National recovery plan for the wallum sedgefrog and other wallum-dependent frog species

Australian Government

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Environmental Protection Agency
Queensland Parks and Wildlife Service

Department of Environment and Conservation (NSW)

National recovery plan for the wallum sedgefrog and other wallum-dependent frog species

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Title page clockwise from top left: wallum sedgefrog (*Litoria olongburensis*), Cooloola sedgefrog (*Litoria cooloolensis*), wallum froglet (*Crinia tinnula*) and wallum rocketfrog (*Litoria freycineti*). Photos by Ed Meyer.

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The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved, and may also be constrained by the need to address other conservation priorities. Approved recovery actions may be subject to modification due to changes in knowledge and changes in conservation status.

This recovery plan includes four species of frog, however adoption as a national recovery plan under the *Environment Protection and Biodiversity Conservation Act 1999* refers only to the wallum sedgefrog *Litoria olongburensis.*

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Species
This recovery plan is a multi-species plan for wallum-dependent frog species of coastal south-east Queensland and eastern New South Wales. The species covered by this plan are the wallum sedgefrog *Litoria olongburensis*, Cooloola sedgefrog *L. cooloolensis*, wallum rocketfrog *L. freycineti* and wallum froglet *Crinia tinnula*.

Current species status
The species in this plan are listed as 'Rare' or 'Vulnerable' under state legislation, the Queensland *Nature Conservation Act 1992* and the New South Wales *Threatened Species Conservation Act 1995*. However, only the wallum sedgefrog is listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). All species in this plan are listed as 'Vulnerable' or 'Endangered' by the World Conservation Union (IUCN).

Habitat and distribution
The species in this plan are wholly or largely restricted to lowland sand plains, dunes and sand islands of coastal south-east Queensland and New South Wales (including coastal 'wallum'). All breed in oligotrophic (nutrient poor) acidic (pH < 6.0) coastal swamps and/or lakes. Rarely, except in disturbed habitat, are these species found together with related species (i.e. the common sedgefrog *Litoria fallax*, striped rocketfrog *Litoria nasuta* and beeping froglet *Crinia parinsignifera*).

Threats
The species in this plan have suffered significant habitat loss due to urban and resort development, the establishment of pine plantations and sand mining. Habitat loss and fragmentation due to urban development remains one of the main threats to wallum frog species, particularly in coastal south-east Queensland and northeast New South Wales. Other known and potential threats include habitat degradation, predation of eggs and larvae by introduced fish (in particular the mosquito fish *Gambusia holbrooki*), inappropriate fire regimes, use of biocides in weed and mosquito control, habitat disturbance and predation by pigs, chytrid fungus infection, a possible rise in sea levels as a consequence of global warming, competition with ecologically-similar species, exotic disease and vehicular traffic.

Overall objective
The overall aim of this plan is to improve the conservation status of wallum frog species through effective management, protection and rehabilitation of wallum frog habitat.

Specific objectives
The specific objectives of this five-year plan are:

1. To identify areas of habitat critical to the survival of wallum frog species more accurately.
2. To protect habitat critical to wallum frog survival and important wallum frog populations from threatening processes.
3. To rehabilitate degraded wallum frog habitat.
4. To determine population trends in areas of disturbed undisturbed and rehabilitated habitat.

Performance criteria
The success of this plan will be measured against the following criteria:

1. Non-breeding habitat critical to the survival of wallum frog species is identified.
2. Important populations and their habitat are identified.
3. Essential habitat outside protected areas is conserved.
4. Threats to wallum frog populations in protected areas are mitigated.
5. Knowledge of threats is improved and utilised to ensure wallum frog habitat and populations are appropriately managed/protected.
6. Stakeholders and the broader community are engaged in the recovery of wallum frog species.
7. Degraded wallum frog habitat is rehabilitated.
8. Data on population trends are collected for all wallum frog species in areas of undisturbed, disturbed and rehabilitated habitat and used to guide management actions.

Recovery actions
Actions needed for recovery of wallum-dependent frog species include:

1. Identify and assess essential habitat.
2. Protect wallum frog populations and manage habitat.
3. Acquire additional information on threats to inform management.
4. Engage stakeholders and the broader community in recovery of wallum frog species.
5. Rehabilitate degraded wallum frog habitat.
6. Monitor frog numbers and distribution.

Evaluation and review
Recovery actions and management guidelines will be reviewed annually by the South-east Queensland Threatened Frogs Recovery Team. A comprehensive review of this plan will be undertaken before 2011 by the South-east Queensland Threatened Frog Recovery Team in consultation with affected stakeholders.

1. General information

Species covered by plan
This recovery plan is a multi-species plan for wallum-dependent frog species of coastal south-east Queensland and eastern New South Wales (here after referred to as 'wallum frogs'). The species covered by this plan are the wallum sedgefrog *Litoria olongburensis*, Cooloola sedgefrog *L. cooloolensis*, wallum rocketfrog *L. freycineti* and wallum froglet *Crinia tinnula* (See Appendix 1 for detailed species information).

Conservation status
The species in this plan are listed as 'Rare' or 'Vulnerable' under state (Queensland/New South Wales) legislation (Table 1). Currently, only the wallum sedgefrog is listed nationally. All species in this plan are listed as 'Vulnerable' or 'Endangered' by the World Conservation Union (IUCN) (IUCN, 2004) (Table 1).

Species	Queensland *Nature Conservation Act 1992*	NSW *Threatened Species Conservation Act 1995*	Common-wealth *EPBC Act 1999*	Action Plan for Australian Frogs (1997)	IUCN status (2004)
Cooloola sedgefrog *Litoria cooloolensis*	R	-	-	-	E
Wallum rocketfrog *Litoria freycineti*	V	-	-	I	V
Wallum sedgefrog *Litoria olongburensis*	V	V	V	V	V
Wallum froglet *Crinia tinnula*	V	V	-	I	V

Table 1. Conservation status of wallum frog species: R = Rare; V = Vulnerable; E = Endangered; I = Insufficiently known. EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*; IUCN status = status according to the World Conservation Union Red List of Threatened Species (2004).

International obligations
The frog species in this plan are not listed on any international agreements. Habitat utilised by these species is, however, listed under UNESCO World Heritage and Ramsar Conventions. This includes wetlands on Fraser Island, islands in Moreton Bay, Myall Lakes, Hunter Estuary Wetlands and Towra Point (Sydney). Under these conventions Australia must ensure the unique ecological characteristics of wetlands in these areas are maintained.

Affected interests
Affected interests include the following organisations:

<u>Queensland Government</u>
- Environmental Protection Agency/Queensland Parks and Wildlife Service (EPA/QPWS)
- Department of Natural Resources, Mines and Water (QDNRM&W)

- Department of Main Roads
- Department of Primary Industries and Fisheries

New South Wales Government

- Department of Planning (NSWDoP)
- Department of Natural Resources (NSWDNR)
- Department of Primary Industries – Forests NSW
- Department of Primary Industries – Agriculture and Fisheries Division
- Department of Environment and Conservation (NSWDEC)
- New South Wales Roads Traffic Authority (NSWRTA)

NRM and CMA bodies

- Burnett Mary and South-east Queensland Natural Resource Management (NRM) bodies.
- Northern Rivers, Hunter-Central Rivers, Hawkesbury-Nepean, Sydney Metro and Southern Rivers Catchment Management Authorities (CMAs).

Local councils

- Gold Coast City Council
- Redlands Shire Council
- Brisbane City Council
- Caboolture Shire Council
- Caloundra City Council
- Maroochy Shire Council
- Noosa Shire Council
- Cooloola Shire Council
- Maryborough City Council
- Tiaro Shire Council
- Hervey Bay City Council
- Isis Shire Council
- Bundaberg City Council
- Miriam Vale Shire Council
- Tweed Shire Council
- Byron Shire Council
- Lismore City Council
- Richmond Valley Council
- Clarence Valley Council
- Coffs Harbour City Council
- Bellingen Shire Council
- Nambucca Shire Council
- Kempsey Shire Council
- Port Macquarie-Hastings Council
- Greater Taree City Council
- Great Lakes Council
- Port Stephens Council
- Maitland City Council
- Newcastle City Council
- Cessnock City Council
- Lake Macquarie City Council
- Wyong Shire Council
- Gosford City Council
- Wollongong City Council
- Shellharbour City Council
- The Council of the Municipality of Kiama
- Shoalhaven City Council
- Councils of Inner Sydney

Others

- Bush care groups
- Conservation groups
- Universities
- Special interest groups (e.g. Queensland Frog Society and New South Wales Frog and Tadpole Study Group)
- State Threatened Species Networks
- Sand mining companies
- Indigenous landowners
- Private landholders

These organisations or individuals are potentially responsible for, and may be involved in, the protection, rehabilitation and management of wallum frog habitat, education of the public and land managers, raising awareness of wallum frogs, habitat assessment, surveys and monitoring (see Section 5).

Consultation with Indigenous people

The habitat of wallum frogs includes areas culturally significant to Indigenous peoples (e.g. Lake McKenzie on Fraser Island). Native title claims covering Fraser Island, coastal lands from Bundaberg south to Brisbane and Byron Bay to Yamba also include significant areas of wallum frog habitat. The frogs themselves are part of the totemic system of clans whose traditional lands includes wallum frog habitat (e.g. the Buttchulla people from Fraser Island). Traditional owners were consulted in the development of this plan and their involvement will also be sought in the implementation of recovery actions including surveys and monitoring, and adaptive fire management.

Benefits to other species and communities

The frog species in this plan occupy the same habitat as a number of nationally threatened plant and animal species (Table 2). Actions benefiting wallum frog species (particularly protection and rehabilitation of wallum frog habitat) will benefit these species as well. Actions outlined in this plan may also help conserve regional ecosystems under threat (Table 3). To ensure maximum benefit to threatened species implementation of recovery actions in this plan should be co-ordinated with recovery of these species/ecosystems.

Common name	Species name	Status under Commonwealth *EPBC ACT 1999*
Fauna		
Oxleyan pygmy perch	*Nannoperca oxleyana*	E
honey blue-eye	*Pseudomugil mellis*	V
eastern bristlebird	*Dasyornis brachypterus*	E
eastern long-eared bat (south-eastern form)	*Nyctophilus timoriensis*	V
long-nosed potoroo (South-eastern mainland)	*Potorous tridactylus tridactylus*	V
grey-headed flying fox	*Pteropus poliocephalus*	V
green and golden bell frog	*Litoria aurea*	V
Flora		
an acacia	*Acacia attenuata*	V
a casuarina	*Allocasuarina simulans*	V
a casuarina	*Allocasuarina defungens*	E
Key's boronia	*Boronia keysii*	V
swamp stringybark	*Eucalyptus conglomerata*	E
Goodwood gum	*Eucalyptus hallii*	V
lesser swamp orchid	*Phaius australis*	E
swamp orchid	*Phaius bernaysii*	E
greater swamp orchid	*Phaius tankarvilleae*	E
wallum prasophyllum	*Prasophyllum wallum*	V

Table 2. Nationally threatened plant and animal species which share habitat with wallum frog species: V = Vulnerable, E = Endangered.

Ecological communities	Status in QLD[1]	Status in NSW[2]	Status under Commonwealth legislation[3]
Freshwater wetlands on NSW north coast	-	Endangered	-
Swamp Sclerophyll forest on NSW north coast	-	Endangered	-

Table 3. Threatened regional ecosystems occupied by wallum frog species. E = Endangered. [1] Listing under the Queensland *Nature Conservation Act 1992*; [2] listing under the New South Wales *Threatened Species Conservation Act 1995*; [3] listing under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Social and economic impacts

The implementation of this plan will have a positive social impact through the involvement of indigenous peoples and community groups in various recovery actions. At the same time, implementation of actions in this plan may have an adverse economic impact on some stakeholders (e.g. private landholders and developers). In order to minimise any adverse economic impacts, recovery actions will be implemented in consultation with affected stakeholders. Actions ensuring proper consultation with stakeholders are included in this plan.

2. Biological information

Distribution of species

The frog species covered by this plan occur along Australia's eastern seaboard from Bundaberg, south-east Queensland, south as far as Jervis Bay, New South Wales; although not all species occur this far south (Figure 1). The geographic distribution of these species includes coastal sandy lowland areas and sand islands off the Queensland coast (Fraser, Bribie, Moreton and North Stradbroke Islands). The patchy coastal distribution of these species reflects to a large extent the distribution of 'wallum' habitat on which most species depend (see below). Maps showing the current distribution of each species are included with species profiles in Appendix 1 of this recovery plan.

