

Study Trip to the Atlantic Forest and Amazon Rainforest

Merlin Trust Bursary Report

Lucie Oldale 04th February 2017

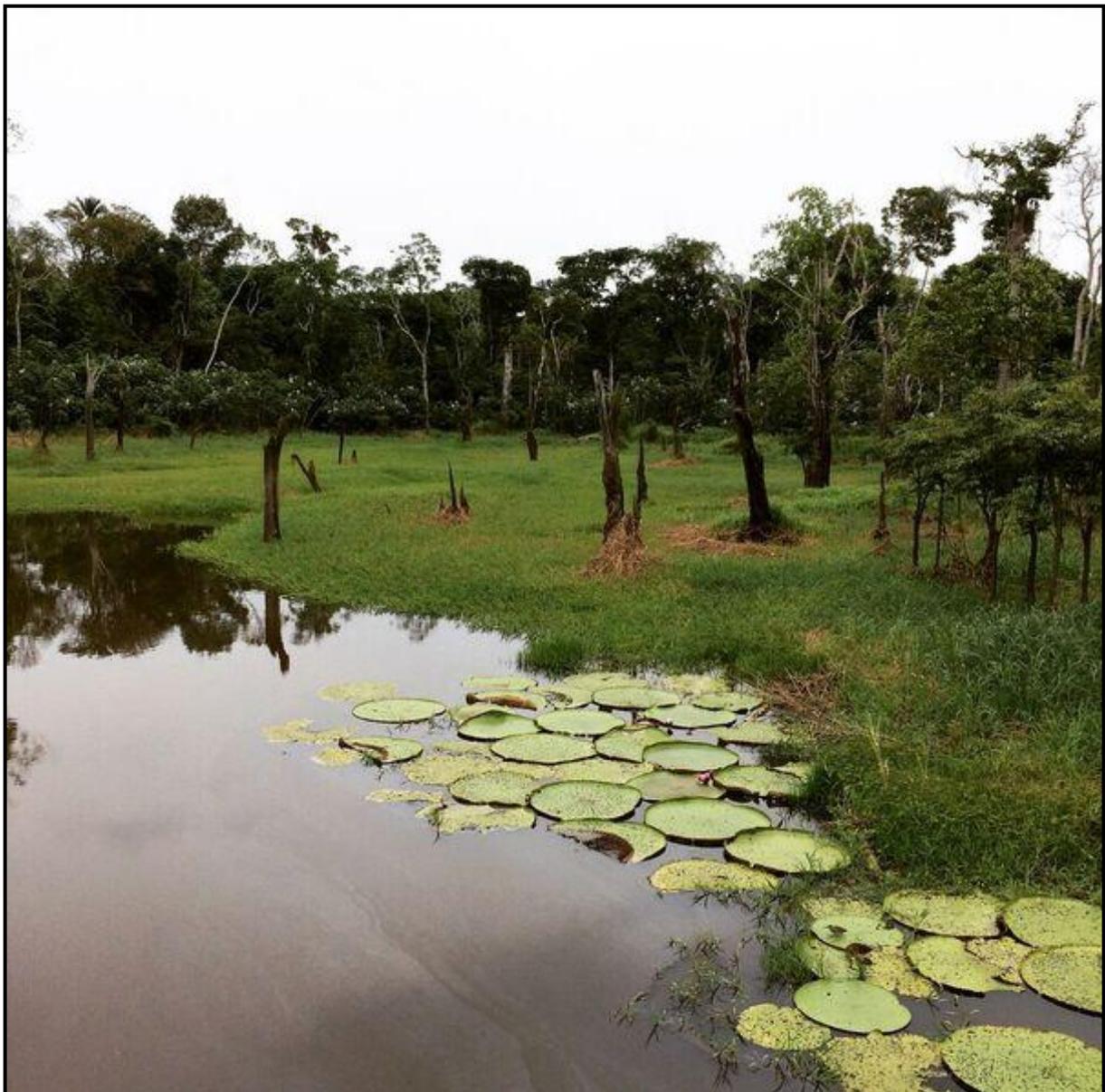


Figure 1- *Victoria amazonica* growing in the flood waters of the Amazon River

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Introduction

In September 2016 after two years of working at the Eden project as a Skilled Horticulturist looking after the Tropical South American section of the rainforest biome I embarked on a study trip to Brazil. This fact finding trip began in the state of Minas Gerais where drier Cerrado savannah vegetation transforms into Atlantic Forest. I spent a week at Inhotim gardens where I concentrated on studying palm and tree collections in the gardens as well as specific practices for both seed germination and sapling aftercare. From here I travelled south east to the state of Rio de Janeiro to spend some time in the depths of both lowland and upland Atlantic Forest. I visited botanical gardens, national parks and a conservation and reforestation project to explore the possibilities of suitable tree species for our biome at Eden. I strived to understand and study the structure and habit in which each plant grows in its natural habitat to create mature forest. For the last week of my trip I travelled further north to Amazonia where I was based in Manaus and was able to experience the immense heat and humidity of the Amazon rainforest. I worked in the herbarium at INPA (National Institute of Amazonian Research), joined a field work collection trip into primary Amazonian rainforest reserve and explored the Amazon River by boat. As my first trip to South America, visiting these diverse regions of Brazil provided me the unique opportunity to experience the massive range and variety of Brazilian flora. This trip was generously funded by the Royal Horticultural Society, the Merlin Trust and the Eden Project.

Daily Itinerary

<u>Date (September)</u>	<u>Location</u>	<u>Activity</u>
2 nd Fri	Cornwall-London-Belo Horizonte	Travel to London, fly to Brazil
3 rd Sat	Belo Horizonte- Brumadinho	Arrive in Brazil, travel to hostel, evening tour of Inhotim gardens
4 th Sun	Brumadinho	Rest day
5 th - 9 th Mon-Fri	Inhotim	Tour + working/ studying at Inhotim
10 th Sat	Belo Horizonte	Travel to Belo Horizonte, tour of city museums + market
11 th Sun	Belo Horizonte- Rio de Janeiro	Fly to Rio
12 th Mon	Rio de Janeiro- REGUA	Busses to REGUA, site tour
13 th Tues	REGUA	Work in nursery, tour of reforestation work
14 th Wed	REGUA- Teresopolis	Busses to Teresopolis, evening city tour
15 th Thurs	Serra dos Orgaos National Park	Day trip to national park
16 th Fri	Teresopolis- Rio de Janeiro	Bus to Rio de Janeiro, visit to Parke Large
17 th Sat	Rio de Janeiro Botanic Gardens	Tour of Rio BG and evening city tour
18 th Sun	Rio de Janeiro- Manaus	Fly to Manaus and tour of INPA Herbarium
19 th -20 th Mon- Tues	INPA	Working with Lecythidaceae herbarium collection
21 st Wed	Reserva Ducke	Field trip into Reserva Ducke on Phd students' collection trip
22 nd Thurs	MUSA	Visit to MUSA
23 rd Fri	Manaus	Day long boat trip up river
24 th Sat	Manaus	Sick day
25 th Sun	Manaus-London	Tour of Manus market in morning, fly to London
26 th Mon	Cornwall	Train London- Cornwall

Aims and Objectives

In pursuit of becoming an expert in tropical horticulture the aims of this study trip were to:

-Improve and develop my practical knowledge of the cultivation of Tropical S. American flora by observation in their natural habitat and by working alongside horticultural experts

-Learn specific techniques and protocols for tree propagation and establishment

-Research trees which are suitable for healthy growth in lower light levels and growing conditions within the biome

-Practise the study and identification of tropical plants growing in their natural habitats

-Apply everything I've learned to growing tropical S. American plants and managing living collections in the enclosed environment of the Rainforest Biome at the Eden Project

In order to achieve these aims I visited a large variety of institutions including public gardens, botanical gardens, national parks, research institutes and conservation projects. During my time at each institution I documented the plant life extensively both note taking and photographing as much as possible. I met with experts to seek advice in relation to the aims of my trip and spent time on tailored tours with expert professionals where I could gain detailed technical advice and study the flora of the region in close regard. This allowed me to observe and work in many areas which are closed to the general public; for example propagation areas, seed collection and storage facilities, reforestation sites and herbarium collections. Now that I have documented all I have learned I am able to implement and propose new strategies with colleagues and develop my horticultural practice within the living collection of tropical South American plants in the rainforest biome.

