

Samara

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Recording *Saussurea gnaphalodes* at 6,221 m asl.



Photo: GBOWS

Seed collecting on Mount Everest

Plants that grow at high elevations and in polar regions are usually some of the most sensitive to the impacts of climate change.

Yongjie GUO (Germplasm Bank of Wild Species, Kunming Institute of Botany, Chinese Academy of Sciences)

Mount Everest, the highest summit on Earth, is a hotspot for both mountaineers and scientists. To our current knowledge, human beings began to climb Mount Everest in 1921, and climbers discovered plant distributions in extreme altitude areas. One such climber was Eric Shipton, a famous British alpinist who collected *Saussurea*

gnaphalodes and *Lepidostemon everestianus* at the East Rongbuk Glacier of Mount Everest at ca. 6,400 metres above sea level (m asl) in 1935 – the highest elevation collection record for a seed plant in the world to date. These rare, high-elevation plants could be threatened by popular climbing activities, as well as by climate change.

In order to understand and monitor alpine plants at risk from climate change and human activities at extreme high elevation, collectors from the Germplasm Bank of Wild Species (GBOWS), Kunming Institute of Botany, Chinese Academy of Sciences conducted seed collecting expeditions to Mount Everest in 2021. Five seed plant species were found around 6,200 m asl,



Solms-laubachia himalayensis flourishing at 6,212 m asl.

and mature seeds of *Solms-laubachia himalayensis* and *Saussurea gnaphalodes* were collected and stored at GBOWS. The initial germination of *Solms-laubachia himalayensis* showed a 100% germination rate, and after eight months of cold storage at -20°C, the seed germination rate remains high. Researchers will continue to work on these collections to understand the biological mechanisms involved in adapting to the extreme adverse environment.



Photos: GBOWS

Seeds of *Solms-laubachia himalayensis*.



Seed germination of *Solms-laubachia himalayensis*.



A message from Marian Chau and Uromi Manage Goodale

(Co-Chairs, Seed Conservation Specialist Group, IUCN Species Survival Commission)

Seed banking is a critical tool in the conservation of rare and threatened species. Thanks to the long-term efforts and research within the Millennium Seed Bank Partnership and other well-established seed banking institutions, we have reliable protocols for seed storage, and information on seed characteristics and storage behavior for an impressive number of species globally. Building on that foundation, seed banks around the world have made progress on Target 8 of the Global Strategy for Plant Conservation: 'At least 75% of threatened plant species in *ex situ* collections, preferably in the country of origin, and at least 20% available for recovery and restoration programmes.' The [Convention on Biological Diversity reported in 2020](#) that while there is not yet a systematic survey of how many threatened species are preserved in seed banks, there are several regional examples of great progress:

- In Hawai'i, 75% of 724 species of conservation concern are conserved in seed banks.
- In Europe, 62.7% of threatened species are conserved in seed banks through the European Native Seed Conservation Network.
- In Australia, 61% of nationally listed threatened flora species are conserved in seed banks through the Australian Seed Bank Partnership.
- The Chinese Germplasm Bank of Wild Species has preserved more than 10,000 wild plant species as seed collections.
- In South Africa, 514 of 2,842 threatened species are conserved through the Millennium Seed Bank Partnership.
- In Mexico, 52% of endangered species are conserved in *ex situ* collections.

The IUCN [Seed Conservation Specialist Group](#) (SCSG) was founded in 2017, with a mission to promote seed conservation by providing a network for knowledge-sharing in different ecosystems around the world, and aiding in prioritisation, capacity building, and development of best practices. We have over 100 members from more than 25 countries on six continents, including seed bank managers, academic researchers, conservation practitioners, national and international coordinators, and



Marian Chau (left) and Uromi Manage Goodale (right) in Abu Dhabi, UAE at the 2019 IUCN Species Survival Commission Leaders' Meeting.

Photo: Marian Chau and Uromi Goodale



Map from the SCSG Seed Conservation Directory of Expertise, showing locations of experts in the area of 'Extinction prevention: Germplasm storage of rare plants as back-up to prevent extinction'.

Photo: Marian Chau

other specialists. In 2018, we launched the [Seed Conservation Directory of Expertise](#), a database and global map of over 450 specialists with expertise relating to seed conservation. The directory is interactive and can be filtered by country or by numerous categories, such as types of storage conditions, facilities, research, plant growth forms, habitats, and other areas of expertise in seed collection and preservation.

In the expertise area of 'Extinction prevention: Germplasm storage of rare

plants as back-up to prevent extinction', the directory includes 183 experts, reflective of the good progress on Target 8. These experts are distributed across the globe, although there is higher representation in North America and Western Europe, while North Africa and Central and West Asia are underrepresented. The SCSG is working to address this gap as one of our current targets, while continuing to broaden our network globally. We invite anyone with expertise in seed conservation to add themselves to the directory by filling out our survey (surveymonky.com/r/SeedDirectory), visit our webpage to join the SCSG (seedconservationsg.org/membership), and/or connect with us on Facebook ([IUCN Seed Conservation Specialist Group](#)) and Twitter ([@IUCN_Seeds](#)).

Resource links:

Convention on Biological Diversity 2020 report – cbd.int/doc/publications/cbd-ts-95-en-hr.pdf

Seed Conservation Specialist Group – seedconservationsg.org/

Seed Conservation Directory of Expertise – seedconservationsg.org/seed-conservation-directory-of-expertise

The UK Threatened Flora Project

Jennifer Peach (RBG Kew)

We have already gone a long way to conserving the UK's flora at the Millennium Seed Bank, with the vast majority of bankable native species now represented by at least one collection. The UK Threatened Flora Project is expanding the breadth of collections of some of the UK's most threatened flora, with the aim of creating a more comprehensive set of collections representing the range of genetic diversity of these taxa.

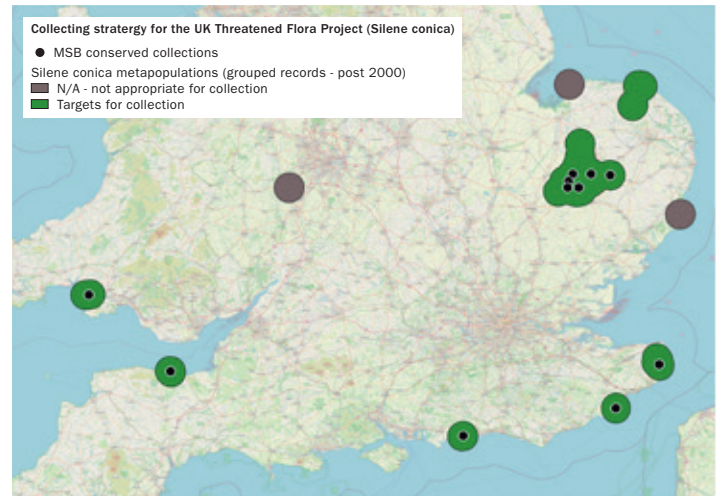
A sampling strategy was devised to identify key populations to sample from across each target taxon's UK distribution, to maximise the genetic diversity conserved. By the end of the project, at least 50 nationally threatened taxa will have their seed conserved from each of these key populations, optimising the resource available for conservation and research.



