

# THE "PREFERRED FUTURES" OF BOTANIC GARDENS

Charles Stirton

(National Botanic Garden of Wales, Carmarthenshire, SA32 8HW, Wales)

**Abstract:** The National Botanic Garden of Wales is the first national botanic garden to be built with a clear vision derived from the principles of sustainability laid down at the Rio Earth Summit. Although the garden is embracing sustainability as its overall theme that is not our focus—merely how we go about our business. Sustainability at the Garden of Wales is based on a holistic approach within a social, political, economic, cultural, spiritual and environmental context. The garden offers a wide range of approaches to help people make new choices about their futures. It will be a flag-bearer for "preferred futures". The paper describes how the Garden of Wales is helping regenerate the region economically by adopting a preferred futures approach which involves envisioning a desired future then working back from there ("backcasting") in partnership with others to change the present in order to achieve that future. Examples covered include: Biotechnium (the world's first Biosciences business incubator within a botanic garden); new partnership-based tourism products for Wales; local and regional product development and sourcing for retail outlets in the garden; and the creation of traditional healing and lifelong learning centres in the garden. Reference will also be made to: how the garden recycles water, deals with its effluent in a "Living Machine", generates its heat and power in a Biomass Boiler, runs its farms organically, uses slate waste as mulch, is creating genetic and global warming gardens, planning its demonstration organic and heritage vegetable gardens and biomass plantations. A broad outline will also be given of the scientific role of the garden and the role it will play in conserving the flora of Wales and West Atlantic Europe. A key theme of the paper is that through ideas generated in the paper that botanic gardens can and should help increase economic wealth, improve health and promote stable communities. It is how we map out our futures and set tough actions to achieve them that will ensure that the 1 860 botanic gardens around the world will remain relevant, vital, and flourishing.

**Key words:** sustainable development; economic regeneration; biosciences business incubator; botanic garden; preferred future

中图分类号: Q94.339 文献标识码: A 文章编号: 1004-0978(2002)02-0053-08

植物园的“最佳未来” 斯特顿 C (威尔士国家植物园, 卡马森郡 SA32 8HW, 威尔士), *J. Plant Resour. & Environ.* 2002, 11(2): 53-60

**摘要:** 国立威尔斯(士)植物园是按里约全球最高会议明确的可持续性原则而建立的第一个国家植物园。可持续性虽然是其总方针, 却并非其焦点, 只是其工作的准则。在该园, 持续性是建立在社会、政治、经济、文化、精神和环境诸方面的整体性基础上, 该园也提供了广泛的建议有助于人们对未来作出新的选择。它是“最佳未来”的旗手。本文论述了该园是怎样通过最佳未来的途径来帮助复苏地区经济。事例包括: 生物技术孵化器、合作旅游、地方产品开发和园内零售及国内传统康复和学习中心。也对园内“活机器”的永循环、生长量活锅炉、有机农场、废石用作覆盖、如何建球形增温园和有机菜园等提供想法。概括了该园的科学作用和在该地区的植物保护工作中的作用。本文的重点是以文中的观点说明植物园可以而且应该帮助增加财富, 改善人民健康和促进社会稳定。

**关键词:** 可持续发展; 经济复苏; 生物技术孵化器; 植物园; 最佳未来

The National Botanic Garden of Wales opened its doors to the public for the first time on the 24th May 2001. The garden was the first new national botanic garden to open in the third millennium. It is one of 26 landmark millennium projects in the United Kingdom and

is half-funded by the Millennium Commission, a subsidiary of the UK National Lottery.

收稿日期: 2002-01-07

作者简介: Charles Stirton(1945-), 男, 威尔士人, 博士, 主任, 主要从事植物学研究。

The opening day was a day of excitement and promise. Many who attended saw it not only as a new national institution for Wales but also as an exemplar of one of the exciting new experimental botanic gardens that were being constructed around the world. What makes the Garden of Wales special is that although it looks like any other major garden it seems to operate somewhat differently.

Seventeen months on it is useful to take stock of what has been achieved and to explore the context of its creation. It is an opportunity to reflect on the wellspring of its ideas and approaches, and see how these are becoming rooted in practice.

The aim of this paper is also to use the experience of building the Garden of Wales to explore and develop further the idea of "preferred futures" and how it is, or might be, applied by other new botanic gardens in the decades ahead.

