



samara

The International Newsletter of the Millennium Seed Bank Partnership

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The Australian effort as part of the MSBP

By Dr Lucy A. Sutherland
(Australian Seed Bank Partnership, Australian National Botanic Gardens)

Australia's large land mass means field experts often work in remote locations. The team at the Botanic Gardens and Parks Authority (BGPA) are well set up for long field trips

PHOTO: LUKE SWEEDMAN, BOTANIC GARDENS AND PARKS AUTHORITY

Australia was one of the first countries to join the Millennium Seed Bank Partnership (MSBP). As highlighted by the *Global Strategy for Plant Conservation* (GSPC 2012) targets, there was a clear need for conservation seed banks that provided a safety net for plant diversity, as well as providing a resource for much needed research on Australia's native flora. More specifically, the work of seed banking was needed to enhance knowledge around methods for successful species recovery and restoration of plant communities.

More than three quarters of Australia's 18,500 flowering plant species are endemic and Australia's dedicated efforts towards *in situ* conservation are well recognised. Nevertheless, there are ongoing substantial losses of native vegetation and new biosecurity incursions that threaten species and plant communities. The role of *ex situ* conservation in integrated conservation management has until recently been poorly acknowledged beyond the voices of botanic gardens. During the past fifteen years in Australia, through the leadership provided by the MSB and commitment by members of the Council of Heads of Australian Botanic Gardens Inc. and government environment agencies, there have been significant resources directed to *ex situ* conservation and seed science.

The MSBP has created a substantial legacy through the work undertaken from 2000 to 2010. Pre MSBP, seed banks associated with botanic gardens

were commonly for the purpose of supporting the development and maintenance of living collections for display and horticulture. Through the efforts in Australia, guided by the MSBP, we have seen an expansion of the role of these seed banks into plant conservation. The associated institutions have also increased their conservation efforts, which have often involved greater collaborations with community groups and non-government organisations, and the formation of long-term conservation partnerships.

Reflections by some Australian Partners highlight other aspects of MSBP's legacy including:

- improving the quality of collections and storage in Australia
- an exponential growth in the number of species held in collections
- enhanced education and training opportunities, including postgraduate studies in seed science
- enhanced research opportunities and the resulting publications
- technology transfer

The dedicated long-term investment has also advanced seed science for Australian native species and increased knowledge through extensive field work that has led to the discovery of new species, the rediscovery of species

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Collecting for the 1000 Species Project near Twin Falls: (Left to right) Ben Wirf, Craig Djandjomerr and Johnny Reid

PHOTO: TOM NORTH, AUSTRALIAN NATIONAL BOTANIC GARDENS



Collections from this roadside remnant of *Gmelina leichhardtii* in New South Wales were made as part of Kew and the Garfield Weston Foundation's Global Trees Project

PHOTO: GRAEME ERRINGTON, ROYAL BOTANIC GARDENS AND DOMAIN TRUST



Eucalyptus youngiana

PHOTO: DAN DUVAL, BOTANIC GARDENS OF SOUTH AUSTRALIA

thought to be extinct, and provided information on new populations of species and range extensions.

As skills and expertise in seed banking and research have been enhanced in Australia, there has been a growing recognition at a state and federal level of the role of *ex situ* conservation in integrated conservation management; evident by the incorporation of seed banking actions and targets into the Australian Government's *Threatened Species Strategy* (2015) (www.environment.gov.au/biodiversity/threatened/publications/threatened-species-strategy). Recognition in policy at a national level should help to reduce the limited understanding, and at times cynical view, of the role of botanic gardens in conservation. The significant effort in seed banking has added depth to these institutions' conservation efforts and thereby, has enabled botanic gardens to continue to maintain relevance through evolving to meet society's needs.

In 2010, the Australian Seed Bank Partnership was established to build on the legacy from phase one of the MSBP and to assist Australia with implementing GSPC targets. The Council of Heads of Australian Botanic Gardens Inc. governs the Partnership and it is supported by the provision of executive leadership through the Australian National Botanic Gardens. The Partnership's mission is a national effort to conserve Australia's native plant diversity through collaborative and sustainable seed collecting, banking, research and knowledge sharing.

A 10 year business plan (2011–2020) guides the Partnership's collaborative efforts. Through shared efforts, the Partnership bridges the gap between policy-makers, researchers and the conservation and restoration sectors to help safeguard Australia's plant populations and communities.

The Partnership's early efforts focussed on establishing governance arrangements and determining national priorities through such activities as:

- A gap analysis to determine the status of eucalypt taxa in Australian conservation seed banks.
- Assessment of *ex situ* collections of threatened flora species known to be susceptible to *Phytophthora cinnamomi* and provision of advice on priorities to the Australian Government.

Other important collaborations have included:

- 1000 Species Project – preparing a national list for seed collections of 1000 new species for conservation seed banks with priority being placed on threatened, endemic and those of known economic value – the tally of 542 new species to seed banks has recently been reached, supported through MSB's Fieldwork Funds.
- Australian Seed Bank (online) – this project involved working with the Atlas of Living Australia to build an accessible seed information hub, which operates as an aggregator of data and gives Australia's conservation seed collections a 'common' presence on the web (asbp.ala.org.au/).