Locations Visited



Figure 2- Map of Locations Visited

1. Inhotim Botanical Garden
2. REGUA (Reserva Ecologica de Guapiacu) and Serra dos Orgaos National Park, Teresopolis
3. Rio de Janeiro Botanical Gardens
4. Manaus- INPA (National Institute of Amazonian Research), MUSA (Museu da Amazonia), Reserva Ducke

Inhotim Botanical Garden and Art Institute

Inhotim is situated in Minas Gerais state, about an hour's drive from Belo Horizonte and close to the small town of Brumadinho. The site consists of a 140 hectare public garden and exhibitions space and a further 145 hectare reserve called the Inhotim Private Reserve of Natural Heritage. The PRNH consists of remnants of the seasonal semi-deciduous mountain forest, found in different stages of ecological succession, and of some patches of Cerrado biome at the tops of the mountains.

With over 5000 accessions, Inhotim has the largest collection of living species of all Brazilian botanical gardens. It possesses one of the most significant collections of palms in the world, with about 1,400 species, more than 1,800 accessions and a total of more than 20,000 individuals (including seedlings and adult plants). Of particular grandeur are the *Bismarkia nobilis* and *Roystonea regia* planted throughout the gardens. The Araceae collection is the largest in Latin America, with more than 600 accessions and about 450 species. The orchids are represented by about 420 accessions, with more than 330 species including a huge display of the native *Cattleya sp.*

Primary Contact- Juliano Borin: Agronomist at Inhotim and previous Eden Project Rainforest Biome Team Member responsible for the American area of the Rainforest Biome.



Figure 3- Inhotim Botanical Gardens with lake and *Bismarkia nobilis*

Reserva Ecológica de Guapiaçu (REGUA)

REGUA is a family run NGO and charity that for the past 20 years have been dedicated to guaranteeing the wellbeing of the forest. In order to protect the land REGUA managed to create a private reserve on family owned pastureland thanks to the rich biodiversity of flora and fauna thriving in the forest. Pre-REGUA, the land had been logged for the past 300 years and been used for plantations and pastureland thereafter so contains no primary forest but does have mature secondary forest. Their biggest achievement to date is the reforestation of 100 hectares of land over 2 years, this allowed for the employment of 25 extra staff throughout the project including geographers, planters, administration which brought employment opportunities to the area. REGUA is now a UNESCO biosphere reserve with a dedicated local team who live on site. Success stories such as this have allowed REGUA to purchase additional surrounding pastureland and expand the reserve where they can continue to restore and safeguard the forest.

REGUA has a fantastic volunteer program and also creates income by hosting bird watching expeditions which are very popular both due to the fact that there are now 470 confirmed bird species on site and there is relatively easy access from Rio de Janeiro. The site has several well marked trails leading through a mixture of wetland and mature forest with a number of hides on the way for bird enthusiasts. REGUA has also established connections with biology departments in Universities in Rio de Janeiro to create research and academic opportunities and can now cater for up to 30 students at a time.

Primary Contact- Nicolas Locke: Founder and President of REGUA



Figure 4- Capybara having an early morning swim in the lake on part of the Wetland Trail at REGUA

Serra dos Órgãos National Park

The national park is situated within the Serra dos Orgaos mountain range running from the cities of Petrópolis and Teresópolis in the state of Rio de Janeiro. It is in the upland Atlantic Forest with an average elevation of 1,100m and highest point of 2,263m. The complex geological structure of the mountain has created an outstanding array of peaks and ridges due to the greater resistance of granite to erosion in comparison to the gneiss rock nearer the base of the mountains. The many mapped trails offer an excellent way to observe the vegetation and topography of the mountain range. The park has the largest variety of bird species in the Atlantic Forest and over 2,600 identified plant species. There are a multitude of bromeliads, clumps of *Eurpe edulis* palms and many rare tree species. The National Park and the whole Atlantic Forest are both biologically rich and diverse but also contain many threatened and endangered species due to large scale fragmentation and deforestation.

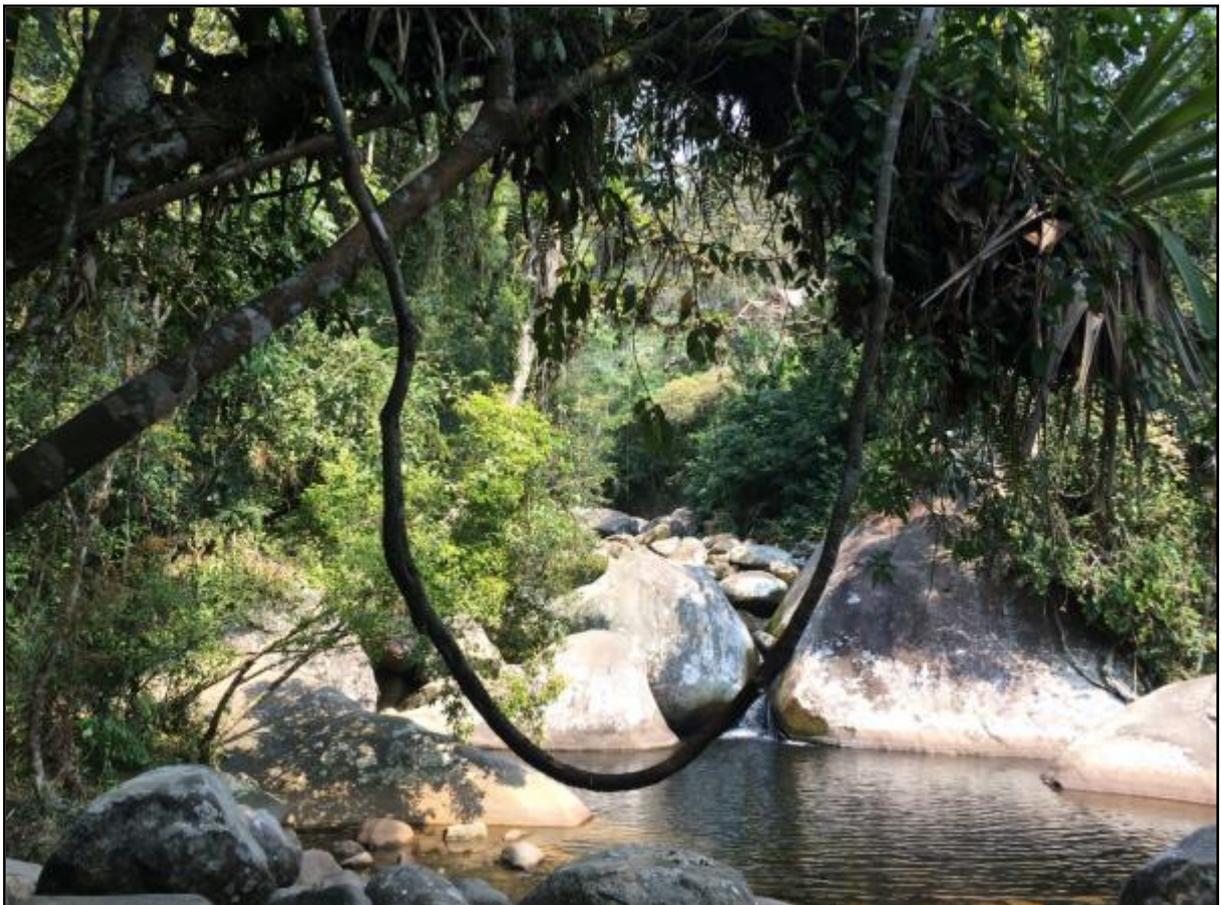


Figure 5- Serra dos Orgaos National Park

Rio de Janeiro Botanical Gardens

The Gardens are historically rich and were first established in 1808 by King John VI of Portugal for the acclimatisation of spices imported from the West Indies. The garden is 54 hectares with a surrounding Atlantic Forest reserve which is part of a UNESCO Biosphere Reserve making a total area of 184 hectares. The Botanic Garden is a federal government run institution currently with around 70 horticultural staff. It was built in 1808 and opened to the public in 1822 so contains a very historical collection retaining many original features such as family beds, a walled medicinal plants collection and its extensive formal avenues of *Roystonea regia*, *Couroupita guianensis* and *Syzygium aromaticum*. The gardens have a custom built bromeliad house with formal and ornamental planting grown mainly from wild collected seed of the Atlantic Forest. As well as the bromeliad collection the garden also has a young fern collection, large native Araceae and Areceaceae collections and a School of Conservation which teaches Masters and Phd courses.

