

# Roots

Botanic Gardens Conservation International Education Review

Volume 16 • Number 2 • October 2019

## Citizen Science



**BOTANIC  
GARDENS**  
CONSERVATION  
INTERNATIONAL



## Contribute to the next issue of Roots

### Have you got a pollinator project you want to share?

The next issue of Roots is all about pollination. With pollinator species in decline and so much still to learn about the complex role between plant and pollinator, pollination is a key subject for botanic gardens to address through their interpretation and educational offering. Have you developed a new and innovative way of engaging your visitors with the topic of pollination? Are your garden visitors involved in contributing towards pollinator science? Or does your garden have a joined up approach to pollination that you would like to share?

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 [Helen.miller@bgci.org](mailto:Helen.miller@bgci.org) by 10th January 2020.



## Download the LearnToEngage module resources!

The LearnToEngage modules are 12 week blended learning modules that were developed as part of the LearnToEngage project (2016-2019). Each module consists of a trainer and participant handbook and also includes online resources which are hosted on RBGE's PropaGate Learning platform. Information about how to access these resources is available in the relevant module handbook. The four modules are Interpretation, Working with Diverse Audiences, Science Communication and Evaluation and Research.

Download the module resources here:  
<https://www.bgci.org/resources/bgci-tools-and-resources/learntoengage-module-resources/>



<b>FIRST WORD CITIZEN SCIENCE</b> Liliana Derewnicka	<b>...04</b>
<b>PLANTS NAP</b> Brian Lainoff and Eric Ralls	<b>...06</b>
<b>BEYOND DATA COLLECTION: USING THE SCIENTIFIC PROCESS TO BUILD SCIENTIFIC LITERACY</b> Jennifer Schwarz Ballard and Jessamine Finch	<b>...08</b>
<b>CITIZEN SCIENCE PROSPECTS AND PITFALLS: A DEVELOPING WORLD REFLECTION</b> Benjamin Ong, Thary Gazi Goh, Kai Ren Tan, Affan Nasaruddin and Zeeda Fatimah Mohamad	<b>...11</b>
<b>THE URBAN PRAIRIES PROJECT: CULTIVATING A COMMUNITY OF STEWARDSHIP</b> Amy Yarger	<b>...15</b>
<b>RESPONSIBLE GARDENING WITH GREEN PIONEERS AT MEISE BOTANIC GARDEN</b> Sofie Meeus, Ann Bogaerts, Sofie De Smedt, Jutta Kleber and Quentin Groom	<b>...18</b>
<b>BHUTAN BIODIVERSITY PORTAL: CITIZEN SCIENCE INITIATIVE IN BHUTAN</b> Choki Gyeltshen, Karunya Prasad, Sangay Dema and Tashi Yangzome Dorji	<b>...22</b>
<b>CITIZEN SCIENCE: A TOOL TO COORDINATE LOCAL ACTION FOR GLOBAL GOALS</b> Tara Moreau, Christina Prehn, Bev Ramey and Katie Teed	<b>...25</b>
<b>CITIZENS SCIENCE: AN ENDEAVOUR WITH PURPOSE AT THE BOTANIC GARDEN</b> Beatriz Maruri Aguilar, Yazmin Hailen Ugalde de la Cruz, José Belem Hernández Díaz, María Magdalena Hernández Martínez, Ilse Alonso Anaya and Emiliano Sánchez Martínez	<b>...29</b>
<b>POLLI:BRIGHT: A CITIZEN SCIENCE PROJECT AT THE PISA BOTANIC GARDEN</b> Raffaella Grassi, Giada Cordonì, Gemma Giannetti, Lorenzo Peruzzi and Gianni Bedini	<b>...32</b>
<b>AUSTRALIAN CASE STUDY: NATIONAL ARBORETUM PARTNERS WITH CITIZEN SCIENCE VOLUNTEERS</b> Lauren Brown	<b>...35</b>
<b>THE FAIRCHILD CHALLENGE IN XALAPA, VERACRUZ, MEXICO</b> Norma Corona and Andrew Vovides	<b>...38</b>
<b>CITY NATURE CHALLENGE AND NATUSFERA</b> Felipe Castilla Lattke and Cristina Villaverde Úbeda-Portugués	<b>...41</b>
<b>GROWING BEYOND EARTH: EMPOWERING A COMMUNITY TO FIND SOLUTIONS</b> Amy Padolf and Carl Lewis	<b>...44</b>
<b>RESOURCES</b>	<b>...47</b>



Chicago Botanic Garden



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**Cover Photo:** Student preparing to plant an aster (Chicago Botanic Garden)

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# FIRST WORD

## CITIZEN SCIENCE

As the title suggests, this issue of *Roots* looks at citizen science. Many botanic gardens around the world are making creative use of a most vital resource, the public, to enhance their science. So much so that it was very hard to narrow it down and this issue of *Roots* is one of our fullest.

I was recently having a conversation with a colleague about the importance of scientific vocabulary in formal education. Scientific language, he argued, is a barrier to engagement and should therefore be removed from science education. Although I agree with the first half of his statement, I cannot with the second. It reminds me of reading about CP Snow's two cultures lecture, in which he argued that the cultural divide between those within and those outside the scientific community was harder to bridge than a language barrier. To overcome a language barrier, we try to work out what words mean, we don't stop using them. It is the same with science. We need to find ways to get us all talking the same language. There are many ways in which we can, and are, doing this in both formal and informal education. And the better we get, the closer together scientists and non-scientists become. Citizen science is one of the results and stepping stones in this journey. Not only does it offer a robust engagement tool to excite people about science by getting them involved, but it is also impossible if people feel excluded through a lack of common understanding. Therefore, it is important that botanic gardens and related organisations offer carefully considered citizen science projects. In doing so, they can act as a powerful force towards an open and democratic scientific landscape.

Citizen science isn't just an engagement tool. It is also about getting more hands on deck. With many hands, science can proceed in new and exciting ways. Obvious examples are projects which work through collecting and analysing big data such as Galaxy Zoo, utilising large numbers of people to carry out research on a scale that would not be possible through more traditional means. This is an approach that Cadereyta Regional Botanic Garden have found effective in recording the biodiversity of their garden (page 29). A venture that was showing limited success until the launch of Naturalista, the Mexican arm of iNaturalist.

For a long time, crowd sourcing data was what citizen science looked like. Important though it is, as citizen science becomes more sophisticated, we can see other approaches to it. This idea is discussed in further detail by Jennifer Schwarz Ballard, who explains (on page 8) how Budburst is going beyond citizen science that uses public energy to either collect or analyse data, and into developing enticing research questions that involve the public in all stages of the scientific process.

In similar efforts, many botanic gardens are using an army of volunteers to carry out real science with them and for them, for example, the Urban Prairies Project (page 15) are restoring urban areas with the help of the public. Similarly, the National Arboretum Canberra makes use of skilled volunteers to support research on many areas of the arboretum's work, from frogs to special seeds (find out more on page 35).



*“Citizen science is the involvement of the non-academic public in the process of scientific research – whether community-driven research or global investigations”*  
(Citizen Science.org n.d.).

*“Over the past decade, there has been a rapid increase in the diversity and scale of citizen science. Initiatives range from crowd sourcing activities, in which the time and effort of large numbers of people are used to solve a problem or analyse a large dataset, to small groups of volunteers, who are experts in their own right, collecting and analysing environmental data and sharing their findings”*  
(Tweedle et al, 2012).



What is pleasing to see, from the articles submitted for this issue of *Roots*, is the Community of Practice approach to citizen science that is happening within botanic gardens. Many of the articles reference the same platforms or projects (iNaturalist, Project Budburst, PlantSnap, etc.) that worked as jumping off points or inspiration. Others have directly become involved or adapted existing endeavours.

For example, colleagues at the botanic garden of the University of Pisa have adapted the UK's Polli:Bright project to help them to involve school children in monitoring pollinators (find out more on page 32).

In Xalapa, Veracruz, Mexico staff have applied the Fairchild Challenge to the Mexican context and as a result have engaged 1,536 primary and secondary schools in developing and delivering conservation projects (page 38). Find out about how Fairchild Tropical Botanic Garden have used their Fairchild Challenge audience as a jumping off point for a project with NASA on page 44.

For some areas of the world citizen science is not yet common place. Benjamin Ong discusses (on page 11) the trailblazing work of the Rimba Ilmu Botanic Garden who are participating in the City Nature Challenge, to illustrate the opportunities and challenges faced by developing nations when it comes to embracing citizen science.

The City Nature Challenge, as Castilla Lattke and Villaverde Úbeda-Portugués explain (on page 41), seeks to encourage large-scale biodiversity documentation by encouraging a sense of "friendly competition". The 4th City Nature Challenge, in 2019, saw participation from 159 cities around the world.

This issue also features more pioneering work from Bhutan (page 22). Colleagues from the National Biodiversity Centre discuss how they have harnessed the fundamental duty towards environmental conservation of all Bhutanese people, according to the 4 pillars of their Gross National Happiness philosophy, by developing the first crowd sourced biodiversity portal in South Asia.

Botanic gardens and their visitors can play an important role in tackling global challenges. Tara Moreau, Christina Prehn, Bev Ramey and Katie Teed, use examples from the University of British Columbia Botanical Garden (on page 25) to illustrate the vital role of harnessing this power to work towards global challenges and the UN Sustainable Development Goals.

Botanic Garden Meise focuses on the public engagement power of citizen science in the hope of creating "a generation of responsible gardeners". Find out how on page 18.

Finally projects like PlanSnap, a BGCI supported initiative are supporting the involvement of gardens in citizen science by offering a customizable global plant identification app (find out more on page 6).

All in all, to me, citizen science is about people power. It is a grassroots approach to science; for the people and driven by the people. It's an approach where we, scientists and non-scientists alike, sing from the same hymn sheet and work towards a common goal – bringing these two cultures together for a worthwhile cause. It is for that reason that I am so glad to see that the botanic garden community is wholeheartedly embracing it.

This issue of *Roots* will be my last. During my time as editor I have gained so much respect for the amazing efforts that botanic gardens and other organisations are making to bring people and plants together. One significant aspect of this is the increasingly strategic and sophisticated approaches to science communication, including citizen science. Keep up the good work!



*Many botanic gardens around the world are making creative use of a most vital resource, the public, to enhance their science.*



↑ *Natusfera* users photographing bumblebees (*Bombus* sp.) and nazarene flowers (*Muscari neglectum*) in Barcelona (Spain) ©Pau Guzmán

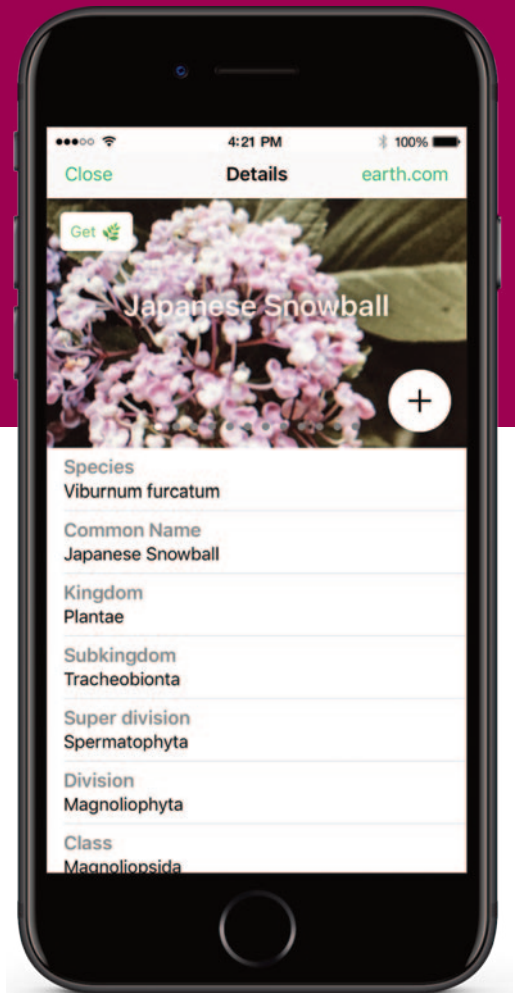
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# BGCI'S PLANTSNAP INITIATIVE: A UNIQUE OPPORTUNITY FOR BGCI MEMBERS



BGCI has partnered with PlantSnap so that BGCI Members can collaborate on the creation of possibly the most comprehensive database of plant photos and geo-locational data in the world! Let's empower our garden visitors worldwide to become citizen scientists in their own communities.



**P**lantSnap is the most technologically advanced, comprehensive and accurate plant identification app ever created. It provides a whole new way to explore the natural world in everyday life.

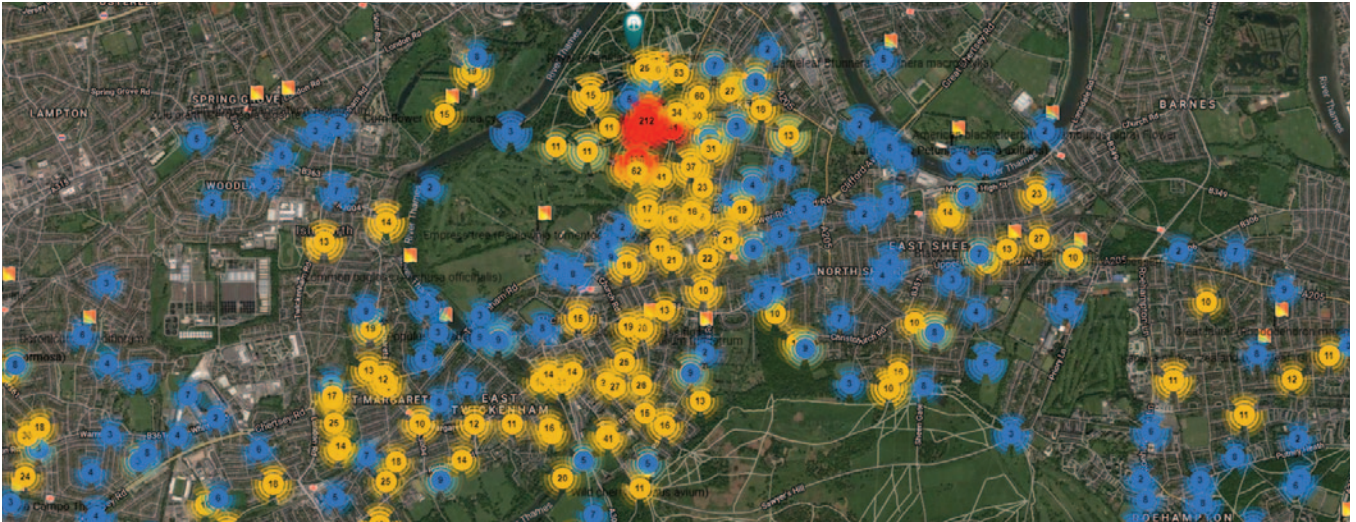
PlantSnap is a simple way for everyone to play a role in protecting and saving the environment simply by snapping photos of plants. This allows us to map and track every plant on the planet and share this data with scientists.

PlantSnap's open source plant database features 600,000+ plants and 150 million+ plant images. The app recognizes nearly all species encountered in botanical gardens and is available in 37 languages. To date, there have been more than 25 million downloads.

BGCI has partnered with PlantSnap so that our Member gardens can offer the app to their visitors. As a partner in BGCI's PlantSnap Initiative, the main role of a garden is to actively promote the app to their members and visitors and encourage them to make use of the educational and scientific benefits of diving deep into the importance of plant conservation through PlantSnap.

↑ After identifying the plant, a user can learn more about the plant in the PlantSnap app! ©PlantSnap  
↩ PlantSnap in action ©PlantSnap





BGCI and PlantSnap will provide each garden with a customisable set of marketing content to support their efforts, but ultimately it will be up to the garden to entice visitors to download the app.

Through PlantSnap, garden visitors will be given a unique interactive experience and be able to learn about unlabelled plants like ornamentals, and get detailed information about the plant's taxonomy, habitat, care and uses.

Participating gardens will benefit from the PlantSnap initiative because they will receive the photos and data associated with each visitor that they encourage to download the app. This will provide the garden with the chance to understand more about their visitors through demographic data collected through the app.

Gardens will also be able to understand more about how people use the garden as the photos will provide insight into which plants and parts of the garden receive the most footfall.

