

WETLAND MANAGEMENT PROFILE

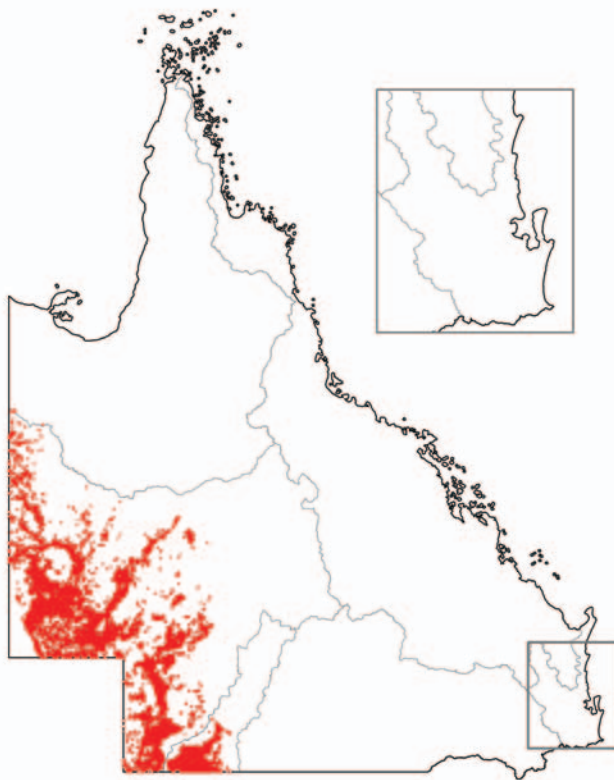
ARID SWAMPS

Arid swamps vary from predominately fresh to predominately saline, or move from fresh to **brackish** to saline as they dry out; they might support grass, sedge, herb, shrub or tree vegetation communities and are found in the **arid zone**. These swamps can be sites of extraordinary biological diversity when inundated, supporting abundant and diverse waterbirds, native fish, invertebrates and **aquatic** plants. Swamps in arid environments can experience highly variable inundation regimes resulting from erratic and unpredictable water inputs from year to year. After large floods, many arid swamps provide prime fodder for livestock and some support enormous populations of waterbirds providing food and nesting sites for breeding colonies.

Maintaining the natural flows of inland floodplain rivers is essential to support grazing enterprises and to ensure arid floodplain swamps maintain their ecological integrity. Other management issues include grazing pressure and invasive species.

This profile covers the habitat types of wetlands termed arid tree swamps, arid and semi-arid lignum swamps, arid and semi-arid grass, sedge, herb swamps, and arid and semi-arid saline swamp—isolated and fringing lakes.

This typology, developed by the Queensland Wetlands Program, also forms the basis for a set of conceptual models that are linked to dynamic wetlands mapping, both of which can be accessed through the WetlandInfo website <www.derm.qld.gov.au/wetlandinfo>.



Map showing the distribution of arid swamps in Queensland; grey lines indicate drainage divisions. Map: From Queensland Wetlands Mapping v2.0 (September 2009)

Description

The term 'swamp' refers to palustrine wetlands: those dominated by trees, shrubs and/or other persistent **emergent** plants and contained in basins (depressions) or flats. The **palustrine** definition also includes wetlands lacking such vegetation which have the following three characteristics: where active waves are formed or bedrock features are lacking; where the water depth in the deepest part of basin less than 2m at low water; and the salinity due to ocean-derived salts is still less than 0.5 per cent.

This profile excludes riverine wetlands within major rivers and creek channels, but includes wetlands with networks of shallow **braided** channels (gutters).

Lacustrine wetlands, that is, water bodies (lakes, and claypans larger than 8 ha) in basins but not dominated by perennial emergent vegetation, are addressed in the arid and semi-arid lakes management profile <www.derm.qld.gov.au/wetlandinfo>. These broad types can sometimes occur in the same site, for example, where inundated shrub or sedge swamp occurs as a wide fringe around a lake.

In gently sloped **arid zone** landscapes, on wide floodplains, it can be difficult to determine wetland from non-wetland ecosystems during dry periods.

Inundation of wetlands can be highly variable and generally tends to be less frequent and less predictable with distance from the coast. Those areas that are wet more frequently (in the arid zone context, once every 2–5 years) or annually (rather than infrequently, for example inundated once every 6–10 years) tend to have vegetation communities present that reflect a more regular presence of water.

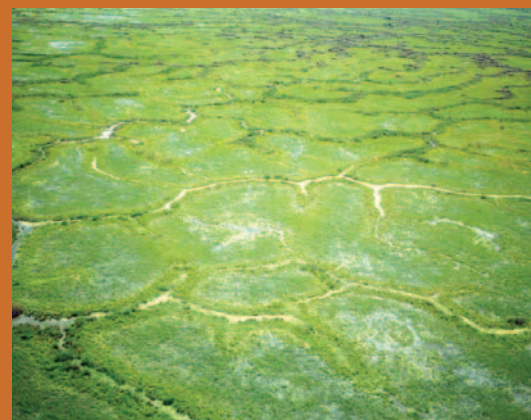
In terms of location in the landscape and water flows, arid swamps can be found in a range of positions on diverse **substrates** and can form complexes of different swamp types. This, combined with unpredictable flows, creates a wide range of temporally and spatially different aquatic ecosystems.

Arid floodplain swamps form on **alluvial** sediment such as deep-cracking grey clay and are watered by flood events that may originate hundreds of kilometres upstream. These swamps include:

- dense linear networks of braided and/or tightly meandering shallow gutters through which water passes slowly, differing from more deeply channelled floodplains that transmit water quickly
- delta-like networks of radiating distributary channels that have no clearly defined downriver connection
- networks of interconnected gutters in patterns of joined polygons, which do not drain efficiently
- low-lying areas near the upland margins of the floodplain, often at the end of delta swamps, from which much of the water cannot escape or flows out slowly
- extensive swamps up to many kilometres wide around lakes in large depressions within floodplains, or around major waterholes, or on the beds of lakes or large claypans connected to major river systems by a tie channel.

Near the floodplain edge arid swamps may receive significant inflow and different sediment from adjacent upland areas, especially where the upland is hard or stony, such as a plateau with a stony surface.

Other arid floodplain swamps form where parallel sand dunes extend from upland regions on to major floodplains and trap river flood waters in their swales. These linear swamps (and lakes) lie on a combination of deep cracking and harder clays and may be several kilometres long with narrow connections between swales. Some of these swamp complexes are also fed by local creeks: a major example is at the confluence of Farrars Creek and the Diamantina River.



Arid floodplain swamps form in a variety of geomorphic settings such as these braided gutters (above), mazes of interconnected gutters (middle) and polygons of interconnected gutters (below). These are found on broad floodplains fed by river flows. Photos: Roger Jaensch, Wetlands International



Inland non-floodplain swamps in the swales of desert sand dunes.

Photo: Roger Jaensch, Wetlands International

Arid non-floodplain swamps occur on hard (weakly cracking) clay substrate underlying sand masses such as the dunefields of the Simpson Desert and, because of impeded drainage, comprises countless individual swamps and ponds. These non-floodplain swamps obtain water from direct rainfall, local run-off, or minor creeks during very wet conditions. They consist of open water habitats and swamps of up to a few hectares in area and occur between long, parallel sand dunes and within broad fields of crescent-shaped, near-circular or irregularly-shaped dunes.

Others occur on plateau surfaces comprising small stones (**gibber**) overlying hard clay. They can be isolated, round-shaped sump wetlands with distinctive radial gutters, or complex networks of myriad irregular wetlands where parallel sand dunes extend across a plateau.

Arid saline swamps occur either fringing inland saline lakes or as isolated swamps on sediments that contain salts.

Water in arid swamps can range from fresh to saline and from naturally highly turbid with suspended clays (brown or milky in colour) to clear.

The above typology applies directly to the Channel Country but outlying arid swamps in surrounding **bioregions** generally fit into this scheme. Many hundreds of unconnected or semiconnected swamps in depressions on gently undulating sand plains occur in the western Mulga Lands.

Many arid swamps, especially those on floodplains, have pronounced **gilgai** hollows less than 1 m deep and 1–3 m wide, which may be nearly continuous across the wetland.

Water quantity, quality and physical structure determine the ability of a wetland ecosystem to function and its suitability for species habitat or foraging. Water in arid swamps is normally fresh and naturally highly turbid (brown or milky in colour) due to fine clay in suspension. Water in some swamps may clear where it has been standing for some weeks, where there is dense low vegetation, or where an increase in salinity occurs as the wetland dries out, but water in many swamps may never clear. Arid tree swamp may have acidic brown-coloured water due to the presence of **tannins**.

