Appendix 1 to Murray, K., Skerratt, L., Marantelli, G., Berger, L., Hunter, D., Mahony, M. and Hines, H. 2011. *Guidelines for minimising disease risks associated with captive breeding, raising and restocking programs for Australian frogs*. A report for the Australian Government Department of Sustainability, Environment, Water, Population and Communities.

ARAZPA Amphibian Action Plan

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1. Background

Amphibian species across the world have declined at an alarming rate in recent decades. According to the IUCN at least 122 species have gone extinct since 1980 and nearly one third of the world's near 6,000 amphibian species are classified as threatened with extinction, placing the entire class at the core of the current biodiversity crisis (IUCN, 2006). Australasia too has experienced significant declines; several Australian species are considered extinct and nearly 25% of the remainder are threatened with extinction, while all four species native to New Zealand are threatened.

Conventional causes of biodiversity loss, habitat destruction and invasive species, are playing a major role in these declines. However, emergent disease and climate change are strongly implicated in many declines and extinctions. These factors are now acting globally, rapidly and, most disturbingly, in protected and near pristine areas.

Whilst habitat conservation and mitigation of threats *in situ* are essential, for many taxa the requirement for some sort of *ex situ* intervention is mounting.

In response to this crisis there have been a series of meetings organised by the IUCN (World Conservation Union), WAZA (World Association of Zoos & Aquariums) and CBSG (Conservation Breeding Specialist Group, of the IUCN Species Survival Commission) around the world to discuss how the zoo community can and should respond. A number of documents have been produced from meetings and workshops that provide a strong lead globally and regionally for the zoo industry to take action. These include (in chronological order):

- IUCN Declining Amphibian Populations Taskforce *Ex Situ* Conservation Advisory Group has produced draft Guidelines and Procedures for Management of *Ex Situ* Populations of Amphibians for Conservation: August 2005.
- Declaration of the Amphibian Conservation Action Plan (ACAP) arising from the Amphibian Conservation Summit in Washington, D.C., USA, in September 2005.
- CBSG/WAZA report on the Amphibian *ex situ* Conservation Planning Workshop in Panama, February 2006 (Zippel, *et al*., 2006);
- At its 2006 Annual Meeting in August, in Leipzig, Germany, WAZA adopted a resolution calling on the global zoo community to join with CBSG and the Amphibian Specialist Group to form, support, and develop an Amphibian Ark initiative to fulfil the *ex situ* components of the ACAP.

One of the key outcomes of these activities has been identification of the need for regional action plans to provide strategic direction and focus at the national or regional level. Following attendance at the Amphibian *ex situ* Conservation Planning Workshop in Panama, February 2006, Graeme Gillespie (Zoos Victoria, ZV) and Gerry Marrantelli (Amphibian Research Centre, ARC) concluded that the current challenges facing Australasian frog conservation greatly exceeded current regional capacity to address them, let alone overseas challenges; and that if the Australasian zoo community were going to rise to any of these challenges, then it must build capacity and develop a plan of action locally. This strongly reinforced the previously discussed and agreed position of the ARAZPA Reptile & Amphibian Taxon Advisory Group (TAG).

2. Introduction

To date no regional planning has occurred in Australasia for amphibian *ex situ* management for conservation. A National Conservation Action Plan was produced by DEH (formerly Wildlife Australia) in 1996 (Tyler, 1997); however, this document provided little or no direction for *ex situ* management and conservation, and has never been updated. Similarly, a 1997 conference on the "Declines & Disappearances of Australian Frogs" pulled together a range of important presentations, but did no provide guidance on regional *ex situ* conservation action (Campbell, 1999). The recent IUCN Global Amphibian Assessment (see Stuart *et al*., 2004 and http://www.globalamphibians.org) and various State and Federal threatened species recovery plans have provided some direction and identified some priorities from the Australasian amphibian conservation community. It is clear from these documents and broader consultation with amphibian conservation biologists that the perceived need for various kinds of *ex situ* intervention has increased significantly in recent years. However, so far the response from Australasian zoological institutions has been limited. Individual zoos have responded to varying degrees, but not in the context of a regional approach (see various authors in ARAZPA, 2005).

This document is a strategic plan of action for ARAZPA institutions to respond to the current conservation crisis facing amphibians. Its intent is to provide direction for zoological institutions to increase their capacity in amphibian *ex situ* management in ways that maximise their ability to support amphibian conservation priorities.

This Plan has been prepared in consultation with the ARAZPA Reptile & Amphibian TAG, external regional and global expertise in *ex situ* amphibian management, and the broader amphibian conservation and research community.

3. Conservation status of Australasian Amphibians

At least 27 % of the 219 Australian frog species are threatened with extinction (Fig. 1). Seven species are now believed to have become extinct in the last 30 years (Appendix I). At least 33 species are now considered Endangered or Critically Endangered. Based upon recent unpublished assessments, at least six of these species are in imminent risk of extinction in the wild within the next decade.

All of the four recognised taxa in New Zealand are considered threatened (http://www.conservation.co.nz/templates/MultipageDocumentPage.aspx?id=39585). Fiji has one Endangered and one Near Threatened species (http://www.globalamphibians.org). In Papua New Guinea (PNG) two species are recognised as Vulnerable and ten are Data Deficient; however, PNG also has numerous undescribed species, so these figures are conservative (Menzies, 2006).

Causes of amphibian declines are varied and include habitat destruction, invasive species (fish, mammals, cane toads), chytrid fungus and most likely climate change (see Campbell, 1999). Chytrid has been strongly implicated in many of the declines of species from relatively undisturbed upland habitats in the wet tropics, eastern and southern highlands of Australia (Berger *et al.*, 2004). However, in many cases multiple threats are implicated (Hero *et al.*, 2005, 2006). The bulk of reported declines have been in stream-breeding frog communities, alpine communities or species in upland areas. Some species in other areas and habitats have also declined, mostly due to habitat destruction and invasive species.

In New Zealand, invasive mammal species are believed to have had a big impact upon some species, although habitat loss has also played a role. Chytrid has also been strongly implicated in the decline of one mainland species, *Leiopelma archeyi*. The main threats in Fiji are invasive species such as mongoose and cane toads (Morrison, 2003).

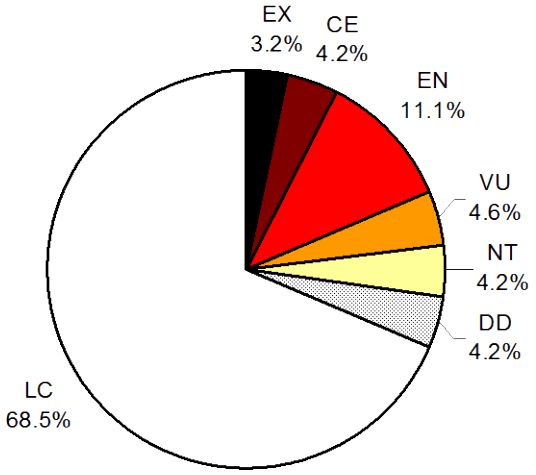

Figure 1. Summary of conservation status of Australian amphibians. EX – presumed extinct; CE – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern; DD – Data Deficient (Note: species in this category are unclassified and could occur in any of the previous categories of extinction risk).

The IUCN Global Amphibian Assessment (GAA) has identified 15 Australian species recommended for '*ex situ* intervention' and a further 11 species have been recommended by State or Federal recovery plans or recovery teams. In most cases, specific objectives for captive intervention have been identified as either captive breeding for re-introduction; insurance population, research or education/public awareness (Table 1). Twenty three threatened species have been identified as requiring captive intervention for insurance purposes; five species are identified as requiring captive breeding for re-introduction/translocation; twelve species for conservation-related research and five for education and community awareness.