Additionally, 10% of the revenue generated by each user associated with a BGCI Member garden will be donated to fund plant conservation projects worldwide.

### HOW DO YOU GET INVOLVED?

- 1) Let us know you're interested by sending an email to [plantsnap@bgci.org](mailto:plantsnap@bgci.org).
- 2) Update your plant list in PlantSearch at [https://tools.bgci.org/plant\\_search.php](https://tools.bgci.org/plant_search.php).
- 3) We'll send an agreement for you to sign.
- 4) We'll organise a video call with key people from your team, helping you get a plan together to introduce PlantSnap at your garden.
- 5) We'll send a set of marketing materials that can be easily customised including a download link connected to your garden.
- 6) We'll help you launch the app at your garden.
- 7) Every month you'll receive demographic data of all visitors to your garden who download the app, along with all plant images (fully verified and identified) taken by your visitors.
- 8) You'll get ongoing marketing tips to help ensure the success of the app at your garden.

We hope you'll participate. It's never been more important to track plant species worldwide. This is a chance to create a massive, global contingent of citizen scientists.

Working together, we can make it happen. For more information, get in touch at [plantsnap@bgci.org](mailto:plantsnap@bgci.org).

↑ This screenshot shows all photos taken around the Royal Botanic Gardens, Kew during a one-week period ©PlantSnap

*This is an incredible opportunity for BGCI Members to maximise the impact of their conservation efforts and educational programmes on visitors.*

*Paul Smith  
Secretary General, BGCI*



*To date, there have been more than 25 million downloads.*

*Through PlantSnap, garden visitors will be given a unique interactive experience.*

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# BEYOND DATA COLLECTION: USING THE SCIENTIFIC PROCESS TO BUILD SCIENTIFIC LITERACY



↑ Educators learning the budburst curriculum ©Jennifer Schwarz Ballard

Citizen science shows promise for engaging participants in understanding natural phenomena through authentic science research, especially in the environmental sciences. However, the role of the public in citizen science has traditionally been limited to one piece of that process, data collection or extraction. Budburst is developing a portfolio of specific, time-bound, ecologically relevant research questions that engage participants throughout the scientific process and contribute to our understanding of human impacts on the environment. Budburst Nativars, the first research project, puts this approach into action posing the question: Does pollinator visitation vary between cultivars of native species (nativars) and true natives?

As human impacts on the environment become more visible, public gardens are seeking more than ever to engage a wider audience with nature, conservation, and with the specific work of our individual organizations. One way to achieve these goals is through citizen science, which offers the opportunity to actively involve a variety of audiences both on-site and in communities with our collections, our research, and our conservation activities, increasing scientific and environmental literacy as well as awareness of our work.

*The role of the public in citizen science has traditionally been limited to one piece of that process, namely data collection or extraction.*



The goals of citizen science are many: some projects aim to generate large datasets, others prioritize growing the scientific literacy of the public, while still others focus on engaging communities in identifying and solving local environmental concerns. While a key aspect of all these approaches relies on participants understanding the scientific process, the role of the public in citizen science has traditionally been limited to one piece of that process, namely data collection or extraction. Budburst is addressing this issue through the development of a portfolio of specific, time-bound, ecologically relevant research questions designed to engage participants throughout the scientific process and contribute to our understanding of human impacts on the environment in actionable ways.

Since its inception in 2007, Budburst (previously Project Budburst) has asked participants to submit observations of the timing of plant life cycle events (phenology) to contribute to a collective understanding of how plants and ecosystems are responding to their changing environments. In 2016 when the Chicago Botanic Garden took over ownership and management of Budburst, we identified four additional goals:

- engage participants more deeply in conservation action on-site and in communities,
- increase participants understanding of the scientific process, from hypothesis formation through analysis and conclusion by engaging them fully in that process,
- provide a series of increasingly involved opportunities that allow participants to progress in their expertise, and
- provide the satisfaction of contributing to a project that has a specific question so participants can see the direct impacts of their contribution.

To that end, we expanded the scope beyond phenology to include question-driven research projects. These projects continue to be grounded in plant phenology, but also include the collection of other types of data, e.g. pollinator observations. Through these projects, participants have the opportunity to engage directly with the data, provide their own hypotheses, analyses and conclusions, and grow our scientific body of knowledge.

The first of these projects, launched in 2018, is Budburst *Nativars*. Developed in response to growing concerns about declining pollinator populations, Budburst seeks to answer the question: *Does pollinator visitation vary between cultivars of native species (nativars) and true natives.* A common “call to action” to support pollinators encourages the creation of pollinator-friendly gardens to support the foraging and nesting needs of pollinators. Given their shared evolutionary history, native plants are promoted as a key ingredient. However, true natives are scarce in most garden centres, while nativars are widely available. Often, nativars are labelled as “native plants,” despite the fact that they can differ substantially from the native. Cultivars can vary in flower colour, size, and scent, as well as bloom time, all traits directly related to attractiveness to and use by pollinators.

We have brought together home gardeners, schools, botanic gardens, colleges, and community organizations to collect data on this critical question. Plant lists were developed based on the three hubs for the project: Chicago Botanic Garden, Denver Botanic Gardens, and San Diego Botanic Garden, each of which identified five ecologically suitable native species, along with 3-4 cultivars. Citizen scientists collect phenology and pollinator visitation data on the selected species and contribute that data through the Budburst website. Participants plant at least one native species and one cultivar from their regional plant list and conduct pollinator observations weekly during the flowering period. A mobile-responsive website also allows for direct submission of observations and photos.

***Citizen science offers the opportunity to actively involve a variety of audiences both on-site and in communities with garden collections, research, and conservation activities.***



↑ Students posing in front of the planted garden  
©Chicago Botanic Garden

***While intuitively we assume that natives are most appealing to pollinators, current research has only begun to explore the question.***



↑ Students removing a plant from its pot  
©Chicago Botanic Garden





Data can also be collected using paper data sheets and entered online. Participants are invited to share their hypotheses, ideas, experiences, photographs and conclusions with the Budburst Twitter, Facebook and Instagram feeds, where our research scientists can engage with their ideas.

Budburst has created supporting partnerships with a variety of organizations in the Chicago region to provide participants with opportunities to interact meaningfully with the data, and build a community of scientists. Chicago Public Schools and the Waukegan Community Unit School District are integrating the Nativars research project into life sciences curriculum for students in grades 2-8. Each of 13 participating schools has installed a Nativars research garden and students observe pollinators as part of a ten lesson Next Generation Science Standards aligned curriculum unit covering the form and function of plants and animals, ecosystem interactions and human impacts on the environment, depending on grade level. In Fall 2019, over 40 teachers and 1,200 students participated in the Nativars project. A number of these school gardens are shared with neighbourhood community organizations, which implement the curriculum in an out-of-school time setting with exiting program participants, providing time outdoors as well as STEM enrichment activities.

There are also partnerships that support informal learning opportunities, for example with the Forest Preserves of Cook County (FPCC) (where the city of Chicago and the Chicago Botanic Garden are located). Research gardens have been installed at three FPCC Nature Centres, where casual visitors are introduced to the project and provided with self-guided opportunities to collect and interact with the data. The projects are also integrated into the more formal programming – summer camps, afterschool programs, and seniors programs – at each Centre where participants engage longer term and have the chance not only to collect data, but also to draw conclusions.

An additional key aspect supporting participation throughout the scientific process is the direct involvement of scientists. Participants are able to communicate with Budburst scientists as they encourage hypotheses and preliminary results sharing through social media and via the Budburst e-newsletter. This year, 2019, we have enough data to share back some very preliminary results with the citizen scientists who contributed data. This sharing and communication supports ongoing participation, the development of scientific literacy, and the creation of a community of scientific practice.

The development of a portfolio of special projects with a more focused research approach is bringing in new audiences and engaging them more deeply. Annual participant surveys and future analysis of contributor data will assess engagement and changes in scientific literacy. Ultimately, through expanding the traditional role of citizen scientist from data collector to more closely mirror that of a professional scientist, Budburst aims to deepen the scientific and environmental literacy of the public.

↑ *Students proud of their Budburst research garden*  
©Chicago Botanic Garden



↑ *Close up planting the research garden*  
©Chicago Botanic Garden

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# CITIZEN SCIENCE PROSPECTS AND PITFALLS: A DEVELOPING WORLD REFLECTION

Citizen science is a fairly new concept in Malaysia, where institutional environmental education and public engagement has not been prioritized. Citizen science has yet to be widely embraced by the scientific establishment. In 2018 and 2019, the Rimba Ilmu Botanic Garden's Rimba Project led the Klang Valley's participation in the City Nature Challenge, an international bioblitz-style competition to document urban wildlife. We engaged widely with schools, local communities, businesses and institutions. This article reflects on challenges likely to be faced by resource-poor institutions in the tropical developing world, and how we addressed some of these through a bottom-up, grassroots-driven approach.

In postcolonial developing Malaysia, research and education are predominantly top-down, institution-centred and expert-driven. Whereas natural history institutions in developed countries are well equipped with education resources and personnel, and natural history concerns have entered public discourse, most of Malaysia's science education is classroom-based, with little practical or field instruction. Like other countries outside the "western world," institutional barriers impede citizen science (Pocock, *et al.*, 2019). It is a fairly new concept here, to which the scientific establishment appears ambivalent at best, and resistant at worst.

In megadiverse Malaysia, conservation is typically focused far from centres of human population. Meanwhile, Malaysia's urban population proportion has grown from 25% to 75% over the last 50 years (World Bank, 2015). It is in this light that citizen science may help urban communities reconnect with nature, while shedding light on emerging trends in urban and residential ecology (Dickinson, *et al.*, 2012). Digital platforms can be easily utilised as language and technology is not a barrier: English is widely spoken and mobile network infrastructure in urban areas is generally good.

↑ *Klang Valley City Nature Challenge (KVCNC) collaborators, Water Warriors, led wildlife documentation along urban rivers, many of which, like Sungai Pantai here, have been canalised and stripped of their identity as a habitat. ©Benjamin Ong*

*Engaging a small number of participants through a training-of-trainers model may be a more sustainable medium-term strategy for overcoming capacity constraints.*





← Undergraduate volunteer Khai Xian Lee in action during the bioblitz at the Tuan Mee oil palm estate. ©Kai Ren Tan

**Most of Malaysia's science education is classroom-based, with little practical or field instruction.**

**Many [school] teachers were new to citizen science, and not tech-savvy enough to guide their students in using [popular platforms like] iNaturalist.**

As a citizen science pilot, we coordinated the 2018 and 2019 Klang Valley City Nature Challenge (KVCNC), part of the global City Nature Challenge (CNC) organised by the Natural History Museum Los Angeles and the California Academy of Sciences. This annual, international four-day bioblitz engages urban communities in the documentation of urban wildlife through the iNaturalist platform. The Klang Valley is Malaysia's largest urban metropolis, home to 7-9 million people (out of a national population of 32 million). In 2018, our inaugural year, a total of 682 observers, assisted by 284 species identifiers, made 25,287 observations across 1,775 species. In 2019, 519 observers, assisted by 547 identifiers, made 37,921 observations across 2,761 species.

In 2018, a mere 14 schools supplied 50% of our participants, who contributed over 5,000 observations. However, the quality of observations was generally poor and a large number was disproportionately made by a small pool of participants; the majority of users, in fact, made very few observations. This was likely motivated by the interschool challenge we organised. Furthermore, many teachers were new to citizen science, and not tech-savvy enough to guide their students in using iNaturalist.

In 2019, we maintained engagement with schools while establishing new partnerships with NGOs, local communities, business and government. A number of NGOs took the initiative to partner with us following positive coverage of the 2018 KVCNC. Of note was Badan Warisan Malaysia's (The Heritage of Malaysia Foundation) event, fully run without our guidance, representing organic growth. While NGOs were generally well organised and independently engaged participants, most were new to citizen science and more guidance is needed moving forward.

A palm oil company partnered in running citizen science workshops with their employees and conducting a bioblitz in one of their estates. This was encouraging as the plantations industry and conservation interests typically find themselves at loggerheads with one another. In the same year, we secured official endorsement from Malaysia's Ministry of Education (MoE) to run the KVCNC in schools. While dense bureaucracy hindered timely recruitment of more schools or participants, we nonetheless considered this a strategic step towards wider institutional embrace of citizen science.



↑ A school participant documents a patch of wildflowers. ©Kai Ren Tan

**[Partnering with a] palm oil company [...] was encouraging as the plantations industry and conservation interests typically find themselves at loggerheads with one another.**





As a resource-poor institution in the tropical developing world, we encountered three key constraints over both years: the challenge of megadiversity and scepticism of citizen science methodology; weaknesses in taxa identification; and poor organisational resources.

In both years, there were far more species than we could adequately document. Megadiversity was a liability for environmental education: limited online resources and layperson-oriented publications may have hindered accurate identification of taxa. Some local taxonomists were reluctant to participate as they viewed iNaturalist as a form of biopiracy, not unreasonable in light of recent biopiracy and poaching controversies (Law, 2018). Additionally, many Malaysian scientists are sceptical of data quality obtained through citizen science and prefer to use more traditional methods.

iNaturalist's image recognition algorithms caused many misidentifications. Often, local tropical trees were mistaken for oaks and elms and naïve observers accepted the app's automatic species suggestions. Local names were not typically available, and many species were given unintuitive names. The shrub, *Spondias dulcis*, widely known for its fruit called 'kedondong' or 'umbra', was named 'English plum' in iNaturalist. Incidences like this may have confused many observers to dismiss the correct species and select names that sounded more intuitive.

Finally, we also struggled with human capacity constraints: the KVCNC was organised by a handful of amateur volunteers on a shoestring budget, further hampered by the general reticence of the local scientific community to participate. In both years, we had limited capacity to promote the event, train and guide various interested communities. However, as a small, agile team we were able to focus engagement on a modest pool of partners and still produce results competitive with larger, more well-established institutions.

Overall, we can infer that citizen science is increasingly well embraced, especially by non-expert, lay and local communities. However, the immediate future of citizen science may still be oriented around a bottom-up, grassroots-driven approach due to poor institutional buy-in. A lot of effort is required to maintain the new intersectoral partnerships we forged, and we need a sustainable leadership structure to anchor the development of citizen science (Dickinson, *et al.*, 2012).

↑ Local community participants documented wild plants and animals in patches of spontaneous vegetation in their residential areas. ©Kai Ren Tan

**Megadiversity was a liability for environmental education: limited online resources and layperson-oriented publications may have hindered accurate identification of taxa.**



↑ The KVCNC helped draw attention to common, but often overlooked, plants like *Mimosa pudica* that help support populations of pollinators like bees and butterflies. ©Benjamin Ong

Funding for this niche is hard to come by, particularly resources to recruit medium-term staff to conduct public engagement. Eschewing the temptation to go big, and instead engaging a small number of participants through a training-of-trainers model, may be a more sustainable medium-term strategy for overcoming capacity constraints. By targeting schoolteachers, local community representatives, and NGO leaders, and partnering with ongoing social movements, we may be able to free up resources to engage a wider audience.

Education on how to produce high-quality data is essential given low public participation in scientific research. This includes developing creative ways to help amateurs make sense of their local environments, e.g., through production of layperson-friendly interpretive guides, online and otherwise. (Much of the existing natural history literature caters to a more "advanced amateur" market.) Finally, we need to continue the push for government buy-in if citizen science is to become widely embraced. It is hoped that this reflection will draw out more voices from the tropical developing world, which may be relatively new to the citizen science scene.

## ACKNOWLEDGEMENTS

We would like to thank and recognise our fellow KVCNC organising committee members: Nurul Fitrah Marican, Siti Norasiah Abd Kadir, Siti Syuhada Sapno, Sugumaran Manickam and Vanessa Ting.



↑ The KVCNC interschool competition was well received by schools and inspired many students to participate. ©Courtesy of the Rimba Project

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## THE URBAN PRAIRIES PROJECT: CULTIVATING A COMMUNITY OF STEWARDSHIP

To support habitat restoration on open space parks and to cultivate a stewardship ethic among residents, Butterfly Pavilion, the City of Westminster and the City and County of Broomfield launched the Urban Prairies Project (UPP) in 2016. The UPP partners created an avenue for residents to get involved, the Restoration Master Volunteer program. These long-term volunteers participate in intensive trainings, then assist with leading restoration project days, data collection and environmental education. Restoration Master Volunteers have made it possible for local land managers to adopt data-based approaches to land management and to improve habitat for pollinators and other wildlife.

