2019 University Student Grants Scheme winners

The Australian Wildlife Society's University Research Grants are scholarships offered to honours or postgraduate students at Australian universities. Each year, ten grants of $1,500 are awarded. Grants are available for research projects of direct relevance to the conservation of Australian wildlife; plant or animal. Grants may be used for the purchase of equipment and consumables, travel expenses related to field research, or attendance at conferences at which you are presenting your work.

The Australian Wildlife Society is delighted to announce the winners of the ten grants of $1,500 each to honours or postgraduate students conducting research that will contribute to the conservation of Australian wildlife. The winners for 2019 are:

AMY ROWLES - Hawkesbury Institute of the Environment, Western Sydney University
Project Title: Seasonal importance of high elevation habitat for Australian bats

BRYONY PALMER - School of Biological Sciences, The University of Western Australia
Project Title: Assessing the impact of reintroducing Australian digging mammals

JAMES PEYLA - Future Industries Institute, University of South Australia
Project Title: Investigating the long-term effects of ocean acidification on the giant australian cuttlefish

JINGYI DING - School of Biological, Earth and Environmental Sciences, University of New South Wales
Project Title: How does the structure of Eucalyptus and Acacia forests vary along a rainfall gradient?: implications of changes in climate

KATE CORNELSEN - Centre for Ecosystem Science, University of New South Wales
Project Title: Conserving the greater bilby (*Macrotis lagotis*): breeding bilbies fit-for-release to safeguard their future

KIARRAH SMITH - Fenner School of Environment and Society, Australian National University
Project Title: Reintroduction of the yellow-footed antechinus (*Antechinus flavipes*) to its historic habitat

LACHLAN PETTIT - School of Life and Environmental Sciences, University of Sydney
Project Title: How have Australia's large reptile predators adjusted to a toxic invader through time?

ROSALIE HARRIS - Research School of Biology, Australian National University
Project Title: Does sediment shape biodiversity in tropical macroalgal forests?

SEAN KRISANSKI - School of Technology, Environments and Design, University of Tasmania
Project Title: Understanding spotted-tail quoll behaviour in relation to habitat structure using UAV remote-sensing techniques

VANESSA BROWN - School of Biological Sciences, University of Western Australia
Project Title: Novel seed enhancement technologies to improve restoration success.










Seasonal migration of Australian tree-roosting microbats

AMY ROWLES
Hawkesbury Institute of the Environment
Western Sydney University

Bats are highly mobile animals, which provides them the opportunity to migrate and take advantage of spatial variation in food resources and climatic conditions. The conspicuous nature of large-scale bat migrations in the Northern Hemisphere, with thousands of swarming bats, diurnal activity and large numbers of individuals arriving at particular locations, has attracted the attention of bat researchers for many years. However, recently, more cryptic shorter migration patterns have been realised.

In Europe and North America many studies have documented the seasonal migration of bats, both on a large and small scale. In Australia, however, only a few documented studies on the migration of microbats (small insectivorous bats) have taken place, and as a consequence, the extent to which Australian bats migrate is largely unknown. We know that the distribution of the white-striped freetail bat in Western Australia expands 1,200 km to the north in winter, retracting as temperature and humidity increase. However, this pattern has not been investigated in eastern Australia. The regional migration of eastern bent-winged bats was uncovered in the 1960s when a large-scale banding project tracked movements between maternity caves and winter roost locations. Apart from these examples, we have little other information about the seasonal movements of Australian microbats, which is where my project comes in and includes the following three stages:

1. Gathering evidence from existing records

The initial stage of my project will involve a review of existing records and collation of anecdotal evidence, both published and unpublished, to assess the current evidence in support of either sedentary behaviour or seasonal movement patterns for south-eastern Australian bat species. This review will highlight candidate species for migratory study and will also identify gaps in our knowledge for those species with insufficient data.

2. Stable isotope analysis to predict migration in Australian bats

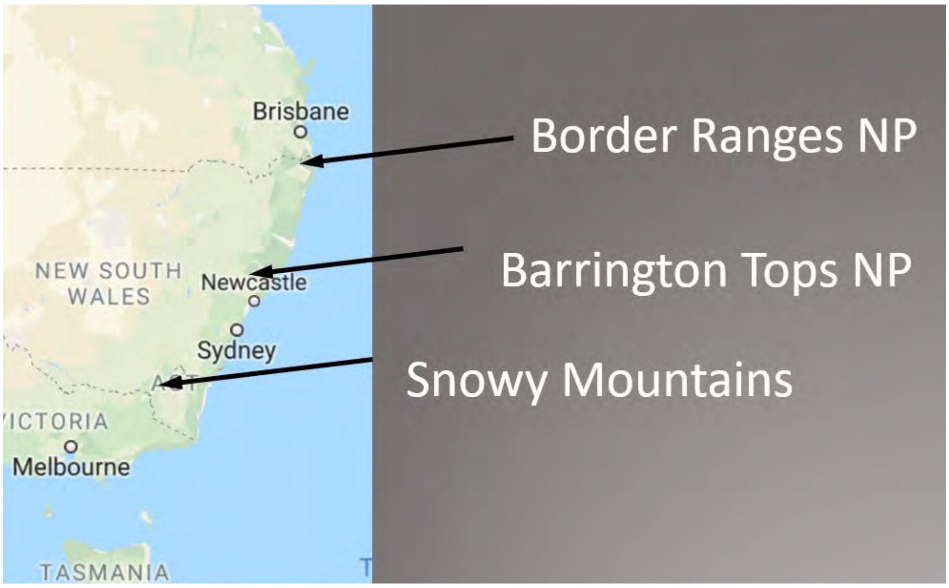
I am going to collect fur samples from a selection of sedentary bat species across south-eastern Australia to create a background map of isotope ratios and then use this data to predict the origin of migratory species. The ratio of stable isotopes in the environment for elements such as hydrogen, carbon and nitrogen vary across geographic regions, and these isotope concentrations become incorporated into body tissues. Stable isotope ratios in fur can be used to predict whether a bat has migrated and where it was residing when the fur grew. This technique has not previously been used in Australia but has been used successfully in the Northern Hemisphere.

3. Elevational migration in tree-roosting bats

I will investigate elevational migration in Australian bats, by measuring seasonal variation in bat activity at different elevations, and test for seasonal movements. Three study areas have been selected, including the Snowy Mountains, Barrington Tops and Border Ranges. I will also investigate how insect activity, climate and environmental factors affect bat activity in these areas to gather information on why migration is or is not occurring in these highly seasonal environments.

To further understand movement dynamics of bat populations in high-elevation areas, I will investigate residency at a mid-elevation site throughout the year in Chichester

Above: Amy Rowles with the new purchases, two SM4ZC bat detectors, thanks to an AWS grant.



Location of elevation study areas.

State Forest (adjacent to Barrington Tops). A long-term mark–recapture study at this site found that residency between years was quite high; however, residency throughout the year has not been addressed yet. This survey will indicate which species are resident (sedentary) throughout the year and which species may migrate seasonally to a higher or lower elevation. The trapping of individuals will also provide valuable information on sex-ratio to investigate sex-biased migration.

Why?

Understanding migratory movements are vital for successful management and conservation of a species. Timing of movements, distance and location of movements, whether all or only sub-populations are moving, and the reasons for migrating are examples of questions that need to be investigated. Such knowledge is now more important than ever with climate change advancing rapidly, and the ongoing loss and degradation of habitat.

