Buchanan Award Report

Gardens of the United States of America

30th April – 13th May 2016

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Overall Itinerary

29th April – 4th May CHICAGO
Visiting Chicago Botanic Garden

4th May – 7th May ST LOUIS
Visiting Missouri Botanic Garden

7th May – 10th May PHILADELPHIA
Visiting Longwood Gardens

10th May – 14th May NEW YORK
Visiting New York Botanic Garden, Brooklyn Botanic Garden, the Highline

Diary and meeting notes

Day 1 - 30th April

Chicago Botanic Garden

I first visited Chicago Botanic Garden. Admission is free which is great, although they do charge for parking. The first stop was to the glasshouses where the titan arum had just finished flowering and was closed. Chicago BG has several titan arums so regularly have one flowering. They had some great interpretative signage and directional signage so you could learn about the plant and easily find it. There are even t-shirts in the gift shop with their logo and titan arum on it, so it must be extremely popular. What was great about this display was almost all stages of this plants lifecycle were displayed. The previous titan arum that flowered in 2015 'Alice the titan' was there and had been hand pollinated and was covered in fruit. There was a leaf too, plus the plant that had just finished flowering. Although I had seen the titan arum in full flower at the Auckland Winter gardens, they will never have fruit there as they have no pollen to pollinate it and get fruit. The titan arum is in one of three greenhouses, tropical, subtropical and arid. The arid had plants like cacti and aloes. Subtropical glasshouse had *Clivia* and orchids. One orchid flower was the size of my hand which was amazing but far too high to photograph.

I went for a long walk around the gardens (in the pouring rain). I visited most parts of the garden mainly trying to learn as many new plants as possible and see the types of gardens they have. The garden is composed of islands and waterways (originally they were bogs and swamps which were turned into man-made lakes). There is a lot of Japanese influence in this garden with two dry gardens, or Zen gardens. There is also a bonsai collection which is alarmed and will go off if you touch one! There is a network of bridges across one of the lakes to view the aquatic collection made up of water lilies, but were not flowering during my visit. There were lots of bulbs, stunning tulips, all over the garden, as well as in the bulb collection. A few other collections visited include the landscape garden, Evening Island, native plant garden, sensory garden, waterfall garden and dwarf conifer collection.

Many of the conifers, particularly *Pinus sylvestris,* have been trained to look the way they do, with very straight, horizontal branches and are pruned a couple of times a year so they look very manicured but amazing.

Figure 1 *Pinus sylvestris*, Scots pine

I took a wonder through the library which had an orchid book display. It was a beautiful library, very quiet, some computers to do research and a staff member to ask questions. It's a classic library but there was about four other people browsing like me. Right outside the library is a desk that is signed 'Plant Information'. Two people staffed the desk to answer plant queries. They had a massive range of books and computers to help with queries. It also is connected to the library so they have all resources at their fingertips, much like Bec and I do at ABG. In the same building was a gallery of beautiful macro flower or seed head photos. There were stunning images and something to attract people into the building.

I went on a guided tour, by tram, around the gardens. This was a 35 minute trip around the garden. The garden is 325 acres with 6 million plants and 10,000 species. It is open every day of the year, including Christmas when only the buildings are closed. There is a butterfly

garden that is only a seasonal attraction so unfortunately was not able to see hundreds of butterflies. There is natural native vegetation, which was heavily infested with exotic plants originally. These exotic plants were removed, native plants planted, many native mammals introduced and 20 species of birds re-introduced to the area. It is now a naturally functioning ecosystem that is not managed by the gardens. Reminds me a bit of totara park. The Island of Everlasting Love is a no access island. It was created as a garden for the Gods. This is where many of the pruned pines can be viewed across the water. It is spectacular. The Japanese garden with its dry gardens also has a zigzag bridge which is said to ward off evil spirits as they only travel in a straight line. The building in the garden was built using traditional techniques in Japan and then reconstructed at the gardens. Evening Island has 300 crab apple trees, thousands of bulbs, water plants, perennials and ornamental grasses. They wanted to create year round interest on this garden, hence the range of plants used. Layers of bulbs are planted deeper and deeper so that the display period is increased. The plant evaluation area has a number of very large beds arranged in a circle, with a sundial in the centre. There are at least 7000 plants at any given time and all plants are trialled for a minimum of three years. If they aren't sure about a plant's performance, then it is trialled further, up to 7-10 years. David Austin roses are trialled also. There are green roofs on top of the Plant Science Centre.

New developments at the gardens include new propagation facilities. There are many new greenhouses for propagation, study and research and one for only growing orchids. This is because every year there is a huge orchid exhibition so they need lots of orchids for this. Also a new teaching facility is currently being built for student education. There are two large classrooms and an outdoor garden for practical classes. The prairie garden is another part that is left to be a natural system and is not managed. There are a range of prairie types such as sand dunes. Because it is a natural system, the species composition changes over time. There are only a couple of trees in this collection, specifically on the edge of the area, because in prairies trees do not survive fires, therefore they are not normally present. The copper beech in the garden is a success story regularly shared as it was the oldest ever successful transplant. It was transplanted when it is 65 years old and is now 95 years old. Chicago BG has 2000 volunteers which is the only way they manage to have such an impressive gardens. The tour guide also pointed out there were no weeds at the gardens, they are not allowed. I didn't spot any on my walk but I will now be keeping an eye out to see if it is true. I think he might be right though!

The gardens were started in 1965 and opened to the public in 1972. Chicago BG is only 10 years older than ABG.

Day 2 - 1st May

Chicago

Being the weekend, I used this free day to visit Downtown Chicago. Visited the Navy Pier area and the Field Museum where there were many exhibitions on natural history, including plants of the world and lichens! There was also a display on the Terracotta Warriors of China.

There are a lot of street trees and plantings with the main city of Chicago. There were signs promoting planting of trees, mulching and water trees, which was provided by the Morton Arboretum. Lots of large planter boxes, some containing grasses and daylilies, some with herbs such as chives and mint, and some just with lawn grass. These are all helping to green up the city. Street trees mostly are *Malus* and other deciduous American species.

Day 3 - 2nd May

Chicago Botanic Garden

I first met with Boyce Tankersley who introduced me to his staff which is a team of three plus one seasonal worker. Chicago BG gets 1 million visitors a year. They have 250 staff with 250 seasonal workers employed. 40% of budgets come from the local council and the remaining 60% comes from a combination of memberships, the gift shop and horticultural society. Donations also pay for many large projects.

