# The beauty of conservation – developing a science-based conservation horticulture programme at Longwood Gardens, Pennsylvania, USA

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## Abstract

While historically serving ornamental, medicinal and agricultural purposes, botanic gardens and arboreta have opened their doors to the public and have extended their missions to encompass the study, preservation and support of plant diversity. Longwood Gardens (Kennett Square, PA, USA) has embarked on this journey, leveraging its scientific expertise to establish a conservation focus. Navigating this initiative with its strength in horticulture, the Longwood team outlines key steps in creating a conservation horticulture programme, emphasising the importance of (a) assessing horticultural competencies, strengths and existing infrastructure; (b) aligning systematic conservation priorities and global need; (c) amplifying impact through partnerships; (d) developing research initiatives and expanding mission-aligned work; and (e) leveraging audiences. The article concludes by emphasising the importance of collaborative partnerships, avoiding mission creep through maintaining a strategic focus and understanding that a continuum mindset is essential. Longwood's work, focusing particularly on terrestrial orchids, illustrates how a public garden can use this process to result in a successful and strategic impact-focused conservation horticulture programme that supports plant diversity.

## Introduction

In this dynamic and ever-changing world, botanic gardens and arboreta (hereafter gardens) are evolving. Historically, gardens served as tranquil retreats for the elite or as collections of plants deemed useful for medicinal, financial or agricultural purposes (O'Donnell & Sharrock, 2018; Westwood *et al*., 2021). Regardless of function, both historically and today, horticultural expertise is a constant requirement and an essential component of a garden's success. While gardens are still places of beauty and repose, they are increasingly expanding their mission to leverage their expertise, vast audiences and facilities to study, grow, conserve and champion plant diversity (Smith, 2017; 2018; Cavender & Donnelly, 2019; Westwood *et al*., 2021; Turner-Skoff *et al.*, 2022; Hiscock *et al.*, 2024). The involvement of gardens for these conservation and engagement directives is essential as plants are becoming extinct at an alarming rate, largely because of humans (Pimm & Joppa, 2015; Antonelli *et al.*, 2023).

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Global plant conservation efforts are guided by international policies and agreements that emphasise collaboration, science-based strategies and equity-driven approaches. These include the Convention on Biological Diversity (CBD), which sets the biodiversity agenda; the Kunming-Montreal Global Biodiversity Framework, which defines the actions; and the Global Strategy for Plant Conservation (GSPC), a plant-focused approach that provides a framework for safeguarding plant diversity (Sharrock *et al.*, 2018). These frameworks help prioritise actions. Through the combined utilisation of these, botanic gardens can coordinate, prioritise and mobilise their staff to cultivate, propagate and conserve threatened plant species in their *ex situ* collections (Cano *et al.*, 2025). For a resilient future, conservation action to protect plant diversity, especially plants that are threatened, must be taken now. Longwood Gardens (Kennett Square, PA, USA) is embracing its role as a display garden that actively advances local to global conservation, from single plants to whole ecosystems (Turner-Skoff *et al.*, 2024).

The Longwood team identified the major steps they took as an institution to create a conservation horticulture programme. To assist other gardens interested in leveraging their expertise in horticulture to support similar efforts, the team at Longwood started by (a) assessing horticultural competencies, strengths and existing infrastructure; (b) aligning systematic conservation priorities with local and global need; (c) amplifying impact through partnerships; (d) identifying research initiatives and expanding mission-aligned work; and (e) leveraging audiences. This article serves as a narrative of these key steps, and highlights select case studies to provide context on the process. The paper then features lessons confirmed and future initiatives.

## *Longwood Gardens: a history of conservation and horticulture*

Longwood Gardens is globally renowned as a horticultural display garden that advances the art and science of growing plants through skill, technique and design vision. Spanning more than 445 ha in Pennsylvania's Brandywine Valley, the organisation is the living legacy of founder Pierre S. du Pont (1870–1954), with the mission of bringing joy and inspiration to everyone through the beauty of nature, conservation and learning. It is a showcase of extraordinary plants, ranging from uncommon in cultivation to rare in the wild, and plants grown in extraordinary ways, pushing the extremes of how a plant can grow, regarding form, size and number of flowers. This is demonstrated through expertise that encompasses:

- creating standards, or the process of training a plant to form a single trunk with a rounded canopy (Fig. 1A)
- growing plants that require expertise, time and finesse, such as *Meconopsis* 'Lingholm', *Echium* and *Clivia* (Fig. 1B)
- developing hanging baskets of uniformly grown plants that can weigh from 45 to 113 kg each (Fig. 1C)
- showcasing speciality groups such as chrysanthemums through an annual celebration that highlights techniques and cultivars that are rarely seen outside Japan, including the Thousand Bloom Mum (Fig. 1D)
- using laboratory-based *in vitro* methods to solve propagation and production issues to support display and collections development throughout the gardens (Fig. 1E)
- planting lush, highly diverse seasonal gardens that inspire joy (Fig. 1F).

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**Fig. 1** Longwood is known for its horticultural displays and the ability to grow extraordinary plants. This specialisation in techniques includes (A) Standards, such as this poinsettia (*Euphorbia pulcherrima* cv.); (B) The famed Himalayan blue poppies (*Meconopsis* 'Lingholm'); (C) Large hanging baskets, such as this *Hydrangea* and *Streptocarpella* 'Concord Blue'; (D) The Thousand Bloom Mum – a single plant that takes over 18 months to grow; (E) Tissue culture for *in vitro* propagation and production of clean stock; (F) Stunning outdoor gardens, especially the Flower Garden Walk. Photos: Longwood Gardens.

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Longwood is firmly rooted in science, horticulture and conservation. The land where the garden sits has a long history of plants being grown, cared for and celebrated by stewards ranging from the indigenous people of the Lenni Lenape tribe to the Longwood staff and volunteers (Randall, 2018). Since the 1950s, a dedicated horticulture and science staff has worked to expand expertise in speciality horticulture, research, plant breeding and genetics, natural areas stewardship, plant tissue culture and laboratory skills.

