Nature on the brink: The importance of urban ecology

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One of the considerable challenges in the development of the Homebush Bay industrial area and associated precincts in preparation for the Sydney Olympics was the protection and restoration of habitats that for several historic reasons had been isolated and provided a refuge in the heart of the Sydney metropolitan area for numerous threatened species and ecological communities. One species that occurred at the site was the threatened green and golden bell frog, but in a perverse way this species occupied disused industrial habitats. Most developments at the site were in the degraded industrial lands, and a program was necessary to create and restore habitats for the frog in the proposed parklands. While this objective was achieved by the time the Olympics occurred it became apparent that the long-term security of the population was uncertain. The largest issue was that many created wetlands were initially successful but gradually not used by the frogs, and others not used at all. Studies were undertaken to investigate the ecological reasons and threats to the population. Studies of the structure of the population found that there was a low number of adult females, and thus low reproduction. Thus investigations focused on the cause of low female survival and means to mitigate the impact of habitat loss by additional habitat construction.

These studies, undertaken on one threatened species, are considered in the context of the role and importance of urban ecology in providing a link between the broader human population and the challenges facing most natural systems and species.

Urban ecology and species adapted to human modified environments

Wildlife in the city, or urban wildlife as it is most commonly called, is the subject of numerous ecological studies, not least because ecologists are keen to understand the adaptations and behaviours that enable some animals to survive and thrive in the human dominated landscapes, where so many others cannot. There is a great deal to be learnt about the pace of natural selection and adaptations that these successful native survivors or invaders have made. A primary question is whether they were pre-adapted, with natural physical features and behaviours that enabled them to fit right in with human habitats, or whether rapid selection enabled them to survive. There are also some cases where fauna persist in small remnants with natural habitats within urban landscapes, and there is no particular adaptation to human impacts. This is contrasted with the inability of many native species to make this transition and which rapidly disappear as human habitats expand. There are also the in-between species, those that can survive in the back yards and gardens of the suburbs but gradually succumb to more intensive human habitation.

There are common links between the study of urban ecology and invasive species biology, whereby one great interest is in trying to address what are the biological features that enable some animals to occur almost everywhere man is. Among these animals are those that are commensal with man, the domestic pigeon, the black rat, the house mouse, the Indian myna, feral cats and foxes, the honey bee and of course the brown cockroach, and many more. Also there are those invaders that do not need human constructed habitats, such as the cane toad, carp, rabbits and pigs. What do all these animals have in common that make them successful invaders? These are representatives from the major groups of vertebrates and invertebrates, and of course this list is not comprehensive. For an Australian, a trip to urban habitats in the northern hemisphere will usually delight us with the sight of squirrels going about their daily lives in urban parks and gardens. Undoubtedly they are cute, however, thank heavens they were not successfully introduced to our shores. I presume foreign visitors to Australia are equally delighted to see brush tailed possums and magpies in Hyde Park Sydney, or water dragons at Roma Street in Brisbane.

There are several answers to the question of reasons for success. Among them must be the capacity of individuals to find suitable food and habitats to shelter, in this regard they can be described as generalists, capable of obtaining nutrition from a variety of sources, being able to seek out the novel sources (bread crumbs and chips!). As a group their behaviour can be described as alert and wary. They can avoid the obvious physical disasters such as vehicles and roads. Typically, they have a high reproductive capacity. Most importantly, and often not considered, is that when introduced, they escaped their natural predators, parasites and diseases. They are living in a new world without the enemies they had co-evolved with and that in many cases kept their populations in check.