Celeste Vandermey is the plant records supervisor at Chicago BG. Chicago BG has their own custom developed database, so not an off the shelf one. It is called Sequel, which is not an access database, and runs off Alligator tech. It automatically generates accession numbers every night when information has been inputted into the system. Horticultural field staff put in requests/orders of plants into the database. Another staff (Monica) who is involved in administration checks off and pays the order through the database. Celeste verifies names and activates the records so that all relevant information can now be entered. The accession is now active for entry and movement records can be completed. At this point the accession is linked to its planting bed destination, for example the greenhouse, and the XY coordinates for the centre of that bed are linked to the record. This means that there is a lot of planning behind ordering the plants and the intended destination of the plants in the garden has already been specified to the bed level. There are over 200 plant codes for the 'dead' status of the plants to reflect why they were removed e.g. planted too deep. This provides very detailed information regarding the deaccessioning and removal of plants. Herbarium specimens are in the same database and therefore have accession numbers. This database can easily report plant quantities and the number of varieties in the garden. At ABG we cannot do this easily, and rather can easily report accessions which are not as useful. There is a plant disease department at the garden to identify the cause of plant deaths, down to specific levels such as phytophthora. Chicago BG uses RHS, The Plant List and Tropicos to verify names which is the same as ABG. However, they think the RHS/Kew is getting behind in taxonomy and rely more heavily on Tropicos for up to date information. The database easily links to websites and books as a reference for where the name has been verified from. This is useful for following up changes and knowing the dates of when changes were made.

The Plant Finder part of the database and therefore on the website, is inputted all by volunteers. This is information such as flower colour, phenology and size. There is a team of staff that take all the plant photographs for the Plant Finder and mobile app. The 'What's in bloom' feature of the website and app, and also physical display at the entrance to the gardens is produced by volunteers and staff. There are 13 volunteers who all have assigned gardens and every week they walk around and record the plants in flower. From this Celeste collates 5 plants for the 'What's in bloom' every fortnight. She writes a short paragraph for

each plant if one is not already in the database. All plants that the 13 volunteers have recorded as flowering are put together in one document on the website so visitors can see a list of everything in flower. This also provides the basis of their phenology data which another group of volunteers are working on putting into a format that can be used more easily. With 2.8 million plants acquired for the garden every year, they aim to never have the same plant displayed more than once in a year. That's impressive but with 2.8 million plants that shouldn't be too hard. Other fields that already are populated in the database, by the volunteers, then also populate the 'What's in bloom'. The Production Delivery Form is similar to the ABG Plant Movement Record form which holds all the same information, including labelling orders which are passed onto Gabriela. There are no quarantine procedures at Chicago BG. They do not seem concerned with possible pest and diseases that may come from local nurseries. Trees, shrubs and perennials are only accessioned. There is also a weather station which is to standard specifications that readings are taken from every day and will hopefully be used to compare phenology against various weather measurements.

Figure 2 Chicago Botanic Garden What's in Bloom cart outside the Visitors centre

Veronica Harry-Jackson is the geographic information specialist at Chicago BG. Mapping technology is advanced at Chicago BG. Trees are all mapped individually as single points. Shrubs will also be mapped individually unless they are planted in a mass. Perennials have only just started to be mapped and are drawn as polygons. There are 650-700 beds at the

gardens. There is a base map of the gardens and each bed has had a polygon drawn around it so that the bed area is easily available for calculations of plant numbers required. The base map is available as a digital file. The increase in demand of bed maps with plant points on it increased when more horticultural field staff started entering their own records. Maps are drawn in ArcGIS and links to AutoCAD which is where the base map originates from. This means that it is easy to make changes to the map via the database. Only Veronica has access to ArcGIS as it is very expensive but she can save the maps in Adobe Acrobat PDF and this saves the layers of the map. The horticultural staff can then use these PDF maps relatively easily and turn on/off layers to view their desired plantings e.g. they can turn off the perennial layer so only trees and shrubs are shown. The habit type from the database is use to code the map. BMRN = bed map reference number. The tool used in the field to collect the GPS data is called Leica Zeno 20. Every single plant has a survey ID (SID) which links into the database and allows individual trees to be map. This SID is only on the plant tags. (NB plant tags have the plant name, source, SID and accession number).

Gabriela Rocha is the labelling coordinator at Chicago BG. Label budget is $10,000 (USD) a year and it's not sufficient for labelling 2.8 million plants. There are 7 volunteers who assist with labelling. They have a few different sizes, some metal and some plastic (to ensure there are several companies used). Only botanical name and common name are on the label. No family name or origin is included because they increased the font size for accessibility. Family name is also not included to avoid having extra taxonomic changes to change on labels. Accession number is not put on the label. Mainly because all labels are reused so that the accession number of it would mean it needs to be disposed of. Labels are bolted onto the stand and when finished with, the label is removed and filed in the massive alphabetical library of labels and the stand is washed and ready for reuse. Tags are only put on trees and shrubs. It takes weeks for the vendor to make the labels which isn't very fast. They use two vendors to supply labels; one makes plastic labels and the other makes metal labels. Labels must be put out on plants immediately so Gabriela prints a temporary label on waterproof paper (formatting them herself) and sticks it on an old label. Gabriela also formats all labels that are sent to the vendor unlike we do at ABG (Metal Image do this for us). They have a metal embosser on site to make the tags. They are black and about twice the size of ABG tags and are attached with a plastic coated wire. Gabriela puts out all the tags, which easier to do when plants are still in the nursery, and the field staff put out all the labels. Routinely, Gabriela and her volunteers go out and check the plants in the garden are labelled and straighten up the labels.

Figure 3 Chicago Botanic Garden tag machine

Boyce Tankersley is the Director of Living Plant Documentation at Chicago BG. We discussed the Plant Requisition System which is part of the Chicago BG database. There are four major plant orders during the year and staff must order before the deadline. Staff are planning plantings 2-7 years in advance. They are even planning a southern hemisphere bulb display which will be in 7 years' time! The Plant Requisition System ensures that plants ordered go through a process of approval 1) quality and appropriate plants are selected, 2) there is space and staff time to attend to that plant, and 3) there is budget to purchase the plant. Each step is approved by a different staff member. A 'Curatorial' table in the database allows data to be recorded against individual plants rather than an accession. This is valuable for if 1 out of 10 trees are performing poorly due to diseases. It can also track weediness or pruning requirements. Reports can easily be pulled to show lists of these. The Chicago BG app is designed to give people ideas of what they can include in their garden. The photographers are working on any photo gaps that they see on the app. Weed names are flagged on the database so if anyone tries to purchase one, an error message will come up saying that they cannot purchase it. Garden censuses are done once every 5 years.

There are 90 volunteers for the Living Plant Documentation department. They are used for a number of projects including What's in bloom, the Bloom cart, labelling, surveying, mapping data, inventories, photography, DNA collection, herbarium specimens, data entry, slide scanning, accession tags, CO_2 sequestration, weather database and phenology database.

There is a form for volunteers to complete to find out which projects they are interested in. There are volunteer team leaders to coordinate the volunteers and answer queries. This means they are almost completely independent of the staff.

Boyce lead me on a garden tour while it was still beautiful sunny weather. I learnt about the aims of some of the gardens and the development that went into them.

