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Building Kew's Programme in Restoration Ecology

By Bruce Pavlik

Restored species-rich grassland around the MSB building at Wakehurst Place

PHOTO K. HARDWICK

If collections-based research is at the heart of RBG Kew, then perhaps restoration ecology resides near its soul. The application of systematic, physiological and horticultural knowledge to healing damaged ecosystems could ensure the future of a diverse, functioning planet. Maintaining genetic and species resources "in the wild" may be the last, best, and most sustainable hope for improving the quality of human life as well.

I began my work as Head of Restoration Ecology in February 2010 by examining a database of current restoration projects being conducted at Kew. Kate Hardwick had painstakingly assembled data on more than 60 such projects that spanned from genes to ecosystems. Needless to say, I was amazed by the variety and scope of these endeavours, all informed by a great array of scientific expertise and powered by ambition, dedication and optimism. When the interdepartmental Restoration Ecology Team (RET) first met in March 2010, the database provided a burst of communication, acknowledgement and pride because colleagues could talk about an emerging programme in restoration ecology that already had an impressive track record.

But it also became clear that building a programme to utilize the full power of Kew science, expertise and facilities would require more than a collection of individual projects; it would require collaboration, technical challenge, public support and funding on a scale that botanic gardens, even those as esteemed as Kew, had yet to achieve. My job then became clear – build and fund a restoration programme based upon internal and external collaboration that met a key challenge to biodiversity and ecosystem health, AND explain its importance to the general public. Doing so would meet our Breathing Planet goals while fostering new growth in ecological science.

Story continues on page 2

MSB-2 and Restoration

by Kate Hardwick

As it enters into MSB-2, the MSBP is also developing its restoration agenda. During the first ten years, all our efforts were focused on building up our conservation collections and the network of partners that would support them. Now, with the MSB Partnership firmly in place, we are broadening our ambitions to include the sustainable use of MSBP seeds in habitat restoration and to support human wellbeing. While we will continue to bank conservation collections to insure against extinction, MSB-2 will see increasing emphasis on storing 'restoration collections', available for immediate use in habitat restoration. These collections will need to be bigger and more genetically diverse than conservation collections and the species and provenance must be carefully selected.

Many MSBP partners are already involved in restoration, as can be seen by the inspiring examples in this issue of Samara. Kew now aims to support these activities by generating species selection and collection protocols for restoration use and providing advice on generating, handling and storing larger quantities of seed. Collaborative research will be carried out in areas such as seed priming for restoration, nursery propagation and field management. New initiatives will be needed to help disseminate this information effectively.

As we look ahead to the next ten years, we hope to see our collections expanding beyond the freezers and making their way back to the field, to be put to use rebuilding and repairing the Earth's damaged landscapes.

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Building Kew's Programme in Restoration Ecology Continued from page 1

At present there are three "pillars" of the Kew programme in restoration ecology: 1) developing a large collaborative project that brings together Kew scientists and research partners from other institutions, 2) building a robust, global network of botanic gardens that perform restoration on adopted ecosystems, and 3) demonstrating the principles and practice of ecological restoration to the general public at Kew and Wakehurst Place.

Our developing collaborative project will focus on a species rich ecosystem that has been degraded or destroyed by human activity. Typically, restoration efforts begin years after degradation, long after it is possible to know the original diversity and key synergisms that make an ecosystem functional and self-sustaining. We are, therefore, proposing a novel approach: careful disassembly of the intact ecosystem prior to mining, deforestation or other impending disturbance. Once inventoried of microbes, plants and animals, we can test for critical interrelations that facilitate reassembly to ultimately improve the recreated ecosystem to meet human, commercial and biodiversity needs. This "disassembly-reassembly" project will produce useful science and economic benefits over a 30-year period. We are currently engaging with extractive industries to find the necessary funding, project location and support facilities.

Kew is also leading the effort to bring botanic gardens across the world together to improve restoration projects and increase global restoration capacity. We have partnered with Botanic Gardens Conservation International to form a "spearhead" of 10 gardens on five continents that will lay the foundation. We hope to encourage new initiatives at 100 restoration gardens. Additionally, the global scale will attract funding sources not otherwise available to single gardens.

At a UK level, we are developing a design for a grasslands restoration experiment to be performed at Kew. The experiment will test the effects of different seed compositions, locally sourced, on the maintenance of species diversity. In addition to the scientific knowledge gained through this project, it will also create a prototype education experience for our 2 million annual visitors.

Kew will be able to not only harness and maximise the efforts of sister organisations across the globe, but also provide some of the answers to mitigating the human footprint on our planet.

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Bruce Pavlik's post is funded by Man Group PLC

Above: **Restoration work in the Hanging Meadow at Wakehurst Place**
PHOTO: I. PARKINSON

Left: **Restoration 2005: Carly Cowell and her team engaged in restoration work near Cape Town**
PHOTO: A. HITCHCOCK

Below: **Participants in the restoration ecology workshop, held at Kew in June, 2008**
PHOTO: RBG KEW

Developing Expertise in Ecological Restoration at the MSB: Bloomers Valley Project

by Richard Smith

Planting out in Bloomers Valley

PHOTO: KATE HARDWICK

Nestled in a woodland valley in the grounds of Kew's Wakehurst Place lies Bloomers Valley. The land was used for food production during the early 20th century and was then managed for recreational use for around 30 years. Bloomers Valley is typical of most grassland in the UK: species-poor due to a history of management that diminishes biodiversity and surrounded by agricultural land – meaning that the potential source of wildflower seed for natural re-colonisation is also impoverished. The Millennium Seed Bank and Wakehurst's Living Collections team are using Bloomers Valley to develop, test and demonstrate methods to restore important and rare plants to these habitats. This work is being funded by the John Ellerman Foundation.

In the southern part of Bloomers Valley, Iain Parkinson and his team have created plots demonstrating various grassland enhancement methods. These include spreading green hay – a well established technique for reintroducing diversity to hay meadows where plant material from one species-rich meadow is harvested and transported to another. The method can be altered by varying the type of plant matter harvested and the time of year when the harvest is made.

Because Bloomers Valley is typical of meadow grassland in the UK, it represents an excellent experimental site. In 2009, an MSc student, Adam Devenish, along with Iain Parkinson (Wakehurst), Kate Hardwick and Rosemary Newton (MSB), designed a series of experiments to determine the most effective ways to reintroduce crucial species of plants to meadow grasslands.

The research focuses on whether seeds can be directly sown into the soil, or whether the plants are more likely to survive when raised in the laboratory or nursery before being planted on site. One experiment has already shown that for some species, laboratory germination produces better first year flowering success in the field.

Raising seed in the laboratory or nursery requires a great time investment, but it makes every seed count. Sowing seed directly in the field is much less time consuming, but if the plants do not establish easily then this method may waste large quantities of valuable seed. By showing which treatment is best for each species, the results of this experiment will ensure that future restoration projects know how much time investment will be required for each species, so they can best allocate their resources.

Phil Singleton in the nursery with germinating seeds

PHOTO: KATE HARDWICK

Adam Devenish staking plots

PHOTO: KATE HARDWICK

Due to initial problems with the poor quality of seed purchased for the project, specialist teams from the MSB collected local seed of ten important species in 2010, using MSBP collecting protocols. Early results show that this year's seed is of excellent quality, and seedlings have already been germinated for the next round of experiments.

