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the biology and cultivation
of the Australian flora

Research Matters

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Inside

Biosolar green roofs – achieving biodiversity outcomes and solar power on the same roof, at the same time

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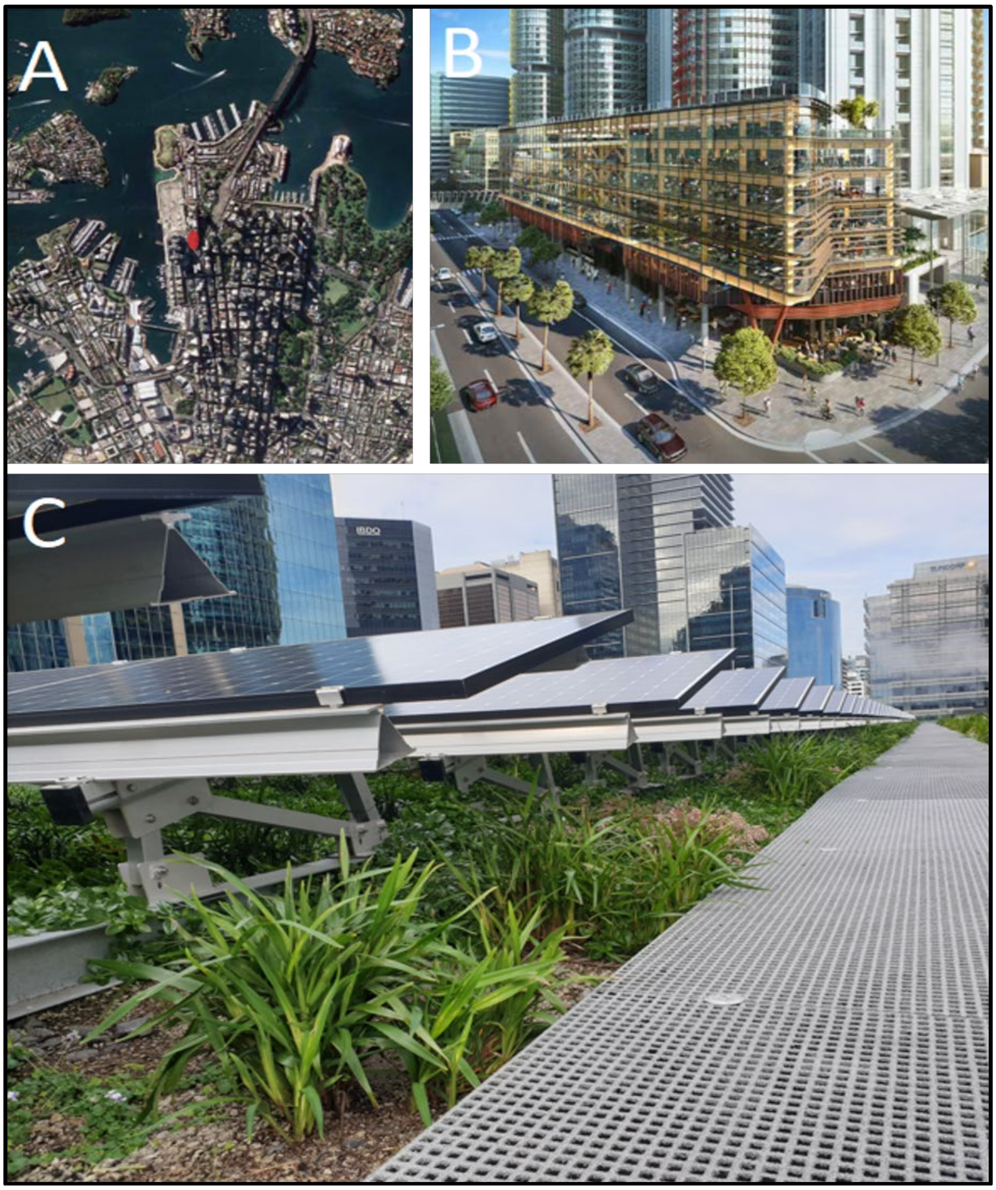
Introduction

Urban green spaces, such as parks and vegetation along roadsides, are readily recognisable examples of ecologically significant urban green areas. However, with growing human populations and limited space in cities, there is a rising trend for the adoption of space-efficient green solutions such as green roofs and green walls. While the ecological importance of residential and roadside vegetation is acknowledged in terms of supporting biodiversity, the impact of urban green roofs on biodiversity is still not well understood.

Additionally, green roofs play a role in regulating urban ambient temperatures, thereby enhancing the efficiency of solar panels by creating favourable conditions for energy production. There is a compelling correlation between the performance of photovoltaic panels (PV) and the negative impacts of rising ambient temperatures in their vicinity. What may come as a surprise to some is that as surfaces of solar panels heat up beyond 25°C, panel efficiency decreases. Green roofs have the potential to lower ambient temperatures around solar panels through evapotranspiration, thereby maximising the power output of PV systems.

Green roof studies

To date, many green roof studies have tested a single rooftop divided into 'green roof' and 'non-green roof' sections to measure differences in the effects of vegetation. However, studies using this design may be constrained by 'spatial confounding' due to the proximity of treatments leading to their effects influencing one another. Conversely, studies that use distinct buildings sometimes produce comparisons with limited validity due to the buildings being too far apart or too different in construction to be comparable. Further, most of the previous studies about removal of air pollutants by green roofs have assessed removal at the leaf scale, followed by modelling to generalise findings to an ambient scale. This is a process which has rarely been validated empirically.



Top left: (A) Map indicating the study site location (red dot) within the Central Business District of Sydney. Top right: (B) Architectural design of the Daramu House Building. Bottom: (C) View from the rooftop of the Daramu House Building looking southward and showing plant coverage around and underneath solar panels.

In this study, we aimed to determine whether established green roofs have greater abundance and diversity of organisms than conventional roofs. We investigated a Biosolar green roof – where a PV system is combined with a green roof – and compared it to a conventional roof containing only a PV system. We exploited a unique experimental design with the presence of a green roof as the sole variable. Our study sites were in the same geographic location and the buildings we used were the same height, size, and shape. We assessed avian, arthropod, and gastropod diversity across both roofs using motion-sensing camera traps at both macro- and micro-scales to quantify the biodiversity associated with urban green roof spaces. Further, plant community dynamics and succession were documented to investigate plant performance when influenced by shading due to the PV array.

