A charity fostering scientific research into
the biology and cultivation
of the Australian flora

Research Matters

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President's Report 2021

Delivered by Assoc. Prof. Charles Morris at the Annual General Meeting, November 2021.

This year marked the 40th year since the inaugural Meeting of the Foundation in August 1981. When the first payments for the 2021 round of grants have been distributed, the Foundation will pass the one million dollars mark for the distribution of grants to support research. Our members, donors, Councillors, and office bearers past and present can take pride in this achievement. From fairly modest beginnings, something greater has grown. The foresight of the Founders in establishing the Australian Flora Foundation has been well and truly justified. With the receipt of the Malcolm Reed Bequest during 2021, there will be a step increase in the support for research that the Foundation is able to offer. At the projected rate of expenditure now possible from the Bequest, the Foundation should spend its second million dollars on research over the next four or so years.

The year has been busy on the administrative front. Council took the opportunity of the Reed Bequest to review the current investment portfolio, which was established in 2000. The existing three Managed Funds have been wound up, and six new Managed Funds selected to hold the assets of the Foundation (now approximately four million dollars) into the future. The Granting Scheme has been re-thought, with grants offered over a larger range ($20-65K) and a smaller range ($5-20K). We will trial this system initially and modify if required as we go.

For the round of Foundation grants commencing in 2022, the successful applicants are shown below:

Principal investigator	**Project objectives**	**Funding approved ($)**
Bok	Disentangling the genetic and environmental drivers of manna quality in *Eucalyptus viminalis* and its consequences for native ecosystem function	19,272
Chong	Conserving wild population diversity in the Desert Quandong of Central Australia	15,726
Gerwin	How influential are plant neighbourhood interactions in community responses to extreme climatic events?	19,320
Coad	Improving germination success for Australian native plant seeds using cold plasma treatments	14,996
Total		**69,314**

Final Reports for earlier Grants received in 2020 were: Rymer (2015) on genetics of Moreton Bay Figs; Minchington (2016) on seed banks of endangered salt marsh plants; and Fowler (2017) on urbanisation effects on *Banksia* woodland.

Thanks are also due to the hard working members of Council who keep the granting program and administration of the Foundation going. A very special thanks must go to Peter Goodwin, who is retiring from the position of Grants Officer, which he has held since 2006. Peter also served as President during this period, for a number of years. Thanks, Peter, for your unstinting dedication and contribution to the running of the Council and administration of the Grants scheme. Ian Cox is a very capable and competent Secretary; Michelle Leishman heads the Scientific Committee, Tina Bell organises the excellent newsletter, and Jennifer Firn oversees the Foundation's web page. Thanks are due to Council members, ordinary members, and our donors, all of whom allow the Foundation to function and support plant research.

E. Charles Morris
President
20 October 2021

Australian Flora Foundation Councillor recognition

We are proud to announce that Prof. Michelle Leishman, a Foundation Councillor and Chair of the Scientific Committee, has been recently honoured with two awards. The first accolade is the award of Eminent Ecologist for 2021 by the *Journal of Ecology* for her significant and important contributions to international scientific literature. As part of the award, Michelle was invited to create a Virtual Issue for *Journal of Ecology* highlighting some of her key publications. She also features in an article and a blog post discussing her research career and provides sage advice for young researchers. Please follow this link to read more: https://besjournals.onlinelibrary.wiley.com/doi/toc/10.1111/(ISSN)1365-2745.Eminent-Ecologist-2021.

The second award is the Clarke Medal 2020 (Botany). This award is presented annually by the Royal Society of NSW for distinguished research done in Australia in the natural sciences. Michelle earned the award for her nationally and internationally recognised work in plant ecology including advancing understanding of invasive plant pathogens, plant adaptations to climate change, urban green spaces, and plant conservation. Please follow this link to read more: https://royalsoc.org.au/awards/clarke-medal.

Michelle will deliver the Clarke Memorial Lecture on 17 March 2022, which will be presented both live and streamed. The title and abstract of her presentation are provided below. For more details please see: https://www.royalsoc.org.au/events-news/events-2022.

Congratulations Michelle!

From bulldozers, pests and pathogens to urban futures and climate change: the tough life of plants

The life of plants on our planet today is tougher than ever before. The UN FAO estimates that 1 million hectares of forest globally were cut down each year over the last decade. There are over 20,000 plant species that are considered to be threatened with extinction, and the actual numbers are likely to be far higher. In NSW alone there are 111 ecological communities and 672 plant species considered to be endangered, and yet our knowledge of their biology and ecology is surprisingly limited. Key threats to these plant species are loss of habitat, invasive species, and climate change. In this talk, Professor Leishman will examine why some plant species 'jump the garden fence' to become serious environmental weeds and how climate change may be giving them some extra help. She will also look at one of the most serious recent threats to many of Australia's iconic plant species and communities – the invasive fungal pathogen Myrtle Rust that affects species in the family Myrtaceae, including our eucalypts, bottle brushes and tea-trees. Even the plants in our urban parks and gardens are affected by weeds, pests, diseases, and climate change. Prof Leishman will discuss the benefits provided by our urban green spaces, the challenges they face with increasing urbanisation and extreme climate, and ways forward to improve the resilience of our urban forests into the future.

Australian Flora Foundation Grants awarded

Four grants were awarded by the Foundation for research to begin in December 2021.

Disentangling the genetic and environmental drivers of manna quality in *Eucalyptus viminalis* and its consequences for native ecosystem function

Erin Bok, University of Tasmania, Tasmania

The intentional movement of plant species to new habitats is an increasingly applied strategy to mitigate the loss of biodiversity in the face of climate change. However, these decisions are undertaken with little consideration of potential downstream impacts on ecosystem processes (e.g., resource provisioning). This project will investigate how genetics and the environment influences plant survival and resource provisioning (‘manna’, a high-quality food resource) in a foundation tree species, *Eucalyptus viminalis* (Manna Gum). Results will inform guidelines on the assisted movement of foundation tree species, providing the needed confidence in the environmental sector to make informed decisions to manage Australian forests.

Manna Gum is a widespread species of Australia’s iconic temperate eucalypt woodlands that plays an integral role in providing food and habitat for many dependent insects, birds, and mammals. The sugary carbohydrate (manna) produced by this species is a critical food resource for honeyeaters (*Melithreptus* genus), insects (ants, beetles, butterflies, moths), gliders/possums (including the endangered Leadbeater's Possum) and the endangered Forty-spotted Pardalote (*Pardalotus quadragintus*). However, across its distribution in south-east Australia, this species has experienced extensive dieback associated with heat and drought stress and increased pest populations, extreme events putatively linked to climate change. Consequently, *E. viminalis* is a key target species of conservation and ecological restoration programs across the south-east of Australia, particularly the dry Midlands of Tasmania where this PhD research will be based.

