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EDITORIAL:
EX SITU CONSERVATION – THE VALUE OF PLANT COLLECTIONS

The United Nations has declared 2010 to be the International Year of Biodiversity calling on the world leaders and all in a position to help, to take action to safeguard the variety of life on earth. Throughout the year there will be a focus on the 2010 Biodiversity Target. Adopted by the Convention on Biological Diversity (CBD) in 2002 this Target set out to significantly reduce the rate of loss of biodiversity by 2010. Overall it has scarcely been achieved but for the botanic garden community, 2010 will also be the year that we celebrate the significant achievements of the Global Strategy for Plant Conservation (GSPC). Outcomes of this Strategy directly support the overall 2010 Target.

Sadly there is little evidence that the rate of loss of biodiversity has been reduced since 2002. In fact with greater awareness of the impact of climate change, predictions based on modelling suggest that the rate of loss of biodiversity will significantly increase. Perhaps it is time to re-think our approaches to biodiversity conservation? A greater sense of urgency is certainly needed and ways must be found to involve more people in tackling the issues. Most people know what they can personally do to cut carbon emissions and help (in a small way) to address climate change - not so for stemming the loss of biodiversity. The connections between these two big issues, climate change and biodiversity loss need to be made more explicitly, with of course, plants at the core of the debate.

This issue of BGjournal focuses on the role of botanic gardens in *ex situ* conservation. Are we doing enough and are we doing it well? As Diana Pritchard and Stuart Harrop point out the role of *ex situ* conservation is one of the aspects of biodiversity conservation that would benefit from re-evaluation in the light of climate change. The CBD considers *ex situ* measures to be valid when complimentary to *in situ* conservation, with the ecosystem approach the prevailing paradigm. Now with the threats to biodiversity increasing and action on the ground inadequate, perhaps we need to ensure that all wild plant species are backed up in well-documented *ex situ* collections, and available for restoration programmes. We should be increasingly linking the two approaches and not emphasising the distinctions.

In 2002, a global review of *ex situ* conservation, noted that, *Botanical gardens maintain the largest assemblage of plants species outside nature, but no overall assessment of the diverse array has been conducted. Even though they contain a large proportion of the world's flora, the gardens have traditionally not been integrated, and their holdings have been known only locally*. (Keller *et al*, 2002). Target 8 of the GSPC calls for 60 percent of threatened plants to be in *ex situ* collections. BGCI developed the PlantSearch database to help monitor progress towards this target on a global scale, thus addressing the issues noted by Keller *et al*. At least 40 percent of globally threatened plant species are now known to be in *ex situ* collections. Various articles in this issue draw on data from the global PlantSearch database.

During 2010 BGCI will be preparing a report on the role of botanic gardens in *ex situ* conservation to be presented at the CBD Conference of the Parties (COP) in October. To ensure that the work of your garden is included in the report, we urge you to follow the example provided by Abby Hird and Michael Dosmann (p18) and submit your collection information for inclusion in the PlantSearch database. We are also conducting a survey on the ways in which botanic gardens are implementing the GSPC as a whole and will be presenting the results of this at the Fourth Global Botanic Gardens Congress to be held in Dublin in June. If you have not yet completed the questionnaire – please do so. Links to it can be found on the BGCI website's homepage.

The revised GSPC with its targets for 2011-2020 will be debated and hopefully accepted by all Parties to the CBD at their meeting in October, where BGCI plans to have a strong presence. Thank you to all who have helped us in our regional workshops to review the GSPC and to discuss the way forward.

We look forward to seeing many of you in Dublin.

Happy New Year!

Sara Oldfield

Sara Oldfield
Secretary General, BGCI

[1]Chances and limitations of *ex-situ* conservation of species and genetic diversity on a global perspective, T. Keller, H. Korn, H. Schmid, Ch.F. Weisser, Landwirtschaftsverlag, 2002.

Authors: Diana J. Pritchard and Stuart R. Harrop

A RE-EVALUATION OF THE ROLE OF *EX SITU* CONSERVATION IN THE FACE OF CLIMATE CHANGE

Will conservationists need to change their approach as climate change limits our ability to conserve species in the wild?

In situ and *ex situ* conservation have been established as two distinct approaches to the protection of "wild" biodiversity with *ex situ* approaches relegated to a subsidiary position. In this article, we explore whether *ex situ* conservation should still be subordinated in this manner, particularly in view of climate change models which predict the extinction of species and drastic, rapid and chaotic shifts in the distribution of habitats and species across the globe.

The prevalence of *in situ* and *ex situ* as its complement

The *in situ* paradigm has predominated, and since the 1992 Earth Summit at Rio has been designated, expressly, as the legal and institutional priority. The regulations and policy generated at Rio emphasise the maintenance of ecosystems, habitats and component species in their home ranges. Thus the prevailing regulation, the Convention on Biological Diversity (CBD), addresses a range of practices relating to *in situ* measures for conservation.

Other conventions also establish the prevalence of *in situ* conservation methods with some appreciation of the benefits of *ex situ* strategies. Thus CITES acknowledges that *ex situ* approaches in ranching can be a solution to avoid an outright trade ban on endangered species, although generally a CITES listing is designed to support *in situ* strategies. Similarly, global policies and strategies emphasise the role of *in situ*, and regard the use of *ex situ* methods as subsidiary. This is the case with the Global Strategy for Plant Conservation where the requirement is to:

> "*employ* in situ *conservation measures as the primary approach for conservation, complementing them where necessary with* ex situ *measures.*"

The *in situ* focus derives primarily from scientific considerations regarding the conservation and ecosystem benefits understood to accrue from the protection of integrated habitats and ecosystems. Yet, analysis of the process of negotiations leading up to the multilateral agreements defined at Rio reveals that the *in situ* focus was also key in addressing the concern of developing nations to end the extraction of biological resources which had typically occurred since colonial regimes.

Over the decades *in situ* conservation has been implemented widely through a variety of mechanisms such as protected areas, reserves, and integrated management approaches. The value of these being that they extend over the territories that correlate broadly to the ranges and distribution of threatened, vulnerable or endangered species and

Hedychium *species invading a hillside in the Azores*

habitats. In the context of rapid climate change this fixed geographical approach may be their weakness.

Importantly, this *in situ* conservation work has been institutionalised through myriad public and private organisations and actors who operate at local, national and international levels. Large international organisations have become powerful implementers, and manifest the face of 'corporate conservation' which has characterised the science and practice of conservation in the late twentieth century (Adams, 2004). These have formed transnational networks of alliances which inform international conservation policy and facilitate the flow of funding, such as that available via the Global Environmental Facility, which has no focal area for *ex situ* activities.

Although *ex situ* strategies are dealt with expressly in the CBD in Article 9, they are unequivocally relegated to a support role as "*complementing* in-situ *measures*".

Article 9(c) states that countries are required to adopt *ex situ* measures to facilitate the *rehabilitation* of threatened species and the reintroduction of them into *their natural habitats*. This confines their significance to that of returning species to their habitual *situ*. Nonetheless, in recognition of relentless extinction rates, key elements of the international conservation community have since elevated the role of *ex situ* conservation.

> Ex situ *techniques must be adopted because* in situ *conservation will not always be sufficient to ensure the long-term existence of many species.*
>
> IUCN

The implications of climate change for the *in situ* paradigm of conservation

Climatic conditions are now apparent which suggest the need to revise the prevalence assigned to *in situ* conservation strategies. In addition to the rapid extinction rates of species generated by direct anthropogenic causes (epitomised by Diamond's 1989 evil quartet) we are faced with amassing evidence of the current impacts of climate change, and a view of the changes in the near future provided by sophisticated predictive modelling techniques. Some ecosystems are rapidly and demonstrably shifting, and even vanishing especially at the extreme polar areas. Although predictive models do not agree on the precise scope of these shifts in intermediate zones, they suggest that, without human intervention, fragile ecosystems may disappear altogether and some apparently robust ecosystem ranges are likely to shift geographical range and distribution (Bakkenes *et al*, 2002).

> *The evil quartet: habitat destruction, over-exploitation, invasive alien species and chains of extinction.* Diamond, 1989

This means that any one particular area may soon experience very different meteorological conditions. Since the velocity of climatic and environmental change compromises their potential to evolve, the species components of corresponding ecosystems may face extinction unless they are able to adapt, disperse or migrate to other latitudes or altitudes. Studies on an array of taxa of fauna and flora show that individual species respond differently to environmental changes, that the range areas of species are shifting, and that those with specific habitat requirements and limited dispersal mechanisms are the most vulnerable to extinction (Hawkins *et al*, 2008). Given this, a number of protected areas may soon no longer harbour the species for which they were originally designated. Moreover, migration processes are jeopardised by ongoing habitat fragmentation (by the usual drivers of land use change) which inhibit the ability of species to re-colonise in new ranges, or even adjoining habitats. Given this, conservation strategies, predominated as they are on the management of habitats and species within specific geographical locations, will need to be reviewed.

In situ *conservation - a protected area in South Africa*

Further reasons why *ex situ* conservation should have an increased role

Other factors converge to make a review of the role of *ex situ* conservation necessary. Primarily these comprise the advances made in recent decades by institutions (including botanical gardens, arboreta, gene banks, aquaria and zoos) involved in *ex situ* techniques relating to collection strategies, genetic assessment, gamete and zygote storage. These institutions have also increasingly responded to the need to expand from their traditional focus on acquiring horticultural and exotic animal collections, to demonstrate their contribution to conservation (Maunders and Byers, 2005). Studies now document their contributions and provide indicators to assess them.

Ex situ organisations have proliferated across the globe, and within countries. There has been an exponential rise in the use of *ex situ* facilities with half a million samples of plant genetic material stored in less than ten gene banks in the 1970's, rising to more than 7.4 million samples stored in more than 1,750 gene banks in the present day (UN FAO, 2009). Some are developing the capacity through engaging with wider international policy agendas such as: development, food security, and community rights, whether or not motivated by the need to secure international donor support. Experience of international collaboration involving combining *ex situ* and *in situ* activities is also accumulating as exemplified by the new International Treaty on Plant Genetic Resources for Food and Agriculture. This enhanced technical and organisational capacity constitutes a stronger base from which to advance the case for a greater role for *ex situ* conservation.

Moreover, since one of the key drivers in the CBD to temper the role of *ex situ* strategies was the need to halt the trend of expropriation of resources, it may be that the concerns in this respect are now largely satisfied. Many range countries have enacted strict access and benefit laws in line with the provisions of the

Monitoring an ex situ *collection*

It is also clear that it is necessary to diversify our own survival strategies by re-evaluating our established framework of thought on how to inhibit biodiversity loss. Necessarily, this will force a re-evaluation of accepted concepts such as the nature and meaning of what constitutes the "range" of a species. Such an analysis will require legislative changes. Within the CBD *in situ* conservation is defined in relation to wild species, by reference to their *natural surroundings* and this perspective pervades the concepts of *in situ* and *ex situ* strategies. As we have seen, this fixed concept may be approaching the meaningless for a number of species in that predictions describe a shifting of habitats in extension and distribution. A more fluid regulatory paradigm may need to be identified.

