



# BGCI Technical Review

The role of botanic gardens in urban greening and conserving urban biodiversity



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greening and conserving urban biodiversity

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## INTRODUCTION

The world population has increased by more than 400% since the beginning of the 20th century, and the current trend is rapid urbanization with a prediction of 68% of people living in urban areas by 2050 (UN DESA, 2018). According to BGCi's GardenSearch database ([http://www.bgci.org/garden\\_search.php](http://www.bgci.org/garden_search.php)), there are around 3,000 botanic gardens in the world, and the majority are situated in cities and urban environments. Often, they are the largest green areas available to city residents and, invariably, they are the most biodiverse parts of the city. Botanic gardens provide invaluable services for citizens and biodiversity, especially where they conduct outreach activities that contribute to a broader purpose of greening the community outside their garden boundaries. The botanical and horticultural skills and knowledge that gardens have amassed over decades, and even centuries, is needed now more than ever, and should be applied where it is needed most - where people live, work and play.

This BGCi Technical Review summarises some of the work of botanic gardens in supporting resilient urban forests and landscapes, promoting community gardening, boosting urban biodiversity, providing ecosystem services and improving human well-being. These activities are illustrated through case studies from all around the world. This Review is based on a questionnaire focused on urban greening (57 respondents) and a literature survey encompassing websites, peer review publications and grey literature such as annual reports. For convenience, this Review divides botanic garden activities in this sphere into three areas:

1. Contributing to urban forestry and resilient landscapes
2. Supporting and advancing urban agriculture
3. Conserving urban biodiversity

In practice, there is a great deal of overlap between all of these activities.



# 1. CONTRIBUTING TO URBAN FORESTRY & RESILIENT LANDSCAPES

Jorgensen (1970) defines urban forestry as **“the management of trees for their present and potential contributions to the physiological, sociological and economic well-being of urban society”**.

In a fuller definition, Deneke (1993) defines urban forestry as follows: **“Urban forestry is the sustained planning, planting, protection, maintenance, and care of trees, forests, greenspace and related resources in and around cities and communities for economic, environmental, social, and public health benefits for people. The definition includes retaining trees and forest cover as urban populations expand into surrounding rural areas and restoring critical parts of the urban environment after construction. Expansion at the urban/rural interface raises environmental and public health safety concerns, as well as opportunities to create educational and environmental links between urban people and nature. In addition, urban and community forestry includes the development of citizen involvement and support for investments in long-term on-going tree planting, protection, and care programs.”**

These definitions not only embrace the management of trees in cities and metropolitan areas but also consider a broader view that encompasses other management components of ecosystems including shrubs, forbs and grasses, with an emphasis on benefits. Here, we exclude the introduction of crops and community gardening, which are covered in **Section 2 Supporting and Advancing Urban Agriculture**.

The benefits of urban forestry are significant, and advances in science and technology have made it possible to quantify many of them. Contributing to urban forestry can help cities and countries meet fifteen of the seventeen internationally supported United Nations Sustainable Development Goals (Turner-Skoff and Cavender, 2019).

**The benefits of a thriving urban forest**

1. Promoting physical and mental health and well-being for urban residents
2. Supporting community ties and reducing crime rates
3. Increasing a student’s ability to succeed in school
4. Improving the economy and reducing energy bills
5. Improving aesthetics
6. Mitigating the Urban Heat Island Effect
7. Storing and sequestering carbon
8. Providing critical habitat
9. Managing storm water, and reducing air, noise and water pollution



*Reintroducing native plants into urban areas (Pixabay)*

In many instances, urban forests are managed by municipal authorities who are also responsible for planning and maintaining streets, parks and other green spaces (e.g. university campuses, cemeteries etc.), which include trees, shrubs and other plants. Because all people living in urban communities are affected, developing solutions and action plans should be a social endeavour and include diverse partnerships. Botanic gardens and arboreta can provide key resources for supporting these wider endeavours.

By applying their strengths in horticultural and botanical knowledge combined with public engagement through visitation, interpretive displays, education and outreach, botanic gardens can provide meaningful contributions in a variety of ways (Cavender and Donnelly, 2019), and many botanic gardens have developed successful models and approaches. These activities generally fall in the following categories:

1. Plant evaluation, selection and breeding
2. Inventories and mapping
3. Urban planning and development
4. Community planting and stewardship
5. Tree ordinances and protection policies
6. Research
7. Training and consulting
8. Plant sales

## CASE STUDY

### Selecting plants for green cities



(Shanghai Chenshan Botanical Garden)

Shanghai, like many other metropolises of the world, faces many challenges when it comes to urban greening. These include a lack of space for above and below ground canopy and roots, poor compacted soil, pest invasion and limited access to water due to impervious surfaces. To address these challenges, **Shanghai Chenshan Botanical Garden** has screened more than 70 plant species and cultivars to try to meet the demands of these urban areas, mainly testing for hardiness, drought tolerance and low maintenance. The overall goal has been to increase biodiversity throughout the city. Of the 70 taxa tested, nearly all are currently used for different purposes in Shanghai. Visit <http://www.bgci.org/garden.php?id=4544>

## CASE STUDY

### Urban plant research, evaluation and selection

**The University Botanic Gardens Ljubljana (UBGL) in Slovenia** is heavily involved in supporting the city authorities with tree research and selection. For example, during recent renovations of central city streets, UBGL recommended use of a diverse palette of species such as *Fraxinus ornus*, *Ostrya carpinifolia*, *Sorbus aria* and *Prunus mahaleb*, and in an open marketplace, they recommended the shade tree *Celtis australis*. Elsewhere in the city, along the river, the garden has helped to remove invasive species and establish native vegetation. Visit <http://www.botanicni-vrt.si>

The following case studies illustrate many of these activities and may also lead to other ideas.

### 1.1. Plant evaluation, selection and breeding

Urbanized landscapes are often faced with the challenge of low diversity, which comes with the risk of compromised future resilience. A key strength of botanic gardens is rooted in their knowledge and access to plant diversity and the practice of horticulture. Botanic gardens cultivate about a third of known plant diversity (Mounce *et al.*, 2017). Their diverse collections provide the opportunity to develop innovative approaches and carry out research on new species that might be brought into urban forests and green spaces. These approaches and species promote future resilience and deliver ecosystem services such as shade, pollution control, water saving and health benefits for people and wildlife. In addition, the skills, knowledge and provenance data associated with botanic garden plant collections enables horticulturists to assess climatic and edaphic tolerance, management practices and susceptibility to pests and diseases for a wide range of species. For these reasons, botanic gardens are at the forefront of research and applications aimed at creating and maintaining resilient green urban landscapes in the face of climate change and other threats.



