Recovery plan for the stream-dwelling rainforest frogs of the wet tropics biogeographic region of north-east Queensland 2000–2004

Prepared by the Northern Queensland Threatened Frogs Recovery Team

Nyctimystes dayi Lace-eyed tree frog

Queensland Government
Queensland Parks and Wildlife Service

Natural Heritage Trust
Helping Communities Helping Australia

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Prepared by: The Northern Queensland Threatened Frogs Recovery Team

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Contents

Summary

This document is a five-year multi-species plan for the recovery of seven endangered species of frogs in the Wet Tropics. A better understanding has been gained of the conservation biology of these species since the preparation of the 1995 draft of the plan, necessitating updating of the original plan.

Three species have not been located in their known habitats and an additional four have suffered significant declines. The causes of these dramatic population crashes are unknown. Consequently, ongoing monitoring of key sites and investigations into causes of decline continue to be essential activities for the recovery of these species at this time, and are integral to the development of effective threat abatement measures.

This recovery plan details the decline, possible threats and current and proposed research and management actions required in the second phase of recovery for each species. The estimated total cost of implementing this plan is $1.523 million and involves the co-operative efforts of community groups, researchers, land managers and funding agencies.

The plan will be reviewed by the recovery team and two independent reviewers at the end of its third year.

Overall objective

To significantly improve the conservation status and long term survival of each species through protection of existing populations, location of additional populations or expansion of existing populations into previously inhabited areas.

Specific objectives (2000-2004)

1. Establish the continued existence of populations of *T. acutirostris*, *T. rheophilus*, *L. lorica* and *L. nyakalensis*.
2. Secure the existing populations of all extant species.
3. Identify and reduce or eliminate the major threatening process(es).
4. Increase the number of stable populations of all extant species by expansion into their former ranges.
5. Ensure that frog conservation is incorporated into all appropriate land management decisions by raising the awareness of the declining frog problem within all levels of government and the general community.

Performance criteria (2000-2004)

1. Location of at least one self-sustaining population of *T. acutirostris*, *L. lorica* and *L. nyakalensis* by 2004 if they are extant.
2. If populations of *T. acutirostris*, *L. lorica* and *L. nyakalensis* are located by 2004, population densities are self-sustaining and remain at or increase above the levels at which originally detected.
3. Population densities of *L. nannotis*, *L. rheocola, N. dayi* and *T. rheophilus* remain at or increase above current levels at selected monitoring sites.
4. The major threatening process(s) are identified by 2004.
5. Strategies for the reduction of threatening processes are developed by 2004 and threat abatement measures are being implemented.
6. At least one additional self-sustaining population of *L. nannotis*, *L. rheocola* and *N. dayi* is established in part of their former range by 2004.
7. Communication between investigators, planners, land managers and the community is effective.

8. The public and local communities are well informed about species covered in this plan and have access to information.

Actions

1. Assess and monitor populations.
2. Investigate disease as a threatening factor.
3. Translocate and reintroduce species on an adaptive management basis.
4. Clarify the needs of the species.
5. Inform and involve the public in the recovery of species.
6. Ensure frog needs are considered in relevant land management decisions.

Introduction

Current Species Status

The seven species considered in this recovery plan are listed as endangered in the Queensland *Nature Conservation (Wildlife) Regulation 1994*, the *Action Plan for Australian Frogs* (Tyler 1997) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Table 1).

Table 1. *Conservation status of species*

Common Name	Scientific Name	Action Plan 1997	Qld NC(W) Reg 1994	EPBC Act 1999
Sharp-snouted Day Frog	*Taudactylus acutirostris*	EN	EN	EN
Northern Tinker Frog	*Taudactylus rheophilus*	EN	EN	EN
Armoured Mistfrog	*Litoria lorica*	EN	EN	EN
Waterfall Frog	*Litoria nannotis*	EN	EN	EN
Mountain Mistfrog	*Litoria nyakalensis*	EN	EN	EN
Common Mistfrog	*Litoria rheocola*	EN	EN	EN
Australian Lace-lid	*Nyctimystes dayi*	EN	EN	EN

All seven species have undergone range contractions, with dramatic population declines in most populations at altitudes greater than about 300m. Four species, *Taudactylus acutirostris, T. rheophilus, Litoria lorica*, and *L. nyakalensis* were only known from locations above this altitude. Populations of three of these species can no longer be located, with the fourth, *T. rheophilus*, only known from two small streams. The remaining three species, *L. nannotis*, *L. rheocola* and *Nyctimystes dayi*, appear to have stable populations at lower altitudes. Further information on individual species is contained in Appendix 2, Species Information**.**

Habitat Requirements and Limiting Factors

Historically the seven frogs were all restricted to perennial rainforest streams of the Wet Tropics biogeographic region. *L. nannotis, L. rheocola, N. dayi*, *L. nyakalensis*, and *T. acutirostris* were widely distributed within the region, the latter two species restricted to upland areas. *L. lorica* was confined to upland rainforest on Thornton Peak, and *T. rheophilus* has four disjunct populations in upland rainforest between Thornton Peak and Bellenden Ker.

Litoria lorica and *L. nannotis* were largely restricted to cascades and splash zones of fast-flowing streams. *L. nyakalensis*, *L. rheocola* and *N. dayi* use a variety of streamside vegetation and rock perches, usually near fast-flowing sections of stream. *T. acutirostris* and *T. rheophilus* are found among rocks, roots, or leaf litter in and beside streams.

Threatening Processes

(based on McDonald and Alford 1999*)*

The declining species are associated with rainforest streams in upland areas. Declines occurred suddenly for highly susceptible species which had close associations with streams. Despite considerable effort, the cause(s) of these declines have not been determined, although several hypotheses have been put forward for testing. The aim of this recovery plan is to explain these threatening processes.

Eight species in the Wet Tropics have experienced population declines (Richards *et al.* 1993, Laurance *et al.* 1996, Martin and McDonald 1995 and McDonald unpublished). Known declines in the Wet Tropics occurred between 1988 and late 1994 (Richards *et al.* 1993, Laurance *et al.* 1996). *T. acutirostris*, *L. lorica*, and *L. nyakalensis* have not been observed in substantial numbers since late 1994 (Ingram and McDonald 1993, McDonald, unpublished). The most recent reports are of a single individual of *T. acutirostris* at Slaty Creek in 1994 (L. Roberts, pers. comm.), a sub-adult at Big Tableland in January 1995 (McDonald unpublished), and a call of a single frog near Millaa Millaa in November 1996 (Marshall 1998). *T. rheophilus* has recently been relocated on the CarbineTableland and the Bellenden Ker Range with small populations reported in two creeks (Marshall 1998). Three species (*L. nannotis*, *L. rheocola* and *N. dayi*) have stable populations at lower altitudes (below approximately 400m).

In each case where population crashes were observed, tadpoles remained and metamorphosed after the adult population had crashed. This indicates that the causal factor did not affect this stage of the frog life cycle (Richards *et al.* 1993, Dennis and Mahony 1994, Laurance 1996, Laurance *et al.* 1996, Martin and McDonald 1995). Tadpoles removed from declining populations successfully metamorphosed, but all individuals died before attaining adult size (Dennis and Mahony 1994). It is possible that post-metamorphic mortality was more rapid in individuals in contact with stream water, but there is no statistical evidence to support this conclusion (Dennis and Mahony 1994).

At a monitored site at Big Tableland, four species of frog declined suddenly in late 1993. Another species at the site, *L. genimaculata*, decreased in numbers at the same time, but did not disappear entirely. Similar patterns have been reported for *L. pearsoniana*, *Adelotus brevis,* and *Litoria lesueurii* elsewhere in Queensland; there have been no total disappearances but populations have decreased in size (Ingram and McDonald 1993, Hines *et al.* 1999). Species which declined but did not disappear from sites are similar in having the largest number of eggs of all the declining species.

At O'Keefe Creek, Big Tableland (400m) species declined at the same time as those at the primary monitoring site at 620m in 1993. This site has been monitored every 4-6 weeks since mid 1992. At times since June 1995, *L. rheocola* and *N. dayi* (but not *T. acutirostris* and *L. nannotis*) have occasionally reappeared near the 400m site, but have not established resident populations. This site is immediately above a steep escarpment which forms a disjunction between upland and lowland populations. The lowland populations still persist. No colonisation of areas above the O'Keefe Creek site (400m) has occurred, which may indicate that the factor which caused the declines is still operating.

In December 1997, two *N. dayi* were heard calling below the primary monitoring site (620m) suggesting some individuals might be moving upstream, although tadpoles and eggs were not located. *N. dayi* is very seasonal in its appearance at streams and spends more time away from them than the other species (McDonald unpublished).

The habitat has remained intact with no clearing or logging of forests in the Wet Tropics World Heritage Area since 1988. Until recent population declines, many species had been present throughout their range even though the rainforest had been logged and mined in the past (McDonald 1992). However, this does not rule out more subtle, unmeasured environmental changes.

No obvious environmental changes were detected during monitoring at the times when declines occurred (Richards *et al*. 1993, McDonald unpublished). Water characteristics such

as pH, conductivity, water temperature, concentrations of metal ions and biocides, and dissolved oxygen, measured during monitoring of a large number of sites, did not differ significantly between locations which did and did not have declines. Rainfall has remained within expected ranges with no periods of prolonged drought. For periods with rainfall in the lower deciles, no declines were observed (Laurance 1996). Attempts to correlate environmental changes with declines depend strongly on information about when the environment affected populations. Recent evidence (Alford *et al.* 1999) suggests that environmental effects preceded some declines by 1-2 years, so many of these analyses may need to be repeated. However, data from other populations (Snout-vent length/weight ratios, McDonald 1990) failed to indicate any decline in health of monitored populations before declines occurred.

There has been repeated speculation that UV-B light has caused declines. However, this possibility appears to be unlikely in north Queensland as: all declining species in this area are found in rainforest with dense canopy cover, several species are active only nocturnally, several lay eggs under rocks (*L. genimaculata* is an exception) and tadpoles are still present when adults disappear (most UV-B hypotheses concern effects on aquatic stages, rather than adults; Blaustein *et al.* 1996). Declines have been rapid, occurring over 2-3 month periods (McDonald and Alford 1999). All of these observations make it unlikely that declines have resulted from direct effects of UV-B on populations. Most importantly it is now well established that there have been no significant changes in stratospheric ozone in the tropical areas which can be linked with UV-B increases as experienced in higher latitudes (Madronich and de Gruijl 1993, McPeters *et al.* 1996, Moise 1998.)

A hypothesis has been advanced suggesting that a virulent pathogen, possibly a virus or chytrid fungus, has decimated frog populations (Laurance *et al.* 1996, Berger *et al.* 1998). Circumstantial evidence of the effect of disease comes from observations of rapid declines, and the location of sick and dying animals. This evidence suggests that disease is the most likely cause of some declines (Dennis and Mahoney 1994, Laurance *et al.* 1996, Berger *et al.* 1998). However, there are alternative interpretations (Alford and Richards 1997) of all lines of evidence which suggest that a disease might be the sole cause of declines (Laurance *et al.* 1996). Recent evidence (Alford *et al.* 1997) suggests that the health of adults began to decline before populations crashed. However, decreases in body condition were not observed in *Rheobatrachus vitellinus* at Eungella before declines (McDonald 1990). All hypotheses clearly require further testing and refinement.

In a study of ecological guilds within Wet Tropics rainforest, frogs belonging to guilds characterised by low fecundity, a high degree of habitat specialisation and reproduction in fast flowing streams were the most likely to decline (Williams and Hero 1998). However, in other locations within Australia other species which have undergone declines do not have these guild characteristics (Mahoney 1999). These characteristics may only be a feature of declines in Wet Tropics frogs and not applicable to species in all areas where declines have occurred.

The research and documentation of declines have focused to date on rainforest species which do not appear to have suffered direct anthropogenic effects. Little systematic survey and monitoring effort have been devoted to species in other habitats. Monitoring around Townsville and in the Wet Tropics open forests suggests no population declines other than those obviously related to anthropogenic causes such as clearing of habitat.

Tenure and land management

Most of the distribution of all species occurs on protected land within the Wet Tropics World Heritage Area (WHA), Millstream National Park and Mt Baldy State Forest. Some habitat

with declining frogs is also located on unprotected private land, especially in the Daintree lowlands.

Within the World Heritage Area, land tenures are primarily national park, state forest and timber reserve (Table 2).

Table 2. *Land tenures in the Wet Tropics World Heritage Area and responsible agencies.*

Land Tenure	**Percentage of WTWHA**	**Responsible agency**
State forests/timber reserves	47.18	Department Natural Resources (DNR)
National parks	30.17	Queensland Parks and Wildlife Service
Unallocated State lands	7.88	Department Natural Resources
Commonwealth land	0.74	Department Defence, Telecommunications
Freehold	1.22	Individuals
Leases*	10.66	Department Natural Resources
Various dams and reserves, transport corridors, esplanades	2.15	State Government (DNR, QPWS, Queensland Transport, Department of Mines and Energy)
TOTAL	100.00	

* 'Leases' do not include leases on the other tenures shown in the table (e.g. state forests, timber reserves).

As can be seen from Table 2, the Wet Tropics World Heritage Area comprises a variety of land tenures. World Heritage listing does not affect land ownership, therefore State and local laws still apply and land management agencies are still responsible for issuing permits on land under their control on the basis of the responsible agency's own legislation.

As the World Heritage Area is characterised by a diversity of tenures, with levels of protection for natural values, it is desirable to have a system of land use controls which provide consistent and high level protection of the natural values for which the World Heritage Area was listed. This is achieved to a large extent by the *Wet Tropics Management Plan 1998* which is subordinate legislation to the *Wet Tropics World Heritage Protection and Management Act 1993* and is designed to provide a consistency to land management decisions with regards to allowed, prohibited or permitted activities across all tenures. Many activities which are not explicitly controlled by the Wet Tropics Management Plan are, however, still regulated under other legislation.

Compliance with the *Nature Conservation Act 1992* with regard to threatened wildlife on lands within the World Heritage Area rests with individual landholders. Government departments are bound by the Act to take account of the presence of threatened species in planning and implementing activities.

The Wet Tropics Management Authority

The Wet Tropics Management Authority (the Authority) is a policy, planning, co-ordinating, funding and monitoring body whose primary goal is to implement Australia's international duty to protect, conserve, present, rehabilitate and transmit to future generations the Wet Tropics of Queensland's World Heritage Area.

The *Wet Tropics World Heritage Protection and Management Act 1993* together with its subordinate statute, the *Wet Tropics Management Plan 1998* provide the legal framework

and mechanisms for management of the WHA, and for constraining potentially damaging activities. In general, the legislation regulates activities within the World Heritage Area that could potentially impact on World Heritage values including destruction or disturbance to native vegetation, watercourses or earth.

Key components of the *Wet Tropics Management Plan 1998* include:

1. Permit System
   The plan incorporates a permit system for consideration of applications for regulated activities. The most important consideration in assessing permit applications is the likely impact of the proposed activity on the integrity of the WHA.