CBD which on the face of it would make it very difficult for commercially stronger countries to continue expropriation of natural resources.

In addition, evidence points to the need to review some of the basic assumptions which have underpinned the *in situ* paradigm. In particular, in the same way that hunting and other extraction patterns exert selective pressure on targeted species, individual species respond differentially to climatic change.
Thus, the underlying principle of *in situ* conservation, that ecosystem conservation ensures the protection of component biodiversity, is less compelling. The concept of 'wilderness' also holds a weaker grip since it is challenged by the documentation of the widespread impact of human activity on habitats across the globe and through time, including in places hitherto considered remote. The example iterated by Posey that many apparently pristine jungle surroundings were actually gardens created by humans over thousands of years, illustrates the point (Posey and Balee, 1989). This demonstrates that nature is not external to human beings and has anyway not been wild or pristine except perhaps at the poles.

> *"The fixed concept of 'natural surroundings' may be approaching meaningless for a number of species."*

Conclusion

The current agendas of conservationists, and the conceptual bases informing them, may have to be modified as our understanding of the impact of climate change unfolds. If the conservation mission is to be coupled successfully, as it should be, with the pressing issues of wider global agendas including the need to secure food security, human health and even human survival, *ex situ* strategies can no longer be regarded as mere support mechanisms for *in situ* conservation but rather as a crucial means in themselves to fulfil a wider and integrated mission to preserve global biodiversity.

The adoption of alternate conservation options may, of course, meet some resistance. Insights from policy analysis of international development (Haas, 1997; Mosse, 2005) prepare us to anticipate how the interests of the networks of professionals and organisations working on *in situ* conservation become linked to the continuity of this paradigm. Through their involvement in the international structures of conservation, these 'epistemic communities' exert influence on the policy agendas of, and funding for, international conservation.
Nonetheless, agents of conservation have proved adept during the last decade at modifying their approaches, and at trying to improve conservation practise (Adams, 2004).

Ice storm damage to forests in China

Ultimately, the challenge may force us to question more than mere regulatory definitions and institutional policies. With the recognition that populations decline or become extinct in their original ranges and habitats comes an heuristic challenge to the very concept of *in situ*. Reintroduction of species into the original home ranges will no longer be a desirable outcome of regeneration or captive breeding programmes.
Therefore, a critical analysis of what, in some cases, have become sacred ecological cows may be required. This may well result in the distinction between concepts of *ex* and *in situ* conservation blurring to the point of disappearing altogether.

Medicinal plants on sale in South Africa

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Encroaching desertification – a consequence of climate change? (Peter Wyse Jackson)

Authors: Lucy Sutherland and Craig Cosgrove

VALUING A NATIONAL COLLECTION

A WORK IN PROGRESS AT THE AUSTRALIAN NATIONAL BOTANIC GARDENS

How can botanic gardens ensure the continuing relevance and importance of their plant collections in rapidly changing times?

Introduction

Many botanic gardens around the world are challenged for resources to adequately secure and maintain their collections. However, as similarly argued by Suarez and Tsutsui (2004) in relation to museum collections, the maintenance of collections is inexpensive compared with the potential costs of their absence. It is suggested that beyond botanic gardens staff, there is often little understanding of the relevance and critical value of botanic gardens to conservation. Nevertheless, with ongoing cross cutting issues such as habitat loss and climate change threatening the conservation and sustainable use of biodiversity, the value of these *ex situ* collections is increasing in importance. Australia's botanic gardens, for example, have significant planted living collections, seed banks and gene banks that are essential for managing the risk of species and associated ecosystem loss in the wild (Council of Heads of Australian Botanic Gardens (CHABG) 2009:7). Furthermore, these living collections can and do support valuable research on seed biology and storage, taxonomy and systematics, ecosystem restoration and horticultural and/or threatened species (CHABG 2008:19).

The potential for botanic gardens to provide greater value to biodiversity efforts is large. This will require individual institutions to reflect and evaluate their collections in terms of critical values that link to conservation, together with the other key functions of the botanic garden.

The potted collection (including this Swainsona formosa*) being valued*

Valuing any collection is challenging, but it has been more commonly done in relation to museum collections (e.g. Morgan 2002; Ponder *et al*., 2001; Suarez and Tsutsui, 2004). Available literature addressing the challenge of valuing a botanical institution's living collection appears to be inadequate. Nevertheless, there are valuable studies on the conservation value of palm collections (Maunder *et al*., 2001) and the effectiveness of European botanic garden collections in supporting conservation (Maunder, Higgens and Culham, 2001).

> *"Living collections support valuable research, restoration, horticultural and educational activities."*

The purpose of this article is to describe the process being undertaken at the Australian National Botanic Gardens (ANBG) to value its living collection. The article will also highlight some of the key challenges being faced by the ANBG during this process. The authors

Developing a reliable tool for measuring subjective values, such as aesthetics, is a challenge

acknowledge that this is a trial process in its early stages which is still undergoing discussion and review. The authors welcome communications, as well as examples of reviews that other botanical institutions have undertaken.

For the purpose of the review, the Living Collection refers to all of the living plant material held by the ANBG, including its display garden collections, its glasshouse display collection, its glasshouse research collection, its nursery collection and its seed bank.

Challenges for a national institution

Based in Australia's capital city, Canberra, the Australian National Botanic Gardens is a unique institution in the history of Australian botany and possesses the largest single collection of Australian native flora in the world. This collection has added value because it is a national living collection with known provenance. The institution's leading work in native plant horticulture has provided a catalyst for the development of regional botanic gardens cultivating Australian plants throughout the country. In addition, since the late 1940s, it has challenged previous thinking about botanic garden landscapes in Australia (Lester Firth Associates, 1987; National Capital Planning Authority, 1995) by moving away from the previously common colonial model.

Since its establishment, the ANBG's Living Collection has had two key foci that have successfully generated interest at a national and international level during different times. The first was in relation to the cultivation of Australian plants during the 1960s and 1970s and the second was plant conservation in the 1980s and 1990s.

> ***"The Australian National Botanic Garden possesses the largest single collection of Australian native flora in the world."***

Since the early 1980's, the ANBG has been a major contributor to developing the role of botanic gardens in plant conservation. The ANBG Living Collection has played an important part in this work. The ANBG conservation work was commenced with the establishment of the Rare and Threatened Collection in an effort to develop its role in *ex situ* conservation. Not only were a large number of threatened species brought into cultivation, but an effort was made to ensure that any species was represented by a broad range of genetic samples so as to make them useful for research work (Richardson, 2008), and for the species as an entity to survive long term.

In the 21st century, several factors have resulted in the drive to review the ANBG's living collection and thereby support the repositioning of the institution in coming years to ensure its continuing relevance and importance in

Hibiscus insularis, *endemic to Phillip Island in the Norfolk Island Group, has reduced genetic diversity and is listed as Critically Endangered* rapidly changing times. One such factor was the need to revise the aim of the collection as the original goal for the ANBG as a comprehensive national collection is no longer being achieved in one botanic garden, but rather by a number of botanic gardens across different climatic conditions in Australia (Richardson, 2008). Another driving factor has been the drier climatic conditions being experienced in Canberra over the past decade, presenting challenges when trying to align the institution with the principles of environmental sustainability. In addition, there are also the challenges of continuing to secure, maintain and develop the collection without greatly increasing financial resources.

The ANBG's review of its living collection

Historically the ANBG has primarily taken a 'stamp collecting' approach to building its living collection aiming to have as full a representation as possible of the Australian flora. Previous Living Collection reviews were largely a part of the ongoing effort to achieve this aim and tended to focus on determining the success of the plantings in any one of the thematic or systematic collections (ANBG, 2002).

The current review of the living collection aims to revisit the original basic principles of the major underlying reason for the ANBG's Living Collection and evaluate the collection in terms of the ANBG's role as a national institution and its vision and mission, its diverse stakeholders, its sustainability and the collections role in supporting science and education, as well as Australia's priorities in biodiversity conservation.

The broad outcome of the review aims to be a long term (50 year) vision for the ANBG Living Collection, including recommendations on its content and management. The review will also produce:

- A strategic report that can be used to better reflect and promote the value of the Living Collection, both nationally and internationally.
- An accurate record of what is currently in the Living Collection, together with comparative data from previous censuses.
- A reliable and valid tool that can be used to value the collections and has the potential to be transferable to other institutions.

The ANBG management decided to undertake most of the review process internally and use this opportunity to draw on existing corporate knowledge and further build capacity within the institution. The review is supported by botanic garden consultant, Mark Richardson and a Panel of External Experts from such fields as horticulture, ecology, landscape architecture and botanic gardens.

The review process

The review process involves four key phases:

1) Phase one (completed)
Preliminary work for the review involved:

- development of a proposal for the living collection review (Richardson, 2008);
- an in-depth stock-take of the ANBG living collections;
- facilitating 10 focus group discussions with community members associated with botanic gardens in 7 state capital cities and two regional areas to gain insight into what people want and expect of a living collection from a national institution (i.e. ANBG).

2) Phase two (nearing completion):

- undertaking a comparison of the latest stock-take findings with information from the 2002-2008 Thematic Planting Plan;
- running reports on the Integrated Botanical Database System (IBIS) to build statistical data on the living collection;
- developing criteria and a system for assigning values to the living collections;
- first trial of the 'value' system with several collections including permanent pots, display glasshouse and two display garden collections; followed by a revision of the value system;
- second trial of 'value' system on 20 collections; followed by further revision of the value system;
- investigation of options for integrating the new classification into the IBIS.

3) Phase three (progressing):

- rapid assessment of all display garden and nursery collections to provide initial information on the values of each collection against the assessment criteria;
- use of data to inform and set priorities for management, including maintenance and development/ redevelopment programmes.

Horticulturalist Julie Percival assigning a yellow tag to plants that have an undetermined origin

4) Phase four (yet to be initiated) – focus on individual plants:

- develop criteria and a system for assigning values to individual plants in the living collection;
- trial the 'value' system on individual plants; followed by a revision of the value system;
- detailed assessment of all collections, focussing on priorities identified during phase three (see above), to evaluate individual plantings according to the criteria (this will be a major undertaking conducted over a number of years);
- use of the data to inform the development of collection management plans and new developments.

The 'valuing' tool

Attributing a value to each ANBG living collection involves developing an evaluative scoring system that produces an 'end' score when each collection is assessed against criteria (Table 1; Box 1). Noteworthy is that a low aggregate score can be used to guide management decisions in various ways e.g. adding plants with a conservation value to the collection can increase its value, as can greater use of some collections for education.

Box 1: Assessment Example

Using the criteria outlined in Table 1, a collection that has: a clear theme (2); a theme generally related to the ANBG mission (1); the majority of plantings relevant to the stated theme (2); labelled plants (1); interpretive guide use (1); occasional use for formal education (1); some use for conservation (1); and been regularly audited (1) would score 11. On that basis, any collection scoring at least 11 could perhaps be considered to be effectively contributing to the aims of the Living Collection and the mission of the ANBG. The highest score would be 17.

