

# WETLAND MANAGEMENT PROFILE

## COASTAL AND SUB-COASTAL NON-FLOODPLAIN ROCK LAKES

Coastal and sub-coastal non-floodplain rock lakes (commonly known as crater lakes) form in the volcanic **calderas** or craters after a volcano has been inactive for some time. Coastal non-floodplain rock lakes have high biodiversity, social and cultural values. They support threatened and migratory species, recreation, and are important to Indigenous people. They occur mostly in the Wet Tropics of north Queensland but are not common wetland types across the state. Pests and weeds, and unnatural disturbance have degraded some crater lakes. Recreation is also a possible source of degradation.

This profile covers the habitat types of coastal and sub-coastal non-floodplain rock 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](http://www.derm/qld.gov.au/wetlandinfo)>.

### Description

Coastal and sub-coastal non-floodplain rock lakes (crater lakes) form in volcanic craters some time after a volcano has become inactive. In Queensland they are predominantly formed in remnants of basaltic volcanoes. Generally water in crater lakes is fed from stream flow, runoff and floodout from the localised **catchment** within the crater rim or from underground springs.

Crater lakes can form in **maars** and calderas in a number of ways. For example, crater lakes may form where explosive volcanic eruptions produce wide craters (maars). Lake Eacham and Lake Barrine are examples of this type of crater lake formation. The inner walls are usually relatively steep and when the volcanoes become extinct, a lake may form. These are the most common form of crater lakes in Queensland.

Calderas are formed where an empty chamber below the summit of a volcano collapses inward to form a large crater. Where the sides remain intact and the catchment of the crater rim is able to capture sufficient water, a lake or ponds may form.

In the case of Coalstoun Lakes in south-east Queensland, crater lakes have formed in maars within calderas.

Over time, crater lakes may gradually fill with sediment and become relatively shallow swamps such as Bromfield Swamp in far north Queensland.

Some crater lakes are permanent while others are seasonal to intermittent lakes or marshes. They range in size from small ponds of less than one hectare to larger lakes of over 100 ha. Because of the way the volcanic mounds or cones are formed, in Queensland these lakes are usually between 300 and 750 m above sea level.



Map showing the distribution of coastal and sub-coastal non-floodplain rock lakes in Queensland; grey lines indicate drainage basins. Map: From Queensland Wetlands Mapping v2.0 (September 2009)

## CRATER LAKES NATIONAL PARK

Lake Eacham and Lake Barrine are part of the Crater Lakes National Park in north Queensland. While Lake Eacham is enclosed by the park, Lake Barrine is partly surrounded by national park, freehold and leasehold tenures. Both are water filled explosion craters or maar, located on **Cainozoic** olivine basalt and surrounded by upland complex mesophyll vine forests. Water is supplied to Lakes Eacham and Barrine entirely from the localised catchment within the crater rim, which are 64 and 240 ha respectively.

The rainforest around Lakes Eacham and Barrine contains large kauri pines *Agathis* spp., descendants of species which dominated the Tableland forests for thousands of years. Lake Eacham's rainforests demonstrate how soil type affects vegetation. On less fertile soils, the rainforests are simpler with more uniform trees and few buttresses.



**Lake Barrine in the Crater Lakes National Park.**  
Photo: DERM

On the deeper, more fertile soils around the crater, the rainforest is more complex. The canopy is uneven and trees vary in size, have large buttresses and are covered in **epiphytes** like orchids and ferns.

Crater lakes may include submerged or floating aquatic vegetation. The outer margins may have a saturated sedge and/or grass component. Further away from the water's edge you may encounter herbland or low shrubland. A complex mesophyll vine forest (generally in the Wet Tropics) or a low microphyll rainforest and semi-evergreen vine thicket may occur within the crater rim and surrounding the inner vegetation.

## Distribution

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](http://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](http://www.derm.qld.gov.au/wetlandinfo)>.

## National conservation status

The Wet Tropics World Heritage Area as defined in the World Heritage List maintained by the World Heritage Convention includes crater lakes. There are also migratory shorebirds that inhabit crater lakes in Queensland, which are listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (that is, they are listed under the Japan-Australia and China-Australia Migratory Bird Agreements (**JAMBA/CAMBA** respectively) and/or the **Bonn Convention**) (see Species of conservation significance).

