


AUSTRALASIAN Seed Science Conference

Linking seeds with needs; securing our future in a changing world

6th-10th September 2021

https://seedscience2021.com.au

Presented by

AUSTRALIAN SEEDBANK PARTNERSHIP

Hosted by

Australian National Botanic Gardens

Acknowledgement of Country

The Organising and Scientific Committees, the Hosts and the Australian Seed Bank Partnership acknowledge the Ngunnawal and Ngambri Peoples, the traditional owners on whose land this conference was originally planned to take place. We pay our respects to their elders: past; present; and emerging.

As a fully virtual global conference we extend this respect to all First Nations Peoples for their ongoing evolving knowledge and their stewardship of culture, land, sea and air.

Respect and Courtesy

We aim to make this conference a safe space for all participants.

Please remember that English may be a second language for many delegates. Be considerate in your communications and engagement with others.

We ask all delegates to interact respectfully during all formal and social conference proceedings, recognising diversity and supporting inclusion of cultures, languages, abilities and the identities of our delegates.

Welcome to the Conversation

On behalf of the Organising and Scientific Committees of the Australasian Seed Science Conference 2021 we extend a warm welcome to all special guests, Keynotes and delegates.

All life depends on plants, and there is growing international recognition of the critical role seed and gene banks play in ensuring their conservation through the collection and long-term storage of seed and other germplasm material, and associated research into seed longevity in storage, seed germination requirements, regeneration from seed under climate change, and more.

Critical discussions on scientific advances are crucial to ensuring ongoing achievements in plant conservation, integrated conservation management, agricultural cropping, cultural seed banking and landscape restoration. In 2020 our in-person conference was postponed just three weeks out from the opening ceremony. With COVID-19 creating ongoing uncertainty around national and international travel, we are pleased to offer a fully virtual, global event. We are hopeful that this format will enable many more delegates to join the conversation on seed science, providing new opportunities for collaborations and knowledge sharing across institutions internationally.

Organising Committee

(2021)
Dr Sally Norton
Dr Lydia Guja
Dr Cath Offord
Mr Damian Wrigley
Dr Katherine Whitehouse
Dr Jenny Guerin
Dr Kamalesh Adhikari
Dr Gemma Hoyle
Mr Brad Desmond
Ms Millie Stevens

(2020)
Dr Sally Norton
Dr Lydia Guja
Dr Cath Offord
Mr Damian Wrigley
Dr Katherine Whitehouse
Mr Tom North
Dr Andrew Crawford
Dr Suz Everingham
Ms Jo Lynch

Scientific Committee

(2021)
Dr Cath Offord
Dr Lydia Guja
Dr Sally Norton
Dr Adrienne Nicotra
Dr David Merritt
Dr Mark Ooi
Dr Jose Barrero
Dr Katherine Whitehouse
Dr Suz Everingham
Dr Kamalesh Adhikari
Mr Damian Wrigley
Mr Bradley Desmond

(2020)
Dr Cath Offord
Dr Lydia Guja
Dr Sally Norton
Dr Adrienne Nicotra
Dr David Merritt
Dr Mark Ooi
Dr Jose Barrero
Dr Katherine Whitehouse
Dr Suz Everingham
Mr Damian Wrigley

Conference Themes

In light of the catastrophic events occurring globally in recent years, such as the 2019/2020 Australian bushfires, we believe seed science has an important role to play in assisting the environment and humanity to overcome the complex and increasingly urgent challenges of our time. Our overarching conference theme is intended to capture the opportunities for the seed science sector in the years ahead.

Linking seeds with needs: securing our future in a changing world

Securing this future will require dedicated efforts from a wide diversity of disciplines across the seed science sector. We have therefore identified four key conference themes that collectively aim to capture this diversity and provide opportunities for further engagement and collaboration.

1. **Seed Biology and Evolutionary Ecology** – Unlocking the challenges of germination, dormancy and seed ecology in a changing world

2. **Seed Sourcing and End Use** – Considering genetic diversity, restoration and translocations as well as sector specific approaches to seed conservation and use.

3. **Seed and Genebank Management** – The ins and outs of managing ex situ seed banks and gene banks and the methods for maximising seed quality and longevity.

4. **Seeds in Culture and Society** –Sharing stories and learning about historical, socio-cultural and legal practices of seed conservation, use, exchange, and repatriation, including collaborations between traditional use, community, and ex situ seed banks and gene banks.

Conference Partners and Sponsors

We would like to acknowledge the generous support of our Partner organisations who have dedicated their time and resources to making this conference a reality. We would also like to acknowledge our Sponsors whose generous financial contributions have enabled us to secure the technical capabilities to run the conference and provide complimentary registrations for delegates from remote areas and developing nations. These financial contributions also supported our international Keynote speaker for the Seed Biology and Evolutionary Ecology theme to visit Australia and meet with seed banks in 2020 before the COVID-19 related postponement of the Conference. Dollar values equate to in-kind and/or cash contributions.

~ WOLLEMIA ~
$10,000+

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The Organising and Scientific Committees would like to thank the many individuals who contributed their time and expertise behind the scenes to help make this conference possible, including staff, students and volunteers in seed banks, the Australian National Botanic Gardens and the Australian National University who made a tremendous effort to prepare field trips and tours for delegates for the 2020 conference.

The Organising and Scientific Committees would also like to thank Ben, Amy, Katie and the team at Arinex for their professional support and expertise in helping us prepare and deliver this conference.

Conference Program

Every effort has been made to ensure the accuracy of the program however it is subject to change.

Monday - 6th September				
		Paper #	**Author/Presenter**	**Title**
		Chair Mr Damian Wrigley (ASBP)		
Opening session and Plenary	**0900-0930**	Invited	Mr Damian Wrigley, National Coordinator ASBP	Welcome from the Australian Seed Bank Partnership
		Invited	Ngunnawal elder Mr Richie Allan	Welcome to Country
		Invited	Dr Judy West AO, Executive Director, ANBG	Welcome from the hosts, Australian National Botanic Gardens
		Invited	Dr Lydia Guja and Dr Cathy Offord	Research Front, synthesis of the National Seed Science Forum 2016
		Invited	Mr Costa Georgiardis	Official Opening of the Conference
Themes	**Seed Biology & Evolutionary Ecology - Chair - Dr Adrienne Nicotra (Rapporteurs - Dr Jenny Guerin; Mr Tom North)**			
Plenary keynote - Seed Biology & Evolutionary Ecology	**0930-1000**	Keynote	Dr Si-Chong Chen	Biological scaling in seed functional components
		Questions		
Plenary - Seed Biology & Evolutionary Ecology	**1000-1040**	10	Dalziell	Resting metabolic rates in seeds: relationships with mass, phylogeny and climate
		119	Schulz	The risk takers and risk avoiders: germination sensitivity to water stress in an arid zone with unpredictable rainfall
		127	Rosbakh	Snowmelt timing shapes seed germination patterns in alpine plants of the North Caucasus
		131	Collette	Stepping up to the plate: using a bidirectional thermo-gradient plate for predicting seed germination response in a changing climate
		4	Everingham	Time travelling seeds reveal seed trait and plant responses to climate change
	10.40-10.50	Questions		
	10.50-11.00	Break		
	1100-1205	132	Emery	Predicting germination sensitivity to temperature and moisture stress in Threatened Ecological Communities in northwest New South Wales
		125	Hoyle	Impact of red : far red light ratios on germination in Australia's tropical mountain cloud forests
		28	Lewandrowski	Born To Rock: Seed Traits Of Rare And Common Banded Ironstone Species From Semi-arid Ecosystems
		106	Notarnocola	Warmer conditions reduced seed size and viability in the alpine herb Wahlenbergia ceracea
		94	Guja	Polyploidy affects seed germination of native flora
		55	McGill	Seed coat responses to desiccation in two New Zealand Fabaceae genera
		122	Widjaya	Campolay Fruit (Pouteria campechiana (Kunth) Baehni) and Its Seed Viability in Various Weight and Longevity
		104	Pouton	Soil seedbank diversity under variation in fire regimes in a temperate heathland
		Questions		
	12.05-12.15	Break		
		9	Barrerro	A promising weapon for bruchid control in cowpea
		115	Walsh	Unpacking the seed bank: Variation in germination behaviour of physically dormant seeds extracted from forest soil.

	1215-1315	134	Mertin	Integrating seed microbiome knowledge into restoration and conservation
		129	Van Der Merwe (Miss Merize)	Fungal endophytes of Banksia seed: Diversity and Dynamics.
		91	Ooi	Regulation of smoke-stimulated germination by diurnal fluctuations in soil temperature reduces seedling emergence in unburnt vegetation
		108	Gairola	Seed conservation and germination response of important native grasses from arid deserts of United Arab Emirates
		105	Tahsmasian	Comparative quantitative study of conglutin seed storage proteins across narrow-leafed lupin varieties
		13	Liyanage	Techniques for breaking seed dormancy of rainforest species from genus Acronychia
		Questions		
	1315-1320	Close of Theme		
Lunch	**1320-1400**	**LUNCH BREAK**		
Themes	**Seed Sourcing & End Use- Chair - Dr David Merritt (Rapporteurs - Mr Damian Wrigley; Mr Brad Desmond)**			
Plenary keynote - Seeds Sourcing & End Use	**1400-1430**	Keynote	Prof. Robert Henry	Use of Australian Plant Biodiversity for Food and Agriculture
		Questions		
Plenary - Seeds Sourcing & End Use	**1430-1535**	46	Mikli	The Revegetation Industry Association of Western Australia Native Seed Accreditation System
		96	Maina	Advent Diagnostics applications within germplasm post entry quarantine towards safeguarding Australian biosecurity pulse and grain industry
		83	van der Merwe (Dr Marlien)	Capturing genetic diversity with seed collections: empirical data to guide sampling strategies
		30	Commander	An update of the Florabank Guidelines: national guidelines for best practice native seed collection and use
		109	Gibson Roy	Seed Resourcing for lage-scale TEC restoration
		110	Humphries	Unlocking Australian indigenous germplasm in the Australian Pastures Genebank
		73	So	Selling seeds and seedlings for livelihood development – A case from Cambodia
		Questions		
	1535-1545	Break		
	1545-1655	25	Merritt	Quantifying seed germination and establishment traits for ecological restoration in the Pilbara region of Western Australia
		54	Erickson	Overcoming the constraints to precision seed delivery in mined landscapes that possess rocky soils, steep terrain, and severe edaphic conditions
		135	Talonia	Tackling limitations for seed germination of Australian native plants for ecological restoration in north-western NSW
		136	Talonia	Seed coating: effects on seed germination, handling and costs associated
		116	Newby	Comparative Longevity Of Australian Rainforest Seeds: Seed Attributes And Habitat
		72	Duval	Conservation of endangered orchids in the Mount Lofty Ranges
		12	Vos	Botanical Garden Chateau Perouse
		Questions		
	1655-1700	Day One Close	Mr Damian Wrigley	House Keeping
	1700-1800			
	1800-2100	Social Event – EMCR Networking Event – Gather.Town - Link to be emailed to delegates		

Tuesday - 7th September				
		Paper #	**Author/Presenter**	**Title**
		Chair Dr Sal Norton (AGG)		
Day Two Open and Launch of the Germplasm Guidelines	**0900-0940**	Invited	Dr Sal Norton	Welcome and Housekeeping
		Invited	Dr Amelia Martyn-Yenson	Introduction to the Review of the ANPC's 'Plant Germplasm Conservation in Australia' guidelines
		Invited	Craig Connelly	Germplasm Guidelines - Project Funding Partner
		Invited	Dr Cathy Offord	Chair of the Germplasm Guidelines Steering Committee
		Invited	Prof. Tim Entwisle	Official Launch of the Germplasm Guidelines including Plant Treasures Video
Themes	**Seed & Gene Bank Management - Chair - Dr David Bush (Rapporteurs - Dr Mark Ooi; Mr Bradley Desmond);**			
Plenary keynote - Seed & Gene Bank Management	**0940-1010**	Keynote	Dr Elinor Breman and Dr Sally Norton	Genebanking and seedbanking – perspectives from the agriculture and conservation sectors
		Questions		
Plenary - Seed & Gene Bank Mangement	**1010-1050**	29	Ballesteros	Preservation of trees recalcitrant seeds: when the cryobiotechnology is ready but the implementation is wanting.
		44	Sommerville	Assessing the storage potential of Australian rainforest seeds: a decision-making key to aid rapid conservation
		38	Hu	Triacylglycerol-estolides may determine the unusual storage physiology of Mallotus seed
		67	Funnekotter	Cryopreserving Recalcitrant Seeded Species: Oxidative Stress Limits Cryogenic Survival
		Questions		
	10.50-11.00	Break		
	1100-1200	16	Chong	Ex situ conservation of a critically endangered fern
		24	Schmidt-Lebuhn	Seed identification using computer vision
		43	Hardstaff	Cryostorage of exceptional Myrtaceae species
		79	Jawad	Optimization of seed harvest protocols of genebank accessions of a crop (durum wheat) and crop wild relatives
		97	Rahman	Assessment of seed quality of Indica rice
		112	Kingsley	Suc'seed'ing at Microscopy: Imaging and Digitizing the Seeds of Hawaii
		Questions		
	1200-1210	Break		
	1210-1255	88	Latifah	Seed Conservation and Utilization in Indonesian Botanic Gardens Seed Banks
		50	Cai	Seedbanking China's plant diversity
		27	Crawford	Achievements of 25 years of conservation seed banking in Western Australia
		128	Irawanto	Seed Exploration and Collection of Wetland – Riparian in the Downstream of Brantas River, East Java
		Questions		
	1255-1300	Close of Theme		
Lunch	**1300-1400**	**LUNCH BREAK**		
	1330-1400	**Poster Session on Gather.Town - 1330-1400 - link to be emailed to delegates**		

Themes	Seeds in Culture & Society - Chair - Dr Kath Whitehouse (Rapporteurs - Dr Kamalesh Adhikari; Dr Suz Everingham)			
Seeds in Culture & Society	1400-1530	Keynote	Dr Terri Janke	Sowing the Seeds of Change: Recognition of Indigenous Traditional Knowledge
		Questions		
		Keynote	Prof. Brad Sherman	Resolving the legal uncertainty created by the Nagoya Protocol
		Questions		
		Keynote	Dr Ola Tveitereid Westengen	International collaboration to safeguard crop diversity: the rescue of the international genebank collection at ICARDA in Syria
		Questions		
	1530-1540	Break		
	1540-1640	130	Jacob	Exploring the diversity in wattleseeds for food applications
		111	Bell	Native grasses as a traditional and emerging source of food
		49	Loos	The importance of regional seed banks
		31	North	Seed Banking and National Parks - an ideal conservation partnership
		121	Raneng	The growth of community gardens as ex situ dynamic seedbanks
		95	Wrigley	The Australian Seed Bank Partnership and our new Partnership Strategy 2021-2030
		98	Hardwick	Do we need another network? Examining the potential for a new seed conservation network for Asia, Australia and the Pacific
		Questions		
	1640-1655	Invited	Dr Cathy Offord; Dr Sally Norton and Dr Lydia Guja	Conference Synthesis - AJB and APC
	1655-1700	Day Two Close	Mr Damian Wrigley	House Keeping and Plenary Close
	1700-1800			
	1800-2100	Social Event – Quiz Night – Gather.Town - Link to be emailed to delegates		

Program Key

House Keeping and Opening Sessions
Keynotes and Questions
8-minute talks
3-minute talks
Session Breaks
Lunch Breaks, Poster Session and Social Networking

Special Guests
Monday, 6th September 2021

Welcome to Country - Mr Richie Allan, Ngunnawal / Kamilaroi

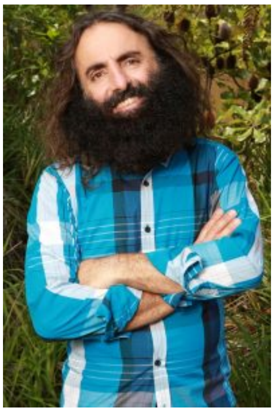
Richie is a Ngunnawal Kamilaroi custodian who was born in Ngunnawal Country and raised on both Ngunnawal and Kamilaroi Country.

Richie is TOAC's Cultural Director where he manages cultural awareness, education and Ngunnawal relationships. He is also our Ngunnawal expert and provides valuable advice to organisations on culture and creating safe workplaces for Aboriginal people to thrive in.

Dr Judy West AO, Executive Director, Australian National Botanic Gardens

Judy West is Executive Director of the Australian National Botanic Gardens, and Assistant Secretary, within Parks Australia, a Division of the Commonwealth Department of Agriculture, Water and Environment. Besides the Botanic Gardens, she oversees Parks Australia's science, natural resource and knowledge-management activities, and manages Parks Partnerships.

Judy has more than 30 years experience in scientific research and policy as a research scientist in CSIRO Plant Industry and director of the Centre for Australian National Biodiversity Research and the Australian National Herbarium. She holds an adjunct professorial position at the Australian National University. For her contributions to Australian plant systematics and Australia's Virtual Herbarium, she was awarded the Nancy Burbidge Memorial Medal in 2001 and an Order of Australia in 2003. Judy's scientific expertise is in plant systematics and phylogenetics, biodiversity informatics and conservation biology. Using her skills developing partnerships that link science and policy, Judy is building an active science and knowledge-management network in Parks Australia.



Mr Costa Georgiardis, Landscape architect and host of Gardening Australia

2019 Logie Award Winner, Costa Georgiadis is a landscape architect who has an all-consuming passion for plants and people – he knows how to bring out the best in both of them, and takes great pleasure in bringing them together. He is the host and co-creator of Costa's Garden Odyssey for SBS television currently hosts Gardening Australia on the ABC.

Costa believes in embracing and celebrating mother nature's cycles and seasons and nurturing her balance, beauty and bounty organically. His holistic approach is all about gardening the soil and the soul.

Launch of the Germplasm Guidelines
Tuesday, 7th September 2021

Dr Amelia Martyn Yenson, Project Manager, Germplasm Guidelines, Australian Network for Plant Conservation

Amelia Martyn Yenson is a Project Manager at the Australian Network for Plant Conservation and coordinated updates for this third edition of 'Plant Germplasm Conservation in Australia'. She has research interests in seed lifespan and germination, with a focus on improving seed quality for conservation storage and utilisation of Australian native plant species. Amelia's research is based at the Australian PlantBank, part of the Australian Institute of Botanical Science, Royal Botanic Gardens and Domain Trust.

Prof Tim Entwisle, Royal Botanic Gardens Victoria

Professor Tim Entwisle is a highly respected scientist, scientific communicator and botanic gardens director. He took up the role of Director and Chief Executive of Royal Botanic Gardens in March 2013, following two years in a senior role at Royal Botanic Gardens Kew, and eight years as Executive Director of the Royal Botanic Gardens and Domain Trust in Sydney. Tim is an Honorary Professorial Fellow in the School of Botany at The University of Melbourne and an expert in freshwater algae but has a broad interest in plants. Tim is a regular contributor to ABC and other radio and writes for science, nature and garden magazines. He is active on social media, including his popular Talkingplants blog.

Dr Cathy Offord, The Royal Botanic Gardens & Domain Trust

Cathy is the Manager of Germplasm Conservation at the Australian Institute of Botanical Science at the Royal Botanic Gardens Sydney. She is based at the Australian PlantBank, which is an integrated plant conservation facility. She oversees the seed, tissue culture and plant growth research programs and laboratories. Cathy's main area of interest is the conservation of threatened species in situ and ex situ. In 2018 she won the 2018 NSW Premier's Prize for Innovation in Public Sector Science and Engineering. Cathy is the Chair of the Scientific Committee of the Australasian Seed Science Conference.

