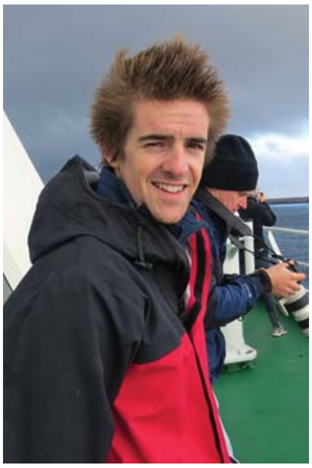


Changing climate and the winter foraging ecology of Antarctic fur seal populations

Ben Arthur,
Marine Science,
University of Tasmania

The Southern Ocean is a rapidly changing environment and there is a pressing need to increase our understanding of this complex ecosystem, the impacts of large-scale climate changes, and the effectiveness of conservation and management measures. Despite many studies into the effects of large-scale climatic changes on the physical structure of the Southern Ocean, how such changes will impact ecosystem structure and function are poorly understood. Any changes, however, will be reflected in the responses of high-trophic level species, such as the Antarctic fur seal (*Arctocephalus gazella*), making them ideal indicators of wider ecosystem change.

In the Southern Ocean, variation in prey availability to higher trophic levels occurs as part of normal oceanographic and atmospheric phenomena. However, there is increasing evidence of anthropogenic changes in the distribution and abundance of prey, particularly through large-scale climate changes. Several studies have already documented demographic changes in predator populations associated with the predicted effects of climate change and there are growing signs that responses such as these are indicative of large-scale ecosystem shifts. However, despite these studies, the links between the physical effects of climate change, biological productivity and the response of top predators in the Southern Ocean remain poorly understood.

During the winter, Antarctic marine predators face a substantially different environment, both physically and

Antarctic fur seals on sub-Antarctic Marion Island in the Southern Indian Ocean. Photo: Ben Arthur biologically, from the summer season. As a result, winter foraging patterns can differ markedly from the more constrained summer foraging behaviours that are well documented for many species. Quantitative studies into the winter habitat use and foraging ecology of top predators are therefore critical to better understand the influence of environmental variability and fluctuations in prey resources on higher trophic level species. Until recently, quantifying the habitat use of Antarctic marine predators during the pre-breeding winter period was difficult, but advancements in bio-logging technology have made tracking the at-sea movements of animals more attainable and affordable.

The winter foraging behavior of the Antarctic fur seal is the focus of an international collaborative study lead by the Institute for Marine and Antarctic Studies (IMAS) at the University of Tasmania. The Antarctic fur seal is a numerous and key Southern Ocean predator with a global population that has increased rapidly since sealing operations ceased in the early 20th century after the species was driven to economic extinction. Of the 10 major breeding islands of the species, two are Australian territories: Macquarie and Heard Island. The populations of fur seals at both of these colonies are still recovering from over-exploitation, having re-established in the second half of the 20th century.

Since 2008, the winter foraging movements of over 200 female Antarctic fur seals has been studied at three circum-polar breeding sites using miniature geo-locating (GLS) tags. The project is a collaboration between the Antarctic research programs of Australia, South Africa, Britain, the United States and, soon, France. Such a coordinated study is greatly increasing our understanding of the habitat and dietary preferences of this top predator, information that is needed to inform ecosystem models and management measures in the Southern Ocean. Australia has a particularly important obligation in this regard due to its large territorial claim of Antarctic and sub-Antarctic waters.

The rare behavioural data set resulting from this program also provides an exceptional opportunity to understand the effects of climate shifts on a higher-level predator. To date, this project has revealed considerable variability in the overwintering migrations of female fur seals from different colonies, the long-term re-use of important oceanic foraging grounds by individuals over multiple years and the first insights into the diving behaviour and vertical habitat use of this species during the winter period. Future work aims to identify important foraging habitats, and the oceanographic factors influencing these, for female Antarctic fur seals from several Southern Ocean colonies including those with no previous data, and model the potential responses of Antarctic fur seals to the rapidly changing Antarctic marine ecosystem.

