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The importance of peripheral areas for biodiversity  
conservation: with particular focus on endangered  
rainforest frogs of the Wet Tropics and Eungella



Conrad J. Hoskin and Robert Puschendorf



Australian Government  
Department of the Environment



# **The importance of peripheral areas for biodiversity conservation: with particular focus on endangered rainforest frogs of the Wet Tropics and Eungella**

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**Australian Government**

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and assessment of whether populations are recovering from disease

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## Acronyms Used In This Report

<b>ABRS</b> .....	Australian Biological Resources Study
<b>AWC</b> .....	Australian Wildlife Conservancy
<b>EHP</b> .....	Department of Environment & Heritage Protection
<b>JCU</b> .....	James Cook University
<b>NERP</b> .....	National Environmental Research Program
<b>QPWS</b> .....	Queensland Parks & Wildlife Service
<b>RRRC</b> .....	Reef and Rainforest Research Centre
<b>TOs</b> .....	Traditional Owners
<b>WTMA</b> .....	Wet Tropics Management Authority
<b>WTWHA</b> .....	Wet Tropics World Heritage Area

## Abbreviations Used In This Report

<b>Mtn</b> .....	Mountain
<b>Ra</b> .....	Range
<b>Tbld</b> .....	Tableland

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## Executive Summary

In the 1980s and early 1990s a frog disease, chytrid fungus, spread through the rainforests of Eungella (west of Mackay) and the Wet Tropics (between Townsville and Cooktown), decimating populations of some frog species. Several species appear to have gone extinct, while others persisted in certain areas, primarily the lowlands. However, it was increasingly noticed that some of these endangered rainforest frog species appeared to be surviving well in upland dry forests adjacent to rainforest. This included the rediscovery of a population of the Armoured Mistfrog (*Litoria lorica*) on the western side of the Carbine Tableland in 2008. These observations drew attention to the potential importance of peripheral areas around the Wet Tropics and Eungella: hotter, drier habitats on the western ecotones, and isolated patches of rainforest set apart from the core rainforest areas. It was hoped these poorly surveyed peripheral areas, offering different environmental conditions, might harbor populations of missing and endangered frogs, and threatened or unknown species more broadly. This NERP project investigated these areas and found: 1. Several endangered frog species are indeed persisting better in peripheral areas than in adjacent 'core' rainforest areas, 2. These populations are persisting despite high prevalence of chytrid fungus, probably due to the hotter environmental temperatures, 3. There is evidence for recovery of frog populations in some areas of the Wet Tropics and Eungella, 4. Four rainforest frog species were not detected despite targeted surveys and are most likely extinct, 5. A reintroduction of the critically endangered Armoured Mistfrog (*Litoria lorica*) requires continued monitoring to determine whether a second wild population of this species will establish, 6. Several new species (two lizards and a frog) were discovered in peripheral areas and described during this project, and 7. Peripheral areas of the Wet Tropics and Eungella harbour unique environments and communities are vital to the short- and long-term resilience of these areas.



# Introduction

## ***Core versus peripheral areas***

The Wet Tropics and Eungella are rainforest areas of outstanding international value due to their high diversity and endemism. Much of this diversity and the bulk of the endemic species are found in the 'core' rainforest areas. These are the cool, wet, mountainous areas that (i) currently provide optimal conditions for rainforest, and (ii) have offered suitable conditions for rainforest persistence through time (Moritz et al., 2005). In the Wet Tropics, this includes areas such as the Atheron Tableland, Carbine Tableland and Thornton Peak. The core rainforest in the Eungella region, is centred on the Eungella Tableland and Mt Dalrymple. In both the Wet Tropics and Eungella regions, rainfall is driven to a large extent by the orographic effect of the mountains intercepting moisture-laden air coming off the sea. This results in fairly extensive rainforest on the eastern side of the ranges and in the coastal lowlands versus much drier conditions on the 'rain-shadowed' western side of the ranges.

The 'peripheral' areas of the Wet Tropics and Eungella are the areas of rainforest and associated habitats around the core areas. These consist of (i) ecotonal areas along the western margin of the rainforested ranges, and (ii) rainforest isolates to the west, north and south of these regions. Figure 1 shows examples of peripheral areas. Climatic conditions in these peripheral areas are less suitable for rainforest than in the core areas (e.g., drier, warmer, more seasonal), and rainforest flora and fauna is less diverse in these areas. However, far from merely being depauperate versions of the adjacent core areas, peripheral areas may be important in their own right and vital for the long-term persistence of these rainforest communities. The ecotonal areas of the Wet Tropics are poorly surveyed compared to the core areas but are known to have several endemic species and subspecies of vertebrates: the frogs *Uperoleia altissima* and *Pseudophryne covacevichae*, the lizards *Pygopus robertsi* and *Delma mitella*, and mammals including the Northern Bettong and the northern subspecies of the Yellow-bellied Glider. Further, peripheral areas offer unique abiotic (climatic and substrate) and biotic (different communities and species interactions) environments, such that populations of species present in these areas are likely under different selective pressures compared to those in the core rainforest areas (Hoskin et al. 2011; Hoskin & Couper 2013).



