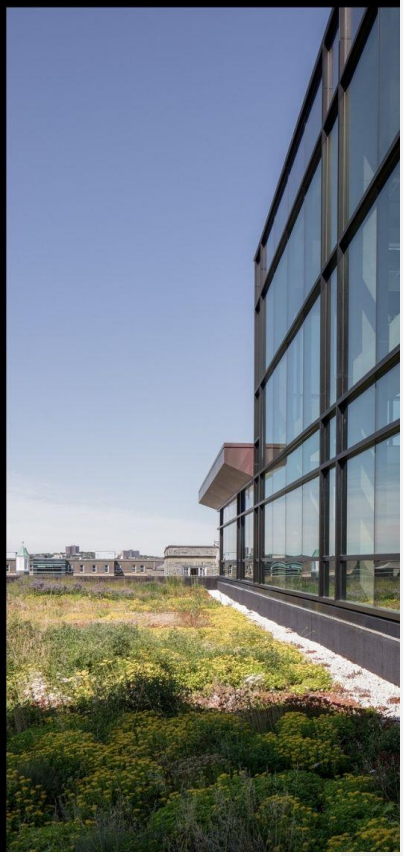
Growing Upwards: An Assessment of Student Perceptions on Studley Campus Green Roofs

ENVS/SUST 3502: The Campus as a Living Lab



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DALHOUSIE UNIVERSITY

COLLEGE OF SUSTAINABILITY

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Abstract

The rapid urbanization occurring in Halifax, Nova Scotia necessitates the implementation of carbon dioxide offsetting structures such as green roofs. This report seeks to investigate student perceptions of green roofs and the barriers present between students and information about green roofs on Studley campus at Dalhousie. It was important to gauge student's current knowledge to understand the origin and extent of this information. Previous research has been completed on the feasibility of implementing and improving green roofs at Dalhousie, although no further work has been done by the University. A short online survey was released to the undergraduate students to measure their current knowledge and future visions for Dalhousie green roof initiatives. We received 132 responses which displayed overwhelming support for green roof enhancement and implementation. Interviews with Dalhousie Staff and a literature review were also crucial in data collection. It was evident that students in the Faculty of Science are much more knowledgeable than non-science students on the existence, advantages, and definition of green roofs. However, there is no significant difference in knowledge about green roofs and willingness to support projects. The findings also indicate that students would be interested in open access to intensive green roofs for study purposes. Further analysis should be completed on the feasibility of implementing faculty-wide sustainability modules, so all undergraduate students are supported in making informed decisions.

Keywords: Green Roofs, Sustainability, Perceptions, Open Access, Student Knowledge, Halifax, Campus, Faculty, Students

1.0 Introduction

Development is an ongoing action that is happening in our evolving world. Development encompasses many different aspects including economic growth, industrial and infrastructure advancements while growing social equity, environmental sustainability, and technological innovation. The topic is more prevalent in today's world and focuses on sustainability and how our development can become more sustainable and environmentally friendly. Addressing this issue along with sustainable development Goals (SDG) has been in the spotlight with more initiatives to implement infrastructure in relation. So, what does sustainable development impose? Sustainable development looks at human and infrastructure development while considering the environment, and society while considering intra and interdisciplinary equity (Hoai-Anh et al., 2023). Sustainable development correlates with the United Nations Sustainable goals that are set out to be reached by 2030 by improving human health, equity, and decreasing the effects of change.

One way both topics can be satisfied is by implementing green infrastructure which can be described as infrastructure consisting of natural and semi-natural components while delivering ecosystem services (Hoai-Anh et al., 2023). Green infrastructure provides many benefits as they can decrease energy and water consumption, minimize waste generation, safeguard biodiversity, and enhance both health and social well-being. These infrastructures are available in different forms such as green roofs, green spaces, and green walls (Hoai-Anh et al., 2023).

Recent research on sustainable development shows that individuals who interact with green infrastructure can grow their understanding of environmental education and social sustainability. This knowledge can shift individuals to have a pro-environmental attitude which is important for encouraging future action, educating, and awareness about climate change and sustainability (Hoai-Anh et al., 2023). Universities become a perfect place to implement green infrastructure as they can promote education with sustainable practices (Hoai-Anh et al., 2023).

After exploring different types of sustainable infrastructure this paper is going to focus on green roofs. Green roofs, also known as living roofs, are a revolutionary approach to modern architecture and environmentalism, blending nature and urban development. Green roofs revolve around the cultivation of vegetation on rooftop spaces, transforming them from man-made structures to elaborate ecosystems. Although this concept has gained substantial popularity in

recent decades, it is not a modern innovative concept but rather an evolution of ancient practices (Innova Top Green, n.d.).

A green roof system typically consists of several layers, including a waterproof membrane, root barrier, drainage system, growing medium, and finally, the vegetation layer. These components are designed to support plant life without compromising the structural integrity of the building. The choice of plants varies widely, from native grasses to shrubs; elaborate gardens can include shrubs and small trees, depending on the roof's structural capacity and the climate. (Lampert, 2020)

The environmental advantages of green roofs are profound. Green roofs absorb and retain a substantial portion of rainfall, thereby mitigating runoff and easing pressure on stormwater infrastructure. Cities often suffer from higher temperatures due to the vast expanse of concrete and asphalt (Climate Atlas of Canada, n.d). Vegetation on green roofs cools the air through evapotranspiration, reducing the ambient temperature around buildings and contributing to a cooler urban environment. Green roofs improve air quality by filtering pollutants and particulate matter from the air. The plants on green roofs can capture airborne pollutants and sequester carbon dioxide, contributing to the reduction of greenhouse gases in the atmosphere (EPA, 2023). Addressing critical issues such as stormwater management, energy consumption, habitat creation, urban heat, and air quality. Cities implementing more sustainable infrastructure is a key steppingstone to achieving SDGs, creating healthier, more resilient, and more livable urban spaces.

1.1 Literature Review

Much research on green roofs focuses on environmental benefits and less about the perception of aesthetic and social benefits (Jungles et al., 2013). Studies have also shown it was statistically significant when participants with prior green roof knowledge rated the environmental benefits higher than those who did not have any knowledge (Hoai-Anh et al., 2023). A survey was done in 2009 at Temple University where students were asked about green roofs and many of them were unfamiliar with the topic (Jungles et al., 2013). Research has stated the perception between intensive and extensive green roofs. Extensive green roofs employ a minimal substrate depth that supports basic plant types, reducing weight and maintenance

demands and typically limiting public access. Intensive green roofs, conversely, use deeper layers of soil to support a diverse array of plants and accessible recreational spaces. (Holcim Elevate, n.d.) Semi-intensive types combine these features, providing moderate plant diversity and optional public accessibility (Holcim Elevate, n.d.). Typically, it's found that intensive green roofs are more preferred than an extensive green roof (Jungles et al., 2013). An interesting study was done in Singapore where the perception of intensive green roofs on high rise apartments were looked at. The findings show that awareness (90%) and willingness to use them (84%) were high although only 17.7% used them. While many of the respondents explained that they would rather visit ground level parks as they were more accessible (Yuen & Wong, 2005).

