BGANZ Congress 2009
Paper submissions

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Nine years ago there were three isolated plants of the mallee honey-myrtle (*Melaleuca brevifolia*) left in the Barossa. Today there are several hundred. Other species which are being brought back from the brink of local extinction in the Barossa by Barossa Bushgardens and sold to local homes, vineyards and properties are:

- quandong (*Santalum acuminatum*)
- native apricot *(Pittosporum angustifolium*)
- silver banksia *(Banksia marginata)*
- lavender grevillea (*Grevillea lavandulacea*)
- iron grass *(Lomandra multiflora/densiflora)*
- muntries *(Kunzea pomifera*)
- dwarf hakea (*Hakea rugosa*)
- flame heath *(Astroloma conostephioides)*
- leafless bitter-pea *(Daviesia brevifolia)* etc etc

Over 140 out of 400 species endemic to the Barossa are now growing at Barossa Bushgardens Regional Native Flora Centre, situated on 20 acres of Crown land within the township of Nuriootpa in the Barossa Valley. It comprises a native seed orchard, grassland, and six urban water-wise display gardens encircling a 400 year old river red gum tree exclosure.

Given the context of only 3% of the native vegetation remaining in the Barossa, the Bushgardens has evolved as a not-for-profit community group whose three main aims are to conserve, and provide a sanctuary for local species, as well as educating the community about them and their uses.

The Bushgardens is a business-focussed three-way partnership between local government, State government and community, based on a sustainable funding and operational model. Some thirty local businesses provide cash and in-kind sponsorship.

In nine years it has evolved from a native seed orchard into a green social enterprise, generating income from seedling sales which is then re-invested into regional biodiversity conservation.

The current Strategic Plan (2009-2012) has identified the need for a transition from a natural resource to a community resource. To that end the Bushgardens has gained one-off local government funding plus applied for Federal 'nation-building' funding to construct a multi-purpose Education and Volunteer Centre incorporating a Community Nursery to create a 20 acre regional biodiversity facility.

Nursery a key part of the visitor experience

Given the context of 97% native vegetation loss in the region, the need for an educational reference point where people can go to see what local (water-wise) plants look like growing in the ground and not just in pots, and then make wise plant choices at the nursery, is obvious.

Where can you go in *your* local area to see local plants on display *in situ*, complete with signage and display gardens, and be able to purchase them at the same place?

The vision of connecting the nursery sales area and urban display gardens has benefits in terms of volunteer involvement, income generation, visitor and customer appeal and future traineeships/apprenticeships. The focus is on conserving, promoting, and selling locally indigenous plants, and the proposed relocated nursery will be marketed as a key part of the visitor experience, being located en route from the carpark to the display gardens and as the focal point for visitors emerging from the Volunteer Centre.

The connection between the nursery sales area and the display gardens is essential to the project's economic viability.

Outcomes on private land

The Bushgardens is an ecological restoration project with multiple locations. Our aim is to make plants available on private land across the Barossa (as well as public land). Proceeding from the Bushgardens themselves, the ripple effect of its existence is visible in Barossa home gardens, vineyards, wineries, farms and properties as local native plants re-appear on *private land* across the Barossa landscape.

This project model is value-adding regional conservation efforts and saving government money by achieving outcomes mainly on *private land*, with landowners/homeowners as paying Bushgardens customers who revegetate and maintain plantings at their own expense. We are 'mobilising capital to the cheapest place' – plantings on private land 'spread the risk' and build resilience in natural systems in a context of imminent climate change, land-cover change and dispersal of plant and animal species for survival.

In addition seedlings are sold to the region's largest retail nursery, plants which would otherwise be commercially unavailable.

Sustainable green industry of the future: creating traineeships/ apprenticeships, employment opportunities and a better skills base

Barossa Bushgardens has undergone a transition from simply an environmental project into a social enterprise, recognising the potential to build long-term jobs, skills and social capital in a new green industry. Construction of the proposed Volunteer Centre and Community Nursery will enable the use of an existing natural asset, ie local native plants, to set up:

- school-based 'VET in Schools Program' traineeships with local secondary schools
- apprenticeships in horticulture with a focus on locally indigenous species and their management
- Centrelink Newstart positions (over 55 age group) to be engaged at the nursery and gardens
- Retention and expansion of current jobs at the Bushgardens managing the existing volunteer workforce

Locally we have identified a shortage of skills base for sustainable green jobs in the horticultural and revegetation industry, especially with regard to knowledge of local native plants and their management. We hope to be able to address this shortage and help young people in particular train for a career in native/indigenous horticulture.

A Cultural education

Australia needs regional native flora centres for many reasons: biodiversity conservation, as well as education; to help foster a local 'sense of place'; to give (young) people first-hand contact with their native flora; and to stave off increasing alienation from the environment in the face of increased urban consolidation and development.

In "The Future Eaters" Tim Flannery asks: "given that it is essential that Australians evolve a culture that will help them survive long-term on the continent, two major questions arise: what laws and values should Australians encourage?.....the critical values that a truly Australian culture must enshrine are dictated by the impoverished nature of Australian ecosystems" and goes on to say "we must do all in our power to ensure that Australians have intimate contact with, and a working knowledge of, their ecosystems. If these basic values are not enshrined in our culture, then any sense of Australian nationhood is bound to conflict with environmental sustainability." (p 400-1)

Two points:

- Much community capacity and goodwill, and new networks, have been established across socio-economic boundaries because of the existence of a regional native flora centre focusing on local plants
- The Bushgardens encourages school visits and has developed a series of interactive games based on local biodiversity. A partnership with the NRM Board's Australian Sustainable Schools' Initiative-SA will see these games further developed and linked to the web and school curricula

Return on investment

We are a business-focused volunteer organization. The return on investment set out below underscores the economic effectiveness of the Bushgardens model:

Current annual income is $97 270, comprised as follows:

Seedling/seed	*$44 000*	*45%*
Sponsorship	*$27 100*	*28%*
Grants/funding (sourced by the group)	*$21 500*	*22%*
Investment income	*$3 610*	*4%*
Tours, fees	*$1 060*	*1%*
Total	*$97 270*	*100%*

Note:

- 86% of our income is self-generated through seedling sales, attracting grants/funding, sponsorship by local businesses, tours and donations,
- Volunteer value: volunteers contribute more than 8 450 hours per year. The value of this contribution has been conservatively estimated at $169 000 per year (8 450 hrs@ $20hr).
- Overall community value: for an annual outlay by Council of $14 000, combined with an NRM Board and Council-funded co ordinator position (0.4FTE), the Barossa community receives a regional biodiversity benefit valued at $266 270 (direct income and in-kind support) per annum from Barossa Bushgardens'existence.

Administrative set-up

The Bushgardens operates as a Section 41 committee of The Barossa Council with a committee of 12. There is also a Friends' Group of 120 members which has applied for Tax Concession Charity (TCC) and Deductible Gift Recipiency (DGR) status to be able to access philanthropic funding sources.

Biography

Chris Hall is one of the founders of Barossa Bushgardens and is currently project coordinator. He is a project officer with the Adelaide & Mt Lofty Ranges Natural Resource Management Board, delivering the Australian Sustainable Schools' Initiative - SA. He is also a secondary teacher and has worked in European as well as South Australian schools.

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Is your botanic garden ready for a 9 billion-humans world? A short, illustrated look at the past and future of human sustainability.

Richard Cassels, Director Climate Leadership

In my lifetime the world's human population has increased from 2.8 billion people to nearly 7 billion today. I may live to see it passing 8 billion. Many of our major botanic gardens were created between 1750 and 1880, when the human population first passed 1 billion. Then it took 10,000 years to go from 1 million humans to 1 billion humans. Now it takes 12 to 13 years to add a billion. So are the concepts and values of the I billion-person world still the right ones as we plan for a 9 billion-person world in 2040?

One way of understanding and communicating the rate and scale of change is to review human history in terms of "Population Milestones" . Let us look at these milestones and consider both the changes and the rates of change.

This historic trajectory of human sustainability (and unsustainability!) has been spectacular, from the acquisition of the control of fire 100,000 years ago to the "invention" of agriculture, towns, cities and extraordinary scientific achievements and technology, leading to the Industrial revolution 200 years ago. We humans have now been so "successful " that our impacts now extend even to the stability of the global climate system.

This trajectory is remarkably well documented by "museums" in the broadest sense, including landscapes, archaeological and historic sites, museums and botanic gardens. They document, intentionally or otherwise, the successes and the failures of human society, from the remains of the great human revolutions to the ruins of collapsed civilisations.

So let me take you on a personal illustrated tour of these population eras and of some of the museums and landscapes that tell their stories and reflect their values. And while we are touring, ask yourself this really critical question: should be thinking about the future botanic garden as culminations of the past, or beginnings of the future? What lessons can we draw from our history tour?

- Population era 1. 1 million humans (100,000 -10,000 years ago). It's the Old Stone Age; Ice ages repeatedly turn the human world upside down. Humans reach Australia.

- Population era 2. 5 million humans (10,000 BP). The last glacial ends, and 10,000 years of a generally benign, warm and stable warm climate begins. Unusually for such a climatic change, the megafauna dies out in Eurasia, Australia and the Americas, perhaps affected by human hunting. The first farmers of the Near East are successful, then collapse before recovering a thousand years later. All humanity's major food crops now domesticated.

- Population era 3. 20 million humans (6000 B.P.). The world's first cities and civilisations are found in ancient Iraq. The Sumerian civilisation rises and collapses, affected by human-induced environmental damage and more successful civilisations to the north. In contrast,Egyptian civilisation is sustained.

- Population era 4. 200 million humans. (200 A.D.) Roman ruins around the Mediterranean reflect the height of the Roman empire; this is followed by environmental and social collapse; Polynesian settlement of Easter Island (500 A.D.).

- Population era 5. 500 million humans (1600 A.D.). European maritime expansion- illustrated in maritime museums; The "Great Global Plant Exchange"; early European botanic gardens; extinction of the N.Z. moas; the collapse of the Easter Island population.

- Population era 6. 1 billion humans (1800 A.D.): The Industrial Revolution and its industrial archaeology; focus shifts to fossil plants (coal, later oil); the end of slavery; growth of European museums and botanic gardens (Kew 1759, Brisbane City Botanic Garden 1855).

- Population era 7. 2 billion humans (1927). Age of Oil; the chemical revolution, Population recovers from the First World War. America becomes a global power. Decline of the British Empire.

- Population era 8. 3 billion humans (1959). Nuclear energy has been industrialised. The 'Green Revolution' starts after World War 2. First jet airliners. Mt. Coot Tha Botanic Garden opens 1976.

- Population era 9. 6 billion humans (1999). Hottest year in historic records (1998). 150th anniversary of Brisbane City Botanic Gardens (2005). Al Gore's Inconvenient Truth (2006); an Emissions Trading Schemes in Australia (2009?).

- Population era 10 .9 billion humans (2040? 2050?). 2040 Deadline for 90% decarbonisation of the whole human economy, climate tipping point.

- Population era 11. 11 billion humans?? Optimists assume that world has decarbonised and global womanhood will be choosing and having much smaller families by 2050. Will they?

Every generation seems to assume that all they have to do is to solve their current ecological problem. Today we know this to be untrue. We know that future human-induced global warming of 2oC is already locked in; and that a human population of at least 9 billion is almost certainly unavoidable; and that the ecological footprint of almost every person is increasing, not decreasing. The simple mathematics indicate the extraordinary scale of the change we are about to face.

Many of the great botanic gardens of the world were created at the time of European expansion and the Industrial Revolution (500 million to 1 billion people). Will those concepts and values be more or less relevant in a 9 billion person world? Have we truly comprehended the pace and scale of present and future change- environmental and social?

To take a local example: should the Brisbane City Botanic Gardens at Gardens Point revert to their original function as a food garden for the settlement of Brisbane? Or to their second function as an experimental farm and educational establishment? Or become a combined botanic garden, historic place and local history museum? Or be just another, intensively used public park? Or something totally new, that has never been tried before?

What of new regional botanic gardens? What does a flexible, adaptable and resilient botanic garden look like? What will we need and demand from our local botanic garden in 2040?

We seem to have a tendency to see today as the end point of the past, instead of the beginning of the future. And we all seem to refuse to take the future seriously. What will 20250 be like and what kind of botanic garden do we want or need for that future?

Transformations and milestones in human history. (Richard Cassels, BGANZ Conference 2009)

Date.	"Revolutions"	Population milestones.	Notes		Botany
100,000 B.P.	Evolution of Homo sapiens.	(P.M. 1). 1 million	Old Stone Age.	100,000 B.P. human control of fire. New technology and huge expansion 50,000 B.P., colonisation of Australia, America.	Hunter-gatherer life style. Ice Age, glaciations. Control of fire.
10,000 B.P.	Agriculture	(P.M.2). 2.5 million	New Stone Age.	First agriculture, villages, pottery.	Begin cultivation of ALL the major food crops for humanity.
4,000 B.C	Cities	(P.M.3). 20 million	Bronze Age.	Cities, temples, writing, counting, bronze.	Plough, irrigation.
2,000 B.C.	Empires (Rome peak 200 A.D.)	(P.M.4). 200 million	Iron Age in Eurasia.	Empires, slaves, armies, engineering. Cycle empires / collapse.	Organised food and resource transport, serious overexploitation.
1450-1699.D.	European Maritime expansion	(P.M.5). 500 million	European Renaissance.	New maritime technology (compass, stern rudder, lateen sails). Guns, germs and steel. 1492 Columbus to America, 1499 Da Gama to India. 1608 Galileo's telescope; 1633 heresy trial. 1654 Ussher: world created 4004 B.C.	New World plants in Old World. European botanic gardens (1543 Pisa, 1545 Padua, 1550 Florence, 1580 Lepizig,1587 Leiden,1621 Oxford, 1670 Edinburgh, 1682 Amsterdam). Landscaping: Villa D'Este garden 1550-73, Versailles 1664-8. Museums: Ashmolean, Oxford 1683.

1700-1800			European Enlightenment (Age of Reason).	1761. Accurate time measuring: Harrison's H4 chronometer. 1769- Cook's voyages. 1776 American Independence declared. 1778 First Fleet to Sydney.	1706 Coffee grown Amsterdam. Linnaeus Systema Naturae 1735. 1737 Mauritius- 1st tropical BG. 1753 British Museum, 1759 Kew. Cook's botanists 1769-71. Ca. 1770 Capability Brown. 1787 Calcutta BG. 1793 Louvre Museum.
1770-1865	Industrial Revolution	(P.M.6). 1 Billion	Age of coal and steel.	1770 Industrial Revolution starts in Britain. First steam ships-coal-fired. UK Abolition of slavery trade 1807. Darwin Origin Species 1859, Antiquity of Man accepted 1860-3. Mendel's genetic work (peas) 1865 American Civil war, 1861-5. Transatlantic telegraph 1866. Telephone 1876.	1804 French plant collecting. Sydney BG 1816. London Zoo 1828. Melbourne BG site selected 1846. Auckland Museum established 1852. Adelaide BG 1857.Missouri BG 1859. Queensland Museum founded 1862. Dunedin & Christchurch BGs 1863.. Brisbane City BG 1865,Wellington BG 1868.
1927		(P.M.7). 2 billion	Age of Oil (and plastic).	Wright brothers flight 1903. Model T Ford 1908. WW1: 1914-18. Chemical industries	Chemical fertilisers. Otari BG 1928-.
1959		(P.M.8). 3 billion	Nuclear age	World War 2: 1939-1945. Green Revolution post WW2. Military computers post WW2. 1952 First passenger jet service. 1961 First man in space.	
1962-1999	Chinese Industrial Revolution, Sustainability Revolution		Information Age/ Digital Revolution.	1969 First men on Moon. First jumbo jet 1970. Chinese Industrial Revolution from 1978. Personal computers, Internet, Digital Revolution ca. 1982.	Silent Spring 1962. CITES 1975. Mt. Coot Tha BG 1976. First IPCC Report 1990. Rio Earth Summit 1992. Kyoto protocol 1997.
1999		(P.M.9). 6 billion		4th IPCC Report 2007 on Climate Change. Peak Oil 2008. Copenhagen Climate conference 2009.5th IPCC Report 2014.	Kew Millennium seed bank project 2000. GSPC 2002. AuSCaR (Seed Conservation and Research) 2007.
2040		(P.M.10). 9 bn.		Climate tipping point 2030.	?

Biography.

Richard Cassels is Director of Climate Leadership, an active consultancy and community group in Brisbane. He convened the Greenfest Speakers Festival in 2008, the “Climate Change Down Under” public seminar in 2007 and the “Pioneering a Sustainable Queensland” lecture series in 2006 –both the latter at the Queensland Museum. His 25 year career in museums included holding the positions of Director of Exhibitions and Publications at the Queensland Museum and Director of the Otago Museum in Dunedin, New Zealand. At the Queensland Museum he oversaw the “Museum Zoo” exhibition project, highlighting animal conservation issues, and the creation of Dandiri Maiwar, the Aboriginal and Torres Strait Islander Cultures Centre. As a Lecturer / Senior Lecturer in Prehistory at the University of Auckland he carried out research into prehistoric people and their environments in New Zealand. He trained as an archaeologist at the University of Cambridge and worked in Europe, the Middle East and North Africa. He is a keen bird watcher. His wife Joan is a keen gardener, experienced community facilitator, a partner in Climate Leadership and a driving force behind the building of two “sustainable” houses in Brisbane.

