2021

GREEN Project Executive Summary

UNIVERSITY OF SASKATCHEWAN

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Multi purpOse Slope Testing Facility
GLOBAL INSTITUTE FOR WATER SECURITY
MOSTFACILITY.USASK.CA

Western Economic Diversification Canada
Diversification de l'économie de l'Ouest Canada

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GREEN Project: Executive Summary

March 2021

Preamble:

This summary covers the findings from two years of research at the University of Saskatchewan Multi-purpOse Slope Testing (MOST) facility Green Roof Environment and EngiNeering (GREEN) project. This summary was written by Cody Millar, MOST facility lab manager.

1. Background

- A green roof is one that is partially or completely covered with vegetation and a growing medium (typically engineered soil substrate).
- Green roof technology is a key 'clean tech' approach used to reduce CO_2 emissions, improve storm water management in urban areas, improve urban air quality, reduce urban heat island effects, and amplify urban greenspaces.
- The benefits of green roof technology come with additional capital costs, but benefit from long term savings.
- Green roofs have been used successfully in many cities globally, but design and performance of green roof technology has been focused mainly on temperate regions.
- The performance and design of green roofs in very cold climates is far less extensive.
- In 2017 with seed funding from Western Economic Diversification Canada (WD) the MOST facility introduced a highly capable cold climate green roof testing facility.

The mission of the GREEN project is to help industry improve green roof design in cold regions by improving risk mitigation strategies, troubleshooting design challenges, improving the accuracy of green roof water retention assessments, and reducing green roof development costs.

Primary Investigators:

The GREEN project is composed of a multidisciplinary team of academics and industry professionals. The PIs are Cody Millar, Dr. Jeffrey McDonnell, Dr. Colin Laroque, Dr. Bing Si (University of Saskatchewan). Dr. Ali Ameli (University of British Columbia), and Michael Molaro (accredited Green Roof Professional).

2. Current Status

- The GREEN project has collected two full years of data, summarized in the *GREEN 2021 Data Summary Report* which can be viewed in its entirety at https://mostfacility.usask.ca/green/
- Continued data collection is ongoing.

3. Design and Data Collection

- The GREEN project at MOST was designed to collect data sets comparable to the University of Toronto Green Roof Innovation and Testing (GRIT) lab data sets, but in a cold climate setting.
- GREEN is composed of 8 roofs testing 2 unique soil depths and 4 unique soil mixes (Figure 1).
- Group A roofs (C1-4) have 15 cm deep soil profiles. Group B roofs (C5-8) are 10 cm deep.
- Test roofs are non-irrigated and were planted with an identical layout of drought tolerant sedum species (Figure 2).

- Each roof is outfitted with a suite of instruments that collects data on soil and air temperature, soil volumetric water content, soil electrical conductivity, and test roof outflow volumes.
- Regular photographs and vegetation health and coverage assessments are used to establish vegetation health outcomes (Figure 3).
- A co-located weather station collected local climate data: precipitation, temperature, humidity, and air pressure.

Research was focused on the following questions for the first two years study:

1. *How does planting bed soil depth effect vegetation health outcomes?*
2. *How does soil composition effect vegetation health outcomes?*
3. *How does soil depth effect water storage and release under cold climate conditions?*

4. Summary of Findings

How does planting bed soil depth effect vegetation health outcomes?

- Planting bed depth had a positive effect on vegetation health outcomes. Thicker planting beds (group A) showed greater vegetation surface coverage, survival rates and growth relative to the thinner beds (group B).
- Group A roofs had 70-90% surface coverage and substantial growth since planting.
- Group B roofs had 25-50% surface coverage and limited growth since planting.
- Thicker planting beds provided the following advantages:
  - Greater water storage capacity allowing for enhanced water reserves during dry periods.
  - Greater nutrient reserves relative to the thinner slopes based on volume of soil.
  - Slower responses to temperature shifts which act as a buffer, allowing plants time to adapt to temperature swings.

How does soil composition effect vegetation health outcomes?

