GROWERTALKS

Cover Story

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Living Art

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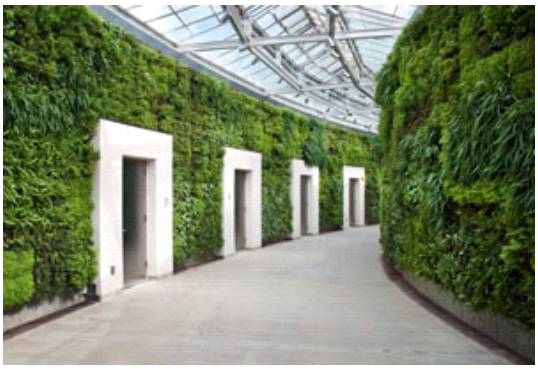

Longwood Gardens' living wall was designed to envelop visitors with a hallway of foliage. Photo courtesy of Larry Albee

Longwood Gardens is one of the great gardens of the world. Nestled within the Brandywine Valley, the Gardens stretch over 1,000 acres and provide guests with a unique opportunity to appreciate the beauty of nature through creative seasonal displays, native woodlands, a world-renowned conservatory, plus year-round performances and educational opportunities. The gardens were founded in 1906 by Pierre S. du Pont, whose legacy lives on today through Longwood's excellence in garden design, horticulture, education and the arts.

Upon visiting Longwood Gardens, the conservatory is always a highlight no matter what time of year. Under glass, there are 4.5 acres of paradise for a plant enthusiast. Over five years ago, the east wing of Longwood's conservatory underwent a complete renovation. Included in this transformation was a re-designed East Conservatory and the new Indoor Children's Garden. In 2010, the renovation was completed with the addition of a grand new entrance to welcome guests into the conservatory and new restroom facilities. This new wing includes 17 individual comfort stations, with the entrances to each encased by an amazing horticultural creation—a green wall covering more than 4,000 sq. ft. This living wall exemplifies one of the newest trends in vertical horticulture and provides the beauty and inspiration that Longwood is known for.

The green wall's design was created by Kim Wilkie Associates, a landscape firm based in the United Kingdom. Wilkie's vision was to envelop guests in a hallway of lush foliage (pictured). He accomplished this by creating a simple design with natural patterns replicating what one might see in native woodlands. Wilkie's team collaborated with Wels Appel, a Philadelphia-based landscape architecture firm, to develop the innovative and cutting-edge design.

Construction of the entire facility took 13 months and was completed in October 2010. The 14-ft.- high living wall follows a curving corridor and covers more than 4,000 sq. ft. The wall showcases 25 different species of plants with different textures and growth habits.

Planning and implementation

One of the first steps in the planning process was to select a vertical growing system. Longwood Gardens and a team of landscape architects researched many different systems and determined the best fit was a product designed by GSky, a green wall and green roof company based in Vancouver, British Columbia. The basics of GSky's product are a 1 ft. × 1 ft. × 3 in. stainless steel frame that contains a block of fibrous coconut coir growing media. Holes are pre-cut into the media to allow for easy planting of liner-sized plugs. A lightweight fabric covers the coir and two metal brackets hook onto the frame, keeping everything contained within the panel.

Metal support frame for the panels and an irrigation line being installed on top of a row of panels. Photo courtesy of Matt Taylor

The next step in the green wall planning process was to conduct a light study to determine the palette of plants best suited for the green wall. The corridor has a glass roof and is situated on an east/west axis. The north wall gets moderate light throughout the year, while the south wall is under very low light conditions, especially in the winter. Once the light study was completed, a team of plant experts gathered to create a list of possible plants that would grow successfully under these conditions. Not only would the selected plants have to grow under a range of temperatures and light levels, but they would also have to be readily available from commercial growers since very large quantities were needed to accommodate the sheer size of the wall.

Longwood Gardens wanted a full and lush green wall on the opening day of the project, so it was decided that the green wall panels would be planted and placed horizontally on greenhouse benches to allow time for the plants to reach the desired size. Michael's Nursery in Boynton Beach, Florida, was selected to plant and grow all of the panels for Longwood's green wall until installation in September 2010. Beginning in January 2010, more than 47,000 2-in. plugs grown in a peat-based media were received from various suppliers around the country. The plugs were planted into the panels according to the design provided by the landscape architects. Each planted panel was labeled according to its position on the wall. At the end of August, the panels were placed in individual boxes, labeled with their intended location on the wall, and then shipped to Longwood Gardens.

