Green Walls Utilizing Native Missouri Plants

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ABSTRACT

Green Walls have become popular in recent years as people search for innovative ways to not only add aesthic value to buildings, but also environmentally friendly ways to regulate energy loss and consumption in buildings. This investigation seeks to discover howa selection of seven Native Missouri plants behave when confined to a vertical box with shallow soil. This is not a investigation of if the plants will survive but rather how will the plants and boxes adapt to the changing environmental conditions.

INTRODUCTION

Green walls

What is a Green Wall? Livings walls, often referred to as Green Walls, ecowalls, biowall, or vertical gardens (Coronado 2015), are all systems that enable a vertical surface to be greened with plants (Manso 2015). The plants in a green wall are typically not rooted in the ground, instead they have plants which are self contained on the side of an existing structure. Green Walls are highly adaptable systems that can be utilized for all kinds of buildings. There are several ways to build a Green Wall, from planting boxes of various material hung on the wall, to complex hydroponic systems, to even growing plants in tubular sacks stacked on a rack. These systems can use a variety of substrate from soil, to soil-less hydroponics, making them extremely versatile for a variety of needs. Green Walls have a variety of functions. Aside from aesthetic value of having plants on a wall, they also can help reduce energy cost of a building by adding an extra layer of insulation and reducing the amount of heat loss or gained, help reduce the Urban Heat Island Effect, improve air quality, provide biodiversity and habitats, and can have a psychological impact on the humans using the space (Wood et al. 2015).

Landscape Architecture

Landscape architecture is a dynamic, collaborative field. The role of a landscape architect is to analyze, plan, design, manage, and nurture the built and natural environments. Given the nature of landscape architects work from designing parks, campuses, streescapes, etc there is a large emphasis on working with the community these new installations will impact (ASLA). Therefore it becomes harder to decide what is and is not landscape architecture. It is design based, people based, and space based. Utilizing a wide range of tools to transform and inspire those who will be utilizing the space.

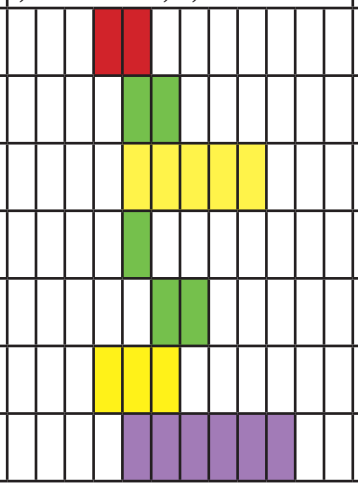
Native plants

Native Missouri Plants are plants that have had a long history of growing in the region. These plants are ones that have adapted to the climate, pathogens, soil, and moisture conditions of Missouri. Native plants play an important role in the ecosystem. Not only do they supply habitat and food for a variety of species that live in Missouri, they also provide human benefits, beyond aesthetic value. By using native plants in the landscape in place of turf or ornamental plants, maintenance can be reduced on a piece of property because these plants generally require less water and are adapted to the climate and soil conditions of the area. Native plants have also proven useful in erosion control and storm water management. Many of the Missouri native plants have extensive root systems that help stabilize the soil and also pull water out of the soil, reducing flooding. The utilization of native plants in the landscape provides a unique education opportunity by bringing plants that often go unnoticed to the forefront of a planting bed (Shaw Nature Reserve). It is often assumed that plants in their natural states are wild and messy, making them unappealing to the general public, but by utilizing them as landscape plants it is possible to break the taboo of the “wild” or “messy” plant misconception.

MATERIALS

Plants

Latin Name	Common Name	Height	Spread	Bloom	Sun	Water
Aquilegia canadensis	Columbine	2-3’	1-1.5’		Full Sun to Part Shade	Medium
Carex crinita	Fringed sedge	1-3’	1-2’		Full Sun to Part Shade	Med- wet
Carex muskingumensis	Palm sedge	2-3’	2-3’		Full Sun to Part Shade	Med- wet
Carex pensylvanica	Pennsylvania sedge	0.5-1’	0.5-1’		Part Shade to Full Shade	Dry- Med
Heuchera richardsonii	Alumroot	1-2’	1-1.5’		Full sun to part shade	Dry- med
Packera obovata	Squaweed	1-1.5’	0.5-1’		Full Sun to Part Shade	Med- wet
Ruellia humilis	Hairy Petunia	1.5-2’	1.5-2’		Full Sun to Part Shade	Dry-Med



