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Jean Zollinger (1925-2007), La Rambertia, Switzerland
Alpine and Arctic Botanical Gardens are an extraordinary set of gardens, with their own history, outstanding collections, and specific challenges. To share knowledge and experiences within their field, the first Congress of Alpine and Arctic Botanical Gardens ("AABG I") was held in Lautaret in 2006. In 2009, Munich proudly hosted the second congress ("AABG II").

A participant of the previous meeting was Jean Zollinger, the curator of La Rambertia, Switzerland, who died in 2008. With him, the community lost an open-minded friend and committed colleague, and it is an honour to dedicate this congress to him.

In total, more than 30 participants joined AABG II, representing 19 Botanic Gardens from nine European nations. As agreed during the first meeting, AABG II was scheduled before the start of the main gardening season to also enable staff of smaller gardens to join the congress.

The meeting was opened with a ‘who’s who’ of the participants, each giving a brief presentation of his or her garden, with a focus on those who were not presented in major talks during the sessions. From North to South, the participating gardens were:

Norway: Tromsø, Kongsvoll
Germany: Brockengarten, Schachen
Austria: Vorderkaiserfelden, Kitzbüheler Horn, Patscherkofel
Switzerland: Schynige Platte, La Rambertia, Schatzalp
France: Lautaret, Haut Chitelet
Italy: Viotte, Monte Baldo, Saussurea
Slovenia: Juliana
Georgia: Bakuriani

As associated guests, Jardin Botanique Paris and Royal Botanic Gardens Kew also sent representatives to the Congress.

The AABG II programme consisted of five sessions chaired by Serge Aubert, Costa Bonomi, Arve Elvebakk, and Andreas Gröger. Special enrichments to the programme were slide shows on the flora and natural habitats of various alpine and arctic environments. These presentations covered the following regions: Lesotho (J. Wainwright-Klein), the Caucasus (A. Gröger), Patagonia (R. Douzet), New Zealand (A. Humburg), and Svalbard (A. Elvebakk). There also were guided tours to the alpine collections of Munich Botanic Garden and an excursion to the nature reserve ‘Garchinger Heide.’

The Munich staff thanks our colleagues and friends from other gardens for their continuing support, which made the event possible. Special thanks are due to Serge Aubert. It is our hope and conviction that AABG II will have contributed to the long-term interactions between European Alpine and Arctic Botanic Gardens.

Susanne Renner
Andreas Gröger
Jenny Wainwright-Klein
(Botanischer Garten München-Nymphenburg)
Experiences with the introduction of southern hemisphere alpines: Drakensberg and Maloti Mountains of Lesotho

Jenny WAINWRIGHT-KLEIN
Alpengarten auf dem Schachen / Botanischer Garten München, Germany

In 2001, the centenary year of the Alpine Garden on the Schachen, it was decided to expand the existing collection to include alpine plants of the southern hemisphere. In the following years two new geographical beds were laid out, landscaped and planted. Some of the plants were bought in but the majority have been grown from seed obtained through the international Botanic Garden seed exchange network and specialist plant societies, such as the New Zealand Alpine Club. The southern African plants originate from a joint plant collecting excursion with the Alpine Botanic Garden at Katse, Lesotho.

Up until recently the main focus of the collections in the Alpine Garden on the Schachen was on the plants from the European Alps and the Himalayas with smaller collections from the Caucasus, Carpathians and Pyrenees, and some representatives of the flora of the Rocky Mountains and the Arctic. For years, Helichrysum milfordiae was the sole representative of the Southern Hemisphere montane vegetation and helped to propagate the myth that “southerners will not grow on the Schachen” by struggling along year after year, never flourishing but not managing to die either. Then, in 1998, young plants of Senecio macrospermus, a large forb which colonizes steep, damp mountain slopes in the Drakensberg and Maloti Mountains, were planted in the alpine garden and they flourished! This unexpected success, together with experience gained from the cultivation of plants grown from seed collected during an early excursion in the Lesotho mountains in January 2002, convinced me that there were a lot of plants in the high mountains of Lesotho which would do well on the Schachen. The critical factor for success lay in collecting from habitats with a similar microclimate to the Schachen, i.e. the high mountain passes along the eastern Lesotho border, preferably above 2500 m, with snow cover in winter and high summer rainfall.

As part of the co-operation project with Katse Botanical Garden, two field trips to collect seed and herbarium specimens have been undertaken in the Drakensberg and Maloti Mountains with a third trip planned for January 2010.
Notes on cultivation
Propagation for the Schachen is carried out in the Munich Botanic Garden. Seed is sown at the beginning of February in a heated glasshouse with a minimum temperature of 18°C. Under these conditions the majority of seeds germinate within three weeks and can be pricked out within the next couple of weeks. The faster growing young plants, such as *Athrixia, Heliychrysum, Dianthus* or *Felicia*, are planted in the Alpine Garden in June/July of the same year while plants such as *Kniphofia* which need a year to bulk up nicely are planted out the following year.

A basic soil mix with a neutral pH is used for sowing the seed. For pricking out and for potting up young plants a neutral to slightly acidic soil mix, rich in nutrients, is used. Peat is avoided where possible and a soil mix with a ratio of 1:1 of fertile soil to fine weathered granite grit works well.

Preparing the new southern hemisphere beds
On account of the Alpine Gardens position, in the middle of a nature protection area, and the small size, approximately ½ hectare, only the locally occurring limestone rocks are used for landscaping within the garden. The base of the plant bed consists of a layer of broken rocks to assist drainage.

The prepared area was filled with a mix of free-draining soil with fine weathered granite, pumice chips and a small amount of well-rotted manure. The soil of the high mountains of Lesotho is not very deep, on average only 40 cm, but it is very fertile.

Some crevices were incorporated in the rock work but due to the limestones ‘break pattern’ it is difficult to obtain enough suitable rocks for a continuous design of crevices.

The length of the bed lies roughly along an east west axis and is open to the predominating west winds which keep the snow level low in this area of the garden. The soil is not as wet for as long a period during snow melt, although the plants are exposed to frost burn if the snow cover thaws early in the spring. A second bed for southern hemisphere plants lies on the north side of the first bed and is mainly for the taller forbs.

The Lesotho plants flower very late in the season due to the long snow cover and cool early summer months. This has the benefit of an extended flowering season into October with the disadvantage that seed seldom ripens before winter.
Successes and failures

Plants which have done well: *Alepidea natalensis*, *Athrixia fontana*, *Cotula socialis*, *Dianthus basuticus*, *Dierama pauciflorum*, *Felicia rosulata*, *Helichrysum albobrunneum*, *Helichrysum witergense*, *Hirpicium armerioides*, *Kniphofia caulescens*, *Kniphofia hirsuta*, *Kniphofia triangularis*, *Osteospermum barbarea Senecio macrocephalus*, *Senecio macrospermus*

Planted this summer (2009) and still being trialed: *Agapanthus campanulatus*, *Berkheya purpurea*, *Cyranthus breviflorus*, *Eumorphia sericea*, *Euryops acreus*, *Euryops decumbens*, *Gazania krebsiana*, *Geranium multisectum*, *Helichrysum praecurrens*, *Hesperantha coccinea*

It was too wet for *Dierama robustum* but there are other *Dieramas* from the moister slopes which should be easy to establish. Only two geophytes have been tried on the Schachen, *Galtonia viridiflora* and *Cyranthus breviflorus*, neither have flowered, perhaps because of the short mainly cool summers. Surprisingly, it has been difficult to establish *Rhodohypoxis* on the Schachen but with some plants one has to persevere and try different angles of slope or perhaps crevices.
The Andes have a rich and colourful flora which is very different from the northern hemisphere flora. However, the absence of botanical gardens at high altitude in South America limits the possibilities of exchanges and culture of theses plants in Europe. In this context the number of Andean species presented in alpine botanical gardens is very limited. Since 2003, botanical expeditions are organised in order to collect non-protected species and display a collection of Andean plants at the Jardin botanique alpin du Lautaret. Since the previous AABG congress at Lautaret (Douzet & al. 2007), new techniques have been developed to cultivate the plants.

Experiences in the cultivation of Southern Andean plants
Plants grown from seeds are cultivated near Grenoble (at Saint-Marcelin, using the facilities of the horticulturist Joseph Sarreil-Baron). As for most of the other alpine plants, the culture at low elevation (500 m) permits a much faster growth. Among various combinations of soil, the following one gave the best results with plants grown from seeds: 60% brown peat; 20% black peat; 20 % perlite.

The use of big pots for sowing seeds (fig. 1) permits to avoid a repotting step: young plants are transported to Lautaret during the first or second summer which follows sowing in spring. Plants are first kept in the nursery which is equipped with a net reducing the high light stress prior to installation in the rockeries (usually the year after).

We use longer pots (fig. 2) for the plants grown from cuttings and for the plants with very long root systems (a frequent phenomenon for plants growing in Andean volcanic screees or in sandy soils of Patagonian steppes).
Extension of the rockery “Andes and Patagonia”

This rockery has been initiated in 2004. Landscaping is designed to correspond ecologically and aesthetically to the volcanic Andes: red volcanic stones and sand have been installed with a depth of around 20 cm. Figs. 3 and 4 show the rockery when finished in 2008 (see Douzet & al. 2007 for the main steps of landscaping and the website http://sajf.ujf-grenoble.fr/).

The following species have been successfully acclimated at Lautaret: Acaena magellanica, Acaena sericea, Acaena sp., Azorella filamentosa, Azorella fuegiana, Berberis buxifolia, Berberis empetrifolia, Blechnum penna-marina, Bolax gummifera, Brachyclados caespitosus, Bromus setifolius, Calceolaria acutifolia, Calceolaria corymbosa ssp. corymbosa, Calceolaria darwinitii, Caltha sagittata, Chiliorchium diffusum, Colobanthus quitensis, Deschampsia antarctica, Ephedra chilensis, Eriogon sp., Festuca gracillima, Hordeum comosum, Hordeum sp., Hypochaeris incana, Hypochaeris tenuifolia, Laretia acaulis, Loasa nana, Maihuenia patagonica, Maihuenia poeppigii, Maihueniopsis darwini, Mimulus cupreus, Mimulus
Fig. 3. The rockery “Andes and Patagonia” in 2008 (on the right) and the rockery “mountains of Northern America” (on the left, with grey granite and white limestone). They are separated by the “natural garden”, i.e. the natural subalpine meadow. In the distance, the chalet-laboratory and the Grand Galibier range (3200 m).

Fig. 4. The rockery “Andes and Patagonia” in 2007 (upper part), with La Meije (3987 m) in the distance.
depressus, Mulinum microphyllum, Mulinum spinosum, Nardophyllum bryoides, Nassauvia aculeate, Nassauvia glomerulosa, Nassauvia lagascae, Olsynium biflorum, Olsynium junceum, Oreopolus glacialis, Oxalis adenophylla, Oxalis enneaphylla, Oxalis laciniata, Perezia recurvata, Philippiella patagonica, Primula magellanica, Rubus geoides, Samolus spathulatus, Saxifraga magellanica, Senecio patagonicus, Senecio sp., Silene chubutensis, Stachys tridentata, Taraxacum gillliesi, Valeriana cariosa.

References:

Fig. 5. Some species recently acclimated at Lautaret: 1. Nassauvia aculeata (Asteraceae), 2. Valeriana cariosa (Valerianaceae), 3. Mulinum microphyllum (Apiaceae), 4. Loasa nana (Loasaceae).
The Betty Ford Alpine Gardens is regarded as North America’s highest public garden. At an elevation of about 2500 m more than 2100 varieties of plants are shown in an area with a size of 0.8 ha. The alpine garden operates as a non-profit organisation. Funding is mainly based on private contributions, gifts, grants and special fundraising events, like the Betty Ford Spirit Gala. Smaller amounts are obtained by government contributions, annual memberships and programme services.

Half of the expenses are utilised for the garden itself and its programmes. About 30 % of the budget is for administrative purposes. In total, the garden employs five full-time staff: an executive director, a director of horticulture and research, a garden supervisor, an office and event coordinator and a gift shop manager. Each activity and each resulting expense is evaluated by means of a management plan. This plan describes the general mission of the garden which wants to be achieved by every single garden operation. The mission can be divided in the following themes: beautification, education, conservation, research and growing green.

Beautification comprehends the value and benefit of a public garden in the township of Vail, a popular tourist resort. New plantings, maintenance or designing and reconstructing of garden areas are implemented to fulfil the goal of beautification.

Education plays an important role. Educating adults as well as young people is accomplished by docent-led tours, children’s programmes, horticultural therapy, internships, lectures to

As the highest public botanic garden of North America situated in the heart of the Rocky Mountains, the Betty Ford Alpine Gardens do not only provide the perfect location for growing alpine plants. They also pursue a mission in conservation, education and research. Being a non-profit organisation which relies predominantly on private donations these goals are not always easy to fulfil but the success of the garden in recent years proved that high standards can be reached with an appropriate management.

Betty Ford Alpine Gardens: the many faces of North America’s highest botanical garden

Anne HUMBURG
Seligenstadt, Germany
community groups and many other activities.

Due to the extraordinary location of the alpine garden conservation aspects play another important role. Actions to sustain the environment, principally the surrounding alpine environment, are usually performed in cooperation with other local or national nature and conservation organisations. Sustainability in the gardens is applied by use of organic fertiliser, natural pest control, compost and river water. Ex-situ conservation of some rare North American alpine plants has been undertaken by the garden. To make these plants available for viewing by the general public, awareness should be increased.

So far, there is only little focus on research by reason of the sparse capacities. Activities like an online database (BG Base is used) which lists, describes and records the progress and specific location of every single plant in the gardens, regional, national and international seed collecting expeditions, seed exchange and smaller research projects joined with other institutions are carried out.

