National Recovery Plan for the Southern Bell Frog *Litoria raniformis*

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Australian Government

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This Recovery Plan has been developed with the involvement and cooperation of a range of stakeholders, but individual stakeholders have not necessarily committed to undertaking specific actions. The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved. Proposed actions may be subject to modification over the life of the plan due to changes in knowledge.

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Cover photograph: Southern Bell Frog *Litoria raniformis* by Nick Clemann

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Summary

Concern about the decline of amphibians around the world has been increasing for more than a decade. The Southern Bell Frog *Litoria raniformis* is one such declining species. Once one of the most common frogs in many parts of south-eastern Australia, the range of this species has declined markedly, and loss of populations has resulted in a fragmented, disjunct distribution. The Southern Bell Frog is listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). It is also listed as Endangered in New South Wales (*Threatened Species Conservation Act 1995*) and Victoria (DSE 2007), Vulnerable in South Australia (*National Parks and Wildlife Act 1972*) and Tasmania (*Threatened Species Protection Act* 1995), and Threatened in Victoria (*Flora and Fauna Guarantee Act 1988*). Current threats include habitat loss and degradation, barriers to movement, predation, disease and exposure to biocides. This Recovery Plan summarises current knowledge of the Southern Bell Frog, documents the research and management actions undertaken to date, and identifies the actions required and organisations responsible to ensure the ongoing viability of the species in the wild.

Species Information

Description

The Southern Bell Frog *Litoria raniformis* (also known as the Growling Grass Frog) is a large frog, with females growing to at least 100 mm snout-urostyle length. Colouration varies from dull olive to bright emerald-green on the dorsum, with large irregular golden-bronze blotches. The groin and hind side of the thighs are usually bright bluish, while the lower sides and underside are off-white. The skin has numerous rounded warty projections on the back and sides (description from Barker *et al.* 1995; Cogger 2000). The Southern Bell Frog is active during both the day and night, and is highly mobile - it is known to move up to one kilometre in 24 hours (K. Jarvis pers. comm. cited in Robertson *et al*. 2002). Tadpoles have an aquatic period lasting 2 – 15 months, grow to 110 mm in total length and, in the later stages of development, have a characteristic green to yellowish dorsal colouration (Anstis 2002).

Distribution

The Southern Bell Frog is endemic to south-eastern Australia, including South Australia, Victoria, Tasmania, New South Wales and the Australian Capital Territory (Figure 1). In NSW the species occurs from Bombala in the far south-eastern corner of the state, through the Southern Tablelands, and along the Murrumbidgee and Murray Rivers (Pyke 2002). It formerly occurred as far north as Bathurst and the Willandra National Park (NSW) (White and Pyke 1999). The species occurs throughout much of Victoria except for the semi-arid north-west, far east Gippsland and higher parts of the Eastern Highlands (DSE Victorian Biodiversity Atlas). In South Australia there are four separate groupings of records – one in the far south-east of the state adjoining Victorian

populations, one along the length of the Murray River, one in the Mt Lofty Ranges and one on the Adelaide Plains (South Australian Museum database). The latter two groups probably represent non-endemic populations originating from captive stock (Walker and Goonan 2002, cited in Harley 2006), and both are likely to have now died out (J. Van Weenen, South Australian Department of Environment and Natural Resources, pers. comm. 2008; Harley 2006). In Tasmania most records are from the eastern half of the State, as well as a few sites in the state's north-west, and also on Flinders Island and King Island (Ashworth 1998). The Southern Bell Frog has been introduced to New Zealand, where it was first released in 1867, and is now widely distributed (Gill and Whitaker 2001).

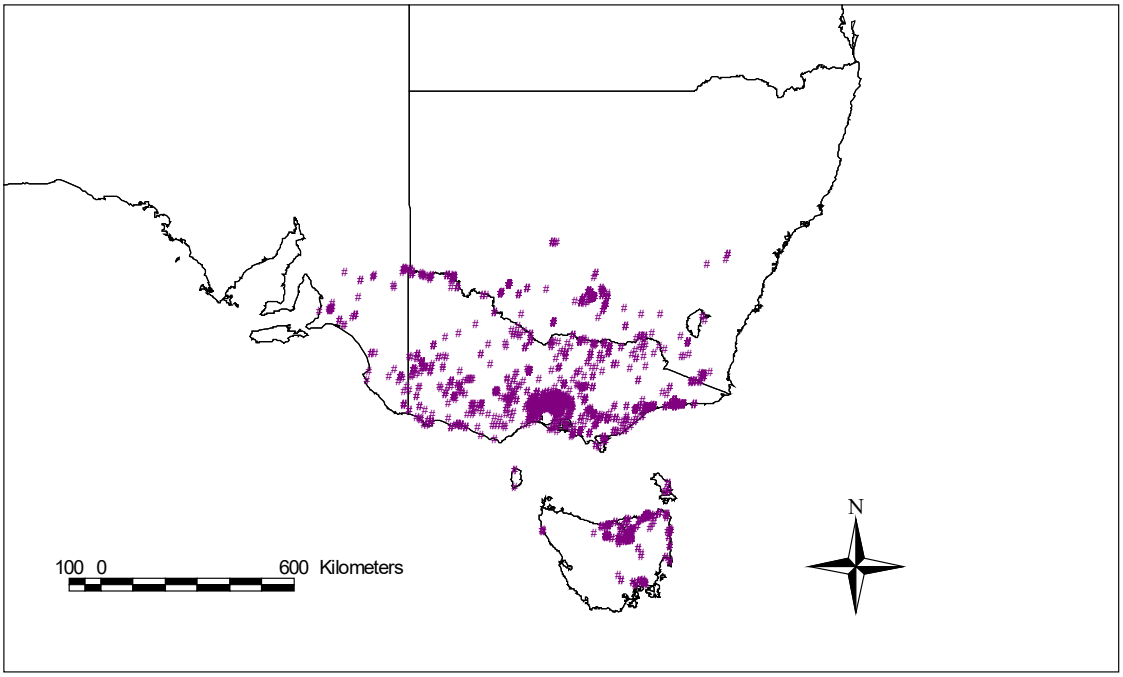

Figure 1. **Recorded distribution of the Southern Bell Frog**

(sources: Victorian Biodiversity Atlas , Atlas of New South Wales Wildlife, Tasmanian Parks and Wildlife Service GTSpot database, Museum Victoria, Australian Museum, South Australian Museum).

Population Information

Within the broad distribution of the Southern Bell Frog, there are two apparently distinct biogeographical groups, differentiated by differences in biology and ecology. For populations in the northern and western parts of its range (NSW and parts of Victoria and South Australia bordering the Murray River), breeding is triggered by flooding of ephemeral waterbodies during spring or summer, and the larval period can be as short as two months (Schultz 2007, 2008). In this area the frogs are concentrated in refugia prior to flooding, then disperse across the landscape during flooding / breeding events (Wassens 2006; Schultz 2007). The second group (south-eastern NSW,

much of Victoria, far south-eastern South Australia and Tasmania) typically breeds in spring and summer, and does not appear to be reliant upon flooding (White and Pyke 1999; Victorian Biodiversity Atlas). The larval stage may last up to 15 months, although it is often shorter than this (Anstis 2002). The spatial organisation of many populations within this group conform to a metapopulation structure (Robertson *et al*. 2002; Heard *et al*. 2004).

