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North Carolina Botanic Gardens (NCBG) intern Joshua Pil collects seeds of *Geum geniculatum* (bent avens) along a high elevation stream as part of the CPC seed longevity study.

Photo: Michael Kunz, NCBG

Using RNA as a next-generation metric of seed health in the wild rare plants of the United States

K. Heineman (Center for Plant Conservation, USA)

Seed banking is a technique that allows an enormous diversity of plant species to be conserved for decades, if not centuries.

However, huge variation exists among species in terms of how long seeds can safely remain viable in a traditional seed bank, and as the practice matures, we suspect more and more collections may be reaching their 'expiration date'. To address this matter, the Center for Plant Conservation (CPC), its network of botanic gardens and the US National Laboratory for Genetic Resources and Preservation (USDA-NLGRP) are studying a new way to track ageing rates of seeds from wild rare plant species. This study, funded by the Institute for Museum and Library Services, applies a ribonucleic acid (RNA) integrity number (RIN) as a metric for seed ageing, initially demonstrated for crop species. RNA integrity relates to the structure of RNA molecules, where higher numbers equate to more intact or 'healthy' seeds. CPC's partner gardens re-collected seeds from accessions aged 15+ years in seed banks to compare the RIN and germination-based viability in 100 wild rare plant species from both the continental US and Hawaii. The species included in this study were selected to test long-held hypotheses about how species adapt to their environment and how their evolutionary history affects their longevity in *ex situ* seed storage. RIN-based estimates of seed ageing may have the potential to lend insights that can be difficult to discern from germination-based testing alone. Whether or not a seed

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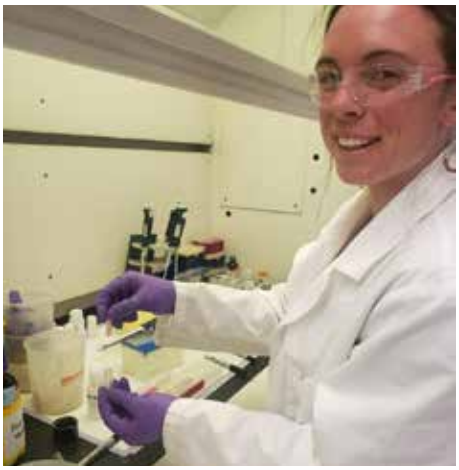

Photo: Lisa Hill, USDA-ARS NLGRP

Zoe Zingerman extracting RNA from seed for the CPC seed longevity study.

MILLENNIUM SEED BANK PARTNERSHIP

Royal Botanic Gardens Kew

Photo: Michael Kunz, NCBG

Mature seeds of *Geum geniculatum* (bent avens) collected for the CPC seed longevity study by NCBG.

germinates is obviously a critical measure of seed health, but just because a seed doesn't germinate, it doesn't mean that it's not alive or healthy: seeds are often dormant with unknown or difficult to replicate germination requirements, whereas RIN can be measured regardless of whether the germination requirements of a seed are known.

Early results indicate that declines in seed RIN over time appear to correlate with declines in germination, suggesting that RIN is a promising method for detecting seed health in native endangered species. Furthermore, we have found that woody species and plant species with lower latitude distributions produce seeds with lower initial RIN and faster rates of RIN decay in *ex situ* collection compared to herbaceous species and species with more northerly distributions. Our next step is to create a model that leverages the insights from the study species to estimate species-specific 'expiration dates' for seed lots currently in the collection, given ecological inputs such as life form, geographic coordinates and seed mass. Our hope is that practitioners can use this information to efficiently re-collect or regenerate irreplaceable seeds in their care. In fact, one of the most important benefits of this study is that it has given partners a funding opportunity to revisit and re-collect populations with ageing seed collections, thereby reducing extinction risk for these plants for years to come.

A message from Dr Elinor Breman

Senior Research Leader Seed Conservation, RBG Kew

It is great to see this issue of Samara focusing on seed conservation innovations. At a time when 45% of the world's flowering plants are faced with extinction, the need for seed conservation has never been greater. This, combined with the increased demand for seeds from native plants to support plant reinforcements, reintroductions and restoration, means that we need to innovate in the ways that we work with seeds.

How do we innovate to determine what species to prioritise for conservation, given limited resources and a lack of time? We need to ensure that existing datasets for conservation seed collections are brought together, and that this data is used with distribution data to determine which species need collecting and from where. We can also include other layers, such as climate change scenarios, to identify the areas at the greatest risk. While these questions are not new, the methods available to answer them have moved forward, with new modelling and artificial intelligence (AI) techniques meaning that we are closer to answering them than we have been before. Using these new technologies also helps to answer the question at a range of scales – from a country to a global level – and for a range of purposes, such as crop wild relatives, threatened species, medicinal plants, and so on.

Kew is about to embark on a new project to develop and deliver a global data portal to aggregate information on wild-origin seed collections, together with information on their quality and the quantity of seeds held. The platform, SeedPOD, will also host a seed ordering system, enabling more institutes around the world to provide seeds for use.

Once we have collected our seeds, we are still continually learning the best ways to handle them and ensure we maintain their high quality, and thus longevity, in storage. Several of the articles in this edition highlight innovations that are being made around the world in seed cleaning and in longevity and germination experiments. It is great to see this application of new techniques moving species conservation forward.