Over a 10-day period, panels were unpacked and directly hung onto a stainless steel framework mounted onto the concrete wall behind it. Each panel has brackets welded to the back, which simply hook onto the framework. As the panels were hung, an irrigation line with five emitters per panel was installed on top of each row of panels (pictured). Irrigation lines were tested during installation to ensure water was being

adequately distributed to the roots of the plants. The irrigation system itself is divided into 24 different zones to handle the challenging task of maintaining optimal root zone moisture throughout a wide range of environmental conditions. Irrigation zones were determined based on height of the panels, as well as the amount of light received.

After installation, the plants began to acclimate to their new locations on the wall. Originally grown in a greenhouse, the green wall plants were now forced into a wide range of growing conditions within this new facility. During the first winter, temperatures in the green wall corridor dropped into the mid-40sF, which was coupled with dry air from the radiant floor heating. The following summer, temperatures climbed above 90F (32C) with high humidity. Light intensity during the summer months was too great and plants were shaded by coating the glass roof with a spray-on white wash. A light coat was applied in April, and then a second heavier coat was applied for the mid-summer months. Shading was removed in October to restore maximum light transmission during the lower light months of the year. Even though light levels drop dramatically during the winter months, no artificial lighting is used.

Table 1.
All species and their overall performance in Longwood Gardens' green wall.

- Venus' Hair Fern *Adiantum capillus-veneris* Low Performance
- Lipstick-plant *Aeschynanthus radicans* Medium Performance
- Variegated Holly Fern *Arachniodes simplicior* Variegata Low Performance
- Asparagus-fern *Asparagus densiflorus Sprengeri* Medium Performance
- Spleenwort Victoria High Performance
- Hybrid Spleenwort *Asplenium dimorphum* × *difforme* Austral Gem High Performance
- Hart's-tongue Fern *Asplenium scolopendrium* Medium Performance
- Lady Fern *Athyrium filix-femina Frizelliae* Medium Performance
- Spider-plant solid green form High Performance
- Grape-ivy *Cissus alata* Low Performance
- Japanese Holly Fern *Cyrtomium falcatum* Low Performance
- Rabbit's-foot Fern *Davallia fejeensis* Low Performance
- Microsorum *Microsorum scolopendria* Medium Performance
- Lemon Button Fern *Nephrolepis cordifolia* Duffii Low Performance
- Boston Fern *Nephrolepis exaltata* Compacta Medium Performance
- Boston Fern Dallas Jewel High Performance
- Boston Fern *Nephrolepis exaltata* Fluffy Ruffles Medium Performance
- Button Fern *Pellaea rotundifolia* Medium Performance
- Oval-leaf Peperomia *Peperomia obtusifolia* Low Performance
- Heart-leaf Philodendron High Performance
- Hare's-foot Fern Blue Star High Performance
- Hare's-foot Fern *Phlebodium aureum* Green Wave Medium Performance
- Artillery-plant *Pilea microphylla* Low Performance
- Shield Fern *Polystichum polyblepharum* Low Performance

- White-lined Cretan-brake *Pteris cretica var. albolineata* Medium Performance
- Leatherleaf Fern *Rumohra adiantiformis* Iberia Medium Performance
- Trailing Spike-moss *Selaginella kraussiana* Gold Tips Low Performance
- Piggyback-plant *Tolmiea menziesii* Low Performance

Growing On

Since Longwood's facility imposed a wide range of environments for the plants to grow, plant performance varied across the selected species (Table 1). Plants such as the artillery plant and oval-leaf peperomia could not tolerate the constantly moist media and the spike-moss did not enjoy the high humidity of the summer months. These were eventually replaced with more suitable selections, such as Japanese holly fern and Dallas fern. Replacing plants is a very simple process and involves pulling the failing plant from the panel and inserting the new plugs into the previously pre-cut holes. The coconut coir media that makes up the panel inserts is fairly unprocessed and very recalcitrant. This helps the coir maintain its square form, as well as the form of the pre-cut plugholes.