The criteria of an 'Important Population' of the species is outlined in the EPBC Act Policy Statement for the species (DEWHA 2009a, 2009b). 'Important Population' is defined below (DEWHA 2009a, 2009b):

'Much of the habitat for L. raniformis *has been isolated or fragmented, restricting the opportunity for important population processes such dispersal and colonisation. As such, any viable population is considered to be an important population for the persistence and recovery of the species.*

For this species, a viable population is one which is not isolated from other populations or waterbodies, such that it has the opportunity to interact with other nearby populations or has the ability to establish new populations when the suitability or availability of waterbodies changes. Interaction with nearby populations and colonisation of newly available waterbodies occurs via the dispersal of individual frogs across suitable habitat.

'In addition, a population of L. raniformis *could be considered an important population if it is near the limit of the species' range (for example small isolated populations in South Australia), is well-studied or has a history of monitoring, and hence provides opportunity for greater understanding of the species and its conservation status through the collection of long-term data'.*

Some populations are important in the sense that they are the subject of intensive and extensive research that will improve our understanding and management of this species. The large metapopulation occurring in the Merri Creek catchment north of Melbourne is particularly important for the understanding of habitat use and population dynamics. This population is the subject of a large research project that has extended over a decade (Robertson *et al*. 2002; Heard *et al*. 2004; 2010; 2012a; G. Heard Melbourne University, pers. comm.), and as such has greatly enhanced our understanding of habitat use and patterns of movement, therefore refining conservation efforts for the species in this area. Similarly, populations in the Lowbidgee and Coleambally areas in NSW have been subject of a long-term study that will make a significant contribution to the understanding of the species in that region (Wassens 2006).

Recent research (Heard *et al.* 2012a) suggests that, at least in areas other than the semi-arid / riverine part of the species' range, there are specific interactions between neighbouring populations. Where a number of waterbodies occur in close proximity, metapopulation dynamics appear to be important (Heard *et al*. 2004), and movement between sites according to prevailing seasonal conditions plays a key role in the persistence of the species (Robertson in prep). For the northern semi-arid / riverine populations, the distribution of frogs in the landscape may change from random prior to the breeding season, to strongly clustered during the peak breeding season (Wassens 2006).

Habitat

Habitat critical to the survival of the Southern Bell Frog differs throughout its range. In the more mesic areas including Tasmania, most of Victoria and the south-east of South Australia, the species is usually found among vegetation within or at the edges of permanent water such as slow-flowing streams, swamps, lagoons and lakes. In disturbed areas it also commonly occurs in artificial waterbodies such as farm dams, irrigation channels, irrigated rice crops and disused quarries, particularly where natural habitat is no longer available (Hamer and Organ 2008; Heard *et al.* in prep.). Favoured sites frequently have a large proportion of emergent, submerged and floating vegetation, and slow-flowing or still water (Robertson *et al*. 2002; Scroggie and Clemann 2003; Heard *et al*. 2004; in prep, Hamer and Organ 2008).

Because the Southern Bell Frog breeds in spring and summer, and populations in the southern part of the taxon's range often have a long larval phase, permanent waterbodies, or those in close proximity to permanent water, are favoured by the species. In these areas, frogs overwinter beneath thick vegetation, logs, rocks and other ground debris, sometimes at considerable distances from waterbodies (P. Robertson, Wildlife Profiles pers. comm.). Although the Southern Bell Frog almost always occurs in freshwater, at one site near Kingston (SA) the species occurs in a swamp that periodically reaches salinities of >8 ms/cm (D. Harley, DEH, pers. comm. 2007). However, the species does not occur in waterbodies where salinity levels exceed 7.0 ms/cm for lengthy periods, and numbers decline rapidly as salinity approaches these levels (M. Smith, formerly Victorian Department of Sustainability and Environment, pers. comm. 2006).

Populations from the north and west occur in swamps dominated by River Red Gums *Eucalyptus camaldulensis*, Lignum and Typha, and Black Box (*Eucalyptus largiflorens)* / Lignum / Nitre Goosefoot (*Chenopodium nitrariaceum*), and will also occur in irrigated rice crops (Wassens 2006). In these areas the larval phase may be as short as two months (Wassens 2006). Critical features of these latter habitat types appear to be that they are large, continuous areas containing both permanent and ephemeral waterbodies that undergo regular flooding, and are surrounded by areas containing suitable refugia in the form of ground debris, vegetation cover and cracking soils (Wassens 2006; Schultz 2007, 2008; B. Lewis, consultant biologist, pers. comm. 2008).

Therefore it is important to consider habitat critical for survival of the Southern Bell Frog at both a local and a landscape scale, and also consider non-breeding refugia and habitat along dispersal / recolonisation routes.

Decline and Threats

The Southern Bell Frog was formerly common throughout much of south-eastern Australia (Pyke 2002, and references cited therein), but has suffered a substantial decline in range and abundance in recent decades. It has disappeared from the ACT (Osborne *et al.* 1996) and much of its former range in NSW, where the current distribution is restricted to isolated populations around Coleambally, the Lowbidgee district and Lake Victoria, and possibly around Moulamein / Wakool

(although much of the Murray River and its tributaries have not been surveyed) (Wassens 2006). In Victoria, the species has undergone a substantial decline across the northern and north-eastern plains (W. Osborne, University of Canberra, pers. comm. 2007), although recent surveys have confirmed the presence of the species at a couple of locations in north-eastern Victoria (Organ and Abboltins 2007). Populations persist in scattered localities throughout lowland regions, particularly in coastal areas and along major watercourses. The species is still locally common in some wetlands in north-western and south-western Victoria (M. Smith, formely Victorian Department of Sustainability and Environment, pers. comm.). In South Australia, populations in the Mt Lofty Ranges and on the Adelaide Plains have disappeared (Harley 2006; J. Van Weenen, South Australian Department of Environment and Natural Resources, pers. comm. 2006), although these were thought to be non-endemic populations originating from released captive stock (Walker and Goonan 2002, cited in Harley 2006). On King Island (Tas), the species may be on the brink of extinction (J. Ashworth, consultant biologist, Tasmania, pers. comm. 2008).

The decline of the Southern Bell Frog, from one of the most common frogs in south-eastern Australia to a species of considerable conservation concern, appears to have commenced in the late 1970s, coinciding with anecdotal reports of many dead and dying frogs (P. Robertson, consultant biologist pers. comm.). Numerous threatening processes have been suggested as likely agents of this decline, and several of these processes may be acting in concert. These processes are detailed below:

Loss and degradation of habitat

The Southern Bell Frog is reliant on aquatic and riparian habitats and, in some areas, specific hydrological regimes, for breeding and the subsequent development of the larval stage. Loss, modification, degradation and fragmentation of aquatic and adjacent terrestrial habitats are likely to have had a considerable adverse impact on the species. Most of its historic range has been subjected to land clearing for agriculture, urban and industrial development, changed hydrological regimes for irrigation and other purposes, increasing salinity and draining of wetlands (Graetz *et al*. 1995). As a relatively mobile species that relies on movement between waterbodies to maintain the integrity of populations, it is also vulnerable to loss of habitat and connectivity between breeding and non-breeding habitats. A formerly large population occurring at Clarinda, south-east of Melbourne, was destroyed by landfill as part of land reclamation in a former quarry, and other populations occupying former quarries on the outskirts of Melbourne are at risk from current landfill proposals (Gillespie and Clemann 1999; G. Heard, Melbourne University, pers. comm.).