2. Guidelines
   Section 62 of the plan allows the Authority to prepare guidelines relevant to decision making and may include guidelines for fauna conservation and water extraction. The Authority must have regard to the information in the guidelines when considering a permit application.

3. Zoning
   The plan divides the WHA into four management zones, based on a "distance from disturbance" model (Table 3). Part 3 of the plan describes those activities which are allowed, or subject to a permit, in the different zones.

4. Co-operative management agreements
   The plan provides for the Authority to enter into co-operative management agreements (CMAs), including joint management agreements with land holders, Aboriginal peoples particularly concerned with land in the WHA and other persons. CMAs provide for variation of standard controls prescribed under the plan.

Table 3. *Zoning Scheme Summary*

	Zone A	**Zone B**	**Zone C**	**Zone D**
Physical condition	Remote from disturbance and in a mostly natural state.	Not remote from disturbance but still in a mostly natural state.	Land on which or adjacent to which there is existing infrastructure needed for community services.	Land on which there is, or is proposed to be, significant developed facilities to enable visitors to appreciate and enjoy the Area.
Physical and social setting	A natural area remote from disturbances associated with modern technological society. Visitors may expect opportunities for solitude and self reliance without an obvious management presence.	A natural area, which may be undergoing recovery or rehabilitation towards its natural state. An area where a visitor may expect opportunities for solitude and self reliance with a limited management presence.	An area with some disturbance by activities associated with modern technological society. A visitor may expect low key opportunities for nature appreciation and social interaction in a natural setting. Management	A mostly natural area with visitor facilities integrated into the surrounding landscape. Visitors may expect many opportunities to appreciate and enjoy the Area in a natural setting. A management presence may be obvious.

	Zone A	Zone B	Zone C	Zone D
			presence may be obvious.	
Management intent	To protect land in its natural state. If land is disturbed, to remove disturbance and restore land to its natural state.	To restore land to its natural state wherever practical, by relocating disturbances to land where they will have less impact, or to rehabilitate the land over time where opportunities arise.	To accommodate community services. To ensure that the impact of activities associated with community services is managed to minimise the effect on the integrity of the Area.	To accommodate developed visitor facilities to enable visitors to appreciate and enjoy the Area. To ensure that the impact of visitor infrastructure is managed to minimise the effect on the integrity of the Area.
Total Area	461,620 ha	414,372 ha	18,259 ha	168 ha

The Authority has also prepared a policy document, *Protection Through Partnerships,* which outlines policies, guidelines and actions for achieving desired management outcomes thereby providing a framework for guiding management decisions made by the Authority in relation to:

- management processes,
- conservation practice and land protection,
- World Heritage presentation, visitor management and enjoyment,
- managing resource use.

Demand on the water resources of the Wet Tropics region is increasing as agricultural, urban and industrial needs expand in line with population growth and changing land-use practices. Increasing demand on water resources increases the threat to species considered in this recovery plan, and indeed to whole ecosystems, that are dependent on the provision of adequate stream flow.

Large dams and weirs are major landscape modifiers. They result in the direct loss of both terrestrial and aquatic habitats through drowning and act as barriers to the upstream or downstream movement of aquatic fauna. Such barriers may interfere with successful reproduction or recruitment of juveniles into adult habitats. Due to the reduction in the frequency of channel maintenance flows, streams below impoundments are not capable of maintaining their characteristic geometry and channels may become choked with sediments and aquatic plants. This process totally destroys or alters the habitats of species considered in this recovery plan.

There are three dams in the WHA, Copperlode Falls Dam, Paluma Dam and Koombooloomba Dam. Tinaroo Dam is outside the WHA. The first two supply the urban water requirements of the Cairns and Townsville region respectively while Koombooloomba provides a water source for hydroelectric power generation. Tinaroo Dam is primarily associated with agricultural irrigation and recreation. Eight local authorities have 22 water intakes within the WHA. Table 4 lists the community water supply infrastructure located within the WHA. Many of these water extraction sites are within the known habitat of species

considered in this recovery plan. However, the potential impact of existing or proposed water harvesting on these species has not been examined.

Table 4. *A list of existing community water supply infrastructure within the WHA*

Atherton Shire Council	Barron Weir
Douglas Shire Council	Rex Creek Intake
	Martin Creek (Daintree) Intake
	Little Falls Creek (Whyanbeel) Intake
Mareeba Shire Council	Hunter Creek (Mt Molloy) Intake
Cairns City Council	Copperlode Dam
	Stoney Creek Intake
	Bessie Point Intake
	Freshwater Intake
	Behana Gorge Intake
	Fishery Falls Intake
	Bellenden Ker (Junction Creek) Intake
	Frenchmans Creek (Babinda) Intake
	Bartle Frere/Woopen Creek Intake
	Bramston Beach Minor Intake
	Bramston Beach Major Intake
Herberton Shire Council	Herberton Intake (Wild River)
Johnstone Shire Council	Nyleta Intake
	Jurs Creek Intake
Cardwell Shire Council	Meunga Creek (Cardwell) Intake
	Boulder Creek (rural) Intake
	Bulgun Creek (Tully) Intake
Thuringowa Shire Council	Paluma – Crystal Creek
	Paluma Dam
Stanwell Power Company	Kuranda Weir
	Koombooloomba Dam/Kereeya Power Station

Wet Tropics Permits must be obtained for any new community water infrastructure development proposals or changes to existing management regimes within the WHA including upgrades to any existing facilities or changes to extraction regimes. Assessment of any proposal will now consider frogs as a major, key attribute of interest in the assessment of any permit condition or in the terms of reference for any environmental impact study relating to interference with a watercourse.

Department of Defence

Four sites in WTWHA are regularly used for military training exercises - Cowley Beach (4769ha), Battle School near Tully (1731ha), special lease State Forest (23,473ha), and Townsville Field Training Area - special lease State Forest (11,600ha). The 41,573ha affected by Department of Defence activities include 4.6 percent of the WHA. In addition, specific activities are undertaken in other parts of the WHA based on agreements with land managers (e.g. state forests under a permit to traverse, and national parks with conditional approval).

Defence activities are bound by the *Environment Protection and Biodiversity Conservation Act 1999*. The Department of Defence has in place standing orders for a code of behaviour by defence personnel which cover potential impacts on the environment by defence activities. Currently, the Defence Department is conducting surveys of threatened frogs on lands used by defence personnel and will determine a code of conduct which addresses likely impacts on threatened frogs.

Telecommunication industry

There are several telecommunication towers, radar facilities and associated infrastructures in the Wet Tropics which can potentially impact on streams with frogs. These infrastructures are owned mainly by Commonwealth agencies such as Telecom, the Civil Aviation Authority, and the National Transmission Agency, with leases over national park and state forest. Private telecommunications are sometimes associated with these facilities.

Environmental Water Flows

Three dams and 27 weirs operate as major surface water extraction sites within the habit of species considered in this recovery plan. The potential impact of existing or proposed water extraction on these species has not been examined.

Queensland's statute law relating to the allocation and management of water is primarily contained in the *Water Resources Act 1989*, which is administered by the Department of Natural Resources.

The *Water Resources Act 1989* does not explicitly provide for allocation of water on an ecologically sustainable basis.

A new water allocation and management system is being established. The new system provides a framework within which State-owned, semi-government and private water development can operate equally to provide for ecologically sustainable development, among other things. The new system will progressively replace the existing licensing system with Water Allocation and Management Plans (WAMPs). WAMPs are currently under way in the Barron and Burdekin River basins, including Freshwater Creek surface water extraction site, within areas inhabited by species considered in this recovery plan.

Of primary concern is the long-term sustainability of water and its potential impact on the existing populations of species considered in this recovery plan. Potential impacts are related to alteration of the baseflow regime and periods of extended drought which may affect the composition and distribution of aquatic habitats of frogs, their food sources, and increase water or predation stress (Bartareau 1999). In cases where an existing or proposed water demand exceeds the historical Order-in-Council entitlement, a new authority to water may be required under the provisions of the *Water Resources Act 1989*. Further information is required to ensure ecologically sustainable water allocation and management at sites inhabited by species considered in this recovery plan.

Consultation with affected interests and Social and Economic Impacts

Appropriate consultation with and involvement of interested parties has been provided for in the development of this plan and through mechanisms established by the Northern Queensland Threatened Frogs Recovery Team. The recovery process outlined is unlikely to have any significant adverse social or economic impact.

Estimated Cost of Recovery 2000–2004:

Action #	Action Description	Cost Estimates years 1-5					Total
		1	**2**	**3**	**4**	**5**	
1	Population monitoring	$69,000	$69,000	$69,000	$69,000	$69,000	$345,000
2	Disease investigations	$142,000	$160,000	$160,000			$462,000
3	Translocation investigations	$64,000					$64,000
4	Needs of species	$59,000	$59,000	$59,000			$177,000
5	Public information and participation	$20,000	$20,000	$20,000	$20,000	$20,000	$100,000
6	Land management decisions	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Total		$429,000	$383,000	$383,000	$164,000	$164,000	$1,523,000

Biodiversity benefits

Increased information on the ecology, habitat usage, and threatening processes that determine the distribution and abundance of the stream-dwelling rainforest frogs of the Wet Tropics biogeographic region will assist in understanding the declines of other amphibians in Australia and overseas. Amphibians are exposed to both terrestrial and aquatic environments during their life cycles, have highly permeable skins, and are regarded as important indicators of environmental change. The rainforest stream-dwelling frogs of north Queensland are an important component of the rainforest stream trophic system, and fluctuations in their numbers may considerably influence the abundance and distribution of their predators and food sources. Threatened fish are known in catchments with declining frogs. Little information is available for other potentially threatened stream fauna. Understanding the causes of declines in these amphibian populations may identify changes to catchment ecosystems, and will contribute to the development of catchment management plans for the Wet Tropics biogeographic region.

Recovery objectives

Overall objective

To improve significantly the conservation status and long term survival of each species through protection of existing populations, location of additional populations, or expansion of existing populations into areas previously inhabited.

Specific objectives (2000–2004)

1. Establish the continued existence of populations of *T. acutirostris*, *T. rheophilus*, *L. lorica* and *L. nyakalensis*.
2. Secure the existing populations of all extant species.
3. Identify and reduce or eliminate the major threatening process(es).
4. Increase the number of stable populations of all extant species by expansion into their former ranges.
5. Ensure that frog conservation is incorporated into all appropriate land management decisions by raising the awareness of the declining frog problem within all levels of government and the general community.

Performance criteria (2000–2004)

The criteria for achieving these objectives are:

1. Location of at least one self-sustaining population of *T. acutirostris*, *L. lorica* and *L. nyakalensis* by 2004 if they are extant.
2. If populations of *T. acutirostris*, *L. lorica* and *L. nyakalensis* are located by 2004, population densities are self-sustaining and remain at or increase above the levels at which originally detected.
3. Population densities of *L. nannotis*, *L. rheocola, N. dayi* and *T. rheophilus* remain at or increase above current levels at selected monitoring sites.
4. The major threatening process(s) are identified by 2004.
5. Strategies for the reduction of threatening processes are developed by 2004 and threat abatement measures are being implemented.
6. At least one additional self-sustaining population of *L. nannotis*, *L. rheocola* and *N. dayi* is established in part of their former range by 2004.
7. Communication between investigators, planners, land managers and the community is effective.
8. The public and local communities are well informed about species covered in this plan and have access to information.

Recovery actions

The following actions are aimed at recovery of threatened frogs in the Wet Tropics biogeographic region.

1. Assess and monitor populations.
2. Investigate disease as a threatening factor.
3. Translocate and reintroduce species on an adaptive management basis.
4. Clarify the needs of the species.
5. Inform and involve the public in the recovery of species.
6. Ensure frog needs are considered in relevant land management decisions.

The Northern Queensland Threatened Frogs Recovery Team (current membership is shown in Appendix 1) is responsible for the implementation and evaluation of this recovery plan. While the following actions relate principally to activity over the five-year period 2000–2004, this plan continues work from the 1995 draft. Progress on the actions identified in this plan will be reviewed each year, and copies of all reports arising from implementation of the actions should be forwarded to the recovery team to facilitate this process. Where necessary the recovery plan will be modified by the recovery team to incorporate new information. The recovery plan will be re-evaluated again by December 2002, before writing a new plan for the next phase of the recovery program.

Action 1. Assess and monitor populations

Monitoring will be conducted at different levels of intensity:

- intensive monitoring conducted frequently and at a small number of sites;
- historical monitoring at a large number of sites with a history of the species present but visited twice a year; and
- extensive surveying searching for extant populations of frogs in suitable habitat.

1.1 Long-term, intensive population monitoring

Long-term population monitoring commenced in 1992. During 2000-2004, long-term monitoring of the remaining populations will be continued to assess their continuing viability and determine if relative population densities remain within the current range. This will rely on regular mark-recapture surveys and tadpole searches along fixed transects, supplemented by remote recording devices which are capable of detecting the key species *L. rheocola* and *T. acutirostris*. Frequency of sampling at survey sites will be determined by the recovery team, and periodically reviewed. Two sites, Tully Valley and Big Tableland are visited monthly.

1.2 Monitoring population recovery at historical sites (commenced 1992)

During 2000–2004, monitoring will be conducted twice yearly along transects in streams at historical collection sites during the peak breeding season in order to detect any re-establishment of populations of the endangered frogs within their former range. These surveys will be presence-absence surveys, as well as transect counts along streams at a range of altitudes and latitudes. Should recovering populations be discovered, these will then enter the more detailed long-term monitoring. Where possible, more regular monitoring will be undertaken by park staff and community volunteers, even if this only involves maintaining recording devices at select sites. Thus, park staff could tend recorders near regularly visited facilities, enabling a greater area to be monitored for a limited increase in funds - e.g. the camping area at Palmerston National Park.

The historical monitoring program will be linked with other Natural Heritage Trust funded projects such as WATERWATCH. Linking will expand the environmental features being measured and enable other volunteers to participate in both WATERWATCH and frog monitoring.

1.3 Extensive surveys of suitable habitat

Extensive surveys of suitable habitat commenced in 1992. Areas of potentially suitable habitat have been identified throughout the Wet Tropics. Many of these sites are within areas where historical monitoring sites have been established. Working in conjunction with volunteers including WATERWATCH, Tablelands Frog Club, Cape York Herpetological Society and the Wet Tropics Volunteer program, surveys will be conducted along streams during the peak breeding season to try to detect unreported frog populations. Surveys will be conducted annually according to availability of volunteers. The surveys would be conducted in conjunction with action 1.2. Initially this should concentrate on sites with the likelihood of detection of populations including private land. Should a population be located on private land every effort will be made to encourage landholders to conserve the rainforest stream habitat and adopt best practice land management procedures.

Costing Action 1

2000	2001	2002	2003	2004
$69,000	$69,000	$69,000	$69,000	$69,000

Contributions of 'in kind' from community participation have not been included in the assessments.

