



Green and Golden Bell Frog
Litoria aurea (Lesson 1829)
Recovery Plan



draft for public comment

February 2005

Department of
**Environment and
Conservation (NSW)**

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Requests for information or comments regarding Green and Golden Bell Frog Recovery Plan should be directed to:-

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Department of Environment and Conservation NSW Recovery Planning Program

Green and Golden Bell Frog
***Litoria aurea* (Lesson 1829)**

Draft Recovery Plan

Prepared in accordance with the New South Wales
Threatened Species Conservation Act 1995
and the Commonwealth
Environment Protection Biodiversity Conservation Act 1999

February 2005

Executive Summary

This document constitutes the draft Commonwealth and New South Wales State Recovery Plan for the Green and Golden Bell Frog *Litoria aurea* (Lesson 1829), and as such considers the conservation requirements of the species across its known range. It identifies the future actions to be taken to ensure the long-term viability of the Green and Golden Bell Frog in nature and the parties who will carry out these actions.

The Green and Golden Bell Frog *Litoria aurea* is listed as Vulnerable nationally under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and as Endangered on Schedule 1, under the NSW Threatened Species Conservation Act 1995.

The Green and Golden Bell Frog (GGBF) has gone from being one of the more commonly encountered frogs, present in vast numbers throughout the most populated areas of eastern Australia, including the Sydney Region, to being one of the most threatened. It has also attained an extremely high profile for a number of other reasons. It was the first frog encountered on arrival at Botany Bay in 1770 by Cook's party. It was discovered as a remnant population at the Sydney Olympic Park area at Homebush Bay and its motif was mooted as a mascot for the Sydney 2000 Olympics. Its symbol was eventually used in a promotional way at the Royal Agricultural Show and by ORTA and is also used in Catchment Management signage being symbolic of returning the health of catchments to a condition where the species again flourishes. It is ironic that today the species still persists at Kurnell, the birth place and gateway to modern Australia, and also that a large Bell Frog sculpture at Kingsford Smith Airport ensures that the GGBF is the last Australian animal people encounter prior to departing Australia's contemporary gateway. Finally and most importantly the species has significance due its somewhat remarkable life strategies, its role in the ecosystem and its fight for life story. Consequently the species has risen to icon status and is representative of the more widespread concern felt regarding the National decline of frogs generally.

Remarkably it is still found in various small pockets of habitat in otherwise developed areas and has the tendency of often turning up in highly disturbed sites. Unfortunately this has further raised its status for the wrong reasons and earned it a less than endeared profile among some developers who have had to deal with its threatened status. But even here the frogs endearing nature has won over some proponents and resulted in positive and sensitive development outcomes.

Its former distribution was predominantly coastal but extended inland to the central and southern tablelands, including Bathurst in the west. It was known from the northern coastal part of NSW from around Brunswick Heads south along the entire NSW coast extending into the north-eastern portion of Victoria. Today the Green and Golden Bell Frog has dwindled to its current status with a fragmented distribution of mainly near coastal locations. There are 43 identified remaining key populations some comprising tenuously connected sub-populations. Only twelve of these populations are represented within sections of conservation reserves and the remainder located on other lands with various tenures.

Several broad threatening processes are operating and have caused fragmentation and decline across the species distribution and it displays the classic symptoms generally associated with patterns of decline exhibited by other broad ranging threatened species. The threatening processes thought to be operating at a distribution wide level include disease, predation on larvae by exotic fish and broad scale habitat alteration, isolation and loss. Other threats with uncertain impacts are also operating to a greater or lesser extent on the various populations and include: pesticides, agricultural chemicals, water quality issues, predator/prey interactions with cane toads and other stochastic and incremental impacts due to development pressures operating on specific populations.

To provide for the future recovery of The Green and Golden Bell Frog (GGBF), this recovery plan advocates a program that:

- increases the security of key GGBF populations by way of preventing the further loss and favouring in-situ protection and management of GGBF habitat at key populations as well as secure opportunities for increasing the protection of these habitat areas;
- ensure extant GGBF populations are managed to eliminate or attenuate the operation of factors that are known or discovered to be detrimentally affecting the species;
- implement habitat management initiatives informed through a coordinated monitoring program;

- establish self sustaining and representative colonies of 'at risk' captive populations of the GGBF for the primary purpose of maintaining 'insurance' colonies for re-establishment and supplementation; and
- through educational programs and involvement increase the level of regional and local awareness of the conservation status of the GGBF and provide opportunity for community participation in the implementation of this recovery plan.

This recovery plan will be implemented over a five-year period. The total cost to implement the plan is estimated to be \$973,000 over this five years. The annual implementation cost equates to around \$4,500 per key population per year. Obviously some sites may require more funding than others. Costs for the majority of actions will be met by recurrent funds of the responsible parties; funding opportunities will be sought to assist implementing urgent actions identified in site management plans.

I now invite you to make a written submission to the Department of Environment and Conservation (DEC) regarding this draft recovery plan prior to the advertised closing date. Please refer to Appendix 5 for how to make such a submission. Following consideration of comments the plan will be finalised by the Director General and the Minister for the Environment.



Simon A.Y. Smith
Deputy Director General
Environment Protection and Regulation Division

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- access to or advice on unpublished post graduate research findings or other investigations that were in progress;
- provision of specific site information and otherwise unreported records;
- participation in site specific actions and assistance through the establishment of and participation in “Friends of GGBF Groups” and their related activities;
- support for translocation programs and the establishment of captive breeding colonies;
- permission for entry on private lands and/or a sympathetic approach to land management; and,
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1 Introduction

The Green and Golden Bell Frog (*Litoria aurea* Lesson, 1829) is a high profile frog species belonging to the Tree-frog Family Hylidae (Pelodyadidae of some authorities). It was once one of the more common frog species in the Sydney region, and was in fact very common throughout its entire range. Its former distribution was, and still is; predominantly coastal but did extend inland at least as far as Bathurst, its type locality. It also occupied, in part, the elevated tablelands in the north and south of the State. However today its distribution is markedly reduced to isolated remnant populations of varying size and, in many instances, of poor long-term conservation security.

This plan describes our current understanding of the Green and Golden Bell Frog *Litoria aurea*, documents the research and management actions undertaken to date, and identifies the actions required and parties responsible to ensure the ongoing viability of the species in the wild.

The Green and Golden Bell frog is a highly significant species. Not only has it gone from being one of the most common frogs encountered, present in vast numbers throughout the most populated areas of eastern Australia to being one of the most threatened, but it has also attained an extremely high profile for a number of other reasons. This has included its discovery as a remnant population at the Sydney Olympic Park site at Homebush Bay and its proposed status as a mascot for the Sydney 2000 Olympics, to its promotional use by the Royal Agricultural Show and ORTA (Olympic Roads and Transport Authority), also at Homebush. Even some Catchment Management Committees (later amalgamated as Catchment Management Boards and now Catchment Management Authorities) adopted the species as a motif for signage, symbolic of healthy land and water and with the objective of returning or maintaining catchments in a condition where this species can again flourish.

Remarkably the species is still found in small pockets of habitat in Sydney and has the tendency of quite often turning up in highly disturbed sites. Unfortunately this has further raised its status for the wrong reasons and earned it a less than endeared profile among some developers who have had to deal with its threatened status. But even here, in some instances, the frog's disposition has won over proponents and resulted in positive and sensitive development outcomes.

Historically it is also a species of some importance in that it was one of the first species encountered by Cook on his arrival at Botany Bay and ironic that a significant population still persists today at Kurnell, the 'birth place' of modern Australia. The erection of a large frog edifice at Kingsford Smith Airport depicting the Green and Golden Bell Frog means that today the last Australian animal encountered when leaving Australia through its main international gateway is the Green and Golden Bell Frog.

Finally and probably most importantly the species has significance due its somewhat remarkable life strategies, its plight and its 'fight for life' story are the reasons it has risen, to icon status and representative of the concern felt regarding the decline of frogs generally.

2 Legislative Context

2.1 Legal status

In NSW the Green and Golden Bell Frog *Litoria aurea* is listed as endangered under Part 1 of Schedule 1 of the Threatened Species Conservation Act 1995 (TSC Act). The species was transferred to the TSC Act Schedules from Schedule 12 of the National Parks and Wildlife Act 1974 (NPW Act), as amended by the Endangered Fauna Interim Protection Act 1991 (EFIP Act), with the ascent of the new Act.

At the National level the Green and Golden Bell Frog is listed as Vulnerable under Schedule 1 Part 2 of the *Environment Protection and Biodiversity Conservation Act 1999* (EP&BC Act 1999). This Act replaced the Endangered Species Protection Act 1992 (ESP Act 1992) and has adopted its schedules as an interim measure. In Victoria the species is not listed as "threatened" under the Victorian Flora and Fauna Guarantee Act 1988 (Mansergh *et al.*, 1993).

The consequences of being listed as a Threatened Species under the EPBC Act 1999 (Cth) and the TSC Act 1995 (NSW), are that a recovery plan must be prepared and considerations given to the species when assessing the impacts of developments and activities on populations of the species or its habitat.

2.2 Recovery plan preparation

The TSC Act 1995 (NSW) provides the legislative framework to protect and encourage the recovery of threatened species, endangered populations and endangered ecological communities in NSW. Under this legislation the Director-General of National Parks and Wildlife (NPW) has a responsibility to prepare Recovery Plans for all species, populations and ecological communities listed as endangered or vulnerable on the TSC Act schedules. Similarly, the EP&BC Act 1999 (Cth) requires the Commonwealth Minister for the Environment to ensure the preparation of Recovery Plans for nationally listed species and communities or to adopt plans prepared by others including those developed by State agencies. Both Acts include specific requirements for the matters to be addressed by Recovery Plans and the administrative process for preparing Recovery Plans.

This Recovery Plan has been prepared to satisfy both the requirements of the TSC Act and the EP&BC Act and therefore will be the only Recovery Plan for the species. It is the intention of the Director-General of DEC to forward the final version of this draft Recovery Plan to the Commonwealth Minister of the Environment for adoption, once it has been approved by the NSW Minister for the Environment.

2.3 Recovery plan implementation

The TSC Act requires that a public authority must take any appropriate measures available to implement actions included in a Recovery Plan for which they have agreed to be responsible. Public authorities and councils identified as responsible for the implementation of Recovery Plan actions are required by the TSC Act to report on measures taken to implement those actions. In addition, the TSC Act specifies that public authorities must not make decisions that are inconsistent with the provisions of this Plan.

The EP&BC Act states that the Commonwealth must implement a Recovery Plan on those areas that apply to Commonwealth lands. The EP&BC Act additionally specifies that a Commonwealth agency must not take any action that contravenes a Recovery Plan.

Commonwealth and NSW public authorities responsible for the implementation of this Recovery Plan are:

- Commonwealth Government Departments – Department of Defence and Department of Environment and Heritage (DEH).
- NSW Government Departments – DEC (formerly NPWS), Department of Primary Industry – Trading DPIT (formerly SFNSW), Department of Infrastructure Planning and Natural Resources (DIPNR), Department of Commerce, Department of Primary Industry Fisheries (formerly NSW Fisheries), Sydney Water, Rural Fire Service, Sydney Olympic Park Authority (SOPA), Freightcorp, RailCorp (formerly State Rail Authority of NSW and Rail Infrastructure Corporation – RIC), NSW Department of Corrective Services and the Roads and Traffic Authority.

- Local Government areas administered by the Councils of – Armidale-Dumaresq, Ashfield, Auburn, Ballina, Bankstown, Bathurst, Baulkham Hills, Bega Valley, Blacktown, Blayney, Blue Mountains, Bombala, Botany Bay, Burwood, Byron, Camden, Campbelltown, Canada Bay, Canterbury, Cessnock, Cooma-Monaro, Crookwell, Dungog, Eurobodalla, Evans, Fairfield, Gloucester, Gosford, Goulburn, Grafton, Great Lakes, Greater Lithgow, Greater Taree, Gunning, Guyra, Hastings, Hawkesbury, Holroyd, Hornsby, Hunters Hill, Hurstville, Kempsey, Kiama, Kogarah, Ku-ring-gai, Lake Macquarie, Lane Cove, Leichhardt, Lismore, Liverpool, Maclean, Maitland, Manly, Marrickville, Merriwa, Mossman, Mulwaree, Murrurundi, Muswellbrook, Nambucca, Newcastle, North Sydney, Nundle, Oberon, Parramatta, Pittwater, Port Stephens, Penrith, Pristine Waters, Queanbeyan, Randwick, Richmond River, Rockdale, Ryde, Rylstone, Scone, Severn, Shellharbour, Shoalhaven, Singleton, Snowy River, South Sydney, Strathfield, Sutherland, Sydney, Tallaganda, Walcha, Warringah, Waverley, Willoughby, Wingecarribee, Wollondilly, Wollongong, Woollahra, Wyong, Yarralumla and Yass.

Consequently, public authorities who manage lands containing habitat of the Green and Golden Bell Frog, must, as the relevant land manager, manage the populations and habitat within those lands, in accordance with this plan. Relevant land management issues include wetland, estuary and riparian zone management, stormwater management, grazing and clearing, fire management, feral predator control, pesticide/herbicide use, habitat disturbance, environmental impact assessment and strategic planning.

2.4 Relationship to other legislation

The Green and Golden Bell Frog is known to occur across a broad area of NSW and across various land tenures. This includes lands owned and/or managed by the Commonwealth, NSW and Local Government agencies indicated in 2.3 above as well as private landowners.

Relevant legislation that may effect *Litoria aurea* populations includes:

- National Parks and Wildlife Act 1974 (NSW) – (NPW Act 1974)
- Threatened Species Conservation Act 1995 (NSW) – TSC Act 1995)
- Environmental Planning and Assessment Act 1979 (NSW) – (EP&A Act 1979)
- Local Government Act 1993 (NSW) – (LG Act 1993)
- Forestry and National Parks Estate Act 1998 – (FNPEA Act 1998)
- Crown Lands Act 1989 (NSW) – (CL Act 1989)
- Rural Fires Act 1997 (NSW) – (RF Act 1997)
- Native Vegetation Conservation Act 1997 (NSW) – (NVC Act 1997)
- Rivers and Foreshores Improvement Act 1948 – (NSW)
- Protection of the Environment Operations Act 1997 (NSW) – (POEO Act 1997)
- Pesticides Act 1999 (NSW)
- Fisheries Management Act 1994 – (NSW)
- Water Management Act 2000 – (NSW)
- Environmental Protection and Biodiversity Conservation Act 1999 (Cth) – (EP&BC Act 1999)

2.5 Critical habitat

The EP&BC Act 1999 (Cth) and the TSC Act 1995 (NSW) make provision for the identification and declaration of critical habitat for species, populations and ecological communities listed as endangered. Under the TSC Act, Critical Habitat may be identified for any endangered species, population or ecological community occurring on NSW lands and is defined as “the whole or any part or parts of the area or areas of land comprising the habitat of an endangered species ... that is critical to the survival of the species”. Once declared, it becomes an offence to damage critical habitat (unless the action is exempted under the provisions of the TSC Act 1995). A Species Impact Statement is mandatory for all developments and activities proposed within declared Critical Habitat and they require the concurrence of the Director General of the DEC before any approval is given. Under the EP&BC Act 1999 (Cth) the Federal Minister for the Environment must keep a register of habitat critical to the survival of a species or ecological community listed under that Act. Under the EP&BC Act, Critical Habitat may be registered for any nationally listed threatened species or ecological community. When adopting a Recovery Plan the Federal Minister for the Environment must consider whether to list habitat identified in the Recovery Plan as being critical to the survival of the species or ecological community. It is an offence under the EP&BC Act for a

person to knowingly take an action on a Commonwealth area that will significantly damage Critical Habitat (unless the EP&BC Act specifically exempts the action). Although this offence only applies to a Commonwealth area, any action that is likely to have a significant impact on a listed species occurring within registered Critical Habitat on other areas is still subject to referral and approval under the EP&BC Act. Proposed actions within registered Critical Habitat on non-Commonwealth areas are likely to receive additional scrutiny by the Commonwealth Minister.

To date Critical Habitat, as defined by the TSC Act, has not been declared for the Green and Golden Bell Frog.

The declaration of critical habitat in NSW is not currently considered a priority for the species as other mechanisms provide for its protection. This decision may be reviewed on the basis of additional information.

2.6 Key Threatening Processes

“Predation by the introduced Plague Minnow or Mosquito Fish *Gambusia holbrooki*” was listed on 20 September 1999 as a Key Threatening Process (KTP) under Schedule 3 of the TSC Act 1995 (NSW). *Gambusia holbrooki* is known to attack the tadpoles and spawn masses of *Litoria aurea* as well as other frog species and this has been demonstrated/observed in the field and under laboratory conditions (Webb, 1994; Morgan and Buttemer, 1996; Webb and Joss, 1997; Pyke and White, 2001; NPWS, 2001). The decision by the NSW Scientific Committee to list this KTP was based on the above information and the circumstantial evidence of declines in *Litoria aurea* correlated to *Gambusia holbrooki* distribution. The consequences of listing this Key Threatening Process is that activities that may lead to or are likely to result in *Gambusia* entering or proliferating in habitat of the GGBF needs to be considered as a component of any formal environmental impact assessment process.

The Threat Abatement Plan (TAP) for *Predation by Gambusia holbrooki – the Plague Minnow* was approved in August 2003.

Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands was listed as a KTP on 31 May 2002. This key threatening process has clearly had a significant impact on the habitat of this species throughout its range and is a process continuing to have such impacts at some sites or has the potential to do so at others (section 8, p.47). At the time of publication no TAP has been prepared for this KTP.

Amphibian chytridiomycosis, a disease, was listed as a key threatening process under the EP&BC Act 1999 (Cth) on 23 July 2002. *Litoria aurea* is a species of amphibian known to be affected by this disease (M. Christy; K. Rose; L. Berger; M. Mahony; all pers. comm.; Speare and Berger, 2000) as is another Bell Frog group member *L. moorei* (Aplin and Kirkpatrick, 2001). The disease was also listed as a KTP on schedule 3 of the TSC Act 1995 (NSW) on 22 August 2003.

Other KTPs that have been listed and have relevance to *Litoria aurea* include:

Clearing of Native Vegetation (as defined and described in the final determination of the NSW Scientific Committee on 21 September 2001). This KTP includes within its definition, destruction of habitat, fragmentation of vegetation and degradation of riparian zone vegetation. It also identifies removal of native vegetation for cropping, urban, industrial and infrastructure development as causative agents. At the time of publication no TAP has been prepared for this KTP.

Predation of the European Red Fox *Vulpes vulpes* (Linnaeus, 1758) was listed as a KTP on 20 March 1998 and a TAP was approved by the NSW Minister for the Environment on 12 December 2001. It should be noted that *Litoria aurea* has not been identified as a primary prey species impacted by this KTP within the DEC (NPWS) Fox Threat Abatement Plan. However, the remains of *Litoria aurea* have been identified in fox scats within key populations of the species (M. Christy pers. comm; A. Hamer pers. comm.) and so it is therefore likely that local populations already under stress from the cumulative impact of other threats could be further impacted by fox predation. The predator/prey interaction between *L. aurea* and the European Red Fox requires further investigation.

2.7 Environmental planning and assessment

2.7.1 State environmental planning and assessment

Among other things, the New South Wales *Environmental Planning and Assessment Act 1979* (EP&A Act) provides for the protection and conservation of biodiversity (including threatened species, populations and ecological communities), via a series of provisions relating to landuse planning and assessment of development proposals. There are specific responsibilities for Councils, landowners, and government agencies throughout the plan making (Part 3) and environmental assessment (Parts 4 & 5) processes, as well as various opportunities for community input and involvement in each. A best practice approach to incorporating biodiversity objectives into landuse planning is provided in *The Biodiversity Planning Guide for NSW Local Government* (NSW NPWS, 2001b).

EP&A Act, Part 3: preparation of environmental planning instruments

Part 3 of the EP& A Act provides the statutory framework for strategic planning in NSW. It includes the statutory requirements in relation to the preparation of environmental planning instruments (EPIs), including State Environmental Planning Policies, Regional Environmental Plans, and Local Environmental Plans. Among other things, EPIs may make provision for protecting and conserving native animals and plants, including threatened species, populations and ecological communities, and their habitats [EP&A Act, s26(1)(e1)].

In relation to the local environment plan (LEP) making process there are specific consultation requirements where critical habitat and/or threatened species, populations, ecological communities and their habitats (hereafter ‘threatened species’) are concerned. Under s34A it is a requirement that, prior to the preparation of a Local Environmental Study (LES) or the making of a Draft LEP, Councils consult with the Director-General of the DEC if threatened species and/or critical habitat “will or may be affected”.

To carry out its statutory obligations under s34A, Councils should obtain sufficient information to form an opinion as to whether threatened species and/or critical habitat will or may be affected by a proposed LES and/or Draft LEP. Documentary evidence that a council has formed an opinion regarding whether or not threatened species and/or critical habitat “will or may be affected” should be included when a council notifies the Department Infrastructure Planning and Natural Resources (DIPNR) under s54 of the EP& A Act of its decision to prepare a LES or Draft LEP.

The DEC considers that the Green and Golden Bell Frog Recovery Plan may assist councils in making an informed opinion as to whether a proposed LEP will or may significantly affect the species. Additionally this recovery plan, and any critical habitat that may be declared in the future, should form a component of any relevant s34A consultation regarding the Green and Golden Bell Frog. This Recovery Plan may also need to be considered under s62 where further consultation may be triggered when a council determines to proceed with a LES and/or Draft LEP that, in this instance, will or may affect Green and Golden Bell Frog or other matters identified in this recovery plan.

EP& A Act Part 4 and Part 5: Development and environmental assessment

The EP&A Act requires that consent and determining authorities, and the Director-General of the DEC as concurrence authority, consider threatened species when exercising a decision-making function under Parts 4 (s78 and s79) and 5 (s112) of the EP&A Act (see also s69 and s71 of the TSC Act). Where the Minister for Planning and Infrastructure is the consent authority there may also be a requirement to consult with the Minister for the Environment before consent is granted. Further information on statutory requirements for development and environmental assessment regarding threatened species is found in [NPWS Information Circular No. 2 November 1996– Threatened Species Assessment under the EP& A Act: 8 part test; NPWS Policy and Procedures Statement No. 2 March 1998– Concurrence and Consultation; and NPWS Information Circular No. 5 June 1998- Species Impact Statements].

The following NSW authorities are currently known to have a decision making function in relation to *Litoria aurea* and its habitat as a component of their planning and environmental impact assessment role:

- The Local Governments of Armidale-Dumaresq, Ashfield, Auburn, Ballina, Bankstown, Bathurst, Baulkham Hills, Bega Valley, Bellingen, Blacktown, Blue Mountains, Bombala, Botany Bay, Burwood, Byron, Camden, Campbelltown, Canada Bay, Canterbury, Cessnock, Coffs Harbour, Cooma-Monaro, Crookwell, Dungog, Eurobodalla, Evans, Fairfield, Gloucester, Gosford, Goulburn, Grafton, Great Lakes, Greater Lithgow, Greater Taree, Gunning, Guyra, Hastings, Hawkesbury, Holroyd, Hornsby, Hunters Hill, Hurstville, Kempsey, Kiama, Kogarah, Ku-ring-gai, Lake Macquarie, Lane Cove, Leichhardt, Lismore, Liverpool, Maclean, Maitland, Manly, Marrickville, Merriwa, Mossman, Mulwaree, Murrurundi, Muswellbrook, Nambucca, Newcastle, North Sydney, Nundle, Oberon, Parramatta, Pittwater, Port Stephens, Penrith, Pristine Waters, Queanbeyan, Randwick, Richmond River, Rockdale, Ryde, Rylstone, Scone, Severn, Shellharbour, Shoalhaven, Singleton, Snowy River, South Sydney, Strathfield, Sutherland, Sydney, Tallaganda, Walcha, Warringah, Waverley, Willoughby, Wingecarribee, Wollondilly, Wollongong, Woollahra, Wyong, Yarralumla and Yass in relation to lands within their respective Local Government areas.
- The DEC in relation to lands reserved under the *National Parks and Wildlife Act 1974* (NSW) and where a concurrence or consultation role is required under the *EP&A Act 1979* (NSW). Where an action is not captured under the definitions of development or activity but will or is likely to have an impact on a threatened species the DEC may also have a licensing role under the *NPW Act 1974* (NSW) where other exemptions do not apply.
- The Department of Lands in relation to Crown Land, subject to the provisions of the *Crown Lands Act 1989* (NSW).
- The Department of Infrastructure Planning and Natural Resources (DIPNR) in relation to vegetation clearing in accordance with the provisions of the *Native Vegetation Conservation Act 1997* (NSW) as amended and water sharing in accordance with the *Water Management Act 2000* (NSW).

Other authorities listed in section 2.3 above are considered to potentially have a decision making function and/or a management role in relation to *Litoria aurea* or its habitat. In respect to the listed local government areas this is based on the historic distribution known for the species and the persistence of potential habitat on lands under their care, control or jurisdiction. In relation to other State Government Agencies this is in respect of the extent to which they may have an approval role under Part 5 of the *EP&A Act 1979* (NSW), a licensing role under other legislation or a management role as a landowner/manager. Any other action not requiring approval under the *EP&A Act*, and that is likely to have a significant impact on the Green and Golden Bell Frog and/or its habitat, will require a Section 91 Licence from the Director-General of DEC under the provisions of the *TSC Act*. Such a licence may be issued with or without conditions, or refused.

Appendix 2 - Environmental Impact Assessment Guidelines, provides information to assist consent and determining authorities with the assessment of the effect of activities and developments on the Green and Golden Bell Frog or its habitat.

Commonwealth environmental assessment

The Commonwealth EP&BC Act regulates actions that may result in a significant impact on matters of national environmental significance and this includes nationally listed threatened species and ecological communities. Under the EP&BC Act (1999), an action will require the approval of the Commonwealth Minister for the Environment (in addition to any State or Local Government approval), if the action will have, or is likely to have, a significant impact on a matter of national environmental significance. It is an offence to undertake any such actions in areas under State or Territory jurisdiction, as well as on Commonwealth-owned areas, without obtaining prior approval from the Commonwealth Environment Minister. As the Green and Golden Bell Frog is listed nationally under the EP&BC Act, any person proposing to undertake actions likely to have a significant impact on this species should refer the action to the Commonwealth Minister for the Environment for consideration. The Minister will then decide whether the action requires EP&BC Act approval.

The EP&BC Act 1999 criteria for determining whether a significant impact on a threatened species or community is likely to differ from those applied under the NSW environment assessment process (ie s5A of the *EP&A Act 1979*). If the proposed action is likely to have a significant impact on a nationally listed threatened species or community (according to the Commonwealth criteria), the matter must be referred to the Commonwealth Minister

for the Environment for consideration. If the Minister decides that a significant impact is likely, the EP&BC Act 1999 (Cth) environmental assessment procedure will apply in addition to that of any State or Local Government process and approval, (subject to any bilateral agreement between the Commonwealth and the State). The Commonwealth Minister may decide to either approve or reject the application to carry out the action.

The Environment Minister can also delegate the role of assessment and approval to other Commonwealth Ministers under a Ministerial Declaration and to the States and Territories under bilateral agreements. The development of a bilateral agreement between NSW and the Commonwealth is not yet complete, but when in place will avoid the need for duplication of environmental assessment.

Administrative guidelines are available, from Environment Australia, to assist proponents in determining whether their action is likely to have a significant impact. In cases where the action does not require EP&BC Act approval, but will result in the death or injury to an individual of the Green and Golden Bell Frog and the individual is in, or on a Commonwealth area, a permit issued by the Commonwealth Minister under the EP&BC Act will be required.

Further information concerning the operation of the EP&BC Act 1999 (Cth) environmental assessment requirements can be obtained from the Australian Government Department of Environment and Heritage (DEH) <http://www.deh.gov.au>.

3 Conservation Status

The NSW Scientific Committee, when producing the original schedules of the EFIP Act 1991, stated that the reason for listing *Litoria aurea* as endangered was: “Population severely reduced over entire range; severe threatening processes.” This situation would appear to still prevail and the ongoing operation of threatening processes is severely reducing recruitment in many locations and justifies the species status remaining as endangered and its listing as Schedule 1 under the TSC Act in NSW.

The Green and Golden Bell Frog has declined from a status where it was regarded as an extremely abundant species, with a widespread and almost continuous distribution between approximately 28° 32' 24" in the North (NE NSW) and 37° 47' 24" in the South (NE Victoria), to one where it now has only a fragmentary distribution throughout this former range.

It is currently considered to be absent from at least 90% of its former distribution (White and Pyke, 1996; Mahony, 1999; White, 2001). These authors document the species as having undergone a marked reduction in the spatial extent of its distribution, the number of sites at which it occurs and, for some populations where this is known, the number of individuals.