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High **evaporation rates** (measured in metres and so greatly exceeding rainfall) ensure that most arid swamps, both river-fed and isolated, are temporary, unless they have a groundwater source during dry periods. Many hold water only for weeks at a time, and often only during one year in five. Despite this, the biodiversity values of these wetlands are not diminished; biological productivity can be 'explosive' when inundation occurs, partly because arid zone species are both opportunistic and highly adapted to these conditions. The existence of wetlands that support an abundance of flora and fauna in an arid zone imparts special importance in the same sense as oases in a desert.

Shrubs, grasses, sedges and herbs are commonly associated with arid swamps, particularly following inundation but many persist during dry times also. Trees dominate some arid swamps, particularly those with higher water input, which can also experience a growth of tall tussock grasses, legumes, sedges and herbs in their understorey following inundation.

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Waterbirds are conspicuous in inundated arid swamps because many of them are sizeable, mobile and abundant and they comprise many species. Even more abundant in freshwater arid swamps are frogs and fishes, the latter as transients as long as swamps remain connected to river channels. Invertebrates and **phytoplankton** of arid swamp are the food that sustain many of the larger animals but are poorly known, compared with invertebrates of waterholes. This is partially due to the transient nature of the swamps.

Distribution

The wetlands described in this profile occur prolifically in the Channel Country bioregion in the far south-west of Queensland (the arid zone) and to lesser extent in surrounding bioregions (Mitchell Grass Downs, Mulga Lands, Desert Uplands). This distribution principally is a consequence of landform: depressions in alluvial plains, the braided inland rivers and extensive sand-dune fields that provide the water or impede the drainage of many of the inland wetlands have their greatest extent in the far south-west of Queensland. The dune fields are in turn partly a consequence of the arid climate, which is most pronounced in the south-west of the state: dry (and often windy) conditions favour the spread of sand that is not stabilised by vegetation. Mean annual rainfall in the south-west corner of Queensland is less than 250 mm; rain may fall in any season but periods longer than 12 months can pass without any rain.

ARID swamps occur prolifically in the Channel Country of Queensland.

The existence of many of the arid swamps in this area is due to the passage of major rivers through the arid zone, notably the Georgina (which becomes Eyre Creek in its lower reaches), Diamantina, Cooper, Bulloo and Paroo Rivers. Inundation of many arid swamps is determined largely by rainfall in the headwater **catchments** of the rivers, though major creeks within the arid zone (for example Mulligan, Farrars, Whitula, Kyabra and Wilson Rivers/Creeks) can deliver substantial volumes of water. Accordingly, local climate can be unrelated to local wetland conditions. The northern catchments (Georgina and Diamantina) are entirely watered by summer–autumn **monsoonal** rainfall and thunderstorms; this applies in part to the central (Cooper) and southern (Bulloo, Paroo) catchments but winter rain in those areas can also cause some river flows.

Arid swamps vary greatly in size from less than 1 ha to more than 10 km wide. Examples of smaller swamps are plentiful in the sand dunes and stony plateaus within 100–200 km of the South Australian border. Large examples include these swamps: that associated with Eyre Creek between Bedourie and the Simpson Desert; on the Diamantina River floodplain downriver of the junction of Farrars Creek; in the prominent westwards bend of the Cooper Creek floodplain, near the junction of the Wilson River; and those forming part of the Bulloo Lake complex, which continues into New South Wales.

The *WetlandInfo* website provides in-depth data, detailed mapping and distribution information for this wetland habitat type.

Queensland status and legislation

Wetlands have many values – not just for conservation purposes – and the range of values can vary for each wetland habitat type and location. The Queensland Government maintains several processes for establishing the significance of wetlands. These processes inform legislation and regulations to protect wetlands, for example, the status assigned to wetlands under the **regional ecosystem** (RE) framework.

A comprehensive suite of wetlands assessment methods for various purposes exists, some of which have been applied in Queensland. More information on wetland significance assessment methods and their application is available from the *WetlandInfo* website <www.derm.qld.gov.au/wetlandinfo>. Queensland has also nominated wetlands to *A Directory of Important Wetlands of Australia* (DIWA), see the appendix.

The Queensland Government has direct responsibility for the protection, conservation and management of wetlands in Queensland, a responsibility shared with local government and the Australian Government (for some wetlands of international significance). These responsibilities are found in laws passed by the Queensland parliament, laws of the Commonwealth, international obligations and in agreements between state, local and the federal governments. More information on relevant legislation is available from the *WetlandInfo* website <www.derm.qld.gov.au/wetlandinfo>.

Cultural heritage values

Because traditional use of arid swamps was transitory, there will generally be a lower density and more dispersed distribution of archaeological evidence of traditional occupation and use associated with these areas. Therefore, there is only a moderate likelihood of encountering cultural heritage sites within arid swamps. However, sites are more likely to be visible during dry periods when vegetation cover has decreased and soils are exposed such as through erosion.

Evidence of traditional occupation and use recorded within arid swamps is associated with occupation sites such as open camps, hearths, middens, stone artefact scatters and cultural sites (see <www.derm.qld.gov.au> for further information). Arid swamps can also have particular significance as story places, landscape features and as sites for cultural activities.

Scarred coolabah *Eucalyptus coolabah* and river red gum *E. camaldulensis* trees are encountered in some of the wetlands. Indigenous sites are likely to be found along swamp margins and in areas of higher ground adjacent to arid swamps, particularly in the vicinity of more permanent water.

Some arid swamps also have non-Indigenous (historic) cultural heritage significance, although most have not been surveyed or assessed for historic heritage values. The few historic heritage places recorded in arid swamps demonstrate evidence of their past and present use by the pastoral industry, including stock camps, stockyards, huts and watering points for cattle and sheep grazing. It is important to note that evidence of traditional occupation and use may also be encountered at historic sites.

Ecological values—introduction

Arid swamps are key components of the landscape of western Queensland and provide **ecosystem services** that include:

- **provisioning services**, such as livestock fodder
- **regulating services**, such as sediment and nutrient retention
- **cultural services**, such as Indigenous cultural values and sites
- **supporting services**, such as being important as habitat for animal taxa at a particular stage of their life cycle (for example, feeding and breeding, both juvenile fish and birds).

ALGAE, plants and invertebrates grow and complete their life cycles in a short timespan due to the ‘boom and bust’ ecology of arid swamps. They in turn support an abundance of fauna.

The ecology of arid wetlands is often described in the terms ‘boom and bust’. This means that, when inundation occurs, accumulated dry nutrients in the wetland bed interact with the water to drive an explosion of biological productivity. Algae, submerged, floating and emergent plants and invertebrates grow and complete their life cycles in a short time-span (often only days or weeks) and thereby support an abundance of **vertebrate** fauna (frogs, reptiles, fishes, waterbirds).

This phenomenon intensifies as the wetlands progressively dry out, particularly with the change in salinity that influences the invertebrate species present throughout this dynamic ecosystem response. Once the wetlands dry out (typically, only weeks or months later), plants and small animals die, returning nutrients to the soil, while mobile animals such as birds move away to other wetlands or regions. While this scenario is not unique to the arid zone, it is a key to the survival and successful recruitment of the opportunistic arid zone inhabitants, both **migratory** and local.

Ecological values—flora

Some arid swamps support just a small number of plant species, whereas others support diverse communities of trees, shrubs, grasses, sedges and **forbs**. The flora is not fully documented but at present no plant species is recognised as being **endemic** to the arid swamps of Queensland. The following description of plants in arid swamps focuses on the Channel Country bioregion but applies substantially to outlying wetlands of this type in nearby bioregions.

Where trees occur as a dominant species (to 5 m in height) or as scattered specimens in arid swamps, coolabah is the characteristic species. In outlying examples in the Mulga Lands, Mitchell Grass Downs or Desert Uplands, gidgee *Acacia cambagei*, yapunyah *E. ochrophloia* and/or river red gum may be present.

The most widespread and characteristic shrub of arid swamps is lignum *Muehlenbeckia florulenta*. In some broad wet areas on the Diamantina and Georgina systems, lignum occurs in parallel groves (to more than 3 m in height) or leopardskin patterns (as viewed from overhead).

During drought, lignum may reduce to spiny stems or a leafless grey clump of sticks; after inundation, the reinvigorated green lignum shrub, being a dense tangle of woody stems and intertwined vine-like stems, provides shelter and breeding sites for many animals.

