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Botanic gardens and food security

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Cover Photo: Emmer wheat (*Triticum dicoccum*) being cultivated at the Royal Botanic Gardens, Kew (Suzanne Sharrock)

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United Nations Decade on Biodiversity 2011-2020

GUEST EDITORIAL
BOTANIC GARDENS AND THEIR CONTRIBUTION TO FOOD SECURITY

Botanic gardens have long served as repositories for a wide range of plants including those associated with agriculture and commercial horticulture. Commonly, though, such gardens have rarely engaged with the diversity that exists within cultivated species or the ways in which certain traits and properties have been exploited through selection by people. However, this picture is beginning to change as Gardens realise that engagement with the public is often made easier by utilising plants that have an immediate effect on people's lives, and that their conservation activities can be promoted in association with plants of economic importance.

Food security is back on the agenda of many countries. There are many reasons for this including a bigger and generally wealthier population, increased political commitment to abolish hunger and malnutrition, low reserves of grains worldwide, increased energy prices, changing climates and more variable weather, and increased trading of grains as commodities. Furthermore, food retailers are increasingly concerned to secure their sources of supply and simultaneously to meet their customers' demands for food that meets their multiple needs. What role can botanic gardens play in this debate?

As mentioned above, botanic gardens are increasingly highlighting economically useful plants to their visitors through demonstrations and public education. Many have active programmes of outreach with schools and local communities which encourage people to grow plants and to experience at first-hand the delights of consuming fresh, self-grown food. Such activities often lead people to a greater appreciation of all plants and the need for different environments to be conserved; the expansion of wildlife gardening in the UK alongside an increased interest in home vegetable production is suggestive of this.

An interesting example of a more direct contribution to future food security is provided by the Institute of Botanics and Phytointroductions located in the Botanic Garden, Almaty, Kazakhstan. Central Asia and Kazakhstan are the source of many cultivated plants including garlic, apricots and apples and the Institute has played a particular role in the preservation and conservation of the wild apple, *Malus sieversii*. The cultivated apple (*Malus pumila* Mill.) is economically the fourth most important fruit crop in the world, it is nutritionally valuable, and has been demonstrated through genomics to be related to *M. sieversii*. Unfortunately the wild apple orchards of the Tien Shen mountains have been substantially destroyed through carelessness and by hydridisation with domesticated apples.

The Institute and associated Botanic Garden have collected over 200 wild apple accessions which are being preserved *ex situ* from forest locations that are being preserved *in situ*. Over a period of about 40 years the apples have been gathered together to form an impressively diverse collection of materials. This collection is also being used to study the concentrations of biologically active substances present in the leaves and fruits, and to provide clonal materials for forest restoration. It has been found that the concentrations of phenolics in the wild apples are, perhaps not surprisingly, much higher than in present day domesticated apples, but vitamin C levels are also substantially higher.

Wild apples growing in the Almarty Botanic Garden, Kazakhstan

This is an important, indirect contribution to food security as it is preserving the genetic diversity and traits that may one day be useful in commercial breeding programmes for new apple varieties. Of course, conservation is important in its own right but when allied to economically important products, the case is that much more difficult to refute.

Botanic gardens will never match the scope of the large genebanks of cultivated plants, but they can play a valuable role in connecting people to the origins of their food crops and in preserving and conserving potentially valuable traits. Who knows what uses they might have in the future?

P.J. Gregory
Chief Executive, East Malling Research, UK

Author: Suzanne Sharrock

BOTANIC GARDENS AND FOOD SECURITY – THE RESULTS OF BGCI'S SURVEY

Vine species being tested at the Kemper Home Gardening Centre (Missouri Botanical Garden)

Introduction

Achieving global food security whilst reconciling demands on the environment is considered by many to be one of the greatest challenges facing humankind today. By 2050 it is likely that we will need to feed 9 billion people, with the increasing population also demanding a more varied, protein-rich diet.

All this means we need to grow more food on less land, with limited access to water and increasing costs for fertiliser and fuel. The impact of increasing food prices has already been felt in many countries, with associated riots and civil unrest. A less well-known fact is that more people die each year from hunger and malnutrition than from AIDS, tuberculosis and malaria combined (World Food Programme[1]). The World Bank estimates that compared to production in 2000, cereal production needs to increase by 50% and meat production by 85% to meet demand in 2030[2].

The role of botanic gardens

Botanic gardens are already involved in a wide range of activities that have relevance to the growing food security crisis. It is important that these activities are recognized, promoted and enhanced.

For example, using improved crop varieties with enhanced resistance to pests, diseases and environmental stress is key to developing a food system that has a lower impact on biodiversity and uses less land and water. Producing such varieties relies on the deployment of genes often found in the wild plants conserved in botanic garden collections. At a local level, growing suitably adapted food plants in community and school gardens can have a significant impact on the quality of diets, especially for those in poor and deprived areas. The horticultural and outreach skills found in botanic gardens are invaluable to support such initiatives.

In order to identify and understand how botanic gardens are addressing food security issues, BGCI carried out a survey in May 2013. The results of this survey are presented below.

Green Corps urban-farming programme (Cleveland Botanical Garden)

The survey respondents

The survey was made available on the BGCI website during the month of May 2013. The survey was advertised in Cultivate (BGCI's regular e-bulletin) and emails were sent to botanic gardens via national and regional networks. A total of 88 responses were received from botanic gardens in 40 countries around the world. The responses covered a range of types, ages and sizes of botanic gardens (Figs. 1-3).

[1] http://www.wfp.org/content/wfp-says-hunger-kills-more-aids-malaria-tuberculosis-combined#
[2] http://www.foodsecurity.ac.uk/issue/future.html

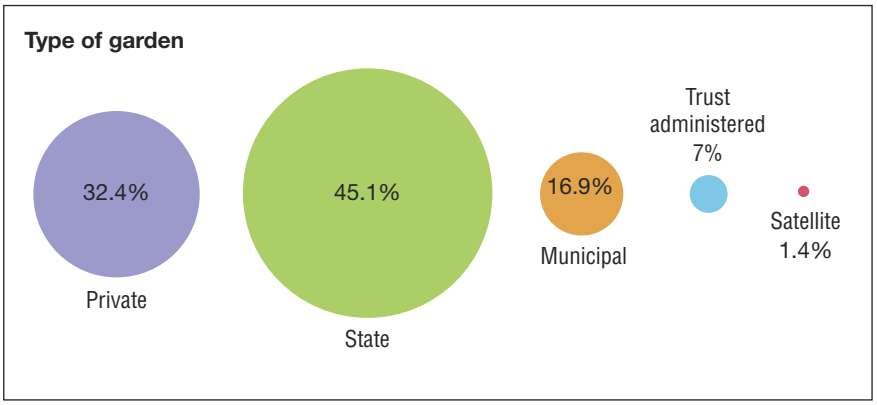

Figure 1

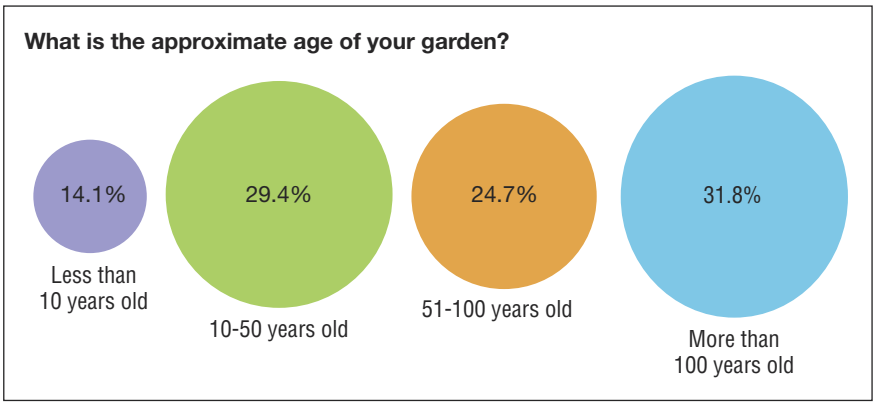

Figure 2

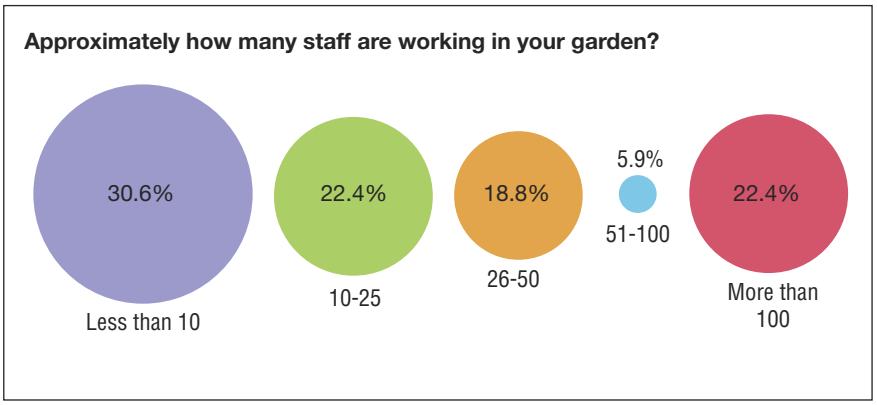

Figure 3

Food security activities in botanic gardens

Food production

Botanic gardens are involved in the growing of food crops both within the garden and working outside the garden walls. Within the garden, activities focus around demonstration food/vegetable gardens and gardening projects with local communities, as well as the conservation and promotion of local varieties of food plants (Figure 4). Fewer gardens reported activities outside the garden itself – but here the focus appears to be more on providing advice to enhance local food production, with some gardens also working with local schools and community groups on food production activities (Figure 5).

Working with local communities on food production projects is clearly a very important part of the work of many botanic gardens and Box 1 provides some examples.

Box 1: Urban agriculture

Botanic Gardens of Adelaide, Australia: addresses food security mainly through outreach work, such as the Green Infrastructure project in collaboration with external partners, including the community garden and kitchen garden initiatives. They are working to facilitate and promote green infrastructure throughout the urban environment, and this includes productive plants in urban agriculture, community gardens, edible verges, backyards etc. It also includes the greater vision of connecting and linking all green spaces and water systems. Food is a part of this bigger vision[3].

Real Jardín Botánico Juan Carlos I, Spain: has recently started a project on Organic Vegetable Gardening in which the local communities can grow their own organic vegetables in plots provided by the botanic garden. The garden also provides them with advice, plants, seeds and tools. In this project, charities and organizations of people with special needs are learning and working and they are supported by the staff of the Garden.

Chicago Botanic Garden, USA: runs more than $1 million of urban agriculture projects outside the garden itself, ranging from four youth development garden sites (Green Youth farm) to a 9-month certificate in sustainable urban agriculture for adults (Windy City Harvest, in collaboration with the City Colleges of Chicago) to an incarceration phase gardening training and post-release Transitional Job program for alternatively sentenced inmates[4].

Cleveland Botanical Garden, USA: the "GreenCorps" program operates 5 urban farms within the city of Cleveland, which teach and employ 60 high school youths every summer, growing vegetables and other edibles for sale at on-site farm markets, as well as a booth at a large neighborhood Farmer's Market. One of the farms includes a community fruit orchard and community garden plots. The staff also offer classes on food gardening and nutrition[5].