There are currently 43 populations herein classified as ‘key’ populations, for the purposes of this recovery plan, known or considered likely to persist throughout the species range within NSW. In the absence of detailed genetic or other information that may provide more meaningful insights, a population of the Green and Golden Bell Frog is herein considered as a distributional entity of the species separated by distances of up to 10 kms from other such entities or over shorter distances where barriers prevent interconnection (see also Section 5). Key populations are those populations considered to have significant measures of viability (regularly sighted at a locality, 10 or more adult individuals having been detected on more than one occasion over the last 5 years, breeding events having been observed over the last 10 years) and/or have a regional distribution considered essential or vital to the state-wide conservation of the species. The maintenance of the species representation within and across these regions is considered critical to the overall conservation of the species and in particular fundamental to conserving the widest genetic diversity possible and thus maximising the species evolutionary potential.

Information on the status of the different key populations varies widely. For some ‘key’ populations short to medium term monitoring is providing significant information on population size, recruitment and movement patterns (White and Pyke, 1996; Hamer, 1998; White, 1999; Australian Museum Business Services [AMBS], 2003). At other sites information varies from maximum numbers observed to repeated observation of individuals but with little other information that enables measures of viability or population size estimates to be compared.

In addition to the identified ‘key’ populations a number of other recent or suspected localities are known. Some of these are based on single records and/or are difficult or unreliably re-detectable. These locality records may eventually prove to be populations having significant conservation value but at this point require further monitoring and evaluation for this to be ascertained.

Litoria aurea is known to currently occur across four bioregions (NSW North Coast, Sydney Basin, South Eastern Highlands and South East Corner) as defined in the Interim Biogeographic Regionalization of Australia (IBRA) (Thackway and Cresswell, 1995). These bioregions also include the full extent of the known historic distribution of *Litoria aurea* (see Figure 1).

The current distribution pattern (Figure 5) illustrates a classic pattern of decline to extinction for species with previously wide distribution (Clark *et al.*, 1990).

Such decline is characterised by:

- contraction at a broad scale resulting in widely isolated populations across the former range and with complete absence from some regions;
- at the regional scale populations are fragmented to varying degree and have tenuous levels of interconnectivity and so may exchange individuals irregularly or not at all; and
- at the local level populations are divided up into sub-populations or smaller ‘pockets’ of distribution that can collectively be considered a group of populations or a ‘metapopulation’ (Andrewartha and Birch, 1954; Clark *et al.*, 1990).

- The long term viability of each metapopulation component is in turn influenced by the degree of communication with other components and the mix of environmental, demographic, behavioural, genetic, catastrophic and other threatening process factors operating (Wilcox, 1986; Clark *et al.*, 1990).
- The net result of this process is the ongoing cumulative contraction and loss of populations at all scales that could lead to extinction.

Superimposed on this general pattern of decline for populations of the Green and Golden Bell is an apparent trend for populations to persist away from inland elevated locations and towards areas with a near coastal marine influence. These disjunct remnant populations show all the general trends outlined above varying in size, long term security and other indications of viability. Many populations are isolated widely from other populations and with little possibility for re-colonisation if lost. Many sub-populations and other 'pockets' of distribution have tenuous interconnectivity with each other. Consequently the various isolates are at risk of being lost through stochastic and catastrophic incidents and the incremental impacts of various threatening processes.

It is likely that this process and pattern of decline has resulted in the species current status and distribution. It seems likely that this process will continue unless specific actions are undertaken to address the factors operating. This recovery plan will attempt to halt the trend by addressing threatening processes wherever possible, maintaining regional representation of the species across its distribution (including re-establishment if necessary) and make efforts of ensuring connectivity between populations, sub-populations and other 'pockets' of distribution wherever possible.

Since populations are the fundamental evolutionary and ecological unit on which extinction pressures operate the focus of this recovery plan will be on conserving populations at all levels. Consequently, for the purposes of this Recovery Plan, the species distribution has been regionally subdivided into eleven planning units or regions (see Figure 2). These planning regions are based on the local government boundary areas in which all key populations currently occur but also includes adjoining LGAs within the historic distribution and hence the full extent of known habitat for *Litoria aurea*.

An evaluation of the species conservation status across the regions reveals that the species has undergone its most dramatic declines in the inland and higher altitudinal parts of its range. The lack of recent reports of any substantial populations (ie populations of over 20 adult individuals) from the south coast of NSW is also cause for concern (Daly, 2001). It is self evident (see figure 5) that the species distribution is now concentrated to coastal or estuarine locations (only two populations are known more than 20km inland of the coast or an estuary and with the majority at less than 2km). This coastal contraction has been noted by various investigators (White and Pyke, 1996; Mahony, 2000; Daly, 2001; White, 2001) but without proposing possible mechanisms. Given this trend the declines across the various regions have still not been uniform. A breakdown of the current distribution of key populations by planning region is as follows - Upper North Coast 4 (9%); Lower North Coast 4 (9%); Hunter 4 (9%); Central Coast 2 (5%); Sydney 8 (19%); Illawarra 4 (9%) Shoalhaven 11 (26%); South Coast 5 (12%) and Southern Tablelands 1 (2%).

The eastern coastal portion of Victoria also has major significance for the conservation of *Litoria aurea* at both the regional and national level. Substantial populations are known to occur within the north-eastern Victorian region east from about Lakes Entrance. Large numbers of individuals have been detected at some sites and are considered more or less continuous populations (A. White pers. comm.; E. Burns pers. comm.; Pyke and White, 2001).

Of the identified 43 'key' populations eleven are entirely or predominantly within DEC or other statutory conservation reserves and a further four are partly within conservation reserves. Twenty two 'key' populations are at least partially represented on other public lands with four of these populations occurring on Commonwealth lands and three on DPI (SFNSW) lands. The remaining populations occur wholly or in part on private land or on land for which the tenure remains undetermined (see Table 1 on pages 28 and 29).

Reserves from which the species is recorded include: Ben Boyd NP, Booderee NP**, Botany Bay NP, Hat Head NP, Jervis Bay NP, Killalea SRA*, Kooragang Island NR, Myall Lakes NP (including Broughton Island), Nadgee NR, Narrawallee Creek NR, Meroo NP, Royal NP†, Seven Mile Beach NP, Towra Point NR, Tyagarah NR†, Yuraygir NP, (administered by *Department of Lands & **EA; † populations believed to be no longer extant). It should be noted in some instances the centre of distribution of the indicated population is not within the reserve.



Figure 1. Bioregional representation of *Litoria aurea*

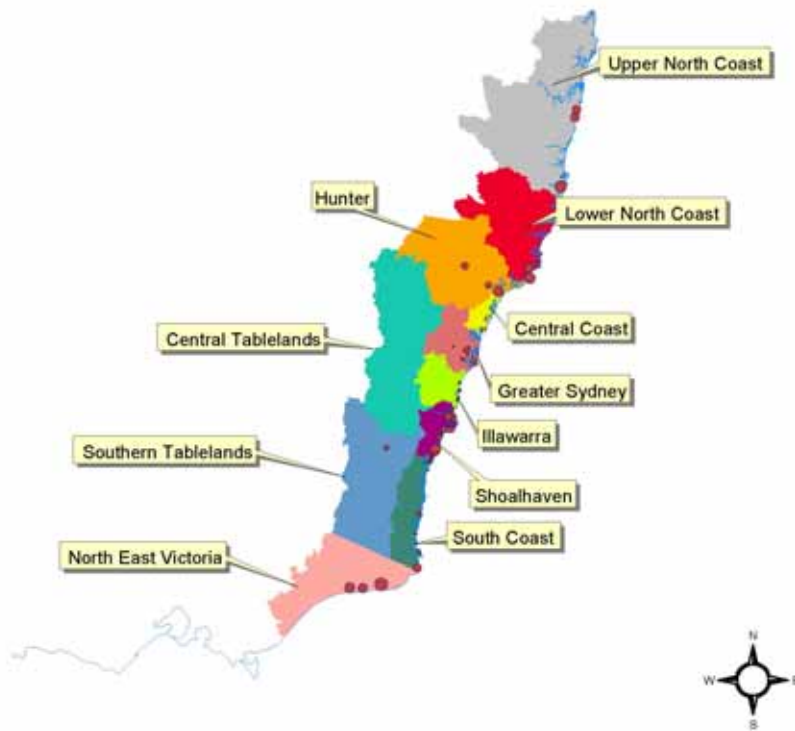


Figure 2. Regional Planning Units for *Litoria aurea*

4 Description and Taxonomy

4.1 Description

4.1.1 Adult Frogs

The Green and Golden Bell frog is a relatively large, muscular frog species with robust body form. Adult size ranges from approximately 45mm to approximately 100mm with most individuals being in the 60-80 mm size class. Males are generally smaller than females (maximum size 70-75mm) and, when mature, tend to have a yellowish darkening of the throat area. Males also develop nuptial pads on the inner finger and these can be observed as a brown pigmented patch. Mature females by contrast are larger bodied (maximum size 90-100mm) and become bulky when gravid. The dorsal colouration is quite variable being a vivid pea green splotched with an almost metallic brass brown or gold. The backs of some individuals may be almost entirely green whilst in others the golden brown markings may almost cover the dorsum. The patterning of the gold markings over green is individually unique and it is possible, when dealing with low numbers, to identify individuals in this way. However during cold weather or when the frogs are otherwise inactive colouration can darken to almost black which then renders this method of identifying individuals inaccurate. A glandular creamish white stripe extends from behind the eye almost to the groin along the upper edge of the sides of the body (dorso-lateral). The lower margin of this dorso-lateral stripe is black or dark brown; the upper margin is edged gold. The belly is usually an immaculate but granular creamish white. The lower sides of the body are adorned with raised glandular creamish spots of irregular size. Legs are a variegated green and gold with the groin area and inside leg a brilliant electric blue particularly in reproductive males. The eye has a horizontally elliptical pupil and a golden yellow iris. The fingers and toes have expanded terminal pads but they are barely wider than the toe/finger itself. The feet are heavily webbed indicative of an extensively aquatic lifestyle; hind legs are elongated, powerful and able to propel the frog quite large single bound distances. Juveniles are smaller versions of the adults and metamorphose at around 25-30mm SVL.

M. Mahony



Figure 3 Green and Golden Bell Frog *Litoria aurea*

4.1.2 Tadpoles

The tadpoles of the Green and Golden Bell Frog are relatively large reaching 65-100mm at limb bud development stage (Stage 26 of Gosner, 1960). They are deep bodied and possess long tails with a high fin that extends almost half way along the body. Mouthparts consist of two upper and three lower labial rows (Martin, 1965; Courtice and Grigg, 1975; Tyler and Davies, 1978) and have a dental formula of

$$\begin{array}{ccc} & 1 & \\ 1 & & 1 \\ \hline 1 & & 1 \\ & 2 & \end{array}$$

(Anstis, 1979; White, 1995; Anstis, 2002).

The behaviour of tadpoles is variable and is likely influenced by water depth, clarity, benthic vegetation and the presence of predators. White (unpubl. obs.) has observed them utilising mid water levels whereas Daly (1995a) states that they have a more benthic habit. Wellington (unpubl. obs.) has observed both behaviours with the former behaviour in ponds with a depth of over a metre where tadpoles could be observed swimming individually or in schools with a slow almost relaxed swimming motion. A more cryptic behaviour was exhibited in shallow ponds 15cm or less in depth where a more frantic and evasive swimming pattern was practised. Morgan and Buttemer, (1996) observed similar behaviour patterns which appeared to be related to presence or absence of predatory fish.



M. Parsons

Figure 4 *Litoria aurea* Tadpole

4.1.3 Spawn

The spawn can be described as clear and gelatinous rather than foamy. The eggs are laid on the water surface where they float initially and then sink after 2-3 hours adhering to fringing vegetation (Harrison, 1922; Tyler and Davies, 1978; Barker, Grigg and Tyler, 1995; White, 1995). The eggs are small about 1.5mm in diameter and are laid in large numbers reportedly ranging between 2-11.5 thousand (White, 1995; Daly, 1995a, 1996; van de Mortel and Buttemer, 1996; Pyke and White, 2001; Anstis, 2002).

4.2 Taxonomy and Interrelationships

4.2.1 Taxonomy

Taxonomic hierarchy:

Class: Amphibia
 Order: Salientia (Anura)
 Family: Hylidae
 Sub-family: Pelodryadinae

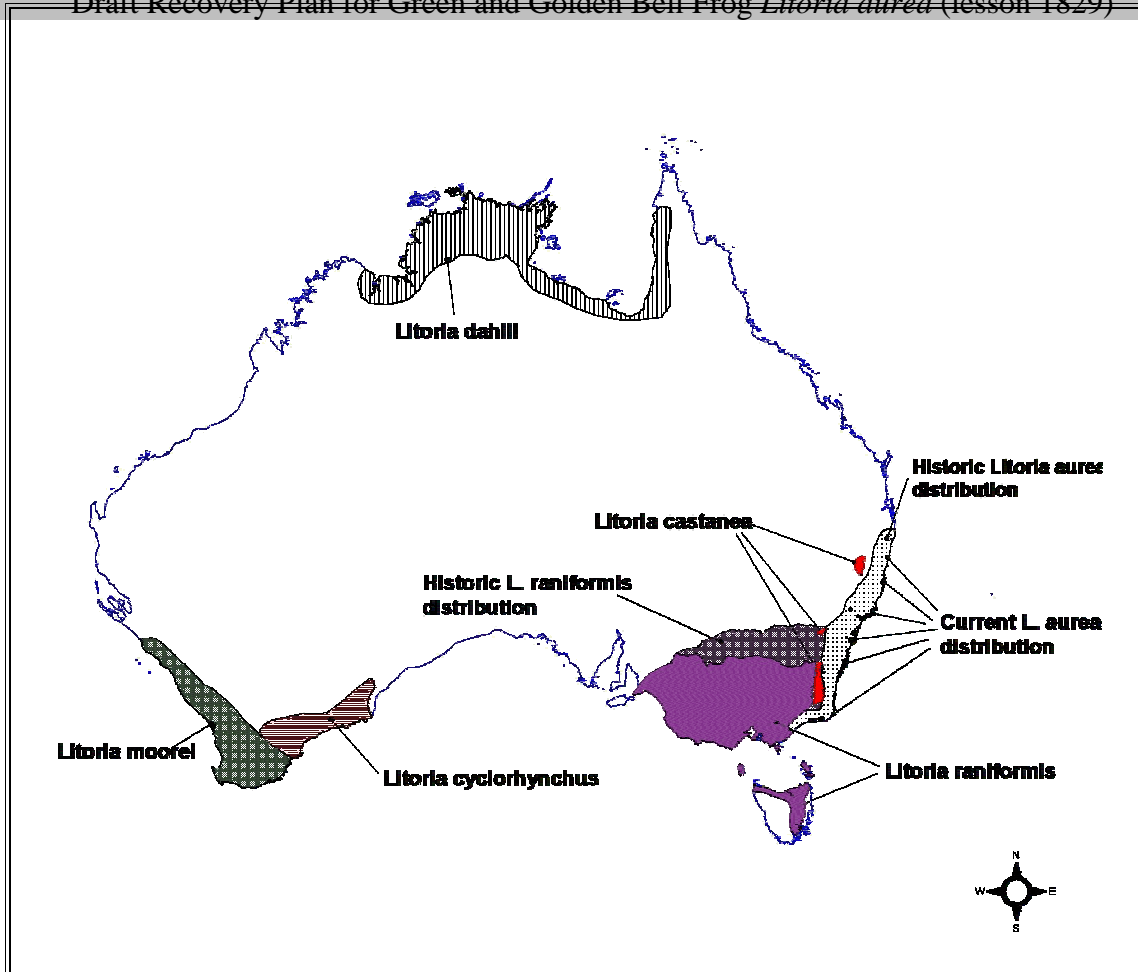
Genus: Litoria
 Sub-genus: Ranoidea
 Species: aurea
 Authority: (Lesson)
 Year: 1829

4.2.2 Interrelationships

The Green and Golden Bell Frog *Litoria aurea* is the nominate form of the distinctive Bell Frog Group of species (*aurea* group of Tyler and Davies, 1978). The recognised species included in the group are: *aurea* (Lesson, 1820); *castanea* (Steindachner, 1867); *cyclorhyncha* Boulenger, 1882; *dahlii* (Boulenger 1896); *moorei* (Copland, 1957); *raniformis* (Keferstein, 1867) and an undescribed Southern Tableland form currently included within *castanea* (see Courtice and Grigg 1975 for a taxonomic review of the *aurea* complex but see also Thomson *et al.*, 1996; Anon, 1999; and White and Pyke, 1999 for further information and a discussion of the *flavipunctata/castanea* nomenclatural status issue). Figure 5 illustrates the Bell Frog or ‘Ranoidea’ species group distribution.

The Bell Frog group of species is considered unique within the Hylidae and has been proposed as the possible ‘archetype’ for perhaps the whole Australian tree frog radiation (Tyler, 1976). Based on a morphological and behavioural analysis of a representative majority of Australopapuan Hylid frog species it has been asserted that the *aurea* species group is highly differentiated from all other species of the genus *Litoria* (Tyler and Davies, 1978) “...and in the Hylidae is without parallel elsewhere in the world” (Tyler, 1982). Chromosomal analysis of the group also supports the relatedness of the assemblage. The *aurea* group members all have characteristic karyotype morphology ($2n = 26$), characteristic centromere position and also in possessing the derived secondary constriction (nucleolar organiser region) on the same chromosome pair (Tyler, Davies and King, 1978; King, Tyler, Davies and King, 1979; King, 1980, 1981;). Immunological and other biochemical analyses of the *aurea* group also support the *aurea* group as a monophyletic assemblage (Adams *et al.* [cited in King, 1981]; Maxson, Ondrula and Tyler, 1985; Hutchinson and Maxson, 1986; Hutchinson and Maxson, 1987). Tyler (1979b,c) and Hutchinson and Maxson (1987) have indicated the likely validity of recognising the ‘*aurea*’ group as an independent genus from *Litoria* because of it being clearly identified on a number of grounds as a unique assemblage within the Australian Hylidae. The generic name *Ranoidea* Tschudi, 1838, [Type species *Ranoidea jacksoniensis*] is an available generic name for the ‘*aurea*’ species group (Cogger, Cameron and Cogger, 1984) and was elevated from synonymy and proposed as an appropriate generic name for the group (Wells and Wellington, 1985).

The Green and Golden Bell Frog overlaps in its historic distribution with the closely related Southern Bell Frog (*Litoria raniformis*) and Yellow-spotted or Tablelands (New England) Bell Frog (*Litoria castanea*) (Cogger, 2000). In previous times these three species have been found at the same pond (Courtice, 1972; Courtice and Grigg, 1975; Humphries, 1979; Ford 1986) and general area (White and Pyke, 1999). There is, however, little evidence of hybridisation occurring between them. Moore (1960) conducted hybridization experiments between eastern and western elements of the group and his results supported their specific distinctiveness. *Litoria aurea* and *L. raniformis* presently overlap in distribution in East Gippsland and formerly had a similar area of sympatry in the ACT (Courtice, 1972; Courtice & Grigg, 1975; W. Sherwin, reported in Watson & Littlejohn 1985, Ford 1989, Gillespie 1996 & Tyler, 1997). Sherwin found individuals with possibly intermediate features in East Gippsland and this he suggested, was indicative of hybridisation between the two species (Watson & Littlejohn, 1985; Ford, 1989; Gillespie, 1996; Tyler, 1997). However, in a study based on serum proteins, haemoglobin and eye lens proteins, no evidence of introgression from such hybridisation was found in samples taken from both East Gippsland and the ACT (Courtice 1972; Courtice & Grigg 1975). The two species have also been detected at the same ponds in New Zealand (where both are introduced) and without any apparent hybridisation occurring (Pyke and White, 2001).



modified from Barker *et al.*, (1995) and Mahony (1999)

Figure 5 Distribution of 'aurea' Group Bell Frog members.

5 Distribution and Habitat

As the former state-wide distribution of the Green and Golden Bell Frog is nowadays restricted to isolated remnant populations of varying size scattered across the vast area that was its former distribution, it is convenient for management purposes to recognise regional management units of populations (see figure 2).

Populations are also the fundamental evolutionary units on which factors causing extinction operate and it is the cumulative loss of populations which results in biodiversity loss at all levels (Clark *et al.* 1990). Consequently it makes sense for conservation efforts to focus at the population level. Therefore within each region populations have been identified as ‘key’ populations, based on the information available, with the purpose of focusing conservation and management efforts within each region (see Table 1 pages 28 and 29). The level of understanding of some of these populations is limited and, where specific information is available, has not generally been gathered in any systematic way. Consequently this makes quantitative site to site and region to region comparisons difficult. Systematic information gathering and assessment will occur during the implementation of this plan and new populations may also be discovered. Consequently revisions of the list of ‘key’ populations may be required during the life of this plan and will be reviewed annually. This plan will be implemented with due reference to the regional framework described below (see Section 5.1.2).

The definition of population used in this recovery plan is based on that proposed by the IUCN (1994) ie a geographically or otherwise distinct group from which there is little or no genetic interchange to other similar groups. This is generally considered less than one migratory interchange per generation (Mills and Allendorf, 1996; Vucetich and Waite, 2000; 2001). The current macro distribution of the Green and Golden Bell Frog is comprised of separate populations, that at the micro level, are in fact groups of populations that interact with one another to varying but in most cases unknown degrees. These presumed “metapopulations” are the focus of the management and conservation efforts outlined within this recovery plan given the likely high conservation value each affords the species as a whole (Lacy, 1987; Moritz, 1994; Frankham, 1995b; Lesica and Allendorf, 1995; Paetku, 1999; Crandall *et al.* 2000; Marsh and Trenham, 2000; Pearman, 2001). The species is known to be capable of significant migratory movements, at least a kilometre in a day (White and Pyke 2001; A. White pers. comm.; R. Wellington unpublished). Mark recapture studies have also provided evidence of movements at some locations (M. Mahony; A. Hamer; A. White pers. comm.) but evidence of genetic exchange is so far lacking for most (but see Colgan, 1996). Consequently in the absence of this information, and mindful of the species vagility, populations have been herein defined as sites of occurrence separated by distances of up to 10km where there is continuity of habitat. This has in some instances resulted in a somewhat arbitrary decision or a decision based on knowledge of the likely impediment certain geographic or constructed features may have on movements and hence connectivity. Units separated by relatively shorter distances 1-3 kms are considered sub-populations of a population unit (metapopulation). Genetic investigations in progress should enable a refinement of the population definitions used in this recovery plan and an emphasis to be refocused on refined definitions of populations, management units and evolutionary significant units (E. Burns pers. comm.; see also Burns *et al.* in prep.).

5.1 Distribution

5.1.1 General description of distribution

The Green and Golden Bell Frog had an extensive distribution which ranged, not only through the coastal lowland areas of eastern NSW from approximately 50 km south of the NSW Queensland border and extending south into northeast Victoria, but also into the more elevated southern tablelands and central slopes of Bathurst (Type Locality: Macquarie River at Bathurst – see Cogger, *et al.* 1984). Some historic locality records from the New England, Central and southern tablelands need to be considered with caution due to early confusion with *L. castanea* and/or *L. raniformis* where they overlapped in these areas. The northern extent of distribution has been reported from the vicinity of Brunswick Heads, the southern extent in NSW is believed to be Nadgee on the NSW Victorian border, the western most extent recorded in NSW is from Wimbledon south west of Bathurst. In Victoria the species is known to extend coastally west to the vicinity of Lakes Entrance.

Generally declines in NSW went unnoticed until the early 1980s but had possibly begun earlier in the mid 1970s (or perhaps even earlier) but documented evidence is lacking. It is also likely that as a once extremely common species instances of occurrence often went unrecorded.

A workshop held on the species during May 1995 resulted in the production of a 17 article monograph reporting on the state of knowledge of the Green and Golden Bell Frog (GGBF) (Pyke and Osborne 1996). Several papers contained therein, (White and Pyke, 1996; Osborne and McElhinney, 1996; Gillespie, 1996; Mahony, 1996; Lemckert, 1996 and Clancy, 1996) provide specific regional overviews of the species distribution and status.

Figures 6a and 6b provides a distributional map indicating pre and post 1990 records and shows the marked contraction and fragmentation of the distribution that has occurred. Table 1 on pages 28 and 29 provides a list of the remaining key populations by region.

5.1.2 Regional Distribution

North Coast

Northern populations apparently disappeared during the period from the mid 1970s to early 1980s and resulted in a southerly range contraction of over 140km. There are no known records from north of Grafton after 1986 (White and Pyke, 1996; L. Tarvey pers comm.; Lewis and Goldingay, 1999). Suitable habitat and previous known sites have been routinely and opportunistically revisited without success (L. Tarvey pers. comm.; Lewis and Goldingay, 1999). The most northerly record known is from Brunswick Heads and is based on a Queensland Museum Specimen (QMJ22708) collected in 1972. The precise locality data for this specimen is unavailable but it has been suggested that it may have been collected at more suitable habitat just south of Brunswick Heads (L. Tarvey pers. comm.). The most northerly verifiable record is from Tyagarah NR approximately 7km south of Brunswick Heads reported in 1986 by G. Schmida and M. Fitzgerald. Other records in the north include Lake Ainsworth at Lennox Head - 1977 to 1979 and the vicinity of Kingsford Smith Park at Ballina - 1972 to 1973. Other records from Ocean Shores and Byron Bay are probably in reference to the Tyagarah and Lake Ainsworth sites respectively (L. Tarvey 1999, *in lit.*).

Within this recovery plan the north coast is divided into two management regions.

Upper North Coast – This region includes the northern most limits of the species former distribution near Brunswick Heads and extends south to the vicinity of Crescent Head. Within this area Key Populations are currently known from:

Yuraygir NP near Grafton in Pristine Waters LGA (Clancy, 1996; Gray, 1999; Lewis and Goldingay, 1999). Yuraygir NP is considered to contain two Key Populations and these are located near:

1. Wilsons Headland in central Yuraygir NP; and
2. Station Creek at the southern end of Yuraygir NP just north of Red Rock.

There is an apparent 'gap region' of approximately 120km south to the next two known key populations. These occur at:

3. Clybucca where a population occurs in wetlands on private land (White 2001; A. White pers. comm.); and
4. Crescent Head 20 km to the south east of Clybucca where the population is believed to occur largely within Hat Head NP (Wellington, 1998; M. Parsons unpublished; Filmer, 1999). The latter two populations are in Kempsey LGA.

The former distribution of the species in the Upper North Coast Region would have also taken in suitable habitat within the additional local government areas of Armidale-Dumaresq, Ballina, Bellingen, Byron, Casino, Coffs Harbour, Copmanhurst, Glenn Innes, Grafton, Guyra, Kyogle, Lismore, Maclean, Nambucca, Richmond River, Severn and Tweed. These local government areas may still contain remnant populations and may also be the subject of reintroduction proposals.

Lower North Coast – This region extends from Port Macquarie to Myall Lakes and is considered as having four Key Populations.

1. The Port Macquarie population exists as two discrete sub-populations. One south of the township on the boundary of Lake Innes NR and the other at North Shore, (Hastings LGA);
2. A population that occurs in the vicinity of Bridge Hill and Smiths-Lake near Bungwahl;
3. A Mungo Brush population occurring east of Bulahdelah in Myall Lakes NP and believed to exist as a number of satellites but the exact location, status and other details have been difficult to determine;
4. An apparently flourishing population occurring on Broughton Island off the coast near Tea Gardens (G. Pyke pers. comm.). Preliminary genetic results suggest that this population may be inbred (E. Burns pers. comm.; see also Burns *et al.* in prep.). Broughton Island forms part of Myall Lakes National Park and the latter three populations are all within Great Lakes LGA.

Recent reports suggest that a remnant population may still exist near Taree at Tinonee in the Greater Taree LGA and the additional LGAs of Gloucester, Nundle and Walcha contain areas of former distribution and habitat that comprise the remainder of the management region.

Hunter

This region is herein considered to include the LGAs of Port Stephens, Newcastle, Maitland, Singleton, Cessnock and Muswellbrook within mid to lower reaches of the Hunter River catchment and from where all the key populations and recent records are to be found. The region also extends to include Dungog, Merriwa, Murrurundi and Scone LGAs in the upper reaches of the Hunter drainage. These areas still contain potential habitat as well as known former distributional locations.

Historically the Green and Golden Bell Frog was apparently widespread across much of the Hunter Valley and was commonly found associated with the various floodplain wetlands of the Hunter River and its tributaries during the 1950s, 60s and 70s (R. Wells, pers. comm.). The Hunter Valley is also likely to have formed a connective link between coastal populations and those of the central tablelands. However declines of the species in the region went apparently unrecorded until recently. The species is now believed restricted to four Key Populations in this region and these include:

1. a recently rediscovered population at Sandgate on the margins of Hexham Swamp;
2. a large population on Kooragang Island in the delta of the Hunter River. This population is considered to be the most robust in the region but occurs across several land tenures and its conservation is not secure as only a small portion of its habitat occurs within the islands nature reserve. This population is the subject of ongoing investigations by Newcastle University but also faces the potential impact of severe development threats;
3. a population in the Gillieston Heights/East Maitland, Ravensdale areas and also incorporating Wentworth Swamp. This presumed metapopulation is known from a number of discrete sites on the periphery of Wentworth Swamp with individuals utilising the limited breeding habitat available at these locations during ideal conditions; and
4. another presumed metapopulation in the Ravensworth/Liddell/Bayswater area that is considered highly significant due to its inland location and despite its apparent transient nature and seemingly small population size. This population has been most recently detected around Liddell and Bayswater Power Stations and at sites near Jerry's Plains. Several of the most recent records have been reported in association with the various opencut coal-mining operations across this part of the Hunter (eg Mt Owen, Ravensworth East and Cumnock). These observations lend some support to the view that a diffuse population occurs across this area of the Hunter Valley. Until very recently this population was the most distant from the coast known to still persist. Consequently this adds to this conservation units significance.