The subject “Growing Green” refers to the original idea of the gardens. In 1987 the gardens was built as a display garden for the residents to show them what can be grown in a high altitude environment. To this day, this objective is still present but others have been added. They pursue a more ecological and environment-friendly point of view. For example, the xeriscape garden demonstrates how to garden with limited water resources and thereby promotes ecological landscape standards. The target group also altered and encompasses not only the community but visitors from all over the world.

Right from the start, the gardens was always dependent on donations and volunteering workers. Especially, the generous donations of time by volunteers who support the garden staff with several jobs concerning running a public garden result in the success of the Betty Ford Alpine Gardens. The success is not only shown in a positive annual finance balance, the “growing green culture” continues to mature, the gardens’ value to the community continues to increase, its reputation as world-class, high-altitude botanical garden and research centre continues to evolve.

To maintain and advance the standard achieved over many years, public relations are a key issue within the management plan. “Investing in our children, engaging our community, sustaining our environment” is the central idea through which the gardens tries to draw attention to its presence.

Besides the mission and the outreach, another ambition is to offer most of the programmes free of charge and to rely on the donations as admission fee.

Being a relatively young alpine garden, the Betty Ford Alpine Gardens is looking back on a successful past but more important is looking optimistically on a promising future.
Fig. 3. “Journey around the World” - a children programme at the Betty Ford Alpine Gardens

Fig. 4. *Penstemon debilis* at its natural site is one of the most rare North American plant species

Fig. 5. The European Alps Garden is home of alpine plants from the western to the eastern Alps
On a beautiful day the view of the mountains is absolutely overwhelming. It is not difficult to understand, that in 1925 the idea of an alpine garden on Schynige Platte came up.

Foundation of the Alpine Garden
1925 at a meeting of the Swiss Botanical Association in Interlaken the idea of an alpine botanical garden on Schynige Platte was brought up.
1927 The founders of the “Association Alpengarten Schynige Platte” represented science, tourism and nature conservation.
1930 The garden was opened to the public.

Ecological concept of the Alpine Garden
The goal of the garden is to show all plants existing in Switzerland above timberline.

All plants are presented whenever possible in their natural plant-community or very close to these conditions, together with the same plants as in nature. When the natural community is lacking on Schynige Platte, artificial communities are constructed. Only the medical plants make an exception.

The effect of cultivation is kept as low as possible, so that our plants could be used as a gene-reservoir if necessary.

Experimental field of Dr. Werner Lüdi (1930)
1930 W. Lüdi started his experimental field on Schynige Platte, 300 m SE of the garden and some experiments in the garden itself. This was the second fertilizing experiment of the world in natural vegetation, the oldest at timberline.
His intention was to make the Nardetum, a very poor pasture on acid soil, more productive and with better fodder. He treated 340 squares of 1m² in many different ways, especially with different fertilizers. O. Hegg got the results and the data of this experiment in 1975. Later on, he changed the goals of the research. He laid the main interest in species diversity and long lasting influences of fertilization (Hegg 1984, 1992). There are various young scientists gathering new results from this experiment now. One important result for species conservation: Any fertilization is bad for species of nutrient-poor vegetation, and its effect lasts for a very long time. In 2006 we can still see differences in species composition and in ecological measurements for an impact made in 1936, after 70 years (Spiegelberger et al. 2006)!

**Both, the alpine garden and the experimental field, are of a very high ecological value today, even more in future. Both show the long-term effects of human influence on alpine vegetation.**

**Short look at the garden (see www.alpengarten.ch)**Today, visitors can enter the garden directly beside the railway station and walk on 420 m of main paths and ca. 500 m of smaller ones. They do not have to climb on many peaks; they can walk on comfortable paths to find 600 species that means two thirds of Swiss alpine plants, most in their natural association or planted very close to these conditions.

The Garden lies in an altitude of 1975 m and measures about 8500 m²

The whole garden was used as a pasture until 1928. The greatest part shows natural vegetation in about 20 phytosociological associations. Four are very frequent and important: The blue grass-meadow, the meadow of rusty sedge, the alpine pasture and the mat-grass meadow (Seslerio-Caricetum sempervirentis, Caricetum ferrugineae, Crepido-Festucetum rubrae, Geo montani-Nardetum). The other associations are present in small parts in the garden, but most of them in quite typical examples.

For species foreign to Schynige Platte, it was tried from the beginning to develop artificial associations (Lüdi 1957). Compared to the plant sociological garden of Tüxen in Hannover (Tüxen 1940), it is much more difficult to establish artificial associations in an alpine environment, mainly because of the topography which changes much more on very short distances.

Already in 1928 the construction of the “Urgesteinsfeld” (part with granitic soil) was started, for all plants from the central Alps with their soils poor in Calcium.

All these artificial associations give the possibility to show many plants from other parts of the
Swiss Alps. They must be carefully watched and maintained.

**How to keep the present species**

In our Garden with its phytosociological order, every species has its place in the suitable association. Those present in the garden before it was founded should be kept by continuing the maintenance as before. When this had been pasturing by cattle, we must slow down the succession leading towards more productive pastures and later on to dwarf shrub heaths etc. Grazing may partly be replaced by mowing. To find the correct simulation (mowing at the right time, taking away the hay with its mineral nutrients etc.) needs many years of experimenting that have not yet passed, especially for the traditionally pastured Carex ferrugineae, Crepido-Festucetum rubrae and Nardetum.

The artificial associations give other problems. They need the right ecological conditions including the correct soil and a good care to protect them from the surrounding indigenous vegetation. Usually that means of course “weeding” all competitive species coming from the neighbourhood into the plantation, etc.

**How to get new species**

At the start of the garden, most lacking species came from the botanical garden in Bern, were bought from wild-flower nurseries or have been dug out in nature. Today we usually collect seeds from wild populations, sow them in our nursery on Schynige Platte and bring them into the garden after two years or later. This cultivation at their future place prevents them from the shock following the jump from 600 m up to 2000 m a.s.l. In the garden they all get into plantings providing an ecological niche as close as possible to the one in nature and where they are protected from competition. It has been tried to bring them into the closed vegetation, but the result was normally that they disappeared soon. The root-competition is usually too strong (Lüdi 1957). It was then decided to have a compromise, to plant the species in groups. The “natural” mixture can not be cared all right, and until it comes from itself, there may be necessary centuries (a tuft of Carex curvula increases its diameter about 1 mm per year).

Only very few species have propagated themselves into closed vegetation, as Lüdi expected at the beginning. He cited Hugueninia tanacetifolia as the only one that had left its first place and was found on new places on open soil (Lüdi 1957). In 1985 we discovered Eryngium alpinum in a pasture related to Carex ferrugineae, and since then we know about half a dozen of species that had been brought into the garden and tend to get aggressive now. Achillea clavennae, Aposeris foetida, Horminum pyrenaicum, Rhodiola rosea, Linum alpinum, are such species foreign to Schynige Platte. Heracleum sphondylium, Crepis bocconi, C. conyzifolia, Laserpitium latifolium are some indigenous species that are quite aggressive. Cicerbita macrophylla was introduced
unintentional probably before 1950. As it is not a Swiss plant it makes some problems. Most of the introduced species we can still find only in the places where they have been planted many years ago. An example is *Cortusa matthioli* that has been planted in 1949 into an alder bush. It is still there, just the branches of alder must be cut off, so that it gets enough light, and the megaforbs must be shortened sometimes. Only once some young plants grown from their seeds have been planted to the old ones.

**What may happen without maintenance**

The mat-grass-pasture (*Geo montani-Nardetum*) may be discussed as a vegetation type that tends to change strongly in the garden. It was intensively grazed by cattle over the past centuries. – It began very soon to change towards a more productive vegetation-type close to *Crepido-Festucetum rubrae*, without all the typical species of poor and acid soils. When we will keep the typical species here it is necessary to maintain this pasture. We try it by pasturing with sheep instead of cows. We have the impression that the place looks better than in 1976 when we started this experiment.

**Maintenance guidebook**

The basis of our garden is the ingenious concept that Lüdi and the other founders gave it: All plants grow according to their ecological needs, in their phytosociological associations. The older the garden and the experimental field get, the more valuable and interesting will be the observations and experiences there. When we want to progress concerning the knowledge of the plants, we need as many observations as possible to be noted carefully, in the past as in the future. Only then we don’t repeat always the same mistakes.

It was a great challenge for both of us to gather and to coordinate all the data concerning the plants in the alpine garden, to reflect them, including the discussion with our staff, with scientists, with gardening experts, to search in literature and periodicals, and in the notes concerning the developments in our archives. We completed one another in an almost unique way. Verena as former chief gardener in our Alpine Garden during 8 summers, later landscape gardener and almost constant partner on excursions brought the know-how and the knowledge from this side, Otto had the botanical background, especially in ecology and phytosociology. Together we combined science and practice. The result is an up-to-date determination of our momentary position to the problems in the garden, but we are aware; development goes on, and parts of this guidebook must be questioned again and again. The most important mistake of our guidebook: we wrote it only now and not much earlier.

![Fig. 4. Eiger, Mönch and Jungfrau, the beautiful mountains through a part of tall forbs in the garden.](image)

**The maintenance guidebook** (Hegg 2007) consists of two main parts. An introduction gives the concept and the history of the garden. **Description of the Quarters.** In the first part a characterization is given for every one of the 68 quarters in the garden: development, important work that has been done, expected aspect, actually present vegetation, goal in this quarter, and care needed to reach this.

**Description of the Works.** The second part shows, where and why the work in the alpine garden differs from normal gardening. To complete it, we produced several lists and reports:

- **Weekly report** for the works done and for many observations.
- **Culture list**, data of maintenance for a species from sowing till the establishment in the garden.
- “**Flowering calendar**” with times of flowering and of ripe seeds.
• List of **species in the 68 quarters** with desired, allowed and forbidden species according to the natural vegetation or the goals to reach.
• List of all **600 species with phytosociological alliances** in which they grow in nature (according to O. Hegg in Flora indicative 2009, for the part of the Swiss alpines).
• List of species being invasive in the garden. Seeds are collected before they are mature.
• **Data base** with notes on origin, time of acquisition, place of cultivation, time of introduction to the quarter and other observations. It goes back to 1930 (Since 2000 in an Access-Program). Thanks to this it is possible to make a yearly control of success of important species, too. We see here, which maintenance is good for this plant. We see unfortunately many lost species too. Like this we learn much about the needs of the species we cultivate in the garden, and this will certainly be important when such species should be cultivated for nature conservation or when they should be brought back into nature sometimes.

The guidebook is the basis to keep the garden according to its concept by a controlled maintenance.

**Team**

Our staff consists of 3 gardeners, 1 farmer and all-rounder and his wife, who works in part time job at the entrance. Because of the very short summer season (only 4 ½ months), our gardeners work for us only for 3 years on average. For the frequently repeating training of new people we need a good documentation.

**Thanks**

We have to thank our gardeners for their good work in gardening and with computers, and the committee of the association for support. The association of the Alpine Botanical Garden hopes that this garden can bring pleasure to the 30,000 to 40,000 visitors, contribute to the preservation of biodiversity and to scientific progress.

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**Fig. 5.** Survey of the Alpengarten Schynige Platte: the path beginning behind the houses of the station and the Alpengartenhaus.

**References**

There is no long tradition in Norway with alpine rock gardens, except a less intensive landscape in Oslo and smaller, private versions. When we had Bjørn Thon constructing our first rock garden in 1990, it was considered a rather controversial experiment. He arranged our Himalaya dominated by large granitic boulders, and continued with our Primulaceae collection, including an artificial water fall above an artificial pond. Our experiences were very positive, and this initial construction determined our later garden profile with a strong focus on rock landscapes. This was much in contrast with initial plans made by landscape architects.

A few years later we obtained some iron-rich, hard, schistose boulders for our Arctic Valley. Then this source of rocks was closed, and we had a period with less dramatic landscapes with lower quality rocks available, mostly without lichen cover. Now our third phase has started, with very large, quartzitic rocks with beautiful lichen vegetation originating from a very impressive boulder slope, a 45 min. drive east of Tromsø. Such rocks, several in the range 7-10 tons, a single one weighing 12 tons, are now creating a dramatic new Arctic Hill together with our Caucasus, bordering the improved New Zealand, Africa and Gentianaceae collections in the same style.
A cuesta-style rock outcrop has been established in our Saxifragaceae hill by David Holubec, who together with Petr Hanzelka, also from Praha, constructed a quite large crevice garden landscape in our Primulaceae collection. This is in the traditional Czech crevice garden style, with flattened rocks arranged vertically.

Our rock garden landscapes have made the area much more aesthetically attractive. Rather small arctic and alpine plants are much better shown against a simulated alpine rock landscape than in traditional beds. It also reduces the weed problem, although we must admit that even the Tromsø area has a poor availability of gravel, with colours which can make surfaces match their background of boulders.

Most important, our new landscapes have widened very much our range of garden habitats. In the south-facing rock fissures we have now established three species of succulents (*Delosperma alpinum*, *basuticum* and *nubigenum*) from South Africa/Lesotho. Also other species from this area, such as *Athrixia fontana*, *Berkheya purpurea*, *Cotula socialis*, *Eucomis bicolor*, *Glumicalyx flanaganii*, *Hirpicium armerioides*, and *Phygelius capensis* and *aequalis* have survived at least one winter. A few of these originate from seed exchange with Katse Botanic garden in Lesotho, through their cooperation with Munich Botanical Garden.

As much as six species of cacti survived their first winter outside, with only a winter roof and 1-1.5 m open spaces around instead of walls. Several *Ephedra* species and species such as *Calceolaria arachnoidea*, *Araucaria araucana*, and *Perezia lanigera* have managed out-doors in Tromsø in south-facing, gravelly slopes, although an improvement of the South American collection with more dramatic rock landscapes is on top of our priority list. The Australian shrub *Prostanthera cuneata* has survived three winters, and many other xerophytes and/or thermophilous species are now being tried. Strongly sloping and well-drained landscapes are the best way to avoid the ice-sheets which are a threat in our long, snowy winter, which regularly also includes periods of heavy rainfall due to our coastal climate. To us it is a great fun to be able to cultivate such exotic plants, and the new rock landscapes increase our range of plant habitats significantly.