The present geographic range and extent of occurrence[1] of wallum frog species is largely unchanged since pre-European times. Since European arrival, however, the area of occupancy[2] of these species has been significantly reduced due to land clearing (for agriculture, the establishment of pine plantations, resort and residential development, and sand mining) (Ingram and McDonald, 1993). With clearing, the habitat of wallum frogs has also become highly fragmented, especially on the mainland.

Species in this plan are known or likely to occur on freehold land, on land managed by the Department of Defence, on mining leases, in state forest and national parks, on road reserves and in council parks and reserves. Lands occupied by wallum frog species occur within Burnett Mary and South-east Queensland NRM regions and within the jurisdiction of Northern Rivers, Hunter-Central Rivers, Hawkesbury-Nepean, Sydney Metro and Southern Rivers Catchment Management Authorities (CMAs).

[1] defined as the area within the shortest continuous boundary encompassing all the known sites or likely sites of occurrence

[2] defined as the area within the extent of occurrence occupied by a species

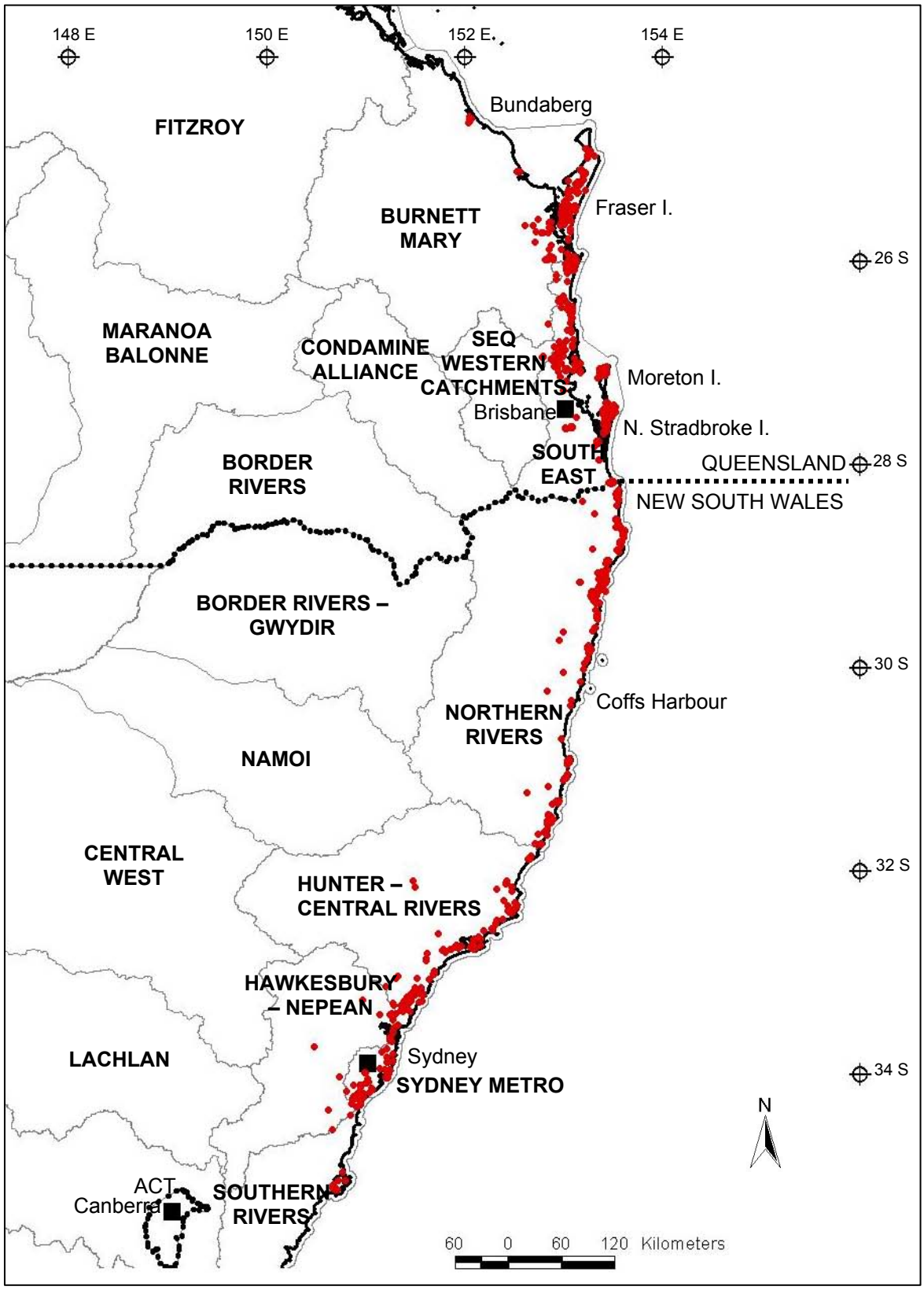

Figure 1. Occurrence of wallum frog species along Australia's eastern seaboard. NRM region and CMA boundaries are shown in grey. Records sourced from the Australian Museum, Queensland Museum, South Australian Museum, Environmental Protection Agency/Queensland Parks and Wildlife Service WildNet database, New South Wales Dept of Environment and Conservation Wildlife Atlas database, and various biologists.

Habitat critical to the survival of the species
Various habitat types are critical to the survival of the wallum frogs, this includes sites which meet essential life cycle requirements (e.g. breeding); sites of food sources, fire and flood refuges; essential routes between these sites; habitat used by important populations; habitat that is required to maintain genetic diversity; and areas not occupied by species but essential for the maintenance of areas where they do occur (e.g. the catchment of wetland communities). Properly defining essential habitat therefore requires a sound knowledge of habitat usage, population size and dynamics and genetic variation within species.

While the breeding habitat of wallum frog species is reasonably well known, habitat usage and movement of animals outside breeding areas is not. Identification of core or important populations and sites is also problematic with little data on population size and dynamics and genetic diversity within species. Accurately describing essential habitat for wallum frog species is therefore difficult.

Based on current knowledge, essential habitat for these species may be defined as freshwater wetlands and associated vegetation communities occurring on low nutrient sandy soils along the east coast of Australia, from near Bundaberg south to Jervis Bay. These soils are usually deep silicious sands (e.g. the coastal sandy lowlands or 'wallum' of south-east Queensland/northern New South Wales (Coaldrake, 1961), or shallow sandy soils overlying clay or sandstone. While nutrient poor, these soils support a range of vegetation types including melaleuca (paperbark) woodland, sedgeland, rainforest, eucalypt forest and heath (the dominant vegetation type on soils of this type).

The frog species in this plan are typically found amidst heath vegetation and sedges where water collects above organic hardpan layers forming 'perched' swamps and lakes (Bayly, 1964; Bensink and Burton, 1975). These acidic (pH < 6.0) swamps and lakes provide essential breeding habitat for wallum frog species.

For breeding habitat, the wallum sedgefrog shows a clear preference for ephemeral (seasonally inundated) perched swamps with emergent sedges while the Cooloola sedgefrog is common around perched lakes with emergent sedges and reeds (Ehmann, 1997; James, 1996; Hopkins, 2003; Lewis and Goldingay, 2005). The more widely distributed wallum froglet and wallum rocketfrog are more commonly associated with ephemeral swamps and soaks than lakes (Ehmann, 1997; Neilson, 2000). These species will also breed in disturbed habitat more readily than the wallum sedgefrog and Cooloola sedgefrog (Queensland DNR, 2001; Hopkins, 2000; E. Meyer, unpub. data). Wallum and Cooloola sedgefrogs have also been recorded from dams in disturbed habitat (K. McDonald, QPWS, pers. comm.; P. Smith, Consolidated Rutile Pty Ltd, pers. comm.). However, whether these dams provide suitable breeding habitat for these species is unknown.

With the exception of the wallum sedgefrog, wallum frog species have at various times been recorded in rainforest, eucalypt forest and eucalypt woodland, some distance from water (Queensland DNR, 2000; E. Meyer, unpub. data). The extent to which wallum frog species rely on vegetation away from breeding sites is largely unknown. Vegetation surrounding lakes and swamps may, nevertheless, play an important role in maintaining hydrology and water quality at breeding sites as well as facilitating movement of animals and gene flow between catchments/populations. Vegetation within swamp and lake catchments may therefore also be considered habitat critical to the survival of the wallum frog species.

Spatial data accurately describing essential habitat are lacking. Habitat maps generated by the EPA/QPWS and NSWDEC do, however, give some indication of the extent of wallum frog habitat north of Sydney, to Bundaberg (Figures 2 and 3).

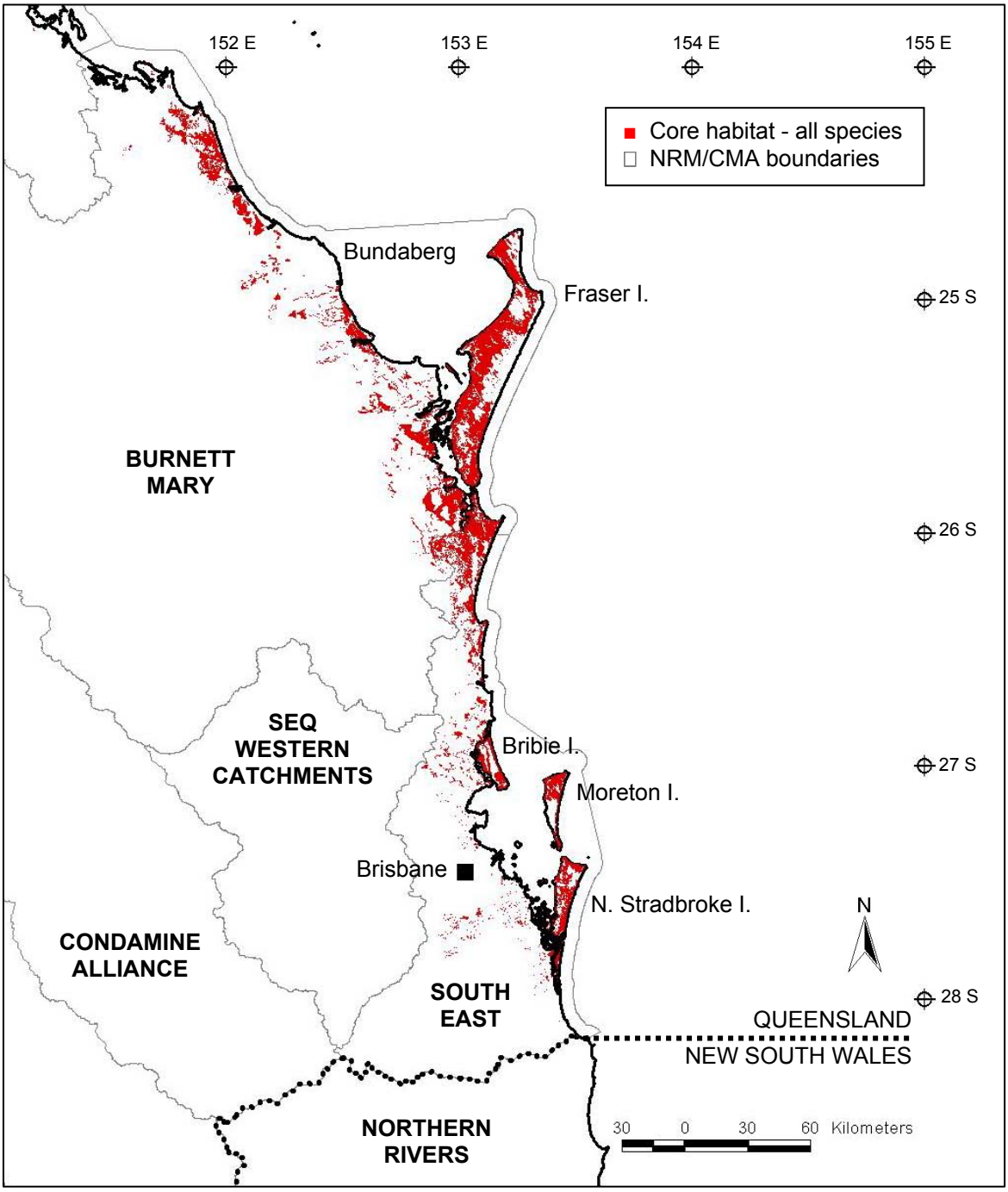

Figure 2. Map produced by EPA/QPWS showing core habitat (known and potential) for wallum frog species in Queensland, as of 2002. This mapping is based on the known distribution of wallum frogs in Queensland, the association of wallum frog species with particular regional ecosystems and expert opinion.

