National Wetlands R&D Program

Scoping Review

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Introduction

Background

The Land and Water Resources R&D Corporation (LWRRDC) decided to evaluate the potential for developing a National Wetlands R&D Program in 1996. It is the belief of the corporation that significant gains have been made in the understanding of wetland functioning in various parts of Australia over the last decade. The new program, therefore, will focus on the key gaps in knowledge. LWRRDC is also aware that some major wetlands policy and management initiatives are in progress, including the Wetlands Policy of the Australian Government and the Murray-Darling Basin Commission Wetlands Management Strategy. The new Wetlands R&D Program will complement these activities wherever possible. To define the directions of a new Wetlands R&D Program, LWRRDC funded this scoping review of wetland management issues and R&D needs across Australia. The R&D priorities identified in this review will guide the development of the new program.

Definitions of wetlands

Wetlands are notoriously difficult to define. This is because they form an intermediate zone along the margins of well-defined terrestrial and aquatic systems, and accordingly vary markedly in size, location and hydrological regime. Nevertheless, they do share many distinguishing features, including the presence of standing water at some time, the related presence of unique soils, and a distinct vegetation (hydrophytes) adapted to or tolerant of these saturated soils. Mitsch and Gosselink (1993) have discussed the problems of defining wetlands, and we direct the reader to their text for elaboration. They note that no single definition will prove satisfactory for all users. From the Australian perspective, it is noteworthy that many of our wetlands are temporary, either intermittently (ie. seasonal, predictable) or episodically (ie. unpredictable). This is a condition not always fully appreciated in definitions devised for northern hemisphere conditions.

The definition adopted by the International Union for the Conservation of Nature and Natural Resources in the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (better known as the Ramsar Convention) is widely used for legal purposes. Under the text of the Convention (Article 1.1), wetlands are defined as:

> *"areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres" (Davis 1994).*

In addition, the Convention (Article 2.1) provides that wetlands:

> *"may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands" (Davis 1994).*

As this definition has as its basis primarily the status of migratory birds, it includes all aquatic systems and hence may not be suitable for the purposes of defining issues in shallow wetlands.

An alternative is the definition adopted by the US Fish and Wildlife Service in 1979:

> *Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water… Wetlands must have one or more of the following three attributes:*
>
> - *at least periodically, the land supports predominantly hydrophytes,*
> - *the substrate is predominantly undrained hydric soil, and*
> - *the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year.*
>
> *(from Mitsch and Gosselink 1993).*

The NSW Wetlands Management Policy (NSW Department of Land and Water Conservation 1996) defines wetlands in terms of land that is inundated with water

- on a temporary or permanent basis;
- that is usually slow moving or stationary;
- that is shallow; and
- that may be fresh, brackish or saline.

For the purposes of this review, we consider only inland standing (lentic), shallow bodies of water, and exclude *coastal marine wetlands (eg. saltmarshes, mangroves and seagrasses), except insofar as they are relevant to LWRRDC. Similarly, riverine systems are included only in relation to their floodplain wetlands.*

Current state of wetlands in Australia

Specific comments on the condition of Australian wetlands are given in the Background Papers. The loss and degradation of wetlands by clearing, draining and filling and modifications to water regimes has been prevalent in Australia since humans began to modify landscapes for their own purposes. The consequence of these activities has been that most Australian wetlands have been altered considerably, and there has been a severe loss of some wetland types or wetlands in some geographic areas. More than 89% of wetlands in the Murray-Darling Basin have been lost due to drainage. In coastal New South Wales, 75% of the original wetlands have been lost, and a similar percentage from the Swan Coastal Plain in Western Australia have been filled or drained. In Victoria, areas of both shallow and deep freshwater marsh wetlands have been reduced by more than 70%. It is clear that wetlands are among the most threatened environments in the country.

Threats to wetlands

McComb and Lake (1988) listed the major threats to the conservation of wetlands in Australia (see Table 1). That assessment provides a useful introduction to this scoping study, as it is these threats which result in the most significant modifications to wetlands. However, in the eight years since publication, there has been no further national review and there has been little progress by some of the government agencies to address the issues raised. There are still misperceptions about the values of certain wetlands (eg. salt lakes, intermittent and temporary wetlands), and public appreciation of wetland values remains low.

Recent activities in Australia concerning wetland management

There have been several recent developments in wetland management in Australia. As noted in Section 1.1, LWRRDC has sponsored a variety of R&D projects concerned with wetlands. The draft Floodplain Wetlands Management Strategy by the Murray-Darling Basin Ministerial Council promises to provide a framework for the management of wetlands in the Murray-Darling Basin. Likewise, the NSW Government has published a Wetlands Management Policy (NSW Department of Land and Water Conservation 1996). Currently under development by the Australian Nature Conservation Agency is a Wetlands Policy of the Australian Government. The Australian Society for Limnology has recently released a policy statement on wetlands. Other recent initiatives include the first wetlands to be listed in Queensland under the Ramsar Convention (Moreton Bay and Bowling Green Bay) and additional nominated sites in other States. The hosting of two major wetlands conferences in Australia in 1996 (Ramsar in Brisbane; INTERCOL in Perth) has also prompted broader interest in Australian wetlands.

Objectives

The objectives of the LWRRDC scoping review were:

1. To summarise wetland resources in general terms in Australia using existing information, and identify where information required for ecologically sustainable development is lacking.
2. To identify the key issues for wetlands management, within the context of overall natural resources management.
3. To identify and prioritise the generic, national or regional issues for which R&D investment could bring the greatest returns in terms of maximising national benefits.
4. To describe the current state of knowledge of the priority issues in a concise, well referenced format including the scale, impact, significance, costs, threats and opportunities.
5. To propose specific R&D requirements for each issue that will be sufficient to resolve the technical components of the problem.
6. To identify social, economic and policy impediments or constraints to resolving the priority issues and propose R&D or other projects that might assist in overcoming these impediments.

Review team

LWRRDC commissioned the scoping review with a 'Geographic' team working in combination with a 'Processes/generic' team. In addition to these two groups, other contacts were included to assist in the review process and ensure adequate input from water resource managers, and consultation with principal stakeholders.