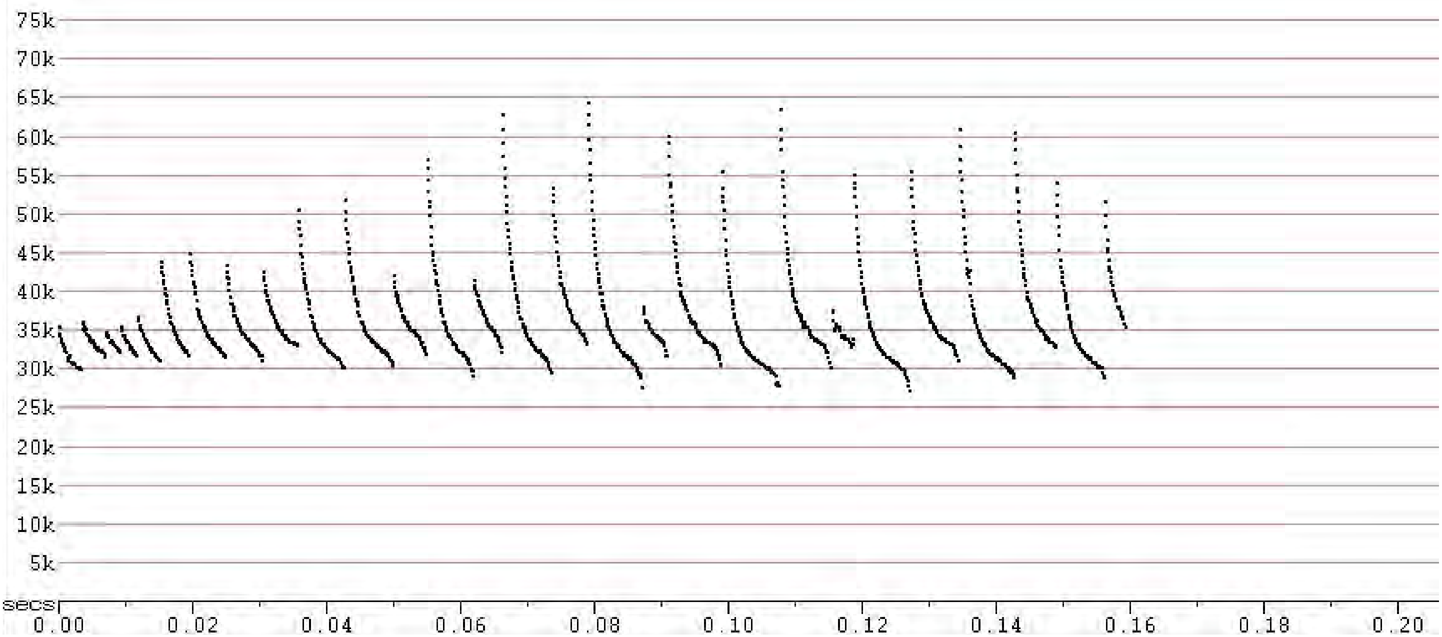
Targeted microbat surveys in New South Wales are usually conducted in the warmer months when bat activity is higher; however, this has led to a lack of information on what resources these bats require in winter. The continuous recording of bat activity throughout the year is likely to give some important further insight into winter bat activity and habitat use.

Greater broad-nosed bat. This is one of the species that occur at the Chichester State Forest site and is listed as Threatened in New South Wales.

As well as general bat activity data, this project will also contribute to the accumulation of information on particular species. There are several threatened species known to occur in my study areas, including a higher elevation specialist, the eastern false pipistrelle, a species listed as Vulnerable in New South Wales. Details of the ecology of many bat species are poorly known, and this project has the potential to improve knowledge of these species.

Thank you

I am honoured and very grateful to have received a University Student Research Grant from the Australian Wildlife Society. This grant has allowed me to purchase two SM4 ZC bat detectors to record ultrasonic bat calls. Ultrasonic calls are used to identify species as well as provide an index for activity levels. I am very excited to investigate the migratory behaviour of Australian bats and above all contribute to the conservation of these amazing animals.



Ultrasonic bat calls are recorded and converted into zero-crossing format as pictured above. The shape and frequency of the calls vary between species and allow for species identification in many cases. However, not all species can be distinguished from others and recording calls results in the identification of species groups instead. The image pictured here is from a Gould's wattled bat, recorded in the Snowy Mountains.

Assessing the impact of reintroducing Australian digging mammals

BRYONY PALMER
School of Biological Sciences
The University of Western Australia

I am a PhD student at the University of Western Australia, and my project is focussed on investigating what happens to soils and vegetation when we reintroduce digging mammals.

Digging mammals are species that dig either to obtain food, such as truffles or soil-dwelling invertebrates, or to create shelter in the form of a burrow or warren. Australia has many species of digging mammals, but my research focusses predominantly on bettongs (especially boodies, *Bettongia lesueur*), bilbies and bandicoots.

'Ecosystem engineers' are species which physically alter their ecosystems to such an extent that they significantly affect resource availability for other species. Bettongs, bilbies and bandicoots are great examples of ecosystem engineers. Their digging activity turns over soils, and this results in increased water infiltration, decomposition rates and nutrient levels. This helps to increase seedling germination rates as well as alter plant species richness, composition and productivity. Their burrows and warrens also provide shelter for a

Above: Bryony releasing a golden bandicoot.

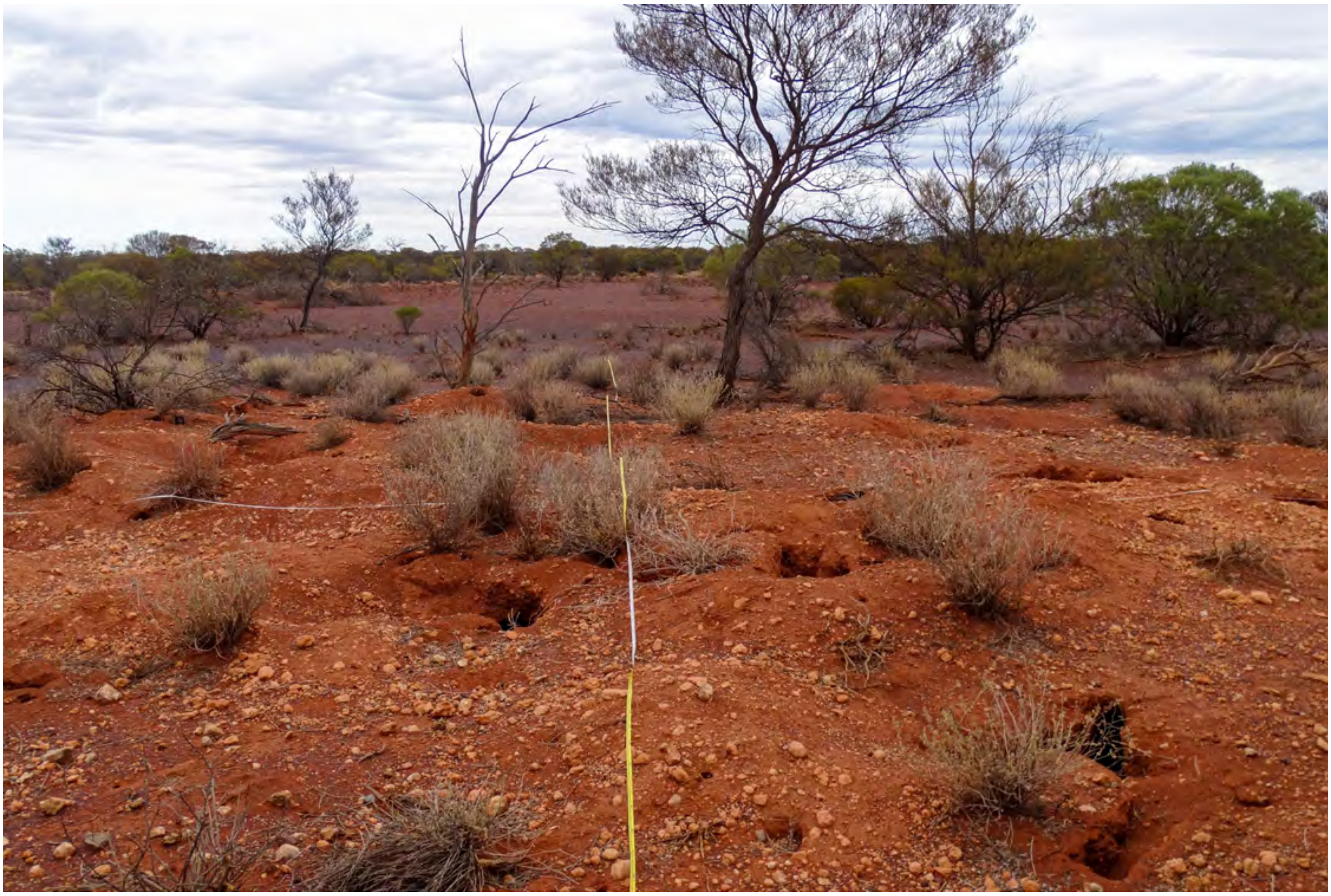
Bryony, and volunteer Gergana, conducting drone surveys.