Conversely, sufficiently large and cool north-facing slopes probably also represent our only chances to maintain over time high-alpine species such as *Ranunculus glacialis* and High Arctic specialists such as *Saxifraga platysepala*, *Ranunculus sulphureus* and several *Draba* species. This sheltered area at the base of a steep north-facing slope will be a key area in future presentations in our garden, dealing with high alpine and High Arctic plants threatened by global warming.

We should admit that our different rock garden areas have been constructed with a surprisingly low degree of premade plans agreed on by ‘everybody’. Initiatives have been much left to the persons in charge of the projects, knowing that the rock material at hand is a most decisive factor in the construction process. When we now
try to evaluate our own landscapes we see that two major concerns have evidently been adapted: constructions of suitable plant habitats and imitation of real geological features. Most often these two intentions overlap, in some cases we can see a conflict between them.

Our decision now is to define imitation of true geological feature as an overall guideline for our rock garden construction projects. This helps us to decide if features are successful or not and if they need adjustments. Alternatively, there may be numerous opinions on what is aesthetically successful and what is not. With this new focus, we can see that our oldest landscapes, Himalaya and most of Primulaceae, really mimic granitic outcrops, as quite large boulders are set closely to each other. This is enhanced by the waterfall passing through the latter.

The Czech style Androsace Hill strongly contrasts the surrounding rock landscapes. It certainly mimics an outcrop of laminated bedrocks, arranged vertically. We are very content with this structure, but it needs to be supported by smaller hills continuing above and below, making it look like a natural geological structure passing through the Garden.

The new Gentiana Hill is also very nice, but some of the smaller rocks should be rearranged to make it look more like a high alpine rock outcrop, where rocks are moved by the frost actions. The most recent addition to our Saxifraga collection mimics a cuesta. This is a geological feature of laminated rock outcrops situated in maybe a 45 degree angle, on a ridge and eroded to one side. In our hill we need to harmonize some of the rock orientations, but we believe that this type of geological landscape is among the best models as habitats for cushion plants.

Our large new construction involving the Arctic, Caucasus, and Southern Hemisphere collections resemble a terminal moraine with large boulders arranged with orientations simulating casual deposition as opposed to a wall-like construction. This works well, but puts limits to our mesoscale constructions, as there are no true crevices in a hill of loose boulders, which do not originate from a protruding bedrock outcrop. We are now trying to solve this by simulating a few laminated boulders that have fallen apart, creating a ‘window’ of crevices in a morainic landscape.

Fig. 3. The Androsace Hill during May with Primula orbicularis, calderiana and strumosa at its lower slope.

Fig. 4. The new Saxifraga Hill photographed during October 2008.

Our conclusion is that this concept provides a variety of artificial garden landscapes. Visitors also feel them looking natural, although they often do not know what features we have tried to mimic. Paths will always be a challenge in such landscapes, but we only use natural rocks and try to make smooth curves following the landscape features.

We also allow for artificial rock landscapes which do not simulate real features, such as an amphitheatre near the pond, walls near the old houses and a larger planned wall which will hide our future plant nursery. However, these should be distinct, and we should avoid ‘hybrids’ between architectonic and nature-style landscapes. There will be still more rock landscapes during the years to come, and our overall conclusion is simple: we can never get enough of rocks!
Management of a semi-natural alpine garden facing changes in climate and grazing regimes

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At Kongsvoll centuries of farming and grazing has resulted in subalpine areas without forest, but well suited for alpine plants. The alpine garden has until now been a self-supporting system of species and plant communities. The main input has been nearby grasslands, brooks and hiking paths, and possibly directly from surrounding mountains. Open grasslands, grazing fields and rocky outcrops surrounding the garden are now being replaced by trees and shrubs. Fewer domestic animals and warmer and wetter climate are main reasons for this. Local sources for alpine plants are being reduced, and the garden needs alternative sources for seeds and propagules. Planting specimens and seeding of alpine plants may be important to maintain species richness in the garden.

Kongsvoll Alpine Garden is located in the central part of South Norway. Kongsvoll Biological Station and the hotel Kongsvold Fjeldstue are next to the garden. The garden is open at least between 15 of June and 15 of August, depending on weather conditions. The garden can be reached by car, bus and train. The main road between Oslo and Trondheim is next to the garden, along with hiking and pilgrim routes.

Kongsvoll Alpine Garden is situated at ca. 900 m asl in an old farming landscape surrounded by birch forests and mountains. It is a semi-natural garden of about one hectare presenting local flora and nature types. The main purpose of the garden is to present botanical diversity of Dovre Mountains (Botanical Gardens of Museum of Natural History and Archaeology 2009).

The flora of Dovre Mountains

The Dovre flora was discovered by Professor Georg Oeder (Copenhagen) 1755-60 when working on Flora Danica for the Kingdom of Denmark - Norway. The first thorough investigation was made by Professor Mathias N. Blytt (Oslo), starting in the 1830s. Kongsvoll with the mountains Knutshoene are among the botanically most interesting mountain areas of Norway, including many red listed species (Elven et al. 1996). Many European botanists visited Dovre
Fig. 1. Many trees and scrubs are removed from the alpine garden (left of the electric fence). Management of the cultural landscape surrounding the garden must be more intense to maintain populations of alpine species.

Fig. 2. Kongsvoll Alpine Garden located next to the main road, hotel and railway. The garden and the old farming landscape in surrounded by Betula pubescens forest and distance to mountains increases.

Mountains after Blytt period and they collected vast numbers of specimens. In 1911 collection of some rare plants was prohibited by law; the first legal plant protection in norwegian history. The starting point of an alpine garden at Kongsvoll was a presentation of rare vascular plants next to the railway station in 1924 – established by Thekla Resvoll (Oslo). Since 1966 the university in Trondheim is responsible for the garden and in 1992 manager Simen Bretten developed the original garden and concept for the present location and purpose. Kongsvoll Alpine Garden is located in a landscape protection area surrounded by a National Park (Brox 2008).

Diversity and local climate conditions

In Kongsvoll Alpine Garden habitats of cliffs, willow scrubs, tall-herb and other meadows, small rich fens, snow patch vegetation, alpine rigdes, a scree and a brook are present (Kongs- voll Alpine Garden 2009). Due to this ecological variation most of the common vascular plants of the alpine flora can be seen, along with species characterizing the Dovre flora. Forest species and species of the cultural landscape can also be seen. At present more than 200 species of vascular plants and more than 50 species of lichens and bryophytes are present. Presentation of bryophytes, lichens and fungi is a new feature which will be focused more in the years to come.

The precipitation at Kongsvoll is about 475 mm per year, but has increased by ca. 20% over the last 20 years (Hofgaard 2006, Meteorological Institute 2009). Mean July temperature is ca. 10 ºC and January –10 ºC. Annual amplitude is ca. -30 to +28 ºC. Climate scenarios for 2050 indicate an increase in temperature of 2.5-4 ºC and prolongation of the growing season with 3-6 weeks. The bedrock is calcareous mica schist, greenstone and phyllite. The forest limit in the area varies between 1060-1100 m asl but is rising.

Management challenges

Centuries of farming, including grazing, hay making and logging for firewood has resulted in an open boreal landscape resembling the alpine zone with many alpine species, but with additional features as well.

Most vascular plant species are self-established in the garden, reproducing and replacing themselves. The garden changes all time: New species establish, some disappear after a dry summer or severe frost and some species are supplied from nearby populations. Recently established species are boreal species like Equisetum pratense, Ribes spicatum, Sorbus aucuparia.

The garden is termed semi-natural because management efforts are needed to maintain the flora and vegetation of the alpine zone and the cultural landscape. This is done by removing trees and bushes, mainly Betula pubescens, Salix spp. and Juniperus communis. Reducing the populations of Achillea millefolium, Campanula rotundifolia, Deschampsia cespitosa, Galium boreale, Rumex acetosa, Rumex acetosella, Silene vulgaris, Taraxacum spp., Trifolium repens and others are important to keep the alpine species.
No alien invasive species occur in the garden. The summer farming landscape surrounding the alpine garden is important for threatened species and nature types. A management plan of the area has been worked out (Fremstad 2000) but the follow-up is not satisfactory. Management of the cultural landscape involves grazing, hay making, burning and logging of trees and bushes. Some of this is performed regularly, other tasks are missing. At present the meadows are grazed by horses, some sheep and introduced, wild musk oxen. Management has to be more intense to prevent forest and scrub establishment. Previously, grazing by goats and cattle was also important and the total number of grazing animals was much higher than today.

Managing the alpine garden does not involve grazing at present. Grazing mammals are kept outside by an electric fence as they will eat plants we like to present to the visitors.

We now see the results of reduced grazing and changes in grazing regimes during the last decades, and perhaps climatic changes. The alpine garden and the farming landscape at Kongsvoll have become isolated “tree-less islands” in a forested landscape. Still the “islands” contain many alpine species, but distance to natural alpine populations is increasing. Self-establishment in the garden may be more difficult as surrounding vegetation changes. Seed rain may be less efficient and recruitment from alpine populations may be more occasional when specimens in the garden die. This favours self-establishment of boreal species whereas alpine species must be replanted to keep viable individuals or populations.

Conclusion

Maintenance of the present concept of Kongsvoll Alpine Garden is highly dependent on rather intensive and correct management of both the alpine garden and the surrounding vegetation. The follow up of the management plan of the cultural landscape at Kongsvoll must be more intensive. Still, the only way to maintain some of the species in the alpine garden may be planting of specimens. Kongsvoll Alpine Garden will then change from a semi-natural garden based on self-establishing specimens to become more dependent on planting of specimens. Alpine species may be replaced by boreal species.

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The Jardin botanique alpin du Lautaret has started to have a static website since 1999 with the objectives to communicate the activities of the garden and to participate in public and student education. In collaboration with the department of information systems (Elodie Terret and Tim Catinat) we have developed a new website in 2007-08, using new facilities: a dynamic content management system (CMS open source SPIP) connected to the online photo management and sharing application Flickr ®. After one year of use, the efficiency of the strategy is clearly demonstrated both for the public (easy access, ergonomic navigation) and for the staff of the Garden which develops the website (easy uploading and updating, web promotion).

Internet has become a powerful tool for education. The Jardin botanique alpin du Lautaret has developed a new website in 2007-2008, «sajf-grenoble.fr», proposing information on the different activities of the garden. Concerning education the available information deals with classic botany and alpine plants and environment. An image bank has also been developed ([Flickr/]) and linked to the website. It proposes more than 10,000 pictures, all with tags permitting an optimal referencing. The major themes are: the plants of the garden, the native plants and vegetation of the Lautaret area, the plants of various mountains of the world including Andes and Patagonia, New-Zealand, Australia.

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This website is divided into 4 sections: Garden, Arboretum¹, Research, Botany.

The section “Garden” provides much information on the garden: location, opening dates, activities, virtual visit, job offers, index seminum, ongoing projects, etc. Concerning education, the following items are developed:

- The history of the garden since 1899
- The natural environment: geology, climate, vegetation, etc.

¹ The arboretum is located in Grenoble. It was created by Robert Ruffier-Lanche, the gardener and botanist of the Jardin alpin du Lautaret in the sixties. It is managed by the same staff as the garden.
The pdf file of the guidebook sold at the garden (100 pages) in French, English and Italian (fig. 1)
The pdf files of the brochures presenting the garden (8 pages) in various languages: French, English, German, Dutch, Italian, Spanish, Arabic, Chinese, Romanian, Norwegian, Slovak, and Turkish
Plants of the garden (link to Flickr *, see below).

The section “Research” permits to communicate on the research activities and facilities at the Lautaret pass. All the ongoing projects are displayed, as well as the list of publications (in English) and a yearly activity report in French. Part of the research activities are directly associated with the Garden since they use its botanical expertise.

The section “Botany” is mainly focused on education of the public and students of botany:
- Information on the flora of the region of Lautaret pass: bibliography (all the old and recent publications available as pdf files) and images (link to Flickr *, see below)
- Basic botany education resources (fig. 2): description of a plant with all the vocabulary explained (glossary) and illustrated, presentation of the main plant families (organisation of the flowers, diagrams, pictures)
- Education resources: support of conferences (sub-antarctic flora, flora of the Andes, etc.) and papers (reproduction of alpine plants, adaptation of alpine plants to extreme environments, etc.)
- Bibliography of the botanists of Grenoble university
- Information on all alpine and arctic botanic gardens

Fig. 1. The guidebook of the garden

Fig. 2. Elements of botany
Education through the image database on Flickr

Flickr is one of the biggest and most efficient photo management and sharing applications on the web. Our database (http://www.flickr.com/photos/stationalpinejosephfourier/) comprises more than 10,000 images, all of them referenced with tags and organised in folders. The following themes are illustrated:

- Flora and vegetation of the Lautaret region: plants are displayed by habitats, vegetation belts (fig. 3) and colours of the flowers
- Flora and vegetation of Patagonia and Tierra del Fuego. Various expeditions have been organised by the garden to Chile and Argentina since 2005. Around 2,500 images illustrate ca 900 species, displayed by locations (national parks), by major vegetation types (fig. 4) and by plant types (trees, shrubs, colours of the flowers)
- Flora and vegetation of the Andes (Patagonia excluded): expedition of the garden to Chile in 2003, private expeditions to Ecuador, expeditions of colleagues (e.g. A. Gröger in Venezuela)
- Flora and vegetation of the mountains of Australia and New-Zealand (expeditions of the garden in 2004 and 2006), of East Africa (private expeditions)
- Insects of the Lautaret region
- Plants cultivated in the garden displayed by rockeries: pictures of ca 80% of the 2300 species cultivated
- Landscaping in the Jardin alpin du Lautaret since 2003: images and comments by Richard Hurstel, head gardener (fig. 5).