**Figure 1:** This figure shows an area of core rainforest (Carbine Tableland, northern Wet Tropics), and two types of peripheral habitat: an ecotone and a small rainforest isolate. Background image from Google Maps.

### **Chytrid disease, rainforest frog declines, and links to environment**

Chytridiomycosis, a disease caused by the amphibian chytrid fungus (*Batrachochytrium dendrobatidis*), has impacted frog populations globally. Many species are believed to have gone extinct primarily due to chytrid fungus and many more species have declined dramatically. Ten frog species disappeared from the upland rainforests of the Wet Tropics and Eungella during outbreaks of amphibian chytrid fungus in the late 1980s and early 1990s. Five of these species occurred only in the uplands and were presumed extinct because no individuals could be found despite intensive searches (Table 1). However, one of these species, the Armoured Mistfrog (*Litoria lorica*), was rediscovered in 2008 after 16 years of no records (Puschendorf et al. 2011). It was rediscovered at a site it was not historically known from, and, more interestingly, from a habitat it was not formerly known to occupy. *Litoria lorica* was thought to be rainforest restricted but the rediscovered population occurs in dry sclerophyll forest downstream from the rainforest on the western Carbine Tableland (Puschendorf et al. 2011).



**Figure 2:** Adult *Litoria lorica* (left) and *Litoria nannotis* (right) beside waterfall. Photo: Conrad Hoskin

This fitted a general pattern that had been observed in several other Wet Tropics frogs (particularly *Litoria nannotis* and *L. rheocola*) – that some endangered rainforest frogs appeared to be persisting better in hotter, drier ecotonal forests than in cooler, wetter core rainforest areas. The frogs are restricted to permanent streams, which are sourced in rainforest mountains, but there seemed to be an emerging pattern of species being absent at historic rainforest sites but present downstream where the streams flowed into open canopy, dry forest types. Puschendorf et al. (2011) found that the rediscovered population of *L. lorica* coexists with chytrid fungus, suggesting that at some sites these endangered species can persist with the pathogen. This rediscovery suggested that other missing frogs may well still be out there (including *Litoria nyakalensis*, *Taudactylus acutirostris*, *Taudactylus rheophilus* and even the Northern Gastric Brooding Frog *Rheobatrachus vitellinus*) but may have been overlooked because searches have focussed on rainforest and not the adjacent dry forest. Additionally, surveying chytrid at these sites may be key to understanding how frogs can survive through disease outbreaks. These ecotones also offered an assessment of whether frog populations are recovering from disease declines. A number of frogs declined dramatically during disease outbreaks but persisted in the lowlands and in ecotonal areas (e.g. *Litoria nannotis*, *L. rheocola* and *L. dayi*). Therefore, surveying sites across an altitudinal or ecotonal gradient through time offers the opportunity to assess whether populations are recovering back into upland rainforest.

**Table 1:** Rainforest frog species that declined due to chytrid in the Wet Tropics and at Eungella.

Species	Region	Pattern of decline
<i>Taudactylus acutirostris</i>	Wet Tropics	Severe – last seen 1997
<i>Taudactylus rheophilus</i>	Wet Tropics	Severe – last seen 2000
<i>Litoria nyakalensis</i>	Wet Tropics	Severe – last seen 1990
<i>Litoria lorica</i>	Wet Tropics	Severe – single population rediscovered 2008
<i>Litoria nannotis</i>	Wet Tropics	Widespread decline
<i>Litoria rheocola</i>	Wet Tropics	Widespread decline
<i>Litoria dayi</i>	Wet Tropics	Widespread decline
<i>Rheobatrachus vitellinus</i>	Eungella	Severe – last seen 1985
<i>Taudactylus eungellensis</i>	Eungella	Severe – reduced to small populations
<i>Taudactylus liemi</i>	Eungella	General decline

## Study region

This study was centred on two areas: the Wet Tropics and Eungella (Fig. 3). In both areas, surveys were conducted in core rainforest areas and in peripheral areas. For the Wet Tropics, this covered an area from Mt Elliot (halfway between Townsville and Ayr) in the south, to Cape Melville (north of Cooktown) in the north. The focal area for the Wet Tropics was the northern Wet Tropics, particularly the Carbine and Windsor Tablelands, due to historic records, persistent populations, and extensive peripheral habitats. For Eungella, surveys extended from rainforest isolates near Carmilla in the south, to isolates near Bowen and Proserpine in the north. The focal area was the Eungella Tableland.

