Pesticides - a pest for amphibians?

Investigating the hormone disrupting effects of pesticides

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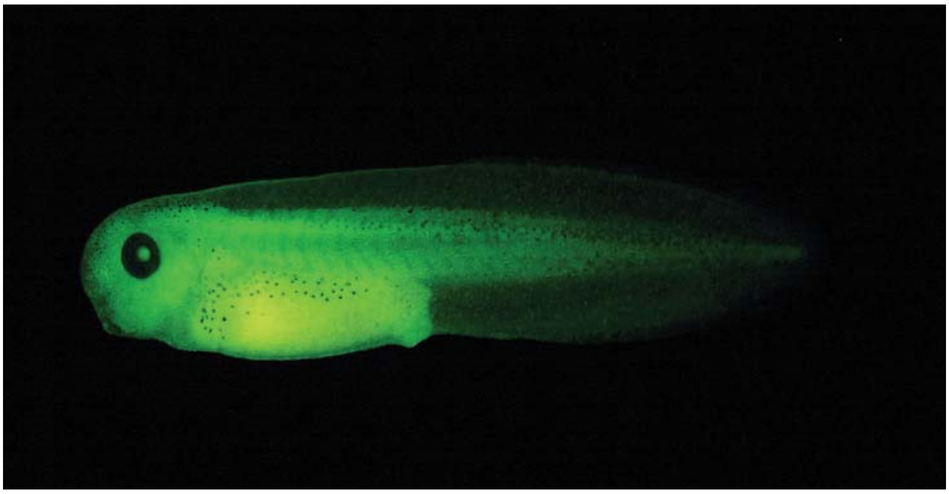
Earth is currently experiencing its sixth mass extinction and amphibians are among the worst affected: almost a third of amphibian species are extinct or threatened (categorised as Vulnerable, Endangered or Critically Endangered by the IUCN). Drivers of this biodiversity crisis are numerous, with human activities being largely responsible. Apart from habitat destruction, threats from invasive species and the spread of disease, a likely contributing factor is pollution by chemicals we release into the environment. Major sources of exposure include agricultural runoff and wastewater, so there is a high risk to aquatic organisms in particular. Amphibians are exceptionally vulnerable due to their permeable skin and aquatic habitat during sensitive embryonic and larval stages.

Environmental pollutants need not be lethal to affect the survival of wildlife. Over 800 substances are suspected to be endocrine-disrupting chemicals (EDCs): they act by disturbing the hormonal systems of animals, consequently impacting development, growth, immune defences and reproduction. Some developmental life stages are more sensitive to the effects of endocrine disruption because of the critical role that hormones play during these periods. For example, a correct progression of metamorphosis in amphibians is dependent on timed increases and interactions of thyroid hormones and stress hormones (corticosteroids). Despite well-documented endocrine-related effects in wildlife and increasing EDC exposure to populations worldwide, the vast majority of chemicals in current commercial use have not been tested for endocrine disruption. Moreover, most EDC research has focused on the reproductive system, leaving other hormonal systems under-investigated.

Agricultural pesticides are a major source of endocrine disrupters in the environment. My Honours research centres on a class of pesticides known as juvenile hormone analogs (JHAs) that disrupt insect development by mimicking the action of insect juvenile hormone. In Australia, JHAs are routinely used in agriculture, and ecologically significant concentrations of JHA were detected in southeast Australian stream sites. These areas are home to several frog species, including the growling grass frog (*Litoria raniformis*) which is already listed as Endangered. While considered to be safe to non-target organisms (including mammals and amphibians), the endocrine-disrupting properties of JHAs in higher animals have never been tested. We suspect that JHAs interfere with the amphibian thyroid hormone system. This hypothesis is based on the fact that JHAs closely resemble thyroid hormones in chemical structure, to the extent that thyroid hormones and their metabolites mimic JHA effects in insects. As mentioned above, thyroid hormones are critical for amphibian development, particularly metamorphosis. Exogenous chemicals which mimic, block or modulate endogenous thyroid hormone action could produce adverse developmental effects, compromising individual survival, with potentially disastrous consequences at the population level.

