Conclusions from the 3rd Global Botanic Gardens Congress

1. Understanding and documenting plant diversity

Achievements

- Botanic gardens are making major contributions to our knowledge of plant diversity, through research in areas such as taxonomy, genetic diversity, conservation and restoration ecology.
- Technological advances are allowing botanic gardens to be more productive and data efficient and are facilitating the management and exchange of information.

Challenges

- Preliminary assessment of the conservation status remains incomplete for most taxa.
- The quality of plant-related information of botanic garden collections is often poor or incomplete.
- The integration and sharing of plant-related information between institutions is limited.
- The potential of new technologies to manage data is often not realised due to institutional constraints.

Recommendations

- Wider participation at the national level is encouraged in the preparation of the world plant list.
- To address the immediacy for conservation action for some species, a pragmatic approach should be adopted to identify and define threatened species.
- Research and information exchange on the impacts of climate change is required in order to develop models to mitigate and adapt to climate change.
- Databases should be strengthened to facilitate access to comprehensive information on plants, including location in collections and active conservation programmes.

The network of Conservatoires Botaniques Nationaux in France and the implementation of the GSPC: results of fifteen years of activities

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Abstract

The Conservatoire Botanique National of the Bassin Parisien: a leading role in plant diversity conservation in the French Ministry of Ecology and Sustainable Development (Departement Ecologie et Gestion de la Biodiversite) In France, the Conservatoires Botaniques Nationaux are responsible for the conservation of plant diversity. The Conservatoire Botanique National of the Bassin Parisien, which comes under the National Museum of Natural History, has five main activities, which are in total accordance with the targets of the GSPC. The communication will present many advancements which have been obtained in these five domains:

1. *The ambitious programme of biodiversity inventory: it allows us today to provide a widely accessible list of two thousand known species, with more than three million data items (the seventh GBIF contributor). The database is useful to support public policies for territorial projects including biodiversity*

2. *The research activity is carried out on very limited size populations and include demographic and genetic studies, the development of protocols and relevant tools for ecological engineering*

3. *A large programme of ex situ conservation, with a seed bank, an in vitro micropropagation unit and a living collection as a back up for the in situ conservation projects*

4. *Numerous in situ programmes are carried out: population reinforcement, reintroduction and transplantation. At the same time, an ecological management of habitats is established to protect the ecosystems*

5. *Communication and education of the general public through the use of different medias*

Introduction

Although France played a major role in the creation of the IUCN at Fountainebleau in 1948 (now called the World Conservation Union), this country has since had a low profile on the international scene. However, since 1990, the creation of the Conservatoires Botaniques Nationaux has enabled France to develop a strong programme in plant biodiversity and conservation. The Conservatoires Botaniques Nationaux, now regarded as the leaders of knowledge in the field of plant conservation, do not have an equivalent in Europe or anywhere in the world. Because its activities have been primarily within France, this country has not been a major contributor to the *Global Strategy for Plant Conservation* (GSPC). Similarly, the activities of the Conservatoires Botaniques Nationaux are seldom represented within Botanic Garden specialized networks (BGCI, ENSCONET…). Now, however, the expertise of the Conservatoires Botaniques Nationaux has progressed to such an advanced degree that they must take on the role of a world leader in this field.

The Conservatoires Botaniques Nationaux have four main objectives:

1. investigate the distribution and evolution of wild flora and natural or semi-natural habitats, using scientific methods

2. identify and conserve rare and endangered wild species and natural or semi-natural habitats

3. publish assessments for the Administration and all local communities

4. educate the public about plant biodiversity and protection

The results obtained within the framework of these missions are evaluated every five years, which leads to the renewal of the ministerial agreement for a new five-year period. At the same time, the scientific committee of each Conservatoire meets every year to assess the actions carried out during the previous year and to make any adjustments thought necessary.

Today, there are eight Conservatoires Botaniques Nationaux, and there will soon beten with the creation of two new Conservatoires (East of France, French Guiana). With the completion of the ministerial agreement for three others (Franche-Comté, Sud-Atlantique and French West Indies), all the French territory will be covered (Figure 1).

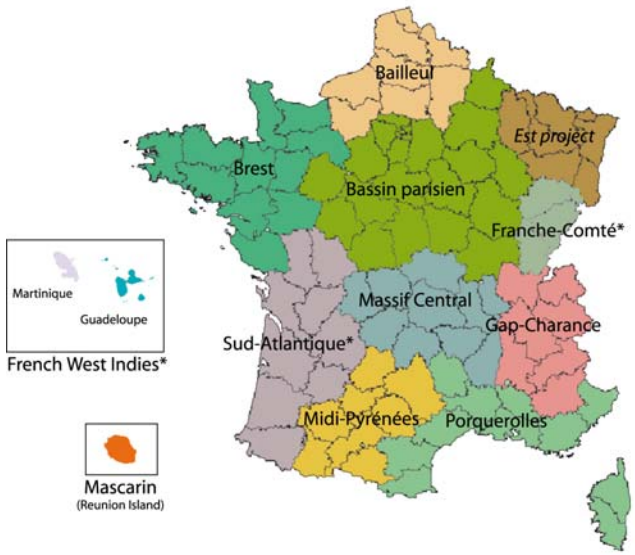

*Figure 1. The network of Conservatoires Botaniques Nationaux in France. *Conservatoires which are waiting for their "National" ministerial agreement*

Since 2000, the Conservatoires Botaniques Nationaux have been gathered in a Federation that:

1. coordinates and standardizes working methods

2. implements and leads national programmes of knowledge of the conservation of flora and their habitats

3. supports new Conservatoires

Moreover, following the adoption of the *Global Strategy for Plant Conservation* in La Haye in 2002, the Federation of Conservatoires Botaniques Nationaux have been aiding the French Ministry of Ecology and Sustainable Development to formulate a French National Strategy for Plant Conservation which is based on the main targets of the GSPC.

Fifteen years after the creation of the network of the Conservatoires Botaniques Nationaux, the Federation is pleased to report significant progress in the knowledge of the distribution of wild flora, understanding of

plant conservation as well as in the success of the public education programmes. France is now making a significant contribution to the implementation of the GSPC.

Understanding and documenting plant diversity

Concerning the flora, the first mission of the Conservatoires Botaniques Nationaux is an understanding of the spatial distribution for all species over the whole national territory. A thorough inventory is carried out which, in addition to data collected by plant fanciers and data from the literature, leads us to a very good knowledge of the plant biodiversity (Figure 2). With more than twelve million items of data, the Conservatoires Botaniques Nationaux have documented the French Flora in great detail. The network of Conservatoires Botaniques Nationaux is the sixth largest contributor in the world to the GBIF programme and provides the only contribution from the Conservatoire Botanique National of the Parisian Basin. The network of Conservatoires Botaniques Nationaux may soon be the third largest world contributor.

This knowledge permits publication of several floristic Atlases, at the local and regional levels, and it permits us to establish regional Red Lists of threatened species, using IUCN criteria.

Moreover, these lists are very useful for planning the programme of seed harvesting and defining the priorities for *in situ* conservation trials.

Finally, this thorough knowledge of plant distribution is very useful for territorial development. For example, the Conservatoire Botanique National of the Parisian Basin developed the "Parisian Hot Spots Map", which is used for public policies. This map is made from the rare and protected species distribution map (Figure 3).

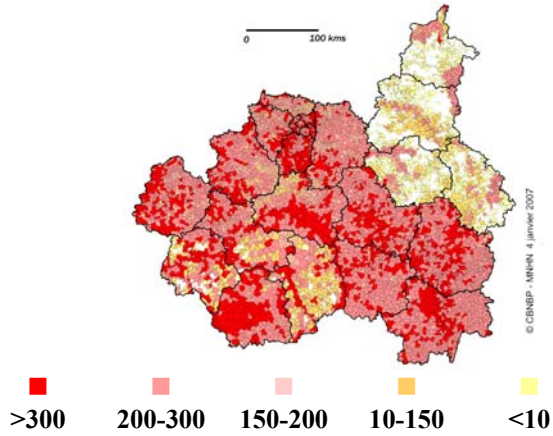

Figure 2. Number of species per commune (after 1990) for the study area of the Conservatoire Botanique National of the Parisian Basin

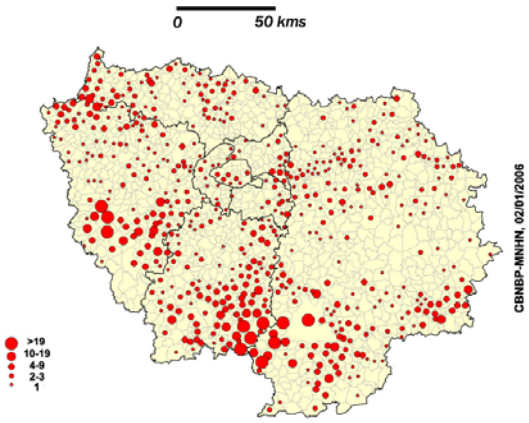

Figure 3. Number of protected species per commune (after 1990) for the Parisian region

Over the last few years the Conservatoires Botaniques Nationaux have improved the knowledge of natural and semi-natural habitats. After having set up a typological reference frame (which establishes common tools for cartography at the national level), a methodological cartography guide has been developed, as well as a guide for identifying natural and semi-natural habitats. Both guides provide a standard method of mapping the habitats. Thus, several hundreds of thousands of hectares were described and mapped, both at a regional level and a local level (Figures 4 & 5).

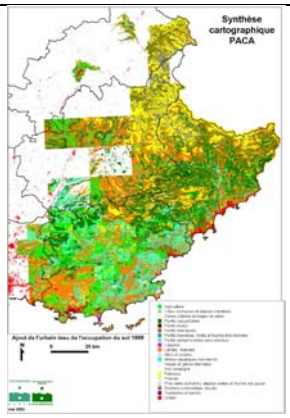

Figure 4. Cartography of natural habitats in the Provence-Alpes-Côte d'Azur region

Realization : Conservatoires Botaniques Nationaux of Porquerolles and Gap-Charance

Figure 5. Cartography of natural habitats of a Seine Valley loop (west of Paris)

Realization : O. JUPILLE, CBNBP-MNHN

The information is available for the public by consulting the different websites of each Conservatoire Botanique National. A website of the Federation is under construction and it will organize access to all French data on flora and habitats.

Thus, the work carried out for more than fifteen years helps achieve two of the prime targets of the *Global Strategy*, and this knowledge will be maintained at a high level, thanks to the installation of Regional flora Institutions.

Development of models and protocols for plant conservation

Relevant programmes of *in situ* conservation require effective tools that are developed in the laboratory and field. This research in conservation biology is interested in population genetics and demography. It is centred on very limited size populations, in order to understand the threats weighing on these weakened populations (consanguinity, Allee effect…).

This research is conducted in partnership with the main French universities, and other institutions with a high degree of expertise (National Natural History Museum in particular).

Conserving plant diversity

The Conservatoires Botaniques Nationaux have developed an integrated vision of plant conservation, whose main target is to ensure the preservation and the conservation of species in their natural habitats. For that, the Conservatoires use the following adapted tools: legal rules for species and spaces, scientific surveys, reinforcement, reintroduction and transplantation of populations in nature (that is often made through partnership with natural area managers), *ex situ* conservation if necessary, research activities on biology and species ecology.

A national assessment is being prepared, about the many actions conducted by the Conservatoires on the 486 species regarded as the most threatened on metropolitan territory, according to *The red book of the threatened flora of France* (*Livre rouge de la flore menace de France*) edited in 1995 (http://inpn.mnhn.fr/inpn/en/conservation/LR/index.htm).

Today, the Conservatoires Botaniques Nationaux have conducted a lot of threatened species conservation programmes, in the field. Ecological management of habitats, reinforcement (Figures 6 & 7) and reintroduction of populations are the tools commonly used to reach this aim. If destruction of habitats is inescapable, transplantation of populations. Each one of these programmes must be authorized by the French Ministry of Ecology and Sustainable Development.

Some of these experiments help develop the conservation methods which must be used for *in situ* conservation trials such the importance of the source of the material in relation to increased genetic diversity, the number of ramets for a reintroduced population and the spatial organization of the ramets.

In addition to the development of relevant tools for *in situ* flora conservation, these experiments help the necessary evolution of laws as regards species reintroduction and origin of plant material used.

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Figure 6 & 7.A reinforcement trial for Equisetum variegatum *(L.) Schleich, a mountain species on the brink of extinction in the French plain*

Ex situ conservation is one of the main aims of the Conservatoires Botaniques Nationaux too. It is carried out both in the laboratory and in the garden.

In the laboratory, seeds which are collected from threatened plants are preserved according to three different modes (dry cold at +4°C, freezing at -20°C and freeze-drying). Various tests are usually carried out to verify if batches keep their capacities to germinate.

The seed harvest is based on legally protected species. Because the revision of the lists is not often done, the seed harvest is extended to species that are threatened according to local botanists.

Garden conservation is arranged around three themes: the supply of material that is absolutely necessary for activities of research in conservation, the precautionary conservation of threatened species, and the creation of plant collections, which after a phase of large scale multiplication, will be used for plans of reinforcement and reintroduction.

This is in fact a dynamic conservation: besides the seed banks of which the goal is to anticipate the changes in the French floristic landscape, the plant material collected *in natura*, after a phase of multiplication in the garden, is intended to maintain the threatened populations in nature.

Invasive species are a problem on which the Conservatoires Botaniques Nationaux have worked for a long time. They have taken an active part in the identification of species which can be regarded as invasive. They contributed to a publication dealing with the biological invasions caused by the exotic plants, including the study of the situation and some proposed solutions (Muller 2004). The Conservatoires Botaniques Nationaux currently contribute to designing tools that allow the French Government to establish rules and prohibit trade in invasive species. As announced in the *French Strategy for Biodiversity* (http://www.ecologie.gouv.fr/IMG/pdf/FRENCH_STRATEGY_FOR_BIODIVERSITY-2.pdf), an institution for invasive species will be created very soon, on the initiative of the French Ministry of Ecology and Sustainable Development, thanks to the information provided by the Conservatoires Botaniques Nationaux.

Promoting education and awareness about plant diversity

The work done by the Conservatoires Botaniques Nationaux to promote education on plant biodiversity and to increase public awareness about the need for its protection is very important. Each Conservatoire uses its own methods but the targets are the same: to give each citizen the tools to take part in some aspect of plant biodiversity protection.

Schools: the Conservatoire Botanique National of the Parisian Basin wrote a handbook dealing with biodiversity and called "*La biodiversité à la portée de tous*" (*The biodiversity that anyone can understand*). This sixteen page handbook was distributed to all the classes in each primary school of the Parisian region (about forty thousands handbooks). Like the other Conservatoires Botaniques Nationaux which accommodate school classes, the Conservatoire Botanique National of Bailleul has a laboratory of three hundred square metres to organize botanic workshops for children

Students: the Conservatoires Botaniques Nationaux accommodate many trainees, from bachelor's degree to post graduate theses. The staff of the Conservatoires teach courses at university on biodiversity conservation and they ensure professional sessions about natural heritage

General public: open days are regularly organized for the *ex situ* collections and the seed banks. Moreover, the scientists of the Conservatoires Botaniques Nationaux take part in many conferences about ecology and biodiversity, and they are often interviewed by the media. The partnership, initiated by the Conservatoire Botanique National of Brest with the foundation of a great industrial parapharmaceutic group, which is interested in conservation and the good use of the plants, has recently supported the publication (two hundred and fifty thousands units) and the free distribution of a handbook of fifty pages dealing with the threatened plant species. At the regional level, the Conservatoires Botaniques Nationaux publicized the problem of invasive species through conferences and publications

Decision makers: to inform public policies is a priority for species that are threatened by extinction. Thus, the Conservatoires Botaniques Nationaux inform the decision-makers of the presence of protected or threatened species. These data must be known before any decisions are made as regards town planning and important building sites. The Conservatoires Botaniques Nationaux accompany and advise local councillors for the setting up of actions for the protection of plants that are on the brink of extinction.

Conclusion

Thus the Conservatoires Botaniques Nationaux are establishments that show a high relevance in the following contexts:

- Convention on Biological Diversity (http://www.cbd.int/default.shtml)
- Bern Convention (Convention on the Conservation of European Wildlife and Natural Habitats (http://www.coe.int/t/e/Cultural_Co-operation/Environment/Nature_and_biological_diversity/Nature_protection/)
- *French Strategy for Biodiversity* (http://www.ecologie.gouv.fr/IMG/pdf/FRENCH_STRATEGY_FOR_BIODIVERSITY-2.pdf)
- *Global Strategy for Plant Conservation* (http://www.cbd.int/programmes/cross-cutting/plant/default.asp)
- *European Plant Conservation Strategy* (http://www.plantlife.org.uk/international/plantlife-policies-strategies-epcs.html)

- Habitats Directive (http://ec.europa.eu/environment/nature/nature_conservation/eu_nature_legislation/habitats_directive/index_en.htm)

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From Kew to Montserrat and beyond: the development and delivery of training programmes to meet the challenges of the *Global Strategy for Plant Conservation*

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Effective Training for the Conservation Challenge

The *Global Strategy for Plant Conservation* (GSPC), the key underlying theme of this Congress, has as its central objective "to halt the current and continuing loss of plant diversity". This is the key challenge for the world's plant conservation community and provides a clear role for botanic gardens worldwide.

Target 15 of the GSPC calls for "The number of trained people working with appropriate facilities in plant conservation increased, according to national needs, to achieve the targets of this strategy". Meeting this target is central to successfully achieving the overall objective of the GSPC. It places a great responsibility on those Institutions that have the capacity to provide effective training and support to raise the overall capacity of the world's botanic garden community to meet the challenges and opportunities provided by the adoption of the GSPC.

The two components of target 15 identify that needs may be based at the individual level by identifying training needs in specific disciplines needed for conservation practitioners (Figure 1). The needs may also be at the Institutional level where the improvement needs to be in providing 'adequate facilities' for conservation practitioners to be able to meet the targets of the GSPC (Figure 2). The balance between these two types of requirements needs to be established on a local and national needs basis.

This session explores a range of approaches and successful examples that the botanic garden community has implemented in their efforts to provide "effective training for the conservation challenge" and in this way enable colleagues internationally to achieve the targets of the GSPC.

Figure 1. Field training in plant identification – Colin Clubbe (RBG Kew) working with Calvin Fenton and Gervaine Greenaway on the Darwin Initiative Centre Hills Project in Montserrat. (Photo: Andrew McRobb, RBG Kew)

How botanic gardens change the world – institutional arrangements & policy influence in plant conservation

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What drives success in plant conservation programmes?

Successful plant conservation depends on a range of partnerships between government, industry, NGOs and the community. The influence of botanic gardens in plant conservation depends as much on their relationships with regulators, developers, educators and communicators as on their intellectual and genetic resources. Cutting-edge plant conservation science is genuinely effective when translated into successful plant conservation programmes. However, this translation is dependent on effective policy influence. Botanic gardens can do a great deal to facilitate successful plant conservation outcomes through analysis and application of national and local conservation policy frameworks, and careful attention to integration with key partners to facilitate policy change.

The balance between conservation research, policy influence and conservation programmes will reflect the environment that a botanic gardens operates in. The location of a botanic gardens within a particular sector - for example, in government, within an educational institution, or privately supported through volunteers or endowments has a significant impact on the charter of a botanic garden, as well as on the nature of cross-sector relationships. However, policy influence can be achieved from any location through a careful analysis of the policy environment, a commitment to effective policy integration and an investment in relationships.

What is policy?

What is policy? Policy is challenging to define – policy is the instrument of governance that directs resources in a particular direction. Policy is the outcome of the competition between ideas, interests and ideologies that impel political and cultural systems (Bridgman & Davis, 2004). The challenge of changing policy has been described by Peter Shergold, the Secretary of the Australian Department of the Prime Minister & Cabinet as '*a contest of ideas*' (Shergold, 2006). Contestability is a fundamental issue – in-house policies are only forged by a limited internal contest. A key challenge in conservation policy is to ensure that the ideas developed through conservation research can be delivered through successful conservation programmes on the ground. In this context, the challenge is to invest in the broader policy contest regionally, nationally and even internationally. How often have ideas established through research been neglected in conservation programmes in the field? Such failures in translating research into action are sometimes seen rather simplistically as a failure in communication. However, such failures may also be seen as failures in policy influence. The complexity of communicating in complex cultural and social environments comprising communities, industries and government can be daunting. In essence, investing in policy is a way of finding the most effective path to communicate, and in turn, to influence outcomes.

Case study – Botanic Gardens of Adelaide

In South Australia the State's botanic gardens, although managed by an independent Board, are within the Department for Environment & Heritage. In this context the Botanic Gardens of Adelaide are well positioned to influence the discussion on nature conservation policy locally and nationally. However, this position doesn't provide any assurance that the Gardens' advice will be taken! The Gardens must work collaboratively through existing policies and programmes to establish an effective link between conservation research undertaken by the Gardens and conservation programmes delivered by the Department and other sectors of Government, by industry and by the community and NGOs.

The Botanic Gardens of Adelaide, together with other Australian botanic gardens, endeavoured to achieve greater recognition for the Global Strategy for Plant Conservation (CBD Secretariat, 2003) targets nationally. The Gardens found a voice by promoting a national working group on biodiversity decline within the context of the Natural Resource Ministerial Council (NRMMC. While conservation agencies nationally didn't see their aspirations as adequately served by the GSPC framework, they recognized key ecosystem-wide threats (- habitat loss & degradation, invasive species & climate change) and have identified the importance of reviewing the national biodiversity strategy. This review provides an opportunity for botanic gardens to contribute to national policy. However, botanic gardens are often unwilling to contribute substantially to policy debate as priorities in conservation research and on-ground conservation programmes are seen to have a significantly higher priority. This policy investment has informed both a South Australian draft biodiversity strategy (Department for Environment & Heritage, 2006), an unpublished report on biodiversity decline in Australia under the auspices of the NRMMC that has in turn has driven a current review of Australia's biodiversity strategy.

Institutional arrangements

Policy only has three levers to effect change – education, regulation and economic instruments such as grants, subsidies and levies. Botanic gardens' conservation research and conservation programmes are likely to be most effective when a reasonable connection is made to these levers. While that connection can be achieved if a genuine endeavour is made to engage policy makers, there are opportunities for structural change to achieve policy integration. The nature of governance arrangements amongst cultural and scientific institutions such as universities, museums, zoos and botanic gardens, and their relationship with government and non-government organizations deserves considerably more exploration than there is time for in this paper. Suffice to say that governance is more often historically-driven than goal or values driven.

Future directions

A dialogue within botanic gardens about the development of policy and investment in policy capacity is worthwhile. Few botanic gardens make such an investment and in some cases might even confuse investments in compliance with regulations such as CITES with genuine policy capacity. If policy investment can effectively influence the translation of conservation research to conservation programmes such an investment may pay significant dividends.

Botanic gardens have changed the world in the past and have the potential to change the world in the future. In the past botanic gardens have profoundly influenced medicine, the nature of our relationship with the natural world, the establishment of empires and economies and the diaspora and commodification of plants.

Botanic gardens intellectual and genetic resources represent an incredibly powerful resource for change. Botanic gardens are currently involved in conserving and harnessing the world's flora to address issues such as dryland salinity, water management, biomass production, carbon sequestration and plant conservation. On the face of it, this is the greatest challenge botanic gardens have ever faced. An engagement in policy development and with policy makers will be critical to botanic gardens achieving success.

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Progress on the *International Agenda for Botanic Gardens in Conservation* in Canada

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Abstract

Introduced in 2000 by Botanic Gardens Conservation International, the *International Agenda for Botanic Gardens in Conservation* has now been adopted by over 400 botanic gardens and networks around the world. The registration process developed by BGCI invites institutions to use the *International Agenda* as a flexible, non-binding framework for their activities in conservation and sustainable development. As of 2006, 27 institutions in Canada have registered their participation in the *International Agenda* with BGCI. The *International Agenda* has had important effects on the network and communities of botanic gardens in Canada, including helping to generate funding support for educational and conservation programmes, and in the development of the *Biodiversity Action Plan for Botanic Gardens in Canada* (2001), and in 2006 an update to the action plan and the nomination of Royal Botanical Gardens as the Canadian National Focal Point for the *Global Strategy for Plant Conservation*. In this presentation we will look at how the *International Agenda* has been used in Canada and the responses of individual institutions.

Introduction

The International Agenda for Botanic Gardens in Conservation (Wyse Jackson & Sutherland, 2000) was introduced to the botanical gardens community at the First Global Botanic Gardens Congress in Asheville, North Carolina, USA, in the summer of 2000.

Initially intended as an update for the 1989 *Botanic Gardens Conservation Strategy* (Peter Wyse Jackson, pers. comm.), months of consultations by Botanic Gardens Conservation International (BGCI) led to a completely different document and approach, which emphasizes the broad range of contributions that botanical gardens make to many issues. The *International Agenda* itself is a very lengthy set of recommendations for individual institutions, national networks and for BGCI as the global network. It makes reference to all relevant treaties such as the Convention on Biological Diversity and the UN Framework Convention on Climate Change.

Immediately following the formal launch of the *International Agenda* in 2000, BGCI established a process called "Registration" through which institutions and networks could formally issue an endorsement of the document. While registrations were slow at first, by 2003 the pace had quickened. Royal Botanical Gardens became the first Canadian institution to register in the fall of 2001, through a resolution of the Board of Directors. By early 2007, 27 institutions in Canada and over 400 around the world have registered.

The purpose of this paper is to place the response to the *International Agenda for Botanic Gardens in Conservation* into context within Canada and make recommendations for effective use of the document by institutions and networks.

The Context of Botanical Gardens in Canada

The botanical gardens community within Canada is neither large nor old. The first botanical garden in Canada, at the medical school of what is now Queen's University at Kingston, Ontario, existed only for about ten years in the middle of the 19th Century. The oldest and largest botanical gardens in Canada today trace their history to development in the first quarter of the 20th Century.

The exact number of institutions that could be classified as botanical gardens is not easy to ascertain. The largest reasonable number is 94 gardens, listed within Botanic Gardens Conservation International's PlantSearch Database. Of these, fewer than 30 could be classified as institutions open to the public with educational, research or plant conservation programmes. A study of educational needs and capacity conducted in 2005 identified 17 institutions with educational programmes or present capacity (McIvor, 2004).

Botanical gardens have not, until recently, been perceived as institutions with strong national relevance in Canada. Multiple attempts were made in the 20th Century to develop a national botanical garden under the auspices of the federal government, but none were successful (Chan, 1972). A national arboretum was developed in Ottawa, called the Dominion Arboretum, under the control of the federal agriculture ministry. This institution included a botanical garden section, but was not developed as a major institution. By the early 1990s, no paid staff were assigned to the Dominion Arboretum; functions of that institution which remain are provided by a volunteer group called the "Friends of the Farm."

Although there was not sufficient interest within the government to support a national botanical garden in the 20th Century, there have been multiple programmes undertaken to link and strengthen the programmes of botanical gardens in Canada.

Several issues lie behind the difficulties of linking and development botanical gardens capacity in Canada. Geographic distance and the resulting isolation are important but are only one element. Another is that each institution is very much an individual entity. Approximately half of the institutions in Canada are based in or operated by university departments of quite varying disciplines, ranging from departments of home economics to forestry and agriculture. For the most part the linkages between these institutions and traditional university botany departments is weak, especially as Canada now has only a handful of such departments. The remaining institutions are a mixed group of agencies reporting to municipal, provincial or federal government departments, or are self-governing not-for-profit organizations.

Development of the Planning Framework in Canada

In 1995, following consultations which led to the Canadian Biodiversity Strategy, the Canadian Botanical Conservation Network (CBCN) was launched as a project of Royal Botanical Gardens, with funding support from Environment Canada, McMaster University and two corporate sponsors, in addition to funds provided by RBG itself. The premise of CBCN is that botanical gardens and arboreta have a great relevance to the conservation of biological diversity and its sustainable use. Since founding, the network achieved incorporation as a charitable organization in 1998, and presently has about 20 institutional members.

In 1997 discussions with Environment Canada and BGCI led to the idea of an action plan on biodiversity issues specifically directed at the botanical gardens in Canada. A new project to complete the plan was launched in 1998. Following more than two years of consultations and editing, the *Biodiversity Action Plan for Botanic Gardens and Arboreta in Canada* (Galbraith, 2001) was published by Royal Botanical Gardens and CBCN. The text of the Action Plan actually predates the release of the *International Agenda for Botanic Gardens in Conservation*. The intent of the *Action Plan* was to bring together the national aspirations of the *Canadian Biodiversity Strategy* (http://www.eman-rese.ca/eman/reports/publications/rt_biostrat/intro.html) with the

programmes that could be delivered by the botanical gardens sector. The project itself was largely funded through Environment Canada, by a three year contribution agreement. The *Canadian Biodiversity Action Plan* was developed with the *International Agenda* in mind.

In an effort to provide an explicit linkage between the targets of the *Global Strategy for Plant Conservation* (GSPC) (CBD Secretariat, 2003) and the work of botanical gardens, BGCI held global and regional workshops at the Second World Botanic Gardens Congress in Barcelona in 2004. The global workshop resulted in a set of specific targets linked to the GSPC but appropriate to the botanical gardens sector. These targets were published in the first issue of BGCI's new publication, *BGjournal* (No. 1(1) July 2004).

By 2005 it was clear that the 2001 Canadian *Action Plan* was already behind the times. The publication of the 2001 plan preceded the completion of the GSPC, and several other relevant developments. Under the auspices of the Investing in Nature: A Partnership for Plants in Canada project, funded by Botanic Gardens Conservation International and its partner HSBC, a global financial services firm, and with support from the Museum Assistance Program of the Canadian Department of Heritage, Royal Botanical Gardens and BGCI-Canada undertook an update of the 2001 *Action Plan*. This document, published in both English and French, showcases plant conservation and education projects across Canada in addition to making a coherent set of recommendations that align with international recommendations and the ideas in the 2001 *Action Plan*. Environment Canada kindly provided support for translation of the document into French.

They were also used in developing the 2006 update to the *Biodiversity Action Plan for Botanical Gardens and Arboreta in Canada.* The update is entitled *Conserving Plant Diversity: the 2010 Challenge for Canadian Botanical Gardens* (Galbraith & McIvor, 2006). This document is subtitled *the 2010 Challenge for Botanic Gardens in Canada* because 2010 is widely recognized as a watershed year. It is the year that the targets of the GSPC are to be achieved; it is also the year in which a series of other important targets related to biodiversity conservation and sustainable development are to be completed or reviewed by the UN.

Progress since 2001

The strong linkages among all of these documents have at their heart the central role of the *International Agenda for Botanic Gardens in Conservation*. They form a deliberate and coherent set of recommendations stretching from the global to the local. Every botanical garden, regardless of its size or present capacity, can make use of these documents to indicate their relevance to their stakeholders, funders, governing agencies and the visiting public.

Despite the complete framework which now exists linking Canadian institutions to the North American and global situations and the many ways that botanical gardens can be relevant to conservation issues, the basic action plans that provide the relevance are at times daunting documents. The *International Agenda* itself contains over 180 individual recommendations, which would be impossible for any individual institution to implement. Instead, individual institutions can scan the many recommendations within these documents and select those which best fit their own capacities and plans, or which may provide guidance in the development of future programmes.

As of 2007, a total of 27 institutions across Canada have registered with BGCI as being in support of the International Agenda. This is the largest single expression of interest in the conservation and biodiversity mission of botanical institutions within Canada. The list of registrants includes several museums and major parks in addition to more conventional botanical gardens. Indeed, it has been suggested registration with BGCI in the *International Agenda for Botanic Gardens in Conservation* provides a self-selection process defining botanical gardens (Galbraith & Rapley, 2005), complementing and expanding an earlier definition by Wyse Jackson (1999) included in the text of *International Agenda* itself.

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Using the *International Agenda*: a global overview

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Introduction

Following a two year consultation process involving contributions from over 300 individuals and organisations, the *International Agenda for Botanic Gardens in Conservation* (IABGC) was launched at The World Botanic Gardens Congress held in Asheville, North Carolina in 2000. Today the International Agenda is now available in all the main languages of the world and freely available as a download from BGCI website.

The *International Agenda* provides botanic gardens with a common global framework for the development policies and action in support of conservation (Wyse Jackson and Sutherland, 2000). Within the framework of the International Agenda, individual botanic gardens can review existing and plan new activities which contribute to conservation whilst maintaining their own uniqueness and the diversity amongst the c.2500 botanic gardens around the world today. A contribution to conservation includes activities directly conserving threatened plants as well as activities such as environmental education and sustainable development.

The *International Agenda* defines the global mission of botanic gardens worldwide in conservation as follows:

- Stem the loss of plant species and their genetic diversity worldwide.
- Focus on preventing further degradation of the world's natural environment.
- Raise public understanding of the value of plant diversity and the threats it faces.
- Implement practical action for the benefit and improvement of the world's natural environment.
- Promote and ensure the sustainable use of the world's natural resources for present and future generations.

International Agenda Registration of Commitment

In 2002, BGCI launched a process whereby institutions and organisations could register their commitment to work to achieve the objectives and targets of the *International Agenda*. Today, 480 institutions and organisations from 85 countries have registered their commitment to conservation through the *International Agenda*. The commitments can either be formal, e.g. governing body resolution, or informal. An institution registering its commitment is under no legal obligations; the process is a public statement of commitment towards conservation.

The number of registrations in each country (Figure 1) is greater in countries where the national network has strongly supported it, such as in Poland, and where BGCI has had national programmes of work such as in Argentina. Naturally countries which have many botanic gardens, e.g. USA, are also likely to have a higher number of registrations than countries with few botanic gardens e.g. Africa countries.

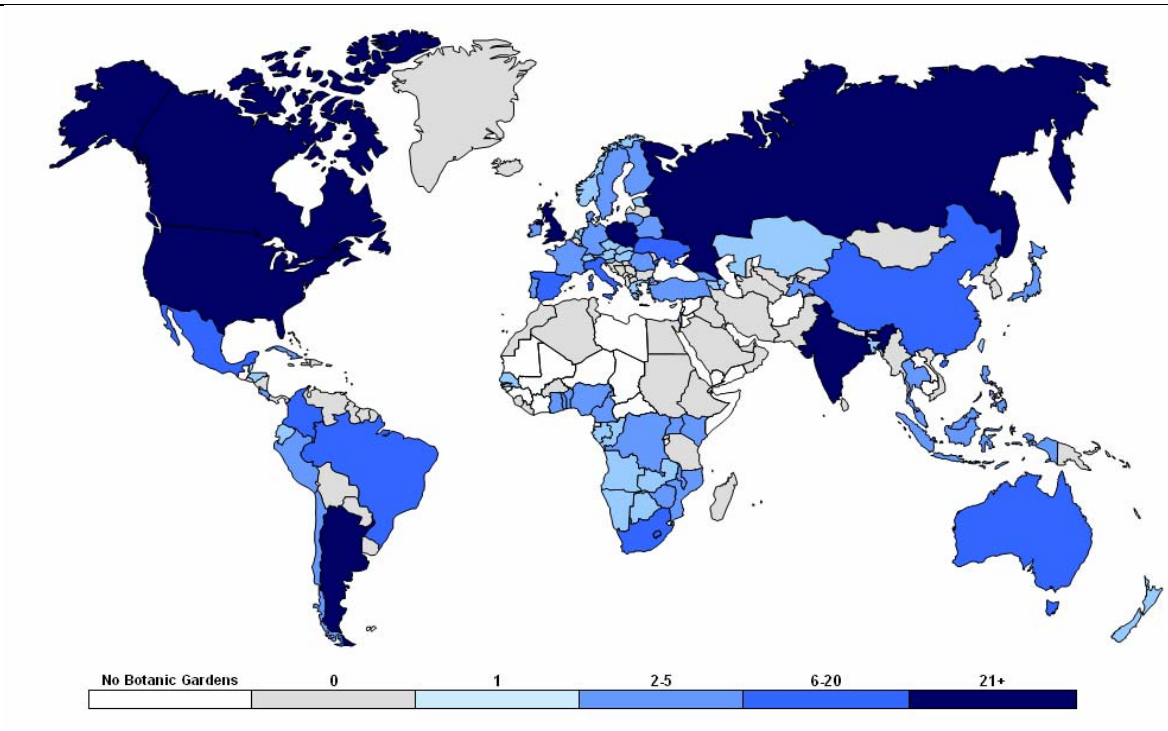

Figure 1. International Agenda for Botanic Gardens in Conservation – Global distribution of participants.

The Convention on Biological Diversity (CBD) has also recognised the *International Agenda* as representing the botanic garden community's response and contribution to the achievement of the *Global Strategy for Plant Conservation* (GSPC).

In order to help measure the achievements of the objectives of the International Agenda and as a contribution to the GSPC, a series of 20 targets were developed for botanic gardens at the 2nd World Botanic Gardens Congress, held in Barcelona, Spain in April 2004. Further details on these 20 botanic garden targets can be found at www.bgci.org/worldwide/bg_targets

Self-assessment of the implementation of the *International Agenda*

With 211 potential activities listed in the *International Agenda*, no single institution is expected to be able to or should wish to implement it in its entirety. Each botanic garden will have its own mission and focus, therefore only sections of the *International Agenda* will be relevant to it work. However, by assessing what an institution is currently doing with respect to the International Agenda it will be able to identify opportunities to improve its current contributions towards conservation.

Dr David Galbraith developed an IABGC self-assessment tool when The Royal Botanic Garden, Hamilton, Canada decided to review its activities (Galbraith, 2003). The spreadsheet tool goes through each of IABGC activities and asks the assessor to judge whether it is engaged in a particular recommendation ("Doing"), might do so in the future ("Considering") or is not doing it now nor contemplating such action in the future ("Not Doing").

David Galbraith's tool has subsequently been used by The South African National Biodiversity Institute (SANBI) to review the work of its network of National Botanic Gardens.

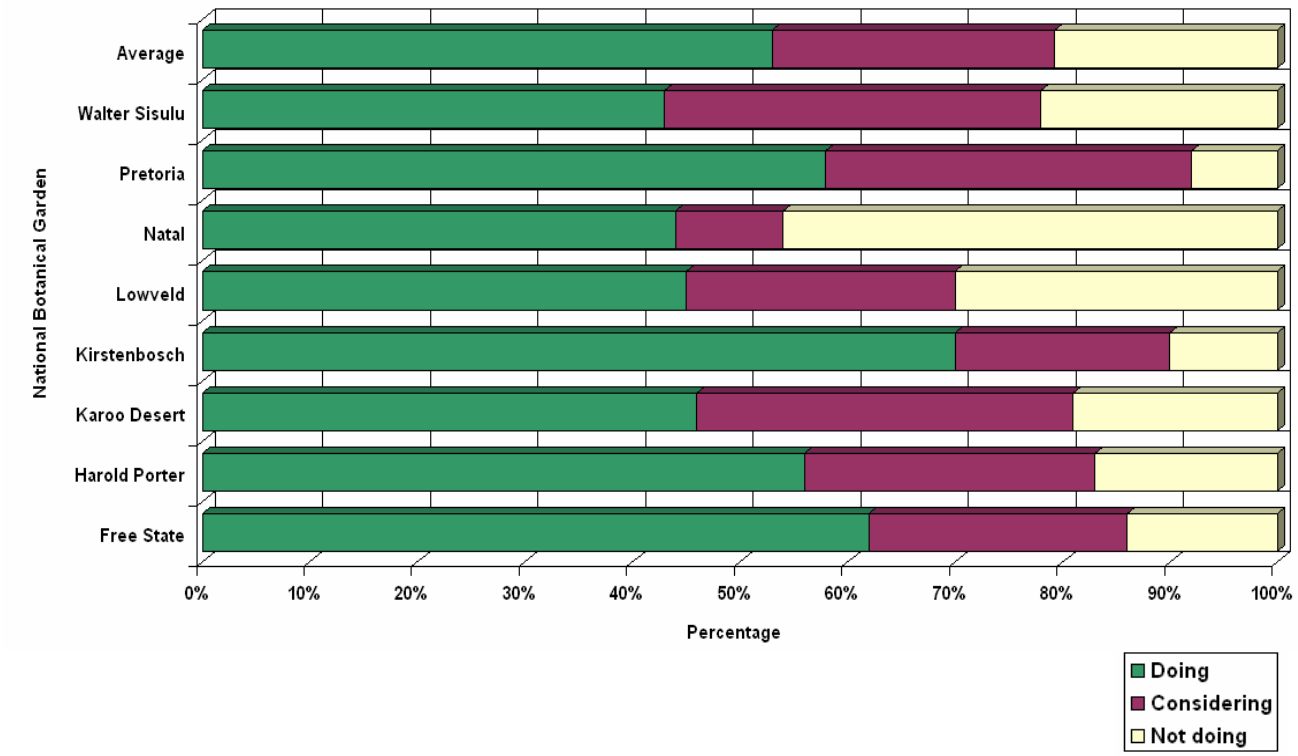

Table 1. International Agenda Implementation across South Africa's National Botanical Gardens South African National Biodiversity Institute

The assessment carried out by SANBI (Table 1) illustrates two important points about the *International Agenda*. Firstly, no single institution will implement the entire *International Agenda*. Secondly, even within a network of botanic gardens under the same national institution there can be great differences in each individual botanic gardens focus and therefore how it will implement the *International Agenda*. A detailed discussion on the SANBI *International Agenda* assessment was presented by Willis (2006).

Following on from the success of the self-assessment tool by The Royal Botanic Garden, Hamilton, Canada and the botanic gardens of South African National Biodiversity Institute, BGCI is currently developing an online version of the tool. This tool will allow gardens to self-assess their activities against the International Agenda, section by section, and to periodically revisit the tool and reassess themselves over time. Not only will this tool provide valuable information to the garden for planning and monitoring their activities, but will also allow BGCI to provide a more comprehensive overview of the implementation of this important global initiative.

