetland values. Such assessments can be further extended by intersecting wetland mapping with other information sources, such as regional ecosystem mapping of remnant wetlands. This provides ecological context for the wetland map data on wetland classes and local hydrology/disturbance and results in a detailed regional summary of wetland types, extent and broad ecological condition and trends.

For example, in the Queensland section of the Murray-Darling Basin (QMDB), wetland mapping (version 1.2) identifies 10 982 wetlands, covering a total area of 380 846 hectares, about 2 per cent of the total catchment area. A breakdown of wetlands area into ecological systems shows that dams contribute about 16 per cent of wetland area in the QMDB (Table 3.3), but natural lakes cover a greater area than dams. About 18 per cent of wetlands in the QMDB in 2001 had substantial local hydrological modification, including geomorphological changes, built structures and urban development (building over wetlands, crops etc). The figures for individual catchments range from less than 1 per cent in the Paroo and Warrego catchments in the west to more than 30 per cent for the Severn and Condamine catchments in the east (EPA 2008). About 5 per cent of palustrine wetlands in the QMDB in 2001 had substantial local hydrological modification, but more than 20 per cent of these wetlands occurred on cleared land, suggesting that ecological disruption is much more prevalent than hydrological modification. Using regional ecosystem mapping to assess the extent of wetland clearing in the QMDB suggests that, by 2003, about 27 per cent of the natural wetland area in the QMDB had been cleared of vegetation (Table 3.3). Clearing varies greatly between catchments within the QMDB (EPA 2008).

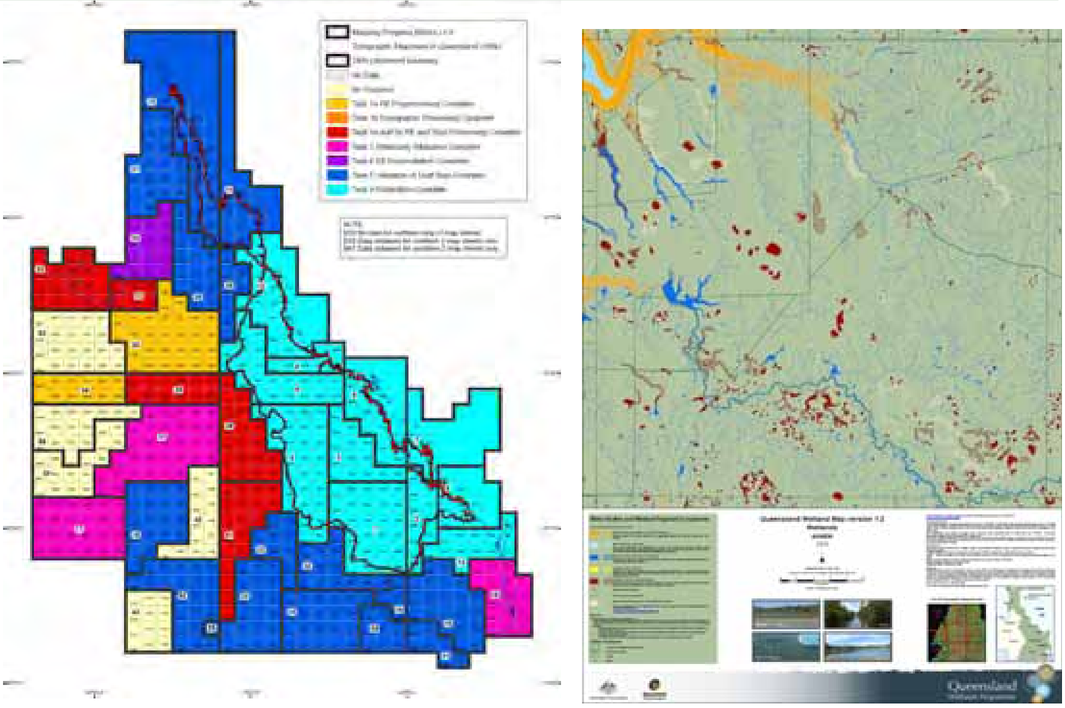
Table 3.3 Wetland statistics for the Queensland portion of the Murray-Darling Basin

Ecological class	Total area[a] (ha)	% modified local hydrology[a]	% in remnant vegetation[ab]	RE % pre-clearing extent[b]	RE clearing rate 1997–2003 (% of 1997 extent)[b]
Lacustrine (dams)	59 677	100	6	-	
Lacustrine (others)	74 085	2.8	74	99.8	0
Palustrine	116 888	4.7	79	87.6	2.3
Riverine	130 196	<1	83	65.3	4.5
Total	380 846	17.7	67.9	72.6	3.6

RE = regional ecosystem

Source: Based on (a) Murray-Darling Basin (QMDB) wetland mapping, version 1.2 and (b) version 5.0 remnant regional ecosystem mapping.

Figure 3.3 Queensland wetland mapping and classification



Case study 3.2 Wetland ecosystem extent and condition in the south-east region of South Australia (Johnson 2008)

Description and significance

The south-east region of South Australia is characterised by relatively high annual average rainfall, ranging from more than 850 mm at Glencoe Station in the south to less than 500 mm at Keith and Bordertown in the north (Penney 1983). This comparatively high and reliable annual rainfall combines with the unique geology and geomorphology—essentially limestone overlain by parallel quaternary sand dunes—of the region to produce one of the most important areas in the state for wetland conservation.

Certain wetland types associated with this landscape are recognised for their particular significance, notably the so-called ‘rising spring’ wetlands of near-coastal areas between Carpenters Rocks and the Victorian border. The Piccaninnie Ponds/Pick Swamp complex, 30 km south of Mt Gambier, is the best example of this formerly extensive and unique wetland habitat type. Piccaninnie Ponds is one of South Australia’s premier permanent freshwater reserves and is part of a larger wetland system that covers up to 1100 hectares of spring-fed and associated wetlands. The area is listed on the Register of the National Estate as a wetland of national importance and is currently being nominated for Ramsar listing. Another significant wetland area is the Bool and Hacks Lagoons. These lagoons are considered of international importance and have been listed under the Ramsar Convention since 1985. Both sites provide essential habitats for a huge range of regionally, nationally and internationally significant threatened species.

Trends in extent

Before European colonisation, intermittent, seasonal and permanent wetlands covered approximately 50 per cent of the south-east of South Australia (Foulkes and Heard 2003, Harding 2007). Updated wetland mapping indicates that 18.3 per cent of the pre-European wetland area of the lower south-east can still be described as wetland (Taylor 2006). In the upper south-east, less than 6 per cent of the pre-European wetland extent remains (Harding 2007). Most of the extant wetland areas are degraded. For example, Harding (2007) estimated that less than 10 per cent of the remaining wetland area in the upper south-east is intact. Land clearance and drainage for agriculture have been the primary causes of wetland loss.

Threats

Drainage works began in 1863 (Jolly *et al* 1985) and continue today. Major government-sponsored drainage works in the south-east have had a profound impact on wetlands, intercepting flows from the south and altering the regional flow paths. A network of smaller private drains channelling seasonal surface waters into the wider drainage system has resulted in a landscape where few wetlands are unaffected by drainage. More recently, the upper south-east Dryland Salinity and Flood Mitigation Program has resulted in a network of (predominantly) groundwater drainage in the upper south-east. These drains have further intercepted local catchment flows and modified hydrological regimes for wetlands already cut off from southerly flows. There has been recent work to improve drain design; however, the nature of the impacts of the program on the wetland values of the upper south-east may never be fully understood.

The combined effects of drainage and plantation forestry are likely to have considerably reduced groundwater recharge (Allison and Harvey 1983, Taylor 2006). In the south-east, the total area planted to pines (*Pinus radiata*) and blue gums (*Eucalyptus globulus*) is approximately 104 000 hectares and 33 000 hectares, respectively. The pine plantation industry has steadily expanded since the early 1900s and, at present, more than 50 per cent of the existing pine estate is more than 20 years old. This is in strong contrast to the expansion rate for the blue gum plantation industry, where almost 90 per cent of the existing estate was planted between 1998 and 2003 (Harrington 2007). Expansion of the blue gum industry in adjacent areas of Victoria, where much surface and groundwater for the region is generated, has been equally rapid (Sheldon 2007).

