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Review

Reimagining Relationships with Resources as a Public Garden: Case Studies of Longwood Gardens' Sustainability and Stewardship Practices

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Abstract: Longwood Gardens (Kennett Square, PA, USA) is working toward a future where the beauty of nature can be enjoyed by all through its sustainability and stewardship efforts. Using case studies highlighting water quality and conservation, carbon footprint reduction, material circularity, and land stewardship, this paper examines the multifaceted approach that Longwood takes to address its environmental impact. First, a description of Longwood's innovative water quality and conservation strategies and their integration of green and gray infrastructure is described. Next, the paper explores the comprehensive measures adopted to curtail its carbon footprint, from energy-efficient infrastructure to renewable energy sources. Then, Longwood's commitment to material circularity is investigated, showcasing initiatives that reuse organic materials and create necessary products for the Gardens onsite. Finally, the Gardens' holistic land stewardship practices are detailed, including habitat preservation and biodiversity enhancement. The paper concludes with valuable findings learned from the organization's sustainability and stewardship journey, offering insights applicable to other gardens or campuses seeking to improve their ecological impact while maintaining a commitment to esthetic and horticultural excellence.

Keywords: public gardens; botanical gardens; arboreta; campus; green energy; sustainability; material circularity; water management; land management; science-informed stewardship; conservation of natural resources

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1. Introduction

1.1. Botanic Gardens, Sustainability and Stewardship

Botanical gardens and arboreta have been reimagined: their role in society has shifted from respites of the few to public gardens that are often conservation and scientific institutions. They serve as advocates for biodiversity and sustainability, and they are sources of education, beauty, and inspiration [1,2]. These institutions, hereafter referred to as gardens, are popular destinations, as 500 million people visit +3000 gardens around the globe each year [1]. While the planet is experiencing rapid biodiversity loss and climate change, gardens are in the unique position to leverage their resources, expertise, and audiences to protect biodiversity [1], especially through stewarding the land the gardens occupy, implementing green infrastructure, and modeling sustainable practices geared at the promotion of healthy ecosystems and biodiversity conservation [3–9].

As each garden is unique, efforts to address these overarching environmental goals must be aligned with place and institutional strengths. Glasshouses, plant collections, natural areas, horticultural displays, and local to international conservation projects give gardens the opportunity to be creative with how they link their mission to sustainability and stewardship. Leveraging nature-based solutions, infrastructure, and modernization can create a comprehensive approach to meeting sustainability goals [3,9,10]. Longwood

Gardens (Longwood), located in Kennett Square, Pennsylvania, USA, is implementing a multi-prong strategy that addresses water quality and conservation, carbon footprint reduction, material circularity, and land stewardship. To advance these goals while optimizing financial resources and demonstrating fiscal prudence to support its mission, Longwood is relying heavily on its own strengths: its large suburban campus and facilities; a skilled workforce with expertise in science, stewardship, and environmental engineering; and a collaborative culture.

1.2. Longwood Gardens—An Overview

Longwood Gardens is one of the world's premier gardens, known for its stunning horticultural displays that highlight plant diversity and advanced cultivation practices. Throughout the year, it hosts cultural performances and showcases picturesque fountains. Longwood Gardens welcomes over 1.6 million guests annually and enjoys the support of over 78,000 household memberships. The mission of Longwood Gardens is to uphold the living legacy of Pierre S. du Pont, by bringing joy and inspiration to all through the beauty of nature, conservation, and learning. Longwood strives to enrich society by offering educational programs, conducting research, stewarding the land, and engaging the community [11]. To achieve this, Longwood is dedicated to preserving biodiversity, inspiring its visitors, and promoting environmental responsibility through its efforts in conservation, sustainability, and stewardship.