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Eden Project, facilitating change

Alistair Griffiths

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Abstract

Eden Project was conceived in 1994 and built in a former Cornish clay pit in the South West of the United Kingdom.

The 21st Century will be a time of radical change for society. Rising energy costs, changing demographics, escalating extinctions, global economic shifts, pandemics – all represent major challenges and are all set against a background of climate change that may be the greatest threat of all. Eden's aim is to present, to the widest possible public audience, the need for environmental care through celebrating what nature gives to us. Eden provides a stage on which to illustrate the choices we can make to foster a better world.

Introduction

Eden Project was conceived in 1994 and built in a former Cornish clay pit in the South West of the United Kingdom costing so far £135 million (Figure 1). Eden's Visitor Centre opened to the public in May 2000 and the full site opened in March 2001. Eden is a not-for-profit Charitable Trust. Its mission is to promote the understanding and responsible management of the vital relationship between plants, people and resources leading towards a sustainable future for all. Five years after opening, Eden has contributed £700 million to the local economy; it is amongst the top five paid-for visitor attractions in the UK, and since opening has hosted eight million visitors. Eden Project provides a 'Living Theatre' where examples of positive initiatives from around the world are displayed, explained and supported. Eden communicates its story through various media using a backdrop of great architecture and 1,000,000 plants representing 5,000 species from many of the climatic zones of the world. Many of these can grow in the mild conditions of Cornwall, others need greenhouses or Eden's two gigantic Biomes - the biggest conservatories in the world. These Biomes feature plants, crops and landscapes from the humid tropics and warm temperate regions and act as a backdrop to the outdoor temperate landscape which mirrors our UK environment.

The 21st Century will be a time of radical change for society. Rising energy costs, changing demographics, escalating extinctions, global economic shifts, pandemics – all represent major challenges and are all set against a background of climate change that may be the greatest threat of all. Eden's aim is to present, to the widest possible public audience, the need for environmental care through celebrating what nature gives to us. Eden provides a stage on which to illustrate the choices we can make to foster a better world. In setting this goal, however, we need to have a sophisticated understanding of the barriers to engagement that most people experience. Eden believes that people really want to do something positive to make a difference but are: Confused about the complex issues; Held back by a lack of understanding about the connections between them; Overwhelmed by the scale of the challenges; Unclear what actions are really effective; What changes are under their control and generally worried that there will not be a positive route to the future. Eden's role is to tackle these barriers by developing an interpretation and education programme that builds connections, illustrates choices and also crucially builds an understanding that we can rise to the challenge and face change with hope. In the face of these challenges we need to build an awareness of how to sustain that which sustains us.

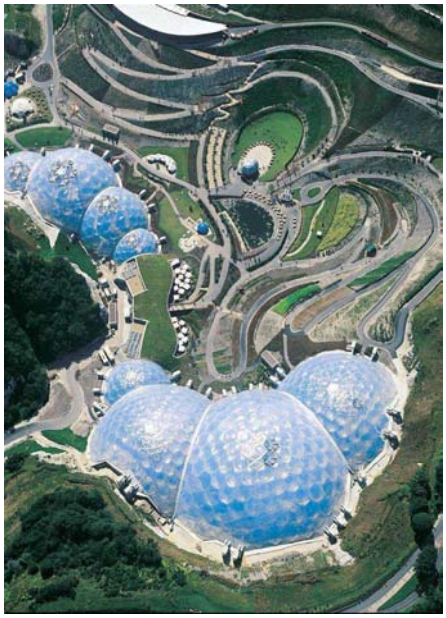

Figure 1: Left: Photograph taken in 1995 of the former Cornish china clay pit Right: Photograph taken in 2001 of the Eden Project with the two biomes the larger being the Rainforest Biome, the smaller, the Warm Temperate Biome.

Eden uses exhibitions, art, storytelling, workshops, retail, lectures and events to explore themes and topics with the public, professionals and formal education groups. This education programme comprises major themes of great significance such as climate change and energy, food, nutrition, health and well-being, biodiversity and sustainable use of natural resources. This presentation aims to provide an insight into how the Eden Project has explored and began to successfully facilitate change in the world.

Finally this presentation will discuss a future development of the Eden Project called The Edge. The Edge has its roots in our original ambition to have a Biome that focused on the desert regions of the world. This building will be a landmark construction and complement the existing Eden Project, it will focus on the challenges of water use and water security, energy use and energy security and climate change. Together these issues will lead to pivotal social challenges affecting us all in the next two decades, with impacts on individuals and communities that will be arguably as significant as the great transformations of history – settled agriculture, the reformation, the enlightenment and the industrial revolution. The Edge aims to raise the following questions: How do the choices we make affect our collective futures? Are we in shape for the 21st century? And how well are we equipping our children for the world ahead of them?

A public consultation process for Christchurch Botanic Garden

Jeremy Hawker

Christchurch Botanic Gardens, New Zealand

Abstract

A unique public consultation process was recently undertaken for the draft management/master plans for the Botanic Gardens in Christchurch, New Zealand. This process also highlighted the measures necessary to bring these Gardens up to an international standard that contributes to achieving the objectives of the *Global Strategy for Plant Conservation*.

Christchurch Botanic Gardens

The Gardens will be 150 years old in 2013 and the planning undertaken, the development of facilities and functions during the coming years will mean that the City of Christchurch will have a proven world class facility that is fully 'botanic' without loss of its garden beauty.

The Gardens is located in an 'enclave' defined by the Avon River within Hagley Park, less than one kilometre west of Cathedral Square in the City of Christchurch on the east coast of the South Island of New Zealand, latitude 43º, 31', 48" S, longitude 170º, 37', 13" E (see Figure 1).

Figure 1. Hagley Park with the Christchurch Botanic Gardens at the centre

Master Plan Approach

The separate areas of land administered by two unique management plans quickly highlighted the range of issues that needed to be discussed, addressed and resolved.

Visions were developed, "For Hagley Park to remain an iconic inner-city open space for the City of Christchurch - a place for present and future residents and visitors for recreation and enjoyment", and "The Christchurch Botanic Gardens is foremost to celebrate and present plant diversity through collections and programmes, including promoting the relationships that people have with plants".

The drivers for change came from a need for effective and up to date planning documents. This included an obligation for the Council to implement stated management policies and actions in a reasonable space of time, implications of adjacent land use planning and development, ensuring an acceptable public experience, recognition of environmental and wildlife values, recognition of heritage values, best practice management, changing needs of partnerships, and bringing the Botanic Gardens into the 21st century.

The master plan document integrates both the Park and Gardens planning, and lists significant projects impacting on both.

Strategic planning was needed to address the Gardens existing state, and the adjoining Hagley Park, as well as other adjacent land e.g. road networks. Beginning in 2004, a planning exercise was undertaken to evaluate the gardens, and examine its current functions with the intended purpose of enhancing the visitor experience, developing plant conservation strategies, developing research programs, and address infrastructure issues.

The Master plan provides strategic direction and vision, while the Management Plan provides policy and guidance to the ongoing management of the Gardens.

The Gardens strength, without a doubt, lies in its amenity and horticultural elements, developed by successive Curators and staff since 1863. The plan aims to reinforce these elements, but importantly indicates that the future direction of the Gardens will be to increase and strengthen science, research, conservation and education.

Why Public Consultation?

Protected under central government statute - the Reserves Act 1977, the area is classified as Local Purpose (Botanic Garden) Reserve.

The Gardens are zoned in the City of Christchurch City Plan as Conservation 2.

The Christchurch Botanic Gardens are administered by the Christchurch City Council, and are solely funded by rates, with an operational budget of NZ $3,000,000 per annum.

While there is no statutory requirement under the Reserves Act to have a management plan, the plan is used to communicate the functions, direction, and management, of the Gardens, and is reviewable every 10 years.

Public consultation allows for open dialogue with key stakeholders, assists in providing direction, and increases ownership within the local community.

Significant differences to previous plans

The late Dr David Given, undertook a strategic review of the gardens, highlighting its current function and evaluating its strengths which include: around 35,000 accessions, comprising 6,500 catalogued species and cultivars, as well as around 2,500 conservatory specimens: large annual visitor numbers, (last year above 1.5 million, made up of three quarters of Christchurch residents and about 250,000 international tourists).

The Gardens are part of the cultural precinct of inner city Christchurch. This includes the Canterbury Museum, Christchurch Art Gallery and Christchurch Cathedral. The temperate climate permits a wide range of plant material displaying the changes over the four seasons. This allows for a wide range of material to be displayed within easy reach of residents and visitors.

The review highlighted several deficiencies: a very limited range of functions based on living collections, conservation, education, and research. There is a herbarium onsite, though small. Education programmes are delivered to a limited extent, and there is a desire to enhance the education opportunities provided.

Conservation programmes are limited, and the threatened plant collection is in need of refurbishment and enhancement. There is no active participation in the recovery of threatened species.

The infrastructure is inadequate providing little available space for the existing library. Added to this is the absence of a seed bank or germplasm facilities.

The draft plan had four sections for consideration:

1. an underlying principle for the Botanic Garden in Christchurch, considering the history, development and nature of botanic gardens

2. the significance of botanic gardens in the contemporary world

3. an examination of resources and issues affecting the gardens currently; the present and proposed management goals, objectives, and policies

4. an issue and action that provides direction for the future of the Gardens is promoted. This includes a discussion of issues, resulting in an action plan to address deficiencies

The consultation process

In October 2006, the “Christchurch Botanic Gardens Management Plan”, a “Management Plan for the adjacent Hagley Park” and a Master Plan for both areas were presented to local residents for consideration and requesting their submissions (Christchurch City Council, 2006a, 2006b, 2006c). A series of public meetings, and media communication were undertaken resulting in 600 submissions on the combined plans. Hearings were undertaken in front of a panel comprised of local elected officials. Consideration of submissions and recommendations are to be presented to the local authority council for ratification.

A time of change

Basic botanic garden activities, such as education, conservation and research, are not yet well catered for in Christchurch. They are becoming recognised by the City as significant botanic garden functions that need to be considered in any redevelopment.

The City asked residents the following questions:

1. Does the collection make a significant contribution at any scale to scientific knowledge and research, or does it provide important research material?

2. Does the collection preserve threatened species, provide material for restoration projects or in any other way facilitate the achieving of biodiversity conservation?

3. Does the collection make a significant contribution to regional or national cultural needs, including providing a source of materials for cultural use and training?

4. Does the collection contribute to formal education or more informal awareness of botanical and ecological principles, plant knowledge, conservation biology, horticulture or relationships between people and plants?

5. Does the collection contribute to raising awareness of the role of amenity horticulture, lead to providing training and capacity building of people working in the horticultural field, profile new plants (including trialling) and provide sources of acceptable plant material?

6. Does the collection contain species that are of known economic value and does it provide an opportunity for the trialing of plants that have proven or potential economic value?

7. Can the collection be readily maintained, given present facilities and climatic/soil conditions, or is it likely that such conditions and facilities can be acquired within the foreseeable future?

8. Is this a collection that will have high value as a primary collection not held elsewhere or are there numerous duplicate collections (and should the Gardens support those other collections instead?)?

Conservation Strategy

Within the plan a conservation strategy is proposed. This includes a list of goals to be achieved to contribute to the *Global Strategy for Plant Conservation* (GSPC) (CBD Secretariat, 2003). The explanation "Conservation means ensuring that a range of plants, especially those that are threatened in some way in their natural environment, are protected in collections." It was followed by the objective, "The Gardens will contribute to the conservation of global and regional plant diversity through collections and genetic banks, education and awareness, and practical conservation action, while also setting high standards in biosecurity, energy and waste conservation, wildlife habitat maintenance and environmental health." A series of goals and actions form the body of the conservation strategy.

Subject groupings and the action points state how this is going to be achieved. Goals include the role the Garden will take in maintaining collections of threatened species both within the gardens and wild populations. This includes an advocacy role, a source of information for biological conservation, a targeted biosecurity policy, and external strategies on conservation to be adopted. Importantly this contained the following action point:

"The Gardens will support and actively promote the *Global Strategy for Plant Conservation* under the Convention on Biological Diversity, including achieving national targets, and apply the framework for good

conservation practice by botanic gardens as promoted in the *International Agenda for Botanic Gardens in Conservation* [Wyse Jackson & Sutherland, 2000]."

The way forward

After having reviewed the existing plans, setting forth clear directions and objectives, and seeking the mandate from the local community for the proposed changes and developments, through a public consultation process, the Christchurch Botanic Gardens is clearly seeing the need to increase its current range of functions. Conservation, research, education and, enhancing the visitor experience are at the forefront of future developments and planning. Providing these raises the questions of implementation, and it has been clearly communicated that partnerships with existing institutions will be considered as a way of achieving mutually beneficial results.

The Christchurch City Council have provided funding for infrastructural changes to staff work areas and visitor facilities, including increased library, herbarium, research and education facilities. Currently discussions are being undertaking in setting up a joint appointment between the Christchurch City Council and the University of Canterbury for the position of Curator.

These initiatives are an indication of the direction and desire for the Gardens to contribute to the international botanic community, to provide resources and facilities for education, contribute to the conservation and research of plants, while still maintaining an environment that allows for people to develop relationships with plants, in an aesthetically pleasing setting.

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The GSPC implementation in Spain: first steps towards a National Plant Conservation Strategy in Spain

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Abstract

Since the *Global Strategy for Plant Conservation* (GSPC) (CBD Secretariat, 2003) was established, Spain has made an outstanding contribution to the implementation of this Strategy. The process began in 2000 with the *The Gran Canaria Declaration calling for a Global Program for Plant Conservation* (BGCI, 2000). One of the meetings of the international commission to draw up the GSPC objectives was also held in Gran Canaria. At least two Spanish members – representing international organizations involved in the CBD - attended these meetings. With their attendance, two Spanish botanical gardens were also present. When the GSPC was adopted during COP 6 (The Hague. 2004), Spain held the EU Presidency and played an important role in the search for the necessary international consensus.

Furthermore, the REDBAG constitution (Red Española de Bancos de Germoplasma de Plantas Silvestres - Spanish Network of genebanks for wild plants) provided an early response to the Spanish commitment to GSPC (Target 8 for *ex situ* conservation). The Ministry of the Environment will soon recognize REDBAG as an official Network. More recently (November 2006), an international Symposium was held at the Cordoba Botanic Garden supported by the Areces Foundation which meticulously analyzed the degree of GSPC implementation in Spain. This work shows the fulfilment target by target. The conclusions of this Symposium will require the Ministry of the Environment to draw up a single Spanish Strategy for Plant Conservation. This proposal has been accepted and the first steps have been taken to initiate it.

Introduction

Since the *Global Strategy for Plant Conservation* (GSPC) (CBD Secretariat, 2003) was established, Spain has made an outstanding contribution to the creation and development of this Strategy. The process began in 2000 with the *The Gran Canaria Declaration calling for a Global Program for Plant Conservation* (BGCI, 2000). which was drawn up during the meeting held in the *Viera y Clavijo* Botanical Garden, Gran Canaria.

In order to draft the GSPC text and objectives, a work team was created which assembled in Montreal, London, and once again in Gran Canaria. These meetings were always attended by at least two Spanish members, in representation of international organizations or committees, as well as diverse Spanish institutions and Botanical Gardens.

When the GSPC was adopted during COP 6 (The Hague. 2004), Spain held the EU Presidency and their position in favour of this Strategy jointly with the role played by the Spanish Representation during the Conference was essential in the search for the international consensus required for its approval. Simultaneously, REDBAG (Spanish Network of genebanks for wild plants) was founded within the Central Office of the Ibero-Macaronesian Association of Botanical Gardens of Spain, in which they offered the Spanish Ministry of the Environment (MIMAM) the national network role as a direct response to Target 8 of GSPC. This recognition is still in the approval process.

In February 2006, also promoted by the *Viera y Clavijo* Botanical Garden, the work team assembled in Gran Canaria again in order to prepare the Gran Canaria II Declaration, which considers the response of botanic

gardens and the scope of the *ex situ* conservation to address the problems caused by climatic change on biodiversity (BGCI & Cabildo de Gran Canaria, 2006).

More recently (November 2006), a Symposium supported by the Areces Foundation and held in the Botanic Garden of Córdoba, meticulously analyzed the fulfillment level of all the GSPC targets in Spain. The Spanish State already had a National Biodiversity Strategy but it was necessary to carry out an in-depth revision of the GSPC targets and even to propose the elaboration of a National Strategy specifically for Plant Conservation which has a more direct response to the GSPC goals.

As a result, MIMAM has been requested to write up the Spanish Plant Conservation Strategy (ECP). This proposal has been positively accepted and the first steps have been taken to draft it.

The ECP must have minimum objectives which are clear and realizable in a specific time period and size, and it must include mechanisms which stimulate the participation of all the relevant sectors and coordination between government departments and institutions. It must also incorporate specific action plans, work tools, financing mechanisms, and tracking, as well as indicators and evaluation systems.

This Strategy must be the reference framework in which the activities developed by the different government departments and institutions converge in a coordinated programme, in order to achieve the targets set forth by GSPC, as well as other actions which it considers necessary to include in order to ensure the conservation of plant diversity.

The Public Administration sectors must be considered, including the State and Autonomous territories, in order to promote the cooperative policies required to fulfill the GSPC goals. The Public Sectors related to the fields of agriculture and forestry must also be integrated in the ECP development. It also welcomes the participation and integration of other public and private institutions related to this matter, which include, the Spanish National Research Council (CSIC, Iberian Flora Project, Anthos), Universities (Departments and Research Groups), Ibero-Macaronesian Association of Botanical Gardens of Spain (AIMJB), Spanish Society for Conservation Biology of Plants (SEBCP), Spanish Bryological Society (SEB), Spanish Network of genebanks for wild plants (REDBAG), the Spanish IUCN Committee, and other NGOs committed to the conservation of plant diversity.

A review of the present contribution by Spain to the implementation of the GSPC

Following the analysis of the commitments acquired for the GSPC and the fulfillment level achieved in Spain at present, for each of the 16 targets of GSPC, the main achievements accomplished and the desired objectives for ECP are mentioned:

(a) Understanding and documenting plant diversity:

(i) The Iberian Flora project is highlighted (http://www.rjb.csic.es/floraiberica/). At present, there are complete regional and local floras, including the Canary Islands, jointly with various information technology projects and on-line consultation of the distribution of species (Anthos, GBIF). Nevertheless, there is an urgent need to prepare a complete and accessible list of all the vascular plants of Spain's flora which is also desirable for the bryophytes, as well as to promote and improve the Internet consultation systems on the Spanish flora species.

(ii) The Red List (Lozano, 2000) of Spanish vascular plants includes 1414 taxa (IUCN criteria 1994). Of these, 466 have been re-evaluated with IUCN criteria (2001) including in the Atlas and Red Book (Bañares *et al.,* 2003, republished in 2004). 441 have been considered CR, EN, VU, or DD and 25 as EX, EW, or LC. Several Autonomous Communities (Andalusia, Balearic Islands), have recently published their own Red Books for vascular plants (see European Plant Data Sheets http://www.plant-talk.org/country/spain.html). In relation to bryophytes, of the 1012 Spanish species, 370 are considered as threatened (88 E +V and 283 R).

The aim is now to finish the evaluation of the conservation status of the VU and DD species, completing their revision before 2008, as well as the Red List of Bryophytes (Sérgio *et al*., 1994).

(iii) There is extensive experience in the preparation of protocols for plant conservation. Several Autonomous Communities perform activities which as a whole, constitute "strategies" for threatened flora conservation, with directives for the integration of *in situ* and *ex situ* conservation, artificial propagation by means of *in vitro* cultivation techniques, maintenance of plant species within their ecosystems, establishment of conservation priorities and actions for the reintroduction or reinforcement of endangered populations. It now seeks to reduce the dispersion, facilitate availability, and establish common homologated criteria for the methods and protocols applicable in conservation works and sustainable usage models for plant species.

(b) Conserving plant diversity

(iv) The Natura 2000 network covers 25% of national territory and integrates 116 types of Spanish habitats, but it is necessary to set up measures for their conservation, as well as other Protected Natural Spaces (ENPs) in order to assure that the areas with the highest floral interest are efficiently conserved for each of the four biogeographical regions that exist in Spain.

(v) It can be affirmed that over 50% of the important plant areas are located within ENPs, but even so, it is necessary to increase the protected areas to suitably cover the threatened species not included in the sites of the Natura 2000 network or in other Protected Natural Spaces. It is worth considering the option to promote the creation of micro-reserves.

(vi) Several agroforestry systems such as the Cork Tree pastures are an international example of sustainable exploitation. However, it is necessary to prepare and apply sector-based agricultural and forestry plans and integrate the targets of the *Global Strategy for Plant Conservation* in them, as well as perform an in-depth analysis to quantify the useful agricultural surface area. The areas with forestry uses must also be managed in coordination with the conservation of plant diversity. It must include certain exceptional agroforestry systems of the Spanish territory such as olive groves, pine groves, and pastures, and discover management models which are compatible with the conservation of plant diversity which they contain.

(vii) Although it can be assumed, that the majority of the 466 plants studied in the AFA project are conserved in ENPs, it is essential to guarantee their effective inclusion in the Natura 2000 network or in other Protected Natural Spaces.

(viii) Over 60% of the endangered plant species in Spain are conserved in accessible *ex situ* collections due to the existing 12 wild flora seed banks (REDBAG). It is now necessary to recognize this network, coordinate its work, and promote the creation of a national seed bank.

(ix) In Spain, there is a National Seed Bank for cultivated species and over 20 local Seed Banks for specific crops. It is now necessary to create a National Register of varieties and traditional knowledge and establish mechanisms to promote *ex situ* or *in situ* conservation of these varieties and knowledge, promoting their cultivation and the participation of local communities in the benefits derived from this usage.

(x) There is a work and tracking team as well as a national atlas of invasive plants. Several Autonomous Communities also have their own atlas and eradication plans, but it is necessary to prepare an official catalogue of invasive plant species and set up suitable measures and management plans for their prevention, control, or eradication. It has been suggested to promote the use of native species or plants with low invasiveness in the restoration of plant cover, silviculture, and landscaping.

(c) Using plant diversity sustainably

(xi) It is necessary to develop suitable measures so that no Spanish species demanded by international trade is subjected to unsustainable extractions, and promote international cooperation projects for the plant species subject to importation by Spain, which are extracted in a harmless way for their survival in their countries of origin, in application of the commitments acquired as a signatory country of CITES. It is also

necessary to reinforce the capacity in the identification and detection of the illegal traffic of species and specimens, by the Spanish civil servants involved in this control.

(xii) It is necessary to increase the production of organic foods, certified wood, agricultural surface areas managed by integrated production methods, and perform a national inventory of harvested species with commercial purposes based on natural populations, their uses and utilities (aromatic, medicinal, ornamental), and the extraction methods, analyzing the sustainability of their usage, and if required, appropriate regulatory formulas.

(xiii) This requires the completion of the national inventory of our Ethnobotanical patrimony, promoting the compilation of the traditional knowledge from all the villages and territories of the Spanish State in relation to the usage of plant species, plant formations, and the ecosystems in which they are integrated. It proposes the creation of a national register of traditional knowledge for the protection, certification of origin, sustainable use, and fair and equal distribution of the benefits derived from this usage.

(d) Promoting education and awareness about plant diversity

(xiv) Despite all the accumulated experience, we must make an effort to increase citizen awareness and incorporate the importance of plant diversity and the necessity of their conservation in educational programs, modifying the contents of teaching plans and programs and promoting new Mass Media initiatives in favor of diversity as a paradigm of conservation and sustainability.

(e) Building capacity for the conservation of plant diversity

(xv) After analyzing the current situation, it is essential to identify the real needs and evaluate the number of professional staff that is required to facilitate the achievement of the GSPC targets, and where required, increase the number of these professionals.

(xvi) In spite of the existence of networks, associations, and organizations such as NATURA 2000, AIMJB, SEBCP, REDBAG, AIMJBH, etc., we must strengthen and support their operation and promote the new networks which are required.

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A molecular assessment of the key biological processes of dispersal and mating in Banksias: implications for conservation

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Abstract

The conservation and management of biodiversity should be based not only on numbers, but also on a clear understanding of key biological processes in the target species. These long-term studies on Banksia hookeriana *(Proteaceae) demonstrate that molecular markers provide unique opportunities to understanding key processes such as mating and the dispersal of pollen and seed. Using a population allocation approach, it was found that both the numbers (ca. 6.8%) and distance (up to 2.5 km) of seed dispersal between discrete populations was much higher than expected. Using paternity assignment, it was also found that as many as 10% of all seeds were sired by plants outside of the local population. These results highlight the importance of inter-population dynamics in this species. It was also found that near random pollinator movements among plants within the population of* B. hookeriana *by highly mobile nectar-feeding birds, and possibly selection against the products of consanguineous matings, influence a more or less panmictic pattern of realized pollen dispersal and very high multiple paternity. These pollen dispersal processes act to sustain high genetic variation within naturally fragmented populations. These results highlight the importance of not only the correct pollinators, but also population size and metapopulation dynamics for the conservation of key processes, all perhaps critical considerations in reintroductions and translocations of other rare Banksias and other species pollinated by highly mobile nectar-feeding birds.*

The conservation and management of biodiversity should be based not only on numbers, but also on a clear understanding of biological processes in the target species that have shaped and sustained genetic diversity.

Information regarding the key biological processes, such as the extent of dispersal within and among populations is therefore critical to determine whether a species requires translocation of individuals to prevent inbreeding and loss of genetic diversity. Gene flow, migration and colonization are fundamental processes in metapopulation dynamics. Migrants create gene flow, colonize empty habitats and counteract genetic differentiation through local adaptation. In the ongoing process of habitat fragmentation gene flow will become even more important for the long-term survival of species. An understanding of the spatial and temporal dynamics of dispersal with respect to extant landscape features can be helpful in predicting demographic and genetic responses of species to naturally occurring or human-mediated population subdivisions (Sork *et al.,* 1999, Cain *et al.*, 2000).

Our long-term studies on *Banksia hookeriana* (Proteaceae) demonstrate that molecular markers provide powerful opportunities to understanding key processes such as mating and the dispersal of pollen and seed, which are critical to manage as part of species conservation and recovery. *Banksia hookeriana* Meissner (Proteaceae) is a fire-killed shrub up to 2.5 m tall that is endemic to the upper slopes and crests of deep sand dunes of the Eneabba sandplain, southwestern Australia, about 300 km north of Perth (George, 1981; Taylor & Hopper, 1988; Lamont *et al*., 1989). *B. hookeriana* exists in at least part of its range as a metapopulation in which individual populations on dune crests are geographically separated by uninhabitable intervening swales of metres to kilometres in width as a consequence of the undulating landscape within which it occurs. Genetic methods provide a broadly applicable way to best quantify long distance dispersal (Ouborg *et al.,* 1999; Cain *et al.,* 2000), stimulated in part by the powerful new statistical approaches that utilize highly polymorphic molecular markers have been developed recently (Rannala & Mountain, 1997; Waser & Strobeck, 1998; Cornuet *et al*., 1999).

Assignment tests, which were based on multilocus genetic data (AFLP, amplified fragment length polymorphisms) and used both individual genotypes and population level allele frequencies, were conducted on 221 individuals from 18 populations allocated each of 177 (80.1%) to a single genetic population. Of these, 6 (2.7%) were identified as genetic outliers from the population from which they were sampled and were allocated to another population within the metapopulation sample (Fig. 1). A further 9 individuals (4.1%) were allocated to outside of the metapopulation sample. Therefore, 6.8% of all individuals sampled were statistically allocated based on genotype to populations other than that from which they were sampled. For the 6 individuals assigned within the metapopulation to a known population other than that from which they were sampled, the geographic distance between source and sink averaged 2.0 km, with a range of 1.6 km to > 2.5 km (Fig. 1). Exact distances between source and sink populations for the 9 individuals allocated to outside of the metapopulation area are unknown, but the minimum distance from each sink population and the edge of the metapopulation area averaged 1 km. This molecular approach sheds light on a previously intractable topic of long distance seed dispersal, and contrasts markedly with direct observations of primary seed dispersal in *B. hookeriana* following fire, which shows a typically leptokurtic distribution, with 75% of all known dispersal events within 15 m and a detectable tail extending to only 36 m. This was assessed directly by moving 11 adult plants to a newly burnt location, torching cones to stimulate the release of seeds and subsequently monitoring the distance of seedlings from source plants.

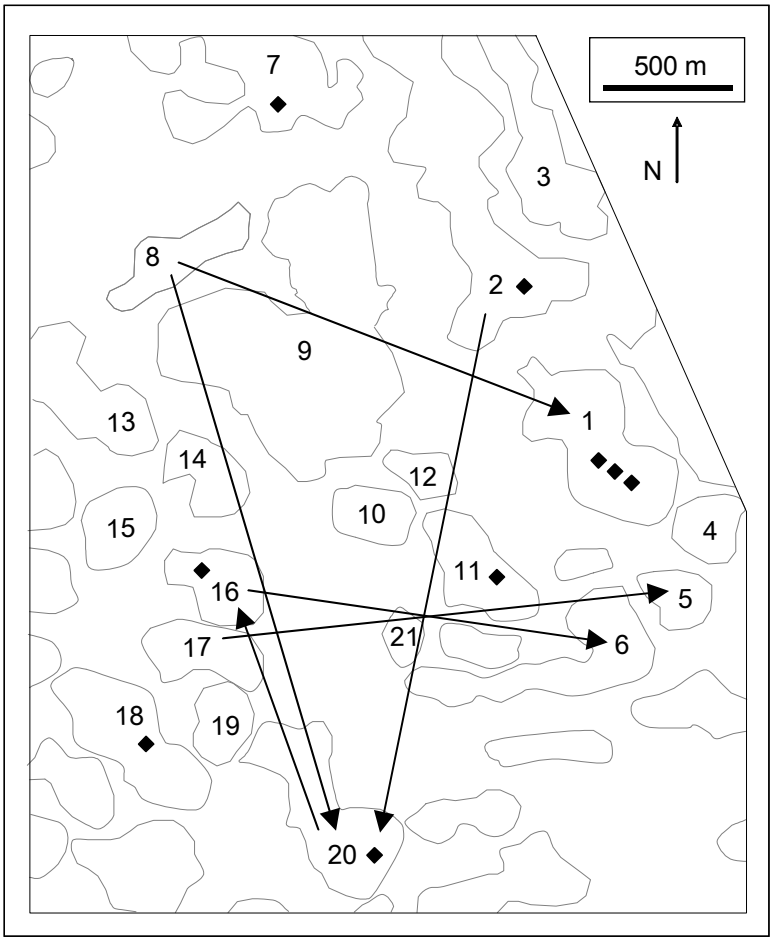

Figure 1. Seed dispersal events between populations of Banksia hookeriana*, inferred from the statistical allocation of individual genotypes to genetic populations based on AFLP data. Diamonds indicate the genetic allocation of an individual to outside of the metapopulation sample, suggesting a seed dispersal event from outside the study area*

Our molecular results have indicated that seed dispersal can extend to at least several kilometers. Wind vortices, a common feature observed after fire (Hammill *et al.,* 1998), together with reduced obstacles to wind dispersal after fire (Lamont, 1985), may facilitate this long-distance seed dispersal in *B. hookeriana*. Another possible long-distance dispersal vector is granivorous birds. Black cockatoo (*Calyptorhynchus latirostris*) are common in the area, and they seek out Banksias after fire to feed on the seeds that are made more readily accessible by the fire-triggered rupture of the protective woody follicles and removal of camouflaging foliage. Multiple fires during the juvenile period cause local extinction – a phenomenon common to species killed by the fore (Benson, 1985). Additionally, increasing development of the region since the 1960's – including farming, infrastructure and population – are adding ignition sources and increasing the frequency of fire (Bell *et al,.* 1987), so that increased fire frequency threatens the survival of fire-killed woody species such as *B. hookeriana.* Consequently, the capacity of the species to naturally recolonise sites lost to local extinction needs to be understood for conservation and management purposes.

Using Amplified Fragment Length Polymorphism (AFLP), the realized pollen dispersal within a population of *Banksia hookeriana* was also investigated. Realized pollen dispersal was assessed in a population with 112 individuals using 148 polymorphic AFLP markers and a likelihood assignment approach to paternity for 274 seeds from 5 families. Realized pollen dispersal demonstrated a significant departure from nearest-neighbour

pollination and a distribution that was not significantly different from the spatial distribution of plants for 4 of the 5 families (Fig 2), and best described by a two-parameter Weibull function with scale 29.9 m and shape 1.9. Overall, only 8% of all realized pollen dispersal events occurred between plants in the shortest distance class (up to 10 m), while most (32%) realized pollen dispersal events occurred between plants separated by between 10 and 20 m. Pollen dispersal frequency then declined exponentially for distance classes beyond 20 m, up to a local maximum of 77 m (Fig. 3). With adjustments for deceased local plants that may have contributed to past mating, it is estimated that 9% of offspring were sired by pollen originating from outside the local population. Comparison with the earlier direct estimates of seed flow of 7% indicates a pollen: seed flow ratio near unity, which is at least an order of magnitude lower than indirect estimates for most other species.

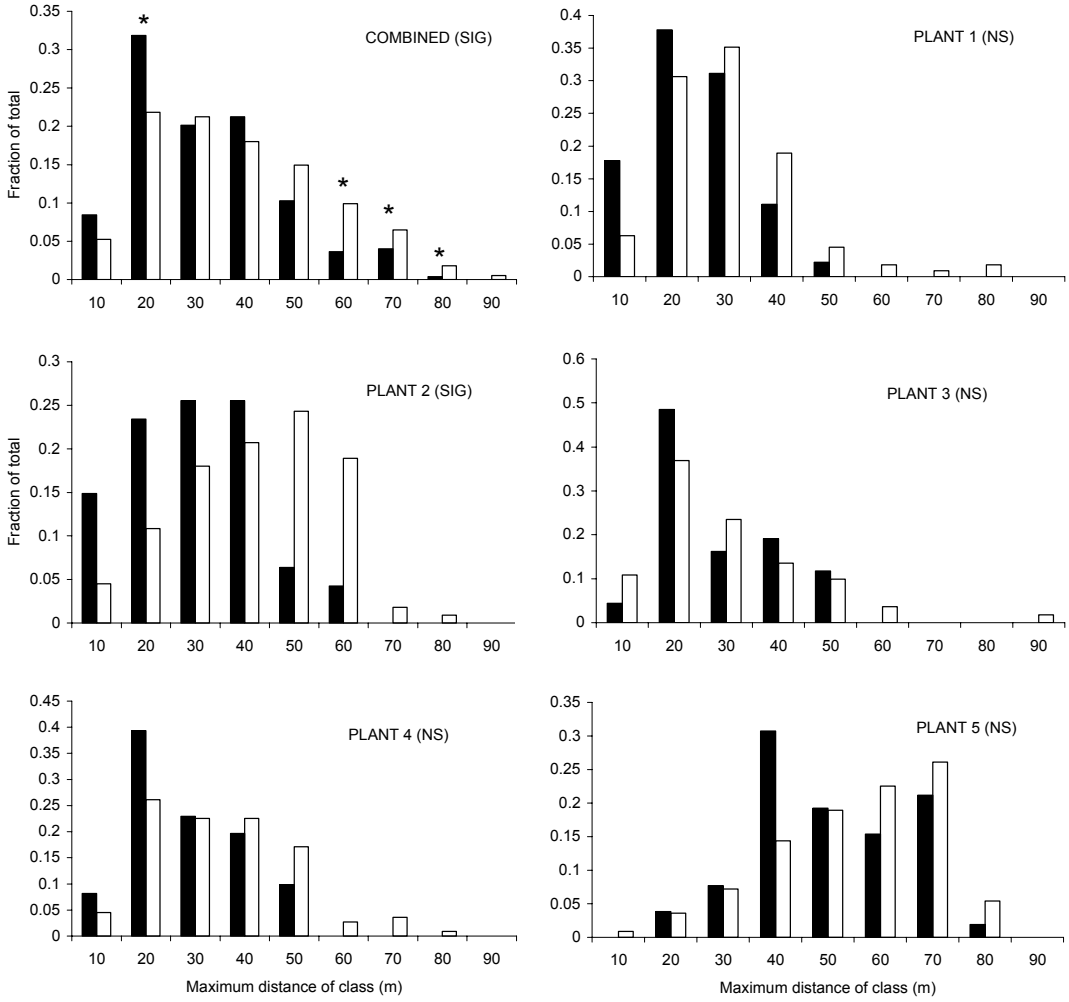

*Figure 2. Fractions of realized pollen dispersal (solid bars) and plant pairs (unfilled bars) for each distance class for the combined data set across all five maternal plants, and for each plant (1 to 5) from a population of Banksia hookeriana. "SIG" indicates a significant departure ($P < 0.001$) between the two distributions, "NS" indicates no significant departure ($P > 0.05$) between the two distributions, as determined by Kolmogorov-Smirnov two-sample tests. * indicates significant difference (t-test, $P < 0.05$) between fraction of realized pollen dispersal and plant pairs within a distance class for the combined data set.*

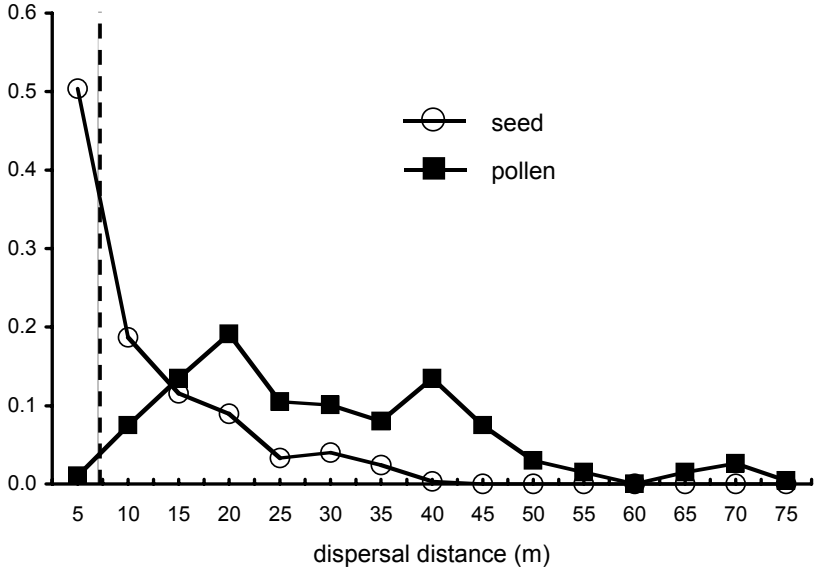

Figure 3. Realized seed- and pollen- dispersal in Banksia hookeriana, showing the percentage of dispersal events for each 5 m distance class. Vertical dashed line indicates the longest distance at which positive genetic structure was detected by spatial autocorrelation analysis of a population of 112 plants.

We suggest that near random pollinator movements among plants within the population by highly mobile nectar-feeding birds, together with extensive movements between populations, and possibly selection against the products of consanguineous matings, influence a near panmictic pattern of realized pollen dispersal. These results highlight the importance of not only the correct pollinators, but also the importance of population size and metapopulation dynamics for the conservation of key processes, all perhaps critical considerations in reintroductions and translocations of other rare Banksias and other species pollinated by nectar-feeding birds. With 15% of the Australian temperate flora pollinated by nectarivorous birds, these results have broad and novel evolutionary significance for many other Gondwanan plant species.

The results indicate that extensive pollen dispersal and metapopulation dynamics play a key role in influencing the genetic structure and genetic variation within and among naturally fragmented populations of nectarivorous bird pollinated plants. Such key evolutionary processes determine the response of a species to changes in the biotic and physical environment and, thus, population viability under current and future conditions.

Acknowledgements

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The botanic gardens & ecological city - case study of Shanghai Botanic Gardens

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The difficult problems in Shanghai's ecological urban construction

Shanghai is located on the lower reaches of the Yangtze River delta alluvial plain. The physical features of the area are low lying and flat, the original vegetation is lost and also lacks the heterogeneous habitat for natural species diversity.

The plants also do not grow well in these disadvantaged natural conditions, such as the high water level, the glue-heavy soil, the sea waves and soil which is contaminated and has a high salt content.

The climate belongs to the subtropic monsoon climate area with an annual average air temperature of 15.5ºC, and average relative humidity of 80%. The summer temperature and humidity are high, sometime reaching 40.2ºC; winter is freezing, and the lowest is -12ºC. Subtropical plants are difficult to grow through the winter; temperate plants are difficult to maintain over the summer, which leads to a decrease of screening space. The summer and autumn typhoon can bring about damage to shallow- rooted plants.

Shanghai is facing rapid development, the natural ecosystem has been disturbed, indigenous plants have been destroyed, and the original habitat is reduced day by day. The original plant species are hardly evident as it limits ecological urban construction and development in Shanghai.

The goal of Shanghai's ecological urban plan

Shanghai urban development changes every day; the urbanization is accompanied by some urban sickness, such as the dense housing, traffic jams, worsening environment, habitats destroyed and the ecological equilibrium out of balance. After 1980, with the ecological city theory developing, it was considered to be a future city model. Urban greening contributes a great deal to the ecological city construction. Shanghai is aiming to become an ecological city. Plants, plant communities, and plant ecosystems in the city is a framework of the ecology.

As the resources of natural ecosystems have suffered injury, indigenous plants should be restored, plant introduction and domestication extended to enrich the green planting.

To improve the greening of the city, the viaduct, the roofs, walls and the balconies in Shanghai have been fully utilized.

The integrative green network is being constructed between the city and countryside which will increase the heterogeneity of the city landscape.

Shanghai Botanical Gardens (SBG) has put forward new theories and technology for greening the city to resolve urban sickness, meet people's requirement for leisure and activity, and illustrate its ecological functions for improving climate, relieving heat island effect, reducing noise and preventing disasters.