Data from: Missouri Botanical Garden Plant Finder

Other Materials

Wood

- 1x4x12 Pine Deck Plank
- 1x2x8 Cedar trim
- 1.5x2x4 Pine Plywood

Hardware

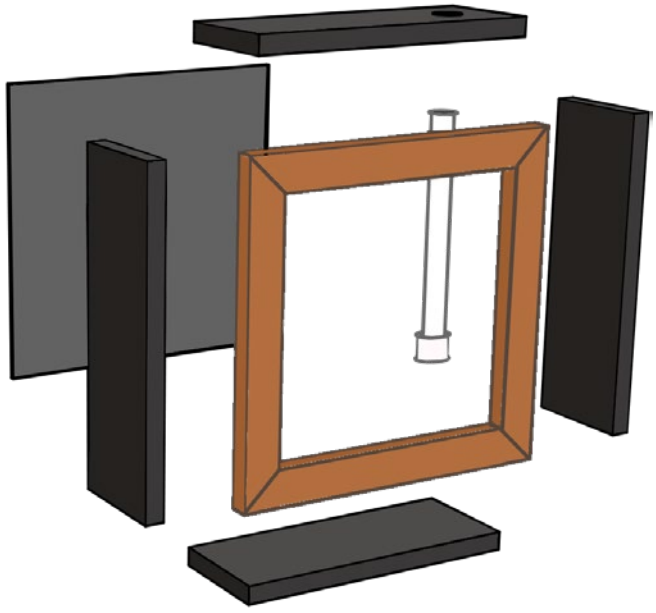
- 1.75” screws
- Finishing nails
- Staples
- Washers
- Barndoor stop
- Landscape Fabric
- 0.5” PVC Pipe
- 0.5” PVC Cap
- Silicone sealant
- Woodglue
- Waterproof Stain
- Paint Brushes

Tools

- Nail gun
- Air compressor
- Staple gun
- Drill
- Scissors
- Miter saw
- Circular saw
- Ruler
- Tape measure
- Metal square
- Moisture meter
- Thermometer

METHODS

Designing and Building Boxes



In order to implement a vertical garden system with native plants it was first necessary to build custom boxes that would fit into the already existing infrastructure of the surroundings. These boxes were to be hung around the Glasshouse at the Litzsinger Road Ecology Center.

The simplest way to do this was to build wooden boxes that could be hung over the black railing that was abundantly present around the Glasshouse.

It was not feasible to implement a large Green Wall, so instead boxes that have the dimension of 18”x18” made of treated wood were used instead. The design was adapted from several existing designs found both on the internet and within the book by Coronado, who offered a wide variety of greenwall designs that suit to serve different purposes.

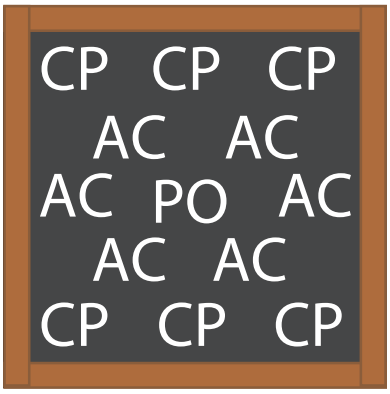
Pieces of 1x6 pine deck board were cut to lengths of 18” and 16”. Two of each board were used in each box. After exploration of what material to use as a back it was decided plywood would be stable and supportive enough. Each box has a piece of plywood cut to 18”x18”. It was necessary to think about how to water the box. For this a hole was drilled into what would become the top of each box using a 5/8 paddle drill bit. A 1/2” PVC pipe cut to 12” was used as a mechanism to distribute the water. Hole were arbitrarily drilled into each pipe and it was capped at the bottom. It was then inserted into the hole and sealed into place using a silicone sealant. The challenge became how to hang these boxes on the railings. Large barn door stops were used for this as they provided a large surface to surface contact and had a 2” wide gap that allowed for it to perfectly hang over the rails. Lengths of cedar trim about 2” wide were cut into 18” lengths and mitered at 45 degree angles. Under the trim black landscape fabric was stretched over the boxes to hold soil in (done after the addition of soil). Everything was assembled using wood glue, screws, nails, and staples where appropriate. Soil was used in favor of other materials as a growing medium. Professional Grow Mix was used and mixed with some Osmicote fertilizer. Soil was packed into the boxes before adding the decorative trim and landscape fabric.