Action 2. Investigate the role of disease as threatening factor

Studies in progress since 1993 have shown that threatened species of amphibians in Australia die from a disease caused by a newly discovered infectious agent, the amphibian chytrid fungus. This fungus appears to be responsible for epidemic disease in Australian amphibians and appears highly likely to be the cause of the declines seen in pristine populations of stream-dwelling frogs in Australia (Berger *et al.* 1998). Current epidemiological evidence suggests that the amphibian chytrid fungus is a highly virulent microorganism that swept through frog populations in eastern Australia in an epidemic wave, and now appears to have become endemic in these areas. The amphibian chytrid fungus is a previously undescribed agent and as yet the interactions between frogs, the fungus and environmental factors are poorly understood. To assist in the conservation of threatened species of frogs a much more comprehensive understanding of this agent, and other significant disease agents, is required.

A comprehensive program to address the risks of disease in amphibians has the following elements:

1. Generation of scientific data to underpin policy and management (sections 2.1, 2.2, 2.3, 2.4, 2.5, 2.6).
2. Development of protocols to stop and prevent spread of infectious agents (section 2.6).
3. Dissemination of accurate and relevant information on diseases of threatened frogs (section 2.7).

In these actions, work is concentrated on the amphibian chytrid fungus while encouraging continued background monitoring and searching for other agents affecting threatened amphibians.

2.1 Examination of ill and dead amphibians for disease and its causative agents

Maintain the current Australia-wide system for pathological examination of ill and dead amphibians by the Amphibian Disease Group located at the Australian Animal Health Laboratory (AAHL) in Geelong and James Cook University in Townsville. Dead or ill frogs are examined by amphibian pathologists and routine tests are performed to determine cause of death. If the case or cause is considered significant, more sophisticated studies are performed including electron microscopy, viral culture, immunodiagnostic tests, and molecular biological studies. The system will support work by frog ecologists and husbandry programs for threatened species. Frog researchers monitoring threatened species can submit any ill and dead specimens for diagnosis, e.g. investigators undertaking the wet tropics translocation projects. Ill and dead frogs will be prioritised according to a number of criteria to avoid time and effort being spent on non-productive investigations. The descending order of priority will be: (i) wild and captive threatened frogs; (ii) wild frogs from established monitoring or translocation experiments; (iii) other wild frogs; and (iv) captive frogs. The system will provide for the training of veterinarians in selected locations to enable them to perform adequate post mortems on dead and ill frogs in that region, prior to specimens being forwarded to amphibian disease experts in AAHL and Townsville.

The system will provide more comprehensive knowledge about the pathogens of Australian amphibians and a better understanding of the role played by diseases in the population dynamics of threatened species, and in particular that caused by the amphibian chytrid fungus. The current network was fully established in 1999 and should be maintained at least until 2003.

2.2 Develop sensitive diagnostic tools

Standard protocols have been developed to detect the chytrid fungus in fresh and fixed amphibian specimens. Further studies will investigate other techniques, notably tissue culture; molecular biology and immunological techniques, to determine which techniques have the highest sensitivity and specificity.

2.3 Understanding the factors determining pathogenicity

Investigate the interaction between the amphibian chytrid fungus and environmental variables to determine why mortality has been greater in threatened frogs at higher altitude, and how the chytrid fungus, host and environment interact.

2.3.1 Experimental studies in the laboratory investigating environmental variables

Initial work will be performed in the laboratory and will involve a complex series of experiments to firstly, establish a reliable model for infection and production of disease, secondly, to evaluate the effect of individual environmental variables on pathogenicity, and thirdly, to evaluate the effect of multiple variables.

2.3.2 Field studies on pathogenicity

Once the interaction between chytrid fungus, frogs and environmental variables is better understood, field studies under natural conditions should be initiated. This will be completed in 2002.

2.3.3 Effect of species and genotype on pathogenicity

Epidemiological evidence suggests that the threatened frog species are more susceptible to death from the amphibian chytrid fungus than other frog species. Once an experimental model for pathogenicity has been established, a comparative study will be done to compare the susceptibility of selected frog species to infection and disease.

Epidemiological evidence suggests that once a naive population of frogs has been exposed to the amphibian chytrid fungus, mortality rate is subsequently lower. If populations of threatened frogs can be selected for resistance, this adapatation may be used to allow re-establishment of threatened species into environments where the chytrid is endemic. For several species, comparative infection trials can be carried out to investigate the effect of a population's previous exposure to the fungus on pathogenicity of the fungus, to look for a selection trend for resistance to the fungus.

2.4 Examining frogs used to determine FA index for the amphibian chytrid

Alford *et al.* (1997) showed that frog populations were stressed as measured by a fluctuating asymmetry index (FA) for about 2 years prior to declines in the Paluma area. Concurrent studies of FA indices and chytrid prevalence on historical and current populations will clarify the relationship between FA and the occurrence of the amphibian chytrid.

2.5 Surveys of museum specimens for chytrid and other agents

2.5.1 Surveys of museum specimens to investigate the historical occurrence of chytrid

The amphibian chytrid fungus appears to have been newly introduced into Australia. To investigate this hypothesis pieces of skin and toes from collected and preserved specimens of frogs from key areas will be examined using the standard protocol to provide chronological and geographic information about "when" and "where" the fungus first occurred. A survey of Queensland species will be completed by late 2001. Surveys of museum specimens of other Australian threatened amphibians will continue until 2001.

2.5.2 Surveys of surviving populations of endangered frogs to determine prevalence of chytrid

In conjunction with frog ecologists monitoring populations of threatened frogs, the prevalence of the amphibian chytrid fungus will be determined. This will enable a better understanding of the dynamics between frogs, chytrid and the natural environment. It will also provide a guide to possible low prevalence collection and release sites if assisted recolonisation programs are initiated. Prevalence data will also provide a valuable baseline with which to compare the historical records obtained in section 2.5.1.

2.6 Protocols to prevent spread of pathogens to threatened amphibians by human activity

2.6.1 Protocols to prevent transmission of pathogens between populations

Protocols to prevent transmission of pathogens between populations of frogs have already been established, extrapolating from data on ranaviruses, a genus of environmentally durable pathogens of amphibians. The current protocols adopt worse case strategies, and less rigorous protocols may prevent transmission of the amphibian chytrid, a much less environmentally durable organism than ranavirus. Experimental studies will be used to provide a factual basis for revision of protocols if necessary.

2.6.2 Protocols for detection of the amphibian chytrid in culture facilities

Captive breeding programs are already playing a significant role in the management of several species of threatened frogs in temperate Australia. Protocols are needed to ensure that pathogens are kept out of these facilities; and the pathogens are not disseminated when captive bred frogs are released. Separate protocols will be developed for tadpoles; and terrestrial stages.

2.6.2.1 Protocols to stop transmission within premises

Protocols will be developed, based where possible on scientific testing, to prevent chytrid fungus from entering and spreading within amphibian facilities.

2.6.2.2 Protocols to clear infected premises
Techniques to eradicate the amphibian fungus from infected batches of tadpoles and frogs will be developed.

2.6.2.3 Protocols for certifying batches of frogs as free of chytrids
Chytrids cause high mortality in frogs held in captivity. Protocols will also become important on an international level if trade in amphibians between nations is restricted as a result of the chytrid status of the exporting nation. Based on experimental work, protocols for certifying amphibians free of chytrid fungus will be developed.

2.6.2.4 Protocols for reintroduction of threatened frog species from husbandry facilities to the wild
If captive breeding and release is used for particular threatened species of frogs, it is undesirable to release animals infected with chytrid fungus into the wild. Protocols are required to certify these animals free of chytrids before release. Protocols for the introduction of endangered species from culture facilities to the wild should be supported by experimental results. Initial protocols were completed in July 1999.

2.7 Information dissemination
The Amphibian Disease Home Page (http://www.jcu.edu.au/dept/PHTM/frogs.ampdis.htm) currently makes basic data available on the World Wide Web. This will be expanded to become the major site on amphibian diseases on the Internet. This will be comprehensive, will focus on Australian frogs, will provide objective scientific data, and will suggest protocols for investigating ill frogs, handling frogs, preventing spread, and for data collection. All data on the site is freely available, and some data of general relevance could be mirrored on other sites such as the EPA frog site, and Environment Australia's threatened species site.

Costing Action 2

2000	2001	2002	2003	2004
$142,000	160,000	160,000		

Contributions of ‘in kind’ from community participation have not been included in the assessments.

Action 3. Translocate and reintroduce species on an adaptive management basis.

3.1 Development of husbandry techniques
During the period 1998 to 2001, husbandry techniques for stream-dwelling amphibians will be developed in the field, with the aim of establishing stable breeding populations in captivity. Initially, populations of *Litoria rheocola* will be established in enclosures adjacent to lowland streams where this species currently occurs. After this has been achieved, captive populations of *Litoria nannotis* and *Nyctimystes dayi* may also be established. Enclosed populations will require intensive monitoring for extended periods. The knowledge acquired during the development of husbandry techniques for these species can provide baseline information for the husbandry requirements of other species that occupy similar habitats. This could prove to be invaluable should similar declines occur in the future.

Establishing populations in replicated enclosures both connected to and detached from streams will verify that animals can survive in captive environments away from their natural

stream water. These replicates will also serve as controls for the translocation experiments outlined below. The use of two water sources rather than one will also protect each captive population from being totally eliminated through any deterioration of stream water quality. If these populations are established successfully, they will then act as a source of captive-bred animals for translocation experiments and for use in amphibian breeding programs at some recognised zoological institutions around Australia. For participation in these breeding programs, preference will be given to institutions that have proven experience in amphibian husbandry techniques.

Small numbers of wild animals will also be provided periodically for these participating institutions, so that appropriate husbandry techniques for these species may continue to be improved, and so that the genetic diversity in each captive population is maintained. Establishing populations of these species outside their known distribution range (i.e., in zoological institutions in other regions of Australia) should place some breeding populations beyond the influence of the factor(s) which caused recent declines. This will provide a precautionary measure against the extinction of these species if they suffer further declines in the future. Release of captive-bred animals into the wild is not envisaged until the cause of the recent population declines has been identified, and its effects have been reduced.

3.2 Translocation Trials

From 1998 to 2001, the cause(s) of local extinctions and declines of populations of stream-dwelling frogs will be investigated by experimental translocation of animals from lowland sites to formerly occupied upland sites. Translocated populations will be confined to large enclosures because of the poor success rates of other release programs (Dodd and Seigel 1991), and the lack of understanding of the cause(s) of population declines in Queensland and of the ecological requirements of declining species. They will not be released into the wild immediately.

A factorial design of replicated treatments will be established, so that animals relocated to enclosures at upland and lowland sites will be placed in contact with natural stream or rain water. Treatments will include the effects of different altitudes and contact with stream water or rainwater.

A pilot study will first be conducted to determine suitable enclosure designs and husbandry techniques for *L. rheocola*, and animals in enclosures at lowland sites will verify the suitability of these factors during the experimental translocation. Adults and tadpoles of *L. rheocola* will be introduced simultaneously to all enclosures, and the health and survival of animals will be monitored for an extended period. If animals in enclosures with stream water at high altitudes become ill or die in the manner described by Dennis and Mahony (1994), then autopsies will be conducted on these animals to determine the cause(s) of their illness or death. Later, a sample of affected animals from all treatments will be moved to each of the three other treatments and then closely monitored for signs of recovery.

Recovery of animals would suggest that population declines were influenced by an environmental factor at the affected site. The relative extent of recovery of animals in the different treatments would indicate whether this factor is associated with altitude, stream water or both. These translocation investigations will also provide important material for the disease investigations outlined under action 3.2, and will proceed in conjunction with the husbandry experiments outlined under action 5.1.

3.3 Repatriation to formerly occupied sites

3.3.1 Repatriate populations

Animals surviving from actions 3.1 and 3.2 will be released into the wild at sites from which those species disappeared during the declines. In this experiment an attempt will be made to re-establish wild populations at areas within each species' former range to facilitate a widespread recovery at upland sites by all extant affected species.

If the cause of the population declines is identified under any of the actions 3.1-3.3, and corrective measures have been satisfactorily completed, then animals surviving from actions 3.1 and 3.2 may be released at sites above 300m from which those species disappeared during the declines. The purpose of the releases would be to re-establish wild populations within their former range and facilitate a widespread recovery at upland sites by all species. Consideration of the available genetic and ecological information on the extant and extinct populations is necessary to ensure that all repatriated animals are from an appropriate evolutionary lineage. This will also help in determining an appropriate number of animals to release at each site.

3.3.2 Monitor progress of repatriated populations

Intensive monitoring of the progress of each repatriated population will be required for an extended period. The stability and growth of repatriated populations can be compared with naturally occurring populations that have been intensively monitored since the declines. If it can be shown after three years that stable breeding populations have been established in the wild, then further repatriations from lowland populations and from captive breeding populations can be undertaken.

Costing Action 3

2000	2001	2002	2003	2004
$64,000				

Contributions of 'in kind' from community participation have not been included in the assessments.

Action 4. Clarify the needs of species

4.1 Population dynamics

There is very little information available on the magnitude of normal population fluctuations for species of stream-dwelling frogs in the Wet Tropics biogeographic region. To determine if the observed population declines are a natural occurrence of unusual magnitude, or are the result of some human interference, it is necessary to conduct further studies on the population dynamics of declining and non-declining species. Factors that may influence population fluctuations under natural conditions will be recorded and quantified. This will allow managers to determine the impact of various natural resource uses on the remaining populations and assist in the refinement of husbandry techniques required for captive breeding and translocation studies.

4.2 Movement patterns and habitat use

The influence of habitat variables on abundance, distribution and habitat usage of adult and larval stages will be investigated. This research is necessary to determine why some species of stream-dwelling frogs have experienced population declines, and others have not. This study will require further development and implementation of radio and spool tracking techniques to examine movement patterns and habitat usage, especially when distant from streams. Due to limitations of current radio tracking technology, this aspect of the study will be restricted to larger frogs. These include *M. schevilli*, *L. genimaculata*, *L. nannotis*, *L.*

xanthomera, and *N. dayi*. Improving our knowledge of the habitat utilisation of these species will also aid in the identification of survey sites, and the development of better husbandry techniques for Action 3 and help determine the exposure of each species to potential threats.

4.3 Diet

Compare the diet of declining and non-declining species to test if the energy source of the two groups differs. This would rely on faecal analysis of adult frogs, although stomach flushing and dissection of previously fixed material may also be used.

4.4 Analyse and publish ecological data already collected

A substantial amount of ecological data is available from research done through James Cook University and the CRC for Tropical Rain Forest Ecology and Management. However, these data have not been analysed and published so are not available for use by the recovery team or land managers. This information will be of high value in the many areas including continuing investigations of frog declines; assisting captive husbandry techniques for translocation experiments; re-introductions and captive breeding; use of best practise management by land managers; and development of vegetation clearing guidelines (see also section 5.3).

