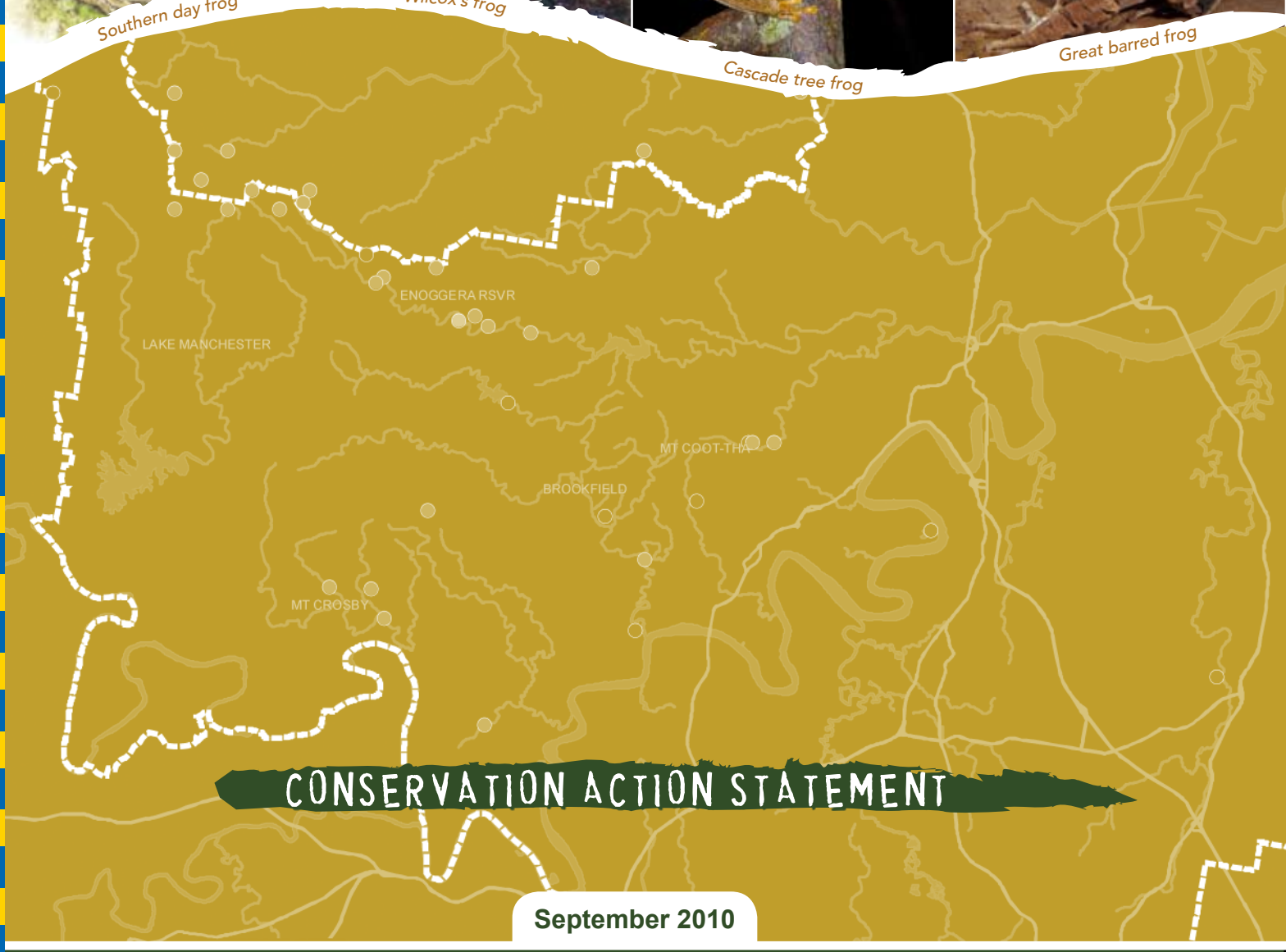
STREAM-DWELLING FROGS

Southern day frog

Wilcox's frog

Cascade tree frog

Great barred frog



CONSERVATION ACTION STATEMENT

September 2010

I ♥ BNE
That's why I'm taking action to conserve our wildlife.

BRISBANE CITY

Dedicated to a better Brisbane

Contents		

Tables	

Maps	

Photography acknowledgements

- Southern day frog, *Taudactylus diurnus*, ©Queensland Museum, Sally Elmer.
- Wilcox's frog, *Litoria wilcoxii*, ©Queensland Museum, Gary Cranitch.
- Cascade tree frog, *Litoria pearsoniana*, ©Queensland Museum, Gary Cranitch.
- Great-barred frog, *Mixophyes fasciolatus*, ©Queensland Museum, Gary Cranitch.

1 Introduction[1]

This Conservation Action Statement addresses the following frog species, collectively referred to as stream-dwelling frogs, two of which are identified as significant species within Brisbane, as per Council's Natural Assets Planning Scheme Policy (Brisbane City Council 2000):

1. 

2. 

3. 

4. 

1. Southern day frog *(Taudactylus diurnus)* (currently not listed in the Natural Assets Planning Scheme Policy).[2]
2. Wilcox's frog *(Litoria wilcoxii)* (referred to as stony-creek frog *Litoria lesueuri* in the Natural Assets Planning Scheme Policy).
3. Cascade tree frog *(Litoria pearsoniana)* (referred to as cascade treefrog *Litoria pearsoniana* in the Natural Assets Planning Scheme Policy).
4. Great barred frog *(Mixophyes fasciolatus)* (currently not listed in the Natural Assets Planning Scheme Policy).

These species are referred to as stream-dwelling frogs because they require a stream that is large enough to hold water for a sufficient length of time for their tadpoles to develop to metamorphosis (transform from tadpoles into tiny frogs). Because streams have running water, tadpoles of stream-dwelling frogs have several adaptations to life in running water such as specially adapted mouth parts to allow them to adhere to the substrate, muscular tails and low fins.

This Conservation Action Statement will be updated as new information becomes available and to report progress on conservation actions. For more information about this or any other Conservation Action Statement, visit Council's website at **www.brisbane.qld.gov.au** or phone Council on **(07) 3403 8888.**

Aims

This Conservation Action Statement details Council's management intent for the long-term protection and conservation of significant stream-dwelling frogs within Brisbane through the following actions.

- Collating **existing information** on the distribution, ecology and management requirements of these species within Brisbane and surrounds.
- Identifying **key threats** that significantly impact upon these species within Brisbane.
- Identifying **gaps in existing knowledge** of the habitat and management requirements of these species and allowing research priorities to be defined.
- Detailing **practical and affordable strategies and actions** that support the long-term protection and conservation of these species within Brisbane.

[1] Unless otherwise stated, the information in this section is compiled from BAAM (2005).

[2] This document follows the nomenclature provided by the Commonwealth Department of Water, Heritage and the Arts' online 'Australian Faunal Directory' (DEWHA 2010), which is kept up to date with taxonomic revisions and provides a single, categorical point of reference for common names and scientific names for all Australian taxa.