A female Antarctic fur seal and pup. The female is carrying a geo-location tag attached to her flipper, which records light level used to estimate the location of winter migrations. Photo: Chris Oosthuizen

Christine Evans holding a male superb fairy wren. Photo: Katharina Peters

The hidden costs of extra pair paternity:

Implications for survival and reproductive success in an endemic woodland bird

Christine Evans, PhD Student,
BirdLab, School of Biological Sciences,
Flinders University

The superb fairy-wren is an iconic and charismatic Australian woodland songbird found throughout south-eastern Australia. The species is considered common but like many woodland birds, superb fairy-wren population numbers are rapidly declining in the face of habitat fragmentation, degradation and destruction in the Mount Lofty Ranges region of South Australia. Monitored populations within this region also suffer from high nest predation and low rates of nesting success. My project examines how the behavioural ecology of this species influences offspring survival and reproductive success.

Like most fairy-wren species, superb fairy-wrens are notorious for being highly promiscuous. The female mates with males other than her pair male and most nests have at least one chick sired by an extra-pair male. This female strategy increases the genetic variance of her offspring yet there may be hidden costs of extra-pair paternity (EPP) as pair males lower their parental care when they perceive low parental investment into offspring. Parental care includes feeding chicks and nest guarding, which are important for the development and survival of chicks, and overall reproductive success. Mating with multiple males therefore can be a risky strategy for the female, because her offspring might receive less male parental care.

Female superb fairy wren feeding chicks in nest. Photo: Katharina Mahr

My study examines the impacts of EPP on the survival and reproductive success in the superb fairy-wren. We test if nests with many extra-pair young receive less male parental care, and if nests with lower parental care have lower fledgling success. Over the past three years we found and monitored over 70 nests of superb fairy-wrens at Cleland Conservation Park and Scott Creek Conservation Park, in the Mount Lofty Ranges. Active nests were monitored every 2–3 days to assess breeding stage, clutch size, hatching date, brood size, chick body condition, number of fledged young, fledging date and nest outcome. We also monitored behaviour of adult birds at the nests, including incubation behaviour, male nest guarding and male and female feeding rates. These data will be analysed in relation to the proportion of extra-pair young per nest to determine if the mating of the female with extra-pair males adversely affects offspring survival.

Thanks to the financial support of the Australian Wildlife Society, I am able to fund my lab work to determine which chicks are unrelated to the pair male. This involves extracting DNA from small blood samples taken from adult birds and chicks and comparing the genotypes between the female, male and chicks. Differences in the genotypes between the pair male and chick will indicate the male is not the genetic father of the chick. The outcomes of this project on extra-pair paternity and male parental care will provide an important snapshot of selective forces and behavioural patterns that shape survival and reproductive success in this locally declining species.

Male superb fairy wren at nest. Photo: Katharina Mahr

Male superb fairy wren feeding chicks in nest

Contact networks and transmission of facial tumour disease in the Tasmanian devil

David Hamilton,
Department of Biological Sciences,
University of Tasmania

I'm a PhD student at the University of Tasmania and my main research focus is the patterns of contact Tasmanian devils have with one another in the wild.

Tasmanian devils are severely threatened due to a novel, contagious cancer known as Devil Facial Tumour Disease, or DFTD. The disease has been spreading through the island state since 1996, causing declines of up to 90 percent in some devil populations. One of the reasons that DFTD has spread so rapidly, and comprehensively, throughout Tasmania lies in its ability to transfer from devil to devil when they bite one another. It is therefore of great importance to gain an understanding of how devils interact in the wild, and how this affects the ability of DFTD to spread. This is where my research comes in.