Three animals that inhabit crater lakes in Queensland are listed as threatened under the EPBC Act and/or the Queensland *Nature Conservation Act 1992* (NC Act) and/or the **IUCN Red List**.

Listed migratory species, threatened species and World Heritage properties are matters of national environmental significance 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 listed migratory species, threatened species or World Heritage property will be subject to an environmental assessment and approval regime under the EPBC Act.

A management plan is in place for the Wet Tropics World heritage Area (see <[www.wettropics.gov.au](http://www.wettropics.gov.au)> for further information). At present there are no crater lakes contained within **Ramsar** sites in Queensland.

## Cultural heritage values

All wetland ecosystems are of material and cultural importance to Indigenous people and many will have profound cultural significance and values. Some Indigenous people of Queensland have strong cultural associations with crater lakes dating back thousands of years. Crater lakes were important for Indigenous people providing food and other material resources, as well as having ceremonial and spiritual values. A number of Indigenous cultural heritage sites have been recorded in association with crater lakes in Queensland. However, most crater lakes have not been systematically surveyed or assessed for cultural heritage significance.

Indigenous occupation of crater lake areas on the Atherton Tableland is believed to date from at least 20 000 years ago. A number of crater lakes in that region have particular significance as mythological and ceremonial sites. Indeed, traditional lore records the volcanic creation of the maar craters at lakes Eacham, Barrine and Euramoo. Geological evidence indicates that the volcanic activity that created these crater lakes occurred as little as 13 000 years before present and supports the events described in traditional lore. Similarly, the crater lakes of Coalstoun National Park have traditional mythological significance for the Wakka Wakka people.

Almost all plant and animal species had some form of traditional use, particularly vegetation, **crustaceans**, fish, reptiles, mammals and waterbirds (particularly

their eggs), or cultural significance (for example totemic significance). Many plant species **endemic** to crater lakes were traditionally used for food, fibre and medicinal purposes.

Crater lakes have particular significance as story places, landscape features and as sites for cultural activities. Indigenous sites, such as artefact scatters, open camp sites and scarred trees, are likely to be found along lake margins and in areas of higher ground adjacent to crater lakes. Some crater lakes also have non-Indigenous (historic) cultural heritage significance. The few historic heritage places recorded in crater lakes demonstrate evidence of their past and present use for recreation, nature based tourism and health. For example, lakes Eacham and Barrine have been popular recreation and tourism destinations since the 1930s. They were also used for training purposes and for rest and relaxation places by the Australian and American military forces during World War II. It is important to note that evidence of traditional occupation and use may also be encountered at historic sites.

## Ecological values

Crater lakes such as Lake Eacham and Bromfield Swamp are **lacustrine** wetlands with areas of relatively deep open water. They usually exhibit a **limnetic** zone and a very narrow **littoral** zone, which may be overhung with vegetation and in some cases, rainforest. Others such as the Coalstoun Lakes exhibit a **palustrine** component around a smaller lacustrine wetland component.

Crater lakes may include submerged or floating aquatic vegetation. The outer margins usually have a saturated sedge and/or grass component. Closer to the waters edge you may encounter herbland or low shrubland. In the Wet Tropics, complex mesophyll vine forest may be encountered within the crater rim while in south-east Queensland, low microphyll rainforest and semi-evergreen vine thickets may be encountered.

Most taxon groups are represented in crater lake habitats. Mammals, birds and reptiles are nearby or often visit to drink or feed around the lakes. Turtles and frogs often occur in and around some crater lakes. A variety of waterbirds, including some migratory species, use crater lakes to feed and nest. In some areas the crater lakes are relatively isolated and provide significant refuge for flora and fauna.



## Species of conservation significance

WetlandInfo provides full species lists of wetlands animals and plants.

### Wet Tropics

Lakes Eacham, Barrine and the western edge of Quincan Crater have been mapped as essential habitat for the southern cassowary *Casuarius casuarius johnsonii* (endangered NC Act and EPBC Act), although cassowaries do not currently reside in any of these areas. However, the planting of vegetated corridors to improve connectivity in the area may well facilitate the movement of cassowaries into these areas in the future. Lake Euramoo, which is on the edge of a large area of continuous cassowary habitat, is currently surrounded by vegetation that is mapped as essential cassowary habitat.