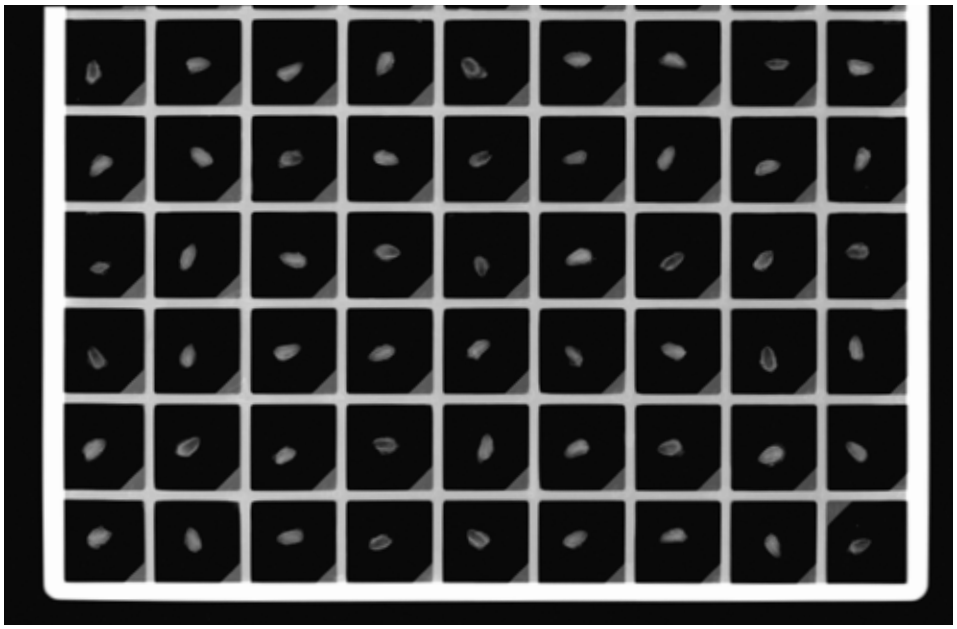

Photo: Pablo Gómez-Barreiro

Radiograph of *Juniperus communis* seeds. Scientists at Kew are studying this and other UK native species to understand their complex dormancy and germination behaviours and identify morphological traits which could be used to inform optical seed sorters. Working with industry partners (Elsoms Trees Ltd., Elsoms Seeds Ltd.), scientists aim to improve the quality and germinability of commercially available tree seed for restoration uses.

As a community, we have refined the traditional seed banking process and we now better understand how to optimise our work with orthodox seeded species, but we still have a long way to go in other areas of plant conservation. We need to innovate in our conservation of species that fall into the 'exceptional' category (plants that don't produce seeds, or have seeds that are sensitive to drying, or are short-lived in –20°C storage, or possess deep dormancy requiring unconventional recovery methods). To enable this, we need to develop our research and training capacity in cryobiotechnology and innovate in the storage of these species – including going beyond seed banking and working with other propagules.

It is vital that we continue to share our successes and failures as we experiment with new ways of working. As a community, we are innovating on a daily basis, and only by letting others know what we have achieved – and just as importantly, what has not worked – can we learn from others and continue to make advances at the pace needed to address the challenges we are facing.

Seed collection and conservation upstream of the Brantas river watershed

E.R. Firdiana, E. Renjana & L.W. Ningrum (National Research and Innovation Agency – BRIN, Indonesia)

The Brantas River is the longest river in East Java, Indonesia and it plays a crucial role in the provision of water for drinking, industry and irrigation, and hydroelectric power generation. The river consists of riparian, wetland and aquatic areas, which each provide important ecological and hydrological functions such as flood control, flora and fauna conservation, edge stabilisation and water quality improvement. However, these areas are directly affected by development such as land conversion, canalisation and dam construction.

Considering the importance of conserving the area around the Brantas River, we carried out an expedition upstream of the Brantas River watershed. We aimed to collect and conserve riparian and wetland plant seeds which, when used in restoration, have the potential to maintain the environment of the Brantas River. We focused on points in the upstream area of the Brantas watershed, covering three administrative regions: Batu City, Malang Regency and Blitar Regency.

The expedition took place in the rainy season. On almost every day of our fieldwork, we were challenged by heavy rain when collecting specimens and recording data. Some locations were steep and slippery (Figure 2) and we had to hold on to each other to make sure that we were safe and would not fall into the ravines. There were times when we had to use walking sticks. It was also hard to record the data completely underneath a raincoat.

Fig. 1: Collecting specimens in the rain.

Fig. 2: Collecting specimens in the rain.

Fig. 3: *Zapoteca tetragona* in its natural habitat.

Fig. 4: *Leucaena pulverulenta* in its natural habitat.

Photos: Elga Renjana

Another challenge was that we had to find plants that bear fruit all year round, since during the rainy season, the fruiting season of most plants has passed. Luckily, we managed to collect and conserve seeds of 15 species. Interestingly, seven of them were Fabaceae. Some Fabaceae species seemed to be abundant in certain watershed areas. *Zapoteca tetragona*, or kaliandra putih as the local people call it, was abundant in Kepanjen, Malang Regency and *Leucaena pulverulenta* in Bumiaji, Batu City. With the large number of saplings around the mature plants, it is reasonable to assume that these two populations are increasing. They were all located on steep slopes on the riverbanks and appeared to have a very important function in retaining the land to prevent landslides (Figure 3).