My research is a pilot study which aims to investigate the thyroid hormone-disrupting capacity of selected JHAs. The greatly appreciated support of the Australian Wildlife Society allows me to perform multiple laboratory tests to examine the many modes of action by which JHAs could potentially disrupt amphibian thyroid hormone systems. This project could lead to further research investigating evidence of adverse effects in wildlife and possible synergisms with other stressors, ultimately dictating whether the continued use of JHAs is ecologically sustainable. Adequate testing of agricultural pesticides and development of safer alternatives could well help lessen the impact that human activities are having on the world around us.



Fluorescent *Xenopus laevis* tadpole, as part of a screen for thyroid hormone disruption. Photo: Museum national d'Histoire Naturelle.

Contribution to the conservation of long distance, high-Arctic migratory shorebirds

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Worldwide, migratory shorebird populations are under threat and therefore of particular conservation concern. Migratory shorebirds use distant habitats and cover the distance between these habitats in long flights that often span across continents and hemispheres. There is particular concern of declining shorebird populations along the East Asian–Australasian flyway (EAAF). Besides the importance of protecting their populations, migratory species may also have great effect on the ecosystems of which they form part, warranting our concern. Their dynamic distribution pose a great challenge to develop sound conservation strategies for such intercontinental migrants.

The aim of my thesis is to shed more light on some of the factors associated with global change processes that have been considered to explain the decline of waders along the EAAF. I am thus studying (*i*) the effect of Arctic lemming cycles on the reproductive success of waders, (*ii*) the flexibility of shorebirds in response to changes in their stopover habitats using stochastic dynamic programming, (*iii*) differences in quality of non-breeding sites in Australia (i.e. the birds' 'wintering' sites) using stress biomarkers to understand why some individuals fly further south to winter than others, and (*iv*) levels of industrial chemicals in migratory birds along the EAAF.

Our results show that lemming cycles in some parts of the Arctic have changed in the last decades, and may be responsible for faltering periodicity in wader breeding success along the flyway. These changed conditions, however, have so far not resulted in any marked changing trends in breeding success across years. Declining numbers of waders

The cannon net in action, flying over the surprised birds. Photo: Roger Minton.

Ruddy turnstone (*Arenaria interpres*) contributing few feathers for stress analysis. Photo: Roger Minton.

The rain will not stop us! Simeon and Yaara processing birds in the back of the field car. Photo: Rob Patrik.

along the EAAF are therefore more likely a result of changing conditions at stopover and wintering sites than changing conditions on the breeding grounds.

Preliminary model results show the crucial importance of good quality wintering sites in Australia for population maintenance. Due to a latitudinal gradient in food availability, it may be beneficial for these long-distance migrants to fly the extra distance to the southern end of Australia rather than to stay the winter at the top end. Although thus covering a longer distance, this detour may ultimately result in a more successful migration back to the breeding grounds. Higher stress levels measured by white blood cell counts in ruddy turnstone (*Arenaria interpres*) in north Western Australia compared with wintering habitats in South Australia and Tasmania, as well as low corticosterone content in feathers of birds from these southern sites, support these findings. Hampering the quality of these sites (e.g. lower prey abundance, human disturbance) may severely affect the ability of these athletes to repeat their annual migration and reproduce in the harsh Arctic environment.

I would like to thank the Australian Wildlife Society for their generous contribution, and all the volunteers from the Australian Wader Study Group and my lab mates for making this project possible. The project is still continuing and we look forward to reporting our results to the Australian Wildlife Society.

Preparing the cannon net on the beach before the waders are coming.

The conservation status of Western Australia's sea snakes:

Are species disappearing before they have been discovered?

Blanche D'Anastasi,
James Cook University

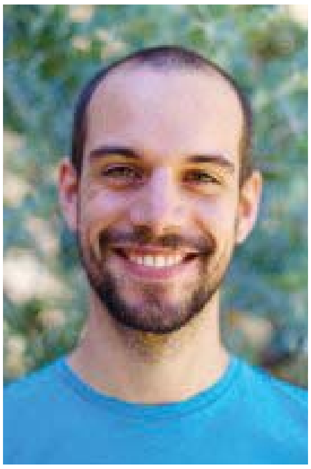
True sea snakes are a highly diverse group of live-bearing marine reptiles that act as both predator and prey in tropical marine ecosystems. Australia is a biodiversity hot spot for sea snakes, containing more than half of the 62 described species, including 11 endemic species. Western Australia is particularly important for sea snake biodiversity as it is home to 21 of Australia's 35 sea snake species, including five restricted-range endemics that occur predominantly on coral reefs. In 2010 three Western Australian endemics were listed as Critically Endangered or Endangered by IUCN, due to severe declines in abundance over the previous decade, however reasons for these declines are not known. To date these are the first sea snake species listed as threatened with extinction by IUCN. Many other species are currently listed as Data Deficient due to a lack of basic data about taxonomic status, range extent, population size and connectivity, which are essential to evaluating conservation status.