Table 1: Threats to wetlands (adapted from McComb and Lake 1988)

Direct Threats to Wetlands

1. Drainage of wetlands for agriculture, horticulture and forestry.
2. Commercial and other developments involving reclamation or modification of wetlands.
3. Draw-down of water levels through extraction of groundwater.
4. The extraction of water from wetlands, and diversion of water from them for other purposes.
5. The inundation of wetlands to provide additional water storage.
6. Techniques of flood mitigation which involve diversion or barrage construction on streams.
7. River regulation, involving channel construction, walling of channels, and de-snagging of streams.
8. Surface mining of wetlands.
9. Use of wetlands as evaporation basins for irrigation water with high salinities.
10. Some 'landscaping' techniques in urban areas.
11. Weed invasion, including aquatic and rooted woody exotic plants.
12. Introduced animals
13. Relocation of native species to 'new' areas.
14. Insect control and the chemicals and drainage associated with this.
15. Grazing of wetland vegetation by stock and watering of stock in wetlands.
16. inappropriate recreational activities.
17. Wildfires.
18. Invasion by pathogenic organisms.

Indirect Threats to Wetlands

19. Nutrient enrichment following the clearing of catchments for agriculture or horticulture.
20. Salinisation of wetlands.
21. Other effects of clearing of catchments—erosion, flooding and inundation.
22. Diversion of water from rivers enhancing siltation.
23. Discharge of industrial effluents.
24. Oil discharge and oil spills.
25. Lack of coordinated land-use policies for large regions, including wetlands and their catchments.
26. Lack of recognition of wetlands as linked interdependent systems.

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Review process

The key steps in the review process were:

- a preliminary meeting of the review team in August 1995 to discuss details of the review process, including a standardised approach to the regional reviews, expected contributions from each group, and a time schedule.
- regional reviews prepared by the Geographic team (following consultation with key stake-holders and interest groups).
- a one-day workshop in October 1995, attended by all team members and the management contacts, including: brief presentations of the findings of the regional reviews and (ranked) priority issues; selection of issues deemed to be of national and/or generic significance; discussion of a single list of priority issues for the proposed National wetlands program
- subsequent effort of the scoping review was focussed on the top four topics identified in the list of 'natural resource' issues, and addressed by each of the Geographic team, as follows:
  1. Water regime—Lloyd/Moore
  2. Habitat modification—Lukacs/Pearson
  3. Eutrophication, other pollutants (including salinity)—Boon/Davis/Froend
  4. Exotics—Finlayson/Hall
- three additional topics also were considered to warrant further attention and the team members responsible for the review were as follows:
  5. Monitoring—Mitchell
  6. Valuation—Bennett
  7. Technology/information transfer—McDonald
- a full list of additional topics considered by the review team is summarised in Table 2. Some of these are dealt with in more detail in the Regional Reviews.
- each of the Geographic teams coordinated the review of one of the top four issues as identified above, including proposed R&D and other aspects specified in the terms of reference. Similarly, 'other' issues were reviewed by the team member nominated above.
- in addition to the four regional reviews, a Main Report and Executive Summary were prepared dealing with these seven priority issues
- the draft documents were then circulated to all members of the 'processes/ generic' team and LWRRDC for comment in early December 1995 and then the edited documents circulated for broader consultation in early January 1996. The final deadline was 9 February 1996.
- the draft documents were further reviewed and discussed at a meeting in Canberra on 8 May 1996. This involved representatives of the original review team (Boon, Bunn, Schlusser and Schofield) and an independent wetland specialist (Dr Margaret Brock).
- the draft Executive Summary was revised to serve as the Scoping Review document and the draft Main Report edited as a series of Background Papers to the review.

Outputs

The outcomes of the wetlands scoping review have been edited into six separate documents:

SCOPING REVIEW

This document

Table 2: Additional topics considered by the review team

'Natural resource' issues	'Other' issues
• nuisance insects	• wetland rehabilitation
• climatic change	• strategies for remote sensing of wetlands
• buffers	• economic incentives/disincentives
• salinisation	• catchment management
• barriers to fish	• risk assessment
• burning	• management strategies for degraded wetlands
	• community involvement
	• water quality standards
	• land tenure
	• policy—isolated decisions
	• biomanipulation

BACKGROUND PAPERS

A comprehensive review of key issues at a national level.

REGIONAL REVIEWS OF WETLAND MANAGEMENT ISSUES:

1. Western Australia (except Kimberley) and Central Australia
2. Wet-Dry Tropics of Northern Australia
3. Queensland and northern New South Wales
4. Southern Australia

These documents have been prepared with the primary goal of guiding the development of the LWRRDC National Wetlands Program. ***They are not intended as definitive reviews of all R&D issues for Australian wetlands.***

Priority issues identified in this review

The seven major issues identified during the scoping review are outlined in this document in order of priority, as determined by the review team. Much of the detailed information from the *Regional Reviews* and *Background Papers* has been summarised in tabular form. Sub-issues identified within some of the major issues are also listed in the tables in order of importance. However, no attempt has been made to rank sub-issues across the seven major issues. For example, the lowest ranked sub-issue in *Habitat modification* (Issue 2) is not necessarily perceived to be more important than the highest ranked sub-issue in *Pollutants* (Issue 3).

Water Regime

Water regime in Australian wetlands

The monsoonal, arid zone, mediterranean and temperate climatic patterns of regions of Australia are major influences on water regime. Therefore, generalisations about water regime issues in Australian wetlands are difficult because of the complexity and diversity of water regimes. However, the clear selection of water regime as the highest priority issue for Australian wetlands establishes the need to define issues and to seek solutions across the breadth of water regimes.

Definition and components

Water regime is the general term used to describe where, when and to what extent water is present in a wetland. Both above- and below-ground hydrology are involved. The concept is complex and hence the components of water regime and how the term is applied has varied among users. Most commonly, the concept of water regime is applied at the level of the wetland or whole system; less commonly, it is applied to the requirements of a specific organism or parts of a wetland. For wetlands, the 'unit' of interest is often water level and its fluctuation. Lack of information and understanding of ground water hydrology have meant that, to date, most ideas on water regime are governed by what is seen above-ground.

In this review, 'water regime' is used to describe the pattern of water inundation in a wetland. The important components of water regime for wetlands are:

- timing
- frequency
- duration
- extent and depth
- variability

The **timing** of water presence both within and between years is important. Within year patterns are most important in seasonal wetlands, whereas among year patterns and variability may be more important in intermittently and episodically filled wetlands.

Frequency of filling is often used to describe non seasonal wetlands. The frequency of filling and drying of most wetlands is difficult to determine as records are rarely kept. Some wetlands permanently contain water whereas many are subject to wetting and drying cycles at a range of intervals. Some wetlands fill and dry annually or more regularly, others fill intermittently for a short time, while others only dry for short periods. In Australia, a full range of wetting and drying frequencies can be found in wetlands.

