Australian Academy of Science *Fenner Conference on the Environment* 'Exceptional Times, Exceptional Plants'

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A workshop on identification and conservation of plant species that are difficult to bank using conventional techniques

Sophisticated technologies to preserve plants not suitable for conventional conservation techniques were in the spotlight at the Australian Academy of Science *Fenner Conference on the Environment*. Held during the Australasian Seed Science Conference in September 2021, the virtual event attracted more than 300 scientists, practitioners, students and artists from 29 countries, with about one third already working on these more difficult species. Participants were keen to ask questions, chat with other attendees, respond to poll questions during the sessions, and complete a post-conference evaluation.

The conference focus was on methods to identify and conserve plant species that cannot be conserved using conventional seed banking, which entails drying seeds to 3-7% moisture content and storing them at -20°C. Seed banks are well established to conserve the majority of seed-bearing plant species for future use in restoration, translocation, agriculture and horticulture; 67% of Australia's threatened species, for example, are now represented in conservation seed banks (Figure 1).

Recognition is growing, however, that we need to think beyond seed banks, across Australia and globally, to conserve plant species that don't produce seeds or that produce seeds which don't survive well in conventional storage.

These species are collectively known as 'exceptional species', a term that includes species for which seeds are not available (not produced at all, inadequately produced, or non-viable), species with desiccation sensitive, freezing-sensitive or short-lived seeds, and species with deeply dormant seeds (Case Study 2.5 in the Germplasm Guidelines, Martyn Yenson *et al.* 2021).

Significant advances in identifying and conserving exceptional species *ex situ* have been made in the last decade (*e.g.,* Sommerville *et al.* 2021); however, access to resources for methods other than seed banking, as well as difficulty accessing relevant information, remains a challenge for many conservation facilities. In addition, difficulties with germination and propagation can make it hard to assess seed storage behaviour, and to produce plants that can be returned to their habitat *in situ*.

Knowledge sharing is essential for supporting conservation of these species around the globe and has the potential to greatly increase the speed and effectiveness of our conservation efforts. Dr Karen Sommerville explains: "Rainforests in the South Pacific, for example, hold thousands of plant species from more than 1500 different genera. Many of those genera are shared across several South Pacific nations, providing a great opportunity for knowledge exchange and collaborative research."

Identifying exceptional species

Between 5-10% of seed-bearing plant species in the world are not able to be 'banked' using conventional methods and this proportion may be much higher in wetter habitats such as rainforests [48% of 162 Australian rainforest species were recently found to respond poorly to either drying or freezing under standard seed banking conditions; Sommerville *et al.* 2021]. While some plant species are readily identified as exceptional by their inability to produce seeds (*e.g.,* ferns and mosses), seed-producing species require a series of experiments comparing germination of fresh seeds to germination of seeds following drying and freezing to determine whether they will survive storage in a seed bank. Species that are tolerant of drying and freezing but likely to be short-lived in storage can be identified by testing germination after artificially aging the seeds at high temperature and humidity.