There have been research groups at Dalhousie University that have investigated this topic before. Many of them focused on the feasibility and benefits of constructing new green roofs at the university. In 2006 a feasibility analysis for implementation of a green roof on the Kenneth Rowe building was conducted. The report explains that the implementation of a green roof could be economically beneficial over time. An accessible intensive green roof without planters would be the most beneficial. However major economic barriers were found as there was simply not enough funding compared to the cost of the green roof (Luus et al., 2006). The results are correlated with a separate group of researchers at Dalhousie that asked multiple faculties their support and opinions on alternative funding for a green roof. Support for green roofs was found although alternative funding methods such as diverting their departments funds for development was not supported (Copley et al., 2007). An Additional study done on campus highlighted that implementing green roofs at Dalhousie University could reduce their carbon emissions by 7% (Macdonald et al., 2016).

1.2 Purpose

When trying to further our knowledge regarding green roofs, we noticed a large disconnect of knowledge. This drew us to want to understand other Dalhousie undergraduate student's perspectives and knowledge regarding the topic. With further research conducted through online surveys, we were able to analyze the results to learn more about these disconnects between students. Specifically analyzing the knowledge of green roofs on the Studley campus between science and non-science undergraduate students. Through background knowledge

collected from past university studies and studies conducted globally, we were able to further our knowledge regarding the topic. As well, through conversations with faculty members at Dalhousie we observed a significant disconnect of knowledge and information regarding Dalhousie green roof initiatives. This led to the formulation of our research question: *What are Undergraduate student's perspectives and knowledge of green roofs on the Dalhousie's Studley campus?*

The study's research objectives aim to explore various aspects of information accessibility and comprehension among students. The study also seeks to differentiate the level of knowledge between science and non-science students, gauge student interest in accessing diverse types of information, and develop strategies to minimize the knowledge gap. These objectives collectively strive to enhance information literacy and accessibility for educational advancement.

2.0 Methodology in Review

The procedures began with an intensive literature review to gain a thorough understanding of green roofs, which was discussed earlier in the paper. To deepen our understanding, we met with Alexa Goodman from the College of Sustainability to gain insight into developing our report in hopes of helping future projects on campus. We were then able to develop a series of survey questions which we later designed a poster to advertise the survey. After collecting responses, we closed the survey and analyzed the data to gain some insight.

2.1 Gathering Data

An extensive literature review was conducted to ensure a comprehensive understanding of green roofs both in a general sense and with a scope on Canadian Universities. This was done using various search engines such as Google Scholar and Novanet which is provided through Dalhousie's Libraries. In addition to published articles, they were complimented with searches for new articles and other general websites. To gain further understanding we conducted interviews with Alexa Goodman on Microsoft Teams from the College of Sustainability where they provided the research team with a new perspective that helped guide. This alignment with

Alexa enables the research to be beneficial for the college in hopes of further development of the research topic.

2.2 Sample Size

The focal of the research was undergraduate students at the Dalhousie University Studley Campus. This area was selected because of the accessibility of the area. Studley campus is comprised of primarily undergraduate classes and buildings all in a small area around the "quad", which was appealing to collect data from a large sample size in a short amount of time. The survey posters were posted in the Kenneth C. Rowe Management Building, Student Union Building, Le Merchant Place, Killam Library, Chemistry Building, Wallace McCain Learning Commons, Computer Science Building, Life Science Centre, and Collaborative Health Education Building. This was in the goal to collect data from all faculty and programs across campus.

2.3 Developing the Survey Questions

Using the literature review and Alexa Goodman's input the development of the survey questions came together. The set of questions went through various revision phases and feedback from Professor Caroline Franklin and Alex Legault before settling on the final approval by the department with the finalized set of 16 questions. The survey was conducted by Google Forms which was an accessible and user-friendly software. The survey intended to collect both qualitative and quantitative data by asking various styles of questions. These include multiple choice, open-ended, Likert scale, and number-response questions. This pool of diverse questions contained a variety of questions from simple to more complex answers for a dynamic answering style.

2.4 Survey

The 20 printed posters were posted around the Studley campus. The posters and survey opened on March 9th, 2024, and closed on March 21st, 2024. During these 12 days of the survey being active, there was a collection of 132 responses. When compared to the undergraduate student population of around 16,000 students, the survey reached 0.83% of Dalhousie's student body.

2.5 Data Analysis

The data was collected from a Google Forms survey and was transferred over to an Excel sheet where the data could be sorted and prepped for further analysis. Specific data was chosen to be shown visually by creating bar graphs through Excel. The aim and scope of the data analysis was focused on a comparison between science and non-science students where all testing was looked at alpha 0.05. This entails that we are 95 % confident in our results as there could be a 5% margin of error. A Chi-square test was used to determine if there was a significant difference in responses between science and non-science students. The Chi-square tests were run on an online Chi-square calculator. There was a specific parameter used to ensure the test is valid for the test called Yates parameter as some of the expected frequencies were below 1 or less than 5 in more than 20% of the cells (Preacher, 2001).

In comparing the mean responses of science against non-science students, a two sample T-test, assuming unequal variance was used to quantify if there was a statistically significant difference in mean values. This method was chosen due to the sample groups having a different number of responses (Science ~50 and non-science ~80). The three variables quantified or scored in this instance, willingness to support green roof enchantments on campus, knowledge of green roofs on the Studley campus, and ability to define what a green roof is.

Willingness to support green roof enchantment was scored from 1-5, 1 being opposed and 5 being fully supportive. Knowledge of green roofs on campus was scored out of three due to there being three correct responses out of the five possible options, in addition to this a point was taken away for every incorrect response selected. The student response in defining a green roof were scored on a scale of 1-6, one point was granted for stating that a green roof is a rooftop with vegetation, an additional point was granted for mentioning each of the key characteristics of a green roof, them being: water management, air purification, heat dispersion, biodiversity enhancements and social benefits. All these scores were divided by their max possible response score (5, 3, 6) to get the proportion of the best score indicating the most knowledge/support. These proportions were then graphed in **Figure 10** to compare the response from science and non-science students.

In addition to this a regression was run to see if there was a relationship between willingness to support and the knowledge level on defining green roofs and of their location on campus. In this analysis willingness to support was considered the dependent variable with knowledge being the independent.