Longwood's extensive, varied campus occupies 440 ha, which includes 140 ha of formal grounds and conservatories and 300 ha of forests, wetlands, meadows, crop fields, and supporting infrastructure. The site contains 200+ structures containing over 93,000 m^2 of floor space and includes just under 2 ha beneath glass, as well as dozens of water features [12,13] (Figure 1). The Garden employs more than 700 people full-time, part-time, and seasonal employees. Over 500 volunteers assist in supporting the mission and operations of the Garden. Forty buildings house resident students and employees.

Figure 1. Longwood's 140 ha of formal gardens and conservatories are surrounded by 300 ha of natural and agricultural areas, with over 225 distinct plant communities represented here by distinct colors and shapes. Sustainability infrastructure is embedded in this landscape, including a composting facility that processes spent soil and plant waste into useful products, a solar power production array, and an integrated wastewater treatment facility with an effluent spray field that results in no discharge of wastewater to streams.

Longwood's natural areas reflect the diversity of the Pennsylvania Piedmont ecoregion as it merges with the rich Atlantic Coastal Plain, encompassing over 225 distinct plant communities and providing regionally scarce habitats. Historically, the landscape has been cared for and managed by many people, from Lenni Lenape communities who stewarded the land for generations, to the Pierce family of Quakers who planted a 6 ha arboretum in 1798, to Pierre S. and Alice du Pont who conserved its forests and cultivated gardens, and to the many staff members and volunteers who work there today [13]. Longwood honors these legacies.

Since its establishment as a public institution, Longwood has expanded its sustainability and stewardship efforts. This includes adding 'conservation' to its mission, enhancing its focus on science initiatives, and thoughtfully developing integrated institution-wide environmental goals. Expansion and preservation projects being completed in 2024 add new conservatories, buildings, and gardens that open viewsheds to natural areas and to Longwood's sustainability in action. These efforts, collectively called Longwood Reimagined, create opportunities to strategically use green technology, apply nature-based solutions, prioritize efficiency, and implement new sustainability measures.

Building on ten years of activity, Longwood's Sustainability Committee expanded in 2023 to become a 'Sustainability & Stewardship Committee' to prioritize and connect institutional, facility-wide environmental sustainability and land stewardship efforts. This committee contributes to strategic goal setting and provides visionary direction and oversight for the implementation, measurement, and communication of progress on sustainability and stewardship initiatives. Longwood's approach is guided by the American Public Gardens Association (APGA) Sustainability Index. This index was developed at Longwood and then shared with and expanded by the APGA Peer Advisory Group.

As with many changes to large and historic institutions, sustainability and stewardship are evolving processes. There is always more work that can be carried out, but over the years, there have been many significant achievements in reducing Longwood's environmental footprint (Table 1). This paper will explore key areas of progress as case studies: (1) water quality and conservation; (2) carbon footprint; (3) material circularity; and (4) land stewardship.

Table 1. A timeline of institutional efforts across water quality and conservation, carbon footprint reduction, materials circularity, and land stewardship at Longwood Gardens.

Category	Year	Milestone
Water Quality and Conservation	1988	Wastewater treatment system upgraded to switch from stream discharge to land application.
	2003	Reuse of treated effluent in lawn irrigation
	2014	First streamside forest buffer plantings
	2019	First formal watershed plan established
	2023	Treatment system upgrade to achieve standards for reclaimed water allowing reuse to flush toilets
Carbon Footprint	2005	Transition of onsite vehicle fleet to electric Conservatory energy efficiency upgrades
	2011	4.45 ha solar array
	2012	Fuel-efficient fleet replacement plan
	2017	First geothermal heating/cooling system
	2023	Second geothermal heating/cooling system
Material Circularity	1956	First recorded formal composting
	1969	Established composting facility
	2007	State-approved composting of pre-consumer food waste and horse manure from nearby farms
	2023	Compost certified by US Compost Council and sold in The Garden Shop
Land Stewardship	1970	Wild bird monitoring and bluebird nest box programs
	1980	Prescribed fire introduced as a management method
	2014	Expanded an 18.6 ha native Meadow to a 34.8 ha native Meadow Garden
	2019	Science-led Land Stewardship and Ecology group established
	2021	Ecological Baseline Study begins

2. Case Studies

2.1. Water Quality and Conservation

Longwood uses a 'One Water' approach: a water management concept that emphasizes the perspective that all water has value and that, within the system, the benefit of every drop should be amplified. Longwood strives to use water efficiently and intelligently and, when possible, they reuse it.