Costing Action 4

2000	2001	2002	2003	2004:
$59,000	$59,000	$59,000		

Contributions of 'in kind' from community participation have not been included in the assessments.

Action 5. Inform and involve the public in the recovery of species

5.1 Disseminate information

A brochure containing information on the declining frogs and the recovery plan was produced and distributed in April 1999.

Workshops will be conducted to ensure that management planners recognise the importance of the frog fauna, and their population declines. Through these workshops, park staff will be encouraged to implement and run regular survey programs to monitor endangered frogs on parks.

The implication of population declines for frog conservation and the steps that are being taken to reverse this trend will be publicised through the local, state and national media. Publicity will include the publication of articles in the popular press (i.e. Nature Australia, Wildlife Australia, GEO, etc). This will increase community awareness of the importance of frogs in general, and the population decline of these species in particular.

5.2 Community participation

Local community participation in the monitoring of frog populations will be encouraged. Programs such as NatureSearch and the 'Missing Frog Search' organised by J-M Hero of James Cook University provide a pool of trained community volunteers able to assist scientific officers in the field. This will aid the dissemination of information and significantly increase the number of people capable of identifying the species of concern, increasing the likelihood of additional populations being located.

The current monitoring program has already recruited volunteers from a variety of local community groups including the Tablelands Frog Club, Cape York Herpetological Society and WATERWATCH. This has been achieved through holding monitoring workshops, publicising the monitoring program through club and society newsletters, and through articles in the local press (newspaper and radio).

For all volunteers, a handbook has been produced which introduces the project, details health and safety issues and provides information on the frog species which are being monitored. This publication will be updated if and when appropriate.

It is envisaged that the close relationship with local groups will continue through encouraging regular contact between those staff involved in the frog monitoring program and group members. Activities such as guided walks and identification workshops will be held as necessary to meet the needs of volunteers and to highlight the issue of frog declines to the wider community.

5.3 Liase with and involve land-owners

Private land owners

Should significant populations of the declining species be discovered on private lands (Action 1), every effort should be made to encourage the land-owners to actively support the recommendations in this recovery plan. This would include liaising with them over all research and management actions for populations on private land. Publications and other relevant material and information on the results of monitoring would also be provided to them. Where possible, landowners will be involved in the monitoring process. Ultimately, landowners may be encouraged to take out voluntary conservation agreements to protect habitat containing endangered frog species.

Government land managers

Consultation with all relevant managers of crown lands is required in order to develop appropriate ways of using natural resources while protecting populations of the endangered frogs. Environmental impact assessments should be conducted before the approval of any activity that may adversely affect populations of the endangered frogs. Of particular importance is the provision of guidance regarding water extraction, waste disposal, habitat disturbance and siltation. For example, it is envisaged that the recovery team will provide expert advice on the impact of specific water allocation management proposals (WAMPS).

5.4 Ensure effective recovery team function

To facilitate the participation of individuals from universities and non-government organisations in recovery team meetings, an allowance will be made for their travel costs.

Costing Action 5

2000	2001	2002	2003	2004
$20,000	$20,000	$20,000	$20,000	$20,000

Contributions of ‘in kind’ from community participation have not been included in the assessments.

Action 6. Ensure frog needs are considered in relevant land management decisions

The recovery team will undertake the following management actions through provision of information and advice on potential impacts on threatened frog species in the Wet Tropics.

- Seek formal adoption of this plan by Queensland and Commonwealth Governments by the end of 2000.

- Provide input to Wet Tropics Management Authority environmental codes of practice with land management agencies (fire, water infrastructure, transport and public utility, mining and quarrying, defence and grazing).

- Provide advice on DNR water management issues and programs including:
  - domestic extraction of water,
  - water extraction policy/usage through the Water Allocation Management Program,
  - impact of ground water pumping,
  - impact of water extraction on water flow, and
  - in-stream riparian impacts including small perennial streams and seasonal streams.

- Collate information on water abstraction sites in the Wet Tropics biogeographic region to determine potential impacts on threatened frogs. This project will be of benefit to land managers, planners and local councils by providing a useful database.

- Provide disease field protocols for researchers and land managers (handling, diagnostic keys, etc.) and advice to government on disease management and control.

- Provide input on the development of CMAs with private landholders and government agencies in the Wet Tropics World Heritage Area.

- Provide input into the impacts of electricity and transport corridors and roads especially in the Wet Tropics World Heritage Area.

- Provide input into the impacts of the telecommunication industry on frog communities.

- Provide input into the impact of tourist / visitor nodes, commercial activities and recreational plans on potential threats to threatened frog populations.

- Provide advice and information on the use of herbicides / biocides against pests and diseases in areas with threatened frogs.

- Provide information to participants in the environmental impact assessment process required through the *Integrated Planning Act 1998*.

Costing Action 6

2000	2001	2002	2003	2004
$75,000	$75,000	$75,000	$75,000	75,000

Contributions of ‘in kind’ from community participation have not been included in the assessments.

Implementation schedule

Action #	Action description	Priority	Feasi-bility	Responsible party	Cost estimates years 1-5					Total
					1	**2**	**3**	**4**	**5**	
1	Population monitoring	1	100%	QPWS	$69,000	$69,000	$69,000	$69,000	$69,000	$345,000
2	Disease investigations	1	80%	JCU / Rainforest CRC, AAHL	$142,000	$160,000	$160,000			$462,000
3	Translocation investigations	1	70%	QPWS	$64,000					$64,000
4	Needs of species	2	70%	QPWS, JCU / Rainforest CRC	$59,000	$59,000	$59,000			$177,000
5	Public information and participation	1	100%	QPWS, NGO	$20,000	$20,000	$20,000	$20,000	$20,000	$100,000
6	Land management decisions	1	100%	QPWS, NGO, DNR	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Total cost per year					$429,000	$383,000	$383,000	$164,000	$164,000	$1,523,000

Contributions of ‘in kind’ from community participation have not been included in the assessments.

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References

Alford, R.A. and Richards, S.J. 1997. Lack of evidence for endemic disease as an agent in catastrophic decline in Australian rainforest frogs. *Conservation Biology* 11:1026-1029.

Alford, R. A., Bradfield, K.S., Richards, S.J. 1997. Increasing fluctuating asymmetry precedes frog population declines. (Abstract) *Declining amphibian symposium, Third World Congress of Herpetology.* Prague.

Alford, R.A., Bradfield, K.S., Richards, S.J. 1999. Measuring and analysing developmental instability as a tool for monitoring frog populations. Pp 34-43 in Campbell, A (ed), *Declines and disappearances of Australian frogs.* Environment Australia, Department of the Environment and Heritage, Canberra. 234 pp.

Andersson, L.G. 1916. Results of Dr E. Mjoberg's Swedish scientific expeditions to Australia. 1910-1913. IX. Batrachians from Queensland. *K. Svenska. Vatensk. Akad. Handl*. 52: 1-20.

ANZECC, 1999. *List of Endangered Vertebrate Fauna*. ANPWS, Canberra.

Bartareau, T. 1999. *Appraisal of Environmental Flow Considerations for Proposed Yield Analysis of Existing Rex Creek Water Supply*. Department of Natural Resources, Engineering Services, State Water Projects. Draft November 1999.

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

Blaustein, A.R., Hoffman, P.D., Hokit, D.G., Kiesecker, J.M., Walls, S.C. and Hays, J.B. 1996. UV repair and resistence to solar UV_B in amphibian eggs: A link to population declines? *Proceedings of the National Academy of Science USA* 91: 1791-1795.

Cogger, H.G. 2000. *Reptiles and Amphibians of Australia*. Reed New Holland, Sydney.

Covacevich, J.A. and McDonald, K.R. 1991. Frogs and Reptiles of tropical and subtropical eastern Australian rainforest: Distribution patterns and conservation. Pp 281-309 in Werren, G. L. and Kershaw, A. P. (eds), *The rainforest legacy. Australian National Rainforests Study Vol.2: flora and fauna of the rainforests*. Special Australian Heritage Publication Series 7. Australian Government Publishing Service, Canberra.

Covacevich, J.A. and McDonald, K.R. 1993. Distribution and conservation of frogs and reptiles of Queensland rainforests. *Memoirs of the Queensland Museum* 34:189-199.

Czechura, G.V., Ingram, G.J. and Liem, D.S. 1987. The genus *Nyctimystes* (Anura: Hylidae) in Australia. *Records of the Australian Museum* 39: 333-338.

Davies, M. and McDonald, K.R. 1979. A new species of stream-dwelling hylid frog from northern Queensland. *Transactions of the Royal Society of South Australia* 103: 169-176.

Davies, M. and Richards, S.J. 1990. Developmental biology of the Australian hylid frog *Nyctimystes dayi* (Günther). *Transactions of the Royal Society of South Australia* 114: 207-211.

Dennis, A. 1982. A brief study of the Sharp-snouted Torrent Frogs *Taudactylus acutirostris*. *North Queensland Naturalist* 50: 7-8.

Dennis, A. and Mahony, M. 1994. *Final report to Wet Tropics Management Authority on the experimental translocation of the endangered sharp-snouted day frog* Taudactylus acutirostris *and observations on the cause of declines among montane riparian frogs*. Unpublished report to Wet Tropics Management Authority.

Dennis, A. and Trenerry, M. 1984. Observations on species diversity and habitat compartmentalization of the frogs of Mt. Lewis rainforests, North Queensland. *North Queensland Naturalist* 52: 2-9.

Department of Natural Resources 1998. *Improving the Water Allocation and Management System in Queensland*. Draft Policy Paper. Water Reform Unit, December 1998.

Dodd, C.K. and Seigel, R.A. 1991. Relocation, repatriation, and translocation of amphibians and reptiles: are they conservation strategies that work? *Herpetologica* 47: 336-350.

Hines, H., Mahony, M. and McDonald, K.R. 1999. Assessment of frog declines in wet subtropical Australia. Pp 44-63 in Campbell, A. (ed) *Declines and disappearances of Australian frogs*. Environment Australia, Department of the Environment, Canberra. 234 pp.

Ingram, G. 1980. A new frog of the genus *Taudactylus* (Myobatrachidae) from mid-eastern Queensland with notes on the other species of the genus. *Memoirs of the Queensland Museum* 36: 111-19.

Ingram, G.J. and McDonald, K.R. 1993. An update on the decline of Queensland's frogs. Pp 297-303 in Lunney, D. and Ayers, D. (eds), *Herpetology in Australia. A diverse discipline*. Royal Zoological Society of New South Wales, Mosman. 414pp.

IUCN 1994. *IUCN Red List Categories*. IUCN, Gland, Switzerland.

Laurance, W.F. 1996. Catastrophic declines of Australian rainforest frogs: is unusual weather responsible? *Biological Conservation* 77: 203-212.

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

Liem, D.S. 1974. A review of the *Litoria nannotis* species group and a description of a new species of *Litoria* from north-east Queensland, Australia. *Memoirs of the Queensland Museum* 17: 151-168.

Liem, D.S. and Hosmer, W. 1973. Frogs of the genus *Taudactylus* with description of two new species (Anura: Leptodactylidae). *Memoirs of the Queensland Museum* 16: 435-457.

Madronich, S. and de Gruijl, F.R. 1993. Skin cancer and UV radiation. *Nature* 366: 23.

Mahoney, M.1999. Review of the Declines and Disappearances within the Bell Frog Species Group (Litoria aurea species roup) in Australia. Pp 81-93 in Campbell, A (ed), *Declines and disappearances of Australian frogs.* Environment Australia, Department of the Environment and Heritage, Canberra. 234 pp.

Marshall, C. 1998. The reappearance of *Taudactylus* (Anura: Myobatrachidae) in north Queensland streams. *Pacific Conservation Biology* 4: 39-41.

Martin, W.E. and McDonald. K.R., 1995. *Recovery plan for the stream-dwelling rainforest frogs of the Wet Tropics biogeographic region of north-east Queensland*. Report to Environment Australia, Canberra.

McDonald, K.R. 1990. *Rheobatrachus* Liem and *Taudact*ylus Straughan & Lee (Anura: Leptodactylidae) in Eungella National Park, Queensland: distribution and decline. *Transactions of the Royal Society of South Australia* 114: 187-194.

McDonald, K.R. 1992. Distribution patterns and conservation status of north Queensland rainforest frogs. *Conservation Technical Report 1*. Queensland Department of Environment and Heritage, Brisbane.

McDonald, K.R., and Alford, R.A. 1999. A review of declining frogs in northern Queensland. Pp 14-22 in Campbell, A (ed), *Declines and disappearances of Australian frogs.* Environment Australia, Department of the Environment, Canberra. 234 pp.

McDonald, K.R., Covacevich, J.A., Ingram, G.J. and Couper, P.J. 1991. The status of frogs and reptiles. Pp 338-345 in Ingram, G.J. and Raven, R. J. (eds), *An atlas of Queensland's frogs, reptiles, birds and mammals*. Queensland Museum, Board of Trustees, Brisbane. 391 pp.

McPeters, R.D., Hollandsworth, S.M., Flynn, L.E., Herman, J.R., and Seftor. C.J. 1996. Long-term trends derived from the 16 year combined Nimbus 7 / Meteor 3 TOMS version 7 record. *Geophysical Research Letter* 23: 3699-3702.

Moise, A. 1998. *Frog declines in Queensland and changes in solar ultraviolet-B radiation since 1978*. Report to Environment Australia.

Richards, S.J. 1992. The tadpole of the Australian frog *Litoria nyakalensis* (Anura, Hylidae), and a key to the torrent tadpoles of northern Queensland. *Alytes* 10: 99-103.

Richards, S.J. 1993. *A guide to the identification of declining frogs and their tadpoles in the Wet Tropics biogeographic region, Queensland*. Unpublished Report, Queensland Department of Environment and Heritage.

Richards, S.J., McDonald, K.R., Alford, R.A. 1993. Declines in populations of Australia's endemic tropical rainforest frogs. *Pacific Conservation Biology* 1: 66-77.

Speare, R. 1995. *Preliminary study on diseases in Australian Wet Tropics amphibians. Deaths of rainforest frogs at O'Keefe Creek, Big Tableland*. Final Report to Department of Environment and Heritage. Unpublished Report, Queensland Department of Environment and Heritage.

Thomas, M.B. and McDonald, W.J.F. 1989. *Rare and threatened plants of Queensland*. 2nd ed. Queensland Department of Primary Industries, Brisbane.

Trenerry, M. P., Laurance, W. F., and McDonald, K. R. 1994. Further evidence for the precipitous decline of endemic rainforest frogs in tropical Australia. *Pacific Conservation Biology* 1: 150-153.

Tyler, M.J. 1997. *The Action Plan for Australian Frogs.* Environment Australia, Canberra.

Werren, G. L. 1993. Conservation strategies for rare and threatened vertebrates of Australia's Wet Tropics Region. *Memoirs of the Queensland Museum* 34: 229-241.

Williams, S.E. and Hero, J-M. 1998. Rainforest frogs of the Australia Wet tropics: guild classification and the ecological similarity of declining species. *Proceedings of the Royal Society London* 265: 597-602.