The **duration** of inundation in days, weeks months or years will vary between and sometimes within wetlands. The rates of rise and fall of water level can also be important.

The spatial **extent** and the **depth** of water in a wetland will influence the dynamics of a wetland and hence need to be considered.

The **variability** of these components of water regime, whether on long or short time scales, is recognised as an essential part of wetland water regime. Variability is not often quantified and yet it is often dramatically altered under management.

Water regime and wetland ecology

Water regime is a major key to wetland ecology:

- Water regime has been modified markedly in many Australian wetlands
- The consequences of modifying water regime can only be appreciated by understanding how above- and below-ground water regime, determines wetland ecology.

Both water inputs and losses control the water balance of a wetland:

- the main inputs are surface water inflow, groundwater discharge and precipitation;
- the main losses are seepage, evapotranspiration, evaporation and outflows
- stochastic events such as drought and major floods must also be considered especially as they have a marked effect on the variability component of water regime.

Water quality dynamics can be influenced by the water regime patterns:

- by affecting water chemistry through evapo-concentration, leaching and in-flow
- by providing a range of aerobic and anaerobic conditions (through wet-dry water regime patterns) which can influence rates of nutrient cycling and carbon flux.

Biotic processes are also controlled by water regime patterns:

- for individuals, by ensuring growth and cues for life history responses
- for populations, by controlling population dynamics and primary and secondary productivity.

Modifications to water regime

Water regime modification has caused:

- significant habitat modification to Australian wetlands
- impacts that are pronounced in temporary wetlands.

Water regime can be modified by altering the rate or timing of either inputs or losses (or both) or by changing retention capacity. Such alterations can lead to changes to ecological processes which may result in changes in:

- growth, viability and reproduction of species
- population structure
- community structure
- species richness
- aesthetic and agricultural and cultural and heritage values
- opportunities for invasion by exotic or nuisance species
- water quality.

Such changes may be symptoms of degradation at local, regional or landscape level.

State of Australian knowledge

Basic knowledge of the links between water regime and ecology is uneven across taxonomic groups and geographic regions:

- larger organisms, usually animals (and especially vertebrates), have been preferred as study species
- there is more known about some geographic areas and some wetland types (eg. SE and SW of Australia, and permanent rather than temporary wetlands)
- populations rather than communities have been the topic of most study
- there is scant and uneven knowledge on the significance of each component of water regime (singly or combined), to individual species, communities and to wetland processes at the ecosystem scale
- the importance of the dry phase of wetland water regime is very incompletely understood (eg. some aspects of the significance of wet-dry-wet cycles for biological and chemical processes are being established in a few wetland types. However, applicability to other wetland systems and other aspects such as the cues signalling drawdown and triggers for seeking refuges or formation of resistant stages are poorly known)
- most studies have been specific and local whereas whole system studies are unusual because of their complexity
- studies of the influence of water regime on wetland processes, such as transformations of nutrients and carbon flow, are few.

A conceptual framework for making generalisations and addressing management questions on water regime issues is lacking because:

- the information base on water regime and how it influences wetland dynamics is uneven and incomplete
- both monitoring (phenomenological) and experimental (predictive) perspectives on water regime are needed
- how water regime modification alters processes such as food chains is unknown
- understanding of the role of temporal and spatial scale in water regime issues is poorly developed
- wetland ecology lacks functional models of change and response
- the implications of use of different sources of water for water regime management are unknown, hence there is difficulty in being predictive or prescriptive.

Table 3 Priority issues and proposed R&D—Water regime

Issue(s)	Underlying cause(s)	Outcomes for management	Proposed R&D	Justification
Altered Water Regime Change to water regime in all types of wetlands is widespread. Although it is now recognised that most modifications have been made without regard to wetland ecology and function, we do not know enough to predict and estimate the water regime, • timing, • frequency, • duration, • extent & depth, • variability, requirements of wetlands.	• changes in timing, frequency, duration, depth, extent and predictability (variability) of wetland inundation have resulted from a wide range of water and land use practices eg. irrigation, river management etc, • severely changed (reduced or increased) flows to wetlands (both groundwater and surface water) from practices such as—irrigation, damming or abstraction for water supply, surface water drainage, rises in groundwater etc • wetland loss from the above factors • wetland water quality degradation from the above • insufficient water for all uses, including water for wetlands	• baseline information for water regime management in wetlands • baseline information that can be used to develop models and decision support systems • guidelines for environmental water allocation requirements • efficient use of water resources that will give the greatest benefit to wetlands when there are competing use requirements • appropriate planning and management guidelines that will promote conservation and biodiversity and ecologically sustainable uses of wetlands	We need : • to understand the importance to wetland ecology of timing, frequency, duration, depth, extent and predictability (variability) of wetland inundation in all wetland types • to identify the water requirements of wetland populations, communities and ecosystems in all regions • to understand how the dry phase of a wetland influences the biota and processes in all wetland types • to develop ways of applying water regime knowledge to wetland restoration issues • to determine the available/required flows for various wetland types and wetland functions and uses eg. analysis of catchment yields and environmental allocations • to investigate the effects of wetting and drying on wetland processes such as nutrient cycling and food chain dynamics	• it is essential to understand the water requirements of wetlands and the species in them before water allocations for wetland needs can be made • there is a need to understand the water regime requirements of a geographically broad range of wetland types • it is essential to understand wetland water needs to manage for sustainable wetlands and conserved biodiversity • understanding of water regime will allow sound planning for wetland maintenance and restoration • understanding of the effect of water regime on wetland processes will allow prediction of the changes a wetland can sustain without degradation • integration of water regime results into models, guidelines and management plans is needed • this knowledge of water regime is needed for more holistic and equitable water management • a wetland classification based on water regime will allow management predictions to be made both within and across wetland types

Table 3 Priority issues and proposed R&D—Water regime (cont)

Issue(s)	Underlying cause(s)	Outcomes for management	Proposed R&D	Justification
We do not understand the influence of fluctuations of (both natural and altered) water regime on • the biota • physical and geochemical conditions in all wetland types	• insufficient work relating water regime to wetland ecology		• to develop a national comprehensive, system which incorporates critical elements of water regime requirements and watertable information into wetland classification • to develop and apply to wetlands, the decision support system currently being developed to aid in decisions on environmental water allocation in rivers	• this knowledge will provide the basis for protection of wetland values while minimising loss of other wetland use values
Wetland loss due to draining, filling and clearing	• see Table 4			

Priority Issue 2

Habitat modification

Many aspects of habitat modification pose direct and indirect threats to wetlands. Although three of the priority issues are listed separately (viz water regime, pollutants, and weeds and feral animals), they also have a major role in habitat modification. These issues are dealt with fully in separate sections. Other discrete aspects of habitat modification are considered here.

