# National Recovery Plan for the Stuttering Frog *Mixophyes balbus*

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This is a Recovery Plan prepared under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, with the assistance of funding provided by the Australian Government.

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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# Summary

The decline of amphibian populations, both in Australia and worldwide, has received much attention over the past two decades (refer to Alford & Richards 1999 for review). Within Australia, since the late 1970s, at least three frog species may have become extinct and a further 37 species have declined to levels warranting consideration for listing as threatened nationally (Hero & Morrison 2004). Many of these declines appear to have occurred abruptly and at about the same time, suggesting common causal factors. Of major concern is that many of these declines have occurred within protected areas (e.g. national parks, nature reserves), where environmental disturbance appears minimal.

The Stuttering Frog (*Mixophyes balbus*) is one species that has suffered an extensive decline in distribution and abundance. Formerly occurring from north-eastern New South Wales to far eastern Victoria, the species is now rare or absent throughout much of its former range. Precise causes of decline are not known, but are thought to include disease, habitat modification, introduced fish and climate change. The Stuttering Frog is listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), Endangered under the NSW *Threatened Species Conservation Act 1995* and Threatened under the Victorian *Flora and Fauna Guarantee Act 1988*.

This Recovery Plan summarises our current knowledge of the Stuttering Frog, documents the conservation research and management actions undertaken to date, and identifies the actions required and parties responsible to ensure the ongoing viability of this species in the wild. Achieving the objectives of this Recovery Plan is subject to budgetary and other constraints affecting the parties involved. It is necessary that this Recovery Plan be viewed as dynamic, such that changes are made in the priority or structure of recovery actions as new information arises.

# Species Information

## Description

The Stuttering Frog (*Mixophyes balbus*) is a large frog, with adult males attaining 65 mm and females 80 mm in snout-vent length. Dorsal coloration is yellow-brown to olive-green, which merges laterally into the white ventral coloration. A dark stripe runs from the snout through the eye to the tympanum, and there are several faint, thin dark bars on the hind limbs. The fingers lack webbing while the toes are three-quarters webbed. Adults have a pale blue crescent along the upper part of the iris. This pale blue crescent, in combination with a lack of conspicuous spots or blotches on the side, distinguishes the Stuttering frog from other *Mixophyes* species. The male advertisement call is a soft grating trill of about 10 pulses (description from Barker *et al*. 1995 & Cogger 2000). Tadpoles are dark brown, dorso-ventrally compressed, have a muscular tail with narrow caudal fins and grow to about 80 mm total length (Anstis 2002).

## Ecology

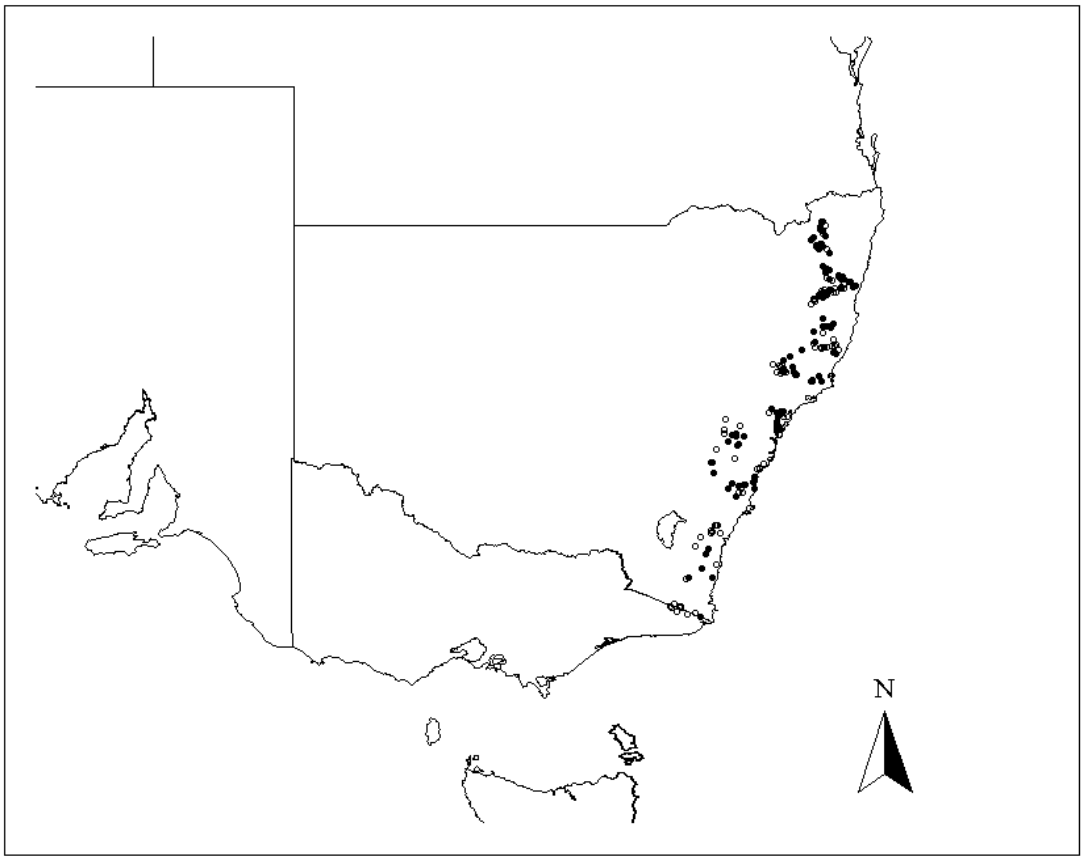
The Stuttering Frog is an obligate stream breeder. Breeding occurs from early spring to mid autumn, usually after heavy rainstorms (Mahony *et al*. 1996; Gillespie 1997). Eggs are deposited in very shallow, slow-flowing riffle sections of the main channel of streams, in shallow nests dug into gravel or leaf litter substrates, or pasted directly onto bedrock (Lewis 2000; Knowles *et al*. in prep.). Females will lay eggs in several nests (Lewis 2000), and may lay over 1,000 eggs in a season (Anstis 2002). Upon hatching, Stuttering Frog tadpoles remain in the nest until their yolk sack is fully absorbed and they have attained full motility, after which they disperse into stream channels and pools.

Tadpoles are free-swimming benthic grazers, foraging amongst stones and leaf litter in riffle and pool sections of the stream channel (Anstis 2002; Knowles *et al*. in prep.). It may take up to 12 months for tadpoles to reach metamorphosis (Anstis 2002) and, at some sites, there are always at least two cohorts of tadpoles present (B. Lewis pers. comm. 3/8/2004). For the terrestrial frog stage, annual survivorship rates of 60 percent were estimated for one population, with a maximum age of six years reached (B. Lewis unpub. data 3/8/2004). Adult frogs are highly cryptic, mostly

remaining buried in leaf litter or loose soil during drier periods, but actively move about above ground at night after heavy rainfall (Mahony 1993).

## Distribution

The Stuttering Frog occurs in eastern-flowing streams of the Great Dividing Range, between the Cann River catchment in East Gippsland, Victoria, and the Clarence River catchment in north-eastern NSW (Figure 1), in the NSW North Coast, New England Tableland, Sydney Basin, South Eastern Highlands and South East Corner IBRA Bioregions (*sensu* DEH 2000). In the south of its range, the species occurs from near sea level to 1,100 m ASL, whilst in the north of its range it occurs above 200 m to 1,420 m ASL (Gillespie & Hines 1999; NSW Wildlife Atlas). Virtually the entire range of the Stuttering Frog is in NSW, with the few Victorian records from the far east of the State, just south of the NSW border.




Closed circles indicate records collected after 1990 and those of unknown collection date
Open circles indicate records collected before 1990

**Figure 1.** Distribution of the Stuttering Frog

## Population Information

Most recent records of the Stuttering Frog are from the north of its range, with few records south of Sydney (Gillespie & Hines 1999; NSW Wildlife Atlas), although there was little survey effort for riverine frogs in this region prior to 1980. A recent genetic study identified two major lineages within the Stuttering Frog, a northern and southern lineage that apparently meet in the Barrington Tops region of NSW (Donnellan 2008). The divergence between these two lineages is greater than levels of divergence observed among other *Mixophyes* species (Donnellan 2008), which suggests the likelihood that more than one taxon currently exists within the Stuttering Frog. However, further genetic material is required to fully resolve the status and geographic relationships of these evolutionary significant units **(**ESUs). Until this taxonomic issue is resolved (see Action 1.2), the northern and southern lineages of the Stuttering Frog should be given the

highest level of conservation priority, and managed independently. Further field surveys and genetic work are required to identify possible sub-structuring within the northern and southern Stuttering Frog lineages, particularly in the south of the species' former range where few extant populations are known and limited genetic material is available. Populations important to the survival of the Stuttering Frog have not been determined, but this will be clarified as part of a proposed recovery action. There are only three records of the Stuttering Frog from Victoria, all prior to 1980 (Atlas of Victorian Wildlife database) (see Decline and Threats section below).

### Habitat

The Stuttering Frog inhabits naturally vegetated streams typically in hilly or mountainous topography, between 20 m and 1420 m elevation, in a wide range of vegetation types including: subtropical, warm and cool temperate rainforest, and wet and dry sclerophyll forest (Mahony *et al*. 1996; Gillespie 1997; White 2000). In north-eastern NSW it has been found along small first-order tributaries and larger third or fourth-order streams. The species has also been found in moist gullies within areas of dry forest, sometimes utilising small trickles of water (Tyler 1997). In the south it has mostly been found in headwaters, along small first or second-order streams (NSW Wildlife Atlas; Gillespie 1997). Streams are typically precipitous, have steep banks with deep leaf litter and/or dense riparian vegetation cover (Mahony *et al*. 1996). Soils are usually rich organic with high humus content (Mahony 1999), typical of riparian and gully habitats, although some sites in the south have granitic sandy soils (G. Gillespie pers. obs. 2004). No specific geological associations are apparent, with the species occurring on sedimentary, igneous and metamorphic substrata (Mahony 1999).