One species being trialled is Yellow Rattle, *Rhinanthus minor*. This attractive wildflower is a useful tool for re-establishing species rich wildflower meadows. The plant parasitizes the roots of grass species. This reduces competition and helps to break up the sward, exposing ground so that other species of wildflower can flourish.

Ultimately the results of the Bloomers Valley research will feed into Kew's own restoration projects, as well as informing future restoration work around the UK.

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Restoration of Mined Areas in Namibia's Sperrgebiet

By Herta Kolberg

Seedlings of *Juttadinteria albata* being transplanted onto the experimental site

PHOTO: T. THOLKES

The south-western corner of Namibia, known as the Sperrgebiet, has been declared a national park. However, the area has a long history of diamond mining, with Namdeb Diamond Corporation holding the current mining licence. Namdeb are committed to biodiversity restoration prior to handing mined areas back to the park authorities. Between 2006 and 2010 the MSBP worked with Namdeb on this activity. Two areas, Bogenfels and Sendelingsdrift, were selected because of their importance for biodiversity conservation, importance for tourism, and opportunity for involvement before mining commenced.

Very little is known about restoration in Namibia and in the southern Namib desert, with its difficult environmental conditions, this is quite a challenge. The work centred on collection and storage of seed as well as small trials to test restoration methodologies. The approach to restoration had to be as simple and practical as possible, because it would have to be implemented by non-specialist personnel at the mine. We also included some training of mine staff in seed collecting and storage on-site.

Seed Collection and Storage

As much as possible of the seed that was available, was collected and stored both on-site (in paper bags in a wooden shed) and at the genebank in Windhoek. The on-site storage served as an experiment to test if seeds could survive under ambient conditions for the relatively short time until re-seeding. Another test was to store whole plants of those species that retain their seed and establish whether spreading of this dried plant material would aid re-seeding. Seed in on-site storage was tested for viability in 2009 and most still showed acceptable germination percentages. Because of unforeseen delays in the mining process, re-seeding of mined-out areas has not yet commenced and we cannot yet assess the effectiveness of these methods.

Re-establishment of *Salsola* hummocks at Bogenfels

It was already known that the predominant perennial species at Bogenfels, *Salsola nollothensis* (Chenopodiaceae), does not easily re-establish.

Windbreaks constructed of seaweed

PHOTO: : H. KOLBERG

Therefore work at Bogenfels focused on re-establishment of *Salsola* hummocks, as well as collection and storage of a representative variety of seed for re-seeding mined-out areas.

For fast and efficient seed collection it was decided to collect the debris that gathers in depressions and in the lee of plants which contains *Salsola* seed. Windbreaks were constructed using washed-up seaweed and seeded with *Salsola* in May 2007, in the hope of rain during the upcoming rainy season. There was, however, not sufficient rain during the 2007 nor the 2008 season and to date no emergence of any *Salsola* in the windbreaks is evident.

To supplement seeding experiments, seedlings were raised off-site (at the National Botanical Research Institute). Several young plants have now been grown and transplanting will start in May 2011. It is planned to provide initial watering and shelter from wind.

Research into the seed properties of *Salsola nollothensis* was established at the MSB to investigate factors that could contribute to the lack of re-establishment. The work revealed that less than half of collected fruit were filled and that seed loses viability relatively rapidly. Burial experiments showed that with increasing depth of burial the number of emerging seedlings decreases significantly. The results suggest *Salsola* seed needs to receive sufficient rain at just the right moment before it is buried too deeply, blown into unsuitable habitat or has lost viability. It was found that it is possible to manually separate filled from unfilled fruit, and that fruit with bracts removed germinate better than fruit with bracts intact. Full results are due to be published in *Ecological Restoration* in July 2011

Sendelingsdrift

Mining at Sendelingsdrift will affect the core population of *Juttadinteria albata* (Aizoaceae), a threatened succulent plant with a very limited distribution.

An experimental site was set up at Sendelingsdrift using medium-sized and fine mine tailings and a control natural area. Over 50 mature plants of *Juttadinteria* were transplanted into these sites and watered only once at planting. In July 2008 cuttings and seedlings raised at the National Botanic Garden in Windhoek were transplanted onto the experimental site and watered weekly or every second week for a month. At the last monitoring in October 2009, the control site showed much better results than the tailings site. Seedlings also performed better than the cuttings or whole transplanted plants. It was decided to re-think the use of tailings material in ways that more resemble the natural conditions. Further experiments with the age of seedlings need to be conducted, as it seems that the seedlings transplanted may have been too young.

Conclusions

Activities undertaken under this project have shown that restoration in the southern Namib desert is complex, depending on both environmental conditions and properties of the species concerned. The importance of seed-based research to clarify these conditions, was demonstrated.

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Restoration – Tales from the Riverbank by Angie Bell MSB

Kew staff and colleagues planting the Triangular Club Rushes
PHOTO: STEPHANIE MILES

Jo Walmisley with one of the pots ready for planting out
PHOTO: STEPHANIE MILES

Schoenoplectus triqueter, or Triangular Club Rush, is extremely rare and can now only be found in one spot on the banks of the River Tamar in South West England in an area of about 4m². Although not as spectacular, it has been described as the UK's botanical equivalent to the tiger. Reasons it is close to extinction in the UK are thought to be changes in riverbank management, stormier weather conditions and the increased competition from other, faster growing reeds and alien waterside plants. A collaborative project between Kew, the National Trust, the Environment Agency, Natural England and Panscape Environmental Consultants, is working very hard to save this precious native species.

The first successful re-introductions were made to the River Tamar in the 1990s. In June 2010, staff from the MSB travelled to Cornwall to deliver 285 plants to a specially created nursery on the river bank. These plants had been grown at Wakehurst Place from both seeds stored at the MSB, and from propagated plants kept in the nursery since the last re-introductions.

Staff at the MSB carried out non-routine germination tests to generate the extra seedlings for the project. Seeds were sown on 1% agar and chilled at 5ºC for 8 weeks before being moved to 35/20ºC. 145 out of the 150 seeds sown germinated into healthy seedlings within 21 days at the germination temperature. These were then passed on to the nursery where they were grown on ready for re-introduction.

Ted Chapman, Wakehurst Plant Propagation and Conservation Unit Team Leader, said, "We are delighted that, by using the scientific and horticultural expertise at Wakehurst Place, we have been able to help return such a significant number of these critically endangered plants to the wild."

Monitoring of the S. *triqueter* population on the upper Tamar continues with all the 1998 and 2010 transplants being assessed. The observations have found that the plants have established well with very few losses. The 1998 transplant population has increased in biomass and area during the 2010 season and the number of clumps producing flowers has also increased.