Conserving wild population diversity in the Desert Quandong of Central Australia

Caroline Chong, Flora and Fauna Division, Department of Environment, Parks and Water Security, Northern Territory Government

This project will contribute to conservation of Desert Quandong, *Santalum acuminatum*, by improving knowledge of the genetic diversity of wild populations in the Northern Territory. This iconic desert species is highly prized by Aboriginal people as a bush tucker plant. It is also a commercial bush food plant, and it is now under commercial production. The Desert Quandong is a member of the sandalwood family Santalaceae. In the Northern Territory it occurs as a series of discrete subpopulations, mainly in the south-west. One of the largest occurrences is at Watarrka National Park, while other significant stands occur on pastoral properties and on Aboriginal lands. The population at Uluru-Kata Tjuta National Park is small (eight plants) but is of high cultural significance.

Although widespread in inland Australia, the species is listed as Vulnerable in the Northern Territory under the Territory Parks and Wildlife Conservation Act. Here it is impacted by multiple threats (fire, browsing, weeds, drought, over-harvesting) across its range. More recently, however, climate change impacts have become apparent. Specifically, Park Rangers reported significant drought mortality in the Watarrka National Park population over the 2019-2020 period. This coincided with one of the driest and hottest periods in recent history – a result that is consistent with climate change predictions for central Australia. Changes in rainfall seasonality is a potential further threat to this species. Reduced winter rainfall could result in lower seedling recruitment given that this species requires germination under cooler temperatures. Climate change represents a significant present and future threat to this species, and coupled with other threats, could lead to a significant range contraction.

Translocation is an identified recovery action and Aboriginal people wish to see this bush tucker species thriving again on country. Genetic information will inform the selection of appropriate source populations for translocation. For example, knowledge of how genetic variation is distributed geographically will help managers to identify priority seed sources for other translocations and where threat mitigation and propagation efforts need to be focused to conserve priority wild populations in the Northern Territory.

How influential are plant neighbourhood interactions in community responses to extreme climatic events?

Melissa Gerwin, University of Tasmania, Tasmania

Positive plant-plant interactions have the potential to mitigate the effects of climate change on plant communities. Given that extreme climatic events such as droughts and heatwaves, are becoming more frequent, investigating the drivers of positive interactions and the conditions under which they occur has never been more critical. This PhD project will determine the role of positive plant interactions in reducing the impacts of climatic extremes on plant communities and will identify the mechanisms underpinning facilitation. Additionally, the project will collect and use data on plant functional traits and neighbourhood properties to determine the underlying mechanisms driving the observed responses to climate change.

The research will investigate the responses of a Tasmanian subalpine grassland community to experimentally induced climatic changes. As alpine and sub-alpine species are limited in their ability to disperse upwards in altitude to cooler regions, they are predicted to be extremely vulnerable to the effects of climate change, particularly global warming. The study area, Silver Plains, is classified as a Highland *Poa* grassland, dominated by the native tussock grass *Poa gunnii*. The Department of Primary Industries, Parks, Water and Environment list this grassland as a threatened native vegetation community under the Nature Conservation Act 2002, making it a top priority for conservation. The study area is an excellent location to ascertain the community response to experimentally induced extreme future climates. This research will pave the way for the development of pro-active management in threatened plant communities and will contribute significantly to their conservation.

Improving germination success for Australian native plant seeds using cold plasma treatments

Bryan Coad, University of Adelaide, South Australia

Growing native plants from seed is important for revegetation and restoration of ecological systems. This project will use a form of energy known as cold gas plasma to treat seeds. This novel treatment has been shown to benefit the germination of some cereal crop and native plant species, but little is known about why this is so and whether there is a demonstratable improvement over current best-practices used to break seed dormancy for native species. Outcomes from this study aim to understand how plasma can be used to improve germination outcomes for the benefit of seed and plant conservation.

Plasma is a state of matter where gas molecules are excited by energy and then form reactive species such as ions, radicals, and molecular fragments. Seeds placed in a plasma discharge are exposed to these energetic species resulting in chemical changes and etching that modifies their seed coats (testa). For seed applications, it is appropriate to use a form of gas plasma known as ‘cold plasma’ which uses vibrational energy to excite the gas molecules. As the name implies, this is a low-power (50 watts), low temperature (less than 50°C) plasma discharge familiar to us all in common fluorescent light tubes. Plasma penetration depth is incredibly small but can cause chemical changes to the surface biomolecules (e.g., waxes, polysaccharides, proteins) of the testa and act to etch the seed surface.

This project will build on research done by Prof. Hans Griesser in a project funded by the Foundation in 2004. Plasma technology is considerably more advanced in 2021 warranting a new study of the possible benefits for enhancing seed germination.

Young Scientist Awards

The Australian Flora Foundation awards prizes annually to encourage young scientists to continue studying the flora of Australia.

At the annual conference of the Ecological Society of Australia (ESA), held online in November 2021, the Foundation’s prizes were presented to the following two students.

Outstanding spoken presentation on the biology or cultivation of an Australian plant

What the heck is a Caltha Herbland? And why should we care?

Alex Blackburn-Smith, Botany and Plant Ecology Research Group,
Research Centre for Applied Alpine Ecology, La Trobe University, Victoria

Abstract

Caltha introloba herbland communities (Caltha Herblands) are restricted to high mountain areas where there is persistent water outflow. Typically, they are comprised of sparse, semi aquatic vegetation on a rocky or gravelly substrate, but there is some conjecture about their origin. This conjecture has led to the community being significantly understudied in comparison with other types of high mountain wetlands such as Sphagnum bogs.

This two-part study aimed to further the understanding of Caltha herblands by first asking: what controls the distribution of these communities at the landscape-scale? What controls within-site vegetation patterns?

Results suggest that pavement communities vary at landscape-scales due to elevation, that within-site patterning is apparent, that site rockiness and water availability explains distributions of many species, and that these ecosystems harbour many restricted and threatened species.

Secondly, we asked: How does the flow of water into these systems change over the summer growing season? What is the chemical composition of this water? Does composition change as water moves through a site?

We found that flow of water into a pavement varies throughout a season and spread of water, perpendicular to flow, also varies through the growing season and is significantly correlated with the distribution of key plant species found within the community. There was no significant change in ionic composition of water occurring between the source and base of a Caltha Herbland.

We conclude that Caltha Herblands are likely a previously overlooked, groundwater-dependant ecosystem (GDE) that is extremely vulnerable to a changing climate.