Impacts of plantation forestry on groundwater resources are either recharge interception or direct extraction. A significant proportion (77–83 per cent) of mean annual recharge is intercepted over the growth cycle of the forests (Harrington 2007). Where tree roots can directly access the watertable, they may extract groundwater during times when shallower water sources become unavailable. Rates of groundwater extraction by forests in areas overlying shallow watertables can exceed 4.35 ML/ha/year (Benyon and Doody 2004). Groundwater extraction in excess of sustainable limits is of particular significance in areas of the south-east. The combined effects of climate, reduced recharge through drainage and forestry, and direct extraction from forestry and pumping are manifested in watertable decline throughout much of the region. Depth to the unconfined aquifer is increasing by an average of approximately 0.1 m per year throughout much of the lower south-east, and as rapidly as 0.3 m per year in some areas (Harrington 2007). Many wetlands of the south-east are likely to intersect the water table intermittently, seasonally or permanently (Taylor 2006). The alarming decline in depth to groundwater is therefore a key threat to wetland values.

The direct and indirect impacts of plantation forestry may result in a reduction in the frequency and magnitude of stream flows (Harrington 2007), which in turn will impact on systems reliant on stream/watercourse inputs such as Bool Lagoon. Water level declines could also reduce, and potentially reverse, groundwater throughflow to discharge areas (e.g. the coast), which would ultimately cause long-term decline in water quality (Harrington 2007).

Future scenario

Although the implications of climate change for the wetland values of the south-east are not clearly understood, a system of adaptive management—where water allocation is dependent on annual recharge and groundwater trends—will be necessary. Further data will be needed to implement such a system and to underpin water policy on, for example, the proposed environmental protection zones. Further wetland inventory work will assist in identifying wetland values worthy of protection and further wetland restoration opportunities. Better partnerships and integration between water management organisations in the south-east of South Australia and adjacent areas of western Victoria must be developed if shared water resources are to be managed sustainably.

Case study 3.3 Monitoring of wetland extent and condition over time—Macquarie Marshes and coastal wetlands in NSW (DECCW 2008)

Description

Wetlands in Australia are among the most degraded of all ecological systems and are significantly affected by physical loss, salinisation, changed water regimes and changed water quality. Wetlands are under-represented in the New South Wales reserve system, with most of the state’s wetlands located on private and leasehold land (Kingsford and Nevill 2005).

Wetland monitoring provides land managers with information on the effects of threats to wetlands, and guides wetland management and prioritisation of funding. Long-term wetland monitoring will indicate changes in wetland extent, wetland condition, threatening processes and management activities, and will help in understanding the effects of climate change.

Methodology

The New South Wales Monitoring, Evaluation and Reporting Strategy aims to refocus the resources of New South Wales natural resource and environment agencies and coordinate their efforts with catchment management authorities (CMAs), local governments, landholders and other natural resource managers to establish a system of monitoring, evaluation and reporting on natural resource condition.

In 2003, the New South Wales Government established 13 community-driven CMAs to deliver natural resource programs at a regional level. An independent Natural Resources Commission was charged with recommending statewide standards and targets to guide the work of the CMAs. These have now been adopted by the government. The CMAs have developed their own catchment targets to promote the statewide targets.

The state-wide targets for wetlands by 2015 include improvements in:

- the condition and extent of important wetlands, and
- the condition of estuaries and coastal lake systems.

Many actions and programs have been implemented to achieve these targets, with particular emphasis on the New South Wales coastal lakes and Macquarie Marshes (see below). These include:

- The NSW Wetland Recovery Plan, which incorporates a suite of projects involved in water efficiency, water buy-back and improved wetland management.
- The NSW Rivers Environmental Restoration Project, which uses market-based water recovery, focusing on the voluntary acquisition and effective, active management of environmental water.
- The NSW RiverBank, which has been allocated $105 million to buy water entitlements for the environment from willing sellers.

Macquarie Marshes

The Macquarie Marshes, located on the lower Macquarie River in north-west New South Wales, are one of the largest semiarid floodplain wetland complexes in south-eastern Australia. They provide the largest nesting site in Australia for colonial nesting waterbirds and support a number of threatened species, including brolga, Australasian bittern, blue-billed duck, magpie goose, freckled duck and painted snipe.

Part of the Macquarie Marshes, 18 000 hectares, is a nature reserve and an internationally recognised wetland, listed under the Ramsar Convention (Kingsford 2000). The marshes are also listed in the Australian Directory of Important Wetlands, on the National Heritage Register, and on the National Trust Register as a Landscape Conservation Area. Thirty-four species listed in the New South Wales *Threatened Species and Conservation Act 1995* are known to occur (or have occurred) in the marshes; this includes five species listed as endangered. Five of these species are believed to be extinct within the marshes (Shelley 2004).

Since the 1960s, more than 50 per cent of the southern marshes area has been lost (Brereton 1994, Wolfgang 1998). Losses in the northern marshes correspond with a decrease over the same period of 40–50 per cent in the area inundated by large floods and have resulted in a well-documented decline in the waterbird population (Kingsford 2000).

The primary cause of wetland loss in the marshes is a 30 per cent reduction in annual river flows since the construction of the Burrendong Dam in the late 1960s (Kingsford 2000). Prolonged inundation and alienation of floodplain areas from the river by levees, and erosion of river channels, have also had significant impacts. Some of the marshes have been reclaimed for farming, with grazing and irrigated agriculture common activities in the wetland catchment.

The reduction in wetland area in the marshes has had additional downstream impacts, including increasing salinity and erosion (Brereton 1994, Kingsford 2000).

Future scenario

In order to meet state targets for improvement in condition of wetlands by 2015, the monitoring regimes and projects highlighted in this case study will require ongoing commitment and support for at least the next seven years.

Monitoring during a period of changing climate regimes presents particular challenges in terms of uncertainty and risk assessment. Long-term monitoring of a broad range of wetland indicators will be critical for measuring and assessing changes.

Wetland health is heavily dependent on the adequacy and surety of water flows and catchment condition, and these should be critical determinants in selecting wetlands for protection. An important priority should be to protect unregulated major rivers and substantially intact wetlands.

Wetlands are not adequately represented in the terrestrial reserve system, and under-represented wetland types need protection. Greater consideration needs to be given to the adequate assessment of current assets, as well as the further protection of wetlands, in the planning processes for the terrestrial reserve system. Improved coordination and integration of management of the coastal reserve system and marine protected areas are also desirable to optimise outcomes across all marine and coastal ecosystems.

3.4 River and wetland condition

The following findings are drawn from information provided in this section and from selected case studies:

- River health assessment techniques have evolved considerably since 2002, from using a single indicator to a suite of indicators resulting in more comprehensive and holistic river condition monitoring programs being undertaken. Techniques are evolving with development of new approaches.
- Most states have developed their own methodologies for data collection and analysis of different indicators, with the exception of the standardised collection and processing methods of AUSRIVAS for macroinvertebrates.
- Threats and pressures are generally not routinely identified and reported by existing river health monitoring programs. However, pressure/stressor/response models are being developed for state-wide implementation, to inform management actions to improve river health.
- There is collaboration between jurisdictions in aligning their classification of wetland types; and in the development of pressure/stressor/response models for different wetland types, as management tools.
- Wetland health assessment methodologies are being developed, as is a wetland health assessment program for state-wide application in one state. Other states are developing wetland condition assessment techniques for potential use.

- Jurisdictions have collaborated in developing and implementing river health assessments in the Murray-Darling Basin (MDB) and the Lake Eyre Basin (LEB). Case studies of these two assessment identified :
  - The Sustainable Rivers Audit (MDBC 2008) of the Murray-Darling Basin found 13 river valleys to be in ‘very poor’ health, seven in ‘poor’ health, two in ‘moderate’ health and one in ‘good’ health. Native fish species were found in only 43 per cent of river zones where they were predicted to occur under reference condition, indicating a decline of native fish in the Basin.
  - The Lake Eyre Basin (LEB) Rivers Assessment (LEB Scientific Advisory Panel 2008) found the rivers and catchments of the LEB to be in generally good condition. In particular, the low level of hydrological modification means critical aquatic ecosystem processes remain intact. Intact aquatic ecosystems make the LEB rivers unique compared with other arid river systems in Australia and around the world. The LEB may therefore provide critical aquatic habitat, especially for migratory waterbirds, given the greater impacts seen in other river systems.
- The Australian Government has been working with the states and territories to develop national indicators and protocols, and to trial a possible national river and wetland assessment technique, to improve national reporting capabilities.
- Case studies using indicators of biodiversity to reflect condition are listed at Table 3.4, and case studies of river health assessments are listed at Table 3.5.