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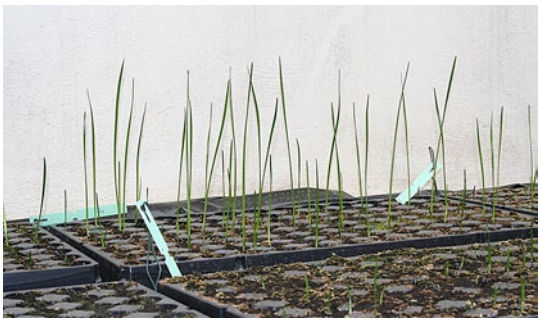
Bridging the Gap Between Seed Banks and *in situ* Conservation

by Thomas Abeli, Gilberto Parolo, Andrea Mondoni, & Graziano Rossi
of the Lombardy Seed Bank/Centro Flora Autoctona of Lombardy Region (LSB/CFA), DISTA – University of Pavia

Above: ***Leucojum aestivum* in the wild on the river Po plain**
PHOTO: G. PAROLO



Top right: **One year old *Leucojum aestivum* in the University of Pavia's botanic garden**
PHOTO: : G. PAROLO

Bottom right: **- Germinating *Leucojum aestivum* seeds**
PHOTO: G. PAROLO

Plant re-introductions are a vital component in the conservation biology of threatened species. However, re-introductions are expensive and often have high rates of failure due to poor horticultural practices, poor ecological understanding and lack of post-planting monitoring. An effective way to provide propagation material to re-establish, or reinforce wild plant populations, is to collect and bank seeds of species at risk of extinction, as well as endemic and locally rare plants. Seed banks provide seeds that have been collected, tested and stored following high quality protocols.[1,2]

As a practical example of how *ex situ* collections can contribute to *in situ* conservation, we present the case of *Leucojum aestivum* L. (Amaryllidaceae), a wetland species from Central-Southern Europe under threat due to the intensification of agriculture and the reduction of wetland habitats. As a consequence, *L. aestivum* has been the target species of several restoration projects in Northern Italy, carried out by the University of Pavia with seed provided by the Lombardy Seed Bank.[3] We want to reinforce about 15 relict populations of the species in the Po Plain, enlarging their population size and genetic variability.

Seeds from more than 20 populations growing in the valley of the River Po were used for germination tests. Some of the plants obtained have already been used in restoration projects, whilst others are currently growing in the Botanical Garden of the University of Pavia and will later be reintroduced into the wild. The aim is to grow individuals of different ages, from seedlings, to 3-4 year old plants, in order to simulate a natural population.

To avoid the high failure rate typical of most re-introduction programs, the whole species life cycle needs to be understood and controlled, along with the species ecology and reproductive traits. Long-term studies are usually required for this, but we were able to infer the species population structure by analysing natural populations spatially instead of temporally, thus studying several populations in one year, with the aim of developing a rapid procedure to make re-introductions more effective in terms of species survival, costs and management.

Our results can be summarised at two levels: 1) a general level, where a rapid assessment of the species population structure can be applied to other taxonomically related species and/or growth forms; and 2) at a species-specific level, where controlling the most important phases of the reproductive cycle allows knowledge of the population structure, dynamics, size and density. *L. aestivum* is self-incompatible, thus its reproductive success is strictly connected to the attractiveness of populations to pollinators and can be related to plant density. This trait is extremely important when planning a re-introduction/ reinforcement or restoration program.

In conclusion, *ex situ* conservation, and in particular seed banks, represent an important opportunity for improving the results of *in situ* conservation through the refining of germination and cultivation protocols, by producing high numbers of propagules that can ensure higher rates of success in re-introduction programmes and can advance the effective conservation of the target species.

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References

1 ENSCONET (2009) *Seed collecting manual for wild species.* [England] ENSCONET

2 ENSCONET (2009) *Seed banking manuals.* [England] ENSCONET (both manuals are available online via the ENSCONET website)

3 Other ongoing projects include LIFE+, Pianura Parmense, Corinat and Pot Plant

MSBP Supporting the Use of Native Plants for Habitat Repair and Re-introduction in the UK

By Robin Probert, Head of the Conservation & Technology Section, MSB

Seedlings of native plants

PHOTO: : W.STUPPY

Responding to new United Kingdom Government initiatives[1,2], 2011 will see the start of a step change in Kew's capacity to support the use of native plants for species re-introduction and landscape-scale habitat repair in the United Kingdom. Matching the approach of many of our international partners, we will work with government organisations, commercial companies and community groups across the UK, to increase the quality, quantity and diversity of plants and seeds available to conservation and restoration practitioners.

The MSB has already shown on a small scale how critical its seed collections are to the re-introduction and recovery of threatened species such as the triangular club rush (*Schoenoplectus triqueter*) and star fruit (*Damasonium alisma*), which were both on the brink of extinction in the United Kingdom. However, having started to work with commercial seed companies and conservation organisations, it has become evident that the availability, appropriateness and quality of seed for re-introduction and recovery initiatives in the UK is extremely limited. Commercial companies are rarely able to provide seeds genetically adapted to the intended site of restoration, and local conservation organisations have insufficient financial clout and technical back-up to influence a market to provide such appropriate seed.

This new initiative will bring together Kew's seed conservation, horticulture and public interpretation expertise at Wakehurst Place. Multi-provenance, founder collections of high priority UK species held in the seed bank will be regenerated in field plots. The resulting high quality, genetically representative 'restoration collections' will then be made available to commercial seed companies and nurseries for field production of seeds and plants for landscape-scale restoration projects.

A dedicated seed store will be established and the seed production beds will be open to the public for education purposes. We will also carry out research to assist the development of improved nursery and plant production techniques for native plants. This will essentially be a not-for-profit venture where products and technical services will be shared freely or offered for sale to customers on a cost recovery basis.

For further information please contact Robin Probert (**r.probert@kew.org**)

References

[1] Lawton, J.H., Brotherton, P.N.M., Brown, V.K., Elphick, C., Fitter, A.H., Forshaw, J., Haddow, R.W., Hilborne, S., Leafe, R.N., Mace, G.M., Southgate, M.P., Sutherl and, W.J., Tew, T.E., Varley, J., & Wynne, G.R. (2010) *Making Space for Nature: a review of England's wildlife sites and ecological network*. Report to Defra.

[2] www.defra.gov.uk/environment/natural/whitepaper

Re-introduction of *Serruria furcellata* and *Erica verticillata* in Cape Town, South Africa

by Nicolette Stoll and Olivia Tyambetyu, South African National Biodiversity Institute

Successful *Erica verticillata* in full flower at Rondevlei
PHOTO: N.STOLL

At the South African National Biodiversity Institute, the MSBP team have been working on 'integrated conservation' for some years. In addition to collecting and banking seed of threatened species, the team works with horticulturalists and local conservation agencies to re-introduce species into the wild and restore damaged habitats. During the winter months of 2010 the MSBP (Cape Town), together with Kirstenbosch National Botanical Garden and the City of Cape Town Nature Conservation, started re-introducing *Serruria furcellata* into the wild at Bracken Nature Reserve. *Serruria furcellata* is a critically endangered member of the Proteaceae family, found in sandy soils 90 – 310 m above sea level. It grows up to 0.5 m tall and 1 m across, with sweetly scented pink flowers that bloom in August and September. The biggest threat to its natural habitat is from housing developments. In 1987 fewer than 250 plants remained at Northpine, on the outskirts of Cape Town. Today just one plant remains and a school building has been earmarked for this site.