The process of developing objective criteria that are reliable (i.e. the application of the criteria yields the same result on repeated trials) and have validity (i.e. accurately assess the value) is challenging (Table 1). The criteria have initially been developed by a consultant and are currently being critiqued by staff, Friends and external experts. A trial process, as part of Phase two (see above), involves 2 stages to fine tune the measuring instrument for valuing the collections (Box 1) and it will also be the basis for the value assessment tool for individual plantings in the longer term.

This rapid assessment of collections will provide vital information for setting priorities for management, including maintenance schedules and developments. In addition, it will provide an immediate indication of how well the current Living Collection is meeting the aims of the ANBG.

The finalisation of the assessment tool is still a work in progress. At the time of publication, the criteria are being critically reviewed and subsequently fine tuned following the trial outcomes. There are also discussions focusing on developing additional criteria for measuring sustainable horticulture to address the need to align with sustainability principles. Furthermore, there is ongoing debate relating to the use of subjective criteria such as valuing the aesthetic and landscape appeal of individual collections.

An emerging initiative supported by the federal environment department (Department of Environment, Water, Heritage and the Arts[1]) is to approach the valuation of collections from an environmental economics viewpoint. An early career researcher begins a one-year Postdoctoral fellowship in December 2009 to research the means of identifying and realising the social and environmental benefits of collections, such as specimens housed in herbaria and museums. It is envisaged the outcomes of the Department's project will further inform the ANBG's Living Collection review.

"Assessing collections will provide vital information for priority setting and awareness raising."

Table 1: Draft assessment criteria and scale:

Clarity of theme 0-2
- 0 = no clear theme given (e.g. mixed planting)
- 1 = a mixture of unrelated themes
- 2 = a clear theme given

Relevance of theme to ANBG Mission 0-2
- 0 = theme unrelated
- 1 = theme generally related
- 2 = theme closely related

Relevance of plantings to stated theme: 0-3
- 0 = plantings unrelated
- 1 = a mix of related and unrelated plantings
- 2 = the majority of plantings related
- 3 = all of the plantings related

Main Use: A. Informal education/Labelling & interpretation
- 1 = plants labelled
- 2 = other interpretation present

Main Use: B. Informal education/ Guides
- 0 = no use by guides
- 1 = used by guides

Main Use: C. Formal education
- 0 = no use for formal education
- 1 = occasional use for formal education
- 2 = frequent use for formal education

Main Use: D. Conservation 0-2
- 0 = no activity recorded
- 1 = plants present with conservation status
- 2 = collection of plants with conservation status

Main Use: E. Research 0-2
- 0 = no activity recorded
- 1 = plants present that have been used for research purposes
- 2 = collection of plants for a research purpose

Collection audit; 0-1
- 0 = collection stock-take (No)
- 1 – collection stock-take (Yes)

A work in progress...

The ANBG Living Collection review is very much a work in progress. The initial phases have provided an opportunity to reconcile existing electronic information with the reality of the collection. This has been very informative because it has highlighted limitations in some procedures and the documentation of activities.

Further progress hinges on the fine tuning of the measurement tool for valuing the collection and is the immediate priority. Once finalised, we will undertake a rapid assessment of around 250 collections that form the ANBG's Living Collection. The development of the tool for valuing individual plants within the collection is the final phase of the review process.

An important outcome from the living collection review process, thus far, has been the bringing together of staff and experts from various disciplines to critically discuss the valuing of the Living

[1] The Australian National Botanic Gardens is a government institution managed by the Department of Environment, Water, Heritage and the Arts.


ANBG staff discuss the landscape design and values of the Mallee collection

Collection. This helps to strengthen cross-institutional communications, engage staff in the process and raise awareness of its relevance and importance.

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Authors: Patrick Griffith and Chad Husby

THE PRICE OF CON$ERVATION:
MEASURING THE MISSION AND ITS COST

Montgomery Botanical Centre has been investigating the relationship between the conservation value and the financial costs of their living collections.

Introduction

Conservation is a primary purpose of the botanic garden living collection. Recent worldwide economics have placed every aspect of botanic garden operations under closer scrutiny. So, these days, measuring success is vital, and controlling cost is critical. In a world of disappearing plants and shrinking resources, knowing real success and real costs of conservation work is essential.

The limiting element of conservation work is funding. Maximizing conservation per dollar spent is important. For plant conservation goals, straightforward metric assessments of success have been lacking – often, success is qualitatively evaluated. Modern tools allow direct measurement of conservation. DNA-based studies are increasingly less expensive and offer greater resolution.

> *“When funding is in short supply, maximizing conservation per dollar spent is important.”*

Our garden is focused on three plant groups, all with myriad conservation concerns: Cycads, Palms, and Tropical Conifers. Protocols for living conservation collections at Montgomery Botanical Center (MBC) were developed in the 1990s following isozyme-based studies of cycad genetics (Walters and Decker-Walters, 1991). Basically, within a single population, we seek to conserve at least 15 individual plants, preferably from at least 3 different mothers. In other words, maintaining 3 accessions per population, each with multiple qualifiers, is our goal.

This protocol is a good place to begin investigating the relationship between the genetics and economics of conservation collections in a botanic garden setting. To frame the question directly: how effective is our conservation strategy, as measured against the investment?

A case study

Botanical science can directly inform botanic garden management; science can guide strategy. To approach this living collections management question, we located a suitable model system. Our collections of Keys Thatch Palm (*Leucothrinax morrisii*) were well suited to the exercise, owing to large numbers of plants curated from a single isolated population. We maintain almost 60 palms from this population on the grounds, and curate them by accession, so we can separate them into half-sibling groups. All of these resulted from a single collecting trip in the late 1990s.

Using a recently-developed genetic assessment method, we compared these 60 plants in the collection to a broad sample of plants still surviving in the original population (Namoff *et al*., ined.). Stated simply, around 94% of the wild genes in that population are represented in the collection.

So, in this case a collection of 60 plants captures all but a few percent of the population diversity. Often, though, collections may contain fewer representative plants. We spent time processing these data to model how genetic capture functions over a range of collection sizes. We believe these results are useful as a point of consideration for collections planning.

Economics of the conservation collection

The data gleaned here, when compared to investment in the collection, can offer some potential insight of use for botanic garden conservation. Here, we present a simple visualization of the interplay of three variables: plants, genetic capture, and cost.

Sampling methods vary amoung collectors and gardens, so to offer broad applicability for the very diverse botanic

Corypha taliera is extinct in the wild, and known from perhaps fewer than 20 individuals. MBC maintains 13 plants garden community, we simplify the main sampling metric as “number of plants maintained in collection.” This is a straightforward count, very easy to calculate, and is perhaps the simplest benchmark for measuring an institution’s investment in a particular plant group, species, or population. Since this is such a fundamental parameter, we chose to also make it the “common denominator” for this model.

The important metric with regard to conservation success is “degree of genetic capture.” For our case study, this was measured via ISSR (inter-simple sequence repeat) data, but a broad variety of modern methods exist for the assay of genetic diversity.

The third metric examined is monetary investment. Managers and governing organisations are quite familiar with this measure. Calculating the cost of maintaining a collection of plants may be performed in a way that makes the most sense to the organization involved. The cost of obtaining the collection in its first year is almost always greater than the annual cost of keeping the collection. In our study, we calculated fixed costs (fieldwork expenses) and variable costs (cost to maintain an individual plant per year). One quick, straightforward way to estimate this cost is to divide the annual “horticulture” and “plant records” costs by the number of plants maintained.

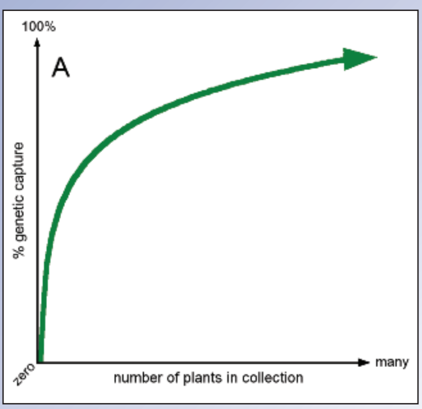
Keys Thatch Palm, which provided a model system for ex situ *conservation economics*

Insights from this model

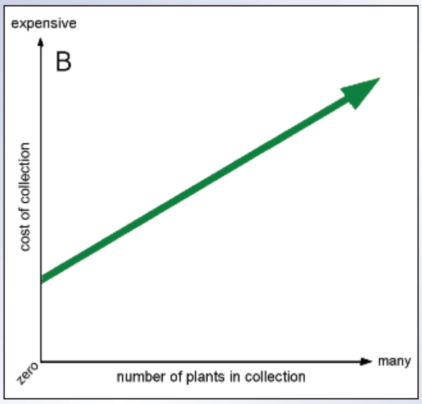
The three graphs presented here show the interaction of these three variables. The first graph (Graph A) models the increase in genetic capture, as the number of plants is increased. Essentially, this relationship follows an inverse exponential pattern. The important consideration here is that initial increases (for example, from 1 plant to 5 plants, or from 1 plant to 10 plants) give a steep increase in genetic capture. There is a point at which additional plants in the collection do not add significant conservation value. In economics, this type of pattern is called the “law of diminishing marginal returns.”

The second graph presented here (Graph B) shows the relationship between collection size and cost. Since each plant costs the same to maintain, there are really no surprises here; more plants equal higher costs. The position of the Y-intercept is equal to the fixed cost of bringing the plants to the garden, and is never equal to zero. For most conservation work, major costs here include travel to field sites and personnel costs for the field botanist. The slope of the line reflects the efficiency of the horticulture operation. Administrators grasp this type of straight-line function easily.

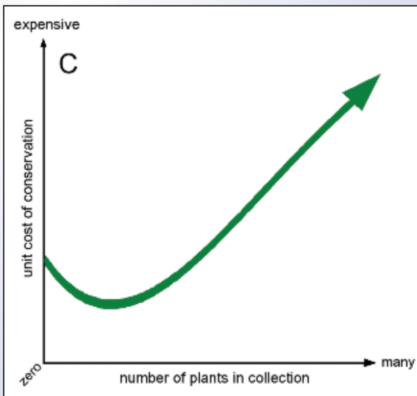
The third graph brings all three variables together (Graph C). Again, we use the number of plants as the basic benchmark. Our metric, “unit cost of conservation,” is simply the % genetic capture divided by the cost of that collection. The behavior of this curve has much to say about the economics of botanic garden conservation. First, there is significant decrease in the unit cost as the collection increases above one



***Graph A**: The conservationist’s curve: graph of collection size vs. allele capture.*



***Graph B**: A manager’s view: graph of collection size vs. cost.*



***Graph C**: reconciling cost and conservation: graph of collection size vs. “unit cost” of genetic capture.*

individual. This is followed by a steady increase in the unit cost as the collection is increased further. Ultimately, the unit cost more or less increases linearly.