## Aims

1. Determine the status of several 'missing' stream frogs of the Wet Tropics and Eungella.
2. Determine whether peripheral areas harbor significant populations of endangered stream frogs.
3. Survey the prevalence of chytrid in peripheral areas, and assess environmental temperatures as a possible mechanism for frog persistence.
4. Assess whether frog populations are recovering in the Wet Tropics.
5. Perform a reintroduction of the critically endangered Armoured Mistfrog (*Litoria lorica*) to establish a second wild population.
6. Survey peripheral areas for other vertebrates.





**Figure 3:** Map of the study region. Areas of rainforest (dark green) are obviously distinct from drier habitats (paler green and brown). Background map from Google Maps.

# Methodology

## *Site selection*

Surveys included both historical rainforest sites for missing and endangered species, and sites in peripheral areas. Historical sites were selected from Queensland Museum records. Peripheral sites were chosen based on being hotter, drier habitats with suitable habitat for stream frogs (particularly permanent streams). Most of these sites did not have historical frog records; indeed most of these sites had never been previously surveyed for vertebrates.



**Figure 4:** Map showing location of all sites surveyed. Red square shows the northern Wet Tropics, a focal area for this study. Background map from Google Maps.

## Surveys

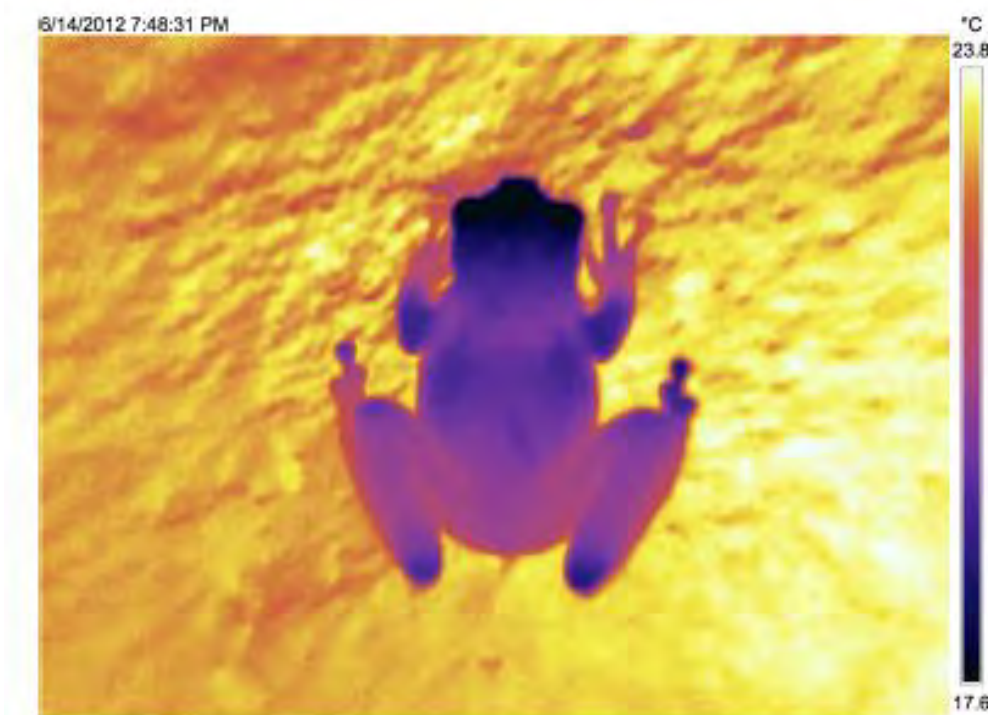
Surveys were typically 3 days/2 nights long at a site. Access was either by 4WD then on foot, or by helicopter then on foot. Surveys typically involved two highly experienced people. Surveys were primarily conducted in Spring/Summer (Sept-Feb), the ideal period for surveying stream frogs. The primary target of the surveys was, in most cases, stream frogs. A typical survey consisted of surveying a couple of kilometres of stream habitat. Ideally this involved covering a transition from dry, open forest habitat up the stream to the rainforest. Both diurnal and nocturnal surveys were conducted. A typical survey consisted of arriving at the site around lunch, doing an afternoon survey, then a night survey until about midnight, then a morning survey, afternoon survey and another night survey, and then a short morning survey before departure from the site. Most surveys were conducted in the vicinity of streams, and targeted all vertebrates. Reptiles and birds were a particular focus of the diurnal surveys, and the nocturnal surveys particularly targeted frogs. All surveys were simple searches and did not involve traps, baits, call-back, etc. nocturnal surveys were performed with head-torches for eyeshine. Additionally, automatic call recorders (Wildlife Acoustics SM2+) were deployed at two sites, Mt Lewis and Mt Bellenden Ker, the last two known sites for *Taudactylus rheophilus*. The recorders were set along streams and recorded 1 minute of sound every hour for approximately 3 months.