In addition to plants belonging to the Fabaceae plant family, we also succeeded in collecting seeds from Malvaceae, Petiveriaceae, Asteraceae, Solanaceae, Lamiaceae and Convolvulaceae families. All seeds collected were obtained from wild plants and are of various shapes and sizes. Surprisingly, we found that all of them had orthodox seeds, despite aquatic plants' common recalcitrant seed behaviour.

We also assessed the quality of river water using a water test strip. In general, river water quality at the three points sampled was relatively good. Most of the pollution indicators were either not detected or were detected at low concentrations, for example in Batu City, which is the location of Brantas river springs. However, as we made our way downstream, pollutant levels increased along with the increase in human activity.

Fig. 5: Seeds of *Verbena* species.

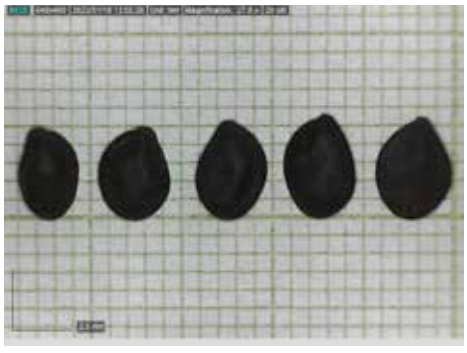

Fig. 6: Seeds of *Zapoteca tetragona*.

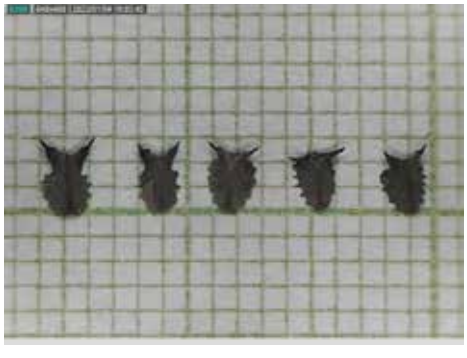

Fig. 7: Seeds of *Sida acuta*.

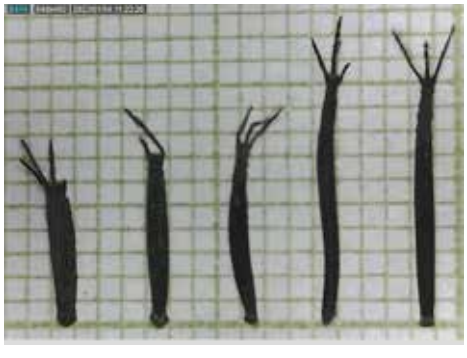

Fig. 8: Seeds of *Bidens pilosa*.

Photos: Elga Renjana

Searching for the best techniques for seed cleaning of *Sesamum forbesii* (Decne.) Byng & Christenh., a near-endemic species from Mozambique and South Africa

C.J. Chirinzane Manhiça (Agricultural Research Institute of Mozambique – IIAM) & J. Osborne (RBG Kew)

***Sesamum forbesii* is a near-endemic species in the sesame plant family (Pedaliaceae). It occurs in the Maputaland centre of plant endemism and is only found in Maputo Province in Mozambique and KwaZulu-Natal in South Africa. In Mozambique, the plant is used as a natural shampoo, a soap for washing babies and a medicine to treat fevers in babies. In 2022, as part of the MSBP collecting programme, we collected the fruits of this species for long-term conservation for the first time.**

Fig. 1: A cut-test of a fresh *Sesamum forbesii* fruit, with the two thorn-like tips visible.

How to clean/process the *Sesamum* seeds

Processing the fruits of this species was a big challenge. They have two thorn-like tips (Figure 1), which become so hard when ripe (indicated by the brown fruit colour) that they can easily penetrate human boots, animal feet and vehicle tyres. The fruits are naturally dispersed this way and they eventually break open, aided by the mechanical action of animal trampling, which releases the seeds. As can been seen in Figure 2, we tried using many different tools to extract the seeds from inside the fruits (such as a hammer, secateurs, table knife and nail cutter). In the end, we found that the best technique for processing *Sesamum forbesii* is to partially break open the fruits using a hammer (carefully!), use a nail cutter to cut the remaining fruit coat, and then take out the eight small black seeds with forceps or the end of a corkscrew.

While it is possible to store the seeds inside their dry fruits, cleaning the seeds saves valuable space in our seed bank freezers.

Photos: Cacilda Manhiça

Fig. 2: Processing S. *forbesii* using different tools to find the best technique.

Improved techniques for seed cleaning of *Pterocarpus angolensis* DC.