2.1.1. Historical Efforts

Historically, Longwood used groundwater as its sole water source. Wastewater was treated by an onsite sewage treatment system and the treated effluent was discharged to a creek that transported the water out of the local watershed. Longwood upgraded its sewage treatment system in 1987 and created a 16 ha spray field where treated effluent is applied instead of being discharged to streams. In 2003, additional upgrades were completed to the wastewater treatment plant, including the installation of a piping system to distribute treated effluent as lawn irrigation. This piping system reduced the demand on groundwater by approximately 11 to 15 million liters annually and has saved an estimated 265 million liters since 2003.

2.1.2. Current Practices

Technology is also being used to minimize water use, especially regarding turfgrass care. Of 69 ha of turfgrass on the Longwood grounds, only 3.4 ha are irrigated. Longwood's grounds team monitors and measures soil moisture levels and salinity, reducing irrigation time and water consumption by up to 28%. This precision management saves thousands of liters of water a year, without a negative impact on the health of the plants or the esthetics of the landscape. Similarly, drip emitters are the primary form of plant irrigation used outdoors and in production greenhouses, ensuring that water supplied is taken up by plants with minimal runoff.

Longwood is on a ridgeline, with six small streams flowing from the property. To protect these streams, stormwater is directed into a variety of basins, swales, and constructed wetlands that prevent sediment and pollutant transport and high-velocity scouring flows. Longwood works to improve stream water quality by planting native trees and shrubs along streams and wetlands to widen cooling streamside forests, filter and slow storm runoff, and reduce erosion while providing essential habitat for native plants and wildlife.

Because water moves across property lines, water conservation efforts should encompass broad landscapes and involve local communities. Addressing regional threats to water quality, like elevated chloride levels from winter road salting, the transformation of natural areas to other land uses, pollution, and climate change, requires connecting and collaborating with other local nonprofits, institutions, homeowner associations, government agencies, and experts. For example, key stakeholders came together to help conserve the watershed of Bennett's Run, a stream with headwaters on the Longwood property and that is part of the Brandywine River watershed. Longwood contributed significant thought-leadership and financial support to help develop the *Bennett's Run Watershed Conservation Plan*, finalized in 2022. This document establishes a vision for the watershed, identifies key issues and management priorities, provides recommendations for implementation, and serves as a guide for action over the next 10 to 20 years [14].

2.1.3. Future Plans

In 2024, Longwood will complete a third wastewater treatment plant upgrade, further improving water quality and providing new opportunities for water reclamation. Longwood will use reclaimed water as flush water in about 60 bathrooms in new facilities opening in 2024. This use of reclaimed water is projected to reduce demand on groundwater by an additional 3.8 million liters annually. These upgrades will also use technologies that require fewer chemicals to reduce the accumulation of salinity that can impact plant propagation. Longwood will also begin stormwater harvesting from the rooftops of the

new buildings, filtering the water to remove dirt and debris, allowing the water to be used for water features and irrigation. Stormwater harvesting is expected to reduce demand on groundwater by an additional 3 million liters annually.

Going forward, Longwood intends to use reclaimed water wherever appropriate, while ensuring a positive guest experience and meeting regulatory requirements. Buildings and impervious surfaces are being evaluated for additional stormwater harvesting and opportunities to reduce water consumption through technology and operational best practices. Longwood's efforts to protect and enhance the quality of streams are being planned for the next 50 years as part of comprehensive land stewardship plans.