Bromfield Swamp is a locally important roost for brolga *Grus rubicunda* and sarus cranes *Grus antigone*. The sarus crane is listed as vulnerable in the IUCN Red List and it is a listed migratory species under the EPBC Act.

Bird species that have been recorded using crater lakes on the Atherton Tableland and listed as migratory species under the EPBC Act include wandering whistling-duck *Dendrocygna arcuta*, hardhead *Aythya australis*, Pacific black duck *Anas superciliosa*, grey teal *Anas gracilis*, whistling kite *Haliastur sphenurus*, grey goshawk *Accipiter fasciatus*, sarus crane *Grus antigone*, and Latham's snipe *Gallinago hardwickii*.

**SOME** wildlife is endemic to crater lakes or the ecosystems surrounding them due to their isolation.



The brolga *Grus rubicunda*.  
Photo: DERM



The Lumholtz's tree-kangaroo *Dendrolagus lumholtzi*. Photo: DERM



Lake Eacham in Far North Queensland.  
Photo: DERM

Because of the isolation of crater lakes some wildlife is endemic to particular lakes or the ecosystems that directly surround them. This is particularly the case for aquatic taxa such as fish. The forests around lakes Eacham and Barrine contain twelve species of birds endemic to the Queensland Wet Tropics. Ten of these species are also restricted to the Australian Tropical Rainforest **biome**. There are many species of frogs in the Wet Tropics crater lakes, usually common and widespread. In the Wet Tropics where the crater lakes are surrounded by or abut rainforest vegetation there are a variety of endemic reptiles and mammals. These may not be reliant on the lakes for their survival.

The endangered (EPBC Act) Lake Eacham rainbowfish *Melanotaenia eachamensis* was once found in the lake it is named after but is now thought to be extinct (see box).

Where the crater lakes are surrounded by or, abut rainforest vegetation, there is a variety of endemic Wet Tropic mammals, reptiles and amphibians.

The green ringtail *Pseudochirops archeri* is found at Lakes Eacham and Barrine. The lemuroid ringtail *Hemibelideus lemuroids* and Herbert River ringtail *P. herbertensis* are less common—these species of possum are only found in the upland rainforests of the Wet Tropics. Lakes Eacham and Barrine also support a

high density of musky rat kangaroo *Hypsiprymnodon moscatus*, the smallest, most primitive member of the kangaroo family. Lumholtz's tree-kangaroo *Dendrolagus lumholtzi*, listed as rare under the NC Act, also occurs in forest surrounding Lake Eacham and Quincan Crater, although it is not reliant on the crater lakes for its survival. The geckos *Saltuarius cornatus* and *Carphodactylus leavis*, the skinks *Carlia rubrigularis*, *Coeranoscincus frontalis*, *Eulamprus tigrinus*, *Glaphyromorphus fuscicaudis*, *Gnypetoscincus queenslandiae*, *Saproscincus basiliscus* and *S. tetradactylus* are also endemic to these areas. *C. frontalis* and *E. tigrinus* are listed as rare under the NC Act. Also present are Boyd's forest dragon *Hypsilurus boydii* and the northern dwarf crowned snake *Cacophis churchilli*. Lakes Eacham and Barrine are significant population centres for the amethystine python *Morelia kinghorni* on the Atherton Tableland, which is the largest snake in Australia and the largest terrestrial carnivore in the Wet Tropics. The ornate nurseryfrog *Cophixalus ornatus* and northern whistling frog *Austrochaperina fryi* are present at lakes Eacham and Barrine. The tapping green eyed frog *Litoria genimaculata* is present on streams in both Lakes Eacham and Barrine sections of the Crater Lakes National Park. This species is listed as rare under the NC Act.

## LAKE EACHAM RAINBOWFISH

A survey of Lake Eacham in 1978 revealed the existence of the Lake Eacham rainbowfish *Melanotaenia eachamensis*. The species was formally described in 1982 and initially it was believed that the species was endemic to Lake Eacham, a crater lake on the Atherton Tableland in the Wet Tropics.

In 1987, surveys indicated that the species no longer occurred in the lake. It was thought to be the first freshwater fish species in Australia to become extinct in the wild. The main cause is likely to be the unofficial release of translocated native fish predators into the lake such as mouth almighty *Glossamia aprion*, sevenspot archerfish *Toxotes chatareus*, bony bream *Nematalosa erebi* and barred grunter *Amniatabe percoides*. These species were not found in the lake until the rainbowfish disappeared. Despite a number of reintroduction attempts, the Lake Eacham rainbowfish remains absent.