Nationally vulnerable *Illecebrum verticillatum* growing in the MSB nursery.



UK Collections Coordinator Steph Miles collecting *Bupleurum baldense* on a cliff edge with the support of the Sussex Coastguard.



Photos: Jennifer Peach

The locations of nationally vulnerable *Silene conica*: one further collection to 'complete' our collections of this species according to our sampling strategy. (Dark green = target populations; black = collections conserved at the MSB).

The three-year project, funded by Esmée Fairbairn Foundation, runs to 2023, with an expected 360 collections to be made over the course of the project. We have developed a large network of partners and collectors working with us across the UK to fulfil this expectation. This year alone, we have provided seed collection training to over 60 people across more than ten different conservation organisations.

Propagation trials are being carried out for 24 species that are endangered or vulnerable in the UK, including *Illecebrum verticillatum* (pictured). A total of 12 protocols will be published on the Millennium Seed Bank Partnership website at the end of the project.

Stepping up seed collection of threatened Belgian flora with IZABEL

Sandrine Godefroid (Meise Botanic Garden), Annelies Jacobs (Natuurpunt) & Filip Vandeloek (Meise Botanic Garden)

Through the Convention on Biological Diversity (CBD), Meise Botanic Garden has committed to preserve 75% of all threatened Belgian plant species *ex situ* (Target 8 of the Global Strategy of Plant Conservation, GSPC). Meise Botanic Garden and the NGO Natuurpunt recently signed a three-year partnership agreement to pool resources to boost seed collections to help get beyond the 44% of threatened species which are currently conserved *ex situ*.

The joint project has been named IZABEL, from the Dutch for 'collection of seeds of the Belgian flora' ('Inzameling van ZAden van de BELgische flora'). Our aim is to collect 850+ seed samples from over 400 species across three years, targeting not only rare and red-listed species, but also crop wild relatives, species that are dispersal-limited and species that reach their distributional limit in Belgium or have a restricted geographical distribution.

Natuurpunt is renowned for its skilled volunteer plant working groups, and professional staff with excellent knowledge of rare plants. Staff also have extensive knowledge of the natural areas they manage. This expertise makes Natuurpunt the ideal partner for efficient seed collection.



Photo: Annelies Jacobs

A volunteer collecting seeds of *Veronica triphyllos*, a species threatened with extinction in Belgium.

We currently have around 80 volunteer seed collectors. They are trained in seed collection methods and compliance with the protocol developed by the European Native Seed Conservation Network (ENSCONET). This ensures that seed samples are of a high quality and are collected without endangering the

populations of wild plants from which they come.

During our first year of collaboration, we have collected 254 samples from 156 species, allowing us to reach 58% of threatened species now conserved in the seed bank. By continuing at the same pace, we will be able to reach GSPC Target 8 by the end of 2023.



Arnoseris minima seeds, collected in 2021 from the only authentic population left in Belgium.

Photo: Maarten Strack van Schijndel

Seed collecting in Important Plant Areas of Thailand: Doi Hua Mot, Umphang District, Tak Province

Voradol Chamchumroon (Bangkok Forest Herbarium, Department of National Parks, Wildlife and Plant Conservation, Bangkok)

Since July 2021, a team from the Bangkok Forest Herbarium (BKF) has been collecting seeds from endemic plants in Thailand's Important Plant Areas (IPAs). Doi Hua Mot is one of these areas, and its limestone hills are home to numerous endemic plants.

The project forms part of the global Threatened Biodiversity Hotspots Programme, a targeted programme of work funded by the Arcadia Fund, which

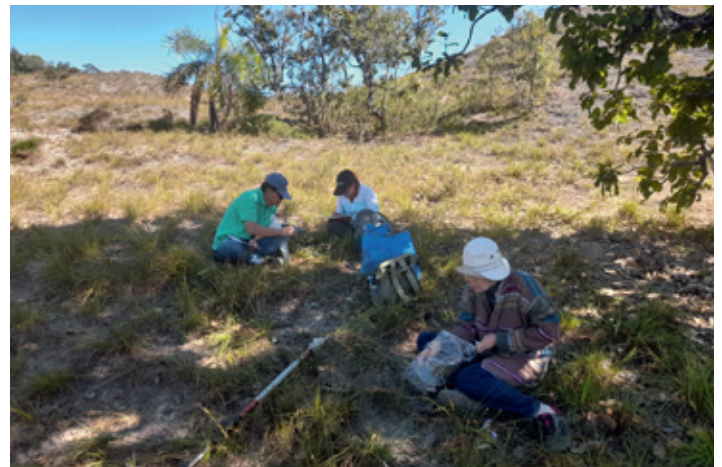
aims to secure the future of 5,000 plant species. In Thailand, project partners BKF and the National Biobank of Thailand (NBT) aim to collect and conserve seeds of 320 herbaceous species and climbers. BKF will collect seeds from 160 species towards this target. The seeds will be banked at NBT and duplicated at the Millennium Seed Bank, with field and processing data shared via the

Millennium Seed Bank Partnership's online database, the Data Warehouse.

BKF and NBT will also conduct 400 plant conservation assessments of Thai native herbaceous species, with support from RBG Kew's Plant Assessment Unit, of which BKF will conduct 200 assessments. All project partners will work together to publish the results on the IUCN Red List and in the scientific literature.



A team from the Bangkok Forest Herbarium (BKF) survey and set plots for recording data for red list assessments at Doi Hua Mot, Thailand.



Staff from the Bangkok Forest Herbarium (BKF) collect seed and record data at Doi Hua Mot, Thailand.

A ten-year plan to conserve five endemic Corsican *Limonium* species

L. Fausti & L. Hugot (National Botanical Conservatory of Corsica)

The National Botanical Conservatory of Corsica (CBNC) is currently focusing on the conservation of five *Limonium* species: *Limonium bonifaciense*, *Limonium florentinum*, *Limonium patrimoniense*, *Limonium portovecchiense* and *Limonium tarcoense*. These endemic and rare species are all evaluated as Endangered on both national and regional red lists, due to their restricted range and their location on shorelines that are impacted by both human activities and climate change.

In 2021, a national action plan was developed with collaboration between a scientific committee, relevant stakeholders and the French Ministry of Environment. The plan describes 15 actions to be implemented over the next ten years to

improve the conservation status of the five *Limonium* species.

Ex situ conservation is included as one of the 15 actions to be implemented. Seed collection will take place and germination tests will be carried out. Collection of plant material and knowledge of ideal germination conditions are therefore necessary in order to restore and strengthen *Limonium* populations. The goal for each taxon is to create a representative seed bank of genetic diversity but also to investigate germination and propagation conditions. Seed recollection, germination tests and storage will be carried out by CBNC. For cultivation, a partnership with a local nursery is in the development stages. We will work along the lines laid out in this action plan until 2030, when we hope to have good news to share!

For more information:

CBNC website: cbnc.oec.fr

The ten-year plan: biodiversite.gouv.fr/projet-pna/wp-content/uploads/PNA_statices_endemiques_de_corse_Limoniums_2021.pdf

PNA contact: Lillia.Fausti@oec.fr

Ex situ conservation contact: Caroline.Favier@oec.fr



Limonium florentinum, Patrimonio.