Case study of Shanghai Botanical Gardens

Shanghai Botanical Gardens (SBG) covers an area of 81.86 hectares, started in 1974 and began as a small nursery, called Longhwa nursery. The mission of the botanic gardens focuses on research on plants and their utilization, public education, and entertainment, especially important in an urban area. Being a city botanic gardens, the main function is to provide correct plant materials for urban greening.

According to "climate similarity theory" and "acclimatization", a large number of indigenous trees and excellent plants were introduced into the city by plant collecting and seed exchange. This has enriched city biodiversity and helps build a sustainable city.

According to the statistics, since 1973, from primary data more than 33,000 accessions were grown. By the end of 2003, 19,000 trees were introduced and the greenhouse plants reached 14,000 accessions. At present, the botanic gardens has 1,336 taxa in the field and more than 3,700 greenhouse plants with the entire gardens collection of more than 5,000 of both native and introduced plants.

SBG also holds some rare and endangered species numbering 60, with more than 100 accessions. These taxa include three species of primary concern, 23 species of secondary concern, and 35 species of tertiary concern such as, *Neolitsea sericea*, *Tapiscia sinensis*, *Pteroceltis tatarinowii*, *Cinnamomum japonicum*, *Phoebe chekiangensis.*

Since the 1980s, on the basis of commonly introducing varieties, special families were given priority for introduction such as, Magnoliaceae, Araceae, Aceraceae. Since the 1990s, ground cover plants, perennials, bulbs, plants for foliage, vertical greening plant, water plants, and coloured-leaf plant have been introduced.

More than 600 plants from China and abroad have been introduced and about 300 kinds were selected and recommended. Now 40 demonstrations in eight districts have been established with more than 240 species such as *Cinnamomum camphora*、*Choerospondias axillaris*、*Michelia chapensis*、*Elaeocarpus sylvestris*、*Pistacia chinensis*、*Farfugium japonicum.*

Scientific research achievements have influenced and guided government policy

The government policy of tree planting, plant conservation, plant arrangement, and green system planning and the concept of an ecological city may be influenced by the botanic gardens and its achievements.

Botanic gardens guide urban tree planning

Following the theory of landscape ecology, indigenous plants and the near zonal plants were introduced and some special and excellent cultivars from other places were also moderately introduced. The aim is to construct the pattern of urban biodiversity which has regional flora and vegetation features.

Conservation genetics progress affects the protection of urban biodiversity

Conservation genetics was developed in the 1980s. Botanic gardens are the main base for protecting biodiversity and sustainable utilizing the plant resources. SBG undertakes research on biodiversity conservation and inheritance as its main task, followed by *ex-situ* conservation of rare and endangered plants, and has introduced almost one hundred nationally protected plants. The first stage is to protect the plants and then use them in urban planting which promote urban biodiversity protection.

Affect city planting arrangement style

The landscape is designed for people, to satisfy people's physiological and mental needs. SBG attaches special importance to the ecological service function and building a sustainable future. It has been beneficial to resolve urban environmental problems, especially to relieve the heat island effect. Beautiful, fit for purpose and the ecology are essential ingredients for green space construction.

Produce many kinds of green style and promote urban vertical greens

Research on the technique of spatial three-dimensional use of planting living material on roofs and walls has enriched the urban green style, improved the ecological benefit and landscape effect. New styles of plant arrangements have been developed, such as a wind path induced by plants to prevent the hot-island effect in an urban area to achieve a green city. There is a demonstration of roof and wall plants in SBG.

Botanic Gardens influence urban greening and promote ecological urban construction

A mass of ornamental flowers, fruit and foliage plants were introduced and used, which laid the foundation for transforming the green city to the coloured city, from the two season scenery city to the four season scenery city. Green needs to optimize the spatial, transform from the pure landscape demands to the omni-directional ecological construction, finally steps into humanist, harmonious and beautiful ecological city.

The scientific research in botanic gardens should closely support the ecological city development. However, it should be unceasingly innovative to guide the development of the urban greenspace**.**

Conservation planning: Chinese Magnolias at the Shenzhen Fairy Lake Botanical Garden

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Shenzhen Fairy Lake Botanical Garden, Shenzhen, P. R. China

Abstract

The collection of magnolias in Shenzhen Fairy Lake Botanical Garden started in 1991 when the Magnolia Garden was established. The collections now include more than 124 taxa. Among them 37 taxa have 1-2 known distribution sites, 33 taxa are listed in the IUCN red list and 22 taxa are included in the list of China Rare and Endangered Plants. Study of the collections has identified 3 new species. A number of collections need further study to clarify their taxonomical identities. Further conservation significance of the collections includes the living collections of some critically endangered species of which the protection status has not been recognized by any authority organizations, e.g., Manglietia rostrata D. X. Li et R. Z. Zhou, Michelia guangxiensis Y. W. Law et R. Z. Zhou, Michelia microcarpa B. L. Chen et S. C. Yang, Michelia fulva Chang et B. L. Chen, etc. The living collections provide a suitable platform for understanding and conserving the diversity of China magnolias.

Introduction

Conserving plant diversity is the goal of many projects and organizations of global, regional, and national levels and actions taken place include networking institutions and individuals, promoting government to provide in time financial support, etc. The results of these actions are not very often encouraging. Good wishes from individuals of scientific communities were not very often well understood by other social classes and not even by other members of scientific communities. In a perspective view, political and economical issues will still be the main obstacle for the networking approach of conservation. Facing this difficult situation, Dr. C. Samper of Smithsonian National Museum of Natural History proposed an alternative approach of an individual one in a workshop of the 17th International Congress of Botany held in Vienna, Austria. If each one of the more than 4200 participants in the congress went into the field and found a single endangered species and got it saved, then more than 4200 species had been saved and all the complexity with networking approach would be avoided. The author was sitting in the workshop and realized the sense and power of this individual approach and decided first to have one plant species saved in the name of himself. China magnolias had been chosen because they have a high ratio of threatened taxa and the authors' institution has a well developed living Magnolia collection. After less than two years' work, the results are very encouraging and demonstrative of the effectiveness of the individual approach. This paper summarizes the main outcomes and demonstrates that promoting an individual immediate response to the Global Strategy for Plant Conservation (GSPC) without waiting for establishing comprehensive networks and applying big grants from governmental agencies is practical and important for achieving GSPC targets.

Study of the living Magnolia collections of Shenzhen Fairy Lake Botanical Garden

Living plant collections of botanic gardens have often been regarded as a 'plant show' place and botanic gardens compete to increase the number of taxa of their living collections. An easy way to increase the taxa number is to obtain new collections from other botanic gardens. Therefore, botanic gardens are likely to have a high degree of overlapping collections. This attitude also resulted in collections of many cultivated plants in botanic gardens. The Magnolia garden of Shenzhen Fairy Lake Botanical Garden has more than 128 taxa of wild Magnolia plants and more than 50 taxa of cultivated Magnolia plants. This collection fashion does not fit well with the mission of conserving plant diversity in botanic gardens.

A thorough study has been undertaken on the living Magnolia collection in order to allow them to fit well with the goal of conserving plant diversity. First, the historical records of the living collections were computerized and studied in detail. For collections coming from other botanic gardens, information on the geographical site of the original collection was required and added into the records. Information on the conservation status from the IUCN Red List and China National Key Protected Wild Plants (1989) was added to the records. The historical plant performance information was integrated into the records and plant performance was observed carefully and recorded in the year of 2006. Analysis of the plant performance data found that success in developing fruit and time required for the plant to reach flowering age were two important factors correlated with Magnolia threatened status in the wild (Table 1).

	Number of taxa*							Percentage (%)	
	Total	China	IUCN	New	Combined	Flowering	Fruiting	Threatened	Flowering
Magnolia	28	4	3	5	8	7	0	28.6	87.5
Manglietia	23	4	12	8	15	10	6	65.2	66.7
Michelia	50	2	10	11	21	3	1	42.0	14.3

Table 1. The number and percentage of flowering, fruiting, and threatened taxa of Magnolia, Manglietia*, and* Michelia*.* ***** *China denotes protection by China national regulation, IUCN protection by IUCN, New newly recommended for protection, Combined a combination of all the three kinds of protection, Flowering in flowering age, Fruiting developing fruit.*

Confirming taxonomic identities of the living collection found that the identities of many taxa had been mistaken for years and several new taxa had been found. For example, *Manglietia stella* G. L. Jiao had been mistaken as *M. paruicula* Law et R. Z. Zhou for many years. Only when they started to flower and fruit (Figure 1), their novo taxonomic identity became evident. What is very interesting is that this tree grows very fast and is, very likely, the fourth kind of known fast growing tree after poplar, Paulownia, and eucalypt. Finding new taxa from living plant collections raised many questions as where they are in the field, what their conservation status is, if immediate conservation actions are needed, etc.

Figure 1. The flower (A) and fruit (B) of Manglietia stella *G. L. Jiao*

Studying the original collection data and interviewing those who did the collections allowed preliminary assessment of the conservation status of all the taxa in the living collections to be made (Table 2). To our surprise, China magnolias have a very high ratio of threatened taxa. The IUCN Red List includes more China Magnolia taxa than that of the China National Key Protected Wild Plants (Ministry of Agriculture, 1989), probably due to the more recent assessment of Chinese magnolias for the IUCN Red List than that for China National List. The study recommended a further 25 taxa to be included in the living Magnolia collections for protection. The total number of protected taxa from 128 taxa of the living Magnolia collection was 63, nearly 50%. China magnolias might be an exceptional case, but the very high ratio of threatened taxa makes conservation very difficult.

	Number of taxa
Wild Magnolia plants of the Magnolia Garden	128
Protection by China National List	18
Protection by IUCN	30
Recommended for protection from this study	25
Combination of the above 3 kind protections	63

Table 2. Number of protected taxa and recommended taxa for protection in the living Magnolia collections of Shenzhen Fairy Lake Botanical Garden

The newly published book, China Magnolias (Law *et al*., 2004), summarized almost all known China Magnolia plants. Based on information from this book, most of China magnolias had been discovered rather recently (Figure 2). We visited people who had many years field experience of magnolias to assign each Magnolia taxa a proper conservation status (Figure 2). Many newly discovered magnolias have no field information to assign conservation status but, very likely, are threatened.

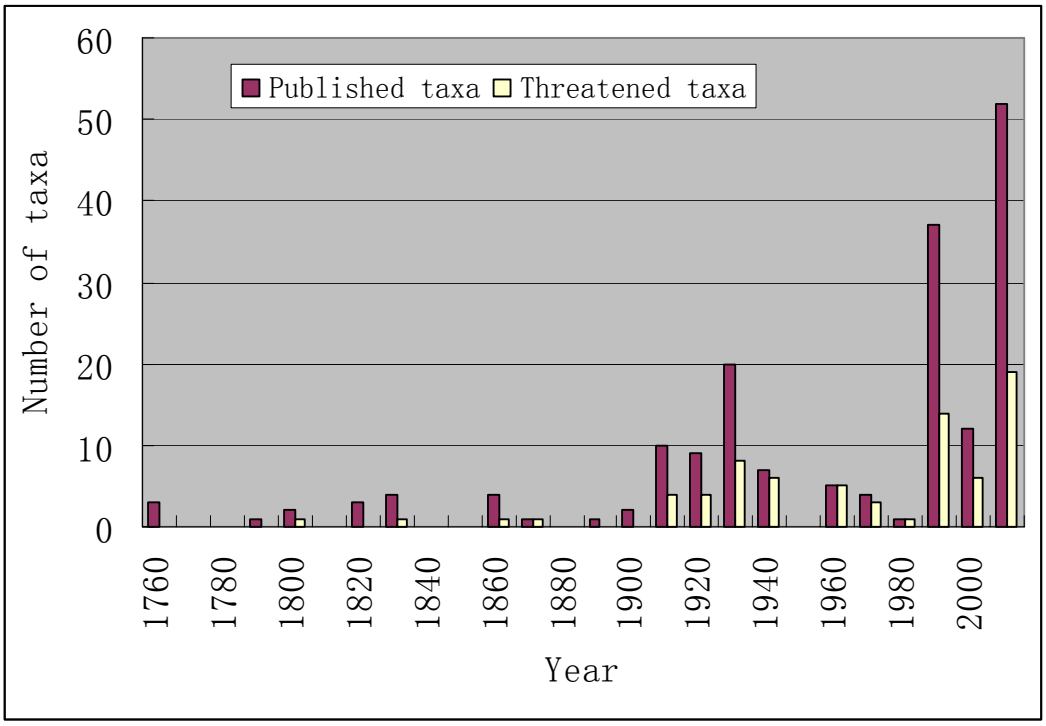

Figure 2. The number of published taxa and threatened taxa in very ten years over the discovering history of China magnolias

The threatened taxa were a combination of protection by China national regulation, IUCN, and recommendation for protection from this study.

Surveying magnolias in other ex situ collections and in field

In order to better focus our conservational work, we visited a number of living Magnolia collection sites to understand the ex situ conservation status of China magnolias. Living Magnolia collections very often started as a conservational project. A good number of Magnolia taxa had been collected during the project time. After the project was over, financial support ended and personnel doing collecting and gardening left. No further development of the collection occurred and the collections were left alone. Comparing with other collections, the living Magnolia collections of Shenzhen Fairy Lake Botanical Garden are outstanding because collecting and studying continued ever since its begin. It is evident that supporting ex situ conservation in the form of a grant for a few years is not proper. Ex situ conservation need to find a way to continue the work for long.

In order to confirm our work of assessment of China Magnolias conservation status, we conducted a field survey in southeast of Yunnan, China. In a field site of *Michelia pachycarpa* Y. H. Law et R. Z. Zhou (Figure 3), only tow giant tree were found. It was fruiting season and no a single fruit was found on the trees. A local guider told the author that there are about 50 individuals in the whole area and in some years seeds could be collected from the trees. The main threat comes from the local people who might cut the tree on any day for house building timber. Although a small number of individuals occurred in the field, a good number of individuals had been in ex situ collections.

Figure 3. Michelia pachycarpa *(A) and* Michelia ingrata *(B) in the field near Bazai of Maguan county of Yunnan, China*

The *Michelia ingrata* B. L. Chen et S. C. Yang site (Figure 3) was located on top of a small hill aside a village of Maguan county of Yunnan, China. Three big plants and one sapling were found. Two big plants had been cut in different years and the regenerated shoots had developed in different stages. It was in fruiting season and infertile fruit was found on the intact big tree. The local guider told the author that the tree rarely makes seeds. There are only three known sites and about 10 individuals in total. The site was very wet and limestone hill landscape provided good aeration for their root system. The plant provides a very hard case for ex situ conservation. Only one individual survived in ex situ collection so far and after 20 years growth the plant was a little more than one meter high.

Discussion

A lot of effort had been devoted into networking botanic gardens and individuals and applying governmental grant for plant conservation. The effort yielded nothing important when the application was rejected. We had presented here a case of an individual approach for plant conservation. People from one institution formed a group and used readily available resources to undertake tasks formulated in the GSPC. A working list of China magnolias was formed by computerizing the historical records of our Magnolia Garden. Taxonomical identification of the living collections resulted in finding of several new taxa. To understand the peculiar high ratio of threatened taxa in China magnolias, plant performance of flowering and fruiting in the living collections was analyzed and found that both factors were correlated with plant threatened status in the wild. A preliminary assessment of conservation status of China magnolias was achieved through interviewing people who collected the plants and had field experience of China magnolias. A big number of newly discovered magnolias had no proper field information for assigning conservation status. The current China magnolia ex situ conservation situation was assessed by visiting several ex situ conservation sites. Some once great ex situ collections are short of maintenance money. Field work had found very rare and critically endangered magnolias for future conservation work. All these important achievements demonstrate that serious

conservational targets could be met with individual approach of conservation. Each member of plant conservation community could consider what kind of GSPC targets could be met with readily available resources.

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Review of Chinese local and national Floras

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Floristic works in China in the past ten years have been developed rapidly, especially on floras. Three different kinds of works are summarized here.

First, Flora Reipublicae Popularis Sinicae (FRPS, Chinese edition) represents the largest floristic project in the world. The final product, 80 volumes in 126 parts, represents work by four generations of Chinese plant taxonomists over 40 years (1959-2004). The general aspects about the history, research team, contents and some comments on outline, timing, authorship, editors / authors, quality, concept of species, new taxa, specimens, statistics, largest taxa and conclusion of this monumental work are summarized.

Second, Flora of China (FOC, English edition) started more than 10 years ago from the Missouri Botanical Garden, and cooperated world wide right now, has reached more than 40% at this time, and 10 volumes of 25 planned project have been published so far, plus 8 volumes of 25 Illustrations. The whole work will be done in less than 10 years as predicted. The general differences between the Chinese edition and English edition as well as their contents are summarized here for the first time, especially regarding the treatment of different taxa as well as their coverage.

Third, local floras of China also gained very good progress at this time, and almost every province has their own floras among 31 provinces (Municipalities and Autonomous Regions), and most of them have been done very well, some even revised already. The whole pictures showed the great differences among different provinces, including the treatment of taxa, used systems, as well as their history, and development.

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Scientific value of herbarium vouchers of botanical garden living collections

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The Desert Botanical Garden's living and herbarium collections are focused on desert plants of the world, with special emphasis on plants from the southwestern United States and adjacent Mexico. Especially noteworthy are the collections of Agavaceae and Cactaceae; the Garden possesses one of the world's largest collections of members of these two plant families. Since the founding of the Desert Botanical Garden in the late 1930's, most plants accessioned into the living collection have documentation that includes collection locality, date of collection, and collector. Such documentation makes the living collection an extremely valuable source of material for systematics research and other botanical investigations. Throughout the early history of the Desert Botanical Garden, botanists associated with the institution occasionally prepared voucher herbarium specimens of materials obtained from documented living collections. For example, founding Director George Lindsay made herbarium specimens consisting of spine clusters and flowers obtained from living specimens of *Ferocactus latispinus* (Haw.) Britton & Rose, acquired for the Garden's living collection from Oaxaca, Mexico in 1937. However, a regular program to prepare voucher specimens from documented living collections was not begun until the early 1990s.

In the late 1980s, funding from a federal program (Institute of Museum Services) provided a professional assessment and report on the Cactaceae in the living collection. This assessment, conducted by Dr. Edward Anderson, strongly recommended the development of an herbarium voucher program dedicated to the preservation of materials from the accessioned living collections. Acting on this recommendation, the Herbarium Voucher Project was begun in 1993. Successful implementation of the Herbarium Voucher Project has been due, in large part, to the efforts of a well-trained team of volunteers. The Assistant Herbarium Curator administers the voucher program and volunteer activities. One lead volunteer has been involved with the voucher program since its inception. This person oversees the daily collecting, data entry, and mounting of specimens by eight to ten other volunteers who regularly contribute to the effort. Before becoming involved with the program, volunteers complete general training for volunteers offered through the Garden's Education Department and specialized training in tasks associated with the voucher program. Each volunteer contributes a minimum of three hours one day per week on the program. The goal of the program is to eventually obtain herbarium specimens form all of the documented living specimens. To date, approximately 1500 herbarium specimens have been made from living garden collections, including 200 from agaves and 900 from cacti.

There are multiple benefits of documenting the living collections of botanical gardens and arboreta with herbarium collections. The most obvious is that despite the horticultural care given to living collections, these living specimens will eventually die. Herbarium specimens of these plants provide a permanent record and physical voucher of the plants for later use and study. For example, nine out of 26 original living specimens of *Ferocactus latispinus* are alive at the Desert Botanical Garden. Only four plants of the once proposed subspecies *spiralis* from Oaxaca, Mexico, including those originally collected by Lindsay in the 1930s, were ever collected with associated data. Although none of those plants is alive today, herbarium specimens made of those plants are essential for systematic research.

Herbarium specimens preserve flowers that are only produced infrequently or only after a considerable period of time. A type of ocotillo, *Fouquieria shrevie* I.M. Johnston, is found only on gypsum soils of Coahuila, Mexico. Few botanists have seen plants in flower. The Desert Botanical Garden has two living plants; one finally

flowered 27 years after it was originally collected. As another example, agaves are monocarpic and typically require 20 to 40 or more years to mature and flower. Howard Gentry added hundreds of agaves to the Garden's living collections for his work on *Agaves of Continental North America* (Gentry 1982) and for study by future students of *Agave* systematics. Gentry and Rodney Engard collected five plants representing *Agave glomeruliflora* (Engelm.) Berger from Coahuila, Mexico in 1972. This rare taxon is infrequently found in Big Bend National Park and Coahuila and is hypothesized to be of hybrid origin. Over the past five years, four of those original living collections have flowered, providing important material for discerning the evolutionary history of this taxon. The flowers provided the materials required for morphological and cytological studies; these materials were also preserved for future study as documented herbarium specimens. This information was incorporated in the taxonomic treatment of *Agave* published in *Flora of North America* (Reveal and Hodgson 2002). Another of many examples concerns a type of prickly-pear. Clover and Jotter (1941) collected and described *Opuntia longiareolata* from the Grand Canyon of Arizona. Benson (1982) viewed this taxon as dubious at best, perhaps representing a lone anomaly, since it was only known from one collection. Live and herbarium material collected by Garden staff from 1947 to 2000 provided evidence that it was a valid taxon and was included in *Flora of North America* (Pinkava 2003) and that it is the dominant prickly-pear in the Grand Canyon and Glen Canyon. All of the plants, with the exception of the 1947 collections, still exist in the Garden's living collection, and all are vouchered as herbarium specimens.

Another benefit of herbarium vouchers is the preservation of materials from plants originally collected from areas where acquisition of new specimens is difficult or impossible. From 1939 through the early 1980s the Garden's living collections grew considerably with plants collected in Mexico, often from remote areas. Since then, it has become more difficult to collect due to more stringent permit requirements. The number of plants collected from Mexico since 1986 has declined considerably. For example, all plants of *Ferocactus latispinus* were collected between 1938 and 1968; only seeds have been collected after 1968. Another example is a more recent collection expedition by Garden staff to the coastal deserts of Peru (McAuliffe 1994). A substantial collection of cacti was added to the living collection in this effort, but in most cases, flowers essential for systematics research were obtained for herbarium specimens years after the living collections were obtained.

The Garden's Rare and Endangered Plant Collection is responsible for 36 species of rare plants in the region that are part of the Center for Plant Conservation (CPC) collection of rare plant taxa of the United States. At the Desert Botanical Garden, living specimens of each rare taxon is vouchered with herbarium specimens that can be referred to by researchers without having to remove additional specimens from wild populations.

The Garden's living collection provides plant materials for study by researchers around the world. Any such plant used, whether it is for molecular, morphological, pollination, pharmacological, or any other of a multitude of studies, is documented with an herbarium specimen made from that particular plant. Information regarding the particular research use is included on the label of that herbarium voucher. For example, University of Chicago scientists performed chemical analyses of creosotebush (*Larrea tridentata*) for possible anti-tumor capability; the particular plants used in those investigations were vouchered with herbarium specimens.

The Desert Botanical Garden's herbarium has an active loan program, providing specimens to bona fide researchers and herbaria. Such a program is an integral and important means by which researchers have access to information about the living collection via herbarium specimens. Providing loan material also benefits the Desert Botanical Garden since it increases the exposure of the Garden and its collections and also increases the percentage of accurately identified taxa. The Garden's living collections and herbarium are inextricably linked. Because of the considerable amount of data associated with many of the plant in the living collection, herbarium specimens of those plants can be of considerable use to researchers. The future value of today's living plant collection is ensured through the permanent documentation of these plants with herbarium specimens.

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Managing health and safety at the National Botanic Gardens of Ireland

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In the modern botanic garden today the management of health and safety is an evolving but fundamental feature of the management process requiring careful consideration in terms of how it is managed. It is therefore an intrinsic part of the day-to-day institutional operations. Health and safety initiatives are put in place to protect staff working within the garden and visitors who come to enjoy the garden. In order for health and safety measures to be effective there must be input from all staff within the garden using basic observation and experience to pinpoint areas and issues where risk is present. It is clearly laid down in law that all members of staff have a responsibility to observe and to mitigate against all risks.

In this respect management of health and safety is all about understanding and minimising potential hazards. Having done this it is essential to put in place safe methods of work, at the National Botanic Gardens of Ireland these are called 'Safe Operating Procedures' (SOP's).

In Ireland today the Safety, Health and Welfare at Work Act 2005 applies to all work places. This act covers such items as the employer's obligation, the workers obligation, and the obligation of other users of work areas. Any transgression may be investigated and if necessary fines imposed and in certain circumstances jail sentences handed down.

The Safety Manager has overall responsibility for health and safety and must ensure that adequate budgets are put in place to implement safety policy and that an effective Safety Committee is in operation. The Safety Manager must appoint an Assistant Safety Manager who will normally oversee the implementation of the Safety Manager's decisions according to current regulations.

The Assistant Safety Manager ensures that the Safety Committee meets regularly, observes where health and safety is effective or lacking and addresses issues before accidents happen, ensuring that a flow of information is maintained both at committee level and among staff in general. The Safety Committee is key to the smooth running of safety policy. It is the vehicle through which all issues are fully dealt with. The Safety Committee is elected at a general staff meeting after which roles are given to the elected members. The Safety Committee sits for a period of three years at which point further elections will take place. The committee ensures that there is adequate consultation between staff and management. It reviews all training issues, health and safety matters making recommendations where necessary. It is essential that accurate minutes of all meetings be taken. The Safety Manager is obliged to attend at least two meeting of the Safety Committee each year. A Safety Committee has been in operation at Glasnevin since 1969.

The Safety Representative has an important role, being appointed by staff to monitor health and safety. He or she consults directly with management and is given full access to all information in relation to safety matters. Appropriate training is given to the Safety Representative so that he has an understanding of current legislation regarding health and safety. The Safety Representative is the link person between staff and management.

Under Irish legislation all places of work must have a site-specific safety statement, which documents the safety policy. It is a working document and is reviewed and updated annually. Staff must be made aware of it and given the opportunity to become familiar with it particularly at induction to the workplace. The safety statement contains general information regarding the management of safety within the Gardens, hazard & risk assessments

and safe operating procedures for the various tasks that are undertaken both regularly and infrequently. Reference is also made to the management of visitors particularly with regard to lost children etc. The safety statement must be readily available to all staff and it is of benefit to have several copies of the statement in different locations to allow easy access. Hazard & risk assessment is an examination of any possible risk associated with particular tasks. Specially designed forms, with a list of questions and tick boxes, ensures that all hazards are considered and appropriate measures put in place to eliminate risk to staff and visitors. Safe operating procedures are written based on the risk assessment and are put in place for all routine work. Trees are assessed on an annual basis for potential risk and an agreed qualitative scale (1-4) is in use. High-risk specimens are included in a programme for restoration or removal. The information is recorded and updated in the plant catalogue.

Appropriate personal protective equipment (PPE) must be provided to protect staff at risk while undertaking work practices. The wearing of protective footwear is obligatory and all staff are issued with steel toe capped shoes or boots along with other items of clothing including suitable waterproof rain jackets and trousers. Gloves, eye and ear protection, and facemasks are issued periodically as required. More specialised equipment is made available to staff particularly when using chain saws.

Training is an integral part of safety management and includes manual handling training, which should be made available for staff at induction to the workplace. Other types of training include first aid, personal safety, safe use of all types of machinery and use of chemicals. Some training courses may only take a half-day whereas others may take a week or in some cases two. Refresher courses are required at regular intervals. On completion staff are issued with certificates and accurate records are kept in a database.

A senior member of staff coordinates the management of fire safety. The fire register contains information relating to fire drills, fire safety training including the use of extinguishers and maps with the locations of fire hydrants. Fire Marshals are appointed to specific areas of the workplace. In the event of a fire, the emergency services must have easy access to the fire register.

Despite best practice and efforts accidents do happen and are damaging to the morale of the workforce. They are potentially expensive to the employer due to loss of man-hours from injury and possible compensation. There is a set procedure for the investigation of serious accidents, which must be undertaken within 24 hours of occurrence. It is important to keep records of all accidents and near misses however trivial as valuable lessons may be learned from them.

In this age of technology it is possible to have a tailored made database available to keep accurate health and safety records. Maintaining excellent records is an essential part of implementing an effective institutional health and safety policy. Within the data base records of all accidents, training, issuing of PPE, job safety plans, asset register and machine maintenance can be accessed and updated as required.

A botanic garden's vital assets, along with its plant collections, are its workforce and its visitors. The management of safety issues must be kept in proportion, getting work completed and keeping everyone safe. It requires input from staff, taking responsibility for their own safety and the safety of others. The complex and varied working environment of the botanic garden means that health and safety will increasingly be an important, time consuming and high profile management issue that needs to be addressed by all botanic gardens

Ghanaian taxonomic needs assessment: criteria and findings

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Abstract

Ghana has started a project of national taxonomic needs assessment to understand all the issues connected with the paucity of information on biodiversity. This is considered as a way to initiate the implementation of the programme of work of the Global Taxonomy Initiative. The project has an 18 month duration and it is a joint effort between Ghanaian national institutions and two UK institutions that had earlier demonstrated a successful taxonomic assessment for the UK.

The project is going through a seven-step process identified in the UK example. Collation and analysis of the raw data from the field including those from interviews and questionnaires are being done.

The outcome of the project is expected to feed into national policy decision on training and practice of taxonomy in issues of conservation, sustainable use and equity (benefit-sharing) of Ghanaian biodiversity.

Introduction

In providing information on the implementation of the Programme of Work of the Global Taxonomy Initiative (GTI) as part of the 3rd national report to the secretariat of the Covention on Biologiccal Diversity (CBD), Ghana highlighted the urgency to undertake national level Taxonomic Needs Assessment. This was borne out of the desire to overcome the dearth in the training and practice of taxonomy in Ghana and the obvious appreciation of the promise inherent in the noble ideals of the GTI programme which were considered as useful.

Project duration

The assessment in Ghana is scheduled for 18 months from January 2006 to August 2007.

The purpose of the project

The main purpose of the assessment is to provide the Government of Ghana and the key stakeholders (those who use and those who provide taxonomic services) with a clear priority analysis of the taxonomic needs of biodiversity-related sectors in the country. The aim is to provide a basis for the integration of taxonomic issues in biodiversity into government policies, and to provide appropriate actions of the Ghanaian taxonomic institutions on identified needs.

The Main Actors in the project

The following institutions have been identified as the main actors:

- The Council for Scientific and Industrial Research (CSIR) which is the foremost Ghanaian science and technology organization with 13 institutes responsible for specific mandates for national research and development. It has direct contact with all the other academic institutions including the universities.
- BioNET-WAFRINET which is the West African loop of BioNET-INTERNATIONAL and whose secretary based in Accra Ghana
- BioNET-INTERNATIONAL which is the secretariat for all the loops and based in the UK
- Natural History Museum (NHM) of the UK based in London

The concept and beginning of the project

BioNET-INTERNATIONAL acting through the BioNET-WAFRINET and the CBD focal point in Ghana started discussing the possibility of funding a project that will enable Ghana to achieve her desires in addressing the GTI issue mentioned in its 3rd national report. Through a funding support source from the WSSD Implementation Fund (WIF) of the UK Department of Environment, Food and Rural Affairs (Defra) made available to the Natural History Museum of London, the start of the project became possible.

At COP 6 of the Convention on Biological Diversity held in Curitiba, Brazil in March 2006, a workshop was held as a side event to introduce and formally launch the project.

The Approach

The approach adopted to this project is based on the one developed by the UK. Prior to the launch of the Ghanaian project, the UK had published a needs assessment which brought out a seven-step operational focus and this was found useful and adopted for the Ghanaian project. The process identified was as follows:

- Selection of assessment focus
- Assessment of national user needs and priorities for taxonomic information
- Assessment of existing taxonomic knowledge about national biodiversity, its availability to and employment by users, and the sustainability of these sources
- Assessment of current national taxonomic infrastructure
- Assessment of current national human resources in taxonomy
- Analysis of results; and
- Recommendations for action

In following these steps, the methods adopted to get the required base-line information in Ghana identified the consideration of workshops, interview schedules and questionnaire application.

The purpose of the adoption of these methods, referring particularly to the first five bullet points, was to enable an identification of the wide spectrum of taxonomic users (across all sectors of the Ghanaian economy for selection) , available sources of important documentation and knowledge about Ghanaian biodiversity.

Achievements

The following actions have taken place:

- A first national workshop has been held
- Questionnaires have been circulated and are being collected for analysis
- Interviews are on-going and details will be collated for analysis

The outcome of the first national workshop was very impressive. The opening ceremony attracted a very large spectrum of the Ghanaian society and the Press carried it widely on radio, print and electronic media. The news was also carried on the internet and by other international press. The main part of the national workshop was restricted to only nominated representatives of national institutions that had been identified in the assessment focus and it lasted for additional four days.

The following topics were presented and discussed: Taxonomic practice, process and product; Case studies situations from the African Pollinator Initiative, fruit fly taxonomy in national and international economies and BioNET-WAFRINET initiatives; the why and the how for a needs assessment including other relevant questions; the Millennium Development Goals (MDGs) and taxonomy in Ghana ; possible regional solutions to issues of taxonomy.

The case studies component provided opportunity for the workshop participants to understand why taxonomy matters through a series of information provided on the following:

- how Invasive Alien Species were prevented from establishment
- how taxonomy promotes trade
- how it encouraged development of a cheaper and safer road network
- how safer herbal medicines are prepared
- how an insect pest was identified as responsible for mango and citrus devastation in West Africa
- how identification skills contribute to prevention of harmful algal blooms and the development of very healthy fish stocks
- how information on pollinators of crop plants contribute to wealth creation
- how taxonomy of fruit fly can remove trade restrictions placed on exports from Ghana

The next activities

By the end of August 2007 when the project would have come to an end, the following activities are expected to have been conducted:

- Collation of interview reports

- Collation of questionnaire reports
- Analysis of all collated data
- Development of Draft Recommendations including strategies for goals and actions
- Holding of second national workshop to discuss and adopt the draft recommendations.

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Teaching and Research: How University Botanic Gardens address Conservation

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The modern concept of the botanic garden emerged from the Universities of Renaissance Italy about 450 years ago. Botanic gardens have since then diversified away from these academic roots in such different directions that it is no longer a simple matter to give a generic definition of this concept. As with the mechanisms of organic evolution, the world's botanic gardens have changed over time due to chance events and random changes on the one hand (like neutral evolution) or driven by strong needs and financial or political pressures (evolution under selection) on the other. They have even recruited from other types of structure, such as the gardens and collections of wealthy individuals, in a process similar to introgression.

The demands placed on University botanic gardens shift and veer as biological, and primarily botanical, thinking has developed. They have often been subject to shifts in educational orientation and their existence challenged by financial stringency. However, in most countries of Europe and North America the thread of University Botanic Gardens has been a continuous one from these ancient roots to modern times. In developing countries too, linkage of Botanic Gardens to academic institutions has been a frequent occurrence. Sadly, in Britain particularly, a decline over the last 50 years in University teaching of botany has put severe financial pressure on their botanic gardens forcing some into an amenity status or causing others to close. Currently only nine remain amongst more than 100 Universities in Britain.

What then distinguishes University botanic gardens from others? The distinction resides in the commitment of Universities to advanced learning through teaching and research. The mission statements of University botanic gardens generally lack a specific focus on economic, medicinal or indeed environmental concerns but concentrate on teaching and learning.

The University gardens then have reacted to new academic areas of concern and have responded, consciously or unconsciously, to these areas. Thus we can often see in the structure and plantings of older European gardens the 18th and 19th concerns with the diversity of plants and the accumulation of new and novel species feeding intellectual curiosity about the world. As emphasis shifted from species-centred study into the 20th century, one can see the gradual development of habitat-based understanding derived from ecology affecting plantings. At the same time, the botanical academic tradition tended to fragment, with experimental science largely turning its back on botanic gardens. However, the influence of one experimental discipline, the science of genetics, is often implicit in University botanic garden plantings. For example, most gardens will attempt to illustrate the evolution of crop plants, a research area combining agriculture with traditional and molecular genetics.

The University botanic gardens then are heirs to a long intellectual tradition. How can they address our pressing need for conservation, an essentially applied discipline, while maintaining their primary roles in teaching and research? Clearly, University botanic gardens will hold collections illustrating the diversity of green plants. However, these collections will often differ from those of national botanic gardens, originating as they have from their own idiosyncratic roots and with unique intellectual drivers. They are likely to reflect studies carried out in the institution. Thus a walk around the University Botanic Garden here in Cambridge will quickly reveal distortions to the overall pattern of diversity – concentrations of species of *Geranium*, *Fritillaria*, *Bergenia*, *Ribes* and so on - resulting from Ph.D. studies and academic curiosity over the years.

Few collections in University gardens, then, directly target conservation concerns. There may, however, be some which provide insights into serious issues of conservation science, and which can give a firm foundation to practical conservation. I will illustrate this by reference to the species *Juniperus communis* in

Britain and Ireland. Over 50 years ago, systematic collections of this woody coniferous species were made from across the whole country by taking cuttings from shrubs in nature. As a result our extensive collection is an actual representation of genetic diversity in this highly variable species. During the last 50 years there has been a dramatic crash in numbers of populations across Britain and population sizes have plummeted to as low as 1-5 individuals.

By assessing morphology, *Juniperus* can be divided into 'highland' and 'lowland' forms. It is the lowland forms which have suffered most, perhaps through pollution adding to pressures of climate change. Conservation measures would point to transfer between different lowland populations by seed or cuttings coupled with habitat management. Genetic studies, however, have revealed a strikingly different situation. The 'highland' and 'lowland' forms have no genetic identities; instead there are distinct groups of genotypes which cut across this divide, and reflect not habitat but post glacial origins and the invasion of Britain. An academic study, therefore, has revealed ancient patterns which would have been destroyed by conventional conservation considerations.

Despite this, University botanic gardens cannot normally put conservation itself at the top of their agendas. There may, as we have seen, be unexpected but significant outcomes to academic study, but the nature of research leading to academic achievement generally puts a straight jacket on highly applied conservation; the award of Ph.D degrees generally requires intellectual debate not species restoration.

University gardens, however, must view their role as the dissemination of information, as enablers in the process of learning within the community. And the 'community' is not simply that of the University but should be the whole of society. Local people should be encouraged to turn to their University botanic garden for education in the broadest sense, for the provision of authoritative information, as well as for enjoyment. Collections can be taylored to teach the lessons of conservation through their displays. Recently, we have restored a superb range of 75 year old teak glasshouses to near-pristine condition. The restoration itself has given us opportunities to put over messages concerning sustainability and forest management, as well as the use of timber in 'green' architecture. Within the glasshouses we are concentrating on displays with strong conservation messages, concentrating on unique floras of the world and threatened floral kingdoms. Thus the large Temperate House compares and contrasts the Gondwanaland floras of the Cape floral kingdom and western Australia. The smaller houses of the range will focus on island floras, destroyed like that of Saint Helena or threatened like the Galapagos Islands.

The beauty of plants captures the emotional aesthetic senses of visitors, whilst allowing strong, and overt, messages about diversity, conservation and sustainability to be delivered effectively. University gardens must combine these two elements in their public presentations: aesthetics alone is not sufficient for their mission.

Universities with botanic gardens usually offer a wide range of academic disciplines to students, and so are supported by a highly skilled and diverse professional force of teachers and researchers. University gardens can position themselves to take advantage of this intellectual milieu and become centres for a broad spectrum of conservation concerns. At one level, the botanic gardens can be information foci for local individuals or organisations who have practical conservation aspirations. In Cambridge, for example, the local Wildlife Trust was formed within the Botanic Garden. Botanic gardens can also be viewed as a source of authoritative information by local, regional or national governments, with the intellectual independence of Universities key to this. But gardens can also draw to themselves other bodies such as conservation NGOs and provide them with a venue and home for exchange of views in a neutral but sympathetic setting. Here in Cambridge an informal linkage of individuals from within the University with their colleagues in locally-based NGOs has grown into the Cambridge Conservation Forum, a body which now has the power to lobby on conservation issues at local, national and international levels. This loose but focussed group started in the University Botanic Garden and holds all its meetings within the Garden.

The term 'conservation' covers an enormous spectrum of activities and encompasses a great range of disciplines – conservation has to be both multidisciplinary and often inderdisciplinary to be effective.

Within Universities, these distinct academic strands coexist - from biological sciences through engineering to social science – all of which may impinge on conservation problems.

University gardens can use their particular strengths to gather together these strands into groupings which can address issues of national and international significance. They can be the catalysts in developing thinking about wide conservation issues in novel contexts and from distinctive perspectives. But the growth must come always from teaching and research.

Status of *in situ* and *ex situ* plant conservation in the Sultanate of Oman, Southern Arabia

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Oman as a regional centre of plant biodiversity

Oman, southern Arabia, has a high percentage of endemics, with 79 species being strictly endemic to the country, and 46 species near-endemics. Sixty-five species are regional endemic to the Arabian Peninsula. Southern and central Oman have been identified as one of the world's key 35 biodiversity hotspots – areas that contain at least 1500 endemic species of vascular plants (> 0.5% of the world's total) (Mittermeier 2005) and the areas was added to the 'Horn of Africa' hotspot. This hotspot is estimated to contain c. 5000 vascular plants species of which 2750 (c. 55%) are endemic.

Oman has an active conservation policy and is leading conservation efforts in Arabia. A detailed study containing proposals for systems of nature conservation areas has been produced already 20 years ago (Clarke 1986). Unfortunately, until today the majority of rare and threatened plant species and their associated vegetation types are not represented with protected areas. Only few reserves for the coastal lagoons have been created for the protection of natural vegetation *per se*.

The areas included in the global biodiversity hotspot cover the monsoon-affected escarpment mountains of southern Oman and the surrounding dry gravel deserts. Isolation in space, time and climate has lead to plant communities dominated by endemics (Patzelt in review). These vegetation types are exclusively found in southern Arabia, but do not receive *in situ* conservation per se.

