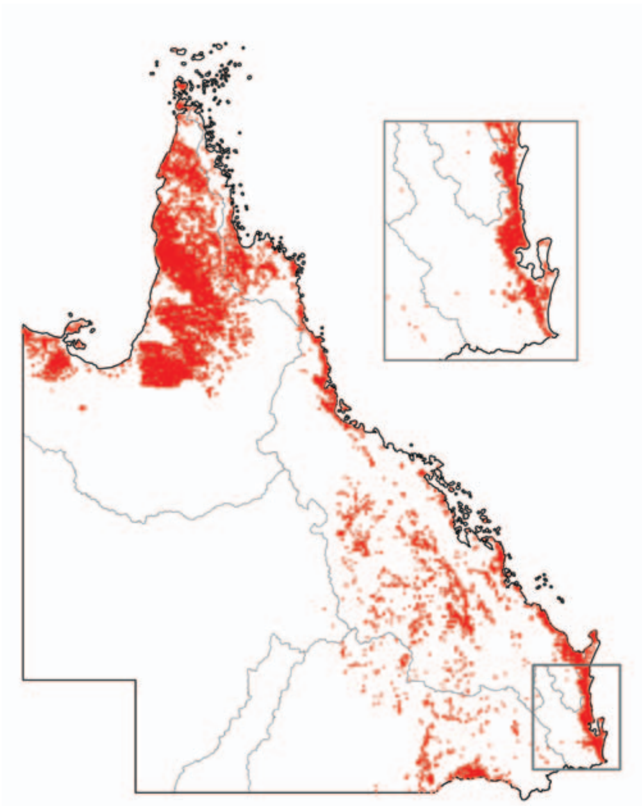
Australian Government

Queensland Government

WETLAND MANAGEMENT PROFILE

COASTAL AND SUB-COASTAL TREE SWAMPS

Coastal and sub-coastal tree swamps are non-tidal, wooded wetlands occurring in equatorial tropical and sub-tropical areas of Queensland. Occupying depressions, drainage lines and dune ***swales****, they might be inundated with water for 3–6 months of the year. They might be dominated by one plant species, such as the melaleucas (commonly known as tea-trees or paperbarks) and might also have a small range of trees, shrubs and grasses. These wetlands provide nesting or roosting sites for a number of bird and bat species, but are most significant as a food resource for migratory species. They also play an important role in filtering water that flows through them by removing contaminants and nutrients. Coastal and sub-coastal tree swamps are naturally restricted and highly susceptible to threats such as clearing for agricultural, urban and industrial development; fire; weed and pest invasion; and modification of water flows by man-made structures.*



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

*This profile covers the habitat types of wetlands termed floodplain tree swamps—*Melaleuca *spp. and* Eucalyptus *spp. and coastal and sub-coastal non-floodplain tree swamps—*Melaleuca *spp. and* Eucalypt *spp..*

*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 Wetland*Info *website <www.derm/qld.gov.au/wetlandinfo>.*

Description

This management profile covers coastal and sub-coastal tree swamps dominated by tree species from the Myrtaceae family, such as melaleucas, eucalypts and corymbias. For more information on tree swamps dominated by palm species, see the coastal palm swamps profile. Coastal and sub-coastal tree swamps are low-lying areas, seasonally inundated by freshwater and dominated by species adapted to saturated soil conditions or inundation, such as the Melaleuca spp. and some species of eucalypts and corymbias.

The genus Melaleuca is highly diverse with about 46 different species growing throughout Queensland, some of them in wetlands (Greenway, 1998). Melaleucas are often known as 'paperbarks' due to the distinctive paper-like layers of bark, separated by thin fibrous layers that can build up to 5 cm thick before peeling off. This bark protects the tree from moisture loss and fire. The first description of these trees by the early European explorers noted a white, paper-like bark with a stocking of black bark. It has been suggested that the black stocking was probably scarring due to the effects of fire (Boland *et al.*, 1984).

Some species of eucalypt and bloodwoods (corymbia), such as the river red gum *Eucalyptus camaldulensis*, swamp mahogany *Eucalyptus robusta*, coolabah *E. coolabah*, forest red gum *E. tereticornis*, Moreton Bay ash *Corymbia tessellaris* and Clarkson's bloodwood *Corymbia clarksoniana* are also adapted for living in waterlogged conditions. In the Murray–Darling Basin (Queensland) coastal and sub-coastal tree swamps dominated by *E. camaldulensis* occur. *E.camaldulensis* is the most widespread eucalypt in Australia, typically found associated with water courses and drainage depressions (Boland, 1984). Seedlings can develop **adventitious** and **aerenchymatous** roots to cope with anoxia resulting from waterlogging (Heinrich, 1990), however, they cannot survive complete immersion unless it is brief (Roberts & Marston, 2000). *E. camaldulensis* has probably one of the fastest growth rates for a tree and with a good water supply can attain a height of 12–15 m in a few years (Cunningham *et al.*, 1981).

This profile focuses on non-riverine swamps—the **palustrine** wetlands—though these treed swamps can also be found as a component of **riparian** vegetation. Even within the two types covered in this profile (floodplain and non-floodplain tree swamps), climatic factors, position within the landscape, **hydrology**, water regime and vegetation composition can vary substantially; for example, melaleuca species are dominant in non-floodplain wetlands; however, on flat land with good subsoil moisture adjacent to streams, they frequently occur alongside eucalypts in mixed tall open-forests (Boland *et al.*, 1984). Floodplain tree swamps (melaleuca and eucalypt) are embedded within **alluvial floodplains**, inhabiting the depressions where water persists for months after a flood event has occurred across the alluvial plain.

Leaves of melaleuca trees are generally **alternate**, flat and green, sometimes silvery or hairy and can be upright and rigid (such as the broad-leaved tea-tree *Melaleuca viridiflora*) or **pendulous** bundles of leaves (such as the swamp tea-tree *M. dealbata*). Flowering is commonly dramatic, in long fluffy spikes at the end of **branchlets**, with colours that vary from white or cream (most commonly), to light green, pink, mauve, yellow or deep red. The flowers are rich in nectar and attract a variety of feeding bird, bat and other mammal species. The trees have spreading root systems, providing stability during floods and prolonged waterlogging and are tolerant to a limited extent of both saline and **brackish** water.

Fibrous or adventitious roots around the lower trunk of the tree are thought to be breathing roots that help the tree survive during long periods of submersion, for although they thrive in moist environments, melaleucas cannot withstand permanent inundation (Hauenschild, 1999).

The floristic composition of coastal and sub-coastal tree swamps varies with the duration and depth of wet season flooding. As well as melaleucas and eucalypts, both of which can form almost pure stands, other flora found in coastal and sub-coastal tree swamp habitats include the cabbage tree palms *Livistonia australis* or *L. decora*, swamp box *Lophostemon suaveolens*, swamp oak *Casuarina glauca*, *Endiandra sieberi* and *Melastoma malabathricum* subsp. *malabathricum*.

The subcanopy can include liniment bush *Asteromyrtus symphyocarpa*, with false casuarina *Calycopeplus casuarinoides* on the margins of the wettest areas. The composition of the **understorey** also varies with location in Queensland and the length of time the swamp contains water, but can include shrubs such as quinine berry *Petalostigma pubescens*, *Banksia dentata* and golden grevillea *Grevillea pteridifolia* on the margins; sedges such as soft twigrush *Baumea rubiginosa*, *Lepironia articulat*a and bogrush *Schoenos breviofolius*; noderushes such as *Dapsilanthus ramosus*; saw-sedges such as *Gahnia sieberiana*; reeds such as the common reed *Phragmites australis*; other grasses such as *Ischaemum*

Red blossoms of the broad-leaved tea-tree *Melaleuca viridiflora* Photo: Kylie Joyce, DERM

Coastal and sub-coastal tree swamp dominated by broad-leaved tea-tree *Melaleuca viridiflora* with a native grass understorey
Photo: Kylie Joyce, DERM

spp., swamp rice grass *Leersia hexandra*, blady grass *Imperata cylindrica* and saltwater couch *Sporobolus virginicus* (also known as sand or marine couch), fire grass *Schizachyrium* spp., three-awn spear grasses *Aristida* spp., wanderrie grasses *Eriachne* spp., *Pseudoraphis spinescens* and *Eremochloa bimaculata*; open-tussock grassland of *Ectrosia* sp. (hare's foot grass) or beetle grass *Leptochloa fusca* and ferns such as the climbing swamp fern *Stenochlaena palustris* and the swamp fern *Blechnum indicum*. Coastal and sub-coastal tree swamps can also contain rare and threatened flora species including *Phaius australis*, *P. bernaysii* and *Schoenus scabripes*.