C. Manhiça (Agricultural Research Institute of Mozambique – IIAM) & J. Osborne (RBG Kew)

***Pterocarpus angolensis* is a deciduous tree in the legume family that produces good quality wood used for the manufacture of high-end furniture (tables, chairs, doors, cupboards, and so on). The fruits are unusual, winged, circular, indehiscent pods containing one or two seeds. The pods are thickened and covered with long bristles in the centre, making seed cleaning very difficult.**

In November 2022, a Seed Conservation Techniques (SCT) course was held in Mozambique, with four participants from the South African National Biodiversity Institute (SANBI) and 11 from Mozambique. During the practical sessions, one of the challenges was to find the best method for seed processing and cleaning of different native species. A group led by Naomi Mdayi from SANBI attempted to find the best method for cleaning the *P. angolensis* seeds.

They started cleaning and it was so difficult that they decided to go outside the laboratory to search for a good method (Figure 1). After 25 minutes, they had extracted only four damaged seeds. They agreed it was a challenge that would need more research!

After careful research, the IIAM team have now discovered the best technique for cleaning and processing the *P. angolensis* seeds without suffering from the bristles or damaging the seeds.

1. **Soak the pods in water for 10 minutes to soften the thick outer tissue.**
2. **Using leather gloves and secateurs, cut the pods to take out the seeds (very carefully to avoid cutting the seeds).**
3. **Use forceps to take out the seeds (Figure 2).**

It is necessary to clean the seeds of this species because the pods are very bulky and would take up valuable storage space in the seed bank freezers.

Fig. 1: The pile of *P. angolensis* pods ready for processing.

Photos: Cacilda Manhiça

Fig. 2: Laura Fumo (left) and Carlota Nhamtumbo (right) from IIAM staff processing the *P. angolensis* seeds using water (bucket), leather gloves, secateurs and forceps to take out the seeds.

Seed storage: a low-cost solution for *Ochlandra* bamboo species

B. Gopakumar, A. Dhyani & M. Dan (Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Kerala, India)

Fruits of *Ochlandra travancorica* desiccated to a critical moisture content in a well-ventilated room.

Photos: B. Gopakumar

Fruits of *Ochlandra travancorica* preserved in sand and soil, sealed in a bottle for storage.

***Ochlandra travancorica* and *Ochlandra wightii* are endemic reed bamboo species in the southern Western Ghats of India. The species are a vital resource for the paper and pulp industry. These species exhibit monocarpic behaviour, naturally regenerating through seeding at intervals exceeding 30 years.**

To better understand seed storage, ripe fruits from both species were directly collected from the parent plants. These fruits were placed on the floor of a well-ventilated room for a few days until their outer surface began to wrinkle. Subsequently, these fruits were used for the storage study. Our preliminary research revealed that the recalcitrant seeds of these bamboo species remain viable for only three months at 20°C.

To find a cost-effective and accessible seed storage technique for the general public, we explored the use of dry soil and sand, known for their seed-preserving properties. River sand and black topsoil were collected and sieved with a high mesh size to eliminate large stones and debris. The media were then transferred to aluminium trays and heated over a flame at 120°C for 30 minutes. Once dried, the media were allowed to cool in a desiccator/closed vessel at room temperature. We used the cooled river sand and topsoil to store the fruits of both *Ochlandra* species. The fruits were placed in polycarbonate bottles immersed in the sand/soil to ensure even distribution. Each bottle was securely sealed and labelled. These bottles were stored inside a steel cupboard at ambient room temperature (25 ± 2°C).

The results demonstrated that this seed storage method effectively extended the storage life of *Ochlandra* bamboo species fruits to seven to eight months, offering an accessible and affordable solution for the general public. This technique eliminates the need for specialized laboratory facilities or expensive chemicals. The use of heated, dried soil/river sand to extend the storage life of *O. travancorica* and *O. wightii* fruits represents a novel and cost-effective approach.

Challenges for *Hopea odorata* Roxb. cryopreservation techniques

L.A. Rohmah (Universitas Muhammadiyah Lamongan, Jl. Raya Plalangan Indonesia)

Hopea odorata Roxb. is one of the species from the Dipterocarpaceae family and is globally assessed as Vulnerable to extinction. According to an assessment for the International Union for Conservation of Nature (IUCN), the global population of *H. odorata* is estimated to have decreased by 30–50% due to deforestation and the exploitation of its wood and resin (Ly *et al*., 2017). In Indonesia, *H. odorata* is widely known as a type of wood-producing plant and is locally referred to by its vernacular name, merawan. This species is classed as a productive plant because it has a fast growth rate, it reaches harvest time within 25 years (diameter 53 cm) and it has a survival rate of almost 100%.

The use of *H. odorata* needs to be balanced with efforts to ensure the availability of seeds in adequate quantities and at useful times. Unfortunately, *H. odorata* seeds are recalcitrant and show a rapid decline in viability because they are very sensitive to desiccation. Therefore, cryopreservation is regarded as a good solution for storing *H. odorata* seeds for long-term *ex situ* conservation preservation.

Hopea odorata seeds.

H. odorata cryopreservation research has been attempted using plant vitrification solution (PVS) using mannitol (PVS-1) and a mix of dimethyl sulfide (DMSO) 15%, ethylene glycol 15% and glycerol 30% (PVS-2) (Rohmah *et al*., 2022). The results of the study show that PVS-1 suppresses the amount of total malondialdehyde compared to PVS-2, but none of the cryoprotectant treatments were effective in increasing the viability of *H. odorata* after it was stored in liquid nitrogen.