With the present incomplete protected areas system in the 'Horn of Africa' hotspot, current conservation activities are inadequate for long-term preservation of its biodiversity. The *Oman Plant Red Data Book* publication (Patzelt, in press) and the newly to be established *Oman Botanic Garden* (Diwan of Royal Court, Office of the Advisor for Conservation of the Environment) are therefore crucial contributions towards approaches that will be required to retain the country's rich botanical heritage.

Of the 261 species included in the *Oman Plant Red Data Book*, 190 species (15.8%) are range-restricted and 71 additional species (5.9%) are threatened non-endemic species. Of the total of 190 range-restricted species, 79 species (6.6%) are strictly endemic to the country, and 48 species (3.8%) are near-endemics. Sixty-five species (5.4%) are regional endemic to the Arabian Peninsula (Figure 1).

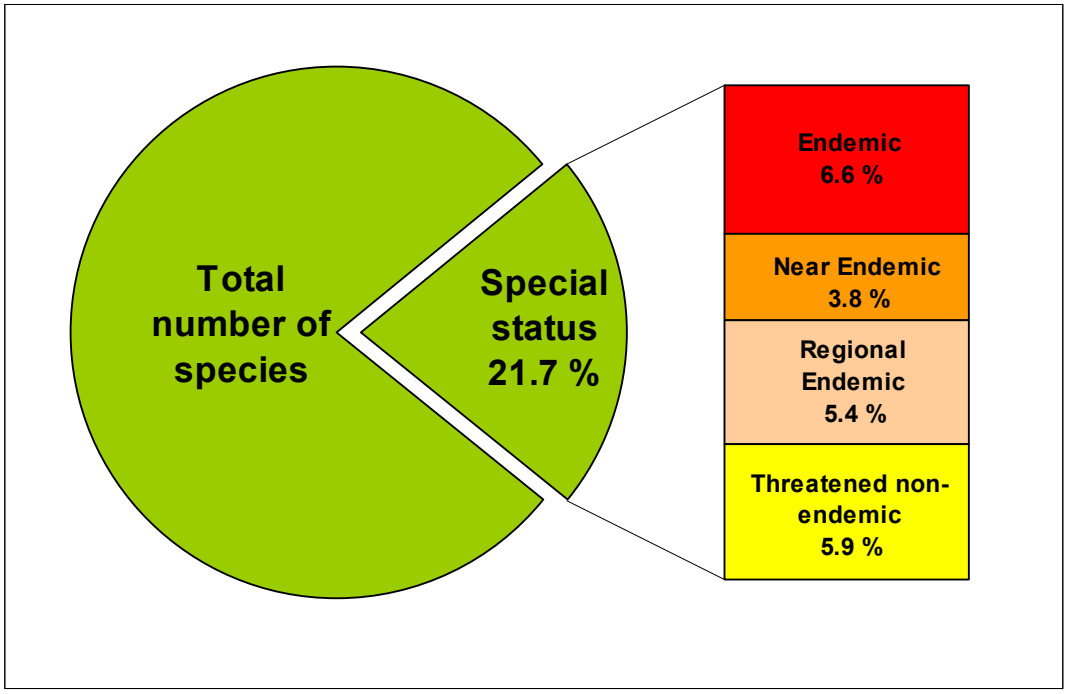

Figure 1. Proportion of plant species in Oman with special status compared to the total number of plant species

In situ Conservation

Species management are actions directed at managing or restoring species, focused on the species of concern itself. Until today, no such actions are taking place in Oman, although there is growing recognition that the long-term persistence of protected areas, primarily for the protection of flora and vegetation, and the threatened species within them, depend on active management. It is vital to develop species management plans, e.g. for 'flagship' species, such as the Juniper (*Juniperus excelsa* subsp. *polycarpos*) in the northern mountains and *Dracaena serrulata* in Dhofar and for threatened and endemic species. 'Flagship species' can stimulate conservation awareness and should receive priority in species management programs. Monitoring of populations of species, which are evaluated in the *Oman Plant Red Data Book* as Critically Endangered, and Endangered is strongly recommended, but again is not yet implemented.

Although the country-wide overgrazing problem is addressed to some extent by active conservation policies, the problems are not yet solved (Fisher 1998). Government and conservation organisations would need to address this aspect directly by development of grazing system plans and controlling stocking densities. Land protection and land management aimed at threatened plants and fragile vegetation types are urgently needed to alleviate the causes of overgrazing.

For fragile and endangered habitats the development of management plans, strongly focusing on environmental aspects is of crucial importance for the protection of nature. Areas of special importance for flora and vegetation (Clarke 1986) should receive the status of a protected area.

As many baseline data about the distribution area of species and their population sizes are still lacking, detailed botanical surveys throughout the whole country are needed to determine estimates of critical species. All

initiatives and projects need to be underpinned by accurate data for the identification of past and present distribution of threatened species, the size and state of the remaining populations and an understanding of their genetic variability and biology. Monitoring of individual species, their populations and habitats and the sharing of this information is essential if conservation measures are to be successful. It is aimed that the *Oman Plant Red Data Book* will contribute to those targets.

Restoration programmes may involve the propagation and replanting of selected species within their original or nearby habitats. Many of such projects often require long periods of time before they can become self-maintaining. To date, only one project is undertaken in Oman, on restoration, conservation and management of mangrove, with the Ministry leading responsibility for following up the recommendations.

In order to gain an understanding of which habitats are the most important for the species on the *Oman Plant Red Data List*, the major habitats in which each species on the Red List occurred were recorded. The analysis clearly indicates that range-restricted and threatened species are not distributed randomly, but are concentrated in certain habitats (Figure 2).

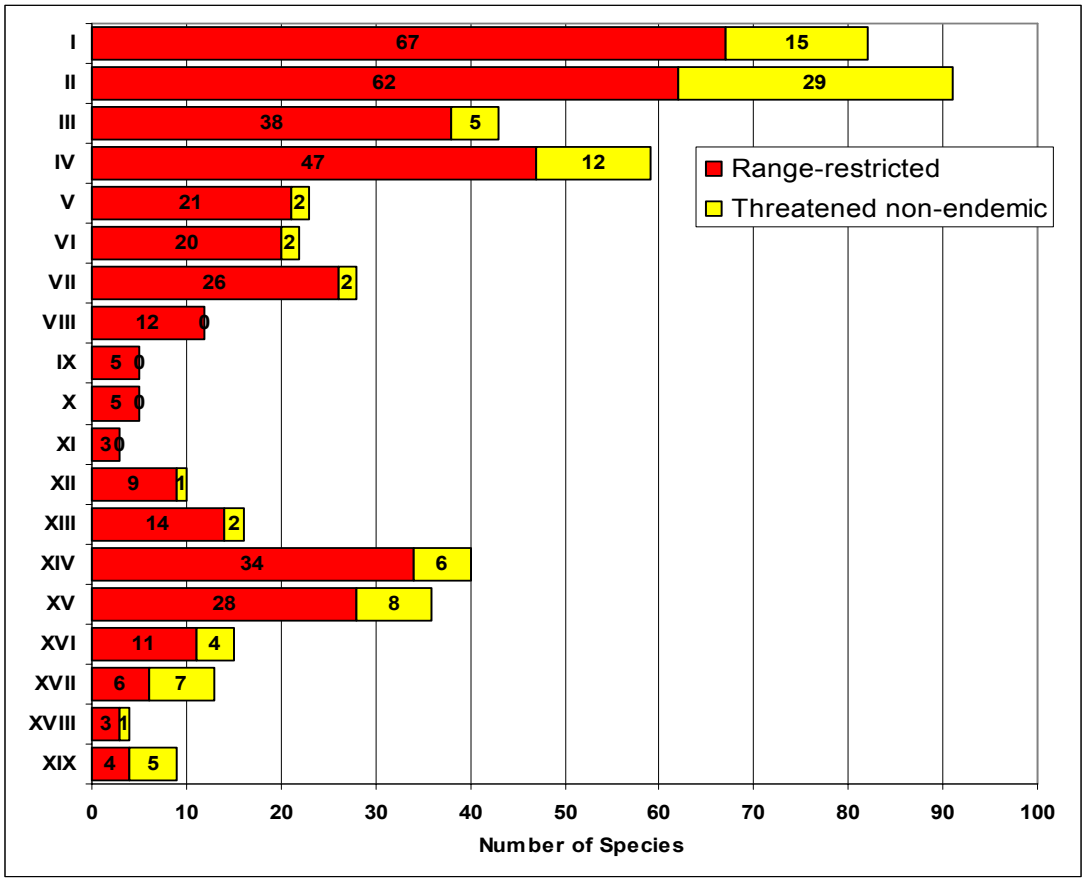

Figure 2. Distribution of range-restricted and threatened non-endemic species in habitats (absolute values indicated on each column; I coastal zone, dry hills and wadis in Dhofar; II Anogeissus dhofarica forest (including the Acacia-Commiphora woodland) in Dhofar; III Euphorbia balsamifera cushion scrub, Dhofar; IV Dracaena scrubland, Dhofar; V Boswellia sacra zone, Dhofar; VI Desert Plateau, Central Oman; VII Escarpment, Central Oman; VIII Plains, central Oman; IX Ar Rub Al Khali; X Eastern Sands; XI Sabkha; XII northern wadis; XIII northern plains; XIV northern foothills

and lower mountains (including Acacia tortilis woodland); XV= Olea-Sideroxylon zone, northern Oman; XVI Juniperus excelsa zone, northern Oman; XVII Musandam plains and mountains; XVIII coastal vegetation; XIX Oasis vegetation)

A species can occur in more than one habitat and so the values within a habitat type are non-exclusive. But many species are almost entirely dependent on one or two main habitat types. The habitat with the highest concentration of range-restricted and threatened non-endemic species is the semi-deciduous fog-affected *Anogeissus dhofarica* forest in southern Oman. This plant community is a species-rich unique palaeo-African relict association of the xerotropical tertiary Arabian vegetation. It comprises at least 300 species, 32% being range-restricted and/or threatened. Also, the *Themeda quadrivalvis* savanna revealed an endemic plant community characterised by relatively high species richness, with a moderate portion of species being endemic (10%) (Patzelt in review). The analysis indicates the richness in plant diversity of the coastal zone and dry lower hills in southern Oman, and the fog-affected *Euphorbia balsamifera* cushion shrub and *Dracaena serrulata* scrubland. All these plant communities are restricted in their worldwide distribution to the monsoon affected area of the Dhofar Fog Oasis (Miller 1994).

The analysis shows that there are some key habitats that constitute clear conservation priorities. Southern Oman is the richest region of the country in terms of floristics, and also contains the majority of range-restricted and threatened non-endemic species. *In situ* conservation of extensive areas of these globally unique habitats in the monsoon-affected fog oasis is essential if we are to prevent the loss of a large number of plants, most of which are on a global scale totally dependent on this habitat for survival.

Ex situ Conservation

South West Asia and the Middle East only have a small number of botanic gardens, although the area accounts for an estimated 58,500 species (http://www.bgci.org.uk/botanic_gardens/.html). Thus, botanic gardens worldwide do not adequately reflect the Arabian plant diversity, and number of accessions is the smallest of all botanic garden living plant material (http://www.bgci.org.uk/botanic_gardens/.html). A range of logistical constraints precludes incorporation of Arabian plant species into Botanic Gardens and accordingly, reduces their direct contribution to ex situ conservation.

In Oman, only a limited amount of *ex situ* conservation has been undertaken. In the small Botanic Garden of Sultan Qaboos University baseline propagation data for *ex situ* conservation were gathered from propagation experience with plants that to a large extent have so far not been propagated anywhere else. The project suffered under typical restraints of a "developing" country with regards to *ex situ* conservation: no horticultural experience on propagation of native plants was available, and the garden lacked from funding and manpower (Patzelt in review)..

The main aims of this project were a) to gain knowledge on propagation of native plants using simple techniques b) to propagate threatened plants species with the long term aim of *ex situ* conservation c) to implement those aims within a limited time of three months at low financial resources and d) to raise environmental awareness in a country not having a history of Botanic Gardens. In conclusion, all four aims were reached and the project therefore can be used as an encouraging example that even under limited resources *ex situ* conservation can be obtained.

One of the most appropriate actions for safeguarding threatened species is to improve propagation techniques and to encourage cultivation. As some plants are increasingly rare, knowledge on propagation of threatened and range-restricted taxa has become essential to conserve the present phytodiversity of the country.

This project is to enhance the effective role a Botanic Garden can play, which so far is the only representative in a vast area, in the light of the convention on biological diversity. The gained experience on propagation will be useful for people working on threatened plant collections and particularly important for the development of the proposed *Oman Botanic Garden* (BGCI 2006), which is currently in the stage of detailed design.

The implementation of this iconic new *Oman Botanic Garden* is coordinated by the Diwan of Royal Court, Office of the Advisor for Conservation of the Environment. The *Oman Botanic Garden* will act as a haven for native plant species. It is intended that the *Oman Botanic Garden* will implement a conservation strategy, where threatened species and habitats can be targeted and where *ex situ* conservation can be practised. Focussing on native plants only, the *Oman Botanic Garden* is unique worldwide and will be able to contribute to *ex situ* conservation of Oman's threatened plants.

After one year, 30000 native plants have been propagated, all from material collected in the wild and for most of them no or little information on propagation information is so far available. This unique living collection already provides opportunities for research into the biology of threatened and/or endemic plant species and for environmental education. In turn, this can provide critical knowledge for the success of *in situ* programmes.

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Diversity of wild and cultivated tomatoes: perspectives for conservation and sustainable use

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Wild tomatoes are native of western South America, distributed from Ecuador to northern Chile, and with two endemic species in the Galápagos Islands (Darwin et al. 2003; Peralta & Spooner 2005; Peralta et al. 2005). They grow in a variety of habitats, from near sea level to over 3,300 m in elevation, in arid coastal lowlands and adjacent hills or "lomas" where the Pacific winds drop scarce rainfall and humidity; in isolated valleys in the high Andes, and in arid regions like the severe Atacama Desert in northern Chile. Andean geography, diverse ecological habitats, and different climates have all contributed to wild tomato diversity (Figure 1). A recent taxonomic revision of the tomatoes and their relatives (Peralta et al. 2007) provides new species definitions, illustrations, descriptions and distributions, revises and updates the nomenclature, summarizes several morphological and molecular studies and discusses phylogenetic relationships.

Figure 1. Distribution of wild tomato species in western South America, different habitats in isolated Andean valleys, coastal lowlands and adjacent hills or "lomas", and in arid regions like the severe Atacama Desert.

This treatment, that is part of the genus *Solanum* Planetary Biodiversity Inventory project, uses data from approximately 5000 specimens from 49 herbaria and observations of 900 germplasm accessions of all species grown in common gardens. These evidences confirm the earlier (Spooner et al. 1993) inclusion of tomatoes in the genus *Solanum*. Based on morphological characters, phylogenetic relationships, and geographic distribution, 13 species of wild tomatoes (*Solanum* section *Lycopersicon*) have been recognized, including *S. galapagense* and *S. cheesmaniae* endemics to the Galápagos Islands (Darwin et al. 2003) and the cultivated tomato (*Solanum lycopersicum*) and its weedy escaped forms that are distributed worldwide. Closely related to wild tomatoes are two species in *Solanum* section *Juglandifolia*, *S. juglandifolium* and *S. ochranthum*, distributed in Colombia, Ecuador, and Peru, and two species of *Solanum* section *Lycopersicoides*, *S. lycopersicoides* and *S. sitiens*, distributed in southern Peru and northern Chile (Table 1, Figure 2).

Name	Fruit colour	Distribution and habitats
Solanum lycopersicoides Dunal	Green-yellow when maturing, black when ripe	Southern Peru to northern Chile on the western slopes of the Andes on dry rocky hillsides, 2800-3700 m.
Solanum sitiens I.M. Johnst.	Green-yellow when maturing, brown when ripe	Northern Chile, western Andean slopes on rocky hillsides and dry quebradas, 2350-3500 m.
Solanum juglandifolium Dunal	Green to yellow-green	Northeastern Colombia to southern Ecuador, on the edges of forest clearings, open areas and roadsides, 1200-3100m.
Solanum ochranthum Dunal	Green to yellow-green	Central Colombia to southern Peru, in montane forests and riparian sites, 1400-3660 m.
Solanum pennellii Correll	Green	Northern Peru to northern Chile, in dry rocky hillsides and sandy areas, from sea level to 2850 m.
Solanum habrochaites S. Knapp and D.M Spooner	Green with darker green stripes	Central Ecuador to Central Peru. In premontane forests to dry forests on the western slopes of the Andes, occasionally in lomas formations in northern Peru, 400-3600 m.
Solanum chilense (Dunal) Reiche	Green to whitish green with purple stripes	Southern Peru to northern Chile. On western slopes of the Andes, hyper-arid rocky plains, dry river beds, and coastal deserts, from sea level to 3000 m.
Solanum huaylasense Peralta	Typically green with dark green stripes	Northern Peru (Department of Ancash). On the rocky slopes along rivers, 1700-3000.
Solanum peruvianum L.	Typically green to greenish-white, sometimes flushed with purple	Central Peru to northern Chile. In lomas formations and occasionally in coastal deserts from sea level to 600 m, sometimes growing as a weed at field edges in coastal river valleys.

Solanum corneliomuelleri J.F. Macbr. (1 geographic race: Misti, Arequipa)	Typically green with dark green or purple stripes, sometimes flushed with purple	Central to southern Peru. On western slopes of the Andes, (400) 1000-3000 m, and on lower slopes on the edges of landslides towards the southern range of the species distribution.
Solanum arcanum Peralta (four geographic races: 'humifusum', lomas, Marañon, Chotano-Yamaluc)	Typically green with dark green stripes	Northern Peru. Coastal and inland Andean valleys, on dry rocky slopes, 100 to 2500 m.
Solanum chmielewskii (C.M. Rick, Kesicki, Fobes and M. Holle) D.M. Spooner, G.J. Anderson and R.K. Jansen	Typically green with dark green stripes	Southern Peru to northern Bolivia (Sorata). In high dry Andean valleys, 2300-3000m.
Solanum neorickii D.M. Spooner, G.J. Anderson and R.K. Jansen	Typically green with dark green stripes	Southern Ecuador to southern Peru. In dry Andean valleys, 1950-3000 m, often growing over rocky banks and roadsides. Sometimes found in sympatry with *S. chmielewskii*
Solanum pimpinellifolium L.	Red	Apparently native to coastal areas from central Ecuador to southern Peru, although populations are found in Vallenar, Chile, 0-500 m. Grows in humid places and on the edges of cultivated fields throughout its native range and has apparently escaped from cultivation in the Galápagos.
Solanum lycopersicum L.	Red	Apparently native to Peru; the domesticated form of *S. lycopersicum* now occurs worldwide. The cherry tomato, *S. lycopersicum* var. *cerasiforme,* is the possible ancestor of cultivated tomato and can often be found growing as a weed in temperate habitats and the edges of cultivated fields, where it is not necessarily native.
Solanum cheesmaniae (L. Riley) Fosberg	Yellow, orange	Endemic to the Galápagos Islands (Ecuador) from sea level to 1350 m.
Solanum galapagense S.C. Darwin and Peralta	Yellow, orange	Endemic to the Galápagos Islands, particularly the western and southern islands, mostly occurring on coastal lava and on volcanic slopes, sea level to 650m, exceptionally up to 1,500m in Fernandina and Santiago Islands

Table 1. Species list for tomatoes along with characteristic fruit colour, distribution and habitats.

Figure 2. Diversity of wild tomatoes; upper left: inflorescence of Solanum arcanum*, upper right: fruits of* Solanum chilense*, middle left: bilocular and multilocular fruits of* Solanum lycopersicum*; middle right leaves of* Solanum habrochaites*, and* Solanum chilense *(grey); lower left: inflorencences and leaves of* Solanum peruvianum*; lower right: pubescent fruits of* Solanum corneliomulleri

Tomatoes were introduced into Europe from America about the middle of the sixteenth century, and latter distributed worldwide. Breeding have produced a great diversity of cultivated tomatoes, but the traditional selection for pure lines has narrowed its genetic base (Stevens and Rick 1986). Fortunately, genetic resources from the primary center of diversity provide a wealth of useful genetic traits to improve the crop (Rick 1982, 1995). All wild tomato species are diploid (2n = 2x = 24) and can be crossed to the cultivated tomato (Rick 1979). They are of great use in breeding programs as sources of disease resistances and agronomic traits (Esquinas Alcazar 1981, Stevens et Rick 1986). The International Board for Genetic Resources (IBPGR) recognized the need for maintaining valuable vegetable genetic resources, and nominated tomatoes for priority conservation status. Ross (1998) considered that the diversity of tomato is likely to be well conserved "*ex situ*", and cited 62,832 accessions maintained in gene banks around the world, although most of these accessions are from the cultivated species *Solanum lycopersicum*.

It is important to protect wild species in their natural habitat, especially the endemic species *S. galapagense* and *S. cheesmaniae* that are threatened by environmental changes and the introduction of invasive plants in the Galápagos Islands (Darwin et al. 2003). Other species are also threatened in the continent, by habitat modification, urban and agricultural expansion. It is a conservation priority to study natural populations of species with narrow distributions, adapted to extreme arid conditions or high altitudes in the Andes (Table 1). I consider also a priority to collect new wild species samples, especially from endangered populations, and maintain them in germplasm bank and botanical gardens. Recently, two herbarium specimens of *S. chmielewskii* documented the presence of this species in Bolivia, and draw attention to explore the area of Sorata and San Pedro to find more populations in the Eastern range of distribution of *S. chmielewskii*. Similarly, three herbarium specimens of *S. pimpinellifolium* found in Vallenar, Chile, documented the most Southern populations of this species. It will be important to study and characterize them for their value as genetic resources related to the crop, for example evaluate the drought resistance properties.

I would also like to point out my concern about the conservation of traditional local varieties that people cultivate and maintain in different regions of the world. Social, economic and ecological factors are affecting the conservation "in situ" of these genetic resources. A current project in Argentina (Peralta 2007) is focused in the recover and evaluation of tomato landraces traditionally maintained by local communities in Andean valleys. These landraces (Figure 3) were incorporated in the Argentinean Vegetable Crop Germplasm Bank for their conservation and potential use in breeding programs. Our aim is to preserve, reproduce and return these locally adapted varieties to their communities for a sustainable maintenance.

Figure 3. Argentinean landraces of cultivated tomatoes: platense and corazón de buey

Botanical Gardens in association with Germplasm Banks could assure the "ex situ" conservation of wild tomatoes, maintaining and reproducing living collections. Botanical Gardens could also play an important role supporting research and "in situ" conservation of these valuable genetic resources.

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Landscape assessment and development plans

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Abstract

Botanic gardens are generally very focussed on developing the quality and content of their living collections to ensure that they can contribute as effectively as possible to research, education and conservation. The development of a collection in this respect is normally governed by a Collection Policy that describes the driving principles behind the collection, presents targets for the future and lists of plants to concentrate on. While this concentration on plant content is right given the purpose of most botanic gardens, it is important also not to loose sight of the overall quality and cohesion of the landscape. The Royal Botanic Garden Edinburgh (RBGE) is now producing Landscape Assessment and Development Plans for each of its four gardens to sit alongside their Collection Policy (Rae et al, 2006). The Plan for Benmore Botanic Garden is complete (Daniel and McDermott, 2006) and Plans for Dawyck and Logan Botanic gardens are currently in production. The content starts by describing the history and development of the landscape, then assesses the strengths and weaknesses of each garden area, articulation and path/road networks, views in and out of the garden, focal points, and ends by making recommendations for future development.

Introduction

Most horticultural staff in botanic gardens are understandably concerned mostly with the quality of the living plant collection. They want to ensure that the content of the collection reflects the guidance given in their Collection Policy and that they are growing the plants that are required by various user groups such as science, conservation and education. They need to ensure that species representation is correct, that there are no gaps, that they have accessions from as many localities as possible and that propagation, cultivation, labelling and plant records are all under control. Evidence that the 'right' plants are being grown and that the Collection policy is being adhered to comes in the form of a plant catalogue. RBGE, for instance, produces a catalogue of this type approximately every five years (Rae, 2006).

While the content and quality of the living collection is indeed the main focus for curators and the horticultural staff it is important also to take care of the quality of the landscape. While this could focus on the quality of the turf, hedges and general weediness of the garden which of course are important, what is being referred to here is the quality of the design, layout, articulation within the landscape, views in and out, access, the network of paths, location of information points and much more.

When the Director of Horticulture at the Royal Botanic Garden Edinburgh (RBGE) was appointed in 2000 he thought it would be a good idea to review the quality of the landscape, even if if the conclusion was that everything was alright. He reviewed the literature and spoke to various landscape architects to see if there was an 'off-the-shelf' system or process that could be adapted to review a botanic garden landscape for the issues listed above. He was surprised to find that there was little or nothing written up in the botanic garden literature and that, while there were various ideas about how to review designed landscapes in general, there was no readily known process for helping to review the landscape in the way that was envisaged or that would be helpful in the Edinburgh context. The only possible exception to this was the publication An inventory of gardens and

designed landscapes in Scotland (Land use consultants, 1987). After the history, a description of the site and noteworthy comments about design, each property is categorised against criteria such as work of art, architectural value or horticultural interest. Table 1, below shows the summaries for Edinburgh's four gardens. However, while interesting and relevant, the scope of review was not sufficiently in-depth and the purpose was to catalogue existing designed landscapes with a view to protection rather than looking towards improvement and development as envisaged here.

	Benmore	**Dawyck**	**Edinburgh**	**Logan**
Work of Art	Outstanding	Outstanding	Outstanding	Outstanding
Historical interest	Some	Outstanding	Outstanding	High
Horticultural interest	Outstanding	Outstanding	Outstanding	Outstanding
Architectural value	High	High	Outstanding	High
Scenic value	Outstanding	Outstanding	Some	Little
Nature conservation	Some	High	Little	Little

Table 1. The Royal Botanic Garden Edinburgh's four gardens ranked by design criteria in An inventory of gardens and designed landscapes in Scotland (Land use consultants, 1987)

Following some initial discussions with colleagues from the family of gardens that come within the title of the National Botanic Gardens of Scotland (RBGE and Benmore, Dawck and Logan Botanic Gardens) it emerged that there were a few ideas about how one might start the process and it seemed that the work could be done internally. However, following careful reflection it was decided that it would be better to have the work done by people from outside the garden (but with good cooperation from garden staff) as they would be seeing each garden with a 'fresh pair of eyes'. It is very much the case that garden staff become used to flaws or inadequacies in the landscape after a while and genuinely don't see aspects of the landscape that require improvement.

It had always been agreed that all four gardens would be assessed but since there was no agreed methodology the decision was made to run a trial at Benmore Botanic Garden (see Figure 1) to see how such a process might work and also to assess the value of the exercise. After discussing the idea with various landscape architects Peter Daniel and Siobhan McDermott were contracted to undertake the work. Choice of landscape architect was vital and they proved to be ideal for the job. It was important that they wanted to collaborate with the Curator and that they were prepared to take their time and work over a period of a year or more rather than rush things through. Finally, it was important to ensure that they were meticulous and had a somewhat academic and considered approach to their work rather than being ultra modern theorists who were more interested in, say, urban planning than garden or park planning.

Figure 1. Plan of Benmore Botanic Garden showing path network and main landscape features.

Initial work

Before even going to Benmore meetings were held to discuss possible approaches and desired outcomes. It was agreed, for instance that the title should be *Landscape Assessment and Development Plan* and so the work should analyse and assess the landscape and then make suggestions for development and improvement. However, it was agreed that detailed plans for improvements should not be made at this stage- those could come as part of a separate contract if necessary. At present all that was required as far as any improvements or changes were concerned were some simple sketches of how those improvements might be made for problem areas. Then, once they had fully understood what was wanted they travelled to Benmore to meet Peter Baxter, the Curator, and walk over the garden. They spent a considerable amount of time at the garden discussing the history of the site, its climate, soils and staff views about what might be achieved from the project. They inspected paths, views, individual areas, access, orientation- indeed all aspects of the design and layout. Over an 18 month period they visited several times, met with the Curator frequently, discussed progress during interim meetings with the Director of Horticulture at Edinburgh and amassed photographs, plans, maps and archival material.

Structure of the report

The report was published in May 2006 and is presented as a well illustrated landscape format booklet of 54 pages containing 13 sections.

Geography, topography, climate and soils

This is very much an introductory section that deals with background information and the ways in which they have a bearing on the collection and landscape. The hilly terrain, thin acid soils and rainfall of 2000-3000mm per year, coupled with the warming influence of the Gulf Stream all combine to have a very direct and obvious impact on the site.

History and the garden today

The report includes much more of the history of the site and includes more early maps of the garden than had been expected. Indeed, during the process of visiting the garden and gathering information it began to seem at times that the landscape architects were spending too much time or historical matters to the detriment of future developments. However, as the process progressed and now having seen the full publication it has been a valuable lesson to appreciate that this was a fundamentally important piece of work. Not only does it make interesting reading but it also explains why the garden looks the way it does and how options for the future are constrained by the actions of the past.

Development plan and landscape zones

In order to describe the plan of assessment and development the landscape architects divided the garden into ten zones or areas (see Figure 2) which were based partly on physical attributes and partly on their own subjective interpretation of the different landscape characters within the Garden. For each zone they have commentated on both good and poor characteristics and, for the latter, have described what the problems are how they could be improved (an example is shown in Figure 3). Simple plans and sketches have often been included to show how the design could be improved. Two examples of text from this section are shown below.

"The Redwood Avenue and the Ground skirting it.

There has always been a significant conflict between visitors crossing the road to enter the Garden and vehicles using the estate road. The present clutter of warning signs is crude. A traffic calming system would be more acceptable and also more visually pleasing. At present the vista up the Redwood Avenue is belittled by a deer fence. You are not really aware of its majesty from the other side of the River, at least until one gets to the centre of the bridge. We propose that a simple contemporary railing be designed here, which would allow visitors having crossed the road to stand within the Avenue at this new viewpoint. The repositioned entrance would become part of the Avenue railing design, which would also allow a realignment of the paths so that the visitor may be directed to the different routes within the Garden…."

"*The Rhododendron Avenue to the Golden Gates*

Apart from the enormous size of its mature trees, this area tends to be overshadowed in the afternoon and is therefore quite dark. It holds an exceptional collection of rhododendrons so there is much to see for those who love the genus but also for the visitor making his way to see the ornate 'Golden Gates', now in isolation without the South Lodge. It is unfortunate that the first view of the gates is from end on. They look less than impressive. We suggest that this view is screened off and that the visitor is forced to first see the gates as they were intended- as James Duncan's grand entrance to his estate. We suggest a shelter be made here and a more formal setting be made for the gates…"

Figure 2. Plan showing Benmore Botanic Garden subdivided into landscape areas prior to an analysis of the design within each area.

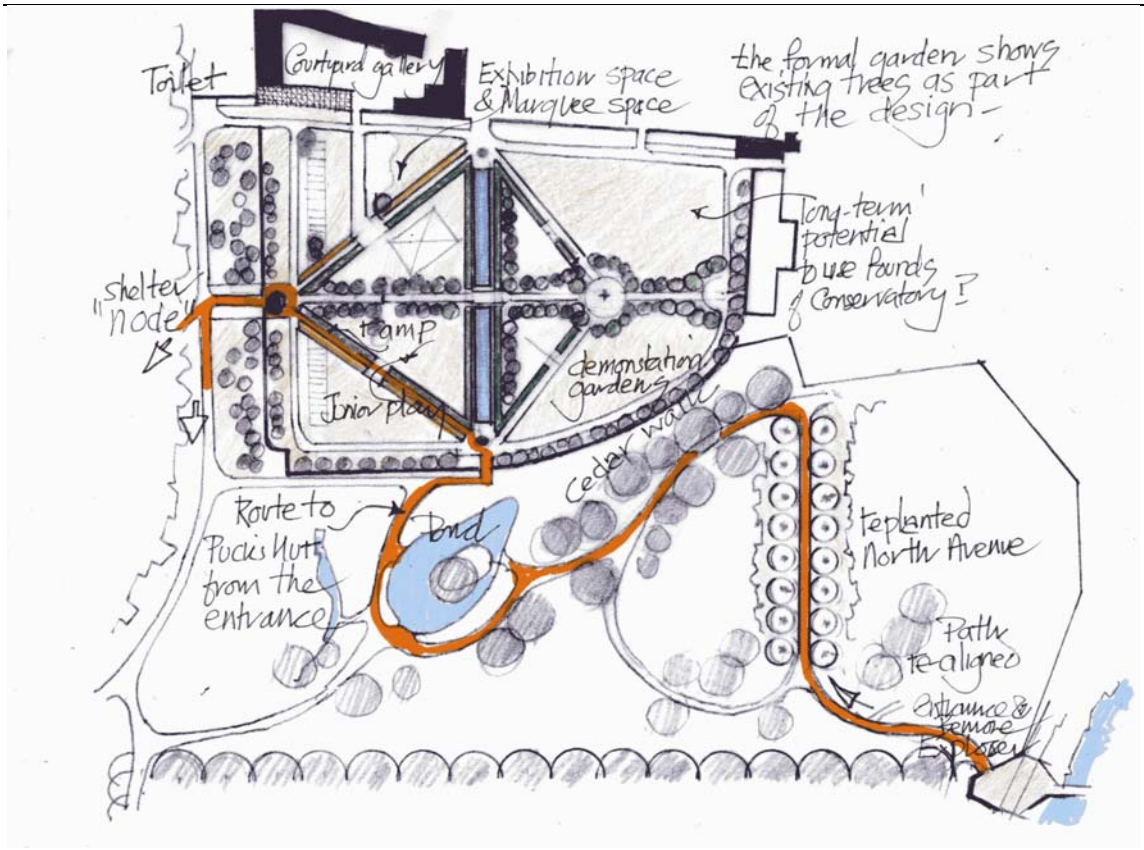

Figure 3. Sketch showing suggested improvements for access to and around the formal garden, including the replanting of the North Avenue

Proposals for improved access, orientation points, shelters, viewpoints and vistas

This section of the Plan reviews the framework of facilities and infrastructure of the site. Again, each of the topics listed above are scrutinised carefully and suggestions for improvements are made. A plan showing suggested orientation points, shelters, viewpoints and vistas was included in the report (see Figure 4) for reference and will be useful in the management of the site in the future. Parts of the section on access and shelters are shown below to illustrate the types of comment being made.

"*Access*

The visitor enters the garden by a single route, across the river. Once across the river we propose a more dignified entrance, with the conflict between the traffic on the estate road and the pedestrian visitor solved by narrowing the road into a single lane at the entrance, giving the pedestrian priority, and where it would be possible to have an electronic warning light system to warn of any approaching traffic. There is confusion as to where to go on entering the garden with a network of paths, none of them demonstrating a hierarchy, leading in various directions. The path system should be simplified to allow a choice between going to the Redwood Avenue and to the Pond and formal garden areas. We propose the replanting of the 'North Avenue' so that it would in time become a more significant feature and the centrepiece of a rejuvenated Eachaig Arboretum, creating a more grand approach to the wonderful Cedar Walk and Formal Garden and leading the visitor to the very popular and attractive planting around the pond."

"*Shelters*

In suggesting shelters we believe their function is quite simple- somewhere to rest and shelter from the elements- they need not be elaborate commemorative structures, nor must they look like bus shelters. We have in mind timer structures, perhaps with green roofs to help them merge into their woodland setting, at the orientation points. They should be able to shelter more than one or two people- small parties of visitors to the Garden"

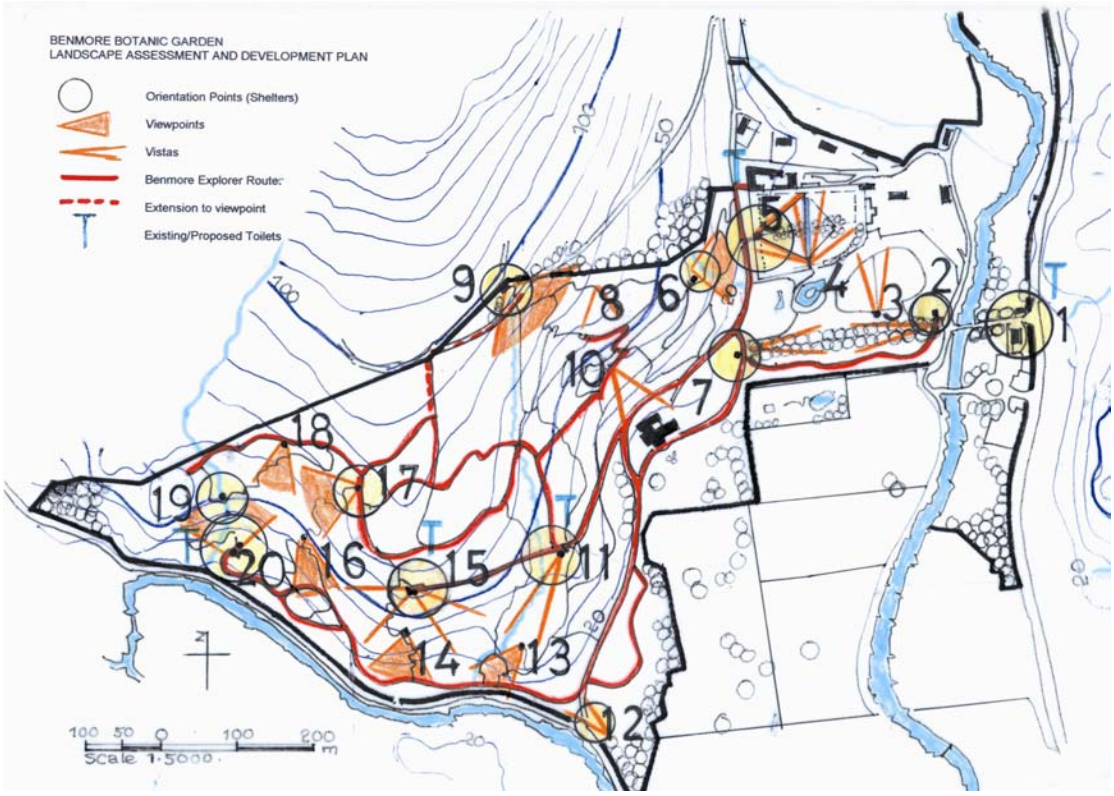

Figure 4. Plan summarising orientation points, viewpoints and vistas

Final sections

The plan ends with short sections on the types of interpretation found in the garden, a very brief overview of the collection, bibliography, list of maps used and notes on visitor numbers and garden equipment. These sections are not included with the intention of making any particular comments about changes or improvements. Rather, they have been included as background material to enable current and future readers to better understand the nature of the garden and its resources.

Conclusion

The process of commissioning the Plan, of speaking with the landscape architects and discussing landscape issues with the Curator at Benmore Botanic Garden has been interesting and worthwhile. Choice of landscape architect proved to be very successful and the nature of their investigations and assessments was very much a two-way discussion. They also brought a level of professionalism and experience to the project that we could not have found in-house and the importance of them seeing things with 'a fresh eye' proved to be important. Finally, they completed the task on time and on budget and their work continued right through to include designing and publishing the Plan in conjunction with staff from RBGE's Publications Department. We now have a list of suggestions for improving the landscape some of which are small and can be implemented soon and without much cost and others which are larger and will require time to plan for. We now also have a template which can be used as a model for similar Plans at Edinburgh's other three gardens.

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Are botanic gardens doing enough for conservation in Europe?

Jan Rammeloo and David Aplin

National Botanic Garden of Belgium, Meise, Belgium

Europe is home to more botanical institutes than any other continent, yet one quarter of its native species are under threat, with 800 facing global extinction. In late 2006, an *ad hoc* meeting drawn from European institutes and organisations involved in plant conservation met at Meise to discuss '*Are botanic gardens doing enough for conservation in Europe*?' The aim of this paper is to report on its findings and subsequent progress to better support the sustainability of wild plant populations.

Evidently, most botanic gardens could be more committed to conservation. This obligation is not necessarily money dependant. At minimal expense, advocacy, the promotion of pertinent research projects to universities, education and the preparation of guidelines and standards can be achieved. Additional funding could facilitate a shifting of emphasis in traditional practices (ill-defined plant collections and garden-gathered seeds in Index Semina) and the publication of protocols. Greater financing would enable a 'flagship project' learning to grow threatened species beyond the seed bank. In all these aspects, it is vital that ex-situ and in-situ communities co-operate if the targets in the Global Strategy for Plant Conservation are to be reached. Despite the focus on European conservation here, it is evident that this paper has application beyond this continent

Diverse and threatened flora needs help

Europe is home to an estimated 12,500 vascular plants (Akeroyd, 1992). They inhabit a diverse range of conditions, from arctic tundra in the north to semi-arid desert in the south, and from high alpine peaks to Mediterranean coastlines. The flora represents one of the best known and most studied in the world. Over thousands of years, Europe's landscape has undergone dramatic, human-led changes. Despite this, important areas of natural and semi-natural vegetation remain. As on other continents, Europe's flora faces unprecedented threats through climate change (BGCI & Cabildo de Gran Canaria, 2006, Intergovernmental Panel on Climate Change, 2007) and other human-related activities. According to extensively documented predictions, these threats could occur quickly and result in significant habitat and species loss. Current estimates, depending on the criteria adopted, suggest 2,000–3,000 species are under threat (Council of Europe, 1977; European Commission, 2005) while c.800 face global extinction (European Commission 2006). In order to safeguard our natural heritage for future generations, urgent action is required from all sectors of the botanical community.

The European region as defined by the United Nations comprises 53 countries. It has the greatest concentration of botanic gardens in the world (Guerrant *et al*., 2004), with 1001 gardens, arboreta and institutes registered with Botanic Gardens Conservation International. Included in this number are 728 located in 27 European Union (EU) Member States (*pers. comm*. Diane Wyse Jackson). The continent potentially offers an enormous and influential community to aid the conservation of native plants, and yet botanic gardens are the most under-used plant conservation resources in the world (Maunder *et al.* 2004). This is compounded by institutes' preferentially growing and conserving exotic flora. The selection pressures on these taxa will be markedly different to those they would face in nature. While exotics will always attract the publics' gaze there should also concerted efforts to cultivate and conserve flora of local provenance.