Day 4 - 3rd May

Chicago Botanic Garden

Richard Hawke is the Plant Evaluation Manager and Associate Scientist at Chicago BG. Perennial trials are in the ground for 4 years, first year is establishment phase and the following three years is for evaluation. Shrubs and vines are trialled for 6 years and trees for 10 years. Trees are rarely trialled. There are 7000 plants in the plant evaluation garden at once. It is important to know why you are trialling a plant. Trials are selected by either being something that everyone is talking about i.e. timely, or secondly little is known about them. Having been working in gardens for a long time, Richard is very familiar with all groups of plants and has trialled most groups over the years. They are mainly looking at pest and disease resistance. Often plants are added after a trial has started as good to have same genera to compare to. Every plant is evaluated the same way with the same codes i.e. the same template. Soil testing and data is collected from beds throughout trials to explain some of the results and variability seen during the trial.

General criteria assessed are:
1) Cultural adaptability (light, wind etc.) - plants are only watered and mulched, no other treatments are applied
2) Winter hardiness (do the plants survive winter)
3) Pest and diseases (what it gets and to what level)
4) Ornamental properties

Assessments are conducted every couple of days, if not every day, but data is not necessarily recorded every time. Data is only recorded as and when it is required i.e. if something has changed since the last evaluation. Data is entered onto a hand held pad which holds the plant accession number and codes that are entered to represent a stage in phenology, pest and disease etc. Some codes have associated codes and a field to enter a percentage or size (cm). Trials are written up into the Plant Evaluation Notes and also articles are published in the 'Fine Gardening' magazine. There is one volunteer that helps with trials to maintain the beds called Janice.

Figure 4 Chicago Botanic Garden plant evaluation beds with 7000 plants at any given time and the Science Centre in the background with a green roof

Kay Havens oversees conservation programmes at Chicago BG. I had a tour of the Plant Science building with Kay who showed me the eight or so labs that are there. Each lab has a different research area. There is a herbarium which has three key purposes: 1) flora of the Cook County, 2) holds specimens from seed collection trips and research species, and 3) the living collection of Chicago BG. This means that cultivars are held in the herbarium. There are currently 30,000 sheets but can hold 150,000 so there is about 10 years' worth of room still. One lab is working on Echinacea and the effects of habitat fragmentation on its natural distribution. There are two growth chambers, one of which can have carbon dioxide levels changed which is useful for climate change research. They also work on doing inventories of the native areas at the gardens. There is a soil and fungal lab, in particular focusing on red listing fungi species. The science building is 7 years old and was modelled on the Millennium seed bank. The GIS lab work on the distribution of native plants across America and the effect climate change will have on native species distribution. This helps to inform where seed should be collected from for future restoration projects and also where restoration efforts should be focused. The seed bank is well established. Seed follows regular procedures such as quarantine; volunteers clean and sort seed, and put into freezer. There are facilities to test seed viability and incubators for seed germination experiments. The x-ray machine is useful as it is a non-invasive way of checking if seed are full rather than the invasive cut test i.e. less seed destroyed and wasted. All seeds are imaged. Studies on plant-pollinator interactions are also conducted. A genetics lab holds the DNA material of the living collection but is not sequencing the data unless there is a reason for testing it. There is

a PhD and post-doc working on population genetics at the moment. There is a volunteer programme called the rare plants monitoring programme which volunteers survey about 600 sites in the greater Chicago area. They either do a census of what is at each site or a demographic study and follow individual plants over time. It depends on their skill level and time commitments as to which survey technique they choose. The citizen science project has been running for 14 years. It contributes to the Chicago State conservation outcomes but is facilitated by the Botanic Garden. There is a conservation intern program which allows young students to get plant field experience and work on public land. The programme has been running for 15 years and had 1000 students through it. They either intern for 5 or 10 months. There is 50 staff working within this department, 15 PhDs, 40 graduate students from North Western University, and about 200 volunteers. Most volunteers are retired, some with a science background and a number of younger volunteers who mostly work in the field. Chicago BG has funding for only two PhDs a year, so the others are from the University and are hosted at the BG which acts as the botany department.

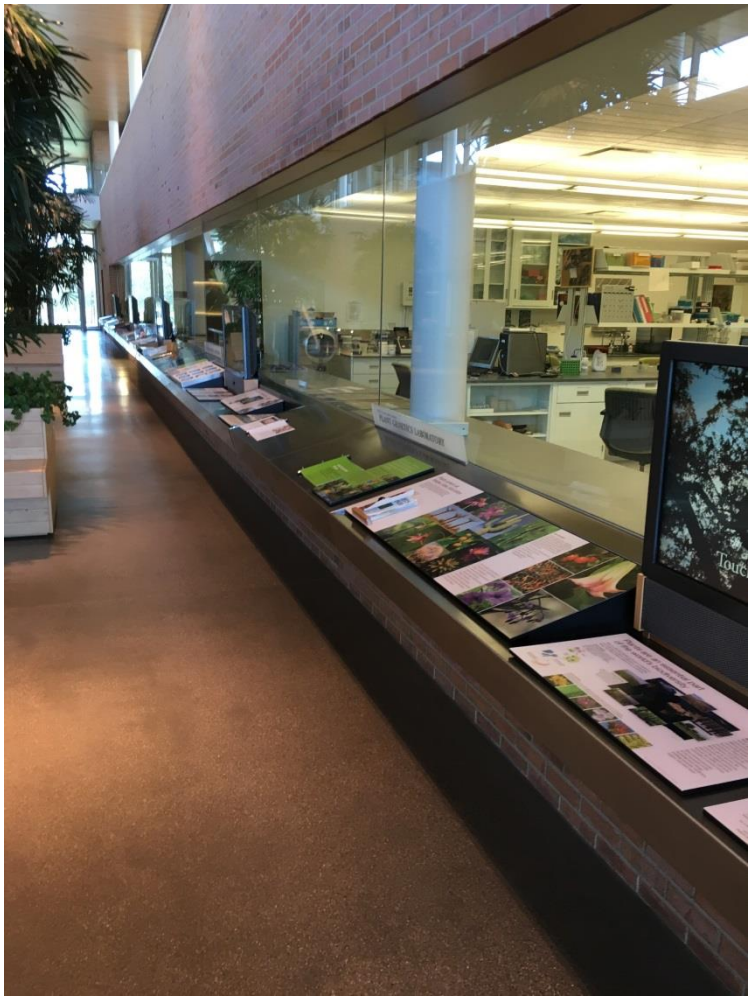

Figure 5 Science centre with laboratories and interpretation outside each different lab to explain to work happening there

Jim Ault is the Program Manager and Plant Breeder at Chicago BG. Jim showed me around the plants which are part of the breeding programme. He is the only staff member to work on breeding and tends to work on plants that there isn't much competition in the industry to produce. The current focus is on spring flowering *Phlox*. *Phlox* crosses are sterile and therefore cannot go past the F1 hybrids. Jim collected all the *Phlox* species in the USA so that he could get new and unique forms, including very prostrate types and bicolour. Chicagoland Grows is a State wide programme for plant introductions which is how Jim gets plants into the industry. He has introduced 21 cultivars into the market. He also goes to plant trade shows that are for businesses to promote the plants. He only uses plants that are already disease resistant so this is not the focus of breeding but rather a given.