Over the next two years I'll be studying the encounters devils have with one another in the wild, using devices called proximity loggers. These emit unique ultra-high frequency signals that allow units to identify when they are in close range (30 cm or less, i.e. within devils' biting range) of other units, and log the duration of their interaction. When outfitted on collars which can be put on a population of devils, this allows me to study which individuals are interacting, and for how long. In addition to this I also regularly re-catch collared devils in order to monitor when they pick up new bite wounds, as these are representative of encounters which could lead to disease transfer.

This year I've been studying a completely healthy population of devils in the far north-west of Tasmania, while next year I'm going to be studying a population which has recently contracted the disease. This will allow me to assess a variety of things, including if the patterns of contact within devil populations alter with the arrival of DFTD, and whether this is assisted by behavioural changes in the devils themselves. For example, do devils become more aggressive as a result of contracting the disease; a mechanism the cancer could use to facilitate its own spread, much as is the case with rabies in dogs.

Studying devil contact patterns will also allow me to establish whether certain sex/age classes of animals are of particular importance to disease spread.

In the event that a vaccine is developed (which is looking hopeful; field trials of a potentially effective vaccine are commencing in Narawntapu National Park in September), this will be of particular importance. These animals, known as 'super-spreaders', are those which should be prioritised for vaccination; they come into contact with such a high proportion of the population that their removal as potential disease carriers can considerably slow, or even halt, the spread of disease.

A greater understanding of how devil behaviour in the wild contributes to disease spread will enhance our ability to manage the disease which has proven so destructive to devil populations Tasmania-wide.

Thanks to advancements in our understanding of both the nature of DFTD itself, and how it affects its host, there is definitely hope for the future of the devil.

Tasmanian devil at the entrance to a trap

Plant invasion ecology:

Relationship between species traits and demographic dimensions of invasiveness

Estibaliz Palma,
The School of Bio Sciences and the Faculty of Sciences,
University of Melbourne

Invasive plants are recognised as one of the most important drivers of environmental change, with detrimental impacts on native biodiversity and ecosystem services worldwide. More than 28,500 exotic plants have been introduced to Australia, which is almost double the number of native plant species. Roughly 10 percent of these exotic plants have become naturalised and 1 percent are currently considered invasive. Weed management costs the Australian economy over $4 billion each year. Improving our understanding of causes and impacts of plant invasion will not only have benefits for Australian unique ecosystems, but it will also reduce, or at least optimise, the budget dedicated to weed management.

The ability of a plant to become invasive (i.e. invasiveness) relates to its characteristics, or traits. However, it is unlikely that all invasive plants share a unique set of traits, given that they may become invasive for different reasons and through different mechanisms. In fact, recent advances in invasion science suggest that the inconsistent and contradictory findings about invasive plant traits may reflect the existence of different types of invaders. Thanks to the support of the Australian Wildlife Society, I aim to quantify the relationship between plant traits and four types of invasive species: locally abundant plants, rapidly spreading plants, plants that occur in many different environmental conditions (e.g. habitat types), and widely distributed plants that occur across Victoria. Doing so, I will be able to determine whether specific traits promote particular forms of invasion and whether trade-offs exist among different forms of invasiveness in Victoria, and more generally in Australia.

The results of this project will be useful to improve weed management. First, knowledge of which traits of the introduced flora match ecosystem impact is of paramount importance to improve Australia's biosecurity and quarantine services. Current risk assessment procedures may be improved by explicitly acknowledging that traits boost invasion through different mechanisms. Second, results stemming from this project can guide the strategic investment of management budgets for exotic plants already introduced to Victoria. My findings of the main invasion mechanisms used by plants with different life-strategies will inform managers of the potential efficiency of currently used management tools (e.g. is it better to prioritise control of quickly spreading plants or local abundant ones?). Finally, this project has the potential to identify recently introduced types of plants (i.e. functional groups) expected to become problematic in the near future. This is essential information for government and local managers to develop effective contingency plans while control of the species is still an affordable option.