- Findings relating soil mix ratios and vegetation health outcomes were inconclusive.
- The main component of all four unique soil mixes was Sopraflor X by Soprema Canada. This is a specially designed soil for extensive green roofs with vegetation such as sedums.
- Future testing should monitor soil macro and micronutrient content changes over time.
- Cold climate green roofs are likely more impacted by soil profile depths that by soil composition and its water retention ability.
- Soil composition should be chosen with vegetation species selection in mind.

How does soil depth affect water storage and release under cold climate conditions?

- Differences between group A and B water retention were small but not insignificant.
- Group A roofs retained a larger portion of their input water than group B.
  - In 2019 the group A roofs released 7.6% of their total inputs as liquid outflow. For the same time group B roofs released 10.5% of inputs as liquid outflow (2.9% difference).
  - In 2020 group A released 4.6% of total inputs as liquid outflow. Group B released 7% of inputs as liquid outflow (2.4% difference).

- For both 2019 and 2020 the bulk of outputs occurred during spring snowpack melt off and during summer rains.

5. Suggestions for Green Roof Construction in Cold Climates.

- Our findings suggest that soil profiles deeper than 10 cm are a better choice for long term vegetation health outcomes in cold climate regions.
- The thicker soil profile allowed for larger water storage capacity, likely higher nutrient reserves, and importantly a buffered response to temperature changes improving vegetation survival outcomes.
- The thicker soil profile roofs retained a larger portion of input water, which provides the benefit of slower storm water release.
- While the structural requirements to bear the load of a thicker soil profile roof would be higher, this thicker soil depth would provide added insulation benefits, which in turn could decrease CO_2 emissions from a heating and cooling perspective.