## 1 Building a new botanic garden from scratch

### 1.1 Roles of botanic gardens

What is a botanic garden? What distinguishes it from ordinary gardens? This question has been much written about and the answer will vary depending on the period which is referred to. Botanic gardens have changed their role over the millennia and there have been different gardens with different roles contributing significantly to cultural development, economic progress and commercial exploitation<sup>[1]</sup>. Most accounts of the history of botanic garden have been written from a euro-centric perspective and follow the usual model of early origin as medicinal gardens, changing to centres for the study of biological diversity, experimental stations for germplasm exploitation, civic and municipal amenities, and more latterly environmental or conservation centres. Each period has reflected the fashions of the time and has undeniably left a staggering legacy of architecture, design, knowledge, and living and preserved collections.

Has not the time come to review the history of botanic gardens from a truly global perspective giving a

more considered view to the significance of the great "botanic gardens" of the past from the phenomenal Arabic, Persian, prehispanic American, Indian, Chinese and South East Asian civilizations. Their continuing influence on design, purpose, and utility on the evolution of the western models of gardens<sup>[2]</sup> are massively under-rated in the main. It could be argued that the euro-centric western world-view of botanic gardens has been responsible for the translocation from Europe of inappropriate models to many parts of the world over the last 200 years. The social ecology of botanic gardens is a fascinating but understudied topic<sup>[3]</sup>.

### 1.2 New gardens as economic and cultural regenerators

Two of the new models to emerge for new botanic gardens in this century will be the roles of local botanic gardens as regional economic regenerators and or as cultural regenerators<sup>[4]</sup>. These emergent models will draw on best practice of the past but will be re-interpreted against the needs of their specific locale set within their historical context.

A broadly acceptable definition of modern botanic gardens are "that they are institutions holding documented known origin collections of living and preserved plants and plant parts for the purposes of scientific research, conservation, display and education". There are 1 846 botanic gardens in world, custodian to 4 million accessions. One third of all plant species are contained in them. Over 150 million people visit them annually. But what attracts the visitors?

Botanic gardens have many dimensions<sup>[2]</sup>. These include *inter alia* different emphases on scientific research, conservation, education, heritage support, visitor attractions, recreation, preservation of significant architecture, libraries, and herbarium collections and as intermediaries in the introduction of economically important plants.

### 1.3 Building a new garden in the United Kingdom

Our predecessors in the UK built their gardens over a long period of exploitative colonial expansion, in a world of presumed infinite resources, of huge exploration and discovery, a global commons approach to genetic

resources, and over a period of rapid discovery of immense diversity of plants and animals in the tropics.

Today we, and the Eden Project in Cornwall, two of a new generation of gardens with a global view, have had to build our gardens to a very different agenda in a world of finite resources, a globally linked economy, a backdrop of genetic sovereignty, a massive loss of habitats and species, an explosion in human numbers (500 million since Rio), and with few areas left unexplored.

The key challenges that the new gardens have had to face have been to develop the garden within the aspirations for sustainable living, yet without compromising the heritage of the past on site and the needs of the area in the future. All this has had to be done against the need to develop a viable and sustainable business plan, without the comfort support of local or central government funding.

*1.3.1 Philosophy and guiding principles* The ethos of the Garden of Wales arises from the concerns of the Rio de Janeiro Earth Summit, Agenda 21 and the aspirations of an emerging confident outward looking Wales taking its place in the modern world. Wales is one of the four constituent countries of the United Kingdom (which with Ireland forms the British Isles). We wish to help the 2.9 million people of Wales understand how plants work and contribute to human welfare.

We are embracing sustainability as an overall theme offering innovative approaches to helping people make new choices about their future.

Our central aim is for visitors to understand the role that plants play in their lives and the dependence of people upon them. They will touch, smell, and taste plants yet above all enjoy the experience of living conservation, thus contributing towards a 'preferred future'. The philosophy of the garden is available on our web site [www.gardenofwales.org.uk](http://www.gardenofwales.org.uk)

*1.3.2 The site* The garden is set in the 18th Century Regency park of Middleton Hall in Carmarthenshire, Wales. The estate comprises 230 hm<sup>2</sup>. It is situated on the edge of the beautiful Towy Valley floodplain, virtually free of pollution and with spectacular views of the surrounding countryside, steeped in Welsh history and culture.