Distribution

Coastal and sub-coastal tree swamp habitats are widespread in coastal and sub-coastal districts from the New South Wales border north to Cape York and along the margins of the Gulf of Carpentaria and its river systems. In south-east Queensland significant examples occur on Bribie, Stradbroke and Moreton Islands and at Coombabah Lake and Carbrook wetlands on the mainland and further north at Deepwater and Eurimbula national parks. In central Queensland, examples may be found in the Byfield/ Corio/Shoalwater Bay areas as well as Slade Point, Mackay. These wetland habitats are also found in the Hinchinbrook area, in Bowling Green Bay National Park and on Cape Melville, as well as in the Daintree in north Queensland.

THE most extensive coastal and sub-coastal tree swamps occur in depressions on broader floodplains, in the valleys between coastal and sub-coastal dunes or on the inland side of mangroves.

Coastal and sub-coastal tree swamps mostly occur in coastal and sub-coastal, **unconsolidated** landscapes formed by wind and water action (**land zones 1, 2 and 3**) on level or gently undulating **topography**.

Their ability to tolerate flooding, salt and poor soil types has enabled melaleucas to colonise areas unsuitable for most eucalypts or many other species. The most extensive swamps occur in depressions on broader floodplains, in the valleys between coastal and sub-coastal dunes or on the inland side of mangroves (this mainly applies to melaleuca swamps).

Coastal and sub-coastal tree swamp with a native grass ground layer, Iwasaki Wetlands
Photo: Kylie Joyce, DERM

Swamp mahogany *Eucalyptus robusta* scattered through a coastal and sub-coastal tree swamp, Iwasaki Wetlands Photo: Kylie Joyce, DERM

Swamp fern *Blechnum indicum* is commonly found in the understorey of coastal tree swamps.
Photo: Kylie Joyce, DERM

FOR all coastal and sub-coastal tree swamps, adequate moisture is critical, either as free-standing, slow-draining surface water on clays, as groundwater close to the surface or in perched water tables among parallel or **parabolic dunes**.

They are found on a broad range of soil types, from the predominantly silty to loamy clays on the edges of water bodies (preferred by weeping tea-tree *M. leucadendra* and swamp paperbark *M. quinquenervia*) to sandy alluvia soils on a floodplain to the **siliceous** sands of the non-floodplain dune systems and poorly oxygenated marine clays or the black soil plains of south-east Queensland (Boland *et al.*, 1984). Eucalypts prefer deep moist subsoils with clay content (Costermans, 1989) and though they are commonly related to channels of sandy watercourses and creeks (Boland, 1984), forming ribbon stands (riverine wetlands), they also extend over extensive areas of regularly flooded flats and can therefore form palustrine systems.

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

Weeping tea-tree *Melaleuca leucadendra* waterhole in Byfield National Park Photo: Kylie Joyce, DERM

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 Wetland*Info* 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 Wetland*Info* website <www.derm.qld.gov.au/wetlandinfo>.

National conservation status

The Moreton Bay, Shoalwater and Corio bay areas and the Great Sandy Strait Ramsar sites (Wetlands of International Importance under the **Ramsar Convention**) contain coastal and sub-coastal tree swamps (melaleuca and eucalypt). The Fraser Island, Great Barrier Reef and Wet Tropics World Heritage Areas, as defined in the World Heritage List maintained by the **World Heritage Convention**, also include areas of these wetland habitats. The Shoalwater Bay Military Training Area (Byfield), the Wide Bay Military Reserve (Tin Can Bay) and the Greenbank Military Training Area (Greenbank) are Commonwealth heritage places under the Commonwealth Heritage List and also include these wetland habitats.

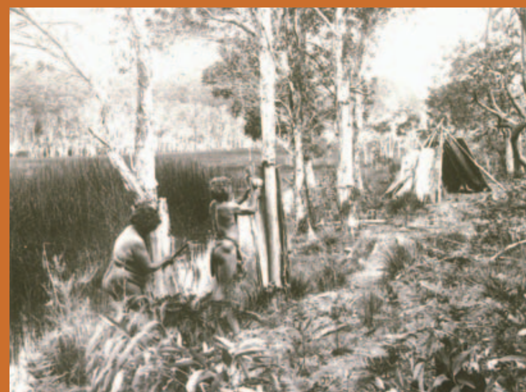
Several plant and animal species that occur in coastal ans sub-coastal tree swamps in Queensland are listed as threatened under the federal *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and/or the Queensland *Nature Conservation Act 1992* (NC Act) and/or the **IUCN Red List** (see Species associated with coastal and sub-coastal tree swamps).

Ramsar wetlands, threatened species, World Heritage properties and Commonwealth heritage places are matters of national environmental significance (NES) under the EPBC Act and as such, are afforded protection under the Act. Any action that will, or is likely to have a significant impact on a declared Ramsar wetland, threatened species, World Heritage property, or Commonwealth heritage place will be subject to an environmental assessment and approval regime under the EPBC Act. For each of these World Heritage and Ramsar sites, management plans or equivalent are in place; in some instances they may not apply to the entire Ramsar site. Recovery plans that set out research and management actions to support the recovery of threatened species under the EPBC Act might be available for some of these species (see <www.environment.gov.au/biodiversity>).

Cultural heritage values

All wetland ecosystems are of material and cultural importance to Indigenous people and many will have profound cultural significance and values. More than 400 Indigenous cultural heritage sites have been recorded within coastal and sub-coastal tree swamps in Queensland, most dating from the mid-**Holocene**, being less than 4000 years old. Most coastal and sub-coastal tree swamps have not been systematically surveyed or assessed for cultural heritage significance.

There is a very high likelihood of encountering cultural heritage sites within and adjacent to coastal and sub-coastal tree swamps. Evidence of traditional occupation and use recorded within coastal and sub-coastal tree swamps include painted rock art, burials, stone and earth arrangements, pathways, scarred trees, middens, stone artefacts and scatters, grinding grooves, food and fibre resources and historic contact sites. Some coastal and sub-coastal tree swamps have particular significance as story places and as sites for cultural activities.



Traditional use of coastal and sub-coastal tree swamp vegetation Photo: Thomas Dick, © Queensland Museum

MATERIAL evidence of cultural sites, such as stone artefacts and shells, are often concentrated along **ecotones** around the margins of coastal and sub-coastal tree swamps in association with neighbouring wetlands such as coastal and sub-coastal wet heath swamps, grass, sedge, herb swamps and saltmarsh wetlands.

The most commonly recorded sites associated with coastal and sub-coastal tree swamps are shell middens and stone artefact scatters associated with open camp occupation sites. These sites are likely to be found in areas of higher ground within or adjacent to coastal and sub-coastal tree swamps. Material evidence of cultural sites, such as stone artefacts and shells, are often concentrated along ecotones around the margins of coastal and sub-coastal tree swamps, and in association with neighbouring regional ecosystems such as coastal and sub-coastal wet heath swamps, coastal and sub-coastal grass, sedge, herb swamps and saltmarsh wetlands. The clustering of sites along ecotones reflects the concentration of traditional occupation and use within areas of greatest biodiversity.

Some coastal and sub-coastal tree swamps also have non-Indigenous (historic) cultural heritage significance, although most have not been surveyed or assessed for historic heritage values. DERM has records of more than 60 historic sites associated with coastal and sub-coastal tree swamps. The historic heritage values of coastal and sub-coastal tree swamps demonstrate evidence of their past occupation and use associated with the pastoral, agricultural, timber and forestry industries and coastal and sub-coastal defence. Sites include camps, settlements, roads, tramways, stockyards, sawmills, log dumps, blazed trees and relics of maritime transport and communications and coastal and sub-coastal defence installations. It is important to note that evidence of Aboriginal occupation is often encountered at historic sites.