Other characteristic shrubs of these wetlands are belalie (river cooba, native willow, myall) *Acacia stenophylla* (see box Belalie) and Queensland blue bush (golden goosefoot) *Chenopodium auricomum*, both of which may be dominant over entire swamps.

Where salinity increases, particularly in the western rivers (Georgina-Mulligan systems), **samphires** *Halosarcia* spp. and *Sclerostegia tenuis* and old man saltbush *Atriplex nummularia* are common in the swamps.



Coolabah *Eucalyptus coolabah* (above) and gidgee *Acacia cambagei* (below) are found in some arid swamps. Photos: Roger Jaensch, Wetlands International

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Lignum *Muehlenbeckia florulenta* shrubs.
Photo: Roger Jaensch, Wetlands International



Lignum can grow in parallel groves (above) and in a leopard-skin pattern (below).
Photos: Roger Jaensch, Wetlands International



Queensland blue bush *Chenopodium auricomum* can dominate large areas of arid swamps.
Photo: Roger Jaensch, Wetlands International



An arid swamp supporting Queensland blue bush surrounded by yellow flowered forbs that appear after a major flood.
Photo: Roger Jaensch, Wetlands International

Swamp canegrass *Eragrostis australasica* is a typical tussock grass of arid swamps and is generally found on harder, less deeply cracking clays.

Dense stands of fresh leafy plants to 2 m height occur in floodplain and inter-dunal swamps, but under drought conditions they may be reduced to small stubs. Channel millet (wild sorghum) occurs in wetter sites (see box). Other typical grasses include beetle grass *Leptochloa fusca*, pepper grass, rat's tail couch, neverfail *Eragrostis setifolia*, *E. dielsii* and Flinders grasses *seilema* spp.. Different species such as spiny mudgrass *Pseudoraphus spinescens*, *Elytrophorus spicatus*, *Brachyachne tenella*, silky browntop *Eulalia aurea* and *Paspalidium jubiflorum* occur in outlying sites in surrounding bioregions.



Swamp canegrass *Eragrostis australasica* is a typical tussock grass of arid swamps.

Photo: Roger Jaensch, Wetlands International



The spike rush *Eleocharis pallens* is found along gutters of arid swamps.

Photo: Roger Jaensch, Wetlands International



Eleocharis plana in the Channel Country.

Photo: Roger Jaensch, Wetlands International

The dark green, flat-stemmed spike-rush *Eleocharis plana* occurs extensively in swamps within floodplains, sometimes occupying all space between any shrubs that are present (for example, in some Diamantina and Bulloo wetlands). Another spike-rush, *E. pallens*, persists along the edges of gutters or sometimes across entire swamps. Downs nut-grass *Cyperus bifax* and rice sedge *C. difformis* also are typical sedges, their mature seed-heads providing a distinctive, short, brown-yellow vegetation community.

If inundation of deep-cracking clay occurs in the hotter months, dense stands of the legumes *Sesbania cannabina* and budda pea *Aeschynomene indica* may fringe swamp gutters or extend throughout the swamps. Where several pulses of flooding occur in a season, these thickets may reach 2 m in height but occurrence seems to be cyclic, not usually in consecutive years. Common, shorter erect forbs appearing after inundation include nut heads *Epaltes cunninghamii*, joyweed *Alternanthera nodiflora*, annual verbine *Cullen cinerea*, *Ammannia multiflora*, fireweed *Senecio lautus* and *Goodenia* spp.

Swards of some of these forbs provide a colourful spectacle as they mature and flower, even more so on the less frequently inundated floodplain. Of special value to graziers is Cooper clover *Trigonella suavissima*, which can be prolific in swamps and higher floodplains after flooding in the cooler months.

Aquatic plants on the water surface in wetter sites include cow (potato) vine *Ipomoea diamantinensis* (favoured by cattle) and water primrose *Ludwigia peploides* ssp. *montevidensis*.



Budda pea *Aeschynomene indica* (above) and sesbania pea *Sesbania cannabina* (below) are legumes that can be found in arid swamps. Photos: Roger Jaensch, Wetlands International

Submerged plants include red water milfoil *Myriophyllum verrucosum* (see boxes Nardoo, Channel millet and Belalie).

Natural dieback or disappearance of the vegetation of arid swamps is mainly caused by climatic variation or cycles. These changes can be compounded by inappropriate land use practices and the impact of feral animals (see Sustainable grazing and Feral animals).



Cow vine *Ipomoea diamantinensis* with water primrose *Aponogeton queenslandicus* in the background. Photo: Roger Jaensch, Wetlands International



Water primrose *Ludwigia peploides* ssp. *montevidensis* is an aquatic plant that occurs in arid swamps. Photo: Roger Jaensch, Wetlands International

NATURAL dieback or disappearance of the vegetation of arid swamps is mainly caused by wet-dry cycles and major dry periods. These changes can be compounded by inappropriate land use practices and the impact of feral animals.

NARDOO

Nardoo is a small plant that forms dense mats in wetlands both on deep-cracking clay and harder claypan substrates. It is a good indicator of land subject to inundation. The common species in the arid zone is *Marsilea drummondii* but other species occur in swamps in less arid regions of Queensland. During dry periods, the copper-red dry foliage can persist above ground but when inundation returns, bright green cloverlike leaves on short stalks emerge from the below ground rhizomes and float on the



Nardoo *Marsilea drummondii* (an aquatic fern) floating on the highly turbid water found in arid swamps. Photo: Roger Jaensch, Wetlands International

water surface or stand erect above water forming a lush marsh up to 30 cm high. Nardoo is a fern and produces spores in capsules (sporocarps) below ground when mature. The spores can withstand drought and germinate rapidly. Indigenous people collected large quantities of the sporocarps and after grinding and adding large amounts of water to dilute the toxins, formed it into a thin paste that was eaten raw or cooked into thin cakes. Nardoo may be toxic to livestock under certain conditions.



Characteristic copper-red foliage of dry nardoo being inundated with new-season flood water. Photo: Roger Jaensch, Wetlands International

CHANNEL MILLET

If floods inundate arid swamps of the Channel Country in the hotter months (November–February) and soil and seed conditions are favourable, wetter parts of these wetlands can produce a prolific crop of channel millet *Echinochloa turneriana*. This indigenous tussock grass stands up to 2 m high and can be heavily laden with seeds (of large size for a grass).



Channel millet *Echinochloa turneriana* is common in arid swamps of the Channel Country. It is used by waterbirds to line their nests and provides fodder for cattle. Photo: Roger Jaensch, Wetlands International

It is a valuable fodder plant for cattle and remains common in swamps on deep-cracking grey clay in the Channel Country, but has declined due to excessive grazing pressure in some parts of Australia. Though not structurally adequate for supporting waterbird nests on its own, ducks and water hens nest in lignum shrubs that are intermixed with channel millet, using this grass to line their nests.



Head of channel millet *Echinochloa turneriana*. Photo: Roger Jaensch, Wetlands International

BELALIE

Acacias are not usually thought of as wetland plants but belalie or river cooba *Acacia stenophylla* is a particularly important tall shrub or low tree of arid zone swamps. Known in some areas as 'native willow', the plant is distinguished by its weeping silvery green foliage and dark trunk. It grows in the frequently inundated parts of swamps on floodplains and on river channels. Two species of colonial breeding waterbird seem to prefer nesting in this plant if large specimens occur in an inundated wetland where a colony has established: glossy ibises *Plegadis falcinellus* and nankeen night herons *Nycticorax caledonicus* typically nest in low forks of belalie, well below the canopy. Other colonial species that commonly nest in belalie include great egret *Ardea alba* and little black cormorant *Phalacrocorax sulcirostris* (in the canopy) and darter *Anhinga melanogaster* and royal spoonbill *Platalea regia*. Unlike wetland eucalypts, belalie is not fire resistant but it will re-shoot from ground level.



Belalie *Acacia stenophylla* is a characteristic shrub of arid swamps. Photo: Roger Jaensch, Wetlands International



Nestling glossy ibis in belalie shrub. Photo: Roger Jaensch, Wetlands International

Ecological values—fauna

The diversity and composition of animal species in arid swamps varies according to wetland sub-type, and inundation through either connection to floodwaters or filling by local rain and remaining separated from river flows. Generally diversity is at moderate to high levels, imparting considerable biodiversity value to these wetlands. Larger and more complex arid swamps can support more than 70 waterbird species, with over half of them breeding on site, and a suite of freshwater fishes and frogs. Information on invertebrates is patchy and incomplete but, based on research in the Currawinya Lakes area, substantial and distinctive invertebrate assemblages occur in temporary arid wetlands and different suites of species are present under different inundation regimes.