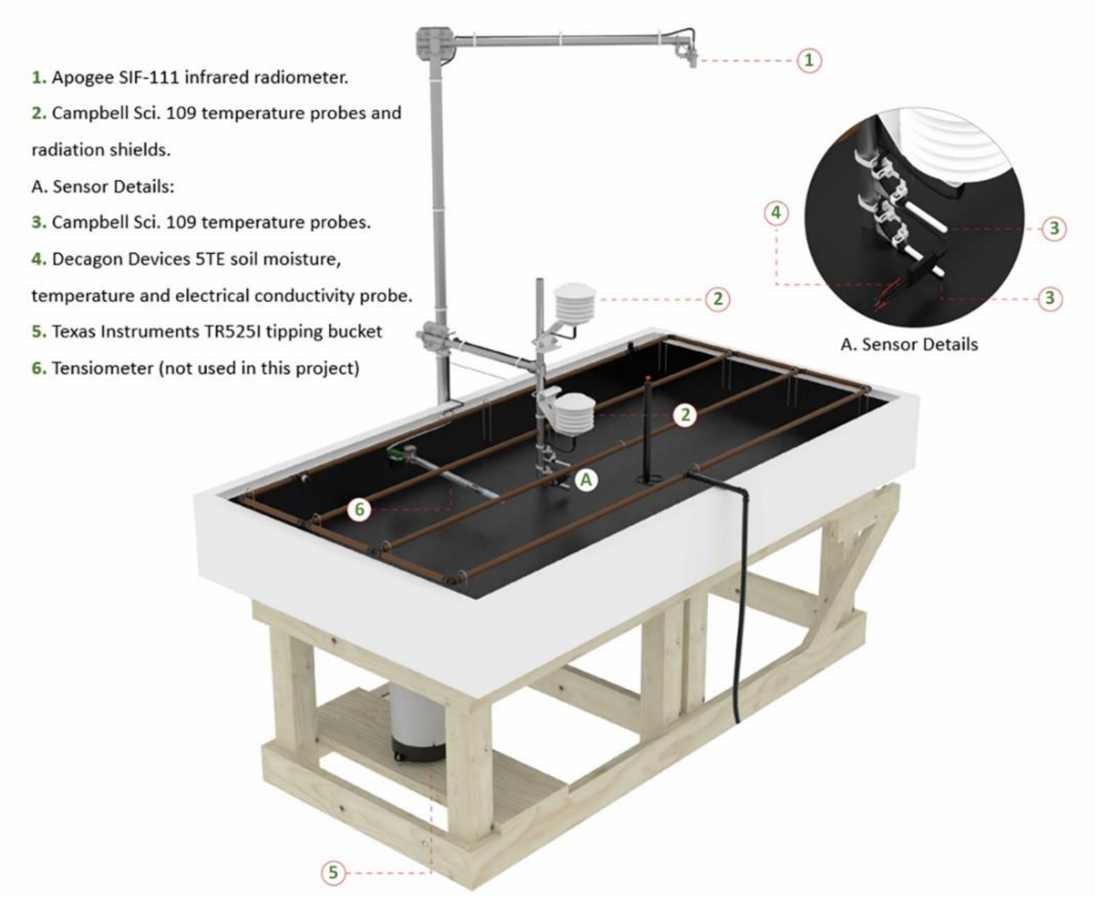

Figure 1: Example test roof and instrumentation of a GREEN test roof. Figure modified from original GRIT lab design schematic generated by Benjamin Matthews (2012). Reproduced with permission.

Figure 2: The four drought tolerant vegetation species used in the GREEN test roofs.

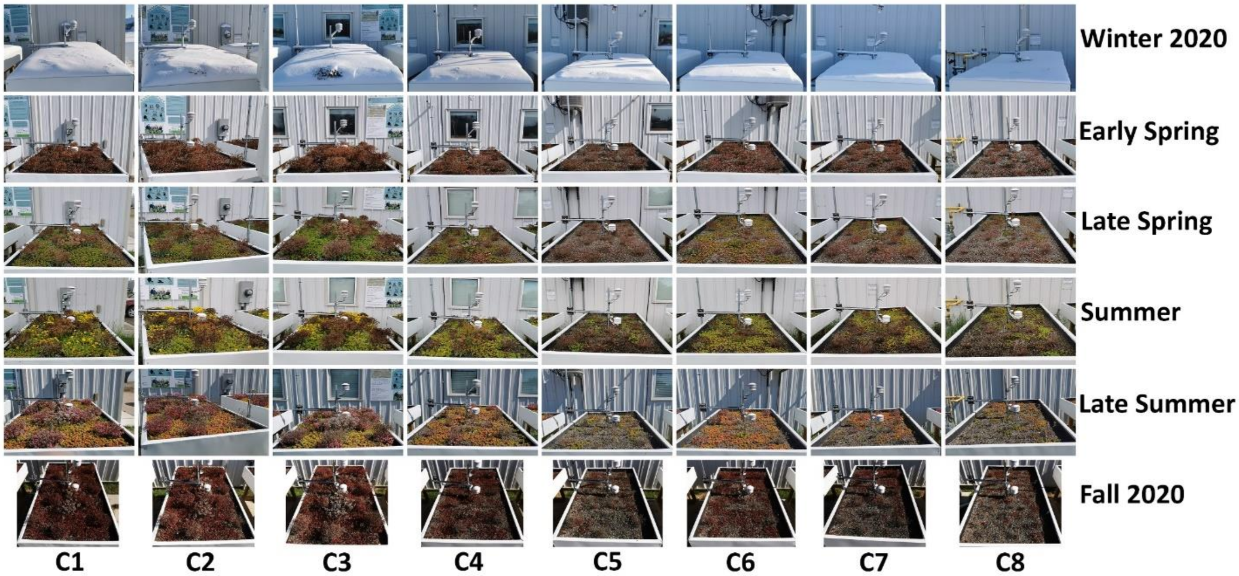

Figure 3: Photographic compilation of vegetation growth for 2020, the second year of test roof growth, at various seasonal points for all roofs. Note differences in vegetation cover and health between Group A (C1-4) and Group B (C5-8) roofs. Winter: January 14th, 2020; early spring: March 23rd, 2020; late spring: May 27th, 2020; summer: July 2nd, 2020; late summer: August 31st, 2020; fall: October 8th, 2020. The summer photo set is during peak blooming for test roofs.