3.4.1 The health of rivers and wetlands as a measure of biodiversity

A river ecosystem is deemed ‘healthy’ when its essential character (its native flora and fauna, for example) is maintained over time, notwithstanding disturbance due to human activities or the vagaries of climate. In these circumstances, the ecosystem is resilient enough to withstand disturbances and to continue to support processes and supply resources. Its resilience depends on the degree and nature of exploitation or change, as well as inherent properties like biological diversity and patterns of water and sediment transport, at a range of scales (MDBC 2008). The same principles apply to wetland health.

Methods to determine river health have evolved considerably since 2002. It is widely recognised that information about the condition of one indicator alone, such as macroinvertebrates (e.g. AUSRIVAS), is not sufficient, and a more comprehensive and holistic indication of river health is required. Data are now gathered on several ecosystem components represented by individual ‘indicators’ (e.g. hydrology, riverine/riparian vegetation, fish, birds, macroinvertebrates), that are linked to ecosystem processes (e.g. carbon exchange, energy transfer, nutrient cycling). The capacity of an ecosystem component to support these key processes is referred to as its ‘condition’, and data from a number of components is integrated to determine river health. This methodology provides the basis of the recent SRA of the Murray-Darling Basin, the Lake Eyre Basin Rivers Assessment, as well as most state-based river health assessment programs. Case study 3.4 indicates Tasmania's initial implementation of AUSRIVAS and its move to a comprehensive river health assessment system.

There is potential for river health assessment to be further strengthened by including floodplain wetlands and woodlands, measures of processes like recruitment (the accrual of reproductive individuals to populations) and the system's capacity to recover from disturbance (resilience). Methodologies to include these additional aspects are either evolving or need to be developed.

Most states have developed their own methodologies for data collection and analysis of different indicators, with the exception of the standardised collection and processing methods of AUSRIVAS for macroinvertebrates. AUSRIVAS was developed and adopted nationally under the National River Health Program[1].

Individual aquatic biodiversity indicators can provide different levels of information, depending on sampling techniques used. The health of native fish, for example, is generally based on an assessment of data on identity, origin and condition of individuals, their abundance and the species composition of communities.

The biodiversity component that indicates symptoms of a healthy river or wetland ecosystem may be, for example, whether native species of flora or fauna persist, and alien species are scarce or absent. Symptoms of an unhealthy ecosystem may be where alien species of flora and fauna are dominant, and native species reduced or absent. In more extreme cases, total species and community diversity declines.

However, it is important to note that there are a range of different river types that respond to disturbance and intervention in different ways. Some river types are robust and others are not. In some areas, there is insufficient information on the different river types that exist, their condition and how different river types respond to particular impacts.

3.4.2 Why are particular aquatic biodiversity indicators chosen?

Information might be obtained about algae, fish, invertebrates, aquatic and floodplain vegetation, amphibians, birds, mammals, reptiles and microbial communities. Biological components are chosen that are easily measured, that represent ecological roles, patterns and processes over a range of spatial and temporal scales, and are responsive to river-ecosystem drivers. The main aquatic ecosystem driver and biodiversity indicators, that have been incorporated to deliver more comprehensive and holistic river health assessments in Australia, are described below.

Hydrology

While not an individual indicator of biodiversity, hydrology is important in any assessment of river and wetlands ecosystem health. It defines the quantity, spatial

---

[1] A national river health monitoring program was partially developed under the National River Health Program (NRHP), in Phase One of the Natural Heritage Trust (1996-2002). However, the NRHP did not continue beyond 2002.

and temporal distribution of water in the system. The flow regime transports materials in suspension and solution and sustains aquatic and terrestrial organisms in channel and floodplain environments. It governs the quality and extent of habitat and provides cues for biological responses (e.g. reproduction and migration), is sensitive to short- and long-term human interventions, and links the ecosystem to the regional landscape.

Macroinvertebrates

Benthic macroinvertebrates (bottom-dwelling invertebrates visible to the naked eye) are abundant, locally diverse, easily sampled and identified, and sensitive to natural and human disturbance over the short- to medium-term. Taxonomic families include a diverse range of aquatic insects, crustaceans, molluscs, worms and other forms, in variable numbers. They are a large part of aquatic biodiversity, a food resource for fish and other fauna, and they contribute to carbon and nutrient processing. The composition of macroinvertebrate communities is strongly influenced by variations in flow regime, water quality and other conditions within and between sampling sites, and there are regional variations.

Fish

Fish are near the top of the aquatic food chain, are a food source for birds and sensitive to environmental changes in the short- to long-term.

Vegetation

Vegetation is a part of aquatic and floodplain biodiversity, a habitat and food resource for flora and fauna, and a source sink for carbon and other nutrients. Vegetation in channel and floodplain habitats is sensitive to natural changes and to human disturbances in the short- to long-term.

The states have developed a number of different approaches to assessing riparian vegetation. For example, Victoria is assessing the suitability of using remote sensing imagery to replace the current site- and field-based method for collecting riparian vegetation data (case study 3.5 refers). One recently developed assessment approach tailored for tropical savannas, is the Tropical Rapid Assessment Appraisal of Riparian Condition (case study 3.6. refers).

Birds

Waterbirds are considered those birds that are highly dependent on water to complete their life cycle (Kingsford & Norman 2002). There is good evidence that waterbird communities are responsive to changing flooding regimes. Waterbirds have not as yet been widely used as indicators of river health, but were a component in the Lake Eyre Basin Assessment.

As well as being an individual indicator of aquatic biodiversity, waterbird communities represent a potentially useful group of organisms for monitoring changes to freshwater ecosystems, given they are obligate aquatic organisms responsive to changes in river and wetland ecosystems. For example, waterbird abundance and the community composition can reflect detrimental changes in ecosystem condition, such as changes in water quality or changes to flow regimes (Kingsford & Thomas 2004).

In addition, they may be ordered into functional groups representing a combination of diet and habitat use that allows assessment of changes to wetland habitats (Kingsford & Porter 1994). For example, the different functional groups may correspond to different food preferences (Barker & Vestjens 1989) and where birds usually forage (Kingsford & Porter 1994). Some waterbirds are exclusively piscivores (e.g. cormorants, Australian pelicans, terns), herbivores (e.g. Black swan, Eurasian coot) or invertebrate feeders (e.g. Red-necked avocet, Pink-eared duck).

Long-term information on waterbird abundance and composition on specific wetlands, through aerial surveys and on-ground monitoring, has allowed clear demonstration of the effects of landscape change. In particular, when combined with analysis of satellite imagery and changes to hydrology, the likely causes of major declines in waterbird numbers can be identified (Kingsford *et al* 2008).

Waterbirds may also provide indirect measures of changes in other indicators. For example: colonial waterbirds (e.g. ibis, egrets, spoonbills, cormorants, herons), can be used as an indicator for hydrology, as breeding events are highly responsive to flooding regimes, usually requiring a threshold flood event before they respond. Large flood events are required to provide sufficient food resources for adults to raise their young. In addition, different species require different types of nesting habitat. For example, ibis generally nest in lignum and reed swamps while herons and egrets nest in inundated river red gum and river cooba (Kingsford *et al* 2008).

Case study 3.7 uses existing data to explore the use of waterbirds as an indicator of wetland condition in Tasmania.

Table 3.4 Case studies using indicators of biodiversity to reflect condition

Case study	Jurisdiction
3.4 Assessing river condition in Tasmania	Tasmania
3.5 Riparian vegetation condition assessment in Victoria	Victoria
3.6 Monitoring the condition of riparian zones in Australian tropical savannas	Northern Territory
3.7 Wetland ecosystem condition in Tasmania	Tasmania

Case study 3.4 Assessing river condition in Tasmania (Jansen 2008)

River condition

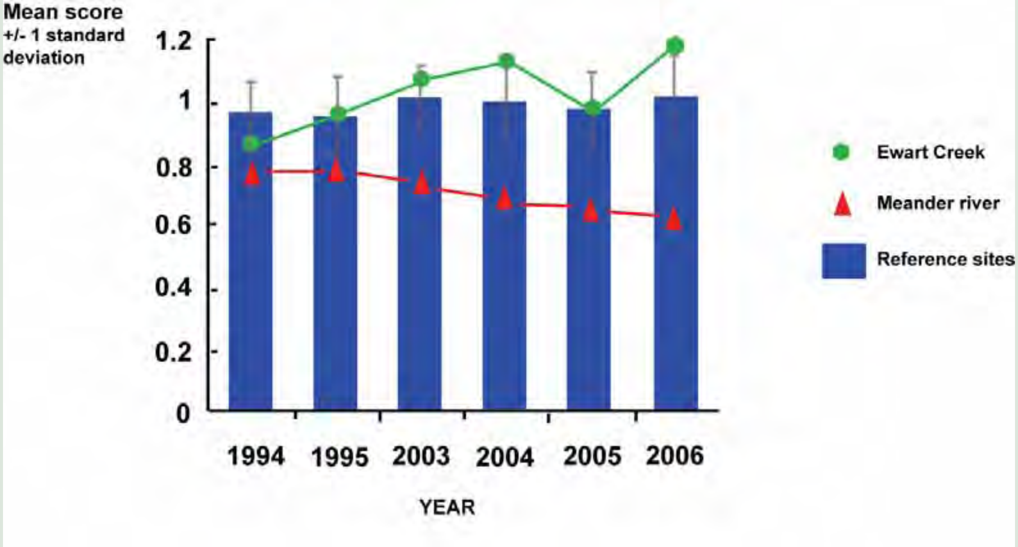
Tasmania has a high proportion of rivers within its formal reserve system and these rivers remain in a largely intact state (DPIWE 2005). However, others have been heavily impacted by habitat alteration as a result of clearing, grazing and channelisation, altered flow regimes resulting from damming for water extraction and hydroelectricity schemes, and pollution.