2.2. Carbon Footprint

Longwood Gardens is committed to reducing its carbon footprint through energy sustainability initiatives and investments in solar power, geothermal energy, and passive cooling technologies.

2.2.1. Historical Efforts

Longwood's energy sustainability initiatives began in 2005 with rebuilding a major conservatory with more energy-efficient building components, converting heating systems to natural gas, and shifting from vehicles with internal combustion engines to electric golf-carts for internal transportation across its large campus. Longwood has also been transitioning from gas powered to electric rechargeable equipment in other areas such as lawn care and powered tools. To support guests using electric vehicles, charging stations are available in the guest parking lots.

To move toward renewable energy, a 4.45 ha solar array was installed in 2011 in a former hayfield. This was accomplished in partnership with an electricity company and a 20-year power purchase agreement. The solar array produces over two million kilowatt hours per year and contributes energy equal to approximately 25% of the gardens' annual electric use. Solar panels were installed without altering the existing topography and the field was planted with native meadow species selected by research staff to support biodiversity.

2.2.2. Current Practices

The remaining 75% of Longwood's electricity needs are met by purchasing green energy (hydroelectric, solar, and wind) from the local power company. The switch to green electricity reduces the institution's annual carbon emissions by approximately 4600 short tons when compared to a natural-gas-fired power plant.

In southeast Pennsylvania, summers are hot and humid, but winters are cold. To address the challenge this presents for climate control in buildings, Longwood uses two ground-source ("geothermal") heat pump systems. Geothermal systems provide many environmental benefits, including a 30% to 40% reduction in energy consumption when compared to air source heat pumps.

2.2.3. Future Plans

Expanding on the success of geothermal systems in existing buildings, new buildings associated with Longwood Reimagined projects will be equipped with 96 m deep ground-source heat exchange wells. These 127 wells will be part of a geothermal system that will provide heating and cooling to the lower level of the new West Conservatory, Administration Building, and Lower Reception Suite. The new West Conservatory will also use ten 91 m long, 1 m diameter earth ducts to provide natural ventilation and maintain cooler temperatures in warmer months.

Longwood is investigating introducing sheep to the solar array to further reduce the carbon footprint of energy production. While continuing to provide pollinator habitat, grazing will replace the use of internal-combustion mowers.

2.3. Material Circularity

The circular economy is a theoretical system adopted by the European Union that emphasizes sustainability by reducing environmental impact and fostering efficient resource utilization [15]. To enhance the circularity of these material systems, Longwood works to find ways to recycle, reduce resource consumption, and recapture 'waste' whenever possible. At Longwood, this process is referred to as material circularity.

2.3.1. Historical Efforts

The beauty that Longwood visitors enjoy is supported by the beauty of previous displays. Since 1956, Longwood has collected spent plant material throughout the gardens and composted it. This practice has expanded as the facilities, teams, and processes have grown. In 2007, the Pennsylvania Department of Environmental Protection (PADEP) approved a plan to add pre-consumer food waste from the onsite dining facilities into the compost. As an institution, Longwood has prioritized material circularity of this nature for decades.

2.3.2. Current Practices

In 2022, almost 86.7 tons of single-stream recyclables, 35.5 tons of source-separated recyclables (i.e., cardboard and paper), 69 tons of food waste, and approximately 7646 m^3 of garden waste were collected. The garden waste (i.e., woody and herbaceous plant waste, spent soil, etc.) is used to generate products necessary for garden operations: finished mulch, wood chips, compost, acidic compost, and leaf mulch. To create compost, food waste and garden waste are mixed with horse manure from the local community, and transformed over months into blends for a variety of uses throughout the gardens. This process includes frequent temperature readings, regular turnings, and a final evaluation to understand each batch's nutrient analysis and to ensure correct chemical composition prior to distribution. The end compost product has a Seal of Testing Assurance certification through the US Compost Council and is even available for guests to purchase at The Garden Shop [16].