Adult Stuttering Frogs are terrestrial, often found sheltering in leaf-litter along the banks and lower slopes of streams. As with the ecologically similar species Mixophyes fleayi, (Doak 2005) Stuttering Frogs may also use habitats considerable distances away from riparian areas and may routinely disperse into surrounding forests outside of the breeding season (Mahony 1999). Consequently, terrestrial habitats in catchments containing populations are also of importance for foraging, shelter and possibly dispersal. The egg and tadpole stages are fully aquatic.

In view of the habitat preferences and ecological attributes of the species, stream geomorphology and hydrological processes are clearly important in influencing the distribution of the Stuttering Frog. Because Stuttering Frog populations are dependent upon the integrity of the physical stream habitat, they are also dependent upon catchment processes, such as hydrological regimes, sediment movement and nutrient cycling, that influence the stream environment. The integrity of forest habitats throughout catchments may also be important for foraging, shelter and maintaining dispersal levels. Consequently, habitat considered critical to the survival of the Stuttering Frog may comprise not just the stream habitat and adjacent riparian zones, but also the entire catchment adjacent to, and upstream of populations. This habitat has not been mapped.

## Decline and Threats

Prior to the mid-1980s the Stuttering Frog was perceived to be secure in NSW, which comprises almost all of its range(Gillespie & Hines 1999; Fig. 1). Since then, the species has undergone a substantial decline in distribution and abundance (Tyler 1997), such that it is now rare or absent in much of its former range. In the Watagan Mountains on the central coast of NSW, by 1986 the species had declined or disappeared from areas where it was previously abundant (Mahony 1993). There are also numerous anecdotal reports of decline in the northern sections of its former range (Gillespie & Hines 1999). The species was once common in some streams below 800 m elevation at Bondi State Forest in the far south of NSW (Webb 1991), but has since disappeared from most historical sites south of Sydney (Lemckert *et al*. 1997; Daly 1998), with the most recent targeted surveys locating this species at only three localities (Daly *et al.* 2000; White 2000; Hunter 2001). The Stuttering Frog was last seen in Victoria in the early 1980s, and surveys specifically targeting the species have been unsuccessful (Holloway & Osborne 1996; Gillespie 2011). The Stuttering Frog may, therefore, be extinct in Victoria; however, as the species is highly cryptic, it may remain undetected when at low population densities.

The precise causes of the decline of the Stuttering Frog are unknown, but it is likely to be the result of several factors including habitat destruction and disturbance, altered hydrological regimes, disease and pollution (Gillespie & Hines 1999; Hines *et al*. 1999). The following information summarises the factors currently considered most threatening to this species.

Disease

The pathogenic Amphibian Chytrid Fungus *Batrachochytrium dendrobatidis* (Bd) causes the disease chytridiomycosis in frogs (Longcore *et al.* 1999), and has been implicated in the decline of many frogs in Australia and elsewhere in the world (Berger *et al.* 1998; Lips 1999). Bd is highly virulent to infected frogs under laboratory conditions, and sick and dead frogs infected with Bd have been detected in populations during and after (but not before) declines (Berger *et al*. 1998). Bd usually infects post-metamorphic frogs (Berger *et al*. 1998), but may also infect tadpoles (Parris 2004). Mortality occurs when Bd alters the electrolyte balance within infected frogs, resulting in cardiac arrest (Voyles *et al.* 2009).

The increased virulence of Bd under cooler, moist conditions (Woodhams *et al*. 2003) is consistent with frog populations at higher elevations in mesic environments appearing to be more susceptible to decline (Laurance *et al*. 1996). Consequently, the Stuttering Frog is likely to be highly susceptible to this pathogen as much of its historic distribution was in cool, moist upland habitats. Stuttering Frogs infected with Bd have been recorded on several occasions (Murray *et al.* 2010). The pathogen has also been reported in the related species *Mixophyes fleayi* and *Mixophyes iteratus* (Berger *et al*. 2004, Murray *et al.* 2010), and *Mixophyes fasciolatus* was found to be highly susceptible to Bd in a laboratory study (Berger *et al*. 1999a). The low genetic variation among strains of ACF collected from several continents including Australia suggests it has only recently emerged as a frog pathogen (Morehouse *et al*. 2003). The pathogen is listed under the EPBC Act as a Key Threatening Process involved in the decline of Australian frog species.

Other pathogens may also be impacting on the Stuttering Frog. The bacterium *Chlamydia pneumoniae* has been identified from a sick, wild *Mixophyes iteratus*, although it is not known if this pathogen has contributed to population declines of any frog species (Berger *et al*. 1999b).

Fish predation

The introduction of non-indigenous predatory fish species has been strongly associated with a number of amphibian declines throughout the world, primarily through predation on the egg and tadpole stages (Bradford *et al*. 1993; Gillespie & Hero 1999; Gillespie 2001; Vredenburg 2004). The release of fish into stream systems may also act as an efficient vector for potentially harmful pathogens to frogs (Kiesecker *et al*. 2001). While there have been no specific studies undertaken into the possible impact of fish species on the Stuttering Frog, introduced fish species are likely to impact on populations of this species due to its long larval period in the aquatic stream environment (Gillespie and Hero 1999). Introduced salmonid species, which have been shown to impact on other frog species in eastern Australia (Gillespie 2001), have been continually released in streams in NSW that historically or continue to support Stuttering Frog populations. Reliable information on the dates of commencement of salmonid introductions into catchments containing Stuttering Frog populations are unavailable but stocking was widespread in southeastern Australia by the 1940s (Clements 1988). The time taken for trout to colonise headwaters of catchments is unknown, so it is not possible to determine the timing of arrival of trout in most streams containing Stuttering Frogs. Furthermore, information on the distribution and population density of the Stuttering Frog prior to the arrival of trout is unavailable so historical changes in demography due to trout predation cannot be determined. There have been no direct observations of trout impacting on the Stuttering Frog (Clulow et al 2009), however such observations are difficult to detect (see Gillespie 2001) in the absence of specific experimentation (Gillespie and Hero 1999).

Tadpoles of the Stuttering Frog cohabit with several native fish species (Mahony 1999), and may have survival strategies that help to minimise predation from these native species. Anecdotal observations suggest that eggs removed from nests are palatable to Mountain Galaxias (*Galaxias olidus*); the nests may offer protection from fish predation. Large Stuttering Frog tadpoles have been observed eating conspecific eggs in nests (B. Lewis pers. comm. 2004). The relative influences of predation and competition on the distribution and abundance of the Stuttering Frog have not been examined.

Habitat destruction and modification

Some riverine frogs are known to be susceptible to changes in catchment processes, such as hydrological regimes, sediment movement and nutrient yields, that influence the stream environment (Gillespie 2002). Catchment processes are in turn influenced by management activities, such as forestry operations, mining, impoundments, and other disturbance processes, such as fire and grazing. The integrity of forest habitats throughout catchments may also be important for foraging, shelter and maintaining dispersal levels. In NSW, Stuttering Frog habitat is likely to be altered by subsidence and mining-associated activities (SC 2005).

Since European settlement there has been considerable habitat destruction and modification within the historic range of the Stuttering Frog, which has undoubtedly contributed to the broad scale decline in this species. Habitat destruction continues to threaten the Stuttering Frog, primarily through forestry activities and agriculture (Gillespie & Hines 1999; White 2000). Stuttering Frogs are not known from any localities with significant human impacts up-stream (Mahony *et al*. 1997; White 2000), suggesting that they may be sensitive to such disturbances.

Many remaining Stuttering Frog populations occur in catchments managed by Forests NSW (Industry and Investment NSW) for timber harvesting. Forestry activities have the potential to impact on frog populations in a number of ways. The most direct impact is through mortality of individual frogs, and the loss of suitable habitat (including that required for movement or dispersal) through disturbance to ground substrates and removal of native vegetation. Forestry activities may also directly impact on the aquatic riverine environment used by the Stuttering Frog. This is primarily through increased sediment loads into the river as a result of road construction and maintenance, and the use of heavy machinery to extract timber. Increased sediment loads into streams are likely to reduce the availability of suitable oviposition sites and tadpole habitat (Gillespie 2002; Mahony 1999).

Areas occupied by the Stuttering Frog are also subject to a range of agricultural practices that are likely to impact on this species. The greatest impact from agriculture is removal of native vegetation. Various other practices are also likely to have an on-going impact on the habitat of the Stuttering Frog, such as grazing cattle and other stock in close proximity to the riparian environment, and associated fire regimes. Cattle grazing has been identified as a major threat to the Cascade Tree Frog (*Litoria pearsoniana*), a stream-breeding frog of south east Queensland and north east NSW (Parris 2001). Feral pigs (*Sus scrofa*) could also potentially cause significant damage to habitat utilized by the Stuttering Frog. Recreational activities such as four-wheel driving and bushwalking may also impact on important habitat areas.

Climate Change

Steffen *et al.* (2009) identifies frogs as the terrestrial vertebrates possibly most at risk from climate change in Australia. Frogs typically have a life cycle that is strongly governed by climatic variables, particularly temperature and rainfall (Duellmann & Trueb 1996). Hence, changes in climatic variables are likely to have a strong influence on the viability and distribution of frog populations. While the influence of climate change is well documented for pond breeding amphibians (Pounds *et al*. 2006; Steffen *et al.* 2009; MacNally *et al*. 2009; Bickford *et al*. 2010), there is little information on the influence of this process on stream breeding species such as the Stuttering Frog. Several aspects of the Stuttering Frog's life cycle are likely to be strongly influenced by climate, including calling and breeding activity, capacity to move and forage and whether certain habitat types are suitable. For instance, large numbers of Stuttering Frogs have been observed actively moving over the ground after heavy rainfall events (Mahony 1993).