About Alex

Alex is a Master candidate at La Trobe University in Melbourne, where she is specialising in high-mountain ecology and particularly interested in groundwater-dependant and rock dominated systems. Growing up in the Snowy Mountains, NSW gave her a unique appreciation of the Australian

Alps through winter skiing and summer hiking. However, a real appreciation for the unique alpine flora was gained during her undergraduate studies, through field subjects and a summer cadetship with the Research Centre for Applied Alpine Ecology (RCAAE). Alex is currently close to submission of her Master research and continues to work in the Alps with the RCAAE.

Top left: Master student, Alex Blackburn-Smith braving a cold, wet day of field work in May 2020. Top centre: a section of Caltha Herbland coming out of snow in spring in November 2021. Top right: White/pink flowers of *Psychrophila introloba* (formerly *Caltha introloba*), the namesake of the community. This species typically flowers under the snowbank as its melts. Bottom: An example of a Caltha Herbland community with a large early season snowbank forming in May 2020. Images courtesy of Alex Blackburn-Smith.

Outstanding poster presentation on the biology or cultivation of an Australian plant

Increased genetic diversity via gene flow provides hope for an endangered wattle facing extinction

Colette Blythe, University of Adelaide, South Australia

Abstract

We apply a conservation genomics approach to make evidence-based management recommendations for *Acacia whibleyana*, an endangered shrub endemic to Eyre Peninsula, South Australia. We used population genomic analysis to assess genetic connectivity, diversity, and historical inbreeding across all known stands of the species sampling remnant stands, revegetated stands of unknown origin, and a post-fire seedling cohort. Our results indicate a degree of historical connectivity across the landscape, but habitat loss and/or pollinator community disruption are potential causes of strong genetic structure across the remnant stands. Remnant stands had low genetic diversity and showed evidence of historical inbreeding, but only low levels of intra-stand relatedness indicating that risks of contemporary inbreeding are low. Analysis of a post-fire first generation cohort of seedlings showed they likely resulted from intra-stand matings, resulting in reduced genetic diversity compared to the parents. However, admixed seedlings in this cohort showed an increase in heterozygosity relative to likely sources and the non-admixed seedlings of the same stand. Assisted inter-stand gene flow may prove an effective management strategy to boost heterozygosity and corresponding increases in adapting capacity in this endangered species.

About Colette

Dr Colette Blyth is a Scottish scientist based at the University of Adelaide, South Australia. She recently completed her PhD thesis, titled ‘Seed sourcing in the Genomics era’. This research utilised modern genomic technologies to guide the genetic management of native Australian plant species to increase overall adaptability and resilience to climate change. This project worked directly with practitioners to develop seed sourcing guidelines which are already being implemented into practice.

Colette is now continuing with her interest in genetic diversity through a postdoctoral position at the University of Adelaide. As part of this position, she is the project coordinator of the DivSeek International Regional Hub for Australasia and is working with the group to establish a database of plant genetic resources across Australasia.

Top left: Dr Colette Blyth, the author of the Foundation's outstanding poster prize. Image courtesy of Colette Blythe. Top right: Some of the Whibley Wattle research team at the Tumby Bay art mural, with painter Danica Gates. From left: Doug Bickerton (Department for Environment and Water), Dr Jasmin Packer (University of Adelaide (UoA)), Dr Renata Faast (UoA), Danica Gates, Geraldine Turner and Dr Colette Blyth (UoA). (image from https://www.portlincolntimes.com.au/story/5930097/wattle-in-the-limelight/). Bottom left: *Acacia whibleyana* in bloom. Image copyright Jasmin Packer. Bottom right: Flowers of *A. whibleyana*. Image copyright South Australian Seed Conservation Centre.

Urban greenspaces are important for soil microbes

David Eldridge*
Centre for Ecosystem Science, School of Biological, Earth and Environmental Sciences, University of NSW, Sydney

Over the past two years most of us have developed a newfound appreciation for greenspaces in our suburbs, with COVID restrictions often keeping us close to home. Parks and gardens make up most of the open spaces (greenspaces) available to city dwellers, and therefore play an important role in in our health and social engagement. They are places of solitude, somewhere to exercise, walk the dog, or just sit and think.

Research from the University of Colorado, Boulder suggest that getting outdoors is also good for our mental wellbeing.

Although they are often highly modified compared to semi-natural environments, greenspaces are typically the closest environments that many people get to semi-natural within big cities (O'Riordan *et al*. 2021). With 68% of the global population set to live in cities by 2050, urban greenspaces are likely to become more important for city dwellers promoting mental and physical wellbeing.

However, city greenspaces are more than just a place to unwind. They play important roles curbing pollution, reducing noise, and lowering air temperatures. Open spaces in the city are also important habitat for plants. Globally, cities are hotspots for threatened species (Ives *et al*. 2016), and greenspaces provide habitat for plants that attract bees and other insects that are critical for pollinating crops. These urban refugia are likely to become more important over time as climates get hotter and drier many species only manage to survive because of plentiful water provided by irrigation.

Typical urban green spaces in Australia. Left and right: Mildura and Yackandandah, Victoria. Images courtesy of David Eldridge.

Lots of diversity in greenspace soils

Greenspaces such as Queen Victoria Gardens in Melbourne, King’s Park in Perth and Centennial Park in Sydney are a haven for plants and animals, but not just the ones we can see. We don’t often think about the importance of those small organisms that live in the soil of our parks and gardens, the microbes; the rich consortia of bacteria, fungi and Archea that play critically important roles in soils and soil processes. Understanding the importance of these microbes helps us to manage urban greenspaces more effectively and design future greenspaces that are not only useful, but also serve an important ecological process.

A recent paper published in Science Advances by Delgado-Baquerizo and colleagues (2021) examined soil microbial communities in urban greenspaces in 56 cities across the world. Their study sites ranged from affluent cities in Norway and Sweden, to poorer cities in Asia. The authors were particularly interested in the types of microbes found in greenspaces, how they might differ from those in natural areas, and their functional importance in greenspace soils. Their study represented the first truly global assessment of microbes in urban greenspaces, although other studies have looked at microbes in specific locations, such as New York's Central Park (Ramirez *et al*. 2014). In their study, Delgado-Baquerizo and colleagues (2021) compared microbial communities in human managed landscapes (parks, gardens) with those in nearby unmanaged, semi-natural environments such as forests.