The wide extent of potential habitat and occasional 'one-off' records within the Hunter suggests that other populations may still survive in the region but such observations need verification.

Central Coast

The Central Coast Region is contained within the Local Government Areas of Gosford, Wyong and Lake Macquarie where the species was considered common at least until the late 1970s. Populations occurred across the extensive wetlands and floodplains of the Tuggerah Lakes system and were also known from the wetlands to the south of the region at Pearl Beach, on the Umina-Woy Woy sandplain, surrounding Brisbane Water and also from the Gosford coastal lagoon systems near Wamberal, Terrigal and Avoca. To the north in Lake Macquarie LGA the species was known from the Jewells Swamp between Gateshead, Redhead and Belmont and was known, also during the 1970s, from the stream floodplain wetlands in the western parts of Lake Macquarie between Wyee and Morisset.

Today only two Key Populations are definitely known to be extant in the region and both are in the Gosford LGA. These Key Populations are located:

1. adjacent to Avoca Lagoon; and
2. within wetlands of Brisbane Water at Davistown.

Several promising recent records of the species have been detected in Wyong, a former regional stronghold, and are suggestive that other important populations may still be found in the region and if rediscovered would require appropriate consideration in accordance with this plan.

Sydney

The Sydney Region includes all of the LGAs of the greater metropolitan area north to the Hawkesbury, west to include Blue Mountains and south including Camden and Campbelltown. This region is known to have had major populations within its separate catchments. This included the wetlands around the margins of Botany Bay and including the Georges River and Cooks River sub-catchments; wetlands of the Parramatta River drainage and also associated with the Hawkesbury Nepean drainage to the west and south west. Pyke and White (1996) and White (1993b, 1996) document in some detail the declines in some of these populations and numerous other historical records of various herpetologists have assisted in piecing together the species former Sydney distribution (R. Wells pers. comm.; L. Tarvey pers. comm.; M. Mahony pers. comm.; R. Wellington unpublished).

Sydney still contains some of the largest but also most disturbed and isolated populations. Eight key populations exist within the greater Sydney Region along with a number of other transient sites that are believed to consist of small populations difficult to reliably locate or based on observations of migrating individuals. Some of these populations are considered to be operating more or less as metapopulations but their fragmented and isolated nature is the product of development and other human disturbances rather than a naturally patchy distribution. However preliminary genetic analysis of selected populations has demonstrated that differentiation between proximal populations does occur and warrants a conservative approach to conservation initiatives, management and environmental impact assessment decisions (see Colgan, 1996).

The Key Populations in Sydney include:

1. Kurnell where a large and fairly robust population persists, which is ironic given that it was here that the species was first detected in 1770 by Cooks party. This population is currently represented across several private and public land tenures and is currently subject to at least three operational site specific management plans. This includes Sydney Water land at the Cronulla STP as well as private land owned by Australands and Breen Holdings. The species is also known to occur on other private lands on the peninsula but which are not currently managed for the species. Individuals are also occasionally detected within the adjacent Botany Bay NP and Towra Point NR but these reserves are not considered to contain the critical habitat areas for the greater Kurnell population. A coordinated peninsula wide management strategy across all land tenures will be required and is identified herein as a priority to improve the long-term conservation status of this likely metapopulation. This population is within Sutherland LGA.
2. Homebush Bay where a large population, estimated at over 1500 frogs (AMBS, 2002), is known to occur across the Sydney Olympic Park lands and is managed by the Sydney Olympic Park Authority (SOPA). This

population has been the subject of intensive active management, monitoring and publicity since around 1993. It is considered as being comprised of three sub-populations, the most secure being centred on the old state brickworks brickpit, but also occurs in constructed and other habitat across almost 200 Ha of the Sydney Olympic Park site. The population has elements that occur in Bicentennial Park, Wilson Park and Newington Nature Reserve. The population also extends onto Correctional Services land at the Silverwater Correctional Centre and other private land in the vicinity. This population is within Auburn LGA and has been systematically monitored on an annual basis since 1998. A DEC endorsed Frog Management Plan (SOPA/AMBS, 2002) guides and regulates an adaptive management program and further statutory protection is afforded to the population through the Parklands Plan of Management (SOPA, 2003), prepared in accordance with the Sydney Olympic Park Authority Act, 2001). Of the eight key populations occurring in the Sydney region the Homebush Bay/Sydney Olympic Park population is considered secure at an individual site level and monitoring is ongoing.

3. Greenacre where a presumed metapopulation exists centred on the disused, but soon to be developed, Punchbowl Brickpit and comprised of a number of sub-populations on the nearby Freightcorp and RailCorp lands as well as at Cox's Creek Reserve and adjacent Bankstown Council land. This population is within Strathfield and Bankstown LGAs and is in an area experiencing re-development pressures. A strategic management approach is required for this population across the various affected land tenures.
4. Clyde/Rosehill where a population is known to exist in wetlands at the confluence of the Parramatta and Duck Rivers. The population is known to exist on the Shell Refinery and CSR Emoleum Lands and within adjacent wetlands.
5. Merrylands has, as far as is known, a relatively small population that persists within the Holroyd Gardens estate. This population is known from within a recent development site that includes habitat creation and enhancement works to assist the population and improve its conservation security. The species is considered likely to be making use of the adjacent Walpole Street Park and the associated Duck Creek drainage.
6. The Arncliffe population consists of a long known population in the vicinity of the Marsh Street wetlands and which has recently been the subject of major road works and infrastructure development associated with the M5 East motorway construction. Habitat creation and enhancement works coupled with a captive breeding program was undertaken to improve the conservation prospects of this population. However proposals to develop the adjacent golf course area has implications for the long-term security of this population despite some early success with habitat creation and the supplementation initiatives. A Green and Golden Bell Frog management plan is a requirement of the statutory planning instruments for the area.
7. St Marys population consisting of a number of sub-populations that are somewhat transient in the reliability with which their population can be detected at a given site. The included sub-populations may possibly be operating as a metapopulation and are located on RailCorp lands, Transgrid lands, Sydney Water lands and private lands at St Marys, Mt Druitt, Prospect and Riverstone. The distance between some of these sites and the barriers to connectivity may mean that some are operating as isolated entities; and
8. Hammondville population that has apparently undergone severe declines in recent years and its current status is likely precarious (A. White pers. comm.). This population is known to occupy the wetlands associated with the lower Georges River floodplain but needs urgent assessment and perhaps active management.

Occasional records are still being reported from North Ryde near Macquarie University and tributaries of the Lane Cove River; at Holsworthy within the Department of Defence lands associated with wetlands and drainage lines there, at La Perouse where a population was previously known to exist on Golf Course lands in the vicinity and from Rosebury where residual records have been reported from properties in the vicinity of the Dalmeny Avenue site destroyed by the Meriton development there in 1993. (The remnant Rosebury population that was salvaged to establish a breeding colony at Taronga Zoo provided the stock that forms the basis of three Sydney reintroduction trials – see below). Some of these scattered Sydney records could indicate the continued persistence of unknown populations with conservation significance.

Sydney also has three reintroduction sites at Botany in Joseph Banks Reserve, at Marrickville on Council nursery land and at Collaroy within Long Reef Golf Course (the Arncliffe Marsh Street wetland (M5 East) site of tadpole releases is herein considered a 'supplementation' site).

Illawarra

The Illawarra region, as here defined, includes the LGAs of Wollongong, Shellharbour, Kiama, Wollondilly and Wingecarribee. Historically the species was well represented and was frequently encountered at least up until the late 1960s and early 1970s. In the north the species was recorded at Wollongong from about 1890, Woonona from 1910 and Thirroul from 1920. Records from Fairy Meadow date to the early 1970s. In the Shellharbour/Warilla area during the 1970s a population occurred around the Little Lake coastal lagoon catchment and including wetlands between Shellharbour township and Bass Point (R. Wellington unpublished; G. Daly pers. comm., Lewis, 1997). In the Kiama/Jamberoo area a population occurred in the floodplain wetlands associated with the Minnamurra River and also at Albion Park in farm dams and wetlands associated with the Macquarie Rivulet flood plain (R. Wellington unpublished; M. Robinson pers. comm.). These populations had apparently declined by the early 1980s.

Four Key Populations are considered to currently occur within the region and are located at:

1. Woonona where a population occurs associated with the old Boral brickpit and the drainage lines of Collins Creek and the Bellambi Creek system (Farrahers, Hollymount, Cawley, Russell Vale and Rixon's Pass Creeks) north of Wollongong. This population appears to utilise the coastal lagoons and wetland remnants and these drainage lines as connective corridors to other required habitat components towards the escarpment. This is the northern most Illawarra population currently known.
2. Port Kembla is the most well known and considered the most significant Illawarra population. This population occurs near Port Kembla and is comprised of several satellite populations. Collectively these sub-units are thought to be operating as a metapopulation (Daly, pers. comm.; Goldingay 2000; White 2001) and this aspect of the population is worthy of further investigation. Coomaditchee Lagoon, Boilers Point and Korrungulla Wetland occur on Wollongong City Council land with other sub-populations occurring on private land (including MM, Incitec, Southern Copper, BHP, Garnock Engineering and Cleary Bros). A component of one sub-population (South Pond) also occurs on Crown Land. The species is also regularly detected in suburban gardens in the vicinity and includes reports of regular significant breeding events in garden pools/ponds over a number of seasons (Robertson St. and Third Ave) (G. Daly; A. Fox; D. Deighton, M. Fox, G. Smith all pers. comm.). The various Port Kembla population sub-components are all to some degree isolated and the challenge for on going conservation may well be maintenance of connectivity. Recent genetic studies suggest that allelic differences occur between the northern and southern satellites (E. Burns, pers.comm.).
3. Shellharbour today consists of only a small remnant population in the Bass Point/Dunmore area. Killalea SRA and Bass Point Reserve could prove to be vital for the survival of this population as it is only irregularly detected in the Killalea Lagoon area. Proposed upstream developments have the potential to threaten the population further and habitat enhancement initiatives are likely warranted.
4. Kiama where there are two isolated sub-populations occurring at Minnamurra Headland and along Springs Creek near Bombo.

Other records exist for Fairy Meadow in the north, from Port Kembla Golf Course on the Windang Peninsula (which could represent dispersing individuals from the Port Kembla population) and in Foys Swamp to the south on the Kiama-Shoalhaven LGA boundary.

Shoalhaven

The Shoalhaven appears to be the stronghold for the species. It is a region comprised of a single LGA (Shoalhaven City Council) and currently has the largest number of Key Populations for any region with eleven (11). The region is characterised by extensive areas of wetlands and, whilst significant habitat loss and modification has occurred, it still contains some of the most extensive areas of relatively natural habitat for the species. Historically the species was known from many localities throughout the region including; Tomerong, Comerong Island, Nowra, Wooragee Swamp and Vincentia as well as other locations where it is still known to occur. Some of the key populations in the region are known to be large and with an almost continuous distribution.

The Key Populations occur at:

1. Shoalhaven Heads where the population is centred on the Coomonderry Swamp and a portion of which is within Seven Mile Beach NP. However a major portion of the habitat is on private land;
2. Crookhaven Floodplain - this key population takes in what are considered herein to be sub-populations occurring at Greenwell Point, Brundee Swamp, Saltwater Swamp and the northern drainage of Currumbene SF. This is an extremely large area of low lying land and wetland and the species occurs on various private lands, Council land and includes DPI (SFNSW) lands;
3. Lake Wollomboola near Culburra where the population is known to occur along the northern margins of the lake. At Culburra the population occurs on Council land, private land and a portion of the population is likely to be within recent extensions to Jervis Bay NP. This population has been the subject of habitat creation and enhancement initiatives and a joint DEC-Council local population Management Plan has been prepared (drafted) for this population;
4. Woollamia Currumbene Creek – this poorly known population occurs within the Currumbene catchment to the south of Currumbene SF;
5. Jervis Bay Beecroft Peninsula – this northern JB peninsula population is poorly known and occurs on Commonwealth Department of Defence Land;
6. Jervis Bay Bherwerre Peninsula – this southern JB peninsula population is comprised of a number of sub-populations including Greenpatch, Murrays Beach, Ryans Swamp, Cave Beach and Steamers Beach. The land is Commonwealth Territory and is incorporated within the Commonwealth’s Booderee NP;
7. Jervis Bay Bowen Island – this population occurs on a small offshore island at the entrance to Jervis Bay and is Commonwealth Territory;
8. Sussex Inlet – this population occurs at the Sewage Treatment Plant (STP - council operational land) and within the adjacent Crown Reserve wetlands and other surrounding private land;
9. Lake Conjola – this population occurs largely on private land within a partially disused sand quarry, in part within Narrawallee Creek NR near Buckley’s Point and near Pattimore’s Lagoon.
10. Meroo-Kioloa-Bawley Point – this Key Population is known to be a large population with the majority located within the recently gazetted Meroo NP (formerly Termeil SF). Other sub-populations considered herein as components of this metapopulation occur at O’Hara headland near Kioloa and on various private and council lands in the intervening Murramarang, Bawley Point and Willinga Lake areas; and
11. North Durras – this population is known from the vicinity of the North Durras caravan park where it has been recorded from water storage reservoirs and is the southern most Shoalhaven population.

South Coast – this region is contained within Eurobodalla and Bega Valley LGAs. The status of populations on the south coast is poorly known and historical details are even less clear. The species was present in good numbers on farmland during the early 1980s around Murrah, (R. Wells pers. comm.) and was also well represented around Pambula and at Twofold Bay (P. Johnston pers. comm.). DEC atlas and Victorian Museum records demonstrate that the species was recorded across large parts of the region during the 1960s and 1970s. The species occurrence in pristine areas such as Nadgee suggested that it should be secure on the south coast. Relatively recent sightings exist for the vicinity of Pedros Swamp near Moruya Heads, Murrah River north west of Tanja, Cobargo, Saltwater Creek in Ben Boyd NP to the south of Eden and Ludwig’s Swamp west of Wonboyn in Nadgee SF. Several sites within and just north of the rarely frequented and relatively pristine Nadgee NR are also known and are still extant in this reserve (J. Baker, pers. comm.). Recent targeted surveys have cast concern over the conservation status of some of the other key populations with only one small population detected just north of Merimbula (Daly, 2001). This could be indicative of further regional decline that has otherwise gone largely unnoticed. A reintroduction proposal is currently being considered for a coastal location near Merimbula (R. Pietsch, pers. comm.).

The Key Populations within this region occur at:

1. Ben Boyd NP where it has been recorded near Saltwater Creek lagoon;
2. Mumbulla SF near Murrumbidgee River where it has been irregularly detected along floodplain wetlands in the vicinity;
3. Tura Beach north of Pambula where a small population was recently detected associated with the Sewage Treatment Plant (STP) and adjacent wetland.
4. Ludwig's Swamp within DPI (SFNSW) land west of Wonboyn;
5. Nadgee Nature Reserve.

Central Tablelands

Inland historic records exist for Bathurst from where the Green and Golden Bell Frog was formally described. White and Pyke (1999) present a summary of their investigations of historic Bell Frog records from the Bathurst/Orange area and demonstrate that the three eastern species of the *aurea* species group were at least parapatric and perhaps sympatric in the area. In the western part of its range declines of the GGBF appear to have begun earlier in the mid 1960s. It was recorded as very common around Bathurst in 1950 and there are records from several locations south of Bathurst up to the late 1960s with the last positive record known from Charlton in 1973 (White and Pyke, 1999). Recent reports of Bell Frogs still occurring in the area have been forthcoming from the Winburndale Dam area but remain unconfirmed (I. McCartney, pers. comm.). Other recent possible records have been reported from the gorges of the upper Blue Mountains near Blackheath but are also unconfirmed.

Central Tablelands Key Populations - no extant populations are known although possible recent records from NE and SE of Bathurst need to be investigated. The possibility of reintroduction to the region should be considered in the light of genetic studies, provenance issues and the management of likely threatening processes.

Southern Tablelands (including the ACT) – Up until the late 1970s the species was considered common in the southern tablelands and ACT, (Humphries, 1979; Osborne, 1992; Osborne *et al.*, 1996). In 1986 declines were first reported in the Canberra area (Osborne, 1986) and by 1990 there were concerns over possible extinction in that area (Osborne, 1990). It is today presumed extinct in the ACT (excluding Jervis Bay) (Rauhala, 1997) and until early 2000 the species was also presumed extinct elsewhere on the southern tablelands (Patmore and Osborne, 2000). In March/April 2000 a population was detected during environmental impact assessment for a gas pipeline on the Molonglo River flats near Hoskinstown and Bungendore. Investigations so far have revealed that the population is significant, is comprised of several sub-units and is more extensive than at first thought (Patmore and Osborne, 2000; Osborne and Patmore, 2001; Osborne, pers. comm.). Frog chytrid was detected in the population (L Berger pers. comm.) and all sites so far detected are on private land (R. Pietsch pers. comm.; W. Osborne pers. comm.).

This single Key Population in the Southern Tablelands region is of high conservation value. Not only is it the furthest population from the coast but it is also at the greatest elevation. This population may provide the opportunity to determine with certainty the threatening processes which appear to be operating most severely at these distributional limits and elevation and have resulted in the species complete disappearance from other similar locations elsewhere. This population may provide the ideal provenance stock for captive breeding and reintroduction to other southern tableland locations and the ACT.

Northern Tablelands – no extant populations are known. Some historic records are likely to have been based on *L. castenea* records and so historic distributional records need to be treated with caution. The northern tablelands area is included within the upper north coast region as here defined.

North-east Victoria – In Victoria substantial populations occur around Mallacoota, Brodribb River near Orbost, Tostaree, on the Bemm River and Lake Tyers (A. White pers. comm.). These populations were assessed as being apparently 'healthy' and with no *Gambusia* present (A. White pers. comm.). From about the late 1980s the apparent declines in southern NSW, perhaps in part a result of the arrival of frog chytrid, along with the report of

scattered occurrences of *Gambusia* in southern NSW (G. Pyke pers. comm.; Daly, 2001) suggests that some of these apparently robust Victorian populations should be monitored. Any change in the status of Victorian populations would likely alter the national conservation status of the species to endangered under the EP&BC Act, 1999.

Figures 6a and 6b (opposite) illustrates the current and historic distribution of *Litoria aurea*.

International – Other expatriate populations of the Green and Golden Bell Frog also exist having been introduced to various countries in the Pacific Region. These populations may prove useful in assisting to determine threats to NSW populations and, if original provenance could be determined, may have other conservation value. Populations currently occur in New Zealand, New Caledonia and Vanuatu but see Sarasin (1926), Thomson (1926), McCann (1961), Tyler (1979a), Bell (1981) and Pyke and White (2001; 2002) for an account of these populations.

Region	Population	LGA	Tenure	Pops	Sub Pops	
Upper North	Yuraygir	Pristine Waters	DEC	2	2	
	Clybucca	Kempsey	Private	1	1	
	Crescent Head	Kempsey	DEC	1	2	
Lower North	Port Macquarie	Hastings	Private-Council-DEC	1	2	
	Bungwahl	Great Lakes	DEC - Private	1	2	
	Myall	Great Lakes	DEC	1	3	
	Broughton	Great Lakes	DEC	1	3	
Hunter	Kooragang	Newcastle	Private-Dept. Commerce, DIPNR - DEC-AGL	1	4	
	Sandgate	Newcastle	Private- Council	1	1	
	Ravensfield/Gillieston	Maitland	Private	1	2	
	Ravensworth	Singleton	Private	1	3	
	Davistown	Gosford	Private- Council	1	2	
Central Coast	Avoca	Gosford	Council	1	2	
	Homebush	Auburn	SOPA-DEC- Corrective Services - Private	1	6	
Sydney	Clyde/Rosehill	Parramatta	Private- Council	1	2	
	Holroyd	Holroyd	Council- Private	1	1	
	Hammondville	Liverpool- Bankstown	Private- Council	1	3	
	Greenacre	Strathfield- Bankstown	Council- Freight Corp- Rail Corp - SPA	1	4	
	Arncliffe	Rockdale	RTA- Council-DIPNR- SPA	1	1	
	Kurnell	Sutherland	Private-Sydney Water DIPNR - DEC	1	5	
	St Marys/Mt Druitt	Penrith- Blacktown	Private-Transgrid- Council- RailCorp	1	3	
	Illawarra	Woonona	Wollongong	Private- Council	1	1
		Port Kembla	Wollongong	Council-Private- DIPNR	1	8
Shellharbour		Shellharbour	Dept. Lands - Private	1	1	
Kiama		Kiama	Council- Private	1	2	
Shoalhaven	Coomonderry/Shoalhaven Heads	Shoalhaven	Private - DEC	1	4	
	Crookhaven Floodplain	Shoalhaven	Council-Private-DPI -T	1	6	
	Woollamia-Coorambine Ck	Shoalhaven	Private-Council	1	3	
	Culburra/Wollumboola	Shoalhaven	Private-Council-DEC	1	4	

Region	Population	LGA	Tenure	Pops	Sub Pops
	JB Bherwerre/Booderee	ACT	DEH	1	4
	JB Bowen Island	ACT	DEH	1	1
	Jervis Bay Beecroft	Shoalhaven	Cth. Dept. Defence	1	2
	Sussex Inlet	Shoalhaven	Crown-Council	1	1
	Conjola	Shoalhaven	Private - DEC - DIPNR	1	3
	Meroo/Kioloa/Bawley Pt.	Shoalhaven	DEC – Private - Council	1	7
	North Durras	Shoalhaven	Council - Private	1	1
South Coast	Murrah	Bega Valley	Private- DPI - T	1	3
	Ludwig Swamp	Bega Valley	DPI -T	1	1
	Ben Boyd	Bega Valley	DEC	1	1
	Tura Beach	Bega Valley	Council	1	1
	Nadgee	Bega Valley	DEC	1	3
Southern Tablelands	Bungendore/Hoskinstown	Yarralumla	Private	1	2
Totals				43	115

Table 1. Key populations of *Litoria aurea* by planning region.

5.2 Tenure

The definition of each population has not been easily demarcated in every instance. However a broad definition has been applied (see above, this Section) in order to provide an indication of regional representation and also the relative importance of different classes of land tenure for conservation of the species.

Of the 43 known key populations, comprised of around 110 ‘satellite’ sub-populations, only 12 are located predominantly within DEC estate equating to approximately 21%.

The level of understanding of each of these populations is varied in terms of knowledge of the indicators of population viability in each case. Furthermore bioregional, distributional or management region factors need also be considered when assessing a particular populations significance.

Other State Government and other Agencies that may have a management responsibility include: – SOPA, DIPNR, Dept. of Lands, DPI Trading (SFNSW), FreightCorp, RailCorp, RTA, Dept. Commerce, Sydney Water, Dept. Corrective Services, Transgrid and AGL.

Commonwealth Lands include Department of Defence (DD) and the Commonwealth Territory lands of Booderee NP managed by the Commonwealth Department of Environment and Heritage (DEH).

Tenure	Populations	Demes	Pop. %	Dem. %
DEC	10	19	25	20
DPI (SFNSW)	2	5	5	5
Other State Government	6	14	17	15
Commonwealth Lands	2	3	6	4
Council	11	15	30	16
Private	21	37	58	40
Totals	52	88		100

NB. some populations are represented across more than a single tenure.

Table 2 Green and Golden Bell Frog populations by tenure.

5.3 Habitat

5.3.1 Habitat Description

The habitat preference and requirements of the Green and Golden Bell Frog are not well understood and difficult to define (Mahony, 1999), in fact the species has the propensity, on occasion, of turning up in the most unlikely locations. It would appear that the species makes use of a number of habitat components to fulfil its requirements during different parts of its life cycle. These include breeding, foraging and refuge habitat and perhaps suitable habitat to facilitate its movement patterns. The current general view of what constitutes the species habitat has

emerged from the collective observations of habitat use by various authors but most of these observations have been heavily biased toward breeding habitat when the species is most obvious (see Pyke and White, 1996; Gillespie, 1996; Mahony, 1999; Pyke and White, 2002). The species has been detected utilising a wide range of waterbodies and this includes both natural and man-made structures (Pyke and White, 1996). For example the species has been recorded associated with coastal swamps, marshes, dune swales, lagoons, lakes and other estuary wetlands as well as riverine floodplain wetlands and billabongs. Constructed water bodies such as storm water detention basins, farm dams, bunded areas, drains, ditches and other excavations capable of capturing water such as quarries and brick pits are also known to be occupied, even relatively minor structures such as tanks, safety bunds surrounding storage tanks, wells, cavitation pits, water troughs, old laundry tubs and baths have all been recorded as being utilised by the GGBF for breeding purposes. Lotic situations such as fast flowing streams appear to be one of the few water bodies not utilised by the GGBF, at least for breeding purposes (Mahony, 1999). However the instream ponded sections of non permanently flowing streams are known to be utilised (R. Wells pers. comm.; M. Anstis pers. comm.).

Other habitat attributes associated with the various waterbodies occupied by the GGBF, and that appear to make such habitat more likely to be occupied, have also been described (Pyke and White, 1996; Mahony, 1999; Patmore, 2001; Hamer *et al.*, 2002). These features include that the water body is shallow, still or slow flowing, ephemeral and/or widely fluctuating, unpolluted and without heavy shading. There is still some debate as to the relative importance of some of these attributes (Gillespie, 1996; Patmore, 2001; Pyke and White, 2001; Hamer *et al.*, 2002).

Other associated terrestrial habitat attributes that also appear to favour the species include extensive grassy areas and an abundance of shelter sites such as rocks, logs, tussock forming vegetation and other cover (Pyke and White, 1996; Mahony, 1999; Patmore, 2001; Pyke and White, 2001). There is also a clear preference shown by GGBF for sites with a complexity of vegetation structure (Patmore, 2001; Hamer *et al.*, 2002). These habitat features are often but not always found peripheral to breeding habitat and are considered foraging and/or refuge habitat. Refuge habitat is least well understood but is required by the species during periods of metabolic quiescence particularly during the cooler parts of the year ("over-wintering" habitat) but also at other times when not diurnally active or seeking shelter from adverse conditions or predators. The range of habitat that has been recorded as being used for this purpose includes:

Amongst dense tussock forming vegetation (Hamer, 1998 and pers. comm.; Patmore, 2001); deep fissures in mud (R. Wells pers. comm.; M. Christy vide Patmore, 2001); amongst rocks (White and Pyke, 1996; Hamer, 1998; Pyke and White, 2001; M. Christy vide Patmore, 2001); underground holes or burrows (Patmore, 2001); within rotting logs or under embedded logs and timber piles (R. Wells pers. comm., R. Wellington unpublished; Pyke and White 2001); and other human refuse such as sheet iron, fibro, bricks etc (Pyke and White, 2001; R. Wells pers. comm.). Such shelter has been recorded utilised by aggregations of the GGBF (R. Wells pers. comm.; R. Wellington unpublished; Pyke and White, 2001; Patmore, 2001).

Whilst the above habitat description is consistent with most of the published and other information available on the currently occupied habitat of the species in NSW, there is some question over whether it is biased to some extent either by a possible shift in habitat preference or a restriction in the types of sites able to be tolerated in the face of the threats currently operating.

Gillespie (1996) points out that in Victoria the species is recorded occupying both forested and unforested areas. He also records the species from a wide variety of waterbodies, much as in NSW, but with the exception that permanent waterbodies appear to be preferred. Patmore, (2001) and Hamer *et al.* (2002) also comment on this apparent contradiction between the findings of Pyke and White (1996; 2001) and Gillespie (1996).

Similarly Pyke and White (1996) and Lemckert (1996) on the basis of their survey data consider that the species does not occupy forested lands. Mahony (1999) poses the question that perhaps the apparent absence of GGBF from forested areas and their apparent preferred current use of ephemeral sites may be more a consequence of the factors affecting the species status in NSW. Anecdotal accounts of the species historical distribution by numerous herpetologists describe the species as being regularly encountered in large, often deep and permanent bodies of water (eg R. Wells pers. comm.; J. Cann pers. comm.; H. Cogger pers. comm.) and these observations are also supported by various authors (eg Cogger, 1962; 1983; 1992; Courtice and Grigg, 1975; Humphries, 1979; Barker, Grigg and Tyler, 1995; Anstis, 2002) and who make no suggestion of an ephemeral habitat preference. This may indicate that there has been a shift in habitat preference in recent times or an ability to survive in ephemeral

locations more successfully than permanent ponds in the face of the current threats that are operating (eg frog chytrid, predation by *Gambusia*)?