Expanding urban and industrial development, especially throughout Melbourne's urban growth area, threatens populations. Draining and degradation of coastal wetlands is a major threat to Southern Bell Frog in Tasmania (J. Ashworth, consultant biologist, Tasmania, pers. comm. 2007, , and the species is close to extinction on King Island (Tas) due to habitat loss and degradation caused by the expanded dairy industry (J. Ashworth, consultant biologist, Tasmania, pers. comm. 2007). A significant proportion of the wetland habitats of the Southern Bell Frog in south-eastern South Australia have been degraded or lost due to a large-scale drainage program (D. Harley,

formerly South Australian Department of Environment and Natural Resources pers. comm. 2007). The construction of these drains continues, and is likely to be a major threatening process in that region.

Major watercourses within the species' range have been substantially altered by impoundments, river regulation and irrigation release schemes. Alterations to the timing, frequency and extent of flooding events have resulted in dramatic changes to many natural processes, such as preventing or greatly reducing spring flood events across natural floodplains. Cold water releases from impoundments have had a considerable impact on downstream ecological processes and native fish populations (MDBC 2003), and are likely to adversely affect the development rates and survivorship of Southern Bell Frog eggs and tadpoles. Natural flooding of floodplains probably triggered breeding activity in semi-arid areas of NSW in the past (Wassens 2006), and altered hydrological regimes have grossly modified natural processes around extant populations of the Southern Bell Frog in NSW. The Lowbidgee (NSW) population is immediately threatened with extirpation due to a lack of flooding in core habitat in recent years (as of 2006). This lack of adequate water flow has resulted from the diversion of water away from floodplains to agricultural areas, and has been exacerbated by drought (Wassens 2006).

The reduction of inflows to wetlands is having a detrimental impact on these habitats in areas occupied by the Southern Bell Frog. In particular, piping and channelling of water increases the efficiency of water transport and directs water away from wetland habitat. For example, the construction of the Mallee – Wimmera pipeline in western Victoria may have resulted in drying of wetlands, increased salinity and loss of wetland vegetation (T. Ryan, consultant biologist, pers. comm. 2008). Increases in water salinity are evident in many waterbodies across the northern and north-western parts of the historic range of Southern Bell Frog (T. Ryan, consultant biologist, pers. comm. 2008), and these elevated salinity levels far exceed the likely tolerance of their tadpoles (Christy and Dickman 2002).

Grazing by domestic stock is a dominant agricultural practice across much of the former range of Southern Bell Frog. This grazing, particularly at high intensity, can cause considerable damage to the margins of waterbodies (e.g., Jansen and Robertson 2001). Aside from the impact of clearing native vegetation and ground debris to create grazing land, grazing may affect frog habitat in several ways. Stock compact soil and create pugging in damp areas, which can destroy soil cracks used by sheltering frogs. Grazing directly removes vegetation that is used by frogs for shelter and as movement corridors, and seed predation by stock can prevent regeneration of habitat (Meeson *et al*. 2002). Similarly, removal of vegetation affects microclimate, including humidity levels, at ground level. A domestic stock incursion into the margins of waterbodies leads to trampling of breeding habitat and pollution of water. Conversely, at some sites where other factors have resulted in dense weed invasion or too thick vegetation, periodic light grazing may create open areas adjacent to waterbodies that are used by Southern Bell Frogs for foraging (Heard *et al.* 2008)). Targeted light grazing could be used in some situations as a management tool where it is deemed that thick, rank vegetation is choking habitat.

With such widespread disruption to habitats and ecological processes throughout the range of the Southern Bell Frog, the vulnerability of the species to stochastic processes such as disease, drought and wildfire is heightened, and the ability of many populations to recover from these processes is compromised. The entire range of the Southern Bell Frog underwent a period of prolonged drought since the late 1990s, although the consequences of this for the species have yet to be assessed.

Barriers to movement

The Southern Bell Frog is a highly mobile frog that can move at least one kilometre in 24 hrs, and there is mounting evidence that its persistence in many areas is dependent upon the movement of adults between particular waterbodies, and between breeding and non-breeding habitats (Heard *et al.* 2004, 2010; 2012a Wassens 2006). At least some populations may be dependent upon a small number of waterbodies in which successful breeding occurs. Human-induced changes to landscapes have created barriers such as fences, roads and unsuitable habitat (e.g., industrial and urban estates) to frog movement. This is likely to compromise the ability of the species to respond to periodic drought, changed hydrological regimes and fluctuations in water levels (Robertson *et al*. 2002; Heard *et al.* 2004). Barriers disrupt the movement of frogs and may compromise the viability of many populations.

Disease

The disease chytridiomycosis caused by the fungal pathogen *Batrachochytrium dendrobatidis* has been strongly implicated in rapid declines of amphibians in several parts of the world (Berger *et al*. 1999). This waterborne pathogen infects the keratinised mouthparts of tadpoles and the skin of adults where it impacts the structure and physiological function, ultimately resulting in high mortality in many species. Chytrid fungus is known to infect Southern Bell Frogs, with infected specimens being recorded in South Australia (R. Speare, James Cook University, Qld, pers. comm. 2005) and Werribee (Vic) (Heard *et al.* in prep.; H. Butler, formerly Zoos Victoria, pers. comm. 2006). In New Zealand, chytridiomycosis is known to readily kill this species (R. Speare, James Cook University, Queensland, pers. comm. 2005). The nature of declines of Southern Bell Frogs suggest that it is highly likely that chytridiomycosis played a key role in losses of this species. Chytridiomycosis is listed as a threatening process under the Commonwealth EPBC Act.

Predation

Introduced fish may have a devastating impact on some frog species (Gillespie and Hero 1999). The eggs and tadpoles of the Southern Bell Frog may be vulnerable to fish predators, especially the introduced Eastern Gambusia *Gambusia holbrooki* (Pyke 2002), which has been implicated in the decline of the closely-related Green and Golden Bell Frog *Litoria aurea* (Morgan and Buttemer 1996; White and Pyke 1996; Pyke and White 2001, and references therein). However, the implicated impact of Eastern Gambusia is based on circumstantial evidence (i.e., the majority of observations of eggs and larvae in waterbodies lacking these fish; Daly 1995) and laboratory trials (Morgan and Buttemer 1996, Pyke and White 2000) that may not adequately replicate natural

conditions. Within the Merri Creek Corridor north of Melbourne, successful reproduction and recruitment of Southern Bell Frogs occurs within waterbodies containing introduced fish, including Eastern Gambusia and Oriental Weatherloach *Misgurnis anguillicaudatus* (Heard *et al.* 2004).