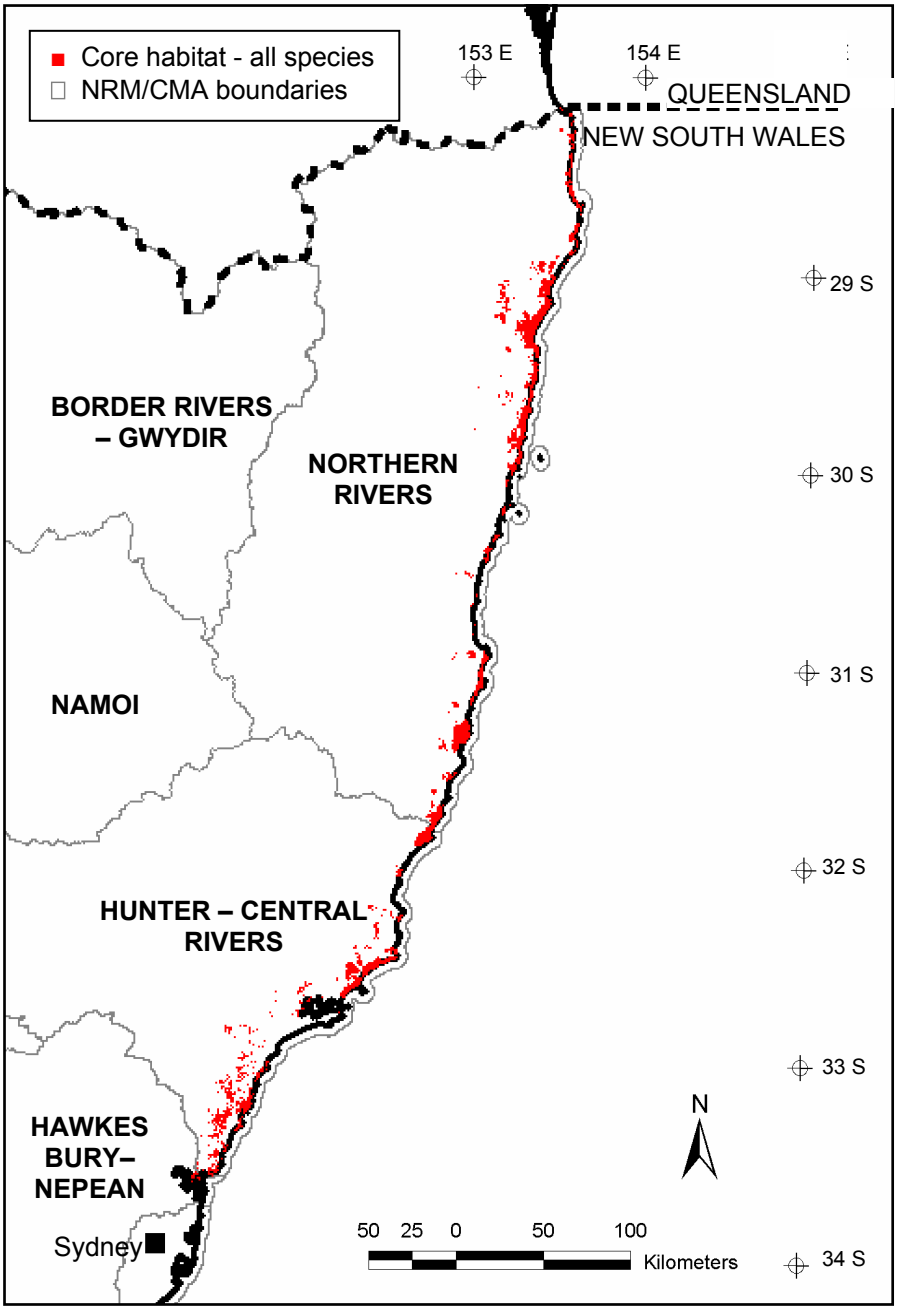

Figure 3. Map of New South Wales showing wallum frog habitat (known and potential) on public land, as of 1998 (produced by NSWDEC for the Comprehensive Regional Forest Assessment). NB. This map does not include habitat south of Sydney or habitat on private (freehold) land.

Existing data on wallum frog species clearly do not allow essential habitat to be defined properly. Actions enabling essential habitat to be described more accurately are included in this plan.

Important populations

With limited data on population size, population dynamics and genetic diversity within species, the relative importance of wallum frog populations is difficult to judge. Populations, which might be considered important because of their size, are listed in

Table 4.The list of important populations provided here (Table 4) should not be considered complete. Populations may be added to this list as more is learnt about population size and dynamics and genetic diversity within wallum frog species.

Location	**State**	**Latitude**	**Land tenure**	**Species/populations**
Great Sandy National Park (Fraser I. and Cooloola sand mass)	QLD	24° 30' to 26° 20'	National Park	*L. olongburensis, L. cooloolensis, L. freycineti* and *C. tinnula*
Bribie I. National Park	QLD	26° 50' to 27° 05'	National Park	*L. olongburensis*, *L. freycineti* and *C. tinnula*
Moreton I. National Park	QLD	27° 02' to 27° 13'	National Park	*L. olongburensis*, *L. freycineti* and *C. tinnula*
N. Stradbroke I.	QLD	27° 25' to 27° 45'	Mining Lease and National Park	*L. olongburensis*, *L. cooloolensis*, *L. freycineti* and *C. tinnula*
Broadwater National Park	NSW	29° 01' to 29° 06'	National Park	*L. olongburensis*, *L. freycineti* and *C. tinnula*
Bundjalung National Park	NSW	29° 08' to 29° 25'	National Park	*L. olongburensis*, *L. freycineti* and *C. tinnula*
Yuraygir National Park	NSW	29° 42' to 29° 53'	National Park	*L. olongburensis*, *L. freycineti* and *C. tinnula*
Myall Lakes National Park	NSW	32° 24' to 32° 39'	National Park	*L. freycineti* and *C. tinnula*

Table 4. List of important wallum frog populations based on current knowledge of wallum frog species.

3. Threats

Biology and ecology relevant to threats[3]

The frog species in this plan are usually found in association with wetlands and vegetation communities occurring on low nutrient sandy soils. This includes coastal freshwater lakes and swamps, wet heath, and nearby eucalypt forest/woodland in areas of sandy soil overlaying clay and sandstone (Hines *et al.,* 1999).

The swamps and lakes in which these species breed are typically oligotrophic (i.e. nutrient poor), tannin-stained and acidic (pH < 6.0). These attributes may render wallum frog breeding habitat unsuitable for related species (i.e. the common sedgefrog *Litoria fallax*, striped rocketfrog *L. nasuta*, clicking froglet *C. signifera* and beeping froglet *C. parinsignifera*). This could explain why wallum frog species and related species seldom occur together (Ingram and Corben, 1975; Straughan, 1966).

At present, little is known of non-breeding habitat use by wallum frogs. Anecdotal observations, however, suggest the Cooloola sedgefrog, wallum froglet and wallum rocketfrog may disperse into eucalypt forest and woodland and/or rainforest after breeding (Queensland DNR, 2001; E. Meyer, unpub. data). The wallum sedgefrog, by contrast, appears more sedentary, sheltering amongst sedges, reeds and ferns during dry periods (Lewis and Goldingay, 2005). However, during wet periods it too may move away from breeding areas (Lewis and Goldingay, 2005).

Like all amphibians, wallum frogs are reliant on moisture for survival. All four species in this plan require freestanding water to breed and cover to avoid dehydration. Because of this reliance on moisture, wallum frogs may be sensitive to water-borne toxicants. Because of their position in the food chain these frog species may also be sensitive to accumulation of toxins or a decline in the availability of insect prey.

Identification of threats

Given current knowledge of the distribution and biology of the species in this plan, a number of threats can be identified. Known and potential threats are listed below in order of importance based on current knowledge.

(1) Habitat loss

The habitat utilised by these frogs, particularly that on the mainland, has been extensively cleared and/or drained for agriculture, sand-mining, resort and residential development, and the establishment of pine plantations (Ingram and McDonald, 1993; Ehmann, 1997; Lewis and Goldingay, 2005). This is especially true for mainland coastal areas of south-east Queensland and northern coastal New South Wales, which have seen a marked increase in residential and resort development in the last 10-15 years (Abbott, 2003). This trend is expected to continue with rapid population growth predicted for south-east Queensland and northern coastal New South Wales over the next decade (Abbott, 2003; Maganov *et al*., 2003). Thus, much of the remaining wallum habitat on freehold land may be under threat of development. In the longer term, predicted rises in sea levels with global warming could also bring about habitat loss on both the mainland and offshore sand islands, including the loss of habitat in conservation reserves.

[3] Details of the biology of each species covered by this plan are provided in Appendix 1.

(2) Habitat degradation

The degradation of wallum habitat at sites impacted by urban and resort development and other human activities could impact negatively on wallum frog species in a variety of ways. Of particular concern in this regard, are the trampling of reed beds, changes in hydrology, altered water chemistry, and increases in soil and water nutrient levels.

Trampling of reed beds

In areas with high levels of human visitation (e.g. lakes on Fraser Island and North Stradbroke Island), trampling of reed beds has led to significant loss of sedgefrog habitat. This could impact seriously on sedgefrog numbers at a local level.

Changes in hydrology

Changes in hydrology may impact negatively on wallum frog species in several ways. A reduction in the hydroperiod for ephemeral swamps (i.e. a reduction in the permanency of water), may limit reproductive success. Conversely, increased permanence of water could lead to the establishment of predatory fish in otherwise fish-free ephemeral swamps. Changes in hydrology could affect water pH, making conditions favourable for less acid-tolerant species which might displace wallum frog species (i.e. the common sedgefrog, striped rocketfrog, clicking froglet and beeping froglet).

Habitat eutrophication and pollution

Studies have shown that increased nitrate levels in water can inhibit larval growth and development as well as reduce larval survivorship in frogs and toads (Mann and Bidwell, 1999). Breeding naturally in oligotrophic (nutrient poor) waters, wallum-dependent species may be especially sensitive to increased nitrate levels in water. Nutrient-laden runoff from urban areas and golf courses could therefore render wallum habitat unsuitable for wallum frog species. Nutrient enrichment of nutrient-poor wallum soils may also favour the establishment of non-wallum native plant species, including problem 'weed' species (e.g. *Typha* spp.). This to could render wallum habitat unsuitable for wallum frog species.

In addition to nutrients, runoff from urban areas may contain other toxicants such as surfactants and oils. Accumulation of these toxicants in wetland areas could also have a negative impact on wallum frog species in areas adjacent to developed areas.

(3) Habitat fragmentation as a result of land clearing

The distribution of wallum frog species is highly fragmented. This fragmentation is due in part to natural processes thousands of years old, most notably a rise in sea levels at the end of the last glacial period (beginning circa 19,000 years ago) (Coaldrake, 1961). More recently, land clearing has increased fragmentation of wallum frog habitat especially in mainland areas (where most land clearing has taken place) (Hines *et al.,* 1999; Ehmann, 1997).

Increased fragmentation of habitat may further reduce opportunities for dispersal/ movement of frogs between wetland catchments or subpopulations within catchments. This could potentially increase the likelihood of extinction of 'sink' populations whose viability is dependent on immigration of animals from other ('source') populations. Habitat fragmentation may also reduce the likelihood of recolonization following local extinction of frog populations/sub-populations after severe habitat disturbance (e.g.

fire). Lack of movement of animals between populations or subpopulations may also lead to genetic problems (e.g. inbreeding, genetic drift), which could compromise the long-term viability of populations.

(4) Inappropriate fire regimes

An increase in the frequency or intensity of fires could impact significantly on frog numbers through direct mortality or loss of vegetation, the loss of cover exposing frogs to predators, extremes of temperature and dehydration. Monitoring data from Lennox Head (New South Wales) show fire may have a significant impact on wallum sedgefrog numbers, at least in the short term (Lewis and Goldingay, 2005). Long term monitoring data from Western Australia also suggest frog numbers may be slow to recover following fire, even when heath vegetation is quick to do so (Driscoll and Roberts 1997). Frequent fires, especially over large areas, could therefore pose a serious threat to the long-term viability of wallum frog populations.

(5) Predation by the introduced mosquito fish

Predation by the introduced mosquito fish *Gambusia holbrooki* (listed as a key threatening process in New South Wales) poses a significant threat to native species (New South Wales National Park and Wildlife Service, 2002; Gillespie and Hero, 1999; Komak and Crossland, 2000). Most of the water bodies which wallum frog species breed in are fish free (Hopkins, 2003; E. Meyer, unpub. data). These species may therefore not have evolved effective means for dealing with fish predators, especially exotic fish like the mosquito fish. Wallum frog species may therefore be highly susceptible to predation by this species.