The study found that soils of urban greenspaces were hotspots of diverse bacteria and protists (cellular organisms, other than plants, animals, and fungi). These greenspaces supported unique microbial assemblages compared with nearby semi-natural environments, but, unlike these natural environments, the soil microbiome (assemblage of microbes, akin to the concept of plant community) was very homogeneous. This situation is similar to what we might expect from other organisms such as plants and birds that inhabit urban greenspaces. Parks and gardens in our capital cities tend to be dominated by a low diversity of bird species such as noisy miners, white ibis, and feral pigeons. The plants are often dominated by lawn grasses and a few shrubs. Homogenisation of the microbial community is likely due to the way that greenspaces are constructed and maintained. Unlike natural areas, greenspaces are highly managed, regularly fertilized, and watered, and are often constructed on soil that has been brought in from elsewhere.

Because urban greenspaces are often irrigated, they tended to support fast-growing bacteria and algae, fungal parasites, and plant pathogens that prefer moist environments or patches of bare soil. They also contained fewer key microbes that are important for establishing symbiotic relationships with plants compared to adjacent non-urban vegetation. About 2% of the world's vascular plants depend on a close association with ectomycorrhizal fungi. These associations allow plants to absorb nutrients and water from the soil. When you lose these important symbiotic microbial couplings, the plants are more susceptible to harsh environmental conditions. In Australia, many of our plants rely on associations with fungi to help them acquire sufficient phosphorus (Lambers *et al*. 2016).

Urban green spaces investigated in the study by Delgado-Baquerizo *et al*. (2021). Top left and right: Bodo, Norway and Uppsala, Sweden. Bottom left and right: Utrera, Spain and Kamloops, British Columbia. Images courtesy of David Eldridge.

Good microbes, bad microbes

When Delgado-Baquerizo and colleagues looked at the soils in urban greenspaces, they found that there were more functional genes associated with human pathogens such as *Listeria* and *Diphtheria*, and a greater diversity of antibiotic resistant microbes. Antibiotic resistance is a major global health issue, and the overuse of antibiotics is the big culprit. But this was not the case in all cities. Some cities use recycled sewerage water to irrigate their greenspaces. Those cities that tended to have more antibiotic resistant genes tended to be the less affluent ones, with a lower GDP, and were also more likely to have less rigorous management of antibiotics. Soil from urban greenspaces also had more functional genes associated with denitrification (the gaseous release of nitrogen from the soil) as well as more methane production by bacteria and Archea (an ancient group of eukaryotes similar to bacteria).

It might appear that we are painting a picture that all of these microbes are bad, and that we don’t want ‘bad microbes’ in our greenspaces. All microbes play important roles in ecosystems. Indeed, microbes are important for human health because they promote effective immunoregulation and help to reduce allergies. Children eating dirt is all part of building up an effective community of gut microflora. A study by researchers at the University of Colorado Boulder found that the soil bacterium *Mycobacterium vaccae*, common in many open spaces, increases serotonin levels in the brain, acting as an antidepressant (Lowry *et al*. 2016). Hanging around in parks can therefore be good for your mental health.

Urban green spaces investigated in the study by Delgado-Baquerizo *et al*. (2021). Top left and right: Cape Town, South Africa. Bottom left and right: Colorado and Fort Collins, United States. Images courtesy of David Eldridge.

Even road verges are important

As well as greenspaces, the research group found that even road verges were full of important microbes. Comparing three cities in western Sydney of markedly different ages: Richmond (settled in 1872), South Penrith (1970s) and Jordan Springs (2011), Eldridge and colleagues (2021) showed that older settlements have greater microbial activity and plant richness, but effects on soil nutrients were relatively weak. Some of the effects of older settlements were due to a greater variety of different niches in older parks and gardens, which supported a greater variety of plants. These plants in turn have a broader range of root structures, with their associated carbohydrates and gels supporting a richer microbial community. Far from being ecological deserts, roadside verges contributed a range of important microbial communities that are critically important for sustaining productive ecosystem services such as filtering pollutants, sequestering carbon dioxide, and breaking down organic matter.

Promoting healthy microbes

Promoting a diversity of microbes is about providing a diversity of habitats, which means different plantings of different species, moving away from the planting of monocultures, perhaps encouraging the planting of native grasses rather than exotic kikuyu or couch grass, different patches of vegetation, and different patches of soils. One area where this is obvious in Sydney is the reconstruction of Sydney Park, where patches of reinstated threatened communities exist alongside reconstructed wetlands, off-leash dog area, and a community garden (Conybeare Morrison and Mackenzie 1982). We need a mix of different substrates, different soils, different environmental conditions, and different patches of vegetation to get the maximum potential out of our soils. And soil microbes are an important component in this mix. We have to be aware of their negative health issues, but overall, they are critical for providing functional healthy systems on which plants, animals and humans depend.

Left and right: Urban green spaces in Sydney Park, NSW. Images courtesy of David Eldridge.

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*About the author
Dr David Eldridge is an ecologist at the University of NSW who has pioneered research on the ecology and management of dryland soils in Australia. His other interests include the effects of animal disturbance on soils, woody plant encroachment, and the impacts of grazing by native animals and livestock on soils and ecological functions. He can be contacted by email at d.eldridge@unsw.edu.au

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The need for fire to sustain the diversity of fire-adapted vegetation: a response to the need for any management intervention of bushfire-affected rare plants

Roger Farrow*
“Tilembeya”, 777 Urila Road, Urila, NSW

I have been studying the regeneration and recovery of the vegetation in the Moreton National Park (Nerriga Road Area) and Tallaganda National Park (Mulloon Fire Trail) following the 2019-2020 megafires. The shrub and forb layers in these National Parks were completely obliterated by the intensity of the fires leaving just a bed of ash. Although my observations are not strictly quantitative (e.g., through the use of quadrats), I did return to the same places to identify what was coming back and took photos.

These observations were complemented by a review of the extensive literature about the impact of fire on Australia's flora and discussions with colleagues, including Michael Doherty (CSIRO). Michael has undertaken a long-term study (using quadrats) of the recovery of vegetation in Namadgi National Park after the megafire of 2003. He found no net loss of species.

My conclusion is that the Australian flora outside of the rainforest ecosystem is highly adapted to survive fire. Most species, from the largest tree such as Mountain Ash to the smallest forb such as the Pink Flannel Flower, are dependent on fire for successful reproduction and long-term survival. Many species of Proteaceae and Myrtaceae only release their seeds after fire. Fire has always been part of the earth's environment. It is closely associated with the appearance and radiation of the angiosperms in the Cretaceous era, 100 million years ago, and goes back to the very start of plant life on land in the Devonian era.