(Shanghai Chenshan Botanical Garden)



## CASE STUDY

### Climate change adaptation and climate resilience

**The Royal Botanic Gardens, Victoria (RBGV)** and the University of Melbourne in Australia recently assessed the climate risk of the Melbourne Gardens living collection by comparing the temperature of locations where each species naturally occurs and is known to be cultivated, with several temperature projections for Melbourne's future climate (Kendal & Farrar, 2017). These temperature 'envelopes' for each species were compared with projected climates under current temperatures, and moderate and extreme climate change scenarios for Melbourne to identify the vulnerability of the Melbourne Gardens' living collection to current and projected future temperatures. A total of 6,103 taxa (comprising 4,660 distinct species) were assessed, including 1,110 tree taxa (961 distinct species). Under the moderate climate scenario, where the mean annual temperatures are projected to increase by 1.7 °C by 2040 (assuming emissions stabilisation), 15% of tree taxa and 20% of other taxa are considered to be at high risk. Under the extreme climate future where temperatures are projected to increase by 3.0 °C by 2070 (assuming 'business as usual' emissions), 20% of tree taxa and 26% of other taxa are considered to be at high risk. The risk to existing taxa can be used to inform management at the Gardens in several ways including:

1. Change species selection (particularly for long-lived species) to favour species at less risk. There are hundreds of possible new species that are potentially suitable for planting in Melbourne.
2. Ameliorate conditions for species at risk that are of high value and choose best locations for new plantings of species at risk.

The methodology developed by RBGV and the University of Melbourne has potential application worldwide for both botanic gardens and municipal or local government authorities. To this end, RBGV has established a Climate Change Alliance, which aims to use global collaboration to tackle the climate change threats facing plant species. The co-creators of this Alliance signed a declaration "to safeguard life by protecting landscapes" and agreed that "the time for action is now." Visit <https://www.rbg.vic.gov.au/plants-and-landscapes/landscape-succession-strategy/climate-change-alliance-inaugural-summit>.

## CASE STUDY

### Climate resilience of cultivars in harsh climates

**Reykjavik Botanic Garden** is part of the Yndisgróður Project in Iceland, which aims to carry out research on and select the best-suited plant material for a range of defined uses in urban environments. Most species and cultivars used in Iceland are the result of long experience and the selection of plants of native and foreign origin that have proved to be well adapted to the harsh Icelandic climate. More recently, however, imported cultivars, often badly adapted to the Icelandic climate, are pushing old and well-adapted cultivars and provenances out of the market. So far, the result of the Yndisgróður project is an assessment of a collection of over 500 cultivars in six demonstration gardens. This project will not only result in benefits for consumers and nursery growers but also form an essential foundation in preserving and maintaining the important green infrastructures and green spaces established in Iceland, and adapted to the Icelandic conditions over time.

## CASE STUDIES

### Disease and pest management

One of the consequences of a changing climate, together with the increased movement of plants – particularly through the international horticulture trade – is the emergence of new pests and diseases. **Botanic Gardens Conservation International** co-ordinates the [International Plant Sentinel Network](#), a consortium of over 40 botanic gardens in 18 countries that provide an early warning system for emerging pests and diseases. **The National Botanic Garden Pretoria**, an IPSN member in South Africa, recently detected the Polyphagous Shot Hole borer, the first record of this insect in South Africa.

Staff at the Royal Botanic Gardens Sydney provide plant identification and plant pathology services, including root identification and plant disease diagnostics, visit <https://www.rbg Syd.nsw.gov.au/science/plant-id-disease-diagnostic-services>. **The Royal Botanic Gardens, Kew** provides plant quarantine services for UK government agencies and a range of other customers. Visit <https://www.kew.org/read-and-watch/behind-the-scenes-plant-quarantine-unit>



*The Morton Arboretum*

## CASE STUDY

### Breeding and introducing resilient plants

Chicagoland Grows is a corporate partnership between the **Chicago Botanic Garden**, **The Morton Arboretum** and the Ornamental Grower's Association of Northern Illinois (OGA), a network of wholesale nurseries located in northeastern Illinois. Together, they lead an innovative plant introduction program developed to promote the use of new plant cultivars that are well adapted to the growing conditions of the Upper Midwest. While regional in focus, the program's plants can be grown successfully in all zone-appropriate regions of North America, Europe, and around the world.

The partnership works collectively with industry professionals in the OGA and throughout North America to develop, select, evaluate, produce and market new and recommended plant cultivars. These selected plants offer fine ornamental attributes and proven dependability to both landscape professionals and home gardeners.



*Urban plant research, evaluation and selection  
(The Morton Arboretum)*

## 1.2. Inventories and mapping

An important aspect to planning and managing urban forests and associated landscapes is first understanding the quantity, quality and distribution of the resource across the landscape and demographic. Tree inventories and canopy analyses use an assortment of tools, technologies, and procedures that help understand the structure, function and benefits of urban forests and landscapes. The data and information gained from these assessments, enables resource professionals and policy makers to make informed decisions that help meet community and policy goals. This is often a great opportunity for botanic gardens to get involved with community engagement and citizen science, leading and engaging especially through their knowledge and experience with plants.

## CASE STUDY

### Tree census and canopy analysis of the Chicago region

The Chicago Region Trees Initiative (CRTI), a partnership founded by **The Morton Arboretum** in 2013, was organized to leverage collaborative efforts for a holistic approach to improve the urban forest and quality of life for Chicago region residents. To make a significant, measurable improvement to the regional forest and the lives of its inhabitants, CRTI is setting actionable goals for canopy cover, species and age class diversity and management expertise to create a more resilient forest. To achieve these goals and prioritize efforts, CRTI created an interactive map that integrates baseline data on Chicago's urban forest composition, canopy cover, operational capacity and socio-economic census data. These datasets were created using LiDAR, aerial imagery, land cover, forest inventories (private and public), forest management capacity, socio-economic data, pre-settlement ecosystem mapping, human and tree health data. Among its many uses, CRTI utilizes the map to track its own progression and impact as well as to identify communities with disproportionately low tree cover and greatest need for trees.

## 1.3. Urban planning, development and sustainable land management

Urban forestry has advanced over the years from being an aesthetic amenity that softens the urban landscape to increasingly being perceived as a solution to many more pressing urban environmental problems, as well as a way to enhance community well-being. There are several points of intersection where botanic gardens can play an important role in the process of planning and developing new green spaces, and helping to maintain them sustainably.