Refer to the *Coastal and sub-coastal fringe wetlands—cultural heritage profile* <www.derm.qld.gov.au> for more information on identifying, assessing and managing cultural heritage values associated with coastal and sub-coastal tree swamps.

Ecological values

Coastal and sub-coastal tree swamps play a critical role in the **hydrological** regime of the coastal and sub-coastal area: they provide a protective buffer against erosion; they absorb and filter water before it enters other wetland ecosystems such as mangrove swamps, **estuaries** and eventually the sea and off-shore reefs; they also retain flood waters and act as nutrient sinks. Tree swamp species such as Eucalyptus camaldulensis access and transpire substantial volumes of groundwater and can contribute to maintaining watertables at depth, which can reduce the risk some types of salinity (Dalton, 1990). Before European settlement, coastal and sub-coastal tree swamps were more extensive, providing wide buffer zones between shorelines, estuaries and river systems, protecting these waterways from channel erosion and nutrient run-off. Clearing for agricultural development such as timber plantations and sugar cane production and more recently for industrial and urban development has removed these protective buffer zones (Greenway, 1998).

COASTAL and sub-coastal tree swamps are dynamic and the timing of fire and extreme wet and dry events is likely to play a key role in these dynamics.

Coastal and sub-coastal tree swamps are dynamic and the timing of fire and extreme wet and dry events is likely to play a key role in these dynamics. The coastal and sub-coastal tree swamps can expand onto alluvial floodplains if **levee banks** retain water in these areas for long periods, or they can contract where fires repeatedly enter from adjacent lands such as cane fields, pasture paddocks or weedy urban fringes. Monitoring in the Cooloola area of south-east Queensland over the past 40 years shows coastal and sub-coastal tree swamps and forests appearing and disappearing through time, to be replaced by or to replace wet heaths, grass, sedge and herb swamps.

The location and botanical characteristics of coastal and sub-coastal tree swamps in Queensland make them important habitat for a range of bird species. Abundant food and nest resources, high water availability and a favourable **microclimate** are all factors that contribute to this richness. A coastal tree swamp, when not in flower, can be relatively silent but within a day of a widespread flowering event becomes one of the noisiest places in the Australian bush. During the day, birds flock to the nectar-rich flowers, to be replaced at night by the flapping, crashing and squabbling of flying foxes competing for the same resource.

THE location and botanical characteristics of coastal and sub-coastal tree swamps in Queensland make them important habitat for a range of bird species.

The black flying-fox *Pteropus alecto* and the spectacled flying-fox *P. conspicillatus* often form roosting camps in coastal and sub-coastal tree swamps, the latter species often preferring these habitats to those of mangroves.

In southern Queensland the cyclic flowering of swamp paperbark *Melaleuca quinquenervia* can extend from mid-summer to the end of winter (January–August). These flowering events provide important food resources for **nectivorous** birds in summer, before honey-rich heath plants (for example, dwarf banksia *Banksia oblongifolia*) of the adjacent **wallum** have commenced flowering. During winter, these and many other bird species move to coastal and sub-coastal areas during their seasonal northerly or altitudinal migration. Birds of the coastal and sub-coastal tree swamps include honeyeaters, often referred to as ‘blossom nomads’, such as the noisy friar bird *Philemon corniculatus* and several species of lorikeets, which are conspicuous during flowering events.

Other coastal and sub-coastal melaleuca species flower during winter and into spring, for example the broad-leaved tea-tree M. leucadendra, and in early summer the blue leaved paperbark M. dealbata, ensuring that there is almost year-round flowering and therefore food availability within the landscape.

Spoonbills, herons, ibises and other waterbirds roost and nest in coastal and sub-coastal tree swamps with some species, such as the royal spoonbill *Platalea regia* and white-necked heron *Ardea pacifica*, favouring nest sites with sustained surface water. Honeyeaters, such as the bar-breasted honeyeater *Ramsayornis fasciatus,* also nest over water and, like many small **passerines**, line their nest with the soft under-bark of melaleuca trees.

The rich insect and **arthropod** fauna of coastal and sub-coastal tree swamps also attract bird life, particularly during the cooler winter months when other ecosystems might have diminished food

SWAMP SECRETS REVEALED

The coastal and sub-coastal tree swamps of the Hull River in north Queensland are unique environments, occurring in the wettest part of Australia, where over 5000 mm of rain falls each year. Within this environment of melaleuca swamps and mangroves, the vulnerable Apollo jewel butterfly (Wet Tropics subspecies) *Hypochrysops apollo apollo* (NC Act) is found at a few localities between Cooktown and Ingham.

The butterfly lays its eggs singly on the outside surface of the **epiphytic** ant plant *Myrmecodia beccarii* (also a vulnerable species, NC and EPBC Acts), which grows on the trunk and branches of coastal and sub-coastal swamp trees such as melaleucas and lophostemons. The butterfly larvae feed primarily on the internal tissue of the ant plant and sometimes on the leaves at night. The ant plant has enlarged stems that form a tuberous structure and, as the plant grows, hollow chambers form within the plant, allowing the golden ant *Philidris cordatus* to colonise it. Caterpillars (hatched larvae) of the Apollo jewel butterfly have glands that secrete a sugary substance that attracts the golden ant so that after hatching they are carried inside the plant by the ants. In the process of feeding, the larvae further enlarge the ant galleries, and over many generations can eat out the host plant and leave only its shell. No more than one larva is generally found in any one plant.

This is a good example of the complex ecological relationships to be found within a coastal and sub-coastal tree swamp: the trees provide habitat for the ant plant; the ant plant provides shelter for the ant colony; the ant colony provides nutrients for the ant plant from ant food leftovers stored inside the plant’s chambers; the butterfly larvae provide a sugary secretion as food for the ants and assist the ants by enlarging the chambers of their colony; and the ants provide a safe haven for the developing larvae before they emerge from the plant as butterflies.

Ant plant *Myrmecodia beccarii* growing on *Melaleuca quinquenervia*, Cowley Beach Photo: Roger Jaensch, Wetlands International resources. Coastal and sub-coastal tree swamps and adjoining mangroves provide habitat and a narrow migration zone that draw many bird species, such as the shining flycatcher *Myiagra alecto,* much farther south than their typical tropical habitat.

Often fauna species not typically associated with coastal and sub-coastal tree swamps utilise these and other wetland habitat types to meet their needs. For example, the cassowary *Casuarius casuarius johnsonii* generally resides in the rainforests and the mahogany glider *Petaurus gracilis* in the lowland forests and open eucalypt woodlands of the Wet Tropics in north Queensland. Both will leave the protection of these vegetation communities when the melaleucas, eucalypts and corymbias flower in nearby wetlands. The water mouse *Xeromys myoides* depends on a variety of wetland habitats such as coastal and sub-coastal tree swamps, grass/sedge/herb swamps, mangroves and saltmarshes.

Species associated with coastal and sub-coastal tree swamps

Preservation of coastal and sub-coastal tree swamps is crucial to protect species dependent on these wetlands for habitat, nesting, breeding and/or feeding, particularly species threatened with extinction. A number of species associated with coastal and sub-coastal tree swamps in Queensland are listed as threatened under state (NC Act) and Commonwealth (EPBC Act) legislation and/or recognised under international conventions or agreements such as the IUCN Red List (see Appendixes). Some of the species of fauna and flora associated with coastal and sub-coastal tree swamps include those listed below:

Wetland*Info* provides full species lists of wetlands animals and plants.