Appendix 1

Northern Queensland Threatened Frogs Recovery Team

Members as of April 2000

Keith McDonald	Queensland Parks and Wildlife Service
Ross Alford	James Cook University
Tadd Bartareau	Department of Natural Resources (Water Resources)
Derek Ball	Queensland Parks and Wildlife Service
Steve Goosem	Wet Tropics Management Authority
Elanoir Duigan	Community Groups
Ellen Weber	Conservation Groups
Nicola Wright	WaterWatch Program
Brigitta Wimmer	Environment Australia
Andrew Millerd	Department of Natural Resources (Forestry)

Appendix 2

Species information

1.1 *Taudactylus acutirostris* (Andersson, 1916)
Sharp-snouted day frog or sharp-snouted torrent frog.

1.1.1 Description of species:
A small frog, males 20 - 25mm, females 23 - 31mm in length (McDonald and Martin unpubl. data), with a narrow snout, wedge shaped in profile. The dorsal surface is greyish olive to dark chocolate brown above, with or without dark V or W shaped markings. A broad, dark grey or black band, bounded above by a distinct pale line, runs along the lateral surface from the level of the eye to the groin. The hind legs have darker cross bands on them, sometimes barely detectable, but usually quite conspicuous. The ventral surface is greyish white in colour, with dark flecks and blotches. The posterior portion of the ventral surface and the underside of the limbs are olive-yellow. A distinct white patch edged with black is present at the base of each forelimb. The lower jaw is edged with black. The skin is smooth above and below, with tubercles arranged in a triangle or ridges on the lower back and a distinct dorso-lateral skin fold. The fingers and toes have slightly expanded toe pads, and are fringed but lack webbing. (Liem and Hosmer 1973, Dennis 1982, Cogger 1994).

This species appears to have two calls. A high pitched metallic tinkling sound, "tink tink", repeated several times in quick succession (Liem and Hosmer 1973, Dennis 1982, Richards 1993), and a second call variously described as a popping call (McDonald 1992) or a short, scratchy chirp, "eek eek eek" (Ingram 1980, Richards 1993).

The tadpoles are small, with a dark, oval body, transparent posteriorly. There are discrete spots of pigmentation across the tail muscle and fins. The eyes are on top of the head, and the spiracle is sinistral, usually visible from above. The vent tube is dextral. The oral disc is surrounded by rows of marginal papillae with an anterior gap. There are two rows of teeth anterior to the jaws, and three posterior to the jaws. The inner two rows of teeth are divided in the middle (Liem and Hosmer 1973, Richards 1993).

1.1.2 Distribution:
Taudactylus acutirostris was widely distributed through the rainforests of the Wet Tropics Biogeographical Region at altitudes of 300-1500 m, from Mt Graham (18 ^{o} 24'S, 145 ^{o} 52'E) to Big Tableland (15^{o}42'S, 145^{o} 16'E), north-east Queensland (McDonald 1992) (Figure 1).

T. acutirostris has undergone a massive and rapid range contraction, with only one adult, one juvenile, and small numbers of tadpoles encountered since February 1994 (McDonald and Martin unpubl. data, J.M. Hero pers. comm.) (Figure 1).

1.1.3 Habitat:
T. acutirostris are generally found among rocks and leaf litter along the edges of rainforest streams, though in wet weather they may be found some distance from the water (K.R. McDonald pers. obs.).

The tadpoles normally inhabit debris in pools or slow flowing areas of rainforest streams (K. R. McDonald pers. obs.)

1.1.4 Life history/Ecology:
T. acutirostris is a diurnal species, and will often bask in the sun. Males call from exposed positions on rocks, sand or gravel banks at the water’s edge, or from beneath rocks or leaves (Ingram 1980, K.R. McDonald pers. obs.). They call from first light, and may continue until early evening (Dennis 1982). The males establish territories (Dennis 1982). After a period of basking, individuals will move off to forage along the sides of creeks and the rainforest floor

nearby. When disturbed they will leap into the water, and lie on the substrate for some minutes before resurfacing (Ingram 1980).

Calling males and gravid females have been encountered year round (McDonald and Martin unpublished data). Females lay 25-40 large (2.2-2.7mm diameter) unpigmented eggs in a large gelatinous clump on the underside of rocks at or below the waterline in flowing creeks (Liem and Hosmer 1973, McDonald 1992).

1.1.5 Reasons for listing:
T. acutirostris is one of seven species of frogs occurring in upland rainforest streams which have undergone substantial range contraction in north-eastern Queensland (Ingram and McDonald 1993, Richards *et al.* 1993, Trenerry *et al.* 1994).

T. acutirostris was a very conspicuous and abundant frog, Richards *et al.* (1993) estimating a density of 100 frogs per 100m of stream at Mt. Lewis in 1989. Its prognosis was described as 'very good' prior to 1990 (McDonald 1992), but *T. acutirostris* could not be located in the southern part of its range in 1988 (McDonald 1990). A survey during the summer of 1991 - 1992 found that this species could not be located in over nine tenths of its former range, and this range contraction was continuing (Richards *et al.* 1993).

Monthly monitoring of the last healthy population, at Big Tableland, showed a dramatic population decline in December 1993. By February 1994, *T. acutirostris* adults could no longer be located at the site (A. J. Dennis pers. comm., McDonald and Martin unpubl. data). Small numbers of tadpoles persisted, and one juvenile was found in January 1995, and recaptured the following month (McDonald and Martin unpubl. data). No other populations have been found (Trenerry *et al.* 1994, J.M. Hero pers. comm.).

To ensure the survival of this species, efforts have been made to establish breeding colonies in captivity, but these have met with little success. The last sub-adult in captivity died in August - September 1995 (A.J. Dennis pers. comm.).

The conservation status of *T. acutirostris* has been defined as critically endangered, following the 1994 categories for the IUCN (IUCN 1994, Ingram and McDonald 1993), and endangered, following Thomas and McDonald, 1989 (Covacevich and McDonald 1993, McDonald *et al.* 1991). A group of leading herpetologists, attending a workshop to examine the conservation status of the biota of the Wet Tropics Region, identified *T. acutirostris* as a critically endangered species requiring urgent conservation action (Werren 1993). The Action Plan for Australian Frogs prepared for the Australian Nature Conservation Agency in 1997 lists *T. acutirostris* as endangered (Tyler 1997). The fact that this species is well protected throughout its range within several conservation reserves has not guaranteed its survival (Covacevich and McDonald 1993).

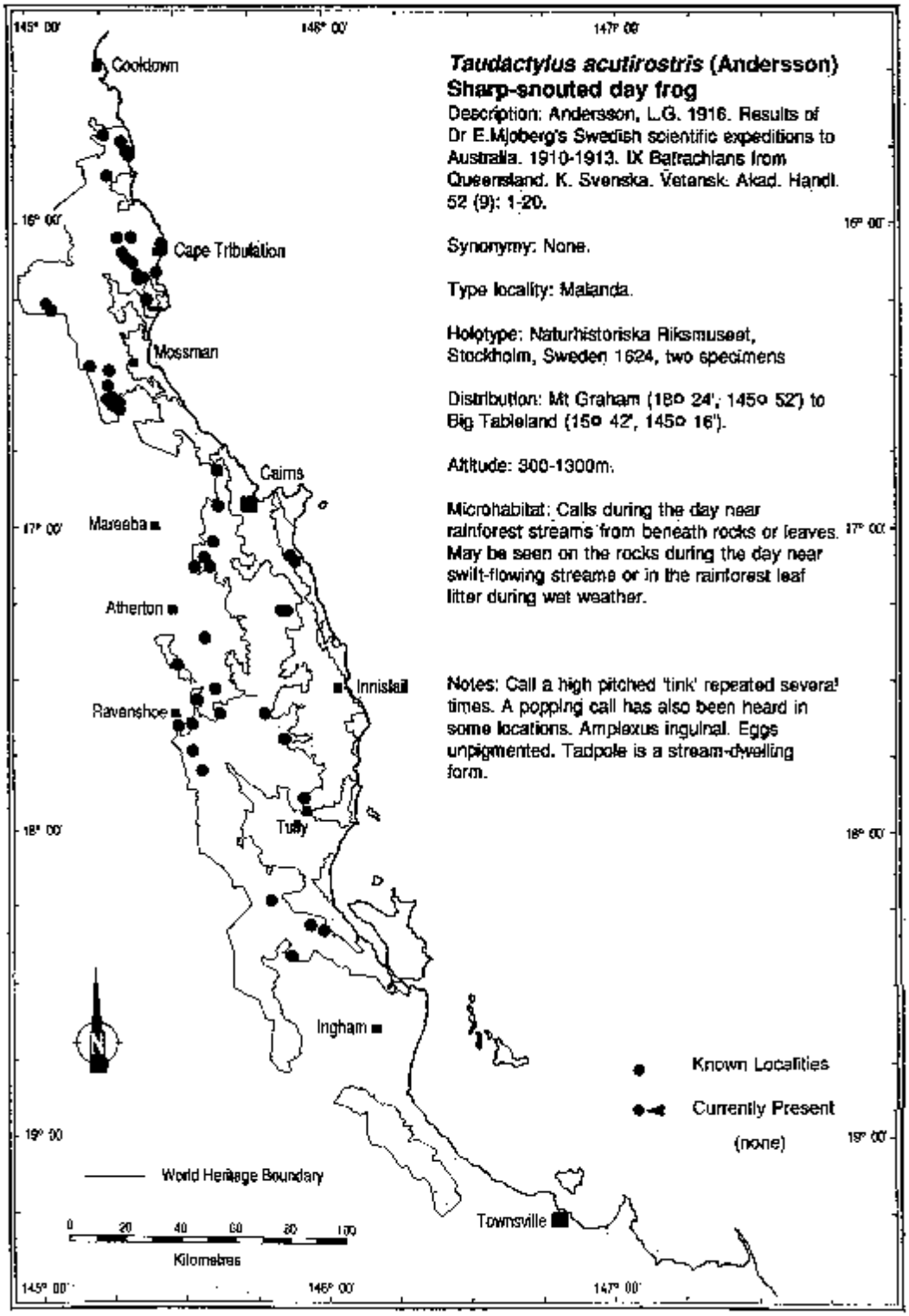
The causes of the range contraction remain unknown. Richards *et al.* (1993) found no evidence that drought, floods, habitat destruction or pollution by pesticides, inorganic ions or heavy metals were responsible for the population declines.

In view of the dramatic range contraction of this species, it is likely that it is close to extinction.

1.1.6 Existing conservation measures:
The entire distribution of this species is protected within the Wet Tropics World Heritage Area, with 32.9% of known collection sites located within national parks, 60.3% within forestry reserves, 2.7% in other reserves and 4.1% on private lands. However, presence

within a reserve has not prevented the catastrophic range contraction of this species. It is listed as endangered in the Queensland *Nature Conservation (Wildlife) Regulation 1994,* ANZECC list 1999, and the *Environment Protection and Biodiversity Conservation Act 1999*. Environment Australia and the Queensland Parks and Wildlife Service (QPWS) are continuing to fund research on the ecology, diseases, captive breeding and genetics of this species, as well as monitoring of sites where it formerly occurred.

***Figure 1**. Past and present distribution of Taudactylus acutirostris* (modified from McDonald 1992).



1.2 *Taudactylus rheophilus* Liem and Hosmer, 1973
Northern tinker frog, mountain day frog, blunt-nosed torrent frog, tinkling frog.

1.2.1 Description of species:
A small frog, 24 - 31mm in length, with robust body and truncated snout. The dorsal surface is smooth or finely granular, and may be grey-brown, reddish or dark brown in colour, with irregular darker markings. A narrow pale greyish streak runs from the eye to the groin, bordered below by a broad black band whose lower edge breaks up into a marbled or reticulate pattern on the flanks. There is a faint, pale transverse bar between the eyes, and a pale glandular patch runs from the angle of the jaws to the base of the forearm. The loreal region is black with some irregular grey markings. The ventral surface is smooth, brown in colour, with conspicuous, irregular, creamy-white markings. The limbs have irregular blackish cross bands, and the digits are barred with dark brown and creamy grey. The tips of the digits have small but conspicuous discs, the toes are fringed but lack webbing (Liem and Hosmer 1973, Cogger 1994).

The call has been variously described as a soft metallic tapping sound, "tink tink tink" repeated 4-5 times in quick succession (Liem and Hosmer 1973, Ingram 1980), or a gentle rattling sound (McDonald 1992).

The tadpole has not been described.

1.2.2 Distribution:
Taudactylus rheophilus is restricted to four mountain tops at altitudes of 940-1500 m within the Wet Tropics World Heritage Area of north-east Queensland, from Thornton Peak ($16^0$10'S, 145^0 22'E) to Mt Bellenden Ker (17^0 16'S, 145^0 22'E) (McDonald 1992) (Figure 2).

T. rheophilus has undergone a sudden range contraction, and has not been located in the wild since October 1991 (Figure 2).

1.2.3 Habitat:
T. rheophilus is a cryptic species, found under rocks, roots and logs in seepage and trickle areas beside fast-flowing rainforest streams (McDonald 1992).

1.2.4 Life history/Ecology:
The adults are very cryptic, and mainly nocturnal, though they may be active on overcast days. Males form a chorus, calling from under rocks or roots, and may be partly in water (Ingram 1980, K.R. McDonald pers. obs.).

Little is known about its developmental biology, but females carry 35-50 large (1.8-2.4 mm diameter) eggs (Liem and Hosmer 1973). Juveniles have been collected in the months of December and May (Liem and Hosmer 1973).

1.2.5 Reasons for listing:
T. rheophilus is one of seven species of frogs occurring in upland rainforest streams which have undergone substantial range contraction in north-eastern Queensland (Ingram and McDonald 1993).

Although its prognosis was described as 'good' before 1990 (McDonald 1992), surveys during the summer of 1991-1992, 1993 and 1994 failed to find any individuals (Richards *et al.* 1993, Trenerry *et al.* 1994, J.M. Hero pers. comm.). It was last reported from the wild in October 1991 (Richards *et al.* 1993), and continued searches have failed to locate any individuals.