My PhD research aims to fill some of these knowledge gaps for sea snakes in coastal Western Australia, where almost no sea snake research has been conducted. To date I have been able to collect habitat, use observations and tail clips from 150 sea snakes, from five species in Shark Bay. My research has demonstrated that species ranges are poorly defined, as I discovered new records on the range extent of two species, which will be published shortly.

The next phase of the project is to evaluate the level of genetic connectivity between populations of the small-range, endemic Shark Bay sea snake (*Aipysurus pooleorum*) and the endemic olive-headed sea snake *Hydrophis major* (*Australo-Papuan*). Using a powerful, cutting-edge population genomics approach which uses thousands of genetic markers (called single nucleotide polymorphisms or SNPs), I will examine the level of genetic connectivity and genetic diversity between shallow sea grass beds in the Western Gulf and the Stromatolite Reefs of the Eastern Gulf of Shark Bay. The genetic connectivity data obtained from this research will provide information that is critical to managing and conserving sea snakes in the Shark Bay World Heritage Area.

Releasing a large female Shark Bay sea snake from a sea-wall in the Western Gulf of Shark Bay. Photo: Tara Fullston.

This is *Aipysurus pooleorum*, the Shark Bay sea snake. My research represents the first major study on this small-range, endemic species and will provide data that is critical to assessing its conservation status.



Spawning site identification of Macquarie perch (*Macquaria australasica*) using environmental DNA

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The nationally endangered Macquarie perch (*Macquaria australasica*, C. 1830) is a fish species endemic to south-eastern Australia. Historically this species was highly abundant and widespread throughout the Murray–Darling Basin, but its current distribution is restricted to the cool, upper reaches and only four self-sustainable populations remain (Abercrombie River, upper Murrumbidgee, Cotter River and Dartmouth Dam). The historical and continued decline of the Macquarie perch is the result of detrimental interactions with invasive alien species and anthropogenic habitat modification (clearing of vegetation, construction of dams and weirs). Spawning takes place from October to December. Adults migrate from lakes into tributaries where they spawn at the foot of pools and eggs drift downstream into the riffles until they get stuck into the gravel.

In order to ensure the long-term persistence of the remnant populations it is of critical importance to protect habitats that are essential for the completion of their life cycle. Macquarie perch spawn from October to December. Adults migrate from lakes into

Adult Macquarie perch caught at Kissops Flat (NSW). Photo: Ben Broadhurst.

tributaries where they spawn at the foot of pools and eggs drift downstream into the riffles until they get lodged into the gravel. Although limited information on migratory movements, spawning and nursery grounds is available, the identification of exact spawning periods and spawning habitats is relatively unknown. Current methods rely on acoustic tags to track the movements of adult fish (acoustic telemetry) during the proposed spawning period or the collection of downward-drifting eggs in rivers. However, acoustic telemetry only provides information on fish movements during the proposed spawning period and does not provide information on when, where and whether the adults actually spawn. Egg collections are a more direct measurement of spawning but they are often unfeasible since species identification is difficult and several fish species burrow their eggs in the gravel or attach them to aquatic vegetation.

Recent advances in environmental DNA (eDNA) technologies offer new opportunities since they rely on non-invasive sampling methods and circumvent and/or reduce limitations and biases associated with conventional monitoring tools. Species detection and monitoring using eDNA relies on the fact that all fish species secrete DNA into the water through faeces, urine, gametes and the shedding of skin cells. The general workflow of eDNA-based species detection involves sampling water, extracting eDNA, amplifying a DNA fragment through species-specific polymerase chain reaction (PCR) and a positive amplification is then considered as a positive detection. All currently published studies have relied on the amplification of mitochondrial DNA fragments since they are relatively easy to extract from environmental and degraded samples compared to nuclear fragments. However, during spawning, large amounts of nuclear DNA will be released into the water in the form of gametes thereby significantly increasing the quantity of detectable nuclear eDNA fragments. Consequently, we hypothesise that the relative abundance of both nuclear and mitochondrial eDNA fragments can be used as a direct indication of spawning activity and would be suitable for the identification of important spawning habitats. The proposed hypothesis will be initially tested under controlled conditions using aquarium-based experimental trials with Macquarie perch. Following this proof of concept, a small-scale field survey will be conducted in the Cotter River (ACT) in order to validate the method. During this survey, water samples will be collected and the relative abundance of mitochondrial and nuclear eDNA fragments will determined. In addition, downward-drifting eggs will be collected using larval drift nets and the results of both monitoring tools will be compared.