Methods

The Biosolar green roof was located on top of the Daramu House Building in Sydney's Central Business District. Both the green roof and conventional roof were 1863.4 m^2, with 593.9 m^2 and 567.4 m^2 PV panel coverage, respectively. The green roof had a planted area of 1460.7 m^2 (78.4% total roof space), with PV panels covered 40.7% of the planted area. The green roof had a substrate depth of 120 mm and was irrigated with belowground hoses on a timer.

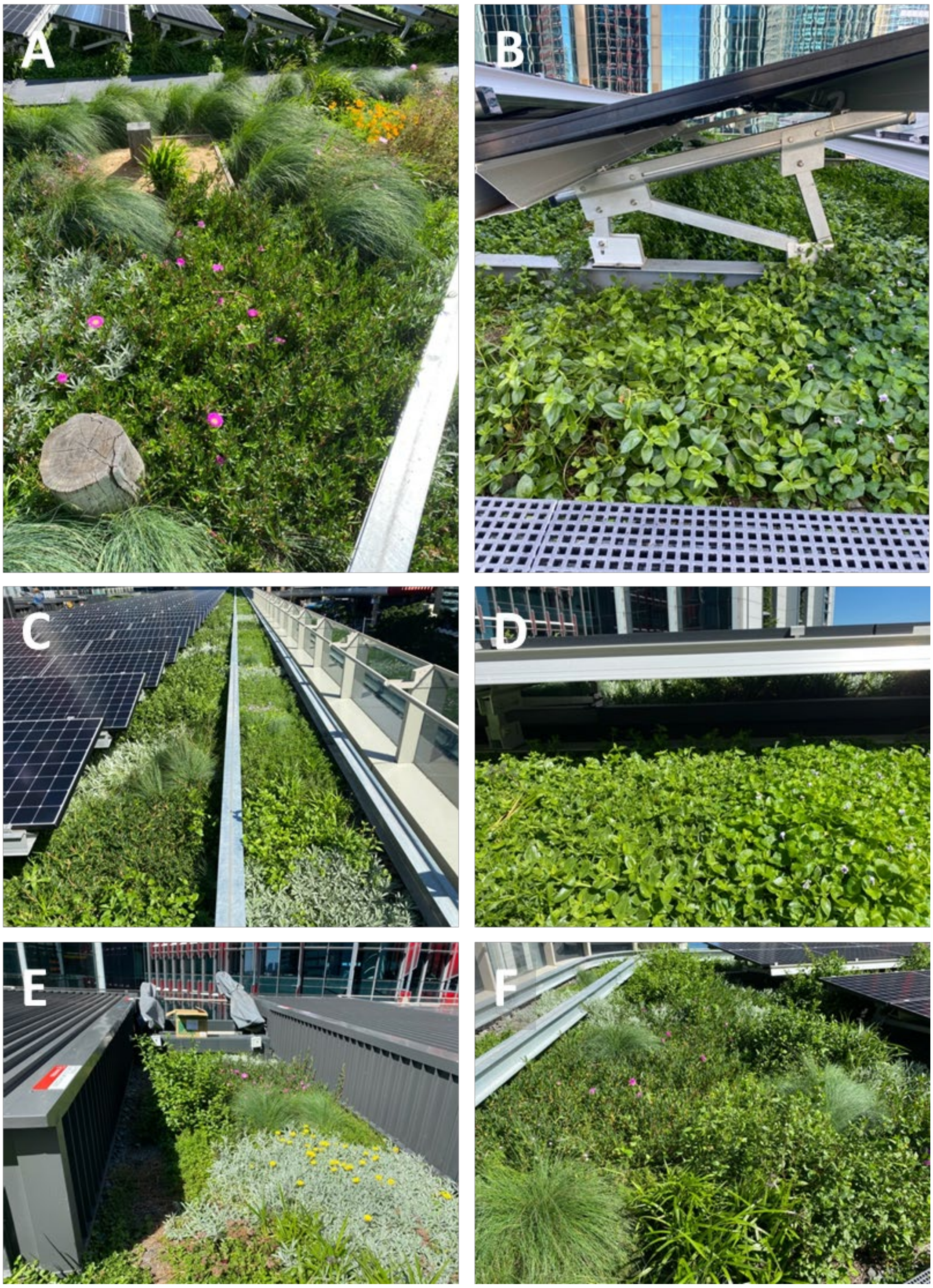
The Biosolar green roof was planted with a selection of native and non-native grasses and herbaceous plants (see table below). The plant assemblages were specifically selected to attract a diverse faunal community to the roof, with plants that would flower across all seasons.

Plant species	Common name	Spacing (plants/m^2)	Area (m^2)	Quantity
Under solar panels		5	615	
Viola hederacea	Ivy-leaved Violet			1542
Dichondra repens	Kidney Weed			1542
Around solar panels		10	248	
*Crassula multicava**	Fairy Crassula			496
*Aptenia cordifolia**	Baby Sun Rose			1488
Dianella caerulea	Blue Flax-lily			496
Open areas		10	595	
Dianella caerulea	Blue Flax-lily			745
Myoporum parvifolium	Creeping Boobialla			745
Brachyscome multifida	Cut-leaf Daisy			490
*Gazania tomentosa**	Silver Leaf Gazania			490
Goodenia ovata	Hop Goodenia			490
Poa poiformis	Coastal Tussock Grass			490
Themeda australis	Kangaroo Grass			490
Carpobrotus glaucescens	Pigface			490
				Total plants: 9994

*Indicates non-native species

Vegetation dynamics

Throughout the study period, we did vegetation surveys of the green roof to investigate the dynamics of vegetation growth and changes in the plant communities. In the open areas, there was minimal observable shift in the proportion of vegetation cover compared to the initial planted community. Each species in this section contributed an equal proportion to the overall vegetation cover on the green roof. However, in the 'Around solar panel' section, we observed the highest level of plant growth throughout the study period, with numerous species doubling in size since the time that they were initially planted. This growth is likely attributed to the deliberate selection of fast-growing vegetation for this section.



Top left: (A) An example of evenly distributed plant cover around solar panels. Top right: (B) Evidence of the succession of *Aptenia cordifolia* (Baby Sun Rose) and the dominance of this species beneath solar panels, minor cover of *Viola hederacea* also evident. Middle left: (C) Vegetation around solar panels along the outside of east section of the roof. Middle right: (D) Additional evidence of the dominance of *A. cordifolia* beneath solar panels and die back directly beneath the panels. Bottom left: (E) Relatively even cover of a range of species and marked increase in height in *Goodenia ovata* (Hop Goodenia). Bottom right: (F) Substantial height increases for the entire vegetation community.