Bracken Nature Reserve was chosen as the re-introduction site as it is protected and close to Northpine. The reserve covers over 30 hectares with granite outcrops across the landscape. These are low-lying, relatively undisturbed, and significant as they occur within a metropolitan area; conserving some of the last remnants of West Coast Renosterveld and Sand Plain Fynbos. A large diversity of succulents, geophytes, orchids, mosses, ferns and lichens can be found there.

About 600 plants were grown at Kirstenbosch and separately by a specialist grower. The young plants were planted in groups of three and marked with an orange label for identification. Eight sites were chosen; some sandy with minimal protection, others in areas previously under pine trees, and others amongst taller existing shrubbery. After monitoring the population during the height of summer we found a low success rate. One possible cause for poor survival may have been insufficient rainfall in the weeks following planting.

Another 400 plants have been grown for planting in winter 2011, with focus on successful areas and new areas that may be more suitable.

Serruria furcellata
PHOTO: A.HITCHCOCK

Citrus Swallowtail (*Papilio demodocus demodocus*) on *Erica verticillata*
PHOTO: N.STOLL

On a more positive note, *Erica verticillata*, which is listed as extinct in the wild, was re-introduced to the Kenilworth Racecourse Conservation Area, where one of the last patches of Sand Plain Fynbos remains, and to the Rondevlei Nature Reserve. Both sites are within the Cape Town metropolitan area.

Rondevlei is a wetland area, home to about 230 bird species, a variety of small mammals, reptiles and a hippopotamus population. The area has unusual and threatened Strandveld, Sand Plain Fynbos and indigenous Coastal Fynbos vegetation. Planting of *Erica verticuillata* started in 2005, conducted by MSBP staff and Kirstenbosch National Botanical Garden horticulturists in collaboration with reserve managers. Consecutive plantings took place in subsequent years. Today, the plants are flourishing and stand over a metre tall. They attract many 'visitors' such as bees, butterflies and even chameleons. It is indeed a spectacular sight to see these plants flourishing in the wild.

It is clear from these examples that success is not always guaranteed. However, our challenge is to learn from our mistakes and persevere – we are confident that we will achieve further successes in 2011!

Thanks to Richard and Kara Gnodde and the Arcadia Fund who have funded the MSB South African Programme.

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Understanding Seed Stress

by Charlotte Seal, Research Biochemist, MSB

Seeds, like all living organisms, are constantly exposed to stress. Factors that induce stress can be 'biotic', resulting from living organisms, such as fungi and insects, or 'abiotic', resulting from non-living factors, such as drought, extreme temperatures, salinity and pollutants (e.g. heavy metals). Understanding how stresses impact upon seeds is important, as stress can affect plant establishment, reproduction and productivity.

A recent publication in the journal '*New Phytologist*' by Kew scientists Drs. Ilse Kranner and Charlotte Seal and colleagues from the Kazan Institute of Biochemistry and Biophysics (Russia), and the University of KwaZulu-Natal (South Africa), has addressed a lack of attention given to stress concepts in seeds and plants[1]. Considering the recent progress in molecular biology and biochemistry, Kranner et al. have taken one of the most widely accepted stress concepts in medicine, the 'General Adaptation Syndrome' (GAS), to the molecular level and modified it for seeds, identifying three stages of stress response. First, in the 'alarm phase', a stress factor is perceived by a signalling network of seed hormones and 'reactive oxygen species', and signals are transduced to activate the stress response systems. Under continuing stress, the 'resistance phase' is reached when the stress response is sufficient for cellular protection and repair, maintaining seed viability. The third and final 'exhaustion phase' is reached if the protection and repair mechanisms fail; leading to the breakdown of essential molecules, including DNA, proteins and lipids, and ultimately resulting in seed death. This modified version of the GAS also has relevance to plants as many of the causes of stress and response systems are common to both.

The article also points out that stresses are not always negative, and some even have positive roles. This was further highlighted in a recent publication in the journal *Environmental and Experimental Botany* by Kew scientists Drs. Ilse Kranner and Louise Colville, discussing the biochemical and molecular implication of heavy metal stress for seed germination[2]. The presence of heavy metals in soils as a result of pollution, for example, can be toxic and prevent water uptake in germinating seeds. However, some species may utilise heavy metals in seeds as a defence strategy against predation and low concentrations may even stimulate germination, particularly in seeds of metal-tolerant plants. Furthermore, stress-tolerant plants can be utilised to improve the environment and crop productivity, for example, metal-tolerant plants can be applied to technologies as phytoremediation, enrichment of food crops with mineral nutrients and water purification.

Current stress research at the MSB is investigating the role of oxidative stress in seed ageing, the biochemical basis of how seeds of salt-tolerant plants germinate under salt stress and ways to predict germination in saline environments, embedded in COST Action FA0901 supported by the European Union[3]. By understanding more about the types of stresses, the inter- and intra-specific variations of tolerance and the impact of the stress at the molecular level, we can support successful plant establishment and regeneration in degraded environments.

For further information contact Charlotte Seal (**c.seal@kew.org**)

References

1 Kranner I, Minibayeva FV, Beckett RP and Seal CE. 2010. What is stress? Concepts, definitions and applications in seed science. *New Phytologist* 188: 655-673.

2 Kranner I and Colville L. 2010. Heavy metals and seeds: Biochemical and molecular implications and their significance for seed germination. *Environmental and Experimental Botany* doi:10.1016/j.envexpbot.2010.05.005.

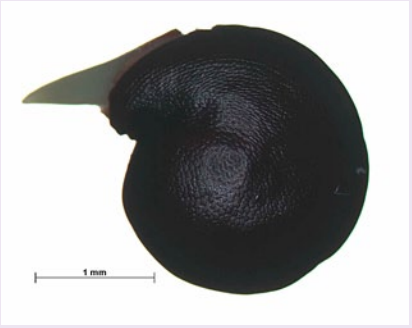
3 COST Action FA0901. Putting Halophytes to Work - From Genes to Ecosystems. http://www.cost.esf.org/domains_actions/fa/Actions/FA0901-Putting-Halophytes-to-Work-From-Genes-to-Ecosystems-End-date-May-2013

Fluorescent staining is used to investigate the process of embryonic cell death in recalcitrant seeds experiencing stress from desiccation.

PHOTO L. COLVILLE

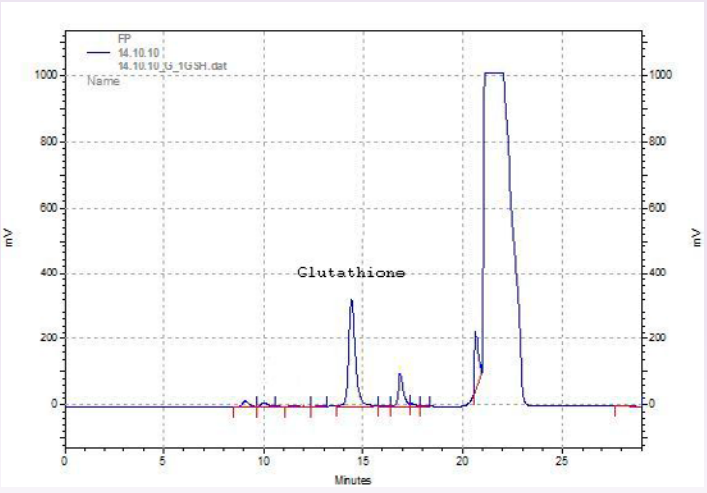
***Suaeda maritima* plants, a salt tolerant species under study, in East Sussex, UK.**

PHOTO C. SEAL.