## CASE STUDY

### Sustainable green landscape design and practice

**Phipps Conservatory and Botanical Garden**, in Pittsburgh, USA, has created the Studio Phipps Sustainable Design Group, a landscape design group that aims to inspire commercial clients to look at nature differently by considering ways to integrate the natural world into buildings and find feasible solutions to sustainability challenges. Studio Phipps staff are also certified in healthcare garden design, bringing multidisciplinary training and experience to the creation of healing and restorative green spaces for hospitals and other institutions. The studio draws from the latest research in green infrastructure and biophilia, as well as their own knowledge of designing, creating and maintaining innovative sustainable landscapes and green buildings.

## CASE STUDY

### Sustainable weed control

Another consequence of climate change and the movement of plant material is invasive plant species and weeds. Weed control costs billions of dollars annually, and mainly involves the use of conventional herbicides that have wider impacts on the environment. **The Real Jardín Botánico Juan Carlos I**, at Alcalá de Henares near Madrid in Spain, established the Cisnerianos Gardens Project in the Botanical Garden at the beginning of 2018. The Project has set up trials with different volumes and concentrations of bioproducts, derived from wood, and promising results are being obtained in its application for the control of grasses, as a non-aggressive biological solution that could be an alternative to the use of conventional herbicides. The first phase of the project is aimed at the control of grasslands on roadsides and slopes, and the second part will be targeted at adventitious herbs in horticultural crops. In this phase, natural bioproducts will be tested on vegetables grown in four plots of the Cisnerian Gardens.



## CASE STUDIES

### Water catchment management

The **Arboreto Parque Doña Inés in Puerto Rico**, is a key member of the San Juan Ecological Corridor Special Commission that plans and manages 400 acres of greenspace in the capital city, San Juan, to protect the city's watershed, enable ecosystem functioning and protect wildlife. Visit <http://www.bgci.org/garden.php?id=5001>

**Bogor Botanical Gardens in Indonesia** conducts research and monitoring of the Ciliwung Watershed Degradation Area. This activity is part of its in-house research, and the gardens have been monitoring the results of planting in the Ciliwung watershed since 2010 in collaboration with the Cijulang Asri Group. Visit <http://krbogor.lipi.go.id/id/beranda>

## 1.4. Community planting and stewardship

One of the most tangible ways botanic gardens can get involved with urban greening is to help coordinate and carry out planting activities in their communities. These coordinated activities help promote public awareness about the benefits of urban greening and help teach basic horticultural and stewardship skills to community members. Events can be organized for a variety of locations such as parks, neighborhoods, business districts, and schools and be a great avenue for volunteer engagement and citizen action.



## CASE STUDIES

### Working with communities to develop urban forestry management plans

Rather than using a top-down method to inspire change, **The Chicago Region Trees Initiative (CRTI)** works with local communities to train and empower people to take action to plant and protect trees in their own neighborhoods. CRTI invited priority communities to participate in training programs in which they learned how to draft their own Urban Forestry Management Plans to fit each communities' unique needs. In the historic Pullman neighborhood, CRTI worked with community volunteers to conduct a tree inventory. This inventory is being used by the City of Chicago to identify sites for planting and to increase species diversity. In addition, volunteers had opportunities to talk with Pullman residents about their trees, fostering a culture of greater urban forest stewardship. For more information about CRTI, visit <http://www.chicagorti.org>.



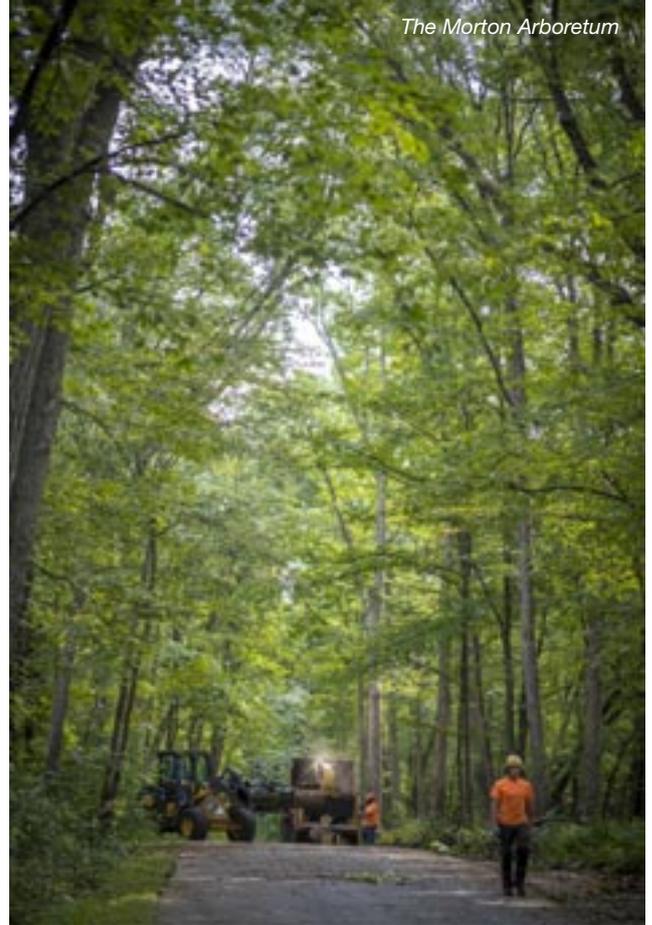
**Brooklyn Botanic Garden in New York City** runs the Street Tree Stewardship Initiative, which aims to make the borough of Brooklyn a cleaner and greener place to live and grow by empowering the public to care for their trees. Urban trees face a great number of natural and man-made threats and require ongoing maintenance, such as regular watering and tending to the tree bed. The initiative, which is run in partnership with NYC Parks and Recreation Department among other organizations, aims to educate the public about the proper care of urban trees in order to maintain and improve the aesthetics and health of trees throughout Brooklyn. As well as tending to existing trees, the project also aims to ensure the survival of thousands of new trees planted by the [MillionTreesNYC initiative](#).

## 1.5. Tree ordinances and protection policies

Protection policies are necessary to preserve and protect government entity resources and infrastructure. “Green infrastructure” should be included. A tree ordinance establishes authorization and standards for addressing a wide range of issues regarding trees. They should be developed and implemented as part of a broader effort to identify and address a community’s tree-related goals. Botanic gardens can work with their local government entity to ensure that these policies are in place. The International Society of Arborists can be a resource. (Swiecki, T.J., and Bernhardt, E.A. 2001. Guidelines for Developing and Evaluating Tree Ordinances.)