(6) Use of biocides in weed and mosquito control

Many widely used pesticides have been shown to be toxic to frogs causing deformities, hermaphroditism and death (Mann and Bidwell, 1999). Thus, the widespread use of pesticides in weed and mosquito control in coastal areas is another potential threat to wallum frog species.

(7) Pig damage

Pigs, which are known to occur in wallum frog habitat, are a potential threat to wallum frog species. Pigs may destroy breeding habitat when foraging or using breeding sites as wallows, rendering them unsuitable for wallum frog species (Department of the Environment and Heritage, 2003). Ground-dwelling frogs, such as the wallum froglet and wallum rocketfrog, may also be at risk of predation by pigs. The threat posed by pigs to native species has led to the listing of predation and habitat degradation by pigs as a key threatening process under the EPBC Act.

(8) Exotic disease

Exotic disease has emerged as a significant threat to amphibian populations here and internationally. In Australia, amphibian chytridiomycosis, an exotic disease caused by the chytrid fungus *Batrachochytrium dendrobatidis*, is believed to be responsible for the recent decline and extinction of a number of rainforest frogs (Daszak *et al.,* 2003). It is now listed as a key threatening process under the EPBC Act and NSW *Threatened Species Conservation Act 1995*. In the absence of information as to whether this particular disease poses a threat to wallum frog species, a precautionary approach, assuming that the disease does pose such a threat, is advisable.

(9) Vehicular traffic

In northern New South Wales, significant mortality of adult wallum sedgefrogs is known to occur on busy roads bisecting wallum swamps (R. Goldingay, unpub. data). Thus, in some areas, vehicular traffic may pose a threat to populations of this species.

Areas under threat
The areas where wallum frog species are most under threat are on the mainland. It is the loss of wallum habitat on freehold land that is of most concern. With population growth in coastal areas on the increase, much of the remaining habitat on freehold land may be lost to residential development and associated infrastructure (i.e. roads and sewerage lines). In terms of habitat degradation, it is those areas adjacent or adjoining residential and resort developments (including golf courses) that are most under threat.

Populations under threat
Populations under greatest threat, in the short term, are those, which occur on freehold land in mainland coastal areas (i.e. coastal south-east Queensland and north-east New South Wales). In these areas, habitat has become highly fragmented leaving many small isolated populations. These populations may be at greater risk of extinction because of limited gene flow, reduced likelihood of immigration, and greater vulnerability to stochastic demographic and genetic processes (i.e. chance fluctuations in population structure and size, and genetic drift).

Populations not on freehold land, but also under threat, include the wallum sedgefrog and wallum froglet at Tugun (on the Queensland/New South Wales border), Brown Lake on North Stradbroke Island (where the Cooloola sedgefrog, wallum froglet and wallum rocketfrog have declined markedly in abundance following the introduction of the mosquito fish) and Karawatha Forest Park, near Brisbane (where the wallum froglet's abundance has declined significantly in recent years) (E. Meyer, unpub. data). Populations in pine plantations may also be threatened with habitat loss as remnant vegetation is damaged during logging (Keith McDonald, QPWS, pers. comm.).

4. Recovery Objectives

Overall objective
To improve the conservation status of the wallum sedgefrog and other wallum-dependent frog species through effective management, protection and rehabilitation of wallum frog habitat.

Specific objectives

The specific objectives of this five-year plan are:

1. To identify areas of habitat critical to the survival of wallum frog species more accurately.
2. To protect habitat critical to wallum frog survival and important wallum frog populations from threatening processes.
3. To rehabilitate degraded wallum frog habitat.
4. To determine population trends in areas of disturbed undisturbed and rehabilitated habitat.

5. Performance criteria and Recovery actions

Performance criteria
The success of this plan will be measured against the following criteria:

1. Non-breeding habitat critical to the survival of wallum frog species is identified.
2. Important populations and their habitat are identified.
3. Essential habitat outside of protected areas is conserved.
4. Threats to wallum frog populations in protected areas are mitigated.
5. Knowledge of threats is improved and utilised to ensure wallum frog habitat and populations are appropriately managed/protected.
6. Stakeholders and the broader community are engaged in the recovery of wallum frog species.
7. Degraded wallum frog habitat is rehabilitated.
8. Data on population trends are collected for all wallum frog species in areas of undisturbed, disturbed and rehabilitated habitat and used to guide management actions.

Evaluation of recovery plan
Recovery actions and management guidelines will be reviewed annually by the South-east Queensland Threatened Frogs Recovery Team (SEQTFRT). A comprehensive review of this plan will be undertaken within five years of adoption by the SEQTFRT in consultation with affected stakeholders.

Recovery actions
Actions needed for recovery of wallum-dependent frog species include:

1. Identify and assess essential habitat.
2. Protect wallum frog populations and manage habitat.
3. Acquire information on threats to inform management.
4. Engage stakeholders and the broader community in recovery of wallum frog species.
5. Rehabilitate degraded wallum frog habitat.
6. Monitor frog numbers and distribution.

These actions will potentially be undertaken by state and local government agencies (in both Queensland and New South Wales), Burnett Mary and South-east Queensland Natural Resource Management (NRM) bodies, Northern Rivers, Hunter-Central Rivers, Hawkesbury-Nepean, Sydney Metro and Southern Rivers Catchment Management Authorities (CMAs), bush care groups, conservation groups, universities, special interest groups (e.g. the Queensland Frog Society and New South Wales Frog and Tadpole Study Group), state Threatened Species Networks, sand mining companies, traditional (aboriginal) landowners , and private landholders. The costs of actions in this plan are for travel, consumables and equipment as well as the salaries and associated costs of stakeholders involved in implementing actions. Contributions from volunteers and community groups are not included.

Action 1. Identify and assess essential habitat

Protection of habitat critical to survival is essential for the recovery of wallum frog species. Essential habitat of wallum frog species must, therefore, be accurately defined. Knowledge of non-breeding habitat usage, abundance and genetic diversity within species will need to be improved for this to occur.

1.1 Determine non-breeding habitat usage

Knowledge of non-breeding habitat usage is needed to inform management and ensure the proper protection of wallum frog habitat. Non-breeding habitat usage by wallum frog species should be determined through pitfall trapping and/or spool-lining of animals across a range of seasons and habitats.

Potential contributors:, QDNRM&W, NSWDEC, EPA/QPWS and universities.

Estimated cost: $20,000 a year (travel, personnel and equipment) over years 1 and 2.

1.2 Map wallum frog habitat

The association of wallum frogs with particular vegetation and soil types can be used to model the extent of remaining habitat and identify areas of important habitat (according to size of area, disturbance history, location, land tenure and land use). These maps can be used to identify areas for survey (see Action 1.3).

Some preliminary mapping of wallum frog habitat has been carried out. More work is needed to validate, refine and extend this mapping.

Potential contributors:, QDNRM&W, EPA/QPWS, NSWDEC, Burnett Mary and SEQ Catchments Natural Resource Management bodies, Northern Rivers, Hunter-Central Rivers, Hawkesbury-Nepean, Sydney Metro and Southern Rivers Catchment Management Authorities and Universities.

Estimated cost: $10,000 (personnel) for years 1 and 2.

1.3 Conduct surveys

Areas identified in Action 1.2 will need to be surveyed to determine presence/ absence and abundance of wallum frog species and to assess habitat condition. Data from surveys will be used to refine mapping and prioritise areas for protection and rehabilitation.

Potential contributors: Burnett Mary and SEQ Catchments Natural Resource Management bodies, Northern Rivers, Hunter-Central Rivers, Hawkesbury-Nepean, Sydney Metro and Southern Rivers Catchment Management Authorities, EPA/QPWS and NSWDEC.

Estimated cost: $100,000 a year (personnel and transport) over years 1 and 2.

1.4 Acquire genetic data for prioritising areas/populations for conservation
Knowledge of genetic diversity within species is important not only for describing essential habitat, but also prioritising areas/populations for conservation management.

While genetics of the Cooloola sedgefrog and wallum sedgefrog are reasonably well known, little is known about genetic diversity in the wallum froglet and wallum rocketfrog. Genetic data are needed to properly define essential habitat and prioritise areas for conservation of these species.

Collection of tissues for DNA analysis during surveys and monitoring (Actions 1.3 and 6.2) will help reduce costs associated with this action.

Potential contributors: Universities, Queensland Museum and South Australian Museum.

Estimated cost: $20,000 a year (travel, DNA analysis and consumables) for years 1, 2 and 3. Collection of tissues for DNA analysis during surveys and monitoring (Actions 1.3 and 6.2) will help reduce costs associated with this action.

Action 2. Protect wallum frog populations and manage habitat
The protection of wallum frog habitat from human impacts is essential for the recovery of species listed in this plan, as is management of habitat/populations in parks, reserves and state forest. The sub-actions below will ensure wallum frog populations and habitat on freehold and crown land (protected or otherwise) are properly protected and managed.

2.1 Ensure appropriate legislative protection of wallum frog habitat
The listing of wallum frog species under state and Commonwealth legislation provides an important mechanism for protection of wallum frog habitat.

A review of the status of wallum-dependent sedge frogs will be conducted as part of the review of this recovery plan.

Potential contributors: SEQTFRT, EPA/QPWS, NSWDEC and Universities.

Estimated cost: $0

2.2 Protect wallum frog habitat on freehold land
Protection of habitat on freehold land will require the cooperation of landholders and local government. Cooperation of landholders in the protection of wallum frog habitat may be sought through voluntary conservation agreements (i.e. agreements between landholders and state governments providing protection for wildlife habitat e.g. Nature Refuge agreements). In addition, protection of habitat on private land may be arranged through local government councils responsible for planning and development approvals and incentive schemes run by CMAs and NRM bodies. Where incentive schemes allow for protection of important habitats or ecosystems, wallum frog habitat should be nominated as ‘priority habitat’.

Potential contributors: Local councils, NSWDoP, EPA/QPWS, NSWDEC, Burnett Mary and SEQ Catchments Natural Resource Management bodies, Northern Rivers, Hunter-Central Rivers, Hawkesbury-Nepean, Sydney Metro and Southern Rivers Catchment Management Authorities.

Estimated cost: $80,000 a year (personnel and travel) over years 1,2,3,4 and 5.

2.3 Apply guidelines for habitat protection and management
Guidelines for habitat protection and management are needed to assist local and state government in assessing development applications and to inform management of wallum frog habitat in parks and reserves.

Preliminary guidelines for management and protection of wallum frog habitat, based on current knowledge of wallum frog species, are provided in this document (see Section 6). Applying these guidelines will help mitigate the impact of development and other threats on wallum frog habitat.

Potential contributors: Local councils, QDNRM, NSWDoP, EPA/QPWS, NSWDEC, Burnett Mary and SEQ Catchments Natural Resource Management bodies, Northern Rivers, Hunter-Central Rivers, Hawkesbury-Nepean, Sydney Metro and Southern Rivers Catchment Management Authorities, Queensland Department of Main Roads, NSWRTA, and developers.

Estimated cost: $0

2.4 Assess guidelines for habitat protection and management
The efficacy of management guidelines in Section 6 of this plan will be assessed. Information from monitoring and survey work (Actions 6 and 1.3) will help with this task. However, additional monitoring of sites before and after disturbance, in particular sites impacted by development, is also required.

Potential contributors: Local councils, QDNRM, NSWDoP, EPA/QPWS and NSWDEC, Burnett Mary and SEQ Catchments Natural Resource Management bodies, Northern Rivers, Hunter-Central Rivers, Hawkesbury-Nepean, Sydney Metro and Southern Rivers Catchment Management Authorities, Queensland Department of Main Roads, NSWRTA, and developers.

Estimated cost: $65,000 a year (personnel, travel and consumables) over years 2, 3, 4 and 5.

2.5 Manage fire
Adaptive research (monitoring of frog numbers by land managers before and after prescribed burns) is needed to inform fire management in coastal area where wallum frog species occur. This will provide land managers with valuable data on the response of wallum frog species to fire, which could be used to modify existing practices as necessary. Indigenous landowners may also be able to provide advice on appropriate fire management for wallum frog habitat.

Potential contributors: Indigenous landowners, DNR, DIPNR, local councils, EPA/QPWS, NSWDEC and NSW Rural Fire service.

Estimated cost: $20,000 a year (personnel, travel and consumables) over years 1,2,3,4 and 5.

2.6 Manage amphibian disease
Diseases, which are harmful to frogs, could be spread by humans, translocation of wild animals or release of captive animals into the wild. Implementation of the Australian Government ‘Threat Abatement Plan for Infection of amphibians with chytrid fungus resulting in chytridiomycosis’ will see the development of hygiene protocols for

reducing transmission of disease amongst amphibian populations. Adherence to these guidelines is important for management of amphibian diseases spread by humans.