Two primary points are meaningful here. First, there is a collection size at which there is a maximum efficiency for conservation. This is at the lowest Y-value on the curve. Second, there is a maximum collection size where the unit costs are equal to the lowest collection size. Simply stated, "if you would grow one, you may as well grow twenty," as the unit cost of conservation is the same.

Going forward

This study compares the conservation value of a living plant collection, and its monetary cost over time. What does this mean for the botanic garden? Space, staffing, funding, and priority are all important considerations for any project. For conservation, a direct metric of success is helpful for evaluation and future planning. From the managerial perspective, knowing projected outcomes relative to investment is the key to most decisions. In very broad terms, this model provides one potential starting point for the Comptroller and the Curator to sit down at the same table.

Like all models, this one is best when it is used with accurate data. Our case study of *Leucothrinax* employed a long-lived, polycarpic perennial palm, with a monoecious breeding system and a straightforward life history. The targeted population shows healthy recruitment, and is easily circumscribed by the boundaries of Big Pine Key, an island. We selected it as a case study for these reasons, as it is more or less generalized in its biology.

Within the palm family alone, there are many other life histories, habits, phytogeographies, conservation concerns, and breeding systems. One prominent example is *Corypha taliera*. This species is known from perhaps fewer than 20 living individuals, and is extinct in the wild. Its century-long, hapaxanthic life history adds another level of complexity to its management. One high-profile species, *Wollemia nobilis*, has no discernable genetic variation in the wild (Peakall *et al*., 2003), so any single-specimen garden collection is perhaps a more-or-less complete genetic collection.

Examining our protocol with this model system, we found that our existing target of 15 individuals does provide for a healthy level of genetic capture, consistent with our goals. We found that our highest efficiency in conservation versus cost occurs at around 5 individuals.

> *"In many cases it is prudent to grow as many plants as you can afford."*

The upper limit to a conservation collection need only be limited by resources, though. There are certainly many cases where it is prudent to grow as many plants as you can afford, and examine the genetics when you get a chance. Here at Montgomery, we recently planted our most extensive single-species cycad collection, 79 individuals of *Cycas micronesica*, representing 29 accessions from 2007. This cycad has a high likelihood of going extinct in the wild, and our recent conservation efforts may have obtained some of the last seed that will be produced *in situ*. As the genetic information becomes available (Cibrian *et al*., 2008), we can consider thinning any potential genetic duplicates if space is needed. Since unforeseen circumstances can also cause the loss of individuals in a collection (Griffith *et al*., 2008), some redundancy is important. In such cases, it is absolutely worth the extra cost to grow a large collection.

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Native populations of Cycas micronesica *are in severe decline due to an exotic insect*

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Authors: Sara Oldfield and David Hunt

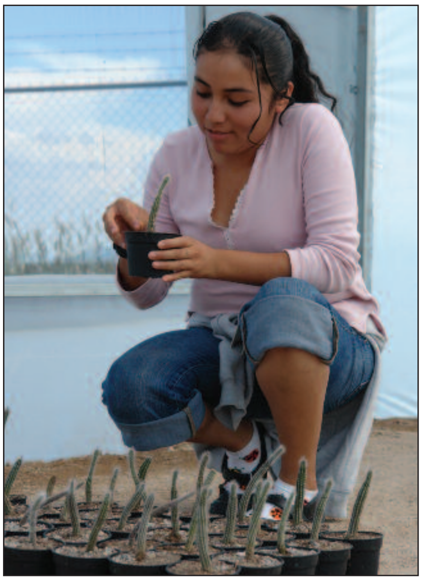
THE CONSERVATION OF CACTI AND SUCCULENTS IN BOTANIC GARDENS

Botanic gardens have an important role to play in ensuring that no species of cactus or other succulent plant becomes needlessly extinct.

Introduction

Botanic gardens around the world have impressive collections of cacti and other succulents for display, landscaping, research and education purposes. With a significant proportion of arid land plant species being threatened with extinction in the wild, the living collections in botanic gardens also have huge potential for *ex situ* conservation and restoration of natural populations. Some botanic gardens are already using their collections to fulfill these important roles. Individual gardens can use the BGCI PlantSearch database to check the conservation status of cacti in their collections (See also p 18). At a global level the PlantSearch database can be used to analyse the extent to which threatened cacti and other succulents are in *ex situ* collections and to assist in planning for the long term conservation of these popular and charismatic plant species. BGCI has recently begun working with the International Organisation for Succulent Plant Studies (IOS) to evaluate collections of cacti for conservation purposes both in botanic gardens and in private collections.

Threatened Didymaotus lapidiformis *growing in Karoo Desert Botanic Garden, South Africa (Christopher Willis)*



Transplanting Echinocereus schmolli *(JB Cadereyta, Mexico)*

The Cactaceae

The Cactaceae family has over 1,400 species and 380 heterotypic subspecies almost confined to the Americas. Mexico is the richest centre of diversity for the family with nearly 600 species and 170 heterotypic subspecies within the country. Threats to the species in the wild include over-collection for international commerce, the all too familiar processes of habitat degradation and destruction and the overarching problem of global climate change. A full Red List assessment for the family is currently being carried out coordinated by Dr Barbara Goettsch at University of Sheffield, UK in collaboration with the IUCN/SSC Cactus and Succulent Specialist Group, the Center for Applied Biodiversity Science at Conservation International (CI/CABS) and BGCI.
As an interim measure, a preliminary assessment of the conservation status of cacti published in 2006 suggests that 542 species and subspecies are threatened with extinction (equivalent to CR, EN, VU) at a global scale (Taylor *et al*, 2006). Using this preliminary list an analysis of cactus holdings in botanic gardens has been undertaken using the PlantSearch database. According to this survey, 366 of the globally threatened taxa are recorded in botanic garden collections.

Ex situ collection of Parodia rechensis in Brazil

Cactus collection at the Botanic Garden 'Viera y Clavijo', Canary Islands

> ***"The Cactaceae are almost entirely endemic to the Americas; from British Columbia and Alberta in Canada, to Patagonia in Argentina."***

Botanic garden collections

The most commonly recorded globally threatened cactus in botanic garden collections is *Echinocactus grusonii*. This distinctive species, now widely cultivated, was first discovered in 1889. Large numbers of wild plants were exported from Mexico and by the end of the 19th century there were fears about the potential extinction of the species. Unfortunately in 1995, the original habitat of the golden barrel cactus was destroyed by the construction of a dam in the Moctezuma River Canyon between the states of Querétaro and Hidalgo. Twenty years later, a new disjunct population of this species was discovered about 500 km away in the state of Zacatecas. The DNA structure of the plants from the new and original locations is currently being studied by researchers from the Universidad Autónoma de Querétaro, University of Reading and the National Autonomous University of Mexico. *Echinocactus grusonii* is listed as Critically Endangered by Taylor *et al*, 2006. Over 130 botanic gardens have this species in their collections, according to BGCI's PlantSearch database. For *ex situ* conservation purposes, plants of known wild origin are, of course, particularly valuable as they form part of the original gene pool of the species and have potential for re-establishment of populations close to their original localities.

Other globally threatened cacti that are held by a wide range of botanic gardens include the Mexican CITES Appendix I listed species, *Ariocarpus trigonus, Aztekium ritteri, Obregonia denegrii* and *Turbinicarpus pseudomacrochele* and *Mammillaria* spp such as *M. plumosa, M. microhelia, M. magnifica, M. wiesingeri*, and *M. zeilmanniana*. All of these are represented in over 30 botanic gardens as recorded in the PlantSearch database.

> ***"Cacti have long been regarded as one of the most highly threatened plant families."***

In contrast, numerous globally threatened cacti including the Critically Endangered species, listed in Table 1, are not yet recorded in *ex situ* collections and BGCI is keen to hear from botanic gardens that might have these species in cultivation. It is clearly important that the world's rarest cacti species are established as genetically representative and well-documented living collections as an insurance policy against extinction in the wild. In line with Target 8 of the GSPC, *ex situ* collections should preferably be in the country of origin. For cacti however there is a global responsibility to conserve the species that have been cultivated around the world for over one hundred years. Curation of collections valuable for conservation purposes needs to be carried out with particular rigour.

IOS/BGCI collaboration

In botanic gardens as in private collections, specialist skills and a keen interest in the species and their requirements will benefit the long term maintenance of cacti in cultivation. The IOS, with a membership of individuals working in botanic gardens and/or with private collections, has promoted conservation of cacti and other succulents for nearly 40 years. In 1980 the IOS published a Register of Succulent Collections with 73 collections included, 33 of which were at botanic gardens that are now BGCI members. Under the new IOS/BGCI collaboration we intend to assist collection holders in assessing and recognizing the resource value of individual plants in their collections, promote good practice in the documentation and secure labeling of plants, promote collaboration between collection holders in selecting groups to be treated as 'specialities' or as back-up collections, and assist collection holders with plant identification or verification via contacts with IOS experts.

The endangered Parodia rechensis growing in Caxias do Sul Botanic Garden, Brazil

The next stage in the IOS/BGCI collaboration will be to contact specialist cactus collections to seek information on the current status of plants maintained and to seek further collaboration. The intention is to maintain a shared record of the conservation value of collections based on factors such as accession policy, rarity of species in the wild and in cultivation, access to the material and willingness to collaborate and exchange propagation material. The need to reflect both the letter and the spirit of international agreements through CBD and CITES will be respected at all times.

> *68% of threatened cacti are recorded in botanic garden collections.*

Cactus collection at Bonn Botanic Garden, Germany

A joint meeting will be held at the 31st IOS Congress being organized in collaboration with the Jardin Botanico "Viera y Clavijo" in Gran Canaria. This will consider how best to ensure that all globally threatened cacti are conserved with links between *ex situ* and *in situ* conservation. There are some good practical examples to draw on. In Mexico for example, with BGCI support, the Jardín Botánico Regional de Cadereyta "Ing. Manuel González de Cosío", Querétaro, carried out a very successful project conserving threatened cacti with the participation of local communities - the species involved were *Astrophytum ornatum, Echinocactus grusonii, Echinocereus schmollii, Mammillaria herrerae* and *Thelocactus hastifer*. The project involved establishment of a community nursery to propagate the species which have been threatened by commercial collectors in the region.

Botanic gardens have an important role to play in ensuring that no species of cactus or other succulent plant becomes needlessly extinct. Working with the expertise available through IOS will enhance that role. At a practical level it remains a priority to develop more projects to support conservation of cacti in their natural habitats as far as possible involving local people as custodians of their flora. *Ex situ* collections indirectly support such activities, allowing for research into propagation techniques, provision of propagules for restoration and long term storage of living material and seeds. Raising awareness of the diversity and conservation needs of cacti is another important role for botanic gardens to play.