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Photos: Laila Ainur Rohmah

Hopea odorata.

Measuring climate risks for seed germination in the Mediterranean Basin

D.M. Cruz Tejada (University of Pisa), E. Mattana (RBG Kew), E. Fernández-Pascual (University of Oviedo) & A. Carta (University of Pisa).

Despite historical and future challenges for plant conservation and ecological restoration in the Mediterranean Basin (Mattana *et al.*, 2022), germination data for this region is still difficult to access (Fernández-Pascual *et al.*, 2023).

Therefore, as part of a PhD project at the University of Pisa that involves identifying native plants of the Mediterranean Basin that have a germination niche compatible with future climate change, we are developing MedGermDB, the first open-access database of seed germination records for the Mediterranean Basin. Whilst building MedGermDB, we are also developing a new systematic approach for the automatic identification and compilation of literature sources on seed germination.

The current version of MedGermDB will offer germination data for dominant and specialist species of the Mediterranean habitats as defined in the pan-European EUNIS habitat classification (Chytrý *et al.*, 2020). MedGermDB will contain records of germination under controlled laboratory conditions, using different incubation temperatures, dormancy-breaking treatments, and photoperiods. Records have been tested for their representativeness of the whole scope of Mediterranean habitats and phylogenetic plant clades.

The application of recent advances in phylogenetic meta-analysis (Carta *et al.*, 2022) to MedGermDB will allow us to identify and understand germination patterns at the species and above-species levels. We will be able to model species' thermal limits for seed germination and to measure the seed germination risk under current and future climatic scenarios (Sentinella *et al.*, 2020). This PhD project will contribute to global efforts in aggregating germination data, and will serve as a knowledge backbone for successful seed-based conservation and climate-smart ecological restoration (Mattana *et al.*, 2023).

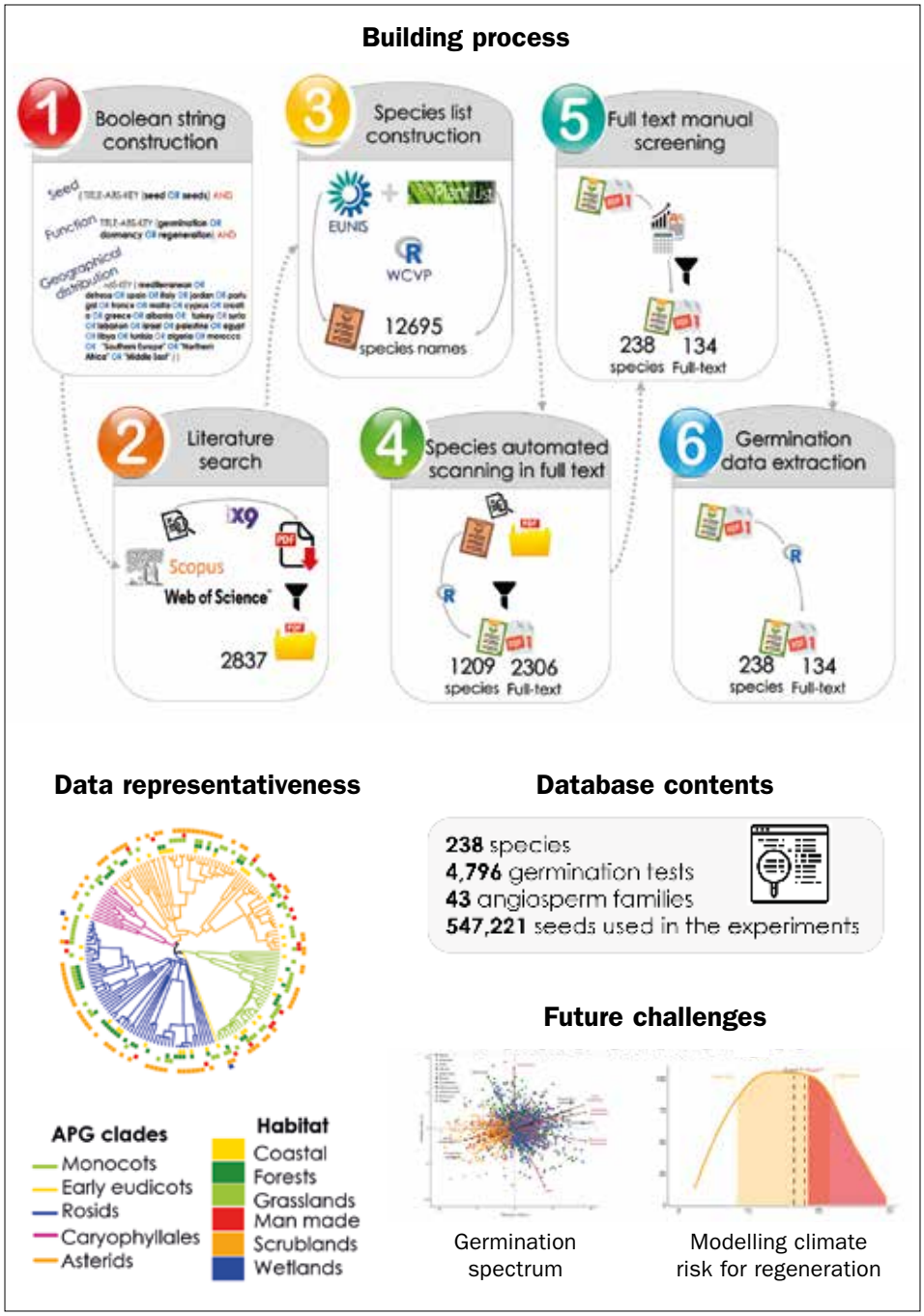

Image: Diana Maria Cruz Tejada, Efisio Mattana, Eduardo Fernández-Pascual & Angelino Carta

MedGermDB database development process.

