Samara

The International Newsletter of the Millennium Seed Bank Partnership

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Collecting, integrating and sharing our data

Fondey Mashimba Hussein taking charge of gathering field data in Tanzania.

Photo: Tim Pearce

Samara

Contents

TIM PEARCE
(MSBP Africa Programme Coordinator, RBG Kew)

Many of us have studied herbarium specimens in order to make sense of a particular plant group or perhaps in order to develop a regional checklist. Isn't it brilliant that the botanical collectors of the past got it just about right? Herbarium labels even from two centuries ago basically recorded *who* collected *what* from *where* and *when*. OK, the detail of the data has changed, so rather than *"Tanganyika Territory"* we now routinely secure a geo-reference that enables us to map a point with a few metres resolution. But, it's a great recording system which has evolved into the field data recording protocols we are all familiar with. It would be nice to say that there is a single global standard for field data recording, and whilst there are global standards to assist data exchange even the "MSBP Standard Data Form" is only a suggested minimum for long-term seed collections.

As a botanic garden, RBG Kew is getting smarter at gathering different material and data in one event. We routinely gather leaf material in silica-gel for DNA extraction, seed collections for long-term conservation and use, the herbarium voucher, field images, and data for our Red Listing work. The concept of the Collection Event which generates these materials is now considered the norm and our field data gathering exercise reflects this growing complexity.

The various material that derives from this collection event is often subsequently dealt with differently. Different teams look after different material, and they are likely to end up in different storage locations. A herbarium voucher may have a determination done initially and if we are fortunate enough, a later confirmation or redetermination by a specialist. Material is still loaned out but with many herbaria putting

Royal Botanic Gardens Kew

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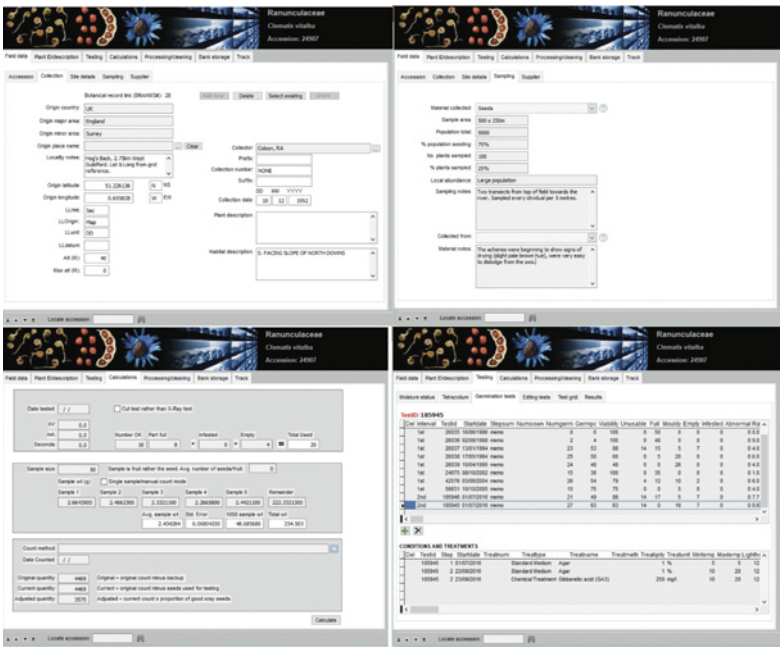
The Collection Event: A single collecting instance may end up with many different types of material; seed, herbarium vouchers, dried leaf material for DNA, Living plants, additional data and images for Red Listing.

material online, I suspect the amount of herbarium material loaned between herbaria will reduce significantly.

As they are living material, seed collections inevitably have a much more active management life. We receive, accession, dry, clean, count, x-ray, store, germinate, re-test, distribute, stock-take: a continuum of activities each of which generates significant and often complex data that needs to be recorded, managed and made available for analysis.



Data Management tools must be able to gather and integrate different data from the field and the seed bank. (Top left: Field "Passport" data. Top right: Sampling data. Bottom left: Seed weight, x-ray and count data. Bottom right: Multiple germination tests.)

I know that many teams across the MSBP have developed their own data management systems to cater for their particular needs, as we have done at RBG Kew. Some teams will have opted to use existing systems such as BGBase or BRAHMS. Either way, all of these systems must be able to quickly respond to the many rapidly evolving tools being developed commercially that make the job of data analysis easier. It is incorrect and rather futile to imagine that a single system will do everything we want to do with our data. We have an enormous array of tools at our disposal to help us in our task.

Whatever we do with "our" seed data must of course be available to, and integrated with, those data that are generated by the other collections gathered during our initial collection event – after all, they are all linked through that event. I have been working with the BRAHMS software for many years and we have made some strong steps in achieving the integration of data from the collection event such as linking the seed collection with the herbarium voucher, or being able to monitor the management of the living plants generated from our seed. What remains a challenge is the better integration of data from different data sets. For example, wouldn't it be good to easily explore how the distribution and availability of pollinators impacts on seed longevity, or perhaps be able to correlate seed germination test results with seedling attrition rates in *in situ* restoration trials?

As the amount of data that we generate increases we should be mindful that the onus is on us to make our knowledge available to the wider research community. It is easy to put in place levels of security so as not to jeopardise fragile communities of rare plants and so at RBG Kew we are committed to putting our data online for others to add value to. This edition of SAMARA has some nice examples of how data can be effectively shared across botanical networks and beyond; our experience with the MSBP Data Warehouse certainly demonstrates that it is not just the seed conservation community that are interested in our collective data.

Just as those early botanical explorers left a data legacy that we still use today, bear in mind that those data we generate when we record our sampling strategy in the field or score a seed germination test, could be around for centuries, as will your name attached to it – so do a good job please!

A message from Colin Clubbe

Head, Conservation Science Department - Senior Research Leader of UK & Islands Programme, RBG Kew

In today's world data are big business and constantly in the news. Decisions need to be evidence based and data provides that evidence. At the same time, we are witnessing a technological revolution in the facilities we have at our disposal to store, analyse and present data. The costs of these technologies are falling, making things more affordable and giving us more for our money. Data storage is no longer a barrier in many circumstances. However, collecting these data still mostly relies on people's efforts and this is certainly the case with conservation activities and seed collecting. We need to work smarter to maximise the opportunities that new technologies afford us in the field and when we get back to base with our collections and their associated data.

This issue of Samara is very timely as it focusses on technology and data, sharing some of the most innovative things that are happening across the MSB Partnership. At its heart is the MSBP Data Warehouse which I've watched grow and develop into the valuable tool it is today. Thanks to the whole Partnership we have an extraordinary resource to track our collective progress in conserving the world's plant species and sharing the tools we are using to achieve this. The range of articles in this issue highlight great innovation across the MSBP and I'm sure you will be as excited to read them as I have been.

A message from Herta Kolberg

Millennium Seed Bank Partnership Coordinator, National Botanical Research Institute, Namibia

Since officially joining the Millennium Seed Bank Partnership in 2001 the Namibian partners have increased their *ex situ* collection of wild indigenous species by more than 1,500 accessions of which c.1,200 were duplicated at the MSB. Having the luxury of a full-time seed collector, funded by the MSBP, since 2005 made all the difference. We made good progress toward the Global Strategy for Plant Conservation's (GSPC) Target 8 (75% of threatened species in *ex situ* collections) by banking 61% of these species locally, with a subset of these duplicated at the MSB. The information gathered during seed collecting also feeds into the assessment and updating of the conservation status of species (GSPC Target 2). As seed collectors spend their time in the field towards the end of the season, whereas botanists are out there at prime flowering time, we have added either new records or new species to the flora of Namibia (Target 1). Five new species discovered during seed collecting have already been described while another three species await description. More than 18 species known from neighbouring countries were first collected in Namibia by the MSBP team. Many species that were known from Namibia but of which only one, often very old, specimen was known, were re-discovered through concerted efforts to find them for seed collection. We are particularly grateful that through this partnership's training programmes some Namibians could improve their capacities to better contribute towards the conservation of our plant diversity (GSPC Target 15).

Droning for seeds

DR STEPHEN ELLIOTT (Biology Department, Science Faculty, Chiang Mai University, Thailand)

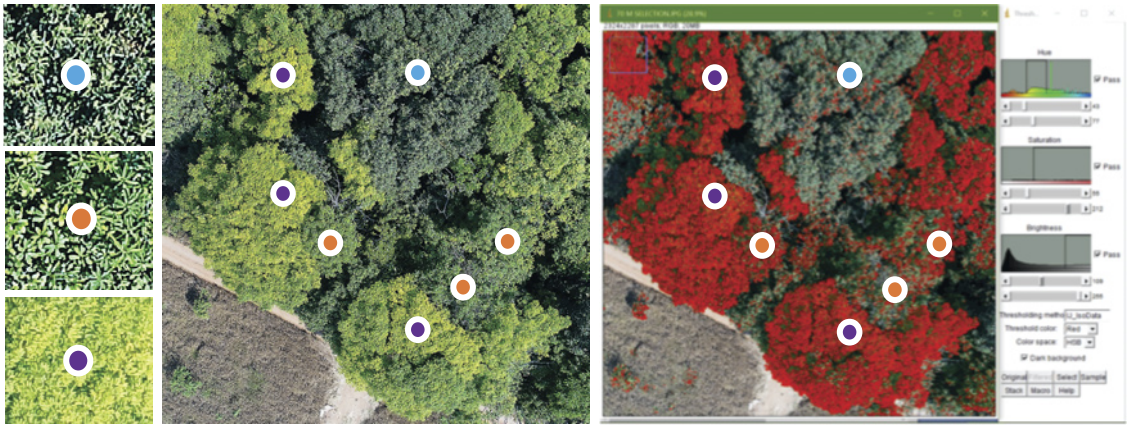
The UN is calling for the restoration of 350 million hectares of forest to degraded land around the world by 2030, but where will the seeds come from? Targets like WWF's "Trillion Trees Partnership" will require seed collection on an almost industrial scale. With most countries still lacking native seed supply chains, seed collecting in remnant forest remains essential, but current methods can be restrictive. Collectors must push their way through dense forests, with binoculars pointed aloft, searching for ripe fruits amongst the minute fraction of the forest canopy that is visible from the ground. Even when a fruiting tree is found, the seeds may not be ripe, necessitating a tedious return trip. So, conventional seed collection can be inefficient, unpredictable and consequently expensive.

