Catch It If You Can:

Determining the Appropriate Areas for Tree and Shrub Plantings on Dalhousie University's Four Campuses

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ENVS/SUST 3502: Environmental Problem-Solving II

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April 11th, 2023

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Executive Summary

In an era of increasingly extreme weather events exacerbated by the climate crisis, cities could benefit greatly from increasing the density of trees and shrubs in their urban landscapes. With three locations in Halifax and one in Bible Hill, Nova Scotia, Dalhousie University's campuses are studied as small-scale Canadian urban coastal areas. The goal of the study is to determine where tree planting on all four campuses would be most beneficial. Three factors are selected as the most important determinants to inform decision-making at Dalhousie. Tree and shrub species, planting locations, and planting configurations should be selected to maximize their capacity to help control stormwater, to enhance local biodiversity, and to require little maintenance. Preliminary research made use of maps of the four campuses, provided by Dalhousie's Office of Sustainability, to detail the potential locations for future tree and shrub planting. From there, digital maps were created to represent the best areas to plant vegetation. A focus group was also conducted with several members of the Dalhousie community who were selected based on their expected expertise on the topic of stormwater control, biodiversity enhancement, and maintenance requirement. The focus group was aided by seven open-ended questions to facilitate the conversation and to encourage people to share their opinions on the matters with few constraints. Members of the focus group emphasized the importance of trees on campus and their benefits for education, in terms of strengthening the learning experience of university students directly and indirectly; plant health, by enhancing biodiversity, carbon sequestration, and climate change mitigation; and human health, by providing aesthetic, psychological, and social benefits. Due to the prevalence of impermeable surfaces on Dalhousie University's campuses, stormwater control is an issue that could be greatly improved with the addition of trees, shrubs, and permeable surfaces. Plant and animal biodiversity in urban areas can also be increased by adding more vegetation. Increased biodiversity also has intrinsic benefits by providing ecosystem services. Plant species and planting locations can be chosen to require less maintenance to reduce costs, and the choice to naturalize certain green spaces and can be even more effective at reducing maintenance requirements on Dalhousie's campuses.

Key words: stormwater control, biodiversity, university campus, green space maintenance, classroom inclusion

Introduction

Background and Rationale

With the climate crisis exacerbating severe weather patterns across the globe, coastal cities are seeing negative effects more acutely than farther inland (Patankar et al., 2013). Thus, Halifax, Nova Scotia, a coastal city in Atlantic Canada, will most likely begin to see increasingly frequent and extreme weather events (Burgess, 2013). Trees, shrubs and other permeable surfaces in urban areas provide a buffer against the detrimental effects of strong winds and stormwater, but as storms intensify, they have a higher likelihood of being damaged or lost completely. The loss of vegetation also counteracts efforts of conserving and promoting biodiversity (Livesly et al., 2016), which is already deficient or in decline in most cities around the globe. Damaging storms also put additional strain on maintenance operations, especially when damaged urban trees interfere with city infrastructure.

Dalhousie University has three campuses on the Halifax Peninsula, while the university's Agricultural Campus is in Bible Hill, NS, located 83 km northeast of Halifax (Google, n.d.). As a university with several campuses located close to the coast, with varying degrees of urban development, Dalhousie University has many characteristics that resemble coastal cities, but on a smaller scale, making it an appropriate study area that can correspond to larger urban areas.

Cities and urban university campuses alike struggle with stormwater management due to the lack of permeable surfaces and vegetation, a common shortcoming of urban infrastructure (Thom et al., 2020). The accumulation of stormwater runoff can cause local environmental issues like soil degradation, flooding, and contamination of water reserves (Berland et al., 2017). Dalhousie University struggles both with flooding and stormwater control on all four of its campuses due to the high rainfall Nova Scotia experiences each year. More specifically, Halifax has a yearly rainfall average of 184.92 mm per year (Government of Canada, 2023). The incorporation of trees native to the environment has been proven to enhance water retention rates by 24%, as has been seen in Melbourne, Australia (Thom et al., 2020). Even smaller flora, like shrubs and young trees, can have a significant impact on stormwater control. For example, a study conducted in Manchester, England, found that small tree pits reduced runoff from asphalt

plots by 62% (Berland et al., 2017). Increasing the amount of tree and shrub plantings in an urban area also inherently increases the biodiversity of the area.

In addition to stormwater management, increased vegetation within an urban area can also have a positive effect on biodiversity. This not only includes plant diversity, but it also largely dictates the diversity of animals (Livesly et al., 2016). As urbanization removes habitat from native species, re-introducing appropriate vegetation can provide new habitat and small-scale “wildlife corridors" (Dearborn & Kark, 2010). However, a lack of biodiversity in urban spaces negatively affects a campus’s ability to adapt to severe weather patterns, while high biodiversity on university campuses offers many benefits, such as cleaner air quality, and ensures more pleasant environmental conditions (Susilowati et al., 2021).

Livesly et al. (2016) assert that the places that need trees most urgently are places without an established tree canopy, and wherever there is a lack of green spaces. It is also important to incorporate native plants and to help them establish more quickly by planting trees, as opposed to seedlings, which face lower success rates (Oldfield et al., 2013). The placement of tree planting sites is crucial to ensure that trees provide benefits for their community and campus as much as possible. A study done in Los Angeles, California, used a GIS-based program to identify the best potential planting sites for urban trees. Each potential site had to follow certain criteria to be a viable planting site where a tree would be able to thrive (Wu et al., 2008). In total, 2.2 million potential planting sites were designated in Los Angeles, with the majority being better suited for smaller trees in the urban environment, which would drastically increase the absorption rate of stormwater (Wu et al., 2008). In our study, we are using ArcGIS as a software to map and select the most impactful areas for planting sites on Dalhousie’s campus. This research identifies potential future locations of tree and shrub plantings on Dalhousie campuses that are the most appropriate and beneficial in order to enhance biodiversity and assist in stormwater control.

Additionally, maintenance is an important determinant in choosing which tree species should be selected and where they should be planted on Dalhousie University’s campuses. With trees and shrubs being planted in urban areas, the required maintenance of those potential green spaces must be considered. Maintenance ensures that the green spaces are providing the ecological benefits they were meant to provide (Rojas et al., 2021). However, limited time and

staff could make it difficult to manage tree planting areas. That is unless, perhaps, those planted areas are intentionally less managed. If the proper plants are selected during the initial rehabilitation of the green space, it can be successfully left alone, thereby significantly reducing maintenance costs. Less interference in its natural processes allows the green space to return to a more natural state while still providing beneficial ecosystem services (Rojas et al., 2021).

Project Definition

This project looks at the four campuses of Dalhousie University and seeks to determine which locations of tree and shrub plantings would provide the most benefit to the University in terms of its ability to manage stormwater, require little maintenance, and increase biodiversity. Dalhousie University's Office of Sustainability is tasked with fostering spaces on its campuses that exemplify good ecological practices (Dalhousie University, 2023), and this project will hopefully advise the office in future decision-making in terms of planting trees and shrubs to work toward this sustainability goal.

The aim of this research project is to compile and provide information about tree and shrub species and the most ideal spaces on each of the four campuses to plant them. Trees and shrubs have the capacity to increase biodiversity and to help in managing stormwater. Depending on the species and planting configuration, they may require little maintenance. In providing a framework to inform decision-making as to which species and locations will be selected on Dalhousie's campuses, the capacity to assist in the control of stormwater, the contributions to biodiversity, and the ability to require limited maintenance will be considered. Due to the pervasiveness of impervious surfaces on campus, such as paved roads and concrete walking paths, water-absorbing plants are important to control damaging runoff from quickly accumulating stormwater. Other factors studied in this research that could inform decisions include the tree and shrub species' tendency to enhance biodiversity, which is key to supporting healthy ecosystems. Low maintenance species would also lower the cost of upkeep, so species that do not need to be pruned or watered would be ideal.

Our research question is formulated as follows: which locations of tree and shrub plantings on Dalhousie University's four campuses are the most appropriate and beneficial in order to assist in stormwater control, enhance biodiversity, and require little maintenance?

Methods

For this research project, we chose to focus on two distinct research methods that enabled us to both identify suitable tree and shrub planting species, and the prime locations for planting on Dalhousie University's campuses (Studley, Sexton, Carleton and Agricultural). Primarily, in partnership with the executive director, Rochelle Owen, and sustainability manager of the Office of Sustainability, Kareina D'Souza, a focus group took place with the purpose of discussing tree, shrub and planting opportunities on Dalhousie's University four campuses. Moreover, thematic coding was employed to categorize and analyze the data collected from the focus group notes, as well as literature review as a group before and after the focus group in order to collect more generalized data and information about different tree and shrub species on campuses.

Survey and Campus Maps

Preliminary photographs detailing the potential locations for tree and shrub plantings on all four Dalhousie campuses were provided by the Office of Sustainability (see Appendix A) to be used in the future group survey. They also provided access to their Sustainability Map of the Dalhousie Campus (found on the Office of Sustainability Dalhousie website). As an in-depth discussion and analysis of these areas was necessary, four separate maps were created (see Appendix B) using the ArcGIS online software to facilitate better visuals and clarification of said areas.