Figure 6 *Phlox* plants used for breeding by Jim Ault and are currently under plant evaluation by Richard Hawke

I finished the day with a walk around the gardens to photograph some of the collections. Gabriela kindly took me to her home for dinner with Veronica who I got to know more and ask more questions about how the garden works and their roles.

Day 5 - 4th May

St Louis - Missouri Botanical Garden

After spending the morning traveling from Chicago to St Louis, I managed to spend some time at Missouri Botanical Garden. This garden is in an urban area and had a lot of visitors while I was there. There is no charge for parking but there is a fee for entering the garden. It

is discounted to members and residents of St Louis. There is a very large gift store and café within the Visitors Centre. First thing I saw walking out of the visitor centre was a water fountain with bright blue water. A glasshouse, called the Linnaean House, holds many plants we can grow outside in Auckland; however they obviously cannot be grown outside in Missouri. These plants include camellias, aloes, cacti and citrus. Many of these plants were also in pots rather than in beds so that the display can regularly be changed with other plants in the nursery. The magnolia grove only had one type, *Magnolia* x *soulangeana*, the saucer magnolia. The roses were starting to come out which is interesting as there were no roses in flower at Chicago BG and they aren't that far apart geographically. There were a few gardens which are like the rooms at Hamilton garden such as the Ottoman garden and Bavarian garden. Both featured buildings that were appropriate to the theme of that garden. There was a very impressive collection of daylilies, hundreds of cultivars that were grouped together based on flowering or flower type. There was no rust seen on any of the plants. Only about three were flowering and they were species *Hemerocallis*. I didn't recognize any of the cultivars that were displayed. There was also an extensive *Iris* collection with some unusual forms and colours. A Japanese garden features here too.

Figure 7 Daylily collection at Missouri Botanical Garden

The Centre for Home Gardening has a series of small gardens to inspire home gardeners; areas included fruit trees, herbs, turf comparison area, ground covers and trees. The garden is laid out in a way that there are plenty of plant combinations and ideas. The building next to this garden is where the horticultural experts are available to answer queries. There is a desk where brochures for purchase are (much like the ABG advisory leaflets); a corner wall of books with a desk and computers for research, displays on 'how to', and a desk signed

'Plant Doctor'. Volunteers can answer questions any time. This building also holds workshops and courses regularly as part of their for adult education programme.

There is a lawn which is being converted into a bulb meadow for a lawn alternative. It is surrounded by dawn redwoods. The lawn is mowed infrequently in summer to accommodate the growth and flowering seasons of naturalized bulbs. The bulbs are animal resistant, drought tolerant and self-sowing, providing low maintenance, and pleasing palette throughout most of the growing season.

Figure 8 Alternatives to turf? A bulb meadow which is mowed infrequently

The Climatron is one of three glasshouses but this one is really impressive as it is dome shaped full of tropical plants, but again things that ABG can grow outside. It opened in 1960 and holds 2800 specimens inside. The name comes from the computer system that controls the temperature and humidity of the house. The temperate house is next door with some very cool plants that are found in places with Mediterranean conditions, including carnivorous plants (sundew, pitcher plants and modified hybrid pitcher plants). To my surprise there was a specimen Chinese privet in full flower.

There is a small trial garden for plants that are undergoing evaluation. It looks well landscaped so it could easily be mistaken that these plants are plants of merit, rather than currently under trial. Plants are assessed to ensure they grow well in the Missouri area, easy to maintain, are not invasive in the area, resistant to pests and diseases, reasonably available and have outstanding ornamental value. A number of groups have partnered with Missouri BG to work on the evaluations including Powell Gardens of Kansas City, Mizzou Botanic Garden and University of Missouri Extension.

I also went on the tram tour which was only 25 minutes and was a real whirlwind trip around the garden. The guide talked so fast that I could hardly keep up with what she was saying. They did mention what all the sculptures around the garden were and their significance to the garden. Three reflecting pools are the central point of the garden and were built in 1970 to display water lilies. Glass onion sculptures are currently on display while there are no water lilies as it's still too cold for them. Pin oaks are the dominant tree in Missouri. A plant lab is where heaps of practical learning happens for students. They also

have a children's garden which I didn't go into as it looked a lot like a playground but plenty of plants in their too. Missouri BG has a sister city which donated the Chinese garden. There are a few honeybee hives to promote pollination in the garden. New developments include a bonsai collection. The herb garden is maintained by the St Louis herb society. Henry Shaw was the founder of the garden. His tomb is in the garden under a sculpture of him holding his favourite flower, a rose.

Day 6 - 5th May

Missouri Botanical Garden

I first met with Rebecca Sucher and Andrew Wyatt to discuss the overall aims of the gardens and to go over the database. Missouri Botanical Garden is one of the oldest Botanic Gardens in the USA. They have 412 staff and 120 research staff, most of which work in Madagascar (90 taxonomists). They have a lot of volunteers too. The database was custom developed for them and based off the Tropicos database which many of their taxonomic staff work on. The development of the current database was funded by a state grant and uses Sequel (like Chicago BG). It is web based so that it can be accessed through the internet, any computer and iPads through the app. It means there is a high level of security on the data. The aim is to be the leaders in living collections management and probably have the best database in the world. Unfortunately many people ask about whether they can share the database for other gardens to use but it is very complicated to do this, IT issues and costs would be difficult to determine for outside users. The database for the gardens links to Tropicos which means any wild plant collection records entered into Tropicos will link when the accession is created in the Missouri BG database. They have specifically written collection notebook, which I was given a sample of, which has the exact fields the database and phone app have so it is easy for field staff to collect the correct information. All horticultural staff have an iPad to update records and GPS locations on. It was tested on the two oldest volunteers to ensure that it was easy to use. It means that plant records are updated almost immediately and there is no need for paper records.

Labels are created on site with the Epilog Laser Helix which links to the database and all information is printed from there. This reduces errors on the labels. No accession numbers are on the labels because the labels are reused. They are stored in a filing system, when a label is added or removed from the filing shelves, then the excel spreadsheet is updated. At any time you can refer to this spreadsheet to see what labels already exist. They print about 5000 labels a year. Staff can order labels directly through the database which is collated by one of Rebecca's staff and printed by a volunteer. They are printed on plastic sheets. Volunteers look after the production side of labels. They use the ME2000 (the same tag machine as ABG) with two tag sizes.