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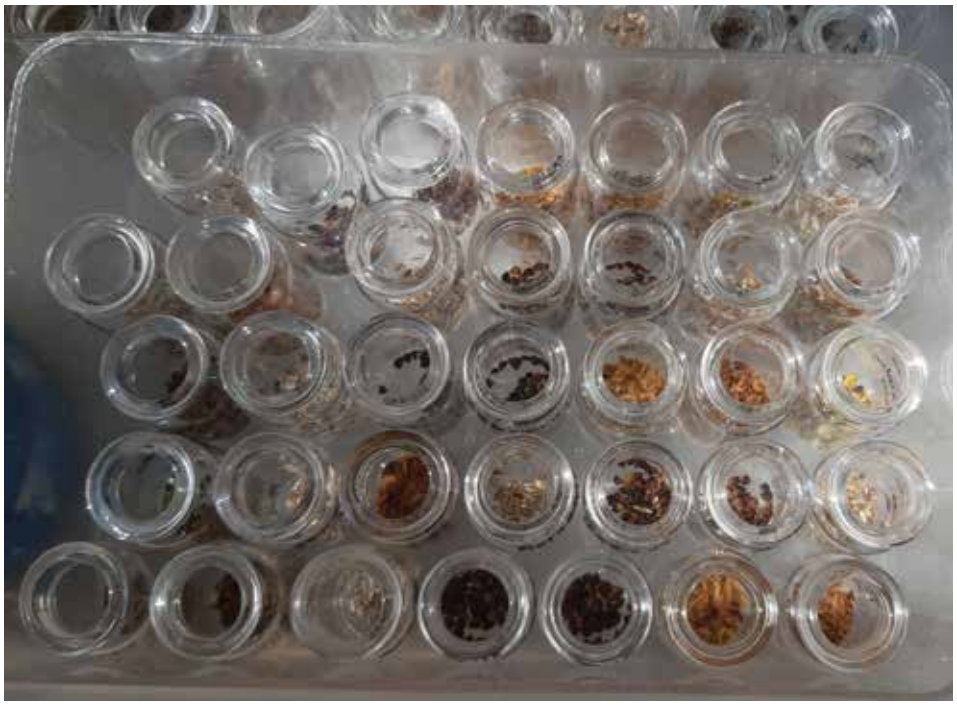
An analysis of seed longevity under differing storage conditions

I. Negri (RBG Kew)

Orthodox seeds must be dried and cooled in order to maximise their lifespan. In particular, Harrington's rule states that for every increase of 5°C, or 1% seed moisture content, the lifespan of the seeds is halved. However, native seeds produced for restoration purposes are sometimes still stored in suboptimal conditions – for instance, in a barn or warehouse, where temperature and humidity are not controlled.



Photos: Isabel Negri

Fig. 1: Samples of *Centaurea nigra* (lesser knapweed), *Ranunculus acris* (meadow buttercup) and *Rhinanthus minor* (yellow rattle) seeds in glass vials ready for storage and germination testing.

For this reason, in 2013, MSB student intern Justin Byrne began investigating seed storage at ambient conditions, in comparison to storage at various controlled temperatures. He worked with seeds of three species often used in UK grassland restoration projects: *Centaurea nigra* (lesser knapweed), *Ranunculus acris* (meadow buttercup) and *Rhinanthus minor* (yellow rattle). The yellow rattle was of particular interest, since it is known to have a transient seed bank in the field.

As part of the research component of the UK Native Seed Hub project, since 2022, I have been adding to and expanding Justin's original investigations. Seed longevity is usually tested with a rapid ageing protocol, which consists of ageing seeds using extreme conditions (45°C and 60% relative humidity). Whilst this allows for a relatively rapid comparison of the longevity of different seed collections, there is evidence that the biochemical changes seen in seeds aged in this way differ from those seen in seeds stored for longer periods of time under suboptimal conditions (Stegner *et al*., 2022). I have been testing whether seed longevity differs between several collections of the species that Justin selected, by using the rapid ageing protocol and storing them in a barn and at three controlled temperatures in the lab.

Fig. 2: *Centaurea nigra* (lesser knapweed) seedlings on agar in one of the experimental germination tests.

The experiment is long-running and involves taking samples of seeds out of storage at set intervals for germination testing. I have been working with 15 collections and using four storage conditions plus a controlled ageing treatment. This means a total of 645 germination tests, or 1935 individual agar plates. Thankfully, I have had a lot of help with plating, scoring and cut-testing the seeds during busy times – special thanks for this go to interns Lola Andrews, Jamal Rowe-Habbari, and Leela Watt Poddar, as well as Chris Cockel, Jenny Peach and the rest of the UK team at the MSB.