5.3.2 Climate

The broad climatic conditions that are experienced across the full extent of the species current and historical distribution reveals a considerable range in all factors. In particular the annual average temperature ranges between 11°C and 20°C and total annual rainfall from 410mm to 1980mm. This wide range of climatic values tolerated is of little predictive value in demarcating the extent of habitat likely to be utilised however they do provide useful comparative values for observing trends revealed by the species current contracted distribution. With the exception of the single southern tableland population the annual average temperatures across the other current distribution ranges from 14.6°C to 18.8°C and rainfall from 1210mm to 1870mm. A clear shift away from cooler and drier localities towards more mesic and coastal sites is evident (DEC unpublished data).

5.3.3 Landscape and Topography

The ranges of elevations occupied by the species historically versus currently are quite different. An analysis of historic distribution suggests that the species was regularly detected above 700m ASL and reached at least 1000m. Current distribution, with the exception of three populations, is generally below 50 m and most sites are at or near to sea level. The three current exceptional locations to this lower altitudinal and coastal distributional contraction are worthy of further examination. Only one site is currently known from the southern tablelands and is at 745m ASL a transient upper Hunter population occurs at 110m and another remnant colony on the escarpment bench of the northern Illawarra is at 205m. These higher altitude populations may be instructive in determining the factor(s) that have resulted in the apparent total loss from other elevated parts of the species distribution.

6 General Biology and Ecology

Research activity aimed at increasing our understanding of the biology and ecology of the Green and Golden Bell Frog (GGBF) has undergone a considerable surge in interest in recent years. Compared to other NSW frog species, the GGBF is relatively well known. Presumably as a consequence of its historic abundance and wide spread distribution the species was the subject of university anatomical and physiological investigations that resulted in the production of laboratory manuals, dissection guides, general biology texts and nature studies booklets depicting this species (Buchanan, 1921; Briggs, 1940; Kestevan, 1944; Dakin, 1948; Sterrett 1968; Leyden, 1969). Whilst this body of information provides a significant platform of general anuran anatomical and physiological information on which to build, much less information is known about the species general ecology and life history. Relevant information can be gleaned from a number of publications including (Fletcher, 1889; Harrison, 1922; Moore, 1960; Copland, 1957; Cogger, 1972; Cogger, 1992; Barker and Grigg, 1977; Tyler, 1976; Tyler, 1994). Pyke and Osborne, 1996; White, 1997, Hamer, 1998 and Mahony, 1999 have, more recently, in response to the recognised threatened status of the species, reviewed much of the published or known but still unpublished information on the species. A literature review (Pyke and White, 2001) examines much of the literature covering various aspects of the biology and ecology of the species and this section relies heavily on an interpretation of this report. For the future of key importance is the development of an improved understanding of the demographics and dynamics of specific populations of the species. In particular movement patterns, longevity and factors influencing mortality and recruitment are essential information to be gained. The long-term monitoring of populations required to provide this information is underway in some locations and is an intended action of this recovery plan.

6.1 Predator/Prey Relationships

Green and Golden Bell Frogs have been recorded naturally feeding on a wide variety of prey items. Such prey items include many invertebrates such as insect larvae, crickets, cockroaches, dragonflies, earthworms, flies, grasshoppers, mosquito wrigglers, isopods, freshwater crayfish and slugs (Krefft 1863; Fletcher 1889; Lucas & Le Souef 1909; Copland 1957; Barker & Grigg 1977; Dankers 1977; Humphries 1979; Hoser 1989; Hero *et al.* 1991; Cogger 1992; White, 1994; Wellington 1995; Cawood 1997; Miehs, 2000; Patmore, 2001; Pyke and White, 2001).

It has been generally known among herpetologists for many years that the GGBF is highly anurophagous (frog eating) in habit (Hoser, 1989). Anyone with an historical experience of collecting GGBFs and making the mistake of placing smaller species or individuals in the same bag or enclosure can attest to this as fact. Recent studies at Broughton Island and reintroduction trials at Marrickville have clearly demonstrated that cannibalism and anurophagous behaviour also occurs in the wild (G. Pyke pers. comm.; A White pers. comm.) and has also been observed in other populations (M. Parsons, pers. comm., Pyke and White, 2001).

In captivity the GGBF is known to feed on house crickets, fruit flies, domestic flies and maggots, mealworms, beetles, various other insect larvae, slaters, silkworms, instar plague locusts, cockroaches, water snails, spiders, earthworms, other frogs, mice and even a small tiger snake (Fleay 1935; Copland 1957; Tyler 1976; Coupe 1993; Robinson 1993; Hobcroft 1997; Pyke and White, 2001).

In captivity the GGBF will not readily respond to stationary food items (Hobcroft 1997) and this and the various other observations above have led to the general view that GGBF will eat almost anything that moves and can be accommodated (Krefft 1863; White 1995). It is likely, however, that the species would show some selectivity, even if only based on a shift in size of prey item consumed dependent on relative size of frog (Pyke and White, 2001). Sub-adult GGBFs appear to hunt and feed mostly on relatively small insects, especially flying ones (A. White pers. comm.). Juveniles can be observed performing amazing gymnastic feats to snatch small insects in flight (R. Wellington unpublished). Adult frogs appear to show a marked preference for larger ground dwelling insects and frogs (Pyke and White, 2001).

Miehs and Pyke (2001) have also demonstrated that the GGBF, under some circumstances at least, will readily feed on aquatic prey including tadpoles and other aquatic organisms and therefore not necessarily restricting itself to just terrestrial prey. Recently metamorphosed individuals have also been observed to dive into shallow water to capture mosquito wrigglers (R. Wellington unpublished.).

The anurophagous behaviour exhibited by this species, including its predation on tadpoles, is potentially another factor that may have contributed to declines or disappearance in the northern parts of its distribution. In such locations the GGBF is, or was, sympatric with the introduced cane toad and both species are known to occupy similar habitat. Tadpoles and juvenile cane toads are known to be toxic when consumed although metamorphs may not be (M. Anstis pers. comm.). Clearly there is potential for a negative predator/prey association between the species that is worthy of further investigation.

There has also been little available information on the importance of the various known types of prey items in the natural diet of the species. This has precipitated recent studies to quantitatively determine the proportional make up of prey items in different Green and Golden Bell Frog populations (Miehs, 2000; G. Pyke pers. comm.).

In captivity the GGBF consumes more during the warmer months than during cooler periods of the year (Hobcroft 1997).

In a natural highland population, Humphries (1979) found that the GGBFs spent less time feeding during episodes of breeding and during “brumation” (a period of aestivation) and was more likely to be observed foraging at other times. In the same population Humphries (1979) also found that newly metamorphosed immature froglets continue to forage later in the year than did adults.

Dietary preference of tadpoles of the GGBF has been summarised in Pyke and White, (2001) where it is suggested that they predominantly graze on the algal or bacterial scum growing on submerged rocks and other substrata. More advanced tadpoles may show some preference for vegetable matter but also scavenge or become carnivorous on other aquatic organisms (Pyke and White, 2001). In captivity GGBF tadpoles have been raised on various combinations of fish flakes, boiled lettuce leaves and various types of pet food pellets (Hobcroft, 1997; Pyke and White, 2001; T. Russell, pers. comm.; R. Porter, pers. comm.; M. Anstis, pers. comm.). Predation on GGBF tadpoles has apparently been rarely directly observed in the wild (Pyke and White, 2001) however predation on GGBF tadpoles by the following species has been recorded:

White-faced Heron (*Ardea novaehollandiae*) (Bell, 1982– in New Zealand; Pyke and White, 2001); Reef Egret (*Ardea sacra*) (R. Wellington, unpublished); Swamp Harrier (*Circus approximans*) (Bell, 1982 – in New Zealand); White Ibis (*Threskiornis aethiopica*) (M. Christy, pers. comm.; Pyke and White, 2001); Long-necked Tortoise (*Chelodina longicollis*) (Pyke and White, 2001); Red-bellied Black Snake (*Pseudechis porphyriacus*) (Pyke and White, 2001); Water Beetles (Family: Dysticidae) (A. Hamer, pers. comm.); Water Scorpion (Family: Nepidae) (Pyke and White, 2001); Dragon-fly Larvae (Order: Odonata) (A. Hamer, pers. comm.; Hamer, 1998); Plague Minnow (*Gambusia holbrooki*) (eg., Morgan, 1995; Morgan and Buttemer, 1996; Pyke and White, 1996; White and Pyke, 1996, 1999b) and Eastern Water Skink (*Eulamprus quoyii*) (Pyke and Miehs, in press).

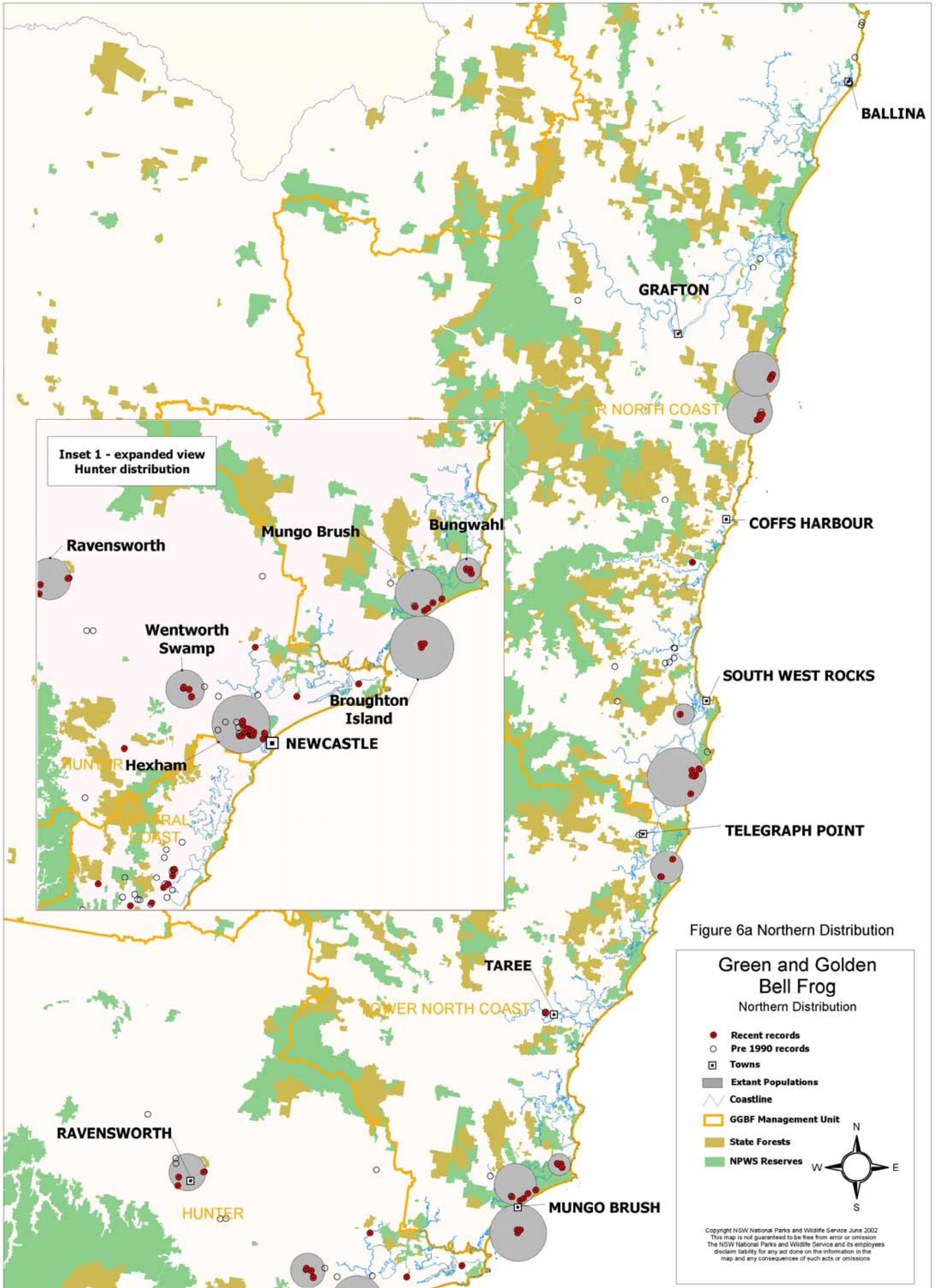
Other likely predators of GGBF tadpoles includes various introduced fish such as the Redfin Perch (*Perca fluviatilis*) (Pyke and White, 2001) and the European Carp (*Cyprinus carpio*); Native fish such as the Freshwater Eel (*Anguilla spp.*) (Pyke and White, 2001); Empire Gudgeon (*Hypseleotris compressa*) - White and Pyke, 1999; Fire-tailed Gudgeon *H. galii*. - White and Pyke, 1999; Blue Eyes (*Pseudomugil signifer*) A. White pers. comm.) and wading birds such as the Pacific Heron (*Ardea pacifica*) and Intermediate Egret (*Ardea intermedia*) (Pyke and White, 2001).

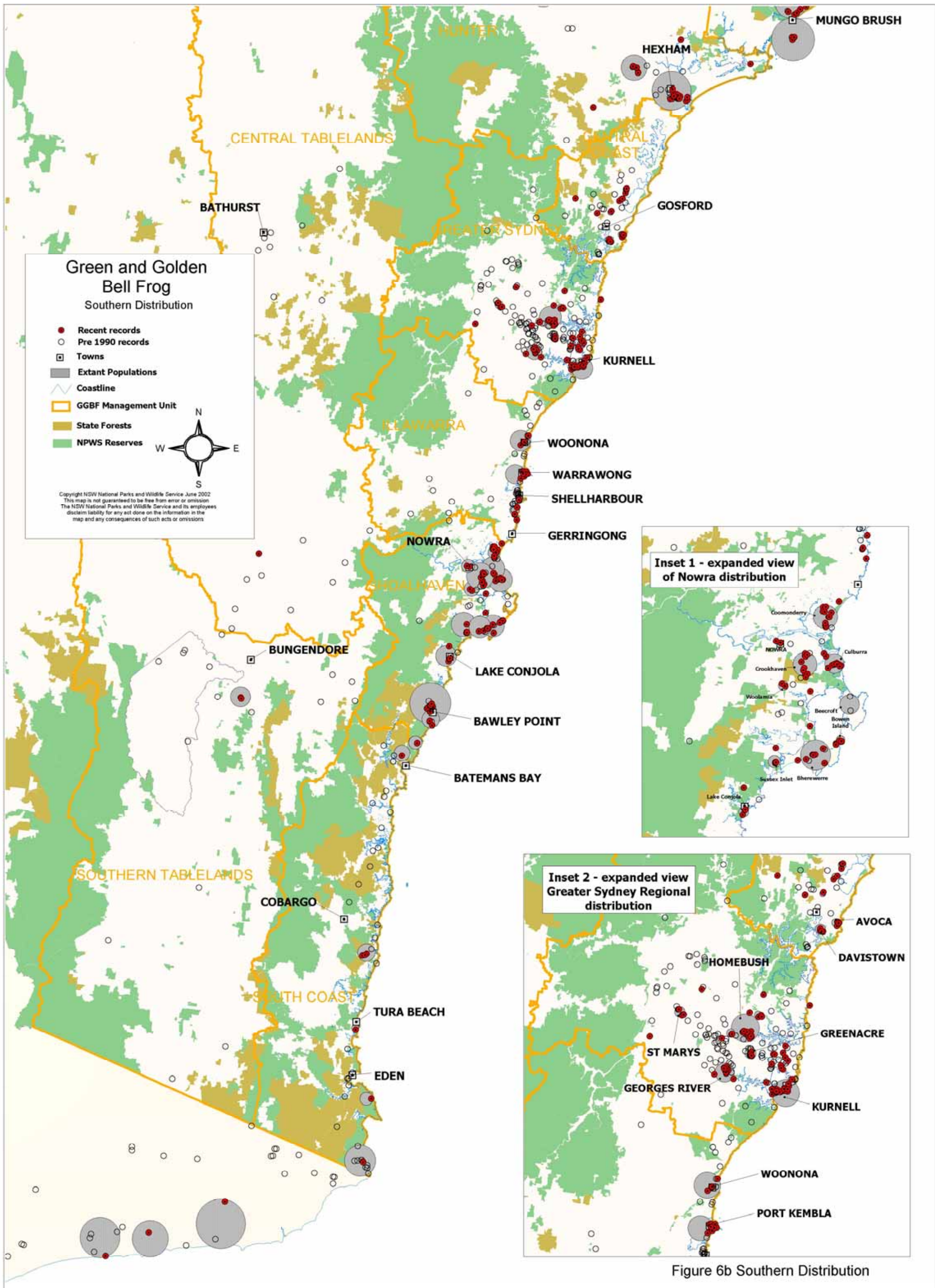
One opportunistic feeding observation of a Reef Egret (*Ardea sacra*) at Crescent Head, found that the bird walked in the shallow margins of a hind-dune swale breeding pond 10-15cm in depth, flushing tadpoles from the cover afforded by alga growth on the bottom. Tadpoles were seized in the bill and manipulated and then with a head flick they were eviscerated and then swallowed. A trail of approximately 15 intestinal coils, with other viscera attached, were observed left uneaten in the wake of the birds feeding movements until it was disturbed and flew off (R. Wellington unpublished).

Nevertheless there is presently little or no known information available on the extent to which any particular predator impacts on tadpoles of the GGBF. The impact such predation may have at the local population level and hence recruitment is also unknown.

Predation on adult GGBFs or at least metamorphosed frogs has been recorded for:

Red-bellied Blacksnake (*Pseudechis porphyriacus*) P. Johnston, pers. comm.; R. Wells, pers. comm.; I. McCartney, pers. comm.; R. Wellington, unpublished; Pyke and White, 2001); Tiger Snake (*Notechis scutatus*)





(J. Cann, in Pyke and White, 2001); Laughing Kookaburra (*Darcelo gigas*) (Pyke and White, 2001); Sacred Kingfisher (*Ardea sancta*) (Pyke and White, 2001); and GGBF are also almost certainly preyed on by various other wading birds and other snakes (Wellington, 1995) such as the Green Tree Snake *Dendrelaphis punctulatus* (R. Wells pers. comm.) and the Copperhead (*Austrelaps superbus*). E. Rotherham (in Australian Academy of Science, 1973) recorded the Copperhead feeding on the closely related and previously sympatric Southern Bell Frog *Litoria raniformis*).

At some sites where remnant GGBF populations have been detected recently there have also been populations of Red-bellied Black Snakes or Tiger Snakes detected nearby (W. Osborne pers. comm.; R. Wells pers. comm.; R. Wellington unpublished). Whilst this is only circumstantial evidence, when coupled with the numerous incidental records of predation by various water birds, it does support the view that the GGBF is (or at least was) an important prey item in its community.

6.2 Reproduction

6.2.1 Breeding Period

Breeding events and other associated reproductive behaviours have been recorded from late winter to early autumn but generally between September and February (Fletcher, 1889; Harrison, 1922; Barker *et al.*, 1995; Pyke and White, 2001) with a peak around January-February after heavy rain/storm events, (White, 1995a; Daly, 1995a; Griffiths, 1997; Anstis, 2002). Reproductive events are however clearly influenced by the prevailing weather conditions from season to season and also appear to be influenced by geography. More southerly and higher altitude populations appear to have a narrower window of opportunity for breeding than more northerly and lower altitude populations. More northerly populations appear to more often commence breeding earlier and continue longer than southern and tableland populations which appear to have a much shorter breeding period (Humphries, 1979; Clancy, 1986; Daly, 1995a; Patmore, 2001; G. Daly pers. comm.; Wellington and Parsons, in prep.).

6.2.2 Mating Call

Only males elicit the mating call and can be heard throughout the breeding period. Calling is mostly at night, although occasionally also by day. Individual males can sometimes also be triggered to respond to a call recording play back or call imitation. This may indicate that calls are a reflex response and may in part explain the observed coordinated choruses from around breeding habitat and with apparent chorus leaders (Barker and Grigg, 1977; J. Barker pers. comm.; Barker *et al.*, 1995; Pyke and White, 2001). Calls are usually made whilst floating in water but also occasionally from positions amongst pond-side vegetation (Barker and Grigg, 1977; Barker *et al.*, 1995; Pyke and White, 2001; Anstis, 2002). Males appear to reach maturity at around 45-50mm (9-12 months) and at this size begin to develop a grey to brownish yellow wash beneath the chin (Pyke and White, 2001). This discolouration indicates the development of a vocal sac (Tyler, 1994) and consequently that an individual has commenced calling behaviour.

6.2.3 Amplexus

In the GGBF amplexus is axillary with males grasping the females near the armpits rather than around the waist (which is the alternative and termed inguinal amplexus Tyler, 1994; Pyke and White, 2001). Males develop raised "nuptial pads" on their thumbs once they reach sexual maturity at about 45-50mm SVL. These pads are dark brown during the breeding season but become paler and much less obvious at other times. The nuptial pads assist the males to maintain their grasp on the female during amplexus and in some frog species the nuptial pads are adorned with microscopic spines and stylets to improve grip (Tyler, 1994). Amplexus occurs mainly in water or adjacent to breeding sites but has also at times been observed some distance from water (Pyke and White, 2001). Monitoring of breeding sites during the breeding season has indicated that males are more likely to be encountered at these sites for longer periods than are females (G. Pyke, pers. comm.; M. Bannerman, pers. comm.). Females have been observed to show site fidelity for shelter and foraging sites some distance from breeding sites (Hamer, 1998; Pyke and White, 2001; R. Wellington unpublished). It would appear that various cues (call and climatic) trigger the appearance of females at the breeding sites (Barker and Grigg, 1977; Hamer, 1998; M. Bannerman pers. comm.). It has been suggested that such females may avoid breeding sites until ready to shed so as to avoid 'forced shedding' that may result in reproductive failure (M. Mahony pers. comm.).

Observations of amplexing pairs has provided evidence that females reach sexual maturity at two years (Pyke and White, 2001). Females smaller than 65mm SVL are not seen in amplexus and 65mm size class both in the wild and captivity is not attained until the second season after metamorphosis. Anatomical or other studies may need to be undertaken to confirm this.

6.2.4 Fecundity

The Green and Golden Bell Frog is a highly fecund species with recorded clutch sizes ranging between approximately 2000 to 11500 eggs (Pykes and White, 2001). Average clutch size has also been estimated and in rounded figures is about 3700 eggs per clutch with 3-5 thousand apparently the norm (White, 1995; Daly, 1995a; Pyke and White, 2001; Anstis, 2002; Mahony, 2002) see also Section 4.1.3.

6.2.5 Rates of development and metamorphosis

Hatching takes place 2-5 days after ovipositing/fertilisation and is affected by water temperature (Penman, 1998; Pyke and White, 2001; Anstis, 2002). Tadpole development is generally completed within 6-12 weeks although in some instances this may take 11-12 months to be completed (Pyke and White, 2001; Anstis, 2002) and thus over-winter if development is not completed before temperatures fall (Pyke and White, 2001) and would be more likely to occur if rain events trigger breeding late in a season.

Metamorphosis is completed with individuals having 24-30mm SVL (Daly, 1995a; Hamer, 1998; Pyke and White, 2001; R. Wellington, unpublished).

6.3 Life history and species dynamics

The GGBF has been described as a successional or colonising species and having 'weed like' life history attributes (White, 1997; Pyke and White, 1996; 2001; Hamer, 1998). The development of adaptations for this type of life strategy has been termed 'r' selection (Pianka, 1970). Usually such species are generalists with tolerance for a wide range of environmental factors. They are also often associated with habitats with high variability such as fluctuating conditions and/or unpredictability in climate. Such life history strategies quite often pre-adapt a species for colonising and occupying disturbed environments. Much of the available information on the GGBF typifies such a life strategy (eg Pyke and White, 1996; 2001). However 'r' strategists also typically experience high mortality with losses independent of density and have fluctuating population size (generally below carrying capacity) but offset by high fecundity and rapid development to reproductive maturity, they are generally small and short lived (Krebs, 1972). There is insufficient information for the GGBF available on some of these other life table attributes to assess the species conformity as a classic 'r' strategist. However the GGBF does have high fecundity with 3-5000 eggs in an average clutch (Pyke and White, 2001 see section 6.2.4), develops rapidly to maturity in 1-2 years (Hamer, 1998; Pyke and White 2001) but the species is medium to large in size by frog standards (reaches over 90mm SVL), information on longevity in the wild is poorly known (the species has been recorded as reaching 10-15 years of age in captivity (J. Barker vide Pyke and White, 2001) and factors influencing population density and size are also unknown. Furthermore 'r' strategists usually only reproduce once and normally have low competitive ability (Odum, 1971). The available evidence on these factors for the GGBF is less certain. White, (1997) has suggested that the GGBF is displaced by other frog species or replaced in a successional sense (Pyke and White, 1999). However the species is known to breed more than once in captivity (P. Harlow pers. comm.) and in the wild large (90mm+) individuals have been observed gravid and then observed to exist for over 3 years after breeding at that size (R. Wellington unpublished). The species does not appear to conform, in 'r' strategist terms, with respect to longevity and nor is it a 'one off' breeder.

6.4 Demographics

Information on the demographics of GGBF populations is important but will only become available through long term monitoring of populations. Only then will population viability analysis (PVA) be possible. Some populations have now been monitored over several seasons but analyses of the results of these studies are only just beginning to become available. Population size estimates for seven populations are believed to be over 1000 individuals (Pyke and White, 2001). How these population levels might fluctuate seasonally or be affected by climatic condition are unknown and will only be revealed by repetitive monitoring over extended periods. Measures of mortality of the various age classes will be likely critical in determining where threatening processes are exerting most influence. Longevity in the wild is unknown and whilst individuals in captivity provide some evidence that the species is potentially long lived, this may be infrequently realised in the face of various risk factors for survival. Migratory patterns and measures of recruitment are also unknown.

6.5 Movement Patterns and other behaviour

The Green and Golden Bell Frog displays a variety of behaviours and movement patterns from population to population, site to site and even season to season within specific populations. Consequently it is very difficult to generalise about movement patterns and other behaviours. Clearly the species has a variety of habitat requirements and these are spatially or temporally met in different ways at different locations. Various studies have been undertaken that provide some insight into these patterns of habitat utilisation (eg Humphries, 1979; Hamer, 1998; M. Patmore, 2001; Pyke and White, 2001; Hamer, *et al.*, 2002; M. Christy, pers. comm.).

The species is capable of making quite large movements in a single day/night up to 1-1.5 km (A. White, pers. comm; Pyke and White, 2001; R. Wellington unpublished). Mark and recapture studies have shown tagged individuals have moved up to 3km (Pyke and White, 2001) and revealed frogs several kilometres from the nearest breeding habitat (Gillespie, 1996; Pyke and White, 2001) or demonstrated significant movements within a presumed home range (Murphy, 1996; Hamer, 1998; Patmore, 2001; Daly, 2001; Wellington and Parsons, in prep.).

Recently metamorphosed individuals have been observed to rapidly vacate the breeding site particularly when foraging habitat is also in the vicinity (Pyke and White, 2001; G. Pyke pers. comm.). At other sites where the breeding habitat is at some distance from the nearest habitat suitable for adult foraging juveniles may remain for some time (R. Wellington unpublished). The cannibalistic nature of adults is a likely cause of this avoidance behaviour (Pyke and White, 2001).

There is evidence the species can show strong site fidelity with individuals returning to or remaining at an identified site (Murphy, 1994; Patmore, 2001; Hamer, 1998; M. Christy pers. comm.; R. Wellington unpublished). Similarities and differences in the reported observations of Patmore (2001), Hamer, (1998) and Hamer *et al.*, (2002) seem to be suggesting that the GGBF will remain at a site and show strong site fidelity provided all the required habitat attributes for its needs are present. Where some of these requirements are not met the species will move over a wider area to satisfy those needs. When conditions become unfavourable the species will move the required distances to find suitable habitat and when ample habitat is present those areas which have the greatest habitat complexity are favoured. The long-term studies that should confirm such trends in habitat utilisation are ongoing at a number of sites (Kurnell, Homebush, Kooragang Island, Avoca Lake, and Broughton Island) and their continuation is a desired outcome of this recovery plan.

7 Previous management actions

7.1 Green and Golden Bell Frog Recovery Team

A recovery team was established in 1997 with many of the recognised experts on the species represented. The recovery team has met several times to discuss and set objectives, actions and resolve issues of conservation significance. Members of the team have commented on and contributed in many significant ways to the development and compilation of this Recovery Plan.

7.2 Survey and monitoring

Systematic and opportunistic surveys have been conducted at many of the species known former locations by a variety of investigators. Pyke and White (1996) undertook to summarise the statewide status of the species by collating distributional records and systematically inspected many of them. Osborne (1995; 1999) similarly assessed the species status in the ACT and southern tablelands generally and other workers have investigated various other parts of the species distribution for example White, (1993; 1996); Wellington, (1993); Mahony, (1996; 1999); Clancy, (1996); Gillespie, (1996); Daly, (1997); Goldingay *et al.* (1998a; b); Pyke and White (1998); Hamer, (1998); Mahony, (2001); Hamer, *et al.* (2002). Furthermore targeted surveys were commissioned by the DEC and undertaken in the perceived 'gap' regions of the north and south coast of NSW during the 2000/01 season (White, 2001; Daly, 2001). Specific surveys were also undertaken to determine the extent of a recently detected high altitude remnant population at Bungendore (Patmore and Osborne, 2000; Osborne and Patmore, 2001; Patmore, 2001).

