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The challenge of
sustainability



BGCI

Plants for the Planet



Editors: Suzanne Sharrock and Sara Oldfield

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Design: John Morgan, Seascape
E-mail: studio@seascape-design.fsnet.co.uk

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Further details available from:

- Botanic Gardens Conservation International, Descanso House, 199 Kew Road, Richmond, Surrey TW9 3BW UK. Tel: +44 (0)20 8332 5953, Fax: +44 (0)20 8332 5956 E-mail: info@bgci.org, www.bgci.org
- BGCI-Russia, c/o Main Botanical Gardens, Botanicheskaya st., 4, Moscow 127276, Russia. Tel: +7 (095) 219 6160 / 5377, Fax: +7 (095) 218 0525, E-mail: seed@aha.ru, www.bgci.ru
- BGCI-Netherlands, c/o Delft University of Technology Julianalaan 67, NL-2628 BC Delft, Netherlands Tel: +31 15 278 4714 Fax: +31 15 278 2355 E-mail: l.j.w.vandenwollenberg@tudelft.nl www.botanischetuin.tudelft.nl
- BGCI-Canarias, c/o Jardín Botánico Canario Viera y Clavijo, Apartado de Correos 14, Tafiira Alta 35017, Las Palmas de Gran Canaria, Gran Canaria, Spain. Tel: +34 928 21 95 80/82/83, Fax: +34 928 21 95 81, E-mail: jmlopez@grancanaria.es
- BGCI- China, 723 Xingke Rd., Guangzhou 510650 China. Tel: (86)20-37252692. email: Xiangying.Wen@bgci.org www.bgci.org/china
- BGCI – South East Asia, c/o Registry, Singapore Botanic Gardens, 1 Cluny Road, Singapore 259569. E-mail: Bian.Tan@bgci.org.
- BGCI-Colombia, c/o Jardín Botánico de Bogotá, Jose Celestino Mutis, Av. No. 61-13 – A.A. 59887, Santa Fe de Bogotá, D.C., Colombia. Tel: +57 630 0949, Fax: +57 630 5075, E-mail: jardin@gaitana.interred.net.co, www.humboldt.org.co/jardinesdecolombia/html/la_red.htm
- BGCI-Deutschland, c/o Botanische Gärten der Universität Bonn, Meckenheimer Allee 171, 53115 Bonn, Germany. Tel: +49 2 2873 9055, Fax: +49 2 28731690, E-mail: biogart@uni-bonn.de
- BGCI(US) Inc, c/o Chicago Botanic Garden, 1000 Lake Cook Road, Glencoe, Illinois 60022, USA. E-mail: usa@bgci.org, www.bgci.org/usa

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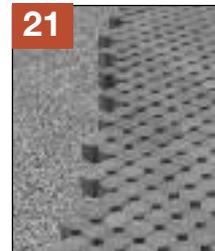
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Editorial

The challenge of sustainability for botanic gardens



Sustainable development is generally accepted to encompass environmental, social and economic sustainability. Botanic gardens have a role to play in supporting sustainable development and at the same time are looking at their own sustainability. Considerations of energy and water use are critical at a time of global climate change whilst at the same time financial sustainability is foremost in all our minds. The papers in this issue of BGJournal provide case studies of how botanic gardens are tackling various aspects of sustainability around the world.

A key advantage of botanic gardens is their ability to demonstrate sustainable practices in a wide variety of ways whether by promoting domestic vegetable growing, demonstrating waste recycling or selling sustainably sourced products within the gift shops. Of course it all comes back to plants – the importance of plant diversity in maintaining carbon and water cycles and climate regulation is often overlooked – but as all involved in botanic gardens know is absolutely essential. Displaying endangered plant species acts as a reminder of the plants that are being lost with the consequent impacts on ecological sustainability. Biodiversity conservation may be out of fashion compared with tackling climate change but botanic gardens are uniquely placed to demonstrate the inextricable links between the two.

The Global Strategy for Plant Conservation (GSPC) of the CBD is guiding the policies and practices of many botanic gardens around the world. This in turn allows botanic gardens to help implement targets on sustainable plant use and trade as well as conservation of plant diversity in all its forms. The Strategy already helps to address the impacts of climate change on biodiversity together with adaptation and mitigation measures. BGCI is currently supporting a process to revise the GSPC so that its 16 targets are more explicitly linked to tackling climate change. We look forward to wide involvement in this process.

Becoming more sustainable is a challenge however many targets and guidelines are in place. Sharing ideas and solutions for sustainability in horticulture is an area where botanic gardens can have an enormous impact. Looking ahead we hope that sustainability will remain on the agenda for all botanic gardens and that BGCI can foster and strengthen the debate. We look forward to sharing ideas and discussing these issues at the 7th International Congress on Education in Botanic Gardens in Durban in November and at the 4th Global Botanic Gardens Congress in Dublin next year. And we will ensure that our travel plans support carbon offset schemes.

Sara Oldfield
Secretary General, BGCI

Developing botanic garden policies and practices for environmental sustainability

Achieving environmental sustainability has become a major concern and challenge for governments and most major institutions worldwide as we become increasingly aware that the Earth's natural resources are finite and need to be used and managed with care and responsibility. We realise today that sustainability has also to become a matter of individual responsibility and one of the greatest personal challenges we will face to ensure that our actions are not detrimental to the planet or threaten its environment or biodiversity. For botanic gardens, as leading environmental organisations, we face an even greater challenge not only to improve our own environmental performance but also to ensure that we develop our institutions as models of sustainability.

It is clear that we also need to provide leadership and guidance for those who still remain to be convinced of the urgency of the environmental crisis and the need to stem the loss of biodiversity. However, developing an individual botanic garden to become



such a model is not an easy task. Most botanic gardens are very significant producers of carbon dioxide and reducing our carbon footprint requires innovation, determination and sacrifices. In the temperate world most major botanic gardens have large expanses of heated glasshouses. Very few are currently maintained by the use of renewable energy sources. Retrofitting botanic gardens to become modern energy-efficient institutions with a low environmental impact is a particularly difficult task, especially for gardens that have inherited a diverse range of historic buildings, facilities and glasshouses.

Nevertheless, despite the challenges we face it is clear that much can be achieved and constant improvements can be made to the ways in which we perform environmentally. In this article, I outline some of the ways in which the National Botanic Gardens of Ireland have sought to transform their policies and practices to become more environmentally sustainable.

The National Botanic Gardens were established in 1795 and have become Ireland's leading botanical institution. The gardens are government funded and receive over 600,000 visitors per annum. Like most of the major European botanic gardens they fit into the category of 'classic' botanic gardens, balancing roles in scientific research, horticulture, environmental education, training, biodiversity conservation and in providing a range



of social, recreational and community benefits to the visitors they serve. In recent years, the Gardens have very deliberately added supporting sustainable development to the range of tasks that are recognised as core responsibilities.

To develop a more coherent response to the need to promote sustainability, the National Botanic Gardens has developed and adopted a range of new policies and practices to guide its actions in this regard. The key components of its Sustainability Programme can be categorised under the following headings:

- Developing environmentally friendly practices in horticulture and Gardens management
- Promoting and supporting biodiversity conservation
- Supporting sustainable development in Ireland and internationally
- Education for and about the environment
- Recycling and reducing waste and energy consumption

Above:
A visit by Trevor Sargent, Minister for Horticulture in Ireland to the Sustainable Environment Fair

Left:
Large-scale compost making provides a valuable resource for horticulture



Right: A week's rubbish on display as part of the 'reducing waste campaign'



We believe that it makes very good sense to integrate the work of the Gardens in biodiversity conservation into such a programme on sustainability. For too long biodiversity conservation and sustainable development have been inadequately linked and seen as separate concerns. Today we understand that safeguarding biodiversity must be a part of sustainable development. Indeed, it was only in 2002 that the World Summit of Sustainable Development in Johannesburg, South Africa adopted its 'Plan of Implementation' which provided the first intergovernmental acknowledgement of the link between sustainable development and biodiversity. It was only recently too that the 2010 biodiversity target ("to reduce the rate of loss of biodiversity worldwide") was added to the Millennium Development Goals (MDGs), becoming a sub-goal as part of the MDG Goal 7: to achieve environmental sustainability.

Right: A sealed bin forms part of the 'Sustainability week' activities

1. Developing environmentally friendly practices in horticulture and Gardens management

The key activities in relation to environmentally sustainable horticulture in the Gardens include new composting programmes, the reduction and eventual elimination of the use of peat from non-renewable sources, elimination of harmful pesticide use and a major reduction in the use of herbicides. As part of our work in composting, almost all organic waste

materials generated in the Gardens are composted, including waste paper from the offices, much of which is now composted. The

use of peat has been very considerably reduced – for example, new tropical forest plantings in a recently restored major historic greenhouse, the Great Palm House, were achieved without the use of peat in composts. In the heated glasshouses, Integrated Pest Management solutions are being applied instead of using pesticides. For example, cockroach control is undertaken by the use of sugar-solution baited pitfall traps.

A significant new development for the National Botanic Gardens is a new Fruit and Vegetable Garden, managed according to best 'organic' or environmentally-friendly practices. This has proved to be of huge public interest, attracting tens of thousands of visitors since it opened in June 2008. This Garden has also become the focus of new public education programmes in horticulture and is used for composting workshops as well as gardening classes and demonstrating specific topics, such as growing summer salads, organic gardening, fruit tree pruning etc.

Encouraging and conserving wildlife in the Gardens is also recognised as a component of our programmes. This has included the development of a plan to prepare a comprehensive Biodiversity Inventory of the wild organisms found in the institution, including birds, insects and other invertebrates, plants and fungi. One of the most significant finds in recent years has been a rare slug, Mauge's shelled slug (*Testacella maugei*), a burrowing slug discovered in the Gardens' car park in September 2008 which had not been seen in Ireland since 1931, and then before that only in 1892. The Gardens were formerly a well known home for the native red squirrel but these have not been seen for over a decade and have been replaced by the more aggressive, invasive North American grey squirrel. Control measures for the grey squirrel are gradually being put in place in the hope that a future red squirrel reintroduction programme can be undertaken.

2. Promoting and supporting biodiversity conservation

Support for the implementation of the U.N. Convention on Biological Diversity (CBD) has been mainstreamed into the Gardens' activities. In particular the Global Strategy for Plant Conservation has been adopted as a central component of the Gardens' priorities and policies. The Garden is a proud member of Botanic Gardens Conservation International since its establishment in 1987 and became a member of the Global Partnership for Plant Conservation when it hosted the first GPPC Conference in 2005. It has also hosted a series of expert meetings (GSPC Liaison Group meetings) on the GSPC in 2006 and just recently in 2009, which form part of the on-going flexible coordination mechanism of the Strategy. In June 2010 the Gardens will also host the 4th Global Botanic Gardens Congress, when plant conservation will be at the forefront of many of the congress sessions. The Gardens has also ensured that the collections it maintains of plants that are listed by IUCN as threatened are afforded particularly priority care. Data on them are included in BGCI's on-line database, PlantSearch. In 2009 a new greenhouse display of threatened island endemics was unveiled to help raise public awareness of endangered plants, as well as to highlight the Gardens' roles in their conservation. The display includes critically endangered plants from a number of oceanic islands, including Mauritius, the Juan Fernandez Islands and Pitcairn Island.





At the national level, biodiversity conservation activities include leadership of a National Plant Conservation Strategy, as well as specific research and conservation programmes on some of the most threatened native plant species. Priority programmes include integrated scientific research and recovery work on several critically endangered plants. In 2010 a new native plant conservation area will be inaugurated in the Gardens that will include a series of experimental reconstructions of native habitats, including karst limestone pavement, heaths, acid and basic grasslands, woodland and hedgerow habitats. Such a development requires close cooperation between the horticultural and scientific teams in the Gardens to ensure that this development is undertaken following the best available scientific advice but applying practical horticultural solutions.

Staff of the Gardens are also active in assisting in the development of national biodiversity policies, such as a forthcoming new National Biodiversity Strategy that is due to be completed later in 2009 and participate in national delegations to CBD meetings.

3. Supporting sustainable development in Ireland and internationally

A range of activities are undertaken to support sustainable development in different ways, both in Ireland and overseas. Staff of the Gardens play active roles in some of Ireland's governmental committees on overseas development aid. In recent years

training places for staff from botanic gardens in other countries have been provided, supporting institutional capacity building in countries with which the Gardens has particular links, such as in Belize, Chile, China, Jordan, Mauritius and Russia.

Efforts are being made to ensure that the sustainability principles of the institution are demonstrated to visitors throughout the Gardens' activities. For example, only Fair Trade tea and coffee are now served in the Gardens' restaurant and some organic food options are provided too. The Gardens are also closely involved in a major urban regeneration project in Ballymun, a part of Dublin city where there have been major social and environmental problems for decades. The Ballymun link for the Gardens includes participation in community composting programmes, development of a local biodiversity strategy and action plan and encouraging and supporting the development of local gardening groups.

4. Education for and about the environment

Sustainability is a key and fundamental part of the education programmes, much of which is focused on the theme



of education for sustainability. Special guided tours and workshops are provided (free of charge) for schools on sustainability. Annual evening courses on gardening and Irish botany are provided for the general public, which have proved very popular since they were launched in 2004. Over 600 students have passed through these two courses since their commencement.