Even though some small swamps might support few conspicuous vertebrates, they can harbour a diverse microfauna. Phytoplankton plays a key role in these ecosystems as well. Swamps provide specific shelter and food resources for aquatic invertebrates. The composition and biomass of invertebrates changes through the filling and drying cycles. Largest among the **macroinvertebrates** are the freshwater crayfish *Cherax destructor*, freshwater crab *Austrothelphusa transversa* and shrimp *Macrobrachium australiense*. Some of these **crustaceans** can survive short drought periods by burrowing deep in the mud. Other typical invertebrates of lignum swamp wetlands are the **copepods** *Boeckella triarticulata* and *Calamoecia canberra*; the **cladocerans** *Daphnia* spp. and *Moina australiensis*; insects such as the water beetle *Eretes australis* and hemipterans; and the freshwater snail *Isidorella newcombi*. In isolated small claypans decapods can be absent but certain fairy, clam and tadpole shrimps (**phyllopods**), copepods and cladocerans are characteristic. Small pans are more alkaline than lignum swamps and have a rich and distinctive invertebrate fauna. The invertebrate fauna of swamps is significantly different to that of lake and riverine wetlands in the arid zone.

FISH are a key ecosystem component of arid swamps that recolonise these areas via flood waters from connecting major creek/river systems. Connectivity across floodplains is essential for juvenile fish to access these rich, temporary habitats.

Fish are a key ecosystem component of arid swamps that are replenished through floodwaters that form connections to major creek/river systems. Little is known of the fish fauna of the swamp wetlands, with most research being focused on permanent and semi-permanent waterholes. Many of the smaller species can be assumed to frequent swamps during and soon after inflows because they make substantial migrations.

Recolonisation of swamp by fish might depend on fish surviving in permanent waterholes during drought periods. Thus connectivity across floodplains is essential for juvenile fish to access these rich, temporary habitats. Known or likely inhabitants of swamps include the moonfish (silver tandan) *Porochilus argenteus* and Hyrtl's tandan catfish *Neosilurus hyrtli*, bony bream *Nematolosa erebi*, spangled perch *Leiopotherapon unicolour*, banded grunter *Amniataba percoides* (only in the Georgina River system), desert rainbowfish *Melanotaenia splendida tatei*, western chanda perch/glassfish *Ambassis mulleri*, and gudgeons *Hypseleotris* spp.. Several taxa, for example Welch's grunter *Bidyanus welchii* and the poorly known false-spined catfish *Neosilurus* sp. from the Bulloo drainage system, are endemic to certain arid zone rivers but their status in swamp is unknown.



Banded grunter *Amniataba percoides* is found in arid swamps of the Georgina River system.
Photo: Roger Jaensch, Wetlands International

Frogs of the arid swamps include the chirping froglet *Crinia deserticola*, water holding frog *Cyclorana platycephala*, *Neobatrachus centralis* (in the far west), desert burrowing frog *Limnodynastes spenceri* (in the far west), broad palmed rocket-frog *Litoria latopalmata*, ruddy treefrog/desert treefrog *Litoria rubella* and holy cross frog *Notaden bennetti*.

The eastern snapping frog *Cyclorana novaehollandiae*, greenstripe frog *Cyclorana alboguttata*, grassland collared frog *Cyclorana cultripes*, northern snapping frog *Cyclorana australis*, rough collared frog *Cyclorana verrucosa*, and spotted grassfrog *Limnodynastes tasmaniensis* can be found in some arid swamps. Detailed studies of frogs and reptiles in arid swamps are few.

Most desert frogs burrow so species composition for frogs in the wetlands may vary according to the suitability of the substrate of the wetland bed and margins, that is, deep cracking clay versus sand.

Waterbirds travel great distances, probably from around the continent, to exploit abundant fish, frog and invertebrate resources when arid swamps are inundated. The following information refers particularly to swamps of river systems of the Channel Country but much of it (apart from breeding colonies) applies at a smaller scale to arid swamps in general.

Fish-eating waterbirds that feed and breed in river-fed swamps include little black cormorant and darter (nesting in inundated coolabah or belalie trees), while the tree-nesting little pied cormorant *Phalacrocorax melanoleucos* mainly feeds on freshwater crayfish. Whiskered terns *Chlidonias hybridus* catch small fish and invertebrates and nest in loose colonies atop deeply inundated canegrass and shrubs, often in smaller swamps off-floodplain; nests are rarely seen and young spend only a short time in the nest. Fish as well as frogs/tadpoles and other wetland animals are the main food items for great egrets, intermediate egrets *Ardea intermedia*, nankeen night herons *Nycticorax caledonicus* and white-necked herons *A. pacifica*, which are abundant after floods have peaked and until the swamps dry up. Breeding colonies of hundreds to many thousands of these herons are situated in flooded trees and lignum at regularly used sites and are active during moderate to major floods.



The eastern snapping frog *Cyclorana novaehollandiae* (above) and the water holding frog *C. platycephala* (below) can be found in arid swamps. Photos: Craig Eddie, DERM

WATERBIRDS travel great distances, probably from around the continent, to exploit abundant fish, frog and invertebrate resources when arid swamps are inundated.



Nestling great egrets *Ardea alba*. Photo: Roger Jaensch, Wetlands International



Nankeen night heron *Nycticorax caledonicus* nestlings. Photo: Roger Jaensch, Wetlands International



Young straw-necked ibises *Threskiornis spinicollis* at nests in lignum shrubs.

Photo: Roger Jaensch, Wetlands International

Ibises and spoonbills are the other waterbirds that breed in colonies in the Channel Country, but invertebrates are their principal food. Straw-necked ibises *Threskiornis spinicollis* obtain grasshoppers, beetles and other insects from dry upland as well as floodplain meadows and breed (usually together with other colonial species) in aggregations of thousands to tens of thousands in major stands of lignum. They may be joined in the colonies by smaller numbers of Australian white ibis *T. molucca* and glossy ibis (see box), which feed in shallow swamps by probing, and by royal spoonbills *Platalea regia*, which filter feed. Yellow-billed spoonbills *P. flavipes* and white-necked herons are commonly found feeding in even the most isolated arid swamps and may nest as dispersed pairs.

Aquatic invertebrates are also a prime food for rails such as the Australian spotted crake *Porzana fluminea*, which nests in small inundated shrubs infused with grass/sedge, whereas the larger black-tailed native-hen *Gallinula ventralis* (see box) and purple swamphen *Porphyrio porphyrio* have more diverse diets and the Eurasian coot *Fulica atra* consumes submerged plants; all are lignumnesting species. Brolgas *Grus rubicundus*, small numbers of which nest on mounds in arid swamps, eat invertebrates as well as plant food.

The abundant black-winged stilt *Himantopus himantopus*, red-kneed dotterel *Erythrogonys cinctus* and Australian pratincole *Stiltia isabella* (ground nesters) and migratory shorebirds (non-breeding in Australia: see Species of conservation significance) feed principally on invertebrates. More than 10 species of ducks and allies occur in arid swamps and of the species that regularly breed (have nest sites and/or raise their young) in the wetlands, the plumed whistling-duck *Dendrocygna eytoni* and black swan *Cygnus atratus* feed mainly on plants, not always in the wetlands.



Royal spoonbills *Platalea regia* (above) nest in lignum. Photos: DERM and Roger Jaensch, Wetlands International

Grey teal *Anas gracilis*, freckled ducks *Stictonetta naevosa* (see box) and pink-eared ducks *Malachorhynchus membranaceus* feed on aquatic invertebrates by dabbling and/or filter feeding at the water surface, and hardheads *Aythya australis* dive for these items; all nest in the swamp, for example inside flooded lignum shrubs. Other species, more typical of southern or northern Australia, are sometimes present in wetter years.

The swamps also provide habitat for other animals such as the grey grasswren *Amytornis barbatulus* which is endemic to the arid swamps: it occurs only in lignum and canegrass swamps, dry or inundated, of the Lake Eyre and Bulloo-Bancannia **drainage divisions**. The long-haired rat *Rattus villosissimus* periodically occurs in large numbers in arid swamps.

MILLIONS of waterbirds can be present in major flood events in the Channel Country, when water persists for several months over several million hectares of swamp.

