LANDSCAPE PERFORMANCE SERIES presented by the Landscape Architecture Foundation

Phipps Conservatory Center for Sustainable Landscapes

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Overview of CSI: This investigation was conducted as part of the Landscape Architecture Foundation's 2016 *Case Study Investigation* (CSI) program. CSI matches faculty-student research teams with design practitioners to document the benefits of exemplary high-performing landscape projects. Teams develop methods to quantify environmental, economic and social benefits and produce Case Study Briefs for LAF's *Landscape Performance Series*.

The full case study can be found at: https://landscapeperformance.org/case-study-briefs/phipps-conservatory

Overview of Research Team Strategy

The Phipps Conservatory's Center for Sustainable Landscapes (CSL) is a new facility housing sustainability research, science education programs, and an extension of the public gardens at Phipps Conservatory. Built on a former City of Pittsburgh maintenance yard, a documented brownfield site, it is designed to be a net-zero energy and net-zero water facility. The landscape portions of the project (the CSL grounds) contribute to this through the implementation of an extensive water management system that addresses both stormwater and wastewater. The garden spaces incorporate native plant communities based on local reference sites while navigating significant changes of grade and steep existing slope conditions to connect the new permeable asphalt parking lot to the building entry and larger Conservatory campus.

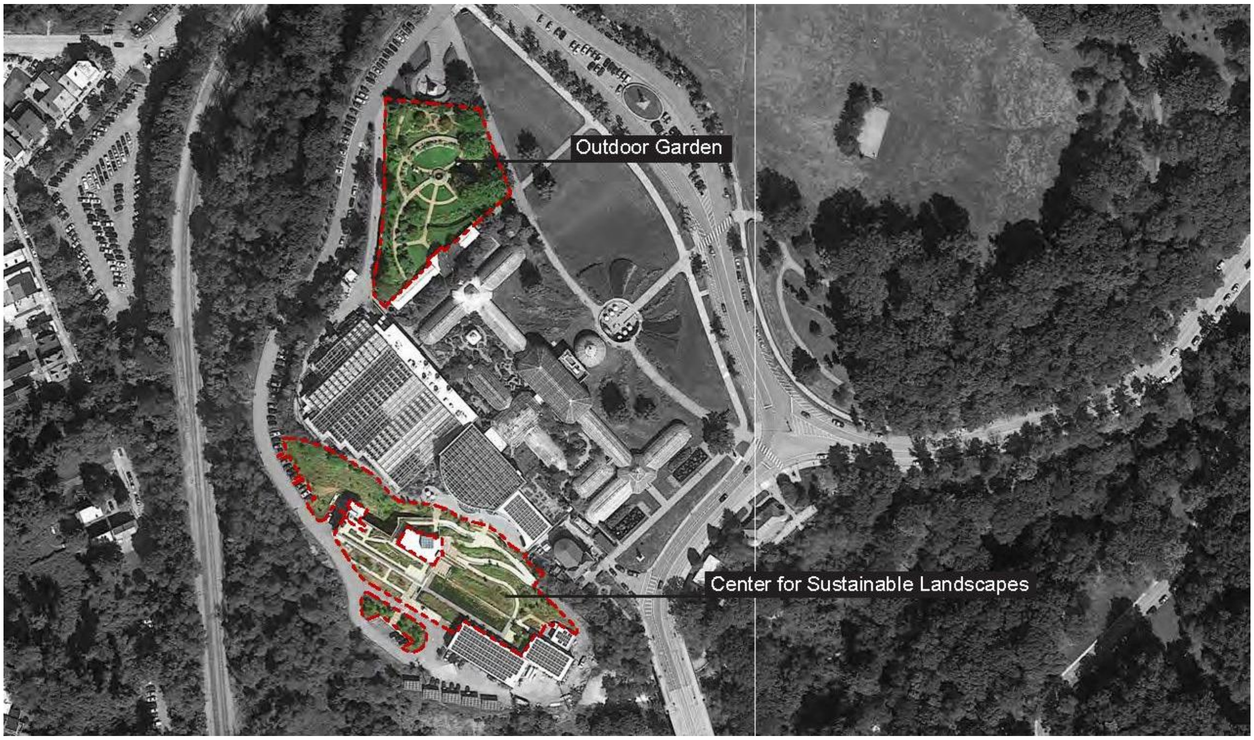
Reference/Comparison Landscapes

In order to assess the performance of a landscape, it needs to be evaluated against some kind of benchmark. In approaching an assessment of landscape performance at Phipps' CSL, the research team took a comparative approach, with some analyses including a comparison with a "traditional" conservatory landscape of similar size and in the same region, and other analyses including a comparison with the pre-existing condition of the CSL study site prior to the design's construction.

For the nearby "traditional" reference landscape, we identified the Outdoor Garden of Phipps Conservatory as an appropriate comparison site, because of its rough equivalency in terms of:

- size (1.04 acres for the Outdoor Garden vs. 1.48 acres for the CSL Landscape),
- management and ownership structure (both owned and managed by Phipps Conservatory),
- proximity

Primarily composed of manicured planting beds with perennial planting and trees, periodic additions of annuals and tropical plants, mowed lawn areas, and pathways, the Outdoor Garden is a good example of a typical "traditional" conservatory outdoor landscape.



Landscape Performance Benefits

ENVIRONMENTAL BENEFITS

Environmental Benefit 1

Manages all stormwater on-site for up to a 5-year, 24-hour storm event. Based on historic rainfall, the site will manage 99.7% of rainfall events, with no stormwater releases to the municipal sewer observed to date.

Methodology:

Any stormwater runoff from the Center for Sustainable Landscapes building as well as roof runoff from the adjacent Tropical Greenhouse (11,880 sq. ft.) are captured and stored in a 1,700 gallon below-grade cistern for make-up water for the water reuse system within the building. Any water overflow from the cisterns, as well as any runoff from the Center for Sustainable Landscapes garden, are captured in the following BMPs: a 4,000sf lagoon; 3 additional rain gardens that capture water from the site parking lot , the service drive and the steep slope landscape on the west side of the Center for Sustainable Landscape building; and a 60,000 gallon below-grade crate storage system for a total system storage capacity of 80,000 gallons. 20,000 gallons of the below-grade crate storage system is unlined, allowing excess water to infiltrate naturally as needed.