I would like to thank the Australian Wildlife Society and the Fisheries Scientific Committee (NSW Department of Primary Industries) for providing funding towards this research. Additionally, I would like to acknowledge Dr Dianne Gleeson, Dr Elise Furlan, Mr Mark Lintermans, Mr Ben Broadhurst and Mr Rhian Clear for their input and advice on outlining the proposed research project.

The Cotter River (ACT), which holds one of the only four self-sustaining Macquarie perch populations. Photo: Rhian Clear.

Above: Amy Northover releasing an adult woylie

The ecology of parasite transmission in fauna translocations

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My PhD project will investigate how fauna translocations impact the transmission of parasites in critically endangered woylies *(Bettongia penicillata)*, and what consequences this has for translocated hosts and other cohabiting species. As we lack a rigorous understanding of whether current parasite management protocols enhance translocation success, we will also assess the impact of parasite removal on translocated hosts.

Whilst fauna translocations play a pertinent role in the conservation management of Australia's threatened species, less than 50 percent of native fauna translocations within Australia are reported to be successful. Thus, investigating the factors that influence their success is vital. Polyparasitism, in which a host is co-infected with various parasite species or strains, is common in wild animal populations. Whilst parasites have been implicated in a number of species declines, the role of polyparasitism as a potential factor contributing towards translocation failures has never been investigated.

In collaboration with the Department of Parks and Wildlife (DPaW), we have been undertaking field-based research to determine the incidence of polyparasitism in woylies and other cohabiting species, and explore its impact on host fitness, survivability and translocation success. The woylie or brush-tailed bettong has undergone a 90 percent decline in population size over seven years (1999-2006), and now only two remanent wild populations remain; the largest of which exists within the south-west corner of Western Australia – an international biodiversity hotspot. Although predation by feral cats and foxes is a major threat to wild woylie populations, parasitic disease is suspected of playing a role in the recent decline of this small endemic Australian marsupial.

A male joey having his pes measured

For the first translocation, which was successfully completed in June 2014, 182 woylies (90 male and 92 female) were translocated from Perup Sanctuary to two adjacent sites within nearby State Forest, in the south-west corner of Western Australia. Pre-translocation, woylies from both the source and destination sites were measured and weighed (to estimate body condition), and pouch activity was recorded for females (to measure reproductive output). Blood, faecal, and ectoparasite samples were also collected for parasitological examination (gross, microscopic, molecular DNA techniques). In both destination sites, sympatric marsupials (brush-tailed possum - *Trichosurus vulpecula*; western quoll – *Dasyurus geoffroii*) were also sampled so that we are able to quantify parasite transmission between species post-translocation. For the blood-borne protozoan parasite *Trypanosoma*, we will quantify parasite transmission on a finer genetic scale using novel molecular epidemiological tools to track transmission between hosts.

In order to empirically test whether the removal of parasites from translocated woylies improves host fitness, survivability and translocation success, we treated half the woylies (50 percent male and 50 percent female) with an antiparasitic drug prior to translocation. In order to determine the efficacy of our anti-parasite treatment, we collected repeat blood, faecal and ectoparasite samples from translocated woylies four and 12 weeks post-translocation (July and September 2014).

At present, we have collected preliminary data from our source and destination sites. From September 2014 onward, we will be collecting samples from both destination sites every three months until 12 months post-translocation. After the first 12 months, monitoring will be carried out six monthly until 30 months post-translocation. A second woylie translocation is tentatively scheduled for winter 2015, the details of which are yet to be determined.