Water hyacinth is one of the world's worst aquatic weeds. It infests rivers, dams, lakes and irrigation channels on every continent except Antarctica. It devastates aquatic environments and costs millions of dollars every year in control costs and economic losses

Conservation of an endangered reptile of Blue Mountains' highland swamps

Sarsha Gorissen, PhD candidate,
Shine Lab, School of Biological Sciences,
The University of Sydney

Worldwide, the endangered Blue Mountains water skink (*Eulamprus leuraensis*) is found solely within the Eastern Highlands of Australia, inhabiting a rare type of montane peat swamp of the Blue Mountains and the adjacent Newnes Plateau. As the only vertebrate endemic to the area, this lizard is an icon; admired by locals, its image and profile feature publically. The skink is known only from about 60 fragmented swamps, which range in locality from bush swamps in the national park and state forest, to urban swamps on council, crown and private land. Genetic studies suggest very low rates of lizard dispersal and thus gene flow between populations of these isolated swamps. The swamps themselves are also threatened by processes acting on a local scale, such as urbanisation (industrial development, weed invasion, introduced animals, and pollution), forestry and mining; and, on a landscape scale, such as changes in climate, and in fire and hydric regimes. Until now, the response of this endangered reptile to disturbance via these key threatening processes was unknown.

By conducting annual field surveys we have collected data from the majority of known swamps, mainly on lizard distribution and demography, and quantified habitat characteristics associated with the Blue Mountain water skink's occurrence at both macro- and micro-scales. We focused on the impacts of threatening processes, such as fire and groundwater loss, on urban and bush populations of the skink, ultimately with the aim of developing conservation strategies and management guidelines for the species.

The beautiful black and yellow Blue Mountains water skink (*Eulamprus leuraensis*) atop the thick and spikey swamp vegetation. Photo: Sylvain Dubey

Broadly, we have uncovered more on the ecology and conservation biology of the Blue Mountains water skink and its endangered swamp habitat. We were able to extend the range of the known distribution of the species and get a better estimate of skink health and population. In combination with GIS-based mapping, our survey results indicate fewer lizards in urban-associated swamps and in sites that have experienced major, frequent fires over the last half century. However, we have determined that populations of this endangered reptile persist even in anthropogenically disturbed swamps and swamps that have experienced several fires over decades. We have applied this research by informing all relevant stakeholders of our project outcomes to date and suggested appropriate management guidelines. We are currently analysing our remaining data to develop further guidelines for more effective conservation of this highly distinctive, highly threatened ecosystem.

The Australian Wildlife Society has further assisted in conserving the Blue Mountains water skink by enabling the presentation of my latest research at a paramount international conservation conference (ICCB-ECCB) in Europe earlier this year. I thank them for their generous support and congratulate them on the excellent work they are doing for Australian wildlife.

Fingers crossed for lizards: checking a funnel trap for fauna in a pristine swamp at Newnes Pleateau, New South Wales, on a lovely summer's day. Photo: Nakia Belmer

Success! Trapping a healthy Blue Mountains water skink in a 'sophisticated' trapping device known as a 'pitfall trap' (i.e. a bucket in the ground)

Dispersal and genetic structure of the forty-spotted pardalote across fragmented landscapes: conservation of an endangered songbird

Amanda Edworthy,
Research School of Biology,
Australian National University

The forty-spotted pardalote is a small, but tenacious songbird found on islands and remnant mainland patches of eastern Tasmania. These birds are one of Australia's most endangered species, having declined by 60 percent within the past 18 years. Unlike their close relatives, striated and spotted pardalotes, they are year-round residents of Tasmania, and are uniquely adapted to the cold, wet winters of the state. Forty-spots glean insects and manna (a sugary exudate of *Eucalyptus viminalis* trees), helping to keep forest canopies healthy. However, forest clearing and fragmentation has led to contraction of their distribution to just 4,500 hectares in southeastern Tasmania.