In New Zealand insurance populations have been recommended for two species, with the potential to breed for release and approved non-invasive research, as directed by the Department of Conservation.

4. Current amphibian *ex situ* activities in Australasia

4.1 Species in Captivity

Australian ARAZPA institutions currently hold 33 native amphibian species. The ARC currently holds 40 species. The total number of species currently held in captivity in Australasia by these institutions is 50. Two New Zealand endemic species are presently held in zoos; *Leiopelma archeyi* at Auckland Zoo and *L. hochstetteri* at Hamilton Zoo. One Fijian endemic, *Platymantis vitianus*, is held at Kula Eco Park in Fiji. ARAZPA institutions also hold six exotic species.

The Australian species held in captivity represent approximately 22% of the presently described Australian amphibian fauna. However, representativeness of the Australian amphibian diversity in some sort of *ex situ* management is poor (Fig. 2). Of 32 currently recognised genera and phylogenetic groupings within the large unresolved genus *Litoria*, only 12 are currently represented in captivity. Major gaps include: the entire Microhylidae family; the genera *Philoria* and *Taudactylus*, all of which are threatened with extinction or already extinct; the *Litoria nannotis* and *Nyctimystes* groups, which comprise all of the declining wet tropics tree frog species; and virtually all arid zone and dry tropics species.

The species held in ARAZPA institutions are also heavily biased towards species considered secure in the wild (Figs. 3 & 4), which are mostly common and widespread species that occur in the vicinity of Australia's major population centres. Of 26 threatened species recommended for some form of *ex situ* management, only 11 are currently held in any ARAZPA institutions (Fig. 4) and an additional two species are held by the ARC (Table 1).

Only 16 species have ever been bred in captivity by ARAZPA institutions. Most of these have only been bred successfully (captive mating and progeny raised to sexual maturity) by one or two institutions. With the exception of only a few species, these have been *ad hoc* breeding events. Several threatened species have been regularly bred successfully in various captive situations (zoos and private holdings) over the past 10-15 years. These include: the Green and Golden Bell Frog *Litoria aurea*, Growling Grass Frog *L. raniformis*, Spotted Tree Frog *Litoria spenceri*, Stuttering Frog *Mixophyes balbus*, and Red-crowned Toadlet *Pseudophryne australis*. Some success has also been achieved with *Geocrinia rosea*, the Southern Corroboree Frog *Pseudophryne corroboree* and Booroolong Frog *Litoria booroolongensis*. To date ARAZPA institutions have only successfully bred four of these species: *L. aurea*, *L. raniformis*, *M. balbus* and *P. australis* (Table 1, Fig. 4).

Historically, Adelaide University had a colony of Gastric Brooding Frogs, *Rheobatrachus silus*, but they were not maintained for conservation purposes and were not bred in captivity. Attempts were made in the early 1990's to secure the Sharp-snouted Torrent *Taudactylus acutirostris* in captivity at Melbourne and Taronga Zoos, but this was before any knowledge of chytrid fungus, which killed all the animals (Banks & McCracken, 2002). Whilst some lessons may have been learnt from these experiences, the opportunity now appears to have been missed to secure some of these 'presumed extinct' species in captivity.

In summary, within the Australasian region further extinctions of numerous species (9 Critically Endangered and 24 Endangered) and increased endangerment of others (15 Vulnerable) are imminent. However, attempts to secure any of these species in captivity are very few (see

Appendix I). In fact there is a strong bias in collections and captive management success towards species requiring the least, or no, *ex situ* conservation augmentation.

Table 1. IUCN-listed species recommended for *ex situ* intervention and their current representation in ARAZPA institutions or the Amphibian Research Centre (ARC). Sources: IUCN GAA; various State and Federal Recovery Plans (published and unpublished); Recovery team representatives: Gerry Marrantelli (ARC), David Hunter (NSW Dept. Environment & Conservation), Harry Hines & Keith MacDonald (Qld. Environment Protection Agency), Dale Roberts (University of WA); Helen Robertson (Perth Zoo). *Currently listed by IUCN as CE. Insur - insurance population; Re-intro – captive breeding for reintroduction; Res – research program related to conservation; Edu – display for education and increased public awareness.

Species	**IUCN Status**	**Recommendation for *ex situ* intervention**			**Presently in captivity**		**Captive-bred**
		IUCN	**Other**	**Purpose**	**Aust. zoo**	**ARC**	
Litoria castenaea	EX*	+		Insur			
Litoria piperata	EX*	+		Insur			
Geocrinia alba	CE		+	Insur; Re-intro; Res; Edu			
Philoria frosti	CE	+		Insur; Res		+	
Pseudophryne corroboree	CE	+	+	Insur; Re-intro; Res; Edu	+	+	F1
Taudactylis acutirostris	CE		+	Insur			
Taudactylis eungellensis	CE		+	Insur			
Taudactylis pleioni	CE	+		Insur; Res			
Litoria booroolongensis	CE		+	Insur; Re-intro	+	+	F1
Litoria spenceri	CE	+	+	Insur; Re-intro; Res; Edu	+	+	F4
Litoria nannotis	E	+	+	Insur			
Litoria raniformis	E	+		Edu; Res	+	+	F4
Litoria rheocola	E		+	Insur			
Nyctomystes dayi	E		+	Insur			
Mixophyes balbus	E		+	Insur; Res	+	+	F2
Mixophyes carbinensis	E	+		Insur			
Mixophyes coggeri	E	+		Insur			
Mixophyes fleayi	E	+	+	Insur	+		
Mixophyes iterates	E	+		Insur			
Philoria richmondensis	E	+		Insur			
Pseudophryne pengilleyi	E	+	+	Insur; Res	+	+	
Litoria aurea	V	+	+	Re-intro; Res; Edu	+	+	F3
Geocrinia vitellina	V		+	Res; Edu	+		
Spicospina flammocaerulea	V		+	Insur; Res	+		
Geocrinia lutea	NT		+	Insur; Res	+		
Taudactylus liemi	NT		+	Insur; Res			

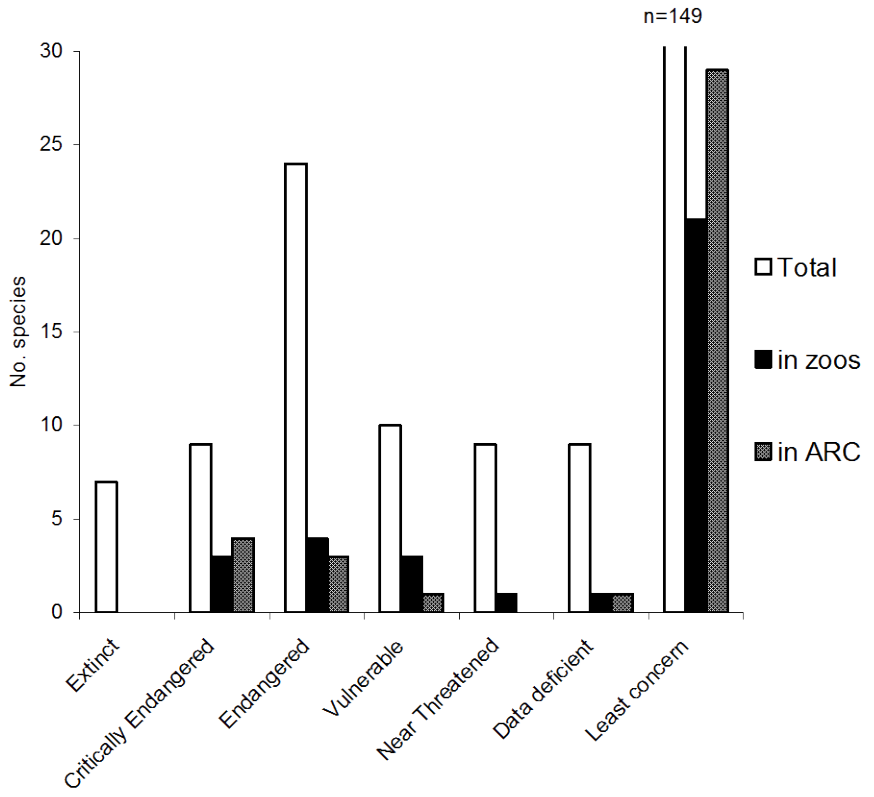

Figure 2. Number of species in each IUCN category currently held in ARAZPA institutions or the ARC.