[3] http://www.environment.sa.gov.au/botanicgardens/Learn/Green_Infrastructure
[4] http://www.chicagobotanic.org/community/
[5] http://www.cbgarden.org/lets-learn/green-corps.aspx

The student vegetable plots at the Royal Botanic Gardens, Kew (Suzanne Sharrock)

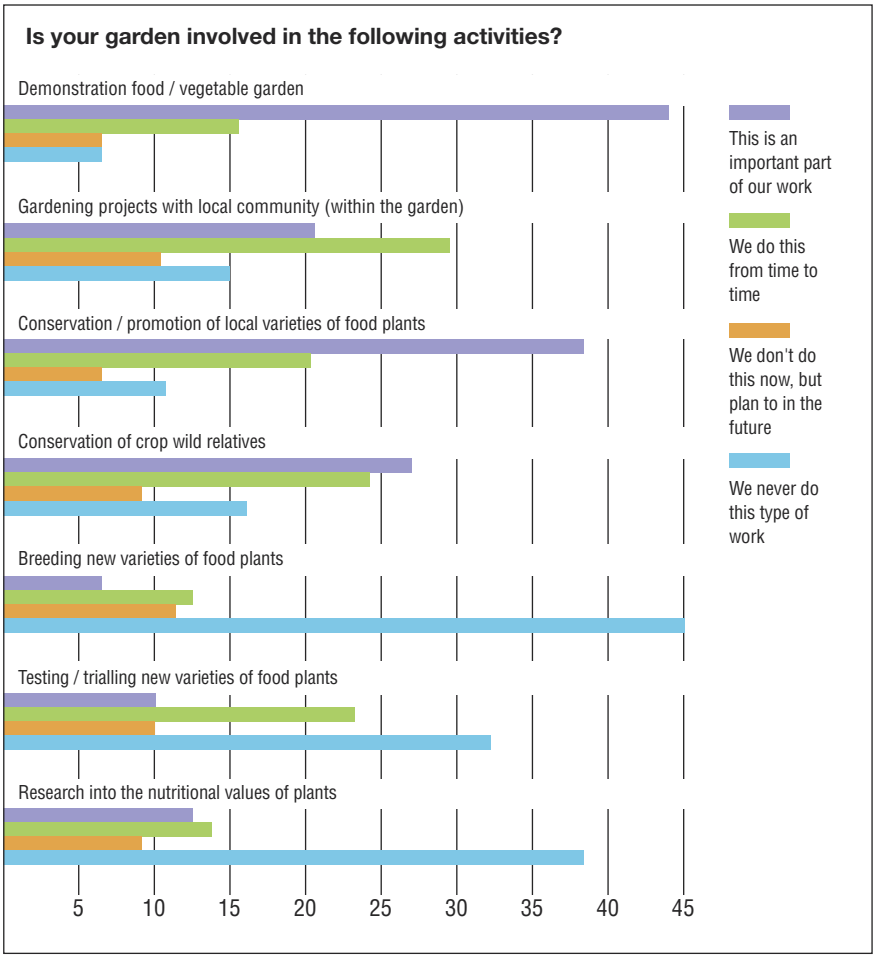

Figure 4

Conserving local varieties and crop wild relatives

A number of gardens reported being involved in the conservation of local varieties of food plants and crop wild relatives (Figure 4). A particularly significant example of this is provided by the National Tropical Botanic Garden in Hawaii, which is home to the Breadfruit Institute which manages the largest and most extensive collection of breadfruit species and varieties in the world and is preserving some varieties that no longer exist in their native lands. The collection contains 226 accessions and approximately 120 varieties from 34 islands in the Pacific, as well as Indonesia, the Philippines, the Seychelles and Honduras.

Another example comes from Purwodadi Botanic Garden in Indonesia which provided the following information:

"As a botanic garden, our activities are specifically designated for the ex situ *conservation of plant species from typical habitats of low and dry areas, throughout Indonesia. Musaceae and Dioscoreaceae are the focus of our research programmes in 2012-2017. We have been collecting many wild species, local varieties / landraces of bananas and yams. We conduct exploration and collect materials, and carry out characterization and documentation of the accessions."*

Developing improved varieties

Very few gardens appear to have any involvement in research, breeding or testing of new varieties of food plants. (Figure 4). However, the following information was provided by Missouri Botanic Garden:

"We recently planted out a research vineyard to compare and identify genes associated with precipitation and temperature stress in two native Missouri grapevine species. Although these grapes are not used to make wine per se*, they are used as rootstocks in the global grape industry. The two species are adapted to different environments in nature and we are curious whether or not they respond to abiotic stress in similar ways in a common garden environment. Our research vineyard is being planted in the Kemper Home Gardening Center of the Missouri Botanical Garden."*[6]

Collecting Musa planting materials in Indonesia (Purwodadi Botanic Garden)

[6] www.news.stlpublicradio.org/post/climate-change-prompts-renewed-interest-native-missouri-grapes

"In a time of global change: rising population, climate change and overuse of natural resources and loss of biodiversity all these issues have to be faced and challenged. We need to develop robust solutions to feeding the world population using less resources and causing less pollution. We have a role to play - not many yet take it seriously - but I believe it is of the most importance."

Kevin Frediani, Paignton Zoo

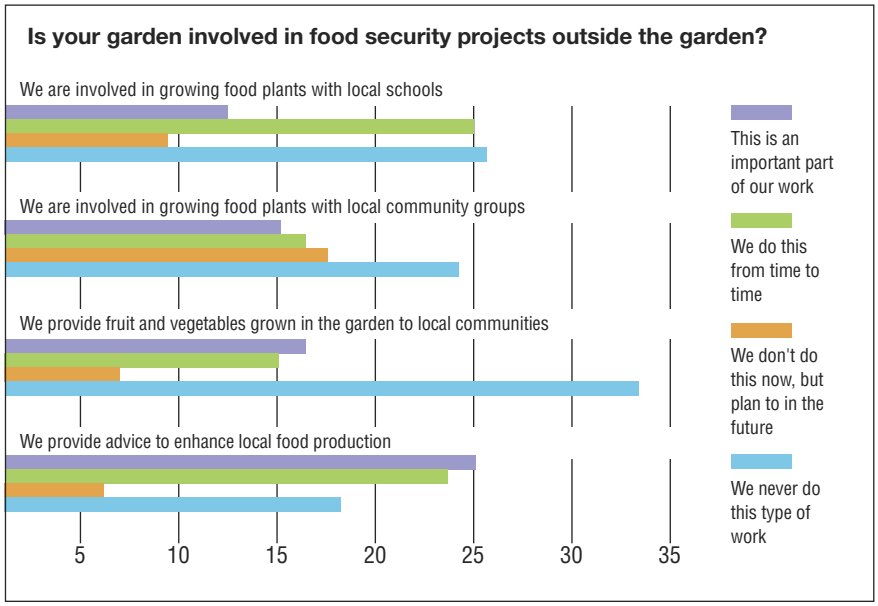

Figure 5

Engaging the public

Not surprisingly, the most common way respondents reported engaging the public is through providing interpretation in the garden that addresses food security issues. Almost half of the gardens who responded to the survey also organize lectures and debates on food security, and a significant number sell seed and/or plants of food crops (Figure 6).

Interestingly, despite the fact that some 80% of gardens reported having demonstration food gardens in place in their gardens, at least part of the time, relatively few (22%) use fruit and vegetables grown in the garden in their cafes / restaurants.

Box 2 – Engaging the public – special events

Missouri Botanical Garden, USA: Foodology: Dig In. Throughout 2013, the Garden is inviting its visitors to dig deep into the roots of food, think about plants on their plate in whole new ways, connect and share with others and get inspired. Through a series of exhibits, events and fun activities the garden is helping people to learn about the plants that feed us.

Royal Botanic gardens, Kew, UK: IncrEDIBLES – A voyage through surprising edible plants. This summer and autumn, Kew celebrates the amazing bounty of the plant world, inviting visitors to experience first-hand a selection of the 12,000 species we humans can feast on. As well as a wide range of activities, talks and workshops in the garden, a staff blog on the website shares their behind-the-scenes experiences as well as shedding light on the wonderful world of edible plants.

Above: The student vegetable plots at the Royal Botanic Gardens, Kew (Suzanne Sharrock)
Left: Halifax Street Children's Centre (Botanic Gardens of Adelaide, Australia)

Activity	"Very important" or "Important" (% of respondents)
Working with local communities to enhance food production	80%
Conserving local crop varieties and crop wild relatives	69%
Raising awareness of food security issues with the public	65%
Providing seed and planting materials of food crops	52%
Producing food crops in the garden for local use	40%
Breeding new varieties of food crops	35%

Table 1 - How important do you think the following activities are for botanic gardens

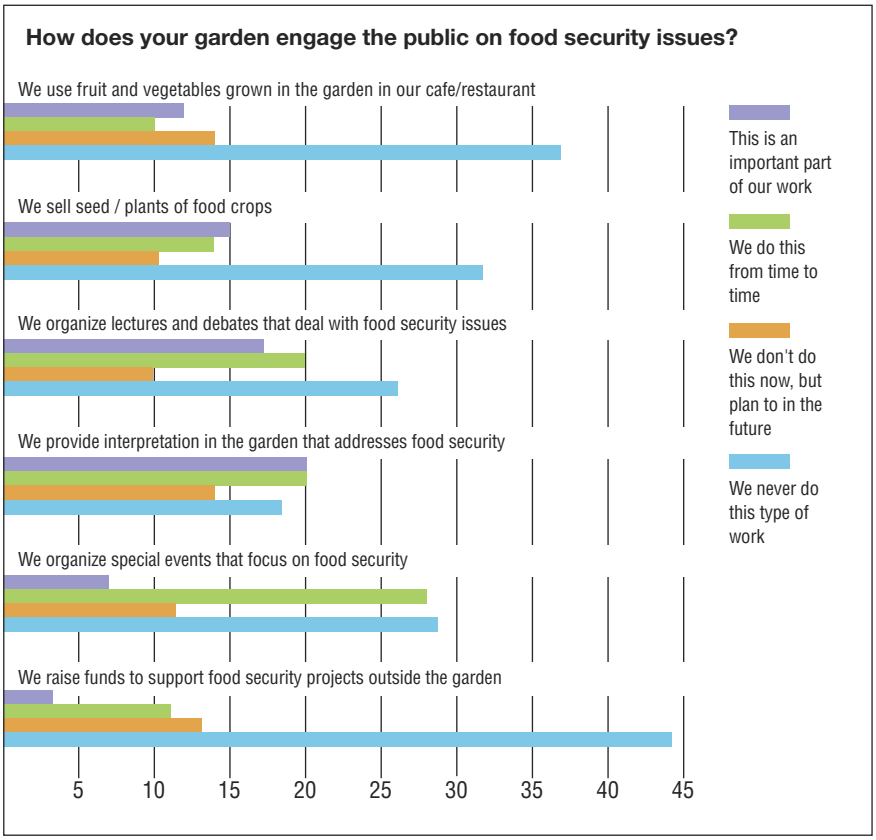

Figure 6

Engaging children (Botanic Gardens of Adelaide)

Looking to the future

Survey respondents were asked to rank how important they thought a range of activities are for botanic gardens. The responses are provided in Table 1

Role of BGCI

Survey respondents were asked to comment on the role of BGCI in supporting the work of botanic gardens in relation to food security. The majority of respondents felt that *"Collecting and sharing information and best practice examples"* was the most important role for BGCI, while "*advocating and raising awareness of the work of botanic gardens on this topic"* was also highly ranked.