There are limited data on the condition of rivers in Tasmania. It may be possible to use data collected using the Australian River Assessment System (AUSRIVAS), for a state-wide trend assessment of benthic macroinvertebrates as indicators of river condition (Norris and Thoms 1999). As a ‘snapshot’ of current condition, the Conservation of Freshwater Ecosystem Values (CFEV) project provides modelled data on biological condition and naturalness of rivers across the state, along with spatial reservation information. Some of the data that have been used to generate measures of naturalness or condition, such as the vegetation and physical components, are based on limited ground-truthed data and provide only a superficial indication of the resource at any given site. The condition measures are useful, however, in guiding initial management decisions but do not provide a “real” picture of condition.

AUSRIVAS models are developed using data collected at ‘reference’ sites (sites that are in relatively intact condition and not subject to any environmental stresses such as pollution, habitat degradation or flow regulation) for different river types, seasons, and different habitats (e.g. riffle, edge). Comparisons are then made between the numbers and types of macroinvertebrates found at test sites and those found at the reference sites of similar rivers and habitat.

Macroinvertebrate data has been collected at more than 900 sites in Tasmania. Combined season samples were assessed against a set of reference sites. The macroinvertebrate data suggests that there has been no overall decline in the condition of rivers in Tasmania within the past 13 years, however, given the low numbers of impacted rivers sampled, this is not surprising**.** Some sites showed improvement, such as Ewart Creek (Figure 3.4), which is in a protected area with little disturbance. The Meander River, a site surrounded by agricultural land with sparse and weedy riparian vegetation, showed a declining trend.

Figure 3.4 AusRivAS scores for reference sites and two test sites (Meander River and Ewart Creek)



Monitoring river condition is a critical component of managing rivers, since it provides information on baseline conditions as well as information on the effects of management actions and the effects of climate change.

Approximately 40 per cent of Tasmania's river length is well protected within formal reserves (DPIWE 2005), although these rivers can be subject to upstream influences such as acid mine drainage and flow regulation.

Future scenario

The AUSRIVAS sites have been established as long-term monitoring sites as part of the Tasmania Together initiative. Although AUSRIVAS provides one measure of river condition and is an indication of stream macroinvertebrate biodiversity, other aspects of river condition such as in-stream habitat, riparian vegetation, geomorphology and water quality are not well reflected in AUSRIVAS score. An additional, more comprehensive, holistic river condition monitoring program is being developed. This program, the Tasmanian River Condition Index (TRCI), which was completed in March 2009, uses a new method to incorporate measures of aquatic life, hydrology, geomorphology and riparian vegetation, and aims to obtain a statewide overview of river condition on a five-yearly cycle. The TRCI has been applied to several catchments across the state. It uses a referential approach based on benchmarks to monitor change in condition over time for several indicators – macroinvertebrates, fish, stream-side (riparian) vegetation, physical form and hydrology.

Case study 3.5 Riparian vegetation condition assessment in Victoria (DSE 2008)

Description

The Victorian Department of Sustainability and Environment (DSE) is undertaking a project to assess the suitability of using remote sensing imagery to replace the detailed on-ground measurements of riparian vegetation and geomorphology that are used with the Index of Stream Condition assessments of river condition. This work is being trialled in the Werribee basin (to the west of Melbourne).

Methodology

Index of Stream Condition (ISC) is the standard method used in Victoria to assess river condition (DSE 2005). The ISC comprises five subindices: hydrology, water quality, aquatic life, streamside vegetation and physical form. The streamside vegetation subindex is based on the Habitat Hectares approach (the standard method for assessing vegetation condition in Victoria), but has been modified to take account of narrow linear corridors.

DSE has commenced a pilot project to compare and contrast two forms of imagery (SPOT-5 and QuickBird) to assess their viability in assessing riparian/streamside vegetation at the reach scale (ie section of river or creek). The aim of this work is to take the ISC streamside zone assessments from a detailed site-based assessment to a true reach-based assessment approach, providing a level of information not previously available.

The trial aimed to determine whether the riparian zone (plants dependent on the stream for their survival) can be distinguished from the wider streamside zone (vegetation adjacent to the stream).

As expected, the QuickBird images provided more detailed information than the SPOT5 images on riparian zone land-cover classes and on indicators of riparian zone condition, such as percentage canopy cover, longitudinal canopy continuity, and bank stability. However, the successful use of the two image datasets relates to the spatial extent of the riparian zones, with SPOT5 image data more useful for wider vegetation corridors (due to its larger pixel size).

Future scenario

In the next stage of this investigation, the imagery and fieldwork will be undertaken in the same month before the end of summer. The current analysis will then be repeated to determine if all the major issues identified can be resolved. One area requiring further work is the identification of willows. If these issues can be resolved, the use of remote sensing imagery has the potential to largely replace the current site- and field-based method for collecting vegetation data.

Case study 3.6 Monitoring the condition of riparian zones in Australian tropical savannas (Fisher 2008)

Description

Rivers, streams and creeks are important and valued elements of most landscapes. One key element of these watercourses is the riparian zone—the riverbank and the land immediately alongside it, where the vegetation is influenced by elevated watertable or flooding. Riparian zones have many important functions and values, including slowing water flow and stabilising banks; filtering sediments, nutrients and pollutants before they enter streams; and providing food and habitat for terrestrial and aquatic plants and animals (Naiman and Decamps 1997). The values of riparian zones are increasingly recognised, and maintaining or improving the condition of riparian zones is often identified as a priority for management.

In the tropical savannas of northern Australia, riparian zones are generally very distinctive, linear elements in a vast expanse of eucalypt woodland. Although limited in total extent, they make a disproportionately large contribution to the biodiversity, economic and cultural values of northern Australia (Woinarski *et al* 2007).

Methodology

Reliable methods for assessing the condition of riparian zones are important, both for prioritising management investment and for monitoring the effectiveness of management. One recently developed approach, tailored for the tropical savannas, is the Tropical Rapid Appraisal of Riparian Condition (TRARC) (Dixon *et al* 2006).

The TRARC is designed for on-ground, site-scale assessments of the current condition of a riparian zone. The assessment uses 24 indicators, grouped under four subindices. The indicators were selected to encapsulate the major ecological functions performed by riparian zones, as well as the common pressures and their likely impacts.

Outcomes

The TRARC was designed to be used by land managers without specialised expertise, other than knowledge of local weeds. The TRARC systems have been trialled in a number of catchments throughout the tropical savannas, covering a range of management regimes, as well as with a diversity of land managers—including Indigenous, conservation, pastoral, government and community groups. This has allowed for an evolution and improvement of the indicators and scoring categories, and modification of the methodology to suit particular catchments and different land managers.

Future directions

One interesting potential development is the extrapolation of ground-based assessment of condition to much longer stretches of the riparian zone using remote imagery. Initial studies in the Daly River catchment in the Northern Territory showed that several indicators used by the TRARC could also be measured on high-resolution ‘QuickBird’ satellite imagery, with a strong correlation between on-ground and image-derived measurements. Using change-detection analysis, image data can also provide detailed information on gradual change over time (Johansen *et al* 2007).