Low germination after seed banking due to reinforced seed dormancy rather than seed mortality

Shineka Logeswaran & Andreas Ensslin (Conservatory and Botanic Garden of the City of Geneva, Switzerland)

It is believed that desiccation-tolerant seeds of rare plants can be stored under standard banking conditions (15% RH, -20°C) over decades, if not centuries, for conservation purposes (Walters and Pence, 2020) (Fig. 1). However, reduced germination with increasing storage duration may threaten the utility of the collections and has generally been attributed to increased seed death over time (Solberg *et al.*, 2020). At the same time, seed dormancy can be affected by seed storage and may thus also present a challenge for conservation projects (Godefroid *et al.*, 2011).

To investigate this, we performed germination tests (GT) with eight rare annual species preserved in the seed bank of the Geneva Botanic Garden, and with fresh (non-banked) seeds from the same species collected at the same locations in the wild. To check dormancy after the GT, we cut-tested all non-germinated seeds and evaluated their viability status. We also used accelerated ageing (AA) tests (at 40°C, 60% RH), which simulate the effects of long-term seed storage (several decades) in a very short time (several weeks), and compared these with the results of the tests on banked and non-banked seeds.

We found that germination indeed decreases with increasing banking time, as well as with increasing AA treatment.

However, seed viability did not decrease during storage time, and the decline was less steep than the decline in germination during the AA treatment, suggesting increased seed dormancy with increased seed storage time. Our results suggest that increased seed dormancy during seed storage may be responsible for the decline in germination, rather than seed mortality as previously thought. They also highlight the crucial role of effective seed dormancy breaking protocols to minimise selection for low dormancy when using seeds for conservation measures.

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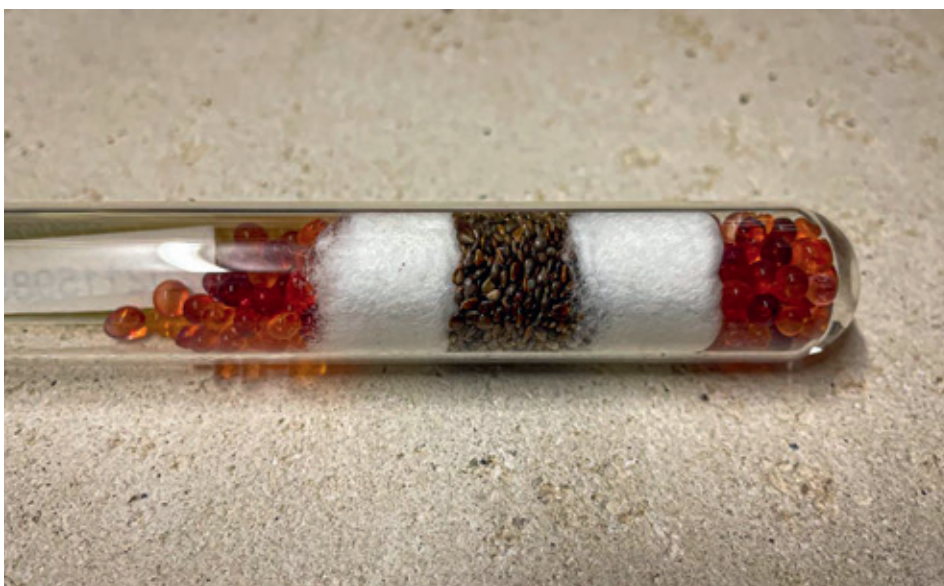


Figure 1a: Seeds stored frozen in a glass vial in the seed bank.

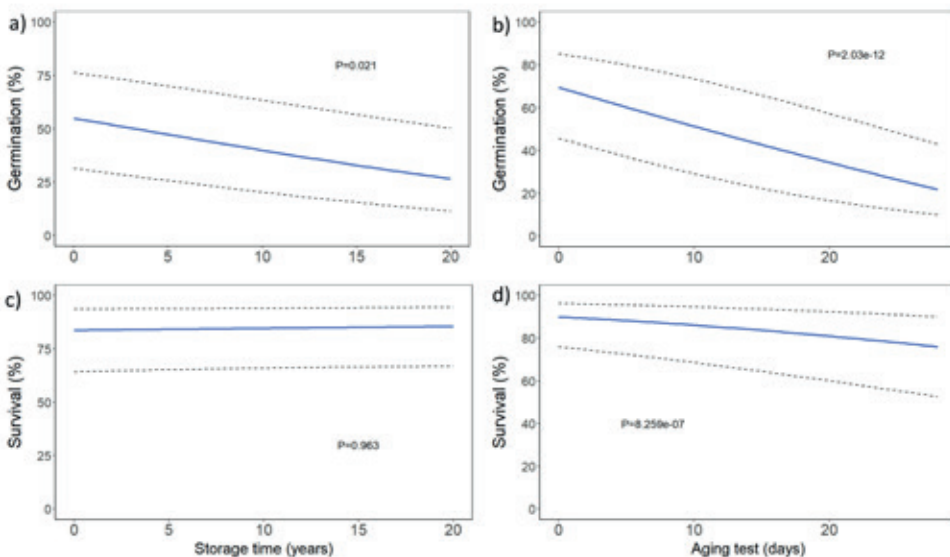


Figure 2: Results of the germination tests carried out with seeds from the seed bank and fresh seeds collected from the same original wild population. a) and c) germination and seed survival in relation to storage time in the seed bank (wild seeds had a storage time of 0. b) and d) germination and storage time of seeds in relation to the accelerated aging treatment. Curves depict regression lines with standard errors.



Figure 1b: Seeds in the accelerated aging treatment in a climate chamber under 40°C and 60% humidity.

Seed collecting and propagation of endangered and endemic species of Bhutan

Kezang Tobgay (Royal Botanical Garden, National Biodiversity Centre, Bhutan)

The conservation agenda in Bhutan provides a platform for national efforts on *ex situ* and *in situ* conservation and management of rare and endangered species' genetic diversity from different floristic regions across the country. The conservation of plant species via different means, through seed collections and live plant collections, safeguards some of the most threatened, rare and useful plant species in Bhutan.

Through our exploration efforts, many new records of plant species were discovered and seed collected. We have collected endemic and endangered species including *Ceropegia dorjei* C. E. C. Fischer, which is a slender climber from the broadleaved forests of Trongsa, and *Cheirostylis sherriffii* N. Pearce & P. J. Cribb – a terrestrial orchid found in warm broadleaved forest. *C. sherriffii* is collected as a living specimen from its only known location, which is suffering from habitat destruction due to road construction and settlement. This species is now growing at the Royal Botanical Garden, Serbithang, Thimphu. It can be propagated through root stock division and seed micro-propagation; further research into propagation of threatened orchids continues at RBG Serbithang. In addition, seeds of rare and threatened



Cheirostylis sherriffii.



Sorbus lingshiensis.