The final date for sampling seeds from storage and germination testing will be 13 October 2023. By the time this article is published, I should have a complete dataset ready for analysis. The evidence uncovered will be useful to organisations such as the MSB in communicating the importance of good seed storage practices for restoration projects.

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The Global Tree Seed Bank: Unlocked – taking the MSBP into a new phase

C. Callow (RBG Kew)

From 2015 to 2023, we received three rounds of funding (£8 million in total) from the Garfield Weston Foundation to develop the Global Tree Seed Bank (GTSB) at the MSB and internationally. The Garfield Weston Foundation has now committed their largest grant yet to Kew – £5 million for a further three-year programme named the Global Tree Seed Bank: Unlocked.

Photo: Jo Osborne

Fig. 1: Miombo woodland on the São Sebastião Peninsula, Inhambane Province, Mozambique.

Working across 16 countries (Figure 2), the focus of the collecting branch of the programme will be to prioritise woody species which are threatened and under-represented in *ex situ* collections, particularly from Madagascar. Estimates vary, but at least 66.5% of Madagascar's tree species are now formally recognised as being threatened with extinction, with only 16% being found in *ex situ* collections. The critical level of threat facing the tree flora of Madagascar, combined with the team of experts based at the Kew Madagascar Conservation Centre (KMCC) and Kew's long history in the country, means that Kew is in a position to really make a difference.

Supporting the restoration of forests is the main focus of GTSB: Unlocked. Across the programme, initiatives are being developed to make multi-provenance collections of framework species; to support research into germination tolerances, climate envelopes, the conservation of exceptional species and population genetics; and to support the creation of restoration-ready collections. We will undertake nursery trials, develop propagation protocols, and aim to elucidate seed and plant traits that will predict the performance of different species in restoration projects. In some countries, research will be undertaken into the supply and demand for native tree species with a view to improving systems and removing bottlenecks. We want to investigate short-term storage of seeds at local seed hubs for use in restoration and to develop trials for different seed delivery methods.

Restoration and conservation do not work without the involvement of local people, and across GTSB: Unlocked, we will be working with local communities to maximise the impact of our work and ensure its sustainability after the end of the programme lifetime.

We are planning some exciting developments in our programme of training, to include new topics relating to restoration and cryopreservation and an innovative way to expand our offer (see separate article, pg. 12, for more detail).

Next steps

The GTSB: Unlocked will officially start on 1 January 2024. If you are interested in learning more about any of our work under this programme or in discussing a potential collaboration, we would be happy to hear from you. One of the excellent things about this programme is that it is pulling together colleagues from across Kew's science priorities, and from across partner countries, who all have their own specialism to focus on so that together we can deliver what we all agree is the most important work in the world!

Image: RBG Kew

Fig. 2: Global Tree Seed Bank partner countries in Phases 1 to 4.

Photo: Aisyah Faruk

Fig. 3: Tree seed collecting in Armenia.

Safeguarding rare plant seeds in the Western Ghats

A. Dhyani, K.C. Abinlal, S. Bindu & C. Anilkumar (Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Kerala, India)

The lush Western Ghats of Kerala, a UNESCO World Heritage site and a global biodiversity hotspot, house an array of endemic plant species. Among them, five International Union for Conservation of Nature (IUCN) Red Listed Critically Endangered trees and shrubs have become the focus of a conservation effort by the Jawaharlal Nehru Tropical Botanic Garden and Research Institute (JNTBGRI). These species are *Cinnamomum chemungianum*, *Dipterocarpus bourdillonii*, *Ixora johnsonii*, *Syzygium travancoricum* and *Utleria salicifolia*. These trees, unique to the Western Ghats, thrive amidst the complex hill systems of Pulikkayam, Nilgiris, Anaimalai, Palani, Agasthyamalai, Kalakkad, Palode, Chemunji, Kulathupuzha, Pamba and Nelliyampathy. These regions provide specialised habitats essential for the survival of these endemic plants.

JNTBGRI, with a legacy of four decades in exploring, collecting and preserving seeds from this region, was awarded project funding from the Global Botanic Garden Fund supported by Botanic Gardens Conservation International, UK. The project's primary goal was to collect and store seeds of these IUCN Red Listed Critically Endangered plants, aiming to enhance knowledge about seed conservation. The team conducted field surveys, collected seeds, analysed them for viability and moisture content, and stored them under various conditions. Through these storage studies, the team plans to not only preserve these endangered species but to also establish a strategy for conserving other endemic and threatened plants in the Western Ghats.

This initiative aligns with the Global Strategy for Plant Conservation, specifically Target 8, which emphasises the need to have at least 75% of threatened plant species in *ex situ* collections. Through meticulous fieldwork, JNTBGRI plans to identify, collect and bank the seeds of these endangered species, ensuring their genetic diversity for future recovery and restoration programmes. The seeds preserved in the JNTBGRI seed bank have a dual purpose, not only as a conservation measure, but also as a resource for reintroduction and restoration programmes, further bolstering the biodiversity of this ecologically significant region.