In addition to its beauty as a public garden that attracts over 1.6 million guests a year, Longwood is also (a) a botanic garden that boasts a living collection of approximately 13,500 taxa with 12 carefully curated core collections; (b) an ArbNet-accredited arboretum with many state champion trees onsite (Schuessler, 2013; Longwood Gardens, 2016; ArbNet, 2024); (c) a collection of gardens, with many famous designers and landscape architects sculpting the aesthetics, from Roberto Burle Marx to Isabelle Greene (Randall, 2018); (d) a stewarded natural landscape with over 200 distinct plant communities (Turner-Skoff *et al.*, 2024); (e) a research facility with skilled experts across numerous fields; and (f) a place that honours the diversity and the spectacular wonder of the natural world. All these components support Longwood's mission.

### *The intersection of conservation horticulture and gardens*

Gardens are gaining recognition regarding their critical role to slow and prevent the plant extinction crisis (Westwood *et al.*, 2021). Despite this, there remains a need to connect and engage plant experts and garden professionals with the importance of conservation horticulture to prevent species extinction (Gratzfeld, 2017; Meyer *et al.*, 2024). The importance of horticulture for supporting conservation efforts for plants is not a new idea (Affolter, 1997). If how to grow and care for rare or threatened plants is unknown, they cannot be conserved, either *ex situ* or *in situ*. Regardless of size, facilities or resources, gardens often have a wealth of horticultural expertise which can be used to protect biodiversity through staff, volunteers and institutional knowledge. Gardens can leverage this horticultural knowledge in support of both local and global conservation, both in practice and through maintaining and protecting landscapes and collections.

Given that each garden has a different history, mission, capacity, legacy, expertise and location, each garden also has a unique opportunity to participate in environmental efforts that are aligned with its identity (Turner-Skoff *et al.*, 2024). Generating conservation action that is aligned with mission is essential (Miller *et al.*, 2004); a display garden starting a conservation horticulture programme is an opportunity to further leverage established expertise, facilities and capacity. Conservation serves as a strategic goal and part of the mission for Longwood and, as such, it is a central focus for the science programme. This underscores and elevates the critical message that horticulture is essential for conservation (Rae, 2004; Gratzfeld, 2017; Meyer *et al.*, 2024).

## Assessing horticultural competencies, strengths and existing infrastructure

The first steps Longwood took to develop a conservation horticulture programme were to assess global conservation need (see the

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section 'Aligning systematic conservation priorities and global need'), evaluate current living collections and horticulture competencies, and align institutional strengths and resources. Living collections are invaluable for conservation and research efforts (Dixon, 2007), and they provide an opportunity for specialisation. For example, the Montgomery Botanic Center (Coral Gables, FL, USA) prioritises work regarding Cycadaceae and Arecaceae (Calonje & Griffith, 2020; Griffith *et al*., 2021). The Morton Arboretum (Chicago, IL, USA) leverages the genus *Quercus* in collections, research and *in situ* conservation (Beckman Bruns *et al.*, 2022; Carrero *et al.*, 2020). The Royal Botanic Garden Edinburgh (Edinburgh, Scotland) focuses on living collections of *Rhododendron* and native Scottish plants, and maintains a scientific programme dedicated to cryptogamic plants and fungi (Knott, 2021; Rae, 2008). To wit, identifying a focal group from existing living collections can be an efficient prioritisation tool. Members of the family Orchidaceae were an early and enduring interest of Longwood's founders, Pierre and Alice du Pont. This originally led to orchids being a core collection in the gardens' living plant collections policy, and thus a point of institutional identity.

Historically, a myth existed that it was difficult, perhaps impossible, to propagate and grow terrestrial native orchids outside their habitats (Swarts & Dixon, 2009a; Zale *et al.*, 2022a; Zale *et al.*, 2022b). The idea of 'growing the ungrowable' to advance conservation was particularly appealing to the Longwood team. This, coupled with the fact that Longwood has a tissue culture laboratory, associated laboratory expertise and a legacy of developing and maintaining orchid collections, was also an important component in deciding to prioritise orchids. These factors provide scientists at Longwood with opportunities to lead original research projects regarding (a) propagating orchids using both sterile asymbiotic and symbiotic seed propagation techniques (Fig. 2A,B); (b) growing genetically diverse seedling populations of orchids for *in situ*/*ex situ* introductions; and (c) maintaining a fungal bank to support germination protocols and experimentation (Fig. 2C,D). These reasons provided further evidence that orchids were an excellent priority group for the Longwood scientists to focus initial conservation horticulture efforts on.

Through applied horticultural research and scientific expertise, both at Longwood and beyond, the myth that orchids are impossible to propagate for *in situ* and *ex situ* conservation is being dispelled (Ramsay & Stewart, 2008; Wraith *et al*., 2020). There is a long-time recognition that propagation efforts need to be expanded to include a greater diversity of species (Brown, 1996). As an example, Longwood's conservation horticulture science team refined methodologies for the cultivation of *Cypripedium kentuckiense* C.F. Reed (southern lady's slipper orchid), one of the rarest native orchids in the United States (Fig. 3). While advances are being made for orchid cultivation, there are still significant opportunities for research of this nature within several native orchid genera, such as *Platanthera* (see Case Study 1).