According to a Living Building Challenge Narrative provided to the research team by Civil & Environmental Consultants, Inc. the system was designed to manage a 5-year storm event (2.87 inches of rainfall over 24 hours). Per historic rainfall records, this design capacity will manage, on average, 99.7% of rainfall events.

Civil & Environmental Consultants, Inc. collected data within the parking lot rain garden with data loggers tracking soil moisture, temperature, soil water potential, soil water depth and conductivity and monitors the high water line within the rain garden with a clear tube filled with floating cork particles. A ring of cork particles is left within the tube at the high water line. The only on-site overflow and sewer connection is a catch basin located in the western parking lot rain garden at an elevation of 891.00. According to John Buck, project manager, Civil & Environmental Consultants, Inc., at no point since the completion of the project has the high water level reached the elevation of the overflow catch basin. From this monitoring, Civil & Environmental Consultants, Inc. infers that there have been no events in which stormwater has flowed off site and entered the municipal sewer system.

Limitations:

The only measurement for overflow is the elevation measurements being taken in the rain garden monitored by CEC which requires on-site observation and measurement of a relatively imprecise above grade water measurement system that is prone to tampering if someone were to flush the inside of the gauge with water between readings. There have been no known instances of such tampering.

Sources:

Buck, John and Perkovich, Joel. “Green Infrastructure Design and Evaluation for One of the World’s Greenest Buildings: The Center for Sustainable Landscapes”. Presentation Slides. 2013.
Civil & Environmental Consultants, Inc. *Phipps Conservatory Issued for Bid Plans*. PDF.
Civil & Environmental Consultants, Inc. Living Building Challenge Narrative for Net Zero Water.
Interview with John Buck, Project Manager, Civil & Environmental Consultants, Inc.

Interview with Michael Takacs,Principal, Civil & Environmental Consultants, Inc.

Environmental Benefit 2

Reduces annual runoff by 87% on the Center for Sustainable Landscapes building green roof as compared to a traditional roof.

Methodology:

A pan lysimeter is installed on the Center for Sustainable Landscapes 6,050 sf green roof that is used to monitor green roof runoff. Data loggers and sensors collect data every 5 minutes and the data is tracked and analyzed by Civil & Environmental Consultants, Inc. Measured runoff data from the pan lysimeter is compared to total roof rainfall to determine the percentage of runoff reduction. This data and analysis was shared with the research team by Civil and Environmental Consulting Inc (Figure 7).

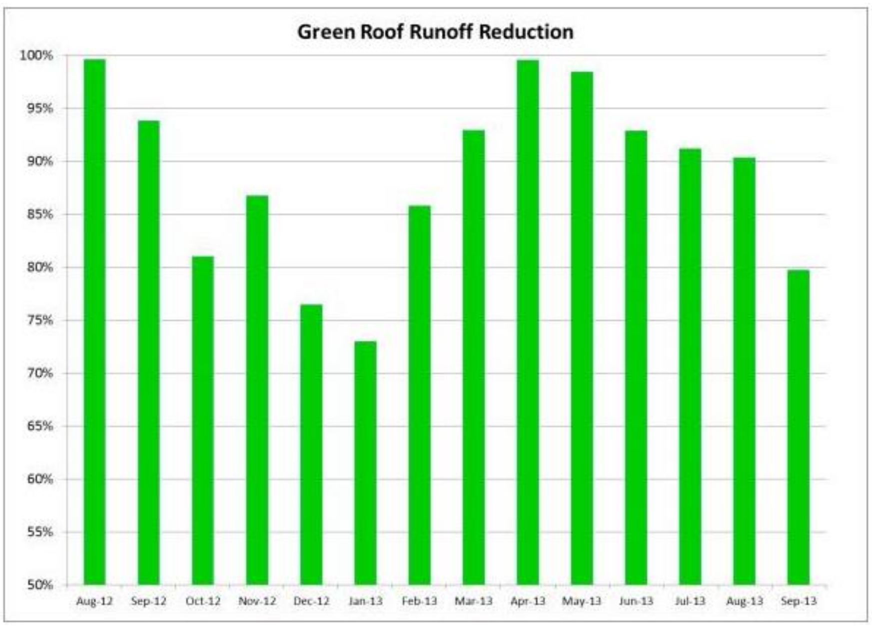


Figure 7. *Green Roof Runoff Reduction. Civil and Environmental Consultants Inc.*

Assume 100% runoff on a traditional roof.
Average runoff rate for 1-year monitoring data was computed at 87%

Limitations:

There is one pan lysimeter present on the roof monitoring the runoff through the soil profile of a small section of the vegetated portion of the roof, with no catchment beyond the precipitation that falls directly onto the capture area. Therefore, runoff reduction may vary in areas of the roof that capture runoff from impervious surfaces or exhibit a variance in soil depth.

Computation provided by consultants. Researchers did not independently verify the data.

Sources:

Buck, John and Perkovich, Joel. "Green Infrastructure Design and Evaluation for One of the World's Greenest Buildings: The Center for Sustainable Landscapes". Presentation Slides. 2013.

The Design Alliance Architects. *Phipps Conservatory Issued for Bid Plans*. PDF.

Environmental Benefit 3

Retains and reuses 100% of greywater and sanitary water on-site through features designed to treat up to 416 gallons per day of building's wastewater.

Methodology:

Waste water at the Center for Sustainable Landscapes building is collected in a 1,000 gallon septic tank. From there, it is released 50 gallons at a time into two 180 sf horizontal subsurface flow treatment wetlands. After filtering through the treatment wetlands, the water is recirculated through a sand filter. After passing through the sand filter the water is conveyed to a UV disinfection system in the Center for Sustainable Landscapes building, prior to being stored in a 1,700 gallon water cistern.

The system was designed with a capacity of 416 gallons/day: 243 gallons/day from flush fixtures and 174 gallons/day from flow fixtures. According to an interview with Michael Tackacs, Principal, Civil & Environmental Consultants, Inc, the actual building water use has to this point been significantly lower than the designed capacity, so captured stormwater is run through the system to keep it flowing at the required rate for operation.