The impact of climate change in south-eastern Australia is likely to result in overall increasing temperatures, decreasing rainfall and increasing evaporation, which is likely to reduce the availability of suitable habitat for Stuttering Frogs. During drought conditions, smaller streams typically used by the species for breeding are no longer suitable, due to reduced flow rates (Mahony 1993). Lower rainfall is also likely to decrease mobility above ground, reducing chances for finding a mate and dispersal between populations and habitats. As such, rapid climate change is likely to be a major threat to the Stuttering Frog. Climate change may also operate synergistically with other threatening factors, such as habitat disturbance or disease, to exacerbate their impacts on the species.

Pollution

Over the past 20 years there has been an increase in the use of broad-spectrum herbicides in many areas of Australia (Tyler 1989). Formulations that contain glyphosate and surfactants are toxic to frogs and tadpoles (Bidwell & Gorrie 1995), and these are commonly used to control emergent waterweeds within catchments occupied by the Stuttering Frog (see Ensbey 2011). Ammonium nitrate and calcium phosphate fertilizers have been implicated in the decline of the Green and Golden Bell Frog (*Litoria aurea*) from parts of NSW (Hamer *et al*. 2004). Potential pollutants can accumulate in varying concentrations in river systems occupied by the Stuttering Frog following heavy rain periods. In addition to pollution from agricultural chemical use, streams occupied by the Stuttering Frog are also subjected to pollution from urban runoff (White 2000). Given the lack of knowledge on the possible role of pollution in the decline of the Stuttering Frog,

the use of large amounts of chemicals within catchments occupied by the Stuttering Frog should be considered a potentially threatening process for this species.

Hydrological Changes

The reproductive success of Stuttering Frogs is likely to be highly reliant upon the availability of specific microhabitats for breeding, especially shallow gravel shoals, in which to construct their nests, and flow regimes that provide the appropriate substrates and hydrological conditions during the breeding season. Altered hydrology within catchments is therefore likely to have had a substantial impact on the Stuttering Frog, especially on eggs and tadpoles. The construction of dams leads to loss of shallow riffle breeding areas and inundation of previously suitable terrestrial habitat upstream, and changed flow regimes, temperature and water chemistry downstream (Ligon *et al*. 1995). Similarly, the clearing of habitat for agriculture and urbanisation, which has occurred throughout parts of the historic range of the Stuttering Frog (Mahony *et al*. 1996), produces changes in hydrological regimes and increases in sediment and nutrient levels in streams.

Other potential threats

The extent to which predators such as the Red Fox (*Vulpes vulpes*) and Feral Cat (*Felis catus*) prey on the Stuttering Frog in not known, but these predators are known to prey on large terrestrial frogs in southeastern Australia (Gillespie & Hines 1999). Actions include investigating the extent to which these animals may impact on populations.

Cane Toads (*Rhinella marina)* have recently been recorded at high altitude in the Border Ranges in northern NSW and could potentially reach areas occupied by the Stuttering Frog (D. Newell unpubl. data, 2011 ).

### Populations and Areas Under Threat

In view of the extent and rapid nature of the recent population declines of the Stuttering Frog throughout its entire distribution, all extant populations are considered critical for the long-term survival of this taxon at this stage. Furthermore, the causes of these declines are poorly understood, and declines of some if not all populations may be continuing. Consequently no populations may be considered secure. Since all the known populations of the Stuttering Frog south of Sydney are extremely small and restricted, this species appears to be particularly under threat of local extinction in this region.

## Recovery Information

### Existing Conservation Measures

Current conservation measures for the Stuttering Frog include the following:

- A considerable amount of research, including surveys (e.g. Mahony 1993; Daly 1998; White 2000; Hunter 2001; Gillespie 2011), population demographic and mark-recapture studies (Mahony 1999) and population genetics and taxonomy (Donnellan 2008).
- Preparation of a NSW hygiene protocol for the control of diseases in frogs (NSW NPWS 2001).
- Preparation of a national Threat Abatement Plan for Amphibian Chytrid Fungus (DEH 2006), which identifies *B. dendrobatidis* as being endemic in Stuttering Frog populations in NSW. This plan outlines the broad goals of, firstly, preventing amphibian populations or regions that currently have Bd from becoming infected and, secondly, decreasing the impact of infection with Bd on amphibian populations that are currently infected.
- Preparation of a NSW Statement of Intent for Bd (DECCW 2009a), which outlines the approach that NSW will take to manage the impact of Bd.
- Captive populations of Stuttering Frogs established at the Amphibian Research Centre and Melbourne Zoo, to facilitate further research, and support a reintroduction program if this is deemed necessary. Melbourne Zoo has succeeded in maintaining and breeding this stock through to a third (F3) generation (R. Hobbs, pers. comm. 2011).
- Management prescriptions for minimising the impact of forestry on the Stuttering Frog in the NSW Integrated Forestry Operations Approval (IFOA) process. In the IFOA for the Eden

region, all recent records of the Stuttering Frog must have a 200 ha exclusion zone, while in the IFOA for the South Coast region, all Stuttering Frog records must have a one kilometre radius planning area involving a 300 metre wide exclusion zone on each side of the stream channel. In the IFOA for the Upper and Lower North East region, Stuttering Frog localities must have a 30 metre wide buffer zone on both sides of the stream for 200 metres up and downstream of the record. The implementation of these prescriptions relies entirely on Stuttering Frogs being located at a specific point along a stream.

- The inclusion of the Stuttering Frog on the NSW Threatened Species Information Disclosure Policy (DECC 2007a). Under this policy, the Stuttering Frog is a category 2 species, which means that records from the NSW Atlas of Wildlife database are only provided to Licensed clients, and no coordinate information is provided to non-licensed clients. This is due to the risk that the provision of precise locations would subject the species to threats from collectors and consequently, disease.

Related management actions that may also benefit the stuttering frog include:

- In NSW, declaring the introduction of fish to fresh waters within a river catchment outside their natural range as a Key Threatening Process under the NSW *Fisheries Management Act* 1994 (FSC 2001a). Actions to address this Key Threatening Process are targeted primarily toward reducing the impacts on native aquatic flora and fauna, although such actions also benefit the Stuttering Frog and other frogs.
- In NSW, declaring degradation of native riparian vegetation along waterways as a Key Threatening Process under the NSW *Fisheries Management Act* 1994 (FSC 2001b). Actions addressing this Key Threatening Process are targeted toward reducing the impacts on native aquatic fauna, although actions also benefit the Stuttering Frog and other frogs.

## Recovery Objectives

Within the five-year life span of this Recovery Plan, the **Specific Objectives** for recovery of the Stuttering Frog are to:

1. Determine the distribution, habitat requirements, conservation status, taxonomy, population demography and genetic structure of Stuttering Frog populations.
2. Identify and address the causal factors of the decline, and prevent the local extinction of important populations of the Stuttering Frog across its geographic range.
3. Build community support for the Stuttering Frog recovery program.

## Program Implementation and Evaluation

The implementation of this Recovery Plan will be managed by the Environment Protection and Regulation, Office of Environment and Heritage, Department of Premier and Cabinet, NSW and the Department of Sustainability and Environment, Victoria. Coordination and information exchange between the state agencies will be maintained. Technical, scientific, habitat management or education components of the Recovery Plan will be referred to specialist groups on research, *in situ* management and community education as required. Within five years from adoption as a National Recovery Plan an independent external review will be conducted and the plan revised if considered necessary.

## Recovery Actions

A summary of recovery objectives, performance criteria and actions is provided in Table 2. Details on each recovery action are described in Appendix 1.

## Cost of Implementation

The estimated cost of implementation of recovery actions over five years is $1 182 000.

| Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Total Cost |
|---|---|---|---|---|---|
| $325,000 | $335,000 | $224,000 | $159,000 | $139,000 | $1,182,000 |

**Table 2: Summary of Recovery Objectives, Performance Criteria and Actions**

| OBJECTIVES | PERFORMANCE CRITERIA | ACTIONS |
|---|---|---|
| 1. Determine the distribution, habitat requirements, conservation status, taxonomy, population demography and genetic structure of Stuttering Frog populations | All extant populations and priority populations critical to species survival identified; geographic genetic structure determined; habitat requirements are determined and information is available to land managers. | 1.1 Undertake targeted surveys to establish the location and distribution of extant populations<br>1.2 Determine geographic genetic structure; identify evolutionary significant units and their taxonomic status<br>1.3 Establish a population monitoring program of priority populations to determine population demography and evaluate the effectiveness of management actions |
| 2. Identify and address the causal factors of the decline, and prevent the local extinction of important populations of the Stuttering Frog across it geographic range. | Major threats pivotal to recovery of the species are determined and control measures formulated and implemented. | 2.1 Determine the demographic impact of the Amphibian Chytrid Fungus and its influence on potential population recovery<br>2.2 Minimize spread of disease through implementation of most up to date protocols in the vicinity of all extant Stuttering Frog Populations<br>2.3 Minimise the impact of exotic and translocated native fish in streams containing extant populations of Stuttering Frogs<br>2.4 Determine the impact of exotic pests and, if necessary, implement control programs at high priority Stuttering Frog populations<br>2.5 Establish a captive breeding program capable of augmenting reintroductions of Stuttering Frogs at selected extinction sites or for enhancement of extant populations<br>2.6 Develop effective license conditions and interim protocols to minimise adverse impacts of all commercial activities near to, and up stream of, all Stuttering Frog populations<br>2.7 Minimise the impact of recreational activities at all extant population sites and in headwater subcatchments<br>2.8 Incorporate markers for site recognition at all extant population sites |
| 3. Build community support for the Stuttering Frog recovery program. | There is community support for the objectives and actions within the Stuttering Frog Recovery Plan, and community involvement in | 3.1 Promote public education and awareness of the Stuttering Frog and the actions required for its recovery |

| | | |
|---|---|---|
| | its implementation. | 3.2 Develop conservation and management guidelines for habitat protection and restoration for public land management agencies and private land managers<br>3.3 Identify and develop initiatives to increase participation of indigenous communities in the recovery program |

# Management Practices

Given the recent dramatic decline in the Stuttering Frog, the uncertainty as to whether this decline is continuing, and the inability to remove certain threatening processes such as Bd, reducing the impact of further habitat destruction or modification should be considered paramount for the Stuttering Frog Recovery Program. Until several of the actions outlined in this recovery plan have been achieved the precautionary principle should prevail with regards to assessing any proposed works that may alter the habitat of this species.