Primary Contact- Maria Lucia nova doa Costa: National Centre for Conservation of Threatened Species



Figure 6- Central Fountain with Christ the Redeemer in the far distance, Rio de Janeiro Botanical Gardens

INPA (National Institute of Amazonian Research)

The Institute was founded in 1952 with the purpose of furthering scientific knowledge of the Brazilian Amazon Region. Most of INPA's research focuses on tropical forest management, ecology, botany and tropical agriculture. It was initially established for political reasons to stop other countries from creating an international research station within the Amazon and so protect it from exploitation. The Institute has a public area on site which consists of a small circular walkway through managed and planted forest with some interpretation and plant labelling. They have many ethnobotanically important mature tree specimens on display such as *Hevea brasiliensis* and *Bertholletia excelsa*. They also have a small public interpretation room with exhibits on rubber tapping and Amazonian fauna. The herbarium collection at INPA is the largest in Amazonia with over 273.000 specimens. INPA does not do and physical reforestation work but it owns Reserva Ducke and it does the research and theory behind reforestation eg. Publications, Phd work, field work within the reserve and seedling research.

Primary Contact- Mike Hopkins: Co-ordinator of Postgraduate Program and Curator of Herbarium Collection at INPA



Figure 7- Lecythidaceae seed head display at INPA

MUSA (Museu da Amazônia and Botanical Garden)

Musa is situated in a public area of Reserva Ducke and is described as a 'living museum' aiming to educate and popularise scientific knowledge and promote appreciation of traditional knowledge. The museum contains many exhibits showcasing biological diversity within the Amazon and offers guided tours through a network of short trails. The most popular highlight of the park is the 42 meter tall observation tower with a number of lookout platforms throughout the canopy. The small botanical garden has an open air orchid house and butterfly house as part of their public collection.



Figure 8- View of the rainforest canopy from the lookout tower at MUSA

Reserva Ducke

The Adolpho Ducke Forest Reserve is one of the most important research sites in Amazônia located 25 km from Manaus. With 100 km² of terra firme forest, this reserve was set up to promote research in tropical ecology. In the Brazilian Amazon, there is no other comparable area of relatively intact native habitats so close to a major urban centre. The reserve was originally made far from the city but as Manaus has grown it has become under increasing threat. To combat this, a 1km buffer zone has since been created to protect the reserve and raise public and political awareness of the importance of conservation.

The Reserva Florestal Adolfo Ducke has been site of diversified field research, from climatological and hydrological studies, to those focusing on zoology and botany, carried out by different Brazilian and overseas institutions. Specific field projects have also entailed the ecology of insects, ecology of cayman and turtle populations, community ecology of fishes, population ecology of frogs, lizards, snakes and birds, growth and phenology of trees, and forest management.



Figure 9- Scenic views in the reserve

Program of Work

Day 1

Friday 2nd September

Travel from Cornwall to London Gatwick and fly to Belo Horizonte, Brazil via Madrid and Sao Paulo.

Day 2

Saturday 3rd September

Arrive in Belo Horizonte and the first thing I notice having never been to a tropical country before are the city's ornamental street trees. There are avenues of *Roystonea* and roadside plantings of many species I'm only familiar with from the rainforest biome at Eden such as *Schzolobium parahybum*, *Bowenia fortificata*, *Terminalia catapa*, *Ceiba speciosa* and *Erythrina sp.* I go straight to Inhotim Botanic Gardens with Juliano Borin who is the agronomist and my main contact at the gardens. He takes me on a quick evening tour around some of the site to get to grips with the layout of the massive the 5000 hectare gardens and galleries until dark. Inhotim was established in 2006 as a private museum by Bernardo Paz. In 2008 Inhotim became a public institute and is still largely supported financially by Paz with ticket prices covering only 15% of total annual running costs.



Figure 10- *Ceiba speciosa* with fluff coated ripe seed heads in Belo Horizonte

Day 3

Sunday 4th September

Rest day.

Day 4

Monday 5th September

I meet Juliano in the morning and we have a proper tour round site until midday. Inhotim has the largest palm collection in Brazil and we spend some time looking at the collection. One of my favourites is *Euterpe oleracea*, Acai. They are clump forming and the thin layer of fruit around the seeds is edible and branded as a 'superfood', it is eaten all over Brazil. The palm can also be harvested for Palmito (heart of palm) which is a vegetable harvested from the inner core and growing bud of some palm trees. *Euterpe edulis* produces a more desirable and delicious Palmito but this palm is not clump forming. To harvest the Palmito the whole plant must be killed so alternative sources of Palmito are being promoted as more sustainable options such as the *E.oleracea*.



Figure 11- *Euterpe oleracea* clump at Inhotim



Figure 12- *Wodyetia bifurcata* seedlings

We walk through the nursery areas and see where palm seedlings are germinated and grown on. Palm seedlings are sown into a mix of sand and perlite to provide a free draining media. For palms

germination rates generally take from between 6 to 12 months. Fig.10 shows trays of germinated *Wodyetia* seedlings grown in this mix. Inhotim currently does not have a seed bank for long term storage of seed but does do a lot of seed collection on site. These seeds are cleaned and stored short-term in labelled glass jars until required for sowing.



Figure 13- Collected seed in the Seed Room (*Hyophorbe lagenicaulis*, *Anadenanthera macrocarpa*, and cleaning *Enterolobium contortisiliquum* seed)



Figure 14- *Ceiba speciosa* seed pods drying in the seed collection room

The tree nursery has a massive polytunnel with sliding doors and extra ventilation with irrigation. For tree seedlings, seeds are sown in root trainers onto wire benches in the polytunnel where humidity is higher and they are watered frequently. The benches are lines of wire on posts that the root trainers sit on so are very free draining. The soil mix for sowing into is a combination of compost made on site, sandy grit and an NPK slow release fertilizer (Brazilian version of Osmocote). After germination the root trainers are moved outside under netted shade and watered less frequently to harden off before planting out. They are not potted on, only grown in the root trainers until planting.



Figure 15- *Pachira aquatica* seedlings in root trainers and the hardening off area outside

Fig.14 shows the hardening off area for tree seedlings. Many of the trees in this image are destined for a community project. Seed was collected locally, sown at Inhotim and will be planted out with the local community when ready. This project helps to maintain a connection with the local community and their environments, most locals are not able to afford the entrance fees to Inhotim so projects like this are important.

By around 11am the daily temperature is about 30C dry heat, not humid and no wind. I spend some time studying the trees after lunch while most of the staff is resting.

Eucalyptus sp. is grown as monocrops popular for timber and charcoal as the charcoal is used to smelt iron ore before sale. The state of Minas Gerais is historically a mining state which used to mine for diamonds but now mainly iron. There are *Eucalyptus* trees in the garden that existed before the garden was made but have been selectively kept and now mingle with the more recent planting.

One tree I was particularly interested in is the *Copaifera langsdorffii*. It is a Fabaceae tree and produces oil tapped from the trunk by drilling a hole and inserting a hose. Much like rubber, tapping doesn't kill the tree if managed well and the oil is used medicinally on the skin to help heal scars and to swallow a few drops as a tincture. It has potential to be used as a biofuel, hence the common name Diesel Tree. The new leaves are a beautiful shade of red when they first break bud which looks quite striking throughout the forest when a few trees are dotted throughout a sea of green.

Day 5

Tuesday 6th September

I meet Juliano in the morning at the main entrance gate with Willy who works on the site mapping and record keeping at Inhotim. We drive round site for morning GPS marking the locations of all the *Bambusa sp.* on site and taking photographic records of each one to be identified by an expert as many of the plants were not identified at the time of planting. Inhotim is

much more known for its contemporary art collection than its botanical collection but the horticultural team are working hard to raise the profile of the gardens as a horticultural institute. Improving the plant records and mapping is an essential part of the process. This work around site gave me a chance to study some of the plant species in the garden I'm not familiar with and also find out more about plants that will grow well and be suitable for the rainforest biome at Eden.

Bauhinia forficata is a native medicinal Brazilian tree which is very common as a street tree as well as an ornamental tree within the garden. Its common name is the Brazilian orchid Tree because of its large ornamental flowers. Medicinally it is well used for diabetes treatments as the leaves can lower and regulate blood sugar levels.