Figure 9 Missouri Botanical Garden laser label machine

The propagation element of the database is relatively new but again Missouri BG want to be the leaders in propagation information as it provides the basis of their conservation efforts. They do a lot of international conservation projects in Madagascar and the Mauritius so they need to keep track of how these species from other countries are propagated. They can also produce plant propagation protocols from the database. The acquisition search of the database is where plants are requested for ordering. This generates a list of names in an email that can be sent to the supplier/source. This means the order is already in the system for when the plants arrive, they can be checked off and automatically assigned an accession number. If two people are doing accessioning at the same time, then they can edit the accession number if need be. There is a section to hold permits and phytosanitary documentation which are scanned in and linked to the associated accession. Images can be linked to the accession, planting/qualifier or taxon. Staff can take photos on their iPad and link these themselves.

You can link all sorts of visitor related 'gardening' information such as audio files, facts, plant descriptions and more. This probably would service many of ABG visitor centre needs which can be pulled onto the website in the format they wish. Missouri BG has an app on their iPads for mapping. There are Wi-Fi hotspots around the garden but they are looking to roll it out everywhere so that horticultural staff can update records and maps anywhere in the garden, rather than just the hotspot areas. Horticultural staff are responsible for updating

their own records and mapping plantings. There are two IT developers that Rebecca meets with every week to get glitches and developments sorted out with the database and associated apps. Census work is only done when required. They believe that if staff are entering their records regularly and accurately then census work shouldn't be necessary. There is a high commitment to excellent records which is reflected in their annual performance reviews.

Oxford uses a database called BROMS which is customizable and is something ABG could research as an alternative option to BGbase.

Rebecca has four staff that specialise in plant records, 3 which focus on the plant records, accessioning and labelling and 1 who does the GIS/geospatial work to create maps and apps for the gardens.

Rebecca took me on a tour of the garden, mostly of the nursery area but also to the Centre for Home Gardening. Here I was introduced to staff that run the Master Gardener programme. Only people who have gone through this programme can volunteer for the Plant Doctor desk. This is so that the information given to visitors is accurate and reliable. There are a couple of volunteers there at all times and they regularly attend workshops and plant identification quizzes to ensure their knowledge relevant and up to date. Here I found out that Missouri BG only trial annuals which are donated by a supplier. Missouri BG assesses the annuals about three times and produces a top 10 list for their website and in the Centre for Home Gardening. A report of the results is then given to the plant suppliers. There are smaller research projects going on that are usually partnered with another research organisation such as the local University. For example a current project to monitor ozone levels using weather technology and plants that display symptoms when ozone levels change involves the University and Missouri BG. The gardens are starting to follow and record phenology using a State app which they hope will become more popular. Sounds a bit like nature watch.

Day 7 - 6th May

St Louis – Shaw Nature Reserve

Rebecca Sucher organised me to visit the Shaw Nature Reserve with one of her records staff, Alanna Slack. The Shaw Nature Reserve is about 40 minutes from the Missouri Botanical Gardens and is a division of the Missouri BG. The reserve was purchased in 1925, initially created as an arboretum; many of the tree species are now classified as weeds and are gradually being removed, and later were changed to a nature reserve. There are 18 staff working at Shaw Nature Reserve. We met with Meg Engelhardt, who is the Seed Bank Manager and works for the Missouri BG, although the seed bank is based at the Shaw Nature Reserve. The seed bank opened in 2013 and is aims to hold the flora of Missouri which is approximately 2000 species. Meg goes on regular seed collecting trips, mostly in the nature reserve and has collected 400 species to date. They aim for 10,000 seeds per species but so far collections have been much smaller. They either test seeds using germination tests or send the seed to Chicago BG who test seeds with the x-ray machine. They are still working on what processes work best for them. The work benches have ion

bars above them for during the winter. There are lots of native meadows, prairies and glades which we walked around and learnt some of the native prairie plants. There is a small cultivated native plant garden to give visitors home garden ideas.

Figure 10 Meg showing Alanna and I the seed bank at Shaw Nature Reserve

Alanna Slack is working on a standard protocol for plant record best practice to take to a conference in Panama for gardens that want to improve their record keeping but also gardens that do not currently have a database. The workshop is called Bridging gardens or something to that effect and think this would be a useful resource to get access to.

Here I met Scott Woodbury, Curator of the wildflower garden at Shaw Nature Reserve, who had a volunteer just visit New Zealand. They saw some of the signage and interpretation in the ABG Threatened Native Plant Garden and would like to do something similar so hopefully he will be in touch.

Day 8 – 7th May

I travelled from St Louis to Philadelphia.

Day 9 – 8th May

Longwood Gardens

I arrived at the Gardens at opening time, as it was Mother's Day and it was going to be very busy at the Gardens. There are new developments and renovations going on at Longwood. The Main Fountain Gardens are undergoing a revitalization which takes up a significant area of the garden. It is due to re-open in 2017. This also meant that the topiary garden was closed but could still be viewed from a distance. Walking around the garden, I noticed very few labels and signage. Plant labels only had Latin name and common name. When there was a family name on the label it was the common name of the family e.g. Arum family. No accession numbers were on the labels. Metal tags had the accession number, name, family and origin. Large trees have tags attached by nail and spring, much like the ABG tree labels, which is an interesting idea and something to consider for trees that don't have lower branches or branches that are shed off. Other than directional signage, there was no interpretation around the gardens. It would have been great to know what collection I was in or what was seasonally interesting about a particular area. As a visitor you therefore have to rely on the map mainly. There were a few signs in the natural meadow to explain where controlled burns had recently occurred and why burning is important for the biodiversity of natural meadows.

The Conservatory is a huge series of glasshouses holding different plants from regions e.g. Mediterranean, tropical, orchids and more. The collection of silvery plants was great. The way they were displayed was much like a perennial border with drifts and specimens like cacti and aloes integrated into it. This was something I had no seen before and really made you think about how those plants can be used in different plantings. The orchid area smelt amazing with a range of species, colours and flower shapes. The Conservatory also houses the bonsai collection and noted a few bonsai species that I have identified for our visitors, *Zelkova serrata* and *Lagerstroemia indica*. The camellias in the Conservatory are there for research purposes. Longwood are looking at breeding a year-round flowering camellia by using *Camellia azalea* as the pollen donor because it is a year-round flowering species and is also endangered. If they are successful, then the variety created will be introduced into the nursery trade for the public to buy. I could find a few tags to show flowers that had been hand pollinated. There were a couple of signs next to plants to listen to audio tours from the gardeners by calling a phone number and typing in the extension number on the sign. This seems like a novel idea but not very accessible especially for overseas visitors who have to pay $5 per minute for phone calls. There is a large green wall inside too with mainly ferns and biocontrol traps.

Figure 11 Silvery plants of the Conservatory at Longwood Garden

Lots of spring colour out in the main gardens. The dogwoods were at peak flowering and looked spectacular.

