Samara

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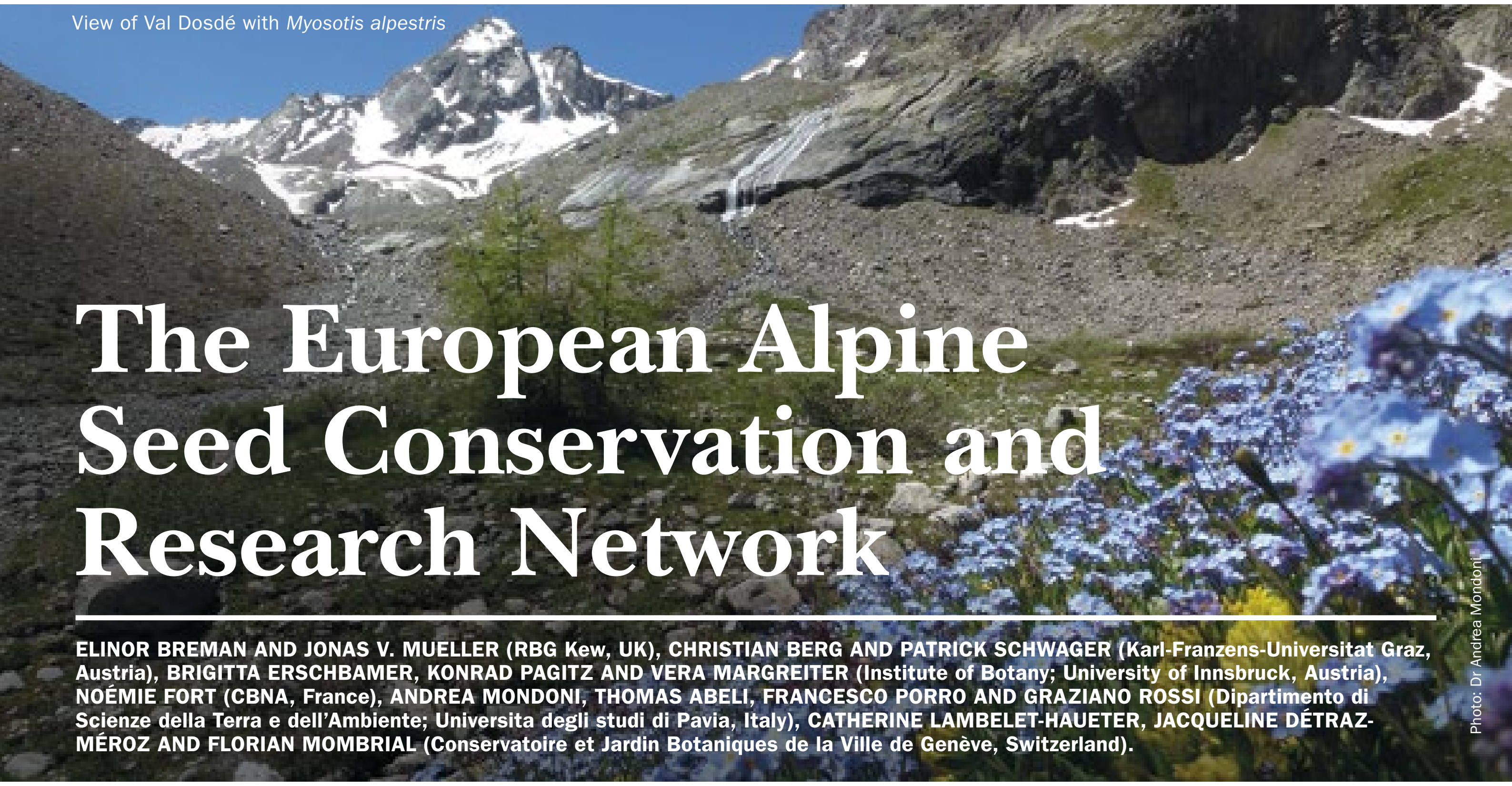

View of Val Dosdé with *Myosotis alpestris*

Photo: Dr Andrea Mondoni

The European Alpine Seed Conservation and Research Network

ELINOR BREMAN AND JONAS V. MUELLER (RBG Kew, UK), CHRISTIAN BERG AND PATRICK SCHWAGER (Karl-Franzens-Universitat Graz, Austria), BRIGITTA ERSCHBAMER, KONRAD PAGITZ AND VERA MARGREITER (Institute of Botany; University of Innsbruck, Austria), NOÉMIE FORT (CBNA, France), ANDREA MONDONI, THOMAS ABELI, FRANCESCO PORRO AND GRAZIANO ROSSI (Dipartimento di Scienze della Terra e dell'Ambiente; Universita degli studi di Pavia, Italy), CATHERINE LAMBELET-HAUETER, JACQUELINE DÉTRAZ-MÉROZ AND FLORIAN MOMBRIAL (Conservatoire et Jardin Botaniques de la Ville de Genève, Switzerland).

The European Alps are home to nearly 4,500 taxa of vascular plants, and have been recognised as one of 24 centres of plant diversity in Europe. While species richness decreases with increasing elevation, the proportion of endemic species increases – of the 501 endemic taxa in the European Alps, 431 occur in subalpine to nival belts.

The varied geology of the pre and inner Alps, extreme temperature fluctuations at altitude, exposure to high levels of UV radiation and short growing season mean that the majority of alpine species are highly adapted to their harsh and changeable environment.

These ecosystems – and the services that they provide – are under threat, and many plant species require urgent conservation action. Climate change has already led to an upward movement of plant distributions, leaving those at the top with nowhere to go. Changes in land use are affecting many plant communities. A decrease in traditional land use practices, such as haymaking and grazing on high alpine grasslands, means they are converting to shrub land and forest with reduced species diversity. Conversely, over-grazing in some areas (notably by sheep) is leading to eutrophication and a loss of species adapted to low nutrient levels. The expansion of urban settlements, modern ski runs and the increase in alien and invasive species are further threats. Sustainable land management and the protection of species in nature reserves will not be sufficient to conserve the majority of species, particularly in the context of climate change.

A new project has been developed by RBG Kew, with funding from the David and Claudia Harding Foundation, to conserve European alpine flora and to raise awareness of its increasing vulnerability. The Alpine Seed Conservation and Research Network currently brings together five plant science institutions across the Alps, housed at leading universities and botanic gardens:

- Austria, Karl-Franzens University of Graz; Botanic Garden
- Austria, Botanic Garden of the Institute of Botany, University of Innsbruck
- France, Conservatoire Botanique National Alpin

Story continues on page 2

Royal Botanic Gardens Kew

MILLENNIUM SEED BANK PARTNERSHIP

Continued from page 1

- Italy, University of Pavia, Department of Earth and Environmental Sciences
- Switzerland, Conservatoire et Jardin Botaniques de la Ville de Genève

The overarching aim of the project is to set up a network for seed conservation and research in the European Alps, and improve the conservation status of endangered plant species and communities in their European Alpine habitats.

The five specific objectives of the network are:

1. Improve the conservation status of grassland communities and their constituent species in the high-montane, alpine and nival altitudinal belts.
2. Make high quality seed material available for conservation, research and restoration.
3. Improve knowledge of the ecology of target species through specific research projects.
4. Develop a network for seed conservation and research in the European Alps, fostering collaboration, development of early-career scientists, and expanding knowledge on key ecological species in the European Alps.
5. Raise awareness of the importance of Alpine grassland communities through engagement with schools and public outreach.

Over three field seasons, seed of 500 vascular plant species will be collected from grassland communities in the subalpine, alpine and nival altitudinal belts and adjacent, directly connected specialist communities. These communities include calcareous and siliceous grasslands at high altitude (including dry and semi-dry grasslands), calcareous and siliceous rock communities, limestone scree (alpine scree communities), snow bed and alpine pioneer communities. The first priority for sampling will be given to endemic and threatened species, or those that are particularly valuable for other reasons e.g. a species used in traditional medicine or local cuisine. This approach will result in collections of a mix of rare, threatened and more common species.

The project began earlier this year and we have already had our first, highly-successful collecting season. Despite various challenges – poor weather, late seed set, remote populations and poor seeding – 150 species have already been collected and conserved for future use.

As part of the programme, one MSc and three PhD research projects investigate evolutionary patterns and processes of alpine species in response to global warming, identify niche adaptation, gather new data on the conservation status of endemic species in the target areas, and investigate germination, seedling recruitment, establishment and persistence in the soil seed bank of target species along altitudinal gradients. The research uses a combination of field and laboratory experiments and results will be published in leading journals. There's more information on these projects on pages 16 and 17.

