

Title: Morris Arboretum Green Roof Evolution Tracking

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Abstract:

Morris Arboretum's intensive and extensive green roofs are one of the Horticulture Center's many green features. The planting material used on these roofs is experimental in this region. Because there are only a few green roofs in the Philadelphia area, little research has been done on what plants do well in these specific conditions. Green roofs have many limiting factors, which include limited growing space, extreme light and heat intensity, susceptibility to high winds, and moisture stress. Morris Arboretum's green roof was designed to be functional as well as aesthetically pleasing. The intensive green roof uses a variety of grasses, shrubs, annuals, and perennials in its design.

The purpose of this study is to determine what plants from the original installation have done well under the harsh conditions of the green roof, which annuals were successful in reseeding, and how larger shrubs have filled in the space. This study also provides information on the seasonal interest of the roof—including spring emergence, bloom time, seed formation, and fall color. This information will be useful in future designs for green roofs in this area.

Morris Arboretum Green Roof Evolution Tracking

TABLE OF CONTENTS

ACKNOWLEDGEMENTS 3

INTRODUCTION 4

GREEN ROOF BASICS 5

METHODS 6

RESULTS 7

HORTICULTURE CENTER GREEN ROOF BLOOM AND FOLIAGE LOG 2010..... 8

DISCUSSION..... 12

CONCLUSION..... 13

MAINTENANCE PLAN..... 13

FUTURE RECOMMENDATIONS 14

SUGGESTED PLANT LIST 14

REFERENCES 15

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INTRODUCTION

With the recent dedication of the Horticulture Center, The Morris Arboretum is taking the lead in sustainable and modern design. This building is one of few that were built to meet LEED platinum standards—the highest level in sustainable building standards. With these forward-looking goals of sustainability the Horticulture Center includes features such as geothermal heating and cooling, green lighting, and a rain garden complete with rain collecting cisterns.

In addition to these features, green roofs lay atop both the four-bay and six-bay garages. The four-bay garage is planted with sedum mats from Sempergreen and the six-bay garage is planted according to a design by 2009-2010 Natural Lands Intern, Sarah Presogna.

The installation of this green roof meets with the Morris Arboretum's mission of "promot[ing] an understanding of the relationship between plants, people and place," by connecting working space with aesthetic quality via environmentally sound concepts and natural design. It also "integrate[s] science [and] art" by incorporating a carefully designed, yet experimental, planting plan on these newly established buildings. In addition to this, the green roofs act as a learning opportunity, and make for many "teachable moments" for newcomers to the Horticulture Center.

The purpose of my project was to track the evolution of these two roofs over the course of this year. I assessed plant health, as well as seasonal interest. This included observing bloom time, dormancy in the fall, and reemergence in the spring. I also tracked plant distribution to assess reseeding and vegetative growth. Grid markers were placed on the roof to help me with this effort. This data is important to reap the maximum benefits from the roofs.

It is a common misconception that green roofs need little to no maintenance, because the roof was designed with harsh conditions in mind. However, some plants that we trialed did not do well despite their hardiness. One must realize that plants on a green roof must withstand moisture stress, elevated temperatures, high light intensities, and high wind speeds¹. This first year gave us the opportunity to observe the different plants, and how readily they established themselves. This data helps us in determining which plants need little to no care from its installation throughout its life.

In addition to the initial plant layout, I also did several trials on the roofs which include planting spring and fall flowering bulbs as well as taking a look at different methods of Sedum propagation. I have developed a simple plant log to document changes in the plants themselves as well as log any actions we took on the roof.

¹ Oberndorfer, Erica, Jeremy Lundholm, et. al. "Green Roofs as Urban Ecosystems: Ecological Structures, Functions, and Services." *BioScience*. November 2007. 57: 10. Pp 825.

As the only changing entity of the actual buildings themselves, it is important to keep records to develop a maintenance routine for the green roof. This data will also provide valuable information on future green roofing projects in this area.

GREEN ROOF BASICS

The simplest definition of a green roof is: a roof that has purposefully installed plant material as a permanent feature of the building itself. They differ from non-permanent roof gardens because, in green roofs, the plant growing medium is incorporated into the building instead of in pots or planters.