As a veterinarian, I have always had a passion for wildlife conservation (studied Veterinary Science and a Master of Veterinary Studies in Conservation Medicine at Murdoch University). With the aim of improving the outcome of native fauna translocations, it is hoped that the information obtained from this research will directly assist our partner organisation (DPaW) in planning future fauna translocations. Importantly, the insights gained from this project will be broadly applicable to other conservation agencies for the management of fauna translocations, which will assist in the conservation management of threatened native fauna species and ensure the sustainability of wildlife and ecosystem health.

Field anaesthesia on a brushtail possum

An anaesthetised chuditch (Western quoll) having his head measured

An anesthetised brushtail possum

A woylie joey. All furred pouch young receive a health check (including head and pes measurements) prior to being reinserted into their mothers pouches and released.

What's driving our albatross populations?

Jaimie Cleeland
University of Tasmania and
the Australian Antarctic Division

Project: Macquarie Island albatrosses: Assessing the environmental and anthropogenic influences on population and demographic status and trends.

Understanding the interaction between a species and its environment is crucial to understanding the drivers of population trends. For albatross populations, drivers can originate from the 'bottom' of the food chain by affecting the food resources available, or from the 'top' through increased mortality. Long-line and trawl fishing operations have been identified as a key contributor to a global downward trend in breeding numbers by increasing adult mortality through by-catch. Less known is the influence of climate on these populations. Climate-driven changes to the Southern Ocean can impact the survival and individual body condition of marine

Wandering albatross

predators through fluctuations in the availability of prey resources.

For Australia's albatross populations the extent to which fisheries interactions and climate influences have contributed to observed trends is unknown. Sub-Antarctic Macquarie Island is home to four albatross species: wandering, light-mantled, grey-headed and black-browed albatrosses. After spending three summer seasons working on Macquarie Island's escarpment observing these incredible creatures, I have developed a deep respect for their extreme life-history strategy and am passionate about disentangling the key drivers affecting their populations.

To evaluate the nature of climate and fisheries interactions on albatross life-history strategy requires knowledge of their key foraging areas and robust statistical methods. With the support of the Australian Wildlife Society I am able to present the results of a Macquarie Island albatross tracking analysis at the 5th BioLogging Science Symposium in Strasbourg, France, and with scientists from the British Antarctic Survey (BAS) in Cambridge, United Kingdom, learn the latest techniques in demographic modelling.

Developing a strong understanding of past trends will assist us in predicting the future under different plausible scenarios of climate and fishing effort supporting effective management for protecting these iconic ocean wanderers.

Black-browed albatross

Light-mantled albatross

Wandering albatross

Do the natural arrangements of plants need to be incorporated into revegetation design?

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In Australia, widespread vegetation clearance was common following European settlement and often occurred for agricultural use (Hobbs 1993). Vegetation clearance did not occur evenly across the country, with disproportionate clearing occurring on higher productive lands (Paton and O'Connor 2010). In some areas, such as the Mt Lofty Ranges and Adelaide Plains, less than 10 percent of the original vegetation remains (Paton 2010; Bradshaw 2012). This has led to a number of environmental issues as native vegetation provides habitat and food for wildlife and maintains land, soil and water health (State of the Environment 2011; Environment Protection Authority 2013). Many regions are now faced with severe land degradation and biodiversity losses, and the number of threatened species and ecological communities continues to increase (Saunders *et al.* 1991; Ford *et al.* 2001; Vesk and Mac Nally 2006; Environment Protection Authority 2013). These issues are particularly evident in temperate southern Australia, where extensive vegetation clearance occurred for cereal cropping and sheep grazing (State of the Environment 2011).

Research suggests that the protection and restoration of remnants alone will not be enough to counter biodiversity decline; large-scale revegetation will be required (Bennett *et al.* 2000; Mac Nally 2008). However, the presence of restored sites in the landscape may not necessarily result in long-term species persistence (Broadhurst 2013), as revegetated areas can take decades to centuries to mature (Mac Nally 2008; Vesk *et al.* 2008) and may not be ecologically equivalent to native vegetation (Kyle and Duncan 2012). One aspect of restoration that has received little attention is the influence of plant spatial arrangements (Miller *et al.* 2010). In natural systems, spatial patterns occur for a number of reasons and at a variety of scales (Alados *et al.* 2007) and include environmental factors such as climate, soil type and topography, and ecological factors such as seed dispersal, succession, facilitation and competition (Bartha *et al.* 2004; Alados *et al.* 2009; Miller *et al.* 2010; Gastŏn and Garćia-Viňas 2013). Finer scale arrangements

Kimberly collecting fruit from *Eucalyptus leucoxylon* (South Australian blue gum) at the Monarto Revegetation area, South Australia. Photo: Rachel Ladd, 2014 of plants are rarely considered in revegetation design (Miller *et al.* 2010), even though patterns at population and community level are common in natural systems (Alados *et al.* 2010).

