Biodivers Conserv (2011) 20:217–220
DOI 10.1007/s10531-010-9979-6

EDITORIAL NOTE

Botanic gardens in the age of climate change

Leif Schulman · Susanna Lehvävirta

Published online: 4 January 2011

We are facing an unprecedented plant diversity crisis. If current trends in habitat conversion, over-exploitation, alien species invasions, and climate change continue, up to 50% of the world's vascular plant flora is expected to become threatened with extinction within the twenty-first century (Pitman and Jørgensen 2002; Root et al. 2003; Hahns et al. 2009). Climate change seems to rapidly have become recognized as the primary threat to many plants. In Europe, more than half of the vascular plant flora may become endangered by the year 2080 as a result of climatic changes (Thuiller et al. 2005), and the first unfavourable trends in the threat status of plant species attributable to such changes have already been observed in successive Red List evaluations (Rassi et al. 2010).

The Global Strategy for Plant Conservation (GSPC; Secretariat of the CBD 2002) was adopted under the Convention on Biological Diversity (CBD) in 2002 as a policy response to the dire situation of plant life, and an updated version of the strategy up to 2020 was recently approved at the Conference of Parties to the CBD in Nagoya (Convention of Biological Diversity 2010). Botanic gardens of the world, largely through their advocate Botanic Gardens Conservation International (BGCI), were pivotal in the writing and promotion of the GSPC, and have continued in this role in the implementation, follow-up, and further development of the strategy (Secretariat of the CBD 2009).

The role of botanic gardens in the creation and mainstreaming of the GSPC has been a manifestation of the fact that these time-honoured institutions have fully adopted a fourth main task—conservation—alongside their traditional responsibilities in research, teaching, and public education in the field of botany. However, the GSPC puts due emphasis also on these traditional tasks through the recognition that successful conservation must be based on a solid knowledge base and that the understanding of the value of plant diversity must also be disseminated to the widest possible audience in order to make a difference

L. Schulman (✉)
Finnish Museum of Natural History, University of Helsinki,
PO Box 17, FI-00014 Helsinki, Finland
e-mail: leif.schulman@helsinki.fi

S. Lehvävirta
Finnish Museum of Natural History, University of Helsinki,
Botanic Garden, PO Box 44, FI-00014 Helsinki, Finland

(e.g. Targets 1, 14, and 15; Secretariat of the CBD 2002). Botanic gardens thus have a mandate as well as an obligation to continuously pursue their goal to document and understand the vegetal world as well as to teach students at different levels and educate the public about what is being learnt during this endeavour. An acute challenge, nevertheless, is to speed up and re-direct all these activities as a response to the new demands posed by climate change.

This Special Issue of *Biodiversity and Conservation* provides an overview of the ways in which botanic gardens are taking on the challenge. It comprises 17 contributions (one of which, Krigas et al. 2010, was previously published) that form the core of the proceedings of the Fifth European Botanic Gardens Congress, EuroGardV—Botanic Gardens in the Age of Climate Change, which was organised by the European Consortium of Botanic Gardens, BGCI, and the Helsinki University Botanic Garden (HUBG), and took place in Helsinki in June 2009. A total of 127 papers were presented at the congress, including nine keynote lectures, and seven workshops were arranged (Lehvävirta et al. 2009). A supplementary proceedings is expected to be published in HUBGs series *Ulmus* later this year.

Rapid global change not only emphasises the need for conservation research and actions but also puts demands on the basic functions of botanic gardens, in particular with regards to resource use. By stream-lining their activities and strengthening collaboration with other actors, gardens could overhaul their traditional role as introduction centres of plant germplasm and, thus, provide society with a means of adapting to global change (Heywood this issue). However, this requires that the live plant collections, which are at the very core of the work of all botanic gardens, must be curated to the highest standards of sampling and record-keeping to make sure that the plants are 'fit for purpose' in research as well as in conservation (Maunder et al. 2001, Rae this issue). Failure to continuously keep up standards rapidly diminishes the scientific value of living collections and, thus, results in the squandering of resources (e.g. Hällfors et al. this issue). Even traditional basic operative work should be and is being developed by gardens to save money and time and to provide better access to data held in collections (van den Wollenberg this issue; Delmas et al. this issue). Gardens also need to assess their policies both in research and in collection development. Although botanic gardens are contributing to climate change related research, there is still room for re-directing research in order to make a stronger contribution to climate change mitigation and adaptation (Donaldson 2009; Primack and Miller-Rushing 2009; Ali and Trivedi this issue). An example of a new initiative in this direction is the study Neuffer et al. (this issue) have launched for botanic gardens to uncover plant responses to global change.