Although green roofs are a relatively new trend in North America, they are quite common in Europe. Early European green roof research in the 70s and 80s led to their popularity. Today, Germany's green roofs increase by about 145 million square feet per year²!

There are many reasons for their popularity. One reason to install a green roof is for their aesthetic value. Property values for taller, surrounding buildings also increase because of they serve as a pleasing break from the "concrete jungle." Additionally, there are practical reasons for installing green roofs. This includes: reducing and filtering storm water runoff, reducing dust and pollution surrounding the building, cooling and humidifying the air, and releasing additional oxygen³.

These benefits can have important environmental implications. Urban development often correlates with the increase of impervious surfaces. This, in turn, causes increased storm water runoff that diverts into streams and other bodies of water when it rains. These storm water systems often cannot handle the increased runoff, which then result in flooding and damage. Green roofs provide an effective storm water management system for the areas they cover by absorbing the rain that falls on them. A green roof does this by absorbing rain water in its substrate. This is especially effective for smaller rain events. For higher-intensity storms, green roofs help mitigate runoff by spreading out runoff over a longer period of time, allowing watersheds more time to divert this storm water⁴.

Adding vegetation to a building is also beneficial because it can reduce the building's energy consumption.⁵ A green roof can mitigate extreme temperatures, minimizing heating and cooling costs. Research suggests that the energy is conserved by the reduction of heat flow into buildings in warmer temperatures, and the reduction of heat loss through the roof in cooler temperatures⁶.

² Snodgrass, Edmund C. and McIntyre, Linda. 2010. The Green Roof Manual: A Professional Guide to Design, Installation, and Maintenance. Timber Press. Portland, OR. Pp. 38

³ Clarke, Louise. "Green Roofs from the Ground Up." Power Point Presentation. Morris Arboretum. Philadelphia, PA. 22 Sept 2010.

⁴ Dunnett, Nigel and Kingsbury, Noel. 2008. Planting Green Roofs and Living Walls. Timber Press. Portland, OR. Pp. 57

⁵ Ibid Oberndorfer et. al. Pp 823.

⁶ Ibid Snodgrass et. al.

Green roofs are usually categorized as being either intensive or extensive. An extensive green roof has a shallower profile, with only about six inches of growing medium or less. These roofs are usually planted with sedums, grasses, or other low maintenance, hardy plants. Intensive roofs, however, have deeper profiles and range from six to eight inches in depth. These roofs are usually designed to be more of a conventional garden, where plants are cared for individually. Also, because the roof has a deeper profile, it is able to support more plant types including: grasses, shrubs, annuals, and perennials⁷.

Intensive roofs allow building owners to get creative with the design and plant materials that they can use in this space. However, this flexibility often comes with the responsibility of more intensive plant care. Additionally, the aesthetic expectations for intensive roofs highly increase with more complicated plantings⁸.

METHODS

The plants observed in this study are located on the Morris Arboretum's intensive green roof above the Horticulture Center's six-bay garage. The site measured 144' x 24' with a substrate that is eight inches deep.

Throughout this project, I tracked each species on the Morris Arboretum's intensive green roof. Records were taken once a week via photos and a written log. Observations I made include: spring emergence, bloom time, seed formation, and fall color. I also noted if any plants were diseased, struggling, or dead. I documented any actions we took on the roof including irrigation, weeding, and other types of maintenance.

The seasonal interest of the roof was recorded into an Excel spreadsheet, using colors to represent different lifecycle changes in each species. This gives a visual representation of peak seasonal interest times on the roof. This information will be analyzed to determine when there is little seasonal interest on the roof, and what we can do or add to make the roof an aesthetic feature of the Horticulture Center during all seasons.

This data will provide valuable information on future green roofing projects in this area.

⁷ Ibid Dunnett Pp. 4.

⁸ Ibid Orbendorfer et. al. Pp. 824

RESULTS

The attached Excel sheet as a visual representation of seasonal interest documents when plants have leaves and their bloom time. I also have photo documentation of the roof throughout my time here, which will act as a resource for future use.