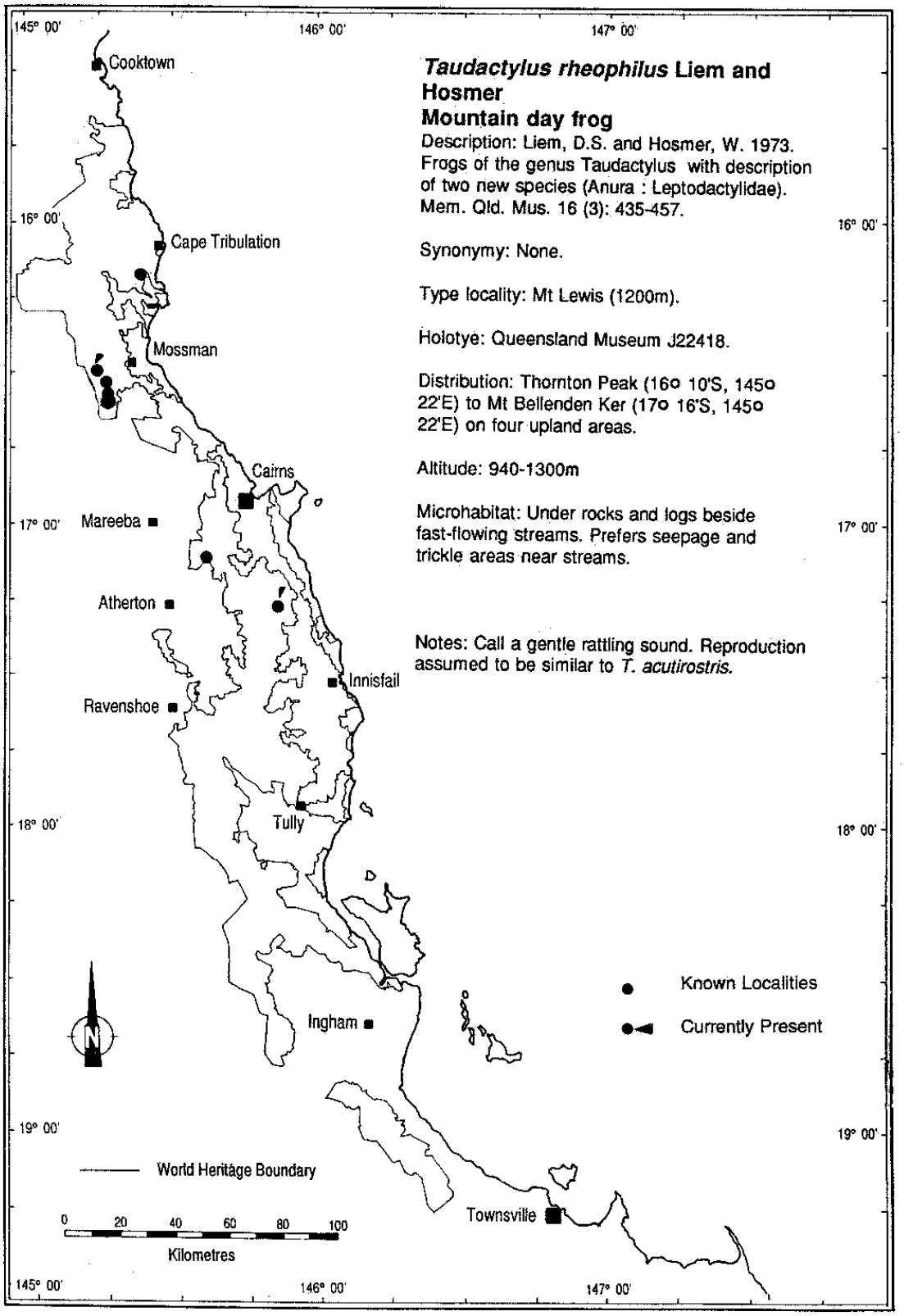
The conservation status of *T. rheophilus* has been defined as critically endangered, following the 1994 categories for the IUCN (IUCN 1994, Ingram and McDonald 1993) and endangered, following Thomas and McDonald, 1989 (Covacevich and McDonald 1993, McDonald *et al.* 1991). A group of leading herpetologists, attending a workshop to examine the conservation status of the biota of the Wet Tropics Region, identified *T. rheophilus* as a critically endangered species requiring urgent conservation action (Werren 1993). The Action Plan for Australian Frogs *T. rheophilus* as endangered (Tyler 1997). The fact that this species is well protected throughout its range within several conservation reserves has not guaranteed its survival (Covacevich and McDonald 1993, McDonald 1992).

The causes of the population decline remain unknown. Richards *et al.* (1993) found no evidence that drought, floods, habitat destruction or pollution by pesticides, inorganic ions or heavy metals were responsible for the population declines.

In view of the dramatic range contraction and continued absence of this species, it is likely that it is close to extinction.

1.2.6 Existing conservation measures:
The entire distribution of this species is protected within the Wet Tropics World Heritage Area, with 18.2% of known collection sites located within national parks, 72.7% within forestry reserves, and 9.1% on private lands. However, presence within a reserve has not prevented the catastrophic range contraction of this species. It is listed as endangered in the Queensland *Nature Conservation (Wildlife) Regulation 1994,* ANZECC list 1999, and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. The Queensland Parks and Wildlife Service is continuing to fund monitoring of sites where this species formerly occurred.

***Figure 2**. Past and present distribution of Taudactylus rheophilus* (modified from McDonald 1992).



1.3 *Litoria lorica* Davies and McDonald, 1979
Armoured mistfrog, Thornton Peak tree frog or little waterfall frog.

1.3.1 Description of species:
A medium sized frog, males 29.6 - 33.1mm, females 32.9 - 37.3mm. The dorsal surface is uniform grey or grey-brown. The ventral surfaces are white, variably peppered with dark brown on the throat. The skin is finely tubercular dorsally, prominently so on the upper eyelids and in the tympanic region. The lower surfaces are granular on the thorax, abdomen and backs of the thighs, but smooth elsewhere. The finger and toe discs are well developed. The fingers have basal webbing and the toes are fully webbed. The hands have an enlarged prepollex. Males have black spiny nuptial pads and accessory spines on the chest. The head is evenly rounded, with a truncate snout and terminal nostrils. The tympanum is small and indistinct. The vocal sac is absent (Davies and McDonald 1979).

The call is unknown.

The tadpole has not been described.

1.3.2 Distribution:
It is known only from the type locality - Alexandra Creek near Thornton Peak (16^0 07'S, 145^0 20'E) and Hilda Creek, Daintree National Park (16^0 10'S, 145^0 22'E), north-east Queensland at altitudes of 640-1000 m (McDonald 1992) (Figure 3).

L. lorica has not been located at these sites since 1991, despite recent efforts to relocate it (Ingram and McDonald 1993, J.M Hero pers. comm.) (Figure 3).

1.3.3 Habitat:
L. lorica is found on boulders in the splash zone near turbulent, fast-flowing water in upland rainforest (Davies and McDonald 1979).

1.3.4 Life history/Ecology:
Females carry large unpigmented eggs (2.3 mm in a female paratype) (Davies and McDonald 1979).

The tadpoles, though undescribed, are probably similar to those of *L. nannotis* - with large suctorial mouths for adhering to rocks in fast-flowing streams (Davies and McDonald 1979).

1.3.5 Reasons for listing:
L. lorica, a member of the *L. nannotis* species group, is one of seven species of frogs occurring in upland rainforest streams which have undergone substantial range contractions in north-eastern Queensland recently (Ingram and McDonald 1993).

A poorly known species described in 1979 (Davies and McDonald 1979). *L. lorica* was considered rare due to its restricted distribution, but at no immediate risk as recently as 1990 (McDonald 1992, McDonald *et al.* 1991). Due to similarities in habit to other declining frogs, concerns were expressed about its future (Werren 1993, Trenerry *et al.* 1994). Experienced collectors have been unable to locate this species since 1991 (Ingram and McDonald 1993, J.M. Hero pers. comm.).

The conservation status of *L. lorica* has now been defined as critically endangered, following the 1994 categories for the IUCN (IUCN 1994, Ingram and McDonald 1993) and vulnerable, following Thomas and McDonald, 1989 (Covacevich and McDonald 1993). A group of leading herpetologists, attending a workshop to examine the conservation status of the biota

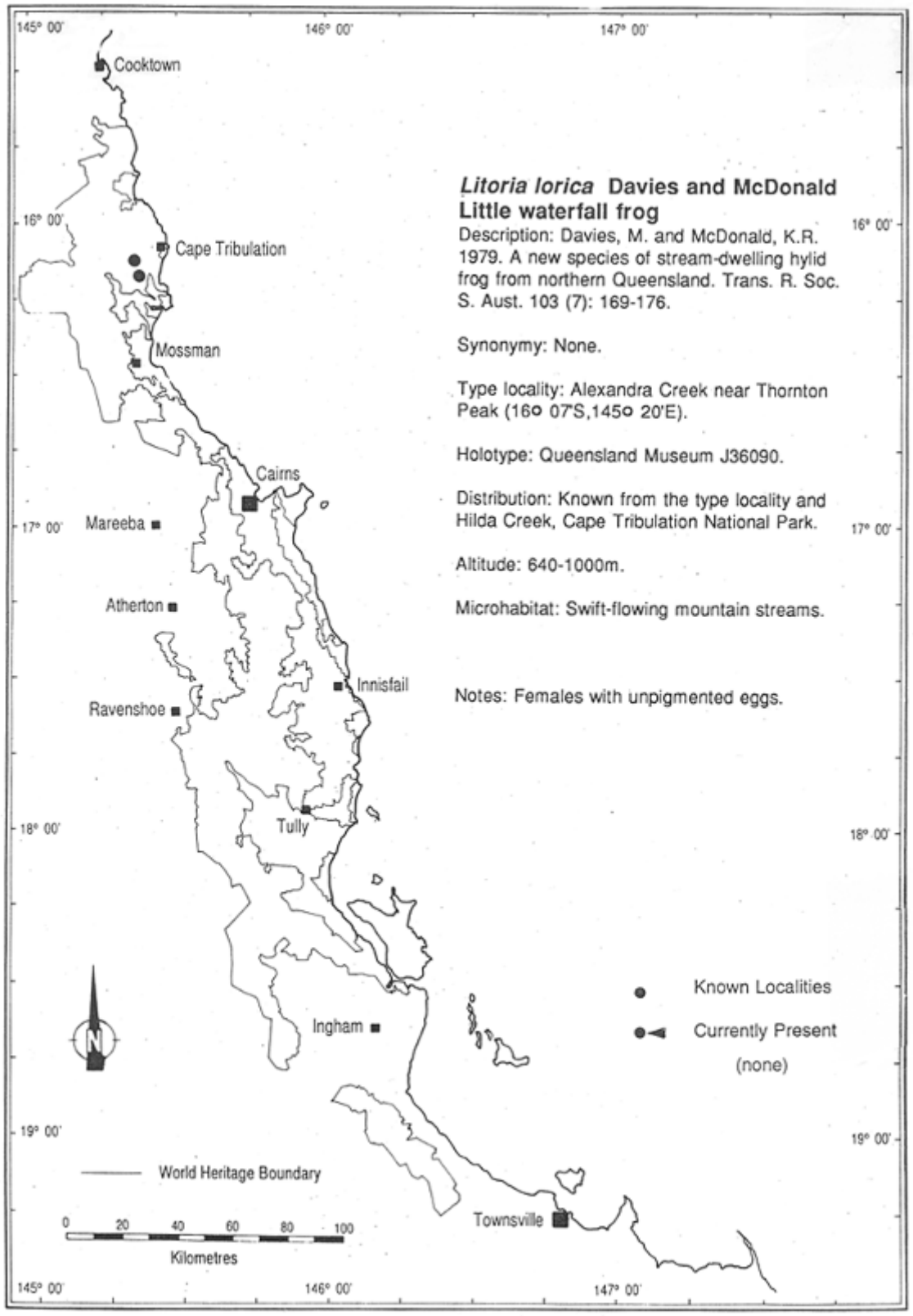
of the Wet Tropics Region suspected *L. lorica* could be endangered, but lacked sufficient field data (Werren 1993). They classed it as vulnerable, requiring intensive study to ascertain its status. The Action Plan for Australian Frogs prepared for the Australian Nature Conservation Agency in 1997 lists *L. lorica* as endangered (Tyler 1997). Although restricted to the Thornton Peak area, *L. lorica* was considered well protected at the time of its decline (Covacevich and McDonald 1993).

The cause(s) of the population decline remain unknown. Richards *et al.* (1993) found no evidence that drought, floods, habitat destruction or pollution by pesticides, inorganic ions or heavy metals were responsible for the population declines.

In view of the dramatic range reduction and continued absence of this species, it is likely that it is close to extinction.

1.3.6 Existing conservation measures:
The entire distribution of this species is protected within Daintree National Park and Timber Reserve 165 within the Wet Tropics World Heritage Area. However, presence within a reserve has not prevented the catastrophic population decline of this species. It is listed as endangered in the Queensland *Nature Conservation (Wildlife) Regulation 1994,* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

***Figure 3**. Past and present distribution of Litoria lorica* (modified from McDonald 1992).



1.4 *Litoria nannotis* (Andersson, 1916)
Waterfall frog or torrent frog

1.4.1 Description of species:
A moderately large, robust species, males 31.6 - 52.1mm, females 48.2 - 59mm (McDonald and Martin unpubl. data). The dorsal surface is slate, olive or dull brown colour, with irregular dark mottling. The ventral surfaces white or cream in colour, often with brown on the throat. The axilla and groin are flesh coloured. The skin is shagreened, finely granular, or with numerous small scattered warts above, granular below. The fingers have basal webbing, and the toes are fully webbed. The finger and toe discs are well developed. Males have a large prepollex, with black spiny nuptial pads and accessory spines on the chest, head, forearm and thighs. There is no vocal sac. The snout is bluntly rounded, and the tympanum is indistinct (Cogger 1994, Liem 1974).

The call has been described as a repeated "crawk crawk crawk" or a gentle, popping, slow growl-like sound that is difficult to hear above the sound of flowing water (McDonald 1992, Richards 1993).

The tadpoles are adapted for fast flowing stream conditions with suctorial mouth, muscular tail, narrow tail fins and ventro-lateral spiracle (Liem 1974). The body colour is grey or olive-green with dark abdomen, yellowish tail, and numerous diffuse dark-brown blotches across the tail muscle and fins (Richards 1992). The oral disc is surrounded by marginal and submarginal papillae, and has two anterior tooth rows, and three posterior (Liem 1974).

1.4.2 Distribution:
L. nannotis occurred throughout the Wet Tropics Biogeographical Region between Paluma (19^0 01'S, $146^0$12'E) and Mungumby Creek (15^0 42'S, 146^0 16'E), north-east Queensland (McDonald 1992) (Figure 4).

No population declines have been observed in populations occurring below 400 m, but *L. nannotis* is now absent from most sites above this altitude (Figure 4).

1.4.3 Habitat:
L. nannotis inhabits fast-flowing streams around waterfalls and cascades in rainforest from 80-1300 m (McDonald 1992). Frogs are generally found on boulders beside or behind waterfalls, but may be perched on trees or litter beside streams (Liem 1974, K.R. McDonald pers. obs.).

Tadpoles are found predominantly in fast flowing sections of the stream, attached to rocks (Richards 1992, K.R. McDonald pers. obs.)

1.4.4 Life history/Ecology:
Gravid females are encountered year round, as are males with nuptial pads (McDonald and Martin unpubl. data).

Large (2.7-3.4 mm diameter) unpigmented eggs are layed as a gelatinous clump under rocks in streams (Liem 1974).

The tadpoles graze on algal-covered rocks in fast flowing streams (K.R. McDonald pers. obs.)