"Botanic gardens have been somewhat overlooked as 'players' in the area of food security. Their roles are particularly important in relation to wild plant diversity and also for their educational / awareness activities. Raising the profile of these aspects of botanic garden work may help to attract significant new support for botanic garden work in this area from development agencies, in particular if they are seen to be relevant to addressing poverty issues and sustainable livelihoods."

Peter Wyse Jackson,
Missouri Botanical Garden

Pumpkin festival (RBG Kew)

"Organizing meetings/ workshops at regional/global level" and *"supporting specific food security related research in botanic gardens"* were felt to be of some importance, whereas *"highlighting botanic garden food security projects on our website"*; *"Representing botanic gardens in the wider food security community"* and *"developing partnerships with other international organizations involved in food security"* were considered to be the least important roles for BGCI.

Acknowledgements

BGCI is extremely grateful to all those who took the time to complete our survey. The information you have provided will help us to fulfill the roles you propose for BGCI – that is, sharing best practice examples and raising awareness of the work of botanic gardens.

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THE ROLE OF KISANTU BOTANICAL GARDEN IN BIODIVERSITY CONSERVATION: A FIRST EFFORT TO SUSTAINABLY MANAGE USEFUL PLANTS OF BAS CONGO

Plant species that play an important role in food security are rapidly disappearing in Bas Congo due to over-exploitation. The Kisantu Botanical Garden is working to secure and restore indigenous plant diversity for the benefit of local communities

The nursery at Kisantu Botanical Garden

Introduction

The Democratic Republic of Congo is demographically in rapid evolution. The annual population growth is above 3% and according to the latest estimates, the population will increase from 73 million in 2012 to about 190 million in 2050 (Marien *et al*., 2013). This population increase is occurring mainly in the cities and is only poorly controlled, causing adverse effects on natural resources.

The basic needs for food and wood energy contribute to the overexploitation of resources in urban and suburban areas and the degradation of natural ecosystems in an even wider area. This is certainly the case for the city of Kinshasa, a megalopolis of 8 million inhabitants, which strongly affects the entire Bas Congo region.

To augment agricultural production, environmentally harmful practices are increasingly used. These include slash and burn agriculture, monoculture (especially cassava), shortening of the fallow period with the consequent overexploitation of soils and recurring bush fires.

In addition, the need for charcoal ("makala") to fulfil the energy needs of Kinshasa has accelerated the modification of ecosystems in the region: forest fallows have been reduced, erosion has increased and biodiversity has decreased. Due to the lack of alternatives, even fruit trees are cut to produce charcoal for daily cooking. Important savannah plants such as *Imperata cilindrica* (Poaceae) for thatching roofs are disappearing at a high rate and are substituted by invasive exotic species such as *Chromolaena odorata*.

Gnetum africanum

Kisantu – the last forest

Traditionally, the population of the Bas Congo used a wide variety of plants and products for their daily needs: such as leaves, fruits and seeds for food, bark for medicine and trees for construction and energy. However rapid population growth and loss of biodiversity has meant that knowledge about the traditional, sustainable use of plants is being lost and replaced by unsustainable exploitation of the natural resources.

Kisantu Botanical Garden

Located 120 km south of Kinshasa, the Botanical Garden of Kisantu (JBK) is a vast garden of 225 ha. A Jesuit Mission created the garden in 1900 in order to introduce useful and economically beneficial plants to the Democratic Republic of Congo. Initially, efforts were made to cultivate plants to feed the missionaries but these soon became part of the diet of the local population. A range of vegetables and fruits were introduced to the Bas Congo region and throughout the Democratic Republic of Congo such as potatoes, carrots, onions, tomatoes, rice, mangosteen …

Kisantu was a thriving scientific institution until 1980 when the decline of the governmental institutions began. The infrastructure was all but destroyed by lack of maintenance and by war; living collections were left untended, and the government failed to allocate financial resources to the Garden.

Despite this, a core group of devoted researchers and technicians managed, against the odds, to preserve the Gardens' potential. Thanks to these few individuals, the loss of local knowledge of Central Africa's rich flora has been limited and the heritage of the institution has been kept alive.

In 2004 the European Union financed the program for the rehabilitation of the protected areas of the Democratic Republic of Congo and this included the Kisantu Botanic Garden. The World Wildlife Fund (WWF) and the National Botanic Garden of Belgium (NBGB) provided technical assistance, logistical support and advice to the program.

At the Garden, progress has been swift. During the past eight years, infrastructure, paths, plantations, glasshouses, living collections, herbaria, library, and the Internet have been improved or established. The revival of scientific research has been one of the pillars of the program: this activity is absolutely necessary to fulfil the educational and conservation functions of the Garden.

Since its rehabilitation, Kisantu has become one of the most advanced botanical gardens in Central Africa and is ready to play an important role in nature conservation. The success of the restoration project can be seen in many aspects, for example in the impressive increase in visitor numbers. In 2005, 9,000 people came to the Kisantu Botanical Garden compared with 35,000 in 2011.

The role of Kisantu in the development of Bas Congo region

The Garden includes the only remaining forest in the District of Lukaya, and in the vicinity of the towns of Inkisi and Kisantu. The surrounding natural vegetation in the area of the Kisantu Garden has disappeared, as the result of human activities, only secondary vegetation remains. Even in recent times, people came to the garden to harvest leaves, fruits, medicinal plants, wood etc. in an almost uncontrolled way.

"Without the easy availability of a wide range of useful plants, life becomes harder for rural and urban dwellers, particularly for the poorest." (Latham 2004)

In order to support the local community, the Garden's direction and the NBGB staff have developed activities of reforestation and plant propagation, with a focus on fuel wood, medicinal plants, host plants for caterpillars (for cultivating these protein-rich insects), plants that attract honeybees, vegetables and a range of different fruits. The ultimate goals are to provide the local communities with a supply of useful plants with which, as in the past, they can surround their homes and which are available for direct and immediate use, while at the same time, conserving the Bas Congo's original vegetation where it still occurs.

In order to the implement this project four tasks were defined:

- Carry out a literature review of plants traditionally used by the local communities;

Plots of forgotten vegetables

- Carry out a socio-economic and ethno-botanical analysis of resource exploitation;
- Establish living collections of plants and study their development;
- Test simple techniques of reproduction and domestication of useful plants in the Kisantu Botanical Garden.

These actions need trained teams in the field of plant production (hence the need to strengthen the nursery facilities) and communication and awareness raising (environmental education).

Useful plants were grouped into four categories - namely:

1. Host plants for caterpillars;
2. Honey plants;
3. Medicinal plants;
4. "Forgotten" vegetables

Results

The literature review highlighted that for several years very few studies or research had been conducted on plants and vegetables traditionally consumed in the region.

The last author and the horticulture team of the garden of Kisantu conducted interviews with community leaders and farmers around Kisantu. The most spectacular result was the unforeseen wealth of medicinal plants and vegetables used today or in the past. In sharp contrast, the knowledge on the ecology and better cultivation methods of these useful plants were largely lacking. The garden of Kisantu therefore started a program to propagate these plants and to develop strategies for their sustainable use.

Host plants for caterpillars – Caterpillars are part of the traditional cuisine of the population and they are used in many traditional dishes. In addition they form a very important source of proteins and minerals. The survey showed that seven of the most popular caterpillar species are mainly found on seventeen indigenous plant species, belonging to eleven families. With the disappearance of these species, the caterpillars also disappear. Replanting these species in and around the villages will result in a partial restoration of the original vegetation and encourage more caterpillars, therefore providing important nutrients to the poorest families (Malaisse 1997).

Honey plants – The people of Bas Congo know about eighteen honey plants belonging to eight families. Knowledge and use of honey in this region dates back to the earliest days of its history and it is undoubtedly part of the oldest foods. In addition to its use as a food, honey is used for its healing properties and to beautify the skin.

Medicinal plants – About 25 medicinal plants belonging to 21 families are still used by local communities of the Bas Congo. Different parts of the same plant may have different uses. Plants with medicinal properties also sometimes have culinary uses.

"Forgotten" vegetables – About 35 edible plant species were identified that could be categorized as "forgotten" vegetables. Some have been introduced a long time ago and knowledge is lost of how to cultivate them, while others are indigenous species that have become very rare as the natural habitat has been destroyed. Some species, such as *Gnetum africanum*, have become so rare in the area that they are now imported into the region from as far as Kisangani, more than 1,750 km from Kinshasa. (Ingram *et al*., 2010)

To conserve these vegetables and the traditional dishes derived from them, fields of these plants were established within the Kisantu Botanical Garden. These were grown from seeds that were harvested in villages where the plants are still cultivated. They form a living museum to educate children and visitors about these traditionally used plants and how they can be cultivated.

Finally, the aim is to have enough seeds to distribute to interested visitors (for which there is a high demand) and to introduce these vegetables into the garden restaurant menu for a "taste" of the flavours of the past.

Conclusion

Anthropogenic disturbances in the ecosystems of the Bas Congo province are mainly related to shifting cultivation techniques and the unsustainable exploitation of forest resources. This strongly affects the quality of life and well being of the local people. Natural resources that traditionally played an important role in the daily lives of thousands of people have become very rare and knowledge about their proper utilisation is fading quickly.

The botanical gardens in the Congo Basin have an important role to play in raising public awareness, particularly in urban areas, about the importance of natural ecosystems and the ecosystem services they provide. They should convey information about the main themes for the protection of the environment (deforestation, fuel wood, global warming, biodiversity conservation, endangered species) and promote environmental education (Ingram *et al*., 2010). Recent activities developed by the Kisantu Botanic Garden show how the garden contributes to this overall mission at a small scale, but with very concrete actions. Apart from the installation of a vegetable and medicinal garden, the Garden has planted 6.5ha of local and introduced tree species to highlight the role of trees in local agricultural systems and in the sustainable production of wood for fuel. It is to be hoped that the Kisantu Botanical Garden can continue its mission in the future and that it can play an even more prominent role in safeguarding indigenous plants and the local knowledge about these natural resources.

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*Forgotten vegetable (*Solanum *sp.)*

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The overall scheme of the Community Food Garden

THE TASMANIAN COMMUNITY FOOD GARDEN

A unique initiative in community food security within botanical gardens

Introduction

Food security is a major global concern impacting government policy and, perhaps more significantly, community action.

Tasmania had one of the very first recorded vegetable gardens in Australia, established by the French at Recherche Bay in 1792. It also has the second oldest botanical garden after Sydney with the Royal Tasmanian Botanical Gardens (RTBG) becoming established in 1818. Developed on the site of a farm established in 1806, the RTBG has an unbroken history of fresh produce production onsite through to this day.