The production of the coded word cloud was done using Free Word Cloud Generator (Free Word Cloud Generator, n.d.). Responses were coded from the question asking students to define a green roof. The response was coded using a posteriori method to ensure the data coded is based on emergent themes in responses. Correct responses for defining a green roof were coded as "Green roofs" and the other correct or incorrect responses (attributes of green roofs) were coded based on common responses among the students.

3.0 Results:

3.1 Background Information

Table 1: Displayed below is a frequency table for the total responses of what faculties the students were in that participated in the survey.

Faculty	**Frequency**	**Percent**
Management	51	38.6%
Science	50	37.9%
Engineering	4	3%
Computer Science	3	2.3%
Health	15	11.4%
Arts and Social Science	16	12.1%
Architecture and Planning	1	0.8%

Table 2: The frequency table below represents the total response for year of study that's students were in that participated in the survey.

Year	Frequency	Percent
1	5	3.8%
2	17	12.9%
3	64	48.5%
4	36	27.3%
5+	10	7.6%

3.2 Student General Knowledge

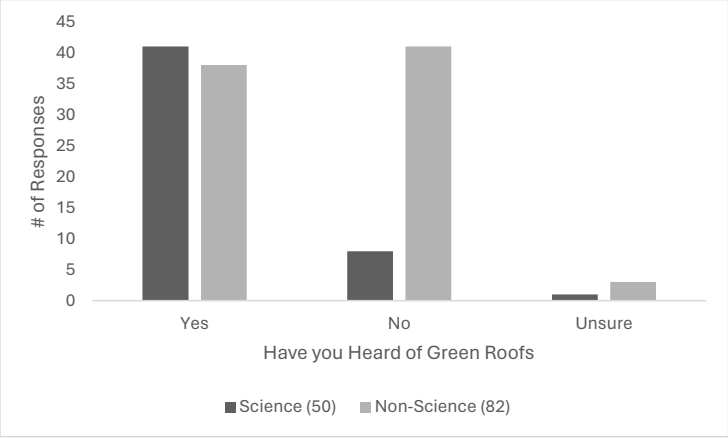

Figure 1: Shown above is the comparison of response distribution (Yes, No, Unsure) among science and non-science students regarding their awareness of green roofs.

Using the response distribution in **Figure 1**, a Chi-square test was performed with Yates parameters to make the test appropriate. This test was chosen to see if there was significant difference in responses between science and non-science students. Based on the analysis it was determined that there was significant difference in response between science and non-science students regarding their awareness of green roofs. The test revealed a Yates Chi-square of 14.795 and 2-degrees of freedom. This was found significant with a Yates p-value of 0.00061278 at alpha 0.05 as $p < 0.05$.

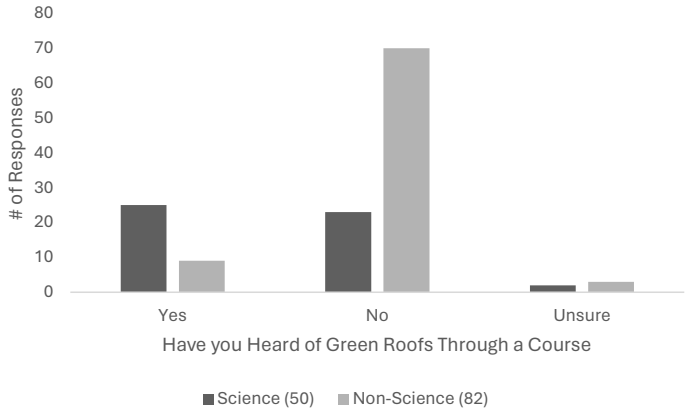

Figure 2: The bar graph above represents a distribution analysis of (Yes, No, Unsure) between science and non-science students regarding information of green roofs through a course at Dalhousie University.

The analysis depicted in **Figure 2**, is important insight to test the disparities in responses between science and non-science students if they have been informed of green roofs within a course they have taken at Dalhousie University. To test if there was a significant difference among the two groups a Chi-square test was performed with Yates parameters for the test to be declared appropriate. The test deemed that there was in fact a significant disparity amidst science and non-science students. The results indicated a Yates Chi-square of 23.297 with 2-degress of freedom. The responses resulted significant with a Yates p-value of 0.00000873 at alpha 0.05 as $p < 0.05$.

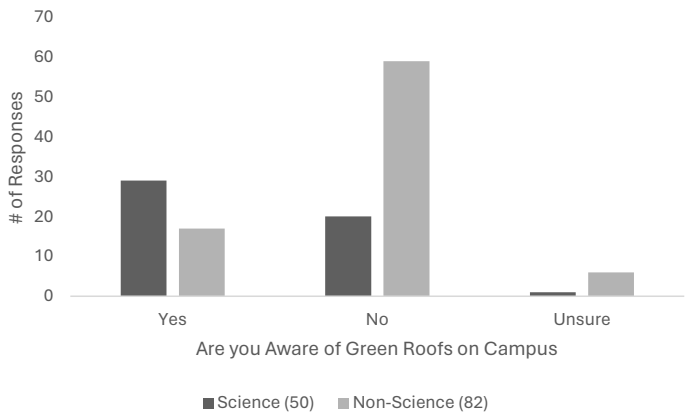

Figure 3: Represented above is a response comparison (Yes, No, Unsure) amidst science and non-science students regarding their knowledge of their being any green roofs on Dalhousie Studley campus.

To analyze the student knowledge surrounding green roofs on Studley campus we referred to the data shown in **Figure 3**. The data was used to test the difference in responses among science and non-science students. The test chosen for this scenario was a Chi-square analysis with Yates parameter to ensure the test is appropriate. The findings from this analysis show that there was a significant difference in responses between the two groups. A Yates Chi-square of 16.916 with 2-degrees of freedom were gathered from the results. The was seen as significant with a Yates p-value of 0.0002122 at alpha 0.05 as $p < 0.05$.

3.3 Willingness to Support

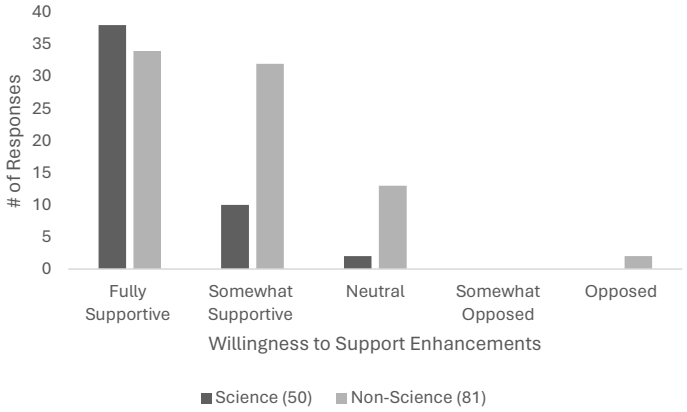

Figure 4: The graph above displays a distribution comparison (Fully Supportive, Somewhat Supportive, Neutral, Somewhat Opposed, Opposed) among science and non-science students regarding their willingness to support green roof enhancements on Studley campus.

