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

draft for public comment

February 2005
Requests for information or comments regarding Green and Golden Bell Frog Recovery Plan should be directed to:-

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Your comments on the Draft Recovery Plan may contain information that is defined as “personal information” under the NSW *Privacy and Personal Information Protection Act 1998* and which identifies you. Following consideration of submissions and finalisation of the Draft Recovery Plan, copies of all submissions will be available for inspection at the DEC Office at 43 Bridge Street, Hurstville 2220 (ph: 02 9585 6444). If you do not want your personal details to become public please mark on your submission that you want your details to remain “confidential”. The submissions will ultimately be stored in the DEC records system.
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
Acknowledgments

A number of people have assisted the preparation of this Recovery Plan in various ways. This support is gratefully acknowledged.

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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,
- the proactive development of draft site specific PoMs and MPs at several important locations in anticipation of the preparation of this Recovery Plan.

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Table of Contents

EXECUTIVE SUMMARY ................................................................................................. I

ACKNOWLEDGMENTS ........................................................................................................ III

1 INTRODUCTION ............................................................................................................. 1

2 LEGISLATIVE CONTEXT ................................................................................................. 2
  2.1 LEGAL STATUS ........................................................................................................... 2
  2.2 RECOVERY PLAN PREPARATION ............................................................................. 2
  2.3 RECOVERY PLAN IMPLEMENTATION ......................................................................... 2
  2.4 RELATIONSHIP TO OTHER LEGISLATION .................................................................. 3
  2.5 CRITICAL HABITAT .................................................................................................... 3
  2.6 KEY THREATENING PROCESSES .............................................................................. 4
  2.7 ENVIRONMENTAL PLANNING AND ASSESSMENT ..................................................... 5
    2.7.1 State environmental planning and assessment ....................................................... 5
    2.7.2 Commonwealth environmental assessment .......................................................... 6

3 CONSERVATION STATUS ................................................................................................. 8

4 DESCRIPTION AND TAXONOMY .................................................................................. 11
  4.1 DESCRIPTION ............................................................................................................ 11
    4.1.1 Adult Frogs ........................................................................................................... 11
    4.1.2 Tadpoles .............................................................................................................. 12
    4.1.3 Spawn ................................................................................................................. 12
  4.2 TAXONOMY AND INTERRELATIONSHIPS ....................................................................... 12
    4.2.1 Taxonomy ............................................................................................................. 12
    4.2.2 Interrelationships ............................................................................................... 13

5 DISTRIBUTION AND HABITAT .................................................................................... 15
  5.1 DISTRIBUTION .......................................................................................................... 15
    5.1.1 General description of distribution ....................................................................... 15
    5.1.2 Regional Distribution .......................................................................................... 16
  5.2 TENURE .................................................................................................................... 24
  5.3 HABITAT ................................................................................................................... 24
    5.3.1 Habitat Description ............................................................................................. 24
    5.3.2 Climate ............................................................................................................... 26
    5.3.3 Landscape and Topography ................................................................................. 26

6 GENERAL BIOLOGY AND ECOLOGY .......................................................................... 27
  6.1 PREDATOR/PREY RELATIONSHIPS .......................................................................... 27
  6.2 REPRODUCTION ....................................................................................................... 29
    6.2.1 Breeding Period ................................................................................................. 29
    6.2.2 Mating Call ........................................................................................................ 29
    6.2.3 Amplexus .......................................................................................................... 29
    6.2.4 Fecundity ........................................................................................................... 30
    6.2.5 Rates of development and metamorphosis ......................................................... 30
  6.3 LIFE HISTORY AND SPECIES DYNAMICS ............................................................... 30
  6.4 DEMOGRAPHICS ..................................................................................................... 30
  6.5 MOVEMENT PATTERNS AND OTHER BEHAVIOUR ............................................... 31