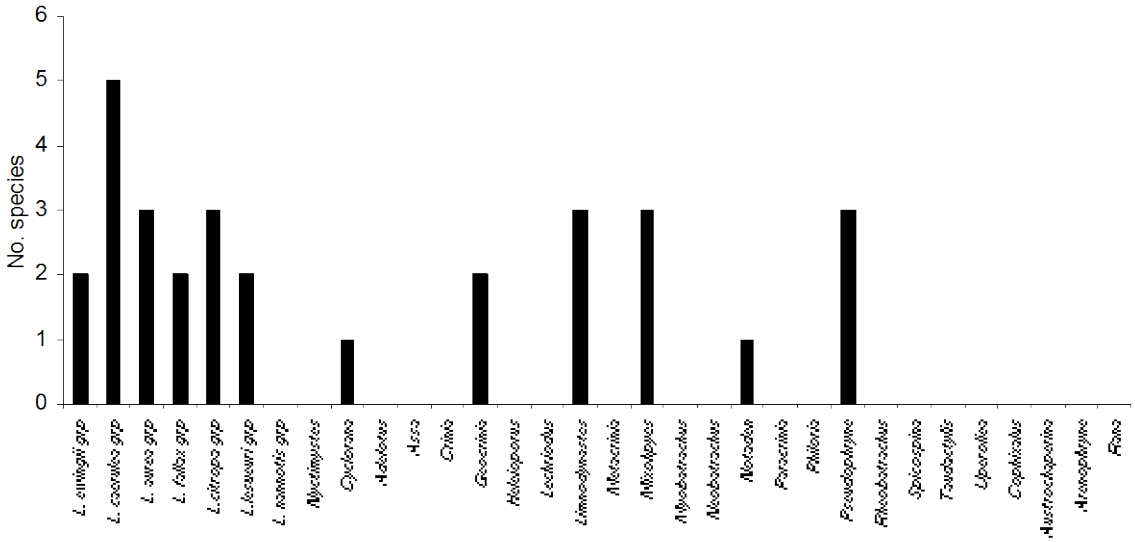

Figure 3. Current representation of Australasian amphibian diversity within zoological institutions. Phylogenetic diversity is represented either by genera or major phylogenetic groups within the genus *Litoria*.

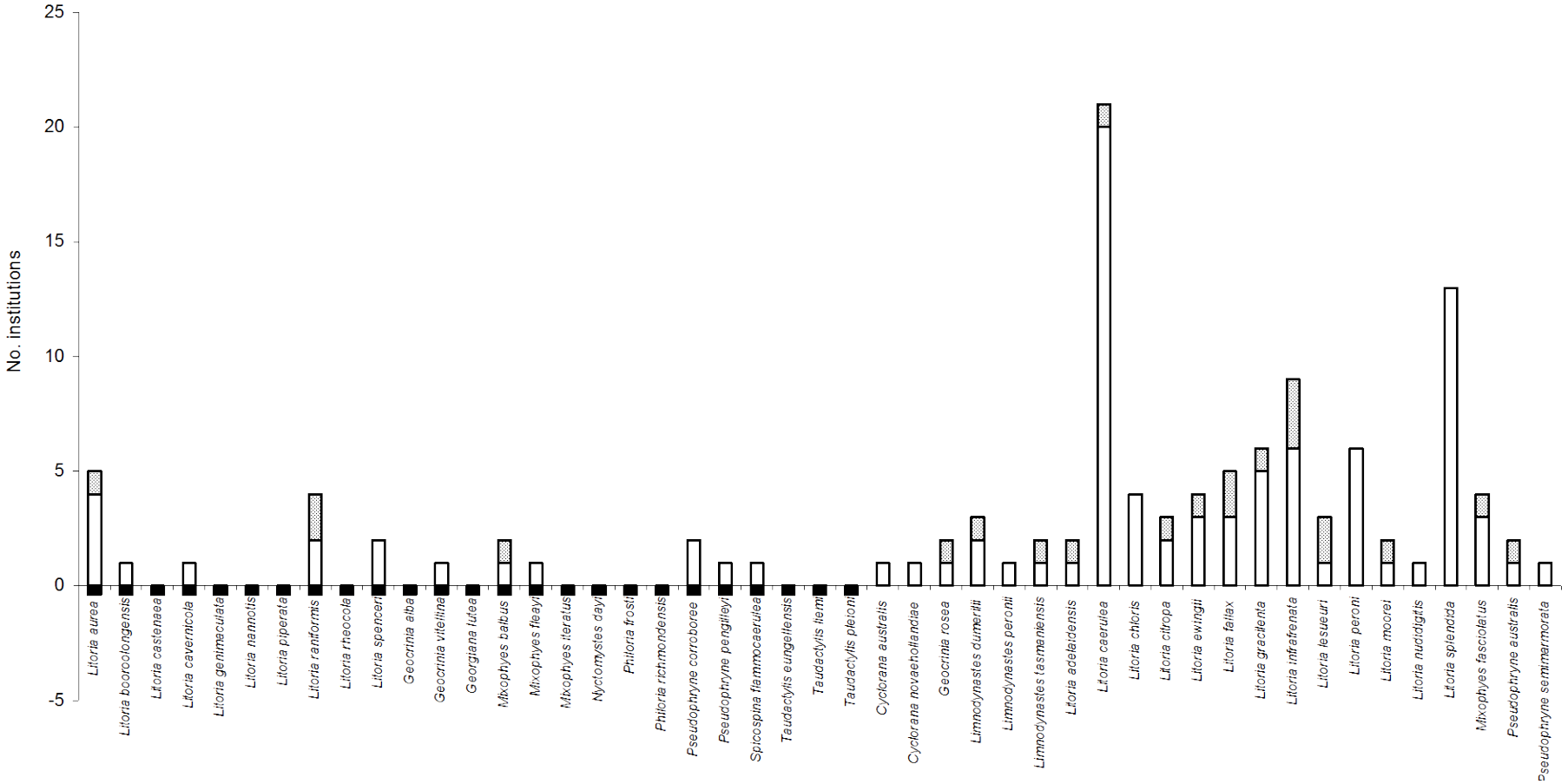

Figure 4. Relationship between species currently in ARAZPA institutions and identified need for *ex situ* conservation management of species in Australia. Species with identified need for *ex situ* conservation management are identified by a black bars below the x axis; open bars – number of ARAZPA institutions holding species; stippled bars – number of institutions that have bred the species (breeding is defined as successfully raising progeny to reproductive maturity).

4.2 Institutional Capacity

Based on the data submitted for the 2006 Regional Census and Plan, 31 ARAZPA institutions either hold native frogs now, or are planning to do so in the 2006-2007 year. These are located in three countries: 26 in Australia (6 in NSW, 6 in Victoria, 1 in South Australia, 1 in Western Australia, 2 in the ACT, 8 in Qld. and 2 in the NT); 4 in New Zealand and 1 in Fiji. The bulk of these (22) hold less than 5 species each, most of which are represented by less than 10 specimens of any species. With the exception of Melbourne Zoo, which currently holds 13 species (11 planned), the remaining institutions each hold 5-10 species.