Using the distribution comparison in **Figure 4,** a Chi-square test was completed with Yates parameters to ensure the tests correctness. The test was chosen to determine if there was a significant difference in responses between science and non-science student when asked about their willingness to support green roof enhancements on Studley campus. According to the results there was a significant difference found among the two groups. The test showed a Yates Chi-square of 12.079 with 4-degrees of freedom. This was deemed significant with a Yates p-value of 0.01677337 at alpha 0.05 as $p < 0.05$.

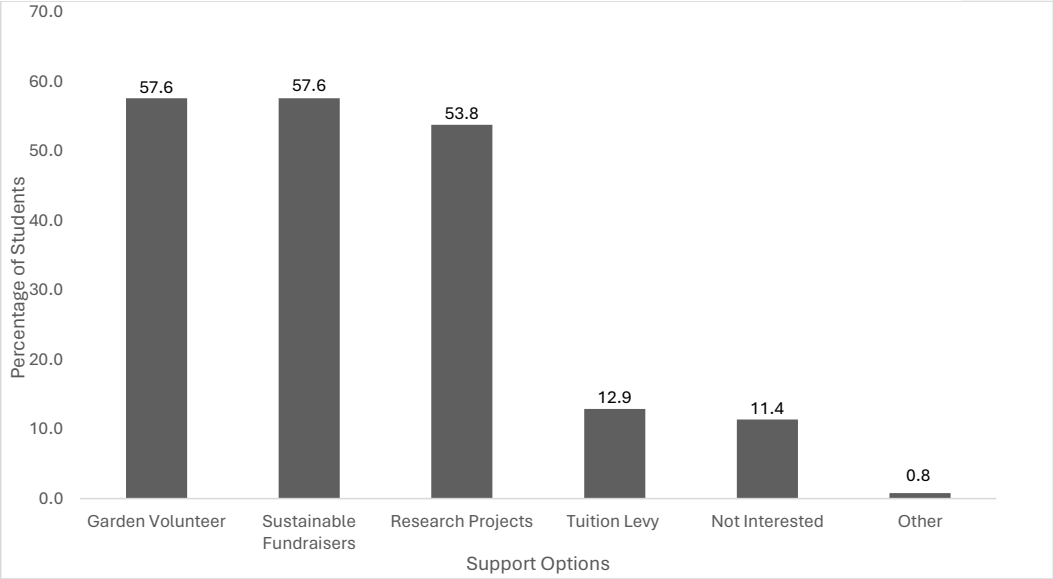

Figure 5: The graph above represents the percentage of student responses regarding the green roof support options that Dalhousie students would take part in.

3.4 Personal Perspectives

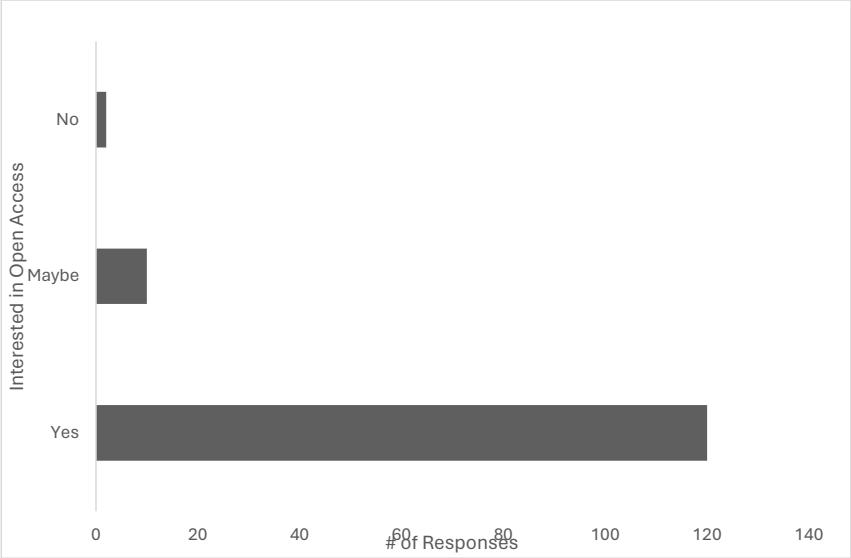

Figure 6: The bar graph seen above displays the distribution of responses (Yes, Maybe, No) regarding student interest in open access of green roofs on Dalhousie Studley campus.

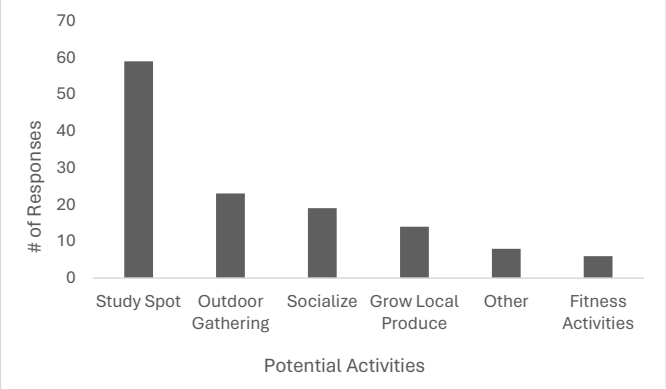

Figure 7: Displayed above is the distribution of response (Study Spot, Outdoor Gathering, Socializing, Growing Local Produce, Other, Fitness Activities) for what potential activities students would use the green roofs for.

3.5 Overall Interest in Additional Green Roofs on Campus

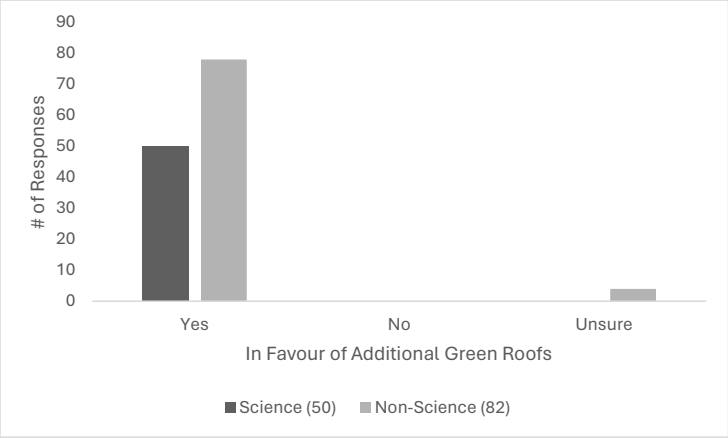

Figure 8: Represented above is the distribution of responses between science and non-science student regarding their opinion of additional green roofs on Dalhousie's Studley campus.