Urban habitats are displacing natural habitats

Sydney Olympic Park and the bell frog

What has all this to do with Sydney Olympic Park? For over two decades I have been involved in one way or another with efforts to ensure that the local population of the native green and golden bell frog (*Litoria aurea*) continues to thrive. The irony is that this frog survived in a post-industrial landscape in the middle of the metropolis of Sydney, yet it had declined from many country areas with open grasslands and wetlands. Here we have one of our most beautiful frogs living in the heart of a great metropolis. Whether by accident, good luck or specific features of the local landscape, the population survived in habitats at Sydney Olympic Park and this history has been presented in the past (Darcovich and O'Meara 2008). This history is important when considering how to maintain that animal-habitat connection, and is part of the considerable challenge to provide for on-going persistence. I could discuss a swag of reasons as to why it is important to protect such populations, and there are books devoted to the philosophical arguments (Ehrlich 1988, Wilson 1988, Wilson 2016), however I will consider only two here. First there is the scientific value that comes from investigating urban wildlife, and second how these animals and habitats provide a unique opportunity for humans whose life is concentrated around urban landscapes. Surprisingly these two very disparate activities go hand in hand since these habitats are places where urban dwellers can gain some sense of nature, its beauty and fragility, while the scientific study seeks to understand the biological answers as to how these remnant populations survive amidst the intense pressures of human activities. It is possible that these habitats and animals will be the only direct exposure that many urbanites have to the greatest dilemma that faces our planet – the wave of species extinction that is occurring almost everywhere.

In 1988 one of the greatest conservation writers of our time E O Wilson wrote: “The one process now going on that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats. This is the folly our descendants are least likely to forgive us.” Like those that warned of climate change and its economic impacts and environmental consequences, there are those, like Wilson, who have been pointing out for decades that we are on a trajectory to disaster as we destroy the natural systems and species of our planet.

Green and golden bell frog

Perhaps the bell frog is the only frog that a child and adult of the urban landscape can see and marvel at. It is not through the glass at a zoo, or on a lavishly filmed documentary, it is there in the reeds, basking in the sun, just next to the boardwalk. On a warm summer night it can be heard singing - well that is a bit of an exaggeration, a bit more like a moaning dirge. Can this be the beginning of a greater appreciation and understanding of nature, an appreciation that may change how individual by individual we approach the broader dilemma of preserving life itself? Hopefully it will it stimulate some to go

CASE STUDY 1:
Creating and restoring habitat for the threatened green and golden bell frog

The use of habitat offsets to mitigate the impact of development on threatened species is an approach adopted by planning agencies. However, this policy is contentious with most ecologists warning that creation of habitat is complex and restoration may take many years. Despite a plethora of theoretical work on the requirements of habitat offset to achieve no net loss, there are very few examples of successful habitat offset programs and monitoring regimes to detect success. The concept of no net loss is itself controversial since in most cases it is a mathematical impossibility to provide habitat for one species that is not habitat for others. There is always a loser. The objective is to restore land that has been degraded or not useful for natural purposes. The example of restoration of disused industrial land, such as occurred at Homebush Bay, is one such case.

Our study was one of the few to provide empirical evidence of the efficacy of applying no-net loss in conservation planning situations.

The problem of habitat loss

Loss and alteration of habitat has resulted in the reduction of species at the local, national and global scale and these factors are listed as the most common cause of species decline. Though the large-scale clearing of natural habitat for agriculture has recently declined in many developed countries, industrial and urban development continues to endanger many species and habitats over a wide geographical area.

The effectiveness of habitat offset has been widely debated, as the quality and extent of offset and level of monitoring and review are often insufficient to ensure that successful offset has been achieved. The creation of habitat is made difficult by the level of uncertainty in the eventual outcome of the program. Though created habitat can resemble the composition of existing habitat, certain ecological processes can be difficult to restore, possibly reducing the compatibility for the target species or community. A time lag is also expected between the creation of habitat and habitation by the target species, as resources require later-stage succession. This can result in some developments proceeding before the offset habitat has the capacity to achieve no net loss. This time lag is pronounced in certain habitat such as woodlands and some grassland, but can be rapid in highly dynamic or transient systems, such as mudflats, salt marshes and freshwater wetlands. The uncertainty of success for the development of offset habitat has resulted in some broad recommendations for its implementation.