When surplus arises, flexibility and creativity are required—such as working with partners who can repurpose materials or by innovating new uses. For example, when the impact of Emerald Ash borer created an influx of woody material in 2022, the Land Stewardship and Ecology team incorporated wood chips in an experimental study, testing the efficacy of deep mulching as an approach to invasive species management that can help to build forest soils in reforestation areas. This experiment is part of an evaluation of stewardship techniques using strategies that could easily be implemented by practitioners with different available resources. For example, land managers working where herbicides are not used need information about the effectiveness, costs, and benefits of non-chemical approaches to managing invasive plants—such as using wood chips. The results of these studies will be distributed to practitioners and scientific professionals alike.

2.3.3. Future Plans

In 2024, there will be increased efforts to compost food waste, with new equipment and facilities being constructed to facilitate the process. Longwood also protects and promotes healthy soil, an often-overlooked aspect of sustainability [17]. The Longwood Reimagined project provided around 6880 m^3 of soil through excavation during recent construction. Most of this excavated soil is being mixed with components such as compost made from a local mushroom producer (as it exceeded Longwood's compost production volumes) and will be reintegrated into new outdoor garden spaces. The surplus topsoil from the project will remain on site and will be used in numerous ways, such as enriching the organic matter content in some of Longwood's agricultural fields. Additional uses include being used to backfill holes when transplanting woody plants from the nursery, support for sod installations, and contributions to sterilized potting mixes in the greenhouses, amongst others. The soil conservation program will continue to grow, especially through advancing in-house soil testing and increasing technical support for teams throughout the institution.

2.4. Land Stewardship

Land stewardship is crucial for sustainability because it involves responsible and ethical management of land to ensure long-term health and productivity. Stewardship of the natural areas surrounding Longwood's formal gardens has moved steadily in the direction of increasing biodiversity and ecosystem health over time.

2.4.1. Historical Efforts

Acquisition of neighboring farms in the early 1900s conserved mature forests, streams, and meadows that buffer the gardens from surrounding development. Crop and pasture lands were used for agricultural production into the 1950s, when cow and sheep pastures were converted to hay meadows. In 1969, conservation-focused staff began planting native meadow plants in former pastures, and in the 1970s volunteer programs supporting bluebird nest boxes and monitoring bird diversity began. In the 1980s, prescribed fire was introduced as part of meadow management. Stewardship of the "perimeter" lands gradually refocused, and the land surrounding the formal gardens came to be called the "natural lands"—an important change reflecting updated management practices accompanied by recruitment of personnel with expertise in ecological systems. The expansion of the Meadow Garden in 2014 doubled the area of native meadow open to the public, providing inspiration for supporting biodiversity at home.

2.4.2. Current Practices

In 2019, Longwood formally established the Land Stewardship and Ecology program. This multidisciplinary group within the Science Division uses the tools of ecological science to test innovative stewardship practices, collaborates to support regional and global biodiversity, and studies long-term environmental change [18]. Initiatives of this group include the systematic reforestation of stream corridors in former fields for water quality and habitat; testing and comparison of techniques for invasive species management, reforestation, and plant protection; and a GIS-based land management tracking system to enable the analysis of the impact of different approaches to common management challenges. This team launched Long-Term Ecological Research at Longwood with the Ecological Baseline Study of Plant Communities in 2021, followed by baseline measures of stream health. This research has identified more than 225 distinct plant communities across the property.

In addition to monitoring ecosystems and stewarding communities, Longwood Gardens leverages its expertise in horticulture to grow, cultivate, and display native plants of conservation value. For example, staff have perfected techniques to grow one of the rarest native orchids in the United States, the Southern Lady Slipper Orchid (*Cypripedium kentuckiense* C.F. Reed). Through these efforts, the organization has been able to successfully propagate, grow, and plant this rare species onsite for guests to enjoy as well as to provide plants for the expansion of this species in the wild. Longwood will continue to prioritize species of conservation concern, emphasizing native orchids and rare or endangered Pennsylvanian plants, with the goal of reintroducing them to both their natural areas and the wild.