## Aligning systematic conservation priorities and global need

For conservation efforts to be the most impactful, a systematic, science-based approach is necessary (IUCN, 2024). These steps serve as essential actions for determining conservation priorities,

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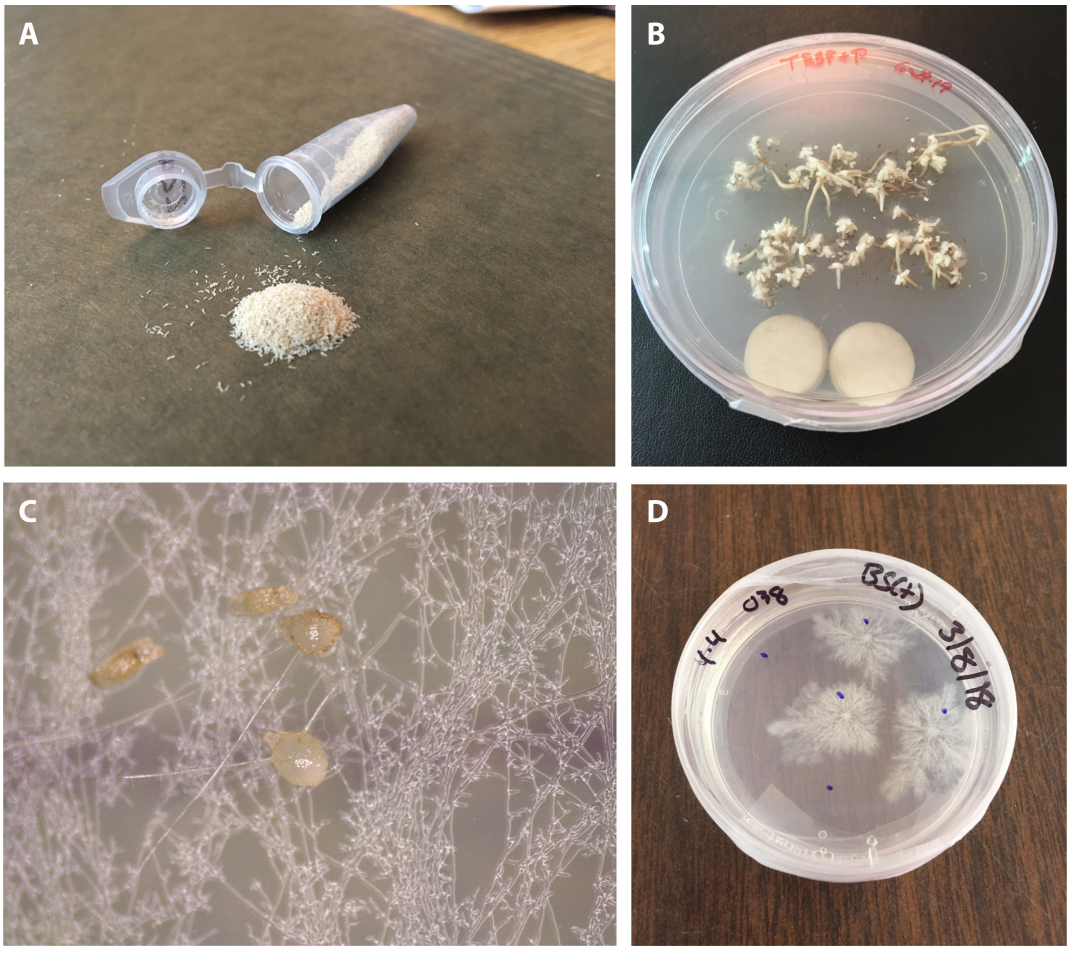


**Fig. 2** Images representing core activities of the Longwood Gardens native orchid conservation programme. (A) An orchid seed accession pulled from a large seed bank that supports research and *ex situ* conservation; (B) A petri dish illustrating asymbiotic germination of *Cypripedium* seeds. The round discs are russet potato, added to stimulate germination; (C) Symbiotic germination of *Platanthera*; (D) An orchid mycorrhizal fungus isolated from the roots of an adult plant and maintained in Longwood's fungal bank. Photos A and B: Peter J. Zale; Photos C and D: Ashley Clayton.

assessing the effectiveness of research initiatives and supporting the refinement and optimisation of conservation strategies. There are many tools that can also help guide institutions on how to identify and prioritise species that need protection. This includes leveraging pre-existing frameworks, such as the global International Union for Conservation of Nature (IUCN) Red List system and the US-centric NatureServe listings (Carrero *et al*., 2023). A vital component of prioritisation is understanding a plant group's conservation value and any immediate support needs.

In addition to the rich cultural and historical role that orchids contribute to Longwood's institutional history, the orchid family has conservation value. Almost 60 per cent of all orchid species that have been assessed for the IUCN Red List are threatened with extinction (Antonelli, *et al.*, 2023; BGCI, 2025). There is a clear need to conserve this large and important family, with special focus on improving the

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**Fig. 3** Longwood's conservation horticulture staff have refined methodologies for the cultivation of *Cypripedium kentuckiense* (southern lady's slipper orchid), one of the rarest native orchids in the United States. The team's work was featured in the Chelsea Flower Show in 2024. Photo: Peter J. Zale.

number of species in *ex situ* collections and seed banks (Vitt *et al.*, 2023). Pennsylvania native terrestrial orchids are not immune. Habitat loss appears to be the leading cause of decline, but numerous field observations of various taxa throughout the eastern US indicate that the unnaturally large populations of white-tailed deer (*Odocoileus virginianus*) are having a major negative impact on all species through intensive herbivory (Knapp & Wiegand, 2014). Additionally, like many specialised plants, climate change will likely negatively impact orchids (Gale *et al.*, 2018; Fay, 2018). Understanding how to implement *in situ* conservation by propagating and reintroducing these ecologically important species to local ecosystems will be essential in securing their future. This is especially true as rare plant translocation efforts can experience greater success through improved techniques (Bellis *et al.*, 2024). The Center for Plant Conservation (CPC) has a document of best practices for a wide range of *in situ* and *ex situ* strategies (CPC, 2019).