Open space parks and trails can address many of the challenges of urbanization by providing vital environmental services and accessible opportunities for people to experience the natural world. The link between nearby natural areas and human health is reinforced by a traditional association between the beauty of nature and healing. In 2013, the American Public Health Association officially recommended that land use decisions should prioritize the preservation and restoration of natural areas and green spaces for people of all ages, income levels and abilities. Researcher Stephen Kaplan has demonstrated other benefits of natural areas for urban and suburban residents, including a “safe haven” from city life, a greater sense of pride in and stewardship of the local environment, and increased awareness and understanding of the needs of local conservation issues.

↑ Partnerships with other nonprofits such as the Denver Zoo help with large plantings at Skyestone Pond ©Amy Yarger

**By restoring local open space parks to a greater degree of biodiversity, land managers and volunteers can include “planned complexity” in urban and suburban landscapes.**





↑ Goat impact monitoring training is one of the available community science options at Standley Lake Regional Park ©Amy Yarger

But not all open space parks are created equal. Urban and suburban open space parks often struggle with a high degree of ecological disturbance, due to fragmentation, pollution from industry and residential use, and colonization by invasive species. In comparison to wild lands, human-influenced landscapes generally support a far lower number of plant and animal species, along with less structural complexity. By restoring local open space parks to a greater degree of biodiversity, land managers and volunteers can include “planned complexity” in urban and suburban landscapes. With over half of the human population now living in cities and towns, a habitat network of restored natural areas and parks as well as private landscapes can add significant resources, especially for beneficial wildlife such as pollinators. Urban parks and natural areas also present an exciting opportunity – proximity to diverse community members who bring different skills, different perspectives and different networks to stewardship. As urbanization increases, effective community mobilization is key to ensure equal access to the benefits of natural areas.

The growing communities of Westminster and Broomfield, Colorado currently manage over 11,000 acres of open space parks and trails. These trails receive heavy use throughout the year, and 80% of residents in Broomfield report that they visit open space parks, with over half visiting over 10 times annually. Effective habitat restoration plays a central role in maintaining these sites for the community to enjoy. While restoration is currently a priority in these communities’ open space management plans, limited personnel and resources consistently challenge the effective management of these urban parcels. In order to increase impactful restoration activities on open space parks and to cultivate a stewardship ethic among local residents, Butterfly Pavilion, the City of Westminster and the City and County of Broomfield launched the Urban Prairies Project (UPP) in 2016.



↑ Restoration projects often happen within sight of local neighborhoods such as this one in Brighton, ©Amy Yarger

***Not only do these volunteers support ecological restoration within their communities, they also serve as passionate ambassadors in their networks, raising awareness about the natural world in their own neighborhoods.***



Each year, UPP partners work together to identify habitat restoration priorities throughout park systems, then develop a comprehensive scope of restoration work for each project, including activities, timeline, available resources, communication plan, risk management and evaluation plan. In order to successfully implement these restoration projects, the UPP partners created an avenue for interested members of the community to build expertise and get involved, the Restoration Master Volunteer program.

Restoration Master Volunteers contribute their time, enthusiasm and expertise to further ecological restoration in parks and natural areas in their communities. Urban Prairies Project partners recruit and train this cadre of long-term, committed open space volunteers who assist with leading restoration project days, collect data about the plants and wildlife at the site and engage the public with information about their local open spaces. Not only do these volunteers support ecological restoration within their communities, they also serve as passionate ambassadors in their networks, raising awareness about the natural world in their own neighborhoods. By training and leading other volunteer teams, these stewards extend the impact of habitat restoration to a larger audience. This program makes the most of an abundant and renewable resource: people.

Restoration Master Volunteers come to the program from a number of avenues, from traditional and social media to neighborly word-of-mouth and public outreach events. Restoration Master Volunteers are required to complete 25 hours of intensive classroom training, which includes subjects from weed identification and management to the dissemination of scientific information to the public. Restoration Master Volunteers then complete an additional 25 hours of field training and shadowing within the first year. Volunteers can pick and choose among a diverse array of restoration-focused projects and events which activities are the most convenient and meaningful for them. Volunteers report that they enjoy the opportunity to get the “insider’s view” of open space management and to learn more about native plants and wildlife in a social setting.

So far, the Urban Prairies Project has trained 65 Restoration Master Volunteers, who have contributed their efforts to everything from weed mapping to revegetation projects to pollinator monitoring to preschool nature walks. These volunteers have astounded us with their skills and expertise, as well as their enthusiasm for the sometimes arduous physical labor of restoration. Restoration Master Volunteers have made it possible for municipal land managers to follow trends in pollinator diversity and abundance, heron rookery success and the changes to soil in restoration areas. UPP has also worked closely with local schools and aligned nonprofits, such as the Broomfield Open Space Foundation and Wildlands Restoration Volunteers, in order to involve more local residents in restoration work. A relationship with Legacy High School has resulted in twice yearly youth service learning projects, including planting native shrubs and collecting invertebrate diversity data at a site adjacent to the school.

Over the next three years, project partners will evaluate restoration progress by measuring the changes in biodiversity and ecological function at project sites and use the results in order to fine-tune existing restoration plans and create new plans. The expansion of the Project will eventually include working with local businesses, schools and residents to train and certify them in creating their own pocket habitats to provide connectivity to the restored open spaces. This wide-ranging strategy can then serve as a basis for successful restoration efforts throughout the region, and eventually, healthier, more engaged communities in the Colorado Front Range.



↑ Restoration Master Volunteers enjoy the hands-on nature of the work at Plaster Reservoir in Broomfield CO. ©Amy Yarger

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# RESPONSIBLE GARDENING WITH *GREEN PIONEERS* AT MEISE BOTANIC GARDEN



When asked about the issues that prevent adequate control of invasive species, researchers and managers of invasive species rank public awareness first among all the issues. *Green Pioneers* is a citizen science project that aims to raise the general public's awareness of the potential risks of introducing alien species into the wild. The project organizes a range of activities to reach a broad demographic. With *Green Pioneers*, we want to encourage recording of alien species by amateur botanists and create a generation of responsible gardeners who understand the consequences of releasing problem plants into the wild.

← *Transcribathons for Online Pioneers are organized in Bouchout Castle at Meise Botanic Garden ©Quentin Groom*

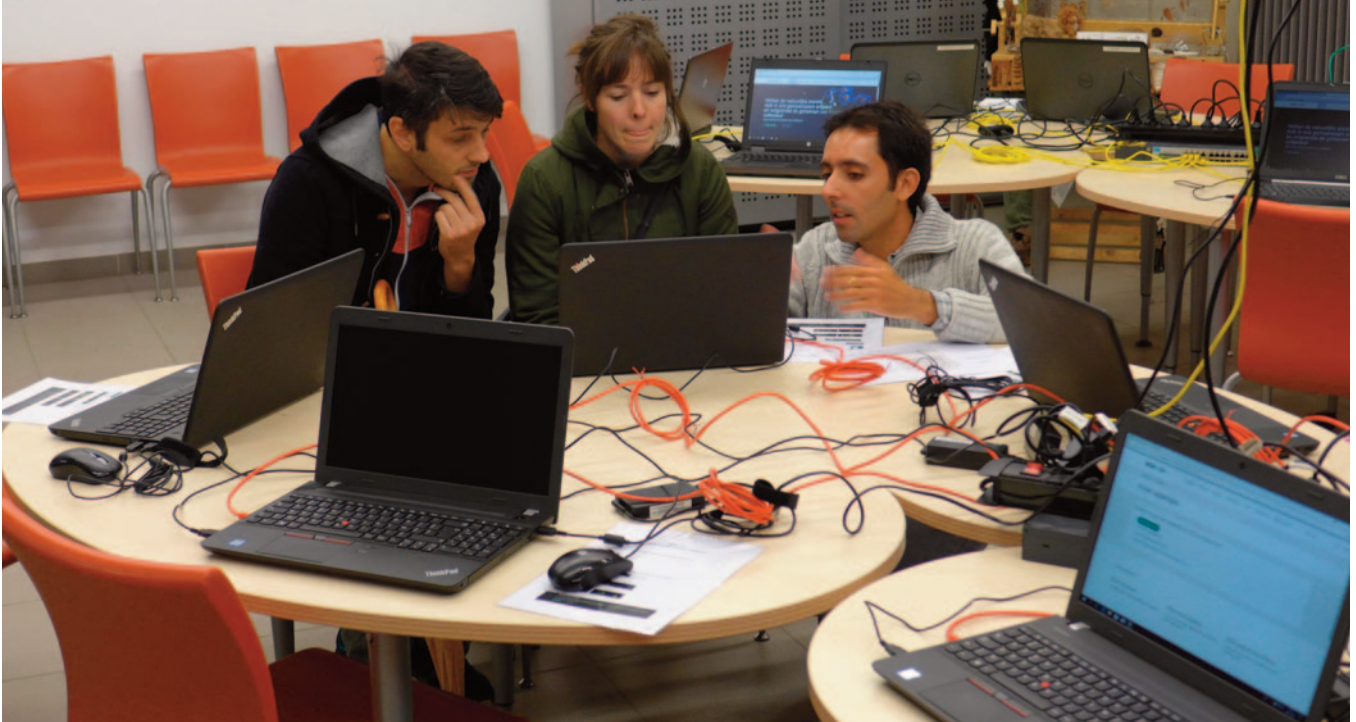
## “GREEN PIONEERS” INFORMS ABOUT INVASIVE SPECIES

The “*Green Pioneers*” project at Meise Botanic Garden is a citizen science project focusing on invasive species, which are species that have established beyond their native distribution range and pose a threat to the local fauna and flora. A recent survey of researchers and managers of invasive species ranked public awareness first among issues that need to be addressed at a regional and national level (Dehnen-Schmutz *et al.*, 2018).

With “*Green Pioneers*” Meise Botanic Garden aims to raise the general public's awareness of the potential risks of introducing alien species into the wild as well as to increase the quality and quantity of data on invasive species as these data are of interest to a wide-range of stakeholders in invasive species research, policy and management.

*Green Pioneers wants to encourage recording of alien species by amateur botanists and create a generation of responsible gardeners who understand the consequences of releasing problem plants into the wild.*





## “GREEN PIONEERS” GENERATES DATA ON INVASIVE SPECIES

In recent years, we have seen advances in electronic monitoring systems, remote-sensing, geographic information systems and statistics for tracking and predicting biological invasions. The Botanic Garden’s research programme on alien plants includes the Alien Plants of Belgium website and research on the ecology and taxonomy of alien plants in Europe (e.g. Groom *et al.*, 2017; Hulme *et al.*, 2017; Piria *et al.*, 2017; Pyšek *et al.*, 2017; Roy *et al.*, 2017). The Garden also plays an active role in the National Scientific Council on Invasive Alien Species and is leading the TriAS project in Belgium, which aims to monitor trends in species invasions, but also using statistical models to predict future invasions and identify potential risks. Nevertheless, these models are only as good as the data they are based upon. More data and more accurate data are always needed and because monitoring is continuous the demand for new data never stops.

Over the past 10 years, the Garden has made huge efforts in digitization and data sharing. To date we have imaged over 1.7 million specimens of the 4 million specimens kept in the Garden. From these 4 million, 25% have at least some of their label data transcribed. These labels hold large amounts of data, which include data on the locations and habitats of invasive species in their introduced and native ranges. With “Green Pioneers”, we want to encourage citizens to help us with the transcription of label data through our volunteer platform DoeDat.be and contribute in expanding the volume of data on invasive species.

## “GREEN PIONEERS” ACTIVITIES

We want citizens to become pioneers in the science of biogeography, just as the invasive plants are pioneers in Flanders. We aim to reach a public of all ages and all over Flanders by creating three streams of participation. We will have an online component for people to do at home or at school (*Online Pioneers*), and we will have two components based at the Botanic Garden, one for students (*Young Pioneers*) and another for adults (*Visiteers*).

↑ *Online Pioneers* use the Garden’s crowdsourcing platform DoeDat.be to help us transcribe the label information of herbarium specimens ©Ann Bogaerts

*The three primary objectives of Green Pioneers are to:*

- 1. Create more awareness of invasive plants, how invasions can be avoided and how negative impacts can be reduced.*
- 2. Create two-way communication between citizens and scientists on biodiversity and invasive plants.*
- 3. Increase the volume and improve the quality of data on invasive plants in Belgium.*

*We want citizens to become pioneers in the science of biogeography, just as the invasive plants are pioneers in Flanders.*





## YOUNG PIONEERS

We developed tools for teachers in science, technology, engineering and mathematics for school children from 12-15 years old. Yearly, approximately 9,300 children visit our Botanic Garden in the context of formal education. From 7th to 9th grade in Flanders, children learn about organisms and their habitats. With Young Pioneers we will add an extra dimension to the habitat study we offer to schools in our 92 ha garden. We will make use of existing technology such as the iNaturalist app to show them how and why it's important to record observations of invasive plants and how these data can be used for mapping distributions of species in the Global Biodiversity Information Facility (GBIF). In Young Pioneers, we will show students that technology is serving science and society and how it can be used to predict the future spread of invasive species.

## ONLINE PIONEERS

The Garden's crowdsourcing platform DoeDat.be is an important tool in Green Pioneers. DoeDat.be is an online, open-source platform that enables the annotation of images, the geolocation of specimens and the transcription of documents. The system is versatile and accommodates a variety of projects accompanied by an educative introduction and a tutorial. For Green Pioneers we created specific projects on invasive species that we use to explain the importance of knowledge on invasive species. Doedat.be also provides a forum to communicate with volunteers, both for support and for volunteers to support each other. Finally, the data will be imported into the collection's database of the Garden and will be made freely available on [www.botanicalcollections.be](http://www.botanicalcollections.be) and on GBIF.

Twice a year, the Online Pioneers are welcomed in the garden for a transcribathon at Bouchout Castle where they can transcribe label data all together at the same time and the same place. Through these events we, researchers and curators, get to know the Online Pioneers and they get to know us and each other. At least one of these transcribathons is organized during the WeDigBio (Worldwide Engagement for Digitizing Biocollections) event, a 4-day event that engages participants online and on-site in digitizing natural history collections.

↑ Companies, societies and clubs can participate in visitteering events themed around the science of invasive plants organized by the Garden  
©Naomi Bousson



↑ Giant hogweed (*Heracleum mantegazzianum*): an invasive plant spotted in the Garden by our visitors  
©Naomi Bousson



## VISITEERS

The volunteering community has been focused on people who can spend a part of their spare time on volunteer work. A new way of volunteering is visitteering, a concept created by the Natural History Museum in London, aimed at working age people and their employers, a segment of the community that is hard to reach otherwise. Visitteering is volunteering without commitment to repeated involvement and with minimum formality, involving short and specific actions that are quick to start and complete. Visitteering offers the chance to get involved alongside scientists and help with genuine collections-based work for a day, taking you from visitor to active volunteer.

We theme our visitteering event around the science of invasive plants. We can flexibly organize a number activities to suit the skills and interests of the participants e.g. mounting specimens of invasive species, helping our gardeners to weed invasive species in the Garden, introducing data of herbarium specimens into our institutional database or through our citizen science platform DoeDat.be, collecting invasive species growing in our Garden as an addition to our herbarium. Furthermore, in the visiting part of the activity the participants gain knowledge about invasive species and their Latin names, impacts of invasive species on biodiversity, plant and specimen preparation and data management.

## BIOBLITZ

Finally, we will be organizing a BioBlitz in spring 2020 (May 22-24) at Meise Botanic Garden where we will celebrate plants and all our Green Pioneers, while also spreading the message of invasive plant awareness. During our 48 hour BioBlitz, scientists, volunteers and citizens are working together to survey the biodiversity of our Botanic Garden.

By organizing all these activities, Green Pioneers wants to encourage recording of alien species by amateur botanists and create a generation of responsible gardeners who understand the consequences of releasing problem plants into the wild.