The vegetation community that underwent the most changes where in the areas directly below and surrounding the solar panel arrays, especially with increases in the coverage of *Aptenia cordifolia*. This species emerged as the dominant plant within the vegetation community, occupying most of the space beneath and surrounding the solar panels, despite being initially planted in relatively low densities. The extent of this shift in the composition of the vegetation community was unexpected.

Dense plant growth under solar panels. *Aptenia cordifolia* (Baby Sun Rose), which was not originally planted under solar panels, is thriving in amongst *Viola hederacea* (Ivy-leaved Violet), *Dianella caerulea* (Blue Flax-lily) and *Dichondra repens* (Kidney Weed).

Measuring biodiversity

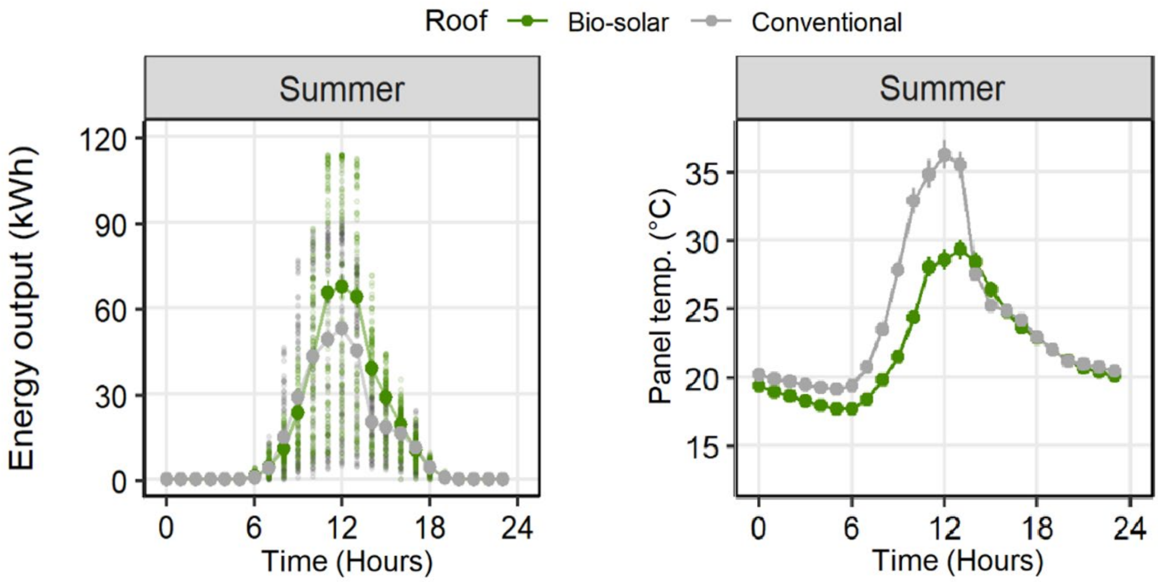
Environmental DNA (eDNA) metabarcoding surveys were done to assess and monitor green roof biodiversity. eDNA surveys involved collecting water run off samples from both the green and conventional roofs and processing samples on site using portable Smith-Root eDNA Citizen Scientist sampling equipment. The study compared biodiversity detected across the roofs using COI and 12S primers for the detection of eukaryotic species such as macroinvertebrates, fungi, and vertebrates (i.e., birds).

The results demonstrated the utility of eDNA metabarcoding to detect rooftop biodiversity, detecting a range of rooftop species and communities (i.e., algae, fungi) not evident using other survey methods. The method uses an easy-to-use citizen science workflow. eDNA results confirmed the presence of avian species observed using cameras and suggested that some other bird species visited the green roof but were not detected through other survey approaches.

The findings of this research extend beyond green roofs and have relevance to a broader range of ecosystems. Additionally, the study highlights the utility of eDNA metabarcoding and the potential for employing rapid, on-site workflows involving citizen scientists to advance the field of urban ecosystems research. This is particularly relevant as the use of eDNA sampling allows for a non-invasive and efficient method to assess species' presence and diversity.

Left and right: Handsome Jack Rojahn conducting eDNA sampling on the green roof site.

When measuring thermal effects, the green roof was able to reduce surface temperatures by up to 9.63°C and 6.93°C for the solar panels and roof surfaces respectively. There was also an average peak temperature reduction of 8°C on the green roof, which has substantial implications for thermal comfort. This reduction in temperature was then demonstrated experimentally to increase the solar performance of the photovoltaic panels on the roof, achieving a maximum increased output of 21-107 %, depending on the month. Additionally, performance modelling indicates that an extensive green roof in central Sydney can produce 4.5% more electricity at any given light level, averaged over the overall output.



Energy output from and surface temperatures of solar panels on a biosolar roof compared to solar panels installed on a conventional roof with no vegetation. During summer, the solar panels on biosolar roof are up to 5°C cooler in the middle of the day promoting greater energy output.

The results presented here are significant, both for the generation of sustainable energy, but also for demonstration that building owners/stakeholders should not have to choose between a green roof or a solar roof but can combine the two options and take advantage of the many benefits of biosolar green roofs.

Future research

Green roofs are a promising technology for creating more biodiverse, sustainable cities, however, there is still a long path to fully understanding their role in built environments. Future work could look to understand what behavioural and ecological traits make wildlife more likely to interact with novel green infrastructure and incorporate this knowledge into designing green roofs for biodiversity. Further, existing research has not been able to capture the effects of widespread implementation of green roofs to attract wildlife into cities across large scales. This is an important area of research as green roofs and other green infrastructure may alter the activity patterns of existing urban wildlife and may eventually attract non-urban species.

Further reading

Fleck R, Gill RL, Saadeh S, Pettit T, Wooster E, Torpy F, Irga P (2022) Urban green roofs to manage rooftop microclimates: A case study from Sydney, Australia. *Building and Environment* 209, 108673.

Fleck R, Gill R, Pettit T, Wooster E, Torpy FR, Irga PJ (2022) Urban green roofs to manage rooftop microclimates: A case study from Sydney, Australia. *Building and Environment* 226, 109703.