Five years on, Australia continues to contribute to MSBP seed banking targets and is currently collecting for Kew and the Garfield Weston Foundation's Global Trees Programme. Some of the Australian Seed Bank Partnership's other priorities include:

a) Enhancing the sharing of seed science and bringing together scientists working in the conservation, agriculture and restorations sectors. The Partnership is holding a National Seed Science Forum in March 2016, in collaboration with Australian Grains Genebank and Australian Network for Plant Conservation, and hosted by Australian Botanic Garden Mount Annan.

b) Expanding collaborations to address international and national priorities. The Partnership is working with the Australian Grains Genebank to secure support and resources for collections of Australian Crop Wild Relatives. It is also collaborating with the Agriculture and Law Department of the University of New England and the Cooperative Research Centre for Remote Economic Participation in the development of protocols for managing of traditional knowledge and seed banking while working with Traditional Owners on Indigenous lands. Through a new alliance with the Society for Ecological Restoration Australasia, the Partnership is providing expertise in strategic discussions to guide the preparation of national standards for the practice of ecological restoration in Australia.

c) Enhancing the provenance of *ex situ* conservation collections in an attempt to capture diversity found in different populations, which is not always reflected at a taxonomic level. The Partnership is seeking support for this vital work.

In Australia, the Millennium Seed Bank Partnership is enabling seed science and conservation, building academic and technical capability and guiding the application of international standards for managing these collections for research, species recovery and as a safety net. Furthermore, it has assisted in the growth of the conservation work of Australia's capital city botanic gardens. The members of the Australian Seed Bank Partnership continue to build on this legacy and there is a strong sense of collaboration that is critical when working in a federated system of states, where there are political obstacles to be overcome. Through bringing together diverse expertise and having a strong vision and mission, Australia's conservation seed banks continue to make an important contribution to safeguarding the world's flora.

Acknowledgements: I wish to acknowledge the assistance of Tom North, Dr Anne Cochrane and Dr Andrew Crawford and thank them for their reflections on the MSBP.

Reference

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The MSBP – 15 Years of Partnership

A message from Colin Clubbe Head of the Conservation Science Department



Colin Clubbe, St Helena PHOTO: V. THOMAS

The MSB Partnership is 15 years old. In human terms that's a teenager, actively growing, gaining experience and knowledge, and demonstrating its value to the world. At Kew we think of the Partnership as our family, one that we value and enjoy our interactions with as we work towards our collective goals. Like family, we are always afforded a warm welcome when visiting partners and are always happy to reciprocate when partners are able to visit us. We've welcomed many partners to Kew over the years and actively encourage you to keep coming.

Some of these interactions are on a more formal basis for capacity building and technology transfer to our mutual benefit. October saw the completion of a very successful Seed Conservation Techniques course which brought together twelve practitioners involved in Crop Wild Relative conservation from twelve institutions in 11 countries. November saw the start of a series of in-country courses which include Brazil, Thailand and Bhutan.

Wild plants are under threat. During the 15 years of our partnership we have lost some battles, with species and habitats declining, but also won some. The most significant success is that since 2000 our partnership has included almost 200 partners from more than 95 countries and territories working together to conserve wild species diversity. The activities of this partnership have resulted in more than two billion seeds being conserved in the Millennium Seed Bank, representing collections from 36,386 species. Furthermore, the MSBP Data Warehouse records additional species conserved in partners' seed banks but not duplicated in the MSB. We are well on our way to our ambitious target of collectively conserving 25% of the world's bankable species by 2020.

The road ahead is challenging, but the prize is enormous. Together we will succeed. Thank you all for being part of this great partnership.

A message from Jonas Mueller Senior Research Leader, Seed Conservation



Kew's Science Strategy, "A Global Resource for Plant and Fungal Knowledge", has nine major outputs, one of which we refer to simply as the "25% target". That is, to collect and conserve in long-term duplicate storage, high quality seed material of 25% of the world's bankable flora, which corresponds to roughly 75,000 species. These seed collections provide a conservation backup, but also a vital resource for the advancement of science through their use in plant research programmes. We are halfway

through the timeframe we set in 2010, the target is ambitious, and we still have a long way to go.

Pablo Picasso once said "Our goals can only be reached through a vehicle of a plan, in which we must fervently believe, and upon which we must vigorously act. There is no other route to success." My plea to all of you

is, on our route to success, help us achieve our 25% target and let us continue to work in true collaboration across our Millennium Seed Bank Partnership. I believe that together, working in partnership, we will succeed. I am reminded of the strong collaborative ties linking our Millennium Seed Bank Partnership with every project meeting I attend and every partner institute I visit.

On our way to the 25% target we will increase the geographical coverage of the MSBP, forging new partnerships in new countries and species-rich areas of the world. We will jointly develop proposals and raise funds for collaborative work and joint seed collecting missions. We will maintain strong technical links, underpinned by our MSBP Seed Conservation Standards, and continue to train colleagues across the partnership in seed conservation techniques.

This year alone has seen five training courses take place, funded by individual projects and hosted both at Wakehurst Place and MSBP partner institutions overseas. In addition, the MSBP Data Warehouse continues to grow, and feedback from users underlines its importance for seed collection data management, aiding seed banking and research work, whether or not seed collections are duplicated to the seed storage vaults here at Wakehurst Place.

Please stay in touch – we are counting on you!

The Millennium Seed Bank Partnership

The view from Kew's collections

By John Dickie (Senior Research Leader and Assistant Head of Collections, RBG Kew)

So, what does the restructure of Kew's science mean for the MSBP's collections housed in the vault at Wakehurst Place; and for the Seed Collections team directly responsible for managing and caring for them? The answer is 'business as usual - and some!'

Aimed at better integration and synergy of its science, Kew's new science structure includes Collections as one of six new, cross-institutional departments. It is responsible for managing all of Kew's diverse scientific collections; and my role is leading Seed and Lab-based Collections, the latter being the Kew DNA & Tissue Bank, based in the Jodrell Laboratory at Kew.