It can thus be deduced that 100% of sanitary and greywater from the CSL building is being treated on site, and not added to the site's combined sewage system. Excess treated water that is not required for building demand is pumped to UV filtration systems located elsewhere on the conservatory grounds. After the UV filtration, the water may be either distilled and used to offset irrigation required within the Conservatory's Orchid Room or infiltrated into the ground for disposal.

Limitations:

Building water usage is not being actively monitored and data related to actual building water use was not available. Therefore the exact water demand and amount of water filtered is unknown.

Sources:

Buck, John and Perkovich, Joel. "Green Infrastructure Design and Evaluation for One of the World's Greenest Buildings: The Center for Sustainable Landscapes". Presentation Slides. 2013.
Civil & Environmental Consultants, Inc. *Phipps Conservatory Issued for Bid Plans*. PDF.
Civil & Environmental Consultants, Inc. Living Building Challenge Narrative for Net Zero Water.
Interview with John Buck, Project Manager, Civil & Environmental Consultants, Inc.
Interview with Michael Takacs, Principal, Civil & Environmental Consultants, Inc.

Environmental Benefit 4

Saves 7,846 gallons of potable water annually by using harvested rainwater for irrigation, saving $709 annually.

Methodology:

The Center for Sustainable Landscapes grounds do not utilize a permanent irrigation system. When supplemental watering is required, it is supplied by the rainwater harvesting system, so that no municipal water is used on the landscape.

Claire Dusak, Outdoor Display Foreman at Phipps Conservatory, provided the research team with the Center for Sustainable Landscape's 2015 landscape water usage. The total usage for 2015 was 7,846 gallons over a 9 months period from April to December. No landscape watering is required January through March.

Based on water rates the assumed charge for water is $78.77 per month for any consumption up to 5,000 gallons. $78.77 per month * 9 months = $708.93 with the assumption that an irrigation system using potable water would require a dedicated metered water line.

According to the Pittsburgh Water and Sewer Authority's 2016 water usage rates, The Conservatory would be charged a flat rate of $78.77 per month.

Limitations:

The municipal water rate is based upon the latest water rate for a Commercial customer available from Pittsburgh Water and Sewer Authority. The rate calculation requires knowledge of the size of the metered water line. The metered line is assumed to be 1", a common size for irrigation lines.

Sources:

Interview with Claire Dusak, Outdoor Display Foreman at Phipps Conservatory.
Pittsburgh Water and Sewer Authority. *Rate Brochure 2016.* PDF.

Environmental Benefit 5

Reduces irrigation demand by 99% of the estimated water requirement of a comparable traditionally irrigated landscape by using native plants.

Methodology:

Claire Dusak, Outdoor Display Foreman at Phipps Conservatory, provided the research team with the Center for Sustainable Landscape's 2015 landscape water usage. Based on the irrigation data provided, the actual peak watering month at the Center for Sustainable Landscape in 2015 was September, with 2,300 gallons used.

The comparable SITES baseline (Baseline Landscape Water Requirement (BLWR), explained below) for the same-sized landscape would be 232,460 gallons/month. 2,300 gallons is a 230,160 gallon reduction – or 99% – compared to the SITES baseline water requirement.

The SITES standard to calculate water savings against is the Baseline Landscape Water Requirement (BLWR). The calculation is:

$$\textbf{BLWR (Gallons)} = ET_0 \times A \times C_U$$

Where:

ET_0 =	*Average Reference Evapotranspiration for the Site's Peak Watering Month (July) Provided Locally in Inches/Month (Data from Northeast Regional Climate Center)*
A =	*Area of Irrigated Landscape in Square Feet*
C_U =	*Conversion Factor = 0.6233 (for results in Gallons/Month)*

Limitations:

The estimated water usage is assumed to be the baseline condition as defined by SITES, utilized as a proxy for the irrigation requirements of a "traditional" reference landscape. SITES calculations were provided to the research team.

Sources:

Phipps Conservatory. *SITES Credit 3.2* documentation. PDF.
CH2M Hill. *Phipps Conservatory Issued for Bid Plans.* PDF.
Interview with Claire Dusak, Outdoor Display Foreman at Phipps Conservatory.
Pittsburgh Water and Sewer Authority. *Rate Brochure 2016.* PDF.

Environmental Benefit 6

Increases ecological quality as demonstrated by an increase in Floristic Quality Index (FQI) from 7.7 to 53. An FQI above 35 is considered to be "natural area" quality.

Methodology:

The vegetated areas of the pre-existing site primarily consisted of areas of steep slopes, including vertical exposed rock faces that were unmanaged and vegetated by volunteer plant communities (Figure 1). The Center for Sustainable Landscapes design removed existing on-site vegetation, amended and filled steep slope areas with an engineered fiber-reinforced soil mix and seeded with a native seed mix, along with some tree planting. Planting areas along main pedestrian paths within the CSL grounds receive ongoing weeding and maintenance, while the back-of-house steep slope areas at the northwest of the CSL grounds have remained unmanaged since construction. For this environmental benefit, the research team looked at the extent to which Floristic Quality has increased compared to pre-existing site conditions.

Floristic Quality Assessment (FQA) is a method that uses characteristics of a plant community to derive an estimate of habitat quality, originally defined by Swink and Wilhelm in *Plants of the Chicago Region*, 1994.[1] The primary unit of measurement for Floristic Quality Assessments is the *Floristic Quality Index* (FQI), with higher scores representing higher quality habitats. The FQI equation utilizes a *Coefficient of Conservatism* (C) value assigned to individual species by a panel of experts with knowledge of a region's native flora. The C value can range from 0-10, with high C values assigned to species typically occurring in high-quality habitats, and low C values assigned to those occurring in a wide variety of conditions and showing a tolerance of disturbance.[2]

The FQI is calculated using the equation $FQI = \bar{C}(\sqrt{N})$ where $\bar{C}$ stands for the Native Mean C (i.e., the average Coefficient of Conservatism for native species) and N is native species richness (i.e., the number of native species).

[1] F. Swink and G. Wilhelm. *Plants of the Chicago Region, 4th ed.* Indianapolis: Indiana Academy of Science, 1994.