Environmental impact assessment coupled with the species high profile has also resulted in considerable survey effort at various sites due to development or landuse management requirements (for example Greer, 1994; 1995; 1996b; Cogger, 1993; Fanning, 1996; Gunninah, 1996; White, 1993a; 1997; Pyke, 1995). Frog interest groups, independent herpetologists and other community members with an interest in the species have also informally surveyed sites and reported observations G. Daly pers. comm., R. Wells pers. comm., A. White pers. comm., D. Deighton, pers. comm., J. Baker, pers. comm., M. Robertson, pers. comm., L. Tarvey, pers. comm., M. Bannerman, pers. comm., E. Burns, pers. comm., R. Wright, pers. comm.

These ongoing investigations have resulted in the detection of several new populations or sites and added knowledge to the baseline compilation already reported in Pyke and Osborne, (1996).

To date not all investigations have been documented in formal publications and may only occur in low circulation development related assessment reports or management plans. Much of the survey effort undertaken has been by its very nature on an 'ad hoc' or 'as required' basis with little prior coordination.

Monitoring of several of the known populations has also occurred in recent times. Monitoring studies have been undertaken at Broughton Island off the coast at Tea Gardens, Avoca Lagoon on the Central Coast, Kooragang Island in the lower Hunter, Ravensworth in the upper Hunter, Yuraygir and Hat Head on the north coast, at Coomaditchie and environs near Port Kembla in the Illawarra, at Greenacre, the Olympic site at Homebush Bay, at Bungendore on the southern tablelands and at several sites at Kurnell and Arncliffe in the southern suburbs of Sydney. Such monitoring programs have been the result of either independent research interest or as a consequence or requirement of development consent. Many sites still remain in need of serious targeted search effort and assessment and large areas of potential habitat could still harbour significant populations in apparent distributional 'gap' regions. Many of the known sites are also in need of an ongoing monitoring program to assess the species status and the threats that are operating in these locations.

7.3 Site specific management plans

Site specific management plans (MP) are under development for several of the known 'Key Populations' and for some have already been produced.

Sites for which Management Plans are either complete or under development include:

- Port Kembla - populations centred on Coomaditchie Lagoon.
- Port Kembla – Incitec site
- Homebush Bay Olympic Site (Sydney Olympic Park)

- Marsh Street Wetland/M5 East at Arncliffe
- Freight Corp Site at Enfield Marshalling Yards
- Cox's Creek Reserve, Greenacre
- Punchbowl Brickpit site
- Kurnell Landfill Co. site
- Kurnell Australand site
- Kurnell STP and pipeline sites
- Kooragang Island
- Ravensworth Mt Owen mine site
- Yuraygir NP sites
- Hat Head NP sites
- Culburra Lake Wollumboola sites
- Currumbene DPI (SFNSW) site
- Jervis Bay Bherwerre Booderee sites
- Sussex Inlet STP site
- Lake Conjola Quarry site
- Shell Refinery, Clyde
- Holroyd Gardens, Merrylands
- CSR Emoleum Plant, Rosehill
- Boral Brickpit site, Woonona
- Avoca/Davistown
- Port Macquarie sites

Management Plans for the above sites/populations have been produced for a variety of reasons. Some have arisen as requirements of development consent, others out of the statutory responsibility of the land managers concerned and still others as biodiversity conservation initiatives of Councils, land owners and/or community groups. Some of the management plans already produced may require revision to be aligned with the objectives, framework and/or reporting requirements of this recovery plan.

7.4 Integrated Forestry Operations Approval (IFOA)

Approvals given to State Forests of NSW (DPI) under the Forestry and National Parks Estate Act 1998 – IFOA provide for licences to be issued to undertake forestry related activities within certain DPI (SFNSW) regions of NSW. The licences issued, including a threatened species licence (TSL), detail, among other things, general and specific prescriptions that were negotiated between SFNSW (DPI) and the DEC to ameliorate impacts of forestry operations on various threatened species.

The Green and Golden Bell Frog was identified as a species with the potential to be impacted by forestry operations in some locations and prescriptions to deal with the potential for impacts on this species were formulated. Under the Eden, Upper North East (UNE), Lower North East (LNE) and Southern IFOAs the relevant TSLs require certain general and specific prescriptions to be put in place to minimise possible impacts on the GGBF and its habitat. This includes 50m exclusions around records and the extent of identified habitat present. The TSL also defines targeted survey requirement for this species as part of the assessment process for forestry operations under the respective IFOAs (see RACAC 1999 a,b,c)

7.5 Research

Considerable research effort on *Litoria aurea* has been recently conducted or is currently underway. Some preliminary information is available from these incomplete or ongoing investigations and much is as yet unpublished. Fortunately much work is being undertaken by members of the recovery team assisting with the preparation of this recovery plan or through research conducted by students and colleagues. Other less species specific, though still highly relevant, research is also underway investigating the threats to frogs generally.

Current research activity includes:

Genetic Investigations

An initial genetic analysis of some of the Sydney GGBF populations was undertaken in response to the occurrence of the species in a number of high profile proposed development locations throughout Sydney. This

analysis demonstrated that proximal populations could possess quite significant genetic differences (Colgan, 1996). This resulted in DEC adopting a conservative approach to development related management decisions at a number of locations.

Further development pressures resulted in a comprehensive DNA level genetic analysis being undertaken that commenced in 1998 and is nearing completion. This study was undertaken with the objectives of determining levels of genetic variation within and between populations of the GGBF. It is anticipated that findings from this study will provide some insight into the demarcation of evolutionary significant units (ESU), management units (MU) and provide evidence of inbreeding/bottlenecking that may be useful for management decisions at the local and population level. These studies are being undertaken at the University of NSW with additional support from the RTA, DEC and Taronga Zoo (Burns, 2000; 2001; B. Houlden pers. comm.; see also Burns *et al.* in prep.).

Reintroduction Experimentation

Experimental reintroductions are being undertaken to determine whether it is possible to establish self-sustaining populations of the species. A significant consideration of these reintroductions has been the apparent loss of the species from the vicinity of the proposed reintroduction site. Such reintroductions have occurred at Botany (commenced 1996), Marrickville (commenced 1998) and Collaroy (commenced 1999) (see White and Pyke, in prep for a summary) and further reintroduction proposals are being considered for Merimbula on the south coast and at the Wetlands Centre, Shortlands in the Hunter. Others may be considered as an outcome of this Recovery Plan (see Section 13.3.2).

These reintroduction trials have not been in progress long enough for overall success or failure to be determined. To date tadpole introductions have had varying success through to metamorphosis. At the Botany and Collaroy sites individuals still persist as adults and this is a certain qualified measure of success. To date no females have reached maturity (two years) at either the Botany or Collaroy sites and so an F1 breeding event from captive bred and released tadpoles or juveniles has not been achieved. A successful reintroduction can only be considered to have been achieved when breeding by the reintroduced stock is followed by a second successful reproductive cycle involving these F2 individuals (Semlitsch, 2002) and as a result that a potentially self-sustaining population has been established. Only the Marrickville reintroduction has achieved such a breeding event but as this is a 'contained' population with other frog species excluded it cannot be considered a successful 'natural' reintroduction. Nevertheless the Marrickville reintroduction does provide some useful insight into the value of 'backyard' scale conservation initiatives for the species (Pyke and White, in prep.). The recent loss of this reintroduced Marrickville population to frog chytrid disease (Arthur White pers. comm) has clearly brought to light the likely significant threat this disease is to successful reintroduction. Chytrid attenuation trials using low levels of salinity coupled with further reintroductions are now continuing (A. White pers. comm.).

Habitat Creation Experiments

The creation of experimental and/or compensatory breeding habitat as a result of development proposals has occurred or is occurring at a number of known Green and Golden Frog sites. In these instances the constructed habitat was located close to existing populations to facilitate natural colonisation. These initiatives have mainly come about as a consequence of development pressures but also through the recommendation of site specific management plans or as a result of research interest. Most notably this has occurred at the Homebush Bay Olympic site (Greer, 1994; Pyke, 1995; AMBS, 1999a,b; G. Muir pers. comm.) but also at Enfield/Greenacre (Greer, 1995; Lees, 1996; White 2000, 2001, 2002), Kurnell (Greer and Le Provost, 1996; Greer, 1996; Christy, 1998; White, 1999), Arncliffe (White, 1998), Merrylands (White, 1999), Culburra (Daly pers. comm.), Port Kembla (White, 2001) and Clyde (ERM, 2001). In some instances this habitat creation has occurred in concert with either captive bred tadpole supplementation or with the assistance of active transfer of adult frogs, though successful establishment appears to be mostly the result of self colonisation (M. Christy, A. White, G. Muir pers. comm). Habitat creation at all the above sites has resulted in at least initial colonisation by the Green and Golden Bell Frog of some of the created habitat. Some created sites have also resulted in successful breeding, at least initially, although levels of recruitment that may have resulted from any breeding events is still largely unknown or unavailable. A number of other in-situ habitat creation trials have also been considered for Avoca and Davistown on the Central Coast, at Kooragang Island and the Wetlands Centre at Shortlands near Newcastle, at Greenwell Point in the Shoalhaven, at Yuraygir near Grafton and Woonona in the Illawarra.

At Newcastle University a series of replicated experimental ponds have been established to conduct controlled experiments on the utilisation by Green and Golden Bell Frogs of various microhabitat features. These studies are

aimed towards assisting later rehabilitation and restoration trials proposed for parts of Kooragang Island and the Hunter generally as well as for state-wide conservation initiatives.

Captive Breeding and Captive Management

Development of captive breeding and management programs has occurred at Taronga Zoo and at the Australian Reptile Park. These projects have been set up to determine the requirements of the species for sustained management in captivity. They include maintaining the genetic diversity of the breeding stock through several generations and also to determine the requirements for breeding on demand to support possible reintroduction and supplementation experiments or other proposals in the future. The captive stock held at these two facilities represent three provenances and provide a certain measure of insurance against future declines or disappearance of the populations they represent. Small captive colonies of the GGBF are also maintained at the Australian Museum and Newcastle University and other licensed private amphibian keepers also maintain this species. Some of this stock is known to be of other provenance to that held by Taronga Zoo and the Reptile Park (Michael Mahony, Arthur White; Rob Porter, Peter Johnson, all pers. comm.).

Investigations of known or potential threats

Investigations into the affect of UV-B radiation on *L. aurea* tadpoles and eggs have been undertaken (van de Mortel, 1996; van de Mortel and Buttemer, 1996). Results of this study suggested minimal effect by UV on the development of *L. aurea* eggs to tadpole stage. Further work is warranted on the effects of UV on the later tadpole developmental stages and successful metamorphosis before this can be ruled out as a likely threatening process (W. Osborne, pers. comm.).

Studies of predation by the Plague Minnow *Gambusia* on *L. aurea* tadpoles (Morgan, 1995; Morgan & Buttemer, 1996; White and Pyke, unpublished). These studies support the long suspected and purported view that *Gambusia holbrooki* is a significant predator on *L. aurea* eggs and tadpoles. The density of aquatic vegetation was found to be a factor in increasing reproductive success rate in the face of this predation (Morgan and Buttemer, 1996; White and Pyke unpublished).

Laboratory studies of tadpole competition and inhibition trials suggest that *Limnodynastes peronii* tadpoles may successfully compete with and/or inhibit maturation of *L. aurea* tadpoles (A. White, pers. comm.) however this is not supported in the wild on Broughton Island where *L. aurea* predominates (G. Pyke pers. comm.). Penman, (1998) suggests this may be the result of *L. aurea*'s greater tolerance of a wide range of physico-chemical factors presumably at the expense of a greater competitive ability under any specific set of conditions. However it could also be explained by the differential susceptibility between the species to a threatening process, such as disease, fortuitously absent from Broughton Island.

Water quality parameter influences such as salinity, temperature, pH and nutrient levels on tadpole survival, growth and development have been undertaken and/or are ongoing (T. Penmann, 1998; Christy and Dickman in prep; M. Mahony, pers. comm.; S. Lane, pers. comm., G. Pyke pers. comm.; Pyke and White, in prep). These studies suggest an ability to survive salinities approaching 10% that of seawater although salinity levels over 5% were observed to produce increased tadpole mortality and/or developmental abnormalities. Other serendipitous findings imply that salinity may afford an improved survivorship for developing tadpoles exposed to the frog chytrid pathogen (M. Mahony pers. comm). These very early and inconclusive findings lend support to other circumstantial evidence for a 'coastal' (salinity?) factor being involved in the survival of many remaining populations of the GGBF. Such a factor has been hypothesised in an attempt to explain the almost exclusive coastal distribution pattern exhibited by surviving remnant populations of the GGBF (see Fig 6). Other studies to date suggest that tadpoles of *L. aurea* have a relatively high tolerance to fluctuations in pH (4-9), temperature (Penman, 1998) in addition to the relatively high salinity tolerance levels for an amphibian. Remnant GGBF colony associations with known contaminated sites at Bungendore, Port Kembla, Kooragang Island, Clyde and Homebush (among some other possibles) also lends support to the view that contaminants may afford some protection either against the pathogen or facilitates an acquired immunity in surviving adults (Wellington, unpublished). These observations require further investigation.

Breeding pond, microhabitat selection trials in replicated pond systems at Newcastle University (mentioned above) are also intended to attempt to identify critical habitat components and threatening processes that may limit *L. aurea* colonising and surviving at certain pond sites (M. Mahony pers. comm.; S. Lane pers. comm.).

Monitoring programs at certain sites as outlined in 7.2 above are underway and include mark recapture and previously radio tracking programs. These investigations are already providing preliminary information on population size estimates, population density, timing and location of breeding events, movements and habitat utilisation. Over time these studies should add to the knowledge base on population demographics such as population level fluctuations, movement patterns, recruitment and longevity as well as ongoing changes in the status of specific populations.

Observational studies are underway to determine extent of predation pressure on Green and Golden Bell Frogs as well as trials to determine the efficacy of procedures to study dietary preference in the GGBF (G. Pyke, pers. comm.).

Investigations into the development of monoclonal antibody techniques for the field detection of infected frogs (chytridiomycosis) are also currently underway (R. Haering; M. Mahony; L. Berger, R. Speares pers. comm.). The development of such a field test procedure would be beneficial for detecting frog chytrid pathogen infections in *L. aurea* populations (as well as in other frog species).

7.5 Species information profile and environmental impact assessment guideline

A species information profile (SIP) and environmental impact assessment (EIA) guideline have been prepared by the DEC with input and advice from the recovery team. These documents have been developed in accordance with s5A and s110 of the TSC Act to assist with the identification and informed assessment by decision-makers. Copies of the SIP have been provided to consent authorities and consultants and are available on the DEC web site. Copies of the SIP and EIA guideline are also provided in the Appendices section of this recovery plan.

7.6 Community survey

Several localised community survey efforts have been undertaken for the GGBF. These initiatives have included local media stories and the development and dissemination of information brochures with appeals for the community to report observations. Important new populations and locality records have resulted from enlisting community survey effort in this manner.

Friends of the Green and Golden Bell Frog were established to monitor and survey for additional local occurrences of the species as well as seek support/funding and protection for their local population of the species.

These groups include:

Avoca-Davistown - established 1997

Coomaditchie-Port Kembla - established 1996

Marrickville - established 1998

Long Reef-Collaroy - established 1999

Merimbula - established 1998

8 Management Issues

8.1 Level of Understanding

Conservation biologists recognise that there are three integrated components to managing endangered species. These are an understanding of the biological and technical aspects of the species including identification of the known and potential threats; an understanding of the social and political parameters that may impinge on the success or otherwise of the program (most threatened species have become threatened because of the activities of humans, their attitudes to wildlife and/or the policies and programs of government agencies at the time); and thirdly the economic factors that provide the resources to be able to implement the necessary actions identified for the recovery of the species. Each of these factors needs to be considered together to maximise the chances of success.

The following sections identify our current understanding and/or limitations in knowledge of the biology and ecology of *Litoria aurea*. It also identifies the threats and potential threats operating on the various populations and further considers the social and economic factors that have an ability to affect the success of the recovery program.

8.2 Threatening Processes

Several factors or threats have been implicated in the demise of the Green and Golden Bell Frog. Virtually all can be identified as being the direct or indirect consequences of previous or current human activity. The whole picture is still not completely clear and it is probable that new threats or perhaps a better understanding of known threats and their interaction will emerge.

8.2.1 Habitat Loss, Habitat Modification and Disturbance

Habitat destruction on a large scale has occurred across a large area of the species distribution directly as a result of development. Historically in NSW large tracts of poorly drained coastal flood plain land and wetland areas have been drained, in-filled or otherwise developed. Thus the spatial extent of wetland that would have constituted prime habitat for this species has been dramatically reduced. No study has been undertaken to determine the precise extent of the various coastal and floodplain wetlands present in NSW at colonisation. However Goodrick (1970) undertook a survey of coastal wetlands in NSW and attempted to estimate the area of various wetland habitat categories present at that time and, where known, documented the areas that had been lost. His estimate of the high value coastal wetland that had been lost by 1969 was around 50%. These estimated losses of wetland habitat are however unlikely to correspond exactly to the preferred wetland habitat of the GGBF (nor do they include other riparian flood plain wetland habitat of the species away from the coast). For example estimates of "wet meadow" habitat losses are likely major underestimates and these habitats are important GGBF habitat components. Nevertheless Goodrick's study still provides one of the best estimates available of coastal wetland loss and modification and further losses have continued since 1969. The serious impacts of changes to flow regimes and flooding on western components of the species wetland habitat have also been documented (Kingsford, 1995; 2000).

Examples of activities that have occurred at a broadscale and that have contributed to significant areas of habitat loss include: flood mitigation, irrigation works and dam construction that have changed river flow regimes and hence inundation events sustaining floodplain wetlands, channelling wetlands to drain and so as to convert to pasture, market gardens or for turf growing; landfill/waste disposal operations, sites for sewage treatment plants; industrial developments requiring large areas of cheap land, golf courses, playing fields and also residential development including canal estates.

The massive habitat destruction that has occurred to wetlands has undoubtedly reduced dramatically the available habitat for the Green and Golden Bell Frog, however the extent of this habitat loss will likely never be precisely known.

The GGBF is capable of ranging quite widely utilising different suitable areas of wetlands as these fluctuate with the season and prevailing climatic conditions. The loss and modification of extensive areas of wetland has reduced the extent of its availability as a 'habitat mosaic' for use by GGBF populations at the local and regional

level. This has in turn most likely predisposed the GGBF to be more severely impacted by other threatening processes.

The NSW Scientific Committee made a final determination to list “Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands” as a Key Threatening Process on Schedule 3 of the TSC Act 1995 (Gazetted on 31 May 2002).

8.2.2 Fragmentation and Isolation of Habitat

Habitat fragmentation has historically occurred over wide areas as a result of major blanket developments or through construction of significant barriers to natural movement. Such activity continues to occur at some locations and remaining tenuous connections are incrementally lost through in-filling and redevelopment. For different populations this has restricted or entirely prevented connections between various portions of a population. Over time this is likely to reduce the evolutionary potential of populations through inbreeding depression and also predisposes localised demes to extinction from stochastic events (Frankham, 1995a; 1995b).

Green and Golden Bell Frogs have been observed to undertake movements over considerable distances (over 1 km) (White and Pyke, 2001; A. White pers. comm.; A. Hamer pers. comm.; R. Wellington unpublished). Although not well understood such movements appear to be seasonal or the result of climatic or resource requirements. Drainage lines are frequently used to facilitate these movements (G. Daly pers. comm.; A. White, pers. comm.; R. Wellington unpublished). However in many instances development of catchments containing the Green and Golden Bell Frog has occurred to the point where these riparian zones have been dramatically altered. The resultant conversion of natural streams to concrete canals or weed-infested, modified and degraded channels or, in some instances, completely encased conduits underground has undoubtedly reduced habitat value and their effectiveness as corridors. This has likely contributed significantly to the fragmentation and isolation of some populations particularly in urban areas.

The proliferation of roads and the incidental mortality associated with movements across roads is also likely to be significant particularly when population numbers are already depressed through other threatening factors (Daly 1995a; 2002; G. Daly pers. comm.).

Whilst the genetics of isolation and fragmentation have been documented for other species (Frankham, 1995a; 1995b), little is known of the genetic diversity of the Green and Golden Bell Frog throughout its whole distribution. Studies underway will likely improve the level of understanding of this factor and be instructive for management decisions (E. Burns, pers. comm.; see also Burns *et al.* in prep.).

Preliminary studies of the genetic variation of some Sydney populations (Colgan, 1996) has indicated that there are significant allele frequency differences between some geographically proximal populations and these findings have serious conservation implications. Founder effects, drift, sampling biases as well as inbreeding are all possible explanations for these findings and each has quite different management implications. Given the amount of habitat disturbance and fragmentation that has occurred in the Sydney area it would seem likely that some small populations may have undergone significant inbreeding and consequent loss of genetic variation. The resultant genetic ‘bottlenecking’ could predispose such localised and isolated populations to extinction. Consequently the dilemma arises where geographically close populations show significant allele frequency differences. Should such populations be encouraged to outcross or conversely prevented from doing so to maintain localised adaptive differences? Clearly historical geography should be a consideration in such modified environments along with adequate unbiased sampling which otherwise might fail to differentiate between low frequency private alleles, present through drift and founder effects, from alleles undergoing localised selection.

A detailed genetic study using DNA techniques is currently underway with the aim of providing information to answer some of these questions (Burns, 2000, 2001; B. Houliden pers. comm.; see also Burns *et al.* in prep.). This recovery plan will promote the retention or proactive creation of corridor/habitat linkages between populations and population sub-units wherever possible as a currently assumed benefit to the conservation of this species (Bennett, 1990; Beier and Noss, 1998).

The NSW Scientific Committee made a final determination to list “Clearing of Native Vegetation” (as defined and described in the final determination of the Scientific Committee) as a Key Threatening Process (KTP) on Schedule 3 of the TSC Act 1995 (Gazetted 21/9/2001).

8.2.3 Predation by Introduced Fish

Predation on the eggs and tadpoles of frogs generally, and on those of *Litoria aurea* in particular, by the introduced Plague Minnow or Mosquito Fish *Gambusia holbrooki* (in some references *G. affinis*) have been reported (Ovington, 1970; Cogger, 1993; Mahony, 1993; Morgan and Buttemer, 1996, Pyke and White, 1996; Harris, 1995; Mahony, 1996).

The NSW Scientific Committee listed “Predation by the introduced Plague Minnow *Gambusia holbrooki*” as a Key Threatening Process (KTP) on Schedule 3 of the TSC Act 1995 (Gazetted 29 January 1999). The threat abatement plan was approved in August 2003 (NSW NPWS, 2003).

Other introduced fish such as Brown Trout *Salmo trutta*, Rainbow Trout *Oncorhynchus mykiss*, Gold Fish *Carassius auratus* and European Carp *Cyprinus carpio* have also been identified as a threat to some species of frogs, however of these, the Carp and perhaps Goldfish are likely potential threats to the Green and Golden Bell Frog. Carp have the ability to persist in billabongs, dams and other lentic locations following flooding or as a result of intentional introductions and such sites are also likely to be selected by Green and Golden Bell Frogs as breeding sites. Goldfish are at times released as unwanted pets into waterbodies and so this may also pose a threat if a release site was also that of a remnant Green and Golden Bell Frog colony.

8.2.4 Disease

A pathogenic chytrid fungal disease ‘chytridiomycosis’ has been recently identified infecting over 30 species of Australian frogs (Berger and Speare, 1998; Berger *et al.*, 1998; 1999). The amphibian chytrid fungus *Batrachochytrium dendrobatidis* has been recently described (Longcore, *et al.*, 1999) and this pathogen has been implicated as a causative agent in the ‘world-wide’ frog decline phenomenon and is considered likely to have been introduced to Australia (Berger, *et al.*, 1998; 1999). Studies to date have revealed that the fungus is water borne and transmitted via motile zoospores (Berger, *et al.*, 1999). These zoospores are able to attach to keratinised areas of frog skin and tadpole mouthparts (Berger, *et al.*; 1999) with infected frogs showing high mortality (up to 90%) (Luntz, 2000) and total losses (H. Hines pers. comm.). Tadpoles do not appear to show symptoms but the pathogen rapidly invades other areas of the body as the keratinisation process occurs at or about the time of metamorphosis (L. Berger pers. comm.). Observations of an apparent increased incidence of abnormality in tadpole mouthparts may also be a consequence of infection of tadpoles by the pathogen (M. Anstis pers. comm.) and could have fitness/survival implications for tadpoles if the feeding apparatus is impaired (Parris and Baud, 2004).

The frog chytrid fungus is known to infect the Green and Golden Bell Frog (M. Christy; K. Rose; L. Berger; M. Mahony and A. White all pers. comm.) and has also been identified and/or suspected in several observed post-metamorphosis ‘die off’ incidents (M. Christy; K. Rose; P. Johnson; A. White; M. Mahony; G. Daly pers. comm., R. Wellington unpublished). Recent patterns of decline exhibited by this and other frog species at sites experiencing low winter temperatures has resulted in suggestions of increased activity of a pathogenic disease at cooler temperatures (Laurance *et al.*, 1996). Reintroduction trials in the Common Mist Frog *Litoria rheocola*, a north Queensland treefrog species, revealed high mortalities at elevations over 300m and also support heightened activity of frog chytrid at sites experiencing low temperatures (Retallick and Dwyer, 2000). Whilst increases in UV radiation and other factors have been proposed to explain frog declines at altitude (Blaustein *et al.*, 1994 but see Mahony, 1999) other intrinsic factors should also be considered. For example low temperatures have been long known to reduce the rate and level of response of the amphibian immune system (Tait, 1969). The current contracted distribution of the GGBF to near coastal locations often within a saline influence (Mahony, 1999; Daly 2001) and/or in a number of other instances the vicinity of contaminated sites (eg Patmore, 2001; R. Wellington unpublished and see above) is worthy of further investigation. If, as suspected, disease is proved to be the major contributor to the current state of decline of the GGBF an understanding of the aetiology of the disease at such locations could assist management of the GGBF and benefit the conservation of other frog species.

The NSW NPWS Declining Frog Working Group (DFWG) has prepared a frog hygiene protocol to reduce the risk of further avoidable spread of this and other diseases amongst frogs (NSW NPWS, 2001).

8.2.5 Water Quality and Pollutant Issues

The types of development and other activities occurring within a catchment have consequences for down stream areas and may include changed flow regimes, increased nutrient loads, weed infestation and the potential for introducing a ‘cocktail’ of other contaminants and rubbish. It is suspected that deteriorating run-off water quality

and increased soil erosion and sedimentation reduces an area's suitability for frogs including the Green and Golden Bell Frog.

There is also ample evidence that various anthropogenic changes to soil and water chemistry may be affecting frog populations (Mann and Bidwell, 1999a). It is well known that there has been broad-scale use of insecticides particularly organochlorins for many years throughout much of NSW (up until the mid 1980s when using such compounds became prohibited). These chemicals are known to produce developmental abnormalities in amphibians (Cooke, 1970; 1972; 1973; 1974) and are persistent in the environment. Little known pesticide survey findings conducted during the 1980s (Llewellyn *et al.*, 1987) revealed extreme accumulated levels of DDT and other organochlorin metabolites in the various NSW frog species sampled (eg *Limnodynastes fletcheri* with levels over 700mg/kg body fat). This may have had implications for *Litoria aurea* particularly in agricultural areas of the former western parts of the species range as well in areas that have undergone mosquito control treatment using this class of compounds in the past. Similarly wide usage of fertilisers has also been suggested as having deleterious effects on frog populations particularly via impacts on tadpole development (Berger, 1989). In overseas studies on other frog species high nutrient loads of nitrate, ammonia and phosphate have been implicated in frog declines (Berger, 1989). For an overview of other environmental toxicological implications for amphibians and, as a consequence, other possible threats to *L. aurea* see Mann and Bidwell, (1999a).

The relatively recent wide use of herbicides containing glyphosate compounds such as *Round Up*[®] and *Round Up Biactive*[®] also have serious implications for *L. aurea*. The only known studies undertaken in Australia on the effects of these glyphosate compounds on frogs has revealed acute toxicity to tadpoles and adults of the Western Bell Frog *L. moorei*, a close relative of *L. aurea* (Bidwell and Gorrie, 1995; Mann and Bidwell, 1999b). These studies did reveal a reduced toxicity for glyphosate herbicides with altered surfactants eg *Round Up Biactive*[®] (Mann and Bidwell, 1999b). However the development of these less harmful formulations is negated by the apparent widespread practice by end users of adding additional surfactants to improve the herbicides effectiveness on weeds. That *L. aurea* is now virtually restricted to a coastal distribution where there is also widespread use of such herbicide to control the pest Bitou Bush could mean that such weed control measures in areas of known habitat are a real threat to the species and warrant further investigation.

Invasion of native plant communities by *Chrysanthemoides monilifera* (Bitou Bush or Boneseed) was listed as a KTP under Schedule 3 of the TSC 1995 (Gazetted 12 March 1999). Actions to control this KTP should consider the above information.