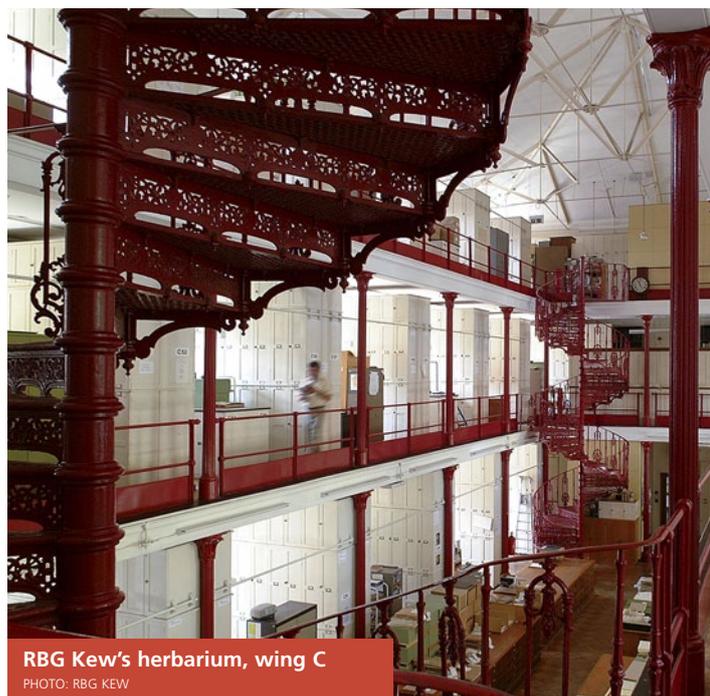
In the Seed Collections team, 22 of us, in the MSB at Wakehurst we continue to manage the seed collections, from their arrival to the distribution of samples to users. Janet Terry, Seed Collections Manager, still leads the three seed curation teams. As we move forward, they face a stretching target, to look after a high proportion of the 25% of the world's bankable flora expected to be in the Bank by 2020; as well as additional collections from separate new projects to sample populations of individual species more intensively, e.g. Crop Wild Relatives, MSBP UK Programme. Alongside this, Seed Data Resources Manager Udayangani Liu (Udi) now manages both the collection management database (SBD) and the online seed trait data in the Seed Information Database (SID). Plus, she is working to develop a tool to aid better prioritisation of collection management operations. Further support comes from our Germination Specialist, Rachael Davies, solving germination and dormancy problems, as well as monitoring comparative longevity of banked collections. Completing the team, recently arrived Early Career Research Fellow, Sarah Wyse will be developing predictive models of seed behaviour – storage type, survival and germination.



Seed collections in the Millennium Seed Bank, RBG Kew PHOTO: RBG KEW

The view from the Kew Herbarium

By Laura Jennings (Herbarium curator for the MSB, RBG Kew)



RBG Kew's herbarium, wing C PHOTO: RBG KEW

Herbarium voucher specimens are an integral part of seed collection; we need them to verify which species the seed was collected from, and they form a permanent record we can refer back to if necessary.

Over the last 15 years scientists in the Kew herbarium have verified almost 20,000 voucher specimens, which is testament to the incredible store of botanical knowledge (stored in herbaria, and in scientists' minds) the project relies upon. These specimens, and the many thousands more which have been verified by partners, have enriched the Kew herbarium in various ways, such as adding specimens from areas from which, for historical reasons, Kew had very few specimens, such as Georgia and Kyrgyzstan.

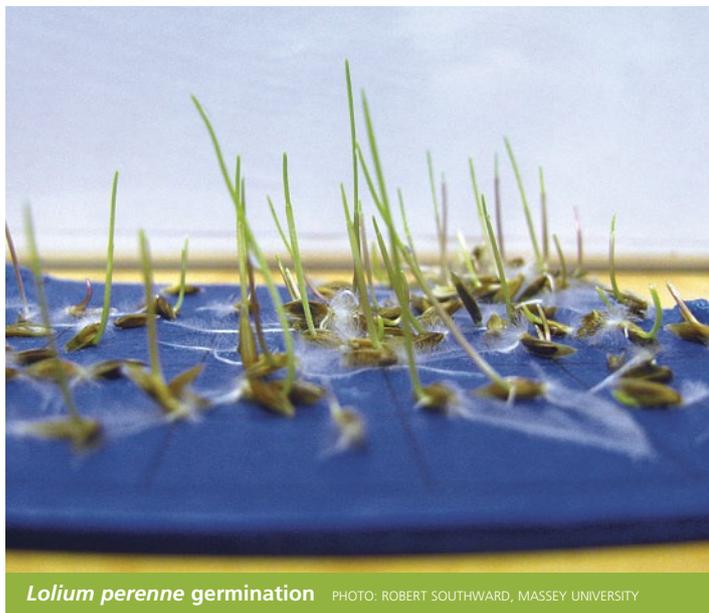
Several new species have been described from MSBP material, most notably from Africa, e.g. *Pavonia blephicarpa* and *Pycrus okavangensis*. There have been numerous new records at the country level, e.g. *Hereroa glenensis* collected in Botswana was the first record of that genus from that country.

There have also been many species for which an MSBP voucher specimen is the first representative in the Kew herbarium. As MSBP specimens are recent collections, they have been valuable to researchers for extracting DNA and collecting pollen which would be more difficult from older specimens.

A final benefit of the influx of MSBP herbarium specimens, speaking from personal experience, has been the unique, generalist botanical training they've provided to a succession of botanists who've had to identify plants from every part of the plant family tree and from across the world.

How can ISTA help with wild species?