Table 1 Critically endangered cacti not currently recorded in the PlantSearch Database

Taxon	Country of natural distribution
Acharagma aguirreanum	Mexico
Ariocarpus bravoanus ssp. *bravoanus*	Mexico
Browningia columnaris	Peru
Cereus estevesii	Brazil
Cleistocactus winteri ssp. *winteri*	Bolivia
Cleistocactus xylorhizus	Peru
Eriosyce megliolii	Argentina
Haageocereus tenuis	Peru
Leptocereus carinatus	Cuba
Mammillaria sanchez-mejoradae	Mexico
Melocactus curvispinus ssp. *dawsonii*	Mexico
Melocactus pachyacanthus ssp. *viridis*	Brazil
Pilosocereus azulensis	Brazil
Rauhocereus riosaniensis ssp. riosaniensis	Peru
Turbinicarpus gielsdorfianus	Mexico
Turbinicarpus mandragora ssp. *mandragora*	Mexico
Turbinicarpus mandragora ssp. *pailanus*	Mexico
Turbinicarpus saueri ssp. *saueri*	Mexico
Turbinicarpus schmiedickeanus ssp. *andersonii*	Mexico
Turbinicarpus schmiedickeanus ssp. *jauernigii*	Mexico
Turbinicarpus schmiedickeanus ssp. *rioverdensis*	Mexico
Turbinicarpus subterraneus ssp. *subterraneus*	Mexico

Box 1: Cactus audit at the National Botanic Garden of Belgium

One of the valuable ways in which the PlantSearch database can be used by botanic gardens – or other *ex situ* plant collections – is to help audit a particular collection. Such an audit was undertaken to assess the relevance and merit of the major glass house collection of cacti at the National Botanic Garden of Belgium at Meise. The plants were verified by independent experts, Dr David Hunt, IOS Secretary and Dr Nigel Taylor of RBG, Kew in July 2007. Updating the nomenclature used in the Garden's record systems was an important step. To determine the conservation importance of the collection, the list of species present in the collection was compared against the PlantSearch database. Taking one species example of the Meise collection, the PlantSearch database showed that *Weberbauerocereus cuzcoensis* grown at the National Botanic Garden of Belgium, was recorded by only one other botanic garden. Overall the audit found that of the approximately 1,600 cactus taxa grown by the National Botanic Garden, only about one-third had conservation, education or research merit. Only 21 out of 251 wild-collected accessions were considered valuable for conservation purposes. The National Botanic Garden took the bold decision to donate over 1000 cacti to other institutions including the Museum National d'Histoire Naturelle in Paris for use in education and display and also to discard surplus specimens.

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GETTING THE MOST OUT OF YOUR BGCI PLANT UPLOAD

BGCI's PlantSearch database provides a unique tool for measuring progress towards Target 8 of the Global Strategy for Plant Conservation.

Paeonia suffruticosa v *papaveracea* *Vulnerable (IUCN). Conservation status previously not recognized in the Arnold Arboretum living collections (Nancy Rose)*

The public garden community has a daunting task at hand to answer the "call to arms" for plant conservation outlined in the Global Strategy for Plant Conservation (GSPC) (CBD, 2002) and, for gardens in North America, the North American Botanic Garden Strategy for Plant Conservation (NABGSPC) (BCGI, 2006). Such a task requires the integration of a variety of garden activities ranging from awareness-building and advocacy, to floristics work and *in situ* monitoring. Not to be discounted are well-documented living collections, which are acknowledged in Target 8 of the GSPC (Box 1) as one of the greatest assets of public gardens. Many gardens, however, do not have access to vital information about their collections, including threat status of corresponding natural populations. Fortunately, BGCI's PlantSearch database (http://bgci.org/plant_search.php) offers a vital resource to aid gardens, and includes significant benefits for the botanical community. In light of this important resource, we offer this case study to provide insight into the Plant Upload process.

Box 1. Global Strategy for Plant Conservation: Target 8

60 per cent of threatened plant species in accessible *ex situ* collections, preferably in the country of origin, and 10 per cent of them included in recovery and restoration programmes.

Identifying threatened plants

The mission of the Arnold Arboretum of Harvard University (hereafter, the Arboretum) supports a "greater understanding, appreciation, and stewardship of the Earth's botanical diversity". Like other gardens, the Arboretum includes plant conservation within the scope of its mission and has identified threatened plants as a priority in its Living Collections Policy (Living Collections Committee, 2007). To further these efforts, we are developing a novel conservation analysis that prioritizes threatened taxa within the collection for various curatorial actions. One of the initial steps is the identification of threatened taxa.

"We used BGCI's PlantSearch database to help us identify threatened plants in our collections."

To help us identify threatened plants in our collection, we used the BGCI PlantSearch database to provide up-to-date IUCN Red List (IUCN, 2009) threatened species information. We followed the online Plant Upload

Table 1. Examples of Arnold Arboretum nomenclatural diversity* in required BGCI Plant Upload .CSV format**

genhyb	gen	sphyb	sp	isprk	isp	cul
,	ABELIA	,	chinensis	,	,	,
,	ABIES	X	borisii-regis	,	,	,
,	CRATAEGUS	,	oxyacantha	V	,	,
X	CUPRESSOCYPARIS	,	leylandii	,	,	Haggerston Grey
,	FOTHERGILLA	X	,	,	,	,
X	MAHOBERBERIS	,	neubertii	,	,	,
,	MALUS	X	robusta	V	persicifolia	,
,	MALUS	,	domestica	,	,	Antonovka
,	NYSSA	,	sp.	,	,	,
,	RHODODENDRON	X	(bakeri x viscosum)	,	,	,
,	SORBUS	,	aucuparia	F	albertiana	,
,	SPIRAEA	X	arguta	,	,	Compacta
,	TILIA	,	dasystyla	S	caucasica	,
,	TORREYA	,	taxifolia	,	,	,

* Refers to the variety of taxonomic entities present in the living collections and plant records database
** Names arranged by Plant Upload criteria: genhyb (generic hybrid), gen (genus), sphyb (specific hybrid), sp (specific epithet), isprk (infra-specific rank), isp (infra-specific epithet), and cul (cultivar). Commas present in fields not containing data.

instructions (http://bgci.org/worldwide/plant_upload/) and submitted a .CVS (comma separated value) file containing a list of our taxa (Table 1) via our BGCI garden profile. Within 24 hours of the upload, the PlantSearch database verified each of our plant names using an automated IPNI (International Plant Names Index, www.ipni.org) query.

Heptacodium miconioides *Vulnerable (IUCN), formally assigned conservation value as a result of the BGCI upload (Michael Dosmann)*

The results: a list of "accepted" taxa with any associated IUCN Red List information available to download from our BGCI garden profile, and a list of taxa not recognized by IPNI or the PlantSearch database sent to us via e-mail.

Using BGCI's PlantSearch database

The first time we logged on to the Arboretum's BGCI profile in early 2008, we were surprised to find only 112 taxa listed on our plants list – 28 of them listed as threatened. We knew this was not an accurate representation of our collections so we commenced with the first upload attempt in 2008, and electronically submitted all 4,046 taxa in the Arboretum living collections. Upon reviewing the accepted and rejected taxa reported following the upload, we found that nearly 40% of the taxa we submitted were not included on either list and therefore missing (Table 2). A closer look at the data submitted to BGCI showed wide nomenclatural diversity (Table 1), and we hypothesized that some of the names may have caused ambiguous results via the IPNI query. For example, we wondered if names with multiple infra-specific ranks

Metasequoia glyptostroboides *Critically Endangered (IUCN) (Arnold Arboretum Archives)*

(e.g., *Picea glauca* var. *albertiana f. conica*), names without a specific epithet (e.g., *Weigela* 'Bristol Ruby' or *Nyssa* sp.), or even cultivars or hybrids could cause problems during the upload process.

Following the first upload, we contacted Meirion Jones, Head of Information Management at BGCI, to inquire about our experience. Through these discussions, we determined the need for further testing to identify potential problems between the types of plant names submitted and the upload results. We completed three unique data uploads in the summer of 2008, and repeated them again in the fall of 2009 (Table 1). They consisted of all taxa (Upload 1), all non-cultivar and non-hybrid taxa (Upload 2), and all taxa with a specific or hybrid epithet (Upload 3) in the Arboretum living collections. In addition to the "control" aspect of the first upload, Upload 2 sought to determine if hybrids and cultivars were problematic during the upload process, and Upload 3 attempted to establish if the presence or absence of a specific epithet made any difference in upload results.

Franklinia alatamaha *Extinct in the Wild (IUCN), the Arnold Arboretum has the oldest and largest specimens in North America (Nancy Rose)*

Lessons learnt

What did we learn from these various upload strategies? Simply conducting an upload in the first place resulted in the largest increase: Upload 1 in 2008 yielded numbers of cultivated and threatened taxa approximately 20- and 8-times greater than before, respectively (Table 2). A comparison of Upload 1 results between 2008 and 2009 also showed significant improvements in the numbers of accepted and missing taxa. It is probable that upgrades to the IPNI, BGCI, and the Arboretum plant records databases were responsible for these noticeable changes, as new information acquired, data cleaned, etc. Among the three upload versions, results demonstrate relative stability in the return of threatened taxa. However, with a goal of submitting as broad a sample of our plant records data to maximize taxonomic representation both on the BGCI database and in our conservation analysis, Uploads 1 and 3 seem to be the most effective. Finally, the differences between the two years, even if minor, illustrate the importance of updating our data regularly.

Box 2. North American Botanic Garden Strategy for Plant Conservation, Target B4, Sub-Target 3:

75% of gardens that maintain plant record databases participate by sharing their plant collections list with the global BGCI database of plants in cultivation.

“It is clearly important to update your records regularly.”

Box 3. To get the most out of your PlantSearch Upload, we suggest the following tips:

- First, check your garden’s BGCI profile! Is the number of taxa listed representative of your garden’s current living collections?
- Consider the taxonomic composition of your garden’s living collections. Do the taxa agree with the IPNI database? Can any obscure names be updated or removed from your list? Inspect the data you submit to the Plant Upload, and possibly do some data cleaning.
- Update your garden’s Plant Upload on an annual basis – gardens and threat ranks change!

Beyond our own institution-specific need to identify the Arboretum’s globally threatened holdings, this process benefits others as well. Our collections information is now part of BGCI’s PlantSearch database and is available online to anyone. Although our plant inventory is already accessible online, this provides yet another resource and helps us achieve NABGSPC Target B4, Sub-Target 3 (Box 2). Furthermore, our

Magnolia amoena *Vulnerable (IUCN) (Arnold Arboretum Archives)*

Table 2. 2008-2009 BGCI Plant Upload tests for the Arnold Arboretum Living Collections

Year	Upload Version	Submitted[a]	Accepted[b]	Threatened[c]	Rejected[d]	Missing[e]
Pre-2008	Unkown	-	112	28	-	-
2008	**Upload 1** – All taxa in the living collections	4,046	2,365	247	234	1,447
	Upload 2 – All non-cultivar, non-hybrid taxa: species or infra-specific (sub-species, varieties and formae)	2,201	2,047	257	138	16
	Upload 3 – All taxa with a specific or hybrid epithet: species, hybrids, cultivars or infra-specific (sub-species, varieties and formae)	3,601	3,421	267	144	36
2009	**Upload 1** – All taxa in the living collection	3,989	3,412	258	476	101
	Upload 2 – All non-cultivar, non-hybrid taxa: species or infra-specific (sub-species, varieties and formae)	2,203	2,077	255	114	12
	Upload 3 – All taxa with a specific or hybrid epithet: species, hybrids, cultivars or infra-specific (sub-species, varieties and formae)	3,592	3,348	258	142	102

a Number of taxa submitted to the upload; b Number of taxa accepted via the upload IPNI query;
c Number of taxa assigned an IUCN Red List rank via the upload; d Number of taxa rejected via the upload IPNI query;
e Number of taxa not included as 'accepted' or 'rejected' via the upload.

threatened taxa can be included in global assessments like the Target 8 assessment of the 2009 Plant Conservation Report (CBD, 2009).

