University Botanic Garden

Annual Report 2012-2013

CAMBRIDGE UNIVERSITY *Botanic Garden*

UNIVERSITY OF CAMBRIDGE

Director's Report

This year the Garden saw the development of some exciting new plantings and welcomed record visitor numbers.

I took up post as Director of the Cambridge University Botanic Garden in July 2013, and so feel like something of a fraud reporting on a year of successes that mostly happened without any input from me at all. The Garden is a remarkable institution, and a great place in which to work. Our collections were designed to last for generations, and we continue to design plantings today that will be at their best for generations to come. This long term view also applies to our staff, many of whom have been with the Garden for all or most of their careers. I have found this spirit of continuity extremely helpful this year in finding my way around the workings of the Garden.

There have been a number of exciting horticultural developments this year. We followed up the extremely popular annual meadow plantings from summer 2012 with a new perennial meadow this summer. The display was developed in collaboration with James Hitchmough, Professor of Horticultural Ecology at the University of Sheffield, and showcases a range of drought tolerant plants from around the world. Plants from dry climates are becoming increasingly important in Cambridge gardens, and are also an important part of our research and teaching provision, as plant scientists focus on developing crops that can withstand a wider range of conditions. In complete contrast we also opened a new Tropical Wetlands display in the Glasshouse Range. The raised, heated pool is home to the spectacular giant Amazonian waterlily *Victoria cruziana,* and the care and maintenance of this new addition to our collection challenged the Horticulture team to develop some new skills. I'm pleased to say they were successful, and we are now in the happy position to pass seed on to other Botanic Gardens and to grow up our own plants for next summer's display. We also took the opportunity to grow a range of heat-loving plants with important economic roles – such as banana and rice – and some other water plants with unusual surface properties. Particularly noteworthy is the sacred lotus, *Nelumbo nucifera* (cover picture), whose water-repelling leaves have been replicated by engineers to create unwettable paint. Plantings like these provide us with a unique opportunity to develop our research and teaching role at the same time as providing an enriching experience for our visitors.

Perhaps as a result of our horticultural efforts, and perhaps in part as a result of a long, hot summer, the calendar year 2013 saw a record number of visitors to the Garden. By the end of December 2013 we had passed the 220,000 mark, a good 10% up on last year and some 15,000 more than our previous record year. We hope to continue to attract a large number of visitors from outside Cambridge, and will be continuing to refresh our plantings and events to maintain interest among our loyal local visitors.

Perhaps surprisingly, visits from school parties are not counted in our annual visitor total. This year was relatively quiet for the Education team, as they were without a Schools Officer for much of the year, but we still hosted some 8,816 children on organised school visits. The Education team are essential to another of our core remits, that of providing botanical education to a wide range of non-specialists. One of their highlights of this year was the development of a set of summer trails for children, which changed each week, generously supported by Microsoft Research. It was clear from the enjoyment of those families that came back each week to try the different trails that the Garden plays a central role in developing a love of nature, and particularly of plants, in young people.

We have had a relatively quiet year in terms of staff changes. We were particularly pleased to recruit Bronwen Richards from the Field Studies Council to our Schools Officer post, and also welcome Jenny Sargent as Cory Library Manager. However, there will be big changes in the coming year as our Curator and Deputy Director, Dr Tim Upson, has accepted the post of Director of Horticulture at the Royal Horticultural Society. Tim has played a central role in the development of the Garden over the last 17 years, including a stint of 2.5 years as Acting Director. We will all be very sorry to see him leave, but wish him all the best in his new post while appreciating the compliment that the RHS are paying to his work and, by extension, to the Garden.

Professor Beverley Glover
Director

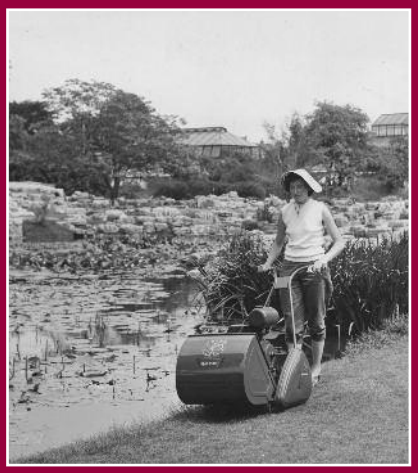
The year in pictures...

HOWARD RICE

The Sainsbury Laboratory, hosted at the Garden, wins the RIBA Stirling Prize in October, for making the greatest contribution to the evolution of architecture in 2012.

LUCY RAWLEY

2012 proved the wettest year since records began at the Garden in 1904, with 812.7mm of rainfall recorded. It was a great year for fungi!



In January the Heritage Lottery Fund confirms support for a one-year oral history project, Voicing the Garden.

ALEX ORROW

ALEX ORROW

The Garden's Festival of Plants in May immediately becomes a feature event of the annual calendar. Dedicated to bringing plants into focus for the general public, the day featured pop-up plant science demonstrations, bite-size science lectures and specialist tours.

Hedgehogs pay a visit for our summer half term family workshops.

JULIET DAY

The five July Sounds Green proms, supported by Mills & Reeve and delivered in collaboration with the Cambridge Summer Music Festival, attract record numbers.

JULIET DAY

An annual meadow sown under the new silver limes on the Hills Road boundary is enjoyed by many.

PAUL ASTON

James Hitchmough helps the Herbaceous and Display team sow his bespoke drought-tolerant perennial meadow mix.

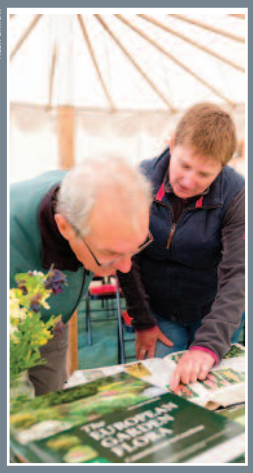
Snow sculptures appear around the Garden during the prolonged freezing weather.

Ann Gray is the Garden's Thresholds poet in residence as the season turns from winter to spring.

PAUL ASTON

The landscape around Station Road gate is planted up in May with a palette of blues and golds for long summer interest.

ALEX ORROW



Visitors to Festival of Plants enjoyed discovering floral diversity on the Systematic Beds, shopping the Plant Prom of independent nurseries, and finding out how science underpins horticulture.

CHLOE EDWARDS

The Young Explorer backpacks are completely overhauled with new Weird and Wonderful World of Plants trails, thanks to support from Microsoft Research Ltd.

CHLOE EDWARDS

TIM UPSON

First year flower and colour on the perennial meadow, just six months after sowing, includes the Indian paintbrush, *Castilleja integra*.

Horticulture and Estates

Our 40 acres of grade II* listed heritage landscape and collection of over 8,000 plant species is cared for and curated by the Horticulture and Estates teams. Last year over 200,000 visitors enjoyed a number of highlights, described below.

THE NEW WATERLILY HOUSE, WITH THE SANTA CRUZ WATERLILY STARRING, OPENS AT FESTIVAL OF PLANTS

SANTA CRUZ WATERLILY FLOWER

A new Tropical Wetlands display

During spring we installed a Tropical Wetlands display in the Glasshouse Range, the inspiration for which was the spectacular giant Amazonian waterlily genus, *Victoria*. Seed of *Victoria cruziana* (Santa Cruz lily) was donated by Helsinki Botanic Garden in November 2012. Germination rates of this species can be low, and following consultation with other experts the seed was nicked to remove the operculum. With this intricate task completed, the seeds were placed in water-filled plastic bags and immersed in a tank of water at 30°C. Much to our relief we had reasonable germination, but we were unsuccessful in establishing seedlings. Fortunately we were able to call upon a network of colleagues in other Botanic Gardens, and both the Royal Botanic Gardens of Kew and Edinburgh generously donated semi-mature plants. The two young plants were moved into raised pools in May. Water temperature was maintained at 30°C in the Tropical Wetlands House, and at 26°C in the adjacent external Glasshouse Bay.

Once planted the circular, rimmed pads, bearing ferocious spines on the underside, quickly began to emerge and develop to a diameter of 1.5 metres in time for the opening of the new display at Festival of Plants on 17 May. These mighty leaves were followed throughout the summer months by a succession of impressive flowers, each opening on their first night as a white, pineapple-scented female, and closing on their second evening as an unscented, pink, male flower. After pollination the peduncle contracts and the remnant of the flower is drawn underwater. If fertilised, the ovary then swells and the seeds develop.

The warm, humid atmosphere of the house was the perfect environment in which to grow not only *Victoria,* but a range of other tropical species. These included *Nelumbo nucifera* (sacred lotus, with the most spectacularly unwettable leaves), *Ensete ventricosa* (banana), *Colocasia esculenta* (taro) and *Cyperus papyrus* (papyrus). These economically valuable plants jostled for space with densely cascading passionflowers, including *Passiflora quadrangularis, P. phoenicea* and *P. citrina.* The house proved a success with visitors, many of whom regularly visited throughout the summer months to chart the progress of the spectacular Santa Cruz lily, and with students and research scientists, who found inspiration in the intricate floral biology of the water lily and in the complex leaf surface of the sacred lotus. The staff are also pleased that, despite anxious moments and minor setbacks, we now have a comprehensive understanding of the propagation and cultivation requirements of *V. cruziana,* which we can share with colleagues within the Botanic Garden community. In addition, with the annual growing cycle of our *Victoria* culminating in the production of 194 seeds, we can attempt to germinate and grow to maturity plants from our own seed in the future. We are also in a position to share seed with other collection holders, including this year Stellenbosch Botanic Garden, Amsterdam Botanic Gardens, and Chatsworth House, the first English garden to successfully flower the sister species, *Victoria amazonica.*

FIRST YEAR FLOWER AND COLOUR ON THE PERENNIAL MEADOW, JUST SIX MONTHS AFTER SOWING

Making a modern meadow

Work continued to finalise reinstatement of Garden displays following the completion of the Sainsbury Laboratory. The semi-circular area located by Cory Lodge, which had temporarily been home to the Garden's café, provided the perfect place to create a new seed-sown perennial meadow with the help of James Hitchmough, Professor of Horticultural Ecology at the University of Sheffield. Complementing the perennial planting on the west side of Cory Lodge, the display represents another modern style of planting and again utilises a range of drought tolerant plants. The selection has a strong emphasis on Mediterranean and steppe environments from the Colorado plateau through to central Europe and Asia, the North American prairies and summer rainfall areas of South Africa. The display is a demonstration both of the science behind establishing seed-sown meadows and of drought tolerant plants suited to the dry climate of Cambridge.