Fig. 3. Flora and vegetation of the alpine belt around Lautaret
Fig. 4. Flora of the mixed forests in Northern Patagonia

Fig. 5. Landscaping course by R. Hurstel
In the context of an EU funded FP6 project, specific teaching activities, aimed at children aged 8-10, have been developed jointly across Botanic Gardens in Austria, Italy, the UK and Bulgaria. The programme focused on plants and sustainability, investigating the concepts of plant ecology, extinction and conservation, plants as food and plants in art. Enquiry centered and active learning techniques were employed to stimulate scientific thinking at an early stage (e.g. concept cartoons, role plays, play-decide games, predict-observe-explain sessions, designing experiments). Viotte Alpine Botanic Garden developed the extinction and conservation theme with many modules uniquely adapted for alpine gardens and their education activities.

Plascigardens (Plant Science Education for Primary Schools in European Botanic Gardens) is an EU project funded under FP6 in Science-and-Society as a specific support action that runs from October 2005 to December 2007. This project had been jointly developed by four European botanic gardens: the University Botanic Garden in Innsbruck, Austria; the Viotte Alpine Botanic Garden in Trento, Italy; the University Botanic Garden in Sofia, Bulgaria; the Royal Botanic Gardens, Kew, UK along with the Institute of Education in London, UK.

The project aimed at developing a number of resources to deliver better plant science at the primary level (target age group 8-10), promoting young people’s interest in plant science and conservation (Johnson, 2004). The project had been structured in 4 stages: a preliminary analysis of the status of plant science education in primary schools, a creative stage in which an education tool was devised and structured, an active trial phase in which the materials were tested with selected schools over an 8 month period along with an evaluation stage from both teachers and children and a final part producing and disseminating the teaching resources and the training materials to schools and botanic garden educators.
Education for sustainability using enquiry centered learning

The whole programme focused on plants and sustainability, aiming at showcasing that all life depends on plants (Tilbury, 2004), investigating four key concepts: plant ecology, extinction and conservation, plants as food and plants in art (Summers et al., 2003; Sanders, 2005). Each country specifically developed one key concept and all four of them were later circulated for feedback from all partners (Tizzard and Hughes, 1984; Sandoval, 2003; Driver et al., 1994, 1996; Wandersee, 1983; Wood-Robinson, 1991). The final product is an enquiry centered, multilingual, multicultural plant science education tool focusing on plant diversity and employing enquiry centred and active learning techniques to stimulate scientific thinking at an early stage, such as concept cartoons, role plays, play-decide games, predict-observe-explain sessions, designing experiments (Harlen, 1999; Price and Hein, 1991; Wolins et al., 1992; Cox-Petersen et al., 2003).

The extinction and conservation module was designed and developed by the Viotte team and is ideally suited to be used in alpine gardens, specifically addressing the conservation theme in an alpine context, introducing specific threats to plant diversity that might have potentially dramatic effects in the Alps such as global warming and presenting hotly debated issues such as ski slope development and its consequences on the environment, stimulating kids to understand the benefits and to practice sustainable development.

The theme includes 10 modules with a series of interactive steps that lead the pupils to appreciate the problem of plant extinction (fig. 1) and its global consequences. They can then consider how they might contribute to plant conservation and how mankind can attain sustainable development locally and globally. Step one introduces children to the plant kingdom and encourages them to find ways to describe and illustrate different plant samples. Step two stimulates them to become aware of the problem of plant extinction. A specific role play game has been designed to showcase this concept. In it the children play the part of plants receiving the nutrients, light and water they need (specific cards) in order to survive in a given number of sites (fig. 2 and 3). The storyboard then introduces a series of events (e.g. draught, new roads, changes in land use, new protected areas) that initiate variation in the number of resources and sites (fig. 4). Eventually some plants will go extinct and some others will increase their presence. The third step is a discussion of the games’ outcome to encourage children to appreciate the percentage of extinct species, the causes of extinction and the different significance of partial versus global extinction. The final step makes them think of what mankind can do to prevent extinction, with special reference to the role that botanic gardens can play.

The attention naturally focuses on seed collection, safe storage, germination and cultivation. A simplified play-decide game is used to make the kids aware of the special germination requirements of the different species and poses
the question on how they can make the seed germinate (story cards introduce different germination behaviours). In particular the concept of seed dormancy is presented and a final challenge card requires a decision on the more likely way to overcome it (e.g. a cold period mimicking winter, a hot period mimicking summer, etc., fig. 5). An additional interactive step presents seed structure and seed dispersal mechanisms. A concluding role play introduces the concept of sustainable development. Here the children play citizens of an alpine valley where a major skiing area is about to be developed heavily impacting on the environment and plant survival. Different options are introduced and alternative scenarios for future developments are presented with their short and long term effects. A final decision needs to be taken and groups of citizens must argue and vote for the preferred option taking into account the long term results of their choice (Malone and Tranter, 2003).

**Evaluation, Applicability and transfer**

The effectiveness of the cooperative learning approach employed and its impact on the children's self esteem and motivation have been constantly evaluated during the course of the project (Hein, 1995; Naylor et al., 2004; Brady, 2003). The final cross tested products, evaluated and nationally adapted, are available on-line (www.plantscafe.net) and also in form of a printed book and CD available on request from the project partners. Training materials are available for teachers and botanic garden educators for Continuing Professional Development.

**Conclusions**

All of those involved in this project hope that these activities will contribute to making future generations aware of the importance of plant conservation for the sustainable development of human society. Sowing in children the seeds of a sense of stewardship and the values that encourage them to care for our natural resources and plants in particular.
Fig. 4. Part of the master story in the extinction role game where the different event are introduced as part of the extinction and conservation module.

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References
Educative tools to connect an alpine garden to the surrounding vegetation

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The Schachen Alpine Garden is a centre of knowledge about alpine plants, situated in the nature reserve 'Schachen und Reintal'. Since 2007 the garden and its surrounding environment are connected closer by an educative concept. On the basis of relevées and soil profiles in the surroundings of the garden as well as literature research, plant species, soils and vegetation types were recorded and ecological and historical data about the region were gathered. Facts worth knowing to the visitor about the area were sorted by topics, which are presented to the public on five permanent panels (survey map, geology, elevation belts, succession, history) in the garden. Completing this basic information, flyers are available as hand-outs, guiding the visitor on the two most frequented foot-paths leading to the garden. These flyers introduce to the different types of vegetation next to the paths together with typical plant species.

Since 2007 the Schachen Alpine Garden, satellite garden of the Botanical Garden München-Nymphenburg in the Wetterstein Mountains (Bavaria), and its surroundings are connected closer by an educative concept developed by the Botanical Garden München-Nymphenburg in cooperation with the FH Weihenstephan, University of applied science.

The purpose of the project is to give the visitors the opportunity first to see alpine plants from the most diverse mountain regions of the world inside the garden, and then to get a closer look at the native vegetation and ecological relations outside in the Schachen area.

The surroundings
The garden is a centre of knowledge about alpine plants from all over the world. It is situated in the nature reserve Schachen und Reintal (the red line in fig. 1 is marking the boarder), where a fascinating variety of alpine vegetation can be found.

Also important for walkers and tourists are huts like the “Wettersteinalm”, “Schachenhaus” and “Meilerhütte”, where board and/or lodging are offered.

All these locations are connected by highly frequented footpaths within the nature reserve.
The garden

From its surroundings the garden is separated by a huge fence to prevent chamoises and other animals from getting into the garden during wintertime.

Inside the garden you can find plant species from mountainous regions from all over the world. Near the entrance the beds with native flora are located. Though it’s a big part of the garden, not every flowering plant of the surrounding vegetation can be cultivated there and of course there’s a difference between seeing a plant in the garden or in its natural habitat.

The intentions of the concept

- to somehow get over the fence and connect the garden closer to the surrounding vegetation.
- to give the visitors information about ecological relations and the native vegetation without placing anything like a sign or a presentation board outside garden (not allowed in the nature reserve).
- to strengthen the garden's function as a natural-science-information-centre.
- to realize the whole project with a low financial budget.

The target group

To develop a successful concept it’s important to get to know the target group: in this case the garden’s visitors and the walkers outside. By interviewing them, we got the following information:

Who they are:
- nature enthusiasts
- people with basic knowledge in botany
- tourists
- families
- of all ages
What are they interested in:
- plants and vegetation outside the garden
- geology
- climate
- soils
- types of vegetation
- history of land use
- animals

How would they like to get the information?
- pictures and colour photos
- something to take on the walk

Collecting information
After evaluating the interviews, the facts worth knowing to the visitors were sorted by topics and research could be started.
On the basis of relevées and soil profiles in the surrounding of the garden, as well as literature research, plant species, soils and vegetation types were recorded and ecological data of the region were gathered.

The concept
Under the already described preconditions and with the previously named intentions in mind the following concept was developed:
Facts worth knowing to the visitor about the area (geology, elevation belts, succession, history of landuse) were extracted from the collected information. They are now presented to the public on four presentation boards in the part of the garden dedicated to native vegetation. (fig. 4)
In addition to this basic information, flyers for the two most frequented foot-paths, leading to and from the garden, were developed, introducing the different types of vegetation next to the paths together with typical plant species (fig.2).
Every flyer introduces five vegetation types in the same order as you can find them next to the two selected trails (I: from “Alpengarten” to “Meilerhütte”, II: from “Alpengarten” to “Wettersteinalm”).
An example for one vegetation type is shown in fig. 3. First, one photo gives an impression of the vegetation type which is described shortly in an accompanying text. Beneath this text follows a series of pictures of typical plants, easy to find and to recognize. Another criterion for the choice of species was a different point of flowering, so that the flyers can be used during the whole summer. In addition to that, below the picture series, there is a listing of further plants which can be found in that habitat.
Both flyers are available in the garden as well as download from the webpage of the botanical garden. It was decided to go for coloured flyers in high quality and to sell them for a nominal charge. On the one hand to prevent the visitors
from leaving the flyers somewhere in the nature reserve and on the other hand because colour-pictures make it easier to recognize the plants outside.

Since the boards are fixed in the garden, each year a lot of flyers have been sold and visitors take the opportunity to learn more about the area and its ecological relations. Of special interest is the presentation board with the aerial view, which is a less abstract copy of the landscape than a map of trails.
Kew’s Alpine House – what’s the point?

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Royal Botanic Gardens Kew, United Kingdom

A general question is why we should use our limited resources to grow and display alpine plants in a lowland botanic garden. The talk explores the work of the Alpine and Rock Garden units at the Royal Botanic Gardens, Kew, explains the technology behind the new Davies Alpine House and shows some of the landscaping and cultivation techniques both in the nursery and the display house.

At a congress for gardens situated at high altitudes, which offer optimum conditions for the cultivation of a huge range of plants, the obvious question is, what is the point of trying to grow alpines in a lowland garden such as Kew?

There are many obstacles to successful cultivation at Kew: the increasingly warm, dry summers of south-east England mean that many of the plants have to survive temperatures far beyond their natural limits; the mild, wet winters threaten those which, in their native habitats, spend up to nine months in cool, dry dormancy, wrapped in a protective blanket of snow.

But there are five compelling reasons to maintain an alpine collection at Kew: duty, beauty, science, education and horticulture.

First, duty: as the national botanic garden for England, Kew is obliged to maintain a national botanical reference collection, representing as many plant families as possible from as many parts of the globe as possible. Mountains cover 25% of the world’s landmass, so the mountain flora is a critical part of that reference collection. Even if it were the only justification, then surely beauty would be reason enough. The diverse beauty of the mountain flora is explored through four distinct areas in the north-eastern zone of the Gardens: the Woodland Garden, which concentrates on herbaceous woodland plants; the Rock Garden; the Alpine House and the Alpine Nursery. The alpine collections contain dramatic species from six continents. South American flora includes plants from the barren, windswept uplands of Patagonia – *Petunia patagonica* and *Calceolaria uniflora*, the extraordinary *Leontochir ovallei* from the coastal mountains of Chile's Atacama Desert; from New Zealand comes
Raoulia albo-sericea, Leucogenes grandiceps; Craspedia uniflora; North Africa yields the lovely Syrian Pelargonium endlicherianum, the Yemeni Helichrysum arvae and Primula verticillata; North America offers us Lewisia rediviva, Monardella macrantha and the lovely Mariposa lilies, such as Calochortus tolmiei; Western Asia offers jewels of the Primulaceae family, like Dionysia tapetodes, and exquisite monocots such as Tulipa montana and the junio Iris nicolai; further east we find Pakistan’s Arnebia benthamii and China’s Helleborus tibetanus, Japan’s Ranzania japonica and Epimedium sempervirens; in France’s maritime alps grow the Primula allionii and high in the Pyrenees, another Primulaceae, Androsace hirtella. And finally, in northerly coastal meadows, Primula scotica.

Now to science. Scientists from Kew and from other organisations around the world consider Kew’s alpine collections to be a valuable resource. Living material is collected for inclusion in Kew’s growing DNA bank; monographs have been completed on the genera Crocus, Cyclamen, Lewisia, Arum, Galanthus, Epimedium, Allium section Allium and Roscoea. Kew’s Head of Genetics, Dr Mike Fay, studied collections of Gilliesia, an insect mimic, for Alliaceae systematics and led the Liliales project, investigating the evolutionary history of the genera Fritillaria, Gagea and Tulipa. Conservation has to be a key rationale for Kew’s collections. The quarter of the world’s landmass occupied by mountains also provides home for at least 12% of the global population, with another 14% living in close proximity. A further 24% depend on stable mountain ecosystems for water, food, hydroelectricity, timber and mineral resources. Research suggests that this stability is threatened by climate change: in 2007, Italian scientists repeated a 50-year-old plant survey, and found that, in response to a 1.5°C rise in temperature, many plants have retreated to higher, cooler altitudes, and now occur 430m higher than 50 years ago. There is a limit, of course, to how much higher they can go. There is an equally grave threat from human activity – tourism, forestry and dam building for example.