An important annual educational event organised by the Gardens now in its third year is a special 'Sustainable Environment Fair' that is held over a weekend in May or June. A range of environmental organisations are invited into the Gardens for the event and other activities are organised, such as an organic Farmers' Market, recycled wooden furniture sales, basketry and wood turning demonstrations, guided tours of our sustainability efforts and sales of fair trade and other products. A popular part of the event is the networking that takes place between the exhibitors too.

5. Recycling and reducing waste and energy consumption

One of the greatest sustainability challenges for the Gardens has been in the area of waste reduction and

Above left and below: View of the arboretum at the National Botanic Gardens

Bottom left: *Daboecia cantabrica*, growing through *Ulex gallii*, two heathland species from the west of Ireland





Above: School children participating in an environmental education programme

recycling. Each year visitors to the gardens left thousands of tonnes of waste in its litter bins, all of which had to be disposed of. In 2004 only 20% of the waste generated in the Gardens and sent off-site for disposal was recycled – 80% went to landfill. It was realised that this was unacceptable and a new target of reversing these percentages was adopted: to ensure that 80% of waste leaving the Garden is recycled and only 20% goes to landfill by 2010. Good progress has been made towards this target. Today about 60% of waste is recycled and the volume of waste generated has been cut by more than 50%.

In 2009 an experiment was conducted to establish a number of recycling centres in the Gardens, by including 'green bin' options for use by visitors. In the event the experiment was completely unsuccessful and some visitors continued to dispose of all forms of waste in any bins provided – green or otherwise. Volumes of waste left by visitors actually increased! In November 2009 an alternative approach was initiated – to remove all waste bins from public places in the Gardens. To date this approach has been highly successful with few complaints, little increase in litter and a greatly reduced volume of waste that must be processed. An added advantage and incentive for this approach has been financial savings of thousands of Euros already achieved on the cost of removal, sorting and disposal of rubbish left by visitors. The Gardens' policy to reduce energy consumption and using energy from sustainable sources has been more difficult to achieve. The National Botanic Gardens includes a wide range of major heated greenhouses, mostly strictly protected historic buildings in which very little original energy

Right: Organic vegetable produce from the new Fruit and Vegetable Garden

(Photos: National Botanic Gardens of Ireland)

efficiency was included. Nevertheless during the restoration of several of these in recent years new computer-based environmental controls have been fitted which help to minimise unnecessary heat loss; but more needs to be done. Efforts are made to reduce minimum temperatures in the greenhouses, offices and other buildings. A 'Turn down/switch off' campaign for staff has been launched, guided by a team of energy conservation officers chosen from the staff of the Gardens and representing each area of the institution. Monthly energy consumption tables and graphs are generated so that performance can be monitored on an on-going basis. Annual targets have been set for energy consumption reductions and we continue to seek innovative solutions to saving energy wherever we can throughout the institution. The feasibility of introducing a hydro-electricity generating turbine on a river flowing through the Gardens is being investigated, as well as evaluating new biomass fuel options for heating the nursery and other buildings. Whenever machinery requires to be replaced, efforts are being made to obtain electric powered vehicles and other equipment, instead of the traditional reliance on petrol and diesel powered-equipment.

Conclusion

It is a huge challenge for any major institution to become a model for sustainability and the National Botanic Gardens of Ireland is no exception to this. Nevertheless some significant first steps have been achieved, not

only in recognising and accepting that environmental sustainability has to be at the heart of the institution but also by implementing practical measures to enhance sustainability throughout the institution. However there will be a very long road to travel before a complete transformation in this regard is achieved. All we can hope for is to make gradual improvements, set realistic but ambitious targets and work to achieve those targets; monitor our progress and celebrate achievements and successes, while at the same time accept that not all efforts will be successful; and be prepared to try out new ideas.

One of the most successful drivers of change for sustainability will be for economic reasons. If financial savings can be made (for example through reduced energy costs) there is a very positive incentive for an institution to 'go green', quite apart from the moral and ethical reasons. Being 'sustainable' does not always need to be a costly or more expensive option.

Finally, it is important to ensure that the sustainability 'ethos' is supported by all staff, who will be crucial to its achievement. The staff team will be the force that transform policies and our environmental rhetoric into the practical action that will deliver the model of sustainability that we all wish to achieve for our institutions.

Peter Wyse Jackson
National Botanic Gardens of Ireland
Glasnevin, Dublin 9. Ireland
Email: peter.wysejackson@opw.ie



Gaining accreditation for sustainability - Oman Botanic Garden and Leadership in Energy and Environmental Design (LEED)

Oman Botanic Garden

Situated about 20 km from Oman's capital city of Muscat, the now fast-developing Oman Botanic Garden will be the first major botanic garden in the Sultanate of Oman and one of the few in the Middle East.

Originally proposed by Oman's ruler, Sultan Qaboos bin Said, the Oman Botanic Garden concept has been developed by the Office for Conservation of the Environment, Diwan of Royal Court and remains its responsibility. The botanic garden will feature the flora of Oman in a series of naturally occurring and re-created habitats on a site of approximately 420 hectares. The habitats to be featured will include the northern mountains, seasonal rainforest, gravel and sand deserts and wadi ecosystems. Despite its largely arid landscape, Oman has an impressive number of indigenous plant species. In fact, in a review of the world's biodiversity hotspots, southern and central Oman were added to the

'Horn of Africa' hotspot, which includes threatened and degraded areas of high plant endemism.

Focusing on the native flora of Oman and the Omani culture, the Oman Botanic Garden will illustrate the linkages between plant diversity, culture and traditional knowledge through displays on a wide range of plant uses, from food to medicine to cosmetics to clothing, and their traditional management systems.

The new on-site nursery is already operational and construction of the visitor orientation, research and education centres and heritage village has commenced. The garden is expected to open in 2012.

Main sustainability issues to be faced

Oman's climate is hot and dry with an average annual rainfall of less than 100 mm. This aridity means that maintaining an adequate supply of water for agricultural and domestic use is Oman's most pressing environmental problem. Both the limited average rainfall and occasional droughts contribute to shortages in the nation's water supply and this will impact strongly on the future management of the Oman Botanic Garden.

In addition, the OBG will be displaying the striking unique woodland and succulent plant communities from Dhofar, southern Oman. The south-



west monsoon results in seasonal dense mists and rainfall in this area. Maintaining such flora, which will be displayed in a large conservatory, will put yet further pressure on the OBG in relation to water use.

Policy regarding sustainable practices

One of the goals of the Oman Botanic Garden will be to assist in changing both national and global approaches to sustainability. To achieve this, Oman Botanic Garden will be built and managed using the latest

Above: Oman Botanic garden site at dusk with *Acacia tortilis* (Photo: Sarah Kneebone)

Left: Desert rose being grown in the nursery (Photo: Sarah Kneebone)





Above: Material for cultivation is collected from the wild as seeds or cuttings (Photo: Sarah Kneebone)

Top right: The arid and fragile site of the new Oman Botanic Garden. Great care is being taken to limit disturbance (Photo: Mark Richardson)

conventional buildings in metropolitan areas rather than broad-scale botanical reserves it was still seen to be appropriate for specific buildings planned to be built within the Oman Botanic Garden. These are, namely, the Orientation, Field Study and Research Centres. Whilst only these buildings are specifically identified for LEED accreditation, the principle of sustainability in design and construction is being developed and used throughout the Oman Botanic Garden.

As the LEED program was initially based on office and commercial buildings in the US there have been some interesting challenges in adopting it to a relatively remote botanic garden project in the Middle East. None the less, innovative design and ongoing cooperation with the construction contractor has allowed for the project to be aiming for the Gold LEED Accreditation status. Although the Oman Botanic Garden will be the first in the region to seek LEED accreditation, several have already done so in North America. These include the National Tropical Botanical Garden Botanical Research Center at the Kalaheo headquarters, Kaua'i, Hawaii which achieved Gold and the Queens Botanical Garden Visitor & Administration Center in New York which achieved Platinum. The new Californian Academy of Science is promoting itself as the 'greenest museum in the world' through achievement of its platinum certificate, and includes details on a comprehensive website.



The Oman project embraces sustainability over a wide range of design parameters covering site selection, energy and water efficient processes, selection of materials and resources as well as catering for the personal environmental quality of the building for its occupants,

This ranges from car park design that promotes car pooling and fuel-efficient vehicles to the selection of water efficient plants in landscaping and the use of recycled water for irrigation and toilet flushing as well as water conserving bathroom and kitchen fixtures.

As sunshine is an abundant resource in Oman, the buildings lend themselves well to the use of renewable energies via photovoltaic cells and solar thermal panels on the rooftops. Renewable energy will be used in conjunction with architectural design to produce buildings that are 35% more energy efficient than similar 'non-green' buildings.

Material selection in the construction process promotes the use of recycled content such as fly ash in concrete, locally manufactured materials,

environmentally-friendly technologies wherever possible. Much of the water required will be from rain-replenished bores and recycled waste water, treated via a series of reedbeds. In addition, energy requirements are planned to be met in part from renewable sources, primarily solar power.

However, even if sustainability is accepted as being a premium principle underlying the development of a new or existing institution, the question remains, *How can the institution's success be measured?* To try to address this, it was decided early in the planning phase that all of the Oman Botanic Garden, or a sizeable part of it, will achieve Leadership in Energy and Environmental Design (LEED) certification.

Leadership in Energy and Environmental Design

LEED is a "green building" accreditation program, established in 1998 by the United States Green Building Council which provides projects with a Certified, Silver, Gold, or Platinum accreditation status. (<http://www.usgbc.org/>).

Right: LEED was initially established to accredit sustainable building design, construction and operation for office and retail facilities in the United States. Although the programme suits *Acacia tortilis* on site (Photo: Sarah Kneebone)



accessing timber from approved and accredited sustainable forest operations and sourcing rapidly renewable products. During the construction period very tight targets are placed on the generation of waste and materials are segregated and sorted to ensure an absolute minimum goes to landfill. For example, waste concrete is crushed on site for reuse in road base or temporary access roads.

The internal work environment provided for the buildings' occupants is also considered and all paints, sealants, glues and carpets are selected to meet stringent requirements relating to the emission of organic compounds. The buildings are designed to maximise natural light and ventilation as well as the temperature and lighting needs of their occupants.

The selection and procurement of these materials has been a challenge as the local Oman market is fairly immature in terms of technical requirements of green building products. However persistence, and education of providers, has been met with quite a degree of success in finding these products.

An important aspect of Oman Botanic Garden's use of sustainable practices will be their promotion. Oman Botanic Garden will be the first LEED accredited building in the Sultanate of Oman and many of the technologies being used have never been applied before in Oman. The notion of 'green buildings' in Oman and hopefully the region will be promoted through the Oman Botanic Garden with interpretive signage and educative material pointing out elements of the building that contribute to sustainability in design.

One of Oman Botanic Garden's main education goals is to engage visitors with the environmental problems faced

by the country and empower them to take action in their own lives. Within site interpretation will promote a wide variety of methods and tools for individuals to 'live more lightly', including those encompassed by LEED. Wall cut-throughs to show layers of insulation, digital displays of the power output of the solar panels, animation of the processes taking place in the reed bed filtration and panels about the low Volatile Organic Content of the interior finishes will all help to show what the garden is doing to address its own footprint, inspire others to do the same and win an additional LEED point.

As the Oman Botanic Garden will involve the construction of numerous large specialised buildings and the services and facilities to support them, great care needs to be exercised in ensuring that the delicate and beautiful landscape is protected during construction. In order to minimise the footprint of impact of construction, specialised planning processes are implemented prior to construction and the contractor's workforce are specially trained in appropriate use of heavy machinery and vehicles. Site detail and logistic plans are produced to ensure that stockpile, lay down areas and haul routes are located in areas of permanent development so as to limit disturbance for the long term. Topsoil is stockpiled to retain the existing seed bank for future rehabilitation and trees and vegetation are protected throughout construction.

Summary

The interest in achieving sustainability and reducing environmental impact in new building projects is growing fast, as is the need to demonstrate that such goals are actually being met.

The Oman Botanic Garden is helping to lead the way in the Middle East, not only in terms of the conservation of the country's indigenous flora and related cultural heritage, but also in relation to the need for commitment to sustainable design, construction and operation in new building projects. Using the LEED accreditation scheme, the Oman Botanic Garden will be able to demonstrate its success in employing a wide range of

environmentally-responsible practices and techniques. While the LEED scheme is enabling the project to gain recognised accreditation, there have been many issues associated with using a scheme developed for very different conditions. There are already a number of equally credible schemes that may be more relevant to a particular project; these are worth investigating prior to commencing on this extremely worthwhile process.