By **Craig McGill** (ISTA Vice-President and ISTA Rules Vice-chair, Massey University, Palmerston North, New Zealand) and **Steve Jones** (ISTA ECOM member and ISTA Rules Chair, Canadian Food Inspection Agency, Saskatoon, Canada)



Lolium perenne germination PHOTO: ROBERT SOUTHWARD, MASSEY UNIVERSITY

The International Seed Testing Association (ISTA) was founded in 1924 as a group of governmental seed testing laboratories with the aim of developing standardised seed testing methods. The first edition of the International Rules for Seed Testing (ISTA Rules) was published in 1931. By providing methods for seed sampling and testing, the world trade in seed has been facilitated while maintaining robust seed certification and enforcement. As well as the ISTA Rules, ISTA publishes handbooks to support the testing methods and the journal: *Seed Science and Technology* (see www.seedtest.org for links).

For over 80 years the ISTA Rules have been developed to provide methodology for accurate and reproducible quality assessment of seed of species traded nationally and internationally. Until now ISTA methodology has largely focussed on species used for agriculture, horticulture and forestry, but some wild species are included, such as *Tetragonia tetragonioides*. While the focus had been on agronomic species, many of these have wild relatives to which the ISTA testing principles can be applied. ISTA methods have prescribed testing regimes and strict control of environmental parameters, validated by comparative testing between accredited laboratories. Using existing ISTA methodologies the quality of seed of wild species can also be determined.

The 'regular' ISTA tests are analytical or %purity, species identification, other seed determination, germination and moisture tests. The relevance of a given test will depend on how the seed has been collected.

The %purity test allows the percentages by weight of the species of interest to be determined in a mixed species collection, together with the percentage and identity of other seeds present at least to the genus level, plus quantifying other debris such as soil or vegetative material. Seed of wild species collected by hand and hand cleaned is likely to be of high pure seed content, whereas that harvested by mechanical means, for example brush harvesting of a hay meadow, may be of lower purity and hence a purity test will be more relevant.

The germination test is designed to determine the maximum potential germination of the seed lot. Germination is assessed using specified temperature and light regimes, and suitable germination media, which minimise, or eliminate, biotic stress. Germination% on an ISTA certificate is



Seed mixtures, agricultural or wild can be a problem. Seed identification to species level is what ISTA laboratories do on a daily basis. Applying pure seed definitions to determine what is seed and what is chaff (inert matter) is just one part of the ISTA Rules. PHOTO: RBG KEW

the % of normal seedlings – those that contain all the essential structures to enable the seedling to develop into a healthy independently functioning plant. For wild species whose genus is already in the ISTA Rules, development of normal and abnormal seedling definitions will be relatively straightforward.

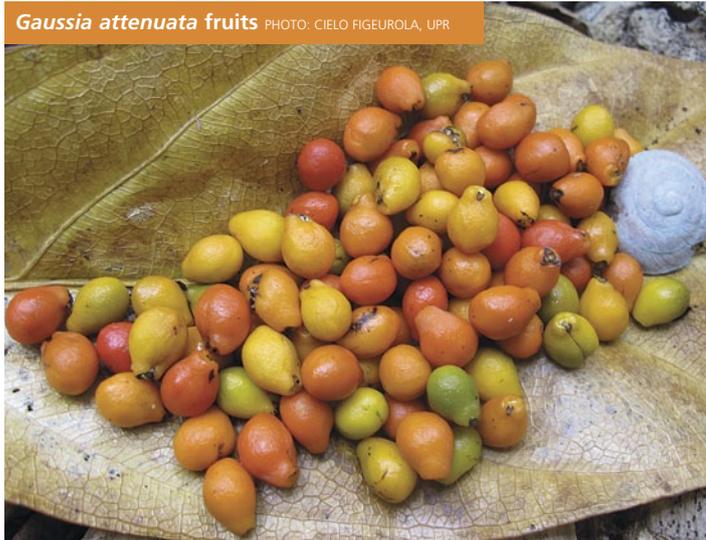
Although the ISTA germination test uses dormancy breakage treatments it is usually aimed at species with shallow or transient dormancy. For species with deep dormancy (e.g. some tree species) ISTA makes use of other tests such as the excised embryo and tetrazolium test to assess viability. Seed of many wild species will have deep or even variable dormancy as a mechanism for survival/colonisation that will inhibit uniform germination; they may, therefore, benefit from such tests.

As wild species become more commercially traded the need for accurate and reliable determination of seed quality that can be applied by laboratories worldwide will increase. Existing ISTA methods can be used for species listed in the Rules, or by applying the ISTA philosophy of how to sample and test seed, suitable methods for related species can be developed. Engaging people actively involved in working with native or wild species to help develop validated methods is one of the reasons ISTA has established a wild/native species working group. The aim of this group is to develop guidelines for determining the viability, germination, purity and moisture content of seed of wild species.

ISTA is always willing to discuss potential collaborations for developing methods for assessing the quality of species for which ISTA methods do not currently exist. Please feel free to contact Nadine Ettl at the ISTA Secretariat (nadine.ettl@ista.ch) in the first instance for more details on how you can get involved.