**Figure 5:** Robert Puschendorf (left) and Conrad Hoskin (right) swab *Litoria nannotis* on Mary Creek, western Carbine Tableland.

## Chytrid surveys and temperature measurements

The endangered Waterfall Frog (*Litoria nannotis*) was chosen for chytrid swabbing because: (i) it was the species deemed most likely to be encountered across sites, and (ii) it generally shows relatively high chytrid prevalence and intensity compared to other frogs (e.g., Puschendorf et al. 2011). Adults were captured at sites and swabbed using standard swabs and techniques (Puschendorf et al. 2011). The swabs were subsequently analysed by qPCR (by Masters student Barbara Rizzo, The City College of New York) to genetically test for both chytrid presence and infection intensity on each individual. A thermal imaging camera was used to take photos of frogs and background surfaces at rainforest and ecotonal sites. Figure 6 shows a representative photo obtained from the camera. Temperature data was extracted from the photos for a preliminary analysis of frog and rock temperature differences between rainforest and open canopy (dry forest) sites.



**Figure 6:** Thermal camera image of a *Litoria nannotis* that has emerged from cold water to sit on a warm rock after dark.

## Reintroduction

Discussions between ourselves and EHP Threatened Species Branch through the early stages of this project centred on possible management actions for the critically endangered species *Litoria lorica*. A reintroduction was deemed the best option. The aim was to move a small proportion of the adult frogs (< 10%) from the single remaining population (distributed on a stream on the western Carbine Tableland) to an environmentally similar site about 4 km upstream. These two sites are separated by a barrier of unsuitably flat stream habitat that the frogs are not likely to cross in an upstream direction without human assistance. The reintroduction site was also chosen because it is a long-term stream frog monitoring transect. The reintroduction was



performed in two phases. Phase 1 involved moving 40 adults (20 males and 20 females) in September 2013. Phase 2 involved moving another 20 adults (10 males and 10 females) to the same site in September 2014. Monitoring of the main and reintroduced populations was conducted at regular intervals throughout the NERP project (approximately every 4 months) on a 400 m long-term monitoring transect at each site. The reintroduction was a collaboration between ourselves (NERP/JCU), the Dept. of Environment and Heritage Protection (Threatened Species Branch), and the Western Yalanji Aboriginal Corporation.

## Results & Discussion

### **Determining the status of 'missing' stream frogs of the Wet Tropics and Eungella**

Three Wet Tropics frogs and one Eungella rainforest frog have not been seen for many years and are feared extinct (Table 1). However, given the rediscovery of *Litoria lorica* in dry forest habitat outside the rainforest (a habitat it was not formerly known to occur in) and the general impression that several endangered rainforest streams frog species are persisting well in ecotonal areas, we hoped to rediscover populations of these 'missing' frog species in peripheral areas. We surveyed over 50 sites, which included both historical sites for these species and sites in adjacent hotter/drier habitats. We did not find populations of *Taudactylus acutirostris*, *T. rheophilus* or *Litoria nyakalensis* in the Wet Tropics, or *Rheobatrachus vitellinus* at Eungella. The search for one of these species, *Taudactylus rheophilus*, continues with automatic call recording boxes still deployed at a historical site on Mt Bellenden Ker.

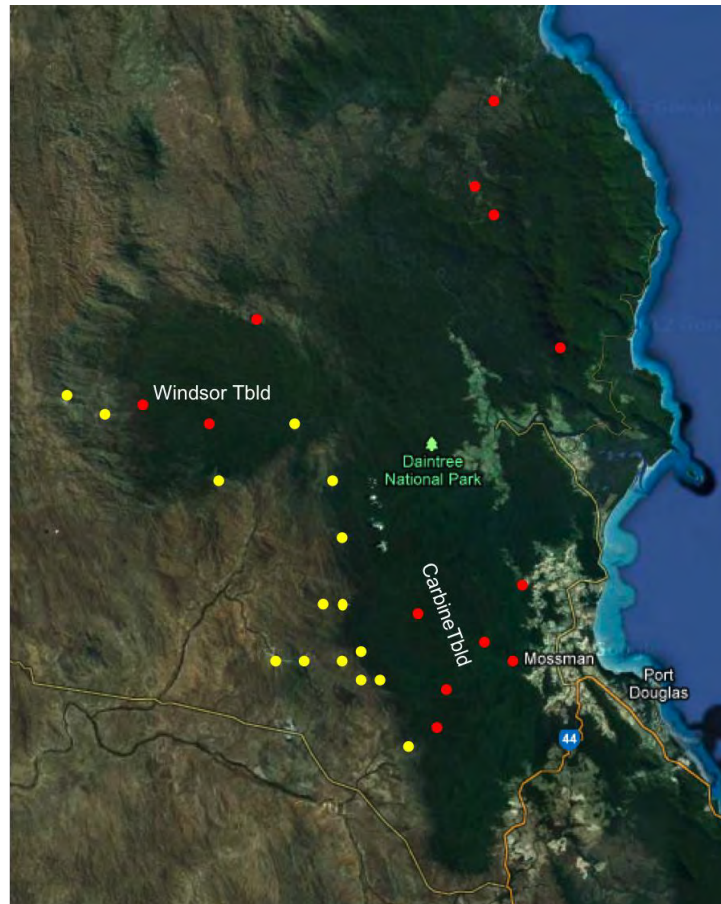
### **Determining whether peripheral areas harbor significant populations of endangered stream frogs**