Key to establishing such a meadow is creating a seed bed by spreading 7.5 cm of sand across the site. Burying annual weed seed below this depth creates a sterile seed bed which is also free draining. The mix was sown in January to allow exposure to the necessary winter cold to break seed dormancy. Despite the cold spring, good germination was achieved and a surprising number of species produced a good display of flowers during the first year, attracting much attention from our visitors. The overall concept uses a low layer of mostly winter evergreen or semi-evergreen herbs to create a multispecies tapestry punctuated by tall grasses and flowering emergents. Particularly notable were *Berkeya purpurea* from South Africa, *Oenothera macrocarpa* subsp. *incana* and the unusual *Castilleja integra* (Indian paintbrush), both from the southern United States. Planted roots of *Eremurus stenophyllus,* the foxtail lily, perhaps provided the most spectacular display, the yellow flower spikes contrasting with the dark green background of the yew hedge. It is exciting to consider that this experiment in sowing a perennial meadow will evolve and change over the coming years as other seedlings reach flowering size to create both a changing horticultural experiment and a dynamic visual display.

A new boundary for wildlife

One of the fastest changing areas of Cambridge abuts our eastern boundary and we have been taking the opportunity to improve and refresh this area. Around the Station Road Gate a new herbaceous perennial planting has been established with a strong gold and blue theme to provide colour through the seasons. The intention is to provide a colourful mix to welcome visitors from the busy Hills Road and Station Road.

This herbaceous planting peters out into the wooded boundary that screens the Garden from the recently built seven storey office, Botanic House, and ultimately the apartments further along that are due to be developed in this area. This year we have taken the opportunity to totally redevelop the boundary. The existing trees were assessed and the best retained to provide a backbone whilst creating new planting opportunities for the future. With the help of Dr Nancy Harrison, a long-term collaborator and ornithologist from Anglia Ruskin University, the new display will reflect her research findings by developing a best practice planting to encourage wildlife. Research into the breeding success of birds has shown the importance of plant species that support a diversity of invertebrates, which in turn provide a vital food supply for the successful raising of broods. We will plant the boundary with those species that support invertebrates, including many native trees and shrubs but also a surprising number of exotic species. The *Betula* (birch) and *Acer* (maple) families are both very good, and not just for their native species but many of their exotic family members too. Surprisingly, the exotic flowering Japanese cherries are also good supports for birds needing to feed their young. Given the narrow nature of the boundary we will also use selections recommended as street trees, their narrow or conical nature and neat habit ensuring we won't have boundary issues with neighbours in the future. A range of autumn fruiting shrubs will provide lower level screening that acts both as a display to complement the adjacent autumn colour area and as another food source for birds. Dr Harrison's research is of great significance, questioning the common belief that only native species are good for native wildlife. The planting will illustrate how a mix of natives, selected cultivars and exotics can be successfully used to create an attractive and interesting planting that is a valuable resource for wildlife.

FELLING *POPULUS* X *CANADENSIS* 'SEROTINA'

DIGGING IN THE NEW RHIZOME BARRIER ALONG THE STREAM

Tree Survey

The Garden's impressive tree collection is dominant in our landscape, providing year round structure and interest and also shelter from prevailing weather and noise. Our oldest specimens were planted when the Botanic Garden was established in 1846, and through the decades subsequent custodians have continued to plant to maintain a succession of maturing trees. We are fortunate that their vision and foresight provides the familiar landscape of today. However, an ageing tree stock comes with concerns about disease and decay, which naturally affect maturing trees. In a Garden in which visitor numbers continue to increase, we have to consider the health and safety concerns arising from such trees. Regular inspections of our tree stock are carried out by our staff. These essential assessments focus on our mature trees, those known to have structural defects, and those in which regular maintenance includes the bracing of limbs, crown reductions and dead wooding.

In order that we can better manage and record our tree stock, we commissioned Tim Moya Associates to undertake a comprehensive survey of all trees within the Garden during the summer. In total 2,200 trees were surveyed, and this provided us with vital information to manage our tree stock into the future. The condition of all trees and large shrubs within the Garden was recorded, including height and spread data, GPS location, and structural issues and hazards. This information will be imported on to our plant records database (BGBase) for future reference.

The results of the survey reflected the observations and assessments undertaken by our own staff, and provided re-inspection dates ranging from 3 months to 5 years, along with priorities. Work identified in the report began during late summer 2013, and will continue through the coming years. 130 trees were cited as having a hazard risk requiring work, and for most of these the work entails only minor interventions, such as the repositioning of benches, removal of ivy, dead wooding, or branch reduction. In a few extreme cases more dramatic intervention was advised. One such example is the *Pterocarya fraxinifolia* (Caucasian wingnut) by the Brookside Gate, which has required remedial work through the years to ensure its safety. This specimen, which numbers amongst the original plantings of the Botanic Garden, bears characteristically brittle wood and overhangs key access routes. Each of these factors was considered in the tree survey, which identified the need for limb reductions and removals from this majestic clump. In other cases the survey recommended the removal of mature specimens, as was the case with *Populus x canadensis* 'Serotina', another brittle-wooded species, whose base showed signs of extensive decay.

While any such works can appear dramatic, they are essential in maintaining the Garden. With the survey completed and works well under way, we can be confident that we now have a comprehensive baseline from which to manage our trees for the enjoyment of future generations. Of course, all these works are complemented by a continued programme of new planting to ensure the long term future of the collection.

Maintenance

Much of the horticultural staff's time is taken up with perpetual maintenance tasks, such as weeding, edging, mowing and irrigating, which are a prerequisite to ensuring high horticultural standards. Some maintenance tasks, however, can be of greater significance, such as those undertaken in the vicinity of the stream this year. The streamside beds have been completely cleared of plantings to allow the eradication of invasive, perennial weeds (particularly ground elder and bindweed), and invasive rhizomatous bamboos, planted in close proximity. In order to effectively clear the bed, existing ornamentals were lifted, divided and retained in our nursery, and repeated applications of weed killer were then used to treat emerging weeds. In order to prevent bamboo rhizomes infiltrating the bed, an impermeable polyethylene barrier was inserted at a depth of approximately 600 millimetres along the bamboo-threatened edge. We intend to re-plant with moisture-loving marginals such as *Lythrum salicaria* (loosestrife), *Primula japonica, Hesperantha coccinea* and *Hosta* species during winter and spring of 2014, and hope that these plantings will thrive in the absence of undesirable competitors.

Adjacent to the streamside plantings runs an irregular York stone path. This paving requires regular re-laying by our Landscape and Machinery Staff, to secure loose paviors and to eliminate any trip hazards. The section in the Bog Garden was re-laid in spring 2012, and this year we took the opportunity to re-lay the stretch from the Bog Garden to the Woodland Garden. Work required the lifting of this section of path which was then re-laid on to a base layer of sand and cement, upon which the jigsaw of mismatched paving was set. The resulting new path ensured a durable, hard wearing surface along which visitors with wheelchairs and pushchairs can readily access this calm, secluded area of the Garden. In the coming year, the final stage of paving from the Bog Garden to the Sandstone Rock Garden will be re-routed to allow similar ease of access to the eastern end of the lake.

In the Experimental Section of the Garden, preparations for future plantings have been in evidence. On the Ecological Mound work has begun to thin some plantings, and we are also undertaking an inventory of plantings to establish which British wild flowers we currently hold. As a managed natural display there exists a delicate balance between ensuring a naturalistic-looking planting, and an overly-manicured one. In recent years the balance has tipped towards the naturalistic, with invasive species such as *Brachypodium, Calamagrostis* and brambles becoming dominant. The thinning of such species will allow us to assess the collection and plan for future plantings. This year we have direct sown species of *Orobanche* and *Lathraea,* to extend our collection of native parasitic plants. We anticipate that achieving the balance will be on-going for several years.

During the building of the Sainsbury Laboratory, much of the space on the Garden's Experimental plots was given over to temporary accommodation to enable construction of new facilities on site. Upon completion of the building phase these temporary buildings, associated concrete bases and vehicular access routes were removed, and sugar beet washings (a fine silt lacking in organic matter) were used to re-soil the area as part of the reinstatement process. Unfortunately these actions resulted in a compacted pan about 40cm beneath the soil surface, and impoverished and poorly drained soil. In order to improve the soil, four skip loads of compost were incorporated into the soil mechanically during the autumn. This was followed in spring by the sowing of buckwheat *(Fagopyrum esculentum)* as a green manure to further break down the soil and, upon rotavation, to add organic bulk. With the soil now much improved we are developing plantings in this area to demonstrate the role of research within the Botanic Garden, the Sainsbury Laboratory and the rest of the University.

ROTOVATING IN THE BUCKWHEAT GREEN MANURE

WE HAVE SEED SOWN *LATHRAEA* ON THE THE ECOLOGICAL MOUND WHICH DISPLAYS OUR BRITISH WILD FLOWER COLLECTIONS

Welcoming colleagues – PlantNetwork Conference and AGM 2013

It was with pleasure that the Garden hosted the PlantNetwork AGM and spring conference on "Urban Public Gardens: challenges and opportunities" on April 11th and 12th. PlantNetwork represents the plant collections network of Britain and Ireland, and nearly 70 delegates attended from around the country. The immediate area around the Botanic Garden is undergoing major urban developments, providing a catalyst to hold the conference. An overview of the potential impacts on the Garden was given by Dr Tim Upson, who is also a Trustee of PlantNetwork. Other topics ranged from the social role of gardens, urban food production and sustainable urban drainage to an update on the Olympic Park in London and urban biodiversity. The second day offered the opportunity to visit the Sainsbury Laboratory and enjoy tours of the Botanic Garden with our staff.