## 1.6. Research

A key strength of botanic gardens is the botanical knowledge and records that have been amassed over decades and centuries. Botanic gardens have an important role in participating in research that advances understanding of ecosystems in built environments, the benefits that trees and urban landscapes deliver, and the methods to improve plant production, planting and care. Results from these experiments and scientific observation lead to improved knowledge and best practices to ensure a healthier environment for people and wildlife.



### CASE STUDY

#### Urban street tree and green roof research

**Shanghai Chenshan Botanical Garden in China** is collaborating with the Shanghai Municipal Landscape Management and Instructional Station to develop an overall strategy for root pruning of street trees for restricted spaces, based in part on techniques used for bonsai cultivation. They are testing structural soil that allows root expansion, sustainable nutrition and optimal balance between roots and crown. This research has been patented and is currently being applied in the city. Shanghai Chenshan and the Shanghai Municipality collaborates internationally with Morton Arboretum’s Center for Tree Science to develop research and applications that improve growth and survivability of urban street trees.

Shanghai Chenshan Botanical Garden has also carried out research to develop optimal protocols for green roofs in the city. The right depth and composition of soil is critical to the success of green roofs, and the garden has tested soil depth against the yearly average rainfall in order to ensure good moisture retention and provide the best growth conditions for plants. Appropriate soil mixtures were also evaluated according to the species selected. These recommendations are now part of the City of Shanghai regulations and specifications for green roof installation. Visit <https://www.bgci.org/garden.php?id=4544>



### CASE STUDIES

#### Tree ordinances

The **Chicago Region Trees Initiative** has developed examples of three different levels of templates that can be used by communities. Visit <http://chicagorti.org/OrdinanceTemplates>

The **National Botanic Garden of Georgia** is administered by the Tbilisi Municipality, and one of the Garden’s statutory functions is to evaluate sites earmarked for development. This includes assessing the health of existing trees and serving protection orders where trees are protected under the law. Visit <http://nbgg.ge>



Evaluation of species for pollution mitigation, shade and shelter (The Morton Arboretum)

### CASE STUDY

#### Evaluation of species for pollution mitigation, shade and shelter

At **Gothenburg Botanic Garden in Sweden**, extensive research is being carried out on evaluating the capacity of trees to deliver ecosystem services. For example, over 15 tree species with different leaf/needle structures have been evaluated for their capacity to take up pollution particles. Gothenburg BG also evaluates trees for their capacity to provide microclimates in urban environments, e.g., through provision of shade, shelter from cold winds etc. Another research area is the capacity of trees to perform well in warm and dry inner-city environments, focusing particularly on non-traditional species and genotypes in order to detect the trees for the future (Sjöman *et al.*, 2018). Guides are also provided for Tree Species Selection for Green Infrastructure (Hiron and Sjöman, 2019). These research activities are collaborations between universities, the nursery industry and municipalities where the plant expertise is mainly provided by the botanic garden.

### CASE STUDY

#### Assessing hurricane resilience and selecting adapted trees

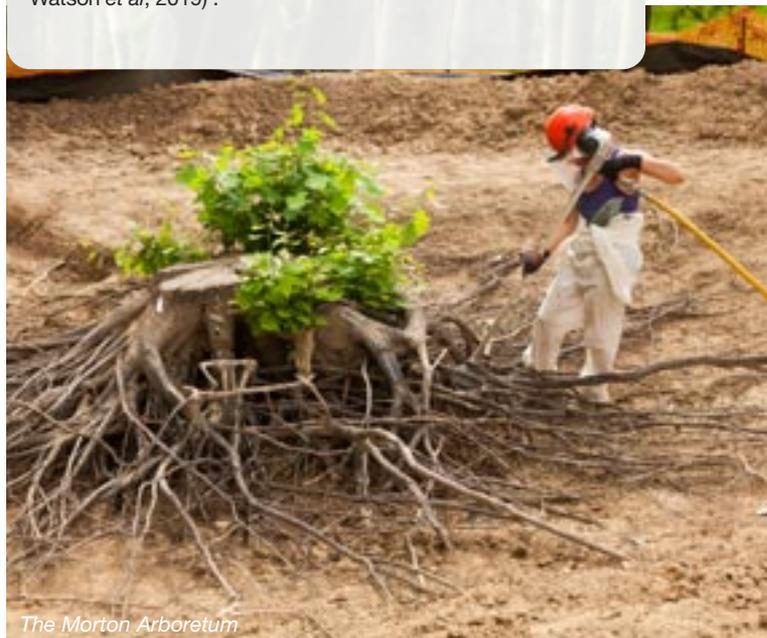
In September 2017, hurricanes Irma and Maria struck Puerto Rico causing US \$90 billion in damage and nearly 3,000 deaths. Preliminary studies from Landsat images suggest that the hurricanes may have caused mortality or severe damage to 20-30 million trees. Severe damage was caused to the **Arboreto Parque Doña Inés**, an urban forest composed of native and endemic species in the capital city of San Juan, with 465 (36%) of its native and endemic trees killed by uprooting. Ten species were lost from the collections. In the aftermath of the hurricanes, researchers at the garden are undertaking ground and remote sensing research to document the impacts of hurricanes Irma and Maria on their plant collection and evaluate the native trees that are best adapted for hurricanes in the city. Visit [https://www.wfuf2018.com/public/file/PS44TorresSantana\\_PUERTORICO-25880-25881.pdf](https://www.wfuf2018.com/public/file/PS44TorresSantana_PUERTORICO-25880-25881.pdf)

### CASE STUDY

#### Tree growth, management and function in the built environment

Understanding the science behind tree growth, management and function in the built environment is essential if we want trees to grow successfully in urban environments. **The Morton Arboretum in the USA** works to understand trees holistically, and works with experts from around the world, through its Center for Tree Science, to apply science knowledge into action.

The Arboriculture Research Lab at The Morton Arboretum conducts applied research to provide science-based information to tree care managers, elevating the care of urban trees. The Arboriculture Research Lab guides industry best management practices for tree crown restoration pruning. The research is designed to determine how urban trees injured by severe storm events respond to various pruning treatments. The Soil Ecology Lab at The Morton Arboretum examines plant-soil interactions in a changing world. A division of the Soil Ecology Lab studies best practice management strategies to ensure a viable urban soil environment that supports healthy, long-lived trees. The Root Lab at The Morton Arboretum is an established leader in urban tree root management. As part of the Center for Tree Science, researchers are focused on expanding the boundaries of knowledge linking root growth and development to the health of trees in natural systems and urban landscapes. The Root Lab is studying structural root development in young trees, as well as the implications for urban tree management and longevity. Since 1993, the Landscape Below Ground Conference has provided a forum for presentation of the latest research and management practices in all aspects of tree root development in urban soils. The conference's impact on arboricultural practices has been significant; practices now commonplace, such as load-bearing soils that provide space for root growth beneath pavement, were introduced to international audiences at the conferences and through conference proceedings (Watson *et al.* 2009; Watson *et al.*; 2019) .