A fundamental part of the project is to foster cooperation and collaboration, and to promote the exchange of experience and ideas. Joint field trips and staff and student exchanges are helping the network develop between the institutes involved. To raise awareness of the threats to alpine plant communities as well as the project's initiatives to protect them, a communication and publication strategy is also being developed, involving stakeholder groups at the local level across the whole alpine region. In addition to disseminating research, an educational programme is being set up with schools in Austria and Switzerland, and through institutional connections in Italy. Living collection displays will also be tied in to the project at each of the botanic gardens involved. To follow the success of the project, please visit www.alpineseedconservation.eu.

Ranunculus glacialis, Obergurgl, 2,850 m

Ranunculus glacialis L. is a pioneer species from the upper alpine to the nival belt. It is among the few vascular species able to reach the uppermost summits in the Alps. Nutrient-poor siliceous rocks and scree sites are the typical habitats of this arctic-alpine species. In artificial warming experiments in the Arctic, the species showed no phenotypic plasticity in reproductive or phenological growth (Totland & Alatalo, 2002), suggesting that *R. glacialis* might be highly vulnerable to climate change. In the Alps, reproductive plasticity was found to be quite high with optimal sexual reproduction in the sub-nival zone (i.e. at 2,880 m a.s.l.). Here, the mean length of the growing season was about three months with mean temperature of 8°C at the soil surface. Under these conditions, seeds can mature each year (Wagner et al., 2010). However, germination ability and factors determining germination have yet to be studied.
R. glacialis is locally on the Red List of endangered species in North and East Tyrol, and in Vorarlberg, Austria.. In former times it was used in folk medicine as a remedy for fever and dizziness.

Collected 2016. Three other collections at the MSB (Italy, Finland, Austria).

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Photo: B. Erschbamer

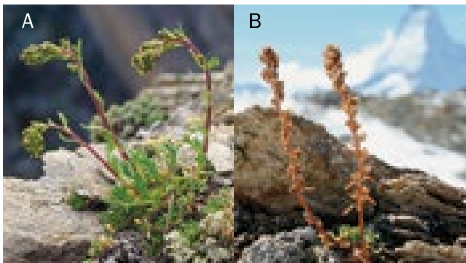

Photo A: *Artemisia nivalis* flowering, 5 August 2013

Photo B: *Artemisia nivalis* at harvesting time, 22 September 2016

Artemisia nivalis Braun-Blanq. (Snow wormwood), is a narrow endemic species located in the area of Zermatt (Upper Wallis). It grows only on calcschists ridges of the Rothorn summits between 3,000 and 3,400 m. *A. nivalis* is a species close to *A. genipi* and differs from it by its hairlessness and strong and pleasant smell (photo A). These plants very often grow close to each other, but no hybrid has been found between these two species.

So-called mountain wormwoods – in French *génépi*, in German *Edelraute* or *Bergwermut*, in Italian *genepi* – like *Artemisia genipi* (black genepi) or *Artemisia umbelliformis* (white genepi), are traditionally used in alcoholic maceration to produce an olive to pale gold-coloured herbal liqueur, popular in the Alps.

Mountain wormwoods have been appreciated as medicinal plants since the Middle Ages. Books devoted to aromatic plants emphasize the digestive, expectorant, neurotonic and stimulating properties of these plants. Aphrodisiac powers have even been attributed to them. Indeed, it is said that 'génépi is good for Madam when it is Monsieur who drinks it'. It doesn't appear that *A. nivalis* is used for this reason today, which is probably a good thing as it is protected at the national level.

Seeds were collected for the project after the first snowfall (photo B).

Photos: B. Baümler / J. Détraz-Méroz

A message from Colin Clubbe

(Head of the Conservation Science Department, RBG Kew)

Earlier this year Kew published the first *State of the World's Plants* report (www.stateoftheworldsplants.com). One chapter examined the impacts of climate change on the world's plant species and their associated ecosystems. The concentration of global atmospheric carbon dioxide has increased from its pre-industrial level of around 280 ppmv to the current 400 ppmv. Global temperatures are warming at a faster annual average rate than any trend seen in the past 1,400 years. Alpine floras are particularly under threat. Long-term observational studies are providing evidence of altitudinal migration over the last few decades in response to climate change. For example, across European mountain systems plant communities above the tree line are transforming, with mounting evidence of a decline in the more cold-adapted species and an increase in the more warm-adapted species.

There has never been a greater urgency to secure the future of alpine plants. For this reason, alpine habitats are important areas for Millennium Seed Bank Partnership activity. Securing the future of these plants through seed collection and *ex situ* storage is a key priority for us. There are lots of great projects underway to conserve alpine plants, and this issue of Samara reviews a selection of them from across the globe. The success of these projects gives us hope that we are making progress in securing the future of these plants and improving the overall status of plant species globally – something we will be reviewing annually in our *State of the World's Plants* report.

A message from Jonas Mueller

(Senior Research Leader, Seed Conservation, RBG Kew)

The Swiss botanist Carl Schröter (1855-1939) was one of the pioneers of alpine ecology. He introduced the terms 'autecology' and 'synecology', and he first described scientifically the phenomenon that the natural treeline in large mountain ranges lies generally higher than that of smaller, isolated mountain ranges – something we know nowadays as the 'mass elevation effect'. I was reminded of this during a recent trip to the Himalaya – while taking my breath at about 3,500 m above sea level, I was standing in a dense forest formed of mighty *Abies*, *Tsuga* and *Pinus* trees – unthinkable in Europe, where I had learnt my botany.

This issue of Samara focuses on high mountain floras. As Colin Clubbe points out, it is a truly global issue, bringing together contributions by our Millennium Seed Bank partners from four continents; the scale ranges from individual taxa, like the Colombian genus *Espeletia*, to whole landscapes, like the Afromontane highlands of Kenya, Tanzania and Uganda. The predictions of the impacts of global warming on plant distribution and their survival in high mountain areas are grim at times, making the *ex situ* conservation of those alpine plants an urgent task. We need to have in mind that 10 per cent of the world's population live in mountain regions, and an estimated 40 per cent depend in some way on mountain resources. I find it personally very encouraging to witness the passion for alpine plants across the partnership and your commitment to plant conservation of high mountain areas and their seeds.

Reading the articles in this issue, you will see the similarities (and differences) between the individual projects, and I trust you will gain as much joy and inspiration from these articles as I did.

Giants of the East African Mountains

TIM PEARCE (Conservation Partnerships Coordinator for Africa, RBG Kew)

Photos: Tim Pearce, RBG Kew

Tiziana Ulian driving through Afromontane heathland in the Aberdare National Park, Nairobi.

The mountains of Kenya, Tanzania and Uganda comprise some stunning landscapes and provide habitat for some of the most iconic plant species on the African continent. These ecosystems are at the centre of Conservation International's 'Eastern Afromontane' Biodiversity Hotspot, which includes Mount Kilimanjaro, Africa's highest point at 5,895 metres above sea level.

East African mountains have a range of vegetation zones, essentially correlated with altitude and rainfall. Typically, the base of the mountains are covered by montane forest, dominated by *Podocarpus milanjianus, Afrocarpus gracilior, A. usambarensis* and *Juniperus procera*. This thick forest gradually gives way to extensive tracts of the highland bamboo (*Arundinaria alpina*), much loved by the mountain elephant. Beyond the bamboo forest are mosaics of grass and sedge tussocks, and xerophytic shrubby heathers. At about 3,500 m this Afromontane heathland gives way to upland forests of *Hagenia abyssinica*, which frequently forms the treeline below the true Afroalpine zone. This extreme environment is home to the giant Senecios and Lobelias, perfectly adapted to the high altitude life of summer every day, winter every night. In

'... these equatorial mountain islands are highly sensitive to changes in temperature and, in a rapidly changing climate, represent some of the most threatened habitats on the continent.'

Frank White's Vegetation map of Africa, the term 'Afromontane Flora' is used to refer to the montane forest, bamboo, moorland and Afroalpine zones combined.

To date, these unique habitats have been threatened with logging, fire and grazing, but thankfully most of the higher elevations of the Afromontane areas fall within protected area systems. Nevertheless, these equatorial mountain islands are highly sensitive to changes in temperature and, in a rapidly changing climate, represent some of the most threatened habitats on the continent. It is estimated that some 900

Paul Kirika from the East African Herbarium with *Dendrosenecio battiscombei*. Mt. Satima, Aberdare National Park, Kenya.

vascular plant species can be found above 3,000 m in Kenya, Tanzania and Uganda, many of which are narrowly endemic to one or two mountain ranges. Only a quarter of these have been safeguarded across the Millennium Seed Bank Partnership, and only a handful of the species have been subject to full IUCN Conservation Assessments.