Case study 3.7 Wetland ecosystem condition in Tasmania (d’Arville and Blackhall 2008)

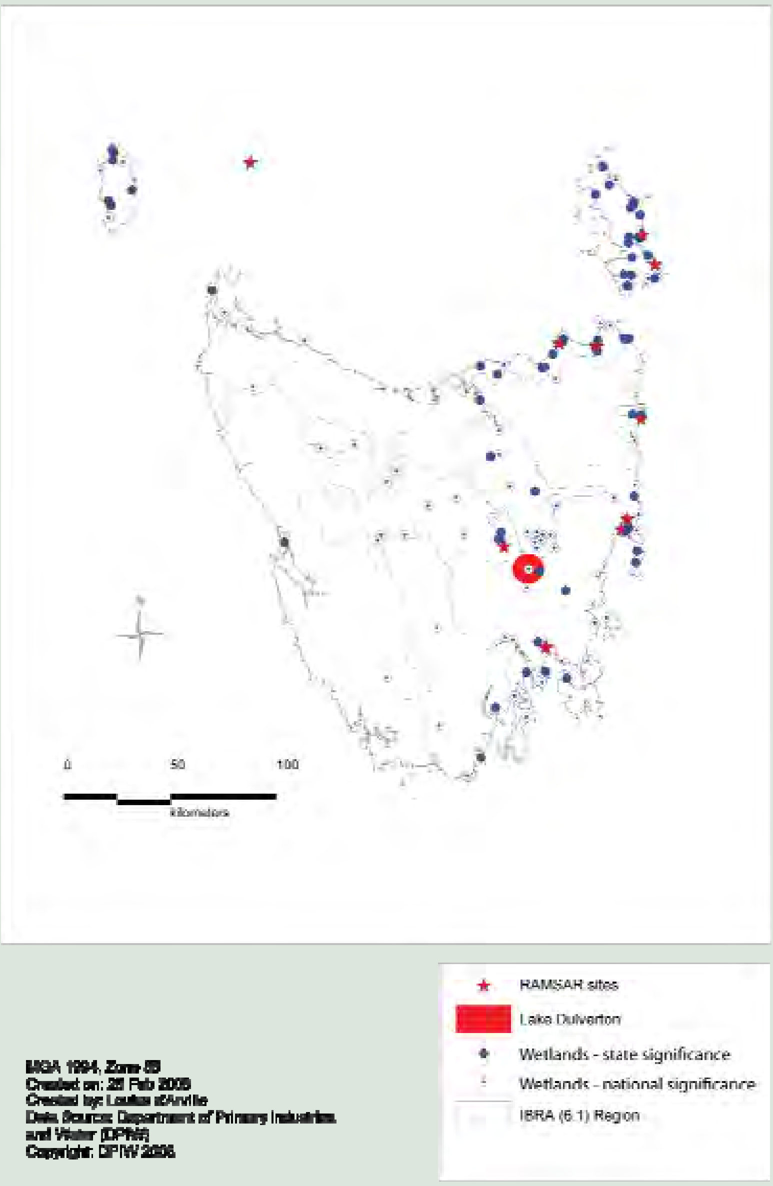
Description and significance

A rich, diverse assemblage of wetland types is present in Tasmania (Dunn 2002). Many are in good condition and are representative of wetland types found in temperate regions of Australia (SoET 2006). Wetlands are biologically diverse habitats and are often a vital component of both terrestrial and aquatic ecosystems (DPIWE 2000). Although Tasmanian wetland systems are likely to support a distinct and endemic array of flora, fauna and microorganisms, they are poorly known biologically (Dunn 2002).

Lake Dulverton is located immediately south-east of Oatlands on the western perimeter of the South East Interim Biogeographic Regionalisation for Australia (IBRA) 6.1 region

(Figure 3.5). The lake is an important wetland that has provided both common bird species (i.e. the Black swan) and rare species (i.e. Great crested grebe) with important nesting habitat and feeding resources. Lake Dulverton no longer holds any permanent water and has been almost completely dry for at least the past decade. Despite inconsistent water availability, at times it supports a diverse population of waterbirds. Eleven of the 19 species of waterfowl in Tasmania have been observed here, and 78 species of birds in total, with 45 being frequent visitors. Perhaps the most intriguing inhabitant of the lake is the great crested grebe, *Podiceps cristatus*. Despite this species being distributed across the east coast of Tasmania, Lake Dulverton is the only location in Tasmania where it has been recorded breeding (ANCA 1996).

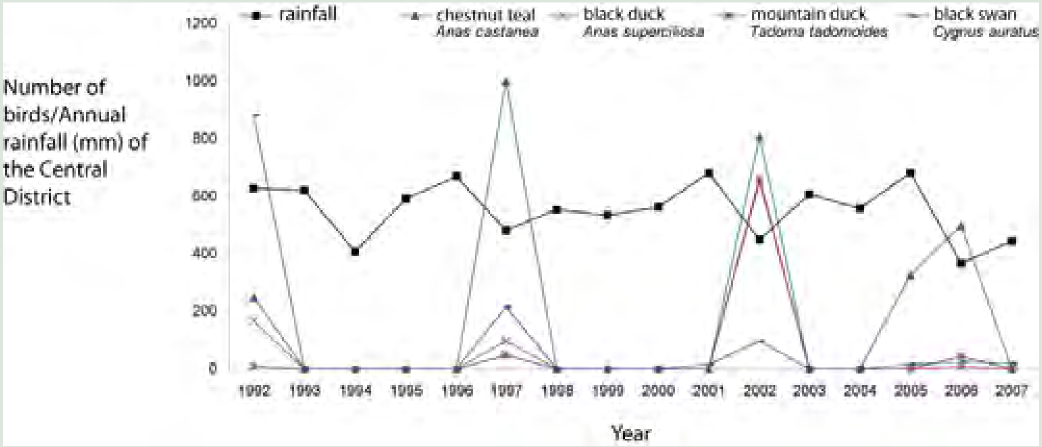
Figure 3.5 Important wetlands in Tasmania



Trends in waterbird populations

It is clear that rainfall is a key factor influencing waterbird populations at Lake Dulverton. Trends in data on bird populations that extends back to 1992 show that mass congregations of a number of bird species are observed in the first year after rainfall has exceeded 660 mm (Figure 3.6). When rainfall declines in subsequent years, bird populations fall to zero. The ability of populations to increase so dramatically in high rainfall years strongly suggests that core populations are being maintained in areas of the state with more resources.

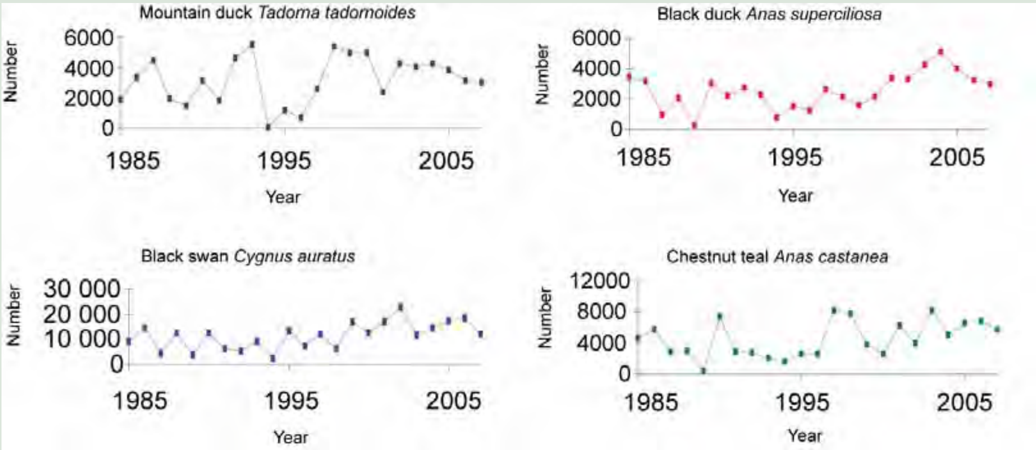
Figure 3.6 Rainfall and bird populations at Lake Dulverton 1992–2007



Source for rainfall data: Bureau of Meteorology 2008

The peak numbers of species observed in boom years declined between 1997 and 2006. Annual surveys across 80 wetlands in Tasmania do not indicate a sustained declining trend in any of the bird species surveyed above (Figure 3.7). This suggests that the decline in bird populations at Lake Dulverton is likely to be due to reduced wetland condition, rather than overall population decline of these species. Low rainfall may be affecting resources such as vegetation for feeding and nesting, resulting in reduced carrying capacity of the lake when it does intermittently contain water. The extensive waterbird data has potentially provided a useful indicator of changing wetland condition.