For further analysis the data from **Figure 8** was used to conduct a Chi-square test with Yates parameter to ensure for test to be deemed acceptable. This test was selected to determine whether there was a significant difference among science and non-science students regarding student in favor of additional green roofs on Studley campus. The test was deemed insignificant as there was no significant difference in response between the two groups. The results displayed a Yates Chi-square pf 1.377 with 2-degrees of freedom. There was no significance found with the Yates p-value 0.502329 at alpha 0.05 as $p > 0.05$.

3.6 Science vs Non-Science Students

t-Test: Two-Sample Assuming Unequal Variances

	Willings to support enhancments (Score) (NS)	*Willings to support enhancments (Score) (S)*
Mean	0.837037037	0.944
Variance	0.031111111	0.011493878
Observations	81	50
Hypothesized Mean Dif	0	
df	129	
t Stat	-4.316795711	
P(T<=t) one-tail	1.56332E-05	
t Critical one-tail	1.656751594	
P(T<=t) two-tail	3.12665E-05	
t Critical two-tail	1.978524491	

t-Test: Two-Sample Assuming Unequal Variances

	Definition Correctness (Score) (NS)	*Definition Correctness (Score) (S)*
Mean	0.907407407	1.49
Variance	0.638194444	1.535612245
Observations	81	50
Hypothesized Mean Dif	0	
df	74	
t Stat	-2.96565673	
P(T<=t) one-tail	0.002031926	
t Critical one-tail	1.665706893	
P(T<=t) two-tail	0.004063851	
t Critical two-tail	1.992543495	

t-Test: Two-Sample Assuming Unequal Variances

	Knowledge of Green Roofs Locations on Campus (Score) (NS)	*Knowledge of Green Roofs Locations on Campus (Score) (S)*
Mean	0.456790123	1.26
Variance	1.276234568	1.543265306
Observations	81	50
Hypothesized Mean Dif	0	
df	96	
t Stat	3.719948301	
P(T<=t) one-tail	0.000167767	
t Critical one-tail	1.66088144	
P(T<=t) two-tail	0.000335534	
t Critical two-tail	1.984984312	

Figure 9: T-test results comparing mean responses for Science and Non-Science Students were significantly different for 3 variables. Willingness to support P = (3.126e-5), Correctness of defining a green roof P = (4.064e-3) and knowledge of green roof locations P = (3.355e-4).

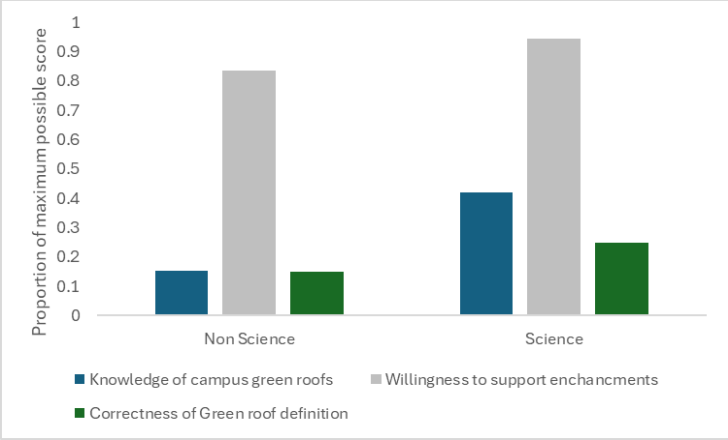

Figure 10: The graph shows the mean proportion of scores (y-axis) for each variable for the specific faculty (x-axis). Knowledge of the location of green roofs on campus (blue) science students = 0.42 and non-science = 0.15, willingness to support green roof enhancements on campus (grey) science students = 0.94 and non-science students = 0.84 and correctness or knowledge of green roofs in general (green) science students = 0.25 and non-science students = 0.15.

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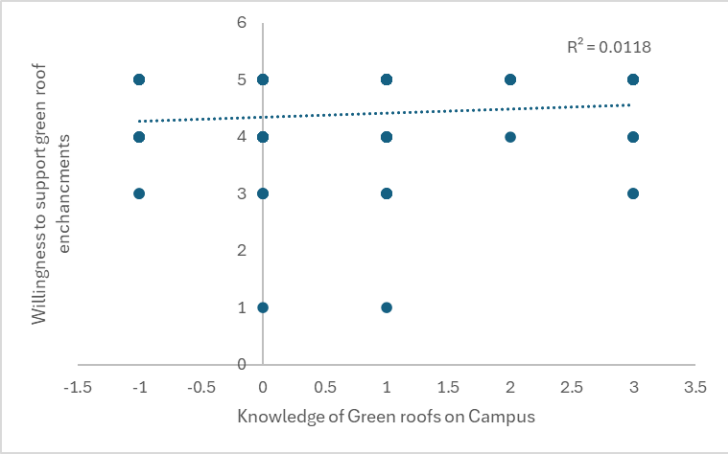

Figure 11: This graph shows the relationship between the knowledge level of green roofs on campus and a student's willingness to support green roof enhancements. This regression analysis ($R^2 = 0.0118$) shows a weak relationship between variables.

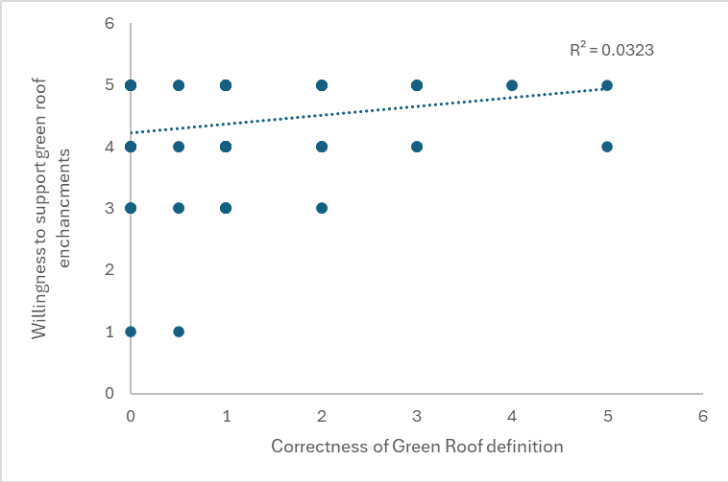

Figure 12: This graph shows the relationship between a student's ability to correctly define a green roof and common attributes to a student's willingness to support green roof enhancements on campus. This regression analysis (R^2 = 0.0323) shows a weak relationship between variables.