"The basis of all food is plant life and botanical gardens can, and we would argue should, have a significant role in developing better food security for all."

With food insecurity in the general Australian population at more than 5% and more than 10% of the population in low socioeconomic areas[1] there is a significant need for action to address the community need for food. Increasing levels of diabetes and cardiovascular disease that have clear links to nutritional inadequacies and the

Mid 1850's image of the early colonial food garden

recognition that many basic food production and preparation skills are not present in our community indicate a clear need for greater community

[1]Food for all Tasmanians: A food security strategy
http://www.dpac.tas.gov.au/__data/assets/pdf_file/0005/159476/Food_for_all_Tasmanians_-_A_food_Security_Strategy.PDF

education to allow individuals and communities to build the capacity to improve their own food security situation.

The RTBG has been involved for some time in discussions with individual communities seeking advice on establishing food production areas. What emerged were some significant underlying issues common to many if not all community food production initiatives; these included lack of governance structures, over dependence on key individuals, lack of leadership, inexperience with funding processes and, most importantly, limited horticultural knowledge.

Arising out of what became an extensive consultative process, in which the RTBG invested significant resources, there is a new and exciting project underway in the grounds of the Royal Tasmanian Botanical Gardens.

A model community food garden

The Tasmanian Community Food Garden (TCFG) is a model community food garden being established by the Tasmanian Community Food Garden Coalition, a community of organisations that share a similar community focus and goals aimed at improving food security for all. The RTBG is a founding member of this coalition, a prime mover in bringing together the membership and host to the model garden. The project has initial funding from the Tasmanian Community Fund and co-contributions from the coalition, the major part of which comes from the RTBG in terms of the in-kind support for the development of the Food Garden.

The original membership of the coalition includes a wide diversity of groups with differing ethnic, cultural and socioeconomic backgrounds. Internationally recognised organisations such as the Salvation Army, St Vincent DePaul, and the Red Cross have joined with other Tasmanian organisations such as Relationships Australia and the Tasmanian Aboriginal Centre as well as smaller organisations including a number of community and school gardens and neighbourhood houses. There were around 25 main groups associated with the initial project with membership increasing all the time.

Peter Cundall – the presenter of ABC TV Gardening Australia, who delivered his popular national television program from the previous RTBG Veggie Patch. This is now the site of the new Food Garden.

The TCFG will provide a centre for skills development and inspiration for individuals and communities, essentially establishing a centre of excellence in food production and community engagement. It will provide opportunities to demonstrate design and use of productive plants in creative and innovative ways that are easily replicated within other community sectors. It has been likened to a one-stop-shop for guidance, resourcing, skills development and sharing.

The TCFG is the first of its kind in Australia, both in its objectives and its structure; with the large coalition of community organisations involved, it will be a valuable demonstration model for other mixed community initiatives. Its overall benefits go beyond the physical site; through its partnerships with well established community food distribution services, it will provide for the distribution of fresh food into communities and will develop community leaders through formal and informal training opportunities, empowering communities to help themselves.

The centralisation of community organisations and groups in one area will offer them opportunities to promote their work with a collective momentum to others on a state, national and international level; while at the same time providing huge benefits to their own members through participation in the Garden. Working together will also generate new networking opportunities and the ideal space in which to 'seed' and 'germinate' new collaborations. This alone we believe is a new concept for developing community engagement amongst community organisations.

Even within a small geographical area like Tasmania many community gardens or groups are not aware of others, some perhaps only a few blocks away. Bringing groups together will develop participation and sharing, helping limit duplications therefore saving resources,

time and money. The intention is not to centralise these groups at the expense of what they are currently doing but to help them build the capacity in their regional areas.

The TCFG will be a professionally managed and maintained community garden with a level of quality in keeping with the expectations of a public garden environment. It is hoped that it will be inspirational to participants and visitors alike.

Participation

Organisations and groups can participate in the TCFG in a number of ways including actual participation on the site by working in an allocated garden plot. Individuals nominated by their organisations will be encouraged to add their own individual flavour to the design of their plots including the types of plants and design of the plantings. Although the overall site will be managed by the RTBG staff and the TCFG board with a strategic plan integrating with that of the RTBG and an overall site design concept; individual organisations will have flexibility in how they work their plot. One benefit to organisations will be onsite access to low cost seed and plantlets for use within their gardens.

Organisations can also nominate individuals to a working group that will help oversee day to day decision making and to the management board of the TCFG with opportunities likely to open up at the end of each sitting year. This will give them a voice in the management, direction and future development of the TCFG as well as ensuring sustainable and cohesive management.

An extract of the design of the new Tasmanian Community Food Garden

RTBG horticultural staff managing the overall site will provide seven day maintenance of the gardens, with the expectation that participating groups spend a minimum period, yet to be determined, maintaining and looking after their plot. Participants will have access to qualified and experienced horticulturists to help them as they need advice and information. The project will also provide a bus service using community vehicles to enable participants to get to and from the Garden throughout the week. Transport was identified during the community consultation phase, as a fundamental limitation for community members and a significant cause of non participation in these types of community initiatives.

Produce grown by participants in the individual community plots can be harvested by the respective groups or organisations with an estimated ten percent of their overall harvest to be returned to the community pool which will then be distributed to the wider Hobart community. The intent here is to model a behaviour which, if adopted by all community food production initiatives, would make a significant contribution to the emergency food relief provided by organisations such as Salvation Army, St Vincent de Paul and SecondBite, all partners in this project.

Work underway on the RTBG site

A large proportion of the TCFG will be assigned to productive food plant displays that will be engaging, inspirational and push boundaries not usually seen with standard vegetable and fruit gardens. It will provide areas for groups to get together and socialise, demonstrate their use of fresh food through formal and casual cooking demonstrations, offering a chance to cook together and celebrate healthy food. It excites us to think of the opportunities of this area for participants sharing the diverse cultural knowledge of mixed communities in a collective and safe environment.

The TCFG received start up funding of close to AUD $300,000 from the Tasmanian Community Fund. The RTBG has provided up to another $200,000 of

A plan of the RTBG in 1856. The new Food garden will be located in the area shown in the top right corner of the plan.

in kind support in design, construction and ongoing management. In relation to other investments by botanical gardens in Australia this amount of money might seem small for this type of garden, but the value achieved by the RTBG onsite through creative and clever management with this development promises to set a benchmark for other similar sized institutions.

To ensure a sustainable financial future for the TCFG it is envisaged that a range of service costs will be included into further organisational participation and use of the garden. The degree and type of costs will be determined as a collective decision by the TCFG Board in the near future.

The physical creation of the TCFG has been primarily an in-house project of the RTBG with a special structural management group formed to implement the project on the ground and coordinate with the interim Board of the Coalition. The Structural Management Group has overseen the overall design, development and construction and ensured compatibility with the RTBG's strategic plan. The work has been undertaken within restrictive budgets and with limited access to specialists. We have incorporated and used the help of specialist interns and horticultural students to assist staff, provide valuable learning opportunities for them and reducing overall project costs.

The Coalition has an interim Board that reflects the membership of the original applicants for funding. This group is responsible for the broad project and the involvement of all community members. The RTBG Board and staff are both represented and the Interim Board works closely with the RTBG Board. From the outset there has been recognition that the coalition is an independent body and that its Board represents the interests of all parties in developing and maintaining a community of community food gardens and allied organisations. There is, however, a clear understanding that the RTBG hosts and manages the physical Food Garden and that ultimate decision making authority rests with the Board of the RTBG.

In addition to the two Boards and the structural management group there is now a group that will oversee the plantings, design and horticultural content of the TCFG. Its membership is drawn from the specialist staff at the Gardens and they will have a role in long term horticultural planning and will help inform decision making of the interim Board. Moving forward it is anticipated that there will also be a working party that will have membership of both Gardens staff and individuals from organisations active on the grounds in the TCFG. The role of this group will be to manage day-to-day running protocols and help everyone to work well together!

The physical garden is currently under construction and the Board is working to finalise details of governance, management and operation. The intent is to have the new Food Garden open to the public at the annual RTBG Spring Festival in October.

Organisations such as botanical gardens are rightly perceived as experts in the culture and science of horticulture and most gardens have a commitment to community. The RTBG sees an obvious need for botanical gardens to play a stronger role in areas of community food security; the opening of the Tasmanian Community Food Garden as an integral part of the Gardens will be a clear demonstration of how seriously the Gardens takes this responsibility.

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COMMUNITY-BASED RANGELAND REHABILITATION: ADDRESSING FOOD SECURITY AND BIODIVERSITY REHABILITATION AT THE ROYAL BOTANIC GARDEN OF JORDAN

Local community field visit

Introduction

Global food security will remain a worldwide concern for the next 50 years and beyond. Recently, crop yield has fallen in many areas because of declining investments in research and infrastructure, as well as increasing water scarcity. Although agroecological approaches offer some promise for improving yields, food security in developing countries could be substantially improved by increased investment and policy reforms (Rosegrant, 2003).

When the Royal Botanic Garden (RBG) of Jordan was founded in 2005, it identified food security as a major challenge facing Jordan. Climate change, overgrazing, desertification and a rapidly expanding population in Jordan are combining to create huge imbalances between food security and natural resource management. Water is scarce, with a supply of only 145 m^3 per capita per year (UNESCO, 2012), or under one-third of the global average. In addition, low wages and a high cost of living make it difficult for a large sector of society to obtain nutritious food in sufficient quantity.

The project

To address habitat loss and food security problems at a fundamental level, the RBG set up the Community-Based Rangeland Rehabilitation project (CBRR) in 2007, starting with five families living near the RBG site. Participation rose to 38 families by 2013.

The CBRR is successfully improving the livelihood of sheep and goat herders and improving family hygiene, which has greatly decreased illness among the community while increasing herd health.

CBRR grazing studies

As a direct result, herd productivity has risen significantly. Thus, by introducing managed grazing protocols and engaging the community, the CBRR is restoring local biodiversity while lessening overexploitation of natural resources.

Working with the community

The local herding community initially opposed the creation of the RBG, when an area of land traditionally used for grazing was fenced off for the Garden. Herders would sometimes cut the fence at night and take their animals inside the site to graze illegally. Like most unregulated rangeland areas in Jordan, the condition of the land at that time was poor, due to constant overgrazing, illegal wood cutting and picnicking. The vegetation was sparse, erosion rampant, and the soil dry and unhealthy.

The CBRR's first step was to hold meetings with community members, to speak of the need for sustainable land management and encourage herding families to cooperate. Local livestock owners were offered forage replacement (barley) in exchange for not grazing on the site while the RBG conducted vegetation surveys, estimated the biomass and developed sustainable stocking rates. Grazing studies, in all seasons, found among other things that spring grazing prevented plants from seeding the earth, thus perpetuating a cycle of land degradation. It was also noted that when lush vegetation was available, sheep were satisfied after just 2.5 hours of grazing.

Based on the collected data, the CBRR team established stocking rates and developed managed grazing plans that have led to a significant rise in biomass and plant diversity, and better soil conditions. The formerly overgrazed land can now bank more rainfall and retain moisture in the dry summer months, all the while allowing herders to graze their flocks inside the RBG site on a supervised basis.