Endangered 'rainforest' stream frogs are persisting well in peripheral areas of the Wet Tropics. In some areas, some species are present in high densities in upland dry forest areas, while remaining absent or at very low density in adjacent core rainforest areas. To break this down in more detail:

- Of the two types of peripheral areas surveyed (ecotonal dry forests and rainforest isolates), endangered stream frogs were found in most ecotonal areas but in none of the small rainforest isolates surveyed. Ecotonal sites with endangered stream frogs were typically within several kilometers of the rainforest margin, but endangered stream frogs were found considerably further into dry forest at some sites. For example, *Litoria nannotis* is present on lower Picanniny Ck (Windsor Tblld) about 8 km downstream of the rainforest, and the same species is present at Blencoe Falls (Kirrama Ra.) about 20 km from the nearest rainforest. The dry forest sites with endangered stream frogs were characterized by being on the western side of the range and having a permanent stream sourced in rainforest. The sites ranged from about 400 m elevation up to about 1000 m.
- Areas of particular mention for ecotonal frog populations are: 1. The western slopes of Carbine Tableland (Fig. 8), 2. The periphery of Windsor Tableland (Fig. 8), 3. The western slopes of Lamb Range, 4. The western slopes of the Atherton Tableland, and 5. Blencoe Falls, west of the Kirrama Range.
- The Waterfall Frog (*Litoria nannotis*) was found at nearly all sites surveyed. This species was found at all dry forest sites surveyed around the Carbine and Windsor Tablelands. In some cases this species was present at all dry sites surveyed in a region but none of the adjacent rainforest sites (e.g., Windsor Tableland and western Atherton Tableland).
- The Mistfrog (*Litoria rheocola*) persists at some dry forest sites on the western slopes of the Carbine Tableland. This species was not found in other regions (including Windsor Tblld and western Atherton Tblld) and has not persisted in peripheral areas as well as *L. nannotis* has. This is supported by the fact that this species was not found as far from rainforest (max. 4 km).

