

Frogs of the Holbrook Region



A report for Holbrook Landcare Network regarding the results of amphibian surveys undertaken in 2012 and 2013

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Figure 1: Spotted Marsh Frog calling in a wetland in the Wantagong Valley near Holbrook, NSW. (Kylie Durant)

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Licenses and Ethics Approvals

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Table of Contents

Introduction	1
What frogs could we expect to find in the study area?.....	3
Where and how did we look?	5
What we found: frogs and their habitat	8
Biodiversity and habitat	11
Farm Dams and constructed wetlands	12
<i>Carex</i> spp. swamps.....	17
Wetlands adjacent to creeks	18
Shallow depressions.....	19
Creeks.....	20
Large complex wetlands	21
Water quality and soil health.....	23
Water quality	23
Toxins	23
Fertilisers.....	23
Connectivity	25
Recommendations	27
Site management	27
Landscape management	27
Monitoring and research	28
References	29

Table of Figures

Figure 1: Spotted Marsh Frog calling in a wetland in the Wantagong Valley	1
Figure 2: Photo of a Peron’s Tree Frog in the bathroom.	3
Figure 3: Frog, fish and fertiliser field day	5
Figure 4: Map of the sites surveyed for frogs in 2012 and 2013	6
Figure 5: The Eastern Banjo Frog.	8
Figure 6: The Plains Froglet.....	9
Figure 7: Photo of aquatic vegetation and habitat for eggs, tadpoles and adult frogs	12
Figure 8: Dams with no vegetation and pugged ground do not provide any habitat, food resources or breeding spots for frogs.....	13
Figure 9: Photo of frog eggs are laid hidden in vegetation.....	13
Figure 10: Photo of tree beside the dam at site Northeast which had several hollows.....	14
Figure 11: Photo of Wantagong Site Dam/Wetland in construction	15
Figure 12: Photo of the Wantagong Site ? Dam/Wetland in 2012	15
Figure 13: Photo of erosion control dam at Northeast Site 2.	16
Figure 14: Photo of <i>Carex</i> swamp at Wantagong site 16 and a Common Eastern Froglet.....	17
Figure 15: The Wantagong Valley contains a number of impressive wetlands adjacent to creeks such as this series of wetlands at Wantagong site 21.	18
Figure 16: Photo of a shallow depression and overflow in a cattle grazing paddock.....	19
Figure 17: Photo of a small shallow depression adjacent to North east Site 5. This tiny pond contained a number of tadpoles (Alexandra Knight).....	19
Figure 18: Photo of Wantagong site 20 on a frosty winter morning.	20
Figure 19: Painted Burrowing Frog, <i>Neobatrachus sudelli</i>	21
Figure 20: Large complex wetland north of Holbrook	22
Figure 21: Photo of gilgais. The darker patches in this landscape are gilgais.....	22
Figure 22: Giant Banjo Frog crossing Ralvona Lane, Hobrook	25
Figure 23: Photo of natural vegetated ponds at Wantagong 15	26
Figure 24: Photo of production areas with few frog linkages.....	26

Introduction

In March 2010 heavy rainfall occurred in south eastern Australia. The resulting runoff filled dry wetlands and dams and caused major flooding along creeks and rivers. As the wetlands and creeks filled, the calls of frogs arose, calls which hadn't been heard in such strength during the 11 years of the Millennium drought. The calls of breeding frogs continued to increase over the next two very wet years. Some people responded with annoyance at the noise which kept them awake at night and some responded with curiosity – what is that noise?

In response to the enquiry Holbrook Landcare Network (HLN) initiated the study that is reported upon here. The study aimed to find out what species of frogs were present on the farms of interested landholders in the Holbrook region and to gain an idea of the abundance of those frog species. It also aimed at locating less common frog species including the threatened Sloane's Froglet. The study was limited to sites within 30 km of the town of Holbrook.

Frogs appeal to many people; kids and adults are often delighted and interested to find frogs in their toilets or on their kitchen windows or tadpoles in their frog pond or dam. This project aimed in part to provide those people with information about the species of frogs that they might find and give them the ability to listen to frogs calling and identify the differences in their calls.

There is a very serious side to monitoring frog diversity and abundance. Amphibians have suffered decline around the world since the 1990s. In fact, around 30 percent of our frog species are threatened or already extinct. In Australia, 50 species or 23% are considered threatened or have become extinct recently (Hero et al. 2006).

Due to their remarkable life cycle, frogs (unlike mammals and birds) require both aquatic and terrestrial habitats. They depend on good aquatic habitat to lay their eggs and for tadpoles to grow in. They are strongly dependant on the hydroperiod; they need the water to remain in the waterbody until they are able to undertake metamorphosis. Then the adults need suitable land areas to grow, forage and use as refuge. Because frogs have moist skin which is semi-permeable and they are particularly susceptible to toxins in their environment (Mann *et al.*, 2009).

Frogs have suffered from changes to their habitat. Loss of vegetation, leaf litter and logs, changes in the length of time water is present and changes in water quality due to agricultural practices and urban pollution have all contributed to the reduction in numbers and diversity. It is considered that habitat loss due to agricultural activity is the “single most important human activity” causing lowland amphibian declines (Mann *et al.*, 2009). After habitat loss, pollution is the next major factor (Mann *et al.*, 2009). It is also possible that for many of our burrowing frogs changes in both soil structure and chemistry have affected frog diversity and abundance. Furthermore, the introduction of predators such as gambusia and carp has impacted frog populations (Kats and Ferrer, 2003; Hamer and Parris, 2013).