As human colonisation of the Pacific proceeded eastwards from Asia, it progressively took a huge toll on fragile ecosystems throughout the region. Islands, often small land masses of volcanic origin, have fragile, porous and easily eroded soils. These ecosystems have always been vulnerable and precarious. Simplistically, Polynesians were able to adapt and had the 'luxury' of being able to colonise new islands scattered throughout an area more than 5 greater times the area of the Australian continent. As the island populations grew, the sustainability of resources was often tested and species were lost.

The arrival of Europeans, their technologies and Christianity quickly impacted on Island life. The Second World War saw Polynesia irrevocably changed. They were no longer idyllic isolated island states thousands of miles from anywhere. They became military then civilian outposts with all the attributes of western society: 'better' technology for harvesting primary resources, intensified agricultural and horticultural practices, medicines and ease of access to the first world countries of New Zealand, Australia and the United States.

This has come at a cost: overfishing, overuse of land, use of chemicals to stimulate and sustain productivity, reliance on world markets which now bypass them, consumerism and waste. The emergence of a cash society had the same effect as it had elsewhere in the world. Forests and seas were, and continue to be, exploited in the face of offers of unimaginable wealth. The needs of the land have not been understood, ignored or sacrificed leading to severe declines and, in places, decimation of terrestrial and marine biodiversity. Often this is at the hands of foreign companies through corruption and brazen illegal activities. Compounding this is the islands' extraordinary vulnerability to the impacts of climate change.

World-wide, the largest number of documented extinctions (28 between 1600 and 1899 and 23 this century) has occurred on islands of Oceania which now have more threatened species (110) than any other region. Dahl (1984) estimates that there are roughly 7 times more endangered bird species per capita in the South Pacific than in the Caribbean, 50 times more than South America, and a hundred times more than in North America or Africa.
http://www.unescap.org/mced2000/pacific/background/biodiv.htm

Yet in a desktop survey of smaller Pacific Islands, a surprising amount of work had been done on biodiversity assessments and planning. One of the most significant recurring themes is the lack of capacity to implement programmes, to monitor and to report. At the National Environment Forum 2004 in the Cook Islands the follow guiding principles were identified which have universal application and have their origins in Agenda 21 of the Rio Declaration on Environment and Development

- *Equal Responsibility - All Cook Islanders have equal responsibility for looking after our environment*
- *Natural Resources Utilisation and Management - We will use and manage our precious and diverse natural resources in a sustainable manner*
- *Values consistent with our Traditional and Cultural Practices - We will retain positive aspects of our cultural heritage, and traditional values and practices to guide us in enhancing and sustaining the qualities of our environment that will make our children proud owners in the future.*
- *Innovative and Exciting Means - We will continue to adopt innovative and exciting mechanisms and technologies to improve ways of delivering our environmental programmes.*
- *Rights of all Cook Islanders - We will safeguard the customary rights as well as constitutional rights of all Cook Islanders for a healthy environment, and sustainable resource use and practices.*
- *On-going Commitments by All - All of our communities and people will provide uncompromising commitment to the better welfare of our environment and natural resources.*
- *New and Strengthened Partnerships - Our partnerships within Government, and between government and the Aronga Mana, Island Councils, business community, NGOs, local communities, regional and international organisations will be based on good governance principles and empower our people to actively participate in decision making processes pertaining to environmental management.*
- *Meaningful Actions at every level of Cook Islands society - Many of our communities are aware and talk of the need to protect and conserve our environment, but remain inactive. It is therefore a challenge for all of us to actually act on what we preach to achieve the common goal of environment sustainability.*
- *Equitable Sharing of Benefits - All Cook Islanders must be given the opportunity to equally share and enjoy the benefits from the utilisation, protection, conservation and management of our environment and natural resources.*
- *National enabling environment - We will strengthen and improve our planning, policies, regulatory and administrative regimes to support our environmental and related programmes.*

- *To Ensure Access to Healthy and Resilient Ecosystems - We will endeavour to prepare, adapt and manage our ecosystems and the influences impacting on them to ensure that our environment, communities and livelihoods remain healthy, safe and sustainable into the future.*

  http://www.environment.org.ck/ncsa.htm

At the BGANZ Congress in 2005 in the forum discussing *'A role for BGANZ members in Asia/Oceania'*, Roy Banka and Dr David Given spoke of Pacific gardens which had, or potentially had, funding resources available but lack a skilled staff to effectively maintain and manage them. Subsequent casual conversations set me to considering just how we could participate and support restoration and conservation in the Pacific – how could we genuinely and sustainably support BGCI and BGANZ objectives for creating and sustaining capacity as our contribution to meeting Target 15 of the 2010 Global Strategy for Plant Conservation. It seemed to me that we could play an effective training role to support delivery of an operationally based programme for 'on the ground' biodiversity management and restoration.

Dr David Given spoke of the Solomon Islands being devastated by foreign logging companies, on the verge of being pillaged by pharmaceutical companies and of a botanic garden, holding threatened palms and orchids, that had been degraded through neglect and civil unrest. He had a strong view, which he was again to repeat before his death, that New Zealand Gardens did have a role to play. Today the Solomon Islands have 3200 species of higher order plants with significant endemism amongst orchids and palms. Of these sixteen are on the IUCN Red List.

In considering a possible pilot programme run from Wellington Botanic Garden and the wider Parks & Gardens unit I reviewed the resources we could apply

- strong basic horticultural practice
- pest plant and pest animal monitoring and control programmes (at both staff and management levels)
- nurseries producing ecosourced native plants and participating in threatened species restoration programmes
- a strong training ethic
- a well established integrated pest management programme
- a good understanding of the roles of our gardens
- established community volunteer programmes
- a city wide biodiversity action plan including coasts, lowland and coastal forest, grey shrublands, and catchment systems management
- knowledge of how we tell our stories through interpretation.
- we could continue individual's programmes with online peer support

But as a city funded garden we would struggle, especially in a tight financial climate, to deliver any on site programmes other than through volunteerism. Philosophies in aid funding have also changed and delivery has moved to more directly targeted on site delivery rather than general project funding of past models.

To further indentify opportunities there may be for us to provide support in the Pacific I met with Dr Peter Swain, Director of Volunteer Service Abroad in NZ. VSA specialises in matching volunteers to communities with specific needs through on site placements. I wanted to test the following assumptions

- That we had a role to play in capacity building through an off site programme
- That it was feasible and realistic to externally fund the programme
- That ex pat Pacific communities in New Zealand could assist with supporting trainees
- That there would be suitable partners for such a programme.
- That NZ and Pacific governments would be receptive
- That we could genuinely add sustainable value

His response was very encouraging

- Yes there are precedents for purpose developed short course off site training programmes
- It is possible that NZAID or similar aid funding agencies may be able to assist through scholarship programmes
- Ex pat communities would struggle to support the programme as they are usually lower decile communities already under pressure

- Trainees would need a lot of support – they come from large close families with the support that offers. They would be coming to a country which is almost totally foreign to them in climate, landscape, people and lifestyle. It would be cold and they would have to wear shoes!
- Because organisations such as VSA already have links with governments and government funders such as NZAID we can shortcut otherwise drawn out and speculative processes. This is particularly important with the requests for aid having to come from the island governments
- Governments would be receptive to assistance where there is no cost to them and there is a real and sustainable benefit to the people and to the land. Dr Swain also indicated that programmes such as this could, if well managed, create strong momentum for supporting communities in their own capacity building initiatives.

It should also be remembered that Pacific governments often do not choose to ignore environmental issues – they don't have the luxury of making those choices when their economies are in constant deficit, there are the welfare demands of aging populations, unemployed citizens returning home, and in some instances, their economies almost dependent on remittances from ex pat populations.

By coincidence Peter Swain was heading to Honiara and would bemeeting with the beautification programme team VSA have been supporting in the town after the civil war. Co-ordinator, Solomon Islands Environment and Beautification(SEB) has extended its attention to the Honiara Botanic Garden where a NZ volunteer is also now working. After floating the idea with them, SEB have suggested that two staff would like to undertake training to support their nursery work and that the garden would very much like to build relationships with established Botanic Gardens

In another fortunate coincidence Alan Matchett from Dunedin Botanic Garden forwarded correspondence with Anahilia Fofoa from the village of Hofoa in Tonga.

Hofoa village is located near a lagoon which was blocked from the sea and developed for rice production. Unfortunately it failed from high levels of salinity and the lagoon became an overgrown swamp. Later, to restore villagers' access to the sea, a road was put through which then allowed people from around the island access to dump their rubbish. The villagers now want to reclaim lagoon and surrounding land for a garden displaying plants from across the Tongan Islands and are actively lobbying for the return of the lagoon to the village. At the same time they are also encouraging families to donate up to $400 for a plant to cover costs of establishment and maintenance of the garden. Anahilia is very keen that we could assist in some way. The villagers want to demonstrate the value in growing plants to both create and enhance awareness of the flora while illustrating the diversity of plants in Tonga.

Translocating people even for a short amount of time is always going to be the most difficult part of any proposed programme. Peter Swain reinforced the need for support from a resident community and then went on to point out that there were only 2 Solomon Islanders in Wellington! Anahilia Fafoa indicated that there would be strong community support especially from families associated with or near the Hofoa community. Like many local authorities, Wellington City Council has a strong community services directorate focussed on the needs for migrant communities. Discussing the proposal with them indicated that the Pacific Island community is an embracing one and would in all likelihood provide community support and pastoral care especially through the churches.

It is intended that the programme will have a strong hands on focus exposing trainees to the operational concepts of botanic garden operations while at the same time seeking to affirm traditional knowledge, where it exists. The programme does not set out to displace traditional knowledge but to enable trainees to harness and apply it. We can demonstrate resources that can be available and that they do not all need significant monetary input. But most importantly, we can further expose minds to the importance of maintaining, restoring and preserving biodiversity in their botanic garden and by extension, to their communities.

The programme would not be without risk.

- Pacific governments may be wary of perceived neo colonialism: a clash of cultures and that we may be seen to be interfering and participating in tokenism
- Tribalism and patriarchies remain a strong influence when delivering supporting community programmes either directly or indirectly through botanic gardens
- It will be a challenge to prepare and deliver a programme at the right level despite our intention to try to tailor it to individuals
- Establishing effective partnerships with local ex pat communities is essential. Their support would be critical to the engagement of the trainees and the success of the programme
- The programme has the potential to become very expansive. It will be important to keep it contained and managed with in the scope and resources of the project.

- The programme is dependent on being able to source funding external to Wellington Botanic Garden to make it succeed.
- It will need strong sustainable partnerships – each partner will have a role to play with expectations that need to be carefully managed

We will now work forward in establishing funded, effective and durable partnerships so that we can contribute back to the Pacific Islands and meet our obligations through providing grass roots capacity building thereby supporting Target 15 of the Global Strategy for Plant Conservation.

In the last episode of the television series "Around the World in 80 Gardens", the presenter Monty Don, visits a Balinese temple with its beautiful and purposeful garden. He asks the temple custodian what their philosophy is. The custodian replies "It is to bring into harmony our relationship with nature, each other and our gods".

This is a nice description of the triple goals of sustainable management- managing for environmental, socio-economic and a meaningful sustainability.

When it comes to environmental sustainability, no-one can doubt that our society has a truckload of trouble heading our way. When I was born, the human population was 2.8 billion. Now it's nearly 7 billion and heading for over 9 billion by 2050, with no guarantee it will stop there. The many significant challenges for human (if not planetary) sustainability include:

1. Maintaining a safe climate.
2. Dealing with shortages of water, food and energy.
3. Maintaining ecosystem services and resilience (including biodiversity).
4. Managing the capacity to overpopulate.
5. Managing consumption and waste.
6. Eliminating or minimising toxic by-products of our technology and lifestyle.
7. Adapting to present and unavoidable future climate and environmental changes.
8. Tackling the inertia of our inflexible social and physical infrastructure.
9. Maintaining economic viability.
10. Maintaining or re-assessing our lifestyle and standards of living.
11. Minimising inequity (social, generational and international).
12. Moving away from dependence on finite resources.
13. Developing new social values and beliefs, and a sense of "connectedness".

The challenge of sustaining 9 billion people by 2050 without irretrievably damaging our planet is perhaps the greatest one ever faced by humanity. To put it mildly, we need to be very inventive right now!

In this context botanic gardens rightly focus on their critical mission of preserving global plant diversity through research, conservation and education. They implement, and can promulgate, sustainable gardening practices. They can become exemplary sustainable businesses through developing green supply chains, recycling, waste- and toxin-elimination.

They can play an important role in all the sustainability challenges listed above by widening the scope of their education programs to take a wider view of human sustainability (as, for example, the Eden project has done). They can showcase new green technologies like green buildings, roofs and walls and new processes like biochar and biosequestration. They can address the emerging world food and energy crises by growing and showing plants of the future-new food crops and plants being grown for biofuel. They can pay more attention to, and prominently feature, the "bad plants"- invasive weeds that are threatening biodiversity as much as human consumption. They can focus as much on teaching the skills of the future as the botany and ecology of plants. They can treat storm, flood, fire and drought in their gardens as learning opportunities, rather than obstacles for managers and grounds staff. They can trace the origins of imported plant food and materials and tell the stories behind of the overseas communities that provided them. They can consider issues of international equity.

When it comes to socio-economic sustainability, the managers of not-for-profit, "permanent" institutions like botanic gardens and other museums have long been expert at managing for long-term sustainability. They are used to finding an acceptable and motivational balance between, on the one hand, the almost limitless scope of their missions and the ambitions of their enthusiastic workers or stakeholders and, on the other hand, the realities of funds and resources. They balance the ambitions of designers to create monuments to their skills and vision with the costs of long-term maintenance and the need for flexibility and refreshment of "exhibits". They continually assess the importance and 'sanctity' of the collections against their core reasons for being- to research, preserve and educate. With small staffs, they have to manage successful staff succession. For a secure future, they have to encourage and tap into the widest possible range of ideas and suggestions, while maintaining their core business and values.

They have to live with the reality that what many visitors want from a botanic garden may simply be a good café and nice place to meet existing or new friends. (A former director of the Victoria and Albert museum in London recognised this when she marketed the museum as "An ace café with quite a nice museum attached"-much to the outrage of some). So they have to further the "missionary"

objectives of their museum or botanic garden by cleverly harnessing the public's desire for recreation and relaxation and politicians' desire for "bread and circuses"-public parks packed with picnickers and concert-goers.

When faced with how best to service their community (which included some of the poorest communities in Europe), the Glasgow Museums Service identified that one of the best community services it could provide was to break down social isolation by creating public programs that would bring people together. This became an important basis for accessing ongoing public funding.

The third Balinese objective was to manage for a good relationship with their gods. In the largely secular world of government-funded public institutions in developed countries, museums cannot do this. But they certainly contribute to a sense of belonging, connectedness, to things like a "sense of place".

As in other museums, botanic garden educators recognise the extraordinary power of stories to reach their audiences. Incorporating personal human stories increases the power of story-telling exponentially. There is in some centres such as Mackay for considering actually physically combining a botanic garden with a history / natural history museum on site. World wide a number of famous museums have created a huge internal vigour by crossing traditional boundaries: Te Papa in Wellington brilliantly combines art gallery with museum; Sovereign Hill In Victoria combines the Gold Museum with heritage buildings and outdoor re-enactments; Melbourne Zoo combines zoo with botanic garden and recreated cultural landscapes .Such an integrated institution in Mackay could provide a home for people' stories, memories and emotions and even contribute to a search for meaning. It can powerfully enhance a sense of place and feelings of belonging and connectedness, and hence a sense of responsibility for place and people. This is "managing for mind, heart and soul".

In many ways regional botanic gardens are uniquely placed to contribute to a more sustainable society. Their plants are part of living local ecosystems, so educators can exploit the learning opportunities of linking plants with their ecosystems- insects, birds, mammals, soil, topography and climate. Managers can exploit the power of nature to work with them, not against them. Local botanic gardens can join up with the new "Local Living Economy" movement. With global change happening at an unprecedented pace, they may be small and flexible enough to adopt radical new ways of operating – whether that is combining with a history museum or something even more radical. They certainly can exploit their natural advantages of being able to build "a sense of place". To paraphrase Sam Ham, they can encourage their communities to ask "What makes my place different from any other place on earth?" They can help them to become permanently committed to <u>their</u> special place on the planet, to caring and sustaining it.

So the sustainable management of botanic gardens is not just about sustainable gardening and managing plant collections. It is of course about managing the connections between people and plants and plant collections, between people and planet, people and people, people and place, people and purpose.

If there is one common theme in human yearning, it is for connectedness with nature, each other and purpose in life. If there is one underlying key to human sustainability, it is to feel connected to, and hence to care for, place, people and planet. If there is one simple lesson for the manager of a botanic garden or museum, it is to focus on the connections, not the collections! And all this may be easier to achieve in a young, local or regional botanic garden than a capital city garden created in the Victoria era.