Only five zoological institutions have dedicated[1] frog husbandry capacity in Australasia: Melbourne Zoo, Perth Zoo, Taronga Zoo, Tidbinbilla Nature Reserve in the ACT and Auckland Zoo. In addition, Healesville Sanctuary is currently constructing a breeding facility for the Spotted Tree Frog. Apart from the ARC, these are also the only institutions with any involvement with threatened frog recovery programs, either through maintaining insurance colonies, supporting reintroduction programs, and research and display for education (Table 2). These are also the only institutions with staff having any demonstrable frog husbandry skills and experience. Presently, none of these institutions holds more than four threatened species. Further, none of them have the capacity to breed and hold large numbers of adults of more than any two species, as would be required for a robust captive breeding program.

In summary, the majority of institutions holding or planning to hold frogs have no, or very little, expertise in breeding frogs or maintaining large numbers of specimens. These institutions are principally geared to maintaining frogs for display, usually in small numbers. Present regional capacity and expertise to undertake *ex situ* management of threatened species is limited to a few larger institutions. Furthermore, these resources and available expertise are limited to only a few species. Husbandry experience is nonexistent for most of the more specialized Australasian amphibian life history modes.

[1] Facilities dedicated to breeding amphibians, staff with specific amphibian husbandry expertise, and clear husbandry and conservation objectives.

Table 2. Institutions currently involved with threatened frog conservation or research programs.

Institution	No. threatened species held	Insurance population	Captive breeding/rearing for re-introduction	Research (eg. husbandry or threat-abatement)	Display/ education/ interpretation
Auckland	1	*	*	*	*
Hamilton	1	*	*	*	*
Melbourne	3	*	*	*	*
Perth	2	*		*	*
Taronga	4	*	*	*	*
Tidbinbilla	1	*	*		
Healesville	1		*	*	*

5. Role of ARAZPA in the Amphibian Conservation Crisis.

There are a variety of ways that zoological institutions may contribute to amphibian conservation. However, to contribute meaningfully to an amphibian conservation initiative, *ex situ* captive management should not only form part of a recommended conservation/recovery action for a species, but must also have clearly defined roles in the conservation of the species or its habitat. The *ex situ* Conservation Advisory Group of the Declining Amphibian Task Force considers the following to be clearly definable conservation roles for the *ex situ* management of amphibian species:

i. *Ark:* An amphibian species that is extinct in the wild (locally or globally) and which would become completely extinct without *ex situ* management.

ii. *Rescue:* An amphibian species that is in imminent danger of extinction (locally or globally) and requires *ex situ* management as part of the recommended conservation action.

iii. *Supplementation:* An amphibian species for which *ex situ* management benefits the wild population through breeding for supplementation as part of the recommended conservation action.

iv. *Farming:* An amphibian species threatened through wild collection (e.g. as a food resource), which is being bred in captivity – normally in-country, *ex situ* -to replace a demand for wild harvested specimens. This category generally excludes the captive breeding of pet and hobbyist species.

v. *Conservation Research:* An amphibian species undergoing specific applied research that directly contributes to the conservation of that species, or a related species, in the wild. This would include clearly defined ‘model’ or ‘analogue’ species.

vi. *Conservation Education*: An amphibian species that is specifically selected for management, primarily in zoos and aquariums, to inspire and increase knowledge in visitors, in order to promote positive behavioral change: for example, when a species is used to raise financial or other support for field conservation projects. (This would include clearly defined ‘flagship’ or ‘ambassador’ species.).

Role ‘iv’ does not currently apply to Australasia, although it is conceivable that frog farming may commence in PNG in the future. With this exception, these roles provide clear guidance on how ARAZPA institutions may potentially contribute, through *ex situ* action, to amphibian conservation.

Furthermore, there are increasing levels of activity around *in situ* programs, such as population monitoring, research, and habitat management. However, there are increasing limitations on resources available to conservation agencies and research institutions to meet these needs. As ARAZPA institutions build their amphibian expertise and roles in amphibian conservation programs, there are increasing opportunities for them to fill some of these gaps. Broader involvement with *in situ* activities will also facilitate integration of *ex situ* and *in situ* actions, and augment the development of interpretation and education.

5. Conservation Priorities

5.1 Regional Priorities

In Australia, it is clear that enormous gaps exist between the immediate and future needs of *ex situ* amphibian conservation and the capacity of ARAZPA institutions, either in terms of space, expertise or operating capacity. Although less significant, due to fewer species, this situation is paralleled in New Zealand. Therefore, if ARAZPA is going to make any meaningful contribution to amphibian conservation, it is essential that we focus upon closing these gaps within our region. We must get our own back yard in order before directing attention to other regions to avoid diluting what limited resources we have.

In the longer term, as we build our capacity in amphibian *ex situ* conservation and management, we may then consider other regional priorities. In these circumstances, South-east Asia would be the next highest priority. That region supports a large and diverse amphibian fauna, which, like all biodiversity in that region, is under immense pressures. In contrast to other global amphibian hotspots, such as Central America and north-east Australia, to date this region has received little attention from amphibian conservationists. However, pressures from habitat loss, over harvesting, invasive species and potentially emergent diseases are mounting. South-east Asia has been identified by WAZA and ARAZPA as a regional conservation priority for Australasian zoological institutions and ARAZPA zoos are already supporting *in situ* conservation programs in a number of south-east Asian countries.

Concerns surrounding disease risks will severely constrain future plans to undertake *ex situ* intervention of exotic species within Australasia. Any future support of international programs will most likely be in the form of local, research, *in situ* conservation *ex situ* capacity-building.

5.2 Species Priorities

In PNG, the absence of zoological institutions possessing the necessary infrastructure and staff expertise prevents the development of *ex situ* management programs for PNG amphibians at this time. Moreover, the generally poor understanding of the status of PNG amphibians does not allow for meaningful prioritisation of either *in situ* or *ex situ* resources.

Because of the few native species present in New Zealand and Fiji, taxonomic priorities for *ex situ* intervention in those countries are relatively straightforward.

However, the amphibian assemblage of Australia is large and diverse and the conservation issues are more complex and challenging. It will not be possible for all the problems to be tackled at once; therefore priorities must be established.

At the CBSG/WAZA Amphibian *ex situ* Conservation and Planning Workshop in 2006, a decision tree was developed for the regional selection and prioritisation of taxa for *ex situ* conservation (Zippel *et al*. 2006; see Appendix II). This decision tree has been adapted to the Australian situation and used to establish *ex situ* conservation priorities for Australian amphibians. As yet no formal process has been undertaken by the federal or State conservation agencies to systematically assess whether or not species require *ex situ* conservation action. Recommendations made during the IUCN GAA Australian assessment (in 2001) do not necessarily reflect the views of the various responsible conservation agencies and are now six years out of date. Accordingly, all listed species have been ranked here, irrespective of the whether or not they have been recommended for *ex situ* conservation action previously. Furthermore, species presumed extinct have been included; in the unlikely event that any of these are rediscovered, *ex situ* intervention will need to be seriously considered.

Priority rankings are highly consistent with previous recommendations for *ex situ* conservation action (Table 3). Aside from extinct species, some ARAZPA institutions have already commenced *ex situ* programs on several of the highest priority species, namely: Southern Corroboree Frog *P. corroboree*, Green and Golden Bell Frog *L. aurea*, Growling Grass Frog *L. raniformis*, Spotted Tree Frog *L. spenceri*, Stuttering Frog *M. balbus* and the Sunset Frog *Spicospina flammocaerulea*.