7 PREVIOUS MANAGEMENT ACTIONS .......................................................................... 32
  7.1 GREEN AND GOLDEN BELL FROG RECOVERY TEAM ............................................... 32
  7.2 SURVEY AND MONITORING .................................................................................. 32
  7.3 SITE SPECIFIC MANAGEMENT PLANS ................................................................. 32
  7.4 INTEGRATED FORESTRY OPERATIONS APPROVAL (IFOA) ...................................... 33
  7.5 RESEARCH ............................................................................................................. 33
  7.5 SPECIES INFORMATION PROFILE AND ENVIRONMENTAL IMPACT ASSESSMENT GUIDELINE ........................................................................................................ 36
14.2 COMMUNITY EDUCATION, AWARENESS & INVOLVEMENT CRITERIA .......................................................... 57
14.3 COMMUNITY EDUCATION, AWARENESS & INVOLVEMENT RECOVERY ACTIONS ........................................ 57
  14.3.1 Species information and communication of the recovery program .............................................................. 57
  14.3.2 Community involvement in recovery program ............................................................................................. 57
15 CO-ORDINATION OF THE RECOVERY PROGRAM ......................................................................................... 59
  15.1 CO-ORDINATION OF RECOVERY PROGRAM OBJECTIVE ........................................................................ 59
  15.2 CO-ORDINATION OF RECOVERY PROGRAM CRITERIA ............................................................................. 59
  15.3 COORDINATION OF RECOVERY PROGRAM ACTIONS ............................................................................. 59
  15.3.1 Maintain on-going State-wide coordination of the Green and Golden Bell Frog Recovery Program .......................................................... 59
16 COSTINGS .......................................................................................................................................................... 61
17 PREPARATION DETAILS ................................................................................................................................ 62
  17.1 DATE OF LAST AMENDMENT ........................................................................................................................ 62
  17.2 REVIEW DATE ................................................................................................................................................ 62
18 CONTACTS ........................................................................................................................................................ 63
19 REFERENCES .................................................................................................................................................... 64
20 APPENDICES .................................................................................................................................................... 72

List of figures

Figure 1. Bioregional representation of *Litoria aurea* ........................................................................................................ 10
Figure 2. Regional Planning Units for *Litoria aurea* ......................................................................................................... 10
Figure 3. Green and Golden Bell Frog *Litoria aurea* ........................................................................................................ 11
Figure 4. *Litoria aurea* Tadpole ........................................................................................................................................ 12
Figure 5. Distribution of ‘aurea’ Group Bell Frog members. ................................................................................................. 14
Figures 6a and 6b (opposite) illustrates the current and historic distribution of *Litoria aurea* ..................................... 23

List of tables

Table 1. Key populations of *Litoria aurea* by planning region. ......................................................................................... 24
Table 2 Green and Golden Bell Frog populations by tenure. ............................................................................................... 24
Table 3: Costing Table Estimated costs of implementing the actions identified in the Green and Golden Bell Frog recovery plan are provided below................................................................................. 61

Appendices

Appendix 1 Species Information Profile
Appendix 2 Environmental Impact Assessment Guideline
Appendix 3 Management Plan Preparation Guide
Appendix 4: Monitoring Data Recording sheet
Appendix 5: Making a submission regarding this draft recovery plan
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 (Pelodryadidae 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.

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:

- Environmental Planning and Assessment Act 1979 (NSW) – (EP&A Act 1979)
- Rural Fires Act 1997 (NSW) – (RF Act 1997)
- Native Vegetation Conservation Act 1997 (NSW) – (NVC Act 1997)
- Rivers and Foreshores Improvement Act 1948 – (NSW)
- Pesticides Act 1999 (NSW)
- Fisheries Management Act 1994 – (NSW)
- Water Management Act 2000 – (NSW)

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– Concurrency 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 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

\[
\begin{array}{c c c c c}
\text{I} & \text{1} \\
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\text{1} & \text{1} \\
\text{1} & \text{2} \\
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\]

(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.

![Litoria aurea Tadpole](image)

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).
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 refocussed 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 coastal 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.


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 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).
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. Coomaditchie 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 ongoing 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 Vincenita 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 Currambene 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 Wollombboola 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 Currambene Creek – this poorly known population occurs within the Currambene catchment to the south of Currambene 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 Narrrawallee 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 Murrah 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;

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 _Litoria 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 Charlotte 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.

<table>
<thead>
<tr>
<th>Region</th>
<th>Population</th>
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<th>Tenure</th>
<th>Pops</th>
<th>Sub Pops</th>
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<td></td>
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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 Murrar | 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

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).

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<tr>
<th>Tenure</th>
<th>Populations</th>
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<tr>
<td>Totals</td>
<td>52</td>
<td>88</td>
<td>100</td>
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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 occur 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.