**Management practices required for the conservation of the Stuttering Frog**

- Consolidation of previous survey information and undertaking additional surveys to better define the distribution and size of remaining populations.
- Implementing a long-term population monitoring program to determine population trends, responses to environmental processes and the effectiveness or impact of various management actions.
- Specific assessment of Stuttering Frog habitat use, particularly non-breeding habitat, movement and dispersal patterns, to assess the potential impacts of current forestry and fire management practices.
- Reducing population stress caused by other threatening processes (e.g. altered hydrological regimes, habitat degradation/destruction) to reduce the impact of disease on populations.
- Liaison with land managers including private landholders about protecting and maintaining habitat.
- Investigating the causes of decline.
- Establishing captive breeding and reintroduction programs
- Community participation in recovery actions, particularly in regard to implementation of on-ground works and conservation of the Stuttering Frog on privately owned or managed lands.

**Management practices to be avoided**

- Changing hydrological regimes in sub-catchments occupied by Stuttering Frog populations, especially actions that result in reduced or more erratic stream flows.
- Disturbance to or destruction of instream, riparian and slope habitat near Stuttering Frog populations.
- Disturbance to or destruction of habitat that could function as dispersal routes between populations and watersheds.
- Use of biocides or other chemicals within or close to waterways supporting Stuttering Frogs.
- Release of native and introduced fish species to waterways supporting Stuttering Frogs.

## Affected Interests

The Stuttering Frog occurs across a variety of land tenures with various managers, including parks and reserves, state forest and private land. Consequently, management is the responsibility of a range of agencies, organisations and individuals. Several organisations have legislative responsibilities for the Stuttering Frog, and will be involved in the implementation of this Recovery Plan. At a national level, the species is listed as threatened under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Any action that could have a significant impact on a listed taxon may require approval. For information regarding the Commonwealth referral process go to: http://www.environment.gov.au/epbc/approval.html.

Within New South Wales, the Environment Protection and Regulation Group, Office of Environment and Heritage (EPROEH) within the Department of Premier and Cabinet is the key agency as outlined in the *Threatened Species Conservation Act 1995* (TSC Act). The species also occurs on land managed by Forests NSW (part of Industry and Investment NSW), who may be involved in some recovery actions. In Victoria, the few records occur on land managed by the Department of

Sustainability and Environment (DSE) and Parks Victoria, and DSE will be involved in the recovery program.

The Stuttering Frog also occurs on freehold land in NSW, 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 Stuttering Frog, and any such developments commencing since the inception of the Act will trigger a referral. Other interested community groups include the National Parks Foundation of NSW and the Threatened Species Foundation of Australia.

This Recovery Plan has the support of state government agencies and land managers identified, and community groups involved in nature conservation in general, and more specifically native frog conservation (e.g. Frog and Tadpole Study Group, NSW Declining Frogs Working Group).

## Role and Interest of Indigenous People

Indigenous communities on whose traditional lands the Stuttering Frog occurs have been advised, through the relevant regional Indigenous Facilitator, of the preparation of this Recovery Plan and invited to provide comments and be involved in the implementation of the Recovery Plan.

## Biodiversity Benefits

This Recovery Plan includes a number of potential biodiversity benefits for other species and vegetation communities occurring within the range of the Stuttering Frog. These benefits will primarily be attained through the protection and management of habitat. The distribution and habitat used by the Stuttering Frog overlaps with a range of other threatened species from all major vertebrate groups (e.g. Hastings River Mouse (*Pseudomys oralis*) - EPBC Endangered, Golden-tipped Bat (*Kerivoula papuensis)*, New England Tree Frog (*Litoria subglandulosa*), Stephens' Banded Snake (*Hoplocephalus stephensii*), Rufous Scrub Bird (*Atrichornis rufescens*). As such, conservation and management of habitat for the Stuttering Frog are likely to provide direct benefits to many other threatened species.

In addition to habitat protection, the research and management outlined in this Recovery Plan will also greatly benefit other threatened frog species. Valuable distribution and population information will be gathered on other sympatric threatened frog species, such as New England Tree Frog, through surveys and population monitoring of the Stuttering Frog. In addition to habitat loss there is increasing evidence that other threatening processes underpin the apparent declines of numerous amphibian species along the eastern ranges of Australia (Hero & Morrison 2004). Investigation of the underlying causes of the decline of the Stuttering Frog, and how to ameliorate these, are likely to aid our understanding and management of other declining amphibian species, particularly other riverine species occurring along the eastern ranges of Australia.

The Recovery Plan will also provide an important public education role as threatened frog species have the potential to act as 'flagship' species for highlighting broader nature conservation issues in aquatic and terrestrial habitats, such as habitat loss and degradation, habitat management (e.g. fire), introduced predators, disease and climate change.

## Social and Economic Impacts

Protection and enhancement of habitat values within catchments containing Stuttering Frog populations may have significant social and/or economic impacts. Maintaining water quality, natural flow regimes and minimising off-stream habitat disturbance will be high priorities for recovery of this taxon. Timber harvesting, urban development, impoundment construction and water management, recreational use (e.g. recreational vehicles), mining and stock grazing represent potentially conflicting uses in some catchments. These will be evaluated as action proposals are implemented through forest management plans, catchment management plans, national park management plans, and town planning.

Where other potentially detrimental activities are to proceed in catchments, additional costs may be incurred to meet management guidelines established in this Recovery Plan. Rehabilitation of road networks, improved pollution control measures for urban run-off and weed management in catchments will involve substantial costs. Restriction or displacement of recreational users (e.g. campers, anglers, four-wheel drive enthusiasts) from some areas may result from implementation of this Recovery Plan.

Stuttering Frog populations often co-occur with many other biodiversity and conservation values, typically associated with minimally disturbed forest catchments. Protection and enhancement of habitat values for the Stuttering Frog will have broad benefits for biodiversity and catchment values. This in turn will contribute to provision of important ecosystem services, such as higher water quality from catchments, and social benefits to the Australian community that places increasing value on conservation of natural areas.

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## References

Alford, R. A. and Richards, S. J. (1999). Global amphibian declines: a problem in applied ecology. *Annual Review of Ecology and Systematics*, 30: 133-165.

Anstis, M. (2002). *Tadpoles of South-eastern Australia: a Guide with Keys*. Reed New Holland, Sydney, NSW.

Barker, J., Grigg, G. C. and Tyler, M. J. (1995). *A Field Guide to Australian Frogs*. Surrey Beatty & Sons: Chipping Norton, NSW.

Berger, L., Speare, R., Daszak, P., Green, D. E., Cunningham, A. A., Goggin, C. L., Slocombe, R., Ragan, M. A., Hyatt, A. D., McDonald, K. R., Hines, H. B., Lips, K. R., Marantelli, G. and Parkes, H. (1998). Chytridiomycosis causes amphibian mortality associated with population declines in the rainforests of Australia and Central America. *Proceedings of the National Academy of Science USA*, 95: 9031-9036.

Berger, L., Spear, R., Hines, H, B., Marantelli, G., Hyatt, A. D., Olsen, V., McDonald, K. R., Clarke, J., Gillespie, G., Mahony, M., Sheppard, N., Williams, C., and Tyler, M. (2004). Mortality in amphibians due to chytridiomycosis increases in winter and with lower experimental temperatures. *Australian Veterinary Journal* **82**, 31-36.

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

Berger, L., Volp, K., Mathews, S., Speare, R., Timms, P. (1999b). *Chlamydia pneumoniae* in a free-ranging giant barred frog (*Mixophyes iteratus*). *Australia Journal of Clinical Microbiology*, 37: 2378-2380.

Bickford, D., Howard, S. D., Ng, D. J. J. and Sheridan, J. A. (2010). Impacts of climate change on the amphibians and reptiles of Southeast Asia. Biodiversity and Conservation Published online 2 February 2010 DOI 10.1007/s10531-010-9782-4.

Bidwell, J. R. and Gorrie, J. R. (1995). Acute Toxicity of a Herbicide to Selected Frog Species. Prepared for the Western Australian Department of Environmental Protection, Perth. Curtin Ectotoxicology Program, Curtin University of Technology.

Bradford, D. E., Tabatabai, F. and Graber, D. M. (1993). Isolation of remaining populations of the native frog, *Rana mucosa*, by introduced fishes in Sequoia and Kings Canyon National Parks, California. *Conservation Biology*, 7: 882-888.

Clements J. (1988). *Salmon ant the Antipodes.* John Clements, Ballarat.

Clulow, S., Clulow, J., and Mahony, M. (2009). Status of populations of threatened stream frog species in the upper catchment of the Styx River on the New England Tablelands, near sites where trout releases occur. University of Newcastle. Report to NSW Department of Primary Industries.