[2] Mid-Atlantic Wetlands Workgroup. "Floristic Quality Assessment Index (FQAI)." http://www.mawwg.psu.edu/tools/detail/floristic-quality-assessment-index-fqai

Figure 1. *Pre-existing conditions. (Andropogon Associates)* *Current conditions. (Nicholas Pevzner, CSI 2016)*

Floristic Quality Assessment Index metrics were used to compare 1) the pre-existing and 2) current conditions at the CSL grounds. The study area is outlined in Figure 2 below.

1) Pre-existing plant species were obtained from SITES Credit 4.1 documentation (Credit 4.1: *Control and manage known invasive plants found on site*)

2) The current conditions species mix was derived by comparing planting plans provided by Andropogon Associates with the current conditions on-site, and noting any substitutions or alterations. In addition, species growing on areas of steep slope currently unmanaged by Conservatory staff were assessed by running three transects from top of slope to bottom of slope, and documenting all species found along these transects. This cataloging along the transects was supplemented by a rapid visual canvassing along the slope for any species not captured in the transects.

The species lists were entered into the Universal FQA Calculator[3] using the Mid-Atlantic Allegheny Plateau (non-glaciated) database. Species that were present on site but not present in the database were excluded from the FQA calculations.

The current conditions showed a substantial increase in both FQI and mean C value relative to the pre-existing conditions.

[3] Freyman, William A. "Universal FQA Calculator". http://universalfqa.org/

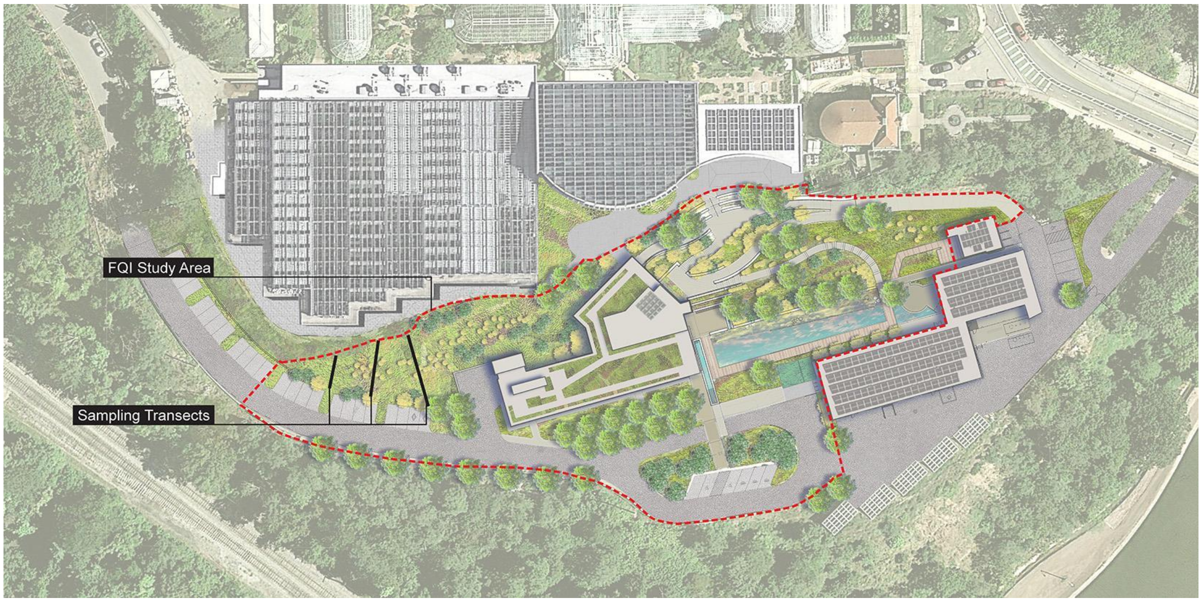


Figure 2. *FQI Study Area. Base plan image provided by Andropogon Associates.*

Pre-existing Condition
Conservatism-Based Metrics:

Total Mean C:	2.9
Total FQI:	7.7
Species Richness	7

Species inlcuded in C, FQI calculation

Scientific Name	Family	Native?	C
Gleditsia triacanthos	Fabaceae	native	6
Heracleum maximum	Apiaceae	native	5
Parthenocissus quinquefolia	Vitaceae	native	3
Phytolacca americana	Phytolaccaceae	native	1
Rhus typhina	Anacardiaceae	native	2
Robinia pseudoacacia	Fabaceae	native	1
Solidago canadensis	Asteraceae	native	2