Clearing, draining, filling and damming

Wholesale loss of wetlands by clearing, draining, filling and damming is prevalent

- As a consequence of past and present small and large-scale clearing of native vegetation, direct and indirect impacts on wetlands are impossible to avoid.
- Estimates of loss since European settlement include for example, 89% of the wetlands in south-eastern region of South Australia, 75% of the wetlands in coastal NSW, 75% of the wetlands on the Swan Coastal Plain (WA), and 70% of freshwater marsh wetlands in Victoria.
- Development of new irrigation schemes and expansion of urban areas are two major contributing factors to this on-going threat.

Altered water regimes

(See Priority Issue 1)

Contaminants

(See Priority Issue 3)

Grazing in wetlands

- Most coastal floodplain wetlands are grazed, as are most inland wetlands and their catchments.
- Impacts of grazing are poorly understood, though damage to some systems may be permanent and severe.
- Impacts include; selective grazing of aquatic macrophytes, damage to banks and wetland surface by trampling, contamination of wetland waters (eg. increased turbidity, eutrophication, and faecal contamination), introduction of weeds.

Exotics/pests

(See Priority Issue 3)

Other factors

Cropping

- There is little information on Cropping of wetlands as a habitat modifier, and particularly lake bed Cropping.
- Impacts on soil structure and water infiltration rates, nutrient dynamics, the maintenance of seed banks of native species, macrophyte abundance and diversity (particularly as habitat for waterfowl) are unknown.

Extraction and mining

- Traditionally, extraction and mining has been viewed as an issue of 'on-site' damage.
- The impacts from these extractive industries include dunes and forests being destroyed, windblown sand causing infilling of bays, pollution of waterways and the lowering of water tables.
- The development of 'mega-mines' has, however, produced the potential for regional impact, eg. the major potential pollution threat to Northern Territory wetlands is from mineral extraction and processing.

Commercial harvesting

- The resources harvested from wetlands include fish, timber, reeds, wildfowl, crustaceans, plant parts, such as tubers and rhizomes for commercial, recreational and sustenance purposes (including Aboriginal harvesting).
- Important issues include the sustainability of the harvest (eg. in preventing over-fishing or over-logging) and the introduction of exotic species into natural wetlands for the purposes of harvesting.

Barriers to fish

- The construction of irrigation systems and the channelling of waterways has often been shown to restrict fish movement between riverine systems and adjacent wetlands.

Recreation

- The increase in recent times of water-based recreational pursuits is placing extra pressure on wetland habitat.
- Impacts are caused by litter, increased sewerage needs, boating, shooting, recreational fishing, landscaping of wetlands and ecotourism into wetlands (eg. disturbing biota, especially waterfowl).

Fire

- There is little information regarding the role of fire in many wetland types.
- Peatlands are particularly sensitive to burning and this has led to the total destruction of vegetation in some areas.
- Needs in fire research include further investigations of litter inputs into wetlands, recovery periods following fire, and further study of different fire frequencies and their impact on aquatic and riparian biota.

Dumping

- Despite arguments by conservationists over many years that wetlands are not wastelands, these are still convenient places for refuse disposal and large areas have been filled to make way for various developments.

Table 4 Priority issues and proposed R&D—habitat modification

Issue(s)	Underlying cause(s)	Outcomes for management	Proposed R&D	Justification
Draining, filling, clearing and damming: Loss and modification of wetlands across the landscape has been and is still prevalent.	• agricultural expansion has meant land clearance and wetland drainage or damming have been, and are still, encouraged. • urban development and expansion has led to degradation and destruction of urban wetlands by damming for water supplies and drainage for land reclamation	• integration of all wetlands types into landscape planning • increased retention of all types of wetlands • protection and management of existing wetlands • recognition of the value of wetlands • recognition that some wetland loss and degradation can be redressed by restoration and management	We need • improved methods of wetland delineation eg. rapid determination of temporary wetland boundaries • inventory and classification eg. development of methods for rapid assessment of change • feasibility study into adopting 'no net loss' policy or equiv-alent for Australia • to communicate wetland values eg. development and support for 'Wet-Land Care' • to develop wetland restoration techniques	• it is essential to quantify wetland types, boundaries and change to stop and reverse loss of wetland types, biodiversity and habitats • we need better recognition of wetland values • better planning and coordination of wetlands in the Australian landscape will help conservation of wetlands and their values • we need an improved ability to adhere to international agreements (eg. JAMBA, CAMBA, Ramsar etc) • we need to improve our ability to restore and maintain wetlands
Water regime	• see Table 3			
Pollutants	• see Table 5			
Weeds and feral animals	• see Table 6			

Table 4 Priority issues and proposed R&D—Habitat Modification (cont)

Issue(s)	Underlying cause(s)	Outcomes for management	Proposed R&D	Justification
Grazing in wetlands Grazing in wetlands and their catchments is widespread and has altered the physical, chemical and biological characteristics of wetlands. Sedimentation, changes in species diversity and ecological processes result.	• access to wetlands for stock water supply • use of wetlands as a grazing resource • These underlying causes have consequences such as: • grazing/trampling of macrophytes • erosion and sedimentation • eutrophication • overgrazing	• maintenance of riparian and aquatic plant diversity • reduced sediment loadings in wetlands • improved water quality • guidelines for acceptable grazing practice for various wetland types	We need to: • determine the impact of different levels of grazing on wetland structure and function; eg. the impact of grazing wetlands on plant communities (species richness, competition, introduction of exotics) • to plan and develop integrated grazing systems eg. examine the feasibility of wetland protection (eg. fencing) whilst maintaining other values (eg. water harvesting) • to determine sustainable stocking rates in different wetland types eg. further investigation of erosion and sedimentation and beneficial and detrimental effects on aquatic communities	• assessment of grazing impacts will allow planning for conservation of biodiversity and maintenance of wetland habitat • assessment of sustainability of grazing in wetland landscapes is needed • need for information on the effects of grazing from replicated field experimental studies • such information will lead to planned management of wetlands for multiple uses.

Priority Issue 3

Pollutants

Wetlands may be adversely affected by five main classes of pollutants:

- plant nutrients, especially nitrogen and phosphorus
- inorganic compounds other than nutrients, especially NaCl
- toxic compounds, including heavy metals and organic substances such as pesticides
- natural organic compounds, such as organic matter in sewage effluent
- suspended solids.

