Evaluating the Thermal Benefits of Living Wall Systems

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ABSTRACT

Eighteen circular (7-foot diameter) green retaining walls have been located on the SIUE campus. The project is designed to evaluate the thermal performance of green wall systems planted with five Sedum species and one unplanted wall on north, south, east, and west aspects. During warmer months, particularly for midday and evening measurements, we have determined that plant surface temperatures are less than wall block surface temperatures while the growing medium (Ameren Bottom Ash) has the greatest surface temperature. North and east wall aspects have the lowest afternoon surface temperatures – up to 25°F lower than west and south aspects. However, all morning measurements taken so far indicate no significant differences for any treatment. Additionally, measurements taken from late fall through winter have also not yielded significant results, perhaps due to *Sedum* dormancy and less incoming solar radiation. Nonetheless, based on our evaluations so far, living wall systems have the potential to mitigate the urban heat island effect.

INTRODUCTION

Metropolitan areas often suffer from excessive temperatures as a result of reduced vegetation and increasing paved surfaces. This situation can lead to the urban heat island effect, which is the phenomenon of significantly elevated temperature within developed urban areas (VanWoert et al. 2005). To reduce the heat island effect, places like city parks can provide some relief by promoting evapotranspiration, but their benefits are limited to the area of green space (Alexandri and Jones 2008). As a result, the majority of an urban environment is plagued with warmer, drier air.

Green (living) walls may be used to help reduce the Heat Island Effect and to associated with metropolitan areas. When the plants of a green wall grow to maximum coverage, their shade and evaporative capabilities should help to reduce the amount of heat that would otherwise be absorbed and radiated by the wall material. The walls planted with *Sedum* species may also aid in reducing flood potential by retaining stormwater. As a succulent plant, *Sedum* exhibits superior water retention capabilities and drought resistance (Wolf and Lundholm, 2008). Evaluation of the biowalls (green walls) planted at SIUE is needed to determine which plant species provide the greatest thermal benefits. This study evaluates the surface temperatures of 4 different *Sedum* species walls, a mixed *Sedum* species wall, and an unplanted control. It is hypothesized that planted walls will have lower surface temperatures than unplanted walls.

MATERIALS AND METHODS

Eighteen green retaining wall systems with five vegetated treatments and an unplanted control, with three replicates of each, were arranged in a completely randomized design. Green wall systems were constructed on the SIUE campus in 2007 (Figure 1). Each 7-foot diameter wall utilizes patented green wall blocks, donated by Hercules Manufacturing of St. Louis (Retzlaff et al., 2008). The core of each wall was filled with bottom ash donated by Ameren UE. Bottom Ash (80% by volume) blended with composted pinebark (20% by volume) was applied to the pocket of each block and along the top surface of each wall at 2 in. depth. Green walls, aside from the controls, were planted on July 1, 2007 with one of the following: *Sedum hybridum 'Immergrauch'*, *Sedum kamtschaticum*, *Sedum (Phedimus) takesimensis*, and *Sedum spurium*. The mixed Sedum wall was planted with *S. spurium*, *S. sexangulare*, *S. cauticola*, *S.kamtschaticum*, and *S. album*.

Thermal Measurements – A digital non-contact infrared thermometer is used to measure surface temperatures of the block, media, and plants, where applicable (Figure 2). Surface temperature measurements on the north, south, east, and west aspects have been taken since March 2010. Midday thermal measurements are taken on two to three week intervals. Dawn and dusk measurements are taken on monthly intervals. A one-way ANOVA for a completely randomized design is being used to test for differences between treatments. A Tukey's post-hoc test is then used to rank differences at an alpha level of 0.05 (Proc GLM, SAS version 9.1).

Coverage Measurements – Plant growth is measured using a dot grid coverage template with 78 4cm- diameter holes, spaced 1.1cm apart, arranged in 13 rows and 6 columns. The coverage template is placed over the wall aspect. The number of holes containing no vegetation is recorded. Measurements are made on the North, South, East, and West aspects of each wall. Coverage is measured on a monthly interval.

Figure 1. Eighteen circular living walls are being evaluated (left). *Sedum* species are planted in every pocket and on the top of each wall except the unplanted control wall (planted wall on right).

Figure 2. The surface temperatures of the block, media, and plant are recorded from each wall aspect.