Revegetation undertaken with little or no thought to planting arrangements may limit natural regeneration and ecosystem function, impact plant growth and biodiversity, and reduce the long-term persistence of revegetated areas (Silvertown *et al.* 1992; Balvanera *et al.* 2005; Alados *et al.* 2010; Miller *et al.* 2010). However, to date the influence of planting arrangement on revegetation success is not well understood. If revegetated populations do not have the ability to become self-sustaining, replanting will be required as original populations senesce. Consequently, revegetated areas may not be viable in the long term (across multiple generations).

My study is centred on understanding how fine-scale planting arrangements in revegetated systems influence gene flow, pollination and plant reproduction and, by doing so, exploring whether it is necessary to recreate natural spatial arrangements in revegetated sites. The research has three major components: first, natural spatial patterns and spatial heterogeneity will be assessed in areas of native vegetation; second, plant reproduction will be assessed as a function of conspecific density for revegetated and remnant sites; and third, patterns of gene flow will be assessed in remnant and revegetated systems. Research will be conducted in three areas of South Australia which are currently a focus for large-scale revegetation – Mt Lofty Ranges, Adelaide Plains and Kangaroo Island.

Initially, systematic surveys will be undertaken in 200m x 200m plots in areas of native vegetation. Location data for all plant species of interest will be recorded with a GPS. This information will be used to determine how variable plant spatial patterns are between species and locations (i.e. nearest neighbour distances, plant density, number of individuals per aggregation). Spatial heterogeneity across the survey areas will also be assessed. Results will be used to determine practical methods for incorporating natural spatial arrangements into revegetation design. In addition, baseline data will be used in sections 2 and 3 of the research and to guide revegetation works.

One of the study species, *Eucalyptus calycogona* (square-fruited mallee) in flower. Monarto revegetation area, South Australia. Photo: Kimberly McCallum 2014

Flowers of *Eucalyptus calycogona*. Monarto, South Australia. Photo: Kimberly McCallum 2014

Buds and flowers of *Eucalyptus leucoxylon*. Monarto revegetation area, South Australia. Photo: Kimberly McCallum 2014

The second component of the research will examine how seed production and seed viability varies with conspecific density and nearest neighbour distance for three *Eucalyptus* species (*E. leucoxylon, E. porosa* and *E. calycogona*) within the Monarto revegetation area. Hand pollination experiments will be undertaken during the flowering season to determine the response of the study species to selfed and outcrossed pollen and to assess pollen limitation. In addition, pollinator behaviour will be observed to determine if there are any differences in foraging behaviour with conspecific density. Lastly, DNA fingerprinting techniques will be used to examine levels and patterns of gene flow in revegetated and remnant systems. Level of outcrossing and pollen diversity will be assessed as a function of conspecific density and nearest neighbour distances.

If the prediction that fine-scale planting patterns are important to the function of revegetated systems is correct, this work will provide justification for more careful consideration of spatial patterns in revegetation design. It is hoped that this research will contribute to creating self-sustaining and resilient ecosystems that will be viable for the long term.

Many thanks to the Australian Wildlife Society for providing support for this research under the University Students Research Grant scheme. Thanks also to my supervisors Associate Professor David Paton, Professor Andy Lowe and Dr Martin Breed.

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Investigating fine-scale geographic variation in a newly described Australian funnel-web spider (*Atrax sutherlandi*)

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My research focuses on *Atrax sutherlandi*, a newly described species of funnel-web spider belonging to the same genus as the notorious Sydney funnel-web, and named after the late toxicologist Professor Struan Sutherland. *A. sutherlandi* is distributed across south-eastern Australia, including the Tallaganda forests of New South Wales. Previous work in this region has shown that throughout past Pleistocene glacial-interglacial cycling, native eucalpyt forests would repeatedly contract into isolated low-lying hydrological catchments otherwise known as 'refugia'. During such harsh climates, these isolated forest remnants preserved local habitats and enabled a variety of species to persist in an otherwise inhospitable region. While the forest is now continuous, many of Tallaganda's species still reflect this ancient isolation in their genetic makeup. That is, in many groups including water skinks, velvet worms, springtails and flatworms, several distinct genetic forms are presently recognisable across the forest.