Picking plants

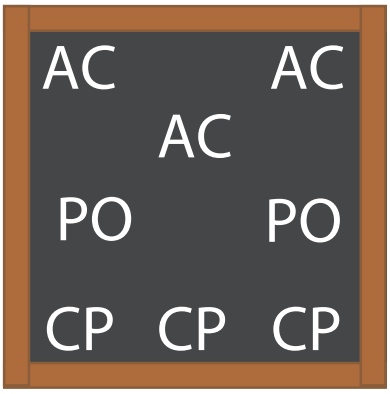
Plants for these vertical gardens were chosen based on these criteria: root depth, height of plants, amount of sun required, flowering schedule, and aesthetic. The most important criteria of the boxes is the root depth of the plants. Because many of Missouri’s native plants have extensive root systems it was imperative to use plants who do not send out these deep roots. Root depth of the plants was determined by observation of habit in the field, and natural habitat of the selected plants. Another important criteria for the plants was mature height, a plant that reaches 4ft tall would likely not do well in an 18in box. The plants chosen have foliage that remains less than 1.5ft in height, although some of the plants when flowering send up stems up to 2ft in height. Boxes were chosen to have not only ecological benefits but to also be aesthetically pleasing to people. A mixture of sedges and flowering plants were chosen to give a variety of texture, color, and seasonality to the boxes. Information on the plants was obtained from the Missouri Botanical Garden Plant Finder.

The boxes are divided in two groups, one set of boxes in higher sun conditions and one set of boxes in shade conditions. Boxes arrangement for planting was more an experiment of design and did not follow any strict guidelines.

Box A



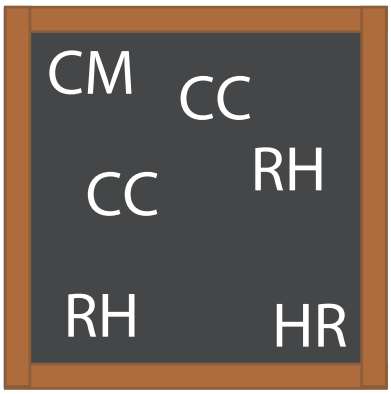
Box B



CP= *Carex pensylvanica*
AC= *Aquilegia canadensis*
PO= *Packera obovata*

Box C

Box D



CC= *Carex crinita*
CM=*Carex muskingumensis*
HR= *Heuchera richardsonii*
RH= *Ruellia humilis*

Recording data/ data obtaintion

Temperature

Temperature for each box was taken in the center using a digital thermometer. The center was chosen as the reading site as there were no considerable differences in readings when taken in the corners. The thermometer was inserted into the boxes and left to adjust while moisture readings were taken. Thermometer is inserted with the full probe inside the box.

Temperature for air was gathered by using the Hourly Weather report from NOAA, so that readings would be consistent and void of human error in reading or positioning a thermometer.

Moisture

Moisture for each box was taken using the same analog Soil Moisture meter. The meter was placed in the top and bottom center of each box, except for box D where there was no hole at the bottom center, it was instead placed consistently at the bottom left corner. The Soil Moisture meter has a numerical range from 1 to 10, 1 being dry and 10 being saturated. The top and bottom were chosen over a center reading as there will be a moisture gradient due to the nature of a vertical planting system. The meter was inserted into the boxes ½ way or 3in.

Temperature and moisture readings were taken twice a day at 8am and 4pm, Monday- Friday. Initial readings were transposed into a notebook and then entered into a spreadsheet. Observations were made everyday on the habit and nature of the boxes and how they have changed overtime.