New partnership in Puerto Rico

By **Thomas Heller** (Islands Conservation Partnership Coordinator, RBG Kew), **José A. Sustache** (DNER), **Cielo Figuerola** (UPR), **Jeanine Vélez Gavilán** (UPR) and **Omar A. Monsegur Rivera** (US-FWS)

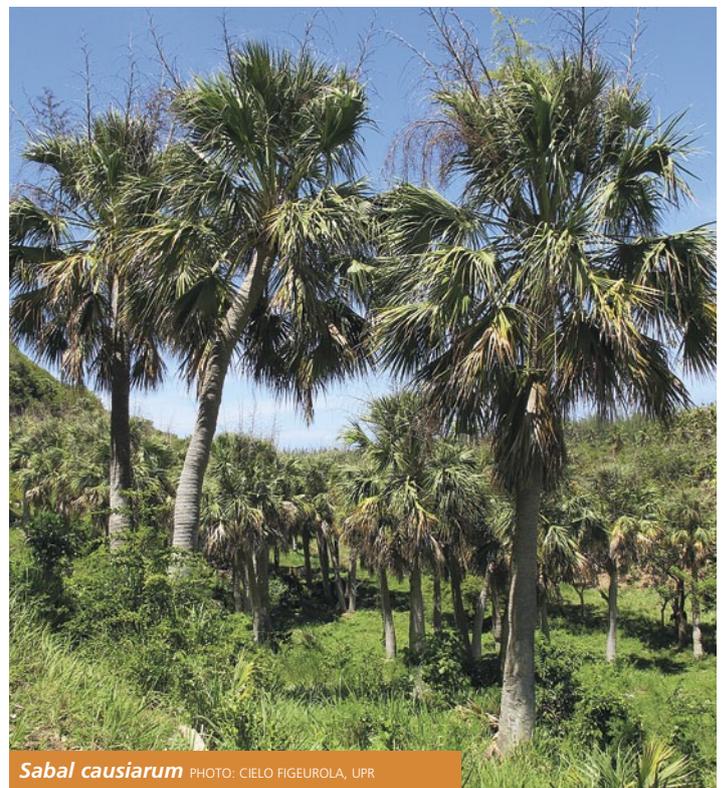


15 years into the Millennium Seed Bank Partnership and the network of seed conservationists continues to grow. As part of regional work in the Caribbean, the University of Puerto Rico (UPR) at Mayaguez has recently joined the partnership with an MoC agreed with Kew.

Kew has been supporting seed conservation activities in Puerto Rico since 2013, with the Department of Natural and Environmental Resources (DNER) undertaking a programme to collect the seeds of endemics and other plants of conservation concern and bank them at the MSB, Wakehurst Place. During this time, state botanist José A. Sustache and Cielo Figuerola have collected the seeds of more than 59 species.

The species collected are important for the conservation of biological diversity, and function as food and habitat for other endemic and native species in their ecosystems. The majority of these species face a variety of threats to their long term survival, including small population sizes, narrow geographical ranges and invasive species, among others. Some examples of rare and endemic species from Puerto Rico that have been banked are *Lobelia vivaldii* (endemic to Mona Island), *Anemia portoricensis*, *Sabal causiarum* and *Gaussia attenuata*. The palms *Sabal causiarum* and *Gaussia attenuata* were proposed in 2015 as endangered species by DNER (Regulation 6766) due to the low numbers of individuals in the wild, a result of development pressures and over-collecting. One of the most significant aspects of the project has been understanding why some species at risk have increased in rarity. Some of the problems affecting them include low fertility which prevents significant recruitment to populations. This project is highly important for the protection of the Puerto Rican flora as it ensures that the germplasm of the rarest species is safeguarded and banked for the long term, enabling researchers and managers to investigate them and take key decisions regarding their conservation and management.

These seed accessions represent an immensely valuable *ex situ* conservation resource, with the natural habitats of Puerto Rico, in common with many Caribbean islands, facing increasing pressure from development, competition from non-native species and plant pathogens. Puerto Rico and the Virgin Islands (Puerto Rican Bank), are home to over 2,200 taxa, with 13.6% endemism. Puerto Rico was nearly completely deforested by the 1930s with less than 6% of forest cover, and less than 1% of pristine forest, surviving. By 2009 the forest cover had increased to nearly 55%, but the majority of the endemics and the rarest species remain restricted to small remnants of native forest. This highlights the importance of this collaboration for the conservation of the endemic flora of the Puerto Rican Bank.



Collecting by DNER continues, and the University of Puerto Rico (UPR) have joined the collaboration under the Garfield Weston Global Tree Seed Bank Project. As part of the Caribbean strand of the project, UPR are establishing facilities to collect, process and bank tree seeds within Puerto Rico at the Biology Department of their Mayaguez campus. This is an important development as seed collections from Puerto Rico have, to date, only been banked at the MSB in the UK. The duplication of seed collections is an important principle of the MSBP, ensuring greater security for banked collections. With a home at the University, the availability of locally banked seeds will be an important resource for research studies at the University as well as conservation initiatives in Puerto Rico. In tandem with the DNER collecting team, UPR and partners will be targeting tree species of conservation concern and value in habitat restoration for collecting and banking. This project sets the basis for a broader collaboration between KEW, DNER, UPR and Federal Agencies (i.e., US Fish and Wildlife Service).

MSBP UK Programme update

By **Clare Trivedi** (Conservation Partnership Coordinator, RBG Kew)



Banking the UK flora as part of the UK Flora Project PHOTO: RBG KEW

While teams all around the world are working hard to contribute to the MSBP global aims, the MSBP UK team is also making a significant contribution to Kew's conservation targets. The MSBP UK Programme comprises three main strands which are intertwined to deliver a programme to support UK conservation efforts.

Our main collecting project is the UK Flora Project which has been running for many years. The headline target of this project has always been to seedbank 100% of the orthodox, seed-bearing native flora of the UK. This target was largely met before the international programme was launched in 2000 and we now have 94% of the UK flora safely banked in the MSB. We continue to work with botanists and other partners across the UK to bank those very tricky final species which are often hard to identify or rarely seed. The UK Flora Project is also working to increase both the overall quantity of UK seed collections in the MSB, and to increase the genetic representativeness of those collections, in order to ensure we can provide high quality collections for use in science, education and conservation. There is a focus here on species which are in greatest demand from our users.