Tasmanian land managers and residents are increasingly interested in planting *E. viminalis* trees to help restore forty-spotted pardalote habitat, and several small-scale planting efforts have attracted forty-spot pairs over the past 15–20 years. Currently, both Maria Island National Park and Murrayfield Farm, which manage nearly three quarters of remaining forty-spot habitat, are actively engaged in using nest boxes and *E. viminalis* planting to provide habitat for forty-spots. However, we lack information about whether seedlings are best used to form corridors or to expand existing patches and create large areas of unbroken habitat.

In addition to expanding existing habitat, Tasmanian biologists are also considering translocation of the species to isolated patches of habitat where forty-spots are close to extirpation (e.g., Finders Island). Because the Flinders population has been long separated from other Tasmanian populations, it will have adapted to its environment and diverged genetically. For reintroduction, source birds should be taken from the population that most closely resembles the remaining Flinders Island birds; genetic analysis of population structure across regions will enable us to select the birds most likely to succeed in the Flinders environment.

Translocation and restoration of habitat connectivity are both important strategies for protecting and increasing abundance of forty-spotted pardalotes. However, to do

Above: Amanda Edworthy in Tasmania. Photo by Linda Edworthy

A banded forty-spotted pardalote

these well, we need to understand meta-population dynamics and genetic structure of forty-spots at the landscape scale. New DNA sequencing methods can detect large amounts of genetic variation across individuals and populations, which allows us to analyse patterns of dispersal and genetic relatedness among habitat patches and regions.

My project uses genetic markers to assess rates of forty-spot dispersal among habitat patches in relation to patch size, isolation, and habitat matrix (e.g., native forest, paddock, water channels, or residential development). I will also determine the degree of genetic relatedness among populations at Maria Island, Bruny Island, and mainland Tasmania near Bruny Island in comparison to samples from Flinders Island, as groundwork for a translocation program.

Like many hollow-nesters and habitat specialists across Australia, forty-spotted pardalotes are vulnerable to loss and fragmentation of forests. However, strategic revegetation of continuous habitat and corridors can restore healthy, interconnected populations. We hope that greater knowledge of how forty-spots move through the landscape will enable us to protect and restore critical areas of habitat, and to ensure long-term survival of the species.

Amanda Edworthy in the field. Mist nets allows us to catch, band, and collect blood samples from forty-spotted pardalotes. Photo by Angi Kim

Habitat is fragmented at Bruny Island. Photo by Linda Edworthy

A forty-spotted pardalote provisions its nestlings with manna (white clump visible in bill). Manna is the main food source for nestlings, and is only produced by E. viminalis among the forest species of southeastern Tasmania. Photo by Sam Case

Banding a nestling, soon to disperse. Colour bands allow us to identify and monitor movement of individual birds in conjunction with genetic methods.

Checking a Malaise trap and swapping over the collection jar so I can collect nocturnal invertebrates.

The contribution of native flower visitors and their host plants to crop pollination on the Yorke Peninsula, South Australia

Bianca Amato,
School of Natural and Built Environments,
University of South Australia

Land clearing, primarily for agriculture, is the most extensive cause of environmental degradation in Australia. Fragmentation has resulted in the loss of biodiversity and ecosystem services. I will be conducting my field work on the Yorke Peninsula, South Australia, a region that has been extensively cleared for livestock and cereal production. Only 13 percent of the original native vegetation remains, and most native vegetation patches are too small to retain their original biodiversity and functionality.

Remnant vegetation provides valuable habitats for Australian native bees, including species from the genera *Megachile, Amegilla, Homalictus*, and *Lassioglossum*. Native pollinators such as these bees play a vital role in maintaining natural ecosystems. Declines in pollinator diversity and abundance can adversely affect plant communities, with subsequent reductions in resources for other animal species.