The Morton Arboretum

## 1.7. Training and consulting

Many residents may not know where to go to consult with urban forestry or landscape management experts. Botanical gardens are valued for their expertise and knowledge. By providing these services or referring people to trusted contractors, they can be an important avenue that leads to improved professionalism and care of urban forests and landscapes.

### CASE STUDIES

#### Training of landscaping and horticultural professionals

**The University of Washington Botanic Gardens in the USA** offers ProHort classes geared to landscape professionals and Ecological Restoration classes for restoration practitioners. Classes include both classroom time and field instruction, and participants are encouraged to bring their daily workplace challenges and success stories to the group for support and discussion.

Similarly, the **Arboreto Parque Dona Ines in Puerto Rico** offers specialized guided tours for students, seminars, workshops, and hands-on fieldwork with professionals. They also provide training to staff from the Municipality of San Juan, the Puerto Rican Electricity Power Authority, the PR Department of Public Works, and other partners.

Students and interns doing horticulture and landscape architecture receive training at the **Reykjavik Botanic Garden**.

**Phipps Conservatory and Botanical Garden in the USA** also offers a Sustainable Landcare Accreditation for landscape and lawn care professionals in the Pittsburgh area. This accreditation offers a curriculum, which covers organic landcare principles, practices, design and maintenance. The course is aimed at garden centre employees, horticulturists, conservation property managers, master gardeners, educators and others.



### CASE STUDIES

#### Consultancy services

The **Volcji Potok Arboretum in Slovenia** provides expert consultation, tree risk and species recommendations, tree inventories, and professional pruning, planting, and tree condition assessment. They advocate for arborists assisting residents with their urban trees and position themselves as experts on dealing with challenges trees have in urban environments. The arboretum is the largest in Slovenia.

Visit <http://www.arboretum.si/projektiva/arboristika>

**The Morris Arboretum in the USA** has a team of Urban Forestry Consultants. They consult with landscape architecture firms, educational institutions, businesses, professional organizations, and government. They also advise on best management practices for the trees and their clients' budgets. These services include tree inventories, risk assessment, the development of tree management plans, ordinance writing and development, inspection, and tree valuation.

## 1.8. Plant sales

Plant sales can be a great way to help distribute diverse and regionally appropriate plants, especially to homeowners.

### CASE STUDIES

#### Plant sales

**The Australian National Botanic Gardens in Canberra** runs a biannual native plant sale, courtesy of the Australian Native Plant Society. The Australian Native Plant Society is a non-profit, voluntary organisation dedicated to the growing, conservation, preservation, promotion and appreciation of Australian native plants. A wide range of native plants are sold, all from local sources (within 50km of Canberra CBD) and are suitable to be grown in the local climate. Visit <https://nativeplantscbr.com.au/events/biannual-plant-sales/>

**San Francisco Botanical Garden** propagates a wide variety of plants, many of which are exclusive to the Garden's nursery, and has been running monthly plant sales for more than 50 years. The sales are focused on (but not limited to) a seasonal features theme, for example 'Spring Bloomers' and 'CA native plants & succulents'. Additionally, plants are available to purchase every day, with volunteers on hand to provide advice. Visit <https://www.sfbg.org/plant-sales>

## 2. SUPPORTING AND ADVANCING URBAN AGRICULTURE



The Morton Arboretum

Wikipedia defines urban agriculture, urban farming, or urban gardening as:

**‘The practice of cultivating, processing and distributing food in or around urban areas. Urban agriculture can also involve animal husbandry, aquaculture, agroforestry, urban beekeeping, and horticulture.’**

Many botanic gardens have on site demonstration vegetable or fruit gardens. However, some gardens take this much further, and invest in substantial outreach and training activities that have a much greater impact on the urban communities in which they are situated.



### 2.1 Urban community gardens

#### CASE STUDY

##### Urban community gardens

The **Royal Botanic Garden Sydney, Australia’s** Community Greening programme serves the broader community by taking its expertise ‘beyond the garden walls’ through innovative outreach programmes such as community-led gardens in social housing estates across New South Wales. Community Greening was established in 2000 and has since reached more than 100,000 participants including adults and children to promote communal garden projects. The main aims of the programme are to: improve physical health, improve mental health, reduce anti-social behaviour, build community cohesion, tackle economic disadvantage, promote understanding of native food plants, conserve the environment, provide skills training and share expert garden knowledge. Certain population groups (e.g. urban deprived populations, disadvantaged social groups, minority ethnic groups, those over the age of 65 and disabled people) are less likely to be able to visit green spaces for a number of reasons. The programme empowers these vulnerable communities whilst providing a wide range of health, training, economic and social benefits. When surveyed, Community Greening participants reported that 85% felt that the programme had a positive effect on their health and 91% said it had a positive effect on their community. The demand for Community Greening continues to rise, so the aim is to deliver 850 gardens and engage 150,000 participants by 2021.



## CASE STUDY

### Sharing skills and knowledge with diverse communities

The Edible Gardening Project based at the **Royal Botanic Garden Edinburgh (RBGE)** in the UK shares horticultural knowledge, skills and enthusiasm for growing food with diverse communities. The Demonstration Garden at RBGE is maintained by a team of community gardeners and dedicated volunteers and it provides a space where local community groups are able to look after their own vegetable plots. They attend on a weekly basis to get hands on growing experience and learn horticultural skills with one of the community gardeners. The team also provides weekly 'Meet the Gardener' sessions in the Demonstration Garden, in which members of the public can attend to get growing advice and inspiration for their own gardens. The project also runs a range of free workshops to community garden groups, covering topics such as vegetable growing for beginners, composting and organic pest and disease control.

## 2.2. Improving access to fresh food

### CASE STUDY

#### Access to fresh food

Homegrown is a program run by **Phipps Conservatory in the USA**, which is dedicated to increasing community access to fresh produce, promoting better food choices and improving the overall health of families and children by installing vegetable gardens in inner cities. Homegrown was established in 2013 and has since installed over 210 raised-bed vegetable gardens at households in underserved neighborhoods and provided mentorship and resources to the community members to enable them to maintain and benefit from the gardens. The program helps families to keep their gardens flourishing by honing participant's gardening skills and knowledge with topics such as weed management and healthy cooking skills. Homegrown also provides the opportunity for neighbors to connect. The Homegrown program began in Homewood, where the gardens were established in almost one in 10 households. The program has now expanded to multiple other Pittsburgh neighborhoods with plans for continued expansion in the future.