Restoration principles applied in no net loss

Two of the major recommendations concern the size and location of habitat offset projects as a means of increasing the probability of creating the ecological processes required for success. A high offset ratio, where more habitat is created than lost, is recommended for species with a risk of failure. Under this circumstance, a small proportion of success within created habitat may still achieve no net loss as a large quantity of habitat is created. The second recommendation is to build offset at a close proximity to the lost habitat in an attempt to maintain the original composition, increase the probability of colonisation and to incorporate localised habitat characteristics or ecological processes. The third recommendation is to delay development so as to allow succession of offset habitat to achieve no net loss. However, the slow succession of some environments and the economic value of some developments to society mean that many developments proceed before this is achieved, and therefore management of the offset habitat is often neglected.

Theoretical solution

The intention of habitat offset is to achieve 'no net loss' or ideally lead to a 'net gain' in the conservation value of an area impacted by development. For habitat offset concerning a single threatened species, this usually means no loss in population size or viability through the actions of a development.

Case study at Sydney Olympic Park

We examined the population of the threatened green and golden bell frog (*Litoria aurea*) at Sydney Olympic Park which was impacted by development through the removal of nine ponds. Development was concurrent with habitat offset and construction of a large number of ponds which resulted in a 19-fold increase in available pond area.

Our findings

Through the use of demographic surveys, the population size was determined pre- and post-development. Despite the creation of ponds in the immediate vicinity of the development there was a decrease in the pond area and a measured decline in the population located within the area where the development occurred. However, the overall pond construction program also involved the addition of considerable habitat away from the immediate vicinity of the development which resulted in a 19-fold increase in pond area and an approximate 1.2–3.5-fold increase in population size. No net loss in population size to 95% confidence was achieved only when including all pond construction. This study demonstrated that to achieve no net loss for a habitat offset program can require extensive levels of habitat creation with intensive monitoring to detect it.

Conclusions

Our study showed that habitat offsetting was successful in achieving no net loss through the creation of large areas of habitat. This could be successfully evaluated with the use of long-term data that was collected for the target populations prior to and after a development that resulted in the loss of habitat. This case study highlights the complexity of dealing with habitat offsets for a species which is perceived to be 'straightforward' based on its biology and habitat requirements, and demonstrates that the level of effort required to successfully construct and monitor habitat offset may be drastically underestimated for most infrastructure projects.

Habitat offset projects have the capacity to contribute to conservation efforts when successfully implemented if they achieve net gain. However, habitat offset aimed at achieving and detecting no net loss can only be successful where the offset ratio is large, monitoring is long-term, robust and precise and funding is available to substantially increase the amount of habitat if monitoring indicates that this is necessary.

This is the major short-fall of most offset programs, and this study illustrates that even for species that are perceivably ideal for habitat offset, a large amount of effort is required for successful outcomes.

For more detail see:

Evan Pickett, Michelle Stockwell, Deborah Bower, James Garnham, Carla Pollard, John Clulow, and Michael Mahony. (2013). Achieving no net loss in habitat offset of a threatened frog required high offset ratio and intensive monitoring. *Conservation Biology* 157:156-162.

further, to delve into the deeper consequences of extinction and become advocates for a greater appreciation?

There is nothing that makes the bell frog more or less important than any other frog, just like there is nothing that makes the koala more or less important than a small marsupial mouse. Their survival is equally important. However, the koala stands as an icon, a flagship, a visible sign of what is happening to our natural forest ecosystem. It is an animal we can relate to and one that represents all the small and unseen creatures that share the trees, hiding in hollows, under the bark, and eating the foliage. For every koala there are perhaps a hundred beetles, ants and spiders of maybe ten or twenty species that share the tree. Similarly, the bell frog is a flagship for all our native frogs (perhaps more importantly a flagship for coastal wetlands), fortuitously coloured green and golden, relatively large and visible by day to those with sharp and enquiring eyes. If we cannot conserve a frog, what are our chances of saving nature, and who will be the champions for nature? Hopefully it will be those experiences that for young and old begins or sustains a life-long journey of discovery of the amazement and peace that comes from spending time in nature away from the urban hubbub. And hopefully, this appreciation builds a constituency that will require more to be done to protect it.