A germinating seed of *Suaeda maritima*

PHOTO C. SEAL.



Measuring the antioxidant glutathione (by high-performance liquid chromatography) in response to salt stress in the salt-tolerant species *Cakile maritima*.

PHOTO C. SEAL

Cycad Seed Cryopreservation

by Jayanthi Nadarajan, Cryobiology Specialist, MSB & Satya Dandugula, MSc student, University of Bedfordshire

The cycads are remnants of the most ancient group of higher plants. Cycads have been referred to as living fossils, as this group of plants are acknowledged to be the oldest seed plants still in existence, with origins dating back to the late Carboniferous period, 300 million years ago, the same time as dinosaurs roamed on the Earth's surface. Cycads are repositories of information for the study of the evolution of the development of higher plants[1]. The cycad flora consists of 297 species and subspecies. Based on Stevenson's (1992) classification[2], these species and sub-species can be grouped into three families, Cycadaceae, Stangeriaceae and Zamiaceae. These families are distributed throughout the warmer areas of North and South America, Africa, Asia and Australia. Many species exist as relatively small isolated populations, often in transformed habitats. The increasing interest in cycads has resulted in this group of plants becoming popular subjects of research, collecting and landscaping. Illegal harvesting of cycads from their natural populations has caused destruction of colonies and has led to extinction of several wild populations.

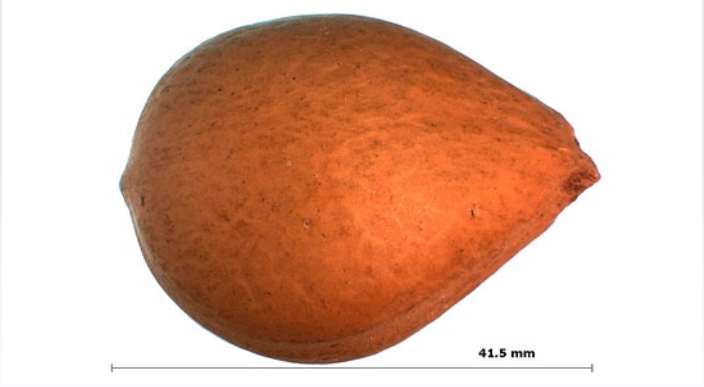
The global conservation assessment of cycad species shows that 62% of them are listed as threatened in 2010. Conservation of this group of species requires integration of both *in situ* and *ex situ* strategies. Due to the recalcitrant nature of the cycad seeds, conventional seed banking is not possible for this group of plants. Hence, cryopreservation (storage in liquid nitrogen at the temperature of -196^{0}C is the only viable option to store cycad seeds. An attempt was made at the Millennium Seed Bank to develop efficient cryopreservation protocol for *Cycas revoluta*. This study involved an assessment of seed desiccation sensitivity, establishment of the embryos in vitro and development of cryopreservation protocol. Both the seeds and embryos of *C. revoluta* showed desiccation sensitivity, where viability was completely lost, when the seeds were desiccated to around 15% moisture content. The embryos were established *in vitro* on Murashige and Skoog medium at 25^{0}C. No embryos survived dehydration and direct freezing into liquid nitrogen, however they showed 93% viability following cryopreservation after treatment with cryoprotectant. These findings show promising results for successful cryopreservation of *C. revoluta* and would be a key step in the *ex situ* conservation for safe-guarding the vulnerable cycads flora in general.

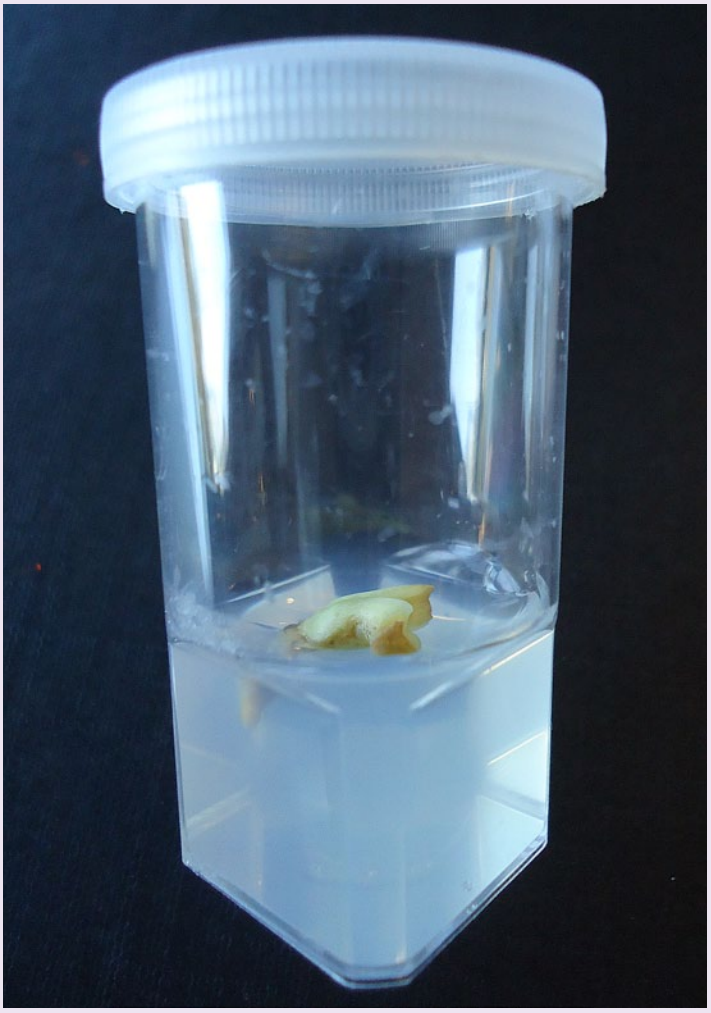
For further information please contact
Jayanthi Nadarajan (**j.nadarajan@kew.org**)

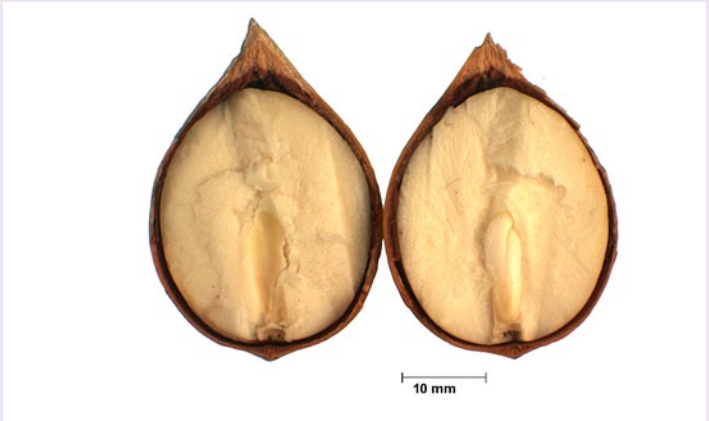
References

1 Norstog K, 1987 Cycads and the origin of wind pollination. *American journal of science* 75: 270-279

2 Stevenson, DW 1992 A formal classification of the extant cycas. *Brittonia* 44: 220-223







Top: **Growing embryo of *Cycas revoluta* following cryopreservation**
PHOTO: J. NADARAJAN