Not only are orchids iconic for Longwood Gardens, they are also iconic for the systems where they live. The presence of terrestrial orchids is often an indicator of ecosystem quality (Swarts & Dixon, 2009b). Their complex interactions with mycorrhizae and pollinators, presence in highly floristically diverse ecosystems and susceptibility to climate change result in orchids often being referred to as the colloquial 'canaries in the coalmine' and indicators of intact, healthy ecosystems worldwide.

The foundation of Longwood's conservation horticulture programme began with terrestrial orchids native to Pennsylvania since they are linked to the du Pont legacy; are aligned with one of the gardens' core collections; match the institution's identity, expertise, capacity and current facilities; and are in direct need of conservation action. Native terrestrial orchids, however, are only the beginning.

## Amplifying impact through partnerships

Active and engaged partnerships are required for conservation efforts to be effective. The scale and complexity of conservation challenges is greater than the capabilities of any single organisation or entity (Wall & Fulk, 2011; Dietsch *et al.*, 2021). Collaborative partnerships and broad networks bring together diverse expertise, resources and perspectives, fostering a more comprehensive and effective approach to addressing environmental issues (Breman

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*et al.*, 2021). Databases are available to understand the distribution of species in the botanic garden network (BGCI, 2025), which can support conservation efforts. By engaging stakeholders, leveraging capacity and sharing responsibilities, collective action can be easily mobilised to increase the long-term impact. Partnerships are a necessity to address conservation challenges, but they should be mutually beneficial and not facilitate mission creep (see the section 'Lessons confirmed').

After identifying native orchids as the priority group in 2015, and creating and defining programme goals, new and renewed partnerships were identified as integral to success (Table 1). At first, regional partnerships were highly prioritised. Collaborating with partners helped the scientists at Longwood identify offsite populations of plants and provided perspective on the conservation needs of different species. In essence, it provided context for where to focus initial efforts, which can sometimes be one of the biggest challenges when working on a large project. Leveraging the network of public gardens and botanical institutions is also a critical factor to develop successful partnerships (Westwood *et al.*, 2021). Through increased access to specialised facilities, germplasm and knowledge, collective expertise can be magnified. Working on a national scale, Longwood's partners support collaborative research initiatives, such as molecular sequencing to identify orchid mycorrhizal fungi – an essential component of holistic orchid conservation programmes. As the conservation horticulture programme at Longwood continues to grow, more national and international partnerships are being cultivated and activated (see Case Study 2), including the IUCN Orchid Specialist Group.

## Research initiatives and expansion of mission-aligned work

### *Case Study 1: Propagating the impossible:* Platanthera

Scientists at Longwood embarked on understanding how to propagate seed from the *Platanthera* genus. There are about 40 species of *Platanthera* in the flora of the US, with a centre of distribution in the eastern United States and Great Lakes region (Sheviak, 2024). Nearly all of these species are of conservation concern in at least one of the states where they occur, and three taxa are considered federally endangered (NatureServe Explorer, 2000–2025). As with most terrestrial orchids of the region, habitat loss and overbrowsing from white-tailed deer serve as the biggest known threats (Knapp & Wiegand, 2014). Given conservation concern and environmental pressures, the genus *Platanthera* needed to be prioritised for *ex situ* and *in situ* work. However, as mentioned above, growing certain species, especially *P. peramoena* (A.Gray) A.Gray and closely related species such as *P. grandiflora* (Bigelow) Lindl. and *P. psycodes* (L.) A.Gray, has historically seldom been attempted and has been considered 'impossible', or at best very difficult, to propagate from physiologically mature seeds (Stoutamire, 1974). There is a paucity of literature-based evidence and general absence of documented protocols.

To help support conservation efforts, the scientists at Longwood tested whether embryo culture (immature seed propagation or 'green podding') could be a successful solution to propagating *Platanthera* (Tsuchiya, 1954). This method is often used for orchid seed propagation efforts, but the timing of seed harvest is critical to success, as it differs between genera and even species (Malmgren,

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1996). As there are gaps in the scientific literature, this information has not been determined for many orchid genera, including the *Platanthera*. With the knowledge that *Platanthera* seeds are physiologically mature at 30 to 35 days after pollination (Zale *et al*., in preparation), a study was devised using *P. peramoena*, a Pennsylvania threatened (S2) species, as a model species to optimise timing of seed harvest for successful immature seed germination (Fig. 4) (Pennsylvania Natural Heritage Program, 2024).

After harvesting capsules weekly over a five-week period for two consecutive growing seasons, and rigorous testing, successful germination was achieved and repeated when seeds were harvested 18 to 29 days after pollination (Zale, in preparation). The resultant seedlings were grown *in vitro* to a size where they could be successfully transplanted to greenhouse conditions, and experiments with *ex vitro* acclimatisation are ongoing. These results were repeated with closely related species such as *Platanthera grandiflora* and *P. psycodes.* Future initiatives include propagating the endangered and closely related species *P. leucophaea* (Nutt.) Lindl. 1835 and *P. praeclara* Sheviak & M.L.Bowles.

While some propagation techniques are known, mature seed germination requirements for many orchid species worldwide remain untested, unknown or unsuccessful. Since many terrestrial orchid populations are declining worldwide, it is increasingly important to decipher all available seed propagation techniques as well as to understand pollination events, to aid in conservation efforts that could ultimately impact the restoration of wild populations. Understanding how to successfully seedbank temperate terrestrial orchids still requires research and development to provide species-specific optimal recommendations (Francisqueti *et al.*, 2024; Machado-Neto & Custódio, 2005; Magrini *et al.*, 2019). Use of immature seed is a viable approach to the propagation of difficult species, and this work highlights the success of such an approach, indicating that it is a necessary tool for global *ex situ* orchid conservation efforts.

## *Case Study 2: Expansion of orchid conservation work to support global effort*

As Longwood's conservation horticulture scientists unlock new techniques and develop a greater understanding of the biology and ecology of native Pennsylvanian terrestrial orchids, it has become apparent that the scope of the programme could facilitate international terrestrial orchid conservation. However, global *ex situ* orchid conservation efforts are often restricted by the limited information available to support propagation efforts, the complexities associated with international projects focused on living organisms and difficulty finding meaningful partners.

