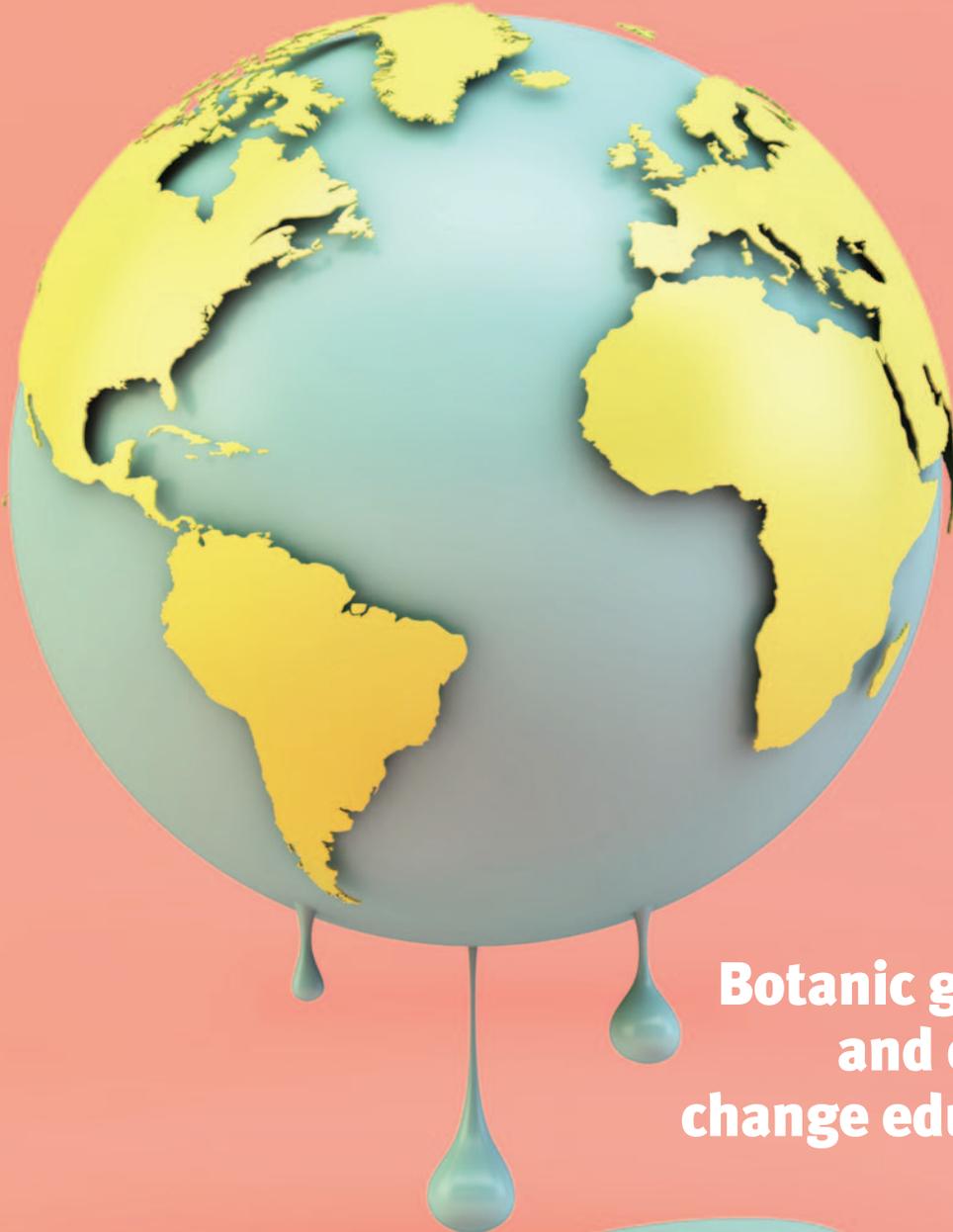


Roots

Botanic Gardens Conservation International Education Review

Volume 18 • Number 1 • May 2021



**Botanic gardens
and climate
change education**



**BOTANIC
GARDENS**
CONSERVATION
INTERNATIONAL

CONTRIBUTE TO THE NEXT ISSUE OF ROOTS

The next issue of Roots is about Measuring Impact. Now more than ever it is important that we can demonstrate the impact of our work – particularly when it comes to our education and engagement programmes. Evaluating our activities is a great first step, but can we go further and look at the short and longer term impact of the engagement work that we do? How are you measuring impact within your engagement or education programmes? Have you developed a new and innovative way of measuring impact?

We are currently looking for a variety of contributions including articles, education resources and a profile of an inspirational garden staff member.

To contribute, please send a 100 word abstract to **dominic.grantley-smith@bgci.org** by 15th June 2021



BGCI'S ONLINE TRAINING PLATFORM

BGCI has launched an online training platform to provide online and blended learning training courses to BGCI members and other interested individuals. The platform, which is Moodle based, allows the creation of a range of interactive content with resources designed to complement BGCI's existing face-to-face training courses, projects and publications.

As we launch the platform there are three modules available:

- An Introduction to Interpretation
- Vegetative Propagation of Threatened Trees
- Defining a Botanic Garden

This latter module is the first in our Botanic Garden Basics series to provide practical training to complement the publication 'From Ideas to Realisation - BGCI's Manual on Planning, Developing and Managing Botanic Gardens' (2016). Further modules will be released each quarter.

Find out more by visiting:

<https://www.bgci.org/our-work/training-and-capacity-building/bgcis-online-training-platform/>

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Forthcoming Issue

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BGCI is a worldwide membership organisation established in 1987. Its mission is to mobilise botanic gardens and engage partners in securing plant diversity for the well-being of people and the planet. BGCI is an independent organisation registered in the United Kingdom as a charity (Charity Reg No 1099834) and a company limited by guarantee, No 4673175. BGCI is a tax-exempt 501(c)(3) non-profit organisation in the USA and is a registered non-profit organisation in Russia.

Opinions expressed in this publication do not necessarily reflect the views of the Boards or staff of BGCI or of its members.

FIRST WORD

BOTANIC GARDENS AND CLIMATE CHANGE EDUCATION

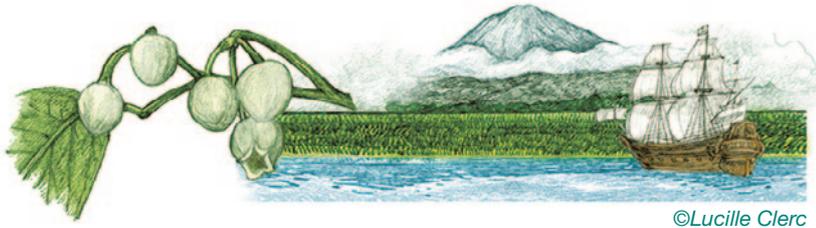
Humans have transformed the planet, but our progress has come at a huge cost to nature with changes in extreme heat, increased rainfall, rising sea levels and the loss of biodiversity just some of the impacts we are seeing as a result of climate change. Climate change is defined as very rapid changes in the climate over the past 50 years, with scientific evidence showing that these changes are mainly driven by human activities and their contribution to global warming (Climate Assembly UK, 2020). We now stand at a critical juncture, with less than 10 years to significantly reduce carbon emissions if we are to avoid the worst consequences of climate change (IPCC, 2016).

It is clear that we are experiencing a climate emergency and high-level action is required, however we cannot rely on governments alone. Every one of us needs to be part of the solution and embrace a more sustainable way of life. But, making that link between our individual actions – the food that we eat and throw away, the way that we heat our homes, the modes of transport we use to go to work or on holiday, or the way that we treat nature – and climate change, can be difficult, with many believing that their individual actions won't make a difference. There is also still much for us to learn about the way in which climate change is impacting our environment and what nature can tell us about how native species are responding and adapting.

Botanic gardens have a key role to play in raising awareness about and engaging visitors with the topic of climate change. This issue highlights the varied way in which botanic gardens are tackling this subject, inspiring action, provoking thought, and involving visitors in important climate change research.

BGCI and Phipps Conservatory and Botanical Gardens have been working together over the last few years to develop a global sustainability challenge project for botanic gardens and share ideas around how we can better engage our visitors to take action. Read about the work that Phipps has been doing around sustainability on page 10. BGCI is also launching a brand new pilot project this year focusing on food waste, challenging visitors of botanic gardens to take on a 30 day food waste challenge, read more on page 6.





©Lucille Clerc

At Cartagena Botanical Garden in Colombia, they have been developing a new forest plot which is being used to collect important data on the impacts of climate change on dry tropical forest habitats. The plot will also be used to train up students in scientific monitoring methods and to engage local visitors with climate change. Read more on page 14. At the Royal Botanic Garden Edinburgh, they have created a new online course about plants and climate change that has already been accessed by over 1000 global students. Read more about the course and find out how you can sign up on page 24.

Citizen science projects are a great way to involve visitors resulting in increased awareness of important subjects, increased scientific skills and understanding, and promoting action. We have two climate change themed citizen science projects in this issue. Read about Chicago Botanic Gardens Budburst project, which is creating community scientists on page 18. And on page 27, read about the Hortus botanicus Leiden's new citizen science project about pavement plant diversity.

There are also many ways to explore climate change education and engagement through botanic gardens. The Tropism Art & Science Collective have developed a new and innovative exhibition to explore the climate emergency, previous versions of which have been successfully hosted by UK and European botanic gardens. Read about this latest exhibition on page 21. On page 35 you can read about the work of the Beijing Educational Botanical Garden to support schools in their climate change education. And on page 31, Missouri Botanical Garden discuss the varied ways in which they have been approaching climate change education.

Finally, this issue includes a climate change resources page, packed with lots of great free resources for educators about the subject (page 42) as well as a short article from Jonathan Drori on his new book – *Around the World in 80 Plants* (on page 39). A must read for any botanic garden educator!

As this issue illustrates, there are many ways in which botanic gardens contribute towards climate change education. However, there is much more that we can do but time is of the essence. We know that we must engage as many people as possible, as quickly as possible, worldwide to address the climate emergency. As a network of gardens that reach hundreds of millions of visitors each year, botanic gardens have the potential to have real impact in inspiring and engaging our audiences into climate change action.



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In its new five-year strategy, BGCI is focusing on how we can use the collective power of our visitors to address global challenges such as climate change and food security. Every year hundreds of millions of people visit botanic gardens around the world. Imagine if we could promote environmental sustainability to each one of these visitors, with each visitor changing just one behaviour after their visit, be that switching to renewable energy, having a meat free day, or reducing their food waste. Just think about the impact botanic gardens as a network could make. This is the premise of BGCI's Sustainability Challenge, a large inspirational project that we are currently developing. Under this larger umbrella, BGCI has also been developing a series of individual challenges and projects that will eventually form part of this wider programme. The first of these is the Fruit and Veg Food Waste Challenge.

THE BGCI FRUIT AND VEG FOOD WASTE CHALLENGE



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FOOD WASTE

In high-income countries such as the UK, food waste generated at the household level represents about half of total food waste (Stancu et al 2016), thus interventions that support households to reduce their food waste could contribute significantly to the UK's annual food waste efforts and our climate change actions. At the same time, numerous studies show we need to eat more fruit and vegetables in our diet and move towards a more sustainable diet. However, the Health Study for England 2018 found that only 28% of adults and 18% of children aged 5 to 15 ate five standard portions of fruit and vegetables per day (NHS Digital 2019). There is therefore a need to develop interventions that tackle the challenge of food waste, but also complement access to healthy and nutritional diets.

The challenge will be open to everyone, but we will particularly focus on families, a target group for botanic gardens.

