Managing Pond Breeding Frogs in the Forests of Eastern NSW

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Statement of Originality

I hereby certify that the work embodied in this thesis is the result of original research. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying subject to the provisions of the Copyright Act 1968.

I also hereby certify that this thesis is in the form of a series of published or submitted papers of which some I am a joint author. I have included at the front of each relevant chapter a written and signed statement from each co-author, endorsed by the Faculty Assistant Dean (Research Training), attesting to my contribution to the joint publications.

Francis Lemckert

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Abstract

Environmental sustainability through the successful management of the impacts of forestry related activities on native wildlife in New South Wales (NSW) is a core requirement for Forests NSW, the government authority overseeing timber harvesting in the state. Populations of all native species must be protected adequately to allow their survival into the foreseeable future. A major proportion of the timber harvesting in NSW occurs along the coast and adjacent ranges of central and northern NSW. Timber is extracted using selective logging (not clearfelling) and the impacts of this activity on wildlife ameliorated through the use of strategies such as the placement of buffers around riparian sites, and the retention of hollow bearing trees, downed woody debris and undisturbed corridors of vegetation. This region, encompassing Latitudes 30° to 34° South, is dominated by native temperate wet and dry sclerophyll forests distributed along a gradient from coastal lowlands to montane areas over 1000 m.

There are two families of anurans present in this region, the hylidae (approximately 25 species) and myobatrachidae (approximately 20 species), and are considered to have evolved in the region over at least 60 million years. Understanding of the effectiveness of protective measures requires a confident understanding of the habitat requirements of the frogs present in the forests so that they are used in appropriate locations. Presenting scientifically based information on the response of frogs to disturbances with these measures in place is also of primary interest to provide indications as to the effectiveness of these measures. Studies of pond breeding frogs in this region were undertaken to provide information on their habitat requirements and so direct the appropriate placement of the required protective measures. Tests were also undertaken to assess if there is an evident negative relationship between forestry disturbances and
the use of ponds by frogs, indicating if current protective measures are effective. Current monitoring data was also investigated to provide insights into successful monitoring strategies for frogs which will provide the opportunity to more effectively demonstrate ecologically sustainable management of frogs into the future. Finally, records available on the distributions of frogs were used to study relationships between frog records and the current protected area system to assess its value as a means of protecting the frog species in the study region and throughout Australia.

The majority of the research work undertaken was based on surveys of anurans at 93 semi-permanent and permanent ponds found in four areas: The Watagan Mountains, Bulahdelah, Wauchope and Dorrigo. Each site was surveyed on multiple occasions between 2001 and 2008, using aural and visual nocturnal searches conducted over different seasons to provide long-term information on the species using the sites. The presence and abundance of each species at each pond on each occasion was recorded as was micrometeorological data during the surveys. Each site was also visited in the day-time to collect data on variables associated with both the breeding pond and with the habitat within an 80 m radius of the site.

A basic understanding of the extent and types of habitats individual frogs use is an important first step in understanding the extent of area requiring management for ongoing conservation. Published studies of frog movements were collated and reviewed to provide data on the likely habitat requirements and patterns of habitat use of frogs. The data, obtained from a 68 studies covering 50 species world-wide, indicating that in most cases (39 of 57 studies) adults have both specific breeding and non-breeding habitats. Mean distances moved from breeding to non-breeding habitats ranged from 38-1810 m and means for different anuran families falling around 300 m.
Individuals in non-breeding habitat tended to restrict their activity to core areas (means from 6.3 m\(^2\) to 5099 m\(^3\)). This review indicated the strong need to consider both the breeding ponds and the surrounding habitat in the management of frogs.

The calling seasons assigned by field guides to anuran species present within the study region are both highly variable and often vague. Therefore an objective assessment of the calling seasons of the frogs in eastern mesic NSW was developed to more accurately determine the months during which each species is most likely to call – the core calling period – and so be best surveyed. This was defined for each species as the months that covered > 90% of calling records. The 17,461 records covering 67 species provided enough information to reasonably determine the core calling periods for 46 species. Of these, 43 had clearly definable core calling seasons centred on the spring-summer months, two called year-round and one had an uncertain calling season, but probably calls year-round. Increasing latitude usually, but not always, led to a small reduction in the core calling period. This information confirmed the appropriate timing of surveys used in this study and should improve the outcomes of future research, management, and conservation.