Fauna

Mammals

- mahogany glider *Petaurus gracilis*
- water mouse *Xeromys myoides*
- Gould's wattled bat *Chalinolobus gouldii*
- hoary wattled bat *Chalinolobus nigrogriseus*
- little bent-winged bat *Miniopterus australis*
- Beccari's freetail bat *Mormopterus beccarii*
- yellow-bellied sheathtail bat *Saccolaimus flaviventris*
- black flying-fox *Pteropus alecto*
- spectacled flying-fox *Pteropus conspicillatus*

Birds

- white-necked heron *Ardea pacifica*
- cassowary *Casuarius casuarius johnsonii*
- white-faced heron *Egretta novaehollandiae*
- brown honeyeater *Lichmera indistincta*
- shining flycatcher *Myiagra alecto*
- little pied cormorant *Phalacrocorax melanoleucos*
- noisy friar bird *Philemon corniculatus*
- royal spoonbill *Platalea regia*
- bar-breasted honeyeater *Ramsayornis fasciatus*
- Australian white ibis *Threskiornis molucca*
- straw-necked ibis *Threskiornis spinicollis*
- scaly-breasted lorikeet *Trichoglossus chlorolepidotus*
- rainbow lorikeet *Trichoglossus haematodus*

Fish

- jungle perch *Kuhlia rupestris*
- Oxleyan pygmy perch *Nannoperca oxleyana*
- honey blue eye *Pseudomugil mellis*

Amphibians

- wallum froglet *Crinia tinnula*
- Cooloola sedgefrog *Litoria cooloolensis*
- wallum rocketfrog *Litoria freycineti*
- wallum sedgefrog *Litoria olongburensis*

Reptiles

- red-bellied black snake (*Pseudchis porphyriacus*)
- Arafura file snake (*Acrochordus arafurae*)
- freshwater snake (keelback—*Tropidonophis mairii*).

Insects

- Australian fritillary *Argyreus hyperbius inconstans*
- Apollo jewel butterfly *Hypochrysops apollo apollo*
- golden ant *Philidris cordatus*.

Zooplankton and **microcrustaceans**—microscopic aquatic fauna that graze on phytoplankton and detritus—can also be present.

THE HONEY BLUE EYE

The vulnerable (NC Act) honey blue eye *Pseudomugil mellis* is **endemic** to Queensland, occurring in slow flowing, slightly acidic, **tannin**–stained lakes, streams, swamps (including coastal and sub-coastal tree swamps) and wet heath swamps in sandy landscapes of south-east Queensland. It is often found along grassy banks and among reeds and water lilies. At 3cm long, it is one of the smallest threatened species in Queensland. In addition to its characteristic blue eyes, the fish has a distinctive amber to orange colour.

Large areas of its coastal and sub-coastal habitat have been cleared for residential development, forestry and agriculture. Habitat protection is the key measure for ensuring the survival of this fish. The species is also collected for aquariums, which poses an added threat. It is likely that the introduced mosquito fish *Gambusia holbrooki* could out-compete the blue eye where the two co-exist. It is also important to maintain the genetic diversity of the species by protecting individual populations and ensuring that breeding can occur between adjoining populations. Small breeding populations are also being maintained in captivity.

Honey blue eye *Pseudomugil mellis*.
Photo: Gunther Schmida

THE ACID FROGS

A group of four amphibians called 'acid frogs' inhabit the swamps, lakes, creeks and soaks of south-east Queensland and New South Wales. These frog species undergo tadpole development in **soft waters** of high acidity and low nutrient content—commonly found in coastal and sub-coastal tree swamps and coastal and sub-coastal wet heath swamps.

These species include the wallum froglet *Crinia tinnula*, Cooloola sedgefrog *Litoria cooloolensis*, wallum rocketfrog *Litoria freycineti* and the wallum sedgefrog *Litoria olongburensis*. Recent records indicate all species still occur throughout their pre-European range, however populations have suffered habitat loss and disturbance due to land clearing.

The acid frogs have specialised breeding requirements and are particularly susceptible to changes in water chemistry. Exotic pine plantations, associated road construction and changes to burning practices have led to changes in hydrology and water chemistry that have been detrimental to the frogs' breeding success. The clearing of native vegetation to establish exotic pine plantations has now ceased but habitat loss continues as a result of increased urban development. Damage to **microhabitats** (reed beds and sedges) by too-frequent fire, human trampling and recreation activities has also been identified as detrimental. Various other potential sources of impact have been identified but, as yet, their effects are poorly studied, for example the use of chemicals to control mosquitoes and weeds, grazing and predation by feral pigs.

A number of actions to protect the habitat of the acid frogs have been identified: establishing minimum protective buffers around known breeding sites (for example, 100 m; refer to Using buffers to protect wetlands) that exclude a range of routine uses including timber harvesting and chemical use; maintaining natural drainage patterns, water tables and water quality when conducting activities adjacent to or upslope of known breeding sites; and monitoring and managing grazing, feral pigs and **pine wildings**. Handling frogs should be avoided, to reduce the risk of disease transfer.

Wallum rocketfrog *Litoria freycineti* Photo: DERM

Flora

Some of the flora species associated with coastal and sub-coastal tree swamps include:

Club mosses

– bog clubmoss *Lycopodiella serpentina*

Ferns

– *Asplenium wildii*
– swamp water fern *Blechnum indicum*
– climbing maidenhair *Lygodium microphyllum*
– climbing fern *Stenochlaena palustris*

Herbs

– *Prostanthera palustris*
– *Sowerbaea subtilis*

Orchids

– **swamp orchid** *Phaius australis/tancarvilleae*
– yellow swamp orchid *Phaius bernaysii*
– wallum leek orchid *Prasophyllum wallum*

Epiphyte

– ant plant *Myrmecodia beccarii*

Grasses/reeds

– blady grass *Imperata cylindrical*
– *Ischaemum* spp.
– swamp rice grass *Leersia hexandra*
– saltwater couch *Sporobolus virginicus*
– common reed *Phragmites australis*
– fire grass *Schizachyrium* spp.
– three-awn spear grasses *Aristida* spp.
– wanderrie grasses *Eriachne* spp.
– *Pseudoraphis spinescens*
– *Eremochloa bimaculata*
– hare's foot grass *Ectrosia* sp.
– beetle grass *Leptochloa fusca*

Sedges/rushes

– soft twigrush *Baumea rubiginosa*
– *Cyperus ohwii*
– *Dapsilanthus ramosus*
– *Gahnia sieberiana*
– *Lepironia articulata*
– bogrush *Schoenus breviofolius*
– *Schoenus scabripes*

Trees/shrubs

– tiny wattle *Acacia attenuata*
– *Acacia baueri subsp. Baueri*
– bacon wood *Archidendron lovelliae*
– Key's boronia *Boronia keysii*
– Byfield matchsticks *Comesperma oblongatum*
– hop bush *Dodonaea rupicola*
– durringtonia *Durringtonia paludosa*
– swamp mahogany *Eucalyptus robusta*
– *Germainia capitata*
– grevillea *Grevillea venusta*
– *Habenaria harroldii*
– cabbage tree palm *Livistonia australis* or *L. decora*
– swamp box *Lophostemon suaveolens*
– *Melaleuca* sp. aff. *viridiflora*
– sprengelia *Sprengelia sprengelioides*
– liniment bush *Asteromyrtus symphyocarpa*
– *Casuarina glauca*
– *Endiandra sieberi*
– *Melastoma malabathricum subsp. malabathricum.*
– false casuarina *Calycopeplus casuarinoides*
– quinine berry *Petalostigma pubescens*
– *Banksia dentata*
– golden grevillea *Grevillea pteridifolia*
– *Melaleuca quinquenervia*
– *Eucalyptus tereticornis*
– *Eucalyptus camaldulensis*
– *Eucalypts coolabah*
– *Eucalyptus platyphylla*
– *Acacia holosericea* or other *Acacia* spp.

Open water aquatics and emergents

– *Potamogeton crispus*
– *Myriophyllum verrucosum*
– *Chara* spp.
– *Nitella* spp.
– *Nymphaea violacea*
– *Ottelia ovalifolia*
– *Nymphoides indica*
– *Nympboides crenata*
– *Potamogeton tricarinatus*
– *Cyperus difformis*
– *Vallisneria caulescens*
– Hydrilla verticillata.

Managing the coastal and sub-coastal tree swamps

Coastal and sub-coastal tree swamps are naturally restricted in distribution and highly susceptible to threats such as clearing for agricultural, urban and industrial expansion; water pollution and high nutrient loads; high chemical loads (such as those resulting from **acid sulfate soils**); changes in hydrology such as modification to water flows by man-made structures; fire, weed and feral animal invasion; and recreation and resource use (for example, sand mining). The impacts of these threats occur either directly through clearing, draining and/ or filling of coastal and sub-coastal tree swamps, or indirectly through upstream or adjacent land use. Changes in flooding regime and hydrology can affect germination success of species like *Eucalyptus camalduensis* so changes in upstream hydrology of floodplain wetlands can have significant effects on the wetland's vegetation community (Roberts and Marston, 2000).