The cultivation of alpine plants ex-situ feeds back into conservation efforts by governments and communities around the world. Our knowledge could help in future habitat restoration. Our collection could provide living material to support such work. In the Alpine House we grow Centaurea akamantis, one of IUCN’s top 50 most endangered Mediterranean plants. It occurs only on the shady cliffs of one gorge in Cyprus. This endemism – a frequent characteristic of alpine species - confers vulnerability.

The staff of the Alpine and Rock Garden units travel widely, to observe alpines growing naturally and to source new material for the living collections. Collections Manager Richard Wilford traveled to Chile to work with government agencies, training staff to carry out ex-situ conservation of their flora. Joanne Everson, Rock Garden manager, mounted a significant collecting trip to New Zealand in 2006, working with government partners and botanic gardens to ensure full compliance with the Convention on Biodiversity. Kit Strange collected material in Canada; Stewart Henchie and Charles Shine in Chile; Graham Walters in Morocco. Other recent study tour destinations include Georgia, Italian alps, Nepal, Tibet, Bhutan, USA, Kyrgyzstan, the Maritime Alps, Schynige Platte and the famous Schachengarten in Bavaria.

Kew’s Living Collections database is a powerful tool for conservation. Each collection of plant material held by Kew has assigned to it a unique ‘accession number’, linked to a record of its
provenance, its curation and cultivation details. This resource holds the collection details and field notes of its natural sourced (wild-collected) material, including information about exact geographical position, altitude, geology, habitat, associated flora.

A key mission for Kew is education. The Gardens welcome over 1.3 million visitors per annum and we give tailored tours of the alpine collections to the general public, school and college groups, horticultural societies, other botanic gardens, Kew students and trainees. The alpine collections allow us to graphically explain physiological adaptation to extreme habitats, endemism, diverse pollination mechanisms, plant communities, climate change and sustainability. We value our close links with the Alpine Garden Society: an organization with 9,000 members meeting in over 50 local groups in England, Wales and Ireland. I and my colleagues, Kit Strange and Joanne Everson, have given over 35 lectures in the last 2 years, chiefly to AGS members but also to horticultural societies, NCCPG groups, Women's Institutes and natural history organisations. I have been privileged to work on two award-winning AGS exhibits at the Chelsea Flower Show. We also extend our education work through collaboration on books, such as Richard Wilford's *Tulips*, reports, websites and magazines such as *Curtis' Botanical Magazine*.

Underpinning our scientific, conservation and education work is horticulture. Kew horticulturists maintain strong connections with horticulturists and gardeners in the UK and beyond, exchanging knowledge and experience. When alpine material is acquired by the gardens, there are four separate areas in which it can be cultivated: the Rock Garden, with approximately 2,600 accessions of which 1,250 are natural sourced; the Woodland Garden, with around 1,700 accessions, 960 of which are natural sourced; the Alpine House with 400 accessions, of which over half are natural sourced; and the Alpine Nursery with over 4,650 accessions, an astonishing 3,120 of which are natural sourced. The successful cultivation of this amazing collection of living material requires the highest possible standards of observation, propagation, experimentation and communication. Newly acquired material, such as that brought back by Joanne Everson from New Zealand in 2006, is propagated to provide enough material to try in several different locations. *Calceolaria uniflora* and *Draba bryoides* have survived the last winter to thrive this year on the Rock Garden, having previously been confined to the Alpine House. Several *Dionysia* species, including *D. mozza-farrianii*, until recently destined exclusively for pot culture in the Alpine Nursery, are growing extremely well in the Davies Alpine House.

The Davies Alpine House is Kew's third alpine house. It is named after businessman and philanthropist Edwin Davies OBE, whose generous donation funded the project. It replaces the second alpine house, which was built in the late 1970s and which had consolidated the reputation of Kew's alpine collections. However, in the soaring summer temperatures of recent years,
the second house struggled to maintain the cool conditions, high light levels and low humidity required by the more demanding alpines. So Kew had a great opportunity to capitalise on new technology and advances in architecture in the creation of a bespoke new glasshouse for alpine plants.

Architects Wilkinson Eyre were given a demanding brief. The new alpine house was to provide: protection from winter wet; high light intensity; cooling mechanisms; good air movement and various habitats. In addition, it needed to be environmentally sustainable. Lastly, in line with Kew’s status as a World Heritage Site, the building had to complement the historic glasshouses such as the Palm House and the Temperate House. The new house was to be sited in a far more prominent position, as a gateway to the 125-year old Rock Garden.

In developing their ideas, the architects turned to natural forms. The Barossa termite of Africa builds nests up to 20 feet in height, with fully integrated passive temperature control. Air is drawn from the surroundings through tunnels into an underground chamber, which has a large contact surface area with the ground to help cool the space on hot days and warm the space on cold days. When the central core becomes too warm, the termites unblock openings to ventilation shafts to exhaust the air out of the top of the nest. As the air leaves at the top, fresh, cool air is drawn in through the lower tunnels. So the whole structure acts like a big air conditioning system.

The Davies Alpine House reflects this model. Its shell of glass is supported by a curved steel spine, 10m high at its apex, with glass vents that remain permanently open except in rain or high winds. The steeply sloping glass walls convey warm air up to escape through these vents, and fresh air is drawn in from below. The low iron content glass allows over 90 per cent of light to pass through it, with minimal hindrance from the slender, steel cable structure on which the panes are suspended. Beneath the landscape and floor, a concrete labyrinth acts as a heat sink. A small fan pushes air through a maze of concrete passages and a series of vents direct the cooled air up and across the plants above. The building presents its narrow face to the south to limit exposure to the sun at its zenith and beautiful fan-shaped sails are drawn up on the eastern and western sides to shade the plants from the sun at its most aggressive. The structure works well: the temperature inside the house does not exceed the exterior temperature and the environment is dry due to the constant movement of the air.

The landscaping affords many opportunities to experiment with the cultivation of the more exacting alpines, particularly the cushion plants. The interior landscape is primarily made of sandstone rocks, recycled from the previous alpine house. This creates sun-baked terraces, north- and west-facing cliffs, horizontal and vertical crevices, shady gullies. There are two plunge beds and two steel benches, where plants cultivated in pots in the Nursery are displayed, ensuring that the Alpine House is ablaze with
colour, whatever the season. There is a tufa wall and two ‘drystone’ walls. The 400 accessions permanently planted in the Alpine House landscape are joined by up to 100 plants from Nursery at any one time. Not bad for a space of under 100 square metres! The plants are irrigated individually using lances, and pests – such as vine weevil, aphid and carnation tortrix moth larvae - are managed using biological controls.

So can the expense of a bespoke, cutting edge glass house be justified? The Davies Alpine House caused a great stir when it was first opened and continues to attract the attention of tens of thousands of Kew’s visitors. The structure and the plants prompt endless questions from curious adults and school children alike, raising awareness of the beauty and diversity of mountain flora and at the same time broadening the understanding of contemporary threats to these extraordinary environments. If an organization like Kew does not push the boundaries of technology and horticulture, who will?

In the three and a half years since planting began, many changes have been made both to the landscape and the plantings, as we observe the way in which the structure performs and how the collections respond. The Davies Alpine House has a stream of regular ‘fans’ and is a key element of the daily guided tours of the Gardens. It has quickly established itself as one of the ‘must-see’ features and delivers strong messages about Kew’s science and conservation work, as well as being a showcase for alpines and for their cultivation.

Fig. 6. Leontochir ovallei
Investigation on renaturation of the subalpine meadow vegetation on top of the Brocken mountain

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Since 1990 great efforts have been done to restore the former military area on top of the mountain Brocken into the Harz National Park. The restoration measures aimed to establish mosaics of the former natural vegetation with subalpine Calluna-heathland and meadow vegetation as well as to support endangered plant species like Pulsatilla alpina subsp. alba. Moreover, effective management to control the increasing dominance of grasses (e.g. Calamagrostis villosa) caused by a tremendous input of atmospheric nitrogen should be developed. Since 1991 small-scale heathland restoration experiments were performed using two different methods (sod cutting in different depths and mowing). Overall the sum of the restoration measures led to an increasing number of Pulsatilla alpina subsp. alba individuals on top of the Brocken. To stabilize that positive trend in population dynamics the management and restoration of the subalpine heathland communities on the Brocken must be continued.

Because Prof. Peter from the Georg August University in Göttingen knew that the ecological conditions on top of the Brocken were comparable with the ecological situation in the Alps at about 2.000 m, he founded the Brocken-garden in 1890.

On the Brocken we have the timber-line at about 1.100 m. In the German low mountain range only the Brocken has a natural timberline area.

The climatic conditions on the Brocken are extreme. The mean annual precipitation is 2.000 mm (rain and snow); the mean annual temperature is about + 3°C. Furthermore we have 306 days of fog and so in winter very often hoarfrost on the trees.

But among these climatic factors storms are the most limiting factor for the growth of the spruces. That’s why the trees are not able to grow tall. The spruces (fig. 3) are 150 to 200 years old and only about 5 m high. The Brocken is the most windy and stormy place in Germany.

From 1961 to 1989 the Brocken area became a military zone, and was therefore closed to the public. In 1990 the Brocken looked like a big military camp (fig. 1).
But just from the beginning the national park concept of Brocken development included the restoration and regeneration of nature and the scientific monitoring of succession processes.

So the protection of nature, the scientific investigation and public relations are important tasks of the Brocken garden.

Before it was possible to start the renaturation on top of the Brocken mountain, we had to establish permanent test areas. We did that in 1991, before the Russians left the Brocken in 1994. As we needed very good arguments for our renaturation programme it was very important to do that. Every year we have about 1.5 million visitors on the Brocken and the area of the military-camp was very attractive to Mac Donalds.

After the decontamination there weren’t any plants left in the area.

Only three years later the test area was covered with vegetation up to 50%. Because *Deschampsia cespitosa* tolerates changing humidity it dominates in this test area. Now the area is covered with vegetation up to 80%. All in all we found about 25 different plant species.

So we proved that it is possible to renature the Russian camp under the extreme climatic conditions of the mountain Brocken.

When the Russian army left the Brocken, we renatured the whole area. First we eliminated the Brocken wall (fig. 2). After that we removed 20,000 t of limestone. It was necessary to remove this basic material, because native animals and plants of the Brocken are adapted to acid granite.

After we had removed the military camp we established 10 permanent test areas. In the beginning the area was without any vegetation, just like the first test areas in 1991.

Ten years later the whole area was covered with vegetation: *Deschampsia cespitosa* covered the area to over 50% (fig. 4). At the same time we

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**Fig. 1.** In 1990 the Brocken looked like a big military camp

**Fig. 2.** When the Russian Army left the Brocken the national park renatured the whole area

**Fig. 3.** The timber line at about 1,100 m on top of the Brocken mountain

**Fig. 4.** Permanent plot (2006): bare of vegetation (white); other species (light blue)
investigated the permanent test fields, and we mapped the vegetation of the whole area by the method of Braun-Blanquet. After five years, this investigation will be repeated.

But from the beginning we counted the individuals of the *Pulsatilla alba* population (fig. 5). Mostly we found this species together with *Deschampsia flexuosa* and *Calluna vulgaris*.

But *Deschampsia cespitosa* and *Calamagrostis villosa* conquer the area, because we have an annual precipitation of 2,000 mm and that's why the nitrogen input is very high. In such vigorous grass cover *Pulsatilla alba* isn’t able to exist.

Therefore we investigated the conditions to promote the typical vegetation associations like the subalpine meadow vegetation *Anemono-Callunetum*. We tested the influence of mowing and we removed the grass and its roots together with the uppermost soil layer.

*Deschampsia flexuosa* dominates in the test area, if we cut and remove the grass every year. If we don’t do that, *Calamagrostis villosa* prevails.

Furthermore we tested the influence on the meadow vegetation if we removed the grass with a thin or thicker soil layer. Taking a shallow soil layer, *Calamagrostis villosa* is the dominant species, but if we were removing more *Calluna vulgaris* and *Deschampsia flexuosa* prevail. On weekends volunteers often help us to remove the grass and to plant heath.

The trend is that the number of *Pulsatilla alba* individuals increases (fig. 5). So I think our Brocken garden fulfills a lot of different tasks:

It is a place where unique nature is protected, and environmental education as well as research programs are conducted.

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Fig. 5. Monitoring of *Pulsatilla alpina* ssp. *alba* on the Brocken (1990 - 2008)
Detection of climate change impacts in alpine and arctic botanic gardens: a phenology program

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Since decades many Botanic Gardens in the lowlands are conducting standardized phenological observations of cloned plants, recording timing of leaf unfolding, flowering, fruit ripening, leaf coloring, and leaf fall (e.g. International Phenological Gardens project, since 1959). But long term observations from higher elevations, which are affected even more severely by climate change, are still very scarce. Alpine and Arctic Botanic Gardens (AABGs) offer a perfect field for these studies, allowing to compare the effect of climate change on genetically identical plants under alpine as well as arctic conditions. Following AABGs agreed to cooperate in a joint phenological program: Alpengarten auf dem Schachen (Germany), Giardino Botanico Alpino Viotte (Italy), Jardin Botanique Alpin du Lautaret (France), Tromsø Arctic-Alpine Botanic Garden (Norway) and Reykjavik Botanic Garden (Iceland).