Day 10 – 9th May

Longwood Gardens

Matt Taylor, Research Manager met with me to discuss some of the research at Longwood. We mostly discussed the Camellia research he started a number of years ago. The project is now run by volunteers. Camellia pollen can be stored in the freezer for up to a year in silica gel beds in a pipette tube. All cross pollination is done under the greenhouse, where the flowers are emasculated and bagged. When the flowers have been pollinated, they are then taken outside. The plants set more fruit when they are outside. Matt has found that the float test only works on capsules that have not cracked open. Seeds are cold stratified for 90 days to increase seed germination. They use tissue culture to propagate camellia material, along with many other species grown for the gardens. The aim of their camellia breeding is to develop a cold hardy plant that flowers year round, hence why *Camellia azalea* is used as one of the parents.

Peter Zale, Curator and Plant Breeder, showed me the tissue culture labs. Also he runs the orchid conservation programme which they are working on getting a Memorandum of Understanding with their Department of Conservation to help return plants to the wild. They want to focus of propagating native orchids and working on restoring nearby populations. Five orchid species are focused on this year. Research is going into their germination and experiments into mycorrhizae fungi. The plants grown from the research

will be used in their orchid displays and reintroduction into the wild. Most orchids prefer germination in the dark on agar. There is cultivar *Chrysanthemum* material in the tissue culture lab for the gardens as these cultivars are not readily available in the trade and easily gets infected with a virus. They keep the material in the culture lab so that they can restock their plants if they do get infected with the virus. Longwood has introduced about 12 *Canna* cultivars into the trade from their breeding programme. There is a number of *Canna* in the nursery at the moment that are being trialled. There are 300 permanent staff, 300 part time staff and 800 volunteers at Longwood. There is a long waitlist for volunteering and many of the volunteers are retired scientists which can be valuable in the tissue culture lab and on other research projects. Peter has an intern every year for a year to assist with his work. He mentioned that the graduate programme at Longwood is undergoing some major changes to become a 13 month fellowship that will be opened to anyone, including international students. Much of the breeding work at Longwood focuses on native plants.

Alan Petravich, Research Specialist, took me on a tour of the research greenhouses. These houses are extensive with plants that are undergoing plant evaluations, twice a month, and propagation research. There are a range of plants in these houses and a collection of plants from a recent collecting trip to Asia. Alan works on *Clivia* breeding, which there are a number of cultivars that have been released from his breeding.

Kristina Aguilar, Plant Records Manager, uses BGbase at Longwood. She has one intern for a year each year and a few volunteers to help with data entry, such as flower colour, form and habit. She also has 15 volunteers who collect phenology data using iPads that have an app that has the same fields as BGbase which she can download the data into BGbase. Records started in 1955 and their first database was in 1970. All old paper records have been archived and put in a special room that is fire proof. The boxes have all been catalogued into the library archives and include accession books, movement records and hand drawn detailed plantings for each bed in the garden. The documents have also been scanned. Longwood have been using BGbase for 10 years and they also got BG Map at the same time. They only started accessioning everything in 2011, including annuals and bulbs.

Kristina makes all the labels and tags. Labels are ordered by the field staff, who decide what they need and how many. There is no standard policy for labelling plants so some gardens have fewer labels that others depending on personal preference (this is something I noticed walking around the gardens). Labels are sent to a vendor to make. Temporary labels for seasonal plants are made by printing onto plastic paper. The tag machine is also a ME2000 with two different sized brass tags. The brass starts shiny but over time darkens which means it is hard for the visitors to see.

Figure 12 Plant label at Longwood Garden

Seasonal plants, such as annuals, reuse accession numbers. Once they have had a cultivar, the same accession number remains with it forever in the garden. A code, 'Off Display', is used when that plant is not currently in the garden, like a dead code, but means when the database links to their online Plant Explorer that it appears to search. These seasonal plants have no information, such as date arrived, source etc., stored under the accessions table because it will change from year to year when new seasonal plants arrive. Permanent plants are accessioned and as much information as possible is recorded, including who it is for (justification and staff, page 2 of accession table) and price. There is a volunteer photography team and the photos are put into a folder under the BGbase file to be linked into the Image table. The Image table also holds scanned documents that link to accessions. Longwood would like to do more in terms of records and focus of more propagation information, scheduling crops and horticultural information. The dedication label text field under the plants table is used as a free text field for notes, stories etc. related to that particular accession. Kristina doesn't use some fields in BGbase as they were intended. Special Characteristics is another useful field that can be edited and could be used for anything. The Plant Explorer has a specific module for staff. Staff use this to update their records rather than using BGbase. They can search a name, accession or location and click on a record that automatically generates an email to the 'Plant Records Email' with accession details and then they just type in dead. Kristina updates all records in BGbase. The arborists and Alan are the only staff that edit BGbase and this is because they are adding specific details and extra information.

The 'What's in Bloom' page on the website links to the Plant Explorer to pull information. Longwood has BG Map which is created by one person, Mark Lickman, who is not associated with BGbase. Mark is excellent at giving annual updates that are driven by user feedback. It is very easy to use and only requires a base map created in AUTOCAD. Points are stored in BG Map database but no other information is stored there as otherwise both database would be doubling up on information. Using other programmes for mapping require technical knowledge of GIS so this is a straight forward and easy option. Most gardens that use GIS have a dedicated staff member for it. Longwood has a dedicated server for BGbase and BG Map and this is where all photos in the Image table are stored, so there is no issue with file path changes. Longwood has a second image library which is accessed through the internet, called Asset Bank, and ideally they would only use one image library but they got

this one after BGbase. The propagation table of BGbase is used as a secondary location table, which is not the intended purpose of the table but is used for orchids and experimental plants only.

Kristina can produce monthly reports of name changes. I need to get the slist code for this so that I can produce quarterly reports after I update names so that ABG staff are aware of these changes. Convert list is a great tool to pull information for two different tables. In slist, you write your 'select' code and press enter. Then type in the next 'select' code with will filter down your search further. Save the list. Open convert and type in the saved list name and click the convert, e.g. ACCESSIONS TO PLANTS. You can continue to filter with 'select' codes or open in excel. This type of search would allow me to produce a report of those wild collected plants in the Threatened Native Plant Garden for example. I can ask Kristina or Mike (from BGbase) if I need help with this. BGbase doesn't calculate sums but you can do that once a report is opened in excel. All woody plants of one accession have individual qualifiers. This means when one dies that the qualifier is deaccessioned. All other plants are recorded as 'mass', therefore they are not interested in plant number changes. There are no accession numbers on the plant labels are they think this is not information that the visitors need to know, they have been doing this for as long as Kristina has been working there, and it also means that labels can be reused or moved if need be. The BGbase advanced training is where you can learn the slist and reports that would be very useful to make better use of the database. You can set up saved slists and convert file types to pull pre-defined fields. This would save time in typing the code every time a list is pulled and that reports look the same. This is important at Longwood for the monthly reports created.

Day 11 – 10th Day

I travelled from Philadelphia to New York via train.