Wooster EIF, Fleck R, Torpy F, Ramp D, Irga PJ (2022) Urban green roofs promote metropolitan biodiversity: A comparative case study. *Building and Environment* 207, 108458.

Your go-to guidelines for germination, propagation, and *ex situ* conservation of Australia's national plant treasures

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Germplasm conservation in Australia: what is it and why is it needed?

Members of the Australian Flora Foundation would be well aware that Australia is home to more than 21,000 plant species, many of which occur nowhere else. Our national plant treasures face a multitude of threats and more than 10% of Australian plant species are currently listed as threatened.

Conservation of plant material *ex situ* (off site) provides plant material and research opportunities to better understand and restore *in situ* populations and landscapes. The plant material – known as germplasm – is stored as seeds in conservation seed banks, as 'living plant' collections in botanic gardens and nurseries, as tiny shoots grown in tissue culture, as fern spores and fungal filaments, and even as cryo-stored seeds or plant parts ready to be reinvigorated many years after storage. The figure below illustrates the scale of plant germplasm conservation in Australia.

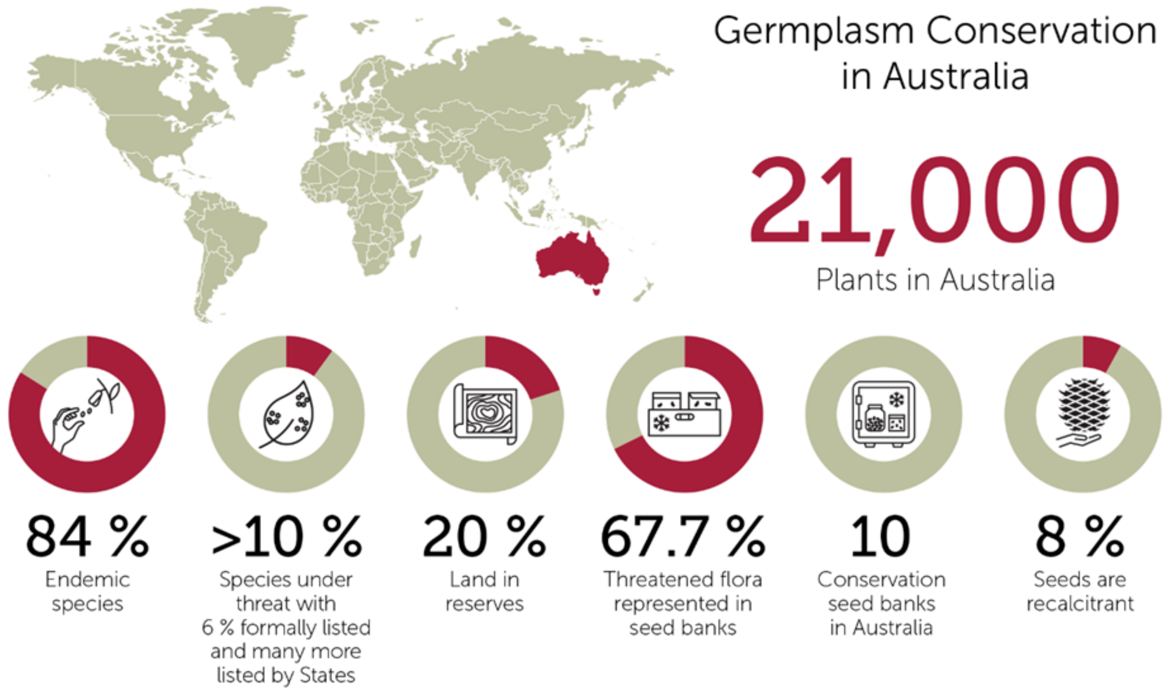
Anyone working to propagate, grow and conserve native plants outside of their natural habitats now has access to up-to-date research and evidence-based guidelines in the new third edition of 'Plant Germplasm Conservation in Australia'. The book is written as a guide for a range of users, including conservation agencies, scientists, nursery and seed bank staff, students, volunteers, restoration practitioners and anyone else interested in applied plant/seed biology.

The Australian Network for Plant Conservation and the Australian Seed Bank Partnership joined forces with the restoration and agriculture sectors, botanic gardens, CSIRO, and universities from Australia and overseas to produce the publication, which was generously funded by The

Ian Potter Foundation. It was released during the Australasian Seed Science Conference in 2021 by Prof. Tim Entwisle and was downloaded more than 700 times in the year following publication.

Revision and launch of the Germplasm Guidelines, third edition

Dr Paul Smith, Secretary General of Botanic Gardens Conservation International, who wrote the foreword, says the new guidelines are timely: "*The emergence of new pests and diseases, such as Myrtle Rust, the increasing frequency and intensity of bushfires, and recurring extreme weather trends and events are not just confined to Australia. They are a worldwide phenomenon. This gives added urgency to our mission to conserve and manage plants for future generations. Fortunately, we continue to learn from what does and doesn't work and – crucially – to share that learning through publications like this.*"



Germplasm conservation in Australia: an overview, as of April 2021. The proportion of recalcitrant species is a global estimate (Hay and Probert 2013) though prevalence is higher in some habitats. Source: Martyn Yenson AJ, Commander LE, Offord CA, Makinson RO (2021) Chapter 1 Introduction. In 'Plant Germplasm Conservation in Australia: strategies and guidelines for developing, managing and utilising *ex situ* collections. Third edition.' Australian Network for Plant Conservation, Canberra.

Contents of the Germplasm Guidelines

The Germplasm Guidelines, as they are commonly known, focus on *ex situ* collections of common and threatened plant species, which are often housed in botanic gardens. The first two chapters cover the 'why' and ‘how’ of *ex situ* conservation, including a handy decision-making guide and the key considerations for planning. This edition includes new chapters to ensure good genetic representation in *ex situ* collections, an overview of nursery practice (including must-read sections on propagation techniques), how to identify species with seeds that are ‘exceptional’ or difficult to store, handling of orchid seeds and mycorrhizae (symbiotic fungi), storage of non-seed plants such as ferns, conservation of carnivorous and parasitic plants, and the use of *ex situ* collections.

Updated chapters on seed collection, cleaning and storage, and germination and dormancy will be valuable background reading and a source of practical guidance for students and researchers working with seed collections. Boxes highlight reminders about sampling considerations for experimental work, principles of germination testing, and the design and analysis of seed experiments.

The guidelines include 50 case studies showcasing *ex situ* conservation in action, particularly in Australia and New Zealand.