Cogger, H. G. (2000). *Reptiles and Amphibians of Australia.* 6th Edition. Reed New Holland, Frenchs Forest, NSW.

Daly, G. (1998). Review of the status and assessment of the habitat of the Stuttering Frog *Mixophyes balbus* (Anura: Myobatrachidae) on the south coast of New South Wales. *Herpetofauna,* 28: 2-11.

Daly, G., Pennay, M. and Coombes, D. (2000). Targeted surveys for the Stuttering Frog, *Mixophyes balbus*, on the south coast of New South Wales. Unpublished report to the New South Wales National Parks and Wildlife Service.

DECC (2007a). Threatened Species Information Disclosure Policy V.3, Department of Environment and Climate Change , Sydney.

DECC (2007b) *Northern Rivers Region Pest Management Strategy 2008-2011*. Department of Environment and Climate Change, Sydney.

DECCW (2009a). Statement of Intent 2 - Infection of Frogs by Amphibian Chytrid Causing the Disease Chytridiomycosis. Department of Environment, Climate Change and Water (NSW), Sydney.

DECCW (2009b). *Draft Northern Rivers Regional Biodiversity Management Plan*, DECCW, Sydney.

DECCW (2009c). *Draft Border Ranges Rainforest Biodiversity Management Plan (NSW & Qld)*, DECCW, Sydney.

DEH (2000). *Revision of the Interim Biogeographic Regionalisation of Australia (IBRA) and the Development of Version 5.1. - Summary Report*. Department of the Environment and Heritage, Canberra.

DEH (2006). Threat Abatement Plan for Infection of Amphibians with Chytrid Fungus Resulting in Chytridiomycosis. Department of the Environment and Heritage, Canberra.

Doak, N. (2005). Phylogeography, dispersal and movement of Fleay's Barred Frog, *Mixophyes fleayi*. Unpublished Ph.D. Thesis, School of Environmental and Applied Sciences Griffith University, Queensland.

Donnellan, S. (2008). Genetic analysis of *Mixophyes balbus* from the Sydney Basin to far northern NSW. South Australian Museum. Unpublished Report.

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

DPI (2005). NSW Freshwater Fish Stocking Fish Management Strategy. NSW Department of Primary Industries.

Duellman, W. A. and Trueb, L. (1986). *Biology of Amphibians*. McGraw-Hill: New York.

Ensbey (2011). Noxious and Environmental Weed Control Handbook: A Guide to in Non-crop, Aquatic and Bushland Situations. Fourth Edition, Industry and Investment NSW Management Guide. http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0017/123317/noxious-and-environmental-weed-control-handbook.pdf. Accessed 13 June 2011.

FSC (2001a). Introduction of fish to fresh waters within a river catchment outside their natural range - Key Threatening Process listing, Fisheries Scientific Committee.

FSC (2001b). Degradation of native riparian vegetation along New South Wales water courses - Key Threatening Process listing, Fisheries Scientific Committee.

Gillespie, G. 2004. Personal observation. Senior Research Fellow, Zoology Department, University of Melbourne, Parkville 3052, Victoria.

Gillespie, G. 2004. . Unpublished data. Senior Research Fellow, Zoology Department, University of Melbourne, Parkville 3052, Victoria.Gillespie, G. R. (1997). Survey design and management prescriptions for the giant burrowing frog (*Heleioporus australiacus*) and the

Stuttering Frog (*Mixophyes balbus*). Unpublished report to the New South Wales National Parks and Wildlife Service.

Gillespie, G. R. (2001). The role of introduced trout in the decline of the spotted tree frog (*Litoria spenceri*) in south-eastern Australia. *Biological Conservation*, 100: 187-198.

Gillespie, G. R. (2002). Impacts of sediment loads, tadpole density, and substratum on the growth and development of tadpoles of the Spotted Tree Frog *Litoria spenceri*: an in-stream experiment. *Biological Conservation,* 106: 141-150.

Gillespie, G. R. and Clemann, N. (in review). The Spotted Tree Frog Recovery Plan: 2009-2014. Department of Environment, Heritage, Water and the Arts, Australia, Canberra.

Gillespie, G. R. and Hero, J.-M. (1999). Potential impacts of introduced fish and fish translocations on Australian amphibians. In: A. Campbell (Ed.) *Declines and Disappearances of Australian Frogs.* Environment Australia, Canberra, pp. 131-144.

Gillespie, G. R. and Hines, H. B. (1999). Status of Temperate Riverine Frogs in South-eastern Australia. In: A. Campbell (Ed.) *Declines and Disappearances of Australian Frogs.* Environment Australia, Canberra, pp. 109-130.

Gillespie, G. R. (2011). Survey for the Southern Barred Frog *Mixophyes balbus* in Victoria. Unpublished report to the Department of Sustainability and Environment, Orbost, Victoria.

Hamer, A.J, Makings, J. A., Lane, S. J. and Mahony, M. J. (2004). Amphibian decline and fertilizers used on agricultural land in south-eastern Australia. *Agriculture Ecosystems and Environment*, 102: 299-305.

Hero, J.-M. and Morrison, C. (2004). Frog Declines in Australia: global implications. *Herpetological Journal,* 14 (4):165-166.

Hines, H. B. and the South-east Queensland Threatened Frogs Recovery Team. 2002. Recovery plan for stream frogs of south-east Queensland 2001-2005. Report to Environment Australia, Canberra. Queensland Parks and Wildlife Service, Brisbane.

Hines, H., Mahony, M. and McDonald, K. (1999). An assessment of frog declines in wet subtropical Australia. In: A. Campbell (Ed.), *Declines and Disappearances of Australian Frogs*. Environment Australia, Canberra, pp. 44-63.

Hobbs, R. (2011). Unpublished data. Melbourne Zoo, Elliot Avenue, Parkville 3052 Victoria.

Holloway, S. E. and Osborne, W. S. (1996). The stream-breeding frogs of far East Gippsland. Unpublished report to the Department of Natural Resources and Environment, Victoria.

Hunter, D. (2001). Surveys and monitoring of threatened frog species in South-eastern New South Wales between October, 2000 and March, 2001. Unpublished report to the NSW National Parks and Wildlife Service.

Kiesecker, J. M., Blaustein, A. R. and Miller, C. L. (2001). Transfer of a pathogen from fish to amphibians. *Conservation Biology*, 15: 1064-1070.

Laurance, W. F., McDonald, K. R. and Speare, R. (1996). Epidemic disease and the catastrophic decline of Australian rain forest frogs. *Conservation Biology*, 10: 406-413.

Lemckert, F, Potter, M. Smith, B. and Bruest, T. (1997). Recent records of the southern barred frog *(Mixophyes balbus)* from the south coast of NSW. *Herpetofauna* 27: 43-45.

Lewis, B. D. (2011). Unpublished data. Lewis Ecological Services, 1877 Wallanbah Road, Bucca Wauka NSW 2429

Lewis, B. D. (2004). Personal communication. Lewis Ecological Services, 1877 Wallanbah Road, Bucca Wauka NSW 2429.

Lewis, B. D. (2004). Unpublished data. Lewis Ecological Services, 1877 Wallanbah Road, Bucca Wauka NSW 2429.

Lewis, B. D. (2000). A breeding observation of the Stuttering Frog (*Mixophyes balbus*) in Northern New South Wales. *Herpetofauna*, 30: 30-33.

Ligon, F. K., Dietrich, W. E. and Trush, W. J. (1995). Downstream effects of dams. *Bioscience*, 45: 183-192.

Lips, K. R., (1999). Mass mortality and population declines of anurans at an upland site in western Panama. *Conservation Biology*, 13: 117-125.

Longcore, J.E., Pessier, A.P. and Nichols, D.K. (1999). *Batrachochytrium dendrobatidis* gen et sp nov, a chytrid pathogenic to amphibians. *Mycologia*, 91: 219-227.

Mahony, M. J. (1993). The status of frogs in the Watagan Mountains area of the central coast of New South Wales. In: D. Lunney and D. Ayers (eds) *Herpetology in Australia: a Diverse Discipline*. Transactions of the Royal Zoological Society of New South Wales, Mossman, pp. 257-264.

Mahony, M. (1999). Great Barred River Frogs Research Plan. University of Newcastle. Report to the Australian Nature Conservation Agency.

Mahony, M. (2011). Unpublished data. School of Environmental and Life Sciences, University of Newcastle, Callaghan, NSW.Mahony, M., Knowles, R., and Pattinson, L. (1997). Stuttering Barred Frog (*Mixophyes balbus*). In: H Ehmann (Ed.) *Threatened Frogs of New South Wales: Habitats, Status and Conservation*. The Frog and Tadpole Study group of NSW Inc, Sydney South, pp. 66-71.

Mac Nally R, Horrocks G, Lada H, Lake PS, Thomson JR, Taylor AC (2009). Distribution of anuran amphibians in massively altered landscapes in south-eastern Australia: effects of climate change in an aridifying region. *Global Ecology and Biogeography,* 18: 575-585.

Morehouse, E.A., James, T.Y., Ganley, A.R.D., Vilgalys, R., Berger, L., Murphy, P.J. and Longcore, J.E. (2003). Multilocus sequence typing suggests the chytrid pathogen of amphibians is a recently emerged clone. *Molecular Ecology*, 12: 395-403.

Murray, K., Retallick, R., McDonald, K. R., Mendez, D., Aplin, K., Kirkpatrick, P., Berger, L., Hunter, D., Hines, H. B., Campbell, R., Pauza, M., Driessen, M., Speare, R., Richards,S. J., Mahony, M. J., Freeman, A., Phillott, A. D., Hero, J.-M., Kriger, K., Driscoll, D., Felton, A., Puschendorf, R. and Skerratt. L. F. 2010. The distribution and host range of the pandemic disease chytridiomycosis in Australia, spanning surveys from 1956–2007. *Ecology* 91:1557.