Sorbus rinzenii.

endemic plant species – *Sorbus lingshiensis* Rushforth and *Sorbus rinzenii* Rushforth – were collected from the high-altitude, remote area of Lingzhi for gene bank conservation and use in restoration. They are both small trees, listed as Critically Endangered and Endangered on the IUCN Red List.

Due to a lack of comprehensive information available, further studies are needed to generate information on the distribution of, and propagation protocols for, rare and threatened Bhutanese flora. Documentation of rare and threatened endemic species is crucial, especially when their ecosystem is being affected by climate change and global warming. In Bhutan, literature linking climate change and biodiversity is limited.

Saving the threatened in the wild!



Naomi Mdayi & Cape Nature Staff hand pollinating *Sorocephalus imbricatus*.

Sorocephalus imbricatus – Naomi Mdayi (South African National Biodiversity Institute, SANBI)

Sorocephalus imbricatus is a beautiful and striking plant, making it difficult to miss in the wild. This species is known to be stimulated by fire and is short lived after setting seed. However, it has not been doing well after fires and the cause is still unknown. *Sorocephalus imbricatus* is declining in the wild due to habitat degradation – it is found in the same proximity as pine plantations. *Phytophthora cinnamomi* has been identified as one of the possible causes of plant death. *Sorocephalus imbricatus* is listed as Critically Endangered on the Red List of South African Plants.

The good news is that Cape Nature, SANBI, MSBP South Africa and CREW have teamed up to try and rescue this species. *Sorocephalus imbricatus* is currently not banked at the Millennium Seed Bank and is not held as part of the living collection at Kirstenbosch Gardens, so both *ex situ* conservation tools are being used to back up



Conophytum pageae.

this species and prevent possible extinction. The partners are conducting a monitoring programme to ensure that the seeds are banked with the MSBP and living collections are grown at Kirstenbosch Gardens. A hand pollination and bagging system was used on the remaining wild population during flowering time; 241 flowerheads were covered in 36 bags, and 212 flowerheads were hand pollinated and not covered. Following this, 213 seeds were found in bags of hand pollinated flowerheads and 63 seeds in flowerheads that were not covered. Two hundred seeds were submitted to the MSBP South Africa and were further processed by Naomi Mdayi, and they are now ready to be shipped to Kew. The remaining seeds were used for germination trials, and cuttings were taken for propagation to be grown at Kirstenbosch Garden.



Yandisa Ndzeke looking for *Conophytum* species in rock cracks in the Northern Cape.

Conophytums – Yandisa Ndzeke (South African National Biodiversity Institute, SANBI)

The succulent biome is recognised internationally as a biodiversity hotspot and is the only arid hotspot in the world. This biome is threatened by a rapid increase in succulent plant poaching. Poaching is prominent in regions such as the Western and Northern Cape, where it is pushing the endemic plants to extinction. Law enforcement has made several confiscations of poached plants. The focus of poachers currently appears to be the genera *Conophytum*, *Crassula*, *Adromischus* and *Anacampseros*, which is leading to a rapid downgrade of the conservation status of these species. SANBI has established a work group that seeks to find solutions to this problem. The MSBP forms an integral part of this work group, and is responsible for collecting seeds of these threatened species to ensure that they are banked before their extinction. Yandisa Ndzeke was employed as an intern, as part of the response to the succulent poaching problem, and he is focusing his energies on collecting seeds of Critically Endangered succulent species from the Northern Cape. Naomi Mdayi and Yandisa went on a collection trip to the Northern Cape with the CREW team, where they targeted conophytums and other threatened species. These species are mostly single locality species, which means that if they get obliterated from the area in which they are known to occur, that will be the end of the species. A total of 45 collections were made, of which six were *Conophytum* species. More trips to the Northern Cape are planned for seed collection of these threatened plants.



Naomi Mdayi, Phindile Gazu (former Kirstenbosch Gardens intern) and Yandisa Ndzeke in the Northern Cape trip, targeting the genus *Conophytum*.



Seeds of *Sorocephalus imbricatus*.

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Exploration of threatened plants in Malinau, North Kalimantan, Indonesia

Prima W. K. Hutabarat (Research Center for Biosystematics and Evolution – BRIN, Bogor, Indonesia), Peniwidiyanti (Research Center for Ecology and Ethnobiology – BRIN, Bogor, Indonesia), Rizmoon N. Zulkarnaen (Research Center for Plant Conservation, Botanical Gardens, and Forestry – BRIN, Bogor, Indonesia), Bina Sitepu (Research Center for Ecology and Ethnobiology – BRIN, Bogor, Indonesia), Trisno (Balikpapan Botanical Gardens, City of Balikpapan, East Kalimantan, Indonesia) & Harto (Directorate of Scientific Collection Management – BRIN, Bogor, Indonesia)

In August 2022, a 17-day plant exploration for threatened plants in the Malinau Regency, North Kalimantan, Indonesia, was carried out by a group of young researchers from the Bogor Botanic Gardens, the National Research and Innovation Agency, and Balikpapan Botanical Gardens. Malinau still contains a relatively large and intact area of primary forest. Moreover, North Kalimantan has the least-recorded floral record when compared with the other provinces of Kalimantan and the other areas of Borneo. This project aims to collect and conserve plant materials (DNA, herbarium specimens, seedlings, seeds and cuttings) of threatened tree species in the region, as well as contribute to the floristic record of North Kalimantan.

The exploration was carried out in August, when mast fruiting for tropical dipterocarps usually takes place. The team surveyed various locations and habitats in the Malinau Natural Forest (PT Inhutani II concession) and found at least eight threatened species. Three species are listed as Critically Endangered: *Hopea mengarawan* Miq., *Shorea johorensis* Foxw. and *Shorea*



Expedition team members standing under *Shorea johorensis* Foxw. in the Malinau Natural Forest.

Photo: Natanel Singan



An extremely tall Bangkirai Tree (*Shorea laevis* Ridl.) stretching into the canopy.

peltata Symington, and five species listed as Vulnerable: *Dipterocarpus gracilis* Blume, *Hopea beccariana* Burck, *Shorea balangeran* (Korth.) Burck, *Shorea laevis* Ridl. and *Shorea smithiana* Symington. At the end of the fieldwork, we had recorded 241 accession numbers, with more than 1,000

specimens of plant materials to be brought into cultivation. These have now been planted and are acclimatising in the nursery of Bogor Botanical Gardens and Balikpapan Botanical Gardens. The ultimate aim is that our conservation efforts will help save the threatened plants of Kalimantan.



Tree sapling of *Shorea peltata* Symington growing vigorously on the rainforest floor.

Photos: Peniwidiyanti

Photo: Peniwidiyanti

South Africa's succulents added to IUCN Red List assessment

Domitilla Raimondo (South African National Biodiversity Institute, SANBI)



Photo: Andrew J. Young

Conophytum vanheerdei has most recently been assessed for the IUCN Red List of Threatened Species as Critically Endangered under criteria A4cd; B1ab(iii,v)+2ab(iii,v).



Photo: Domitilla Raimondo

The quiver tree (*Aloidendron dichotomum*) one of three species of quiver tree listed as threatened for the first time on the IUCN Red List due to climate change.