The post-fire response of the vegetation, especially if there is significant follow up rain, is that species diversity actually increases in the aftermath of the fire. This is due to the germination of plants from the seedbank that has been steadily building up during the inter-fire period. Hard-coated seeds of the Fabaceae and Mimosaceae are a conspicuous element here, as they need a seed dormancy-breaker like fire to germinate. In addition, there are also species with tiny seeds that remain dormant until there is a very hot fire (e.g., *Dampiera fusca*, *Actinotus forsythii*). Species diversity starts to decline post-fire as regrowing shrubs out compete the forbs and fire-dependant ephemerals that disappear. This response applies to all species, whether common or rare.

Soil is a great insulator and plants in fire-affected ground also regrow from underground rootstocks (sedges, grasses, and other monocotyledons), bulbs and corms, (many monocotyledons, including orchids), taproots (e.g., many species in the Apiaceae and Asteraceae) and lignotubers. Shoots sprout from aboveground, epicormic strands in the stems of Myrtaceae. All these survival mechanisms were seen in the plants growing back in fire-affected areas of Moreton and Tallaganda National Parks and elsewhere.

Orchids

Unprecedented numbers of orchids appeared in the autumn and spring following the Morton National Park megafire. They include several threatened species, namely *Corunastylis superba*, *C. plumosa* (new locality), and *Caladenia tesselata*, plus other species like *Prasophyllum* *australe*, never seen before, presumably because it was hidden under the dense cover of shrubs in previous years.

Fire-dependent ephemerals

Vast numbers of seedlings appeared after the fires and included three species never seen in the previous two decades in the Nerriga area, *Actinotus forsythii*, *A. gibbonsi*, and *Commersonia hermannifolia*. These species could not be identified until they flowered. Their seeds could have been in the seed bank for decades since after the last major fire. These plants are also known as obligate pyrogenic species as they require fire for seed germination.

Left: Post-fire flowering of the Dense Midge Orchid, *Corunastylis densa*. Right: Seedlings of Pink Flannel Flower, *Actinotus forsythii*, an obligate pyrogenic species. Images courtesy of Roger Farrow.

Pomaderris

Tallaganda National Park contains six known species of *Pomaderris*, and all the plants were destroyed by the megafire. Some, such as *P. costata*, were in a senescent stage before the fire. By the following spring, large numbers of seedlings of all the known species were abundant and more widespread than before. By August 2021, some seedlings had produced flower buds.

Dampiera fusca

Two years after the 2003 ACT megafire, a blue carpet of *Dampiera fusca* appeared on several summits in the Brindabella Range among the burnt shrubs. These were new records for the ACT. The plants only lasted 2 years before disappearing, leaving their progeny in the seed bank.

It has been suggested that the survival of rare or threatened plant (ROTAP) species has been put at risk by the mega-fires of 2019-2020, notwithstanding their adaptations to survive fire. To demonstrate an adverse impact of fire, we still need evidence that such species have not left any progeny in the aftermath of the fire. Most plants are put on the ROTAP list because of factors like loss of habitat and lack of burning at an appropriate temperature. For example, for *Pomaderris bodalla* it has been shown that low temperature control burns adversely affect mature plants without breaking seed dormancy leading to population declines. In another case, the loss of *Prasophyllum petalum* from Captains Flat Cemetery Reserve was probably due to lack of burning, that resulted in a thick thatch of *Themeda australis* developing and shrub invasion by *Hakea microcarpa* and *Kunzea ericoides*.

Species of *Pomaderris* that are found in the Tallaganda National Park. Top left and right: *P. costata* and *P. elliptica*. Bottom left and right: *P. phylicifolia* and *P.* aff. *intermedia* "Bungonia". Images courtesy of Roger Farrow.

Any restoration work in burnt areas should probably focus on tasks like weed removal, although the heathlands of Moreton National Park and the forests of Tallaganda National Park are remarkably weed free. Finally, I do not expect to see any loss of plant species, whether common or rare in Moreton and Tallaganda National Parks, despite one of the most intense fires on record.

A beautiful display of Kydra Dampiera (*Dampiera fusca*) at Booroomba Rocks. Photo courtesy of Roger Farrow.

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*About the author

Dr Roger Farrow is a retired insect ecologist who previously worked in the Division of Entomology at CSIRO. After retiring he joined the Canberra

Branch of the Australian Native Plants Society to further his interest in native plants and their relationships with insects, especially pollinators. For more than two decades he has led excursions with the Society to places of botanic interest both in the local area and further afield. He is the author of *Insects of South-Eastern Australia: An Ecological and Behavioural Guide* (CSIRO 2016) and co-author of *Field Guide to Orchids of the Southern Tablelands of NSW Including the ACT* (2020). He can be contacted by email at r.farrow@iimetro.com.au

We've unveiled the waratah's genetic secrets, helping preserve this Australian icon for the future

Stephanie Chen, Jason Bragg and Richard Edwards
University of New South Wales, Sydney and Royal Botanic Gardens and Domain Trust, Sydney, NSW

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When the smoke cleared after the Black Summer bushfires of 2019-20, the bush surrounding the Blue Mountains Botanic Garden Mount Tomah was charred. Among the casualties was a NSW waratah, *Telopea speciosissima*, that had recently become the first of its species to have its genome sequenced. We have published this genome in the journal Molecular Ecology Resources.

The waratah is the official floral emblem of New South Wales, and its spectacular red blooms have been adopted as the logos of state government agencies and sporting teams.

The genome sequence paves the way for the waratah to serve as a model for understanding how plant populations change over time and adapt to their environments, and particularly how this species bounces back after a bushfire.

Genome sequencing has come a long way in a short time. The first human genome, completed in 2003, cost around US$1 billion and took about 13 years to compile the roughly 3 billion "letters" of our genetic code. Today, sequencing a human genome would cost less than $1,000 and take just a few days.

With rapidly decreasing costs and advancing technology, the genomic era presents the opportunity to decode many plant genomes that we can then use as reference resources. In turn, this will help us understand and conserve Australian flora for the long term.

What is a genome anyway?

An organism’s genome is the complete set of genetic information it needs to develop, grow and survive. Plants, animals and many other living things are made of DNA, which consists of a string of four chemical “bases”, known as A, C, G and T.

Sequencing a genome involves determining the order of these bases. When we began our project, we knew from previous research the waratah genome would be quite long, at around a billion bases, that it was likely to be arranged into 11 large parcels called chromosomes, and that each plant would have two copies of the genome in each of its cells.

Cracking the waratah code

Generating the waratah reference genome first involved sampling young leaves from a plant growing naturally in the Blue Mountains. We extracted DNA from the leaves, and used three different sequencing technologies to piece together its genetic code. This approach generated many sequences, hundreds or thousands of bases long, which we then needed to assemble to determine the full genome.