Focus Group

Our primary research tool was a focus group, which can be defined as an interview with a specific population, being 'focused' on a specific topic. In this project, the participants were

selected by Rochelle Owen and Kareina D'Souza based on the criteria that they would have expertise on the topic, have similar values related to the topic, and are comfortable talking in a research interview setting. The focus group was composed of several key campus stakeholders; professors from the Department of Earth and Environmental Sciences as well as instructors and members of the Department of Biology, Landscape Architecture, Plant and Food Sciences as well as Facilities Management. It was fortunately unnecessary to employ any methods of recruitment as most of the participants were highly motivated and/or directly involved with the Office of Sustainability and thus, no incentive for participation was required.

These participants were all chosen for their in-depth knowledge of planting species and other varied subjects (such as vegetation maintenance, biodiversity and storm water control management), and were key to understanding the possible pros and cons of certain plant-able locations. Furthermore, having both a representative from the University's Facilities Management and Landscape Architecture Department enabled us to gauge whether planting in certain areas is permissible and feasible in terms of spatiality and costs. The main goal was to gather as much information as possible about the participants' cultivated knowledge of planting locations on campus, as well as potential ethical, social and environmental benefits/issues of these locations. The research team and the partners from the Office of Sustainability found that a focus group interview as a qualitative data analysis tool was the best choice for the research as it generates a fair amount of data to work with, encourages stakeholder and community representation, and maximizes the validity of the results.

The focus group interview was held over an online Microsoft Teams meeting that took approximately one and a half hours. The meeting started with introductions from both the participants and the researchers, followed by a short presentation of the research project. It was decided that a short presentation was necessary to provide background and context, so the participants are aware of the research question and project objectives. Visual aids in the form of campus maps were used to facilitate discussion (see Appendix B). Given that all the individuals were from different departments and career fields, utilizing their diverse opinions and points of view to tackle this project was of utmost importance. The focus group were asked seven open-ended and short answer survey questions (see Appendix C) that had been sent to them beforehand via email. The questions were stated in the interview and posted in the Microsoft chat

to allow the participants time to refer to the question if needed. The participants answers and other comments were recorded using Word, and thematic coding in Excel is used to find themes in the results. The research team decided to use open-ended questions in this research as they allow the participants to answer in any way they see fit, allowing for further expression and in-depth conversation if need be. The participants answered in discussion-style, with the option to answer, or add points in the Microsoft chat.

Limitations Related to Methods

The first limitation to the focus group research methodology was not being authorized to record the interview session. For ethical reasons and to ensure that participants felt most comfortable with answering questions, recording the interview was not permitted. This limited the ability to create exact thematic coding of the answers and required precise notetaking. Another limitation is the number of interview sessions/lack of follow-up questions. Rabiee (2004) suggests running focus groups until clear answers and patterns emerge. However, our research timeline was also limited by the length of the winter semester; follow-up surveys do not fit within this timeframe.

Ethical Considerations

There are a few ethical concerns that could be attributed to this research project. One could be ensuring that the prime locations found within this research will have no adverse effects on the individuals in and around that area; this means that no animals, humans or plant-life should be negatively affected by the new plantings. Furthermore, ensuring that both the local ecosystems surrounding the planting areas receive maximum long-term benefits is extremely important. Moreover, as the data being collected is from humans, a Research Ethic Board Application is completed to ensure respect is maintained and consent is informed as the participants are voluntary. Before agreeing to participate in the focus group interview, participants were asked to sign a consent form (see Appendix D). The consent form outlines the background of the research, risks and benefits to participating, confidentiality, and data

collection. By signing the consent form, participants are agreeing to participate and have their answers used in the study but are aware of their right to withdraw at any time. As there is always a concern about minimizing harm and maximizing benefits, our focus group note taking focused on collecting the data we needed and ensuring that confidentiality, anonymity and the 'right to withdraw' are adhered to.

With the knowledge obtained through the completion of the research project, the data will inform the Office of Sustainability in its decision-making process for planting trees and shrubs on Dalhousie University's four campuses. Species of trees and shrubs that will be studied will be acclimatized to Nova Scotia and adhere to criteria laid out by the Office of Sustainability. The research will also consider the responses from Dalhousie's forestry manager's decisions on planting species on the campuses.

In terms of deliverables, the findings of the research project were shared with the Office of Sustainability primarily, as the research is contributing to their greater "Catch it if You Can" project. It is assumed that by contributing to the Office of Sustainability's project, the next step is for the plan to be executed on the Dalhousie campuses. Through this preliminary research provided, as well as locations suggested from the focus group, four finalized campus maps (one for each of Dalhousie University' campuses) were created on the geospatial software ArcGIS (see Appendix B), focusing on highlighting good locations for planting trees and shrubs as well as Venn diagrams depicting the overall thematic coding analysis results (see Results). Ultimately, all the information will be shared with the Office of Sustainability by sharing the final report of the data analysis, which will also be presented to the Environmental Problem-Solving II class (ENVS 3502).

Results

As a means of introduction to the subject explored, the focus group was asked a primary question asking their opinion on the value of having trees and gardens located on the university campuses; this type of "opening question" was used to get the participants thinking about the varying roles vegetation fulfills on campuses.

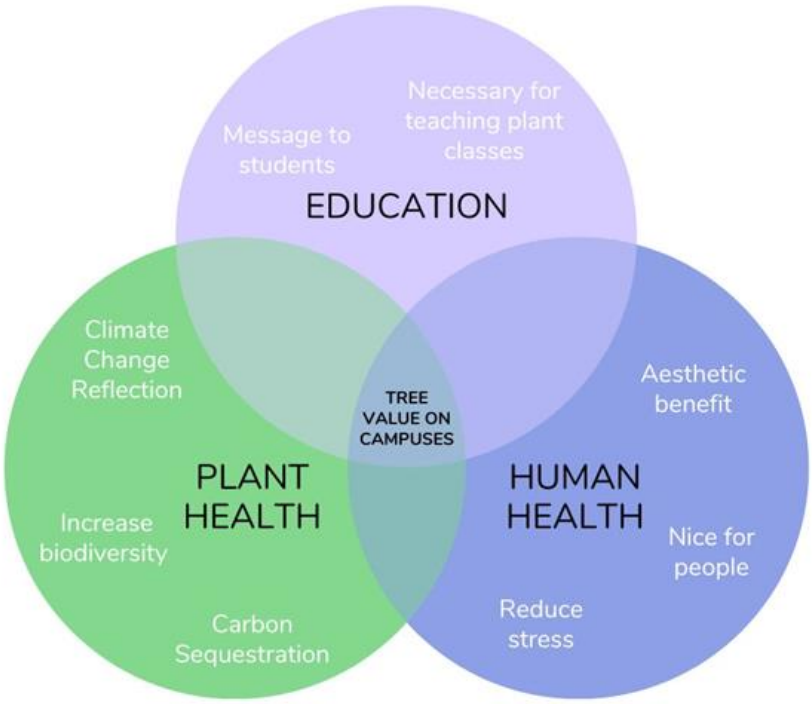

Figure 1: Venn Diagram illustrating key findings in focus group, detailing the value of trees (and gardens) on all four Dalhousie Campuses.

As shown in Figure 1, most answers are determined to fit into 3 main categories: plant health, human health, and for the purpose of education. In terms of promoting plant health at Dalhousie, various points dictate how a larger number of trees and plantings would help increase biodiversity as well as help better prepare the campuses against climate change in the years to come; biodiversity is essential to clean the air and help tackle increasing temperatures and pollution by absorbing carbon dioxide. Moreover, an overall discussion of the importance of human health on campuses was brought forth, illustrating the benefits that trees possess on reducing stress and upholding aesthetic and scenic values at the university. Finally, trees and gardens were also determined to be beneficial for educational purposes, providing both necessary teachings for plant-based knowledge on campus as well as sending a message to students that Dalhousie's goal is to strengthen campus biodiversity as well as maintain natural spaces in the years to come (Natural Environment Plan, 2022).

In order to determine which locations of tree and shrub plantings would be the most appropriate, the focus group was asked to observe the four campus maps made and determine

whether the chosen areas would be beneficial; they were also asked to identify new opportunities and barriers to planting.