Plants no longer present on the Roof:

Agave Americana var. protoamericana 'Silver Surfer'

Agave parryi var. truncata

Agave sp. 'Mr. Ripple'

HORTICULTURE CENTER GREENROOF BLOOM AND FOLIAGE LOG 2010

Horticulture Center Greenroof Bloom and Foliage Log 2010

Month	August				September				October				November				December			
Week	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	
Key	Few Blooms				Moderately Blooming				Full Bloom				No flowers				X	Not present or unobservable		
	Leaving Out				Fully Leafed				Moderate Fall Color				Full Fall Color				No leaves	S	Seeds present	
Plants																				
<i>Achillea millefolium</i>									S	S	S	S	S	S	S	S	S	S	S	
<i>Achillea tomentosa</i> 'Aurea'									S	S	S	S	S	S	S	S	S	S	S	
<i>Achillea</i> x 'Fireland'									S	S	S	S	S	S	S	S	S	S	S	
<i>Achillea</i> x 'Terra Cotta'									S	S	S	S	S	S	S	S	S	S	S	
<i>Aesclepius tuberosa</i>					S	S	S	S	S											
<i>Agave Americana</i> var. <i>protoamericana</i> 'Silver Surfer'																				
<i>Agave parryi</i> var. <i>truncata</i>																				
<i>Agave</i> sp. 'Mr. Ripple'																				
<i>Allium cernuum</i>																				
<i>Allium schoenoprasum</i>																				
<i>Allium thunbergii</i> 'Ozawa'																				
<i>Andropogon gerardii</i>																				
<i>Antennaria dioica</i>	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
<i>Aquilegia canadensis</i> 'Little Lanterns'	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
<i>Aquilegia canadensis</i>	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
<i>Armeria maritima</i> 'Rubifolia'	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
<i>Artemisia ludoviciana</i> 'Silver Frost'																				
<i>Artemisia</i> x 'Powis Castle'																				
<i>Calamagrostis</i> 'Karl Foerster'																				

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Key	Few Blooms				Moderately Blooming				Full Bloom				No flowers				X	Not present or unobservable			
	Leafing Out				Fully Leafed				Moderate Fall Color				Full Fall Color				No leaves				
<i>Calluna vulgaris</i> 'Firefly'	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
<i>Carex eburnea</i>	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
<i>Carex flacca</i>																					
<i>Cerastium tomentosum</i> 'Yoyo'																					
<i>Crocus chrysanthus</i> 'Blue Bird'	X	X	X	X	X	X	X	planted	X	X	X	X	X	X	X	X	X	X	X		
<i>Crocus medius</i>	X	X	X	X	X	X	X	planted	X	X	X	X	X	X	X	X	X	X	X		
<i>Crocus ochroleucus</i>	X	X	X	X	X	X	X	planted	X	X	X	X	X	X	X	X	X	X	X		
<i>Delosperma cooperi</i>										S	S	S	S	S	S	S	S	S			
<i>Delosperma dyeri</i>										S	S	S	S	S	S	S	S	S			
<i>Delosperma nubigenum</i> 'Basutoland'										S	S	S	S	S	S	S	S	S			
<i>Dianthus deltoides</i> 'Arctic Fire'																					
<i>Dianthus gratianopolitanus</i>																					
<i>Gypsophila repens</i> 'Alba'																					
<i>Iberis sempervirens</i> 'Little Gem'																					
<i>Iberis sempervirens</i> 'Snowflake'																					
<i>Juniperus conferta</i> 'Silver Mist'	Replaced some with smaller plants										Some dead										
<i>Juniperus horizontalis</i> 'Bar Harbor'																					
<i>Juniperus horizontalis</i> 'Wiltoni'																					
<i>Levandula x intermedia</i> 'Seal'																					
<i>Monarda fistulosa</i> 'Pette Wonder'	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
<i>Muscari armeniacum</i> 'Christmas Pearl'	not yet planted								planted	X	X	X	X	X	X	X	X	X			
	not yet planted								planted	X	X	X	X	X	X	X	X	X			