1 Introduction[1] continued...

Aims continued...

There are many other biodiversity benefits associated with the conservation of stream-dwelling frogs including the following.

- The protection and management of habitat that will also help conserve other threatened flora and fauna.
- Increased information on the ecology, habitat requirements, diseases and other threatening processes that have influenced the distribution and abundance of stream-dwelling frogs and that will assist in understanding the declines of other amphibian species.
- The importance of amphibians as indicators of environmental health due to their dependence on both terrestrial and aquatic environments throughout their lifecycle.

In addition to having highly-permeable skins, amphibians are extremely susceptible to environmental changes (Hines 2002). The conservation of highly-susceptible stream-dwelling frogs can ultimately result in the conservation of other less and/or equally vulnerable species.

2 Conservation status

The conservation status of a species will influence how it is managed. 'Threatened' species are typically accorded a more stringent management regime than 'common' species'. Various conservation registers identify the status of fauna species at local, regional, state and national levels. The current conservation status of the stream-dwelling frogs is provided in Table 1.

Table 1: Official conservation status of Brisbane's stream-dwelling frogs

Species	Brisbane City[1]	South East Queensland[2]	Queensland[3]	National[4]
Southern day frog	Not listed	Not listed	Endangered	Extinct
Wilcox's frog	Noteworthy: species uncommon in Brisbane region	Not listed	Least concern	Not listed
Cascade tree frog	Significant: species in decline and a habitat indicator	Regionally-significant priority taxa	Vulnerable	Not listed
Great barred frog	Not listed	Not listed	Least concern	Not listed

[1] Brisbane City Council 2000, *Brisbane City Plan 2000*, Natural Assets Planning Scheme Policy, vol. 2 [2] Significant for South East Queensland Bioregion under Biodiversity Assessment and Mapping Methodology (Environmental Protection Agency 2002) [3]*Nature Conservation (Wildlife) Regulations 2006* under the *Nature Conservation Act 1992* [4] *Environment Protection and Biodiversity Conservation Act 1999.*

3 Distribution[3]

National/state

Southern day frog

- Listed as extinct on the International Union for the Conservation of Nature (IUCN) red list, because it has not been recorded in the wild since 1979. Extensive searches over the last 25 years have failed to locate this species.
- Occurred in disjunct (not continuous) populations in three sub-coastal mountain ranges (Blackall, Conondale, and D'Aguilar Ranges) in the South East Queensland region from Coonoon Gibber Creek in the north to Mt Glorious in the south (Czechura and Ingram 1990, Hines *et al.* 1999).
- This species occurred over a relatively narrow altitudinal range of 350–800 metres with most records falling between 500 and 800 metres (Czechura and Ingram 1990).

[3] Unless otherwise stated, the information in this section is compiled from BAAM (2005).

3 Distribution[3] continued...

National/state continued...

Wilcox's frog

- Occurs along the coast and ranges of eastern Australia from north Queensland to southern New South Wales.

Cascade tree frog

- Restricted to the forests of South East Queensland and northeast New South Wales.
- Distributed from the Kandanga State Forest in South East Queensland south to Gibraltar Range in northeast New South Wales (Hines *et al.*1999), with an isolated population at Kroombit Tops.
- No recent records from sites at Girraween National Park where it was known historically, despite targeted surveys there (Hines 2002).
- Recent studies indicate that the isolated population of cascade tree frog at Kroombit Tops is genetically distinct and is an evolutionary significant unit (Donnellan *et al.* 1999).
- Some declines have been recorded in South East Queensland (D'Aguilar National Park and Conondale Ranges). However, a recent study (Parris 2001b) found it to be relatively common and easy to detect at suitable forest streams.
- The species occurs at low densities at some sites where seemingly suitable habitat exists.

Great barred frog

- Wide geographic distribution extending from mid-east Queensland to central New South Wales.

Local

Southern day frog

- There are no records for the southern day frog in the Brisbane area, although suitable habitat for the species occurs in parts of Brisbane City along the D'Aguilar Range.

Wilcox's frog

- Recorded at Bellbowrie, D'Aguilar National Park, Bardon and Anstead.
- Appears to be restricted to the outer western suburbs of Brisbane.
- Has been listed as abundant in suitable habitat in D'Aguilar National Park and the rocky streams within its catchment, reaching the fringe of some inner suburbs (Frost and Morgan 1999).