Lastly, this process facilitated a number of very fruitful conversations among Arboretum staff, IPNI, and BGCI representatives that have helped improve all of our efforts.

Key points:

Dynamic collections, Dynamic world
With respect to the differences in the total taxa we submitted (4,046 vs. 3,989) in 2008 and 2009 (Table 1), it is vital to note that living collections are constantly in flux, as are threat ranks (IUCN updates Red List threat ranks on an annual basis). Thus, the Plant Upload should be conducted by gardens annually to ensure all datasets are up to date.

Accurate conservation information
We compared the threatened names reported via the Upload, with IUCN data obtained independently, and found approximately 95% congruency. This confirms the valuable benefits of using the Upload.

Data updates by Gardens
Perhaps the most important take-home message from this small case study relates to our initial increase from 28 to nearly 250 known globally threatened taxa in our living collections. This begs the questions: How many other gardens face similar circumstances? Are we underestimating species richness and genetic diversity of cultivated plants in public gardens simply because of insufficient data? And, even if you have recently uploaded your garden's collection data to the database, how complete and representative are they?

Call to Gardens
Based on our experience, we wholeheartedly advocate for a specific "call to gardens". To have a significant impact upon global *ex situ* plant conservation efforts, contribute your garden's plant records to the BGCI PlantSearch database. The benefits are twofold: a greater understanding of the conservation value of your own garden's collections, and an increase in the known world's cultivated taxa and *ex situ* conservation holdings.

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The BGCI PlantSearch database provides collections information about gardens worldwide and enables beneficial exchanges within the botanical community

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SAFEGUARDING EXTINCT PLANTS IN *EX SITU* COLLECTIONS

Ex situ collections may provide the only lifeline for an increasing number of species – but are we taking the necessary steps to ensure their survival?

Background

For threatened plants, *ex situ* conservation is generally considered to be a temporary or transitional stage in a long-term strategy aimed at achieving conservation *in situ*. However, for those taxa that are extinct in the wild, *ex situ* conservation in living plant collections provides the only lifeline. For such plants, their natural habitat may have entirely disappeared or their seeds cannot be stored.

Since the late 1980's, I have maintained a database of those taxa that are documented to be extinct (EX) or extinct in the wild (EW) as defined by IUCN (2001). This is by no means a complete list as only published documented cases are included. This is to prevent the inclusion of species such as *Tecophilaea cyanocrocus* (Watson, 2008) which was listed as extinct until extensive *in situ* surveys were conducted and the species was rediscovered in great abundance.

Of the 844 extinct taxa in the database, 72 are listed as still being present in cultivation. Having monitored these taxa for more than 20 years, I have been surprised at the lack of focus on these taxa and am concerned about their continued long-term survival. I have also identified 39 taxa that used to be in cultivation but have now apparently disappeared altogether. The reasons for the apparent lack of interest is possibly because conservation conventions and infrastructure have largely used *ex situ* collections as a means to support *in situ* conservation rather than as a conservation focus in itself. For threatened plants that survive *in situ*, this is of course the right strategy. However this can mean that those species that are extinct in the wild are not given the attention they deserve.

Tulipa sprengeri in a forgotton corner of the garden

> *“I am concerned by the lack of focus on conserving plants that are extinct in the wild.”*

Although Target 8 of the Global Strategy for Plant Conservation (GSPC) focuses on *ex situ* conservation, no specific measures or infrastructure have been established to deal with the specific vulnerabilities of EW plants in cultivation. The only targeted publication to date was one published by IUCN/BGCI in 1989. As we are only dealing with a small number of taxa, I believe that with little effort an effective infrastructure could be set up to ensure the long-term survival of EW taxa in *ex situ* collections. It is especially important for these taxa to conserve all the surviving genetic diversity- in other words - every individual counts.

> *“When dealing with nearly extinct taxa, every individual counts.”*

Over the years I have identified a range of problems faced by extinct taxa. These are listed below, together with some possible solutions. Although many of the examples are from the Royal Botanic

Gardens (RBG), Kew (my home institution), this is not because the situation here is particularly bad, but rather that it is representative of the general situation. It should also be noted that many extinct taxa are being grown at RBG Kew and the gardens have had notable success in saving a number of taxa from certain extinction.

1. Trophy plants

The best example in this category is undoubtedly *Encephalartos woodii* which is widespread in collections (11 are listed in the BGCI PlantSearch database). Although individual trophy plants are normally well taken care of, little effort may be made to propagate them. After all if you have more than one in your collection you can no longer tell the visiting public that it is the only surviving specimen. The danger of course is that when the one individual dies, none are left. *Encephalartos* is after all relatively easy to propagate from leaf-cuttings. There is also the option of multiplying the plant by micropropagation, with the view of potentially creating female specimens in the future. The quest for the creation of a female specimen has for the moment been taken up by a commercial company (Hurter, 2008), possibly due to the limited resources available in many botanic gardens. *E. relictus* is in an identical situation to *E. woodii*. Although it is less of an icon, there is still the need for a well organised strategy to be in place to ensure the survival of this taxon.

Trophy plants, by their very nature, are especially vulnerable to theft. With specimens of *E. woodii* being valued at $20,000 on the open market, it is not surprising that plants are regularly stolen from collections.

Although trophy plants can be useful in promoting awareness amongst the public of plant extinction risks, it is important that the bigger picture is not forgotten, and efforts are made to continue propagating the taxon. Of course only one individual need be put on display to maintain the power of its story.

2. Horticultural fashions

Some of the extinct plants in cultivation are widely grown and easy to cultivate, such as *Tulipa sprengeri*. The original plant was collected in Amasya, Turkey and it has been maintained in horticulture and botanic gardens ever since (18 gardens are listed in BGCI's PlantSearch database). As it is commonly seen in gardens, is easy to cultivate and often naturalises from seed, it may not be considered important and may end up in a forgotten corner somewhere. The danger is that because of this lack of vigilance, the specimens may be accidentally destroyed. Tulips suffer from a multitude of diseases so it is a distinct possibility that a disease could appear and destroy all plants in a given locality in a short period of time. As mentioned before, it is very important for the survival of a species to maintain all existing diversity, even for a common taxon.

The greatest danger of relying on horticulture for long-term survival is of course that fashions change and the plant may become unpopular. The species may then disappear from horticulture altogether, as is the case with *Hindsia violacea*, now thought to be completely extinct.

> *"As fashions change, rare species may disappear from horticulture altogether."*

Conservation of extinct plants should remain immune from fashion and each species, even each individual, should be valued equally. For a species like *T. sprengeri*, seed banking would probably be the best option for long term conservation. Unfortunately however, many seed banks have a policy of storing only seeds collected from wild origin plants – thus excluding species that are extinct in the wild. It is good to know that the Millennium Seed Bank at Wakehurst Place has recently relaxed its rules and now has a programme of collecting seeds from threatened plants in cultivation.

3. Project – the dirty word

Much conservation work is funding as projects. The first problem with this is that projects are by definition short-term, mostly 3-5 years. This may be the right strategy for many aspects of plant conservation but is definitely inadequate for the long-term survival of species. Kew has been involved in saving a number of species before they became extinct in the wild. Typically these species are a priority for a few years, but once the initial rescue project is completed, resources are focussed elsewhere and the species' survival prospects decline. *Commidendrum rotundifolium* for example was discovered as a single surviving tree in 1982. Thanks to the skills of Kew's micropropagation unit, the species was successfully propagated. In 1986 the single wild tree was destroyed by a severe gale and by 1991 the last remaining plant at Kew Gardens had died as well. Now only a few trees remain in cultivation on St. Helena seemingly unable to produce viable seeds.

The defined nature of projects can also pose a problem, with activities lying outside such projects not being supported. One such example is that of *Anthurium leuconeurum*. This species

Attempts made to reintroduce Lysimachia minoricensis *in the wild have until now failed* was only collected once in Chiapas, Mexico and has not been seen since. Although it is widespread in cultivation, until 1999 it had never been recorded to produce seeds (Govaerts & Frodin, 2002). However, once seeds were produced, no institution could be identified with a relevant conservation project into which continued work on this taxon could fit. Consequently, an opportunity was missed to take the survival of this species forward with a possible view to reintroduce it into the wild.

4. Refocus and restructuring

These are words commonly used these days, all too frequently as a euphemism for financial and staff cuts. Such cuts often go unnoticed and may result in extinct plant material dying or being destroyed. One such example is *Bromus eburonensis*, the only Belgian endemic (except for perhaps some microspecies like *Rubus prei*). It, together with the near-endemic *B. bromoideus* and artificial crosses used in research experiments were for many decades cultivated at the Botanical Garden of the University of Liège. However, when the activities were scaled down and the area transformed to a public park, the plants disappeared as well.

This situation could be avoided if an international infrastructure were to be set up to track which institutions care for extinct taxa, and identifying when they are no longer able to continue to do so. A simple allocation of responsibilities and annual reporting on the state of health of extinct taxa might be trialled.

The bottom line of course is that sufficient funding should be made available for institutions to continue to maintain important collections of threatened plants.

5. Knowledge is survival

Even though we live in the age of instant access to information and most botanic gardens have their collections databased, with the possibility to include IUCN red list categories, this information does not always get to the horticulturalists and gardeners that look after the actual plants. A recent example is that of *Aechmea serrata*. The Bromeliad living collection, as well as the electronic data

A flowering Anthurium leuconeurum *grown in a greenhouse in strong competition with common Marantaceae*

attached to it, is very well managed at Kew Gardens. Nevertheless the Conservation category for this taxon was blank. So the person in charge was not aware of the importance of this plant and the possible conservation implications. While it is important for databases to be more closely linked so that relevant information is always available, a more practical, immediate action could be to use red-coloured labels for extinct and critically endangered plants. In this way, the information is not lost when staff change or temporary staff take over the care of these valuable plants.