In addition to these well known threatening processes, frogs are also susceptible to disease. Chytridiomycosis, caused by the chytrid fungus *Batrachochytrium dendrobatidis*, has caused the decline of many frog species including the iconic Southern Corroboree Frog of the nearby Snowy Mountains (Hunter, 2007). It has been assumed that this disease has only impacted upon frogs in cooler elevated areas around the world and although it is known to be present in other frog populations, no research has as yet been undertaken to quantify or investigate the effect of the disease in other regions (Blaustein and Johnson, 2010) including inland Australia.

What frogs could we expect to find in the study area?

The region around Holbrook is potentially home to a number of different frogs as it contains a variety of habitat types, from running creeks, seeps and dams in hilly areas to large open wetlands or smaller interconnected wetlands in the flatter areas.

Two of the three major families (the Myobatrachidae or the Ground dwellers and the Hylidae or Tree frogs) of Australian native frogs were expected to be found during the surveys. The species that could possibly occur are listed in Table 1.



Figure 2: Photo of a Peron's Tree Frog in the bathroom. Peron's are often seen on kitchen windows. They were one of the frogs most commonly detected in the Holbrook study (Dirk Spenneman). Inset shows the distinctive cross in pupil (Alexandra Knight)

Table 1: Frogs potentially occurring around Holbrook, their conservation status and whether previously found in the study area (Note: whether previously found determined from examining the NSW Wildlife Atlas)

Common Name	Scientific name	Status	Previously detected in the study area
Plains Froglet	<i>Crinia parinsignifera</i>	Protected	Yes
Common Eastern Froglet	<i>Crinia signifera</i>	Protected	Yes
Sloane's Froglet	<i>Crinia sloanei</i>	Threatened	No
Spotted Marsh Frog	<i>Limnodynastes tasmaniensis</i>	Protected	Yes
Striped Marsh Frog	<i>Limnodynastes peroni</i>	Protected	Yes
Eastern Banjo Frog	<i>Limnodynastes dumerilii</i>	Protected	No
Giant Banjo Frog	<i>Limnodynastes interioris</i>	Protected	Yes
Painted Burrowing Frog	<i>Neobatrachus sudelli</i>	Protected	No
Bibron's Toadlet	<i>Pseudophryne bibronii</i>	Protected	Yes
Smooth Toadlet	<i>Uperoleia laevigata</i>	Protected	No
Wrinkled toadlet	<i>Uperoleia rugosa</i>	Protected	No
Booroolong Frog	<i>Litoria booroolongensis</i>	Endangered	No
Green Tree Frog	<i>Litoria caerulea</i>	Protected	No
Brown Tree Frog	<i>Litoria ewingii</i>	Protected	No
Broad-palmed Frog	<i>Litoria latopalmata</i>	Protected	No
Peron's Tree Frog	<i>Litoria peronii</i>	Protected	Yes
Southern Bell Frog	<i>Litoria raniformis</i>	Endangered	No
Verreaux's Tree Frog	<i>Litoria verreauxii</i>	Protected	No

Where and how did we look?

People who had previously expressed an interest in finding out about their frogs were approached by HLN to see if they would like to be involved in the project. A field day was held on 27 May 2012 (Figure 3) and the media was notified and through this others became informed and involved. In addition, some sites were included that were surveyed as part of the fish component of the project (managed by Luke Pearce of NSW Department of Primary Industries).

Sites were clustered in five general areas. There was a cluster of ten sites in the Wantagong valley to the east of Holbrook, three sites on one property to the south of Holbrook near Mullengandra, six sites to the north east of Holbrook and five sites to the north of Holbrook. There were three sites within the Holbrook township. In addition a number of extra sites within the Holbrook township were surveyed in Winter months in the hope of locating Sloane's Froglet. Figure 4 is a map of the survey sites. Table 2 gives details of the site location and type.

The approach was to survey each site three times in Autumn/Winter and three times in Spring/Summer in order to detect as many species as possible. The number of visits to each site was influenced by the weather conditions – at times it was too wet to enter sites, and then the dry summer of 2012-13 resulted in less days with frogs actively calling. Due to the conditions all sites were surveyed intensively in the Winter/early Spring period, but not all sites received intensive late Spring/summer surveying. Sites were visited in the evening and later at night in the Spring/Summer survey period. Species were identified by call. An estimate of abundance of each species was made at each site.



Figure 3: Frog, fish and fertiliser field day (Kylie Durant)