Figure 3.7 Waterbird populations across Tasmania



Future Scenario

This case study suggests that waterbird populations may be useful indicators of changing wetland condition until more comprehensive information is available. Similar future comparisons are possible, using the extensive information available regarding waterbird populations and wetlands in Tasmania. This information will be invaluable for determining the causes of fluctuating waterbird abundance and changes in wetland condition over time.

3.4.3 Trends in river and wetland health

The national 2006 State of Environment Report stated that "*whether river health is getting better or worse or has been stable at a national scale over the last five years is difficult to assess because of lack of data*" (Beeton *et al* 2006). There are no datasets of nationally consistent information on the health of Australia's rivers, nor on the extent, distribution and health of Australia's wetlands.

The majority of states and territories have developed and implemented systematic river health monitoring programs, although approaches and methodologies differ and geographical coverage may be limited. A triennial Sustainable Rivers Audit (SRA) has been implemented in the Murray-Darling Basin, and a ten-yearly Lake Eyre Basin Rivers Assessment has been implemented in the LEB. As river health assessment methodologies have been evolving since 2002, the capacity to identify many state-based trends is unclear. However, it may be possible to identify trends for macroinvertebrates (AUSRIVAS), the only indicator to have protocols and tools developed and implemented nationally under the former Natural Heritage Trust's National River Health Program.

The SRA has implemented consistent data collection methodologies to facilitate the identification of trends within the Murray-Darling Basin (MDB). The MDB was divided into 23 river valleys, 13 were found to be in 'very poor' health, seven in 'poor' health, two in 'moderate' health and one in 'good' health. Native fish species were found in only 43 per cent of valley zones where they were predicted to occur under reference condition, indicating a decline of native fish in the MDB. More information on the SRA can be found at case study 3.8.

Threats and pressures to aquatic ecosystems are generally not routinely identified and reported by existing river health monitoring programs. In some cases, however, they are identified to inform management actions. For example, the Lake Eyre Basin (LEB) Rivers Assessment notes that the aim of a monitoring program in the LEB must be to directly link ecosystem thresholds with management actions, in order to identify those actions that protect the natural values of the LEB. Threats to the condition of the LEB rivers and catchments include inappropriate water resource development, invasive pests and land use intensification, all of which could severely impact aquatic ecosystem condition. The aquatic ecosystems in the LEB will be monitored for any effects of these threats, to inform management actions. Information on the recent assessment can be found in case study 3.9.

River health assessments in some regions of Queensland clearly identify related threats and pressures that affect the condition of rivers within catchments, as an aid to management. The Stream and Estuarine Assessment Program, a pressure/stressor/response methodology, is being developed for state-wide implementation. Case study 3.10 identifies the threats that will be the focus of management actions to improve river health in south-east Queensland, under the Environmental Health Monitoring Program. The threats include increases in population, point source and diffuse pollution, and stream/gully erosion increasing sediment loads.

Queensland is also developing pressure/stressor/response models for different wetland types, also as a management tool. South Australia, New South Wales and Queensland have been working together to align their wetland types and may develop and share models where relevant. Depletion of groundwater through recharge interception or direct extraction by plantation forestry is identified in case study 3.2, as the major threat to wetlands in the south-east of South Australia.

Victoria is developing the Victorian Index of Wetland Condition for use as a rapid assessment technique, and will be the first state to implement a state-wide wetland health monitoring program. Wetland condition assessment techniques are being developed in other states for potential use. Victoria is also developing a Wetland Catchment Disturbance Index, based on wetland catchment land use data. New South Wales has developed a Monitoring, Evaluation and Reporting Strategy, and state-wide targets for wetlands by 2015 include improvements in the condition and extent of important wetlands, and the condition of estuaries and coastal lake systems. Case study 3.3 refers.

Table 3.5 Case studies of river health assessments

Case study	Jurisdiction
3.8 Sustainable Rivers Audit in the Murray-Darling Basin	Murray-Darling Basin
3.9 Lake Eyre Basin—State of the Basin 2008: Rivers Assessment	Lake Eyre Basin
3.10 Taking the pulse out of south-east Queensland waterways—the Ecosystem Health & Monitoring Program	Queensland

Case study 3.8 Sustainable Rivers Audit in the Murray-Darling Basin (MDBC 2008)

Description

The Sustainable Rivers Audit (SRA) is a comprehensive assessment of the health of river ecosystems in the Murray-Darling Basin. It systematically collects and analyses biophysical data from locations in all 23 designated valleys. Each valley is divided into zones. Environmental indicators, grouped as ‘themes’, are used to assess the ‘condition’ of key ecosystem components, and condition assessments are combined to indicate ‘ecosystem health’.

In SRA Report 1 (2004-2007), the first in a series of three-yearly reports, the SRA has utilised three themes: fish, macroinvertebrates and hydrology.

Health and condition are rated as good, moderate, poor, very poor or extremely poor. All indices are rated relative to reference condition, or the state of the ecosystem as it would be, had there been no significant human intervention.

The SRA is an initiative of the Murray-Darling Basin Commission, in partnership with state, territory and federal governments. The SRA is linked to a number of other regional and state river monitoring programs through shared methods, data, reports and conceptual frameworks.

The Basin experienced a severe drought during the Audit period. It is too soon to identify the extent to which this has affected fish and macroinvertebrate communities. It has also limited the availability of sampling sites in some Valleys.

River condition

Ecosystem health

Thirteen of the Basin's valleys were found to be in 'very poor' health, seven in 'poor' health, two in 'moderate' health and one in 'good' health. Health ratings and valley rankings can be found in Table 3.6.

Fish

More than 60 fish species are known from the Murray-Darling Basin, including a complex of species (*Hypseloetris* spp.) awaiting formal description. The total also includes 10 species that are alien, having originated outside Australia, and seven marine or estuarine species that enter fresh water.

SRA methods for using fish as indicators rely on information about identity, origin and condition of individuals, their abundance and the composition of communities.

In assessment, all valleys (487 sites) were sampled for fish, involving 38 species and more than 60 600 individual specimens with a total biomass of over 4 tonnes.

On average, Fish Condition Index scores indicated 'very poor' condition for most of the Basin. Eight valleys rated 'extremely poor', three valleys 'very poor', nine valleys 'poor' and three valleys 'moderate'. Communities in the northern Basin often were in better condition than those in the southern Basin. Many native fish species expected to occur in valleys under reference condition were not recorded. Overall, native fish species were found in only 43 per cent of valley zones where they were predicted to occur under reference condition, indicating a decline of native fish in the Basin.

Alien species are a major part of Basin fish fauna. Three alien species, Common carp, Gambusia and Goldfish, were present in all rivers. Redfin perch and trout species also were widespread. Common carp were overwhelmingly dominant, being 87 per cent of alien biomass and 58 per cent of total fish biomass. Alien species rivalled or outnumbered native fish in nine of the 23 valleys. Of the 38 species caught, 28 were native, contributing 57 per cent of individual fish but only 32 per cent of biomass. Ten alien species contributed 43 per cent of abundance and 68 per cent of biomass.

Golden perch were common and present in 21 of 23 valleys. Other native species included Murray cod (16 valleys), Freshwater catfish (seven valleys), Silver perch (five valleys) and Trout cod (three valleys).

Macroinvertebrates

More than 140 taxa (mainly taxonomic families) of benthic marcoinvertebrates have been recorded in SRA sampling throughout the Basin, including a diverse range of aquatic insects, crustaceans, molluscs, worms and other forms, in variable numbers.

Most methods for using macroinvertebrates as indicators of river health rely on information about the identity and abundance of individuals and the composition of the community. In the SRA, sampling methods were those developed for the Australian River Assessment Scheme (AUSRIVAS), under the National River Health Program (Davies 2000). Macroinvertebrates were sampled using the AUSRIVAS kick-sampling method, which does not accurately represent the abundance of macroinvertebrates, so abundance was not used in the assessment of condition. Nor does the method adequately sample several groups of molluscs and crustaceans, especially larger species like freshwater mussels and crayfish. These limitations will be addressed in future refinements of the sampling protocol.

All valleys (773 sites) were sampled for macroinvertebrates, yielding over 209 100 specimens in 124 families. Twenty-three families were present in all 23 valleys. Many are typical of edge and slow-flowing river habitats throughout eastern Australia, and are tolerant to pollution and other human disturbance. In contrast, some families were rare, with 14 each found at only one site.

There were distinct differences in the condition of macroinvertebrate communities between southern and northern valleys, and between upland and lowland zones, with changes in representation of families tolerant of slow flow and high temperatures. Overall, two valleys were rated in 'very poor' condition, 18 valleys in 'poor' condition and three valleys in 'moderate' condition.