RESULTS

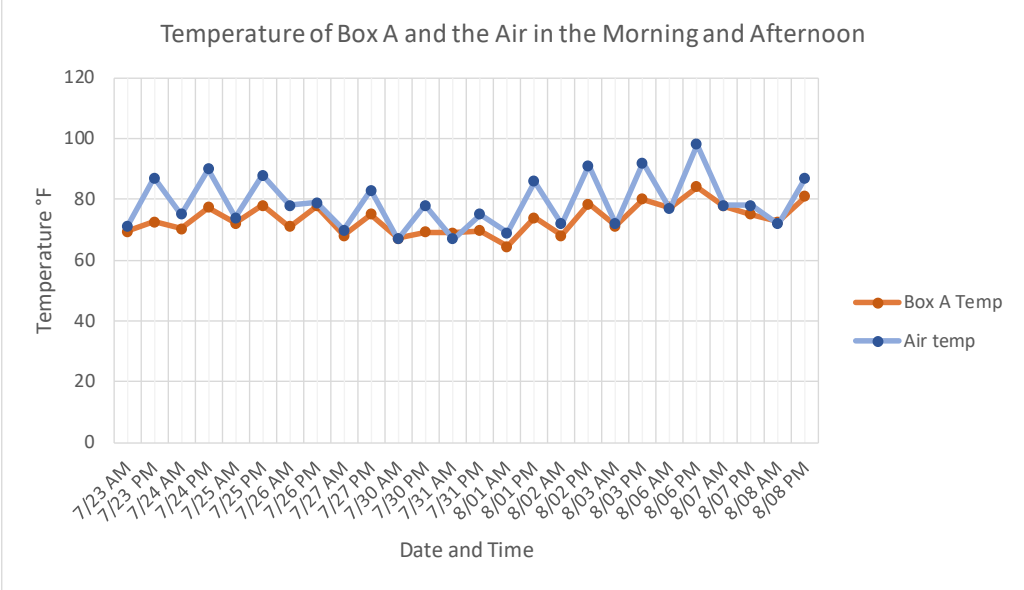
Temperature

Temperature in all boxes never reached air temperature. Morning and afternoon temperatures in each box were within a stand deviation of around 4, whereas the air temperature had a stand deviation of around 8. The boxes were placed in groups, Shade group was Box A & B, Sun group was Box C & D. Variation in temperature was dependent on these locations. There was no clear pattern on the temperature of the different groupings, boxes within groups were similar temperatures, where as the two groups had differing ranges of temperatures.

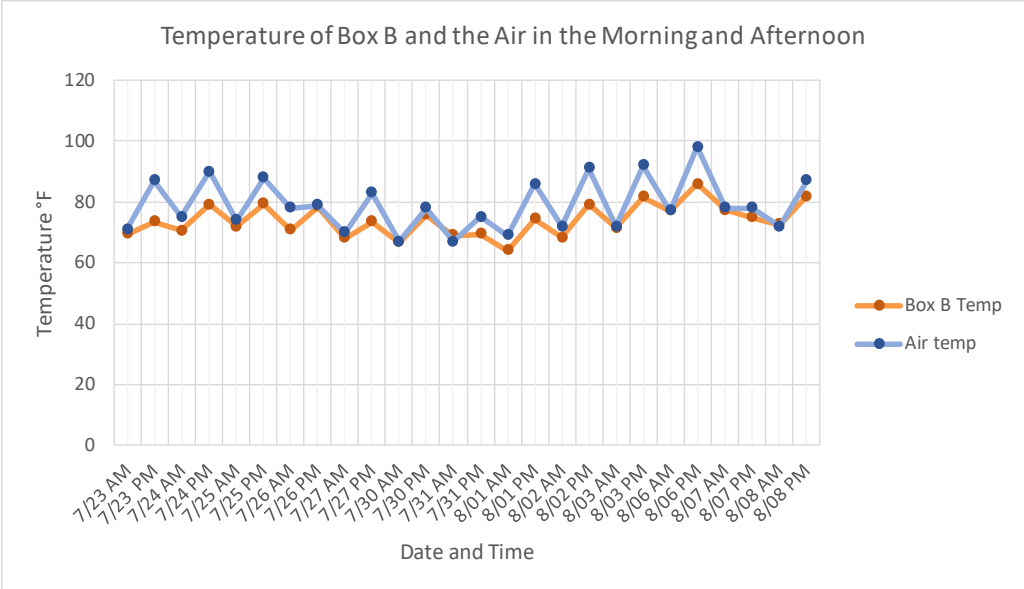
Figure 1: Temperature Data for all Planter Boxes and the Air in °F