So why not look for seed trees from above? This has been attempted by scanning high resolution photos, taken from planes 500-1,000 m up, for distinctive crown features to devise simple dichotomous keys (Gonzalez-Orozco, et al., 2010). Other researchers have achieved some success using hyperspectral imagery and lidar (Baldeck, et al., 2015), but such technologies are expensive and the details discernible from planes are limited. With the advent of affordable unmanned aerial vehicles (UAV's or drones), high-resolution digital cameras can be flown much closer to the forest canopy, so the development of much finer, cost-effective tree identification systems becomes possible.

At Chiang Mai University, Thailand, a graduate student in the international Environmental Science Program, Krishna Rai (from Bhutan), is trying to spot the crowns of target seed tree species within a seasonally dry tropical forest, using an off-the-shelf drone (DJI Phantom 4 Pro), an automated flight planner and open-source, image-processing software. Flying a drone low over an undulating forest canopy is, of course, risky, but the Phantom 4's collision-avoidance sensors have so far prevented crashes. Rai is experimenting with three types of data: i) crown morphology, ii) leaf characteristics and iii) image filtering. Leaf type, shape and arrangement can be discerned easily and are highly distinctive for some species. Image filtering can also dramatically distinguish the crowns of some species, but its effectiveness varies among species and seasonally. A species that is distinctive, when flushing new leaves may become indistinguishable just a few weeks later. Consequently, we envisage drones being used to locate target species, when they are at their most distinctive and to monitor them subsequently for fruit-set and ripeness using auto-flight plans. Who knows – one day soon, drones might even be able to collect fruits autonomously, with sensor-rich robotic arms: not so farfetched since robots that are capable of picking fruits in orchards already exist. As the use of drones becomes routine, the way we find and identify tree species is about to change fundamentally. Although conventional taxonomic species descriptions will remain a staple of tree guides, they may shortly become complemented with drone photos of tree crowns and the image-filter settings that distinguish tree crown species at various seasons.

Photo: K. Naruangsri

Testing drones in the field.



	Species	Family	Leaves	Crown	Filtered
●	*Castanopsis calathiformis* (Skan) Rehder & E.H.Wilson	Fagaceae	Simple, lanceolate, scattered	Rough "cauliflower"	Dotted (flowers)
●	*Magnolia garrettii* (Craib) V.S.Kumar	Magnoliaceae	Simple, lanceolate, rosettes of 7	Medium punctuated	Blotchy (young leaf rosettes)
●	*Choerospondias axillaris* (Roxb.) B.L.Burtt & A.W.Hill	Anacardiaceae	Pinnate dense	Smooth fractured	Soild (flushing leaves)

Figure: S. Elliott, K. Rai

An example of an output from drone imagery and the image-processing software.

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Next generation BRAHMS Seed Manager; Optimising the value of seed bank data with new technology

DENIS FILER (Senior Research Associate, University of Oxford) and TIM PEARCE (MSBP Africa Programme Coordinator, RBG Kew)

The first iteration of what is now the BRAHMS Seed Manager was published in 1988 – *"A database for Tree Improvement and Seed Bank management: SISTEM"*, which was an acronym for Species Information Seed Trials and Environment Management. This software package was initially developed for the Oxford Forestry Institute forest genetics research programme on tree breeding in southern Africa and Central America. Renamed to SISTEM+, it was then extended collaboratively with two other projects: the UK Forestry Commission Seed Section and the Forest Tree Seed Centre in Zomba, Malawi. This early database ran successfully for 5 years under the MS DOS operating system, installed from three 5.25 inch floppy disks.

SISTEM+ was then further extended to cover botanical research more broadly and in 1995, it was renamed to BRAHMS. BRAHMS steadily evolved over 25 years from its earliest iterations to what we now have as Version 7.

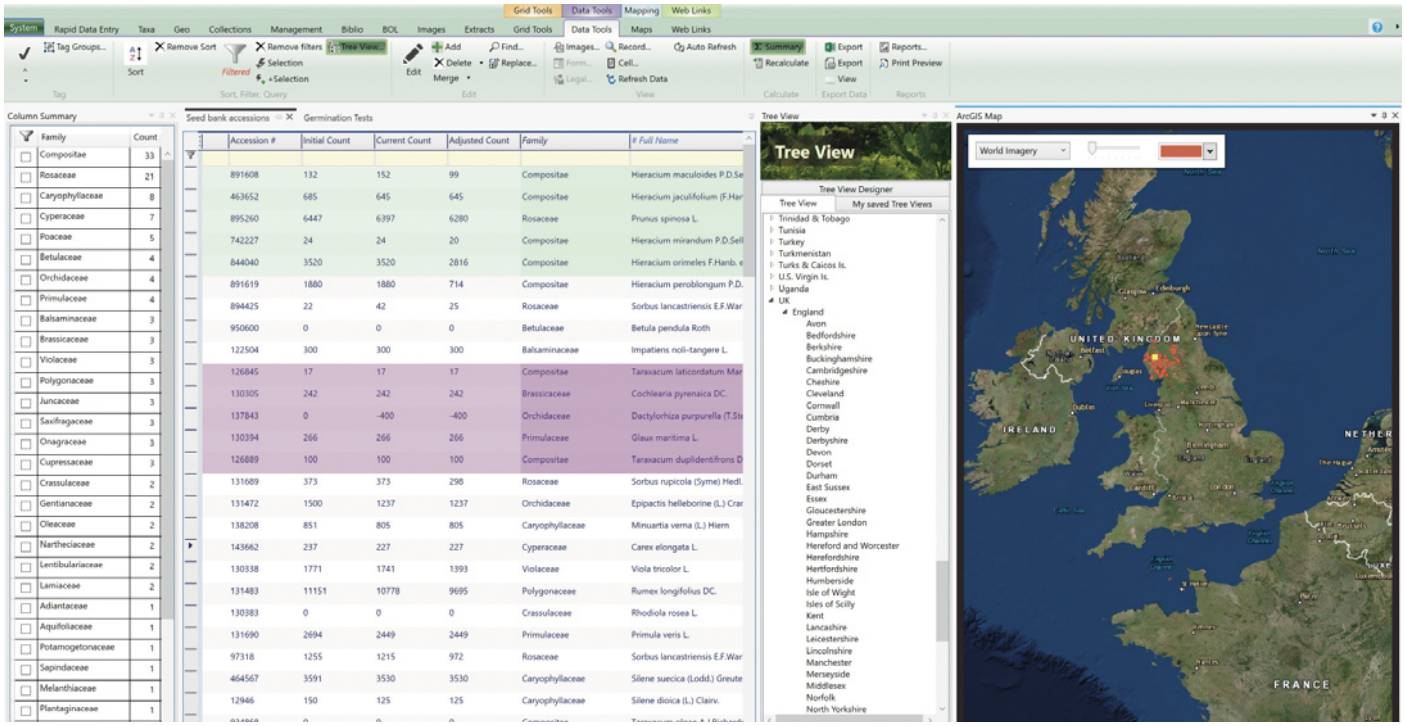
In the latter part of this period, the Seed Module was completely redeveloped. Undertaken collaboratively with the Millennium Seed Bank, its role was extended to include all the data management requirements for modern day seed conservation programmes. We made much use of the data model of the MSB's own Seed Bank Database and integrated these with the taxonomic and collections management elements of BRAHMS, to provide what we now have – a comprehensive seed bank system that encourages the step-by-step gathering of seed collection, vouchering, processing, storage and testing data – all of which adheres to well-known data standards.

Included in the seed module were several handy tools such as geographic and taxonomic level summaries of seed accessions, an analysis of test results and an automated 'collection standards' review tool which scores each collection against a number of the MSBP Seed Conservation Standards.

The new version of BRAHMS, v8, adopts the latest Windows based technologies and allows users to choose their preferred data store ranging from the highly portable SQLite to server-based PostgreSQL RDBMS. Many of these new features are described on *https://herbaria.plants.ox.ac.uk/bol/ brahms/software/v8* . As one example, the BRAHMS v8 UI can equally be presented in Amharic, Chinese and English. The priority translations are likely to be French, Spanish and Portuguese.

The seamless link between BRAHMS v8 and BRAHMS Online websites (such as the MSBP Data Warehouse itself) continues to be developed ensuring that appropriate seed accession and related data are delivered as widely as possible, both for curation and research use. The online system is also to be extended to include seed supply and ordering components.

Contact: Denis Filer, *denis.filer@plants.ox.ac.uk*; Tim Pearce, *t.pearce@kew.org*



Mapping seed accessions using the in-built ArcGIS mapper with a Tree View to help navigate and filter. BRAHMS v8 uses ribbon technology for menus and toolbars – the same as that used in MS Office.