Conference Keynotes

Seed Biology and Evolutionary Ecology

Dr Sichong Chen, Millennium Seed Bank of the Royal Botanic Gardens Kew, UK

Dr Si-Chong Chen is an ecologist working on the macroecological patterns in seed ecology at the Millennium Seed Bank of the Royal Botanic Gardens Kew, UK. She received her PhD from the University of New South Wales, Australia, and a postdoctoral fellowship at the Ben-Gurion University of the Negev, Israel.

For years, she continuously built her interests in various aspects of seed predation, seed dispersal, seed germination and relevant disciplines. Si-Chong's research aims to contribute to further understanding of seed ecology in three key ways: 1) by narrowing the gaps between data, intuitive ideas and theories; 2) by enhancing the integration of replicated studies at a macro-ecological scale; and 3) by extending understanding from a local scale and a small number of species to a global scale spanning many biomes and taxonomic groups.

Keynote Abstract: ***Biological Scaling in Seed Functional components***

A diaspore has usually been treated as an integrated unit in its ecological and evolutionary characteristics, despite the fact that it consists of several functional components: dispersal component (e.g. dispersal structure), defense component (e.g. seed coat) and survival component (e.g. seed reserve). Their absolute masses and relative proportions influence a suite of ecological processes, from seed development to seedling establishment. In contrast to the well-studied seed mass as a whole, biomass allocation across the functional components of diaspores has been much less studied; and their ecological and evolutionary trajectories remain remarkably unknown despite their importance. Allometry has been widely documented in life-history traits of organisms. Compared with biomass allocation patterns in plant vegetative organs, biological scaling has been much less studied in reproductive organs. By partitioning biomass allocation across seed/diaspore functional components, we conducted intraspecific and interspecific studies to understand the variation of seed functional components. A mass isometry between pappus and seed coat within a species suggests an equivalent rate between dispersal investment and defense investment. The global synthesis of 940 species showed that seed coat ratio was negatively correlated with seed mass, and the evolutionary rates in reserve mass significantly outpaced those in coat mass. Together with the findings of our interspecific study, we suggest that smaller seeds invest proportionally more biomass in protective tissues than do larger seeds, in agreement with traditional ideas that small seeds may have advantages in physical defense. Additionally, across 91 Euphorbiaceae species, we discovered a significant and positive allometry between fruit wall mass and elaiosome mass, indicating that the relative investment in ant dispersal increases more compared to that in ballistic dispersal. Overall, the quantification of the within-diaspore biomass allocations demonstrates strong correlations between functional components, and improves our understanding of plant reproductive strategies.

Conference Keynotes

Seed Sourcing and End Use

Professor Robert Henry, Queensland Alliance for Agriculture and Food Innovation

Prof Robert Henry conducts research on the development of new products from plants. He is particularly interested in Australian flora and plants of economic and social importance; conducting research into genome sequencing to capture novel genetic resources, which target improved understanding of the molecular basis of the quality of products produced from plants, and genome analysis to capture novel genetic resources for diversification of food and energy crops.

Robert is Professor of Innovation in Agriculture and was foundation Director of the Queensland Alliance for Agriculture and Food Innovation, a Research Institute at the University of Queensland in partnership with the Queensland Government. He was previously Director of the Centre for Plant Conservation Genetics at Southern Cross University and Research Program Leader in the Queensland Agricultural Biotechnology Centre.

Keynote Abstract: ***Use of Australian Plant Biodiversity for Food and Agriculture***

Australian plant biodiversity includes important resources for use in supporting the sustainability and security of food and agricultural production. Recent advances in genome analysis technologies are allowing a more rapid application of genomic analysis to genetic resources. Examples including applications in rice, sorghum, citrus, coffee, macadamia, and eucalypts will be described. Chromosome level sequences of plant genomes can now be generated routinely. Analysis of all variation across the whole genome in the entire gene pool can be used to support plant breeding. Understanding the changes associated with past domestications provides a guide to support both completely new domestications and the capture of diversity from crop wild relatives. These tools are allowing rapid identification of the genetic and molecular basis of important plant traits and greatly enhance our ability to manipulate these traits in breeding and production. Conservation of and utilization of Australian plant resources in crop improvement and climate adaptation will be facilitated by more widespread applications of these technologies.

Conference Keynotes

Seed and Gene Bank Management

Dr Elinor Breman, Millennium Seed Bank of the Royal Botanic Gardens Kew, UK

Dr Elinor Breman (MA Cantab, MSc Oxon, DPhil Oxon) is the Senior Research Leader for seed conservation at RBG Kew's Millennium Seed Bank. With a background in plant ecology, forestry and palaeoecology, Elinor has been working in seed conservation for the past seven years. Elinor currently oversees the Millennium Seed Bank Partnership, a global initiative to preserve natives species. She is interested in all aspects of conservation seed banking – notably ensuring the quality of collections and building capacity to deliver this.

Dr Sally Norton, Leader, Australian Grains Genebank

Sally Norton is the national Leader of the Australian Grains Genebank (AGG) which is one of the largest and most diverse agricultural ex-situ genebank globally. The AGG is located in Horsham, Victoria, and conserves cultivated crop germplasm from all around the world as well as crop wild relative species that are used by Australia's research and breeders to research and develop new, more resilient grain crop varieties for Australia. Sally has over 20 years' experience in the collection, characterisation and curation of plant germplasm, and is recognised as a specialist on crop wild relatives. Sally is the Chair of the Organising Committee of the Australasian Seed Science Conference.

Keynote Abstract: ***Genebanking and seedbanking – perspectives from the agriculture and conservation sectors***

The Australian Grains Genebank [AGG] is a national centre for storing genetic material from modern and traditional landrace grain crop varieties, breeding materials, and crop wild relatives used for plant research and breeding to develop more resilient farmers varieties. The Millennium Seed Bank [MSB] of the Royal Botanic Gardens, Kew has been working in partnership around the world for the past 20 years to conserve vascular plant diversity. During this time Kew has worked with more than 95 countries and territories to help conserve their native flora, making the MSB Partnership the largest global ex situ conservation programme in the world. The AGG and the MSB operate at different ends of the gene or seed banking spectrum, from cultivated crops through to wild plants. However, both have many things in common, including standards for collecting, processing, and storing plant germplasm, holding this material in trust for future generations and ensuring that it is used by current researchers and practitioners. In this keynote we offer perspectives from the two organisations, including their respective mandates, core activities, outreach activities in support of practitioners, areas of research and breeding. We conclude with future directions in seed banking for both the national agricultural sector and the international conservation sector.

Conference Keynotes

Seeds in Culture and Society

Dr Terri Janke, Managing Director of Terri Janke and Company

Dr Terri Janke became a lawyer to advance the social justice of Indigenous Australians. She is of Meriam and Wuthathi heritage, and is the owner and managing director of Terri Janke and Company, an award winning legal and consulting firm founded in 2000.

The team at Terri Janke and Company strive to empower Indigenous people to manage their culture and attain their business goals. The key to Indigenous self-determination is being able to control and manage your future. She is an international expert on Indigenous cultural and intellectual property. Her book True Tracks: Working with Indigenous Knowledge and Culture will be published in July of 2021.

Keynote Abstract: ***Sowing the Seeds of Change: Recognition of Indigenous Traditional Knowledge***

First Nation Australians have cultural connections with the land and seas that go back thousands of years. Traditional Knowledge of plants and caring for country through the years has led to diversity of species and an understanding of their healing and nutritional value. The use and commercialisation of these resources has in the past been done without recognition of this. Indigenous peoples' rights to their traditional knowledge are increasingly recognised in international treaties and protocols, which require researchers, scientists and depositories to consider their approaches in the collection, management and use of plants from Indigenous lands and seas, and their associated traditional knowledge. This paper outlines the key issues relating to Indigenous peoples' rights to their resources and associated traditional knowledge. Terri will discuss the True Tracks Protocols as a framework for Indigenous engagement.

Conference Keynotes

Seeds in Culture and Society

Professor Brad Sherman, The University of Queensland

Brad Sherman is a Professor of Law at The University of Queensland. Professor Sherman's previous academic positions include posts at Griffith University, the London School of Economics, and the University of Cambridge. His research expertise encompasses many aspects of intellectual property law, with a particular emphasis on its historical, doctrinal and conceptual development.

In 2015 Professor Sherman was awarded a highly prestigious Australian Research Council Laureate Fellowship. His laureate project Harnessing Intellectual Property to Build Food Security looks at the role of intellectual property in relation to food security.

Keynote Abstract: ***Resolving the legal uncertainty created by the Nagoya Protocol***

International law is rarely if ever clear cut. For the most part, the interpretative problems associated with international laws are internal matters for national laws and the people who are bound by them to deal with. In some cases, however -- and this is particularly the case when objects circulate - people may need to ensure that they meet the standards of multiple countries. This is fine and well when international law is clear and nationally implemented laws are consistent. Problems arise, however, when international is unclear or where key issues are left to nation states to decide and they do so differently. The Nagoya Protocol is one such law. The reason for this is that when Nagoya was being negotiated, parties could not agree on a number of important questions including the temporal scope of Nagoya, the type of material that should be excluded from the Nagoya obligations, and whether the Protocol applied to genetic sequence information. Rather than allowing this impasse to delay the signing of the Protocol, it was decided that these questions should be resolved at the national level.

The fact that different countries have responded to these issues differently has created problems for researchers working with plant genetic resources. The most important being: what standard should they work to? While the answer is straightforward when a researcher is working in one jurisdiction (viz they should comply with local laws), the answer is less clear-cut when they are working across jurisdictions with different readings of Nagoya. The situation is even worse when a researcher has no idea of where their research may lead them. These problems have been exacerbated by the growing number of non-State organisations-universities, journals, funding bodies, herbaria-- that have decided that they want to be Nagoya compliant, which often translates into the requirement that third parties interacting with them must be able to show that they are Nagoya compliant. Given the different ways in which Nagoya has been construed at the national level, it is legitimate for researchers to ask; which Nagoya?

This legal uncertainty has created confusion, restricted access, and is having a negative impact on the collection of genetic resources. Given that reform of Nagoya is not a realistic option, this paper explores other ways of helping to resolve the uncertainty associated with Nagoya. Specifically, building on previous efforts by scientist to deal with legal problems (such as the 1935 Gentleman's Agreement or the prohibition on the patenting of taxonomic type specimens), this paper explores the possibility of researcher driven solutions to the legal uncertainty created by Nagoya.

Conference Keynotes

Seeds in Culture and Society

Dr Ola T. Westengen, Norwegian University of Life Sciences NMBU

Dr Westengen is an Associate Professor at the Department of International Environment and Development Studies (Noragric) at the Norwegian University of Life Sciences. He works on the intersections of science and policy research on crop diversity and seed systems. Previous to his current university position, he worked for the Crop Trust, the FAO and the Nordic Genetic Resource Centre. Westengen was the first coordinator of the Svalbard Global Seed Vault from 2007-2015. He does research on conservation and use of genetic resources; seed supply systems; food security and adaptation to climate change; crop evolution and crop diversity as biocultural heritage.

Keynote Abstract: ***International collaboration to safeguard crop diversity: the rescue of the international genebank collection at ICARDA in Syria***

Crop diversity underpins food security and adaptation to climate change. Concerted conservation efforts are needed to maintain and make this diversity available to plant scientists, breeders and farmers. Here we present the story of the rescue and reconstitution of the unique seed collection held in the international genebank of International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria. Being among the first depositors to the Svalbard Global Seed Vault, ICARDA managed to safety duplicate more than 80% of its collection before the war forced the last staff to leave the genebank in 2014. Based on the safety duplicates, ICARDA since 2015 have rebuilt their collections and resumed distribution of seeds to users internationally from their new premises in Morocco and Lebanon. We describe the multifaceted and layered structure of the global system for the conservation and use of crop diversity that enabled this successful outcome. Genebanks do not work alone but in an increasingly strengthened and experienced multilateral system of governance, science, financial support and collaboration. This system underpins efforts to build sustainable and socially equitable agri-food systems.

Key reference: Westengen, O.T., Lusty, C., Yazbek, M. et al. Safeguarding a global seed heritage from Syria to Svalbard. Nat. Plants 6, 1311–1317 (2020). https://doi.org/10.1038/s41477-020-00802-z

Workshops

Workshop 1 – Seed Banking 101

Wednesday, 8th September – 1.00pm-4.00pm AEST

Hosted By Dr Elinor Breman, Dr Kate Hardwick, Dr Aisyah Faruk, Mr Tom North, Dr Andrew Crawford, Mr James Wood and Mr Damian Wrigley

Seed scientists from Australian institutions and the Millennium Seed Bank will instruct delegates in the basics of establishing and managing seed and gene banking programs, including identifying target species, planning and conducting field work, and implementing best-practice approaches and techniques. These methods ensure that seeds are collected responsibly and stored appropriately to maintain viability, and grown-on effectively. These methods can be applied to individual research projects through to long-term conservation programs.

This half-day workshop will cover the basics of collecting, storing, and managing seed collections for long-term conservation. The workshop will be a mixture of pre-recorded lectures, live Q&As and group sessions.

The workshop will cover the following topics

Part 1: Collecting

- Pre-collection activities
- Making high quality collections

Part 2: Keeping seeds alive

- Seed-air moisture
- Seed drying

Part 3: Management

- Managing longevity of collections
- Managing data (MSBP Data Warehouse)

The workshop is particularly aimed at:

- Staff of private and public bodies in the field of nature conservation
- Students/researchers interested in seed banking
- There is no pre-requisite knowledge required for this workshop.

This workshop will be immediately followed by the Australasia-Pacific Seed Network discussion.

All are welcome to attend.

Workshops

Australasia-Pacific Seed Network

Wednesday, 8th September – 4.00pm-5.00pm AEST

Hosted By Dr Elinor Breman, Dr Kate Hardwick, Dr Aisyah Faruk and Mr Damian Wrigley

The Australasian Seed Science Conference provides a space for seed scientists and germplasm conservation practitioners throughout Australasia and the Pacific to explore opportunities for building stronger collaborations and networks. This forum aims to facilitate continuous communications throughout the region beyond the conference program. The following questions are intended to assist with guiding discussions during the hour allocated to this meeting at the end of the Seed Banking 101 Workshop. The questions will be put to participants in an interactive poll.

1. Are you a part of any existing seed conservation networks?
    a. Yes
        i. ASBP
        ii. MSBP
        iii. IUCN Seed Conservation Specialist Group
        iv. BGCI Seed Conservation Network
        v. Other (ANPC, BGANZ, BGCI, NZPCN, etc)
    b. No

2. Do we need an Australasia-Pacific seed conservation network?
    a. Yes
    b. No
    c. Unsure

3. What would be the most useful to you?
    a. Information, knowledge exchange and access to data and other resources
    b. Informal online discussion forums, meetings
    c. Workshops/Training
    d. Conferences/Professional networking
    e. Notification of potential research collaborations

4. If a network was established what should the scope be?
    a. Seed/germplasm conservation for native species only
    b. Seed/germplasm conservation for native, crop and pasture species
    c. All of the above including other germplasm techniques such as nursery techniques etc

5. Do you have capacity to engage and commit resources (time) to a new or existing network?
    a. Yes – active participation (joining network discussions, sharing information, attending conferences etc)
    b. Yes – passive participation (receiving information only)
    c. No
    d. Unsure

Workshops

Workshop 2 - Australian Academy of Science
Fenner Conference on the Environment 2021: Exceptional times, exceptional plants

Thursday, 9th September – 10.00am-3.30pm AEST

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

This Australian Academy of Science Fenner Conference on the Environment will provide an opportunity for scientists working on conservation of Australia's diverse flora, including some of our most threatened species, to evaluate methods for conserving plant germplasm – seeds, plants and other plant tissues – so they are available for species recovery and protected from extinction.

The conference is timely for securing surviving germplasm, particularly in rainforest habitats impacted by bushfires in 2019/20; and plant communities devastated by diseases such as Phytophthora Dieback and Myrtle Rust. Many of these species cannot be conserved using conventional seed banking techniques. Significant advances to identify and conserve these 'exceptional plants' ex situ have been made in the last decade. Knowledge-sharing will support conservation in this critical "window of opportunity" before extinction may occur.

The new third edition of the Guidelines 'Plant Germplasm Conservation in Australia' (https://www.anpc.asn.au/germplasm-guidelines-review/), to be launched on Tuesday, 7th September in the ASSC 2021 program, provide science-based best-practice methods and case studies for assessing and conserving plant germplasm using a variety of ex situ techniques. These Guidelines are an ideal 'handbook' for those involved in conserving exceptional plant species in Australia.

This workshop is funded by a grant from the Australian Academy of Science. Funding for Fenner Conferences on the Environment is offered for conferences that bring together those with relevant scientific, administrative and policy expertise to consider current environmental and conservation problems in Australia, with the aim of contributing to the formation of policies that can alleviate some of these problems.

The program for the Fenner Conference on the Environment 2021: Exceptional times, exceptional plants is available on Page 22.

Australian Academy of Science

This workshop was funded by a grant from the Australian Academy of Science

Australian Academy of Science
Fenner Conference on the Environment 2021:

Exceptional times, exceptional plants

Thursday 9 Sept 2021

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

Introduction: 10:00-10:30am (AEST)	
10:00am	Welcome to participants **Dr Amelia Martyn Yenson.**
10:05am	Introduction from **Dr Fiona Fraser** – Acting Threatened Species Commissioner
10:10am	*Keynote address* **Prof. Hugh W. Pritchard**: Beyond conventional seedbanking.

Session 1: 10:30am-11:50am (AEST) *Identifying exceptional species*	
10:30am	*Presentation* **Dr Karen Sommerville**: Seed storage behaviour categories, identifying seeds that are sensitive to desiccation or freezing.
10:40am	*Video:* Identifying exceptional species
10:50am	*Presentation* **Dr David Merritt**: Identifying short lived seeds.
11:05am	*Presentation* **Dr Eric Bunn**: Tissue culture for supporting ex situ conservation and for preparing material for cryopreservation.
11:20am	*Presentation* **Dr Cathy Offord**: Living collections supporting ex situ conservation.
11:35am	Questions from audience to session 1 speakers.

FIRST BREAK (11:50am for 30 minutes)

Session 2: 12:20pm-1:35pm (AEST) *Cryopreservation of exceptional species*	
12:20pm	Introduction to Exceptional Plants Conservation Network **Dr Valerie Pence**
12:35pm	*Presentation* **Dr Bryn Funnekotter**: Overview of cryopreservation in Australia, cryopreservation of shoot tips.
12:50pm	*Presentation* **Dr Jayanthi Nadarajan**: Extracting and cryopreserving embryonic axes.
1:05pm	*Presentation* **Dr Daniel Ballesteros**: Fern spore cryopreservation.
1:20pm	Questions from audience to session 2 speakers.

SECOND BREAK (1:35pm for 40 minutes)

Session 3: 2:15-3:30pm (AEST) *Using all the tools of ex situ conservation to conserve our national plant treasures*	
2:15pm	Summary of session 1 and 2, introduction to panellists and facilitator **Dr Karen Sommerville**
2:30pm	*Panel discussion*, facilitated by **Dr Cathy Offord** Panellists: **Dr Linda Broadhurst, Dr Nathan Emery, Dr Lydia Guja, Mr Gibson Sosanika, Ms Karin van der Walt, Mr Damian Wrigley.**
3:30pm	Conclusion of panel, closing remarks **Dr Amelia Martyn Yenson**

Free registration at: https://seedscience2021.com.au/fenner-conference/

Workshops

Workshop 3 – Analysing seed data with R

Friday, 10th September – 08:30pm-5.00pm AEST

Hosted by Adrienne Nicotra, Terry Neeman and Sergey Rosbakh

This one-day workshop is devoted to the fundamentals of designing and analysing seed biology and ecology studies. The participants will work through a range of standard and innovative approaches for robust statistical analysis of field and experimental data. The analysis will be demonstrated on real data using the R and Rstudio software (we expect participants to have basic R and statistical skills).