number of other fauna species that can't create their own homes.

Many Australian diggers are now threatened or endangered, but reintroduction programs are helping to reverse this trend by returning these species to areas they once inhabited. In order to manage these populations properly we need to understand what impact they have on their ecosystems. Key questions include: Could reintroduction programs also be helping to restore the ecosystem functions that digging mammals provide? Does reintroducing digging mammals result in long-term changes to soils and vegetation at landscape-scales or are the effects short-lived and localised? How do reintroduced digging mammals interact with novel ecosystem elements such as weeds?

Using a combination of soil and vegetation surveys, aerial imagery collected by a drone, and lab work, my project is working to answer the above questions. The results will help conservation management agencies set priorities, make decisions on which species to include in reintroduction programs, and may help to explain or set into context observed changes to ecosystems. Information on the potential for digging mammals to facilitate weed spread through their digging activities will help land managers develop appropriate weed control programs.

Burrowing bettong or boodie (*Bettongia lesueur*)



A boodie warren.

Message in a cuttle:
The long-term effects of ocean acidification on the giant Australian cuttlefish

JAMES PEYLA
Future Industries Institute
University of South Australia

If you take a stroll down most Australian beaches, you're bound to see at least a few cuttlebones cast up upon the shore. These shells are the remains of cuttlefishes, close relatives of squids and octopuses. In life, a cuttlefish uses its cuttlebone to control its buoyancy; upon death, its cuttlebone often floats to the surface and drifts with the waves until it hits the coastline. Professional and amateur malacologists have been collecting cuttlebones from beaches for decades, depositing their finds in their local museums. Thus, at a museum, there can be several cuttlebones from the same species collected in the same area years apart. This set of specimens forms a series that may provide insight into how a species has changed through time.

One of the most drastic changes in the marine environment since Australian museum collections were begun has been ocean acidification. As more carbon dioxide has been added to the atmosphere, more has been absorbed by the ocean, since the atmosphere and the ocean are in equilibrium. Once absorbed, carbon dioxide reacts with water to form carbonic acid, lowering the pH. This process of acidification has been experimentally demonstrated to have significant impacts on marine organisms that have calcium carbonate shells (calcium carbonate dissolves in seawater when the pH becomes too low). Because cuttlefishes have a large calcium carbonate structure that is vital to their locomotion, they are potentially vulnerable to decreasing seawater pH. However, it is unknown how ocean acidification is affecting cuttlefishes in the wild.

The giant Australian cuttlefish (*Sepia apama*) is the largest cuttlefish species in the world. Endemic to southern Australia, *S. apama* is found in temperate coastal waters from Brisbane in the east to Exmouth in the west. As a predator of many species and prey to many more, it is a key

Two male giant cuttlefish (*Sepia apama*) fight for access to females at the species' famed mating aggregation in the northern Spencer Gulf, South Australia.

trophic link in Australia's temperate coastal marine food webs. The species is most famous for its complex mating behaviours and large spawning aggregation in the northern Spencer Gulf of South Australia; the only known cuttlefish aggregation on the planet, this event attracts scientists, tourists and documentary filmmakers from around the globe each winter.

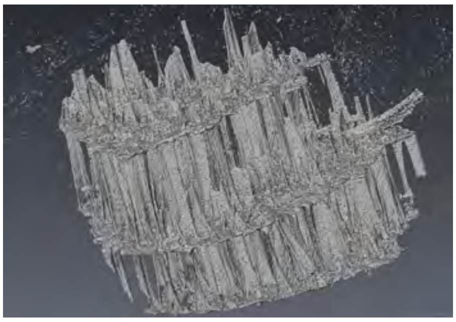
During my year as a Fulbright Student in Adelaide, I am studying how ocean acidification has affected *Sepia apama* over the past century. To do so, I am taking advantage of several series of *S. apama* cuttlebones in museum collections; each series was collected over multiple decades from a single area. I will measure the density of cuttlebones using standard and micro X-ray computed tomography (CT & μCT) scans; since they are essentially 3D X-ray scans, these methodologies have minimal impact on the specimens while delivering accurate and precise results. Here, the Australian Wildlife Society's University Student Research Grant has been critical: these medical-grade scans can be quite expensive, especially given my plan to scan dozens of specimens.

Since *Sepia apama* cuttlebone collections stretch back more than 150 years, this project will provide unprecedented insight into how ocean acidification is affecting a marine animal in the wild. Furthermore, understanding how *S. apama* has been impacted by ocean acidification in the past will inform predictions of the future abundance and survival of this species. This information will benefit managers who protect this iconic species and the ecosystems of which it is a key part.

So, the next time you come across a humble cuttlebone on the beach, take a moment to appreciate what it truly is: a message from the sea itself, describing its current health and even predicting its future.