In major flood events, when water persists for several months over several million hectares of swamp in the Channel Country, millions of waterbirds can be present. Initially at low densities (little more than one bird per hectare), denser aggregations converge on sub-terminal persistent lakes as swamp of all sizes dry out. Ibises, herons, some rails and some shorebirds tend not to congregate but disperse to other parts of the continent, a strategy eventually followed by all species during severe drought. Given the importance of arid swamps to these species, reduced flooding could have an impact on continental populations of waterbirds.

Swamps covered in this profile but located in bioregions beyond the Channel Country tend to be smaller and isolated and so can be expected to support fewer species and fewer individuals of wetland animals.



Plumed whistling-ducks *Dendrocygna eytoni*. (above) and pink-eared ducks *Malachorhynchus membranaceus* feed and nest (below) in arid swamps. Photos: Roger Jaensch, Wetlands International

GLOSSY IBIS

Though not as well known or abundant as Australia's other ibis species, the glossy ibis *Plegadis falcinellus* has a wider range, including parts of the Americas, Africa and Eurasia to Indonesia. An all-dark bird with a coppery red-green sheen on its fresh plumage, it probes in shallow water and mud—especially where supporting short vegetation—for invertebrate food. Although it can be found in most parts of northern and eastern Australia, for a long time there was a mystery concerning its breeding areas. The known small colonies in the Murray–Darling Basin could not account for the large non-breeding aggregations of birds (30 000–60 000) seen each winter in tropical wetlands such as the Alligator Rivers region. Surveys in the last two decades have revealed that glossy ibises also breed at rarely explored swamp in Australia's savannah and arid zones. Some of the largest known colonies (5000–10 000 pairs) are in the Channel Country, where glossy ibises nest in inundated belalie and lignum, usually with other colonial waterbirds, and at least one major colony of the glossy ibis is known from each Channel Country river system within Queensland. Precise movement paths are not known, but most glossy ibises leave the Lake Eyre Basin once its extensive swamps have dried out.



Glossy ibis *Plegadis falcinellus* probe shallow waters of arid swamps for food.

Photo: Roger Jaensch, Wetlands International



Glossy ibis are found in large colonies in arid swamps of the Channel Country.

Photo: Roger Jaensch, Wetlands International

BLACK-TAILED NATIVE-HEN

Known to landholders around Australia as the 'water hen', the black-tailed native-hen *Gallinula ventralis* is a member of the rail family Rallidae and so is related to swampheens, coots and crakes. This olive-black bantam-like bird has been recorded breeding in many parts of the continent but the core area for large scale breeding, particularly since the demise of many Murray–Darling wetlands, is the Channel Country. Soon after the peak of moderate to major floods, native-hens lay clutches of 4–12 eggs (average 6) in nest bowls constructed inside lignum or other shrubs, over water typically 30–50 cm deep, in loose aggregations. The eggs hatch after 20 days, and shortly afterwards the mobile young are tended by the parents away from the nest, so swamps can be noisy with the conversations of native-hen families. As the swamps dry out, adults and independent young may linger for a while feeding on fresh plant growth, but as drought returns, mass exodus follows.



Clutch of black-tailed native hen *Gallinula ventralis* eggs.

Photo: Roger Jaensch, Wetlands International

During major irruptions, tens of thousands of native-hens travel south and east and appear in wetlands, cereal paddocks and other open country as far away as coastal districts. The subsequent mortality losses are not known, and presumably are high, but enough birds survive to return inland and breed when inland rivers flood once again. Native-hens thus provide a classic illustration of the boom and bust cycle of arid swamps.

SPANGLED PERCH (SPANGLED GRUNTER)

Occurring throughout inland Australia, the spangled perch *Leiopotherapon unicolour* is the most widespread freshwater fish in Australia. It is silvery coloured with spotted sides. Never growing much larger than 20 cm, nevertheless by its abundance it is an important link in the food chain, supporting piscivorous waterbirds such as pelicans and cormorants as well as predatory fishes. A hardy fish, the spangled perch occurs in most freshwater wetlands, from rock waterholes to swamps in claypans; it can survive water temperatures up to 42°C but does not tolerate the high salinity of salt lakes. Spangled perch migrate across the full extent of inundation when rivers flood and presumably spawn in swamps. Maintaining full connectivity of wetlands, by not creating barriers to water and fish movement, is therefore desirable. Spangled perch range even farther afield if opportunity presents, moving along roadside gutters and perhaps through sheet flows during rainstorms.



Spangled perch *Leiopotherapon unicolour* form an important part of the food chain in arid swamps and other wetlands in inland Australia.

Photo: Heather McGuiness

Reports of fish 'raining' from the sky have been attributed to species such as the tenacious spangled perch travelling far and wide via temporary waterways. In one instance, hundreds of young spangled perch were observed swimming more than 15 km in six hours along a wheel rut.

Species of conservation significance

Two wetland-dependent bird species that occur in arid swamps are listed as threatened species: the Australian painted snipe *Rostratula australis* (vulnerable under EPBC Act and NC Act) and the gulf/inland subspecies of yellow chat *Epthianura crocea crocea* (vulnerable, NC Act).

Australian painted snipe typically inhabit swamp wetlands that offer a mix of medium to dense low shelter as well as open muddy or marshy shallows for feeding. Swamps in the arid zone therefore seem particularly suitable because often they are not as densely vegetated as many of the coastal swamps, though they may be inundated less often. There is a small number of records from arid swamps in Queensland, in part probably a reflection of suboptimal timing of observer effort. Breeding has been recorded on a low islet in sparse lignum and patchy *Eleocharis plana* on the Diamantina floodplain.

Occurrence of yellow chats of the gulf/inland subspecies *E. c. crocea* in certain bore drain swamps in the arid zone has been known for some decades. However, only in the last 10 years has this subspecies been recorded in numbers in natural wetlands, specifically in lignum-dominated, inundated swamps and lakes on the Georgina–Eyre and Diamantina floodplains. (This new information has been due to

appropriately timed observer effort.) With the capping of some bores in the Great Artesian Basin, these natural wetlands will remain as important habitats for the chat. It seems that yellow chats move to green, dry lakebeds once the swamps dry out, which illustrates the importance of networks of wetland habitats for wildlife.

Migratory shorebirds breed in Asia and visit Australia during the non-breeding period. At least half a dozen species, listed as migratory species under the EPBC Act, occur regularly in arid swamps when inundation has occurred. This usage is probably most pronounced (but not well recorded) during the northward migration period (March–April), due to summer–autumn being the period for most inland river flows in Queensland, and presumably involves some shorebirds that have left the southern coastal regions. During southward migration (August–September) into Queensland from Asia, most arid swamps are dry but drying lakebeds may provide habitat in the arid zone at this time.

A number of inland wetlands in Queensland qualify for listing in the Shorebird Site Network of the East Asian–Australasian Flyway <www.environment.gov.au/biodiversity> and some include arid swamps; nominations to this non-regulatory network are currently under consideration.

Though not proven to be truly migratory, several waterbirds of arid swamps, notably the great egret and glossy ibis, are listed as migratory under the EPBC Act because they are included in the lists of **JAMBA** and/or **CAMBA**.

WetlandInfo provides full species lists of wetlands animals and plants.

FRECKLED DUCK

The estimated population of the freckled duck *Stictonetta naevosa*, an Australian endemic, is normally fewer than 30 000 birds which, for a duck, is relatively small. This species has a similar life history to the black-tailed native-hen (see box) and today depends substantially on floods in Channel Country rivers for recruitment to the population. Its nest is a well-made bowl placed in lignum or in low tree forks over water; most records of breeding are from swamps. After breeding, birds congregate on arid zone lakes of which Lakes Torquinie–Mumbleberry, Muncoonie, Machattie and Numalla are used by largest numbers. The freckled duck has become an iconic species for conservationists because hundreds were killed (illegally) during duck hunting seasons in southern Australia in the early 1980s, following an irruption from the inland to coastal districts.

This threat has been addressed through hunter education, site closures and (in some states) cessation of duck hunting, but a lack of availability of swamp habitat for breeding continues in the



Male freckled ducks *Stictonetta naevosa*.

Photo: Roger Jaensch, Wetlands International

Murray–Darling Basin and is a potential threat in the Channel Country.

Wetland-dependent bird species listed as rare in Queensland (NC Act) and that use arid swamps are the freckled duck (regular breeding visitor or resident) (see box), blacknecked stork *Ephippiorhynchus asiaticus* (vagrant) and grey grasswren *Amytornis barbatus* (resident).