The region in which it occurs is considered one of the poorest regions in Europe with a per capita GDP of 70% of the European Union (EU). Many of the communities have 40% – 60% unemployment. As such it is now part of Objective 1 — a seven year EU structural plan for regional economic regeneration.

West Wales suffers from a number of serious development constraints: minimal inward investment, a collapsing agricultural sector, unsustainable market-sensitive tourism, lack of enough quality jobs, and an ageing population. As a context, it provides the garden with some real opportunities for helping to create new jobs, help establish value-added tourism, and explore new rural enterprises.

#### 1.4 The Middleton Hall Estate

The Middleton Estate was the creation of the Scot Sir William Paxton who bought it from the Middleton family in 1785. He built a fine Neo-classical Mansion, redolent "of Asiatic pomp and splendour", with extensive stable outbuildings and two walled gardens. By the early 1900's the estate had largely fallen into disrepair and was later acquired by the Carmarthen-shire County Council<sup>[5,6]</sup>.

The garden lies in a rural area only a few miles from the industrial, urban south. Working farms surrounds it. Invisible to the park, the M4 motorway intersection is a few miles from the southern tip of the park providing easy access to visitors. A new grade-separated interchange to the M4 motorway extension was built to facilitate access. The Garden enjoys a varied rolling topography, a necklace of lakes, and a range of microclimates. It has the added benefit of established woodlands and wildflower meadows across some 80 types and sub-types of the National UK Vegetation classification scheme. The estate is rich in archaeological remains and living biodiversity, including numerous birds, rare! bats, owls, dormice, badgers, and otters.

## 2 Towards a new pattern of sustainable living

The Rio Earth Summit concluded that to adopt a new

pattern of sustainable living it will require a significant change in attitudes and practices of many people at all levels: individuals, organisations, communities, nations and the world. As soon as these issues are looked at globally it becomes clear that changes must be substantial if we wish to realise a future in which every person on the planet has fresh water, is adequately fed, housed and provided with basic health care.

The preservation of the environment and its associated biodiversity is a crucial aspect of sustainable development but it is by no means the only one. There is an increasing acceptance since the Rio Earth Summit that a wide range of other areas of human experience need to be incorporated within the concept of sustainable development: economic, social, political, historical, cultural, aesthetic, moral, spiritual, creative, linguistic, biological, technological, etc. The cultural, ethical and moral dimensions of sustainable development need far more consideration.

All of these areas of human experience are inextricably inter-linked and must all be involved in the creation of our preferred futures. No one nation, institution or organisation can address them all equally although it can and should be argued that governments and governing bodies have a duty to address as many as possible. Unless a holistic approach is taken to our activities in the present then the route to our preferred future becomes unclear and we risk losing our way, despite the best of intentions.

It could be argued that we now probably know enough about how to live sustainably on this planet. But how do we engage individuals, organisations and society to live sustainably? How do we use the current decision-making processes and partnerships in new and effective ways? How do we move away from a reference point of sustainable development that starts from an approach based on meeting the needs of the present without compromising the ability of future generations to meet their own needs<sup>[7]</sup>. Could it not be argued that such an approach relies on extrapolation from the present into the future creating a probable future — one that we drift into based on today's thinking? Can we not aspire to a

development model that could lead to a preferred future and thus defining what is possible and indeed necessary to change in the present?

### 3 Do we need another approach to sustainable development?

The issue here is that we cannot define what is possible in the present without knowing what future we aspire to. Although we cannot predict the future precisely, we can at least identify a desirable future and work towards it. Once there is a target to aim for then appropriate action in the present can be implemented. We might therefore redefine sustainable development as:

'A process that leads to a preferred future, however determined, that is based on sustainable principles — thereby defining what is possible and indeed necessary to change in the present.'

Many discussions on sustainable development seem to imply that we can continue as we are as long as we look after the environment. This kind of approach avoids the many real issues that face ordinary people, civil society and an increasingly interdependent world.

Big ideas and noble aspirations often seem incompatible with the task of everyday living for billions of people who suffer from a lack of basic human needs. The huge challenge we face as ordinary citizens is how can we transform our own lives within the structures of our very different cultures and societies yet still share a vision about the survival of our species and our home planet Earth? This dilemma so overwhelms most people that they are resigned to the probable futures mapped out for them by the society they live in, whether it operates sustainably or not. Is there a way in which people who are fortunate enough not to have to worry about sheer personal survival can step back and work with others globally who care about the planet they live on?