Biography

Richard Cassels is Director of Climate Leadership, an active consultancy and community group in Brisbane. He convened the Greenfest Speakers Festival in 2008, the “Climate Change Down Under” public seminar in 2007 and the “Pioneering a Sustainable Queensland” lecture series in 2006 –both the latter at the Queensland Museum. His 25 year career in museums included holding the positions of Director of Exhibitions and Publications at the Queensland Museum and Director of the Otago Museum in Dunedin, New Zealand. At the Queensland Museum he oversaw the “Museum Zoo” exhibition project, highlighting animal conservation issues, and the creation of Dandiri Maiwar, the Aboriginal and Torres Strait Islander Cultures Centre. As a Lecturer / Senior Lecturer in Prehistory at the University of Auckland he carried out research into prehistoric people and their environments in New Zealand. He trained as an archaeologist at the University of Cambridge and worked in Europe, the Middle East and North Africa. He is a keen bird watcher. His wife Joan is a keen gardener, experienced community facilitator, a partner in Climate Leadership and a driving force behind the building of two “sustainable” houses in Brisbane.

Public seek	Museum aims to provide*	Museum’s mission*
Pleasant, healthy, safe place to relax outdoors		
Place to eat and drink		
Place to meet friends		
Place for exercise		
Place to be entertained		
Place with nice plants		
To learn about botany	Discovery	Research
	Remembering	Educate
	Imagining	Preserve

Stephen Weil: The Proper Business of Museums: Ideas or Things? *Muse* 7(1), 28-38.1989.

Content

Botanic Gardens are not a well understood resource amongst the community. From the result of surveys, it is shown that people predominantly visit Botanic Gardens for recreation purposes. Further to the struggle for our cause is the lack of knowledge about Native Botanic Gardens or even worse local natives. In most cases people don't recognise what value to the community they have from the native plants around them. This situation is not restricted to the community but also our management, council and even State Government. Because Tondoon Botanic Garden is one of the best examples of collecting and preserving the unique vegetation of regional areas, I would like to use our story to encourage others in their determination for the cause. I will be talking about the many aspects and roles of a local native Botanic Garden and how to best achieve a truly valuable resource.

Introduction

BOTANIC GARDENS – "Institutions holding documented collections of living plants for the purposes of scientific research for conservation, display and education". (Wyse Jackson, Botanic Gardens Conservation International 1999)

This is just a very small statement but a lifetime of hard work to see it fulfilled in even one Botanic Garden. I will use this statement to take you through the 'behind the scenes' story of Tondoon.

I believe Tondoon is a success story in Regional Botanic Garden establishment and development. There are few Botanic Gardens that haven't detracted from their original plans and ideals in some significant way.

- INSTITUTIONS
- DOCUMENTED COLLECTIONS
- LIVING PLANTS
- SCIENTIFIC RESEARCH
- CONSERVATION
- DISPLAY
- EDUCATION

INSTITUTIONS

- Master Plan
- Site Selection
- Planning
- Infrastructure

Master Plan

I like to think that Tondoon is classified as a Category 1 Botanic Garden. Collection incorporated with an associated herbarium, professional and technical staff, adequate recording system, continuity of purpose and tenure assured. This is because of the vision and planning that was first set out in our original master plan, which is vital to the establishment of a Botanic Garden. What has been set out and accepted, needs to be adhered to wherever possible. Management and staff will continually try to make changes that will alter the original concept.

I have found this to happen constantly at Tondoon. An example of this is in our Arboretum area. This area is quite heavily wooded with *Eucalyptus teriticornis* and lawns, which creates a unique feature. I get told regularly that they need to be thinned out or removed mainly because of all the leaf and gumnuts that drop on the precious lawns.

Norm Gibson who was one of our early volunteers was also involved in the original planning. He collected a lot of propagation material and many Herbarium specimens for both the Brisbane Herbarium and Tondoon. Norm said to me once that people asked him why he didn't do more work in other areas like the tropical and temperate regions. His answer was that you don't become an expert of something by being distracted in other areas. Stick to your plans, you will need these strong convictions for guidance and leverage to convince others of your ideals.

Site Selection

Good site selection for Botanic Gardens is a major factor for long term development. Tondoon has grown from the original 55 ha to the present day 170 ha. The location, land formation, and any history of that area can be an added bonus to developing public interest as well as any special features can create diversity within the Botanic Garden environs. Tondoon has some very interesting historical aspects, nestled around the original Gladstone water supply with historic pump station, only 6 kms from the main city centre, located in a developing suburban area and the site of the largest meteorite ever found in Queensland.

All of the undeveloped area is natural bush land, giving us the opportunity to offer activities, like bush walks and spotlight tours. Interpretive signage on the local wild life and birds found within the gardens is a popular interest to our visitors.

Planning

It is important to get the layout of a Botanic Garden right in the initial planning stages. It is in this initial planning stage that will determine visitor interest and ultimately the viability of a Regional Botanic Garden. As I said earlier, it can be assumed that 80% of visitors come for passive recreation reasons. Remember, we are planning for a garden that should exist for 200 years or more and be able to capture the interest of young and old for the entire life of the Garden. There are very few modern institutions expected to last that long.

An enormous amount of research and planning was given to each detail prior to planting at Tondoon, but even so, some areas didn't work out as hoped. Recruit as much skilled help and information as you can, as convincing management that a certain garden bed needs to be reconstructed can sometimes be difficult. We have already recreated two large garden beds and there are still a few other areas that need redesigning. The good thing is that with the knowledge and experience gained, it always works out right the second time around.

Infrastructure design

Structural design is an integral part of any institution with a theme to ensure continuity throughout your plan. The structural design theme at Tondoon is large airy timbers that concur with the natural forestation that surround the development. Twenty years on and it has proved to be an excellent choice for the hot Central Queensland climate and has required only limited maintenance. The only replacements we have made are the seats and tables under irrigated areas.

Here in Mackay the theme is steel and glass in modernistic design, and hopefully with the continued support and funding from the Mackay Regional Council it will expand accordingly. It's during the lean budget times that it is the hardest not to compromise. However, there are ways to ensure the continuity of development, by construction in stages or being patient and waiting for better times. It is during these lean times that you find yourself in disagreements with upper management, as they are motivated by job completion and don't always see the same big picture that was originally established.

Interpretive signage also needs to be in included in the design theme. I was particularly impressed with signage used at the Auckland Botanic Gardens, especially the leaf shapes for directional signs. Attractive shapes and interesting creative initiatives add to the visual appeal Sometimes your interpretive theme may change as new innovative ways of making signage develops.

An essential part of our institutions is to have our own nursery for the propagation of new collections and replenish plants stocks that are not perennial. Over the years it has been suggested that we contract out our propagation. This is not feasible, it would be impossible to cost the work involved or essesive cost would be too prohibitive. With your own nursery there is always an opportunity to educate a part of the community by giving them the special plants that are not obtainable in commercial nurseries.

DOCUMENTED COLLECTIONS

- Record keeping

It may seem a bit out of order here, the documented part of the collection, but if you have ever had to trace back records for hundreds of plants, you will know how important it is to get your recording system organized right from the start. Recording systems don't have to be complicated. The most basic information needed is name, accession number, date collected, date planted, origin and location in your botanic gardens. There are a few other desirables, like latitude and longitude and a notes section for interesting features, such as how it grows, but then who has time to do that? We have 3 separate databases for our record keeping. The Herbarium, Live Collection and the Nursery. They could be rolled into one but as different people are doing the data entering, I felt it is safer and more convenient to have each one separate. Two of the data systems are Access and one is Excel. We still use a card

system in the Nursery and then transfer the info to a particular database. Even though this is all only basic information it takes a considerable amount of time to record and keep track of. This often has to be done without management's knowledge as they can't see "on the ground" results so consider it a waste of your time.

LIVING PLANTS

- Live Collection

This is the best part of the job, getting plants in the ground and seeing them grow. If you are collecting from wild origins, it's a big job and can often be a long process for certain plants, but that of course, this makes it all the more rewarding. Collecting and propagating is a totally different ball game from buying or swapping plants. The National Strategy and Action Plan for the Role of Australia's Botanic Gardens in Adapting to Climate Change makes it quite clear that our priority is to collect from local known provenance. Part of this Strategies coordination policy is also for Botanic Gardens to primarily collect locally so as not to overlap or double up on collections.

There is a misconception that native plants look after themselves. This is not so. In fact, maintenance is all the more demanding because each individual plant is so important. A lot of work, time and energy has gone into collecting, propagating and growing these plants.

Many native plants cannot be allowed to just do their own thing or they will grow with bad form and become weak trees. Stronger species will crowd out the weaker plants, grow over pathways and the dead limbs need to be removed to ensure public safety and add to the visual appeal. Natives have pest problems, nutrition and toxicity problems. So, all the same care and maintenance is required as with any other major garden but these plants will be around longer than most.

Now that many of the plants at Tondoon are flowering and fruiting, a number have been photographed for some well-known plant identification publications. Simply, it is easier to find these species in the gardens than it is to find and photograph them in the bush. Local interest is increased when it is made known that their botanic gardens have been featured in these publications.

The number and expertise of our gardening crews determine the condition of our Botanic Gardens. A great deal of horticultural training and experience is needed to keep gardens in a satisfactory state. This is a continual struggle either with management or the crew itself. The Kershaw Gardens at present is an example of these problems and also Tondoon in some areas.

SCIENTIFIC RESEARCH

- Herbarium
- Plant Selection
- Propagation

I guess there are varying degrees of scientific research and we can only do what we are capable of or what resources are available to us. Our main areas of research at Tondoon are the Herbarium, plant selection and propagation.

Herbarium

Our herbarium is run by volunteers who do an extremely professional job. I oversee this work, give technical advise and make sure there is continued collecting of specimens. A herbarium is a vital part of any botanic gardens and is something that requires a substantial amount of time to maintain a good standard. Unless your herbarium is fully funded, it's a part of the job that you have to take home. You will never find the time at work to press specimens, especially if they were collected while you are out on a bush walk at the weekend.

The herbarium volunteers and I were involved with the weeds CRC program and are still sending weeds to the Queensland herbarium. Volunteers don't generally like collecting weeds, its not exciting like finding out the ID of native plants not previously known in the region, but I'm afraid weeds have now become a part of our ecosystems and it pays to know what you have in your area.

It is very rewarding to stand in the herbarium and see all the specimens that have been collected and mounted. If they are cared for well they will be there for many years to come and are a wonderful resource library for your local gardeners.

Plant Selection

Selection of local native plants for ornamental horticultural use is something we should be taking every opportunity to attain. Anytime special characteristics are noticed in a plant, propagate from it and trial it, you never know what you could develop. It's not uncommon to find a desirable form from the plants you propagate, especially shrubs and they could even turn out to be PBR's. The development of native plants for these purposes is a key element for research in botanic gardens.

At Tondoon we promote bush foods whenever possible, so experimental plots of native food plants can be seen at various places around the gardens. Recently, we had to spray a large patch of Raspberry with Grazon as it had got away on us and the Bush Turkeys were spreading the seed everywhere. Some things work out, some don't.

Propagation

Many Australian plants have there own special way of seed germination. Finding that method sometimes requires some experimentation. Of course, records must be kept of each step, whether it's successful or not. We record in a propagation book, then onto cards and transfer that information to a database as well. It may sound like overkill, but unless you have someone that is extremely efficient in the nursery all the time, this invaluable knowledge will go astray.

Scientific research in Regional Botanic Gardens is always difficult but there are things we can do even if they are only small contributions and done at our own pace. Elaborate laboratories are not the only method for research and not always needed in the smaller regional areas.

CONSERVATION

- Threatened Species –ex-situ
- In-situ Conservation
- Conservation Advisor's
- Seed Source

Threatened Species – ex-situ

Very few flora surveys had been carried out in our region when Tondoon was first developed. So, we were lucky in finding a number of new species and even more new to the region. Many of these new plants turned out to be threatened species and at present we have 40 in our collection. It's important to know the regional threatened species and to know where they are located in your region. Some of our collections are endangered species, of which there are very few plants left in the wild. If a recovery plan were to be carried out on certain species such as *Rhodamnia angustifolia*, *Oldenlandia gibsonii* or *Atalaya collina* these plants would be invaluable in the future. Forest isolation and lack of substantial corridors will make it very difficult for plants to move around naturally in the future.

The Queensland Herbarium is always interested in increasing their collection, so it is important to collect specimens along with propagation material for your live collection.

Threatened species are grown in our nursery to give to interested people or groups. We are careful with these, as we don't like to waste them where they won't be adequately maintained and cared for.

In – Situ Conservation

Opportunities seem to arise regularly to help with conservation if you have knowledge of local ecological communities and make yourself available. Many landholders desire to know what plants they have on their properties and this is often the first step in conserving those plants. We work closely with community groups eg: The Society for Growing Australian Plants who help us find new places to carry out flora surveys.
A plant list is written each time we first visit a property and then updated on any subsequent visits. This means we have about ninety individual plant lists within a day trip from Gladstone. We have found no reluctance from landholders to allow us onto their property. Being from a Botanic Garden, they are not as likely to feel threatened as they might with certain government departments. Various groups in the community have often used these plant lists.

The Fitzroy Basin Association through the Boyne Calliope Sub Region of which I am a committee member has approved hundreds of thousands of dollars in funding for conservation purposes.

Conservation Advisor's

Gladstone is an industrial city, which has tended to make groups shy away from conservation work in the past, but because of this, I feel Tondoon stands out as inspiration of beautification of an otherwise arid and industrial region. We have been here for the long haul and are now reaping the rewards and have the opportunity to advise Industry, Developers and State Departments.

Presently, we have two significant projects happening. One with Main Roads, translocating 500 *Cycas megacarpa* and propagating 50,000 Littoral Vine Forest species with the Central Queensland Ports Authority, for translocation from an industrial site. So, because of Gladstone's industrialization we have the opportunity to contribute in various conservation efforts.

Seed Source

Diligent recording of our collections from local provenance can make botanic gardens a vital seed source for conservation purposes. This is the key to our botanic gardens importance in the future. If we don't have known provenance, then plants will be bought from any nursery and make botanic gardens conservation purposes irrelevant.

Council and the community receive many plants from seed collected at Tondoon, which is a continual promotion process. We collected *memecylon pauciflorum* from Wiggins Island a number of years ago. This year these plants fruited very well. So we have been able to collect fifteen hundred seedlings from under these trees for the Port Authorities translocation job due to the fact that Wiggins Island is the industrial area to be demolished.

DISPLAY

Tondoon's Primary display area was originally set out in geographical and Taxonomic areas. Later this changed to ecological sites only. I feel the ecological sites have worked best for us. The ecosystems in our region seem to be small and scattered so obtaining a varied planting for each area can be difficult. A better way for us to display these species has been to collect from all of the same forest types and plant together in large garden beds. Where you have large ecosystems like Eungella and the Paluma Range to collect from, geographical areas may work better.

I am glad I have had the opportunity to create gardens that are close to the original forests, but I feel there is a need in the modern botanic gardens for demonstration gardens. In fact, I see no reason why a whole botanic garden could not be set out as local provenance demonstration garden beds. People tend to copy from the gardens they have around them, hence we have one long medium strip that looks the same from Brisbane to Cairns. We need to get the message across that local natives are the best water wise plants and can displayed in attractive layouts, so planting with natives needs only a little creativity.

EDUCATION

Education is a vital part of Botanic Gardens. Whether it is about your gardens, conservation, environmental sustainability, indigenous culture or biodiversity, these programs bring a new generation of visitor to the gardening culture. This can be education through interpretation, tours or lessons for school children. All lesson plans for children should be curriculum based and filled with enjoyment for appropriate age groups. I believe education is an area that can be shared through networking with other botanic gardens. We all have a very similar message to get across.

Education and interpretation are functions that performance indicators can convince council of the importance of a Botanic Garden to the local community. Networking with other Regional Botanic Gardens may help demonstrate the success that is achievable.

We are excited about where our education programs are today at Tondoon but it has been a long hard road with plenty of ups and downs. The position of a Visitor Services Officer had to be built up over many years but now creates substantial opportunities. Combined with a good volunteer program, it enables us to run education programs with schools and these programs draw in an average of 4000 students per year. With regular tours, environmental displays in the Visitor Centre plus various holiday programs throughout the year, I feel our involvement with plant and environmental appreciation in our next generation will see further increase of visitors.

CONCLUSION

Curating a Botanic Gardens is a varied and complex job that few people other than those involved, really understand. The role of curator at Tondoon is relatively new but has already had a critical change to management. Tondoon has had five different Directors and five Managers during the years I have been there. They all have their own ideas on what a botanic garden should be and how it

should benefit the council or community. Some of these ideas are opposed to the original concept or even the changing concepts of the modern day botanic gardens. We need to be constantly thinking ahead so we can anticipate these changes.

Primarily, Tondoon is a leading example of a Regional Native Botanic Garden with known provenance for a future gene pool. Because of this, I felt compelled to talk about our achievements. Some of us have very high ideals, which can be costly to us and even our families if we are determined to work for such an institution over a long period. I would like to encourage others to promote regional native gardens, so that at least for a time, the dream can be carried on.