Figure 3. *Pre-existing Conditions Species List.*

Species inlcuded in C, FQI calculation

Scientific Name	Family	Native?	C				
Acer rubrum	Aceraceae	native	1	Nyssa sylvatica	Cornaceae	native	6
Ageratina altissima	Asteraceae	native	3	Osmunda cinnamomea	Osmundaceae	native	6
Allium cernuum	Liliaceae	native	7	Panicum virgatum	Poaceae	native	4
Amsonia tabernaemontana	Apocynaceae	native	3	Parthenocissus quinquefolia	Vitaceae	native	3
Aquilegia canadensis	Ranunculaceae	native	6	Paxistima canbyi	Celastraceae	native	10
Asclepias incarnata	Asclepiadaceae	native	5	Penstemon digitalis	Scrophulariaceae	native	3
Asclepias syriaca	Asclepiadaceae	native	1	Phlox divaricata	Polemoniaceae	native	8
Asclepias tuberosa	Asclepiadaceae	native	3	Phlox paniculata	Polemoniaceae	native	4
Baptisia australis	Fabaceae	native	9	Phlox subulata	Polemoniaceae	native	9
Betula papyrifera	Betulaceae	native	8	Physocarpus opulifolius	Rosaceae	native	7
Bouteloua curtipendula	Poaceae	native	8	Pinus virginiana	Pinaceae	native	5
Brasenia schreberi	Cabombaceae	native	3	Platanus occidentalis	Platanaceae	native	5
Carex appalachica	Cyperaceae	native	8	Populus tremuloides	Salicaceae	native	4
Carex stricta	Cyperaceae	native	6	Prunus serotina	Rosaceae	native	3
Carpinus caroliniana	Betulaceae	native	6	Quercus coccinea	Fagaceae	native	7
Carya glabra	Juglandaceae	native	6	Quercus imbricaria	Fagaceae	native	6
Ceanothus americanus	Rhamnaceae	native	8	Quercus muehlenbergii	Fagaceae	native	8
Cercis canadensis	Fabaceae	native	5	Rhus aromatica	Anacardiaceae	native	7
Chamaecrista fasciculata	Fabaceae	native	2	Rhus typhina	Anacardiaceae	native	2
Clethra alnifolia	Clethraceae	native	5	Robinia pseudoacacia	Fabaceae	native	1
Coreopsis lanceolata	Asteraceae	native	3	Rosa carolina	Rosaceae	native	6
Coreopsis verticillata	Asteraceae	native	5	Rubus odoratus	Rosaceae	native	6
Cornus sericea	Cornaceae	native	4	Rudbeckia fulgida	Asteraceae	native	6
Crataegus viridis	Rosaceae	native	9	Rudbeckia laciniata	Asteraceae	native	5
Dryopteris marginalis	Dryopteridaceae	native	6	Salvia lyrata	Lamiaceae	native	2
Dulichium arundinaceum	Cyperaceae	native	5	Sambucus nigra ssp canadensis	Caprifoliaceae	native	3
Eleocharis acicularis	Cyperaceae	native	5	Schizachyrium scoparium	Poaceae	native	4
Elymus virginicus	Poaceae	native	4	Scutellaria incana	Lamiaceae	native	6
Fragaria virginiana	Rosaceae	native	2	Sedum ternatum	Crassulaceae	native	6
Gleditsia triacanthos	Fabaceae	native	6	Sisyrinchium angustifolium	Iridaceae	native	2
Hamamelis virginiana	Hamamelidaceae	native	5	Solidago caesia	Asteraceae	native	6
Heliopsis helianthoides	Asteraceae	native	5	Solidago canadensis	Asteraceae	native	2
Heracleum maximum	Apiaceae	native	5	Solidago sphacelata	Asteraceae	native	8
Hydrangea arborescens	Hydrangeaceae	native	6	Sorghastrum nutans	Poaceae	native	5
Ilex opaca	Aquifoliaceae	native	4	Sporobolus heterolepis	Poaceae	native	10
Ilex verticillata	Aquifoliaceae	native	6	Symphyotrichum cordifolium	Asteraceae	native	5
Iris cristata	Iridaceae	native	9	Symphyotrichum novae-angliae	Asteraceae	native	2
Iris versicolor	Iridaceae	native	7	Symphyotrichum oblongifolium	Asteraceae	native	5
Juncus effusus var pylaei	Juncaceae	native	2	Tiarella cordifolia	Saxifragaceae	native	7
Juniperus communis	Cupressaceae	native	8	Tradescantia ohiensis	Commelinaceae	native	4
Juniperus virginiana	Cupressaceae	native	3	Typha latifolia	Typhaceae	native	2
Kalmia latifolia	Ericaceae	native	5	Vaccinium angustifolium	Ericaceae	native	5
Liatris spicata	Asteraceae	native	7	Viburnum acerifolium	Caprifoliaceae	native	6
Lobelia cardinalis	Campanulaceae	native	6	Viburnum lentago	Caprifoliaceae	native	7
Magnolia virginiana	Magnoliaceae	native	6	Viburnum prunifolium	Caprifoliaceae	native	5
Mertensia virginica	Boraginaceae	native	8	Vicia americana	Fabaceae	native	6
Monarda didyma	Lamiaceae	native	6	Viola pedata	Violaceae	native	8
Monarda punctata	Lamiaceae	native	3	Vitis riparia	Vitaceae	native	4
Muhlenbergia capillaris	Poaceae	native	9	Waldsteinia fragarioides	Rosaceae	native	7
Nymphaea odorata	Nymphaeaceae	native	4	Zizia aurea	Apiaceae	native	6

Current Condition

Conservatism-Based Metrics:

Total Mean C:	5.3
Total FQI:	53
Species Richness	100

Figure 4. *Current Conditions Species List.*

Limitations:

Pre-existing conditions species were determined based on SITES documentation for credit 4.1, the best currently available source of documentation on pre-existing site conditions. While the species list is consistent with nearby areas of unmanaged steep slope, it may not have fully accounted for all species present on this particular site. This documentation provides an inventory of pre-existing species but does not provide any spatial information. All species listed in the inventory were assumed to be within the study area and were entered into the FQI calculations.

Current conditions of species were determined based on field verification of planting plans provided by Andropogon Associates, as well as on-site transects taken during a single day of documentation. Transects were supplemented by a rapid visual canvassing for any species not captured in the transects. Species were identified both in the field and from collected specimens. While the vast majority of species visually present at the time of survey were accounted for, this survey may have missed some species growing on the slope -- particularly any species that may have exhibited limited above-ground biomass at the time of inventory (May, 2016).

Sources:

Andropogon Associates. *Phipps Conservatory Issued for Bid Landscape Plans*. PDF.
Andropogon Associates. *SITES Credit 4.1* documentation. PDF.

Universal FQA Calculator. http://universalfqa.org/

Environmental Benefit 7

Increases Biomass Density Index from a 0.07 on the pre-existing site to a projected 2.02 ten years after planting. Higher BDI is generally indicative of a greater number and quality of ecosystem services.

Methodology:

Biomass density is used as an indicator of ecosystem services provided by vegetation, with higher vegetative biomass being generally indicative of a greater number and quality of ecosystem services.[4] The Biomass Density Index (BDI) is the primary metric used by SITES to quantify ecosystem services provided by vegetation. BDI assigns coefficient constants to general vegetative coverage categories and accounts for the percentage of site area for each coverage type. A higher BDI value is indicative of greater biomass density.

As part of documentation prepared for SITES credit 4.6, BDI had been calculated for both the pre-existing site conditions (Figure 5) and the as-designed vegetation 10 years after planting (Figure 6).