Above: **Cross section of a *Cycas revoluta* seed**
PHOTO: J. NADARAJAN

Left: ***Cycas revoluta* seed**
PHOTO: J. NADARAJAN

NEWS

New MSBP Partnership Agreements: South Africa and Georgia

The signing of the new Access and Benefit Sharing Agreement at the Kirstenbosch National Botanical Garden

From left to right:
Shireen Harris (Acting Curator: Karoo Desert National Botanical Garden)
Philip le Roux (Curator: Kirstenbosch NBG)
Eliot Lithudzha (Curator: Free State NBG)
Thompson Mutshinyalo (Curator: Walter Sisulu NBG)
Erich van Wyk (SANBI Garden Conservation Programme Manager/MSB Project Manager)
Avhatakali Mamatsharaga (Curator: Lowveld NBG)
Gcina Allen Nene (Curator: KwaZulu-Natal NBG)
Solomon Nkoana (Curator: Pretoria NBG)
Christopher Willis (SANBI Chief Director, Conservation Gardens and Tourism)
Seated:
Carmel Mbizvo (SANBI Deputy Director General)
Prof. Steve Hopper (Director, RBG KEW)

Two partners have recently signed new Access and Benefit Sharing Agreements with Kew under the Millennium Seed Bank Partnership.

The South African National Biodiversity Institute (SANBI), which has been a MSB Partner since 2000, signed a new Access and Benefit Sharing Agreement in September 2010. The new project will shift the emphasis towards more involvement of the different SANBI-administered botanic gardens around the country, and towards use of the collections in restoration and species re-introduction activities. Funds in part-support have already been received from the Arcadia Foundation for the five year duration of the project, while the complement funding has been identified and is likely to be provided in the near future.

In addition, the Tbilisi Botanical Garden and Institute of Botany in Georgia signed an Access and Benefit Sharing Agreeement, with the endorsement of the Ministry of Environmental Protection and Natural Resources. This Agreement was signed on 27 December 2010 and will last for ten years. A detailed three year project has been developed which would allow the conservation of over 300 plant species from this biodiversity hotspot. We are currently seeking funding to allow this project to get underway.

For further details contact:
RSA: Erich van Wyk (**E.VanWyk@sanbi.org.za**) or Michiel van Slageren, (**m.vanslageren@kew.org**)

Georgia: Tsira Mikatadze-Pantsulaia (**tsirapantsu@yahoo.com**) or Clare Trivedi (**c.trivedi@kew.org**)

International Decade of Biodiversity

After the International Year on Biodiversity in 2010, the United Nations General Assembly has proclaimed that 2011-2020 will be the United Nations Decade on Biodiversity.

The Decade will be formally launched on International Day for Biological Diversity, 22 May 2011.

Seed Conservation Techniques for Wild Plants 17 – 26 January 2011

The Kunming Institute of Botany (KIB), partner of the Millennium Seed Bank (MSB), recently hosted its first international training course on "Seed Conservation Techniques for Wild Plants". Seventeen delegates from thirteen countries and regions (Australia, Azerbaijan, Cambodia, Egypt, Hong Kong SAR, India, Indonesia, Lao PDR, Nepal, Philippines, Singapore, Thailand and Vietnam) were welcomed to the Germplasm Bank of Wild Species (GBOWS), venue for the lectures and practicals. Participants varied in their previous experience, a few already had seed banks, others were thinking about establishing one, most wanted to learn about seed banking to complement existing activities on conservation and restoration. The 7-day course, planned, organised and delivered jointly by KIB and the MSB, included plenty of opportunities for participants to practise and share experiences. The KIB botanic garden provided an excellent diversity of fruits at various stages of maturity to dissect, discuss and collect, and the GBOWS collections a good source of material to process and germinate.

Assessing the quality of a potential seed collection
PHOTO: LI LIANGI, KIB

By the end of the course nearly everyone agreed that their expectations had been met or exceeded – the only exception being one person who would have liked a much longer course. The completion of the course was marked by the planting of a tree in the KIB arboretum. The text of the memorial plaque was chosen by course participants and reads "Save the seed today: gift for the future"

Outside of classes, participants and trainers experienced China's famous tea culture and enjoyed a performance of Dynamic Yunnan, a fusion of traditional ethnic and modern dance.

Sponsored by the Bureau of International Co-operation of the Chinese Academy of Sciences (CAS) and the Kunming Institute of Botany, the course was followed by a CAS-sponsored 3-day excursion to Xishuangbanna, a tropical region in the south of Yunnan Province, visiting Xishuangbanna Tropical Botanical Garden, and the Yunnan branch of the Institute of Medicinal Plant Development.

The participation of Kate Gold and Robin Probert was supported by the Sfumato Foundation.

Course participants with the memorial tree
LI LIANGI, KIB

NEWS

Workshop of the Orchid Seed Stores for Sustainable Use (OSSSU) Project

Participants of the OSSSU workshop held at the University of Costa Rica, September 2010
PHOTO: P.SEATON

Orchid biotechnologists from 18 different countries participating in the Darwin Initiative project, Orchid Seed Stores for Sustainable Use (OSSSU), gathered at the University of Costa Rica in September for a four day workshop to discuss their progress and exchange technical expertise. The objectives of the project have been to support the storage of seeds representing a broad range of genera from biodiversity hotspots around the world and in addition, to generate valuable data on pollination, seed production and yield, and on comparative germination and changes in seed viability during storage.

Having completed the three year term of the Darwin grant, OSSSU is rapidly expanding as a global orchid facility, currently consisting of 31 partner institutions in 22 countries, plus the UK, and is aiming to store 2,000 species by 2015. A key to this, is the creation of a web site that will act as a virtual laboratory and forum where partners can access the latest findings and share information on an increasing range of topics, from how to germinate difficult species to seed size and morphology, focusing on some of the world's most endangered species.

For further information, see **www.osssu.org** or contact Phil Seaton (**p.seaton@kew.org**)/Tim Marks (**t.marks@kew.org**)

Discovering New Localities of Rare Species in Georgia

The MSBP team in Georgia made an exciting discovery in October 2010 when local nature lovers alerted the team to the presence of cyclamen in a district in West Georgia. As soon as the team saw a photo they suspected the plant could be the rare *Cyclamen colchicum*, although the species had never been recorded from the district mentioned.

Cyclamen colchicum is an endemic species of West Georgia and extremely important in terms of the investigation of the evolutionary history of the endemic calciphilous flora of Colchis. Its medicinal properties have been mentioned in ancient texts, but populations are now declining in the wild. It is likely that this plant is extensively collected for its medicinal and ornamental properties. In recent years the MSBP team has recorded the absence of target plants from several sites known previously to support the species.