The CBRR works hand-in-hand with people from the local community, who have voluntarily decided to become a part of this programme, by listening, advising and training via direct contact, focus groups and workshops. It keeps a close watch on herders' activities and movements from area to area, in order to improve flock productivity and health, raise production quality, minimize herd losses and maximize herders' profits.

Meeting with members of the local community

CBRR herders

Two local individuals have been trained as para-veterinarians to assist the CBRR veterinarian in recognizing diseases, controlling parasites, administering vaccinations, distributing low-cost animal medicines, preventing improper use of medicines, and updating a herd recording system. By the end of 2012, the CBRR team had vaccinated and treated approximately 10,000 head of sheep and goats. In the past, the community had to wait for a government veterinarian who came according to a limited schedule, leaving them without resources in times of emergencies.

Project success

Lambing rates rose from 40%-60% in 2007 to 85%-97% per flock in 2012. This not only indicates better herd health, but also resulted in a significant rise in herders' incomes. For instance, one herder who earned $8,200 in 2007 saw his income rise to over $20,000 in subsequent years. This result is manifest in smaller flocks as well, as a herder who began with an annual net loss of $496 now earns over $6,300 per year.

As part of the project, local families are also learning how to earn income from sources other than herding. A dozen families have been trained to produce bee products, sun-dried yoghurt (jameed) and mushrooms. Furthermore, local women have been taught sewing and handicraft skills, which empowers them by attaining new skills. The honey project has proven most effective so far, with net profits in 2012 exceeding $3,600, a significant sum for families in this poor area of Jordan (Abuamoud *et al*., 2011). The food micro-projects have greatly contributed to the food security aspect of the programme, as the participants become producers of high-quality food products in sufficient quantities that they can use for themselves and generate extra income to further empower families and diversify their diets.

Healthier and more productive sheep and goat herds are providing better quality meat and milk for market, while yielding higher incomes for livestock owners. While still in the early stages, the alternative income generating projects should continue to grow and offer more opportunities. In addition, the local people have an increased awareness about health and hygiene, and the importance of conserving biodiversity and managing the rangeland appropriately for future food security and economic benefits. All of the above address the Millennium Development Goals.

The CBRR's managed grazing plans have caused a return of profuse vegetation to RBG land, along with more wildlife. The site's biomass increased by over 30% in a three-year period, as measured by biomass surveys. The number of native plant species growing wild on the site increased from 436 in 2006 to 580 in 2012, some of which have not been recorded in the area since the late 1800s.

The multi-faceted activities of the CBRR have brought higher and diversified incomes for local livestock owners, more productive livestock, healthier families, community mobilization, and greater understanding of sustainable land

management practices, all of which are key to achieving enhanced food security locally and throughout the country.

The CBRR was a semi-finalist for the UNCCD's 2013 Land for Life Award (UNCCD, 2013) and was a Katerva Award nominee the previous year (Katerva, 2012). CBRR articles have been published in the Pastoralism Journal (Al-Tabini *et al*., 2012), and the Journal of Ethnopharmacology (Nawash *et al*., 2013).

Conclusions

The impact of the CBRR project is noticeable at many levels. In addition to benefits for the herding community and the environment, there has been a marked effect on community spirit. Young people now have more prospects for earning a living locally, and are no longer feeling the need to migrate to larger urban areas. Several participants in the CBRR programme have recently bought land and are building homes, thus expressing new hope for the future.

The CBRR is a viable, sustainable development project, replicable throughout the country and region. The managed grazing regimes are taking pressure off the environment, and offer a real solution to Jordan's overgrazing problem.

"A participatory approach is the key to success."

The CBRR has always used a participatory approach in its work, giving a voice to local actors in projects that affect their livelihoods. One striking aspect of the CBRR project is that the first families become the teachers of the next, thus empowering the participants

Meeting with local community

Training of the pastoral community and para-veterinarians on herd management

while decreasing the direct dependency on the RBG staff. Without a high level of community participation, the CBRR programme would be another failed top-down approach that refuses to take into consideration the cultural sensibilities and needs of the local population. More importantly, by dealing directly with the people, the CBRR team has also benefited from local knowledge and actively collects and records the knowledge of the elders.

By focusing on the people first, the CBRR has been able to empower and enrich the lives of dozens of families while simultaneously nurturing and restoring the environment they depend on. After watching the rangelands decline and get drier in recent decades, the community is getting a fresh start by partnering with the CBRR.

More information about the RBG and the CBRR project are available at www.royalbotanicgarden.org.

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FOOD GARDEN NETWORKS AND THE ROLE OF BOTANIC GARDENS IN ADDRESSING BIODIVERSITY & HUMAN WELLBEING

Food gardens in botanic gardens can help to promote food sovereignty and develop ecological literacy

Permaculture project

Introduction

The Durban Botanic Gardens is currently the oldest surviving botanic garden on the African continent and Durban's (eThekwini Municipality's) oldest public institution. From its initial development in 1849 as a botanic station for the trial of agricultural crops, the Gardens has progressed as part of an international network of botanic gardens to focus on core areas of biodiversity, education, heritage, research, horticultural excellence and green innovation. As a City botanic gardens, the DBG has an important role to play in helping to fulfill the City's Integrated Development Plan (IDP).

The Permaculture Garden at the Durban Botanic Gardens was established to coincide with World Food Day in October 2008 primarily as a pilot project as part of the Garden Window Vision of the Durban Botanic Gardens that aims to highlight the role of plant-related services, especially food, medicinal plants and urban greening that supports urban biodiversity. Permaculture is a cultivated ecosystem approach to growing food and plays an integral role in the Gardens' education programme which has helped to provide a rich ecological literacy focus. Food gardens are an important part of education programmes within botanic gardens worldwide in terms of promoting food sovereignty and developing ecological literacy. The work undertaken by the permaculture training centre is in line with Target 13 of the Global Strategy for Plant Conservation (GSPC) which calls for the maintenance of indigenous and local knowledge, innovations and practices associated with plant resources that support sustainable livelihoods, local food security and health care.

Gabriel Mngoma was the first permaculturist at the Centre and to date still teaches permaculture. Training is

hands-on and client driven with programmes developed for specific needs. Today the Gardens Permaculture Centre runs courses from its teaching garden and is piloting an outreach programme called the Food Garden Network. The teaching garden is used for training programmes for children and adults. It has an established programme that is facilitated by Jabulani Memela, the current Permaculturist. There is also a bilingual booklet that is in the process of its second revision.

Jabulani Memela was born in the rural setting of Donnybrook in KwaZulu-Natal province. While growing up he was always involved in household farming, which included herding cattle, growing vegetables and interacting with wildlife. In 2001 Jabulani relocated to the City to reside with his relatives where he found himself working at a local nursery where he learnt a lot about basic horticultural practice. In 2006 he received training in environmental education and later became an education volunteer guide at the Durban Botanic Gardens. In 2008 Jabulani trained as a Permaculturist, having volunteered at Durban Botanic Gardens Permaculture Training Centre where he gain a lot of practical experience and was later appointed Permaculturist at the Gardens and employed by the Durban Botanic Gardens Trust.

The Durban Botanic Gardens Permaculture Training Centre offers a wide range of food garden programmes for all age groups. Here people learn an environmentally friendly way of cultivating the earth with an abundant yield of safe organic produce at minimal cost. A minimum of 10 to a maximum 30 people can book for courses of their choice in either English or isiZulu. Programmes include:

Hands- on learning at Durban Botanic Gardens permaculture training center

Starting a school food garden: a hands-on experience for learners in developing an organic food garden at their school.

"Adopt the IDEA" Permaculture Garden Guided Tour: a two hour interactive sensory tour through the Permaculture garden covers a range of Permaculture examples.

Kitchen Garden workshops: a five hour programme practically explores various aspects of Permaculture and organic food gardening and aims to equip the gardener to cultivate an organic kitchen garden for a regular supply of fresh and nutritious leafy vegetables and herbs.

Medicinal Herbs and their Uses: a five hour programme covering herbs for composting, companion planting & remedies.

School Holiday Programme: a three hour programme that is interactive for children aged 9 through to 12 providing an opportunity to reconnect with the sensory wonders of the garden and nature. The focus is on discovering why it's 'cool' to grow your own food with interesting activities such as creating a worm farm, 'food in my shoe' and more.

Community Food Garden Projects: a five day programme for groups involved in community gardening projects. Community food garden projects are beset with many challenges and this programme provides practical solutions that can be implemented in local community food garden projects.

Food Gardening for Educators: a four hour programme introducing permaculture principles and methods that aims to support curriculum-based learning, while promoting ecological literacy and environmental sustainability. Invaluable for educators, who find the

Soil analysis by school learners at the Durban training centre

practical component of the course helpful when illustrating abstract environmental concepts to learners.

Herbal oils, Liqueurs, Vinegars and Preserves Workshop: a five hour programme with step by step techniques for preserving fresh herbs, and the use of herbs in teas, cooking and cosmetics.

Introduction to Permaculture in isiZulu: a six hour programme Introduces a practical hands-on programme that will equip gardeners and other interested people with the necessary skill to be able to create and maintain ecological food gardens for a sustainable future.

The Food Garden Network Project

The Gardens have been excited to discover LIV Village at Canelands on the Northcoast who we would like to partner with as part of a larger initiative to develop an international food garden network. This includes placing a food garden volunteer from Germany at LIV Village as part of the Bremen-Durban Sister City Programme. The role of the DBG Food Garden Network Programme is to establish permaculture teaching gardens in the four strategic wards of the Ethekwini Municipality. These would then promote the propagation of plant resources, and associated indigenous and local knowledge, innovations and practices that support sustainable livelihoods, local food security and health care as is outlined in Target 13 of the GSPC.

Train the trainer workshop for community food gardens champions

LIV Village

Lungisisa Indlela Village (LIV) is currently a one hundred bed orphanage in Mahlabathini, 40km north of the City of Durban. The Canelands area is rural and many of eThekwini's working class

Permaculture garden ad Durban Botanic Garden

Permaculture design interpretation by Jabulani Memela

people live here. LIV was started with the aim of providing holistic residential care for vulnerable children with the core vision to rescue a child, restore a life, raise a leader, and release a star. The Vision and Mission of LIV is to raise the next generation of leaders in South Africa by placing parentless children into a family environment where they can be nurtured for a secure future in society. In 1997, Tich Smith was driving back from a conference in Nelspruit, when God gave him a picture of an African village on a hill, similar to the rural clusters of homes and villages we see when we drive through the Transkei. There were small homes surrounded by children, running and laughing. Mothers were sitting on the steps of these houses interacting with one another. The church was in the centre. There were schools and a skills / business development centre. He saw fields of vegetable gardens. God told Tich to build the village and create jobs.

The Village

Imagine 10,000 villages, each raising and impacting 500 orphans, 'the right way'. 5 million children rescued, raised and rebuilt to become future leaders impacting the continent of Africa, reaching out to other orphans. 5 million each touching 10 orphans. Imagine…The first LIV Village is situated on 31 hectares / 83 acres at Cottonlands, Verulam in KwaZulu-Natal, South Africa.