Date	Box A Temp	Box B Temp	Box C Temp	Box D Temp	Air temp
7/23 AM	69.4	69.4	69.3	69.6	71
7/23 PM	72.7	73.4	75.6	75.7	87
7/24 AM	70.3	70.5	72	72.1	75
7/24 PM	77.4	79.2	77.7	79	90
7/25 AM	72.1	72	73	72.5	74
7/25 PM	78.1	79.3	76.8	77.5	88
7/26 AM	71.1	70.7	71.6	70.7	78
7/26 PM	77.9	78.4	75.4	76.5	79
7/27 AM	68.2	68	67.6	67.5	70
7/27 PM	75	73.4	72.9	73	83
7/30 AM	67.1	66.7	66.9	66.9	67
7/30 PM	69.3	75.7	69.6	69.6	78
7/31 AM	68.9	68.9	69.6	69.6	67
7/31 PM	69.6	69.4	69.8	69.8	75
8/01 AM	64.4	64	64.4	64.4	69
8/01 PM	73.9	74.3	71.2	72.1	86
8/02 AM	68.2	68.4	68.9	68.7	72
8/02 PM	78.4	79.2	76.3	77.4	91
8/03 AM	71.2	71.4	71.4	71.1	72
8/03 PM	80.1	81.7	79.9	80.4	92
8/06 AM	77.4	77.2	77.7	77.5	77
8/06 PM	84.2	85.8	84.9	84.6	98
8/07 AM	77.9	77.4	77.9	77.5	78
8/07 PM	75	74.8	74.8	74.7	78
8/08 AM	72.7	72.7	72.9	72.7	72
8/08 PM	81	81.9	78.6	79.9	87