Effects of climate change on plant life

In 2007, the Intergovernmental Panel on Climate Change (IPCC) has drawn very different scenarios. Two years later, rising CO₂ emissions and further results in climate research proof, that the worst case scenario becomes more than probable, i.e. an average increase of atmosphere temperature of more than 4°C until 2100. The effects on biodiversity will be drastic (Rosenzweig et al. 2007).

One of the hard hit environments will be sub-alpine and alpine biomes. But nevertheless, data on the effects of climate change to ecosystems in high altitudes are still quite scarce. In general, with each °C increase of temperature in the mountains, the duration of snow cover decreases by several weeks, the glacier line shifts upward by 60 to 140 m and the treeline shifts upward by several 100 m.

The only options for plant species to respond to these changes are migration to higher altitudes or higher latitudes (Parmesan & Yohe, 2003) or adaptation (ecological plasticity, micro-evolution). Especially temperature and drought sensitive species and species which are poor dispersers, will face the risk of extinction. For some mountain ranges the prognosis of loss of local plant species exceeds 60%, assuming a temperature increase of 4°C.
Phenology

Plant life rhythms, as bud-opening, flowering, leaf-out times, leaf fall, etc., can act as well tuned indicators for climate change (Inouye 2008, Parmesan 2007). Since 1959, the International Phenological Gardens (IPG) project, now based at the Institute of Crop Sciences at Humboldt University in Berlin, records standard phenological observations, using the clones of 23 different plant species. It is the longest running project of its type and meanwhile some 50 Botanical Gardens all over Europe participate (fig. 1). Observers record the timing of leaf unfolding, flowering, fruit ripening, leaf coloring, and leaf fall.

The evaluation of the records taken between 1971 and 2000, supplemented by additional observational series, revealed that in mid and higher latitudes of Europe there is a significant earlier onset of spring events and lengthening of the growing season (Menzel et al. 2006). The average advance of spring/summer was by 2.5 days/decade, the delay of leaf colouring and fall by 1.0 day/decade, what efficiently matches the measured national warming across 19 European countries. Referring to three decades the vegetation period extended 11 days in average. The records for this analysis were taken in 21 European countries, all in low elevations. Long term observations from higher altitudes, which are affected even more severely by climate change, are still very scarce.

Why Alpine and Arctic Botanic Gardens (AABG)?

Alpine Gardens in combination with the related Arctic Gardens provide a perfect field to study the impact of climate change on plant organisms. Compared to monitoring in the wild, these gardens offer following advantages:

- individual plants are growing separated in sheltered conditions and can be monitored reliably (experimental situation)
- competitive reactions with other plant species and other factors that might influence plant traits, can be controlled
- monitoring by trained gardeners, who are present during the vegetation period and have a good knowledge of “plant behaviour” (reliable observations)
- several gardens are already maintaining a climatological station
- long term institutional backing (scientific know-how)
- possibility of parallel and comparable studies within the network of Alpine and Arctic Botanic Gardens (exchange of clones)
- the topic ‘climate change and its consequences’ can be transported easily to the public (supporting environmental policies)

AABG Phenology Project: objective and implementation

The objective is, to sharpen the scientific profile of AABGs by conducting a long-term phenological monitoring program, which is documenting the effects of climatic change on a set of genetically identical indicator species in European mountains and next to the Polar Circle.

Following five AABGs already declared to join the project: Jardin Botanique Alpin du Lautaret (France), Giardino Botanico Alpino Viotte (Italy), Alpine Garden on the Schachen (Germany), Tromsø Arctic-Alpine Botanic Garden (Norway) and Reykjavik Botanic Garden (Iceland).1

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1 Jardin d'Altitude du Haut Chitelet (France) asked to participate, right after the Conference
The project requires following implementation steps

- selection of a set of 10 indicator species
- vegetative propagation of one clone for each indicative species; long term maintenance of the mother plant collection
- preparation of a standardized protocol for the phenological observations
- distribution of genetically identical plants together with the observation protocol to the participating gardens
- public presentation of the project
- compilation of the collected data; comparison with climatological data; evaluation

Selection of indicator species

The first step is to select and propagate the indicator species. Suitable species have to comply with certain criteria:

- native European species with a considerable ecological amplitude (to be cultivated in very different AABGs)
- species that can be propagated vegetatively (to share the same genetic clone)
- different life forms and different plant families
- with phenological phenomena that can be monitored easily
- with phenological phenomena that cover the whole vegetation period

Following species will be part of the program and propagated from a mother stock on the Schachen and in Lautaret: *Allium senescens*, *Arnica montana* (fig. 2), *Dryas octopetala*, *Geum reptans*, *Helianthemum oelandicum* ssp. *alpestre*, *Rhodiola rosea*, *Rhododendron ferrugineum* (fig. 2), *Ribes alpinum*, *Salix reticulata*, and *Saxifraga paniculata*.

All gardens participating in the phenology project will use the same clone of one species. Only then phenology reflects the influence of environmental factors rather than genetic differences. As phenological observations of *Rhododendron ferrugineum* in Royal Botanic Garden Edinburgh showed, the phenological behaviour of different clones of the same species can vary considerably, even when growing in the same bed (Thompson et al., pers. comm., fig. 3).

Additionally, the participating gardens should start at the same time with the project, because flowering date can be plant size driven (Miller-Rushing et al. 2008). That means, the plants of an indicator species should be of same age.
Outlook

The projects schedule is to select and propagate the indicator species in 2009 and 2010. In the same time, the standardized protocol for the phenological observations should be prepared. In beginning of 2011 the first plants together with the protocoll will be distributed to the participating botanic gardens.

The AABG Phenology Project could contribute to close the gap of knowledge concerning the effect of climate change on plant life rhythms in higher altitudes and latitudes. Especially in the climate change debate, sound scientific data are essential for any progress within the political debate.

References

Concerning two alpine botanical gardens of the Caucasus

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There are two alpine botanical gardens in the Caucasus: Bakuriani Alpine Botanical Garden (founded in 1912, Georgia) and Gunib Alpine Botanical Garden (Dagestan, Russian Federation) with rich plant living collections. Collections of alpine plants also exist in Tbilisi, Baku, Yerevan and other Botanical Gardens of the region. For a long time studies of bio-ecology and genetic selection (the latter mainly in Gunib Garden) of introduced high mountain plants have been carried out in the gardens. In the recent period the alpine gardens have undertaken additional function that is ex situ conservation of rare and threatened plants not protected in the wild (not occurring on protected areas or places inaccessible for people). The issue has become more relevant after starting the IUCN project: Coordination and Development of Plant Red List Assessments for the Caucasus (the Regional Center of the project is in Tbilisi) that revealed ca. 200 critically endangered endemic species of the Caucasus Biodiversity Hotspot, which are in need of ex situ conservation measures. The species should be cultivated in the gardens according to their ecological requirements. Our aim is acquaintance with international methods and technologies of plant conservation and their application in the alpine botanical gardens of the Caucasus.

Bakuriani Alpine Botanical Garden

Bakuriani Alpine Botanical Garden (BABG) is located in the village Bakuriani (N 41°45,972 E 43°31,226) – Georgia’s outstanding mountain resort and skiing center of international importance (1700 m asl). It is situated in a broad depression surrounded by forested mountain slopes. Bakuriani Alpine Botanical Garden was established in 1912 and Engler, Radde and other famous European botanists attended the opening ceremony.

Situated at 1650 m asl the Garden specializes in plants of the Caucasus Mountains and its collections include some 400 species collected in the Caucasus, an arboretum of about 125 species of trees and shrubs (including 75 from the Caucasus), and some 250 species of herbaceous plants from elsewhere in the world grown from seed.
Among others, the following species are in the Garden collections: *Allium globosum*, *Galanthis ssp.*, *Angelica purpurascens*, *Astrantia maxima*, *Heracleum wilhelmsii*, *Asphodeline taurica*, *Primula pallasi*, *Aconitum orientale*, *Aquilegia caucasica*, *Delphinium ssp.*, *Helleborus abchasicus*, *Ranunculus cappadocius*, *Woronowia speciosa*, *Dictamnus caucasicus*, *Saxifraga cartilaginea*, *Digitalis ciliata*, *Valeriana colchica*, *Viola kupfferi*, *Viola pumila*, etc. Because the Caucasus is a center of diversity for many temperate genera, these collections are extremely important for taxonomic research and for genetic conservation (Chelidze et al. 2009, Javakhishvili 1970, Nakhutsrishvili et al., 2006).

The goals of the Garden are:

- Ex-situ conservation of rare and endangered, endemic, and Red Data Book species of Georgia’s flora
- Seed exchange with other botanical institutions
- Training courses for students
- Environmental education

The Garden area is about 30 hectares in total. A Centre for Environmental Education was built in 1997 with support from the WWF (World Wildlife Fund for Nature). This is used for education programs as well as for overnight accommodations for visiting scientists. Regular training courses for teachers, media representatives, and other professional groups are organized and held at the Centre for Environmental Education.

The collections are planted in an area of about 2 hectares, many in rock garden beds. Decorative, medicinal, endemic, and saxicolous plants are grouped together in specific areas.

The Bakuriani Alpine Botanical Garden serves to protect valuable plant genetic diversity, to provide a base for research on the many different plant communities in the region, and to educate residents, tourists, and professionals in the nature and importance of the flora of the region. The Garden collections comprise a number of rare species collected in remote areas of the Caucasus that are currently inaccessible due to political tensions. The collections are unique – many plant species cannot be seen in any other botanical garden.
soddy and mountain meadow soddy-peat soils prevail at the treeline and in the alpine belt. The region is mainly covered by forests. The western part of the Trialeti range, which is often called “Tskhratskaro”, being the most elevated area of the Borjomi district, creates a quite sharp climatic boundary. In general, forest is the prevailing vegetation type in the district; the forests of the Borjomi district particularly include: spruce forests made up of *Picea orientalis*, pine forests made up of *Pinus kochiana*, beech forests made up of *Fagus orientalis* and mixed spruce and beech, also abies (*Abies nordmanniana*) and beech forests.

In the Borjomi-Bakuriani gorge the following vertical belts of vegetation can be distinguished: middle mountain forest (800-1500 m), upper mountain forest (1500-1800 m), subalpine (1800-2400 m) belts and an alpine belt forming a fringe (2400-2600 m) around the region.

**Gunib Alpine Botanical Garden of the Dagestan Scientific Centre**

The main station of the Alpine Botanical Garden of the Dagestan Scientific Centre, Russian Academy of Sciences is located on the central part of the Gunib plateau, the eastern Greater Caucasus. The Garden was established in 1972 as an experimental station of the Laboratory of Plant Genetics under the Department of Biology of the Dagestan Branch of the USSR Academy of Sciences. In 1992 its status was changed and the Garden became an independent scientific institution.

The mission of the Garden includes:
1. Development of scientific principles and techniques for plant introduction in mountainous areas of the North Caucasus;
2. Search for ways to reveal, protect and use genetic resources of wild and cultivated flora;
3. Studies in the fields of population and evolutionary biology, ecophysiology and genetics of introduced plants.

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**Fig. 1.** Bakuriani Alpine Botanical Garden: 1. Ecological Station, 2. *Gadellia lactiflora* in the rock garden, 3. *Scorzonera ketzhovelii*, 4. *Paeonia lagodechiana*
The Garden has collections of ornamental plants of the natural flora of the Caucasus (about 120 species); rare, endemic and threatened species (more than 80); local varieties and forms of fruit crops (about 600 specimens); dendroflora of mountainous countries of the world, etc. Some of the species grown in the Garden collections are: *Allium daghestanicum*, *Asphodeline taurica*, *Campanula andina*, *Delphinium puniceum*, *Eremurus spectabilis*, *Euonymus nana*, *Glaucium flavum*, *Leucojum aestivum*, *Nectaroscordum tripetale*, *Paeonia tenuifolia*, *Papaver bracteatum*, *Psephellus hymenolepis*, *Pterocarya pterocarpa*, *Salsola daghestanica*, *Salvia canescens*, *Sternbergia colchiciflora*, etc.

Gunub mountain is an isolated synclinal limestone plateau stretching from the East to the West, with well-pronounced edges. Its area is about 15 km², maximum altitude is 2351 m asl and minimum 1400 m asl. The plateau, which has the shape of a plateau-like range, is mainly constituted by Upper Jurassic, rarely Upper Cretaceous limestone with dolomites.

Climatic indices at the level of the former location of the meteorological station (1583 m asl) characterize the climate as continental. Annual precipitation is 680 mm with its maximum in June-July; 80-90% of the annual amount falls during the summer months. Mean annual temperature is 6.7°C with its maximum in July-August, mean maximum is 12.3°C and mean minimum 2.8°C.

Soils on the plateau are brown forest and mountain meadow black soil-like stony and rubbly, weak.

Significant areas of the northern and partly southern slope are occupied by fallow lands (since the 1860's) now in part covered by forest communities. At present almost the whole terrace system is transformed into hay fields and pastures. Forests cover about 190 hectares of the northern slope between 140-2100 m asl and are mainly represented by birch forest. On the lower part of the plateau (1430-1500 m) hornbeam (*Carpinus caucasica*) forest, rarely poplar (*Populus tremula*) forest predominate with *Pteridium aquilinum*, *Calamagrostis arundinacea*, *C. caucasica*, *Carex humilis* in the herbaceous cover.

*Pine* (*Pinus kochiana*) forest forms a pure stand in the upper part of the plateau (up to 2100 m), but pine also makes up sporadic micro-communities in the birch forest. Birch forests located at middle altitudes (1500-2000 m) are dominated by three species (*Betula pendula*, *B. litwinowii* and *B. raddeana*), each of which forms both pure and mixed stands usually with *Salix caprea*. *B. raddeana* was first described in 1885 by G. Radde on Gunib plateau (*locus classicus*). The species forms many hybrids with the two other species.