*(Randy Fath)*

## 2.3. Supporting urban agriculture training and jobs

### CASE STUDY

#### Urban agriculture training and jobs

**Chicago Botanic Garden's** Windy City Harvest is an urban agriculture education and jobs-training initiative to help build a local food system, healthier communities and a greener economy. Started in 2003, the initiative runs 13 city farms in cooperation with 80 community organisations in low income parts of the city, producing 130,000 pounds of fresh fruit and vegetables per year and training community members in how to grow their own produce. The initiative has four branches: Youth Farms, Apprenticeships, Corps and Education. Youth Farms employs 80 to 90 teens from low-income communities at three farm sites in Chicago and one in Lake County. Youth Farm students learn to grow food responsibly, work as a team, advocate for food justice, eat in a healthy way, and become accountable—to themselves, their fellow farmers, and to their employers. The Windy City Harvest Apprenticeship Program is a hands-on, technical training program in Sustainable Urban Agriculture, offered in partnership with the City Colleges of Chicago. The certificate includes a 14-week paid internship at Windy City Harvest farms or partnering urban-farming operations. The Apprenticeship focuses on annual vegetable production, using hands-on, plain language, and a team-focused approach. Students are trained in greenhouse and raised bed production, soil science, plant health care, food safety, and more throughout the Apprenticeship program. Windy City Harvest Corps employs 30 to 40 justice-involved individuals and veterans in closely mentored, full-time paid transitional jobs and supports them in finding full-time, long-term employment. Crew members work on Windy City Harvest farm sites gaining hands-on technical training as well as receiving help and training to find long-term employment.



*The Morton Arboretum*

### CASE STUDIES

#### Teaching horticulture and agriculture

Education, training and communication are important functions of the **Royal Botanic Gardens Peradeniya in Sri Lanka**. Whilst training and development of staff is considered part of the corporate operation, there is a significant external role in providing education and training for members of the public, schoolchildren, small businesses, students of Floriculture and Landscape Design and other specialist audiences. At present, the gardens are conducting one-day, two-day and three-month long courses in floriculture and landscape gardening providing training for over 15,000 people a year. Visit [http://www.botanicgardens.gov.lk/?page\\_id=1920](http://www.botanicgardens.gov.lk/?page_id=1920).

**Phipps Conservatory's** Sustainable Horticulture Certificate program consists of a series of core courses that includes Basic and Advanced Horticulture, Soils, Diagnosing Plant Problems and Botany for Gardeners. These classes teach best management practices necessary for gardening with minimal ecological impact. Elective courses further enhance students' understanding of sustainable practices that help protect soil health, water resources, air quality and land usage, and result in the creation of aesthetically pleasing gardens. Visit <https://www.phipps.conservatory.org/green-innovation/at-home/>



*Training of landscaping and horticultural professionals (The Morton Arboretum)*



## 2.4. Food advocacy and education

### CASE STUDY

#### Urban agriculture and food advocacy

The BigPicnic project, comprising a consortium of 19 gardens in Europe and Africa, engages and informs visitors on food themes such as entitlement, access, ecological footprints, food diversity and the importance of a plant-based diet for present and future food security. For example, **Bergamo Botanical Garden 'Lorenzo Rota'** in Italy has developed an interactive exhibition, which focuses on the importance of food security and ecological footprints and encourages visitors, through a series of interactive activities to learn about, discuss and calculate their ecological footprint.

Many gardens also practice what they preach in their restaurants, providing locally sourced, diverse and healthy produce, at the same time providing advice to help their visitors to make informed choices. For example, since 2016, the **Royal Botanic Garden Edinburgh** in the UK has been growing produce on-site for their Café and Restaurant menu. Volunteers maintain the food garden and the programme helps to promote local, seasonal produce and cut the carbon footprint and air miles of the food served. Similarly, the **Balkan Botanic Garden** in Kroussia, Greece, promotes traditional food plants through tasting events, seed fairs and working with local nurseries to make these plants available. **Naples Botanical Garden** in the USA partners with a local slow food organisation to develop educational programmes for students harvesting from their school gardens.



(Markus Winkler)



Soil Specialist, Hands on training (The Morton Arboretum)



### 3. CONSERVING URBAN BIODIVERSITY

Reintroducing native plants into urban areas

Botanic gardens and arboreta are themselves significant urban wildlife refuges, supporting pollinators and local wildlife (e.g. Baldock *et al.*, 2015). However, many gardens engage in significant outreach activities, including managing nature reserves, carrying out species reintroductions and habitat restoration, and helping their local communities to create wildlife friendly gardens.

#### 3.1 Managing urban nature reserves



#### CASE STUDY

##### Urban nature reserves

**Kirstenbosch National Botanical Garden in South Africa** is set against the eastern slopes of Cape Town's Table Mountain. The estate covers 528 hectares, the majority of which is un-cultivated protected area, supporting natural forest and fynbos ecosystems and a wide variety of indigenous species, including more than 125 species of birds (including Sugarbirds, Sunbirds and Spotted Eagle Owl's) and mammal species such as Cape fox, water mongoose, Cape porcupine and Cape clawless otter. Table Mountain is also home to a rich insect life including species such as the spectacular Table Mountain Beauty butterfly, as well as several species of amphibians including the Chirping Frog, Cape River frog and the Critically Endangered Table Mountain Ghost Frog. Resident reptiles include Angulate Tortoises, Marsh Terrapins, Cape Crag Lizard and several species of snakes. Kirstenbosch is adjacent to the Table Mountain National Park and combined they form part of the Cape Floristic Region Protected Area, which was proclaimed a UNESCO World Heritage Site in 2004. Additionally, Kirstenbosch manages two smaller reserves: the Edith Stevens Wetland Park on the Cape Flats and the Tinie Versfeld Wild Flower Reserve.

Visit <https://www.sanbi.org/gardens/kirstenbosch/>

*Orange Breasted Sunbird feeding on the flowers of Erica verticillata in Kirstenbosch NBG. This species is endemic to fynbos ecosystems. (Mark Anderson)*

## CASE STUDY

### Managing and restoring a peri-urban cloud forest reserve

The **Clavijero Botanical Garden (CBG) in Xalapa, Mexico** was founded in 1977, and maintains and manages a Cloud Forest Sanctuary – a natural protected area that has 30 ha of preserved forest, including young and old-secondary forest. The CBG and the Sanctuary goals are focused on conservation efforts through environmental education and ecological restoration. There have been propagation programmes for threatened cloud-forest trees such as *Symplocos coccinea*, *Podocarpus guatemalensis* and *Styrax glabrescens* since 1990. Rescue and propagation of two endangered species, *Magnolia dealbata* and *Talauma Mexicana*, has been a success story for the garden. Seed storage and propagation techniques for these species were developed and the species established in cultivation for the first time. Seedlings have been re-introduced into the adjoining ecological park as well as distributed to state and municipal nurseries as future seed trees for the propagation of the species.