South Africa's succulent plants are experiencing unprecedented rates of decline due to the combined impacts of climate change and illegal collecting to supply a growing ornamental trade in succulent plants.

The recent release of the International Union for Conservation of Nature (IUCN) Red List of Threatened Species includes 210 species of succulents listed for the first time. The majority of these species belong to the genus *Conophytum*, a large and diverse group of dwarf succulents commonly known as 'buttons'. It has been

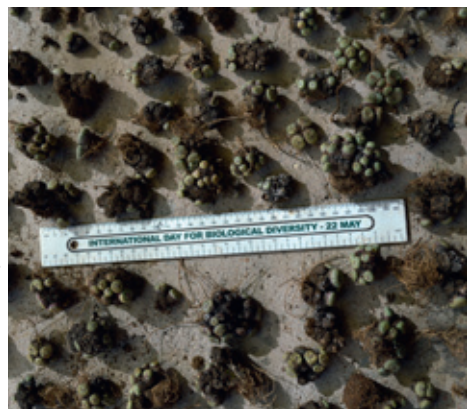


Photo: Pieter van Wyk

Confiscated material of dwarf succulents from the genus *Conophytum* that have been heavily impacted by illegal poaching.

found that 97% of the genus is listed in one of the three threatened categories, whilst 45% are listed in the highest category Critically Endangered (CR), meaning they are on the brink of extinction.

Previously, these succulent species were not assessed on the IUCN Red List; however, they were included on [South Africa's National Red List](#). Since 2019, 143 (91%) of the 157 previously listed *Conophytum* species have experienced an increase in threat status, with the vast majority as a result of illegal poaching. It is very likely that some species have already been poached to extinction in the wild, as the number of confiscated poached plants being housed at secure locations ahead of court cases often exceeds the previously estimated total wild population size.

Three species of the iconic aloe quiver tree that occur in South Africa have been listed as threatened, with the magnificent giant quiver tree (*Aloidendron pillansii*) being listed as CR based on extensive observed dieback over the past decade, and the prediction of climate models suggests that this species will experience a 90% decline by 2080. The better-known quiver tree (*Aloidendron dichotomum*) is listed as Vulnerable. With close to 1,000 plant species endemic to the country's Succulent Karoo biome, hundreds more plant species are experiencing similar levels of decline linked to the extended drought.

A National Response Strategy and Action Plan has been drafted as a collaborative effort by South African government departments, conservation authorities, non-governmental organisations and local communities to ensure the survival of our rich succulent flora whilst promoting sustainable socio-economic development.

For more information on *Conophytum* conservation in South Africa, check out the September 2021 e-newsletter available at brahmsonline.kew.org/msbp/Samara/Enewsletter#Issue1 and pg. 7 of this issue.

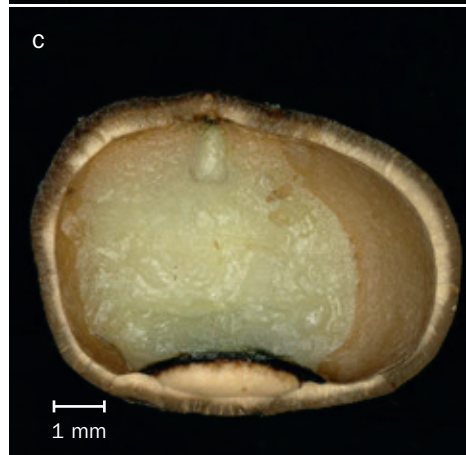
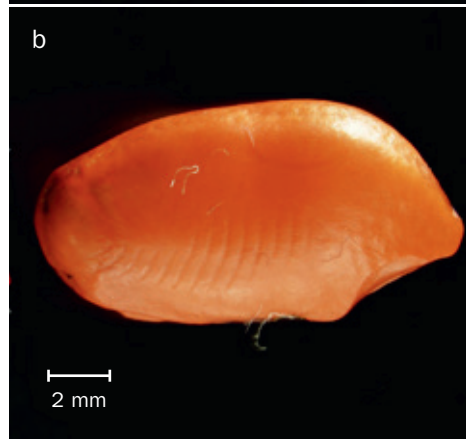


Photo: Andrew J. Young

Conophytum bruynsii has most recently been assessed for The IUCN Red List of Threatened Species as Critically Endangered under criteria A4d; B1ab(iii,v)+2ab(iii,v).

Magnolia sinica seeds banked in GBOWS

Xiaojian HU (Germplasm Bank of Wild Species, Kunming Institute of Botany, Chinese Academy of Sciences)



According to the IUCN Red List, around 38.5% of *Magnolia* species are Critically Endangered or Endangered. Both *ex situ* and *in situ* measures are necessary for conservation of these species. However, many species of Magnoliaceae were reported to produce intermediate and recalcitrant seeds (Royal Botanic Gardens, Kew, 2019) which cannot be preserved in conventional seed banks.

Magnolia sinica is a Critically Endangered species narrowly distributed along the China-Vietnam border. Seed dormancy and germination were investigated at the Germplasm Bank of Wild Species (GBOWS), Kunming Institute of Botany, Chinese Academy of Sciences. Freshly matured seeds germinated to ca. 86.5% at 25/15°C

but poorly at 30°C; GA₃ and moist chilling promoted germination significantly at 20°C (Fig. 1). Embryos grow at temperatures (alternating or constant) between 20°C and 25°C. *M. sinica* seeds possibly have non-deep simple morphophysiological dormancy (Baskin and Baskin, 2014).

Seeds of *M. sinica* maintain a high germination rate when the moisture content reduced to 9.27% and 4.85% as well as after six-month storage at -20°C and in liquid nitrogen, including recovery *in vitro* as excised embryos.

This data (Lin *et al.*, 2022) along with our other findings (unpublished data) imply that seeds of some *Magnolia* species are orthodox and can be banked either at -20°C or in liquid nitrogen. Collecting mature seeds of magnolias is critical for successful seed preservation. GBOWS have started screening the seed storage behavior of magnolias for better banking practice of those endangered species in China.