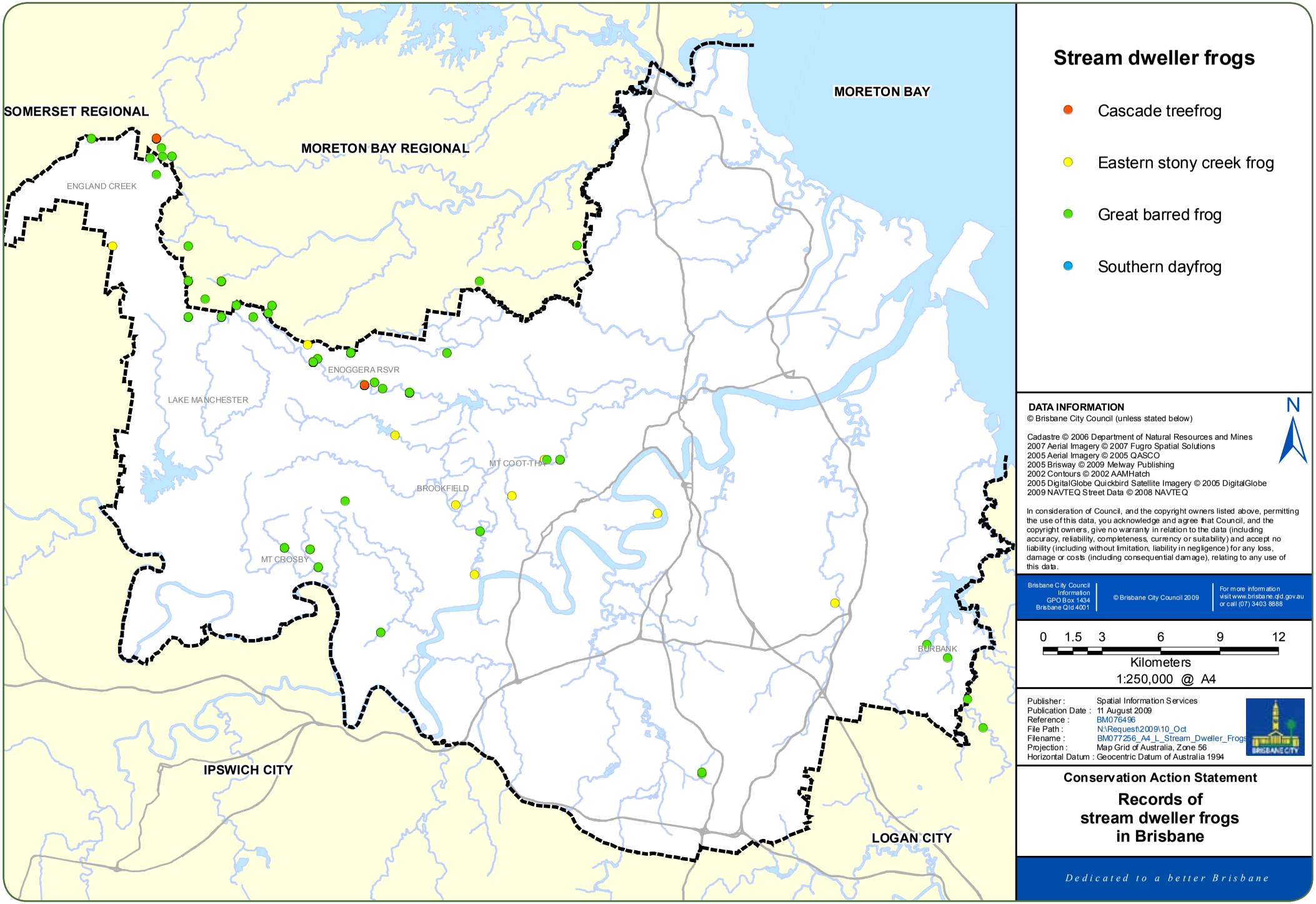
Cascade tree frog

- Scattered small colonies have been recorded in a few sites within D'Aguilar National Park at higher altitudes.
- Historical records indicate its presence in the Paddington/Milton area.
- Most populations exist in reserved protected areas outside the Brisbane area (Frost and Morgan 1999).

Great barred frog

- In Brisbane, observations of this species have been recorded for D'Aguilar National Park, Calamvale, Bellbowrie and Pullenvale.
- Recorded as abundant along the mountain streams in D'Aguilar National Park, spreading down into the adjoining lowlands.
- Isolated populations are found in Burbank and Parkinson.

Verified stream-dwelling frog records for Brisbane are shown on Map 1.



Stream dweller frogs

- Cascade treefrog
- Eastern stony creek frog
- Great barred frog
- Southern dayfrog

N

DATA INFORMATION

Brisbane City Council
Information
GPO Box 1434
Brisbane Qld 4001

For more information
visit www.brisbane.qld.gov.au
or call (07) 3403 8888

0 1.5 3 6 9 12
Kilometers
1:250,000 @ A4

Publisher : Spatial Information Services
Publication Date : 11 August 2009
Reference : BM076496
File Path : N:\Request\2009\10_Oct
Filename : BM077256_A4_L_Stream_Dweller_Frogs
Projection : Map Grid of Australia, Zone 56
Horizontal Datum : Geocentric Datum of Australia 1994

Conservation Action Statement

Records of stream dweller frogs in Brisbane

4 Ecology[4]

Habitat

The stream-associated forest-dependent frogs are generally found in moister forest types (rainforest and wet sclerophyll) over a wide range of elevations.

Stream-dwelling frogs require a stream that is large enough to hold water for a sufficient length of time for their tadpoles to develop. Many frogs that breed in permanent water bodies are excluded from temporary ones because their larval stage is longer than the persistence of water in these habitats. Therefore, the mix of frog species found in different sized streams can be partially explained by the different periods of water availability needed by each species in order to breed successfully.

Southern day frog

- Small diurnal frog (males 22-27 millimetres and females 23-31 millimetres in length).
- Inhabit montane rainforest, tall open forest and other riparian vegetation with a closed understorey along permanent and temporary streams at elevations between 350 and 800 metres (Czechura and Ingram 1990).
- Prefer permanent streams with a rocky substrate, but will use streams with a wide variety of substrates provided the water is not very muddy (Czechura and Ingram 1990).

Wilcox's frog

- Medium-sized terrestrial, nocturnal frog (males 47-53 millimetres and females 55-70 millimetres in length).
- Found in a wide range of terrestrial habitats including forested ridges, dry sclerophyll, coastal heathlands and rainforests.
- Can be found long distances from water (Cogger 2000).

Cascade tree frog

- Small nocturnal stream-dwelling frog (males 24-29 millimetres and females 31-37 millimetres in length).
- Occurs in shaded rainforest gullies and closed forest in association with streams.
- Inhabits streams in rainforest and adjacent wet sclerophyll forest at elevations of 200-1000 metres in South East Queensland and northeast New South Wales.
- May form large, mixed sex aggregations during winter in humid crevices with relatively stable temperatures (McDonald and Davies 1990).

Great barred frog

- A large (60-101 millimetres) ground frog associated with sclerophyll forest and rainforest.
- Generally common in suitable habitat within Brisbane (Frost and Morgan 1999). However the availability of suitable habitat in Brisbane is slowly diminishing due to urban development.
- Occurs across a large range of stream sizes as well as standing bodies of water such as dams (Parris 2002), typically in forested areas.
- It is generally common in areas that provide suitable habitat and has often been found foraging long distances from water (Frost and Morgan 1999).

[4] Unless otherwise stated, the information in this section is compiled from BAAM (2005).

4 Ecology continued...

Diet

To date there has been no research into the dietary requirements of any of the target frog species. All Australian endemic frogs will only recognise a food item if it is moving (i.e. they will not eat dead organisms). Larger frog species require a greater volume of food than the smaller ones (Tyler 1994). Size of prey ingested by frog species is limited by the gape of the mouth. Type of prey consumed ranges from ants, termites, spiders, beetles and bugs to grasshoppers, cockroaches and even other frogs. Habitat and season play a significant role in determining the availability and type of food items that can be eaten.

Southern day frog

- Tadpoles are bottom dwellers, feeding by scraping food from the substrate (Liem and Hosner 1973).

Wilcox's frog

- Tadpoles feed on sediment and vegetation.

Cascade tree frog

- Tadpoles graze on bottom sediment (Anstis 2002).

Great barred frog

- Known to forage for insects and other frogs, long distances from water (Frost and Morgan 1999).
- Tadpoles are bottom-dwellers and graze among vegetation and other detritus including animal remains (Meyer and Hines 2005).

Reproduction

Many stream-dwelling frogs have lower fecundity (lay fewer eggs) than many frogs, which mean that recovery for these species from disturbances, such as disease, may be slow due to the low recruitment rate of tadpoles that are changing into adult frogs.

Southern day frog

- Breeding occurs in warm weather, after or during heavy rain between October and May, with peak breeding occurring in the January to March period.
- Large eggs are deposited in clumps of 24-36 eggs under rocks or branches in the water (Czechura and Ingram 1990).

Wilcox's frog

- Breeding occurs during August to May with peak breeding occurring during the warmer months (Anstis 2002).
- Males call from the ground or rock beside streams.
- Females deposit a single clutch of many hundreds of eggs attached loosely to bedrock in streams, shallow streamside pools or occasionally in dams (Anstis 2002).