Conclusion

After monitoring extinct plants in cultivation for more than twenty years, I'm afraid the conclusion must still be that most are not yet safe from accidental loss. The main solution must certainly be better access to information by linking garden databases directly to the IUCN red list (this can be done through BGCI's PlantSearch database) as well as appropriate labelling. Also better communication between botanic gardens and conservation organisations should be pursued by creating a framework that monitors, either formally or informally, extinct plants in cultivation. This could be strengthened by providing a protocol to which participating gardens would commit. Saving the last individual from extinction can be very expensive - efforts should be made to ensure this does not need to happen again and again.

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EX SITU CONSERVATION OF WILD PEAR, *PYRUS* L. (ROSACEAE) SPECIES AT THE YEREVAN BOTANIC GARDEN, ARMENIA

Armenia is a centre of diversity for wild pear species and the collection at the Yerevan Botanic Garden provides a useful resource for researchers and educationalists.

Introduction

The 'Flora and Vegetation of Armenia' plot at the Yerevan Botanic Garden holds one of the oldest *ex situ* collections in the Caucasus. The collection contains up to 1,000 species of Armenian flora. Plants of various types (herbs, semi-shrubs, shrubs, trees) and bio-ecological groups (geophytes, succulents, lianas, water-plants etc.) are included in the collection. This collection reflects the main elements of the plant kingdom in the Armenian Republic, with models of the main types of plant communities recreated, including those threatened in the wild. The most characteristic taxonomic composition of the flora is selected for each type of vegetation modeled at the plot. Priority is given to rare and threatened species, endemics, insufficiently studied species, and to the species of educational, ornamental or economic value.

Pyrus sosnovskyi *in flower (J. Akopian)*

"Crop wild relatives are an important focus of the collections at the Yerevan botanic garden."

The long history of introducing wild plants into cultivation at the plot has contributed to *ex situ* conservation of the biodiversity of Armenia, including genetic resources of native crop wild relatives (CWR). Special attention has been given to the crop wild relatives since 2007, when the collection was enriched during field surveys conducted within the framework of the UNEP/GEF funded Crop Wild Relatives projects. Today the plot includes more then 200 CWR species (from 130 genera), relatives of food, fodder, ornamental, industrial and medicinal crops (Akopian, 2009). Also there are 38 wild relative species from 25 genera of pome, stone, small fruit, vine, nut and other fruit crops. Among them the collection boasts wild pear species native to the Armenian flora.

Pyrus oxyprion *fruits (J. Akopian)*

The territory of Armenia, especially the southern and south-eastern regions of the country is a center of high polymorphism and local narrow endemism in the genus *Pyrus* (Akopian, 2007). Intensive speciation in the genus has been promoted by several factors, including spatial isolation due to fragmentation of the land; drying of the climate, intensive hybridization, as well a long history in the area of breeding new pear varieties from ancestral species, which escape back to wild. Speciation processes in the pear forests of Armenia continue today (Mulkidzhanyan, 1973).

Creation of an indigenous wild pear collection at the 'Flora and vegetation of Armenia' Plot was initiated in the middle of the last century and continues to the present. Pear specimens were collected from their natural habitats from various districts of Armenia and replanted in the plot. The life cycle of wild pears is up to 50-80 years. Under *ex situ* conditions, as

Pyrus salicifolia *in flower (S.Mnatsakanyan)*

Table 1. Wild pear collection at the 'Flora and vegetation of Armenia' plot.

Pyrus L. *species*	Origin (districts of Armenia)	Initial material	Year of first introduction
P. caucasica Fed.	Gegharkunik, Kotayk	Seedlings	1952,1969
P. georgica Kuth.	Meghri	Seeds	1955
P. medvedewii Rubtzov	Vayots Dzor	Seedlings	1958
P. oxyprion Woronow	Meghri	Seedlings	1955
P. salicifolia Pall.	Meghri	Seedlings, seeds	1955
P. sosnovskyi Fed.	Kotayk	Seedlings	1974
P. takhtadzianii Fed.	Vayots Dzor	Seedlings	1958
P. tamamschjanae Fed.	Kotayk	Seedlings	1974
P. zangezura Maleev	Sjunik	Seedlings	1968, 1982

Pyrus medvedevii *fruit (S. Mnatsakanyan)*

in nature, wild pears propagate by seeds and by root suckers. The plants flower in April - May, before the leaves appear and they are cross-pollinated by insects. Fruits ripen from September to October.

All *ex situ* species observed are relatively drought-tolerant and frost-resistant, and do not demand highly fertile soils. Presently the following species of *Pyrus* are maintained at the plot (see Table 1):

The characteristics of some of the species are provided below:

P. caucasica Fed. Tree 10 - 20 m high, thorny, Buds are from pale rose to white, flowers white, fruits round or slightly oblate. In the *ex situ* collection, it is weakly shade tolerant and is resistant to diseases. It has a dense and beautiful wood. Fruits have a varied taste and are used fresh and dried, for production of vinegar and wine, and for cooking. In horticulture the seedlings of *P. caucasica* are used as a rootstock for cultivated pears. It is considered to be the ancestor of several native pear cultivars.

In Armenia it grows in broad-leaved forests, by river valleys, from 600 to 2,200 masl. The species was described from Armenia. General distribution: Caucasus, Northern and South-Western Anatolia. Highly polymorphic species, allied species is *P. communis* L.

P. georgica Kuth. Tree, seldom shrub, 3-9 m high, thorny. Flowers are plentiful, small. On the plot it blooms earlier than other pear species. Fruits are numerous, small, globular-pear shaped, green, very soft and sweet.

In Armenia it grows in broad-leaved forests, on arid slopes, from 1,200 up to 2,500 masl. The species was described from Georgia, it is endemic to Caucasus. The allied species are *P. elaeagnifolia* Pall, *P. salicifolia* Pall.

P. medvedevii Rubtzov. Tree 10-12 m high, usually thorny. Fruits are small, green-yellow, soft, sour-sweet.

In Armenia *P. medvedevii* grows in arid light forests, from 1,400 up to 2,200 masl. It was described from Nakhichevan. Endemic to and rare in Southern Transcaucasia. The allied species: *P. laeagnifolia* Pall., *P. salicifolia* Pall., *P. syriaca* Boiss.

P. oxyprion Woronow. Tree up to 5 m high, with dense canopy, thorny. Fruits pear-shaped, green, very hard, ripen late. It is very ornamental with glossy green leaves, and numerous rose-coloured flowers.

In Armenia it grows in arid light forests, from 1,400 up to 1,900 masl. The species was described from North-Eastern Anatolia. General distribution: Southern Transcaucasia, Northern Iran,

Pyrus salicifolia *fruit (S. Mnatsakanyan)*

Pyrus caucasica *at the beginning of flowering (J. Akopian)*

North-Eastern Anatolia. The allied species are *P. salicifolia* Pall., *P. syriaca* Boiss., *P. fedorovii* Kuth.

P. salicifolia Pall. Tree 5 - 10 m high, very thorny. Flowers are from light rose to white. Fruits usually are single, round or pear-shaped, brown-golden. *P. salicifolia* is ornamental both in flowers and fruits. It is highly drought- and frost-resistant, can tolerate frosts down to -32^{0}C. In horticulture its seedlings are widely used as rootstocks. *P. salicifolia* played an important role in the origin of cultivated pear varieties.

Pyrus caucasica *fruits (J. Akopian)*

In Armenia it grows in mountain and arid light forests, on scree and rock slopes, in hill foots, from 600 up to 2,200 masl. The species was described from Ciscaucasia. General distribution: Caucasus, North-Western Iran, North-Eastern Anatolia. The allied species are *P. elaeagnifolia* Pall, *P. georgica* Kuth.

P. sosnovskyi Fed. Small tree or shrub with thick crown, Fruits are small, orbicular or shortly pear-shaped, yellow-green, soft, sour-sweet.

It grows in arid or broad-leaved and juniper forests, on the stony slopes, from 1,000 up to 2,000 masl. Endemic to and rare in Armenia. The allied species are *P. communis* L., *P. caucasica* Fed.

P. takhtadzhianii Fed. Thornless tree 5-7 m high, It has large, pear-shaped, brown, juicy fruits. According to some authors, it originated from ancient local pear cultivars, and is a secondary escape into the wild. *P. takhtadzhianii* is ornamental with a crown of grayish leaves of various shapes.

In Armenia it grows in broad-leaved and arid light forests, among mountainous xerophytic vegetation, from 800 up to 2,200 masl. The species was described

Pyrus georgica *in flower (J. Akopian)*

from Armenia. Endemic to Transcaucasia. The allied species are *P. communis* L., *P. elaeagnifolia* Pall., *P. salicifolia* Pall.

P. tamamschjanae Fed. Tree 3-5 m high, usually thornless. Fruits are pear-shaped, sweet and soft, with the shape resembling that of cultivated pears. It is ornamental, especially in autumn with red colored leaves.

It grows in arid light and in broad-leaved forests, from 1,600 up to 2,200 m. Endemic to and rare in Armenia. The allied species are *P. communis* L., *P. sosnovskyi* Fed.

Pyrus oxyprion *in flower (J. Akopian)*

P. zangezura Maleev. Tree 10 m tall, usually thornless, Fruits pear-shaped-globular, after ripening soft, sour-sweet. *P. zangezura* is a highly frost - resistant species.

In Armenia it grows in broad-leaved mountainous forests, from 1,500 up to 2,300 m. The species was described from Armenia. Endemic to and rare in Southern Transcaucasia. The allied species is *P. syriaca* Boiss., which is one of main ancestors of cultivated pears.

Most of observed pear specimens have been growing in the plot collection for more than 30-50 years. The duration of plant specimens' existence in the living collection is an important indicator of the capacity of wild plants to survive under *ex situ* cultivation. So, all wild pear species introduced to the plot, can be classified as adaptable for *ex situ* cultivation and conservation. Under *ex situ* conditions they develop normally and multiply. At the plot they are also now represented by young specimens. Some wild pear species *(P. caucasica, P. medvedevii, P. salicifolia, P. tamamschjanae*) demonstrate potential for intensive vegetative reproduction under *ex situ* conditions, thus providing living materials for rare species reintroduction to the natural habitats. Furthermore, most of the researched pear species are very ornamental and can be used in landscape gardening. They are valuable as food, medicinal and honey plants and for breeding drought-tolerant and frost - resistant pear cultivars.

Pyrus sosnovskyi *fruits (J. Akopian)*

The genus *Pyrus* poses difficulties for researchers, because of its remarkable species polymorphism and variability. The specimens in the collection are therefore interesting for scientific researches in the field of taxonomy, morphology and biology. Data obtained from the collection is used in the Institute of Botany's *Manual of Plants of Armenia*. The collection also provides living *ex situ* material for the forthcoming project 'Fruits for a sustainable future - Assessing the patterns of diversity of the genus *Pyrus* in Transcaucasia' within the context of the 'Pan-Caucasian Plant Biodiversity Initiative - Developing tools for the Conservation of Plant Diversity in the Transcaucasus'.

The native wild pear collection also provides the basis for an exhibition that has educational significance and is of interest for visitors of the Yerevan Botanic Garden.