Newell, D. (2011). Unpublished data. School of Environmental Science and Management, Southern Cross University, Lismore, NSW.

NPWS (2001). NSW Hygiene Protocol for the Control of Diseases in Frogs. Threatened Species Management Information Circular No. 6. NSW National Parks and Wildlife Service, Hurstville.

Parris, K. M. (2001). Distribution, habitat requirements and conservation of the cascade treefrog (*Litoria pearsoniana*, Anura : Hylidae). *Biological Conservation*, 99: 285-292.

Parris, M. J. (2004). Hybrid response to pathogen infection in interspecific crosses between two amphibian species (Anura : Ranidae). *Evolutionary Ecology Research*, 6: 457-471.

Pounds J. A., Bustamante, M. R., Coloma, L., Consuegra, J. A., Fogden, M. P. L., Foster, P. N., La Marca, E., Masters, K. L., Merino-Viteri, A., Puschendorf, R., Ron, S. R, Sanchez-Azofeifa, G. A., Still, C. J. and Young, B. E.. (2006). Widespread amphibian extinctions from epidemic disease driven by global warming. *Nature* 439: 161–7.

SC (2005). Final Determination to list Alteration of habitat following subsidence due to longwall mining as a Key Threatening Process. Gazetted July 15 2005, NSW Scientific Committee, Sydney.

Steffen, W., Burbidge, A.A., Hughes, L., Kitching, R., Lindenmayer, D., Musgrave, W., Stafford Smith, M. and Werner, P.A. (2009). Australia's Biodiversity and Climate Change: Technical Synthesis. Department of Climate Change, Canberra.

Tyler, M. J. (1989). *Australian Frogs.* Viking O'Neil, Melbourne.

Tyler, M. J. (1997). *The Action Plan for Australian Frogs.* Wildlife Australia, Endangered Species Program.

Voyles, J., Young, S., Berger, L., Campbell, C., Voyles, W.F., Dinudom, A., Cook, D., Webb, R., Alford, R.A., Skerratt, L.F. and Speare, R. (2009). Pathogenesis of chytridiomycosis, a cause of catastrophic amphibian declines. *Science* 326: 582–585.

Vredenburg, V. T. (2004). Reversing introduced species effects: Experimental removal of introduced fish leads to rapid recovery of a declining frog. *Proceedings of the National Academy of Sciences*, 101: 7646-7650.

Webb, G. A. (1991). A survey of the reptiles and amphibians of Bondi State Forests and surrounding areas, near Bombala, New South Wales. *Australian Zoologist*, 27: 14-19.

White, A. (2000). The status of the barred river frogs, *Mixophyes balbus* and *Mixophyes iteratus* in the Sydney Basin Region of New South Wales. Biosphere Environmental Consultants P.L.

Woodhams, D.C., Alford, R.A. and Marantelli, G. (2003). Emerging disease of amphibians cured by elevated body temperature. *Diseases of Aquatic Organisms*, 55: 65-67.

## Priority, Feasibility and Estimated Costs of Recovery Actions

| Action | Description | Priority | Feasibility | Potential contributors | Cost estimate | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Total |
| **1** | **Distribution, status** | | | | $0 | $0 | $0 | $0 | $0 | $0 |
| 1.1 | Surveys | 1 | 100% | EPROEH, DSE, PV | $100,000 | $100,000 | $60,000 | $0 | $0 | $260,000 |
| 1.2 | taxonomy, genetics | 1 | 100% | EPROEH, DSE, PV, research institutions | $60,000 | $60,000 | $60,000 | $60,000 | $60,000 | $300,000 |
| 1.3 | Monitoring | 1 | 100% | EPROEH, research institutions | $20,000 | $20,000 | $40,000 | $40,000 | $0 | $120,000 |
| **2** | **Decline & threats** | | | | $0 | $0 | $0 | $0 | $0 | $0 |
| 2.1 | Chytrid fungus | 1 | 90% | EPROEH, CSIRO, research institutions | $45,00 | $45,000 | $8,000 | $7,000 | $5,000 | $110,000 |
| 2.2 | Hygiene protocols | 1 | 90% | EPROEH, CSIRO, research institutions, land managers | $10,000 | $10,000 | $2,000 | $2,000 | $2,000 | $26,000 |
| 2.3 | Fish introductions | 1 | 70% | EPROEH, I&I | $0 | $30,000 | $30,000 | $10,000 | $10,000 | $80,000 |
| 2.4 | Pests | 2 | 50% | EPROEH, I&I, DSE, PV, LGs, CMAs | $30,000 | $30,000 | $15,000 | $15,000 | $15,000 | $105,000 |
| 2.5 | Captive breeding* | 1 | 100% | EPROEH, ARC, ZV | $40,000 | $40,000 | $40,000 | $40,000 | $40,000 | $200,000 |
| 2.6 | Licence conditions | 1 | 80% | EPROEH, I&I | $30,000 | $30,000 | $10,000 | $10,000 | $10,000 | $90,000 |
| 2.7 | Recreation impact | 3 | 90% | EPROEH, I&I, DSE, PV | $15,000 | $15,000 | $5,000 | $5,000 | $5,000 | $45,000 |
| 2.8 | Site markers | 3 | 100% | EPROEH, I&I, DSE, PV | $10,000 | $10,000 | $5,000 | $5,000 | $5,000 | $35,000 |
| **3** | **Community support** | | | | $0 | $0 | $0 | $0 | $0 | $0 |
| 3.1 | Community awareness | 3 | 100% | EPROEH, ARC, zoos | $15,000 | $15,000 | $5,000 | $5,000 | $5,000 | $45,000 |
| 3.2 | Conservation guidelines | 2 | 100% | EPROEH, DSE | $15,000 | $15,000 | $5,000 | $5,000 | $5,000 | $45,000 |
| 3.3 | Indigenous communities | 3 | 100% | EPROEH | $30,000 | $20,000 | $5,000 | $5,000 | $5,000 | $65,000 |
| | | | | **Totals** | **$155,000.00** | **$145,000.00** | **$75,000.00** | **$75,000.00** | **$75,000.00** | **$525,000.00** |

* estimated costs should a captive breeding program for conservation be required

**Abbreviations:** ARC = Amphibian Research Centre; DECCW = Department of Environment Climate Change and Water NSW; I&I = Industry and Investment NSW; DSE = Department of Sustainability and Environment Vic; PV = Parks Victoria; ZV = Zoos Victoria; LGs = local governments; CMAs = Catchment Management Authorities

# Appendix 1. Detail of Recovery Actions

## Objective 1. Determine the distribution, habitat requirements, conservation status, taxonomy, population demography and genetic structure of Stuttering Frog populations.

*Performance criterion: Population location and structure, habitat requirements and populations critical to survival, are determined and information is available to land managers*

### Action 1.1: Undertake targeted surveys to establish the location and distribution of extant populations

A high priority for the Stuttering Frog Recovery Program is to undertake a systematic distributional survey across the entire historic range of this species. An accurate understanding of this species' current distribution is fundamental to the effective implementation of a Recovery Program. Given the broad extent of this species' former distribution, several survey teams operating across its entire distribution are required to achieve this action in a timely manner. Emphasis will be placed upon regions that have been poorly surveyed in the past and where knowledge gaps are largest, such as south of the Illawara catchment. An important initial stage in undertaking this survey will be the development of standard survey methods so that the probability of obtaining false negatives (not locating the species when it is actually present) is quantified and reduced. This will involve an analysis of existing data (particularly mark-recapture data) on this species, and also undertaking further studies to specifically assess different survey techniques.

An important aim of the broad scale survey is to characterise in more detail the habitat requirements of the Stuttering Frog and to determine patterns in the distribution of this species in relation to specific environmental parameters that may be informative about causes of decline. This is a necessary process for testing and developing hypotheses about the causal factors of the Stuttering Frog's decline. This will include an analysis of habitat variables specific to survey locations, and also broader landscape/catchment variables and processes. In particular, this analysis will focus on parameters that relate to hypotheses already identified as possible explanations for the decline of the Stuttering Frog (e.g. disease, habitat disturbance) and related species (see Hines 2002). The broad scale survey will also provide the basis for identifying high priority populations critical to the long-term survival of the species, and will be important in facilitating the implementation of other recovery actions **f**or the species.

**Potential contributors:** Environment Protection and Regulation, Office of Environment and Heritage, Department of Premier and Cabinet, NSW NSW, Dept. Sustainability & Environment Vic.

**Action 1.2: Determine geographic genetic structure; identify evolutionary significant units and their taxonomic status** Further genetic analyses are required to resolve potential taxonomic sub-division within the Stuttering Frog. A recent mitochondrial DNA study identified two lineages with significant divergence within the Stuttering Frog, which may warrant separate species status (Donnellan 2008). However, this study did not include samples further south of the Illawarra catchment, as there are currently no known extant populations in this region and it has not been possible to extract suitable genetic material from museum specimens. Other frog species with similar latitudinal distributions south of the Illawara show strong genetic and taxonomic subdivisions in this region, including members of the *Litoria citropa* species group, (Donnellan 1999) and the Giant Burrowing Frog, *Heleioporus australiacus* (M. Mahony unpublished data, 2011), so there is potential for further subdivision in the southern part of the species' range as well. The following tasks need to be undertaken to resolve these potential taxonomic issues:

1. Examine the morphology of museum specimens from the Barrington Tops/Mount Royal Range region.
2. Survey, collect and analyse male advertisement calls from the Barrington Tops/Mount Royal Range region.
3. Collect more tissue samples from frogs from the Barrington Tops/Mount Royal Range region for mitochondrial DNA sequencing in order to more accurately resolve the geographic relationships of different linearges.
4. Analyse nuclear genes to determine the extent of gene flow between the two lineages in the Barrington Tops/Mount Royal Range region.
5. Genetically screen samples from any populations located south of the Illawarra catchment through further survey work to determine if additional lineages exist within the Stuttering Frog

In addition to alpha taxonomic issues, the geographic relationships of ESUs needs to be resolved to augment identification of important populations and prioritization of other conservation actions.