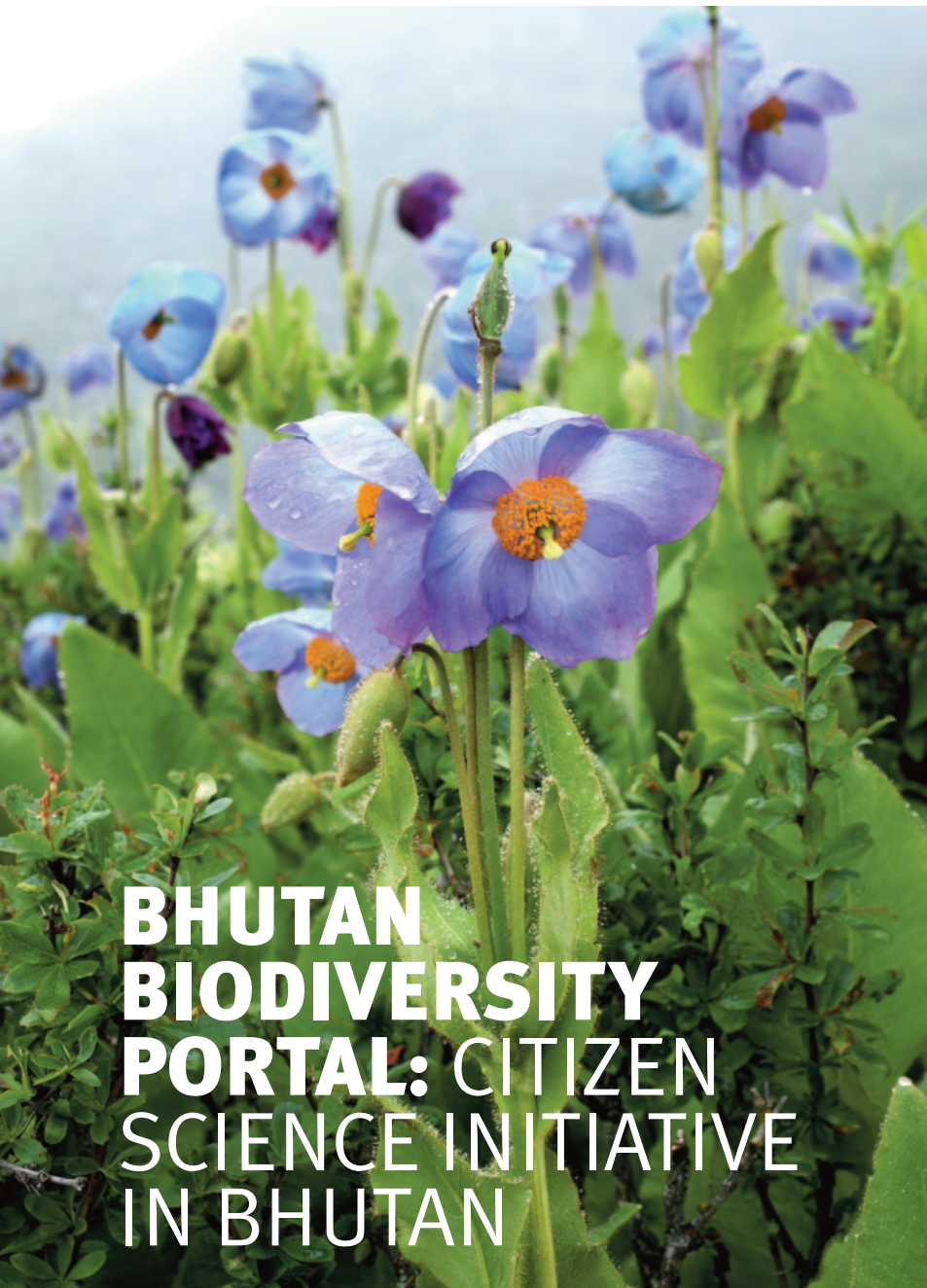
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← *Visitteers collecting invasive plants as an addition to the herbarium ©Naomi Bousson*

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# BHUTAN BIODIVERSITY PORTAL: CITIZEN SCIENCE INITIATIVE IN BHUTAN

The Bhutan Biodiversity Portal ([www.biodiversity.bt](http://www.biodiversity.bt)) is the first of its kind for South Asia - a pioneer initiative, established and guided by a consortium of major biodiversity stakeholders, with technical support from an external collaborator.

The project agreement was initiated under the framework of the UN Conference on Environment and Development (1992) in Rio de Janeiro. This agreement was formalised in 1994 and subsequent programmes led to the creation of the Bhutan Integrated Biodiversity Information System (BIBIS) in 2002. BIBIS was the product of a collaborative effort between many agencies and aimed to create a biodiversity information platform that was accessible to anyone interested in Bhutan's biological resources.

← The national flower of Bhutan, Blue Poppy (*Meconopsis galydiana*) was described in 2017 ©Rinchen Yangzom

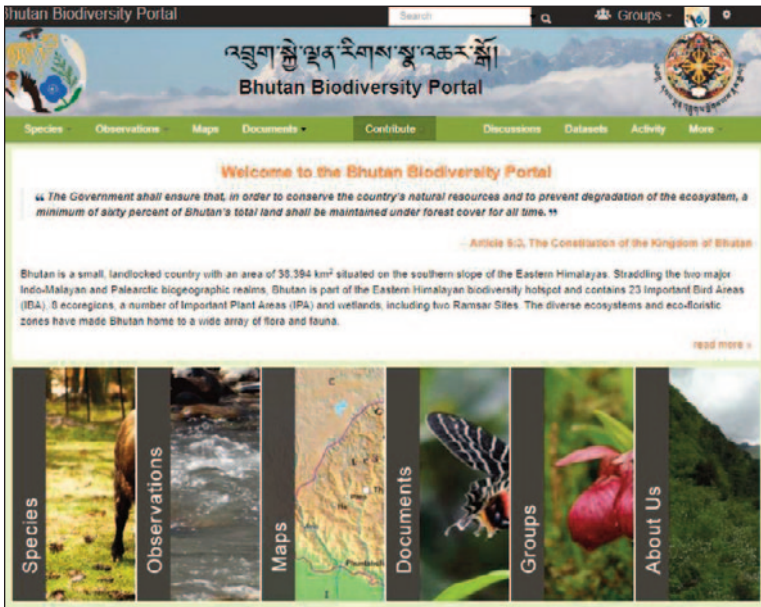
A major challenge for Bhutan is access to reliable and up-to-date biodiversity information for effective conservation planning and sustainable use of natural resources. The Bhutan Biodiversity Portal, is the first initiative of its kind in South Asia, and was launched to address this issue. It is an open access, one-stop citizen science data repository for biodiversity information. The portal aims to aggregate biodiversity data recorded through citizen science, while facilitating a platform for the flow and discussion of biodiversity related information between scientific experts and amateurs alike, in order to promote biodiversity conservation within the community.



↑ An awareness workshop to the students of Samtse College of Education ©Danielle Northey

***Bhutan is home to a recorded 11,248 species within all biodiversity taxa.***





← Web interface of the Bhutan Biodiversity Portal ([www.biodiversity.bt](http://www.biodiversity.bt))

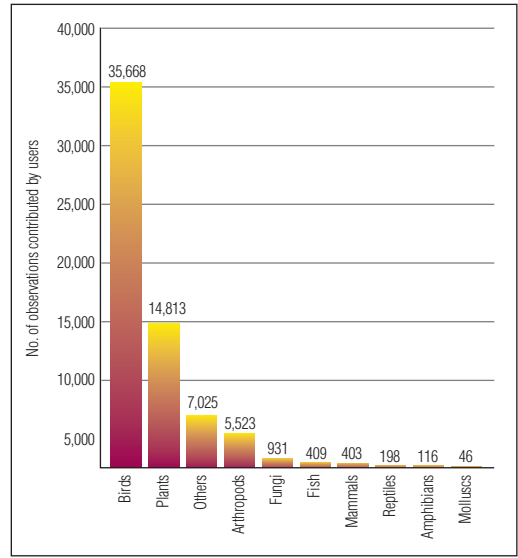
*The country has 71% forest cover and 51.4% of that area is protected.*

In 2008, BIBIS was upgraded to a web-based biodiversity portal and in 2011; it was further advanced to its present form: the Bhutan Biodiversity Portal (BBP), a national consortium-based, citizen science approach to documenting and managing biodiversity. Consortium members include the Royal University of Bhutan represented by the College of Natural Resources, Department of Forests and Park Services represented by Nature Conservation Division, and Ugyen Wangchuck Institute for Conservation and Environmental Research, Information, Communication and Technology Division of the Ministry of Agriculture and Forests, World Wide Fund for Nature – Bhutan; and the National Biodiversity Centre who act as the secretariat for the consortium. Technical support is provided by Strand Life Sciences in Bangalore, India.

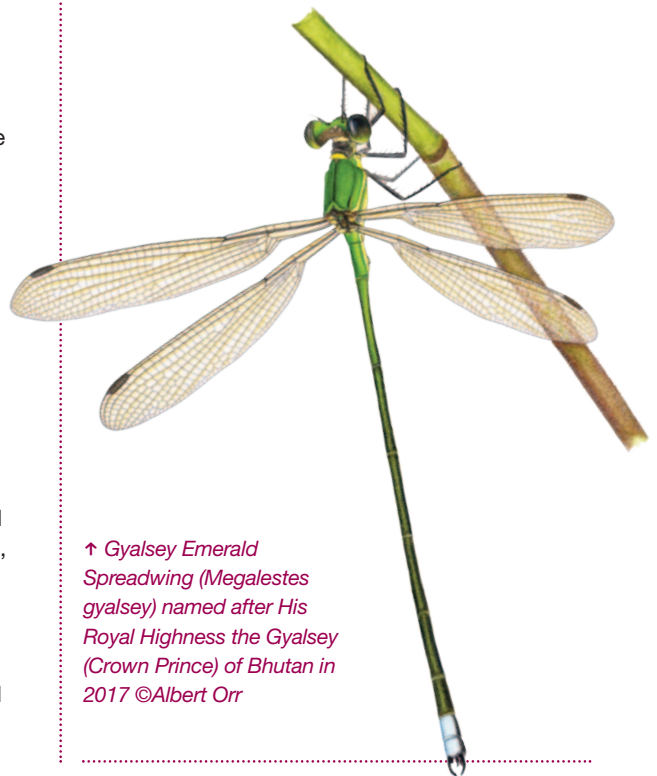
Environmental conservation is one of four pillars of the Gross National Happiness philosophy in Bhutan and the portal encourages Bhutanese citizens to embrace their fundamental duty of protecting their natural environment and biodiversity, as enshrined in Article 5.1 of the Constitution of the Kingdom of Bhutan.

This citizen science initiative aims to promote and harness collective effort in generating and verifying content in a comprehensive, cost-effective and inclusive manner, thereby alleviating the monumental task of documenting the rich biodiversity of Bhutan. Additionally, having a consortium of different biodiversity stakeholders helps address the issue of duplicative efforts in developing and managing isolated information systems and databases around the country. Dickinson, Zuckerberg and Bonter (2010) suggest that this model of citizen science: the monitoring of biodiversity across large geographic regions has been highly influential in the field of ecology. They also argue that multiple species surveillance across an area has the potential to shed light on unexpected or counterintuitive trends that could provide a valuable trigger for more systematic, targeted ecological research.

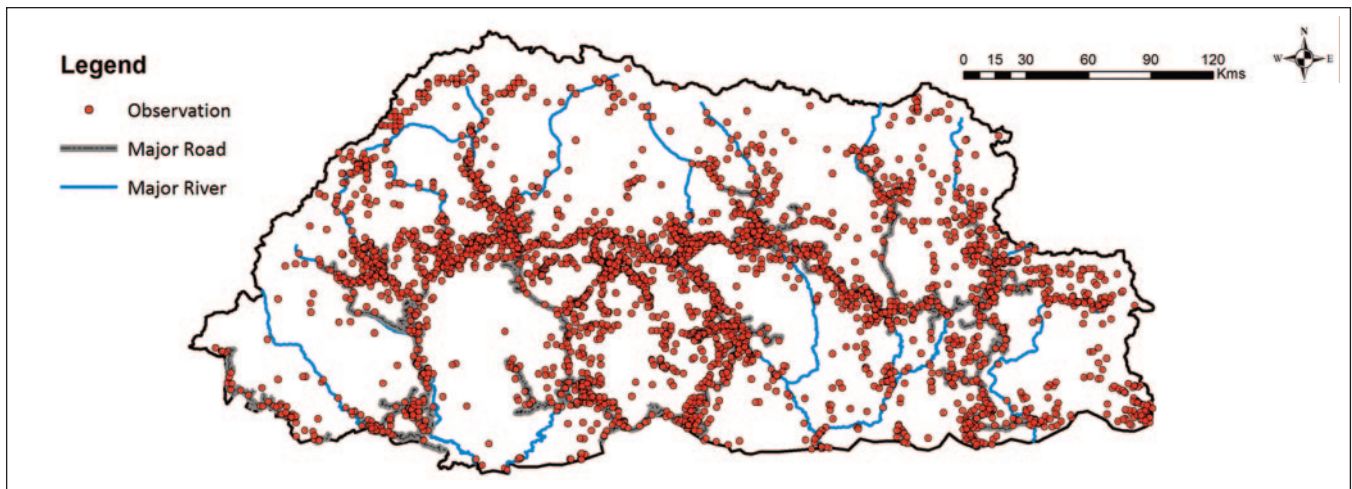
The BBP was officially launched in December 2013 and since then; it has been gaining momentum with steady increases in the numbers of observations and registered members. Currently, there are 1,692 registered users on the BBP and they have contributed a total of 65,151 observations, more than 200 documents and more than 20 datasets related to the country's biodiversity. All data on the portal are open-access and shared under the Creative Commons licensing system. The users upload observations of plant or animal species in the form of photos, video or audio files. They also specify the date and location of their observation and can request assistance from other members of the portal with species identification.



↑ Number of observations (by species group) contributed by registered users until August 2019



↑ *Gyalsey Emerald Spreadwing (Megalestes gyalsey) named after His Royal Highness the Gyalsey (Crown Prince) of Bhutan in 2017 ©Albert Orr*



The portal contains a wide range of reference material such as species information (the curated and detailed description of individual species found in Bhutan); maps (spatial information such as roads, settlements, Important Bird Areas which can be layered and viewed through an interactive user-interface); datasets of specific taxonomic groups, for example a species checklist of fish species found in Bhutan; as well as journal articles and other literature related to local biodiversity.

Promotion of the portal has included awareness raising workshops and seminars, such as Bioblitzes, e-newsletters, print and broadcast media, magazines, audio-visual user manuals, training courses, and social media. In addition, individual Bioblitz campaigns were also launched such as the “Wild River Bioblitz” in April and the “Busy Butterfly Bioblitz” in June. Through user analysis conducted in 2018, the main reasons/responses as to why people were motivated to use the BBP were:

- a. “I want to learn more about the biodiversity of Bhutan”
- b. “Interest in nature conservation”
- c. “I want to contribute to the biodiversity index of the country”
- d. “I want to help with species identification”

The development and management of the portal has however included some challenges. With a continual inflow of data and limited taxonomic expertise for some groups, bottlenecks can form. Alongside funding data, curation remains a major challenge. Technical support, which includes troubleshooting and upgrades is also a challenge for Bhutan particularly due to limited human resources available.

The BBP helps to showcase the high levels of biodiversity found in Bhutan. The country occupies a modest area of 38,394 km<sup>2</sup> but has 71% forest cover and as of 2017, is home to a recorded 11,248 species within all biodiversity taxa. In the last decade, at least 33 species new to science have been discovered in Bhutan, including a dragonfly species named after the Crown Prince of Bhutan (His Royal Highness the Gyalsey) and the national flower of Bhutan, the blue poppy (*Mecconopsis gakyidiana*) which was described in 2017. The largest known kingdom, Plantae, consists of an astounding 4,567 species of vascular plants in addition to numerous other species of flora (NBC 2019). However, currently, the most documented species groups in the portal are birds followed by plants.

A primary objective of this portal is its accessibility to all sections of society: students, researchers, policy makers, conservationists, amateur naturalists, tourism operators and anybody with an interest in Bhutan’s flora and fauna. Our collective efforts will ensure that we (a) understand and appreciate our rich biodiversity, (b) translate this understanding into effective conservation and sustainable use, and (c) respect the principle of inter-generational equity and our sacred duty as custodians to uphold, protect and deliver intact our ‘green heritage’ to future generations.