2.4.3. Future Plans

Long-term research will provide insight into the effects of both management techniques and broader environmental change on plants and ecosystems. The results of this long-term research include detailed vegetation maps that serve as a foundation for adaptive management and long-range stewardship planning, the prioritization of reforestation areas for ecological connectivity and water quality, and the development of stewardship plans for species and communities of conservation value. This careful, systematic inventory and monitoring of biodiversity and ecosystem health will expand from plants and streams to include animals and insects over time. Taking each ecological challenge and need for management as an opportunity to learn and test comparing techniques will contribute to both the health of Longwood's natural areas and broader knowledge that supports the efforts of others, locally and globally [19].

3. Findings

Over time, Longwood Gardens has demonstrated and grown its commitment to conserving water, reducing its carbon footprint, leading material circularity initiatives, and stewarding the natural landscape. This transformation has provided numerous opportunities for growth and leadership, and it has yielded insight into factors important to moving sustainability and stewardship initiatives forward at an institution. These lessons include (1) setting goals and capturing baseline metrics; (2) measuring impacts; (3) creating meaningful partnerships; and (4) generating institutional buy-in to maximize success.

3.1. Setting Goals and Capturing Baseline Metrics

To assess progress over time, it is essential to understand what success looks like as an institution and work backwards to develop meaningful goals. Identifying baseline metrics can help create and foster a cohesive vision. They can illustrate impact, inform reporting, and support adaptive management strategies as challenges arise. While some metrics can be easier to measure and track over time, it is important to consider whether numbers describe the entire picture in complex systems. For example, some measures may fluctuate due to external factors or natural variation. Additionally, Longwood found that when evaluating impact, it is also important to see the value of qualitative measures. As a data-driven institution, this may feel uncomfortable, but it will help assess holistic success.

3.2. Measuring Impacts

New initiatives are growth and learning opportunities. By identifying indicators of performance early in the process and developing measures to understand change over time, the effects of sustainability and stewardship efforts can be understood and practices can be adapted to optimize outcomes. One example of this is Longwood's Ecological Baseline Study of natural area plant communities. Evaluating changes to these plant communities will inform long-range planning and decision-making with data that shows how ecosystems are responding both to the direct impact of land management practices and to broader-scale environmental changes like warmer temperatures and the increased frequency of extreme weather. Efforts like this are occurring throughout the institution to support environmental action. Through constant evaluation, Longwood has established a culture of accountability, transparency, and continuous improvement in sustainability and stewardship.

3.3. Creating Meaningful Partnerships

Creating meaningful partnerships should be considered a strategic imperative for all organizations engaged in sustainability and stewardship. Partnerships amplify the impact of initiatives and yield more comprehensive approaches to addressing complex challenges. Collaborating with outside institutions and communities expands reach and influence and leverages resources and expertise in a more effective way.

The staff understand that Longwood's influence extends beyond the garden gates and is integrated into the community. Having this mindset can support partnership development and create innovative solutions. A meaningful partnership is one where all groups are committed and are contributing their expertise to achieve a common objective. The *Bennett's Run Watershed Conservation Plan* is a strong example of how collaborating with local groups, providing expertise, and valuing the assets of others can amplify impact [14].

Another example of how partnerships can meet sustainability goals is Longwood's 2.4 ha 'Idea' Garden. This garden serves as a source of inspiration for visitors and helps them envision how to create a garden of their own. To complement the interests of a community with a significant Hispanic and Latinx population, culturally relevant crops, such as tomatillos and papalo, are planted. The produce this garden generates is both served in an onsite restaurant and donated to a local community service organization. This garden supports the local community, contributes to sustainability goals, and helps reach new audiences. Since 2020, Longwood has donated over 5400 kg of fresh produce to those who need it the most.