Other introduced fish species such as Redfin Perch *Perca fluviatilis*, Brown Trout *Salmo trutta*, Rainbow Trout *Oncorhynchus mykiss*, Goldfish *Carassius auratus* and Common Carp *Cyprinus carpio* are common in parts of the range of the Southern Bell Frog, and Common Carp may be important predators of tadpoles (M. Smith, formerly Victorian Department of Sustainability and Environment, pers. comm. 2005). The comparative influence of predation by native fish has not been investigated, and the role of introduced fish in the decline of the Southern Bell Frog is unclear.

Both the Red Fox *Vulpes vulpes* and Cat *Felis catus* are known to be effective predators of small native vertebrates, including amphibians (Saunders *et al*. 1995; Dickman 1996), although there is no information about their possible impact on the Southern Bell Frog. Frog populations that have been suppressed by other threatening processes will be particularly susceptible to extirpation by Fox and Cat predation.

Biocides

Amphibians are potentially exposed to a range of pollutants that enter waterbodies, as their semi-permeable skin renders them particularly susceptible to biocides and other pollutants. Toxic compounds have been demonstrated to cause death, morbidity and / or abnormalities in many frog species (Mann and Bidwell 1999; references in Tyler 1989). A herbicide has been implicated in the decline of at least some populations of Southern Bell Frogs (Tyler 1997), and a particularly toxic herbicide, Acrolein, is commonly used to clear vegetation from irrigation channels in areas where the species occurs (P. Robertson, Wildlife Profiles Pty Ltd and T. Ryan, consultant biologist, pers. comm. 2005). The overall impact of pollutants on the species is not known, but could be considerable.

Ultra-violet B radiation

Ambient ultraviolet-B (UV-B) radiation, levels of which have increased due to anthropogenic depletion of the ozone layer (e.g., Kerr & McElroy 1993), are known to have an adverse impact on some amphibians (Blaustein *et al*. 1994, 1995, 1997). Exposure to harmful levels of ultraviolet-B radiation has been postulated as a potential cause of declines in Australia (Tyler 1997), although this issue is the subject of ongoing debate (Licht 2003). Adult Southern Bell Frogs are frequently active (basking or calling) during the day, and eggs and tadpoles are often exposed to sunlight. Consequently, exposure to harmful levels of UV-B radiation has been postulated as a potential cause of declines (Tyler 1997). Deleterious effects of UV-B radiation on the tadpoles of the Alpine Tree Frog *Litoria verreauxii alpina* have been demonstrated (Broomhall *et al*. 2000), although this frog occurs at high altitude where the effects of UV-B radiation may be more pronounced. The effects of UV-B radiation on the Southern Bell Frog are currently unknown.

Populations and areas under threat

The widespread nature of the decline and disappearance of Southern Bell Frog populations, and the uncertainty surrounding the processes driving these declines, suggests that no extant population should be considered secure. Loss of populations due to habitat destruction and disease can occur very rapidly. Certain populations are clearly threatened with imminent destruction, or have been knowingly destroyed in recent years.

Recovery Information

Existing Conservation Measures

The plight of declining amphibians has been receiving considerable attention from scientists and the media in recent times. In New South Wales much of this attention has centred on Green and Golden Bell Frog *Litoria aurea*, whilst the Southern Bell Frog has been the focal species for 'Bell Frog' conservation in Victoria, where much of the previous conservation measures have been undertaken. Recent and current conservation efforts for the Southern Bell Frog include:

- Listing as a threatened species under relevant State and Commonwealth legislation.
- A national Recovery Team (under the name 'Growling Grass Frog National Recovery Team') has been established to coordinate recovery actions.
- Surveys throughout much of its historical range to clarify current distribution.
- Research (summarised in Pyke 2002) including conservation biology, dispersal, spatial dynamics and habitat use (Wassens 2006, Heard *et al.* 2006; 2008; 2010; 2012a;b); testing for and management of chytrid fungus (Heard *et al.* in prep,); impact of rice production (Australian Museum); effects of pesticide on survival (CSIRO Land and Water); conservation status assessment in Tasmania (Ashworth 1998).
- Translocation of individuals from populations threatened with immediate destruction has occurred on several occasions, frequently without *post hoc* evaluation of the success or otherwise of this management practise. One evaluation program has detailed the failure of one of these programs (Smith and Clemann 2008).
- Habitat protection prescriptions for State Forests in NSW.
- A 'Sub-regional Conservation Strategy' for populations that occur in the Melbourne Growth Areas has been prepared (Ecology and Heritage Partners 2011)
- Guidelines for the management of the species in urbanised landscapes throughout Melbourne have been prepared (Heard *et al.* 2010).
- Agreed management prescriptions within the Tasmanian Forest Practices System.
- Identification of key breeding sites in South Australia, and improved site management of these areas.
- Raising community awareness about the species and its habitat requirements via brochures, posters and media releases.

Recovery Objectives

The **Long-term Objective** of recovery is to achieve a down-listing of the Southern Bell Frog from Vulnerable nationally to a lower threat category based on the IUCN 2001 Red List categories and criteria. This down-listing should be achieved within 10 years of the Plan's adoption.

Within the life span of this Recovery Plan, the **Specific Objectives** for recovery of the Southern Bell Frog are to:

1. Secure extant populations of Southern Bell Frogs, particularly those occurring in known breeding habitats, and improve their viability through increases in size and / or area of occurrence.
2. Determine distribution, biology and ecology of the Southern Bell Frog, and identify causes of the decline of the species across its geographic range.
3. Address known or predicted threatening processes, and implement appropriate management practices where possible to ensure that land use activities do not threaten the survival of the Southern Bell Frog.
4. Increase community awareness of and support for Southern Bell Frog conservation.

Program Implementation

The Recovery Plan will run for five years from the time of adoption, and will be managed by the Growling Grass Frog Recovery Team. Subject to the availability of funding, the Team shall meet on an annual or biannual basis to coordinate implementation and review objectives and performance.

Program Evaluation

The Recovery Team will be responsible for annual assessments of progress towards recovery. This Recovery Plan will be reviewed within five years of the date of its adoption under the EPBC Act.

Recovery Objectives and Actions – Summary

A summary of the recovery objectives and actions for the Southern Bell Frog is provided below (Table 1). Detail on the implementation of the recovery actions is contained in Appendix 1.