Figure 16- *Bauhinia forficata* leaf at Inhotim



Figure 17- *Bauhinia forficata* pods at Inhotim

Day 6

Wednesday 7th September

Today is a national holiday so there is no Horticultural staff on site. I use the day to explore some of the fantastic art exhibits which are mapped throughout the park on several different coloured trails accessed on foot and by public passenger golf buggies. I spent the morning exploring some of the outdoor sculptures before it got too hot. One of my personal favourites was Olafur Eliasson's Viewing Machine, a gigantic mirrored kaleidoscope which can be freely rotated by the public and used to view both the planted landscape of Inhotim as well as the Atlantic Forest in the background.



Figure 18- View inside Olafur Eliasson's Viewing Machine

In the afternoon I visited some of the indoor exhibits. One which caught my eye was an installation housed inside a giant geodesic mirrored dome which reminded me of the biomes at Eden. The artist Matthew Barney's installation 'De lama lâmina' depicts an enormous metal tractor/ monster with a massive white tree grasped in metallic pincers.



Figure 19- Viewing the Landscape of Inhotim and surrounding Atlantic Forest through the Viewing Machine

The piece is a statement on progress and conservation, creating and destruction and on man's interactions with the natural world.



Figure 20- Matthew Barney- 'De Lama Lâmina'

The other exhibit I found particularly engaging was a massive photography collection by Claudia Andujar which was housed in a custom build gallery made especially for the collection and opened in 2015. The collection contains over 400 photographs in the Yanomami indigenous people of the Brazilian Amazon taken from 1970-2010. They document the cultures and ways of life as well as the changes that came about after the tribe first had contact with white man. It is a very poignant exhibition highlighting the fragility of the balance of indigenous people and the importance of protecting their culture and habitats.



Figure 21- Cláudia Andujar

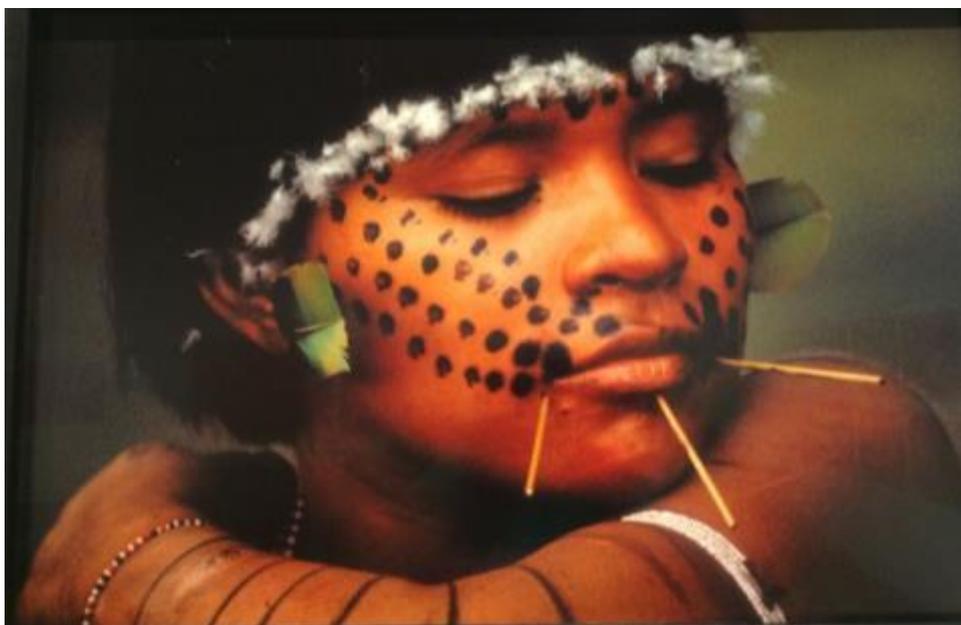


Figure 22- Claudia Andujar

Day 7

Thursday 8th September

I worked in the nursery all day today with the horticultural staff, in the morning with Joseph potting on flowering shrubs into plastic bag containers and in the afternoon with Maria where we worked with tree seedlings. 3 seeds are initially sown into each plug, working with the germinated seedlings we thinned out plugs so that they had only 1 central seedling remaining and used the excess to fill plugs where no seed had germinated being careful not to damage the taproot. I worked with *Luehea grandiflora* seedlings which are native to the state of Minas Gerais. The tree is used as a pioneer species in reforestation projects and is harvested for its wood which is used to make furniture. After completing each row we watered them thoroughly. These trees will stay in their root trainers before being moved out of the protection of the tunnel and under shade outside to harden off before being planted out in the garden.

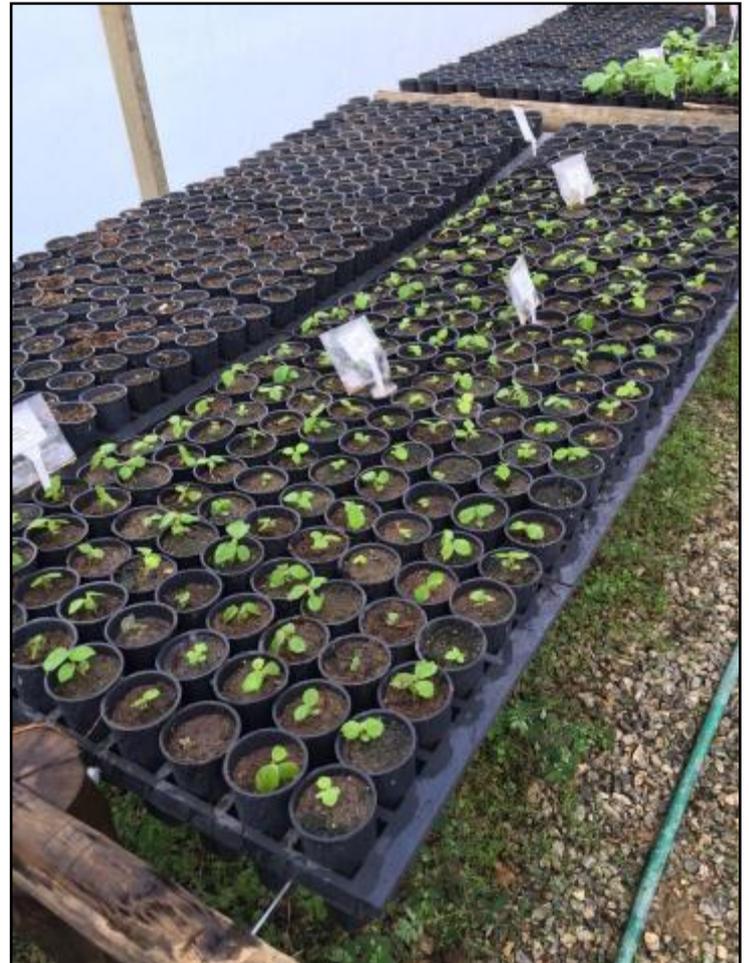


Figure 23- Potting on with Joseph and thinning out the *Luehea grandiflora*

Day 8

Friday 9th September

Today I worked with Juliano and Willie who works on plant records and mapping. We visit the *Cattleya* orchid collection in the garden. Every 2 weeks the flowering plants are photographed and documented by Willie to keep track of their health and vigour. Inhotim was donated 17,000 *Cattleyas* from Orchid Brazil who are specialist orchid breeders that sell commercially but only to specialist buyers. They do conservation and reintroduction work in Brazil and grow hybrids and cultivars as well as species all from micro-propagation. They kindly donated orchids to Inhotim as it is good advertisement for their business; they are keen to do the same in the UK.

Many of the *Cattleya* species donated to Inhotim were planted onto large *Roystonea regia* palms to create a beautiful ornamental display. The orchids were first mounted onto the palms in November 2015 and fed weekly with a rooting foliar feed to encourage the roots to firmly attach to the palms. They took about 2 months to root. They are still fed weekly with one of four different feeds for rooting/ flowering/ general maintenance depending on what they need and the time of year and they are watered every other day. They should have finished flowering in June/ July but some are still going strong even into September. Juliano hopes they will cross-pollinate and self-seed throughout the gardens. Best recognisable by flower are the *Cattleya walkeriana* varieties, Inhotim even stocks a beer named Walkeriana after this orchid in the restaurant.



Figure 24- *Cattleya* display in *Roystonea regia*

Inhotim also has an ornamental Orchid Pavilion with many more *Cattleya sp.* on display attached by wires and hanging down at eye height. Visitors are invited to walk through the display and view the flowering plants in detail.