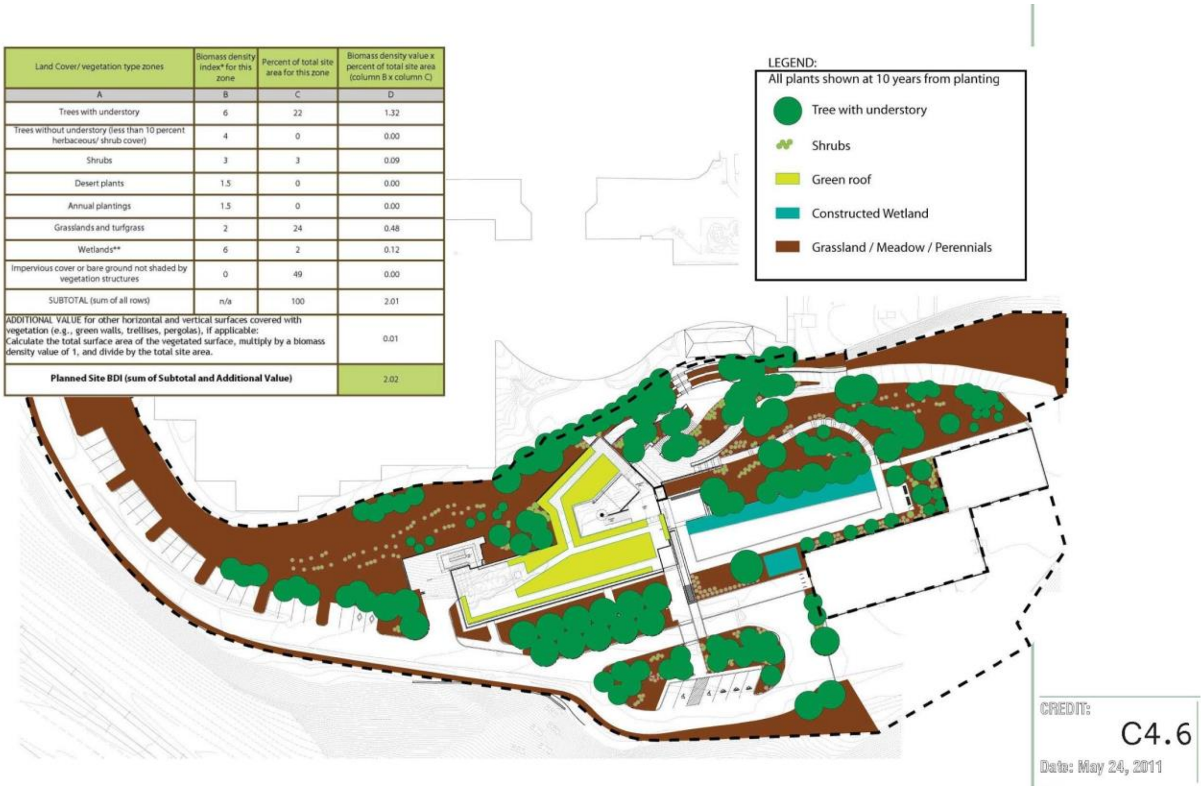
Land Cover/ vegetation type zones	Biomass density index* for this zone	Percent of total site area for this zone	Biomass density value x percent of total site area (column B x column C)
A	B	C	D
Trees with understory	6	0	0.00
Trees without understory (less than 10 percent herbaceous/ shrub cover)	4	1	0.04
Shrubs	3	1	0.03
Desert plants	1.5	0	0.00
Annual plantings	1.5	0	0.00
Grasslands and turfgrass	2	0	0.00
Wetlands**	6	0	0.00
Impervious cover or bare ground not shaded by vegetation structures	0	98	0.00
SUBTOTAL (sum of all rows)	n/a	100	0.07
ADDITIONAL VALUE for other horizontal and vertical surfaces covered with vegetation (e.g., green walls, trellises, pergolas), if applicable: Calculate the total surface area of the vegetated surface, multiply by a biomass density value of 1, and divide by the total site area.			
Existing Site BDI (sum of Subtotal and Additional Value)			0.07

Existing Conditions

Site Aerial

Figure 5. *Existing Conditions BDI calculation. SITES Credit 4.6 documentation. Andropogon Associates.*

[4] Calkins, Meg. *The Sustainable Sites Handbook: A Complete Guide to the Principles, Strategies and Best Practices for Sustainable Landscapes.* Wiley. 2012.



Land Cover/ vegetation type zones	Biomass density index* for this zone	Percent of total site area for this zone	Biomass density value x percent of total site area (column B x column C)
A	B	C	D
Trees with understory	6	22	1.32
Trees without understory (less than 10 percent herbaceous/ shrub cover)	4	0	0.00
Shrubs	3	3	0.09
Desert plants	1.5	0	0.00
Annual plantings	1.5	0	0.00
Grasslands and turfgrass	2	24	0.48
Wetlands**	6	2	0.12
Impervious cover or bare ground not shaded by vegetation structures	0	49	0.00
SUBTOTAL (sum of all rows)	n/a	100	2.01
ADDITIONAL VALUE for other horizontal and vertical surfaces covered with vegetation (e.g., green walls, trellises, pergolas), if applicable: Calculate the total surface area of the vegetated surface, multiply by a biomass density value of 1, and divide by the total site area.			0.01
Planned Site BDI (sum of Subtotal and Additional Value)			2.02

Figure 6. *Planned Conditions BDI calculation (10 Years). SITES Credit 4.6 documentation. Andropogon Associates.*

To determine expected percent increase of BDI:

((y-x)/x * 100
x=existing BDI
y=projected BDI

2.02–.07= 1.95 /.07 = 27.86 x100 = 2,785%
2,785/10 = 278% average annual increase over ten years

Limitations:

BDI was calculated based on projected growth of the planting indicated on the landscape plan. On-site observation revealed that several of the species, quantities, and locations of vegetation has shifted relative to as-designed landscape plans. Such shifts include differing tree species and locations due to tree mortality, relocated and replaced material, ongoing maintenance practices, and appearance and propagation of introduced tree, shrub and perennial species. Given the coarse categorization of vegetation for BDI calculations, and reliance on area takeoffs for the calculations, it is unlikely that these shifts would have had a significant impact on the BDI calculations.

Sources:

Andropogon Associates. *SITES Credit 4.6* documentation*.* PDF.

SOCIAL BENEFITS

Social Benefit 1

Attracted over 6,800 visitors within the first 70 days of being open to the public.