Adjacent to the Clavijero Botanical Garden, a new project began in 2011, when the Instituto de Ecología (INECOL) bought an abandoned pasture with a small area of forest with a spring. The forest fragment and the adjacent Sanctuary are the closest propagule sources. Although no major disturbances occurred while being a pasture (e.g., fires, floods), the introduced grass is an exotic species (*Cynodon plectostachyus*), and is tall and very competitive, with a high growth rate that has arrested the successional process. The forest restoration project has two main objectives 1) to understand the ecological processes and actions that may accelerate the recovery of a cloud forest, and 2) to inform the public about the long and complex process behind the restoration of a peri-urban cloud forest from an abandoned pasture. Visit <http://www.erabg.org/project/62/>



*Symplocos coccinea* (G. Cornejo-Tenorio)

## 3.2 Urban habitat restoration



Fengtang estuary restoration, Shenzhen, China (SCBG)

## CASE STUDY

### Estuary and wetland restoration

Shenzhen is a coastal city in South China with rapid economic growth and urbanization. The Fengtang River estuary in the centre of the city has been polluted by industrial and domestic sewage for 30 years. As a result, water quality was at the most polluted level in China, the diversity and abundance of benthic organisms and birds on Fengtang's tidal flats decreased substantially and the mangroves in the area were threatened due to the invasion of alien species. The **South China Botanical Garden (SCBG)** carried out a research and demonstration project on the restoration of the wetland ecosystem at Fengtang River Estuary in Shenzhen from 2004 to 2016. The project focused on the Fengtang River estuary of Shenzhen Bay in Shenzhen City and its adjacent sea-land ecotone. SCBG studied the ecological impact of rapid urbanization on the estuary and the sea-land ecotone, and developed ecological restoration engineering technology for damaged rivers, wetlands and green spaces. The endangered sedge, *Eleocharis ochrostachys*, and the water palm, *Nypa fruticans*, were successfully reintroduced. SCBG developed supporting technologies for water and soil habitat restoration and halophytic vegetation restoration in the land-sea ecotone, including site preparation, plant selection, planting/reintroduction, tending and management, wetland water distribution, hydrodynamic restoration engineering, monitoring and evaluation. After 12 years of effort, the ecological integrity and ecosystem health of Shenzhen Bay has been restored in the project areas. One monograph, ten papers and two Chinese patents were published in the process. Visit <http://english.scib.ac.cn>

## CASE STUDY

### Urban forest restoration

The Thain Family Forest is a 20-hectare old growth, urban forest in the heart of **New York Botanical Garden (NYBG)**. It is the largest remnant of the forest, which once covered the majority of New York City. This unique urban woodland is dominated by ancient native hardwoods such as oak, tulip trees, sweetgums and maples. Hemlocks originally dominated the canopy, but they began to decline in the 20th century. This decline can be attributed to two invasive insects (hemlock woolly adelgid and elongate hemlock scale) as well as extensive human-caused disturbance (such as soil compaction, over collection of native plants, fragmentation and pollution). Therefore, in 2008, NYBG created an ecological restoration program to mitigate the continuing decline in health of the forest. Between 2008 and 2015, the newly appointed Director of Thain Family Forest developed and implemented an ambitious program of ecological restoration, trail restoration, education, ecological research, biodiversity inventory, and outreach. Visit <https://www.nybg.org/content/uploads/2017/04/Forest-Plan-2016.pdf>



*Thain Family Forest Restoration planting of *Tsuga canadensis* (Canadian hemlock) in the old 'Hemlock Grove'. (NYBG)*

## 3.3 Species reintroductions in urban areas

### CASE STUDIES

#### Reintroducing native plants into urban areas

Singapore has some 228 species of native orchids. Of these, 164 are considered to be extinct, 56 are critically endangered, three are vulnerable and only five are common. An Orchid Conservation Program was initiated in 1995 to monitor these threatened native species and explore ways to conserve their germplasm and increase their numbers for subsequent re-introduction into appropriate habitats. Since the mid-1990s, **Singapore Botanic Garden** has successfully propagated and reintroduced native orchids in parks and green spaces across Singapore. To date, 33 native orchid species have been reintroduced across Singapore, comprising over 20,000 plants at more than 40 different locations.

**Fairchild Tropical Botanic Garden** in Florida manages the Million Orchid Project which is propagating millions of native orchids for reintroduction into South Florida's urban landscapes. The Micropropagation Laboratory at Fairchild will generate an almost limitless supply of young native orchid plants. Local school landscapes, hospitals and urban tree plantings are currently the primary recipients of Fairchild's reintroduction initiatives. The project's goal is to have the first generation of re-established orchids blooming throughout South Florida within five years. Throughout the project, Fairchild scientists will teach visitors, students, and the local community about the complexity and fragility of natural South Florida environments and the importance of habitat restoration.



*Staff conduct a forest inventory every five years to document forest change and track ecological restoration progress (NYBG)*

## CASE STUDY

### Reintroduction of an extinct in the wild species

The Threatened Species Programme at the South African National Biodiversity Institute, **Kirstenbosch National Botanical Garden in South Africa**, includes both *ex situ* and *in situ* conservation activities (Hitchcock & Rebelo, 2017). Plant conservation is driven by South Africa's Strategy for Plant Conservation, which was developed in response to the Global Strategy for Plant Conservation. The whorl heath (*Erica verticillata*) was thought to be extinct by 1950. However, horticulturists have since rediscovered eight clones in botanic gardens and other sites worldwide. *Ex situ* conservation in botanic garden collections and the Millennium Seed Bank has since allowed *in situ* conservation of this species in the critically endangered Cape Flats Sand Fynbos vegetation type. Pioneering work carried out at Rondevlei Nature Reserve identified suitable habitat and this was applied in subsequent *in situ* work at Kenilworth Racecourse Conservation Area and at Tokai Park – the only natural areas remaining in or near this species' historical distribution range. Successful re-establishment of this species depends upon its capacity to recruit after fire, which is an essential ecological process in the fynbos. The key lesson learnt to date is the need to include sustainable management of the entire ecosystem in the restoration process and to not limit it to a single species. Success in restoring a species depends upon a healthy stand of the vegetation type in place, along with pollinators and other key fauna and natural ecosystem processes. It is also recommended that successful re-establishment of a species in fynbos requires the reintroduced population to survive three fire cycles.