A declared rare plant *Aponogeton queenslandicus* has been recorded in swamps on the Cooper Creek floodplain.

LITTLE CURLEW

The little curlew *Numenius minutus* breeds in north-east Asia and most of its population migrates to Australia where it feeds on insects and seeds mainly in wet or dry, treeless tropical grasslands. However, it has a close association with wetlands which it uses for drinking and bathing on a daily basis and where it might also feed. In the last 10 years it has been discovered that internationally significant numbers occur in swamps of the Channel Country rivers (Georgina–Eyre and Diamantina particularly) after substantial floods. In March of 1999, 2001 and 2004, many flocks of hundreds, amounting to thousands in total, were discovered feeding in treeless short vegetation (dry or wet) and bare wet mud within swamps and on grassy lakebeds.



The little curlew *Numenius minutus* occurs in internationally significant numbers in arid swamps.

Photo: Roger Jaensch, Wetlands International

Other flocks were passing constantly in an upriver direction, sometimes stopping at pools in the swamps. This phenomenon together with use by thousands of sharp-tailed sandpipers *Calidris acuminata* documented concurrently, demonstrates that these wetlands (when inundated) play a key role in the annual cycle of migratory waterbirds.

MOST arid swamps are under leasehold tenure, generally operated as pastoral grazing enterprises. Graziers are key stakeholders in the management of arid swamps.

Managing the arid swamps

Most arid swamps are under leasehold tenure. These properties are generally operated as pastoral grazing enterprises and graziers are key stakeholders in the management of arid swamps. In the arid zone, pastoral companies own many of the leases: these entities are relatively few in number and some have a large number of public shareholders. Additional stakeholders include regional natural resource management bodies such as Desert Channels Queensland and Queensland Primary Industries and Fisheries, which facilitate cooperation among graziers on grazing land management. Some arid swamps are within protected areas managed by the Department of Environment and Resource Management (DERM) (see Queensland conservation status) or in privately managed reserves. DERM regulates use of water resources in the inland rivers. Mining companies extract or explore for oil and gas in parts of the arid zone including some swamps. Indigenous communities are stakeholders in regard to management of arid swamps through continuing direct association with sites and use of wetland resources. Native title claims may apply to some wetlands.

Successful management of arid swamps to ensure ecological sustainability of the current grazing industries, manage impacts and optimise conservation outcomes will depend on an integrated approach that engages all stakeholders. Arid swamps occur in wetland complexes that often include riverine and lacustrine wetlands, so it is necessary to manage the wetlands in an integrated manner across entire landscapes.

ENSURING the continuation of natural flows and connection of swamps to the river are the most important issues affecting arid swamps. These flows are crucial to maintaining wetland function and health.

Water

Ensuring the continuation of natural flows and connection of swamps to the river are the most important issues affecting arid swamps. These flows are crucial to maintaining wetland function and health. The flow regime of a river and connections of rivers to swamps govern biotic responses. Larger complexes of swamps within the floodplains depend on moderate to major river floods that drive ecological processes, including the replenishment of organic matter and groundwater. Breeding waterbirds may abandon their colonies if river flows are not sufficient to allow the breeding cycle to be completed. Minor floods serve to 'prime' the river system by giving specific cues for arid

WATER RESOURCE PLANING

Large areas of swamp wetland, many of national importance and meeting criteria for international importance, lie within the floodplains of the arid zone rivers in Queensland. Natural pasture that is prolific in these wetlands after floods is highly valuable to the grazing industry. Planning for the management of water resources in these river systems was conducted by DERM. Under the *Water Act 2000*, Water Resource Plans have been formalised for the Cooper Creek, Georgina and Diamantina, and Warrego, Paroo, Bulloo and Nebine river catchments. The process for preparation of these plans involved development of scientific reports and other information

documents, input by other experts, public meetings and public submissions before final gazettal. The three plans stipulate protection of natural river flows and overland flows to varied extent but do not specifically ensure protection for all swamps that depend principally on river flows for inundation. A widely accepted balance between environmental, agricultural, industrial and domestic requirements for water is difficult to achieve and vigilance is needed to ensure that guarantees of water for wetlands are not eroded in the future when economic demands rise. The challenge remains for implementation through Resource Operation Plans to be effective and faithful to the negotiated outcomes.

ARIDFLO

ARIDFLO, a multi-disciplinary project funded under the Australian Government Natural Heritage Trust and led by the South Australian Government in conjunction with the Queensland Government, investigated and modelled the hydrology and associated biological responses of wetland plants and animals during 2000 to 2003 under various flow conditions. A range of sites was selected varying from swamps to permanent and semi-permanent lakes. It was the first project of this kind in the Lake Eyre Basin, with a study area that crossed state borders, recognising the continuation of catchments and rivers across these arbitrary boundaries.

Five river reaches were selected in the Lake Eyre Basin, including two in Queensland. In Queensland, five sites were selected on the Thomson River reach and six sites on the Diamantina River survey reach. Specialists studied the ecology and populations of fishes, waterbirds, invertebrates and aquatic plants

through major floods (2000, 2001) and subsequent severe drought (2002, 2003).

Some of the major outcomes were the discovery of the importance of swamps for waterbirds and the importance of maintaining connection of floodplains and swamps to the rivers to facilitate fish recruitment. Aerial bird surveys along four rivers and local ground surveys revealed that millions of waterbirds use the swamps during and soon after major floods, before water dries up. Of special significance was documentation of numerous breeding colonies comprising tens of thousands of waterbirds, some of the largest (of ibises, egrets, night herons, spoonbills and cormorants) being in lignum-belalie swamp wetlands. Breeding by several threatened or rare waterbird species and major stop-over areas for migratory shorebirds, were recorded in some swamps. The new information collected comes from community knowledge and scientific surveys and is to be used by governments and communities to assist them in natural resource management.

species to start the reproduction cycle (for example, fish start to develop milt and ripen eggs), and by raising the height and width reached by floods that occur soon afterwards. Moderate floods may saturate the substrate of wetlands and produce new plant growth that slows down subsequent floods, causing them to spread wider on the floodplain and to inundate more swamp wetland, and for longer periods. Shallow sheet flow of water across floodplains is important for transfer of water, nutrients and fishes from channels to swamps but 'flood shadows' can occur where this overland flow is stopped by barriers such as the raised edges of graded tracks.

Accordingly, all river flows are important to the functioning of arid swamps and should be crucial elements of water resource plans. Catchment-based planning for water allocation, led by DERM, has addressed water flow issues in a number of catchments. Water Resource Plans, and where necessary Resource Operational Plans, were prepared under the Queensland *Water Act 2000* in catchments where human consumption needs and industry had a measurable impact or where rivers/wetlands have significant ecological, cultural or social values.

Water Resource Plans and Resource Operation Plans for the Paroo, Bulloo, Cooper and Georgina–Diamantina Rivers vary with respect to protection of

overland flows, swamps and waterholes and allocations for industry and urban/domestic use. For further information on water resource planning in Queensland, see the DERM website <www.derm.qld.gov.au>

A number of large swamps in the Channel Country occur where local creeks meet the river floodplain. Heavy rainfall or storms in the (often stony or hard) catchments of these creeks can lead to significant inundation of the downstream swamps; this can occur when no flow has occurred in the main river, or, alternatively, around the same time as a river flood. Water flows to the swamps can be reduced by the cumulative effect of water captured in small dams placed on tributary creeks.

SWAMPS, especially those in the floodplains of major rivers, provide some of the best pasture for livestock in the arid zone of Queensland. Ecologically sustainable grazing is considered to be achievable in arid swamps.

DRYLAND RIVER REFUGIA

A project team headed by Griffith University researchers investigated the ecology of selected waterholes on the Cooper and Warrego floodplains in Queensland as part of the Dryland River Refugia project. Though principally targeting

waterholes rather than swamps, the project identified benthic algae (algae attached to sediment on the waterhole edge and bed) as an important part of the foodweb in Cooper Creek waterholes. This might have implications for the ecology of associated swamps within floodplains. The project generated additional vital information.

Sustainable grazing

Swamps, especially those in the floodplains of major rivers, provide some of the best pasture for livestock in the arid zone of Queensland. In this context, grazing enterprises are highly dependent on river floodwaters.

Pastoral grazing has been practised for over 100 years in arid swamps and these ecosystems retain high biodiversity and landscape conservation values. Although there is no adequate baseline on condition of the wetlands before grazing started, both graziers and ecologists acknowledge that excessive and untimely total grazing pressure can degrade wetlands. However, ecologically sustainable grazing is considered to be achievable in arid swamps.