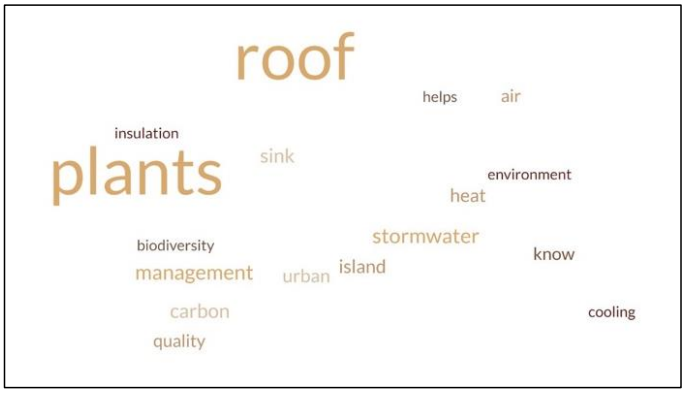

Figure 13: A word cloud of coded responses of science students in defining what a green roof is. Response's size was based on the frequency of responses.

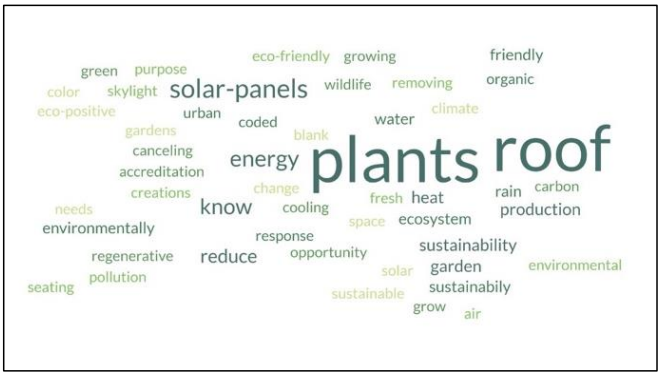

Figure 14: A word cloud of coded responses of non-science students in defining what a green roof. Response's size was based on the frequency of responses.

4.0 Limitations and Constraints

This project had various delimitations which are constraints set by the researchers and limitations which are constraints beyond the researchers' control, which are outlined below:

Table 3: Represented below are the limitations and constraints delt with throughout the study.

Delimitation	**Description**
Sample Population	This project only focused on Undergraduate students on the Studley campus. This inherently decreases the sample population to those on campus and excludes any Tupper and Sexton Campuses undergraduate students.
Limitation	**Description**
Time	The study was restricted to the academic winter semester from January to April. The time frame inherently contributes to a smaller sample size, making results less confident.

Number of responses	Without hitting the sample size goals, the results do not properly represent the undergraduate population at the Dalhousie Studley campus.
Response bias	This limitation occurs from individuals filling out the survey because they are interested in the topic. Since the advertisement used posters, individuals are choosing to approach it. This can affect the results and skew the data.
Validity of responses	The collected data from the survey reveal an unknown aspect of validity of the responses. This would stem from untruthful answers and people viewing themselves higher than in the responses.

5.0 Discussion

5.1 Research Purpose

The purpose of our study was to gain an understanding of undergraduate students' current knowledge and perspectives on the benefits, support, and proposed usage of Studley campus green roofs. Intrigued by the lack of public information made available to students and staff, we aimed to investigate this gap in knowledge. It was hypothesized that students belonging to the Faculty of Science would generally be better educated on green roofs and campus efforts. By increasing the level of knowledge about green roofs, students can be better informed, and a heavier emphasis may be placed on sustainable initiatives.

5.2 Significant Findings

The survey yielded a total number of 132 respondents with 48.5% in their 3rd year of studies. Only 79 (59.8%) students had heard of a green roof before (Fig. 1) with 46 (34.8%) being aware of green roofs on Dalhousie's Studley campus (Fig. 3). Meaning more than half of the participating students have attended the school for at least three years and had little to no knowledge of green roof existence on campus. This could be attributed to the fact that sustainability courses are not required for students outside of the program. This was shown as only 34 (25.8%) respondents had

learned about green roofs through a Dalhousie offered course (Fig. 2) only 9 were non-science students.

To further explore the differences between the level of knowledge in science and non-science students, frequency comparisons were made for all knowledge-based results. With a response rate of 50 science students and 82 non-science students the results were fairly representative of the population. In terms of having heard about green roofs, the test revealed a Yates p-value of 0.00061278 at alpha 0.05, meaning science students were significantly more knowledgeable when compared to non-science students (Fig.1). The same can be said for school course experience with a Yates p-value of 0.00000873 (Fig. 2) and for knowledge of green roofs on campus at 0.0002122 (Fig. 3). Most science students possess an introductory biology background giving them baseline environmental knowledge, this would account for the large differences found in these analyses.

Regarding willingness to support green roof enhancements, analyses were completed to determine if faculty affected the inclination to upgrade these environments. Assessing at alpha 0.05 as $p < 0.05$, the relationship was deemed significant with a Yates p-value of 0.01677337 (Fig. 4). Both groups voted quite heavily in support, with science students having a stronger stance on improvements. Implying that even those who did not know what a green roof was at the start of the study, were interested in enhancements to the campus. Most students were interested in supporting these projects through volunteering in the garden and participating in fundraising activities, both 57.6% in favor (Fig. 5). However, when asking about the implementation of additional green roofs we received a differing result as there was no significance found with a p-value of 0.502329 (Fig. 8). Which could imply that there is an understanding of the cost, effort, and time that would be required in new construction projects.

To better understand the relationship between student knowledge and willingness to support enhancements, a regression analysis was utilized quantify this relationship. It was found that there was a weak relationship between willingness to support and knowledge of green roofs on campus ($R^2 = 0.0118$) (Fig. 11). Students did not need knowledge on the subject to determine if they wanted to aid projects on campus. To further explore the relationship between knowledge level and willingness to support, a secondary regression analysis was completed on the "correctness" in defining a green roof. With results showing ($R^2 = 0.0323$) a weak positive relationship was still

apparent (Fig. 12). Although willingness to support does slightly increase with education, it is not conclusive.

Another method used to gauge the knowledge difference between science and non-science students was to use a coded word cloud with emphasis on the most frequently used word. For both science and non-science students' "plant" and "roof" were the top words. However, the key indication of the knowledge difference is how science students will correctly describe the concept in few words (Fig. 13), whereas non-science students have more variability in their responses showing less confidence in their definition (Fig. 14).