**The Lake Eacham rainbowfish *Melanotaenia eachamensis*.** Photo: DERM

Eradication of its predators has been prevented due to the lack of an environmentally acceptable eradication method.

The species has since been discovered in other locations in the Wet Tropics, including Dirran Creek and Lake Euramoo.



## Managing the crater lakes

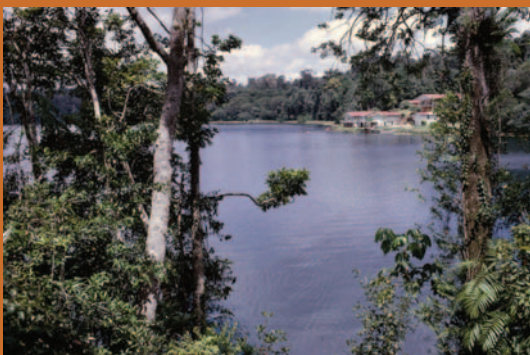
Like all wetlands, the sustainable use of crater lakes and their surrounds must be adequately planned and managed. They occur in a variety of tenures including freehold grazing land, state forests and protected areas. As such there are a number of uses that may impact on crater lakes. Some uses include tourism and recreation, conservation, agriculture (crops and grazing) and horticulture.

Some of the impacts or threats can include weed encroachment, pests, inappropriate fire regimes, inappropriate grazing practices, clearing and overuse from recreation/tourism.

### Tourism and recreation

Because of the unique environments, wildlife, and recreational opportunities that crater lakes provide, they are valued as recreational and tourism resources. Some of these pursuits include boating, fishing, swimming, camping, hiking and day visitation.

Excessive visitation puts a strain on crater lakes. Run-off from poorly designed carparks and roads can cause siltation, damaging water quality and affecting flora and fauna. Unregulated visitation can lead to the trampling of fragile flora species and can cause erosion if walking is not conducted on properly constructed walking tracks. Unregulated or inappropriate recreation and tourism can also pose fire threats, introduce pests and cause pollution as outlined below.



Recreation needs to be properly managed in and around crater lakes.

Photo: DERM

## Pests

Most crater lakes have some exotic flora and fauna problems. Weed encroachment into and around the edge of crater lakes can have significant impacts on crater lakes. The introduction of aquatic species not native to the area and non-native species can affect water quality, impact wildlife habitat, and cause the local extinction of some species. Certain locations, particularly those that are intensively used for recreation or have been cleared of vegetation, or where cattle graze or have previously grazed, are susceptible to exotic weed invasion. Weeds displace native flora by competition, shading and altering vegetation fuel loads, and subsequently change the ecology and threaten the character of crater lake communities. They can be spread as live fragments or seed by vehicles, native, domestic and feral animals, by flowing water and wind.

Control methods for weeds vary and include manual or mechanical removal, chemical application, biological control (if available) and fire. Integrated weed control programs using more than one of these methods are likely to be the most effective. Although fire can be a highly effective control method its use needs to be thoroughly considered (see Fire). For example, fire can be detrimental to many of the native vine forest species that occur in association with crater lakes. It is also important that land managers are well informed about chemicals used for weed control as they are toxic and penalties can apply if native plants and animals are harmed, particularly around wetland areas. Herbicides that only target the weed species and do not contaminate the area are preferred. All methods require follow-up and ongoing monitoring to ensure that weeds remain under control and that there are not unforeseen effects.

Infestations of weeds such as lantana *Lantana camara*, rubber vine *Cryptostegia grandiflora*, groundsel *Baccharis halimifolia* and prickly pear *Opuntia* spp. (other than *O. ficus-indica*) occur at some crater lakes.

Lantana and rubber vine are two of 20 pest species classified as Weeds of National Significance (WoNS). See the Australian Government's Weeds in Australia website <[www.weeds.gov.au](http://www.weeds.gov.au)>, and in Queensland rubber vine, prickly pear, groundsel and lantana are listed as declared plants under the *Land Protection (Pest and Stock Route Management) Act 2002*—rubber vine, prickly pear and groundsel (Class 2), lantana (Class 3). By law all landholders must try to keep their land free of Class 2 pests and it is an offence to keep or sell these plants without a permit.