Due to their close association with adjacent wetland habitat types (such as mangroves, saltmarshes, wet heath and grass, sedge, herb swamps), the management of coastal and sub-coastal tree swamps should be integrated with management practices for these other wetland habitats (see the wetland management profiles for additional information: Coastal and sub-coastal wet heath swamps; Coastal and sub-coastal grass, sedge, herb swamps; Saltmarsh wetlands and mangrove wetlands <www.derm.qld.gov.au/wetlandinfo>.

DUE to their close association with adjacent wetland types such as mangroves, saltmarshes, and wet heath swamps, the management of coastal and sub-coastal tree swamps should be integrated with these other wetlands.

Managing changes in land use

As the human population has increased, residential, industrial and recreational development on the prime real estate of the coastal and sub-coastal strip has escalated. This has greatly impacted on coastal and sub-coastal tree swamps, many of which have been drained and filled for towns and their associated facilities and infrastructure.

Even though the effects of development to date are largely irreversible, future impacts can be minimised by identifying and protecting wetlands and by considering environmental impacts prior to land clearing. The Queensland *Sustainable Planning Act 2009* is one of many pieces of legislation that protect wetland regional ecosystems in the urban environment.

In urban areas, maintaining or restoring coastal and sub-coastal tree swamps is vital to their long-term survival. Raising awareness about the role that coastal and sub-coastal tree swamps play in the environment is necessary.

Agricultural activity has significantly reduced the extent, quality and protective buffering capability of the coastal and sub-coastal tree swamps. Historically, the swamps have been cleared for enterprises such as pine plantations, sugar cane crops, **ponded pastures** and grazing. Apart from the direct loss of coastal and sub-coastal tree swamp vegetation, clearing can alter water flow (hydrology), increase acid run-off by exposing acid sulfate soils and increase pollution, sediment and nutrient concentrations in adjacent land (see Managing water pollution and nutrients and Managing water).

In addition to the impacts that sugar cane farming has on adjacent wetlands, the marginal soil of coastal and sub-coastal tree swamps is also being utilised for cane production now that less of the preferred, agriculturally productive soil types remain. These marginal soils may be prone to **scalding**, erosion and channel erosion. Canegrowers (the representative organisation for Australian cane growers, <www.canegrowers.com.au>) encourages cane growers to retain remnant vegetation and waterways as part of their farm planning.

Grazing can impact coastal and sub-coastal tree swamps by altering vegetation (changing species composition and relative abundance), introducing weeds and fouling water through defecation and urination (see Managing weeds and Managing water pollution and high nutrient or chemical loads).

Although coastal and sub-coastal tree swamps have a relatively high tolerance to increased nutrient loads and have been shown to be effective in treating waste water effluent (sewage), overloading the capacity of the swamp will eventually lead to dieback of melaleuca and other tree species, encourage the invasion of weeds and impact aquatic fauna. Fencing or limiting grazing in wetland areas at certain times can be beneficial. Where ponded pastures have been introduced to areas near coastal and sub-coastal tree swamps, land managers should prevent the spread of exotic pasture grasses such as para grass Brachiaria mutica and Hymenachne amplexicaulis. Ponded

Regrowth of a coastal and sub-coastal tree swamp adjacent to a cane field south of Mackay
Photo: Kylie Joyce, DERM

MOSQUITO CONTROL IN URBAN AREAS—A GOLD COAST CITY COUNCIL EXAMPLE

The Gold Coast City Council in south-east Queensland manages an area of approximately 1402 km^2, spanning 70 km of coastline from South Stradbroke Island in the north to Rainbow Bay in the south. It is the sixth largest city in Australia (497 848 people in June 2008) and contains numerous natural and artificial wetlands.

Like many other Australians living in coastal and sub-coastal urban areas, this brings Gold Coast residents into close contact with wetlands providing breeding habitat for a variety of mosquito species. In 2002, the Local Government Association of Queensland (LGAQ) developed a mosquito management code of practice to provide councils, commercial enterprises and individuals with information and guidelines for environmentally sensitive mosquito control.

The Gold Coast City Council has implemented a mosquito control program to protect residents and tourists from disease and disruption to lifestyle since the early 1960s. Today, this program targets potential mosquito breeding sites such as saltmarshes and temporary and semi-permanent freshwater pools, such as coastal and sub-coastal tree swamps. Fundamental to the program is ongoing monitoring of specific sites for the presence of mosquito larvae. This is done weekly during warm weather and fortnightly throughout winter. Land-based or aerial spraying (larviciding) is undertaken if monitoring identifies high numbers of larvae. The council prefers this control method because it generally uses mosquito-specific chemicals. Monitoring of adult mosquitoes is also carried out weekly and when numbers reach unacceptably high levels, land-based spraying is undertaken using a chemical to kill adult mosquitoes (adulticide) upon direct contact. This chemical is not ideal because it kills all insects it comes in contact with and may affect species such as frogs, reptiles and birds that use insects as a food source. The council complements its chemical control program with biological control and habitat modification where possible, to minimise the amount of chemicals used, limiting the impacts on the environment and potentially human health. Biological methods involve using predators, diseases and parasites to control mosquito larvae (for example stocking small native freshwater fish species in permanent water to prey on mosquito larvae).

Because both the community and environment benefit by reducing mosquito numbers early in their lifecycle, public awareness about control programs and ways of reducing mosquitoes breeding in backyards should be encouraged. It is also essential people recognise wetlands in urban areas as aesthetic and environmental assets and they appreciate that mosquitoes are a natural feature of wetlands.

pastures should not be established in or near natural wetlands due to their unacceptable impacts on these areas, as outlined under the Queensland Policy for Development and Use of Ponded Pastures (DNRM, 2001) at <www.derm.qld.gov.au>. Further information on ponded pastures is available at <www.derm.qld.gov.au/factsheets>.

Using buffers to protect wetlands

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 Wetland*Info* website <www.derm.qld.gov.au/wetlandinfo> contains the latest information on legislation and buffer guidelines.

Managing water—changes in hydrology and modification by man-made structures

The healthy functioning of a wetland depends upon the quality, quantity and timing of the water flowing into it. Therefore, any activity that alters the natural flow of water will alter the characteristics of a wetland. In their natural state coastal and sub-coastal tree swamps play an important role during times of flood. By retaining water and run-off they protect the surrounding landscape from erosion and nutrient run-off, and waterways from siltation and contamination. Coastal and sub-coastal tree swamps are susceptible to hydrological changes caused by climate (for example drought and floods), land use (such as grazing), water use (for example irrigation), drainage for urban and industrial development, and modification to the surrounding terrain by man-made structures (such as drains, levee banks, bund walls, diversion banks, roads and bores).

Decreases or increases to natural water flow can cause coastal and sub-coastal tree swamps to deteriorate, dry out and disappear or become larger and wetter. This in turn affects the diversity, distribution and number of flora and fauna species that occur at a particular site. For example the use of bores to supply water to houses and properties along the coastal and sub-coastal strip of Queensland has resulted in a lowered water table, less water lying in perched lakes, and coastal and sub-coastal tree swamps becoming drier. This move to a drier environment has favoured the growth of eucalypt species at the expense of melaleuca species and other dry rainforest vegetation and caused some coastal and sub-coastal tree swamps to disappear.

Clearing for urban and agricultural development can contribute to increased stormwater run-off entering local streams and swamps, leading to flooding, erosion and alteration of the waterway. The *Sustainable Planning Act* 2009, local development control plans, regional coastal zone plans and building codes are designed to reduce the impacts of urban development on local wetlands.

LOCAL development control plans, regional coastal zone plans and building codes are designed to reduce the impacts of urban development on local wetlands.

Man-made structures (such as bund walls) or activities (for example, clearing and irrigation) can also alter the natural fluctuation between brackish water and freshwater in coastal and sub-coastal areas. Saltwater intrusion occurs when flow rates in rivers and streams are reduced so greatly that saltwater tides, usually blocked by freshwater outflows, are able to push further upstream into reaches that are not tolerant of salty water. This can cause rapid changes in the composition of vegetation and affect flora and fauna that may not be able to adapt to new conditions. Saltwater intrusion is now widespread and has resulted in death and dieback of tree species in coastal and sub-coastal tree swamps.