A final t-test was executed using the proportions of campus green roof knowledge, willingness to support, and ability to define a green roof. In which there was a strong significant relationship between the means at t= 3.126e-5 as science students perform better in each category (Fig. 9). Confirming our theory that science students will be more knowledgeable about sustainable initiatives due to their educational background.

Our findings also outlined the aspirations students have for green roofs on campus. 90.9% of students answered that they would be interested in having open access to a campus green roof (Fig. 6). The remaining 9.1% were either unsure or against open access partially for the reasoning that they enjoyed green roofs as a passive resource, undisturbed by human interference. When asked how they would be interested in using a green roof, the leading response was study spot at 59 votes and outdoor gathering at 23 (Fig. 7). Seeing this overwhelming support for green roof usage and community involvement is inspiring for future green roof efforts.

5.3 Interpretation Based on Prior Research

A similar assessment was completed in 2007; Higher Learning – Greening the Kenneth Rowe Roof, which revolved around faculty perceptions and the accompanied challenges of implementing a green roof. From comparing the findings of the study, it was evident that Dalhousie faculty members were much more knowledgeable than students. It was also discovered that 48% of participating faculty members could identify a course that could benefit from green roof usage (Copley et al., 2007). Considering that our results indicated that 90.9% of students would be interested in green roof access (Fig. 6), university course work could be a great opportunity to

provide them with that. A significant difference between studying students and faculty is the way in which they would prefer to utilize access to green roofs. Faculty would support green roofs based on their environmental (28%) and educational (23.5%) benefits (Copley et al., 2007). By completing our study, it is apparent that students value the educational aspect, but more heavily focus on social benefits such as through study spots or outdoor gatherings (Fig. 7).

5.4 Implications

Based on the results, students do not have the ability to make informed decisions about Studley Campus green roofs, the low self-efficacy will result in less drive to improve campus. Our research outlined the environmental benefits, locations, and potential usage options on campus. By providing this information to students, they can have greater control over their desires for sustainability-related projects on campus. A deeper understanding of environments on campus can translate into better sustainable behaviors in student's everyday lives. Continuing to seek improvements all environments on Dalhousie campus would make the institutional an ideal candidate for a platinum STARS rating, which is a current objective of the Office of Sustainability. Green roofs specifically can improve Dalhousie's ratings for building design, landscape management, rainwater management, and building energy efficiency (STARS, 2021). Recent platinum star recipient, the State University of New York, is admirable in their green roof efforts. They use native plants sourced from Lake Ontario, complete student research projects, use sedum as building insulation, and offer students open access to one of the roofs (ESF, n.d.).

5.5 Future Recommendations

Considering the shocking lack of knowledge about the existence of green roofs and their corresponding environmental benefits, it is suggested that a mandatory sustainability Brightspace module be provided to students. Ideally students would be required to take a 3-credit sustainability course, such as how there is a writing or math requirement. However, this would be a large program adjustment, so our suggestion is an institution wide module to be completed before graduation to educate students as well as to determine student aspirations. Through this course, students will

become more aware of sustainability efforts on campus and have a better understanding of how they can get involved.

It is also essential to publish green roof information on Dalhousie websites so interested parties have access. The current subsection dedicated to green roofs on the Dalhousie public website is very vague and does not even include the locations of green roofs. To bridge the gap between students and sustainability information, it is suggested an inventory be completed of green roofs and uploaded for open access. It is our hope to promote the construction of additional green roofs on campus, as in accordance with our results, there is overwhelming support and desire for these projects. This information aims to help the Office of Sustainability at Dalhousie to determine the feasibility of funding enhancement projects.

An impact assessment should also be completed to ensure the practicality of installing additional green roofs on uninhabited buildings. Although these analyses have been briefly completed by past student projects for the Life Sciences Center (LSC) (Blok et al., 2009) and the Kenneth C. Rowe (Copley et al., 2007), these projects do not consider funding opportunities, native plants, collaborations, or the official roof inventory. A professional would provide a better assessment into feasibility which should be considered by Dalhousie. Considering the amount of interest in green roof usage and enhancement. It is recommended that Dalhousie allocate additional funding to the data collection and analyses of these environments.

5.6 Predicted Barriers

Despite the various environmental and social advantages of enhancing and implementing green roofs on campus buildings, construction is often a large undertaking. Dalhousie would need to allocate funds to these projects or rely on external funding opportunities which can be difficult to obtain. If external funding is not possible, Dalhousie may seek an increase in tuition in order to support these campus projects. Many students may be opposed to paying additional tuition or levy fees for green roofs, regardless of the support displayed in the survey. The university itself may also not be equipped to take on any more development projects in the next couple years. Currently Dalhousie has many large active projects including the Killam Deep Energy Retrofit, Oulton Stanish Centre, Arts Centre expansion and a few others (Facilities Management Dalhousie, n.d.).

Proposed projects can take years for approval, collection of funds, and implementation strategies and Dalhousie may not be willing to invest in any other projects in the near future.

In survey questions, it is easy to assume you would take your time to support projects in general. However, this is not an accurate assessment of the commitment associated with the responses. Providing open access to the public would be immensely beneficial for research and general knowledge purposes. However, Facilities Management would be tasked with executing a green roof inventory of all the buildings, creating a report, and the Office of Sustainability would need to analyze the information, publish it, and ensure updates are current. In short, this is a task that would need to be overseen by Dalhousie.

Based on the results, it is unlikely that allocating resources to improve students' knowledge of what a green roof is or their existence on campus would have a significant impact on a student's willingness to support green roof enhancements on campus. This is supported by low R^2 values indicating that the variance in the independent variable can predict the variance in the dependent (Willingness to support).

6.0 Conclusion

This study concludes that our research highlights a significant gap in the knowledge and understanding of green roofs among students at Dalhousie University, particularly when considering faculties of Science and Non-science students. Despite this, there is a clear willingness among students to support initiatives related to green roofs. Although our data does not definitively show that increasing educational programs surrounding green roofs will enhance student's willingness to support green roofs, the positive attitude towards such infrastructure suggests that additional awareness surround green roofs may not be the best use of resources if the Dalhousie aims garner support from students. The overall knowledge level of students on campus is considered low, as such we feel that the introduction of a mandatory sustainability or environmental module. This would aim to deepen knowledge on green roofs and assist students in making more informed decisions when asked if and how they would support green initiatives on campus, such as the improvements of green roofs. Additionally, considering the high levels of student support for green roofs as indicated by our findings, we advocate for increased investment

in green roof installation on campus. This not only aligns with student interests but also promotes a greener, more sustainable campus environment.