Table 1. Summary of Recovery Objectives and Actions

Recovery Objectives	Performance Criteria	Recovery Actions
1. Secure extant populations of Southern Bell Frogs, particularly those occurring in known breeding habitats, and improve their viability through increases in size and / or area of occurrence.	The areas occupied by extant populations of Southern Bell Frogs are protected and managed for the benefit of the species.	1.1 Identify and protect important populations and prepare habitat management prescriptions at secured sites.
2. Determine distribution, biology and ecology of the Southern Bell Frog, and identify causes of the decline of the species across its geographic range.	The distribution, biology and ecology of the Southern Bell Frog across its geographic range are well understood.	2.1 Determine the current distribution and abundance of the Southern Bell Frog. 2.2 Undertake population monitoring. 2.3 Determine movement patterns of the Southern Bell Frog. 2.4 Conduct a comparative genetic, life history and ecological study of the Southern Bell Frog across different bioregions.
3. Address known or predicted threatening processes, and implement appropriate management practices where possible to ensure that land use activities do not threaten the survival of the Southern Bell Frog.	The causes of decline of the Southern Bell Frog across its geographic range are well understood, and knowledge is sufficient to implement effective management strategies.	3.1 Determine historic and contemporary status of infection by the Chytrid Fungus. 3.2 Determine the impact of fish predation on the Southern Bell Frog. 3.3 Test the responses to various water parameters and pollutants of all life stages of the Southern Bell Frog. 3.4 Investigate the response of Southern Bell Frog to translocation, the creation of artificial habitats, and / or the re-creation or rehabilitation of habitat. 3.5 Investigate the impact of fox and cat predation on Southern Bell Frog.
4. Increase community awareness of and support for Southern Bell Frog conservation.	Community support for, and involvement in, the recovery program for the Southern Bell Frog is evident.	4.1 Identify opportunities for community involvement in the conservation of .the Southern Bell Frog.

Management Practices

Management practices required for the conservation of the Southern Bell Frog include:

- Detailed surveys of known and potential habitat to determine current distribution and, if possible, population sizes and overall importance of populations for long-term population maintenance.
- Habitat retention and legal protection of sites where possible, especially on public land.
- Strict adherence to hygiene planning and protocols, as detailed by Phillott *et al.* (2010).
- Liaison with land managers, including private landholders, to secure sympathetic management of the species and its habitat.
- Investigation of the mechanisms underlying breeding and recruitment, and use of non-breeding habitat.
- Investigation of the relationships between the Southern Bell Frog and associated habitat, and its response to environmental and artificial processes.
- Demographic censusing to gather life history information and to monitor the success of management actions.
- *Ex situ* measures including captive husbandry.
- Community participation in recovery actions.

Affected Interests

Several organisations have legislative responsibilities for conservation of Southern Bell Frog, and will be involved in all stages of this Recovery Plan. At a national level, the taxon is listed as threatened under the EPBC Act. Any action that will have, or is likely to have, a significant impact on a taxon listed on this legislation will trigger the EPBC Act, necessitating approval from the Commonwealth Environment Minister. Critical habitat may be listed for any nationally listed taxon or ecological community under the EPBC Act.

Within NSW, the Southern Bell Frog is listed on the *Threatened Species Conservation Act* 1995 (TSC). This Act outlines the duties of the Office of Environment and Heritage (OEH) in protecting threatened species, ecological communities and critical habitat in NSW. A state recovery plan for Southern Bell Frog is currently being prepared (Bannerman 2005).

In Victoria the Southern Bell Frog is listed as Threatened under the *FFG Act*. This Act provides the main legal framework for the protection of Victoria's biodiversity. When a listing occurs, an 'Action Statement' must be prepared; this is a document that identifies actions that have been or will be taken to conserve the taxon. An Action Statement for Southern Bell Frog has been initiated (Robertson in prep., under the common name Growling Grass Frog). The Department of Sustainability and Environment (DSE) has ultimate responsibility for the management of threatened species in Victoria, and is the primary agency involved in management on public and private land, with the exception of the parks and reserves system, which is managed by Parks Victoria (PV). As

a proportion of the species' Victorian distribution occurs in the parks system, PV has management responsibilities for this taxon within its estate.

In South Australia, Southern Bell Frog is listed as a threatened species under the *National Parks and Wildlife Act 1972*. This Act allows for the protection of habitat and wildlife through the establishment of parks and reserves and provides for the use of wildlife through a system of permits allowing certain actions, i.e. keeping, selling, trading, harvesting, farming, hunting and the destruction of native species. The South Australian Department for Environment and Natural Resources is responsible for the conservation, protection and enhancement of South Australia's environmental resources and natural and built heritage, and is thus responsible for threatened species management in that state.

In Tasmania, the Southern Bell Frog is listed under the *Threatened Species Protection Act 1995*. This Act provides for the protection and management of threatened native flora and fauna. The Department of Primary Industries, Parks, Water and Environment (DPIPWE) is responsible for the management of threatened species in Tasmania. A listing statement for the Southern Bell Frog has been prepared in Tasmania. Listing statements identify the actions that are to be taken for the conservation of the taxon. The Tasmanian *Forest Practices Code* prescribes the manner in which forest operations are to be planned and conducted so as to provide reasonable protection to the environment. The Southern Bell Frog is considered under the 'Threatened Species and Inadequately Reserved Plant Communities' section of this code.

The Southern Bell Frog occurs on freehold land in numerous places, necessitating the involvement of private individuals. Under the EPBC Act these individuals have a responsibility to ensure that development on their properties does not harm the Southern Bell Frog, and any such developments commencing since the inception of the EPBC Act will trigger a referral. Private landowners can facilitate monitoring and recovery actions for the Southern Bell Frog by permitting access to breeding sites and other habitat on their land, consulting with agencies and individuals involved in these activities, and ensuring that their own activities do not negatively impact the species or its habitat on or near their properties.

Role and Interests of Indigenous People

Indigenous communities on whose traditional lands Southern Bell Frog occurs are being advised, through the relevant regional indigenous facilitator of this Recovery Plan. Indigenous communities will be invited to be involved in the implementation of the Recovery Plan.

Biodiversity Benefits

The Recovery Plan includes a number of potential biodiversity benefits for other species and vegetation communities throughout the range of the Southern Bell Frog. Principally, this will be through the protection and management of habitat. The Southern Bell Frog depends on aquatic habitats for reproduction, and a range of terrestrial habitats for foraging and shelter. Because the Southern Bell Frog is a highly mobile species these terrestrial habitats can be some distance from

aquatic breeding habitat. Consequently, conservation measures will need to consider not only local habitat management, but also broader landscape processes, such as catchment function, habitat fragmentation and connectivity.

There is a range of potentially threatening processes that are likely to be acting upon populations of Southern Bell Frog. Mitigation of these processes will have wide-ranging benefits for maintenance of ecological processes and biodiversity conservation. The distribution of the Southern Bell Frog overlaps with habitat critical for the conservation of other threatened species and communities. For example, this species occurs in and adjacent to threatened grassland communities fringing Melbourne. These grasslands provide habitat for threatened fauna such as the Striped Legless Lizard *Delma impar* and the Fat-tailed Dunnart *Sminthopsis crassicaudata*. Conservation measures, particularly habitat protection, for the Southern Bell Frog in these areas are likely to benefit these other species and the overall community.

Similarly, conservation measures related to aquatic environments have the potential to benefit a range of species and communities. For example, Yarra Pigmy Perch *Nannoperca obscura*, Variegated Pigmy Perch *Nannoperca variegata* and Dwarf Galaxias *Galaxiella pusilla* have a distribution that overlaps with the Southern Bell Frog (Cadwallader and Backhouse 1983). Preservation of this habitat will benefit each of these species. The Lower Murray Aquatic Community has been listed as an endangered ecological community under the NSW *Fisheries Management Act* 1994. Protection of this community will augment conservation efforts for the Southern Bell Frog.