Class 3 pests cannot be sold, and landholders can be required to use control measures if their land occurs next to 'environmentally significant areas', such as national parks and reserves but only if the reserve is still free of the weed species. Further information about pest (plants and animal) strategies in Queensland, declared plants (pests) and guidelines on their management can be found on the Department of Employment, Economic Development and Innovation (DEEDI) website <[www.deedi.qld.gov.au](http://www.deedi.qld.gov.au)>.

*Salvinia* *Salvinia molesta* is an aquatic weed found in some crater lakes. *Salvinia* is also a WoNS and can choke waterways by floating on the surface and shading out native species below. Because of its very rapid growth, eradication is only likely early in its spread with an integrated mechanical and herbicide control program. Larger infestations are only likely to be checked by biological control with the salvinia weevil *Cyrtobagous salviniae*.

Effective weed management requires coordinated planning at the national, state, regional, local and property level. Queensland pest management plans that are in place or being developed can be found on the DEEDI website <[www.deedi.qld.gov.au](http://www.deedi.qld.gov.au)>. Under the *Land Protection (Pest and Stock Route Management) Act 2002* local governments must have pest management plans in place and are responsible for ensuring declared weeds and pest animals on all private and public land in their area are adequately controlled.

Although a comprehensive list of weed species is not available for all crater lakes in Queensland, local Land Protection officers and local government weeds and pests officers are a valuable starting point to aid land managers identify which weed species occur in their area, and can provide information about other pest plant and animal issues in Queensland.

Pest animals can also have impacts on crater lakes. Some that have been known to occur around crater lakes include foxes *Vulpes vulpes*, rabbits *Oryctolagus cuniculus*, feral pigs *Sus scrofa* and cane toads *Rhinella marina*. Pest animals can threaten the water quality and ecology of crater lakes in a variety of ways including:

- competing with native animals for food and habitat;
- feeding on native species associated with crater lakes;
- carrying and transmitting diseases.

The fox and the rabbit are declared as Class 2 pests under the Queensland *Land Protection (Pest and Stock Management) Act 2002* and under this Act land managers are required to control these pests on land under their management.



The feral pig *Sus scrofa* can damage all types of wetlands. Photo: DERM



The cane toad *Rhinella marina* Photo: DERM

The feral pig *Sus scrofa* is a pest species that can cause impacts on crater lakes. Feral pigs can cause significant damage to lake margins and can predate ground-nesting birds and other animals as well as carry disease. The species is declared as a Class 2 pest under the Queensland *Land Protection (Pest and Stock Management) Act 2002* and under this Act land managers are required to control feral pigs on land under their management. In recognition of the severe impact of feral pigs on the Australian landscape, predation, habitat degradation, competition and disease transmission by feral pigs has been listed as a key threatening process under the Commonwealth EPBC. Under the Act the Australian Government, in consultation with the states and territories, has developed a Threat Abatement Plan which outlines control techniques and stakeholder roles and responsibilities. This plan can be viewed on the Australian Government's Environment website <[www.environment.gov.au](http://www.environment.gov.au)>.

While the cane toad is not listed as a declared pest in Queensland and there is no legal requirement for landholders to control them, it is acknowledged that the species is a prolific breeder and a threat to native wildlife. Threats to native wildlife from cane toads include competition for food and habitat, poisoning

and predation. The Brisbane City Council in south-east Queensland established a committee that urged all residents to take responsibility for controlling the pest. Freezing the animals is considered to be a humane form of euthanasia.

Further information about the cane toad can be found on the DEEDI website <[www.deedi.qld.gov.au](http://www.deedi.qld.gov.au)> or directly from Land Protection officers and local government weed and pest officers.

An additional threat is the introduction of fish that are not native to the crater lakes. These feed on native fish and can cause them to become extinct, for example the Lake Eacham rainbowfish (see box).

Fish that are not endemic to a crater lake should not be introduced. Where they have previously been introduced, it may be difficult for these to be removed without harming the crater lake ecosystem.

## Fire

The pristine native ecosystems that occur around crater lakes are generally not tolerant to fire. Those that occur in the Wet Tropics are wetter forest types and will generally not burn. Those in south-east Queensland can burn but fire is generally excluded to prevent destruction of the vegetation types that occur there.