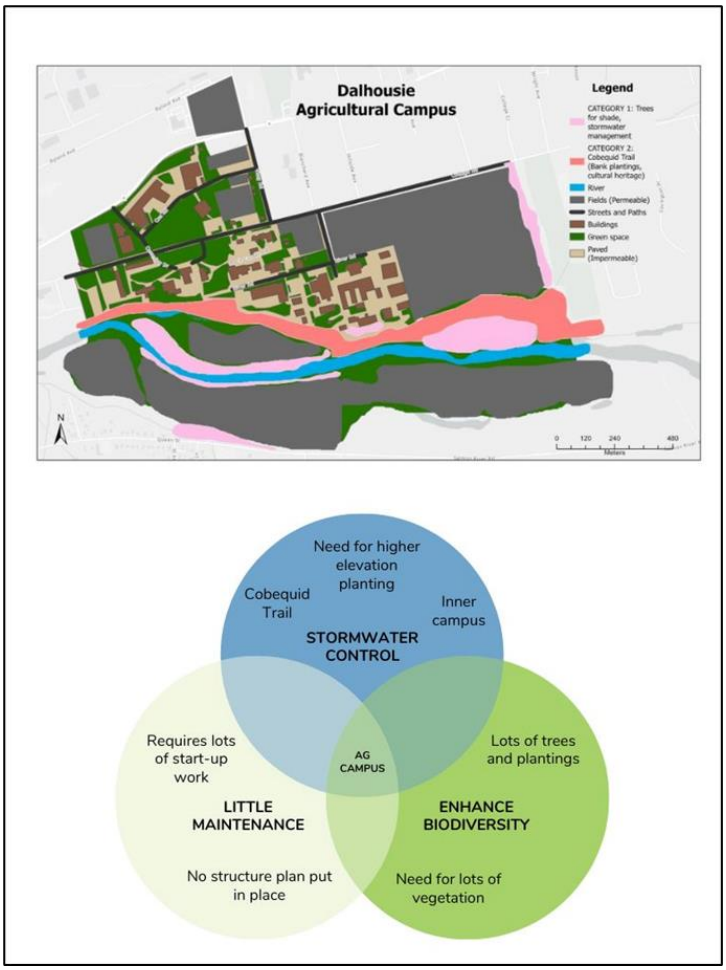

Figure 2: Venn Diagram illustrating key findings in focus group, detailing the AG campus.

Whilst discussing Dalhousie University's Agricultural (AG) campus, major concerns were placed on planting in areas of higher elevation for the chosen locations to be beneficial and appropriate for stormwater management; after large bouts of rain, a lot of water is left to seep down the hills towards the inner campus, flooding various parking lots in the process. The Cobequid Trail area (dark pink on the map in Figure 2) would therefore apply best in terms of proximity to the inner campus and elevation in favor of appropriate stormwater control.

Moreover, a desire to increase biodiversity on the AG campus was greatly expressed by the focus group members, stating that the main goal of an agricultural campus is to be a leader in

sustainability and vegetation levels; especially after Hurricane Fiona in 2022, there is ample opportunity to replace new plantings with more weather resistant species in order to further increase vegetation diversity on campus in the years to come. Again, the Cobequid Trail fulfills this criterion.

However, when addressing the criterion of little maintenance, none of the areas were identified as applicable due to an ongoing wildlife problem the AG campus is dealing with; a large deer problem poses a risk to recently planted trees as they feed and uproot the saplings. In the words of one of the participants, a list of 'deer-proof' plants is not a thing anymore. Moreover, the money and effort that would go into planting and maintaining such a large area requires a lot of effort and conservation; many opportunities for planting more trees and shrubs were acknowledged, but unfortunately, there is no current structured planting plan put in place to fulfill these wishes.

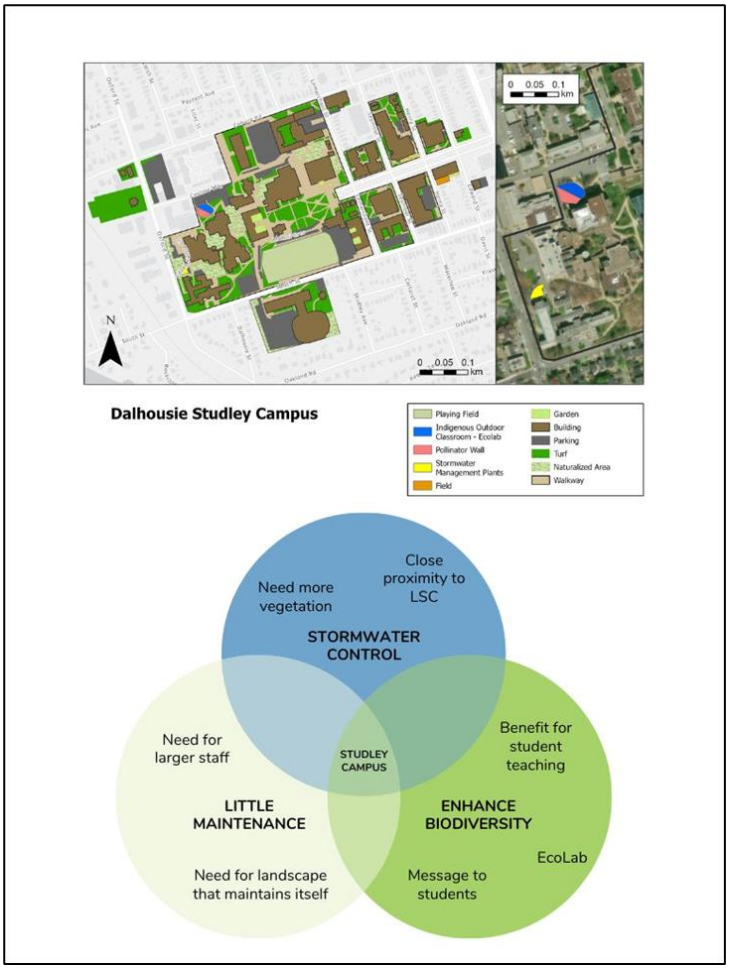

Figure 3: Venn Diagram illustrating key findings in focus group, detailing the Studley campus.

When discussing Dalhousie University's Studley campus, a large emphasis was put on prioritizing stormwater control around the Life Sciences Centre in hopes of mitigating the flooding issues the building has been dealing with since Hurricane Fiona; by intercepting and slowing rain hitting the ground, an increased amount of vegetation around the building would substantially reduce the volume and rate of stormwater runoff (Trees for Energy Conservation, 2019). A desire to plant on the rooftop area of the LSC was suggested but rejected due to various permit concerns. Therefore, the location for both the EcoLab (shown in blue in Figure 3) and the Pollinator Wall (shown in pink in Figure 3) would be most beneficial for stormwater control around the LSC.

In terms of increasing biodiversity on campus, both the EcoLab and Pollinator Wall would help introduce of variety of new species to strengthen plant-based learning for Dalhousie students; previous research indicates that pollinator diversity enhances its surrounding vegetation and helps further attract insects as well as provide cultural and aesthetic values (Katumo et al., 2022). Furthermore, the teaching opportunities and potential green activism at the university could greatly increase for Dalhousie students, especially by properly utilizing the space as a living lab and introducing different classes for a multitude of departments. It is important to note that many of the participants voiced a need to further involve students in terms of both the planting and organization of said areas, to provide them with hands-on learning activities and experience.

Moreover, if constructed and planted properly, both the EcoLab and Pollinator Wall could be self-maintaining and require very little upkeep once established. However, strong concerns over low staff numbers on the Halifax campuses were remarked as extreme barriers to take on such an enterprise: participants voiced many issues with finding people to work on Dalhousie grounds whilst juggling the need for more self-maintained naturalized spaces. Another barrier addressed was that naturalized areas can be perceived as 'messy' to the general public, so a greater effort would need to be made to change attitudes towards self-maintaining 'wild' landscapes on university campuses. Moreover, various concerns about how the underground infrastructures of the LSC could affect vegetation planted on top were voiced.

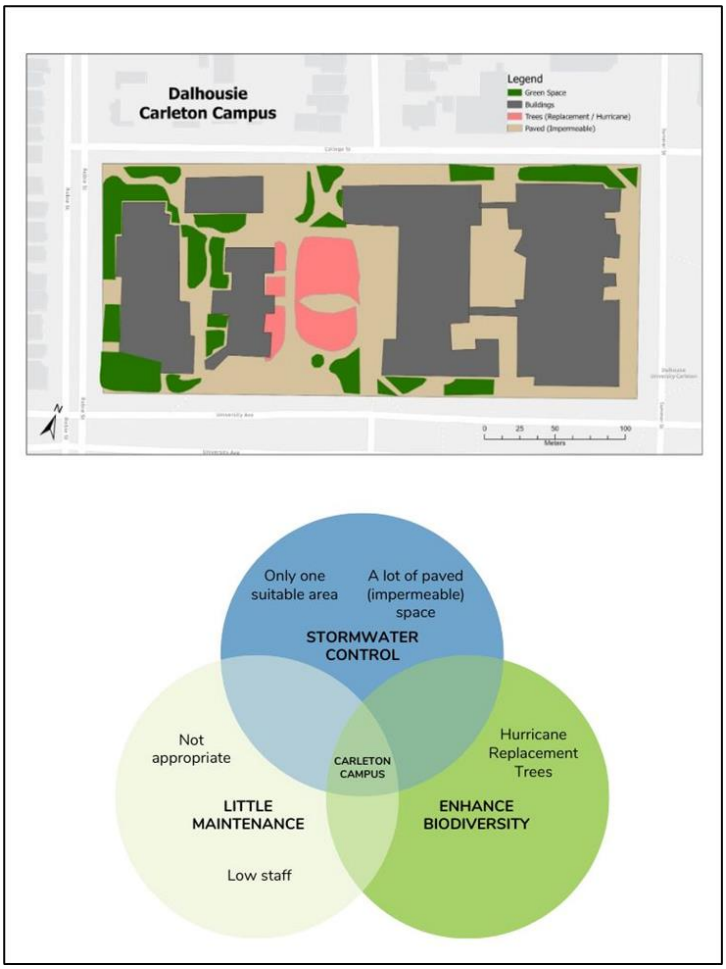

Figure 4: Venn Diagram illustrating key findings in focus group, detailing the Carleton campus.

