

## GUEST ESSAY

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Dr Paul Smith is the Secretary General of Botanic Gardens Conservation International (BGCI). BGCI is the largest plant conservation network in the world, comprising 500 member botanic gardens in 100 countries. With a career spanning 25 years working in conservation, Paul joined BGCI as Secretary General in March 2015.

Prior to his appointment as Secretary General of BGCI, Paul was Head of the Royal Botanic Garden, Kew's Millennium Seed Bank (MSB). During his nine years at the helm there, seeds from >25,000 plant species were conserved in the MSB and, in 2009, the MSB achieved its first significant milestone, securing seed from 10 per cent of the world's plant species, prioritising rare, threatened and useful plants. Since then, the MSB Partnership has set itself the target of conserving 25 per cent of the world's flora by 2020. During his tenure at the MSB, Paul and his team promoted the concept of seed banks as a resource for human innovation, adaptation and resilience, and, today, seeds from the MSB and its partner seed banks are being used in agriculture, horticulture, forestry and habitat restoration.

Paul trained as a plant ecologist, and is a specialist in the plants and vegetation of southern Africa. He is the author of two field guides to the flora of south-central Africa and the Vegetation Atlas of Madagascar. He is a Fellow of the Linnean Society and the Royal Geographical Society, and is the recipient of the New England Wildflower Society's Medal for services to international plant conservation and the David Fairchild Medal for Plant Exploration. He is a member of the Trapnell Board at the University of Oxford and the Board of BGCI (US) based at Chicago Botanic Garden.

## BUILDING A GLOBAL SYSTEM FOR THE CONSERVATION OF ALL PLANT DIVERSITY: A VISION FOR BOTANIC GARDENS AND BOTANIC GARDENS CONSERVATION INTERNATIONAL

### ABSTRACT

Botanic gardens and arboreta offer the opportunity to conserve and manage a wide range of plant diversity *ex situ*, and *in situ* in the broader landscape. The rationale that botanic gardens have a major role to play in preventing plant species extinctions is based on the assumptions that (1) there is no technical reason why any plant species should become extinct, and (2) that, as a professional

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community, botanic gardens possess a unique set of skills that encompass finding, identifying, collecting, conserving and growing plant diversity across the entire taxonomic spectrum. Botanic Gardens Conservation International (BGCI) is the pivotal centre of a global network of c. 2,600 botanic gardens and arboreta, which includes living collections representing at least one-third of known plant diversity; world class seed banks, glasshouses and tissue culture infrastructures; and technical knowledge networks covering all aspects of plant conservation. Following the example of the crop conservation community, BGCI is promoting the concept of a cost-effective, rational, botanic garden-centred Global System for the conservation and management of plant diversity. This system will aim to collect, conserve, characterise and cultivate samples from all of the world's rare and threatened plants as an insurance policy against their extinction in the wild and as a source of plant material for human innovation, adaptation and resilience.

## INTRODUCTION

Plants are essential for human and other animal life on Earth in that they capture energy from the sun and convert it into food in the form of their seeds, leaves and roots. Human life is further sustained by the medicines, building materials and fuel that plants provide. Plants are central to many ecological processes such as climate regulation (including carbon dioxide absorption), soil fertility and the purification of both water and air. In spite of their importance, more than 80,000 seed-bearing plant species (20 per cent of the total) are currently under threat (Millennium Ecosystem Assessment, 2005). The threat of extinction is largely due to habitat degradation, invasive alien species and over-exploitation, and is likely to be exacerbated by climate change. This threatened plant diversity will be essential to solving some of this century's major challenges in the areas of food security, energy availability, water scarcity, climate change and habitat degradation.

It is estimated that humans have modified more than 50 per cent of the world's land surface (Hooke *et al.*, 2012), with approximately 40 per cent given over to agriculture and livestock management. For plants with natural distributions that fall within these transformed areas, *ex situ* conservation or active human management may be the only way they can survive. Even in national parks and wilderness areas not significantly altered or actively managed by people, plant populations may be vulnerable – particularly to invasive species, pests, diseases and a changing climate.

Botanic gardens offer the opportunity to conserve and manage a wide range of plant diversity *ex situ*, and *in situ* in the broader landscape. The rationale that botanic gardens have a major role to play in preventing plant species extinctions through integrated plant conservation action is based on the following assumptions:

- There is no technical reason why any plant species should become extinct. Given the array of *ex situ* and *in situ* conservation techniques employed by the botanic garden community (seed banking, cultivation, tissue culture, assisted migration, species recovery, ecological restoration, etc.) we should be able to avoid species extinctions.
- As a professional community, botanic gardens possess a unique set of skills that encompass finding, identifying, collecting, conserving and growing plant diversity across the entire taxonomic spectrum.