Horticulture Volunteers

We began recruiting a small number of horticultural volunteers during the summer. Opportunities for volunteers were identified by the horticultural sections within the Garden, and this has enabled us to offer places with a clear focus, particularly to those keen to pursue a career in horticulture. Places are offered according to our needs, and also depend on our ability to ensure close supervision and considered instruction. We are delighted to have a small team of dedicated volunteers, not only regularly assisting us in the maintenance of the Garden and its collections, but also developing their own skills and knowledge. We anticipate that we will continue to run this scheme into the future, but will only be able to offer limited places as opportunities arise.

Dr Tim Upson, Curator
Sally Petitt, Head of Horticulture

The Outreach Office

The Outreach Office handles all the administration for the Friends of the Garden, the Education section and for the Volunteers, including our Guides. The Outreach Office has two members of staff: Emma Daintrey, who is the full-time Outreach Administrator, and Heidi Bradshaw, part-time Outreach Assistant.

FRIENDS VISIT TO CORNWALL

Friends' membership continues to grow with an overall increase in membership applications of 495 during the reporting period. There were 1945 joint memberships and 1771 single memberships making a total of 5661 individual Friends, an increase from the previous year of 724 people. Membership subscriptions remained at £32 (single) and £55 (joint).

There were 65 organisations holding Corporate Friends memberships this year, half of them had Category A memberships (admission 7 days per week) and the other half Category B (admission Mon-Fri only excluding Bank Holidays). The cost of Corporate subscriptions increased in April 2013 from £150 to £240, the first increase for six years.

The Friends Annual Lecture, 'Thinking like a vegetable - how plants decide what to do' with Professor Ottoline Leyser, Director of the Sainsbury Laboratory, took place in November 2012 in the Sainsbury Laboratory lecture theatre and was attended by over 140 Friends. During the first eight months of 2013 Friends enjoyed tours of the Botanic Garden 'Alpine' yard area (behind the scenes), early morning bird walks in the company of Dr Nancy Harrison followed by breakfast in the Garden Cafe, and an evening with Penhaligon's Perfumiers. In May there was a residential trip to the Gardens of Cornwall and other summer outings included trips to Rousham House and Garden and to Waterperry Gardens in Oxfordshire, Felbrigg Hall and Peter Beales Roses in Norfolk, Hever Castle and Garden with Merriments Garden and Nursery, and East Ruston Old Vicarage Gardens. We are very grateful to the Volunteer Committee of Emma Daintrey, Jenny Leggatt, Pam Newman, Richard Price and Elizabeth Rushden for all their work on behalf of all Friends and Volunteers. In April 2013 the Committee was joined by volunteer Gail Jenner, with Heidi Bradshaw as minute taker.

On 107 individual occasions Garden Guides provided tours for 2,065 visitors. There are twenty four qualified volunteer Garden Guides. Their commitment, enthusiasm and professionalism are an invaluable resource with each giving freely of their time and experience for the benefit of the Garden. Our Guides are provided with training sessions in seven different subject areas.

The Outreach Office, together with many Garden volunteers, supported Garden events during the year including Twilight at the Museums (February) and Festival of Plants (May). The Outreach team, through the Education section, also supports University events including Science Festival and the Festival of Ideas.

Emma Daintrey, Outreach Administrator

The Education Department

This year has been one of great change in the Education department at the Garden. Following the retirement of Judy Fox (Schools Officer) and departure of Karen van Oostrum (Head of Education) we had a busy period of recruitment. Our new Head of Education, Felicity Plent, was appointed in January, and a new Schools Officer, Bronwen Richards, joined the team in August.

FESTIVAL OF PLANTS

For a considerable period of the last year we were without a Schools Officer, and as a result were forced to restrict the number of assisted visits available to schools. However unassisted visits, using our self-led resources, continued to increase and overall there were 372 school visits, with 8,816 children visiting the Garden through their school during the year.

With a new team in place we are now beginning the process of reviewing school resources, adding new sessions and developing the schools programme further with the particular aim of engaging more with secondary schools in the region. In addition we have developed a third formal strand to the programme which has led to the reorganisation of Sally Lee's post to be Education Officer for Community and Families.

Schools and the Schools Garden

This year we piloted a scheme to provide students from Hills Road Sixth Form College, studying A level Biology, Geography, Photography or Art, with free entry passes to the Garden. The idea was to encourage students to visit and use the Garden to support independent study. We hope to extend the scheme to other sixth form colleges in the City.

While we were without a Schools Officer it wasn't possible to run our usual children's gardening club sessions and so the Garden's horticulture team and our education volunteers planted up and managed the main growing beds in the Schools Garden this year. As a trial we used two beds for growing pictorial meadows and two for square meter veg plots, as well as climbing vegetables covering the garden's new pergola. The pictorial meadows were hugely successful, attracting many more visitors to the Schools Garden, and we plan to develop a new resource for schools on how this type of planting can be used in school grounds to inspire learning across the curriculum.

Adult Courses and Workshops

Our range of courses and workshops continues to expand and this year planning began for a transition to an online booking system for courses, which went live in November 2013. The year saw over 60 courses run at the Garden on topics ranging from Plant Identification and Gardening to Basketry and Garden History. New this year was a weekend 'Learn to Garden' course led jointly by our Head of Horticulture, Sally Petitt, and Head of Education, Flis Plent. Novice gardeners were put through their paces on a chilly March weekend and the enthusiastic feedback from them showed us that this is an area that can hopefully extend our reach to new audiences. Many of the participants were new both to the Garden and to our courses programme. We plan to run this course for a second time next year and follow it up with a range of horticulture courses looking at different aspects of managing a garden.

NEW EXPLORER BACKPACKS

SUMMER TRAILS

Community and Families

Every summer holiday for the last few years we have run a two or three day family event, usually during August. These drop-in activities are usually well attended, with around 200 children taking part. But if you were a first time visitor who came to the Garden the following week you would have missed the event, and if it rains on the key two days (which it has done in other years) not as many families attend. With this in mind we decided to spread the activities throughout the summer holidays by offering more self-led activities under the banner of the 'Weird and Wonderful World of Plants'.

The objectives were to encourage families to come to the Garden more than once during the summer holidays and to use our young explorer backpacks, which we have been able to revamp this summer with the generous support of Microsoft Research. We developed four new self-led activity trails which featured beautiful illustrations, fascinating facts about plants, covers to colour in, passports to stamp, battle cards to collect, and stickers to find homes for. The trails swapped over each Friday in August and were supported by wider publicity in the local press and beyond.

'Be a Bee' was inspired by our Bee Borders and asked you to spend a day in the life of a bee by seeking out a bee's favourite plants and places in the Garden. *'PAH!* (Plants, Animals and Humans)' challenged young visitors to track down useful plants in the glasshouses and work out which sticker went where. *'Superpower Plants'* introduced the plant heroes' hall of fame, where you could rate plant superpowers and pitch them against each other. Finally, *'Around the World'* gave a thumbs-down to airports and took you and your plant passport to find plants from all over the world, stamping as you went. Our evaluation of the trails shows that they were well received by families and children.

As part of a reorganisation of the structure of the education team Sally Lee's post has been revised to now cover Community and Family learning. This post will oversee the Sainsbury Community Art Programme and other community initiatives that do not have an 'art' component. Community groups involved in projects over the last year include the Cambridge Young Carers, the Women's Institute, Cambridge Celebrates Age, Children and Young People's Participation Service (ChYpPS) and the Centre at St Paul's. Highlights in the past year include visits from the Thursday group for mental health issues at St Paul's, who for the past year have visited each month to see plants of interest and do activities in the Garden. Over the last year the group sessions have included learning all about the plants in the new tropical wetlands glasshouse, making bunting for the Festival of Plants, carrying out moth identification and even a session of Tai Chi in the Garden. We hope to continue working with this group next year and also expand by offering these kinds of sessions to other local charities.

Another highlight was our work with the Centre 33 Young Carers Project, a group with which we have worked regularly since 2011. This group is for Cambridge based young people under the age of 18 who provide care, assistance or support to another family member who is disabled, physically or mentally ill, or has a substance misuse problem. The Garden works closely with Centre 33 to coordinate fun activities in the school holidays where the young people can enjoy spending some time outdoors connecting with nature. In August 2013 we ran a very special evening camp out for this group. A tent was set up in the Schools Garden and we worked with artist Alex Hirtzel to deliver art activities, cooking and exploration of the Garden by torchlight, to the delight of the participants.

Festival of Plants

This event in May was a new one for the Garden, but a follow on from last year's Fascination of Plants day which was part of an international initiative led by the European Plant Science Organisation (EPSO). It was supported by the Cambridge Partnership for Plant Science and the Sainsbury Laboratory. Our event this year was designed to broaden the scope and focus of the day by bringing plant scientists, horticulturists and plant enthusiasts together at the Garden to cover topics as broad as which plant to grow where, discovering the inner workings of flowers and how plant science underpins the way a garden grows. The day's activities included 'ask the gardener' and talking plant science sessions, pop-up plant science demonstrations, fantasy flower making by our systematic beds and tours of the Garden and glasshouses.

Connecting Collections

This was an extremely busy year for the Connecting Collections programme across the University Museums and Collections. We were involved in two major collaborations, Thresholds and Twilight at the Museums.

'Thresholds' was a poetry project supported by the University and Arts Council England, which took place across all the University Museums and Collections. Ten poets were invited by the Poet Laureate Carol Ann Duffy to take part in residencies, run workshops with young people to develop their writing skills and write a poem inspired by their experience of our collections. Our Poet, Ann Gray, wrote a series of five poems and we worked with students from Red Balloon, a charity which runs learning centres for children who have been severely bullied.

The poems and more details on the project are available on the website www.thresholds.org.uk

In February we again took part in the family orientated 'Twilight at the Museums' event, which saw over 800 visitors explore the Glasshouse range after dark with their torches. Our event focused on the interactions between plants and nocturnal animals.