↑ *Distributional map of observations contributed by registered users until August 2019*

*A pioneer initiative; the first of its kind in South Asia. The portal encourages Bhutanese citizens to embrace their fundamental duty of protecting their natural environment and biodiversity.*

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# CITIZEN SCIENCE: A TOOL TO COORDINATE LOCAL ACTION FOR GLOBAL GOALS

## Bald Eagle

Pygargue à tête blanche 白头鹰



These iconic raptors were close to extinction until coordinated conservation actions across North America were taken and populations increased.

## Common Raven

Grand Corbeau 渡鸦



Among the smartest of all birds, ravens can mimic the calls of other bird species. Ravens are common tricksters in oral stories of Indigenous Peoples of the Pacific Northwest.

## Cooper's Hawk

Épervier de Cooper 库柏鹰



Skillful and stealthy fliers, Cooper's hawks provide excellent rodent control. Male hawks build nests and provide food to females and young.

## Northwestern Crow

Corneille d'Alaska 西北鸦



Murders of crows are often seen flying across Vancouver to North Burnaby at sunset to roost (gather) together.

## Black-capped Chickadee

Mésange à tête noire 黑顶山雀



With complex calls and songs, the black-capped chickadee is often heard before seen. They can remember the many hiding places where they cache seeds.

## Rufous Hummingbird

Colibri roux 棕煌蜂鸟



These feisty birds spend much of the year migrating in a clockwise circuit around the West Coast of North America. They are primarily nectarivores, feeding on flower nectar.

## Ruby-crowned Kinglet

Roitelet à couronne rubis 红玉冠戴菊鸟



Always on the move, the ruby-crowned kinglet is small and olive-coloured. Males have red crowns that are often kept hidden.

## European Starling

Étourneau sansonnet 欧洲掠鸟



First brought to North America in the early 1890's, these invasive birds were introduced in New York's Central Park to re-enact the birds in Shakespeare's plays.

## Spotted Towhee

Tohi tacheté 斑唧鸟



During conflicts between two towhees, one may pick up a stick, leaf, or bark and carry it around. This single species has been separated into 20 different subspecies.

## Song Sparrow

Bruant chanteur 歌带鸟



Widespread and common across North America, male song sparrows sing trills (deep deep deep-deep chrrrrr tiiiiiii tyeeur) to attract females.

## Pacific Wren

Troglodyte de Baird 鹪鹩



Wrens make impressively loud songs and calls for such small birds. Males will build multiple nests within their territory for females to choose from.

## American Robin

Merle d'Amérique 美洲知更鸟



Robins are similar to varied thrushes. They migrate across North America and look for fruit in winter months. They flock together and will gather in large roosts.

## Barn Swallow

Hirondelle rustique 家燕



All swallows in North America are migratory. These steely blue birds like to nest in the eaves of barns and stables.

## Northern Flicker

Pic flamboyant 北扑翅鸟



Flickers are often heard pecking, drumming or making a loud call (kew-kew-kew). Unlike other woodpeckers, they will feed on the ground, using their long-barbed tongue to lap up ants or other insects.

## Varied Thrush

Grive à collier 杂色地鸫



The varied thrush is called "the voice of old-growth forests" in British Columbia. These birds can be seen on or near the ground.

## Red-winged Blackbird

Carouge à épaulettes 红翅黑鹂



One of the most abundant birds in North America Red-winged Blackbirds can be seen in dense flocks. The males bear bright red shoulder patches with yellow edges.

Addressing the biodiversity crisis requires action locally and globally. For botanical gardens, citizen science is a tool to grow a garden's influence and impact by inviting collaboration and connection between scientists and citizens. At UBC Botanical Garden diverse programs are underway exploring how citizen science can advance plant collections, conservation, and other goals at the University and regionally. As part of the University of British Columbia's Faculty of Science, the Garden is positioned well to serve as a bridge between the public, the University, and science.

↑ Top 20 bird species recorded on eBird in the Garden based on 2018 data ©UBC Botanical Garden, photos used with permission, see [botanicalgarden.ubc.ca/bird](http://botanicalgarden.ubc.ca/bird) for details

Public awareness of climate change and biodiversity loss is long overdue and time is running out to conserve and protect our planet. Scientific research and evidence-based decision making are core to coordinated, scaled up action. The UN Sustainable Development Goals (SDGs) outline 17 goals that serve as a call to action aimed at transforming our world to a more sustainable future by 2030 (United Nations General Assembly, 2015). Recent reports contribute to raising awareness of the loss of biological diversity worldwide and highlight causes such as land use change, agriculture, urbanization, and other challenges (IPBES, 2019).

*"UBC Botanical Garden's monthly bird survey is popular. When there are no bird sightings or sounds, our interest readily shifts to the plants. Our growing plant awareness as habitat and food is heightening our birding appreciation."*  
Bev Ramey

Increasingly, global strategies call for citizen involvement to prevent the loss of species and move towards a net positive, biodiverse landscape. However, addressing the biodiversity crisis while advancing multiple sustainable development goals requires coordination of people, information and action. For biodiversity in particular, it is a significant challenge to monitor species, understand their biology, identify threats, and conserve them across multiple species levels, spatial ranges and temporal scales. These efforts cannot be tackled by any one policy, research project, person, institution or sector. Botanical gardens are positioned well to act as convenors and coordinators for citizen science programs that build local capacity for global change. Stories and recent examples from UBC Botanical Garden are shared as the organization explores future opportunities and challenges of scaling up community citizen science efforts.

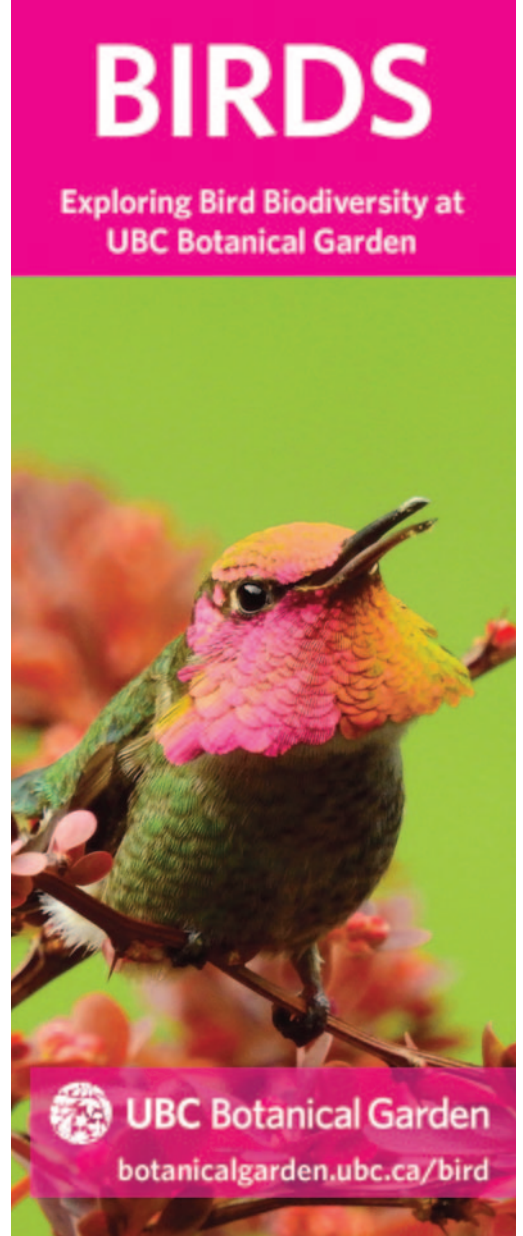
## BOTANICAL GARDENS AND CITIZEN SCIENCE

Botanical gardens are important institutions in the fight to save the world's plants. Conservation of plants, biodiversity, and ecosystem services are central to their organizational missions, educational programs, research initiatives, partnerships and programs. As a network, botanical gardens are well connected through associations like BGCI and the American Public Gardens Association. Increasingly, efforts are underway to align and build capacity of gardens as local conservation leaders for global action towards the SDGs. Citizen science offers a unique tool for botanical gardens to grow their influence and impact by providing opportunities for the public to participate in research programs that support individual and collective engagement with conservation, community development and scientific process.

Citizen science programs can raise participant awareness of local issues and solutions through diverse approaches, which is important for building conservation networks, increasing best practices and informing local environmental policies and biodiversity management decisions. Further work is needed to advance citizen science research, clarify goals and target audiences, manage data, ensure sound scientific process and communicate findings and key lessons.



↑ Collaborative team working with Metro Vancouver, UBC Data Science for Social Good and UBC Botanical Garden to map citizen science data on sensitive ecosystems ©UBC Botanical Garden



↑ UBC Botanical Garden bird brochure produced in 2018 based on the most abundant bird species recorded in e-bird by Nature Vancouver. ©UBC Botanical Garden, photo: Faith Uytengu

↓ UBC Botanical Garden's hotspot page on eBird where monthly bird surveys by Nature Vancouver are recorded. ©UBC Botanical Garden

SPECIES NAME	COUNT	DATE	BY
1 Rufous Hummingbird	1	18 Aug 2019	Thierry Besancon
2 Warbling Vireo	1	18 Aug 2019	Thierry Besancon
3 Common Raven	1	18 Aug 2019	Thierry Besancon
4 Black-capped Chickadee	3	18 Aug 2019	Thierry Besancon
5 Chestnut-backed Chickadee	5	18 Aug 2019	Thierry Besancon
6 Barn Swallow	3	18 Aug 2019	Thierry Besancon
7 Red-breasted Nuthatch	1	18 Aug 2019	Thierry Besancon
8 Cedar Waxwing	1	18 Aug 2019	Thierry Besancon
9 American Goldfinch	3	18 Aug 2019	Thierry Besancon
10 Spotted Towhee	1	18 Aug 2019	Thierry Besancon





## UBC BOTANICAL GARDEN AND CITIZEN SCIENCE OPPORTUNITIES

Our Garden, part of the University of British Columbia's Faculty of Science, is Canada's oldest university botanical garden and serves as a bridge between the public, the University and science. At UBC Botanical Garden, our team has been exploring how citizen science programs can impact our collections, mission, University and our region. Visitors to the garden can learn and engage with science and scientific process through our plant collection database, online resources, guided tours, interpretive signs, team building experiences, and by participating in citizen science programs.

Citizen science programming at UBC Botanical Garden has emerged through collaboration with partners and community groups. Recent initiatives include projects specialized to specific taxa and species (e.g. bird surveys with Nature Vancouver, magnolia phenology studies with Friends of the Garden volunteers, tree and shrub mapping on campus with horticulture students, and bumblebee diversity and abundance assessments with UBC Faculty and students), and others which are more generalized (e.g. mapping broad citizen science data on sensitive ecosystems in Metro Vancouver).

## GENERALIZED AND SPECIALIZED CITIZEN SCIENCE PROGRAMS AT UBC BOTANICAL GARDEN

An ongoing specialized citizen science program at UBC Botanical Garden is the monitoring of bird diversity and abundance on-site in collaboration with Nature Vancouver. Nature Vancouver has a long history of leading and monitoring bird diversity in the region. The organization has published regional bird checklists for three decades, hosted annual Christmas bird counts since 1958, and has conducted bird surveys at multiple locations across the region with data being logged onto eBird. Started in 2017, volunteers from Nature Vancouver spend 2.5 - 4 hours a month surveying birds in the Garden. Data from monthly bird surveys is collected across 10 areas of the Garden, entered into an Excel spreadsheet and aggregated data is uploaded to eBird, which provides a publicly viewable profile for the Garden (<https://ebird.org/canada/hotspot/L367520>). eBird Canada ([ebird.ca](https://ebird.ca)) is managed by Bird Studies Canada as a national page for eBird, the international project run by the Cornell Lab of Ornithology. eBird provides a central tool for individuals and groups to record bird sightings. The data can be explored using various tools such as printable checklists, seasonal bar charts, details on bird species, and dates of records. All entered data is reviewed by knowledgeable birders who verify the quality of the entries for accuracy.

↑ Aerial photo of Grow Green Guide demonstration garden beds at UBC Botanical Garden in collaboration with Metro Vancouver ©UBC Studios

***“As UBC Botanical Garden is looking to increase its impact and reach, we are exploring why, how and where citizen science can be strategically implemented to achieve our plant conservation and biodiversity stewardship goals.”***

*Tara Moreau*

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Collaboration on monthly bird surveys is not the first time our Garden has partnered with Nature Vancouver. The history between the two organizations began over 100 years ago when the Garden's first director, John Davidson founded our Garden in 1916 and Nature Vancouver in 1918. The two have worked together on and off, but the collaboration was revived in 2018 in anticipation of the world's largest ornithological congress coming to Vancouver. Nature Vancouver birders, UBC students, and Garden staff designed a bird brochure to raise awareness of local species by highlighting the top 20 birds identified in the data collected in eBird.

Another collaboration with Metro Vancouver and UBC Data Science for Social Good (UBC DSSG) provides an example of a generalized project aimed at advancing conservation and public engagement with biodiversity. Over three years, the Garden and Metro Vancouver have collaborated on the Grow Green Guide (Metro Vancouver, 2019). This online tool hosts over 100 garden designs to inspire residents to grow gardens that support wildlife, native plants, water conservation and lawn alternatives. During the summer of 2019, a new project with UBC DSSG engaged students from three disciplines in creating an innovative tool to map regional data onto local sensitive ecosystem inventories. The final product provides a tool for local and regional planners to evaluate biodiversity.

Citizen science programming offers interesting lessons and opportunities for how technology, public interest and regional priorities can be achieved. By engaging the public, gardens have an opportunity to foster evidence-based decision making and actions to inform the planning, management, and protection of our landscapes in order to prevent the loss of species and foster a healthy, biodiverse world.

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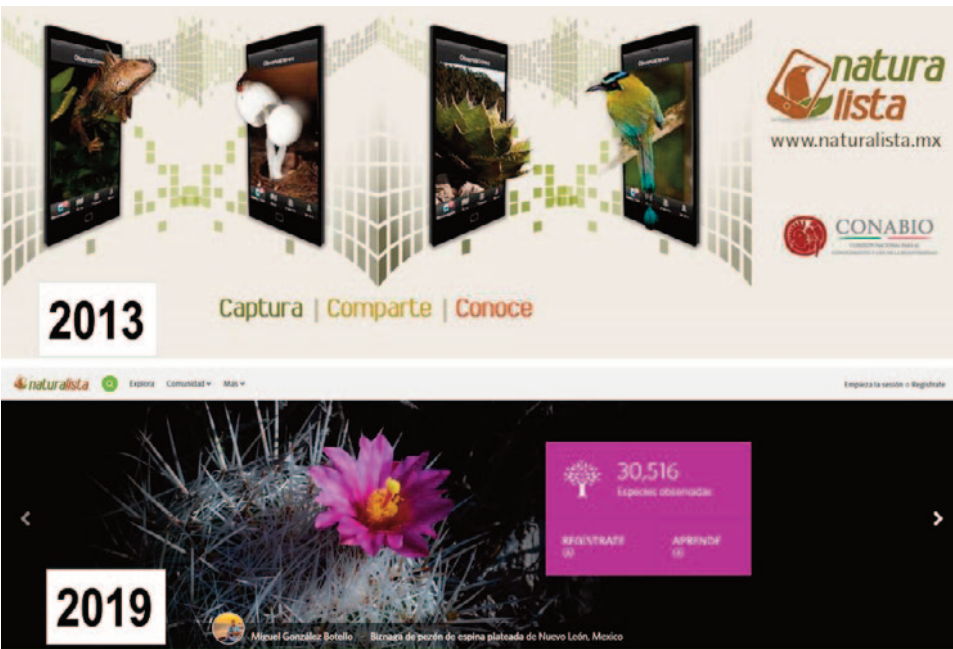
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↓ Aerial photo of the Food Garden and Taylor Plaza at UBC Botanical Garden. The Taylor Plaza is a gathering space used in educational programs and by groups conducting citizen science ©UBC Studios





# CITIZEN SCIENCE: AN ENDEAVOUR WITH PURPOSE AT THE BOTANIC GARDEN



Over the years, researchers and staff of the Cadereyta Regional Botanic Garden have collected observations and records of native flora and fauna. These have been complemented by contributions from external participants, who upload data to the “Naturalista” platform, hosted by the National Commission for the Knowledge and Use of Biodiversity (CONABIO). Some of these citizen scientists have contributed to formal assessments and studies regarding local and regional biodiversity. Today, the Botanic Garden has become a “multiplier place” of the “Naturalista” platform and offers divulgation talks and training about its use to visitors.