The Germplasm Guidelines are available for free download or ordering of print copies: https://www.anpc.asn.au/plant-germplasm/

Sharing the Germplasm Guidelines

The revision of the Germplasm Guidelines created an opportunity to capture video footage, host webinars on a wide range of plant conservation themes, and share knowledge through capacity building events, including an Australian Academy of Science Fenner Conference on the Environment.

Evaluation of the Guidelines’ impact indicates that the new edition is influencing practical conservation activities, as well as provoking conversations on best practice within and between organisations. A wide range of audiences were reached through traditional outputs and capacity building events (see figure below). Through webinars and conference presentations, we estimate the Guidelines has reached over 1,500 people in more than 40 countries with key messages around planning and managing *ex situ* conservation collections.

Video content includes:

- Plant Treasures: showcasing the *ex situ* conservation of Australia’s national plant treasures.
- Assessing seed storage behaviour: hallmarks of non-orthodox seeds and alternatives to seed banking (filmed at The Australian PlantBank).

- The role of the nursery and living collections in *ex situ* conservation (filmed at the Cranbourne Gardens of the Royal Botanic Gardens Victoria).
- Using *ex situ* collections of Australian native species: Translocation and other end uses (filmed at Kings Park and Botanic Garden).
- Techniques including cutting propagation, collection and processing of fern spores and using differential scanning calorimetry to identify freezing-sensitive seeds (filmed at the Cranbourne Gardens of the Royal Botanic Gardens Victoria, the Australian National Botanic Gardens, and The Australian PlantBank, respectively).

These videos can be accessed via the ANPC YouTube channel and viewing the playlist 'Plant Germplasm Conservation in Australia' (https://www.youtube.com/c/AnpcAsnAu).

A resource page has been created that includes all available content, including videos, webinar recordings, a selection of case studies, links to the Fenner Conference, a downloadable poster and slide desk (for use in conference packs or teaching), and background on the revision process.

Impact and target audiences for the Germplasm Guidelines revision. Modified from Graham *et al*. (2022) *Global Change Biology* 27, 4935-4945.

Acknowledgements

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Patricia Meagher, Tony Auld, David Bush, David Coates, Lucy Commander, Lydia Guja, Sally Norton, Bob Makinson, Rebecca Stanley, Neville Walsh, Damian Wrigley, Linda Broadhurst, Jo Lynch, and Christine Fernance. We acknowledge the input of 78 contributors for writing chapters and case studies, and additional subject matter experts who provided peer-review for the third edition of 'Plant Germplasm Conservation in Australia'.

Useful links

Please consider sharing the Germplasm Guidelines resource page with anyone you think may benefit: www.anpc.asn.au/germplasm-guidelines-review/.

For more information about the Australian Network for Plant Conservation: www.anpc.asn.au

For more information about the Australian Seed Bank Partnership: www.seedpartnership.org.au

*About the author

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It's official: Australia is set for a hot, dry El Niño. Here's what that means for our flammable continent

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https://theconversation.com/its-official-australia-is-set-for-a-hot-dry-el-nino-heres-what-that-means-for-our-flammable-continent-209126

An El Niño event has arrived, according to the World Meteorological Organization, raising fears of record high global temperatures, extreme weather and, in Australia, a severe fire season.

The El Niño is a reminder that bushfires are part of Australian life – especially as human-caused global warming worsens. But there are a few important considerations to note.

First, not all El Niño years result in bad bushfires. The presence of an El Niño is only one factor that determines the prevalence of bushfires. Other factors, such as the presence of drought, also come into play.

And second, whether or not this fire season is a bad one, Australia must find a more sustainable and effective way to manage bushfires. The El Niño threat only makes the task more urgent.

Understanding fire in Australia

An El Niño is declared when the sea surface temperature in large parts of the tropical Pacific Ocean warms significantly.

The statement by the World Meteorological Organization, released on Tuesday, said El Niño conditions have developed in the tropical Pacific for the first time in seven years "setting the stage for a likely surge in global temperatures and disruptive weather and climate patterns".

The organisation says there's a 90% probability of the El Niño event continuing during the second half of 2023. It said El Niño can trigger extreme heat and also cause severe droughts over Australia and other parts of the world.

But before we start planning ahead for the next bushfire season, it's important to understand what drives bushfire risks – and the influence of climate change, fire management and events such as El Niño.

The evidence for human-induced climate change is irrefutable. While the global climate has changed significantly in the past, the current changes are occurring at an unprecedented rate.

In geologic time scales, before the influence of humans, a significant shift in climate has been associated with an increase in fire activity in Australia. There is every reason to expect fire activity will increase with human-induced climate change as well.

Humans have also changed the Australian fire landscape – both First Nations people and, for the past 200 years, European colonisers.

Changes brought about by Indigenous Australians were widespread, but sustainable. Their methods included, for example, lighting "cool" fires in small, targeted patches early in the dry season. This reduced the chance that very large and intense fires would develop.

Changes brought about by European colonisers have also been widespread – such as land clearing using fire, and fire suppression to protect human life and property. But this approach has been far from sustainable, either financially, ecologically or socially.

Australia has just experienced a period of high rainfall across the continent due to a La Niña event combined with two other climate drivers: a negative Indian Ocean Dipole and a positive Southern Annular Mode. It means the soil is moist and plants are flourishing.

Now, we're set to enter into a drying period driven by an El Niño. The abundant plant growth leading into a dry period is likely to result in widespread bushfires across Australia.

Initially, this is likely to occur in semi-arid inland areas where grasses have flourished in the wet period, but will dry out quickly. If the drying cycle persists for two or three years, then fires might become more prevalent in forests and woodlands in temperate Australia.

But an El Niño year doesn't necessarily mean a bad bushfire season is certain.

In Australia, El Niño events are associated with hotter and drier conditions, leading to more days of high fire danger. But large and severe forest fires also need a prolonged drought to dry out fuels, especially in sheltered gullies and slopes. Soils and woody vegetation are currently moist following the La Niña period.

So El Niño and its opposite phase, La Niña, are on their own are a relatively poor predictor of the number and size of bushfires.

Fight smarter, and be prepared

Climate change will continue to test our fire management systems. And the return of an El Niño has fire crews on alert.

When it comes to fire management, Australia must be much smarter than it has been for the past 200 years. This means changing the focus to holistic fire management. Throwing huge amounts of money and resources at controlling bushfires – such as purchasing more and larger firefighting aircraft – is not sustainable or sensible.