The Afromontane Plant Conservation Project brings together partners from national herbaria, seed banks, universities and conservation management authorities in Kenya, Tanzania and Uganda, to deliver data and strategies to improve the conservation of the Afromontane flora. As well as establishing extensive seed collections of the most threatened plant species, we are ensuring that up to date conservation assessments are produced using the data compiled in a botanical records database. This searchable online database (brahmsonline.kew.org/afmp) contains information on the East African flora from herbarium specimens and literature, to assist with species targeting for seed conservation, conservation assessments and to raise awareness of this unique flora.

Several of these mountain ranges are renowned tourist destinations, generating vital income for the local communities. Safeguarding biodiversity and wildlife in the region will therefore play a crucial role in sustaining the local economy. I first visited these stunning landscapes some 30 years ago as a student. At that time, evidence of climate change was still to be presented in earnest but I am now left with the almost philosophical challenge of where to put these African giants when their habitat can no longer sustain them.

Alpine Plants of Armenia

DR ANUSH NERSESYAN (Leader of the Seed Bank of Armenian Flora, Institute of Botany of the Armenian National Academy of Sciences)

Silene chustupica described from Southern Armenia

Photos: A. Nersesyan

Dianthus raddeanus in flower

Armenia is a mountainous country, with many of its mountain ranges formed by different geological events. The northern summit of Aragats volcanic massif (4,090 metres above sea level) is the highest peak in the country. Armenia's alpine zone starts at an altitude of between 2,500–2,700 m and its alpine flora totals around 550 species, from over 200 genera and 50 families (Baloyan, 2005). The mountains of northern Armenia have a mostly Caucasian flora, whilst the mountains of central Armenian volcanic highlands are equally influenced by both the Caucasian and Armeno-Iranian floras, and are also rich in plant species. The Caucasian flora's influence decreases towards the southwestern and southern mountain ranges located along the Arax River. Nevertheless, there are some outlying species of the Caucasian flora in southern Armenia, for example, the yellow-flowered *Viola caucasica* Rupr.

The main types of alpine vegetation in Armenia are alpine meadows, alpine carpets and petrophilous vegetation on rocks and screes. Numerous Caucasian endemics, as well as six Armenian endemics, occur in the alpine belt of Armenia. *Silene chustupica* Nersesian, a local endemic, has been described from the Khustup Moutain in southern Armenia. *Campanula zangezura* (Lipsky) Kolak. & Serdjuk., *Dianthus raddeanus* Vierh. and *Cerastium szowitsii* Boiss. are among the most attractive species of the Armenian alpine zone.

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From giant buttercups to vegetable sheep – endemic alpines of New Zealand are a conservation priority

CRAIG MCGILL (Project Leader, New Zealand Indigenous Flora Seed Bank), JESSICA SCHNELL (Seed Bank Coordinator, New Zealand Indigenous Flora Seed Bank) AND RUTH E. BONE (International Project Officer (Pacific), RBG Kew)


Photo: J.Barkla

Mount Cook Lily (*Ranunculus lyallii*)

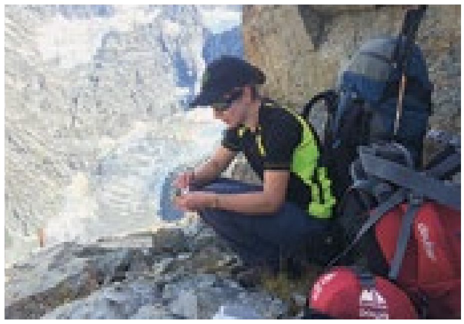
Photo: R.E. Bone

Jessica Schnell (NZIFSB) collecting *Celmisia daisies*


Photo: R.E. Bone

Jessica Schnell outside Mueller Hut (1,800m on the Sealy Range, Aoraki Mt. Cook National Park)

New Zealand is recognised as one of the world's biodiversity hotspots, with a rich and unique flora (82 per cent endemism; de Lange and Rolfe, 2010). New Zealand's alpine zone includes the Southern Alps as well as some volcanic summits on the North Island. The zone ranges from sea level in the sub-Antarctic Islands, rising to 900 m on Stewart Island and reaching 2,000 m in the central Southern Alps (Wilson, 2007). Despite covering only 11 per cent of New Zealand, the alpine zone hosts approximately one-third of New Zealand's flora (about 1,000 species), including the world's largest buttercup, the Mount Cook lily (*Ranunculus lyallii*). Of these 1,000 species, around half are unique to the alpine zone.

Typically, plants of the alpine flora are small and compact, with relatively large, predominantly white, flowers (Wilson, 2007). Despite the subdued colours, stunning landscapes and botanical curiosities reward adventurous hikers (and seed collectors!) who explore New Zealand's alpine range.

'The alpine flora of New Zealand has been a high priority for collecting since the launch of the New Zealand Indigenous Flora Seed Bank (NZIFSB) in October 2013, with a number of dedicated seed collecting expeditions.'

Mountain daisies (*Celmisia*), tussock grasses (*Chionochloa* and *Poa*), forget-me-nots (*Myosotis*), and eyebrights (*Euphrasia*) line paths and scree slopes among the low, furry domes of the 'vegetable sheep' (cushion plants *Haastia* and *Raoulia*). Shrubs and small trees (such as *Coprosma*, *Hebe* and *Podocarpus nivalis*) occur on the lower mountain slopes.

The alpine flora is under threat from clearance and grazing, trampling and erosion from recreational use, introduced weeds such as *Pinus contorta*, and browsing from introduced animals. The flora is especially vulnerable to climate change, which is likely to allow species of lower altitudes to compete more effectively with alpine flora, and may see current alpine species shift to higher altitudes. Many alpine species are classified as either being at risk or threatened. For example, of the 74 species of *Myosotis* listed in *The Plant List* (2010), 40 are endemic to New Zealand and 70 per cent are threatened or at risk.

The alpine flora of New Zealand has been a high priority for collecting since the launch of the New Zealand Indigenous Flora Seed Bank (NZIFSB) in October 2013, with a number of dedicated seed collecting expeditions. In November 2014, NZIFSB joined staff from the Dunedin Botanic Garden to visit the Flagstaff Reserve, where they focused on collecting Mānuka (*Leptospermum scoparium*) – a culturally

Photo: R.E. Bone

View of Aoraki Mt. Cook National Park

Photo: R.E. Bone

Mueller Hut at 1800m on the Sealy Range, Aoraki Mt. Cook National Park

and economically significant species that is the pollen source for Mānuka honey, and potentially threatened by myrtle rust. A collecting expedition to Mount Burns in 2015 resulted in another five species being collected and banked (*Aciphylla pinnatifida*, *Astelia linearis* var. *novae zelandiae*, *Coprosma cheesemanii* and a sundew, *Drosera arcturi*). In March 2016, two collecting trips were undertaken: one to Aoraki Mount Cook, which added a further 16 species including the 'at-risk' Rock Willowherb (*Epilobium petraeum*), and one in the Old Man Range in Central Otago that added a further six species to those already banked.

Community engagement in the project is actively encouraged through a series of lectures, seed collection workshops and regular contributions to the New Zealand Plant Conservation Network (NZPCN) newsletter *Trilepidea*. More recently, the NZIFSB team established a project in *iNaturalist* (www.inaturalist.org/projects/nz-indigenous-flora-seed-bank), to encourage standardised recording of phenological observations among the New Zealand botanical community.

As new threats to this unique alpine flora emerge, the New Zealand Indigenous Flora Seed Bank, and its network of supporters, are well placed to develop seed conservation methods as part of a broader *ex situ* conservation strategy for New Zealand.

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Researching *ex situ* conservation of 'frailejón' seeds in Colombia

LAURA VICTORIA PÉREZ-MARTÍNEZ (Bogotá Botanic Garden *ex situ* Seed Bank Manager) & MANUELA CALDERÓN-HERNÁNDEZ (Seed Conservation Line professional of *ex situ* Seed Bank)

The páramo is a unique neotropical mountain biome located between the high Andean forest (near 3,000 metres above sea level) and the lower limit of snowfields (above 4,700 masl). It is characterized by its extreme conditions, which include very high solar and UV radiation, great temperature differences during the day and between day and night (greater than seasonal differences), frost, strong winds, low atmospheric pressure and low oxygen. The environmental conditions tend to change and are more extreme with elevation. It is the most diverse high mountain ecosystem and has very high endemism (Madriñán, et al., 2013). Furthermore, it offers ecosystem services, particularly in relation to water preservation.