**Potential contributors:** Environment Protection and Regulation, Office of Environment and Heritage, Department of Premier and Cabinet, NSW, South Australian Museum, University of Newcastle

**Action 1.3: Establish a population monitoring program of priority populations to determine population demography and evaluate the effectiveness of management actions.**

The aim of the monitoring program is to assess trends in population abundance/distribution across a representative sample of extant sites, and to provide a basis for assessing the effectiveness of management and research actions. Populations selected for monitoring will include those considered the highest priority for conservation; they will necessarily be spread across the current distribution of this species, incorporating all ESUs identified. Site selection will also consider biophysical areas that have suffered frog declines. For the Stuttering Frog this will specifically include sites at higher altitudes and latitudes. This program will be used to assess the influence of different land management practices, including agricultural areas on freehold land and habitat rehabilitation sites. Where possible, environmental factors that are suspected to be important in the decline or population regulation of the Stuttering Frog will also be monitored for the purpose of interpreting the nature of population fluctuations or change.

An important initial phase in undertaking this action is the development of rigorous monitoring protocols so that the level of population change perceived as important can be statistically determined from the monitoring results. This will involve an analysis of mark-recapture data already obtained for this species and related species (e.g. *M. fleayi* see Doak 2005; Hines 2002), and will require further mark-recapture/population studies to obtain additional information.

In addition to developing monitoring protocols, the mark-recapture studies will be important for obtaining the demographic parameters of age to sexual maturity, age-specific mortality, and levels of variation in mortality in relation to environmental factors (e.g. elevation or prevalence of Bd). Understanding these demographic parameters enables interpretation of future population changes observed. This information will also be used to develop demographic models for the Stuttering Frog, which can be used to design field experiments, predict population response to management actions, and evaluate long-term viability of different populations in relation to different key threats and management responses.

**Potential contributors:** Environment Protection and Regulation, Office of Environment and Heritage, Department of Premier and Cabinet, NSW; research institutions

## Objective 2. Identify and address the causal factors of the decline, and prevent the local extinction of important populations of the Stuttering Frog across its geographic range.

*Performance criterion: Major threats are determined and control measures formulated and implemented.*

**Action 2.1: Determine the demographic impact of the Amphibian Chytrid Fungus and its influence on potential population recovery.**

There is evidence that the Amphibian Chytrid Fungus *Batrachochytrium dendrobatidis* (Bd) has played a significant role in the rapid decline of several frog species in eastern Australia over the past three decades. It is important to determine the likely role of this pathogen in the decline of the Stuttering Frog, and to what extent this pathogen is restricting the capacity for this species to recover. Determining the historic impact of Bd will involve retrospective sampling of museum specimens, and laboratory experiments testing the level of sensitivity of the Stuttering Frog under a range of different environmental treatments that may be interacting with this pathogen (e.g. temperature, moisture, pollutants).

Determining the extent to which Bd is contributing to the current regulation of Stuttering Frog populations will involve assessing the distribution of this pathogen throughout the current range of the Stuttering Frog and incorporating pathogen testing into mark-recapture studies for this species. Determining the current distribution of Bd will be undertaken in conjunction with the broad-scale survey. Incorporating Bd testing into

mark-recapture studies will also allow an assessment of how infection rates may vary within a population over time, and how infection influences an individual frog's survival probabilities. This information can then be used to model the potential contribution of this disease to the overall regulation of Stuttering Frog populations, and how future climate change may exacerbate this. There is currently a National Threat Abatement Plan for the Amphibian Chytrid Fungus (DEH 2006) and a NSW Statement of Intent for the disease (DECCW 2009a). Undertaking this recovery action will be integrated with the implementation of these plans, along with recovery plans for other *Mixophyes* species (see Hines 2002) and temperate stream-breeding species in southeastern Australia, such as the Spotted Tree Frog, *Litoria spenceri* (Gillespie and Clemann in review). Reducing the impact of this pathogen in the field is likely to involve techniques aimed at reducing overall population stress, maintaining genetic variation and minimising spread via humans.

**Potential contributors:** Environment Protection and Regulation, Office of Environment and Heritage, Department of Premier and Cabinet, NSW, CSIRO, research institutions

**Action 2.2: Minimize spread of disease through implementation of most up to date protocols in the vicinity of all extant Stuttering Frog Populations.**

There is increasing awareness of the potential for pathogens to have a major impact on amphibian populations, and the potential for humans to act as vectors for these harmful pathogens. For this reason, all actions, recovery or otherwise, undertaken in the vicinity of Stuttering Frog populations will be reviewed for their potential to transport harmful pathogens. This is particularly the case for recovery actions that involve the handling of frogs or tadpoles (e.g. surveys and monitoring), or the moving of frogs/tadpoles/fish and water from one area to another (e.g. reintroduction programs, fish stocking). Hygiene protocols intended for use in the Stuttering Frog Recovery Program will be experimentally tested for their capacity to stop the spread of harmful pathogens before application in the field. All research and management being undertaken in the vicinity of Stuttering Frog populations will be evaluated for their capacity to introduce or spread harmful pathogens into and within the area. All research and management will implement the NSW NPWS hygiene protocols for minimising the spread of amphibian diseases (see NPWS 2001). An important aspect of this is ensuring that protocols are kept up to date and promoted amongst all potential spreaders of the disease.

**Potential contributors:** Dept. Environment, Climate Change & Water NSW, CSIRO, research institutions, other land managers

**Action 2.3: Minimise the impact of exotic and translocated native fish in streams containing extant populations of Stuttering Frogs**

The release of fish species, native or introduced, into streams supporting extant Stuttering Frog populations will be assessed for potential impacts on this species, focusing on the potential for elevated levels of predation on eggs and tadpoles, or the possible introduction of harmful pathogens. The 'NSW Freshwater Fish Stocking Fishery Management Strategy' (DPI 2005) currently has a prescription that no harvest stocking will occur within 5km radius of confirmed Stuttering Frog records in the Clarence River, Macleay River, Manning River and their tributaries. However, this strategy may not adequately achieve the purpose of protecting the Stuttering Frog from impacts of fish stocking because frog locality records are likely to represent survey localities rather than the actual distribution of the species. Furthermore, fish may disperse to extant frog sites if releases are in the same major catchment or river basin. Restricting fish stocking may also have some social impacts, and as such, imposing restrictions will be based on a case-specific assessment of the potential impacts on the Stuttering Frog.

In the absence of specific studies testing the impact of a fish species, recommendations for existing fish stocking programs will be based on an assessment of the Stuttering Frog population status. If the Stuttering Frog population is perceived to be either in a state of decline or threatened with local extinction due to small population size, then fish stocking will be discontinued unless a rigorous scientific assessment suggests otherwise. This assessment will include adequate experimental research and field correlative studies. New fish stocking programs in streams containing the Stuttering Frog will not be supported unless rigorous experimental research suggests no adverse impacts on the Stuttering Frog. Experimental research is often complicated by the limited capacity to relate the results of *ex-situ* studies to the field situation. Proposed stocking programs will not proceed until it is confirmed that the eggs and tadpoles are not palatable to the fish species in question. The only exception to this will be the stocking of indigenous fish species within their natural range for conservation purposes.An assessment of the potential for fish stocking programs to introduce potentially harmful pathogens to Stuttering Frog populations will be undertaken for all existing and

proposed fish stocking programs. This will involve field-testing, literature review, and determining whether facilities providing fish for stocking programs import material that may contain harmful pathogens. A document will be produced that can be used to assess new stocking proposals, and which can be updated whenever new information on amphibian pathogens is available. The release of any fish species, particularly non-indigenous species, into streams known or suspected to support extant populations of the Stuttering Frog will be considered potentially threatening until research demonstrates otherwise. In NSW, support will be given for the implementation of the actions identified in the draft NSW Fisheries (Industry and Investment NSW) Priorities Action Statement relating to introduction of fish to fresh waters within a river catchment outside their natural range.

In the event that introduced populations of exotic or native fish species are found to be harmful to Stuttering Frog populations, either by direct predation or facilitating disease transmission, then a feasibility assessment will be undertaken of eradication of harmful introduced fish species from priority Stuttering Frog streams.

**Potential contributors:** Environment Protection and Regulation, Office of Environment and Heritage, Department of Premier and Cabinet, NSW, Industry & Investment NSW

**Action 2.4: Determine the impact of exotic pests and, if necessary, implement control programs at high priority Stuttering Frog populations.**

The extent to which pests, particularly the Red Fox (*Vulpes vulpes*) and Feral Cat (*Felis catus*), prey on the Stuttering Frog is currently unknown; however indirect evidence suggests that this is a distinct possibility (Gillespie and Hines 1999). Predation events by carnivores on this species may be detected through direct observations during radio-tracking studies, or the trapping/shooting of carnivores and subsequent analysis of stomach contents. However, most Stuttering Frog populations are in low abundance and the probability of detecting predation events is likely to be very low and unlikely to provide a real evaluation of its significance to population decline or recovery. A more informative approach would be to reduce predator abundance and monitor the subsequent response of the frog populations as has been done for threatened critical weight-range mammals in various parts of Australia. Strategic broadscale predator baiting programs have already been established in NSW and Victoria in areas where the Stuttering Frog is formally known to occur or potentially persists. Monitoring and evaluation of Stuttering Frog and other terrestrial frog species population responses will be undertaken at sites within existing broadscale baited areas and compared to non-baited areas through monitoring at other priority Stuttering Frog sites. In the event that a significant benefit of predator suppression to Stuttering Frog populations is detected, then the feasibility of establishing predator suppression programs at other priority Stuttering Frog sites should be assessed.

