

## 6 General Biology and Ecology

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in response to the recognised threatened status of the species, reviewed much of the published or known but still unpublished information on the species.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

### 6.1 Predator/Prey Relationships

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

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

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

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

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

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

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

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

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

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

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

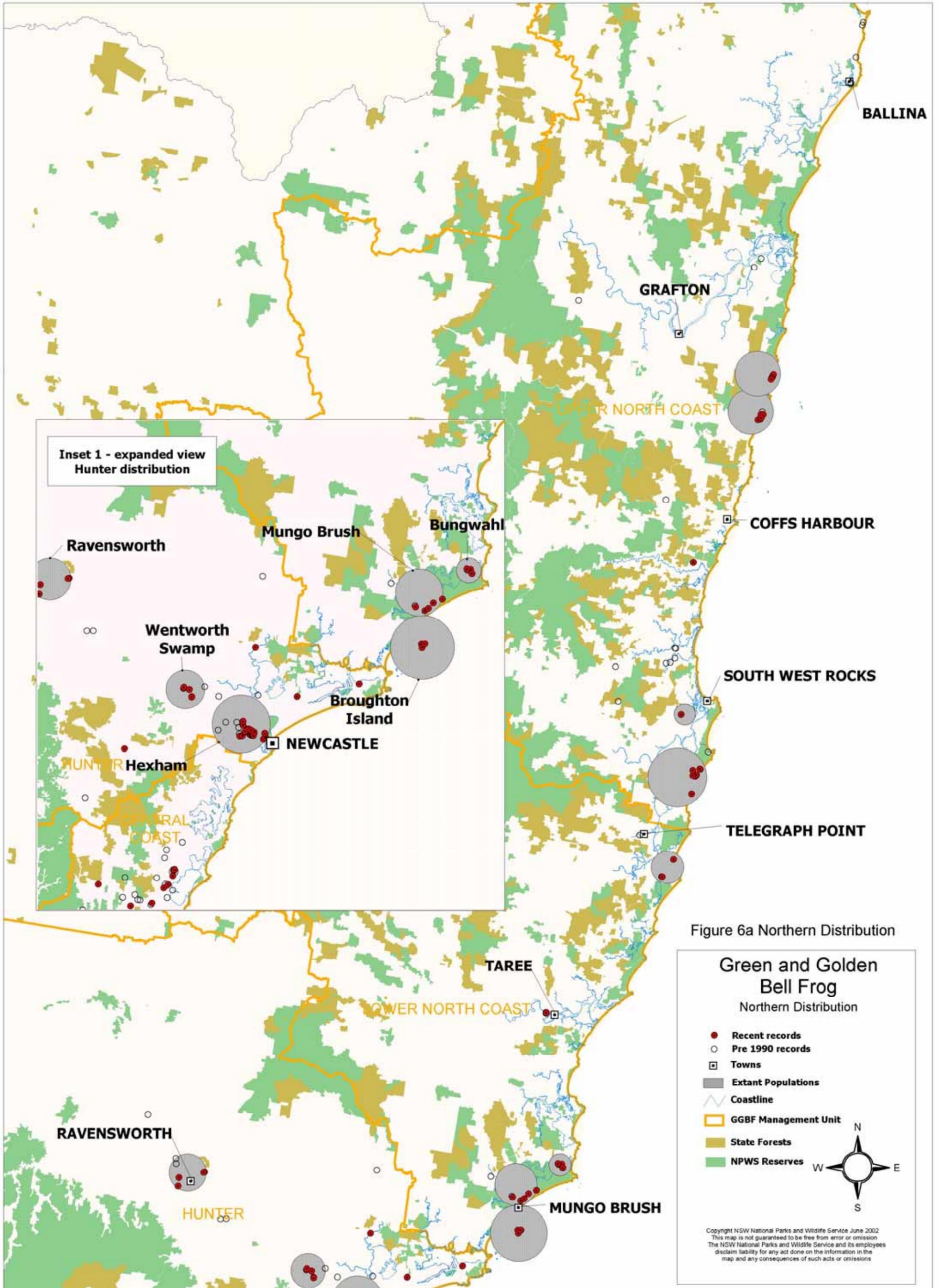
Other likely predators of GGBF tadpoles includes various introduced fish such as the Redfin Perch (*Perca fluviatilis*) (Pyke and White, 2001) and the European Carp (*Cyprinus carpio*); Native fish such as the Freshwater Eel (*Anguilla spp.*) (Pyke and White, 2001); Empire Gudgeon (*Hypseleotris compressa*)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