Figure 25- More *Cattleya sp.* on display in the orchid pavilion

On our journey round site photographing the orchids we visit a beautiful tree, the *Cariniana estrellensis* in Lecythidaceae which is quickly becoming my favourite tropical tree family. This tree is a large semi-deciduous rainforest canopy tree which can reach heights of up to 40m and is also fairly fast growing. It is grown as an ornamental tree but also has many local uses.

The bark is very fibrous and used as a cloth, blankets or matting. The inner bark can be removed and used as a paper substitute for rolling cigarettes and cigars and the wood can be used for carpentry and furniture making, it has a pinkish-brown colour.



Figure 26- *Cariniana estrellensis*

Day 9

Saturday 10th September

I travel from Brumadinho to Belo Horizonte with Juliano and he took me to a massive market in the city which sold literally everything from tropical fish and birds to tobacco, fruits, herbal medicines and souvenirs like hammocks, baskets and calabash gourds. It was very busy and great to explore some of the fresh fruit and natural produce, to see the sellable produce from the trees I have become familiar with since arriving in Brazil.

After the market we head home and I prepare to leave the following morning.



Figure 27- Fruits and seed pods for sale, Leythidaceae seed pods!



Figure 29- Tobacco and calabash gourds



Figure 28- *Hymenia* seed pod and chillies



Figure 30- Sunset over Belo Horizonte

Day 10

Sunday 11th September

I took a bus from Belo Horizonte to the airport and then fly to Rio de Janeiro where I find my hostel for the night after a long taxi ride.

Day 11

Monday 12th September

I travel from Rio de Janeiro to REGUA, a reforestation project in the lowland Atlantic Forest only 30-100m above sea level. After several busses and several hours I ended up on the back of the bus driver's motorbike and he very kindly dropped me at the main entrance to REGUA.

I was met by George who gave me a quick tour of the public areas and showed me to my accommodation. George specialises in insects and butterflies and is employed at REGUA to oversee research projects taking place on site. REGUA hosts English lessons for local children and they encourage all their visitors and volunteers to join in so I spent the afternoon with 6 year olds practicing pronouncing 'hello, how are you' and learning the English for different coloured pencils, it was fun.

In the evening I met Nicholas and Rachel who own and run REGUA and we talk about the project:

REGUA is an NGO and charity, Nicholas' family are Anglo Brazilians who have owned the large area of farmland REGUA now conserves since 1908. Nicholas and Rachel wanted to guarantee as a family the wellbeing of the forest so created a private reserve to initially protect the land. All staff live on site and REGUA is now a UNESCO Biosphere Reserve with a dedicated local team and good access to Rio de Janeiro for volunteers, students and tourists. The reserve doesn't have any primary forest but it does have mature secondary growth. It has been selectively logged for around the past 300 years and used as pastureland/ plantations for crops like bananas and palms The initial plans for REGUA began around 20 years ago in the planning stages and it has only been 11 years since planting began. . Now that the land is under protection there is a big difference.

When reforesting new areas the team usually use a 60/40 mix of pioneer/ climax species. The pioneers provide an immediate canopy and fruit and seed for wildlife while the slower growing climax trees helps to develop a mature secondary forest more quickly than would occur naturally. Seed is mainly collected on site and some is bought in, it is germinated and grown on in the vivario (nursery).

REGUA is funded by sponsors mainly from the UK and USA but also gains help from larger companies who carbon offset by funding regeneration projects.

It was great to have the chance to properly discuss the project in detail.

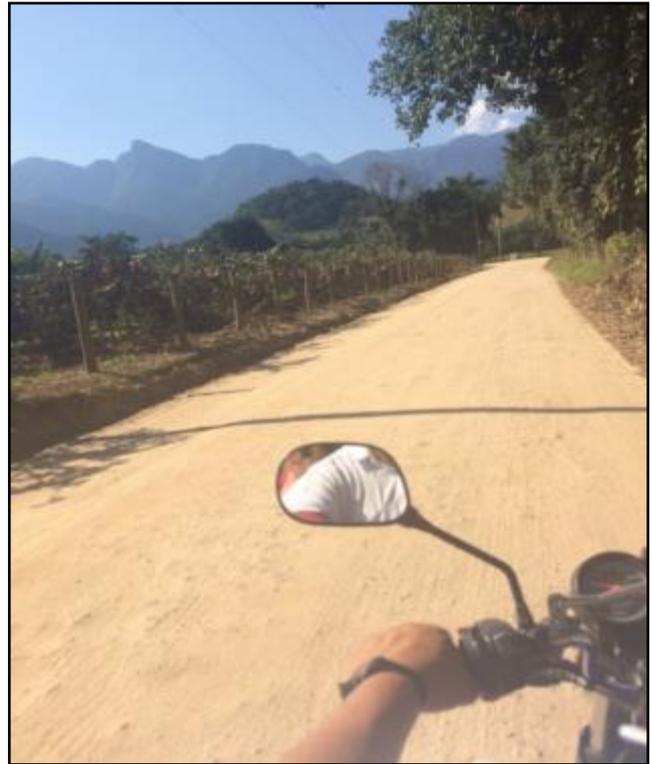


Figure 31- Final leg of the 'bus' journey to REGUA

Day 12

Tuesday 13th September

In the morning I worked in the viverio mostly filling plastic sack pots with soil and potting on tree seedlings. The soil mix is manure, clay, hummus, sand and added calcium. I worked until around half 11 then everything stops as the heat becomes too much and the temperature rises about 40C. Seeds are sown in a sandy free draining mix in irrigated raised concrete beds under netting shade cover and potted on under lighter shade with less frequent watering to harden off. As they grow they are moved to full sun and planted out at 8 months old.



Figure 32- Seedling nursery and older seedlings ready for planting in full sun

Later in the afternoon once the temperature has dropped a bit I go for a hike with George who shows me recently reforested areas and more mature sites which are developing into secondary forest. Often for the first 1-2 years Cassava (*Manihot esculenta*) is planted between reforested saplings to keep the grass from becoming too vigorous and also to create some income until the trees establish and create shade and canopy. George has seen all of these areas reforested from bare pastureland and his knowledge of the trees and wildlife is incredible. He shows me many of the species commonly planted in reforestation work at REGUA.



Figure 33- George showing me round some of the reforested sites and identification techniques for young trees



Figure 34- Saplings maturing

In Fig.33 maturing saplings of *Ceiba speciosa*, *Piptadenia gonoacantha* which grows well in poorer drier soils, *Schizolobium parahybum*, *Inga sp*, *Cecropia sp*, *Cariniana sp*, and many Sapindaceae and Meliaceae species. George pointed out the ridges or young trunks and aborted terminal leaves which help to distinguish between young Sapindaceae and Meliaceae. *Gochnatia polymorpha* in Asteraceae is the local pioneer species which will grow first after fires and grow well on poor soils. The wood is very durable and is harvested for its use but it can also make a good ornamental tree as the foliage is dusty silver and the tree stays relatively small, 6-8m. Some of the land owned by REGUA is still leased as pastureland to create income and some has been earmarked for future reforestation work, the landscape looks very different in areas where trees have previously been deforested. In some areas only the high altitude steep terrain has trees remaining, everything on lower flat and more easily accessible ground has been deforested.



Figure 35- Spikey trunk of young *Ceiba speciosa*



Figure 36- Land owned by REGUA currently still pastureland with forest in the background at altitude

In previous planting projects REGUA ran some feeding trials for tree saplings. Trees which were fed at the time of planting grew well at first and more quickly than trees which had not been fed but as soon as the feed ran out the trees became stressed and died. Since then REGUA don't feed their young trees when planting, they grow more slowly but also don't die. Planting usually occurs during the wet season as irrigation is impossible but during unexpected drier spells a hydrogel is sometimes added to the soil when planting to help retain moisture while the trees are at their most vulnerable.

As young trees develop a canopy leaves drop and act as mulch, the increased canopy and leaf mulch increase humidity and more species begin to establish in the understory. George notes the appearance of *Piper sp.* as good indicator of increased humidity and understory development.

We look at the difference between naturally reforested pastureland in comparison to areas that have been planted by REGUA. There is a much faster development and higher variety of species in the planted areas. If naturally reforested land was at closer proximity to mature forest this process would be faster as seed would naturally disperse into open space.