↳ Edible plants workshops
©University of Warsaw Botanic Garden



↑ Tomatoes ©School Biology Centre Hannover

BEHAVIOUR CHANGE CHALLENGES

Interventions that use challenges to motivate individuals to change their habits and behaviours are common place and there are many popular and successful examples covering all sorts of environmental issues such as sustainable diets, zero waste, plastic and of course food waste. For example Veganuary, which invites individuals to sign up to a vegan diet for the month of January had 250,000 signups for its 2019 campaign. Challenges can however be overwhelming when the task itself feels complicated or there are too many elements to think about. A 2010 study published in the European Journal of Social Psychology found that the more difficult the behavioural change was perceived, the longer it took for the habit to form (Lally et al 2010). Additionally, most current challenges provide little or no support to those taking part. A 2018 study published in the Journal of Biomedical Informatics illustrated that interactive digital support systems are important to help individuals establish specific habits (Karpinnen et al 2018), and there are some nice examples, particularly health focused apps where regular support and progress tracking have been shown to be successful. Some apps such as Fitbit also allow you to invite friends and family and take part in challenges together and this element of gamification in the form of badges, leader boards and incentives is now commonplace among health and fitness apps (Edwards et al 2016). Due to this increase in behaviour change applications for the health sector, there has also been an increased interest in the success and benefit of such applications. Providing useful considerations and lessons learnt that could be applied to future initiatives and new sectors (such as food waste). For example, there is evidence to suggest that applications that offer a diversity of support mechanisms will cater for a wider range of users and are likely to be more successful than a one size fits all approach (Knittle et al 2018).

FRUIT AND VEG FOOD WASTE CHALLENGE

Beginning in March 2021, BGCI is launching the Fruit and Veg Food Waste Challenge – a one year pilot project, focusing on England (due to funding) in which we will challenge households to sign up to a 30 day challenge, reducing food waste with a particular focus on plant based foods that are due to go off or that would be thrown away.

BGCI is launching the Fruit and Veg Food Waste Challenge – a one-year pilot project, in which we will challenge households to sign up to a 30-day challenge.



↑ Food waste ©Grahamphoto23

We want to encourage people to explore the world of fruit and vegetables, appreciate the diversity and versatility that these food types offer in our diets, and showcase the simple ways that we can reduce our food waste, whilst enjoying more fruit and vegetables in our food. By narrowing the focus, we aim to make the challenge more accessible and feasible, whilst still promoting the importance of food waste reduction more generally.

Over the next six months, we will be working with a website designer to develop a bespoke website for the challenge. This will differ from similar websites and/or challenges as interested individuals will be able to sign up directly on the website, to create their own profile. From here, they will be able to add detail on their progress with the challenge, answering a series of questions each week about how much food waste has been reduced. This will allow each individual to track their own progress and compare it to others taking the challenge. As well as being able to compare progress against the challenge community, there will be an option to nominate friends and family to get involved, linking specifically to their profiles and creating a good-natured competition to see who can make the most interesting meals out of food waste and reduce their weekly food waste total.

The website will also act as a forum, where individuals can ask questions, share their progress, photos of the food they have made and recipes they have used. Thereby building a food waste community able to support each other through the challenge. It will also include a resources hub, where challenge participants can find recipes, storage ideas and community food waste programmes. Each individual who signs up to the website will also receive regular messages offering support, hints and tips, which will be tailored using the data they have added. We will use gamification, rewards and social activities to provide a full range of support to individuals and households taking the challenge.

We are aiming to utilise our network of BGCI members to promote the challenge and this summer/autumn will be running up to ten recruitment events in English botanic gardens to discuss the challenge and encourage people to sign up.

The challenge will be open to everyone, but we will particularly focus on families, a target group for botanic gardens. The project will also work with a food waste charity who will provide expertise and advice, and an evaluation expert.

The objectives of the project are:

- To create an increased awareness of food waste reduction in over 1 million people
- To support at least 2500 people to sign up to the fruit and vegetable food waste challenge
- To recruit at least 10 people/households to take part in a more intensive challenge
- To demonstrate that taking part in a challenge can lead to changes in environmental behaviour
- To evaluate the success of different forms of support
- To create a simple challenge (and supporting website) that can be scaled up and replicated

By challenging households to sign up to the challenge and providing a range of support materials, we expect to see a reduction in fruit and vegetable food waste during the challenge period. This will be complemented by an increased awareness of the need to reduce food waste and strategies that work for different individuals. We will show that a commitment to this challenge will lead to an increased interest in adopting other environmental behaviours.

In high-income countries such as the UK, food waste generated at the household level represents about half of total food waste.



↑ Astino vegetables ©Bergamo Botanical Garden

This summer/autumn will be running up to ten recruitment events in English botanic gardens to discuss the challenge and encourage people to sign up.

Following the completion of this one-year pilot, it is our intention to continue to host the challenge website and embed the project within our wider Sustainability Challenge programme, so that any botanic garden in our network can use the website to encourage food waste reduction in their visitors.

If you are an English botanic garden and would like to know how you can get involved with the pilot project please contact Dominic Grantley-Smith (dominic.grantley-smith@bgci.org).

The Fruit and Veg Food Waste Challenge project is funded by the Resource Action Fund - an £18 million fund, provided by Defra and managed by WRAP, which supports resource efficiency projects in England in the key areas of food, plastics, textiles, recycling and litter.



← Edible plants basket ©Sofia University Botanic Garden

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GREENER TOGETHER: A SHARED PATH TO CLIMATE LEADERSHIP

↑ Center for Sustainable Landscapes ©Paul g. Wiegmann

Climate change is a symptomatic problem primarily related to human lifestyles. Botanical gardens are important, respected spaces of respite and learning in their communities. This history of excellence provides the opportunity for gardens to lead their communities to address human and environmental health issues. To conserve and protect nature is critical, but each garden's leadership must also address the root causes of issues like climate change. This article proposes steps to address those causes directly and in a way that can be replicated and amplified by guests, and shares why this is an easier and more impactful process when gardens work together.

The climate crisis is one of the biggest challenges facing the world today, and we — the leaders, horticulturists, educators, and others who bring botanical gardens to the public — can play an essential leadership role in addressing it. The way in which we do so, and our ability to share our resources and work together, will determine our success.

As a species, human beings are natural problem-solvers, but we tend to focus our energy on the symptoms of problems rather than root causes. Much attention is paid to climate change, loss of habitats and biodiversity, and how to slow or reverse the environmental changes we are experiencing. In the short-term, these efforts are critical, but too often left unexplored is the fact that these issues have an inextricable, causal relationship to the lifestyles we lead. By shifting our attention to lifestyles, we can have a significant impact on resolving these issues.

Can we leverage the collective action of botanical gardens worldwide to address these issues on an unprecedented scale?

Can we further leverage this action by engaging all of our constituents, over 500 million visitors per year, to take action themselves?



Botanical gardens are important, respected spaces of respite and learning in their communities. They are trusted, they have evolved to meet the needs of their specific ecoregions and communities, and their points of greatest impact are immediate and local. This history of excellence provides us with the opportunity to be leaders in our communities on human and environmental health issues. To conserve and protect our natural world is important, but each garden's leadership must also address the root causes of the unique environmental issues our communities face and do so in a way that can be replicated, and amplified by guests.

STEP 1: EXAMINE HOW YOU SEE THE WORLD

In her work, author and educator Carol Sanford describes four paradigms for how we interact with the world. The “extractive” model is all about “me”; the individual in this model is either unaware or doesn't care who or what they hurt to get what they want, and the world is seen in fragments, there for the taking. In the “less bad” model, we see a shift in thinking from “me” to “us”; an individual in this paradigm sees the world as fragments, and tries to stabilize them, and reverse some of the bad. This is where the environmental movement started. The “do good” model is also about “us,” but recognizes reciprocity; an individual in this model sees the world as fragments and tries to improve it with their own vision of what good looks like. Some later iterations of green building programs fit this model. The final paradigm is “regenerative”; it is about “us” and seeing the world as a whole interconnected and nested system, a series of relationships that we have with each other, other species, and the planet. Respecting those relationships is key to creating harmony and allowing each entity to develop to its highest capacity based on its own individual essence. This is how many indigenous communities think.

We can be most effective when our organizations and the communities we serve follow a regenerative approach, in which individuals move beyond thinking about themselves in isolation and see the larger social and natural systems that we collectively need to survive.

STEP 2: ENSURE THAT YOUR EFFORTS ARE CONSISTENT WITH YOUR VALUES

Everyone begins a sustainable journey with the best intentions, but it's important to ask yourself the question, “What does ‘good’ look like?” Conduct a thorough audit of your efforts that asks, “Are we addressing or contributing to the underlying problem that is resulting in many environmental catastrophes?” Conducting an energy audit is a good first step; analysis of food service, transportation, water and waste management, horticulture and operations are also useful areas for examination.



↑ Welcome Center ©Paul g Wiegman
 ← Phipps Lower Campus ©Lofty Views Photography

Our goals must carry our organizations and the communities we serve into the regenerative world, in which individuals move beyond thinking about themselves in isolation and see the larger social and natural systems that we collectively need to survive.



↑ Center for Sustainable Landscapes ©Annie O'Neill

Collectively, botanical gardens can have some of the most profound impacts in the world in addressing climate change.

STEP 3: TRANSFORM YOUR OPERATIONS TO REFLECT YOUR VALUES

How do your efforts contribute to regenerative thinking? Begin to apply the questions in Step 2 to everything you do, from capital projects to daily operations, to ensure that your organization is “walking the talk.”

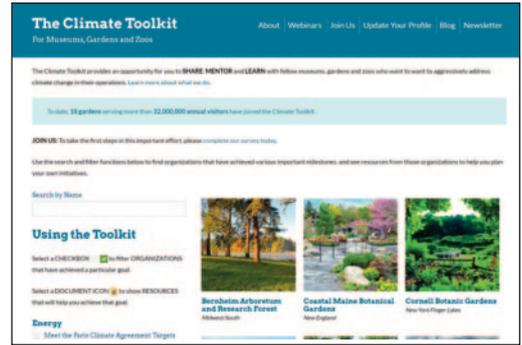
Can we leverage the collective action of botanical gardens worldwide to address these issues on an unprecedented scale? Can we further leverage this action by engaging all of our constituents, over 500 million visitors per year, to take action themselves? Transformation is the biggest and most difficult step, but organizations can help one another. This is where the Climate Toolkit comes in.

THE CLIMATE TOOLKIT ([HTTPS://WWW.CLIMATE TOOLKIT.ORG](https://www.climate toolkit.org))

The Climate Toolkit is a collaborative opportunity for botanical gardens worldwide who want to share information, mentor one another, learn how to aggressively address climate change, and inspire the communities they serve to follow their lead. The Toolkit embraces twenty-four goals for addressing climate change within the categories of energy, food service, water, transportation, waste, landscapes and horticulture, investments, visitors, and research.

The bar is intentionally set high and there is a limit to the time frame gardens can set to accomplish each goal. We have after all a very limited time to stop carbon emissions before we reach the tipping point of climate related disaster.

The Toolkit is built with the understanding that every garden is different, every community is different, every bioregion is different, and each garden will have to prioritize the areas that make the most sense for them to address. There are many actions that are not on the list, and gardens are encouraged to explore and adopt new actions. Gardens are also encouraged to share those new ideas on The Climate Toolkit so that others can learn from what they are doing.



↑ Climate Toolkit

The Climate Toolkit is a collaborative opportunity for botanical gardens worldwide who want to share information, mentor one another, and learn how to aggressively address climate change and inspire the communities they serve to follow their lead.

↓ CSL green roof ©Paul g. Wiegman



The Toolkit also suggests that gardens develop challenges based on their accomplishments that they can use to engage their visitors and communities to adopt in their own lives. For example, at Phipps, we developed a Green Power Drive after we switched all of our electricity to renewable energy. At Phipps, guests can switch their home electricity generator to 100% green power right on the spot, and when they do, they are given a free Phipps family/household membership. Since January 2017, more than 5,500 Phipps guests have switched their household electricity to fossil-free renewable energy, saving the CO₂ emissions equivalent of 92,414 barrels of oil from being burned on an annual basis.

In the future, a youth advocacy program will be added to the Toolkit to engage local youth to develop challenges that they can take out into the community. The Toolkit will link youth between cities and countries so that they can share, mentor and learn from each other as well.

The Climate Toolkit is still in early stages; to date, 18 organizations serving more than 32,000,000 annual visitors have joined. When membership grows to encompass a larger selection of gardens worldwide, bioregion-based filters will be added so that gardens can connect with others that share similar climates.

Collectively, botanical gardens can have some of the most profound impacts in the world in addressing such symptomatic problems like climate change by getting to the root of the problem, human lifestyles, and working to make lasting change. When we do that, not only will we have helped address this and other major symptomatic issues, but we will have set a new path for people to reconnect with nature and think regeneratively about how they interact with the rest of the world.