Assembling the genome involved a range of different software tools, running on powerful computers. The result was a sequence of slightly less than a billion bases, mostly in 11 large sequences, as expected. The sequences appear to contain around 40,000 genes in total – roughly twice as many as humans have.

Why we sequenced the waratah

Previous sequencing efforts have focused on important crops and on “model organisms” such as *Arabidopsis*, which is widely studied by researchers and was the first plant to have its genome sequenced, back in 2000. But of course, there are many other types of species in the plant tree of life.

The NSW waratah is one of five waratah species in the genus *Telopea*, which grows throughout southeastern Australia, and one of around 1,700 species in the family Proteaceae. This family includes other iconic Australian plants such as banksias, grevilleas and macadamias. Yet despite this, very few Proteaceae genomes have so far been sequenced.

A collaborative effort between the Australian Institute of Botanical Science and UNSW Sydney, the waratah genome project was the first completed as part of the Genomics for Australian Plants (GAP) Initiative. A key aim of this initiative is to generate genomes to enable better conservation and understanding of Australia’s unique plant diversity.

Hope for the future

For many Australians, Black Summer embodied the threat posed by climate change to our unique natural heritage. But waratahs evolved with fire, and can regenerate with the help of a modified stem called a lignotuber, from which masses of fresh shoots emerge after a bushfire. It offers a potent symbol of our hope for the future.

The waratah plant whose genome we sequenced has resprouted after being burned in the Black Summer fires, and has now been propagated at the Blue Mountains Botanic Garden Mount Tomah and will become part of the garden’s living collection.

A display inspired by this plant and its genome will also feature in the foyer of the new National Herbarium of NSW when it opens at the Australian Botanic Garden Mount Annan next year.

The waratah’s genome sequence will provide a platform for future studies of its evolution and environmental adaption, ultimately informing breeding efforts and helping us better conserve this iconic species. By sequencing its DNA, we can uncover its evolutionary past and pave the way for its survival long into the future.

Australian Flora Foundation Final Report: Is mitochondrial function the key to improving cryopreservation of threatened Australian flora?

Bryn Funnekotter, Curtin University and Kings Park Science, Western Australia

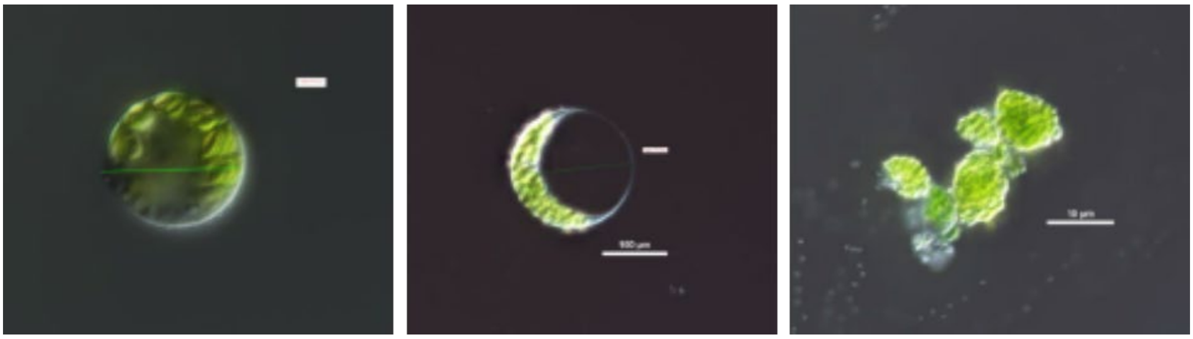
Project summary

Cryopreservation is a method of *ex situ* conservation for threatened plant species. Although this method allows long-term storage, it also causes damage to plant tissues, which must be repaired for survival to occur. This repair process is fuelled by mitochondria; however, little is known about how mitochondrial function is affected by cryopreservation in plants. While metabolic rates and mitochondrial function have been tested in animal cryopreservation, this is the first study to investigate the relationship between metabolic rate and cryopreservation in plants.

The project aimed to increase our understanding of the stresses experienced by Australian plants during cryopreservation. This project used new non-invasive techniques to assess mitochondrial function during the cryopreservation process in threatened Australian species. This includes the ASTEC Global Technology Q2 Oxygen Sensing Technology to assess metabolic function before and after cryopreservation; mitochondria-specific fluorescent probes to visualise mitochondrial damage within cells during cryopreservation; and the Seahorse XF Flux analysis, to gain specific insight into the toxic nature of the effect of cryoprotective agents on the various components of mitochondrial function.

The overall findings of this study showed that mitochondrial function is severely impacted by the stresses of cryopreservation; however, alterations to the cryopreservation protocol can help alleviate some of this stress and reduce damage to mitochondria. Further work will aim to develop new less stressful cryopreservation protocols.

The work on the importance of mitochondrial function is ongoing. In 2021, two PhD students and an honours student continued experimental work on the vital role mitochondria play during cryopreservation. The final AFF report submitted summarised the results collect so far, with a focus on the Q2 Oxygen Sensing Technology as it has proven to be particularly applicable to analysing mitochondrial function pre- and post-cryopreservation.