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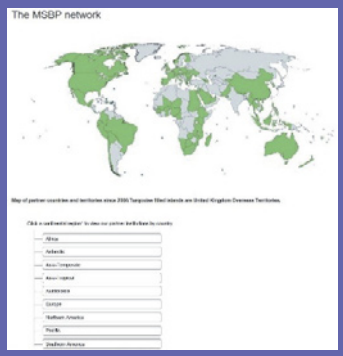
The new MSBP website

EVA MARTENS (MSB Partnership Administrator, RBG Kew)

The new MSBP website is an expansion of the MSBP Data Warehouse website and includes more information on the Partnership and a greater number of links to useful information and resources. The new site was designed to provide information about the partnership to interested parties, and importantly as a central location for useful resources for partner organisations.

Here's what the website has to offer



About Us

Here you can find an introduction to the MSBP at Wakehurst Place and a full list of partner institutes. A list of MSB staff can be found in the Contacts tab.

Where We Work

Here you will find more details of our partnerships, including projects, who we work with in each region and information on the flora.

Projects

Information on the MSBPs larger projects, including our crop wild relatives project and global tree seeds project can be found here. There is also a list of national seed conservation programmes.

Seed Data

The MSBP Data Warehouse can be found under the Seed Data tab. For quick access, an Explore button is located on the Homepage.

Information on what the MSBP Data Warehouse offers can be found overleaf.

The MSB welcomes comments and suggestions from partner organisations as to other features that would make the site useful. Please contact Eva Martens – E.Martens@kew.org – if you have any feedback

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Resources available to download

Resources updated as they are developed

Resources

Useful resources for partner institutions can be found here, including: Technical Information Sheets; Seed Conservation Standards; the Samara newsletter; collecting guidelines and lots more. The section also includes information on training and capacity building. **Resources will be updated as more are developed**.

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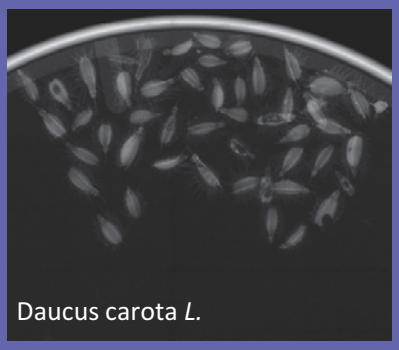
What's new with the MSBP Data Warehouse?

NAOMI CARVEY (Data Warehouse Project Officer, RBG Kew)

X-ray Images now available

Selected X-ray images of MSBP seed collections are now available to view. Simply log in to the Data Warehouse and click on the "Images" tab to view over 3,000 images – more will be added soon!



Daucus carota *L.*

113,756
Seed collections available to view and download

Base lists

Retrieve a base list of species conserved throughout the MSBP plus instructions on how to check your species target list against the MSBP base list here http://brahmsonline.kew.org/msbp/SeedData/BaseLists.

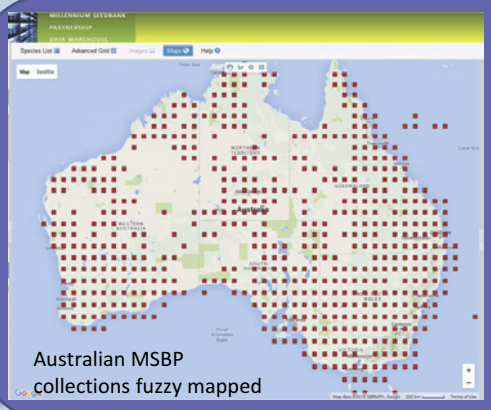
161
Countries represented in the Data Warehouse

Future developments Coming soon!

IUCN Mapping – Use different colours to show different IUCN threat categories in mapping

Batch reporting tool – input your batch code or other search criteria in a simple form to retrieve relevant collections with one click

166,869
Germination tests available to view and download



Australian MSBP collections fuzzy mapped

What is fuzzy mapping?

BRAHMS online can obscure exact latitude and longitude values, instead showing a point reset to the centre of the container grid square. This results in an obscuration of up to + / - 55 km. Fuzzy mapping is designed with threatened species in mind but can be applied to any seed accession or taxa.

Can't access the Data Warehouse?

Access is available to MSBP members only, to register go to http://brahmsonline.kew.org/msbp/Account/Register then email your details to msbp.datawarehouse.access@kew.org.

The MSBP Data Warehouse is constantly evolving, and we continue to work to make the database better for you. Please do contact the Data Warehouse administration team if you have any questions or have any feedback at msbp.datawarehouse.access@kew.org. The Data Warehouse is a BRAHMS Online database.

A new GPS-based system for seed collection at the Israeli Gene bank

Einav Mayzlish Gati, Andrey Beerman, Alon Singer, Tomer Faraj, Dikla Lifshitz, Dana Bar and Sivan Golan (Israel Gene Bank, ARO Volcani Center)

When the Israel Gene Bank (IGB) began systematically collecting wild seeds from natural habitats it established a unique database management system. Built by Mr. Andrey Beerman, an IT programmer specialist, the system is a multi-purpose database for the IGB to manage about 30,000 wild, landrace and modern crop plant accessions. The system administers all IGB units including its seed inventory, cleaning and packing processes, germination examination, data acquisitions from different depositors, and the collection work itself.

The IGB collection strategy focuses on genetic diversity and collects the same species from as many different populations and geographic locations as possible. The collection team, working to IGB guidelines, includes a team of botanists. During the first decade of activity a target list of species for collection, according to the prioritisation suggested by its founders (Barazani et al., 2007; 2017), was prepared annually and distributed to the collection team. The target list specified species to be collected but was not equipped to specify locations using the IGB seed inventory and past collections. As the work progressed, certain sites were visited repeatedly and yielded multiple seed collections, while other sites failed to be examined.

To address this, the IGB database management system was expanded to include a new GPS-based field system. The new system acquires information from the IGB inventory, the distribution map of the target species and the location of the user. Collectors can locate the species approved for collection on the map and discern the likelihood of finding it according to its predicted distribution.

The annual target list is recorded in the system to ensure that only these particular species will be collected. The system provides two lists; the first details species that may be found at a given location and are to be collected. The system assesses existing collections with over 1,000 seeds within a 20 km radius of the collector's location and removes such species from the collection list for that particular location. Although distribution maps are based on previous observations and studies, physical facts in the field may not always match the map data. Therefore, collectors also receive a second list of all the allowable species for collection (i.e. species not previously collected for the IGB within the 20 km radius or with fewer than 1,000 seeds), including species that, based on the maps, are not expected to be found in the vicinity.

Collectors can access the online system for the planned collection location using a PC computer or a GPS-based mobile device with internet access in the field. Should collectors find unripe seeds, they can store in the system the location where a specific plant was found and plan a seed collection for when the seeds are ripe.

The new system not only improves the collection mission but also other processes at the IGB, such as cleaning and packing, by focusing on the required samples rather than wasting resources working on samples from a population already found in the inventory.

In the coming years, IGB will focus in its collection missions on the collection of endangered species, medicinal plants of Israel (with the cooperation of the MSB) and the genetic conservation of the native Israeli flora in disturbed areas. The target species for collection for these projects will be integrated into the new system and we predict that annually about 300-400 new accession will be added to the bank.

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IGB botanists collect seeds for plant genetic diversity conservation in damaged areas, areas of intensive human activity and development.

IGB botanists collect seeds in the field using the new GPS-based system.

A model to predict likely seed storage behaviour

SARAH V. WYSE (Early Career Research Fellow, RBG, Kew)

Approximately 8% of the world's seed plant flora may produce recalcitrant (desiccation-intolerant) seeds (Wyse & Dickie, 2017); however, this figure varies between habitat types – in tropical moist forests it may be nearly 20%, while in areas like deserts, xeric shrublands, and temperate grasslands it is less than 1%. The likelihood of a species having recalcitrant seeds is therefore related to climate and habitat. Species from some families or genera (e.g. *Lauraceae*, *Quercus*, and *Syzygium*) are highly likely to have recalcitrant seeds, while those from other taxonomic groups are much less so. We can use this, and other information, to model the probability that a species produces recalcitrant seeds.

We have developed models that allow us to predict the probability that a species has recalcitrant seeds (Wyse & Dickie, 2018). This enables us to advise on which species may be most, and least, suitable for conservation in a conventional seed bank. MSBP Conservation Coordinators use the models to advise their partners about likely seed storage behaviour for species of interest. We are working on developing a web app to provide an interface for these models that will be available to RBG Kew partner organisations.

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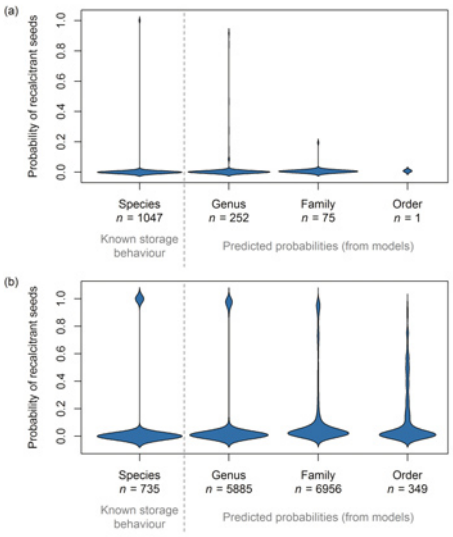


Beanplots showing the density (i.e. frequency distribution) of the probabilities of species producing recalcitrant seeds for species with known storage behaviour (value 0 or 1) and species with predicted probabilities for (a) a list of plant names for Britain and Ireland and (b) a catalogue of the vascular plants of Ecuador. Predictions were made using the relevant model, depending on whether the closest relatives to a species with known storage behaviour were related at the genus-, family- or order-level. The species beans represent known storage behaviour rather than predicted values. Modified from Wyse and Dickie (2018).