Support from our major Botanic Gardens and organizations such as BGANZ would be helpful and appreciated. The occasional letter of assistance to our councils appreciating the conservation work we are doing would go a long way, especially from our umbrella organization in Brisbane.

Sometimes it's the little things that help us endure difficult times. People have said to me that they are so glad that I am still here they don't know what would have happened to the gardens if I had left. They were referring to the continuity of the original concept and vision of those who were involved in the initial idea of a Regional Botanic Garden in Gladstone. I feel very privileged to been able to carry that vision with them.

In order to keep those goals and aspirations true for the future and for those who will come after us, we must fight for our rights now.

Peter Symes, Environmental Horticulture, Melbourne Gardens, Royal Botanic Gardens Melbourne

It is not the strongest of the species that survives, nor the most intelligent,
but rather the one most adaptable to change (Clarence Darrow).

Abstract

Climate change is projected to have significant affects on south-eastern Australia, due to the current assessments of future climate scenarios, concentration of development in coastal areas, relative aridity of existing climate compared to others around the world, and lack of altitudinal and or geographical "escape paths" for flora as temperatures shift. Regardless of water supply issues, increases in annual mean temperature may threaten the effective physiology of plant taxa adapted to previously cooler conditions, whether these are growing in natural or artificial habitats. Successful adaptation strategies for the management of plant conservation, living landscapes and planning for vegetation succession need to address both issues of temperature rise and uncertain water supply. As climate change projections for south-eastern Australia continue to typically suggest for higher average temperatures and lower rainfall scenarios, this is the basis that is used in this paper for the assumptions that are made. However, individual botanic gardens must consider specific projections for their location and also consider the possibilities of lower temperatures and increased rainfall which can also present challenges for *ex-situ* plant conservation.

As effective planning for living and natural landscapes requires long lead times, botanic gardens must implement adaptation strategies regardless of whether the climate change is anthropogenically driven or due to natural variability.

In October 2008, the author completed a 4-week study tour of numerous botanic gardens and landscapes in south-western USA to evaluate strategies for long-term planning and management. Comparisons and conclusions drawn from this research and its application to the living landscapes of south-eastern Australia are described.

Botanic gardens have an excellent capacity to study the 'symptoms' of climate change upon living collections through sciences such as plant phenology. However, urgent focus is now needed on the implications of climate shift for the management and future development of *ex-situ* plant conservation.

Microclimate variability and diverse landscape styles in botanical gardens offer prospects in the interim for the protection of taxa sensitive to the effects of climate change. It is anticipated that robust regional partnerships in landscape expertise, plant cultivation and research will ultimately inform *ex-situ* plant conservation programs both nationally and globally.

Introduction

The strengths of Botanic Gardens include valuable intrinsic expertise in long-term landscape planning – often within 50 year-plus temporal scales. This exceeds political governance where decisions are often only made for the short term within an election cycle. Therefore botanical organisations must embrace the philosophy of being custodians or stewards of living landscapes and plant habitats. The supposition can then be made that botanic gardens as conservation organisations will not only collectively adapt to changing climatic conditions, but will resolve to make bold decisions and show innovative quantum leaps in leadership.

There is a very real danger that timely implementation of adaptation strategies to climate change can be stymied by 'organisational hysteresis (Faulkner and Campbell 2006). This is a phenomenon where a time lag occurs between a respective organisation's recognition of an issue, and the active changes that are actually implemented. Some recent models applying a global temperature increase of 2-3 ^{o}C are projecting that over the next century up to 50% of vascular plant species could be threatened with extinction (Bramwell 2007). There is no room for tardiness when it comes to tackling the threats of climate change whether these are from water scarcity, temperature shift or biosecurity issues.

Our measurements of success cannot be just focussed on financial bottom lines or cost benefit studies. Inspirational leadership and vision involves being prepared to take risks and make bold financial decisions to improve the chances of better outcomes for our living assets. Thomas Edison would probably not have pursued the continued development of the light bulb if he had only considered cost benefit analyses as the measurement of his success, particularly if his labour time of 1.5 years was considered against an incandescent lamp with a filament of carbonised sewing thread that only burned for 13.5 hours! (http://inventors.about.com/library/inventors/bledison.htm)

Flora in south-east Australia is threatened by a distinct lack of altitudinal and or geographical "escape paths" for flora as temperatures shift (CHABG 2008; CSIRO 2008; Hawkins et al. 2008). Rainfall decline and variability also adds to the stressors upon taxa already compromised by humankind's insatiable demand for natural resources. While not within the scope of this paper, invasive plant species and other pests more biologically adapted to the new regimes also add to the threat loading. In RBG Melbourne (RBGM), Palm Pink Rot (*Gliocladium vermoesenii*) (normally seems to be a tropical disease) has killed some Bangalow Palms *Archontophoenix cunninghamiana* since 2004. In January 2009 after unprecedented hot weather, *Phytophthora multivora* was implicated in the damage to cool temperature species such as *Drimys winteri*, *Podocarpus nivalii* and *Quercus robur*.

However, it is considered that the primary threat to *ex-situ* plant conservation in Botanic Gardens are changes to temperature regime and the subsequent physiological stresses on taxa more suited to cooler climates (Kozlowski and Pallardy 1999; Hawkins et al. 2008). Many other climate-driven issues are readily mitigated when compared to temperature change. For example, (whilst not ignoring the challenges) a decline in rainfall can be relatively more easily managed for ex-situ plant conservation by increased irrigation and sourcing of alternative water supplies. Yet, in the longer term, increases in prevailing temperature can only be practically managed in individual living landscapes by landscape transition, careful plant selection and translocation of plant species to more suitable locations.

A case in point is how horticultural techniques such as misting are applicable to raise relative humidity and provide evaporative cooling in unenclosed environments. Some studies in RBGM using data loggers to measure temperature and relative humidity found no significant differences between misted/protected and non-misted/exposed zones. It is of course possible that higher relative humidity levels may be found very close to the ground layer, but even in this situation, the relative exposure of landscapes to wind mixing is expected to reduce this benefit.

Ultimately, it is understood that the most successful approach is to consider *ex-situ* plant conservation as a national and even global living collection imperative. The maintenance of artificial living landscapes creates varying levels of continuing tension between the required environmental conditions, and available resources such as energy, water and management. It is proposed that for more sustainable practices and less risk of plant losses, living collections ideally should be curated where they are most climatically suited or in homoclimes (regions sharing similar climates) (Booth 1988) - whether intra-location or inter-regional. There is no scope for organisational egos or 'empire building' when it comes to plant conservation. Botanic gardens highlight plants as their main objective in mission statements. This must be the continuing focus as greater sharing of plant material and expertise is essential to collegiate success. If a specific botanical garden is able to grow certain species more successfully due to the prevailing and projected climatic conditions, then is expedient to consider replication of live genetic material from less suitable sites.

Invasive species complicate plant conservation strategies (Hawkins et al. 2008). Australia is under siege over large tracts of land from weedy plants (Scott and Kritcos 2009). Botanical gardens have no desire to be implicated in the rise of a new invasive species that has 'escaped' from living collections. Even if arduous, weed risk assessment processes will be required to reduce the likelihood of this occurrence. It is an intricate dilemma, as some species more suited to landscape succession for the prevailing and future climate, will likely have a higher potential for weediness. However, there is a case to contemplate the curation of the most vulnerable taxa to climate change in their natural habitats, even if increased management inputs such as supplementary irrigation is required. For instance, the Springs Preserve in Las Vegas, Nevada curated some taxa that were potentially weedy outside their natural range, but due to the extreme aridity of the region were unable to successfully recruit outside the confines of the managed land.

It is timely that agreement is forged for a national system that duplicates valuable plant accessions across more suitable climatic zones in botanical gardens. In 2007, RBG Melbourne developed a decision support tool for plant selection that incorporates the choices of transferring high priority plant accessions to more suitable climatic locations and other living landscapes to more effectively conserve those species. The 8 major and 150 regional botanic gardens in Australia (CHABG 2008) provide a rich palette of microclimates diversity for plant conservation, especially when considered at a national and indeed global context, and have a critical role in meeting this need.

Overview of current climate change projections and implications

A precautionary approach is recommended as the best risk management method when examining climate change projections (UNFCCC 1992). Currently, the climate change models are generally following the higher emission scenarios or the projected changes are happening more quickly than formerly predicted (Steffen 2009). These changes include the threat of recurring extreme events such as acute bushfires, droughts, heatwaves, floods and drying trends (CSIRO 2008; State of Victoria 2009; Climate Change in Australia 2009). While there are still uncertainties about the extent of the main processes driving serious impacts, most of these ambiguities are still heading towards more rapid and serious climate change (Climate Change in Australia 2009; Steffen 2009).
In other words, the historical approach to risk management of examining past occurrence, frequency, consequences and likelihoods (Standards Australia 1999), are not as applicable 'to the letter' when considering the protection of dynamic living systems. Therefore, its seems prudent to apply scenarios of 'worst case' temperature and rainfall changes in future landscape planning, especially when

considering the long lead times required to establish more resilient living collections. If those situations do not eventuate, then it is anticipated that the living landscape will have been transitioned to a more sustainable position regardless. However, if management actions are based on lesser change scenarios, but worse projections are realised, then it is too late to then attempt to restrict losses of biodiversity and living landscape values. In this paper, worst case scenarios of increasing temperature and decreasing rainfall are used as the basis for botanic gardens management planning. The other lesson we must all heed is that climate change projections are constantly changing. Apart from threats of resource scarcity, it seems that these changing climatic conditions will become the major influence on how we operate as botanic gardens in the future. Therefore, to manage effectively for the survival of our living collections and organisations, we need to be accessing contemporary climatic information on a regular basis.

In Victoria, climate change over the coming decades is anticipated to result in increased temperatures; drier conditions and increased frequency in severe events such as extreme rainfall, bushfires and droughts (CSIRO 2008), and most of these events are also common to the rest of south-east Australia (Suppiah et al. 2006; ACT 2007;CSIRO 2007; CSIRO 2008; SEACI 2009). For RBGM, it is expected that by 2070 that annually under a lower greenhouse gas emission growth scenario that it will be 1.3°C warmer with 6% less rain, and under a higher greenhouse gas emission growth scenario it will be 2.6°C warmer with 11% less rain (CSIRO 2008). The greatest increases in temperature are expected during summer, whilst the greatest rainfall reductions are projected during spring (CSIRO 2008).

The projected seasonal changes to climate may already be impacting upon regions. Murphy and Timbal (2007) found that there had been a 61% decline in autumn rainfall for south-east Australia from 1997 to 2006, and that there is likely to be an influence from global warming on the climate of south-east Australia - at least for temperature. Cai and Cowan (2008) studied the reduction of autumn rainfall in Victoria and found that for the period 1950–2006, this had decreased by about 40% from its long-term average, primarily during May. Although the causes of this decline are not fully understood, it seemed to be linked to weakening of atmospheric conditions linked to the Indian Ocean, increases in the frequency of El Niño contrasted with reductions in La Niña events, and possible affects from climate change. The prospective, and alarming (if realised) issue with current changes to seasonality climate is that future projections may in effect build on current deficit patterns.

Studies by researchers from the South Eastern Australian Climate Initiative (SEACI 2009) have found that the major influences on south-eastern Australia rainfall such as the El Niño Southern Oscillation (ENSO), Indian Ocean Dipole (IOD) and Southern Annular Mode (SAM) do not explain the changes to autumn rainfall (SEACI 2009). The influence of these weather phenomenons are weakest during autumn when the greatest declines in rainfall have been noted. The cause of the rainfall decline is now considered to be linked to increases in mean sea level pressures over Australia (Steffen 2009). Changes to a band of high pressure known as the sub-tropical ridge (which sits at about 30 degree's latitude), impacts on these sea level pressures. During the 20th century, pressures have increased along the sub-tropical ridge and this change seems to be linked to global warming. The researchers conclude that about 70% of the rainfall decline in south-eastern Australian can be explained by this increase in sub-tropical ridge pressure (SEACI 2009). Variation in the Southern Annular Mode is also being linked to significant reductions in rainfall all across southern Australia (Steffen 2009).

Table 1 - Major Climatic Influences on Rainfall in South-eastern Australia

Name	Description	Impact	Reference
El Niño Southern Oscillation (ENSO),	Caused by rising sea surface temperature in the eastern Pacific Ocean and cooling in the western Pacific Ocean	Warm, dry conditions in spring Major droughts	SEACI 2009 Bureau of Meteorology
Indian Ocean Dipole (IOD)	The Indian Ocean Dipole (IOD) is a linked ocean and atmosphere event equatorial Indian Ocean that affects the climate of Australia	Positive IOD Sea Surface Temperature (SST) is linked to a decrease in rainfall over parts of central and southern Australia. Main influence is on maximum temperatures and rainfall during winter—spring	SEACI 2009 Bureau of Meteorology
Southern Annular Mode (SAM)	Climatic variability system that affects the north-south movement of the band of westerly winds that dominate latitudes just south off Australia and are often linked to storms	Significant influences on rainfall and minimum temperature in all seasons except for Autumn Variation of SAM implicated in considerable rainfall reductions across southern Australia	SEACI 2009 Bureau of Meteorology Steffen 2009

Historical weather and projected climate data is often based on mean values. It needs to be highlighted that managers of biodiversity such as in botanical gardens must also consider extreme events. For instance, a projected increase in annual average temperatures could also result in an increase of individual or a flush of consecutive days at extraordinary temperatures. In January 2009, this was experienced in Melbourne where 3 consecutive days above 45°C resulted in significant damage to many taxa across RBGM – especially cool temperate species. While this extreme can occur at daily or monthly temporal scales, there are also yearly considerations. For example, the worst case long term annual average reduction in rainfall for Melbourne is forecast to be about an 11% reduction (CSIRO 2008). This may actually be significantly greater for the average 10th percentile (1 in 10 driest) rainfall years. We can comprehend one year of extremely reduced rainfall is enough time to severely damage or kill high percentages of plant taxa. There are other flow-on impacts that are not always elucidated in these reports - although this seems to be improving as the science develops. Attention needs to be drawn to changes in rainfall that amplify changes in stream flow and runoff into storages. A 1% annual change in average rainfall can result in 2-3% changes in stream flows (SEACI 2009). Melbourne Water commissioned a study by the CSIRO in 2005, which projected by 2050 changes in rainfall by +1 to -13% and subsequent stream flow reductions from -7 to -35%. (Howe et al. 2005).

The Murray-Darling river system attracts national socio-political attention, and particularly from south-east Australia. Currently, the situation remains dismal with the Murray Darling Basin Authority (MDBA 2009) advising via its *June 2009 Drought Update* that the situation for the Murray-Darling Basin for the autumn of 2008-09 was the ninth consecutive one with below average rainfall. Inflows are close to record lows and well below long-term average. For June 2008 to May 2009, Murray system inflows were the third driest in over a century of records. The total volume in all government-managed Basin storages is only at 17% of capacity. It seems that the outlook for irrigation volumes during this financial year continues to be bleak (MDBA 2009).

Post et al. (2009) reports that by 2030, the majority of Global Climate Change (GCM) models show a decrease in average annual rainfall across the SEACI region of south-east Australia, and particularly, lower average rainfall over winter in the future when most runoff occurs. Relative to 1990, the best estimates indicate that by 2030, runoff will be 0-20% less in the north-east and southern half of the SEACI region, and by 10-30% less in Victoria (Post et al. 2009). If the mean annual runoff is modelled from 15 of the GCM's, then there is increasing variability in the results for the SEACI region with +30 to -30% changes in the northern area, +10 to -30% in the southern half, and 0 to -50% for Victoria (Post et al. 2009). It seems that the drying trend becomes more likely in the southern parts of south-east Australia. It is important to understand the implications of reduced runoff whether water supplies are sourced internally or externally to a living landscape. Water resource planning for botanic gardens has to be modelled on future projections and 'worst case' scenarios, and not rely on long-term mean values. Existing water storages are obviously at risk, but the viability of rainwater collection, groundwater and stormwater harvesting schemes are particularly vulnerable to runoff changes.

One of the general observations of botanic gardens in south-western USA was that employees did not seem to be adequately cognisant of climate change impacts for their landscapes, or the meteorological resources that were available. Although this may have been politically mediated, it seemed unusual compared to the current level of knowledge of their Australian colleagues. In California and Denver, the response to climate change threats was a reliance on upgrading of infrastructure such as automatic irrigation systems, and while improvements in water use efficiency are worthwhile aims, it is not the only objective required. This response may be culturally influenced by the historical construction of massive engineering projects in the USA Southwest to deliver water along aqueducts and pipelines over great distances. It seems that this construction was a source of water security for the community, even if it is now misplaced. Ultimately, we cannot construct our way out of climate change impacts and this highlights that there is no scope for complacency. There is a vital need for continuing diligence to actively seek out climatic information and incorporate it in living collections management.

Selection of projected climatic changes for south-eastern Australian cities

Increased temperatures and numbers of hotter days on average are commonly projected across south-eastern Australia. Decreases in average rainfall are also projected for most south-eastern Australian cities including Adelaide, Melbourne and Sydney. Canberra is only expected to have small changes to average annual rainfall (Suppiah et al. 2006; SSP 2007;CSIRO 2007; CSIRO 2008; SEACI 2009).