Botanic gardens are a diverse community, fulfilling multiple objectives including attracting visitors, public education, scientific research, horticulture and conservation. They have the potential to maximise their plant conservation impact by prioritising plant conservation action, becoming better organised as a professional community, and effectively communicating their role and objectives in plant conservation to policy makers, funders and the general public.

Botanic Gardens Conservation International (BGCI) is a membership organisation, representing botanic gardens in more than 100 countries around the world. We aim to support and empower our members and the wider conservation community, including ordinary citizens, so that our knowledge and expertise can be applied to reversing the threat of extinction facing plants. Our vision is a world in which plant diversity is valued, secure and supporting all life, and our mission is “to mobilise botanic gardens and engage partners in securing plant diversity for the well-being of people and the planet”.

In this article I will set out how we will achieve this mission through the establishment and promotion of a botanic garden-centred Global System for the conservation and management of plant diversity that aims to collect, conserve, characterise and cultivate samples from all of the world’s rare and threatened plants as an insurance policy against their extinction in the wild and as a source of plant material for human innovation, adaptation and resilience.

#### THE CONCEPT OF A COST-EFFECTIVE, RATIONAL GLOBAL SYSTEM

The Global System approach is exemplified by the endeavours of the global crop research community. Despite its importance to food security, much of the world’s crop diversity is neither safely conserved nor readily available to scientists and farmers who rely on it to safeguard agricultural productivity. Crop diversity is being lost, and with it the biological basis of our food supply. Given the urgent need to achieve food security in the face of a changing climate and burgeoning human population, the crop research community has developed the concept of a cost-effective, rational Global System for the conservation and sustainable use of plant genetic resources in food and agriculture (FAO, 2011). This Global System, established by the Food and Agriculture Organisation of the United Nations (FAO), comprises elements of policy, planning, a review process, physical infrastructures, human resources, germplasm collections and data. It consists of:

- the International Treaty on Plant Genetic Resources for Food and Agriculture (PGRFA)
- the Global Plan of Action for PGRFA
- a review process (State of the World’s PGRFA)
- a network of international institutions and crop collections
- a global portal of accession-level data (Genesys)
- a universal gene bank information management system (GRIN Global)
- advanced bioinformatics tools that allow users to mine crop characterisation data (DIVSEEK)

Compared to the botanic garden community, the crop community is highly centralised around the FAO and the multilateral germplasm collections in the gene banks of the Consultative Group on International Agricultural Research (CGIAR). Likewise, the International Treaty – in theory at least – facilitates access to material and data between national gene banks, multilateral gene banks and users. No such centralised multilateral infrastructure exists for botanic gardens. Nevertheless, there are strong parallels with the policy, infrastructural and collections frameworks that exist in the botanic gardens community.

#### A GLOBAL SYSTEM FOR BOTANIC GARDENS

Following the example of the crop conservation community, a botanic garden-centred Global System for the conservation and management of plant diversity aims to collect, conserve, characterise and cultivate samples from all of the world's rare and threatened plants as an insurance policy against their extinction in the wild and as a source of plant material for human innovation, adaptation and resilience.

This Global System comprises the following components:

- a global policy framework: the Convention on Biological Diversity
- a global action plan: the Global Strategy for Plant Conservation
- a review process: the Global Partnership for Plant Conservation
- a collections infrastructure comprising an international network of botanic gardens and their living collections
- a global portal of plant collection data: PlantSearch (BGCI, 2015)
- an array of data sources providing access to phenotypic and genotypic data enabling conservation and use of the collections for human development and well-being
- a range of tools, resources and activities that aim to increase awareness and participation in plant conservation, resulting in wide-reaching benefits for society

Most of the policy, planning and review architecture already exists, as indicated above. In addition, BGCI itself sits at the centre of a network of more than 500 botanic gardens in over 100 countries around the world, which includes the following:

#### *Globally significant ex situ collections*

These cover at least a third of total known plant diversity. BGCI's PlantSearch database (BGCI, 2016) includes 1.3 million accession names from 1,141 botanic gardens around the world. A recent comparison with the Plant List (2013) indicates that those gardens manage at least 115,787 different species in their living collections – equivalent to 33.02 per cent of all the species appearing in the Plant List. There are, of course, caveats, such as the fact that accession records are not always up to date or accurately named. However, this can be balanced against the fact that PlantSearch itself is not compre-

hensive, covering only about 40 per cent of all botanic gardens. What is clear is that, as a professional community, botanic gardens conserve and manage a far greater range of plant diversity than any other sector.