Open source, DIY zig zag aspirator

BEN WIRF (Seed Bank Coordinator, George Brown Darwin Botanic Gardens)

In 2015, George Brown Darwin Botanic Gardens embarked on a conservation seed banking program. As we were not an established seed bank, we started with very little in terms of facilities and equipment. One item we most needed was a zig-zag aspirator, as seed bank staff and volunteers were spending a lot of time sieving and hand picking collections, and we lacked funds to purchase one.

I found a YouTube video of a home-made zig-zag aspirator, designed by The Real Seed Collection Ltd, which had a link to open source plans on their web page, so I decided to have a go at building one. With an initial outlay of under $100 AUD, and a couple of days spent in its construction, I was pleased with the results. The airflow is provided by a vacuum cleaner. The air speed and volume are adjustable via the vacuum cleaner and by the panel which covers the three different-sized vent holes in the waste chamber, allowing a fine level of adjustment to the airflow. Seed collections are introduced through a funnel at the top of the zig zag channel with seeds travelling through the air column and settling in a container at the bottom, and lighter material such as chaff and empty seeds are drawn up and into the waste chamber. The suction can be varied if viable seeds are being drawn into the waste chamber with the chaff, or conversely if too much chaff is ending up with the seed.

GBDBG Seed Bank assistant, Marj King cleaning a collection with the DIY aspirator.

GBDBG's home built, vacuum powered zig zag aspirator.

We have been using this DIY aspirator for almost two years and I am very pleased with how well it works and how much time it has saved our seed bank staff. I would highly recommend this as an option for any seed bank on a tight budget.

REFERENCES

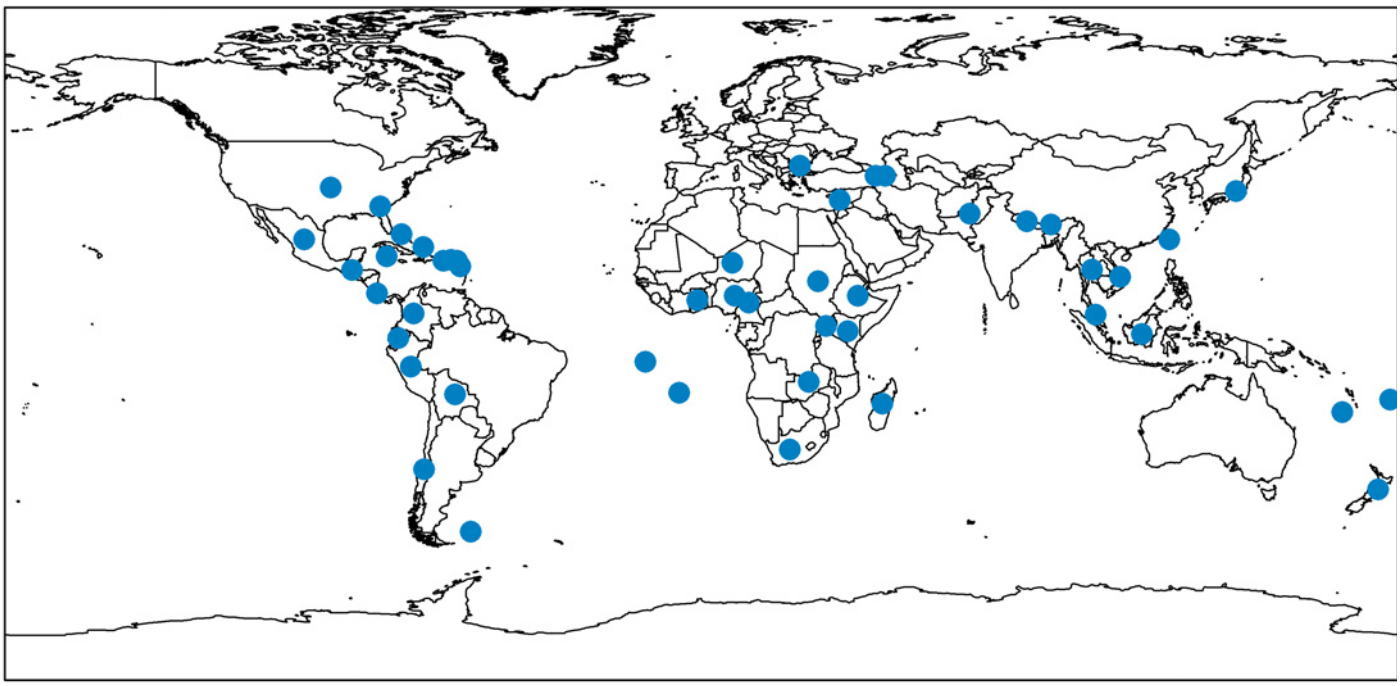
The Real Seed Collection Ltd. The Real Seed Collection Ltd http://www.realseeds.co.uk/seedcleaner.html Shared under CC BY-NC-SA 3.0 https://creativecommons.org/licenses/by-nc-sa/3.0/

MSBP blue drum kits

EVA MARTENS (MSB Partnership Administrator, RBG Kew)

The Millennium Seed Bank Partnership (MSBP) blue drum kits are in high demand from partners across the entire network.

The concept of drum drying kits arose from low-technology drying studies conducted at the Millennium Seed Bank (MSB) to develop the capacity of overseas partners lacking in-country drying facilities. The MSB's first prototype blue drum kit started in 2006 as a low-tech method for drying seed collections ready for processing and long-term storage. With careful monitoring of seed equilibrium relative humidity (eRH), either with a hygrometer or indicating silica gel, these kits produce a dry environment, ideal for drying seeds to the 15% eRH needed for long-term storage. Drying kits can be taken to the field on seed collecting expeditions to begin the drying process. They are a great way of maximising the storage life of the seed collections, which is especially valuable during collecting trips in remote locations where seed collections may not make it back to seed bank facilities for an extended period. They are also especially useful when collecting in humid environments where ambient conditions will damage the seeds. The MSBP blue drum kits are designed for use in the field, or for short-term drying, not as a long-term storage option. Once the collected seeds reach the desired 15% eRH they can be removed and stored in any airtight container, ideally at -20°C. On a longer collecting trip, an empty drum can be used for storage of the dried, sealed seeds simply by keeping it somewhere shaded and cool.



To date, the MSBP has distributed blue drum kits to 47 different countries and territories, and 18 more blue drum kits are to be sent to partners in the next year.

Kew's Ruth Bone demonstrating a blue drum kit during the Seed Conservation Techniques course that took place in New Zealand in December 2017.

With careful monitoring of seed collection eRH, blue drum kits can be used for drying and then as short-term storage containers of small collections for restoration or nursery production, if kept in a cool and shaded location. Seeds age over time (the rate and extent to which this occurs will be

Left to Right, Bobbi Hope, Alexandra Davey and Naomi Carvey from Kew with a blue drum kit at Gatwick Airport on their way to partners in Indonesia.

species dependent) and blue drum kits are not a replacement for cold-storage at -20°C but are ideal where this is not immediately available, in the field or for pre-storage drying.

Blue drum kits can be tailored for specific project requirements. They can serve as full seed collecting expedition kits, including everything you need for a collecting programme, or for drying-only. The drums that we use for the MSBP are 60 L in volume - for every 10 kilograms of silica gel, up to 10 kilograms of seed can be dried at one time and the blue drum kits can be re-used indefinitely. Depending on the collecting requirements, different sized drums can also be used. The case study highlights an interesting way in which a blue drum kit is being used by colleagues in horticulture here at RBG Kew. The map gives an illustration of the countries around the globe that have received a blue drum kit through the MSBP.

Case study

NOELIA ALVAREZ and MICHELE SANCHEZ (Tropical Nursery, RBG Kew)

Behind the scenes at Kew, the Tropical Nursery holds an extraordinary living plant collection, with c.16,960 accessions from tropical to temperate regions of the world. Besides living plants, the nursery also holds seeds of c.923 accessions stored in our local seed bank, an industrial walk-in fridge kept at a temperature of 4^{0}C. These seeds are not only a backup of the plants cultivated in Kew's glasshouses and nursery, but also collections sourced from botanic gardens and other institutions worldwide. Our role includes collecting seeds across Kew Gardens and managing the nursery seed bank. One of the essential tools for our work are the blue drying drums containing silica gel. After collection and cleaning, the seeds are placed in a paper envelope containing a saturated (green) indicator silica gel sachet and left to dry in the sealed drums. Once a week we check moisture levels for all seeds in the drum. When the sachets turn amber and the optimum seed moisture content for storage of 15% eRH has been reached, the seeds are sealed in foil envelopes and stored in the fridge. Training and information is provided to horticulturists and scientists using the seed bank, including information on the correct processing of the collections prior to storage to help maximise the viability of the seeds. With a little care, the seeds in the nursery seed bank will last for several years to come.

Michele Sanchez drying seeds in the Tropical Nursery at RBG Kew.

Noelia Alvarez collecting *Aechmea mertensii* from the Tropical Nursery at RBG Kew.

Sharing a fascination for the seeds of South Australia

DANIEL DUVAL (Botanic Gardens of South Australia) and DR JENNY GUERIN (South Australian Seed Conservation Centre, Botanic Gardens of South Australia)

South Australia has more than 3,500 native plant species, with one in four of these considered threatened. At the founding of the South Australian Seed Conservation Centre (SASCC) at the Adelaide Botanic Gardens, we realised that for people to value the *ex situ* conservation of South Australia's rare flora they would need access to images and information about these species. With this in mind, research from fieldwork, microscopy and laboratory experiments was made accessible to the public via the 'Seeds of South Australia' website. In 2018 the website will reach a milestone by displaying information for more than 3,000 native plant taxa in South Australia.