In addition to these larger events we are continuing to develop links with the University Museums in the delivery of our education programme. Our popular garden history courses this year had a focus on Tudor and Elizabethan gardens. The final session of the course was run in conjunction with the Fitzwilliam Museum. The session was run by our tutor in the Museum looking at the connections between art and gardens and using the information gathered from looking at art of the time to inform our understanding of gardens from that era.

Conferences

We were represented at two conferences this year by members of the education team. Judy Fox and Sally Lee led a CSI (Crime Scene Investigation) plants session at the BGEN conference in November hosted at RHS Rosemoor. They also represented the Garden at the BGCI conference in Mexico City, speaking about our young carers' Magic Brick Tree project and the 'Sweets and Treats' family activity.

Education volunteers

As ever we are indebted to our corps of volunteers who continue to support and enhance our education programme. From the regular First Saturday volunteers who inspire us with their creativity and help children and families to get the most out of the garden to those who took part in Twilight and Festival of Plants or those who surveyed visitors to gain feedback on our new summer trails, we thank them all for their generosity with their time.

Flis Plent, Head of Education

MAKING FANTASY FLOWERS AT FESTIVAL OF PLANTS

GLASSHOUSE RANGE AT TWILIGHT AT THE MUSEUMS

Science and Plants for Schools

TEACHER TRAINERS FROM AROUND THE UK AT OUR THIRD *'TRAIN THE TRAINER'* EVENT

Recognition for excellence in biology education

This year brought national and international recognition for the work of Science and Plants for Schools (SAPS) in supporting plant science education in UK schools and colleges. Two of our SAPS Associates, teachers Beverley Goodger and Richard Spencer, were awarded winner and runner-up, respectively, in the 2013 Society of Biology Secondary Teacher of the Year competition. In July, the SAPS team were invited to attend the Annual Meeting of the American Society of Plant Biologists (ASPB) in Providence, Rhode Island. We were honoured at being selected as one of only two winners of the ASPB Education Competition for Innovative Instruction, and delighted to demonstrate a new technique for cloning cauliflowers to American plant scientists and educators.

> *"I want to thank you for contributing so importantly to a successful ASPB Education booth, and for your interest and evident passion for developing and communicating exciting and new approaches to plant biology education."*
>
> Scott Woody, University of Wisconsin and ASPB Education Committee member

Celebrating 21 years of SAPS

In January we commemorated 21 years of SAPS with a series of events at the Association for Science Education Annual meeting at the University of Reading. With a lecture on 'Transforming Photosynthesis' by Dr Colin Osborne from the University of Sheffield, 3 days of drop-in sessions on 'Biology Practicals That Work', a 'Meet the SAPS Associate' workshop and an interactive stand with colleagues from the Society of Biology, we celebrated in fine style with hundreds of science teachers and technicians. We are tremendously thankful to all those people who have worked with SAPS over the years, particularly our colleagues in the Botanic Garden.

GATSBY

Science &Plants for Schools

MARY WILLIAMS

HARRIET TRUSCOTT DEMONSTRATING A SAPS LAB PRACTICAL AT THE ASPB ANNUAL CONFERENCE, RHODE ISLAND

ALEXANDRA FRAGNIERE

DAN JENKINS DEMONSTRATING LAB PRACTICALS FOR OUR NEW VIDEO SERIES

Supporting teachers throughout their careers

This year we produced 14 new teaching resources for secondary schools. These included: *Tackling tropisms; How do plants grow in space?; Photosynthesis quiz - test your knowledge; Using a Potometer; More uses for algal balls;* and *More uses for Cabomba.* In total, use of the SAPS website doubled, with 400,000 visits over the course of the year. We have also begun to populate a YouTube channel with some short videos showing some of our most easy-to-do practicals. *How do Nettles Sting?* featuring SAPS team member Dan Jenkins is proving a very popular resource and we will be adding to this channel in future.

Trainee teachers have become a real focus for our work. This year we held another two workshops for those educationalists who train biology teachers, giving them two days to try out a range of SAPS practicals and plan how to embed plant science better in their courses. We are delighted that we have now reached over 50% of all university-based teacher training institutions in the UK through these workshops.

> *"Great to see plant biology as a real focus and such interest. Thanks for a really interesting and thought provoking course."*
>
> Teacher trainer from the University of Brighton.

In addition, we created 'Plant Science Survival Guides' – sets of our most popular resources stored on a USB memory stick - and made them directly available to all trainee biology teachers. The positive feedback we gained has meant we will be repeating the production of these Guides next year.

Strengthening our networks in the UK

Our regular newsletter is now e-mailed out to over 3,500 teachers, technicians and educationalists. Packed full of new teaching materials and ideas, it shows that plant science can be one of the most exciting and interesting subjects to cover in the classroom.

> *"Thanks very much for your regular SAPS updates - most appreciated and very useful. I often simply use your newsletter at the start of a lesson to generate interest about the topic we are discussing - it never fails to spark some students."*
>
> Secondary Biology Teacher

Over the last year, we have moved to a new online e-mail tool which allows us to track which news stories and resources are of most interest to teachers. We now know that within hours of the newsletter being sent out, a few hundred teachers have visited the website to take a look at our teaching materials. A particular highlight this year was a 'top trumps' style card game looking at the pharmaceuticals derived from plants. We have continued to develop our social media channels as well, with SAPS communications guru Harriet Truscott providing a daily highlight from the world of plant science to over 1,500 people via Twitter and Facebook.

We remain very grateful to the Gatsby Charitable Foundation for their generous support of the SAPS programme which enables us to offer all our resources for free to secondary schools and colleges around the UK.

Ginny Page, Director, Science and Plants for Schools

Research

The diversity of roles the Garden plays in Research, both across the University and more widely, is astonishing. Pages 16-17 of this Annual Report provide a summary of Research conducted in 2012-2013. As well as the perhaps expected role in providing access to plant collections and horticultural support for botanical projects, the Garden also provides underpinning facilities supporting research in Architecture, Chemistry, Archaeology, Zoology and Computer Science. Professor Glover decided to use the opportunity of her first Annual Report as Director to focus on an area of particular interest to her, the interaction between flowers and the animals that pollinate them.

ALISON REED

BEE ON *SALVIA* INFLORESCENCE

SILVIA VIGNOLINI

BUTTERCUP REFLECTING YELLOW LIGHT ONTO THE CHIN

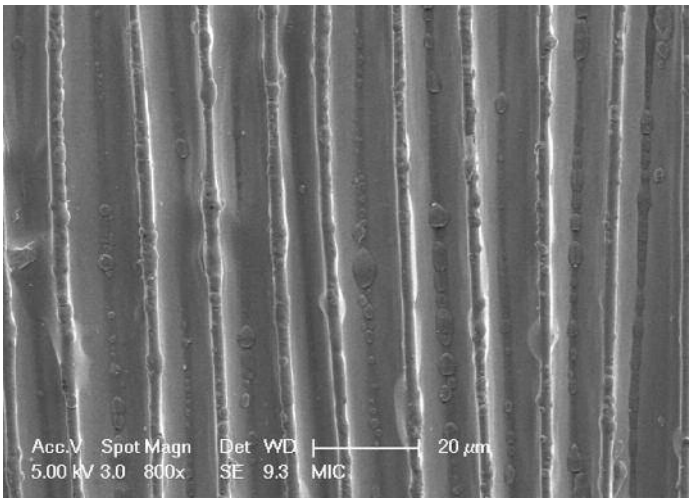
Pollinators in the Garden

The Garden is an excellent resource for research in pollination, because as well as housing a scientifically important collection of flowering plants it is also home to large numbers of pollinating insects. These come to take advantage of the range of habitats our various plantings provide, and of course the bee borders were specifically designed to provide a reliable and highly rewarding food resource over an extended summer season. Kirsty Lloyd, a PhD student at the University of Plymouth, visited us this summer to study *Bombus hypnorum,* the tree bumblebee, in the Garden. *B. hypnorum* is an invasive European and Asian species which was first recorded in the UK in 2001. It has since expanded rapidly and is now well established across the UK. The origin and colonization route of the introduced population, and why it has been able to colonize the UK so rapidly, is largely unknown. In June 2013 Kirsty conducted fieldwork collecting tree bumblebees from across the UK, including in the Garden. With these samples she is conducting genetic analyses to investigate the spread of the species. She is also assessing foraging competition with native bee species. Kirsty's studies will reveal which features of *B. hypnorum* have contributed to its success as a coloniser, and should indicate whether or not it has the potential to negatively impact native species.

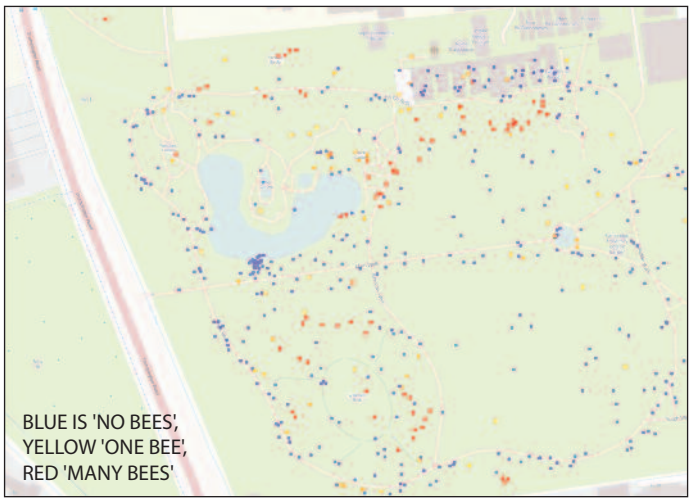
Bombus hypnorum is one of several species of bumblebee that forage in the Garden. Understanding how these different species interact in communities, and how those communities and the pollination service they provide are affected by land management, is the remit of a large scale project called "Agriland" (http://www.agriland.leeds.ac.uk), based at the University of Leeds. This project uses 96 field sites across the UK, including 16 in Cambridgeshire, and measures pollination at each site using arrays of potted California poppies *(Eschscholzia californica).* These are known as "phytometer" plants because their seed set is a useful measuring device for estimating pollinator service. This year the Garden was pleased to provide horticultural support, maintaining 144 potted *Eschscholzia* plants in transit to the Cambridgeshire field sites.