The School

The School offers an education based on Christian values in which every child can achieve his or her full potential and grow in spirit and trust and service to all people; thus contributing to a free and just society. Through cost-effective management, the schools can provide an environment which attracts a committed and talented staff of professionals to promote excellence in all fields.

The Durban Botanic Gardens Permaculture training centre has begun a food gardening project at the school as part of its food garden network. We are excited with the partnership emerging between the Gardens and LIV Village and are confident that the LIV model is one that will be instructive in learning how best Gardens can engage in community food garden outreach programmes as well as demonstrating the value of active networks in achieving Target 13 of the GSPC.

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PAIGNTON ZOO ENVIRONMENTAL PARKS VERTICAL FARMING PROJECT: A NOVEL APPROACH TO CONSERVATION EDUCATION THROUGH AN INTENSIVE AGRICULTURAL EXHIBIT

VertiCrop exhibit housed in the centre of Paignton Zoo Environmental Park

Introduction

As society becomes increasingly developed we stand witness to a process that distances humans from nature and promotes damaging environmental practices in the advancement of an ideal of economic growth and universal prosperity. The consequences of this are profound for the world’s natural resources, including the loss of biodiversity in the world’s ecosystems, increasingly put under stress compounded as public and therefore political interest wains over environmental issues. A result of people understanding more, but feeling less inclined to personally engage to make a difference through their own life choices at the very time of greatest need.

Feeding the world – the need to act differently!

The origin of civilisation is through the domestication and cultivation of wild plants and animals to enable individuals to be more efficient in their food and domestic security provision through collective organising and the division of labour. This early act in forming the first

First feeding with the VertiCrop produce

community resulted in a chain of improvements that can be celebrated as one of civilisations greatest single accomplishments; the global supply of food through industrial development. This chain of custody sees the worlds cultivated plants and animals shipped from producer to consumer with a minimum of people involved at a minimum of cost. So more people can live their lives freed from the need to grow their own food. However, success has not been globally shared with the United Nations Food and Agriculture Organization (FAO) estimating that nearly 870 million people, or one in eight people in the world, were suffering from chronic undernourishment in 2010-2012 (FAO, WFP and IFAD. 2012).

Concurrent to this failure has been recognition of the loss of global commons and the ecosystem service benefits they bring, essential for all life on earth including the provision of fresh water (MEA, 2005[i]). The true cost of economic growth and universal prosperity is the unsustainable use of the world's natural resources. This includes the minerals used as fertiliser and oil reserves used for fuel that enable irreversible land use change. As land that was formerly natural habitat is harvested of its biodiversity and intensively cultivated for crop or animal production (see United Nations web server "*Our Common Future, Chapter 8: Industry: Producing More With Less*[ii]).

As fossil fuel replaces people power to support global food supply chains, control is lost from local communities to the hands of a few well-placed organisations that oversee the packaging of water as green plants, transporting them from water-poor to water-rich regions of the world. Such a free-market commoditised food-led approach, which is inherently unstable and subject to fluctuating status of availability and price on international markets, causes unrest. Recently this has forced intervention by the world's G20 nations who agreed a series of measures they hoped would reduce food prices and boost supplies when they met in Paris on 22nd June 2011 (Tran, 2011). Admitting they have urgent work to do[iii]—collectively and at home, accounting for the world's largest food producers, consumers, importers and exporters, as on all these fronts, existing food systems are failing (Murphy, 2011).

The consensus being that:

- The world's population is predicted to increase from around 7 billion to 9 billion over the next 30 years;
- 70% of this increased population will live in urban developments, up from around 50% currently;
- Land to produce food is coming under increasing pressure from demand for alternative uses such as biofuels and is subject to contamination and environmental erosion;
- Clean water and energy are experiencing similar demand and cost increases;
- The carbon footprint of traditional food production is too high;
- The number of people facing starvation is currently increasing despite aid;
- Agricultural production and consumption patterns need reviewing; to explore more sustainable approaches.

The 'perfect storm' of global change that Sir John Beddington, UK Government's Chief Scientific Advisor coined in his launch of the UK Governments foresight report looking at the Future of Food and Farming: *Challenges and choices for global sustainability (Foresight; The Future of Food and Farming (2011) Executive Summary). The Government Office for Science, London*.

The technological solution – a return to local production!

There is a compelling argument to reduce the impact of food supply on the worlds natural resources by returning to a balanced local agriculture that serves the needs of increasingly urban communities by producing food close to where it is consumed using more sustainable approaches (Bows, *et al*., 2012; Despommier, 2010[iv]; Frediani, 2009; Foster, *et al*., 2006; Morris & Burgess, 2012). Such an integrated approach could benefit from controlled environmental agriculture in or close to the urban centres, working alongside extensive food production on the wider land around these centres. Freeing some aspects of agriculture from its primary resources such as land and water, while optimising the potential for yields from plants cultivated in fully controlled,

Food issues in the modern zoo

- Food security
- Food control
- Food quality
- Food quantity
- Food costs
- Food miles
- Food sustainability
- Food ethics

	Crop and culture	Fresh mass per plant (g)	Plant density (m^2 ground area)	Yield (fresh) (kg/m^2)	Energy use (kWh / kg fresh mass)
1	Spinach; VertiCrop™, measured	48	132	6.34	1.85
2	Spinach; single layer conventional greenhouse, estimated	111	20	2.2	5.64
3	Lettuce; VertiCrop™, measured	125	132	16.5	0.71
4	Lettuce; single layer conventional greenhouse, estimated	150	35	5.25	1.65

Table 1: Summary of the comparison of cultural methods on yield and energy use in a 3m VertiCrop at Paignton Zoo and a conventional greenhouse with a single layer re-circulating hydroponic system, assuming the same irrigation and environmental controls.

closed environment structures. Until recently it was difficult to find evidence for an urban complimentary approach, but now the Paignton Zoo exhibit has revealed that it is possible to supply sustainable year round produce free from the vagaries of inclement weather or market-led supply chains (Bayley, *et al*., 2011; Frediani, 2010a, b; Frediani 2011a, b; Morgan, 2009; Resh, 2012).

Key findings of the VertiCrop project (after Frediani CEUG proceeding, 2011 & unpublished trial data from 2012 & 13):

Since summer 2009, 11,200 plants have been grown at any one time in plugs on trays in a vertically integrated system over eight levels stacked 3m high, covering a ground area of approximately 85 m^2 and rotating within a greenhouse. The data shown above are examples of productivity against energy use to date (Table 1) with clear advantages for the VertiCrop™ in both cases over conventional greenhouse hydroponics on a single layer. Building upon previously published work that showed that advanced hydroponic technologies can optimise water and nutrient use, which when re-circulated within the system, result in minimised agricultural run-off (Carruthers, 2007).

The system is specifically suited to the growing of fresh leafy vegetable crops with fibrous root systems. The focus of the work being on improving yield, uniformity and yield per unit energy used for these internationally traded crops. The success of the first system resulted in an improved iteration of the original growing configuration being housed within a fully enclosed model system. This new production system seeks to prove that better energy yield results for crops obtained through reducing the unpredictable disadvantages of natural daylight within a well-insulated warehouse, using the light and otherwise wasteful heat gain from supplementary Hortilux 315 W Schreder day light units to provide an optimal growing environment. As an example of a closed system it sits off-show to the public and is being used to compare with thermally inefficient glasshouses as an improvement in potential protected environmental building design. Sponsored by an industrial partner without cost to the zoo, the structure uses 100mm thick insulation board giving a heat transmission coefficient of around 0.21 W m/2/K (U-value) compared to 5.6 for conventional single glass and 2.6 for double glazing.

These experiments have revealed significant yield increases with reduced energy inputs. Particularly in areas of climatic extremes where growing crops in greenhouses or plastic tunnels can entail very high energy inputs in order to maintain a stable temperature for optimum plant growth. In addition the warehouse provides an environment where the grower has complete control over light, temperature, humidity and carbon dioxide levels compared with crops grown using the greenhouse model (Bayley, unpublished). Energy efficient lighting - combinations of piped daylight and new generation LED lighting – give the advantage of reducing cooling requirements and improved control over energy consumption, which is likely to remain fairly constant year round, enabling the grower to make use of lower rate and off-peak tariffs (Kim *et al*., 2007; Watanabe, 2011). Early data prove the outperformance of its glasshouse counterpart in the winter and spring (Table 2).

System	Yield per rack (kg*)	Growing space (m^2)	Yield per crop cycle (kg)	Yield per m^2	Crop cycles per year	Annual yield per m^2
VertiCrop glasshouse	8.32	19.8	66.56	3.36	11.06	37
Improved system warehouse	12.48	19.8	99.84	5.04	11.06	56

*Based upon average trail data for Basil accumulated since start of trial in November 2012.

Table 2: Performance summary of comparable systems grown under polythene and in an insulated warehouse using high density vertical growing technology

The following results (Table 3), scaled up from the baseline data, provide an idea of what is achievable from a fully commercial model using this or comparable technology.

Yield (m^{-2} day^{-1})	Energy (m^{-2} day^{-1})	Water (m^{-2} day^{-1})	Labour (m^{-2} day^{-1})
0.5	1.4	2.5	0.04

Table 3: Summary of input required for the warehouse system being trialled at Paignton Zoo Environmental Park

Is there potential for realising Urban Farms?

The current UK food supply chain consumes many times more calories of energy for every calorie of food energy released to the end user. The majority of this embedded energy is currently supplied through fossil fuels and is consumed in the post-harvest stages of the supply chain where transport, processing, storage, packaging and distribution all use fossil fuels which contribute to greenhouse gas emissions. Much of this is avoided or at least minimised when food is grown in the packing house, in the distribution centre, on the industrial estate, around the ring road serving our cities and large towns. This model is sustainable because it provides more food on less space using fewer resources. It frees up land outside cities to grow less intensively, so landscapes can provide essential ecosystem services as well as staple foods. By enabling an initial community to grow their own food, a platform is provided for transferring new skills into and between urban communities. Empowering people to reduce their own impact through localised food supply will have a lasting positive impact on our planet at a time when we need to minimise the drivers of global change (human population increase; climate change; loss of natural resources).

This intensive vertical production method provides enormous potential market opportunities around the UK and abroad that is currently being explored. To enable this transfer of knowledge from the zoo to benefit the community the author established the Foundation for Research into Environmentally Sustainable Horticulture in 2010 (F.R.E.S.H) with the Dartington School of Social Entrepreneurs, with the aim of helping communities grow food closer to where they live and work (Frediani, 2013):

Paignton Zoo - Kevin Frediani with VertiCrop

Conclusion

Since realising the project in 2009 the VertiCrop exhibit at Paignton Zoo Environmental Park has been an outstanding success as an educational, research and advocacy project, winning awards and recognition nationally[vi] and internationally. Highlights include the 2011 Nora Stucken Award from the UK Institute of Horticulture and a nomination to represent the Earth Charter principle 5 *Protect and restore the integrity of Earth's ecological systems, with special concern for biological diversity and the natural processes that sustain life*[vii]. Within the zoo it has helped to reduce reliance on outside food supplies for the zoo's animals, reduce costs and improve quality and security (Frediani, 2011a, b). Outside the zoo it provides the potential to be rolled out as a sustainable business model that enables collective localised food provision while providing commercial leverage for communities to help sustain themselves. Bridging the gap between what has been written and discussed and realising the potential to change the way we feed our hungry cities (Steele, 2008). An example of positive action to enable the change we need to see if biodiversity is not to continue to lose out to apathy and lack of interest in conservation matters.