These available guidelines will be publicised via the Web, facts sheets and workshops (Action 2). Until then persons working with wallum frogs or in wallum frog habitat should follow guidelines on disease management developed by the New South Wales Department of Environmental and Conservation. These are available on the internet at http://www.nationalparks.nsw.gov.au/pdfs/hyprfrog.pdf.

Potential contributors: EPA/QPWS, NSWDEC, QDNRM and New South Wales Department of Primary Industries – Forests NSW.

Estimated cost: $2,000 (for disinfectant and other consumables used by volunteers and personnel involved in field work) for years 1 through 5.

2.7 Reduce impact of introduced fish

The deliberate introduction/translocation of the mosquito fish (*G. holbrooki*) to wallum areas could have a serious impact on wallum frog populations. To counteract this threat, relevant government agencies and the general public must be educated on the potential impact of fish translocations and introductions. Education of the public about this threat may be undertaken as part of Action 4. This action is also likely to benefit other threatened aquatic fauna including the Oxleyan pygmy perch and honey blue-eye.

Potential contributors: SEQTFRT, QDNRM&W, NSWDNR, EPA/QPWS, NSWDEC, local councils, frog groups and NSWDPI – Agriculture and Fisheries Division.

Estimated cost: Costs for this action are ostensibly covered under Action 4.

2.8 Control feral pigs

In some areas pigs are known to cause significant damage to wallum frog habitat. Where pig damage to wallum frog habitat is significant, pigs should be removed.

Potential contributors: QDNRM&W, NSWDNR, EPA/QPWS, NSWDPI – Agriculture and Fisheries Division and NSWDEC.

Estimated cost: $5,000 a year (personnel, ammunition, bait and traps) years 1,2,3,4 and 5.

Action 3. Acquire additional information on threats to inform management

To ensure effective management of wallum frog species in the future, knowledge of threatening processes will need to be improved. Of particular concern are potential threats about which little is known including: the impact of biocides on wallum frogs, the effect of predicted sea level rises on wallum frogs, and the impact of storm water drainage pollution, weed invasion and competition from invading species. Research into these threatening processes is needed to inform management as well as refine and prioritise actions. Information from this research will be particularly important in assessing the adequacy of management guidelines (Action 2.4).

Potential contributors: universities, local councils, QDNRM&W and NSWDNR.

Estimated cost: $30,000 a year (personnel, travel, consumables and equipment) in years 3, 4 and 5.

Action 4. Engage stakeholders and the broader community in recovery of wallum frog species

Recovery of wallum frog species is possible only through the cooperation and involvement of stakeholders and the broader community. The sub-actions identified below will help raise awareness amongst stakeholders and the community at large, facilitating implementation of actions outlined in this plan.

4.1 Produce and distribute fact sheets and poster boards

A fact sheet with photos and information on wallum frog species, threats, habitat management and protection of wallum frog habitat will be produced and distributed through conservation and land management agencies, local councils and community groups. More detailed information will be made available on the internet (e.g. on websites run by the EPA/QPWS, NSWDEC, CMAs, NRM bodies and Threatened Species Networks). Web access to this information will be publicised through facts sheets, conservation agencies and community groups. A series of poster boards highlighting the plight of wallum frog species will also be produced for public display at libraries, council offices, schools, workshops and special events.

Potential contributors: EPA/QPWS, NSWDEC, Burnett Mary and SEQ Catchments Natural Resource Management bodies, Northern Rivers, Hunter-Central Rivers, Hawkesbury-Nepean, Sydney Metro and Southern Rivers Catchment Management Authorities, Threatened Species Networks, local councils, conservation groups, and landcare groups.

Estimated cost: $16,500 (design and printing) in year 1

4.2 Disseminate information on important habitat and management guidelines

Information on important habitat, including spatial data, needs to be disseminated to local councils, state government agencies, NRM bodies and CMAs. This information will be disseminated electronically via the SEQTFRT. Habitat and disease management guidelines may also be disseminated electronically via the SEQTFRT and government, CMA and NRM body websites.

Potential contributors: SEQTFRT, QPWS/EPA, NSWDEC, Burnett Mary and SEQ Catchments Natural Resource Management bodies, Northern Rivers, Hunter-Central Rivers, Hawkesbury-Nepean, Sydney Metro and Southern Rivers Catchment Management Authorities.

Estimated cost: $0

4.3 Conduct training workshops

Regional workshops will be held to provide stakeholders with information on habitat management and protection as well as disease management. Workshops will also be held to recruit and train volunteers in frog identification and monitoring.

Potential contributors: Threatened Species Networks, frog groups (Queensland Frog Society and New South Wales Frog and Tadpole Study Group), EPA/QPWS and NSWDEC, QDNRM&W, NSWDNR.

Estimated cost: $5,000 a year (personnel) for years 1 and 2.

4.4 Expand South-east Queensland Threatened Frog Recovery Team

Membership of the SEQTFRT will need to be expanded to ensure adequate representation of stakeholders affected by this plan. Stakeholders without

representation will be invited to attend recovery meetings and included on the SEQTFRT email list.

Potential contributors: SEQTFRT

Estimated cost: $0

Action 5. Rehabilitate degraded wallum frog habitat

Rehabilitation of disturbed wallum frog habitat in protected areas can help offset habitat loss. Revegetation of corridors linking protected areas can also help, facilitating movement of wallum frogs between wetlands.

A number of community groups are actively involved in rehabilitating/ revegetating disturbed wallum habitat. The efforts of these groups will be supported. The SEQTFRT can assist these groups by supporting applications for funding as well as providing advice on management and restoration of frog habitat. Raising awareness of the plight of wallum frogs (Action 2) may also increase community support for and involvement in rehabilitation of disturbed habitat. Areas of wallum frog habitat in need of rehabilitation will be identified and prioritised based on information from surveys (Action 1.3).

Potential contributors: SEQTFRT, local councils, community volunteers, bushcare groups, Burnett Mary and SEQ Catchments Natural Resource Management bodies, Northern Rivers, Hunter-Central Rivers, Hawkesbury-Nepean, Sydney Metro and Southern Rivers Catchment Management Authorities, EPA/QPWS and NSWDEC.

Estimated cost: $50,000 a year (materials for restoration work) for years 1,2,3,4 and 5. Funding for materials will be sought from local councils and other grants programs.

Action 6. Monitor frog numbers and distribution

Monitoring is needed to assess population trends for all wallum-dependent frog species. Knowledge gained from monitoring will help provide a clearer picture of the current conservation status of these species as well as providing baseline data against which the effectiveness of recovery actions can be judged.

6.1 Develop methodology for monitoring

An appropriate methodology must be developed for monitoring wallum frog numbers to ensure data are comparable across sites and seasons. In developing an appropriate methodology, consideration must be given to seasonal variation in detectability and logistic constraints.

Potential Contributors: SEQTFRT, EPA/QPWS and NSWDEC.

Estimated cost: $10,000 (personnel) for year 1.

6.2 Undertake monitoring

Regular (quarterly) monitoring of wallum sites is needed to ascertain population trends for all wallum-dependent frog species. Monitoring will be carried out in disturbed as well as undisturbed habitat so that the response of wallum frogs to disturbance can be better understood. This is especially important for fire management (Action 2.5). Monitoring of frogs at rehabilitated sites is also needed to determine whether habitat restoration (Action 5) has been effective.

Potential contributors: Community volunteers, QDNRM&W, NSWDNR, EPA/QPWS and NSWDEC, Burnett Mary and SEQ Catchments Natural Resource Management

bodies, Northern Rivers, Hunter-Central Rivers, Hawkesbury-Nepean, Sydney Metro and Southern Rivers Catchment Management Authorities.

Estimated cost: $75,000 a year (for personnel and transport) for years 1,2,3,4 and 5.

Summary Table
(Note: priority 1 = high priority; 2 = medium priority; 3 = low priority)

Objectives	Criteria	Actions	Priority
1. To identify areas of habitat critical to the survival of wallum frog species more accurately	1. Non-breeding habitat critical to the survival of wallum frog species is identified	1.1 Determine non-breeding habitat usage	1
	2. Important populations and their habitat are identified	1.2 Map habitat	2
		1.3 Conduct surveys	2
		1.4 Acquire genetic data for prioritising areas/populations for conservation	3
2. To protect habitat critical to wallum frog survival and important wallum frog populations from threatening processes	3. Essential habitat outside of protected areas is conserved	2.1 Ensure appropriate legislative protection of wallum frog habitat	1
		2.2 Protect wallum frog habitat on freehold land	1
	4. Threats to wallum frog populations in protected areas are mitigated	2.3 Apply guidelines for habitat protection and management	1
		2.4 Assess guidelines for habitat protection and management	2
		2.5 Manage fire	2
		2.6 Manage amphibian disease	2
		2.7 Reduce impact of introduced fish	3
		2.8 Control feral pigs	3
	5. Knowledge of threats is improved and utilised to ensure wallum frog habitat and populations are appropriately managed/protected	3. Acquire additional information on threats to inform management	3
	6. Stakeholders and the broader	4.1 Produce and distribute fact sheets and poster boards	1

	community are engaged in recovery of wallum frog species	4.2 Dissemination of information on wallum frog habitat management and protection	1
		4.3 Conduct training workshops	1
		4.4 Expand South-east Queensland Recovery Team	1
3. To rehabilitate degraded wallum frog habitat in protected areas	7. Degraded wallum frog habitat in protected areas is rehabilitated	5. Rehabilitate degraded wallum frog habitat	2
4. To determine population trends in areas of disturbed, undisturbed and rehabilitated habitat	8. Data on population trends are collected for all wallum frogs species in areas of disturbed, undisturbed and rehabilitated habitat and used to guide management actions	6.1 Develop methodology for monitoring	1
		6.2 Undertake monitoring	2

6. Management practices

Proper management of wallum frog habitat is critical to the survival of wallum frog species. Guidelines for habitat management, based on current knowledge of the biology of wallum frog species, are outlined below. These guidelines may be modified as knowledge of the biology and threats to wallum frog species improves.

1. Minimising soil disturbance

Earthworks may adversely affect soil hydrology and water quality at breeding sites. Of particular concern in this regard are the breaching of organic hardpans holding water, increased water turbidity (due to runoff) and liberation of sub-soil aluminium. Soil disturbance should therefore be kept to a minimum near wallum swamps and lakes. Where earthworks are carried out in the vicinity of breeding habitat, runoff from earthworks must be appropriately contained.

2. Retention of vegetation

Natural vegetation surrounding water bodies may provide cover and foraging habitat for frogs and should be left intact. Bushland linking wetlands may also provide an important route for dispersal of animals and should, likewise, be retained. Thus, further clearing of vegetation within wallum swamp and lake catchments, especially in mainland areas where much vegetation has been cleared already, should be avoided. At a minimum, vegetation within 50m of breeding sites must be left intact.

3. Preventing nutrient enrichment

Habitat eutrophication may have a significant adverse impact on wallum frog species. It is therefore important that storm water runoff from golf courses, urban areas and agricultural land be directed away from breeding sites or treated to remove nutrients and other contaminants before being discharged into wetland areas. To further reduce the likelihood of habitat eutrophication, residents in wallum areas should be discouraged from fertilising lawns and encouraged to plant native species that tolerate nutrient-poor sandy soils.

4. Adaptive fire management

An adaptive approach is needed to fire management in areas of wallum frog habitat. This will necessitate monitoring the response of wallum frogs to fire and modifying burning practices as necessary.

5. Limiting use of biocides in wallum frog habitat

Until their impact on wallum frogs is ascertained, biocides should not be used in the immediate vicinity of wallum frog breeding sites.

6. Managing recreational use of coastal lakes

In a number of conservation parks and reserves with high visitation (e.g. Brown Lake Conservation Park and Great Sandy National Park), trampling of reed beds has led to significant loss of breeding habitat and cover for the wallum sedgefrog and Cooloola sedgefrog. To reduce the impact of human visitation at these sites, visitor numbers and access to lakes and swamps must be reduced or boardwalks constructed to allow visitors access to water without reed beds being trampled.

7. Managing the impact of feral animals

Repeated trampling and browsing of vegetation and fouling of water by livestock must not be allowed at breeding sites. Where this is a problem, fencing should be erected to exclude stock from breeding areas. Where pigs are causing significant damage to wallum frog habitat, pig numbers must also be reduced.

Every effort must be made to exclude the mosquito fish *G. holbrooki* from wallum swamps or lakes. Increased connectivity between water bodies or increased water permanence, caused by changes to hydrology, may increase the chance of introduction of the mosquito fish and therefore should be avoided. Changes in hydrology, which may affect this introduction, can be caused by urban development.