Left: Part of the site will be maintained as a nature reserve (Photo: Sarah Kneebone)

Further Reading

Oman Botanic Garden
<http://www.oman-botanic-garden.org>

U.S. Green Building Council:
<http://www.usgbc.org/>

California Academy of Science:
http://www.calacademy.org/newsroom/releases/2008/leed_platinum.php,

Craig Tucker
Environmental Sustainability Manager
Bovis Lend Lease International Ltd
P.O. Box 246, Muscat 100
Sultanate of Oman
Email: craig.tucker@eu.bovislendlease.com

Sarah Kneebone
Education and Interpretation Expert
Oman Botanic Garden
P.O. Box 246, Muscat 100
Sultanate of Oman
sarah.kneebone@oman-botanic-garden.org

Mark Richardson
Botanical Consultant
P.O. Box 41
Greenacres, SA 5086, Australia
mrichardson.consultant@yahoo.com.au

Left: Natural vegetation on the site of the Oman Botanic Garden (Photo: Sarah Kneebone)



Water conservation initiatives of the Royal Botanic Gardens Melbourne

Right: Automatic irrigation system - 150 mm main line trench through the Mounds Area

Background

The availability of water for urban landscapes is under increasing threat, whether from regulation, social-political views, population demand or the impacts of climate change. Most Australian cities have imposed severe water restrictions at some stage within the last decade. Melbourne is currently on stringent restrictions and approaching critical water shortages after a decade of unprecedented below average rainfall conditions. It was through strategic planning that the Royal Botanic Gardens (RBG) Melbourne began its water management journey in 1993, well before the current water crisis now experienced in Victoria. The Gardens became recognised as a leader in urban landscape management. Public recognition of RBG Melbourne's achievements was highlighted by the Savewater awards with the RBG winning Garden and Design Construction categories in 2003 and 2004, and reaching the finalist shortlist in 2003 (Efficiency in Government) and the Garden Management category in 2005 and 2006. RBG Melbourne was one of the first Australian botanic

gardens to develop irrigation management plans to guide efficient water use and these plans have been used as a resource by other Botanic Gardens (Devin Riles pers. comm., 2008, Irrigation Specialist, Denver Botanic Gardens, USA).

Below: Aerial photograph of RBG Melbourne



The picturesque landscape of RBG Melbourne covers over 38 hectares of managed land. Over 50,000 individual plants are cultivated in the living collections representing a diverse 12,000 taxa from a variety of habitats and geographical locations around the world. Considerable benefits are provided to the community with the Gardens enjoying over 1.6 million visitors during 2007-08 which was a 14% increase from 2006-07.

RBG Melbourne's intrinsic diversity of plants, environments, soils, landscapes and functional activities presented both stimulating challenges and opportunities for adopting appropriate strategies to improve water use efficiency.

Strategies to improve water use efficiency

Strategy 1 – Upgrade delivery infrastructure

Past landscape irrigation practices revolved around the daytime use of an inefficient manually operated hose and sprinkler system. Water losses to evaporation are highest during the day and these are exacerbated by more exposure to wind. Another significant issue was that up to 70% of the Curator's time was estimated to be spent just on shifting sprinklers.

Following extensive hydraulic modelling and soils surveys, the installation of an automatic irrigation system (AIS) was completed during 1993-1994 at a cost of over AUD \$1.3 million (US\$1 million).



Careful attention was given to installation techniques such as directional boring to ensure minimal disruption

to the mature landscape, particularly the health of existing trees. Today the PC centrally-controlled system comprises of 18 satellite controllers, 480 stations, 6,800 sprinklers, 4 flow sensors, 16 soil moisture sensors and over 40 kilometres of pipework. In consideration of the past historical difficulties to effectively irrigate the living collections, the completion of the AIS was a very significant milestone for the Gardens.

Strategy 2 – Focus on professional development

In 1995, water management training and subsequent development of irrigation scheduling methodologies was facilitated by Burnley Campus, University of Melbourne. This training initiated an improvement in understanding soil hydrology, plant water use and climatic factors at a time when the knowledge of urban water management was very limited. Following the training there was an immediate improvement in water use efficiency of about 230%. Commitment to professional development and the practice of applied science cannot be over emphasised. For example, the total cost of the training programs in Melbourne gardens is estimated to be less than AUD\$5,000, while those same employees have helped deliver

water savings since that time of about AUD\$1.4 million. Water management development programs are continued to ensure that employees are provided with the current scientific information and skills to inform horticultural judgement. The present reputation of RBG Melbourne as an efficient water user in the community can be primarily attributed to the early development of employee expertise in water management.

Strategy 3 - Develop research and industry partnerships

One of the core values of the Gardens is the emphasis in the development of strong relationships with other organisations for mutual benefits such as research outcomes. Applied science and industry expertise are vital foundations for continuous improvement.

University of Melbourne

Since 1995, RBG Melbourne and University of Melbourne continued on from those early training programs to develop a strong partnership in urban water management research and publication including technical presentations at various conferences. Currently, this partnership includes an industry partner - Sentek Pty Ltd an Australian manufacturer of soil moisture sensors - in a project to examine landscape water use against inputs from soil moisture data, automatic weather station and human insight through horticultural judgement. Methodologies are currently being developed to assist in the management of complex landscapes under water scarce conditions and according to soil moisture stress indicators. A paper was presented at the Irrigation Australia national conference in May 2008.

Monash University

Monash University and RBG Melbourne are also engaged in a project to study rainfall interception by mature tree canopies in the urban landscape. Indicative results indicate interception losses (Xiao *et al.*, 2000) of up to and over 60% of monthly rainfall. This is an important issue as there is some evidence that the nature of rainfall patterns in Melbourne is also changing to the extent that more rainfall will be intercepted (David Dunkerley pers. comm., 2009,



Associate Professor, School of Geography and Environmental Science, Monash University) notwithstanding any further impacts from climate change. With tree canopy coverage of over 60% across its landscape, the study of rainfall interception is very pertinent as an irrigation management issue for RBG Melbourne.

The quality of existing water bodies is also a very important consideration when focussing on integrating site hydrology. The Water Studies Centre, Monash University and RBG Melbourne have been working together through quality student projects to build a knowledge base on the RBG Lakes System for improving water quality, ecosystem functioning and future capacity for water storage.

Irrigation Australia

RBG Melbourne has been a member of the peak industry body - Irrigation Australia (IAL) for about a decade. Since 2004, the Gardens have been the preferred host site of IAL in Melbourne for the delivery of irrigation efficiency training due to the added value of its water management experience and site diversity. Over ten workshops have been sponsored by the Gardens so far to extend the benefits of water management expertise out into the wider community.

South East Water

Since 1999, RBG Melbourne has enjoyed a strong relationship with its water authority - South East Water Limited (SEWL) through delivery of water conservation information to the community, particularly through the award-winning Water Conservation Garden. This collection was developed and is maintained by sponsorship from SEWL. Due to its track record in significant water conservation and heritage importance, RBG Melbourne has been allowed limited exemptions by SEWL from water restrictions since November 2002. SEWL regularly draw

on the water management expertise of RBG Melbourne when examining urban water management in the broader sector.

Strategy 4 - Improve application efficiency

Improve sprinkler effectiveness

Interception of the sprinkler stream by foliage, branches and trunks of plants compromises effective delivery. Stream-type sprinklers are more effective and efficient than sprays in delivering water through shrubberies and were adopted widely across the landscape. Most spray-type sprinklers have been replaced with modern multi-stream types. These were found to be significantly more efficient when tested by horticultural employees. Some of the current difficulties are maintaining reasonable clearance around sprinklers through plant selection and judicious pruning to optimise sprinkler performance.



Left: Monash University Water Studies Centre Student projects - sediment study

Left: Measuring pressure of rotating stream sprinkler that was used highly effectively in garden beds

Optimising the use of rainfall

Attaining high levels of efficiency also involve making the best use of any rainfall. The use of a 10 mm effective rainfall event across RBG Melbourne results in a potential saving of 3.8 million litres of water or AUD\$4,600 in today's costs. In early 1999, improvements to flow management and pressure resulted in an increase of the effective flow rate of the irrigation from 35 L/s to 50 L/s. Although available flow rate was increased by 43%, average irrigation water use decreased by about 40-50% during 1999-2007. The generation of high flow capacity through hydraulic efficiency provides much greater flexibility in scheduling as operators can afford to delay irrigation and increase the probability of harvesting additional rainfall.

Measure performance

Many performance measures proposed to determine water use efficiency are best suited to production agriculture

Right: Making best use of landscape rainfall



Right: Automatic weather station

and horticulture (turf-farms, floriculture) where the end product can be measured in quantity compared to the water used. Irrigation performance for ornamental landscapes is often subjectively measured in a qualitative manner as plant aesthetics and health are regarded as paramount. RBG Melbourne adopted an irrigation management performance indicator called the Irrigation Index (ii). This indicator accounts for climatic conditions and specific plant water use rates. It is calculated by dividing the volume of water actually applied to the site by the estimated requirement. For example, an irrigation index of 1.0 is the 'ideal' rating, while a result of 1.3 would possibly indicate a 30% oversupply. From 2000-2009, during severe drought conditions, irrigation indices of 1 have been consistently achieved. In more recent years an irrigation/rainfall aggregate of <900mm per annum and less than 90 litres/visitor/year have also been set as benchmark targets to cater for climate change shift and increased visitation demands. Auditing of irrigation systems is also undertaken by specially trained staff to assess efficiency. Distribution Uniformity (DU) is a measurement of sprinkler uniformity that is examined against the RBG Melbourne target to maintain all sprinkler irrigated turf areas with a Distribution Uniformity (DU) value greater than 75%.



irrigation management, obtain records for BOM, and assist in the horticultural management of the site. A modified Penman-Monteith algorithm (FAO, 1990) calculates the evapotranspiration rate (ET_o) of a standard 'crop' from a wide range of climatic variables such as solar radiation, air temperature, wind speed and relative humidity. Crop coefficients (K_c) (Allen *et al.*, 1998; FAO, 1990) are required as modifying values to adjust ET_o and calculate evapotranspiration of distinct plant types or landscape zones. Up to four specific landscape irrigation schedules (High X, High, Medium and Low) based on distinct landscape coefficients KL (Costello & Jones, 2000) are applied to both garden and turf areas (Connellan & Symes, 2006). It has been the Garden's experience that weather-based irrigation scheduling can be successfully applied to maintain the health of highly diverse plant collections and landscapes.

Soil moisture sensors

Sixteen tension-based 'Watermatic' soil moisture sensors are installed in turf areas across the Gardens and the data is directly fed back to the irrigation control system for monitoring. This system has the ability to cease irrigation upon reaching certain set-points in soil moisture.

Up-to-date and detailed knowledge of the extraction of soil moisture from the different soil layers in the garden beds at RBG Melbourne is proving to be extremely valuable in the water management of these gardens. In a collaborative project with Sentek Pty Ltd and the University of Melbourne, landscape soil moisture is being monitored by multi-sensor capacitance type probes (EnviroSCAN®), supplied by Sentek Pty Ltd in selected garden beds. This information is continuously relayed at frequent intervals to a host website from where it can be viewed and analysed by the project partners.

Soil moisture sensing technology assists adaptive irrigation management in providing information on actual plant water use rates, rainfall effectiveness, drainage rates and the influences of mulch, overhead tree canopy and water repellent soil on soil hydrology.

Strategy 6 – Reduce water demand Warm-season grasses

Due to physiological (C4 photosynthesis) and morphological adaptations (deeper rooting), warm-season grasses are more efficient users of water than cool-season species and can be managed to use up to 30% less water. Changing landscape turf composition from cool-season grasses to one dominated by warm-season species, either by management techniques or direct propagation, was one strategy to improve water use efficiency. A form of regulated deficit irrigation (RDI) is also applied to transition from a domination of cool-season grass to warm-season in early summer. This has been successfully managed to the extent that turf areas in the Gardens now use less water annually compared to garden beds.

Right: 'Plugging' of warm-season grasses



Water sensitive urban design

The Water Conservation Garden and the Melbourne-indigenous flora collection developed at Long Island are key examples of proactive landscape planning to reduce water demand. Both areas are more adapted to Melbourne's climate, including seasonal dry periods. Long Island receives no supplementary irrigation and the Water Conservation Garden is watered at about 50% of other moderately irrigated garden areas. Guilfoyles Volcano is a landmark project just in the making and will feature xerophytic plantscapes, water reuse, efficient irrigation and water quality treatment.

Right: Early auditing program of sprinkler system using recycled pet food tins as catch cans



Strategy 5 - Adopt current technology

Automatic weather station

Horticultural staff initially relied on climatic information supplied by the Melbourne Bureau of Meteorology (BOM) to guide irrigation scheduling. However this data was not representative of site conditions. In 1998, an automatic weather station (AWS) was installed in RBG Melbourne to provide climatic data to assist



Strategy 7 - Diversify alternative water sources

The Gardens is currently planning the development of a stormwater harvesting system and the improvement of ornamental lake water quality through recirculation, bioremediation and wetland construction. About 50% of the funding has been provided for the construction of the AUD\$2.2 million 'Working Wetlands' scheme through philanthropic donation, whilst the rest is being sought through government. However the projected additional annual water volumes of 70 ML will only be enough to maintain the lake quality as rates of evaporation are too high to also support irrigation demand. For water supply security, additional sources of decentralised alternative water supplies are currently being sought, particularly those that do not rely on continued patterns of average rainfall. Current projections are suggesting a potential decrease in average rainfall for the Port Phillip Catchment of Melbourne (where RBG Melbourne is situated) of up to 24% less by 2070 (DSE, 2008).

Strategy 8 - Adapt to climate change

Plant selection methodologies are being applied to facilitate a transition to a landscape more suited to less water demand and greater heat tolerance over the next 50 years, whilst still maintaining the heritage style. Gardens policy has been developed and documented through the Masterplan Review and Living Collections policy. Regardless of whether alternative water sources can be identified, RBG Melbourne is still planning for the future on the basis of increasing average temperatures (up to 2.6°C by 2070) (DSE, 2008). Whilst extremes in temperatures are also a threatening process for the landscape – in late January 2009, Melbourne

experienced three consecutive days over 40°C which had a very significant impact on many of our living collections. These temperature issues are very difficult to mitigate unless significant adaptation to the planting palette occurs over time. In October 2008, one employee completed a 4-week technical scholarship (funded by the Friends of RBG Melbourne) tour of Southwest USA landscapes and botanic gardens to glean insights into implementing these adaptations. Research is currently being done to try and establish comparative climates (homoclimes) with Melbourne using past long term averages and also for future projections as a guide for plant selection. One simple model that has been used is an Aridity Index (Gentilli, 1971) that only requires monthly temperature and rainfall data which are relatively available around the world. Plant selection frameworks are also being developed concurrently with climatic comparisons.