The living plant collections and, increasingly, seed banks and cryopreserved tissue cultures maintained by botanic gardens, form a significant ex situ reservoir of endangered plants. Screening the consolidated European Red List of plants, recently collated by BGCI, against BGCIs PlantSearch database of plants in cultivation in botanic gardens and the European Native Seed Conservation Network ENSCONETs database of plants conserved in European seed banks showed that 42% of European threatened species exist in ex situ collections (Sharrock and Jones this issue). Even though this is short of the GSPC target 8, which called for 60% of threatened plant species to be conserved in ex situ collections by the end of 2010, it must be seen as quite a remarkable achievement given the often very limited resources at the disposal of most botanic gardens.

Storing living plant material in ex situ collections is not, however, a straightforward task. Innovative approaches to gain knowledge for proper ex situ protocols are needed, such as the use of GIS as reported by Krigas et al. (2010). An emerging challenge for collection policies and maintenance is that climate change may also threaten the endurance

of the living plant collections (Monteiro-Henriques and Espírito-Santo this issue). This renders the aim of having collections of threatened plants preferably in the country of origin questionable (Target 8 of the GSPC; Convention on Biological Diversity 2010).

Another example of a topic with a current need of revision is seed banking. It requires new knowledge and development since the seeds of some species cannot be successfully conserved without understanding factors affecting their longevity and dormancy behaviour (e.g. Mira et al. this issue). Other species may require special propagation techniques, such as micropropagation in vitro (Piovan et al. this issue), because they do not set seed or because their extremely diminished natural populations would be put at risk if seeds were collected from the wild. The staff of botanic gardens are often ideally positioned to conduct or supervise research on these aspects of ex situ conservation.

Conserving plants and their seeds ex situ is not an end in itself, but the real value of this activity comes from the possibility to use this stock for research and for the re-enforcement of wild populations or for the re-introduction of species into the wild. An example of novel research utilising living plant collections is the DNA barcoding of plant species that helps in understanding and preserving plant diversity (von Cräutlein et al. this issue). Through their established activities, such as inter-institutional seed and spore exchange and propagation in garden nurseries, botanic gardens have the basic know-how to carry out re-introduction projects, but even these activities call for better understanding acquired through pilot trials (Aguraiuja this issue). It must also be kept in mind that long-term ex situ conservation may alter the genetic structure of the conserved population in relation to its wild progenitor via loss of genetic diversity (Rucińska and Puchalski this issue) or through hybridisation with other accessions or even related species (Guerrant et al. 2004). Furthermore, the reproductive systems of plants may be disrupted by environmental changes (Bazhina et al. this issue), for example through the transfer of plants to ex situ sites. Both of these issues should be studied further especially since ex situ conservation is already the last resort for some species, and the need to apply ex situ approaches much more widely in connection with assisted migration as a response to rapidly shifting climatic regimes is becoming more apparent (Vitt et al. 2010). Indeed, given this development, botanic gardens with their unique expertise on collecting, storing, propagating and cultivating wild plants are turning into indispensable links in the chain of effective plant conservation actions.