8.2.6 Other threats

Other possible threats to *Litoria aurea*, although by and large only supported by anecdotal evidence, include: predation by the introduced Red Fox (M. Christy pers. comm.; A. White pers. comm.), predation by feral cats, dogs and rats (A. White pers. comm.; Pyke and White, 2001; White and Pyke, in prep.), road mortality (Daly 1995a, 1996d; 2002; Pergolotti, 1995), mowing activities near breeding and feeding habitat (W. Smith pers. comm, L. Mitchell pers. comm., Goldingay, 2000), predator/prey interactions with the introduced Cane Toad *Bufo marinus* as evidenced by the total disappearance of the Green and Golden Bell Frog from sites north of the southern continuous extent of the Cane Toad, predation on suppressed populations by natural predators such as wading birds and snakes (White and Pyke, 1999; Pyke and White, 2002), artificial and natural opening of coastal lagoon estuaries, changes to flow/flooding regimes of streams and associated wetlands and sudden increases in salinity due to 'Spring' tides or storm events, flood events that introduce *Gambusia* or other predatory fish to otherwise isolated fish free breeding sites (see 8.2.3 above), off road vehicle access to certain sites at inappropriate times (M. Parsons pers. comm.); excessive grazing or trampling of habitat (Wellington and Wells, 1994) and fire which is most likely to impact on the species when foraging or shelter habitat is burnt and particularly when juveniles are most likely to be affected.

The NSW Scientific Committee made a final determination to list "High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition" as a key threatening process on Schedule 3 of the TSC Act 1995 (Gazetted 24 March 2000).

Extended drought episodes have also been proposed as contributing to population declines and perhaps loss (Osborne *et al.* 1996). Though some of these proposed threats are natural phenomena, they may impact in concert with some or all of the other proposed anthropogenic factors mentioned. These various factors should be given

consideration on a site by site basis when developing specific management plans for populations as actioned in this plan (see section 11).

8.3 Community Education and Awareness

There is a considerable amount of community knowledge and awareness of the GGBF and frogs generally. In fact the GGBF has become a self appointed “flagship” species that has highlighted the plight of threatened frog species generally. Individuals in the community are coming to recognise more and more the need to become involved in doing something about reversing the trends in declines of frogs and the loss of biodiversity generally.

There have been at least 50 media items in the last 5 years in the form of newspaper and magazine articles at the national, regional and local level about the GGBF.

The Green and Golden Bell Frog has been used as a logo and in signage by catchment management organisations, it was the focus of an extensive television advertising campaign by ORTA leading up to the Sydney 2000 Olympics. It has featured in television documentaries and as an item of several lifestyle, comedy, gardening, news and current affairs programs. An education and fitness program, designed around the GGBF, was developed by the NSW Department of Education and Training (DET) with support from OCA in the lead up to the Sydney 2000 Olympics and vast numbers of students did school projects on the GGBF during 2000. It is also the subject of interpretive signage at a number of locations. The controversy surrounding its discovery at the Olympic site at Homebush Bay, along with the extensive efforts to create/enhance new habitat in the face of such major development and so ensure its survival there, brought it wide attention and at one time it was mooted as an Olympic mascot. It has featured in annual reports of organisations such as Taronga Zoo, the RTA, OCA/SOPA and even industrial companies like INCITEC. This culminated in 2000 with the installation of a large mosaic tiled GGBF sculpture at Kingsford Smith Airport, Australia’s main international gateway. Consequently the Green and Golden Bell Frog has an extremely high public profile and, as a result, is an iconic species for threatened frogs and other threatened species generally.

The wider community is currently highly receptive to frog conservation issues. People generally like frogs and enjoy having them around and although perhaps not ‘warm and cuddly’ aren’t venomous and most people find them attractive and seemingly friendly to look at. Frogs have tended to be inculcated into our psyche as ‘nice creatures’ by cartoon characters like ‘kermit’ and ‘freddo’ over the years and so, when threatened, frogs readily attract public sympathy and support.

Consequently a number of ‘Friends of the Green and Golden Bell Frog’ groups have already become established. These groups have demonstrated that community members are ideally placed to make a significant contribution to the conservation of this species. To date four established community interest groups have shown commitment to assisting with the monitoring of and fund raising for important local populations. This involvement has contributed to a heightened community awareness of frog related conservation issues and are continuing to contribute to an improved understanding of longer term trends within these populations. Similarly it is often community members that discover and bring to wider public attention the occurrence of new populations or their reappearance at sites from where they were thought to have disappeared. The extremely large area from which this species was formerly known and the large apparent ‘gap’ regions in its current extent means that the community has a likely key role in detecting any cryptic populations that may have thus far eluded discovery.

Consequently a community education and awareness campaign linked with some targeted survey will likely result in the detection of currently unknown sites and/or the reappearance of individuals. From such programs the formation of local interest groups are often catalysed and they in turn promote the development of local skills and knowledge that can, when needed, be called on for specific monitoring or habitat enhancement tasks.

An increased understanding within the general community of the problem of frog declines and the stewardship role that community members can play have positive biodiversity conservation consequences. The community is currently highly receptive to frog conservation issues and this interest can be readily harnessed into local conservation actions.

8.4 Translocation and Reintroduction

Translocation is defined as the deliberate reintroduction of species into an area where it once occurred or introduction to an area where it never occurred. Translocation may also involve the supplementation of a

declining population with additional individuals. Captive breeding may be a component of a translocation program and be used as a source of animals for such initiatives.

Translocation programs are usually devised to assist in the conservation of a threatened species, within the context of a broader recovery strategy (NPWS, 1997). Translocation programs can provide a measure of security for critically endangered populations in the event of catastrophes such as the impacts of fire or disease.

To date there have been several reintroduction attempts but this should not be viewed as a standard management option for solving difficult problems associated with specific development proposals. Those re-introductions that have been attempted are viewed as being largely experimental.

A reintroduction has been attempted at Joseph Banks Reserve at Botany and translocation/introductions have been undertaken at Marrickville and Long Reef/Collaroy and are ongoing. Results from these translocations/introductions are not conclusive but some promising indications have been forthcoming. An early attempt at reintroduction at Joseph Banks Reserve initially failed but this was attributed to both the presence of *Gambusia* and possible “poaching” by school children (White and Pyke, in prep.). A subsequent attempt was carried out following eradication, using the ichthyocide ‘rotenone’, of *Gambusia* and an educational program that involved school children was instituted by Taronga Zoo in conjunction with their education centre staff and ‘Frog Focus’ program. A small number of frogs are understood to have survived and continue to exist at the site but no breeding is thought to have occurred (W. Meikle, *in lit.*).

At Marrickville an initial small introduction achieved high recruitment success but subsequent supplementation was thwarted by cannibalism by the original animals (White and Pyke in prep.). Breeding events within this ‘contained’ colony has also occurred. However further developments at this site have indicated the catastrophic impact of the arrival of the frog chytrid pathogen (White and Pyke in prep.). It is believed that the arrival of infected *Limnodynastes peronii*, which had previously been excluded, may have introduced the pathogen and resulted in total mortality of the introduced GGBF colony. Further reintroductions have occurred with slightly elevated salinity levels provided in an attempt to attenuate the action of the pathogen. These latest releases have failed to result in a viable adult population and the projects continuance is currently being reassessed (White and Pyke in prep.; A. White pers. comm.).

An introduction trial at Long Reef Golf Course has also been undertaken and involved the release of large numbers of tadpoles and metamorphlings. These introductions appear to have had early success with many tadpoles reaching metamorphosis (G. Pyke, pers. comm.) followed by high mortality and/or disappearance of the juveniles. These mortality levels appear to have prevented sufficient females from reaching reproductive maturity in the second year and so enable breeding to take place. The release of captive reared females to supplement the prior tadpole releases is now proposed to increase the likelihood of breeding success within this population (G. Pyke pers. comm.).

The general proposal of undertaking reintroductions as a conservation strategy has been widely accepted in principle as desirable, with some exceptions (see Greer 1996). The low representation of extant populations in some regions means that reintroduction is the only means available for the species to again exist at the previous extent of its former distribution. A more difficult question however involves proposals to supplement existing populations. Population genetic studies will be important in determining the best conservation strategy for some of the relatively small and/or isolated populations.

Taronga Zoo has an established captive-breeding program with representative specimens from Rosebery and Arncliffe and also the Australian Museum holds some individuals from Homebush. Taronga Zoos program has already demonstrated an ability to produce significant numbers of offspring from prescribed source stock and have bred Rosebery provenance stock through three generations (W. Meikle pers. comm.). Newcastle University holds stock from the lower Hunter area for research purposes. The Australian Reptile Park has also indicated a preparedness to undertake a captive-breeding program for conservation purposes and currently maintains stock from Broughton Island for educational display purposes.

A licensed, privately held collection of *Litoria aurea* with a Merimbula provenance are also being maintained with the future possibility of a supervised and approved breeding and reintroduction program. DPI (SFNSW), the south coast Catchment Management Committee (now Southern Rivers CMA) and local ‘Environetwork’ supported by Bega Valley Shire Council (with support from DEC) have sponsored this captive breeding project and are in the process of preparing a reintroduction proposal.

8.5 Consideration of Social and economic consequences

8.5.1 Social considerations

The main social impacts resulting from the implementation of this recovery plan may affect the local communities and landholders with Green and Golden Bell Frog habitat on their land. Increased awareness regarding the conservation of threatened species will help to bring about changes in social behaviour. These changes relate to preventing land management activities from impacting on Green and Golden Bell Frog habitat, modification to weed control methods and maintenance works undertaken by Councils and perhaps altered access to some areas with vehicles or machinery.

Negative social impacts may include public dissatisfaction with recovery plan actions that encourage sensitive management of Green and Golden Bell Frog habitat. Adaptive management of the Green and Golden Bell Frog based upon informing the local community and liaising with landholders is an avenue to reduce some of these impacts.

The continued liaison with the local community, affected landholders, and relevant government agencies will address and minimise social impacts arising from the conservation of the Green and Golden Bell Frog.

8.5.2 Economic considerations

The economic consequences of this recovery plan relate to implementation costs and possible development restrictions. Implementation costs include population monitoring, habitat management and community liaison. The potential impact on development approvals will be minimal since most of the actions primarily expand the provisions of the *Environmental Planning and Assessment Act 1979*.

Another impact may result from consideration of the Green and Golden Bell Frog in any environmental impact assessment for proposed development. As a taxon listed pursuant to the provisions of the TSC Act 1995 (NSW), the Green and Golden Bell Frog must be considered in any development proposals where populations or potential habitat are known to occur. Due to the taxon's occurrence at over 40 sites across a wide area of the State, it is possible that a number of development proposals will be affected by the need to consider their likely effects on the Green and Golden Bell Frog or its habitat.

Management costs related to DEC land should be reflected in the Plans of Management for the Reserves in which they occur (currently known from 10). Management costs on other public lands include development of Management Plans by 'known to be affected' Councils and the potential for such plans to be needed in other LGA's if additional populations are discovered, the implementation of these management plans is likely to be relatively minor in most cases and may include such things as: fencing, signposting, training of staff, possible amendment of recurrent activities required for the normal management of the land such as: fire management, vehicular access, mowing schedules, use of pesticides/herbicides, amendment of coastal lagoon opening policies and other forms of weed control. Monitoring activities stipulated in management plans can vary in cost depending on whether it is undertaken by consultants, existing staff that have undergone some training or the community with agency supervision.

Funds will also be sought from external sources for community based survey initiatives.

8.6 Roles/Interests of Indigenous People

The *TSC Act 1995* requires that, when preparing a recovery plan, consideration must be given to any special knowledge or interests that indigenous people may have in the species and the measures to be contained in the plan. In addition, the *EPBC Act 1999* requires that in the preparation of a recovery plan, that regard must be had to the role and interests of indigenous people in the conservation of Australia's biodiversity.

There are 46 Local Aboriginal Land Councils (LALC) covering the area identified within this recovery plan as the known distribution of the Green and Golden Bell Frog. These include: Awabakal, Bahtabah, Batemans Bay, Bega, Birpai, Birrigan-Gargle, Bodalla, Bogal, Bowraville, Bunyah, Coffs Harbour, Darkinjung, Deerubbin, Eden, Forster, Gandangara, Grafton-Ngerrie, Illawarra, Jali, Jerringah, Karuah, Kempsey, Koombahtoo, La Perouse, Merrimans, Metropolitan, Mindaribba, Mogo, Moruya, Nambucca, Ngulingah, Ngunawal, Nowra, Orange, Pejar, Purfleet-Taree, Tharawal, Thunggutti, Tweed-Byron, Ulladulla, Unkya, Wagonga, Wanaruah, Windradyne, Worimi and Yaegl. Representatives of these groups were contacted by the relevant DEC cultural

heritage/liaison officer and requested to provide information on the GGBF's specific cultural significance or traditional uses.

It is understood that the GGBF was used traditionally as a food item, at least in the Sydney area (Krefft, 1863) but no further information on traditional uses of the GGBF is available. The Coomaditchie Aboriginal Corporation, at Port Kembla within the Illawarra LALC, have demonstrated a strong interest in the conservation of the GGBF key population at that location and are involved with recovery actions being undertaken locally. At Jervis Bay on Commonwealth Territory and within Booderee NP the indigenous staff managing the reserve along with nearby Wreck Bay Aboriginal community representatives monitor and manage the GGBF populations on parts of the Bherwerre Peninsula (adjoining Jeeringah LALC). Similarly the Dharrug Tribal Aboriginal Corporation (DTAC), through the Murumittigar Aboriginal Cultural and Educational Centre at Penrith (Deerubin LALC), have indicated an interest in undertaking a GGBF reintroduction program as part of the Penrith Lake Development Corporation's Penrith Lake Scheme. The DEC is not currently aware of any other specific indigenous interests in, or traditional uses of, the GGBF and other indigenous communities with an interest in the actions proposed within this recovery plan have not yet been identified. Implementation of recovery actions within this plan will, wherever possible, seek to include further consideration of the interests of indigenous communities within the relevant region.

8.7 Biodiversity Benefits

The Green and Golden Bell Frog is an icon species in that it is one of the best known frogs in Australia. Its presence at the Olympic site at Homebush and its fortunate 'Green and Gold' colour and name have pushed it to the forefront of investigations into frog declines. Its profile as an endangered species has obvious biodiversity benefits for less photogenic or endearing species that will experience direct or indirect flow ons in awareness and financial support.

Coupled with this is the fact that it was once an important member of its community. In previous times it would have provided an important element of biomass to its community and supported the trophic levels above it. Some known natural predators such as certain wading birds and snakes have also suffered population declines but linkages are difficult to prove. Clearly communities have undergone a simplification with the loss of this species and this has biodiversity conservation implications. Similarly conservation efforts undertaken for the benefit of this species will have biodiversity benefits for other companion species or species with similar habitat requirements.

8.8 Ability to Recover

The Green and Golden Bell Frog's ability to recover is likely to be limited only by the availability of habitat free of significant threats.

The species has high fecundity, good dispersal capability and is also considered a colonising species so potential exists for good recovery ability. What is not known is the extent of genetic diversity still remaining in the various populations as high fecundity could easily mask previous bottlenecks. Studies investigating this issue are currently underway and may extend our understanding of this issue as a possible ongoing threat and influence the likely ability of given populations to respond, in an adaptive way, to environmental change in the long term.

Many areas of former distribution still contain apparently suitable habitat and whilst some threats have been identified the extent to which those threats are still operating is unknown.

Development of methods to control or eliminate *Gambusia* is required and at some sites this will be impossible to carry out with current knowledge. Also the extent of the impact of the frog chytrid fungus on GGBF populations is presently unclear however the emerging view is that it may have had a major impact that went largely undetected (Mahony, 2001). Several current populations are known to have individuals infected with the pathogen eg Homebush Bay (M. Christy pers. comm.; AMBS, 1999a,b), Avoca (G. Pyke pers. comm.) and Hoskinstown (R. Pietsch pers. comm.). The frog chytrid fungus has the potential to severely restrict the recovery of the species and measures of mortality within known afflicted populations is required along with investigations into factors that appear to limit the effect of the frog chytrid ie sites with a saline (and/or perhaps certain other contaminant) influence. Consequently at this stage the likelihood of recovery for the Green and Golden Bell Frog at sites that are known to be affected with the frog chytrid fungus is not known.

Ongoing monitoring of key Green and Golden Bell Frog populations will need to be undertaken to provide an assessment of the Green and Golden Bell Frog's response to recovery actions, to provide information to assist in the ongoing review of recovery actions and to identify alternative management practices.

8.9 International obligations

In making a Commonwealth recovery plan, regard must be had to meeting Australia's obligations under relevant international agreements and membership and these include;

- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).
- Convention on Biological Diversity, ratified by Australia in 1993
- The International Union for the Conservation of Nature – IUCN (DEH, DEC and DSE members).

The Green and Golden Bell Frog *Litoria aurea* is not listed in the CITES Schedules.

The actions proposed within this plan are consistent with and promote Australia's obligations under these international agreements.

9 Overall Objectives and Criteria

9.1 Overall objective

The two overall objectives of this recovery plan are time frame dependent. The first objective framed to operate within the first five years of this plan is to manage threats impacting on currently known populations of the Green and Golden Bell Frog, so as to stabilise and prevent further decline of the species. The longer term objective likely to operate in a time frame more like 10-20 years, but critically dependent on the success of the initial 5 year objective, is returning the species to its former distribution, abundance and role in the ecosystem where-ever possible.

9.2 Specific Objectives

This plan consists of five specific objectives that aim to achieve the overall recovery objectives and ultimately the 'vision' of this recovery plan.

The specific objectives for achieving this are to:

- increase the security of key GGBF populations by way of preventing the further loss of GGBF habitat at key populations across the species range and where possible secure opportunities for increasing protection of habitat areas (reservation / conservation status, Section 10);
- ensure extant GGBF populations are managed to eliminate or attenuate the operation of factors that are known or discovered to be detrimentally affecting the species (threat and habitat management, Section 11);
- implement habitat management initiatives that are informed by data obtained through investigations into the general biology and ecology of the GGBF through a systematic and coordinated monitoring program (research and monitoring, Section 12);
- establish, within more than one institution, self sustaining and representative captive populations (particularly 'at risk' populations) of the Green and Golden Bell Frog for the primary purpose of maintaining 'insurance' colonies for re-establishment and supplementation of populations of the species (captive breeding and translocation, Section 13; with research and educational purposes a secondary objective.); and
- increase the level of regional and local awareness of the conservation status of the Green and Golden Bell Frog and provide greater opportunity for community involvement in the implementation of this recovery plan (community education, awareness and involvement, Section 14).

9.3 Overall Criteria

Overall criteria for assessing the success or otherwise of this recovery plan are that:

- No net loss of habitat will occur at key populations across the species range and mechanisms to improve security of each of these populations will be explored and implemented where possible;
- Currently operating threats at key populations will be better understood, ameliorated and/or reduced to a level such that the populations are no longer subject to imminent extinction threats and an integrated habitat rehabilitation, creation and management program (involving the community where possible) will be established to address long term on-going site management issues at key populations;
- Investigations into critical aspects of the species' general biology and ecology and essential to the recovery program will be encouraged. A monitoring program will be undertaken to gather baseline data on measures of viability of the key populations to assess change and inform management strategies;
- A captive breeding program will be implemented as a safeguard to ensure the maintenance of genetic diversity, where necessary, and to enable reintroduction and supplementation initiatives to be undertaken; and
- An increased level of awareness, knowledge and skills relevant to GGBF conservation issues will be evident in the community and there will be increased participation by the community in recovery initiatives.

10 Reservation / Conservation Status

The distribution of the GGBF was historically well represented in the 10 regional management unit areas of NSW (see pp 9-12). Section 3 details the current conservation status of the species and identifies the known key populations remaining within each region. This objective will set the framework for initially maintaining the existing populations in the short term and then improving security on a region by region basis in the longer term.

10.1 Reservation / Conservation Objective

To increase the security of key GGBF populations and thereby prevent the further loss of GGBF habitat at key populations across the species range.

10.2 Reservation / Conservation Criteria

Specific measures by which the success of this objective will be assessed will include that:

- there is no net loss of GGBF habitat at key populations across the species range; and
- legislative and/or non-legislative measures to increase the security of GGBF habitats will be explored for all key populations and implemented where possible.

10.3 Reservation / Conservation Recovery Actions

10.3.1 Actions to address habitat loss and degradation

Liaison with public authorities

The DEC will liaise with public authorities responsible for managing key GGBF populations on public lands. This liaison will be directed towards increasing the level of statutory protection of areas of GGBF habitat. In order to give effect to this action, the DEC recognises that there are several mechanisms to improve the security of habitat on public land, including joint management agreements, property management plans and DEC acquisition, among others.

Liaison with private landholders

The DEC will liaise with private landholders whose properties contain key populations of the GGBF. This liaison will be directed towards increasing the level of protection of areas of GGBF habitat. In order to give effect to this action, the DEC will seek to secure sympathetic management and/or enhancement of GGBF habitats and, where possible, implement property management agreements, Voluntary Conservation Agreements, Land for Wildlife schemes and Wildlife Refuges in cooperation with private landholders.

11 Threat and Habitat Management

Section 8.2 of this recovery plan identifies the various threats that are known or are suspected of operating to the detriment of GGBF populations. This section of the recovery plan identifies the need to implement an integrated threat abatement and habitat management program for the species in order to address this range of threats. It will be essential to build on the previous and current work being undertaken by a range of stakeholders and groups in managing populations of the species. In particular, it will be necessary to integrate the GGBF recovery program with parallel threat abatement programs for recognised, State and/or National, Key Threatening Processes that are relevant to the species (eg spread of *Chytridiomycosis* and predation by *Gambusia*).

In addition to integrating existing programs, it will be necessary to initiate new threat abatement actions in areas not currently subject to active habitat management arrangements. Such measures are required to be implemented on public and private land tenures, and will require co-operation among Local, State and Commonwealth Government agencies as well as private landholders in order to be successful.

11.1 Threat and Habitat Management Objective

To ensure that extant GGBF populations are managed to eliminate or attenuate the operation of factors that are known or discovered to be detrimentally affecting the species.

11.2 Threat and Habitat Management Criteria

Specific measures by which the success of this objective will be assessed include that:

- the mechanism and extent of operation of known threats as well as currently unknown threats impacting on populations of the species will be identified for key populations; and
- imminent threats to the survival of key populations of the species will be minimised or managed to the point where their detrimental effect is no longer significant, within 5 years.

11.3 Threat and Habitat Management Actions

11.3.1 Actions to address strategic planning and impact assessment

Strategic planning instruments

The DEC, DIPNR, Department of Lands, Rural Fire Service, relevant Local Governments (see section 5) and other relevant land managers/authorities will ensure that the contents of this recovery plan are considered during the preparation/revision and implementation of strategic land-use planning documents such as DEC Reserve Plans of Management, Local Environment Plans, Regional Environment Plans, Regional Vegetation Management Plans, Bushfire Risk Management Plans and during the preparation of other site specific or local management plans as required.

Environmental impact assessment guidelines

Consent and determining authorities are required to consider this recovery plan when assessing the impact of development or activity proposals that potentially affect areas known or likely to represent GGBF habitat, in accordance with the *Environmental Planning and Assessment Act 1979* and the *Native Vegetation Conservation Act 1997*. In order to ensure that relevant matters are considered, the DEC has prepared Environmental Impact Assessment (EIA) Guidelines for the Green and Golden Bell Frog (Appendix 2) for use by consent and determining authorities and consultants and should be considered in conjunction with this recovery plan

11.3.2 Identification and assessment of threatening processes

Threat identification and assessment

The DEC will co-ordinate the identification and assessment of threats operating at each of the key regional GGBF populations on DEC estate and will encourage similar assessment for other key populations where possible. This information will be documented in a statewide GGBF database (see action 12.3.1 below) in order to prioritise the implementation of habitat management initiatives. This information will also be used to develop site specific GGBF plans of management at key populations (see action 11.3.4 below).

Conservation Assessment Protocol

The DEC will develop a conservation assessment protocol and endeavour to have the protocol applied to all known populations of the GGBF particularly those on DEC estate. The purpose of the protocol is to determine the comparative status of regional GGBF populations and their habitat. This will assist with the prioritisation of resource allocation.

11.3.3 Habitat enhancement, rehabilitation and construction

Preparation of guidelines

The DEC will co-ordinate the preparation of guidelines for the construction, enhancement and maintenance of supplementary or compensatory *in situ* GGBF habitat. The guidelines will attempt to facilitate and improve habitat creation and enhancement works where breeding or other habitat attributes are absent or are subject to significant threat. A review of known pro-active habitat creation/enhancement initiatives will be undertaken during the preparation of these guidelines with the assistance of the GGBF recovery team and in liaison/consultation with other stakeholders/agencies/proponents involved with such works.

Habitat enhancement activities

The DEC will encourage relevant local government authorities, other public authorities/land managers as well as private land holders to undertake (or require to be undertaken) pro-active habitat enhancement or creation initiatives in strategic locations. The DEC will assist in the identification of potential sites for undertaking such initiatives particularly for key populations. Where important habitat and/or habitat linkages are identified as occurring on private land, private land conservation initiatives as outlined in 10.3.1 will be promoted to facilitate habitat enhancement activities.

Habitat enhancement or creation works undertaken will, wherever possible and appropriate, involve and enlist the support of the local community, local councils and other land managers.

11.3.4 Preparation of GGBF Plans of Management at key populations

DEC-managed estate

The DEC will prepare and implement a 'GGBF Management Plan' in accordance with Appendix 3 for each key population occurring on DEC estate (see Section 3 p.12 and Section 5, Table 1 for a list of key populations on DEC estate).

Land managed by other public authorities

The DEC will liaise with other public authorities and encourage the preparation and implementation of a 'GGBF Management Plan' for key populations occurring on other public lands where such plans do not exist or are up for renewal/revision (see Section 5, Table 1 for a list of other key populations). Such plans should also give consideration to Appendix 3 as a minimum standard of issues for inclusion/matters to be considered.

Where key GGBF populations are identified in this plan, (or as an outcome of the implementation of the plan), as occurring on public land (classified as 'community land' under s36 of the Local Government Act 1993 as amended) will require the relevant council to prepare and implement a specific Management Plan. Public land classified as community land is also taken as including Crown Land vested in Council under s76 of the Crown Land Act 1989. The DEC considers the preparation of specific MPs for all public land identified as containing key GGBF populations (as identified in this plan or through the implementation of the plan) as a matter of best practice and is considered the recommended action for other state government agencies. As an adopted plan under s269A of the EPBC Act 1999 Commonwealth agencies must not take any actions which contravene this recovery plan (s268) and it is therefore also recommended that Commonwealth agencies/land managers also prepare a MP for key populations of the GGBF where identified in or by this plan (see Section 5.2 for a listing of affected Commonwealth land/agencies).

11.3.5 Frog Disease Management Strategy

Implementation of recovery actions

The DEC will implement this recovery plan in accordance with the 'NSW NPWS Frog Hygiene Protocol'. The DEC will require all recovery actions funded by the DEC to be implemented in accordance with measures outlined in the protocol.

The DEC will ensure that copies of the 'NPWS Frog Hygiene Protocol' (NSW NPWS 2001a) are distributed to public authorities, researchers, consultants and other individuals implementing actions associated with this recovery plan. Section 132 licences issued to conduct research on or surveys for GGBF will be conditioned in accordance with the NPWS Frog Hygiene Protocol. Heightened awareness of the protocol is essential to reduce the risk of further spread of the chytrid fungus (see Section 8.2.4) and other pathogens within and between GGBF populations.

Integration of Recovery Plan with relevant Threat Abatement Plans and other threat reduction initiatives.

The DEC is required to prepare a 'Threat Abatement Plan' (TAP) for each 'Key Threatening Process' (KTPs) listed in Schedule 3 of the TSC Act, 1995. There are several currently listed KTPs that have been identified as adversely affecting the GGBF and/or its habitat and other KTPs may be listed in the future. It is, therefore, necessary to ensure this recovery plan is effectively integrated with the relevant TAPs and other threat reduction initiatives so as to avoid duplication or compromise actions.

Plague Minnow (*Gambusia holbrooki*) Threat Abatement Program

The DEC in collaboration with DPI (formerly NSW Fisheries) will develop strategies for the control and/or eradication of *Gambusia* from specific Green and Golden Bell Frog sites, where appropriate. This will be done in concert/accordance with the Threat Abatement Plan for this KTP.

The DEC will, where possible, initiate installation of supplementary breeding habitat when other *Gambusia* control measures are not feasible or have failed, and where this is supported by trials and identified in relevant key population site management plans. The DEC will encourage investigations into the value of artificial pond structures as supplementary breeding habitat for the GGBF where *Gambusia* is identified as a threat to populations of the species (see research priorities, section 12.3.2).

The DEC and NSW Fisheries will use the GGBF as a 'flagship' species to undertake a public awareness-raising program to alert the community of the pest status of *Gambusia*, and the impact it is having on the GGBF and other threatened and protected native frog and fish species. This program will seek to address the mosquito control issue, alternatives to *Gambusia*, and allay concerns regarding mosquitoes associated with GGBF habitat creation initiatives. (see section 14.2).