Through an international network, scientists at Longwood learned about experts in Tanzania who were interested in orchid conservation. Tanzania is located in an area of incredible floristic diversity (Polhill, 1952–2012). With about 10,000 distinct species of plants, it is estimated to have roughly 1,100 endemic species (Kideghesho *et al.*, 2013). This country also has a proliferation of terrestrial orchid species of conservation need. Many of these orchids are becoming rare due to both habitat loss and the harvesting of their tubers, which are used to produce a food called *chikanda* (Veldman *et al.*, 2014). *Chikanda* is popular and is consumed throughout the larger geographical region. This has led to

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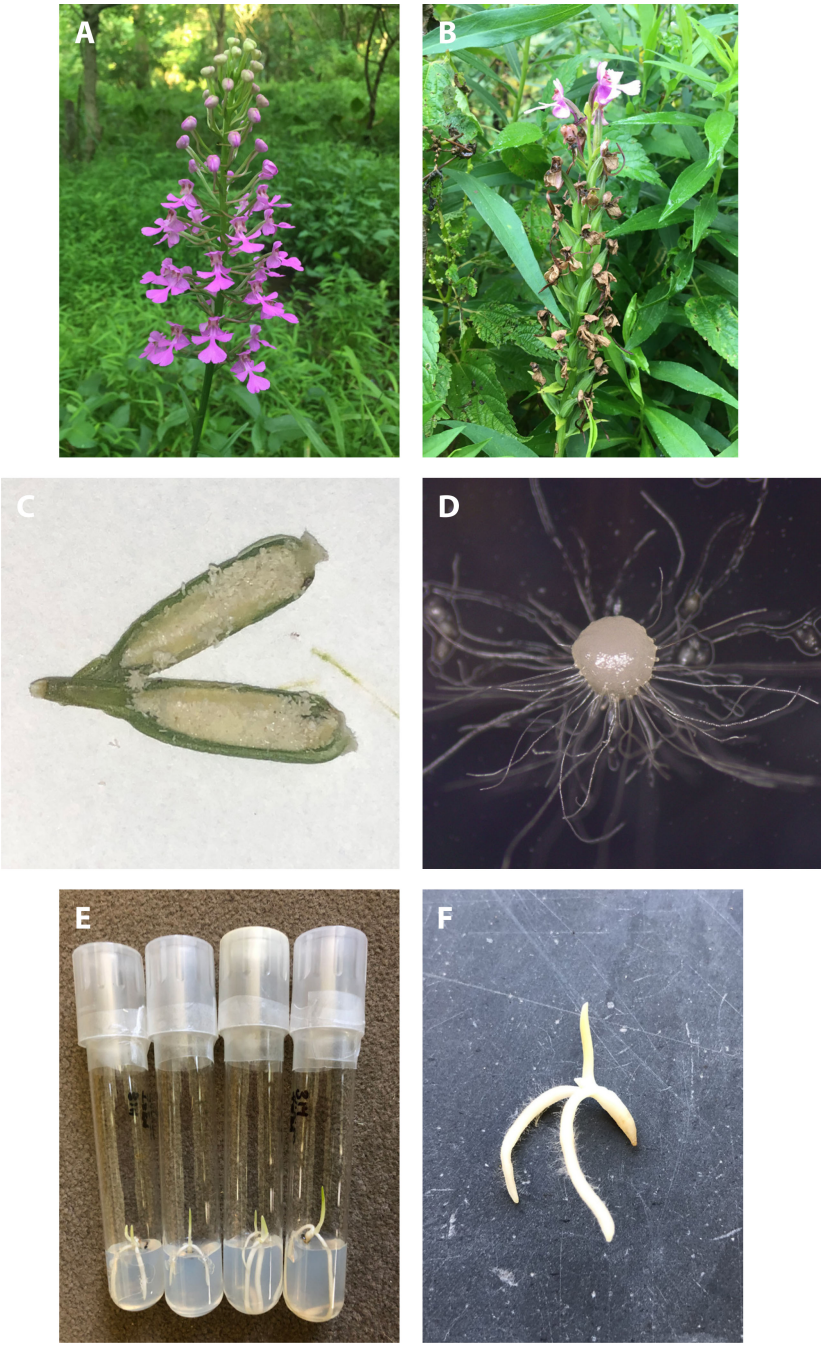


**Fig. 4** Images illustrating the experimental process for determining timing of seed harvest for successful immature seed propagation of *Platanthera peramoena*. (A) A flowering plant of *P. peramoena* in central Pennsylvania; (B) Developing capsules of *P. peramoena* three weeks after the appearance of flowers at the base of the raceme; (C) Immature seeds harvested at the correct time for successful germination. Note the white colour and 'flaky' texture of the partially developed seeds that indicate proper timing of harvest; (D) A protocorm (seedling) of *P. peramoena* at six weeks after initiation in culture; (E) Developing seedlings of *P. peramoena* ten months after initial transfer; (F) Deflasked seedling of *P. peramoena*. The next stages include greenhouse acclimatisation, *ex situ* collections development and restoration/population augmentation. Photos: Peter J. Zale.

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widespread illegal wild collecting, with up to 4 million orchid tubers illegally exported from Tanzania annually. With such a demand, it is estimated that 85 terrestrial orchid species are at risk of overharvesting (Veldman *et al.*, 2017). Two popular orchids selected for *chikanda* are *Disa robusta* N.E. Br., named for its large stature and correspondingly large tuber, and the narrowly endemic *Satyrium monadenum* Schltr., which also forms a tuber and has extremely showy spikes of bright red flowers (Fig. 5) (Dr Neduvoto Mollel, pers. comm.). However, these species occur in remarkably diverse orchid habitats, which often results in sympatric species of orchids inadvertently being harvested. To understand which species should be conserved, there is a need to study and document the terrestrial orchids in the region.