8. Road construction
Roads should be built around or over, not through, wallum frog breeding habitat so as to avoid habitat disturbance and prevent mortality of frogs on roads. This is most important where roads are likely to carry high volumes of traffic.

9. Monitoring
Habitat condition and frog numbers should be monitored to ensure threats to wallum frog species are properly managed. Monitoring should include tadpole surveys (to identify breeding sites) and must be undertaken with sufficient regularity (i.e. quarterly) to detect significant changes in recruitment success. Where the impact of development is to be assessed, monitoring must be carried out a year or preferably more, before development starts.

7. Cost of recovery

Estimated cost of implementing recovery plan ($'000s)

Action	Sub-action	2007 ($)	2008 ($)	2009 ($)	2010 ($)	2011 ($)	Total ($)
1. Identify and assess habitat	1.1 Determine non-breeding habitat usage	20	20	0	0	0	40
	1.2 Map wallum frog habitat	10	10	0	0	0	20
	1.3 Conduct surveys	100	100	0	0	0	200
	1.4 Acquire genetic data	20	20	20	0	0	60
2. Protect important wallum frog populations and manage habitat	2.1 Ensure appropriate legislative protection of wallum frog habitat	0	0	0	0	0	0
	2.2 Protect wallum frog habitat on freehold land	80	80	80	80	80	400
	2.3 Apply guidelines for habitat protection and management	0	0	0	0	0	0
	2.4 Assess guidelines for habitat protection and management	0	65	65	65	65	260
	2.5 Manage fire	20	20	20	20	20	100
	2.6 Manage amphibian disease	2	2	2	2	2	10
	2.7Reduce impact of introduced fish	0	0	0	0	0	0
	2.8 Control feral pigs	5	5	5	5	5	25
3. Acquire additional information on threats to inform management		0	0	30	30	30	90
4. Engage stakeholders and the broader community in recovery of wallum frog species	4.1 Produce and distribute fact sheets and poster boards	16.5	0	0	0	0	16.5
	4.2 Disseminate information on important habitat and management guidelines	0	0	0	0	0	0
	4.3 Conduct training workshops	5	5	0	0	0	10
	4.4 Expand South-east Queensland Threatened Species Frog Recovery Team	0	0	0	0	0	0
5. Rehabilitate degraded wallum frog habitat		50	50	50	50	50	250
6. Monitor frog numbers and distribution	6.1 Develop methodology for monitoring	10	0	0	0	0	10
	6.2 Undertake monitoring	75	75	75	75	75	375
	Total cost per year ($)	413.5	452	347	327	327	**1866.5**

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Appendix 1. Species profiles

A. Wallum sedgefrog *Litoria olongburensis* Liem and Ingram 1977

Other names: Olongburra frog; Olongburra tree frog, sharp-snouted reed frog, wallum tree frog

Description: A small tree-frog with a pointed snout; snout-to-vent length (SVL) of adult males approximately 25mm, SVL of adult females 27-31mm. Dorsal colouration is grey-brown, beige or bright green, occasionally with dark flecking. The skin is smooth above and granular below. The venter (underside) of frogs is white except for the throat, which is peppered with brown. A dark brown stripe runs from the snout through the eye and tympanum (the ear). A prominent white streak, starting below the eye, runs back over the shoulder onto the flanks, breaking up into a series of raised (glandular) spots. The toes are partly webbed while the fingers have vestigial webbing. The finger discs and toepads are conspicuous. The posterior thigh is blue or purple-blue in colour, with a little orange ventrally. Usually there is some blue colouration in the groin as well. (Barker, Grigg and Tyler, 1995; Liem and Ingram, 1977)

Distribution: Lowland coastal south-east Queensland and north-east New South Wales, from Lake Wongeel, Fraser Island. (24° 53'S 153° 14'E) south to Woolgoolga (30° 08'S 153° 11'E) (see Figure 1) (Hines *et al*., 1999; Liem and Ingram, 1977).

Current distribution: *L. olongburensis* is likely to have suffered significant habitat loss in areas impacted by urban development, the establishment of pine plantations and sand mining (Ehmann, 1997; Hines *et al.,* 1999). Despite this, sizeable populations of *L. olongburensis* persist in protected areas in both Queensland and New South Wales. In Queensland, *L. olongburensis* is known from Great Sandy, Noosa, Poona, Bribie Island, Blue Lake and Moreton Island National Parks. In New South Wales, *L. olongburensis* is known from Broadwater, Billinugel, Bundjalung, and Yuraygir National Parks as well as Tyagarah and Broken Head Nature Reserves. Recent monitoring in northern New South Wales suggests numbers of *L. olongburensis* remain stable at most sites. (Ehmann, 1997; Hines *et al.,* 1999; Lewis and Goldingay, 2005)

Conservation status: Listed as 'Vulnerable' under the *Environment Protection and Biodiversity Conservation Act 1999*, Queensland legislation (Queensland *Nature Conservation Act 1992*) and New South Wales legislation (New South Wales *Threatened Species Conservation Act 1995*). Listed as 'Vulnerable' by the IUCN (IUCN, 2004).

Habitat: Ephemeral and semi-permanent swamps with emergent reeds, ferns and/or sedges, in undisturbed coastal wallum. While most common in swamps, *L. olongburensis* may also be found around creeks and freshwater lakes in coastal wallum. Rarely is *L. olongburensis* found sympatric with the common sedgefrog *Litoria fallax*. At swamp sites, *L. olongburensis* can be found sheltering amongst sedges, reeds and ferns, not only in spring/summer but also autumn and winter. (Anstis, 2002; Ehmann, 1997; Ingram and Corben, 1975; Lewis and Goldingay, 2005; James, 1997; Liem and Ingram, 1977; Nielsen, 2000).

Breeding biology: Breeding occurs in spring, summer and autumn, after rain. Males call from sedges above water. Amplexus is axillary and eggs are laid singly in water at the base of sedges. Usually, *L. olongburensis* breeds in ephemeral and semi-permanent swamps with thick emergent vegetation. Water at breeding sites is usually clear, heavily tannin-stained and acidic (pH< 6.0) (Anstis, 2002; Ehmann, 1997). Fish are generally

scarce at these sites (Ehmann, 1997; Hopkins, 2003; B. Lewis, unpub. data; E. Meyer, unpub. data).

Call: A soft 'buzzing' call (Barker *et al.,* 1995).

Tadpoles: Deep-bodied and high-finned. The snout is angular in profile and the eyes laterodorsal. The dorsum of *L. olongburensis* tadpoles is a dark purple-brown or sooty grey colour with or without darker mottling. The tail, which terminates in a flagellum (long, lash-like appendage), is heavily mottled with dark brown or grey and sometimes orange. The flagellum is usually darkly pigmented and therefore conspicuous in *L. olongburensis* tadpoles. The venter (lower surface of the body) is silver-white; with a rolling blue sheen laterally. Best seen out of water, this blue sheen extends half-way along the tail. Tadpoles of *L. olongburensis* reach a maximum size of 37mm and are found hovering in mid-water or, more commonly, resting or grazing on matted sedges. Tadpoles of *L. olongburensis* feed mostly on algae growing on sedges. (Anstis, 2002; E. Meyer, unpub. data).

Threats: Habitat loss and fragmentation resulting from residential and resort development, agriculture, and establishments of pine plantations (especially in mainland areas). Trampling of reed beds at sites with heavy visitation (in particular freshwater lakes on sand islands such as Fraser, Moreton and North Stradbroke) may also pose a threat. Other likely threats include: habitat alteration due to weed invasion, Chytrid fungus infection, and inappropriate fire regimes. Deterioration of water quality and altered hydrological regimes may also be of concern, especially in habitat adjoining areas subject to development. In addition to these threats, the mosquito fish (*Gambusia holbrooki*) may threaten populations in low-lying areas subject to inundation. Biocides used in weed and insect control may also pose a threat in urban and urban-fringe areas. Competition with the related common sedgefrog *L. fallax* in disturbed areas is of concern. In some areas, pig damage may have a negative impact on *L. olongburensis* (Hines *et al*., 1999; Ingram and McDonald, 1993; James, 1996; Lewis and Goldingay, 2005; Tyler, 1997).

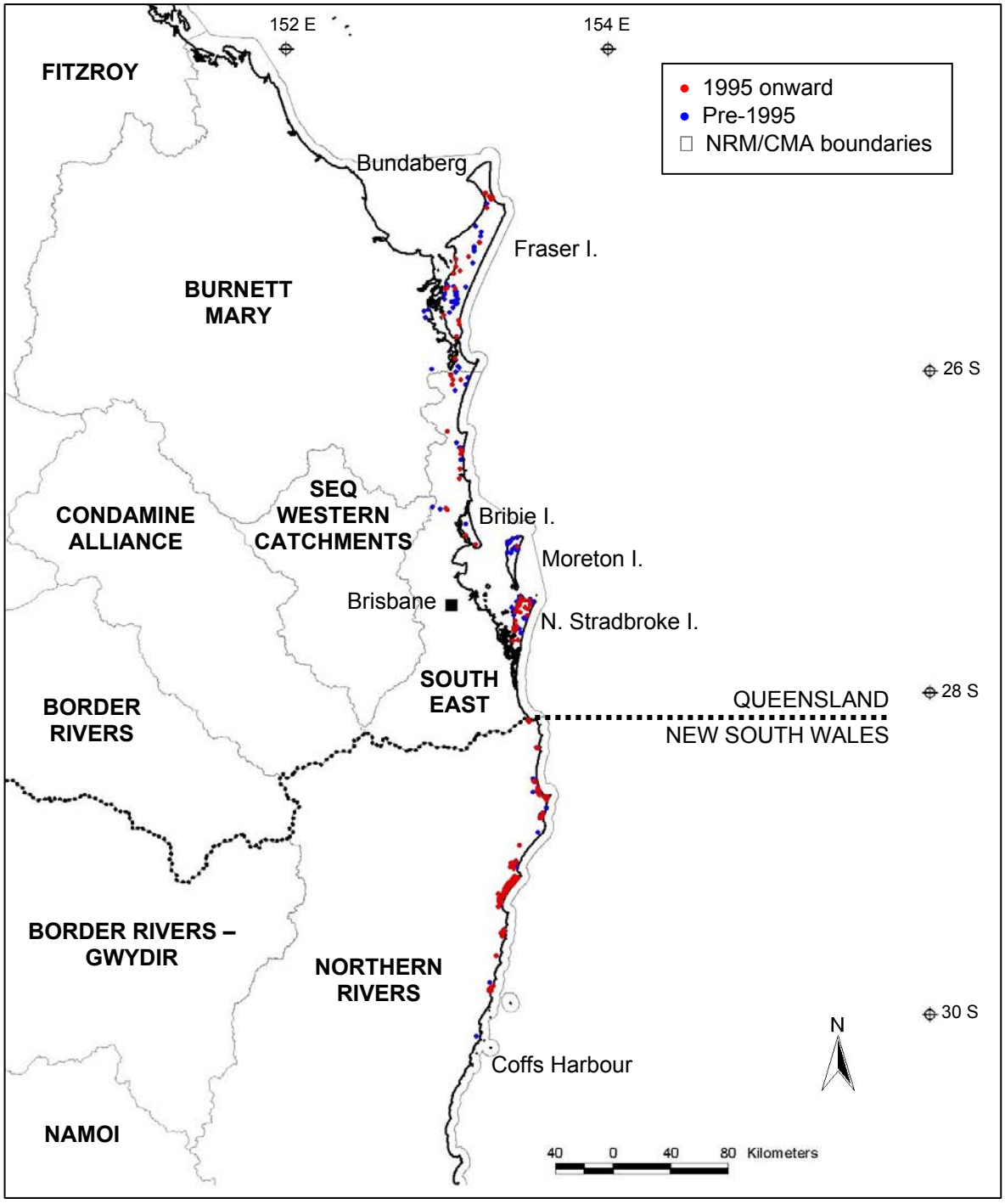

Figure 1. Map showing distribution of the wallum sedgefrog *Litoria olongburensis*. Blue circles are records from before 1995. Red circles represent records from 1995 onwards. Records sourced from EPA/QPWS, NSWDEC, the Australian Museum, Queensland Museum, South Australian Museum, and various biologists.