Such genetic biodiversity associated with geographically distinct refugia regions is also well illustrated for the funnel-web spider *A. sutherlandi*, where differences between six refugia populations in Tallaganda are of a magnitude generally attributable to distinct species. Given that such unequivocal genetic differentiation and short-range endemism at Tallaganda was induced by historical climate change, it may be advantageous to investigate corresponding geographic variation in *A. sutherlandi* phenotype, since this could potentially aid in elucidating and demonstrating the effects of climate change on a species' physical characteristics. This would in turn be relevant to conservation planning and land management in the face of increasing climate change. Furthermore, as *A. sutherlandi* displays geographically-associated phylogenetic patterns similar to those of other terrestrial invertebrates in Tallaganda, such communities are likely to have shared analogous

Atrax sutherlandi female. Photo: M Wong 2014

Above: Mark Wong laying out a transect in Tallaganda forest. Photo: Thomas Wallenius responses to previous climate change, and thus information from studying *A. sutherlandi* may be extrapolated to a variety of other important species. Exploring the phenotypic variation associated with ancient geographic refugia regions has therefore been the main focus of my research on these handsome but deadly spiders, and the phenotypic characters I am presently studying range from morphological characters such as body size and shape, to physiological characters which include metabolic rate, water loss rate and venom yield. A secondary aim of my research is to examine the extent to which such variation can also be explained by the contemporary environment.

At present, I am undertaking statistical analysis to interpret the phenotypic and environmental data that I have collected for various *A. sutherlandi* populations distributed across Tallaganda forest. While it is still too early to tell, the initial results do appear to hint at the presence of variation between the geographic regions in some phenotypic characters. My subsequent work will thus focus on scrutinizing and evaluating any apparent variation in an evolutionary and ecological context.

I would like to express my sincere appreciation to the Australian Wildlife Society for not only providing me with support for this research, but also many valuable insights into the conservation of Australia's native species.

Mark Wong in the field

Distinctive 'funnel-web' of *Atrax sutherlandi* on Tallaganda forest floor. Photo: M Wong 2014

Atrax sutherlandi male. Photo: Andras Keszei

Ecosystem services provided by birds in agricultural landscapes

Rebecca Peisley, PhD candidate
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Ecosystem services are ecological processes that benefit human society (MEA 2005). There is growing appreciation of ecosystem services provided by birds, particularly for their potential to provide significant benefits, such as pollination and pest control, for agricultural production (MEA 2005, Kellermann et al. 2008, Kross *et al*. 2012). However, birds can also cause damage to crops (Fukuda et al. 2008, Klosterman *et al*. 2013), and as agriculture continues to expand and intensify there is an urgent need to mitigate conflicts between wildlife and production. This requires research into the activity of birds in these agroecosystems.

Studies are now highlighting a range of important services that threatened species can provide for growers and are focusing attention on the potential benefits that agroecosystems can have for animal conservation. For example, Luck *et al*. (2013) and Luck (2013) found that almond crops in northern Victoria provided an important food resource for the threatened regent parrot (*Polytelis anthopeplus*), especially in years when natural food availability is low, and in turn the regent parrot provided a beneficial service to almond growers by cleaning up old, unharvested nuts (a source of fungal infection or insect pest infestations).

Natural predators can also reduce the damage caused by pest species (Mols and Visser 2007, Kellermann *et al*. 2008, Triplett *et al*. 2012). A recent study in New Zealand by Kross *et al*. (2012) showed that introducing the threatened New Zealand falcon (*Falco novaeseelandiae*) into vineyards could reduce grape damage caused by pest birds by 95 percent, with possible savings of US$234–$326/ha in avoided damage due to the falcons scaring the pest birds that consumed the crop.