↑ Green Power Drive ©Paul g. Wiegman

Since January 2017, more than 5,500 Phipps guests have switched their household electricity to fossil-free renewable energy.



↑ ©Paul g. Wiegman

← Exhibit Staging Center ©Paul g. Wiegman

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PERMANENT FOREST PLOTS: A TOOL TO ACHIEVE CLIMATE CHANGE AWARENESS

Educational strategies that allow the public to understand scientific methods are needed to close the gap between science and society, and raise awareness of global challenges. A permanent forest plot within a botanical garden is a unique opportunity to communicate these methods, educate about climate change, and highlight the importance of conserving native ecosystems as nature-based solutions to mitigate global warming. Permanent plots measure the forests' impact on climate as repositories and sinks of carbon emissions, which are essential factors to reach the Paris Agreement's goal of limiting the global temperature increase to 1.5 °C.

The impacts of the current climate crisis are becoming more evident for the inhabitants of the Colombian Caribbean. The erratic rains have affected the regional crop production (El Universal, 2014), and coastal cities, like Cartagena, are threatened by the sea level rise and the frequency, and duration, of extreme climatic conditions such as torrential rains and droughts (El Universal, 2019). These events directly impact the population, resulting in an increased interest in understanding their cause and how to tackle them. During the past decades, science has advanced to understand the reasons and solutions to the current climate crisis; however, these methodologies are often unknown to the public. Involving the population during this process will create awareness of the scientific and educational institutions' efforts to face climate change. Therefore, the Cartagena Botanical Garden created a living experiment to measure its forest carbon stock and educate visitors regarding tools to understand the current climate crisis.

A permanent forest plot within a botanical garden is a unique opportunity to communicate scientific methods, raise awareness about climate change, and the importance of conserving native ecosystems.

↳ Children observing wildlife in the Cartagena Botanical Garden (pre-COVID19) ©Sofia Lissbrant



← The permanent forest plot of the seasonally dry tropical forest is crossed by a path that is accessible to visitors ©Sofia Lissbrant

A way to mitigate climate change is to enhance carbon sinks and strengthen carbon stock through forest cover. NASA, (2021).

THE CARTAGENA BOTANICAL GARDEN – AN OPPORTUNITY TO EXPERIENCE A UNIQUE ECOSYSTEM

Ten kilometres southeast of Cartagena, in the municipality of Turbaco, the Cartagena Botanical Garden protects over 9 ha of seasonally dry tropical forest. Natural springs maintain humidity all year round, and large trees such as espavé (*Anacardium excelsum*), caney (*Aspidosperma desmanthum*), and Spanish cedar (*Cedrela odorata*) dominate the landscape. Howler monkeys, cotton-top tamarins, sloths, and squirrels can be seen and heard in this crucial forest remnant that is also a hotspot for bird watching, and the site of the discovery of several new insect species. Of the 65,000 yearly visits to the Garden, the majority are from school children and subsidized visits by low-income urban populations, for whom the Cartagena Botanical Garden may be one of few opportunities to experience and understand this unique ecosystem.

The Colombian Caribbean dry tropical forest has a highly seasonal rainfall pattern, with less than 1500 mm per year. For Cartagena, the rains are divided into two distinct periods; dry season from December to April, and heavy rainfalls from August to November. These harsh climatic conditions have resulted in unique biodiversity adapted to hydric stress with a substantial endemic species presence. However, the forests are highly threatened due to the loss of cover caused by agriculture, mining, and expanding cities. In Colombia, only 8% of its original extension remains, and of this area, only 5% is protected (Pizano and García, 2014). In addition to anthropogenic pressures, climate change increases species vulnerability as the rapid rainfall variations, temperature swings, and elevated rates of atmospheric CO₂ (National Research Council, 1993) are not allowing time for proper plant adaptation.



↑ Orlando Escobar and Juan José Tapasco, undergraduate students from Universidad de los Andes collected and analyzed the first data set from the permanent forest plot ©Viviana Londoño-Lemos

← The Cartagena Botanical Garden is the home of several families of howler monkeys (*Alouatta seniculus*) that are frequently seen and heard in the area ©Maria Paula Contreras





PERMANENT FOREST PLOTS AS TOOLS TO STUDY CLIMATE CHANGE EFFECTS AND TRAIN NEW RESEARCHERS

Because of their cultural significance for the Caribbean people, vulnerability, and limited knowledge regarding their potential as carbon sinks, the Colombian Caribbean seasonally dry tropical forests need to be further studied. Forest carbon data exist from some locations, but the carbon accumulation values vary widely (Phillips *et al.*, 2016; Montes-Pulido, Parrado-Rosselli and Álvarez-Dávila, 2017). Therefore, we set the goal to determine the Cartagena Botanical Garden forest remnant's carbon stock and create a setting to educate the public on this research methodology. We established a 1 ha permanent forest plot within the Garden's native forest and collected data regarding the vegetation's composition, structure, and function. This initiative was carried out with two undergraduate biology students from Universidad de los Andes. We found a total of 1568 tree individuals with more than 2.5 cm diameter at breast height in 62 species, and the forest was estimated to contain 93.7 Mg/ha of total biomass, equivalent to 42.7 metric tonnes of stored carbon. The plot data is freely available through the Colombian (SIB) and Global (GBIF) Biodiversity Information portals (Londoño-Lemos *et al.*, 2020). Since it is easily accessible, the permanent forest plot is now used to train students in measuring techniques and data analysis, allowing future researchers to get hands-on experience that will serve them during their professional careers.

VISUALIZING SCIENCE

In addition to generating scientific information and training new researchers, the permanent forest plot brings an opportunity to educate visitors on climate change topics. There is a path crossing the forest plot that visitors can access. When walking through this area, they can enjoy the natural structure and biodiversity of a seasonally dry tropical forest, and see how the trees have been mapped and tagged for future sampling to establish growth and carbon sink rates. Visualizing evidence of research activities creates an opportunity to bridge the gap between science and the people, who often have little experience of such tasks.

← Visiting the seasonally dry tropical forest and the permanent plot creates an opportunity to communicate science (pre-COVID-19) ©Elmer Arrieta

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Although the permanent forest plot was recently installed, and the COVID-19 pandemic has limited the Garden visits during the past year, we foresee that school children and the general public will soon return to the Garden. The permanent forest plot now constitutes a valuable tool to reach out to the community. We will implement guided tours in the forest plot to raise awareness about climate change and the importance of the seasonally dry tropical forest ecosystem. This initiative will also serve as a training site for future students developing similar forest plots in the Colombian Caribbean region.

We aim to include the forest plot information in our citizen science programmes by generating dynamic content for facilitating scientific communication. Some of our current approaches include photo identification guides through a partnership between BGCI and PlantSnap, and observation registration through the iNaturalist and eBird platforms. We also plan to install informational signage to explain the purpose, process and results of the study.

CONCLUSIONS

As scientific and educational institutions, botanical gardens must develop strategies to conserve and restore native ecosystems by closing the gap between science and people. The Cartagena Botanical Garden has assumed this mission with the Colombian Caribbean seasonally dry tropical forests by building a permanent forest plot that contributes to achieving four objectives: (1) conserve the native flora and fauna, (2) understand the forest dynamic and role as a carbon sink, (3) train new researchers, and (4) educate visitors on the methods to study climate change.

ACKNOWLEDGEMENTS

We thank the “Fundación para la promoción de la investigación y la tecnología” of the Colombian Central Bank for co-financing this project, and Álvaro Javier Duque Montoya for his valuable inputs regarding the methodology. We also thank Juan José Tapasco García and Orlando Andrés Escobar Hadechini for all their hard work with collecting and analysing field data.

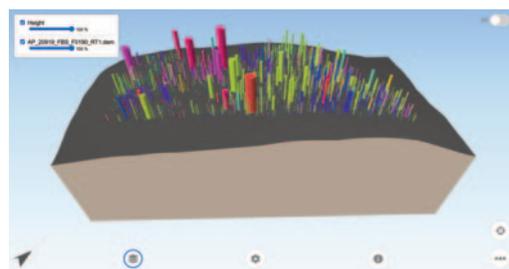


↑ The permanent forest plot is being used as a tool to teach students how to collect ecological data ©Sofia Lissbrant



↑ Student learning how to use a laser range-finder to measure the height of the trees ©Sofia Lissbrant

Visualizing evidence of research activities creates an opportunity to bridge the gap between science and people who often have little experience of such tasks.



↑ 3D visualization of the species, heights, and diameters of the trees measured in the forest plot (<http://www.jbgb.org.co/ParcelaJBGPI>) © Santiago Madriñán

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USING BUDBURST FOR CLIMATE CHANGE RESEARCH AND CLIMATE SCIENCE EDUCATION

Budburst is a community science program at Chicago Botanic Garden that brings together researchers and community scientists to answer climate change research questions by observing the timing of plant life cycle events. Budburst connects people to the nature in their neighborhoods, increases science literacy, and is used for place-based climate science education, all of which help increase awareness and action. With a new mobile app and website, in both English and Spanish, we hope to reach a much broader audience. Community scientists and botanic gardens can set up special projects or groups tailored to their species and questions of interest.

Budburst, a project of the Chicago Botanic Garden, brings together researchers, educators, and community scientists on a shared journey to uncover the stories of plants and animals affected by human impacts on the environment. Budburst has historically focused on plant life cycle events, also called phenology. Recently, we have expanded our research focus to include specific, time-bound ecological research questions that not only focus on plant phenology but on plant-animal interactions as well. Budburst addresses climate change topics directly, through the research questions we investigate, and also works to combat climate change by engaging community members and students in this research, increasing their connection to the nature around them, and improving science and environmental literacy.

↑ *Students planting a native pollinator garden*
©Chicago Botanic Garden

Budburst strives to foster a welcoming environment that provides research and educational opportunities for people of all ages and backgrounds.

Budburst contributes to advancing climate change knowledge through our long-term phenology project and short-term, focused research projects. Since its start in 2007, Budburst has focused on collecting plant phenology data to document when plants go through seasonal changes. We now have a dataset with over 100,000 data points from all 50 states and Canada, collected by over 16,000 community scientists. Having such an expansive dataset across a wide geographic and temporal range allows Budburst data to be used to answer questions about how plant seasonal changes have shifted in comparison to historical datasets.

In addition to the long-term phenology research, Budburst has recently expanded our work to include shorter-term, ecologically focused research projects that center on plants and climate change and plant-animal interactions. One such project is EcoFlora, which was founded by the New York Botanical Garden in 2018. The project has expanded to include several new partner gardens all across the US, including Budburst and the Chicago Botanic Garden. All EcoFlora projects are dedicated to cataloging urban biodiversity but each participating garden has their own focus. At the Chicago Botanic Garden, our focus is on native and invasive plants. We use monthly 'EcoQuests' to direct Budburst participants to collect data on native plants that are important for pollinators and emerging invasive plants that could become problematic in the Chicago region.

Last year Budburst also launched a new research project, Milkweeds and Monarchs. Monarch populations are suffering from a sharp decline, in part due to habitat loss and exacerbated by unpredictable milkweed flowering timing due to phenological shifts as a result of climate change. For this project, we are investigating whether monarch butterflies preferentially lay more eggs on flowering or non-flowering milkweed plants, potentially due to decreased predators on non-flowering plants. Participants in this project observe milkweeds patches, monitor plant phenology, and document monarch egg and caterpillar presence. Learning about the important ecological relationship between monarch butterflies and milkweed plants, while helping to preserve the monarch population in the face of global change, helps participants engage in local conservation and deepen their understanding of the scientific research.

Community scientists that participate in Budburst are able to collect data for many different research projects that all contribute to conservation efforts and will ultimately help us better understand how plants are responding to human impacts on the environment. Participating directly in community science research allows participants to engage with research in a meaningful way and have an important impact in the field of climate science.