The inundation, boggy and prolific biting insects of swamps tend to naturally discourage use by

livestock until the wetlands have substantially dried out. However, if livestock are kept out of swamp paddocks (or densities minimised) until the swamps are dry, **pugging** (which breaks up less robust plant communities) may be reduced and completion of seeding by wetland plants (which will benefit future plant generations) may be enhanced. During drought, landholders could consider reducing grazing pressure on perennial vegetation such as lignum, when better food sources are scarce or unavailable.

Vegetation control

Lignum and belalie swamps are important habitats for wetland fauna and major waterbird breeding colonies occur in some of the larger lignum/belalie swamps when inundated. This can, however, be difficult country in which to muster stock. Consequently, it is a common practice for graziers to burn lignum–belalie

MANAGING GRAZING PRESSURE IN ARID SWAMPS

A swamp on a family run cattle property in the Channel Country bioregion provides a balance in an otherwise grazed landscape: a refuge for fauna and a place to simply relax and enjoy the natural values of the area.

The 300 ha swamp lies in 1000 ha of eucalypt–acacia woodland and stock are excluded by a fence constructed with assistance from the Australian Government Envirofund. Coolabah *Eucalyptus coolabah* and belalie *Acacia stenophylla* surround the swamp, and river red gum *E. camaldulensis* occurs along the adjacent creek line. Sedges *Cyperus* spp. occur in the shallow water and wet margins.

Many waterbirds frequent the area including white-necked herons, terns, grebes, spoonbills, water-hens and many species of duck which have successfully bred there. Cockatoos and parrots nest in the swamp's eucalypt hollows and honeyeaters feed on nectar from flowering

bats-wing coral trees *Erythrina vespertilio* along the associated creek lines. Burrowing frogs and possums are common in the swamp area.

In discussing what they see as the values of the swamp and surrounding bushland, the owners said 'We enjoy being able to watch the natural processes complete their cycles, unimpeded by domestic stock. It is a good spot to teach the kids about nature, or just to boil the billy and relax. We often take visitors to the swamp as there is always something interesting to see.'

'Managing the area is really just a case of checking the fence occasionally and watching out for weed species (none have turned up yet). Feral pigs are shot on sight—they can do a lot of damage in a place like this. We are careful not to disturb the area on a hot summer's day if birds are breeding. The summer temperature can be in the high forties—if the parent birds are disturbed and the eggs exposed to the sunlight even for ten minutes the chicks will die.'



Fire can travel along channels and burn lignum *Muehlenbeckia florulenta* to the ground. Further work needs to be done to determine an appropriate fire regime for arid swamps.

Photo: Roger Jaensch, Wetlands International



Burnt belalie *Acacia stenophylla* regenerating after a subsequent flood. Photo: Roger Jaensch, Wetlands International

swamps when the country is dry in the hope that these wetlands will be easier to work and more productive for grazing. The shrubs are often burnt to the ground but both lignum and belalie can regrow from below-ground root stock.

Some older Indigenous stockmen believe that, over time, burning produces a greater density of shrubs in the swamps but there has been no systematic scientific investigation of a managed fire regime (in terms of frequency, intensity and pattern) for swamps in the arid zone. To ensure that biodiversity is sustained under ongoing grazing land use, scientists and graziers could collaborate to determine an appropriate fire regime for lignum–belalie swamps as a high priority.

Weeds

At present, many of the arid swamps are free of weeds or are subject to relatively minor infestations of a few species, with long periods of **desiccation** providing a natural retardant to the expansion of outbreaks. *Parkinsonia Parkinsonia aculeata* (one of 20 Weeds of National Significance). Occurs sparsely in some swamps in the Channel Country, but is more prevalent in the Mitchell Grass Downs and Desert Uplands bioregions. Under the Queensland Land Protection (Pest and Stock Route Management) Regulation 2003, it is a serious offence to introduce, keep or supply this plant without a permit.

CONTROL OF PARKINSONIA IN THE COOPER FLOODPLAIN

The Cooper Creek floodplain in Queensland has long been spared the encroachment of major weeds. However, parkinsonia has become established at low density, extending downriver of Windorah. From an initiative developed by the Cooper Creek Catchment Committee grew the Cross-Catchments Weed and Feral Animal initiative. In collaboration with state and local governments, and supported by Desert Channels Queensland, the initiative facilitated a series of actions: aerial and ground weed survey work; digital mapping and prioritisation of infestations and weed-free areas across the Channel Country, Mitchell Grass Downs and Desert Uplands bioregions; and financial support of strategic on-ground weed control projects. This resulted in an accurate knowledge of weed distribution, an understanding within the rural community of what



Parkinsonia Parkinsonia aculeata is a Weed of National Significance that can infest arid swamps.

Photo: Roger Jaensch, Wetlands International

needed to be done and a much-reduced risk of weed invasion, especially of the Channel Country wetlands.

This thorny shrub can form dense thickets in wetlands and hinder stock movements but can be controlled by poisoning. Vigilance must be maintained to prevent the extent of infestation that has occurred in the northern savannas. Property managers can seek assistance from regional bodies and primary industry agencies to recognise and deal with these weed threats. See the Australian Government's Weeds in Australia website <www.weeds.gov.au> for further information.

Feral animals

Feral pigs *Sus scrofa* have been present in the arid zone of Queensland for many years but have not reached large numbers in the most arid and least inundated wetland systems. Wet years and/or large floods, especially when occurring in more than one successive year, probably facilitate the spread and increase in numbers of feral pigs in the Channel Country. Droughts serve to reduce numbers. As elsewhere, pigs dig up the soft edges or beds of wetlands looking for plant tubers and animals such as frogs and are a menace in general terms due to the potential for spread of diseases that may affect livestock. They may take eggs and chicks in waterbird breeding colonies.

There are a number of avenues where land managers can seek further information or assistance with the control of feral pigs.

A Threat Abatement Plan was prepared by the Australian Government under the EPBC Act to address the impact of feral pigs on the Australian landscape through predation, habitat degradation, competition, and disease transmission. The plan outlines control techniques and stakeholder roles and responsibilities and can be viewed on the Australian Government Environment website <www.environment.gov.au>. For further information on pest animal control

(including feral pigs) contact your local Land Protection officer or a local government weeds and pests officer. A list of declared animals (pests), pest animal strategies and fact sheets to assist land managers can also be found on the Department of Employment, Economic Development and Innovation (DEEDI) website <www.deedi.qld.gov.au>.

Most of the swamps addressed in this wetland management profile are within the Lake Eyre Basin. At least in the middle and lower reaches of the Basin's rivers, exotic fishes are relatively few in number and diversity compared to other inland river systems such as the Murray–Darling.

Goldfish *Crassius auratus* occur in the Cooper Creek and gambusia (plague minnow or mosquito fish) *Gambusia holbrooki* occur in bore drains, and sections of the Lake Eyre Basin. Gambusia is a declared species that is reported to cause declines in indigenous fish populations in non-riverine wetlands.

Murray cod *Maccullochella peelii peelii* and yellowbelly strains, which are not native to the Lake Eyre Basin, have been released into the Cooper river system. Though these species live mainly in waterholes, persistent terminal lakes and/or artesian bore overflows (see below), they may spread into swamps during and after floods where they can compete with indigenous fish. There is potential for different yellowbelly strains to interbreed (as has occurred in aquaculture situations), with the long-term effect of reducing wild fish health and reducing resistance to disease. Local residents and visitors to these regions should not release any fish or use live bait, which can and have entered the wetland systems (for example, goldfish). It has proven extremely difficult in these types of river systems, where floods spread out over vast distances, to prevent escapees of both fish and crustaceans, for example, redclaw crayfish *Cherax quadricarinatus* has escaped and is now established in the Burke and Hamilton Rivers in the Georgina River system, and in the Thomson River in the Cooper River system. It is illegal to stock farm dams with redclaw crayfish and fish that are not native to the Lake Eyre Basin in Queensland. Noxious fish are listed in the Queensland *Fisheries Regulation 1995* and include carp *Cyprinus carpio*; substantial penalties can be imposed on people who release such fish into the wild or who have noxious fish in their possession without a permit.

The cane toad *Rhinella marina* has recently established in the more permanent waterholes and water sources in and near towns in the Lake Eyre Basin (Barcaldine and Longreach) and is moving west and also south down the Cooper River system with each wet season. Little work has been done to assess



Feral pigs *Sus scrofa* can damage all types of wetlands. Photo: DERM

impacts, but in Longreach large goannas have been affected through ingestion and poisoning, dying as a result. Effects on other local frog, reptile and bird species are as yet unknown. The cane toad's inability to burrow and preference for a more constant water source may limit its impact on the highly temporary arid swamps.