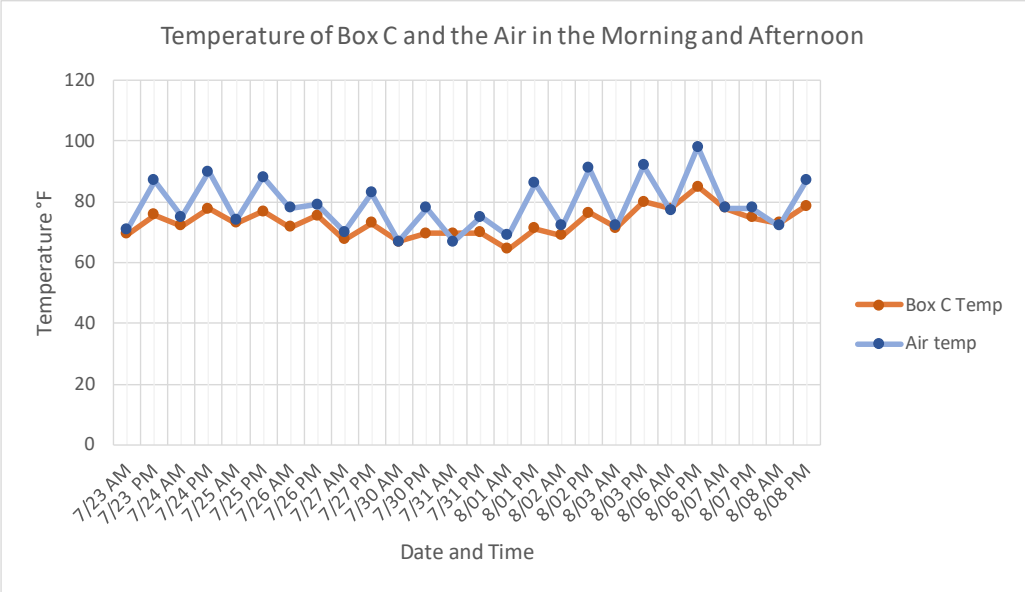
Graph 1: Temperature Box A



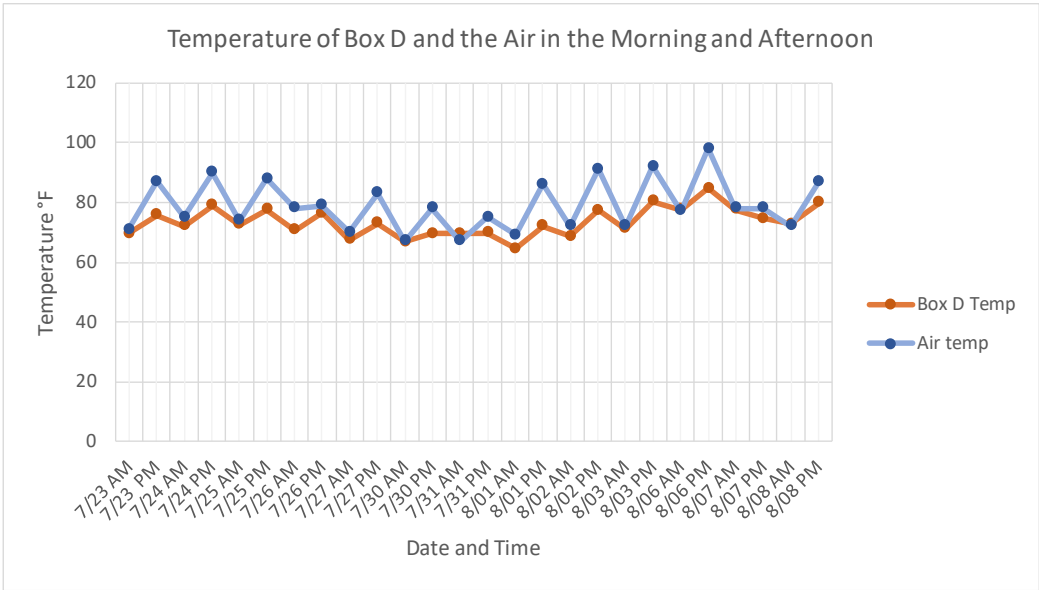
Graph 2: Temperature Box B



Graph 3: Temperature Box C

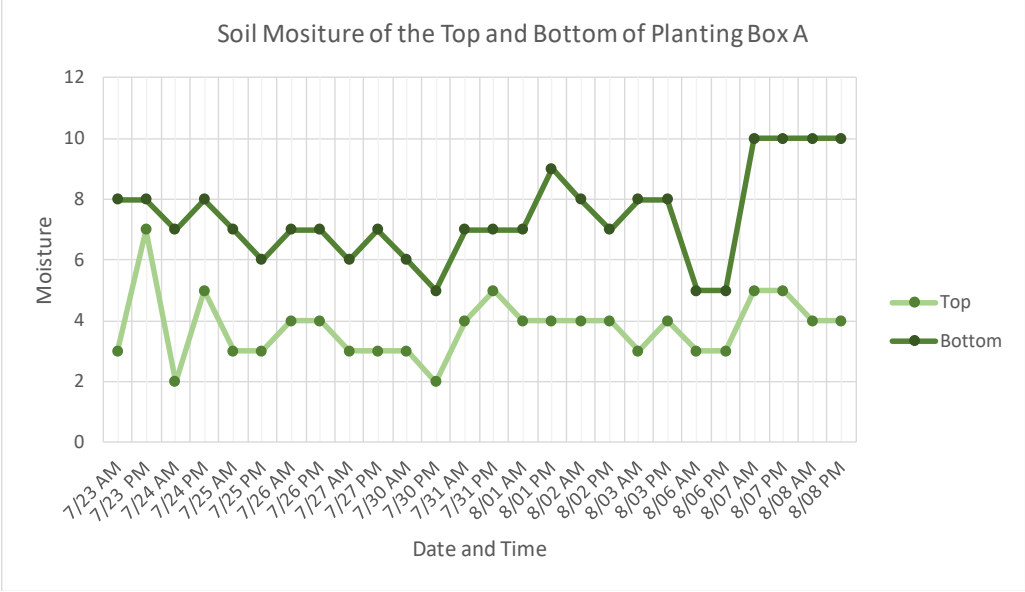


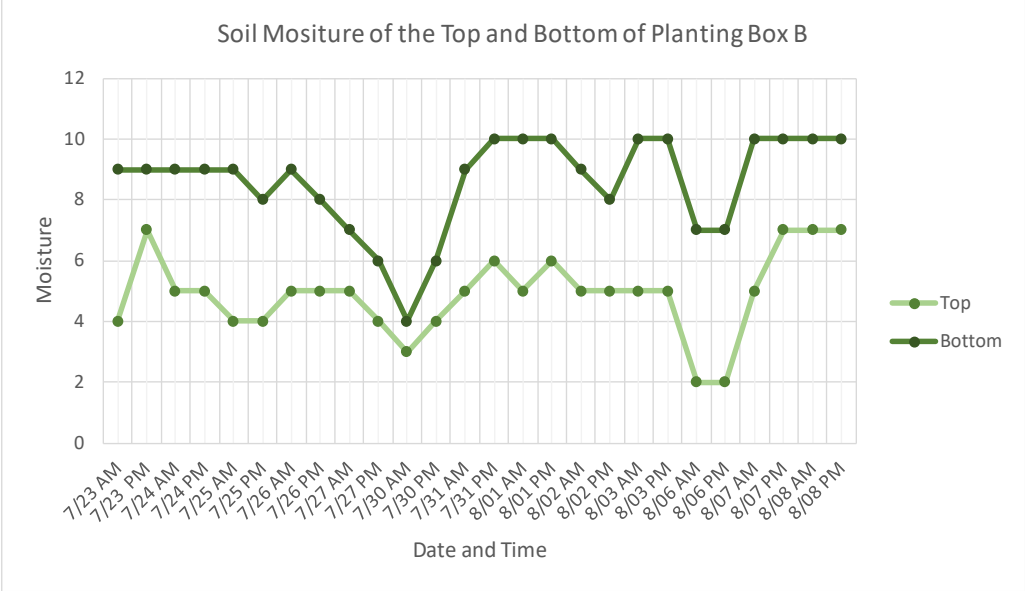
Graph 4: Temperature Box D

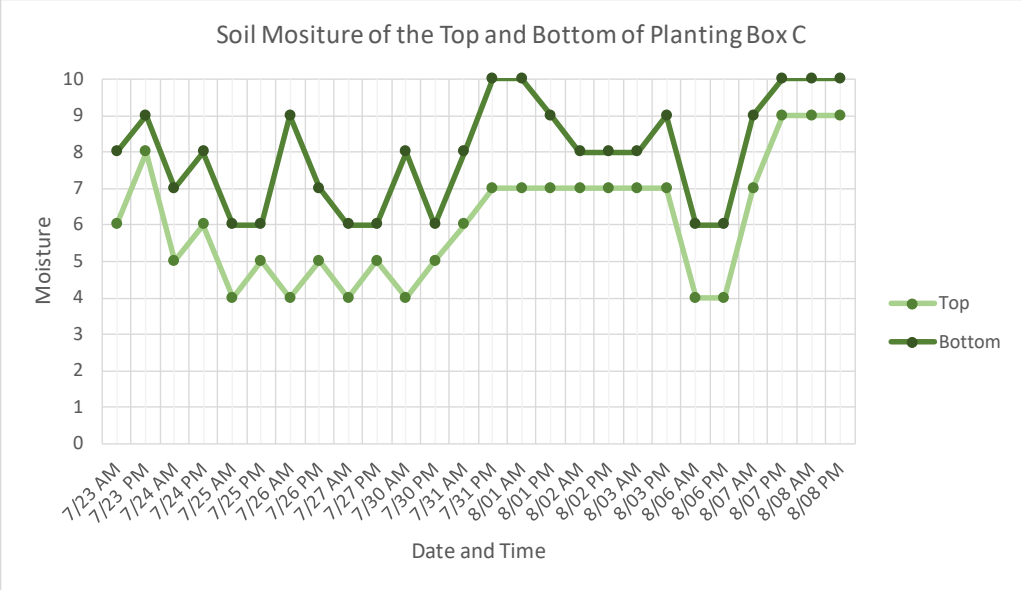


Moisture

Moisture between the top in the bottom was expected to have a gradient of low to high. The measurements for moisture showed this trend, where the top was consistently drier than the bottom of the box. However the top and bottom both dried out around the same rate. These moisture readings were taken to test how often the boxes would ultimately need to be watered. These boxes were watered every 5-7 days, which is most noticeable by a spike in the moisture levels of the bottom of the boxes. For future iterations of this experiment this data becomes useful in the arrangement of plants in the boxes. Plants that can tolerate more dry conditions should thrive in the top of the box, whereas plants that prefer wetter conditions should be tolerant of the bottom of the box. With this knowledge for this particular type of green wall system, it could be possible to prevent as much die off of the plants.






Soil Mositure of the Top and Bottom of Planting Box C
Moisture
Date and Time
Top
Bottom