The shrub layer of the Gunib forests is rather homogenous, if present, and comprises *Juniperus oblonga*, *Rosa oxyodon*, *R. pulverulenta*, *R. spinosissima*, *Cotoneaster racemiflorus*, *Euonymus verrucosa*.

Secondary and subalpine meadows (1700-2350 m) used as pastures are represented by stepped meadows dominated by sod-forming grasses, mainly *Festuca varia*, *Carex humilis*, *Alchemilla sericata*, *A. rigida*, etc. Grasslands are totally degraded on account of overgrazing.

Large areas on southern and eastern inner slopes of the plateau are occupied by petrophytes, and mountain steppe and rock xerophytic species communities grow on erosion cones. *Salvia canescens* C. A. Mey. (= *S. daghestanica* Sosn.) is a constant component of these communities.

In the flora of the plateau there are a great number of species endemic to Dagestan and more widely distributed endemics of the Caucasus, many of which are first described from this plateau (*Allium gunibicum*, *Medicago gunibica*, *Rhamnus awarica*, *Gentiana grossheimii*) or from Limestone Dagestan. Among them are species from various families: *Asteraceae* (*Artemisia daghestanica*, *Jurinea ruprechtii*, *Kemulariella rosea*), *Brassicaceae* (*Alyssum daghestanicum*, *Matthiola daghestanica*), *Campanulaceae* (*Campanula andina*, *C. daghestanica*), *Caryophyllaceae* (*Silene daghestanica*, *Gypsophila capitata*, *Dianthus awaricus*), *Cistaceae* (*Helianthemum daghestanica*), *Convolvulaceae* (*Convolvulus ruprechtii*), *Dipsacaceae* (*Cephalaria daghestanica*, *Scabiosa gumbetica*), *Fabaceae* (*Astragalus alexandrii*, *Medicago daghestanica*, *Onobrychis bobrovii*), *Lamiaceae* (*Thymus daghestanica*), *Iridaceae* (*Iris timopheevii*), *Poaceae* (*Stipa daghestanica*, *Psathyrostachys rupestris*), etc.
Threatened and rare ornamental plant species occur on the plateau and the most noteworthy are species of the families Liliaceae (*Lilium monadelphum, Fritillaria lutea, Merendera trigyna, M. ghalghana, Puschkinia scilloides*) and Orchidaceae (*Orchis coriophora, O. militaris, O. ustulata, Dactylorhiza triphylla, Traunsteinera globosa*, etc.).

The minimum number of gymno- and angiosperms recorded on the plateau to date is 500. But if the species occurring on outer slopes between 900-1400 m asl and all vascular plants are included, the number reaches 800, i.e. about 25% of the flora of Dagestan (about 3000 species). This makes Gunib plateau a good object for scientific-educational activities in the fields of floristics, plant resource study and nature conservation (Chilikina, 1962).

References

- Chilikina, L. N., Shiffers, E. V. Vegetation map of Dagestan ASSR. Moscow-Leningrad, 1962, 96 p. (In Russian)
International Plant Exchange Network (IPEN): a transparent documentation instrument in accordance with the Convention on Biological Diversity (CBD)

Andreas GRÖGER
Alpengarten auf dem Schachen / Botanischer Garten München, Germany

168 nations worldwide signed the Convention on Biological Diversity. The legal consequences of the CBD are hitting Botanic Gardens into their heart: the acquisition and international exchange of plant material is restricted severely. The main dilemma is that within CBD negotiations Botanic Gardens are not perceived adequately as non-commercial “users of plant genetic resources”. For this reason Botanic Gardens designed a voluntary certification and monitoring system to transfer plants in accordance with the CBD: the International Plant Exchange Network. 124 Botanic Gardens adopted this policy. But a significant increase of IPEN membership is necessary to influence politics and to prevent a very restrictive “International Regime on Access and Benefit Sharing”, on which the forthcoming Conference of Parties in Nagoya in 2010 will decide.

CBD and the reaction of Botanic Gardens
The Convention on Biological Diversity converts more and more into a mere conflict of commercial interests between the industrialized ‘North’ and the biodiversity rich ‘South’. And Botanic Gardens are right on the conflict line! Meanwhile 168 nations worldwide signed the CBD. By implementing especially Article 15 (Access and Benefit Sharing, ABS) of the CBD in national legislation, countries rich in biodiversity try to restrict the access to their ‘genetic resources’. With these restrictions, Botanic Gardens are hit in their heart. The acquisition and international exchange of seeds and plants is affected seriously. The main dilemma is, that in ABS negotiations commercial and non-commercial users of plant genetic resources are not differentiated adequately. A Botanic Garden is underlying the same restrictions as e. g. a pharmaceutical enterprise does. To alter this and to increase the confidence of countries of origin, the community of Botanic Gardens developed standardized voluntary ABS policies. Two initiatives are the most advanced: (a) the Kew Principles on ABS and (b) the International Plant Exchange Network (IPEN).

IPEN is designed as a voluntary certification and monitoring system that facilitates the acquisition and non-commercial exchange of plant material.
between Botanic Gardens, according the provisions of the CBD. In 2003 it was endorsed by the European Consortium of Botanic Gardens and now it counts 124 members in 16 countries.

Key elements of IPEN

All IPEN tools are available as download at Botanic Gardens Conservation International (www.bgci.org/resources/ipen). The three key elements are:

(a) Code of Conduct, which has to be signed to become a registered IPEN member. It sets out a common policy for the acquisition, maintenance and transfer of plant material between member gardens, as well as non-members. Additionally it offers advice for sharing of non-monetary benefits. Once registered, BGCI provides each new member garden with an own acronym (Garden Acronym)

(b) Each plant material that circulates within IPEN has to be tagged with an individual IPEN Number. The IPEN Number consists of four consecutive parts:

- Country of origin (two-lettered ISO country code, “XX” for unknown origin).
- Restrictions of transfer (“1” indicates an existing restriction; “0” if none).
- Garden Acronym (of the Garden which entered the plant material into IPEN)
- Accession number (of the Garden which entered the plant material into IPEN).

(c) Material Transfer Agreement (MTA): In-between IPEN-members the circulation of plant material is unbureaucratic. No transfer agreement has to be signed. Only the correspondent IPEN Number has to be transferred with the plant material, comprising all relevant information. But if plant material is going to leave the network, the recipient has to sign a standardized MTA in advance, guaranteeing that CBD provisions are fulfilled. Therefore this MTA is part of the Index Seminum of every IPEN member.

IPEN Number as a unique identifier

The IPEN Number is the essential element, guaranteeing that the origin of the plant genetic resource is traceable at any time of plant exchange. It acts as a unique identifier that with every transaction travels unmodified with the plant. All derivatives, like seeds, offshoots, DNA samples, etc., maintain that very same IPEN Number.

The IPEN Number is assigned by the first garden, which enters a plant genetic resource into IPEN. This garden is the one, which has to store the full available documentation for the plant material (such as taxonomic data, type of material, source or collecting data, permits related to the acquisition and any conditions or terms of the country of origin). The following gardens, which receive and pass on the plant material, only have to maintain the IPEN Number with the plant. Thereby, IPEN represents a feasible monitoring system according CBD provisions with a minimised bureaucracy.
Some examples, how IPEN Numbers can look like:

**Example (1):** A good deal of IPEN Numbers has to be assigned to plant material without any further information on its origin. For this **plant material with unknown origin** an IPEN Number would look like the following:

```
XX-0-RAM-89.2769
```

**XX:** country of origin is unknown  
**0:** no transfer restrictions  
**RAM:** Jardin Alpin La Rambertia entered the material into IPEN  
**89.2769:** accession number of La Rambertia

**Example (2):** For plant material with documented origin an IPEN Number would be assembled like this:

```
SI-0-TR-A673/3428
```

**SI:** country of origin is Slovenia  
**0:** no transfer restrictions  
**TR:** Giardino Botanico Alpino Viotte entered the material into IPEN  
**A673/3428:** accession number of Viotte, under which detailed information is available

The “country of origin” may not mistaken for information on the general distribution of the species. It is only used, if it is documented that the plant material was collected originally in this country.

**Example (3):** Plant material with transfer restrictions usually is not suited for IPEN. Only in rare cases, an IPEN Number can look like the following:

```
LS-1-M-2003/2855w
```

**LS:** country of origin is Lesotho  
**1:** material with transfer restrictions, which have to be requested  
**M:** Munich BG entered the material into IPEN  
**2003/2855w:** accession number of Munich, under which detailed information is available

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**Reasons to join IPEN now**

The major mission of IPEN is that Botanic Gardens demonstrate that they are complying with CBD provisions. IPEN aims towards an increasing transparency in the transfer of plant material, thereby creating a climate of confidence between countries of origin and Botanic Gardens.

In October 2010, the Conference of Parties to the CBD (COP 10) will meet in Nagoya (Japan). This meeting will be crucial, because after 16 years of negotiations a decision will be taken on the form of the “International Regime", which should regulate the implementation of ABS aspects for all Parties. That means that after COP 10 there will be hardly any scope left to interpretate CBD provisions in an individual way.

The “International Regime” could become a legally binding instrument, that every country has to implement. It could also result in an internationally recognised collection of already existing agreements, laws, and certificates. But
during COP-10 negotiations, voluntary ABS certification and monitoring systems, like IPEN, will only be considered if they are backed by a large (and/or influential) membership. Until now, 124 Botanic Gardens joined IPEN. Only by a significant increase of IPEN members there is a certain possibility to influence politics positively. Otherwise a last chance would have been missed, that the voice of Botanic Gardens would be heard within this political machinery.

Most of the Alpine and Arctic Botanic Gardens participate in the international seed exchange, publish an own seed catalogue or their collections comprise more than only the native flora. To maintain an unproblematic access to plant resources and a free circulation of plant material inbetween the gardens, IPEN is an important instrument, designed as slim as possible, and should be adopted by much more botanic gardens.

References
For more information, see:

In 1974, several representatives of Alpine Botanical Gardens, decided to create an association that united these institutions and approved the statute of AIGBA (International Association of Alpine Botanical Gardens), which aims to study, protect and preserve the alpine flora of every continent. AIGBA promotes scientific, cultural and research programs in collaboration with member Alpine Botanical Gardens, university institutes and public and private organisations. Currently it has about 30 associated gardens and more than 100 private individual members. In Aosta Valley (North-West Italy) there are four wonderful member gardens amidst the highest mountains in Europe: Chanousia, Paradisia, Saussurea and Castel Savoia.

In 1970, several representatives of Alpine Botanical Gardens decided to create an association that united these structures. At the Botanical Garden Rea of San Bernardino di Trana (Turin - Italy), thanks to the efforts of Giuseppe Giovanni Bellia, director at the time, the CIGAAO (International Confederation of Alpine Gardens of the Western Alps) was born. Many gardens in other regions became members, and following this success after four years, at the Garden of Pietra Corva, the confederation became the Association (1974) and approved the statute of AIGBA (International Association of Alpine Botanical Gardens), which aims to study, protect and preserve the alpine flora of every continent.

The Association promotes scientific, cultural and research programs in collaboration with:
- member Alpine Botanical Gardens
- University Institutes
- Public and private organisations.

It organizes at least once a year, an excursion of several days, which assumes the character of a Congress.

Since 1974 - year of the first international conference - AIGBA has passed through more or less brilliant periods. Currently it has about 30 associated gardens and more than 100 private individual members.

During the nineties, there was a brief pause in the Association’s activities, but in 1999 the
publication of the newsletter of the Association: “AIGBA Notes” resumed, a tool for information and exchange for members.

According to Pedrotti (1990) an Alpine Botanical Garden is a botanic garden established in a mountain area for the cultivation of species of alpine flora, meant both as a flora of the Alps, and that of the other mountain systems in Europe and outside Europe.

Roles of alpine botanical gardens are multiple:
- systematic demo (review of the various species present on the territory and not only)
- Educational (perhaps the most important)
- Conservation of rare species in an area
- Research (both flora and vegetation)
- Ornamental

In Aosta Valley there are four wonderful gardens amidst the highest mountains in Europe.

**Chanousia** was born in 1897 thanks to the Abbot Pierre Chanoux, rector of the hospice on the Little St. Bernard Pass. It reached its heyday in the 1920’s with as many as 4500 species from all over the world and with the construction of the building housing the offices, a laboratory, a small museum, a library and accommodation for alpine plant experts. The Second World War left the garden abandoned and it was only in 1978 that restoration work began. Chanousia now holds 1600 species of alpine plants, together with a laboratory and small museum.

**Paradisia** in Gran Paradiso National Park. The name of this garden comes from the delicate flower, the white mountain lily *Paradisea liliastrium*. Today the garden contains 1000 species from different geographical areas, mainly from the Alps and the Apennines as well as from other European, Asian and American mountain areas. The collection of lichens, which grow on 12 rocky areas, is of particular beauty and rarity. Other mountain habitats have been reconstructed in the surrounding area, such as humid areas, moraines and areas of limestone deposits.

**Saussurea** was created by Donzelli Gilberti and Ferretti Foundation and opened in 1987. It contains around 900 species of plants on moraine land which is partially covered by an ancient granite landslide deposit, giving the garden a fair diversity of landscape. In the first area, the
rockeries are planted according to geographical origin – alpine flora from the Aosta Valley, from the western and eastern Alps and also rare species. Further on, we find various mountain environments, several of which have been entirely reconstructed, such us the alder plantation, the humid area, the shores of the stream and the area of limestone debris.

**Castel Savoia** Garden is inside the Castel Savoia park, it was established by Queen Margaret of Savoy in 1898. The Castle is now owned by the Regional Government which has sought to make use of the park land by creating a rock garden, opened in 1990. It can be distinguished from other gardens in the Aosta Valley for the way in which the ornamental quality of the plants is highlighted.

Returning to AIGBA, we've seen its history, now we have a new web-site, for the moment it is in Italian only, but we are preparing the English and French versions, and the future?