The workshop covers following topics:

- Part 1 Introduction to robust experimental design (Adrienne Nicotra)
- Part 2 Data wrangling and vizualisation (Terry Neeman)
- Part 3 Linear models (Sergey Rosbakh)
- Part 4 Generalized linear models (Sergey Rosbakh)

The workshop is particularly aimed at:

- PhD and Master's students
- Ecologists, evolutionary biologists, plant conservation biologists
- Staff of private and public bodies in the fields of nature conservation and restoration (e.g. botanic gardens, seed banks, seed companies, environmental and project consultants)

Social Networking

Seed Science 2021 on Gather.Town

The Australasian Seed Science Conference is offering virtual social networking throughout the five days of the conference. Opportunities to network will be available through our dedicated 'Seed Science 2021' virtual venue on Gather.Town, a video chat platform designed to make virtual interactions more human!

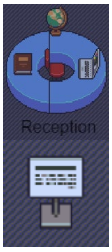
Social Networking – After the Plenary on Day 1 and Day 2 we invite you to join us from 6pm-9pm AEST at Seed Science 2021 on Gather.Town!

Access - Gather.Town will be available from 6-10th September for delegates to meet and discuss the conference, as you would during a regular conference. A link to Gather.Town will be sent to delegates on Monday, 6th September.

Games Room – A Games Room will be available for you to join colleagues for online games

Respect and Courtesy – This conference is a safe space. Delegates are expected to behave respectfully at all times otherwise your access will be removed. Inappropriate behaviour can be reported to info@seedpartnership.org.au.

For those new to Gather.Town there are helpful tutorials and guides on the Gather.Town website: https://support.gather.town/help/movement-and-basics. Reception booths and bulletin boards have also been set up to provide more information as you move around the Seed Science 2021 venue.



Reception Booths will have some help available should you need to ask for directions around Seed Science 2021 on Gather.Town.

Bulletin Boards will provide more information about the conference and related events.

If delegates are still experiencing technical difficulties, troubleshooting guides are also available: https://support.gather.town/help/av-troubleshooting

Social Networking

Early to Middle Career Researcher Networking Event!

Day: Monday 6th September 2021

Platform: GatherTown (access details will be sent to delegates a few days prior)

Time (AEST): Room opens 6pm.
Come along on Monday at 6pm on Gathertown for an early to middle career researchers networking event. It will be a fun social event to meet other seed scientists and create new networks during the conference. Bring along your drink of choice!
More information will be emailed to delegates prior to the conference.

Facilitator: Susan Everingham is a PhD candidate in plant evolutionary ecology at UNSW and the Australian Botanic Garden studying plant responses to climate change. Her research aims to use historic data such as herbarium specimens, ex situ stored seeds and old datasets to determine if plants have adapted through time. In particular, Susan focuses on combining these changes and adaptations in computer models with multiple climate indices to determine if climate change; and which aspects of climate change; are impacting our plant traits and adaptations.

ASSC 2021 – Trivia Night!

Day: Tuesday 7th September 2021

Platform: GatherTown (access details will be sent to delegates a few days prior)

Time (AEST): Room opens 6pm. Quiz starts at 6.10pm. Quiz finishes 6.45pm.
Team Size: max of 5 people per team

Quiz Maximum Capacity: max of 50 people can participate in the quiz.

Prize: There will be a mystery seed-related prize for the winning team

Quizmaster Nathan Emery is a fan of puns and a Restoration Biology Officer firmly planted at the Australian Institute of Botanical Science. When not asking difficult trivia questions, Nathan's research is a combination of plant ecology, seed biology and translocation, and he has worked on difficult to propagate species such as *Actinotus* and *Persoonia*. He also works on the seed biology of threatened ecological communities in northwest NSW.

Submitted Abstracts

Theme: Seed Biology & Evolutionary Ecology

Session 1

Paper ID: 10

Resting metabolic rates in seeds: relationships with mass, phylogeny and climate

Emma Dalziell[1]
Sean Tomlinson[2], David Merritt[1], Wolfgang Lewandrowski[1], Shane Turner[1] and Philip Withers[3]

[1] Kings Park Science, Department of Biodiversity, Conservation and Attractions, Western Australia
[2] School of Molecular & Life Sciences, Curtin University, Western Australia
[3] University of Western Australia

The scaling of metabolic rate (MR) with mass is one of the most pervasive relationships found across biological systems, to the extent that a universal theory has been suggested for all organisms: that MR scales as $mass^{0.75}$. Within animals, understanding of this relationship has provided significant insights into animal ecological and physiological adaptations and functions. However, the mass x MR relationship has predominantly been overlooked for seeds. We assessed the resting metabolic rate in seeds of 108 wild and domesticate species, spanning 24 different families and 19 orders. Our aims were to: (1) determine how seed RMR scaled with mass, (2) determine whether phylogeny or measurement temperature influenced the relationship and (3) determine whether any plant or climate traits influenced RMR. We utilised repeated-measures fluorescence-based closed-system respirometry using a Q_2 seed scanner to measure RMR. Within our dataset, seed mass varied by four orders of magnitude. We found inter-specific differences in seed mass to have a significant influence on RMR, and a powerful phylogenetic signal. After correcting for phylogeny and measurement temperature, we found RMR scaled with $mass^{0.75}$. Using the mass-, phylogeny-, and measurement temperature- corrected residuals from our allometry, we found seeds of domesticated species to have higher mass-corrected RMRs in comparison with seeds of wild species. Furthermore, for seeds of wild-collected species, we found seeds collected from arid and semi-arid environments that receive summer rainfall tended to have higher mass-corrected RMRs in comparison with seeds collected from more temperate, Mediterranean-type climates. Measurements of seed RMR should therefore provide fundamental insights into seed function, physiology and ecology and we propose RMR will be a useful addition to the seed functional traits library.

Submitted Abstracts

Theme: Seed Biology & Evolutionary Ecology

Session 1

Paper ID: 119

The risk takers and risk avoiders: germination sensitivity to water stress in an arid zone with unpredictable rainfall

Nick Schultz[1]
Corrine Duncan[1], Megan Good[2], Wolfgang Lewandrowski[3] and Simon Cook[1]

[1] School of Science, Psychology and Sport, Federation University Australia
[2] Biosciences, University of Melbourne, Australia
[3] Kings Park Science; Department of Biodiversity, Conservation and Attractions, Western Australia

Water availability is a critical driver of plant population dynamics and germination thresholds in arid zones, but our knowledge of arid zone seed ecology is largely derived from regions with predictable wet seasons. We investigated the role of water availability in the germination traits of keystone shrubs in arid western New South Wales, Australia, which has stochastic rainfall and no predictable wet season. We measured seed germination responses of five species with respect to temperature and water potential under controlled laboratory conditions. We calculated cardinal temperatures and base water potentials for seed germination and applied the hydrotime model to assess germination responses to water stress. Based on the results, we classified species according to two suites of germination traits: (i) the risk takers (*Casuarina pauper* and *Maireana pyramidata*) required less moisture availability for germination, and germinated over a wider range of temperatures even when water availability was low, and (ii) the risk avoiders (*Atriplex rhagodioides*, *Maireana sedifolia* and *Hakea leucoptera*) had greater moisture requirements, a preference for lower temperature germination, and narrower temperature ranges for germination when water availability was low. For the risk avoiders, the hydrotime model predicted lower base water potentials for germination than observed by the data, further supporting our assertion that those species are adapted to avoid germination during drought. The results inform our understanding of the population dynamics of these species and suggest that restoration success for the risk avoiders will be higher if sowing is timed to coincide with cool and wet periods—a challenge in a stochastic rainfall climate.

Submitted Abstracts

Theme: Seed Biology & Evolutionary Ecology

Session 1

Paper ID: 127

Snowmelt timing shapes seed germination patterns in alpine plants of the North Caucasus

Sergey Rosbakh[1]
Eduardo Fernández-Pascual[2], Andrea Mondoni[3] and Vladimir Onipchenko[4]

[1] Ecology and Conservation Biology, University of Regensburg
[2] Departamento de Biología de Organismos y Sistemas, Universidad de Oviedo
[3] Department of Earth and Environmental Sciences, University of Pavia
[4] Department of Geobotany, Biological Faculty, Moscow State Lomonosow University

In high-elevation environments, regeneration from seeds is critical for plant population dynamics. Despite an increasing interest in the study of alpine plant reproduction, there is still a knowledge gap about how microenvironmental conditions control the germination ecology of alpine plants. We studied the effects of temperature and water potential on seed germination of 20 North Caucasian alpine species representing four communities located along a steep snowmelt gradient from dry alpine lichen heaths (growing season 5 months) to snow beds (growing season 2-2.5 months). Seeds were germinated in a full-factorial experiment with 5 temperatures (10/2, 14/6, 18/10, 22/14, 26/18 ºC) and 5 water potentials (0, -0.2, -0.4, -0.6, -0.8 MPa) representing the full range of germination niches available in the study system. The experiment revealed clear habitat-specific patterns in seed germination reflecting the soil temperature and water availability in the focal communities. Seeds of plants from dry alpine heaths germinated under a broad range of temperatures and water potentials implying that seed germination in the field occurs shortly after snowmelt before soil dries out. On the opposite side of the snowmelt gradient, in snow beds, plants tend to produce seeds with very specific germination requirements for high temperatures and wet soils, a combination of conditions typical for the end of snowmelt. Species from *Festuca varia* grasslands and *Geranium-Hedysarum* meadows showed an intermediate pattern reflecting their central position along the snowmelt gradient. The results of the present study are discussed in the context of species distributional patterns in the alpine vegetation zone and their potential shifts due to climate change.

Submitted Abstracts

Theme: Seed Biology & Evolutionary Ecology

Session 1

Paper ID: 131

Stepping up to the plate: using a bidirectional thermo-gradient plate for predicting seed germination response in a changing climate

Justin Collette[1]
Karen Sommerville[1], Mitchell Lyons[2], Catherine Offord[1], Graeme Errington[1], Zoe-Joy Newby[1], Lotte von-Richter[1] and Nathan Emery[3]

[1] Australian Institute of Botanical Science, The Australian Botanic Garden Mount Annan
[2] Centre for Ecosystem Science, School of Biological, Earth and Environmental Sciences, University of New South Wales
[3] Royal Botanic Gardens & Domain Trust

Seed germination is strongly influenced by environmental temperatures. With global temperatures predicted to rise due to climate change, the timing of germination for thousands of plant species could change, leading to potential decreases in fitness and knock-on ecosystem-wide impacts. The thermo-gradient plate (TGP) is a powerful but under-utilised research tool that links seed germination with a broad range of temperatures, giving researchers the ability to predict germination characteristics in current and future temperatures. Previously, experimental limitations and difficulties in data analysis have limited its use in seed biology research. Through several experiments, we developed a workflow using a freely available R script to guide users on configuring the TGP, and illustrate its output on three case study species (*Alectryon subdentatus*, *Callitris baileyi* and *Wollemia nobilis*). In this workflow the raw data is analysed and then interpolated to make predictions on a range of germination metrics for current and future climate scenarios. Our script generates over 40 germination indices including rates and final germination, which are modelled with generalised additive modelling. Model selection is semi-automated, and the best performing model is predicted into current and future monthly maximum and minimum temperatures anywhere on the globe. In our case study species, modelled data was highly correlated with observed data, allowing confident predictions into monthly germination patterns for current and future climate. *W. nobilis* consistently germinated across a broad range of temperatures and was relatively unaffected by predicted future temperatures. Contrarily, *C. baileyi* and *A. subdentatus* showed strong seasonal temperature responses, and the timing for maximum germination was predicted to seasonally shift under future temperatures. Our experimental workflow is an exciting leap forward for guiding researchers on how to set-up and analyse TGP experiments, thereby improving research predictions and providing substantial information to inform management and conservation of plant species globally.

Submitted Abstracts

Theme: Seed Biology & Evolutionary Ecology

Session 1

Paper ID: 4

Time travelling seeds reveal seed trait and plant responses to climate change

Susan Everingham[1]
Cathy Offord[2], Manon Sabot[3] and Angela Moles[3]

[1] The University of New South Wales and the Australian Botanic Garden, Mount Annan
[2] Royal Botanic Gardens and Domain Trust
[3] The University of New South Wales

Studies assessing the impacts of climate change on plants and animals used to rely on long-term, historic data. Here, we overcame the problem of absent historical data for a particular aspect of ecology by introducing a new method that uses paired modern/historic seed collections. This method allowed us to identify previously unmeasured marked changes in seed and seedling traits through both space and time. To overcome the impacts of seed storage and/or age on trait changes in time, we paired modern/historic seeds from regions that have undergone different amounts of climate change. In regions where climate has changed to a greater degree, we found plant regeneration and growth traits to have changed more than in regions where climate changes have been marginal. Statistical model predictors of regeneration and growth trait changes (except stem density change) combined at least two measures of climate change, indicating that these plant trait changes are correlated to climate change and that compounded changes, rather than change in a single climate metric, lead to trait responses. These trait responses to climate change are positive news for the future of plants, hinting at their ability to respond and adapt relatively swiftly as the climate continues to change. Seed viability and seed germination significantly increased with increasing change in temperature variability. Seed shapes became significantly thinner and flatter as the maximum dry spell duration increased and plant height significantly decreased in regions where the maximum heatwave duration increased. A majority of ecological research on the impacts of climate change focuses on mean values of temperature and precipitation. Our results highlight the importance of considering a range of climate variables and metrics, as we found climate variability and extremes (e.g. heatwave duration and maximum precipitation of the season of collection) to explain the most trait change.

Paper ID: 132

Predicting germination sensitivity to temperature and moisture stress in Threatened Ecological Communities in northwest New South Wales

Nathan Emery[1]
Catherine Offord[1] and Justin Collette[1]

[1] Royal Botanic Gardens & Domain Trust

Threatened ecological communities (TECs) within the Brigalow Belt South bioregion in northwest NSW are under intense environmental pressures. Around 60% of the woody native vegetation cover has been cleared for agriculture. Most TECs occur in fragmented, isolated patches that are susceptible to environmental stresses, such as an increase in drought frequency and intensity. Three TECs in particular – Brigalow, Semi-evergreen Vine Thicket and Ooline (*Cadellia pentastylis*) – are prime examples of plant communities in the region that are subject to these critical threats. With the possibility of restoring degraded sites or supplementing small populations in the future, we assessed the germination sensitivity of several species from the three TECs to varying temperature and moisture conditions to predict suitable recruitment conditions. We hypothesised that most species would preference warmer summer temperatures for germination and be highly sensitive to moisture stress. We used a bi-directional thermogradient plate (TGP) to record germination responses at constant and alternating temperatures and examined germination responses under moisture stress using different solutions of polyethylene glycol (PEG 6000). Furthermore, we used our TGP data to forecast germination at the local site under current and future temperatures. Temperature optima varied among species but overall reflected local spring and summer average. Several species were capable of germinating across a broad range of current and future temperatures, while others with more specific temperature requirements were predicted to experience a seasonality shift in maximum germination from summer to winter. Under optimal temperature regimes most species were highly sensitive to moisture stress, typically with <10% germination at -0.6 MPa. There were few significant differences in germination rates among moisture stress treatments where germination occurred. These results have several applications, most notably the timing and methodology of direct seeding and the identification of species that may be at the greatest risk of future climate change.

Paper ID: 28

Born to rock: Seed traits of rare and common banded ironstone species from semi-arid ecosystems

Wolfgang Lewandrowski[1]
Carole Elliott[1], Jason Stevens[1], Sean Tomlinson[2], Ben Miller[1], Chane Dolin[3], Nathaniel S. Anderson[3], Shane Turner[1]

[1] Kings Park Science, Department of Biodiversity Conservation and Attractions, Western Australia
[2] School of Molecular & Life Sciences, Curtin University
[3] Terrestrial Ecology Research Group, Murdoch University

Regeneration from seed is an important component for community dynamics, particularly in episodic pulse environments where a long period of time may elapse before environmental conditions (i.e. sufficient soil moisture) are favourable for recruitment and plant growth, or in habitats that are prone to broad-scale disturbances such as fire. Little is generally known about the germination traits of species from banded ironstone formations (BIF) from Western Australia, despite their high rates of species endemism, and the fact that they are the principal habitat for over 20 species of conservation concern. We set out to explore the seed traits explaining hydrothermal requirements for germination in order to predict the recruitment potential and found rare and threatened species to display particular germination requirements compared to a range of common species from the same semi-arid habitat. After dormancy alleviation, seeds of several rare BIF species displayed slow germination speed (time to initial germination, T10 = 8 – 53 days) and a preference for cooler and wetter conditions in the soil, compared to faster germination speed and wider hydrothermal envelopes of the common species. We discuss implications of these findings in context of distributional limits and threatened species conservation under current and predicted climate change trajectories and present initial results from novel hydrothermal time modelling approaches.

Paper ID: 125

Impact of red : far red light ratios on germination in Australia's tropical mountain cloud forests

Gemma Hoyle[1]
Amelia Stevens[1], Lydia Guja[1], Karen Sommerville[2], Stuart Worboys[3] and Darren Crayn[3]

[1] National Seed Bank, Australian National Botanic Gardens
[2] Australian Institute of Botanical Science, The Australian Botanic Garden Mount Annan
[3] Australian Tropical Herbarium, James Cook University Nguma-Bada Campus

In Australia, tropical mountain cloud forest (TMCF) is restricted to the Wet Tropics World Heritage Area of northeast Queensland and contain over 70 endemic plant species. Suitable TMCF habitat is predicted to decline or disappear for many species by 2085. While alarming, these findings assumed that the current niche occupied by each TMCF species is essential for its survival when, in fact, virtually nothing is known about factors that determine the regeneration and distribution of these species. Regeneration via seed is essential for the persistence of many plant species and is determined by temperature, moisture and light conditions. Light quality, specifically the ratio of red to far-red light (R:FR; 660:730 nm), has been shown to influence seed germination of light-sensitive seeds, including many small-seeded tropical species. Canopy cover, leaf litter and cloud immersion all affect the R:FR that plants are exposed to, potentially permitting fine-scale discrimination of light conditions for seed germination. We investigated the impacts of R:FR using natural sunlight and polyester filters. Seeds of six previously unstudied TMCF species, including endemic and more widespread species, were sown in a temperature-controlled glasshouse beneath R:FR ranging from 0.1 (beneath thick plant canopy) to 1.14 (unfiltered sunlight). Germination of *Dracophyllum sayeri* increased exponentially with increasing R:FR, including low germination in the dark. In contrast, *Abrophyllum ornans*, *Melastoma malabathricum* subsp. *malabathricum* and *Lenbrassia australiana* required light for germination and germinated well in all R:FR. Similarly, light quality had no effect on germination of *Dianella caerulea*. Interestingly, germination of *Gahnia sieberiana* was greater in the dark than in unfiltered light but was inhibited by a low R:FR reminiscent of beneath a plant canopy or leaf litter. Findings provide insights into plant recruitment *in situ*, and the acclimation potential of these species. Such information can also inform the long-term management of TMCF flora.

Paper ID: 106

Warmer conditions reduced seed size and viability in the alpine herb *Wahlenbergia ceracea*

Rocco Notarnicola[1]
Adrienne Nicotra[1], Loeske Kruuk[1] and Pieter Arnold[1]

[1] Australian National University

Global climate change will affect temperature and other environmental cues to which seeds respond in order to germinate under the appropriate environmental conditions, as well as plant reproduction and survival. In a previous experiment, we found that waxy bluebell (*Wahlenbergia ceracea*) grown under future projected temperatures produced far fewer and smaller seeds. We therefore sought to understand how seed traits affect germination and whether the reduction in seed size under future temperatures has beneficial or detrimental impacts on germination. We conducted germination assays under relatively cool and warm temperatures using the seeds produced by parental individuals grown under historical (1970) or future (2100) temperatures. We assessed the effects of seed production and size, germination temperatures, parental temperatures and their interactions on total germination, the fraction of dormant seeds, germination rates, and the fraction of viable seeds. Larger seeds germinated more quickly and were more likely to be viable. Germination under cool temperatures resulted in higher germination of smaller seeds while warm temperatures alleviated dormancy and induced germination of larger seeds. Finally, the correlation between seed size and the number of viable seeds was stronger for parents under future temperatures, providing evidence that the reduction in seed size is due to development under stressful and limiting conditions rather than to active parental adjustments. Despite the positive effect of warm conditions on germination, the drastic reduction in seed production and viability due to development under warm conditions for the parent plants will substantially reduce in the overall fitness of individuals of *W. ceracea* under future warmer temperatures.