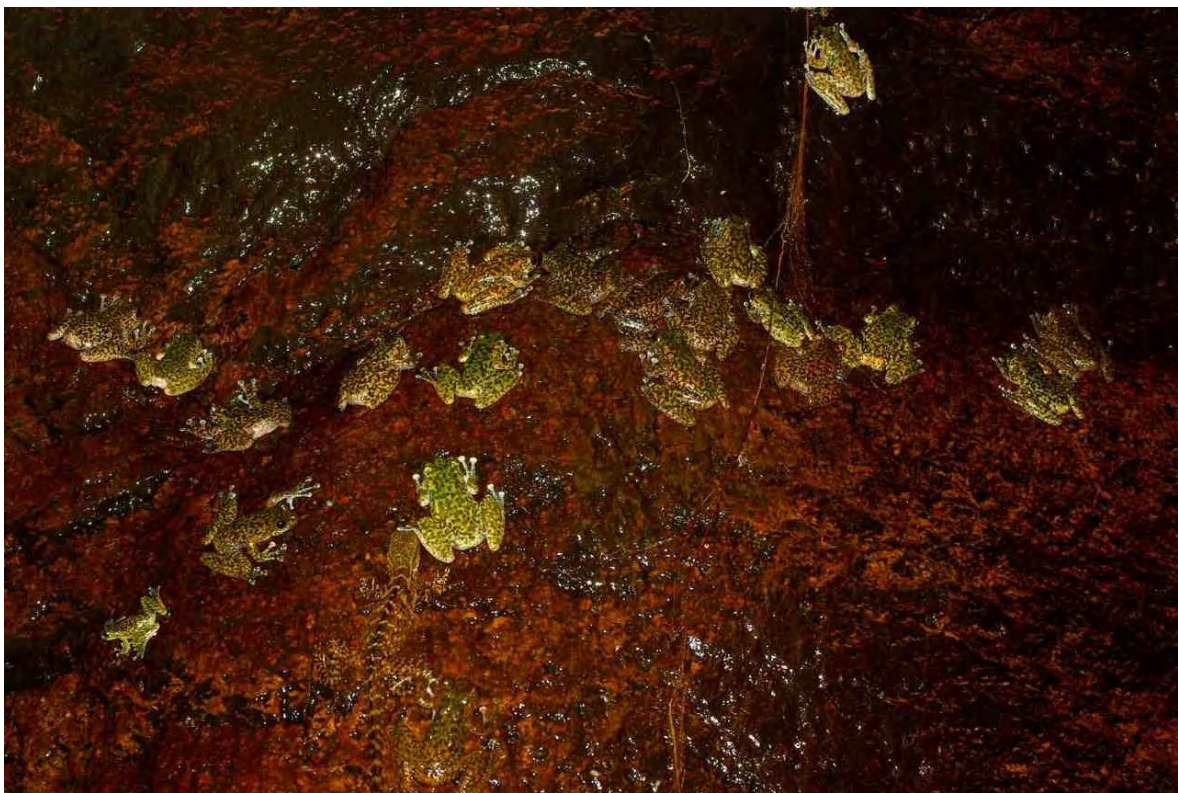


**Figure 7:** Photo of an ecotonal site, western Carbine Tableland. This is a permanent stream surrounded by open forest, and is about 5 km downstream from rainforest. The rediscovery of *Litoria lorica* occurred at this site. Photo: Conrad Hoskin



**Figure 8:** Circles show sites surveyed in the northern Wet Tropics. The primary focus was ecotonal areas on the Carbine and Windsor Tablelands. Yellow circles show ecotonal or dry forest sites that had abundant *Litoria nannotis*. This species was swabbed at all these sites and in all cases chytrid was present. The remaining sites (red circles) were primarily rainforest sites; frogs were swabbed at some of these sites. Background image from Google Maps.

- The Australian lace-lid (*Litoria dayi*) is not present in peripheral areas. This species is more rainforest dependent because females live in the rainforest canopy. In Lamb Range, *L. dayi* was found breeding in ecotonal forest but at sites very close to rainforest (typically < 500 m).
- The Armoured Mistfrog (*Litoria lorica*) was not found at any additional sites despite targeted survey effort across most potential habitat in the northern Wet Tropics. Finding additional populations of this species was the number one priority of the surveys in the northern Wet Tropics. The single known site for this species was thoroughly surveyed during this project. *Litoria lorica* was found to occupy patchy waterfall and cascade habitat along a 4 km extent of river, with a total adult population estimated at 600–1000 individuals. A long-term monitoring transect at this site revealed a decline in numbers of the period of this project but good breeding success (as measured by metamorph abundance) in late 2014.
- Peripheral areas on the western side of Eungella proved very hard to access. Surveys of peripheral isolates north and south of Eungella revealed a variety of new vertebrate records but no endangered frogs.



**Figure 9:** Abundant *Litoria nannotis* (and a water dragon) clustered on a waterfall at an ecotonal site, western Carbine Tableland. Photo: Robert Puschendorf.

**Surveying the prevalence of chytrid in peripheral areas, and assessing environmental temperatures as a possible mechanism for frog persistence**

Over 400 *L. nannotis* were swabbed across 18 sites (approx. 20/site) to assess chytrid prevalence and intensity patterns. The particular focus was ecotonal sites, particularly in the northern Wet Tropics. Analysis of the swabbing data is continuing but a summary of results so far:



- In total, across all sites, chytrid was detected on > 50% of frogs swabbed. Some sites had very high prevalence, with up to 93% of frogs infected (Rizzo et al., unpub. data).
- More frogs were infected with chytrid during winter sampling versus summer sampling. Additionally, chytrid loads were higher on frogs in winter (Rizzo et al., unpub. data).
- Chytrid was detected on frogs at 17 of the 18 sites (Rizzo et al., unpub. data). Only one frog was swabbed at the single site where chytrid was not detected, so chytrid is highly likely to be at that site too with further sampling.
- Chytrid was detected at all ecotonal sites (see northern Wet Tropics sites marked in yellow in Figure 8). On average, chytrid prevalence and loads are higher at ecotonal sites than at rainforest sites (Rizzo et al., unpub. data). This may relate to higher frog abundance at ecotonal sites than at rainforest sites.
- The continued high abundance of frogs at ecotonal sites shows they are surviving chytrid infection in these environments. Only at one dry forest site (Picanniny Falls, western Windsor Tableland) did frogs show clinical signs of chytrid disease (i.e., sick and dying frogs).
- The fact that some endangered stream frogs are persisting in the face of high levels of chytrid infection at dry forest sites supports the 'dry forest disease refuge' hypothesis (Puschendorf et al. 2011). This hypothesis suggests that the high environmental temperatures experienced by frogs at these sites (due to rocks the frogs sit on at night remaining hot for hours after sunset), chytrid does not proliferate on their skin. This is because higher temperatures are not optimal for chytrid growth and/or because frogs can clear themselves of chytrid at higher temperatures (Puschendorf et al. 2011). Preliminary temperature measurements revealed that average rock temperatures at dry forest sites were 23°C and average frog temperatures were 20°C, versus average rock temperatures of 12°C and frog temperatures of 12°C at nearby rainforest sites. These temperature differences and their impacts on the frog-chytrid ecology need further investigation.