The sixth extinction

As Wilson (2016) and many others have pointed out life on earth is in the midst of the sixth extinction event (Kolbert 2014). What makes this one different to the others that are known from the fossil record, is that it is us, humankind, that is the driving force, and not a major geological or astronomical event. If ever we needed evidence of this, the summer of 2019-2020 in south and eastern Australia, brought it to our doorstep. Our land experienced a drought and heat wave conditions that broke all previous weather records (BoM 2020), and resulted in wild fires the extent and severity of which we had not previously imagined possible. The most used media word was “unprecedented”, as if that enabled us to wash our hands of responsibility. That way we could blame nature, and not our own collective long-term neglect. Greater than 80 % (853,977 hectares) of the Greater Blue Mountain World Heritage Area, and 53% (196,000 hectares) of the Gondwanan Rainforest of Australian World Heritage Area burnt. These are landscapes that we as Australians protect and manage on behalf of all humanity, not just our own community (UNESCO World Heritage Charter 1972). Several estimates of the number of animals killed in the fire have been made, and there is general acceptance that over 1 billion perished. What of the survivors, will there be sufficient unburnt habitat to enable a recovery and over what time period will that occur? While our government devotes funds to recovery efforts ($25m for animal welfare recovery efforts and about the same for on-ground mitigation effort. Department of Agriculture, Water and Environment (DAWE)), we devote $50b to building a fleet of submarines, and globally billions to find if there was ever evidence of life on Mars, while the biodiversity of the planet where 99.99% of us will live and die, is threatened by our wilful negligence and greed. Or is it blind ignorance? How do we change the ignorance, where is the beginning of appreciation and love of nature?

The status of threatened species – life on the brink

It appears that even legislating to redress species declines and extinctions is a forlorn task. For over two decades we have had national and state legislation to protect threatened species. An outcome of our ratification of the United Nations Convention on Biological Diversity (United Nations, 1993). Is it a sign of failure of our legislation or a lack of biological understanding of the real issues that sees the threatened species list grow annually, with only rare occasions where a species is removed as being secured? In New South Wales, after being considered ineffective, the *Threatened Species Conservation Act* (1991, 1995) has been replaced by the *Biodiversity Conservation Act* (2016), and the mechanisms to protect and recover threatened species have been changed. New thresholds for species survival are set and can be traded as in a market place. One can only ask, by setting new thresholds, are we just moving the goal posts, and kicking the can of species persistence further down the road. As a clear example of the extent of the current status, it is valuable to look at recent catastrophic events. After the summer fires, the federal Department of Agriculture, Water and the Environment published a list of priority species, developed from a multi-trait ranking process that included over 90 vertebrates, and 20 ecological communities, considered to be likely impacted by the wildfires. The majority of these species were already listed on national and state threatened species lists. All of a sudden in one season a large proportion of the lands set aside to protect our natural heritage along the eastern slopes of the Great Dividing Range in southern Queensland, NSW and Victoria were destroyed. On Kangaroo Island in South Australia, our largest offshore island and one of the few large terrestrial environments free of foxes, almost half of the native vegetated habitats were burnt. It is not with a feeling of justification that many conservation biologists could say, the warnings were made and ignored. It is with feelings of great sadness and distress. My observation is that most conservationists are optimists, they have to be in the face of such rapid change and the destruction of nature, otherwise they would move into depression. They continually question how to deliver a message of doom and at the same time provide a solution. One of our solutions was to have about 15% of habitats protected in reserves, and in the summer of 2019-20 we observed that even that could be destroyed in a matter of weeks.