The solar field is another example of how a meaningful partnership can create a mutually beneficial situation that furthers sustainability initiatives. The solar electricity company provides solar panel infrastructure, equipment, management, and technical expertise, while Longwood provides the acreage required for a solar array and leverages its stewardship expertise to create a sustainable landscape. This partnership highlights the importance of community engagement and building connections with industry partners. The result of collaboration is more efficient, effective, and impactful than if each group acted alone.

3.4. Generating Institutional Buy-in to Maximize Success

Generating institutional buy-in is a form of collaboration that is crucial for the success of sustainability and stewardship initiatives. When making decisions to support sustainability and stewardship projects, costs, capacity, and desired impact must be weighted similarly. Work of this nature requires teams across the institution to contribute, so that everyone is more committed to supporting change. This ensures the alignment of goals, facilitates strategic resource allocation, and enhances the decision-making processes of the team. Furthermore, it creates a shared sense of responsibility, promotes engagement, and fosters a culture of innovation.

At Longwood Gardens, the importance of institutional buy-in is evident with material circularity. Teams across Longwood support these efforts, and their input is important to decision-making processes. Systems and processes have been developed and adapted to reduce, reuse, receive, process, and reintegrate materials. For example, the production team grows plants in fiber pots that become part of aged mulch. The turf management team spreads compost in early spring to aid in moisture retention and support soil health. The outdoor landscapes team amends the garden bed soils with compost and mulch annually to enrich the soil with organic matter.

The need for staff support for these processes was made clear when there were changes in the staff utilization of compost. One primary outlet of compost utilization was redirected, and an alternative outlet was not identified. For a season, the team was generating surplus compost that was not being fully integrated into the gardens and displays. After connecting with the horticulture team, educating staff about this available resource, and finding ways to tailor the product and improve accessibility, internal use of Longwood-produced compost increased again. This led to many benefits, including a reduction in the volume of synthetic fertilizers used. Encouraging people to contribute their voice and provide feedback on systems and processes ultimately ensures action and furthers institutional impact.

4. Conclusions

Longwood has reimagined how water, energy, and material resources are used onsite and what role it has as a garden to promote sustainability and stewardship. To do this, Longwood leverages its large campus, facilities, expertise, and collaborative culture to meet sustainability goals, alongside conserving and restoring local ecosystems. Looking to the future, Longwood will continue to demonstrate leadership in sustainable production practices, the cultivation of biodiversity, and stewardship of both materials and natural resources. Longwood has both an opportunity and responsibility to lead in best practices and to use metrics to understand and communicate important benchmarks.

Gardens often have missions that prioritize horticulture, research, education, and conservation. As popular destinations, they are ideal candidates to model sustainability and stewardship practices with audiences who already have affinities for nature and the environment. Not every garden has the same opportunities, capacity, or mission. Aligning efforts with institutional strengths is an important first step. Sustainability and stewardship goals can be met creatively, from how landscapes are managed, to how facilities are created or retrofitted, and to how resources are used. Gardens can serve as a source of inspiration to individuals and to other public institutions, as they pave the way—metaphorically—with a green, regenerative, future-focused mindset.