Alongside our research-related goals, Budburst prioritizes education as one of our central aims. Our project makes climate change visible by providing hyper-local, place based, educational opportunities. We hope that participating in a community science project focused on global change helps to create a population that understands the fundamental importance of scientific data and analysis in personal and public decision-making. Budburst provides free, publically available curriculum for student grades - pre-kindergarten through college, covering a variety of topics including plant life cycles, pollinators, seasonal change, data analysis, and climate change. Locally, we partner with schools and colleges in the Chicagoland area on our Nativar research project, in which students make pollinator observations on native and cultivated varieties of native plants (nativars). More recently, we've teamed up with Scholastic to create a Budburst Plant Trackers curriculum for grades 3-6. By helping students build personal connections to nature, become scientifically literate, and understand that climate change is happening in their own backyards, Budburst is working to create a new generation of environmentally educated, and climate change aware youth that will grow into engaged green community members.



↑ Students learn about plants and pollinators as they set up their Budburst research garden ©Chicago Botanic Garden

Community scientists can contribute Budburst data on any plant at any location to help us better understand how climate change affects plant phenology.



↑ Budburst participants can collect data on monarch butterflies and milkweed plants with our new research project ©Chicago Botanic Garden



Budburst strives to foster a welcoming environment that provides research and educational opportunities for people of all ages and backgrounds. We have done this by creating a project in which data can be collected on any plant at any location, providing free educational materials, and making our data publically available. Additionally, we are working on two innovations that will make Budburst accessible to an even broader audience. We are building a mobile application, the Budburst App, and we are translating all of our online content and educational materials into Spanish.

In March 2021, Budburst launched the Budburst App, a mobile app that allows participants to upload data directly from their phones. With this app, Budburst community scientists are able to more easily take photos of plants in their neighborhoods or on hikes and collect and submit data on the go. The Budburst App also integrates iNaturalist technology to create an in-app plant identification tool to assist users in accurate data collection. Now, more than ever, you do not have to be a plant expert to use Budburst! Budburst users will be able to map their own plant observations, join local groups to collaborate with fellow community scientists, and complete Budburst Challenges to help us collect important data. With the Budburst App, collecting data with Budburst is easier than ever before!

In 2021, Budburst will expand its work in several ways that aim to break down barriers of racism and historical inequity that have excluded communities from nature and conservation. We work towards these goals by partnering with neighborhood organizations and schools in majority Latinx and majority Black communities that have been historically underrepresented and marginalized in conservation work. We are also creating a bi-lingual app and website in an effort to engage a more diverse population than has been traditionally served by community science programs. The translated materials will allow Spanish-speaking members of our community to more easily participate in community science, collect and analyze data, and learn about the plants and animals in their neighborhood. The translation of the Budburst website, mobile app, and accompanying educational materials will facilitate broader participation in community science and help engage families and students that have previously been unable to participate due to the inaccessibility of project materials.

Whether you're an aspiring community scientist, a botanic garden or nature center, or an educator, there's a way for you to engage with Budburst. Budburst community scientists can make plant phenology observations, observe plant-animal interactions to help support monarch populations, or document urban biodiversity with an EcoFlora project. With the use of the Budburst App and our online and educational materials in Spanish, we aim to be a community science project that anyone can enjoy, participate in, and contribute meaningful data to - whether you're a plant expert or are just taking a walk around your block.



↑ Community scientists collecting valuable data about plants and their pollinators ©Chicago Botanic Garden
 ↩ Anyone can contribute data to Budburst through our various research projects ©Chicago Botanic Garden



↑ Students and Budburst staff planting a research garden at a Chicago-area school ©Chicago Botanic Garden

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FLORA'S ARK AN ARTISTIC SEED BANK AND STATEMENT OF HOPE

Flora's Ark, the photosynthesis solution

Climate change is a catastrophe in slow motion, caused by the way humans relate to nature. It might already be too late to reverse the trend. Our planet will then become largely uninhabitable. Research into terraforming Mars will soon be applicable on Earth. Starting from this disturbing idea, the artist group Tropism Art & Science Collective proposes an exhibition concept for botanic gardens called Photosynthesis. With photography, art, film, and installations they investigate ways of perceiving nature differently from the common perspective. The centrepiece is Flora's Ark, a monumental terraforming time capsule with a small seed bank.

THE CLIMATE EMERGENCY

As a term, climate change doesn't sound very threatening. Changes can be good or bad, and what harm is there in a slight rise of summer temperatures anyway? But in fact, what we are dealing with is a major catastrophe threatening life on earth, and it is happening right now.

The artists of the Tropism Art & Science Collective investigate a scenario in which this climate catastrophe is already irreversible. It cannot be stopped, only be slightly toned down. Each year rising temperatures break record after record. Forests are burning, the polar ice caps are melting, sea levels are rising, permafrost is melting, deserts are spreading, storms and flooding are more frequent and severe, and pandemics are rampant. Animals and plants are becoming extinct at a speed not seen since the end of the age of the dinosaurs. Meanwhile, we clear-cut forests in an unprecedented way, pollute air, water and soil, suffocate the oceans with plastics, drill for oil in the last remaining wildernesses, and so on.

↪ *Biotope Box installation with sweeping plants, symbolises the remaining rainforests*
©Margot van de Stolpe

Animals and plants are becoming extinct at a speed not seen since the end of the age of the dinosaurs.

What we have to do is some serious terraforming.

Flora's Ark wants to be a monumental statement of hope.



← Help, projection mapping installation showing video typography with raging wild-fires
©Alfred Marseille

Extrapolating the statistics of this ecocide shows that someday soon the earth will become a barren place not unlike Mars. In anticipation of this scorched earth, we should already now prepare to revitalise the planet into the green-blue one it once was. What we have to do is some serious terraforming. The good thing is, we can do it right here, on earth. By not going to Mars we can even save billions in travel expenses. But we have to prepare for it right now.

JOIN FLORA'S ARK

The idea in anticipation of this worst-case scenario is the project 'Flora's Ark'. An initiative for botanic gardens, zoos, science museums, and other institutions. A Flora's Ark is a monumental artwork consisting of a time capsule containing a small seed bank and instructions to build a water vapour condenser for emergency irrigation. This enables small scale, but widespread, terraforming opportunities for future use. If you join, we can make this into a real Flora's Ark Armada.

STATEMENT OF HOPE

Of course, many botanic gardens do already have conservation plans and maintain seed banks. By proposing the idea for future terraforming, Flora's Ark aims to raise public awareness about the severeness of the climate catastrophe and the need for conservation.

Most of all, Flora's Ark wants to be a monumental statement of hope. Probably, most of the seed banks of the Flora's Ark Armada will not really be utilised in the future. They metaphorically state the hopeful promise of the resilience of nature and of mankind. Because the only sustainable solution to global heating is the elementary process of life itself: the photosynthesis of algae, of plants, of forests.

CONCEPT OF THE CLOSED SEED CONE

The concept of the Flora's Ark time capsule is inspired by the serotinous behaviour of certain pinecones releasing their seeds after a fire. Likewise, the time capsule will be opened only after being exposed to severe heat, fire and drought. With this concept in mind, each time the capsule will be designed by a different artist or team, in consultation with the participating venue.



↑ Flora's Ark monumental time-capsule, seed bank inspired on the cabbage butterfly egg
↑ Flora's Ark monumental time-capsule based on the serotinous phenomenon of a Banksia, simulated at the Hortus Botanicus Amsterdam ©Tropism team

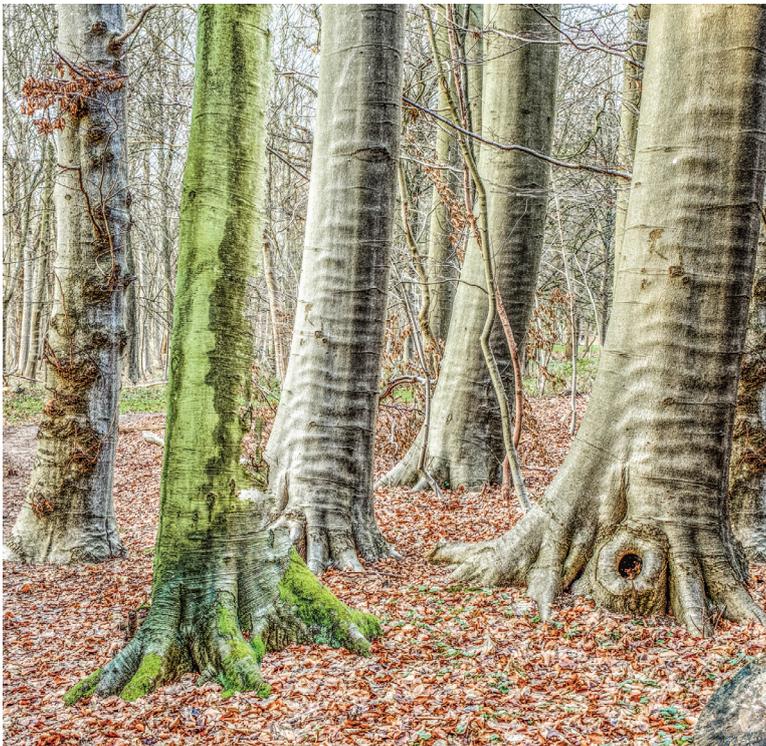
The concept of Flora's Ark time capsule is inspired by the serotinous behaviour of certain pinecones releasing their seeds after a fire.

THE PHOTOSYNTHESIS EXHIBITION

The Flora's Ark monumental seed bank will also be the centrepiece of an exhibition called Photosynthesis. The Tropism Art & Science Collective has curated exhibitions under this name in the Hortus Botanicus Amsterdam (2013), in the Royal Botanic Gardens Edinburgh (2015), and in the Dutch Flower Art Museum (2018, 2019 and 2020). The exhibition in Edinburgh was the largest, with 140 artworks, 10 films, two big installations, and a plant concert. These exhibitions, made by artists and scientists associated with the collective, emphasize the fundamental source and force of life: photosynthesis. They are shedding new light on plants and do so in a variety of ways, often using scientific visualization techniques. The current exhibition proposal, called 'Photosynthesis versus Ecocide', focusses on the extrapolated impact of the climate catastrophe. Disguised as an art exhibition it confronts us with treats like deforestation, dying coral reefs, mass-extinctions, and the misperception of biomass. It celebrates the most important and elementary force of life: Photosynthesis. Interested venues can visit the page www.tropism.eu/floras-ark for more information and guideline downloads.

TROPISM ART & SCIENCE COLLECTIVE

A tropism (from Greek τροπος, tropos, 'a turning') is a biological phenomenon, indicating a turning movement of a biological organism in response to an environmental stimulus. The most common example of tropism is a plant growing in the direction of light. Taking their lead from the biological phenomenon, the Tropists are a Dutch collective of installation artists, visual artists, photographers, designers, filmmakers, technologists, and scientists. In their work, they deal with phenomena occurring literally or figuratively at the edge of perception - events that are hardly noticed, but which trigger reactions similar to the way plants respond to light. The Tropists feel a great affinity with the natural world, and their work seeks to depict natural phenomena in new and unusual ways. Tropism triggers the tide to turn.



↑ "Leyduin" from the series Places, unravelling virtual forest landscapes ©Alfred Marseille



↑ From the series Flora Imago, a trampled down herbarium of yesteryear ©Margot van de Stolpe



↑ Sample of a series of contemporary dead trees photographed in infra red giving a future view in an apocalyptic spectrum ©Robin Noorda



↑ Diorama artwork made in X-ray. The transparent flowers with chameleon stand for the resilience and adaptivity of nature ©Arie van't Riet

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In September 2020, Royal Botanic Garden Edinburgh (RBGE) released a free, interactive short course, Plants and Climate Change, which explores the relationships between plants and the changing climate and looks at how everyone can take action to reduce climate change. Since launching, the course has attracted over 1200 students and feedback shows it has inspired learners to find out more and play their own part by making changes to their behaviour. Collaboration between different departments has led to the development of a unique and successful course, which focuses on the topic of climate change through the lens of plant life.

AN ONLINE OPPORTUNITY FOR ENGAGING PEOPLE WITH THE CLIMATE EMERGENCY

INTRODUCTION

Climate change is a defining issue of our times and the need for action and behaviour change is imperative. Awareness of and interest in climate change, biodiversity loss, and sustainability is greater than ever before, with the COVID-19 pandemic serving to further highlight the value of nature to people's lives.

The ability to educate people about the world around them, what is happening in it, and what they can do to tackle issues, is one of the most powerful tools we have to tackle climate change and biodiversity loss. Education of all people is extremely important - children and adults, and people at all levels of society. Knowing about something gives it deeper meaning and helps us find solutions. Once we have knowledge, it can be passed on to others.