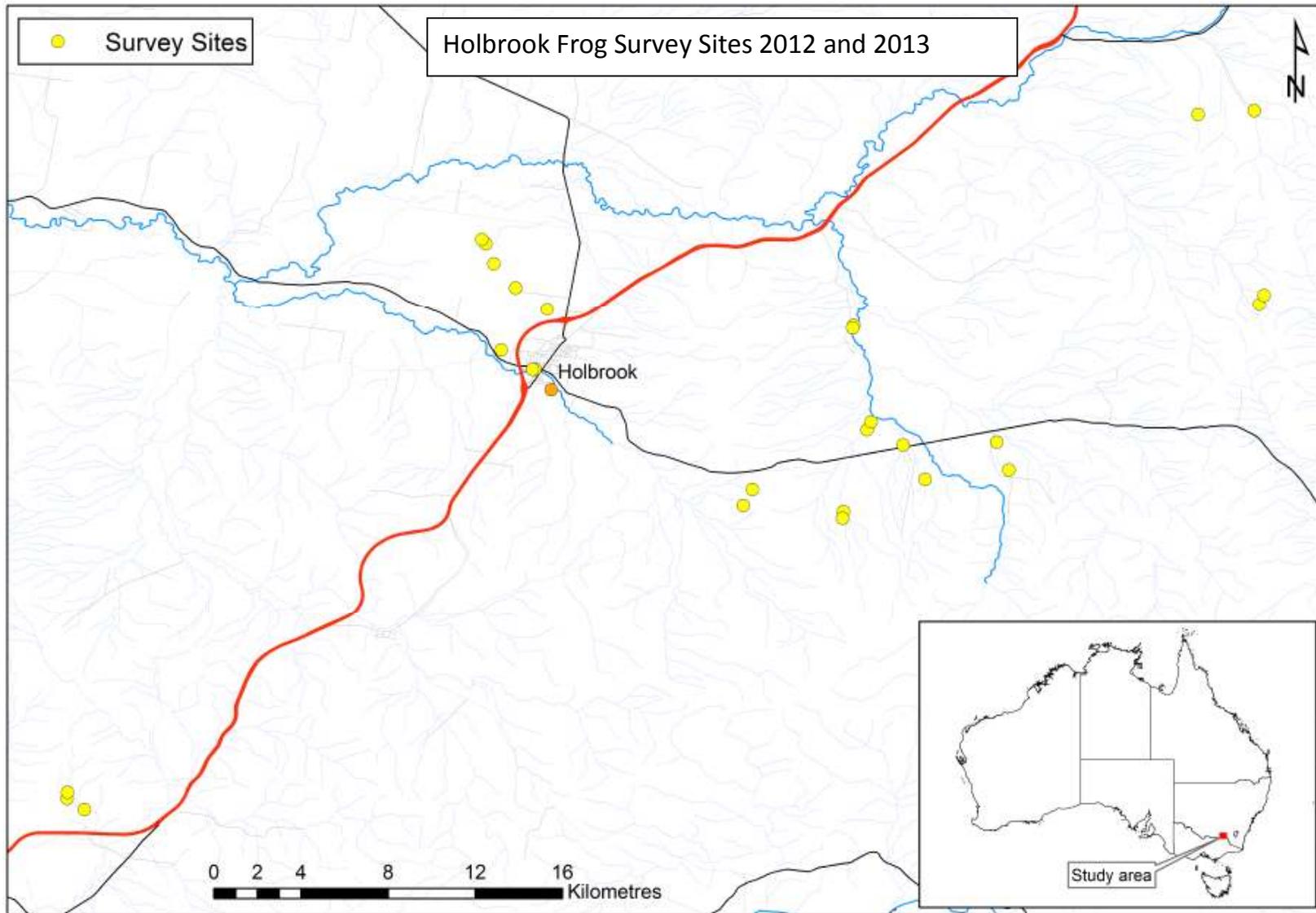


Figure 4: Map of the sites surveyed for frogs in 2012 and 2013.

Table 2: Sites surveyed, type of wetland and surrounding landuse.

Location	Site type	Surrounding land use
North east 1	Dam	Grazing
North east 2	Series of dams and small depression, erosion works	Erosion control, occasional grazing
North east 3	Natural depression adjacent to creek	Grazing
North east 4	<i>Juncus</i> spp. depression	Grazing
North east 5	Small dam	Habitat protection, occasional grazing
North east 6	Medium dam	Habitat protection
North 7	Medium dam	Cropping
North 8	Natural swamp	Habitat protection, occasional grazing
North 9	Complex wetland with gilgais, larger depressions and creek overflow	Occasional grazing
North 10	Complex wetland with gilgais, larger depressions and creek overflow	Occasional grazing
North 11	Dam	Grazing and cropping
Central 12	Creek	Recreation
Central 13	Small dam	Recreation
Central 14	Large natural waterway with shallow overflows and ponding	Habitat protection
Wantagong 15	Natural depression adjacent to creek	Grazing
Wantagong 16	Large natural <i>Carex</i> spp. shallow swamp	Grazing
Wantagong 17	Dam, constructed wetland	Habitat protection
Wantagong 18	Dam	Fenced off for water supply
Wantagong 19	Natural spring and depression	Grazing
Wantagong 20	Creek overflow	Grazing
Wantagong 21	Series of natural depressions adjacent to creek	Grazing
Wantagong 22	Dam	Habitat protection
Wantagong 23	Ephemeral creek	Habitat protection
Wantagong 24	Large natural <i>Carex</i> spp. shallow swamp	Habitat protection, occasional grazing
South 25	Large natural <i>Carex</i> spp. shallow swamp	Grazing
South 26	Dam	Grazing
South 27	Creek	Habitat protection

What we found: frogs and their habitat

Eight species of frog were detected during the surveys. The frogs found were: the Common Eastern Froglet, *Crinia signifera*, the Plains Froglet, *C. parinsignifera* (Figure 6), the Spotted Marsh Frog, *Limnodynastes tasmaniensis*, the Eastern Banjo Frog, *L. dumerilii* (Figure 5), the Giant Banjo Frog, *L. interioris*, the Painted Burrowing Frog, *Neobatrachus sudelli*, the Broad-palmed Frog, *Litoria latopalmata* and Peron's Tree Frog, *L. peronii* (Figure 2). The frogs found at each site are shown in Table 3.