Most communities showed lower diversity (fewer families) than expected under reference condition.

Hydrology

The hydrology theme assessments encountered several problems, including data limitations, some analysis and reporting inconsistencies within and between states; and incomplete quality assurance procedures. Overall condition ratings were made based on data available, though the non-random distribution of sample sites prevented fully quantitative assessments at the zone and valley scale. It is important to note that the flow models used for hydrological condition assessments calculate reference and current flows over identical periods, accounting for the effects of prolonged wet and dry periods. Results reflect the effects of water resource development on the flow regime rather than the prevailing drought.

One-third of valleys were rated in 'good' condition, and another third were in 'moderate to good' condition. Most sites that fell short of reference condition were in the channels of the Basin's principal rivers. Most sites rated in 'poor condition' were in the lowland zones of these rivers. Results for all indicators, except seasonality, showed 'extreme differences from reference condition' at a few sites.

Future Scenario

Two more themes, vegetation and physical form will be added to the next SRA report, due in 2011. Future reports will also describe trends.

Table 3.6 Health rating and valley rankings from the Sustainable Rivers Audit 2004-2007

Health rating	Valley	Rank
Good	Paroo	1
Moderate	Condamine, Border Rivers	2
Poor	Namoi, Ovens, Warrego	3
	Gwydir	4
	Darling, Murray Lower, Murray Central	5
Very poor	Murray Upper, Wimmera, Avoca, Broken, Macquarie	7
	Campaspe, Castelreagh, Kiewa, Lachlan, Loddon, Mitta Mitta	8
	Murrumbidgee, Goulburn	9

Case study 3.9 Lake Eyre Basin—State of the Basin 2008: Rivers Assessment (Lake Eyre Basin Scientific Advisory Panel 2008)

Description

The State of the Basin 2008: Rivers Assessment (the 2008 Report) presents the first Lake Eyre Basin Rivers Assessment based on current best available information. The LEB Rivers Assessment focuses on the health of the LEB rivers systems, including their catchments, floodplains, lakes, wetlands and overflow channels. The Assessment covers the entire LEB. It aims to provide the basis for ongoing monitoring to further develop understanding of the LEB river systems and to enable changes in the condition of these systems to be detected.

The Lake Eyre Basin, occupying almost one-sixth of Australia, is among the world's largest internally draining river systems. The rivers of the Basin are unique on a world scale, with highly variable and unpredictable flow regimes creating a distinctive 'boom and bust' ecology. Both high and low flows have important ecological functions, and overall flow patterns, rather than just individual floods, are important to maintain the ecology of the Basin. The Basin includes five catchments: the Georgina Diamantina, the Desert Rivers, the Western Rivers, Lake Frome and Cooper Creek. Refer to Figure 3.8.

Methodology

Methodologies for assessing rivers and catchments elsewhere in Australia and the world have limited application to the ephemeral rivers of a large, internal basin spanning multiple jurisdictions such as the LEB. In this regard, the Rivers Assessment is the first of its kind in the world, and designing a monitoring and assessment program for this purpose has been a major challenge.

Assessments were generally based on existing reports, scientific data and expert opinion, and in all cases were reviewed by the LEB Scientific Advisory Panel and the Rivers Assessment Steering Committee. For assessment purposes, each of the catchments were divided into three regions, headwaters, channels and waterholes, and terminating wetlands. Four indicators were used: hydrological condition, landscape stress, water quality, and fish and birds.

River condition

- The rivers and catchments of the Lake Eyre Basin are in generally good condition. In particular, the low level of hydrological modification means critical aquatic ecosystem processes remain intact.
- Intact aquatic ecosystems make the LEB rivers unique compared with other arid river systems in Australia and around the world. The LEB may therefore provide critical aquatic habitat, especially for migratory waterbirds, given the greater impacts seen in other river systems.
- Of the five main LEB catchments, the Cooper Creek catchment is the most studied. However, even for Cooper Creek, our knowledge is still far below that for many coastal catchments in Australia. Additional knowledge, especially of hydrology and the 'boom and bust' cycles of the aquatic ecosystems, are priorities for research to guide future LEB Rivers Assessments.
- Threats to the condition of the LEB rivers and catchments include inappropriate water resource development, invasive pests and land use intensification—all of which could severely impact aquatic ecosystem condition.

Hydrological condition

The five catchments had low levels of flood and flow modification.

Landscape stress

Landscape stress is a combination of grazing pressure, proportion of native vegetation conserved, density of weeds and feral animals and number of threatened species, and is used as a surrogate for catchment condition.

Georgina Diamantina: Headwaters were most stressed, with channels and waterholes and terminating wetlands moderately stressed.

Desert Rivers: Landscape was minimally stressed.

Western Rivers: Headwaters were moderately stressed, channels and waterholes moderately stressed, and terminating wetlands minimally stressed.

Lake Frome: Headwaters and channels and waterholes were most stressed, and terminal wetlands were minimally stressed.

Cooper Creek: Headwaters and terminal wetlands were minimally stressed, and channels and waterholes were moderately stressed.

Water Quality

Where sufficient datasets were available, assessment indicated that water quality was good.

Fish

All expected fish species were present, with few introduced species. Surveys found relatively high numbers and diversity of native fish compared with the MDB (in NSW). Less than one percent of fish caught were introduced species and this was considered a sign of good ecological condition (Good *et al* 2008).

Early surveys in Queensland LEB watercourses had capture of only one exotic species, Plague Minnow (*Gambusia holbrooki*) (Bailey and Long 2001).

ARIDFLO surveys undertaken in South Australia and Queensland found the diversity of species, abundance and low proportion of introduced species were as expected for sites in good condition (Balcombe and Kerezy 2008, McNeil and Reid 2008).

In the Northern Territory, the assemblages of native fish have been found to be consistent with the presence or absence of permanent water features in each catchment, and there were virtually no introduced fish species (Duguid *et al* 2008).

Birds

Where sufficient datasets were available, assessment indicated that all expected bird species were present at natural levels of abundance. Georgina Diamantina’s and Cooper Creek’s terminal wetlands were found to be significantly large wetland systems with supporting Lignum shrub structure important for waterbird nesting. Lake Frome’s terminal wetlands were found to be significantly large wetland systems important for waterbird nesting and feeding areas. However, Lake Frome is not greatly used by waterbirds.

The majority of recorded inland waterbirds species were found during ARIDFLO surveys and large scale breeding events were observed in response to one-in-ten year flood events in 2000 and 2001 (Good *et al* 2008).

Table 3.7 provides an overview of the assessment results for water quality, fish and birds.

Future scenario

As the LEB Agreement requires the LEB Rivers Assessment to be repeated every ten years, a robust and thorough ecosystem condition monitoring program is being developed. The aim of a monitoring program in the LEB must be to directly link ecosystem thresholds with management actions, in order to identify those actions that protect the natural values of the LEB. The LEB Rivers Assessment will continue to focus on issues related to:

- the resilience of catchments, river and waterhole ecosystems to disturbance, and
- the hydrological regimes necessary to retain that resilience.