Tricks of the Light

Eschscholzia californica has been one of the focal species of my own research this year. For 15 years now I have used the Garden's collection in my research into flower development and evolution. Sometimes the species I study are selected for their phylogenetic position, perhaps occupying a key place in the plant phylogenetic tree. Sometimes I choose groups of plants where there is a lot of diversity of floral form, or where floral form is very constrained – and for those studies the Systematic Beds are a great resource. And sometimes I simply choose species because something about their morphology or the way pollinators are interacting with them catches my eye. This year's work on the California poppy falls into this last category. California poppy caught my eye a year or two ago, flowering in the Chronological Bed, because it was simply incredibly glossy. Glossiness in flowers can be produced in a number of ways. In 2012 my group published a paper



SURFACE OF CALIFORNIA POPPY



LOCATION MAP OF BEES IN THE GARDEN ACCORDING TO PARTICIPATORY SENSING STUDY

explaining how the common buttercup produces such a glossy yellow surface that it can reflect yellow light onto the chin of children playing the traditional "do you like butter?" game (Vignolini et al., Journal of the Royal Society Interface, 2012). The trick turned out to involve a double mirror system, with a very smooth glass-like surface structure reflecting a lot of white light, and a second mirror below, an air layer, reflecting back the yellow light that was left when the pigments had absorbed all other colours. The SAPS team in the Garden, who make this sort of work accessible to schoolteachers, pointed out to me that one of the national newspapers had run a story on the paper under the headline "Cambridge scientists prove that buttercups don't know whether you like butter"!

Another way of producing glossiness is to use a diffraction grating, a series of regular structures on the petal surface that interfere with light, causing directional reflection of particular wavelengths. This can give an iridescent colour effect, as seen in the tulip variety "Queen of the Night" (often growing in the pots by the fountain, as well as in the Cory Lawn planting), as well as simple gloss (Whitney et al., Science, 2009). The diffraction grating itself is produced by folds of the cuticle, the waxy waterproof layer that covers the petal surface. My research group is particularly interested in the developmental processes that generate this nanoscale pattern. To dissect out the genetic basis of a morphology we need to use a plant that flowers frequently all year round, and we've chosen another example that we first noticed in the Garden for this work – the Venice mallow *(Hibiscus trionum)*. This *Hibiscus* species is a small weedy annual, and the horticultural staff often use it around the glasshouse range to brighten up the plantings. The centre of the flower contains a dark red region with a wonderfully iridescent diffraction grating overlying the red pigment. Working with this plant in the lab we have developed a transgenic line in which the cell membranes are marked with a fluorescent protein, and we are now watching carefully how cell growth is related to the development of the grating. The next step will be to modify other genes that control final cell shape and size, to see how perturbing these processes perturbs grating development (Kourounioti et al., Journal of the Royal Society Interface, 2013).

The California poppy is probably generating its glossiness through another mechanism again. If you shine a light on its petal surface you see a band of white, like a laser beam, running straight across the petal. As you move the petal, or your light, the white beam moves as well. We think this effect is probably created by prism-shaped cells, but we're still working out the details. It is wonderful to have access to the Garden's collections to help with this sort of work. In September 2013 I hosted the annual meeting of the team studying floral surface properties, which includes collaborators from the Physics Department and Nanoscience Centre here in Cambridge (Professors Ulli Steiner and Jeremy Baumberg, and their teams) and colleagues from the Jodrell Laboratory at the Royal Botanic Gardens Kew (Dr Paula Rudall and Professor Richard Bateman). In the middle of the discussion of the California poppy, based around microscope images and graphs showing how light interacts with the surface, we realised that we really needed a flower to test how it would respond to a torch shone from different angles – and we were able simply to collect one from the western edge of the Limestone Rock Garden. It certainly speeds up the science when you can do the experiment immediately, rather than growing the plant from seed!

The Bee Borders work

A different sort of science, but still involving flowers and bees, was conducted by Dr Andrew Rice and his PhD student Mattias Linnap, both from the University's Computer Laboratory, this year. Their research is on Participatory Sensing - a form of volunteer data collection where people answer questions from the field on mobile phones. They decided to test out a new technology in this area in the Garden this summer. Volunteers were asked to report whether they saw any bees as they walked around the Garden. The experiment investigated whether location tracking together with a centralised management server could increase the coverage area and reduce duplicate answers for a sensing study. The results from the experiment were excellent, and showed that the technology increased coverage by 12% and reduced duplicate answers by 75% compared to regular time-based questions. The staff at the Garden were also delighted when Mattias sent us the results of the study. One of the main outcomes was a map, showing where his volunteers had found the most bees (see above). It is always good to know that our bee borders are a success, although we noted that the Asteraceae in the Systematic Beds were also doing very well at attracting bees – perhaps that's where I should be focusing my research group's attention in the coming year!

Professor Beverley Glover, Director

Research supported and facilitated

The Botanic Garden maintains and makes accessible the living plant collection of the University of Cambridge. Research and teaching is supported through: the plant collections of over 8,000 species; the Experimental Section which provides supported glasshouse and open ground research plots; and through use of the 40-acre landscape. In addition to home-grown research the Garden supports a wide range of projects throughout the University of Cambridge and collaborates with a great many external partners.

Cambridge University Botanic Garden

Professor Beverley Glover, Director:

- Research programme focussed on the evolution and development of flowers, plant/pollinator interactions, and plant surface properties. Material maintained at CUBG or accessed from living collection, for projects including:
- Petal surface evolution in *Solanum*, with Dr Sandy Knapp (The Natural History Museum) and Katrina Alcorn (PhD student).
- The relationship of floral morphology to pollination success in *Vicia faba*, with Dr Jane Thomas (National Institute of Agricultural Botany) and Emily Bailes (PhD student).
- Molecular evolution of key developmental pathways in plants, with Dr Sam Brockington (post-doc).
- Evolution of floral form and pollinator type in Antirrhineae, with Cecilia Martinez (PhD student).
- Development and evolution of insect-mimicking petal spots in *Gorteria diffusa*, with Dr Paula Rudall (RBG Kew), Dr Allan Ellis (Stellenbosch University) and Greg Mellers (PhD student).
- Development, function and evolution of iridescence in plants, with Dr Paula Rudall (RBG Kew), Professor Richard Bateman (RBG Kew), Professor Ulli Steiner (Department of Physics, University of Cambridge), Professor Jeremy Baumberg (Department of Physics, University of Cambridge), Dr Silvia Vignolini (Department of Chemistry, University of Cambridge), Dr Edwige Moyroud (post-doc) and Alison Reed (PhD student).
- Evolution of epidermal cell morphology, with Lin Taylor (PhD student).
- The effect of plant viral infection on pollinator attraction, with Dr John Carr (Department of Plant Sciences, University of Cambridge), Dr Alex Murphy (post-doc), Dr Niels Groen (post-doc) and Sanjie Jiang (PhD student).
- Provision of liverworts, mosses, ferns, lycophytes and cycads for undergraduate teaching.

Dr Tim Upson, Curator and Deputy Director:

- Maintaining collections of *Lavandula* and *Rosmarinus* for systematic research.

In collaboration with Tim Pankhurst, Plantlife Fenland Officer based at CUBG:
Maintaining collection of fen plants for conservation including:

- Testing 10 year old *Viola persicifolia* (Fen violet) seed for viability from Wicken Fen.
- Regenerative strategies for *Liparis loeselii* (Fen orchid), with Pete Atkinson (Plant Records Officer) and Pete Michna (Experimental Supervisor)

Department of Plant Sciences, Cambridge

The following groups were supported in their work:

Professor Sir David Baulcombe, FRS (RNA Silencing and Disease Resistance Group)
Use of experimental glasshouses to propagate the progeny of *Solanum lycopersicum* x *S. pennelli* hybrids through to the F4 generation, to investigate transgressive segregation in hybrid plant populations. Transgressive segregation results in plants that have heritable properties that are outside the range of the parents, and this work aims to understand the molecular biology of this important trait so that it can be harnessed more efficiently.

Dr David Coomes (Forest Ecology and Conservation Group)
Plant movements and climate warming: intraspecific variation in growth responses to non-local soils.

Professor Howard Griffiths (Plant Physiological Ecology Group)
Succulent plants and Crassulacean acid metabolism: modelling the compromise between water use and carbon gain to interpret evolutionary origins and biomass production potential, using *Agave, Kalanchoe* and *Mesembryanthemum* plants maintained at the Botanic Garden. The C4 photosynthetic turbocharger: how leaf vein anatomy modifications and metabolic partitioning provided the platform for high-light demanding highly productive grasses predominating in savanna regions and to become staple crops. *Miscanthus* maintained at the Botanic Garden.

Dr David Hanke (Plant Growth Substances Group)
High quality tubers of *Solanum tuberosum*, cvs Majestic and Desiree, grown and harvested for Luke Browning (PhD student) working with David Hanke on an industry funded project to develop diagnostic tests for tuber dormancy.

Dr Julian Hibberd (Molecular Physiology Group)
Species of *Flaveria* grown for RNA isolation and deep sequencing to define changes in gene expression as leaves with C3 photosynthesis and leaves with the more efficient C4 photosynthesis mature.

Dr Uta Paszkowski (Cereal Symbiosis Group)
The mutually beneficial arbuscular mycorrhizal (AM) symbiosis is the most widespread plant-fungal association between roots of terrestrial plants and fungi of the Glomeromycota, in which the fungus receives photosynthates from the plant and enhances its mineral, particularly phosphate, nutrition. This project focuses on the identification and characterisation of molecular mechanisms underlying the development and functioning of AM symbioses in the crop plants maize and rice. Mutants are grown in the Botanic Garden's research glasshouses for genetic characterisation and seed amplification.

Professor Alison Smith and Dr Beatrix Schlarb-Ridley (Plant Metabolism Group)
The Botanic Garden has provided space in a frost-free horticultural polytunnel for the erection of a new algae growth facility co-funded by the INTERREG NW Europe strategic initiative 'EnAlgae' (www.enalgae.eu), and run in partnership with InCrops. The facility is part of a network of pilot plants across NW Europe, where different algal species are being grown to establish what role algae can play in the development of a low carbon economy.