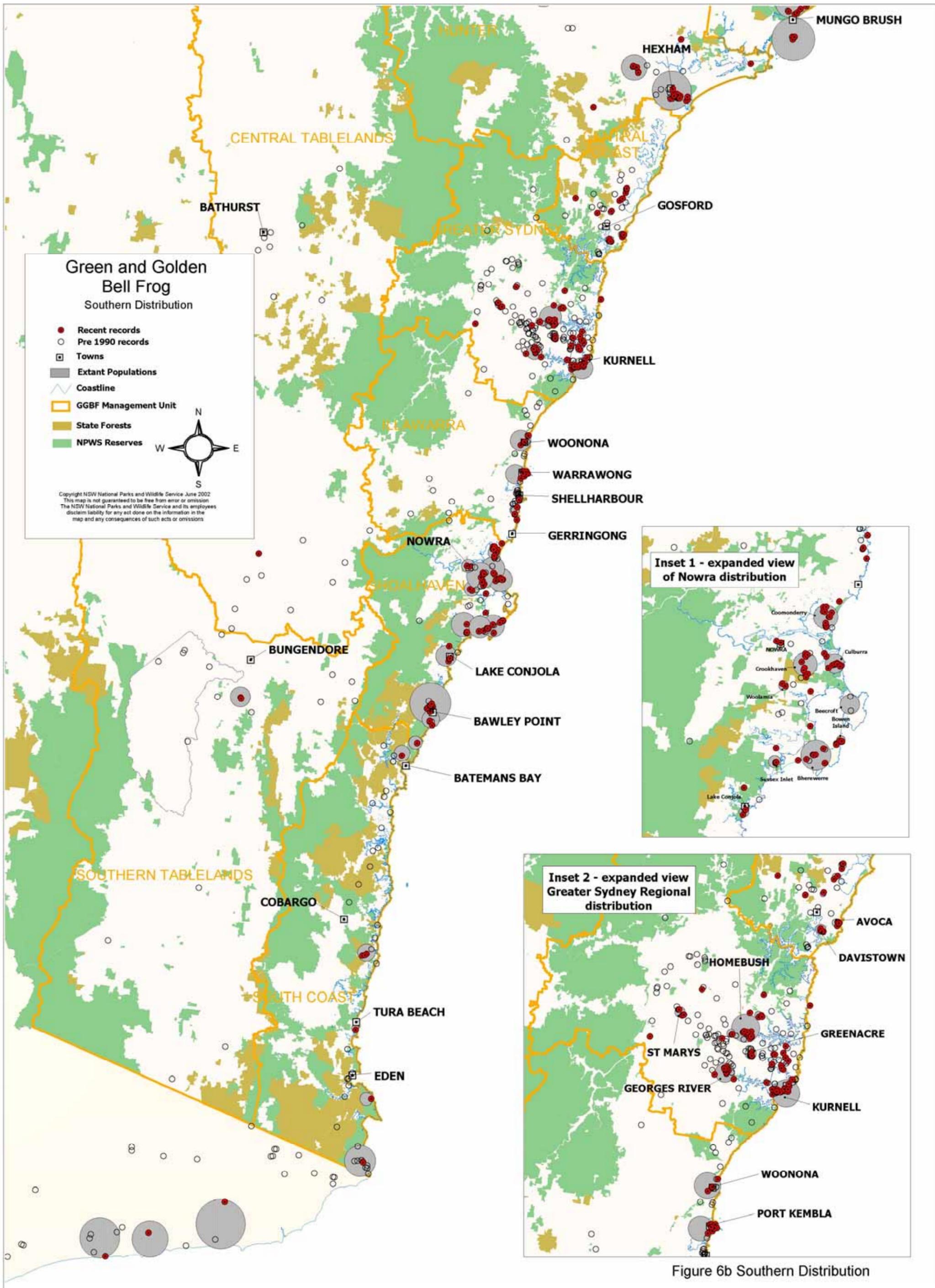
One opportunistic feeding observation of a Reef Egret (*Ardea sacra*) at Crescent Head, found that the bird walked in the shallow margins of a hind-dune swale breeding pond 10-15cm in depth, flushing tadpoles from the cover afforded by alga growth on the bottom. Tadpoles were seized in the bill and manipulated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

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

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

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





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

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

## 6.2 Reproduction

### 6.2.1 Breeding Period

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

### 6.2.2 Mating Call

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

### 6.2.3 Amplexus

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

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

#### **6.2.4 Fecundity**

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

#### **6.2.5 Rates of development and metamorphosis**

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

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

### **6.3 Life history and species dynamics**

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

### **6.4 Demographics**

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

## 6.5 Movement Patterns and other behaviour

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

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

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

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

## 7 Previous management actions

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### 7.1 Green and Golden Bell Frog Recovery Team

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

### 7.2 Survey and monitoring

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

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

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

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

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

### 7.3 Site specific management plans

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

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

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

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

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

## 7.4 Integrated Forestry Operations Approval (IFOA)

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

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

## 7.5 Research

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

Current research activity includes:

### Genetic Investigations

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

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

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

### **Reintroduction Experimentation**

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

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

### **Habitat Creation Experiments**

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

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

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

### **Captive Breeding and Captive Management**

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

### **Investigations of known or potential threats**

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

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

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

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

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

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

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

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

## **7.5 Species information profile and environmental impact assessment guideline**

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

## **7.6 Community survey**

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

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

These groups include:

Avoca-Davistown - established 1997

Coomaditchie-Port Kembla - established 1996

Marrickville - established 1998

Long Reef-Collaroy - established 1999

Merimbula - established 1998

## 8 Management Issues

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### 8.1 Level of Understanding