Summary - Strategies to improve water use efficiency

1. Upgrade delivery infrastructure
2. Focus on professional development
3. Develop research and industry partnerships
4. Improve application efficiency
5. Adopt current technology
6. Reduce water demand
7. Diversify alternative water sources
8. Adapt to climate change

The adoption of these strategies resulted in progressive water savings of 50-60% from 1994-95 to 2008-09 over a decade of drought conditions.

More information

RBG Water Conservation Webpage
http://www.rbg.vic.gov.au/gardening_in_fo/water_conservation

RBG Melbourne Urban Landscape Water Management Research Webpage
http://www.rbg.vic.gov.au/research_and_conservation/Urban_Landscape_Water_Management_Research

Irrigation Australia 2008 National Conference Paper
<http://www.irrigation.org.au/assets/pages/75D132F4-1708-51EB-A6BCF9E277043C3E/19%20-%20Symes%20Paper.pdf>

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Peter Symes
Curator
Environmental Horticulture
Royal Botanic Gardens Melbourne
(Private Bag 2000)
Birdwood Avenue
South Yarra
Australia 3141
Email: Peter.Symes@rbg.vic.gov.au

Top left:
Construction of
Long Island and
Wetland

Left: Water
Conservation
Garden

(Photos: RBG
Melbourne)

The Sustainable Sites Initiative

Two botanic gardens partnering toward sustainable landscapes



Above: Public access through restored wetlands at Point Fraser, Australia (Photo; Syrinx Environmental PL)

Introduction

The Lady Bird Johnson Wildflower Center in Austin Texas and the United States Botanic Garden in Washington DC have partnered with the American Society of Landscape Architects (ASLA) for the last three years developing the Sustainable Sites Initiative. Working with a large diverse group of supporting organizations, this initiative has developed a set of voluntary guidelines and benchmarks that will reduce the environmental impact of designed landscapes.

Botanic Gardens are in an excellent position to understand the use of 'green' techniques and all three partners have been aware of the gaps in current 'green building' technologies. Through the last decade there has been a substantial increase in sustainability awareness and in the number of standards for sustainable

structures or 'green buildings'. In ten years the United States Green Building Council (USGBC) has seen thousands of buildings certified through LEED®, tens of thousands of professionals become LEED certified and the building industry transformed. Green Globes, the Green Building Initiative and countless global organizations continue to challenge the way structures are designed, built and maintained. However, despite this tremendous growth, there were no comprehensive guidelines to create and measure sustainable landscapes. Yet landscapes have great potential to do environmental good and counter previous environmental damage. As a result of this, the Lady Bird Johnson Wildflower Center, ASLA, and the USBG joined forces to insure this vital piece of the built environment is not overlooked. Working with a diverse group of stakeholder organizations the Sustainable Sites Initiative began concentrating on the hydrology, materials (*use and waste*), soil, vegetation and human health as related to a constructed landscape. Analyzing these site components through the lens of ecosystem services should help shape the guidelines to promote not only ecologically sensitive design, construction and maintenance, but landscapes that are also ecologically regenerative.

Ecosystem services are the collective resources and assets provided by the natural world and are the foundation of human existence. Temperature

mitigation, climate control, clean water, clean air, carbon (greenhouse gas) storage are only a few ecosystem services that are crucial, yet these services and the natural world that provides them are underestimated or simply ignored throughout land-use decisions. As these have begun to diminish or disappear, we have made attempts to replicate them. However the difficulty, expense and futility of attempting to replicate these services has become apparent.

A central message of the Sustainable Sites Initiative is that a landscape - any landscape - whether the site of a large housing development, a shopping mall, a park, an abandoned rail yard, or even one home, holds the potential both to improve and to regenerate the services provided by natural ecosystems. With careful consideration through the planning, design, construction and maintenance of landscapes, the natural world should be viewed not as a hindrance, but a resource. Landscapes can assist in the efficient use of resources as well improving air and water quality, reduce the urban heat island effect and sequester carbon, along with many other ecosystem services.

The Sustainable Sites Initiative is therefore creating guidelines to conserve, protect and restore resources, reduce pollution and improve the quality of life and long-term health of both communities and the environment.



Using appropriate plants

Vegetation and soil can help reduce the amount of carbon dioxide, a greenhouse gas, in the atmosphere by capturing and storing it. Studies indicate that in the United States, urban trees capture up to 25 million tons of carbon each year. However appropriate plant use in landscapes is very important. Approximately 85 percent of the invasive woody plant species in the U.S. were introduced for landscape or ornamental use and approximately 5,000 plant species have escaped into natural ecosystems, resulting in millions of dollars in control costs (Pimentel *et al.*, 2005). Through competition with native plant species, invasive species are a threat to native flora and fauna.

Correctly using vegetation can also reduce costs associated with urban heat islands and protect plant and animal biodiversity. Strategically planted vegetation can reduce the energy spent for cooling buildings by up to one quarter. In New York City alone, a study found that trees provided an annual climate-moderating benefit of \$27.8 million, or \$47.63 per tree. Studies by *American Forests* (2001) found that tree canopy reduces residential home cooling costs, saving

an average of between \$11 per household per year in Portland, Oregon, and \$28 per household per year in Atlanta, Georgia. Multiplied across the region, this household benefit can add up: in the Atlanta region, savings in home cooling costs amount to \$2.8 million per year.

Managing soils

Soils compacted during landscape modifications and construction lose the ability to absorb storm water and to supply plant roots with air and water. Over time, soil fertility and health is destroyed by the use of herbicides, pesticides and chemical fertilizers – all of which are currently accepted landscaping practices. Natural organic products and the use of onsite composting can limit and remediate soil damage by mimicking natural nutrient cycles.

Waste management

Retaining and recycling land-clearing materials, construction waste and maintenance debris lowers the cost of waste disposal and could reduce the need for new purchased materials and soil amendments such as compost and mulch. In 2007, approximately 33 million tons of yard waste and landscape trimmings entered the municipal waste stream, representing 13% of total municipal waste in the United States (U.S. Environmental Protection Agency, 2007a). Sustainable Sites will emphasize turning waste into a resource. Sustainable landscapes will greatly reduce waste from construction as well as from landscaping materials and 'green' waste, decreasing the pressure on landfills.



Water use

Lowering the use of potable water in landscapes is another goal of the Sustainable Sites Initiative. Irrigation of current (unsustainable) landscapes accounts for more than a third of residential water use—more than 7 billion gallons per day nationwide (U.S. Environmental Protection Agency, 2007b). On average, a U.S. citizen uses 200 gallons of water daily to maintain turf grass lawn. Turf grasses on residential and commercial lawns, golf courses and other landscapes is the single largest irrigated crop in America. Furthermore, one quarter to half of the electricity used by U.S. cities goes to treat municipal water and wastewater. To make matters worse, up to half of landscape irrigation water may be wasted as a result of evaporation, wind, improper system design and overwatering. While storm water runoff from impervious surfaces is a major pollutant in urban and suburban watersheds, the capture and use of such water runoff can save money and benefit the environment. Therefore a sustainable landscape minimizes, if not eliminates, the use of potable water for irrigation and promotes the reuse of storm water and the use of regionally appropriate plants.

Above:
Site diagram for the Visitor and Administration Center at Queens Botanical Garden (Photo: Conservation Design Forum)

Above left:
American Society of Landscape Architects green roof (Photo: Keith Swan)

Left: Habitat restoration of a former brownfield site at Point Fraser, Australia (Photo: Syrinx Environmental PL)



Reducing pollution

Healthy landscapes with functioning ecosystems filter airborne contaminants, an issue in areas with high automobile emissions. According

Right:
Mery Lea
Cottages (Photo:
Luke Gascho)

to the Environmental Protection Agency, lawn mowers, blowers and other landscape maintenance tools contribute more than 5% of total U.S. air pollution. Careful design of landscapes can reduce our reliance on single cycle engines for maintenance. Sustainable landscapes can also help convert airborne pollutants into clean air as they grow and develop.

Reduction or elimination of the reliance on chemicals is an important factor in sustainable maintenance practices.

A National Research Academy of Sciences study found that more pesticides are used on suburban lawns and gardens than for agricultural use. Not only do these chemicals contribute to water pollution, they require substantial inputs of energy in their manufacture. Heavy use of pesticides increases exposure to these chemicals, which are also carried by rainwater into streams and rivers. Sustainable landscapes require little or no chemical fertilizer, herbicides and pesticides, reducing toxic pollutants that find their way into waterways and groundwater.

Right: Captured stormwater in an ornamental feature at Queen's Botanic Garden (Photo: Jeff Goldberg/Esto)



Below: Point Fraser, Australia, Rendered Plan (Photo: Syrinx Environmental PL)



Human well-being

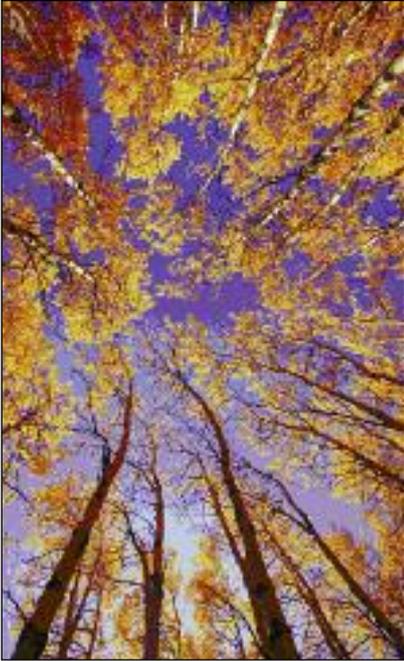
Research indicates that encounters with nature - a green view from an office window, a lunchtime stroll through a nearby park, well-tended landscapes around schools - restore the ability to concentrate, calm feelings of anxiety and reduce aggression (Ulrich, 1986). In addition, a Chicago study links tree and grass cover to fewer property crimes, fewer violent crimes, stronger ties amongst neighbours, more frequent use of common neighbourhood spaces and a greater sense of safety. Low-income communities in urban areas are disproportionately denied the benefits of safe open spaces for physical activity in parks and schools and disproportionately suffer from obesity-related diseases. The epidemic of obesity, inactivity, and related diseases such as diabetes is shortening

children's lives, destroying the quality of their lives, and costing the United States over \$100 billion each year (Pratt *et al.*, 2000).

Long-term vision

Although led by the Wildflower Center, the USBG, and ASLA, a tremendous amount of work has been done by experts from the Environmental Protection Agency's GreenScapes Program and Office of Water, the National Recreation and Parks Association, the American Society of Civil Engineers' Environment and Water Resources Institute, the National Association of County and City Health Officials, The Nature Conservancy's Global Invasive Species Initiative, the Center for Sustainable Development at the University of Texas at Austin, American Planning Association and the U.S. Green Building Council.

The initiative is expanding beyond LEED (Leadership in Energy and Environmental Design) by focusing efforts on improving landscape or site components of sustainable design. The Initiative uses ecosystem services as a framework to illustrate how sustainable sites can improve the quality of life in our communities. The standards and guidelines are based on extensive research with leading practitioners of sustainable approaches and aim to establish science-based parameters for evaluating the sustainability of landscapes during design, construction and maintenance. The Initiative will



provide sustainability principles for any site, with or without buildings, which will be protected, developed or redeveloped for public or private purposes, extending standards to new markets and bringing increased relevance to landscape architects, civil engineers, contractors, and land managers, as well as the large project portfolios they design, construct and maintain.. Examples include parks, corporate campuses, utility corridors and streetscapes. The U.S. Green Building Council (USGBC), a stakeholder in the Initiative, anticipates incorporating the Sustainable Sites Initiative standards and guidelines into future iterations of the LEED, but this 'green landscape' tool can also serve as a stand-alone tool for developers, landscape architects, civil engineers, planners, landscape designers, landscape contractors and land managers.



Left: Point Fraser - view from east (Photo: Syrinx Environmental PL)

Below: Evergreen Campus Aerial Shot (Photo: The Evergreen State College)

For more information and to learn about the pilot project phase and get involved, visit www.sustainablesites.org

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Ray Mims
Conservation Horticulture & Sustainability
United States Botanic Garden
245 First Street SW
Washington
District Of Columbia 20024
USA
Email: rmims@aoc.gov

Treborth Botanic Garden – saving a university botanic garden and making it count in education



Above:
Students
enjoying a work
day in the
Garden

Introduction

In May 2006 Bangor University announced the downscaling of its Botanic Garden at Treborth on the Menai Strait, North Wales after 45 years of service. The news prompted protest and concern from both the student body and the Friends of Treborth Botanic Garden. This article explains why this situation arose and how this special garden was rescued by a combination of youthful student support and concerted effort by local horticulturalists.