For the major botanic gardens in heavily built-up environments, the urban heat island (UHI) affect is expected to magnify any mean temperatures projected under climate change scenarios as UHI influences are not factored into long term projections (Lenart 2008; Coutes et al. 2009).

Table 2 – Selection of projected climatic changes for Adelaide

Parameter	Current	2030	2070
Frosts	3	0.2	1
Temperature Change (°C)	[1]+0.96	+0.4 to +1.2	+0.8 to +3.5
[2 3] Annual Rainfall (mm)	445	-1 to -10%	-3 to -30%
[2 3]Annual Evaporation (mm)	1881		
Days over 35°C	14	15—20	17—39
Days over 40 °C	1	?	2—11

[Adapted from Suppiah et al. (2006) and Government of South Australia website (http://www.climatechange.sa.gov.au)]
[1]Over the last century compared to 0.89 °C for Australia wide (Global = 0.7 °C)
[2]Spring rainfall reductions are projected to range from -2 to -60%
[3]Rainfall and evaporation sourced from Bureau of Meteorology, 023034 Adelaide Airport.(http://www.bom.gov.au/climate/averages/tables/cw_023034.shtml)
[4]At the Kent Town site, annual average evaporation equals 1229 mm.

Table 3 – Selection of projected climatic changes for Canberra

Parameter	Current	2030	2070
Frosts	62	39-60	9-52
[1 2]Annual Rainfall (mm)	632.6	?	?
[2]Annual Evaporation (mm)	1255	?	?
Days over 35°C	5	6-13	8-42
Days over 40 °C	0	0-1	0-10

(Adapted from SSP 2007)
[1]Winter—spring rainfall is projected to decrease by 2-12%, although summer—autumn is projected to be 4—12% wetter.
[2]Rainfall and evaporation sourced from Bureau of Meteorology, 070282 Canberra City site. http://www.bom.gov.au/climate/averages/tables/cw_070282.shtml

Table 4 – Selection of projected climatic changes for [1]Port Philip catchment (Melbourne)

Parameter	Current	Average Recorded by RBG AWS for 1999-09	2030	2070
Frosts	[1]3	[3]4.6	2 to1	1 to 0
[2]Temperature Change	[1]15	[3]14.7	+0.6 to +1.1	+0 to +3.7
Annual Average Evaporation	[1]1241	[4]1272	-1 to +5%	-1 to +17%
[5]Average Annual Rainfall	[1]648	505	0 to -8%	-6 to -24%
Days over 30°C	30	32.4	33—37	35—62
Days over 35°C	9	13	10—13	12—26
[6]Days over 40 °C	1	1.9	2	2—8

(Adapted from CSIRO 2008)
[1]Sourced from Bureau of Meteorology, 086071 Melbourne Regional Office http://www.bom.gov.au/climate/averages/tables/cw_086071_All.shtml
For 086282 Melbourne Airport, mean annual evaporation is 1712mm and rainfall is 532.2 mm.
[2]For Melbourne, the highest seasonal temperature change is projected for summer, ranging from +0.6 to +4.4 °C.
[3]May indicate the cooling capacity of the RBG landscape against the urban heat island.
[4]Reference evapotranspiration (ETo).
[5]Rainfall deficits are anticipated to be greatest in spring ranging from no change to -41%

[6]RBGM has experienced five summer days greater than 40°C in 2005-06, 2007-08 and 2008-09 (includes record high of 46.7 °C)

Table 4 – Selection of projected climatic changes for Sydney

Parameter	Current	2030	2070
Frosts	0	0	0
[2]Temperature Change ^{o}C	[1]17-26	+0.2 to 1.6	+0.7 to +4.8
[3]Annual Rainfall (mm)	1094	-13 to +7%	-40 to +20%
Annual Evaporation (mm)	+1 on average of 1791mm	+1 to +8%	+2 to +24%
Days over 35^{o}C	3	4-6	4-18
Days over 40 ^{o}C	0	0-1	1-4

(Adapted from CSIRO 2007)
[1]Average annual maximum temperature range
[2]Change to mean annual temperature from 1950—2003 has been 0.9 ^{o}C
[3]Average annual rainfall and evaporation sourced from BOM, 066037 Sydney Airport.
http://www.bom.gov.au/climate/averages/tables/cw_066037_All.shtml
(Average annual rainfall at 066062 Sydney (Observatory Hill) is significantly higher at 1214mm per annum

Climate change impacts on the USA Southwest
It is anticipated that the south-western and western regions of the USA will be one of the most affected areas by climate change (Lenart et al. 2007). A higher degree of warming in western USA is already being observed compared to the rest of the continent (Lenart 2008; Moser et al. 2009). Southwest USA is especially expected to have higher temperature rises than most of the world with temperature increases of up to 2.8—4.4^{o}C by the end of this century (Lenart 2008). Consequently, hotter days and heatwaves lasting up to two weeks longer are projected for the region.

Decreases in precipitation of 5-10% are also envisaged by 2100. Winter precipitation is projected to be particularly impacted for south-western USA and northern Mexico (Lenart et al. 2007). Even with the overall decline in precipitation, more intense rainfall events and flooding are projected to increase (Lenart 2008). When the impacts of decreasing rainfall and increasing evaporation are combined, an increased moisture loss of about 8 mm per month is projected (Lenart 2008).

In the city of Phoenix, Arizona, about 66% of the recent warming appears to be related to the expansion of urban areas and ensuing increased urban heat island (UHI) effect. As a result, it is anticipated that growing urban areas in southwest USA cities are likely to warm faster than other parts, especially in overnight temperatures (Lenart 2008). Since 1976, there have been temperature rises of 1.4 ^{o}C and 0.9 ^{o}C for Arizona and New Mexico respectively. From 1920 to 2003, California has experienced an overall increase in the average minimal temperature of about 1.7^{o}C and a 0.5 ^{o}C increase in the average maximum temperature (Moser et al. 2009).

California relies heavily on the volume of snowpack in the Sierra Nevada Mountains for recharge of groundwater (supplies about 50% for human use) and storages. Over the past 100 years, reductions in the volume of the snowpack (due to the precipitation falling as rain), and earlier timing of the melt runoff have been observed. Greater runoff prior to spring presents a problem for storage systems as there is more water being lost as overflow (as a flood mitigation strategy) before demand begins to ramp up in the drier season. There has been a 19—23% reduction in runoff during April-July (spring-summer). It is currently anticipated that continued global warming would also drive the trend to earlier snowmelt and it is projected that 20—40% further reductions could occur (Moser et al. 2009).

Other observations indicate that spring is beginning earlier and autumn is delayed. In the Sierra Nevada range, ecological niches of montane flora and fauna are shifting to higher altitudes (Moser et al. 2009). Studies have found an upwards retreat of *Pinus ponderosa* of about 200 metres, and this is believed to be linked to an increase of minimum monthly temperatures of 3^{o}C over the last one hundred years which increase drought periods inducing greater mortality of seedlings (Moser et al. 2009).

There are some indications that south-western USA is going to share the influences of climate-linked atmospheric pressure and ocean temperature changes with south-east Australia. Current projections for a poleward shift in the jet stream could result in failure of El Niño events to bring precipitation. Lower precipitation in the southwest has also been linked with positive phases of the atmospheric occurrence known as the Northern Annular Mode (NAM) (Lenart 2008).

It does not bode well for the biodiversity of south-western USA. Whilst some of the projected climate changes are not seemingly as extreme compared to south-eastern Australia, these variations are occurring within an already arid climate. For example, annual

rainfall averages for the following Southwest cities are as follows: Tucson, Arizona (322.6 mm); Albuquerque, New Mexico (225.6 mm); San Diego, California (252.5 mm).

Developing water use efficiency

In the interim, botanical gardens with collections that currently require supplementary precipitation need to make concerted efforts to improve efficient use of water resources. In a horticultural context, water use efficiency (WUE) (Fairweather et al. - accessed 2009) can be defined by continuing to obtain similar values of plant health, amenity outcomes and landscape style, but using less water. For urban horticulture and biodiversity conservation it is difficult to define a quantifiable product when the outcome is actually highly qualitative and open to subjectivity. Water use efficiency should be distinguished from water conservation or demand reduction alone as these approaches can result in diminished botanical values. In a crude fashion, an organisation may elect to reduce water demand (by what some could fairly argue is the easy way out) and cease to irrigate some areas all together. This is not necessarily astute management, especially when the same water savings could be delivered by WUE and the landscape values retained. However, we have to accept that under current scenarios of water scarcity in Australia, many botanical gardens have needed to incorporate both WUE and water conservation programs, and adapt to changes in landscape amenity and plant selection.

Early adoption of water efficiency improvements provides immediate benefits for climate change resilience. A reduction in water demand through improved efficiency can realise more effective use of available rainfall; decreases in the scope, cost and energy demand of alternative water sources; and improved capacity to deal with water scarcity, whether from regulation or climate-driven. A focus on efficiency rather than just demand reduction also can improve living landscape management skill, build technical knowledge and enhance the professional development of employees.

In the experience of RBGM, one outcome over the last decade that has become a paramount need is improving the precision of irrigation scheduling for smaller units of area. In 2007, a revision of the irrigation scheduling framework realised 9 rankings of quality/plant requirement for garden beds, arboretum and turf areas. Work is continually being done to improve the accuracy of the lowest level of irrigation control (or hydro-zone). By necessity, the individual hydro-zones will become smaller to compensate for the variability in the edaphic and microclimate environment. The downside to this necessary aim in the shorter term is for larger numbers of solenoid valves and increases in the sophistication of control systems.

Landscape planning and policy

Historical context

One of the confronting issues revolves around establishing the purpose of the managed landscape. For the older sites, cultural and heritage values can create unique tensions between conserving historic identity and meeting contemporary needs for environmental sustainability. As conservation organisations, botanic gardens take their environmental responsibilities very seriously but concurrently also need to meet any custodial obligations. Over the last decade, the need for water conservation and improving water use efficiency has brought increasing community attention to bear on landscapes that require supplementary irrigation to survive and or to meet expectations of amenity. Early in the development of Australian landscapes and botanic gardens, the paradigm was often based on English traditional styles – usually resulting in plant selection that needed significant management inputs to realise the landscape intent. Whilst botanic gardens are scientific institutions supporting living plant collections and plant conservation, the general visitor often considers these landscapes as places for social and recreational pursuits. These are important values that also need to be recognised. Visitor experiences can only be ignored at the peril of ultimately losing political and financial support and the magnet of attracting community involvement in the first instance. The visual landscape becomes the palette on which to display environmental issues, run educational and research programs, support continuous professional improvement, and ultimately highlighting the vital role that plants play on the earth.

Master plans and living collections policies

It is essential to develop documentation that articulates clear direction for the development of the living collections and landscape within the context of a changing climate. Such planning reinforces the continuity of plant and habitat conservation and should transcend the whims of political change and or horticultural fashion. RBGM reviewed its Living Plant Collections Plan in 2006, completed a Strategic Water Plan in 2007, reviewed the Master Plan in 2008 and completed a Tree Strategic Plan in December 2008. All of these documents incorporated adaptation measures against the risks of increasing temperatures and rainfall uncertainty. A greater prominence is now being placed on curation of floras for both current and future homoclimes of Melbourne. Recent living collection developments such as Californian Garden, Water Conservation Garden, Lower Yarra River Habitat (indigenous flora of Melbourne) are more likely to be suited to the projected drier and hotter conditions of the future.

However, there are some important collections that are not well adapted to even the current climatic conditions of Melbourne. These include the Australian Forest (formerly Australian Rainforest Walk), New Zealand and Southern Chinese collections. Modifications to the planting palette of these collections may be necessary to better align their composition to the existing and future climatic conditions for Melbourne. New projects and landscape developments are axiomatic opportunities for continuing adjustments to

changing climatic conditions such as careful plant selection, water use efficiency and landscape design that also remain true to the essence of the place.

While it is generally accepted that wise horticultural practice results in selecting the 'right plants for the right place', too often we can lament our limited knowledge on the species natural environmental conditions and the match to the proposed location. It is no longer adequate to make some educated guesses about these factors. We have to improve our knowledge of the prevailing soil conditions and hydrological patterns throughout the year for our landscapes, and the actual rainfall and temperature variations in the plant's natural habitat. Greater investment in building this knowledge is required if we are going to continue to be more successful in *ex-situ* conservation under changing climates. It is also likely that our social communities are going to be looking to botanical gardens as the experts who can provide this climatic and curatorial information. Politically, botanical gardens need to ensure a voice for the visibility and interests of plant conservation. The famous phrase *scientia potentia est* - "For also knowledge itself is power" (Flyvbjerg and Sampson 1998) if practised in building our plant and climate knowledge base could provide the instrument to successfully inform the policy makers.

For many urban landscapes, the other challenge to planning will be the successful incorporation of stormwater treatment through 'rain gardens', wetlands, bioswales, and other bioremediated treatments without diminishing the landscape intent or living collection quality. High levels of collaboration are required between landscape managers and engineers right across catchments, especially when also considering the likelihood of designing mitigation systems for future extreme storm events (Climate Change Taskforce – accessed 2009; Howard et al. 2009). This extends to locations with *in-situ* water bodies such as ornamental lakes and wetlands. Some botanic gardens are also at risk from saltwater intrusion caused by over extraction of groundwater or rising sea levels wrought by global warming (Climate Change Taskforce – accessed 2009; Steffen 2009). To illustrate, the surface of the RBGM's Ornamental Lake in July 2009 was only 11 cm Australian Height Datum(AHD) above sea level (capacity is 110 cm AHD). This lake was originally a natural lagoon and is currently being managed to retain and try to increase its biodiversity, including indigenous aquatic fauna. An increasing tidal level of the proximate Yarra River from rising sea levels, storm surges or combinations of these effects (Steffen 2009) could result in saltwater intrusion that ultimately would be catastrophic to this ecosystem.

Mapping of landscape microclimates

'Microclimate mapping' within the landscape is one technique that can assist with informed plant selection and the development of living collections. This includes establishing the characteristics of both the edaphic (soil) and atmospheric environments throughout the year. For example, the edaphic environment for shrubs growing under a deciduous tree may contain a higher moisture status during this tree's dormancy period, but concurrently the atmospheric environment for these plants is more highly exposed to radiation and wind. The converse may occur during the tree's active growth period. Microclimate mapping is useful for establishing generic zones within the landscape. Yet, there is still even greater variation involved, even at small units of area. To illustrate, the study of the amount of rain penetrating through overhead tree canopy (through fall) and corresponding soil moisture levels in the RBGM has revealed significant variation even at sub-meter spacing. In natural habitats, plants would only typically establish in niches suited to their recruitment and growth. However, in contrived landscapes, the establishment period and planting site is chosen and this may not be the best match to the environmental conditions. Seasonal soil moisture or the soil water balance is one of the critical factors, and we need to develop specific approaches of examining and monitoring point levels of soil moisture in respective landscape areas. This can be achieved in a technologically advanced way by using soil moisture sensors, or it is just as effective (although more labour intensive) to take soil cores and compare moisture status against standardised methods. At the very detailed level, this could involve measuring the variation in soil moisture content under a given tree and planting to these conditions.

Normalised Differential Vegetation Index (NVDI) (Bureau of Meteorology 2009) is a technique that uses satellites to map spectral reflectivity of solar radiation. Green leaves have greater reflectivity in the near infrared range compared to moisture-stressed vegetation (less green) that reflects less. In Nevada, USA, the Southern Nevada Water Authority uses multi-spectral imagery such as NVDI in the city of Las Vegas to identify the comparative water content and vegetation lushness over a range of landscape areas to target their water use reduction program (Bennett 2008). Similar techniques are used in Australian agriculture to identify areas of greatest evaporative demand and improve irrigation efficiency (Kerridge et al. 2008).

NVDI is one technology that could be applied to identify seasonal microclimates in the landscape used for *ex-situ* conservation. For a prospective botanical site, it would be ideal to map soil moisture gradients over a year, and indicate relative microclimates prior to any landscape planning.

Comprehensive soil surveys (Van Rees et al. 1993) are also an important part of the landscape planning process. Soils are the foundation of existence for so many forms of life, and yet often they are taken for granted, poorly studied or understood in the living landscape context. So often in a project, copious amounts of money are spent on the 'hard landscape' structures, services and infrastructure, but when it comes to soil testing and analysis, it is compromised. We would not even contemplate asking an engineer to not bother with measuring the bearing capacity of a soil for a building, or 'cutting corners' in safety specifications. Soil crucially

supports the invaluable living assets of our organisations, and although very complex, the further we understand the landscape soil environment, more informed decisions can be made for living collections planning and development.