### **Assess whether frog populations are recovering in the Wet Tropics**

Results from surveys and monitoring conducted during this project suggest that populations of some endangered stream frogs may be recovering in some regions. In particular, *Litoria nannotis* and *L. rheocola* are now present at two upland rainforest sites on the Carbine Tableland that they are known to have disappeared from during the chytrid outbreaks in the late 1980s and early 1990s. These species were also recorded at another other upland rainforest site on the Carbine Tableland that they are likely to have been formerly absent from (but no previous data exists). A similar pattern of localized recovery back into upland rainforest is also evident on the Atherton Tableland and in Lamb Range (Hoskin, unpub. data). Population recovery is a slow process, so continued monitoring of select sites is required to establish the extent of this recovery. *Taudactylus liemi* also appears to be more common in the upland rainforest at Eungella than it was 15 years ago (Hoskin, observations), but this is difficult to quantify due to lack of detailed data following the initial frog declines at Eungella.

### **Reintroduction of the critically endangered Armoured Mistfrog (*Litoria lorica*)**

A site 4 km upstream of the single known *Litoria lorica* site was chosen as the reintroduction site. This site is separated by about 4 km of unsuitably flat habitat that poses a significant upstream barrier to natural recolonisation by *L. lorica*. The site was chosen because: (i) the species would have been there pre-declines, (ii) the physical environment offers ideal habitat, (iii) the site is a permanent stream in relatively hot, open-canopy habitat (Puschendorf & Hoskin, unpub. data), (iv) chytrid disease levels and patterns are similar to the main site (Puschendorf &

Hoskin, unpub. data), and (v) the related species, *L. nannotis*, has persisted well at this site on a long-term monitoring transect (Puschendorf & Hoskin, unpub. data). Phase 1 of the reintroduction involved moving 40 adults (20 males and 20 females) in September 2013. Phase 2 involved moving another 20 adults (10 males and 10 females) to the same site in September 2014. Both phases went well and continued monitoring is revealing that frogs are surviving in good condition and some females are carrying eggs. There has been a gradual decline in *L. lorica* numbers on the monitoring transect since the introductions but it is not possible at this point to determine how much of this is due to (i) mortality, (ii) detection in the complex habitat, or (iii) dispersal off the section of stream covered by the monitoring transect. Continued monitoring is required over the next two years at least (2015, 2016) to determine whether enough of the frogs are surviving and breeding to establish a viable second wild population.



**Figure 10:** Conrad Hoskin (middle), Alastair Freeman (right, EHP Threatened Species Branch), and representatives of the Western Yalanji Aboriginal Corporation performing phase 1 of the *Litoria lorica* reintroduction, September 2013. Photo: Anders Zimny

### **Surveys of peripheral areas for other vertebrates**

Many of the sites surveyed during this project had never been previously surveyed. Our surveys revealed many new vertebrate records, including important new sites for threatened species (e.g., Northern Bettong, Spurgeon Ck, Carbine Tld; Northern Quoll, Bakers Blue Mtn, west of Mt Molloy; Red Goshawk, Starcke area; *Litoria andiirmalin* and *Cophixalus zweifeli*; several new sites at Cape Melville). Of particular note was the discovery of three new vertebrate species at Cape Melville during NERP surveys in February 2013 and December 2013. The three species discovered and described during this NERP project were: the Blotched Boulder-frog *Cophixalus petrophilus* (Hoskin 2013), the Cape Melville Rainbow Skink *Carlia wundalthini* (Hoskin 2014), and the Cape Melville Bar-lipped Skink *Glaphyromorphus othelarni* (Hoskin & Couper 2014) (Fig. 11). All three species are endemic to the Melville Range, a rainforest outlier about 170 km north of the Wet Tropics. Several other potentially new reptiles and a frog are currently under examination (Hoskin, in progress).