Working with these orchids in Tanzania required partners who could actively navigate a complex web of government agencies (Table 1). The experts at Longwood had connections to the Tanzania Plant Health and Pesticides Authority (TPHPA), which includes the National Herbarium of Tanzania (NHT!) and germplasm repository, and the Tanzania Sansevieria Foundation (TSF). Both institutions were interested in supporting the project with their own expertise and knowledge. Understanding partners' goals was critical for success. For example, a long-term goal of the Tanzanian government is to establish a programme where people would be able to actively practise orchid tuber farming, thus potentially reducing the amount of illegal wild collection for *chikanda*. Given that Longwood's expertise is growing terrestrial native orchids to support conservation efforts, this created a working partnership, designed to be a long-term relationship where both sides contribute and benefit (Fig. 6).

The partners collectively designed and implemented field work to initiate studies of terrestrial orchids in the Southern Highlands of Tanzania. Focal areas included the Kitulo National Park, which covers a vast tract of the Kitulo Plateau and is the only national park in Tanzania designated for plants. In 2023 a permit was obtained from the Tanzania Commission for Science and Technology, and this team of partners documented dozens of orchid populations for at least 76 taxa, collected over 685 herbarium specimens and made 63 seed collections. All specimens were deposited at NHT! and all seed samples processed and deposited at the Tanzania Plant Genetic Resources Center. Portions of the seed collections will be the basis of an applied research project to determine laboratory-based *in vitro* seed propagation protocols and adaptation to seed banking conditions. Initial research is already demonstrating positive propagation results. However, active engagement with important stakeholders and these results will be key for conservation success (see the section 'Leveraging audiences').

## *Case Study 3: Moving beyond orchids to include rare Pennsylvanian taxa*

Data generated by the Pennsylvania Natural Heritage Program indicates that at least 20 per cent of the state's estimated 2,100 species of vascular plants are of conservation concern, and that at least 14.8 per cent of these species are threatened or endangered (Pennsylvania Natural Heritage Program, 2024). This includes many orchids, but it also includes many other non-orchid taxa for which little is known about *ex situ* conservation requirements. Given Longwood scientists' successful history of propagating thousands of seedlings from

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**Fig. 5** The two orchid species targeted for *chikanda* in southern Tanzania. (A) A flowering plant *Disa robusta* at the Kitulo National Park. It is widespread in sub-Saharan Africa but has become rare due to habitat loss and harvesting; (B) The large tuber of *D. robusta* that was excavated and replanted by Ranger Mayunga after photography; (C) *Satyrium monadenum* is endemic to a small area in the southern highlands of Tanzania and adjacent Malawi and Zambia.


**Fig. 6** 'Team Orchid' at the Kitulo National Park in south-western Tanzania. Left to right: Robert Sikawa (Tanzania Sansevieria Foundation), Fabian Myunga (Ranger at Kitulo National Park), Barry Yinger (TSF), Dr Peter Zale (Longwood Gardens), Dr Neduvoto Mollel (Tanzania Plant Health and Pesticides Authority). Photo: Fabian Myunga.

37 Pennsylvania native orchid taxa, it was time to expand focus. Working with the Pennsylvania Plant Conservation Alliance (PPCA) (Table 1), these collaborators decided to prioritise developing horticulture techniques to propagate some of the rarest taxa in Pennsylvania, especially those with a NatureServe S1–S2 status that are also at least globally vulnerable (G3) (Pennsylvania Natural Heritage Program, 2024).

Using field and laboratory research, through supporting seed collection and banking, and seed germination ecology, the team is now studying species such as *Arabis patens* Sull. (Brassicaceae) (S2/G3); *Paxistima canbyi* A.Gray (Celastraceae) (S1/G2); *Taenidia montana* (Mack.) Cronquist (Apiaceae) (S1/G3); *Trifolium virginicum* Small (Fabaceae) (S1/G3); and *Polemonium vanbruntiae* Britton (Polemoniaceae) (S1/G3) (Fig. 7). All these species are poorly characterised regarding adaptability to horticultural systems, garden settings, seed germination ecology and adaptability to seed bank conditions. Eventually, these rare species will be incorporated into both the natural areas of Longwood and the public-facing gardens. This will provide an opportunity to connect Longwood's visitors to local conservation efforts.

Recent expanded efforts to focus on a range of rare species in Pennsylvania already illustrate the contribution that horticulture can make in supporting plant conservation.

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**Fig. 7** Pennsylvania has numerous state and globally listed plant species. Species A to D all occur in the diverse habitats found in the local biodiversity hotspot of Bedford County and have been incorporated into Longwood's conservation horticulture programme. (A) *Arabis patens* (S2/G3); (B) *Paxistima canbyi* (S1/G2); (C) *Taenidia montana* (S1/G3); (D) *Trifolium virginicum* (S1/G3); (E) *Polemonium vanbruntiae* (S1/G3) has a disjunct distribution in Pennsylvania consisting of only seven small populations. It has become a flagship species for the programme. Photos: Peter J. Zale.

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The work with orchids is long-term due to their ecological complexities as well as extended generation and propagation times; all of this requires patience and forward planning. However, including other species of conservation concern generates early successes. This can be helpful for demonstrating impact to both internal and external institutional audiences. Examples like *Polemonium vanbruntiae* help balance between longer-term orchid initiatives with the immediate *in situ* and *ex situ* conservation needs of rare species. Having both short- and long-term conservation projects across different taxa can maximise skills and resources, create efficiencies, validate hypotheses, and anchor the scope and protocols across an impacted institution.

Finally, conservation activities such as outplanting, pollinating and seed collecting provide conservation horticulture experiences that offer novel ways of engaging, informing and training other employees and students from Longwood, which in turn helps elevate the conservation stories that are disseminated to audiences within and outside the gardens.