The website was devised as a guide to the seeds and native flora of South Australia with a focus on displaying field images of threatened plants and the biology of their seeds. It includes species pages for over 75% of threatened taxa in the state. When the datasets are complete, each taxon will have a dedicated page with images, descriptions, regional threat status (displayed as a colour-coded map), detailed seed images and laboratory data from germination experiments. Designed for ecologists, practitioners and interest groups, the website comprises a substantial body of work accumulated over 13 years of running South Australia's seed conservation programme.

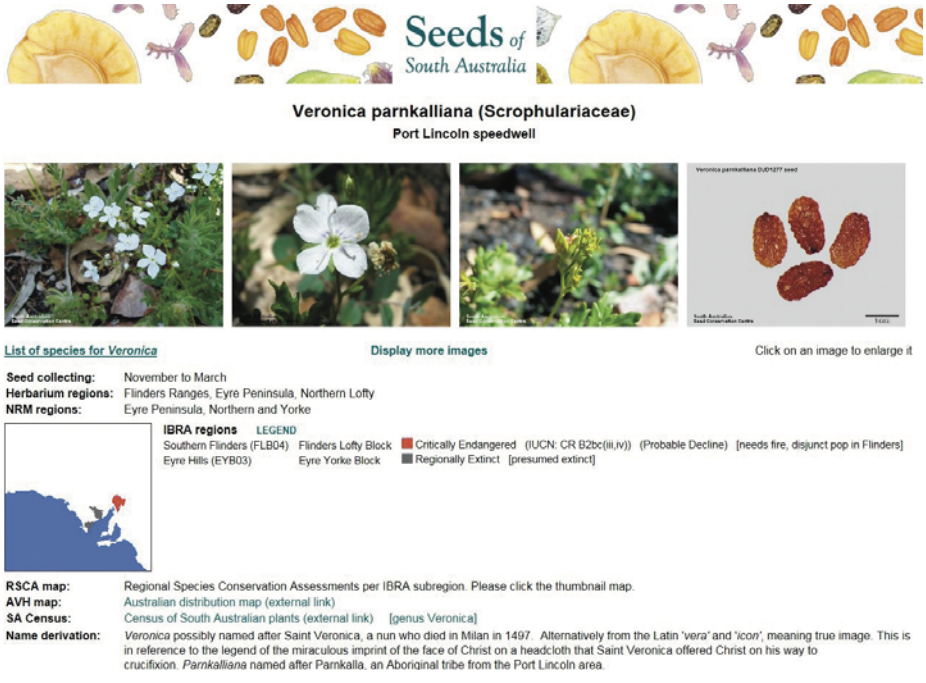
Any web-based platform is only as good as the information it provides. Many partners would appreciate that for every species that is represented on the website, someone has to travel to collect plant specimens, seeds, photographs and field data and, importantly, be able to correctly identify these plant species. The collections are then validated at the State Herbarium and the seeds are processed at the SASCC where data is loaded onto the website. These uploads include photomicrographs of seeds, seed germination data from laboratory experiments and other relevant data including map information and seed collection, cleaning and handling techniques. A large part of this work is undertaken by skilled volunteers, epitomised by two who undertook fieldwork recently.

In 2017, Kieran Brewer and Denzel Murfet travelled to the Everard Ranges in the Anangu Pitjantjatjara Yankunytjatjara Lands in Central Australia using their own resources, a return trip of 3,000 km. They collected over 1,500 photographs, over 100 plant specimens and a number of seed collections new to the SASCC. The information and photographs resulting from this work has contributed valuable content to more than 150 species pages.

Kieran Brewer assessing a *Sida phaeotricha* population for seed collection in the Everard Ranges, South Australia.

The webpage took years of development and was only made possible through the dedication of our small team of expert volunteers and part-time employees. We have been extremely fortunate to have expert programmer Rex Croft onboard, who has developed the platform behind the scenes from his home office in Adelaide. Today we know that the website is valued due to the number of regular requests for photographs, seeds and information we receive both from within Australia and from overseas. Information and images have been used for interpretative signage, journal articles and posters through to information sheets, booklets, identification guides, reports and seed studies, including studies on the diet of rare birds and other animals.

We will always be indebted to the small team that have dedicated their knowledge and time to this project, and this recent milestone is a reminder that we're lucky to have the right people contributing to seed conservation in South Australia.



An example of a species information page - *Veronica parnkalliana* is an endangered fire ephemeral endemic to South Australia.

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Seeds of South Australia *http://www.saseedbank.com.au/*
https://www.environment.sa.gov.au/botanicgardens/blogs/seed-hunters/170831-hunting-in-the-apy-lands
https://www.environment.sa.gov.au/botanicgardens/blogs/seed-hunters/170223-big-in-japan

Finding a needle in a biodiversity haystack

LUKE SWEEDMAN (Curator, WA Seed Technology Centre, Kings Park and Botanic Garden) and PATRICK COURTNEY (Manager, Horticultural Development, Kings Park and Botanic Garden)

Western Australia is a floristic wonderland and has been identified as a global biodiversity hotspot. Its land area exceeds 2.5 million km² - 11 times the size of the UK. The State is sparsely populated, with 92% of its 2.6 million inhabitants living close to the capital, Perth. Around 13,000 plant species have been identified, with 91 of these described just in the last 12 months.

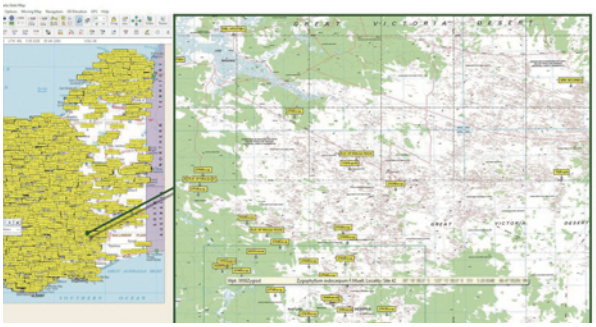
The Western Australian Botanic Garden in Kings Park, Perth has maintained a focus on the cultivation, research, display and interpretation of the diverse Western Australian flora since its establishment over 50 years ago. A field collection programme was created to bring germplasm to the Botanic Garden to form the living collections.

Given the extent of Western Australia and its species richness, collection programmes require a strategic and systematic approach. To achieve this, a range of data sources and information systems are utilised, including: species distribution data; climate and rainfall data; fire history data; GIS systems; *Oziexplorer* - real-time GPS mapping systems; and BGBASE – biological collections management database software.

Analysis of climate, soils, fire history and other datasets are overlaid with species distributions and associated floristic characteristics to allow curators to develop targeted collection programmes.

To maximise productivity in the field, especially in relation to remote locations, Kings Park has developed specialised collection vehicles, equipment and electronic systems. Real-time mapping applications such as *Oziexplorer* can plot plant populations and enable collectors to navigate to any target species or area. Funding from institutions such as the Millennium Seed Bank Partnership has allowed Kings Park to access and collect from remote locations.

Kings Park's mobile seed collection unit approaching the remote Mt Pyramid Station, Northwest Pilbara.



Screenshot from *Oziexplorer* GPS mapping software showing a plot of Kings Park's 2015/16 target species locations, left, and an expanded view showing a mapped target location, right.

New technology report: Emergency tracker used in Colombia fieldwork

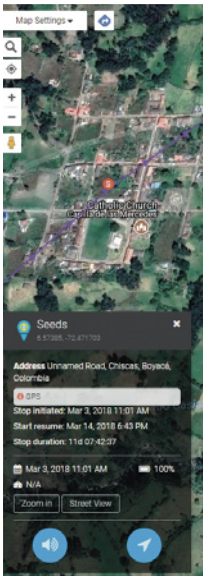
ALICE DI SACCO (Mexico Seed Conservation Projects Officer, RBG Kew) and MICHAEL WAY (Conservation Partnership Coordinator - Americas+, RBG Kew)

During fieldwork in the Páramo of Chiscas, Boyacá, Colombia, Kew staff and counterparts from the Humboldt Institute collected seeds and plant specimens for the Boyacá Bio project and for the first time used a tracking device marketed by Trackimo.

Trackimo device.

The Trackimo (Model TRKM002 Universal 2G) works either by phone signal, through a global SIM card, or by satellite. It records the exact location of the device every 1 to 120 minutes, and, although it is not visible on the device, it is readable by anyone with internet access and device login permits. It is equipped with three buttons, which, if pressed, will send a simple message to previously set telephone numbers or email addresses. The messages can be differentiated to enable use either in an emergency or for communicating one's location to other team members. The system's only limit is that people receiving the messages and checking the location need to have internet access or a phone signal. The battery lasts for about two to five days, depending on chosen settings, and can be charged by USB. We chose this device over alternative models as the data costs for the first year of use are included at no extra charge.

In our case, in the Páramo, we carried this for emergency use only. Luckily we didn't have to rely on it as no emergencies happened, but it was nice to have it while working in remote places in the high mountain!



Example of a screenshot of the user interface with the latest location superimposed on Google maps.

Improvement in drying technology at the National Botanical Garden of Georgia

TAMAZ DARCHIDZE (Director of the National Botanical Garden of Georgia, NBGG)

In the summer of 2017 the National Seed Bank of Georgia, located in the National Botanical Garden of Georgia (NBGG), was equipped with a new dry room; a space with monitoring systems and specific levels of humidity and temperature necessary for the safe processing, drying and storage of seeds.