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The author in the centre of the food production exhibit where 11,200 plants grow in 85 square meters of floor space

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Notes

[i] The Millennium Ecosystem Assessment, released in 2005, is an international synthesis by over 1000 of the world's leading biological scientists that analyses the state of the Earth's ecosystems and provides summaries and guidelines for decision-makers. It concludes that human activity is having a significant and escalating impact on the biodiversity of world ecosystems, reducing both their resilience and bio-capacity. The report refers to natural systems as humanity's "life-support system", providing essential "ecosystem services".

[ii] http://www.un-documents.net/ocf-08.htm

[iii] See more at: http://www.iatp.org/documents/g-20-agriculture-ministers-meet-in-paris-with-little-result#sthash.PX0galiG.dpuf. Also at http://somo.nl/dossiers-en/sectors/financial/eu-financial-reforms/newsletter-items/issue-7-july-2011/g20-agri-ministers-failed-to-address-food-price-volatility-and-speculation

[iv] http://en.wikipedia.org/wiki/Vertical_farming

[v] http://www.dartington.org/sse/fellows

[vi] http://www.horticulture.org.uk/file.php?fileid=1152

[vii] http://www.picturesofsuccess.org/5/5c-promote-recovery-endangered-species-ecosystems

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BOTANIC GARDENS AND FOOD SECURITY: A CARIBBEAN PERSPECTIVE

Introduction

Food security was defined during the World Food Summit in 1996 as existing

> *"when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life."*

Therefore, the concept of food security is built on three principal pillars: food **availability**, food **access** and food **use**. Botanic gardens can have influence in all areas, but perhaps more particularly in relation to use, or nutrition.

Plants are the principal components of safe and nutritious food. Therefore, botanic gardens have an important role to play in educating people about the plants that are most used for food, their properties and how to cultivate them.

The history of botanic gardens in the Caribbean is closely linked to food security. In the 18th Century (1792) the British government decided to introduce the breadfruit tree (*Artocarpus altilis*, Moraceae) to the Caribbean to feed the African slaves working in the sugarcane plantations. This introduction was done through the St. Vincent botanic garden. This botanic garden was also involved in the introduction to the New World of mango, cinnamon and mangosteen, (Leiva, 1997). Mango (*Mangifera indica*, Anacardiaceae) subsequently became a very important local crop for both food and medicine.

Artocarpus edulis *(Breadfruit)*

Trees and food security in the Caribbean region

Life as we know it today would not be possible without trees. Their role in removing carbon dioxide from the atmosphere is well known, but trees provide many other services, including protecting watersheds and providing food, firewood, timber and medicine. In terms a food security, a number of tree species are particularly important in the Caribbean region:

Breadfruit (*Artocarpus altilis*) is rich in both carbohydrates and vitamins. It has been an important staple crop and a component of traditional agroforestry systems in the Pacific for more than 3,000 years and since its introduction to the Caribbean, has become an essential part of the diet there too. The seedless variety of this species is eaten baked or boiled. The National Tropical Botanical Garden in Hawaii is home to The Breadfruit Institute, which was founded in 2003. The Institute is taking a leading role in the conservation of breadfruit diversity and ethnobotanical research documenting traditional uses and cultural practices involving breadfruit. The Institute is actively engaged in an initiative to respond to critical global food security issues by expanding plantings of good quality breadfruit varieties in tropical regions. It is also developing partnerships to make breadfruit varieties available as a viable sustainable resource for agriculture, agroforestry, and reforestation[1].

[1]Find out more at http://ntbg.org/breadfruit/index.php.

Mangifera indica *(Mango)*

Mangos (*Magifera indica*) are arguably one of the most commonly eaten fresh fruits worldwide. They are grown throughout their centre of origin in Asia as well as in Central and South America and in Africa. They are a good source of vitamins and minerals - eating mangoes regularly is said to be one of the easiest ways to add a plethora of important nutrients to one's diet. An important collection of mango diversity is maintained by the Fairchild Tropical Botanical Garden in Florida. Every year, the International Mango Festival organized by the Garden celebrates the mango as an object of beauty and admiration, a subsistence crop for the people and as a niche and mainstream commercial fruit of the future.

Fruits of Tamarindus indica

West Indian Cherry or Acerola (*Malpighia punicifolia* - Malpighiaceae) is a shrub from Central America and the Antilles. The fruit is a small berry which turns red when ripe. Nowadays it is found both wild and cultivated throughout tropical America and is growing in popularity due to its extremely high vitamin C content, which also makes it a useful anti-oxidant for medicinal purposes. Improved clones have been selected in Brazil and Puerto Rico (Vazquez *et al*., 2004).

Tamarind tree (*Tamarindus indica* - Caesalpiniaceae) is a fruit tree known to the ancient Egyptian and Greeks. It is a native of the savannas of Africa and was brought to India several centuries ago. Now it is distributed throughout the tropics. The sour-sweet pulp that surrounds the seeds contained in the brown pod is the edible part, and it contains high levels of carbohydrate and tartaric acid. It is also very rich in phosphorous, potassium and vitamins. It is highly recommended for reforestation in dry areas, and for use in home yards. Great variability has been observed amongst the trees from America and from India. There are several cultivars in Florida and California, USA. (Vazquez *et al*., 2004).

Avocado (*Persea americana* - Lauraceae), aguacate in Spanish, is essential for food security in all tropical countries. The fruit of this tree is the only one that is rich in both proteins and oil of high quality (similar to olive oil). It is also rich in vitamin A with moderate amounts of B and C as well as minerals. The avocado originated in Central America where it was sacred for the Aztecs. There are many different forms and varieties of avocado that are planted for commerce. It is also a very common tree in Caribbean backyards.

There are many other trees from tropical America that also have value for food security in this region. These include **Guava (*Psidium guajava*** - Myrtaceae), a well-known fruit tree naturalized since pre-Columbian times in the Caribbean islands, originating from the South American continent, and found occurring naturally in fields and woods. The fruit is very rich in vitamin C and can be eaten raw and in drinks, or cooked in jellies and desserts (Leiva, 2007). It is also considered to have medicinal properties.

Persea americana *(Avocado)*

The fruit of ***Pouteria sapota*** (Sapotaceae) known as **Zapote**, is a large, brown coarse berry, red in the middle and bearing a single, lustrous dark brown seed. The edible red flesh is rich in sugars. This fruit is very popular, and the tree is long lasting. Many other products are obtained from both the seed and the tree.

Anacardium occidentale *(Cashew)*

The **Cashew (*Anacardium occidentale***, Anacardiaceae) is often eaten in this region, growing wild in the forests. The edible part is the fleshy, sweet, juicy receptacle, rich in pro-vitamin A, as well as vitamin C and other vitamins of the B complex: it is extraordinarily rich in phosphorous; the roasted kernel is also eaten. The oil extracted from the nut is used in medicine and is also used as local insecticide to preserve books and wooden structures against insect attack. Beverages are prepared from fermented fruit (Vazquez *et al*., 2004).

Botanic gardens and food security

Conserving biodiversity is a main focus for botanic gardens. It is therefore important that wild fruit and forest trees, such as those mentioned above are included in their collections, together with other crop wild relatives.

However, as well as conservation, botanic gardens are also involved in education and community development. An important mechanism to achieve food security is to cultivate vegetables within cities, thus allowing us to keep people close to food plants. As many botanic gardens are located in urban areas they have an important role to play in educating people about how to grow highly nutritional vegetables in their own neighborhoods and demonstrating the nutritional value and uses of local plants.

Future actions

The Millennium Development Goals call for the proportion of people who suffer from hunger to be halved between 1990 and 2015. Although this goal is considered to be within reach, 870 million people are still estimated to be undernourished. Accelerated action is clearly needed.

In May 2013, the international Slow Food organization and FAO signed an agreement to work together over the coming three years to address some of the key issues around food security. Actions will focus mainly on joint advocacy campaigns, strengthening local, regional and global networks and raising awareness of global initiatives such as the International Year of Family Farming in 2014.

Actions will highlight the value of local foods and neglected food crops while also targeting market access for small-scale producers, enhancing conservation and use of biodiversity, reducing food losses and food waste, and improving animal welfare. This is a campaign that botanic gardens could significantly contribute to.

We all share the same vision of a sustainable and hunger-free world, saving biodiversity for future generations. Lets work together to try to achieve this!.

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A ROLE FOR BOTANIC GARDENS IN CWR CONSERVATION FOR FOOD SECURITY

A mixture of wild and cultivated fruit trees growing in a dry river bed in the West Bank, Palestine (Nigel Maxted)

What are CWR and why conserve them?

The human population has recently passed seven billion and is forecast to approach nine billion by 2050 (UN, 2011). At the same time, the potentially adverse impacts of climate change on agricultural production are raising questions about our ability to ensure global food security (IPCC, 2007; FAO, 2008). Although there are many approaches to improving food security, one option that is currently under-developed, but which could potentially make a significant contribution, is the more systematic and targeted use of crop wild relatives (CWR) in crop improvement programmes. Maxted *et al*. (2006) define a CWR as: "*a wild plant taxon that has an indirect use derived from its relatively close genetic relationship to a crop*". CWR have the potential to contribute beneficial traits to crops—such as biotic and abiotic stress resistances—leading to improved yield and stability. CWR contain a wealth of genetically important traits due to their adaptation to a diverse range of habitats and the fact that they have not passed through the genetic bottlenecks of domestication (Vollbrecht and Sigmon, 2005; FAO, 2008). The ability of breeders to increase or even sustain crop yield and quality in the face of such a magnitude of threats is being questioned without much greater use of the natural range of diversity found in CWR taxa (Feuillet *et al*., 2008).

The global value of the introduction of new genes from CWR to crops is estimated to be $115 billion annually (Pimental *et al*., 1997). However, CWR taxa cannot be used by plant breeders to sustain food security if they are not conserved and available for utilization. At present CWR conservation is largely neglected. Most of the world's national parks and other protected areas were established to conserve particular habitats or charismatic animal species; sites targeted at *in situ* CWR conservation are extremely rare (Maxted

Wild apples in Almata Botanic Garden (Nigel Maxted)

and Kell, 2009). Furthermore, only 2–10% of global agricultural gene bank collections comprise CWR accessions and these samples only represent a very small proportion of global CWR species (Maxted and Kell, 2009).

CWR, like other wild plants are threatened with extinction. In the most comprehensive assessment of the threatened status of CWR to date, 572 European species in 25 economically important crop gene pools/groups were assessed (Bilz *et al*., 2011; Kell *et al*., 2012). Results of this study show that at least 11.5% (66) of the species are threatened, with 3.3% (19) of them being Critically Endangered, 4.4% (22) Endangered and 3.8% (25) Vulnerable. A further 4.5% (26) of the species are classified as Near Threatened and one species (*Allium jubatum* J.F. Macbr.) is Regionally Extinct. The remaining species were regionally assessed as Data Deficient (DD) (29%) or Least Concern (LC) (54.7%). However, of the species assessed as LC, around a third are threatened at national level (Kell *et al*., 2012).