Land managers should seek advice before installing structures that may alter the hydrology of wetlands. Further information about current legislative requirements regarding construction of dams, bund walls, drains and other structures is available from DERM including management tools such as the *Farm Management System Handbook* and rehabilitation guidelines, which are available from the Wetland*Info* website.

Stormwater run-off control in a Mackay housing estate that is designed to minimise impacts to surrounding coastal and sub-coastal tree swamps
Photo: Kylie Joyce, DERM

Managing water pollution and high nutrient or chemical loads

Coastal and sub-coastal tree swamps have a relatively high capacity to withstand increased nutrient levels (including wastewater effluent) and heavy metals, and are able to remove, recycle and immobilise contaminants and nutrients. Because melaleuca species can grow in a variety of soil types including acid sulfate soils (ASS), nutrient deficient sandy soils, waterlogged soils, nutrient-enriched alluvial soils and saline groundwater soils, they are able to withstand changing environmental conditions. Nevertheless, when coastal and sub-coastal tree swamps are overloaded with nutrients and chemicals, dieback and weed invasion can occur.

Clearing and draining of coastal and sub-coastal tree swamps that are on ASS disturb this naturally occurring but potentially destructive material. When exposed to air these soils produce acid and can cause significant environmental and economic impacts such as the poisoning of aquatic species and the degradation of concrete and steel structures. Potential acid sulfate soils cause problems when exposed to air by excavation or lowering of the water table. Bacteria in estuarine sediments turn sulfates into sulfides under **anaerobic** conditions. Once exposed to air, the iron sulfides (pyrite) in the soils react with oxygen to form sulfuric acid. After rain the acid can be flushed into creeks where the water turns so acidic fish may be killed. In addition, toxic metals may be dissolved out of the soils by the acid and leach into the environment.

A state planning policy for AS (State Planning Policy 2/02: Planning and Managing Development Involving Acid Sulfate Soils and associated State Planning Policy 2/02 Guideline: Acid Sulfate Soils—<www.dip.qld.gov.au>) came into effect in 2002.

For any development on land, soil or sediment at or below 5 m above sea level the policy requires that the release of acid and associated metal contaminants into the environment be avoided by either not disturbing the soils, or by treating and managing the soil and associated drainage water.

Prior to disturbing the soil a management plan must be developed in consultation with a soil scientist or engineer with experience in ASS. After disturbance, ongoing monitoring at the site is essential. Further information regarding ASS and its management is available from the Queensland Acid Sulfate Soils Investigation Team <www.derm.qld.gov.au>. Local development control plans, regional coastal and sub-coastal zone plans and building codes might also provide additional information.

Potential acid sulfate soils (also called 'marine mud' or 'mangrove mud') are typically dark grey, wet and sticky. They can range from sand to clays.
Photo: Queensland Acid Sulfate Soils Investigation Team (QASSIT), DERM

WHAT ARE ACID SULFATE SOILS?

Acid sulfate soils (ASS) are a natural phenomenon, with an estimated 2.3 million hectares occurring along the Queensland coast. The acid sulfate soils found today have predominately formed over the last 20 000 years as mangroves and other organic matter accumulated on tidal flats and mixed with saline water under anaerobic conditions.

ASS usually occur at elevations less than 5 m above sea level (reflecting the extent or sea level and tidal influence in recent times) and are common under low-lying areas such as estuaries, saltmarshes, floodplains, tidal and brackish lakes, mangrove flats and coastal and sub-coastal tree swamps. ASS are highly variable in form, ranging from mud to sand and **peat**, however they all contain iron sulfide. In their normal waterlogged state, ASS are harmless to the environment, however when disturbed by drainage, excavation or other activities, the sulfides in the soil are exposed and react with oxygen in air to produce sulfuric acid. Sulfuric acid breaks down the soil and releases toxins such as aluminium, iron and other metals. These toxins leach into waterways and can cause serious consequences such as poisoning fish, oysters, crabs and other aquatic life. ASS can also promote diseases such as fish red-spot, and corrode and destroy concrete and steel structures. Exposed acid sulfate soils often irreversibly shrink and crack, causing building foundations or roads to subside or split.

Concrete bridge pylons in the Pimpama River, south-east Queensland, corroded by acid sulfate soils
Photo: Queensland Acid Sulfate Soils Investigation Team (QASSIT) DERM

Sulfuric acid produced during the oxidation of acid sulfate soils strips iron from the soil and toxic amounts of the colourless iron can then be washed into waterways. The colourless iron in the acid water changes to rust red when it contacts less acid water, such as rainwater or seawater. This results in a rust-coloured iron oxide scum or 'floc' which can smother vegetation and stain concrete and soil.
Photo: Queensland Acid Sulfate Soils Investigation Team (QASSIT) DERM

Exposure to acid water and toxic heavy metals associated with disturbed acid sulfate soils damages fish skin and gills, increasing the susceptibility of fish to fungal infections such as 'red-spot' disease. Red-spot disease results in red ulcerative lesions, leaving them unsaleable and can result in fish death.
Photo: Queensland Acid Sulfate Soils Investigation Team (QASSIT) DERM

Managing fire

Coastal and sub-coastal tree swamps in their natural state are relatively fire tolerant because the high moisture levels and low fuel loads found in this environment ensure that intense fires are rare events. The swamps provide natural firebreaks and are a refuge for animals in times of bushfire. By contrast, in disturbed or degraded coastal and sub-coastal tree swamps that contain non-natural understorey species, such as guinea grass *Megathyrsus maximus* at the sandy edges or para grass *Brachiaria mutica* or other ponded pasture species throughout the swamp, fires are likely to be hotter and more frequent. This can alter the vegetation composition and affect fauna that rely on melaleuca trees for nesting habitat or food. Frequent burning also tends to produce tall grassy forests. Where there is dense growth of acacia species this can indicate disturbance/degradation of a coastal and sub-coastal tree swamps.

Severely burned peat in a coastal and sub-coastal tree swamp in Byfield National Park
Photo: Rhonda Melzer, DERM

FIRE MANAGEMENT OF BRIBIE ISLAND'S COASTAL AND SUB-COASTAL TREE SWAMPS

Bribie Island is a low-lying 14 300 ha sand island in the north-west of Moreton Bay in south-east Queensland. Much of the island is an extensive system of wetlands including intertidal mudflats, saltmarshes, mangroves, seagrasses and coastal and sub-coastal tree swamps. The surrounding tidal areas are part of the Moreton Bay Marine Park and the internationally important Moreton Bay Ramsar wetland.

Managing fire on the island is complex due to the highly flammable vegetation, its proximity to dense residential and commercial areas and plantation timbers in state forests, and the diversity of interests of island stakeholders. Planned fire management is difficult to accomplish as large arson-lit fires occur at least every three to four years. The Bribie Island Fire Reference Group has now developed a cooperative approach to fire management for the entire island. In 2004, the Bribie Island Fire Strategy was released reflecting the varied interests of the island's inhabitants and industries. The strategy recognises the importance of fire as a management tool for fire-adapted vegetation communities and identifies more fire sensitive vegetation communities suggesting alternative management strategies.

Melaleuca quinquenervia swamps are one of three major vegetation types found on the island. Young melaleuca trees will not reach maturity if they are exposed to fires too frequently, but do require fire to germinate, so it is crucial appropriate fire regimes are adopted. Research has shown burning of these swamps should occur every 15–30 years with burns conducted when the soil is wet, to reduce the risk of fire spreading to surrounding or underlying peat areas. Fire retardants should not be used to control fire in aquatic environments such as coastal and sub-coastal tree swamps because they may damage the ecology of these sensitive areas.

Fire damage to a coastal and sub-coastal tree swamp, Bribie Island Photo: David Cameron, DERM

Careful fire management on Bribie Island will maintain the vegetation crucial for habitat or food for local and migratory fauna, protect cultural values and minimise the risk of wildfires burning extensive areas, ensuring the island's residents, properties and businesses are protected.

WHEN fire is considered the most appropriate weed eradication method, a carefully planned **mosaic** burn pattern considering the location of tree hollows and other habitat features should be used.