In Australian wetlands, particularly those in the southern regions, both eutrophication and salinisation represent the major impacts. Toxic contaminants result in significant impacts in a number of areas, including some rural regions and large population centres. Impacts by sewage and increased suspended solids do exist, but are probably less widespread than for the above major contaminants.

Pollutants may enter the aquatic environment from either diffuse or point sources. Examples of sources include streams and drains, groundwater inputs, industrial and sewage outfalls, spills and illegal dumping, and aerial deposition.

Modern agricultural practice and urbanisation are the major cause of wetland pollution throughout much of Australia. The frequency of agricultural effects is primarily due to the leaching of fertilisers used for crop production into aquatic environments, leading to excessive nutrient inputs (cultural eutrophication), point and diffuse inputs of pesticides (both weedicides and insecticides), and increased salinity arising from altered water tables and hydrological regimes. Urban activities also result in the pollution of natural wetlands: the use of insecticidal sprays in Western Australia, land and road runoff in all major population centres, and eutrophication resulting from nutrient applications to urban landscapes are noteworthy examples. At some sites, extractive industries (such as mining) and industrial activities (eg. chemical synthesis, landfill sites) cause the pollution of wetlands with heavy (and sometimes radioactive) metals, pesticides and other toxicants, and increased loads of suspended solids.

Once introduced into the aquatic environment, pollutants (especially nutrients and toxicants) often become associated with particulate matter and incorporated into bottom sediments. Wetlands are particularly susceptible to the influence of pollutants because:

- they are depositional environments, and as such are often the final receptors for critical contaminants derived from their catchments
- wetland biota are commonly significant bio-accumulators of contaminants.

Wetlands could play an important potential role as indicators of ecosystem health. Wetland sediments, in particular, are key components since they:

- are the major pool for contaminants
- are the site of the major transformations of pollutants
- are a constant source of toxicants to wetland biota, acting as chronic releasers of contaminants into the overlaying water or to benthic organisms.

Despite this likely importance, there is a clear lack of predictive ability regarding the fate and biological impact of pollutants in the aquatic environment and in wetlands in particular. Ecotoxicological studies, that examine the interactions between physical, chemical and biological properties of various pollutant chemicals in the in situ aquatic environment are a central requirement for increasing our predictive capacity regarding the impact of pollutants in Australian wetlands. Moreover, current standards for contaminants in aquatic systems are set largely with a view to human-health considerations. It is unclear whether values outlined under such standards or guidelines are directly applicable to natural environments for ecosystem management.

With respect to nutrients, R&D effort is required to determine:

- the incidence of nutrient limitation and eutrophication in wetland environments
- the type of nutrients (eg., nitrogen versus phosphorus) limiting wetland primary production

- effects of nutrient inputs on wetland ecology (especially alterations to the ‘balance’ between algal and macrophytic production) and to subsequent food web structure
- the role of wetlands in altering nutrient bio-availability, especially in terms of phosphorus transformations
- methods for monitoring wetland health and the use of bioindicators sensitive to nutrient loading
- nutrient standards for ecosystem protection from increased nutrient loadings that are appropriate for Australian wetlands
- determine best practices for restoring eutrophied wetlands.

With respect to salinity, R&D effort should be directed towards:

- assessing the extent of salt-affected wetlands
- quantifying the direct effects on increased salinity on wetland biota, such as decreases in plant vigour and sensitivity of fauna to increased salt levels
- determining the secondary effects of groundwater intrusions, such as shifts in various anaerobic decomposition pathways and consequent sulphide toxicity to biota
- development of methods for monitoring wetland health and the use of bioindicators sensitive to salinisation
- development of salinity standards for ecosystem protection from salt that are appropriate for Australian wetlands
- determine best practices for restoring salt-affected wetlands.

With respect to toxic contamination, appreciable R&D work is required to:

- apply Quantitative Structure-Activity Relationships (QSARs) as a first approximation of impacts of toxicants on wetland biota
- develop meaningful ecotoxicological procedures for Australian conditions to further refine understanding of in situ interactions and transformations of toxicants. This will lead to an improved predictive capacity of the effects (both acute and chronic; lethal and sublethal) of toxicants on wetland biota
- develop methods for monitoring wetland health and the use of bioindicators sensitive to toxicant loading
- develop standards for ecosystem protection from toxicants that are appropriate for Australian wetlands
- quantify the ability of wetlands to ameliorate pollutant loads under real-life environmental conditions of variable climate and hydrology
- determine best practices for restoring toxicant-affected wetlands.

Other R&D effort could be directed towards:

- developing generalised bioindicators for vital signs of wetland and catchment health
- diagnose early warning bioindicators of wetland or catchment stress
- assess the sensitivity and long-term response of wetlands and catchments to low and chronic doses of contaminants
- formulate effective treatment protocols to rehabilitate damaged wetlands.

Table 5 Priority issues and proposed R&D—Pollutants

Issue(s)	Underlying cause(s)	Outcomes for management	Proposed R&D	Justification
Nutrients The structure and function of wetlands is affected strongly by increases in the availability of nutrients to wetland plants, a process called cultural eutrophication	• Nutrients released from sewage treatment facilities and from intensive animal husbandry (eg. feedlots) and lost from agricultural and urban areas via land runoff find their way into streams and rivers, and eventually into wetlands. • Nutrient-rich effluents may be intentionally loaded onto constructed wetlands. • Primary production in wetlands is probably limited by nutrient availability, so increased nutrient availability leads to the acceleration of plant growth, and to shifts in the 'balance' between algal and macrophyte dominance. • Food web structure, controlled primarily by the classes of organic carbon available to fauna, is affected by these alterations in primary production	• protection of biodiversity in natural wetlands • maintenance of natural eco-system function • improved predictive capacity regarding the response of natural wetlands to nutrient inputs, ie improved wetland management procedures • tools for monitoring wetland susceptibility to nutrient enrichment and use of bio-indicators sensitive to nutrient loading • legislative standards for nutrient loading to natural wetlands • improvements in wetland quality, such as lessened problems with cyanobacterial blooms, noxious insects (mosquitos), objectionable odours and lessened incidence of waterfowl poisoning • guidelines for the restoration of natural wetlands adversely affected by nutrient enrich-ment in the past • improved design specifications for constructed wetlands created to treat nutrient-rich effluents • adherence to international treaties for waterbird protection	• quantification of incidence of nutrient limitation in wetland environments, especially for plants • the type of nutrients (eg., N vs P) limiting wetland primary production • bioavailability of nutrients in wetlands and role of wetlands in altering nutrient bioavailability • effects of nutrient inputs on wetland ecology (especially alterations to the 'balance' between algal and macrophytic production) and to subsequent food web structure • methods for monitoring wetland health and the use of bioindicators sensitive to nutrient loading • effectiveness of natural and constructed wetlands in nutrient reduction • performance indicators for constructed wetlands • nutrient cycles and importance of hydrological cycle and altered land use on patterns of cycling • analysis of interactions between nutrient cycling and wetland contamination • restoration protocols for eutrophied wetlands • elucidation of catchment management practices on nutrient inputs to wetlands	• eutrophication is a ubiquitous and widespread side effect of human activity. It occurs in rural and urban catchments, and is a consequence of almost all industrial, agricultural and domestic activities • the response of wetlands to increased nutrient loadings is poorly understood, but bio-diversity and ecological functioning is likely to be compromised • wetlands provide a potentially powerful tool for intercepting nutrients, but much key information on design parameters and performance criteria are lacking • wetlands may be used to decrease human health risk associated with cyanobacterial blooms and noxious insects • creation of wetlands in urban areas will lead to better storm-water treatment and expanded wildlife habitat • eutrophication threatens our adherence to international treaties for wildlife protection