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

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

### 8.2 Threatening Processes

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

#### 8.2.1 Habitat Loss, Habitat Modification and Disturbance

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

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

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

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

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

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

### 8.2.2 Fragmentation and Isolation of Habitat

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

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

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

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

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

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

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

### 8.2.3 Predation by Introduced Fish

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

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

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

### 8.2.4 Disease

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

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

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

### 8.2.5 Water Quality and Pollutant Issues

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

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

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

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

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

### 8.2.6 Other threats

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

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

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

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

### **8.3 Community Education and Awareness**

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

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

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

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

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

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

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

### **8.4 Translocation and Reintroduction**

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

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

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

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

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

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

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

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

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

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

## 8.5 Consideration of Social and economic consequences

### 8.5.1 Social considerations

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

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

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

### 8.5.2 Economic considerations

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

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

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

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

## 8.6 Roles/Interests of Indigenous People

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

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

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

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

## 8.7 Biodiversity Benefits

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

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

## 8.8 Ability to Recover

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

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

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

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

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

## **8.9 International obligations**

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

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

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

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

## 9 Overall Objectives and Criteria

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### 9.1 Overall objective

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

### 9.2 Specific Objectives

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

The specific objectives for achieving this are to:

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

### 9.3 Overall Criteria

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

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

## **10 Reservation / Conservation Status**

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

### **10.1 Reservation / Conservation Objective**

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

### **10.2 Reservation / Conservation Criteria**

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

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

### **10.3 Reservation / Conservation Recovery Actions**

#### **10.3.1 Actions to address habitat loss and degradation**

##### **Liaison with public authorities**

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

##### **Liaison with private landholders**

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

## 11 Threat and Habitat Management

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

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

### 11.1 Threat and Habitat Management Objective

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

### 11.2 Threat and Habitat Management Criteria

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

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

### 11.3 Threat and Habitat Management Actions

#### 11.3.1 Actions to address strategic planning and impact assessment

##### Strategic planning instruments

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

##### Environmental impact assessment guidelines

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

#### 11.3.2 Identification and assessment of threatening processes

##### Threat identification and assessment

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

### **Conservation Assessment Protocol**

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

### **11.3.3 Habitat enhancement, rehabilitation and construction**

#### **Preparation of guidelines**

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

#### **Habitat enhancement activities**

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

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

### **11.3.4 Preparation of GGBF Plans of Management at key populations**

#### **DEC-managed estate**

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

#### **Land managed by other public authorities**

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

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

### **11.3.5 Frog Disease Management Strategy**

#### **Implementation of recovery actions**

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

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

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

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

#### **Plague Minnow (*Gambusia holbrooki*) Threat Abatement Program**

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

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

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

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

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

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

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

#### **Other Threat Abatement Programs**

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

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

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

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

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

## 12 Research and Monitoring

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

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

### 12.1 Research and Monitoring Objective

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

### 12.2 Research and Monitoring Criteria

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

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

### 12.3 Research and Monitoring Actions

#### 12.3.1 Monitoring Actions

##### Database of population localities

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

##### Systematic monitoring program

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

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

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

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

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

### **Other monitoring**

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

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

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

## **12.3.2 Research actions**

### **Research program**

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

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

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

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

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

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

## 13 Captive breeding and translocation

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

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

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

### 13.1 Captive breeding and translocation Objective

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

### 13.2 Captive breeding and translocation Criteria

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

### 13.3 Captive breeding and translocation Actions

#### 13.3.1 Captive Breeding

##### **Captive Husbandry Manual**

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

##### **Representative populations in Captivity**

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

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

#### 13.3.2 Translocation

##### **Current Translocation Trials**

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

##### **Translocation Review**

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

##### **Translocation Guide**

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

**Future Translocation**

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

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

## **14 Community Education, Awareness & Involvement**

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

### **14.1 Community Education, Awareness & Involvement Objective**

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

### **14.2 Community Education, Awareness & Involvement Criteria**

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

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

### **14.3 Community Education, Awareness & Involvement Recovery Actions**

#### **14.3.1 Species information and communication of the recovery program**

##### **Species Profile**

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

##### **Environmental Impact Assessment Guidelines**

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

##### **Regional information profiles**

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

##### **Annual Newsletter**

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

#### **14.3.2 Community involvement in recovery program**

##### **Existing community involvement in GGBF recovery actions**

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

#### **Establishment of regional “Friends of GGBF” groups**

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

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

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

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

#### **Monitoring**

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

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

#### **Community training workshops**

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

## **15 Co-ordination of the Recovery Program**

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

### **15.1 Co-ordination of Recovery Program Objective**

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

### **15.2 Co-ordination of Recovery Program Criteria**

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

### **15.3 Coordination of Recovery Program Actions**

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

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

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



## 16 Costings

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

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

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

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

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

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

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

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

## **17 Preparation Details**

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

### **17.1 Date of Last Amendment**

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

### **17.2 Review Date**

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

## 18            **Contacts**

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