Unfortunately, the Carleton Campus was not greatly discussed throughout the focus group, perhaps given its smaller area and by consequence, the lack of space for naturalization. However, given the previous findings throughout this report and the presence of only one suitable planting area (shown in pink in Figure 4), a consensus for accepting and rejecting a given area based on its appropriate stormwater control, biodiversity and maintenance levels can be suggested.

In terms of stormwater management on Carleton, the tree planting area is very appropriate as it is located at the core of the campus and could help increase soil absorption and reduce soil erosion; given its very close proximity to a lot of paved, impermeable spaces, new tree plantings could help collect debris, chemicals, sediment and other pollutants that could decrease a large amount of urban nonpoint source pollution. Furthermore, the selection of new

tree species to replace the ones lost during Hurricane Fiona could help increase biodiversity on the campus, especially by selecting a variety of trees that will survive intense weather patterns and urban sprawl. However, the area does not fulfil the low maintenance criterion mostly due to the low staff concerns previously addressed as well as the need to restore the area before the planting begins. Furthermore, there are potential issues with the tree's sensitivity to pH: in areas that incorporate concrete products (such as paved areas), the pH of the soil can rise as the chemicals deteriorate over time, significantly affecting the health of a tree and its ability to absorb nutrients (EPA, 2013).

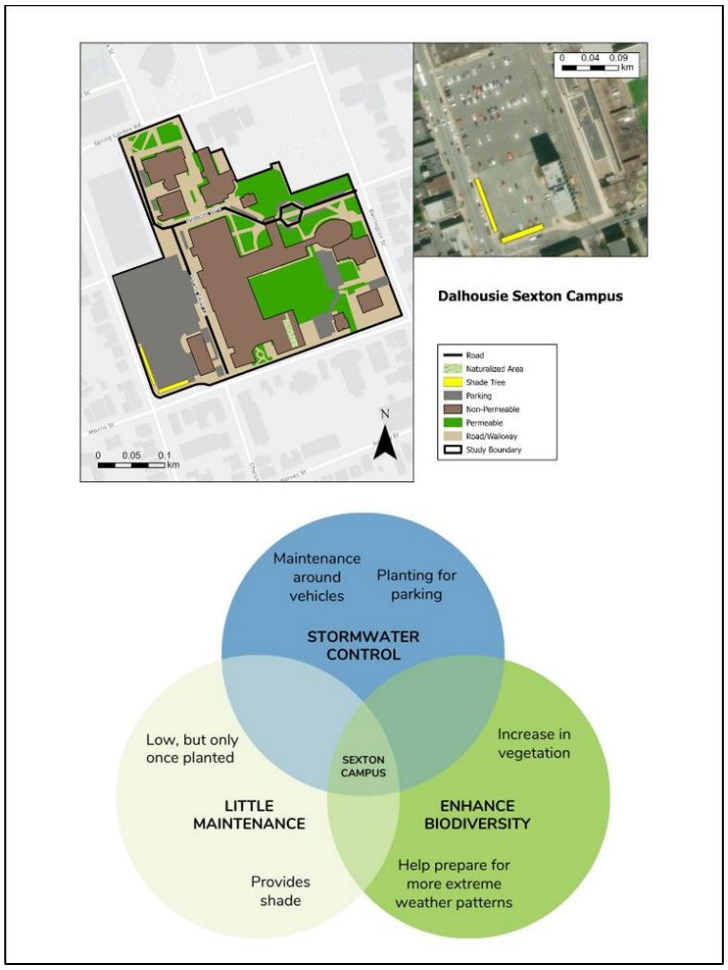

Figure 5: Venn Diagram illustrating key findings in focus group, detailing the Sexton campus.

Finally, when contemplating planting on Sexton campus, the Shade Tree area surrounding the main parking (shown in bright yellow on Figure 5) was approved for all three criteria. In order to prevent flooding that could deteriorate the lot, planting around the parking lot

would be an excellent form of stormwater management to prevent soil erosion and reduce water drainage problems. Moreover, adding an increase in vegetation to an area where there is currently none would only help further increase biodiversity on this campus as well as add oxygen to an environment surrounded by cars. Little maintenance would be required once properly planted; however, participants voiced various limitations surrounding finding adequate space for more planting projects on campus.

It is important to mention that there was a large desire among the participants for the opportunity to better utilize the naturalized area located on top of the Design Building (shown in "grass" imagery in Figure 5) to enhance biodiversity on campus; however, the structural integrity of the building does not enhance stormwater management solutions at this time, and they were unable to get permits to pursue an investigation at this time.

Discussion

Incorporating more trees on the four Dalhousie campuses: Sexton, Studley, Carleton and Agriculture, undoubtedly enhances stormwater management (i.e., runoff complications and flooding) along with other benefits. The purpose of the research is to determine optimal places to plant trees on each campus to better manage stormwater complications. The three Halifax campuses (Sexton, Studley, and Carelton) are urban campuses and their layout is comprised of a lot of asphalt and concrete, leaving little space for greenery. Due to the low amount of vegetation on the urban campuses, flooding and stormwater control are a prevalent issue, as shown by buildings on those campuses flooding. The focus group comprised of Dalhousie professors and facilities faculty also acknowledged the flooding issue on the urban campuses as an issue and other complications that follow. The agricultural campus in Truro also struggles with flooding, but there is more flexibility with planting trees there since the campus is much more rural. With the use of GIS and a focus group consisting of people with relevant backgrounds, each campus was assessed, and specific planting sites were established. The findings for this study not only established the best spots for vegetation to be incorporated on each campus, other initiatives like incorporating students into the maintenance of the trees/shrubs were discussed.

Adopting green infrastructure into urbanized places to help with storm water is not a novel idea, and many cities and college campuses have researched the effects trees have on runoff and stormwater management. Many urban areas consisting of impermeable surfaces convert precipitation into stormwater runoff which causes quality and quantity issues (Berland et al., 2017). Green infrastructure can redistribute, store, and infiltrate stormwater, so there is less stormwater buildup and natural processes like the hydrologic cycle can properly recycle the water (Berland et al., 2017). The GIS maps revealed that out of all the urban campuses, Studley, has the most space available for new tree plantings. A member of the focus group suggested planting trees and vegetation at the top of hills or downslopes to reduce the amount of water that is collected at the bottom and planting at the bottom of those areas as well. For Studley campus planting trees by the bottom of the Life Sciences Center (LSC) and on elevated parts of campus, like the quad, will decrease the amount of stormwater pooling up by the LSC and Killam library. Also, on the Agricultural campus, planting trees next to the McCrae Library that's on a hill leading down to resident halls will help reduce stormwater runoff. Incorporating trees in both areas can intercept incoming precipitation, remove water from the soil, and enhance the performance of other green infrastructure technologies (Berland et al., 2017). Another suggestion for both the Agricultural and Studley campus is allowing turfed areas, like the Studley quad, to naturalize. Allowing areas to naturalize means they require much less maintenance and can provide homes for natural pollinators (Richards et al., 2012). A study done on the campus of Brock University, in St. Catharines, Ontario, saw an increase of natural pollinators (mainly bees) on and near campus after letting grasslands on their campus naturalize (Richards et al., 2012). Naturalized areas will have much higher water retention rates than manicured lawns and can encourage more native species to both campuses.

The two other urban campuses, Sexton and Carleton, have less green space to plant trees on their campuses. The use of GIS maps was very influential for these campuses since they made potential planting areas easier to identify. Similar methods were used in a case study based in Los Angeles, California, that was also trying to discover planting sites in a major city (Wu et al., 2008). Due to high urbanization in both campuses, only two spots were considered viable on either campus. On Sexton campus, the area that surrounds on of its major parking lots was identified and Carleton only had one viable area on campus. There was also discussion on

building rooftop greenspace on one of Sextons buildings, but currently Dalhousie does not have the licensing to do so, and there are doubts about the building's structural integrity. In urban areas, smaller trees are found to be the best fit for that environment (Wu et al., 2008). The researchers in Los Angeles were able to find over 2.2 million potential planting sites and many of them were best suited for smaller trees resulting in a 109km^2 canopy coverage (Wu et al., 2008). Both Sexton and Carleton campuses can benefit from the incorporation of smaller trees since they are well suited for urban areas and will help with stormwater management (Wu et al., 2008). Smaller trees can also reduce the maintenance required for both campuses, which is an important consideration for this project, since Dalhousie has limited facilities staff.