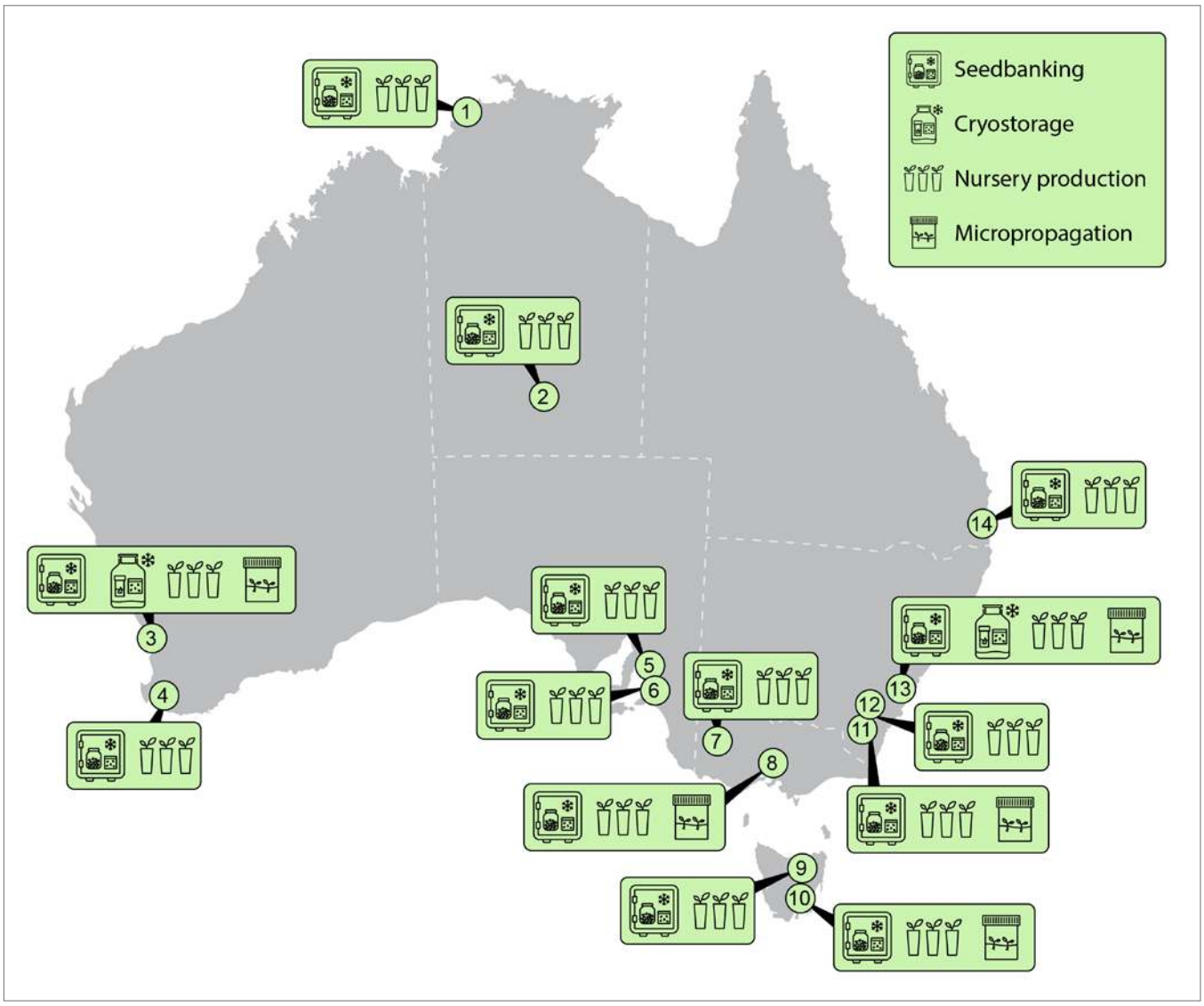

Figure 1. Location of major *ex situ* conservation facilities for Australian flora, including ASBP Partners and Associates*, the Australian Tree Seed Centre, the Australian Grains Genebank and Australian Pastures Genebank (both storing crop wild relatives) and major forestry seed banks with conservation collections (Image: CAM Graphics; in Offord *et al.* 2021 Germplasm Guidelines Chapter 2).

Key:

1. *George Brown Darwin Botanic Gardens conservation seed bank
2. *Alice Springs Desert Park
3. *Western Australian Seed Centre, Department of Biodiversity, Conservation and Attractions, Kensington, and Kings Park and Botanic Garden
4. Forest Products Commission Seed Centre
5. Australian Pastures Genebank, South Australian Research and Development Institute
6. *South Australian Seed Conservation Centre, Botanic Gardens and State Herbarium of South Australia (BGSH)
7. *Australian Grains Genebank, Agriculture Victoria
8. *Victorian Conservation Seedbank, Royal Botanic Gardens Victoria
9. Tasmanian Seed Centre, Sustainable Timber Tasmania
10. *Tasmanian Seed Conservation Centre, Royal Tasmanian Botanical Gardens
11. *National Seed Bank, Australian National Botanic Gardens
12. Australian Tree Seed Centre, CSIRO
13. *Australian PlantBank, Australian Institute of Botanical Science, Royal Botanic Gardens and Domain Trust
14. *Brisbane Botanic Gardens Conservation Seed Bank, Brisbane Botanic Gardens, Mt Coot-tha

These processes are made considerably more difficult when seeds are hard to collect in good quantities, hard to germinate or take a very long time to complete germination. These issues were highlighted in a conference survey in which about half of all participants indicated they found it challenging to identify which species are exceptional. The first session of the Fenner Conference therefore focused on techniques for identifying exceptional species, and included a presentation on a recently published key that can be utilised to determine the likely response of a species to desiccation without germination testing (Sommerville *et al.* 2021; Chapter 6 Germplasm Guidelines). This session also included the first screening of a video, prepared by the ANPC, demonstrating how to use the key (https://youtu.be/Eb-eUFMB5p0).

Cryopreservation as a long-term conservation tool for exceptional species

Cryopreservation is one option for preserving exceptional species and involves the storage of samples at ultra-low temperatures, typically in liquid nitrogen (-196°C). These low temperatures preserve the tissue, as many of the cellular process are halted as the samples vitrify, until the samples are rewarmed as needed in the future. Samples have been cryopreserved for over 40 years with little loss in viability (Pence *et al.* 2017). A wide range of germplasm can be cryopreserved, making it a valuable long-term conservation tool for exceptional species; seed, embryo axes, *in vitro* cultured shoot tips, dormant buds, fern spores and pollen have all been successfully cryopreserved (Chapter 10 Germplasm Guidelines, Martyn Yenson *et al.* 2021). The second session of the Fenner Conference focused on how cryopreservation can be applied to a range of germplasm from exceptional species, primarily in Australia and New Zealand (Figure 2).