### 4 A preferred futures approach

Could sustainable development be re-defined to

ensure integration of environmental, ecological, economic, social, political, historical, cultural, aesthetic, moral, spiritual, creative, linguistic, biological and technological considerations ('sustainability bush')?

By focussing on 'preferred futures' we who may be in a position to influence society must engage the next generation in choices about their future. If we identify our preferred future based on sustainable principles, we can then work back to the present identifying all the various dimensions of the "sustainability bush" cited above that would need changes to them in the legal, planning and strategic frameworks that govern society so that actions evolve from each one. In some instances it may be nothing more than ethical and moral choices; e. g. In Wales it might be whether GM (genetically modified) crops should be grown in Wales or in Britain whether agriculture should be transformed from production to organic farming. In this way focussed change becomes possible. All choices that are made will of course carry the burden of diminished future opportunity so a preferred futures approach has to be an iterative one, testing the burden of each change against the aspirations of the present for future generations. Each culture, creed and faith may place different values on each component in the 'sustainability bush', giving a different approach towards a sustainable future. By exploring the burdens of decision in each approach, and sharing our experiences, we can develop a more empathetic understanding of each approach and so open opportunities to work together on shared elements. There may be many paths towards a shared future, all equally valid in their context.

#### 4.1 Sustainable citizenship

One key to developing consensual choice across communities and society is education for sustainable development. This enables people to develop the knowledge, values and skills to participate in decisions about the way we do things individually and collectively, both locally and globally that will improve the quality of life now without damaging the planet for the future. For example, in some counties in Wales, like Carmarthenshire where I am based, the links and partnerships are already in place so that this could happen. What are missing are

the facilitative techniques that would allow people to engage in preferred futures thinking to help develop consensus. This could develop a new form of sustainable citizenship. One approach is called The Natural Step Method ([www.naturalstep.org.uk](http://www.naturalstep.org.uk)) which uses a number of useful techniques such as backcasting (opposite of forecasting).

*4.1.1 Sustainable Citizenship* is a way of living in a family and community that enhances the quality of life, is sensitive to present and future needs based on a shared vision of the possible futures, and which empowers the citizen to influence and participate in the economic, political and social changes that are necessary for sustainable development (Adapted from a definition by Canon Kenyan Wright of the Scottish Environmental Forum).

*4.1.2 The Garden of Wales and preferred futures thinking* The National Botanic Garden of Wales is a new scientific institution in Wales. It is dedicated to conservation, systematic research and environmental education. It sets out to explore a new model for a botanic garden in the 21st century, doing this in a setting that is both aesthetically stimulating and scientifically challenging. One view of what we aspire to achieve is given in reference [8].

How have we done? Despite closure for foot and mouth disease, a petrol strike and widespread floods in 2000, the garden still managed to attract 243,000 visitors in its first year of opening (30% above target). Although most commentators were flattering about our achievements others are more challenging<sup>[9]</sup>.

#### 4.2 Challenges facing West Wales and the garden's response

West Wales has suffered for some time from declining GDP, declining agricultural and tourism sectors, and a lack of significant inward investment. The low rate of inward investment in West Wales creates new opportunities to focus on the creation of new small sustainable local businesses. The suffering and changing agricultural sector creates opportunities for agricultural diversification. A declining traditional tourism sector enables a shift to more sustainable eco-tourism and cultural tourism. West Wales

is in transition and the Garden is contributing to all these dimensions.

I offer four examples to illustrate how we are rising to these challenges.

1) Biotechnium. As part of the challenge to create new jobs and businesses the garden has created a new Biosciences Business Incubator with support from the Welsh Development Agency (WDA), Europe and the Millennium Commission. The centre opens in July 2002 and will promote the growth of indigenous small and medium enterprises (SME's) through corporate venturing, commercialisation of university based on existing company science, and from start-up companies spun-out from the government and charitable sectors. Biotechnium is part of the WDA-driven Technium Consortium of sector-based business incubators, which are being established in Wales ([www.technium.co.uk](http://www.technium.co.uk)). The garden's £3 million incubator will provide flexible office and laboratory space for up to 48 potential entrepreneurs. Interested parties may contact Technium @ [gardenofwales.org.uk](mailto:gardenofwales.org.uk). The garden will run its own science programme in the centre. Both these initiatives harness existing and new financial resources and talent and will act as a magnet to attract scientists of international repute, attract skilled professionals back to Wales, and will increase public/European funding for science in Wales.