Table 5 Priority issues and proposed R&D—Pollutants (cont)

Issue(s)	Underlying cause(s)	Outcomes for management	Proposed R&D	Justification
Salinisation Salinisation is a widespread and ongoing problem in Australian rural areas. Increases in the concentration of NaCl in wetland soils are caused directly by rising groundwater (consequent to irrigation and tree clearing) and indirectly from inputs of salt-rich irrigation effluents. These increases in salt decrease plant vigour and may affect wetland fauna. An associated issue is that ground-water intrusions not only increase soil salinity, but increase soil sulphate concentrations, thus promoting the activity of sulphate-reducing bacteria. These can cause sulphide toxicity to plants and lead to accelerated corrosion of metals in affected soils.	• Tree clearing associated with agricultural activity on soils covering saline groundwaters has led to rising groundwater. • Ponding of water via irrigation over saline groundwaters. • Irrigation effluents are also salt laden due to the leaching of salt from soils. • Saline (marine intrusions) in coastal wetlands in northern Australia	• quantification of extent of salt-affected wetlands • improved predictive capacity regarding the response of natural wetlands to salt inputs, ie improved wetland manage-ment procedures • tools for monitoring wetland susceptibility to salinisation and use of bioindicators sensitive to salt loading • legislative standards for salt loading to natural wetlands • general improvements in wetland quality arising from better management procedures • guidelines for the restoration of natural wetlands adversely affected by salinisation in the past • protection of biodiversity in natural wetlands • maintenance of natural ecosystem function	• assessment of extent of salt-affected wetlands • quantifying direct effects of increased salinity on wetland biota, such as decreases in plant vigour and sensitivity of fauna to increased salt levels • better understanding of interactions between ground-water movements and wetland structure and function • determining secondary effects of groundwater intrusions, such as shifts in various anaerobic decomposition pathways and consequent sulphide toxicity to biota • development of methods for monitoring wetland health and the use of bioindicators sensitive to salinisation • development of salinity standards for ecosystem protection from salt that are appropriate for Australian wetlands • determine best practices for restoring salt-affected wetlands. • techniques for improved catchment management to lead to decreased salt loads to wetlands	• salinisation is likely to be an extensive and severe environmental problem over the next 50-100 years at least. Wetlands, being often on floodplains and as terminal receiving sites for streams and rivers, are especially sensitive to salinisation • there is increasing evidence that many Australian wetlands are being affected adversely by salinisation and that native wetland plants are sensitive to salt • protection of biodiversity and natural ecosystem function is contingent upon wetlands not being degraded by salinisation • adherence to international treaties for wildlife protection is likewise affected by wetland salinisation

Table 5 Priority issues and proposed R&D—Pollutants (cont)

Issue(s)	Underlying cause(s)	Outcomes for management	Proposed R&D	Justification
Toxic contaminants Wetlands are highly susceptible to the effects of toxicants (mainly pesticides and heavy metals). Contaminants are often associated with particles, and since wetlands are depositional environments, these precipitate to wetland sediments causing long-term pollution. Wetland biota, which include a large number of bottom-dwelling and filter feeding animals plus rooted macrophytes, are often significant bioaccumulators of contaminants	• Toxicants are widely used in modern agriculture and find their way into wetlands either via stream flow or via atmospheric deposition • In some cases, wetlands are sprayed directly with insecticides • In areas subject to mining and other extractive industries, wetlands can be affected by releases of metal-rich waters from tailing dams and mine operations. • In urban areas, wetlands are subject to contamination from street runoff and industrial activity.	• improved predictive capacity regarding the response of natural wetlands to toxicant inputs • tools for monitoring wetland susceptibility to toxicants and use of bioindicators sensitive to toxic contaminants • development of wetlands as holistic indicators of ecosystem or catchment 'health' • legislative standards for toxicant inputs to natural wetlands • general improvements in wetland quality arising from better management procedures • guidelines for the restoration of natural wetlands adversely affected by toxicant inputs • guidelines for the use of insecticides in urban wetlands • guidelines for the use of pesticides in agricultural areas, especially with respect to weedicides in irrigation and insecticides in cotton growing • improved design specifications for constructed wetlands created to treat effluents rich in toxic contaminants • protection of biodiversity in natural wetlands • maintenance of natural ecosystem function • improved adherence to international treaties for waterbird protection	• application of QSARs as a first approximation of impacts to biota of toxicants in wetlands • development of meaningful ecotoxicological procedures to better understand in situ interactions and trans-formations of toxicants and thus to improve the predictive capacity of the effects of heavy metals and pesticides on wetland biota • development of methods for monitoring wetland health and the use of bioindicators sensitive to contaminant loading • development of standards for wetland protection from toxicants that are appropriate for Australian wetlands • quantify the ability of wetlands to ameliorate toxicant loads • determine best practice for restoring impacted wetlands	• the spread of toxicants throughout natural ecosystems is a ubiquitous aspect of Australian life, being caused by widespread use of heavy metals and pesticides in all aspects of rural, extractive and domestic activities • the problem with heavy metal and organic toxicants affects all regions; rural, urban, mining • specific information on the effect of toxicants on wetland structure and function is almost completely unknown, but toxicants almost certainly degrade wetlands at both large- and small- spatial scales, and over acute and chronic timescales, thus threatening biodiversity and natural ecosystem function • as the degradation is likely to be long-term, it will be difficult to correct • constructed wetlands can be created in urban areas, to treat toxicant-laden waters and thus leading to storm-water treatment and expanded wildlife habitat • significant risk from litigation arising from pesticide use in urban areas to control mosquitoes and midges