Plans for the construction of a dry room in the National Seed Bank of Georgia began over ten years ago. Space was allocated in 2011 during refurbishment of the old seed bank building. Companies based in Georgia could not guarantee that the necessary levels of temperature and humidity would be maintained in their construction, so the search for a contractor moved abroad. Due to the high costs of such an endeavor, including purchase and installation of a dehumidifier, considerable piping and wiring, and hermetic insulation, and the limited availability of materials and engineers, Munters Turkey was contracted for the task.

Managing logistics in three languages across three countries required daily communication through Skype and many, sometimes hourly, emails, in order to solve suddenly arising problems. NBGG staff coordinated the arrival of large trucks from the border and their navigation up the steep, cobbled streets of Tbilisi to the botanic garden. Their technical expertise was invaluable during installation and resulted in room completion taking less than two weeks.

The dry room occupies 35 m². Its inner walls and ceiling are insulated with 50 mm Styrofoam and gaps are hermetically sealed. A dehumidifier Munters unit ML270, cooling units, air conditioning and circulation systems were installed to manage airflow. A digital monitoring panel displaying humidity and temperature and equipped with a CO_2 alarm system was installed for the safety of staff.

Efficient drying of orthodox seeds at low temperature is a precondition for the long-term storage of seeds. Proper drying extends seed longevity, allows seeds to withstand extreme temperatures, delays germination and reduces vulnerability to pathogens. 15% equilibrium relative humidity at 15ºC, which roughly corresponds to 3 - 7% of water content depending on seed oil content, is ideal for drying seeds in preparation for long-term conservation. The dry room provides a safe space for packing and storing seed samples before freezing.

As a result of this project the National Seed Bank of Georgia now complies with internationally accepted standards for seed storage and seed research. This is highly important for enabling the NBGG to successfully conserve Georgia's flora. The significance of this project for Georgia was highlighted by the presence of VIP attendees at the official dry room opening ceremony in September 2017, including Director of RBG Kew Richard Deverell, Secretary General of BGCI (Botanic Gardens Conservation International) Paul Smith and representatives of NBGG's partner institutions and botanical gardens, among them Chicago Botanic Garden, the Morton Arboretum, Missouri Botanical Garden, Institute of Botany of Ilia State University and officials from Tbilisi City Hall.

Celebrating the opening of the dry room in September 2017, (left to right) Chuck Cannon of Morton Arboretum, Boyce Tankersley of Chicago Botanic Garden, Botanic Gardens Conservation International Secretary General Paul Smith, Tsira Mikatadze-Pantsulaia of the NBGG, Richard Deverell Director of RBG Kew, Tamaz Darchidze and Tinatin Barblishvili of NBGG, and George Schatz of Missouri Botanical Garden.

The completed dry room with freezers, Munters dehumidifier, cooling unit and blue drum drying kit.

Since its completion in September 2017, the dry room has been operating well. Controlled humidity and temperature made the process of seed drying and adjusting seed moisture content to safe levels less labour and time consuming. During this period, seed collections of 138 plant species have been dried and banked according to the internationally accepted standards; among them seeds of 106 species collected through the "Saving the Flora of the Caucasus" project; 20 collections from the "Garfield Weston Tree Seed Project"; two collections from the BGCI funded *Prunus microcarpa* project; four collections from the "5 Priority Species Pilot Project" and six additional collections.

The NBGG has an important role to play in the study and conservation of plant diversity of the Caucasus. We are thankful to our partner institutions for their support in this very important task. The NBGG will continue to invest efforts towards achieving targets for the Global Strategy for Plant Conservation.

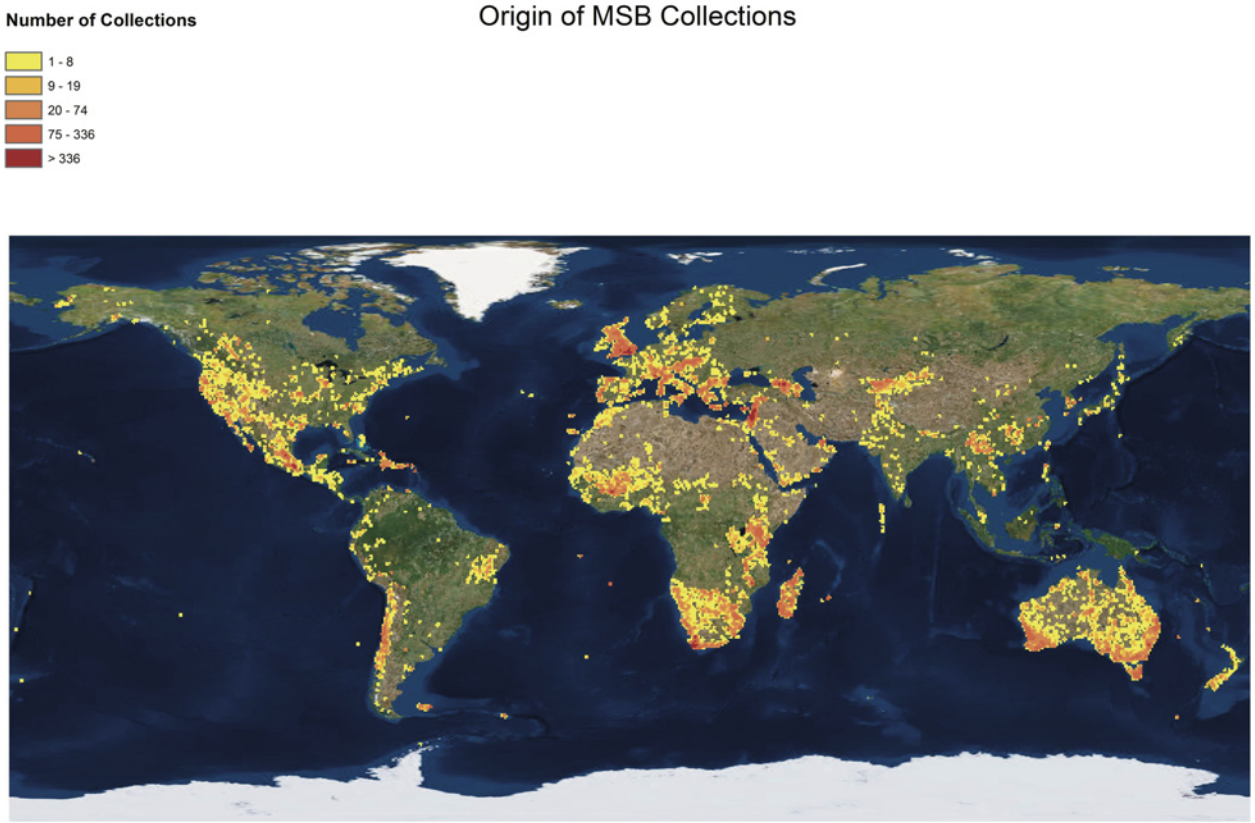
Banking the World's Seeds: Managing data for collections conserved at the Millennium Seed Bank

UDAYANGANI LIU (Data Resources Manager, RBG Kew) and TIZIANA COSSU (Data Resources Assistant, RBG Kew)

Our responsibility is to enable 'Banking the World's Seeds' by managing collection data to the highest standard by ensuring accurate data collection, recording, interpretation, analysis, sharing, interoperability and visualisation. Data are gathered from the point of seed collections in the field (passport data) and during their lifespan in MSB storage (processing data). A range of databases, tools and resources are used at the MSB for efficient management of collection data to empower activities such as collection acquisition, prioritisation, management and monitoring as well as reporting, predicting seed storage behaviour and germination conditions, sharing data and use of collections and their data for conservation, research, display and education. Most of these (in bold below) are accessible to partners either through the RBG Kew website, public portals or the MSB.

(1) Data standards (fields, descriptions, types and formats) and data exchange format (XML schema);
(2) Field data form to capture key passport and quality assessment data during collecting events;
(3) MS Excel data templates to receive passport and germination data to the MSB;
(4) Seed Bank Database (SBD), which is designed to monitor quality, quantity and viability, and is the main data hub for collections;
(5) Taxon Database (TDB) consolidates the plant name backbone with taxonomic identities of collections;
(6) Seed Information Database (SID), a trait database in the public domain (*http://data.kew.org/sid/*), which is a compilation of seed biological trait data (weights, storage behaviour, germination, viability constant, protein content, oil content, morphology, dispersal) from MSB collections and other sources. SID also provides useful tools to predict viability of seeds after a period of storage in a range of environments. SID data are used at the MSB to predict seed storage behaviour and to identify short-lived taxa in long-term storage;
(7) The Data Analysis and Reporting Tool (DART) serves as the user interface where SBD, TDB, SID and other Kew databases can be linked. It is the main tool used for data querying, analysis, and visualisation;
(8) The Germination Predictor Tool uses MSB collection and world climatic data to predict conditions and treatments that are required to germinate seeds based on taxonomy and geographic origin of collections. Kew's UK Germination toolbox, which is in the public domain (*http://data.kew.org/ukgerm/search*), mostly uses SBD germination data and provides successful germination conditions for UK native species;
(9) The Species Prioritisation Tool ranks vascular plants for species-based conservation, by yielding priority scores according to multiple priority-setting criteria;
(10) MSB Seed List (*http://apps.kew.org/seedlist/*) and the Genesys website (*https://www.genesys-pgr.org/wiews/GBR004*), from which a small sample of seeds can be requested by third parties for use in non-commercial activities;
(11) TRY Plant Trait Database (*https://www.try-db.org/TryWeb/Home.php*), JNCC (*http://jncc.defra.gov.uk/page-6573*), UK National Plant Inventory (*https://fusiontables.google.com/DataSource?docid=1WYDRRhsRq2oAe6jhB4rV4c1eRc1yMzlhcCCUp7s#chartnew:id=8*), Eurisco – European Web Catalogue (*https://eurisco.ipk-gatersleben.de/*), BGCI PlantSearch (*https://www.bgci.org/plant_search.php*) and the Millennium Seed Bank Partnership (MSBP) Data Warehouse (*http://brahmsonline.kew.org/msbp/SeedData/DW*) are other portals from where collection and trait data can be accessed.