Day 12 – 11th May

Brooklyn Botanic Garden

I met with Melanie Sifton who is the Vice President of Horticulture and Facilities. We discussed plant records with Karen Kongsmai who manages the database. They currently use a system called File Maker Pro which is free software that needs customisation by a developer. They have had it for about three years and prior to this was using BGbase and BG Map. BG Map is not compatible with anything else so they had to get Arc GIS and a base map in AutoCAD. There are a lot more steps for converting the GPS information into a map. An intern did all the mapping but is not updated as frequently. When the database or map is changed, it does not automatically update the other so this increases the work load. The metal tags are made using the laser machine (Universal Laser Systems) and then the metal embosser puts an accession on it as they aren't sure how well the laser tags will withstand outside conditions. The laser printer needs to be vented which means the building might be modified if ABG were to get one. Karen also puts temporary tags on plants when they arrive with a piece of foil and the accession number etched into it. The database has some photos but they stopped adding these when the capacity was reached (about 300 photos) and the database wasn't working as well. Their database does link to other websites so that they can

verify their plant names within the database. They also use the laser machine to make their labels on a hard plastic material and the mounted onto a stand which the label slides into and a screw is tightened so that the label won't slide out. Phenology is not being recorded but would like to be doing this soon. There is a File Maker Go app which means the database can be accessed on a phone or iPad however the cell phone reception and Wi-Fi on site is so variable that it is often more trouble to try use. Curators update records but mostly are sent to Karen. Ideally inventories of gardens are done every five years but this doesn't always happen.

Figure 13 Metal tag at Brooklyn Botanic Garden which is created by the laser machine

The plant collections are based on taxonomic groupings. The garden is treated as a museum; therefore there are rules, no food or picnicking etc. There are no current conservation or research departments at the gardens but there have been in the past. Their collection of herbarium specimens are housed at New York Botanical Garden temporarily until a facility to house them at Brooklyn BG is built. They don't grow any of their own plants and therefore must buy them all.

Melanie took me on a tour of the garden to see the children's garden which was only recently opened and has lots of outdoor teaching areas and education staff. There is a big water sustainability project at the moment to make the two ponds linked to reuse water and control water in the event of flooding. This means a large part of the garden is blocked off from the public. There are a number of conservatories for plants from different regions including Mediterranean, arid, tropical and subtropical climates.

I visited their library which is large and not easily accessible to visitors. They must check in if they want to go in as it is behind a locked door. This means they don't get as many visitors as they would like, however it is in a beautiful old building which does attract people inside. There is two staff that work in the library, Mimi and Kathy. It is the plant knowledge centre so phone calls are directed there and volunteers answer these calls. Master Gardeners or experienced Gardeners volunteer as they know the answers to plant queries. Most of the book collection is off site and they need a new building to house the entire collection. The library is part of a network of groups that have specific horticultural or agricultural based libraries so they are able to help each other with various projects.

Day 13 – 12th May

New York Botanical Garden

I met with Kristine Paulus who is the Plant Records Manager. She has one other staff member who does plant records. They have a laser machine to make their plant labels. A volunteer kindly purchased the laser machine for the gardens. They use plastic labels which are engraved by the laser machine. Coral Draw is the software that is on the computer which links to the laser machine and has the templates for their labels. The volunteer types in what is required on each label. The labels are reused and stored in an old library card draw system. They have a data card machine to make their tags. Records were started in 1899. The gardens started in 1891 and this year they are celebrating the 125th anniversary. All woody plants have their accession number on the label but herbaceous plants do not.

Figure 14 Labels are reused and stored in this filing system at New York Botanical Garden

NYBG use BGbase and BG Map. Mapping is done by another department not the plant records team. Both databases link to their online Garden Navigator (which is the same system that Longwood Gardens have). It was created by Mark Lickman who is just a one man band but provides a cost effective solution. All systems work well together. Tours, or walking trails, are set up in BG Map to be displayed on the Garden Navigator. There are a team of volunteers who collect phenology data using paper templates. The data is entered by the plant records team. The volunteers each have a walk (about 7 walks in total) each with about 20 plants. These are key plants that the national monitoring network are interested in so the data is available for researchers and entered into BGbase. BG Map is pretty clunky and more so than BGbase. Kristine doesn't use it that much as she only recently got access to it but the asset team use it more for buildings and paths etc. Plants can be added to the general bed location so they appear in the approximate vicinity or the GPS points can be collected. On the map approximate locations and accurate locations are differentiated by a different coloured pin. There is an online staff version of BG Map which staff can add to far more easily than through BG Map, especially on an iPad or smartphone. Multiple woody plants of the same accession are all individually given a separate qualifier. Justification section in the accession table is where they put the staff member who requested or ordered the plants. They don't do memorial plants as it gets very complicated. In the check note field of the plants table has noted when labels are put out. The image database is the same as what Longwood uses, Asset Bank. It links to BG Map and Garden Navigator. They have a staff photographer but also the records staff take specific cultivar photos when they see them needed on the website. BG Map can hold video links via YouTube which can then be displayed on their website. Kristine conducts 6 monthly plant collection statistics via slist. She has given me the code so that I can try it on ABG data.

NYBG has student gardeners who do an intensive two year course including classes and working in all areas of the gardens, plus a weekly plant identification test. They are expected to know 1000 plants by the end of their two years.

NYBG has about 500 staff and half of them are seasonal workers. Most of the research staff work in South America and their research is not related to the garden or reflects the collections that they have.

I visited the library also which provides a plant query service and identifications. They get quite a few visitors because they have a gallery space which attracts people into the building. It is also in a massive spectacular building. The current gallery display links to their main display in the Conservatory which they will get a lot of visitors to. I got a sneak peek at the Impressionism: American Gardens on Canvas which opens in two days. It is a floral display which reflects a number of artworks and runs until September. There are many plants in the nursery as they will need to be regularly changed out as it gets warmer.