In Australia, agricultural pollination services are predominantly provided by the European honeybee *Apis mellifera. A. mellifera* populations worldwide have declined as a result of colony-collapse disorder, viruses, the overuse of pesticides and the ectoparasitic mite *Varroa destructor*. These issues will reach Australia soon. However, several of Australia's 1,647 described native bee species may contribute to crop pollination, but their services have generally been overlooked by the agricultural community, and their roles in crop pollination are mostly unknown.

My project aims to determine the role of native pollinators and their supporting native vegetation on canola pollination. Native vegetation that favours healthy invertebrate communities may have a positive effect on agricultural productivity. Demonstrating the contribution of native pollinators on canola yield could lead private landholders to adopt conservation practices and protect native vegetation, especially in areas where few patches remain.

The ecology and population trends of the majority of native bee species are poorly documented.

Thanks to the support from the Australian Wildlife Society, I have been able to make 27 Malaise traps to sample invertebrates in canola crops and surrounding patches of native vegetation. These traps will not only help to determine the abundance and distribution of native flower visitors in an agricultural landscape, but may reveal areas of native vegetation that support specialist pollinator species found nowhere else.

A Malaise trap positioned in remnant native vegetation is able to collect hundreds of invertebrates every day.

No water, no hope:
The feasibility of a waterless barrier to stop cane toad spread in Western Australia

Emily Gregg
School of Bioscience,
University of Melbourne

For the past eighty years the cane toad (*Rhinella marina*) has been spreading rapidly through northern Australia, causing significant impacts on native wildlife such as the northern quoll (*Dasyurus hallucatus*) and reptile species including the king brown (*Pseudechis australis*) and the yellow spotted goanna (*Varanus panoptes*). The dogged and speedy proliferation of this species is as infamous as its deliberate and misguided human introduction.

Today, cane toads are established in the east Kimberley in Western Australia, and the invasion front is currently moving westward, before it is likely to turn south towards the Pilbara. Unlike the humid northern regions currently occupied by toads, areas south of Broome are arid, and it is hypothesised that toad survival here will rely on the presence of artificial water sources, such as pastoral dams. These artificial water sources provide hydration and breeding sites for toads in the dry season in areas where natural water sources are not available.

Fortunately, the toad's likely dependence on these artificial water points may give us a means to prevent their further expansion. By preventing toad access to these water sources we could create a waterless barrier to stop them moving any further west andsouth. By installing above-ground water tanks we could limit shelter available to cane toads and still maintain infrastructure vital for pastoralists. The barrier must simply be wide enough to ensure that toads will not be able to survive the journey during the wet season, so this infrastructure development need only be applied to a specific locale.

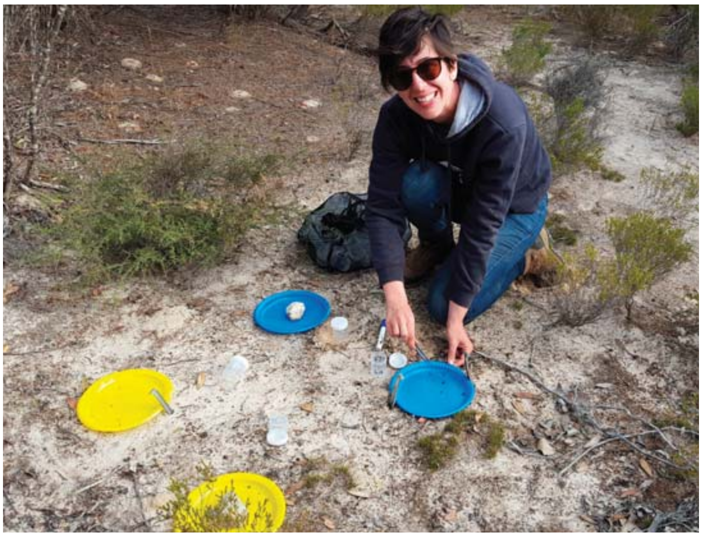
The groundwork for the waterless barrier idea is extensive. Earlier work has shown the importance of artificial water bodies to cane toad survival and modelling has identified areas in which a waterless barrier may prove most effective. My master's research focuses on the next obvious step: testing whether toads can survive in the barrier region without access to artificial water. So, over the past couple of months, a field assistant and I have released and radio-tracked 78 male toads north of Port Hedland and collected data on their water loss and movement rates, as well as the locations where they shelter during the day.