The Cadereyta Regional Botanic Garden (CRBG) uses a multi-pronged approach to address its flora conservation mission. Alongside its main priorities of *ex situ* conservation, environmental education, research and dissemination linked to regional flora, the CRBG is also committed to the preservation, maintenance, study and management of its wild area, which comprises 80% of the whole site. The wild area is considered a refuge or sanctuary that hosts and maintains local biodiversity, which is particularly relevant due to the changes in the surrounding environment.

Numerous efforts have been made to monitor and record the biodiversity in the garden’s wild area (Orozco nd; Chávez and Hernández-Magaña 2003; Martínez y Díaz de Salas *et al.*, 2003). The first official list of wild species was released within the CRBG Integrated Management Plan (Sánchez and Sanaphre, 2009), and included 239 taxa of flora, 51 vertebrate species (32 birds, 12 mammals, 5 reptiles and 2 amphibians), and 44 taxa of insects. A few years later, following a full year of bird watching activities across the site, the first bird guide of the CRBG was published and included 78 species.

Progress has however been limited, until the launch of “Naturalista”, the Mexican platform of the international network iNaturalist (Fig. 1). Since 2013 “Naturalista”, which is managed by the National Commission for the Knowledge and Use of Biodiversity (CONABIO), has been working to provide training and improvement in the knowledge of Mexican biodiversity, and its dissemination among citizens who are encouraged to observe, capture and share photographic records of flora, fauna and fungi.

↩ Then and now: cover image of the “Naturalista” platform, in its launch (2013) and in 2019



↑ Biodiversidad del Jardín Botánico Regional de Cadereyta”, one of the projects conducted by the CRBG at “Naturalista”



← Examples of the 1,500 taxa registered during the period of intense observation in 2018. The image includes: 1. A native species of the region, well represented in the living collection, *Cephalocereus polylophus*. 2. An exotic and invasive species, *Kalanchoe delagoensis*. 3. A species of the wild area, *Sphaeralcea angustifolia*. 4. A resident bird, *Phainopepla nitens*. 5. A migratory species, *Danaus plexippus*. 6. A mesopredator of the region, *Urocyon cinereoargenteus*.

1. Gabriel Cosultchi. 2. Arthur Chapman. 3. User: Letebile. 4. Richard Wood. 5. Hailen Ugalde de la Cruz. 6. Todd Fitzgerald. ©"Naturalista".

↓ Promotion of the "Naturalista" projects and activities in the CRBG social media.

"Naturalista" is a citizen science platform, which along with many others around the world --iNaturalist, eBird, Mosquito Alert, NASA GLOBE, PlantSnap, for example-, systematically collects data that helps to increase our knowledge of species distribution, and to break down barriers of traditional data collection e.g. that it is an exclusive activity only carried out by specialists in the field. Citizens provide information that can be verified, and, when appropriate, channelled to domestic and global databases, such as the National Biodiversity Information System (SNIB), or the Global Biodiversity Information Facility (GBIF) (CONABIO, 2018; Tello, 2018). Citizen scientists can also monitor threatened species and contribute to the planning process of the most endangered plant species, among many other issues (Sharrock *et al.*, 2014).

Many enthusiast users of "Naturalista" have been contributing to the knowledge of the CRBG wildlife since 2014, with their continuous observations and records of plants, animals and fungi. Combining their efforts with those of the CRBG staff; the inventory of biodiversity in the wild area has increased significantly. Today, there are records of more than a thousand taxa, including: 263 plants, 186 vertebrates (144 birds, 19 mammals, 17 reptiles and 7 amphibians), 730 arthropoda (2 diplopoda, 25 arachnida and 703 insects), along with 3 records of mollusca, 2 of crustaceans and 1 anellid (Sánchez *et al.*, unpublished). A special mention should be made of those users who also added information to the formal inventories of the local and regional biota, collaborating with scientists (Hernández Díaz *et al.*, 2015) and through their records, contributing to more than 40 specific projects of the platform.

Part of CRBG's effort to contribute towards conservation targets for the region is through the use and promotion of "Naturalista" inside the garden, and as a learning tool to collect biodiversity data. Furthermore, in 2018 the CRBG signed an MOU with CONABIO to support the "Naturalista" platform, and to increase the knowledge of biological diversity within the area and in the Semi Arid Zone of Queretaro and Hidalgo. Hence, the CRBG joined the "Red de Espacios Multiplicadores de Naturalista" ("Naturalista" Multiplier Space Network, NMSN). Over five months of intensive observations, a group of ten individuals registered more than 1,500 records of plants, animals, lichens and fungi, through three related projects: "Biodiversity of the CRBG", "Biodiversity at the Semi Arid Zone of Queretaro and Hidalgo", and "Phenology at the living collection of the CRBG". The first two were created to document wild biodiversity inside and outside the CRBG boundaries; the third one was conceived to monitor plant phenology of the species of the *ex situ* living collection.



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↑ Training seminars about “Naturalista” were offered to scholars visiting the CRBG. 1. High school students from San Juan del Río, Querétaro (October, 2018). 2. Students from the National Autonomous University of México (September 2018). ©Cadereyta Regional Botanic Garden.

Among those records, there were plants from 72 botanical families, animals of 27 different orders, and several macromycetes and lichens. This number of observations suggests that if the observation period was extended throughout the year, it would be possible to obtain many new records, including those that appear in the area due to migratory cycles and seasonal variations. Further efforts would also enrich the list of observed organisms, through a more careful determination of objectives, biological groups, sampling and analysis methods. Today, these projects are still running and adding records and observations.

Actions of the CRBG included dissemination of the “Naturalista” platform among visitors of the garden through a series of specialized talks, and the promotion of projects and platform via the CRBG social media). As for its collaboration, CONABIO trained the CRBG staff in the “Naturalista” platform use, and donated photographic and computer equipment.

The local registry of biodiversity and the promotion of tools for citizen participation, such as “Naturalista”, reinforces our knowledge of nature, and offers users a chance to get to know the natural world of their locality through photographic observation. The CRBG, as member of the NMSN, is engaged with this task, and its effort will continue. Nature snapping is an endeavour with purpose that connects people with native plants species and opens up more possibilities for sustainable development.



↑ The Garden’s Director, Emiliano Sánchez, thanks Juan Cruzado Cortés (CONABIO) after the initial training sessions offered to the CRBG staff and special guests (July 2018) ©María Magdalena Hernández Martínez

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# POLLI:BRIGHT: A CITIZEN SCIENCE PROJECT AT THE PISA BOTANIC GARDEN

↑ A glimpse of the Botanic Garden of Pisa University (Tuscany, Italy) ©Giada Cordoni

Citizen science is the process whereby citizens are engaged in science as researchers. The Pisa University is a partner of the Polli:Bright project which started as an Italian adaptation of Polli-Nation, a British project of citizen science (<http://polli-nation.co.uk/>). This project aims to build public knowledge about the vital relationship between plants and pollinators by entrusting data collection to primary and high school students. POLLI:BRIGHT allows researchers to gather information on the conservation status of pollinators in Tuscany and to fine-tune the methodology for replicating the project in other Italian regions with the crucial collaboration of community-based groups.

**N**atural processes serve significant benefits to human society. These benefits are commonly considered within a new conceptual framework - *the Millennium Ecosystem Assessment* - that documents and analyses the effects of environmental changes and human actions on ecosystem “services” and human well-being (Carpenter et al., 2009; Birkin and Goulson, 2015).

Indeed, among the most significant ecosystem “services” are insect mediated-pollination which favour high levels of crop production and maintain ecological balance (Dicks et al., 2013; Birkin and Goulson, 2015). Nevertheless, in the last decade, we have witnessed a worldwide decline in the number, range, and species diversity of both wild and managed pollinators. For example, in central Europe, since 1985, honeybee colonies have decreased by approximately 25% (Potts et al., 2010). Several combined factors such as habitat fragmentation, climate change, agricultural pesticides and alien species, may be responsible for pollinator decline (Lebuhn et al. 2013, Smith et al., 2015).



↑ An example of the guides used by students for identifying habitat, plants and pollinators and recording field data ©Giada Cordoni





← The experts of the Natural History Museum of Grosseto and the school teachers involved in POLLI:BRIGHT during the Teacher Learning phase of the project ©Giada Cordoni

***POLLI:BRIGHT is a successful example of an Italian citizen science project carried out by an academic partnership.***

The scientific community is trying to put in place a long-term and worldwide pollinator monitoring plan to collect data to address this critical question. In England, the recent *National Pollinator Monitoring Strategy* (DEFRA, 2014) has defined a 10-year programme for supporting pollination services, highlighting the need to promote the participation of the general public in scientific research (an example of citizen science).

The Botanic Garden of Pisa University (Tuscany, Italy), under the leadership of the Natural History Museum of Grosseto (NHMG) and in partnership with the Botanic Garden of Siena University and the Botanic Garden of Florence University (Tuscany, Italy), participated in a pioneering Italian citizen science project on pollinators: *POLLI:BRIGHT* (<http://www.pollibrigh.it/>). Following the blueprints of the English project *POLLI:NATION* (developed by OPAL - Open Air Laboratories - of the Imperial College and Learning Through Landscapes association), *POLLI:BRIGHT* aimed to involve Tuscan students in the monitoring and conservation of the pollinating insects present in different areas of the region.

The project, conceived as a pilot, involved one primary and two high-school classes per site; all partners followed the same operational and methodological approaches. In February 2019, in the Botanic Garden of Pisa, the experts of the NHMG met with the school teachers involved in *POLLI:BRIGHT* and provided them with information about the aims and organisation of the project which were then shared with their students (phase 1).

From March to May 2019, the classes carried out field surveys at the Pisa Botanic Garden (phase 2). During the monitoring sessions, students became "young scientists", by counting and identifying both insects and pollinated plants. The educators of the Pisa Botanic Garden provided students with habitat, plant and pollinator identification guides and with specific worksheets for data recording. Guides contained photographs and identification tips to aid the identification at a broad taxonomic level of the study taxa.

Finally, in the last phase (phase 3 - data inserting), each class merged their collected data and submitted it via an online form.

Throughout the project, educators tutored the classes and supported the teachers both operationally and in scientific support. All the data coming from the different research sites (Pisa, Grosseto, Siena, and Firenze) was analysed during the summer of 2019 and the results were shown during European Researchers' Night at Pisa (BRIGHT - September 27th 2019).



↑ Students of the field surveys looking at *POLLI:BRIGHT* resources ©Giada Cordoni

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POLLI:BRIGHT has been a great and valid formative tool for the students because:

- they became familiar with “the nature of science” and were able to explore a range of misconceptions about pollinators (e.g. “bees always sting”);
- they gradually make the transition from merely seeing the natural world to observing nature and natural processes scientifically;
- they implemented their knowledge on the complex plant/pollinator relationship and became aware of some environmental challenges;
- they put into practice the scientific method (observing, hypothesising, testing, confirming/rejecting), by analysing “problems” with critical thinking;
- they shared their experience, enthusiasm and learning with other people, thus triggering a multiplier effect.

In conclusion, POLLI:BRIGHT has offered a successful and applicable way to promote the development of citizen science projects focusing on pollinator status in wild and anthropogenic habitats in Italy. Moreover, this project increased the awareness of the participants and their capacity to observe those insects involved in the plant-pollination process. The positive outcome of POLLI:BRIGHT has encouraged the organisers to plan a full-scale citizen science project in Tuscany, aimed at the involvement of school classes from the whole regional territory.

## ACKNOWLEDGMENTS

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← *Different moments of the field surveys by the students at the Botanic Garden of Pisa*  
©Giada Cordoni





## AUSTRALIAN CASE STUDY: NATIONAL ARBORETUM PARTNERS WITH CITIZEN SCIENCE VOLUNTEERS

The National Arboretum Canberra in Australia was established in 2005 after major bushfires burnt across the Canberra region destroying many of Canberra's suburbs, pine plantations and nature parks. The vision for the National Arboretum is '100 Forests and 100 Gardens' showcasing 100 mostly monoculture forests of rare, threatened and symbolic trees from Australia and around the world.

Local citizen science volunteers are attracted to the Arboretum for its diversity, dynamic ecosystems, easy accessibility and networking with like-minded people. Equally, citizen science volunteers provide the Arboretum with valuable data to assist the ongoing development and management of the site and are highly valued for their contributions and expertise.

Officially opened in 2013, the National Arboretum Canberra constitutes a major biological resource based on a wide diversity of monoculture forest tree species that represent global biogeography, ethnobotany and species of international concern with both IUCN Red List and some State or country ratings.

In 2001 and 2003 major bushfires across the Canberra region caused severe damage to many of Canberra's suburbs, pine plantations and nature parks. The establishment of the new National Arboretum was recommended on sections of the burnt-out land, after government consultation with community and experts.

The National Arboretum Canberra development started in 2005, inspired by the original masterplan design for Canberra city. The vision of a '100 Forests and 100 Gardens' involved establishing 100 mostly monoculture forests of rare, threatened and symbolic trees from Australia and around the world.

↑ *STEP volunteers maintain our regional botanic garden and participate in citizen science*  
©National Arboretum Canberra

***Local citizen scientist volunteers are attracted to the National Arboretum for its diversity, dynamic ecosystems, easy accessibility and networking with like-minded people.***





To assist in development of the 250 hectare site, a National Arboretum volunteer program was founded in 2008 by the Friends of the National Arboretum Canberra. In the last financial year, volunteers provided over 20,000 hours of work across a diverse range of activities. These volunteers have enabled crucial public interpretation of the site including events and tours, improved horticultural operations via forest working bees and also provided valuable citizen science research.

The National Arboretum is a Canberra landmark, only six kilometres from the CBD, and is closely connected to the Canberra community. Local citizen scientist volunteers are attracted to the National Arboretum for its diversity, dynamic ecosystems, easy accessibility and networking with like-minded people. Reciprocally, citizen science volunteers provide the National Arboretum with valuable data to assist the ongoing development and management of the site and are highly valued for their contributions and expertise. The diverse project examples below illustrate some of the current and evolving volunteer citizen science projects at the National Arboretum Canberra.

### FROGWATCH RESEARCH

Working with the local FrogWatch group, citizen science volunteers document the frog fauna on-site, focusing on monitoring frog biodiversity in four of our wetland areas. The project examines long-term changes in the frogs of the Arboretum and their responses to climate change, habitat changes as our landscape changes from pine forest to grasslands and forests and woodlands, and to changing management practices. Currently, the Arboretum has seven of the nine native frog species found in urban Canberra.

### WOLLEMI SEED PROJECT

This year is the fourth year of monitoring the production of seeds in one of our most special forests, Forest 32, *Wollemia nobilis*, or the Wollemi pine. We have nearly 90 trees in the forest. Each year a portion of them produce cones which are bagged with a unique identifier by a team of citizen science volunteers. The seeds from these cones are then sorted into viable and non-viable groups, counted and weighed by the volunteers. Seeds are stored at Mt. Annan Botanic Gardens in Sydney and then progressively released for worldwide distribution. The National Arboretum has a unique opportunity to learn more about the reproductive biology of this species through this project.

### TREE MEASURING PROJECT

The Tree Measuring project commenced in 2009 with citizen science volunteers, a few years after the first forests were planted at the National Arboretum. The project aims to provide a quantitative, long-term record of tree growth as measured by height and diameter, completed on an annual cycle. Understanding individual tree species growth patterns on the National Arboretum site, and how their health is trending through time, is important information to both managers of the collection and wider science and conservation communities.