As they are highly adapted to their conditions, páramos are very vulnerable to climate change, and since they are often near human settlement and cities with a growing population, they are continually disturbed by agriculture, deforestation, burnings, livestock and mining. Hence, Bogotá Botanic Garden José Celestino Mutis is implementing the first *ex situ* seed bank specialising in high Andean ecosystems, especially the páramo.

'...Bogotá Botanic Garden José Celestino Mutis is implementing the first ex situ seed bank specialising in high Andean ecosystems, especially the páramo.'

'Frailejón' is a name used to group the species of the subtribe Espeletinae (family Compositae) which are only found in Colombia, northern Ecuador (only one species) and Venezuela. Frailejones are representative and dominant plant species

Photo: Laura Victoria Perez

Frailejón in a páramo landscape.


Photo: Laura Victoria Perez

Espeletia grandiflora seedlings transplanted to nursery from seed germination essays.

Photo: Carolina Mancipe

Espeletia cayetana seed, an endangered species, germinating.

of páramos. They comprise eight genera, are highly endemic and each species is generally restricted to one páramo complex. Additionally they demonstrate great morphological diversity. Like páramo, frailejones per se are very vulnerable to climatic change. Information about seed ecology of páramo species is very scarce. This drives our investigation to successfully conserve our species.

Bogotá Botanic Garden has several species of *Espeletia* and *Espeletiopsis* genera within its seed bank, respectively the first and third richest genera of Espeletiinae. Starting out, we were concerned with representative species of páramos around urban Bogotá and we evaluated the germination and viability of five species. We tested standard laboratory germination (20/10°C, 12-hour day-night photoperiod) for *Espeletia argentea*, *E. grandiflora*, *E. cayetana* (an endangered species), *E. barclayana*, *E. killipii* and *Espeletiopsis corymbosa*. Collections that were made in different localities and on different dates within the localities were tested and compared for some of the species.

As expected, we found that seed viability differed according to species, collecting time, and locality. Seed quality ranged from less than 10 per cent filled seed to as high as 60 per cent, in samples as little as one week apart which hinders the collection of good quality seeds in suitable quantities for the seed bank. The differences may be linked with a decrease in precipitation and a higher availability of pollinators (typically bees). In species with a wide altitude range (e.g. *E. grandiflora*), altitude has a strikingly negative effect on seed viability, even in the dry season. Another challenge has been the incidence of pathogens, linked to climate change (Varela-Ramírez, 2014), which affects the stem, leaves and in some cases the seeds. For example, we have found coleopteran larvae in populations of endemic species. Regarding germination, the evaluated Espeletiinae species ranged between 30 and 80 per cent.

Currently, the seed bank is finalising the seed storage protocols for six *Espeletia* and two *Espeletiopsis* species – seven of them endemics and one threatened – that have been collected in eleven different localities and populations around Bogotá. The seed bank is conserving accessions from different localities to fully represent the genetic diversity of the species. Each seed collection within the bank is also weighed and measured prior to germination. Following germination, we transplant the germinated seeds in nurseries and monitor the survival and growth. In future, we seek to investigate the reinforcement of populations with *ex situ* propagated plants for restoration, once the plants reach an adequate size (approximately 20 cm).

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Seed Bank Conservation Techniques Training, 2016

BOBBI HOPE (Science Administrator - Education [Projects], RBG Kew)

Photo: Oriole Wagstaff

(From left to right) Victor Otieno, Nima Gyeltshen, Mpande Sichamba and Shakeel Ahmad participating in training on sampling techniques in the field.

The Seed Conservation Techniques (SCT) course brought together scientists from 12 partner institutions over three weeks in September and October to gain practical training in seed conservation. This year's group included a wide range of seed conservation practitioners – from researchers to collectors, experienced genebank managers to the CEO of a newly-registered charity. Along with a good deal of tenacity, one thing all the participants have in common is a passion for species conservation. This year's group were as enthusiastic and hardworking as ever, despite a very demanding course which even included homework.

The SCT course reflects the seed conservation standards, which were developed to standardise practices across the partnership and assure users of the utility of the collections. SCT sessions included seed moisture measurement and drying, germination and viability testing, how to design and implement a collecting programme, and collections and processing management.

Every year sessions are adapted to be sensitive to the varied training needs and experience of the participants. This year, two new sessions were developed based on feedback from partners, Millennium Seed Bank regional project coordinators and other training events. The first of these was a funding proposal exercise, which included a lecture on grant writing and a practical session where the participants were asked to write their own grant proposals for a seed conservation project. Participants received feedback on their work and could then use this to form the basis for discussion with their appropriate coordinators, and to develop new project ideas together. This formed an important part of assessing the impact of the course – partners' future work inspired by what they learnt during SCT included: implementing new protocols for post-harvest handling, developing field and laboratory guides for in-house and community use, and running skill-sharing and training sessions for their own staff.

The second session new to this year's course focused on the MSBP's Data Warehouse – how it works, the benefits it represents for partners, and how to input and extract data using BRAHMS and Excel software. There have been a growing number of requests for this type of training from partners developing their accession monitoring and database management. Feedback from this taster session showed that participants would like more in-depth training to be offered in the future.

The final week of the course focused on managing collections, viability monitoring and use. This has always been a vital component of the course, to emphasise that collections are fundamentally designed to be used. The key message of the week is that the partnership is practising conservation, not preservation, demonstrated through real-life case examples on how collections are being used in ecological restoration, research, pre-breeding and supporting livelihoods.

SCT 2016 has been possible due to funding from the Sfumato Foundation and support from Toyota Motor Corporation, as part of the MSB Technology Transfer Project.

An Australian view on current directions in alpine seed and seedling ecology

ANNISA SATYANTI (PhD Student, Research School of Biology, Australian National University and Australian National Botanic Gardens, Canberra), LYDIA GUJA (Seed Conservation Biologist, Australian National Botanic Gardens, Canberra, and research staff Centre for Australian National Biodiversity Research, Canberra), ADRIENNE NICOTRA (Professor, Research School of Biology, Australian National University, Canberra)

Photo: Annisa Satyanti

An experiment to test the transgenerational effect of soil warming on phenology, seed dormancy, and germination traits of Australian caraway (*Oreomyrrhis eriopoda*, Apiaceae).

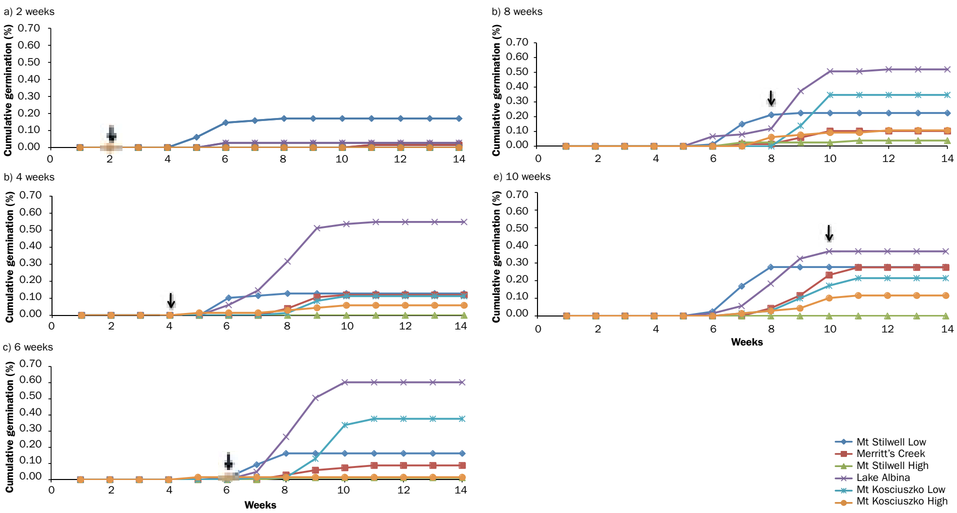
Alpine ecosystems and their plant communities worldwide have been identified as threatened or vulnerable to a changing climate. Future climate predictions for the Australian Alps suggest that snow depth will decrease and by 2050 there will be a 3°C temperature increase relative to 1990. In Australia, only 0.15 per cent of the landmass is alpine, but this area is home to 212 plant species, including 30 exclusively alpine and 21 endemic species.

Plant responses to a changing climate will depend on their potential to recruit *in situ* or migrate upwards, both of which are inherently dependent on establishment from seed. Plant population dynamics and future distributions will therefore be significantly affected by seed and seedling ecology (Briceño et al., 2015). In Australia, where the alpine region extends across an elevational range of just 400 m, understanding the scope and potential of alpine plant migration is crucial.