About the Author:

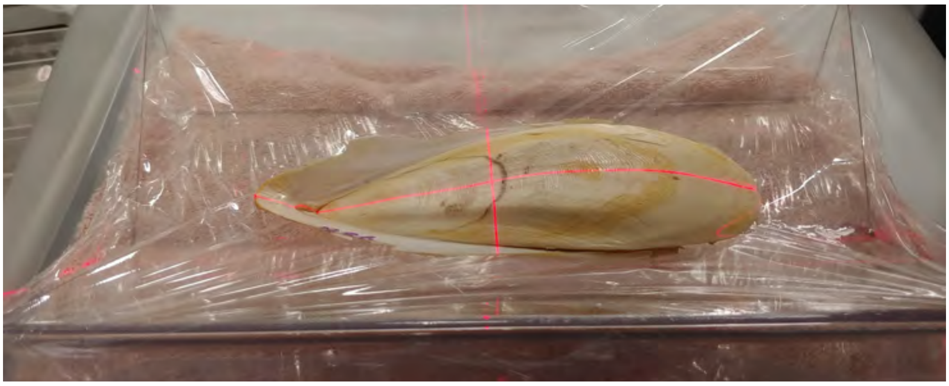
James is an aspiring zoologist with interests in ecology, evolution, systematics, behaviour and physiology. His passion for studying cephalopods has brought him from the United States to the University of South Australia and the University of Adelaide, where he is a visiting researcher through the Fulbright program. He completed his Bachelor of Science in Marine Biology at the College of Charleston in May 2018.



A 3D model of a 1.6 mm fragment of a *Sepia apama* cuttlebone generated by a μCT scan. This type of model reveals the microstructure of a cuttlebone in great detail.

A 3D model of a *Sepia apama* cuttlebone generated by a CT scan. This type of model is useful in measuring the overall density of a cuttlebone.

A *Sepia apama* cuttlebone collected at Cape Leeuwin in April 1969. It is one of hundreds of *Sepia apama* cuttlebones at the Western Australian Museum.



A *Sepia apama* cuttlebone about to be CT scanned. By using CT, James can accurately assess the density of a cuttlebone nondestructively, which is necessary when working with museum specimens.

James in awe of a giant cuttlefish (*Sepia apama*) while diving at the mating aggregation this May.

How does the structure of *Eucalyptus* and *Acacia* forests vary along a rainfall gradient? Implications of changes in climate

JINGYI DING
School of Biological, Earth and Environmental Sciences
University of New South Wales

Most drylands in Australia are covered by native woody plants, such as *Eucalyptus* spp. and *Acacia* spp. They provide shade for livestock and are homes to diverse animals (e.g., birds, lizards, mammals). Australia's climate is predicted to become hotter and drier over the next 50 years with lower and more variable rainfall, which will threaten the survival of native woody plants. Therefore, it is crucial to understand how *Eucalyptus* spp. and *Acacia* spp. adapt to less rainfall under a changing climate.

An easy way to understand the plant adaptation strategy is to look at the plant structure (e.g., plant height and canopy size). For example, plant height affects a plant's ability to reach the light resource and its resilience to fire – taller plants get more light and are more likely to escape the fire risk. Canopy width determines its ability to provide habitat and obtain rainfall resource, with wider plants being able to provide bigger shelters for animals and intercept more rainfall. The difference between woody plant structure in high rainfall and low rainfall areas can reflect the plants' growth strategies in different water stress environments. Exploring how structure of *Eucalyptus* spp. and *Acacia* spp. (e.g. height and size) might change with declining rainfall can show us how Australian native woody plants are likely to survive under drier and hotter climates in the future.

In my research, I measure the structure of *Eucalyptus* spp. and *Acacia* spp. at 150 sites along the rainfall gradient across humid, dry subhumid, semiarid and arid areas in New South Wales. I aim to answer: 1. how different structures of native plants might help them cope with less and more variable rainfall; and 2. how climate changes, soil properties and grazing intensity affect the woody structure in drier environments.

I have been collecting the data on woody plant structure by doing field surveys along a rainfall gradient in eastern Australia, from Sydney (east coast, humid area) to Cameron Corner (arid area). At each site, I measure plant height, height of first branch, canopy width and stem diameter, and count the branch numbers of each tree and shrub along a 100-metre transect. I also survey the soil surface condition (e.g. soil texture, plant cover, litter cover, biological soil crust cover) using one-metre diameter circular quadrats and count the dung of all herbivores within these quadrats as the grazing intensity.

So far, I have conducted field surveys from the east coast to Bourke at a total of 124 sites. I expected that woody plants will change from tall, narrow trees to short, wide shrubs to conserve water resource and intercept more rainfall in drier environments. Preliminary results have found that height of *Eucalyptus* spp. and *Acacia*

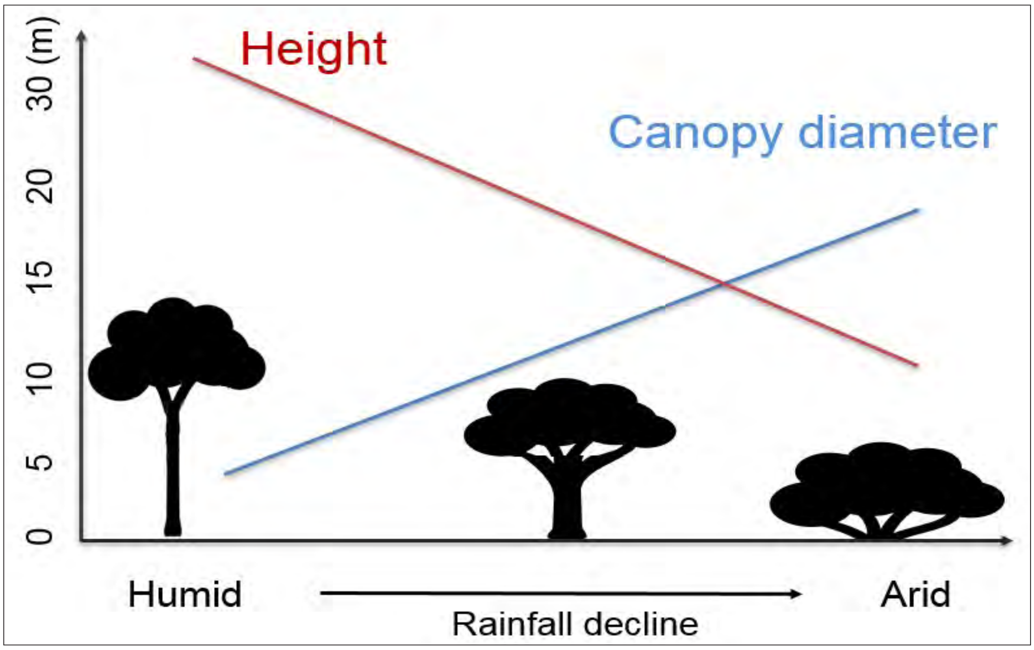
A general view of the woodland in humid, dry subhumid, semiarid and arid areas.

spp. decrease, but canopy didn't change with declined rainfall. My next steps are to finish the field survey towards Cameron Corner to test the variation trend in *Eucalyptus* spp. and *Acacia* spp. structure. I will also analyse the effect of soil and grazing intensity to see how they affect the plant structure in drier environments.