The use of fire in coastal and sub-coastal tree swamps should be carefully managed, for example, it has been found that frequent burning (every 1–3 years) of coastal and sub-coastal tree swamps on Bribie Island in south-east Queensland can hinder seedling establishment and regeneration. Infrequent natural fires (between 15–30 years) are most beneficial in maintaining the integrity of these wetlands.

When fire is considered the most appropriate weed eradication method, a carefully planned mosaic burn pattern, that considers the location of tree hollows and other habitat features, rather than a site-wide burning strategy, should be employed. The nature of the surrounding vegetation types should also be considered and incorporated into the burning strategy.

Many coastal and sub-coastal tree swamps occur on peat, which is highly susceptible to fire especially when dry. In areas of peat, where it is critical that the ground layer is not burned, land managers should ensure that peat soil is saturated or that there is standing water in the swamp when fire management is undertaken. Where the endangered (NC Act and EPBC Act) swamp orchid occurs, burning should only take place prior to August while the swamp orchid is dormant and the tree swamp is moist and less likely to be damaged.

Managing weeds

Coastal and sub-coastal tree swamp wetlands in Queensland are threatened by introduced (exotic) species including devil's fig *Solanum torvum*, groundsel bush *Baccharis halimifolia* and water hyacinth *Eichhornia crassipes*. These weeds are spread by vehicles, native, domestic and feral animals and by flowing water and the wind. The presence of devil's fig is often an indication of heavy grazing pressure.

CONSTANT heavy grazing during the dry season is one method of controlling hymenachne and possibly eradicating it if the grazed plants are completely submerged in the ensuing wet season.

The greatest threat from exotic species comes from two grasses commonly used as ponded pasture—hymenachne *Hymenachne amplexicaulis* and para grass *Brachiaria mutica*. Introduced hymenachne is one of 20 pest species classified as Weeds of National Significance (WoNS), and it is an offence to sell, keep or release these species under the Queensland Land Protection (Pest and Stock Route Management) Regulation 2003. These aggressive grasses can completely dominate coastal and sub-coastal tree swamps and other wetland habitats and choke them, even when being grazed. Ponded pastures should not be established in or near natural wetlands due to their unacceptable impacts on these areas, as outlined under the Queensland Policy for Development and Use of Ponded Pastures (see Managing changes in land use).

Control methods for weeds vary and can include manual or mechanical removal, chemical application and biological control (if available). Although fire can be a very effective method of controlling weeds it is not recommended for coastal and sub-coastal tree swamps (see Managing fire). All methods require follow-up and ongoing observation to ensure the weed infestations are under control. Constant heavy grazing during the dry season is one method of controlling hymenachne and can possibly eradicate it if the grazed plants are completely submerged in the ensuing wet season.

Invasion of the Iwasaki Wetlands by para grass *Brachiaria mutica* Photo: Kylie Joyce, DERM

Invasion of the Iwasaki Wetlands by hymenachne *Hymenachne amplexicaulis* Photo: Kylie Joyce, DERM

It is important to be well informed about chemicals used in weed control because there can be penalties if native plants and animals are harmed, particularly around wetland areas. Herbicides that target the weed species and will not contaminate the area are preferred. Details about suitable herbicides and appropriate timing and methods to control most weeds can be obtained from the Department of Employment, Economic Development and Innovation (DEEDI) <www.deedi.qld.gov.au> or the Australian Government Weeds in Australia website <www.weeds.gov.au>.

Managing feral animals

Feral pigs *Sus scrofa* can cause extensive damage to coastal and sub-coastal tree swamps. They feed on plants and animals within and around the swamps, fouling and muddying water, destroying tuberous plants and other vegetation, and destabilising swamp banks and dunes. Feral pigs also disturb or destroy important feeding, breeding and nesting habitat for native animals and can decimate frog and fish populations through predation. Feral pigs are also a major carrier of weed seeds. These impacts are found in coastal, sub-coastal and inland areas throughout Queensland's wetland and riparian ecosystems.

Many landowners and land managers have a feral pig control program in place, usually involving a combination of shooting, trapping and baiting to reduce pig numbers. Control programs are most effective when considered as a part of a cooperative approach across a local area. For further information on pest animal management, see the DEEDI website <www.deedi.qld.gov.au>.

Managing resource use

Melaleuca trees and swamps are also utilised directly by businesses and industries such as honey and tea-tree oil production, sand mining, plant nurseries, florists, restaurants, and artists who use bark and other products derived from coastal and sub-coastal tree swamps. Permits, state and federal legislation, and industry guidelines determine how land managers can best manage resources and any associated wetlands. This will depend on the wetland tenure, its location and environmental value or uniqueness. To maintain the integrity of coastal and sub-coastal tree swamps land managers and state and local governments must ensure that businesses and industries are sustainable and environmentally sound.

Glossary

Acid sulfate soils (ASS) Soils which are potentially extremely acidic (pH <3.5) because of large amounts of reduced forms of sulfur that are oxidised to sulfuric acid if the soils are exposed to oxygen when they are drained or excavated.

Adventitious Organ or structure in an unusual place such as roots growing from the stem.

Aerenchymatous A spongy tissue with large air spaces found between the cells that provides buoyancy and allows gases to circulate.

Alluvial floodplains Plains created from the deposition of sediments transported by channelled stream flow or over-bank flow.

Alternate An alternate pattern of leaves or buds in which there is one leaf (or bud) per node and on the opposite side of the stem (not in pairs).

Anaerobic Without oxygen.

Arthropod A large group of invertebrate animals with jointed legs, including insects, scorpions, crustaceans and spiders.

Brackish Water that is lightly saline, much less salty than seawater.

Branchlets The youngest and smallest division of a branch, excluding twigs.

Bund walls Low embankments for an area of containment used to describe features such as dams, pond walls and flood banks.

Crustaceans Animals with jointed legs and segmented bodies that have a hardened outer shell and usually live in water, including prawns, crabs and crayfish.

Dieback The progressive death, from the top downward, of leaves and branches and eventually often the whole plant.

Diversion banks Structures that turn aside or alter the natural course of water flow.

Ecotones A transition zone between two or more ecological communities.

Endemic Found only in one particular area.

Environmental values 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 (see www.legislation.qld.gov.au).

Epiphytic Referring to a plant that lives on the surface of another plant, typically a tree, or other structure, that obtains its moisture and nutrients from the air and rain.

Estuaries Semi-enclosed coastal bodies of water with free connections with the open sea and within which seawater mixes with fresh water. They are located at the lower end of a river and are subject to tidal fluctuations.

Floodplains The land bordering a stream, built up of sediments from overflow of the stream and subject to inundation when the stream is at flood stage.

Holocene The geological period of time (epoch) from about 11 000 years ago to the present, following the Ice Age (Pleistocene epoch).

Hydrological Pertaining to water flow.

Hydrology The science dealing with the properties, distribution and circulation of water.

IUCN Red List A list of globally threatened species assessed and maintained by the World Conservation Union (IUCN). The List provides taxonomic, conservation status and distribution information and highlights those species or groups of species that are facing a higher risk of global extinction.

Land zone 1 Marine deposits, subject to periodic inundation by saline or brackish marine waters.

Land zone 2 Coastal sand dunes and swales.

Land zone 3 Near-level alluvial plains with riverine patterns, wetlands and lakeside dunes.

Levee banks Natural or artificial embankments, usually earthen, which parallel the course of a river.

Microclimate The climate of a small area, which may be different from that in the general region.

Microhabitats A small area where an organism lives that has different conditions from other small surrounding areas.

Mosaic A method of patchy burning which creates areas of burnt and unburnt country across a landscape.

Nectivorous Feeding on nectar.

Palustrine Pertaining to marshes, swamps, bogs and fens.

Parabolic dunes Horseshoe-shaped dunes having a concave windward slope and a convex leeward slope. Parabolic dunes tend to form along sandy ocean and lake shores.

Passerines Of the order Passeriformes—commonly known as 'perching birds' or, less accurately, as 'songbirds'.

Peat Partially decomposed organic matter (mostly plant material) which accumulated in water-saturated environments, deficient in oxygen; resulting from anaerobic respiration.

Pendulous Drooping, hanging loosely downwards from a support.