The team had funding for fieldwork provided by the Rufford Foundation, and so decided to go and visit immediately to catch the cyclamen in flower. On 8 October the team from the Tbilisi Botanical Garden and Institute of Botany (Tsira Mikatadze-Pantsulaia, David Kikodze, Tinatin Barblishvili, Manana Khutsishvili and Sandro Kolbaia) headed to West Georgia to meet the local enthusiasts, Roman Tolordava, Temgiz Karchava and Lado Tolordava. The plants were found across several sites, on almost vertical dolomitic limestone crevices, and were for sure *Cyclamen colchicum* with its typical leaves and fragrant flower. Luckily the populations are fertile and fruit set is good. In 2011 seed will be collected from these populations and stored at the Seed Bank of the Caucasus in Tbilisi and the MSB and used to grow plants in the Tbilisi Botanical Garden.

For further details contact: Tsira Mikatadze-Pantsulaia at Tbilisi Botanical Garden and Institute of Botany, (**tsirapantsu@yahoo.com**) or Clare Trivedi at the Millennium Seed Bank, (**c.trivedi@kew.org**)

Cyclamen colchicum
PHOTO: TBILISI BOTANIC GARDEN & INSTITUTE OF BOTANY

NEWS

Rediscovering the Tarcoola Swainson-Pea

Thai Te of the South Australia Seed Conservation Centre collecting the seeds of *Swainsona dictyocarpa*

PHOTO: DAN DUVAL

***Swainsona dictyocarpa* flowers**

PHOTO: DAN DUVAL

On the 29th October 1929 J.B. Cleland, then Professor of Pathology at University of Adelaide, collected a native swainsona-pea whilst travelling from Coondambo to Tarcoola in the north of the state of South Australia. It was the first record of the plant now described as *Swainsona dictyocarpa* (Tarcoola swainson-pea). Only collected once thereafter in the Tarcoola area in 1954, little was known about this rare plant including important information such as flower colour and preferred habitat.

About 80 years later, on the 4th Oct 2010 our team from the Botanic Gardens of Adelaide's South Australia Seed Conservation Centre searched the approximate locality described by J.B. Cleland whilst en-route to field-work in the Arckaringa Hills. Although the locality had been searched twice in previous years without success and the chances of finding this rare plant were very small, we thought we'd search again as there had been some reasonable rainfall. What a difference a good season makes! As a result we recorded at least 500+ plants during this search, in the exact same locality walked and searched with little success in previous years. We were probably repeatedly walking over this rare pea in past searches! However it was undetectable in its other life history stage, as seeds in the persistent soil seed-bank. This year a few thousand seeds from this rediscovered population were collected. They will be used in germination research and stored at low temperatures as long-term conservation collections.

I want to acknowledge J.B. Cleland because we wouldn't know anything about this and many other unique plants if he hadn't collected thousands of plants in his spare time. He was the Professor of Pathology for the University of Adelaide for nearly 30 years and had a passionate scientific interest in botany, anthropology, mycology and ornithology. Browsing his extensive writings, his comprehensive volumes, and the thousands of his botanical collections in the State Herbarium, one can't help but appreciate his remarkable energy and dedication.

For further information please contact Dan Duval (**Daniel.Duval@sa.gov.au**)

References:

Southcott, R.V. 1971 Obituary: John Burton Cleland. *Transactions of the Royal Society of South Australia* 95: 243-247

Launch of the 'Difficult' Seeds Project Web Pages

Kew has recently launched web pages for the 'Difficult' Seeds Project, which supports crop gene banks and farmers in the conservation of plants used for food and agriculture in Africa. The project is supported by the Food and Agriculture Organisation of the United Nations (FAO) and has been funded by the UK government's Department for Environment, Food and Rural Affairs (Defra). The web pages contain information about the project and 160 profile pages for species that have been identified as being difficult to handle, store or use.

At stakeholder workshops held in Burkina Faso and South Africa, Kew worked with managers to identify the training needs of gene bank staff in Africa. These were followed in 2007 by four training workshops (two conducted in English and two in French), to which we invited gene bank technicians from various institutes across the African continent. At these workshops we also got the opportunity to work with local farmers in the host countries and to share information on the appropriate handling and storage of seeds.

As a result, we have put together a list of 220 species that were identified as being difficult to handle, store or use, and have developed species profile pages for 160 of these, to overcome any difficulties. We have also provided training resources and useful links to enable gene banks to run training courses amongst their staff, and with farmers and community seed groups.

For further details please contact Vanessa Sutcliffe (**v.sutcliffe@kew.org**)

You can access the 'Difficult' Seeds Project web pages at:
www.kew.org/science-research-data/kew-in-depth/difficult-seeds

International participants meeting local farmers on the Burkina Faso training workshop

PHOTO: RBG KEW

NEWS

Pilot Project in the Dominican Republic

In January 2010, a pilot project commenced between the University of Pavia in Italy (an ENSCONET partner), the Jardin Botanico Nacional ¨Dr Rafael Maria Moscoso¨ (JBN) in the Dominican Republic and the Millennium Seed Bank Partnership (MSBP). The project 'Ex situ conservation of wild plants for human well being in the Dominican Republic' focuses on one of the most important Caribbean hotspots of biodiversity.

The purpose is to strengthen the technical and institutional capacity of the JBN to contribute to the conservation of the high plant diversity and endemism in the country. The main components of the project are: 1) capacity building of JBN staff in seed conservation, 2) *ex situ* conservation of priority plant species, 3) plant propagation and the development of propagation protocols for reforestation and 4) research on seed storage behaviour. The pilot project will last until the end of the year with the potential to be extended for a second year. The funds for the joint project have been provided by the Council of Milan (Italy) with the support of the Lombardy region, where the University of Pavia is located. In parallel, the JBN has received funds from the Dominican Republic's Ministry for Environment and Natural Resources to build a seed bank for the long term conservation of the most threatened species. The Ministry also has plans to build a seed bank for the short term conservation and propagation of priority species which will be part of the reforestation programme of the whole island of Hispaniola which includes both the Dominican Republic and Haiti.

Mr Keith Manger and Dr Tiziana Ulian from Kew last visited the JBN in July 2010 to provide advice in seed bank design and training to both JBN and governmental staff. During the same visit, Tiziana and Keith delivered a public presentation which was requested and attended by the Minister for Environment and Natural Resources of the Dominican Republic, Dr Jaime David Fernandez Mirabal.