The above applications used at the MSB provide essential systems for collection management in *ex situ* seed conservation.



Crop Wild Relatives Project shedding new light on species distribution

RICHARD ALLEN (Crop Wild Relatives Species Conservation Assessor, RBG Kew)

The Adapting Agriculture to Climate Change project is an ambitious project between RBG Kew, the Crop Trust and seed collecting partners in 24 countries. A key element was to provide partners with a seed collecting guide to assist in identifying and locating species. The guides have a summary for each species, including a description of the species and its habitat, photographs, and maps showing the known and potential distribution. A gap analysis used existing data points of germplasm or herbarium collections to show where a species had been recorded in a country, and where seed collections had already been made. Combining these data with ecological models, the gaps in collections were visible and potential areas where seed could be collected were highlighted (Fig. 1).

Some species were known to occur in a country, but no data was available to show their distribution, and no maps could be produced. Partners have been sending seed to the Millennium Seed Bank which incorporates georeferenced data. These accessions and data have greatly improved knowledge of species distribution. These data sets are also invaluable in estimating the extent of occurrence (EOO) of a species for Red Listing purposes. These new accessions also mean that it has been possible to update the distribution maps and create new maps for species that have not been collected previously. The species *Medicago sativa* subsp. *varia*, a relative of Alfalfa, was known to occur in Georgia, but there was no previous locality data. Following seed collection and georeferencing it is now possible to show new distribution data and maps for this species in Georgia.

Fig. 1. Gap analysis results for *Malus orientalis* in Georgia showing the location of current herbarium and germplasm collections, new collections, and the potential distribution range.

New seed banks help the development of wild seed conservation in Bolivia and Colombia

ALICE DI SACCO (Mexico Seed Conservation Projects Officer, RBG Kew)

Ahead of the opening of new wild species seed banks in Bolivia and Colombia, two seed conservation courses were organised by Michael Way, Alice Di Sacco and Anna Pajdo (RBG Kew) at the Universidad Pedagógica y Tecnológica de Colombia (UPTC), Tunja, Boyacá, Colombia (September 2017) and the Universidad Autónoma Gabriel René Moreno (UAGRM), Santa Cruz de la Sierra, Bolivia (December 2017). Following the training, the new seed banks have been established at the Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, Villa de Leyva, Boyacá, Colombia and the Jardín Botánico Municipal de Santa Cruz, Bolivia.

The capacity for *ex situ* seed conservation has been improved at both labs through the provision of equipment, including collecting bags, blue drums and silica gel for seed drying, GPS devices for data collection, and dissecting kits for cut testing. Additionally, a multifunctional incubator drier was shipped from the UK to the Humboldt Institute. This enables seeds to be dried to 15% relative humidity (the international standard), or allows incubation of seeds at temperatures ranging from -10°C to 40°C.

A seed collecting and processing manual – developed as a guide for new seed banks – has been produced in Spanish (available online soon at *brahmsonline.kew.org/msbp*). The manual provides guidance on how to make quality seed collections that have high genetic variability and high viability, while ensuring the survival of the wild population. Also included is advice on seed processing techniques, including testing seed quality, and preparing collections for long term storage.

Left to right, Daniela Elizabeth Delgado Acabey, Daniel Villarroel Segarra and Roberto Acebey Aldunate during a seed processing practical on the seed conservation techniques course in Santa Cruz de la Sierra.

Collecting, geotagging and databasing the UK's tree seeds

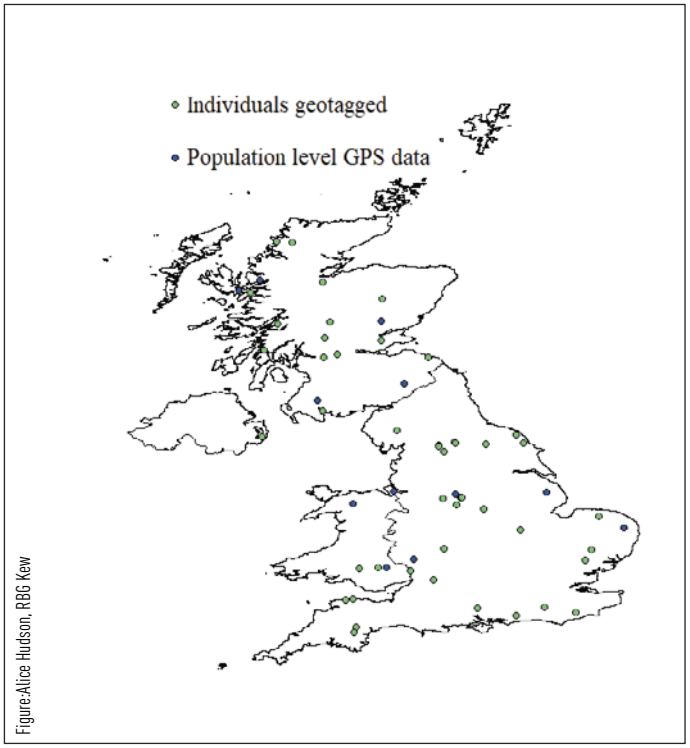
BEDE WEST (UK National Tree Seed Project Fieldwork Officer, RBG Kew)

The UK National Tree Seed Project (UKNTSP) was established in 2013 to capture the diversity of the UK's woody flora beyond the species level due to the increasing threats to UK trees. The project's first 5-year phase finished in March 2018, and it has now transitioned into phase 2 which is planned to run for two years. Collecting seed from multiple populations across the UK means collections should include greater genetic diversity for research and conservation use in the future. To add a finer resolution to the seed collections, the UKNTSP adopted a new approach to Millennium Seed Bank Partnership (MSBP) collections, capturing and storing seed and data per individual tree. Due to this approach, the UKNTSP collections allow not only national and local populations to be studied, but also for families within populations to be studied as well. A bespoke Project Database was established to identify and track progress of target collections.

The UKNTSP approach is a simple but novel methodology to the MSBP: seed collecting, geotagging and databasing by individual maternal plant. There are four key components to the UKNTSP methodology. The first is bagging seed separately per maternal individual, labelling clearly with collection number and tree number. Secondly, using a GPS device (or accurate mapping) to geotag each individual's location. Then, as GPS devices often have limited functionality under canopies, the trees are physically tagged with a metal disc. Lastly, once returned from the field, coordinates are entered alongside collection and maternal tree numbers into the UKNTSP database. Combined, these steps allow individual trees to be re-located should re-sampling or monitoring of mother trees in the future be desired. The map shows collections completed and databased for populations of *Fraxinus excelsior* from every seed zone the species naturally occurs in.

Phase one of the UKNTSP has MSBP collections from 60 species and has captured seed for 517 collecting targets. At the individual tree level, the project collected from approximately 7605 maternal plants, of which it was possible to capture individual locations for 5130. Phase 2 will continue to enhance collections of the original target species as well as a further 16 target taxa.

The UKNTSP seed and data is available to research and conservation organisations on request from *ukntsp@kew.org*, and more information can be found on RBG Kew's UK conservation team's work below:
http://brahmsonline.kew.org/msbp/Projects/UK/NTSP
https://www.kew.org/science/projects/banking-the-uk%E2%80%99s-seeds
And up-to-date news from the UK team on twitter @Kew_MSBUK.



Map of UKNTSP collections of ash (*Fraxinus excelsior*) from across the UK. Each dot represents a collection site.

Bagging and labelling seed from individual trees of *Ulmus glabra*.

NEWS

New seed bank opens in Guinea

DR SÉKOU MAGASSOUBA (Director General, Herbier National de Guinée) and CHARLOTTE COUCH (Project Officer: Guinea TIPAs, RBG Kew)

In November 2017, Xander van der Burgt and Laura Jennings of RBG Kew arrived with equipment including glass jars ready to set up the new seed bank at the National Herbarium of Guinea (HNG), and some larger equipment such as a fridge were purchased locally in Conakry. This seed bank has been planned since a field and classroom-based seed conservation training course took place in Guinea in 2016 under the tutorship of Xander. Earlier in 2017 Pépé Guilavogui, a technician at HNG, joined an MSB-run training course in Uganda on 'Methods in Processing and Data Management', and has been eager to put his training into practice. In April 2017 the majority of the seed collected on previous trips has been dried and stored in the new freezer and more new collections have come in from other Guinean collectors for processing.

Both sides of the partnership are excited to add this new dimension to Guinea's National Herbarium and to continue this valuable partnership to safeguard the many rare and threatened plants found in the country.

Photo: Charlotte Couch

Pépé Guilavogui accessioning seed collections in the Guinea National Herbarium.

Seed Vault in Baekdudaegan National Arboretum

MIN JUNG KIM (External Cooperation Team, Baekdudaegan National Arboretum)

Baekdudaegan National Arboretum (BDNA) is a newly established arboretum in South Korea, scheduled to officially open in May 2018. BDNA plays a key role in plant conservation, addressing climate change issues and the sustainable use of native wild plant resources, through public education, displays and *ex situ* conservation.