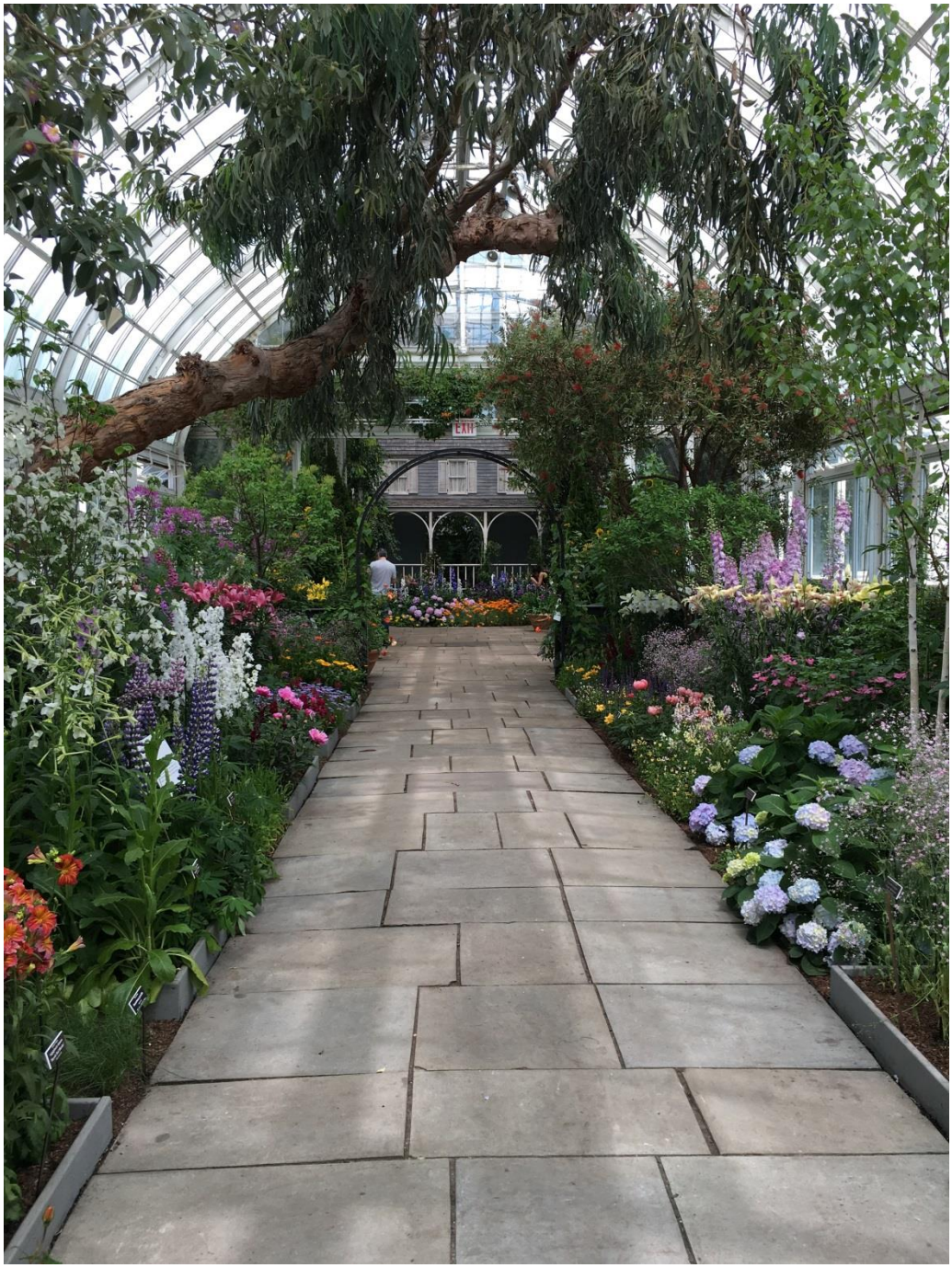

Figure 15 Impressionism display in the Conservatory of New York Botanical Garden

Kristine showed me around the gardens in the morning. For the afternoon I was able to walk around and see some of the other collections. The rock garden and native garden were definite highlights. The Rock garden had limited access and you must have the correct ticket to see it. It has a number of alpine plants and really captures the essence of a rock garden. It's one of the best rock gardens I have seen during this trip with a good use of colour and texture. The native garden was only recently renovated. There is a large garden feature and several different types of habitats. There are two children's gardens. One is for classes so they must book to use it and each child gets a small bed which they look after for 8 weeks. The other children's garden is for families and is open to anyone and is interactive. There is an admission fee, free to members and Wednesdays is free to anyone. They are closed on

Mondays and don't open until 10 am so that lots of the big jobs can be done while there are no visitors around. The biggest development at the moment is a new composting facility.

Day 14 – 13th May

The High Line

I visited the high line which is near Chelsea in NYC. It is run by a non-profit group called Friends of the High Line. This old railway track that was no longer used was turned into a pedestrian route through the local area. Some plants had naturally seeded in and it was decided to develop it further as a green space that is attractive for pedestrian use. The walk is from 14th street to 34th street and is about a 20 minute walk along the entire stretch. There were many people working on planting and weeding, using bikes to get around and transport their equipment. There is not any interpretation about the actual design or plants used on the High Line but there is currently an artwork display called Wanderlust which is interpreted.

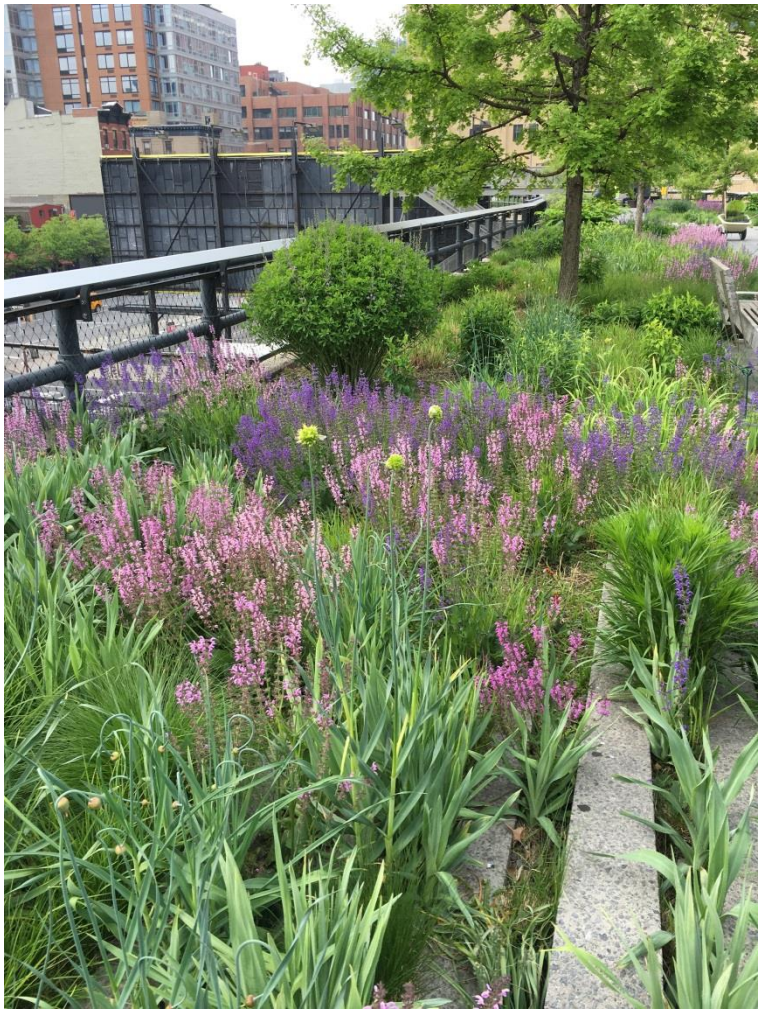

Figure 16 Perennials of the high line

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