Average Surface Temperature of Green Walls (June-September 2010)

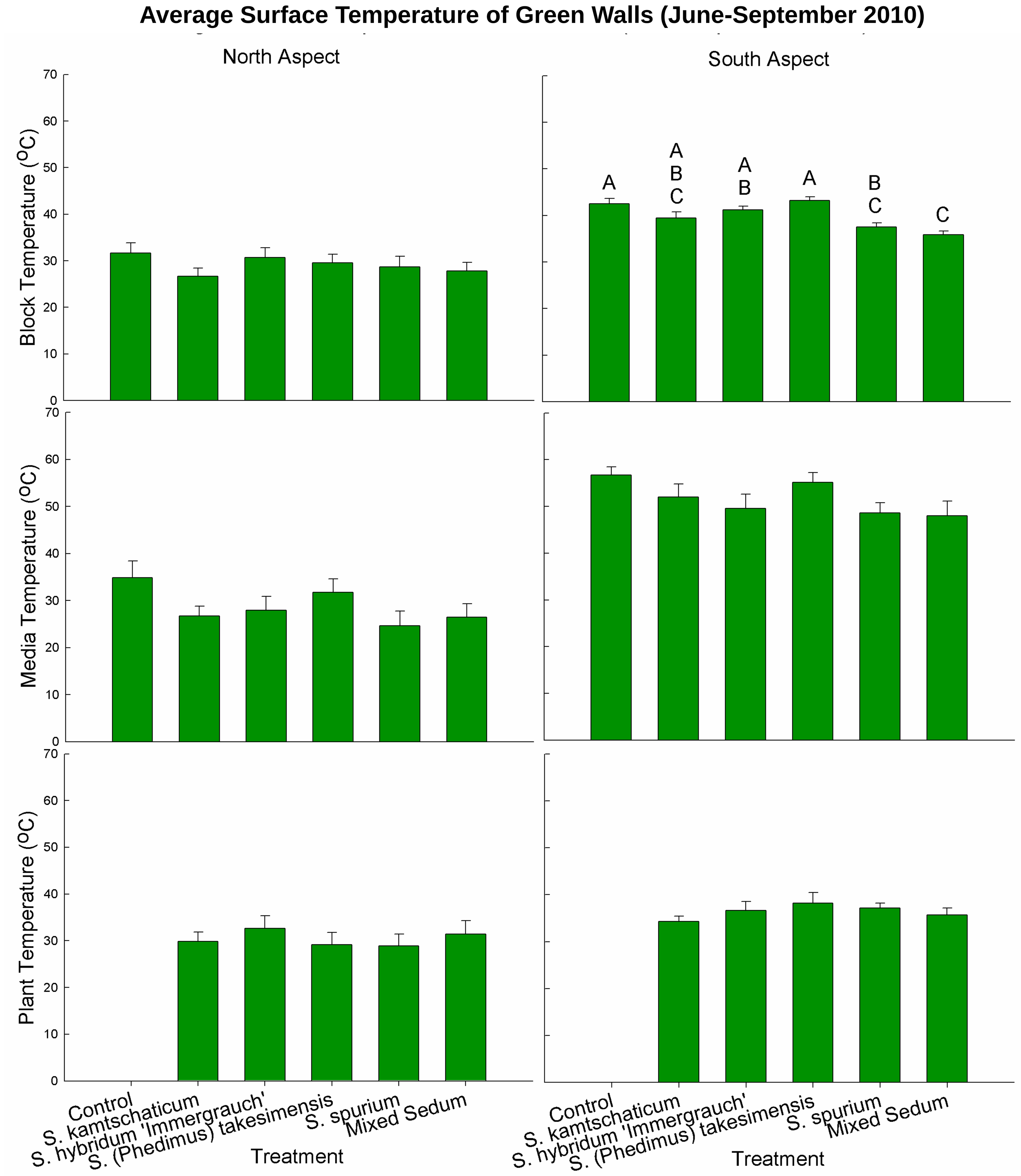

Figure 3. The above graphs show the mean temperatures for the North and South aspect for the block (top), media (middle row), and plant (bottom row).