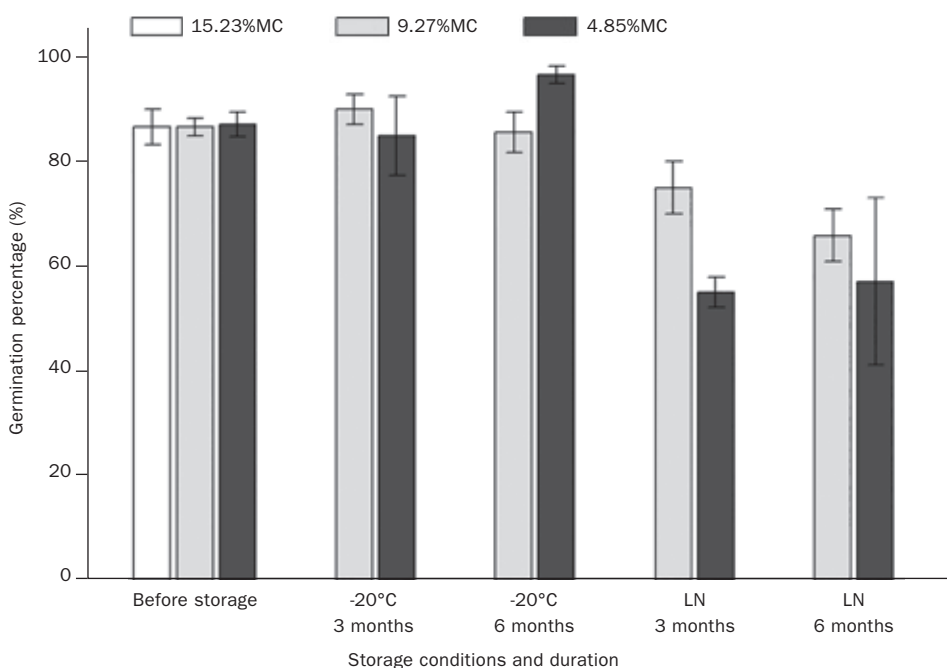


Figure 1: Germination (mean ± standard error) of *Magnolia sinica* seeds at 25/15°C on agar with 200 mg/L gibberellic acid (GA₃) after storage at -20°C and in liquid nitrogen (LN) for 3 and 6 months with different moisture contents (MC). Asterisk (*) indicates significant difference compared with the germination of freshly matured seeds.

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Morton Arboretum guiding *ex situ* collections of Critically Endangered oak

Sean Hoban, Emily Schumacher & Austin Koontz (The Morton Arboretum, USA)

Through a collaboration with the Global Conservation Consortium for Oak (GCCO), The Morton Arboretum is working to document, manage and improve *ex situ* collections of the rare and IUCN Critically Endangered *Quercus acerifolia*, maple-leaf oak. This oak, described by Hess & Stoyhoff in 1990, occurs across only about four populations in Arkansas, USA.

The team collected 172 samples from the wild and 277 samples from 17 gardens (many of which were seedlings from recent expeditions). We used microsatellite DNA markers to assess how much of the wild genetic diversity is present in individuals kept at botanic gardens. The good news is that the *ex situ* collection is diverse: 95 to 98% of all microsatellite alleles are conserved, meeting the general recommendation of safeguarding at least 95% of alleles. As emphasised by Hoban *et al.* (2018) and Griffith *et al.* (2017), collections must also be robust to some

losses, so each genetic variant should be preserved in multiple copies. For this species, 80 to 88% of all alleles are safeguarded with at least five copies.

We also found nearly 80% of garden individuals are half-siblings – which could lead to inbreeding and is therefore suboptimal for the conservation of genetic diversity. Future efforts should collect from more maternal trees, spaced far apart to reduce the number of related seedlings and conserve more diversity in fewer individuals. In addition, using DNA sequence genotyping, we found that using these genomic markers, fewer alleles were conserved (preliminary results say only 75% of all alleles). Lastly, our results suggest grafting (clonal propagation) may be more efficient in conserving genetic diversity than propagation from seed. Grafting may also help avoid hybridisation, and could lead to earlier seed production.

With partners united by the GCCO including Stephen's Lake Park Arboretum and the City of Columbia Parks & Recreation Department, we are helping design seed orchards that could produce seed for supplementing wild populations – and ensure a future for this species.



Quercus acerifolia leaves and acorns.

Photo: The Morton Arboretum

Conservation of *Artemisia laciniata* at the University of Vienna

Andrea Kodym, Thomas Pirker, Frank Schumacher & Michael Kiehn (Botanical Garden, University of Vienna)

The deciduous semi-rosette perennial *Artemisia laciniata* (Asteraceae) is widespread in Central Asia, but has only one remaining European population in the weakly saline Zitzmannsdorf meadows of the Lake Neusiedl National Park (Austria). The species is classified as Critically Endangered in Austria and listed in Appendices II and IV of the EU Habitats Directive (92/43/EEC).

In 2015 the Botanical Garden of the University of Vienna, Austria, in collaboration with the National Park, started a project to secure a viable population of *A. laciniata*. At this time only 11 plants were known in the wild in Austria.

Close to the original population, ten new sites were created. Germination rates for achenes sown out in winter were 24%, but survival after two years was poor (3%). More successful was the planting out of plants raised at the Botanical Garden (82% survival). As rosettes get easily overgrown, a crucial part of the conservation

measures is mowing. This needs to take place outside of the flowering and fruiting season which runs from June to October.

Through our conservation efforts, financially supported by the EU and the local government, the population currently consists of more than 200 individuals and is also present over a larger area. In view of the expected drier and hotter climate, small scale assisted migration to wetter parts of the National Park is now also being considered.

Achenes are regularly harvested for propagation and *ex situ* conservation, and this year's harvest will be sent to the Millennium Seed Bank for storage. Achenes are also used to expand the genetic diversity of the living collection established in 2006 at the Botanical Garden.



Frank Schumacher and Thomas Pirker carrying out monitoring of the new planting sites.



Andrea Kodym planting out *Artemisia laciniata* plug plants in the Zitzmannsdorf meadows.

Photo: Andrea Kodym

Photo: F. Schumacher

The swan song for Greek endemic *Saponaria jagelii*?

Costas A. Thanos, Nick Katsikis, Spyridon Oikonomidis, Sofoklis Mouratidis, Aikaterina L. Stefi (NKUA Seed Bank), Ian Willey & Aisyah Faruk (RBG Kew)

Let's hope this article's title isn't true! Nonetheless, the Critically Endangered *Saponaria jagelii* (included in the Top 50 Mediterranean Island Plants update) is a narrow endemic annual found only on the coastal dunes (EU habitat 2120 – 'shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)') of Elafonisos island (within the NATURA 2000 site GR2540002, just off the south-eastern coast of the Peloponnese), which are losing ground dramatically.

The species occurrence range was studied in early April 2022 and the plant is currently located at only one sandy beach in western Elafonisos, although a 2019 research report documented its occurrence in two nearby beaches. In our present survey we could not find any *S. jagelii* individuals on the second beach



The NKUA field team on site.



Saponaria jagelii seeds, scanned on millimetre paper.

and the entire population of less than 2,000 plants is now confined to a single area of ca. 2,000 m². Fortunately, our team collected 2,000 seeds (May 25, 2022) for long-term storage at both the NKUA and the Millennium Seed Bank, as part of a satellite assignment to the 'Conserving the Flora of the Balkans: Native Plants of Greece' project.

Despite the short life cycle of the species occurring outside of the main tourist season (germination in late autumn; flowering in early spring, March to April; and setting fruit and drying by May to June), touristic development is the main threat for the species. Several building permits for summer houses have recently been issued, along the border of the population, while 10–20% of the individual plants are

growing within private property. Moreover, the introduction of alien, invasive species (*Aptenia cordifolia* and *Carpobrotus edulis*) from neighbouring gardens adds extra pressure to the survival of the species.



A *Saponaria jagelii* seedling at the cotyledon stage.



Flower of *Saponaria jagelii*.



Map of Greece (left bottom), focusing in on the Peloponnese (centre, yellow). The highlighted area of the Peloponnese is Elafonisos island.