Figure 5: The Eastern Banjo Frog, *Limnodynastes dumerilii*, occurred in low numbers at eight of the survey sites (Peter Robertson, Wildlife Profiles. Pty. Ltd., <http://frogs.org.au/frogs/species/Limnodynastes/dumerilii/>).

The Plains Froglet, Spotted Marsh Frog and Peron's Tree Frog were the frogs most frequently detected across the Holbrook landscape. Many waterbodies also contained the Common Eastern Froglet. The Eastern and Giant Banjo Frogs were found at fewer locations. The Painted Burrowing Frog was only found at two sites that were adjacent to one another. The Broad-palmed Frog was only found at one site in the far north east of the study area. This species is regionally significant as records from the South-western Slopes are uncommon, although it has been previously recorded at Carabost, Gilmore and Gundagai (Michael *et al.* 2008).

Despite intense survey effort the threatened Sloane's Froglet (*Crinia sloanei*) was not detected during the study. Suitable habitat for this species appeared to occur especially around Holbrook

township. The nearest known locations for Sloane's Froglet are at Culcairn and on the Bowna Arm of Lake Hume to the south (Knight, 2013). The endangered Southern Bell Frog (*Litoria raniformis*) was not detected, however survey effort for this species was limited. The summer survey season was very dry and it is known to call close to heavy rain. The endangered Booroolong Frog (*Litoria booroolongensis*) was not detected in this study; however, it is known to inhabit streams slightly further east of the study area. It is limited to specific habitat, particularly streams with rocky and cobbled bottoms (Hunter, 2007). No sites meeting these criteria were surveyed. None of the toadlets (Smooth Toadlet, *Uperoleia laevisgata*, Wrinkled Toadlet, *Uperoleia rugosa* and Bibron's Toadlet, *Pseudophryne bibroni*) were found in this study, however it is quite likely that they occur in the study area and they could be detected if further surveys were undertaken.



Figure 6: The Plains Froglet, *Crinia parinsignifera*, was widespread and common throughout the survey area (Dirk Spenneman).

Table 3: Frog species detected at each site

Site ID	Common Eastern Froglet	Plains Froglet	Spotted Marsh Frog	Eastern Banjo Frog	Giant Banjo Frog	Painted Burrowing Frog	Broad-palmed Frog	Peron's Tree Frog
North east 1		✓	✓				✓	✓
North east 2	✓	✓	✓	✓				✓
North east 3		✓						✓
North east 4	✓	✓						
North east 5	✓	✓	✓					✓
North east 6	✓	✓	✓	✓				✓
North 7		✓	✓					✓
North 8	✓	✓	✓					✓
North 9		✓	✓		✓	✓		✓
North 10		✓	✓		✓			✓
North 11		✓			✓	✓		✓
Central 12		✓		✓				✓
Central 13	✓	✓	✓	✓				
Central 14	✓	✓	✓	✓				✓
Wantagong 15	✓	✓	✓					✓
Wantagong 16	✓		✓					
Wantagong 17	✓	✓	✓					✓
Wantagong 18		✓	✓					✓
Wantagong 19	✓		✓					
Wantagong 20	✓	✓	✓	✓				✓
Wantagong 21		✓	✓					✓
Wantagong 22	✓	✓	✓	✓				✓
Wantagong 23		✓	✓					
Wantagong 24	✓		✓					✓
South 25	✓	✓	✓					
South 26		✓	✓					
South 27	✓			✓				✓

Biodiversity and habitat

A wide range of habitats suitable for amphibians is found in the Holbrook area and this study surveyed a cross section of them. 11 sites were located at farm dams or constructed wetlands, 3 sites at shallow *Carex* spp. or *Juncus* spp. swamps, 3 at creeks, 4 at wetland systems adjacent to creeks, 4 at naturally occurring complex wetlands in the flatter part of the landscape and 1 at a spring and associated shallow natural depression. This section of the report describes the habitat at each site type and the different species of frogs detected in those habitats.

Farm Dams and constructed wetlands

Most farm dams contained adequate habitat for a limited number of frog species to survive and reproduce in. The Plains Froglet and the Spotted Marsh Frog were both found to be abundant in farm dam habitats in this study.

Male Plains Froglets were most commonly found calling from *Carex* spp. clumps on the edge of the dams. Spotted Marsh Frogs were found at a range of sites including those with less vegetation. The Eastern Banjo Frog was found in both dams and creeks with deeper holes.

The small dam at Northeast 2 contained a large number of frogs and was the only waterbody in the study where the Broad-palmed Frog was detected. It contained diverse and thick aquatic and fringing vegetation.

Dams with aquatic and fringing vegetation provide habitat for more numbers and a greater variety of frog species (Figure 7) (Hazell *et al.* 2001). Shallower vegetated areas are important for most frogs as they provide opportunities for egg laying (Figure 9) and for tadpoles to feed. Dams with little or no fringing or aquatic vegetation provide few opportunities for tadpoles and frogs to feed or breed (Figure 8).



Figure 7: Aquatic vegetation provides habitat for eggs, tadpoles and adult frogs (A. Knight)



Figure 8: Dams with no vegetation and pugged ground do not provide any habitat, food resources or breeding spots for frogs (A. Knight)



Figure 9: Frog eggs are often laid hidden in vegetation (A. Knight)

Constructed dams and wetlands can play an important role in maintaining frog populations. The constructed wetland at Wantagong site 17 as shown in figures 11 and 12 provides habitat for frogs as well as many birds.