Day 13

Wednesday 14th September

I got up early at 5.30am to walk some of the REGUA trails in the cool morning. I took the Wetland Trail which twists around the edge of a lake dipping into mature forest and opening out across the water. Many of the mature trees were adorned with epiphytes. REGUA is a popular spot for bird watchers with over 470 confirmed bird species on site so the trails are laid out with many hides in order for bird enthusiasts to get the best view. I found a sloth, capybara swimming in the lake and hummingbirds feeding on flowering bromeliads, it was an incredible sight to see in the quiet morning light.



Figure 37- Morning view of the lake from the Wetland Trail

A special moment for me was to be able to see a sloth this close in the wild. I was move by REGUA staff to a safe location away from dogs which often attack them.



Figure 38- Sloth on a *Cecropia*



Figure 39- Capybara enjoying a morning swim



Figure 40- Beautiful canopy of pioneer species *Schizolobium parapybum* from the Wetland trail



Figure 42- Bromeliads and *Rhipsalis* epiphytes thriving along the Wetland trail

I spoke with Rachel about how I can help with advertising in the UK to find horticultural volunteers and students interested in internships at REGUA before catching a bus to the nearest town. From there I caught another bus to Teresopolis which is a small city in the upland Atlantic Forest about 2 hours from Rio de Janeiro. My hostel is a few miles from the entrance of the national park which I will visit tomorrow.



Figure 41- More bromeliads and rhipsalis, a fantastic natural display

Day 14

Thursday 15th September

I spend the whole day in the Serra Dos Orgaos National Park.

The park is the 3rd largest National Park in Brazil and is protected to conserve environmental services such as water, erosion control, weather regulation and carbon fixation. The park preserves the ecosystem and enables scientific research and educational awareness. There are 462 recorded bird species and over 100 frog and toad species. There is a large altitudinal range from 80-2263m so also a diverse and varied collection of flora- over 2600 species.

There are several trails of varying difficulty so I choose 3 that I will be able to complete in a day. I had arrange to meet a biologist who works in the park and would be able to show me round but unfortunately he had to travel out of town so I am my own guide for the day. The temperature is a full 15 degrees lower than at REGUA so hiking is an enjoyable activity. I begin on a trail leading through a forest of Acai plams, *Euterpe edulis*. This palm is becoming endangered due to over exploitation as they are harvested for Palmito which kills the palm.

The second trail is very steep and winding, clambering over huge buttress roots and lianas after a few hours I emerge onto a viewing area where the famous landmark 'God's Finger' can be viewed along the main ridges of the Serra Dos Orgaos mountain range.

The last trail of the day was a suspended trail on a wooden walkway through trees covered in epiphytic bromeliads and ferns. This trail also leads over a waterfall and river and many birds and monkeys were in the canopy, it was beautiful.

The main notable difference here in comparison to the landscape of the forest at REGUA is the amount of water, even now in the dry season there are still rivers and streams flowing.



Figure 43- Acai canopy on the first trail

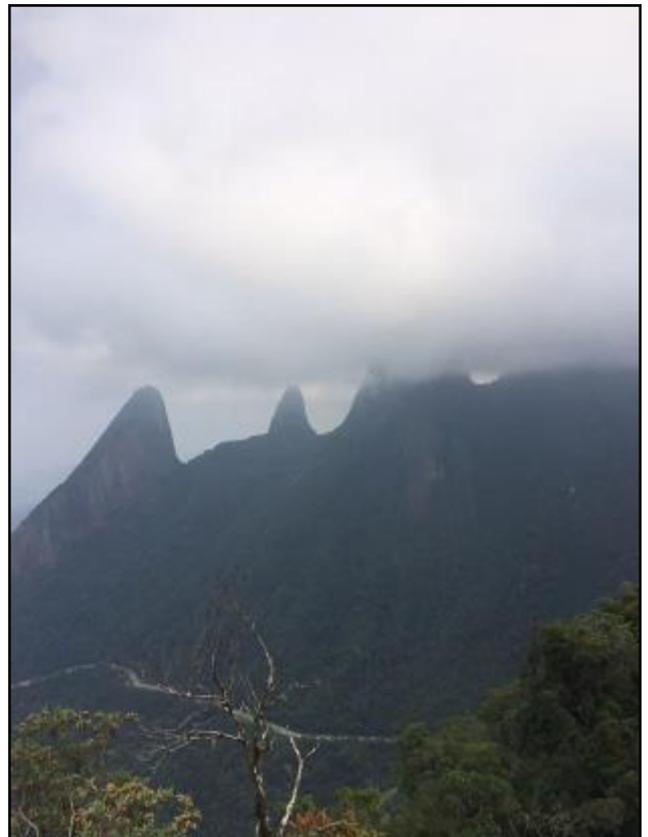


Figure 44- God's Finger

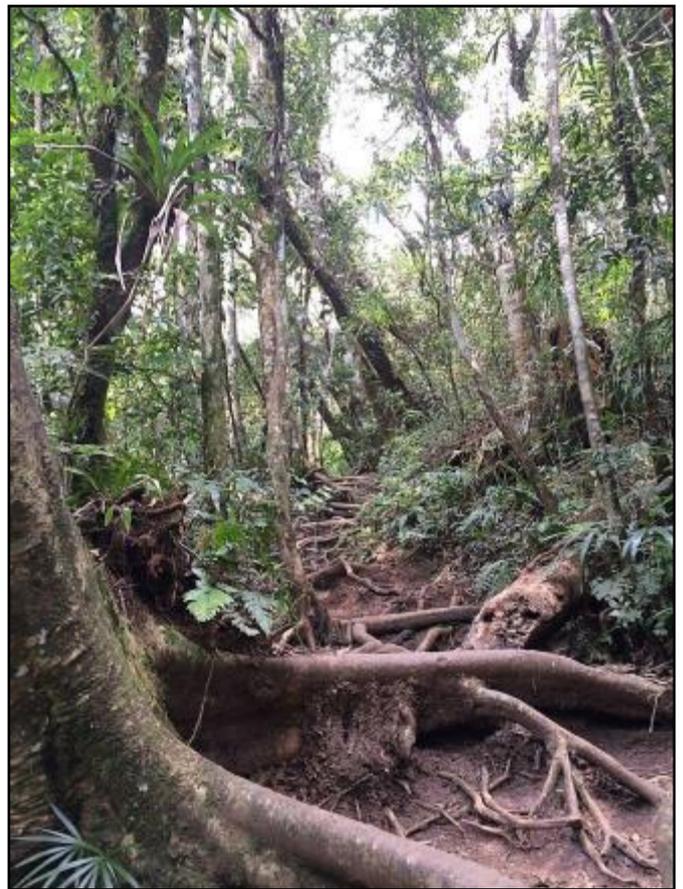


Figure 46- Low water levels still running and buttress roots up the steep path to God's Finger



Figure 45- View from the suspended trail into the canopy with many bromeliads

Day 15

Friday 16th September

I caught a bus in the morning back to Rio de Janeiro and arrived at the hostel at lunch time. I visited a nearby public park for the afternoon called Parque Larg which has a footpath leading all the way up Corcovado Mountain to the famous landmark of the city, 'Christ the Redeemer'.



Figure 47- Piranha

The park had some incredible mature fruiting specimens of my favourite tree in the rainforest biome at Eden- *Couroupita guianensis*; commonly known as the Cannonball tree for its giant spherical fruits. I have never seen this tree fruit before, only the flowers so I was really excited to see so many here. The park also has a small public aquarium with piranha.



Figure 48- Fruiting *Couroupita guianensis*

Day 16

Saturday 17th September

I walk to the Rio de Janeiro botanic gardens in the morning and I'm met by Maria and Tania at the main entrance. Maria works for the national centre for flora conservation of threatened species, in particular working on action plans for ex-situ conservation. Tania is now retired but still does some work with seedling morphology and restoration ecology.

The garden is 54 hectares plus a surrounding Atlantic forest reserve making 184 hectares in total. The garden was first established in 1808 so is very historical and still maintains classic botanic garden features such as family beds and a walled medicinal plants collection though there have been many modifications made too.

We visit the bromeliad house first which contains mainly wild collected seed species from the Atlantic Forest. The planting is formal and ornamental highlighted by flowering *Cyrtanthus sp.* The plants are watered every day by pop up sprinklers.