Micrometeorological variables such as temperature and rainfall are well recognised for their potentially significant influence on the calling activity of anurans, but this effect has been little tested in Australia. The calling records of frogs obtained through the study were compared with the micrometeorological variables temperature, humidity and (previous) 24 and 72 hour rainfall to assess how these related to calling activity. Models obtained for nine species all found calling activity to relate to at least two of these four variables. Calling showed a positive relationship with 72 hour rainfall in eight species, but no relationship for one species. Calling showed a positive
relationship with 24 hour rainfall for six species, a negative relationship for two species and no relationship for one species. Temperature and humidity were found to have a mixture of positive, negative or no relationships with calling being evident. Rainfall over the previous 72 hours appears to be the best predictor consider when planning surveys. Other factors such as social environment and circannual rhythms are likely to be interacting with micrometeorology; hence the complex results. Further work is required to understand them fully. The results do indicate that surveys undertaken for this study were suitably timed to provide good results.

Understanding if there are specific features of available habitats that correlate strongly with the presence/absence of frogs is important for managing frogs. This information may identify which breeding sites specific frogs are likely to use (or use in greater numbers) and habitat elements that may be critical for their survival. It may also provide indications of how human induced modifications may be affecting the frogs in an area. The presence/absence and abundance of anurans was recorded at 45 ponds in the Watagan Mountains, 100 km north of Sydney, and compared with 24 habitat variables. Only nine species occupied > 33% of the ponds. Canonical Correspondence Analysis (CCA) indicated there was no strong community structure. Species richness at a site was related significantly to depth and percentage emergent vegetation, but neither provided great explanatory power, based on their parameter estimates. Total anuran abundance related significantly to 12 variables that accounted for substantial variation in the data, but all contributed small amounts. Models for the four commonest species found many variables with statistically significant relationships to the frog counts, but neither pond attributes nor surrounding habitat attributes explained large amounts of variance in the data. There was little commonality in the habitat
variables significant for the four species. This study indicated that no single variable could be said to influence general anuran presence and abundance and that habitat may not play a large role in determining the presence or abundance of anurans in this system.

The initial study was confined to a relatively small geographic area to minimise differences resulting from variations in altitude, climate and geology. This was followed with a generalised linear model analysis that covered the 93 sites in the four forest blocks. The comparison with the recorded anurans and habitat also considered variation in altitude, geology and habitat types and included GIS derived variables covering more landscape habitat features around the ponds (e.g., moisture indices and solar radiation indices). Species richness increased significantly with increasing emergent vegetation and the presence of sandstone, and decreased as the Prescott Index (a measure of ground moisture), elevation and latitude increased. Total frog abundance increased with increasing emergent vegetation and pond area and decreased with elevation, pond density and the Prescott Index. No consistent patterns were evident between the anuran counts and the significant habitat variables. Pond shading was the variable most commonly related to the presence/abundance of individual species (appearing in models for eight species), followed by tree height (six species). Models explained up to 64% of the deviance for presence-absence and 48% for abundance, but usually explained < 35% deviance. Local scale variables account for 8/17 significantly related variables in presence models and 26/42 in abundance models. There was no pattern evident based on phylogeny and human disturbances showed little relationship with anuran counts, suggesting their influence was minimal.
Managing forest frogs requires consideration of multiple scales and multiple features of the environment. No one pond fits all frogs.