#### *World-leading infrastructures*

Kew's Millennium Seed Bank, the Royal Botanic Garden, Sydney's Plant Bank and Kunming Institute of Botany's Gene Bank of Wild Species are the largest, most sophisticated seed banks in the world. The sector is equally strong in glasshouse and horticulture infrastructures and is more than adequately served with micro-propagation facilities and molecular laboratories. The botanic garden community's most comprehensive data source on garden facilities and foci is BGCI's GardenSearch (BGCI, 2015), a web-based directory of the world's botanic gardens comprising information on 2,671 botanic gardens and arboreta in 135 countries.

#### *Skilled and knowledgeable staff*

At the heart of our network, of course, are the skills and knowledge of our staff. BGCI's GardenSearch database (BGCI, 2015) indicates that the world's botanic gardens employ at least 60,000 people, comprising thousands of plant scientists and horticulturists who possess unique knowledge about plants right across the taxonomic spectrum. This expertise is also manifest in specialist networks covering plant conservation practice such as red listing, seed conservation and ecological restoration.

#### *Well developed databases*

BGCI's PlantSearch database is the most comprehensive register of collection names in botanic gardens. The immediate aim is for PlantSearch to become a portal to individual accessions and their data held in specific botanic gardens and ultimately a means by which gardens can exchange material for conservation purposes in much the same way that the zoo community uses its International Species Information System as a stud book approach to captive breeding (Conde *et al.*, 2011). PlantSearch 2.0, which will trial this approach, will be launched in 2017. A further BGCI database under development is ThreatSearch, which aims to be the most comprehensive consolidated list of plant threat assessments in the world. This database comprises global, regional and national assessments, and currently includes over 180,000 records; it will be launched later this year.

### THE ROLE OF THE BOTANIC GARDEN COMMUNITY

Notwithstanding our impressive array of resources as a global community, substantial investment will be required to build a fully functioning Global System that can prevent species extinctions in perpetuity. Perhaps the most important thing we need to do is

to agree, as a professional community, that we are going to take on the challenge of plant species extinctions. Only by presenting a united front and showing commitment are we going to convince policy makers and funders that we have a substantial role to play.

Second, we need to promote plant conservation action in botanic gardens. This activity is currently competing with the other functions of botanic gardens, particularly the need to increase visitor numbers and generate income. Plant conservation activities in botanic gardens can be substantial or limited and may include plant conservation policy, practice or education. What is important is that all botanic gardens do *something* – preferably plant conservation action, and with local relevance.

Third, we need to better coordinate our work and focus botanic garden efforts on the gaps – making sure that we tackle the rarest, most threatened and most challenging species. Although we maintain a third of known plant diversity in our living collections and seed banks, we are less adept at conserving and managing rare and threatened species. In a recent BGCi analysis of threatened tree species held in botanic gardens (Rivers *et al.*, 2015) it was shown that only one in four threatened tree species are present in *ex situ* collections. As well as covering the species gaps, we also need to address the resource gaps by directing knowledge and financial resources towards smaller, resource-poor botanic gardens in biodiversity hotspots.

Fourth, we need to acknowledge that we cannot work in isolation. An *ex situ* seed or living collection is the means to an end, not the end in itself. The aim is to achieve self-perpetuating populations of plants out in the broader landscape. This means working in an integrated way with *in situ* conservationists (such as park managers, NGOs, etc.), foresters, farmers and other sectors that manage transformed landscapes. Explicitly, this also means that botanic gardens need to go out beyond their garden walls and learn new disciplines. A large number of botanic gardens already manage wild areas and native species assemblages, so this is not a huge ideological leap. However, we have not always been as good at working in partnership with other professional sectors.

Finally, we need to facilitate plant conservation action in broader society through stimulating public dialogue, creating opportunities for participation in local and global conservation efforts, and through provision of education, tools and information. At the same time, we need to be careful that our plant conservation effort does not begin and end here. Currently too many gardens argue that they are fulfilling their role by simply informing the public about plant conservation. This approach conveniently ignores the fact that our sector has the technical skills that broader society does not, and that with those skills comes responsibility.