2) Premier Garden of Wales. This new tourist consortium brings together 12 of Wales's finest gardens. The consortium markets the garden's both in the UK and abroad. The garden of Wales works closely with the Welsh Historic Gardens Trust and hosts their web site (see [www.gardenofwales.org.uk](http://www.gardenofwales.org.uk)).

3) Great Glasshouse Icon. This magnificent award-winning signature building designed by Lord Foster & Partners, with its radical Kathryn Gustafson landscape, is raising the international profile of the garden, Mediterranean regions of the world, and of Wales.

4) Principality Lifelong Learning Centre. This new learning centre received over 10 000 learners in its first year. Our aim is to help people become part of a learning society, stretch their horizons, and reduce social exclusion. We believe that gardens can provide bridges for

volunteers to get back into full time work, or to transfer their life skills to new generations.

5) Agri-environmental Schemes. The garden is a member of 'Tir Gofal', an agri-environment scheme that enhances biodiversity while still enabling profitable farming. For examples, protecting hedgerows and field margins on farms, creating ponds for wildlife, and planting new woodland copses within the existing farm landscape.

The Garden of Wales on the one hand fulfils the need for national and international research on plant systematics while at the same time providing an invaluable aesthetic, educational and recreational resource for Wales and for its international visitors. In this way it meets the definition of a botanic garden. It provides a significant additional tourist and employment resource for the Towy Valley, Carmarthenshire and Wales and may become a valuable proving ground for organic land management as well as setting a standard of excellence for encouraging the upgrading of amenity horticulture and other gardens in Wales.

#### 4.3 Contribution to sustainability

The new botanical garden continues to be built with an innovative and flexible approach to energy and sustainable estate management. The varied topography of the site with its diverse habitats, mild climate and minimal pollution lends itself to providing a rich visitor experience of visually attractive, botanically informative, thematic plantings, as well as managed natural and semi-natural landscapes.

We intend to be an active contributor to debate and best practice in conservation biology, environmental education, sustainable economic development and complementary energy. The garden is a founding member of Ecsite-UK, the new organisation for science and discovery centres in the United Kingdom. We have begun to explore the relationships between art, the humanities and science, seeking to focus this debate through an artist in residence scheme, exhibitions, conferences and publications.

The contribution of the Garden of Wales to the concept of sustainable development is through a vision of a

world where we understand, value, enjoy, use and sustain plants and fungi as vital elements in creating a sustainable relationship with life on earth. This is entirely consistent with our role as a botanic garden but rather than just passively presenting a message to the members of the public who will visit the garden the garden is already embracing sustainability in many areas of its activities and at all levels of the organisation. It is perhaps worth making the point that sustainability is not our business (we are not an ecocentre) but how we try to operate our business<sup>[10]</sup>.

Some of the activities and policies that are contributing to the garden's vision include:

1) The minimising of energy consumption through the use of effective design of buildings and structures, and the maximising of energy efficiency and conservation.

2) The preferential use of sustainable energy sources such as plant biomass; the wood boiler heats water which is pumped around the site to the key buildings.

3) The harvesting of rainwater for irrigation and the minimum use of water for effluent flushing (e.g. Gatehouse & Great Glasshouse).

4) The processing of waste on site wherever feasible — the natural treatment of effluent on site in the Living Machine is a prime example.

5) The minimising of pollution of all kinds including light, noise and chemical.

6) A commitment to the principles of organic production that is manifested in the use of an integrated biological pest control in the glasshouses and the organic management of the estate to increase biodiversity.

7) The provision of education and training to employees and volunteers on environmental issues and other topics. E.g., courses on "The role of modern botanic gardens" and with Lampeter University a bilingual course on sustainable development and biodiversity conservation.

8) The networking with like-minded organisations and specialists at local, regional, national and international levels and the encouraging of collaborative projects in environmental education and research.

9) The development of an educational programme

aimed at all levels and ages that will promote an understanding of the role of plants and fungi as vital elements in creating a sustainable relationship with life on earth — a lifelong learning approach. This last point is in many ways the most important.

10) Membership of sustainability focused organisations, working groups and societies.

## 5 The importance of education for sustainability

The garden has a mission to promote the importance of plants and fungi but its educational programme will go beyond plant biology, mycology and ecology to address all aspects of sustainable development.