Not all breeding species that occur in the study area are considered common and widespread. Conservation of rare and threatened species is usually considered to be of most importance and relies on identifying their specific habitat requirements or specialisations. The heath frog, *Litoria littlejohni*, is a rarely observed threatened species confined to a limited area of the Watagan Mountains. It is protected by placing broad buffer zones around known breeding sites with little knowledge of how this might protect individuals. The distribution pattern of this anuran in the Watagan Mountains was assessed by comparing 12 habitat variables associated with 10 presence and 36 absence sites from the region. Logistic Regression Modelling indicated only that the species was more prevalent at ponds in forests with little grass cover (P = 0.0479, Beta = -0.1759). A logistic regression comparing GIS derived habitat features within 500 m of 61 presence and 20,000 randomly allocated absence sites located within the Sydney region indicated that the presence of the heath frog was positively associated with an increasing Prescott (Moisture) Index (Z = 4.22; P < 0.001) and negatively associated with increasing roughness of the surrounding terrain (Z = -3.62; P < 0.001). Using a regression tree to predict the presence of this species within an area, I classified presence sites (94%) based on a combination of the Prescott Index and Solar Radiation. However, these features provide only a very general ability to identify potential sites. The continued presence of the species at sites logged and burnt multiple times provides confidence that this species is able to cope with some degree of disturbance.
The capacity to effectively monitor populations of anurans to detect early population changes is paramount in their ongoing management. A central requirement is to regularly assess the data being obtained to determine if the program has the statistical power to detect significant changes in population size. The power of the current monitoring program for the threatened northern corroboree frog (*Pseudophryne pengilleyi*) was assessed to determine its sensitivity to detect both increases and declines in the numbers of calling males being recorded at 14 sites. Based on the data collected over nine years, the power analysis indicated that only an annual decline of 7% or greater would be statistically detectable after 10 years (cumulative > 52% decline). Being able to successfully detect a 3% annual decline over ten years (25% total decline) in this population will require sixty sites to be monitored. This increase in sites could be achieved by combining data from other monitoring programs being undertaken in the region. The northern corroboree frog has consistent and easily monitored calling behaviour, yet detecting changes in numbers of calling males is difficult due to inter-year variance in counts at sites. Developing standard effective monitoring programs for “typical” species with inconsistent calling spread over long seasons will be difficult and likely require considerable resources.

In addition to the application of wildlife management practices to maintain populations of amphibians in production forests, there is a need to ensure that species are adequately represented in protected areas (PAs) that can provide populations of animals that migrate into production forests to maintain metapopulations and/or genetic flows. The relative reservation status of anuran species in Australia was determined using the Australian Natural Heritage Tool Database (ANHAT), a very large database with multiple sources of anuran site records. The number of records for
each species inside and outside protected areas was noted, as well the number of reserves from which each species was recorded. Given approximately 10.5% of Australia is covered by PAs, a random allocation of records would result in species having a mean 10% of records falling in PAs. The proportion of records coming from reserves was greater than expected with a mean 30% of sites per species occurring within PAs. Thirty six species had > 45% of record sites in PAs and 18 species < 10% within PAs. The majority of the latter group of species are found in < 10 reserves. Relatively poorly “reserved” species occur within northern Australia or highly productive and poorly protected agricultural belts in eastern and western Australia. All forest dwelling species from eastern NSW are relatively well recorded from the PAs. Species dependent on native vegetation prevalent in agricultural areas are the most pressing conservation issue.

Forestry management practices include the use of controlled burns to reduce the incidence of high intensity and uncontrolled wildfires that threaten forest assets. The effect of these controlled burns on wildlife is widely debated. The impact of a controlled burn on anurans in the Dorrigo area was examined by comparing the trends in counts of anurans obtained at four burnt “experimental” ponds with those obtained at four unburnt “control” ponds. The analysis indicated that the trends in counts at burnt ponds and unburnt ponds did not differ. The fauna and flora of this region has evolved in an environment subjected to regular fires and the anurans present may have developed strategies to cope with low intensity fires.

Current protection of anurans in forests in NSW are based around the retention of areas of undisturbed habitat, with an emphasis on protecting ponds and the adjacent 20-30 m band of vegetation. Linkage corridors of undisturbed vegetation are also required for
migration. For threatened species, larger protection zones are usually set in place, often specifying the exclusion of fire as an important element in conserving species. Hydrology research indicates that 20-30 m buffer zones around breeding sites will protect water quality and such buffers will also protect individuals engaged in reproductive activities. Such a band will not provide significant protection to the surrounding forest that is used as non-breeding habitat and, where there is genuine cause for concern in regard to negative impacts of forestry activities on a species, this buffer should be expanded to a minimum 300 m. However, the studies on habitat relationships indicate that anurans in the region do not have specialised habitat requirements that may become unusable through disturbance and there were no obvious negative relationships between logging, fire or grazing and the presence/absence or abundance of anurans. In general, anurans appear to be relatively robust to the types of forest habitat modification resulting from selective logging and buffer zones greater than 20 m are not likely to be required to maintain populations in such an environment. Species with narrow habitat requirements, such as rainforest/wet forest specialists, may be the exception to this and require consideration in management plans.
Preface