#### BGCi'S ROLE IN BUILDING AND COORDINATING THE GLOBAL SYSTEM

Sitting at the centre of a network of botanic gardens in 100 countries, including the largest and most influential gardens in our sector, BGCi is in a prime position to promote a more efficient, cost-effective and rational approach to plant conservation in botanic

gardens. Building on the objectives outlined in BGCI's Plants for the Planet Strategic Plan (BGCI, 2015), we will do this in four ways:

1. *Leading and advocacy*: We will provide leadership to the botanic gardens sector, grow our membership and promote the role of botanic gardens to policy makers and funders in delivering the Global Strategy for Plant Conservation (2010). This is already happening as an increasing number of countries incorporate the Global Strategy into their National Biodiversity Strategies and Action Plans (Sharrock *et al.*, 2014). In addition, through our strong links with the United Nations, botanic gardens are already recognised as playing an important role in the conservation and use of plant genetic resources in agriculture (FAO, 2011) and forestry (FAO, 2014). BGCI's International Advisory Council, which currently comprises directors from twenty-two botanic gardens on six continents, is the closest approximation to a global leadership forum that the botanic gardens sector has. This body speaks with one voice on the primary importance of plant conservation in our sector.
2. *Leading and coordinating innovative and strategic projects achieving outcomes in plant conservation policy, practice and education*: BGCI leads and coordinates consortia of botanic gardens with specific expertise within the broader network. BGCI's activities include:
  - a providing the secretariat for the Global Partnership for Plant Conservation, which measures progress towards the GSPC targets (Plants 2020, 2010)
  - b providing the secretariat to IUCN's Global Tree Specialist Group and coordinating the Global Tree Assessment which aims to have assessed the threat status of all known trees by 2020 (Newton *et al.*, 2015)
  - c coordinating the Global Seed Conservation Challenge (BGCI, 2016), a consortium of 140 botanic gardens with seed banks
  - d co-managing the Global Trees Campaign with Fauna & Flora International, which aims to avoid all tree species extinctions through integrated tree conservation action (Global Trees Campaign, 2016)
  - e coordinating and providing the secretariat for the Ecological Restoration Alliance of Botanic Gardens (ERA), a consortium that currently includes 30 botanic gardens carrying out more than 100 restoration projects across the globe (Ecological Restoration Alliance, 2016; Shaw *et al.*, 2015)
  - f coordinating the International Plant Sentinel Network, a consortium of 26 botanic gardens that comprise an early warning system for new plant pests and diseases (International Plant Sentinel Network, 2014; Barham *et al.*, 2015)
  - g coordinating Communities in Nature, a group of botanic gardens providing public engagement on plant conservation to ethnically and economically diverse communities (BGCI, 2016).
3. *Building plant conservation capacity in botanic gardens and other sectors*: BGCI's website is already widely used by the botanic garden community as a source of information on running a modern botanic garden, particularly through

the latest iteration of BGCI's botanic garden manual (BGCI, 2016). However, we are working hard to augment this information with resources and tools covering specific disciplines, including red listing, seed conservation, tree conservation, ecological restoration, plant health and public engagement. In addition, BGCI currently provides training courses on plant conservation policy, seed conservation, ecological restoration and modern plant conservation techniques. These courses are aimed at supporting smaller botanic gardens but also professionals in other sectors such as foresters and national park managers.

4. *Providing funding*: BGCI is committed to accelerating our fundraising efforts in order to mobilise funding to deliver plant conservation projects and outcomes, prioritising smaller, resource-poor botanic gardens in biodiversity hotspots. Currently, BGCI disburses around ten times what it receives in subscriptions back into the botanic garden sector – primarily for plant conservation and education activities. Traditionally, this funding comes mainly from trusts and foundations. Over the next five years our aim is to double that funding by building a global botanic garden endowment fund that will be used to generate regular income to support botanic garden-centred plant conservation activities on the ground.

#### CONCLUSIONS

The loss of plant diversity is the most urgent and important issue that botanic gardens need to address, but it is not always seen as a priority given the multiple roles that botanic gardens are expected to fulfil. Botanic gardens, as a professional community, possess unique knowledge and skills to find, identify, conserve and manage plant diversity in the landscape and for this reason they need to show greater leadership in plant conservation. To be most effective the sector needs to organise itself in a rational and cost-effective way by sharing knowledge and enabling all botanic gardens to carry out effective plant conservation in their own geographic or taxonomic spheres. BGCI is ideally placed to facilitate this approach.

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