Fire is as fundamental to our environment as wind and rain. And the amount of energy released from a large bushfire will never be matched by any level of resources humans can muster.

The evidence bears this out. Take, for example, analysis of fire dynamics in two areas north and south of the US-Mexico border. Between 1920 and 1972, authorities on the US side had spent hundreds of millions of dollars on firefighting aircraft and other resources trying to suppress wildfires. This resulted in fewer wildfires than in the Mexico region. But the fires that occurred were larger and more severe.

Similar patterns have occurred in Australia. For example, a study of burn patterns in the Western Desert region showed that after the exodus of Traditional Owners, the number of fires reduced substantially, but the fires became far bigger.

Change must happen

Damaging bushfires will return to Australia in the near future. The expected return of another El Niño should heighten efforts to create a more considered and sustainable fire management regime – particularly in southern Australia.

Experts, including me, have devised plans to guide the shift. They include:

- effectively managing the land with fire, including promoting Indigenous Australians' use of fire
- engaging communities in bushfire mitigation and management

- better coordination across land, fire and emergency management agencies
- ensuring fire management is based on “best practice” approaches.

Australia, with its wealth of scientific knowledge and long history of Indigenous land management, should be well placed to manage fire sustainably – even with the pressures of climate change. Changing our approach will not be quick or simple, but it must be done.

Australian Flora Foundation Final Report: The effects of soil microbial community and topsoil removal on grassland restoration techniques in South Australian Mediterranean-type climate region

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Project summary

Disruptions in relationships between soil microbial communities and plants contribute to the replacement of species, affecting successional processes that can ultimately lead to the dominance of invasive species. Recent research has shown that plant-soil-microbial interactions can play a significant role determining abundance of various plants, as microbes can either favour the establishment of plants or become pathogens for them, and these effects are species specific. Hence, the management of microbial communities should be considered in restoration campaigns that aim to establish native vegetation in degraded sites.

In the temperate grasslands of South Australia, the restoration of former crop paddocks (old-fields) to grasslands dominated by perennial graminoids represents a challenge due to the soil legacies caused by farming, grazing, and the dominance of invasive species. Little is known about the effect of restoration techniques on the soil microbial communities and how these could affect the establishment of native species. We conducted a glasshouse experiment using intact core soil samples from old-fields that were subject to topsoil removal and direct soil microbial inoculation, from different soil origins. We assessed the effects of the combination of these techniques on the microbial community and the biomass production of the native Wallaby Grass (*Rytidosperma auriculatum*).

Soil physiochemical properties, plant biomass and soil microbial communities were significantly affected by topsoil removal. The use of microbial inoculum grasslands affected the number of observed microbial operational taxonomic units. The inoculum elaborated from soils dominated by native graminoids produced higher Wallaby Grass biomass.

Our results indicate that the combination of topsoil removal and inoculums with a native origin can be beneficial to the biomass production of native grasses like Wallaby Grass. This study increases our understanding of the factors driving vegetation succession and represent an opportunity to improve restoration techniques.

Related publication

Guevara-Torres DR, Facelli JM (2023) Choose local: dung addition from native herbivores can produce substantial positive effects on the growth of native grasses compared to livestock dung. *Journal of Soil Science and Plant Nutrition*. https://doi.org/10.1007/s42729-023-01380-7

Australian Flora Foundation Final Report: The living dead – demography of Australian sandalwood in Australia's western rangelands

Richard McLellan and David Watson

Gulbali Institute, Charles Sturt University, Albury, NSW

Project summary

One-third of the worlds' trees are at risk of extinction, with large, old, long-lived trees among the most vulnerable. Long-lived trees in arid and semi-arid biomes are particularly at risk, including Australian Sandalwood

(*Santalum spicatum*, Santalaceae) which is experiencing substantial population decline due to a suite of natural and anthropogenic drivers, with no appreciable recruitment estimated for more than 80 years.

To contextualize this range-wide collapse and quantify regional variation in population dynamics across Australia's western rangelands, we used Australian Flora Foundation funds to investigate the size-class profiles of 12 sandalwood populations in a 1,500-kilometre arc between Shark Bay and the Gibson Desert in central Western Australia. The populations were located on Indigenous Protected Areas, pastoral leases, and public and private conservation parks and reserves. Stem diameters, indicative of age using known growth rates, were recorded for 1,355 sandalwood plants, along with a set of other plant structural and ecological parameters. Using size-class profiles and associated demographic data, we estimated the population age structure and trajectory to determine whether each population was increasing, stable or declining.

Our surveys revealed sandalwood populations are declining and are composed almost entirely of very old trees in advanced states of senescence. Of 1,355 plants sampled, 1,198 (88%) individuals were large (old) trees. A total of 23 seedlings and 21 saplings were recorded across all sites, almost all of which (22 and 19, respectively) were in one population, and located under the canopies of parent trees where they would not be expected to survive to maturity.

Our findings reinforce the urgent need to list *Santalum spicatum* as a threatened species in Western Australia (where wild plants are still being commercially harvested), and to initiate effective conservation actions to secure the species' continued existence across its natural range.

The research generated by this project has attracted considerable interest and comment, including being instrumental in sandalwood being selected as the focal species from Western Australia in the 2022 National Science Week special on 'Australia's favourite trees' on ABC TV Catalyst program (https://www.abc.net.au/education/catalyst-the-fragrant-sandalwood/14003062). The plight of sandalwood also featured as a case study in Australia's 2021 State of the Environment Report which stated: "*dramatic declines (of many old-growth, slow-growing native species like sandalwood) are overlooked until the population crash becomes unequivocally evident*". It is hoped that this research and the contributions of organisations like the Australian Flora Foundation will assist in the critical conservation interventions now required to save the species in the wild in Australia.

Publication

McLellan RC, Watson DM (2022) The living dead: Demography of Australian sandalwood in Australia's western rangelands. *Austral Ecology* 47, 1685-1709.

Australian Flora Foundation Final Report: Assessment of the diversity, distinctiveness, and conservation of Australia's Central Queensland coastal rainforests using DNA barcoding

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Project summary

Globally threatened dry rainforests are poorly studied and conserved when compared to mesic rainforests. Investigations of dry rainforest communities within Australia are no exception.