Early Years

Treborth Botanic Garden was founded in 1960 by Professor Paul Richards, world authority on rainforests and Head of the Botany School at Bangor. This initiative was supported by the Director of RBG, Kew at the time. Several glasshouses were relocated from the

Right:
The plant sales
at Treborth are
now one of the
major fund
raising activities

original botany gardens in the centre of Bangor and borders were created in six acres of unimproved, sheep-grazed pasture. The new Garden also included over 30 acres of mixed woodland and boasted a rocky shoreline. Half of the site was designated an Area of Outstanding Natural Beauty and a significant portion (the shoreline, woodland fringing the shore and a discrete area of ancient oak/ash woodland) was accepted as a Site of Special Scientific Interest.

In the mid sixties the well respected plantsman, Len Beer, became Curator. Contributions to the collection from Len and other staff helped form a broad-based undergraduate teaching collection. The Garden became well known for its collections of Rosaceae, Ericaceae and Orchidaceae. Nigel Brown took over as Curator in 1976 and assumed a significant university teaching role.

Research activities at Treborth centred on Professor John Harper's inspirational ecological studies of the Garden's species-rich, semi-natural grassland. These studies were extended in the seventies to include earthworm ecology leading on to the construction of two innovative underground laboratories, known as rhizotrons.

The overall use of Treborth by students was encouraged by the conversion of the original potting shed to a teaching laboratory in the late seventies. This facility proved enormously popular and

allowed greater use of the Garden for formal teaching and independent study. It also provided a resource for local schools, horticultural societies, wildlife conservation groups and art clubs. The growing number of interested members of the public led to the formation of the Friends of Treborth Botanic Garden in 1997 and a rapid expansion of activities.

In 2004 the Friends initiated the twinning of Treborth Botanic Garden with Katse Botanic Garden of Lesotho. This was an extension of the Wales-Lesotho link and offered Treborth an opportunity to share and gain knowledge, skills and experience with a new botanic garden. The twinning provided an excellent educational opportunity for two ecology undergraduates who travelled to Lesotho to conduct research on the endemic spiral aloe (*Aloe polyphylla*). The collection at Treborth now contains a variety of Lesotho and South African plants.





There has always been student involvement at the Garden, with frequent work days, lectures and events organised by the Friends. This became more formalised when the Students for Treborth Action Group (STAG) was established in September 2006. The group was able to become an official student society, which then received support from the Students Union. The effect of this on the Garden has been massive. Students now organise regular volunteer days, picnics, fun days, academic talks, walks and further fundraising events. Work parties held by both students and the Friends have installed much needed glasshouse insulation. By 2008, income generated by the garden and its supporters more than matched expenditure on heating lighting and water, and a ride-on mower was purchased by the Friends.

Left and below:
Botanical
Beats 5. Our
most successful
fund raising
event so far
with over 600
people

Impending closure

However, falling numbers of botany students and the natural loss of senior botanic academics in the eighties and nineties placed the future of Treborth Botanic Garden in increasing jeopardy. Plant biology was dropped as a degree subject at Bangor in 2005 due to the shortage of applicants nationwide, although botany modules continued to be offered as part of other degrees. Despite the Garden still being significantly involved in teaching, the decision to downscale Treborth was announced in May 2006.

Apart from questioning the academic need for a botanic garden the university was anxious to save itself the £17,000/yr (US\$27,500) running costs (heating, lighting and water) and the staff costs (curator and one horticultural technician). It proposed to eliminate both staff posts and shut down the glasshouses and laboratory. A core teaching collection of plants would be retained and accommodated in another glasshouse 6 miles away. The outdoor grounds would be managed by the university's Estates and Facilities Department as parkland with no further acquisition of specimens.

The horticultural technician (the only gardener employed at Treborth) was made redundant but the curator carried on. A liaison committee was established involving academic staff, Estates, students, and the Friends.

It tried to establish service level agreements for basic operations such as mowing but increasingly the shortfall had to be made up by the curator and volunteers.

Student concern and action

When students discovered the planned changes for Treborth, a support rally for the Garden was organised. This was incredibly successful with over 250 people present and coverage by local and national press. The University could not ignore the overwhelming support from the students and local community, so appointed a recent graduate to research the options for a more sustainable future for Treborth. A business plan with ideas and opportunities for the Garden was formed, encompassing the current financial problems, potential external funding and ideas for self generated income.

From the business plan stemmed the fundraising musical event 'Botanical Beats'. Supporters of Treborth, local musicians and artists all joined to provide a day of festivities, entirely powered by the Sycas-Circus solar and wind system. The event is now a highlight of the student and Treborth calendar. Botanical Beats offers Treborth a chance to attract a wider audience to the Garden and enthuse non-botanists about the natural world. The June 2008 event was the most successful yet, attended by 600 people and raising £3,500 (US\$5,700).



Positive developments

The Stanley Smith (UK) Horticultural Trust supported a 12 month appointment of a horticultural scholar at Treborth in 2007 (and will be financing another scholar in 2009/10) while the Friends of Treborth have employed part-time student assistants. Volunteers still very actively undertake horticultural maintenance and development (e.g. facilitating woodland management) and event planning.

The volunteers recently established a collection of rare native montane species from Wales including *Woodsia ilvensis*. Treborth Botanic Garden fully embraces the Global Strategy for Plant Conservation and has an *ex-situ* collection of 20 rare native plants including *Cotoneaster cambricus*,



Above:
The Friends
Committee
celebrating a
successful
Botanical Beats

endemic to the Great Orme a few miles east. The Garden includes species-rich woodland and grassland which merit proactive, informed *in situ* conservation. A dozen meadow plots of various size are mown at different frequencies to allow maximum flowering activity and species conservation. Rare native plant species benefiting from this include orchids (such as *Ophrys apifera* and *Listera ovata*), and the grassland fern, *Ophioglossum vulgatum*.

A significant area of woodland is threatened by alien *Prunus laurocerasus* and *Rhododendron ponticum* and much volunteer effort has been put into controlling this. Complementing the *in situ* woodland conservation, the Friends of Treborth have established a teaching collection of native woodland species, arranged by National Vegetation Classification Community.

As well as regular student classes on plant evolution, identification and ecology the Garden has an important zoological role. Large second year classes sample invertebrates using pit-fall traps. Final year students carry out individual investigations of birds and moths and help maintain a database of nightly moth catches which spans over 20 years. There is a pigeon loft which accommodates a strong research group investigating bird flight physiology. Developing educational resources for schools and the public is also a theme for student projects and a Living Fossil Trail has proved particularly successful.

A novel practical module this year will involve second year undergraduates experiencing all aspects of work at Treborth, from routine activities such as

watering, to seasonal propagation and planting – it is hoped that such experience will add significant value to biology and ecology degrees.

In September 2007 The Friends of Treborth secured a grant of £10,000 from the European Social Fund to establish a project involving the local community in exploring aspects of 'Plants and People' - in theory and in practice. This involved ten weeks of interactive sessions and field trips, with fourteen participants meeting twice weekly. This was the first time Treborth had received external funding to organise an adult course and it proved to be a great success, with requests for a repeat.

The Friends have recently facilitated a significant grant from the Better Woodlands for Wales Scheme to rid the Botanic Garden's woodlands of invasive rhododendron and laurel. A new wildlife pond, funded mainly through the Countryside Council for Wales (CCW) is under construction and will greatly increase suitability for schools' visits. The first Plant Sale of 2009 raised £1,700 (US\$2,800) and will help fund a part-time assistant for the Curator over the coming months. A Young Wildlife Explorers Club (4-11 year olds) got off to a flying start at Easter, introducing a new and enthusiastic age group to the Garden. June 7th 2009 sees 'Botanical Beats 6' in conjunction with a Wildlife Fun Day (as part of Biodiversity Week) – hopefully Treborth's biggest event ever!

External Support

It is pleasing to acknowledge the unstinting support that Treborth has received in recent times from major botanic gardens and institutions such as Kew, the National Botanic Garden of Wales, BGCI, PlantNetwork, PlantLife International and CCW.

So despite the serious threat two years ago Treborth has not only survived but developed and now has an even stronger body of support. Its purpose is still educational but the breadth of that role is increasing both in terms of age groups catered for and skills and subject matter offered. The Global Strategy for Plant Conservation will continue to play a key role in determining the direction of Treborth Botanic Garden's future. It is hoped that the Garden's future will be shaped by the combined efforts of students, Friends and trained horticulturalists. Success will be measured by the Garden's input into education at primary, secondary and tertiary levels, its appeal and usage by the public and by its direct contribution to scientifically rigorous conservation projects.

Sophie Williams
Treborth Botanic Garden
University of Wales
Bangor, Gwynedd, LL57 2RQ, U.K.
Email:
sophie.williams08@imperial.ac.uk
www.treborthbotanicgarden.org



Right:
Nigel Brown
welcoming the
audience at the
first Botanical
Beats

(Photos: Friends
of Treborth
Botanic Garden)

The greenness of gardens and the Conservation Garden at the North Carolina Botanical Garden

Introduction

In the last decade, 'green' has become a familiar adjective for environmentally friendly practices of all sorts. There are green products, green furniture, green buildings, and green development. At the North Carolina Botanical Garden, we have been building a new 'green' Education Center (set to open in July 2009) and among the many 'green' features of the building is something we call a 'green elevator' (it uses no hydraulic fluid and has the most energy efficient motor we could find). One day, as I led a tour of the construction site, I found myself thinking about the growing use of the word 'green'. This use is all very good, and even somewhat flattering to a botanist, but I found myself saying to the tour participants that day 'let's take back the word green - botanical gardens, botanists, and horticulturists had the world green first!'

Plants are doubly green - green in color and green because photosynthesis is the very process that takes carbon dioxide out of the atmosphere. In another sense, though, gardens aren't always 'green' in performance. Gardeners often think of themselves as pro-environment, yet some gardening approaches lead to unsound and unsustainable practices: overuse and conflict over water supplies, runoff of fertilizers or pesticides, unnecessary use of fossil fuels, and the spread of invasive plants and diseases. In this article I describe



Left: University students in a Conservation Biology class are among the many hard hat tours offered to acquaint our community with this environmental building

both our new 'green' Education Center and the 'greenness' of the garden in which it is being built.

The Conservation Garden

The mission of the North Carolina Botanical Garden is to *inspire understanding, appreciation, and conservation of plants in gardens and natural areas and to advance a sustainable relationship between people and nature*. From the very beginning (the first director, Dr. C. Ritchie Bell was appointed in 1961 and served until 1986, when I was named the Garden's second director), the North Carolina Botanical Garden was devoted to the *understanding, appreciation, and conservation* of the plants of our state and region and about the relationship between people and plants everywhere. The wildflowers of our botanical diverse state were the first focus. Early in the 1990s, we began using the phrase 'a

conservation garden' to represent our unique focus. This phrase is the subtitle on our entry sign, carved on the wood of a red cedar tree that fell on our lands during Hurricane Fran in 1996.

We define 'Conservation Garden' in two ways. The first way was simply by listing all of the conservation areas we work in. One of our first programs was 'conservation through propagation' for North Carolina wildflowers, which aimed to teach how plants can be grown from seed to reduce damage to wild populations that wild collecting can cause. But our programs soon encompassed many other conservation areas: protecting natural areas as nature's own gardens (and thus allowing us to present the complete continuum from human to nature's gardens), seed banking genetic diversity of endangered species and using these seeds in restoration, reducing the use of invasive species

Right:
A porous paving system is used in the parking areas to store water directly beneath these areas in order to manage storm water on the site



Far right:
A view across the porous pavers in the new parking lot towards the Education Center



and biodiversity inventory and documentation, and other areas (Table 1). Our Chapel Hill Thesis, a challenge to botanical gardens on the invasive species issue was published in the BGCI Newsletter in 1999, and led to the St. Louis Codes of Conduct in 2001 (<http://www.centerforplantconservation.org/invasives/home.html>)

Our second definition of Conservation Garden was inspired by Bill McDonough's Hannover Principles. McDonough is a leader in sustainable design in the US. In his Hannover Principles he says that all human activities should be discussed and designed under five headings:

Earth: for use of sustainably produced, non-toxic, recycled, and re-used materials;

Air: for protection of air quality, indoors and out;

Fire: for use of renewable energy;

Water: for sustainable use of the lifeblood of both gardens and human societies;

Spirit: for the spirit of all living things - the staff, volunteers, visitors, plants, birds, pollinators, fungi...

Right:
Six above ground and one below ground cistern will store the water that falls on building roofs, to be used to irrigate a water-efficient garden using only water that falls on the site.

Earth, Air, Fire, Water, and Spirit has become a sort of mantra at the Garden and seeks to position our planning and practices in all ways to achieve leadership in sustainability and environmental issues. For example, we have adopted a trash-free policy for events held at the Garden, whether sponsored by us or by others (these and other policies for sustainability and conservation are accessible on our web site: www.ncbg.unc.edu).

The Education Center

In November, 2007, we began building a new facility. Our staff had doubled in size, and were crowded into the 5,000 sq. ft. (464 sq. m.) Totten Center (the Totten Center will remain in the new Garden as the horticultural center). Our one classroom was limiting our ability to teach and meet the needs of our community. That room was also the staff meeting room, the art gallery, and a gift shop.

One of the easiest choices we faced was to design the building to a high environmental standard. Our staff, board, and volunteers were united in this and so we designed the 31,000 sq ft (2,880 sq. m.) Education Center to achieve Platinum certification, the highest category of the US Green Building Council's LEED (Leadership in Energy and Environmental Design) rating system. Some of the environmental features of the building are listed in Table 2.