Paper ID: 94

Polyploidy affects seed germination of native flora

Lydia Guja[1,2]
Mark J. Wallace[2], Amelia V. Stevens[1,2,3], Jason C. S. Chan[1,4], Stephanie H. Chen[2], Mark Ooi[4,5], Alexander Schmidt-Lebuhn[2], Robert C. Godfree[2], Linda M. Broadhurst[2] and Adrienne Nicotra[3]

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There are numerous potential causes of variation in seed germination, but they are often cryptic or labour intensive to study. Genetic variation such as polyploidy (the heritable condition of possessing more than two chromosome sets) is often cryptic yet can now be identified rapidly and cheaply using flow cytometry. This has enabled the integration of polyploidy into germination studies. Polyploidisation events have occurred repeatedly in the evolutionary history of flowering plants, and polyploidy has been linked to high yield, improved plant performance under stress, and other beneficial characteristics. A number of Australian native species are known to be polyploid or to contain ploidy variation within-species. However, little is known about the effect of polyploidy on seed germination, particularly in Australian native species. This talk will present various examples from our laboratory and glass-house studies of the Australian native flora. We have found that within-species variation in polyploidy alters the amount of seed dormancy in a population of seeds. Polyploidy also significantly affects germination, both within-species, and among closely related species. In some cases, polyploidy is also associated with differing stress sensitivity for seeds and seedlings exposed to increased temperature or drought. These significant effects of polyploidy on seed germination and seedling growth suggest that the ecological consequences of polyploidy warrant further investigation in native plant conservation.

Paper ID: 55

Seed coat responses to desiccation in two New Zealand Fabaceae genera

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Changes in seed coat morphology with desiccation in two genera of the New Zealand Fabaceae, *Clianthus* spp. and the closely related *Carmichaelia muritai* were assessed. *Clianthus maximus* and *Clianthus puniceus* are critically endangered in the wild although both are in cultivation. *Carmichaelia muritai* is nationally endangered. Seeds of all species have an impermeable seed coat. The seed coat imposes dormancy by preventing water uptake. An impermeable seed coat has also been linked to longevity in storage. *Clianthus maximus*, *Clianthus puniceus* and *Carmichaelia muritai* seeds were able to be desiccated to 2.3-2.5% moisture without loss of viability. In *Clianthus maximus* and *Clianthus puniceus* desiccation to below 6% moisture resulted in the alleviation of dormancy. Below 6% moisture the seed coat became permeable to water without artificial scarification. In *Carmichaelia muritai* at 7.8% moisture only 41% of the seeds showed an impermeable coat. However, this decreased to 24% and 17% with desiccation to 5.9% and 2.8% moisture respectively. This contrasts with previous work where in *Carmichaelia williamsii* at 3.7% moisture, 82% of seed remained water impermeable. Scanning electron microscopy revealed changes in the appearance of the seed coat cells and structure of the seed coat in all three species. In *Clianthus maximus* and *Clianthus puniceus* at 2.5% moisture cracking was observed to the lens, hilum and extra hilar areas of the seed coat whereas cracking was only observed to the lens and extra hilar areas at 5-6% moisture. In *Carmichaelia muritai* cracking was observed to the hilum/micropyle area. No cracking was observed in any seed lots at moisture contents in the range of 7.4 – 11.0%, including *Carmichaelia muritai* despite 50% of the seed being water permeable at 7.8% moisture. Methylene blue staining was used to determine the point of water entry and any correlation with cracking observed in the seed coat.

Paper ID: 122

Campolay fruit (*Pouteria campechiana* (Kunth) Baehni) and its seed viability in various weight and longevity

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Campolay has been cultivated in West Java and has become a local fruit planted in the gardens or yards. This fruit has not been widely traded yet. Campolay can be propagated by seeds, grafting, and layering. However, the germination could be inhibited by their hard seed coats related to their impermeability. This study aimed to determine the effect of seed weight (B) and storage period (P) on the viability of the campolay seeds. These experiments used factorial completely randomized design, with several variables such as germination total, germination rate, simultaneity, time to 50% germination, time to first germination, and time to final germination. The first factor was the storage period (0, 2, 4, 6 week) and the second factor was the weight of seeds (heavy, medium, light) indicating the hardness of the seed coats. All variables observed showed that those factors did not affect the germination total. Seeds stored for longer period (up to 6 weeks) resulted in higher germination rate and simultaneity. Time to 50% germination, time to first germination and time to final germination were earlier for longer-stored seeds, while the germination was not affected by the seed weight. There was no interaction between storage period and seed weight. The seed germination capacity of the seeds were 92-97%. Campolay seed storage applications with a media store sawdust moist and dark conditions, it is useful to delay the time to germinate the seed for a few weeks so that more uniform germination, the seed conveyance purposes (takes several weeks) so that the program type of plant germplasm conservation is achieved.

Paper ID: 104

Soil seedbank diversity under variation in fire regimes in a temperate heathland

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Fire has shaped plant diversity over millennia. Heathland plants have adaptations that help them survive recurrent fire, including in soil seedbanks, where fire can stimulate germination. Yet, anthropogenic changes to fire regimes, including fires that are too frequent or infrequent, can threaten species with extinction. Seedbanks are typically neglected in favour of the extant vegetation in fire research, despite the importance of soil seedbanks in post-fire persistence. Soil seedbanks also often reveal additional species to those visible in the extant vegetation. Furthermore, fire effects are often investigated solely through a single aspect of the fire regime. Our study investigates the combined impacts of fire interval, time since fire, and severity of the last fire, on the diversity of soil seedbanks in a heathland ecosystem. We sampled soil seedbanks at 57 sites within Gariwerd (Grampians National Park), in south-eastern Australia, across a range of fire ages (0 to 82+ years), fire frequencies (1-8 fires), and fire severities (low and high). Soil samples from within each site were divided into three groups and subject to the following treatments: low temperatures with smoke (60 degrees for 30 minutes), high temperature with smoke (90 degrees for 30 minutes), and a control. Samples were then housed in an irrigated glasshouse. Germination will be recorded in, and plants identified to species level. Regression analyses will then be used to explore measures of plant occurrence and species richness as a function of fire history variables at each collection site. Analyses of changes in soil seedbank diversity will later be compared with changes in above-ground plant diversity, measured concurrently at each field site. This approach will contribute to developing fire management strategies that protect biodiversity in heathland ecosystems, through the identification of the range of fire regimes that are favourable and/or detrimental to different types of heathland plants.

Paper ID: 9

A promising weapon for bruchid control in cowpea

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Cowpea (*Vigna unguiculata*) is a vital staple crop in West Africa consumed daily by more than 200 million people and providing an important source of income. Nigeria, the largest producer, still needs to import around 500,000 tonnes per year to meet domestic demand. This is because insects can reduce yields by 90%. The major post-harvest or storage pest is the bruchid coleopteran, *Callosobruchus maculatus,* known as the cowpea weevil. It is conservatively estimated that over 30,000 tonnes are lost to bruchids annually during storage. A genetic solution for the problem is feasible using biotechnology, and their deployment in the field to control this pest would allow Nigeria and neighbouring countries to become self-sufficient. There is no effective host plant genetic resistance to the cowpea bruchids, and although there are some traditional practices to control them such as mixing the seed with ashes, they are quite inefficient. Seed-incorporated protection using gene technology to express the α-amylase inhibitor (αAI) gene from common bean (*Phaseolus vulgaris*) has been described for peas and chickpeas and could be an ideal solution for cowpea in Africa. In preliminary studies, we have produced cowpeas carrying the αAI gene from beans which were shown to be fully resistant to *Callosobruchus* spp. The cowpea product is still at the proof-of-concept stage and needs to be produced at scale, and to undergo a full molecular characterization, rigorous biosafety studies, and efficacy tests in the granary. A biotech solution would bring large economic and health benefits to farmers, traders, processors, and consumers.

Theme: Seed Biology & Evolutionary Ecology

Session 3

Paper ID: 115

Unpacking the seed bank: Variation in germination behaviour of physically dormant seeds extracted from forest soil.

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In fire-prone ecosystems, seeds of physically dormant species are typically released from dormancy when exposed to heat generated by fires, although too much heat is lethal. A standard method for examining the fire response of soil-stored seed involves treating soil samples with heat, smoke, or a combination of both, with heat commonly applied at only one or two levels. However, there are limitations with this approach; in particular, it is unable to identify the critical heat thresholds associated with dormancy loss or seed mortality. In this study we describe an alternative approach, in which seeds were physically extracted from soil samples, then exposed to dry heat treatments designed to quantify the full thermal response up to lethal levels. We illustrate this method using the mid-storey tree species *Acacia dealbata* Link, employing a calibrated oven to apply heat treatments from 40-140 ^{o}C. Germination fraction was quantified using an integrated model with parameters for the non-dormant fraction, dormancy release, peak germination and seed mortality, and germination speed was quantified by using empirical models to estimate time to 50% germination (t_{50}). We sampled soil at a range of sites under pure stands of the target species, and sought to quantify the extent of site-to-site variation in germination behaviour. We found that the threshold temperature for dormancy release exhibited substantial variation between sites (58-72 ^{o}C), whilst the threshold for the onset of seed mortality was much less variable (112-117 ^{o}C). Multi-model mean t_{50} varied from 3.0 to 10.4 days, with germination occurring faster in seeds found underneath older stands. Our method could allow greater precision in studies of the behaviour of soil seed banks, and may be particularly relevant for understanding the effects of variable fire intensity on plant demographics.

Theme: Seed Biology & Evolutionary Ecology

Session 3

Paper ID: 134

Integrating seed microbiome knowledge into restoration and conservation

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Microbes such as fungi and bacteria can exist within seed as endophytes. Seed endophytes have been associated with increasing seed germination and plant root development but can also be latent plant pathogens and microbes that can cause seed decay. These microbial species play an important role in forming the plant microbiome although they are rarely integrated into ecosystem restoration and seed based ex-situ conservation. When microbial communities are utilised in restoration the aim is often to restore the functioning of the soil microbial community. These approaches have varying levels of success and considering the important role seed has in restoration and conservation for native Australian plants, the use of seed microbiomes in conservation is a new and exciting area of research. Here we present current knowledge of the research area and the seed microbiomes of two grass species commonly used in restoration: *Themeda triandra* and *Microlaena stipoides.* Seed was collected from sites along the east coast of NSW and within the ACT and we discuss preliminary spatial patterns and their potential role in plant growth promotion. We suggest how understanding the diversity and interactions of both soil and seed microorganisms in natural ecosystems can be studied and how resulting knowledge may be used to inform seed-based restoration and conservation of native Australian plants.

Theme: Seed Biology & Evolutionary Ecology

Session 3

Paper ID: 129

Fungal endophytes of *Banksia* seed: Diversity and dynamics.

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Biodiversity loss worldwide is occurring at an alarming rate due to the continual and increasing influence of anthropogenic disturbances. Understanding how species shift and adapt in these changing urbanised environments while also changing over time is extremely important when considering ex-situ conservation and restoration. Seed fungal endophytes (SFE) are fungi that exist within the seed tissue of a plant. They provide plants with a variety of benefits including promoting seedling germination but can also exist as latent pathogens and saprotrophs. Major knowledge gaps exist regarding factors that influence SFE diversity within both the natural and urbanised environments. Using culturing techniques, morphological analyses and Sanger sequencing, we identified the SFE community within native *Banksia* at two urban and four natural sites in the Greater Sydney Region. We investigated the influence of both spatial and temporal factors on the diversity and composition of these communities and found a taxonomically diverse range of fungi present. Within co-occurring *Banksia* hosts, each *Banksia* species housed distinct and highly abundant fungal species, each belonging to a different ecological guild. Between old and young seed, older seeds contained significantly more fungal species. We also found similar fungal communities within young seeds at sites, which over time, diversify and become distinct and unique to each site. Between urban and natural sites, the overall SFE community composition did not change, although species richness and diversity were greatest at the urban sites. We discuss implications of these findings for seed collecting and seed storage as a means to conserve microbial diversity of *Banksia.*

Theme: Seed Biology & Evolutionary Ecology

Session 3

Paper ID: 91

Regulation of smoke-stimulated germination by diurnal fluctuations in soil temperature reduces seedling emergence in unburnt vegetation

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During fire, smoke is transported via wind and water well beyond the extent of the burnt area, in sufficient quantities to germinate smoke-responsive seeds. However, empirical studies show that for the vast majority of species with soil-stored seed banks, germination in unburnt habitat produces limited or no successful recruitment. This raises the question of how such suicidal germination is prevented in smoke-responsive species. We investigated how smoke and diurnal fluctuations in soil temperature interact to regulate germination of *Boronia floribunda* (Rutaceae), a restricted shrub species from fire-prone southeastern Australia. We quantified the effect of season and the presence/absence of an overstorey on diurnal fluctuations in soil temperature under field conditions. We used these data to investigate how smoke and soil temperature intact to regulate germination in a laboratory trial, and validated our findings by quantifying post-fire seedling emergence under field conditions in relations to season (winter vs summer) and overstorey (present/removed by fire). While smoke treatment was required for germination, the highest germination (50.67% + 10.67) was recorded at winter temperatures representing open conditions (burnt winter), while only 14.67% + 4.81 germinated in closed canopy conditions (unburnt winter). There was only a negligible response in either of the summer treatments. This means that temperatures representative of soil conditions during winter in burnt areas (i.e. gaps) improved germination with an approximate 3.5-fold increase. We conclude that smoke and diurnal temperature fluctuations interact to ensure seedling emergence coincides with the post-fire environment, limiting detrimental germination in unburnt but smoke-saturated vegetation adjacent to fire boundaries.

Theme: Seed Biology & Evolutionary Ecology

Session 3

Paper ID: 108

Seed conservation and germination response of important native grasses from arid deserts of United Arab Emirates

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The Sharjah Seed Bank and Herbarium (SSBH) has been involved in conserving seeds of wild plant species to ensure safeguarding native diversity. Native grasses of the arid Arabian deserts has great importance due to their palatability, nutritive value, and adaptation to local climatic and soil conditions, recognized as a good candidate for fodder production and restoration of degraded rangelands. In this study, germination responses of fresh and stored seed (2.5-3 years of storage) of six native grasses was evaluated at a moderate temperature of 20/30° C under different photoperiods. Freshly collected seeds showed higher germination and germination rate index (GRI) value for *Pennisetum divisum*, *Lasiurus scindicus* (Acc. 2), *Centropodia forsskalii*, *Cenchrus ciliaris* (Acc. 2), *Sporobolus spicatus*, and *Stipagrostis plumosa* compared to stored seeds. However, *L. scindicus* (Acc.1) and *C. ciliaris* (Acc.1) showed higher germination and GRI value for stored as compared to fresh seeds. In these accessions, the storage induced a dark requirement with a significant increase in germination percentage, indicating that storage might change phytochrome sensitivity in the dark. *S. spicatus* maintained high germination percentage (only c. 8 % difference) and velocity (GRI: 48 for fresh & 45.5 for stored). For *C. ciliaris* (Acc.2), there were no change in germination under dark incubated fresh and stored seeds (100%). The difference in germination response of *C. ciliaris* and *L. scindicus* was accession specific that could be related to maternal habitat as it has been shown to affect germination traits in many Arabian Desert species. Further studies on species with low germination after storage are in progress to determine their viability periodically. The results demonstrate that *ex situ* conservation is an effective way to maintain the viability of seeds of native grasses that provides good opportunity for research and understanding of the germination traits essential to improve their future use.

Theme: Seed Biology & Evolutionary Ecology

Session 3

Paper ID: 105

Comparative quantitative study of conglutin seed storage proteins across narrow-leafed lupin varieties

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Lupin (*Lupinus*), a valuable legume crop is gaining increasing recognition as a potential health food due to its favourable nutritional properties, such as high plant-based protein and dietary fibre, and low fat and starch content. In addition, these seeds are reported to having many nutraceutical properties, such as the ability to: lower cholesterol and blood pressure; manage glucose levels; and reduce obesity by lowering energy intake while increasing satiety. The most abundant proteins in lupin seeds are the conglutin proteins which are classified into four major families: α, β, γ and δ. These seed storage proteins, play a major role in supplying nitrogen, carbon, and sulphur to the growing seedling during germination and contribute to specific pharmaceutical and nutritional attributes. For instance, the beta conglutin proteins with desirable techno-functional characteristics are known as the main allergenic proteins in lupin seed, whilst the gamma conglutin proteins have been reported to possess strong anti-diabetic properties. In this study we have applied discovery-based tandem mass spectrometry (LC-MS/MS) for studying the proteome composition of 46 narrow-leafed lupin (NLL, *Lupinus angustifolius*) varieties, which included genetically diverse wild lupin varieties as well as domesticated Australian and European cultivars. The targeted quantitative study of the conglutin seed storage proteins across the selected NLL varieties was achieved through a liquid chromatography-multiple reaction monitoring-mass spectrometry (LC-MRM-MS) experiment. Overall, this evaluation revealed that the conglutin protein expression profiles substantially differ for the examined lupin lines, the variations were more notable for several beta and delta conglutin proteins. These findings can benefit the lupin breeding strategies to optimise the lupin seed protein composition and develop varieties with lower content of antinutritional proteins and higher levels of favourable beneficial proteins.

Theme: Seed Biology & Evolutionary Ecology

Session 3

Paper ID: 13

Techniques for breaking seed dormancy of rainforest species from genus *Acronychia*

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Acronychia is a genus from the Rutaceae family which contains many species with seed germination difficulties. Seed dormancy has been predicted as the cause for these difficulties, but the understanding is still limited. In this current study, we tested different dormancy breaking techniques on three *Acronychia* rainforest species from the Rutaceae family, *A. imperforata*, *A. laevis* and *A. oblongifolia,* to achieve germination. Four dormancy-breaking treatments — (1) seed coat removal, (2) scarification near radicle emergence point, (3) scarification opposite the radicle emergence point, (4) gibberellic acid incorporated agar — were used along with intact seeds to compare the effect of dormancy-breaking treatments on germination. Three replicates with 15-20 seeds were incubated at 25/10°C for each treatment and germination was recorded for six weeks. An imbibition test was also performed using 10 intact and 10 scarified seeds per species. Germination percentages within species were significantly different among dormancy breaking treatments and all three species showed similar responses to each treatment. Germination of intact seed replicates was less than 8% for all three species and indicated the presence of dormancy. Highest germination was observed when the radicle emergence point was scarified (>65% in treatment 2). The imbibition test confirmed the permeability of seedcoats and scarification opposite to the radicle emergence point showed a significantly lower germination (<12%). These results indicate a requirement for scarification near the radicle emergence point to initiate germination of the three *Acronychia* species tested; the method may also be a suitable dormancy-breaking technique for other species in the genus.