← Interpretation and education by volunteer guides ©National Arboretum Canberra



↑ Volunteer sorting viable and non-viable Wollemi Pine seeds ©National Arboretum Canberra

*Currently, the Arboretum has seven of the nine native frog species found in urban Canberra.*



↑ Cones in bags ready for seed collecting on our Wollemi Pines ©National Arboretum Canberra





← STEP wetland in the early years  
©National Arboretum Canberra

↓ STEP wetland now – a wonderful frog habitat  
©National Arboretum Canberra



Our Tree Measuring citizen scientist volunteers are now analysing the past 10 years of research to provide the National Arboretum with data on the health of the trees, as well as their responses to climate with respect to temperature and rainfall and horticultural treatments. The height of many of our forests are now beyond the physical reach of our volunteers and their measuring tools, which has led to further partnering with the Australian National University (ANU). The ANU have now completed the first aerial mapping of the entire National Arboretum by drones armed with sensors including UV and Lidar. These drone-measurements will continue to provide height data to monitor tree growth. Further development of these aerial technologies will assist in the rapid identification of plant stresses resulting in efficient and targeted maintenance programs to facilitate better tree growth and health.

## DATA COLLECTION

Many of our Tree Measuring volunteers are passionate researchers and have recently joined a new citizen science volunteer group called the Data Collection Group. This group is now undertaking a tree audit across the National Arboretum's 250 hectares with advanced GIS technology and a customised asset management app. The group will also be responsible for mapping environmental weed populations. The maps will integrate with local government management strategies and help secure financial assistance for weed management.

## SOUTHERN TABLELANDS ECOSYSTEMS PARK

Our Southern Tablelands Ecosystems Park (STEP) is located in Forest 20 and is planned and managed by STEP volunteers, an all-volunteer community group, in partnership with the National Arboretum. STEP features native trees and understorey plants that represent the ecological communities from the local area. Our 'STEPpers' provide their time, botanical expertise, funds, and energy and have brought the concept of a regional botanic garden to life within the National Arboretum. STEP participates in the Arboretum's Tree Measuring project and also contributes by maintaining the ephemeral wetland which is part of our FrogWatch project. In future years, STEP hopes to work in three-way partnership with the National Arboretum and the local Parks and Conservation Service in a recovery program for 44 hectares of yellow box/red gum woodland next to the STEP site. This is an excellent example of how a volunteer community group has the capacity and skills to work with the local government to enhance and support a government project.

While the National Arboretum does not yet have a permanent science research staff position, it is possible to create quality, statistically-relevant data and critical living collection management information by engaging with citizen science volunteers. By partnering with local universities and working with volunteers, particularly students and retired science research staff, the National Arboretum Canberra has been able to produce robust science research programs. One of the many benefits of this symbiotic relationship is that citizen science volunteers are highly skilled, flexible, innovative and able to grow with the organisation. For more information about our citizen science volunteer journey please contact [arboretum@act.gov.au](mailto:arboretum@act.gov.au).

*Our Tree Measuring citizen scientist volunteers are now analysing the past 10 years of research to provide the National Arboretum data on the health of the trees.*



↑ Volunteers measuring trees  
©National Arboretum Canberra

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# THE FAIRCHILD CHALLENGE IN XALAPA, VERACRUZ, MEXICO



This is the first time that The Fairchild Challenge has been presented in Mexico and it has been met with great success. Over 1,500 schools, 2,900 teachers and 88,000 students have taken part. This is largely thanks to the acceptance and collaboration of the Veracruz Education Secretariat who partially financed and promoted the Challenge among their staff. Teaching staff were thus freed from fundraising and could dedicate their time one hundred percent to the Challenge.

## EARLY HISTORY

The Botanic Garden “Jardín Botánico Francisco Javier Clavijero” (JBC) of the Instituto de Ecología, AC. (INECOL) has been a sister garden to Fairchild Tropical Botanic Garden (FTBG) since 1989 with the aims of collaborative research and education. Andrew Vovides served a postdoc period at FTBG from March 1989 to March 1990. Since then there has been a history of collaboration and exchange visits. Javier Francisco Ortega – a staff member and later coordinator of the Fairchild Challenge (FC) at FTBG, on a visit to JBC, was impressed with its education programme and recommended that the garden participate in the Fairchild Challenge. During early 2011 Norma Corona, education officer of the JBC was invited to FTBG to attend a course on the Challenge and meet relevant staff. Norma has since led the garden’s Challenge. The project is partially funded by the Veracruz Education Secretariat (SEV).

## THE FAIRCHILD CHALLENGE IN MEXICO

The Fairchild Challenge is an international environmental education program that has been running since 2002 at the Fairchild Tropical Botanic Garden. Its concept is a series of competitive, environmental challenges that schools can take part in (with training and resources provided). It has been part of JBC’s environmental education programs since 2011.

↪ Garden staff member Phil Brewster showing an insectivorous pitcher plant ©Norma E. Corona

*Each challenge or environmental project has been designed through the joint efforts of biologists, teachers, agronomists, horticulturists, nutritionists, artists and craftsmen who are part of the coordinating team and provide advice and follow-up to each of the projects.*

*Over 150,000 students out of a total of 32 municipalities and 66 localities have participated in the Fairchild Challenge between 2011 and 2018.*





← Teachers being shown a plant (rue) in the medicinal section of the Garden ©Norma E. Corona

This unique Mexican Fairchild Challenge is delivered in partnership with the Secretariat of Education of Veracruz (SEV) and is part of SEV's program for implementing Experiential Teaching and Enquiry Systems for the Sciences (PASEVIC). Over 1,500 schools, 2,900 teachers and 88,000 students have taken part in the challenge from 2011 to 2018 (Table 1).

The objective of this project is to make use of the scientific living collections of the JBC and actively involve the public in awareness and the conservation of regional flora. The project contributes towards target 14 of the Global Strategy for Plant Conservation (GSPC, 2020), target 6 of the Mexican Strategy for Plant Conservation and 5 of the National Biodiversity Strategy of Mexico (Rodríguez-Acosta, 2000). The objectives of the FC-JBC are to encourage students' interest in the environment, emphasizing the importance of biodiversity, its conservation and teaching them the value and beauty of nature. To achieve this we use techniques from the Pedagogical Model of Science Teaching Based on Inquiry. With this program, reflexive, analytical and participatory processes are fostered in teaching. Since the beginning of the program, preschool, primary, secondary and special educational needs schools have participated in environmental projects or challenges that have addressed issues such as cloud forest conservation awareness, use of orchids, the purpose of living collections in the botanic garden, using bamboo, cycads, dahlias and vegetables, healthy eating and food sovereignty and many more.

Each Challenge or environmental project has been designed through the joint efforts of biologists, teachers, agronomists, horticulturists, nutritionists, artists and craftsmen who are part of the coordinating team and provide advice and follow-up to each of the projects. Participating in the FC-JBC involves carrying out training activities for teachers and students so that together they achieve the set targets. Likewise, it encourages the school to obtain recognition and prizes focused on the development of environmental projects of local and community impact. Each project is designed to strengthen the teaching-learning process of the schools related to their official study program.

Designing and delivering a Challenge takes 12 months and includes planning of the Challenge and ensuring it is aligned with school curricular contents. The project is then presented to the SEV authorities and once approved a registration notice announcement is made to the teacher community. Interested teachers are encouraged to register their schools for the Challenge and invited to a training workshop where we develop the Challenge in their school. Each school then begins work on the Challenge, developing their ideas and investigations/products (to address the Challenge). An exchange of experiences is encouraged between the schools. Schools are then invited to a "Walking among science" forum where students present their posters with preliminary results from their Challenge investigations.



↑ A young student giving a talk on fungi ©Norma E. Corona



↑ Teacher examining a cycad fertile leaf ©Norma E. Corona

## PATICIPANTS IN THE FAIRCHILD CHALLENGE

YEAR	SCHOOLS	TEACHERS	STUDENTS	PROJECTS	TRAININGS
2011–2012	97	291	2507	9	10
2012–2013	182	273	7144	12	14
2013–2014	257	548	18892	14	26
2014–2015	284	509	16480	14	46
2015–2016	301	488	14931	12	78
2016–2017	247	403	12108	13	55
2017–2018	168	406	78738	19	67
<b>TOTAL</b>	<b>1536</b>	<b>2918</b>	<b>150800</b>	<b>93</b>	<b>296</b>

Total of 32 municipalities and 66 localities

↑ Table 1. Participants at the Fairchild Challenge at the JBC from 2011–2018

Over eight years we have worked with 1,536 primary and secondary schools, designed 93 environmental projects and delivered 297 training courses for registered teachers. We have worked with 2,918 teachers and the project has impacted more than 86,000 students and their families.

There have been four “Walking among science” forums, in which students present their preliminary results. Through these forums, posters were presented from 24 special educational needs schools, 94 pre-schools, 22 primary schools and 25 secondary schools.

The results of each of the projects presented are reviewed and evaluated by a group of experts who assign a performance rating. There are three levels:

- Initial level - The objectives are partially met or a process has been initiated that benefits the enrolled students.
- Intermediate level - The objectives are met and the student community and their families are impacted.
- Advanced level - All objectives are met and their locality impacted using communication technologies. Those who completed the process met all the proposed targets, communicated their results and impacted the student community and its area of influence.

## CONCLUSIONS

The Fairchild Challenge in Mexico has been extremely successful and has potential for being adopted in other botanic gardens. This success is largely due to the partial financing and collaboration of the SEV that covered the expenses of their teaching staff to attend workshops at the JBC. Thus the teachers can focus entirely on developing and delivering their school projects rather than fundraising. The JBC is federally funded and expenses for the Challenge come out of the Garden’s education and extension programme.

*The Veracruz Education Secretariat partially financed and promoted the Challenge among their staff. Teaching staff was thus freed from fund raising and could dedicate their time one hundred percent to the Challenge.*

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# CITY NATURE CHALLENGE AND NATUSFERA

The City Nature Challenge (CNC) — renamed in Spain as Biomaratón and in Ecuador as Desafío Naturaleza Urbana— is a competition between cities around the world to get the highest number of natural observations living in urban areas. The fourth edition of CNC was held in April 26-29, 2019 and involved 159 cities on six continents. In this article we share the experience, results and lessons learnt of 11 cities of Spain, Italy and Ecuador that participated in CNC using the citizen science app Natusfera.

## BACKGROUND AND TRANSCENDENCE OF THE CNC

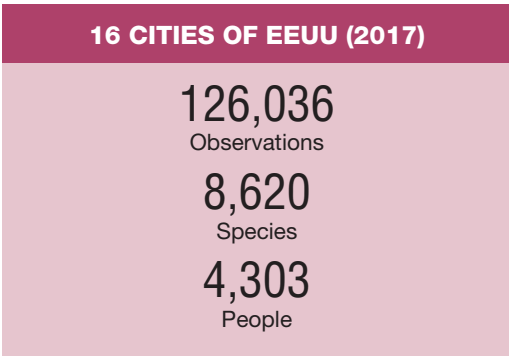
The City Nature Challenge (CNC) is a fun, friendly competition that encourages people to discover and document the biodiversity of our urban spaces. It began in 2016 as a challenge between Los Angeles and San Francisco, and was organized by the California Academy of Sciences and the Natural History Museum of Los Angeles County. The successful results obtained in terms of number of observations, species and participants, encouraged both organizations to extend the scope in 2017 to the entire US territory and make an international call in 2018 and 2019.

In 2018, 68 cities were involved in the CNC, gathering nearly half a million observations and engaging over 17,000 participants. Cities as emblematic and competitive as San Francisco and Los Angeles (USA), London and Bristol (UK) and Madrid and Barcelona (Spain) competed to better understand their urban biodiversity. During the CNC that took place in Spain – so-called “Biomaratón” -, Madrid, Barcelona and Cádiz led the European classification with more than 15,000 observations recorded with the Natusfera citizen science app. Two arthropod species were cited for the first time in the Iberian Peninsula during the contest.

κ Photographing spiders in “Madrid Río” during the Biomaratón, Madrid (Spain) ©Carlos de Mier

*The City Nature Challenge (CNC) is called “Biomaratón” in Spain and “Urban Nature Challenge - Discover Quito Biodiverse” in Ecuador.*

*There are several citizen science applications available (iNaturalist, Natusfera, BioLog, Naturblick ...) according to the needs of the users.*



Observers used the citizen science application that best suited their needs (iNaturalist, Natusfera, BioLog, Naturblick, etc.), as the final goal in such an event was to get the largest participation as possible, regardless of the tool used.

**CONTRAST BETWEEN LONG-TERM USERS AND NEWCOMERS OF THE 2019 INTERNATIONAL CLASSIFICATION**

The same exponential progress continued in 2019 when more than 35,000 people from 159 cities around the world contributed to the 4th edition of the CNC (April 26-29). All together, they registered nearly one million observations of over 31,000 species. Cape Town (South Africa) claimed first place with the most observations and species categories. Quito, also participating for the first time in the CNC, claimed one of the top positions together with well-known cities in the contest, such as San Diego and San Francisco (3rd and 4th position). Quito's participation, together with six other cities in Italy, internationalized Natusfera in the CNC.

26 European cities participated in the CNC, 10 of them used Natusfera to document the biodiversity, meaning that Natusfera was the second most used citizen science platform, both in Europe and worldwide, behind the iNaturalist platform.

**FRIENDLY COMPETITION: THE KEY FOR GETTING A SUCCESSFUL PROCESS AND RESULTS**

Competitive events between cities of the same country, whether they are about society, sports or politics can be complex and often ruthless. However, the CNC has been able to create a different ethos and turned the largest event of citizen participation in biodiversity into an event where citizens compete with a positive spirit and showcase values such as effort, perseverance, equality, respect, empathy, sportivity, solidarity, companionship, personal and collective triumph. CNC encourages people to improve human welfare across borders, it helps us to understand and conserve nature so that we can contribute towards the survival of humans and other living beings. *The richer the biodiversity, the more chances of survival we have on this planet* (Biodiversity Foundation, Spain).

Many associations and public administrations supported and co-organized the CNC 2019 in Spain; this resulted in a lot of media interest and contributed towards promoting the positive values of the project. The "Biomaratón" was coordinated by the Spanish Node of GBIF (Global Biodiversity Infrastructure Facility), the Royal Botanic Garden of Madrid, the Institute of Marine Sciences (Barcelona), the naturalist association ANAPRI (Colmenar Viejo, Madrid), the association Terrabiota-Ciencia Viva (Pamplona) and the Josep Brugat Secondary School (Banyoles). There was also support from universities, museums, schools, city halls, nature associations and companies who carried out about fifty land and marine participatory activities.

↖ ↑ Results of the CNC in 2016 and 2017

*The collected data can be used to improve our cities, to make them work better for humans and for wildlife.*

*Lila Higgins & Alison Young, founders of CNC*



↑ *Pyrgus malvoides, Banyoles (Girona, Spain)*  
©Gerard Funosas



## INTERNATIONAL CLASSIFICATION

Position	OBSERVATIONS	SPECIES	PEOPLE
1st	Cape Town (South Africa) 53,763	Cape Town (South Africa) 4,588	San Francisco (USA) 1,947
2nd	La Paz (Bolivia) 46,931	Hong Kong (China) 3,596	Los Angeles (USA) 1,555
3rd	San Diego (USA) 38,241	Houston (USA) 3,367	La Paz (Bolivia) 1,500
4th	San Francisco (USA) 38,028	Los Angeles (USA) 3,249	Quito (Ecuador) 1,372
5th	Tena (Ecuador) 37,965	San Francisco (USA) 3,183	Washington (USA) 1,258
6th	Klang Valley (Malaysia) 37,916	Klang Valley (Malaysia) 3,020	San Diego (USA) 1,188
7th	Quito (Ecuador) 36,401	San Diego (USA) 3,019	Tena (Ecuador) 1,185

↑ *The international classification of the CNC 2019 showing observations, species and participants. Participating cities: 159*

## CLASSIFICATION IN EUROPE (with app NATUSFERA)

Position	Cities	OBSERVATIONS	SPECIES	PEOPLE	INTERNATIONAL CLASSIFICATION
7th	Madrid (Spain)	4,872	883	85	51th
9th	Barcelona (Spain)	3,808	593	70	58th
12th	Pamplona (Spain)	1,473	355	41	76th
13th	Taranto (Italy)	988	187	38	83th
15th	Banyoles (Spain)	326	84	31	102th
16th	Lecce (Italy)	324	39	15	104th
17th	Ostuni (Italy)	293	60	12	106th
19th	Trinitapoli (Italy)	173	45	14	117th
20th	Trento (Italy)	166	72	6	118th
22th	Catania (Italy)	143	5	4	120th

↑ *The European classification of the 10 European cities that have participated in CNC 2019 with app Natusfera. Participating cities in Europe: 26*

Quito (Ecuador), who first participated in the CNC with Natusfera, was surprised by the participation from citizens and other entities. Felipe Castilla (technician of GBIF.ES-Royal Botanic Garden-CSIC) and Jaume Piera (researcher of the Institute of Marine Sciences-CSIC) actively worked to support the engagement of Quito, where the CNC was called "Urban Nature Challenge - Discover Quito Biodiverse". Néstor Acosta (Head of GBIF Ecuador) and Martin Bustamante (Director of the Zoological Foundation of Ecuador) worked with them to organize and coordinate an intensive week of promotion, providing information and documentation on the CNC so that activities could take place in different locations of the city and in the suburban area of Cumbayá. Quito competed with another Ecuadorian city: Tena, which had previously worked with iNaturalist. These two cities came 7th and 5th respectively in terms of the number of species identified.