In recent years, however, a number of botanic garden-led initiatives have resulted in significant advances supporting the continent's commitment towards the Convention of Biological Diversity (CBD) and the Global Strategy for Plant Conservation (GSPC). These include the establishment of Botanic Gardens

Conservation International (BGCI), a charitable advisory network linking institutes around the globe to aid effective plant conservation, and a number of European-specific initiatives at national and regional scales. These predominantly focus on seed banking wild native taxa, e.g. REDBAG the Spanish network (see Hernández Bermejo & Molina, 2005); RIBES an Italian network (see Rossi *et al.,* 2006); GENMEDOC the inter-regional Mediterranean network and the EU-wide ENSCONET (see Müller & Linington *in press*). Networks incorporating the cultivation of threatened plants are comparatively scarce, the 'PlantNetwork Target 8 Project' and the Conservatoire Botanique National (CBN) in France (see Frachon *et al.,* 2005 and Lesouëf, 2004, respectively) are notable exceptions. The CBN is a model network at national level that finds synergy between *in situ* and *ex situ* conservation. It deals with a range of tasks from monitoring populations, seed collection and gene banking, genetics, *in vitro* and reinforcing local populations.

Are botanic gardens doing enough for conservation in Europe?

Despite these initiatives it is increasingly recognised that the botanical community could and should be doing more to aid plant conservation. This topic had recently been discussed in a number of national institutes which then took on an international dimension at the European Botanic Gardens' Congress (EuroGard IV) in the Czech Republic. A number of debates concluded that reviews and re-evaluations of current practices within botanic gardens were necessary and that this subject needed to be discussed more rigorously.

In December 2006, a meeting was convened at the National Botanic Garden of Belgium (Meise) comprised of an *ad hoc* group drawn from major European institutes and organisations involved in plant conservation (Figure 1). The aims were to: 1) discuss whether botanic gardens could be doing more to aid European plant conservation; 2) highlight current practices could be utilised more effectively for conservation; 3) develop a strategy for addressing these needs.

Figure 1 Delegates at the 'Are botanic gardens doing enough for conservation in Europe' meeting at Meise. December 1st 2006.

Prior to the meeting, a concept document was written with the intention to provoke comment and debate. It questioned whether traditional practices (such as the maintenance of publicly hidden plant collections, that did not aid research or conservation, and the dispersal of garden-gathered seed material through *index semina*) are relevant in meeting the unprecedented challenges to our native flora. It also highlighted areas where a possible 'European-wide conservation network' could aid co-operation and consultation to help prevent habitat and species loss.

It was apparent from the meeting that all European botanic gardens have the potential to further embrace conservation effort. This need not be dependent on funding. Throughout the meeting delegates outlined a number of initiatives that could be achieved. It became clear that they could be divided into funding categories that include initiatives that require: no additional funding; extra financing; and successful grant applications.

Conservation on a shoestring

Few, if any, botanic gardens can boast adequate funding. The lack of money however need not excuse inaction. In fact the initiatives outlined in this section are probably some of the most important, since they do not rely on repeat funding to sustain their continuation, just willingness and motivation from staff.

Establishing the conservation message into the hearts and minds of staff, at all levels of an institute, can still present challenges, yet if taken seriously provides a large benefit to any organisation. Communication beyond the confines of the garden is just as vital. Advocacy is perhaps one of our communities' weakest areas. It is therefore important to establish strong, core messages that highlight conservation needs to politicians and fund-raisers who influence policy and funding opportunities. Suitable platforms for doing just this exist on 'International Day for Biological Diversity' (22nd May) and World Environment Day (5th June). The agenda should highlight the threats to our flora and how by working together the *in situ* and *ex situ* communities can make a difference.

Dialogue should also reach out to the wider research community and get them involved in conservation. In universities, under- and postgraduate research can be directed to aid our knowledge of threatened plants and their interactions in their environment. Increased communication has to be encouraged between researchers to avoid duplication and share results. Research should not just be confined to scientists. Horticulturalists have superb knowledge on cultivating and propagating a large number of diverse species.

This expertise needs to be recorded and made accessible to all. One initiative for doing just this is to develop an online 'one stop knowledge base'. This would enable the altruistic sharing of cultural and ecological information on threatened and near-threatened taxa. It could be facilitated by using a wiki-type website that allows the user to easily add, remove, edit or change content without registration. The site 'Wikispecies' (http://species.wikimedia.org) has been designed for exactly this purpose. The advantage of using such a website is that information is immediately available throughout the world providing an excellent mechanism to aid capacity building. It is also free, simply found by search engines and allows all computer literate people the possibility to add information.

Conservation on a budget

Despite the possibility of significant contributions to plant conservation without additional funding, some form of financing soon becomes necessary. This section highlights a range of practical initiatives, discussed during the meeting that could be deployed by relatively small amounts of money or by re-allocating internal funding. It requires directors and curators to critically examine current practices. The re-allocation of money has obvious advantages, as it does not dependent on successful grant applications.

It is increasingly recognised that climate change and habitat loss is not only likely to affect threatened taxa but also the distribution limits of more common species. It is therefore important to monitor more common taxa with declining ranges because these may become tomorrow's threatened taxa. Conservationists need to act now to save the genetic variation of these plants. For those already threatened, Red Lists provide vital information about a species vulnerability and are a vital starting point for conservation action. However, despite Europe having the most studied flora in the world a European Red List does not exist, although it is an achievable goal for an estimated €30,000 (*pers. comm.* Suzanne Sharrock, BGCI). The natural progression from the Red List would be more detailed work detailing information about a taxa's ecology, past distribution, conservation needs and any other data that may contribute to its successful conservation. There is already such a document for 50 Mediterranean island species on the brink of extinction (Montmollin & Strahm, 2005), but it is ideally required for all threatened taxa.

A comprehensive Red List would enable the evaluation of threatened taxa in *ex situ* collections to be prioritised. This would be done initially on a quantitative basis highlighting institutes with particular taxa and then progressing to qualitative analysis. One such survey was previously conducted by Maunder *et al.* (2001). This study looked at threatened plants defined by the Bern Convention. Results concluded that the

majority of the selected taxa were held in a small number of collections and dominated by garden-origin accessions with poor documentation. The results demonstrate that there is a lot more to legitimate conservation than simply growing threatened taxa in a garden.

Even when well documented wild accessions are cultivated a mechanism is ideally required to trace genotype(s) between gardens. This would clearly highlight the extent of duplicate material in different gardens and avoid taxa being regarded as 'safe' in *ex situ* cultivation when they may well be represented by a single genotype or collection. A mechanism that could facilitate the traceability of accessions is the International Plant Exchange Network (IPEN). IPEN has been developed specifically for botanic gardens as a tool to respect the access and benefit-sharing requirements of the CBD (Von den Driesch *et al.,* 2005). It uses unique numbers to enable the origin of the material (and its legal documentation) to be traced. However, in its current form there is no distinction between the different generations of a particular accession. This means that a plant would have the same code as its garden-gathered seeds despite the potential for great disparity in genotype. This is not surprising, since IPEN was never conceived for discriminating between this type of information, yet with simple modification (an extra code noting generation) it could be an extremely valuable tool aiding *ex situ* conservation.

Reviewing the relevance of traditional practices should be considered in some botanic gardens. Many institutes maintain large, publicly hidden plant collections that do not facilitate research, conservation or education. These collections often represent decades of plant acquisitions corresponding to past research and personal interests. However, many may now be redundant. In space- and financially-limited areas, such as glasshouses, these living holdings could be evaluated to determine whether they represent the best use of space to meet the challenges of today. Similarly, the limitations in the use of garden-gathered seed in *index semina* are critiqued frequently. Recent research has highlighted a steady decline in the percentage of wild-collected seed in European seed lists over the last decade. The majority of seeds represented in European *index semina* (c.80-85%) are from garden-gathered seeds that have limited use (see Aplin & Rammeloo, *in press*). This suggests that this practice is time consuming and inefficient, although, some curators have devised systems to reduce the collection of unwanted or inappropriate seed material (Vanderborght, 1997).

Conservation with sufficient funding

With such a threatened flora, the scope for well-funded conservation projects is large. However, it seems sensible to focus resources on a flagship project, gaining knowledge and experience while developing co-operation between *in situ* and *ex situ* plant communities. It would also enable protocols to be developed and tested for future projects. It might concentrate on a plant group, perhaps a family or genus that grows in a range of different habitats, has seeds that are easily stored yet with plants that are difficult to cultivate. Alternatively, it might concentrate on areas where Europe's species are in greatest peril. Whichever is selected we should not ignore those often neglected "Cinderella species" such as ferns, mosses and liverworts that have important roles in the functioning of ecosystems and may be especially susceptible to climate change.

Concluding remarks

With over a thousand botanic gardens, institutes and arboreta in Europe, no species should be threatened with extinction. Yet today many species are faced with this threat. The December 1st meeting at Meise was hoped to spark motivation and actions that tackle the challenges that face the world's most studied flora. It clearly outlined that our institutes could all being doing more to halt species loss and that it is imperative to work alongside the *in situ* community. The conclusions were not entirely new; Bramwell *et al*. (1987); IUCN-BGCS & WWF (1989); Wyse Jackson & Sutherland (2000), Waldren & Wyse Jackson (2000), Guerrant *et al*. (2004) and Rae (2004), to name a few, have all highlighted many of the issues covered in this manuscript. However, this paper focuses on financial constraints and suggests these need not burden the progress of legitimate conservation. As botanical institutes we have an obligation to help save our

continent's flora and ensure that our gardens do not become a 'Noah's Ark' for the sake of collecting, because one day the rains may never end.

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Reproductive biology studies - the way of understanding plant diversity

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There are two components of biodiversity – the diversity of taxa and diversity of coenoses. Doubtlessly both components need protection. The approach to their protection is distinct in kind, but in all cases it should include the reproductive biology studies. One of the two possible ways of protection of taxa (species, subspecies and variations) diversity is *ex situ* conservation and the leading role in it is played by different botanical gardens, nurseries, forest stations, etc. The protection of coenoses is possible only in-situ, so all necessary actions should be taken to restore it and bring to the original state at the site. It is very difficult to cultivate some plants at the botanical gardens, so the problem of such species propagation is genuine. Some species perfectly develop vegetatively but do not bloom and set fruits and seeds. It is necessary to remember that development of flowers, fruits and seeds occur under the influence of a number of exogenous factors, which stimulate the origin of endogenous ones. Joint action of these factors brings the plant to the reproductive stage of development (Chailakhyan, 1988).

The lack of some of the factors or influence of additional factors can cause the development of parthenocarpic fruits. There are many examples when a plant was collected in nature in vegetative stage and considered to be a well known species, and only later, at the botanical garden it developed flowers for the first time and turned out to be a new unknown species. Such story happened with *Aspidistra elatior* Blume – it was collected by Dr. Nikolaj Arnautov in Vietnam in 1986 and only in 15 years it gave first flowers morphologically different from Aspidistra elatior. Soon a new species *Aspidistra locii* Arnautov & Bogner (2004) was described basing on the plant cultivated in the Botanical Garden of the Russian Academy of Sciences in St. Petersburg. Similarly, the essential difference in flower and fruit characters in specimens of *Magnolia delavayi* Franch. cultivated at the dendrological park "Yushnye kul'turi" (Adler, Sochi, Russian SW Caucasus) brought us to conclusion that in spite of the great similarity of their vegetative features a new species – *Magnolia carpunii* M.S. Romanov & A.V. Bobrov (2003) should be described. A widely cultivated species *Cercidiphyllum japonicum* Siebold & Zucc. also turned out to be an interesting object for reproductive biology studies. At the Arboretum of the Main Botanical Garden of the RAS the species is represented by 20 trees (received from 5 sources), which are easily divided into two groups – with smooth bark and with rugged bark. Knowing that the vegetative features are more adaptive than reproductive we studied the latter in different groups of *Cercidiphyllum*. The size of mature female flowers differs in two times, fruit morphology and anatomy is also different. It is obvious that two different taxa are cultivated and both of them need protection. Thus lacking the information about reproductive structures we take the risk of missing a species from our attention. Strangely enough but sometimes we loose species as the result of a taxonomic treatment of a genus. For example, R. Pilger (1926) recognized seven species of *Phyllocladus* Rich. and the results of our original investigation of seed morphology and anatomy of all seven *Phyllocladus* species confirm their independence (Bobrov *et al*., 1999). On the other hand it was proposed to reduce the number of *Phyllocladus* species to five (Farjon, 1998). So, will all species of *Phyllocladus* be protected *ex situ* and *in situ*? Thus we can conclude an important activity of *ex situ* plant diversity conservation is detailed data on reproductive organs structure and function.

A very similar problem occurs when we protect biodiversity *in situ*. It is well known that biocoenoses are characterized by complex interconnections between all living organisms at different levels, some of which are obvious but other are unknown and require detailed studies. The bearing structure of any land

biocoenosis is the axis of interconnections between plants and animas. It is broadly recognized that connections between the pollinator and the flower, animal–disseminator and fruit (or seed) originated as the result of long co-evolution. Nevertheless, more detailed studies bring us to conclusion that the leading role in this tandem is played by plants. An excellent example of this is the parthenocarpy: plants attract disseminators (in case of zoochory) by fleshy fruits lacking seeds (which don't develop at the current year by some reasons). Thus, trying to reveal basic principles of functioning of ecosystems it is very important to study fruits and their role in the biocoenoses. Insufficient data will make saving numerous coenoses impossible from degradation. Not taking into account this aspect of plant life, we are risking failure in our measures for biodiversity protection *in situ*, focused both on plants and animals.

So, there are several very important reasons for studying structure and function of reproductive organs and especially fruits. First they allow us to reveal specific diagnostic features, both morphological and anatomical. Reproductive organs allow us to estimate the number of the species in every genus more correctly – it is very important to use data on reproductive biology when working on regional floras and taxonomic reviews of all kind. Not taking into consideration these data we are risking losing species, subspecies and varieties as the result of inadmissible mistakes. Different points of view are possible in systematic treatments, but aiming to reach the best results for biodiversity protection it is preferable to use the most detailed treatment of every genus (and species). Reproductive biology studies allow us to determine all interconnections between all inhabitants of the coenosis maximally precisely. Detailed *in situ* investigation of all reproductive processes in any plant species, including the flower development, blooming, pollination, fertilization, fruit and seed development, their dispersal and seed germination (including different kinds of natural stratification and scarification) will allow us to develop correct measures for protection in situ and propagation *ex situ*.

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Botanical collecting effort in Amazonia

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This paper is based on Schulman, L., Toivonen, T., & Ruokolainen, K. Analysing botanical collecting effort in Amazonia and correcting for it in species range estimation, published online May 17, 2007 by *Journal of Biogeography*, DOI: 10.1111/j.1365-2699.2007.01716.x, from which Figures. 2 and 3 are reproduced.

Introduction

A comprehensive list of the world's plants is the goal of several international initiatives, such as the Global Strategy for Plant Conservation under the Convention on Biological Diversity (www.cbd.int/programmes/cross-cutting/plant); Species 2000 (www.sp2000.org); and Encyclopedia of Life (www.eol.org). However, it is clear that a list of known plant species is not equivalent to a list of all plant species, since considerable areas of the planet remain poorly studied. Here we provide information on the state of floristic knowledge of one such area, the Amazonian rainforest biome.

Amazonia is one of the last true wilderness areas on earth. Even though the forests were more densely populated in pre-Columbian times, than previously believed, and human activity may have altered biodiversity patterns (Heckenberger et al. 2007), the overall diversity has not been impoverished to the extent witnessed in densely populated northern hemisphere regions. Deforestation and land conversion in recent decades has nibbled on the peripheral parts of the forest biome but millions of square kilometres of pristine forest remain.

The Amazonian rainforest is generally regarded as one of the floristically richest environments on earth. However, it has also been pointed out that this perception is based on rather shallow exploration. The most telling testimony of this to date is a study by Nelson et al. (1990) in which they plotted on the map the collecting localities of c. 2,300 herbarium specimens of the genus *Inga* (Fabaceae). They were able to show severe bias in the geographical distribution of the collecting: almost all extant specimens originated from the vicinity of a handful of centres of research (Figure 1).

The interior of Amazonia is largely inaccessible due to sparse human populations and, thereby, lack of roads and airports. The region is traversed by numerous navigable rivers, but between these lie extensive continuous blocks of forest. Even so, one could imagine that the coverage of collecting has improved in the last two decades. We took a fresh look at the situation using the data currently available to test this view.

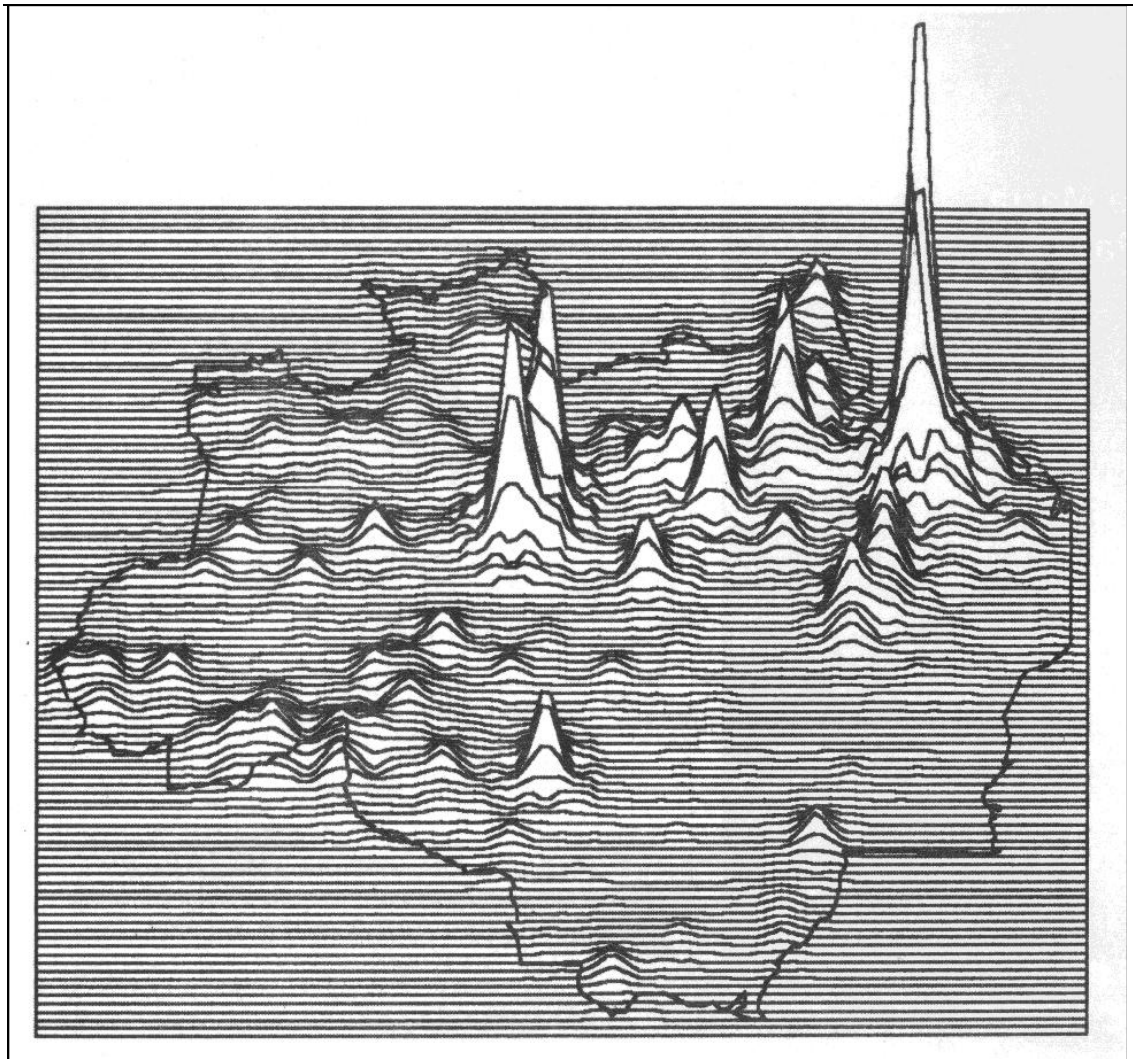

Figure 1. Biased botanical collecting effort discovered by Nelson et al. (1990) as presented in Val, A.L., Figlioulo, R., Feldberg, E. (orgs.) 1991: Bases científicas para estrátegias de preservação e desenvolvimento na Amazônia: fatos e perspectivas, INPA, Manaus.

Material and Methods

Amazonia was defined as the Amazonian rainforest biome, i.e., most of the watershed of the Amazon to c. 1,000 m above sea level (a.s.l.) plus the Guyanas and the lower Orinoco, following e.g. Fittkau (1971), Daly & Prance (1989), and corresponding with Amazonia *sensu latissimo* of Eva & Huber (2005). The exact delimitation of Amazonia was obtained from the ecoregion boundaries of Olson et al. (2001). The size of Amazonia delimited in this way is c. 6.9 million km2.

Using a GIS we plotted on the map the collecting localities of herbarium specimens from the study area contained in the database of the New York Botanical Garden (NY; herbarium acronyms after Holmgren et al.,

1990), and the VAST (VAScular Tropicos) nomenclatural database of Missouri Botanical Garden (MO; available at http://mobot.mobot.org/W3T/Search/vast.html). They were queried in 2002 and 2006, respectively. In total, 377,371 collections were located in Amazonia (duplicates of the two databases were not identified). These were collected in 16,058 different localities (Table 1).

For the illustration of spatial variation in collecting activity, we made three different map products: one grid map with a 1-degree grid and another with a 0.5-degree grid, and a network of Thiessen polygons (polygons whose boundaries define the area that is closest to a certain data point relative to all other data points) based on the collecting localities. We used the GIS to calculate the number of empty cells in the grid maps, and the number of collecting localities in all other cells; this was done separately for each Amazonian country and for Amazonia as a whole.

	NY	MO	Total
No. of collections in terrestrial Neotropics	62,464	1,001,066	1,063,530
No. of collections in Amazonia	34,418	342,953	377,371
No. of collecting localities in terrestrial Neotropics	7,464	55,782	63,246
No. of collecting localities in Amazonia	2,731	13,327	16,058

Table 1 Point data of georeferenced herbarium collections from the database of New York Botanical Garden (NY) and the TROPICOS database of Missouri Botanical Garden (MO) available for this study. NB: NY and MO data may include duplicates of the same collection.

Results

The total number of grid cells in Amazonia was 552 or 2211 (1°- or 0.5°-grid, respectively). Of these, 83 or 940 were void of collections (15.0 % or 42.5 %, respectively). In the half-degree grid, the paucity of data translates into an area of 2.9 million km2 with no collections. Poorly-collected area (= less than one collecting locality per 1000 km2) covered 27.7% (1.9 million km2) of the Amazonian area. In all, more than 70% of Amazonia is covered by a collecting locality network with a density below one per 1,000 km2. This means, on average, that the knowledge of the flora of a square larger than 30 km by 30 km is acquired through plant-collecting at a single point. Comparatively well-collected areas (with more than 20 localities per 1000 km2, i.e., one locality representing a square of c. 7 km by 7 km or smaller) was limited to 1.9% (130,000 km2) of the Amazonian area.

There were considerable differences between Amazonian countries in the distribution of collections. Ecuador had no empty cells even on the half-degree grid, whereas in Colombia > 40% and in Brazil > 50% of the half-degree cells lacked collections (Table 2).

	Amazonian cells		
	N	N_{empty}	$\%_{empty}$
Bolivia	120	19	15.8
Brazil	1342	766	57.1
Colombia	151	67	44.4
Ecuador	46	0	0.0
French Guiana	26	1	3.8
Guyana	67	9	13.4
Peru	275	66	24.0
Surinam	48	10	20.8
Venezuela	136	2	1.5
TOTAL	2211	940	42.5

Table 2 Number of grid cells (N), and number and proportion of cells lacking collections (N empty, % empty) in the nine Amazonian countries. All numbers calculated for the half-degree grid only.

The choice of grid cell size had a considerable effect on the overall picture of the distribution of collecting effort (Figure 2). The coarser grid gave an impression of a more even distribution with fewer gaps (Figure 2a), although it should be noted that even the majority of those areas shown in shades of green in Figure 2 contain only very few collecting localities. The finer grid (Figure 2b) revealed vast areas lacking collections. Both resolutions, however, showed certain trends:

- Western, northern, and southern Amazonia have clearly higher and more evenly distributed collecting effort than central and eastern Amazonia.
- Brazil has considerably lower overall collecting intensity and many more empty cells than other Amazonian countries.
- Colombia, Peru, and particularly Brazil have considerable parts of their Amazonian territory void of collections or nearly so, whereas the Ecuadorean and the Guayanan Amazonia are more evenly covered

The network of Thiessen polygons based on collecting localities conveys a visualisation of the extent of land covered by a single collecting locality (Fig 3). Compared with the grid presentation, it provides a scale-independent presentation of collecting effort: a big polygon indicates regionally low collecting activity, whereas a small polygon tells the opposite, and the size of the polygons varies without threshold values. The polygons show that the knowledge of the flora of interior Amazonia is based on collections from a handful of widely scattered localities. The area of the largest polygons is more than 10 000 km2, indicating that such an area is covered by a single collecting locality. There were 83 of these large polygons (>10 000 km2) in Amazonia.

Discussion and Conclusions

Our results show that Amazonia remains poorly explored botanically. Collecting effort also continues to be very unevenly distributed. The best-collected areas are generally found around larger cities (e.g., Manaus, São Gabriel

de Cachoeira, Iquitos, Saül, and Cayenne), and relatively high collecting activity is also found along the main routes of access (e.g., the Amazon river and Rio Negro, Rio Tocantins, and Rio Madeira, and the roads BR163 and BR364). We must, however, ask how well the observed pattern reflects the real spatial distribution of collecting effort because we mapped registers of only two herbaria.

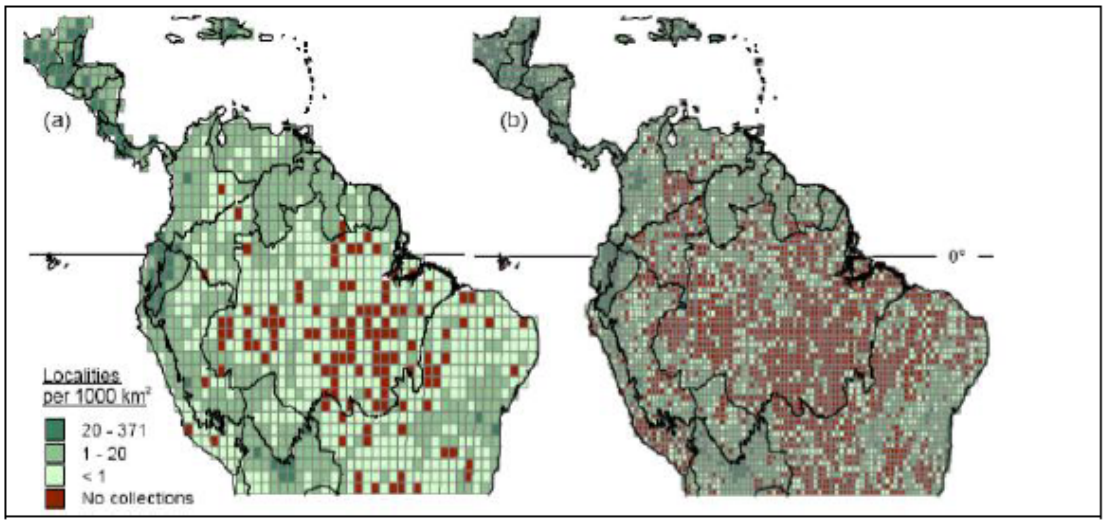

Figure 2. Collecting activity as the number of collecting localities per 1,000 km2 presented per grid cell for (a) a one-degree grid and (b) a half-degree grid. Cells lacking collections are highlighted in red. Cells with at least one collecting locality are divided into four categories, which denote poorly collected, fairly collected, and relatively well-collected areas. Also shown is the delimitation of Amazonia employed, and national borders.

The herbaria of MO and NY have very large Neotropical collections, and collectors all over the world send duplicates to one or both of these major centres of investigation. Nevertheless, at least Brazilian herbaria apparently contain plenty of collections not duplicated in Northern Hemisphere herbaria (especially IAN, MG, INPA, and RB; D. Daly, pers. comm.; M. Hopkins, pers. comm.). Hence our maps may be weak for Brazil. Furthermore, the majority of our data came from MO, which has been particularly active in the Spanish-speaking Neotropics. On the other hand, the pattern of geographical bias in our map is very similar to that found by Nelson et al. (1990), even if they used a quite distinct dataset – their sample came from seven Brazilian and two North American herbaria (NY and US, but not MO), and consisted of collections of a single plant genus. Ours was 160+ times larger and not taxonomically restrained. That the distribution patterns of collecting effort were so similar in both studies despite the methodological differences strengthens the credibility of the results. Therefore, we believe that the pattern in our maps is probably a rather good representation of the true collecting activity distribution. We discuss necessary technical considerations in the mapping of collecting activity elsewhere (Schulman et al. 2007a).

Given the global importance of Amazonia as a centre of biodiversity, it is discouraging to see that many of the gaps in our knowledge of the diversity and distribution patterns within the basin have remained largely unaltered for the last two decades. This study analysed botanical activity but, since the same logistical and financial restrictions apply, the zoological picture is similar (Kress et al., 1998). If uncorrected for collecting gaps and bias, current biological knowledge regarding species ranges in Amazonia may be misleading. For biology to play a meaningful role in land-use planning, e.g., in the selection of conservation areas (cf. Schulman et al., 2007b), corrective models are needed (see Schulman et al. 2007a).

In the long run, the best way to get rid of the deficiencies is, of course, to collect more information. We hope that future expeditions will focus on the white areas revealed by our analyses. Concerted action should be taken to explore the unique Amazonian biome more evenly.

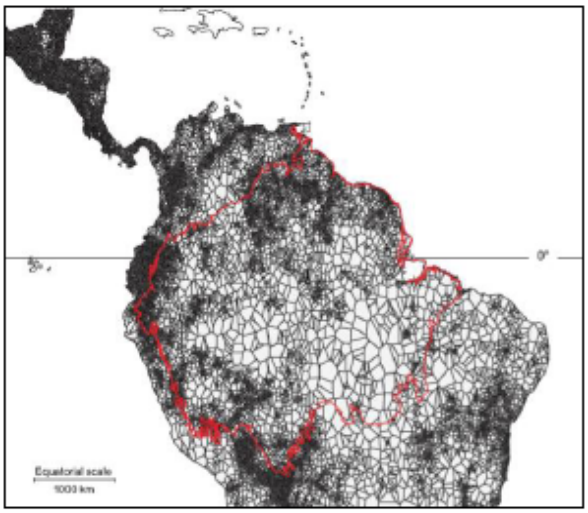

Figure 3. Collecting activity as the area covered by each single collecting locality (=Thiessen polygons); each polygon shows the area closest to the collecting locality that is situated in the centre of the polygon. The smaller the polygons the higher the density of collecting localities. Also shown is the delimitation of Amazonia employed.

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Lost and found in the Greek flora

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Mediterranean-type ecosystems

The five mediterranean-type areas in the world – the Mediterranean basin, California, central Chile, the south-western Cape of South Africa and south-western Australia – are well-known hotspots of plant species diversity and endemism. In very general terms they are characterised by a climate with hot dry summers and cool wet winters – the climate of olives groves, vineyards and citrus orchards. Most of the areas are mountainous with a great diversity of local climate, bedrock and soil. The native vegetation is generally dominated by evergreen, hard-leaved shrubs and feature a number of bulbous and tuberous plants. The northern hemisphere areas and the Mediterranean basin in particular have a high percentage of annuals, often associated with disturbed or manmade habitats. The floras are old *in situ*, and extensive speciation has taken place, resulting in a large number of local and regional endemics some of which can be classified as threatened or vulnerable.

In South-west Asia and the Eastern Mediterranean area transformation of the natural landscape through agriculture and domestication of animals such as cattle, sheep and goats started at least 8,000 years ago. Great civilizations like the Minoan one in Crete developed some 4,000 years ago and by that time agriculture and animal husbandry was already well established. The long and gradual process up to the present day has had profound influences on the natural flora and vegetation, resulting in a complex small-scale mosaic of natural, semi-natural and manmade habitats. In the other four areas of the world with mediterranean-type climate and vegetation the history of human influence is radically different. The aborigines of Western Australia and the native peoples of the south-western Cape walked with light steps on earth, leaving few traces. Agriculture and domestic animals were introduced with European colonization which in the case of Western Australia was as late as 1828. Almost from one year to the other huge areas were cleared for agriculture, mainly cultivation of wheat, and domestic animals, mainly cattle and sheep, were introduced.

Differences between the five areas

In southern Greece, e.g. in the Peloponnese and the Aegean islands, agriculture was old already in classical times. Ancient thrashing floors and disused terraces are frequently found in the hills; some of them may have been used continuously for thousands of years, the surrounding hillslopes being deforested and turned into garigue. A picture from the wheat belt of Western Australia is radically different. Huge areas of flat, sandy ground have been cleared for mechanised agriculture and the few eucalypts still standing are rather an exception.

Although the mediterranean-type areas of the world have some general features in common, there are distinct differences in the patterns of plant species diversity. Species numbers are high to very high in all five regions. Areas with a mediterranean-type climate in the countries bordering the Mediterranean Sea may have a total of 20,000 species of vascular plants, although precise figures are difficult to establish since published Floras and checklists are generally based on politically defined geographical units such as countries or provinces. Greece – a medium-sized country with a land area of some 132,000 km^2 – is home to about 5,800 native species of vascular plants, but many of these are referable to Central European or other phytogeographical elements. In the Cape floral kingdom, an area of only some 90,000 km^2, the figure is even higher, maybe 8,000 native species, making it one of the true botanical hotspots in the world. The mediterranean south-western corner of Australia is somewhere in between, with perhaps 7,000 native species. All mediterranean areas have a high percentage of species with small distribution areas – local or regional endemics.

As mentioned, the history of human impact through agriculture is radically different in the five areas, and this is presumably the decisive factor underlying differences in the weed flora and generally in the percentage of annual species. In lowland areas in countries such as Greece, Italy and Spain, annual species often make up c. 50 per cent of the flora. It is perfectly possible that many of these Mediterranean annuals, which are mostly associated with disturbed habitats, were originally introduced from areas of steppe and semi-desert in South-West Asia, but if so, this happened long before there are any records of it. It is a striking feature of the weed flora of the other four areas in the world with a mediterranean-type climate, that most species have been introduced from the Mediterranean basin. This is very typically so for Western Australia where agriculture has the shortest history. There are few native annuals in the flora of south-western Australia. Further inland, in the semi-desert outback, there are indeed annual members of Asteraceae, Goodeniaceae and many other families but they stood little chance in the competition with aggressive invaders from the Mediterranean basin whose genotypes had been adapted to manmade landscapes through thousands of years of selection. In many temperate areas of the southern hemisphere and particularly on oceanic islands the weed flora has a distinctly European character. A striking example is New Zealand where European weeds have taken over completely even in mountainous area with moderate disturbance mainly by sheep grazing. *Echium vulgare*, for instance – a European species not regarded as a troublesome weed in its native land – covers huge areas in the hill country in the northern part of the South Island.

There are few examples of overseas weeds in the flora of the Mediterranean basin, but a few may be mentioned. *Oxalis pes-caprae*, a species introduced from South Africa, is abundant in southern Greece, painting the olive groves yellow in early spring. Having been around for a couple of centuries and spreading aggressively by means of vegetative propagules it has presumably reached its climatically determined distribution area, being common in the lowland south (even on small islands) but lacking in the north and in the mountains. *Solanum eleagnifolium*, a South American species introduced as late as c. 1940, is spreading aggressively along roads and even invading cultivated fields and semi-natural vegetation.

As a result of wholesale destruction of natural habitats a fairly large number of species in areas such as the Cape Flats east of Cape Town and the wheat belt of SW Australia have gone extinct or survive in tiny, fragmented and threatened populations. As we shall see, the situation is rather different in Greece with few known extinctions and relatively few seriously threatened species.

Botanical exploration of Greece

Modern botanical exploration of Greece, if by that we mean the time after Linnaeus, started with the Oxford professor John Sibthorp who in 1786-87 collected the material for the magnificent *Flora Graeca* which appeared after his death in 10 folio volumes featuring nearly 1,000 hand-coloured copper engravings. The mid-19th century was the golden age of botanical exploration in Greece. Two of the leading figures were Theodor von Heldreich and Thoodoros Orphanides. Heldreich, a botanist of German origin, arrived in Greece as a young man in 1843 and stayed until his death in 1902, exploring throughout the country and collecting some 700 new species. His Greek contemporary Orphanides travelled in many remote mountain areas and made several spectacular discoveries. By the turn of the century, Halácsy's *Conspectus Flora Graeca* appeared in three volumes, summarizing floristic knowledge for the country up to that time.

Plotting the number of new taxa and new combinations per decade from the time of Linnaeus to the present we can observe some conspicuous peaks and valleys (Table 1). An all-time low occurred just after the Second World War, but interestingly there is a new surge in floristic and taxonomic activity from c. 1965. Extrapolating data we find that 12-15 new species and subspecies per year have been described over the last 30-40 years – a high figure for a European country. Most of them are local endemics or species in previously neglected groups. One of the leading collectors of the mid-20th century was Karl Heinz Rechinger, later coordinator of the great *Flora Iranica* project.

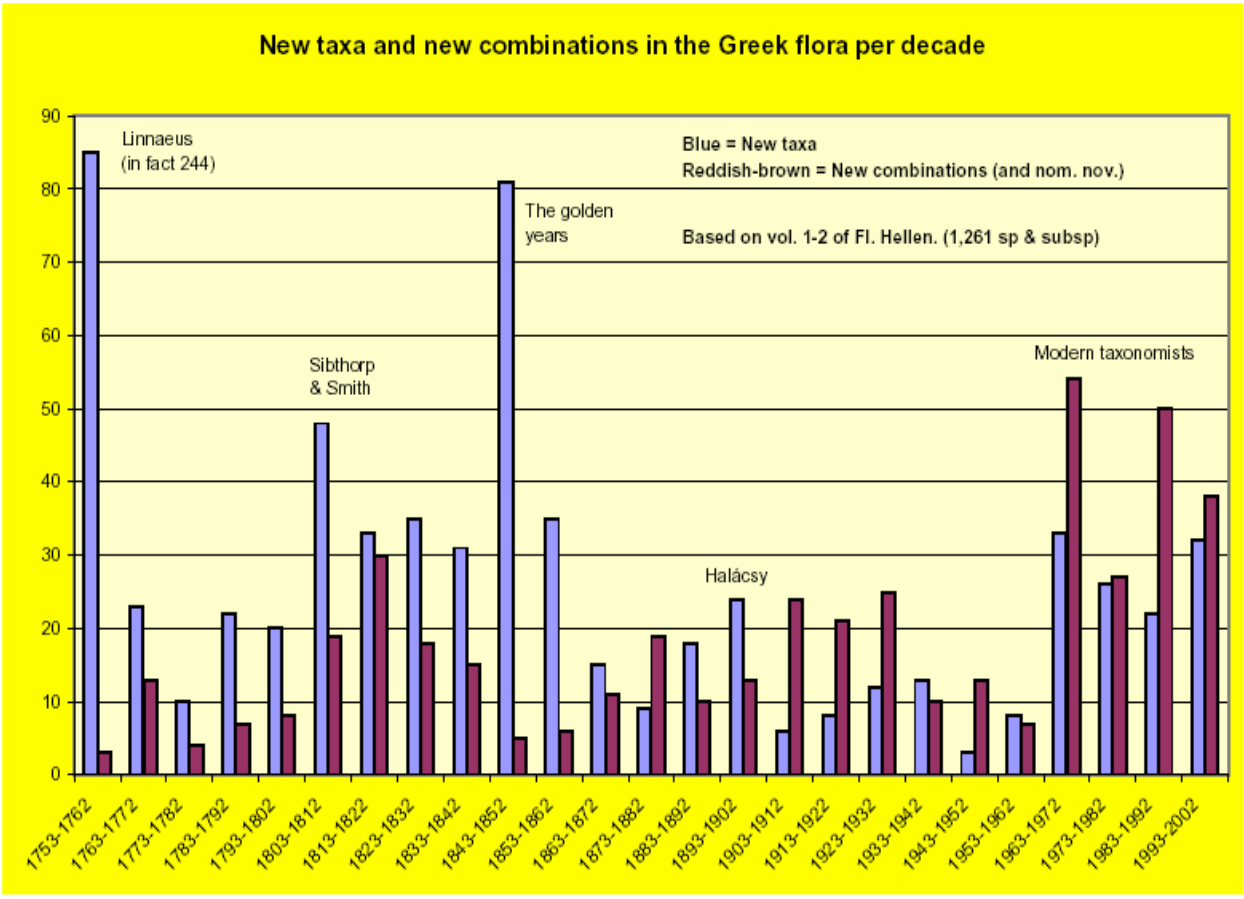

Table 1. Number of new taxa and new combinations in the Greek flora from Linnaeus to the present.

Intensive floristic exploration has taken place in Greece over the past 40-50 years, particularly in the mountains and islands. A database established in connection with the *Flora Hellenica* project now comprises 684.000 records, all with detailed data including geographical coordinates, on the collection or observation of a plant species somewhere in Greece. In the *Mountain Flora of Greece*, which was published in two volumes in 1986 and 1991, we had six or seven species which had not been observed for 100 years or more and were listed as presumably extinct. I am happy to report that all have now been rediscovered, and so have a number of supposedly lost lowland species.