The facility was opened on 2 September 2013, at the annual Algae Symposium being held at the Sainsbury Laboratory in Cambridge, followed on 3 September by an industry focussed seminar on challenges and opportunities for algae in food and feed sector.

The facility showcases a 6m long photobioreactor with patented low energy design by Steve Skill, EnAlgae collaborator. The reactor has a capacity of 300L, and will be used to test the growth of a variety of commercially promising algal strains, as well as for outreach activities to industry and schools.

Dr Edmund Tanner (Tropical Ecology Group)
Undergraduate project student James Syrett evaluated the use of biochar in clay soils in a pot experiment in the experimental glasshouses. Using barley as a test plant James showed no difference in barley growth even when biochar was 75% of the soil/biochar mix. This shows that at realistic rates of application biochar will not reduce (or increase) growth in these fertile soils, but it would allow biochar to store carbon in a relatively inert form in the soil.

University of Cambridge

Dr Siobhan Braybrook and Dr Alexis Peaucelle (Sainsbury Laboratory)
Testing whether organ growth is associated with changes in cell wall chemistry in meristems of Ginkgo, Pine and Oak obtained from the Garden.

Dr Lynn Dicks (Department of Zoology)
Support maintaining Californian poppies *(Eschscholzia)* for the large-scale University of Leeds/Insect Pollinators Initiative project Agriland (http://www.agriland.leeds.ac.uk), studying how insect pollinator communities, and the pollination service they provide, are affected by land management.

Dr Maximillian Bock (Department of Architecture)
Investigating bamboo as a viable alternative to current building materials to help meet CO2 emission targets and lead architects and engineers to a greener and more sustainable future. Cultivation of common and rarer bamboo species at the Botanic Garden for structural analysis.

Dr Cynthia Larbey (Department of Archaeology)
Use of rhizomes of ferns such as *Botrychium lunaria* as Palaeolithic medicine.

Dr Alex Pryor (Department of Archaeology)
Exploring the role of plant foods during the last ice age, in the European Upper Palaeolithic, specifically plant underground storage organs (USOs) and the carbohydrates they provide. This research has included building a reference collection of roots and USOs of plants grown in the Botanic Garden, burning them, and photographing the charcoal residue using a scanning electron microscope to give clear images of surviving cellular structure. These photos are being used to identify carbonised fragments recovered from a Palaeolithic campsite excavated in the Czech Republic, dated to 30,000 years ago. PRYOR, A. J. E., STEELE, M., JONES, M. K., SVOBODA, J. & BERESFORD-JONES, D. G. (2013) Plant foods in the Upper Palaeolithic at Dolní Věstonice? Parenchyma redux. *Antiquity* 87: 971-984.

Dr Andrew Rice and Mattias Linnap (Computer Laboratory)
Research on Participatory Sensing - a form of volunteer data collection where people answer questions from the field on mobile phones. The Botanic Garden hosted volunteers who were asked to report whether they saw any bees as they walked around. The experiment investigated whether location tracking together with a centralised management server can increase the coverage area and reduce duplicate answers for a sensing study.

Dr Sebastian Schornak (Sainsbury Laboratory)
Plants engage with fungi to improve access to nutrients such as phosphate. We have sampled liverwort species from the Botanic Garden *(Lunularia cruciata* and *Pellia endiviifolia*) and stained them to detect fungal structures. We found that *Pellia endiviifolia* harbours fungal structures. Comparing early land plant symbiosis with the root symbiosis of higher plants will allow us to highlight evolutionary aspects of symbiosis establishment in different parts of plants.

Pia Edquist (Fitzwilliam Museum)
Supply of plant material *Gigantochloa apus* to enable identification of component materials of a number of African hair combs from the 19th Century.

External collaborations

Kirsty Lloyd (University of Plymouth)
Genetic analyses to define the qualities of *Bombus hypnorum* that have contributed to its success as a coloniser in the UK.

Rachel Fosberry (Oxford Archaeology East)
Archaeobotany is the study of plant remains from archaeological sites through the identification of preserved plant remains and the interpretation of these findings within specific contexts and time periods. Preservation is variable and ancient plant remains can be difficult to identify. Use of the Botanic Garden collection as a reference to recognise seeds and vegetative parts of different species.

Dr Nancy Harrison and Dr Julie Mackenzie (Anglia Ruskin University in collaboration with the Centre for Ecology and Hydrology)
Blue tits and great tits breeding in the Botanic Garden and in woodlands were studied over 10 years, in association with the detailed temperature and rainfall records made available by the Botanic Garden. The birds in the urban habitat of the Botanic Garden did not have as a disastrous a breeding season in 2012 as was documented in woodland habitat – most likely because they are less specialised on one food source.

Whitehouse MJ, Harrison NM, Mackenzie J, Hinsley SA (2013) Preferred Habitat of Breeding Birds May Be Compromised by Climate Change: Unexpected Effects of an Exceptionally Cold, Wet Spring. PLoS ONE 8(9): e75536 . doi:10.1371/journal.pone.0075536
A pilot study began in spring 2013 using stable isotope techniques to study blue tit and great tit nestling diet in urban environments (the Botanic Garden and Cherry Hinton Hall) compared to woodland (Monks Wood, Cambridgeshire). Initial results suggest that urban birds eat prey higher up the food chain (mainly spiders) compared with woodland birds (mainly caterpillars).

Dr Tim Pankhurst (PlantLife)
The Fen Orchid, *Liparis loeselii,* is the principal focus of a collaboration between Plantlife and the Botanic Garden, also involving RBG Kew, Norfolk Wildlife Trust, Butterfly Conservation and Natural England. We have been trying to understand better the reproductive strategy of this European protected species. This has involved a programme of seed-baiting to a) locate and identify the symbiotic fungus that it relies upon for germination, b) assess the suitability of potential reintroduction sites, and c) develop an ex-situ population, both for study and as stock for reintroduction. This year we have also collected from the wild a small number of growing specimens to test our ability to grow and propagate fen orchid at the garden.

Peter Rooney (University of Reading)
The study concerns the phyllogeography of *Cyperus papyrus* L., famous as the source of "Paper" in Egypt and other ancient civilisations for nearly 4,000 years. Using nine microsatellite loci in DNA extracted from Herbarium and fresh material (including from the Botanic Garden), I am testing the hypothesis that several infraspecies can be distinguished and that they have a geographic basis.

Dr Peter Stroh (Botanical Society of the British Isles)
Working on a Vascular Plant Red Data List for England that will, when complete, give an assessment of extinction threat for all native and archaeophyte taxa found in England. Involvement with the Botanic Garden staff in the introduction of the extinct endemic *Bromus interruptus* (Interrupted Brome) using seed from plants that were previously established in the Botanic Garden from the last known wild population. Seed sown at the introduction site in Whittlesford, Cambridgeshire, have germinated and monitoring with the Botanic Garden staff will continue throughout the winter and spring.

Norman Sills (RSPB)
Re-introducing marsh pea *Lathyrus palustris* to the SSSI part of RSPB Lakenheath Fen nature reserve in Suffolk. Seeds from another RSPB reserve were germinated and grown in the Botanic Garden. The intention is to plant these on the SSSI in spring 2014 and spring 2015.

Emanuela Cristian (McDonald Institute for Archaeological Research)
Supply of various plant materials for comparative archaeological interpretation.

Plant Material provided to other Gardens

Leicester University Botanic Garden
Various *Saxifraga*

Myddelton House
Various *Ruscus*

Royal Horticultural Society
Various *Passiflora,* photographic material for article in The Garden

Murray Edward College
Various plant material

Royal Botanic Gardens, Kew
Various *Salvia*

Christopher Parker
Various *Aesculus*

Reinhild Rastrick
Tulipa schrenkii for botanical drawing

Hewitt Cooper Carnivorous Plants
Aristolochia cathcartii

Plant Heritage
Alchemilla speciosa

Jesus College
New Zealand plant material

Orto Botanico Di Napoli
Strongylodon macrobotrys

Laura Silburn
Aristolochia for dissection and colour matching

Bristol University Botanic Garden
Pulsatilla vulgaris

Dept of Biology, Dresden
Aristolochia cathcartii

Westbirt Arboretum, Forestry Commission
Various *Tilia*

Cambridge University Assessment
Plant material for examination slides

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Funding

With good weather and high visitor numbers, the Garden was able to sustain current operations and increase recurrent revenue which is essential to the long term viability and development of the Garden. Events such as the 'Sounds Green Picnic Proms' and the 'Festival of Plants' were both enjoyable and successful in attracting new visitors and new income.

Admission and Friends subscription income continued to increase, helping to support the public and outreach functions of the Garden. Other key funding sources supporting the teaching, research, public and outreach functions of the Garden were the University of Cambridge, The Cory Trust Fund and other trading income through franchises for the Garden Cafe and Botanic Garden Shop. Gratefully received donations from individuals, corporate friends and through the Giving in Memory programmes proved an invaluable resource, allowing new and existing projects to be developed and implemented for the benefit of all visitors. The Gatsby Charitable Foundation continued to support the activities of Science and Plants for Schools.

Further development of the Garden and Collections is planned, to enhance the visitor experience and maintain the Botanic Garden's position as a globally respected, scientifically important collection of living plants.