In 2013 we launched the UK National Tree Seed Project (UKNTSP) which is taking the ambition for genetic representativeness of the collections to a higher level, for the woody flora of the UK. Our national forestry agency (Forestry Commission) has divided Britain into 24 biogeographic zones to be used for seed sourcing and use. We have mapped the native distribution of the woody flora against these zones and are seeking to make collections in every zone in which a species is found. Wherever possible we are also banking seed from individual mother trees separately. Seeds from the UK Flora Project and the UKNTSP are available to researchers through the standard MSB Seed List.

Finally, the UK Native Seed Hub is an initiative launched in 2011 to increase the quantity, quality and diversity of native plants and seeds available for conservation and habitat restoration in the UK landscape. We have established seed beds which allow us to bulk up large quantities of priority species, and we can also produce plug plants for users. Most often these are species which are difficult to harvest, to store, or to germinate/propagate and so are not easily available to practitioners. Sometimes we carry out 'brush harvesting' to produce seed mixes from a donor site for a suitable recipient site. The UKNSH has developed a quality assurance mark which assures the known provenance and high viability of seed. Seed is initially brought into the UKNSH via the UK Flora Project.

All three projects include research components which aim to overcome the constraints to collecting, banking and using the seed of the UK flora. This includes understanding the storage, germination and propagation requirements of 'difficult' species, and how best to make use of seed in the landscape. We have recently employed a geneticist to better understand how to capture genetically representative collections of the UK flora, and



Field-based training as part of the UK National Tree Seed Project PHOTO: RBG KEW



Seed production beds for the UK Native Seed Hub at Kew's Wakehurst Place site PHOTO: RBG KEW



Plug plants produced by the UK Native Seed Hub PHOTO: RBG KEW

the risks associated with using seed of a certain provenance in different parts of the UK.

All three projects also work with a wide range of partners across the UK, and regularly share scientific, technical and practical skills in order to raise the capacity across the UK for seed collecting, banking and use.

For further information see the project webpages, or contact the Conservation Partnership Coordinator, Clare Trivedi.

Ethiopian Biodiversity Institute joins the Millennium Seed Bank Partnership

By **Bruk Lemma Debebe**,
Marshet Gijan Volodia
and **Hawi Woldeyesus Mengesha**

(Ethiopian Biodiversity Institute,
Addis Ababa, Ethiopia),

and **Tim Pearce**

(Conservation Partnership Coordinator
for Africa, RBG Kew)

Marshet, Hawi & Bruk working in the labs at the MSB PHOTO: RBG KEW



Bruk, Hawi & Marshet banking seeds at the MSB PHOTO: RBG KEW



With over 6,500 vascular plant species, 12% endemism and recognised as a Vavilovian centre of plant genetic diversity, building the *ex-situ* seed collection of Ethiopian native flora has fast become a national priority. With the recent signing of a new Memorandum of Collaboration with RBG Kew, the Ethiopian Biodiversity Institute (EBI) has formally joined the Millennium Seed Bank Partnership.

The EBI is the national institution responsible for *ex situ* and *in situ* genetic resources conservation and sustainable utilisation. With significant support from the German Government, EBI was first established in 1976 and enjoys a close working relationship with many national agencies particularly the National Herbarium at the Addis Ababa University – another key partner with RBG Kew. With a modern facility at its headquarters in Addis Ababa and a new satellite seed bank to be opened in 2016 some 100km from there, EBI is well placed to host the national *ex situ* collection of indigenous plant species.

As with many countries, the seed storage behaviour and germination requirements of the majority of the Ethiopian flora are unknown. Whilst

EBI will benefit from the excellent work of its neighbours in the region, much research needs to be undertaken, particularly on its endemic, threatened and useful species. Recognising this, our management has secured the support of MSB staff to host us for three months at the Millennium Seed Bank. We are here not only to reinforce our understanding of seed banking methods and technologies but also to undertake some studies for our MSc programmes. We will be ensuring that what we learn in our time at the MSB on seed collection and handling, drying, processing, banking, germination and data management will help us improve our ever-increasing workflow at EBI.

We brought some material with us from Ethiopia: *Harrisonia abyssinica*, *Wendlandia arabica* subsp. *aethiopica* and *Uvaria leptocladon* subsp. *septentrionalis*. We have already learned much more about the seed from these species by using the x-ray and drying facilities. We are now finalising our work programmes which will help us unravel the germination and storage requirements for these three highly valuable species of the Ethiopian flora.

Seed germination and longevity in a changing climate. A focus on alpine plants and crop wild relatives

A research theme of the MSB Partner at the Plant Germplasm Bank of the University of Pavia

By **Filippo Guzzon**, **Thomas Abeli** and **Andrea Mondoni**

(Department of Earth and Environmental Sciences, University of Pavia, Italy),

Simone Orsenigo

(Department of Agricultural and Environmental Sciences – Production, Landscape, Agroenergy, University of Milan, Italy),

and **Jonas Müller** (Senior Research Leader, Seed Conservation, RBG Kew)



Climate change is expected to affect the distribution, ecology and physiology of plants. Alpine species, growing in cold habitats, are considered to be particularly threatened by global warming. Major changes in the germination phenology of alpine species are expected under climate change scenarios, with warming predicted to shift the emergence time of plants and to increase seedling establishment of alpine plants (Mondoni et al. 2015, Orsenigo et al. 2015). These changes in germination time and recruitment success may expose plants to abiotic and biotic conditions they have not previously encountered.