Horticulture Center Greenroof Bloom and Foliage Log 2010

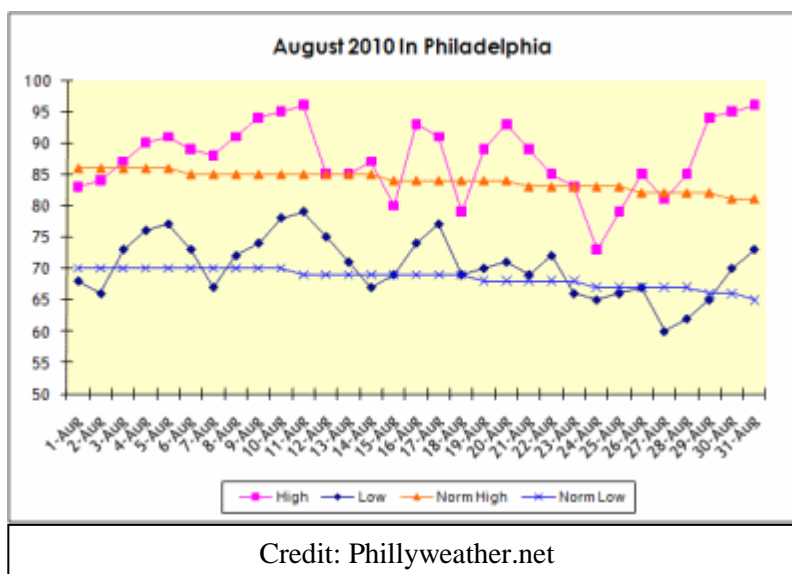
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Key	Few Blooms				Moderately Blooming				Full Bloom				No flowers				X	Not present or unobservable		
	Leafing Out				Fully Leafed				Moderate Fall Color				Full Fall Color				No leaves			
<i>Nepta faassenii</i> 'walker's low'																				
<i>Papaver alpinum</i>	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
<i>Pennisetum</i> 'Foxrot'	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
<i>Pennisetum</i> 'Little Bunny'					S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
<i>Penstemon pinifolius</i>																				
<i>Penstemon pinifolius</i> 'Magdalena Sunshine'																				
<i>Perovskia atriplicifolia</i> 'Little Spire'																				
<i>Phlox subulata</i> 'Emerald Blue'																				
<i>Phlox subulata</i> 'Scarlet Flame'																				
<i>Rhus aromatica</i> 'Gro-Low'																				
<i>Rosmarinus officinalis</i> 'Arp'																				
<i>Schizachyrium scoparium</i>																				
<i>Schizachyrium scoparium</i> 'Prairie Blues'																				
<i>Sedum acre</i> 'Aureum'																				
<i>Sedum album</i>																				
<i>Sedum caudicolum</i> 'Lidakenze'																				
<i>Sedum floriferum</i> 'Weihenstephaner Gold'																				
<i>Sedum</i> 'Silver Stone'																				
<i>Sedum spurium</i> 'Coccineum'																				
<i>Sedum spurium</i> 'Voodoo'																				
<i>Sedum spurium</i> 'White Form'																				

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Week	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	30	31	52							
Key	Few Blooms					Moderately Blooming					Full Bloom					No flowers					X	Not present or unobservable				
	Leaving Out					Fully Leafed					Moderate Fall Color					Full Fall Color					No leaves					
Sempervivum 'Imperial'	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Sempervivum 'Kalinda'	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Sempervivum 'Fame Monstrose'	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Sempervivum hausmanii	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Sempervivum 'Imperial'	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Sempervivum 'Kalinda'	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Solidago caesia																										
Sorghastum nutans																										
Sporobolus heterolepis																										
Talinum teretifolius																										
Thymus serpyllum 'Magic Carpet'																										
Tradescantia ohioensis						S	S	S	S	S																
Triteleia 'Rudy'	not yet planted					planted					X	X	X	X	X	X	X	X	X	X	X	X				
Tulipa bakeri 'Lilac Wonder'	not yet planted					planted					X	X	X	X	X	X	X	X	X	X	X	X				
Tulipa batalinii 'Bronze charm'	not yet planted					planted					X	X	X	X	X	X	X	X	X	X	X	X				
Tulipa humilis 'Alba Coerulea Oculata'	not yet planted					planted					X	X	X	X	X	X	X	X	X	X	X	X				
Yucca aloifolia 'Marjinata'																										
Yucca filamentosa 'Color Guard'																										
Yucca gloriosa 'Variegata'																										

DISCUSSION

It is a common misconception that green roofs need little to no maintenance. This may be true in an accommodating environment, where rain and mild weather conditions exist. However, the installation of the green roofs in March 2010 was followed by a particularly hot and dry summer. “The warmest summer on record was [the result of the] warmest June, second warmest July, and 8th warmest August since 1872 in Philadelphia.”⁹ In conjunction with the “dry spell that has lingered over the region since the start of April,”¹⁰, the newly installed green roof plants struggled to adapt to their new environment. Without supplemental water, many plants suffered drought stress, which may have inhibited some from successful establishment.