Conservation efforts for the Southern Bell Frog will also contribute to efforts to educate the public about the plight of threatened species. Threatened fauna have the potential to act as 'flagship species' for highlighting broader nature conservation issues and threats to biodiversity, such as disease, climate change, grazing and habitat loss and degradation. As they are large and attractive frogs, members of the Bell Frog complex have featured extensively in the media and public education programs aimed at highlighting the plight of declining amphibians.

Social and Economic Impacts

Conservation of the habitat of the Southern Bell Frog may affect activities that conflict with conservation objectives. Examples of this include restrictions on development on private property or the filling of former quarry holes (Robertson in prep.). Development of urban land and infrastructure such as roads frequently conflicts with efforts to conserve habitat for the Southern Bell Frog, particularly within the suburbs of Melbourne (Heard *et al*. 2004, Robertson in prep., G. Heard, Melbourne University, pers. comm.). Similarly, the development of infrastructure such as irrigation channels in rural areas and the alteration of flooding regimes for agricultural purposes are also likely to conflict with recovery efforts for the species (e.g., Scroggie and Clemann 2003). Where conflict occurs between actions outlined in this Recovery Plan and the interests of others, consultation between the appropriate land management agency and the affected individuals should be undertaken with the aim of negotiating a desirable outcome for all parties.

There are considerable positive benefits in protecting Southern Bell Frog habitats, including augmenting intrinsic natural values enjoyed by visitors to such areas. These benefits complement the management aims of national parks and other reserved land where this species occurs, and visitors to these areas provide economic benefits for the local districts. Involving the community and private landholders in recovery efforts can foster a sense of pride in contributing to conservation programs.

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Priority, feasibility and estimated costs of recovery actions

Action	Description	Priority	Feasibility	Responsibility	Cost estimate					
					Year 1	Year 2	Year 3	Year 4	Year 5	Total
1	**Population viability**									
1.1	Habitat protection and management	1	100%	DSE, OEH, DPIPWE, DEH	$20,000	$0	$0	$0	$0	$20,000
2	**Distribution, ecology, decline**									
2.1	Current distribution	1	100%	DSE, OEH, DPIPWE, DEH, PV	$80,000	$80,000	$60,000	$40,000		$260,000
2.2	Population monitoring	1	100%	DSE, OEH, DPIPWE, DEH, PV	$60,000	$100,000	$100,000	$100,000	$100,000	$460,000
2.3	Movement patterns	1	100%	DSE, OEH, DPIPWE, DEH, PV	$60,000	$80,000	$80,000	$0	$0	$220,000
2.4	Genetics, life history, ecology	1	100%	Unis, DSE, OEH, DPIPWE, DEH	$40,000	$40,000	$40,000	$40,000		$160,000
3	**Threatening processes**									
3.1	Chytrid fungus	1	90%	ARC, JCU, CSIRO, DSE, OEH, DPIPWE, DEH	$50,000	$40,000	$40,000	$0	$0	$130,000
3.2	Fish predation	1	90%	Unis, DSE, OEH, DPIPWE, DEH	$80,000	$40,000	$0	$0	$0	$120,000
3.3	Water parameters, pollution	1	90%	ARC, university, DSE	$60,000	$60,000	$60,000	$0	$0	$180,000
3.4	Translocation, artificial habitats	2	100%	DSE, OEH, DPIPWE, DEH	$30,000	$70,000	$60,000	$60,000	$60,000	$280,000
3.5	Fox and cat predation	2	90%	Unis, DSE, OEH, DPIPWE, DEH	$40,000	$20,000	$20,000	$0	$0	$80,000

5	**Community support**									
4.1	Community involvement	2	100%	DSE, OEH, DPIPWE, DEH, PV	$5,000	$5,000	$5,000	$5,000	$5,000	$25,000
				Total	**$525,000**	**$535,000**	**$465,000**	**$245,000**	**$65,000**	**$1,935,000**

Abbreviations: ARC = Amphibian Research Centre; OEH = Department of Environment, Climate Change and Water New South Wales; DEH = Department for Environment and Heritage South Australia; DPIPWE = Department of Primary Industries, Parks, Water and Environment Tasmania; DSE = Department of Sustainability and Environment; JCU = James Cook University; PV = Parks Victoria

Appendix 1. Details of Recovery Actions

Recovery Objectives and Actions

Objective 1: Secure extant populations of Southern Bell Frogs, particularly those occurring in known breeding habitats, and improve their viability through increases in size and / or area of occurrence.

Recovery Criterion: The areas occupied by extant populations of Southern Bell Frogs are protected and managed for the benefit of the species.

Action 1.1: Identify and protect important populations and prepare habitat management prescriptions at secured sites.

Appropriate management of Southern Bell Frog habitat is an important factor in the continued persistence of the species. Current knowledge of habitat use, and consequently the management of habitat, is incomplete. However, at many sites, populations of this species are under imminent threat from a range of processes, and preservation measures cannot be delayed until research findings are available. In these cases urgent management will need to be driven by the best available knowledge, implemented immediately, and refined based upon monitoring of the results of that management and other recent research. Habitat management prescriptions for the Southern Bell Frog will remain dynamic; as our knowledge of the interactions between the frog and its habitat are improved, prescriptions will be refined. To facilitate management of threatened populations, habitat management prescriptions have been prepared (Heard *et al*. 2010) and can be made available to land managers and researchers.

General interim habitat management guidelines.

Manage populations for protection from major threatening processes, particularly by:

- Erecting fences to manage stock access to known breeding waterbodies where overgrazing is affecting habitat;
- Encouraging patches of fringing vegetation, and floating aquatic vegetation in open water areas;
- Providing a variety of terrestrial habitat elements – rocks, logs, dense vegetation, other shelter sites;
- Ensuring adequate water levels are maintained during spring and summer, perhaps with drying of some, but not all, waterbodies within a well-connected metapopulation in occasional years;
- Establishing mechanisms for prevention of access of pollutants to the waterbody;
- Establishing mechanisms to impede access of introduced fish species to waterbodies, and ideally develop a capacity to manage water levels to periodically eliminate fish;

- Ensuring that water quality parameters (such as salinity, turbidity, etc.) are within desired limits. These limits are yet to be unequivocally defined, although some work on this subject has been conducted (Poole 2004; Wassens 2006; Hamer and Organ 2008; Smith *et al*. 2008; Heard and Scroggie 2009; Clemann *et al.* in prep.).
- Ensuring (via consultation with biologists suggested by the Recovery Team) that any modification of breeding or non-breeding Southern Bell Frog habitat will not be likely to negatively affect population viability;
- Ensuring that specific development activities, particularly on the fringe of major urban centres, do not negatively affect dispersal opportunities and terrestrial habitats for the species;
- Investigating opportunities to create habitat for maintenance of local populations during construction projects (e.g., water, sewage and road infrastructure);
- Investigating the potential to remove drains and re-create natural wetland processes in key areas.