Engaging people in climate change education works towards RBGE's strategic objectives (RBGE, 2021a) and in September 2020, we released a new, free short course: Plants and Climate Change. This course has been designed for young adults and adults, and takes 4 - 5 hours to complete. It is hosted on RBGE's online learning platform, PropaGate Learning (RBGE, 2021b).



Royal
Botanic Garden
Edinburgh

↪ *Alpine blue-sow-thistle, Cicerbita alpina, one of the species in the course and the focus of a propagation and translocation project at RBGE aiming to give this rare UK species more resilience to changing environmental conditions and damaging events. ©RBGE*

COURSE CONTENT AND FORMAT

Plants and Climate Change is for anyone who wants to know more about climate change, how it relates to plants and what they can do about it. It has four sections:

- climate
- effects of climate change on plants
- how plants influence climate
- ways in which we can all help reduce climate change

This course builds on the momentum gained around climate action in recent years. It aims to raise awareness and knowledge of the issue of climate change and impacts of the climate emergency, and to draw attention to how plants are affected, and the roles they play in regulating climate. It invites people to consider the importance of nature-based solutions, and conservation, and encourages them to commit to taking action and to share this commitment with others.

The course acknowledges that COVID-19 has changed the way we live and the way our societies and economies function, concentrating on this as an opportunity to reflect, both as individuals and as a society, and to decide what sort of recovery we want to see. Focusing on the issues relating to climate disruption through the lens of plant life gives a different viewpoint to the majority of online courses about climate, engaging potential learners through an area of interest while linking this to the wider world.

By introducing a variety of concepts, topics, and case studies, and linking to external information sources, the course offers an insight into RBGE's wider work, hopefully encouraging learners to educate themselves further. As such, it is an entry point for learning about the wider world of plant and biodiversity conservation and science, all topics included in RBGE's wider education offer (RBGE, 2021c).

The illustrative examples attempt to be relevant to people around the world, though since the audience was anticipated to be predominantly UK-based, there are specific examples from Scotland and the UK to help people connect to the issues and concepts being discussed. Interestingly, although the greater proportion of learners are UK-based, people from 75 countries have registered, which is extremely encouraging.

The course was created using Articulate's Rise 360. This software allows for interactive elements such as flip cards and labelled graphics, as well as embedding of test-your-knowledge questions and videos. Such variety of interactive elements makes the course more engaging for learners; however, these same elements can make the course less accessible to some users, and alternative text-only versions are provided.

COLLABORATION AND SHARING

There was a team of two core education staff developing Plants and Climate Change. Input to the content, and reviewing of the course during planning, development, and before release was a collaboration between members of RBGE staff and research associates from departments including Education, Horticulture, and Science. This range of perspectives and specialist expertise led to a well-rounded course that has been thoroughly reviewed for content and ease of understanding. In the process, new working contacts have been established.

Working on this project alongside development and maintenance of current courses was a challenge, made more challenging by the onset of the pandemic and lockdown. Lockdown meant increasing RBGE's online delivery and moving previously face-to-face teaching to online, as well as

Statement of Participation

Plants and Climate Change

Heather Forbes (tutor)

has completed the course, Plants and Climate Change, offered by the Royal Botanic Garden Edinburgh.

This 5 hour course explored:

- what climate and climate change are and why climate change is happening
- the effects and impacts of climate change and a brief overview of biodiversity and its relationship with a changing climate
- how plants are impacted by a changing climate
- ways in which plants themselves have an effect on the climate
- how we can all help reduce climate change and its effects, from individual and local actions through to regional and global measures

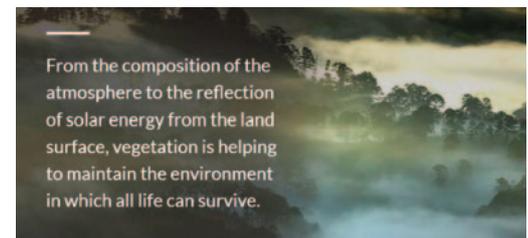
This statement does not imply an award of any RBGE qualification. It confirms that the participant completed a 5 hour short course.

Issue date: 17 February 2021

Verification code: 7ld2fpdeVm



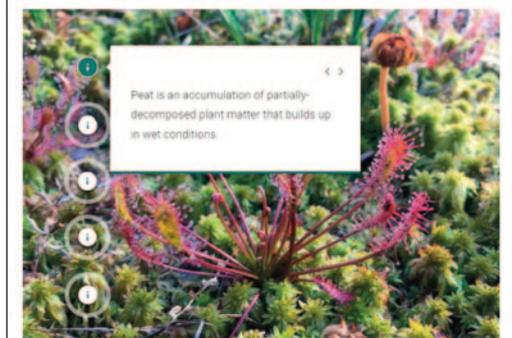
↑ A statement of participation is available for learners to download if they wish; in this way, although the course is not credit bearing, the learner's commitment and completion of the programme can be shown, which may be of interest to employers ©RBGE



↑ A screenshot from the Plants and Climate Change course ©RBGE (images used under Pixabay Licence)

Peatlands

Click on each of the information icons on the image below to find out how these habitats act as sinks for storing carbon



↑ An example of a labelled graphic in the course, in 'Plants as sinks for carbon'. Information boxes appear when the markers are clicked ©RBGE (images used under Pixabay Licence)

furloughing of many staff. Increased workload and adjusting to new work conditions slowed progress of the course, but some re-allocated funding, and dedicated time, helped get us back on track.

The format of the course makes it easier to potentially share and collaborate with other organisations, and to incorporate into RBGE's other educational programmes. We are currently working on embedding it in RBGE/Scotland's Rural College (SRUC)'s HND/BSc Horticulture with Plantsmanship. There is the possibility of creating future versions aimed at specific audiences and expanding particular subject areas.

Actively promoting the course not only through RBGE's social media and marketing, but through BGCI, PlantNetwork, and more has boosted the visibility of the course and led to increased learner numbers.

INCLUSIVITY AND ACCESSIBILITY

When the course concept was discussed, the decision was made to make it entirely free. By doing this it is hoped the course will be accessed by a wider audience, including those who could not afford to pay for it. A PropaGate Learning account is required to access the course; this lets us monitor how many people register and participate.

Online delivery allows a greater number of people to take part than is possible in face-to-face learning. It also allows people across the world to take part: particularly important when the topic is a global one, like climate change. Of course, online delivery does not make resources available to everyone: many people do not have access to reliable or affordable internet or laptops/mobile devices. The issue of digital poverty is key to considering the long-term accessibility of our offer.

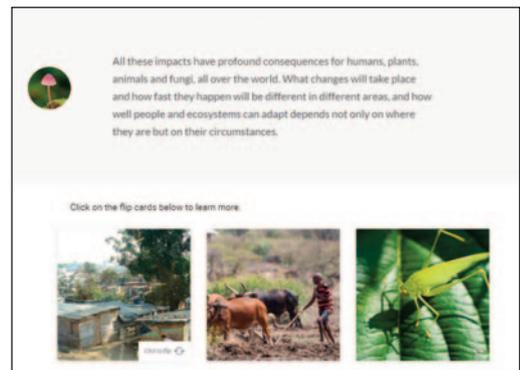
We have worked to make the course as accessible as possible through compatibility with screenreading technology and keyboard navigation, use of alt text, the capacity to adjust text size, and a responsive layout for mobile devices.

To date over 1200 people have registered for the course, with around half this number having actively participated in the course so far.

FEEDBACK AND ACTIONS INSPIRED

An optional feedback form is included at the end of the course, which asks learners' opinions on the course and content, subjects they are interested in finding out more about, and what action for the climate (if any) they have been inspired to take by what they have learned. Of the feedback received to date (approximately 13 percent of those who have participated), all rated the course as Excellent or Above average.

Learners have been inspired to engage in a range of climate actions, from recycling more to saving energy; using alternatives to peat-based compost to growing more of their own veg; gardening for biodiversity to planning to install a green roof; joining a pressure group and considering climate in politics to talking to others; and more. Several people involved in education themselves said what they had learned would inform the courses they teach. We have even inspired a possible phenological study at another botanic garden!



↑ A screenshot from the course, showing an example of flipcards ©RBGE (images used under Pixabay Licence)

The ability to educate people about the world around them, what is happening in it, and what they can do to tackle issues is one of the most powerful tools we have to tackle climate change and biodiversity loss.

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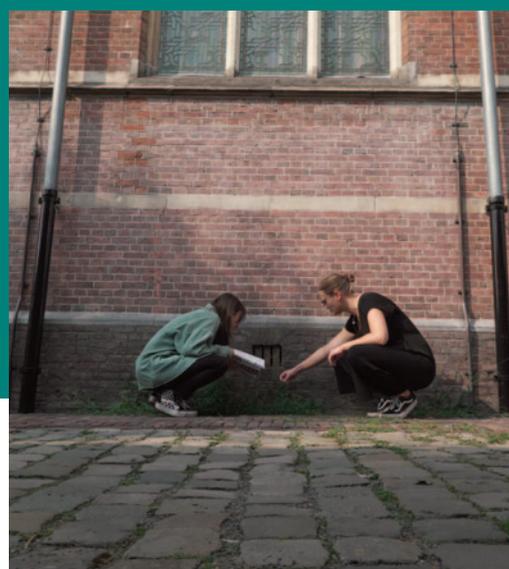
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PAVING THE WAY TO GREENER CITIES WITH PAVEMENT PLANTS

At the Hortus botanicus Leiden we have been working up to a citizen science project involving pavement plant biodiversity and ecology, launching in 2021. In our increasingly urban world, nature might not seem as close by as in the past. By noticing and looking at the wild plants growing in the city we want to stimulate citizens of all ages and backgrounds to appreciate and enjoy nature in their direct environments, however small. Urban nature can improve mental wellbeing and offers valuable ecosystem services involving heat, fire and water management.

At the Hortus botanicus Leiden an interest in pavement plants started with an idea for a project on invasive plant species in the city. Highlighting only invasive species would however, most likely turn into a very negative story. Thus, the interest broadened out to involve all matter of city plants, especially the many small and often overlooked species. During the last year, many ideas for education on the topic of these plants came to fruition. Moreover, funding was found to facilitate educational activities and start a PhD research project on citizen science and pavement plants. With this pavement plants project, we hope to contribute to greener and more climate proof cities.



↑ Identifying pavement plants on the streets of Leiden

©Robbert Folmer

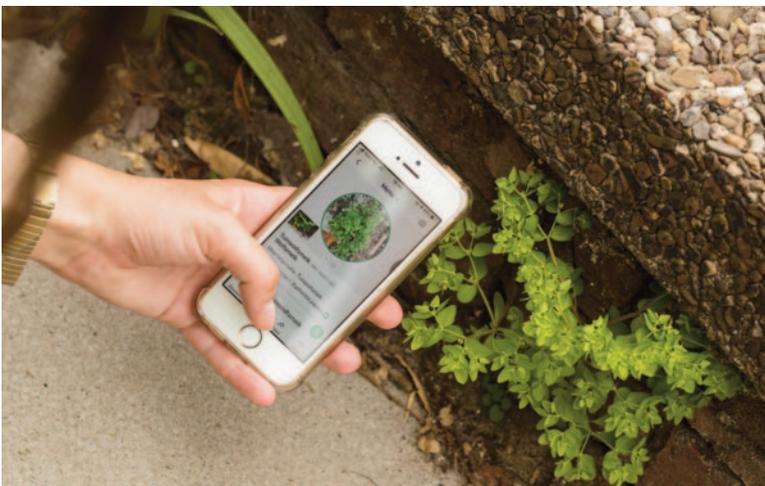
↵ Botanical chalking on the streets of Leiden

©André Biemans



Many pavement plants are known as weeds and are actively removed from our gardens for understandable reasons, like aesthetics, practicality, and their competition for resources with your chosen garden plants. Pavement plants have a bad image. These plants growing in the cracks of our pavement, and other unlikely places, are adapted to an urban climate and can be very tenacious. This, on the other hand, is exactly why they continue to thrive in this environment and why they deserve more admiration and appreciation. In our increasingly urban world, nature might not seem as close by as in the past. However, nature is still everywhere around us. Nature strives to fill all the possible niches, including the cracks we leave in between the pavement stones.