Species lost and found

The following are a few case histories of species believed to be extinct but recently rediscovered:

(1) *Astragalus idaeus*, a low, grey-leaved and yellow-flowered perennial, was collected in Crete by Heldreich in 1846. Although hundreds of botanists have visited Crete it was not rediscovered until 2002, presumably in the original locality – a remote mountainside – where the total population comprises a few hundred individuals.

(2) *Centaurea musarum* ("knapweed of the muses") was found by Orphanides in 1854 on Mt Parnassos above the archaeological site of Delphi, where it was rediscovered in 1995. It is a distinct and taxonomically isolated species apparently confined to a single limestone rock with a total of perhaps 200 individuals. This species as well as the previous were rediscovered by the intrepid Greek field botanist Dionysios Vassiliades.

(3) *Bongardia chrysogonum*, an herbaceous tuberous member of the Berberidaceae, grows in steppic areas and ploughed fields in C and SW Asia. In 1987 the present author discovered it in a small field in the northern Peloponnese, far from its nearest localities in eastern Turkey. The only previous Greek record dated back to 1822 and is dubious, probably resulting from confusion with the superficially similar *Leontice leontopetalum*.

Figure 1. Fritillaria sibthorpiana*, a lost and rediscovered species 219 years between the pictures. Left* Fritillaria sibthorpiana*.* Flora Graeca *tab. 330 (1823). Illustration by Ferdinand Bauer based on a specimen collected by Sibthorp 30.3. 1787 at Porto Cavaleri [near Akyar Burnu], SW Anatolia. Right:* Fritillaria sibthorpiana*. Rediscovered after 185 years by Runemark & Wendelbo in same area (C2 Mugla: Pass SW of Bozburun). Cultivated in Göteborg Botanical Garden, phot. 23.4. 2006.*

(4) In 1787 John Sibthorp and the artist Ferdinand Bauer were travelling by ship from Constantinople to Cyprus. In south-west Anatolia opposite the Greek island of Rodhos they landed at a place known as Porto Cavaleri, and on March 30 they collected a *Fritillaria* which was drawn by Bauer and later described as *Fritillaria sibthorpiana*. It is a distinct species which was never found again until 1972 when two Scandinavian botanists, Hans Runemark and Per Wendelbo, travelled in the area. At or very near locus

classicus they rediscovered the enigmatic *Fritillaria sibthorpiana* which is still cultivated in our garden (Fig. 1).

Conclusions

We may conclude that few if any of the rare and local species of natural and semi-natural habitats in the mountains have gone extinct in the last 100-150 years. Some may be threatened simply by being very rare and occurring in small populations – such as examples 1 and 2 above – but human impact is limited and fairly constant. Shepherds are grazing their flocks of sheep and goats just as they did 100 years ago, but the plants can cope unless there are major disturbances such as mining or construction of large skiing resorts. Local endemics are not necessarily threatened. The famous *Jankaea heldreichii*, for instance, one of the few European members of the Gesneriaceae, is confined to Mount Olympus but is found in large quantity on inaccessible limestone rocks. No amount of collecting or other conceivable disturbances could threaten the survival of this local endemic – which was listed in one IUCN publication as a prime example of a rare and critically endangered species.

There are indeed a few species in Greece which are presumably gone for ever. A fairly typical example is *Astragalus graecus*, a yellow-flowered perennial 40-50 cm tall, once common as a weed in cereal fields in Attica. It was frequently collected and every major European herbarium has several sheets of it. It was last seen in 1947. Scientific collecting was certainly not the reason for its decline, but changing agricultural practices, particularly deep ploughing, as well as the spread of metropolitan Athens.

Weeds of agriculture, especially perennial ones, are often declining and threatened. A spectacular example is the red tulip *Tulipa undulatifolia* which was common in wheat fields of Attica and the Peloponnese, but has now disappeared except in a few places where it is deliberately protected by local farmers managing selected fields by old-fashioned methods. It flowers around Greek National Day (March 25) and is then picked in large quantity for decorating churches and homes.

A number of species adapted to other lowland habitats such as sandy beaches, salines and freshwater swamps are also in jeopardy. They include some local endemics such as *Consolida arenaria* and *Verbascum syriacum* from sandy beaches on the island of Rodhos, an area subject to much development of tourist facilities. Even if most of the species of such habitats are fairly widespread they are often similarly threatened throughout their range.

Redlisting taxa for individual countries or provinces, although politically correct, is of little scientific value. Every species, even the most common and widespread, will be rare somewhere on the far side of an invisible line in the terrain. Consequently, all the world's redlists taken together will comprise most of the world's flora. Interest should focus on species, not countries or other politically defined entities. Conservational measures should be based on intimate knowledge of the species in the field throughout their range of distribution, not on mechanically compiled lists. The term *endemic* should be abandoned and replaced by *range-restricted*, for instance defined as species with less than 500 km distance between the furthest points of occurrence – regardless whether the distribution area is confined to one country or cuts across national borders.

The present condition of plant conservation by Japanese botanic gardens and their provisions for the 2010 Target

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Plant Diversity in Japan

Japan has a long narrow land mass extending from north to south and its climatic diversity spreads from Sub Frigid Zone to Subtropical. It has much precipitation and great climatic difference of four seasons. Diverse natural environments are made by the landscape with a changing topography, namely rivers, plains, basins and mountains. Various plants grow in and adopt this diversity of climate and landscape. Two third of Japanese land is covered by forests. It is one of the most forested countries in the world. We have about 7,000 species of seed plants and ferns. Within the range of species about 2,900 are endemic in Japan. That means 40% of all species.

Based on the Ministry of Environment report released in 2000, 20 plant species are already extinct in Japan and 1,835 are threatened with extinction, which means 24% of the total plant species in our country (Environmental Agency, 2000).

Conservation by Japanese botanic gardens

The Japan Association of Botanical Gardens (JABG), aims to develop and disseminate services for botanic gardens and provide good communication between botanic gardens, government and civil societies. It supports the activities of research, documentation, education, exhibition and etc. by the member botanic gardens. At the moment JABG is made up of 119 Japanese member botanic gardens.

JABG has made two surveys about the condition of plant conservation in the member botanic gardens from 1999 to 2003.

More than half of botanic gardens did or are doing conservation works and/or educational activities for citizens. The main works they did and/or ready to do are as follows.

1. Collection and propagation of endangered species

2. Conservation works *in situ*
3. Emergency evacuation of endangered species
4. Research on the biological property of endangered plants
5. Educational work for the study of plant diversity and conservation for the community
6. Support the conservation activity of NPOs (non-profit organizations - see) http://www.jnpoc.ne.jp/English/index.html)

However, 22% of member gardens have no programme to collect, cultivate and conserve endangered plants in their gardens. That means there are many member botanic gardens which have no facilities to work on plant conservation.

Endangered plants conserved in botanic gardens

Japanese botanic gardens keep and cultivate 695 species of the 1835 endangered plants, corresponding to 38% in 2003. However, 459 species within 695 are cultivated in less than 3 gardens. For the secure conservation of these plants, it is necessary to be cultivated by more gardens. Documents about their habitat are completed on only 29% plants kept in botanic gardens.

Our provisions for the 2010Target

1. Botanic garden network for conservation

There is no botanic garden in Japan which can conserve all the endangered plant species in one organization. In the past, each garden independently undertook conservation work, not knowing the detail of work done by other institutes. Therefore they duplicated efforts on the same activity.

To increase the number of endangered species conserved in Japanese botanic gardens and improve the quality of conserved plants, it is a necessary to establish a national network of botanic gardens, making use of the specialty of each garden and mutual cooperation in undertaking conservation work.

In 2006, JABG set up a new institution, a Network Hub of Botanic Gardens for Conservation, considering their climate, region or field of research. The regions were divided into 9, Hokkaido, Tohoku, Kanto, Hokuriku, Tokai, Kinki, Chugoku-Shikoku, Kyushu and Okinawa.

The hub botanic gardens collect and conserve mainly endangered plants which are occur in their areas and coordinate other botanic gardens in the area, local governments, NPOs and other authorities.

JABG coordinates the network totally and collects, arranges and distributes information about the plant conservation, promotes workshops and organizes the distribution of endangered seeds and plants between gardens.

One of the main activities of this system is to collect and conserve seeds from their habitat.

In addition to this networking system, the collection of information on the genome has to be maintained from four main areas: living plants, specimens, seed and DNA. By establishing the system for the conservation of total plant genomes, we are confident that our important plants will be conserved steadily and continuously.

2. Manual for the conservation of plant diversity in Japanese botanic gardens, compilation and distribution

In 2006, JABG compiled a new technical manual describing the present situation of plant conservation in Japanese botanic gardens, philosophy and technology through the financial support of BGCI, The National Science Museum and Japan Fund for Global Environment.

3. Public relations about the importance of plant conservation and the role of botanic gardens

- A travelling exhibition about the conservation of endangered plants in botanic gardens - Let's conserve our native plants: The travelling exhibition about the conservation of endangered plants is being held in botanic gardens throughout Japan, under the auspices of JABG, BGCI and the Ministry of Environment. It started in 2005 and will be held in about 30 gardens.

- An exhibition about the conservation of endangered plants in the city centre: The exhibition in botanic gardens is not enough to propagate the aim of botanic gardens for plant conservation to the public. In August 2006, the exhibition was held at the Tokyo Shinjuku city centre. Many citizens and commuters visited the exhibition.

- The Botanic Garden Symposium－Let's conserve our native plants: On March 10, 2007 a symposium was held in Tokyo to discuss the conservation work undertaken by botanic gardens and their role in the conservation of plant diversity in Japan.

Reference

Environmental Agency, 2000, *Revision, Japanese Threatened Species – Red Data Book – 8* Plants I (vascular plants), Natural Environment Research Centre, Tokyo.

The endemic flora of Greece

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The total number of species in Greece is approximately 5800. This figure represents all native vascular plants and is surprisingly high for such a small country in Europe. Of these, c. 760 (c. 13% of the flora) are endemic, i.e., they occur only in Greece and nowhere else in the world. This is the highest degree of endemism for any country or territory of a comparable size in Europe and the Mediterranean area.

There are two main reasons for this high incidence of endemism:

1. the great age of the flora which has remained relatively undisturbed by glaciations which have wiped out plant life in the rest of northern Europe since the Miocene.

2. the dissected topography and variety of rock substrates (limestone, schist, granite, serpentine, etc) which have favoured speciation. It is the islands and high mountains which are particularly rich in local and regional endemics.

Endemic species are often of considerable taxonomic and phytogeographical interest and work is currently in preparation on an endemic flora of Greece. Three volumes are planned: the first deals with the Peloponnese, the second will cover Crete and the islands and the third, the rest of mainland Greece. It is noted that published and unpublished data on the many endemics in the Greek flora, correctly evaluated and compiled, are necessary for a sound and scientific basis for plant conservation and education.

Greek endemics belong to two broad categories — paleo-endemics and neo-endemics.

1. Paleo-endemics are generally taxonomically isolated species representing an evolutionary standstill, often with primitive characteristics, and usually found in rocky habitats. Examples are *Beta nana* (Chenopodiaceae) from the mountains of the Peloponnese, Sterea Ellas and Mt Olimbos, and *Anchusa cespitosa* (Boraginaceae) from the White Mountains (Levka Ori) of SW Crete. The islands and mountains have given shelter to ancient species which would otherwise be destroyed.

2. Neo-endemics, on the other hand, are more frequently encountered and have close relatives in adjacent areas or environments, occurring in groups in which active speciation is taking place. They have evolved unique traits, either in the process of adaptations to special conditions, or as a result of random genetic or population drift. Examples are the taxa comprising the *Scutellaria rupestris* group (Lamiaceae) and the *Nigella arvensis* complex (Ranunculaceae). The latter are annuals of the Aegean area and have been subjected to extensive biosystematic studies by Strid in 1970. There are distinct local variants on practically all the large islands, recognisable by a unique combination of features particularly with respect to the shape and colour of the floral parts.

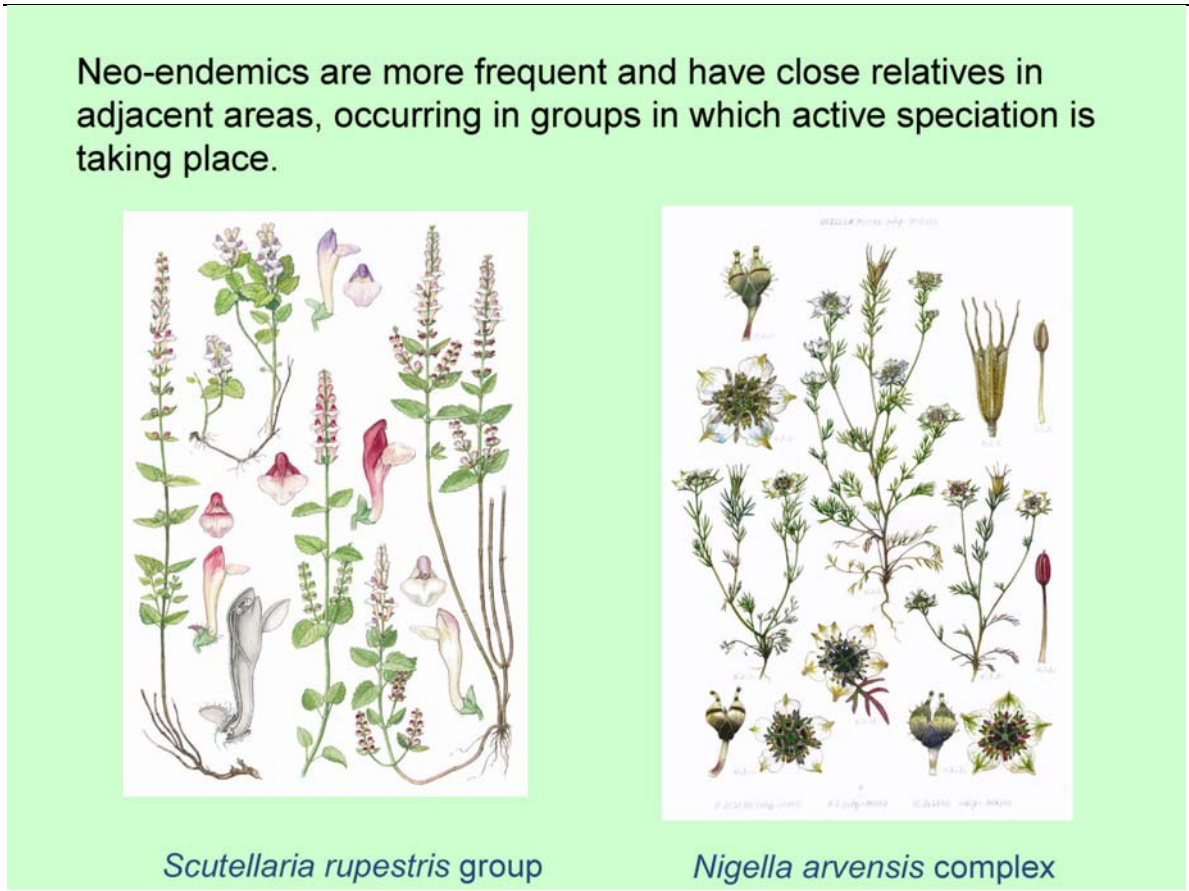

Figure 1. Neo-endemics are more frequent and have close relatives in adjacent areas, occurring in groups in which active speciation is taking place

Crete is the only territory in Greece combining isolation with high mountains, and therefore within Greece, and quite possibly for any comparable area in Europe, it is the region with the highest concentration of endemics. No less than 250 out of the c. 760 Greek endemics occur on Crete. Of these 250, 175 are restricted solely to the Cretan area. When you consider mountain taxa alone, a remarkable 36% is endemic to Crete as compared to 10% for the Peloponnese and 6% for Sterea Ellas. The figures are only 0.5% to 4% in the more northerly mainland phytogeographical regions. We can thus conclude that aridity and isolation have obviously contributed to the evolution and preservation of a number of local endemics, especially in the White Mountains where the number is highest.

You must not think that all endemics are rare or threatened. Indeed some of them are among the most common and most characteristic species especially on Crete, e.g., *Phlomis lanata*, *Ebenus cretica* and *Verbascum spinosum*. On the other hand, there are also species on Crete whose known occurrence in the world is restricted to less than 150 individuals. Examples are *Onobrychis sphaciotica* and *Nepeta sphaciotica*. Such species can well become extinct owing to breeding collapse, even if the habitats they occupy are not further disturbed.

Where are endemics found?

On the smaller islands, local endemics are mainly confined to cliff habitats, e.g., *Carlina diae* (from the island of Dia), *Helichrysum amorginum* (from the islands of Amorgos, Keros and Anidros) and *Aubrieta scyria* (on Skiros). On mainland Greece the highest concentrations of endemics are found in limestone or serpentine rock crevices and scree.

Serpentine (ophiolithic) rock occurs in many parts of Greece. The rocks are blackish or greenish-black when freshly broken, they weather easily developing a rusty-red or purplish patina and they produce extensive scree. The unusual chemical composition of the rocks and soils, with the high amounts of Magnesium silicate and heavy metals, makes them inhospitable to many species. However, there are plants which are strictly adapted to this kind of substrate and serpentine areas are specialized habitats which are important centres for floristic differentiation and speciation. There are probably 50 or 60 taxa, so-called "serpentine endemics" which are restricted to the ophiolithic areas of NW Greece, N & C Albania, C Bosnia and SW Serbia. Examples are *Bornmuellera baldacci, B. tymphaea, Leptoplax emarginata, Centaurea vlachorum, Silene haussknechtii, Alyssum smolikanum, Viola dukadjinica* and *Fritillaria epirotica*. Usually these serpentine endemics are not confined to a single mountain.

Triassic and Jurassic limestones are the most widespread substrate in the Greek mountains. Limestone mountains are generally dry and rainwater or snow melt-water disappears quickly into cracks and fissures. As previously mentiuoned, the Levka Ori or the White Mountains in SW Crete has the highest number of endemics with both paleo- and neo-endemics well represented. It is limestone, exceedingly dry and desolate in the summer. The spectacular Samaria gorge and the mountains above it also have some interesting endemics, e.g., *Staehelina petiolata* and *Symphyandra cretica*. Many of these endemics occur at low altitudes.

The large limestone massifs of the Peloponnese and Sterea Ellas, e.g., Taigetos, Killini, Chelmos, Parnon, Parnassos and Giona, also have a number of local endemics, mostly in rock crevices and screes at alpine levels. Olimbos in the NC and Athos in the NE have 21 and 13 species respectively. The mountains of granite and micaceous schist and other acid rocks in N Greece are rich in Central Balkan endemics but relatively poor in local endemics.

The Peloponnese has long been known as an area rich in regional and local endemics many of which were discovered by the classical collectors of the mid-19th century, e.g., Theodor von Heldreich and Theophanis Orphanides. Some have not been seen for a long time and thus feared extinct, e.g., *Dianthus androsaceus, Astragalus agraniotii, Adonis cyllenea, Helichrysum taenari* and *Micromeria taygetea*. However, all of them have been found alive and well within the last 20 years when floristic exploration in Greece intensified. Indeed some taxa were found to occur in great numbers with several thousands of individuals.

There are c. 330 endemic taxa in the Peloponnese. Approximately 110 of these are restricted to the region. The total flora of the Peloponnese (including Kithira) is estimated as 2630 species. Most of the endemics occur in the Taigetos and Parnon ranges in the south and on Chelmos in the north. The Gulf of Korinthos is a weak phytogeographical barrier and 46 Greek mountain endemics occur in both Peloponnese and Sterea Ellas whereas only 17 Greek mountain endemics are shared by Sterea Ellas and S Pindhos. The connections between Sterea Ellas and S Pindhos are thus weaker than between Peloponnese and Sterea Ellas and this is interesting because the mountains in Sterea Ellas and S Pindhos form a more or less continuous chain. Only four Greek mountain endemics are shared between Crete and Peloponnese, indicating the much weaker floristic connections.

Polyploidy is more frequent in species or groups of species in the Peloponnese than in related taxa occurring elsewhere in Greece. As speciation is often at the diploid level in geographically isolated populations, the Peloponnese seems to be an endpoint at least for some endemics. In other words, the Peloponnese is the region where many taxa have arrived in one of their final stages of evolution and can go no further. They are pushed to the uttermost and remain in a dead-end.

Grazing is often believed to be a major threat but this is a natural environmental factor which has existed for thousands of years. Plants are either able to withstand it, escape it or even depend on it. For the mountain endemics, most are prefectly safe. Overgrazing might threaten the existence of a few, very rare species in Greece but in general, plants face extinction only if they consist of one or a few very small populations, i.e., they are threatened only by their rarity.

You may well ask why should such a work as *The Endemic Plants of Greece* be necessary? As there are so many rare endemics in the Greek flora, conservationists tend to paint an alarming picture as to their case for protection. But unless you know something or quite a lot about these plants, you cannot take any intelligent steps towards protecting them. 520 of the endemics are listed as on the Red Data ”endangered list” by the Council of Europe in 1986, i.e., they are rare or threatened. No one at the moment, knows the nature or extent of the threat, whether it is real or imaginary.

We would like to collate information, both published and unpublished, scattered or widely available, in order to have a scientific basis for knowledge about these endemics. In the work, for each taxon, reference to the original place of publication is given. Description, type citation, chromosome number (when known), habitat, substrate, altitudinal range, flowering and fruiting period, variation, affinities, history, information on pollination ecology, dispersal, economic uses if relevant, are provided. The distribution is accompanied by a dot map.

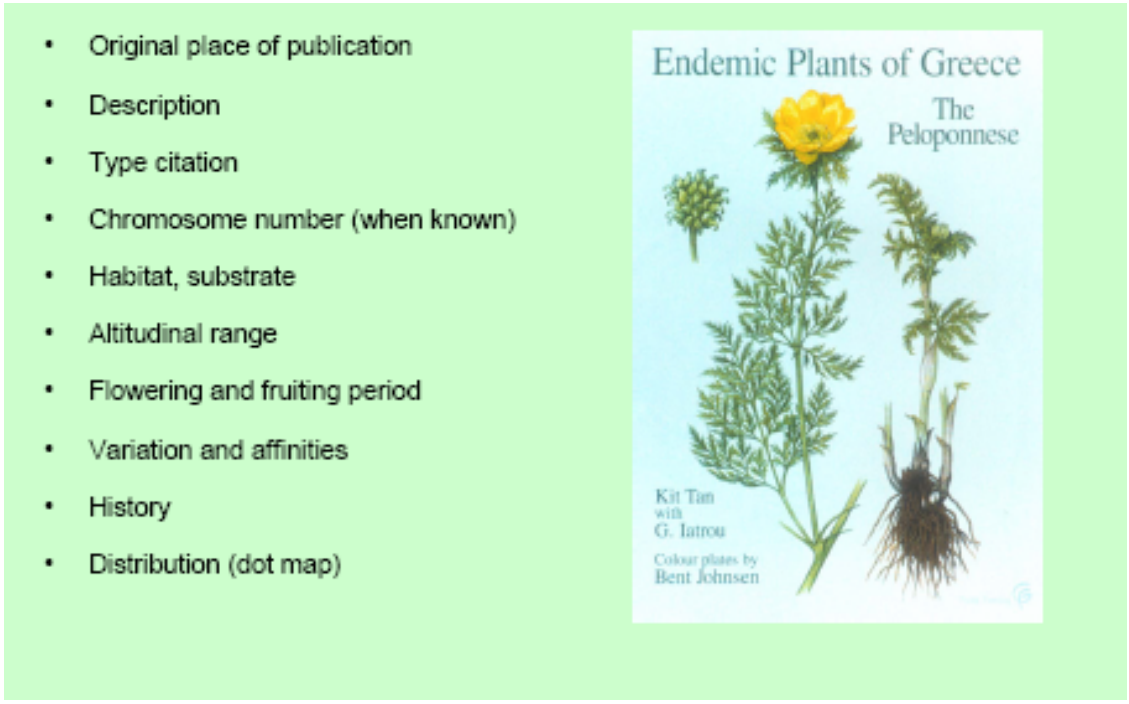

Figure 2. Scientific basis: collate information, both published and unpublished, scattered or widely available

It is a good idea to see the plants in their native habitats, study their ecology and distribution (this means fieldwork), study their closest relatives and affinities (taxonomy, cytology), see if they are growing or going (investigations on seed dispersal, viability, germination, pollination biology, etc.). Only then can the data, be it original or intelligently evaluated and compiled, be used on a sound and scientific basis. Unless we know what plants belonging to a particular group can be found, or had once existed, in a given area, and how to identify and name these plants, we cannot go any further in talking about conservation, natural resources, cultivation or education.

Volume 2 of this work will cover Crete and the islands, and Volume 3, the rest of mainland Greece. The work is meant to be both functional and decorative so 111 colour plates were prepared for the first volume and 111 for the second volume. Each family is represented in a colour plate depicting at least one taxon. This will not be a “coffee-table” work but a rather “covetable” work described as “excellent science married to excellent art, thereby producing excellent communication”.

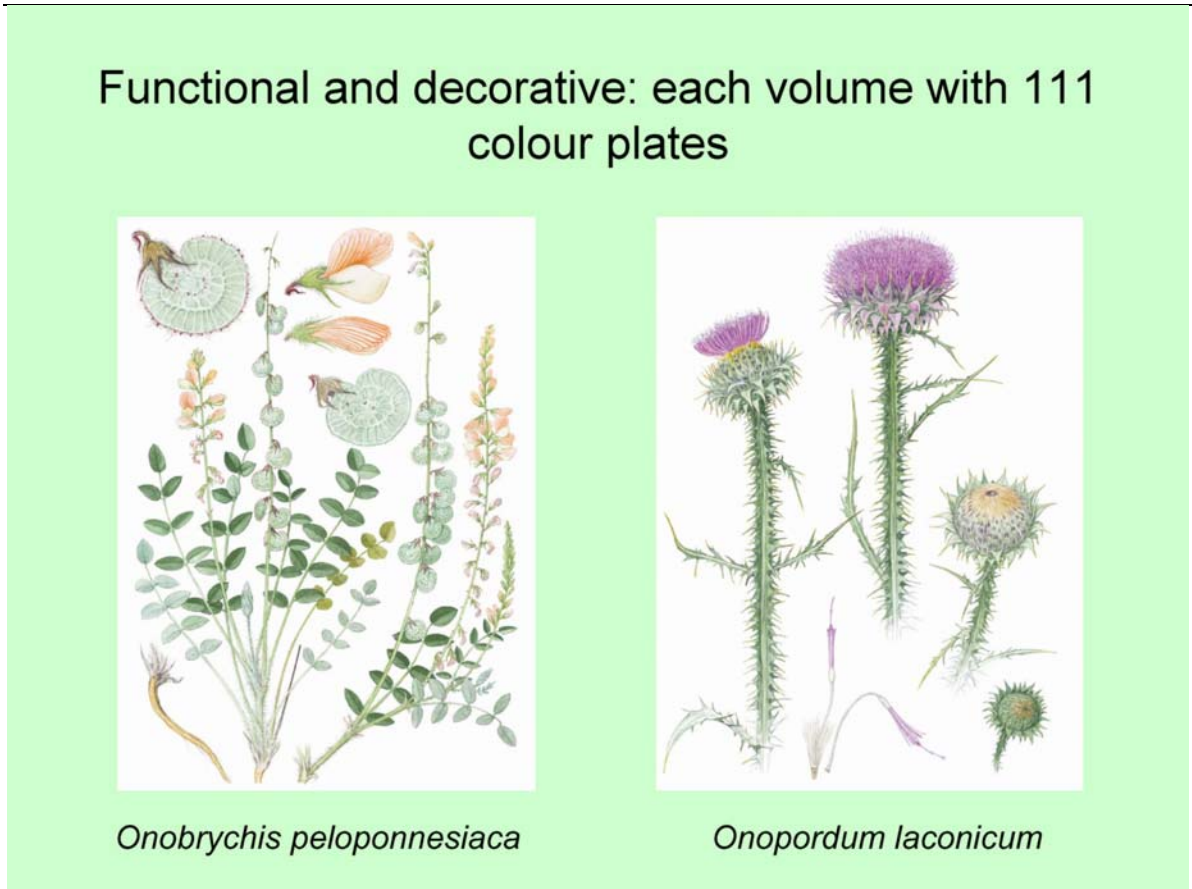

Figure 3. Functional and decorative: each volume with 111 colour plates

BGCI China Programme – training workshops and staff exchanges

Anle Tieu

Botanic Gardens Conservation International, c/o Singapore Botanic Garden

China possesses very rich biodiversity with more than 30,000 species of higher plants accounting for approximately 10 percent of the world's flora. A combination of over 7000 years history of agriculture and China's current rapid economic development have resulted in great pressures on this rich biodiversity. China's botanical gardens, numbering over 130 with more planned or in development, particularly in the last decade have benefited from the growing economy and support from the government. This has lead to a growing number of enthusiastic and motivated botanic garden staff engaged in plant conservation. Although most senior botanic garden staff receive traditional scientific university training, they are not readily exposed to relatively new knowledge and expertise in biodiversity conservation, environmental education and horticulture.

BGCI's 5 year *Investing in Nature* (IiN) Programme launched in 2002 organised a series of training and staff exchange programmes that have raised capacity of botanic garden staff in China. BGCI, through organising training workshops, to the best of our knowledge have come to be the main organisation playing a major role in biodiversity conservation and education in botanic gardens training. Training workshops were held and hosted by different botanic gardens around China including Beijing, Wuhan, Shanghai, Xishuangbanna, Shenzhen, Hong Kong and Kunming. Training themes of each workshop are chosen based on workshop evaluations inviting participants to suggest the next workshop's theme. Trainers were sourced from botanic gardens internationally and locally, many accepting only airfare and board for the training they provided. Workshop themes have included general topics such as introduction to biodiversity conservation and public education to more specific topics which have included database and information management, education and interpretation at botanic gardens, conservation of Chinese medicinal plants (the role of botanic gardens) and seedbanking.

Feedback from participants has generally been very positive. A great majority of respondents finding the workshops useful or very useful as a significant number of respondents comment that it was the first time that they were exposed to concepts of biodiversity conservation, spurring them to seek more information to help them in their work. As the workshops have been co-organised with individual institutions, a sense of ownership has been built with most botanic gardens contributing matching funds and in-kind support to host the workshop. During the course of running the workshop, some valuables lessons have been learned. Many of the workshops tended to be more formal than originally intended. This was mainly attributed due to the formal education system that still exists in China which will take some time to evolve and the co-hosting institutions who have input in the style of workshop format. Although workshops were planned for a maximum of 40-50 participants, due to popularity and interest, some workshops have seen up to 80 participants, which meant that training was less than optimal.

The exchange scholarship similarly had positive feedback from the 37 participants who received training from four rounds of scholarships in 2004-2006. The exchange has been important in bringing together institutions in mainland China and Hong Kong. Participants gain much from the expertise and specialisation of each host botanic garden, which only an extended exposure can provide, which in this case was 2-3 weeks. In most cases the exchange allowed for mainland Chinese botanic garden staff to be exposed to the conservation and environmental education work that is conducted in Hong Kong botanic gardens, namely, Hong Kong Zoological and Kadoorie Farm and Botanic Garden. Mainland Chinese botanic gardens provide botanic gardens staff from

Hong Kong exposure to scientific research, horticulture and propagation technology of endemic flora unavailable in Hong Kong in botanic gardens in Kunming, Xishuangbanna, South China and Beijing.

Bringing botanic gardens from mainland China and Hong Kong together and creating linkages are usually the highlight for most participants such as this respondent –

"The programme is successful and wonderful. I have learned many experiences of plant conservation from the colleagues of KFBG and other conservation organizations. I will use the information to improve my work. At the same time, the colleagues in Hong Kong also had further understood the conservation activities in mainland through our communication" and "Although the training was quite a short period, it was very effective. Throughout the activities, i.e. seminars and field trips, not only our experiences and knowledge were sharing and exchanging, but also - the most important, a communication network was created that ensure a closer working relations and linkages between us in the future."

Participants were also exposed to new conservation and horticulture concepts. For example "it was the first time for me to learn about new concepts such as ecological footprint, horticulture therapy, and arboriculture" and "To sum up, this training let me learn a lot. I understood the ecological way of thinking, and I learned to analyse things from an ecological perspective. I will apply the new theories and new methods that I learned in my own work, and I will share my feelings about the training to people around me"

The benefits were not solely reaped by the trainee as the host botanic garden, particularly KFBG felt that the hosting and training of participants was valuable experience for their staff, particularly younger staff at the garden. KFBG felt that benefits included enhancing staff's training and facilitation skills, team building exercise and creating links with Chinese botanic gardens which lead to future collaborative projects, such as the examples highlighted below. A clear indicator of the success of the programme has been demonstrated by one of the main partners (Kadoorie Farm) who has expressed intention to continue the programme when IiN funding finishes.

Some lessons were learned during the running of the exchange programme. With each new round of scholarships, these lessons were built into the programme to continually improve its content and organisation. It was always the goal of the programme to target young trainees from less prominent and less established botanic garden staff who required the capacity building the most. Thus advertising the scholarship needed to be distributed as widely as possible through as many mediums as possible, including botanic gardens journals, BGCI website and email lists. Once a national network of Chinese botanic gardens is fully established, the dissemination of opportunities such as this scholarship will be made easier and accessible by a wide range of institutions. English proficiency is certainly growing in China, but Chinese remains the main language, so communications still needs to be conducted in Chinese. Botanic gardens in some remote areas of China do not have extensive internet access, so it is important to note that not all communications can be conducted by email. Visa application for Chinese nationals entering Hong Kong can be a bureaucratic and time consuming process, so it is important to allow for at least 4 months for the preparation of appropriate travel documents.

For a significant number of participants in the first round of scholarships, the exchange was considered too short (2 weeks) and generalist. KFBG addressed this by incorporating a third week focusing on 3 streams depending on the participant's field and KFBG key focus areas. These being environmental education, orchid conservation and conservation techniques. Participants also wanted more hands on activities, learning in the field and some suggested on going small research projects on specific topics. Comments along these lines included "Offer more "do-it-yourself" programs. Increase the time for training on topical research", "Hand-on experiments should be included, e.g. assisting the on-going forest researches, specimen collection and preserve treatment techniques" and "I would like to have included / extended the outdoor activities. Site inspection to the tropical rainforest could enhance participants knowledge on the natural growth of plants, their adaptation to the environment and their uniqueness". These constructive comments can be incorporated in future training programmes.

It is often accepted that training workshops and staff exchange are worthwhile activities as it brings people with common goals together, creating linkages and exchange of knowledge and so on. However the true measure of success of workshops and staff exchange is what the participants do after the workshop and the staff exchange. Below are some examples illustrating the positive and tangible outcomes resulting from training workshops and staff exchanges from BGCI China programme.

Plant conservation is now considered a key role for Chinese botanic gardens but gaps in knowledge do exist. At the first training workshop in 2002 in Beijing Botanic Garden, many young botanic garden staff were exposed to the concepts and techniques of plant conservation for the first time. Dr Genlin Jiao from Fairy Lakes Botanical Garden was one of them. Through this introduction, self research and attending an international plant conservation congress, Dr Jiao was inspired to put in practice the science of plant conservation. He embarked on a major conservation project of his own, focusing on the conservation of rare and endangered species of Magnoliaceae including a reintroduction and cultivation programme. At the third training workshop at Wuhan Botanical Gardens, young, up and coming Chinese botanic garden staff met and communicated with international experts who provided the training at the workshop expressing interest in initiating collaborative plant conservation projects. From this initial contact, three staff from Wuhan, South China Botanic Garden and Macau were hosted and trained at Kings Park and Botanic Garden, Perth, Western Australia on short sabbaticals (1 month) to placements (1 year). This has provided the kind of international exposure much sought-after in China at present.

The exchange scholarship has similiarly inspired participants to put into practice what they have seen and learned from their experience at their host garden. Two participants from the 2005 exchange programme, Duan Qi-wu and Yan Tao – from Xishuangbanna Tropical Botanic Garden (XTBG) were given training in plant conservation and environmental education at KFBG. At the same time, they also observed KFBG's annual artist-in-residence programme to help staff understand how scientific education can engage the general public. As well as workshops, seminars and talks, a travelling photo exhibition to complement the work was also organised. This innovative approach in promoting environmental conservation inspired Duan Qi-wu and Yan Tao to propose adopting a similar educational approach at XTBG. They initiated a collaborative photo exhibition that would combine material collected by both botanic gardens. The collaborative exhibition was held in 2006 and in addition to learning through the process of developing the exhibition, 50 XTBG staff were trained in creating exhibitions when KFBG education staff visited the XTBG. As well as collaborating in plant conservation research, the two gardens are also looking to embark on other joint educational opportunities. KFBG's head of Education, Dr Chiu Sein Tuck also felt that the programme was beneficial exercise - "The success of the joint exhibition was very meaningful," and "It provided a good opportunity for the two parties for more exchange and collaboration. Also, the process of organising the exhibition reinforced the co-operation and exchange among the gardens' professionals."

Conclusions

The experience of BGCI's China Programme training workshop and scholarship exchange demonstrates that capacity can be effectively built and can lead to tangible plant conservation outcomes. The strong enthusiasm and support of participating partner botanic gardens has been key in the success of the programmes. So much so that at least one programme will be supported and continued by a partner botanic garden. There is definitely scope for expansion involving more botanic gardens in China who have much to offer in terms of rich plant diversity, extensive knowledge and research.

What to grow? Revaluating the public glasshouse collections at Cambridge University Botanic Garden

Tim Upson

Cambridge University Botanic Garden, UK

Abstract

Deciding what we grow in Botanic Gardens and the messages our plantings can convey is key to ensuring that our collections remain relevant and useful. Restoration of the public glasshouse range at Cambridge University Botanic Garden (CUBG) has provided an opportunity to address this question. This paper discusses the process and philosophy behind the review of our collections and the overarching theme that has emerged, intended to provide a more logical and exciting experience for visitors. Utilising the varied glasshouse environments enables us to showcase some of the key environments from around the World and their plants, 'the drama of diversity'. The collections must be relevant in a multitude of different ways, exotic flowers to excite visitors and showcase glasshouse horticulture, an education resource and to highlight issues of conservation and sustainability, themes in common with many other gardens. But we also wish to give a unique perspective to our collections. As a University Botanic Garden working closely with plant scientists, we plan to show the importance and relevance of plant sciences in 'understanding plant diversity', a theme running throughout the glasshouse range and in time extending to other collections.

Introduction

The glasshouse range at Cambridge University Botanic Garden (CUBG) is one of our best known landmarks and attractions, providing the growing conditions to cultivate nearly 2000 tender plants from around the World. It is of a unique design with a corridor of nearly 90 metres in length from which a succession of eight separate glasshouses open off along the southern edge. The current range was constructed from Burmese teak in 1933 and 1934, a direct replacement for a previous structure of a similar design and layout built from pine in 1888. Much of the original teak structure has survived although some houses have since been replaced with aluminium and the central palm house was rebuilt in steel during the late 1980's. However, the teak houses still form a major part of the range and are, we believe, the only surviving teak range in the UK and hence of great historic value and interest.

Figure 1. The Glasshouse range viewed from across the Main Lawn

In 2000 a five-year plan was developed by the Glasshouse Supervisor and Curator that aimed to develop some of the houses. Lack of resources and maintenance issues hindered the implementation of these changes. In 2005 support from the University Estate Management Service enabled a restoration programme to begin so to secure the future of the remaining teak elements of the glasshouse range. The final phase is scheduled to finish in the summer 2007. The durability of the teak has been remarkable considering it has been exposed to all elements for over 70 years with only sporadic maintenance. Most of the major structural pieces are perfectly sound and with repair have been retained. The glazing bars, which had deteriorated at each end, have all been replaced utilising teak salvaged from the demolition trade around the UK.

The restoration programme has been the catalyst that has enabled us to take a far more fundamental review of the collections and planting themes throughout the glasshouse range. It has also opened up access to funding so new landscapes and plantings could be created and interpreted. This paper discusses the process and outcome of the revaluation of our glasshouse collections.

Figure 2. - The original timbers of the Temperate House roof restored to their former glory pictured during reglazing. The corridor leading to the Palm House, rebuilt in steel and opened in 1989, is shown beyond.

Current highlights and problems

The current glasshouse plantings represent a mix of contemporary and historic plantings arranged according to their environmental requirements. Educational and interpretive themes focus on sustainability, adaptation, conservation and horticulture and the plantings of economic plants are used extensively by the Education Department, particularly for school groups. It is one of the Gardens major visitor attractions and particularly important during adverse weather. Spectacular flowerings of plants such as *Agave sisalana*, the *Amorphophallus titanum* (Titan Arum) in 2004 and the yearly display given by the *Strongylodon macrobotrys* (Jade Vine) are highlights that attract many visitors and publicity.

Figure 3 - Strongylodon macrobotrys*, a favourite in many Botanic Gardens collections, the Cambridge plant flowers profusely each year. An iconic and exotic plant, it highlights their importance in engaging with visitors not usually inspired or interested in plants.*

Analysis of the collections and plantings revealed areas that could be improved and issues that needed to be addressed and are summarised below:

- Taxonomic content - certain plant groups and taxa were poorly represented. Whilst many unusual plant families and genera are grown, others such as the Proteaceae were simply missing or had been lost from the collection. Equally, certain highly diverse floras such as South Africa were poorly represented.

- Planting themes - Some of the plantings represented remnants from previous eras, appropriate to their time but less able to fulfil today's requirements. For example the cacti and succulents were housed as separate collections in different houses. Whilst individual plants in these collections provided opportunities for interpretation, the actual plantings where less successful in conveying a coherent story or theme.

- Green wallpaper - in some houses such as the Temperate House, a typical botanic garden collection of tender plants from around the World, visitors would walk in and through the display without stopping. Essentially the display provided no reason for them to stop and there was little engagement with the planting.