Amphibian declines have been noted throughout the world from the 1980s onwards (eg, Blaustein and Wake 1990; Pechman and Wilbur 1994; Stuart et al. 2004). These declines have often been very severe and led to the extinction of entire populations and even species. The cause of these declines has been widely debated and a number of theories were put forward initially to explain these declines including UV radiation, chemical pollution and disease (Blaustein et al. 1994; Collins and Storfer 2003; Sparling et al. 2003). Ultimately, the chytrid fungus appears to have been the likely cause of many declines (Daszak et al. 1999; Daszak et al. 2003; Lips et al. 2005; Lips et al. 2006). However, other declines have been attributed directly to human actions such as vegetation clearance, habitat modification and the introduction of predators and competitors (see Stuart et al. 2004). Hence, at a local scale, human actions that alter the environment remain as important considerations in the management of amphibians around the world.

Declines in Australian anurans have been no less dramatic than in the rest of the world with several species becoming extinct or presumed so (Osborne 1990; Tyler 1991; Richards et al. 1993; Campbell 1999). Chytridiomycosis remains the likely primary cause in many instances (Berger et al. 1998; Daszak et al. 2003), but habitat modification is also considered likely to be a contributing factor in at least some instances (eg, Ferraro and Burgin 1995; Gillespie and Hollis 1996; Lemckert 1999; Hazell et al. 2003). Actions to ameliorate the impacts of human activities have been proposed in a number of government policy documents and generally revolve around the retention of areas of undisturbed habitat for use by disturbance-sensitive species of frogs (eg, Lemckert and Morse 1999, DSE 2009).
Forest harvesting is one human activity that has often been suggested to be a significant threat to amphibians (e.g., Corn and Bury 1989; Bury et al. 1991; Welsh and Lind 1991; de Maynadier and Hunter 1995; Dupuis and Steventon 1999; Ashton et al. 2006). Potential impacts from timber extraction could occur through several sources (reviewed by Lemckert et al. In Press). There may be direct mortality during logging operations through the crushing of animals by machinery or falling trees. Individuals that survive the initial operations may suffer through exposure to environments with reduced moisture regimes, reduced suitable shelter opportunities (from both climate and predators) or reduced prey availability. Fires that are used to either promote regeneration or reduce the incidence of wildfire are thought to kill individuals. There are concerns over declines as a result of inappropriate fire use. Increased erosion and subsequent silt loads entering streams as a result of fires, clearing or road construction and use threaten the tadpole stages of forest dwelling anurans.

Whilst forestry activities may have contributed relatively little to recent declines, reduced population sizes require that forestry impacts be minimised if species sensitive to disturbance are present. That is because smaller populations of anurans are more prone to extinction (Carlson and Edenhamn 2000; Green 2003) and the increased distance between extant populations will reduce opportunities for recolonisation from nearby populations. The Forestry Act of 1916 specifically requires that species are maintained in the presence of forestry activities and the loss of already reduced populations through such activities could contribute directly to this outcome. Hence it has been my role to provide information on which species may be sensitive to disturbances and how to protect them where this is known or is likely to be the case.
The potential impacts of forest harvesting on anurans are well recognised, but the actual level of impact is not well understood for most species. Indications are that only species with more specialised habitat requirements are sensitive to timber harvesting (Dupuis and Steventon 1999; Lemckert 1999; Wilkins and Peterson 2000). Nevertheless, these concerns have lead to the development of various protective “prescriptions” being applied in production forests throughout Australia (eg, Lemckert and Morse 1999; DSE 2009) that are emplaced to protect resident individuals from serious impacts. Notably however, the value of these prescriptions in protecting the resident species is not documented nor have the likely values been explored in most instances through an assessment of how they meet and protect the requirements of the target species. Therefore, protection of anurans in the forests has proceeded with a large degree of uncertainty. The provision of more specific information on the habitat use patterns, critical habitat requirements and actual assessment of impacts of activities on forest dwelling anurans would greatly assist in developing the most effective conservation strategies possible.