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References

1. Westwood, M.; Cavender, N.; Meyer, A.; Smith, P. Botanic gardens are a solution to the plant extinction crisis. *Plants People Planet* **2020**, *3*, 22–32. [CrossRef]
2. Turner-Skoff, J.; Paist, S.; Byrne, A.; Westwood, M. ArbNet: 10 years of fostering collaborations, furthering professionalism, and advancing the planting and conservation of trees through the global network of arboreta. *Plants People Planet* **2021**, *4*, 128–135. [CrossRef]
3. Miller, H.; Bailey, C.; Smith, P. *BGCI Technical Review: The Role of Botanic Gardens in Practicing and Promoting Environmental Sustainability*; Botanic Gardens Conservation International: Richmond, UK, 2020.
4. Hardwick, K.A.; Foedler, P.; Lee, L.C.; Pavlik, B.; Hobbs, R.J.; Aronson, J.; Bidartondo, M.; Black, E.; Coates, D.; Daws, M.I.; et al. The role of botanic gardens in the science and practice of ecological restoration. *Conserv. Biol.* **2011**, *25*, 265–275. [CrossRef] [PubMed]
5. Miller, J.S.; Ii, P.P.L.; Aronson, J.; Blackmore, S.; Havens, K. Conserving biodiversity through ecological restoration: The potential contributions of botanical gardens and arboreta. *Candollea* **2016**, *71*, 91–98. [CrossRef]
6. Shaw, K. Encouraging and enabling a science-based approach to ecological restoration: An Introduction to the work of the Ecological Restoration Alliance of botanic gardens (ERA). *Sibbaldia Int. J. Bot. Gard. Hortic.* **2015**, *13*, 145–152. [CrossRef]
7. Dodd, J.; Jones, C. *Redefining the Role of Botanic Gardens: Towards a New Social Purpose*; Research Centre for Museums and Galleries (RCMG): Leicester, UK, 2010.
8. Cowell, C.; Bullough, L.-A.; Dhanda, S.; Neves, V.H.; Ikin, E.; Moore, J.; Purdon, R.; Williams, C.; Willison, J.; Willoughby, S. Fortuitous Alignment: The Royal Botanic Gardens, Kew and the Sustainable Development Goals. *Sustainability* **2022**, *14*, 2366. [CrossRef]
9. Piacentini, R.V. Sustainable Energy Use in Buildings: A Leadership Opportunity for Gardens and Zoos. *J. Zool. Bot. Gard.* **2024**, *5*, 179–186. [CrossRef]
10. Turner-Skoff, J.; Cavender, N. The benefits of trees for livable and sustainable communities. *Plants People Planet* **2019**, *1*, 323–335. [CrossRef]
11. Longwood Gardens. About. Available online: https://longwoodgardens.org/about (accessed on 19 February 2024).
12. Randall, C.; Mobley, K.; Schuessler, L. *A Splash of Brilliance: The Fountains of Longwood Gardens*; Longwood Gardens, Inc.: Kennett Square, PA, USA, 2018.
13. Randall, C. *Longwood Gardens: 100+ Years of Garden Splendor*; Longwood Gardens, Inc.: Kennett Square, PA, USA, 2018.
14. Brandywine Conservancy; Stroud Water Research Center, Brandywine Red Clay Alliance. *Bennett's Run Watershed Conservation Plan*; Brandywine Conservancy: Chadds Ford, PA, USA, 2022.
15. European Parliament. Circular Economy: Definitions, Importance and Benefits. Available online: https://www.europarl.europa.eu/topics/en/article/20151201STO05603/circular-economy-definition-importance-and-benefits (accessed on 12 February 2024).
16. Longwood Gardens. Longwood Compost Blend. Available online: https://shop.longwoodgardens.org/product/longwood-compost-blend/ (accessed on 8 February 2024).
17. da Gama, J.T. The role of soils in sustainability, climate change, and ecosystem services: Challenges and opportunities. *Ecologies* **2023**, *4*, 552–567. [CrossRef]

18. Johnson, L.; Anderson, K. Stewardship Science Testing Techniques that Benefit Biodiversity. Longwood Gardens. 26 April. 2023. Available online: https://longwoodgardens.org/blog/2023-04-26/stewardship-science-testing-techniques-benefit-biodiversity (accessed on 31 January 2024).
19. Johnson, L.R. Global biodiversity requires integrating social and ecological goals for urban biodiversity: Insights from ecological restoration. In *Routledge Handbook of Urban Biodiversity*, 1st ed.; Routledge: New York, NY, USA, 2023; pp. 346–360.