- Temporary displays – these were very successfully housed in the Conservatory and changed every 2--3 months. Popular with visitors and an opportunity to create interesting and educational displays they proved to be very high maintenance and with current resources a struggle to maintain.

- The visitor experience – a walk through the glasshouse range took you from one display to another. Whilst each glasshouse formed a display in its own right there was no cohesive theme or experience that linked each together.

The challenge of understanding our purpose and audiences

Key to developing any new scheme is to fully understand the purpose of the collections and the roles they need to fulfil. As declared in the Botanic Garden's Statement of Purpose:

'*The Botanic Garden holds the research and teaching collection of living plants for the University of Cambridge… Its fundamental purpose is to make these collections accessible for the current generation and to maintain them for future generations.'*

Within its 16 hectares the Botanic Garden grows and displays over 8,000 species, a representative collection of plant diversity. The protected and varied growing conditions provided by the glasshouse range dramatically expands the diversity we can cultivate to a global scale, albeit a minute selection. The varied collections and plantings represent a resource that is accessible and is utilised by the University for its research and teaching needs. In addition to these collections more specific research and teaching requirements are also met through our Experimental Section and its associated glasshouses. However, whilst fulfilling these core roles, the public glasshouses are most frequently accessed and used in other ways. They now fulfil a major public education role. Numerically, the primary users of the glasshouse range are our 130,000 visitors each year. The glasshouses are a popular attraction for these groups and offer a great opportunity to both inform and enthuse people about plants, their diversity and endless forms and wider environmental issues.

In essence this represents one of the challenges facing us as a University Botanic Garden. Our collections and plantings need to satisfy a number of different audiences and users. Developing the new glasshouses theme provided an opportunity to meet this challenge – the need to create a resource through our collections and plantings, that can be used in a multitude of different ways.

The opportunity and challenge - defining a theme and new plantings

The opportunity provided by the restoration meant we could tackle several issues. One of the key aims was to develop an overarching theme to provide our visitors with a more logical and exciting experience. As a series of individual but linked glasshouses the range lends itself well to displaying plants from different environments ranging from the wet tropics to arid lands, alpines to the subtropics. Moving from house to house visitors would experience a range of plant diversity from some of the key environments around the World. Each house would display different life forms and associated adaptations, demonstrate various ecologies and highlight conservation issues. In essence this may not be a revolutionary idea, more a reappraisal and reordering of the growing environments. What is significantly different is the philosophy driving this, linking the individual glasshouses and their collections into a coherent experience, which became known as the 'drama of diversity'. This change in philosophy is also reflected in the language used, we have started talking about displays rather than individual glasshouses. This will be reflected in the use of banners along the linking corridor that will introduce visitors to each display.

Current house name	New theme & display name	Rationale
Temperate House	Theme: **Unique Floras** Display name: **Continents Apart**	To show two of the richest floras in the World - South Africa and Australia. To explore their linked origins and the Mediterranean climatic zones of the World together with adjacent external plantings featuring plants from the Mediterranean Basin, California and Chile.
Conservatory	Theme: **Unique Floras** Display name: **Oceanic Islands**	To illustrate the unique diversity found on oceanic islands, including the Galapagos, representing the historic link in understanding evolution through Charles Darwin to his mentor and founder of CUBG John Steven Henslow, plants from the Canary Islands showing evolutionary processes (adaptive radiation) and St Helena illustrating the fragility of island ecosystems and the urgent need for Conservation.
Alpine House	Theme: **Alpine Diversity** Display name: **Mountains**	To illustrate the horticultural diversity of Alpines as a mixed and seasonal display including spring bulbs and to show plantings of 'true alpines' illustrating there major adaptations.
West Tropics, Palm House & East Tropics	Theme: **Tropical Diversity** Display name: **Rainforests**	Tropical Diversity – taxonomic, the range of life forms and ethnobotany. The plantings would be themed to reflect the Old and New World.
Succulent House	Theme: **Diversity of form and function** Display name: **Extreme Diversity**	Exploring plant diversity through form and function including carnivorous plants and Bromeliads.
Belize display and Cacti	Theme: **Arid land diversity** Display name: **Arid lands or Deserts**	To illustrate the diversity of arid land plants from Africa and the Americas. To show convergent evolution between succulent Euphorbiaceae and Cactaceae and the variety of other survival strategies including annuals and drought tolerant shrubs.
Fern House	Theme: **Lower plant diversity** Display name: **Before flowers**	To display examples of extant lower plants groups representing the key evolutionary steps in plant evolution.

Table 1 - Layout of the individual glasshouses showing the current house names and proposed themes, display names and the rationale behind each new planting

The recently planted Temperate House exemplifies the kind of ideas we wished to achieve. It was decided that the existing collection of tender plants certainly contained a diverse and interesting range of species but had limited landscape and visitor interest. Instead, we have focused on two of the most diverse floras in the World, those of the Cape Region of South Africa and Western Australia. Previously poorly represented in our collections, this has introduced a new range of families and genera. Both contain exotic and unusual plants, often of great ornamental value, enabling a visually interesting display to be created. This would appeal to those visitors who are keen gardeners wishing to see something unusual, whilst providing our own staff with the challenge of growing these plants and to display their horticultural skills. However, it is maybe the stories associated with these floras that can be told through the new displays that are of greatest interest. In this case the

key ones identified are: their shared origins as part of Gondwanaland exemplified through the family Proteaceae; and the fire dependence of the vegetation demonstrated as burnt areas of recovering vegetation in the displays. This later theme created great interest – the Botanic Garden burning its plants! This sparked great interest from the media including newspapers, radio and television and resulted in many additional visits. This immediately demonstrated the effectiveness of this new approach - we were successful by increasing the intellectual accessibility of our collections by creating interest and hence engagement with the plantings.

Figure 4 - Artist's impression of the restored and replanted Temperate House. A space has been created in the centre to show the wonderful architecture of the glasshouse. Equally importantly was to create a space for people, otherwise lacking in the glasshouse range. It could potentially provide a unique venue, a key asset when fundraising.

The next house also has the theme of unique floras, this time focusing on oceanic islands. Ideal as laboratories to study evolution, a planting of Galapagos plants will explore this and the historic link through John Stevens Henslow, founder of CUBG, mentor to Charles Darwin and the man who recommended Darwin for his famous voyage on the Beagle. The Canary Islands will take this theme by displaying the results of adaptive evolution through the visually exciting forms that have occurred in genera such as *Aeoniums* and *Lavandula*. Finally, conservation issues and the fragility of island ecosystems will be shown through some of the critical endangered plants from the South Atlantic Island of St Helena, including species such as *Trochetiopsis ebenus* (Ebony) only rediscovered in 1980 as two surviving plants on a steep cliff, and *Mellissia begoniifolia* (Boxwood) reduced to a single plant that was rediscovered in 1998.

In contrast the collections of cacti and succulents will be merged into a single house to create an arid land display. By forming a coherent display focusing on this key environment will allow a range of themes to be explored from the range of adaptations (a useful teaching resource for University students) and examples of convergent evolution, the classic example being the succulent *Euphoria's* of the Old World and the Cactaceae in the New World, illustrated by the juxtaposition of plantings. With arid lands likely to be at the forefront of climate change, a display of hardy cacti outside the glasshouse will, we hope, create an unusual and surprising horticultural display and a way to engage visitors in these wider and more serious issues.

A consequence of taking such a focused view of our displays is that some species we wish to cultivate will not fit a theme. Within the range we need some flexibility and this will be provided through the linking corridor. The corridor theme of tropical and subtropical ornamentals can be interpreted in a more flexible way and also provide areas for temporary displays. During the spring of 2007, the blank canvas provided by the recent

restoration has provided the backdrop for what has proved a very popular orchid display, one that will no doubt be continued in future years on a smaller scale.

Figure 5 - The restored eastern corridor offered a blank canvas for a major orchid display in the spring of 2007 before permanent planting takes place later in the year. The corridor will continue to provide an area for temporary displays in the future.

A unique perspective – Understanding Diversity

The Cambridge University Botanic Garden on its current site is the vision of its founder, John Stevens Henslow, Professor of Botany and mentor to Charles Darwin. He founded the Garden on scientific principles, a place for experimentation. Reflecting Henslow's vision a linking theme running through the plantings will be 'understanding plant diversity'. Using elements of the plantings or individual specimens the importance of plant sciences in understanding and utilising plant diversity will be illustrated. As a University Botanic Garden with a strong connection to a vibrant Plant Science Department we aim to create a unique perspective, a resource for teaching students and informing visitors. It offers the opportunity to explore everything from some of the greatest discoveries through to important current work relevant to today's issues such as climate change and conservation.

Display Name	Understanding Diversity and links to Cambridge based and other Plant Science research
Continents Apart	• Pollination biology and flower structure – illustrated through the beetle daisy, *Gorteria diffusa* reflecting current work on petal cell variation and their importance in pollination. • Useful plant chemicals – *Hoodia gordonii* and development of an appetite suppressant, work carried out by a locally based research companies. • Nutrient recycling and adaptations in poor soils, an area of research interest of Cambridge ecologists.
Oceanic Islands	• The importance of islands in understanding evolution – the historic link through Henslow and Darwin to illustrating adaptive radiation through genera such as *Lavandula*. • Conservation of the St Helena flora in which CUBG, through previous and existing staff have an interest.
Mountains	• Alpines at altitude – Surviving UV exposure at high altitudes and links to climate change. Pioneering research into plant responses to UV was carried out in Cambridge. • Arctic alpine elements in the British Flora as relicts of the ice age, a story first discovered through the Quaternary research in Cambridge.
Rainforests	• Rainforest structures and life forms reflecting the seminary work of Tim Whitmore in Cambridge. • Ethnobotany and its importance to indigenous people through links with the Department of Anthropology. • Regeneration in forests and the importance of sun flecks, a major area of current research in ecology.
Extreme Diversity	• Carnivorous plants – different solutions to living in nutrient poor environments. • Bromeliads – currently being investigated as indicators of climate change.
Arid land	• Succulence and Crassulacean Acid Metabolism, an example of an adaptation associated with arid environments and a major area of current research in the Department of Plant Sciences.

Table 2 – 'Understanding Diversity' – potential research examples and themes identified for each house.

Interpreting the drama of diversity

As important as the plantings themselves, provision of suitable interpretation is a key element to the success of the new plantings. With the help of a specialist the potential interpretation methods were assessed. This confirmed the need to carefully identify audiences and match the means of interpretation - essentially multiple delivery methods.

Our discussions identified permanent interpretation panels as an effective way to provide first line interpretation for our 130,000 visitors so they can understand at least the basic rationale and significance of each display. However, they will be kept to a minimum level in each house to achieve this and other methods utilized to tell the potentially numerous stories. This secondary level of information could be provided through means such as our website (the modern version of a leaflet) or even through laminated walkabout panels.

The very nature of plant displays means there will be times when we wish to interpret plants on a seasonal basis, often when they flower. In addition, repeat visitors form the largest proportion of our audience. Temporary changeable panels provide a way to meet seasonal demands and create continued interest.

However, we do see that guided tours are likely to be the most effective way of interpretation. How this will be organized is still open to discussion but could include special tours run by staff, alongside more regular tours with volunteer guides. Although resources limit our ability to utilise technological solutions it is hoped to explore such avenues in the future. They could certainly provide new and interesting opportunities for audiences such as University students who might be more likely to take advantage of the collections through audio tours linked to their lectures and downloaded to MP3 players.

Measuring up against the *Global Strategy for Plant Conservation* (GSPC)

The development of new plantings and themes has taken place within the context of the GSPC. In this case the major contribution is clearly through Target 14 – promoting education and public awareness. Creation of this new resource provides a powerful way to further raise the importance of plants to our visitors and maybe most significantly to the University students, who will be encouraged to further utilise the collections.

However, there are maybe other ways in which the glasshouse range and its collections can contribute in a smaller way. This includes:

- Target 3 – developing growing and propagation protocols for a wide of range plants.
- Target 8 – ex-situ conservation of island plants particularly those from St Helena by conserving key genetic clones.
- Target 11 – ensuring plants affected by international trade are appropriately sourced. For example, we propose to highlight that any new cacti used in the display are sourced from appropriate nursery sources.

Conclusion

The glasshouse restorations and new plantings at CUBG are taking us into an exciting time. The opportunity to undertake a fundamental revaluation has enabled us to revolutionise our plantings and collections within the glasshouse range, something that will no doubt be furthered in other areas. It highlights the often complex requirements that collections must fulfil and the need to create a resource that can be utilised in a multitude of different ways.

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From NBI to SANBI: the biodiversity challenge.

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Introduction

South Africa is world renowned for its botanical diversity, with 21,693 plant taxa having been recorded in the country, of which 19,600 are indigenous and the remainder naturalized taxa. South Africa is also internationally renowned for its floristic diversity and high percentage of endemism. In particular, the Cape Floristic Region (CFR), one of the world's six floral kingdoms, is entirely contained in an area of 89,000 km^2 within the southwestern part of the country. The CFR – regarded by Myers (1990) as one of the world's "hottest" hotspots – contains c. 8,550 species of vascular plants, of which c. 73% are endemic to the region. The CFR is dominated by fynbos, a sclerophyllous, heath-like shrubland associated with nutrient-poor soils that cover most of the region (Cowling & Holmes 1992). Recent statistics on the flora of the Cape Peninsula mountain chain south of Cape Town show that in an area of 471 km^2, about 2,285 plant species are known to be indigenous (Helme & Trinder-Smith 2005). The Peninsula therefore has the greatest concentration of plant species (per unit area) within the CFR, with 161 plant taxa endemic to the area. The CFR became South Africa's sixth World Heritage Site in July 2004. Classified as a serial site, the CFR World Heritage Site comprises eight protected areas covering 553,000 ha. Kirstenbosch National Botanical Garden, as part of the Table Mountain National Park, was included – the first botanical garden in the world to be included within a natural World Heritage Site.

A synthesis of southern African succulent plants indicates that with 4,600 plant taxa, southern Africa contains c. 46% of the world's known succulent plants (Smith *et al*. 1997).

South Africa as a country contains a wealth of different habitat types, biomes and vegetation types. The biomes include savanna woodlands (including a small patch of *Brachystegia*-dominated *miombo* woodland in the northeastern part of the country), grasslands, afromontane and coastal forests, Succulent Karoo (with the highest species richness recorded for semi-arid vegetation and about 50% of the plant species endemic to the biome), Nama-Karoo, coastal and marine vegetation (including mangroves), and some unique wetland areas. Recent research has refined the list of vegetation types for South Africa, with 440 vegetation types now having been mapped for the country.

One of the key developments that have taken place in the past few years has been the transition within South Africa of the National Botanical Institute (NBI) into the South African National Biodiversity Institute (SANBI) on 1 September 2004. This followed the promulgation of the National Environmental Management: Biodiversity Act (NEMBA) No. 10 of 2004 on the same date. This expanded new mandate has meant a widening of the scope of SANBI from purely botanical into broader biodiversity matters relating to the full diversity of the country's fauna and flora (with the creation of a new Directorate: Biodiversity Programmes, Policy and Planning Services), while maintaining its national network of eight national botanical gardens, as well as its taxonomic and ecological research programmes and the management of the three herbaria within South Africa. Part of this broader mandate includes reporting on the status of South Africa's biodiversity, co-ordinating to some extent the action between organizations and government departments, ensuring there is no duplication in research, providing guidelines, managing biodiversity information and advising the Minister of the national Department of Environmental Affairs and Tourism (DEAT) on areas that need specialist input.

This paper attempts to highlight the challenges faced by SANBI and its national botanical gardens in delivering on its expanded mandate and what SANBI has achieved to date.

Managed Network

The model chosen by SANBI in delivering on its broad mandate was the 'managed network model', whereby SANBI acts as the agent that will leverage expanded contributions from the entire biodiversity community in South Africa, rather than merely using its allocated resources autonomously and on its own.

SANBI Business Case

One of the first challenges faced by SANBI in addressing its broader mandate was to source additional funding from the National Treasury in order to be able to deliver on the expanded mandate as listed in the National Biodiversity Act. A Business Case was prepared in 2006 and after various iterations additional funding of R80 million, spread over a three-year period, was allocated to SANBI as from April 2007. This funding will enable the necessary restructuring of the organization and initiation of programmes as required by the new Biodiversity Act.

National Botanical Gardens

South Africa is one of the few countries in the world where a single institution manages a network of national botanical gardens (NBGs). Kirstenbosch National Botanical Garden (est. 1913 on the eastern slopes of Table Mountain) was the first national botanical garden to be established in South Africa. It focused entirely on the conservation of South Africa's wealth of indigenous plants and the network has subsequently grown to incorporate eight national botanical gardens, spread across five of South Africa's nine provinces (see Willis 2005). Efforts are currently in place to expand the national network by an additional four gardens in order to have a national botanical garden located in each of South Africa's nine provinces. As 'embassies of biodiversity and culture', South Africa's NBGs attract over 1.25 million visitors per annum, with Kirstenbosch receiving over 750,000 visitors annually.

The NBGs are situated in climatically different parts of the country, including predominantly winter-rainfall mediterranean climates (Kirstenbosch and Harold Porter NBG); semi-arid climates (the Karoo Desert NBG, situated at Worcester, with an annual rainfall of 250 mm, is the only truly succulent garden on the African continent as well as in the southern hemisphere); summer-rainfall subtropical to tropical climates (Lowveld and KwaZulu-Natal NBG); and South Africa's interior plateau areas that can receive frost during the dry, cold winter months between May and August (Free State, Pretoria and Walter Sisulu NBGs). This range of climatic conditions means that different gardens are able to grow plants that might not be grown as successfully in other gardens without artificial structures having to be built. The national botanical gardens include large areas of natural vegetation representative of six of southern Africa's seven biome units, namely Forest, Fynbos (characterized by the presence of ericas, restios and proteas), Grassland, Savanna, Nama-Karoo, and Succulent Karoo. The only biome not represented is the Desert Biome of the Namib Desert, which occurs almost exclusively in neighbouring Namibia. One of the challenges facing the national botanical gardens is to assess what animals occur naturally within their boundaries. While there is a good knowledge of the birds that frequent the gardens, lists of other faunal groups such as amphibians, reptiles, mammals, arachnids and insects are, for the most part, incomplete. Determining what animals are in the gardens is a process that has been started in several gardens through surveys and the involvement of societies and experts on the various faunal groups, from insects to mammals.

While the 1990s was the decade for the development of Kirstenbosch, assisted through the Kirstenbosch Development Campaign (which raised over R50 million between 1991 and 2003) and a range of sponsorships including private and corporate donors and the Botanical Society of South Africa, the first seven years of the new millennium have shown a shift in allocation of resources and the completion of new infrastructural developments in the various northern gardens.

Since 2001, SANBI's Gardens Directorate has received project funding allocations from the DEAT's Social Responsibility Programme (SRP) to develop new tourism infrastructure in all its national botanical gardens outside Kirstenbosch. Investment by DEAT's SRP in the development and upgrade of tourism infrastructure in SANBI's national botanical gardens since 2001 has exceeded R50 million – equivalent to the amount raised for the Kirstenbosch Development Campaign projects from 1991 to 2003. While creating employment and developing skills of people employed through the various projects, these facilities are intended to expand SANBI's environmental education programme (currently operational with dedicated facilities in five of SANBI's eight gardens) and to improve tourism infrastructure and revenue generated by the Gardens Directorate through both increased admission fees and rentals. To date, over 135,000 person days have been worked on SANBI's various construction projects involving the temporary employment of over 2,000 people and the permanent employment of more than 80 people required to operate and maintain the new buildings and facilities. It is estimated that by the time all current projects are completed by the end of 2007, over R16 million will have been spent on community wages during DEAT's SRP projects in the various NBGs.

The hosting of events, particularly music concerts, in the Gardens has become increasingly important in generating income as well as in attracting increased numbers of visitors from a broad cross-section of South African society. The events hosted in the various gardens also provide visitors with an opportunity to learn about South Africa's indigenous plants, including their value, conservation status and uses.

All eight gardens are situated in or very close to densely populated urban areas and are therefore relatively easily accessible to a broad and diverse audience. Since the inception of Kirstenbosch in 1913, the gardens have been supported by the Botanical Society of South Africa (BotSoc), a non-governmental organization whose mission is to win the hearts, minds and material support of individuals and organizations, wherever they may be, for the conservation, cultivation, study and wise use of the indigenous flora and vegetation of southern Africa (www.botanicalsociety.org.za). Local branch members act as the 'friends' of the gardens and support both garden-based and *in situ* conservation efforts.

The 94-year partnership between SANBI and BotSoc, based on a shared vision, has certainly been mutually beneficial, and is set to continue and become even stronger, well beyond the anticipated centenary year celebrations planned for both organizations in 2013. BotSoc has 16 branches spread across the country and produces its regular flagship newsletter, *Veld & Flora* (known from 1915 to 1974 as the *Journal of the Botanical Society of South Africa*), that showcases to its members the Society's involvement in plant conservation and education activities countrywide as well as featuring stories and horticultural notes on southern Africa's indigenous plants and their uses. Since 1981, BotSoc has been publishing regional wild flower field guides to the indigenous flora of South Africa, and has to date sold over 100,000 copies.

Between 1993 and 2002, the Botanical Society has also published a series of Education Posters, with sponsorship from Old Mutual. This award-winning series had as its goal the provision of resource material (the poster and accompanying workbook) on each of South Africa's biomes and was linked to the school curriculum. It has been estimated that over 5 million learners have used the resource and it continues to be used by South African schools.

In 2002, BotSoc started the Conservation Unit (CU) in Kirstenbosch. Since this time the CU has been involved in biodiversity planning, actively integrating biodiversity in land use planning and environmental assessment,

developing a range of stewardship options for private lands and testing the implementation of these in pilot sites using appropriate incentive measures.

Interpretation

Interpretation, providing the link between a botanical garden and its visitors, has received increased support in South Africa's national botanical gardens in the past five years, and each of the gardens currently has a dedicated Interpretation Officer. All the gardens have dedicated interpretation themes and plans that assist in guiding their interpretive work. The natural areas in all the gardens include an interpreted self-guided hiking/walking trail.

Although the gardens do not have collections of animals maintained in enclosures or cages, the interpretive signage certainly does promote the links and awareness of the dependence between animals, people and plants. Interpretive labels in the various gardens include a range of indigenous South African languages, particularly the languages spoken in those areas where the gardens are located. Languages generally used in interpretive signage are English, Afrikaans and the local African language. Both standardized permanent and temporary interpretive signs are used in South Africa's national botanical gardens. SANBI has also standardized the directional signage used in the various national botanical gardens.

A range of natural history courses are regularly arranged for members of the public in SANBI's gardens during weekends, covering topics such as spiders, bats, snakes, scorpions, trees, wild flowers and a range of related topics. Using the gardens as a base, these courses provide an opportunity to share knowledge of South Africa's indigenous biodiversity with members of the public.

The development of demonstration gardens featuring useful plants and medicinal plants has been one of the key activities of the NBGs during the past 10 years. Many gardens now include traditional structures, such as huts and cooking shelters, that are surrounded by plants traditionally used by South Africans, thus raising public awareness about the traditional use of various plant materials. Interesting demonstration gardens recently developed in Kirstenbosch include 'Weeds South Africa gave the World' and the 'Garden of Extinction', the latter illustrating South African plants threatened with extinction in their natural habitats. The benefit of the demonstration structures and gardens is that they can be used to share information first-hand with learners and other visitors to the gardens.

One of the challenges facing the national botanical gardens is a way to enhance their position as the public face of SANBI and showcase the organization's diverse activities, partnerships and achievements to visitors and the public. Messages about the importance of biodiversity and the need to conserve our natural ecosystems should be bold, simple and clear.

Environmental Education

While it is quite common for school curricula to include aspects of the diversity of animals and plants while exploring the concept of 'life' for young learners, South Africa's recently adopted Outcomes-based Education (OBE) system takes a much bigger step in introducing learners to biological diversity and conservation. Grade 9 learners (approximately 14-16 years of age) must understand the specific term 'biodiversity'. In many cases, their curriculum includes compulsory aspects such as genetics, population dynamics, evolution and paleontology and greatly promotes learners' awareness and appreciation of South Africa's unique biological resources.

SANBI's environmental education programme includes both garden-based education programmes as well as sponsored outreach greening programmes involving previously disadvantaged schools. Sponsors include the National Lottery and the DEAT.

Outreach has become a primary focus of SANBI's environmental education programme during the past decade, stimulated in 1995 by the sponsorship of a bus to bring learners from previously disadvantaged schools on the Cape Flats to Kirstenbosch. To date, over 100,000 people, young and old, have made use of the Kirstenbosch Bus and outreach programmes. Since 1994, SANBI's environmental education programmes have provided guided educational visits to more than 150,000 learners, many of whom visited the gardens for the first time. In 2002, SANBI's education programmes expanded to the Walter Sisulu, Pretoria, Lowveld and Free State NBGs. This expansion was made possible through funding provided by DEAT for the erection of new environmental education buildings and associated offices.

SANBI Biodiversity Series

SANBI started a new in-house publication series called the *SANBI Biodiversity Series* in March 2006. To date, five numbers have been published in the series, which aims to publish occasional reports on projects, technologies, workshops, symposia and other activities initiated by or executed in partnership with SANBI.

Bioregional programmes and strategic partnerships

South Africa has a long history of biodiversity research, awareness and conservation action. With the change of government and democratization in 1994, innovative ways of integrating biodiversity with development needs have been developed. Within the past few years, SANBI has been instrumental in developing and facilitating bioregional programmes in various parts of South Africa. Bioregional programmes are defined as biome-wide biodiversity initiatives that incorporate an agreed vision, measurable targets and an action plan for co-ordinating a range of multi-stakeholder projects integrating biodiversity conservation with development and social priorities. The programmes involve a systematic conservation planning process and implementation of these plans through projects with participating stakeholders.

SANBI is the management agency for the Cape Action for People and the Environment (C.A.P.E.), a multi-partner programme that aims to conserve biological diversity in the CFR and ensure that the people of the region participate and benefit. The C.A.P.E. Co-ordination Unit is housed at Kirstenbosch, and together with other biodiversity conservation groups, constitutes a dynamic environment for research, planning and action directed at sustaining the CFR for future generations. The C.A.P.E. partners work across the fynbos ecoregion, from lowlands and mountains to wetlands and coastal and marine environments, create awareness and take the lead in projects designed to overcome obstacles and seize opportunities to make a real difference. Some key conservation initiatives that are currently being developed by C.A.P.E. include the Greater Cederberg Biodiversity Corridor, Garden Route Initiative, Baviaanskloof Megareserve, Gouritz Initiative, Agulhas Biodiversity Initiative, and the West Coast Biosphere Reserve. Most of these initiatives involve partnerships between landowners, local communities and authorities, non-governmental organizations and formal conservation bodies. These initiatives are linked to the recently published National Spatial Biodiversity Assessment (NSBA; Driver et al. 2005), the first ever, comprehensive spatial assessment of biodiversity for South Africa. The challenge that lies ahead is to translate the biodiversity priorities identified in the NSBA into conservation action on the ground. As indicated by the authors of the NSBA, "this will involve mainstreaming biodiversity priorities in the policies, plans and actions of a wide range of stakeholders, both public and private, whose core business is not biodiversity, but whose day-to-day decisions will ultimately determine whether our development path is a sustainable one" (Driver et al. 2005).

A major component of C.A.P.E.'s strategy is encouraging industries that put pressure on the biodiversity of the CFR to develop and implement biodiversity best practices. One of the recent initiatives established with industries is the Biodiversity and Wine Initiative (BWI), a partnership between the South African wine industry and the conservation sector. The partnership aims to minimize the further loss of threatened natural habitat (particularly Renosterveld and Lowland Fynbos) within the CFR and to contribute to sustainable wine

production, through the adoption of biodiversity guidelines by the South African wine industry. The BWI presents a great opportunity to both the wine and conservation sectors. The wine industry benefits from using the biodiversity of the CFR as a competitive marketing advantage, and from contributing to natural resource management, as prioritized in the Wine Industry Strategic Plan (WIP). The conservation sector benefits from pioneering biodiversity best practices with the wine industry, which will result in conserving the CFR's threatened habitats. One of the key strategies identified for the BWI is the development of a biodiversity wine route where visitors are exposed to both the wine and the biodiversity experience of each participating producer. For example, guides from the local community would conduct tours of the natural vegetation, communicating the producer's story and the role of biodiversity conservation in sustainable wine production. It also provides an opportunity to create employment and develop a new ecotourism angle for South African wine tourism.

Other bioregional programmes being facilitated by SANBI include the Succulent Karoo Ecosystem Programme (SKEP; a multi-stakeholder 20-year programme focused on the Succulent Karoo and providing cross-border co-operation and links between South Africa and Namibia) and the Subtropical Thicket Ecosystem Programme (STEP; focusing on the conservation of the Subtropical Thicket Biome and associated vegetation types in the Eastern Cape) (Pierce et al. 2005). The vision of the STEP is that the people of the Thicket Biome take custodianship of their unique living landscape and together conserve, enhance and use their natural resources to ensure sustainable ecological processes and livelihoods, now and into the future. A National Grasslands Biodiversity Programme is currently being developed in South Africa to conserve the Grassland Biome, which extends into six provinces in South Africa. The goal is to ensure that the ecological services provided by grasslands are sustained and that they contribute to economic development and poverty alleviation.

Threatened Species Programme

South Africa has had a proud history of producing Red Data Books for plants (e.g. Hall *et al*. 1980; Hall & Veldhuis 1985; Hilton-Taylor 1996; Scott-Shaw 1999; Golding 2002). Two significant conservation projects co-ordinated and executed by SANBI, the Threatened Species Programme (TSP) and the Custodians of Rare and Endangered Wildflowers (CREW), are both supported by donor funding and will considerably enhance the country's ability to respond to the second target of the Global Strategy for Plant Conservation.

Launched by the SANBI in May 2003, the TSP aims to conserve South Africa's rare and threatened species. Its initial phase has focused largely on plant biodiversity, but the NBI's transition to SANBI marks the expansion of the activities to include the full spectrum of the country's biodiversity. The TSP aims to assess the threat of extinction to all c. 19,600 indigenous South African plant species using the IUCN's latest Red Data List categories (version 3.1) by December 2007.

One of the first faunal projects in which the TSP became involved was the Southern African Reptile Conservation Assessment (SARCA) launched in May 2005. Its primary aim is to produce a conservation assessment for the reptiles of South Africa, Lesotho and Swaziland within a four-year period (2005–2009). Other conservation assessments that have been initiated in partnership with other institutions within South Africa include the Southern African Butterfly Conservation Assessment (SABCA), a partnership with the Avian Demography Unit and the Lepidopterist Society of Africa, and the Southern African National Survey of Arachnida (SANSA) with the Agricultural Research Council.

Urban Conservation is a unit of SANBI, based at Kirstenbosch, that focuses on projects and partnerships 'beyond the garden fence' that look at biodiversity conservation from a community development perspective. The Urban Conservation Programme aims to:

- build public understanding of the biodiversity value in threatened urban environments;

- facilitate people's involvement in biodiversity-related action, especially the youth and poorer communities;
- engage in actions leading to protection and restoration of ecosystems threatened by urban activities;
- contribute to processes and partnerships that improve urban environmental management practice.

Urban Conservation has as its flagship project Cape Flats Nature that was started in July 2002. This partnership attempts to build good practice in the sustainable management of fragmented natural habitats in the City of Cape Town's Biodiversity Network in a people-centred way that develops local leadership for conservation action and benefits the surrounding communities. Communities that particularly benefit from this programme are townships where incomes are low and living conditions poor. Cape Flats Nature catalyses on-the-ground conservation management that involves the surrounding communities in preserving the area's natural heritage for future generations. The programme also catalyses access to outdoor classrooms for curriculum-based environmental education and awareness-raising on the doorstep of learners from poor communities. Cape Flats Nature's home is the Edith Stephens Wetland Park (ESWP) on the Cape Flats, a 40 ha piece of land jointly owned by SANBI and the City of Cape Town. Also home to Working for Wetlands (Western Cape) and the Western Cape Primary Science Programme, the ESWP and its associated organizations provide services to surrounding communities, from job creation and youth development to support and training of educators. The ESWP is one of four pilot sites of Cape Flats Nature, a partnership between the City of Cape Town, SANBI, the Table Mountain Fund (WWF-SA) and BotSoc under the banner of C.A.P.E.

The Working for Wetlands, a R65 million per annum programme, was transferred to SANBI in January 2003. The programme focuses on the rehabilitation of wetland areas in various parts of South Africa, working closely with DEAT, the Department of Water Affairs and Forestry (DWAF) and the Department of Agriculture (DoA). The programme recently received a R1.6 million grant from DEAT for the completion of a national wetland inventory for South Africa.

The Greening of the Nation project, managed by SANBI, is a new R75 million programme that has been rolled out in various provinces of South Africa, for community and school greening projects. Activities within this project include the greening of towns (road islands and entrances), schools, crèches, day-care centres, community parks, cemeteries, police stations, cultural villages, as well as the development of community nurseries. Many projects include the development of indigenous gardens as well as vegetable gardens. The programme works in close association with Food & Trees for Africa (FTFA), the first national non-government, non-profit, greening organization in South Africa, established in 1990. FTFA works in response to community requests and through consultation with community leaders. In order to raise funding and spread awareness of the many benefits of greening activities, a proactive media campaign is maintained. As part of FTFA's national tree planting programme, it receives applications for trees from underserved communities across South Africa and attempts to provide as many trees as possible through the help of sponsors. Over 2.2 million trees have been distributed in this way to schools, clinics, old age homes, hospices, police stations, streets and parks.

Conclusion

While plants and plant conservation continue to play a central role in the work of SANBI's national botanical gardens and herbaria, the need to broaden the messages conveyed to visitors and members of the public remains an ongoing challenge. The transition from NBI to SANBI with its broader mandate around biodiversity is a process that was started in 2004 and which offers many exciting opportunities for the organization and the country as a whole. While the subject matter has been broadened for the organization and new programmes have been developed within the organization to address this broader mandate, the fundamental roles attributed to

South Africa's national botanical gardens, namely scientific research, conservation, display and education, remain the same.

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The Conservation Status and Conservation Strategy of *Picea neoveitchii*

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Abstract

Picea neoveitchii is an endemic species in China. It had been listed as an endangered species in red data books. It scatters in several locations of south slope of the Qinling Mt., China. Upon reviewing the related literature, discussing with leading scholars on gymnosperm, ecology and plant conservation, the field survey was carried out in four locations. There are 11 mature individuals and 2 seedlings surviving in its natural habitats. With the survey of quadrat method in four locations, related community index were calculated such as relative important value (RIV), species richness, similarity index, diversity index and evenness index etc. The community could be sorted and characterized as 3 groups based on the community parameters. The analysis of vegetation table elucidates *Picea neoveitchii* is a dominant species with low grouping rate in most surveyed sites.

The RAPD analysis shows target species has intraspecific genetic variability. Also the estimation of Shannon's phenotypic diversity index (Ho) explains the difference of genetic variations of different locations.

Due to the lack of enough knowledge and professional guide of conservation biological perspective, *Picea neoveitchii* had been clear-cut for timber production. The extent of occurrence and area of occupancy declined rapidly from 1950's to 1990's. According to the Conservation Category guideline proposed by the World Conservation Union, the conservation status of *Picea neoveitchii* was reevaluated as Critically Endangered (CR) B2b C2a D. Upon research in areas of ecology, molecular biology, cluster analysis of environmental parameters, a practical conservation strategy is recommended in this research.

Key words*: conservation; status; strategy;* Picea neoveitchii

Picea neoveitchii is an endangered species threatened with extinction. The four currently remaining subpopulations are less than 4 hectares in area. And the locations are separate, far away from each other. According to the principle of plant conservation, the community composition and genetic variability are the

basic parameters to propose the rational conservation strategy. So this research will concentrate on three aspects: plant community, genetic property and conservation.

1. Ecological studies

Accurate data on community composition are desirable for the planning and evaluation of conservation projects. Sampling with quadrats can be used for the survey of most plant communities. The vegetation composition and community structure could be described by this method (Turner, 1985; Kershaw, 1991).

1.1 Description of study sites of *Picea neoveitchii*

The distribution range of *Picea neoveitchii* varies between literatures (Editorial Committee of Flora of China, 1978; Farjon, 1993, 1999; Fu, 1991; Schmidt, 1999) due to taxonomic confusion and clear cutting activities. This species scatters on mountain slopes, river basins, or on rocky talus. The altitude distribution is 1240-2020 m on the south slopes of the Qinling Mountain in central China. The surveyed locations in China show in Figure 1.

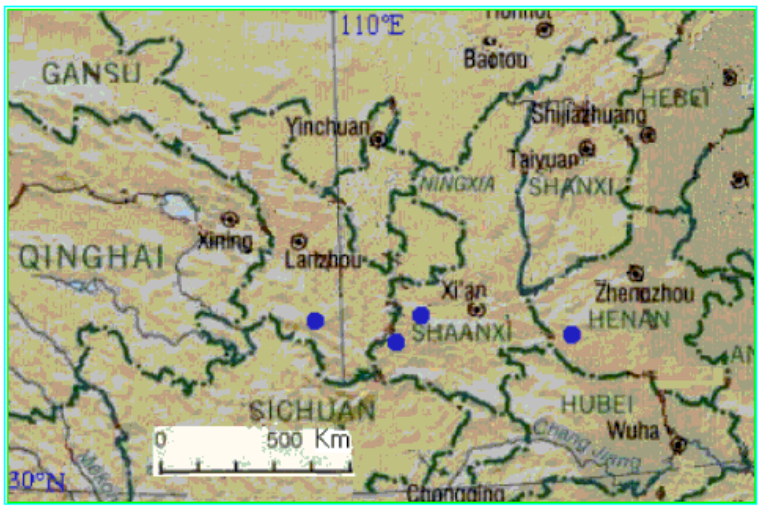

Figure 1. Black marked circles are the surveyed locations of Picea neoveitchii *in China*

1.2 Methods

The existing fragmented communities of the *Picea neoveitchii* have been severely influenced by the climate change and human disturbance. The plant communities in different locations with different vegetation and

geology were characterized using quantitative ecological methods and phytosociological methods (Braun-Blanquet. 1932) based on the quadrat survey.

The soil samples were collected from all surveyed sites; the soil depths from eight distinct vegetation communities were measured in the field survey. Chemical properties such as PH value, organic matter content, soluble nitrogen content and soluble phosphorus content were analyzed in laboratory.

1.3 Results

1.3.1 Relative Important Value (RIV) of all the species in four studied locations

The ecological parameters of density, frequency and dominance reflect community composition and characteristics in their natural habitats. Based on the value of the relative density, the relative frequency and the relative dominance, the relative importance value (RIV) of a species is calculated by the following formula: RIV = RD + RF + Rdo

The RIV of all the species in four studied locations (shrub layer, ground layer and moss layer omitted in this table) shows in Table 1.