With our collaborators (The Australian National University ANU, the Australian National Botanic Gardens ANBG and the University of Queensland, funded by the Australian Research Council and supported by the Friends of ANBG) we have established a research programme on Australian alpine plants to address the wide knowledge gaps in alpine seed and seedling ecology while also securing seed through *ex situ* conservation (Briceño et al., 2015; Hoyle et al., 2014; Hoyle et al., 2015; Hoyle et al., 2013; also all references therein). Here we outline several areas of investigation of Australian alpine seed and seedlings currently underway at the ANU and ANBG in Canberra, Australia (a partner in the Australian Seed Bank Partnership).

Seed germination strategies and seedling growth

Seed dormancy is a common trait among Australian alpine species. In general there are three germination strategies that can be observed: immediate, staggered and postponed (Hoyle et al., 2015). Species with non-dormant seeds germinate immediately after natural dispersal in autumn. The postponed strategy is comprised of species with dormant seeds that germinate after winter. The final category are species with seed germination that is staggered over time. Australian alpine celery (*Aciphylla glacialis*), which exhibits a postponed germination strategy, requires at least six weeks of winter to germinate (Figure 1, Hoyle et al., 2014), suggesting that changing climatic cues could affect the germination pattern in these and other alpine species. The combination of colder winter and summer warming is known to accelerate germination and increase seedling survival for many subarctic species. Under future climate scenarios, species with non-dormant seeds will likely have an advantage over species with dormant seeds, as the growing season becomes longer. However, we might expect that species with an immediate germination strategy that emerge in autumn will be exposed to harsh conditions if snow insulation during winter disappears – species with a postponed germination strategy may survive winter better, as they stay as dormant seeds in the soil. Seedling survival for seedlings with spring emergence may thus be higher, but spring germinants may be outcompeted by larger seedlings that emerged in autumn. Thus, staggering germination over time might be the best strategy to maximize highest seedling survival overall. Our current work tests the hypotheses that, 1) decreased winter duration will reduce seed germination and have a greater influence on germination than increased temperature, and 2) decreased winter duration will reduce the germination of species with postponed germination strategies, including the dormant fraction of seeds for species with a staggered germination strategy. Regarding subsequent seedling growth, we hypothesised that warming will improve



Population	Collection date	Elevation (m above sea level)	No. of plants sampled	Seed moisture content (% ± SE, n = 3)	Seed viability (% ± SE, n = 3)
Mt Stilwell-low	29 March 2011	1927	42	64 (±4)	100 (±0)
Merritt's creek	2 March 2011	1944	202	36 (±2)	94 (±3)
Mt Stilwell-high	29 March 2011	2037	50	70 (±1.5)	97 (±3)
Lake Albina	2 March 2011	2046	120 +	34 (±1)	97 (±3)
Mt Kosciuszko-low	2 March 2011	2058	30 +	34 (±1)	88 (±4)
Mt Kosciuszko-high	15 March 2011	2197	89	49 (±5)	94 (±3)

A recent study on the effect of progressively shorter cold duration (constant 5°C, dark; indicated by the black arrow) on germination in *Aciphylla glacialis* (Apiaceae) seed collected from six populations in Kosciuszko National Park (from Hoyle et al., 2014; with permission) demonstrated markedly decreased germination in this morpho-physiologically dormant species.

seedling survival and growth but could alter patterns of temperature-induced mortality and competition among autumn and spring germinants. Our objective is to better understand the consequences of dormancy and germination timing on plant life history in the Alps, now and under future climate scenarios.

Transgenerational effects and phenotypic plasticity of seed germination

Conditions during flowering and seed development are known to affect longevity, dormancy status, and germination plasticity. Thus, as the maternal environment changes, seed characteristics may also change. Plants may respond to environmental changes through phenotypic plasticity (Nicotra et al., 2010). However, we still do not know the potential for alpine species to respond to changes in the environment via rapid evolution or plasticity, or what seed and phenological traits are most responsive to environmental change. Our research examines the prevalence of transgenerational plasticity in alpine plants, to assess how changing climate will affect dormancy, germination strategy, seedling establishment and survival under future climate. The photo on page 10 demonstrates a current experiment assessing transgenerational effects of warming on seed traits. Plants from 19 populations that vary widely in germination strategies are being grown under simulated current and warmed conditions. For this experiment, we hypothesised that soil warming would lead to earlier flowering and higher seed production and reduce physiological dormancy, causing a shift in germination timing for Australian caraway (*Oreomyrrhis eriopoda*, Apiaceae).

Seed longevity and seed bank persistence

Seed bank persistence is crucial for seeds to disperse over time, and spreads the risk of recruitment failure in a variable and changing environment. Increases in air temperature also mean increases in soil temperature, which may affect seed persistence. The persistence of seed in the soil seed bank is an important trait affected by the environment and closely related to the physical and physiological properties of seeds. For an arid system in Australia where the majority of the species are hard-seeded and possess physical dormancy, an increase in soil temperature results in dormancy loss and decreases the soil seed bank. In contrast, for Australian alpine species where seeds frequently exhibit dormancy (Hoyle et al., 2014), soil warming reduces germination from the soil seed bank, but increases the diversity of species that germinate (Hoyle et al., 2013). Thus, warming will potentially change community composition as mediated by direct effects on germination from the soil seed bank. Further research is needed into seed persistence in the soil seed bank particularly for alpine ecosystems.

A controlled ageing protocol, commonly used to estimate lifespan or longevity of seeds in *ex situ* storage, may also enable prediction of *in situ* seed persistence. Australian native species are on average quite long lived, but studies of alpine seed in other regions suggest alpine seed has low longevity. We are currently investigating the longevity of Australian alpine seed in a controlled ageing experiment, to gain an integrated understanding of seed persistence so that we can better estimate how long seed can survive in the soil or in *ex situ* conservation.

Conclusions

Critical gaps in our knowledge of alpine plant seed ecology in Australia and elsewhere are becoming apparent, and have important implications for our ability to predict and manage biodiversity in the face of climate change. A more nuanced understanding of the regeneration stages from seed to seedling in our changing climate is needed. The studies described here will better inform our understanding of the germination niche and requirements of alpine species, and how dormancy and germination will change in a warming climate with altered patterns of seasonality. This knowledge will contribute to improved understanding of alpine seed and seedling ecology with both applied and pure ecological and evolutionary relevance to Australia, and will make a substantive contribution to our global understanding of alpine plants.

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The Centre for Plant Diversity of Piedmont Region (Italy)

DR VALENTINA CARASSO (Seed bank and *ex situ* conservation expert, external collaborator for Ente Gestione Aree Protette Alpi Marittime), IVAN PACE (Conservation technician, external collaborator for Ente Gestione Aree Protette Alpi Marittime), BRUNO GALLINO (Internal Conservation technician of Ente Gestione Aree Protette Alpi Marittime).

Edible plant roof garden at the CBV

The Centre for Plant Diversity (CBV) of Cuneo province, Italy, was established in 2002 with the goal of identifying, conserving, managing and promoting the wild flora and habitats of the south-west Alps.

The area lies in the Mediterranean Basin hotspot, which is a territory universally recognized to be rich in biodiversity. There are more total species recorded here than in any other Alpine zone, of which 26 are exclusive endemics.

The Centre is organized in different *in situ* and *ex situ* conservation structures such as the Servizio Conservazione e Gestione ambientale, the Piedmont Seed Bank, the Native Flora Nursery and the two Alpine Botanical Stations, located at 2000 m asl. Among various facilities, the CBV hosts a significant botanical library, a climatic chamber used for herbarium work, and a workstation for the Regional Botanical Database with a wealth of information and data about the flora and vegetation of this Alpine region.

The Servizio Conservazione e Gestione ambientale (established in 2002) implements *in situ* conservation strategies through species surveys, monitoring and the creation of habitat and flora maps of the south-west Alps.

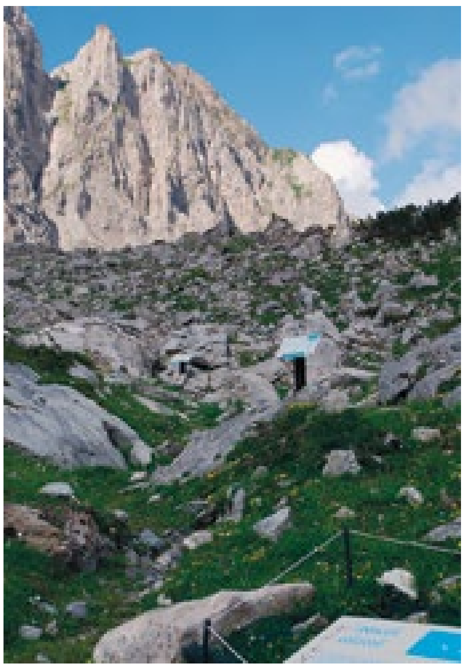
'There are more total species recorded here than in any other Alpine zone, of which 26 are exclusive endemics.'