Where the surrounding ecosystems have been modified with clearing, fire may be used to protect the sensitive vegetation in a crater lake.

**WHERE** possible any development or activities around crater lakes should maintain the natural drainage patterns.

## Altered drainage patterns

One of the most dramatic impacts on wetlands is the alteration of natural drainage patterns. Barriers or drains alter the flows and contribute to changes in the hydrology of crater lakes. Some crater lakes have been altered or destroyed by artificial barriers to flows. Over time this has affected the fragile ecological balances within the lakes.

## Inflowing stormwater, nutrients and pollutants

Because crater lakes are generally closed systems even minor additions of nutrients can have significant ecological impacts, potentially irreversibly altering the lake and the composition of its flora and fauna. This process is known as **eutrophication**.

## DONAGHY'S CORRIDOR

Donaghy's Corridor is the world's first reconstructed tropical wildlife corridor and is privately owned. It follows a creek across the property and links the Lake Barrine section of the Crater Lakes National Park and Gadgarra State Forest. Some land managers surrounding Donaghy's Corridor are assisting to build links between the values of the national park and surrounding natural areas, including the crater lakes. Stock have been permanently excluded and a 1.2 km section of Toohey Creek has been revegetated. The property owner has also signed a conservation agreement with the Queensland Parks and Wildlife Service (QPWS) to establish the area as a nature refuge. The nature refuge supports a range of significant environmental resources and values including critical habitat for the endangered (EPBC Act, vulnerable IUCN Red List and NC Act) southern cassowary *Casuarius casuarius johnsonii* and rare (NC Act) plants such as the bull kauri *Agathis microstachya*.

Parties involved in this internationally renowned project include QPWS, the Wet Tropics Management Authority, and Trees for the Evelyn and Atherton Tableland (TREAT).

Over 100 species of rainforest plants have been established, all propagated and maintained with the assistance of TREAT members at the QPWS Centre for Tropical Rehabilitation at Lake Eacham. Plants are grown from seeds collected from the local area and feature species known to be particularly important in sustaining wildlife on a year round basis.

Volunteers are involved in working days, planting and mulching trees. Students and researchers access the site to carry out monitoring of plant growth and colonisation by animals across the corridor. These studies provide important information for the future design and placement of corridors, as well as answering questions about the effectiveness of corridors in reversing the impacts of forest fragmentation.



A wide range of activities (and their associated chemicals and nutrients) can lead to the eutrophication of crater lakes:

- tourism and recreation
- infrastructure development
- mining and quarrying
- land clearing
- grazing
- feral animals
- inappropriate fire regimes.

Tourism and recreation are extremely popular activities in crater lakes (see Tourism and recreation). The infrastructure developed to provide these opportunities can direct inflowing stormwater, nutrients and pollutants into the lakes. Roads, carparks, walking tracks and camping areas should all be drained in a manner that captures stormwater, slows its progress and filters the water. Successful use of natural vegetation and man-made drainage have been occurred in some cases. Unhygienic camping practices in the proximity of lakes can also lead to nutrification.

To reduce the impact of human-induced pollution, land managers need to educate visitors about the susceptibility of crater lakes to nutrification and where necessary conduct regular water and soil monitoring procedures. If conditions are severe or unsafe it may be necessary to close or restrict a lake's use.

Increased pollution, sediment and nutrient concentrations can also arise from land use activities undertaken in adjacent areas. For example, unnatural chemicals such as oils, pesticides, fertilisers, septic tank seepage and heavy metals can be introduced into lakes through inappropriate development, industrial

uses, mining and grazing. Over time, a build up of these chemicals can cause a reduction in the visual amenity of the lake environment, an imbalance in natural nutrient cycles within the lake, the proliferation of algae, death of sensitive flora and fauna (or a change in the composition and relative abundance of species within the lake environment), and cumulative impacts on fauna that feed on crater lake invertebrates and fish.

Increased sediment and nutrient loads in crater lakes can also result from fires in adjacent areas, land clearing, feral animals and grazing.