Cascade tree frog

- Breeding occurs between August to April with peak periods between October and February.
- Activity is predominantly nocturnal, peaking on warm nights during and after rain, but the frogs may also be active on warm overcast days.
- Males call from low perches up to one metre above water, beside or within the stream. They then retreat to humid crevices during the day.
- Eggs are deposited in a clump of several hundred, attached to rocks, debris or aquatic plants in still, shallow pools adjacent to or connected with the main stream (Anstis 2002).
- Metamorphosis usually occurs within two and a half months.

4 Ecology continued...

Reproduction continued...

Great barred frog

- Breeding occurs between September and February.
- Males call during spring and summer on the ground from well camouflaged positions among leaf litter (Anstis 2002).
- Immediately after some eggs are laid and fertilised, the female rapidly kicks her hindlegs to propel them in a spray of water 15-20 centimetres up onto a bank or rock face where the eggs stick firmly.
- The eggs hatch within a few days/weeks and the tadpoles complete their development over 12 months or more in the waterbody. Metamorphosis occurs from January to March (Anstis 2002).

Table 2: Breeding seasons (green shading indicates breeding months)

Species	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Southern day frog												
Wilcox's frog												
Cascade tree frog												
Great barred frog												

Movement patterns

There has been limited research into the movement patterns and home ranges of most Australian frog species. This lack of knowledge is most likely due to the often cryptic nature of most frogs, making it difficult to locate and capture individuals. Radio-transmitters are also relatively heavy making their use on frogs impractical.

Where frogs have been tracked after breeding has taken place, individuals have moved from anywhere less than 10 metres to hundreds of metres and even several kilometres from their breeding sites (Lemckert and Slatyer 2002, Sinsch 1990, Kusano *et al.* 1995).

A review of the movements of frogs and toads (Lemckert 2003) showed that mean home range for 50 species of frogs ranged from 6.3 to 5099 square metres. Without specific studies conducted on the movement patterns of the subject frog species, it is difficult to evaluate home ranges for these species. Stream-dwelling species are most likely, however restricted to the riparian zone surrounding streams. Genetic studies suggest though that dispersal often occurs between streams and between catchments (McGuigan *et al.* 1998).

After breeding, juvenile and adult frogs disperse into habitats surrounding the breeding site to forage, locate shelter and reduce predation pressure or to locate new breeding sites (Bull and Hayes 2001).

Southern day frog

- Active frogs may be found amongst low vegetation, rocks, leaf litter and other debris, generally within 20 metres of water (Czechura and Ingram 1990).
- Generally very active during daylight hours, but will sit motionless while basking in sunlit patches or on warm rocks (Czechura and Ingram 1990).
- At night they shelter under rocks and debris or within crevices (Czechura and Ingram 1990).
- Tadpoles prefer flowing streams and may be found year round.

4 Ecology continued...

Movement patterns continued...

Wilcox's frog

- Usually associated with flowing streams and may be found sitting on rocks, amidst leaf litter and occasionally on low vegetation beside streams (Meyer *et al*. 2001).
- These ground frogs hide under rocks in dry stream beds and river debris, thick leaf litter and under logs (Frost and Morgan 1999).
- Tadpoles are found mostly in streams, but also occur in ponds. They tend to prefer still, shallow water but are able to maintain their position in reasonable water flow by adhering to rock with the oral disc in their mouth (Anstis 2002).
- Can be found many hundreds of metres from waterbodies.

Cascade tree frog

- Hides amongst rocks and thick vegetation, often in shaded moist gullies next to flowing rocky streams (Frost and Morgan 1999).
- Activity is predominantly nocturnal, peaking on warm nights during and after rain.
- May also be active on warm overcast days (Hines 2002).
- Tadpoles frequent the substrate, mostly at the sides of streams in the shallow water of slowly moving pools or backwaters.

Great barred frog

- Can be found many hundreds of metres from waterbodies.
- The tadpoles occur in permanent deep water. They are powerful swimmers and the suctorial mouth enables firm adherence in flowing water (Anstis 2002).
- Tadpoles have been observed to persist over winter in permanent streams, and this lengthy larval stage presumably results in larger numbers of tadpoles becoming frogs, with an increased chance of survival to adulthood (Parris 2002).

5 Threats[5]

As with most amphibian species, there is no clearly identifiable cause of decline of populations of stream-dwelling frogs, although several factors are implicated. It is well known, however, that amphibians are extremely susceptible to environmental changes due to their dependence on both terrestrial and aquatic environments throughout their lifecycle, in addition to having highly-permeable skins. As such, amphibians are important indicators of environmental health.

Habitat loss, fragmentation and simplification

Since European settlement, an estimated 67,000 hectares, or two-thirds of the original woody vegetation in Brisbane City, has been cleared. This includes approximately 90% of lowland forests and more than 80% of all lowland vegetation (below 100 metres elevation). Habitat fragmentation is extensive – around 80% of the bushland remnants in the city are less than 20 hectares (Council 2001).

- Habitat loss reduces amphibian abundance and diversity. Draining wetlands directly affects frog populations by removing breeding sites and by fragmenting populations (Semlitsch and Brodie 1998).
- Habitat fragmentation has been identified as an important factor in frog declines. Fragmentation of habitat by roadways can have deleterious effects on frog populations either directly (i.e. frogs being run over by vehicles while trying to cross the road), or indirectly through polluted run-off from roads spoiling waterways, and/or populations becoming genetically isolated.
- The cascade tree frog has a pattern of forming large aggregations therefore the destruction of hibernation sites may have severe impacts on local populations of this species.

[5] Unless otherwise stated, the information in this section is compiled from BAAM (2005).

5 Threats continued...

Habitat degradation and modification

- Modification of terrestrial and aquatic habitats for urban development can reduce or eliminate amphibian populations (Alford and Richards 1999). Upstream clearing and urban development are likely to affect downstream flow regimes and water quality (Hines 2002).
- Development of lands adjacent to waterways can also cause acid sulphate soils to pollute catchments. The acidity of aquatic habitats has major impacts on amphibian distribution, reproduction, and egg and larval growth and mortality (Freda and Dunson 1986, Freda *et al.* 1991).
- Farm and forestry practices can adversely affect frog habitat by increasing sediment deposition in waterways (Hines 2002, Gillespie 2002). Increased sediments on stream substrata may have significant impacts upon the fitness of the tadpoles from stream-dwelling frogs by retarding growth and development. This means fewer tadpoles reach adulthood to breed, decreasing frog numbers (Gillespie 2002).
- Logging, roadways, construction of bridges over creeks and clearing of riparian vegetation can have detrimental impacts on frog habitat (both aquatic and terrestrial). The removal of the remnant vegetation and altered light and moisture regimes change the structure and composition of the vegetation, making these areas unsuitable for foraging, sheltering and breeding for frogs (Patterson *et al.* 1999).
- Bridge structures within the stream bed can alter stream flow patterns, causing erosion and instability of nearby banks. The increased sedimentation from earthworks and erosion can have deleterious impacts on tadpoles (Patterson *et al.* 1999).
- Research has shown that restoration and protection of aquatic breeding areas may be of little value if adjacent terrestrial habitat used by frogs for food and shelter is of inadequate amount or unsuitable quality (Semlitsch 1998).