Climate change may also increase the seed longevity of alpine plants when parent plants are subjected to moderate climate warming (Bernareggi et al. 2015), as it has been demonstrated that the parental plant growth environment affects the longevity of seeds of alpine species (Mondoni et al. 2014). Therefore, the regeneration location of a species may have important implications for seed longevity, and so for the conservation of the seeds of alpine plants stored in seed banks. Clarifying changes in seed longevity will be of key importance to alpine species *ex situ* conservation, as currently alpine plants show, on average, a low resistance to ageing (Mondoni et al. 2011).

Extreme climatic events are also expected to deeply affect agricultural production. Crop wild relatives (CWR) act as donors of useful traits for

improving the ability of existing crops to cope with climate change driven stresses. The characterisation of the germination of CWR is needed to enhance their use in breeding programmes. Interestingly, preliminary data shows that in *Aegilops geniculata* (a wild relative of wheat) the resistance to drought in seed germination is connected to rainfall conditions experienced by the mother plant during seed development and maturation (Guzzon et al. 2015); this data underlines even more the need to clarify the transgenerational effects in plants of abiotic stresses resulting from climate change.

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NEWS

Millennium Seed Bank Technology Transfer project

By Elinor Breman (MSBP Administrator, RBG Kew)



Testing the relative humidity of seeds using a TinyTag Data logger, Plant Genetic Resources Research Institute, Ghana PHOTO: TIM PEARCE

Funded by the Toyota Environmental Activities Grant Program, this project enables capacity building and technology transfer across the MSBP and is now halfway through its cycle. To date the initiative has supported a wide variety of work to meet these aims.

Technical capacity assessments were carried out at two partner institutes in Ghana in May 2015, allowing two new seed collection programmes to get underway. The first involved the Plant Genetic Resources Research Institute joining the Crop Wild Relatives project, the second involved the Forestry Research Institute of Ghana joining The Global Tree Seed Bank project (Garfield Weston) banking seed from endangered native trees.

The Margot Forde Germplasm Centre, New Zealand, became the second MSB partner to receive a formal assessment of their procedures and facilities in relation to the MSBP Seed Conservation Standard (LUOMUS in Finland was the first). This has proved a very fruitful endeavour leading to dialogue on the improvement of facilities and to further training of personnel in data management, seed processing (in country) and to a three week study visit by the seed bank manager to the MSB in August 2015.



Blue drum drier kits PHOTO: RBG KEW

The annual MSBP Questionnaire was sent out to our partners earlier in the year and we received responses from more than 50% of those polled, representing 77 organisations (75% of those contacted) in 48 countries (86% of those contacted). The questionnaire covered seed collection data held by partners, the MSBP Seed Conservation Standards, the MSBP Data Warehouse, technical capacity and training, and research. The data provided by respondents has enabled planning of strategies for moving technology transfer forward.

Intermediate technology drum drying kits have been requested by many MSBP partners in order to collect, clean, dry and store seed effectively at low cost. The deployment of these kits is well under way and they should be reaching partners in the Garfield Weston tree seed project shortly after this issue of Samara.

To raise awareness of the work being carried out at RBG Kew on technology transfer in seed conservation Dr Elinor Breman gave a presentation on the MSBP Seed Conservation Standards and the role of the MSBP Data Warehouse in helping monitor them, at the 7th EuroGard meeting in Paris in July, and the associated paper will shortly appear in the conference proceedings. You can learn more about the MSBP Seed Conservation Standards on Kew's website (www.kew.org/science-conservation/research-data/resources/millennium-seed-bank-resources)

Two Seed Conservation Techniques Courses took place this year, the first at Wakehurst Place in October, the second in Brasilia (Brazil) in November. More on this course can be found on page 11.



Jae-hyeun Kim and Kate Hardwick by the partially completed entrance to the KNA Seed Vault PHOTO: RBG KEW

The Korea National Arboretum's International Symposium

By Kate Hardwick (Conservation Partnership Coordinator for Asia, RBG Kew)

The Korea National Arboretum hosted its second international symposium from 20 to 22 October. Amid the vibrant autumn colours of the Arboretum, foreign and local researchers exchanged ideas around the theme of 'Biodiversity Conservation and Seed Vault'. Mark Chase, Mike Fay and Kate Hardwick attended from RBG Kew,

while Jonas Mueller (Senior Research Leader, Seed Conservation) sent a recorded congratulatory message. Researchers from Central, South-East and East Asia were well represented, presenting on diverse aspects of the conservation of the Asian flora.

The third day focussed on seed science and conservation. In the opening talk, Jae-hyeun Kim announced the KNA's ambitious plans for a new seed bank, the 'Seed Vault', currently under construction at Baekdu-Daegan National Arboretum. Foreign participants were treated to a preview of the Seed Vault on a post-Symposium trip to Baekdu-Daegan. The visitors were taken deep underground to the partially-completed Vault (reminiscent of the seed bank at Svalbard) where one of the cold rooms is already equipped and operational. With capacity for up to two million accessions, extensive laboratory and educational facilities, and a beautiful visitor centre, the Seed Vault will make a major contribution to *ex situ* conservation and research in both Korea and the wider Asia region. It will be officially opened in 2017.

NEWS

Seed Conservation Techniques course 2015

By Roberta Hope (Science Administrator – Education, RBG Kew)



Participants on the 2015 SCT course PHOTO: RBG KEW

The Seed Conservation Techniques course has been running every other year since 2002, inviting seed scientists to train in different aspects of seed conservation. This year's SCT course was a special bonus: thanks to funding from the Simon Foundation we were able to run the course during an interim year, to train participants from partner organisations involved in the Crop Wild Relatives project.

