Analyzing the Efficacy of the James Hall Green Roof

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Introduction

UNH's James Hall, the Earth Science building, underwent a renovation in 2010, earning a LEED Gold Certification for sustainability, due to its reusable water system, daylight harvesting, use of 30% reused materials, and a green roof. However, due to design issues, the green roof has gone unused. Our Innovation Scholars group took on the task of analyzing the efficacy of the roof and its potential application to other parts of UNH.

Methodology

We decided to focus our project on the two greatest benefits of green roofs:

1. **Green roofs improve heating and cooling efficiency by acting as an extra insulating layer, as well as lowering surface and nearby air temperatures.**
1. **Green roofs are highly effective for stormwater management because they absorb, store, and slowly release rainwater, reducing the volume and speed of runoff that enters drainage systems.**

To measure this data over some time, we chose to automate the process via Arduinos, as they can log data from sensors over time and store them into microSD cards.

Acknowledgements

A big thank you to our advisors, Matt Davis and Cheristy Jones, the MakerSpace, as well as the Innovation Scholars Program for making this possible!

References

[1] University of New Hampshire. (2016, October 24). *UNH's James Hall granted LEED Gold certification.* UNH Today. https://www.unh.edu/unhtoday/2016/10/unhs-james-hall-granted-leed-gold-certification

[2] United States Environmental Protection Agency. (2023, June 20). *Using green roofs to reduce heat islands.* https://www.epa.gov/heatislands/using-green-roofs-reduce-heat-islands

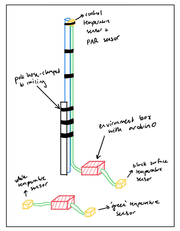
Engineering Design Process- Temperature

To fully analyze temperature, we compared:
- Surface temperature on the vegetation
- Surface temperature on the rest of the roof(white)

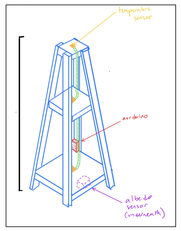
To:
- Surface temperature on a typical black roof
- Surrounding air temperature
- PAR(Photosynthetically Active Radiation)

To do this, we set up an Arduino with:
- 4 waterproof temperature sensors
- PAR sensor
- A timeclock to give data points a time of collection
- A MicroSD card reader

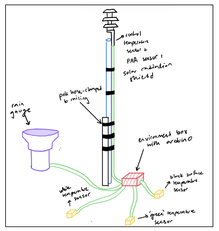
The Arduino was hooked up to a 6' PVC pipe and sensors were taped onto their various surfaces.



Design 1

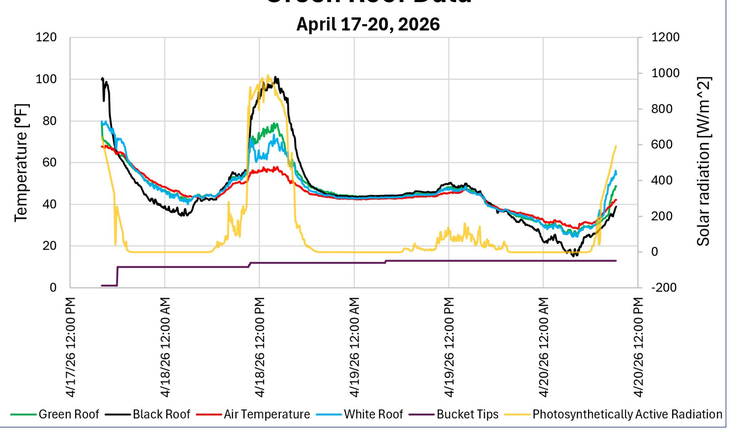


Design 2



Final Design

Final Data



Results

From our data, we can infer:
Temperatures across all surfaces aligned with PAR

During extreme heat, the white roof had the lowest surface temperature, followed by the green roof, while the black roof had the highest surface temperature.
- This is supported by the concept of **albedo**, which is the fraction of sunlight that is reflected by a body.
    - Black surfaces have an albedo of ~0, while white surfaces have an albedo of ~1

During colder temperatures, the green roof maintained the most of its temperature, followed by the white roof and the black roof.

The green roof curve is smoother than the other roof curves, suggesting reduced temperature extremes.

Overall, the results, supported by existing data, indicates that albedo influences peak temperatures, and green roofs offer the greatest temperature. This would likely be exuberated by the continuation of this project into the summer months.

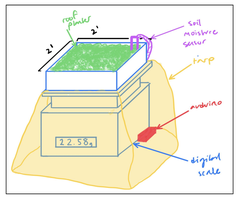
Engineering Design Process- Precipitation

To fully analyze precipitation, we created a system to record the absorption of rainwater that a planter could mitigate from going down storm drains:
- Water sensor
- Load cells

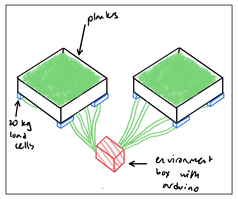
We then compared that data to our control:
- Rain gauge

How they all work together:
Inflow – outflow = amount of water in soil

Unfortunately, after running with the rest of our Arduinos, the load cells did not record data in time for our presentation at the URC.



Design 1



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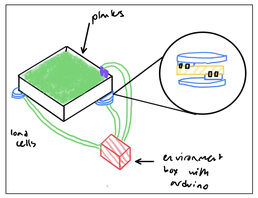
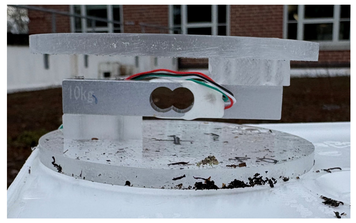


Final Design

Load Cell Design



Arduino load cells measure weight by strain gauges that deform under force, causing a change in electrical resistance and then is translated into a weight measurement.
- Initial plan was to stick the loads cells under the planters, but then we had to design an acrylic attachment once we did more research on how it actually works.

Conclusions

From this project, we were able to apply the engineering design process to ideate, test, and improve our ideas until they came into fruition.
- Working with Arduinos and how to build, test, and debug the code necessary for it
- Researching and testing a variety of new measuring instruments
- Sticking to a strict schedule for the amount of work we took on and making certain sacrificial decisions in our set ups, meanwhile investing in others too

From our perspectives on this project and our findings, we believe that the James Hall Green Roof needs further research to be conducted to fully consider all the aspects, positives, drawbacks, and trade-offs it brings. For these future projects (senior capstone), we recommend intensive testing to avoid mistakes in the future, as well as being adaptable to the unknowns.

We hope that our research and the future research it inspires can