Bell frogs and understanding frog survival

So where does this leave urban ecology and the bell frogs? In the past two decades, studies of the bell frog at Sydney Olympic Park have provided significant insights on how to establish habitats in which frogs can survive in restored habitat deep within an urban landscape and beyond (Case Study 1). Methods to manage the impact of a widespread invasive disease (a fungal invader not listed above, now cosmopolitan, and estimated to have caused the extinction of about 120 amphibian species worldwide) (Skerratt et al. 2007), were developed and the theoretical concepts to minimise the impact of the pathogen that can be applied to many other frogs. Thus studies of the population at Sydney Olympic Park have proven influential in addressing broader issues of conservation biology for amphibians. These studies could have been possible on populations away from urban landscapes, however it was the urban landscape that enabled the studies to be undertaken. The dilemma of survival of the bell frog population was at Sydney Olympic Park.

In the early 1990s when work commenced in earnest to prepare the Sydney Olympic Park site for the Sydney Olympic Games in 2000, one of the promises was to deliver the 'Green Games', and this meant everything from sustainable building materials, water and waste management, to the ecological legacy of the Olympic parklands. An opportunity to redevelop and revitalise a part of Sydney that had a chequered industrial past. What better for the Green Games than to have a threatened frog at the site with the common name the 'green and golden bell frog' (fortuitously the Australian national colours). History tells that the passage was not an easy one (Darcovich and O'Meara 2008), but the games were delivered and with many years work from many dedicated people the bell frog continues to persists twenty years on.

At the time the first conservation actions were to be taken for the bell frog population at Homebush, there was wide debate among amphibian biologists as to the cause of observed worldwide declines in amphibian populations. It is widely accepted that the first international consensus on this situation among those who study amphibians was at the World Congress of Herpetology held in England in 1989, and by 1993, when the second congress was held, there were several contending hypotheses from the impact of exposure to ultra-violet radiation caused by the hole in the ozone, to environmental contamination of hormone by-products, to widespread habitat destruction, or to a disease. While the scientific debate progressed, the green and golden bell frog had been listed as threatened on the NSW *Endangered Fauna (Interim Protection) Act* (1991), since this once common and widespread frog had declined from a vast area of its former distribution. Surprisingly, and perhaps ironically, it persisted in some unusual situations such as in old industrial landscapes, such as those at the pre-development Sydney Olympic Park site, and in a few other notable locations.

Ponds built for the green and golden bell Frog at Sydney Olympic Park

In the absence of a full understanding of the causal agent of amphibian declines, the challenge was to maintain a viable local population of the green and golden bell frog at Sydney Olympic Park. From a biological perspective, the principles behind managing a threatened species require that the cause of decline be identified and then mitigated (Caughley 1994). Why had this population survived when many others, some in relatively benign habitats such as grazing lands on the Southern and Central Tablelands, had disappeared? And how to mitigate the cause when there was active debate among specialists as to the underlying cause? And what if there was no mitigation possible? What can one do to mitigate the effects of a hole in the ozone in the short-term? In the hurly burly of the preparations for the Olympics there was little time to undertake research into the cause of bell frog declines. As areas where the frog occurred were earmarked for construction of a stadium, road or car park, the approach taken was to construct new wetlands within the parklands precincts based on the features of the ones that the frogs were using. This approach was successful initially, but it was not long before there was an observed decline in the distribution and abundance of the population. Biologists and managers alike were frustrated with patterns that made little sense. New wetlands were constructed to a well-defined habitat model, and the frogs moved in and often bred within a season or two. But over time the frogs deserted some of these wetlands and breeding ceased.