Measurement of air and soil temperature, and relative humidity are other climatic factors that can be used to map microclimates but are highly variable even on an hourly basis. To be effective the measurement of these variables really requires continuous datasets through the support of technology such as data loggers. Phenological indicators of plant development may indicate prevailing microclimates over time, but this does not show the actual 'point in time' measurement or the limitations to plant health such as extreme daily temperatures. In California, Berkerley Botanic Gardens grow a wide range of Mediterranean flora successfully from around the world most of the time, but the 'winter freezes' that occur there every decade or so really imposes limits on the longevity of some of this flora (Licht pers.comm. 2008). In the Sonoran Desert of Arizona, snowfalls are common in winter although Saguaro cacti *(Carnegia gigantea)* can only tolerate up to about 24 hours of sub-zero temperatures before they are killed. Whereas temperatures of -7 ^{o}C for 12 hours in late autumn have caused significant damage and death (Phillips and Comus 1999) In Australian contrast, during January 2009, RBG Melbourne experienced an extraordinary consecutive three days above 42 ^{o}C, followed by a record 46.7 ^{o}C on 9 February 2009 which severely damaged many species, particularly on New Zealand flora, including common taxa such as *Phormium* sp. that hitherto had grown reasonably well during Melbourne's summers.

Mapping of microclimates can often reveal that certain living collections will be poorly situated for the taxa being grown. For older botanical sites, the heritage importance of these collections is a vexing problem. In RBGM, large areas of the Australian Forest Collection are highly exposed at elevation in the landscape to hot, northerly winds and also subject to exceedingly hydrophobic, sandy soils of low water-holding capacity. Nevertheless, this collection dates from Guifoylean development in the late 1800's. The current solution for one zone has been to translocate valuable Tasmanian rainforest species to more suitable microclimates in the Gardens, whilst transitioning this problem area to a Victorian flora context with species originating from drier forest habitats.

Plant selection and living collection evaluation

Future plant selection processes need to become more rigorous and inclusive of temperature and drought tolerances. There seems to be a relative dearth of detailed curatorial knowledge for many of the plants we grow, particularly regarding climatic preference (or indeed tolerances), and natural habitats. This is a significant barrier to the progression of any risk mitigation strategies for plant survival, particularly for the threatened and endangered taxa in our collections that are less well known from cultivation experience. In California, ecologists, horticulturists and landscapers are able to freely access online information that details the interconnections of their native flora and their habitats (Calflora – accessed May 2009). As botanic gardens, we need to move not only towards developing these knowledge base systems, but actively and freely sharing this information on a national level.

One of the pitfalls of developing evaluation frameworks is that plant selection can become overly bureaucratic and time intensive. Ultimately, the purpose of these processes should be to up skill curators in their knowledge of plant performance under varying conditions, and subsequently promote behavioural change or culture shift in living collections selection and landscape design.

Fully understanding the preferential growth conditions for our living collections is important and overdue. Nonetheless, in Melbourne the decade of drought and continuing water restrictions is driving the thinking of landscape managers towards improving our understanding of actual plant tolerances or what respective taxa can survive, particularly in the extreme parameters of soil moisture and temperature. Water stress indices have been proposed as one way of managing water scarcity and landscape priorities (Symes et al. 2008). The ability of certain plant species to tolerate drought has been of focal interest for many Australian horticulturists for some time, but now 'heat tolerance' is entering our vernacular, and heat stress indices could become one of our management tools. This means that in the interim at least, we may have to accept a lower level of amenity for many of the plants we grow, as long as they are surviving and maintaining genetic diversity for ex-situ conservation.

There is also a need for vigorous lateral thinking in regard to plant selection for future climates beyond the usual comparisons with current soil moisture tolerances or flora from similar climates. The wide range of Australian flora grown in south-western US botanic gardens gives cause for reflection in selecting plants for hotter, drier climates. In Mediterranean climates such as found in California there is a marked period of very minimal (none) summer rainfall, often for several months (Dallman 1998). It bears thinking about what other species normally associated with these plants in natural habitats back in Australia could also potentially tolerate these dry summer climates. The adaptation of some plants to climatic shift also prompts tangential assessments. For instance, the vegetation of the Sonoran desert in Arizona was believed to be similar to a tropical deciduous forest about 10,000 years ago, and that some plants had actually adapted to the forming of the current desert habitats (Dimmit pers. comm. 2008). For southeastern Australia, it is pertinent to at least examine the possibility that many subtropical species might have the physiology for adaptability to drought as well as normal preferences for warmer conditions. There is a whole world of plant species to explore in this arena, and for the RBGM, many of these would contribute to the embodiment of the Guilfoylean landscape, while they are protected via *ex-situ* conservation from warming beyond their natural range. Here again, there is a real deficiency in the detailed knowledge and measurement of plant performance that is required.

Our assumptions about taxa adapted to periods of aridity have to be assessed. In Australia, there is a strong interest in Mediterranean flora on the basis that these species are drought tolerant due to months of very minimal rainfall, particularly over the summer months in their natural habitat (Dallman 1998; Peel et al. 2007). However, Mediterranean climates are usually characterised by significant winter precipitation (Dallman 1998; Peel et al. 2007) which may also recharge groundwater and subsoil moisture levels. Californian oaks such as *Quercus agrifolia* (Coast Live Oak) and *Q. lobata* (Valley Oak) are considered to be phreatophytes (groundwater-using) (CEM accessed 2009) that have the capacity to tap groundwater for survival over drought periods (Mahall 2009). Specifically, *Quercus lobata* has been reported to access moisture from depths as great as 24 metres (Howard 1992). David et al. (2007) studied *Quercus ilex* ssp. *rotundifolia* (Holm Oak) *and Q. suber* in southern Portugal and found that more that 70% of the trees transpiration was sourced from groundwater at 4—5m depths. Other species from desert climates such as *Proposis* sp. (Mesquite) within the south-western USA region are able to tap groundwater supplies to extreme depths, up to 60 metres (Phillips and Comus 1999).

In Melbourne, over the last decade of drought, the author has observed decline in *Corymbia ficifolia* - a West Australian species from a Mediterranean climate. Naturally, this species is growing in annual rainfall regimes of about 800—1200mm, mostly in winter. On the converse, seemingly non-irrigated *Corymbia ficifolia* populations were observed to be thriving in San Francisco during the late summer period. It is worth musing on the potential capacity of this and other species to tap subsoil moisture reserves or indeed even groundwater that has accumulated over the cooler, wetter months. Studies are being undertaken by a researcher University of Western Australia of deep roots in caves from *Eucalyptus diversicolour* (Karri) and *E. gomphocephala* (Tuart) on the basis (UWA 2009) that these trees are phreatophytes. Interestingly, the same researcher has also studied deep roots of *Quercus fusiformis* (Evergreen Oak) at 20 m depths near Austin, Texas, USA.

For Victoria, the continuation of deficits in the mean autumn-winter rainfall (Murphy and Timbal 2007) raises questions for the long-term survival of Mediterranean flora, especially with further climatic changes. One of the issues for contrived landscapes could be attempting to winter recharge the subsoil 'moisture bank' using supplementary irrigation without causing community dispute. In RBGM, modeling of irrigation needs based on the methodology described by Harris (1998) and Kopinga (1998) suggest that if soil moisture was at full capacity and accessible to 1000 mm soil depths, then the 'average' Gardens tree could subsist for about 90 days in summer with no additional precipitation. This potentially extends to 150 days when considering species more adapted to drought conditions.

Plant selection of the future has to become increasingly provenance-based not necessarily just because of important conservation value, but also due to specific ecotypic variation in tolerances to drought and heat. For instance, *Phoenix reclinata* is a palm commonly grown in Melbourne that most horticulturists would deem to be drought tolerant. Over the last decade, it has become more chlorotic in the RBGM. Soil and pathogen testing has not found any significant causes for concern. It is probably not surprising to find out from studying its natural African habitat that it is often found as a riparian species growing along rivers and streams. Although, a study of its rainfall demographic also shows that it grows across 400—2000mm annual precipitation contours. If *P. reclinata* provenance material was being sourced today, then in Melbourne, this should be selected from plants growing in the rainfall-limited natural areas, whilst higher rainfall ecotypes may be better grown in areas such as Sydney.

Another consideration is species that we assume to be intolerant of drought and or heat, and we discover from cultivation experience that the converse occurs. Kashmir Cypress (*Cupressus cashmeriana*) seems to be one of those 'species out of the square'. It is listed as vulnerable in the IUCN Red List (http://www.iucnredlist.org/details/32311/0) and grows at altitudes of 1250-2800 metres in the eastern Himalaya and north-eastern India. A specimen with a northerly aspect in RBGM grew moderately well through the extraordinary span of +42^{o}C temperatures in January and a combined precipitation total from irrigation and rainfall of 560 mm for 2008-09. It is difficult to find information on its normal rainfall patterns, but one source suggests that the species could grow in regimes of about 700mm per annum (http://www.thomas-caspari.de/bhutan/landeskunde/gtz/59.pdf).

Bromeliaceae are a taxon that is deemed to have high potential for cultivation in south-east Australia under future climates. Bromeliads have morphological advantages in being able to absorb water through specialised leaf scales (trichomes) (Pierce et al. 2001), store water as a reservoir within the base of the leaves; and they also have a physiological capacity for C4 photosynthesis (UCMP Accessed 2009). It is perhaps not surprising then that these plants can be maintained with minimal irrigation. It has been the author's experience that many of the epiphytic taxa flourish with only a weekly misting (using minimal water) in Melbourne. In amenity horticulture, these plants are a choice for those 'dry shade' positions. Of course, it has been observed that xerophytic bromeliads such as *Puya* sp. can tolerate high degrees of drought and solar radiation, although heat tolerance may be dubious for species from altitude.

There is also possibly an argument to be made for a greater focus in botanical gardens on geographic rather than taxonomic based living collections. There is prospectively greater flexibility to develop and maintain a geographic collection with similar homoclimes rather than what could be a quite restrictive genus-based taxonomic approach.

In summary, future plant selection processes for botanical gardens should be more inclusive of detailed assessments of natural habitats, plant physiology including ecotypic variation, seasonal and geographic rainfall patterns, and particular tolerances to drought and heat.

Use of contemporary data stores, software, technology and tools

Meteorological measurement

The Australian Bureau of Meteorology (BOM) should be credited for the climatic resources that are now available. A plethora of highly detailed and useful information is accessible via the internet. Of particular note is access to climatic trends, long term datasets for weather stations, seasonal outlooks the El Niño Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), temperature and rainfall. Also available are resources that show graphical forecast and rainfall probabilities for up to 4 days in advance. In April 2008, the federal government announced that under the 'Water for the Future' initiative, the BOM would have the new role in accounting for and reporting on Australian water resources with the provision of nearly $0.5 billion dollars in federal funding (http://www.environment.gov.au/minister/wong/2008/pubs/sp20080429.pdf) 2008). The Australian Water Resources Information System (AWRIS) is still in the development phase and based on previous achievements by the BOM should prove to be another useful data store for living landscape managers. Many of our south-western US colleagues do not seem to have the same level climatic awareness as their Australian counterparts. Fluency with climatic information must become part of the botanical employee's repertoire of expertise.

On the converse, south-western US have advanced automatic weather station (AWS) networks, particularly in Arizona (AZMET) and California [California Irrigation Management Information System (CIMIS)]. Although, the Australian BOM provides data from an AWS network, specific site data that is valuable for living collections management such as degree days, and reference evapotranspiration estimation is not readily available.

Automatic Weather Stations (AWS) that are site-specific for botanical gardens are a very useful tool, and if possible, are worth the outlay. One of the immediate issues (apart from financial resourcing), is selecting the ideal, long-term location for data relevance and validation. This is where another almost intractable conflict between amenity and science emerges where the position of the AWS can be compromised in favour of amenity. There are highly detailed Bureau of Meteorology protocols for location and site conditions which are often hard to obtain in a landscape setting. However, the benefits can include, but are not limited to, estimations of site specific plant water use through ETo estimation (Allen et al. 1998); measurement of temperature, relative humidity and solar radiation, development of degree day (heat accumulation) programs for pest control, assessments of wind speeds to shut down irrigation or warn of dangerous conditions, informing research programs and education opportunities, etc.

Australian Virtual Herbarium

Botanic gardens have their own resource in the web-based Australian Virtual Herbarium (AVH). This facility is particularly useful in matching Australian taxa with average climatic parameters such as temperature and rainfall. The poor health of *Lophostemon confertus* in Melbourne over the last decade is understandable when using the AVH to examine its natural distribution along coastal northern NSW and QLD with the corresponding average high rainfall patterns (AVH - http://www.rbg.vic.gov.au/cgi-bin/avhpublic/avh.cgi) For climatic matching, the AVH could be made even more useful if it was able to plot monthly or seasonal rainfall, temperature and evapotranspiration regimes.

Soil moisture measurement

Soil moisture sensing is one complementary technological tool that can be used to inform plant water use and assess rainfall effectiveness. Knowledge of the soil moisture content of the soil and the response of plants to soil moisture conditions is essential for precision scheduling of irrigation (Symes et al. 2008). The technology ranges from cost effective, but simple equipment to highly sophisticated and expensive systems that are more used for research purposes or large scale agricultural enterprises (Charlesworth 2000). Nevertheless, the information provides a useful insight into the physical (soil hydrology) and biological (plant water use) patterns under the soil surface and helps 'close the loop' in landscape water management (Symes et al. 2008). It is improved when combined with meteorological measurement and professional judgement to help compensate for the high levels of landscape variability. RBGM is currently involved in a partnership research project to quantify plant water use, including weather data and horticultural expertise (Symes et al. 2008). Apart from the immediate application to improving irrigation management, this research is also anticipated to assist in establishing baselines for understanding the influence of the current climate on plant water use, and assessing future trends that may develop.

Developing techniques for climatic assessments and comparisons

Living collections management and future landscape development requires sound techniques to make comparative climatic assessments. There is a bewildering range of indices, climate models and maps to choose from. One of the significant issues is finding point sources of data for specific natural habitats. The World Meteorological Organisation (WMO) publishes weather data for

major cities and towns around the world but this does not include information for regions and plant habitats between areas of significant human habitation. The simplest climatic models use comparisons between evaporation, temperature and rainfall to predict a soil-water balance, whereas more complex computer-driven models build in more variables. Ideally, the simple models should at least include evaporation or evapotranspiration data, but this is difficult to find or access world-wide.

The Aridity Index (Gentilli 1971) is one simple index that can be applied to compare relative aridity of various climates.
It is expressed as:

$$\frac{r}{(t+10)}$$

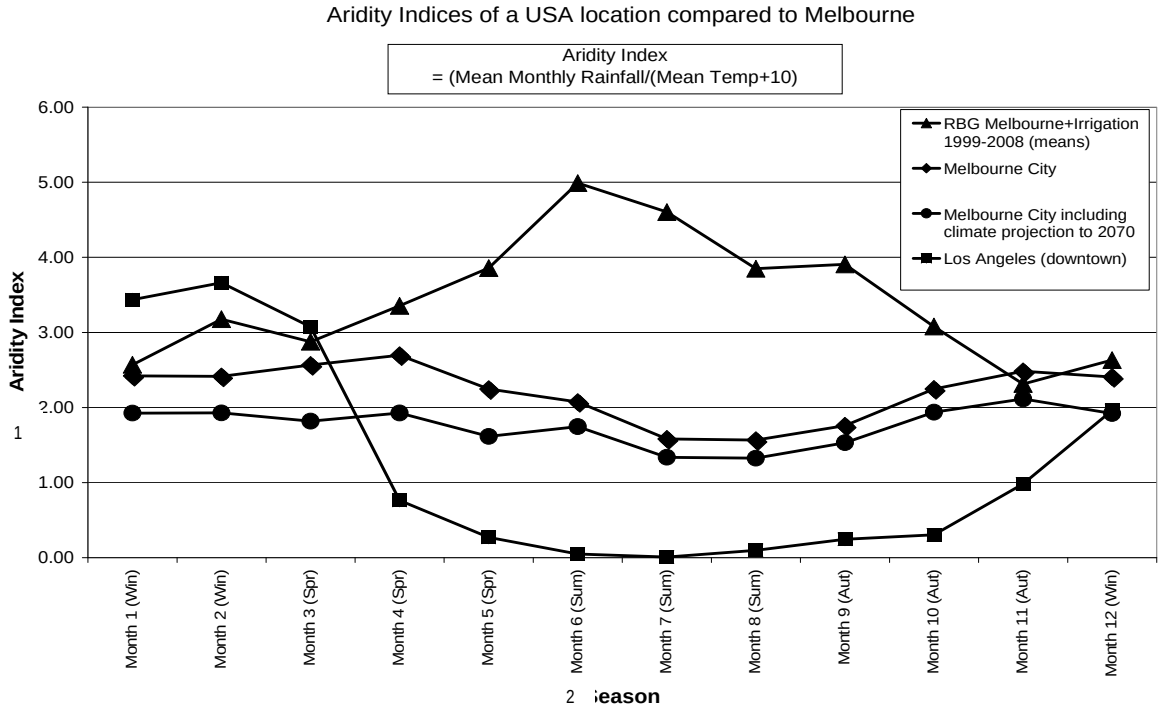
where:

r = average monthly rainfall
t = average monthly temperature

The advantage of this index is that average monthly rainfall and temperature data is usually readily available. Relative comparisons of aridity can be readily made between different locations with web-based access to world-wide meteorological information such as the World Meteorological Organisation (WMO)

A projection of aridity trends in provided in Figure 1. The disparity between precipitation being applied to RBGM and the normal average climate for Melbourne can be clearly seen. Also shown is an estimation of changes to Melbourne's aridity by 2070, with a marked decline in spring rainfall. Based on current irrigation patterns this would mean more water being applied in an earlier irrigation season. The trend line for Los Angeles is typical for those of Mediterranean climates, while the trend line for Melbourne is more typical of a temperate climate. A desert climate trend line would typically range across the seasons well under the Aridity Index value of one.