Red Fox, Feral Cat Threat Abatement and Cane Toad Control Programs

The DEC will promote the assessment of the impacts of predation by the Red Fox and the Feral Cat at specific locations (see research priorities, section 12.3.2) and, if possible, conduct this as an adjunct to the relevant TAP.

The DEC will also monitor possible interactions between the GGBF and the Cane Toad at sites in the vicinity of their current distributional contact zone (Yamba/Yuraygir NP and at Port Macquarie/Lake Innes NR).

The DEC will develop and implement control/management strategies where necessary and if possible in concert with existing control/management programs (eg Reserve PoMs, Red Fox TAP and Cane Toad 'Round Up' program).

Other Threat Abatement Programs

At the time of preparation of this Recovery Plan no threat abatement plans had been approved for the following relevant Key Threatening Processes.

- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands (as described in the final determination of the Scientific Committee to list the threatening process) [see also Section 8.2.1];
- Clearing of native vegetation (as defined and described in the final determination of the Scientific Committee to list the key threatening process) see also [Section 8.2.2]; and
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition [see also Section 8.2.6].

Threat abatement plans for the above KTPs (and others that may be listed in the future) should consider this species, its recovery plan and where possible integrate with or augment actions identified herein.

- Invasion of native plant communities by *Chrysanthemoides monilifera* (Bitou Bush or Boneseed).

Whilst not in itself a KTP likely to affect the GGBF, some of the threat abatement actions likely to be proposed to control or reduce the impact of this KTP may have the potential to impact on many of the remaining key populations of the GGBF. Consequently certain actions likely to be considered within the Threat Abatement Program will need to be mindful of potential deleterious impacts on populations of the GGBF [see also Section 8.2.5].

12 Research and Monitoring

A substantial amount of research and monitoring to assess various individual populations of the species has already been undertaken or is currently in progress (see sections 7.2 & 7.4). However in order to understand any detected changes in the species' conservation status, a consistent and coordinated approach to the research and monitoring of key populations across the species entire distribution is required. Accordingly, this objective attempts to develop a systematic approach to obtaining information on the biology and ecology of the GGBF, and to focus research efforts towards investigating current knowledge gaps that are essential for improved management of populations.

In order to ensure that research and monitoring outcomes are achieved, the GGBF recovery program will rely to a large degree on the assistance and cooperation of the community and specialist research institutions. The DEC will therefore seek to facilitate broad involvement in the research and monitoring of GGBF populations across its range, in accordance with this and the 'Community Education, Awareness and Involvement' sections of the recovery plan.

12.1 Research and Monitoring Objective

To ensure that habitat and threat management initiatives are informed by data obtained through research on aspects of the general biology and ecology of the GGBF and monitored in a systematic and coordinated manner.

12.2 Research and Monitoring Criteria

Specific measures by which the success of this objective will be assessed will include that:

- Baseline data on the measures of viability within key populations will be collected in a systematic and coordinated manner to inform management strategies; and
- Management strategies for the GGBF will be informed by priority research and monitoring outcomes.

12.3 Research and Monitoring Actions

12.3.1 Monitoring Actions

Database of population localities

The DEC will develop and maintain a database of records across the species distribution. This database will serve to maintain a permanent record of GGBF population trends and current habitat management activities that are underway.

Systematic monitoring program

The DEC will establish a systematic monitoring program for GGBF populations occurring on DEC lands across the species' range. This monitoring program will gather data from key sites in each region representing the extent of the species distribution, in order to detect population trends and fluctuations and to record the success of habitat management initiatives.

The following key regional populations are considered a priority for the implementation of a systematic monitoring program:

Upper North Coast – Yuraygir*, Clybucca and Crescent Head*; Lower North Coast – Port Macquarie*; Broughton Island* and Myall Lakes*/Smith Lake populations; Hunter – Kooragang Island; Sandgate, East Maitland/Wentworth Swamp and Ravensworth/Bayswater populations; Central Coast – Davistown/Avoca populations; Sydney – Kurnell, Homebush Bay; Clyde/Rosehill; Holroyd, Greenacre; St Marys and Arncliffe populations; Illawarra – Woonona, Port Kembla, Shellharbour and Kiama populations; Shoalhaven – Coomonderry/Seven Mile Beach*/Shoalhaven Heads, Greenwell Point/Brundee/Crookhaven River, Culburra/Lake Wollumbulla/Jervis Bay*/Beecroft, Booderee/Bowen Island, Sussex Inlet, Lake Conjola (part)*, Meroo*/Kioloa, and Durras populations; South Coast – Pedros Swamp, Murrah River, Tura Beach and Nadgee* populations; Southern Tablelands – Bungendore/Molonglo River population.

Those populations marked* occur, at least in part, on DEC estate. The DEC will be responsible for determining the initial status of these populations and then conduct monitoring. The key sites identified to be monitored will initially be reviewed at the end of two years from the commencement of this plan and then annually.

Where one or more key populations listed above occur on private land or land managed by other public authorities, the DEC will encourage the support of the relevant land owner/manager and attempt to establish a cooperative monitoring/management program. This may also involve assistance from local community groups (see section 14.3.2) and is to be encouraged.

Other monitoring

In addition to systematic monitoring at key populations, the DEC will encourage low key monitoring as opportunity permits at other selected sites, in collaboration with local interest groups, private landholders and/or public authorities. This more opportunistic monitoring is required to ascertain the continued absence of the species from historic locations, and at other sites where occasional or sporadic records have been reported. In particular this will include: Upper North Coast – Lake Ainsworth, Brunswick Heads, Nambucca River; Lower North Coast – Telegraph Point; Taree, Camden Haven; Hunter – Cessnock, Singleton and Muswellbrook; Central Coast – North Wyong, Tuggerah; Sydney – Prospect, Holsworthy, North Ryde; Illawarra – Fairy Meadow, Albion Park, Dapto; South Coast – Bobundara Swamp, Longvale Swamp, Greenway Swamp; Central Tablelands – Winburndale.

In the ACT it is recommended that selected sites, with previously known populations of the GGBF, should be monitored for possible reappearance of the species. This monitoring should be coordinated/undertaken by the ACT Parks and Conservation Service.

In Victoria it is recommended that selected key sites, within the species distribution between Malacoota and Lakes Entrance, be monitored/coordinated by the Victorian DNRE. The apparent viability of these populations is the main reason for the species having a reduced status of Vulnerable rather than Endangered at the national level. Consequently it is important to detect any change in status of these populations given the likely change in the National status that may follow if these populations were to succumb to threats currently operating on populations of the GGBF in NSW.

12.3.2 Research actions

Research program

The DEC will promote and co-ordinate a program of investigations into aspects of the biology and ecology of the Green and Golden Bell Frog. This program will be directed principally towards obtaining a greater understanding of the biological and ecological factors crucial for effective management of populations *in situ*, and of the various threatening processes known or suspected to be impacting on the species.

Particular areas of the biology and ecology of the GGBF requiring specific focus to inform habitat management initiatives include:

- Microhabitat selection and utilisation;
- Life cycle studies, in particular selection & utilisation of over-wintering & breeding habitat;
- Movement patterns within and between areas of suitable habitat;
- Longevity;
- Population demographics; and
- Genetic studies for the purpose of determining variability within and between populations across the species range to identify evolutionary significant units, inform re-introduction, supplementation and out crossing proposals as well as conservation assessment schemes.

In addition to the above *in situ* and *ex situ* species specific programs, investigations into the impacts of the following threatening processes also require priority research attention:

- interactions with the predatory Mosquito Fish *Gambusia holbrooki*;
- effective biological and other control methods for *Gambusia* and alternatives for mosquito control that are not harmful to the GGBF;
- the effectiveness of installing artificial breeding habitat as supplementation for sites with *Gambusia* infestation in the natural breeding sites;

- impacts of Red Fox and feral cat predation;
- predator/prey interactions between the GGBF and the Cane Toad at their distributional interface;
- impacts resulting from the frog chytrid fungus disease (chytridiomycosis), in particular impacts on GGBF populations and mortality levels within infected populations, the immune response of the GGBF to chytrid fungus, possible attenuating effects of salinity and other environmental and human induced factors (environmental contaminants) on chytrid infection rate and infective load within water bodies, development of tests for detecting infected, previously infected and 'naïve' individuals, development of treatments for infected individuals; and
- impacts of pesticides/herbicides and agricultural chemicals.

13 Captive breeding and translocation

Whilst the main focus of the first 5 years of implementation of the recovery plan will be on management of existing populations *in-situ*, the captive breeding and translocation program will focus on the development of successful captive husbandry and breeding techniques to primarily safeguard against extinction of the GGBF in the wild. Such a program will, wherever possible, include maintaining captive stock of suitable provenance to 'insure' against extinction of key regional 'at-risk' populations that may represent discrete evolutionary units.

Sound captive husbandry and breeding techniques provide the tools necessary for interventive action when warranted and may also have other serendipitous conservation outcomes.

This program will also support suitable reintroduction/supplementation proposals and secondarily provide material for *ex-situ* research and assist other educational purposes.

13.1 Captive breeding and translocation Objective

To establish, within more than one institution, representative and self sustaining captive populations of the Green and Golden Bell Frog for the benefit of the conservation of the species.

13.2 Captive breeding and translocation Criteria

Two or more institutions will hold more than one captive self-sustaining population of the Green and Golden Bell Frog in support of conservation initiatives.

13.3 Captive breeding and translocation Actions

13.3.1 Captive Breeding

Captive Husbandry Manual

The DEC will liaise with Taronga Park Zoo and the Australian Reptile Park in the preparation of a guide to the successful care and maintenance of GGBF and the requirements for successful breeding in captivity.

Representative populations in Captivity

DEC will assist where possible and encourage Taronga Park Zoo in its continued maintenance of currently held captive colonies of the GGBF.

DEC will promote the establishment of further GGBF colonies at Taronga Zoo and/or at additional institutions such as the Australian Reptile Park and may seek ARAZPA support/involvement to achieve this. The institutions selected should have a proven track record in captive husbandry and be able to demonstrate a commitment to the conservation targets of this recovery plan. The provenance of future captive colonies should, where possible, be prioritised on the basis of individuals sourced from the Southern Tableland, Upper Hunter, South Coast, Far North Coast, Central Coast, Illawarra and Western Sydney in the given order of priority.

13.3.2 Translocation

Current Translocation Trials

DEC will continue to encourage the translocation trials currently being conducted at Botany, Collaroy and Marrickville and the supplementation trial at Arncliffe.

Translocation Review

The GGBF recovery team will review the success or otherwise of existing translocation/supplementation trials and make recommendations regarding the future direction of such trials and inform the preparation of a translocation guide for this species.

Translocation Guide

DEC will liaise with the agencies/groups currently involved with translocation trials and promote the preparation of a GGBF Translocation Guide, (within the framework of the existing DEC/ANZECC policy on translocation), summarising the state of current knowledge and where further information is required.

Future Translocation

The GGBF recovery team will consider future proposals for reintroduction and prioritise such proposals on the basis of the current knowledge of regional conservation status, distribution and genetics as well as with due reference to the desired overall objective of this recovery plan (see Section 9.1).

The ACT Parks and Conservation Service will be approached by the DEC to give consideration to participation in such translocation trials with the view to re-establishing the species in the ACT using appropriately provenanced material.

14 Community Education, Awareness & Involvement

A successful recovery program for the Green Golden Bell frog will rely heavily on community participation. Consequently, this objective aims to continue to encourage existing initiatives involving the community in recovery related activities. Promote further community involvement through the establishment of additional program components across all regions. It also endeavours to increase community skill levels in frog identification and management techniques and in this way foster community ownership and participation in monitoring, survey and other habitat management related initiatives at a local level. Promoting the formation and involvement of regional frog interest groups is envisaged as an important element in the success of this objective.

14.1 Community Education, Awareness & Involvement Objective

To provide an increased level of regional and local awareness of the conservation status of the Green and Golden Bell Frog and factors affecting the species survival. It will also provide greater opportunities for community involvement in the implementation of this recovery plan.

14.2 Community Education, Awareness & Involvement Criteria

Specific measures by which the success of this objective will be assessed will include that:

- Information on the state-wide and regional conservation status of the Green and Golden Bell Frog and factors affecting its survival is gathered, summarised and disseminated to relevant target audiences; and
- Increased numbers of community groups, private land holders, individuals and other land managers will be participating in key elements of the GGBF recovery program. In particular, at least two community-based "Friends of the GGBF" groups will be established each year of this plan and private land conservation initiatives will be promoted and, where possible, implemented.

14.3 Community Education, Awareness & Involvement Recovery Actions

14.3.1 Species information and communication of the recovery program

Species Profile

The DEC will revise and disseminate a species information profile on the statewide conservation status of the Green and Golden Bell Frog to affected local councils, state government agencies and other affected organisations.

Environmental Impact Assessment Guidelines

The DEC will disseminate the Green and Golden Bell Frog Environmental Impact Assessment Guideline to consent and determining authorities and also make them available to environmental consultants and other interested parties.

Regional information profiles

The DEC will prepare and disseminate information pamphlets on GGBF conservation management region outlining the regional conservation status of the key Green and Golden Bell Frog populations. The pamphlet will identify various threats to the GGBF and the practical measures individuals can take to reduce such impacts/threats and other beneficial actions that can be undertaken. The pamphlet will be disseminated in a targeted way to landholders, land managers and relevant community groups and the offices of relevant local councils where the GGBF occurs.

Annual Newsletter

The DEC will prepare and disseminate, to participating groups, an annual update/newsletter summarising the key actions undertaken as part of the Green and Golden Bell Frog recovery program. The update/newsletter may also take advantage of other DEC publications to broaden its circulation.

14.3.2 Community involvement in recovery program

Existing community involvement in GGBF recovery actions

The DEC will assist and encourage the continuation of activities undertaken by existing GGBF interest groups at Davistown/Avoca, Marrickville/Arncliffe, Port Kembla, Merimbula, Long Reef and Botany.

Establishment of regional “Friends of GGBF” groups

The DEC will promote and assist the formation of community ‘Friends of the Green and Golden Bell Frog’ groups in key regional areas including: Grafton/North Coast, Port Macquarie/Kempsey, Hunter, Cooks River, Kurnell, Woonona/Wollongong, Shellharbour/Kiama, Shoalhaven, South Coast, and perhaps at other sites.

In order to allow community-based GGBF groups to actively manage populations of the species, the DEC will facilitate arrangements for access to sites in cooperation with other public agencies and private landholders. It is anticipated that ‘Friends of the GGBF’ groups in these regional areas will assist in a range of recovery actions, including:

- Habitat management, rehabilitation and reconstruction;
- Reintroduction supplementation trials at selected sites; and
- Survey, monitoring and broader community awareness raising of local and regional GGBF conservation issues.

Some basic resources including background information, guidelines and equipment for undertaking monitoring will be developed and provided to such groups.

Monitoring

The DEC will collaboratively undertake a community survey for the GGBF across its statewide distribution. The community survey will utilise the media, the Internet and existing conservation and environmental education networks (see section 12) in an effort to detect new populations and add to the knowledge of the species’ historical distribution.

The DEC will coordinate the development of a standard systematic community-based monitoring and reporting program for the various key population sites across the GGBF’s distribution where ‘Friends Groups’ become established. Community groups involved in habitat management initiatives for the species will be encouraged to communicate the results of their activities in accordance with these systematic reporting guidelines.

Community training workshops

The DEC will utilise the recovery plan for the GGBF to develop and promote community-training workshops on frog identification, frog handling, frog hygiene protocols and frog monitoring techniques. This action will be undertaken in collaboration with other government agencies, community/frog interest groups and other experts as required.

15 Co-ordination of the Recovery Program

Successful implementation of this recovery plan will require ongoing statewide coordination including effective communication between regional coordinators and the recovery team as well as liaison with commonwealth, state and local government agencies, land owner/managers and the community. The Recovery Plan coordinator will be responsible for the overall implementation of the recovery plan actions but with coordination at the regional level by regional coordinators.

15.1 Co-ordination of Recovery Program Objective

To provide co-ordination and support for the implementation of this plan.

15.2 Co-ordination of Recovery Program Criteria

Each of the actions identified in this plan are initiated by the recovery plan coordinator within the prescribed timeframes (funds availability permitting). Progress toward the achievement of objectives will be assessed annually and reviewed/updated at the conclusion of year 5 of the plan.

15.3 Coordination of Recovery Program Actions

15.3.1 Maintain on-going State-wide coordination of the Green and Golden Bell Frog Recovery Program

The level of understanding regarding status of the various key populations of the Green and Golden Bell Frog is varied. Consequently the degree of active management or other steps required to most effectively manage each population requires a coordinated and efficient approach. The level of stakeholder involvement and community participation envisaged is also significant and will require centralised coordination and liaison with the regional DEC coordinators and other relevant DEC officers.

It is envisaged that the Recovery Team will meet annually to review the progress of the recovery program. This may include making recommendations to amend the Recovery Plan, assessing the implementation and success or otherwise of recovery actions and provide advice on new information or proposals that may eventuate.

16 Costings

Table 3: Costing Table Estimated costs of implementing the actions identified in the Green and Golden Bell Frog recovery plan are provided below.

Action No:	Action Title	Priority	Estimated Cost/yr					Total Cost	Responsible party/funding source	In-Kind	Cash
			Year 1	Year 2	Year 3	Year 4	Year 5				
10.3.1	Liaison	1	\$5250	\$3500	\$3500	\$3500	\$3500	\$19250	DEC	\$19,250	\$0
11.3.1	Assessment Guidelines	2	\$7000	\$0	\$0	\$0	\$0	\$7000	DEC	\$5500	\$1500
11.3.2	Threats to Habitat	1	\$15400	\$15400	\$0	\$0	\$0	\$30800	DEC	\$30800	\$0
11.3.3	Habitat Enhancement Guidelines	1	\$5500	\$0	\$0	\$0	\$0	\$5500	DEC	\$0	\$5500
	Habitat Construction & Enhancement #	2	\$15000	\$15000	\$15000	\$15000	\$15000	\$75000	All responsible agencies	\$10000	\$65000
11.3.4	Management Plans #	1	\$35000	\$30000	\$30000	\$30000	\$30000	\$155000	All responsible agencies	\$0	\$155000
12.3.1	Distribution & Monitoring Database	1	\$3000	\$0	\$0	\$0	\$0	\$3000	DEC	\$3000	\$0
12.3.2	Systematic Monitoring	1	\$61600	\$61600	\$61600	\$61600	\$61600	\$308000	All responsible agencies	\$208000	\$100,000
12.3.2	Other monitoring	3	\$14700	\$14700	\$14700	\$14700	\$14700	\$73500	DEC	\$73500	\$0
13.3.1	Captive Husbandry Manual	2	\$4000	\$0	\$0	\$0	\$0	\$4000	Taronga Zoo/DEC	\$4000	\$0
13.3.2	Translocation Guide	2	\$0	\$2500	\$0	\$0	\$0	\$2500	DEC	\$1000	\$1500
14.3.1	Species Profile Update	2	\$2000	\$0	\$0	\$0	\$0	\$2000	DEC	\$1750	\$250
14.3.1	Regional Brochure	2	\$5000	\$1000	\$1000	\$1000	\$0	\$8000	DEC	\$3000	\$5000
14.3.1	Annual Newsletter	2	\$2600	\$2600	\$2600	\$2600	\$2600	\$13000	DEC	\$10500	\$2500
14.3.2	Community Groups	1	\$7800	\$5000	\$5000	\$5000	\$5000	\$27800	DEC	\$2300	\$25500
14.3.2	Community Survey	2	\$0	\$10000	\$0	\$0	\$0	\$10000	DEC	\$5000	\$5000
14.3.2	Community Workshops	2	\$14000	\$10000	\$10000	\$10000	\$10000	\$54000	DEC	\$15000	\$39000
15.3.1	Recovery Plan/Team Coordination	1	\$35000	\$35000	\$35000	\$35000	\$35000	\$175000	DEC	\$150,000	\$25000
	Totals		\$232,850	\$206350	\$178400	\$178400	\$177400	\$973,350		\$542,600	\$430,750

Priority ratings are: 1- Action critical to meeting plan objectives, 2-Action contributing to meeting plan objectives, 3-Desirable, but not essential action.

'In-Kind' Funds represent salary component of permanent staff and current resources.

'Cash' Funds represent the salary component for temporary staff and other costs such as the purchasing of survey and laboratory equipment.

Recovery Plan Coordination includes all actions associated with 'in-kind' administration and general implementation of the recovery plan.

Natural Heritage Trust (NHT) represents the allocation of funds as contracted under the Yr 2000-2001 Endangered Species Program.

- as identified within the relevant site specific management plan; actual costings will vary between sites as required.

17 Preparation Details

This plan was prepared by Senior Threatened Species Ross Wellington of the Central Directorate Threatened Species Unit in conjunction with the recovery team and with assistance from those listed in the acknowledgments section.

17.1 Date of Last Amendment

This document is the first recovery plan for the Green and Golden Bell frog. No amendments to the plan have been made.

17.2 Review Date

This recovery plan will be reviewed after 5 years from the date of its publication.

18 **Contacts**

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Appendices

1. Species Information Profile
2. Environmental Impact Assessment Guideline
3. Template for the preparation of Management Plans
4. Monitoring and Survey Data Recording Sheets
5. How to make a submission



Green and Golden Bell Frog

Litoria aurea (Lesson, 1829)

Other common names Swamp Frog, Smooth Swamp Frog, Growling Grass Frog

Conservation status

The Green and Golden Bell Frog is listed as an **Endangered Species** on Schedule 1 of the New South Wales *Threatened Species Conservation Act, 1995* (TSC Act).

Description

The Green and Golden Bell Frog is a relatively large frog with stout body form. Adult size ranges from approximately 45mm to approximately 100mm snout to vent length (SVL) with most individuals being in the 60-80 mm size class. Males are generally smaller than females (maximum size 70mm) and when mature, tend to have a yellowish darkening of the throat area. Males also develop nuptial pads on the inner finger and appears as a brown pigmented patch. Mature females are larger bodied (maximum size 90-100mm) (White & Pyke 1996).

The dorsal colouration is quite variable being a vivid pea green splotched with an almost metallic 'brass' brown or gold. The backs of some individuals may be almost entirely green whilst in others the golden brown markings may almost cover the dorsum. When the frogs are inactive colouration can darken to almost black. A glandular creamish white stripe extends from behind the eye almost to the groin. The lower margin of this dorso-lateral stripe is black or dark brown, the upper margin is edged gold.

The belly is usually an immaculate granular

creamish white. The lateral margins of the body are adorned with raised glandular creamish spots of irregular size. Legs are a variegated green and gold with the groin area and inside leg a brilliant electric blue. The fingers and toes have expanded terminal pads but are barely wider than the toe/finger itself. The toes are heavily webbed. The eye has a horizontally elliptical pupil and a golden yellow iris. Juveniles are similar to adults and metamorphose at 25-30mm SVL.

Tadpoles are relatively large reaching 65-80mm. They are deep bodied and possess long tails with a high fin that extends almost to mid-body. They swim actively and evade capture. As tadpoles become larger the golden dorsolateral stripe and a green tinge to the back can be observed just before limb growth commences (White 1995; R. Wellington pers. obs.).

Distribution

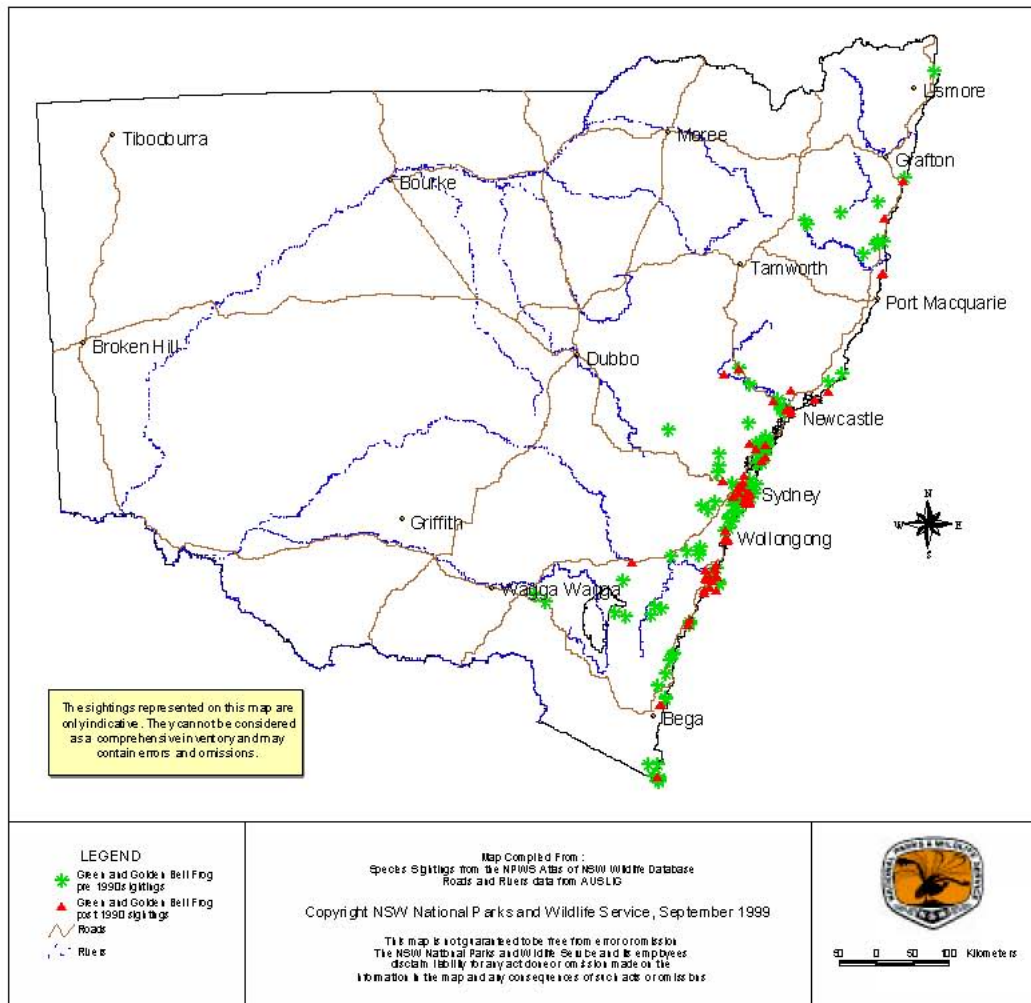
The Green and Golden Bell Frog was formerly distributed from the NSW north coast near Brunswick Heads southwards along the NSW coast to Victoria where it extends into East Gippsland (White & Pyke 1996; Gillespie 1996) west to Bathurst, Tumut and the ACT (Moore 1961; Osborne *et al.* 1996). There are records from the NSW tableland areas such as Armidale/Ulong, (New England Tableland) and Canberra, Cobargo and Jindabyne (Monaro Tableland).

In the 1960s the species was considered widespread, abundant and commonly encountered. They were even regularly used as dissection material for university students (Dakin 1948) and anecdotal accounts report their regular use as food by snake keepers such was their abundance (R. Wells; I. McCartney; J. Cann pers. comm.). Declines were noticed in the late 1970s and became severe in the 1980s such that today the species exists as a series of isolated coastal Green and Golden Bell Frog populations within its former known range.



M Mahony

Green and Golden Bell Frog



NPWS records of the Green and Golden Bell Frog in NSW

In the last 5 years, surveys of known sites have failed to find any highland populations and fears are that these populations are now extinct. Many former coastal populations have also dramatically declined or disappeared altogether (White & Pyke 1996).

Current distribution consists of isolated pockets from various scattered locations throughout its former range. Most are coastal or near coastal with inland, upland and northern populations most affected. Since 1990 there have been approximately 50 locations in NSW where the species is confirmed to still exist (only 11 within conservation reserves). There are 6 populations of substantial size (numbers over 300, two are located in the metropolitan area of Sydney, two in the Shoalhaven and two on the mid north coast (one an island population) (White & Pyke 1996).

Recorded occurrences in conservation reserves

Ben Boyd NP, Botany Bay NP, Hat Head NP, Jervis Bay NP, Kooragang Island NR, Killalea SRA, Myall Lakes NP, Nadgee NR, *Royal NP, Seven Mile Beach NP, Towra Point NR, *Tyagarah NR, Yuraygir NP (NPWS 1999).
[* no longer considered present]

Habitat

The Green and Golden Bell Frog inhabits marshes, dams and stream sides, particularly those containing bullrushes *Typha* spp. or spikerushes *Eleocharis* spp. Optimum habitat includes water bodies which are unshaded, free of predatory fish *Gambusia holbrooki*, have a grassy area nearby and diurnal sheltering sites available such as vegetation and/or rocks (White & Pyke 1996). Some sites, particularly

in the Greater Sydney region, are in highly disturbed areas such as disused industrial sites, brick pits, landfill areas and even cleared land.

Ecology

The Green and Golden Bell Frog is frequently active by day and usually breeds in summer when conditions are warm and wet (Cogger 1992). Males call whilst floating in water and females produce a raft of eggs which initially float before settling to the bottom often amongst vegetation (Harrison 1922). Tadpoles take approximately 6 weeks to develop though this varies considerably and is dependent on temperature and other conditions (A. White pers. comm.; Pyke & White 1996). Tadpoles feed on algae and other vegetative matter adults are voracious insect eaters and will also readily eat other frogs and even juveniles of their own species. They are naturally preyed upon by various wading bird species and snakes and are also presumably fed on as larvae by tortoises, eels and other fish.