Figure 3.8 Map of Lake Eyre Basin

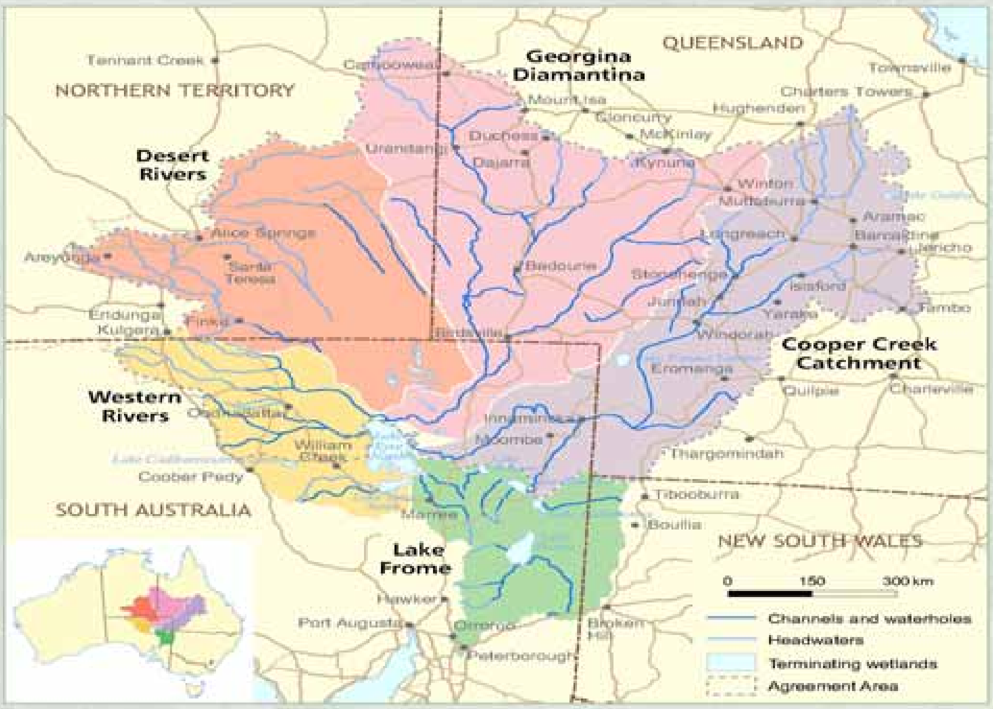
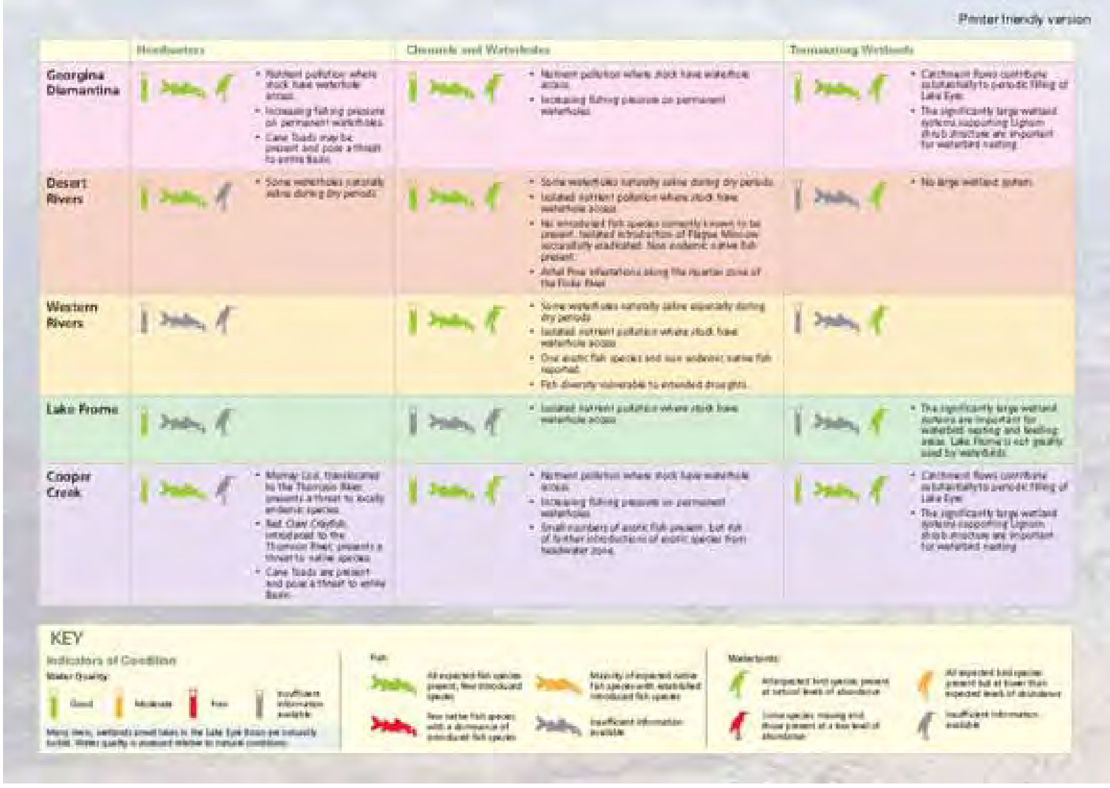


Table 3.7 Lake Eyre Basin Rivers Assessment Overview for Water Quality, Fish and Birds 2008



Case study 3.10 Taking the pulse of south-east Queensland waterways—the Ecosystem Health and Monitoring Program (Guymer 2008)

Description

Waterways provide a number of important ecosystem values, including wildlife habitat; visual and recreational amenities; commercial resources, such as commercial fishing and aquaculture; and water for drinking, agriculture and industrial use. The Ecosystem Health Monitoring Program (EHMP) is one of the most comprehensive marine, estuarine and freshwater monitoring programs in Australia. Since 1999, it has delivered an annual regional assessment of the ambient ecosystem health (or ‘pulse’) for south-east Queensland’s (SEQ’s) 18 major catchments, 18 river estuaries, and Moreton Bay. The EHMP is managed by the South East Queensland Healthy Waterways Partnership on behalf of its various partners and is implemented by experts from the Queensland Government, universities and CSIRO. A freshwater component assesses the non-tidal reaches of streams; an estuarine/marine component assesses the tidal reaches of waterways, including Moreton Bay; and an event-based component measures event or runoff-based pollutant loads entering SEQ’s waterways from the various land use types.

Methodology

The EHMP measures a broad range of biological, physical and chemical indicators of ecosystem health and the condition of SEQ’s waterways. Currently, 127 freshwater sites are monitored twice a year (in spring and autumn), and 254 estuarine and marine sites are monitored monthly. Standardised assessments of the freshwater (non-tidal) reaches of SEQ streams use five different indicators that can be modified, directly or indirectly, by human activities. These indicators, which have been chosen as the key elements of healthy freshwater ecosystems in SEQ (Smith and Storey 2001), are physical and chemical, nutrient cycling, ecosystem processes, aquatic macroinvertebrates, and fish. The results provide an assessment of the responses of aquatic ecosystems to human activities, such as catchment alterations and point-source discharges (e.g. wastewater treatment plants), and also take into account natural processes such as rainfall.

The EHMP, through the publication of its annual Report Card, plays an important role in raising awareness of changes in the condition of the waterways and focusing management efforts on protection of the environmental values identified by the community. It also provides an insight into the effectiveness of investments in waterway and catchment management.

Future scenario

Increases in population are predicted to increase pollution problems in the region’s waterways. The SEQ Healthy Waterways Strategy is therefore focusing on: protection and conservation of areas of high ecological value that are already contributing to good waterway health; management of point sources through wastewater reuse and discharge standards; management of rural diffuse sources by achieving good land management practices and addressing stream/gully erosion to achieve load reductions at source; and management of urban diffuse sources through water-sensitive urban design in proposed and existing urban areas.

3.4.4 Multi-jurisdictional collaboration to improve national reporting capabilities

The Australian Government has been working with the multi-jurisdictional River Health Contact Group and the Wetlands and Waterbirds Taskforce, to develop national indicators and protocols to improve national reporting capabilities. Draft national protocols have been developed for three critical river health indicators (fish, macroinvertebrates and riverine/riparian vegetation), drawing on existing methodologies where available. Draft indicators for wetland health have been developed and trialled. National indicators and protocols on wetland extent and distribution are being developed, informed by the mapping work undertaken by Queensland.

While the protocols are a significant step in the right direction to facilitate nationally comparable data, much will depend on the degree to which they are adopted and implemented. For example, many of the states have invested significant resources in the development of their river health assessment programs.

The National Water Commission has developed a Framework for Assessing River and Wetland Health (the FARWH), which may assist in national condition reporting. The FARWH may enable the results of different state river health programs to be compared and reported across different spatial scales. Two state river health programs, the SRA and the draft national river and wetland health indicators are aligned with the FARWH. The FARWH is being trialled in one state to identify how its existing river health assessment methodology may be aligned with it; in two states that do not have river health programs; and in one state for its suitability for assessing wetlands. The trials will conclude in June 2010.

The FARWH is currently being applied as a ‘broad-scale’ reporting tool at the surface water management area scale only, i.e. arbitrary boundaries that are administered through water sharing plans, but often aligned with catchment boundaries. The application of the FARWH for multi-scale reporting (i.e. sites, river reaches etc) is possible but would require further trialling.

As the FARWH is a condition reporting tool it may not necessarily reflect biodiversity, although certain indicators used to measure condition may also be regarded as biodiversity indicators. The FARWH’s biotic index represents the response to changes in the environment. This can be based on macroinvertebrates sensitive to disturbance, and/or include other components of biota, including fish, water plants, algae, waterbirds and riparian vegetation, to gain a fuller picture of the response to ecosystem change. Work is required to determine the capacity of the FARWH to provide a measure of aquatic biodiversity.