The Piedmont Seed Bank was established in 2003, within a European Interreg IIIA project developed between Italy and France. It conserves germplasm accessions collected mainly in the surrounding Ligurian and Maritime Alps and also seed collections coming from the Piedmontese network of protected areas. Today the seed bank hosts more than 1,500 accessions representing 90 families, 308 genera and 576 species. The *ex situ* conservation strategies of the seed bank involve not only germination tests and periodic viability analysis of seeds kept in long-term storage, but also species-specific research about rare, endangered and endemic flora of the south-west Alps. These activities are very different and consist of comparative studies about the effects of climate change on seed germination, in-vitro plant conservation and regeneration (wild orchids, ferns, aquatic and carnivorous plants), micropropagation experiments, soil seed bank analysis, and in germinating new plantlets for the edible plant roof garden of the Centre (The Giardino Fitoalimurgico).

The Native Flora Nursery, established in 2007, is composed of the experimental station for restoration and the bank of cultivated rare species. Today it comprises more than 100 species which are intended for use in the Alpine Botanical Stations. The Alpine Botanical Stations were created in 1997 to conserve rare and threatened Alpine habitats and the rarest, endemic and most threatened plants of the south-west Alps. The collection includes more than 500 species, of which 150 are listed as very rare or endemic.

Since 2010, the CBV has been collaborating with the University of Virginia and Amherst College (Massachusetts) on a project investigating the biology of infectious diseases in the plant kingdom: *Disease at the margins of species ranges: anther-smut on Alpine species*.

The CBV's action plan for the following years is to develop new conservation projects and, of course, to continue the important partnership with the MSB, with a recent renewal of the Memorandum of Understanding.



Photos: E. Chiecchio

Alpine botanical station

Getting by with a little help from my friends

ANDRÉ MESSINA (Seedbank Coordinator, Victorian Conservation Seedbank, Australia), MEGAN HIRST (Seed Bank Officer, Victorian Conservation Seedbank, Australia), NEVILLE WALSH (Seed Bank manager, Victorian Conservation Seedbank, Australia)

Photo: M J HIRST 2013

Brachyscome tadgellii in flower *en masse*, Bogong High Plains Victoria

As part of her doctoral studies, Meg Hirst, an employee of the Victorian Conservation Seedbank (VCS), has been studying the genus *Brachyscome*. This intriguing group of Australasian daisies occurs in Papua New Guinea and New Zealand, but is largely confined to mainland Australia. They grow in a myriad of environments, from coastal dunes, arid inland areas and riverbanks, to the exposed, treeless Australian Alps. Within the genus, there are species with large geographical distributions that occur across many of these habitats, such as *Brachyscome ciliaris*. Conversely there are species associated with specialised habitats, such as the alpine Victorian endemic *Brachyscome tadgellii*, which is only found in a rare alpine wetland community, above the tree-line of Bogong High Plains within the Alpine National Park.

Using both molecular and morphological traits, Meg's study initially involved constructing a species phylogeny. Both chloroplast and nuclear markers were used to seek a greater understanding of the relationships within the genus and how given lineages may relate to previous taxonomic work (e.g. Short 2014). This initial step required broad taxon sampling, given the overall wide distribution of this genus. With regards to physiological traits, plant performance and survival were explored in a group of alpine Brachyscomes – of which some were locally endemic – in an attempt to determine whether habitat specialisation impeded the performance of alpine endemics outside of their current range. Widespread and narrowly-distributed species were compared and assessed for their performance through field-based reciprocal seed and seedling transplant experiments in the Bogong High Plains, Victoria. Growth responses under different heat regimes were also tested for 19 species not necessarily confined to Victoria. These experiments were conducted in the outdoor research plots located at the Royal Botanic Gardens Victoria (RBGV) Australian Garden at Cranbourne, about 40 km south-east of Melbourne. To obtain seed of non-Victorian species, help was sought from our Australian seed bank friends — Botanic Gardens and Parks Authority and Threatened Flora Seed Centre (Western Australia), SeedSafe (Tasmania), Queensland Seeds for Life, South Australian Seed Conservation Seedbank, Australian PlantBank (New South Wales), George Brown Darwin Botanic Gardens (Northern Territory), and the ANBG National Seed Bank (Australian Capital Territory).

Firstly, early findings suggest *Brachyscome* is not a monophyletic group – supporting some recent moves to split the group into several smaller genera – and although ecologically related, the alpine species have been derived from a range of ancestral taxa. Some of their closest relatives now occur in very different environments and geographic regions. Adaptation studies found that some of the alpine *Brachyscome* species can grow well outside of their current range, with limited evidence of local adaptation in *B. decipiens* (Hirst et al, 2016), raising interesting questions about why they should be so restricted. Could their competitive edge appear to melt away, like the winter snows, outside the alpine environment? When grown together in a heated soil experiment, species showed an array of responses. Surprisingly, it appears that a wider environmental niche occupied by a species does not necessarily relate to a wider tolerance of soil temperatures. The implications for the survival of alpine species under a warming climate are yet unclear – there is still a wealth of data to sort through. Some answers, more questions, all made possible by the carefully maintained seed banks across Australia.

Photo: E. AJAY, 2013

The Australian Garden, The Royal Botanic Gardens Cranbourne

> *'...early findings suggest Brachyscome is not a monophyletic group – supporting some recent moves to split the group into several smaller genera – and although ecologically related, the alpine species have been derived from a range of ancestral taxa.'*

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Seed Banking from a high elevation Andean ecosystem: The case of Chile

PEDRO LEÓN LOBOS (Head and Technical Manager of Base Seed Bank, INIA), SERGIO IBÁÑEZ (Crop Wild Relative Collector, INIA), ANA SANDOVAL (Seed Researcher, INIA), MICHAEL WAY (Conservation Partnership Co-ordinator, RBG Kew), NAOMI CARVEY (Data Warehouse Officer, RBG Kew)

Background: the Andes

The Andes range is the world´s longest uninterrupted high-elevation mountain corridor. It extends from 12°N in Venezuela to 56°S at Cape Horn, in the extreme south of Chile. From north to south, the paramos, puna, and southern Andean steppe form the three main high-elevation ecosystems found in the Andes mountain range. Together they cover more than 913,600 km2, approximately 5.1 per cent of the land area of South America (Arroyo et al., 2010).

The Andes range includes a high diversity of vegetation types along the north-south extension and altitudinal gradient, owing mainly to the range's great variety of climates and the high topological diversity (Arroyo et al., 2013). It is expressed in a high diversity of plants, with more than 6,700 vascular plants from 870 genera within the high-elevation ecosystems. Although there are no endemic plant families, at least 64 genera in 22 families are restricted to Andean mountains and around 25–30 per cent of all high-elevation species turn out to be endemic (Arroyo et al., 2013).

High-elevation Andean ecosystems provide critical ecosystem services such as the regulation of water flow and slope stability and – on account of their steep altitudinal gradients and opposite-facing slopes – offer readily accessible thermal refuges for species affected by climate change. The high-elevation habitat, in addition to being of great scientific interest, is important for conservation, as well as for the welfare of humanity (Arroyo et al., 2013).

The Chilean Andes

In Chile, the Andes span the entire length of the country from 17°S at the Peruvian border to the straits of Magellan at 56°S. In the north of Chile, the dry and desert puna extends to 24°S. The southern Andean steppe occurs south of the puna, to the extreme end of the continent. The lower altitudinal limit is found at approximately 3,200 m at 28°S and at 500–600 m in the extreme south of Chile (Arroyo et al., 2013).

The high-elevation flora has played a key role in the livelihoods of indigenous people, such as the Aymara and Quechua communities that live in the region. Villagrán and Castro (2006) reported that there are 856 recorded uses for 500 plant species in 26 indigenous communities in the northern Altiplano region of Chile.

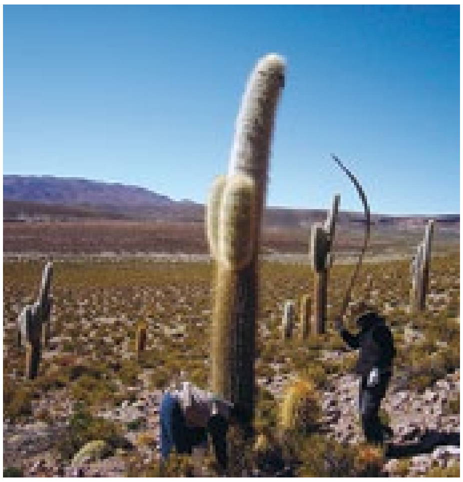

Photo: Marcelo Rosas

Marcos Acosta (INIA) and Pablo Guerrero collecting seeds from *Echinopsis atacamensis*.