A recommendation to counter this limitation is to install an irrigation system. This is especially important for green roofs in their infancy. We did try to add some supplemental water during July and August 2010 via oscillating sprinklers. However, we experienced some problems. One of these was getting full irrigation coverage on the roof. Because the roof was so high, winds often diverted the direction of the water, causing both wet and dry spots. Additionally, getting sufficient water pressure to power the sprinklers was often a problem. This was especially true when nearby water sources were being utilized simultaneously. This inconsistent and spotty watering may have given some plants an advantage that others did not have.

In addition to being spotty and inconsistent, watering using this method was also time consuming. Because we only were able to get one hose line up there, we needed to move it approximately every hour throughout the day to cover the whole roof.

New methods of irrigation will be tested this upcoming season.

⁹ Phillyweather.net: The Delaware Valley’s Weather Center. “August 2010 Cements Hottest Summer on Record.” <http://philadelphiaweather.blogspot.com/2010/09/august-2010-cements-hottest-summer-on.html>. Accessed: March 21, 2011.

¹⁰ Ibid Phillyweather.net

CONCLUSION

I have included a maintenance plan and instruction sheet for the green roof. I have included recommendations for plantings that will add more interest during seasonal lulls and create a list of plants that do well on our roof. This list will provide other green roof designers in our area a planting recommendation resource.

MAINTENANCE PLAN

January—Roof inaccessible because of snow

February—Roof inaccessible because of snow

March

- Cut back any dead wood—this applies especially to Artemesia, Nepeta, Rosmarinus, Lavendula, and Solidago
- Remove fleshy plant parts that have been freezer burned
- Cut back grasses to base

April

- Weed as necessary, look out especially for dandelions
- Continue to cut back any dead wood
- Cut back Perovskia when buds are swollen
- Check for any dead plants—remove
- Reorder and replace dead plants

May:

- Weed as necessary

June:

- Water as necessary
- Weed as necessary, look out for Prostrate Spurge (*Euphorbia maculata*)

July

- Water as necessary
- Weed as necessary

August

- Water as necessary
- Weed as necessary

September:

- Order spring-flowering bulbs
- Propagate Sedum by taking cuttings and placing it on open spots

October:

- Plant bulbs for next spring
- Continue to propagate sedum

November:

- Cut back plants damaged from first frost or that have dried out from earlier in the season

December:

- Continue to cut back frost damaged or dried out plants (This task may be saved for the following spring)

FUTURE RECOMMENDATIONS

- Use large swaths of flowering plants for a more striking effect—*Iberis* was delightful to look at on the roof, but was had impact when viewing from the ground because they were too spread apart. Planting them more densely and in larger quantities would have had a bigger impact. Other plants we could plant in larger quantities include: Dianthus, Opuntia, Phlox and Solidago.
- Plant more spring-flowering bulbs in larger numbers—This year we trialed species tulips. These did well and are some of the earliest flowering plants on the roof. Their planting should be continued in densely, and in larger quantities. *Crocus chrysanthus* ‘Blue Bird’ was the first to flower.
- Have a more permanent irrigation structure—having hoses on the green roof is difficult and dangerous for both the plants and operator. Having a more permanent irrigation line up there would save time as well as keep the plants from getting run over from the hose.
- Use plants that flower earlier in the season. Maybe early flowering bulbs like Siberian Squill or Winter Aconite.

SUGGESTED PLANT LIST

Missouri Evening Primrose—*Oenothera macrocarpa*

Blush Sage—*Salvia* ‘Raspberry Delight’

Mojave Sage—*Salvia pachyphylla*

Blanket Flower—*Gaillardia* ‘Kobold’

Blue Star—*Amsonia hubrichtii*

Lamb’s Ear—*Stachys byzantine*

Roman chamomile—*Chamaemelum nobile*

Moss Rose—*Portulaca grandiflora*

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