## EVERYBODY WINS

Observations documented with Natusfera or iNaturalist are available to everyone through GBIF (Global Biodiversity Information Facility), the world's largest network of open biodiversity data. The data provided by citizens during the CNC will be used in scientific research and will help land managers to make informed decisions about nature conservation in our cities. As Lila Higgins and Alison Young - founders of CNC - usually say, *the collected data can be used to make our urban areas a better place - for you and other species!* By participating in such an event, citizens become aware of the importance of conserving, caring for and exploring biodiversity, and that their active participation matters.

*The richer the biodiversity,  
the more chances of survival  
we have on this planet.  
Biodiversity Foundation, Spain*

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# GROWING BEYOND EARTH: EMPOWERING A COMMUNITY TO FIND SOLUTIONS



For 18 years, Fairchild Tropical Botanic Garden has been home to The Fairchild Challenge, the multidisciplinary science competition designed to engage students of diverse interests, abilities, talents, and backgrounds to explore connections between plants and the environment. With its extensive reach and quantifiable results, it has captured the scientific support of national organizations as a platform for citizen science. In 2015 Fairchild began to engage this established network to assist NASA to expand the palette of food plants and growing techniques used aboard the International Space Station. Today 200+ schools nationally are conducting botany experiments that inform NASA research on growing plants.

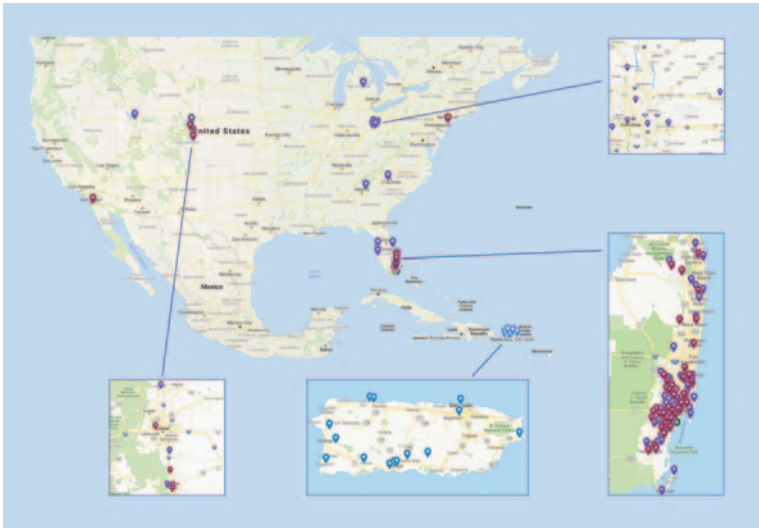
In May of 2015, Fairchild Tropical Botanic Garden in Miami, FL USA began a partnership with NASA to help further their plant-based research by calling upon Fairchild's large network of highly-engaged, STEM-minded, Fairchild Challenge students and teachers. Together with NASA scientists, Fairchild engineered and installed plant growth chambers similar to NASA's Veggie system on the International Space Station in classrooms - leveraging an army of nearly 50,000 middle and high school students and teachers in the nation's fourth-largest school district.

The Growing Beyond Earth (GBE) Project was designed to expand edible plant options and increase plant diversity by testing multiple plants that meet NASA's criteria for nutritional and vitamin content, the ability to grow well with little resources and in small spaces, and robust varieties that are able to handle the stresses of growing in zero/low gravity and taste. The project is based on the precepts of what has become known as "citizen science," in which members of the lay public gather data that contributes to professional scientific knowledge (Bonney et al., 2014). Such authentic scientific projects that address questions for which answers are not known in advance are believed to have considerable educational value.

Each school receives all of the equipment and materials to contribute free of charge including a growth chamber that is analogous to what is on the International Space Station

*Through the program, students have become more knowledgeable about STEM topics, more confident when participating in STEM activities, and more interested in STEM careers.*





← By the end of the 2018-19 academic year, more than 170 middle and high schools were actively participating in the Growing Beyond Earth program  
©Amy Padolf

NASA scientists Gioia Massa, Ph.D., and Trent Smith, Veggie Project Manager at Kennedy Space Center's Exploration Research and Technology Programs, serve as scientific advisors. NASA staff continue to report meaningful benefits to NASA resulting from the data. GBE students have cemented their status as valuable researchers in supporting NASA research by serving as a feeder program into NASA's new plant testing research.

Through the Growing Beyond Earth Project, students conduct plant variety trials in the fall and spring. Classroom temperature, humidity, and plant growth are measured and recorded throughout each trial, and total biomass and edible biomass are recorded at the end of the trial. Data, including relative plant growth rates and plant yield, are shared using online data sheets to be analyzed within R statistical software by Fairchild scientists.

- Students follow formal research protocols developed through a collaboration of Fairchild and NASA scientists. Students refine aspects of the experimental design, devise strategies for data collection and analysis, and modify the hardware design to help address specific research questions.
- Students enter plant measurements and observations into online, multi-user spreadsheets (Google Sheets) that are monitored by Fairchild personnel for quality control. Student data from multiple schools are aggregated and analyzed by Fairchild's statistician and shared with NASA scientists.
- After conducting the prescribed growth trials, students have the option to propose original research projects based on their observations. Proposals are reviewed by Fairchild's scientific team and NASA researchers. If approved, students are invited to conduct a second trial. Once completed, students submit a research poster for presentation at the Annual Student Research Symposium.
- Teachers and students are asked to submit updates, observations, photos, and graphical representations of data via social media (twitter.com/GrowBeyondEarth). All information submitted via Twitter is public, allowing participants to compare observations, results, and strategies for improving the project. Fairchild personnel and NASA scientists monitor submissions and interact with the teachers and students to answer questions, provide advice, and correct errors.



***On April 25, 2018, Fairchild hosted a live, in-flight Education Downlink with NASA astronauts on the International Space Station.....a unique opportunity for students and astronauts to exchange ideas about the role of plants in exploration.***



↑ *Students collect important data which is shared with the scientists at NASA so they can make determinations that they will ground test in their labs at Kennedy Space Center*

During the 2018-19 school year, more than 10,000 students in 176 classrooms across the nation participated in the project. Students: (1) directly participate in scientific practices that are relevant to NASA and Fairchild; (2) propose and conduct original research to address plant growth concerns for long-distance space travel and (3) interact with NASA and Fairchild personnel, who will serve as scientific advisers and role models.

Growing Beyond Earth has elicited a high level of enthusiasm and engagement from students and teachers because (1) students are engaged in authentic research that is important to NASA, (2) students now recognize that plants can be engaging research subjects, (3) the program is accessible to all students (regardless of skill level) and engages students that might not otherwise be drawn to STEM activities, and (4) it addresses several critical development needs of adolescents including empowerment, positive values and positive identity.

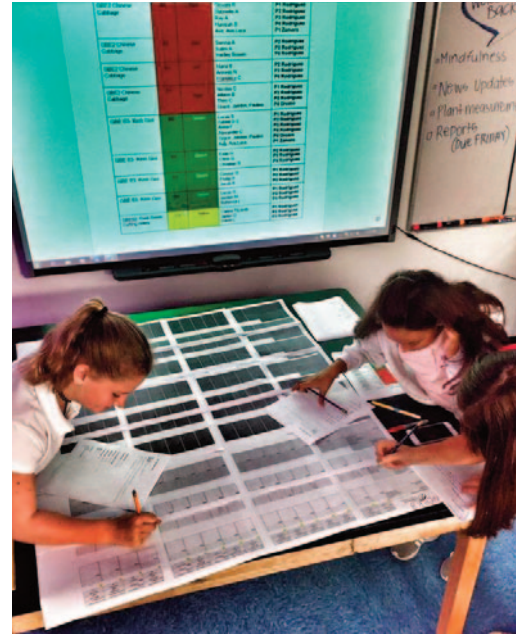
Growing Beyond Earth evaluations indicate the program is impacting participants' interests, attitudes, and knowledge of STEM-related subjects. Based on a culmination of three years of program evaluation, there is evidence that suggests that the program has the potential to engage students in authentic STEM research experiences in real-world contexts, increase student interest and attitudes towards STEM subjects, and improve teacher's self-reported knowledge, skills and confidence in engaging in STEM instruction. Teacher surveys indicate that Growing Beyond Earth is improving STEM instruction in middle and high schools and is uniquely effective in serving groups that are underrepresented in STEM fields, as defined by race, gender, and socioeconomic status.

NASA recognized the impact this project was having on our community. On April 25, 2018, Fairchild hosted a live, in-flight Education Downlink with NASA astronauts Ricky Arnold and Drew Feustal on the International Space Station (ISS). The first ISS downlink to be hosted by a botanic garden, a unique opportunity for students and astronauts to exchange ideas about the role of plants in exploration. The 20-minute video connection included 250 high school students on-site at Fairchild, along with tens of thousands of NASA TV viewers worldwide.

With the third research trials of Growing Beyond Earth completed, we have already learned a tremendous amount about how to grow plants for future space journeys. Participants have sent hundreds of thousands of pieces of data to NASA researchers. Two plant varieties selected through Growing Beyond Earth student research are now in experimental trials on ISS. Seeds of "dragoon" lettuce and extra dwarf pak choi were launched on June 29, 2018, with SpaceX Commercial Resupply Service Mission 15.

NASA continues to look towards the Growing Beyond Earth project to help solve some of their most pressing plant growth issues. They recognize that citizen science can be helpful in providing important information that they don't have the space, time or person-power to gather but also that it can increase interest in STEM careers.

For Fairchild, we understand that, citizen science is incredibly impactful and empowering for students and teachers. Through the program, students have become more knowledgeable about STEM topics, more confident when participating in STEM activities and more interested in STEM careers.



↑ More than 140 varieties of edible plants have been tested. In 2018 two of those varieties were chosen to be flown on the International Space Station; extra dwarf pak choi and dragoon lettuce.

**NASA continues to look towards the Growing Beyond Earth project to help solve some of their most pressing plant growth issues.**

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# RESOURCES

## APPS AND PLATFORMS

### Zooniverse

The Zooniverse is the world's largest and most popular platform for people-powered research. This research is made possible by volunteers — more than a million people around the world who come together to assist professional researchers. The site allows anyone to contribute towards current research projects or use the platform to build their own research project.

<https://www.zooniverse.org/>

### iNaturalist

iNaturalist is a nature app that helps users to identify the wild plants and animals around them. iNaturalist is supported by a community of over 750,000 scientists and naturalists and is a joint initiative by the California Academy of Sciences and the National Geographic Society. By recording and sharing observations, users can create research quality data for scientists working to better understand and protect nature.



<https://www.inaturalist.org/>

### PlantSnap



PlantSnap is a plant identifying app that currently contains over 585,000 species. With users across the globe, the app allows individuals to identify plants from a photo and through doing this is creating the world's largest plant database.

<https://www.plantsnap.com/>

## PUBLICATIONS

### Citizen science: Theory and Practice

Citizen Science: Theory and Practice is an open-access, peer-reviewed journal published by Ubiquity Press on behalf of the Citizen Science Association. The journal focuses on advancing the global field of citizen science by providing a venue for citizen science



researchers and practitioners to share best practices in conceiving, developing, implementing, evaluating, and sustaining projects that facilitate public participation in scientific endeavors in any discipline.

<https://theoryandpractice.citizenscienceassociation.org/>

### Citizen Science - Innovation in Open Science, Society and Policy



This book identifies and explains the role of citizen science within innovation in science and society. The book is geared towards identifying solutions and lessons across science, practice and policy and considers the role of citizen science in the context of the wider agenda of open science and open innovation.

### White Paper on Citizen Science for Europe – Serrano et al 2014

This open access document was written as part of the SOCIENTIZE project, which aimed to improve the understanding and uptake of the impacts, associated with citizen science. This white paper looks at challenges in a European context and proposed solutions at the micro, meso and macro level.

[http://www.socientize.eu/sites/default/files/white-paper\\_0.pdf](http://www.socientize.eu/sites/default/files/white-paper_0.pdf)

### Guide to citizen science – UK environmental observation framework

This guide aims to support people already involved in citizen science, and those new to it. It is based on detailed information gathered and analysed as part of the UK-EOF funded project “Understanding Citizen Science & Environmental Monitoring”, which semi-systematically reviewed 234 projects and included 30 case studies

<https://www.nhm.ac.uk/content/dam/nhm/www/take-part/Citizenscience/citizen-science-guide.pdf>

### Citizen science for all – A guide for citizen science practitioners

This guide is the result of collaboration within the Citizens Create Knowledge (BürGER schaffen WISSen, GEWISS) project. It provides advice on how to develop and deliver citizen science projects as well as a range of case studies across different disciplines.

[https://www.buergerschaffenwissen.de/sites/default/files/grid/2017/11/20/handreichunga5\\_engl\\_web.pdf](https://www.buergerschaffenwissen.de/sites/default/files/grid/2017/11/20/handreichunga5_engl_web.pdf)

## GUIDELINES AND TOOLKITS

### Citizen science toolkit

Developed by the Cornell Lab of Ornithology, this online toolkit is a compilation of resources and ideas, organized under a step-wise framework to support the setup of a citizen science project. Each step organizes tools into six categories – reality check, how-to, resources, tools, questions and cases.

<http://www.birds.cornell.edu/citscitoolkit>

### Guide to running a bioblitz

This guide, produced by the Natural History Museum in London, supports the running of BioBlitzes and similar wildlife events.

<https://www.nhm.ac.uk/content/dam/nhm/www/take-part/Citizenscience/bioblitz-guide.pdf>

### TCV citizen science resources

The Community Volunteering Charity (TCV) provide a series of resources and guides on their website to support the engagement of individuals, schools, families and communities in citizen science projects. This includes a toolkit and lesson plans for teachers, a community guide and an overview of TCV citizen science projects.

<https://www.tcv.org.uk/scotland/discover/citizen-science/get-involved-citizen-science/citizen-science-resources/>

# The BGCI Sustainability Challenge Survey

Following a call to action at the Education Congress in Warsaw in 2018, BGCI is leading the Sustainability Challenge, in which we aim to work with leading botanic gardens to develop a series of simple, small scale sustainability challenges, to empower and bring about behavioural change amongst garden visitors and the broader community.

As a first step, we are gathering information on current sustainability practices. We are encouraging all BGCI members to complete two surveys (on behalf of their organisation). 1. About your organisation's sustainability practices. 2. Sustainability challenges for your visitors. The results of both surveys will form the basis of a new technical review.

Complete the survey here:

Sustainability practices survey: <https://www.bgci.org/resources/bgci-surveys/botanical-gardens-sustainability-practices-survey/>

Visitor sustainability challenge: <https://www.bgci.org/resources/bgci-surveys/botanical-gardens-sustainability-challenge-survey/>







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## BGCI's new Technical Review on Urban Greening

BGCI's new Technical Review on the role of botanic gardens in urban greening and conserving urban biodiversity represents a comprehensive overview of urban greening activities carried out by botanic gardens worldwide. It includes 35 case studies encompassing urban forestry, urban agriculture, food production, ecological restoration and activities that support urban biodiversity. With a growing urban population, these activities are increasingly important, and this review demonstrates that botanic gardens are rising to the challenge.



Download the review here:

[https://www.bgci.org/news-events/  
bgci-publishes-new-technical-review-  
on-urban-greening/](https://www.bgci.org/news-events/bgci-publishes-new-technical-review-on-urban-greening/)