Hydrological changes

- Reduced stream flows and periods when discharges are completely stopped (e.g. the end of irrigation releases) can:
  - reduce habitat availability and diversity for frogs and bottom-dwelling invertebrates
  - strand eggs and tadpoles above the level of flowing water
  - make the highly-productive flood plain areas inaccessible to tadpoles during rearing
  - cause increased siltation which can lead to filling in of crevices needed on the stream bed, the loss of clean attachment sites for eggs and smothering of eggs (Department of Primary Industries 2004).
- In areas with shallow groundwater bodies, land clearing and excessive extraction of water can lead to the encroachment of saline groundwaters which can affect the chemistry/quality of frog breeding ponds (Ezzy and Cox 2003).

Predation, competition and invasive species

- Some amphibian declines have been attributed to the introduction of non-native predators and competitors (Hecnar and M'Closkey 1997, Crossland and Alford 1998, Williamson 1999, Gillespie and Hero 1999).
- Stream-dwelling frogs can be directly impacted though egg and larvae predation and direct aggressive behaviour toward tadpoles by other species. Aggressive species such as mosquitofish *(Gambusia holbrooki)* can wound tadpoles leaving them susceptible to disease and cause tadpoles to abandon their preferred microhabitat, decreasing their growth and success rates.

5 Threats continued...

Predation, competition and invasive species continued...

- Consumption of cane toad (*Rhinella marinus*) tadpoles is lethal to native tadpoles (Crossland and Alford 1998).
- Competition for food resources between native frog species and cane toad tadpoles has been shown to negatively affect growth rates of the native species (Williamson 1999).
- Invasive weeds can have negative effects on frog populations by altering microhabitat conditions within the riparian zone (waterway area).
- It has been suggested that oils contained in the leaves of the exotic tree camphor laurel *(Cinnamomum camphora)* can contaminate water bodies, causing the death of some native frogs (Camphor Laurel Research Centre 2000).
- Southern day frog was not found in areas along watercourses that were heavily infested with *Lantana camara* or where the weeds *Baccharis halimifilia* and mist flower *(Agertina riparia)* occurred (Czechura and Ingram 1990). The frogs were also absent from streams with very muddy water associated with the activities of feral pigs (Czechura and Ingram 1990).
- Cascade tree frog numbers have declined possibly due to degradation of their habitat by introduced animals, weeds invasion and timber harvesting (Parris and Norton 1997).

Disease

- Globally diseases are now recognised as causing the declines and disappearances of many frog species (Skerratt *et al*. 2007).
- *Batrachochytrium dendrobatidis*, the cause of amphibian *Chytridiomycosis* (*Chytrid* fungus) is a potentially fatal skin disease of amphibians and is thought to be responsible for the decline and disappearance of several stream-breeding frog species in South East Queensland (Department of Environment and Heritage 2006). There are records of deaths for all of the target frog species from this disease in Queensland (Berger *et al.* 2004). Adult frogs die within weeks of being experimentally infected. Tadpoles often carry the infection in their mouthparts, but otherwise appear and behave normally (Symonds *et al*. 2007). Because of this, licensed collectors or members of the public may unknowingly spread the disease to other environments (Anstis 2002). Temperature is known to have large effects on occurrence of the disease, with outbreaks of *Chytrid* fungus in South East Queensland mostly occurring in the winter months (Berger *et al.* 2004). Infections of a *Chytrid* fungus have been found on dead individuals of cascade tree frogs from Main Range and from the population at Kroombit Tops. Other ill and dead cascade tree frogs have been found in the Conondale Range but these have not yet been examined to determine the cause (Hines *et al*. 1999).
- Other exotic diseases have the potential to adversely affect local amphibian populations (e.g. *Ranavirus* sp.).

Climate change

- Climate change is very likely to exacerbate the other threats previously listed here, particularly the susceptibility of frogs to disease.
- Moisture is a crucial resource for amphibian reproduction regardless of reproductive mode. Changes in rainfall patterns as a result of a changing climate could reduce amphibian reproduction or recruitment (ability of tadpoles to become mature adults) (Lips 1999).
- Findings from recent research focusing on upland frogs in Eastern Australia have concluded that frog declines significantly coincided with rising minimum temperatures (Laurence 2008).

6 Conservation

Several Council biodiversity initiatives are contributing to the protection and management of stream-dwelling frogs and their habitat across the city. The following are key initiatives.

- Bushland Acquisition program. Through this program more than 2700 hectares of the city's most significant lowland habitats have been purchased and protected to date.
- Wildlife Conservation Partnerships program. More than 600 private properties have established conservation partnerships with Council, covering some 2000 hectares of principally lowland habitat in significant frog habitat areas.
- Conservation Reserve Estate. More than 13,700 hectares of parkland including 7755 hectares of bushland and wetland reserves are managed and protected. This reserve network provides habitat for Brisbane's significant species.
- *Natural Assets Local Law (2003).* Over 61,000 hectares of significant native vegetation is covered by the Natural Assets Local Law.
- *City Plan (2000).* The *City Plan* designates a green space system throughout the city to recognise and protect the contribution of open space areas to ecological functions. The plan's Biodiversity Code and supporting Ecological Assessment Guidelines provide performance criteria and acceptable solutions to protect significant biodiversity values on, or adjacent to, proposed development. *City Plan* also includes statutory schedules of flora and fauna species considered significant in Brisbane. These schedules recognise the conservation significance of species at a citywide and/or regional level.

7 Research[6]

There have been few detailed studies relating to frogs in Brisbane City or South East Queensland. Contemporary investigations relevant to Brisbane's stream-dwelling frogs include the following.

- Surveys and monitoring of stream-breeding frogs in South East Queensland and studies on chytrid fungus conducted by the Queensland Department of Environment and Resource Management.
- The University of Queensland has monitored and investigated the population ecology of stream-dwelling species in South East Queensland.
- Exotic species most likely to impact native frogs are the cane toad and the mosquitofish. The Endangered Frog Research Group (Griffith University) is currently researching the impacts of predators (both native and introduced) on the distribution of threatened frog species.
- The Endangered Frog Research Group has completed a study on the population genetics of the mixophyes species, including the great barred frog *(Mixophyes iteratus)* (Doak 2005). Researchers at the Centre are also examining growth rates of *Mixophyes* tadpoles.
- The population dynamics of native and invasive plants, and modelling dispersal and its consequences in invasive plant populations are currently being researched by Dr Yvonne Buckley, University of Queensland.
- Associate Professor Hamish McCallum for the University of Queensland is currently heading research into the prevalence of the frog chytrid fungus in South East Queensland. Additionally there are two PhD projects underway at the University of Queensland examining the *Chytrid* fungus.