Buffer zones

A buffer around a wetland can help maintain the environmental values of the wetland and protect it from current and future threats from adjacent land uses.

Designing an effective wetland buffer relies upon many factors, including the wetland's characteristics, environmental values, location, surrounding land uses, and the current and future impacts on the wetland.

Queensland already has legislative mechanisms that specify buffer distances. The *WetlandInfo* website <www.derm.qld.gov.au/wetlandinfo> contains the latest information on legislation and buffer guidelines.

Other issues

Extraction of oil and/or gas has resulted in substantial infrastructure development (roads, banks and ponds constructed in swamps) in some parts of the Cooper Basin in South Australia but this has not occurred to the same extent for Queensland operations. Some

extraction pump machinery is situated in swamp wetlands on the Cooper floodplain in the Naccowlah area and exploration lines have been cleared through swamps. Of greater concern, however, are access roads graded across floodplains because the grader spoil at the track edge can interrupt natural flows by creating a barrier to shallow sheet flow during floods and the track can provide new routes for floodwaters thereby changing the patterns of wetland inundation. Any road-works on arid zone floodplains should be planned to prevent or minimise disturbance to natural flood flows into swamps.

Some large mines are in the upper catchment of the Georgina River; any effluent and contaminants from mines must be prevented from polluting downstream wetland systems.

In a few places, water from artesian bores or mining operations flows into swamps. Sometimes this is overflow from water treatment ponds. These flows can be the vehicle for spread of exotic fishes (for example, gambusia) and wetland plants that were not originally present (for example, *Typha* spp.) into natural swamps.

Tourism impacts have increased in the arid zone in the last 10 years, although arid swamps are not a key focus for tourists. Indirect effects from impacts like declining water quality, and associated species decline may become more apparent in the future.

Glossary

Alluvial Soil that contains clay, silt, sand or gravel deposited by running water, for example by streams.

Aquatic Living or growing in water.

Arid zone A dry and hot area, with little rainfall (less than 300mm per annum). In some arid landscapes the vegetation cover is sparse or absent.

Bioregion (biogeographic region) An area of the continent defined by a combination of particular geology, landforms, climate and vegetation. For the definition of regional ecosystems, the bioregions of Sattler and Williams (1999) are adopted.

Brackish Water with a salt content between that of freshwater (0-5 parts per thousand) and normal marine water (35 parts per thousand).

Braided Branching and rejoining repeatedly to form an intricate pattern or network of small interlacing stream channels.

CAMBA The Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment is a treaty that aims to protect and conserve the birds and their habitat of those species that migrate between China and Australia.

Catchment The area of land drained by a creek or river system.

Cladoceran Water flea.

Copepod A member of a large group of species of tiny shrimp-like crustaceans.

Crustacean Animal with jointed legs and segmented body, that has a hardened outer shell, for example, crabs and shrimps.

Desiccation To lose water and dry up.

Drainage division A group of related drainage catchments.

Endemic A species that is native to an area or region.

Environmental value Under the Queensland *Environmental Protection Act 1994*, an environmental value is defined as (a) a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or (b) another quality of the environment identified and declared to be an environmental value under an environmental protection policy or regulation.

Evaporation rate The volume of water evaporated per unit area in unit time.

Forbs Soft-stemmed, broad-leaved, low-growing annual or perennial herbs.

Hydrological The pattern and volume of river or stream flow.

JAMBA The Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in danger of Extinction and their Environment is a treaty that aims to protect and conserve the birds and their habitat of those species that migrate between Japan and Australia.

Lacustrine Pertaining to lakes – includes wetlands and deepwater habitats that might be tidal or non-tidal with ocean salinity less than 1 part per thousand.

Macroinvertebrates Creatures without a backbone that can be seen without a microscope.

Migratory (Bonn Convention definition) 'migratory species' means the entire population or any geographically separate part of the population of any species or lower taxon of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries.

Monsoon A seasonal wind that brings rain.

Palustrine Pertaining to marshes, swamps, bogs and fens.

Phyllopod Crustaceans having swimming and respiratory appendages that resemble leaves.

Phytoplankton Tiny single-celled plants that form the base of a wetland's food pyramid because they transfer the sun's energy into plant matter and provide nourishment to the next level of organisms.

Pugging Soil damage (compaction) caused by grazing animals when their weight cannot be supported by the soil surface, such as deep footprints of cattle in muddy areas.

Ramsar Convention The Convention on Wetlands (Ramsar, Iran, 1971) is an international treaty that aims to halt the worldwide loss of wetlands and to conserve those that remain through wise use and management.

Regional ecosystem The vegetation community that is consistently associated with a particular combination of geology, landform and soil (see Sattler and Williams 1999).

Samphire A fleshy green plant that grows on saline marshes.

Sp./Spp. Sp. is an abbreviation for 'species' and is often used when the genus is known, but the species is not. For example, *Eucalyptus* sp. Means an undetermined species of Eucalyptus. Spp. is an abbreviation for more than one species without naming them individually.

Vertebrate An animal with a backbone; includes mammals, birds, reptiles, amphibians, and fishes.

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WetlandInfo <www.derm.qld.gov.au/wetlandinfo>

Appendixes

Appendix 1: Threatened and migratory fauna associated with Queensland's arid swamps

Taxon group	Common name	Scientific name	NC Act status*	EPBC Act status*	IUCN Red List of threatened species status **
Birds	Australian painted snipe	<i>Rostratula australis</i>	vulnerable	vulnerable	–
	yellow chat (gulf)	<i>Epthianura crocea crocea</i>	vulnerable	–	–
	little curlew	<i>Numenius minutus</i>	–	listed migratory species#	–
	black-tailed godwit	<i>Limosa limosa</i>	–	listed migratory species#	–
	marsh sandpiper	<i>Tringa stagnatilis</i>	–	listed migratory species#	–
	common greenshank	<i>Tringa nebularia</i>	–	listed migratory species#	–
	sharp-tailed sandpiper	<i>Calidris acuminata</i>	–	listed migratory species#	–
	red-necked stint	<i>Calidris ruficollis</i>	–	listed migratory species#	–
	oriental pratincole	<i>Glareola maldivarum</i>	–	listed migratory species#	–
	white-winged black tern	<i>Chlidonias leucopterus</i>	–	listed migratory species#	–

* Under the Queensland *Nature Conservation Act 1992* threatened wildlife are those species listed as presumed extinct, endangered or vulnerable. Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* threatened wildlife includes species listed as extinct, extinct in the wild, critically endangered, endangered, vulnerable or conservation dependent.

** The IUCN Red List of threatened species is an internationally recognised inventory for the conservation status of plant and animal species worldwide.

Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* listed migratory species include those species listed in appendices to the Bonn Convention, and in CAMBA and JAMBA. Listed species that are not truly migratory have not been included here.

Appendix 2: Arid swamps in Queensland included in *A Directory of Important Wetlands in Australia* (2005) and/or Ramsar listings

Bioregion	Directory reference	Directory wetlands	Ramsar wetlands
Channel Country	QLD023	Birdsville – Durrie Waterholes Aggregation	–
	QLD024	Bulloo Lake	–
	QLD025	Cooper Creek Overflow Swamps - Windorah	–
	QLD026	Cooper Creek Swamps – Nappa Merrie	–
	QLD027	Cooper Creek – Wilson River Junction	–
	QLD028	Diamantina Lakes Area	–
	QLD029	Diamantina Overflow Swamp – Durrie Station	–
	QLD030	Georgina River – King Creek Floodout	–
	QLD031	Lake Bullawarra	–
	QLD033	Lake Cuddapan	–
	QLD034	Lake Mipia Area	–
	QLD038	Moonda Lake – Shallow Lake Aggregation	–
	QLD040	Muncoonie Lakes Area	–
QLD041	Nooyeah Downs Swamps Aggregation	–	
Mitchell Grass Downs	QLD117	Austral Limestone Aggregation	–
Mulga Lands	QLD123	Lake Numalla Aggregation	Currawinya Lakes
	QLD125	Lakes Bindegolly and Toomaroo	–
	QLD168	Lake Dartmouth Area	–
	QLD175	Lake Wombah – Kungie Lake Group	–
	QLD170	Mitchell Swamp	–
Desert Uplands	QLD080	Cauckingburra Swamp	–

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