INCOME		**£k**	**£k**
Funding Source	**Details**	**2012-13**	**2011-12**
University Support	Pay	621.0 See Note 1	614.0
	Non Pay	38.4	37.0
	Non Recurrent	62.3	80.6
Trust Funds	The Cory Fund	460.2	452.5
	Other Trust Funds	13.2	12.7
Admissions Income	Gate takings and tours	330.5	262.2
Earmarked Funds	Friends (to include income for activities)	165.6 See breakdown below	123.3
	Other to include Specific Donations and Trade	78.2	62.6
Projects Grants/Funding		19.3 See breakdown below	4.5
Education Courses and Events		44.4	52.1
Science and Plants for Schools		186.5	337.5
Donations – General		8.9	4.4
Other/Miscellaneous income		43.3	13.6
Total Income		**2,071.9****	**2,057.0**

Breakdown of Income (Friends: Earmarked Funds)		
Friends of the Botanic Garden – Subscriptions	154.8	112.6
Friends of the Botanic Garden – Outreach programme	9.2	7.1
Friends 25 Fund	0.4	0.0
Investment Income and Interest Earned on Earmarked Funds Held	0.3	2.0
Other	0.8	1.5
Total	**165.6****	**123.3**
Breakdown of Income (Project Grants/ Funding)		
Schools Garden Fund and Project	0.0	0.1
Tilia – Limes Project (Funded through Giftaid and Donations)	1.0	4.0
Community Art Project - % for Art	0.2	0.4
Voicing the Garden (Funded by Heritage Lottery Fund and CUBGA*)	11.8	0.0
Moth Monitoring (Funded by Amateur Entomologists Soc and Garden Reserves)	0.3	0.0
Connecting Collections (Funded by University of Cambridge Museums)	2.0	0.0
Water Lilly House Project (Funded from Garden Reserves)	0.3	0.0
Cory Lodge Meadow Project (Funded from Garden Reserves)	3.7	0.0
Total	**19.3**	**4.5**

Notes
1. Staff vacancy enabled University funds to be diverted towards non-pay running costs.
2. Vacancy savings were used to contribute towards non-pay costs.

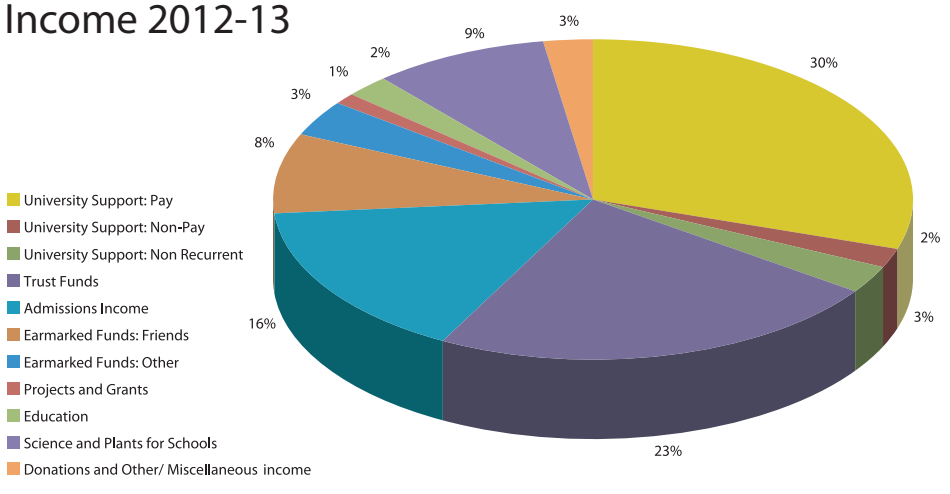
* Cambridge University Botanic Garden Association – CUBGA

** Calculations include minor rounding errors.

Expenditure		£k	£k
Expenditure Type	**Funding Source**	**2012-13**	**2011-12**
Pay	University Support	608.1 See Note 2	543.0
	Trust Funds	416.4	387.1
	Admissions	251.9	241.2
	Earmarked Funds: Friends	53.6	52.6
	Earmarked Funds: Other	0.0	14.3
	Projects Grants/Funding	1.9	4.5
	Science and Plants for Schools	183.7	179.2
		1,515.5 **	1,422.0*
Non Pay	University Support	117.6	99.0
	Trust Funds	20.0	39.1
	Admissions	66.7	80.6
	Earmarked Funds: Friends	23.9	20.5
	Earmarked Funds: Other	26.0	75.6
	Projects Grants/Funding	33.2 See breakdown below	27.6
	Education	27.5	36.4
	Science and Plants for Schools	97.5	86.0
	Donations – General	-2.3	2.6
	Others/Miscellaneous	44.4	2.8
		454.6 **	470.2*
Total Expenditure		**1,970.1**	**1,892.2**

Breakdown of Expenditure (Project Grants/ Funding)		
Schools Garden Fund and Project	1.8	2.2
Education Garden Room Project	10.0	0.0
Limestone Rock Garden Project	2.0	0.0
Tilia – Limes Project	0.0	5.0
Alpine Yard Upgrade	0.0	16.1
2012 Jubilee Meadows (Financed from Friends 25 Fund)	0.0	0.8
Community Art Project - % for Art	8.2	7.9
Voicing the Garden	0.8	0.0
Moth Monitoring	0.3	0.0
Connecting Collections – University of Cambridge Museums	0.1	0.0
Water Lilly House Project	2.7	0.0
Cory Lodge Meadow Project	9.2	0.0
Total	**35.1**	**32.1***
Total Income less Total Expenditure:		
Less: Earmarked funds held for future planned expenditure	-91.7	-157.0
Funds reinvested by Cory and Trust Fund Managers	-9.9	-2.9
Funds remaining for discretionary use	**0.1**	**4.9**

Income 2012-13



Director's Research Grants active in 2012-2013

- 2012-2015: Leverhulme Trust: Payback: do plant viruses compensate their hosts by helping attract pollinators? £241,000 (with Dr John Carr, Plant Sciences, Cambridge).
- 2012-2014: EU Marie Curie Intra-European award: Nanopetals. £164,239 (with Dr Edwige Moyroud, Plant Sciences, Cambridge).
- 2011-2013: Royal Society Joint International Project Grant: Petal spot evolution in populations of the Cape daisy *Gorteria diffusa*. £9,730 (with Dr Allan Ellis, Stellenbosch University, South Africa).
- 2010-2012: BBSRC/NERC SynTax scheme: Molecular control of petal spot evolution in Cape flora daisies. £21,732 (with Dr Paula Rudall, RBG Kew).
- 2010-2012: Isaac Newton Trust: Evolutionary developmental mechanisms underlying the repeated evolution of petals in flowering plants. £27,909.
- 2009-2013: Leverhulme Trust: Iridescence and structural colour in plants. £297,000 (with Prof Ulli Steiner, Cavendish Lab, Cambridge and Dr Paula Rudall and Prof Richard Bateman, RBG Kew).
- 2009-2012: EU Marie Curie Reintegration award: Petal evolution and development. 75,000 Euros (with Dr Sam Brockington, Plant Sciences, Cambridge).

Syndicate and Cory Managers

Four meetings of the Botanic Garden Syndicate were held during the year under the Chairmanship of Professor Keith Richards. Syndicate members were Professor Sir David Baulcombe, Dr David Coomes, Professor Nick Davies, Dr Laurie Friday, Dr Ian Furner, Dr Beverley Glover, Mr Donald Hearn, Professor Nick Jardine, Professor Ottoline Leyser and Dr Mike Rands. Professor Paul Brakefield was co-opted to the Syndicate from January 2013. The Acting Secretary to the Syndicate was Dr Tim Upson from November to May. The new Director, Professor Beverley Glover, assumed the Secretaryship from the July 2013 meeting. The Syndicate again were pleased for the opportunity to meet the Botanic Garden staff following the July meeting.

The Cory Managers met four times during the year under the Chairmanship of Professor Sir David Baulcombe for three meetings and the acting Chairmanship of Dr Alan Munro for the May 2013 meeting. Managers for the year were Mr Michael Allen, Professor Howard Griffiths and Dr Alan Munro. Mr Jonathan Appleton joined the Managers as the representative of the Director of Finance from the Easter Term.

Botanic Garden Staff – October 2012 to September 2013

Director
- Professor Beverley Glover (from July 2013)

Garden Curator, Deputy Director
- Dr Tim Upson

Administration
- Administrator: Brigid Stacey
- Deputy Administrator: Wendy Godfrey (from January 2013)
- Finance Officer: Rachel Agnew
- Deputy Finance Officer: Anouska Arthur
- Finance Administrator: Elaine Dalton
- Garden Administrator: Pat Smith, Sue Wreford
- Outreach Administrator: Emma Daintrey
- Outreach Assistant: Heidi Bradshaw
- PA to Director/Deputy Director: Jane Adams

Visitor Services Team
- Visitor Services Assistant (VSA) Section Supervisor: Nicci Steele-Williams
- Deputy VSA Section Supervisor & Team Leader (Tuesday-Thursday): Laura Welford
- VSA Team Leader (Friday-Monday): David Evans
- VSAs: Andrew Bryant, Jennifer Hills, Amanda Wilkins, Lucinda Fudge, Hannah Winter (maternity cover from December 2012), Susan Baker, Robin Gough, Jacqui Riley, Sam Kuper (from June 2013), Andrew Cameron (from June 2013), Phoebe Monk, Alicia Lloyd, Clare Hall

Development
- Development Officer: Juliet Day

Education
- Head of Education: Flis Plent
- Education Officer: Sally Lee
- Schools Education Officer: Bronwen Richards (from August 2013)

Estates
- Curator: Dr Tim Upson
- Estates Manager: Philip Starling
- Plant Records Officer: Pete Atkinson
- Plant Records Assistant: Mar Millan

Horticulture
- Head of Horticulture: Sally Petitt
- Alpine & Woodland Section: Supervisor – Helen Seal; Assistant – Simon Wallis
- Demonstration & Display: Supervisor – Peter Kerley; Assistant – Paul Aston
- Experimental Area: Supervisor – Pete Michna; Assistant – Sally Hughes
- Glasshouse Section: Supervisor – Alex Summers; Assistant – Alan Langley
- Landscape & Machinery: Supervisor – Adrian Holmes; Assistant – Alistair Cochrane
- Systematics Section: Supervisor – John Kapor; Assistant – Julie Clos
- Tree & Shrub Section: Supervisor – Mark Crouch; Assistant – Ian Barker
- Trainee Horticultural Technicians: From September 2012 to August 2013: Danny Burlingham, Gareth Cox, James English, Juliet Houston, Lucy Rowley, Robert Wooding – From September 2013: Brendan Arundel, Kevin Doidge, Darren Minney, Julia Andersson, Ruth Gomez-Martin, Thomas King.