Although our building is designed for sustainability, I also want to say that gardens have a special role to play - we can go beyond sustainability.

Bill McDonough once remarked "Let's talk about sustainability in a new way...if you think about sustainability, is it really that exciting? What if I asked you, 'How is your relationship with your husband?'" and you say 'Sustainable.' It's not that interesting really. I would almost feel as if I had to say, 'I'm sorry to hear that.' So, shouldn't we really be looking for something that is actually fecund - you know that's full of blood, and vigor and excitement?"

Bill McDonough also said that you should judge a building not just by its energy performance, but also by the number of birds you can hear singing from its edge. In my other role as a professor, I worked with a student team to explore how to evaluate our new building by the birds heard singing around it.

Gardens are perfect places to hear birds singing and to give back to the environment through restoration, repair, and teaching about how people can live best with the environment. Gardens are on the front lines of climate change, whether in the context of lowering contributions to atmospheric carbon dioxide to reduce change or adapting





to it, and we create the habitat for people, as well as the connection between human and natural habitats. We can promote sustainability, but we can also create a place that meets McDonough's challenge, to create that "something which is fecund, full of vigor and excitement".

**Peter White, Director and Professor
North Carolina Botanical Garden
University of North Carolina at
Chapel Hill
Chapel Hill, North Carolina 27599
USA
www.ncbg.unc.edu**

Table 1. (right) Eight elements of the Conservation Garden at the North Carolina Botanical Garden. This was our first, "bottom up", approach to defining our distinctive focus.

Table 2. (below) Environmental features of the Education Center, North Carolina Botanical Garden

Conservation through propagation of native plants ensures that wild populations are not damaged by direct use and collecting from natural populations;

Seed banking and reintroduction, an *ex-situ* conservation program that protects germplasm reserves as a last resort against extinction in the wild and for use in reintroduction of wild populations;

Protection and restoration of natural areas, which recognizes the importance of habitat conservation to the survival of biological diversity and which establishes the importance of nature's own gardens, as well as human gardens;

The elimination of **invasive species** and replacement with non-invasive alternatives;

Gardening in nature's context, which seeks to promote plants that support native biodiversity, including pollinators and seed dispersers;

Sustainable gardening, which seeks to promote environmentally friendly gardening practices and which involves such practices as *sustainable water use*, *protected stream quality*, *xeriscaping* (using drought-tolerant plants), *ecoscaping* (planting plants in the right places according to their ecological requirements), *zeroscaping* (working with the established plants in a landscaping plan), *integrated pest management*, *renewable energy sources*, *non-toxic and sustainably produced materials*, *recycling and reuse*;

Supplying critical **information** on conservation of the flora of the southeastern United States and on the Garden's conservation programs, a program that also includes the University of North Carolina Herbarium, a research and public service facility of the Garden that is the largest Southeastern US collection of plant specimens

People-nature relations, which describes how important plant diversity and natural areas are to the physical and psychological health of all of us and which recognizes that the Garden is not just for information and science, but also for positive outdoor experiences, inspiration, and the arts

Left:
Photovoltaic panels on a south facing roof of the Education Center, designed to provide approximately 15% of building energy needs.

(Photos: North Carolina Botanical Garden)

- **Photovoltaics:** to generate 15% of the building's energy needs in a dual metering system;
- **Geothermal heat exchange:** to reduce energy needs for heating and cooling by one third;
- **Green elevators:** to eliminate use of hydraulic fluids and to increase energy efficiency;
- **Site selection:** to avoid any impact to unique natural areas (we chose a site that was in succession from previous farmland);
- **Trees from the site become lumber:** to celebrate the ecology and life of the trees that once grew on the site, to reduce additional tree cutting, and to save cleared wood as carbon dioxide store;
- **Cisterns:** to harvest all water from building roofs and to grow a garden only from water that falls on and the site, eliminating issues of conflict with other water sources;
- **Reclaimed water:** to flush all toilets;
- **Storm water management:** a porous paving system for parking and rain gardens to slow the descent and improve the quality of water as it moves towards streams;
- **Recycled content:** to encourage recycling of construction materials and reduce new manufacturing;
- **Non-toxic content:** to reduce chemical impacts to air and water;
- **Regional content:** to support local economies and to reduce carbon dioxide given off in transportation of materials;
- **Diversion from landfill:** to divert 95% of construction waste from the landfill and into recycling;
- **Low volatile organic compounds (VOC):** to protect indoor air quality and building health;
- **Controlability:** to provide local control of indoor environment and reduce inefficient use of heating and cooling;
- **Operable windows:** to provide fresh air and to reduce use of mechanized systems for temperature and ventilation;
- **Daylighting and views:** to reduce use of electrical systems and to improve quality of the experience for indoors;
- **Building management system:** computerized tracking system for energy, air, and water to increase performance and supply information that will help staff modify their use of energy systems;
- **Support for public transportation**, walking, and biking;
- **Native seed mix** on steep slopes;
- **Native water efficient** landscaping.

Tooro Botanical Gardens for prosperity and well-being

Right: Rabbit houses at Tooro Botanical Gardens



On the lower hills of the East-African Rwenzori mountains, in the small Ugandan town of Fort Portal, lies the young Tooro Botanical Gardens (TBG). Since its establishment in 2001, the gardens have grown to become an ambitious organisation showing how the benefits of conserving nature and plants can have a positive effect on the local community.

The organisation maintains a 100 acre (40.45 ha) piece of land, dominated by a central swamp and planted with eucalyptus trees. Much of this land has already been cleared in order to develop a structured botanical garden. The garden's main goals lay in conservation, scientific research, education, sustainable horticulture and agriculture, medicine, recreation and demonstrating the culinary and aesthetic uses of plants. It aims to specialise in protecting and growing living plant collections from the Albertine Rift Region which until now, had no specialised or local botanical conservation institution. Through these goals, it aims to link botanical activities with sustainable development for the local community. Ornamental gardens,

educational habitat display gardens, demonstration gardens, a nursery and herbal production fields will eventually cover most of the TBG's lands.

A centre for sustainable development

The East-African Albertine Rift is rich in biodiversity. It harbours a large number of plant and animal species living in many different habitats. But this is also a region where in the recent past, wars were fought out and humanitarian disasters took place. Although normal life has returned, still much needs to be done. Currently the lack of basic infrastructure is one of the biggest problems of the Fort Portal area. Many NGO's and projects are however working to improve this.

The subject of development aid generally conjures thoughts of education, health care, basic economic development and the availability of food. Nature, conservation and even sustainable development are often not linked to the basic needs of a community. But the Tooro Botanical Gardens proves that this is not the case and that biodiversity conservation is essential for sustainable development in the long term.

Sustainable agriculture

There are different areas within its botanical activities that TBG uses to combine conservation and development objectives. First of all, education about sustainable agriculture and horticulture has become one of the

garden's main activities. TBG wants to encourage farmers to produce their crops in a sustainable way, with respect for nature and the environment. Other organisations may have similar goals, but a real centre where demonstration and examples of good agricultural practice can be shown was not previously available. TBG cooperates with several organisations, of which SATNET (Sustainable Agriculture Trainers Network) is very important. Currently SATNET is one of the leading organisations that encourages good agricultural practices and provides training for this purpose. Through demonstration gardens, farmers can be educated about sustainable practices which benefit both the community and the environment. As well as this, TBG maintains collections of crop varieties, hybrids and useful alternative species.

Useful plants

The TBG grows and displays a wide range of medicinal plants and is creating a database of local medicinal plants in order to offer natural and less expensive alternative medicines to the



Right: Herbal growing beds



Left: The nursery

community. An example of this is the growing and processing of *Artemisia annua*, an anti-malaria plant which is becoming increasingly well known by the local inhabitants.

The nursery also produces and collects a wide range of other indigenous and exotic species that can be used by the local community for fuel, timber, dye production, ornamental purposes and for food, as well as producing the plants that are used for display and demonstration in the garden.

Garden facilities

TBG's infrastructure and facilities contain many features that contribute to sustainability and in this respect, the demonstration and educational gardens play an important role. They show examples of sustainable farms, crop collections, demonstration buildings and several kinds of fields and orchards.

An interesting example of how new ideas can be shown and displayed to the public are the rabbit houses. They can easily be erected anywhere and the display shows farmers how to breed rabbits in a profitable and sustainable way. Each 'house' is built on poles holding it above the ground and constructed with wood. The roof of these houses is made with grasses and its walls are covered with clay.



The rabbits can walk on an outside area and their droppings are gathered in a plastic cloth as the floor is made of slatted poles. The droppings can be used as manure on the fields and the rabbits can be kept for their meat.

Ecological composting toilets are also being built and new buildings are being constructed to hold the offices, herbaria, drying chambers for herbs and botanical facilities. The buildings are constructed using clay and concrete bricks which are not baked or poured, but manually pressed with special equipment. Only the columns are made out of concrete, to provide more support. This way of building is more environmentally friendly than using traditional bricks which require fuel wood for baking.

Projects

Several projects are supported within and outside the gardens, all with the aim of supporting and educating the local community. Workshops and demonstrations serve to promote new products and methods and guided tours are available through the gardens. For example, educational paths through the central swamp lands are laid out and projects like 'conservation through cultivation' are displayed. TBG also cooperates with other local NGO's and has agreements with several governmental institutions. These NGO's and institutions include SATNET, the National Forest Authority, Kabarole District Farmers Organisation, several advisory and research institutions, the National Agricultural Advisory Services and the Mountains of the Moon University located in Fort Portal. International partnerships have been made, of which those with the North Carolina Zoo and BGCI are the most important.

Beside these programmes, TBG also carries out regular botanical programmes and activities. It collects local and indigenous plants to create its own unique collection of Albertine Rift flora. Endangered and special plants like orchids are collected and conserved in seed banks and information compiled in databases. Eventually the gardens will contain examples of all the major ecological systems surrounding the Fort Portal

region including tropical forests, savannahs, bush land and afro-montane vegetation.

An example of external projects that TBG encourages for the protection of the environment is promoting the Mpanga Falls site to become a protected area. The Mpanga Falls lie near Lake George and Queen Elizabeth National Park, in the southern part of Uganda. The falls, formed by the Mpanga river tumbling over a 50m high rim, are enclosed by a steep gorge and support a lush cover of spray forest. The isolation of the area and its particular climatic conditions have resulted in the creation of a unique ecosystem, a remarkable feature of which is the cycad *Encephalartos whitelockii*, endemic to this single location. TBG aims to protect this endangered species in the face of plans to build a dam which would destroy this unique habitat.



Left: Garden workers in front of the old offices

Future plans

The future of the TBG is promising as, although it mostly depends on donations, it lies in a region rich in vegetation variety and the climatic and physical conditions of the gardens are good. It will continue to focus on conserving the local flora, while at the same time promoting local community development. Its collections, demonstration plots and educational programmes will help to build capacity locally and will support sustainable development initiatives amongst local groups.

Lee Ingelbrecht and Rudy Lemmens
Tooro Botanical Gardens
P.O. Box 21, Fort Portal, Uganda
Email:
leeingelbrecht0706@hotmail.com
and rudylemmens@mac.com
<http://toorobotanicalgardens.org/>

Left: *Prunus africana* garden

(Photos: Lee Ingelbrecht)

Siit Arboretum's ideas on sustainability



Above: Making bokashi at Siit Arboretum

Introduction

Sustainability issues for the Siit Arboretum in the Philippines have been a regular focus of our projects. Simply said, we cannot afford not to be sustainable in what we do, as our income is very limited. When we do spend some hard earned income, or gratefully receive some grants, it is an extra reward to deliver the outputs in a sustainable way. Here are some examples which might serve other gardens in the same situation:

Building and construction

In the budget for construction, roof support/structure framing is a serious consideration. The cheapest materials for covering for us, as in most places, are at the present time "galvanum", a light type of corrugated steel sheet with good sun reflection, which

normally demands welded steel framing or lumber. We have found that bamboos, which we have in large quantities, can provide an excellent replacement for standard roofing supports and can even accommodate insulation foam with good aesthetic results. Light, strong and flexible, bamboos are long lasting when not exposed to the rain. All our buildings have been framed this way for many years, with no sign of any problems. We have saved money and many trees using this process. Bamboos also are used with palms fronds for shed extensions along the building where an eventual water leak is not a major problem.

Sharing costs with the community

The Siit Arboretum recently received a grant from BGCI, permitting the construction of a library and the installation of an internet connection, the latter needing a costly antenna of great height. However, through the extra investment of a good quality

secondary router for WI-FI delivery, the garden is able to share its internet access with the surrounding neighborhood and, through network participation rent, does not need to spend anything for the actual server yearly fees.

Use of solar power

Siit Arboretum's water delivery and irrigation system works entirely on solar power, with new technology providing controllers, electronic boosting and rearranging the voltage/amp ratio for optimal rating. We therefore have no need for batteries and yet have a good daily delivery with a limited number of solar panels.

Siit exported this technology to Siquijor Island at the request of their Department of Agriculture



Right: Library roof structure

Far right: Reception area roof structure





representatives after a visit to the garden. This island had been entirely dependent on fossil fuels, but two solar pumps are now helping a local community and a good size organic garden produce high quality crops. Two more pumps have been organized by the Arboretum at the request of the Governor who is extremely impressed by the savings generated by the system.