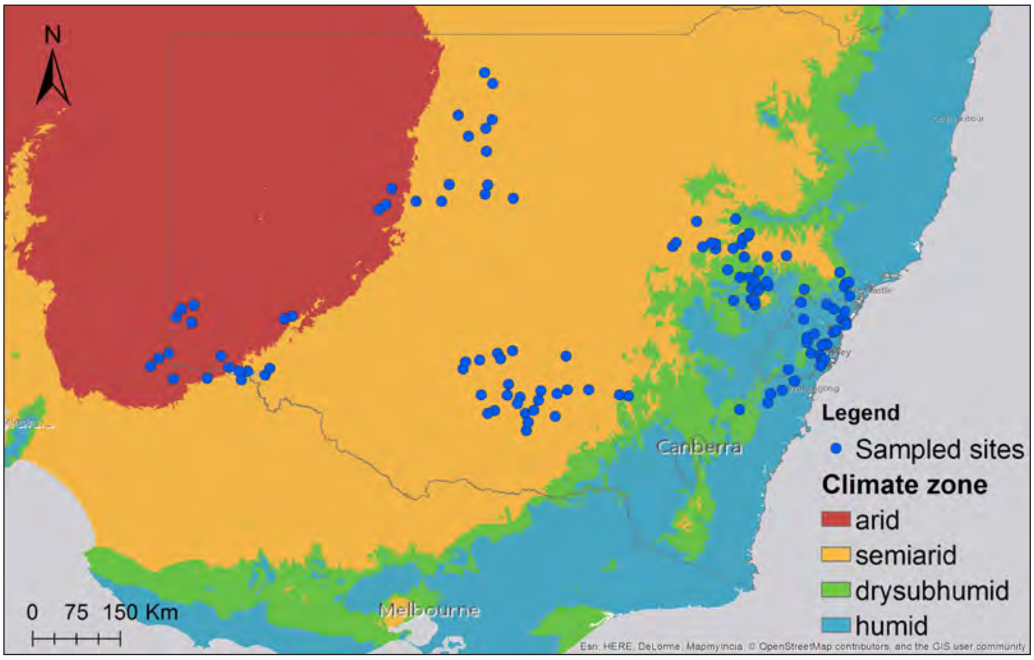
These research results will give practitioners and scientists useful insights into the resilience of *Eucalyptus* and *Acacia* forests, which are critically important as habitat for native animals and sinks for carbon.

Australians regard eucalypts and wattles as important elements in the city and the bush, and the work will reveal how the 'services' provided by these trees are likely to change in a drier world. The work will also add to our knowledge of species that are likely to be more resistant to climate change and therefore those to be promoted by conservation societies and native plant nurseries.

Thank you for the grant from the Australian Wildlife Society, which will support me to finish the whole gradient and get a comprehensive assessment of how these two native woody plant groups adapt to the changes in climate.



Hypothesised changes in woody plant height and canopy diameter with declining rainfall.



A map of the 124 sites that have changed from a humid to an arid area.

A stepping-stone to the wild: Breeding bilbies fit for release to safeguard their future

KATE CORNELSEN
Centre for Ecosystem Science
University of New South Wales

The greater bilby (*Macrotis lagotis*) was once Australia's most widespread marsupial! Before their decline bilbies occupied 70 percent of mainland Australia, from desert dunes to temperate woodlands. The introduction of foxes (*Vulpes vulpes*) and cats (*Felis catus*) to Australia has contributed to the bilby's range contracting to less than 20 percent of its former range. Many other native mammals in Australia, naïve to foxes and cats, have declined, particularly those that fall within the 'Critical Weight Range'. These ground dwelling species that weigh between 35 g and 5.5 kg – including the bilby – are the perfect prey for invasive predators.

Breeding programs are essential to the national recovery and conservation of the bilby. However, current programs are typically a poor replica for conditions present in the wild. This can cause the unintentional loss of phenotypes that make it possible for species to return to the wild. So how can we maintain a healthy breeding population of bilbies while ensuring phenotypes necessary for reintroduction success are encouraged and not lost?

My research aims to address this question by studying the behaviour and ecology of bilbies reintroduced to a sanctuary in Dubbo, New South Wales, hosted by the Taronga Conservation Society Australia. The sanctuary will act as a semi-wild breed-for-release program where individuals can breed with whomever they choose, be exposed to other resident species including some native predators (e.g. goannas) or potential diet competitors (e.g. wallaby, echidna and other bilbies), and learn how to navigate a naturally stochastic environment. Founders will be sourced from captivity, but it is expected that individuals will be able to respond to natural pressures and show plasticity in their behaviour and adaptation to this 'wilder' environment.

How can we tell whether the bilbies are learning and responding to their semi-wild environment? To answer this, personality tests are already being carried out on bilbies pre-release and will be repeated post-release to track the extent of behavioural change over time and generations. To monitor their movements and any shifts in range, each bilby released will be fitted with lightweight VHF and GPS loggers with tail attachment. This will allow me to determine how responsive individuals are to changes in available habitat by recording the habitat they select, both to burrows during the day, and at night when they are active above ground. Variation in breeding success between released individuals will be determined by recapturing individuals every three months to check female pouches for young. As it is more challenging to identify breeding males, DNA will be collected from founders and their offspring to assign paternity and better understand both maternal and paternal influence on phenotypes and recruitment success.

Overall, my research will contribute to making informed decisions about who, how, when, and where to translocate. The continued management of this semi-wild population for breeding and release will increase our understanding of how bilbies can be successfully transitioned back to the wild 'beyond the fence'. With many projects like this currently underway to save the bilby from extinction, there is a bright future for this species in the wild rather than just within fenced enclosures.

I am thankful to the Australian Wildlife Society for awarding me this grant to assist me with my PhD research.

Female bilby having VHF transmitter attached to her tail.

Measuring head length of female bilby.

Reintroduction of the yellow-footed antechinus (*Antechinus flavipes*) to its historical habitat

KIARRAH SMITH
Fenner School of Environment and Society
Australian National University

Imagine for a moment what the Australian landscape must have looked like 250 years ago, before European settlement, where the diversity of animals in the trees and on the ground was bursting at the seams. That is the kind of magical landscape I dream of recreating by bringing back small mammals to Mulligans Flat Woodland Sanctuary (MFWS, Forde, Australian Capital Territory (ACT)). For yellow-footed antechinus, being a small mammal with occurrence records spanning a relatively broad distribution, there is the unfortunate potential to be overlooked when prioritising threatened species management. However, proactive conservation efforts (initiated prior to reaching a crisis point) can reinforce the long-term persistence of species such as the yellowfooted antechinus, while simultaneously enabling whole ecosystem restoration.

The yellow-footed antechinus is listed as Vulnerable in South Australia and has largely disappeared from some parts of its previous range, including the ACT. As part of my PhD at the Australian National University (ANU), in partnership with the ACT Government and Woodlands and Wetlands Trust, and with the generous support of the Australian Wildlife Society, a pilot reintroduction of yellow-footed antechinus to MFWS will take place in autumn 2020. Re-establishing yellow-footed antechinus in this historic habitat could assist the long-term conservation of this species amidst habitat changes caused by climate change and expanding human activities. Moreover, the project will pave the way for subsequent translocations of yellow-footed antechinus and may inform and support the success of future reintroductions of other small mammals in Australia.

A small number of wild yellow-footed antechinus will be sourced from existing populations in New South Wales (NSW) for translocation to MFWS. Initial reintroduction trials will employ a soft-release method where animals will be given a chance to acclimatise to the local environment while being housed and fed in ring-tank enclosures placed within the MFWS. Once released from the enclosures, radio-tracking of individuals (supplemented by footprint tunnel, remote camera and live-trapping surveys) will be undertaken to gain detailed insights into post-release dispersal, survival and habitat use. This project is being undertaken with ANU animal ethics approval, as well as relevant ACT and NSW scientific licences.

Bringing back yellow-footed antechinus is unlikely to be easy or straightforward, but with perseverance, we could someday see this species once again contributing to a diverse and magical landscape in MFWS and beyond.

Yellow-footed antechinus

How have Australia's large predators adjusted to a toxic invader through time?