1.4.5 Reasons for listing:

L. nannotis is one of seven species of frogs occurring in upland rainforest streams which have undergone substantial range contraction in north-eastern Queensland recently (Ingram and McDonald 1993, Richards *et al.* 1993).

L. nannotis was not considered to be at risk as recently as 1990 (McDonald 1992, McDonald *et al.* 1991). Since 1990 population declines have been noted at upland sites throughout the Wet Tropics Biogeographical Region. A survey during the summer of 1991-1992 between Townsville and Cooktown found *L. nannotis* at only one of twenty-one upland sites south of the Daintree River (Richards *et al.* 1993).

This range contraction continued, affecting upland rainforest sites between the Daintree and Bloomfield Rivers in 1993 (Ingram and McDonald 1993, Trenerry *et al.* 1994), and sites north of the Bloomfield River in 1994 (K. R. McDonald pers. comm.). *L. nannotis* is now absent from most upland sites.

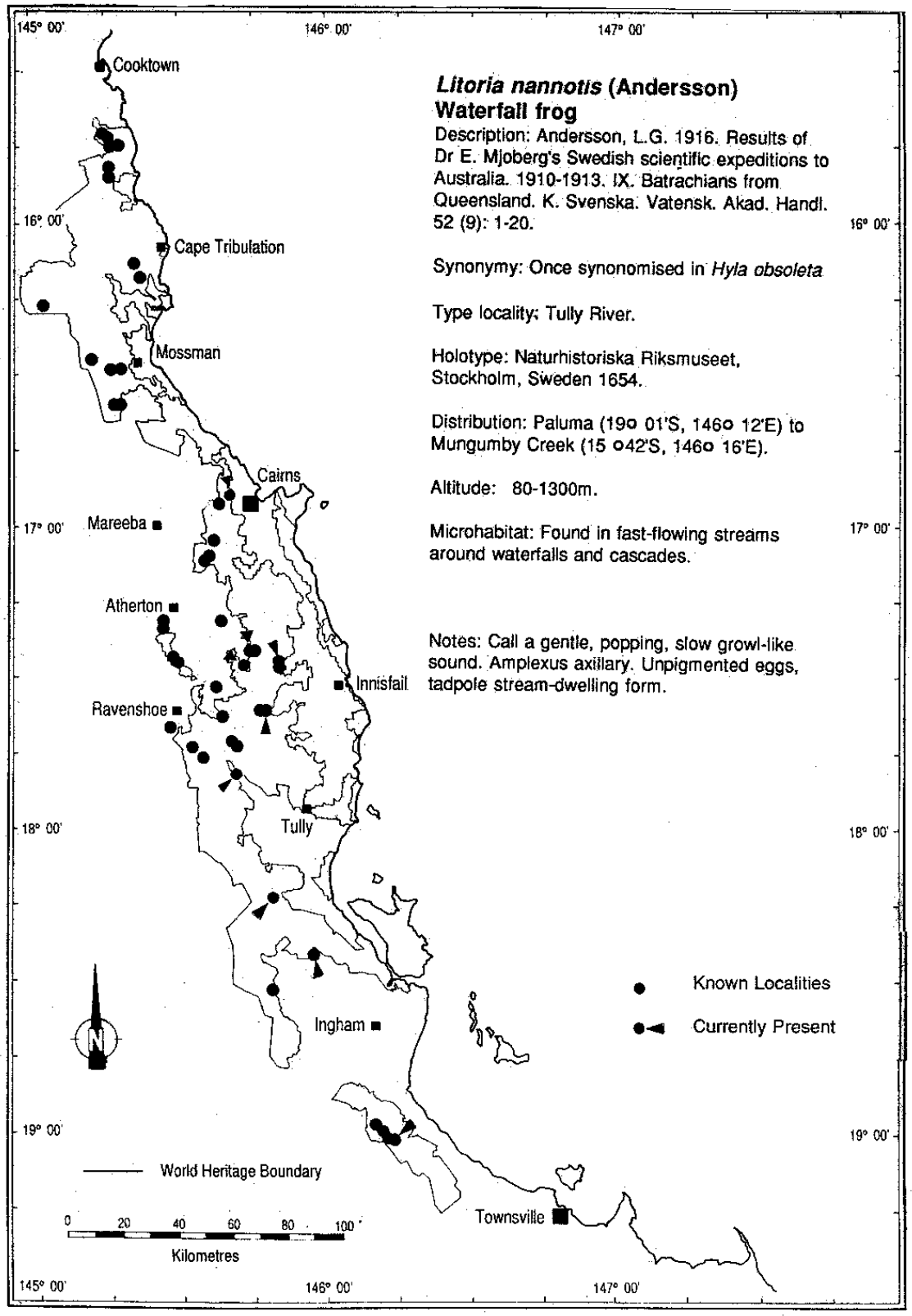
The conservation status of *L. nannotis* has been defined as endangered, following the 1994 categories for the IUCN (IUCN 1994, Ingram and McDonald 1993) and vulnerable, following Thomas and McDonald, 1989 (Covacevich and McDonald 1993). A group of leading herpetologists, attending a workshop to examine the conservation status of the biota of the Wet Tropics Region, identified *L. nannotis* as a critically endangered species requiring urgent conservation action (Werren 1993). The Action Plan for Australian Frogs prepared for the Australian Nature Conservation Agency in 1997 lists *L. nannotis* as endangered. It is considered endangered despite occurring throughout its range within several conservation reserves (Covacevich and McDonald 1993).

The causes of the population decline remain unknown. Richards *et al.* (1993) found no evidence that drought, floods, habitat destruction or pollution by pesticides, inorganic ions or heavy metals were responsible for the population declines.

In view of the dramatic range contraction of this species, action must be taken to maintain the populations of *L. nannotis* remaining at the small number of lowland sites.

1.4.6 Existing conservation measures:
The entire distribution of this species is protected within the Wet Tropics World Heritage Area, with 42.4% of known collection sites located within national parks, 53.1% within forestry reserves, 1.5% in other reserves and 3% on private lands. However, presence within a reserve has not prevented the catastrophic range contraction of this species. It is listed as endangered in the Queensland *Nature Conservation (Wildlife) Regulation 1994,* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*
Environment Australia and QPWS are continuing to fund research on the distribution, ecology, diseases, captive breeding and genetics of this species, as well as monitoring sites where it formerly and presently occurs.

Figure 4. *Past and present distribution of Litoria nannotis* (modified from McDonald 1992).



1.5 *Litoria nyakalensis* Liem, 1974
Mountain mistfrog or Nyakala frog.

1.5.1 Description of species:
A moderate sized, robust treefrog 30 - 48mm in length. The dorsal surface is uniform olive-brown or grey-brown, sometimes with irregular darker olive markings. The skin is smooth above, with scattered tubercles on the head and back. The ventral surfaces are granular, cream in colour with a reddish-pink flush on the limbs and pectoral region, and sometimes dotted or flecked with brown. The iris is brown. The finger and toe disks are large and conspicuous. The fingers have slight webbing, and the toes are fully webbed. The forearm is robust in the male, with a large nuptial pad with coarse spinules. The tympanum is small and indistinct, more or less covered by skin. (Cogger 1994, Liem 1974, Richards 1993).

The call has been described as a regularly repeated, rasping, single note call (Liem 1974), or a soft, slow, popping growl (McDonald 1992).

Tadpoles have a depressed body, light brown in colour with a cream patch between the eyes, less distinct in large specimens. The tail muscle is very robust, cream with distinct light brown blotches that extend into the anterior portion of the clear fins. The tail fin is low anteriorly, high posteriorly and broadly rounded at the tip. The large suctorial oral disc is surrounded with marginal and submarginal papillae. There are two tooth rows anterior to the mouth, and three posterior to it (Richards 1992).

1.5.2 Distribution:
L. nyakalensis occurred across two-thirds of the Wet Tropics Biogeographical Region between Douglas Creek, Kirrama State Forest (18^0 13'S, 145^0 48'E) and Alexandra Creek (16^0 07'S, 145^0 20'E), north-east Queensland (McDonald 1992) (Figure 5).

L. nyakalensis was last reported from the wild in November 1990, and has not been located anywhere since (Figure 5).

1.5.3 Habitat:
L. nyakalensis inhabits fast-flowing streams near riffles and cascades in upland rainforest, and is usually found perched on rocks or overhanging vegetation adjacent to the water (Liem 1974).

Tadpoles are restricted to swiftly flowing rainforest streams. Within these streams, they may be found clinging to rocks in riffles and torrents, and in highly oxygenated pools below waterfalls. Tadpoles have also been collected under rocks buried in sand (Richards 1992).

1.5.4 Life history/Ecology:
Little is known of the adult ecology. Mating calls have been heard from October to March (Liem 1974).

Large unpigmented eggs are laid under rocks in riffles (Richards 1993).

The tadpoles graze on algal-covered rocks in fast-flowing waters. They will burrow into loose sand under rocks, which may help them to withstand the violent floods that often occur in rainforest streams (Richards 1992). They commonly over-winter in upland streams, although those hatching in early summer can metamorphose before the next autumn. (Richards 1992).

1.5.5 Reasons for listing:

L. nyakalensis is one of seven species of frogs occurring in upland rainforest streams which have undergone substantial range contraction in north-eastern Queensland recently (Ingram and McDonald 1993).

L. nyakalensis was not considered at risk as recently as 1990 (McDonald 1992, McDonald *et al.* 1991), but has not been sighted since that year (Richards *et al.* 1993). Extensive surveys throughout its former range in 1991-1992, and 1993 failed to relocate this species (Richards *et al.* 1993, Trenerry *et al.* 1994).

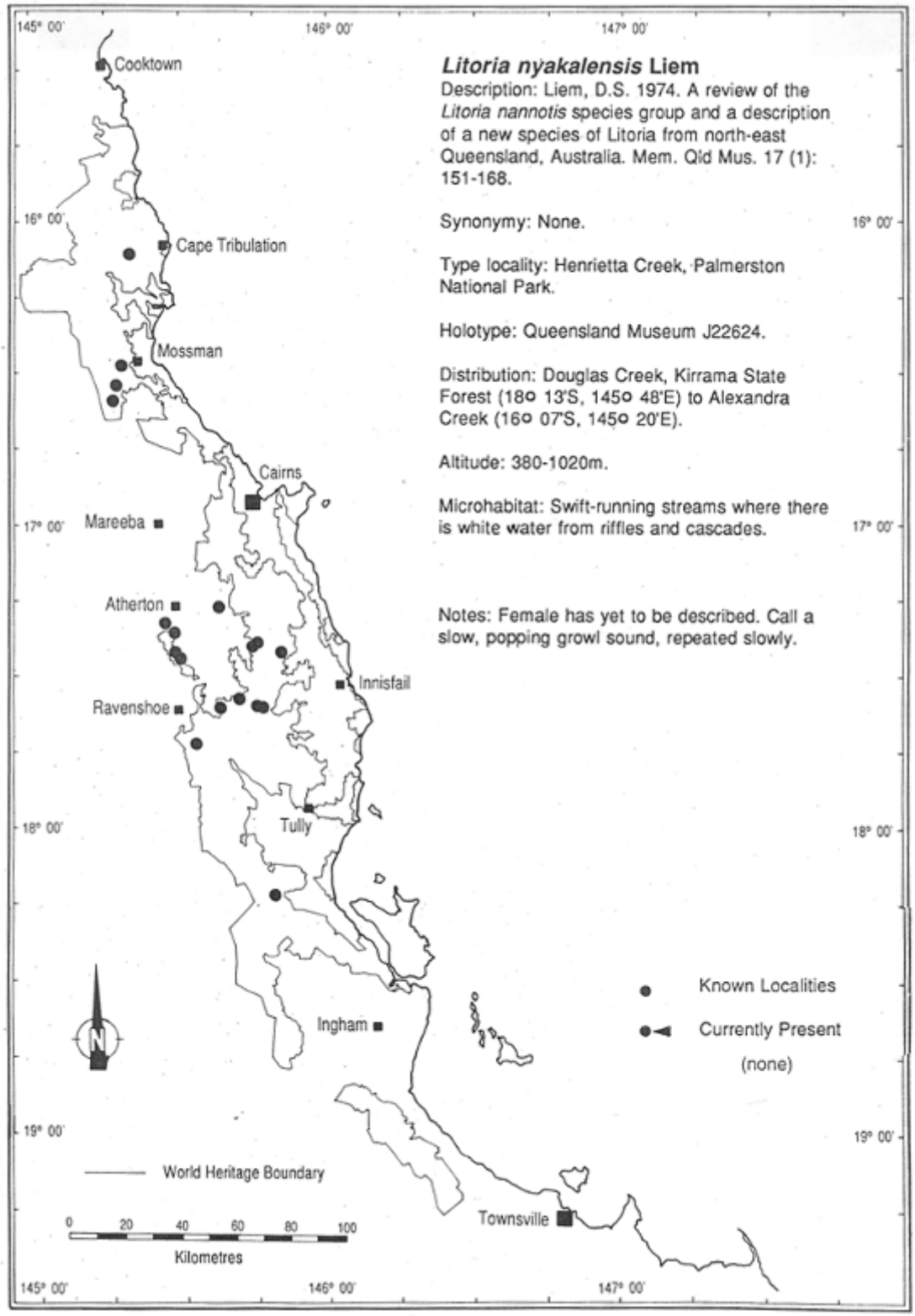
The conservation status of *L. nyakalensis* has been defined as critically endangered, following the 1994 categories for the IUCN (IUCN 1994, Ingram and McDonald 1993) and endangered, following Thomas and McDonald, 1989 (Covacevich and McDonald 1993). A group of leading herpetologists, attending a workshop to examine the conservation status of the biota of the Wet Tropics Region, identified *L. nyakalensis* as a critically endangered species requiring urgent conservation action (Werren 1993). The Action Plan for Australian Frogs lists *L. nyakalensis* as endangered (Tyler 1997). This population decline is all the more disturbing because its habitat is extremely well protected throughout its range within several conservation reserves (Covacevich and McDonald 1993).

The causes of the population decline remain unknown. Richards *et al.* (1993) found no evidence that drought, floods, habitat destruction or pollution by pesticides, inorganic ions or heavy metals were responsible for the population declines.

In view of the dramatic range contraction and continued absence of this species, it is likely that it is close to extinction.

1.5.6 Existing conservation measures:
The entire distribution of this species is protected within the Wet Tropics World Heritage Area, with 47.4% of known collection sites located within national parks, 42% within forestry reserves, 5.3% in other reserves and 5.3% on private lands. However, presence within a reserve has not prevented the catastrophic population decline of this species. It is listed as endangered in the *Environment Protection and Biodiversity Conservation Act 1999.* The QPWS are continuing to fund monitoring of sites where this species formerly occurred.

Figure 5. *Past and present distribution of Litoria nyakalensis* (modified from McDonald 1992).



1.6 *Litoria rheocola* Liem, 1974
Common mistfrog or creek frog.