The idea of incorporating students and classes into the maintenance and planting activities on each campus is also a great way to approach many limitations in this study. Originally brought up in the focus group, the inclusion of students and classes to help add vegetation to the different campuses could be very helpful. One of the biggest limitations brought up throughout our research process was that Dalhousie does not have enough faculty to upkeep each campus, especially if high maintenance trees are planted. However, assembling a volunteer group of students and using the campus as a living laboratory can raise awareness and create a better maintenance system on the campuses. The University of Kentucky (UK) has an Urban Forest Initiative (UFI) that connects students and community members to planting and creation of urban forests on campus, which has increased awareness and involvement in both populations (Rieske et al., 2019). On the urban Halifax campuses there has been discussion of creating a Master of Landscape Architecture and incorporate trees planting and future projects on the campuses to increase their vegetation. The students in such a master's course can also help create a master plan to redesign each campus to be better suited for green infrastructure, like more trees and vegetation. Creating a master plan for each campus will help each campus follow proper procedures and steps to create greener campuses. Students at Kentucky can receive an Urban and Community Forestry Certificate if they join the UFI and there has been a significant increase in interest in urban forestry and student involvement on campus due to the certificate (Rieske et al., 2019). There can be future research on how Dalhousie students would respond to certificates or masters of this interest and gage the interest certain majors would have in volunteering their time towards tree planting and maintenance initiatives. Due to the short

timeline of this project, one school semester, there was no time to gage student interest in those topics, but it could be enlightening research for the future.

There was little to no literature to be found disapproving that native trees and higher vegetation rates in urban areas will help with stormwater management. However, depending on the trees and their locations in cities, the amount of water retention varied per study. One study in Australia found that native trees absorbed 24% more rainwater in the soil than soil with no trees (Thom et al., 2020). The Australian study was conducted by exploring larger trees, but the study conducted in L.A. described smaller trees being better suited for urban environments (Wu et al., 2008). The discrepancy in results is based on the environmental differences in each study. Therefore, further studies can also be conducted to understand which trees would be best suited for stormwater management in the Nova Scotia environment. Such research would need a longer timeline than one school semester since it would be important to understand how each tree functions in every season. Overall, the best planting sports on each campus were identified through the GIS maps, but more information on student involvement and tree species can help with management of the areas.

Conclusion

Table 1: Overall Result and Comparison Chart of all four Dalhousie University Campus areas chosen in terms of their application of stormwater control, increase in biodiversity and requiring of little maintenance.

COMPARISON CHART

DALHOUSIE CAMPUSES	AREA CHOSEN	STORMWATER CONTROL	INCREASE BIODIVERSITY	LITTLE MAINTENANCE
Agricultural Campus	Cobequid Trail	✓	✓	
Studley Campus	EcoLab + Pollinator Wall	✓	✓	✓
Carleton Campus	Replacement Trees for Hurricane	✓	✓	
Sexton Campus	Shade Tree	✓	✓	✓

When observing the Comparison Chart (shown in Table 1), one can determine that all the areas created by the Office of Sustainability were appropriate and beneficial for stormwater management at Dalhousie University. As that was the main objective of the research, it can be confidently said that increasing the amount of tree and shrub plantings on a university campus can assist stormwater control, while also enhancing local biodiversity. Enhancing the biodiversity on campus is not only beneficial to native species but can provide more opportunities for student learning – a valuable consideration mentioned by the focus group.

While an important portion of our research question had been answered successfully, it is noted that the low maintenance criterion still requires more research to fulfill. Only the Studley and Sexton campuses were appropriate locations for tree and shrub plantings that fulfill all desired criteria; both the AG and Carleton campuses fail the low maintenance criterion. In all cases, but especially highlighted by focus group participants from the AG campus, the most prominent barrier achieving the low maintenance criterion is low access to adequate planting and maintenance staff. The Carleton campus has the least amount of space for planting and an absence of a detailed planting plan. It is our hope that as this project progresses with the Office of Sustainability, the low maintenance criterion can be fulfilled by involving student volunteers, acquiring more funding to hire more staff, and planting low maintenance trees in carefully thought areas that would require little upkeep. The final recommendation that could send the results of the study into action is to continue exploring funding opportunities. Some recommendations include the following: aligning planting/maintenance/planning with teaching; creating a nursery to replace damaged trees; and implementing natural spaces that self-keep. Overall, money is a continuous barrier in all projects, and pursuing different ways to minimize costs would make implementation of our research findings easier.

References

Bergeron, M., Lacombe, S., Bradley, R. L., Whalen, J., Cogliastro, A., Jutras, M. F., & Arp, P. (2011). Reduced soil nutrient leaching following the establishment of tree-based intercropping systems in eastern Canada. *Agroforestry Systems, 83,* 321-330. https://doi.org/10.1007/s10457-011-9402-7

Berland, A., Shiflett, S. A., Shuster, W. D., Garmestani, A. S., Goddard, H. C., Herrmann, D. L., & Hopton, M. E. (2017). The role of trees in urban stormwater management. *Landscape and Urban Planning, 162*, 167-177. https://doi.org/10.1016/j.landurbplan.2017.02.017

Burgess, C. M. (2013). Preparing for the costs of extreme weather in Canadian cities: issues, tools, ideas. *SSRN*. https://dx.doi.org/10.2139/ssrn.2197795

Dalhousie University. (2023). Mission Statement and Goals. *Dalhousie University*. Retrieved February 28, 2023, from https://www.dal.ca/dept/sustainability/about/Purpose/Mission_Statement_and_Goals.htm

Dearborn, D. C., & Kark, S. (2010). Motivations for conserving urban biodiversity. *Conservation Biology*, *24*(2), 432-440. https://doi.org/10.1111/j.1523-1739.2009.01328.x

Google. (n.d.). [Distance between Truro and Halifax measured on Google Maps]. Retrieved April 10, 2023, from https://www.google.com/maps/@44.9896644,-63.4644323,9.43z

Katumo, D. M., Liang, H., Ochola, A. C., Lv, M., Wang, Q.-F., & Yang, C.-F. (2022). Pollinator diversity benefits natural and agricultural ecosystems, environmental health, and human welfare. *Plant Diversity*, *44*(5), 429–435. https://doi.org/10.1016/j.pld.2022.01.005

Liu, W., Sun, N., Guo, J., & Zheng, Z. (2022). Campus Green Spaces, Academic Achievement and Mental Health of College Students. *International Journal of Environmental Research and Public Health, 19*(14), 8618. https://doi.org/10.3390/ijerph19148618

Lively, S. J., Escobedo, F. J., & Morgenroth, J. (2016). The biodiversity of urban and peri-urban forests and the diverse ecosystem services they provide as socio-ecological systems. *Forests, 7*(12), 291. https://doi.org/10.3390/f7120291

Oldfield, E. E., Warren, R. J., Alexander, J. F., & Bradford, M. A. (2013). Challenges and future directions in urban afforestation. *Journal of Applied Ecology, 50*, 1169-1177. https://doi.org/10.1111/1365-2664.12124

Patankar, A., Patwardhan, A., Marome, W., & Porio, E. (2013). Impacts of extreme weather events and implications for adaptation planning for coastal cities. *APN Science Bulletin, 3*, 16-24. http://hdl.handle.net/10625/51208

Rabiee, F. (2004). Focus-group Interview and Data Analysis. *Proceedings of the Nutrition Society, 63*(04), 655–660. https://doi.org/10.1079/pns2004399

Richards, M., Rutgers-Kelly, A., Gibbs, J., Vickruck, J., Rehan, S., & Sheffield, C. (2011). Bee diversity in naturalizing patches of Carolinian grasslands in southern Ontario, Canada. *The Canadian Entomologist, 143*(3), 279-299. doi:10.4039/n11-010

Rieske, L.K., Borden, S., Damron, D., Williamson, N., Arthur, M., Kinney, A. (2019) College Campus as a Living Laboratory: Scrubbing Scales, Saving Trees, Engaging Students, *American Entomologist, 65*(1), Pages 43–49, https://doi.org/10.1093/ae/tmz010

Rojas, J. A., Dhar, A., & Naeth, M. A. (2021). Urban naturalization for green spaces using soil tillage, herbicide application, compost amendment and native vegetation. *Land, 10*(8), 854. https://doi.org/10.3390/land10080854

Susilwati, A., Rangkuti, A. B., Rachmat, H. H., Iswanto, A. H., Harahap, M. M., Elfiati, D., Slamet, B., & Ginting, I. M. (2021). Maintaining tree biodiversity in urban communities on the university campus. *Journal of Biological Diversity, 22*(5). https://doi.org/10.13057/biodiv/d220548

Thom, J. K., Szota, C., Coutts, A. M., Fletcher, T. D., & Livesley, S. J. (2020). Transpiration by established trees could increase the efficiency of stormwater control measures. *Water Research, 173*, 115597. https://doi.org/10.1016/j.watres.2020.115597

Trees for Energy Conservation. (2019). Do trees and other vegetation help reduce urban-water runoff? *Trees for Energy Conservation*. https://trees-energy-conservation.extension.org/do-trees-and-other-vegetation-help-reduce-urban-water-runoff/

Wang, J., Zhou, W., & Jiao, M. (2022). Location matters: planting urban trees in the right places improves cooling. *Frontiers in Ecology and the Environment, 20*(3), 147-151. https://doi.org/10.1002/fee.2455

World Health Organization. (2021). Adolescent mental health. https://www.who.int/news-room/fact-sheets/detail/adolescent-mental-health

Wu, C., Xiao, Q., & McPherson, E. G. (2008). A method for locating potential tree-planting sites in urban areas: A case study of Los Angeles, USA. *Urban Forestry & Urban Greening, 7*(2), 65-76. https://doi.org/10.1016/j.ufug.2008.01.002

Acknowledgments

We would like to extend our gratitude to the Office of Sustainability, especially the executive directors Rochelle Owen and Kareina D'Souza, for their support and guidance throughout our research. We would like to acknowledge and give our warmest thanks to professor Dr. Caroline Franklin, who made this project possible, and to our teaching assistant Celia Konowe for her generous feedback and support throughout the course.