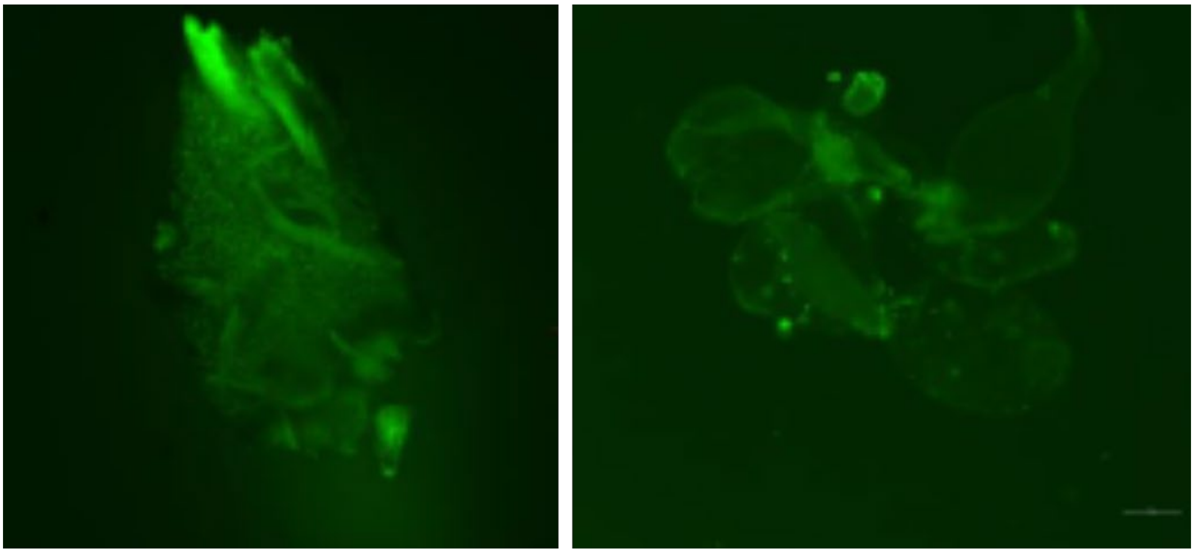


In this study, the initial protoplast protocol was tested on *Arabidopsis thaliana*. Left: For this species, isolated protoplasts retained good morphology overall. Middle: Some modifications to the osmoticum was required to reduce swelling leading to the protoplasts bursting. Right: The protoplast from *A. thaliana* also survived cryopreservation (24 h after cryopreservation).

Q2 Oxygen sensing technology

Use of non-invasive techniques allow the identification of relationships between mitochondrial function and post-cryogenic survival. Oxygen consumption in cryopreserved shoot tips was measured during the recovery period using state-of-the-art oxygen sensors. Minute changes in oxygen concentration can be measured over time, with greater oxygen consumption indicating increased mitochondrial activity and post-cryopreservation regrowth. It was concluded that this technology is applicable for assessing mitochondrial function in shoot tips during the desiccation and recovery phases of cryopreservation, both of which are vital stages for achieving optimal post-cryogenic regrowth.

Mitochondrial fluorescent probes: While the Q2 provides information about metabolic activity of whole sample, knowledge of where and when damage occurs during cryopreservation within the sample is essential for the optimisation of cryopreservation protocols. Mitochondria-specific fluorescent probes give insight into mitochondrial damage in real time when shoot tips are exposed to the desiccation media and the toxic effects of the cryoprotective agents, as well as on how mitochondria recover after cryopreservation.



Examples of images generated using a mitochondrial fluorescent probe. Left: The actively growing meristematic region of a shoot tip has increased fluorescence indicating a greater number of mitochondria present. Right: bright green dots indicate where mitochondria are located in cell cultures.

Seahorse XF Flux analysis

This technique provides real-time measurements of cellular oxygen consumption and extracellular acidification to allow detailed assessment of cellular bioenergetics. The effects of individual cryoprotective agents on extracellular flux analysis as well as their combined effects was tested with the aim to develop new vitrification solutions to reduce metabolic toxicity. The technique was found to have the potential to provide more detailed insights into mitochondrial health but requires further testing to develop a reliable protocol for use with plant cells before experimental work can be done.

Funding from the Australian Flora Foundation went largely towards consumables, hiring a casual research assistant, and for attending the Buck Institute Bioenergetics Master Classes on flux analysis.

Australian Flora Foundation Final Report: Genetic diversity and structure of Moreton Bay Fig (*Ficus macrophylla*): potential for genetic contamination of Lord Howe Island world heritage area

Paul Rymer, Collin Ahrens, Desi Quintans, Matias Simoes, Jane DeGabriel, Seth Menser, James Cook, Hawkesbury Institute for the Environment, Western Sydney University, Richmond, NSW

Project summary

The Moreton Bay Fig (*Ficus macrophylla*) occurs naturally from central Queensland to southern New South Wales and on the World Heritage Site, Lord Howe Island. The island is approximately 600 km offshore from Port Macquarie New South Wales and was created approximately 6.4 to 6.9 million years by the activity of nine underwater volcanoes (Savolainen *et al*. 2006). As a result, it has given rise to unique and endemic species found exclusively on Lord Howe Island and consequently has created interest in better understanding of sympatric speciation (Savolainen *et al*. 2006).

The Moreton Bay Fig exists in two forms, the Australian mainland form (*Ficus macrophylla macrophylla*), a singular free-standing trunk and the Lord Howe Island form (*Ficus macrophylla columnaris*), a buttressing root system called 'banyans'. However, given the morphology of leaves and fruits are similar, and the two forms share the same fig-wasp pollinator (*Pleistodontes froggatti*) the mainland and Lord Howe Island forms have not been elevated to subspecies level (Dixon 2001).

Genetic contamination of natural populations through human dispersal of plants has the potential to erode or change the genetic diversity of wild plant populations. This is of particular concern for the Moreton Bay Fig. We undertook genetic analysis using microsatellite markers from nuclear DNA and chloroplast DNA sequences of mature trees sampled from across the entire known distribution of *F. macrophylla* from eastern Australia and Lord Howe Island to determine the species' genetic structure and diversity. We sampled genotype trees with the *macrophylla* growth form found on Lord Howe Island to confirm their origin, along with seedlings emerging on Lord Howe Island to identify potential genetic contamination from pollen and seeds.

Trees on Lord Howe Island were clearly genetically distinct from those in eastern Australia, forming two discrete clusters in our analyses, validating the recognition of separate mainland and Lord Howe Island forms. On the mainland, the northern population has the greatest genetic diversity and is most likely the ancestral population. The southern mainland population is connected with gene flow from the northern population through a series

of intermediate populations along the east coast. In contrast, the low level of genetic variation detected in the Lord Howe Island population suggest it has gone through a genetic bottleneck. The genetic identity of trees with *macrophylla* form on LHI confirm that they are planted trees of mainland origin.

Left: The typical form of Moreton Bay Fig. Right: Results from BayesAss analysis show that the greatest amount of gene flow is unidirectional towards Illawarra from Lismore (0.31) and that the level of gene flow to and from Lord Howe Island is an order magnitude lower (0.012-0.015). There is also a relatively low level of gene flow towards Lismore from Illawarra (0.022).

Given that we recorded high phenological overlap in reproductive stages between the two forms in co-planted trees in Sydney, and that they shared the same pollinator wasp, there appears to be no premating barrier to genetic exchange between the two forms where they co-occur, e.g., planted *macrophylla* form and native *columnaris* form on LHI. Moreover, mainland nuclear and chloroplast variants were detected in some LHI seedlings, confirming genetic exchange via pollination to and from planted *macrophylla* trees on Lord Howe Island.

Considering the world heritage status, high levels of endemism, and unique biological processes on Lord Howe Island, preventing genetic contamination of endemic forms is an important environmental, social, and economic issue.

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What Research Were We Funding 25 Years Ago?

Note: See http://aff.org.au/results/grant-summaries/ for further details of these and other research projects funded by the AFF.