## 3.4. Supporting wildlife and pollinators

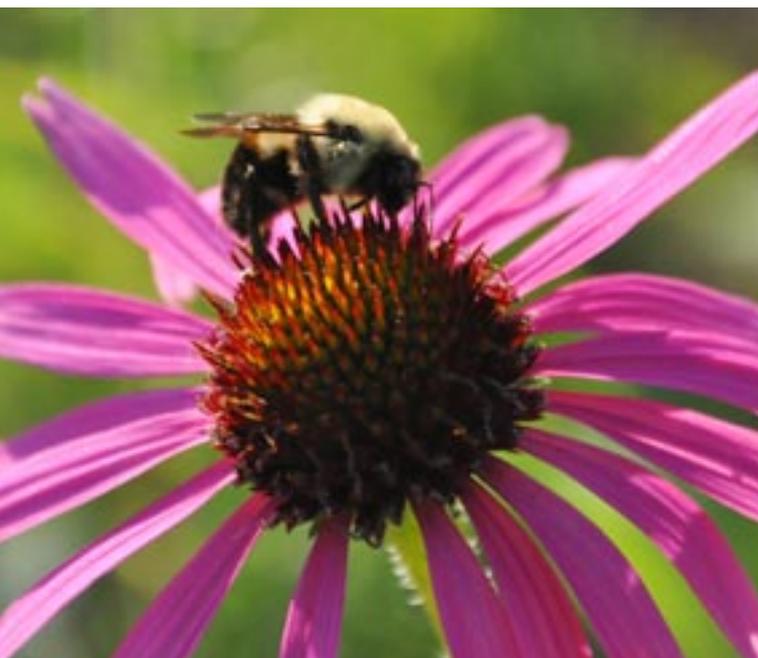
### CASE STUDY

#### Creating urban pollinator gardens

**Atlanta Botanical Garden** in the USA is part of the Greater Atlanta Pollinator Partnership (GAPP). The Partnership is responding to the loss of pollinator habitat and food plants. Over a period of 10 years, Atlanta lost 79,700 hectares (196,921 acres) of tree canopy and green space, and gained 41,790 hectares (103,273 acres) of impervious surface due to urban development. The main goal of the Partnership is to develop pollinator friendly habitat within a 25 mile radius (1.2 million acres) of downtown Atlanta by planting native species, rescuing plants from construction sites, controlling non-native invasive species, creating community gardens, promoting citizen science and conservation, carrying out formal and informal education, and developing schoolyard habitats.

Atlanta BG's objectives are to develop research and conservation strategies on native plant-pollinator interactions through a three-pronged approach: surveying and monitoring of insect pollinators, creating and restoring metro Atlanta pollinator habitats, and developing educational material on pollinator conservation for Atlanta and the Southeast USA. The Garden and its partners have installed seven pollinator gardens across the metropolitan Atlanta area, providing pockets of beauty and ecological resources for pollinators. This effort includes working closely with GAPP to provide straightforward, accessible resources for learning about pollinators and maintaining pollinator gardens to home gardeners, neighborhood associations and educators. Through this partnership, the Garden encourages Atlanta communities to take active steps to involve themselves in pollinator habitat conservation and restoration.

Visit <https://gapp.org/>



## CASE STUDY

### Pollinator conservation

The **National Botanic Garden of Wales (NBGW)** carries out a wide range of pollinator conservation activities. The Garden is a member of the Pollinator Taskforce, a group of key stakeholders in the Action Plan for Pollinators in Wales, which was launched to set the strategic vision, outcomes and areas for action to halt and reverse pollinator decline in Wales. The NBGW is also a world leader on pollinator research, including research into the floral preferences of both honeybees and wild pollinators using DNA barcoding. In addition, the Garden holds an annual 'Pollinator Festival', a program of events, talks and guided walks around the gardens such as 'Garden Plants for Pollinators'. Furthermore, the NBGW includes the Waun Las Nature Reserve, a mosaic of wildflower rich hay meadows and pastures, managed to encourage biodiversity, which provides a haven for pollinators. Visit <https://botanicgarden.wales/science/saving-pollinators/>



*Bee expert Clare Flynn on Waun Las Hay meadow for Wales wildflower day 2015 (Creative Commons Attribution Share)*

## CASE STUDY

### Urban habitat management for biodiversity

The **Royal Botanic Garden, Edinburgh's** work on habitat management spans urban and rural environments. It ranges from primary research to practical advice, actively engaging the public with greenspace benefits for biodiversity, ecological resilience and human well-being. RBG Edinburgh is a founding member of the Edinburgh Living Landscape project, reflecting the institution's increasing focus on support for biodiversity as part of urban green infrastructure. RBG Edinburgh's contributions include practical training to help community groups achieve their ambitions for local biodiversity. Activities aimed to achieve this include: organic edible gardening, public recording schemes for lichens as air pollution indicators and to encourage sustainable transport, working with Butterfly Conservation to expand green roofs across Edinburgh as habitat patches for rare butterflies, development of demonstration rain garden projects for climate change adaptation, contributing to Edinburgh Adapts, and, delivering a major project that celebrates the biodiversity and cultural value of Edinburgh's shoreline. Visit <https://www.rbge.org.uk/science-and-conservation/scottish-biodiversity/urban-and-countryside-management/>

## 3.5. Native plant gardening

### CASE STUDY

#### Native plant gardening

The **Native Plant Trust (NPT; formerly the New England Wild Flower Society)** in the USA manages **Garden in the Woods**, and on its Nasami Farm site:

1. Grows locally sourced New England native plants, many from sustainably harvested seeds
2. Focuses on propagation and research to bring different and hard-to-grow plants into production
3. Partners with local nurseries to grow propagated plants to retail size
4. Sells plants in their seasonal Garden Shop that are grown in partnership with local nurseries.

The NPT also offers classes in native plant horticulture and has produced an online guide called Plantfinder that identifies native plants that will thrive in a user's garden, from the ecoregion scale to the soils, light, and moisture available in their particular garden. People can also choose plants by color, woody or herbaceous species, and wildlife benefits.

**Phipps Conservatory's** Native Plant Landscapes Certificate program consists of a series of courses designed for participants to learn to appreciate and use native plants, discover the importance of habitats and ecosystems, and explore how native plants can fit into our gardens.



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Native plant gardening, red *Trillium* (Pixabay)

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