Finally, the completion of this project could not have been accomplished without the participation and expertise of the members of the focus group, whose willingness to share and teach did not go unnoticed. Our heartfelt thanks.

Appendices

Appendix A

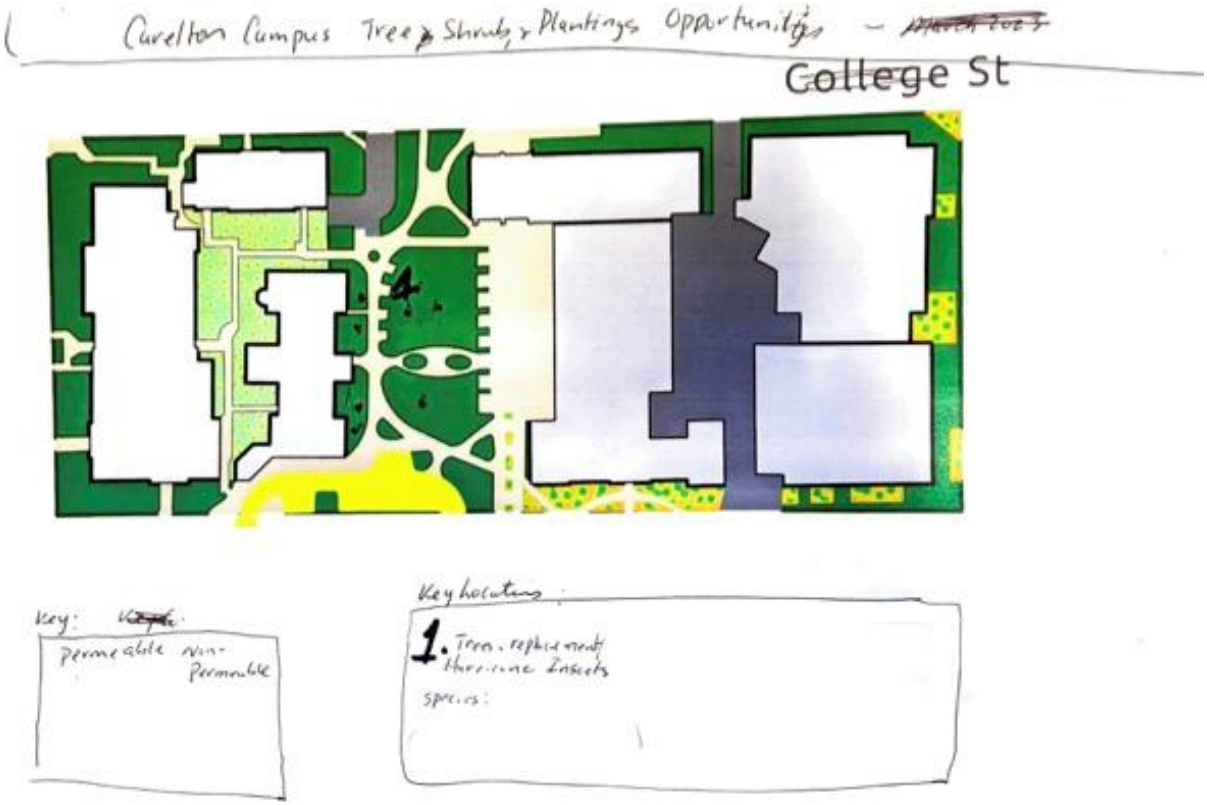

Figure 1. Example layout map of Dalhousie University's Carleton, Halifax, NS, campus that will be presented at end of the project with possible locations numbered and a corresponding description.

Figure 2. Another example layout map of Dalhousie University's Carleton, Halifax, NS, campus that will be presented at end of the project with possible locations numbered and a corresponding description.

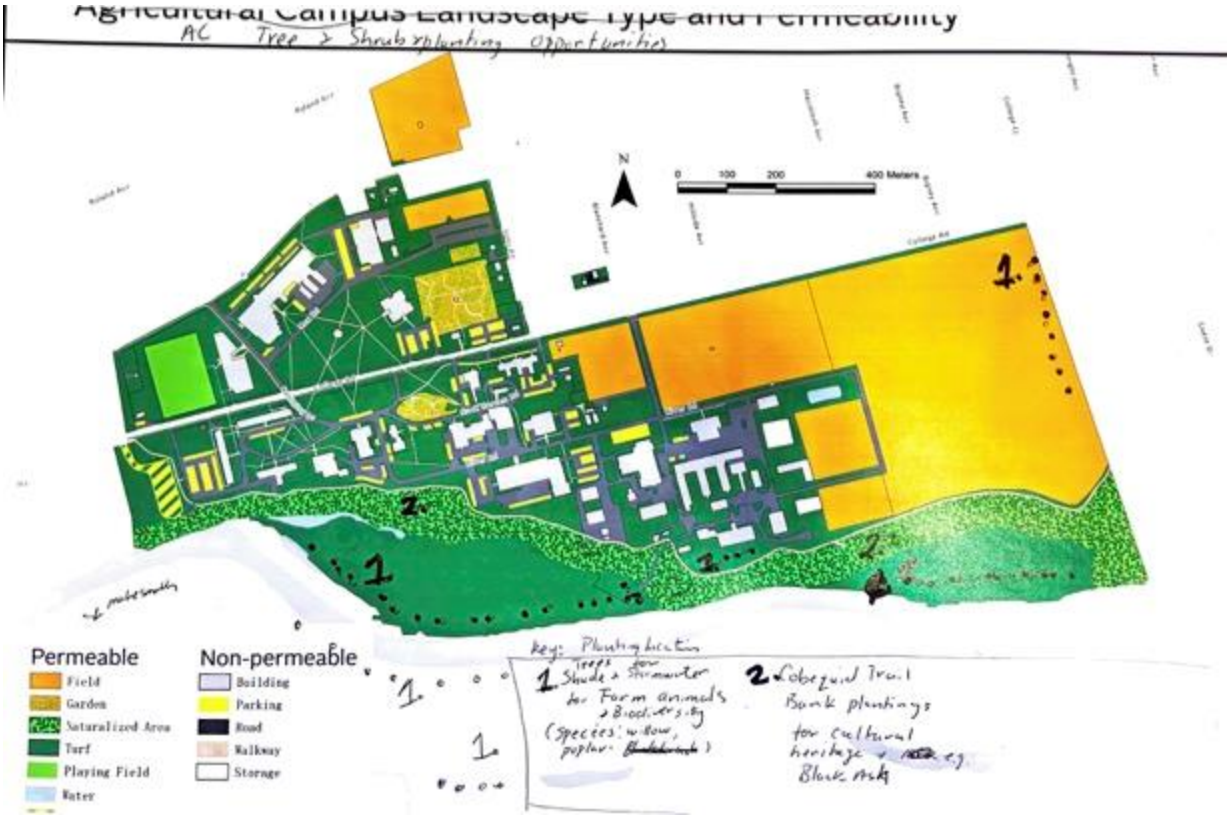

Figure 3. Preliminary map layout of tree planting areas and land description of Dalhousie University's agricultural campus in Truro, NS.