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Appendices

Appendix A: Consent Form

CONSENT FORM

[Anonymous Online Survey/No Signature Required]

Student Perspectives on Green Roofs on Dalhousie Studley Campus

You are invited to take part in a research study being conducted by Alexander Main, Zach Mcgraw, Kaylin Joy, Maggie Stathis, Ryan Brunet, undergraduate students in Environmental Science at Dalhousie University. The purpose of this research is to support sustainability efforts on Dalhousie's Studley Campus. We aim to narrow the gap of green roof information management through collecting data on students' perceptions, interviews with faculty, and assessing building plans. Any undergraduate student currently enrolled for full-time studies at Dalhousie University can participate. We encourage students from all academic backgrounds to answer the survey to the best of their abilities.

If you choose to participate in this research, you will be asked to answer various questions about your knowledge and understanding of green roof usage at Dalhousie. You will also be asked to expand on what you value about green spaces on campus, if anything at all, and your opinion on how they can be improved. This survey is to aid the directors of Sustainability and Environmental Science in determining the importance of green spaces on university campuses. The survey should take approximately 10 minutes.

Your participation in this research is entirely your choice. You do not have to answer questions that you do not want to answer (by selecting prefer not to answer), and you are welcome to stop the survey at any time if you no longer want to participate. All you need to do is close your browser. We will not include any incomplete surveys in our analyses. If you do complete your survey and you change your mind later, I will not be able to remove the information you provided as I will not know which response is yours.

Your responses to the survey will be anonymous. This means that there are no questions in the survey that ask for identifying details such as your name or email address, and no email address will be recorded upon submission. All responses will be collected through Google Forms and results will be stored on our personal secure Dalhousie accounts. Only Alexander Main, Zach Mcgraw, Maggie Stathis, Ryan Brunet, and Kaylin Joy will have access to the survey results.

We will describe and share general findings of this research in a ENVS 3502 class presentation, with an intended publication on Dalhousie's Research Webpage. With your consent we will share your anonymous data in a public research database called Past ENVS 3502 Final Projects, where it may be used in other future research studies. You can choose not to have your data included in this repository and still participate in this research.

The risks associated with this study are no greater than those you encounter in your everyday life.

There will be no direct benefit to you in participating in this research. The research, however, might contribute to new knowledge on green roofs and how they can be better utilized on the Studley campus from a student's perspective**.** If you would like to see how your information is used, please feel free to visit the Dalhousie website to view the final report. https://www.dal.ca/faculty/science/earth-environmental-sciences/research/publications-and-theses/past-envs-3502-projects.html

You should discuss any questions you have about this study with Caroline Franklin. Please ask as many questions as you like before or after participating. Our contact information is al766322@dal.ca, ky268986@dal.ca, maggie.stathis@dal.ca, ryan.brunet@dal.ca, and zc325103@dal.ca.

This study was reviewed and approved by the Department of Earth and Environmental Science at Dalhousie University.

[ ] I consent to complete this survey (required to proceed to survey).
[ ] I consent to have my data stored in a data repository for future research (optional).

Please follow the link here/click continue [ensure participants can proceed only if they click the consent button above].

See TCPS Article 3.2 for additional suggested consent form items that may need to be addressed for your particular study, such as conflict of interest, commercialization, and not waiving legal rights.

Appendix B: Survey Questions

1. In what Undergraduate faculty are you currently enrolled at Dalhousie University? [select all that apply]

a. Management

b. Science

c. Engineering

d. Computer Science

e. Health

f. Arts and Social Science

g. Architecture and Planning

h. Agriculture

2. What is your year of study at Dalhousie University?

a. 1

b. 2

c. 3

d. 4

e. 5+

3. Have you heard of green roofs?

a. yes

b. no

c. unsure

4. Which building do you believe is the most sustainable on Studley campus?

a. Mona Campbell Building

b. Life Sciences Centre

c. Kenneth C. Rowe Management Building

d. LeMarchant Place

e. Dalplex

f. Marion Mccain Arts and Social Science

g. Killam Library

h. Unsure

5. Have green roofs been a topic of discussion in any of your past Dalhousie courses?
a. Yes

b. No

c. Unsure

6. [briefly] How would you describe a green roof? (open-ended)

-Define Green roof-

A green roof is a thin layer of vegetation on a traditional roof which has many benefits that help improve the building's overall sustainability in many ways (Dawn Neumann, 2023). The vegetation may include shrubs, plants and grass.

https://www.forbes.com/home-improvement/roofing/what-are-green-roofs/

7. Are you aware that there are green roofs on Studley campus?

a. Yes

b. No

c. unsure

8. There are 3 green roofs on Studley campus, what buildings are they on? (select all that apply)

a. Mona Campbell Building

b. Life Sciences Centre

c. Kenneth C. Rowe Management Building

d. LeMarchant Place

e. Dalplex

f. Marion Mccain Arts and Social Science

g. Killam library

h. Unsure

9. Do you think we should have more green roofs installed on campus? Why or why not?

a. Yes, Explain

b. No, Explain

c. unsure

10. In your opinion, how can green roofs improve a building's efficiency? (select all that apply)

a. Stormwater runoff management by absorbing rainwater

b. Building insulation produces natural heating and cooling

c. Improves building air quality

d. Green roofs off set building pollution outputs

f. All of the Above

11. What do you value most about green roofs on campus? 1 being least important and 5 being most important. (Likert scale)

a. Climate change mitigation features (1-5)

b. An outdoor social area (1-5)

c. More aesthetic campus (1-5)

d. Energy saving potential (1-5)

e. Research opportunities (1-5)

f. Improved biodiversity (1-5)

g. Urban agriculture (1-5)

12. On a scale of 1-5 how important is the additional installation of green roofs on campus buildings?

a. 1 = Not Important

b. 2 = Somewhat Important

c. 3 = Neutral

d. 4 = Important

e. 5 = Very Important

13. On a scale of 1-5 what would be your willingness to support green roof enhancements on campus? (ex. Upgrades or expansions)

a. 1 = Opposed

b. 2 = Somewhat Opposed

c. 3 = Neutral

d. 4 = Somewhat supportive

e. 5 = Fully Supportive

15. In what ways would you consider supporting the maintenance of current and future green roofs? (select all that apply)

a. Garden volunteer

b. Increase in tuition levy

c. Participate in sustainable fundraising opportunities

d. In-course/honours research projects

e. None/Not interested

f. Other:

16. Would you be interested in having open access to one or more green roofs on campus?

a. Yes

b. No

c. Maybe

17. what would you be most interested in using the green roofs for?

a. Study spot

b. Grow local produce

c. Socialize

d. Outdoor gathering and events

e. Fitness activity (e.g. yoga class)

f. Other: _____

Appendix C: Survey Poster