Paper ID: 46

The Revegetation Industry Association of Western Australia Native Seed Accreditation System

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The Revegetation Industry of Western Australia (RIAWA) has represented the native seed industry in WA for over 15 years. Over this time RIAWA had been approached to develop an appropriate system for accrediting native plant seed that is bought and sold in WA. After extensive stakeholder and industry consultation the RIAWA committee developed a Native Seed Accreditation System in 2015. The primary aim of the system is to raise the quality assurance and sustainability of seed collection and supply in Western Australia. The Accreditation system is considered to be the first of its kind in Australia. The backbone of the Native Seed Accreditation System are the RIAWA Seed Standards which have been developed from the Florabank Guidelines. The standards establish appropriate practices regarding seed harvesting, processing, storage, marketing and supply, payment of contractors and staff, seed orcharding, and collector training. The RIAWA Seed Accreditation Guidelines explain how the accreditation system is managed. Accredited collectors and suppliers must be members of the association and thereby commit to the RIAWA Code of Practice. Costs are kept to a minimum to encourage participation in the scheme and not be a deterrent for smaller collectors. Supportive materials have been developed, including a seed purity/ viability database, an online seed collector training program and quality testing standards.

Main advantages for buyers:

- Confidence that the seed being purchased has been collected sustainably and is of specified quality
- Ability to compare "apples with apples" in terms of prices and quality offered from different suppliers
- Access to a list of accredited seed suppliers and collectors on the RIAWA website.

Main advantages for collectors / suppliers:

- Industry recognition of quality to help differentiate your products and services
- Ability to differentiate product quality by seed grade
- Promoted on the list of accredited seed suppliers and collectors on the RIAWA website.

Paper ID: 96

Advent diagnostics applications within germplasm post entry quarantine towards safeguarding Australian biosecurity pulse and grain industry

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Australia's biosecurity import conditions (BICON) aim to protect and safeguard Australia against the entry and spread of exotic pests and diseases that could decimate our agricultural industry. Australia is relatively free from the numerous pathogens associated with cultivation and international trade of grains and pulses globally. In Australia, crop breeding programs rely on imported seed as new sources of genetic diversity, and hence there is considerable risk of introducing exotic pests and diseases that could result in prohibitive control and eradication costs that could also jeopardize commodity export markets. Consequently, import biosecurity conditions demand on-arrival inspection and mandatory growth in a regulated post-entry plant quarantine (PEQ) facility that includes disease diagnostic assessment before seed lines can be released. PEQ diagnostics including tissue blot immunoassay, ELISA and biological indexing are considered the gold standard pathogen detection tools. However, these tests have inherent weaknesses including sensitivity, availability of test reagents and inability to discriminate between diverse genetic pathogen strains. Similarly, PCR/RT-PCR are more sensitive, but require prior knowledge of the target, and therefore are not effective at detecting unknown pathogens. High through put sequencing (HTS) has been recommended for integration into genetic certification programs worldwide. HTS has immense potential in PEQ screening and could revolutionize simultaneous pathogen diagnostics, and the genetic trait profiles of microbes and the germplasm being imported. Our study explored RNA-Seq and a Targeted pan-virome sequencing approach to detect multiple exotic and endemic viruses of pulses currently processed at Horsham PEQ. Both approaches successfully detected the exotic *Pea early browning virus* and three endemic viruses, *Cumber mosaic virus*, *Bean yellow mosaic virus* and *Pea seed-borne mosaic virus*. Further studies are currently underway to improve both methods. These methods are anticipated to be integrated into Horsham PEQ to facilitate the introduction and screening of germplasm for the grains industry.

Theme: Seed Sourcing & End Use

Session 1

Paper ID: 83

Capturing genetic diversity with seed collections: empirical data to guide sampling strategies

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Genetic diversity is the basis for population adaptability and resilience. In the current climate of constant environmental change, high quality seed collections for restoration and germplasm collections, should thus capture as much of the available genetic diversity of a species or population as possible. Genetically diverse collections will facilitate the long-term self-sustainability of restored communities. While decision support tools such as Restore and Renew (Royal Botanic Garden Sydney) enables practitioners to make informed choices for seed origin under various restoration scenarios there is a lack of empirical data that provides information for best practice to capture genetic diversity with seed collections specifically. Here, we will discuss the results from a multi species study investigating the relationship between genetic diversity of source and seed populations. To address this question, we collected seed from multiple individuals at multiple sites for multiple species (representing *Acacia*, *Banksia* and *Hakea*) common along the east coast of Australia. We recorded and tracked the maternal origin of each seed throughout the study, enabling a comparison of all measured traits (including seed viability, germination response, outcrossing rate and for selected species fitness based on growth rate) across individuals, populations and species. Mothers and offspring were genotyped using commercially available high through-put whole genome sequencing methods and the data allowed us to compare the amount of genetic diversity captured under different collection strategies across populations and species. As expected, diversity increases with the addition of mother plants and populations however our data indicated that mating system significantly affects the percentage of available diversity captured with seed collecting and this can differ between individuals and populations. Along with the variation in percentage germination across maternal lines these results concur the need to keep maternal lines separate in germplasm collections. These results should be considered for germplasm collections and ecological restoration.

Theme: Seed Sourcing & End Use

Session 1

Paper ID: 30

An update of the Florabank Guidelines: national guidelines for best practice native seed collection and use

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A recent analysis of the native seed industry, 'The Australian Native Seed Survey Report' (Hancock et al. 2020) published by the Australian Network for Plant Conservation (ANPC) identified a number of issues with seed supply and the need for improved expertise and training. To address these issues, the ANPC secured funding from the NSW Government through its Environmental Trust for the 'Healthy Seeds Project'. This project has three main objectives: to produce a Roadmap - a plan of action to improve the native seed sector in NSW; to undertake an audit of Seed Production areas; and to update the Florabank Guidelines. Originally published in 1999 by a consortium consisting of Greening Australia, CSIRO and the Australian National Botanic Gardens, the Florabank Guidelines are widely used by seed practitioners. The collection of ten guidelines covers topics including as seed collection, production, processing, storage, and testing. Given the amount of research and knowledge gained over the last 20 years, these guidelines need to be updated to present the latest science and best practice methods. The Florabank Guidelines update commenced in September 2019. Firstly, a reference group was formed, with representatives from ANPC, Greening Australia, CSIRO, Australian Seed Bank Partnership, Royal Botanic Gardens Sydney, NSW Department of Planning, Industry and Environment the Society for Ecological Restoration Australasia and the Australian Association of Bush Regenerators. The original 10 guidelines were then expanded to 15 guidelines. New content includes working with Indigenous Australians, seed enhancement technology and nursery propagation. A large number of people across the sector have generously donated their time to read and review the updated guidelines. We encourage everyone involved in the seed supply chain and those using native seed for any purpose, from licensing officers and collectors to nursery managers and volunteer groups, to read the updated FloraBank Guidelines.

Theme: Seed Sourcing & End Use

Session 1

Paper ID: 109

Seed Resourcing for large-scale TEC restoration

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The proposed Fingerboards mineral-sands project in east Gippsland has ambitious goals for post-mining rehabilitation which include complex grassy-woodland restoration at scale. Accessing seed of appropriate genetic and viability characteristics from a broad range of species from a threated ecological community will be a major challenge. This presentation discusses the projects overall restoration goals and its seed sourcing strategies which include wild regional collections and the use of cultivated seed production approaches. With a long-term project life, clear goals and strong organisational commitment, this project has the potential to create significant beneficial biodiversity outcomes for the Gippsland region and equally important, to develop ongoing regional knowledge, capacity and infrastructure in relation to native seed.

Theme: Seed Sourcing & End Use

Session 1

Paper ID: 110

Unlocking Australian indigenous germplasm in the Australian Pastures Genebank

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There is renewed interest in the use of Australian indigenous flora for landscape rehabilitation, the search for forage species adapted to marginal soils and a drying climate, and to support regenerative agriculture practices. The Australian Pastures Genebank (APG, https://apg.pir.sa.gov.au/gringlobal) has recently identified 2,449 accessions from 407 species in its collection that are native to Australia, including 1582 that are georeferenced with latitude and longitude information. This collection of native seeds is unique and not duplicated at any other international genebanks. The most represented native genera in the APG include: legumes *Glycine* (264 accessions), *Cullen* (209), *Lotus* (114), *Sesbania* (98), *Acacia* (97), *Kennedia* (76), *Senna* (60), *Swainsona* (55) *Indigofera* (49) and *Desmodium* (43); C3 grasses *Anthosachne* (98), *Rytidosperma* (51), *Microlaena* (24) and *Austrostipa* (19); C4 grasses *Themeda* (77), *Dichanthium* (40), *Heteropogon* (37), *Astrebla* (33), *Chloris* (24) and *Bothriochloa* (20); and non-leguminous forbs *Atriplex* (138), *Ptilotus* (49), *Maireana* (44), *Eremophila* (39) and *Chenopodium* (35). The APG now aims to generate new georeferenced datapoints for accessions where this information is missing (where possible) that will allow for visual identification of collection origins in map-based searches. The collection can be further improved by identifying gaps in representation of taxa or provenance, and then collecting or sourcing new germplasm to fill these gaps. The APG is also working to improve seed quality and inventory levels of Australian indigenous accessions, with 790 (32%) having critically low seed numbers for conservation (<500 viable seeds), only 886 (36%) having enough seed for available for distribution (>2500 seeds), and only 682 (28%) backed up at the Svalbard Global Seed Vault. The challenges ahead include managing regeneration and seed monitoring demands against available resources to ensure seed is safely conserved, so that it can exist now and forever to safeguard the future of agriculture and the environment.

Theme: Seed Sourcing & End Use

Session 1

Paper ID: 73

Selling seeds and seedlings for livelihood development – A case from Cambodia

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Local communities in Cambodia have been involved in the supply of tree seeds due to their involvement in managing community forests where many seed sources are located. There are at least 10 farmer seed suppliers across the country supplying more than 20 tree species regularly used in tree plantings. They play an important role in making available seeds from different genecological zones across the country for diverse planting site conditions. However, the business faces some challenges including insufficient seed sources and irregular seed production. This presentation will highlight the case of a farmer, Mr. Sok Em from the northwestern Pursat province, who has struggled to overcome those challenges and made a good living from seed and seedling business. Mr. Em collects and sells about 1,000 kg of seed per year of seven species found in his area. The price of seeds varies between US$150/kg for *Dalbergia cochinchinensis* and US$1.25/kg for *Dipterocarpus alatus*. Mr. Em also produces seedlings of three endangered Rosewoods, *Dalbergia cochinchinensis*, *D. oliveri* and *Pterocarpus macrocarpus*, up to 90,000 seedlings per year. For him, the income from seed and seedling supply has exceeded that from farming. The Forestry Administration provides him and other farmer seed suppliers trainings on seed collection and marketing, and basic seed collection tools which ensure the safety of seed collectors and increase productivity. Since 2019, the UK Darwin Initiative funded project "Conserving Rosewood genetic diversity for resilient livelihoods in the Mekong" has been providing technical and financial assistance to him to make his two long-term plans--upgrading the existing nursery and the establishment of small seed sources of *D. cochinchinensis* and *D. oliveri* from grafting on his farmland--a reality. The project also helps strengthen the supply of quality, genetically diverse seeds of native tree species in the country.

Paper ID: 25

Quantifying seed germination and establishment traits for ecological restoration in the Pilbara region of Western Australia

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Maximising the opportunity for seeds to germinate and establish is central to our capacity for ecological restoration. Over the past five years we have conducted laboratory-, glasshouse-, and field-based trials to inform restoration practices in the semi-arid Pilbara region of Western Australia; an environment characterised by highly seasonal and localised rainfall, with significant land disturbance from mining. For diverse species representative of differing plant lifeforms and seed types we have focused on quantifying seed dormancy, germination and emergence traits in relation to climatic and edaphic factors, and on the development of seed enhancement technologies to increase establishment potential. A series of trials in a rain-out shelter housing five substrate types demonstrate seed dormancy break is fundamental to initiating establishment, and that substrate also has a marked effect on growth and survival. Reduced carbon, nutrients, and water holding capacity of mine waste substrates, as well as their negligible microbial activity, are hypothesised as important limiting factors, as it was common to observe greater seedling establishment and biomass in plots containing pure topsoil or blends of topsoil and waste, as opposed to waste alone. A range of seed enhancement treatments including priming, coating, and pelleting, have been evaluated. In the laboratory, seed priming consistently improves germination performance, enhancing germination speed by up to 40-80% across species, as well as germination under water-stressed conditions. In the field, effects of different priming techniques vary, but priming shows promise as a carrier of germination-promoting compounds including karrikinolide, as well as naturally occurring cyanobacteria to enhance seedling growth and introduce carbon to depauperate waste substrates. We summarise our multi-disciplined approach to defining environmental thresholds for germination and establishment and addressing biotic and abiotic barriers to plant regeneration. We discuss how the findings are informing large-scale field trials and current restoration practice, and some outstanding questions.

Theme: Seed Sourcing & End Use

Session 2

Paper ID: 54

Overcoming the constraints to precision seed delivery in mined landscapes that possess rocky soils, steep terrain, and severe edaphic conditions

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Over the past decade considerable effort has been placed on understanding the biological limitations of seeds when used in mine rehabilitation programs of Australia's arid north-west. Significant fail points exist at the germination and emergence phases across a wide range of plant diversity. However, we have now shown that, if you manage commercially supplied seeds for their quality, dormancy state, and provide species-specific seed enhancement treatments, you can increase seedling emergence from less than 5% to over 40%. This represents a significant improvement in our ability to use seed efficiently in severely degraded landscapes. It is with this knowledge-base that we have shifted our focus to investigate a range of seed enhancement technologies (e.g. extruded seed pelleting) and precision seeding technologies (e.g. modified disc and press wheel direct seeding arrangements) that can further bolster the potential of seedling establishment. For instance, we have recently shown than when sown on the soil surface seed germination and establishment is almost completely absent. Yet, when sown at or below 30mm in rocky soils there is over a 35% chance that an emerging seedling will encounter a rock impacting its ability to emerge once germinated. This introduces an additional bottleneck that is rarely considered. In this presentation, we will discuss several biological, technological, and precision-engineering solutions that that have been developed to overcome these newly identified seed-use shortfalls. Two examples will be showcased that highlight the use of: 1) modified extruded pellets that embed seeds in a beneficial soil matrix allowing surface sowing and the promotion of seedling emergence in the dominant grass genus, *Triodia*, and; 2) custom designed seeding machinery that incorporates seeds into the upper soil surface on sloped landforms significantly improving soil coverage in rocky soils. Both techniques show promise for scalability across mined land in Australia and across the globe.

Theme: Seed Sourcing & End Use

Session 2

Paper ID: 135

Tackling limitations for seed germination of Australian native plants for ecological restoration in north-western NSW

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North-western NSW is one of Australia's biodiversity 'hotspots' with respect to the number of endemic plant species. Yet, there is a large deficit of vegetation cover, mostly due to over-clearing, leading to species and communities in the zone being currently listed as threatened, and their recovery and conservation are promoted. To re-establish native biodiversity at large scale considerable amounts of viable seed are required and rarely available. Besides frequent issues with seed germination ecology that hinder the potential to use many of these species. Research was conducted to assist with the propagation of 40 species native from north-western NSW from seed, in response to concerns from local practitioners who were unable to germinate these species in nurseries or via direct seeding due to the limited understanding of seed germination and seedling establishment. Seed viability, germinability under different seasonal temperatures, dormancy and seed pre-treatments to increase germination were investigated. Seed viability varied widely among, within and between species. Low viability was detected in at least one seedlot of 38 species. Low seed viability of some samples was caused by aged seeds, herbivory, fungal infections and seed collection practices. Seasonal temperature affected germination success in 23 species. Most species had higher germination levels under spring temperature conditions. Dormancy was identified in 16 species. Seed pre-germination treatments were effective in relieving dormancy or increasing germination percentage by approximately two-to-three-fold. The results emphasise the need for seed testing which can (1) assist in selecting species and pre-treatments suitable for propagation in nurseries or direct seeding; (2) serve as a guide to the environmental conditions necessary for high germination percentages, and (3) increase our understanding of seed ecology and management.

Theme: Seed Sourcing & End Use

Session 2

Paper ID: 136

Seed coating: Effects on seed germination, handling and costs associated

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Seed coating consists of applying constituents to the surface of the seed and it is mainly used to modify the physical properties of seed and deliver active ingredients. Seed-coating technology could be a key to improving seedling establishment, plant growth, and restoration efficacy by direct seeding if applied to native Australian species to meeting national and local restoration goals. Yet, seed coatings applied to native species for ecological restoration has not received sufficient attention. We explored different seed coating techniques on seeds of small-seeded eucalypt species and morphologically uneven native grasses. Coating film was used to modify and standardise shape and size to create a more versatile product, durable and able to be handled with greater ease and sown using conventional machinery. Seed coating resulted in single seeds coated, or from two to seven seeds encrusted in a clump or pellet. Germination of coated and uncoated seeds was tested in Petri dishes and incubated in a temperature-controlled growth chamber or buried in soil mix in the nursery. Additionally, the costs and time consumed to deliver a product with added value were estimated. Seed handling and management was improved, and alternative seed coating techniques were explored. The observations suggest that it is possible to adjust the technique to the size and amount of seed in a pellet for seed with different physical characteristics and add practical value to the product. Seed coating did not influence germination when buried in the soil mix, but in the Petri dishes germination was lower with thicker seed coats. The previous suggests that coated seeds and pellets need to be buried in moist substrate to allow moisture to be captured evenly for imbibition and germination. Lastly, seed coating of native species has potential to become an economically viable solution for several seed management issues.

Theme: Seed Sourcing & End Use

Session 2

Paper ID: 116

Comparative longevity of Australian rainforest seeds: Seed attributes and habitat

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While many species of rainforest habitats are predicted to have recalcitrant seeds, a relatively high proportion of Australian rainforest species have recently been found to be desiccation tolerant. Little is known, however, of their expected longevity in storage. Such information informs when recollection is required for seed banking purposes. We assessed the comparative longevity of 26 species collected from rainforest habitats along the east coast of Australia, using the accelerated aging technique. Estimates of the time to 50 % seed loss (p50) were determined using Probit analysis. Subsequently, the p50 values were regressed against seed characteristics (dry weight, endospermy) and landscape and climatic variables recorded at each collection location (latitude, longitude, altitude) or derived from the eMAST dataset for those locations (precipitation, average, minimum and maximum temperatures, pan evaporation & vapour pressure)). Average longevity was 17.9 days, with p50 < 20 for 18 species (69 %) including 10 species (38 %) with a p50 < 10 days. Evaporation and maximum temperature were equally the most significant variables in the prediction of p50, closely followed by altitude. While evaporation was positively correlated with p50, maximum temperature and altitude were both negatively correlated. Variables associated directly with precipitation were not found to be significant and were removed during model minimisation. Based on our results, orthodox rainforest seeds from the east coast of Australia are predominately short-lived, which is in direct contrast to Australian species from other habitats which are considered to be predominately long lived. The negative correlation between seed weight and p50 is also in contrast to previous studies. This research suggests that recollection of rainforest species must occur much more frequently than other Australian species, and that cryopreservation may be necessary for long-term conservation.

Theme: Seed Sourcing & End Use

Session 2

Paper ID: 72

Conservation of endangered orchids in the Mount Lofty Ranges

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In partnership with the Adelaide and Mt Lofty Ranges NRM, Royal Botanic Gardens Victoria and dedicated volunteers from the Native Orchid Society of South Australia, the SA Seed Conservation Centre is undertaking a trial project to conserve nationally endangered orchids occurring in the Mount Lofty Ranges region. This project was motivated by reports that populations of these plants that had been monitored over several years were in decline and in danger of extinction without further conservation measures. The survival of orchids is dependent on interactions with other organisms in the biotic environment such as mycorrhizal fungi and specific insect pollinators. Therefore, it is important that both *in situ* and *ex situ* conservation strategies are used. The objectives for this project have been to establish baseline data on the extent of occurrence and population sizes of orchid species, undertake hand pollination of species showing low levels of natural pollination, protect populations from herbivory through caging and fencing, collect seeds for long term storage and propagate plants from seeds for translocation. The field work involves the searching & assessment of orchid populations, protecting plants from herbivory, monitoring flowering, hand pollination, and the collection of seeds and root samples for fungal isolation work. The collected seeds and fungal isolates are currently being utilised for the symbiotic in-vitro propagation of ten threatened orchid species from the Mount Lofty region, with funding provided through the National Landcare Program. In addition the seeds and the obligate symbiotic fungus associated with each orchid collection will be stored at low temperature at the Adelaide Botanic Gardens for future recovery projects. The nationally endangered *Caladenia argocalla* (White Beauty Spider-orchid) has been one of the species on which work has been undertaken and this species forms a highlight of the program.