Another potential threat is the Cane Toad (*Rhinella marina*), which has recently been detected at high altitude in the Border Ranges northern NSW and could reach areas occupied by Stuttering Frogs (Newell pers. comm.5/5/2011 ). Monitoring and containment on private and public land are recommended, as is the continued implementation of the NSW National Parks and Wildlife Northern Rivers Region Pest Management Strategy (DECC 2007).

Other pests that degrade and destroy Stuttering Frog habitat, such asWild Pig (*Sus scrofa*) should be controlled in priority Stuttering Frog population areas.

**Potential contributors:** Dept. Environment, Climate Change & Water NSW, Industry & Investment NSW, local government, Catchment Management Authorities

**Action 2.5: Establish a captive breeding program capable of augmenting reintroductions of Stuttering Frogs at selected extinction sites or for enhancement of extant populations**

At a minimum, establishment of a viable captive breeding program provides insurance against potential future population extinctions. For populations that are critically small but considered a high priority for conservation, reintroduction may be used to augment or enhance the viability of the population to by time for addressing key threats.

As knowledge and understanding of key threatening processes improves, it may be possible to undertake re-introductions at extinct sites to increase the geographic security of the species. Experimental reintroductions

may also be used to experimentally test the effects of specific threatening processes, such as fish predation, or Bd infection and mortality rates.

The Stuttering Frog has been successfully maintained and bred in captivity (R. Hobbs unpublished data 2011), which indicates that a captive breeding program for conservation of the species can be successfully employed in the recovery program.In the interim, viable captive breeding programs will be established for at least two Stuttering Frog ESUs.

The outcomes of further surveys (see Action 1.1), genetic studies (see Action 1.2) and identification of priority populations will provide a basis for evaluating the potential role of captive breeding and introduction at various sites.

All proposals for captive breeding of the species will have a clear set of objectives and operational guidelines and will examine other alternatives such as gene banking.

**Potential contributors:** Environment Protection and Regulation, Office of Environment and Heritage, Department of Premier and Cabinet, NSW, Amphibian Research Centre, Melbourne Zoo

**Action 2.6: Develop effective license conditions and interim protocols to minimise adverse impacts of all commercial activities near to, and up stream of, all Stuttering Frog populations.**

A number of management and commercial activities occur immediately adjacent to, upstream, or below Stuttering Frog populations (e.g. road maintenance, forestry activities, mining). Some of these activities are subject to existing codes, licence and approval conditions that aim to protect the Stuttering Frog from any major impacts. However, the effectiveness of these conditions has not been rigorously assessed. Determining effective licence and approval conditions will be based on information from various recovery actions including assessing the probability of Stuttering Frog occurrence in areas subjected to different management and commercial activities, ongoing monitoring of populations in areas subject to different activities and fine-scale genetic analysis assessing the potential for population fragmentation. Specific studies assessing the direct impacts of management and other activities will also be required for adequately assessing the effectiveness of licence and approval conditions (e.g. radio-tracking, siltation experiments).

Prior to the development of rigorous licence conditions, a set of interim protocols will be implemented based on current knowledge of the Stuttering Frog's ecology and the precautionary principle. These interim protocols will include different levels of restrictions or habitat protection based on the relative status of the populations that may be affected by the activity. The relative status of different populations will be determined as part of surveys for the species, and will consider other potentially threatening processes occurring in the catchment. Developing protocols as a best practice standard would also allow for distribution to activity and development approval authorities.

**Potential contributors:** Environment Protection and Regulation, Office of Environment and Heritage, Department of Premier and Cabinet, NSW, Industry & Investment NSW

**Action 2.7: Minimise the impact of recreational activities at all extant population sites and in headwater subcatchments.**

Recreational activities may have significant local impacts on the Stuttering Frog, primarily through disruption to critical riparian and in-stream habitats (e.g. four-wheel driving, trail bikes, and public camping close to riparian areas, bush walking). Assessing these impacts will be achieved through the identification of recreational activities that may impact on this species, production of a data sheet that can be disseminated to relevant public land managers to identify specific locations where these activities may be occurring adjacent to Stuttering Frog habitat, and field data collection and assessment at these localities to determine whether an impact is likely to be occurring (see Action 1.1). If particular activities are identified as likely to be having an adverse impact on the Stuttering Frog, appropriate measures will be put in place to minimise those impacts by the responsible local land management agency. Measures may include potential restricted use of roads traversing habitat, improvements to bridge crossings and erosion mitigation measures on public roads, relocation of camp sites, or re-alignment walking trails. If this involves restricting the public from continuing certain activities, appropriate signage will be installed that outlines the broader Recovery Program for this species and why restrictions have been implemented. Minimising the impact of recreational activities would also be linked to other actions such as implementation of hygiene protocols.

**Potential contributors:** Environment Protection and Regulation, Office of Environment and Heritage, Department of Premier and Cabinet, NSW , Parks Victoria, Dept. Sustainability & Environment Vic, other public land managers

**Action 2.8: Incorporate markers for site recognition at all extant population sites.**

Critical riparian habitat for the Stuttering Frog often runs parallel or is crossed by areas subject to ongoing intensive management, particularly roads and walking tracks. These areas need to be readily identifiable by management staff and contractors so that actions can be adjusted in accordance with specific guidelines to minimise impacts on this species. This will be achieved through access to Stuttering Frog records, but will also involve installation of appropriate markers on the ground for more accurate site location and to avoid sites being overlooked. Several marker systems are already in use across NSW and adopting existing systems for this and other threatened species programs will allow site identification without specific reference to a particular species, and will create a general awareness of the significance of areas containing these markers and how to obtain information relative to the site.

**Potential contributors:** Environment Protection and Regulation, Office of Environment and Heritage, Department of Premier and Cabinet, NSW , Parks Victoria, Dept. Sustainability & Environment Vic, local governments, other public land managers

## Specific Objective 3. Build community support for the Stuttering Frog recovery program.

*Performance criterion: There is community support for and involvement in the recovery program for the Stuttering Frog.*

**Action 3.1: Promote public education and awareness of the Stuttering Frog and the actions required for its recovery**

Given the broad distribution of the Stuttering Frog across different land tenures, and the range of threatening processes identified for this species, promoting education and awareness amongst the general public is an integral component of this Recovery Program. Public exposure increases the capacity for Recovery Programs to generate involvement, sponsorship and funding. Promoting an understanding about the conservation of a species may also reduce levels of negative sentiment if recreational and commercial activities are restricted as part of the Recovery Program. A number of strategies will be pursued to achieve greater education and awareness for this program. Fact sheets and information brochures will be produced and made available at appropriate shop-front and information centres, and distributed through Landcare networks within the historic range of the Stuttering Frog. Public seminars and field days for Landcare and other interest groups will also be undertaken. This is particularly important for gaining interest and willingness from private landowners to rehabilitate and protect habitat for this species. Field days will involve demonstrations of how to survey for and identify the species (including hygiene protocols), how to protect and enhance Stuttering Frog habitat, and how people can become more involved in the Recovery Program for this species. Broader dissemination of information about this Recovery Program will be pursued through media releases and publications in popular journals and magazines. Zoological gardens and other husbandry institutions involved in captive breeding programs for this species will be encouraged to develop public displays that outline the Recovery Program for this species. Appropriate signage will also be provided for areas that receive public visitation and where management actions are being undertaken.

**Potential contributors:** Environment Protection and Regulation, Office of Environment and Heritage, Department of Premier and Cabinet, NSW , Department of Sustainability and Environment, Victoria, Amphibian Research Centre, Melbourne Zoo, Taronga Zoo

**Action 3.2: Develop conservation and management guidelines for habitat protection and restoration for public land management agencies and private land managers**

There are increasing opportunities for government agencies, local communities, private institutions and individuals to undertake habitat protection and rehabilitation, particularly in riverine environments on private property. Providing information and integrating these programs so that they meet Stuttering Frog conservation requirements will greatly benefit the recovery of this species. This will be facilitated through the production of a document that details how such programs fit into the broader Stuttering Frog Recovery Program; available options for funding such programs; specific requirements and costs of protecting and

rehabilitating habitat for this species; and how to incorporate individual programs into a broader monitoring and assessment of habitat rehabilitation for the Stuttering Frog. Guidelines for protecting and rehabilitating Stuttering Frog habitat will be developed, using the results of surveys and demographic studies of this species. A starting point for these guidelines will be existing plans relating to protection and restoration of *Mixophyes* species habitat in NSW and Queensland (see Hines 2002).

**Potential contributors:** Environment Protection and Regulation, Office of Environment and Heritage, Department of Premier and Cabinet, NSW

**Action 3.3: Identify and develop initiatives to increase participation of indigenous communities in the recovery program**

The significance of the Stuttering Frog to Aboriginal communities needs to be ascertained to provide opportunities for local Aboriginal Land Councils, Elders and other groups representing indigenous people in the areas where the Stuttering Frog occurs to comment on, and become involved in various recovery actions. The cultural significance of the Stuttering Frog will include a determination on whether this species has particular cultural status, or whether recovery actions may occur in culturally important areas. The DECCW indigenous engagement toolkit to assist indigenous communities achieve practical and sustainable results from the engagement process will be utilised (see DECCW 2009b and 2009c). This includes providing opportunities for the preparation of property management plans on Indigenous-owned land as well as supporting training and employment of the owners of this land to allow them to obtain funds and skills to implement the property plans.

**Potential contributors:** Environment Protection and Regulation, Office of Environment and Heritage, Department of Premier and Cabinet, NSW