The Seed Vault at Baekdudaegan National Arboretum was opened in September 2016 and is Asia's largest permanent wild plant seed storage facility. With an underground tunnel-type structure, covering an area of 4,327 m^2 at 46 m below the surface, it has the capacity to store more than 2 million glass bottles.

Photo: Baekdudaegan National Arboretum

Baekdudaegan National Arboretum Seed Vault.

The mission of the BDNA's Seed Vault is to safeguard plant diversity against the risks of climate change and national disasters. BDNA will store seeds from South Korea and provide a seed duplication service for other national and foreign organisations from around the globe. Given the closely similar objectives of BDNA and the Millennium Seed Bank Partnership, we are exploring ways to share information and support each other to make a valuable contribution to the growing global seed banking network, ensuring that seed is safely stored to international standards and made available for use to benefit mankind and restore the environment.

BDNA's Seed Vault recognizes the sovereign rights of states over their own biological resources and the authority of national governments to determine access to genetic resources, subject to national legislation, so although the facility is owned by South Korea, the seed material would remain the property of the Depositor.

Crop Wild Relatives seed conservation at Kakadu National Park

DAMIAN WRIGLEY (National Coordinator, Australian Seed Bank Partnership)

The Australian Seed Bank Partnership delivered seed conservation techniques training in Kakadu National Park in April. Experts from the Australian Grains Genebank (AGG), Australian National Botanic Gardens and George Brown Darwin Botanic Gardens joined Kakadu Rangers to deliver training to Kakadu's traditional owners, and to scientists from Papua New Guinea and Indonesia.

The team travelled south from Jabiru to the Mary River region to collect seed from crop wild relatives of *Sorghum, Cajanus, Oryza* and *Ipomoea*. The training covered aspects of plant identification and seed collection, as well as techniques for cleaning, drying and storing seed. The team used a version of the Millennium Seed Bank's blue drum kit to ensure collections arrive at seed banks across Australia and at the MSB in the best possible condition.

Access and benefit sharing arrangements are important for the project as Kakadu is jointly managed by the Australian Government and traditional owners. Research for the commercialisation of genetic material from seed collected from Kakadu will require approval under the Australian Government's Environment Protection and Biodiversity Conservation Act (1999) as well as the support of the Kakadu Board of Management. It is essential that this project and future CWR collecting in Australia be supported by meaningful access and benefit sharing agreements that ensure the benefits of commercialising genetic material flow back to the communities from whose country seed is collected.

Floodplains of the East Alligator River in the UNESCO World Heritage Listed Kakadu National Park.

The MSBP and the Crop Trust are supporting this project with funding from the Government of Norway and the Herbert Simon Foundation. Further lab-based training at the AGG was supported by the Crawford Fund.

Amazonia expeditions fill important rice wild relatives gap

MARCELO BRILHANTE DE MEDEIROS and ALUANA G. ABREU (EMBRAPA Researchers)

In mid-2017, representatives from three units of the Brazilian Agricultural Research Corporation (EMBRAPA) undertook two expeditions to collect wild relatives of rice in the Brazilian Amazon, including in the floodplains of the Amazon and Tapajós rivers, and in lake ecosystems on Marajó Island.

These collections were carried out as part of the project "Filling the gaps in Brazilian crop wild relatives in *ex situ* collections: germplasm collecting of wild *Eleusine, Ipomoea, Oryza* and *Solanum*", supported by the Government of Norway via the Global Crop Diversity Trust.

The Brazilian Amazon is considered a high priority biome for collecting *Oryza* wild relatives, according to gap analysis results. Two wild species, *Oryza alta* and *O. glumaepatula*, occur in large populations in this region, particularly in the floodplains of the lower Amazon River. The accessions of these species were sampled in markedly different environments, such as white water rivers (Amazon and tributaries), black water rivers (Tapajós) and temporary lake ecosystems (Arari Lake), filling an important gap in the collection of Brazilian rice wild relatives.

Boat used to access the *Oryza alta* populations along the banks of the Amazon River, Pará state.

Collecting *Oryza alta* on the Tapajós River, a tributary of the Amazon River.

After germination tests at EMBRAPA Genetic Resources and Biotechnology, the accessions were sent to EMBRAPA's Rice Germplasm Active Genebank, where they will be available for research in breeding programmes. Subsequently, a subset of the accessions will be sent to the Millennium Seed Bank. Furthermore, new collections of wild relatives of rice are planned for 2018 in the *Pantanal* biome, the world's largest wetland ecosystem covering an area larger than England and straddling the borders of Brazil, Bolivia and Paraguay.

New MSB Agreements

Country	Counterpart Name	Start Date	Duration (Years)
Australia	Crown in the Right of the State of Tasmania; Trustees of the Royal Tasmanian Botanical Gardens; Trustees of the Tasmanian Museum and Art Gallery	January	3
Kyrgyzstan	Institute of Biotechnology, Kyrgyz National Academy of Sciences	January	4
Mexico	National Forestry Commission of the United Mexican States (CONAFOR)	September 2017	5

Key science publications

Breman, E. & Way, M. (2018). Safe for the future: seed conservation standards developed for the Millennium Seed Bank Partnership. In: Proceedings of the EuroGard VII Congress (July 6-10, 2015). Paris, France: The European Botanic Gardens Consortium pp. 267-274. Available online.

Breman, E., Carta, A., Kiehn, M. & Miranto, M. (2018). Ex situ conservation of native plant species in Europe: The ENSCONET Consortium. In: Proceedings of the EuroGard VII Congress (July 6-10, 2015). Paris, France: The European Botanic Gardens Consortium pp. 290-296. Available online.

Hopkins, H.C.F. (2018). The taxonomy and morphology of Schizomeria (Cunoniaceae) in New Guinea, the Moluccas and the Solomon Islands, with notes on seed dispersal and uses throughout the genus. *Kew Bulletin* 73: 1–41. Available online

Rivière, S., Breman, E., Kiehn, M., Carta, A., and Müller, J.V. (2018). How to meet the 2020 GSPC target 8 in Europe: priority-setting for seed banking of native threatened plants, *Biodiversity and Conservation* 27:1873–1890

Vandelook, F., Newton, R.J. & Carta, A. (2018). Photophobia in Lilioid monocots: photoinhibition of seed germination explained by seed traits, habitat adaptation and phylogenetic inertia. *Annals of Botany* 121: 405–413. DOI: 10.1093/aob/mcx147. Available online

Winchester, V., Hardwick, K., Rasamimanana, H., Raharison, S.M., Mertl-Millhollen, A., Gärtner, H. & McCrae, J. (2018). Berenty Reserve—A Gallery Forest in Decline in Dry Southern Madagascar—Towards Forest Restoration. *Land* 7(1), 8. Available online

Liu, U., Breman, E., Cossu, T.A. & Kenney, S. (2018). The conservation value of germplasm stored at the Millennium Seed Bank, Royal Botanic Gardens, Kew, UK. *Biodiversity and Conservation*: DOI: 10.1007/s10531-018-1497-y. Available online

Sommerville, K.D., Clarke, B., Keppel, G., McGill, C., Newby, Z.-J., Wyse, S.V., James, S.A. & Offord, C.A. (2018). Saving rainforests in the South Pacific: challenges in ex situ conservation. *Australian Journal of Botany*: DOI: 10.1071/BT17096. Available online

Wyse, S.V. & Dickie, J.B. (2018). Taxonomic affinity, habitat and seed mass strongly predict seed desiccation response: a boosted regression trees analysis based on 17 539 species. *Annals of Botany*: DOI: 10.1093/aob/mcx128. Available online

Obituary
Dr. Patrick Nthusi Muthoka (February 1962 – February 2018)

It is with great sadness that we report the death of our friend and MSBP colleague Dr. Patrick Muthoka earlier this year. "Pat" had been collecting seeds of plants from his native Kenya in one way or another for over 25 years and headed up the Plant Conservation Programme of the National Museums of Kenya; one of our major African partners in the MSBP. He received his PhD on the seed biology of selected Kenyan *Euphorbia* and continued his work with rural farming communities in support of the better use of indigenous Kenyan plants. As a husband and father, he is sorely missed, and as a champion for African seed conservation we have a huge gap to fill. I will always remember him dearly as my friend.

Tim Pearce

MSB dashboard

Date	27/04/18
Total Collections	87,474
Total countries (including overseas territories)	189
Total Families	350
Total Genera	5,939
Total Species	39,095
# of Good Seeds	2,253,515,042
Collections Despatched	9,687

Next issue

Issue 34 of Samara will report on sharing seeds. We would like to hear MSB Partner's stories on seed distribution and use, including exciting conservation projects with other collaborators. Do you have successful tales about sharing seeds with the public, scientists, researchers and even governments? If your institution is not currently sharing seeds perhaps you'd like to tell us what your institution does with its seed collections. If so, please contact our editorial team, we would love to hear from you.

TALES FROM THE FIELD

Fieldwork is an important part of the work that we all do. We'd love to hear about your fun, interesting and exciting field trips. Send your contributions to our editorial team!

Contact us
We want to hear from you!
Samara is your newsletter so please send us any articles you feel would be of interest to the MSBP.

The Millennium Seed Bank Partnership is managed by Royal Botanic Gardens, Kew.

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Samara provides information and inspiration for MSBP partners and a flavour of the successes of the Partnership. It is available as a PDF from the MSBP website at brahmsonline.kew.org/msbp/Training/Samara.