LACHLAN PETIT
School of Life and Environmental Sciences
University of Sydney

In 1935, cane toads (*Rhinella marina*) were released into sugar cane fields across Queensland. Biological controls were 'in fashion', and it was hoped that the voracious South American amphibians would eat up insect pests in ailing sugar crops. It was a monumental failure. The toads had no measurable impact on crop yields. Instead, toads immediately spread from the cane fields, wreaking ecological havoc as they began their long march across Queensland and the Northern Territory. Today, their march continues through the last biodiversity stronghold of northern Australia, the Kimberley. For most of our native animals, cane toads pose no problem. However, for our large frog-eating native predators, cane toads can spell disaster.

Toads are highly toxic to Australian predators because the endemic fauna has no evolutionary history of coexistence with 'true toads', and thus has not evolved immunity to the amphibian's powerful toxins. As a result, toad invasion is soon followed by massive population declines for many of our apex predators (elapid snakes, quolls, goannas) who see the arrival of cane toads as a new tasty meal. In turn, declines in apex predators can then send ripples out through the ecosystem, affecting populations of prey species lower down the food chain.

One apex predator severely impacted by toads is the yellow-spotted monitor (*Varanus panoptes*). A relative of the Komodo dragon, these giant "goannas" rule the floodplains, forests and savannahs of tropical Australia. Not only are they iconic, and ecologically important, but they also hold huge cultural significance for indigenous peoples and are a highly prized bush tucker. These animals continue to surprise us as we discover more about their complex behavioural ecology, mating tactics and remarkable nesting strategies. They also have a reputation for being incredibly smart!

Yellow-spotted monitors are generalist apex predators and can reach high densities where resources are abundant. Tragically, yellow-spotted monitors feel the brunt of the toad invasion, with typical population declines of 90 percent when toads invade. The sudden decimation of these giant lizards triggers 'trophic cascades' (changes in the numbers of animals further down the food chain). Thus, the decline of yellow-spotted monitors is arguably the most significant impact of the cane

Yellow-spotted monitor

toad invasion due to the magnitude of goanna declines, the network of indirect effects on the other fauna in the ecosystem triggered by their removal, and the ecological hole left afterwards.

We know that the near-extirpation of goannas by toads has severely impacted ecosystem processes in the short term, but how long does this effect persist? The goanna populations may eventually recover, but we know nothing about the rate of recovery or the ultimate ecological consequences of this perturbation. How do ecological processes (such as scavenging) and faunal communities change over time? Given the critical roles of apex predators in regulating ecosystem function, and the negative impacts of toads on goannas, we need to know the time-course of such effects to prioritise threatening processes.

So how do I begin to answer these questions? With the help of the Australian Wildlife Society, I am surveying 24 sites along the 85-year toad invasion chronosequence in the wet/dry tropics between Broome and Townsville. Six of these sites are in the West Kimberley and are currently free of toads. Surveys and motion-sensing cameras at these sites will provide the baseline numbers for yellow-spotted monitors and their rates of scavenging and will enable me to estimate the population size of key prey species. The other 18 sites across tropical Australia have contained cane toads for between 1 year and 85 years and were selected based on historical records of abundant yellow-spotted monitors before toad invasion. Some of my study sites are situated at the current invasion vanguard in the East Kimberley, whereas sites near the Queensland east coast have had toads in the landscape for over 80 years. Comparing the survey results from toad-present sites against the baseline numbers from toad-free sites will provide a snapshot of how goannas and ecosystems respond to the arrival and long-term residency of toads.

Research on invasive species typically focuses on their initial impacts at the invasion front, but the changes that invaders inflict on ecosystems over longer timescales are less well understood. My research is designed to help address this imbalance. By clarifying the longterm impacts of toad invasion on goannas and ecosystems, I hope to reveal the full extent of invader impacts – an issue that is vitally important for implementing successful management strategies. Perhaps goanna populations cannot survive long-term in the presence of toads, or perhaps they hang on, or perhaps they recover. Hopefully, these magnificent lizards and the environments they inhabit will eventually be able to cope with the challenges that invasive toads have brought to Australia. Only time will tell.

Macroalgae vs urchin: Drivers of biodiversity in macroalgal forests

ROSALIE HARRIS
Research School of Biology
Australian National University

In the tropics, a range of habitat-forming species, such as corals, seagrass and macroalgae, form a mosaic of patches of different sizes and location that together comprise the seascape. For my study, I focused on what may drive patterns of biodiversity in macroalgal forests at local and regional scales in the World Heritage Ningaloo reef ecosystem in Western Australia. This project has been a collaboration between the Australian National University and the local marine park management agency, the Department of Biodiversity, Conservation and Attractions (DBCA) Western Australia.

Macroalgal forests are home and harbour to a huge range of marine organisms, providing them with food, shelter and a place to breed. They not only support organisms in their immediate environment but also support other seascapes far and wide. They do this through the accumulation of biomass in the form of fishes, epifauna, nutrients and organic carbon. In winter, macroalgal phenology, such as day length and temperature, cause the canopy of the algae to detach, which forms wrack or raft. This then floats in the water column and drifts via ocean currents and various circulation patterns to seascapes elsewhere and provides them with a range of ecosystem goods and services.

I was keenly interested in understanding the role of sediment in shaping patterns of tropical macroalgal biodiversity. To do this, I spent a lot of time underwater to measure the community composition, canopy height and density of both adults and recruits, percentage cover of sediment, sediment depth and urchin density. Though my focus was sediment, the whole project took quite a turn once we arrived at Ningaloo and entered the water. Urchins were everywhere, and there was a clear difference in overall macroalgae biomass between sites with and without them. This was something that both of my supervisors – who have been going to Ningaloo for over a decade now – had never seen before.

Diving deeper, we found four species of urchin, but three of these were known ‘drift’ feeders that sit in their little burrows and catch bits of detached algae as they drift past. That left one main culprit, the collector urchin *Tripneustes gratilla*. These urchins are what is known as an active forager; they actively hunt and consume attached macroalgae, and are fairly

Rosie diving, measuring sediment depth and canopy height.

The Marine Hebeco Lab: L to R: Rosie Harris, Chris Fulton (supervisor), David Ellis and Ashleigh Buckley after a great day of diving.

indiscriminate in their choice of food. But they do love fucoids, including the Sargassacea that form extensive forests at Ningaloo.

My project appeared to be turning into the urchin story even more on returning to Ningaloo in winter, when we found the collector urchin had spread to almost every one of my study sites. Species richness was much lower than in the winters of previous years. There were thousands of them, with potentially huge flow-on effects for the macroalgal forests and all the species that depend on them for food and habitat.

From the summer data, we found that sediment depth and cover are powerful predictors of community assembly, alongside the top-down consumer pressure from the collector urchins. This is the first time to show that this is happening at the local scale, at the transect level and is not accurate to assess on a broad scale. If you told me how deep the sediment is, I could give you a fair degree of certainty of what community you are likely to find there. The importance of sediment at this scale should be considered in spatial planning when forming marine parks. Just as wave action and depth are accounted for, it's easy to measure and explains much of the variation in both canopy structure and community composition for macroalgae.

But something possibly more important than sediment right now is the urchins. Urchin densities correlated negatively with macroalgal canopy height and density. They also came out as a strong predictor of community assembly. Further investigation of habitat selectivity and targeted algal species is needed if we are to understand what is going on here. There is a whole range of possible drivers influencing this urchin infestation, such as a high recruitment year, temperature, El Niño Southern Oscillation, wind, etc.