Nearby trees provide hiding and foraging places for frogs like Peron's Tree Frog which are often found sitting under the bark. They also provide opportunities for other wildlife including birds, possums, gliders and bats to nest, hide and feed (Figure 10).

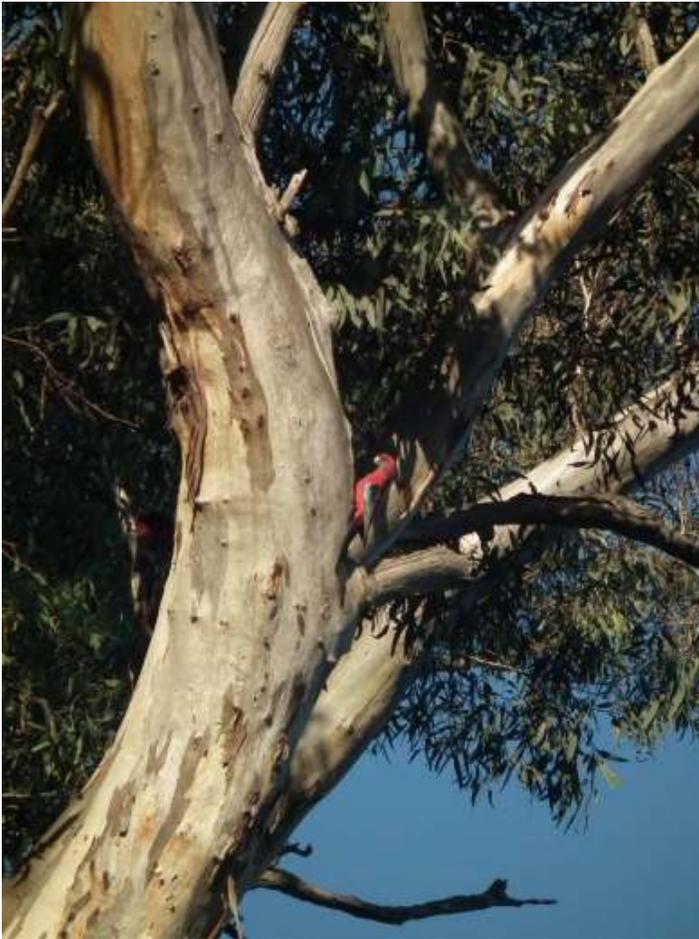


Figure 10: Many Australian parrots nest in hollows. Some species of ducks also nest in hollows. This tree beside the dam at site North east 2 had several hollows (A. Knight)



Figure 11: Photo of Wantagong Site 17 Dam/Wetland in construction (Photo credit unknown)



Figure 12: Photo of the Wantagong Site 17 Dam/Wetland in 2012 (A. Knight). Fringing reeds and *Carex* spp. provides shelter for adult frogs. Trees provide homes for Peron's Tree Frog

Dams with big open areas of water were not generally used by frogs unless there were significant shallow areas with aquatic and fringing vegetation (see Figure 13).



Figure 13: Photo of erosion control dam at North east Site 2. This dam has a large area of open water with very little aquatic vegetation. Both frog and invertebrate numbers are low (A. Knight)

Carex spp. swamps

The study area contained a number of *Carex* spp. Wetlands (Figure 14). These were generally large areas of gently sloping land with shallow surface water with a slight flow. These wetland areas were dominated by the Common Eastern Froglet. Plains Froglets and Spotted Marsh Frogs were also found in them. None of the toadlets were found in this study, however it is quite possible that they may occur in ponded areas within or adjacent to these large swamps.



Figure 14: Photo of *Carex* swamp at Wantagong site 16 (A. Knight). This large area was home for a huge number of Common Eastern Froglets (K. Durant).

Wetlands adjacent to creeks

Small moderately deep wetlands adjacent to creeks were sampled at sites in the Wantagong Valley and north east of Holbrook (Figure 15). These wetlands appear to be filled by rainfall, overland flow and groundwater recharge and thus can have a longer hydroperiod than other depressions. The wetlands surveyed contained diverse native vegetation including Water ribbons, Water milfoil, Native ranunculus and Pondweeds with various reeds including Spikerush, *Juncus* and Flatsedges and fringing *Carex*. They provide habitat for a large variety of aquatic invertebrates as well as birds and reptiles. These wetlands contained abundant frog numbers as well as a variety of species. They are important breeding locations as well as places of refuge.



Figure 15: The Wantagong Valley contains a number of impressive wetlands adjacent to creeks such as this series of wetlands at Wantagong site 21. This site contains diverse wetland vegetation and has the potential to provide a vital breeding place for amphibians. As it is already fenced it can be managed to maintain the natural values. It is recommended to remove grazing in wet times (A. Knight).

Shallow depressions

Those small and large dips found in paddocks are frequently used by frogs (Figures 16 and 17). Shallow depressions provide opportunities for frogs to move across the landscape. They also provide temporary ponds for breeding. Both the common Eastern Froglet and the Spotted Marsh Frog were located in shallow depressions throughout the Holbrook region. It is quite likely that these habitats are used opportunistically by other species at different times.