Additional interim habitat management for populations in semi-arid areas.

- Ensuring appropriate hydrological regimes (including spring floods of appropriate timing, frequency and extent) at key sites;
- Ensuring that appropriately-sized tracts of habitat are preserved within the areas subject to these floods;
- Maintaining and / or restoring native vegetation within and around habitat.

Responsibility: DSE, OEH, DPIPWE, DENR, SEWPaC

Objective 2 Determine distribution, biology and ecology of the Southern Bell Frog, and identify causes of the decline of the species across its geographic range.

Recovery Criterion: The distribution, biology and ecology of Southern Bell Frog across its geographic range are well understood.

Action 2.1: Determine the current distribution and abundance of the Southern Bell Frog.

Patterns of decline in this species suggest that the occurrence or loss of the species at many historic localities requires assessment to better define the geographic distribution of Southern Bell Frog . Broad-scale surveys based on careful consideration of appropriate survey protocols, frequency and intensity (see Heard *et al.* 2006; 2010) need to be implemented across this range.

Habitat use by the Southern Bell Frog is dynamic; within and between years the species' abundance in certain habitats, as well as its choice and use of different habitats, can vary markedly. Similarly, the likelihood of detecting the species relies heavily on the frog's behaviour. They may be detected relatively readily when calling or basking but may be difficult to detect when silent or inactive. Also, detectability between different habitat types is likely to be highly variable, and the species' behaviour in different areas can be quite different. Consequently, surveys for

Southern Bell Frog should be conducted across the spectrum of habitat types available in the landscape, and not restricted to habitats considered likely to contain the species. Similarly, a prescriptive approach to survey methods will not be useful. Instead surveys should attempt to determine habitat occupancy, incorporate repeat visits to all survey sites, and must determine and report their false negative rate (i.e., the proportion of sites recorded as *not* having Southern Bell Frog where the species is likely to be present). Recent work by Heard *et al*. (2006) has been particularly informative in terms of the most productive survey timing and techniques.

The results of these surveys will be combined with historic data to establish a coordinated database containing distribution data, monitoring activities and research results for use by the Recovery Team and each State or Territory agency.

Responsibility: DSE, PV, OEH, DPIPWE, DENR, SEWPaC

Action 2.2: Undertake population monitoring.

Most reports of widespread declines in the Southern Bell Frog have been based on anecdotal observation. It is not known why the species persists at some sites but not others. It is unclear whether some populations are more resistant to certain threatening processes, have not been affected as badly by these threats, or are merely in an earlier stage of decline that will eventually lead to extirpation. Conversely, at sites where the species has reportedly declined it may increase in numbers over time with or without active management. Consequently, there is an urgent need to assess the population dynamics and stability of extant populations.

To gauge the success or otherwise of any imposed management, and to contribute to a greater understanding of ecological processes influencing populations of the Southern Bell Frog, long-term monitoring of populations at selected sites throughout the range of the species should be implemented. Any such monitoring must be of a sufficient intensity, frequency and duration to enable effective remedial measures to be implemented if it becomes apparent that populations are in serious decline.

The life-stage of monitored individuals is important. Female Southern Bell Frogs produce many eggs, and it is likely to be relatively uninformative to monitor reproductive pulses via eggs and larvae (although measures of these life stages may be useful for quantifying reproductive activity at breeding sites). The number of adult frogs in a breeding assemblage is likely to provide the most useful measure for monitoring populations. Therefore, the timing of monitoring must coincide with breeding activity, and should be conducted between October and late December. Assessing numbers of adult frogs can be best achieved using a combination of counts of calling males and spotlight searches along the perimeter of waterbodies. This action may be conducted in conjunction with the field component of Action 4.1.

Translocation of Southern Bell Frogs and / or their eggs and larvae is frequently proposed as a potential conservation strategy for populations facing imminent destruction. A crucial component of translocation programs must be detailed monitoring to establish the success and wisdom of this form of management. Such monitoring must be sufficiently rigorous and of appropriate duration to

effectively evaluate these programs. Southern Bell Frogs have been translocated on several occasions, usually due to the imminent destruction of occupied sites. However, these translocations have occurred without adequate monitoring of the outcomes, although at least one translocation appears to have failed (Smith and Clemann 2008).

Responsibility: DSE, PV, OEH, DPIPWE, DENR, SEWPaC

Action 2.3: Determine movement patterns of the Southern Bell Frog

The continued persistence and conservation of many populations of Southern Bell Frogs will probably be reliant upon landscape-scale conservation efforts. Consequently, it is important to understand habitat use and movement patterns across a range of landscapes. Research into this issue has commenced in the Merri Creek catchment north of Melbourne (Robertson *et al.* 2002, Heard *et al.* 2004, 2010) and within the lower Murrumbidgee catchment (Wassens 2006). However, in order to understand these issues across the geographic range of Southern Bell Frog, it is important to investigate the landscape ecology of the species in a variety of landscape types across its geographic range.

This action involves the investigation of movement patterns of Southern Bell Frog in a subset of sites throughout the extant range of the species to establish the relationship between various breeding and non-breeding habitats within clusters of 'populations'; identify those waterbodies crucial for recruitment and population maintenance, and establish the suitability of these samples for extrapolating management parameters for populations occurring elsewhere.

Responsibility: DSE, PV, OEH, DPIPWE, DENR, SEWPaC

Action 2.4: Conduct a comparative genetic, life history and ecological study of the Southern Bell Frog across different bioregions.

At present, the population dynamics of the Southern Bell Frog are only poorly understood. An understanding of the patterns of reproduction, recruitment, mortality, movements and dispersal within populations of the frog will be crucial for their conservation. It is important that population studies occur across the geographic range of the species to examine variation in these life-history attributes. For example, it is apparent that there is considerable variation in the ecology of populations of Southern Bell Frogs between the two broad biogeographical divisions of the species (semi-arid and southern temperate populations). This variation has not been adequately quantified, and it is not known whether this variation represents phenotypic plasticity or genetic differences. Such ecological variation necessitates specific conservation measures to be implemented in different regions.

This action involves a comparative study of selected populations of the Southern Bell Frog in order to quantify these differences in the context of the genetic variation within the species. One of the benefits of this research will be an appraisal of the applicability of generic management actions across the species' range.

Responsibility: Universities, DSE, PV, OEH, DPIPWE, DENR, SEWPaC

Objective 3 Address known or predicted threatening processes and implement appropriate management practices where possible to ensure that land-use activities do not threaten the survival of the Southern Bell Frog.

Recovery Criterion: The causes of decline of the Southern Bell Frog across its geographic range are well understood, and knowledge is sufficient to implement effective management strategies.

Action 3.1: Determine historic and contemporary status of infection by the Chytrid Fungus

The introduced Chytrid Fungus is now well established in a number of Australian amphibian populations. This pathogen has been implicated as a proximate cause of the recent decline of numerous amphibian species (Berger *et al*. 1998). This includes the Southern Bell Frog, as well as other members of the Bell Frog species complex.