[6] Unless otherwise stated, the information in this section is compiled from BAAM (2005).

8 Management intent

Strategies

Council intends to contribute to the long-term conservation of the city's significant stream-dwelling frogs through the following.

- Adopting and encouraging innovative voluntary and statutory mechanisms that protect important habitats and movement corridors.
- Securing and long-term protection of important habitat for stream-dwelling frogs.
- Ensuring appropriate ecological assessment, reporting and survey procedures are adopted in development, planning and management activities.
- Encouraging land management practices that avoid, or minimise, direct and indirect impacts on frogs and their habitats on both public and private lands.
- Ensuring the timely availability of accurate, adequate and contemporary information for policy, planning and management decisions and actions.
- Facilitating research that targets priority information gaps and contributes positively to the conservation of Brisbane's frogs and their habitats.
- Providing the Brisbane community with appropriate information and opportunities to contribute in a practical way to better understand and protect Brisbane's frogs.

Actions

Table 3 describes priority conservation actions that Council will pursue with its partners to address the stated strategies. These priority actions have been drawn from studies undertaken for Council by recognised frog experts and from consultation with a range of stakeholders. Actions will be undertaken as funds become available through Council's budgetary process. It should be recognised that Council must consider the timing of these actions against other priorities across the whole of the city.

Table 3: Management actions

Management aspect	Action	Timing	Lead agent & key stakeholders *
Habitat protection	Conserve and protect important frog habitat on privately-owned land within Brisbane, through Council acquisition of significant habitat (Bushland Acquisition program) and through conservation partnerships with private landholders (Wildlife Conservation Partnerships program).	Ongoing	Council, private landowners
Habitat management	Develop and introduce specific assessment criteria for developments and other potentially harmful activities occurring within or adjacent to known frog habitat.	2011	Council, universities
	Maintain habitat connectivity by ensuring linear infrastructure does not detrimentally impact on habitat connectivity in areas of frog habitat through Council's Wildlife Movement Solutions program.	Ongoing	Council, DTMR

8 Management intent continued...

Actions continued...

Table 3: Management actions continued

Management aspect	Action	Timing	Lead agent & key stakeholders *
Habitat management continued	Develop protocols for mitigating the effects of waterway rehabilitation for public groups and local government staff.	Ongoing	Council, local conservation groups
	Undertake control or eradication of identified harmful or potentially harmful invasive species from known frog habitat.	Ongoing	Council
Research	Undertake habitat mapping across the city for the targeted frog species in the Brisbane area and develop associated baseline 'aquatic and terrestrial habitat requirement criteria' to ensure management strategies are directed to the most appropriate sites.	Commence 2010	Council, universities, QM
	Seek collaborative partnerships to undertake research on the potential threats to frog populations, particularly the effects of invasive species, the role of disease in frog decline, degradation of breeding and refuge habitats and the effects of climate change on local frog populations.	Commence 2011	Council, universities, QM
	Undertake research on the effectiveness of wildlife movement solutions (such as road culverts).	Ongoing	Council, universities
Mosquito control	Continue the current use of specific and ecologically sound products for the control of mosquito larvae in aquatic habitats.	Ongoing	Council
Information management	Develop a central database for the collation of monitoring data.	Underway	Council
	Relevant Council field staff to be trained in appropriate aquatic habitat management practices including the protocols for the control of disease (*chytrid* fungus).	Commence 2011	Council
	Incorporate information relating to the impacts of invasive species on local frog species into Council's invasive species management community awareness programs.	2010	Council, community, community groups

8 Management intent continued...

Actions continued...

Table 3: Management actions continued

Management aspect	Action	Timing	Lead agent & key stakeholders *
Community involvement	Support a frog identification workshop each year.	Commence 2010	Council, QM, community
	Incorporate frog habitat management information for landholders into community programs, including Wildlife Conservation Partnership program, Creek Catchment Ranger and Habitat Brisbane programs and environment centre curricula.	Ongoing	Council
	Support a workshop each year to inform community rehabilitation groups of frog-friendly techniques for rehabilitating waterways.	Commence 2010	Council, catchment and Habitat Brisbane groups
	Support community based monitoring.	Commence 2010	Council, community groups

*Council: Brisbane City Council, DTMR: Queensland Department of Transport and Main Roads, QM: Queensland Museum

Guidelines

The habitat protection and management guidelines detailed in Table 4 are provided to better assist environmental planners, land owners, land managers, private industry and the broader community to maintain and enhance existing stream-dwelling frog habitat in Brisbane. These guidelines are preliminary and will be refined as more information about these species and their habitat requirements becomes available.

Table 4: Habitat protection and management guidelines

Issue	Guideline	Explanatory notes
Destruction, clearing or alteration of riparian or stream habitats due to local catchment development, localised invasions of invasive plant species and/or localised in-stream channel works.	Apply the Biodiversity, Waterway, Wetland and Stormwater Management Codes, Ecological Assessment Guidelines, other relevant state legislation and any species-specific assessment criteria.	The guidelines provided within the existing codes are generally acceptable for most species but may require the refinement to maintain viable populations of the targeted frog species. The largest identified threat to the persistence of stream-dwelling frogs is degradation of water quality and changes to water flow. Species-specific guidelines will be developed to help Council and stakeholders protect populations when planning future development or changes in land use. The guidelines will suggest possible protective measures for frog populations under different situations. Existing habitat should be protected from future development wherever possible.

8 Management intent continued...

Guidelines continued...

Table 4: Habitat protection and management guidelines continued

Issue	Guideline	Explanatory notes
Habitat restoration or rehabilitation within the stream habitats or in vegetated areas surrounding breeding areas.	A minimum of 30 metres of intact terrestrial habitat and/or buffer should be retained and maintained around stream habitat. Further research is however required to inform the specific management requirements for each frog species.	Some frog species may require additional terrestrial habitat as refuge sites to ensure persistence during dry spells. Information about species' micro-habitat requirements is essential for habitat protection. Habitat restoration management plans must incorporate invasive weed removal and alternative techniques for the use of herbicides and pesticides.
Human activities.	Limit public access to known breeding areas and avoid, where possible, undertaking works in these areas during the breeding season.	Ensure that recreational access and use of water bodies and Council activities do not inappropriately disturb stream-dependant wildlife.
	Educate landowners about the habitat requirements of stream-dwelling frogs and support landowners in conserving such habitat, particularly breeding habitats within farm land or areas close to agricultural practices.	Land use practices in areas near breeding sites should be monitored to ensure frog habitats are not contaminated by run-off of sediments or fertilisers and pesticides, which could cause eutrophication of the aquatic habitat. Trampling of terrestrial habitat surrounding breeding areas by domestic stock and wild pigs should also be monitored.
Mosquito control	Employ 'best practice' principles, and use methods that are deemed 'safe' for frogs. Mosquito control should not be carried out during known frog breeding seasons (see Table 2).	Council will continue to use mosquito control products that are not harmful to frogs. It will maintain its membership of the Mosquito and Arbovirus Research Committee to support research that ensures the use of world best practice in mosquito management.
Displacement of frog populations due to localised invasions of invasive plant and animal species.	Invasive species management activities in important frog habitat areas should incorporate mosquitofish, cane toad and camphor laurel control.	Certain invasive species may need to be locally eradicated to maintain frog population viability at a given location. This may be particularly important in areas overcome by mosquitofish, cane toads and/or camphor laurel.
Lack of knowledge	Landowners, community conservation groups and the broader community to be made aware, through existing Council programs, of habitat requirements, threats and management recommendations in areas known to support significant frog populations.	Information on habitat requirements, threats and management recommendations should be made readily available to the community, particularly Habitat Brisbane and catchment groups, Wildlife Conservation Partnership program landowners and landowners in areas known to support significant frog populations or where frog habitat is under threat.
Community involvement	Community groups involved in restoration and rehabilitation works should, where relevant, be encouraged to consider the habitat requirements of local frog species. Any activities undertaken must not negatively impact on the local frog population.	By fostering community involvement, suitable frog habitat on privately owned and public land can be restored, as can linkages that form dispersal corridors between breeding areas. If an area already supports a diversity of frog species, expert advice should be sought before commencing further restoration work to enhance the frog habitat as restoration may not be necessary or may be detrimental to the existing balance.