Figure 16: Photo of a shallow depression and overflow in a cattle grazing paddock in the Wantagong Valley. This depression contained large numbers of Spotted Marsh Frog and Common Eastern Froglet (A. Knight)



Figure 17: Photo of a small shallow depression adjacent to North east Site 5. This tiny pond contained a number of tadpoles (A. Knight)

Creeks

Four creek sites were surveyed in this study. Spotted Marsh Frog, Common Eastern Froglet, Eastern Banjo Frog and Peron's Tree Frog were all located at creek sites. They were found at deeper slow moving ponds in the creek or in the vegetated margins of wider sections of creeks. Creeks with large overflow areas with reeds and other aquatic vegetation can provide suitable locations for the deposition of eggs and tadpole growth (Figure 18).

Some species like Peron's Tree Frog move between creek and still water habitats. Ponds in creeks and soil moisture in riparian areas can provide important refuges in dry times for a number of species. Some species of frogs such as the Booroolong Frog (which is found immediately to the East of the study area) are limited to living only in flowing waters.

Creek and riparian management is important for frogs. Creeks with incised channels provide little opportunity for the growth of emergent aquatic vegetation resulting in a lack of habitat. The revegetation and addition of snags to creeks can create suitable frog habitat including stream-side pools and aquatic vegetation growth.



Figure 18: Photo of Wantagong site 20 on a frosty winter morning. This creek had a large area of shallows suitable for many frog species as well as ducks. It was also the site where the most possums were detected. (Kylie Durant)

Large complex wetlands

Several sites at two large, complex wetlands in Central Holbrook and just north of Holbrook were surveyed (Figures 20 and 21). These wetlands consisted of creeks or drains which overflowed and spread into surrounding vegetation, small disjunct depressions, nearby moderately deep ponds and at Site North 9 a large area of gilgais. Both large complex wetlands contained a diversity of aquatic and fringing vegetation. Within the wetlands the depth of water and hydroperiod vary greatly, providing habitat for a variety of species.

The site in central Holbrook has been revegetated and other structural components of habitat added (including logs, earth mounds and rocky areas). The wetland to the north of Holbrook is largely undisturbed and contains high quality native vegetation. Both sites contained diverse amphibian fauna. The Holbrook north site and the dam adjacent to it was the only site where the Painted Burrowing Frog was detected (Figure 19). These large complex wetlands are of high value for amphibians and other native species.



Figure 19: Painted Burrowing Frog, *Neobatrachus sudelli* (Flickr CC license: Froggy Beth, <http://www.flickr.com/photos/froggybeth/4981601159/in/photostream/>)



Figure 20: Large complex wetland north of Holbrook (A. Knight)



Figure 21: The darker patches in this landscape are gilgais. These shallow depressions fill with water seasonally and then dry out. They contained large numbers of breeding frogs and tadpoles (A. Knight).

Water quality and soil health

Water quality

Water quality samples were taken at 22 of the 27 sites. Temperature, pH, turbidity and conductivity were measured with a Horiba U-52 Water quality meter. Dissolved Oxygen was also measured but results were highly variable which may be the result of a failure of the probe. pH ranged between 6.48 and 7.47. Turbidity was highly variable across the sites and measured between 5.3 NTU and 435 NTU. Electrical conductivity varied between 0.089 and 1020 mS/cm . All of the water quality measurements were within expected ranges for the water bodies, considering the time of year and the amount of rainfall.

Several studies have tried to find the relationship between the kinds of frogs present and the water quality. These studies have generally shown that habitat, particularly aquatic vegetation, is more important than water quality (Wassens, Healy & Watts 2011, Healey, Thompson *et al.* 1997). However, it is known that poor water quality can affect tadpoles of most species (Smith, Schreiber *et al.* 2007). In addition many studies have shown that the health of amphibians is affected by toxins and agricultural chemicals. While not always leading to immediate death, some chemicals and fertilisers can affect frogs' immune systems, allowing the opportunity for diseases to affect the frogs (Mann *et al.* 2009).

Toxins

Frogs at all life stages are known to be affected by toxins in water. Pesticides, herbicides, surfactants, fertilisers and heavy metals are all contaminants that have potential risks for Australian frogs (Broomhall 2004). Herbicides such as Atrazine (in very low concentrations) have been proved to disrupt the endocrine system and alter the ability of frogs to reproduce by affecting their sexual development (Mann *et al.* 2009). Glyphosate is a commonly used chemical. Used on its own it does not represent a threat to frogs. Unfortunately it is most commonly mixed with a surfactant that incorporates POEA (polyoxyethylene tallowamine). When mixed this product has a relatively high toxicity for tadpoles (Mann *et al.* 2009).

Fertilisers

Fertilisers may be a threat to frogs, particularly when over-applied. A considerable amount of research about the effects of fertiliser has been undertaken in the northern hemisphere where researchers have found a relationship between frog declines and environmental increases in nitrates and ammonia (Shinn *et al.* 2008). Combined effects of fertilisers and other agricultural products may

have an even worse outcome. Compared with the northern hemisphere Australia is naturally relatively low in nitrates and phosphates. Changing land management practices and the increased application of fertilisers may have a strong effect on particular species of frogs and overall frog populations.

Agricultural land management practices change soil structure and soil chemistry. Many Australian frogs such as the Painted Burrowing Frog and the two species of Banjo frogs found in this study live underground when not actively breeding. They respond to seasonal conditions and may spend a long time in the ground when drought conditions occur. Fertilisers change soil chemistry which may reduce the suitability of underground refuges.