Research to improve persistence of the bell frog population

After the Olympics had been completed, a five-year research program on the green and golden bell frog population at Sydney Olympic Park was undertaken by the University of Newcastle with the support of the Sydney Olympic Park Authority and the Australian Research Council. The primary aim of the investigations was to ensure the persistence of the population of the green and golden bell frog at the site. Investigations focused on the cause(s) of decline and if possible, how to mitigate it. By this time there was a firming of the postulated cause of amphibian declines and studies undertaken in Australia had shown that a disease was the most likely agent (Berger and Speare 1998, Scheele et al. 2017). The pathogen had been described (chytrid fungus) and the disease it causes named chytridiomycosis (Berger & Speare 1998). Studies revealed that it arrived in Australia in the 1970s (Berger and Speare 1998). With this in mind a population viability analysis (PVA) was undertaken for the Sydney Olympic Park bell frog population, along with studies of the tadpole and adult stage of the life cycle, water quality, habitat associations and the prevalence of the chytrid fungus in the population. The population viability analysis showed a high mortality rate in the terrestrial stage of the life cycle (juvenile to adult frogs) such that only a small percentage of females reached sexual maturity to contribute to the next generation (Pickett et al. 2013, Pickett et al. 2014a,b,c, Pickett et al. 2016). What was causing the high mortality rates? The answer pointed mostly to the disease (Stockwell et al. 2006a, b, Stockwell and Mahony 2007, Stockwell et al. 2010, Stockwell 2011, Stockwell et al. 2012, Bower et al. 2013, Stockwell et al. 2015a,b). Our studies revealed that bell


Testing for chytrid

CASE STUDY 2:
Impact of a pandemic pathogen specific to frogs, and susceptibility of the green and golden bell Frog

The problem of wildlife disease causing population declines

Introduced pathogens are increasingly being implicated in population declines and their effects are difficult to manage. It is now documented that over 120 amphibian species have disappeared (presumed extinct) in the past three decades to a disease that emerged in the mid-1970s. In the absence of methods to eradicate pathogens acting as threatening processes, intervention before population decline is necessary. Such an intervention requires an ability to predict when population declines will occur, and therefore, an understanding of when exposure will lead to infection, disease, death, and population decline.

Determining susceptibility of a species is a key component of understanding impact and mitigation

We investigated when pathogen exposure leads to disease for the amphibian chytrid fungus *Batrachochytrium dendrobatidis*, which has been implicated as a causal agent in the global amphibian decline.

Susceptibility studies were conducted on two anuran species, the green and golden bell frog *Litoria aurea* and the striped marsh frog *Limnodynastes peronii*, when exposed to the fungus as either tadpoles or juveniles. Host species was found to significantly affect the outcome of exposure, with infection loads in *L. aurea* increasing over time and resulting in significantly lower survival rates than unexposed. By comparison, infection loads in *L. peronii* remained the same or decreased over time following the initial infection, and survival rates were no different whether exposed to chytrid or not. These outcomes were independent of the life stage at exposure.

Our findings were unexpected and changed our understanding of how disease may progress in amphibians. Individuals with higher infection loads were not found to have lower survival rates; rather, an infection load threshold was identified where individuals with infection loads that crossed this threshold had high likelihoods of showing terminal signs of chytridiomycosis.

Why are some frog species more susceptible to the pathogen?

We found that host species determined whether infection load crossed this threshold and the crossing of the threshold determined the incidence of disease and survival.

The development of disease following exposure to a pathogen requires the successful establishment of an infection and the replication of the pathogenic organism to a level that impairs biological function. *Litoria aurea* and *L. peronii* were found to be equally susceptible to infection with chytrid as all exposed tadpoles and juveniles tested positive for infection. However, the multiplication rate of chytrid differed significantly between species. Mean number of pathogen organisms were significantly higher in juvenile *L. aurea* than *L. peronii* and increased over time, whereas mean number of pathogen organisms in *L. peronii* either remained the same or decreased below the detectable limit. Given that both the environmental and exposure conditions were standardised in this experiment, these results suggest that juvenile *L. peronii* possess an innate mechanism that inhibits the replication of chytrid following an initial infection and that this mechanism is lacking in *L. aurea*.

Identification of the first step in understanding which species will be impacted by the disease pathogen

The quantification of infection load thresholds for survival, along with the time it takes to reach them, enables infection loads in wild populations to be related to the likelihood of disease and is the first step in the understanding and prediction of when exposure will result in population decline.

Understanding that disease causes the decline of a population changes significantly how ecologists consider management actions to secure a threatened and susceptible species such as the green and golden bell frog.

For more detail see:

Michelle Stockwell, John Clulow & Michael Mahony. (2010). Host species determines whether infection load increases beyond disease-causing thresholds following exposure to the amphibian chytrid fungus. *Animal Conservation* 13: 62-71

frogs were highly susceptible to this disease, especially in the cooler months of the year. Many females die before they reach maturity and breed (see Case Study 2).