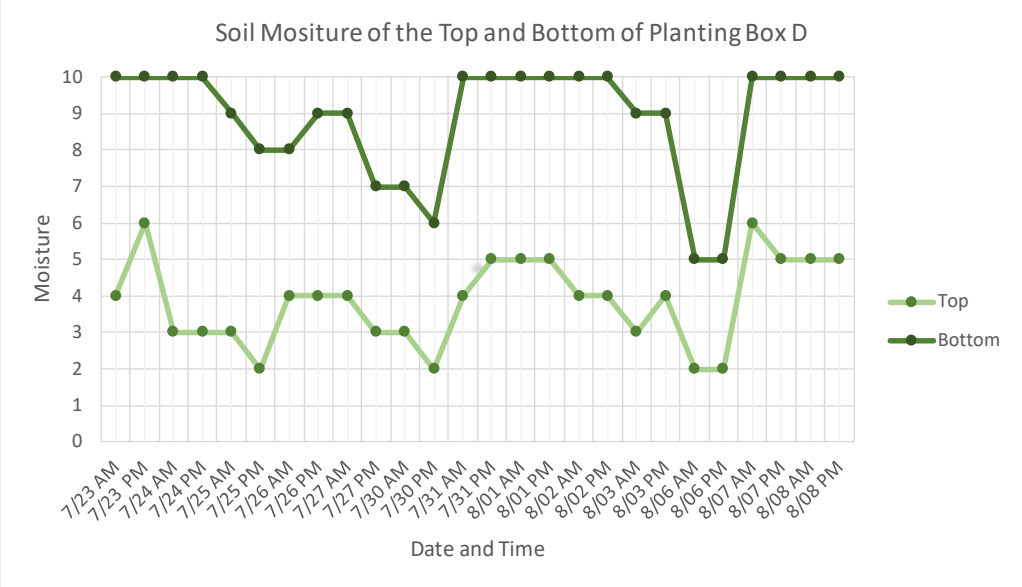

Soil Mositure of the Top and Bottom of Planting Box D
Moisture
Date and Time
Top
Bottom

Figure 2: Moisture data for Box A				
	Top		**Bottom**	
Date	AM	PM	AM	PM
7/23/2018	3	7	8	8
7/24/2018	2	5	7	8
7/25/2018	3	3	7	6
7/26/2018	4	4	7	7
7/27/2018	3	3	6	7
7/30/2018	3	2	6	5
7/31/2018	4	5	7	7
8/1/2018	4	4	7	9
8/2/2018	4	4	8	7
8/3/2018	3	4	8	8
8/6/2018	3	3	5	5
8/7/2018	5	5	10	10
8/8/2018	4	4	10	10

Figure 3: Moisture data for Box B				
	Top		**Bottom**	
Date	AM	PM	AM	PM
7/23/2018	4	7	9	9
7/24/2018	5	5	9	9
7/25/2018	4	4	9	8
7/26/2018	5	5	9	8
7/27/2018	5	4	7	6
7/30/2018	3	4	4	6
7/31/2018	5	6	9	10
8/1/2018	5	6	10	10
8/2/2018	5	5	9	8
8/3/2018	5	5	10	10
8/6/2018	2	2	7	7
8/7/2018	5	7	10	10
8/8/2018	7	7	10	10

Figure 4: Moisture data for Box C				
	Top		**Bottom**	
Date	AM	PM	AM	PM
7/23/2018	6	8	8	9
7/24/2018	5	6	7	8
7/25/2018	4	5	6	6
7/26/2018	4	5	9	7
7/27/2018	4	5	6	6
7/30/2018	4	5	8	6
7/31/2018	6	7	8	10
8/1/2018	7	7	10	9
8/2/2018	7	7	8	8
8/3/2018	7	7	8	9
8/6/2018	4	4	6	6
8/7/2018	7	9	9	10
8/8/2018	9	9	10	10

Figure 5: Moisture data for Box D				
	Top		**Bottom**	
Date	AM	PM	AM	PM
7/23/2018	4	6	10	10
7/24/2018	3	3	10	10
7/25/2018	3	2	9	8
7/26/2018	4	4	8	9
7/27/2018	4	3	9	7
7/30/2018	3	2	7	6
7/31/2018	4	5	10	10
8/1/2018	5	5	10	10
8/2/2018	4	4	10	10
8/3/2018	3	4	9	9
8/6/2018	2	2	5	5
8/7/2018	6	5	10	10
8/8/2018	5	5	10	10

CONCLUSION

From this data it can be said that it is possible to grow native Missouri plants in a confined vertical space. In particular the specific plants that were chosen seem to thrive under the conditions presented to them. The boxes hold a consistent temperature and have minimum watering needs, likely only needing to be watered once a week if that. Time will tell how these miniature green walls perform in the winter. For over wintering it may be necessary to lay the boxes on the ground as a way to keep the root systems safe from frost and so that they obtain much need moisture from snow melt and dew. It will be interesting in the future to see how these boxes flower.

Future studies could involve the attraction of pollinators to the boxes, so far pill bugs and assassin bugs have been observed in and on the boxes, as well as spider webs built on the plants. It would be interesting to do a comparison experiment between the biodiversity of the boxes, a natural habitat, and common urban streetscape plantings. Biodiversity in urban settings is affected by “natural” factors and is also highly influenced by humans (Mueller 2010). Examining climate trends and species diversity may help influence the selection of native plants that would be most beneficial to incorporate into an urban planting box.

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