Photo: Alberto Zúñiga

Pozoa volcanica Mathias & Constance (Apiaceae) growing at 1800 m on the foothill of Lonquimay vulcano, Malalcahuello National Reserve, Chile.

> *'High-elevation Andean ecosystems provide critical ecosystem services such as the regulation of water flow and slope stability and, …offer readily accessible thermal refuges for species affected by climate change.'*

The vegetation of Chile's alpine belt (including the area of permanent snow), found above the treeline, is predicted to experience climate warming of at least 2°C, and is projected to lose around 18 per cent of its surface area as a result of an upward movement of vegetation zones (Pliscoff et al., 2012). There is an urgent need to undertake *ex situ* conservation to support *in situ* measures.

Ex situ conservation effort of Andean species in Chile

Since joining the MSB Partnership in 2001, the team from the Agricultural Research Institute (INIA)'s Base Seed Bank has made more than 200 seed collections from high-elevation sites, of which around 40 per cent are from the Altiplano of northern Chile. Compositae, Solanaceae, and cacti including *Browningia candelaris* and *Echinopsis atacamensis* have been significant target species.

Over half of the Andean collections are from mid and southern Chile. In particular the Calceolariaceae, Asteraceae and Cyperaceae are well-represented in the collections from mid and southern Chile. The rest of the collections (less than 5 per cent) come from those made in the Andes Cordillera, far southern Chile. Most of those, like *Pozoa volcanica* (Apiaceae) were collected around the Osorno district.

INIA Base Seed Bank will continue to collect and bank seeds from the high-elevation flora of the Andes, to safeguard populations against extinction.

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Chilean flora above the tree line banked

Analysis for infographic conducted by Naomi Carvey using MSBP Data Warehouse data downloadable at http://brahmsonline.kew.org/msbp

221

Collections made above the tree line

Families: 42
Genera: 101
Species: 200

189

Collections permitted for use in research

For this analysis Chile was split in to latitudinal zones – 17th to 29th parallel (Northern Chile), 29th to 35th parallel combined with 35th to 40th parallel (Central Chile) and 40th to 50th parallel (Southern Chile). For each of the latitudinal zones a tree line was estimated from a variety of resources at above 3200m, 2400m, 1800m and 1200m respectively.

Northern Chile

97 collections comprising **22** families and **48** genera. Most frequent families are **Compositae (34)**, **Cactaceae (11)** and **Solanaceae (9)**.

Central Chile

119 collections comprising **36** families and **66** genera. Most frequent families are **Compositae (18)**, **Calceolariaceae (14)** and **Leguminosae: Papilionoideae (12)**.

Southern Chile

5 collections of different species from Osorno only.

Projects of the European Alpine Seed Conservation and Research Network

Evolutionary response of annual alpine species to global changes – a study of rock clover populations (*Trifolium saxatile* All.) in the French Alps

NOÉMIE FORT (Chef de Service Conservation, Conservatoire Botanique National Alpin, France)

Photo: Noémie Fort

Trifolium saxatile.

The ability of plants to regenerate (move sequentially through the different stages of life to the development of a new generation) depends to a large extent on the environment they encounter (Grubb, 1977). Contemporary environmental changes such as global warming constrain regeneration (Walck et al., 2011).

In 2013, the Conservatoire National Alpine Botanic (CBNA) initiated a study of the spatial and temporal evolution of regeneration of plants of high conservation value in the Alps, in relation to environmental changes and particularly climate change. The study measures, over several generations, characteristics such as germination, growth and reproduction of individuals in 'ancestral' populations stored in the CBNA seed bank, and in 'descendent' populations also available in the seed bank or collected from the field during the study (Franks, Sim et al., 2007, Matesanz, Gianoli et al., 2010, Bustos-Segura, Fornoni et al., 2014).

Targeted species for this study include annuals, biennials and fast-flowering species. The first stage of this study has two approaches:

1. multi-species approach for assessing common temporal phenotypic differentiation patterns
2. multi-scale approach to assess patterns of phenotypic differentiation and spatial and temporal genetic order, to understand the evolutionary changes potentially related to global change.

We are developing these approaches by investigating the development life cycle (annuality/biannuality) and interactions with soil mycorrhiza of an annual alpine species, rock clover, *Trifolium saxatile* All. This work is supported by the European Alpine Seed Conservation and Research Network project.

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Modelling species distributions to assess future threats to the alpine flora

PATRICK SCHWAGER (PhD Student, University of Graz)

Photo: Patrick Schwager

Alpine sainfoin *Hedysarum hedysaroides*.

The vascular plant flora of the Alps was never so endangered and never so insufficiently protected as today. Beside anthropogenic interferences, global warming is one of the main threats to the alpine flora. In order to protect species, it is important to understand the connections between species and their abiotic and biotic environment. Species distribution models, also called ecological niche models or habitat suitability models, utilise relationships between environmental variables and species observations, to find environmental conditions where these populations could potentially occur. Field work will be undertaken at different localities within the Styrian Alps to describe the habitat characteristics for several species of high conservation value, especially Eastern Alps endemics. Environmental data together with remotely sensed data (digital elevation model, land cover) will build the basis for the models. Calibrated for current conditions, the model can be used to predict the impact of environmental and climate change on species distributions (Franklin, 2010). The aim of the research is to get a deeper insight and understanding of the future threats of the endemic alpine flora.

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Comparative seed germination and longevity studies of alpine plants in the context of climate change.

FRANCESCO PORRO (PhD student) AND ANDREA MONDONI (Researcher RTD) UNIVERSITY OF PAVIA, ITALY

Photo: Val Grauson

Saxifraga moschata.

Alpine ecosystems are considered highly threatened as a result of global warming. Increasing temperatures and earlier snowmelt have caused upward migration and phenological changes in many plant species. Despite many studies into the impacts of climate change on alpine plants, there have been few that investigate the effects on seeds and seedlings, and those that have obtain contrasting results. Greater understanding of the impacts of climate change on plant regeneration from seeds is urgently needed, to predict future species changes in alpine plant communities.

This PhD project investigates impacts of abiotic factors related to climate change on the early stages of plant development, and their relationship with the ongoing changes of alpine plants' persistence and abundance in alpine environments. It will examine long-term temperature and vegetation data, collected at mountain peaks across the entire European alpine region by the GLORIA project (www.gloria.ac.at). It will also investigate the germination ecology of the widespread and under-investigated genus *Saxifraga*.

We hypothesise that ongoing changing of species richness/distribution at high altitude is due to variations in suitable environmental conditions for seed germination and survival, and/or species' ability to persist in the soil seed bank. The results will help explain current changes in plant distribution due to climate warming, as well as predicting future scenarios, we will highlight species and mountain regions under the greatest threat. For each study site and species, patterns of seed germination, dormancy and longevity will be identified, enabling modelling of sensitiveness to changes in temperature and water stress. The results will contribute to habitat conservation in alpine areas of central and southern Europe.

Germination, establishment and phylogenetic plasticity of alpine species

VERA MARGREITER (PhD student, Institute of Botany, University of Innsbruck, Austria)

Photo: Brigitta Erschbamer

Vera Margreiter collecting seeds.

Under climate warming and decreasing precipitation, species able to adapt to increasing temperatures and drought will have a major advantage compared to species which lack phenotypic plasticity, and/or which are adapted to specific environmental conditions. Species from high altitudes may be highly vulnerable, as they are specialists for extreme habitats. Maternal effects, local adaptation and/or phylogenetic effects may interfere with adaptation to new conditions.

From the GLORIA project (www.gloria.ac.at) we know that species occurring at lower altitudes have started to migrate to the alpine zone, certain alpine species are stable, whereas others decline and will probably disappear due to competition and/or drought. Other species occupy a broad ecological niche. We hypothesise that most high altitude species are highly adapted to cold environmental conditions at their home site, whereas ubiquitous species are plastic. We will test this hypothesis with experiments in the field along an elevation gradient, in the growth chamber and in the common garden.

The PhD at Innsbruck, as part of the Harding Alpine Plant Conservation and Research Network, deals with three major topics:

1. Germination and survival of species at home sites vs. new sites – testing the effects of facilitation, below ground competition, species group, and reproductive mode.
2. Effects of provenances and phylogenetic aspects of the genus *Saxifraga*.
3. Effects of temperature and drought on seed germination of alpine nival species.