In the Netherlands and Flanders 1,350 plant species grow in our cities, which makes up about two thirds of the total amount of wild plant species (Denters, 2020). Therefore, cities are very biodiverse. By noticing, and naming the wild plants growing in the city we want to stimulate citizens of all ages and backgrounds to appreciate and enjoy wild plant life in their direct environments. This subject lent itself well to the lockdowns we experienced during COVID-19 because pavement plants grow right outside everyone's own door. Botanical chalking, an activity known from France and Britain also caught on in the Netherlands. We gladly participated in and stimulated this hype. During our time of working on and communicating about this project, we have received much interest and many positive (online) reactions from our visitors and the municipality. This functioned as a great stimulus for the citizen science project, which is about to take off.



← Botanical chalking on the streets of Leiden
©Simone Both



↑ Communications colleague Mathilde Simons with the pavement plant pots in the garden. She has worked hard on the social media success of the project ©Simone Both

Nature strives to fill all the possible niches, including the cracks we leave in between the pavement stones.



↑ *Draba verna* growing on the streets of Leiden
©André Biemans
← Identifying a pavement plant using the Picture This app ©Simone Both



← Botanical chalking on the pavement plant pots in the garden ©Simone Both

The aim of the citizen science project is to combat plant blindness by increasing attention for, and appreciation of plants (Wandersee & Schussler, 1999). The research questions focus on pavement plant biodiversity and ecology as well as the effect of participation on the citizen scientists. Increasing the interest and knowledge on the importance of urban plant life could empower citizens (Bonney et al., 2009; Cornwall, 2008). By increasing scientific literacy, botanical knowledge, and providing open data, we strive to stimulate citizens to formulate their own questions about urban plant life and possibly even take action on this front. Thereby, we hope, to lead the way towards increasingly green and climate proof cities.

Plants in cities provide ecosystem services that help decrease heat, air pollution, water runoff, and flood risk. Green spaces also promote physical and mental wellbeing in citizens (Lee, Jordan, & Horsley, 2015; Livesley, McPherson, & Calfapietra, 2016). Altogether, enough reason to take a closer look at the role of plants in urban planning and city management. There have already been many successful projects, both nationally and in Leiden to create greener, more sustainable cities like: Paving stone out, plant in! (by Stichting Steenbreek), planting forest gardens on schoolyards (by the national institute for nature education, IVN) and removing plastic pollution (by Plastic Spotter). This last project laid bare how thousands of single-use beer cups ended up in the canals after a city festival. This led the municipality to ban these single-use cups in favour of reusable cups. We admire and hope to achieve similar tangible results with this project on pavement plants that focuses on education and citizen science.



↑ The pavement plant mini guide with a key to identify 52 species ©Nienke Beets

We think knowledge about plants and how they work is a crucial part of education on climate change and pavement plants are a good medium to tell that story.

By making all botanical data open access, transparency is provided and citizens are invited to explore the data themselves.

← Illustration of *Oxalis corniculata*, Illustration of *Cardamine hirsuta* ©Nienke Beets





Looking at the progress already made over the last year; we have executed educational activities and developed products relevant to the citizen science project. A poster was made showing 52 pavement plants, one for every week of the year, with a box to note down when or where the plant was first seen. Two identification keys, one for 52 and the other for 104 pavement plant species were made, and published, as a mini guide and a pocket guide with the Royal Dutch Association for Natural History (KNNV). We have successfully organized crowd funding to commission an illustrator to draw a beautiful map of Leiden, which will be used in our citizen science project to show where citizens have identified pavement plants. For the National Art Week, we were present along a walking route highlighting pavement plants with picture frames and connecting with the public. A pavement plant colouring book was published and in April 2021 a Science Café was organized, presenting a first version of our citizen science input platform. During this time, social media accounts and a newsletter were set up, which have accumulated thousands of followers. These efforts were made possible by collaborating with many other institutions, as well as a lot of hard work by volunteers and students.

For the citizen science project, we are working hard to make it as inclusive, approachable and inviting as possible. Last summer for example, a group of honours students tested the most prominent apps for identifying plants. Combining modern technology for education and community building with regular physical events, we hope to build lasting relationships with the participating citizen scientists. By making all botanical data open access, transparency is provided and citizens are invited to explore the data themselves. We expect a modest number of them might use this opportunity to work with the data in detail. Working together with them could lead to surprising research questions and results.

Studying both plants and how we can stimulate more people to study plants using citizen science, befits an academic botanical garden like the Hortus botanicus Leiden. We think knowledge about plants, and how they work, is a crucial part of education on climate change, and pavement plants are a good medium to tell that story. Moreover, our research might help other gardens in their connection with the public and their (citizen science) volunteers. More information about our citizen science project can be found on <https://eu-citizen.science/project/180>.



← Opening of the pavement plant picture frame route in Leiden during the National Art Week
©Anna Biedenkapp

By noticing and naming the wild plants growing in the city we want to stimulate citizens of all ages and backgrounds to appreciate and enjoy wild plant life in their direct environments.

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← PhD candidate Nienke Beets, while botanical chalking in Leiden. ©Hanneke Jelles



MISSOURI BOTANICAL GARDEN: COMMUNITY ENGAGEMENT + SUSTAINABLE SOLUTIONS

Missouri Botanical Garden's concern over climate change guides everything we do. We have chosen to provide greater impact by engaging a wider audience through our community outreach and engagement efforts. That means we reach beyond the Garden and our conservation locations to work directly in the communities. We also expand our program topics so we reach a broader audience with efforts such as waste reduction and energy efficiency. When done more sustainably the day-to-day choices people make in these areas either hurt or help plants, the environment, and the climate. Through the community-based sustainable solutions we offer we're helping make the right kind of difference in our region and in the world.

“We are doing our part to create a more plant-connected, sustainable and resilient world for next generations.”

Peter Wyse Jackson, Missouri Botanical Garden President

↵ MBG outreach work with youth tree planting program ©Missouri Botanical Garden

Plants tell us many things. At Missouri Botanical Garden, we want our audiences to know what plants know, and to love plants as we do. We want them to understand how to make choices that are better for plants and human beings – how to have clean air, water and soil necessary for plants and humans to thrive. This includes choices that reduce carbon emissions and lessen climate change impact. We have a beautiful 79-acre oasis in the city of St. Louis and incredible offsite locations in Shaw Nature Reserve and the Butterfly House. Over one million people visit us each year. We are in 36 countries working with partners to protect endangered plant species and undertake botanical research. We have one of the world's largest herbarium collections. However, if people do not understand how they personally impact the natural world and the importance of plants and biodiversity, those efforts may not matter as much.



We realize we must engage as many people as possible, and reach a wider worldwide audience with these messages. We choose to do that by deeply engaging our visitors and members, and then by expanding outside of Garden grounds, into the community, where people live. We focus on sustainability-related education and connections to sustainable solutions. And it's working! We have thriving community-based programs with engaged audiences that complement our onsite visitors and in-depth conservation and horticulture work to give us hope in these incredibly worthwhile efforts.

All botanic gardens are "going green" in their operations and onsite efforts. We are too, and that is especially apparent in the design and construction of our new Jack C. Taylor Visitor Center that will open in 2022 (<https://discover.missouribotanicalgarden.org/TaylorCenter>.) We incorporate what we learn from our own projects into our education. It gives us credibility. Our community education and outreach work is also informed by what we learn from our own research and conservation efforts as well as the information from our living collections, herbarium specimens and databases.

We have climate information incorporated into all of our k-12 education. It is important to help young people learn early on about the environment and the importance of biodiversity. Our public programs and interpretation efforts incorporate how even small actions we take today can affect the future of our planet. And then we go one step further.

As part of our own strategy to reverse biodiversity loss and promote sustainable livelihoods, Missouri Botanical Garden considers community engagement among the most powerful ways to achieve long-term conservation success. It makes us unique. *"Our community outreach enables exemplary, experience-based learning that increases understanding, appreciation, and conservation of plants and the natural world; it connects people to practical sustainable solutions, and inspires people of all ages, backgrounds and abilities to think and act in more sustainable ways. At Missouri Botanical Garden, our community sustainability work involves finding plant-based solutions to real-world challenges,"* adds Dr. Peter Wyse Jackson, Missouri Botanical Garden President. *"We are doing our part to create a more plant-connected, sustainable and resilient world for future generations."*

↑ [Missouri Botanical Garden Central Axis](#)
©Missouri Botanical Garden



↑ [Solar workshop from MBG](#)
©Missouri Botanical Garden



↑ [St. Louis Green Business Challenge award winners](#)
©Missouri Botanical Garden



← Energy efficient lighting exhibit at Green Living Festival ©Missouri Botanical Garden

As Missouri Botanical Garden's sustainability division, EarthWays Center enriches lives and protects plants and our environment by educating and connecting people to practical sustainable solutions where they live, learn, work and play.

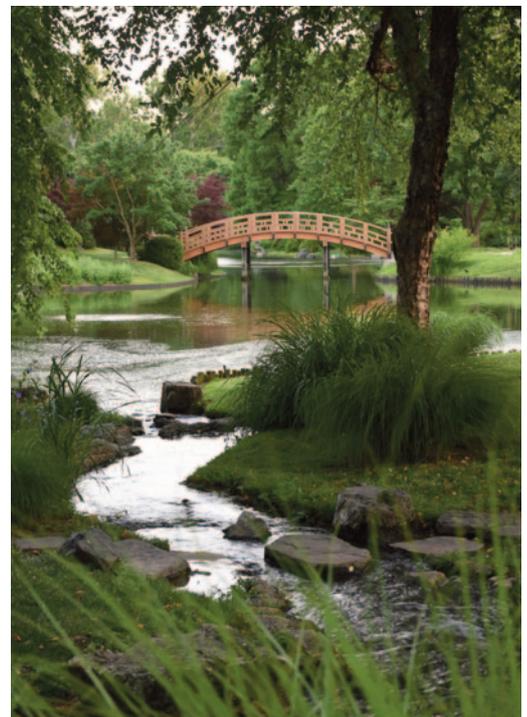
We seek to enrich lives and protect plants and our environment by educating and connecting people to practical sustainable solutions where they live, learn, work and play. We coordinate over 40 community-based initiatives to advance sustainability in the Midwest region of the U.S. Audiences include businesses, local municipalities, individuals and families, homeowners and renters, professionals, schools, k-12 students and educators, and universities and colleges. We help them understand that it is not about just what they do when on Garden grounds, but their choices of how to heat and cool their homes, the transportation they use, and the food they consume. More sustainable choices in these areas results in reduced carbon emissions and cleaner air, water and soil. These are the essential building blocks for improving biodiversity, reducing climate change impacts, and providing for better plant conservation and ecosystem restoration. Most people want to live with less impact on the planet, but some are not sure which choice is the best to make, what will have the most impact, or even how to get started.



↑ Solar car race winners at Green Living Festival ©Missouri Botanical Garden

Education and action are central to our community programs. Partnerships are an essential part of each initiative. Many programs also include access to funding options, such as helping participants obtain grants or incentives for solar installations, landscaping projects, or energy efficiency improvements. We train professionals to provide the sustainable solutions people need, allowing local building and landscaping contractors to engage in our programs while supporting the local green jobs movement. Examples of our community outreach efforts include:

- Green Resources Information Service – a free information resource for green living related questions, presentations and exhibits;
- Green Business Challenge - now in its 12th year, our program serves 60+ businesses and municipalities annually in a voluntary program to advance their sustainable business operations;
- Watershed Alliance and sewer utility program – local St Louis-based initiatives to provide grants to over 120 homeowners annually to install rainscaping features (any combination of plantings, water features, rain gardens, lawn alternatives, and permeable pavement that manage water where it falls);
- Energy efficiency and healthy homes – focus areas for other community programs;
- Grow Solar St. Louis - together with a local installer and regional solar organization, we manage a solar energy program, which has provided more than 60 residential solar installations annually;
- US Green Building Council – the local chapter has 300 members and is managed by staff of the Garden;



↑ Missouri Botanical Garden Japanese Garden ©Missouri Botanical Garden



- Recycling and composting education - we provide this to local schools through an annual grant, now in its 25th year;
- Green Schools program – supporting local schools in their environmental protection efforts;
- Invasive Plant Education and Removal program – this puts ecological restoration at the core of our sustainability efforts;
- BiodiverseCity STL – we manage this urban biodiversity program, with more than 60 partners working together to advance biodiversity in the City;
- Green Living Festival - In 2021, we will host the 20th anniversary of this annual event.