In the coming months, I will be analysing my field data as well as toad occurrence and biosecurity data from around Australia. Toads are occasionally found in areas ahead of the invasion front, having hitched a ride in shoes, camping gear or landscape supplies, for example. Because of this, it is important to investigate the risk posed to any barrier by hitchhiking cane toads.

A barrier north of Port Hedland could safeguard the Pilbara, a region renowned for its landscapes and unique wildlife. The Pilbara may, for example, be the last mainland stronghold of the northern quoll, a species whose populations have suffered greatly from the toxic toad's presence in the Northern Territory. The barrier could provide a simple, cost-effective and humane way of preventing the arrival of toads in the Pilbara, and my research is firmly aimed at assessing the feasibility of such a barrier.

I thank the Australian Wildlife Society for their support of my project.

Cane Toad



Emily Gregg testing in the field

Spatial and temporal interactions between predators in semi-arid Australia

Harry Moore,
School of Life and Environmental Science,
Deakin University

Over the last 100 years, the persecution of dingoes has occurred in a variety of landscapes throughout much of Australia, due mainly to conflict with livestock farmers. Nowhere is this more apparent than in south-eastern Australia, where the species has been exterminated from vast areas. Now, throughout many regions, the reduced dingo presence has facilitated the invasion of mesopredators, or medium-sized predators, such as foxes and feral cats, which prey upon native animals. Such mesopredators are one of the major causes of Australia's shocking record of mammal extinctions, with 30 species becoming extinct within the last 200 years. Control of mesopredators via traditional techniques such as baiting, shooting and trapping, has come at a substantial and sustained financial cost.

Currently there is much as debate over the role that dingoes can play in conservation. Evidence suggests that dingoes do suppress both red foxes and feral cats in arid and mesic environments. However, few studies have distinguished between spatial and temporal segregation of mesopredators by an apex predator, nor considered how these interactions affect small mammals.

My study aimed to address this knowledge gap by investigating how predators interact in space and time,

The Mitchell's hopping mouse is one species predicted to suffer should dingoes be eradicated from the Big-Desert Wyperfeld region. Photo by Tim Doherty in Victoria's Big Desert-Wyperfeld region, as well as predict how this may affect small mammal species such as the Mitchell's hopping mouse. Thanks to funding provided by the Australian Wildlife Society, I was able to deploy motion-detecting camera traps across 7,000 km^2 of the Big Desert Wyperfeld region, in an attempt to address these aims.

Using data collected from the camera traps I was able to show both foxes and feral cats were indeed segregated from dingoes in terms of their distribution and their temporal activity. This finding supports a growing body of research documenting mesopredator release of foxes and cats when dingoes are reduced in their abundance or extirpated.

Whilst the precise mechanism by which dingoes supress feral mesopredators remains unclear, one possibility is that dingoes, red foxes and cats compete for the same resources, such as food. Other studies have demonstrated that in response to competition, dingoes often kill or evict other predators within their home range.

Given the proposed suppressive effects of dingos on feral predators, we also wanted to highlight possible flow-on effects that may occur following typical management interventions (i.e. wild dog/dingo poisoning). Using scenario-based modelling, we predicted the removal of dingoes from the Big Desert-Wyperfeld region could trigger a negative trophic cascade, whereby pressure on feral cats and foxes would be released. This would most certainly have dire consequences for the area's small mammals, including the Mitchell's hopping mouse which has already suffered greatly in other regions due to predation by foxes.