Our lab research team plans to explore this more next year so that we can gain a sense of what implications a serious urchin outbreak may have on these forests. If macroalgae forests are being degraded, this could lead to the collapse of ecosystem goods and services they provide to seascapes already under threat, such as coral reefs.

Collector urchin

Collector urchins on the back reef

Macroalgae patch in winter (*Sargassopsis* sp.)

Drones and deep learning for habitat monitoring: An exploratory study to understand how spotted-tail quolls interact with their environment

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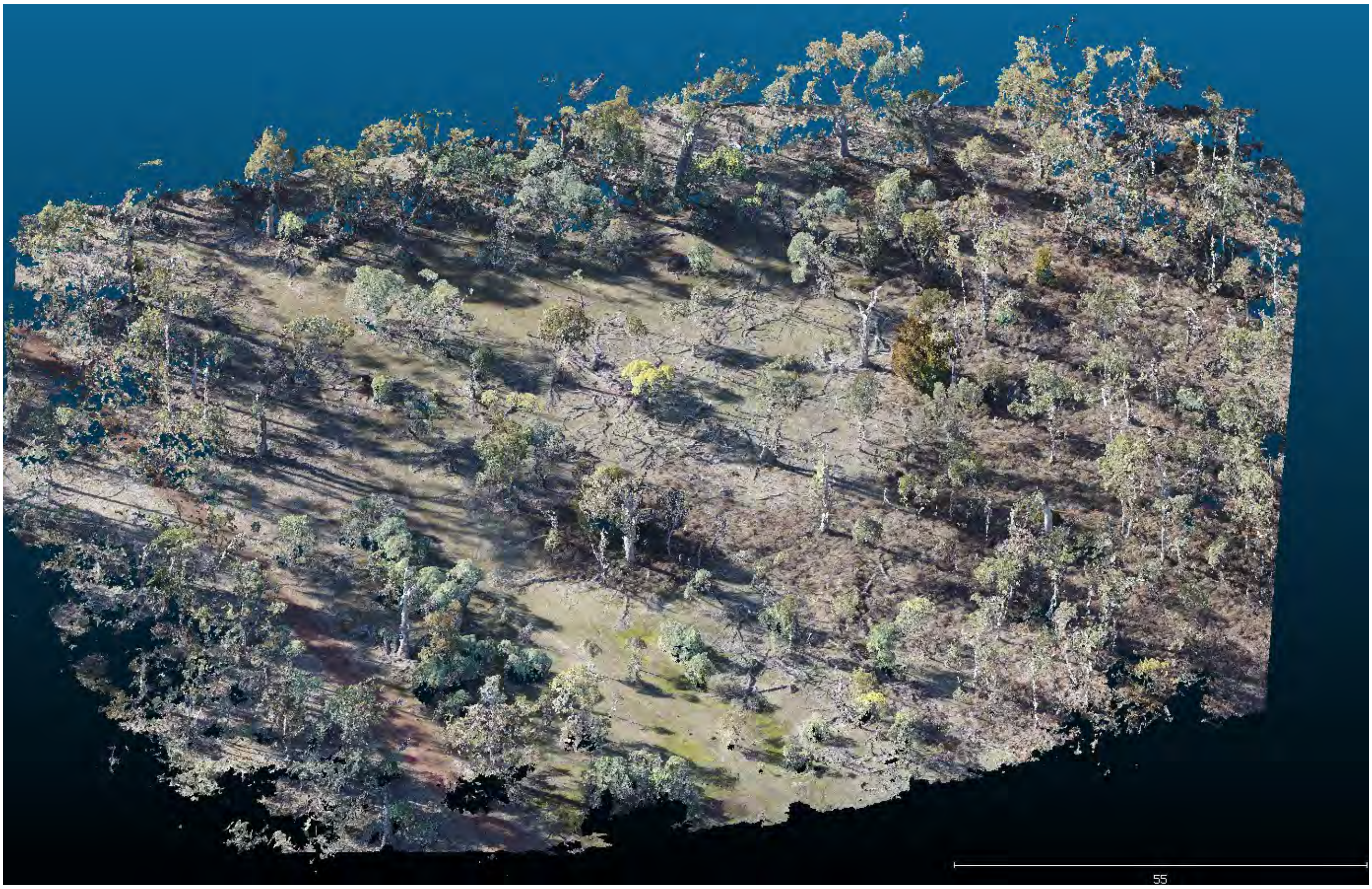
Drones are transforming how we can study and monitor wildlife. They have been shown to be highly effective and accurate tools for monitoring bird populations, spotting whales and even spotting koalas from the air. While many zoology studies investigate the use of drones to count animals, there are other ways we can use these tools to study animal species. Drones are much more than just an eye in the sky; they are also powerful mapping tools.

As part of my PhD at the University of Tasmania, I am using drones to build high-resolution 3D models of spotted-tail quoll habitat in the Tasmanian Midlands. These 3D models are known as point clouds, which are simply a list of points with *x*, *y* and *z* coordinates. In this study, I am using a process known as photogrammetry, which involves creating 3D models from a large number of overlapping photos. This process also provides colour information for these points. On their own, individual points don't tell you much; however, a high-resolution point cloud can contain a great deal of information.

From these 3D models, we can obtain a great deal of information about the structure of the forest; however, extracting this information is challenging. I am using deep learning techniques to separate different structural features of this forest to simplify the measurement process. The attributes I wish to measure are stem size, canopy cover, tree height, and the amount of low-lying vegetation and coarse woody debris. Each of these attributes can contribute to a measure of the structural complexity of the study area. The figure below