Other high priority species include:

- The entire genus of *Taudactylus*, in particular *T. pleioni*, which is possibly the most endangered frog in Australia at present;
- All of the threatened wet tropics endemic stream frogs (*Litoria nannotis*, *L. rheocola*, and *Mixophyes* spp.);
- Other subtropical and temperate stream species (*L. booroolongensis*, *Mixophyes fleayi* and *M. balbus*);
- The entire genus of *Philoria* (the ARC has kept *P. frosti* in captivity for several years with no breeding success).

Table 3. Priority rank-order of species for *ex situ* conservation in Australia. Only IUCN species have been considered. A high rank means high priority.

Species	IUCN status	*Ex situ* rec.	Priority rank order
Rheobatrachus silus	EX		77
Rheobatrachus vitellinus	EX		77
Pseudophryne corroboree	CE	+	75
Philoria frosti	CE	+	66
Litoria castenaea	EX	+	62
Litoria raniformis	E	+	59
Litoria aurea	V	+	59
Litoria spenceri	CE	+	59
Taudactylis pleioni	CE	+	57
Litoria booroolongensis	CE	+	54
Pseudophryne pengilleyi	E	+	53
Taudactylis acutirostris	CE	+	52
Taudactylis eungellensis	CE	+	52
Nyctomystes dayi	E	+	52
Taudactylis diurnis	EX		52
Litoria lorica	EX		52
Litoria nyakalensis	EX		52
Litoria piperata	EX	+	52
Spicospina flammocaerulea	V	+	51
Taudactylis rheophilus	CE		48
Litoria nannotis	E	+	48
Litoria rheocola	E	+	48
Mixophyes iteratus	E	+	48
Mixophyes balbus	E	+	43
Mixophyes carbinensis	E	+	43
Mixophyes coggeri	E	+	43
Mixophyes fleayi	E	+	43
Philoria richmondensis	E	+	43
Philoria kundagungan	E		43
Philoria loveridgei	E		43
Philoria pughi	E		43
Philoria spagnicolus	E		43
Pseudophryne covacevichae	E		43
Geocrinia alba	CE	+	41

Species	IUCN status	*Ex situ* rec.	Priority rank order
Cophixalus aenigma	E		39
Cophixalus concinnus	E		39
Cophixalus monticola	E		39
Cophixalus hosmeri	E		39
Cophixalus mcdonaldi	E		39
Cophixalus neglectus	E		39
Litoria brevipalmata	E		39
Litoria cooloolensis	E		39
Litoria daviesae	V		39
Litoria subglandgulosa	V		39
Litoria freycineti	V		39
Litoria olongburensis	V		39
Crinia tinnula	V		39
Heleioporus australiacus	V		38
Geocrinia vitellina	V	+	37
Litoria cavernicola	DD		35
Uperoleia martini	DD		35
Uperoleia tyleri	DD		35
Pseudophryne australis	V		33
Cophixalus peninsularis	DD		31
Litoria pearsoniana	NT		31
Taudactylus liemi	NT	+	31
Uperoleia arenicola	DD		31
Uperoleia marmorata	DD		31
Uperoleia orientalis	DD		31
Adelotus brevis	NT		29
Geocrinia lutea	NT	+	29
Cophixalus bombiens	NT		27
Cophixalus crepitans	NT		27
Cophixalus exiguus	NT		27
Litoria jungguy	NT		27
Litoria andiirmalin	V		25
Crinia sloanei	DD		25
Notaden weigeli	DD		25
Pseudophryne bibronii	NT		21

The high priority species are dominated by stream-breeding species and montane and alpine species. These species should form the focus for maximum *ex situ* conservation effort.

5.3 Analogue Species

Many of these species have relatively specialized ecological requirements that pose various challenges for *ex situ* management. Husbandry and captive breeding techniques have been developed for only a few species. These priorities must therefore be tempered by existing knowledge and institutional capacity. In some instances, it will be necessary to develop/trial husbandry on ecological analogue species as 'stepping stones' to more challenging and higher risk species. An example of this approach is the development of husbandry protocols at Melbourne Zoo for *Mixophyes fasciolatus*, with the sole aim of developing staff and institutional capacity to apply the skills and knowledge gained to more threatened species in the genus, leading to successful captive breeding of *M. balbus* (Banks *et al*., 2003). This approach has also been implemented by Perth Zoo on *Geocrinia* spp.

Institutions wishing to develop *ex situ* husbandry capacity for threatened species should consider the life history and ecological characteristics of the species, then endeavour to build programs around appropriate analogue species before tackling more challenging, higher risk, target species. For instance, the husbandry of several stream-breeding species, including some threatened species, has now been developed. Successful breeding programs for these species exist, either in Zoos or the ARC. These species provide valuable analogues for developing skills, facilities and experience for other, potentially more challenging stream breeding species. Potential analogue species for some threatened species are provided in Table 4.

Table 4. Priority threatened species and potential analogues.

Threatened target species	**Potential analogue species**
Pseudophryne corroboree	*Pseudophryne australis, P. dendyi*
Litoria booroolongensis	**Litoria lesueuri, L. wilcoxi**
Taudactylis acutirostris	*Litoria, wilcoxi, Mixophyes balbus, Taudactylus liemi*
Taudactylis eungellensis	*Litoria, wilcoxi, L. spenceri, Mixophyes balbus, Taudactylus liemi*
Nyctomystes dayi	*Litoria, wilcoxi, L. spenceri, Mixophyes balbus, Taudactylus liemi*
Mixophyes carbinensis	*Mixophyes balbus*
Mixophyes coggeri	*Mixophyes balbus*
Mixophyes fleayi	**Mixophyes balbus**
Pseudophryne covacevichae	*Pseudophryne australis, P. dendyi, P. bibroni*
Geocrinia alba	*Geocrinia lutea, G. rosea*
Geocrinia vitellina	*Geocrinia lutea, G. rosea*

Some species or genera, such as *Philoria* spp, lack useful ecological analogues with lower conservation status, and due to their specialized life histories, pose significant captive husbandry challenges. At this stage, these species should only be considered for *ex situ* intervention by the most experienced institutions.

5.3 Broader Biodiversity Considerations

In view of the level of uncertainty around the status of many species within Australia and the high potential for increases in extinction risk to species in the future, it is essential that steps are taken to ensure that *ex situ* capacity is developed to assist in the conservation of the region's broader amphibian diversity. Therefore, in addition to species that have already been identified at high extinction risk and requiring *ex situ* conservation action, some effort should also be devoted to developing captive husbandry and breeding capability in other taxa representative of the region's amphibian diversity.

A number of monotypic genera exist in Australia with unusual biology or habitat specialisations, ie. *Arenophryne rotunda, Assa darlingtoni, Metacrinia nichollsi, Myobatrachus gouldi* and *Lechriodus fletcheri*. These species should be targeted for the development of *ex situ* management capability to ensure against its potential future need.

Some genera or phylogenetic groups are already represented within *ex situ* collections and captive breeding has been achieved for some species within them, such as the *Litoria caerulea, L. ewingii, L. fallax* and *L. aurea*, complexes, and *Limnodynastes* spp. However, others are not and should be targeted: *Adelotus, Cophixalus, Crinia, Cyclorana, Helieoporus, Neobatrachus, Notaden,* and *Uperoliea*. Choices of species within these genera for developing captive management techniques should be informed by conservation status, ecological knowledge, educational/display potential and accessibility. The following species could be considered for example:

Crinia riparia	Stream-breeding species
Cyclorana platycephala	Captive-bred by ARC; displays well
Helieoporus australiacus	Vulnerable
Notaden weigeli	Data Deficient
Uperoliea tyleri/martini	Data Deficient

Table 5 summarises the highest priority species within Australia for *ex situ* conservation action, and the kind of actions needed/identified for each species and taxonomic group. All species that have been recommended for *ex situ* intervention are included, irrespective of rank.