The Global Strategy for Plant Conservation 2011–2020 (CBD, 2010a) states in Target 9 that "*70 per cent of the genetic diversity of crops including their wild relatives and other socio-economically valuable plant species [should be] conserved*", while the CBD Strategic Plan (CBD, 2010b) Target 13 called for "*By 2020, the status of crop and livestock genetic diversity in agricultural ecosystems and of wild relatives [will have] been improved*". So CWR are poorly conserved and threatened, but there is a policy basis for their conservation. In terms of providing value per dollar spent on conservation, CWR are obvious candidates due to their indirect value as provisioning ecosystem services.

How can botanic gardens contribute to CWR conservation?

CWR in botanic gardens living collections

Using data extracted from the PlantSearch database managed by Botanic Gardens Conservation International (BGCI), an assessment of CWR species cultivated in botanic gardens (Kell *et al*., 2008) found that 70% of the species in the Plant Search database are found within genera containing crops (including, food, forage/fodder, industrial, ornamental, medicinal and forestry crops) and wild-harvested medicinal and aromatic plants, and that these species include a significant number of major and minor food crops and their wild relatives. Thus, botanic gardens are storehouses of important crop resources and other species of socio-economic importance. The authors noted that this high percentage may simply be due to the fact that, as found in the Euro-Mediterranean region, a high percentage of the flora is of current or potential socio-economic use. However, the historic basis of some botanic gardens as physic gardens housing medicinal plants, as well as some being used as repositories and/or quarantine centres for the early movement of crops around the world, coupled with the fact that many gardens have educational displays of crop plants to show visitors what they look like and how they grow, may account for the high percentage of socio-economically important plants in these collections.

A role for botanic gardens in CWR research

There are a number of potential roles for botanic gardens in undertaking research to assist in national and regional CWR conservation strategy planning. Botanic garden researchers could work with PGR national programmes to provide knowledge of the national CWR flora (taxonomy, biology, distribution, ecology, threat status), the historic herbarium collections have passport data that are critical for conservation planning, and they may also be able to support national PGR programmes in ensuring complementary *in situ* and *ex situ* conservation activities. Most botanic gardens already have active *in situ* and *ex situ* conservation programmes for wild plant species and may have significantly greater field conservation experience for wild species than national PGR programmes, so their specific expertise in reserve management, population monitoring, germplasm collection, storage and regeneration, cultivation in living collections and use of nursery facilities for propagation, cultivation and reintroduction to the wild makes them central to national CWR strategy development and implementation.

Three CWR growing on a UK beach - Beta vulgaris *subsp.* maritima, Crambe maritima *and* Lathyrus japonicas *(Brian Ford-Lloyd)*

It is well known that botanic gardens are repositories of a significant amount of data; therefore, they have the capacity to provide and share data to aid CWR conservation. Botanic gardens could identify the CWR in their collections by cross-checking the taxon names with the global priority CWR list held in the Harlan and de Wet CWR inventory available at www.cwrdiversity.org/checklist/ (Vincent *et al*., 2013). Distribution data for these CWR taxa found in botanic gardens collections can make an important contribution to CWR conservation planning. Information on developing national CWR conservation strategies is provided by Maxted *et al*. (2013).

A role for botanic gardens in CWR education and awareness

One of the most important potential roles of botanic gardens in CWR conservation is in education and awareness (Kell *et al*., 2008). Botanic gardens have extensive expertise in creating informative and educational public displays about the values and roles of plant species. Displays demonstrating the importance of CWR to the public would be a very useful way of raising awareness. The production of a list examples of CWR used to improve crops that would be suitable for such displays and that would put across a strong message was recommended at a CWR workshop at EUROGARD VI (see below). Each example should be accompanied by the key information that would be needed to prepare an educational narrative.

A role for botanic garden in CWR policy formulation

Many botanic gardens are used to dealing with policy matters, such as those relating to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the access and benefit sharing (ABS) issues surrounding the Convention on Biological Diversity (CBD) and International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). They are therefore well placed to advise on and play a role in CWR conservation policy development and implementation.

A resolution from European botanic gardens

During EUROGARD VI: European Botanic Gardens in a Changing World, held in Chios, Greece in May 2012, the workshop 'A role for botanic gardens in crop wild relative conservation' was convened and attended by 30 delegates. The aim of the workshop was to emphasize and explore the current and potential roles of botanic gardens in the conservation and utilization of CWR diversity. The roles of botanic gardens outlined above were presented and discussed and participants resolved that "*botanic gardens have a key and unique role to play in CWR conservation and acknowledge this as part of their remit. In particular, botanic gardens can act as a bridge to increase awareness and educate the public on the significance of CWR for food security, and provide scientific expertise and data for planning and implementing* in situ *and* ex situ *CWR conservation. To foster this role, it is imperative that collaboration is engendered with botanic gardens by policy-makers and agencies responsible for CWR conservation.*" A full report of the workshop is available online: www.botanicgardens.eu/eurogard/eurogard6wkshps.htm#wkshp5.

Allium *species on display in a botanic garden (BGCI)*

Collecting Beta vulgaris *subsp.* maritima *on the Lizard, Cornwall, UK for genetic analysis (Nigel Maxted)*

A call to action

For many years, most botanic gardens have extended their role well beyond the traditional scope of display and education by taking advantage of the collections they already hold to carry out research and conservation activities. As many botanic gardens are already involved in wild plant species conservation, by extending their remit to include CWR, botanic gardens would place themselves at the core of the national agrobiodiversity strategy, making the link between plant diversity and the food we eat and helping to sustain food security.

Where to start? The EC funded PGR Secure project has a helpdesk that offers a range of examples and tools that can lead the user through building a national CWR checklist, the collection of CWR occurrence data, undertaking gap analysis and writing and implementing national CWR conservation strategies (see www.pgrsecure/helpdesk/). The University of Birmingham can also provide individual help to facilitate this process (contact s.kell@bham.ac.uk). We look forward to hearing from you.

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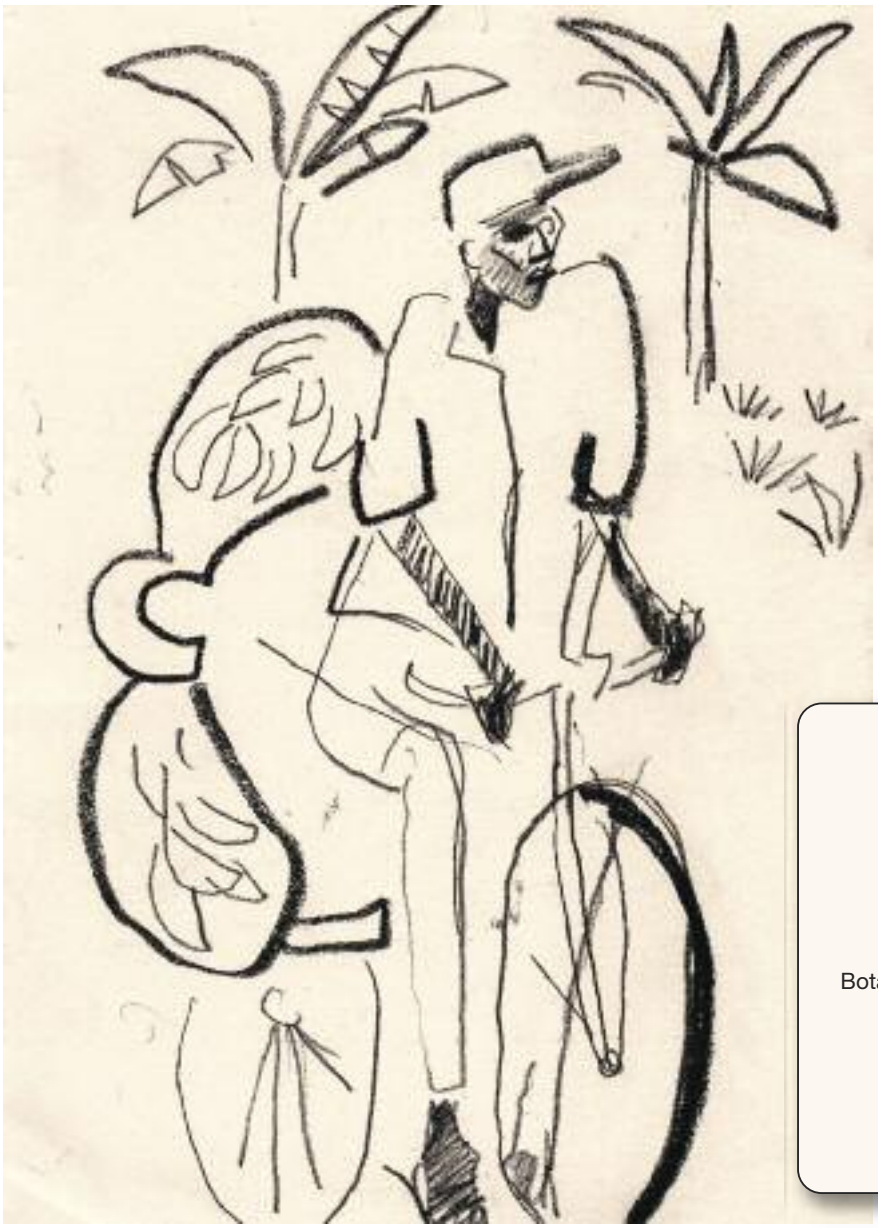
THE SYLVIA SCHOLARSHIP FUND



The **Sylvia Scholarship Fund** was established by **BGCI** in 2012, this new Fund supports training in essential plant conservation skills for young people who work in botanic gardens in developing countries. The Fund is dedicated to the memory of Sylvia Oates who taught and inspired for over 40 years and loved the natural world.

So far we have provided funds for 12 people from around the world to attend the BGCI Education Congress in Mexico. Future grants will provide bursaries to young botanic garden staff to participate in training courses and exchange visits.

If you are able to make a donation to this Fund, it would be sincerely appreciated, enabling future conservation leaders to carry on the vital work of botanic gardens.

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Comments from scholarship recipients after BGCI's education congress:

Meeting educators and environmental specialists from different parts of the world was very important for me as I was able to learn new educational methods for implementing the GSPC.

Since returning to Cuba we have held a workshop to share our experiences and materials with Central Cuban Botanic Gardens.

Ramón Cristóbal Ríos Albuerne,
Villa Clara Botanic Garden, Cuba

Attending the congress gave me an opportunity to see the big picture and to understand the challenges and achievements of other countries. It's really important we work together as botanic gardens and adopt a community approach.

Morelia Amante Calderón,
Cerro Punhuato National Park,
Mexico

BGCI's education congress has opened my eyes to what can be achieved in education in botanic gardens. As a result of the congress, I have made contacts with people and institutions and this will enable me to develop an education programme in Saburo Hirao Park focusing on medicinal and aromatic plants, among other themes.

José Gabriel Cerén López,
Natural History Museum, San Salvador,
El Salvador

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