Cryopreservation of exceptional species in New Zealand

New Zealand is home to approximately 2500 native species of which more than 80% are endemic. The latest New Zealand Threat Classification System listing identified 403 species as threatened with 213 nationally critical; 77 nationally endangered; and 113 nationally vulnerable (de Lange *et al.* 2018). Natural disasters (fire, flood, hurricane and earthquake), climate change, land use for development and agriculture and disease have been the major threats for New Zealand's flora. For example, the incursion of Myrtle Rust (*Austropuccinia psidii*), in New Zealand in May 2017, has resulted in all native New Zealand Myrtaceae species being listed as threatened (Nadarajan *et al.* 2021). *Ex situ* conservation strategies to complement *in situ* conservation programmes are deemed critical for conservation of these threatened species. However, many of New Zealand's endemic species have received little attention in terms of long-term conservation.

Development of cryopreservation protocols for embryos and embryonic axes can be straightforward in some species. Nevertheless, for many species, this requires the understanding of fundamental cryobiology and the incorporation of cryobiotechnology knowledge to elucidate and overcome some of the challenges associated with low or no survival following cryopreservation.

Figure 2. Facilitator and Germplasm Guidelines project manager Dr Amelia Martyn Yenson in discussion with Dr Bryn Funnekotter and Dr Jayanthi Nadarajan during session 2. Image: Lucy Commander

Using all the tools of *ex situ* conservation to conserve our national plant treasures

Conservation of a genetically representative collection of threatened and common species requires a range of *ex situ* techniques – such as cryobiotechnology, micropropagation (tissue culture) or 'extreme horticulture' – to conserve them under expert care away from their natural habitat. The need for a range of complementary *ex situ* techniques was the focus of the panel session at the conclusion of the conference (Figure 3).

Identifying the technologies required to store these exceptional Australian plants requires collaborative research partnerships and sophisticated management of plant collections. But to address these issues with the urgency required in the current environmental crisis, long term funding and cohesive research partnerships must be established.

A good example of this type of work is a 5-year project to preserve plants endemic to tropical mountain tops that are highly threatened by climate change. The project utilises a combination of horticulture, seed banking and seed research to develop *ex situ* collections preserving multiple species at multiple locations. The rescue mission is a collaboration among the Australian Tropical Herbarium, the Australian National Botanic Gardens, Western Yalanji Traditional Owners, the Wet Tropics Management Authority, the Royal Botanic Gardens and Domain Trust, the Royal Botanic Gardens Victoria, and the Dandenong Ranges, Brisbane, Cairns and Mossman Botanic Gardens. See also https://www.jcu.edu.au/news/releases/2019/april/mountain-rescue.

These partnerships are critical to the delivery of the Australian Government's new Threatened Species Strategy. Threatened Species Commissioner Dr Fiona Fraser noted: "Under the Australian Government's first Threatened Species Strategy, our collaborative efforts increased the representation of threatened flora in seed banks. As our changing climate continues to impact biodiversity, the *ex situ* preservation of plant species has never been more vital. We will build on these important efforts in the new Threatened Species Strategy and Action Plan."

A significant outcome of the conference was recognition that both formal guidelines such as the Germplasm Guidelines, and peer-reviewed journal papers, are essential information sources for conservation of exceptional species. Databases, such as those maintained by the Australian Seed Bank Partnership (https://www.seedpartnership.org.au/initiatives/australian-seed-bank-online/) and Kew's Seed Information Database (https://data.kew.org/sid/), are also key to sharing information.

Webinars planned for the final six months of the Germplasm Guidelines revision project, funded by the Ian Potter Foundation, will assist practitioners and scientists throughout the region to consolidate local, regional and personal contacts to support their work in this "critical window of opportunity" before extinction may occur (Sommerville *et al.* 2018). Australian conservation leaders must share their expertise with others in less well-resourced countries to stem global biodiversity losses.

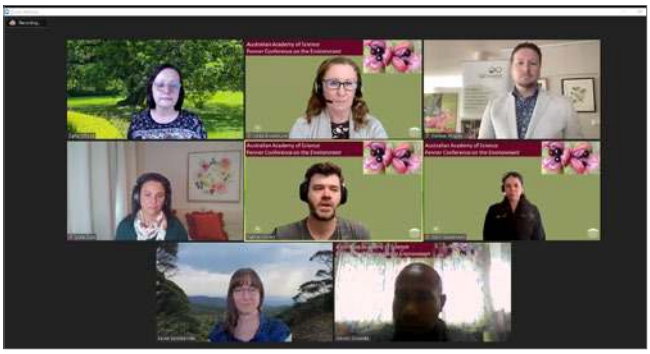

Figure 3. In session 3, Dr Cathy Offord facilitated a panel discussion with Dr Linda Broadhurst, Mr Damian Wrigley (top), Dr Lydia Guja, Dr Nathan Emery, Ms Karin van der Walt (centre) and Dr Karen Sommerville and Mr Gibson Sosanika (bottom). Image: Lucy Commander

Recordings of the Fenner Conference are available on the ANPC's YouTube channel: https://www.youtube.com/c/AnpcAsnAu

For more information on webinars and resources relating to the Fenner Conference, subscribe to ANPC's free e-newsletter: https://www.anpc.asn.au/anpc-news/

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Editor's note: Kew's Seed Information Database will be taken down on 1 May 2022. There are plans for the information to be made available elsewhere, see: https://seedscisoc.org/important-notice-regarding-the-seed-information-database/