Pruning and cleaning the green wall plants typically takes 16 man hours per week, but can sometimes take up to 24 hours during heavy growing periods. This averages to about 25 minutes of maintenance work per week for every 100 sq. ft. of green wall. The maintenance is shared among gardeners and volunteers. The vigorous growers—such as the spider plant, heart leaf philodendron and asparagus fern—are kept contained by heavier pruning and thinning to allow the less-aggressive growers, such as the button fern and hare's foot fern, adequate light and space. The compact Boston fern requires constant cleaning to remove the older, yellowing fronds. And grape ivy needs trimming to keep it contained in its panel. The peak season for all species is late spring, when the plants have developed new growth and have not yet had to cope with the summer temperatures.

Irrigation scheduling has been one of the largest challenges to overcome. The top panels of the green wall dry out very quickly because they receive the most sunlight. However, as the top panels get watered, the excess water drains through to the panels below and the lower panels stay constantly moist. To alleviate this situation, a pulse irrigation program is used to water the top-most panels for only one minute four times a day throughout the summer months. Pulse irrigation has helped reduce leaching from the panels and also provides the plants with the optimum root environment. All excess water that drains through the wall and out of the bottom panels is captured into a floor drain, where it's collected and reused to irrigate the outdoor gardens.

Along with irrigation, the fertility has also required a learning curve. Plants receive 15-5-15 CalMag fertilizer at a rate of 200 ppm N through the drip system. In the winter months, the wall is fertilized once a week since plant growth is minimal. When summer approaches, the frequency is increased to three times per week to assure the plants receive sufficient feed to produce new and healthy growth. As the plants age and their roots require more water and fertilizer, the rates will be adjusted accordingly. The pH and EC of the growing media is monitored with direct-stick probes since traditional pH and EC measurement techniques are difficult with the green wall. Irrigation water for the wall has very low alkalinity and, although a basic fertilizer is used, the pH sometimes gets too low. This situation is remediated by applying potassium bicarbonate through the drip to return the pH to an acceptable level.

An experiment was conducted to measure the correlation between the location of the plants on the wall and nutrient availability. It was discovered that following fertilization, the electrical conductivity (EC) of the growing media decreased faster at the top of the wall compared to the media at the bottom of the wall. These results were expected and indicate that the top-most plants are using higher amounts of fertilizer due to higher light conditions. This is also apparent since the higher plants grow more aggressively and require more maintenance. The opposite is true for plants on the bottom of the wall. Although, accumulation of the excess fertilizer salts in the lower panels has not been an issue due to the low cation exchange capacity of the highly porous coconut coir media and the amount of leaching that occurs in lower panels. With this information, we have been able to adjust the fertilization program to assure that higher amounts of fertilizer are being supplied to the upper plants. This was easily accomplished since the upper plants require more frequent irrigation.

Table 2.
List of beneficial insects, target insects and the average cost per week.

Beneficial insect	Target insect	Average cost per week
Orius	Thrips	$140
Encarsia	Whiteflies	$7
Aphidius	Aphids	$3
Cryptolaemus	Mealybugs	$61
Swirskii	Whitefly and Thrips	$23
Californicus	Spidermite	$80
	*Total =	$314

*Estimated cost per 100 sq. ft. of green wall is $7.85 a week or about $400 a year.

Another maintenance concern for the green wall is pest management. Longwoods' pest management plan relies solely on cultural and biocontrol methods, eliminating the use of chemical pesticides. Twice per month, the Integrated Pest Management team at Longwood releases thousands of beneficial insects into the corridor, including Swirskii mites, parasitic wasps, predatory mites and minute pirate bugs (Photo b). Careful scouting is done weekly to detect any pest outbreaks. If any are found, the release of beneficials is concentrated in the target area. The beneficials used are shown in Table 2.

Beyond the enjoyment of beauty, there are other great benefits of the green wall. It's estimated that the plants clean more than 15,000 lbs. of dust and toxins from the air per year. Longwood Gardens is collaborating with Drexel University to research and learn what compounds are removed from the atmosphere by the plants and associated microbes. So not only is the green wall a horticultural marvel, it's also a step forward to improving our environment.

Since green walls are one of the newest trends in horticulture, Longwood Gardens is honored to have such a beautiful and sizable example for guests, landscape architects and fellow horticulturists to enjoy. Even though the scale of Longwood's green wall is grand, a lot of interest has been stirred in our guests. They go home with ideas about how they could install and enjoy a smaller scale wall in their home or office building. Vertical gardening is surely a marketing opportunity, especially for individuals with limited indoor or outdoor space.

Longwood Gardens is open 365 days a year. Please come visit and enjoy our green wall, along with the world-renowned conservatory and outdoor gardens. **GT**

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