In essence, this project stands as a testament to the commitment of JNTBGRI in preserving the unique and endangered flora of the Western Ghats, ensuring that the natural heritage of this region continues to thrive for generations to come.

Seeds of *Ixora johnsonii*.

Seeds of *Dipterocarpus bourdillonii*.

Seedlings of *Dipterocarpus bourdillonii*.

Photos: K.C. Abinlal

The Mexican native trees database as a tool for research and project management: seed conservation, reforestation and livelihoods

M. Gianella, M. Way & T. Ulian (RBG Kew)

We present the Mexican tree programme database, a compilation of native tree species with a range of taxon-based biological characteristics and biodiversity attributes. It will support analysis and decision-making for the research and conservation programme led by the Royal Botanic Gardens, Kew and the National Autonomous University of Mexico (UNAM), in collaboration with the local NGO Pronatura Veracruz A.C. and the Institute of Ecology (INECOL A.C.) research centre.

Users outside the programme will likely find the data valuable for numerous purposes, such as restoration in natural and urban settings, landscape management, and species selection for conservation efforts. The database combines the data of 422 native tree species – focusing on the Veracruz area – in terms of taxonomy, conservation status, uses that are beneficial for livelihoods and plant or seed traits reported in the literature, captured from seed accessions and/or predicted by using a model. This data is linked to the seed data accessioned in the UNAM seed bank across projects involving seed conservation, plant propagation in Pronatura's nursery, research and planting. Examples of data compiled are seed storage behaviour, germination tests, information on seed and plant management to inform conservation and propagation, data on restoration and carbon capture, and potential impacts and benefits to local livelihoods.

The database is a collaborative tool used across the programme to monitor projects and to identify knowledge gaps to enable us to design proposals and conservation strategies. With this project, we aim to produce a comprehensive but dynamic summary of the most relevant plant traits of Mexican native trees for their sustainable use.

Quercus insignis M.Martens & Galeotti acorns.

Quercus insignis root length stages.

Quercus insignis seedlings.

Photos: RBG Kew

What's new in training?

Participants of a training attachment drying excised plant embryos in two flash dryers (lids removed) over silica beads as part of the preparation for cryopreservation.

Some of the participants of the online Seed Conservation training in September.

Photos: RBG Kew

Seed Conservation training has always been at the core of the Millennium Seed Bank Partnership and demand for it continues to increase. While training at the Millennium Seed Bank and at partner seed banks across the global network provides great learning opportunities to local participants, we are expanding our reach by offering online training courses to help those unable to travel or obtain a UK visa. Providing pre-recorded training sessions with captions, as well as transcripts of sessions that can be translated, allows trainees to take control of their learning. Students were given access to these resources during this year's Seed Conservation Techniques course, which took place online over two weeks in September.

Another development is the expansion in the subject matter covered. In November, we welcomed the participants for the first course in plant cryopreservation – theory and practice, which focused on approaches for the *ex situ* preservation of short lived and recalcitrant species through cryopreservation approaches such as embryonic axis, shoot tip and dormant bud cryopreservation, as well as preservation of pollen and fern and bryophyte spores (for details see website: https://www.kew.org/science/training-and-education/continuing-professional-development/plant-cryopreservation-theory-and-practice). Over the coming years, we plan to develop resources relevant to restoration, which will cover assessing the need for seed, sourcing suitable seed and using it effectively.

While providing direct training remains an important contribution to which Kew remains committed, it can't reach everyone interested in learning. Expanding the training materials available to the public by adding to our collection of technical information sheets provides concise best practice guidance. Translations of these documents allows us to extend our audience. The currently available resources can be found at: https://brahmsonline.kew.org/msbp/Training/Resources.

Another new initiative will be a focus on a 'train the trainer' provision, to support partners in providing high quality training to their staff or regional collaborators. This will include the generation of templates for training materials and resources for organising, delivering and evaluating local training events.

If you would like to hear about training opportunities or learn more about the initiatives mentioned above, please contact MSBTraining@kew.org.

At the MSB, we have recently changed our collection management database, and data management processes. Whilst this transition is still underway, we have paused the MSB reporting.

***Samara* editors**
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The next *Samara* will be an e-newsletter published in March 2024 at brahmsonline.kew.org/msbp/Samara/ENewsletter. If you have a story or publication you would like to share, please email the editorial team (samara@kew.org). The deadline for content is 16 February 2024.

Interns and students – we would like to hear from you!

Are you undertaking a research project? Would you like to interview someone within the seed conservation sector? Do you have a unique idea or perspective to share with the rest of the MSBP? Drop Alice an e-mail at samara@kew.org. The editors of the *Samara* e-newsletter will be on hand to help as needed, and content does not have to be submitted in English.

Please do share this opportunity with any students or interns within your organisations.

MSB intern Rowan Black presenting at a workshop.

Photo: Aisyah Faruk

New MSBP agreements

Country/territory	Partner	Start	Duration (years)
UK	Natural England & the National Trust	January 2023	23
UK	The Secretary of State for Environment, Food and Rural Affairs	April 2023	2
Azerbaijan	Institute of Botany, Azerbaijan National Academy of Sciences	September 2023	3
Australia	Royal Botanic Gardens Victoria	October 2023	5