This thesis is based around my work as a research scientist for Forests NSW, the authority overseeing timber production in New South Wales. I have been investigating various aspects of the ecology and management of forest dwelling anurans in New South Wales in order to provide scientific evidence to guide management actions and strategies that effectively protect species whilst allowing for continued timber production, if possible. Hence, I have undertaken research into several areas requiring information to assist in better management of frogs in forestry environments. These include:
a) Studies of the basic ecology of species requiring information to develop appropriate protective measures.

b) Research into the broader habitat requirements of anurans to guide the general protection of individuals in forests, which has included assessing the likely relationships between different types of habitat disturbances and anurans.

c) Developing effective monitoring programs for use in managing anuran population into the future.

One consequence of my studies being directed to meet the needs of Forests NSW has been the requirement to produce work outcomes as rapidly as practical, publishing the results where possible to indicate their general acceptance using the external peer review process. Hence, the projects and papers that I have undertaken and produced are necessarily narrower and briefer than would have been preferred in a normal research sense. This also has resulted in a series of studies that cover a broad range of research areas rather than focusing on only one or two elements. I would rather have been able to consolidate them into larger bodies of unified work, but this did not meet the needs of Forests NSW and NSW DPI.

A significant challenge that I faced in this work was the requirement to conduct research in the “natural” forest environment that is a very complex and relatively uncontrollable system. I did not have the opportunity to develop classical types of experimental design, where one factor alone is looked at in a research context. Such an approach provides relatively unambiguous results and a much easier scientific framework for decision making. Rather, I have been required to conduct inferential research in environments where there has been variation in multiple factors that may
influence the presence and/or abundance of species. This has led to the production of very complex data sets that have required the use of newer statistical approaches to interpret more effectively. The interpretations have sometimes been relatively complex, but these analyses provide critical information on the habitat requirements of anurans and the potential for human activities to impact them.

Another consequence has been the need to collaborate with others to bring in expertise that I was not able to develop myself with my additional commitments. This was particularly the case with the statistical analyses and I acknowledge my collaborators through their inclusion as co-authors on papers.

This thesis is presented as a series of papers, all except the last of which has been submitted or published. The successful publication and acceptance of this research into the broader scientific literature is essential to ensure its uptake into the management strategies implemented for frogs in NSW, Australia and worldwide. The result is a certain degree of repetition of information, particularly in regard to introductory material and methods. The opening chapter is a review of studies of the movements of frogs. These provided detailed information on the movements and habitat use of individuals of a wide range of species and allowed me the opportunity to look for general patterns in habitat use that indicate the extent of areas required for the day-to-day existence of anurans. They also indicate the range and extent of habitat requirements that different types of frogs possess and which will require specific attention by land managers. This paper highlights the critical need of complementary breeding and non-breeding habitats for most amphibians.

The next two chapters provide basic information on the calling activity of male anurans that is critical to ensure that effective detection and counts of species are
undertaken. Available general field guides almost always provide only vague descriptions of the calling seasons and these often differ between field guides. However, a proper understanding of the preferred calling times of a species is critical as searches at inappropriate times will result in non-detection of species that are actually present. This in turn leads to a failure to properly identify species habitat relationships or detect species when required. Chapter 2 provides an objective assessment of the calling seasons of frog species in the regions where the broader habitat and ecology research was undertaken. This investigation collated records from a wide range of sources, including this PhD work, followed by a tight defining of calling seasons based on the monthly distribution of the calling records. Most species have distinctive periods of the year when calling is most likely, or unlikely, to occur. Similarly, Chapter 3 tackles the important related question of what micrometeorological (weather) factors affect the calling activity of male frogs. Knowing which aspects of the weather relate significantly to calling activity is important to ensure that presence/absence surveys will be effective. The outcome is that both papers will provide more objective information on which to base the timing of anuran surveys for monitoring and management.

The next three chapters investigate if the presence and abundance of anurans can be linked to the habitat available in and around the ponds I have studied. I have conducted research to determine what elements of habitat may make a breeding site important to a given species or provide breeding opportunities for larger numbers of individuals and species. I start with a small project looking at the community of pond breeding frogs in a relatively small geographic area (25x45 km), providing a view of habitat features associated with breeding sites that is relatively unaffected by broader geographic
variation. The second similarly assesses how the different species in pond breeding communities vary in relation to the available habitats, but uses sites on a much broader geographic scale (Gosford to Dorrigo, distance of some 500 km and altitudinal gradient of over 1000 m from near sea-level to high montane areas). This study also includes variables derived from GIS models that provide broader scale information about the ponds and terrestrial habitats and suggest at what scale management may be most critical. So, the two studies, which essentially cover the same species, provide different sets of variables that may be important in the analyses. Both chapters also provide indications as to how human disturbance of the forest environment may alter species abundance or community structure and so provide impact assessment.