5.4 Research

Many research questions relevant to amphibian conservation remain un-answered. Some of these are taxon-specific and others are more general, pertaining to taxonomic groups or regions. Captive management and breeding programs have the potential to play a vital role in supporting various research activities in these areas. This has already been demonstrated by the ARC, through the discovery of chytrid fungus, anti-fungacide research, and development of husbandry techniques and re-introduction trials.

Several endangered species recovery programs in Australia and New Zealand are at advanced stages and quite specific research objectives, relating to understanding impacts/interactions of threatening processes, are being addressed (eg. chytrid, introduced fish and salinity). Increasingly, these research projects are reliant upon experimental translocations, or captive breeding to produce experimental stock or progeny for experimental re-introduction.

Ex situ management and breeding programs can contribute to the following areas of conservation research:

- Husbandry and reproductive biology.
- Experimental translocations.

- Development and evaluation of re-introduction programs.
- Clinical disease research.
- Assisted reproduction technologies.
- Provision of large numbers of individuals of species, otherwise unavailable in the field, for experimental research into causes of population decline.

Generally research needs will be determined by relevant recovery programs or other conservation plans, such as the Amphibian Chytrid Threat Abatement Plan (Department of the Environment and Heritage 2006). These needs also should be considered when designing *ex situ* management programs and selecting species.

Table 5. Summary of Australian species and genera that should be targeted for various *ex situ* conservation-related actions. Threatened and Data Near Threatened species are in priority order; Least Concern (LC) species and genera are in alphabetical order.

Species/genus	IUCN status	Ark	Rescue	Supplementation	Research	Education	Husbandry development
Pseudophryne corroboree	CE	+	+	+	+	+	+
Philoria frosti	CE			+	+		+
Litoria raniformis	E			+	+	+	
Litoria aurea	V			+	+	+	
Litoria spenceri	CE	+	+	+	+	+	+
Taudactylis pleioni	CE	+	+				+
Litoria booroolongensis	CE		+	+		+	+
Pseudophryne pengilleyi	E		+	+		+	+
Taudactylis acutirostris	CE	+					+
Taudactylis eungellensis	CE		+				+
Nyctomystes dayi	E		+				+
Spicospina flammocaerulea	V				+	+	+
Taudactylis rheophilus	CE	+					+
Litoria nannotis	E		+			+	+
Litoria rheocola	E		+			+	+
Mixophyes iteratus	E		+			+	+
Mixophyes balbus	E	+	+		+	+	
Mixophyes carbinensis	E		+			+	+
Mixophyes coggeri	E		+			+	+
Mixophyes fleayi	E		+	+			+
Philoria richmondensis	E			+			+
Philoria kundagungan	E			+			+
Philoria loveridgei	E			+			+
Philoria pughi	E			+			+
Philoria spagnicolus	E			+			+
Pseudophryne covacevichae	E			+			+
Geocrinia alba	CE		+	+			+
Geocrinia vitellina	V				+	+	+
Taudactylus liemi	NT					+	+
Geocrinia lutea	NT				+	+	+
Arenophryne rotunda	LC					+	+
Assa darlingtoni	LC						+
Lechriodus fletcheri	LC						+
Metacrinia nichollsi	LC						+
Myobatrachus gouldi	LC						+
Cophixalus spp.							+
Crinia spp.							+
Cyclorana spp.							+
Geocrinia rosea	LC						+
Helieoporus spp.							+
Litoria lesueuri	LC						+
Litoria wilcoxi	LC						+

Table 5. cont'd.

Species/genus	IUCN status	Ark	Rescue	Supplementation	Research	Education	Husbandry development
Litoria citropa	LC						+
Neobatrachus spp.							+
Notaden spp.							+
Pseudophryne australis	LC						+
Pseudophryne bibroni	LC						+
Pseudophryne dendyi	LC						+
Uperoliea spp.							+

6. Institutional capacity

6.1 Facilities

For ARAZPA to make a meaningful contribution to amphibian conservation, institutional capacity for amphibian *ex situ* management needs to be significantly increased. Due to the special needs of amphibians, this will require significant investment in terms of space, facility design and quarantine.

The priority amphibian taxa identified encapsulate a wide variation in life history traits. Many of these species have relatively specialized ecological requirements that pose a range of significant challenges for *ex situ* management. For instance, most of the endangered species are either stream-breeders or alpine species. These require sophisticated facilities that emulate riverine or alpine micro-environments. In some cases the husbandry and captive breeding requirements of these species have been developed, serving to highlight these challenges, which include, lighting, temperature, humidity, microhabitat structure, water flow and filtration, diet, and disease management. . For most of these species, captive facilities necessary to breed species on scales necessary for long-term captive sustainability or re-introduction programs are large and sophisticated.

Relatively few ARAZPA institutions have the resources and expertise to respond to these needs at present. However, much expertise and experience in amphibian captive management exists within Australia at the ARC. The opportunity therefore exists to build upon this combined expertise and commence capacity building within ARAZPA. Furthermore, enough baseline information exists within the region to enable institutions to commence developing capacity by working upon analogue species, refining husbandry techniques, and then applying these to endangered species programs.

In reality it is likely that this level of support will only be achievable by larger institutions within the region. Nevertheless, small institutions are also able to contribute to the overall ARAZPA amphibian conservation initiatives in a variety of valuable ways. They may be able to provide facilities to house, rear or showcase a species in support of an ARAZPA-managed conservation program. They may also be able to act as a shop front to provide education and provide up date and factually correct advice about amphibians to the public; raise awareness about amphibian conservation issues; and generate support for recovery programs.

Due to the embryonic state of the knowledge base for most species, captive breeding facilities should be designed in ways that make them adaptable and enable experimental husbandry to be undertaken; for example, through manipulation of environments. Some of the more advanced *ex situ* conservation programs, such as the Corroboree Frog and Spotted Tree Frog programs, now

involve several zoo and non-zoo institutions. It is therefore essential that institutions develop and coordinate their activities and infrastructural designs.

6.2 Quarantine protocols

Amphibians intended for release to the wild need to be maintained in quarantine while in captivity. To prohibit the release of novel pathogens into free-range populations, quarantine protocols must be developed to eliminate the risk of introducing such pathogens into the captive population. Protocols should also include procedures to reduce the spread of pathogens within captive populations. Pathogen screening and treatment should occur while animals are in quarantine, on an annual basis and prior to release to other facilities. Prior to captive-exposed individuals being released to free-range populations, a percentage of the intended individuals should be euthanased and subjected to comprehensive pathogen screening. At present, various institutions have developed their own protocols for specific species and circumstances. To ensure regional security, ARAZPA, in conjunction with the ARC and CSIRO Animal Health Laboratories, must develop a regionally agreed minimum set of quarantine protocols. The seriousness of this issue is well-recognised by wildlife agencies and the global amphibian conservation community, such as the 2001 meeting to develop national disease management strategies (Speare, 2001), and the development of a national Threat Abatement Plan by the Commonwealth Government (Department of the Environment and Heritage 2006). It is therefore incumbent on ARAZPA to adopt the same approach.