Figure 1 - Aridity Indices of Melbourne compared to Los Angeles, USA



[1]*Higher aridity value indicate potentially higher available moisture for the month, while lower values indicate increasing aridity*
[2]*Southern and Northern Hemisphere values have been seasonally adjusted*

There are also simple indexes available that compare rainfall directly to evaporation (Gentilli 1971;FAO 2005) and can be expressed as:

$$\frac{r}{e}$$

where:

r = average monthly rainfall

e= average monthly evaporation

It is significantly more difficult to source monthly evaporation values from around the world, but this expression is probably more accurate in indicating relative plant water demand

The Hydric Grade (Gentilli 1971) modifies the above relationship and incorporates a constant with evaporation and is expressed as:

$$\frac{r}{e^{0.7}}$$

Out of the simple soil-water balance modelling, this is probably a superior calculation in simulating generic plant demand as rainfall, evaporation (driven by the energy of solar radiation and temperature), and a modifying value to evaporation to estimate evapotranspiration are included in this expression.

Climatch is a web-based resource accessed through the Bureau of Rural Sciences, Department of Agriculture, Fisheries and Forestry. Climatch provides a means for comparing climate characteristics between regions. Most of the information is sourced from a global database with information from over 9,000 weather stations around the world. The user has the options of comparing world regions and the program generates a map-based indication of the similarity (or not) of the climate (DAFF 2008).

The Köppen-Geiger climate classification is useful as a generic starting point to note major climatic types of the world and even though it originated from 1900 still continues to be widely applied today (Peel et al. 2007). It is based on annual cycles of mean monthly temperature and precipitation. There are limitations to consider carefully. For example, when examining Melbourne's Köppen-Geiger classification of Cfb it is considered to be the same as Wellington (NZ), London and San Francisco, however these locations do not generally experience the same high temperature extremes.

Loclim is a free downloadable climate modelling program developed by the Food and Agriculture Organisation of the United Nations (FAO 2005). It offers advantages in having the capacity to spatially interpolate climatic information between known sets of data from weather stations all around the world. For example, the longitude and latitude grid coordinates of a plant habitat can be used to generate interpolation values for precipitation, potential evapotranspiration, sunshine, temperature and water vapour pressure from proximate weather station data. The generation of potential evapotranspiration values which usually give a more accurate indication of plant water need than just rainfall and temperature values alone. Loclim also produces summary values for a range of aridity indices and Köppen-Geiger climate classes.

These systems are limited in that they are usually based on average meteorological values and generally show a picture of the historical climate, not what might be the situation in the future. However, they are all a good basis to begin the comparison of different climates. There are dangers in applying mean datasets without also considering weather extremes.

Development of in situ research programs

There is a need to accelerate applied science research in urban living landscapes. Climatic measurement is becomingly increasingly vital to inform future living collections management and also maintain relevance of botanic gardens to urban education. Improving our understanding of the local climatic changes within the broader issue of global warming is a botanical concern. Investment in site specific measurement of weather variables is important. This can range from simple rain gauges (which must be read regularly), to data-logged temperature and relative humidity, ultimately to more sophisticated Automatic Weather Stations (AWS). These can provide invaluable sources of information for local water management, pest control (degree day prediction), education and cross referencing any local studies of plant phenology. If this climatic information is considered more broadly in the context of botanical gardens sharing in a national AWS network, then the potential is vast for linking and comparing local climates with *ex-situ* plant conservation.

An overall reduction in annual average rainfall in southeast Australia is one potential impact from climatic change that has been noted by Murphy and Timbal (2007). In RBGM, shifts in the localised trends of rainfall patterns, partitioning of rainfall (fate of rainfall), and rainfall effectiveness is one study being carried out in conjunction with the School of Geographic and Environmental Sciences, Monash University. Measurements to date are finding typical canopy interception rates from 50—60% of rainfall (RBGM 2009). Dunkerley pers. comm. (2009) has also studied changes to the nature of the Melbourne's sub-daily rainfall, and has found a trend to less rain days and intensity since the 1970's. This could be resulting in increased precipitation losses via canopy interception and evaporation. Any trends to decreasing effectiveness of landscape rainfall become a significantly greater concern for living collections

management and design of future living landscapes. Further, this research highlights the need to understand precipitation at higher levels of precision, and smaller temporal scales in future adaptive management.

Plant water use is considered to be poorly studied in botanical gardens, natural habitats and urban environments (Symes et al. 2008). It is of professional discomfort that plant production industries such as agriculture are notably more advanced in understanding plant water requirements under varying weather conditions. It is an area of research that botanical gardens can and must show meaningful leadership. The community often expects us to have this expertise at our fingertips, and when contemplated with the changing climate, improving plant knowledge becomes a priority. It is intriguing that after observing a plethora of poor irrigation practices in California, USA, that the same state probably is one of the world leaders in irrigation science and management tools. The development of the landscape coefficient methodology of estimating plant water use (Costello and Jones 2000; Connellan and Symes 2006) is better suited to diverse ornamental landscapes, and this system is the basis for irrigation scheduling training currently endorsed by Irrigation Australia. Nationally, quantifying plant water needs is an area that botanical gardens can develop networks to compare specific plant taxa under varying climatic regimes. The research has to be superior to just defining certain species as low, medium or high water requirements. It has to advance to working towards fully understanding the relationship between evaporation and plant transpiration, the physiological and morphological capacity of certain species to modify water demand, the impact on increasing temperatures on soil biochemistry, and seasonal variations in water need.

Where possible, replication of these and or similar research programs across botanical networks provides more credence for the results.

Role of botanic gardens in promotion of the environmental and social benefits of living landscapes

Intrinsically, botanical gardens (and other public landscapes) offer many prospects for benefiting the environment and the social community. In particular, the majority of the Australian public are highly conscious about environmental issues. For 2007-08, an Australian Bureau of Statistics survey found that 82% of Australian adults (82%) were concerned about the environment. Young adults (18-24 years) were the demographic of those who were less concerned than all other age groups, with about 26% not being concerned (ABS 2009). On specific issues, almost 90% of the population expressed apprehension about water shortages, and 73% of the population were concerned about climate change (ABS 2009).

Visitor experiences are one area of opportunity to build on this environmental interest. Patronage of botanic gardens is only second to cinemas with 41% of Australian adults visiting botanic gardens at least once annually (ABS 2002). From the day-to-day interactions with our communities, it is considered that there is a public expectation that botanic gardens should have existing expertise in ecology, botany and horticulture, and the ensuing capacity to inform adaptation to climate change.

Botanic gardens have a reputable history in relationships with the community, and networking partnerships and outreach of shared learning with other specialists in biodiversity and living landscapes. There is a real need to extend this to a specific focus on professional development in plant selection, curation and management for the projected climatic conditions. The high diversity of plants and landscapes across botanical gardens everywhere in Australia provides a platform for delivery of highly visible training. We cannot understate the value of our existing living collections as an environmental outcome in its own right. There can be a tendency to become 'apologetic' for living landscapes that require additional water and energy for their continued existence, but they also effectively conserve high levels of plant diversity from all over the world. In 1992, the central plant database of the major Australian Botanic Gardens recorded a total of about 33,000 different taxa [http://www.anbg.gov.au/chabg/census/index.html]. In comparison, the total of Australian species documented is about 20,000 with 90% endemic species (CHABG 2008) The National Strategy and Action Plan for the Role of Australia's Botanic Gardens in Adapting to Climate Change highlights the importance of conserving Australian flora and the vital role of botanic gardens in this regard (CHABG 2008). Nevertheless, there is a wider role of world-wide *ex-situ* plant conservation that is becoming increasingly important as plant habitat is fragmented, lost, and threatened by global climate change. Arid flora is also threatened by the changes to rainfall and temperature. For instance, Telléz-Valdés and Dávila-Aranda (2003) carried out a case study of climate change modelling under various regimes for the impacts on Cactaceae in the Tehuacán-Cuicatlán Biosphere Reserve, Mexico. They found the potential for considerable contraction of species distribution and increasing risks of extinction even under modelling what could be considered to be small climatic changes. In Arizona, a 20-year study was undertaken of plant response to warming temperatures. Over a 1200 m elevation gradient, 93 species out of 363 studied showed a significant change in the elevation they flowered. Although many of the changes in flowering span occurred at higher elevation, there were changes across the entire gradient (Crimmins et al. 2008). These changes to local plant phenology could result in reduced pollination, recruitment and ultimately survival into the future.

Even if living landscapes are contrived, they can also offer havens for biodiversity especially in urban zones. Plant landscapes in urban environments also offer havens for indigenous fauna in a world of increasingly fragmented and lost habitats. There is largely an undeveloped role of botanical gardens to work on linking these green spaces with other urban and natural habitats to establish fauna corridors. For example, the development of the Long Island project in RBGM to support provenance-based indigenous flora from lower Yarra River has seen increases in visits of indigenous birds and amphibians. Extensive frog surveys carried out by the Australian Research Centre for Urban Ecology (ARCUE) prior to this project only found one species - *Litoria ewingii* (Brown Tree Frog) throughout the entire RBGM. Further surveys in October 2008 by ARCUE also identified *Crinia signifera* (Eastern Common Froglet) and *Limnodynastes peroni* (Striped Marsh Frog) in the Long Island wetland (Hodge pers.comm. 2008). This is a living collection that could readily enhance biodiversity to a much greater extent if it was also linked with establishment of other indigenous flora corridors along the Yarra River.

Currently, some studies and community awareness are emerging on the role of plants and landscapes to assist in the mitigation of temperature rise, particularly in urban centres (Climate Change Taskforce - accessed 2009). This supports continuation of human wellbeing and a reduction in the consumption of hydrocarbons (releasing greenhouse gases) for cooling of buildings. In Melbourne, the urban heat island affect shows an increase in average temperature of 2—4^{o}C, with daily peaks to 7^{o}C within areas of the city (Coutes et al. 2009). This phenomenon, even if to a lesser extent, would be expected to also occur in regional centres and small towns. The evaporative cooling provided by green landscapes can reduce this temperature load. On a historical basis, the extensive agricultural irrigated areas in the Central Valley of California have decreased average daily summer temperatures by about 1.8— 3.2 ^{o}C compared to other proximate areas (Moser et al. 2009). In urban areas, air conditioning use can be cut by 50% if a ratio of three trees carefully located per house can be achieved (Thompson and Sorvig 2008). On a hot day, turf areas can be up to about 15^{o}C cooler than asphalt (Thompson and Sorvig 2008). In Las Vegas, the program of funded lawn removal by the Southern Nevada Water Authority is conditional on the basis that lawns are replaced with gardens in recognition of this heat mitigation capacity of plants (Bennet 2008). Over the last decade, many Australian landscapes have been subject to extreme levels of water stress from precipitation deficits and water restriction regimes. Plant transpiration is often restricted by leaf stomatal control under water scarce conditions (Kozlowski and Pallardy 1997), which also limits the benefit of evaporative cooling. Botanic gardens have a vital role to work with other organisations to maintain healthy vegetated space. In the short term, this will be seen in providing education in irrigation efficiency and water management, and other expertise to minimise the damage. For the longer term, assistance with effective plant selection and landscape transition will help maintain these green spaces into the future even under climatic change. Although, it must be noted that transitions to more climate-adapted vegetation could result in the cultivation of more arid-adapted flora that will not provide the current rates of evaporative cooling.

Carbon sequestration is also another benefit of living landscapes. Attention to improving soil organic matter content above current levels should store more carbon. One way to do this is through increasing landscape biomass. Many established botanical gardens will not have the capacity to significantly increase vegetation biomass to store more carbon. However, irrigated landscapes will tend to have more biomass per unit area with subsequent soil carbon storage, especially if taxa using C3 and C4 photosynthetic pathways (Raven et al. 1987) are grown (Hawkins et al 2008). While on the converse, an increasing dominance of arid taxa using Crassulean Acid Mechanism (CAM) photosynthetic pathways (Raven et al. 1987) reduces the potential for carbon sequestration.

If more sustainable water sources can be identified, then it is posed that there could be a role for increasing irrigation application of urban landscapes to both improve both carbon sequestration and evaporative cooling. Regardless, we need to have a comprehensive understanding of the status of the soil organic levels in order engage in future carbon accounting. Interestingly, wetlands are considered to have one of the highest capacities to store carbon out of many vegetation types (IISD 1999; Pant et al. 2003). Thus, the development of bio-remediated treatment of stormwater and habitat improvement in living landscapes could be another opportunity for involvement in carbon sequestration programs.

There is projected increasing public stress from climatic extremes. Green landscapes offer social mediation and solace for people communities (Morison and Mathieson 2008). Studies have found that both physical activity and exposure to nature ('green exercise') are known separately to have positive effects on physical and mental health. There was also a significantly greater synergistic benefit of combining physical activities with exposure to both rural and urban living landscapes. On the converse, unpleasant landscape scenes, particularly rural ones had a greater negative effect on mood (Jules et al. 2005). Whether botanical gardens are based in urban, peri-urban or rural situations, there are prospects to continue to offer considerable and important support for the wellbeing of our communities.

Recommendations

1. Incorporate the adaptive management responses to climate change projections in living collection plans, landscape plans and master plans.
2. Capitalise on the opportunities provided by new collection and project developments to incorporate climate change projections and microclimate understanding in the plant selection process.
3. Focus on and support professional development of curators for building expertise and understanding of natural habitat and climatic information for high-priority taxa.
4. Develop a web-based national and regional plant information network for endangered, threatened and wild collected taxa inclusive of ecological, biogeographic and climatic information (seasonal rainfall and temperature).
5. Formalise a framework to exchange and duplicate valuable and provenance plant material between botanical gardens.
6. Build partnerships with other scientific institutions and industry for landscape research programs related to plant water use, hydrology and climatic factors.
7. Foster global networks with other botanical gardens where mutual exchange in plants and technical information offers the most benefit for plant conservation.
8. Develop systems to measure local meteorological and hydrological data such as through weather stations and soil moisture measurement.
9. Work towards developing microclimate maps or profiles of botanical gardens.

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The purpose of this paper is to share an insight into the treasure that is Gladstone Tondoon Botanic Gardens.

This paper will provide:-

- A brief insight into the establishment of a Regional Native Botanic Garden
- A view of the unique partnership and balance between Industrial Urban Lifestyles and an awareness of the natural environment
- Challenges to Educate for the Future
- Sharing nature and leaving lasting impressions
- Engaging a Regional Community to Bring Plants to Life, the Tondoon way

Content

Tondoon Botanic Gardens is an integral part of the Regional Port City of Gladstone, Queensland, Australia. It is a unique Regional Native Botanic Garden maintaining a scientific collection of Native Regional Plant Species all are from local provenances, including the Port Curtis Region in Central Queensland and Tropical Far North Queensland. Established in 1984, the area of the Garden is 104 hectares, which includes 21 hectares of Developed Display, and 4 hectares of Lake, and natural bushland. The Gardens are fully funded by Gladstone Regional Council which is the local government authority.

Gladstone, a modern highly industrialised City with a large transient population of over 28,000 and a regional centre of another 34,000, has been the recipient of a host of accolades including State Winner of Tidy Towns 2002 and Tidiest Industrial City in Australia 2003.

The Gladstone Region is not only being developed as a major port, but is underpinned by coal exports and a hub for light metals processing. It is also an area of significant visitor interest which is highlighted by its hinterland, subtropical coastline and off shore and reef islands. Gladstone is one of the southern gateways to one of the seven natural wonders of the world the Great Barrier Reef. The region contains a number of unique plant associations which deserve major recognition and conservation.

When you first visit Gladstone, you will notice the bustle of many large industries and the deep water Port. Just fifteen minutes from the Central Business District, the tranquillity of Tondoon is a welcome relief to the industrial cityscape. It is important to remember that Industry has championed opportunities and prosperity for the Gladstone Region and environs.

The area is home to many pristine parks, marina parklands, and green belts. Industry, along with local government and community groups have provided many areas of recreation for the local population.

Creating a Treasure Within the Industrial Hub

The Gardens were officially opened in October 1988 and extensive development has continued since the opening. The physical qualities of the 104 hectare site were the major determinants influencing the planning concept for Tondoon which features a Wildlife Lake, Arboretum, and Forest Reserve as an adjunct to the Botanic Gardens. These elements are also integrated with a large water system linking important elements across the site.

The geography of the site is typical of the region with steep rocky slopes covered by sclerophyll woodland forest, with contrasting with patches of dry eucalypt scrub in the deeper more protected valleys.

However with the massive earthworks required to form the lake and the undulating lower gardens a gentle sloped user friendly garden was created. Many visitors regularly comment on the ease of access, on well laid out pathways with ease of wheel chair use throughout the Garden.

The steeper paths to and along the upper slopes of Mount Biondello provide many different flora and fauna habitats as well as provide views over the expanding City and Harbour.

From what was dry woodland of mainly eucalypts and acacias, these plantings have been enhanced in to a cool green paradise. There are three main themes developed within the Garden, these ecosystems include Dry (microphyll vine forest), Subtropical and Tropical Rainforests all of which are intriguing to the visitor.