Threats

- Alteration of drainage patterns and stormwater runoff (White & Pyke 1996)
- A fungal pathogen (Berger & Speare 1998)
- Changes to water quality (Goldingay 1996)
- Predation by feral animals such as foxes and cats (Daly 1995 & 1996)
- Herbicides and other weed control measures.
- Road mortality where populations are already small due to other threats (Daly 1996)



Green and Golden Bell Frog - juvenile



Green and Golden Bell Frog- tadpole

- Predation by exotic fish particularly the Plague Minnow *Gambusia holbrooki* (Morgan & Buttemer 1996). Recently listed as a key threatening process under the TSC Act, 1995
- Loss of suitable breeding habitat through alteration by infilling and destruction of wetlands (Morgan & Buttemer 1996; Clancy 1996)

Management

- Development of measures to control or eradicate the introduced Plague Minnow *Gambusia holbrooki*
- Strategies to provide for the development or enhancement of frog habitat to improve reproductive success and recruitment at known sites.
- Protocols for the handling of frogs and educational strategies to minimise the inadvertent spread of fungal pathogens from site to site.
- Development of Environmental Impact Assessment Guidelines
- Development of site specific Plans of Management to improve conservation outcomes for targeted populations.
- Community awareness programs highlighting presence of populations and catchment management approaches to improving stormwater quality, habitat retention and management.
- Maintenance of captive bred populations for future possible re-introduction programs.

Recovery plans

A recovery plan is currently being prepared Green and Golden Bell Frog - juvenile for the Green and Golden Bell Frog. This plan will be exhibited and finalised during 2004.

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Green and Golden Bell Frog

Litoria aurea (Lesson, 1829)

Other common names: Bell Frog, Swamp Frog, Smooth Swamp Frog, Growling Grass Frog

The following information is provided to assist authors of Species Impact Statements, development and activity proponents, and determining and consent authorities, who are required to prepare or review assessments of likely impacts on threatened species pursuant to the provisions of the *Environmental Planning and Assessment Act 1979*.

These guidelines should be read in conjunction with the NPWS *Information Circular No. 2: Threatened Species Assessment under the EP & A Act: The '8 Part Test' of Significance* (November 1996), the draft Green and Golden Bell Frog Recovery Plan (December 2002) and the species information profile (NPWS 1999).

Proponents, consent and determining authorities when considering development or other activity proposals must assess direct and indirect impacts on the Green and Golden Bell frog and/or its habitat. Direct impacts can include harm to individual frogs and loss/damage to breeding or other habitat components. Indirect impacts can include actions that increase or exacerbate threats (see threats section below) as a result of a development or activity.

Survey

The Green and Golden Bell Frog can be surveyed for using standard frog survey techniques. These should include:

- Nocturnal surveys using spot light/head lamp search techniques. This should be undertaken amongst emergent and fringing vegetation in the natural and artificial wetland habitat likely to be frequented by the species as well as areas of potential shelter and foraging habitat in the vicinity;
- Aural surveys to call playback response;
- Diurnal visual searches of ground cover (debris, rocks and logs) and for basking individuals, usually amongst emergent vegetation; and

- Dip-netting surveys for tadpoles (this may prove difficult and will require the use of a good identification guide [Anstis 2002] unless the surveyor has had considerable experience with tadpole identification).

Determining the adequacy of survey effort required is difficult. Factors that need to be considered in determining the amount of search effort required includes: the size of the wetland and any surrounding ancillary habitat present, its accessibility, the prevailing weather conditions, the amount of ground cover, the extent of fringing and emergent vegetation as well as the seasonal timing of the survey to be undertaken.

Experienced surveyors tend to gain a 'feel' for the suitability of a site even if frogs are not located on a single visit. It is likely that several visits to a site will be required to detect the species (ideally each survey separated by 2-4 weeks). Surveys must be undertaken during favourable seasonal and climatic conditions. Such surveys may need to be conducted over several activity-breeding seasons to be successful. The ideal timing of survey should be in the warmer activity period of the year usually between the months of August and March. The activity period begins later in the southern and more elevated portions of the species distribution and continues well into autumn in the north (G. Daly; M. Parsons pers. comm.). It is possible to observe the species outside the main activity period if warmer weather breaks torpor early. The species is most likely to be detected during and after heavy rainfall but this should not be taken to mean that the frogs definitely become active after a single rainfall event.

Small areas of habitat (< 0.3 Ha) should be surveyed for a minimum of one hour on three separate occasions during the species activity period. Larger areas, that may include whole wetlands and lagoon margins, are more difficult to survey and require a minimum of 3 separate four hourly searches during the species activity period.

Surveyors should be mindful that the species has a somewhat nervous disposition and will often attempt to evade detection. They are known to actively avoid torch-light and at such times will readily dive or swim off to another location.

Males mainly call between September and January however frogs will take advantage of favourable conditions outside these times and be heard calling. Eliciting a call response to tape playback can be a successful way of detecting the species and even a well rehearsed imitation call by experienced surveyors can have the same result.

Males normally call while floating in water and this can be useful in helping to confirm the identity of a calling frog (G. Pyke pers. comm.). However the call is extremely distinctive and should not be mistaken for any other species except perhaps in areas where other "Bell Frog" species may co-occur (central and southern tablelands Osborne *et al.* 1996; White and Pyke 1999). An absence of their call cannot be taken as an absence of the species without undertaking substantial site survey over several activity seasons.

During inactivity periods, Green and Golden Bell Frogs may also be found taking refuge under or inside objects (both natural and 'man-made') in the vicinity of their habitat. When searching care should be exercised not to excessively disturb or destroy these important refuge sites particularly when the frogs may be aestivating over winter (sometimes collectively) and in a state of torpor.

It is difficult to define the habitat requirements and/or preferences for this species but the various types of habitat utilised has been documented (see Pyke and White, 1996; 2001). In any case when assessing the suitability of habitat it should always be considered in the event of rainfall. A site when dry may appear unsuitable but this may change with moderate rains and so consideration should also be given to the species propensity to turn up to breed in ephemeral locations that are more often dry than wet. Quarries, brickpits, mining sites, STPs, bunded or otherwise 'retained' areas, detention basins, drains, scrapes, depressions and farm dams along with the more natural coastal or floodplain wetland features such as swamps, ponded areas of intermittent

creeklines, lagoons, billabongs and dune swales are all candidate sites for occupation by this species (White 1995; Pyke and White 1996; 2001; Hamer *et al.* 2002). Such sites are occupied and used mainly as breeding habitat.

Foraging habitat requirements include tall, dense, grassy vegetation and tussock forming vegetation is known to be used for foraging and shelter (A. Hamer pers. comm.; A. White pers. comm.).

Over-wintering sites are another important habitat component that requires consideration in any site assessment. Such habitat provides protection from disturbance during the cooler months of the year when individuals enter a period of quiescence/inactivity and become torpid. Such sites include the bases of dense vegetation tussocks, beneath rocks, timber, within logs or beneath ground debris including human refuse such as sheet iron etc (Pyke and White 2001; R. Wells pers. comm.; A. Hamer pers. comm.). Such sites may be adjacent to the breeding sites but may also be some distance away. The full range of possible habitat used for this purpose is not well understood and so assessments should be mindful of this information gap.

The congregation of large numbers of individuals at some breeding sites followed by a dwindling in number of observed animals during non-breeding stages suggests that individuals move off to seek other non breeding habitat where this is absent in situ. Consequently other 'potential' habitat attributes must be considered during any assessment of an area and not just the extent of breeding habitat. The sometimes skewed sex ratios of individuals found around breeding sites indicates there are sexual differences in the spatial and temporal use of various habitat components (M. Bannerman pers. comm.). Therefore the timing of any proposed disturbance to potential habitat may differ significantly in its direct impact on a local population of the species.

In some areas heavy urbanisation and other development has encroached on the species habitat. *Litoria aurea* is a species that has high tolerance to varying levels of certain physical and chemical factors in the environment (T. Penman pers. comm.). This 'colonising' capability appears to have pre-adapted the species to establish itself in the

altered habitats it often utilises. The species strong dispersal ability also means it may be able to satisfy its various habitat requirements, even when these are located some distance apart, provided suitable corridor connections are retained. Examples of this include over-wintering in household gardens and then breeding in wetlands or dams, quarries and other human constructions, considerable distances away.

Life cycle of the species

The general biology and ecology of *Litoria aurea* is described in the referenced literature (see Pyke and White 2001 for a review) and is summarised in the Draft Recovery Plan (NPWS 2003).

The Green and Golden Bell Frog is considered highly dependent on its breeding sites for long term survival at the various remnant population sites. The species is known to be highly fecund (5000+ eggs/spawn mass) and is therefore considered potentially capable of reproductively 'bouncing back' from population "bottleneck" situations provided threatening processes are removed or ameliorated.

Tadpoles develop over an approximate three month period but this can vary depending on prevailing conditions. Some ephemeral breeding locations are prone to drying out before tadpoles have reached metamorphosis. This is considered critical for some of the remnant populations and is believed to be a limiting factor at those sites where recruitment appears to be poor (P. Gray pers. comm.). At other sites tidal inundation of breeding sites can be a factor affecting breeding success (A. Henderson pers. comm.; G. Pyke pers. comm.).

Metamorphlings are highly susceptible to predation and need to forage successfully soon after transformation to improve their chances of survival during the first over-wintering period. To this end, it is important that vegetation for foraging is retained around the breeding sites as well as connecting corridors of vegetation that enable movement away from breeding sites to other areas of habitat. Metamorphlings that remain in the vicinity of breeding sites where a resident population of adults remain are often cannibalised (A. White pers. comm.).

Threatening processes

Key Threatening Processes (KTPs) that have been listed under Schedule 3 of the Threatened Species Conservation Act 1995 and which have known or likely implications for the Green and Golden Bell Frog include:

- *Predation by Gambusia holbrooki (Plague Minnow or Mosquito Fish).*

The presence of *Gambusia* in known or potential breeding sites is a matter of concern as *Gambusia* is known to feed on eggs and early stage tadpoles and to strip tail fins and limb buds at later stages of tadpole development. The density of fish, size of the water body, availability of other food sources and extent of emergent vegetation for shelter, all appear to be factors in the extent of impact *Gambusia* has on *Litoria aurea* breeding efforts (Morgan and Buttemer 1996; Webb and Joss 1997; A. White pers. comm.).

Efforts to control or eradicate the fish should be considered in accordance with the Draft *Gambusia* Threat Abatement Plan but timing, scale and likelihood of reinfestation should be major considerations (NPWS 2002). The presence of *Gambusia* in a waterway is not to be taken as meaning that the Green and Golden Bell Frog is absent or that the habitat is rendered unsuitable. Some sites with *Gambusia* are still utilised by *L. aurea*, but with a likely reduced reproductive success rate, such sites may in any case provide vital foraging or shelter habitat for adults.

- *Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands.*

The Draft Recovery Plan identifies the destruction and alteration of wetlands and stormwater pollution as a major threat to the species and a significant contributor to its current conservation status.

Developments and other activities have the potential to have obvious direct and not so obvious indirect impacts on these processes and include, among others, artificial opening regimes for coastal lagoons, deposition of fill to floodplain areas, diversions, water extraction, flood mitigation works and culvert construction in wetland areas that lower the watertable.

- *Clearing of native vegetation (as defined and described in the final determination*

of the Scientific Committee to list the key threatening process);

Alteration of habitat associated with grazing by stock, development or other land use activities that clear native vegetation results not only in direct loss of habitat but also isolation of habitat through creation of 'barriers' to movement between populations.

- *High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition;* and

This process is likely to result in direct losses as well as removes shelter/cover exposing the species to greater predation and eliminates food reserves.

- *Predation by the European Red Fox Vulpes vulpes (Linnaeus 1758).*

Predation by feral animals such as foxes is another likely threat particularly where populations are already stressed by impacts of other threatening processes.

Other threats include:

- *Chytridiomycosis*, a disease that has been recently listed as a KTP under the Commonwealth EPBC Act and has also had a preliminary listing as a KTP in NSW under the TSC Act.

Recent research has identified an important frog pathogen, an exotic frog chytrid fungus, known to cause chytridiomycosis, a usually fatal condition (L. Berger pers. comm.), and also known to be impacting on many other frog species as well as *Litoria aurea* (Berger *et al.* 1999; Mahony 1999; Mahony and Werkman 2001). This may ultimately prove to be the major causative factor in the recently reported wide scale decline in frogs generally in this country.

- *Broad scale application of herbicides*

Weed control activities involving the broad scale application of herbicides needs to be considered for their potential to impact on this species (Bidwell and Gorrie 1995; Mann and Bidwell 1998; 1999). Such impacts may be the direct result of the toxicity of the herbicides on frogs and tadpoles, as well as indirectly through broad scale ground cover loss.

- *Road Mortality*

At some sites, particularly where populations are impacted by a number of threats, road mortality can be an additional

and quite significant mortality factor (Daly 1996).

Viable local population of the species

It is difficult to determine what constitutes a viable local population however in the absence of a detailed specific local population study all populations should be considered significant and viable unless shown otherwise. The draft recovery plan for the Green and Golden Bell Frog has identified 44 key populations across its overall NSW distribution and these are considered viable populations based on current information (NPWS 2002). The key populations have been subdivided across 9 management regions that incorporate the species state-wide distribution. At most of these sites available information indicates that population sizes are generally small with breeding events infrequent. However at six key sites substantial populations have been found and regular breeding events recorded (NPWS 2002). Implementation of the recovery plan will attempt to address the data gaps for the other key populations where viability indicators (calling males, amplexus, spawning, tadpoles, metamorphlings and recruitment) are presently unavailable. At all sites little information is available about levels of successful recruitment from emergent metamorphling to adult.

Consequently to accurately determine viability of a particular population several seasons of intensive survey and monitoring is necessary. The difficulty of assessing viability is best illustrated via the example of several sites where populations were initially assumed, from the information available, to be in imminent danger of extinction. These were later revealed to be much larger and viable when further survey was completed (R. Porter; M. Bannerman; G. Pyke, R. Wright all pers. comm.). Clearly this illustrates the need for the precautionary principle to be applied in the absence of adequate information.

Additional populations not currently categorised as key populations within the draft recovery plan may be detected in the future. These populations, even when detected as low numbers of individuals, may have high conservation value and are to be considered significant and viable until shown otherwise.

A significant area of habitat

The Green and Golden Bell Frog is most frequently detected in or around its breeding habitat. Such sites are of critical importance to the species and its availability appears to be a limiting factor in many locations. The species tends to congregate at breeding sites during the warmer months (August-March) and during these events aggregations of individuals may represent a substantial proportion of the total population from the surrounding area. Breeding habitat should therefore be afforded the highest level of protection and likely disturbances, during the breeding period in particular, should be totally avoided. However the breeding habitat cannot be considered in isolation from the other habitat components known to be essential for the species to complete its life cycle.

Mitigating impacts

The basic principles of protecting threatened species is to:-

1. Avoid direct impacts and retain habitat;
2. Minimise impacts where ever possible;
3. Mitigate or ameliorate impacts; and as a last resort
4. Compensate or offset for any unavoidable impacts.

Consequently consideration must be given to retention of all habitat components including foraging, shelter and over-wintering habitat that may be at some distance from the more readily identified breeding habitat.

Under some circumstances, consent and determining authorities may be required to give consideration to habitat enhancement and perhaps habitat creation initiatives as a means of mitigating possible degradation to habitat or offsetting unavoidable habitat losses. In such circumstances an in-situ conservation outcome is paramount and there must be no net loss of habitat. Any habitat creation initiatives that are proposed as an offset to a development must be on a tested performance basis. Performance is to be measured by two successful breeding events that demonstrate that the life cycle has been completed in any created/enhanced habitat. Monitoring and mark recapture studies over an extended period would be required to demonstrate this and might reasonably be expected to take a minimum of 4 years ie the time taken for F₁ female progeny to reach sexual maturity (2 years), breed successfully

and any resulting progeny, in turn, to reach sexual maturity and breed (see Semlitsch 2002). Under exceptional circumstances consideration might be given to captive breeding initiatives that could assist with amplification of a local, at threat, population.

Isolation/Fragmentation

The Green and Golden Bell Frog has undergone considerable fragmentation of its once almost continuous state-wide distribution. Most of the remaining key populations are isolated by large distances from other key populations. Many of the remaining key populations also appear to exhibit meta-population structure being comprised of several semi-discreet, variably isolated, sub-populations with an assumed restricted gene flow between them.

Maintenance of the migration/movement paths between various sites is therefore essential if the existing pattern of decline of the species is not to continue. Such movement corridors may include stream lines, other drainage features, swales and depressions as well as built structures and naturally vegetated areas. The species does however exhibit strong migration tendencies, is known to be capable of moving several kilometres and will, when necessary, move across 'hostile' ground, such as roads and cleared land to reach its desired habitat.

Regional Distribution of Habitat

The Green and Golden Bell Frogs historic distribution and hence habitat is contained within the NSW North Coast (8), Sydney Basin (29), South East Corner (5 - NSW) and South Eastern Highlands (1) Bioregions (Thackway & Cresswell 1995). The numbers of key populations identified within each of these bioregions (in parentheses) indicates that there has been an uneven pattern of decline with most severe decline being evident in the South eastern Highlands bioregion whereas the Shoalhaven area of the Sydney Basin has the greatest number of remnant key populations. The Recovery Plan for the Green and Golden Bell Frog places high conservation significance on all remaining key populations and its objective is to prevent any further losses of them. Considerable suitable habitat still occurs across all regions of the species distribution and so other remnant populations may still exist in this habitat. There is therefore a need

for targeted surveys in these potential habitat areas when developments in such areas are being considered.

Limit of Known Distribution

The distribution of the Green and Golden Bell Frog is currently limited to 44 key populations across its distribution (NPWS 2002). The majority of these key populations are near coastal and most are widely disjunct. Consequently the loss of any of these remaining key populations will increase fragmentation and widen existing disjunction. Therefore consideration of individual key populations should be in the context of its distributional limits at the regional level as well as at its northern most or southern most distributional limit to be consistent with the draft Recovery Plan.

Adequacy of representation in conservation reserves or other similar protected area.

The Green and Golden Bell Frog is known to occur within the following reserves:

Yuraygir NP (2); Hat Head NP; Lake Innes NR; Myall Lakes NP (3); Kooragang Island NR; Seven Mile Beach NR; Meroo NP; Towra Point NR; Jervis Bay NP; Narawallee NR; Ben Boyd NP and Nadgee NR. A key population also occurs within Commonwealth Booderee NP and on Department of Defence land on Beecroft Peninsula both at Jervis Bay.

Whilst the species occurs within these reserves only in 11 of 44 (25%) of these cases does the major portion of the species key population habitat occur within that conservation reserve. Consequently the species is not adequately protected within the reserve system because the majority of the species habitat occurs on other tenures.

Critical Habitat

Critical habitat has not been declared for this species but may be reconsidered for declaration during the implementation of the recovery plan.

For Further Information contact

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Management Plan Preparation Guide

This document is intended to assist the preparation of effective Management Plans for Green and Golden Bell Frog populations. The preparation of site specific management plans is an identified action within the Green and Golden Bell frog Recovery Plan. This document should be read in conjunction with the Green and Golden Bell Frog Recovery Plan.

Introduction

The introduction should state the Plans purpose and include:

This Green and Golden Bell Frog (GGBF) population is identified as the [XX] Key Population within the GGBF Recovery Plan and is the [ZZ - extent] population within the [GGBF Management Region] identified therein.

This plan has been prepared to satisfy Action 12.3 of the NSW Recovery Plan for the Green and Golden Bell Frog that was developed in accordance with the Threatened Species Conservation Act 1995 (TSC Act).

This plan has been prepared to ensure that the GGBF population [NAME] located at [LOCATION] is successfully managed and monitored such that the species continues to persist at the location and measures of the populations viability are maintained or improve overtime.

[The Plan need not reiterate general biology and ecology of the species in great detail as this is published elsewhere and is summarized in the Recovery Plan. These review publications and the RP should be referred to.]

A brief description of the frog might be included and an illustration is desirable for ID purposes.

Purpose of this plan

1. To identify and where possible address the threats and other issues/factors affecting or likely to affect the conservation of the species at [X] location and contribute to the conservation of the species in the wider area and region.
2. Manage the species in accordance with the strategies outlined within the GGBF RP

Location

Provide a detailed description of the location.

The population is located [X] kilometers [direction] of [nearest centre] in the [X - LGA]. The populations centre of distribution is/appears to be on [private land Lot DP, Crown Reserve, NPWS Reserve, State Forest – give a complete description] land tenure.

Provide a map (at both local and regional scale) showing:

- current and historical distribution where known [locality records]
- tenure
- extent of known or likely habitat
- other relevant features

Include a description of the habitat components present and if possible a description of the vegetation communities. Where possible the map (or an air photo if available) should also depict the extent of known or likely habitat components in the vicinity including habitat corridors contributing to connectivity.

Describe the species status in the local area as far as is known.

Include historical account of population in the area as far as is known.

- When was it first known from the area?
- Where in the local area was it distributed and what habitat did it use?
- Any information relating to apparent declines or disappearances in the local area.

Current knowledge of the population in the area.

- What are the circumstances surrounding its rediscovery in recent times
- What areas is it now considered to be occupying and what local areas are considered likely to be important for it?
- What indicators do we have regarding population size and viability?

Threat Assessment

Following the identification of the need for the preparation of this Management Plan an assessment of the extent of available habitat was made and, using the Recovery Plan as a guide, an assessment of the general and local threats known or considered likely to be operating was made. [Figure X depicts the habitat components that have been identified [breeding habitat, foraging habitat, shelter habitat, movement corridors etc]

The following threats have been identified [List] a) b) c)

Management Actions Required

The following are some of the already identified requirements of the Management Plan and some other possible requirements dependent on local circumstances for the [X] GGBF population.

- a) Undertake a conservation ranking assessment - Action 11.3.1 of the RP [this protocol is to be completed by the NPWS]
- b) Monitoring of the population 4 times per year in accordance with the RP monitoring procedure [or perhaps at a greater frequency/intensity if part of a broader research monitoring project]
- c) Where this is not adequately known determine what is the extent of habitat for the species in the area (where possible categorise habitat type, breeding; foraging, shelter & over-wintering habitat components)
- d) Gather population viability factors for this population ie maximum numbers of adults seen over time; breeding event indications (indicated by numbers of calling males, amplexus observed; tadpoles or spawn observed; gravid females observed; metamorphs observed; juveniles observed) to determine current status. [longevity, movement patterns and mortality may also be detected if the site is one of those selected for more intense monitoring/research including mark recapture (PIT tag) studies].
- e) Identify threats to the population (from threats observable in the vicinity) eg *Gambusia* present; tidal or flood inundation; water pollution; reports of sick or dying individuals, local pesticide treatments; impacts of existing management actions in the vicinity etc [see RP threats section]

Steps required to be undertaken to appropriately manage the local population will include [a) b) c) [ideally these should also identify data gaps and a means of filling them.]

From an assessment of the above information gathering and assimilation formulate possible strategies to mitigate the identified threats to the species at that location.

- Does failure to successfully breed appear to be limiting the population?
- Is there ample suitable breeding habitat available?
- Is there good connectivity between nearby areas of potential habitat?
- Is there ample foraging or shelter habitat in the immediate vicinity of breeding habitat?

A management action might be to develop suitable breeding habitat with appropriate vegetation, shelter sites and other habitat features and/or to develop swale like depressions and other intervening 'damp' habitat areas vegetated with suitable tussock forming vegetation to facilitate reduced risk movement paths.

- Are there representative areas of all habitat components for the species at each of the sites where it is known to occur?
- Can these be provided eg rock piles and ground timbers such as logs/sleepers, tussock vegetation and emergent reeds/sedges for shelter and surrounding grassy foraging areas.

Is the body of water forming the primary breeding habitat free of predatory fish?

- If not can they be feasibly eliminated or controlled (refer to *Gambusia* TAP) or if not is it possible to provide ancillary breeding habitat beyond the reach of the identified threats within the main water body.
- Can some contingency mechanism be installed for draining the ancillary breeding habitat to eliminate *Gambusia* and perhaps the frog chytrid pathogen (a breeding pond construction and habitat guide is to be prepared);

Can any existing management practices be modified or timed in such a way as to reduce or eliminate potential for impact on the specific local population? [examples of these might include – mowing/slashing practices; application of herbicides/weed control; flood control/lagoon opening procedures; hazard reduction measures;

The management plan should identify a summary of the actions necessary to maintain or enhance the GGBF population at [XX]. It should identify those responsible or who have agreed to participate or undertake certain components. A cost estimate should be provided and an indication of whether funding is available or will need to be sought. A time frame for undertaking the various tasks identified should also be provided. [A table would be an efficient way of presenting this information]

Monitoring and Reporting

Monitoring of this population of the GGBF is necessary to establish baseline information on the viability of the population and to enable detection of any changes in status and perhaps adjusted management actions.

The monitoring of this population is the responsibility of [agency]. The required monitoring will be undertaken by [Council X environment staff; consultant X; Volunteers under supervision of X; DEC area staff; Researcher X in collaboration with DEC area staff, SF NSW staff etc].

Monitoring should consist of 4 site inspections per year. Each site visitation should consist of 1 diurnal visit and two nocturnal visits (say a minimum of two person hours

during the day and say 2 person hrs/night for two consecutive nights). However this may need to be of longer duration at some sites depending on the area and complexity of habitat present and the numbers of frogs present requiring processing. The purpose of the monitoring should be to detect tadpoles by dip netting of water bodies and incidental frog observation by day and the recording of any abiotic factors eg WQ parameters, climatic factors (time since last rain should also be ascertained); nocturnal visits should endeavour to determine absolute measures of frog abundance over two consecutive evenings and will record numbers of calling males, amplexus, spawn masses, numbers of juveniles, numbers/size and sex of adults; (repeated four times per year – but may be more frequent where implemented as a component of a broader research project or where resources allow), frogs should, where possible, be captured by hand following the DEC(NPWS) frog hygiene protocol. The standard recording sheets allow sex, size, weight, age class and breeding condition to be recorded; (at some sites microchip mark and recapture may be employed as part of broader research but this will be negotiated with and sanctioned by the RP coordinator); measures obtained over time should be recorded on the standard recording sheet and a copy of this is to be forwarded to the recovery plan coordinator; an NPWS licensed individual must be present to undertake this work).

The GGBF monitoring will be coordinated by [Officer Name – contact details] with the four monitoring periods occurring during the breeding/activity period of August to March (ideally during or following suitable weather conditions within each time slot).

Session 1 – 1 August – September

Session 2 – October – November

Session 3 – December – January

Session 4 – February – March

The standard recording sheets will be completed during each of the above periods and the data will be collated by [NAME] and a copy forwarded to [XXX].

Review

A meeting of stakeholders will be organised to occur following the activity period each season where results and trends will be discussed and recommendations for additional/modification of management strategies adopted.

Appendix 5: Making a submission regarding this draft recovery plan.

SUBMISSION
DRAFT RECOVERY PLAN

Name Individual/Organisation:

.....

Postal Address:

.....

Postcode: Contact Number(s):

Date:

Draft Recovery Plan: Green and Golden Bell Frog *Litoria aurea* Recovery Plan

The DEC will consider all written submissions received during the period of public exhibition and must provide a summary report of those submissions to the Minister for the Environment prior to final approval of this recovery plan.

Please note that for the purposes of the NSW Privacy and Personal Information Protection Act 1998, any comments on this draft recovery plan, including your personal details, will be a matter of public record and will be stored in DEC records system for a period of up to 2 years from the closing date. The submission of personal information is voluntary. Copies of submissions will be available on request, at the DEC Office responsible for the preparation of the recovery plan¹.

Should you not wish to have your personal details disclosed to members of the public, please indicate below why you wish your personal details to remain confidential to DEC². Please note that access to the details may be requested under the Freedom of Information Act 1989. You will be consulted if this happens.

Further information on the Privacy and Personal Information Protection act 1998 and the Freedom of Information Act 1989 may be obtained from the DEC FOI/Privacy Contact Officer (ph: 02 9585 6460) or the DEC website: www.nationalparks.nsw.gov.au

Yes, please keep my personal details confidential to DEC (explain why)

Submissions should be received no later than the advertised date. Submissions should be addressed to the:

Director-General of Department of Environment and Conservation
c/o Green and Golden Bell Frog *Litoria aurea* Recovery Plan Coordinator,
Threatened Species Unit
Metro Conservation Programs and Planning
Department of Environment and Conservation
PO Box 1967
Hurstville
NSW 2220

¹ Note: Members of the public may inspect submissions for free or ask for a copy. Copying charges are to be charged at the current FOI rate ie \$30/hr

² An assessment must be made by the relevant DEC Threatened Species Unit, as to whether the request for confidentiality will be agreed to. DEC must contact the affected person as to its decision as per the DEC guide to privacy and handling public submissions (NPWS 2002).



**Department of
Environment and
Conservation**