1.6.1 Description of species:
A moderate size frog, males 27 - 36.4mm, females 31.7 - 41.2mm in length (McDonald and Martin unpubl. data). The dorsal surface is dull grey or brown, with irregular darker markings. There is a distinct inverted triangle marking on the top of the head, stretching between the eyes down to the coccygeal region. An obscure darker band runs along the side of the snout, through the eye and ear to the shoulder. The skin is smooth above, with scattered small tubercles. The ventral surface is granular, white in colour. The finger and toe discs are large. The fingers are moderately webbed, and the toes nearly fully webbed. The tympanum is small and covered by skin, though the rim may be distinct. The male nuptial pads are small, with fine dark spicules. The tip of the snout is bluntly pointed (Cogger 1994, Liem 1974).

The call is a regular, repeated long drawn single note call, a rather nasal "wreek wreek wreek" (Liem 1974, pers. obs.).

Tadpoles have a flattened, sandy coloured body, which is darker ventrally. The tail is very muscular, creamy yellow lightly dusted with diffuse dark pigment. The tail fins are clear, with only a few scattered melanophores confined to small aggregations. The mouth is suctorial, surrounded by marginal and submarginal papillae. There are two anterior and three posterior tooth rows (Richards 1992).

1.6.2 Distribution:
L. rheocola occurred in rainforests north of the Herbert River in the Wet Tropics Biogeographical Region from Broadwater Creek National Park (18^0 23'S, 145^0 57'E) to Amos Bay (15^0 41'S, 145^0 19'E) (McDonald 1992) (Figure 6).

No population declines have been observed in lowland rainforests below 400 m, but *L. rheocola* has disappeared from most sites above this altitude (Figure 6).

1.6.3 Habitat:
L. rheocola is usually found on rocks and vegetation near fast-flowing streams in rainforest from 0-1180 m.

Tadpoles are found in swiftly flowing rainforest streams, clinging to rocks in riffles, torrents, and highly oxygenated pools (Liem 1974, pers. obs.).

1.6.4 Life history/Ecology:
Calling males and gravid females are found throughout the year (McDonald and Martin unpubl. data), and breeding has been observed during most months (Dennis & Trenerry 1984, Liem 1974).
Large (1.4 - 1.8 mm diameter) unpigmented eggs are deposited in a compact gelatinous clump under rocks in fast-flowing streams (Liem 1974).

The tadpoles graze on algal-covered rocks in fast-flowing waters (Liem 1974, pers. obs.).

1.6.5 Reasons for listing:
L. rheocola is one of seven species of frogs occurring in upland rainforest streams which have undergone substantial range contraction in north-eastern Queensland recently (Ingram and McDonald 1993).

L. rheocola was not considered at risk as recently as 1990 (McDonald 1992, McDonald *et al.* 1991). The decline of some populations was first noted in 1989 during an ecological study in the rainforests of northern Queensland (Richards *et al.* 1993). An extensive survey over the summer of 1991-1992 between Townsville and Cooktown found *L. rheocola* at only one of twenty-one upland sites south of the Daintree River (Richards *et al.* 1993).

This range contraction continued, affecting sites between the Daintree and Bloomfield Rivers in 1993 (Ingram and McDonald 1993, Trenerry *et al.* 1994), and sites north of the Bloomfield River in 1994 (McDonald and Martin unpubl. data). *L. rheocola* is still common at a few lowland sites. It has disappeared from most sites above 400 m, the last adults being observed at Big Tableland, north of the Bloomfield River in November 1994 (McDonald and Martin unpubl. data).

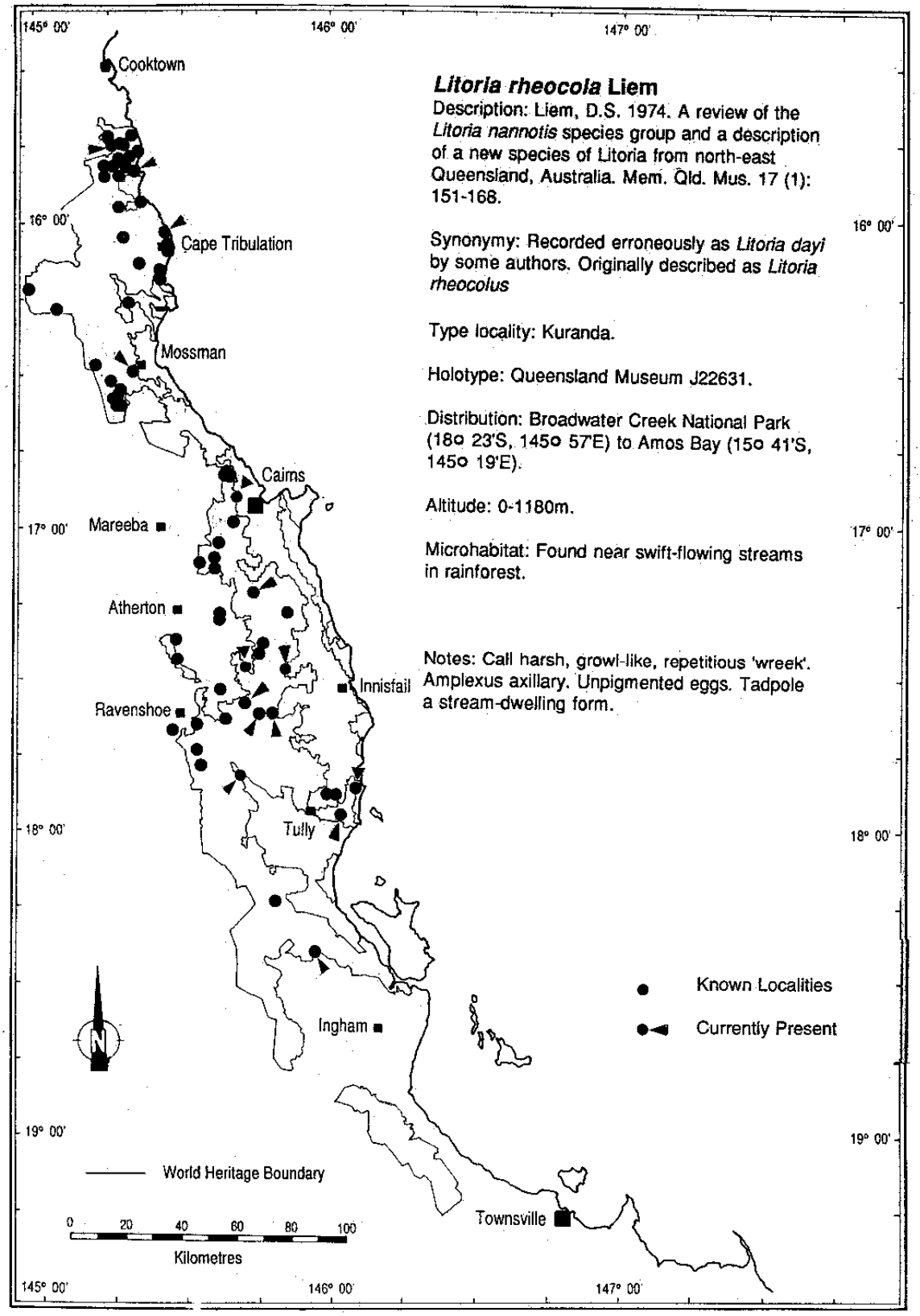
The conservation status of *L. rheocola* has been defined as endangered, following the 1994 categories for the IUCN (IUCN 1994, Ingram and McDonald 1993) and vulnerable, following Thomas and McDonald, 1989 (Covacevich and McDonald 1993). A group of leading herpetologists, attending a workshop to examine the conservation status of the biota of the Wet Tropics Region, identified *L. rheocola* as a critically endangered species requiring urgent conservation action (Werren 1993). The Action Plan for Australian Frogs prepared for the Australian Nature Conservation Agency in 1997 lists *L. rheocola* as endangered (Tyler 1997). It is considered endangered despite occurring in habitat that is well protected throughout its range within several conservation reserves (Covacevich and McDonald 1993).

The causes of the population decline remain unknown. Richards *et al.* (1993) found no evidence that drought, floods, habitat destruction or pollution by pesticides, inorganic ions or heavy metals were responsible for the population declines.

In view of the dramatic range contraction of this species, action must be taken to maintain the populations of *L. rheocola* remaining at the small number of lowland sites.

1.6.6 Existing conservation measures:
The entire distribution of this species is protected within the Wet Tropics World Heritage Area, with 32.6% of known collection sites located within national parks, 49.4% within forestry reserves, 5.6% in other reserves and 12.4% on private lands. However, presence within a reserve has not prevented the catastrophic range contraction of this species. It is listed as endangered in the Queensland *Nature Conservation (Wildlife) Regulation 1994,* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.* Environment Australia and QPWS are continuing to fund research on the ecology, diseases, captive breeding and genetics of this species, as well as monitoring sites where it formerly and presently occurs.

Figure 6. *Past and present distribution of Litoria rheocola* (modified from McDonald 1992).



1.7 *Nyctimystes dayi* (Günther, 1897)
Lace-eyed tree frog, Australian lace-lid or day's frog.

1.7.1 Description of species:
A moderately sized frog, males 32.9 - 41.9mm, females 37 - 57.5mm (McDonald and Martin unpubl. data), readily distinguished from other Australian hylids by the presence of large and prominent eyes with a vertical pupil and reticulated venation of the lower eyelid. The dorsal surface may be shagreened, finely granular or smooth. It is highly variable in colour, and may be dark or light brown, grey or cream above, with or without irregular light markings. White or cream spots reminiscent of lichen are often present, but vary in size and shape. The ventral surfaces are coarsely granular and cream in colour. The snout ranges from acuminate to rounded, the former being more common in specimens from the north. The tympanum is indistinct. The hands are moderately webbed, and the feet extensively webbed (Cogger 1994, Czechura *et al.* 1987).

In chorus, the advertising call of the breeding male is a drawn out "eeeeeeeee" that inflects downwards at the end, repeated three or four times in succession, producing a harsh growl-like sound. Solitary males can voice a short, sharp "ee" every five to six seconds, sometimes over long periods (Czechura *et al.* 1987, McDonald 1992).

The tadpole is a torrent-adapted form. The head and body are flattened, dark brown above, a sandy colour ventrally. The tail is very muscular, with distinct dark and light patches. The tail fins are arched and rounded terminally, transparent with irregular pigmentation. They feature a suctorial oral-disc, larger than those found in tadpoles of the *L. nannotis* group. The mouth is surrounded by marginal and submarginal papillae, although the submarginal papillae posterior to the mouth are poorly defined, being little more than longitudinal bumps and ridges. There are two anterior and three posterior labial tooth rows (Davies and Richards 1990).

1.7.2 Distribution:
N. dayi occurred throughout the Wet Tropics Biogeographical Region between Paluma (19^0 01'S, 146^0 13'E) and Big Tableland (15^0 44'S, 145^0 18'E), north-east Queensland (McDonald 1992, McDonald and Martin unpubl. data) (Figure 7).

No population declines have been observed in populations occurring in lowland rainforests below 300 m, but *N. dayi* is now absent from all sites above this altitude (Figure 7).

1.7.3 Habitat:
N. dayi is restricted to rainforest and rainforest margins from 0-1200 m. In montane areas fast-flowing, rocky streams are preferred, but slower watercourses are also utilised. Adults are generally located on rocks and vegetation adjacent to the stream, though females have been found on large mossy boulders and tall vegetation some distance from the water (Czechura *et al.* 1987).

Tadpoles are found clinging to, or sheltering under, rocks in torrents and riffles of fast flowing rainforest streams (Davies and Richards 1990).

1.7.4 Life history/Ecology:
Breeding occurs from September to April, and numbers encountered increase sharply during this period, peaking during the summer rains (Czechura *et al.* 1987, McDonald and Martin unpubl. data).

Females may lay over a 100 large (2.3-2.6 mm diameter) unpigmented eggs with discrete egg capsules in a cohesive clump on or under rocks in water or just above the water-line (Czechura *et al.* 1987, Davies and Richards 1990).

Tadpoles from eggs laid in early summer complete development in 3-4 months, whereas tadpoles from eggs laid in late summer may over-winter and metamorphose the following summer. During the early stages of development tadpoles from a single clutch aggregate together under a single rock. This behaviour persists until the gut is fully formed, after which they disperse and commence grazing on algal-covered rocks. When disturbed they release their grip on the rocks and are swept downstream, where they shelter under rocks or in crevices. This sheltering behaviour allows the tadpoles to remain in riffles even after flooding (Davies and Richards 1990).

1.7.5 Reasons for listing:
N. dayi is one of seven species of frogs occurring in upland rainforest streams which have undergone substantial range contraction in north-eastern Queensland recently (Ingram and McDonald 1993).

N. dayi was not considered at risk as recently as 1990 (McDonald 1992, McDonald *et al.* 1991). Population declines were first noted in 1989 and have proceeded rapidly since then (Richards *et al.* 1993). A survey over the summer of 1991-1992 between Townsville and Cooktown found *N. dayi* at none of the twenty-one upland sites south of the Daintree River (Richards *et al.* 1993).

This range contraction continued, affecting sites between the Daintree and Bloomfield Rivers in 1993 (Ingram and McDonald 1993, Trenerry *et al.* 1994), and sites north of the Bloomfield River in 1994 (K. R. McDonald pers. comm.). *N. dayi* is now absent from all localities above 300 m. Populations remain unaffected in lowland sites, but these are few.

The conservation status of *N. dayi* has been defined as endangered, following the 1994 categories for the IUCN (IUCN 1994, Ingram and McDonald 1993) and vulnerable, following Thomas and McDonald, 1989 (Covacevich and McDonald 1993). A group of leading herpetologists, attending a workshop to examine the conservation status of the biota of the Wet Tropics Region, identified *N. dayi* as a critically endangered species requiring urgent conservation action (Werren 1993). The Action Plan for Australian Frogs (Tyler 1997) lists *N. dayi* as endangered. It is considered endangered despite having habitat that is well protected throughout its range within several conservation reserves (Covacevich and McDonald 1993).

The causes of the population decline remain unknown. Richards *et al.* (1993) found no evidence that drought, floods, habitat destruction or pollution by pesticides, inorganic ions or heavy metals were responsible for the population declines.

In view of the dramatic range reduction of this species, action must be taken to maintain the populations of *N. dayi* remaining at the small number of lowland sites.

1.7.6 Existing conservation measures:
The entire distribution of this species is protected within the Wet Tropics World Heritage Area, with 41.3% of known collection sites located within national parks, 47.7% within forestry reserves, 6.3% in other reserves and 4.7% on private lands. However, presence within a reserve has not prevented the catastrophic range contraction of this species. It is listed as endangered in the Queensland *Nature Conservation (Wildlife) Regulation 1994,* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.* Environment Australia and QPWS are continuing to fund research on the ecology, diseases,

captive breeding and genetics of this species, as well as monitoring sites where it formerly and presently occurs.

Figure 7. *Past and present distribution of Nyctimystes dayi* (modified from McDonald 1992).