B. Cooloola sedgefrog *Litoria cooloolensis* Liem 1974

Description: A small treefrog; SVL of adult males 21-26mm; SVL of females up to 29-30mm. Dorsal colouration is dark green, beige or yellow, with or without dark spots/reticulations. The skin is smooth or rough above and granular below. The venter is mostly white with the throat of breeding males yellow or orange-yellow in colour. The fingers have vestigial webbing while the toes are fully webbed. Finger discs and toe pads are readily discernible. The posterior thigh is mostly orange or orange-red in colour. A purple-brown streak (diagnostic for the species) separates the dorsal colour (beige/green) from the orange of the posterior thigh. The tympanum (ear) is conspicuous and green or brown in colour (Liem, 1974; Selles, 2004).

Distribution: Known only from Fraser Island (24° 53'S 153° 14'E, the Cooloola region and North Stradbroke Island, south-east Queensland (27° 32'S 153° 29'E) (see Figure 2) (Hines *et al*., 1999).

Current distribution: Common at a number of lakes and swamps on Fraser Island, in the Cooloola region and North Stradbroke Island. Most sites at Cooloola and on Fraser Island occur within National Park. On North Stradbroke Island, however, most sites are on leased or unallocated state land. Monitoring of *L. cooloolensi*s on Stradbroke Island suggests numbers on leased land are stable. Numbers at Brown Lake, North Stradbroke Island, however, are known to have declined dramatically following the introduction of the mosquito fish (*G. holbrooki*) in 2002 (Neilson, 2000; E. Meyer, unpub. data).

Conservation status: Listed as 'Rare' under the Queensland *Nature Conservation Act 1992* and listed as 'Endangered' by the IUCN (IUCN, 2004). James (1996) found North Stradbroke Island *L. cooloolensis* were genetically distinct from Cooloola and Fraser Island animals. Further research is needed to determine whether North Stradbroke Island *L. cooloolenis* are different to Cooloola and Fraser Island animals. Should North Stradbroke Island prove to be a separate species, the conservation status of *L. cooloolensis* populations will need to be reassessed.

Habitat: Oligotrophic (deficient of nutrients), acidic freshwater lakes (pH < 5.5) in coastal wallum; adults usually found amongst reeds near water. *L. cooloolensis* may also occasionally be found in wallum swamps in sympatry with *L. olongburensis*. While commonly found near water, *L. cooloolensis* have been recorded some distance from water both in rainforest and dry sclerophyll forest. Rarely is *L. cooloolensis* found sympatric with the common sedgefrog *Litoria fallax* (Liem, 1974; Ingram and Corben, 1975; James, 1996; Meyer, 2004; E. Meyer, unpub. obs.).

Breeding biology: Breeding occurs in spring, summer and autumn, usually after rain. Males may be heard calling most nights, but calling is usually strongest after rain. Calling generally ceases during extended dry periods. Male frogs usually call from reeds and emergent vegetation over or near water. Amplexus is axillary and eggs are laid in clumps, in water amidst reeds. The lakes in which *L. cooloolensis* breeds are typically oligotrophic and acidic (pH<5.5) (Liem, 1974; Bayly, 1964; Meyer, 2004)

Call: High pitched; a loud 'wrek-kik', staccato 'kik-kik' or simple 'kik' (Liem, 1974; Selles, 2004)

Tadpoles: Tadpoles are deep-bodied with moderately high fins. The snout is angular in profile and the eyes laterodorsal. The dorsum and tail musculature are yellow-brown with irregular darker (black or dark brown) markings. The tail fins are marked with dark splotches and reticulations. The ventral body wall of *L. cooloolensis* tadpoles is silver-white in colour with the intestinal mass fully obscured. Tadpoles reach a maximum size of

45mm. Larval development may take eight or more weeks to complete with metamorphosis recorded in spring and summer (Liem, 1974; E. Meyer, unpub. data).

Threats: Trampling of reed beds in areas with high human visitation; habitat loss and degradation as a result of sand-mining. Predation of spawn and larvae by the mosquito fish (*Gambusia holbrooki*) and Chytrid fungus infection may also pose a threat. Fire may also pose a significant threat to animals living in dry forest or woodland surrounding swamps and lakes. Competition with the related common sedgefrog *L. fallax* in disturbed areas may also be of concern (James, 1996; Hines *et al*., 1999; E. Meyer, unpub. data).

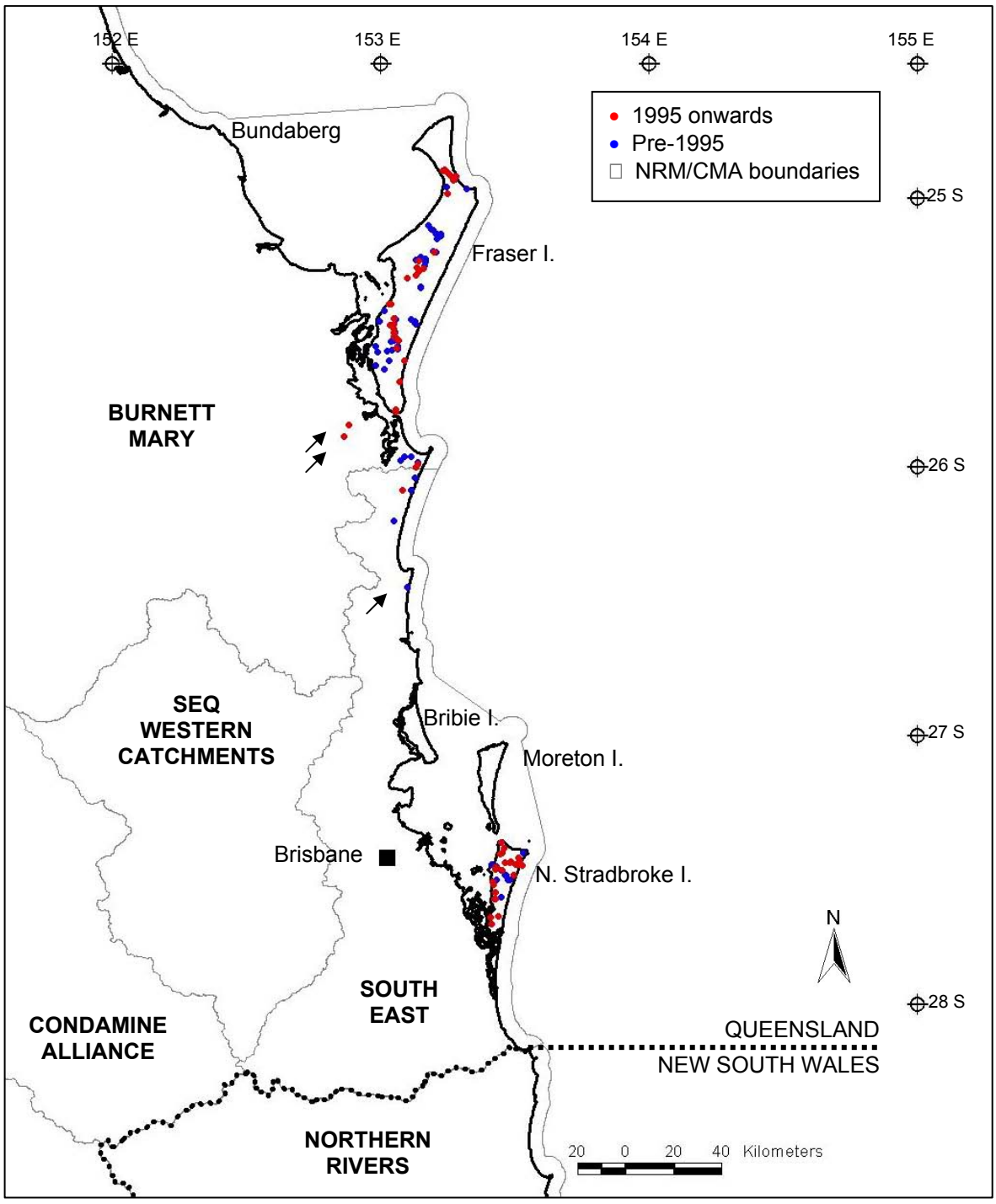

Figure 2. Map showing distribution of the Cooloola sedgefrog *Litoria cooloolensis*. Blue circles are records from before 1995. Red circles represent records from 1995 onwards. Records sourced from EPA/QPWS, NSWDEC, the Australian Museum, Queensland Museum, South Australian Museum and various biologists. Unconfirmed/doubtful records are highlighted with arrows.

C. Wallum rocketfrog *Litoria freycineti* Tschudi 1838

Other names: Freycinet's frog

Description: A moderate-sized terrestrial frog; SVL of adult males 34-39mm, SVL of females 39-42mm. The dorsum (back) is fawn or grey in colour with irregular darker markings (spots and splotches). A dark lateral stripe runs back from the snout, through the eye to the level of the shoulder. This stripe is broken by a white streak in front of the eye. The dorsum is typically warty while the venter is coarsely granular. The venter of *L. freycineti* is mostly white except for dark flecking along the jaw line in breeding males. The poster thigh is brown or grey-brown with cream or fawn spots. The toes are partly webbed while the fingers are free of webbing. Finger discs and toepads are much reduced compared with arboreal (living among trees) *Litoria* species (Barker *et al*., 1995; Cogger, 1993).

Distribution: Lowland coastal south-east Queensland and eastern New South Wales from Fraser Island (25° 6'S 153° 11'E) south to Jervis Bay (35° 08'S 150° 43'E) (Hines *et al*., 1999) (see Figure 3).

Current distribution: Most recent records of *L. freycineti* are from Fraser Island, Moreton Island, Cooloola, Bribie Island, North Stradbroke Island and coastal north-east New South Wales. Like other wallum-dependent species, *L. freycineti* has lost habitat to forestry, agriculture, urban and resort development and sand-mining. With no regular monitoring of *L. freycineti* numbers, the status of populations at most sites is unknown (Hines *et al.,* 1999; EPA/QPWS WildNet database; NSWDEC Atlas database).

Conservation status: Listed as 'Vulnerable' in Queensland (Queensland *Nature Conservation Act 1992*); also listed as 'Vulnerable' by the IUCN (IUCN, 2004).

Habitat: Associated with coastal wet heath. Found around sedge swamps, drainage lines and perched lakes in areas of sandstone and sandy soil. May also be found some distance from water in eucalypt forest near areas of wet heath. Rarely found together with the related striped rocketfrog (*L. nasuta*), except at disturbed sites (Cogger, 1993; Ehmann, 1996; Ingram and Corben, 1975; Queensland Parks and Wildlife Service, 1999; Straughan, 1966).

Breeding biology: Breeds in spring and summer, after rain. *L. freycineti* usually breeds in ephemeral swamps and pools. Males call from wet ground near water, amidst sedges. Amplexus is axillary and eggs are laid in shallow water (Anstis, 2002; Barker *et al*., 1995; Straughan, 1966).

Call: Rapid yapping or duck-like quacking (Barker *et al*., 1995; Robinson, 1994)

Tadpoles: Larvae are deep-bodied with moderately high fins. The snout is angular in profile and the eyes are laterodorsal in position. The dorsum is dark grey or grey-brown in colour, sometimes with irregular darker markings. The ventral body wall is silver white with a copper-pink sheen. Both the tail musculature and fins are heavily suffused with brown. Tadpoles reach a maximum size of 53mm. Development is rapid with larvae completing metamorphosis in less than 60 days. Tadpoles are mainly bottom-dwelling, feeding on detritus, dead insects and worms (Anstis, 2002).

Threats: Habitat loss and fragmentation resulting from residential development, agriculture, and establishment of pine plantations (especially in mainland areas). Trampling of reed beds at popular tourist spots (in particular coastal lakes on sand islands) and Chytrid fungus infection may be of concern. Other likely threats include: habitat

alteration due to weed invasions, and inappropriate fire regimes; deterioration of water quality and altered hydrological regimes in habitat alongside areas subject to development. In addition to these threats, the mosquito fish *Gambusia holbrooki* may threaten populations in low-lying areas subject to inundation. Biocide use poses a threat to developing embryos and larvae in urban or peri-urban areas. Competition with the related striped rocketfrog (*Litoria nasuta*) in disturbed areas may also be of concern. Pigs may pose a threat in some areas (Ehmann, 1997; Hines *et al*., 1999; Ingram and McDonald, 1993; James, 1996; Tyler, 1997).