Priority Issue 4

Weeds and feral animals

Many Australian wetlands have been adversely affected by invasive plants and animals, many of them alien to Australia or to the region. Such species initiate ecological shifts in species composition and in the relative sizes of the populations of different species. These phenomena are little studied and consequently are poorly understood. Similarly, the biology of the invading species, the environmental factors that enable invasion and subsequent proliferation of the invading species, the ecological impacts of the invasion, and the flow-on effects to the ecological stability of adjacent, interacting ecosystems are largely not known or are incompletely recorded. Most of the available data is inadequate or unreliable for the formulation of management programs, whether these are designed as reactive control programs or as proactive strategies to prevent the invasion of systems known to be at risk. Some of these invasions occurred a long time ago and the extent of the impact would now be difficult to assess. However, even relatively recent invasions such as by the common carp (Cyprinus carpio) have not been properly studied.

Wetlands that are subject to interference with their hydrological regime or nutrient status are also susceptible to ecological imbalances caused by excessive proliferation of one or several existing components of the system with similar consequences to the phenomenon described above. In this case, it is difficult to distinguish between such events and those that are within the normal compass of responses of such systems to the naturally high variability in the Australian environment, particularly in respect of hydrological factors. The uncertainties that are an inherent part of these sorts of situations are themselves contributory factors to this regrettable situation and provide strong reasons for a cohesive well-planned program of R&D in this area. This requires justification based on cost/benefit analyses, risk analyses of the consequences of invasion and population displacements, which are themselves in need of research. Of particular importance is the need to extend community awareness of the harmful effects of these phenomena and of the potential benefits of management strategies that will prevent or minimise their occurrence, especially when these strategies depend on the cooperative involvement of the public at large.

A summary of priority species, underlying causes, benefits of further R&D, strategies for R&D, and justifications is set out in the accompanying table (Table 6). Recommendations for specific actions are contained within the text of the *Background Papers*.

Table 6 Priority issues and proposed R&D—Weeds and feral animals

Issue(s)	Underlying cause(s)	Outcomes for management	Proposed R&D	Justification
Wetlands throughout Australia have been subject to invasion by a wide range of plants and animals, both from foreign countries and as transplants from elsewhere in Australia. The effects include reduced bio-diversity, problems with weed infestations (Salvinia, Mimosa pigra etc), modified wetland habitat leading to increased susceptibility to subsequent invasions of feral species, and alterations to food-web structure. Priority plant species include Mimosa pigra, para grass, alligator weed, Lippia, and Salvinia molesta; priority animal species include feral pigs, Gambusia affinis, carp and cane toad.	• ineffective quarantine procedures • major attempts at control have been left until after the pest has become established • little information on biology of problem species, and on the ecological factors that make certain species successful invaders into given wetlands • control procedures are either ineffective or poorly coordinated • little incentive for control at local/individual level • lack of awareness of scale of potential problem • lack of community-wide involvement in surveillance and control • sectoral management restricts effective planning and control • poor understanding of ESD principles	• development of early warning systems to alert managers to potential or incipient problems • development of reference techniques for eradication of future outbreaks or of new pest species • consistent and readily available information on wetland rehabilitation • conservation of biodiversity • improved recreational and commercial fishing • removal of associated animal pest threats consequent to plant invasions • susceptibility to further invasion of additional plant pests is reduced • enhanced aesthetic qualities and carryover into improved tourism etc • saving of control costs • improved access to productive land	• development of rehabilitation strategies for critical wetland regions or types, eg. the role of predation and biological control, chemical usage, the role of fire, and manipulation of water regime as control measures • improved detection of pest species in remote areas, including the instigation of national monitoring and reporting programs • development of eradication techniques for priority species, including the development of training manuals • development of community awareness of, and involvement in, weed planning and management • develop better protocols for integrated pest management (eg. Decision support Systems) • economic incentives for land users to maintain essential ecological features of wetlands that decrease risk of invasion • environmental pricing - mechanisms to encourage the retention of wetland processes and functions • inventory and survey of susceptible areas and potential problem species • quantification of the scale of threat of weeds and feral animals	• the record of environmental and economic losses from weed and animal invasions is alarm-ing. Large areas of formerly pristine wetland have been affected (eg. in Kakadu from Salvinia), many urban wetlands have been seriously affected (eg. Botany Bay wetlands with Ludwegia) and there is a seri-ous problem with weed infest-ations of irrigation structures • public opinion is supportive of significant investment into the control of introduced species • significant progress can be made through risk assessment to identify gaps and reduce cost of research • information on ecological change and the effectiveness of control measures is inadequate • quantifying potential threats from weeds and pests will aid decisions as to where resources for wetland management are best allocated • protection of biodiversity and natural ecosystem function is contingent upon wetlands not being degraded by introduced plants or animals • adherence to international treaties for wildlife protection is likewise affected by wetland degradation through foreign or inappropriate species

Priority Issue 5

Monitoring

Wetlands should be monitored:

- to collect baseline data for inventories;
- to record ecological changes that may be occurring;
- to measure progress of management programs;
- to collect data that will contribute to better understanding of these systems;
- to check on the performance of management agencies.

There should always be a close connection between the monitoring program and the management program. The monitoring data provide a check on the progress of the management program so that the latter can be amended, if necessary, to ensure that management objectives are met most efficiently. The relationship between the two programs should be an iterative one, resulting in the development of a program of adaptive management for the wetland.

A strong relationship between monitoring and research should also be emphasised as a potent means of refining and extending scientific knowledge of wetland systems. This requires that the design of monitoring programs be consistent with rigorous scientific methodology and that expectations and assumptions be stated as hypotheses requiring scientific investigation by means of the monitoring program.

The design of monitoring programs must include:

- objectives, stated clearly in measurable terms;
- systematic evaluation and testing of a range of possible techniques;
- statistical procedures to assess the reliability of the monitoring data;
- field testing of the proposed program prior to its initiation.

Involvement of the community is necessary whenever the results of the program will impact upon it.

A large number of monitoring techniques are available. These include:

- a range of remote sensing techniques;
- measurements of various physico-chemical parameters;
- assessments of the welfare of selected biota as indicators of the ecological health of the system.

Each technique has particular strengths and weaknesses and the final program should consist of an appropriate combination of those that will achieve the objectives of the program in the most effective manner.