Methodology:

From February 12, 2013 until April 23, 2013, docents were stationed at the entrance to the Center for Sustainable Landscapes garden. Docents recorded the number of visitors entering the garden for self guided tours and offered guided tours of the garden. The number of docent-led tours was also recorded. These records were provided to the research team by Dr. Emily Kalnicky, Director of Science Education and Research at Phipps Conservatory and were quantified.

Text for interpretive signage was also supplied to the research team by Dr. Kalnicky. Interpretive signage highlights specific features of the garden and summarize their performative aspects. Included below is a sample of signage text and of signage installed on site:

> *Constructed Wetland*
> *Title: Treating Water Well*
> *Wetlands are some of the most productive ecosystems on earth. When you flush a toilet in the Center for Sustainable Landscapes, you are putting this system to work. These concrete squares before you comprise the constructed wetland – part of a system of plants, sand and UV disinfections – that cleans water from the building's sinks and toilets for reuse.*
>
> *Turtle Lagoon*
> *Title: Wildlife Within*
> *Turtle Lagoon stores rainwater for reuse and is also a thriving ecosystem. Look closely and try to spot the fish, turtles, and insects that are an integral part of this regenerative landscape.*
>
> *Rain Garden*
> *Title: Wet Feet*
> *This beautiful and functional space in front of you is a rain garden, which is simply a depression with plants and soils that can tolerate short-term flooding. When it rains, water pools here until it can naturally soak into the ground. This reduces the amount of runoff that enters the combined sewer system which saves money, energy and keeps the rivers cleaner.*

Figure 8. *Example of on-site educational signage. Landscape Architecture Foundation (Sean McKay, CSI 2016)*

Limitations:
The exact methodology for tracking visitors by CSL docents is unknown and may not account for all visitors to the CSL landscape over the course of its first 70 days. No further visitor statistics have been collected since the garden opening.

Sources:
Phipps Center for Sustainable Landscapes. *Initial CSL Visit and Tour Data.* Excel Spreadsheet.

Social Benefit 2

Attracts over 250,000 visitors annually to the Center for Sustainable Landscapes.

Methodology:
Phipps Conservatory and Botanical Gardens self reports nearly 500,000 total visitors annually. Center for Sustainable Landscapes is recognized as an integral part of the Phipps experience, which attracts over 250,000 visitors annually.

Limitations:
The methodology by which attendance is tracked is unknown.

Sources:
Phipps Conservatory and Botanical Gardens annual visitation
https://www.phipps.conservatory.org/donate/corporate-partnership/

Center for Sustainable Landscapes Contributions to the Phipps Experience https://access.living-future.org/phipps-conservatory-center-sustainable-landscapes

Phipps' Center for Sustainable Landscapes Garners Dozens of International and National Awards for Sustainability
https://www.phipps.conservatory.org/assets/documents/CSL_Awards_Veritas_Final.pdf

COST COMPARISON

The native plants of the CSL grounds require less maintenance than a comparable traditional conservatory garden landscape, costing $.80 per sf as compared to $1.01 per sf respectively. Annual landscape maintenance costs are 20.30% less than the care of the traditional landscape.

Methodology:

In order to compare maintenance costs, the Center for Sustainable Landscape grounds were compared to the Outdoor Garden at Phipps Conservatory, a reference site representing a more traditional conservatory garden. The Outdoor Garden is similar in size to the Center for Sustainable Landscapes grounds and also serves an educational purpose with signage identifying and generally highlighting plants that perform well in the Pittsburgh region based on maintenance requirements, aesthetic value and seasonal interest. The Outdoor Garden is composed primarily of turf lawns interspersed with beds of annual and perennial herbaceous material, with mature shade trees along the periphery that create differing sun and moisture conditions (Figure 9).

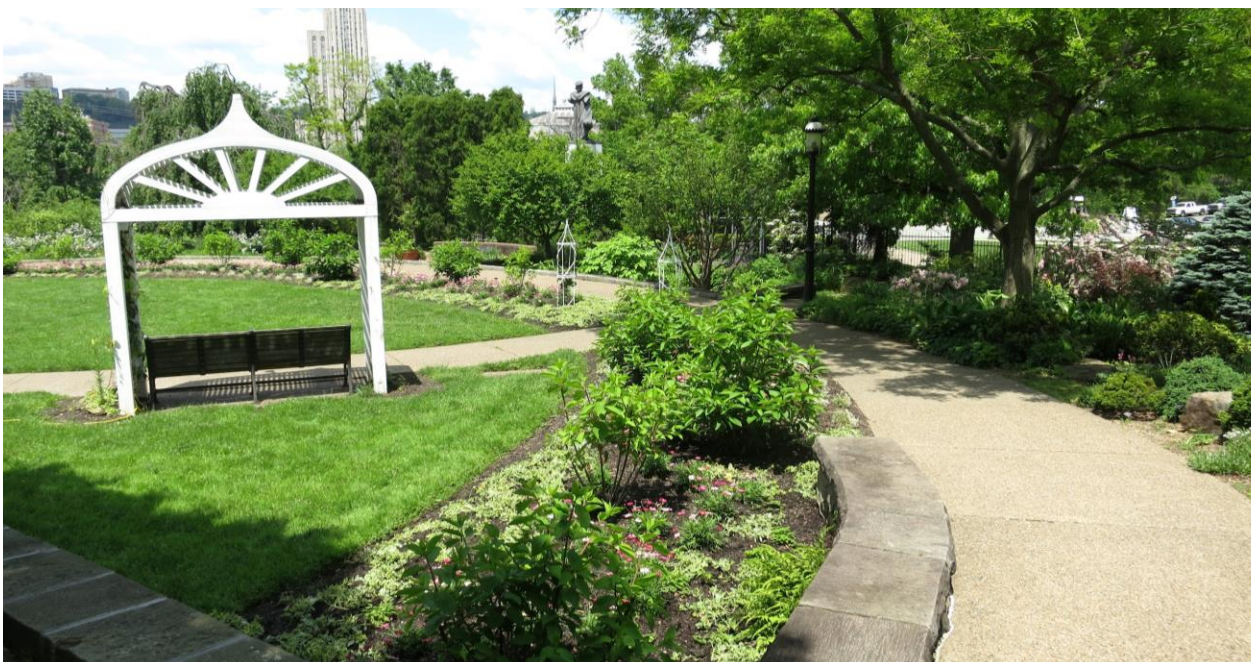


Figure 9. *Phipps Conservatory Outdoor Garden. Landscape Architecture Foundation (Sean McKay, CSI 2016)*

Claire Dusak, Outdoor Display Foreman at Phipps Conservatory, provided budgeting and purchasing information for both the Center for Sustainable Landscapes grounds as well as the Outdoor Garden. The annual maintenance costs for each site were summed, and divided by maintenance area takeoffs based on site aerials from Google Earth, in order to calculate the maintenance cost per sq. ft. for each garden (Figure 10).