We visit an area of the garden closed to the public which contains old plantations from the 1930's of native trees grown for their valuable NTFP's. This area is now protected and regenerating.

Carapa guianensis is one of the most prominent trees in this area, it is an Amazonian tree in Meliaceae which produces oil from the seeds used

medicinally for stomach ailments and as a massage oil for muscle aches.

Tania shows me one of her projects where she has been working to restore the planting to protect the river bank that runs through the garden as it is becoming polluted with rubbish from nearby houses before it runs into areas protected by the garden. All tree species chosen to reforest the riverbank are also important for encouraging animals and birds to increase biodiversity. There are many *Inga sp.*, Myrtaceae and Bombacaceae. Pioneer species *Myrcia guianensis* in Myrtaceae is particularly important for encouraging birds as they love the purple fruits.



Figure 49- Bromeliad House



Figure 50- *Calycophyllum spruceanum* bark

One of the garden's formal alleyways is planted with *Calycophyllum spruceanum* in Rubiaceae which is an Amazonian canopy tree known for its beautiful ornamental bark which peels off in a similar way to some *Eucalyptus sp.* The bark peels off periodically to reveal a smooth bright green trunk. It does this to help control infestations of fungi and lianas which could affect the growth of the tree. There are more fruiting *Corupita guianensis* here too as in Parque Larg yesterday; Tania explained they are pollinated by bees in the wild and that I should experiment with hand pollination of the flowering tree in the biome at Eden to encourage fruiting.

We visit the orchid house which is a small ornamental display house that has an orchid exhibition twice a year. The interpretation is excellent and something I would like to help develop at Eden. The collection consists of a mix of natives and bred hybrids with many *Miltonia*, *Cattleya*, *Epidendrum* and *Oncidium* species. They had some excellent interpretation too.



Figure 51- Orchid House

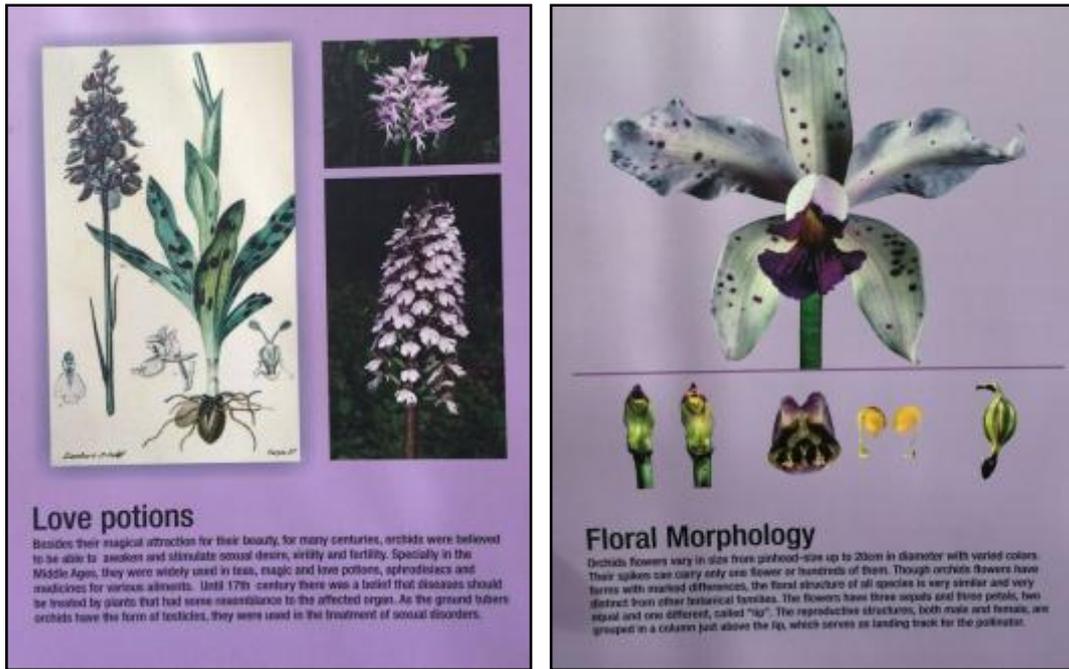


Figure 52-Interpretation in the Orchid House

The most striking thing about the garden to me is that because of its age it has so many mature tree species, some of the buttress roots on species like *Backia multijuga* and *Ceiba pentandra* were amazing.

The medicinal plant garden was also very well labelled with great interpretation, mainly in Portuguese but with a Pharmacist dressed in a lab coat ready to answer any queries.



Figure 54- *Ceiba pentandra* buttress



Figure 55- Medicinal Plants Exhibit

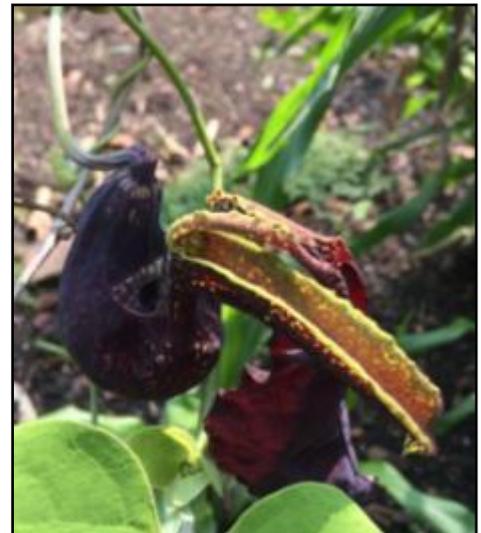


Figure 56- *Aristolochia cymbifera*



Figure 53- Medicinal plants beds

Day 17

Sunday 18th September

I fly from Rio de Janeiro to Manaus, known as the 'gateway to the Amazon' for my last week in Brazil. Mike Hopkins who is the curator of the herbarium and the co-ordinator of the PhD program at INPA (National Institute of Amazonian Research) picks me up from the airport and we head straight to INPA so that I can explore the public areas of the site and visit the herbarium before closing time.



Figure 57- *Hevea brasiliensis* tapped for rubber at INPA

The herbarium is the biggest in Amazonia with 273,000 specimens and was founded in 1950. Iain Prance who has been instrumental in the set-up of the Eden Project was a research fellow in New York and was contracted by NY to go and work at INPA in the 60's. Many herbarium collections made throughout the 70's were due to Prance's collection work. Everything in the herbarium is photographed for upload to an electronic database which is accessible online to the collection can be easily searched and accessed.

MUSA (Amazonian Museum and Botanic Garden) which I will visit later this week is part of Reserva Ducke which is owned by INPA. The reserve is 10x10km including the BG.

After a quick look round the public gardens and some top tree spotting I head home for the evening.

Day 18

Monday 19th September

We arrive at INPA at 7.30 and Mike shows me around the herbarium and equipment rooms. The sorting room is where material arrives that has been sent to INPA by other herbariums or material that has been collected by INPA. Collections are all labelled with the name of the collector and the collector's number (starts at 1 and increases for every specimen personally collected). One specimen is mounted and kept at INPA and any duplicates are sent to other experts and specialists for identification confirmation. Extra duplicates are saved to send to anyone who requests a sample for



Figure 58- Herbarium sorting room

example; research students. They receive their own specimen to keep rather than sending INPA's own mounted one. The database, called BRAHMS stores information on every specimen in the herbarium; when it was collected, by whom, the location the specimen was collected, a description of the whole plant or tree and where in the

herbarium the specimen is now stored. Multiple specimens of a single species are stored so that its distribution can be recorded. Other herbariums can be used to help with identification but it is believed that around 20% of identifications made by experts are incorrect. INPA has an infrared scanner which can be used to identify plant material down to species level. It works on non-flowering material as it scans for chemical structure and composition which is unique to every species. The scanner will only provide the correct ID if it has been given the correct information beforehand. It must be told what to look for so relies on an original positive ID by specialists to base its scan results on. For example, flowering specimens are more easily identified by experts as flowering plants are more easily differentiated than vegetative material. This information can be entered to that if in the future the scanner is given non-flowering material that is harder to recognise by eye the scanner will be able to give a positive ID. Research is being done now to determine whether the glue on herbarium specimens alters the chemical composition to make a scan ID invalid.