Industry and the Gladstone Community

The Garden was established as a special refuge and biological asset for the people of Gladstone. It was also developed to ensure that the nation's environmental heritage of specific local bio regions is passed on to future generations.

Most industries are large by world class standards, and these include Comalco Alumina Refinery, Central Queensland Port Authority, Queensland Alumina, NRG Power Station, Queensland Cement and Lime, and Boyne Aluminium Smelters.

Industry is always trying to create the unique balance in the community. Gladstone is a good model of a mix between large industry and the environment.

There is a sustained effort by all industry to conform to the clean air policy of State and Federal Environmental Protection Agencies, with continual monitoring taking place.

Regular forums, advertising and committees are held within the Community to encourage for ongoing public involvement with Industry in creating a positive image and profile for the region and Botanic Gardens.

The Gladstone Area Promotion and Development Limited work in partnership with all major industries in the area to provide free guided tours to gain an insight into the operation and community profile of each industry. These tours are extremely popular with visitors to the Region. The Gardens are featured on the Industry Tour Brochure as a "Must See", tourist destination whilst visiting the region as further evidence of its importance in the region.

Most industries in Gladstone are eager to create the unique balance between the environment and a vibrant Gladstone community.

Public Awareness of Plants of the Region

The Prime Display area associations are plantings that are arranged in categories such as Geographic and Ecological associations. These specialisations are in a unique area to the Gladstone Region as all species in the Prime Display Area are indigenous plants of the Port Curtis Region.

This area provides a fabulous learning tool for locals and visitors alike, as they can learn more about the local plants and then be encouraged to put this learning into practice in their own home gardens by replacing inappropriate exotic plants with more suitable endemic species. It also provides the visitor to the Garden with a unique area in which to focus on local species plantings. Each area within the prime display is created to replicate a Ecotype typical of plant associations in the area.

> *"Planning and creating Tondoon was in many ways a community experience involving many local people who were enthusiastic about identifying the specific local vegetation, determining its botanic qualities and experimenting with its potential for use in ornamental horticulture. (Lawrie Smith) the Landscape architect worked with Groups such as the Society for Growing Australian Plants, Gladstone City Council, and Civic Beautification, Orchid and Foliage Society and Wildlife Preservation Society in the implementation and development of Tondoon." Lawrie Smith, Landscape Architect Tondoon Botanic Gardens 1999*

Tondoon has vital educational and conservational resources, a Herbarium of Plants of the Port Curtis Region. This is run entirely by volunteers. All specimens all identified by the Queensland Herbarium and then incorporated into the Tondoon Collection.

The Society for Growing Australian Plants, Gladstone Branch, have a unique relationship with Tondoon in promoting the use of native plants. The Gardens have been involved in a number of publications on plant identification, cultivation and advancement of growing local plant species.

Today this work continues with these groups and a dedicated group of Herbarium Volunteers who are instrumental along with the Gardens Curator, Brent Braddick identifying specific local vegetation and participating in field trips to reserves, private property and national parks by further botanic investigations and developments.

Challenges to Educate for the Future – Our Children

Who will teach the Children? The Essence of Nature Will.

The Challenge for the Visitor Services Section at Tondoon is to empower an industrial orientated highly urbanised population in developing an awareness and knowledge of the natural environment surrounding them. A key focus is on hosting local school groups, in 2005 (80 classes participated in lessons in the Garden) over 5,000 School Children visited the site and a 20% increase in requests for visits from local schools was received in 2006. School visits from 2006 onwards are still going well with the ever increasing competitive market of a variety of activities for Schools to participate in.

The following is a quote made by the Gardens first Director of Parks and Recreation Mr Neil Kershaw:

> *"This returns us to the key point: Tondoon is a blurred concept, an organism, that contains practices, techniques, goals and objectives that share overlapping attributes.*
>
> *An undue emphasis on planned precision, although laudable in some respects, is also limiting. Rather it is a wild gesture for the future." Neil Kershaw, Discover Tondoon 2006.*

One of the most popular plant awareness experiences that is presented at Tondoon is the "Australian Plants & Their Uses" for Mid Level Primary Children.

This experience is also offered as a guided walk to the visitor. The interpretation of local plant species and their uses progresses to a hands on tasting commercial products made from native food plants, colloquially termed "Bush Tucker". Lilly Pilly Jam with damper and Lemon Myrtle Coconut Cake are among the favourites.

> *"By learning about the uses of plants such as medicinal, food, shelter, hunting and gathering made by the indigenous inhabitants prior to the arrival of Europeans, Australian Children are learning about Aboriginal Culture. This understanding of Aboriginal Culture also helps to form relationships between Aboriginal and White Australians. Doctor Grace Johansen - Discover Tondoon 2006*

At Tondoon Botanic Gardens our emphasis is on teaching the traditional use of plants along with comparing the modern day applications.

Children and adults alike particularly love the hands on tastings of commercial products. This is a novel approach, which has attracted much visitor and School interest at the Gardens.

A popular local species that we are promoting is Lemon Myrtle (*Backhousia citridoria)* It has many uses commercially, within Bush Foods products ranges and various recipes incorporate the plants wonderfully strong lemon smell. Example of products include, Lemon Myrtle Honey, Lemon Myrtle liquid soap and Davidson Plum Jam.

A number of Gardens Botanical and Environmental Experiences have been developed to increase awareness of the natural environment and stimulate student's awareness in line with Education Queensland's Learning Outcomes.

It is essential that we continue teacher liaison with the planned excursions to ensure that the desired learning outcomes are achieved.

Current programmes require ongoing review to further inject new life into our delivery and content.

Evaluating Tondoon's Education/Interpretation Programmes

The process of evaluation of our programmes has been in the form of developing overall "Positive Partnership and Important Links" from the Garden out into the Community.

The flexibility of our programmes to involve other individuals and local groups for inspiration and technical advice has contributed much to their success.

After each lesson we send out a feedback form to Teachers to clarify that the learning outcomes have been fulfilled for a particular lesson.

Sharing Nature and Leaving Lasting Impressions

Since then the Gladstone Regional Community has embraced environmental education at the Garden extremely well, through our dedicated staff and development of programmes interest is growing from strength to strength. The hands on learning approach has been the best way to deliver interpretation to the Visitor.

Popular programmes for Children include Environmental Puppets & Storytime Sense-sation, Discovering Nature in the Garden, What is a Rainforest? Australian Plants & Their Uses, How Diverse are Australia's Plants, Biodiversity in the Web of Life. School Holiday programmes continue to provide participants with hands on learning and a chance to interface and appreciate the wonderful environment of the Garden.

Being a Regional Botanic Gardens our challenges are numerous, usually associated with inadequate budgets and resources. How we deal with this? We operate activities with the generous assistance of our Friends of the Garden Group, and charge a minimal fee for groups and Schools visiting the Gardens to cover material costs.

Children visitations have been our best source of promoting with our interpretation programmes in Tondoon, "Hands on learning encourages repeat visitation". Hands on programmes involve storytelling, art and craft, sensory, visual, puppets, simple propagation activities.

Our main challenge in the Garden is to factor in that in a reasonably small community local children do visit the Garden more than once during their schooling. It is important for us to receive ongoing feedback and evaluation from Teachers. So we can increase the participation and ongoing visitation.

The Ecofest Concept - Garden, Community & Industry working together

In creating a more positive image between industry and the environment, the ecofest is co-ordinated by the Gladstone Regional Council between the many local industries and environmental community organisations and groups. The festival in 2009 attracted 10,000 visitors with over 80 Stallholders with a totally environmental focus taking part.

The Ecofest concept was developed by the Boyne Island Environmental Education Centre after Staff attended a seminar by world environmental expert David Bellamy. In 1998, Mr Bellamy commented on the surprisingly good balance that exists between industry and the environment in the Gladstone Region. He was also impressed by the level of community involvement and suggested that the Region should promote its environmental attributes.

Education Queensland supported the Ecofest idea to work in partnership with industry and community groups in educating the community on the environment and sustainability.

The Ecofest has been designed to promote environmental sustainability through educational displays and interactive activities provided by local industry, business and community groups as well as promoting products and practices with an “environment” theme for the whole Family.

The theme Ecofest, “Sustainable World, Sustainable Gladstone” was adopted to emphasise the importance of co-ordinated local action by industries, government departments, Councils and community groups that work individually and in partnership to protect and conserve the environment.

The Ecofest provides an opportunity for these organisations to showcase the local efforts, contributing to global sustainability.

Enhancing the Visitor Experience - Discovering the Treasure

Community Education at Tondoon has become increasingly popular, thanks to this amazing facility we are able to focus on requests for Community Education, School Holiday Programmes, Spotlighting Tours, Barefoot in the Park, Ecofest - World Environment Day Celebrations, Group Tours, Garden Events, Weekly Guided Tours in Conjunction with Gladstone Area & Promotion Bureau, Tourism Projects and Guest Speaker Initiatives.

Our latest community education project is "The Welcome to Gladstone Morning Teas" which are hosted in the Garden for new residents of Gladstone, this is a wonderful opportunity for Tondoon to be the host site and provide a wonderful networking opportunity and showcase this facility to many new residents.

In developing the site popular events such as weekly guided walks with the Friends, partnerships with tourism bodies and industry have undoubtly increased Tondoon's profile. In 2009 a weekly guided tour "Gladstone City Surrounds and Tondoon Botanic Gardens" was introduced in partnership with Gladstone Area Promotion and Development Limited, this initiative has been beyond successful with visitation increasing substantially each week with many locals and visitors taking part. The Friends of the Gardens Visitor Services Group have been instrumental in co-ordinating these weekly tours.

There is also an annual calendar of exhibitions in the Tondoon Botanic Gardens Visitor Centre featuring interesting art and interpretative displays

The great horticulturist and garden designer - Gertrude Jekyll said -

> "*I am strongly of the opinion that a quantity of plants however good the plants may be themselves and however simple the number does not make a collection" (Paradise in your garden p.27).*

We believe through our careful stewardship that the Gardens have become a key place for learning and appreciation of horticulture, botany and ecology for the whole community of Gladstone and visitors to the region.

Conclusion

Our role as staff of the Garden is to provide positive learning experiences, lasting memories and impressions to all visitors to Tondoon.

The Gladstone Tondoon Botanic Gardens will continue to provide a unique oasis away from the industrial scape in our community for locals and visitors alike. There is a special balance between humans, and the local biodiversity when you come to experience some special time within this amazing treasure.

The future brings many challenges to Tondoon these include:-

- Sustainable water use - due to diminished rainfall in many catchment areas, sustainable horticultural practices are required to allow for more sustainable innovative water conservation practices.
- Obtain corporate sponsorships to meet deficiencies, resourcing and development.
- Staffing and Maintenance - increase numbers and staff to allow for maintenance and continuing development of the Gardens e.g. Japanese Tea Garden.
- Recruitment and Sustainability of Additional Volunteer Input - Challenges to keep appropriate involvement.
- Development Interpretation/Education Programmes - Limited staff and resources, may limit growth and demand for programmes without careful management and planning.

In just over 20 years since establishment of the Garden current staff has still managed to keep the original concepts pure. Our understandings of the Botanic Garden development are still the same as the original staff. We can only hope that this legacy is

carried on for many years to come. We have also been fortunate to see the unique balance and partnership of a marriage of industrial environments and nature.

> *Like all similar projects Tondoon will never be complete, it provides an invaluable legacy to pass on to future generations, this will ensure that the unique characteristics of the regional flora and fauna will be appreciated and will influence the landscape of the continuing development of Gladstone and the Region. (Lawrie Smith - Tondoon Story p.112)*

With Special Thanks

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He aha te mea nui? He tangata, he tangata, he tangata.
What is the most important thing? It is people, it is people, it is people.
Maori proverb

Will our descendants prize this unique heritage from the dim past and preserve these sanctuaries intact?
Dr Leonard Cockayne, eminent New Zealand plant ecologist and instigator of Otari Native Botanic Garden

There are 130 threatened plant species in Wellington. A significant factor impeding more effective plant conservation in Wellington is relationships and co-operation. Improving relationships between local, regional and central government agencies and relationships between these public agencies and private groups and individuals will improve the outcome for threatened plants in Wellington.

Otari Native Botanic Garden and Wilton's Bush Reserve (Otari) is the only public botanic garden in New Zealand dedicated solely to native plants. Otari is owned and managed by the Wellington City Council (WCC), who manages the Wellington City area, and is one of eight local councils in the Wellington region.

Otari consists of 100 hectares of native forest, and five hectares of plant collections. Landowner and farmer Job Wilton fenced off an area of bush here to protect it from cattle in the 1860s. Its conservation role was furthered when the Otari Open Air Plant Museum was opened in 1926.

Otari's current three central conservation activities are advocacy for New Zealand plants, ex-situ conservation, and in-situ conservation.

Like many botanic gardens Otari maintains a threatened species collection. This collection, developed in the 1990s, was evaluated by staff last year as "an out of the way, eclectic mix of plants not at all meaningfully contributing to plant survival in the wild".

We've recognised that this garden major role is publicity, and that we need to better publicise to our visitors the story of the New Zealand's threatened plants. New Zealand's threatened plants need advocacy; many New Zealanders can't even name five common New Zealand plants let alone plants that are in danger of extinction.

We are moving the collection to a more prominent area and have decided upon three actions for this garden to make the collection more engaging:

- To grow threatened plants that people will recognise. Several endangered New Zealand natives are widely used in amenity gardens but people don't associate with them as being threatened.
- To grow threatened plants that we can tell great stories with. For example, it's generally unknown that New Zealand's rarest tree *Pennantia baylisiana* has been reduced to just one female individual – no more sexual reproduction!
- To grow plants that are threatened in the Wellington region, making the plants relevant to our local visitors.

Elsewhere at Otari, threatened species are grown ex-situ to supply wild populations. *Brachyglottis kirkii*, a forest dwelling epiphytic daisy considered in serious decline nationally and under critical threat in Wellington has recently been propagated at Otari. These plants were sourced and will be distributed by local, regional and central government. More of this co-operative approach is exactly what is needed in Wellington for plant conservation.

In-situ conservation of the forest at Otari also benefits from collaboration with other government agencies. There are some species present in very low numbers (<10 individuals) in the Otari forest reserve and these same species are sparse across WCC estate. Introduction of other intraspecific nonlocal plants is essential to avoid inbreeding depression. These introductions from outside WCC managed estate must be carried out in cooperation with other local, regional and central government agencies.

There are three key government agencies involved with species recovery programmes in the Wellington city area; Wellington City Council (WCC); Greater Wellington Regional Council (GW); and the Department of Conservation (DOC). All three agencies administer to a myriad of public spaces and infrastructure layers in the Wellington region. Partnerships between these agencies are essential to plant conservation in Wellington.

A further group that could be more effectively partnered with for threatened species conservation is the myriad of private groups, schools and individuals that make up our community. WCC currently works with 47 community groups. The majority of these groups are involved with site led restoration work. Typically a site is chosen in need of restoration, weed plants are removed, and selected species are planted to achieve a vegetative cover as quickly as possible.

At Otari community groups have planted thousands of plants over the past 10 years to restore marginal areas of the forest reserve. Initial weed clearance preceded mass planting of plants that 'do the job' of bringing back indigenous vegetation cover. This is a scene typical across WCC estate where community groups are involved.

Community participation in conservation of biodiversity is increasingly a cultural phenomenon worldwide. The reasons for community participation are numerous.

Paul Smith, Head of the Millennium Seed Bank Project, was quoted in a recent journal saying '*…there is no technological reason why any species need go extinct*' (Paul Smith, 2009). It is people that are the cause and solution. There is a range of people in the community who are available to be part of the solution. Retirees, business people, children, researchers; consider who can help you best and what drivers might lie behind their motivations. Delving into a range of these drivers can be part of a way forward in Wellington, expanding upon current site-led conservation efforts of community groups to (threatened plant) species-led restoration in the region.

Here are some examples of how conservation drivers, relationships and partnerships could proceed in Wellington.

Using programmes such as 'Bringing back the birds' and 'restoring the dawn chorus' are excellent examples of how animals, particularly birds in New Zealand, draw public participation into the environmental arena. People seem to be drawn to animals more readily that plants. *Zealandia* is a 288 hectare, predator free, fenced sanctuary in Wellington where rare bird life is the focus for public, but a lot of work is also achieved for plant conservation. If cute and cuddly are what the public want, then we should use it as a means to carry out plant conservation.

Publicise conservation efforts and that biodiversity loss is an issue but what positive actions people in the community are taking. Celebrate the successes and pride of public participation and encourage community groups to champion threatened species relevant to the habitat types they are involved with, forest species for forested areas, coastal species for coastal areas etc. Several community groups in Wellington already have access to propagation and nursery facilities to carry out some of this work as well as government owned nurseries.

Seven Auckland local city councils are shortly to be amalgamated, making Auckland a 'super city'. Wellington needs a super city approach to plant conservation where multiple public and private agencies form relationships, combine resources and knowledge to develop a inclusive and decisive plan which co-ordinates all conservation partners to more effectively change the threatened status of plants in Wellington.

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