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Pyrus georgica *fruits (J. Akopian)*

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RESOURCES

BOOKS AND JOURNALS

Ex situ plant conservation - Supporting species survival in the wild
Edward O. Guerrant Jr., Kayri Havens and Mike Maunder (eds), 2004

This book is based on a conference held in the Chicago Botanic Garden in 1999, entitled "Strategies for Survival: *Ex Situ* Plant Conservation". It provides essential reading for botanic garden staff, whether the gardens have formal conservation programmes or not.

Ex situ plant conservation was in the past seen as largely irrelevant to *in situ* conservation, which was regarded as the preferred means for conservation. However this book explains how well-managed *ex situ* collections can make the critical difference between extinction and survival. Moreover, the authors claim that *ex situ* conservation is the responsibility of botanic gardens, with their collections and other *ex situ* facilities such as seed banks, being amongst the most extensive yet underused plant conservation resources in the world. In the introduction Sir Ghillean Prance also emphasizes the important role of botanic gardens in conservation in responding to the challenges of today's world.

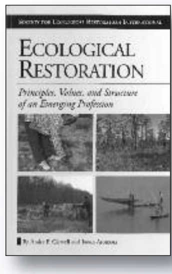
Part I discusses the role of *ex situ* conservation in integrated conservation programmes and the scientific rigour required for the collection, storage and use of the collections. These papers cover the philosophical and ethical concerns with examples of integrated conservation in Western Australia and the United States and a chapter on lessons from zoos. Part II reviews the 'Tools of the trade' from horticulture, seed and pollen to tissue culture. It addresses one of the main criticisms of *ex situ* collections for

conservation, that the samples of growing plant, tissues or seed are subject to genetic modification; Part III reviews the effect of selection pressures of the horticultural and storage environment and provides practical steps to mitigate these pressures. Part IV assesses the role of *ex situ* plant conservation for stemming the loss of biodiversity and makes practical recommendations, notably an urgent need for investment in infrastructure and horticultural skills. This Part provides practical guidelines for genetic sampling, seed storage and the management of collections.

Island Press, Covelo, U.S.A. 424 pp.
ISBN 1-55963-875-3 (paperback)
ISBN 1 55963 874 5 (hardback)

Ecological restoration. Principles, values and structure of an emerging profession
A. F. Clewell and J. Aronson

This book is a concise reference document that will be valuable to all interested in or involved in ecological restoration. Fundamental principles such as the important selection of a reference model and the recognition of people as ecological influences are addressed in general introductory chapters. The underlying importance of plant species composition is stressed as, "it is the plant community that gives an ecosystem its structure and provides habitat." The book's later chapters are aimed at more experienced practitioners of ecological restoration. Case studies of ecological restoration projects around the world are included as "virtual field trips". Included as an Appendix are the Society for Ecological Restoration International's, Guidelines for developing and managing ecological restoration projects, 2nd Edition.



The book builds on and develops the Society for Ecological Restoration International's Primer of Ecological Restoration (http://www.ser.org/content/ecological_ restoration_primer.asp), of which Clewell and Aronson were among the three principle authors.

Available from Island Press as part of the book series "The Science and Practice of Ecological Restoration."
ISBN: 978-1597261692. 2007.

Details of other publications published for the Society of Ecological Restoration International can be found at the website: www.ser.org

Seed conservation: turning science into practice
R.D. Smith, J.B. Dickie, S.H. Linington, H.W. Pritchard, R.J. Probert, eds. 2003.

This substantial and comprehensive book on seed conservation, i.e. the use of seed storage for *ex situ* plant genetic resources conservation (non-domesticated as well as crop species), results from an international workshop of the same title hosted by the Royal Botanic Gardens, Kew at its (then) new Wellcome Trust Millennium Building, Wakehurst Place, West Sussex, UK in 2001. Its 56 chapters cover, in a logical progression, all the elements involved in successful gene banking; from planning and collecting, through processing and testing, to storage and, ultimately, utilization.

Notably, while *Seed conservation* results from a conference, good planning and editing have helped avoid the trap of merely providing a written record of that meeting. It is neither a practical handbook on gene

banking nor a text-book on genetic resources conservation, seed biology, etc. Rather, it combines the best elements of both. For example, chapters 33 and 34 by Millennium Seed Bank staff on seed storage provide detailed information on seed bank design and seed packaging. These chapters update and extend text written more than two decades ago and benefit greatly from the authors' similar duration of practical experience.

Kew Publishing, 2003. ISBN 1842460528. Available from: Kewbooks, Summerfield House, High Street, Brough, Cumbria, CA17 4BX, United Kingdom. Email: kewbooks.com@btinternet.com

Plant Inventory Operations Manual

First edition, January 2010
The Arnold Arboretum of Harvard University

This recently published and freely available reference Manual describes the great lengths the Arnold Arboretum of Harvard University takes to routinely inventory its plant collections – a programme that represents the culmination of over 130 years of trial, error, and refinement. Unlike a static museum collection, Harvard's Tree Museum is dynamic: the objects grow, they may go missing, they may drift in location (think of a mass of shrubs advancing as they layer-in and expand), they may change quickly, they require observation, and their labels often wander and need replaced.

These and other realities mean that in order to have a collection where the plants are accurately mapped, labeled, identified and measured, the landscape must be frequently inventoried and each and every plant has to be skeptically reviewed. In writing the first edition of the Manual, the curatorial team did not want to simply describe current Arboretum procedures. Instead, they embarked upon a thoughtful review of their present practices, made a number of adjustments, and as a result set an even higher standard. The end product, this Manual, is a composite of tried-and-true methods and many new approaches.

Copies of the Manual, can be downloaded from: www.arboretum.harvard.edu/plants/pdfs/plant_inventory_operations_manual.pdf

WEBSITES

Center for Plant Conservation (CPC)

The mission of the Center for Plant Conservation is to conserve and restore the imperiled native plants of the United States to secure them from extinction. The Center maintains the National Collection of Endangered Plants, a collection of cultivated plants and seeds of imperiled, native plants in the United States. The Center's participating institutions work with these imperiled plants off-site and in the wild. In the greenhouse, institution scientists conduct horticultural research and learn how to grow the plants from seed or from cuttings. The Center's scientists then provide plant material for restoration efforts in the wild. Institution scientists also assist in monitoring populations in the wild, managing habitat and restoring plants to native habitats. The National Collection of Endangered Plants contains plant material for more than 700 of the country's most imperiled native plants. An important conservation resource, the Collection is a back-up in case a species becomes extinct or no longer reproduces in the wild. The Collection provides the material needed for restoration work for the species. It's also an important resource for the scientific study of plant rarity, rare plant life cycles and rare plant storage and germination requirements. CPC is committed to spreading knowledge and information about the needs for plant conservation and the protection of biodiversity.

The CPC website includes a range of resources focused on plant conservation and ecological restoration aimed at conservation professionals and educationalists. This includes a bibliographic database on topics broadly relevant to genetic considerations in ecological restoration and a reintroduction database providing current knowledge about plant reintroductions. The website provides many useful links to organizations and resources concerned with native plants, endangered plants and plant conservation. More broad based links for plants and plant sciences are also included.

www.centerforplantconservation.org/

Bioversity International

Bioversity is the world's largest international research organization dedicated solely to the conservation and use of agricultural biodiversity.

Bioversity's website includes a wide range of information about the conservation and sustainable use of world's plant genetic resources. Sections focus on the world's crop genebanks, which store, maintain and reproduce living samples of the world's huge diversity of crop varieties, as well as providing information on the conservation of crop wild relatives and underutilized and neglected plant species. Bioversity maintains a number of databases with summary information on *ex situ* germplasm collections worldwide. Currently, summary information on more than 5 million accessions belonging to more than 20,000 species worldwide is available. The Bioversity Species Compendium is a searchable database providing information about: seed survival during storage; germination requirements and dormancy; reproductive biology; and pests and diseases.

The website also provides links to the System-wide Information Network for Genetic Resources (SINGER), which is the genetic resources information exchange network of the centres of the Consultative Group on International Agricultural Research (CGIAR) and to the European plant genetic resource catalogue, EURISCO, which collects data from the national plant genetic resource inventories and provides access to *ex situ* plant genetic resource information in Europe.

www.bioversityinternational.org

Agricultural Biodiversity Weblog

This Blog was set up by Luigi Guarino and Jeremy Cherfas, united by their passion for agricultural biodiversity and the internet. Their aim is to collect in one place anything they find on the internet that relates somehow to the notion of agricultural biodiversity. Articles and comments cover issues related to the conservation and use of plant genetic resources in the broadest sense, often including information relevant to the conservation of wild plants.

http://agro.biodiver.se/

Please register your contributions to the *International Agenda for Botanic Gardens in Conservation*

International Agenda for Botanic Gardens in Conservation Registration Form

Name of Institution			
Type of Registration	**Formal**	Board Resolution or other form of approval from relevant governing bodies (e.g. university authorities, local, regional or national government	*Please Tick*
	Informal	E.g. by Director/Senior staff.	

BGCI would welcome copies of any formal resolution, motion or other form of endorsement.

Name of responsible person	
Position	
Address	

Email		**Date of Registration**	

Declaration

This institution welcomes the International Agenda for Botanic Gardens in Conservation as a global framework for the development of institutional policies and programmes in plant conservation for botanic gardens.

Without imposing any obligations or restrictions (legal or otherwise) on the policies or activities of this institution/organisation, we commit ourselves to working to achieve the objectives and targets of the ***International Agenda for Botanic Gardens in Conservation.***

Signed		**Date**	

Please sign and detach this registration form and send it to The Secretary General, Botanic Gardens Conservation International, Descanso House, 199 Kew Road, Richmond, Surrey TW9 3BW, U.K.

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Please keep a duplicate copy of this form for your records.

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Established in 1987, BGCI links more than 500 botanic gardens and conservation organizations in 115 countries, working together to save PLANTS FOR THE PLANET.

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  - BGjournal – an international journal for botanic gardens (2 per year)
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D	Institution member (budget US$ 750,000 - 1,500,000)	350	550	450
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M	Friend (*Cuttings*) available through online subscription only (www.bgci.org)	10	15	15

Corporate Membership is available; please contact BGCI at info@bgci.org for further details.

**Contents of the Botanic Garden Management Resource Pack include: Darwin Technical Manual for Botanic Gardens, A Handbook for Botanic Gardens on the Reintroduction of Plants to the Wild, BGjournal - an international journal for botanic gardens (2 past issues), Roots - Environmental Education Review (2 past issues), The International Agenda for Botanic Gardens in Conservation, Global Strategy for Plant Conservation, Environmental Education in Botanic Gardens, additional recent BGCI reports and manuals. BG-Recorder* (a computer software package for plant records) available on request.

Payment may be made online at www.bgci.org/worldwide/members/, or by cheque (payable to Botanic Gardens Conservation International) or VISA/MasterCard sent to BGCI, Descanso House, 199 Kew Road, Richmond, Surrey, TW9 3BW, U.K or Fax: +44 (0) 20 8332 5956.

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BGCI
Plants for the Planet

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