Phosphorus levels in wetlands and creeks have increased as a result of increased application on neighbouring agricultural lands. Phosphorus enters waterbodies after being transported attached to soil particles or dissolved in water. High levels of nutrients in water bodies can lead to eutrophication, decreased water quality and the increased occurrence of toxic algal blooms (Edgar and Davis). These conditions can lower the suitability of the wetland for particular frog species and for the number of frog species.

HLN's Nutrient Management Program that ran in 2011 and 2012 identified that many land owners were applying a uniform rate of Single Super Phosphate (SSP) across their property. After the program 100% of the landholders surveyed changed to a varied rate of application in response to soil testing. After soil testing 20% of landholders were able to decrease their overall SSP use while still maintaining their soil fertility needs. Actions such as these which are based on sensible productivity decisions also benefit the terrestrial and aquatic environments that frogs depend upon (HLN 2012).

Connectivity

Frogs move across the landscape, and the ability to move is essential for their survival (for example Figure 22). Like other animals the movement or dispersal of frogs allows them to find new mates which is necessary for the maintenance of genetic diversity, and can help declining populations find new breeding grounds and food sources (Calabrese & Fagan, 2004). In the highly variable climatic conditions of south-eastern Australia the ability to move is essential (Mac Nally *et al.*, 2009).

On a small time scale frogs move from creeks and ponds into ephemeral waterbodies to breed. Frogs rely on a mosaic of habitats including areas that often dry out such as shallow water and areas of inundated terrestrial vegetation as well as larger waterbodies. Over a longer period of time after dry periods or droughts frogs move from refuge areas out into other water bodies that have dried out and refilled. In agricultural landscapes such as that around Holbrook where areas of natural habitat have been reduced in size and modified and natural drainage lines and hydroperiods have been changed, linkages are especially important for the maintenance of frog populations.



Figure 22: Giant Banjo Frog crossing Ralvona Lane, Holbrook (Kylie Durant)

As with birds and mammals maintaining connectivity is important for the continued survival of native populations. Frogs are dependent on frog linkages or pathways across the landscape from creeks to wetlands to shallow depressions at different elevations. Connections between creeks and adjacent depressions such as those at Wantagong site 15 (Figure 23) provide important opportunities for frog movement. Other important linkages include vegetated roadside drains and natural shallow depressions. Elements of the agricultural landscape that may limit frog movement and survival are large areas of monoculture or pasture improved areas with no fallen timber or depressions that are ephemerally filled (for example Figure 24) and the inappropriate broadscale use of fertilisers, herbicides and pesticides.



Figure 23: These natural vegetated ponds at Wantagong 15 are adjacent to the creek and frogs are able to move between the habitat types when they need to (A. Knight)



Figure 24: Production areas like this provide little opportunity for frogs to move across the landscape. Shallow depressions and fallen timber may provide frog linkages or pathways (A. Knight)

Recommendations

Many actions that provide positive benefits for amphibians are currently being made in the Holbrook region and further actions are possible. Well managed agricultural landscapes can provide breeding, foraging and refuge sites, and linkages that are beneficial for amphibians. The following recommendations suggest actions that can be taken at the site scale; broader landscape scale planning and actions; and research and monitoring requirements.

Site management

Many sites contain good habitat for a diversity of frogs and just require occasional maintenance while others can be improved by active management as suggested below.

1. Logs and fallen timber provide important habitat for frogs and other creatures. It is important to leave some areas of timber at dams and creek sites. If it is not possible to leave fallen timber then choose a particular part of the site to leave a fallen log as refuge.
2. Resnagging creeks may help the development of shallow slow moving water areas with vegetation which provide frog habitat
3. Frogs and tadpoles need aquatic and emergent vegetation in the waterbody. Allow vegetation to grow in wetland or dam shallows. Manage your grazing so that wetland vegetation is not impacted.
4. Manage your grazing so that pugging does not occur all around the waterbody or throughout the wetland
5. When planning your riparian or wetland revegetation projects don't tree every part of the site, leave some areas more open so that frogs can bask. Consider the density of planting so that hydroperiod and flow are not adversely affected.
6. When planning revegetation projects it is important to consider including the adjacent depressions and floodplain areas that fill up with water occasionally. Frogs use these as breeding sites. Fence off areas with as much width from the top of the bank as possible.
7. Use frog-friendly chemicals, for instance choose Biactive roundup
8. Use fertilisers and chemicals responsibly. For instance do your soil testing and apply fertilisers at the appropriate variable rates (this will also reduce input costs). Check up on the best practice for your particular management activity and choose the right chemical for the job.
9. Remember that many of our frogs are burrowers and look after your soil health in areas adjacent to wetlands.

Landscape management

Developing connectivity or linkages between wetlands (farm dams and natural depressions and wetlands) and creek and riparian areas is important for the movement of frogs across the landscape. Achieving this requires good planning as well as site management.

1. Identify and manage refuges spots that frogs use in dry times or drought conditions. For instance, the two large, complex wetlands identified in this study are of high value for frogs and

other biodiversity. Providing good advice and appropriate stewardship rewards to landowners and managers of sites like these is vital.

2. Identify and manage overland drainage floodplain links that frogs may use for dispersal.
3. Identify and manage other links such as roadside drains which play a large role in the dispersal of many species. Roadside drain management is particularly important, for instance, in the areas just to the north and west of Holbrook where frogs appear to be actively moving through the drains. Liaising with Council about the management of these drains so that all the vegetation is not killed by inappropriate spraying or road works is vital.