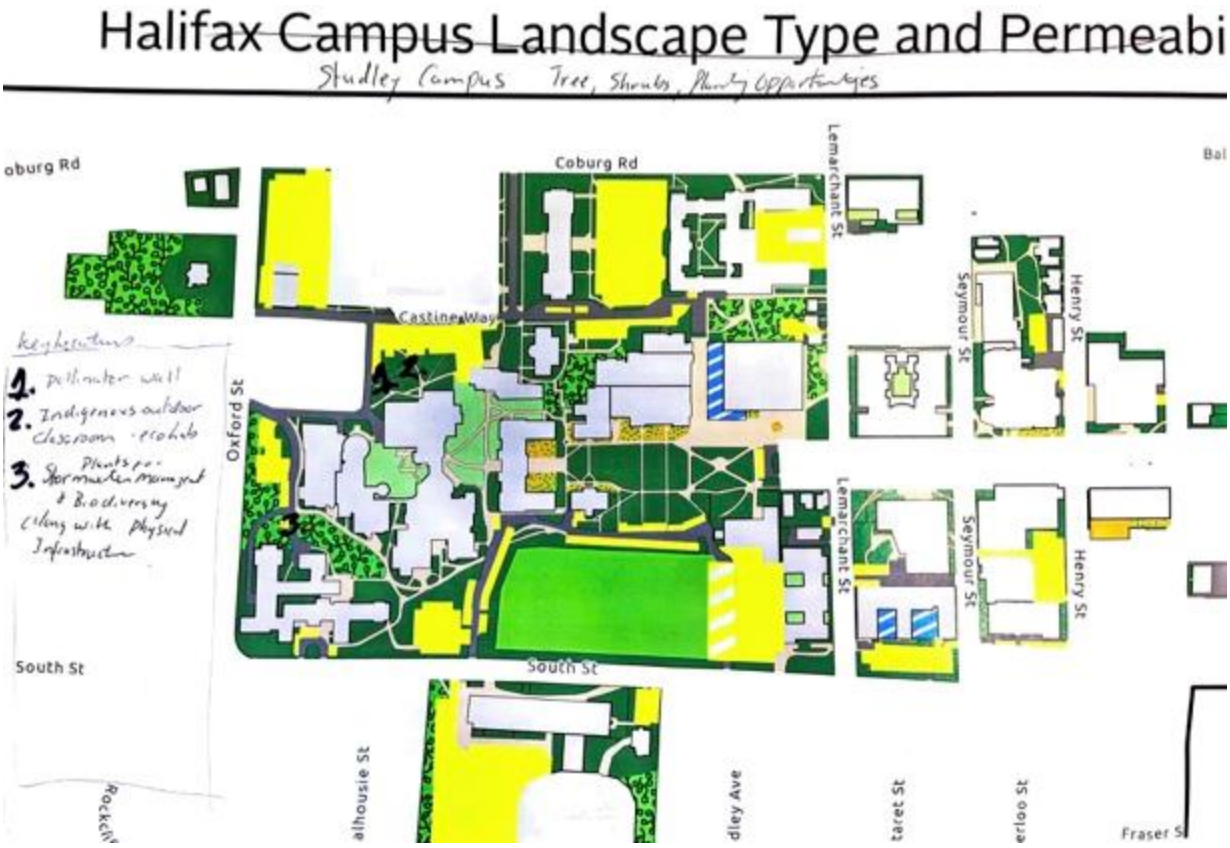

Figure 4. Preliminary map layout of tree planting areas and land description of Dalhousie University's Studley Campus in Halifax, NS, with focus areas.

Appendix B

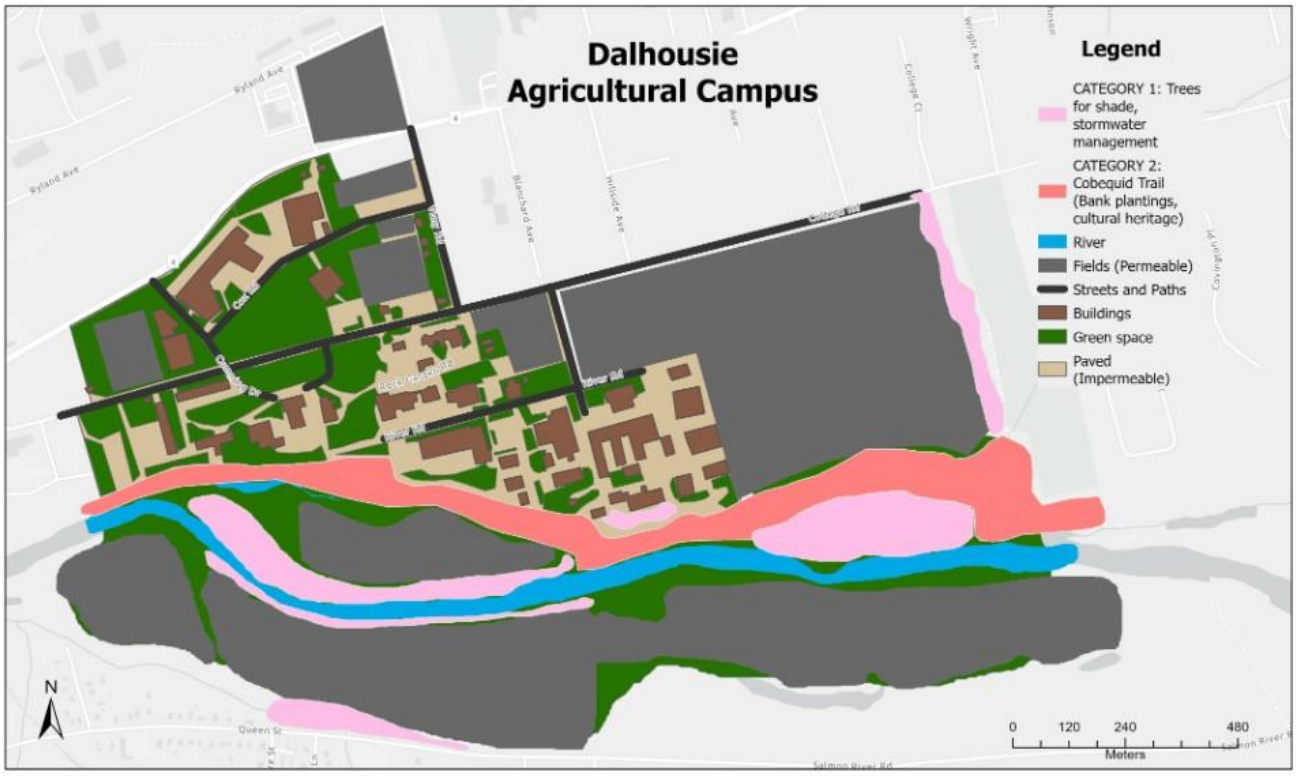

Figure 5. Finalized map layout of tree planting areas and land description of Dalhousie University's Agricultural Campus in Halifax, NS, with two focus areas.

Figure 6. Finalized map layout of tree planting areas and land description of Dalhousie University's Carleton Campus in Halifax, NS, with one focus area.

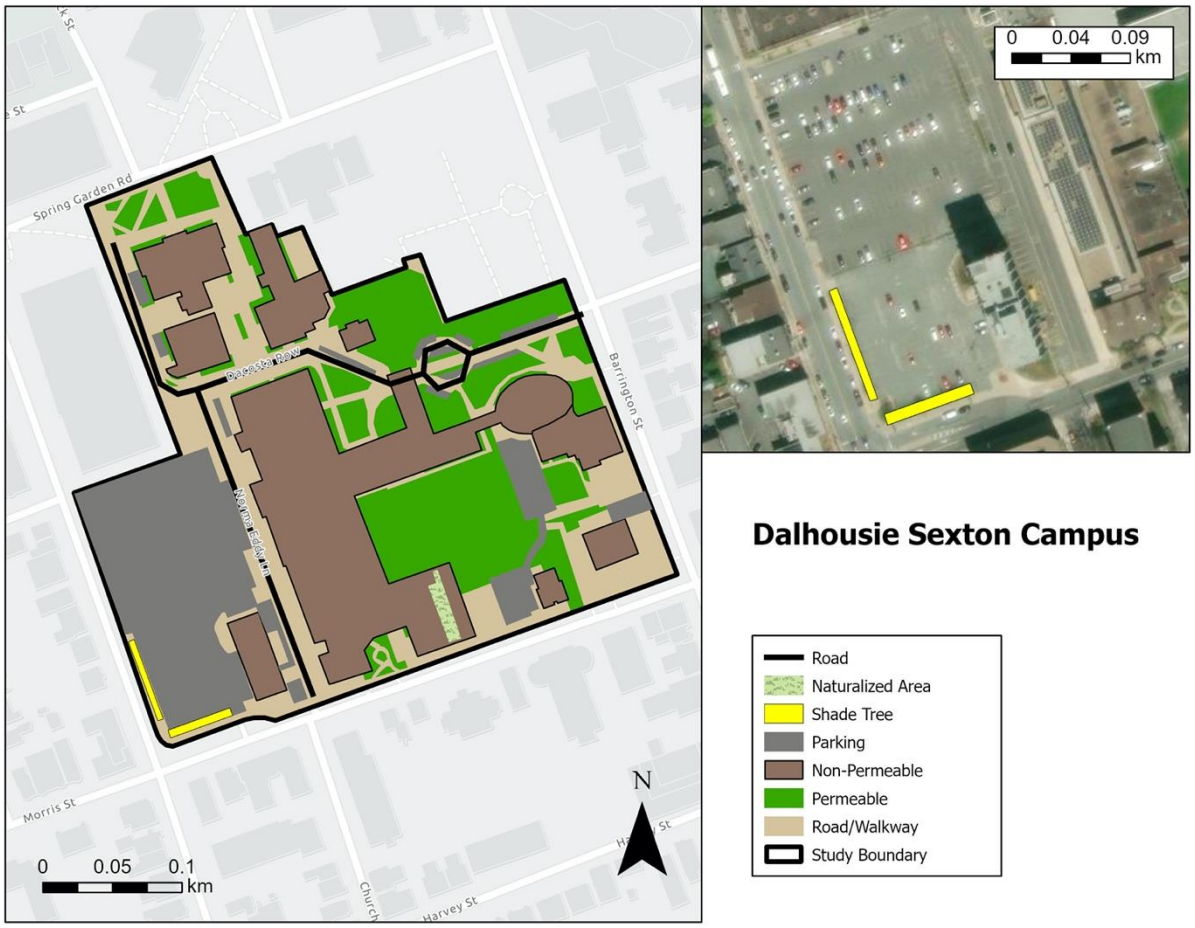

Figure 7. Finalized map layout of tree planting areas and land description of Dalhousie University's Sexton Campus in Halifax, NS, with one focus area.