## Leveraging audiences

As the final step in the scientific process is to communicate results, any institution participating in conservation horticulture must find ways to disseminate conclusions and impact, extending beyond other practitioners and professionals. While most scientists communicate and publish their results, the results of these technical articles are rarely seen in a broader context, or in a way that is inclusive and tailored to audiences (Suleski & Ibaraki, 2010; Baker *et al*., 2012; DiCenzo *et al.*, 2021). The deficit model, or the idea that facts and figures alone can change perspectives, will not create the large-scale societal shift that is needed (NASEM, 2017). It is essential to emphasise the importance of conservation horticulture, as it can lead to mobilisation, magnification of the challenges and opportunities to other potential collaborators, increased awareness of plant diversity and the importance of plants, and even opportunities for financial support (either through donations or grants). Without engaging and providing clear directives tailored to specific audiences, any science-based conservation horticulture work may as well be conducted in a vacuum.

To leverage audiences, gardens must empower people with knowledge and provide clear directives of what to do with this knowledge. In doing so, gardens can utilise their vast network to generate global environmental change. Given that Longwood is located within America's north-east megalopolis (Lauriat, 2023), it is naturally positioned to have tremendous reach. Over 1.6 million people visit the gardens every year and over 83,000 households are members.

The science and the marketing and communication teams at Longwood generate many ways to connect the fruits of their conservation horticulture labours – occurring onsite and beyond – to engage internal audiences, as well as onsite guests and online visitors, with the beauty of these plants and how they need protection (Brumback, 1989). Beyond the display of rare plants in both the formal gardens and the natural areas, these activities include a monthly 'Science Series' programme that highlights research at the institution, a robust blog and social media presence, and various formal educational opportunities at the gardens and online. Further, dissemination occurs through docent-led interactions, guided tours with experts, lectures, podcast and media interviews, scientific and trade publications,

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and even displaying rare native orchids to over 150,000 attendees at the Chelsea Flower Show in England. The team has the end goal of moving people along a series of science communication goals (NASEM, 2017), which can function as a continuum – encouraging excitement, growing appreciation, increasing knowledge, ultimately inspiring passion for the natural world, and creating advocates for rare and threatened plants and their habitat so that the beauty of nature is accessible to all.

## Lessons confirmed

The science team at Longwood have identified important opportunities that can influence the success of a programme. These are (a) develop equal partnerships; (b) strategically expand conservation focus while avoiding mission creep; and (c) understand that conservation horticulture is a continuum, necessitating an incremental approach, while being flexible within a changing environment.

### *Develop equal partnerships*

Equal partnerships offer a more constructive and empowering approach: everyone needs to benefit and provide expertise. By focusing on the strengths, resources and positive attributes that each partner brings to the table, these partnerships foster a collaborative environment built on mutual respect, leveraging the unique skills and assets of each institution or expert to achieve common goals. This can promote a sense of ownership and pride among collaborators, which supports long-term impact and project sustainability. The collaborative work with experts in Tanzania is an example of how equal partnerships with shared goals foster conservation successes (Table 1). Through a unified understanding of the need to document *chikanda* orchids, learn how to grow them and implement conservation actions to protect them that match the needs of the stakeholders, each member of the team has brought specific expertise to the cause.

### *Strategically expand research priorities while avoiding mission creep*

Mission creep, or mission drift, refers to the gradual expansion or broadening of an organisation's or project's goals, objectives or scope beyond its original intended purpose. This phenomenon often occurs incrementally over time, with the organisation or project gradually taking on additional responsibilities or pursuing activities that were not initially part of its core mission (Gooding, 2012). This leads to a loss of focus and effectiveness, and a lack of clarity about the organisation's primary purpose and dilution of its impact.

Managing mission creep is crucial to maintaining organisational efficiency and ensuring that efforts align with institutional identity. This can be countered by developing, and following, a science strategy that is created in alignment with the institution's strategic plan. Taking initial steps in the beginning to identify institutional focus and strategic goals provides a framework that guides decision-making. This should not be a static document, however, and it should be re-evaluated in a cyclical time period. Longwood Gardens released a new strategic plan in 2023 to be used until 2030, at which time it will be updated and a new plan will be framed. A complement to achieving the organisational strategic goals related to science was the development of a science-specific strategy that will direct Longwood's efforts in conservation, growth, sustainability and inspiration. This plan will be released in 2025. It was the culmination

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**Table 1** An overview of key collaborative partners, Longwood's contributions, and their contributions.

| Scale | Partners | Description | Longwood's contribution | Partner contribution |
|---|---|---|---|---|
| Regional | Pennsylvania Department of Conservation and Natural Resources (DCNR) Bureau of Forestry[4] | The Bureau of Forestry is dedicated to safeguarding the long-term health, viability and productivity of the Commonwealth's forests while conserving native wild plants. It oversees and preserves Pennsylvania's diverse native plant communities on both public and private lands. With one of the largest land holdings in the eastern US, the Bureau manages many of Pennsylvania's rare species and serves as a key partner in accessing and protecting these rare plants. | *Ex situ* conservation research and propagation that results in plants for living restoration and collections development | Access to sites where rare plants are growing and permission to collect germplasm from them |
| | Pennsylvania Plant Conservation Alliance (PPCA)[5] | The Pennsylvania Plant Conservation Alliance (PPCA) Network is a programme that utilises statewide partnerships to coordinate stewardship efforts for native rare, threatened and endangered plants. Its mission is to protect these species through conservation practices. The Network is a leading supporter of *ex situ* conservation research and propagation initiatives, working to ensure the survival and recovery of these imperilled plants. | *Ex situ* conservation research and propagation that results in plants for living restoration and collections development | Access to sites where rare plants are growing and permission to collect germplasm from them |
| National | North American Orchid Conservation Center (NAOCC)[6] | The North American Orchid Conservation Center (NAOCC) is dedicated to the conservation of native orchids through initiatives centred on education, preservation and propagation. Its efforts include establishment of regional NAOCC groups focused on aspects of native orchid conservation through *in situ* and *ex situ* approaches. It has also established native orchid seed and fungal banks that are used to support research. Housed at the Smithsonian Environmental Research Center, it is also a world expert on the molecular ecology and identification of orchid fungi. | Orchid propagation information; seed and fungal samples; collaborative research and publication development | Orchid propagation information; seed and fungal samples; collaborative research and publication development |