9 Further information

Agencies

- Brisbane City Council (www.brisbane.qld.gov.au).
- Department of Environment, Water, Heritage and the Arts (www.environment.gov.au).
- Queensland Department of Environment and Resource Management (www.derm.qld.gov.au).
- Queensland Museum (www.qm.qld.gov.au).
- Frogs Australia Network (www.frogsaustralia.net.au).
- Queensland Frog Society (www.qldfrogs.asn.au).
- Threatened Species Network (www.wwf.org.au).
- RANA Frog Group (www.ranafrog.org.au)

Bibliography

Alford RA and Richards SJ 1999, 'Global Amphibian Declines: A problem in Applied Ecology', *Annual Review of Ecology and Systematics*, 30: 133-165.

Anstis M 2002, *Tadpoles of Southeastern Australia. A Guide with Keys*, New Holland Publishers, Sydney.

Barker J, Grigg GC and Tyler MJ 1995, *A Field Guide to Australian Frogs*, Surrey Beatty and Sons, Chipping Norton, New South Wales.

Berger L and Hyatt A 1999, '*Chytrid* fungi and amphibian declines: Overview, implications and future directions', In: *Declines and Disappearances of Australian Frogs*, Campbell A (Ed.), Canberra: Environment of Australia, pp. 23-33.

Berger L, Speare E, Hines HB, Marantelli G, Hyatt AD, McDonald KR, Skerratt LF, Olsen V, Clarke JM, Gillespie G, Mahony M, Sheppard N, Williams C and Tyler MJ 2004, 'Effect of season and temperature on mortality in amphibians due to *Chytridiomycosis*', *Australian Veterinary Journal*, 82: 31-36.

BAAM 2005, 'Conservation status review of stream-dwelling frogs: Southern Dayfrog *Taudactylus diurnus*, Stony Creek frog *Litoria wilcoxii*, Cascade Tree Frog *Litoria pearsoniana*, Great Barred Frog *Mixophyes fasciolatus*', Unpublished report prepared for Brisbane City Council.

Blaustein AR and Dobson A 2006, 'A message from the frogs', *Nature* 439, 143- 4.

Brisbane City Council 2000, *Brisbane City Plan 2000*, *Natural Assets Planning Scheme Policy,* vol. 2, pp. 140-144, BCC, Brisbane.

Brisbane City Council 2001, *Brisbane State of the Environment Report 2001*, BCC, Brisbane.

Bull EL and Hayes MP 2001, 'Post-breeding movements of columbia spotted frogs (*Rana lutriventris*) in northeastern Oregon', *Western North American Naturalist*, 61: 119-123.

Camphor Laurel Research Centre 2000, www.camphorlaurel.com/factfile2.html Cogger HG 2000, Reptiles and amphibians of Australia, Reed New Holland Publishers, Sydney.

Crossland MR and Alford RA 1998, 'Evaluation of the toxicity of eggs, hatchlings and tadpoles of the introduced toad *Bufo marinus* (Anura: Bufonidae) to native Australian aquatic predators', *Australian Journal of Ecology*, 23: 129-137.

Czechura GV and Ingram G 1990, '*Taudactylus diurnus* and the case of the disappearing frogs', *Memoirs of the Queensland Museum*, 29: 361-365.

Daily. G, Alexander. S, Ehrlich. P, Goulder. L, Lubchenco. J, Matson. P, Mooney. H, Postel. S, Schneider. S, Tilman. D, Woodwell, G. 1997, 'Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems', *Issues in Ecology*, No. 2. A publication of the Ecological Society of America, Washington DC.

Daszak P, Cunningham AA and Hyatt AD 2003, 'Infectious disease and amphibian population declines', *Diversity and Distributions*, 9: 141-150.

Department of Environment and Heritage, 2006. *Background document for the Threat Abatement Plan: Infection of amphibians with the Chytrid fungus resulting in Chytridiomycosis*, Commonwealth of Australia, Canberra.

Department of Primary Industries 2004, *Our Inland Wetlands: human impacts*, www.dpi.qld.gov.au/fishweb/1379.html. Accessed 26-04-2005.

DEWHA 2010, *Australian Faunal Directory*, Department of the Environment, Water, Heritage and the Arts, Canberra. www.environment.gov.au/biodiversity/abrs/online-resources/fauna/afd/taxa

Doak N, 2005. 'Phylogeography, dispersal and movement of Fleay's Barred Frog, *Mixophyes fleayi*', Unpublished PhD thesis, Griffith University, Queensland.

Donnellan SC and Mahony MJ 2004, 'Allozyme chromosomal and morphological variability in the *Litoria lesueuri* species group *Anura: Hylindae), including a description of a new species', *Australian Journal of Zoology*, 52:1-28.

Donnellan SC, McGuigan K, Knowles R, Mahony M and Moritz C 1999, 'Genetic evidence for species boundaries in frogs of the *Litoria citropa* species-group (Anura: Hylidae)', *Australian Journal of Zoology*, 47: 275-293.

Environmental Protection Agency 2002, *Biodiversity Assessment and Mapping Methodology*, Queensland Government, Brisbane.

Ezzy TR and Cox ME 2003, 'Implications of land-use changes on groundwater within shallow coastal plain aquifers, Bells Creek Catchment, Southeast Queensland, Australia', *Technologia de la Intrusion de Aqua de Mar en Acquiferos Costeros: Paises Mediterraneos*, IGME, Madrid 2003.

Freda J and Dunson WA 1986, 'Effects of low pH and other chemical variables on the local distribution of amphibians', *Copeia*, 1986: 454-466.