Outdoor Garden

Item	Cost	Comments
Annual Operations	$5,500	Includes plants, mulch, misc. annual purchases and operation needs
Labor	$36,059	Includes 4 paid staff for 8 month period. 1 full time @ 20%, 1 full time @ 50%, 1 full time @ 5%. 1 part time @ 100%, up to 250 hours
Mowing	$4,320	8 month period. Weekly mowings.
Total	**$45,879**	
Total / sq. ft.	**$1.01**	Based on estimated 45,474 sq. ft. maintenance area

Center for Sustainable Landscapes

Item	Cost	Comments
Annual Operations	$2,500	Includes plants, mulch, misc. annual purchases and operation needs
Labor	$24,657	Includes 2 paid staff for 8 month period
Contractor Additions	$24,657	Includes perimiter mowing, twice annually
Total	**$51,814**	
Total / sq. ft.	**$0.80**	Based on estimated 64,431 sq. ft. maintenance area

Figure 10. *Phipps Conservatory Maintenance Budgets.*

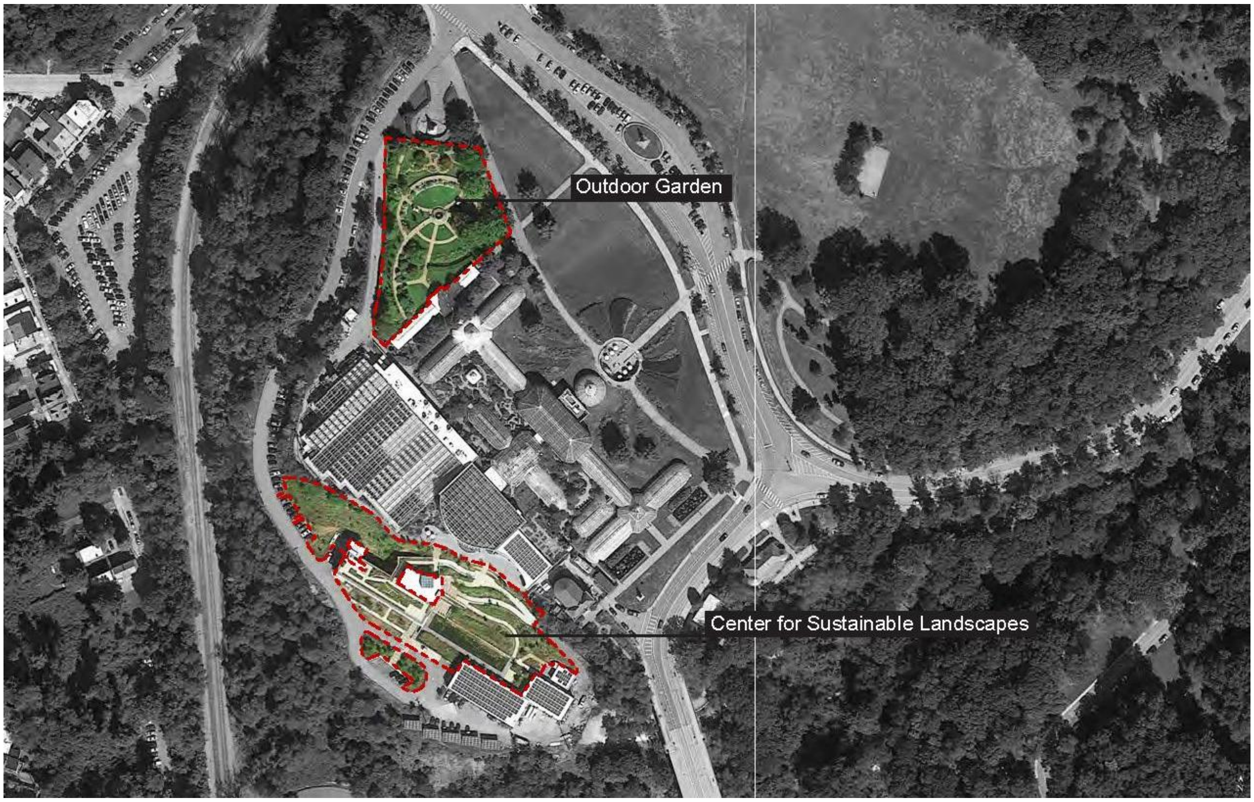


Figure 11. *Outdoor Garden and Center For Sustainable Landscapes Maintenance Areas*

Although the overall annual maintenance costs are higher for the Center for Sustainable Landscapes, the maintenance area is also 18,957 sq. ft. greater in size than the Outdoor Garden. Based on areas the annual maintenance budget is actually $.21 per sq. ft. lower for the Center for Sustainable Landscapes.

There are less staff assigned to the Center for Sustainable Landscapes and a lower budget is required for annual operations. Another factor playing into the lower maintenance cost is the lack of maintenance and associated time and labor of a portion of the steep slopes north of the entry drive as previously described under the Environmental Benefit 1 section of this document. The allocation of no staff time or other resources to a particular area is still a maintenance decision, and one that is more possible on a seeded meadow planting such as the CSL steep slopes, which self-seed and change over time, than on manicured plantings typified by many areas of the Outdoor Garden.

Limitations:

Maintenance costs are based on general budget figures and explanation provided to the research team by Phipps Conservatory staff via email correspondence. Budgeting figures provide an overview of the annual allotted labor and expenses of each garden but do not necessarily reflect the exact totals spent in either garden in a given year.

Sources:

Email correspondence with Claire Dusak, Outdoor Garden Foreman at Phipps Conservatory.
Phipps Conservatory. 40°46’22.53” N 56°48’45” W. GOOGLE EARTH. April 17, 2016.