It is very important that monitoring programs be subject to continuing critical oversight and that the results of the program be made widely available to all who could benefit from its information. In addition, the whole program should be critically reviewed on at least an annual basis, and decisions taken about its continuation/termination, or modification.

Table 7 Priority issues and proposed R&D—Monitoring

Issue(s)	Underlying cause(s)	Outcomes for management	Proposed R&D	Justification
Poor design of monitoring programs	• Objectives not clearly specified • Assumptions not identified • Inadequate statistical rigour • Poor oversight • Uncritical evaluation • Overall appraisal of program too infrequent • Insufficient knowledge of monitoring techniques • Monitoring and management not efficiently linked	• Connection between monitoring and research weak or absent • Relevant, cost-effective monitoring programs • Constructive critical management of monitoring programs • Development of programs of adaptive management • Use of monitoring to refine research understanding • Understanding participation of the community in monitoring	• Training courses at tertiary education level • Training courses within government departments • Focussed awareness programs for managers and decision makers • Public awareness programs for affected communities•	• More efficient use of money and resources in essential monitoring • More sensitive management of natural resources • Better understanding of the nature of environmental sustainability in Australia
Biomonitoring techniques insufficiently developed and proven	• Insufficient understanding and research	• Better and more appropriate techniques for specific situations	• Research on new techniques of biomonitoring	• More efficient use of resources • Sensitive management
Remote sensing techniques restricted in application	• Techniques still under development	• Better techniques for remote and/or extensive systems	• Continuation of existing research and evaluation	• More efficient use of resources • Sensitive management

Priority Issue 6

Wetland valuation

Decisions involving wetlands can usually be characterised as choices between alternative, competing uses for those natural resources. The alternative uses may be direct as in the case of the choice between draining a wetland for a housing development and conserving it as a wildlife refuge. Alternatively the uses may be indirect, involving spill-overs from other activities. For instance, contamination of a wetland may result from the use of toxic compounds such as pesticides in a neighbouring land use.

Choices made in the past between alternative uses of wetlands have frequently been poor because proper consideration has not been given to those wetland uses that produce non-marketed values. It has often been the case that wetlands have been used to secure marketed values such as those arising from agriculture or housing without thought being given to the non-marketed values of wetlands that were given up. Whilst these non-marketed values do not necessarily generate dollar profits, they are nonetheless important to the well-being of the community.

It is important to the well-being of the community that these non-marketed values of wetlands be given recognition in decision making. A powerful way of achieving this recognition is through the estimation of their value in the same units as market values are recognised—money.

Whilst economists have made considerable advances in the estimation of non-market values of natural resources in general, the field of research is still in its infancy. Techniques that have been established are far from perfected and only a very small number of case study applications have been made. The development of the field as it applies to wetlands is embryonic.

What is required is the evolutionary development of non-market valuation techniques across an array of applications. With the advancement of capability will come an expanding set of case studies that will provide a base for the extrapolation of value estimates to other sites of current policy making interest. The LWRRDC National Wetlands R&D Program can make a significant contribution to this process in the context of wetlands decision making.

Table 8 Priority issues and proposed R&D—Wetland valuation

Issue(s)	Underlying cause(s)	Outcomes for management	Proposed R&D	Justification
The conservation values of wetlands are not readily quantified in units that can be compared with the values of competing alternative, developmental uses. Decisions regarding the optimal use of wetlands are thus made more difficult.	Markets do not extend to the conservation values of wetlands. Many of these values are 'public goods'. Market valuation (and allocation processes) are therefore not tenable.	• advances in the ability of economists to provide accurate and reliable non-market values for wetlands and other natural resources • a data base of wetland values to be used as the foundation for a 'benefit transfer' process • an understanding of the most appropriate mechanisms for integrating non-market values into wetland decision making	• experimentation with innovative non-market valuation techniques—a contribution to the evolutionary development of these techniques. • a range of small projects to apply established non-market valuation techniques to a varied selection of wetland case studies • an analysis of the integration of non-market values into wetland policy making	Benefits include: — improved use of wetland resources (sub-optimal decisions regarding wetlands will be more likely avoided with better information); and — lower costs of decision making (especially with the 'benefit transfer' process in place). • These benefits are likely to be substantial, especially given that advances made for wetlands are likely to be transferable to other natural resource settings. • Probability of achieving success is good given that little work has been done in the area in Australia. • Integration of research with other on-going Australian research would be advantageous to all studies. • Costs of the research are likely to be small in comparison to the expected benefits generated.

Priority Issue 7

Information/technology transfer

The Information/technology transfer sub-program aims to communicate findings of the Wetlands Research and Development Program to wetland managers, including landholders, communities and Aboriginal and Torres Strait Islanders. It is intended that the Information/transfer sub-program will run as a separate project and be incorporated into each project that is funded under the Research and Development Program.

In order to develop a strategy for the Information/technology transfer sub-program, the following need to be considered.

- determine who is to receive information on the findings of the Research and Development Program (the target audience);
- ascertain the best way to reach the target audience (eg. publications, training or seminars). This may include deciding whether or not the findings need to be translated into a less technical and more user-friendly format;
- determine how the target group can become involved in the Research and Development Program;
- explore potential links with community education/awareness programs already in existence; and
- obtain currently available education and awareness materials and programs from government, non-government and community groups.

The Wetland R&D Program will achieve information and technology transfer in two ways by:

- establishing a separate Information and Technology Transfer sub-program with the Wetlands R&D Program to fund specific R&D projects. These could include a range of activities such as studies to identify the barriers to adoption of research findings, holding seminars with researchers, managers and community to identify common priorities for wetland R&D projects or the preparation of educational and training materials based on existing research findings.
- establishing an Information and Technology Transfer component in all projects funded under the Wetland R&D Program. This will require that R&D projects specify, at the project stage, how they will address key stakeholder concerns, priorities and involvement in funded projects as well as the communication and adoption of the research findings.

The involvement of communities and wetland managers in the Wetlands Research and Development Program could be achieved through representation on project assessment panels and steering committees. This would ensure that the views of wetland managers were considered and increase the likelihood of research projects addressing the needs of managers. Active community involvement in projects may also help to overcome many of the impediments to the adoption of research findings (outlined as a priority research area in the Scoping Review).

It is hoped that through steering committees or monitoring activities, communities will become better informed about wetland issues and realise ownership and responsibility for wetland health. Community participation in research and development projects could, therefore, extend to on-ground management activities where appropriate.

Justification

The needs of the wider community in relation to wetland management should be addressed by the National Wetland R&D Program. Information about how the Program may affect people locally requires explicit consideration. Research findings require translation into a form suitable for managers and the wider community.

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