The Arboretum provides a good platform to advertise alternative energy and other issues linked to global warming. In the process, a commission on purchases is gladly paid by the recipients for whom we arrange the logistics in procuring the right equipment, and this helps the garden financially.

Medicinal plants

The value of our plant world can hardly be better illustrated than through its medicinal assets. Siit Arboretum now displays a herbal garden including many useful native species and manufactures some basic herbal medicines. Particularly praised are our fresh products of Pau d'arco, *Tabebuia impetiginosa*, "Lapacho", which grows happily here, and delivers excellent anti-bacterial and anti-viral properties.

Various uses are also made of the locally grown *Moringa oleifera*, a highly nutritious plant and *Centella asiatica*, a weed rarely noticed around here but rich in health benefits including skin rejuvenation, and memory enhancement. As the Arboretum is situated on clean land with no neighboring farmers using pesticides, the production of organic medicinal products seems a good prospect for this area.

Essential microorganisms

Recent price rises have made the purchase of fertilizers impossible for many farmers, and many are now decreasing (or stopping all together) their planting of corn and other crops. This is largely due to years of monoculture and soil mismanagement which has depleted their soils of fertility. The Arboretum is now working at demo- manufacturing several types of organic fertilizers using essential microorganism cocktails of various sorts. These are based on easily sourced raw materials and locally available waste products (e.g. copra meal, rice bran, *Leucaena* cuttings). Molasses, the main ingredient to promote fermentation is very cheap in a sugarcane growing area, and many good recyclable waste products are available locally. Some efficient microorganisms are now being manufactured by the Department of Agriculture, working with local NGOs. Botanic gardens are well placed not only to spread awareness of this technology through demonstrations, but also to benefit from using such methods themselves for sustainable production systems.

Solar ovens

Another part of our display is an 'easy to make' solar oven. Solar cooking is not common in the Philippines and



much time is spent in gathering wood everyday and of course cutting trees. However, sun is the one asset that the Philippines islands have never been short of and solar cookers can comfortably provide at least 50% of a family's cooking needs. This technology is also used to produce some of our medicinal plant extracts.

Conclusions

Siit Arboretum still has some way to go before the basic task is accomplished - that is: sustaining itself! However taking into account the above, and adding a few ornamentals sales, seeds sales, further organic ideas, and maybe after all, a botanical garden could survive without a significant income from its visitors.



Top left:
Siit solar
pannels
powering pump

Left:
Siit solar oven

Left: Siit
medicinal
garden

Left: Siquijor
vegetable
garden

For more information, visit www.siitarboretum.com and click on the weblog link for more details of our activities.

Eric Haniquet
Siit Arboretum Botanical Garden
c/o Park avenue hotel
Perdices St.
Dumaguete
Negros Oriental 6200
Philippines
Email:
eric.tambobo@rocketmail.com

Left: Recycling
rice husks
making charcoal
for essential
microorganism
mixes

(Photos:
Eric Haniquet)

Ecological integrity or landscape aesthetics?

The display of natural systems within botanic gardens



Above:
Naturalistic
landscape at the
Rio de Janeiro
Botanic Garden

Introduction

This paper discusses the extent to which the display of more naturalistic environments can convey ecological values to a diverse public in the context of botanic gardens. Over the past several years, many botanic gardens have taken the role of conserving remnants of indigenous vegetation. This situation involves management practices to sustain dynamic systems with the aim of both reversing biodiversity loss and also increasing awareness about the relationships between people and the

natural world. Few studies, however, have explored how people perceive this more naturalistic and dynamic type of plant display and the values people ascribe to these landscapes. This paper elaborates on this issue based on the review of past research findings and preliminary results of a doctoral study undertaken within the context of the Royal Botanic Gardens Cranbourne (RBGC), Victoria, Australia.

The display of natural systems

Based on several targets addressed in botanic garden policies, management efforts over botanic collections have focused on conserving plants for biodiversity. The aim is to develop programmes for the conservation of plant species and increasing peoples' awareness about plant diversity (BGCI, 2005). In doing so, conservation programmes are taking different forms. While some take place within laboratory facilities, for example, propagating endemic species and creating seed banks of endangered plants (e.g. Millennium Seed Bank Project), others have opted for conserving plants in natural habitats. Indeed, the management of natural areas to conserve local diversity is the objective of at least 200 botanic gardens in the world (Oldfield, 2008). Examples of the way in which natural systems are conserved can be observed in practices undertaken by several botanic gardens in Brazil, UK and Australia. Management practices undertaken in these botanic gardens are

aimed at imitating and controlling associated environmental disturbances and are also meant to meet local community requirements. For example, the research institute of the Rio de Janeiro Botanic Gardens is involved in the ecological restoration of the degraded forest area of Poco das Antas (POA). Restoration practices undertaken within POA seek to develop a local scientific culture in relation to indigenous plants. In the UK, the Loder Valley Nature Reserve within the grounds of Wakehurst Place Kew (WPK) is undergoing a 'countryside management' programme, aimed at conserving and restoring British plants and wildlife. In doing so, management practices consist of, for example, cutting trees and shrubs to ground level in order to create healthy habitats and produce goods such as rustic furniture and barbeque products. Similarly, ecosystem remnants at the RBGC are subjected to 'prescribed burning regimes' for improving the habitat of both flora and fauna. In this case, periodical burns are aimed at conserving ecosystems and preventing uncontrolled fires destroying nearby communities.



Right:
Landscape
photos
displayed for
'sorting' by
interviewees



However, while the sustainable management of natural systems in botanic gardens includes displaying plants for both ecological and social purposes, it also creates landscape scenes which can be unsightly for many. Associated exhibits are constantly changing due to life cycles essential for maintaining biodiversity. As a result, while visual landscape changes are related to plant regeneration, flower and fruit, they are associated with less appealing appearances as well, such as the decay, dryness and death of plants.

At this point, several questions can be raised based on botanic garden policies that emphasize increasing peoples' awareness about plants and biodiversity. We may ask for example, what characteristics of plant displays that change over time do people like or dislike. We also may want to understand if garden visitors perceive the visual results of sustainable

management practices as part of life cycles. To what extent do peoples' socio-cultural backgrounds influence their responses? The following sections reflect on these issues and specifically explore the extent to which visual effects of sustainable management practices (e.g. prescribed burning regimes) communicate ecological values to garden users.

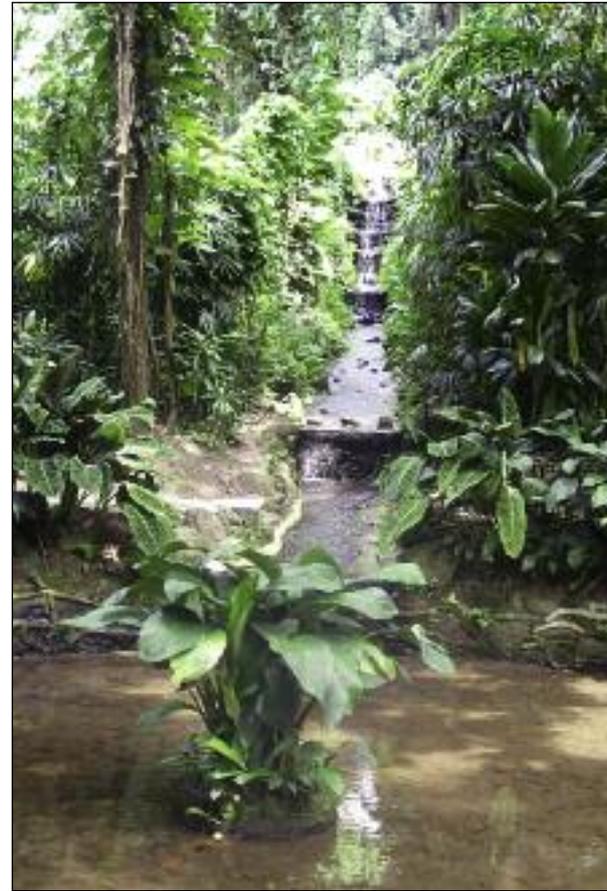
Perception of landscape change

Studies undertaken to explore peoples' perceptions of more naturalistic and dynamic types of plant display are few, yet consistent in their findings. Results suggest people's knowledge, familiarity with the site, and personal interests influence their reaction to landscape changes. Previous studies have shown that the effects of landscape changes on people are either imperceptible or convey both positive and negative connotations.

On one hand, changes that occur over longer time periods – such as geographic changes – and on small landscape scales – such as seed sprouts – are unlikely to be perceived by the general public (Bell, 1999). This situation suggests that what experts perceive within botanic gardens may differ markedly from the views of the wider public. Experts such as ecologists are more likely to understand plant exhibits within natural systems as part of life cycles. For the lay public, on the other hand, establishing relationships between

plant displays and life processes can be a more complex task. However, this may not always be the case. Visitors from botanic gardens come from different socio-cultural backgrounds and consequently have different past experiences and education levels.

Left: Fire management practices at RBGC provide better habitat for native flora and fauna



Changes that are easily perceived can be associated with, for example, seasonal variations. For instance, spring and summer depict characteristics such as greenness, fruits and flowering plants and these have been associated with productive landscapes and peoples' positive responses (Orians & Heerwagen, 1992). Evolutionary biologists suggest people prefer these landscape attributes because they signal resources for survival (e.g. food) and appeal to peoples' emotions. Studies undertaken within botanic gardens suggest similar results. In the Morton Arboretum in Chicago, Shroeder (1991) observed that warm and sunny places convey to visitors joy and happiness and places which combine wildflowers and forest suggest a setting in which 'nature (is) controlling the environment'.

Above: More formal planting at Rio Botanic Garden



Left: Coppicing of trees at Kew's Wakehurst Place, provided construction materials for the 'lookout'



Right: 'Open' landscape at Rio Botanic Garden

Differences in landscape preferences can be observed in relation to personal interests as well. Studies undertaken in rural areas have pointed out that people reject changes that interrupt daily life activities and threaten infrastructure (Zube & Sell, 1986). If this is the case, garden visitors who are emotionally attached to particular garden collections are most likely to reject changes that threaten areas they constantly visit. For instance, changes affecting useful things, such as areas providing recreation, education and rest, may be perceived as negative. This can occur, for example, in cases where visitors see nearby gardens as an extension of their own backyards.

Moreover, results of a study that explored responses to landscapes in rural areas in Australia suggest that differences in landscape perception are associated with the values conveyed by

landscapes. These were described based on Keller and Wilson's (1993) categories of human values of nature as: utilitarian, or the value of the natural world in providing material benefit; naturalistic, or satisfaction obtained from the experience of nature; ecological-scientific, or the satisfaction achieved from the study of nature; and aesthetic, or values received from the observation of physical aspects and beauty of the natural world (Williams 2003).

Case study: Royal Botanic Gardens Cranbourne

In testing previous findings, a study undertaken by the author is exploring how people perceive landscape changes associated with sustainable management practices. The study area is the reserve of the RBGC (363 ha) that was subjected to fires thousands of years ago until man-made

disturbances, such as grazing and mining, took place. In order to reverse this situation, in 1993 the board of the RBGC decided to restore the remnant vegetation. Accordingly, a fire management plan, among other practices, was adopted. It consists of periodically burning small areas of land during spring and autumn and within different time intervals in order to assure landscape diversity. Resulting land-mosaics also provide resources for local fauna, such as wallabies and koalas.

While these burning patterns help to increase biodiversity and prevent uncontrolled fires, they also create plant displays of burnt and un-burnt areas. These are constantly changing in association with life cycles and sustainable management practices. Landscape changes were photographically documented before and after fires for over a year and used in a series of interviews undertaken in Australia and Chile. Participants were asked to evaluate the images according to preferences (rating scale 1-7) and similarities and also to describe them in their own words. Preliminary results suggest that regardless of peoples' socio-cultural backgrounds, they prefer similar landscape scenes. They prefer landscapes depicting semi-open areas with scattered trees and bright green colours. For example, recently burnt landscapes depicting more open areas and providing depth of view received higher rating values than many unburnt landscapes illustrating overgrown and dry vegetation. Areas that underwent a moderate burn - not too hot and not too cold - received high preference values as well. These landscapes changed from darker and dull to brighter and contrasting colours over time. Scenes depicting green and yellow-bright colours were associated with plant regeneration processes and



Right: Local materials were used for constructing the fence at Kew's Wakehurst Place



received the highest preference values. The opposite situation was observed in landscapes scenes subjected to lighter fires. Low fire intensity impeded clearing the land successfully; hence resulting landscapes were described as closed, old and dead and were less preferred.

Findings outlined above are not meant to suggest that everybody interprets landscape scenes in the same way. On the contrary, while experts associated more open scenes with healthier landscapes, lay people liked them because of the accessibility and depth of view these landscapes provide. Additionally, while experts related brighter colours to landscapes in process of regeneration, lay people associated them with life and happiness.

A series of ideas can be outlined at this stage of the study. Firstly, the effects of sustainable management practices undoubtedly influence people's perceptions of plant displays. Secondly, the study suggests that certain landscape attributes are more preferred by people regardless of their own values and previous experiences. However, some landscape features can convey different meanings depending on, for example, peoples' expertise in landscape management practices.

Conclusions

Understanding how people perceive landscape changes associated with sustainable management practices in botanic gardens is a complex situation. Perceptions vary in relation to

landscape characteristics and the individual. The information reviewed here suggests that ecological values associated with naturalistic plant displays are better understood by experts. While expert preferences seem to be based on both ecological-scientific and aesthetic values, lay people like similar scenes purely based on aesthetics. Hence, the importance of complementing more naturalistic landscape exhibits with innovative plant displays and interpretation techniques to enhance the experience of the general public.