Additional outreach programs focus on providing youth in the community with hands-on experiences to build knowledge and skills while exploring connections between humans and the environment. We work to ensure people of all backgrounds and abilities have the same opportunities to love the outdoors. We provide disadvantaged youth with opportunities to explore the environment through education, workforce development, service-learning and skill-building projects.

We also work with community partners in more than 36 international locations where we are doing research. Like in St Louis, there we aim to have a similar focus on understanding the needs, interests and abilities of the local community members. Then we meet them where they are so they understand the impact of their choices and how they can lessen impact on the climate. It is our focus no matter where we are – at home, or around the globe.

We view the funding and offerings of our community sustainability efforts in the same lens of all of our sustainability work: they have to be the right choices for people, the planet, and for the budget. To make that work we connect with many local partners (such as utilities, businesses, and grant funders) in a win-win-win situation. The funder needs work done, we have a mission to accomplish these efforts, and the community needs such projects to help realize all of our goals. This means we bring new funders to the Garden that may not otherwise be engaged, and these partners pay for almost 100% of our community-based efforts. It is a true sustainability success story.

We believe that everyone accepts the need to achieve sustainability, but some are further along the road than others. Our goal is to meet everyone where they are and help them advance along that road. Missouri Botanical Garden is a trusted resource, backed by scientific investigation to inform our efforts. We know we must act boldly and ambitiously. Strong community programs allow us to reach a wider audience and have greater impact. Our goal is to help as many people as possible to live more sustainably, allowing all of us together to reduce the drivers of climate change and mitigate its impacts, as well as to protect the plants and natural sites that are critical for our world. This will also allow us to accomplish our mission: "To discover and share knowledge about plants and their environment in order to preserve and enrich life."

↑ Solar installation on MBG Building
©Missouri Botanical Garden

As part of our global strategy to reverse biodiversity loss and promote sustainable livelihoods, Missouri Botanical Garden considers community engagement among the most powerful ways to achieve long-term conservation success.



↑ MBG Rainscaping workshop
©Missouri Botanical Garden

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HOW TO COLLABORATE WITH SCHOOLS ON CLIMATE CHANGE EDUCATION

Botanical gardens can play a role in supporting school education in the field of climate change education. Through a series of practice, the climate change education project team of Beijing Educational Botanical Garden found that the following methods can help the botanical garden to better cooperate with the school: designing activities with advanced educational concepts, referring to the teaching objectives of the national curriculum, fitting in with the working mode of schools, and using real situations in botanical gardens to enhance school education.

1 BRINGING CLIMATE CHANGE EDUCATION INTO THE CLASSROOM

Climate change is a serious challenge to humanity. People all over the world should develop proactive and effective measures to protect our one and only homeland. The UNESCO (2010) “Climate Change Education for Sustainable Development” project points out that “it is of equal importance to provide education and training, and promote public awareness to the broadest audience possible”. China’s National Climate Change Program 2014-2020 also explicitly states that it is necessary to “promote the education of climate change in schools and classrooms and widely disseminate scientific knowledge on climate change” (National Development and Reform Commission, 2014).

↩ Use cooperative learning methods to learn about organic fertilizers ©Lihua Shi

The botanical garden is a real world in miniature, which can provide various complex situations. It can support and enhance teaching in school.



2 CONVERGENT THINKING: THE KEY TO THE COOPERATION BETWEEN BOTANICAL GARDENS AND SCHOOLS

Climate change is a complex global problem since it is intertwined with many issues, such as energy use, economic development, and ecosystem management, etc. Therefore, classroom teaching alone is nowhere near enough for climate change education, larger and different stages should be provided, such as botanical gardens, zoos, museums, and nature reserves. According to research by Sellmann D & Bognera XF (2013), education in botanical gardens can be effective in enhancing students' learning in terms of climate change knowledge and attitudes. Schools have a responsibility to implement climate change education, however the challenge is that often, the curriculum is already fully arranged and therefore interest in collaborating with climate change education experts at botanic gardens can be low. A simple "additive" approach may place a burden on teachers and students and thus reduce their willingness to collaborate. Under these circumstances, convergent thinking is required. When the right point of integration has been found, the cooperation will develop naturally.

3 CLIMATE CHANGE EDUCATION ACTIVITIES THAT SCHOOLS EXPECT

Since 2017, Beijing Educational Botanical Garden has designed and developed 26 educational programmes about climate change, hosted more than 100 activities, and served over 2,000 students. Here we will talk about some of these activities.

← *Feel the impact of climate change on species by investigating the diversity of species around us*
©Ying Li



↑ *Through meteorological observation activities, students discover the patterns of temperature changes by measuring temperatures and comparing climate data over the years*
©Guanhua Ming



↑ *Continuous climate observation activities help students understand the impact of climate change on species*
©Guanhua Ming

3.1 Designing activities with advanced educational concepts

With constructivism learning theory as the starting point, our climate change education programme emphasizes “student-centred” design, which requires a reduction in the proportion of teacher-driven teaching methods such as lectures, reading, audio-visually and demonstrations, and an increase in the number of experiential methods such as investigations, exercises, experiments, and discoveries where students can gain direct experience. For example, in the “Climate Change and Phenology” event, students observed and recorded the changes of plants over many weeks, and then developed these concepts for themselves. In the “Beijing with A Higher Temperature” activity, students first measured the temperature in the meteorological station and analysed a graph of temperature changes in Beijing, this information was then used by the students to form conclusions about the data themselves. We also use a variety of teaching methods such as inquiry-based learning, cooperative learning, and independent learning, which not only help students achieve their climate change learning goals efficiently, but also help them develop their potential. In this way, it is more likely to be recognized by schools, where the promotion of “holistic development” of students should be the core mission.

3.2 Referring to the teaching objectives of the national curriculum

The curriculum standards that we have mainly referred to are the Science Curriculum Standards for Primary Schools, the Curriculum Guideline for Comprehensive Practical Activities in Primary and Secondary Schools, and the Implementation Guidelines for Environmental Education in Primary and Secondary Schools. After the publication of the Core Competencies and Values for Chinese Student Development (Core Competencies and Values Research Team, 2016), we have adjusted our educational objectives to incorporate the new requirements of the Core Competencies. There are many benefits of being aligned with the national curriculum. First, it can attract school teachers to consider education programmes with the garden. Coming to botanical gardens for some of their learning can help school teachers to complete their teaching goals. Secondly, it facilitates dialogue between botanical gardens and schools, and collaborators can communicate better in the same discourse. Thirdly, being aligned with the national curriculum can help students establish transferable “big ideas”.

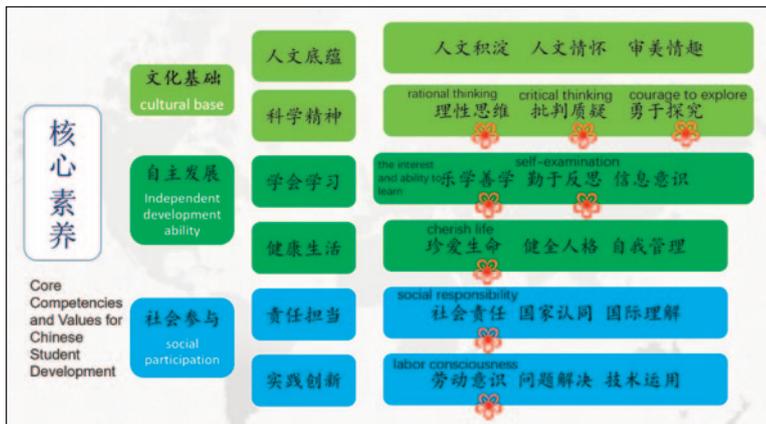


↑ Project team teachers visit schools for cooperation ©Guangwang Li

Convergent thinking: the key to the cooperation between botanical gardens and schools.



↑ The botanical garden has a collection of species threatened by climate change, all of which are excellent teaching resources ©Guanhua Ming
← To solve the real problem of how to repel birds in the crop display area, students work together to make scarecrows out of used clothing ©Guanhua Ming



3.3 Fitting in with the working mode of schools

It is important to fully respect the school's working mode. For example, we found that the school authorities attach great importance to safety issues. Therefore, we have developed safety plans, including renting a car to pick up students, providing safety education before class, checking and controlling possible safety hazards, to alleviate the school authorities' concerns. In addition, for the activity time, we mainly made use of the school's "330" (3:30 p.m.) programme, comprehensive practice classes and other special out-of-school and extracurricular activities, which did not conflict with the major subjects (such as maths, languages, and sciences classes). These types of changes can greatly reduce the school's concerns that participation in climate change educational activities may affect the students' academic performance.

3.4 Using real situations in botanical gardens

Nowadays, school is the main education site and school education plays a key role for students, but some challenges still exist. One of the most notable shortcomings is decontextualization. As the knowledge students learn in school is highly abstract, students do not know where the knowledge comes from and how to apply it (Peng, 2011). In contrast, the botanical garden is a real world in miniature, which can provide various complex situations. It can support and enhance teaching in schools, particularly if botanical garden teachers can discover real situations related to climate change issues and transform them into educational activities for students to experience.

In conclusion, effectively communicating climate change education is a challenging task. Educators in botanical gardens need to communicate more with school teachers to find how best to work together. We should become close partners based on mutual respect and trust, share the responsibility for children's growth, and work towards a better future. It is our job to show the children that each of us has the power to make a difference, and even very small changes to our life style and behaviour can help reduce greenhouse gas emissions and make our planet a more beautiful home for all of us.

← Some details about the course designs in line with the Core Competencies and Values for Chinese Students ©Guanhua Ming

We should become close partners based on mutual respect and trust, share the responsibility for children's growth, and work towards a better future.

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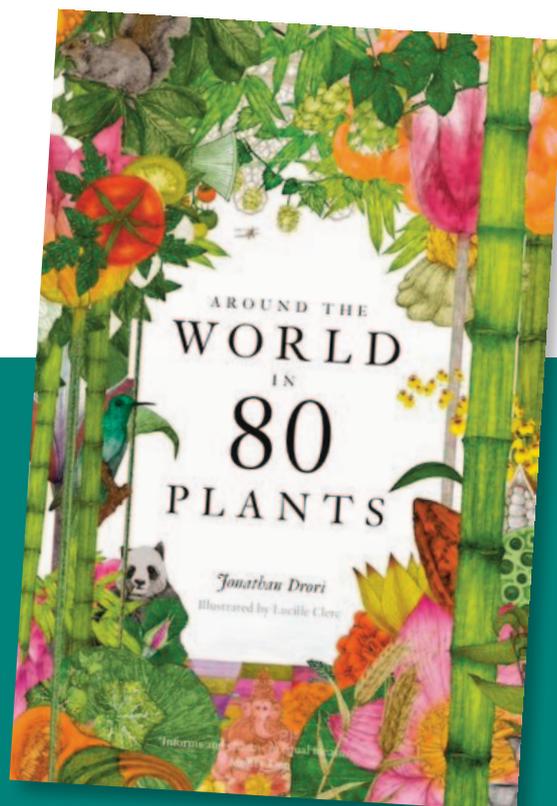
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JONATHAN DRORI ON CLIMATE CHANGE AND HIS NEW BOOK

In *Around the World in 80 Plants*, published in April 2021, Jonathan Drori takes readers on a trip across the globe, bringing to life the science of plants by revealing how their worlds are intricately entwined with our own history, culture and folklore.

In this article, Jon discusses the misconceptions and difficulties of communicating plants and climate change. Using two examples from *Around the World in 80 Plants*, Jon highlights ways to engage the public on plants impacted by climate change.



Readers of *Roots* surely understand climate change, care about biodiversity, and know how plants grow, but I'm often reminded that our audiences see the world differently. Even though the link between climate change and atmospheric carbon dioxide is well accepted by educated people, their grasp of the relationship between plants and CO₂ is surprisingly tenuous.