A particular asset of botanic gardens, in comparison with other research institutes, is their position at the border between academia and the general public. Every year an estimated 200 million people visit botanic gardens around the world (www.ebg2009.org.za/; accessed 16 Dec 2010). This provides the gardens with an excellent opportunity to educate the public about the crucial role of plants in supporting our livelihoods (e.g. Innerhofer and Bernhardt this issue) and, hence, gain wider appreciation for plant conservation. Finally, the gardens themselves, as aesthetically pleasing physical environments, increase the well-being of people, and can be utilised in the alleviation of social challenges brought about by various societal developments, such as the increased life-expectancy of the population in many countries (Borgen and Guldahl this issue).

We hope that the collection of papers in this Special Issue conveys the importance of the multi-faceted work of botanic gardens today, and inspires new collaborative initiatives with and among botanic gardens. Furthermore, we trust these papers demonstrate that even though botanic gardens as a whole are a historical institution, and many individual gardens are historical heritage sites, they are by no means relicts of the past. The botanic gardens of today are the custodians of invaluable repositories of plant germplasm, supporters and performers of cutting-edge basic and applied science, and crucially important in the

build-up of public appreciation of plants. In summary, botanic gardens are vital resources for the conservation of the world's plant life, in particular in the era of climate change.

Acknowledgments We thank the Editor-in-Chief, David L. Hawksworth, for agreeing to publish this Special Issue and for constructive comments on this introductory paper, Johan Kotze for invaluable editorial work, all authors for their valuable contributions, the numerous reviewers for generously providing their time and expertise for further strengthening the papers, and the staff of the Editorial Office of Springer for swift help in a number of issues. We are grateful to all the sponsors of the congress EuroGardV (listed at www.luomus.fi/eurogardv), on which this SI is based.

References

Convention of Biological Diversity (2010) Conference of the parties, tenth meeting, Nagoya, Japan, 18–29 Oct 2010, Agenda item 4.7, advance unedited text, 2 Nov 2010. http://www.cbd.int/. Accessed 16 Dec 2010

Donaldson JS (2009) Botanic gardens science for conservation and global change. Trends Plant Sci 14:608–613

Guerrant EO Jr, Havens K, Maunder M (eds) (2004) Ex situ plant conservation: supporting species survival in the wild. Island Press, Washington

Hahns AK, McDonnell MJ, McCarthy MA et al (2009) A global synthesis of plant extinction rates in urban areas. Ecol Lett 12:1165–1173

Krigas N, Mouflis G, Grigoriadou K et al (2010) Conservation of important plants from the Ionian Islands at the Balkan Botanic Garden of Kroussia, N Greece: using GIS to link the in situ collection data with plant propagation and *ex situ* cultivation. Biodivers Conserv 19:3583–3603

Lehvävirta S, Aplin D, Schulman L (eds) (2009) EuroGard V, botanic gardens in the age of climate change—programme, abstracts, and delegates. Ulmus 13:1–178

Maunder M, Higgens S, Culham A (2001) The effectiveness of botanic garden collections in supporting plant conservation: a European case study. Biodivers Conserv 10:383–401

Pitman N, Jørgensen PM (2002) Estimating the size of the world's threatened flora. Science 298:989

Primack RB, Miller-Rushing AJ (2009) The role of botanical gardens in climate change research. New Phytol 182:303–313

Rassi P, Hyvärinen E, Juslén A et al (eds) (2010) The 2010 Red List of Finnish Species. Ympäristöministeriö and Suomen ympäristökeskus, Helsinki

Root TL, Price JT, Hall KR et al (2003) Fingerprints of global warming on wild animals and plants. Nature 421:57–60

Secretariat of the CBD (2002) Global strategy for plant conservation. Secretariat of the Convention on Biological Diversity, Montreal

Secretariat of the CBD (2009) The Convention on Biological Diversity Plant Conservation Report: A Review of Progress in Implementing the Global Strategy of Plant Conservation (GSPC). Secretariat of the Convention on Biological Diversity, Montreal

Thuiller W, Lavorel S, Araújo MB et al (2005) Climate change threats to plant diversity in Europe. Proc Natl Acad Sci USA 102:8245–8250

Vitt P, Havens K, Kramer AT et al (2010) Assisted migration of plants: changes in latitudes, changes in attitudes. Biol Conserv 143:18–27