6.3 Development of expertise

Presently within this region there are few dedicated or experienced amphibian husbandry individuals. Due to the specific challenges that amphibians pose, it is necessary to develop and expand the level of husbandry expertise within the region in conjunction with the development of facilities. The Durrell Wildlife Conservation Trust (Jersey Zoo), in conjunction with the ARC, has developed a course on amphibian husbandry (Gupta, 2006). There are plans for this course to be operated within Australia. Staff involved with amphibian husbandry should be encouraged to undertake such courses and other training opportunities should be developed at larger zoological institutions with existing experience.

6.4 Collection management

Captive breeding protocols need to be developed for each of the high priority species or genera, in consultation with field biologists and experts familiar with the natural history of each species. Protocols need to be documented and detail essential seasonality and behavioural parameters to enable future replication. At a minimum, information that should be recorded must include average monthly temperatures, detailed descriptions of enclosures and maintenance schedules, light sources and annual light cycles, reproductive behaviour including barometric changes that may have influenced such behaviour, and growth and development morphometric data.

A proforma will be developed that stipulates the minimum information required to be documented for the development of robust husbandry protocols.

The principles that govern *ex situ* management of amphibians should be no different to those applied to any other taxon managed by ARAZPA. Presently, many amphibians maintained by zoological institutions are not part of captive management plans and do not have studbooks. It is essential that *ex situ* management of amphibian species is undertaken in such a way as to maximise genetic diversity, animal health and adequate documentation for future reference. All species

brought into captivity for *ex situ* conservation action should therefore be managed in accordance with current ARAZPA species management policies and guidelines.

7. Recommendations and Actions

1. There are significant gaps between the Australasian regional needs for *ex situ* amphibian conservation action and ARAZPA's institutional capacity to meet those needs. Therefore, ARAZPA will devote its resources to bridging this gap, and focus on priorities for Australasian species, before channelling resources to programs/species outside of this region.
2. All actions and program development undertaken by ARAZPA Zoos under the auspices of this ARAZPA Amphibian Action Plan will be coordinated/managed by the ARAZPA Reptile & Amphibian TAG, in close consultation with the ARC where appropriate. (this is at the broad, over-arching level, notwithstanding the specific references further in these recommendations).
3. ARAZPA institutions need to work in close coordination with their local state conservation agencies and proactively seek partnership with them in order to achieve mutually agreed outcomes. ARAZPA institutions should be encouraged to seek out and collaborate with local university researchers with expertise (or students) who could assist them in reaching ARAZPA goals.
4. Recognising the generally low level of amphibian expertise among staff in ARAZPA institutions, ARAZPA will strongly support and encourage initiatives to address this shortcoming as a high priority.
5. The priority species and taxonomic groups identified in Table 4 should be used as a basis for future planning and development of amphibian *ex situ* conservation activities within Australian zoological institutions.
6. Individual ARAZPA institutions should explore opportunities to provide direct or indirect support to the identified priority programs. However, in doing so, institutions should maximise opportunities for regional collaboration to maximise capacity and conservation outcomes.
7. Many of the species requiring *ex situ* conservation intervention occur in Queensland. However, none of these species are in any form of *ex situ* management and for many of them husbandry techniques have not been developed. The Queensland Government currently does not support any form of *ex situ* intervention in amphibian conservation recovery. However, in some cases this may be the only short-term solution for the survival of some species, such as *Taudactylus pleioni*. Therefore, ARAZPA will consult with the Environment and Protection Authority of Queensland to explore options for establishing threatened species management programs in Queensland institutions having the appropriate capacity and drawing on expertise available outside Queensland.
8. The weight of evidence to date suggests that the emergence of chytrid fungus around the world probably resulted from the movement of African Clawed Frogs *Xenopus laevis* out of Africa for medical research. This phenomenon demonstrated that some diseases are carried by host species that are resistant to those diseases. Knowledge and understanding of amphibian diseases is poor and more diseases are being discovered all the time, some of which are potentially serious. The potential still remains for pathogens to be moved around in resistant host species undetected by the most rigorous quarantine procedures. Once in a new environment they have the potential to infect naïve hosts, resulting in new waves of decline and extinction. Until further knowledge is available on amphibian pathogens and quarantine procedures to screen for them, no more amphibians will be imported into the region or moved between countries within the region.

9. To ensure uniform/consistent regional biosecurity of all amphibian *ex situ* conservation programs, ARAZPA will consult with James Cook University, the CSIRO Australian Animal Health Laboratories and the ARC to develop a regionally agreed minimum set of quarantine protocols.
10. ARAZPA institutions will coordinate their efforts, in conjunction with the ARC, to develop best practice facilities to meet the needs of *ex situ* conservation actions as part of the recovery programs for priority species, and develop infrastructure husbandry capacity for broader amphibian biodiversity conservation.
11. All species brought into captivity for *ex situ* conservation action will be managed in accordance with current ARAZPA species management policies and guidelines. These programs will be designed and developed to be responsive to the specific needs of amphibian recovery conservation and research programs.
12. Through their broad engagement with the community; on-site, off-site and on-line; ARAZPA institutions should act as a 'shop front' for (1) raising awareness about the amphibian conservation crisis and its broader implications; (2) raising awareness about amphibian conservation activities locally and regionally; (3) connecting and involving people with relevant groups or activities in their communities; (4) provision of factually correct advise to the public about amphibians and action that can be taken locally and regionally. This could be coordinated nationally to ensure consistency and efficiency.
13. The ARAZPA Reptile & Amphibian TAG, in consultation with the ARC, will develop a husbandry proforma that stipulates the minimum information required to be documented for the development of robust husbandry protocols.

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Appendix I. Threatened and "Data-deficient" amphibian species in Australia (GAA 2007). * Currently listed by IUCN as CE. ** In other facility.

Species	IUCN Status	Recommendation for *ex situ* conservation		Presently in captivity		*Ex situ* bred
		IUCN	Other	Aust. zoo	ARC	
Rheobatrachus silus	EX					
Rheobatrachus vitellinus	EX					
Taudactylis diurnis	EX					
Litoria castenaea	EX*	+				
Litoria lorica	EX*					
Litoria nyakalensis	EX*					
Litoria piperata	EX*	+				
Geocrinia alba	CE		+			
Philoria frosti	CE	+			+	
Pseudophryne corroboree	CE	+	+	+	+	F1
Taudactylis acutirostris	CE		+			
Taudactylis eungellensis	CE		+			
Taudactylis pleioni	CE	+				
Taudactylis rheophilus	CE					
Litoria booroolongensis	CE		+	+	+	F1
Litoria spenceri	CE	+	+	+	+	F4
Cophixalus aenigma	E					
Cophixalus concinnus	E					
Cophixalus monticola	E					
Cophixalus hosmeri	E					
Cophixalus mcdonaldi	E					
Cophixalus neglectus	E					
Litoria brevipalmata	E					
Litoria cooloolensis	E					
Litoria nannotis	E	+	+			
Litoria raniformis	E	+		+	+	F4
Litoria rheocola	E		+			
Nyctomystes dayi	E		+			
Mixophyes balbus	E		+	+	+	F3
Mixophyes carbinensis	E	+				
Mixophyes coggeri	E	+				
Mixophyes fleayi	E	+	+	+		F2
Mixophyes iterates	E	+				
Philoria richmondensis	E	+				
Philoria kundagungan	E					
Philoria loveridgei	E					
Philoria pughi	E					
Philoria spagnicolus	E					
Pseudophryne covacevichae	E					