↑ *Around the World in 80 Plants* is Jonathan Drori's follow up to *Around the World in 80 Trees*.
↩ Illustrations of nutmeg from *Around the World in 80 Plants*. Illustrations ©Lucille Clerc

For 15 years until quite recently, I ran an annual session for sixty-or-so recent science graduates who were just embarking on a postgraduate teaching qualification. I started each time with a simple test designed to expose some popular misconceptions – ones that might be held by their future students. There were questions about why it's hotter in summer than in winter, whether it's possible to light a lightbulb with a battery, a bulb and a single piece of wire... that kind of thing. One of my questions was this: "A little seed weighs hardly anything. It grows into a big tree, which weighs a lot. Where did all the mass come from, that makes up a pile of wood? Or a heavy bag of charcoal?" Every year, more than 80% of the group said that the mass came from 'nutrients in the soil' and about 10% even suggested 'sunlight'. The idea that water from the roots and carbon dioxide gas could somehow combine to make up most of the weight of a tree and that pretty much all the weight of charcoal had come out of the air, was unthinkable. I found similar results in North America and Australia, and with the general public, science journalists and tellingly, 8-yr-old children.

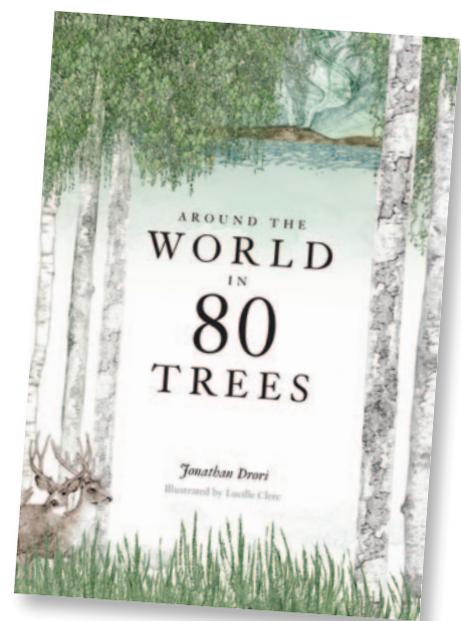
To begin to change such long-held beliefs about how plants grow, botanic gardens need to think carefully about how they explain and demonstrate the everyday miracle of photosynthesis. Part of the problem is that gases in the air are not only invisible but also seem to have no mass. So, at the outset, we need to convince the public that CO₂ is actually heavy, perhaps by making some in a jug and tipping a home-made balance with paper cups. And then pose the killer question; ask why it is that house plants seem to get so much bigger and heavier than their pots and yet we hardly ever, if at all, need to top up the soil?

The public are also confused about why climate change matters. We can readily identify with plants getting too hot or cold, or too wet or dry and therefore that climate change is happening too quickly for many plants to adapt. People can imagine that some pests or diseases might have an easier life in new conditions, just at the time when plants are less able to defend themselves; and they can see that there might be more pressure on forested land if agricultural activity must move from an area that has become less productive. But it is a tricky conceptual leap to see that climate change threatens plants whose pollination or seed dispersal depends on creatures whose lifecycles may themselves be affected by climate change. The system, in other words, goes out of kilter.

In addition to understanding climate change, we hope that people will care about plants enough to want to protect their habitats and value biodiversity. In this context, I have found that a useful analogy is the parlour game in which players take turns to remove components of a tower until it finally teeters and falls. So, when individual species are threatened, our ecosystems become less resilient, until they may become so fragile that one extra nudge could make a whole system collapse. Our futures depend on these ecosystems and the relationships between them.

I delight in plants and am intensely interested in them for their own sake, but I realise that at some point I had to learn to cherish their loveliness. Just as people need guidance about how to appreciate great art, the beauty of plants often needs to be pointed out; their shapes, patterns, colours, scents and so on, not solely from a scientific point of view but out of sheer joy and wonder. We can learn a trick or two from celebrity gardeners, the most talented of whom take this approach when talking about popular garden plants. However I'm always surprised at how receptive people are to descriptions of the beauty, even of less well-known species, especially when they are described enthusiastically and in emotional language by botanic garden staff.

"Around the World in 80 Plants is 80 reasons why we can't live without plants, why they fascinate and why we should care. Jon Drori's wonderful book brings these plants vividly to life through their relationships with us – each is bound to humanity, and each has a story as rich as our own. I can't recommend this book highly enough." Dr. Paul Smith, Secretary General of BGCI



↑ *Around the World in 80 Plants is Jon Drori's follow up to Around the World in 80 Trees. Written by Jonathan Drori and illustrated ©Lucille Clerc*

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For example, in *Around the World in 80 Plants*, when I describe coffee, a plant very much affected by climate change, I describe, “the little evergreen tree that began life somewhere near the forested mountains of southwest Ethiopia; its broad, elliptic leaves with crinkled edges, shiny and dark above and pastel-pale underneath.” Readers may not have thought much about the coffee plant itself – “in full flower, it is a magnificent but ephemeral joy; for just a couple of days, thousands of delicate, white blossoms with a light fragrance of honeysuckle and jasmine, can festoon a single tree. The smoothly oval fruits ripen to pillar-box red; their thin layer of edible flesh tastes of watermelon and apricot and surrounds a pair of deeply grooved seeds that are the familiar coffee ‘beans’.”

Beauty is one way to engage the public. The baroque relationships of plants with each other and with other organisms are another, especially familiar to botanic gardens. But beauty and botany become more widely attractive if they can be woven together into stories that also include hooks into popular interests such as history, culture, religion and folklore. And it helps if everyone will find at least some part of the story surprising.

Nutmeg (*Myristica fragrans*), for example, is a plant with many potentially engaging angles. In *80 Plants*, I describe “the sensual beauty of nutmeg and the blood-red aril that gives us mace; the warm, woody and thrillingly unique scent of the ‘nut’ and the intricate pattern of vessels containing essential oils, gradually revealed by grating.” I felt that the historical skirmishes between European powers for monopoly control of the nutmeg trade, were important but reasonably well known. The species’ use as an aphrodisiac and the paraphernalia that went with it might also be familiar, but of course sex always sells! Fewer readers would be aware that the British ceded to the Dutch their claim to nutmeg territories in exchange for Manhattan. But fewer still, would know that the African-American activist Malcolm X wrote in his autobiography about attempting to get high on nutmeg in jail in the 1940s; it was later banned from US prison kitchens, to avoid misuse! It is that angle that enabled me to discuss why the nutmeg might have evolved with such a chemical cocktail, and indeed, its fleshy fruit and bright red aril.

Although we must be careful not to anthropomorphise, I’ve found that audiences are pleasingly receptive to seeing the world from a plant’s point of view.



↑ Illustrations of coffee from *Around the World in 80 Plants*. Illustrations ©Lucille Clerc



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RESOURCES



Climate Solutions 101 - Project Drawdown

Climate Solutions 101—presented by Project Drawdown—is 100% free, full of hope, and streaming today. Filled with the latest need-to-know science and fascinating insights from global leaders in climate policy, research, investment, and beyond, this video series is the world's first major educational effort focused solely on solutions. This course, presented in a six-part video series along with in-depth conversations, combines resources with the expertise of inspiring thought leaders from around the world. Enjoy a brain-shift toward a brighter climate reality—and spread the word.

<https://drawdown.org/climate-solutions-101>



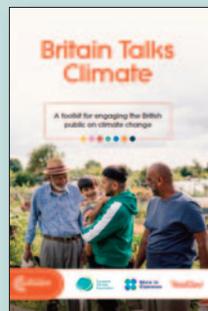
Climate and Nature course - AimHi

AimHi have brought together top-level scientists, educators, behavioural psychologists and expert communicators to equip students with all they need to know about climate, nature and how to make a difference. Get to grips with key climate concepts in four short interactive lessons and feel empowered to make positive change. This course is recommended for people aged 16 and above. You don't need any prior knowledge to attend.

<https://www.aimhi.co/climate-course>

Britain Talks Climate toolkit – Climate Outreach

Britain Talks Climate is an evidence-based toolkit designed to support any organisation that wants to engage the public on climate change. It offers a shared, strategic understanding of the British public, and – against a backdrop of growing concern about polarisation – identifies effective ways to engage across the whole of society.



The segmentation research underpinning Britain Talks Climate reveals a public that is fractured but not deeply polarised, with climate change emerging as an issue that has the potential

to unite us. But building narratives that resonate with a diverse range of values and everyday concerns is critical for the long-term goal of deepening public engagement – and keeping it there.

<https://climateoutreach.org/britain-talks-climate/>

Climate change resources for schools – WWF

These engaging classroom resources, presentations and information sheets have been designed for both primary and secondary schools.



By learning more about the science and geography that affects our world, and the decision makers and organisations who have the power to champion change, WWF want young people to embark on a personal journey with them to understand what needs to be done, to recognise what matters most to them and to take action to help protect the places, animals and things they love.

<https://www.wwf.org.uk/get-involved/schools/resources/climate-change-resources>

Climate Kids – NASA

NASA's Climate Kids website brings climate science to life with fun games, interactive features and exciting articles.

<https://climatekids.nasa.gov/>



Climate Generation curricula – Climate Generation

Bring climate change into your classroom with Climate Generation curricula.

This site provides a suite of Grades 3-12 curriculum resources in the form of curriculum guides, as well as online modules that can be downloaded for free.



<https://www.climategen.org/our-core-programs/climate-change-education/curriculum/>



Botanic Garden Conceptualisation and Design
The Botanic Garden Conceptualisation and Design Directory of Expertise contains information on individuals with expertise related to envisioning, planning, designing and constructing new botanic gardens, and strategically re-imagining existing institutions.

Conservation Assessment
The Conservation Assessment Directory of Expertise contains information on individuals in botanic gardens with expertise and experience related to conservation assessments, including global IUCN Red List assessments, national Red List initiatives, and other threat assessments.

Conservation Horticulture
The Conservation Horticulture Directory of Expertise contains information on individuals with expertise related to propagation techniques, living collection management, urban greening practices, in situ recovery and more.

Ecological Restoration
The Ecological Restoration Directory of Expertise contains information on individuals in botanic gardens with expertise and experience related to ecological restoration, including restoration of habitats and species recovery.

Exceptional Species
The Exceptional Species Directory of Expertise contains information on individuals with expertise related to *in vitro* conservation of plants that cannot be preserved as offspring: term by conventional seed banking because of lack of seed, desiccation or freeze-sensitive seed, very short-lived or deeply dormant seeds.

Plant Health and Biosecurity
The Plant Health and Biosecurity Directory of Expertise contains information on individuals with expertise related to pests and diseases, biosecurity best practices, plant health policy and more.

Policy
The Policy Directory of Expertise contains information on individuals in botanic gardens with expertise related to the implementation of relevant national and international environmental agreements, legislation and policies.

Public Engagement
The Public Engagement Directory of Expertise contains information on individuals with expertise related to education best practice, audience develop and inclusion and key topics such as climate change, food security and pestilence.

Seed Conservation
The Seed Conservation Directory of Expertise contains information on individuals with expertise related to seed collection, banking and research related to seed conservation.

Sustainability
The Sustainability Directory of Expertise contains information on individuals with expertise related to water saving, carbon reduction, energy saving, waste management, sustainable food, urban greening and more.

Tree Conservation
The Tree Conservation Directory of Expertise contains information on individuals in botanic gardens with expertise and experience related to tree conservation, including seed collection, establishing nurseries, tree climbing and species recovery.

BGCI'S DIRECTORY OF EXPERTISE

BGCI's new Directory of Expertise is designed to enable experts within botanic gardens to let other people know about their own skills and knowledge and, if possible, help them to solve a problem or challenge related to botanic gardens or plant conservation. As a membership benefit exclusively for BGCI Institutional Members, staff associated with these institutions can apply to be listed in the Directory.

The Directory currently includes 11 areas of expertise including Public Engagement. BGCI's purpose in creating this Directory is twofold: firstly, to share the knowledge and skills in the botanic garden community with broader society to solve problems or save plant species, and secondly to give staff of BGCI Institutional Members opportunities to broaden their experience and make a contribution that might not come their way in day to day work.

For more information or to be listed as an expert visit:
<https://www.bgci.org/resources/bgci-databases/directory-of-expertise/>