Why the focus on females? Our studies showed that male bell frogs could reach maturity in one year, whereas it takes females two years. With the impact of the disease being so severe, females need to pass through two winter seasons to reach maturity, and that reduces their chances of survival (Pickett et al. 2014b). Once a female bell frog reaches maturity, they are capable of producing a large clutch of several thousand eggs, and one might expect that such a number would be sufficient to shore-up the population. Our studies showed that the high fecundity of females was of great importance to survival of the population. However, the adaptation to produce large numbers of offspring is an evolutionary response to a high mortality rate during the tadpole and juvenile stages. Tadpoles were observed to be an important source of food for many natural predators including turtles, lizards and birds at Sydney Olympic Park (Remon et al. 2016). Indeed, they may be a vital component of the food chain, and the frog is therefore an example of a keystone species. With this understanding, the adaptive research approach was to see for which part of the life cycle it was possible to intervene to increase survival rates. We asked the questions; is it possible to reduce the impact of the disease on adults and increase survival, or is it possible to reduce tadpole predation and increase the numbers that can grow to adulthood? At the time there were no examples in the world of any successful approach to controlling chytridiomycosis in wild frog populations. We tested the increased survival hypothesis by preventing death in a small cohort of female frogs by holding them in captivity over a winter and releasing them at the beginning of the next season. We tested the tadpole survival hypothesis by raising natural clutches in large aquaculture tubs that were covered with mesh to prevent predation. These studies confirmed the theoretical PVA model, and enabled management interventions to secure the population should they be required in the future (see Case Study 2). Following on from the studies at Sydney Olympic Park, and based on the knowledge developed there, we have guided the construction of large natural wetlands that passively control the impact of the disease in a world first approach to controlling the impact of the disease in nature at Kooragang Island in the Hunter River estuary.

In addition to these studies we investigated the impact of the introduced fish, the plague minnow that occurs in several of the wetlands at Sydney Olympic Park. Understanding the impact led to considerations of how to limit the distribution and occurrence of the fish (Hamer et al. 2002, Pollard et al. 2017). Investigation were undertaken on the habitats most favoured by the bell frog, and changes made to management practices. In an innovative study, the first for any Australian frog, we conducted analysis of the population structure and movement of the frogs using genetic markers (DeBoo et al. 2012).

Together these studies were possible because of the unique situation that occurred at Sydney Olympic Park. Urban ecology was able to address major questions that were occurring in the conservation management of amphibians worldwide. The lessons learnt have been applied in several other restoration projects. We did not solve all the problems and dealing with amphibian chytridiomycosis remains a major challenge to amphibian conservation. Science is often a slow and sometimes frustrating process.

Green and golden bell frog metamorph

Perhaps I should share one story of our time in the wetlands at Sydney Olympic Park. As you no doubt appreciate most frog field work occurs at night. Well in one summer the major stadium at the Park was host to the heavy metal rock band AC/DC. It was fun; fitted-out in waders with head torches on, conducting our survey in the large wetland at the end of the Olympic Boulevard, and listening to the band AC/DC pump it out, and we could hear every word. The song list was the same each night and we would wait to hear the fireworks go-off when “TNT I’m dynamite” reached the audience to great applause. Where else can you do field work and listen to AC/DC live? There was a downside however. When the crowd streamed out in the balmy summer night air, excited and still singing, some would walk out on the canter-lever walkway that extended over the edge of the wetland. And we would need to scurry away and turn-off headlamps to avoid some unrepeatable but obvious comments and behaviour.

The bell frog has been a flagship, to show that in the face of total population loss, it is possible to enable coexistence with urban development. Hopefully, it can be more than this, if its occurrence inspires a new generation to understand and appreciate nature, there is a bigger winner. Nurturing appreciation may be the best hope we have of saving nature.

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Images - Sydney Olympic Park Authority

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