Science and Plants for Schools (SAPS)
- Director: Virginia Page
- Project Manager: Daniel Jenkins
- Communication Officer: Harriet Truscott
- Project Officer: Elizabeth McDonald (to June 2013)

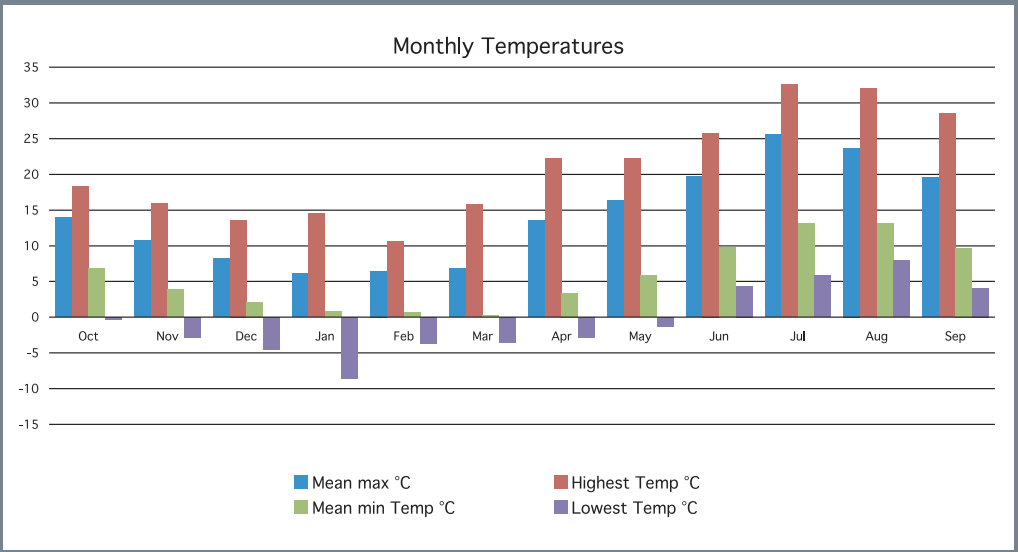
Botanic Garden staff activities

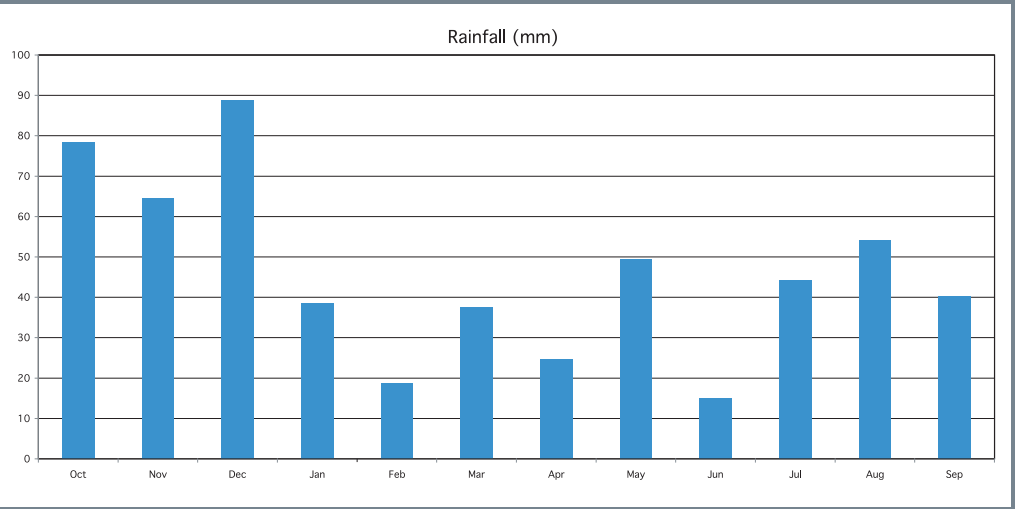
The following members of staff have contributed to external organisations and groups in connection with their posts:
- Professor Beverley Glover served as a member of the Council of the European Society for Evolutionary Developmental Biology, and maintained membership of the Botanical Society of America and the British Society for Developmental Biology. She is Associate Editor for *Naturwissenschaften* and a member of the Advisory Board of *New Phytologist*. As a member of the Editorial Board of *Current Opinion in Plant Biology* she was issue editor of the 2013 Plant Biotic Interactions issue. She continued to serve as a member of the Natural Environment Research Committee's Peer Review College, and was a member of their Environmental Omics Discipline Hopping Panel. She also serves on the Royal Society's Small Grants Panel. She gave an invited lecture at the Institute of Systematic Botany, University of Zurich, and lectures at the Cambridge International Science Summer School, the Cambridge Alumni Festival and at the Gatsby Plant Science Summer School in York. She was a key note speaker at the UK Plant Sciences Federation meeting in April 2013.
- Juliet Day continued as Chair of Great Days Out around Cambridge and to represent the Garden at Love Cambridge meetings.
- Daniel Jenkins continued as a member of the UK Biology Education Research Group.
- Ginny Page continued to serve on the UK Plant Sciences Federation Executive Committee.
- Sally Petitt continued on the Advisory Committee of the Chelsea Physic Garden and as Trustee of the Merlin Trust.
- Helen Seal continued to serve as Secretary to the Professional Gardeners' Trust.
- Harriet Truscott continued as a member of the 'Nucleus' association of professional biology organisations.
- Dr Tim Upson continued as a Trustee of PlantNetwork; as Vice-Chair of the Plant Conservation Committee of Plant Heritage and chaired a working group reviewing collection criteria; as an Editorial Consultant to The Plantsman, published by the Royal Horticultural Society; and as Secretary of the Horticultural Taxonomy Group (Hortax). He was a key note speaker at the Sequim International Lavender Conference, USA in May 2012.

The Cambridge Certificate in Practical Horticulture and Plantsmanship
- Congratulations to Gareth Cox, James English, Juliet Houston, Lucy Rowley and Robert Wooding on their successful completion and award of the certificate.

Weather

The Botanic Garden has been supplying daily weather data to the Meteorological Office at Bracknell since 1904. Overall this was an interesting year with a cold, long winter, spells of hard frosts and snow, giving way to a late and sudden spring and merging quickly into a long, hot summer.





The academic year started warm and dry, although we had a few early touches of frost in September. October became a wet month with a total of 78.5mm of rain and the first air and ground frosts. November had 18 days of measurable rainfall. The temperature was a mixture of mild and cool, with a high of 15.9°C, but 14 nights of ground frost. December gave the first taste of real wintery weather with a light snowfall at the beginning of the month. Christmas was milder, with a temperature of 13.6°C on the 23rd and several days of rain.

January was very wintery with the temperature not rising above freezing on the 16th. The coldest night of the year was recorded on 22 January with -10.3°C on the ground. Snow fell on 9 days and with a hard frost before it fell, the snow stuck readily to the ground. There were 13 days on which snow lay, with a maximum depth of 9cm on 21 January. 21 ground frosts and some freezing fog created spectacular hoar frosts, coating everything with a significant accumulation of rime. The wintery theme continued into February with 6 falls of light snow, although the presence of cloud limited the severity of hard frosts.

March continued cold with only 5 days where the temperature reached double figures. There were 17 air frosts and 9 snowfall days, mostly light flurries, and an accumulation of 4cm of snow recorded on 23 March. Rainfall was below average. This March turned out to be the coldest in many places since 1962. April was still cooler than normal, with 9 air frosts, 17 ground frosts and light snow fall on the 3rd and 4th. Temperatures rose mid-month, to a maximum of 22.2°C, but another cooler spell ended the month. Again we had a drier than average month. Finally spring arrived in May with some warm days but still cool nights, a maximum of 22.3°C and a minimum of 1.4°C ground temperature. Ground frosts were still prominent early in the month, but these died out as the cold air shifted.

June heralded the start of the summer with a 12 day drought from 31 May to 11 June and any rainfall after that period was not significant. The temperature rose throughout the month and stayed steadily in the 20's. In July, the balmy summer weather continued and a 19 day drought at the start meant that the lawns started to brown. However, thunderstorms towards the end of the July gave a high monthly rainfall level. 22 July recorded both the year's maximum temperature, 32.6°C, and the year's highest rainfall day, 20.1mm.

August was hot but damp, with an average maximum of 23.7°C but 13 rain days. September extended the summer with a prolonged dry start and below average rainfall. Still holding on to the summer heat, the hottest day for September was the 5th at 26.9°C.

Sally Hughes and John Kapor, Experimental Assistant and Systematic Supervisor

Thank You

Gifts, donations and support received from 1 October 2012 to 30 September 2013

In Memory Gifts
- Helena Fasching in memory of her daughter Laura, £1000
- Jenny Leggatt in memory of Lee Skinner-Young, for the Schools' Garden, £352

Legacy
- Gillian Toynbee-Clarke, a legacy for the purchase of plants, £5000

Individual Gifts and Donations
- Dr Aileen Adams, £100
- Chris and Sarah Adams, £500
- Frank and Bridget Ahnert, £200
- Mrs L Deakin, £50
- Dr Gordon Johnson, £95
- Julie Lindsay, £50
- Frederic Rich, US$500

We would also like to thank all the Friends of Cambridge University Botanic Garden who continue to make gifts over and above the annual renewal subscription.

Grants, Trusts and Societies
- Heritage Lottery Fund for Voicing the Garden, £9800
- Cambridge University Botanic Garden Association for Voicing the Garden, £2000

Corporate Support
- Cambridge Partnership for Plant Sciences, for Festival of Plants, £500
- Microsoft Research Ltd, for Young Explorer backpacks and summer trails, £5000
- Mills & Reeve for Sounds Green late night openings, £1200
- Sainsbury Laboratory Cambridge University, for Festival of Plants, £500

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WSP

… and thank you to everyone who visited the Garden

- Visitor numbers through ticket offices (including Friends, groups and paying visitors) 222,355
- Adult Education course participants 498
- Educational visit participants 8,816

Front cover image: Howard Rice
The paper used in this publication has been sourced from sustainable resources.

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