We hope the Association will grow and have many new international members including all of you who are here today.
Mutual publicity: a survey panel for European Arctic and Alpine Botanic Gardens

Andreas GRÖGER
Alpengarten auf dem Schachen / Botanischer Garten München, Germany

With the help of a private donation, Munich Botanic Garden has prepared a map of Arctic and Alpine Botanic Gardens in Europe. 66 gardens met the criteria for inclusion: 44 gardens at high altitudes (>1200 m a.s.l.); 5 gardens near the Polar Circle (>64°N); 17 gardens neither in high altitudes nor near the Polar Circle, but dedicated exclusively to alpine and arctic plant species. With 25 alpine botanic gardens, Italy holds the greatest number, followed by Austria (12) and Switzerland (10). The panel will be available as pdf-download for the whole community of Arctic and Alpine Botanic Gardens.

One of the conclusions of the previous conference in Lautaret in 2006 was that a hardware table, which gives a survey of all the Alpine and Arctic Botanic Gardens (AABG) in Europe, would be an attractive tool for every garden and would contribute to mutual publicity. Munich Botanic Garden prepared this panel, with the financial support of a private sponsor and the patience of Christine Freitag for the layout. It was distributed during the conference as a pdf-file, so that each garden can adjust the size of the panel to its conditions. For the whole AABG community the panel is now also available as a download from the Lautaret webpage (http://sajf.ujf-grenoble.fr/).

Criteria for the selected gardens
To compile the list of gardens to be displayed on the panel, selective criteria for an AABG had to be agreed. Of course an AABG has to fulfill the general definition of a Botanic Garden, given by BGCI (Wyse-Jackson 1999):

“A botanic garden is an institution holding documented collections of living plants for the purposes of scientific research, conservation, display and education.”

But many Botanic Gardens hold alpine collections inter alia. Therefore the definition of an AABG was narrowed further to those gardens, which are

- located in high altitudes; >1,200 m a.s.l., or
- located near the polar circle; >64°N, or
• dedicated exclusively to alpine and arctic plants

Of an estimated total of 2,500 Botanic Gardens worldwide, probably far fewer than 100 meet these criteria. In the current survey for Europe a total of 67 AABGs were registered. 45 of them are in high altitudes, 5 near the polar circle, and 17 are neither in high altitudes nor near the polar circle, but their collections are restricted to alpine and arctic plant species.

Layout of the panel

During the selection of the Botanic Gardens for the table, it soon became clear that there would be little space to list more than the mere names. So it was decided that the aim of the table should be to give an idea of the overall distribution of European AABG. For each garden only basic information should be given, such as name, country, elevation, and rough location.

The panel’s size is 88 x 63 cm and displays the AABG distribution on a physical map of Europe, with a magnification of the Alps region.

A short introduction in four languages (English, German, French, Italian) explains what kind of Botanic Gardens are included and where further information for the individual gardens can be found.

Country by country Italy holds the greatest number of Alpine Botanic Gardens with 25. It is followed by Austria (12) and Switzerland (10).

Italy

Giardino Botanico Alpino "Saussurea"
Courmayeur (Val d’Aosta), 2,180 m

Giardino Botanico Alpino "Paradisia"
Parco Nazionale Gran Paradiso (Val d’Aosta), 1,700 m

Giardino di Castel Savoia
Gressoney Saint-Jean (Val d’Aosta), 1,350 m

Giardino Botanico Alpino “Fum Bitz”
Parco Val Sesia (Piemonte), 1,608 m

Giardino Botanico Montano “Nostra Signora di Oropa”
Santuario di Oropa (Piemonte), 1,200 m

Fig 1. The survey panel (original size 88 x 63 cm) displays the distribution of 67 Arctic and Alpine Botanic Gardens in Europe.
Giardino Botanico “Alpinia”
Monte Mottarone (Piemonte), 800 m

Giardino Botanico Alpino “Bruno Peyronel”
Colle Barant (Piemonte), 2.290 m

Giardino Botanico Alpino “Valderia”
Terme di Valdieri (Piemonte), 1.370 m

Giardino Botanico Prealpino “Ruggero Tomselli”
Cima Campo dei Fiori (Lombardia), 1.226 m

Giardino Botanico Alpino “Rezia”
Bormio (Lombardia); 1.350 - 1.420 m

Giardino Botanico Alpino “Viottè”
Monte Bondone (Trentino), 1.540 m

Orto Botanico del Monte Baldo
Monte Baldo (Veneto), 1.230 m

Giardino Botanico Alpino “San Marco”
Monte Corno (Veneto), 1.350 m

Giardino Botanico Alpino Monte Corno
Monte Corno (Veneto), 1.350 m

Giardino Botanico Alpino “Antonio Segni”
Monte Civetta (Veneto), 1.714 m

Giardino Botanico delle Alpi Orientali
Monte Faverghera (Veneto), 1.500 - 1.600 m

Giardino Botanico Alpino “Giangio Lorenzo”
Pian del Cansiglio (Veneto), 1.000 m

Giardino Botanico Alpino di Pietra Corva
Monte Pietra di Corvo (Lombardia), 930 m

Giardino Botanico Alpino “Esperia”
Monte Cimone (Emilia Romagna), 1.500 m

Orto Botanico “Pania di Corfino”
Piè Magnano (Toscana), 1.370 m

Orto Botanico delle Alpi Apuane “Pietro Pellegrini”
Pian della Fioba (Toscana), 900 m

Giardino Botanico Appenninico Campo Felice
Lucoli (Abruzzo); 1.550 m

Giardino Botanico Alpino di Campo Imperatore
Gran Sasso (Abruzzo); 2.110 m

Giardino della Flora Appenninica di Capracotta
Capracotta (Molise), 1.550 m

Giardino Botanico “Nuova Gussonea”
Monte Etna (Sicilia), 1.700 - 1.750 m

Austria
Alpengarten auf dem Freschen
bei Laterns (Vorarlberg), 1.850 m

Alpengarten bei der Lindauer Hütte
im Montafon (Vorarlberg), 1.740 m

Alpenpflanzengarten im Oberen Raintal
Tannheimer Berge (Tirol); 1500 m

Alpenblumengarten am Hahnenkamm
Höfen bei Reutte (Tirol); 1.700 - 1.800 m

Alpengarten am Patscherkofel
bei Innsbruck (Tirol); 2.000 m

Alpenpflanzengarten Vorderkaiserfelden
Zahmer Kaiser bei Kufstein (Tirol); 1.390 m

Alpenblumengarten am Kitzbüheler Horn
Kitzbühel (Tirol); 1.880 m

Alpengarten unterhalb dem Ottogau
Rax (Niederösterreich); 1.600 m

Alpengarten Villacher Alpe
bei Villach (Kärnten); 1.500 m

Alpengarten Bad Aussee
Bad Aussee (Steiermark); 800 m

Alpengarten Rannach
bei Graz (Steiermark); 590 - 650 m

Alpengarten im Oberen Belvedere, Wien

Switzerland
Juragarten Weissenstein
Weissenstein (Solothurn); 1.280 m

Alpengarten Hoher Kasten
Brülisau (Appenzell); 1.790 m

Botanischer Alpengarten Schynige Platte
bei Interlaken (Bern); 1.950 - 2.000 m

Alpengarten Höreli
Adelboden (Bern); 1.500 m

Jardin Alpin ”La Rambertia”
Rochers de Naye (Vaud), 1.980 m

Jardin Alpin ”La Thomasia”
Pont de Nant (Vaud), 1.270 m

Jardin Botanique Alpin ”Flore-Alpe”
Champex (Wallis); 1.500 m

Jardin Alpin ”La Linnaea”
Bourg-Saint-Pierre (Wallis); 1.690 m

Alpengarten Aletsch
Riederfurka (Wallis); 2.080 m

Alpinum “Schatzalp”
bei Davos (Graubünden), 1.870 m
France
Jardin d'Altitude du Haut Chitelet
Col de la Schlucht (Vosges); 1.210 - 1.230 m
Jardin Botanique Alpin "Chanousia"
Colle Piccolo San Bernardo (Val d’Aosta); 2.170 m
Jardin Botanique Alpin du Lautaret
Col de Lautaret (Hautes Alpes); 2.100 m
Jardin Botanique Alpin "La Jaysinia"
Samoëns (Haute Savoie); 700 - 780 m
Jardin Botanique du Tourmalet
Barèges (Midi-Pyrénées); 1.500 m

Germany
Alpengarten auf dem Schachen
Wettersteingebirge (Bayern); 1.860 m
Brockengarten
Nationalpark Hochharz (Sachsen-Anhalt); 1.140 m
Rennsteiggarten - Botanischer Garten für Gebirgsflora
Thüringer Wald (Thüringen); 870 m
Botanischer Garten Adorf
im Vogtland (Sachsen); 430 m
Arktisch-Alpiner-Garten der Walter-Meusel-Stiftung
bei Chemnitz (Sachsen); 350 m

Norway
Ljosland Alpine Garden
Åseral (Vest-Agder); 700 - 750 m
Arctic-Alpine Garden in Breivika
Tromsø; 69°39’N

Iceland
Reykjavik Botanic Garden
Reykjavik; 64°08’N
Akureyri Botanic Garden
Akureyri; 65°41’N

Finland
Oulu Botanic Gardens
Oulu; 65°03’N

Russia
Arctic Alpine Garden Kirovsk
Kirovsk (Murmanskaja Oblast), 67°37’ N

Slovenia
Alpine Botanic Garden "Juliana"
Triglav-Nationalpark (Julische Alpen), 800 m

Spain
Jardin Botanico „Cortijuela“
Cerro Trevenque (Sierra Nevada), 1.800 m

More information on AABG website
This survey is certainly not complete. Even during the preparation for the congress, some more appeared, e.g. the two Alpine Gardens in the Caucasus (see contribution of G. Nakhutsrishvili et al.). Therefore, the panel relates directly to an AABG website, hosted by Jardin Botanique Alpin du Lautaret (http://sajf.ujf-grenoble.fr/). There the complete list of AABG can be held up-to-date.

Furthermore, this list will be complemented by additional information for each individual garden. Munich Botanic Garden already prepared a compilation of following minimum set of data for each garden (only in English and German):

- postal address
- telephone, fax, mail
- webpage
- description of access

As soon as this data is transferred to the Lautaret webpage, the AABG community will own an attractive tool for mutual publicity. Many garden visitors are unaware of the number of AABG in Europe. The panel offers an initial surprising survey and guides them to the website where they will receive further information.

The next step should be to demonstrate the diversity of the collections held in AABG. Focus has to be set on the special collections of each garden (e.g. of a certain geographic area or a certain plant genus). In this way, the public would realize that the AABG are very different in character, which heightens their attractiveness.

References
During the previous conference, “AABG I” in Lautaret in 2006, the gardens represented decided not to establish a formal network in form of an association, because of restricted resources. An informal network was seen as adequate at the moment, providing following tools: a joint webpage, an intranet, survey panels and regular meetings. This decision was approved during “AABG II”. The objectives of AABG conferences that could be accomplished in an informal manner, are:

- to improve communication
- to have a platform to exchange horticultural as well as botanical expertise
- to get inspirations for display and landscaping
- to start joint research projects
- to coordinate collection policies
- to solve common problems
- to strengthen the position of the gardens in the public

The offer of Serge Aubert to maintain a common AABG platform on the Lautaret webpage, was appreciated by the participants. On this platform contact adresses and downloads of joint publications are available. The participants acknowledged the elaboration of a survey panel by Munich Botanic Garden, displaying the location of 67 AABG in Europe. The panel is available as download on the Lautaret webpage.

The general structure of “AABG II” was similar to that of “AABG I”, held in Lautaret in 2006. Participants agreed that future meetings should continue, if possible, in a comparable structure and rhythm. From the five “AABG II” sessions, following needs were concluded:

**Session I (Diversification of collections):**
- Tool to easily source seeds and plants
- Enhancement of focus collections in individual gardens

**Session II (Horticultural practices):**
- List of observations on invasive species
- Survey on germination experience
Session III (Education concepts):
- Education tools / resources for young visitors
- Strengthening AABG as centres of competence

Session IV (Research and conservation activities):
- Research on climate change
- Exchange of mitigation and habitat restauration experience

Session V (Networking):
- Joint webpage
- E-Forum / Intranet

Historically there were several sporadic or mostly regional attempts towards an improved international communication of AABG:

1904  1. Congress of Alpine Gardens, Rochers de Naye (Switzerland)
1905  International Exhibition of Alpine Gardens, Bamberg (Germany)
1906  2. Congress of Alpine Gardens, Pont de Nant (Switzerland)
1974  Foundation of the Associazione Inter-nazionale Giardini Botanici Alpini (Italy)
2001  Exhibition of European Alpine and Arctic Gardens, München (Germany)
2006  1. International Congress of AABG, Lautaret (France)
2009  2. International Congress of AABG, München (Germany)

The forthcoming meeting will be significant, to proof continuity in networking in this framework. For “AABG III” Constatino Bonomi invited to Viotte in 2012. Important subjects to be discussed there, should be:
- ex-situ collections
- hybridization problems
- mission statements
Clusius' gentian (*Gentiana clusii*) in the nature reserve „Garchinger Heide“ (20 km North of Munich), visited by the conference participants, 25 April 2010.
<table>
<thead>
<tr>
<th>Name</th>
<th>Surname</th>
<th>Institution</th>
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<td>Serge</td>
<td>Université Joseph Fourier - Grenoble 1</td>
<td>UJF - Station Alpinique Joseph Fourier, BP 53</td>
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<td>Karim</td>
<td>Conservatoire et jardins botaniques de Nancy</td>
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<td>DELLA BEFFA</td>
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Participant list
25. April – Botanical Garden Munich – photo: Franz Josef Höck
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