NEWS

Bio-Protection New Zealand visit to Kew

AUTHOR: RUTH E. BONE (International Projects Officer (Pacific), RBG Kew)

Ruth Bone (Pacific projects officer) and visiting researcher Jessica Schnell (New Zealand Indigenous Flora Seed Bank coordinator) welcomed Melanie Mark-Shadbolt (Māori Research and Development Manager) and Nick Waipara (Māori Champion) from the Bio-Protection Research Centre in New Zealand. Melanie and Nick attended the Royal Geographical Society Annual Conference in London, presenting their paper on adaptive management of New Zealand Kauri (*Agathis australis*) – developing conventional forest biosecurity with indigenous knowledge and cultural practice.

Melanie and Nick are senior leaders in New Zealand's Biological Heritage - a National Science Challenge that aims to protect and manage indigenous biodiversity, and reduce biosecurity risks.

Following an initial meeting with China Williams (Science Policy Team), Simon Honey (Assistant Plant Health and Quarantine Officer) provided a tour of Kew's Quarantine unit – which also serves as a bonded warehouse for plant seizures made under CITES, Plant health and drug legislation. Tim Utteridge (Head of Identification and Naming) showed us the historic wing C of the Herbarium, including material collected by Cheeseman (author of the *Manual of New Zealand Flora*).

We hope this initial meeting may lead to future collaboration and are grateful to Nick and Melanie for visiting.

Collecting for the Species Conservation Project

MAYA MCCRACKEN AND IAN WILLEY (Seed Conservation Assistants, RBG Kew)

The Centre for Plant Diversity (CBV) in the Maritime Alps National Park, on the extreme southern edge of the Alps, has numerous endemic species of flora and fauna. The alpine zones of the park are vulnerable to climate change and the effects are already visible, making it important to collect, document and conserve this area's native species.

'The alpine zones of the park are vulnerable to climate change and the effects are already visible, making it important to collect, document and conserve this area's native species.'

We collected *Calamintha grandiflora* (used in the Rifugio Pietro Garelli for mojitos!) in the Parco natural del Marguareis at around 1,200 metres above sea level (m.a.s.l.). In the same area, we recorded *Euphorbia dulcis* for collection next year, as its seed was post-dispersal, and dodged a Cleopatra's asp while collecting *Asphodelus albus*. In the Valle Stura we collected *Rhaponticum scariosum* subsp. *scariosum* (Pignatti, 1982), a rare edible plant with only a few extant populations and a wild relative of the artichoke. The Valle Stura is also an important site for *Eryngium alpinus*, the Queen of the Alps, which is currently threatened due to a history of collecting for use in extravagant dried flower displays.

We also collected *Vicia onobrychoides* and *Phyteuma scorzonerifolium* in the Tanaro valley, and climbed to 2,500 m.a.s.l. along the Tende pass into the Ligurian Alps, to collect *Cirsium morisianum* in an isolated area where it would be free of hybridization. *Juniperus communis*, a relict species from a warmer climatic period will also be targeted to collect next year. Overall, 20 collections were made in collaboration with the CBV with a plan for next year to target those not yet accessioned.

Ian Willey, Bruno Gallino (Parco Naturale del Margeureis) and Maya McCracken collecting Cirsium sp along an old salt road. Credit: Ivan Pace, Parco Naturale del Margeureis.

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Seed collecting from Kew's *ex situ* alpine collections

THOMAS FREETH (Rock Garden, Alpine and Aquatics Supervisor, RBG Kew)

Autumn is a busy time for us in the Rock and Alpine Unit at Kew. At the moment the repotting of our spring-flowering bulbs is underway, and there are plenty of autumn-flowering collections currently on display, including *Narcissus*, *Crocus* and *Cyclamen* in the Davies Alpine House, and *Nerine* in the Rock Garden.

While the display of skilfully-grown alpines has long been the practice of horticulturists, our unit also has an important role in supporting the MSB with our living collections. More than 7,000 accessions are held across Kew's Alpine Nursery and the Rock Garden, more than 60 per cent of which are of natural provenance. Our seed collection project team supports the MSB by making quality seed collections for banking. In recent years, 300 successful seed collections have been taken from Kew's alpine collections, 266 (88%) of those from natural source material with detailed provenance. Of these, 57 taxa (20%) are threatened species, according to the IUCN Red List.

Our partnership with the MSB also helps us to identify high-risk taxa within our living collections and verify that our species determinations are correct. High-risk taxa are classed as those assigned a Red List category of Endangered or higher, plus those

The Davies Alpine House at RBG Kew.

that are very uncommon in cultivation, or difficult to impossible to re-collect or study in the wild. This includes species collected from wild populations encountered only once, or from countries such as Syria where conflicts currently prevent travel. We are then able to put the appropriate safeguards in place for these taxa – for example by multiplying stock and sharing it with other institutions and partner countries, banking seed, planting in different locations at Kew and ensuring records are accurate.

I would like to acknowledge Noelia Alvarez and Kit Strange for their valuable contribution to this article.

Narcissus papyraceus polyanthos

Photos: Richard Wilfred

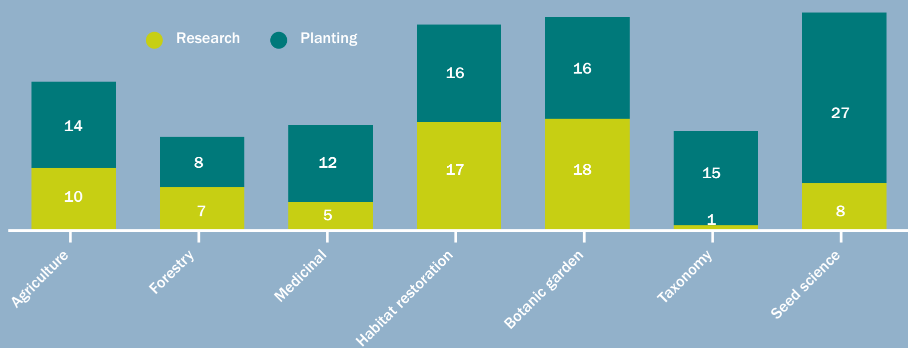
The MSB Partnership 2016 Questionnaire

EVA MARTENS (MSB Partnership Administrator, RBG Kew)

The MSBP questionnaire is sent out annually to our partners. This year the questionnaire covered five topics:

1. Seed collections data
2. The MSBP Seed Conservation Standards
3. The MSBP Data Warehouse
4. Capacity building and technology transfer
5. Research

84 individuals responded, representing 70 organisations (60% of the total contacted) in 44 countries (71% of the total). The main panel in the accompanying figure below shows the purpose for which different MSB Partnership institutions distributed wild seed samples (numbers represent the number of responses).



New MSB agreements

Country	Counterpart Name	Start Date	Duration (Years)
Spain	Atlantic Botanical Garden	August	5
Madagascar	Silo National des Graines Forestières	July	5
Puerto Rico	Universidad de Puerto Rico	July	4
Slovakia	Institute of Botany	December	5
Thailand	Thailand Institute of Scientific and Technological Research (TISTR) *	August	2
Lebanon	Lebanese Agricultural Research Institute (LARI)	May	2
United Kingdom	Royal Botanic Gardens Edinburgh	April	3
Spain	Spanish Institute for Agricultural and Food Research and Technology (INIA)*	March	2

* denotes new partner for the MSBP

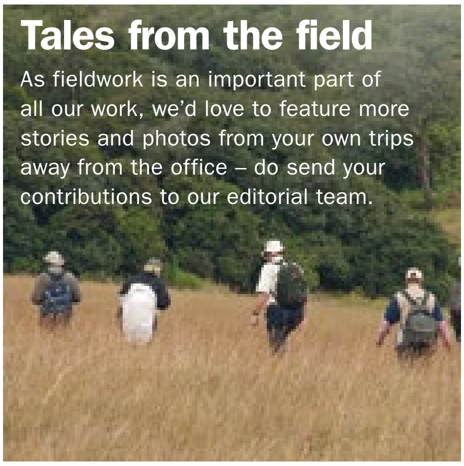
MSB Dashboard	
Total Collections	80,428
Total Species	37,399
Total countries (including overseas territories)	187

Next issue

In the next issue we'll be reporting on the work carried out across the MSBP in relation to plant assessments and red lists. We're keen to hear from anyone involved in plant assessments or red lists at a local or international level, who'd like to share their experience with the wider MSBP community.

Tales from the field

As fieldwork is an important part of all our work, we'd love to feature more stories and photos from your own trips away from the office – do send your contributions to our editorial team.



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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.

Samara Editors
Eva Martens, Aisyah Faruk and Laura Jennings
Royal Botanic Gardens, Kew
Millennium Seed Bank, Wakehurst Place, Ardingly, Haywards Heath, West Sussex RH17 6TN, United Kingdom
Tel +44 1444 894177
Email samara@kew.org

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 www.kew.org/samara