Theme: Seed Sourcing & End Use

Session 2

Paper ID: 12

Botanical Garden Chateau Pérouse

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[1] Chateau Pérouse

The botanical park Chateau Pérouse (started in 2005) will eventually extend over 178 acres; 25 acres for a hotel and residential homes, 25 acres for experimental gardens and nurseries and 128 acres in botanical garden about the five Mediterranean regions of the world; Australia, South Africa; Chile, California and various countries around the Mediterranean Sea and the creation of many microclimates and soils. We are located next to Nîmes in the South of France, on a stony-clay soil. The climate is windy but very mild; there is frost just a few hours per year and an abundance of water via an irrigation canal of the Rhône. In twelve years, a database has been established. It compiles the morphological, biological and cultural elements of 53,000 taxa from the targeted regions. Currently, 7,400 taxa are cultivated out of programmed total of 19,400. To date, experimental gardens and nurseries are covering 30 acres, allowing to observe the acclimatization of the plants. Greenhouses, shade houses, as well as a laboratory with growing room complete the installations. All the information on the plants is managed by our own software. It's easy to add functionalities and many tasks are automated, such as the automatic creation of HTML pages per taxa (available on our website through the online database). From 2019 onwards, more than 3,500 taxa are being sown each year and the germination protocols noted (gathered from bibliographic research and experience). We use most known methods to unlock germination and dormancy of the different species from the Mediterranean climate regions and beyond. Our goal is to analyse every plant for their behaviour in different micro-climates and soils in order to find the optimum. We therefore use a variety of soil assemblages as sowing mediums in order to establish a logical lineage of soil assemblages from the beginning to the end.

Paper ID: 29

Preservation of trees recalcitrant seeds: when the cryobiotechnology is ready but the implementation is wanting.

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Long-term *ex situ* preservation of recalcitrant seeded species can only be accomplished by cryobiotechnologies. Embryonic axes (EA) are the preferable source of germplasm for two reasons: (1) their cryopreservation can capture a large genetic diversity (compared to vegetatively grown tissues such as shoot tips) and (2) their germination and regrowth can be started relatively easy in basic plant in vitro platforms. However, a relatively low success in the cryopreservation of EA for the species studied up to date (often <45% plant in vitro regrowth), has hampered a wide implementation of EA cryopreservation of recalcitrant seeded species across gene banks. From 2015 to 2019, the Global Tree Seed Project has been run at Kew funded by the Garfield Weston Foundation. Along with the seed collecting objectives, fundamental research on the cryobiotechnology of EA of temperate trees was performed. This paper summarizes the results of this project and has been prepared with two aims: (1) review the state of art of the cryopreservation of EA from temperate trees, and (2) present our latest research on desiccation and freezing tolerance of EA from Quercus and Aesculus species. One of the main conclusions from the research conducted in this project is that the technologies and methods to implement the *ex situ* preservation of many recalcitrant seeded species through EA and pollen cryopreservation are ready. We must encourage public bodies, botanical gardens and gene banks with cryogenic capabilities to design implementation routines and start preserving these species with the methods available. Waiting for a highly successful and universal cryopreservation method for all plant species and propagules means delaying the preservation of threatened and endangered species and genotypes with recalcitrant seeds. We need to take action before it is too late and a large genetic diversity is lost forever.

Paper ID: 44

Assessing the storage potential of Australian rainforest seeds: A decision-making key to aid rapid conservation

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We assessed 313 Australian rainforest species for seed banking suitability by comparing the germination percentage of fresh seeds to seeds dried at 15% RH and seeds stored at -20°C after drying. We then compared desiccation responses to environmental, habit, fruit and seed characteristics to identify the most useful predictors of desiccation sensitivity. Of 162 species with ≥ 50% initial germination, 22% were sensitive to desiccation, 64% were tolerant and 10% were partially tolerant; the responses of 4% were uncertain. Of 107 desiccation tolerant species tested for response to freezing, 24% were freezing sensitive or short-lived in storage at -20°C. Median values for fresh seed moisture content (MC), oven dry weight (DW) and the likelihood of desiccation sensitivity (P_{D-S}) were significantly greater for desiccation sensitive than desiccation tolerant seeds (P = 0.000 in all cases). Ninety-four to 97% of seeds with MC < 29%, DW < 20 mg or $P_{D-S} < 0.01$ were desiccation tolerant. Ordinal logistic regression of desiccation response against environmental, habit, fruit and seed characteristics indicated that the likelihood of desiccation sensitivity was significantly increased ($P < 0.01$ in all cases) by a tree habit, fleshy fruit, increasing fresh seed MC and increasing P_{D-S}. The responses observed in this study were combined with earlier studies to develop a simple decision key to aid prediction of desiccation responses in untested rainforest species.

Theme: Seed & Gene Bank Management

Session 1

Paper ID: 38

Triacylglycerol-estolides may determine the unusual storage physiology of *Mallotus* seed

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Lipid is one of the main reserve materials in seed. Lipid crystallization at -18°C was reported in some *Cuphea* species whose seeds contain medium chain fatty acids (C8-C14). A brief heat pulse of 45°C to melt the lipid crystal prior imbibition is essential for some species. Lipid melting temperature can be predicted by the weighted average temperature for β'transitions based on fatty acid proportions for those *Cuphea* species. A similar syndrome of lipid crystallization at sub-zero temperatures was found in seeds of *Mallotus*, Euphorbiaceae. However, some species with very different lipid melting temperatures have very similar fatty acid compositions, thus the sheer fatty acid compositions cannot explain or predict the seed lipid melting temperatures for *Mallotus* species. Those species produce seeds with a high level of hydroxyl fatty acid, which can form triacylglycerol-estolide (TAG-estolide, acylglycerol with more than 3 fatty acids). *Mallotus* species containing seed lipid with very similar fatty acid composition can be very different in composition of TAG-estolides. TAG-estolides can be different in both kind and number of fatty acids, though so far TAG-estolide composition cannot be quantified, our results implied that it is the composition of TAG-estolides instead of fatty acids that determines the seed lipid melting temperature for different *Mallotus* species. Seeds that contain more 'bigger' TAG-estolides (acylglycerol containing more than 7 fatty acids) tend to have a higher melting temperature in this genus.

Theme: Seed & Gene Bank Management

Session 1

Paper ID: 67

Cryopreserving recalcitrant seeded species: Oxidative stress limits cryogenic survival

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Long term *ex situ* conservation options for recalcitrant seeded species are limited, as metabolically active and desiccation sensitive (DS) seeds cannot be stored using traditional seed banking. Cryopreservation provides a viable alternative, allowing long-term conservation for these vulnerable species. Unfortunately, the process of cryopreserving a species imposes various stresses (i.e. ice formation, oxidative stress, mitochondrial damage) and solute toxicity, all of which can limit survival rates after cryopreservation. Cryobiotechnology provides the tools to investigate, understand, and mitigate these cryo-stresses by developing innovative cryopreservation protocols. Oxidative stress is a major contributor to cryopreservation-induced damage and this presentation will focus on recent work on the role of antioxidants in mitigating stress incurred during cryopreservation with DS *Syzygium* species. Addition of exogenous antioxidants to mitigate oxidative stress induced during cryopreservation has been reported with some DS species. However, the same procedure has thus far derived limited benefit with cryopreservation of DS *Syzygium* species, all of which showed significant reductions in antioxidant capacity and increased lipid peroxidation during cryopreservation. Further investigations are ongoing to attempt to understand why *Syzygium* appears to be so sensitive to cryopreservation, why remedial antioxidant treatments have been of limited value so far and provide new information to enhance cryopreservation success for many similar recalcitrant species.

Theme: Seed & Gene Bank Management

Session 2

Paper ID: 16

Ex situ conservation of a critically endangered fern

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Ferns and allies are important components of global biodiversity that are underrepresented in biobanks and IUCN conservation assessments. Fern species with small population sizes, restricted island habitats and biological knowledge gaps face multiple serious threats of extirpation. Commonly known as the Dales Waterfall Fern, *Pneumatopteris truncata* is a nationally critically endangered species with the only Australian population occurring on western Christmas Island. A partnership of the National Seed Bank, the Australian National Botanic Gardens and Christmas Island National Park is progressing the *ex situ* conservation of the threatened Dales Waterfall fern through targeted germplasm collecting, banking, propagation and cultivation and research. I discuss the *ex situ* conservation of the Dales Waterfall fern from germplasm collecting to cultivation as an important case study of collaborative effort achieving conservation outcomes. Time to first germination at 25 degrees Celsius varied from 3.5 weeks to 3 months associated with media type and maternal line. Earliest sporophyte development was observed at 10 weeks post-germination. Observed differences in germination response and sporophyte survival may be associated with differences in germination media as well as differences in maternal line spore maturity and viability. *Ex situ* spore banking and propagation and cultivation of threatened fern species may supplement and inform *in situ* conservation efforts. Insights into species biology and early life history, including spore storage potential, germination and growth requirements and sporophyte generation time can be used to prioritise future conservation actions. This project generated spore germplasm and sporophyte plants from two wild subpopulations to use in research and conservation efforts including in spore longevity and on-ground restoration. Species germination and propagation protocols have been developed to ensure best-practice techniques for *ex situ* cultivation. Spore banking and propagation and cultivation in botanic gardens can provide a feasible and effective approach to progress conservation efforts for threatened fern species.

Theme: Seed & Gene Bank Management

Session 2

Paper ID: 24

Seed identification using computer vision

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In biosecurity, weeds are often intercepted as seeds, for example as contaminants of grain shipments or seed packages, in shipping containers, or attached to vehicles. Seed identification is consequently required to make decisions on expensive and time-consuming decontamination actions, for risk management, and for pathway documentation. Unfortunately, few resources are available, because most botanical identification keys are written for mature plants rather than detached seeds. Identification options for biosecurity officers, inspectors and the general public are often limited to image collections and reference samples. Recent advances in Artificial Intelligence, in particular Computer Vision, have the potential to allow efficient, mobile identification in the form of web services or smartphone apps. In contrast to traditional keys they do not require the user to understand specialised morphological terms. Training of computer vision models to high confidence and accuracy requires, however, the availability of large numbers of high quality and varied training images of reliably identified specimens. Biodiversity collections such as botanic gardens, seed banks and herbaria consequently constitute crucial resources for scientifically responsible image recognition projects. We have utilised such collections, artificial intelligence and computer vision methods to develop a new weed seed identification tool. I will present a prototype weed seed identification app using computer vision developed by CSIRO and Microsoft, discuss the history of its development, and explore future applications and opportunities.

Theme: Seed & Gene Bank Management

Session 2

Paper ID: 43

Cryostorage of exceptional Myrtaceae species

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Myrtaceae is a large and diverse plant family found throughout Australia and contains a number of ecologically and economically important species. Although up to 95% of Myrtaceae are thought to have orthodox seed, some species have been shown to have seeds which are short-lived in storage. Additionally, a number of rainforest species are known to have seeds which are drying and/or cold-sensitive, precluding them from storage in seed banks. As many of these species are threatened by ongoing habitat loss and diseases such as myrtle rust, the development of alternate conservation strategies is vital. Six species from three genera and with different seed storage behaviours were assessed for cryostorage suitability. Successful germination and production of root and leaves on MS basal medium was demonstrated for all species prior to cryostorage testing. Cryostorage experiments compared the initial survival and ongoing growth of seeds or embryonic axes after pre-culture on half-strength MS basal medium containing 0.09, 0.4, or 0.8M sucrose for 48 h and incubation in Plant Vitrification Solution 2 at 0°C (on ice) for 0-60 min before immersion in liquid nitrogen (LN). Seeds of short-lived *Backhousia citriodora* survived storage in LN but had limited continued growth. Seeds of freezing-sensitive *Rhodomyrtus psidioides* had very limited survival and embryos of desiccation-sensitive *Syzygium anisatum* and *S. fullagarii* no survival after storage in LN, however all three species produced roots and shoots in all treatments that were not exposed to LN. Embryonic axes of desiccation-sensitive *S. australe* and *S. paniculatum* had some survival after storage in LN but no continued growth. Contamination in culture was an issue for most species tested. Due to the difficulty of sterilising seed material of rainforest species, particularly when collected in the wild, shoot tips may be a more appropriate material for cryostorage of these species.

Paper ID: 79

Optimization of seed harvest protocols of genebank accessions of a crop (durum wheat) and crop wild relatives

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Seed quality is influenced by numerous factors in the field before, during and after harvest before storage. Controlling external factors before harvesting is difficult, unless seed production is in controlled, or at a modified environment. Controlling environment post-harvest is more feasible. The genebanks within the CGIAR Genebank Platform employ diverse protocols for post-harvest processing of seed accessions, but a common thread is that post-harvest seed processing of small samples is hard manual work, time consuming, and costly. Delayed drying of seeds after harvest may subject the seeds to high and/or fluctuating temperature and relative humidity in the field, and potentially rainfall, which may reduce seed longevity. This research questioned whether current routine post-harvest practices at ICARDA are optimal for subsequent longevity, or can be improved. Seeds of cultivated and wild relatives of wheat were harvested from ears serially at maturity and divided into three treatments: (a) immediately from field to drying room (15°C; 15% RH), to minimize time in the field; (b) left in field until final harvest as a single sample in a cloth bag; (c) current ICARDA practice, cumulative harvests bulked within a common cloth bag in field until the final harvest. Subsequent seed longevity in hermetic storage (45°C, 60% eRH) was improved by delaying the collection of the seeds from field in both cultivated and wild relatives of wheat in comparison to immediate removal from field and drying. Hence current ICARDA seed harvest practices do not damage subsequent seed longevity.

Theme: Seed & Gene Bank Management

Session 2

Paper ID: 97

Assessment of seed quality of Indica rice

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The quality of seed is important to improve as it is relevant not only to yield production but also to secure food sustainability. This study presents effort to investigate changes of seed physiological quality, including potential seed storage longevity of contrasting *Indica* rices cv. (MR220 and MR297). Both seed variety origin from Seberang Perak, Malaysia with initial seed moisture content was 13.8% and 14% respectively has been selected as planting materials. Seed quality parameters; ability to germinate normally, speed of germination, germination energy, seedling length, seedling dry weight and vigor index have been recorded along with potential seed longevity (*p*50). Germination was assessed on a sample of dried seeds. The remainder of the seed was stored hermetically in laminated aluminium foil bags at 2-5˚C, until the subsequent determination of longevity. Samples were maintained at 15±0.5% moisture content based in the original moisture content determination and the change in. Kept the samples in an incubator at 40 ± 0.5℃ and withdrawn at regular intervals for up to 10 days for germination testing. From the present result, the percentage of seed to germinate normally for both cv. was 92% to 100% with no significant difference occurred. However, significant different showed in vigor index with MR297 resulted the highest value (1101.19). Deterioration in subsequent seed longevity occurred sooner in MR220 cv. with *p*50 (69 days) followed by MR297 with 116 days. In conclusion, MR297 have greater tolerance to deterioration, thus is priority strategies for rice seed quality, to maintain future yield particularly for rice production country as well essential for food security.

Theme: Seed & Gene Bank Management

Session 2

Paper ID: 112

"Suc'seed'ing at Microscopy": Imaging and Digitizing the Seeds of Hawaii

Nathaniel Kingsley[1]

[1] Lyon Arboretum, University of Hawaii at Manoa

The Lyon Arboretum Seed Conservation Lab presents a case study for digitizing and databasing a seed collection of rare, endangered Hawaiian flora. Hawaii has over 400 threatened and endangered (T&E) plant species; making up almost half of all the T&E plants in the United States. We employed a series of curation actions to digitize the collection and render it useful to researchers. This included organizing and digitally indexing the collection, housing the collection in climate-controlled conditions, increasing accessibility of the collection by photographing seeds using Z-stacking software, and integrating these images into a newly designed database that encompasses the flora of the entire archipelago. With the objective of enhancing digital accessibility of the collection, we focused our efforts on capturing multi-layered, Z-stacked images of seeds to increase the depth-of-field; allowing us to capture the entire specimen in focus. These images are also associated with the morphological characteristics and seed mass data to increase the utility of the collection for identification and research. In order to demonstrate phenotypic plasticity among the seeds, several images were taken at varying angles: a *feature*; an up-close rendering of one seed; *dorsal/ventral*, to contrast the different sides of the seeds; and *variation,* several seeds in one image, to capture the morphological variation among seeds of the same species. We accentuate the usefulness of increasing visibility of collections through visual, digital representations; thereby promoting the advantage for use in global research.

Theme: Seed & Gene Bank Management

Session 3

Paper ID: 88

Seed Conservation and Utilization in Indonesian Botanic Gardens Seed Banks

Dian Latifah[1]
Kate Hardwick[2], Musyarofah Zuhri[3], Aulia Hasan Widjaya[1], Rony Irawanto[4], Agung Sri Darmayanti[3], Farid Kuswantoro[3], Dewi Lestari[3] and Elizabeth Handini[5]

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[5] Research Center for Plant Conservation and Botanic Gardens - Indonesian Institute of Sciences

The species rich Indonesian flora is facing many threats, such as widespread deforestation for oil palm and timber plantations, fire, mining, natural disasters, as well as climate change. Various *ex situ* conservation strategies have been implemented to protect Indonesia's plant genetic resources, including the establishment and development of a national seed bank for wild plant species at the Research Center for Plant Conservation and Botanic Gardens (RCPCBG), Lembaga Ilmu Pengetahuan Indonesia/Indonesian Institute of Sciences (LIPI), based in Bogor Botanic Gardens. The RCPCBG Seed Bank has been a member of the Millennium Seed Bank Partnership since 2016. It has helped to establish numerous new local botanic gardens in each province throughout Indonesia in collaboration with local governments, with the aim of developing an integrated plant conservation programme to help safeguard the Indonesian flora. Currently there are 43 botanic gardens in Indonesia, consisting of five national botanic gardens under LIPI, three botanic gardens under universities and 35 botanic gardens managed by Local Governments. So far, there are seed banks at four of these botanic gardens – including the RCPCBG Seed Bank at Bogor, with three more at Cibodas, Purwodadi and Eka Karya Bali Botanic Gardens, all of which send duplicates of selected seed collections to the main CPCBG Seed Bank. Together these four seed banks hold 1,018 accessions (891 species) including 442 native species (150 orchid species was counted in). It is estimated that there are around 30,000 seed bearing plants in Indonesia, so the botanic garden seed banks have so far only saved around 2.97% of the national flora – there is clearly much more work to be done. The RCPCBG seed bank has made good use of its collections, utilizing 3,970 seed collections between 2014-2019 for research, academic purposes and revegetation.

Theme: Seed & Gene Bank Management

Session 3

Paper ID: 50

Seedbanking China's plant diversity

Jie Cai[1]
Xiangyun Yang[1], Ting Zhang[1] and Dezhu Li[1]

[1] Kunming Institute of Botany, Chinese Academy of Sciences

The Germplasm Bank of Wild Species (GBOWS), managed by Kunming Institute of Botany, Chinese Academy of Sciences, hosts the largest seed bank for wild plant species in China. As one of the national large research infrastructures and part of Millennium Seed Bank Partnership, GBOWS aims to preserve the country's plant diversity for long-term conservation and future utilization. We assessed the conservation value of the seed collections stored at GBOWS. By the end of 2020, 85,046 seed accession represent diverse and high-quality biological resources with 237 families, 2,119 genera, 10,601 species are conserved. The collections have a wide geographic coverage, representing all major terrestrial ecosystems existing in China from alpine tundra to coastal plain, from temperate woodland to tropical forest. The collections possess significant value of conservation and natural capital: 4,239 species representing 27.96% of China's endemic plants are banked; and about one fifth of China's threatened plants, representing 751 species are preserved for long term conservation. More than 60% of species, representing 70% of collections have at least one identified use to humans. Over the 12-year period since 2009 more than 13,179 seed samples have been distributed for research, conservation and public education. Collection gaps in GBOWS holdings are identified in relation to their geographic representativeness, the taxonomic diversity of China's growing flora, and coverage of threatened taxa. Further analysis across China's wild plant germplasm conservation network is required to underpin future collection activities and maximize the usefulness of collections.