Coverage for August-September 2010

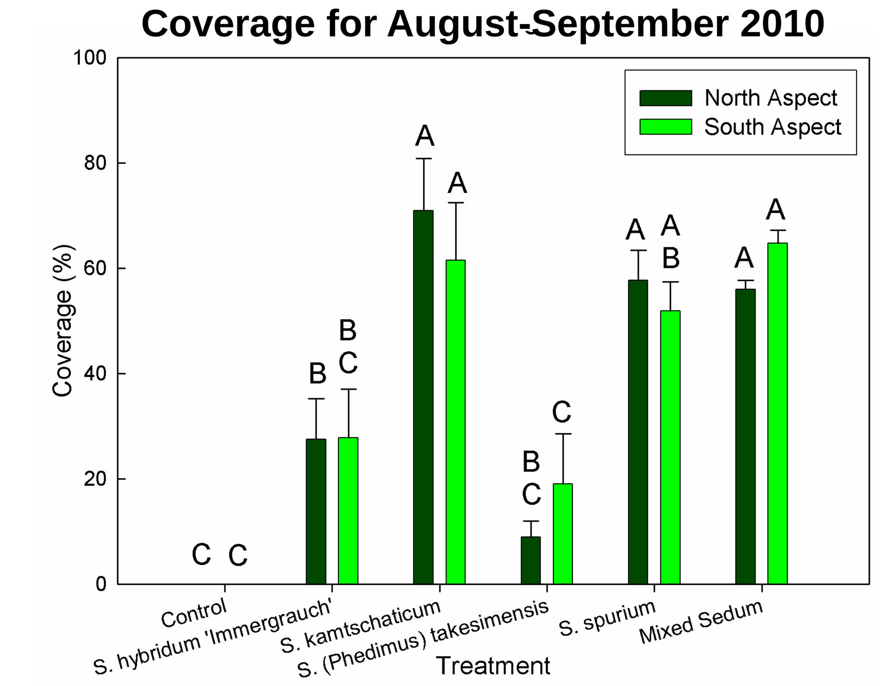

Figure 4. Plant coverage for green wall systems along the North and South aspects. Treatments with different grouping letters are statistically different from one another (α< 0.05).

Block Temperature Comparison for West Aspect

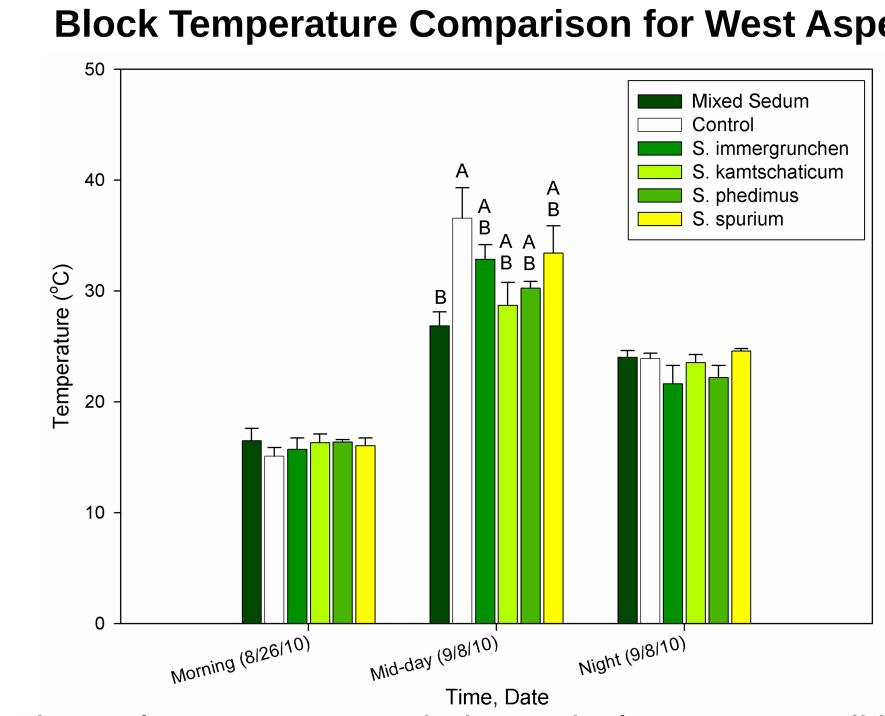

Figure 5. Thermal measurements during typical summer conditions along the West aspect. Treatments with different grouping letters are statistically different from one another (α< 0.05).

RESULTS AND DISCUSSION

Figure 3 illustrates the temperatures of the block, media, and plant surfaces for the North and South aspects from June to September 2010. For the South aspect, the block temperatures for *S. (Phedimus) takesimensis* and the control were greater than the Mixed *Sedum* treatment. The coverage and maximum growth can influence the temperature, and help provide optimal thermal benefits (Koehler et al., 2006). For the South aspect, the controls and *S. (Phedimus) takesimensis* exhibited less coverage than *S. kamtschaticum* and the Mixed *Sedum* treatment (Figure 4). The inadequate coverage of *S. (Phedimus) takesimensis* in the wall pockets has reduced thermal moderation while the greater coverage of the diverse Mixed *Sedum* treatment has greater thermal moderation.

Throughout a typical summer day, the West aspect of the green wall blocks exhibit a trend of heating and cooling (Figure 5). By midday, the West aspect of the control wall block is warmer than that of the Mixed *Sedum* treatment. However, thermal benefits seem to diminish as ambient air temperatures cool through the nights and into the mornings. Actually, for every morning thermal measurement taken so far, no differences in temperatures have been found. Also, thermal measurements taken between November 2010 and January 2011 indicated no differences either.

Thermal data collection for the green wall systems at SIUE is still underway. It is anticipated that the planted green walls will continue to provide more thermal benefits than the unplanted control. Coverage measurements are ongoing in anticipation of reinforcing the relationship between coverage and temperature. Overall, green retaining walls may have the potential to reduce the urban heat island effect, but more study is necessary.

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