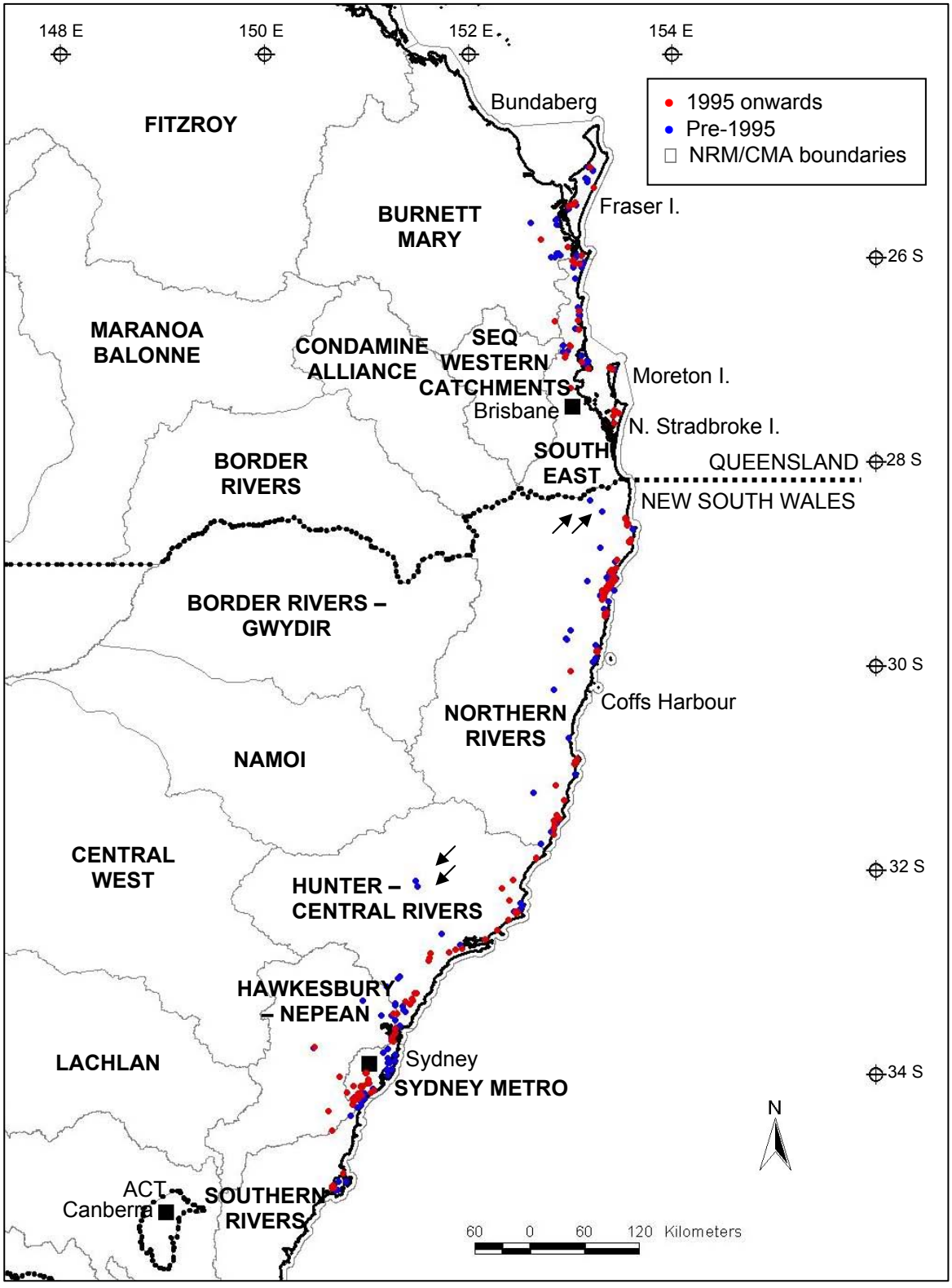

Figure 3. Map showing distribution of the wallum rocketfrog *Litoria freycineti*. Blue circles are records from before 1995. Red circles represent records from 1995 onwards. Records sourced from EPA/QPWS, NSWDEC, the Australian Museum, Queensland Museum, South Australian Museum and various biologists. Unconfirmed/doubtful records are highlighted with arrows.

D. Wallum froglet *Crinia tinnula* Straughan and Lee 1966

Other names: tinkling froglet

Description: A tiny terrestrial frog; SVL of adult males 16-18mm, SVL of females 16-22mm. The snout of *C. tinnula* is pointed in profile, projecting beyond the lower jaw. Dorsal colouration and pattern are highly variable. Animals are usually either beige, red-brown or dark-brown above with irregular darker markings, or stripes. The dorsum may be smooth, tuberose or ridged while the venter is coarsely granular. Ventral colouration is also variable and may be off-white with dark grey flecking, grey peppered with black and white, or dark grey with white flecking. Regardless of colour, there is usually a pale stripe running up the middle of the belly over the throat. Unlike tree frogs of the genus *Litoria*, the toes and fingers have no discs or pads and are free of webbing (Barker *et al*., 1995; Borsboom, 1999; Straughan and Lee, 1966;Meyer *et al*., 2004).

Distribution: Lowland coastal south-east Queensland and New South Wales; from Littabella National Park (24° 41'S 152° 05' E), south to Kurnell (Sydney) (34° 02'S 151° 13'E) (Hines *et al.,* 1999; Meyer *et al.,* 2004) (see Figure 4).

Current distribution: This species has suffered significant habitat loss in mainland areas through urban development and the establishment of pine plantations. Sandmining may also have resulted in habitat loss in some areas. Sizeable populations of *C. tinnula* persist in protected areas both in Queensland and New South Wales. In Queensland, *Crinia tinnula* is known from Great Sandy, Noosa, Cooloola, Bribie Island, and Moreton Island National Parks. In New South Wales, *C. tinnula* is known from a number of National Parks including Bundjalung, Red Rock, Crowdy Bay, Myall Lakes and Botany Bay (Ehmann, 1997; Hero *et al*., 2000; Hines et al., 1999).

Conservation status: Listed as 'Vulnerable' under Queensland legislation (Queensland *Nature Conservation Act 1992*) and New South Wales legislation (New South Wales *Threatened Species Conservation Act 1995*). Listed as 'Vulnerable' by the IUCN (IUCN, 2004).

Habitat: Found along drainage lines in sub-coastal wet heath, in acid paperbark (*Melaleuca*) swamps, and sedge swamps in areas of sandy soil and sandstone; rarely encountered around coastal lakes. *Crinia tinnula* has also been recorded from disturbed wallum habitat, including recently burnt heath, 4WD-impacted sites, an old quarry site, and exotic pine plantations. Animals have also been recorded in eucalypt woodland/forest and dry heath, some distance from water. *Crinia tinnula* is broadly sympatric with other *Crinia* species and is rarely found together with *C. parinsignifera*, except in disturbed habitat (Ehman, 1997; Queensland Department of Primary Industries and Fisheries, 2001; E. Meyer, unpub. data).

Breeding biology: Breeding has been recorded in all seasons following rain. Males call from the base of sedges near water or atop matted sedges. Eggs are laid singly or in clumps attached to submerged vegetation. *Crinia tinnula* generally breeds in ephemeral situations with larvae found in shallow water (<1m deep). Waters at breeding sites in undisturbed wallum are typically tannin-stained and acidic (pH < 6.0). Larvae of *C. tinnula* are rarely found sympatric with fish (Anstis, 2002; Ehmann, 1997; Queensland Department of Primary Industries and Fisheries, 2000; Straughan and Main, 1966; E. Meyer, unpub. data).

Call: A, short high-pitched 'tcheh' with a dominant frequency of 4kHz (Straughan and Main, 1966).

Tadpoles: The body is ovoid and grey or brown above with irregular darker markings. The snout is rounded in profile and eyes are dorsolateral. The tail musculature is brown and fins are semi-transparent with dark spots, flecking or fine reticulations. Tail fins and musculature may also have silver or gold flecking and or spots. Tadpoles reach a maximum size of 37mm. Tadpoles of *C. tinnula* are benthonic subsisting on sediment, detritus and algae (Anstis, 2002; E. Meyer unpub. data).

Threats: Habitat loss and fragmentation resulting from urban and resort development, agriculture, and the establishment of pine plantations (especially in mainland areas). Likely threats include habitat alteration due to weed invasion, water extraction and inappropriate fire regimes. Additional threats include deterioration of water quality and altered hydrological regimes, especially in areas subject to development. The mosquito fish (*G. holbrooki*) may also threaten populations in low-lying areas subject to inundation. Chytrid fungus infection may also be a threat. Mosquito control may pose a threat to *C. tinnula* in urban and urban-fringe areas. Competition with the related beeping froglet *Crinia parinsignifera* may also be of concern, especially in disturbed wallum habitat. Pigs may pose a threat to *C. tinnula* in some areas (Ehmann, 1997; Hines *et al*., 1999; Ingram and McDonald, 1993; James, 1996; Queensland Department of Primary Industries and Fisheries, 2001; Tyler, 1997).

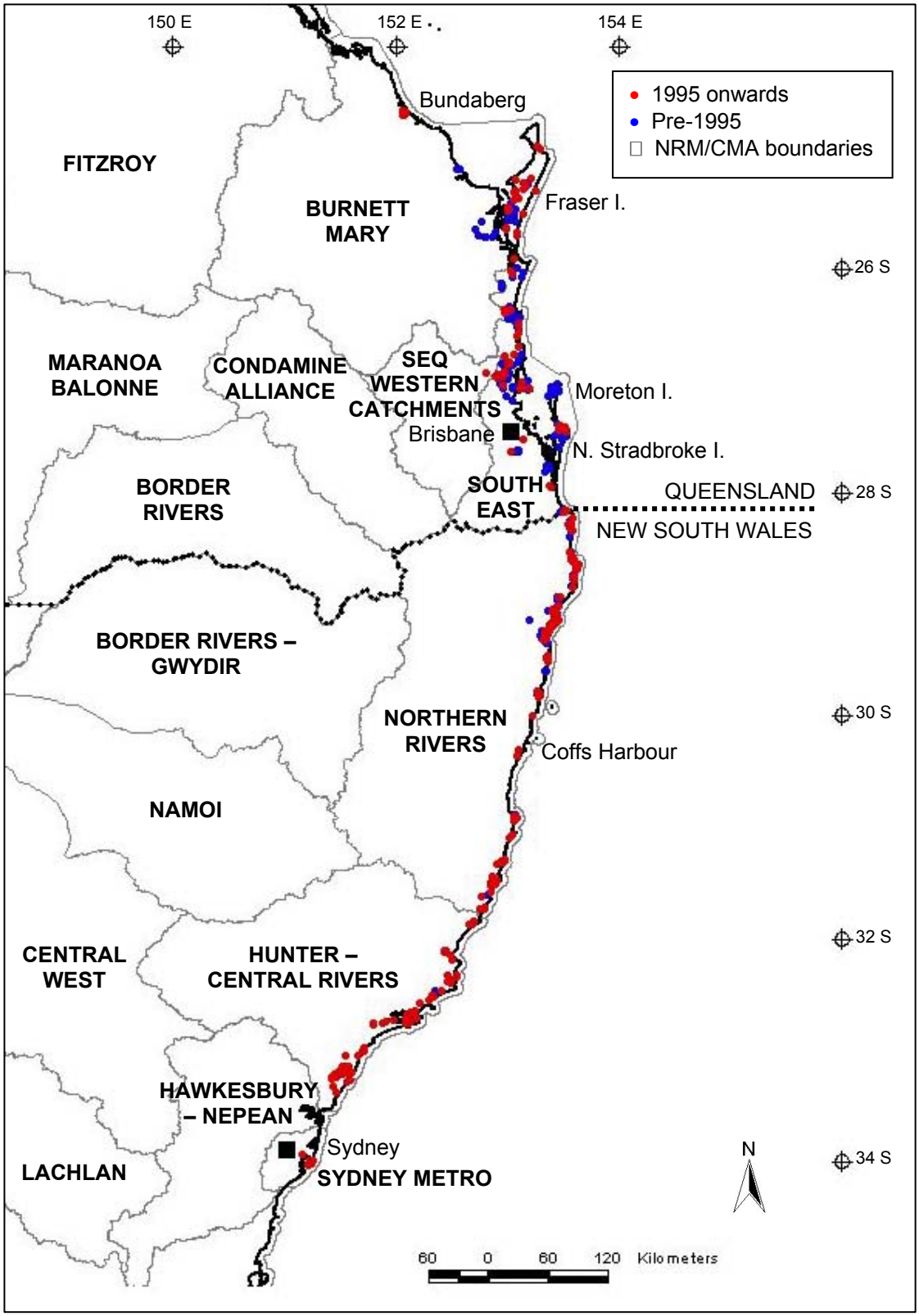

Figure 4. Map showing distribution of the wallum froglet *Crinia tinnula*. Blue circles are records from before 1995. Red circles represent records from 1995 onwards. Records sourced from EPA/QPWS, NSWDEC, Australian Museum, Queensland Museum, South Australian Museum and various biologists.