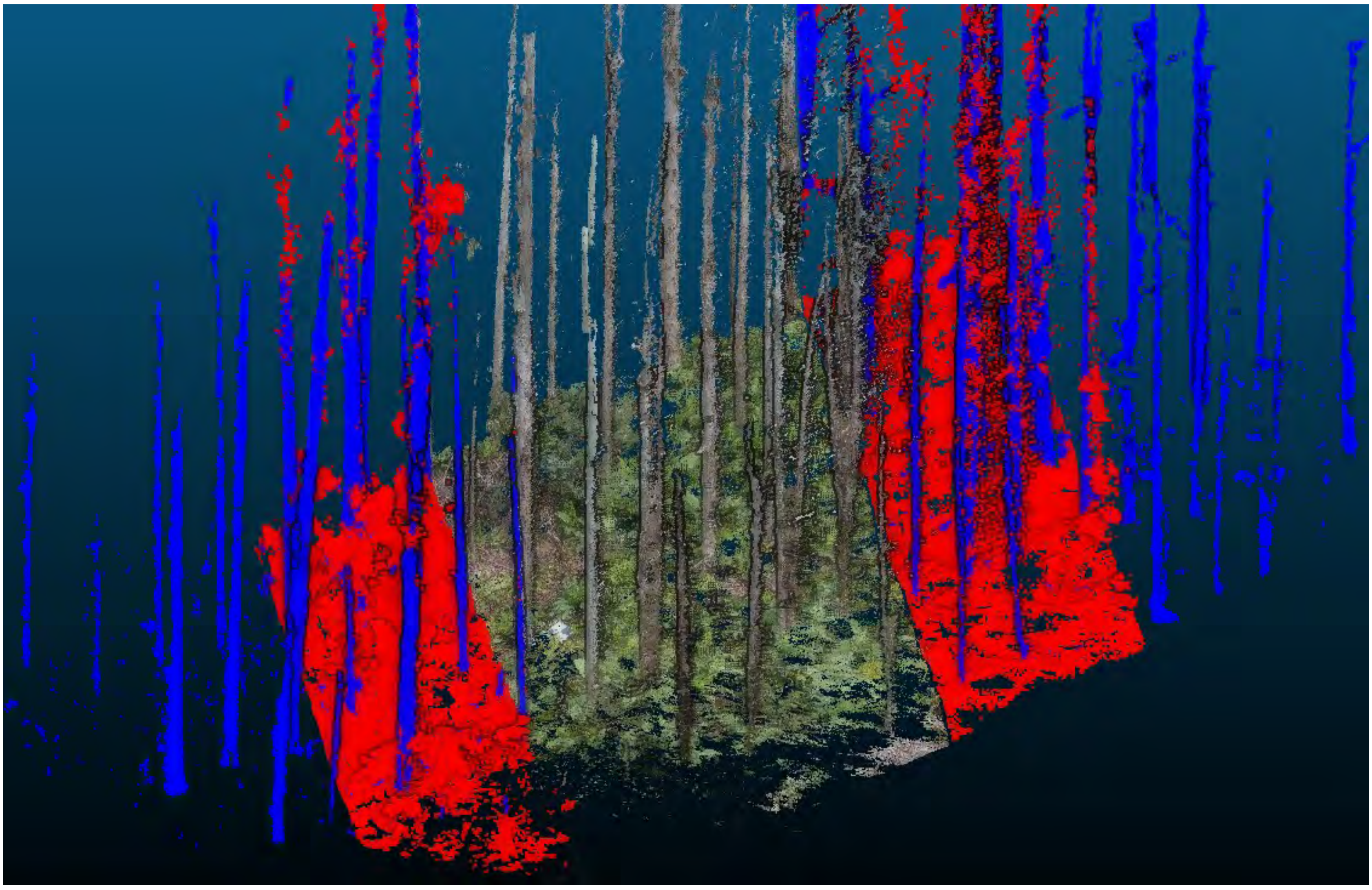
A 3D model of one of the study sites, made from images captured by a drone. The model contains over 50 million points with a point every 2.5 cm. Models such as these capture a tremendous amount of detail about habitat structure, and this example took less than 20 minutes of flying to map.

shows the output of the deep learning model which can separate stems from other forest features to simplify the measurement of the stems. These separated features will be measured automatically with custom software, to quantify the structural complexity of this area in great detail. With these measurements of forest structure, further work will involve interrogating this data in the context of GPS tracks of quolls and bettongs in the area, and potentially other traces of animal presence such as diggings or burrows.

So far, we have performed a pilot trial on a subset of the study area to develop our approach and test equipment and data processing techniques. In the near future, we will perform a detailed study of this area with a refined work flow. With our ongoing research, we aim to explore the effectiveness of drone-based remote sensing combined with data science techniques as a tool for conservation monitoring and research, as well as develop insights about how spotted-tail quolls act depending on the surrounding habitat structure. From high-resolution 3D reconstructions of the landscape, we can extract features of the landscape at a scope and scale which would be impractical to obtain through conventional manual measurement techniques. If we can understand better which structural attributes are most important to the spotted-tail quolls, we can maximise the effectiveness of our restoration efforts to protect this species.

Spotted-tail quoll. Photographer: Michael J Fromholtz

I wish to thank the Australian Wildlife Society for providing me with a University Student Grant. With this grant, I was able to purchase much-needed equipment for fieldwork on this project.



A visualisation of how I am using deep learning techniques to simplify the forest measurement process by separating structural features. In this example, the deep learning model has separated the stems from considerable underlying vegetation which would otherwise interfere with automatic measurements.

Improving the conservation of banksia woodlands with new seed enhancement technologies

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The Banksia woodlands are a unique, biodiverse ecological community found in the south-west of Western Australia and provide important habitat and food source for the Endangered Carnaby's black-cockatoo. These woodlands, which once spanned the Swan Coastal Plain of Western Australia, are now highly fragmented due to extensive clearing for urban infrastructures such as housing and roads, mining and pine plantations. These woodlands were recently listed as a Threatened Ecological Community, and successful restoration is crucial to their conservation. Successful restoration of highly degraded landscapes, such as the Banksia woodlands, can be a complex process, with a number of challenges, including poor native species establishment and weed competition.

Weed invasion and competition from exotic grasses, such as perennial veldt grass, can seriously impact the success of Banksia woodland restoration. High weed loads can reduce the growth and establishment of native species, alter woodland vegetation structure and alter soil nutrients. Weeds are generally controlled through herbicide application; however, this can also negatively impact native species. To protect native species from herbicides, products such as activated carbon can be used. Activated carbon is known to adsorb herbicides because of its high surface area and high degree of porosity. Biochar, a product similar to activated carbon, has also been found to adsorb herbicides. Both activated carbon and biochar can be used in a range of seed enhancement technologies, which may assist when overcoming barriers such as weed competition.

Seed enhancement technologies, which include coating, extruded pelleting, flaming and priming, are a range of techniques used to improve germination, emergence and growth, and improve handling and mechanical

A restored Banksia woodland site near Ellenbrook, Western Australia.

delivery. Traditionally, technologies such as coating and priming have been used in agriculture and horticulture. However, more recently, they have been tested in the restoration of native ecosystems, and technologies such as flaming and extruded pelleting have been developed.

Extruded pellets are created from a dough that incorporates the native seeds. This mixture is extruded through a die (e.g. an industrial pasta machine) and cut into short lengths. Extruded pellets with activated carbon have been tested with different types of pre-emergent, or soil applied, herbicides such as Imazapic and Simazine. Results show that the extruded pellets increased herbicide tolerance of the native seeds, while the herbicides effectively controlled weeds. Biochar has yet to be tested in extruded pelleting.

Overall, my project aims to improve restoration success of highly degraded post-pine and post-mine sites that were previously Banksia woodlands, through the development and deployment of seed enhancement technologies. In particular, I aim to use activated carbon and biochar extruded pellets to overcome weed competition and improve native species establishment.

As part of my project, I am examining the soil chemistry of both post-pine and post-mine sites in comparison to a natural Banksia woodland community. This is important as the soil chemistry of a site can be significantly altered by high weed loads. I will also investigate how my seed coating treatments will impact soil chemistry over time. To complete this task the soil chemistry (e.g. pH, electrical conductivity, nitrogen, carbon, phosphorus and potassium of all sites will be analysed before treatments are applied, and throughout the field trials. The initial characteristics (e.g. pH) of activated carbon and biochar will also be tested. I will be using the grant from the Australian Wildlife Society to complete this soil sampling.

My project, through this soil testing and other experiments, will provide the necessary knowledge to advance our understanding of how we can assist in the recovery of these degraded ecosystems. This knowledge will then feed into the vital conservation of the Banksia woodlands and those who call it home.

Originally a Banksia woodland, this site was cleared for sand mining. Now one of Vanessa's field trials will be installed here, testing a variety of seed enhancement technologies.

Extruded pellets containing activated carbon, ready to deploy in the field.

Vanessa working in the Seed Enhancement Technology Lab, Kings Park, Western Australia.