These results would suggest future predator management needs to consider both the costs and benefits to native species, and highlights the need for detailed and holistic ecosystem conservation and management approaches. Whilst the findings of this study may well be useful in terms of understanding the importance of apex predators in ecosystem dynamics, carefully designed natural experiments should be a priority for future work in order to gain a more comprehensive perspective.

Big Desert National Park (study site)

A dingo detected using camera traps partly funded by the Australian Wildlife Society.

A fox detected using camera traps partly funded by the Australian Wildlife Society.

Landscape genomics of the narrow-leaf hopbush along an environmental gradient

Matthew Christmas,
University of Adelaide

The threats posed to species by increasing global temperatures and more extreme weather conditions resulting from human-induced climate change are being ever more realised. Changes to species distributions, including shifts across the landscape in line with a shifting climate as well as reductions in species' ranges, are evident across the globe. Such changes are likely to become more and more pronounced, particularly as carbon emissions worldwide continue to rise, exacerbating the warming problem. How species, and particularly plant species, will adapt to such changes has been the broad topic of my PhD at the University of Adelaide and, along with two co-authors, I have recently had a review on the topic published in the journal *Conservation Genetics*, titled 'Constraints to and conservation implications for climate change adaptation in plants'.

For my PhD, I have used revolutionary genomic techniques to understand the demographic and evolutionary processes that have shaped the current population distributions and genetic patterns in the narrow-leaf hopbush, *Dodonaea viscosa* ssp. *angustissima*, a widely distributed species that is commonly used in restoration and revegetation plantings. It can be found in a range of habitat types, from rocky outcrops on mountain ranges to sandy plains. How it has been able to adapt and thrive in such a wide variety of conditions interests me greatly, and any answers to this question can help to inform on the adaptability of species under climate change. Specifically, I am interested in whether genetic adaptation to local conditions is

Dodonaea in flower: Narrow-leaf hopbush in flower in the Northern Flinders Ranges. The narrow leaves are an adaptation to aridity.

prevalent within this species and whether there is sufficient gene flow among populations for the movement of adaptive genes as climate conditions shift across the landscape.

We have focussed on a latitudinal gradient throughout the Adelaide geosyncline region, traversing from Kangaroo Island in the south, along the Flinders Ranges and into the Gammon Ranges in the north. There is a steep temperature and rainfall gradient along this transect, with hot, dry conditions in the north and cooler, wetter conditions in the south. We made field collections of leaf samples from 17 populations throughout this region. We then used a number of genomic techniques to generate genetic data for analysis, including transcriptome analysis (sequencing the RNA in order to look at which genes are being expressed), and targeted sequencing of specific genes. Some of this work has recently been published in the journal *BMC Genomics* in a paper titled 'Transcriptime sequencing, annotation and polymorphism detection in the hop bush, *Dodonaea viscosa*'.

These data were used to address two questions: 1) is there any genetic structure among the populations across this region, and 2) can we identify any signatures of selection for specific genes, potentially indicating local adaptation? We have found that there are three distinct population clusters across the region: a Kangaroo Island cluster, a Flinders Ranges cluster, and an Eastern cluster. The genetic data indicate that there is very little gene flow between these clusters, suggesting that they are quite genetically isolated from one another. We have also discovered evidence of selection acting on a number of genes related to water stress along the gradient and it appears that this is driven by water availability. These outcomes help to draw a picture of the future adaptive potential of this species under a changing climate, as well as informing on seed collection strategies for restoration.

Thanks to the support I received from the Australian Wildlife Society through their University Student Grant Scheme, I was able to present my findings at a large international conference in Manchester, United Kingdom, hosted by the Society for Ecological Restoration in August last year. I gave a 15-minute presentation to an international audience and also had many opportunities to discuss my work with a variety of academics and practitioners. It was an incredible opportunity and there was a lot of interest in how genomics can be used to inform conservation and restoration practice.

Dodonaea viscosa is dioecious, meaning there are male and female plants as shown here. The female plant holds purple seed capsules, which mature during early summer Photos: Nick Gellie.