For more information, please contact:
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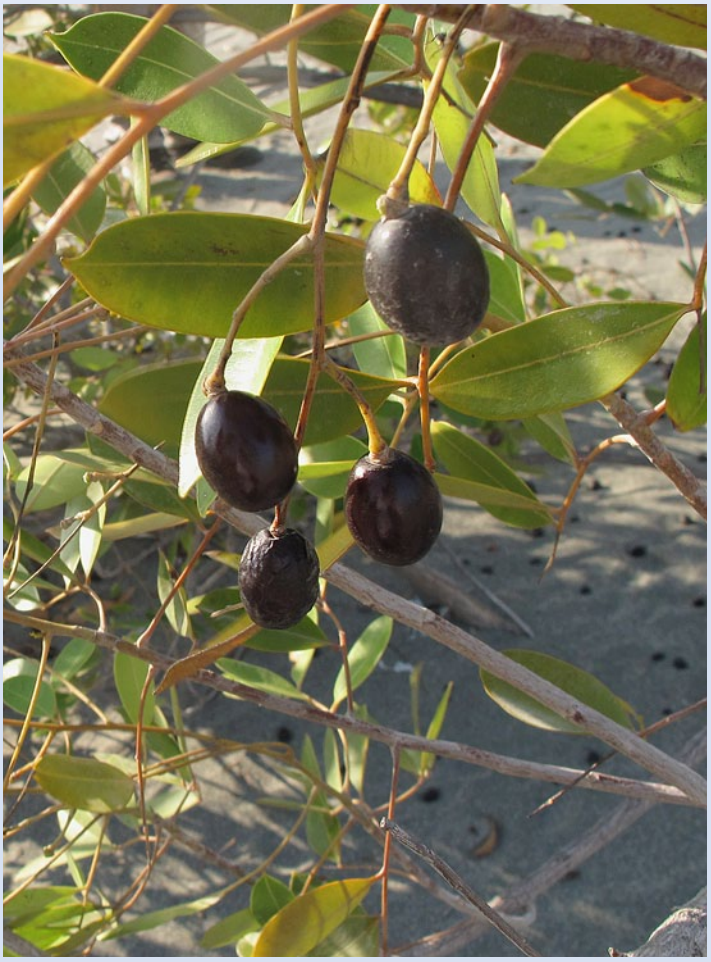
and/or Prof. Graziano Rossi (**graziano.rossi@unipv.it**)



Fruits of *Simarouba berteroana*, an endangered prioririty species (narrow endemic to costal areas of Dominican Republic and Haiti) collected in Dominican Republic in May 2010

PHOTO: T. ULIAN

Planting event in May 2010 in Dominican Republic: from the right, the Minister for Environment and Natural Resources of the Dominican Republic, Dr. Jaime David Fernandez Mirabal; Prof. Graziano Rossi (University of Pavia); Dr. Tiziana Ulian (RBG Kew); the Director of the JBN, Ricardo García, and the student/project officer Paolo Cauzzi (University of Pavia)

PHOTO: JBN

Joint collecting activities of JBN, University of Pavia and Kew staff during expedition in July 2010 in Dominican Republic

PHOTO: T. ULIAN

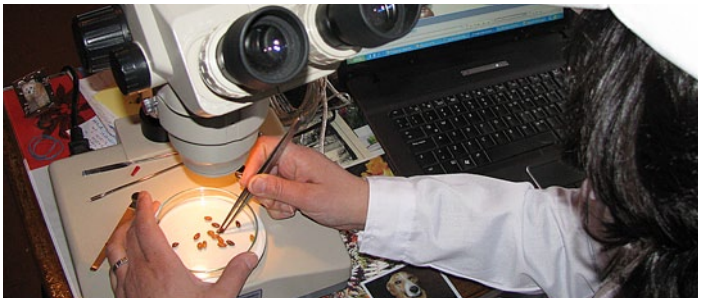
A Message from Paul Smith

This edition of Samara focuses on the role of the Millennium Seed Bank Partnership in habitat restoration. Restoration is a growing discipline that ranges from planting well-adapted, native species in our gardens through to the recreation of diverse and complex habitats in the landscape. The principle is the same whatever the scale – that diverse, well-adapted species assemblages are more productive and resilient than monocultures of exotic species.

The MSBP has been providing expertise and seeds for restoration programmes across the globe for a number of years. Examples range from littoral rainforest in Madagascar through tall grass prairie in the USA to high weald meadows in the UK.

On a recent trip to Cape Town, I was able to see seed scientists and horticulturalists at Kirstenbosch Botanical Garden applying their expertise to the restoration of sand plain fynbos, one of the rarest and most diverse habitats on Earth (see page 8). Since my last visit there six years ago, the Kirstenbosch team have set up restoration seed beds, established common garden plots, and have reintroduced around 15 species back into their native habitat – including two *Erica* species previously extinct in the wild. They are now embarking on a large scale restoration programme in the Tokai Nature Reserve that will see hundreds of hectares restored. I hope that their achievements and the other work highlighted in this edition of Samara will inspire you to get involved in restoration wherever you are.

Seed Images on Flikr



Monica Matus Ardiles carrying out micrometric analysis and photography PHOTO: JARDIN BOTANICO NACIONAL DE VINA DEL MAR

The Viña del Mar Botanic Garden, Chile, uses Micrometrics techniques to carry out detailed research on seed structure and morphology. These studies help to improve our knowledge of the structure, colour, form, texture and size of the seeds of rare and threatened native and exotic plant species. Some of the seeds have never before been photographed at this level of detail.

Photographs of seeds measuring microns to millimetres were taken using a micro imaging camera with a 45x lens and Micrometricstm SE Premium 2.8 measuring software; photos of larger seeds were taken with an 8MB conventional camera.

The photos are available to view on the Viña del Mar Botanic Garden's Flikr site. There are 6 albums in the Semillas folder: http://www.flickr.com/photos/fjbn/collections/72157624321913831/ featuring seeds of exotic cacti, seeds of Chilean orchids, seeds of exotic, ornamental, advenas and weed species, seeds of native species, seeds of endemic and introduced species of the Juan Fernandez islands, and seeds of Chilean cacti.

To date, more than 780 photos of 275 different species are available. These images may be used for educational purposes, citing Viña del Mar Botanic Garden as the source.

For further information please contact:
Monica Matus Ardiles, Jardin Botanico del Viña del Mar, Chile
(email: **laboratorio@jardin-botanico.cl**)
Web site: **www.jardin-botanico.cl**

Millennium Seed Bank Collection Figures March 2011

Total collections	57,009
Number of species	30,405
Number of genera	5,194
Number of families	341
Number of countries represented	165

Key Research Publications January – April 2011

1. Crawford AD, Plummer JA, **Probert RJ** and Steadman KJ (2011). The influence of cone age on the relative longevity of Banksia seeds. *Annals of Botany* 107: 303-309.

2. Flores J, Jurado E, Chapa-Vargas L, Ceroni-Stuva A, Dávila-Aranda P, Galíndez G, Gurvich D, León-Lobos P, Ordónez C, Ortega-Baes P, Ramírez-Bullón N, Sandoval A, **Seal CE, Ulian T** and **Pritchard HW** (2011). Seeds photoblastism and its relationship with some plant traits in136 cacti taxa. *Environmental and Experimental Botany* 71:79-88.

3. Long RL, **Kranner I**, Panetta FD, Birtić S, Adkins SW and Steadman KJ (2011). Wet-dry cycling extends seed persistence by re-instating antioxidant capacity. *Plant and Soil* 338: 511-518.

4. **Kranner I**, Chen H, **Pritchard HW**, Pearce SR and Birtić S (2011). Inter-nucleosomal DNA fragmentation and loss of RNA integrity during seed ageing. *Plant Growth Regulation* 63: 63-72.

5. Prada D, Velloza TM, **Toorop PE** and **Pritchard HW** (2011) Genetic population structure in horse chestnut (*Aesculus hippocastanum L.*): effects of human-mediated expansion across Europe. *Plant Species Biology* 26: 43-50.

For further publications see:
www.kew.org/science-research-data/kew-in-depth/msbp/publications-data-resources/scientific-publications

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