Perched water tables A localised zone of water which sits on top of an aquitard (rock layer with low permeability). A perched zone is typically unconfined and at a higher elevation than the regional aquifer system with unsaturated conditions below.

Pine wildings Young pine seedlings (which develop naturally) often establishing in native bushland adjacent to pine plantations.

Ponded pastures The practice developed by pastoralists to create an environment by either the construction of banks or the modification of naturally wet areas, in which fresh water is impounded or used primarily to grow suitably adapted plant species and produce fodder for grazing.

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).

Riparian Pertaining to the river bank. Riparian vegetation is vegetation along the river.

Scalding Where minerals accumulate on the soil surface, suppressing plant growth and often leading to surface soil erosion (which can expose saline subsoils).

Siliceous Composed of silica (silicon dioxide, SiO_2).

Soft water Water that contains little or no calcium or magnesium salts but is highly acidic.

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.

Swales Slight depressions or valleys in the ground surface where water collects; typically refers to narrow valleys between parallel sand dunes.

Swamp orchid A group of Australian ground orchids with specimens variously assigned to one of three names: *Phaius tancarvillieae*, *P. australis* and *P. bernaysii*. Whilst under taxonomic review, the Queensland Herbarium recommends the use of the names *Phaius australis* (for red/ochre forms) and *P. bernaysii* (for yellow forms).

Tannin A brown pigment found in leaves and other parts of plants. Tannin solutions are acidic and have an astringent taste.

Topography The shape of the land in terms of elevation, slope and orientation.

Unconsolidated Loose sediment that has not been cemented or otherwise converted to solid rock.

Understorey Refers to the flora growing beneath the canopy layer of the forest or woodland and includes ground cover, herb layers and shrub layers.

Wallum Heathland that grows in sandy, low nutrient, acidic soils on the lowlands and offshore islands of south-east Queensland.

World Heritage Convention The Convention Concerning the Protection of the World Cultural and Natural Heritage is an international treaty that seeks to encourage the identification, protection and preservation of cultural and natural heritage around the world considered to be of outstanding value to humanity.

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Appendixes

Appendix 1: Some of the threatened fauna associated with Queensland's coastal and sub-coastal tree swamps

Taxon group	Common name	Scientific name	NC Act status*	EPBC Act status*	IUCN Red List of threatened species status**
Mammals	water mouse	*Xeromys myoides*	vulnerable	vulnerable	–
	mahogany glider	*Petaurus gracilis*	endangered	endangered	endangered
	spectacled flying–fox	*Pteropus conspicillatus*	–	vulnerable	–
Birds	cassowary	*Casuarius casuarius johnsonii*	endangered	endangered	vulnerable
Fish	honey blue eye	*Pseudomugil mellis*	vulnerable	vulnerable	endangered
Amphibians	wallum froglet	*Crinia tinnula*	vulnerable	–	vulnerable
	Cooloola sedgefrog	*Litoria cooloolensis*	–	–	endangered
	wallum rocketfrog	*Litoria freycineti*	vulnerable	–	vulnerable
	wallum sedgefrog	*Litoria olongburensis*	vulnerable	vulnerable	vulnerable
Insects	Apollo jewel butterfly	*Hypochrysops apollo apollo*	vulnerable	–	–
	Australian fritillary	*Argyreus hyperbius inconstans*	endangered	–	–

* 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.

Appendix 2: Some of the threatened flora associated with Queensland's coastal and sub-coastal tree swamps

Taxon group	Common name	Scientific name	NC Act status*	EPBC Act status*	IUCN Red List of threatened species status **
Ferns		*Asplenium wildii*	vulnerable	vulnerable	–
Herbs		*Sowerbaea subtilis*	vulnerable	vulnerable	–
		Prostanthera palustris	vulnerable	–	–
Orchids	swamp orchid†	*Phaius australis/ tancarvilleae*	endangered	endangered	–
	yellow swamp orchid	*Phaius bernaysii*	endangered	endangered	–
	wallum leek orchid	*Prasophyllum wallum*	vulnerable	vulnerable	–
Epiphyte	ant plant	*Myrmecodia beccarii*	vulnerable	vulnerable	–
Trees/shrubs		*Acacia attenuata*	vulnerable	vulnerable	–
		Acacia baueri subsp. baueri	vulnerable	–	–
	bacon wood	*Archidendron lovelliae*	vulnerable	vulnerable	–
	Byfield matchsticks	*Comesperma oblongatum*	vulnerable	vulnerable	–
	hop bush	*Dodonaea rupicola*	vulnerable	vulnerable	–
		Germania capitata	vulnerable	vulnerable	–
	grevillea	*Grevillea venusta*	vulnerable	vulnerable	–
		Habenaria harroldii	endangered	–	–

* 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 taxonomy of swamp orchids is under review. Currently, both *Phaius australis* and *Phaius tancarvilleae* are recognised as two distinct species scheduled as endangered under the NC Act and EPBC Act.

Appendix 3: Wetlands in Queensland that are listed in A Directory of Important Wetlands in Australia (2005) and/or Ramsar sites and that include coastal and sub-coastal tree swamps

Bioregion	Directory reference	Directory wetlands	Ramsar wetlands
Brigalow Belt North	QLD002	Bowling Green Bay	Bowling Green Bay
Brigalow Belt South	QLD012	Fitzroy River Delta	—
	QLD014	Hedlow Wetlands	—
	QLD017	Northeast Curtis Island	—
Central Mackay Coast	QLD043	Corio Bay Wetlands	Shoalwater and Corio Bays Area
	QLD044	Dismal Swamp — Water Park Creek	Shoalwater and Corio Bays Area
	QLD047	Four Mile Beach	—
	QLD048	Island Head Creek — Port Clinton Area	Shoalwater and Corio Bays Area
	QLD049	Iwasaki Wetlands	Shoalwater and Corio Bays Area
	QLD050	Proserpine — Goorganga Plain	—
	QLD052	Sandringham Bay — Bakers Creek Aggregation	—
	QLD053	Sara Inlet — Ince Bay Aggregation	—
	QLD055	St Helens Bay Area	—
	QLD178	Shoalwater Bay Training Area Overview	Shoalwater and Corio Bays Area
Cape York Peninsula	QLD059	Cape Flattery Dune Lakes	—
	QLD065	Marina Plains — Lakefield Aggregation	—
Gulf Plains	QLD109	Mitchell River Fan Aggregation	—
South Eastern Queensland	QLD019	Port Curtis	—
	QLD126	Burrum Coast	—
	QLD127	Bustard Bay Wetlands	—
	QLD128	Carbrook Wetlands Aggregation	—
	QLD131	Fraser Island	Great Sandy Strait
	QLD132	Great Sandy Strait	Great Sandy Strait
	QLD133	Lake Weyba	—
	QLD134	Moreton Bay	Moreton Bay
	QLD135	Noosa River Wetlands	—
	QLD136	Pumicestone Passage	Moreton Bay
	QLD142	Cowley Area	—
	QLD179	Wide Bay Military Reserve	Great Sandy Strait
	QLD180	Greenbank Military Training Area	—

Bioregion	Directory reference	Directory wetlands	Ramsar wetlands
South Eastern Queensland (continued)	QLD182	Deepwater Creek	–
	QLD185	Coolum Creek and Lower Maroochy River	–
	QLD187	Lower Mooloolah River	–
	QLD190	Pine River and Hays Inlet	Moreton Bay
	QLD194	Lake Coombabah	Moreton Bay
Wet Tropics	QLD137	Alexandra Bay	–
	QLD139	Bambaroo Coastal Aggregation	–
	QLD142	Cowley Area	–
	QLD143	Edmund Kennedy Wetlands	–
	QLD144	Ella Bay Swamp	–
	QLD145	Eubenangee — Alice River	–
	QLD146	Herbert River Floodplain	–
	QLD148	Hinchinbrook Channel	–
	QLD149	Innisfail Area	–
	QLD150	Kurrimine Area	–
	QLD154	Lower Daintree River	–
	QLD155	Missionary Bay	–
	QLD157	Port of Cairns and Trinity Inlet	–
	QLD159	Russell River Rapids	–
	QLD161	Tully River — Murray River Floodplains	–
	QLD163	Wyvuri Swamp	–

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