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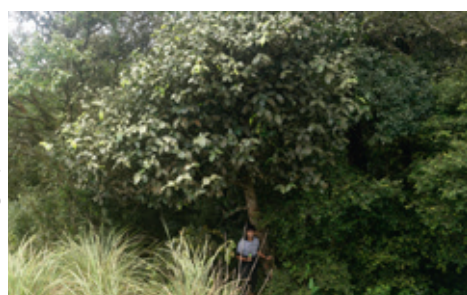
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Collecting seeds in the Southern Western Ghats from a rare and endemic tree, *Garcinia gamblei*

K.C. Abinlal & Anurag Dhyani (Jawaharlal Nehru Tropical Botanic Garden & Research Institute, JNTBGRI, India)

Garcinia gamblei P.S. Shameer, T.Sabu & N.Mohanan (Clusiaceae) is an evergreen, dioecious tree species described in 2017, using flowering and fruiting specimens from the Ponmudi Hills in the Southern Western Ghats. The species can be distinguished from *G. pushpangadaniana* by its sessile pale green flowers, vertical grooved fruits with a depressed apex, and oblongoid seeds. Due to inadequate data about its conservation status, *Garcinia gamblei* is categorised as Data Deficient in the IUCN Red List.



A mature tree of *Garcinia gamblei* in the Ponmudi Hills.

In 2021, during a survey and identification of rare trees in the Shola Forests (a threatened and endemic ecosystem) of the Ponmudi Hills, the team of seed collectors from the Jawaharlal Nehru Tropical Botanic Garden and Research Institute located 31 individuals within an area of less than 1 km² at an altitude of 964–1,097 m (Kavungullachalil *et al.*, 2022). Available mature trees bear a low number of fruits due to a low flowering and fruiting ratio and seed predation.

Seeds of *Garcinia gamblei* were collected from the Ponmudi Hills and brought to the laboratory. These seeds were studied for morphological parameters, seed viability, moisture content and imbibition. The seeds exhibited a high moisture content and delayed germination in our preliminary tests. We are continuing our research of *Garcinia gamblei* seed collection, storage, propagation and reintroduction in near natural habitats and botanical gardens.



Fruits of *Garcinia gamblei*. These fruits are not yet ripe, but two months later ripe fruits will be collected.



Seeds of *Garcinia gamblei*. These seeds were collected for study in JNTBGRI laboratory.

Photos: Abinlal KC

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Conservation of Bornean ironwood (*Eusideroxylon zwageri*) in Bogor Botanic Gardens

Sri Ulie Rakhmawati & Dian Latifah (Research Center for Plant Conservation, Botanic Gardens and Forestry-BRIN)

Bornean ironwood (*Eusideroxylon zwageri*) is one of the most important timbers native to Kalimantan and Sumatra, Indonesia. It grows in lowland primary and secondary forest up to 625 m above sea level. It is commonly found scattered or in groups along rivers and adjacent hills. *Eusideroxylon zwageri* is a tall, slow-growing, evergreen tree with a straight trunk. The trunk has many small, rounded buttresses that give the base an elephant's-foot-like appearance. An individual tree may reach an age of 1,000 years with a height of more than 30 m. The leaves are dark green, simple, leathery, elliptical to ovate, 14–18 cm long and 5–11 cm wide. The fruits are drupes and contain one seed without an endosperm. The seeds are recalcitrant, meaning they can't be stored for long periods of time.

Bornean ironwood has very high economical potency as timber, but it has become rare in the wild. IUCN has categorised it as Vulnerable (A1cd+2cd) and it is listed on CITES Appendix II (Bi – unsustainable level of exploitation from the wild for international trade). Many activities have been undertaken to conserve this plant, including at Bogor Botanic Gardens, where Bornean ironwood has been conserved in the living collection, with 17 plants coming from Sumatra and Kalimantan. It is also preserved as seed

collections in the seed bank, even though it is recalcitrant. Based on research conducted at Bogor Botanic Gardens seed bank, *Eusideroxylon zwageri* seeds can be stored and remain viable for more than a year using a dark container with wet sphagnum moss in a room at 16–18°C temperature and 55–65% humidity. This research is still ongoing, especially focusing on the alternative medium.



Eusideroxylon zwageri seeds ready to store in container.



Dark container for storage.



Germination research.

Photos: SU Rakhmawati

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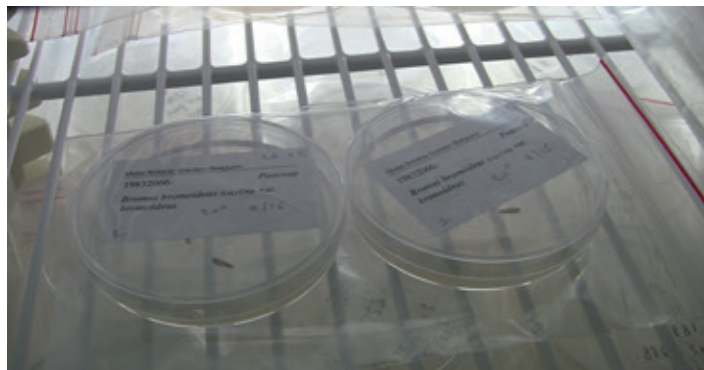
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Successful reintroduction of a Belgian endemic, previously extinct in the wild

Sandrine Godefroid & Franck Hidvégi (Meise Botanic Garden)



Bromus bromoideus reintroduced.



Germination test for *B. bromoideus*.

Bromus bromoideus is an endemic species from Belgium. In the 19th century, this grass was abundant in spelt crops, but it gradually disappeared at the beginning of the 20th century due to the replacement of spelt with common wheat, the conversion of crops into pasture land and the technical improvement of the sorting of cereal seeds. *Bromus bromoideus* was thus observed for the last time in 1935 – since then it has been officially considered Extinct in the Wild.

However, five European botanical gardens still possessed seeds from this species, including the Botanical Garden of the University of Liège in Belgium. In 1983, the Botanical Garden of Liège donated a sample of seeds

to the National Botanic Garden of Belgium (since renamed Meise Botanic Garden), which has preserved them in its seed bank.

In 2005, simultaneous germination experiments were successfully attempted in the laboratories at Meise Botanic Garden, and at the Millennium Seed Bank, which made it possible to envisage cultivation on a larger scale and perhaps one day its reintroduction into the wild. A year later, in 2006, Meise Botanic Garden launched a project to reinvigorate this species, successfully obtaining about 300,000 viable seeds. The collections of the botanical gardens have thus made it possible to 'resurrect' this species.

A feasibility study was carried out between 2010 and 2020 by the University of Liège, the NGO Natagriwal and the Public Service of Wallonia, in order to better identify the ecological requirements of *Bromus bromoideus* and assess the technical feasibility of, and the scientific justification for, reintroducing the species to its historical habitat in Belgium – as well as the possible biological risks and societal obstacles to the project. Thanks to the excellent, long-standing collaboration between the regional authorities, the Nature and Forests Department and an organic farmer, the once-lost *Bromus bromoideus* has now been successfully reintroduced into its original habitat, 85 years after its extinction.