To preserve crater lakes, land use and activities within lake catchments should be conducted in a manner that prevents or minimises soil disturbance and erosion, and maintains water quantity and quality. Wherever possible vegetation cover should be retained (see Buffer zones). It is also essential that any activity occurring at or adjacent to a crater lake comply with the appropriate legislation and industry codes of practice and guidelines. For examples, see the DERM website <[www.derm.qld.gov.au](http://www.derm.qld.gov.au)>.

## 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](http://www.derm.qld.gov.au/wetlandinfo)> contains the latest information on legislation and buffer guidelines.

## Glossary

**Biome** A large, relatively distinct terrestrial region, encompassing many interacting ecosystems, and characterised by similar climate, soil, plants and animals.

**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.

**Bonn Convention** The Convention on the Conservation of Migratory Species of Wild Animals, to which Australia is a signatory, and a Range State for many migratory species.

**Cainozoic** The last of the main geological eras, marked by the rapid evolution of mammals; extending from about 65 million years ago to the present.

**Caldera** A volcanic feature formed by the collapse of a volcano into itself. Calderas may be filled with water, creating crater lakes. The word 'caldera' comes from a Spanish word meaning 'cauldron'.

**CAMBA** The Agreement between the Government of Australia and the Government of the Peoples 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 that collects rain that then flows into a waterway.

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

**Endemic** Found only in one particular area.

**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.

**Epiphyte** A plant growing upon another plant but is not parasitic upon it and receives water and nutrients from the air and rain.

**Eutrophication** Over-enrichment of a water body with nutrients, resulting in excessive growth of organisms and depletion of oxygen concentration.

**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.

**JAMBA** The Agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds and 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 may be tidal or non-tidal but ocean derived salinity is less than one part per thousand (1 ppt). 1 ppt is the equivalent of one gram of sodium chloride (salt) per litre of water.

**Limnetic** Referring to a standing water ecosystem (ponds or lakes).

**Littoral** Of or on the shore of the sea, or a lake; a region lying along a shore.

**Maar** A volcanic crater that is produced by an explosion in an area of low relief, is generally more or less circular, and often contains a lake, pond, or marsh.

**Palustrine** Pertaining to marshes, swamps, bogs and fens.

**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).

**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.

## Information sources

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## Appendixes

### Appendix 1: Threatened and migratory fauna commonly associated with Queensland's coastal and sub-coastal non-floodplain rock lakes

Taxon group	Common name	Scientific name	NC Act status*	EPBC Act status*	IUCN Red List of threatened species status **
<b>Fish</b>	Lake Eacham rainbowfish	<i>Melanotaenia eachamensis</i>	—	endangered	vulnerable
<b>Birds</b>	southern cassowary	<i>Casuarius casuarius johnsonii</i>	endangered	endangered	vulnerable
	sarus crane	<i>Grus antigone</i>	—	listed migratory species#	vulnerable
	Latham's snipe	<i>Gallinago hardwickii</i>	—	listed migratory species#	—
	wandering whistling duck	<i>Dendrocygna arcuta</i>	—	listed migratory species#	—
	hardhead	<i>Aythya australis</i>	—	listed migratory species#	—
	Pacific black duck	<i>Anas superciliosa</i>	—	listed migratory species#	—
	grey teal	<i>Anas gracilis</i>	—	listed migratory species#	—
	whistling kite	<i>Haliastur sphenurus</i>	—	listed migratory species#	—
grey goshawk	<i>Accipiter fasciatus</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.

**Appendix 2: Wetlands in Queensland that include coastal and sub-coastal non-floodplain rock lakes and are listed in A Directory of *Important Wetlands in Australia* (2005) and/or are Ramsar sites and that include coastal and sub-coastal non-floodplain rock lakes.**

Bioregion	Directory reference	Directory wetlands	Ramsar wetlands
Wet Tropics	QLD152	Lake Eacham	—
	QLD151	Lake Barrine	—
	QLD141	Bromfield Swamp	—
South-east Queensland	QLD184	Coalstoun Lakes	—

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**Completion date:** January 2006

**Reviewed:** peer reviewed, January 2006

**Updated:** April 2010

**Published:** Queensland Wetlands Program October 2010

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**Publishing job no:** QWP 2010/10, 29113

**NB:** This wetlands management profile replaces *Crater lakes*  
For more information visit *WetlandInfo* <[www.derm.qld.gov.au/wetlandinfo](http://www.derm.qld.gov.au/wetlandinfo)>