Freda J, Sadinski WJ and Dunson WA 1991, 'Long term monitoring of amphibian populations with respect to the effects of acidic deposition', *Water, Air, Soil Pollution*, 55: 445-462.

Frost G and Morgan R 1999, *Frogs of Brisbane and Surrounding Areas*, The Queensland Frog Society, Revised Edition 1/99.

Gillespie GR 2002, 'Impacts of sediment loads, tadpole density, and food type on the growth and development of tadpoles of the spotted tree frog *Litoria spenceri*: an in-stream experiment', *Biological Conservation*, 106: 141-150.

Gillespie GR and Hero J-M 1999, 'The impact of introduced fish upon Australian frogs', In: *Declines and disappearances of Australian frogs*, Campbell A (Ed.), Environment of Australia, Canberra, pp. 131-144.

Hecnar SJ and M'Closkey RT 1996, 'The effects of predatory fish on amphibian species richness and distribution', *Biological Conservation*, 79: 123-131.

Hines H 2002, *Recovery plan for stream frogs of Southeast Queensland 2001-2005*, Queensland Parks and Wildlife Service and Southeast Queensland Threatened Frogs Recovery Team 2002.

Hines H, Mahony M and McDonald K 1999, 'An assessment of frog declines in wet subtropical Australia', In: *Declines and Disappearances of Australian Frogs*, Campbell A (Ed.), Environment Australia, Canberra.

Ingram GJ 1990, 'The mystery of the disappearing frogs', *Wildlife Australia*, 27: 6-7.

Kats LB, Petranka JW and Sih A 1988, 'Antipredator defences and the persistence of amphibian larvae with fishes', *Ecology*, 69: 1865-1870.

Kusano T, Maruyama K and Kaneko S 1995, 'Post-breeding dispersal of the Japanese Toad, *Bufo japonicus*

formosus', *Journal of Herpetology*, 29: 633-638.

Laurence WF 2008, 'Global warming and amphibian extinctions in eastern Australia', *Austral Ecology*, 33: 1-9.

Leigh JH and Holgate MD 1979, 'The response of the understorey of forests and woodlands of the Southern Tablelands to grazing and burning', *Australian Journal of Ecology*, 4: 25-45.

Lemckert F 2003, 'Variations in anuran movements and habitat use: Implications for conservation', *Applied Herpetology*, 1: 165-181.

Lemckert FL and Slatyer C 2002, 'Short-term movements and habitat use of the threatened green-thighed frog *Litoria brevipalmata* (Anura: Hylidae) in mid-coastal New South Wales', *Australian Zoologist,* 32: 56-61.

Liem DS and Hosner W 1973, 'Frogs of the genus *Taudactylus* with descriptions of two new species (Anura: Leptodactylidae)', *Memoirs of the Queensland Museum*, 16: 435-457.

Lips KR 1999, 'Mass mortality and population declines of Anurans at an upland site in Western Panama', *Conservation Biology*, 10: 406-413.

McDonald KR and Davies M 1990, 'Morphology and biology of the Australian tree frog *Litoria pearsoniana* (Copland) (Anura: Hylidae)', *Transactions of the Royal Society of South Australia*, 114: 145-156.

McGuigan K, McDonald K, Parris K and Moritz C 1998, 'Mitochondrial DNA diversity and historical biogeography of a wet forest-restricted frog (*Litoria pearsoniana*) from mid-east Australia', *Molecular Ecology*, 7: 175-186.

Meyer, E, Hines H and Hero J-M 2001, *Wet forest frogs of Southeast Queensland*, Griffith University, Queensland, Australia.

Meyer E and Hines H 2005, 'Observations of barred frog (*Mixophyes* spp.) tadpoles feeding on carrion in the wild', *Herpetofauna.* 34: 90-91.

Parris KM 2001a, 'Assessment of amphibian diversity in the Blackall and Conondale Ranges in southeast Queensland', In: Nattrass AEO (Ed.), *Frogs in the Community*, Proceedings of the Brisbane Symposium 13-14 February 1999.

Parris KM 2001b, 'Distribution, habitat requirements and conservation of the Cascade Tree Frog (*Litoria pearsoniana*, Anura: Hylidae)', *Biological Conservation*, 99: 285-292.

Parris KM 2002, 'The distribution and habitat requirements of the great barred frog (*Mixophyes fasciolatus*)', *Wildlife Research*, 29: 469-474.

Parris KM and Norton T 1997, 'The significance of State Forests for conservation of *Litoria pearsoniana* (Copeland) and associated amphibians', In: *Conservation outside Nature Reserves*, Hale P and Lamb D (Eds.), Centre of Conservation Biology, The University of Queensland.

Patterson RD, Kraschnefski KL, Thomas R and Hines HB 1999, 'Conservation of The Giant Barred Frog *Mixophyes iteratus* and the Cascade Treefrog *Litoria pearsoniana* at Belli Creek in southeast Queensland', In: Nattrass AEO (Ed.), *Frogs in the Community*, Proceedings of the Brisbane Symposium, pp. 110-119.

Pettit NE, Froend RH and Ladd PG 1995, 'Grazing in remnant woodland vegetation, changes in species composition and life form groups', *Journal of Vegetation Science*, 6: 121-130.

Rowe CL and Dunson WA 1995, 'Impacts of hydroperiod on growth and survival of larval amphibians in temporary pools of central Pennsylvania, USA', *Oecologia*, 102: 307-403.

Semlitsch RD 1998, 'Biological delineation of terrestrial buffer zones for pond-breeding salamanders', *Conservation Biology*, 12: 1113-1119.

Semlitsch RD and Brodie JR 1998, 'Are small, isolated wetlands expendable?', *Conservation Biology*, 12: 1129-1133.

Sinsch U 1990, 'Migration and orientation in anuran amphibians', *Ethology Ecology and Evolution*, 2: 65-79.

Skerratt L, Berger L, Speare R, Cashins S, McDonald K, Phillott A, Hines H and Kenyon N 2007, 'Spread of *Chytridiomycosis* has caused the rapid global decline and extinction of frogs', *EcoHealth*, 4: 125-134.

Symonds E, Hines H, Bird P, Morton J and Mills P 2007, 'Surveillance for *Batrachochytrium dendrobatidis* using *Mixophyes* (Anura: Myobatrachidae) larvae', *Journal of Wildlife Diseases*, 43: 48-60.

Tyler MJ 1994, *Australian Frogs A Natural History*. Halbmeyer M (Ed.), Reed New Holland Publishers, Sydney.

Williams SE and Hero J-M 1998, 'Rainforest frogs of the Australian wet tropics: guild classification and the ecological similarity of declining species', *Proceedings of the Royal Society of London*, 265: 597-602.

Williamson I 1999, 'Competition between the larvae of the introduced Cane Toad *Bufo marinus* (Anura: Bufonidae) and native anurans from the Darling Downs area of southern Queensland', *Australian Journal of Ecology*, 24: 636-643.