[4] www.pa.gov/agencies/dcnr/programs-and-services/about/bureaus-and-offices/forestry.html
[5] www.dcnr.pa.gov/Conservation/WildPlants/PPCN/Pages/default.aspx
[6] https://northamericanorchidcenter.org

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| Scale | Partners | Description | Longwood's contribution | Partner contribution |
|---|---|---|---|---|
| | Native Orchid Propagation for Sustainability (NOPS) | This project includes a subset of NAOCC members that are focused on the role public gardens and research institutions can play in promoting and supporting the *ex situ* conservation of US native orchids. Outcomes of this collaboration include consolidation of propagation protocols, replicated propagation trials and the use of native orchids in supplementing native populations and in public garden living collections. | Orchid propagation information; seed and fungal samples; collaborative research and publication development | Orchid propagation information; seed and fungal samples; collaborative research and publication development |
| | Center for Plant Conservation (CPC)[7] | The Center for Plant Conservation (CPC) unites plant conservationists, creating collaborative partnerships between arboreta, botanical gardens and other plant-focused organisations. The CPC outlines best practice to support the conservation of plants (both *in situ* and *ex situ*) throughout their native range. | Collaboration and information sharing with conservation-oriented public gardens and NGOs | Collaboration and information sharing with conservation-oriented public gardens and NGOs |
| International | Tanzania Sansevieria Foundation | The Tanzania Sansevieria Foundation supports *in situ* and *ex situ* conservation primarily of the genus *Sansevieria*, of which Tanzania has the most species worldwide. Through these efforts it has become an expert in the logistics of expeditions and is our primary partner for planning and executing expeditions in the southern highlands of Tanzania. | Funding to support the discovery and *ex situ* conservation of *Sansevieria* | Logistical expertise in planning and implementing field work in remote regions of Tanzania |
| | Tanzania Plant Health and Pesticides Authority[8] | The Tanzania Plant Health and Pesticides authority is a federal government agency charged with numerous tasks, including conservation of plant diversity within Tanzania. It is the holder of the National Herbarium of Tanzania and the National Plant Genetic Resources Center of Tanzania, both of which have directives to document and preserve Tanzania native plants. It is instrumental in obtaining the necessary permissions required to implement work in Tanzania. | Expertise on the seed collection, identification and *ex situ* conservation of orchids; funding to support field work that results in collection herbarium specimens | Collaborate and facilitate access to permits to collect germplasm from National Parks and other government land holdings in Tanzania |

[7] https://saveplants.org/
[8] https://www.tphpa.go.tz/

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of feedback from internal and external stakeholders, and is aligned with the United Nations Sustainable Development Goals and the GSPC. The science team will be leading and driving the implementation. While these strategies are intended to serve as guideposts through 2030 and beyond, they will be revisited over time to ensure consistency with current events and institutional goals. Achieving ambitious goals of this nature may require an institution to acquire funding through grants, foundations or private donations. At Longwood, achieving the goals outlined in the Science Strategy will require a combination of these external funding sources. While this can be important for developing and implementing science-based conservation agendas, it is essential to ensure each grant is well aligned with the mission of the institution, and programme goals can make sure that the organisation is not extending its reach in a non-strategic direction.

### *Understand that conservation horticulture is a continuum*

The development of a conservation horticulture programme should evaluate the trajectory of deliverable results and the conservation impact across the species of focus annually. The programme at Longwood Gardens now includes herbaceous annual species, running alongside perennial, tree and shrub species. The inherent horticultural science principles and experimental treatments applied to both ends of this spectrum are the same, but with these evaluations running in parallel, Longwood strives to make a contribution to plant conservation every year – whether it is related to strides achieved with annual species or a culmination of evaluations for a species with a longer life span.

## Future initiatives

As part of a multi-pronged plan, Longwood scientists are expanding propagation, seed collection and seed storage work, all the while engaging audiences on the importance of conservation horticulture for both local and global terrestrial orchids and additional S1/S2 species from throughout Pennsylvania. Using Longwood's facilities building off these research projects and collaborating with partners, the team at Longwood will work with multiple institutions to align seed banking, native orchid propagation and replicated propagation trials.

Longwood has embraced its own evolution as an organisation to meet the conservation needs of the plant world. With alignment in current and future mission objectives, and a new Science Strategy, Longwood will continue to make strides regarding its conservation horticulture work. Conservation horticulture will be a key tool as Longwood scientists work to preserve the long-term biodiversity and health of Longwood's natural areas through restoration, stewardship and research; capture horticultural knowledge and expertise through digitisation, training and education; and contribute to the conservation of global plant diversity through plant exploration, research and knowledge sharing.

## Conclusion

Creating a science-based conservation horticulture programme requires forethought and planning. In gardens, as horticulturists evolve to conservation horticulturists and work to formalise efforts and initiatives, any developed programme will be most effective if it reflects the mission and legacy of the institution, aligns with local, national and global plant conservation initiatives,

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and engages with diverse stakeholders. When expertise is shared within the global garden network and translated for multiple audiences, it will strengthen the conservation of threatened plants globally. The authors developed this document to help address an identified need in the garden community, encouraging gardens and experts to merge horticulture and conservation, and to recognise the impact of horticulture on species preservation (Meyer *et al.*, 2024).

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