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IMPACT OF VEGETATION TYPE AND CLIMATE ON EVAPOTRANSPIRATION FROM EXTENSIVE GREEN ROOFS

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1. PROBLEM OVERVIEW

Stormwater management solutions are needed to increase resiliency within urban areas by: (1) maintaining the natural hydrologic cycle, (2) controlling erosion and flooding, and (3) protecting water quality (MOE, 2003). Large impervious areas from urban development results in the loss of vegetated surfaces which leads to an increase in direct runoff (e.g. Paul and Meyer, 2008). Within urban areas, conventional roofs cover 40-50% of the impervious surfaces giving them significant potential to host urban stormwater management solutions (Dunnett and Kingsbury, 2004). Green roofs are able to restore the altered hydrologic cycle closer to its natural state by reducing the volume of runoff from a roof as well as attenuating flowrates. The hydrologic benefits of green roofs are partially attributed due to the vegetated surfaces enhancing evapotranspiration (ET) in urban areas. Predicting ET from green roofs is critical to inform green roof design and for optimization of hydrologic performance. This study focuses on evaluating the influence of green roof design parameters, such as vegetation type and growth media depth, on ET and by extension the hydrologic performance of an extensive green roof. While many studies have now demonstrated the effectiveness of green roofs in attenuating flowrate and reducing the volume of stormwater runoff (e.g., VanWoert et al., 2005a, Fassman-Beck et al., 2013, Berndtsson, 2010), little field research has been completed on directly quantifying ET rates and the hydrologic benefits green roofs in Canada including the influence of different vegetation types. The lack of available data on ET rates from green roofs limits optimal green roof design under the Canadian climate.

2. RESEARCH OBJECTIVES AND QUESTIONS

The objective of this study is to evaluate the impact of vegetation type and growth media depth on ET from experimental modular green roofs installed in three Canadian cities (London ON, Calgary AB, and Halifax NS). The research questions addressed in this study are: (1) Is there a difference in the ET rates measured at the three study sites? If there is a difference, what are the environmental factors that cause the difference in ET rates?; (2) Is the cumulative moisture loss and daily average ET rate different for different module treatments (one bare media and four vegetated treatments)?: (i) between the bare media treatment and the vegetation treatments; (ii) among the three single species vegetation treatments; and (iii) between the mixed species and single species treatments; (3) Is there a difference in the cumulative moisture loss and daily average ET rate when the growth media depth is varied between 10 cm and 15 cm? A summary of the findings for each research question are discussed in this short executive summary.

3. RESEARCH METHODS

The extensive experimental green roofs are of modular design with bare growth media modules (i.e. bare) as well as modules with different vegetated treatments. The four vegetated treatments include: three single species treatments (*Sedum spurium*, *Aquilegia canadensis*, and *Sporobolus heterolepis*) and a mixed species treatment with all aforementioned species. For each treatment, there are modules with a media depth of 10 cm and 15 cm. All module treatments in all cities were manually weighed daily using an electronic scale from May to August 2014. A decrease in the recorded weight over time is the measured rate in moisture loss (i.e. ET rate).

4. SUMMARY OF RESEARCH FINDINGS

(1) Different cumulative seasonal moisture and monthly average ET rates were observed at each study site due to different weather conditions (i.e. vapour pressure deficit and temperature) including cumulative rainfall from May to August. For instance, London and Halifax had relatively wet and warm summers, whereas Calgary had a relatively dry and cool summer during the 2014 field season. The monthly average ET rates in London were the highest throughout the season relative to the other sites, ranging from 1.04 mm/day to 2.22 mm/day. In Halifax, the range of monthly average ET rates were lower than London, ranging from 0.60 mm/day to 1.52 mm/day. Calgary had the largest range in monthly average ET ranging from 0.79 mm/day to 2.11 mm/day.

(2i) The ET rates between vegetated and bare media treatments are not always significantly different under non-moisture limited conditions. However, in the later stages of a drying period, vegetated treatments continue to transpire soil water. This results in a significant difference in the daily average ET rates between vegetated and bare media treatments when comparing the ET rates over the season. For example, in London, the daily average ET rate for vegetated treatments were 0.25 to 0.71 mm/day higher than the bare media treatments ($p<0.05$).

(2ii) *S. spurium*, *A. canadensis*, and *S. heterolepis* can be classified under plant types commonly referred to as succulents, forbs, and grasses, respectively. Of the three individual plant types used in this study, results suggests that *S. spurium* is more effective in reducing and attenuating runoff due its higher ET rates. *A. canadensis and S. heterolepis* are not drought resistant and qualitatively showed signs of wilting during long drying periods. As a result, these two plant types did not survive in Calgary. It should be noted that a limitation to this study is that only one species of each plant type was tested; therefore, there is a possibility that the grass and forb species chosen were not suitable for the weather conditions in Calgary.

(2iii) Mixed species treatments typically had higher ET rates compared to the single species treatments. The difference in daily ET rates between the mixed and single species treatments were not always significant and the results differed for different plant types and study sites. For example, in Halifax, there was no significant difference in ET rates between *S. spurium* and mixed species treatments. In contrast, the results from London indicated a significant difference in daily ET rates between the *S. spurium* treatment and mixed species treatment planted in 15 cm deep growth media.

(3) For the majority of the vegetation treatments in London and Calgary, plant survival and daily ET rates were relatively similar for all treatments irrespective of the growth media depth (10 cm and 15 cm considered). However, in Halifax, there was a significant difference ($p<0.05$) in ET rates between the 10 cm and 15 cm vegetation treatments, with ET rates being higher from the vegetation treatments in 15 cm media depth. The variability in the results across the sites require further investigation.

5. CONCLUSION

With 11 distinct climate regions in Canada (ECC, 2015), it is important to choose plant types which are suitable for the climate region and the harsh microclimate conditions on the urban roof environment. The three Canadian cities chosen for this study, Calgary AB, London ON, and Halifax NS, are found in three different climate regions: Prairies, Great Lakes/St. Lawrence, and Atlantic Canada, respectively. This research has provided insight on how regional weather conditions influences the seasonal range of ET from extensive green roofs in that region. More importantly, this research has highlighted the importance of selecting suitable vegetation types to optimize green roof design in Canada.

6. REFERENCES

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