**Figure 11:** Photos of three new species discovered at Cape Melville during NERP surveys. Top: the Blotched Boulder-frog (*Cophixalus petrophilus*). Middle: the Cape Melville Rainbow Skink (*Carlia wundalthini*). Bottom: the Cape Melville Bar-lipped Skink (*Glaphyromorphus othelarni*). Photos: Conrad Hoskin



## Conclusions & Recommendations

- Despite targeted surveys, we did not find populations of three Wet Tropics frogs (*Taudactylus acutirostris*, *T. rheophilus*, *Litoria nyakalensis*) and one frog of the Eungella rainforest (*Rheobatrachus vitellinus*). *Taudactylus acutirostris*, *Litoria nyakalensis* and *Rheobatrachus vitellinus* should be concluded to be extinct. This is also the likely conclusion for *Taudactylus rheophilus*, pending the results from automatic call recording boxes currently deployed on Mt Bellenden Ker.
- No further populations of the critically endangered species *Litoria lorica* were found, so a reintroduction was performed to establish a second wild population. This reintroduction was completed in two phases and frogs are surviving at the new site. Continued monitoring is required over the next two years at least (2015, 2016) to determine whether enough of the frogs are surviving and breeding to establish a viable second wild population. The success or failure of this reintroduction attempt will be informative for the potential use of this management action for other critically endangered frogs.
- The open forest ecotonal areas that form the western periphery of the Wet Tropics harbor significant populations of some endangered stream frogs (*L. nannotis*, *L. rheocola*, *L. lorica*). These populations are typically more abundant than those in adjacent upland rainforest areas where they were common pre-decline, and ecotonal populations occur in some areas where species did not persist in the rainforest (e.g., *Litoria nannotis* at Windsor Tableland; *L. lorica* at Carbine Tableland).
- These ecotonal populations persist despite high prevalence and infection loads of chytrid fungus. Few frogs show clinical symptoms of disease and the frogs are likely tolerating infection due to relatively high environmental temperatures at these sites.
- The western slopes of Eungella need thorough, targeted surveys to assess whether ecotonal habitats there also harbor endangered or missing frog populations.
- There is some evidence for population recovery of two species (*L. nannotis*, *L. rheocola*) in parts of the central and northern Wet Tropics. This is particularly the case on the western Carbine Tableland where these species now occur at some upland rainforest sites they disappeared from during the initial disease declines. Continued monitoring of select sites is required to establish the extent of this recovery.
- The results of this project suggest changes in status/listing should be considered for a number of rainforest stream frogs. This includes upgrading the listing of some species and downgrading others. See Table 2 for details.
- Our surveys of peripheral areas gained many new vertebrate records, including important new sites for threatened species. Of particular note was the discovery of three new vertebrate species at Cape Melville: the Blotched Boulder-frog (*Cophixalus petrophilus*), the Cape Melville Rainbow Skink (*Carlia wundalthini*), and the Cape Melville Bar-lipped Skink (*Glaphyromorphus othelarni*).
- The persistence of endangered frogs in peripheral areas highlights the value of these areas for the short- and long-term resilience of the Wet Tropics World Heritage Area (WTWHA). Environments and species interactions are different in these areas compared to core rainforest areas, potentially resulting in a greater ability of populations in these areas to persist through, and adapt to, change. Many of these peripheral areas fall outside the



WTWHA, so management of these areas requires collaboration with parties neighbouring the protected areas of the WTWHA (TOs, AWC, cattle properties).

- This project also highlights the value of maintaining and improving links between a spectrum of habitats to enable recovery and recolonisation of species.
- Finally, this project highlights the devastating impact an introduced fungus had (and continues to have) in driving declines and extinctions of populations and species. Broadly, this highlights the importance of on-going biosecurity efforts in limiting the introduction of novel species.

**Table 2:** Current and recommended listings for threatened rainforest stream frogs. Current listings are EPBC (national) and NCA (state). Categories are: Ex = extinct, CE = critically endangered, E = endangered, V = vulnerable, NT = near threatened, - = not listed. NCA (QLD listing) does not include the category 'critically endangered'. Bold in the final column marks recommended listing that requires a change in current listing. \*Pending results for *T. rheophilus* from automatic call recording boxes currently deployed.

Species	EPBC listing	NCA listing	Recommended
<i>Taudactylus acutirostris</i>	Ex	E	<b>Ex</b>
<i>Taudactylus rheophilus</i>	E	E	<b>CE/Ex*</b>
<i>Litoria nyakalensis</i>	CE	E	<b>Ex</b>
<i>Litoria lorica</i>	CE	E	CE
<i>Litoria nannotis</i>	E	E	<b>V</b>
<i>Litoria rheocola</i>	E	E	<b>V</b>
<i>Litoria dayi</i>	E	E	E
<i>Litoria myola</i>	E	-	<b>CE</b>
<i>Rheobatrachus vitellinus</i>	Ex	E	<b>Ex</b>
<i>Taudactylus eungellensis</i>	E	E	E
<i>Taudactylus liemi</i>	-	NT	<b>V</b>

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