Physical and biological factors determining the distribution and abundance of the wild rice *Oryza meridionalis* Ng in the Northern Territory

Penny Wurm, School of Biology, Northern Territory University
Funded in 1994 for $2,661

Australian Wild Rice (*Oryza meridionalis* Ng (formerly *Oryza rufiopogon* Griff.)) is a widespread and abundant annual floodplain grass, endemic to northern Australia. Its seeds provide an important annual food resource for floodplain fauna, particularly the Dusky Plains Rat (*Rattus colletti*) and the Magpie Goose (*Anseranas semipalmata*).

Floodplains of the monsoonal wet-dry tropics are a hydrologically dynamic habitat. During the annual wet season, the underlying clay soils are flooded by 10-200 cm of water, while during the dry season they are dry and deeply cracked. The annual wetting and drying cycles are a reliable occurrence, but the timing of the onset of the wet season and the extent and duration of inundation are not.

This study investigated the significance of inundation regime to growth and fecundity of *O. meridionalis* in a tank experiment, growing potted plants in four inundation treatments. The growth habit, vegetative productivity, fecundity, and mortality of *O. meridionalis* plants were significantly affected by inundation regime, with plants grown in the two intermediate inundation regimes (with maximum depths of 15 and 74 cm) being the most vegetatively productive. The two intermediate inundation treatments also resulted in the greatest number of spikelets per plant (a mean range of 1,900 and 2,300 spikelets per plant). Both the exposed and deepest treatments (0 and 120 cm, respectively) resulted in significantly fewer spikelets per plant.

Although inundation regime had a significant effect on growth and fecundity, reproductive output was still over 700 spikelets per plant in all treatments, illustrating the plasticity of growth of *O. meridionalis* in response to inundation.

The preference of *O. meridionalis* in the field for areas of intermediate depth is unlikely to be explained only by inundation alone. Although spikelet production for *O. meridionalis*, was significantly decreased by the driest and wettest inundation treatments, it was still high (>700) under a 120 cm range of inundation regimes. In the field, inter-specific competition and density-dependent effects may also interact with edaphic factors to limit spikelet production and population size.

In the field, significant differences in growth and fecundity were also detected between years of different inundation period. For example, the 1992 wet season commenced 6 weeks later than it did in 1994. This additional time for vegetative accumulation prior to the initiation of inflorescences also may have contributed to higher spikelet production in the field populations.

In addition to this AFF funded study and the resultant publication (Wurm 1998), a considerable amount of research has been done on Australian Wild Rice since it was first recognised as a distinct species in the early 1980s (Ng *et al*. 1981). One of the main lines of research has been to cross domesticated rice, *O. sativa* with Australian Wild Rice to incorporate important physiological characteristics and disease resistance. With the domestication of rice, the genetic diversity of this species has diminished over time (Moner *et al*. 2018) and wild relatives are being used to selectively improve modern varieties. The genome of Australian Wild Rice was mapped in 2018 because of the considerable potential of this species to be used to develop new rice grain characteristics (Moner and Henry 2018). Examples of desirable traits include tolerance to heat (Scafaro *et al*. 2010), iron toxicity (Bierschenk *et al*. 2020; Wairich *et al*. 2021), and other abiotic stresses (Atwell *et al*. 2014) and tolerance to rice sheath blight disease (Eizenga *et al*. 2015) and leaf blight (Kaushal *et al*. 2006). Development of viable hybrids has been difficult due to low seed set (Naredo *et al*. 1997; Toyomoto *et al*. 2019).

Left: a natural stand of Australian Wild Rice (*Oryza meridionalis*) (image from: https://www.futurefoodsystems.com.au/northern-australias-native-rice-ripe-for-commercialisation/). Right: Grains from Australian Wild Rice (image from: https://www.cdu.edu.au/riel/research/ australian-native-rice-commercialisation).

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Financial Report

This statement is summarised from the Foundation’s audited accounts for the year ended 30 June 2021.

	2021	**2020**
Income	**$**	**$**
Donations	12,390	15,570
Administration contributions	548	487
Grant administration fees	360	300
Membership subscriptions	2,040	1,680
Interest	3,116	5,688
Managed fund distributions	74,535	27,659
Sundry income	-	6
Imputation credits	5,568	5,279
Increase in market value of investments	145,558	-
Bequest Reed Estate	3,706,551	-
Total income	**3,950,666**	**56,669**
Expenses		
Grants	53,438	50,161
Decrease in market value of investments	-	41,627
Audit fees	2,450	2,295
Website costs	-	48
Postage and printing	186	183
Young scientist awards	-	500
Administration	-	29
Total expenses	**56,074**	**94,843**
Surplus (deficit) for the year	**3,894,592**	**(38,174)**
Assets		
Investments and bank accounts	4,808,325	948,044
Debtors	45,076	8,948
Imputation credits receivable	5,568	5,279
GST receivable	5,445	5,870
Total assets	**4,864,414**	**968,141**
Liabilities		
GST payable	239	183
Grant commitments	65, 441	63,816
Total liabilities	**65,680**	**63,999**
Net assets	**4,798,734**	**904,142**
Accumulated Funds		
Accumulated funds from last year	904,142	942,316
Current year surplus (deficit)	3,894,592	(38,174)
Total accumulated funds	**4,798,734**	**904,142**

About the Australian Flora Foundation

The Australian Flora Foundation is an Australian not-for-profit charity dedicated to fostering scientific research into Australia's flora. It is totally independent. All members of the Council and the Scientific Committee give their time freely as volunteers.

Each year the Foundation provides funding for a number of grants for research into the biology and cultivation of the Australian flora. While the grants are not usually large, they are often vital in enabling such projects to be undertaken. Many of the researchers are honours or postgraduate students, and their success with an Australian Flora Foundation grant hopefully stimulates their interest in researching Australia's unique and diverse plants throughout their careers.

This work is only made possible by the generous support of donors and benefactors.

Research grants

The Foundation is currently calling for applications for projects to commence in December 2022. The Foundation has recently received a bequest which will allow grants to be expanded and expects to support the following:

Malcolm Reed (Large) Grants: to support projects for a minimum of $20,000 up to a maximum of $60,000, spread over the time period of the project (up to 3 years).

Small Grants: to support projects for a minimum of $5,000 up to a maximum of 20,000, spread over the time period of the project (up to 2 years).

See the website for application details (http://aff.org.au/grants/grant-criteria/).

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- Prof. Jennifer Firn, Queensland University of Technology, QLD
- Assoc. Prof. Betsy Jackes, James Cook University, QLD
- Prof. Richard Williams, University of Queensland, QLD

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