The third chapter in this group (Chapter 6) looks at a singly species, *Litoria littlejohni*. This is a rarely recorded frog that, in addition to using permanent ponds, also uses ephemeral sites that were not otherwise included in analyses and so contrasts with the species included in the first two papers. It is a species of special interest to Forests NSW and the paper looks to provide an indication of how the species may best be managed, but also demonstrates the difficulty in testing for habitat relationships with rare species.

The main point of conducting these studies is to demonstrate the variation or similarities in critical breeding habitat requirements of various anurans to provide a better overall understanding of managing a diversity of species. Can one or only a few types of breeding sites successfully accommodate all species within an area or is a diversity of breeding sites essential? The latter is the case if all species are to be managed, but a small subset of ponds may accommodate most species. This information then guides land managers in determining if specific ponds have greater
importance for protection and if managers can create ponds, for any number of reasons, which will most benefit the local anuran fauna.

Chapter 7 is a critical step in our long-term management of anurans, looking at the requirements for developing an effective monitoring program. The case study covers monitoring data for the northern corroboree frog, *Pseudophryne pengilleyi*, and undertakes power analysis to determine what levels of change could be detected by such a program, given the evident variability in the data. This provides a model for assessing the ability of any monitoring program on anurans to detect changes that should be applied when commenced. Perhaps of most importance, it demonstrates the extreme difficulty faced in using counts of calling males to effectively monitor overall population sizes of frogs because of the much greater variability in their calling activity. This makes detecting changes in such populations extremely difficult. Only careful planning backed with appropriate analysis is likely to allow such programs to be effective, but they remain critical for long-term conservation through adaptive management.

Chapter 8 takes a broader of the management of anurans, looking at how well they may be represented in the reserve systems throughout Australia, with particular emphasis on southeastern Australian species. The aim of the national reserve system is to provide a level of habitat protection that will allow the majority of species to survive in these areas alone. If this is achieved, the reserve system can then act as a stand-alone system for the conservation of species in perpetuity and as a source environment to provide recruits to colonise adjacent areas of habitat where extirpations have occurred. This may be particularly valuable where areas adjacent to the reserve system are able to be rehabilitated (eg, farmlands) and so may again sustain populations of anurans.
Chapter 9 provides a field study of the response of anurans when their environment is impacted by a human activity. This paper compares count data obtained for frogs at ponds before and after a control burn, determining if changes occurred as a result of a low intensity fire. This was an opportunistic study resulting from the burning of vegetation around monitored ponds and provides experimentally based information on the impacts of fire on forest frogs.

The last chapter considers the management of pond breeding anurans in forests based on the information and insights gained through this work. I review the likely value of current prescriptions that are used given this information and suggest how frogs may best be managed in forestry areas under selective logging regimes.

Presented below are the details of the papers that have been produced as a result of this research and form the subsequent chapters. Dr Michael Mahony is my supervisor, but has not appeared as an author on all papers. This is because I have completed much of the research relatively independently and as specified to fulfil my employment and, whilst Dr Mahony provided some discussion of the work, did not contribute directly to it. Trent Penman and Andrew Haywood provided significant input into the analysis of various data-sets so have been included in the authorships of papers. I recognised the efforts of my assistant at Forests NSW, Tracecy Brassil, in helping to collect, store and manage the data through authorship on two papers. Finally, Cameron Slatyer and Dan Rosauer are co-authors on one paper as they provided access to a data set that I could not otherwise obtain, including providing me with the data exactly as required.
Chapter 1.


Chapter 2.


Chapter 3.


Chapter 4.


Chapter 5.

Lemckert, F.L. & Mahony, M.J. (Accepted). The relationship between multiple-scale habitat variables and pond use by anurans in northern New South Wales, Australia. *Herpetological Conservation and Biology*.

Chapter 6.

Chapter 7.


Chapter 8.


Chapter 9.


Chapter 10.

Management of pond breeding frogs in the selectively logged forests of coastal New South Wales.

References