Monitoring and research

There are huge gaps in our knowledge of Australian frogs; even basic knowledge about their distribution is limited in some cases. This project focussed on detecting frogs at sites within the immediate Holbrook region and could be extended. Finding out more about what exists in our landscape and what habitat features different species rely on is important. Equally important is monitoring our management activities and the way our native species respond to them so that we can take an 'adaptive management' approach and incorporate our learnings into future activities.

1. Undertake further frog monitoring at different locations in order to locate and protect threatened species. High priority areas include Culcairn, where there are historical records for the threatened Sloane's Froglet, and Walla Walla as the area around there contains large complex wetlands that may be a refuge for less common species.
2. Monitor frog populations at wetland sites which come under management agreements through 'Bushlinks' and other incentive programs, so that an 'adaptive management' approach can be taken to understanding and learning about the effects of management actions.
3. Develop a project to identify (and subsequently manage) amphibian refuge and linkage areas.
4. Research the relationship between the soil health and landuse characteristics in grazing and cropping areas, and the numbers and diversity of burrowing frogs, so that recommendations can be developed for the management of soil health that includes this aspect of the biota.

References

- Blaustein, A. R., & Johnson, P. T. J. (2010). When an infection turns lethal: losses in biodiversity and the emergence of new infectious diseases are among the greatest threats to life on the planet. Report. *Nature*, 465 (7300), 881 -882.
- Broomhall, S. (2004) *Frogs in an Effluent Society. Risks, Remedies and Responsibilities*. WWF Australia, Sydney
- Calabrese, J. M. & Fagan, S. F. (2004) A comparison-shopper's guide to connectivity metrics. Review. *Frontiers in Ecology and the Environment*. 2 (10) pp. 529 – 536.
- Edgar, B. And Davis, R. "Managing algal blooms in Australia" Chapter 5 in Lovett, S., Price, P. & Edgar, B. (eds) 2007; *Salt, Nutrient, Sediment and Interactions: Findings from the National River Contaminants Program*, Land & Water Australia, 2007.
- Hamer, A., Lane, S. and Mahony, M. (2002) Management of freshwater wetlands for the endangered Green and Golden Bell Frog (*Litoria aurea*); role of habitat determinants and space. *Biological Conservation* 106, pp. 413 – 424
- Hamer, A., & Parris, K. M. (2013). Predation Modifies Larval Amphibian Communities in Urban Wetlands. *Wetlands: Journal of the Society of Wetland Scientists*, 33(4), 641-652.
- Hazell, D. Cunningham, R., Lindenmayer, D., Mackey, B., Osborne, W. (2001) Use of farm dams as frog habitat in an Australian agricultural landscape: factors affecting species richness and distribution. *Biological Conservation* 102. pp.155 – 169.
- Healey, M., Thompson, D., and Robertson, A. (1997) Amphibian communities associated with billabong habitats on the Murrumbidgee floodplain, Australia. *Australian Journal of Ecology* 22, pp. 279 – 278
- Hero, J.-M., Morrison, C., Gillespie, G., Roberts, J. D., Newell, D., Meyer, E., . . . Shoo, L. (2006). Overview of the Conservation Status of Australian Frogs. *Pacific Conservation Biology*, 12, pp. 319 - 380.
- Holbrook Landcare Network (2012) *Nutrient Management Program – Review. Land management practice change as a result of the program*. Holbrook Landcare Network, Holbrook.
- Hunter, D. (2007). *Conservation management of two threatened frog species in South-Eastern New South Wales, Australia*. (PhD), University of Canberra.
- Kats, L. B., & Ferrer, R. P. (2003). Alien predators and amphibian declines:review of two decades of science and the transition to conservation. *Diversity and Distributions*, 9, pp. 99 - 110.
- Knight, A. (2013) *The distribution of Sloane's Froglet, Crinia sloanei, in southern NSW and northern Victoria: a review of historical distribution records and results from surveys undertaken from 2010 to 2013*. Institute of Land, Water and Society Report No. 70, Charles Sturt University, Albury.
- Mac Nally, R., Horrocks, G., Lada, H., Lake P.S., Thomson J.R., and Taylor A.C. (2009) Distribution of anuran amphibians in massively altered landscapes in south-eastern Australia: Effects of climate change in an aridifying region. *Global Ecology and Biogeography* 18, 575-585.
- Mann, R., Hyne, R., Choung, C. and Wilson, S. (2009) Amphibians and agricultural chemicals: Review of the risks in a complex environment. *Environmental Pollution* 157, pp. 2903 - 2927.
- Michael, D., Crane, M. Montague-Drake, R. and Lindenmayer, D. (2008) A herpetofauna survey of the Visy pulp and paper mill property, Gilmore, NSW. *Herpetofauna* 38, pp. 116 – 122.

Wassens, S, Healy, S. And Watts, R. (2011) *Optimising frog breeding responses to flooding in managed wetlands (ii) frog distributions through the Murray Floodplain. Draft Report.* Institute of Land, Water and Society, Albury

Shinn, C., Marco, A., Serrano, L. (2008) Inter- and intra-specific variation on sensitivity of larval amphibians to nitrite. *Chemosphere* 71 pp. 507 – 514.

Smith MJ, Schreiber SG, et al. (2007) Associations between anuran tadpoles and salinity in a landscape mosaic of wetlands impacted by secondary salinisation. *Freshwater Biology* 52, 75-84.