Theme: Seed & Gene Bank Management

Session 3

Paper ID: 27

Achievements of 25 years of conservation seed banking in Western Australia

Andrew Crawford[1]
Anne Kelly[1] and Anne Cochrane[1]

[1] Department of Biodiversity, Conservation and Attractions, Western Australia

Twenty-five years ago, Australia's first threatened species *ex situ* seed storage facility, The Threatened Flora Seed Centre, was established in Western Australia. Originally established to conserve species threatened by the pathogen *Phytophthora cinnamomi,* the focus has broadened over time to encompass all plant species of conservation significance in Western Australia. From the outset there was a population focus to the collections aiming to sample species diversity within and between populations. The collections were made with the intention of being used in the future to underpin species recovery in the wild. The time over which this facility has been operating provides an opportunity to examine how *ex situ* seed collection and storage practices have been performing for Australian plant species: Have conservation significant species been adequately collected in Western Australia? Is the diversity of these species well represented? Are the collections remaining viable? Are the collections of sufficient size to undertake recovery actions? Have the collections contributed to on-ground species recovery? These questions will be addressed highlighting the lessons learnt over the past 2 ½ decades and will provide insight into the future directions of seed conservation in Western Australia.

Paper ID: 128

Seed exploration and collection of wetland – riparian in the downstream of Brantas River, East Java

Rony Irawanto[1]
Kate Hardwick[2], Dian Latifah[3], Melisnawati H. Angio[4], Elga Renjana[4], Elok Rifqi Firdiana[4] and Linda Wige Ningrum[4]

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[3] Seed Bank of Research Center for Plant Conservation and Botanic Gardens - Indonesian Institute of Sciences (LIPI)
[4] Plants Conservation and Botanic Gardens, Indonesian Institute of Science

Extraordinarily high biodiversity in Indonesia in some cases depends on wetland, riparian and aquatic areas, especially in watersheds. One of the important watersheds for the people of East Java is the Brantas River Basin. Unfortunately, its sustainability and biodiversity is threatened by area degradation and increasing river pollution thus the inventory and documentation of its plant diversity is important. One of the conservation efforts conducted by Purwodadi Botanic Garden - LIPI was the exploration and collection of seeds of plant species along downstream of the Brantas River Basin, East Java. This study used survey method from 17 to 28 November 2020 and to determine which plants to harvest, seeds cut-test was implemented. The fruits were extracted and the seeds obtained were dried and their moisture contents were determined using desiccation method. Out of 15 species obtained, most of them have orthodox seeds such as *Acacia farnesiana*, *Acanthus ilicifolius*, *Coix lacryma-jobi*, *Crotalaria juncea*, *Cyathula prostrata*, *Dolichandrone spathacea*, *Ipomoea carnea*, *Lannea coromandelica*, *Neptunia plena*, *Ruellia tuberosa*, *Senna hirsuta*, *Senna* sp., *Sonneratia caseolaris* and *Thespesia populnea*, and only one of them, *Sesuvium portulacastrum*, has recalcitrant seed.

Theme: Seeds in Culture & Society

Session 1

Paper ID: 130

Exploring the diversity in wattleseeds for food applications

Sera Susan Jacob[1]
Heather Smyth[1], Bernadine Flanagan[1], Barbara Williams[1] and Mike Gidley[1]

[1] ARC Training Centre for Uniquely Australian Foods, QAAFI, The University of Queensland

There is now archaeological evidence that over 200 plant seeds from different species have been utilised by Australian aboriginal communities. These seeds heavily supplemented the meat-based diet of aboriginal communities, especially in central desert regions. *Acacia* seeds, with over forty edible varieties commonly referred to as wattleseeds in Australia, constitute the largest group. Found in a range of different terrains across the country, seeds were often eaten raw, steamed, or roasted. When roasted, they were often ground into a coarse meal, then either stirred into a paste using water and consumed as is or baked on coal into a simple damper. Dietary patterns have however changed, and the usage of wattleseeds has plummeted over the past decades despite documented nutritional qualities. In order to better understand and utilize them in mainstream cuisine, it is worth exploring how food and nutrition have been understood by aboriginal communities. Combining the traditional knowledge and cultural heritage surrounding these seeds with analytical data and food product development could reinvigorate wattleseed use while fostering a shared experience of health and wellbeing. This presentation explores selected pathways to understand the characteristics and potential uses of wattleseeds from the Northern Territory. Visual differences on both macro and microstructural levels point towards the large variability between the species of wattleseeds chosen. These differences are further illustrated by their distinct nutritional compositions and aroma profiles. Preliminary studies based on this variability focuses on understanding the digestibility qualities and impact of processing on aroma characteristics. This provides guidance for unique processing mechanisms to create potential food prototypes with real nutritional benefits.

Theme: Seeds in Culture & Society

Session 1

Paper ID: 111

Native grasses as a traditional and emerging source of food

Tina Bell[1]
Angela Pattison[1], Claudia Keitel[1], Ali Khoddami[1] and Rebecca Cross[1]

[1] University of Sydney

Grain from native Australian grasses have been used by Aboriginal people as a source of nutrition for millennia. Paradoxically, we are only just beginning to realise the potential of bringing native grasses into modern agroecosystems, food markets, and diets. Our recent research involved a paddock-to-plate approach including collecting information about the entire marketing chain – harvesting, threshing, and milling grain, and creating and marketing food products – for a range of edible native species, including grasses. Adding to the compendium of information being amassed for native grains, we also measured the nutrient profiles of selected species and tested their flour properties and performance in baked products. For seed germination studies we investigated the effectiveness of pre-germination treatments – heat, aerosol smoke and soluble compounds in smoke – that can be applied easily in-field and are cost-effective (e.g., burning prepared areas). We found that method of seed collection, storage and provenance all have a role in germination success of native grasses. While some of this information about seed germination requirements may not be new, the reinterpretation of such knowledge for growing and harvesting seed using alternative farming options (e.g., polyculture or 'food ecosystems') is critically important. As the potential of a native grain industry unfolds, a critical element is to acknowledge the cultural importance and understanding of local plant species of local human communities. We are doing this by involving local Aboriginal communities around Narrabri, NSW in all aspects of project design and management, and reporting of results as they emerge. This type of engagement is equally as important as the findings of our research to the scientific community and more widely. The aim is for this new knowledge to be used by Aboriginal communities to establish native grass enterprises to generate economic and social opportunities.

Theme: Seeds in Culture & Society

Session 1

Paper ID: 49

The importance of regional seed banks

Dan Frost[1]

[1] Seeding Victoria

Regional seed banks, also known as conservation seed banks, play a crucial role in the conservation sector. Regional seed banks provide a consistent supply of quality seed for revegetation purposes to counter seasonal variability. They provide a locally based service with a regional focus, with specific knowledge of species populations and characteristics, including climate change response. With adequate resourcing, regional seed banks could develop and maintain strong connections between practitioners linking to a network of ethical collectors, while providing training to build the knowledge and skills essential for the indigenous seed supply industry. Regional seed banks such as Seeding Victoria can also lead the way in terms of standards, adhering to strict ethical standards as we await a Code of Practice. Seeding Victoria has been operating since 1994, and in that time has witnessed the closure of several smaller seed banks in Victoria. The essential service provided by regional seedbanks cannot be sustained by the current level of sales in an unregulated market. If we are serious about providing significant volumes of ethically sourced seed for revegetation and bushfire recovery, regional seedbanks must survive.

Theme: Seeds in Culture & Society

Session 1

Paper ID: 31

Seed Banking and National Parks - an ideal conservation partnership

Tom North[1]
Alasdair Grigg[2], Melinda Wilson[3] and Feach Moyle[4]

[1] Australian National Botanic Gardens
[2] Christmas Island National Park
[3] Norfolk Island National Park
[4] Kakadu National Park

National Parks and reserves are the action we have most commonly taken to conserve species and ecosystems. Under new and changing threats these reserves are not as secure as they once were, and other actions are required to ensure the long-term conservation of plant species. Seed banks can provide another tool in a holistic approach to plant conservation. Since 2012 the National Seed Bank has been working with Commonwealth National Parks to collect key and threatened species across their jurisdictions. This is working particularly well in parks such as Christmas Island, Norfolk Island and Kakadu where our mutual aims of building capacity and meeting conservation targets are providing an example of how this approach can deliver. We have been working closely with Parks Australia staff and Traditional Custodians to deliver training in collecting methods, improve their ability to store and access seed collections within their own parks whilst ensuring that collections deposited with the National Seed Bank are secure for long-term conservation and to undertake research. In developing an approach for national parks to take, the Australian National Botanic Gardens and the National Seed Bank have paid particular attention to the following criteria:
1. ensuring the genetic breadth of sampling for a species,
2. providing training in the adequate documentation and record keeping for the future use of collections, and
3. building capacity for parks to store seed collections under appropriate storage conditions and be able to monitor collection viability for their own use.
The resources to undertake this work have been backed up by projects with the Millennium Seed Bank and the Australian Seed Bank Partnership. In terms of delivering seed collections these projects have been banking species new to seed banks, threatened species collections and crop wild relative collections.

Theme: Seeds in Culture & Society

Session 1

Paper ID: 121

The growth of community gardens as *ex situ* dynamic seedbanks

Jesse Raneng[1]
Catherine Pickering[1]

[1] Centre for Planetary Health and Food Security Griffith University

Increasing in popularity, community gardens contribute broadly to sociocultural practices and the conservation of agrobiodiversity, whilst also providing a diverse range of benefits for local communities. Research conducted by Guitart *et al*. (2013) found that almost all of the 50 community gardens in southeast Queensland practiced dynamic conservation of heritage plants including seed saving, exchanging seeds/plants, and using organic seed/seedling providers. The influence of permaculture was prominent in nearly half of the gardens in Brisbane and on the Gold Coast supporting the concepts of seed sharing but also selecting varieties better suited to non-industrial agricultural practices. Most of the gardens (88%) were running educational workshops on permaculture principles and seed saving practices (Guitart *et. al*. 2013). Despite the use of these results in food security discussions with the UN Food and Agricultural Organisation, further research on this aspect of community gardens remains sparse considering there has been a massive increase in research on community aspects of the gardens internationally. To address this ongoing lacuna, our research will expand on the previous work including surveying the gardens about the types of seeds stored, and the purpose of their seed saving, and how climate changes may be influencing their plant selection and growing practices. We have already found at least 40 more gardens were established since the previous study and, only two of the original gardens have closed, highlighting that community gardens are continuing in popularity in Australia. Additionally, previous research reviewed 65 articles and now we have 1090 articles published within Scopus and Web of Science, demonstrating a dramatic increase in literature. The research will also assess more in-depth the sociocultural practices relating to seed sharing and the diversity of what is grown and why.

Theme: Seeds in Culture & Society

Session 1

Paper ID: 95

The Australian Seed Bank Partnership and our new Partnership Strategy 2021-2030

Damian Wrigley[1]

[1] Australian Seed Bank Partnership

The past decade has seen the Australian Seed Bank Partnership mature from a diversified collective of seed banks collaborating on seed conservation and research to a formalised network providing policy and program advice and critical *ex situ* germplasm conservation outcomes to government, businesses and the community. The Partnership has collaborated on numerous projects over the past 10 years and this presentation will provide a summary of our collective achievements in seed conservation and our contributions to plant conservation both in Australia and overseas. The Australian Bushfires of 2019/2020 presented new opportunities for the Partnership to support seed collecting for new, genetically diverse and duplicate collections to bolster collections already held in seed banks. New projects are also supporting rapid flora assessments to determine bushfire impacts and species recovery with the intention of informing future seed conservation efforts and bushfire preparedness. The Partnership's work is also contributing to the development of new storage and germination protocols, including long term impacts of storage methods on the viability of not only seed, but in some cases the mycorrhizal fungi that they some species rely on to germinate. With the release of the new Partnership Strategy, future areas of focus will include expanding our efforts to improve collaborations with Traditional Owners and Indigenous land managers and prioritising species both for their inherent biodiversity value and for the risks they face from external threats and pressures. The new Partnership Strategy will guide our work for the next decade and provide our Partners, Associates and supporters with clear guidance for how we will continue to operate, as well as how we anticipate adapting our collaborative efforts to prepare for the future of plant conservation.

Theme: Seeds in Culture & Society

Session 1

Paper ID: 98

Do we need another network? Examining the potential for a new seed conservation network for Asia, Australia and the Pacific

Kate Hardwick[1]
Damian Wrigley, Aisyah Faruk[2] and Elinor Breman[1]

[1] Royal Botanic Gardens, Kew
[2] Australian National Botanic Gardens

It is sometimes said that the whole is worth more than the sum of its parts, but does this apply to the seed banks of Asia, Australia and Pacific? Covering a vast area of the world, including 15 biodiversity hotspots and numerous other high-conservation value areas, and experiencing rapid economic growth, the region has seen a recent surge in seed conservation. For example, during the last ten years, new seed banks have been set up in Thailand, Korea and Papua New Guinea, the national seed bank of Indonesia has expanded, and seed banks in Bhutan and Malaysia have broadened their scope from agricultural to native species. There is no doubt that all these initiatives play an invaluable role in safeguarding wild plant species from extinction and making native seeds available for conservation and research, but would their work be easier and more effective if they were part of a regional network? Would it complement or duplicate existing local and international networks? We examine the functions, structures and funding mechanisms of established global and regional seed conservation networks such as the European Native Seed Conservation Network (ENSCONET), IUCN's Seed Conservation Specialist Group, BGCI's Seed Conservation Network and indeed the Millennium Seed Bank and Australian Seed Bank Partnerships, and we ask the question, is a new, regional seed conservation network needed for Asia, Australia and the Pacific?

Posters

In addition to viewing the posters on the conference platform, delegates will have the option to browse the posters in the poster room on Gather Town at any time. A dedicated poster session has been scheduled for poster authors and delegates to meet and discuss the research presented.

Day: Tuesday 7th September 2021

Time (AEST): 1:30pm-2:00pm

Platform: Gather Town in the Poster Room (access details will be sent to delegates a few days prior)

Paper ID: 22

Seed storage behaviour and population of Javan betel nut (*Pinanga javana* Blume), an endemic palm tree from Java

Musyarofah Zuhri[1]
Zaenal Mutaqien[1], Risha Amilia Pratiwi[1], Dian Latifah[2] and Kate Hardwick[3]

[1] Research Center for Plant Conservation and Botanic Gardens - Indonesian Institute of Sciences (LIPI)
[2] Seed Bank of Research Center for Plant Conservation and Botanic Gardens - Indonesian Institute of Sciences (LIPI)
[3] Royal Botanic Gardens, Kew

Javan betel nut or *Pinanga javana* Blume is an endemic palm from Java and their existance in the wild is endangered based on 1997 IUCN Red List of Threatened Plants. Information of their storage behaviour and its population in the wild are clearly unknown. This research is to predict the desiccation sensitivity and to describe the population of *P. javana* in Selabintana, West Java. The desiccation sensitivity was predicted using both seed coat ratio (SCR) approach and 100-seed test covers fresh, desiccated, and moist-stored seeds. A total of fourteen sub-plots of 100x10 m^2 were established in Selabintana, West Java to record their population. The desiccation tolerance of *P. javana* was likely to be desiccation sensitive or recalcitrant using both SCR equation (P-value = 0.97 ± 0.02) and 100-seed test. Moreover, germination of fresh and moist-stored seed of *P. javana* were showed similar germination level and germination was failed after desiccation. The highest percent germination, i.e. 98.08 ± 3.85 reached by moist-stored control with a hundred percent of viability. Mean time to germination (MTG) for fresh, moist storage, and desiccation seeds were 34.65 ± 2.53, 17.01 ± 11.61 and zero respectively. Total individu *P. javana* in Selabintana was 2,230 with the highest number in seedling stage and concentrated in the middle of lengthwise transect. The density of seedling, juvenile and adult of *P. javana* were 14.66, 0.39, and 0.88 stem/ha respectively. Furthermore, our study demonstrated that understanding the seed storage behaviour of *P. javana* and its population provides better results for seed conservation strategies.

Paper ID: 26

Environmental effect on temporal patterns in lentil seed quality development

Katherine Whitehouse[1]
Sal Norton[1]

[1] Australian Grains Genebank

Seed quality is important for the long-term conservation of germplasm as it affects storage longevity in genebanks. The Australian Grains Genebank's (AGG) lentil collection contains approximately 5,328 accessions. It is one of our mandate crops and is widely distributed to research and breeding programmes, globally. Lentil produces orthodox seeds (i.e. they can tolerate desiccation to low moisture levels required for long-term storage at sub-zero temperatures) and are, therefore, expected to survive for a long period of time under genebank storage conditions. However, their inherent longevity is currently still unknown which makes it incredibly difficult for genebank managers to make decisions about the handling of their collections, including viability monitoring intervals and making timely regenerations. Other than inherent (genotypic) differences in longevity, the impact of the environment (humidity and temperature) affects both progression of seed quality through development as well as the end/maximum physiological quality. We decided to map the variation in temporal patterns of lentil seed quality development when grown across four different regeneration zones (glasshouse, big igloo, green igloo and cage) at the AGG in order to help shape our regeneration procedure and to ensure seeds are at their maximum quality, and thus, subsequent longevity, when placed into storage. This poster will outline some of the main results from this experiment.

Paper ID: 33

Unlocking the genetic potential of AGG germplasm to improve genebank conservation, management and accelerate genetic gain for crop improvement.

Sal Norton[1]
Mathew Hayden[2], Josquin Tibbets[2], Surya Kant[2] and Joe Panozzo[2]

[1] Australian Grains Genebank
[2] Agriculture Victoria

The Australian Grains Genebank (AGG) conserves a large collection of plant genetic resources (c. 165,000 accessions) for cereal, oilseed and pulse species of relevance to Australian grain growers. These genetic resources contain vital genetic diversity that has been lost through bottlenecks imposed by domestication and breeding and are used by Australia's plant researchers and breeders for new and novel traits for grain crop improvement. Traditionally, genebanks collect characterisation and evaluation data based on phenotype or physiological response to a biotic or abiotic stress. The collection of this data is highly labour intensive and can be influenced by environmental conditions, and therefore inconsistencies can occur due to the subjective nature of some characteristics. These characteristics are used by genebanks for validation of germplasm identity following regeneration, and by researchers and breeders to select accession for use. Generally, there is a lack of detailed characterisation data available for germplasm, which is a major impediment and cost for its utilisation by researchers and breeders. To address the lack of detailed characterisation data, the AGG is in the early stages of implementing high throughput phenotyping and genotyping technologies. These technologies have the potential to improve efficiencies of genebank activities by identifying duplications, accurately assess genetic diversity and trait identification, and the capture of quantitative phenotypic/physiological data. These technologies over time will enable the AGG to consolidate its collection through the removal of duplication and refocus resources towards the long-term conservation of germplasm with the widest range of diversity and traits. This will not only increase curation accuracy and efficiency of the AGG, it will also provide genebank users with enriched passport information that will improve breeding efficiencies within Australia, and potentially accelerate the production of more resilient grain crop varieties for Australia.