Figure 59- *Bertholia excelsa* herbarium specimen

For the day I work through the Lecythidaceae collection sorting through each specimen alphabetically. I add new name labels to specimens that have had a name change since collection and re-file them under the new name. Many of the specimens I work through were from the 60's and 70's and each has a small label of information giving a little bit of insight into the collection expedition. Reading these labels it is easy to imagine the conditions and setting on the collection trips, collecting and identifying new species on the Amazon Rainforest. There are over 4,500 specimens in Lecythidaceae alone so I don't make it through them all but I make a good start!

Day 19

Tuesday 20th September



Figure 60- Sorting through Lecythidaceae

Mike and I head into INPA early and I continue working through the rest of the Lecythidaceae collection until lunch. After lunch I walk around site to visit the Science House which contains some beautiful interpretation for human interaction within the Amazon Rainforest. There is an example of a rubber tapping camp with tools, a hut where tappers would sleep and some very rustic rubber shoes. Another exhibit shows a cross-section of a mature *Hura crepitans* with string lines to show each year of growth and how old the tree is. This one has rings from 1819-1992. They also have a large collection of old seed heads mainly from Lecythidaceae including whole Brazil nut fruits. I love these seed heads and I'm hoping to be able to find some at the market to bring back to Eden.

Also visiting INPA are 2 PhD students from the University of Sao Paulo who are studying taxonomy and Phylogeny. They are planning on doing some field work deep within Reserva Ducke on



Figure 61- Working in the herbarium

Wednesday and are organising their collection permits from INPA today. I would love to be able to join their excursion but it is very difficult to negotiate for this to happen as officials are wary of foreign visitors entering the reserve. I met with the official permit provider to show him my travel documents and insurance and plea my case. Eventually under the strict understanding that I will join the group as a passive observer and definitely not collect any material my request has been granted which means that tomorrow I can join the collection trip. This will be my only change to gain entry into the real Amazon which is protected and no public access granted.



Figure 62- Rubber camp interpretation

Day 20



Figure 63- *Hura crepitans* interpretation

Wednesday 21st September



Figure 64- Panorama of the reserve

We leave Mikes at 6am and drive to Reserva Ducke. We take collection bags, GPS, cameras, cardboard plant presses, pole pruner, machetes and LOTS of water. We register at security where there is an old base camp, and head off into the rainforest starting on small trails and branching out into the undergrowth in search of flowering Bignoniaceae climbers to take samples. These samples will be used for DNA analysis when the students return to Sao Paulo. It is amazing to experience being fully immersed in primary rainforest; the heat and humidity are overwhelming.

Using the GPS we searched in areas where the species had been found before, not on paths or trails but just trekking through rough steep ground using machetes to clear the way. I was very tough though we were travelling slowly. The most successful way to find flowering climbers is to look for fallen petals on the ground as it is far easier to check the ground for colour than it is to spot them amongst the canopy. We were looking for *Martinella*, there are only 2 species- *obovata* and *iquitoensi* which can be characterised by interpetiolar ridges surrounding the stems. After a morning of searching we returned to the base camp for lunch. One the way back we found a *Tanaecium duckei* also in Bignoniaceae which is named after the reserve and Aldo Ducke. He was an entomologist and botanist who studied and became an expert on Amazonian flora throughout the first half of the 20th century. He described 900 new species and 50 new genera. He suggested to INPA to create a reserve to protect the future of the forest but dies before the reserve was created so it was named in his honour.

After lunch we continued to search for more flowering specimens but I suffered heat stroke in the afternoon and had to stay at base camp. In the evening I helped sort the specimens collected and packed them ready for transport back to Sao Paulo.



Figure 65- Checking for ridges to identify



Figure 67- Searching for Bignoniaceae



Figure 66- Streams running through the vegetation



Figure 68- Aroids climbing through the canopy

Day 21

Thursday 22nd September



Figure 70- Orchid house at MUSA

I catch a bus for an hour in the morning to MUSA, the Amazonian Museum which is the public educational area in Reserva Ducke. The garden and educational centre is small with a few exhibits of fish, orchids and a butterfly house. The living museum aims to share scientific knowledge and spread appreciation of traditional knowledge. It promotes conservation work and the importance of the Amazon and the reserve. Most of the visitors on the small site were school groups on guided tours. There is a 42m observation tower with 3 levels to explore the different layers of the canopy. The observation tower can only be accessed with a guide from MUSA so I

climbed to the very top and the view was breath taking. *Dinizia excelsa* tropical hardwood trees stood out above all others, they are native to the Amazon and the only one nearby even taller than the tower. I struggled with side effects of anti-malaria medication and take the rest of the day to rest.



Figure 69- View from the observation tower at MUSA

Day 22

Friday 23rd September



Figure 72- Meeting of the waters

Still feeling pretty awful from the anti-malarial medication I manage to make it down to the port in the centre of Manaus and board a boat for a river trip on the hunt for *Victoria amazonica* growing in the wild. We pass the meeting of the waters where the dark Rio Negro River originating in Colombia and the yellow Rio Solimões originating in Peru meet and form the Amazon River. The Negro is slower flowing and warmer than the Solimões which is denser and faster moving, this is why the rivers don't easily mix and create such a striking line of contrast where they meet. We dock at a small area of decking and trek into the forest to a clearing where flood waters sit. In this flood water a whole clump of *Victoria amazonica* is growing and flowering. This is a personal highlight for me as I have wanted to see this plant flowering in the wild for a very long time! The plants here die back as the flood waters drop and will then re-grow next year after the wet season.



Figure 71- *Victoria amazonica*

Manaus is only 3 degrees from the equator so has an average annual temperature of 30-35 degrees but the river water levels around Manaus fluctuate 12 meters in height depending on the time of year. Right now is near the end of the dry season so the water levels are low, these *Victoria* will soon die back completely until next year.



Figure 73- Boat on the riverbank

Day 23

Saturday 24th September

Sick day

Day 24

Sunday 25th September

Travel to the airport and fly Manaus-Sao Paulo- Casablanca- London then catch the train to Cornwall arriving in the evening on Monday 26th September.

Conclusions

This was my first horticultural study trip and also my first trip to a tropical country. Having worked with tropical plants for over 2 years at Eden this trip was an absolutely incredible learning experience. To be able to visit both the Atlantic Forest and the Amazon in the same trip was ambitious and exhausting but also an absolute success. In relation to the aims and objectives set out I believe I have learned as much as I could and am looking forward to bringing all of this back to develop the ways in which I work. I feel visiting a mixture of public gardens, botanical gardens, reforestation projects and educational establishments was an excellent introduction into the study of tropical South American flora growing and being cultivated in their natural habitats which is an invaluable experience for my work at Eden and my development as a tropical specialist. The contacts I have been able to make have allowed begin to develop exciting plans for the future such as seed swapping between Eden and Inhotim and also the potential of a donation of orchids from commercial company Orchid Brazil.

To be able to study so many tropical trees in a variety of habitats has proved vital for future planting plans and given me endless enthusiasm for experimenting with new species in the biome. Seeing how this tropical flora performs and what can thrive in particular climates has helped to truly understand the nature of these plants and how I can best manage and maintain the collection I work with to create the most impressive display I can.

This trip has increased my passion for tropical botany and horticulture; I am planning on studying on the KEW Tropical Plant Identification course in summer 2017 to solidify all I have learned during this experience.

Recommendations

This was the perfect trip to travel and cover as large an area as I possibly could. However, if I am able to undertake another trip in the future I would advise spending longer in fewer locations so that I can become more involved in the work happening in each place. For example, spending more time at REGUA would allow me to take part in some reforestation planting work, or to collect seed for their seed bank, rather than a shorter educational visit. I would also endeavour to back up everything I have learned on this trip by seeking more practical experience with experts within the UK, for example a work experience block within the glasshouse collection at Kew to hone in to some real specialist skills and keep this new knowledge fresh.

Financial Summary

Funding received

£939- RHS Coke Trust Bursary Fund

£800- Merlin Trust

TOTAL: £1739

£203- Eden Project (UK transport + vaccinations, not included in breakdown below)

Budget Breakdown

Flights: London- Belo Horizonte: £379

Belo Horizonte- Rio de Janeiro: £49

Rio de Janeiro- Manaus: £179

Manaus- London: £413

Accommodation: £350

Living Costs: £220

Buses/ Taxis: £150

TOTAL: £1740

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Mike Hopkins of INPA for all of his help especially for negotiating my allowance for entry into Reserva Ducke

Image References

All images are my own except Fig. 49 reference: <http://www.ipernity.com/doc/baronijr/13802237>