The twelve participants came from twelve different institutions in eleven different countries, bringing with them a range of experience in various aspects of seed conservation. During the course participants studied theoretical aspects to seed banking such as seed-air moisture relations,

seed storage behaviour, germination and dormancy. Practical aspects included sessions in the lab where participants worked with staff to process seeds, set up germination tests, and test collections to assess their viability, through X-ray, chemical and physical means. The participants also spent a day in the field, learning how to assess whether a population is suitable for seed collection, and how to sample populations in ways which maximise the genetic diversity of collections.

The course concluded by looking at how seeds are used for conservation and restoration, underlining the aim of the Millennium Seed Bank Partnership, to safeguard wild plant diversity.

Training course in Bhutan

By Alexandra Davey (CWR Country Programme Officer, RBG Kew)



Kezang Tobgay, Nima Gyeltshen, Tshering-la and Alicky Davey take stock over tea after fieldwork at the Nikachu hydroelectric dam site PHOTO: RBG KEW



Cupressus torolusa, the national tree of Bhutan PHOTO: RBG KEW

In December we kicked off the Garfield Weston Global Tree Seed Project in Asia with two training courses in the region. The first took place in the foot hills of the Himalaya, hosted by the National Biodiversity Centre, Bhutan. With RBG Kew's help they are aiming to conserve seeds from 100 species of the country's rarest, most threatened and most useful trees. The second course was hosted by the Forest Restoration Research Unit of Chiang Mai University in Thailand and brought

together both university staff and botanists from Bangkok Forest Herbarium and the Bangkok Herbarium.

The courses delivered a whistle-stop tour through seed conservation techniques, from planning and executing a seed collecting expedition to cleaning, drying and banking collections. In both countries some specialised techniques will be required to collect seeds from high up in the canopy, such as the mighty *Cupressus torolusa*, national tree of Bhutan, and these were addressed in the course.

In both Thailand and Bhutan the Global Tree Seed Bank project represents the beginning of new partnerships with the MSBP that we hope will be both long lasting and fruitful.

New MSB agreements

Country	Counterpart Name	Start Date	Duration (Years)
UK	15 partners of the UK National Tree Seed Project	January – October	1 – 4
Dominican Republic	Jardin Botanico Nacional	February	5
Australia	Queensland Herbarium, State of Queensland	April	5
Namibia	The Ministry of Agriculture, Water and Forestry	April	5
United States of America	University of Hawaii*	May	5
Armenia	The Institute of Botany of the National Academy of Science	July	1
17 countries	ENSCONET consortium	August	5
Myanmar	University of Mandalay (Ministry of Education)*	September	1
Thailand	Department of National Parks, Wildlife and Plant Conservation*	September	10
Ghana	CSIR – Forest Research Institute of Ghana	October	5
Ethiopia	Ethiopian Biodiversity Institute*	November	5
Singapore	The National Parks Board	November	5
Puerto Rico	Universidad de Puerto Rico, Recinto Universitario de Mayagüez	December	4

* denotes new partner for the MSBP

Tales from the field



PHOTO: RBG KEW

Fieldwork is an important part of the work that we all do. We'd love to hear about your fun, interesting, exciting field trips. Send us stories and photos of what you get up to when you are out of the office!

Next issue: Samara will be reporting on the work carried out across the MSBP in relation to TREES in the next issue. If your work relates to trees and you would like to share it with the wider MSBP community and beyond please contact our editorial team, we would love to hear from you.

Key science publications (January – December 2015)

Dürr, C., Dickie, J.B., Yang, X.-Y. & Pritchard, H.W. (2015) Ranges of critical temperature and water potential values for the germination of species worldwide: Contribution to a seed trait database. *Agricultural and Forest Meteorology* 200: 222-232.

Eastwood, R.J., Cody, S., Westengen, O.T. & Von Bothmer, R. (2015) Conservation Roles of the Millennium Seed Bank and the Svalbard Global Seed Vault. In *Crop Wild Relatives and Climate Change*, Redden, R., Yadav, S.S., Maxted, N., Dulloo, M.E., Guarino, L. & Smith, P. (eds) Wiley-Blackwell. 173-186.

Fernandez-Pascual, E., Seal, C.E. & Pritchard, H.W. (2015) Simulating the germination response to diurnally alternating temperatures under climate change scenarios: comparative studies on *Carex diandra* seeds. *Annals of Botany* 115 (2): 201-209.

Geniti, R., Fenu, G., Mattana, E., Citterio, S., De Mattia F. & G., B. (2015) Conservation genetics of two island endemic *Ribes* spp. (Grossulariaceae) of Sardinia: survival or extinction? *Plant Biology* 17 (5): 1085-1094.

Gundel, P.E., Sorzoli, N., Ueno, A.C., Ghersa, C.M., Seal, C.E., Bastias, D.A. & Martínez-Ghersa, M.A. (2015) Impact of ozone on the viability and antioxidant content of grass seeds is affected by a vertically transmitted symbiotic fungus. *Environmental and Experimental Botany* 113: 40-46.

Williams, E.V., Breidy, J., van Slageren, M. & Khairallah, S. (2015) New records for the flora of Lebanon. *Webbia, Journal of Plant Taxonomy and Geography* 70 (2): 323-327.



Millennium Seed Bank Collection Figures November 2015

Total collections	76,312
Number of species	36,386
Number of genera	5,676
Number of families	334

WE WANT TO HEAR FROM YOU!

Samara is your newsletter, so send us news and articles about yourself and your work.

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Samara aims to provide information and inspiration for MSBP partners and a flavour of the successes of the Partnership for other interested recipients and is available as a PDF from the MSBP website at: www.kew.org/samara

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