A crucial point as distilled by the Garden's Education Advisory Group is that an education programme or curriculum must reflect the interconnectedness and complexities of sustainability. An inconsistent approach that includes an environmental awareness theme, which emphasises the importance of conservation alongside an economic, and industrial awareness theme that does not, is confusing, and detracts from the educational objectives of preparing people for responsible citizenship.

The vision of the education programme of the garden is to develop environmental initiatives that will support and help the people of Wales become part of a sustainable world.

Our initiatives will complement and extend environmental education. We are convinced that the future is dependent on sustaining and improving the long-term quality of natural habitats, the countryside and the richness of living organisms. By 2010 we hope the garden will have become a leading environmental education organisation offering a wide-ranging programme of courses, visits, workshops, seminars, conferences, open days, public lectures and learning materials.

The garden will be a champion about raising awareness about plants and fungi and their role in developing preferred futures centred on sustainability.

We are aiming to:

1) Build on the increased public awareness and interest in the environment.

2) Help improve the science and environmental understanding and skills of teachers.

3) Strengthen the connection between formal education and informal institutions.

4) Promote whole organism and ecosystematic approaches to the environment.

5) Influence changes in curricula.

6) Use leading edge technology in our education programmes.

7) Support the public in their quest for a better understanding of environmental issues and conservation.

## 6 Conclusion

The National Botanic Garden of Wales is more than just a conventional garden. It is a centre for tourism, for the arts, horticulture, land management, and environmental education, but also focused on economic regeneration and a new science centre with its business spinouts.

Already the garden is building a Biosciences Business Incubator, is sourcing local produce and merchandise, using many local contractors, sustaining over 100 new jobs, and setting challenging standards for itself and others in the region.

I believe that botanic gardens can and should help increase wealth, improve health and promote stable communities. It is how we map out our futures and set tough actions to achieve them that will ensure that the 1 860 botanic gardens around the world will remain relevant, vital, and flourishing. The world will demand more from us. We must help each other deliver. A preferred futures approach will enable those entrusted with

the future a and welfare of gardens a way in which to think of new alternatives and so enhance their chance of survival.

**Acknowledgements:** I wish to thank a number of people who have contributed towards my thinking about botanic gardens or who have encouraged me to put my thoughts to paper: the late Bill Klein, Peter Raven, Klaus Amman, He Shan-an, Nouhou Ndam, Ghillean France, Brian Huntley, Hannes Van Staden, John Simmonds, John Lavin, John Flanagan, Brian Schrire, Susyn Andrews, David DuPuy, Karen Pipe-Wolferstan, Michael Nixon, Ivor Stokes, Wolfgang Bopp, Simon Lees, Jennifer Asscher, Bettina Harden, William Wilkins, David Hassett, and my wife Jana Zantovska Stirton.

### References:

- [1] Heywood V H. The changing role of the botanic garden[A]. Bramwell D, *et al.* Botanic Gardens and the World Conservation strategy[M]. London: Academic Press, 1987.
- [2] Prest J. The history of botanic gardens[A]. Sclater A. The National Botanic Garden of Wales[M]. London: Harper Collins, 2000. 24 - 33.
- [3] Ruskin M. The social ecology of the botanic garden[A]. Sclater A. The National Botanic Garden of Wales[M]. London: Harper Collins, 2000. 140 - 151.
- [4] Stirton C H. Re-inventing the botanic garden for the 21st century[J]. Plant Talk, 2001, 22 - 23: 10 - 11.
- [5] Stirton C H. From ashes to icon[J]. The Historian, 2000, 65: 4 - 9.
- [6] National Botanic Gardens of Wales. Souvenir Guide[J]. Llanarthne, 2001, 34.
- [7] Brundtland Gro H, E World Commission on, *et al.* Our Common Future [report of the] World Commission on Environment and Development[M]. Oxford: Oxford University Press, 1987.
- [8] Stirton C H. Looking ahead — the garden in 2050[A]. Sclater A. The National Botanic Garden of Wales[M]. London: Harper Collins, 2000, 182 - 186.
- [9] Weston R. Between a dome and a soft place[J]. Touchstone, 2000, 8: 12 - 19.
- [10] Harper P. Green dilemmas for the botanic garden[A]. Sclater A. The National Botanic Garden of Wales[M]. London: Harper Collins, 2000. 132 - 139.