Ex situ conservation and study of *Ferula glabrifolia*, a Critically Endangered umbelliferous plant from Armenia

A. Rudov & A. Nersesyan (Department of Conservation of Genetic Resources of Armenian Flora, Institute of Botany after A. Takhtajyan of the National Academy of Sciences of the Republic of Armenia)

Ferula glabrifolia M.Panahi, Piwczynski, Puchalka & Spalik (= *Dorema glabrum* Fisch. & C. A. Mey.) is a highly endangered species in Armenia. The majority of its former populations have disappeared and those remaining are highly fragmented by both human activity and topography. The plant is monocarpic (bears seeds just once in its lifetime) and its populations in Armenia are very small and bear seeds less than every five years. In the Ecoepicenter of the Institute of Botany after A. L. Takhtajyan, we therefore propagate this species *ex situ* to increase its seed material, to study its ecological peculiarities and to plan its reintroduction with the aim to increase its population size *in situ*.

In Armenia, *Ferula glabrifolia* grows mainly on clayey, gypsiferous slopes in the lower mountain belt. Thus, we reproduced a hill with a substrate similar to that of the species' wild populations. The first year of cultivation was tricky, as seeds germinated very unevenly



One-year-old plants of *Ferula glabrifolia* in hibernation in summer 2021.



Two years old rosettes of *Ferula glabrifolia* in our model biotope at the Ecoepicenter.

and the growth period (late spring to early summer) is very short. This brief growth period is crucial to form a carrot-like root, which hibernates for almost a year and only forms a rosette of leaves for little more than a month every year. This continues until the plant is big enough to flower, after which it then dies. Currently we are in the second year of our project and are very impatient to see the plant in flower in several years!

Dune gentian banking in Wales

Kevin McGinn (National Botanic Garden of Wales)

Dune gentian, *Gentianella amarella* subsp. *occidentalis*, is an annual British endemic. Known from only seven sites in South Wales and North Devon, it has a specific niche, growing on the edges of dune slacks. Although treated as a subspecies, it is considered taxonomically distinct and deserving of conservation focus and has

been recently reassessed as Endangered. In recent years, it has not been relocated at two of its Welsh sites – a decline that has occurred despite statutory protection, and it being a listed feature of these Sites of Special Scientific Interest. It is hoped that dormant seed will be present in the soil awaiting the right conditions to germinate – following a nearly 70-year absence, the species was rediscovered at Braunton Burrows, Devon, in 1998. However, seed banking forms the ideal insurance policy.

Population numbers fluctuate hugely from year to year, but 2021 was a plentiful year. With guidance from botanist Tim

Rich, a team from the National Botanic Garden of Wales (NBG Wales) was able to locate populations at two sites on the Gower Peninsula near Swansea. Seed was collected for the Millennium Seed Bank Partnership's UK Threatened Flora Project, as part of a wider collaboration with the MSBP. A new seed bank facility has been established at NBG Wales to process and store collections which are duplicated at the Millennium Seed Bank. To attempt seed bulking for dune gentian, NBG Wales' horticulture team is growing-on Gower seeds using sand collected from the same site as a growing medium.



Dune gentian *in situ* at Oxwich National Nature Reserve, Gower Peninsula.



Dune gentian grown *ex situ* at NBG Wales to attempt bulking-up.



Dune gentian *in situ* at Oxwich National Nature Reserve, Gower Peninsula.

Photos: Kevin McGinn

SCT course returns to the MSB and helps save threatened species

Hanna Oldfield, Sarah Gattiker & Nicola Mills (RBG Kew)

For the first time in three years, the Seed Conservation Techniques (SCT) course was able to take place at the Millennium Seed Bank at Wakehurst from 10 to 21 October. Some of the advantages of online learning were used to offer a hybrid program of pre-recorded theory lectures in September, before most of the course participants travelled to the seed bank the following month from as far as Papua New Guinea, Chile and Hawai'i, as well as Georgia, Slovakia and the Eden Project in the UK.

A wide variety of sessions and practical exercises awaited the visitors, including a field day and a visit to the Herbarium at Kew Gardens. A highlight was the seed processing and cleaning practical led by Nicola Mills and Sarah Gattiker, who together with Frances Stanley had been able to collect fruit from a Plymouth pear (*Pyrus cordata*) tree within the Wakehurst gardens (originally planted from wild collected seeds). This tree is considered to have a conservation status

of Vulnerable. Therefore, this training provided an important opportunity to add to the small collections already held at the seed bank, thereby helping to ensure the future of this rare species.

The course participants removed the seeds from the fruit and carried out cut testing to ensure good seed quality before spreading them out on a mesh for slow ambient drying. Once dry, the seeds will be further processed to remove dried mucilage.



Participants of the 2022 SCT course.



Cleaning Plymouth pear fruits.

Photo: Hanna Oldfield

News

Samara e-newsletter

In September 2021 we launched the new *Samara* e-newsletter. A shorter, more regular version of the *Samara* newsletter but purely online. It is published three times a year, in March, June and September, and all issues are available on the Millennium Seed Bank Partnership website at brahmsonline.kew.org/msbp/samara/ENewsletter.

Over the course of the four issues released so far, there have been many stories relating to the conservation of rare and threatened species, with more to follow in the March

2023 edition. For example, in the September 2022 issue we heard about research on the endemic – and in some cases threatened – species of Lobelioideae of Hawai'i, work on the third edition of the 'Red Book' of Azerbaijan, and the development of a Seed Production Garden on Kangaroo Island, South Australia. Do have a browse through the past editions.

If you would like to receive email notification of new editions or submit an article, please do contact samara@kew.org – we would love to hear from you.



Screenshot from the MSBP Samara e-newsletter site

Kew MSc courses

Kew currently delivers three MSc courses in partnership with two UK universities. This year we have welcomed over 50 students from around the world onto our courses, including from Mexico, the Philippines, Canada and Belgium. The MSc courses cover three of Kew's major themes of research – plant and fungal taxonomy, conservation, and food security and sustainability – and all the courses are taught by Kew scientists as well as academics at our university partners in Queen Mary University of London and Royal Holloway, University of London. Every student takes part in a number of taught modules, learning key skills and concepts, then goes on to do an extended research project – where they join one of Kew's research teams, including those at the Millennium Seed Bank at Wakehurst. To find out more about these exciting courses, visit kew.org/msc.



Students from the Kew MSc course in Plant & Fungal Taxonomy, Diversity and Conservation undertaking a practical session on fungi.

New MSBP agreements

Country/territory	Partner	Start	Duration (years)
Dominican Republic	Jardín Botánico Nacional	December 2022	5
Jordan	National Agricultural Research Center	February 2022	10
South Africa	South African National Biodiversity Institute	April 2022	5
Wales	National Botanic Garden of Wales	April 2022	2

Recent publications

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MSB Dashboard 2 December 2022

Total collections	98,374
Total countries (including overseas territories)	190
Total families (excludes ferns)	349
Total genera	6,123
Total species	40,017
# of good seeds	2,455,311,980

Data prepared by O. Mitrovits

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The next *Samara* will be an e-newsletter published in March 2023 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 17 February 2023.