Fruitful approaches can be achieved if the design and management of plant exhibits is informed by studies exploring relationships between landscape attributes and people's responses. Indeed, the methodology prepared for the RBGC study was developed by the author with the aim of facilitating the exploration of people's responses to naturalistic environments in botanic gardens subjected to other environmental disturbances as well. Associated findings can help to understand educational and emotional effects different types of plant displays have on garden visitors. Results can contribute to improve botanic garden effectiveness as communicational tools.

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Right: Native flora at RBGC

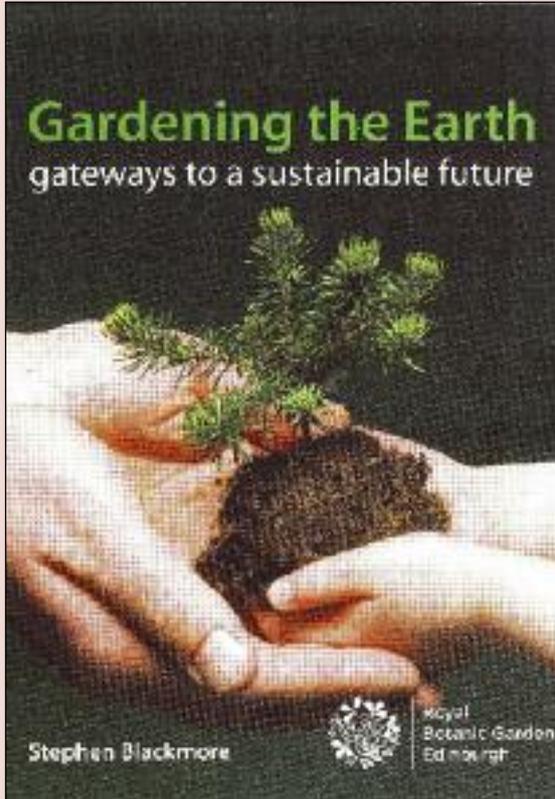
Below: Heathy-woodland vegetation at RBGC 2 years after burning (top) and 4 years after (below)



Paula Villagra-Islas
PhD Candidate
ABP Faculty
The University of Melbourne
Australia
paulav@unimelb.edu.au
paula_villagra@yahoo.com

(Photos: Paula Villagra-Islas)

Book announcement



Gardening the Earth – Gateways to a Sustainable Future

A personal view by Professor Stephen Blackmore

I am often called upon to speak about the contribution that botanic gardens can make to tackling the enormous and interconnected challenges facing our planet, especially biodiversity loss and climate change. Despite the scale of these challenges I am optimistic about the human capacity to respond to a crisis, even if we do tend to put off taking action until the last minute. I enjoy speaking about this topic because gardening in general and botanic gardens in particular have much to offer. Besides, solutions are available to our planet's predicament, if we grasp them quickly enough. However, public speaking is an inadequate way of reaching a wide audience and I have increasingly felt the need to try to write something that will, hopefully, have a wider appeal.

My forthcoming book *Gardening the Earth – Gateways to a Sustainable Future* was never conceived as a weighty compilation of research findings of the kind scientists naturally incline towards. There are many such excellent works already available. Instead I decided to present a personal perspective that draws upon both my childhood fascination with nature and the experiences of a lifetime of travelling to some of our planet's most interesting places. In particular, it has been my aim to convey the fundamental role that plants have played in creating a habitable planet capable of supporting our species and other animals.

I wanted to open the eyes of people who are not necessarily botanists to the impacts that deforestation over millennia has had on the composition and balance of the atmosphere and to present photosynthesis as part of the prescription for a healthy planet. In this long view, our appetite for fossil fuels and the greenhouse gas emissions that

their use causes is no less important but it is presented as an additional burden we have placed upon the biosphere rather than the primary cause of climate change.

As everyone in the world of botanic gardens knows, plants are our life support system, playing major roles in the water cycle and carbon cycles. Building on the fundamental notion of a living planet, I have used a single graph from the Intergovernmental Panel on Climate Change to describe four simple scenarios for futures increasingly different from the biologically diverse and still largely beautiful planet we inhabit today. The messages that I hope will stay with readers of the book, concern the natural economy of the planet and the responsibility each of us has for taking action to reduce our environmental impact. Just as the environmental problems of the planet are created by the cumulative demands of 6.6 billion people so the best hope for resolving them involves mass changes in individual behaviour.

It is no accident that the publication of *Gardening the Earth* coincides with the opening of the Royal Botanic Garden Edinburgh's state-of-the-art visitor centre, the John Hope Gateway. Named in honour of an outstanding 18th Century Regius Keeper, this important addition to the Garden is intended to inspire everyone who visits it to become part of the solution.

Professor Stephen Blackmore is Regius Keeper of the Royal Botanic Garden Edinburgh

Gardening the Earth is published by the Royal Botanic Garden, Edinburgh.
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Recommended retail price: £25 hardback/£20 paperback
Discounts offered for trade orders and BGCI members.

Book review

Biodiversity and gender for sustainable development: perspectives

Rogers W'O Okot-Uma and RoseMarie-Rita Endeley (Eds.)

This publication provides perspectives and insights into the two subject areas of biodiversity and gender in a unique collection of 26 papers from East Africa. The relevant policy issues and concepts are presented in Part One of the book, which focuses on the Convention on Biological Diversity (CBD) and its recognition of the “*vital importance that women play in the conservation and sustainable use of biological diversity and ... the need for the full participation of women at all levels of policy-making and implementation for biological diversity conservation*”. This section covers discussions on the needs to integrate biodiversity into sectoral and cross-sectoral policies, plans and programmes, as well as examining the costs and benefits of biodiversity conservation and the role of valuation of biodiversity. Each of these issues is discussed in the context of the situation in East Africa, with a particular focus on implementation in Uganda.

Part 2 of the publication includes a series of case studies that provide country-specific perspectives on biodiversity and gender. These case studies provide an interesting analysis of the constraints to biodiversity conservation in East Africa, as well as offering a range of different approaches to tackle them. The various sections cover: gender perspectives and case studies on the role of women in environmental management; threats to biodiversity; strategies for the protection and conservation of biodiversity; innovations in biodiversity; policy issues on environmental conservation with a focus on women and biodiversity; and, capacity building for biodiversity conservation in Africa.

The case studies come from 8 African countries: Uganda, Cameroon, The Gambia, Kenya, Lesotho, Mauritius, Tanzania and Zimbabwe. Together they offer solutions for biodiversity conservation, such as the need for strong policies and institutional frameworks, and the importance of community awareness and empowerment, especially of women.

This publication serves to highlight the essential role of women in conserving plant genetic resources and maintaining associated ethnobotanical knowledge and emphasizes the need to consider gender issues at all times in the formulation and implementation of conservation policies, strategies and projects.

Published by the Commonwealth Secretariat, London, UK. Email: publications@commonwealth.int; www.thecommonwealth.org/publications Available in the USA from Stylus Publishing, LLC, VA, USA. Email: StylusMail@PressWarehouse.com; www.styluspub.com ISBN: 978-1901127-30-0. 2005. Price: £25.00

These Guidelines have been produced by BGCI to support botanic gardens in developing and implementing ESD strategies. The Guidelines provide a rationale for why botanic gardens need to be involved in ESD, highlighting the importance of botanic garden education in implementing sustainable development initiatives and offering a range of ideas for educational approaches.

The guidelines lead educators through the process of developing an education for sustainable development strategy for their site. In particular, addressing issues such as; who should be involved, who is the audience, what the definition of sustainability is, the foundations of ESD, learning goals, educational approaches, using themes, resources and evaluation. Case studies are included throughout the guidelines, focusing on the excellent ESD work already going on in botanic gardens, while the final section focuses on the botanic garden as a model for sustainability, proposing a framework for conducting a green audit and providing ideas for implementing the principles of sustainability throughout garden policy and practice.

Published by Botanic Gardens Conservation International, UK. ISBN: 1-905164-09-2. April 2006. Copies of this report are available in English and Spanish from BGCI. Price £5.00. The report can also be downloaded from the website: www.bgci.org/resources/.



Resources

Education for Sustainable Development: Guidelines for Action in Botanic Gardens

Julia Willison, BGCI

Botanic gardens have always been important centres for environmental education and in recent years there has been a growing interest in education for sustainable development (ESD) amongst botanic garden educators. As a holistic process, ESD attempts to represent the complex and dynamic relationships between the natural and social sciences thus providing a means of addressing the environmental and development issues of the 21st century.

Water efficient landscaping: Preventing pollution and using resources wisely

This publication by the US Environmental Protection Agency is a useful resource on water use in landscaping with chapters covering the following topics:

- What is water-efficient landscaping?
- Why use water-efficient landscaping?



- How is water-efficient landscaping applied?
- Water-efficient landscape irrigation methods
- Examples of successful water-efficient landscaping projects

It also provides a list of organizations located across the United States that provide helpful information on water-efficient landscaping and a list of publications and resources on water efficient landscaping.

The publication can be downloaded from: www.epa.gov/WaterSense/docs/water-efficient_landscaping_508.pdf

Carbon dioxide reduction through urban forestry: guidelines for professional and volunteer tree planters

McPherson, E. Gregory and Simpson, James R

Carbon dioxide reduction through urban forestry – Guidelines for professional and volunteer tree planters has been developed in the USA by the Pacific Southwest Research Station's Western Center for Urban Forest Research and Education as a tool for utilities, urban foresters and arborists, municipalities, consultants, non-profit organizations and others to determine the effects of urban forests on atmospheric carbon dioxide (CO₂) reduction. The calculation of CO₂ reduction that can be made with the use of these Guidelines enables decision makers to incorporate urban forestry into their efforts to protect our global climate. With these Guidelines, they can: report current and future CO₂ reductions through a standardized accounting process; evaluate the cost-effectiveness of urban forestry programs with CO₂ reduction measures; compare benefits and costs of alternative urban forestry program designs; and produce educational materials that assess potential CO₂ reduction benefits and provide information on tree selection, placement, planting and stewardship.

Gen. Tech. Rep. PSW-GTR-171. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 237 p. The Guidelines can be downloaded at: www.treesearch.fs.fed.us/pubs/6779

Websites

The US Green Building Council

The U.S. Green Building Council is a 501(c)(3) non-profit community of leaders working to make green buildings available to everyone within a generation. Buildings in the United States are responsible for 39% of CO₂ emissions, 40% of energy consumption, 13% water consumption and 15% of GDP per year, making green building a source of significant economic and environmental opportunity.

The U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system is the foremost programme for the design, construction and operation of green buildings. LEED encourages and accelerates global adoption of sustainable green building and development practices through the creation and implementation of universally understood and accepted tools and performance criteria.

LEED provides third-party verification that a building or community was designed and built using strategies aimed at improving performance across all the metrics that matter most: energy savings, water efficiency, CO₂ emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts.

This website provides full details of what LEED measures and delivers and information on how to achieve certification. It also provides a wide range of resources related to sustainable building research and educational materials.

www.usgbc.org

Centre for Alternative Technology

The Centre for alternative Technology (CAT) aims to offer solutions to some of the most serious challenges facing our planet and the human race, such as climate change, pollution and the waste of precious resources. Leading by example, CAT focuses on demonstrating practical ways of addressing these problems and aims to show that living more sustainably is not only easy to attain but can provide a better quality of life.

The key areas CAT works in are renewable energy, environmental building, energy efficiency, organic growing and alternative sewage systems. As well as the website, CAT also runs a free information service, answering enquiries on a large range of topics by phone, letter or email. For bigger projects, there is also a consultancy service.

CAT offers a variety of short residential courses covering a range of sustainability issues. Courses on renewable energy, environmentally friendly building techniques, and water and sanitation solutions provide opportunities to learn more about sustainable ways of living, and how to put ideas into practice. They also offer introductory classes in ecology, woodland management, organic gardening and wilderness skills, as well as specialist courses aimed at educators and trade professionals.

www.cat.org.uk

Garden Organic

Garden Organic, has been at the forefront of the organic horticulture movement for 50 years and is dedicated to researching and promoting organic gardening, farming and food. Garden Organic began life as the Henry Doubleday Research Association (HDRA) in 1954 and now has over 40,000 supporters and reaches more than 3,000,000 beneficiaries across the world through its expert advice and information. Garden Organic manages demonstration gardens showing all aspects of organic growing. It provides advice on organic production and runs major research programmes that help farmers and growers across the UK and overseas to adopt organic methods. It is also home to a renowned Heritage Seed Library, which protects over 800 varieties of rare vegetable seeds from the threat of extinction.

www.gardenorganic.org.uk

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International Agenda for Botanic Gardens in Conservation Registration Form

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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

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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.

Thank you for registering with the *International Agenda for Botanic Gardens in Conservation*.

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

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*Generally applies to institutions in less developed countries

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Botanic Gardens Conservation International

Descanso House, 199 Kew Road, Richmond, Surrey, TW9 3BW, U.K.

Tel: +44 (0)20 8332 5953

Fax: +44 (0)20 8332 5956

E-mail: info@bgci.org

Internet: www.bgci.org

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Announcement

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Addressing global change:
a new agenda for botanic gardens

13th - 18th June 2010, Dublin, Ireland



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