As part of my PhD research, I will consider both the benefits and costs that birds can inflict in vineyards in northern Victoria. Passerine species

Red-capped robin (*Petroica goodenovii*) hunting for insects in an apple orchard in central Victoria. Photo: Rebecca Peisley

Red-capped robin (*Petroica goodenovii*) contributes to biological control of insect pests in apple orchards in central Victoria. Photo: Rebecca Peisley

Silvereye (*Zosterops lateralis*) provides an ecosystem service to apple growers by gleaning pest insects from trees. Photo: Rebecca Peisley

such as the introduced common starling (*Sturnus vulgaris*) and common blackbird (*Turdus merula*) can cause serious damage to grape crops (Tracey and Saunders 2010), while many native raptor species can potentially reduce the damage caused to grapes by hunting smaller pest species.

I aim to assess the effectiveness of providing perches in vineyards to encourage raptor visitation and by doing so reduce damage to grapes by pest passerine birds. Many raptor species, such as the brown falcon (*Falco berigora*), Nankeen kestrel (*Falco cenchroides*), black-shouldered kite (*Elanus axillaris*) and barking owl (*Ninox connivens*), among many others, occur in this region and prey on small birds (BirdLife Australia 2014, Luck *et al.*, in review). I will be conducting bird surveys, both directly and using motion-sensor cameras, as well as grape damage assessments to determine if providing perches is effective for encouraging raptors into a landscape, and if these birds are providing a pest control service for growers within vineyards.

Expanding agriculture is considered a major environmental threat to biodiversity (Foley *et al.*, 2005, Ellis, 2011, Baudron and Giller, 2014) and is often viewed as a separate endeavour from conservation; however, we are now seeing clear examples of the conservation benefits of promoting ecosystem services provided by birds in agricultural settings. Understanding the benefits of bird activity will elevate the value of birds beyond their aesthetic appeal and provide an important tool for land managers to make informed management decisions that benefit production and conservation in modified landscapes. The results from this study will have immediate applications for agricultural management within vineyards, and have the potential to be transferred into other agricultural systems.

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Big Desert adventures

Carnivores in flames: Predator ecology in a fire-prone landscape

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Imagine for a moment you were staring off into the distance from atop a sand dune, with only stunted mallee eucalypts and banksia scrub stretching to the distant horizon. There might be the odd western grey kangaroo or emu poking about, but for the most part there appears to be very little life. However, your eyes would be deceiving you. In fact, this region, encompassing the Big Desert and Wyperfeld National Park, is quite the opposite.

Holding the enviable title of being the most remote place in Victoria, the Big Desert is teeming with life under the surface. Once, it was home to an abundance of native mammals (quolls, bandicoots etc.). However, since settlement, much like the rest of Australia, it has been overrun by an array of invasive species. These invasive species, such as the red fox and feral cat, have since made the Big Desert their home, much to the detriment of the system. In conjunction with a fire regime that is completely different to centuries gone by, the presence of foreign predators has left the region with only the most resilient mammal species.

Therefore, my honours research explores the mechanisms behind how an apex predator (dingo) and two mesopredators (red fox and feral cat) interact with their prey and the landscape around them. As evidence mounts in support of the role dingoes play in suppressing foxes and cats, and thus benefiting prey species, further questions remain over how consistent this relationship is across different systems.

Variables such as habitat structure and fire history can facilitate or dull the strength of these predator interactions – an especially important concept in Australia. For example, feral cats and foxes are known to visit freshly burnt sites, taking advantage of the smorgasbord of prey left without protective vegetation. This double whammy of fire and predation has the potential to devastate fauna populations. As such, the presence of dingoes in a system may become increasingly important after a fire event, insulating prey

A picturesque Big Desert sunrise

Our camera trap setup allows us to survey a range of fauna

species from hungry mesopredators and contributing to native species conservation.

Using both camera traps and scat surveys at a large scale across the Big Desert region, I've set about determining where and when predators are most active and how they interact with their prey. Do foxes and cats prefer more open habitat as it makes hunting easier? Or does this leave them too exposed to being persecuted by dingoes? Or is prey abundance a more important driver of predator distribution? What role does fire play in the interactions between predators and their prey? Answering these questions is vital to further the conservation of our native fauna.

With Australia boasting a worrying mammalian extinction record, understanding how key threatening processes such as predation and fire interact spatially is paramount. Regardless of the outcomes of my study, having the opportunity to explore the wildest place in Victoria is an absolute privilege. Here's hoping the Big Desert continues to remain just that.

Mallee eucalypts like this dominate the Big Desert landscape