Pseudophryne pengilleyi	E	+	+	+	+	
Litoria andiirmalin	V					
Litoria aurea	V	+	+	+	+	F4
Litoria daviesae	V					
Litoria subglandgulosa	V					
Litoria freycineti	V					
Litoria olongburensis	V					
Crinia tinnula	V					
Geocrinia vitellina	V		+			
Heleioporus australiacus	V					
Pseudophryne australis	V			+		F3**
Spicospina flammocaerulea	V		+	+		
Adelotus brevis	NT					
Geocrinia lutea	NT		+	+		
Litoria jungguy	NT					
Litoria pearsoniana	NT					
Taudactylus liemi	NT		+			
Pseudophryne bibronii	NT				+	
Cophixalus bombiens	NT					
Cophixalus crepitans	NT					
Cophixalus exiguus	NT					
Litoria cavernicola	DD					
Cophixalus peninsularis	DD					
Crinia sloanei	DD					
Notaden weigeli	DD			+		
Uperoleia arenicola	DD					
Uperoleia marmorata	DD					
Uperoleia martini	DD				+	F2
Uperoleia orientalis	DD					
Uperoleia tyleri	DD					

Appendix II

DECISION TREE FOR SELECTION AND PRIORITIZATION OF TAXA FOR *EX SITU* CONSERVATION

Compiled by Andrés Acosta, Kevin Buley, Verónica Cano, Jorge Garcia, Richard Gibson, Graeme Gillespie, Bob Johnson, Bob Lacy, Saskia Lafebre, Francisco J. López- López, César Molina, José Vicente, Rodríguez-Mahecha, and Tim Skelton

From: Zippel, K., R. Lacy, and O. Byers (eds.) 2006. *CBSG/WAZA Amphibian Ex Situ Conservation Planning Workshop Final Report.* IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, MN 55124, USA.

Rationale

Ex situ conservation and management of a threatened amphibian species should only be considered as an alternative when the absolute imperative of *in situ* amphibian conservation cannot by itself ensure the survival of a species and its ecosystem. An *ex situ* initiative should be viewed as just one of the tools that can help in the over-all conservation of a species. It therefore follows that strong links between *ex situ* and *in situ* components are fundamental to the long-term success of species conservation. Full integration between *in situ and ex situ* conservation approaches should be sought wherever possible. This is normally best highlighted through the establishment of a formal Species Action Plan/Species Recovery Plan that explicitly states the short-, medium- and long-term goals of each component of the conservation initiative. When *ex situ* management of an amphibian species is considered necessary and appropriate, the priority should be to establish the initiative within the range state of ecological origin. Emphasis should therefore be placed on developing appropriate capacity within the range state where this does not exist.

Data derived from *ex situ* management of amphibians should be made openly available to workers involved in the *in situ* conservation of the species (or similar species) and *vice versa.* In exceptional cases where an *ex situ* conservation initiative has been established prior to/in the absence of a concurrent *in situ* initiative (e.g. where a political situation prohibits it or where a disease problem invalidates it), emphasis should be placed on establishing the appropriate *in situ* links as soon as it becomes possible to do so. The persistence of a species over the long-term is only assured by its conservation *in situ.* Therefore, an *ex situ* component to a conservation program should only ever be viewed as a short- or medium-term initiative, and its conservation aim should always be to render its own requirement superfluous!

This Decision Tree has been structured in three ‘phases.’ Phase One of the Decision Tree ensures that there is justification for an *ex situ* program. It consists of three fundamental questions with “yes” or “no” answers. These questions should be applied to the taxon under consideration, answering each honestly and objectively.

Phase Two of the Decision Tree takes those species that have ‘passed’ Phase One and attempts to prioritize them, i.e. with limited resources (space, staff, money, etc.), which species should have *ex situ* programs established ahead of others? It takes the form of a series of questions with weighted scores. The total score for a species indicates how ‘important’ an *ex situ* program for the species is in relation to others. Some questions may not be straightforward to answer and will require consultation with colleagues, taxonomic experts and other individuals/groups working with the species.

Phase Three of the Decision Tree considers the practical feasibility of initiating and maintaining an *ex situ* program once justified and considered a priority.

PHASE ONE: Initial Taxon Selection

Phase One of the Decision Tree is designed specifically to establish whether or not the justification exists to consider an *ex situ* program. Phase One does not consider issues of prioritization between taxa. It provides only a 'first cut' using yes or no answers. Only if a species makes it through Phase One, by answering 'yes' to all three questions (but there's only two questions below, so is one missing, or is it just two?), should it be considered for an *ex situ* initiative. It should then be passed through Phase Two to determine the relative importance of the proposed program in relation to other species.

a) General Justification

1. Conservation role: Does the proposed *ex situ* initiative have a clearly defined role (see DAPTF conservation roles for the *ex situ* management of amphibian species) in the conservation of the target taxon or its habitat?

Yes: Go to 2.

No: Insufficient justification for an *ex situ* conservation component at this time. DO NOT CONTINUE.

2. Mandate: Is there an existing mandate (see Appendix 1) recommending the *ex situ* conservation of this taxon?

Yes: Go to 3.

No: Insufficient justification for an *ex situ* conservation component at this time. DO NOT CONTINUE

PHASE TWO: Prioritization of Selected Taxa

Phase Two of the Decision Tree takes those taxa that have been selected for *possible ex situ* initiatives from Phase One and attempts to prioritize them. The questions should again be worked through sequentially, answered as objectively as possible and scores assigned. After all questions have been asked, a total score should be calculated to give a total species priority score.

b) Program Considerations

4. Threat mitigation: How potentially reversible are the threats currently facing the taxa in the short- to medium-term?

Prospect that threats can be reversed within 1-5yrs	Score 20
Prospect that threats can be reversed within 5-10yrs	Score 12
Threats may be reversible in unknown time frame	Score 4
No prospect of threat reversal	Score 0
Threats unknown*	Score 0

*Convey research need to ASG

5. Primary Conservation role: What is the primary conservation role of the program for the target taxon? (as defined in Q.1/Appendix 2) N.B. Taxon may have more than one role, but only score the primary role:

Ark	Score 20
Rescue/Supplementation	Score 14

Conservation Research:	Score 10
Farming:	Score 6
Conservation Education:	Score 0

c) Taxon Considerations

6. Extinction risk: What is the current IUCN Red List category for the taxon?

Critically Endangered	Score 20
Endangered	Score 16
Vulnerable	Score 12
Data Deficient*	Score 8
Near Threatened	Score 4
Least Concern	Score 0

*Taxon has been regionally or nationally recognized as ‘at risk’ despite data deficiency.

7. Phylogenetic uniqueness: e.g. is it a monotypic taxon?

Monotypic family	Score 10
Monotypic genus	Score 7
Species	Score 3
Sub-species	Score 0

8. Biological distinctiveness: e.g., does it exhibit a unique reproductive mode, unique physiology, etc., among the Class Amphibia?

Aspect of biology unique to species	Score 10
Aspect of biology shared with <6 other species	Score 5
No aspect of biology known to be exceptional	Score 0

9. Ecological significance: Does the taxon provide important ecosystem services?

Keystone species	Score 10
Principal component of ecosystem process	Score 7
Major component of ecosystem process	Score 3
Unknown	Score 0

10. Cultural importance: Does the taxon have a special human value within its natural range or in a wider global context? For example,as a national or regional symbol, in an historic context, or as an ‘iconic’ amphibian species.

Yes	Score 10

No	Score 0

11. Socio-economic importance: Does the taxon have an economic value within its natural range (e.g. food, traditional medicinal or tourism), or have the capacity to function as an ‘umbrella’ species?

Yes	Score 10
No	Score 0

12. Scientific importance: Is current or planned research, unrelated to the taxon’s biology and taxonomy, dependent upon the taxon, e.g. human medical or conservation-related studies.

Research dependent upon species	Score 10
Research dependant upon <6 species (incl. this taxon)	Score 5
Research not dependant upon species	Score 0