We assessed the community diversity, distinctiveness, and level of conservation in Central Queensland coastal dry rainforest communities. Our three-marker DNA barcode-based phylogeny, based on rainforest species from the Central Queensland Coast, was combined with the phylogeny from Southeast Queensland. The phylogenetic tree and Central Queensland Coast (CQC) community species lists were used to evaluate phylogenetic diversity (PD) estimates and species composition to pinpoint regions of significant rainforest biodiversity. We evaluated the patterns and relationships between rainforest communities of the biogeographical areas of Central Queensland Coast and Southeast Queensland, and within and between Subregions. Subsequently, we identified areas of the highest distinctiveness and diversity in phylogenetically even rainforest communities, consistent with refugia, and areas significantly more related than random, consistent with expansion into disturbed or harsher areas.

We found clear patterns of phylogenetic clustering that suggest that selection pressures for moisture and geology were strong drivers of rainforest distribution and species diversity. These results showed that smaller dry rainforests in Central Queensland Coast represented areas of regional plant migration but were inadequately protected.

To sustain species diversity and distribution under intense selection pressures of moisture availability and substrate type throughout this dry and geologically complex region, the future conservation of smaller patches is essential.

Publication

Howard M, Pearl H, McDonald WJF, Shimizu Y, Srivastava SK, Shapcott A (2023) Assessment of the diversity, distinctiveness and conservation of Australia's Central Queensland coastal rainforests using DNA barcoding. *Diversity* 15, 378.

What research were we funding 25 years ago?

Photoautotrophic micropropagation of *Banksia* and *Caladenia*

John Godfrey[A], Rob Cross[A] and Gayle Marven[B]

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Photoautotrophic micropropagation (PAM) is a popular method for *in vitro* propagation of plantlets. The medium used does not contain supplementary organic components such as sugars, vitamins, and plant hormones. This minimal environment is used to promote photosynthesis and biomass accumulation. The method was introduced more than 20 years ago but is still a technology with high potential.

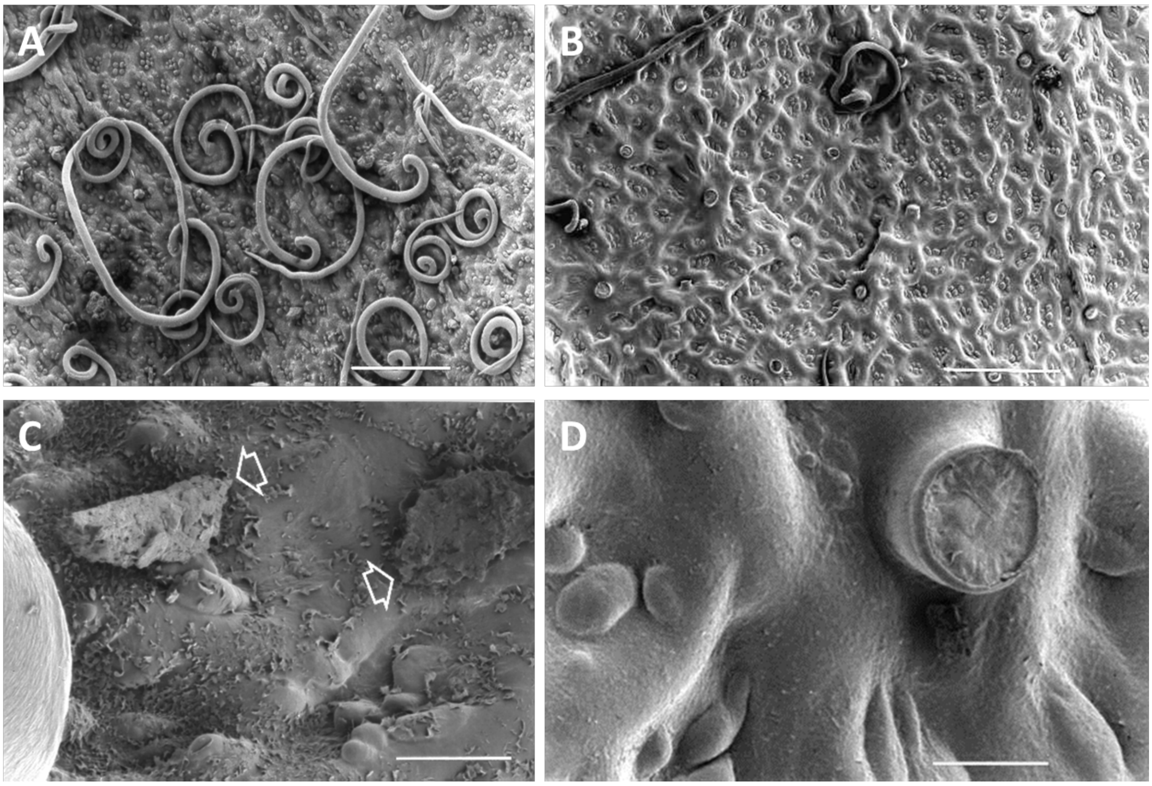
Two projects investigating the efficacy of PAM were funded in consecutive years in 1996 ($2,200) and 1997 ($1,870).

The initial aim of the first project was to develop a tissue culture propagation method for species of *Banksia* grown as a cut flower. *Banksias* are an important component of the Australian cut flower export industry, but most plants are derived from seed, with consequent problems of variability. Tissue culture methods offered the prospect of rapid multiplication of selected forms.

Early in the study it became apparent that a major barrier to successful tissue culture was surface decontamination of plant material. From necessity, the focus was changed into developing a reliable method for introducing *Banksia* into culture.

The method finally developed involved taking terminal shoots of *Banksia coccinea* from greenhouse grown plants, trimming off the leaves, and placing the stems into dilute HCl with a nonionic surfactant and agitating gently. Stems were then transferred to a dilute bleach solution (1% available chlorine) and agitated for 10 minutes and finally transferred to a sterile solution of citric acid solution and agitated for 5 minutes. Sections were rinsed and stored in sterile deionised water. A relatively high proportion (75%) of explants remained green and viable after surface sterilisation using this treatment and survived subsequent placement on tissue culture medium. Explants survived on ½ Murashige & Skoog medium although bud expansion and growth were observed to be best on Woody Plant Medium (both non-PAM media).