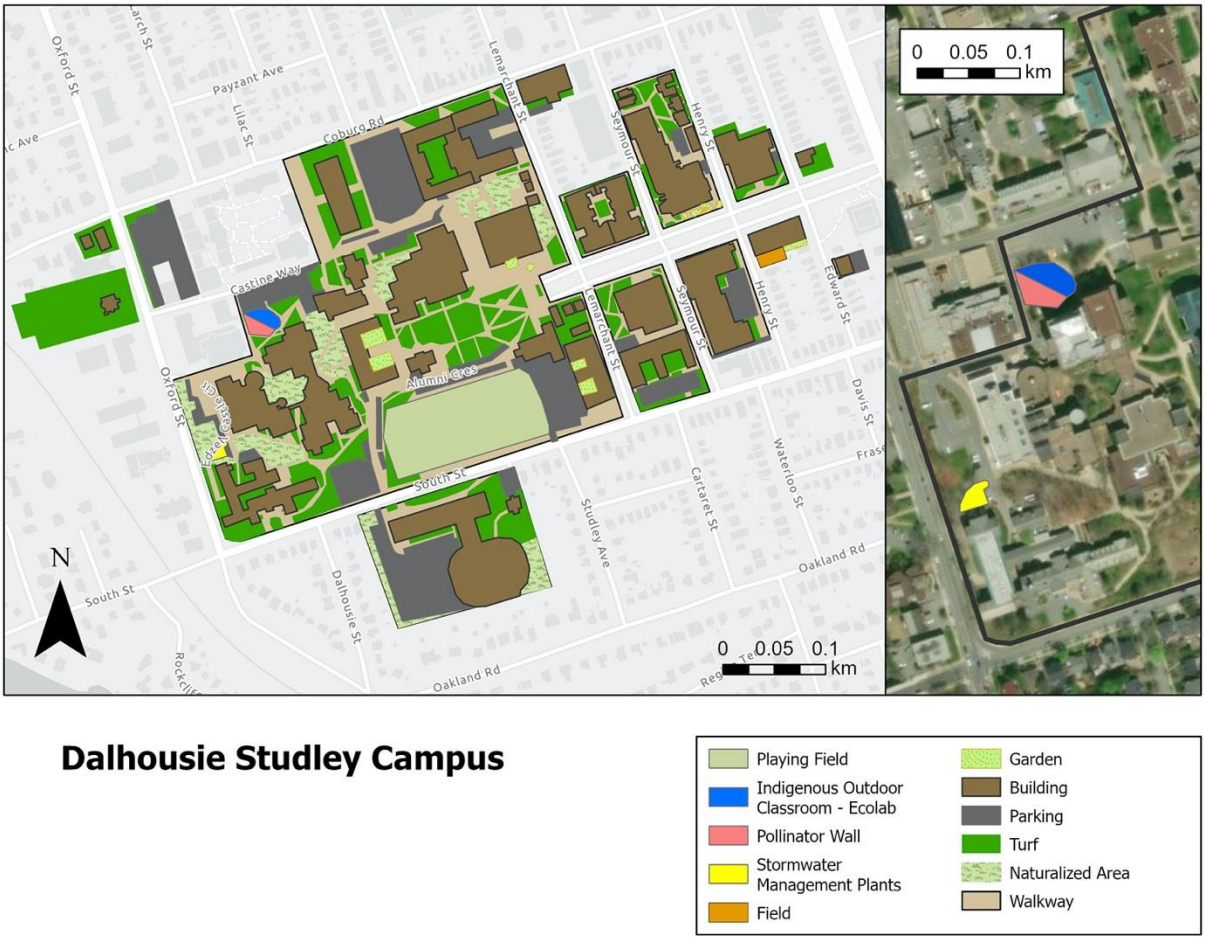

Figure 8. Finalized map layout of tree planting areas and land description of Dalhousie University's Studley Campus in Halifax, NS, with three focus areas.

Appendix C

Table 2. Focus Group Survey Questions, conducted on March 17th via Microsoft Teams.

Open-Ended Questions
What are the values that trees and gardens provide to our campuses?
Looking at the maps, are these appropriate planting areas for gardens and trees?
Do you have any ideas on new areas?
On new approaches?
What are the barriers to planting trees and gardens?
What are opportunities?
What opportunities are there to attract funding for nature-based plantings on campus?

Appendix D

Unsigned consent form given to the participants of the focus group (signature form on a separate page).

DALHOUSIE UNIVERSITY

CONSENT FORM

Project title: Determining Prime Locations for Vegetation Planting on an Urban University Campus

Researchers: Robin Gaudet, Jessie Hudson, Kaela Thomson, Alix Yallowega

In collaboration with: Dalhousie University's Office of Sustainability

Introduction
We invite you to take part in a research study being conducted by Robin Gaudet, Jessie Hudson, Kaela Thomson, and Alix Yallowega, who are Environmental Science students at Dalhousie University. Choosing whether to take part in this research is entirely your choice. There will be no impact on your employment if you decide not to participate in the research. The information below tells you about what is involved in the research, what you will be asked to do and about any benefit, risk, inconvenience, or discomfort that you might experience.
You should discuss any question you have about this study with one of the researchers. Please ask as many questions as you like. If you have questions later, please contact Robin Gaudet at rb202820@dal.ca.

Purpose and Outline of the Research Study
The information that we gather from this focus group will be used to inform our research. We hope to gather data concerning plant and shrub species and the locations in which they would provide the most benefit. Most importantly, we are focusing on the best locations for plantings to facilitate the management. We are additionally interested in seeing how other benefits, such as increasing biodiversity and requiring little maintenance, would complement the locations' likelihood for adequate stormwater management. The information gathered from this focus group has the potential to be very informative for our research project. The gathered data will be used to build maps that summarize the results of the study.

What You Will Be Asked to Do
If you decide to participate in this focus group, you will be asked a few questions to which you are free to answer. That may generate a group discussion to which everyone is encouraged to participate. The focus group will take approximately 1.5 hours.

Possible Benefits, Risks and Discomforts
Benefits: Participating in the study might not benefit you, but we might learn things that will benefit others.

Consent Form

Risks:
The risks associated with this study are minimal. There are no known risks for participating in this research.

How your information will be protected:
During the study, all paper records will be digitized within a week of the focus group and then destroyed once complete. All electronic records will be kept secure on the researcher's password-protected computer. All people who work with us are obligated to keep all research information confidential. The focus group will not be recorded, and names will be left out of any notes taken during the session. Only those involved in the focus group will be aware of the members' identities and no forms with names will be made available.

Confidentiality:
The information provided during the focus group will be kept confidential. Only the researchers listed on the first page, as well as the Office of Sustainability executives Rochelle Owens and Kareina D'Souza will have access to the focus group notes. We will be using simple notetaking on physical and digital paper and use occupation titles only so that the research information we have about you contains no names. We will only refer to people by their professional title and give no other information about where they work, who they work for, or other identifying details. We will group opinions of those in the focus group so not one single person will be referenced. Therefore no one will be able to be identified in our final report.

A general concern to keep in mind is that the other participants might not hold themselves to the same degree of confidentiality that our researchers will. We will not disclose any information about your participation except as required by law or by professional obligations.

Data retention:
Once the data has been collected and analyzed, the focus group notes will be destroyed. The notes taken on paper during the focus group will be burned once analyzed. There will also be a privately shared doc of notes between two of the researchers. This shared document will be deleted once the data is analyzed.

Data repositories:
The research found throughout this study may be shared publicly (most likely in digital form via the Office of Sustainability) to advance knowledge. However, the data will not be in any shape or form inputted into a data repository.

If You Decide to Stop Participating:
You are free to leave the study at any time. If you decide to stop participating during the study, you can decide whether you want any of the information that you have provided up to that

Consent Form

point to be removed or if you will allow us to use that information. After participating in the study, you can decide for up to one week if you want us to remove your data. After that time, it will become impossible for us to remove it because it will already be analyzed.

How to Obtain Results:
We will provide you with a short description of group results when the study and research paper is finished. No individual results will be provided. You can obtain these results by contacting Robin Gaudet (at rb202820@dal.ca).

Questions:
We are happy to talk with you about any questions or concerns you may have about your participation in this research study. Please contact Robin Gaudet (at rb202820@dal.ca) [or Caroline Franklin (at caroline.franklin@dal.ca)] at any time with questions, comments, or concerns about the research study.

Ethical Concerns:
If you have any ethical concerns about your participation in this research, you may also contact Research Ethics, Dalhousie University at (902) 494-3423, or email: ethics@dal.ca

Consent Form

Signature Page

Project Title: Determining Prime Locations for Vegetation Planting on an Urban University Campus

Researchers: Robin Gaudet, Jessie Hudson, Kaela Thomson, Alix Yallowega

I have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I understand that I have been asked to take part in the focus group that will occur at a location acceptable to me. I understand direct quotes of things I say may be used and attributed to me by my professional title. I agree to take part in this study. My participation is voluntary, and I understand that I am free to withdraw from the study at any time, until one week after the focus group.

_____	_____	_____
Name	Signature	Date

Consent Form