Location	Baotianman	Taibaishan	Xinjiashan	Bailongjiang
Upper layer (Trees)				
Acer davidii	18.88	0.00	0.00	0.00
Aralia chinensis	27.10	0.00	0.00	0.00
Fraxinus chinensis var. *rhynchophylla*	0.00	8.33	0.00	0.00
Picea asperata	0.00	0.00	98.29	0.00
Picea neoveitchii	21.88	19.78	25.26	22.69
Populus cathayana	0.00	18.79	0.00	0.00
Quercus aliena var. *acuteserrata*	0.00	8.00	0.00	0.00
Salix caprea var. *sinica*	0.00	8.00	0.00	0.00
Tilia oblongifolia	0.00	9.94	0.00	0.00
Tsuga chinensis	18.01	0.00	0.00	0.00
Subtotal	84.02	69.74	123.55	22.69

Middle layer (Trees)

Acer davidii (seedling)	43.66	0.00	0.00	0.00
Carpinus cordata	39.43	0.00	0.00	0.00
Celtis koraiensis	33.49	0.00	0.00	0.00
Picea asperata	0.00	0.00	0.00	56.38
Picea wilsonii	0.00	0.00	0.00	70.66
Prunus armeniaca *var*. ansu	0.00	0.00	0.00	56.38
Subtotal	116.59	0.00	0.00	183.41

Shrub layer species

Berberis poiretii	0.00	0.00	0.00	7.17
Betula utilis	0.00	0.00	6.91	0.00
Cephalotaxus sinensis	0.00	8.00	0.00	0.00
Cotinus coggygria	0.00	0.00	0.00	29.72
Deutzia glabrata	10.63	0.00	0.00	0.00
Exochorda racemosa	0.00	14.62	0.00	0.00
Forsythia suspensa	37.93	0.00	0.00	0.00
Lespedeza bicolor	0.00	23.80	0.00	0.00
Malus baccata	0.00	0.00	20.54	0.00
Picea asperata	0.00	0.00	10.41	0.00
Pueraria lobata	0.00	15.71	0.00	0.00
Quercus aliena var. *acuteserrata*	0.00	0.00	0.00	9.30
Rhododendron mariesii	9.30	0.00	0.00	0.00
Rosa davidii	0.00	0.00	6.91	0.00
Salix caprea var. *sinica*	0.00	0.00	17.28	0.00
Spiraea pubescens	18.61	0.00	0.00	0.00
Spiraea trilobata	29.95	0.00	0.00	0.00

Tilia mongolica (seedlings)	23.19	0.00	0.00	0.00
Subtotal	129.62	62.13	62.05	46.20

Ground layer species

Achillea sibirica	0.00	0.00	2.18	0.00
Aconitum barbatum	0.00	0.00	2.31	0.00
Allium ramosum	0.00	0.00	7.83	0.00
Anemone tomentosa	0.00	0.00	0.00	5.28
Asparagus cochinchinensis	3.02	0.00	0.00	0.00
Aster tataricus	0.00	0.00	0.00	7.54
Carex lanceolata	29.72	16.00	8.86	0.00
Chenopodium album	0.00	0.00	0.00	3.34
Cotoneaster salicifolius	0.00	0.00	0.00	2.51
Duchesnea indica	0.00	0.00	10.33	14.14
Equisetum ramosissimum	0.00	0.00	43.13	0.00
Fagopyrum esculentum	0.00	0.00	0.00	3.09
Gentiana scabra	0.00	0.00	0.00	2.84
Leontopodium leontopodioides	0.00	0.00	3.42	0.00
Lespedeza bicolor	0.00	0.00	0.00	2.18
Lespedeza davurica	0.00	3.67	0.00	0.00
Liriope graminifolia	0.00	7.22	0.00	0.00
Metaplexis japonica	0.00	0.00	0.00	3.09
Picea neoveichii (7 years seedling)	0.00	2.18	0.00	0.00
Poa annua	0.00	0.00	2.44	0.00
Polemonium coeruleum	0.00	0.00	4.88	0.00
Polygonum lapathifolium var. *salicifolium*.	2.31	0.00	0.00	0.00
Polygonum lapathifolium	0.00	0.00	2.44	2.70
Prunus japonica	0.00	0.00	0.00	4.63

Pyrrosia lingua	0.00	12.85	0.00	0.00
Ranunculus sceleratus	0.00	0.00	2.18	0.00
Rhamnus arguta	0.00	0.00	0.00	5.28
Rosa multiflora	0.00	0.00	0.00	6.24
Rubia cordifolia	0.00	0.00	2.18	0.00
Rubus alceaefolius	0.00	0.00	2.31	0.00
Salix caprea var. *sinica (seedling)*	0.00	0.00	2.05	0.00
Sambucus williamsii	0.00	0.00	0.00	3.09
Saussurea deltoidea	4.46	0.00	0.00	0.00
Schisandra chinensis	8.34	0.00	0.00	0.00
Scorzonera albicaulis	0.00	0.00	2.18	0.00
Senecio nemorensis	0.00	2.97	0.00	0.00
Smilax china	0.00	0.00	0.00	5.91
Stellaria media	0.00	0.00	2.18	0.00
Syneilesis aconitifolia	0.00	0.00	4.01	0.00
Thalictrum minus var. *hypoleucum*	0.00	0.00	0.00	5.00
Toxicodendron succedaneum	0.00	0.00	0.00	2.51
Trollius chinensis	0.00	0.00	8.95	0.00
Vicia pseudo-orobus	0.00	0.00	11.83	0.00
Vicia unijuga	0.00	0.00	2.18	0.00
Subtotal	47.86	44.89	127.87	79.38
Moss layer species				
Sphagnum cymbifolium	0.00	0.00	300.00	0.00

Table 1. Relative Important Value (RIV) of all the species in four studied locations (The Baotianman Nature Reserve, the Taibaishan Forest Farm, the Xinjiashan Forest Farm and the Bailongjiang Forest Farm)

1.3.2 Species diversity and the community evenness in four surveyed locations

The species diversity and the community evenness of the four surveyed locations were calculated in Table 2.

Location	Baotianman	Taibaishan	Xinjiashan	Bailongjiang	Total Number
Species number	17	15	27	25	84
Total numbers of individuals in that location	140	79	188	64	471
Shannon-wiener index H=-Sum ((ni / N)*log (ni/N))	1.002725	0.839597	0.977916	1.267724	
Evenness index E= H/log (S)	0.814926	0.713888	0.683206	0.906851	
Dominance D= 1-E	0.185074	0.286112	0.316794	0.093149	

Table 2. Species diversity and community evenness in four surveyed locations

1.3.3 Similarity Index Matrix of all the survey sites

The same species appearing in two different sites represent the similarity of vegetation patterns. The similarity index matrix of eight surveyed sites shows in Table 3.

Similarity Index							
Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Site 1	0.3810	0.1481	0.1600	0.0741	0.0769	0.0690	0.0909
		0.1481	0.1600	0.0741	0.0769	0.0690	0.0909
Site 3			0.1429	0.1333	0.1379	0.0625	0.2400
Site 4				0.5000	0.3704	0.1333	0.1739
Site 5					0.6207	0.1250	0.1600
Site 6						0.1935	0.0833
Site 7							0.1481

Table 3. Similarity Index Matrix of eight surveyed sites

1.3.4 Community sorting according to the community characters

Altitude, orientation, slope, geographic position, height of canopy, coverage of canopy, mean DBH of canopy, species number of canopy, height of understory, cover of understory, mean DBH of understory, species number of understory, height of shrub, cover of shrub, species number of shrub, mean height of herbaceous, cover of herbaceous, species number of herbaceous, soil depth (A0, A and B), coarse matter content, PH value, organic matter content, soluble nitrogen and soluble phosphorus were used for Cluster analysis. The dendrogram is given in Figure 2.

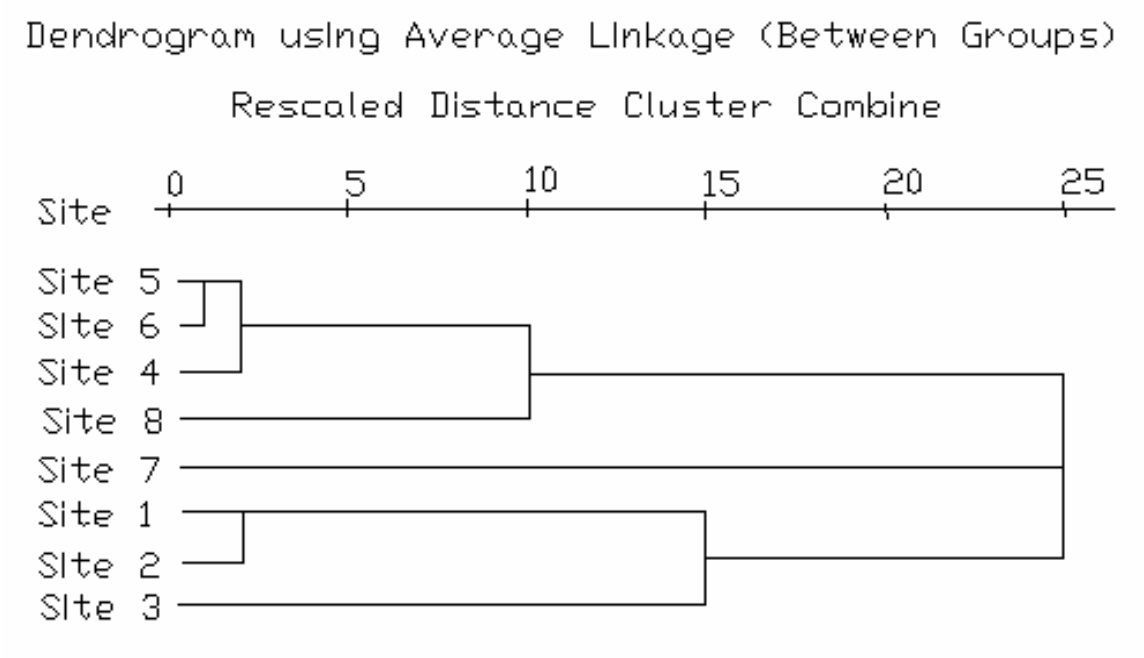

Figure 2. Cluster analysis with canopy parameters of community

1.3.5 Species composition in all the surveyed sites

The Braun-Blanquet's system of rating was applied to describe the community structure. We used two scales. Scale 1 combines the number and the cover of a species. Scale 2 measures the grouping. Vegetation table for community composition (Braun-Blanquet Rating System) is given in Table 4.

Species compositions								
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Upper layer trees								
Acer davidii		3 2						
Aralia chinensis		3 2						
Fraxinus chinensis var. *rhynchophylla*			1 1					
Picea asperata				4 5	4 5	5 5		
Picea neoveitchii	3 2	1 1	5 1	2 1	2 1	2 1	5 1	3 1
Populus cathayana			5 1					
Quercus aliena var. *acuteserrata*			1 1					
Salix caprea var. *sinica*			1 1					
Tilia oblongifolia			2 1					
Tsuga chinensis	4 2							
Middle layer trees								
Acer davidii	2 2							
Carpinus cordata	2 1							
Celtis koraiensis	1 1							
Picea asperata							3 1	
Picea wilsonii							4 1	
Prunus armeniaca var. *ansu*							3 1	

Shrub layer species …
Ground layer species …
Moss layer species …

Table 4. Vegetation table for community composition (Braun-Blanquet Rating System)

2. Genetic studies

Due to the climate change and human disturbance, all the natural habitats of *Picea neoveitchii* have been fragmented into small and scattered populations. A small population can be easily exposed to random genetic drift, inbreeding, loss of genetic diversity, differentiation of populations, and increased probability of extinction. (A ∂ alsteinn, 1993; Lai, 2001; Landhausser, 2001; Markus, 2000; Qian, 2000; Sigurgeirsson, 1993). The survival of a species depands on genetic variabilities to accommodate eventual selection pressures brought on by a long term environmental change. The purpose of using the RAPD (Random Amplification of Polymorphic DNA) analysis in this research was to identify the level of genetic variability in the population of *Picea neoveitchii*.

2.1 Materials and methods

2.1.1 Materials

The young needles were collected from natural individuals of Veitch spruce in all the surveyed sites and a *ex situ* conservation botanical garden (Xi'an Botanical Garden). Twelve samples have been collected and used for the RAPD analysis.

2.1.2 Methods

2.1.2.1 DNA extraction and quantification

The air dried young needle leaf samples were ground into powder, and then placed in 5 ml of extraction buffer for genomic DNA extraction based on a modified CTAB procedure. The sample DNA was precipitated with ethanol, and then washed with 70% ethanol. It was dissolved in 200 µl TE buffer, pH 8.0, and placed in 4°C. The DNA concentration was determined with UV/VIS spectrometer Lambda Bio 10 (PERKIN ELMER Co.).

2.1.2.2 DNA amplification

The RAPD reactions were conducted on a DNA Programmable Thermal Cycler (PTC-100, MJ Research) with three steps: Step 1 was 3 min at 94°C; Step 2 was 45 cycles of 1 min at 94°C for denaturation, 1 min at 37°C for annealing, and 2 min at 72°C for polymerization; and step 3 was 10 min at 72°C for final polymerase reaction. Each reaction contained 500 mM KCl, 15 mM MgCl2, 0.01% gelatin, 100 mM Tris-HCl (pH 8.3), 1 mM dNTPs, 2 µM Primer, 20 ng template DNA, 1 µg RNase, and 1.7 unit Taq polymerase (Amersham Pharmacia Biotech), to a final volume of 20 µl. Products amplified by PCR were resolved using 1.75% (w/v) Nusieve 3:1 agarose (FMC BioProducts) gel containing 0.1 g/ml ethidium bromide electrophoresed in 1X TBE under constant voltage (50V) for 2 h. A molecular size marker (fX 174/HaeIII, Stratagene) was used to assign molecular weights to RAPD bands. Images of each gel were viewed by UV illumination, captured by Electronic Vision Machine, and stored as TIF files.

2.1.2.3 Primer selection

To identify primers that detect polymorphism, 52 primers were screened with 12 universal rice primers and 40 OPERON primers. Twenty-four primers produced polymorphic RAPD banding profiles that yielded a total of 234 reproducible bands.

2.1.2.4 Data collection and statistical analysis

Amplified RAPD markers were scored as present or absent for each sample. The genetic variablity was analyzed with Cluster Analysis.

2.2 Results

2.2.1 Genetic distances and variance partitioning

A total of 234 reproducible bands were scored from PCR with 24 random primers. A examples that polymorphisms detected among some test samples using RAPD primer UPR-2 can be seen in Figure 3.

Figure 3. Polymorphisms detected among some test samples using RAPD primer UPR-2. (left to right: lane 1, 100 bp marker; lanes 2-13, samples)

Dendrogram based on the polymorphism RAPD bands shows in Figure 4. The result of the cluster analysis divided the set of 12 samples into 2 groups. The samples from the Xinjiashan Forest Farm (sample 4, 5, 6 and 7) and the Xi'an Botanical Garden (sample 11 and 12) are in one group. The samples from the Baotianman Nature Reserve, the Taibaishan Forest Farm, and the Bailongjiang Forest Farm (sample 1, 2, 3, 8, 9 and 10) are in another group.

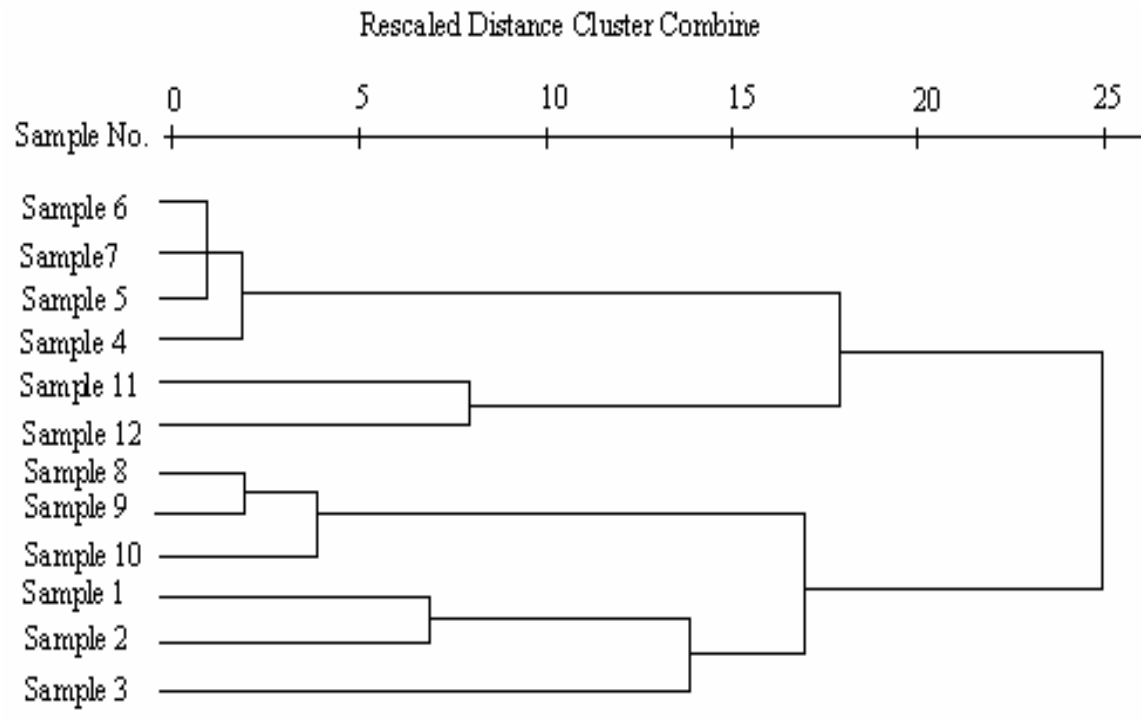

Figure 4. Dendrogram based on the polymorphism RAPD bands

2.2.2 Estimation of Shannon's Phenotypic Diversity Index (Ho) for RAPDs

In order to compare the genetic diversity in different locations, Shannon's phenotypic diversity index (Ho) was used to calculate the numbers of polymorphic bands that yield from 24 successful amplification primers. The estimation of Ho explains the difference of genetic variations of different locations. The higher the diversity index value at that locality is, the more fitness for these individuals at those localities. The Xinjiashan samples have the highest genetic diversity index (2.980).

3. Conservation management

With the rapid decline of the extent of occurrence and the area of occupancy, the endangered status of *Picea neoveitchii* need reevaluation based on the IUCN conservation category and criteria (IUCN, 2001). A rational and practical conservation strategy is necessary to strengthen the *in situ* and the *ex situ* conservation.

3.1 Research methods:

Applying the IUCN Threatened Categories and Criteria as guideline to reevaluation of the endangered status; Citing the Data of REPC-CBG-DATA (Database of Rare and Endangered Plant Conservation in Chinese Botanical Gardens) (Zhang, 1999) for *ex situ* conservation analysis; and survey on decline of extent of occurrence and Area of occupancy over the last decades

3.2 Results

3.2.1 Assessment of conservation status of *Picea neoveitchii*

All the published literature has listed *Picea neoveitchii* as endangered species. Based on criteria of IUCN Red List categories above, the threat level of *Picea neoveitchii* fall into Critically Endangered (CR) B2b C2a D status. In this research, the degree of threat was shown to have increased, more aggravated, than the data from prior research (Farjon, 1999; National Environmental Protection Bureau of China et al., 1994; Fu, 1991; WCMC, 1993; IUCN, 1998, 2001; Zheng, 1982). The conservation status was also evaluated with RAMAS Program. The evaluation result is Critically Endangered that is the same with the previous assessment. However the conservation status has been changed as CR B1 B2ce, C2a, D, E.

3.2.2 Determination of favourable botanical gardens for *ex situ* conservation of the target species for different provenances

Longitude, latitude, altitude, annual mean temperature, maximum of temperature, minimum of temperature, relative humidity and annual precipitation were used for cluster analysis to determine favourable *ex situ* conservation botanical gardens for different provenances of *Picea neoveitchii.* Table 5 is the cluster result of favourable *ex situ* conservation botanical gardens or arboreta for different provenances of *Picea neoveitchii*.

Source of introduction	Suggested capacity building for *ex situ* conservation		
	Most Favourable	Favourable	Less favourable
Bailongjiang Forest Farm	Maijishan Ar	Guizhou BG, Kunming BG, Lushan BG Ar of Guizhou Institute of Forestry Science Kunming Horticultural Landscape BG	
Baotianman Nature Reserve Xinjiashan Forest Farm Taibaishan Forest Farm	Huhhot BG Yanan Ar Yulin Psammophytes BG	Dengkou Psammophytes BG Minqin Psammophytes BG Yinchuan BG, Lanzhou BG Yanchi Arid Land Shrub Garden	Xiji Ar Xining BG

Table 5. Suggested capacity building for ex situ conservation for different provenances of Picea neoveitchii *(BG Botanical Garden; Ar Arboretum)*

3.2.3 Threatened reasons of *Picea neoveitchii*

Based on the literature review, interview with local scholars, field survey and data analysis, the causes behind the decline of *Picea neoveitchii* are summarized as human interventions, species competition, habitat fragmentation, lack of relevant documentations and inappropriate habitat management.

3.2.4 Lack of motivation for *ex situ* conservation

As both an endemic and threatened species, *Picea neoveitchii* had been introduced and cultivated in two botanical gardens according to historic records (Zhang, 1999). However, no overseas botanical gardens have cultivated this species until now. The introduced germplasm was dead in the Baoji Botanical Gardens in 2000. As a newly built garden, the Baoji Botanical Garden has changed the field planting in 2000 and it lacked the management technique for replanting the individuals. The only two individuals in the Xi'an Botanical Gardens are surviving, however in an unhealthy state.

3.3 Conservation strategy

On the basis of the above study and analysis, the conservation strategies of *Picea neoveitchii* are proposed as follows.

3.3.1 *In situ* conservation

There is a need to conserve the individuals, species, or habitats in their places of origin and natural occurrence. The goal of *in situ* conservation is to ensure the continued survival of the species, their population and genetic variation as evolving systems within functioning ecosystems and to maintain their capacity for future change and adaptation. The detailed measures include natural habitat conservation, non-native plant species management and forbidding timber harvest.

3.3.2 Capacity building for *ex situ* conservation

Ex situ conservation is a method that conserve plant taxa or their biological materials away from their natural habitats such as botanical gardens and arboreta, seed bank and DNA bank, etc. As an endemic and critically endangered species, *Picea neoveitchii* had been introduced and conserved in two botanical gardens according to historic records. However, the maintenance in *ex situ* conservation is fallacious. Much research on *Picea neoveitchii* introduction and cultivation in botanical gardens remains to be done like vegetative collection, sampling conservation in favourable botanical gardens, and reintroduction etc.

3.3.3 Integration of *in situ* and *ex situ* conservation strategies

Picea neoveitchii has been over-exploited in the past decades. It has already become a critically endangered species and almost faces extinction in the wild. It is urgent to develop a research project to reintroduce it into

the original sites for rehabilitation. On the other hand, the vast arid or degraded mountain territory, the long-term timber harvest has left, are encouraged to plant seedling of *Picea neoveitchii* for reforestation.

Besides above technical aspects, some social-economic aspects are also worth considering such as reducing pressure on spruce as a resource, education improvement, legislation and implementation for endangered species conservation. Systematically implementing the above strategy and assuring the survival of the target species could be a sustainable germplasm resource for human beings.

4. Conclusion

With the data from the ecological survey in the four locations, community index such as relative density, relative frequency, relative dominance, relative important value (RIV), species richness, similarity index, diversity index and evenness index were calculated that reflect the habitat heterogeneity in all the natural habitats.

The RIV reflect the heterogeneities of community composition and characteristics in their natural habitats. It shows that *Picea neoveitchii* is the predominant species with RIV over 20 in its habitats.

The diversity and evenness index illustrates the Bailongjiang and the Baotianman have higher diversity than other locations and sites.

Similarity index analysis illuminates the Baotianman Nature Reserve and the Xinjiashan Forest Farm have the higher similarity index.

The community sorting shows the community parameters could be described into three groups. Site 4, 5, 6 and 8 in one group, Site 1, 2 and 3 in one group and Site 7 in another group.

The analysis of vegetation table elucidates *Picea neoveitchii* is a dominant species with low grouping rate in most surveyed sites. All the calculated indicators are the important characters to describe the species with its survival habitats.

The RAPD analysis shows target species has intraspecific genetic variability. And the estimation of Shannon's phenotypic diversity index (Ho) explains the difference of genetic variations of different locations.

Heterogeneity of geography, community structure and genetic property, *ex situ* conservation efforts should extend to include materials from all existing habitats. The cluster analysis of the favourable botanical gardens for *ex situ* conservation for different provenances elucidates the detailed introduction guideline.

In accordance with Conservation Category by IUCN, based on field survey and analysis, the status of *Picea neoveitchii* categorized as Critically Endangered (CR) B2b C2a D.

The field survey confirmed that the main loss of habitats of *Picea neoveitchii* occurred in 1950's to 1990's by clear-cutting. Other reasons like species competition, habitat fragmentation, lacks of documentation and inappropriate habitat management also caused the endangered species to extinction. Both *in situ* threats and lack of motivation for *ex situ* conservation of their present status may cause further loss of existing germplasm resources.

The conservation strategy includes two compensatory aspects of *in situ* conservation and *ex situ* conservation. The main target of conservation is maintaining the existing individuals from further decreasing and expand its expand its population.

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Figure 2. Martin Hamilton (RBG Kew) demonstrating the use of a hand held computer for collecting data in the field (Photo – Colin Clubbe, RBG Kew)

Travelling training courses

Staff at the Royal Botanic Gardens Kew are actively committed to sharing information and expertise with colleagues from other botanical institutions around the world. As the need for specialist skills in botany, horticulture and conservation increased, RBG Kew responded by establishing a series of international diploma courses to provide training in identifying and conserving biodiversity and in using it sustainably. The continuing need to build capacity for the conservation of plant diversity is highlighted in two key commitments made by global conservation community: the Convention on Biological Diversity (CBD) and the Global Strategy for Plant Conservation (GSPC). Article 12 of the CBD and Target 15 of the GSPC highlight this need to help build capacity to conserve, sustainably utilize and manage our botanical resources. These have become the two key drivers for the further development of Kew's capacity building programme at home and internationally.

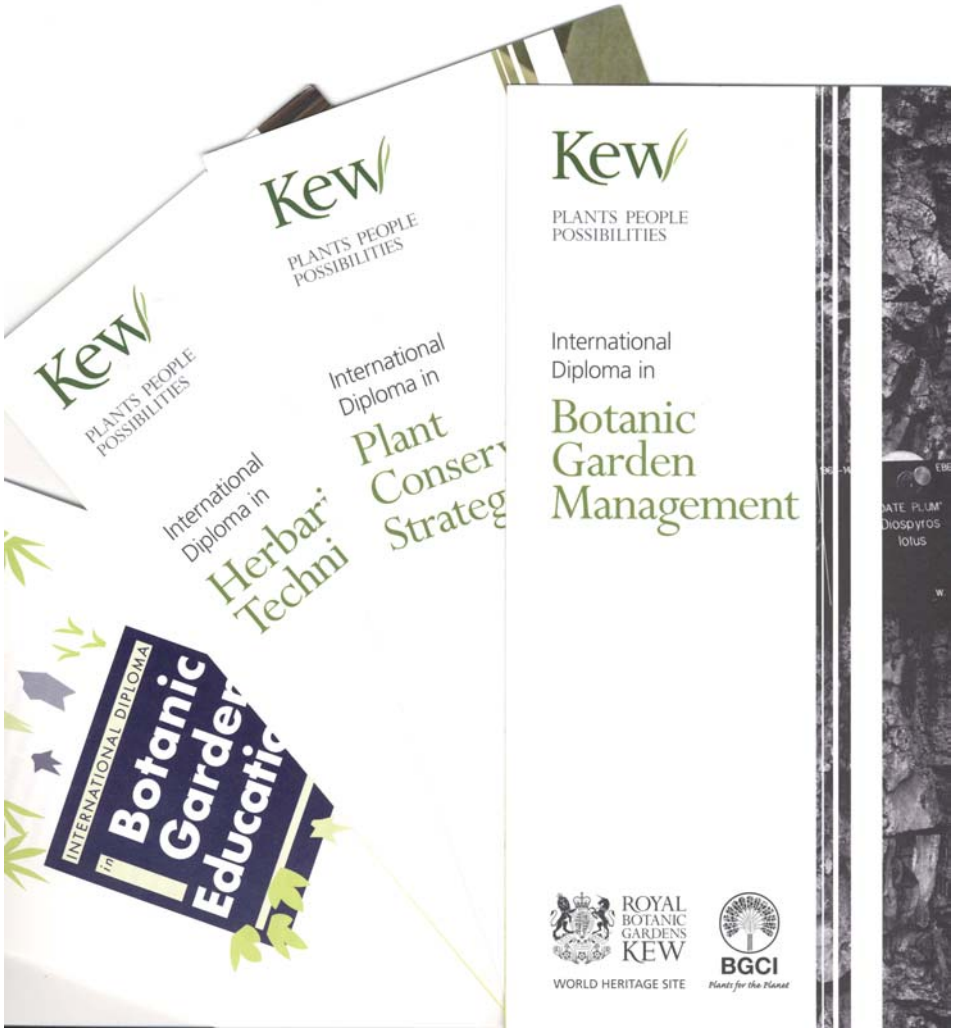

Figure 3. Four international diploma courses are run at Kew aimed at plant conservation practitioners and the international botanic garden community

The international diploma programme at Kew is now well established and 377 practitioners from 103 countries have participated in this programme over its 20 year history (Figure 3). This in itself is an important contribution to Target 16 of the GSPC –"networks for plant conservation activities established or strengthened at national, regional and international levels". Designed to provide specialist training for people working in botanic gardens, arboreta, herbaria and other conservation organisations, these courses bring together participants from around the world. Through lectures and workshops with staff from RBG Kew, BGCI and other international conservation bodies and visits to other UK organisations, they explore a wide range of topics related to their chosen disciplines (Figures 4 and 5). Specialist options and projects enable each participant to become more confident in developing plans for implementation at home. By exchanging ideas and sharing problems amongst themselves, participants from different countries often discover common solutions. Funding for participation in this programme remains a challenge, but solutions are being found. For some participants their home institution is able to sponsor participation either from core funds, directly from a Government Ministry or as specified in a technical training budget line of a project. Recent examples of the latter are within Darwin Initiative funded projects (www.Darwin.gov.uk). Others have been successful in gaining Winston Churchill traveling fellowships (www.churchilltrust.com.au), or grants from educational charities. We strongly encourage applicants to register their interest for course participation early so that help in securing funding can be provided.

Figure 4. Participants from the 2005 Plant Conservation Strategies course discuss issues during a fieldtrip to a local nature reserve (Colin Clubbe, RBG Kew).

Figure 5 Participants from the 2004 Botanic Garden Management course demonstrate materials they have developed for providing a conservation message in Kew Gardens(Colin Clubbe, RBG Kew).

Long after a course ends, the links between its participants remain strong through individual contacts and through the wider network of International Diploma alumni and its regular newsletter *OnCourse* (www.kew.org/education/highered.html). Details of the programme are illustrated in the poster '*Growing Expertise: courses@kew.org.uk'*.

In recent years we have been responding to requests for developing regionally-based training programmes in collaboration with in-country partners. The development of this regional programme is very much led by the needs of our international partners. A host institution is identified, usually as a result of an offer made by that institution and often from a suggestion by an alumnus of one of the Kew-based courses at that Institution. A small team of staff from Kew usually form the core teaching team alongside locally-based resource personnel. Countries that have hosted this type of course include Brazil, Malaysia, Kenya, Tanzania, Russia, Turkey, and China. In other cases our alumnus has organised their own country-level course based on the Kew model but adapted to meet local needs and where Kew staff may or may not join the course as a resource person. Countries that have run this type of course include Kenya, Uganda and India. This really is evidence of building capacity and delivering effective cascade training borne of the confidence gained during the Kew programme. Funding for this regional programmes has come from a number of sources including the Darwin Initiative and corporate sponsors of RBG Kew.

Most recently, in collaboration with BGCI and the CBD Secretariat, we have been developing training courses to specifically address the implementation of the GSPC. The first of these was the African Regional Training Course in Plant Conservation Strategies based on the GSPC which was held in Uganda in November 2004 and hosted by Makerere University. Local co-ordination was provided by Kew alumni and funding for the programme provided by a grant from British American Tobacco (BAT) through a capacity building project coordinated at RBG Kew. Eighteen participants from 15 countries (Benin, Central African Republic, Ethiopia, Cameroon, Ghana, Liberia, Madagascar, Morocco, Namibia, Nigeria, Tanzania, Togo, Uganda, Zambia and Zimbabwe) attended the 3-week course. The main course objectives were:

- To raise awareness of GSPC and its targets
- To identify champions to help steer implementation at a national level
- To examine targets in the African context using local case studies and fieldtrips

The course drew on local resource personnel from a wide range of national and international organisations, both governmental and non-governmental as well as the course facilitators from Kew and BGCI to deliver a wide ranging programme of lectures, workshops (Figure 6) and fieldtrips (Figure 7). Several participants have since been nominated as their country's GSPC focal point and are engaged in developing a national response to the GSPC. Others are working towards the integration of GSPC targets into national biodiversity strategies and action plans. All are determined to help implement the GSPC and strive to achieve the targets.

Figure 6. Course participants from the African Regional Training Course in Plant Conservation Strategies grapple with the targets of the GSPC (Colin Clubbe, RBG Kew).

Figure 7. Course participants from the African Regional Training Course in Plant Conservation Strategies visit the Entebbe Botanic Gardens as part of the fieldtrip programme to investigate the practical implementation of the GSPC (Colin Clubbe, RBG Kew).

In May 2006, a Caribbean Regional GSPC workshop was held on the island of Montserrat aimed at Caribbean UK Overseas Territories (UKOTs) and small island developing states (SIDS). Sixteen participants from Antigua and Barbuda, Belize, Bermuda, Cayman Islands, Dominica, Jamaica, Montserrat, St Kitts and Nevis, St Lucia, Trinidad and Tobago attended the one-week workshop (Figure 8). The objectives were similar to those of the African course:

- To raise awareness of GSPC and its targets
- To identify champions to help steer implementation at a national level
- To examine targets in the Caribbean context using local case studies and fieldtrips

Funding for the workshop was secured from the UK Government's WSSD Implementation fund. The grant also allowed us to invite two resource people who had experience of developing GSPC strategies at a national level in an island context, the UK and the Seychelles, to share their experiences in developing national strategies. Another highly motivated group have become advocates for GSPC implementation and are working on national responses to the GSPC and the integration of GSPC targets into national biodiversity strategies and action plans. A key information gap identified at the Montserrat workshop was the lack of accurate, reliable and up-to-date information on plant taxonomy and species status. This was seen as a potential block to achieving targets 1 and 2 of the GSPC. As a result of this a pilot study has been funded by the UK Government's Overseas Territories Environment Programme (OTEP) to investigate the enabling needs to achieve targets 1 and 2 of the GSPC for the Caribbean. This study is being coordinated at RBG Kew.

Figure 8. Course participants from the Caribbean Regional GSPC workshop consider the effects of an active volcano on biodiversity and livelihoods in Montserrat.

Publicity is a vital tool for conservation and for raising awareness of the GSPC. During all of these workshops we have tried to encourage the local media to get interested by giving interviews on radio and for newspapers. Although it is sometimes difficult to raise initial interest from the media it is worth persevering as the publicity can pay large dividends.

So some final challenges remain:

- Do we enough trained staff?
- Do we have sufficient resources?
- Can we work smarter?
- Can we establish new partnerships?
- How can we best exert political pressure?

…in order to meet the 2010 challenge. The clock is ticking.

2. Conserving plant diversity

Achievements

- Botanic gardens (BGs) have enhanced their role as repositories of plant conservation:
  - Many of the world's threatened plants requiring immediate attention are stored *ex-situ* in botanic gardens either preserved in living collections, seed or gene banks. Using the 1997 Red List as the baseline, and using data from BGCI's PlantSearch database, we know that at least 35% of threatened plants are stored *ex-situ*.
- BGs are increasingly playing a role in conservation efforts *in-situ* and in recovery and restoration work:
  - More than 400 BGs are involved in managing protected areas;
  - BGs have been involved in many plant restoration programmes and projects over the past decade.
- BGs have started to take action in view of rapid global environmental change
  - involving local communities in monitoring the impacts of climate change on plants (as in the US);
  - making increasing efforts in establishing representative seed banks (for example 96% of the UK's flora is conserved in the MSB);
  - giving more attention to 'problem' seeds, recalcitrants, dessication-prone seeds, etc. and improvements in seedbank technology;
  - realizing the impacts of alien invasive species and actively contributing to control and eradication programmes.
- In so doing, BGs are increasingly embracing a holistic way in conserving plant diversity by putting into practice the integration of *ex-situ* and *in-situ* conservation.

Challenges

- Effective conservation action by BGs is constrained by gaps in understanding of plant biology and ecosystem functioning, especially in the context of global environmental change
  - Successful plant restoration projects depend on a clear understanding of propagation/germination of species, considering also recalcitrant, dessication-sensitive species which are often overlooked in *ex-situ* collections as they are difficult to store;
  - There is limited understanding of migration patterns based on models and potential global warming scenarios, as well as the potential of increased invasiveness of alien species as a result of climate change;
- Genetic representativeness of *ex-situ* collections is often incomplete.
- Many important areas for plant conservation are believed to be outside protected area systems but most of these vulnerable areas are currently unidentified.

Recommendations

- Conservation action should give more emphasis to integrating local and science-based knowledge.
- Good scientific research, including research in horticulture and education, is essential to underpin effective biodiversity conservation.
- The role of BGs in advancing an ecosystem approach-based management style should be promoted.
- Partnerships should be strengthened and new partnerships developed to ensure integrated *in situ* and *ex situ* conservation
- While there are some excellent training programmes there is a need for greater focus on capacity building for conservation, taking into account local needs and languages

3. Using plant diversity sustainably

Achievements

- Botanic gardens around the world are focusing research efforts towards the development and sustainable utilisation of local plants. This includes research to produce improved varieties with commercial potential and developing propagation and production protocols for a wide range of useful plants.
- Botanic gardens are involved in projects, often involving their local communities, which use plant diversity in a sustainable manner, to improve human well-being. This includes work on medicinal and nutritional plants, as well as projects that aim to alleviate poverty as well as addressing social and community problems.
- Many botanic gardens are working with CITES to protect wild plants from being threatened by international trade, in a variety of ways. These include: providing comprehensive conservation models; training CITES officials on identification; and providing alternatives (e.g. hybrids) for sustainable trade.
- Among the many other contributions botanic gardens make to society, botanic gardens provide a range of health benefits and in an increasingly urbanised world, botanic gardens are playing an important role in providing green spaces in urban centres.
- Botanic gardens have begun to respond to the access and benefit-sharing requirements of the CBD by developing implementation tools such as the Principles on Access to Genetic Resources and Benefit Sharing and the International Plant Exchange Network. In addition, new innovative models to generate and share benefits derived from the use of plant genetic resources are being developed.
- The need to develop botanic gardens as models for sustainability has made good progress and technology and innovation are being used to support innovation. These models now need to be more widely applied.

Challenges

- A huge number of plant species are used for their medicinal properties (50-70,000). However, there is a great lack of information, for example on the extent of trade in medicinal plants and baseline population data for plants that are being exploited.
- While collecting plants form the wild is often the only option available, information on what constitutes a sustainable level of harvesting is often not available.
- The role of CITES in protecting wild plants, whilst not discouraging trade or damaging livelihoods, is not always well understood.

- Local plant resources are insufficiently used by urban planners in the development of green spaces in cities – botanic gardens have an important role to play in addressing this gap.
- Policy and decision makers at many levels are not aware of the work of botanic gardens in the conservation and sustainable use of plant resources.

Recommendations

- Many wild plants are under threat due to unsustainable harvesting techniques. Bringing these plants into cultivation is not always the answer - although it often has an important role to play). Botanic gardens should also focus on supporting sustainable harvesting initiatives – using the guidelines recently developed – and especially working with local communities.
- Botanic gardens should ensure that conservation efforts include intraspecific diversity and crop wild relatives as these provide important resources for developing new varieties.
- Botanic gardens and BGCI should work with CITES to support the new livelihood initiatives within CITES, providing botanical information and expertise.
- Botanic gardens need to constantly renew their relevance to society. They can contribute to global as well as local benefits, but cannot flourish without the support of their local community.
- In line with the access and benefit sharing provisions of the CBD, botanic gardens should continue to seek more opportunities for collaboration and innovative ways to generate and share benefits and build local capacity for conservation and sustainable use of plant resources.
- Botanic gardens should inform policy and decision makers about the importance and relevance of their work in conservation and sustainable use, so that new national and international laws create and enabling environment for their work.
- There is a need to mainstream sustainability into botanic garden operations. Sustainability should be built into new designs, structure and garden landscapes, rather than being retrospectively applied. Protocols for sustainability need to be developed and shared to guide botanic gardens.

4. Promoting education and awareness about plant diversity

Achievements

A global survey carried out by BGCI revealed that 91% of botanic gardens include education in their mission. This is very encouraging. Sessions have demonstrated that botanic gardens carry out a wide range of education and interpretation programmes and that they are increasing their efforts in environmental education and education for sustainability.

Education provision complements many other botanic garden activities. For example, involving communities in conserving medicinal plants and eradicating invasive species.

Botanic gardens reach a wide range of audiences from school children through to the general public, local communities and tourists with traditional and innovative programmes, including signage, exhibits, events, classes and field trips. Botanic gardens are increasingly becoming extended classrooms for schools and life-long learning.

Collectively, botanic gardens make a significant contribution to implementing Target 14 of the Global Strategy for Plant Conservation incorporating the importance of plant diversity and the need for its conservation into communication, educational and public awareness programmes.

Challenges

Our world is facing major environmental challenges such as climate change, poverty, environmental degradation, lack of sustainability of food systems and rapid urbanisation At the moment, relatively few botanic gardens are developing communication and education programmes to tackle these issues. Botanic gardens need to stimulate reflection and discussion about these topics with their visitors.

Evaluation is essential for ensuring botanic gardens reach appropriate audiences with relevant messages. There appears to be a lack of qualitative evaluation and research on communication, education and public awareness provision being carried out in botanic gardens. This has implications for the quality and type of programmes offered and their success. To address this, botanic gardens need to find new ideas and methodologies for interpreting messages, i.e. thinking outside the box and creating a new paradigm.

Through communication, education and public awareness provision, botanic gardens reach large numbers of specific audiences, e.g. university students, school children and families. However there appears to be a gap with reaching target audiences such as

decision makers, business leaders, people with disabilities and those audiences not currently visiting the botanic garden.

Many gardens report a lack of investment for communication and education provision, whether in terms of finance, resources, staff or capacity building. This may reflect a link with the lack of contact with decision makers and potential funders.

There has been a decline in the teaching of plant science in schools in many regions of the world. Botanic gardens need to address this through their programmes, networking with other scientific and education institutions and influencing policy.

Gardens currently do not make the most of using their unique opportunity to provide ecotourism experiences for their visitors. They can begin by committing themselves to sustainability, using these principles to guide their work and communicating them to their visitors.

Recommendations

In addition to incorporating Target 14 within their education, communication and public awareness programmes, botanic gardens need to address some of the key contemporary environmental and social issues, including climate change, poverty alleviation, food security, alien invasives and urbanization. In addressing these issues there must be an emphasis on attitude and behavioural change with the aim of achieving sustainable development.

Botanic gardens must attract or provide more investment for their education programmes. This may be through targeting policy makers, business leaders and the media, engaging in partnerships and networks, offering capacity building, employing appropriately qualified educators and reaching new audiences, such as ecotourists.

Botanic gardens should carry out research and evaluation to determine audiences, tailor programmes to their requirements and ascertain that these requirements are being met. Botanic gardens need to utilise new technology such as that offered by the internet, and incorporate environmental thinking in their programme development, for example systems theory can be used to illustrate connectivity and biological complexity.

Botanic gardens should address the perceived reduction in plant science education through their education provision, networking with other scientific and education institutions and influencing policy.

There are a wide range of training needs at several levels, but with limited trainers available. A key need is to maximise training by:

- Identifying key training needs

- Developing standardized multi-lingual training materials
- Recognising local issues, needs and resource availability
- Appropriate certification based on simple but rigorous assessment.

Botanic gardens have an increasingly important role to play in communication, education and public awareness. Research needs to be undertaken to determine their impact and verify their importance in creating a sustainable global society.

Botanic gardens need to ensure that they are fun, exciting, provocative, innovative and relevant places for people to visit and engage with the messages being communicated.