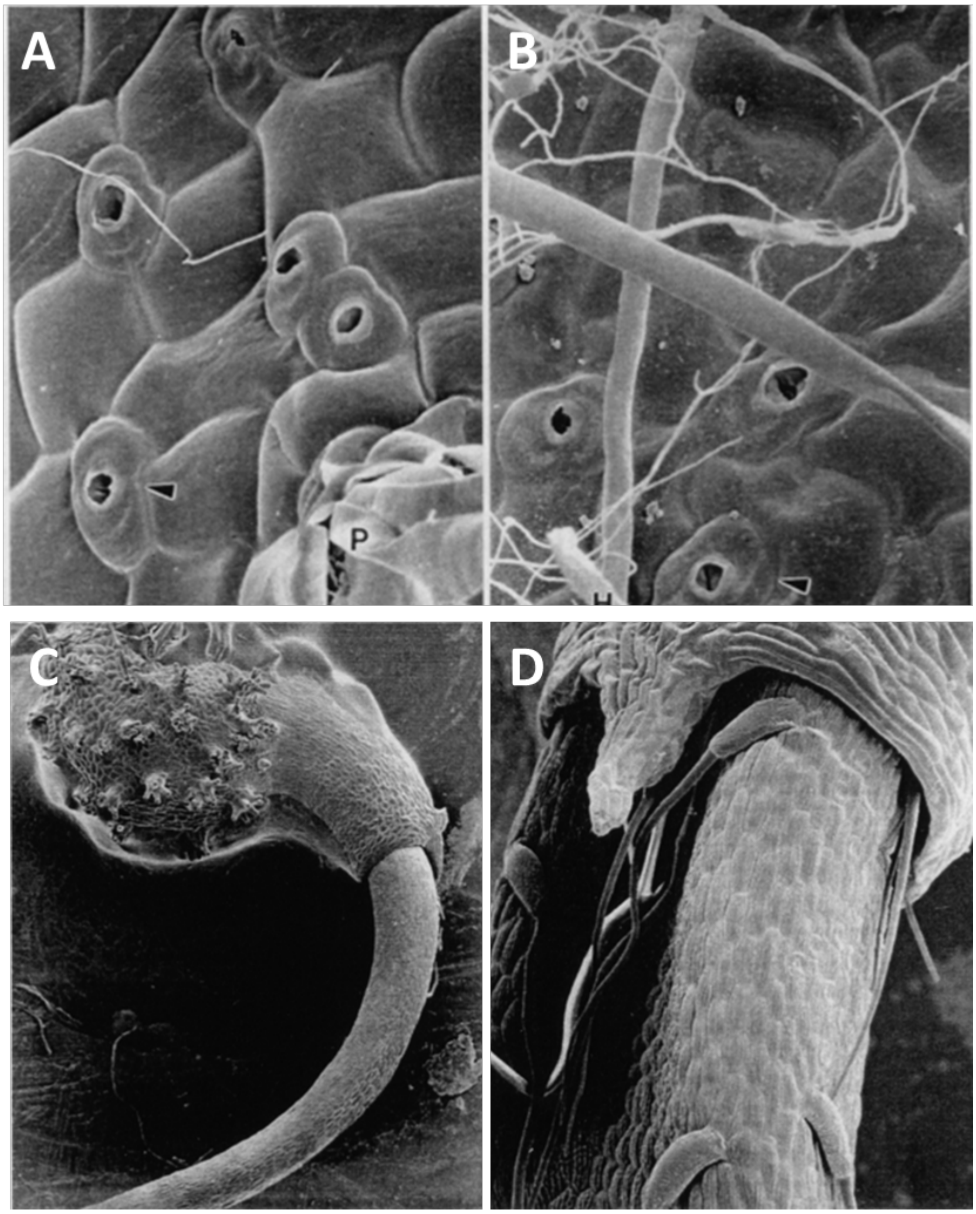
Although the project deviated from what was originally intended the research revealed a fast, simple, safe, and effective means of surface decontamination which did not damage plant cells or destroy surface integrity.



Scanning electron micrographs of the adaxial surface of a *Banksia coccinea* leaf. Top left: (A) A multitude of coiled hairs (x100). Top right: (B) Leaf surface after treatment with HCl, sodium hypochlorite (bleach) and citric acid showing the reduced contamination and fewer hairs (x100). Bottom left: (C) Arrows indicate some contamination on leaf surface (x1000). Bottom left: (D) Smoother surface of the cuticle and markedly reduced surface contamination after treatment (x1000). The base of an abscised hair can be seen in the top right corner.

The aim of the second study was to determine whether *Caladenia* plantlets produced in a PAM (additive-free growing medium) environment had greater germination and improved growth compared to plants grown under heterotrophic conditions (growing medium with additives). At this point in time, plantlets of *Caladenia* species produced through *in vitro* symbiotic germination for reintroduction into natural habitats had less than 10% survival *ex vitro*, possibly due to altered anatomy, physiology, and biochemistry caused by the *in vitro* environment. Previous research had shown that photoautotrophic micropropagation with raised carbon dioxide and light levels promoted increase growth rates and plantlet survival *ex vitro* for the epiphytic orchid, *Cymbidium* and *Eucalyptus camaldulensis*. In this study funded by the AFF, the germination and growth of plantlets of the common orchid species, *Caladenia tentaculate*, produced using PAM techniques was compared with plantlets produced in the usual non-photoautotrophic way (i.e., under heterotrophic conditions).

For *C. tentaculata* it was found that optimum germination occurred with low light and ambient carbon dioxide levels rather than high light and raised carbon dioxide concentrations. High light and raised carbon dioxide levels also inhibited the growth of the associated mycorrhiza. Unfortunately, photoautotrophic conditions did not result in improved symbiotic germination and growth of *C. tentaculata*, and therefore may not be suitable for threatened *Caladenia* species.



Scanning electron micrographs of *Caladenia entaculata* plantlets. Top left: (A) Plantlet protocorms indicating similar stomatal structure for plantlets grown under photoautotrophic conditions, and top right: (B) non-photoautotrophic conditions. Stomata are indicated by arrowheads. Bottom left: (C) A leaf arising from a sheathing leaf base. Bottom right: (D) Hairs on the leaf surface.

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

About the Australian Flora Foundation

The Australian Flora Foundation is an independent, not-for-profit charity dedicated to fostering scientific research into Australia's flora. 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. These include substantive **Malcolm Reed Grants** to support projects for up to 3 years and **Small Grants** to support projects for 1-2 years. 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.

Preliminary applications are due in mid-March each year. Applications may be lodged under one scheme only.

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

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