This action combines the collection and analysis of samples from wild frogs and archived tissue samples from State museums, to determine historic and contemporary infection status for *B. dendrobatidis* in Southern Bell Frog populations. Understanding past patterns of disease is a necessary step in determining causes of decline, and monitoring the infection status of wild populations will aid the understanding of the influence of this disease as a population regulation mechanism. This type of investigation is now routine, with an assurance of providing useful results. The field component of this action can be conducted in conjunction with Action 3.2.

If toe-clipping is used during monitoring for marking individuals in a population, the removed toe should be retained for screening for infection with this fungus. Alternatively, a swabbing technique may be used where toe-clipping is inappropriate. Most frog populations in eastern Australia that are endemically infected with chytrid fungus (sampled in winter) seem to have a prevalence of infection of around 5% or more (R. Speare, James Cook University, pers. comm. 2007). However, this is likely to vary considerably with infection state. Using current detection methods, to confirm infection in such a population with a likelihood of 95%, a minimum of 58 individuals would have to be sampled from the population. Using the same formula for a population that had 1% infected animals, 300 individuals would have to be sampled to detect one positive animal (R. Speare, James Cook University, pers. comm. 2007). Consequently, to examine the relationships between chytrid infection levels and population dynamics will require high levels of sampling. New and more sensitive sampling techniques are currently in development, which may reduce this sampling effort.

Responsibility: ARC, James Cook University, CSIRO - Australian Animal Health Laboratories, DSE, PV, OEH, DPIPWE, DENR, SEWPaC

Action 3.2: Determine the impact of fish predation on the Southern Bell Frog.

The role of exotic predators in the decline of the Southern Bell Frog is unclear. The supposed impact of predatory exotic fish, including Eastern Gambusia and Common Carp, requires elucidation. In particular, the relative impact of a range of exotic versus native fish species should be evaluated, as well as the interactions between fish predation and habitat complexity.

This action involves experiments conducted in the field in order to closely replicate natural conditions. If predation by exotic fish is found to potentially have a significant impact on recruitment in populations of the Southern Bell Frog, informed management strategies may need to be devised and implemented.

Responsibility: University, DSE, PV, OEH, DPIPWE, DENR, SEWPaC

Action 3.3: Test the responses to various water parameters and pollutants of all life stages of the Southern Bell Frog.

Owing to their permeable skin that permits gaseous exchange, frogs are considered to be particularly susceptible to environmental pollutants (Mann and Bidwell 1999). Salinity, biocides and other pollutants have been suggested to be potential threats to the Southern Bell Frog (Robertson in prep.). There has been little specific research on the influence on the Southern Bell Frog of varying water quality parameters. The effects of various concentrations of water salinity have been investigated for the larvae of *L. aurea* (Christy and Dickman 2002). Preliminary research on the effects of salinity on the Southern Bell Frog in western Victoria suggests that the species has salinity tolerances similar to sympatric frog species – i.e., the Southern Bell Frog ceases to occur in waterbodies once salinity levels reach ~10 – 15% of that of seawater (M. Smith, DSE pers. comm.).

This action involves experimentally testing the responses of all life-stages of the Southern Bell Frog to varying water parameters and pollutants. Such parameters and pollutants may include (but are not limited to): water temperature, salinity, pH, dissolved oxygen, various biocides, wetting agents and surfactants. Decisions regarding the choice of the variables to be tested will be based upon field observations and expert opinion on those variables most likely to be affecting frogs in the wild, and the relevance of these variables to achievable management actions.

Responsibility: ARC, university, DSE, PV, OEH, DPIPWE, DENR, SEWPaC

Action 3.4: Investigate the response of the Southern Bell Frog to translocation, the creation of artificial habitats, and / or the re-creation or rehabilitation of habitat.

There is increasing interest in the establishment of habitat specifically for the Southern Bell Frog, and concomitant interest in the reintroduction of this species in newly-established or historic habitat within its former range. One of the tenets of conservation biology is that *in situ* conservation is the ideal, and translocation and reintroduction is less desirable, frequently problematic (Dodd and Seigal 1991), and often unsuccessful (Fischer and Lindenmayer 2000). Such strategies have the greatest chance of success when the processes responsible for the original decline have been mitigated. Consequently, although careful experimental translocation / reintroduction of the Southern Bell Frog may be considered in specific circumstances, *in situ* conservation will be the primary goal. Where reintroduction occurs, it should be conducted in a rigorous experimental manner in order to maximise the knowledge gained from such an exercise.

Notwithstanding this, the Southern Bell Frog is a mobile species that may naturally exploit suitable habitat. Therefore the recreation and rehabilitation of habitat for this species should be conducted

in a rigorous experimental fashion, incorporating long-term monitoring to gauge the colonisation and long-term success of these practises.

This action will investigate the response of the Southern Bell Frog to translocation and / or the creation, re-creation or rehabilitation of suitable habitat.

Responsibility: DSE, PV, OEH, DPIPWE, DENR, SEWPaC

Action 3.5: Investigate the impact of fox and cat predation on the Southern Bell Frog.

The Red Fox *Vulpes vulpes* and feral and domestic Cats *Felis catus* undoubtedly prey upon Southern Bell Frogs. The extent of this predation, and its effect on populations of these frogs is unknown. This action involves the investigation of the impact of predation by Foxes and Cats on selected populations of the Southern Bell Frog.

The two most likely techniques to be employed during this action are the examination of the stomach contents of exotic predators, and / or analysis of predator scats. The collection of scats may be conducted during fieldwork for other actions.

Responsibility: Universities, DSE, PV, OEH, DPIPWE, DENR, SEWPaC

Objective 4 Increase community awareness of and support for Southern Bell Frog conservation.

Recovery Criterion: Community support for, and involvement in, the recovery program for the Southern Bell Frog is evident.

Action 4.1: Identify opportunities for community involvement in the conservation of the Southern Bell Frog.

There is considerable potential for the involvement of the public and relevant agency staff in survey and conservation activities for the Southern Bell Frog. Such involvement can embrace the breadth of these activities, ranging from the reporting of spot-records, to participation in surveys and habitat works. From simply increasing public awareness and sympathy, through to public involvement in activities such as monitoring, habitat management and weed control, public interest and involvement will augment conservation efforts for the Southern Bell Frog. In order to encourage and facilitate this interest and involvement, an information brochure will be developed detailing the identification, biology and plight of the Southern Bell Frog, as well as information on the species' habitat, and protocols for recording observations of this frog. Brochures will also contain contact details for those wishing to contribute to research and management activities. These brochures will be made available to the public through offices of land management agencies in each state and territory in which the Southern Bell Frog occurs, and through zoological parks that display the Southern Bell Frog. Similarly, detailed information sheets concerning habitat management will be prepared. These documents will be primarily aimed at land managers and landowners in areas where the species occurs, and will outline the significance of the species and its habitat, and

provide guidelines on how best to manage this habitat. Appropriate signage will be provided in areas where the species occurs, and where management is taking place.

Responsibility: DSE, PV, OEH, DPIPWE, DENR, SEWPaC