Paper ID: 65

Relationships between plant life-history traits and seed germination in native plant species of the Cumberland Plain Woodland

Philippa Alvarez[1]
Brad Murray[1], Cathy Offord[2] and Megan Murray[1]

[1] University of Technology Sydney
[2] Royal Botanic Gardens and Domain Trust

We examined relationships between life-history traits and patterns of seed germination in 15 native Australian plant species of fire-prone Cumberland Plain Woodland. We sought to understand how seed mass, seed dormancy, fire response, and life form underpin interspecific variation in germination onset, germination duration, and the total proportion of seed germination. Life form was shown to have the greatest impact on seed germination responses. Seed mass and dormancy also played an essential role in determining seed germination responses, whereas fire response had the least impact. In this presentation, I summarise the complex links between life-history traits and seed germination responses for these native Australian plant species.

Paper ID: 75

Achieving better outcomes from Seed Bank data management systems.

Anne Fuchs[1]
Lydia Guja[1,2], Tom North[2] and Amelia Stevens[2]

[1] Australian National Botanic Gardens/Centre for Australian National Biodiversity Research
[2] National Seed Bank, Australian National Botanic Gardens

There are many key activities that contribute to the successful management of a seed or gene bank. One such activity is data management. In undertaking research and collection management activities data is generated. It is the analysis and synthesis of this data which help answer the questions of how to achieve successful banking of seed, germination and breaking dormancy, supports the models for predicting climate adaptability and undertaking ecosystem restoration. This data encapsulates the knowledge and skills of the researchers, curators and technicians who contribute to it. In order to maximise the impact, data itself must follow the FAIR principles - be finable, accessible, interoperable and reusable. Furthermore, in a resource constrained environment organisations need to leverage skills in a collaborative way to avoid duplication of effort, provide timely outputs and maximise skills. The National Seed Bank systems have been developed with these principles and objectives in mind. This poster will present the approach and methods used to deliver better outcomes for the internal business systems and integration to national and international databases.

Paper ID: 77

Seed collecting of Crop Wild Relatives in Thailand under the Millennium Seed Bank (MSB), Royal Botanic Gardens, Kew.

Jakkrit Sreesaeng[1]
Pongsakorn Nitmee[1], Tossawat Pansomboon[2], Worapon Bannajit[1], Pongsak Kaewsri[1], Surasit Wongsatchanan[1], Pramote Triboun[2] and Kate Hardwick[3]

[1] Expert Centre of Innovative Agriculture (InnoAg), Thailand Institute of Scientific and Technological Research
[2] National Center for Genetic Engineering and Biotechnology (BIOTEC), National Science and Technology Development Agency (NSTDA)
[3] Royal Botanic Gardens, Kew

The main genetic diversity of Crop wild relatives was initiated to conserve and enhance food security. Seed collecting of Crop Wild Relatives (CWR) for seed bank in Thailand was initiated in 2017, while, Thailand Institute of Scientific and Technological Research (TISTR) was collaborated with Millennium Seed Bank (MSB), under the Royal Botanic Gardens, KEW, United Kingdom to develop the Collecting Thailand's crop wild relatives for *ex situ* conservation and use project. The objectives were studied the CWR species' distribution areas and seed collecting for seed bank at the MSB. The 3-years project during 2017-2019, which TISTR was collected and sent the collections of CWR seed to MSB about 65 accessions divided to 18 Genera. TISTR were sent CWR seed collections to MSB about 9, 21 and 35 accessions in 2017, 2018 and 2019, respectively. The minimum collections size were 250 seeds, 75% of the collections were larger than 1,000 seeds and 24% reached to the MSB's target size of 10,000 seeds. Although in the last 3 years, the seed bank operations and utilization of crop wild relatives, which operated by TISTR have not able to proceed with concrete. However, TISTR was constructed a seed bank (4 and -20 C°) at Lamtakhong Research Station for seed research and conservation. The main objectives are focus on the conservation of CWR species, edible species and medicinal plants in Thailand. In the future, the utilization of CWR seed collections might be used to pre-breeding program for germplasm and crop improvement.

Paper ID: 81

Challenges of seed banking in aseasonal tropics: Experiences from Singapore

Chow Khoon Yeo[1]

[1] National Parks Board

Since the Singapore Botanic Gardens Seed Bank became functional in July 2019, we have started collecting seeds of native species for seed storage behaviour study and seed banking. From our experience we considered some of the challenges of seed banking in the aseasonal tropics. Some challenges stem from the low population density and larger proportion of recalcitrant seeds. They could be addressed by pooling seeds across individuals and reproductive events and augmenting our practical knowledge in cryopreservation of recalcitrant seeds. Reproductive phenology in aseasonal tropics also tends to sub-annual and supra-annual periodicities. This leads to difficulties of allocating resources towards monitoring and collection of sporadic small events, versus processing, testing and storing of the overabundance from masting events. The latter could be managed by pooling resources with conservation collection and species reintroduction programmes. Severe population reduction owing to habitat loss and fragmentation leads to a multi-faceted problem that has to be addressed using the tools of population and spatial genetics. This informs us which populations should be sampled and how many seeds is enough. Landuse changes (landscape heterogeneity), reintroduction of locally extinct species, non-native cogenerics, and horticultural varieties of native species for managed landscapes, and the maintenance of living collections can affect gene flows among wild and cultivated plants, leading to hybridization, isolation, and unintended selection pressures. This needs to be monitored using tools of population genetics, when seeds are collected from the wild and conservation collections for the Seed Bank. While seed banking is an invaluable tool for species conservation, it does best complementing *in situ* conservation, habitat protection and restoration and species reintroduction. It should be done in concert with monitoring the source populations and the seeds coming into collection to minimize conflicts between these activities. With planning and monitoring, resources could be targeted to optimise the process.

Paper ID: 82

Ficus as a case study for seed banking

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Ficus is a keystone taxon with important mutualistic relationships with pollinators and vertebrate frugivorous, thus its conservation is important for the continued existence of other species. However, it is both a taxon suitable and unsuitable for seed banking as a method of conservation. As a subject of discussion, it could be instructional to consider what could be learnt. 1. Many *Ficus* species have orthodox seeds. Yet its many mutualistic relationships could not be preserved long-term in a medical freezer, a prime example being its mutualism with its agaonide pollinators. While growing *Ficus* from banked seed can regenerate a population of previously extinct plant, such a species would be for all practical considerations evolutionarily extinct without its pollinator. 2. The long-distance pollinator dispersal of *Ficus* leads one to expect low population differentiation, and therefore little spatial genetic structure. However, a number of species of *Ficus* shows the contrary. In these cases, it may still be important to collect from different populations. 3. The pollinator dispersal is dependent on prevailing wind conditions. Thus, the pollen sources, i.e. paternity of the seeds will be different, for different crops. This necessitate the collection of multiple crops to ensure that a sufficiently diverse set of seeds is stored. However, the work is simplified as each pollinated syconium can be considered an independent sample. 4. The effect of landscape heterogeneity is also currently not looked into. As the pollinator is wind dispersed, the difference in surface roughness has a bearing on how easily pollen flows across a landscape. This would in turn affect the geneflow between populations. Therefore, the characterization of populations before collecting seeds may be a way to target one's effort for maximum returns. This is important given the scale at which humans cause landscape changes and having unknown effects on population connectivity.

Paper ID: 107

Predicting seed lifespan for the improved curation of conservation seed banks

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The storage of seeds in seed banks is a primary strategy for plant conservation world-wide in the face of unprecedented biodiversity loss. For example, the Western Australian Seed Centre is responsible for >16,000 accessions of almost 4,000 wild species, including collections that represent the sole remaining wild populations of a species, or populations now extinct in the wild. As these seed collections continue to grow, their effective curation is an ever-increasing challenge. Identifying the storage behaviour and predicting the lifespan of seeds in storage for diverse wild species remains a key component of developing evidenced-based seed bank management practices. Our current research pursues the utility of techniques including respirometry and multispectral image analyses for non-destructively identifying viability decline, in concert with a focus on identifying and developing alternative seed storage procedures for problematic seeds within our collections. We are also exploring novel statistical methods for the analysis of seed storage data to characterise seed population response to time in storage and better predict viability decline. Our aim is to develop new high throughput technologies and data interrogation techniques to allow seed bank managers to more effectively triage and curate their seed collections to ensure irreplaceable collections are not lost and that viable seeds are available when required to support species and habitat restoration in the wild.

Paper ID: 113

History of seed collection, storage and use at the Royal Botanic Gardens and Domain Trust

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The knowledge and technology available to support seedbanking has developed considerably in the last 35 years, with common goals provided by the Global Strategy for Plant Conservation and funding through the Millennium Seed Bank Project and other initiatives. Changes at The Australian PlantBank - formerly the NSW SeedBank and now a component of the Australian Institute of Botanical Science - are one example of the parallel changes in purpose and mission to collect wild species. Our target species have changed over time: initially curating collections for the development of the Australian Botanic Garden, Mount Annan; expanding to include conservation of threatened species; and more recently, addressing the challenges of conserving rainforest seeds and orchids using a variety of *ex situ* methods including cryopreservation. Current projects are supported by a range of partners, including the NSW Government's Saving our Species program[1], the Australian Seed Bank Partnership[2] and The Ian Potter Foundation[3]. With an increasing quantity and diversity of seed collections in storage, comes the challenge of curating existing collections so they are available in coming decades. Management action taken now depends on collection quality and quantity, which has been influenced by the seed drying and storage conditions and associated technology available at the time of collection. This poster describes advances in seed drying, storage conditions, supporting technology and the changing mission, targets and outputs of the *ex situ* conservation program, which is a key focus of the Australian Institute of Botanical Science[4].

[1] https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/saving-our-species-program

[2] https://www.seedpartnership.org.au/

[3] https://www.ianpotter.org.au/

[4] https://www.rbgsyd.nsw.gov.au/science/australian-institute-of-botanical-science

Paper ID: 114

Seed morphometry of associated species of *Musa acuminata* in Bromo Tengger Semeru National Park, East Java, Indonesia

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The morphological characters of seeds can be distinguished qualitatively and quantitatively. Both are used to support the identification and classification process for taxonomy purposes. Quantitative characters or numeric characters i.e. seed morphometry are rarely used in seed identification. The purpose of this study was to determine the morphometric characteristics of the seeds that were most influential in the identification process. The seeds used were those associated species of *Musa acuminata* from Bromo Tengger Semeru National Park. The method used was length, width, thickness, and weight measurement, eccentricity index and flatness index (FI) determination as well as color, texture and shape observation of seeds of 12 species. The color, texture and surface characters of the seeds were converted into numerical characters through scoring. Data were analyzed by PCA and cluster analysis using PAST ver.3.0. The results showed that there were three groupings of seeds of associated species of *M. acuminata* from BTSNP based on the influencing morphometric characters, i.e. species group which was influenced by the color, weight and texture characters; species group which was influenced by length, width, thickness and FI characters; and species group which was not influenced by all characters. The grouping of *Zapoteca tetragona*, *Amaracarpus* sp., *Bryonopsis laciniosa* and *Eumachia montana* was different from other species because their length, width, thickness and FI values characters were significant. Thus, numeric characters can be used as one of the supporting characters in the species grouping process.

Paper ID: 118

Desiccation tolerance of seeds and germination characteristics of tree species growing in the Ryukyu Islands, Japan

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The Ryukyu Islands are one of the most biologically diverse areas in Japan, with a high percentage of endangered and endemic species as well as a large number of species belonging to various taxonomic groups. For these reasons, this area is expected to be registered as a World Natural Heritage site by International Union for Conservation of Nature (IUCN) in 2021. Ex-situ conservation is important for preserving current biodiversity and diverse genetic resources. In particular, seed banks are one of the most effective ways to conserve the forest's genetic resources in a limited space. However, there is still limited information on the desiccation tolerance of seeds, which is a key factor in the feasibility of seed bank conservation. In addition, details regarding the germination conditions of many tree species, especially those in the tropics, are also limited. In this study, we investigated the desiccation tolerance and germination characteristics of seeds of tree species growing in Iriomote Island, one of the Ryukyu Islands. First, we examined seed viability before and after desiccation by Triphenyl tetrazolium chloride (TTC) staining. We found that the viability of 3 out of 28 species decreased after desiccation, suggesting that these 3 species are recalcitrant seeds without desiccation tolerance. Furthermore, germination experiments were conducted in an incubator on 23 tree species from which sufficient seeds could be collected, and germination was observed in 19 species. The speed of germination was different among the species, and the final germination rate also varied. The remaining four species did not germinate even after 6 weeks. Many of these seeds were healthy when cut and were therefore considered dormant. Some treatment may be necessary for the germination of these species. It is necessary to investigate appropriate storage and germination conditions for these species in the future.

Paper ID: 120

Germination and emergence of Australian alpine seeds in response to fire cues

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Seeds of many species found in fire-prone ecosystems across Australia increase their germination in response to heat and smoke. This strategy, often resulting in a mass recruitment of seedlings post-fire, allows seedlings to grow at an opportune time when there is less competition for light and resources. The Australian Alps bioregion is unusual among the world's alpine areas in that widespread fires occur approximately every 50-150 years, including in areas above the tree line. Studies have addressed fire stimulated germination in many ecosystems across Australia, yet knowledge about how Australian alpine species respond to fire is lacking. Presumably, some Australian alpine species may have adapted to increase their germination in response to fire cues. In the aftermath of the 2019/2020 bushfires, we investigated whether fire promotes the germination and seedling emergence of alpine grassland species in the Australian Alps. We used a soil seedbank experiment to compare the diversity and abundance of seedlings emerging from burnt and unburnt soil collected in the high country. A factorial, laboratory-based germination experiment was used to directly assess how alpine and subalpine grassland species respond to heat and smoke fire cues. Preliminary data from the soil seedbank experiment indicates high variability in seedling emergence and abundance across sites. The germination experiment results show that high-country species have diverse, and sometimes surprising, responses to fire cues. This investigation will improve our understanding of fundamental alpine ecology and provide insight into germination requirements, and future management of alpine plant communities.

Paper ID: 123

Seed banking the cloud forests: *Ex situ* conservation of climate-vulnerable Australian tropical mountaintop flora

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Globally, tropical mountain cloud forests (TMCF) are recognised as critically threatened by climate change. In Australia, TMCF is restricted to the Wet Tropics World Heritage Area of northeast Queensland and contain over 70 vulnerable, endemic plant species. Modelling studies predict suitable TMCF habitat will decline by at least 60 % for 37 species and will be eliminated altogether for seven species by 2085. Seed banking provides an *ex situ* conservation tool for safeguarding plant germplasm into the future. However, seed banking efforts to date have focused on the world's dryland flora, species endemic to temperate climates and species with orthodox seed. Little is known about the suitability of seed banking for conserving TMCF species, or the germination techniques required to regenerate stored seed. With this review, we explore the application of *ex situ* conservation activities to mitigate species extinction in Australia's TMCF. To support this action, we cite data from seed literature from similar plant communities around the world. In particular we review approaches to sourcing and collecting seeds in remote tropical areas and examine what is currently known about the storage behaviour and germination requirements of TMCF seeds. We also identify challenges and opportunities associated with preserving TMCF plant biodiversity and highlight seed biology research gaps that are of high conservation priority. Ultimately, we argue that *ex situ* conservation presents a time- and cost-effective approach that compliments *in situ* efforts for this unique and fragile flora and introduce a multi-organisational project currently securing seed of these climate-threatened communities and carrying out associated research.

Paper ID: 124

Seed longevity of southeastern Australian grassy ecosystem species

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Australian temperate grassy ecosystems have been subjected to severe ecological alteration and degradation since European colonisation. Less than 10% of temperate grassy ecosystems remain today and these plant communities are currently listed as endangered or critically endangered. *Ex situ* seed banking can safeguard species against extinction and is being utilised to secure grassy ecosystem species. Effective management of seed bank collections requires insight into seed longevity. However, seed longevity of most grassy ecosystem species is unknown. Comparative longevity can be assessed through artificial ageing experiments. This method requires protocols to elicit high germination for every study species, but the germination requirements of many grassy ecosystem species are also unknown. We used an artificial ageing experiment to investigate comparative seed longevity of >60 species found within southeastern Australian temperate grassy ecosystems. Where germination requirements were unknown, seeds were subjected to a variety of pre-treatments to determine the most effective species-specific germination method. Seeds were then subjected to a regulated climate of 45°C and 60% relative humidity for 250 days and removed at regular intervals for germination testing to determine the time taken for seed viability to decline by 50%. We also explored seed and plant characteristics that may be associated with seed longevity including seed mass, dormancy type, embryo type, endospermy, life-form and life strategy. Results to date indicate that viability decline is variable among grassy ecosystem species and that endospermic seeds are shorter-lived compared to non-endospermic seeds. We expect that by the conclusion of the experiment we may find temperate grassy ecosystem seeds to be short-lived compared to general Australian species, but longer-lived than Australian alpine species. Findings have implications for the long-term conservation of Australian grassy ecosystem species and provide insight into soil seed bank dynamics and plant recruitment *in situ*.

Paper ID: 126

Tracing the Origin of Native Seed/SEARCH Across Political, Social, Organizational, and Cultural Geographies

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Native Seed/SEARCH (NS/S) is a seed bank and non-profit organization located in Tucson, Arizona. The mission of Native Seed/SEARCH is dedicated to conserving the seeds of arid-adapted crops native to the southwestern United States and northern Mexico for the purposes of preserving crop diversity, enhancing sustainable agriculture, and improving food security. Founded in 1983, NS/S was the brainchild of a group of ethnobotanists and archaeologists associated with the University of Arizona's Arid Lands Studies program. At the time of NS/S inception, the founders were employed by Meals for Millions, a community development organization distributing seeds, including modern hybrid broccoli and brussels sprouts, to local Indigenous farmers as part of a US Department of Agriculture food security program. In the early 1980s, Southwestern farmers participating in the Meals for Millions program began to request seeds they knew to be more suitable for the Sonoran Desert. However, most of the requested varieties could only be sourced from isolated communities of northern Mexico and this posed a problem for Meals for Millions as the organization was only allowed to distribute seeds produced within the United States. In resolving this issue NS/S was born. This poster presents a visual and textual representation of NS/S's origins to analyse how the mismatch between national-political, cultural and botanical boundaries gives rise to new organizational forms and ethnobotanical practices. In doing so, the poster reveals how, on the one hand, the US-Mexico international border has increasingly functioned to restrict the circulation and distribution of native seeds, while on the other hand, social and academic networks have worked to erase these limits. The need to transcend multiple boundaries and reshape social networks produced NS/S, a new community seed bank, that, in turn, both joined and influenced the development of southern Arizona's vibrant native foods culture.

Paper ID: 133

Seed-based conservation of Norfolk Island's rare and endemic plants

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Habitat restoration is key to preserving biodiversity and preventing extinctions. Flora extinctions are of global concern as native plant communities provide invaluable ecosystem and economic services yet are disappearing rapidly. Plant species with small populations, limited geographic range, and low genetic diversity are particularly vulnerable. Islands have a high degree of endemism as well as a high proportion of the world's extinctions, primarily due to habitat loss and invasive species. A lack of recruitment in insular plant populations means their persistence largely depends on conservation and restoration efforts. Norfolk Island is a remote subtropical island in the South Pacific, with 33 EPBC listed endemic plant species. This island has been subjected to deforestation and biological invasions since European settlement, resulting in a decline of native plant communities and the extinction of native plant species. Restoration is a vital intervention to reduce an extinction debt in extant plant populations experiencing low recruitment and has already been effective in rescuing some of Norfolk Island's most endangered plant species from extinction. The success of these propagation efforts has led to increased plant propagation programs and a greater diversity of native species being used in restoration, amenity plantings, and private gardens across Norfolk Island and beyond. We present a new book, providing a consolidated resource summarising seed collection and propagation insights developed by researchers, practitioners, and local gardeners over many years. This resource helps set the direction for further research into the seed ecology of Norfolk Island's native species to optimise germination success, improve seedling establishment, and expand seed-based restoration efforts.