

UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Stakeholder Analysis of the Beaty Biodiversity Green Roof

Wasin Chalanuchpong, Joyce Chan, Maria Chisholm, Michelle Nguyen

University of British Columbia

ENVR400

April 24, 2017

Disclaimer: "UBC SEEDS Sustainability Program provides students with the opportunity to share the findings of their studies, as well as their opinions, conclusions and recommendations with the UBC community. The reader should bear in mind that this is a student research project/report and is not an official document of UBC. Furthermore, readers should bear in mind that these reports may not reflect the current status of activities at UBC. We urge you to contact the research persons mentioned in a report or the SEEDS Sustainability Program representative about the current status of the subject matter of a project/report".

Stakeholder Analysis of the Beaty Biodiversity Green Roof

Wasin Chalanuchpong, Joyce Chan, Maria Chisholm, Michelle Nguyen

Advisor: Sara Harris

Course: ENVR 400 001

09/04/2017

Abstract

As a publicly accessible green roof at the University of British Columbia's Beaty Biodiversity Museum, numerous stakeholders utilize this space for a variety of functions and purposes. To enhance its use to the community, it is necessary to determine the possibility for a more focused and diverse range of uses that may be valuable to its stakeholders. Based on the analysis of a public questionnaire regarding current perceptions and suggestions for future uses, as well as a field assessment of the plant species identified on the green roof. Results showed that passive activities such as eating and relaxing are the primary interest for stakeholders. This assessment created baseline data for the management team of the Beaty Biodiversity Museum to use as a guide for maintaining the green roof in a manner that will benefit stakeholders.

Team Biographies

Our team is composed of four Environmental Sciences undergraduates at the University of British Columbia, three of which are working towards a Land, Air, and Water specialization, and one towards an Ecology and Conservation specialization.

Wasin Chalanuchpong is an international student who has experience in poster making and designing, and has worked for an environmental consulting firm in Bangkok, Thailand.

Joyce Chan is interested in botany, geomatics, sustainability and programming.

Maria Chisholm is interested in studying the interplay between science and nature and has experience collecting ecological data and analyzing data sets using MS Excel.

Michelle Nguyen is passionate about marine biology and conservation as well as entomology. She has knowledge pertaining to field data collection, Photoshop and analyzing data sets.

Table of Contents

Abstract	1
Team Biographies	2
Background information	4
Introduction	5
Methodology	6
Public Questionnaire	6
Plant Survey	6
Results	7
Survey Summary	7
Understanding	8
Opinions	10
Discussion	15
Strengths and Limitations	18
Conclusion	19
Acknowledgements	20
References	20
Appendix A	23

Background information

What is a Green Roof?

A green roof is a conventional roof layered with soil and vegetation. Green roofs increase the energy efficiency of buildings by reducing incoming heat in the summer and insulating heat in the winter (Niachou *et al.* 2001). This results in less energy used for cooling or heating, and higher cost savings. They are also used to mitigate stormwater runoff by using plants and soil to absorb the water (VanWoert, et. al, 2005). This process allows the plants to retain the water for a period of time to slow down the flow of water. With numerous benefits for urbanized areas, green roofs are becoming increasingly popular as a more sustainable alternative to traditional roofs.

The Beaty Biodiversity Green Roof

The Beaty green roof was put into place as part of the Beaty Biodiversity Centre, which opened in 2010. The \$50-million project included the Beaty Biodiversity Museum as well as the Biodiversity Research Centre, both of which border a courtyard featuring the green roof as a central meadow (Fig. 1) (Board of Governors, 2012). The green roof was intended as a sustainability feature to catch stormwater runoff and to drain into a connecting stormwater channel along the side of the courtyard.

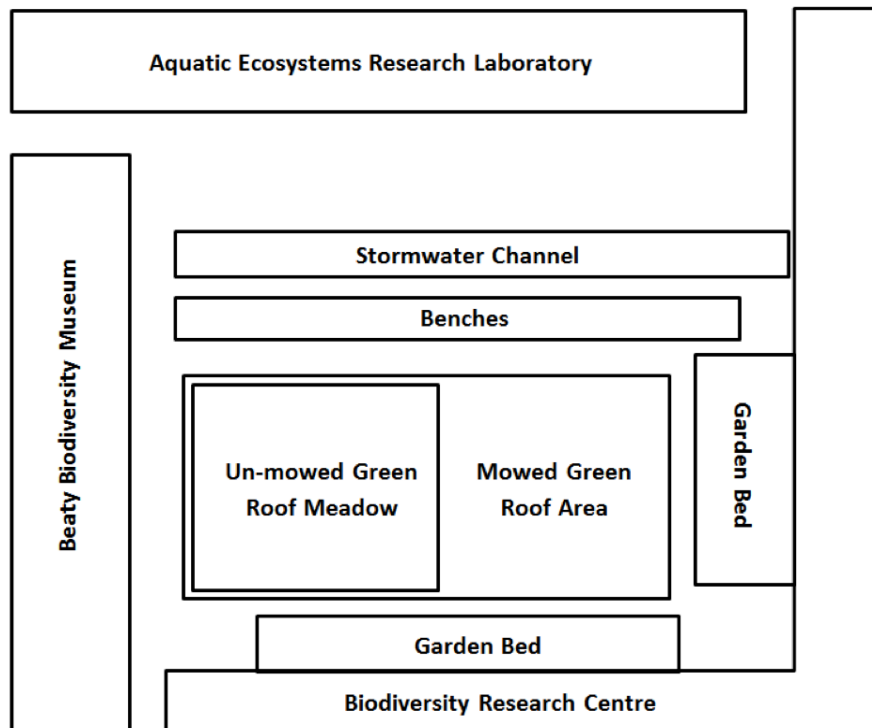


Figure 1. A simplified overhead view of the Beaty Biodiversity green roof, the surrounding courtyard, and nearby buildings.

The courtyard contains beds of native plants bordering narrow walkways that enclose the central green roof meadow. The green roof meadow consists of a layer of soil topped with a variety of grasses and other herbaceous plants. Most of the species that currently inhabit the meadow were not originally planted there, and have come in on their own from other sources. It is currently mowed once per year at the beginning of fall, allowing most plants enough time to grow through the spring and summer and go into seed. Ideally, the meadow provides food and shelter to bird and insect species.

Sitting atop the underground Beaty museum, the green “roof” is on ground level, making it easily accessible to passersby. According to Beaty Museum staff, the green roof is frequently visited by students, researchers from the surrounding buildings, visitors of the museum, and families that live in the UBC area.

In 2014, the green roof was redesigned to reflect the biodiversity initiatives by including a meadow landscape. The intention was to be biodiverse and attractive while incorporating a space for recreation and teaching.

Introduction

Aside from their structural purpose, green roofs can be used in various ways that benefit the community. Potential uses of green roofs include recreation, education, gardening, as well as promoting biodiversity and aesthetics. The complexity of managing a green roof depends on its functional use, and conflict between activities may inhibit the multiple uses coexisting.

Since the opening of the Beaty green roof in 2010, there has not been any studies done to assess how people on campus (stakeholders) would like to use the space. In collaboration with the Beaty Biodiversity Museum, we collected baseline data on social perspective of the Beaty green roof as a tool for future management decisions.

Our team administered a public questionnaire to study stakeholders’ current understanding of the Beaty green roof and their involvement (frequency, type, and season) of using the space. Stakeholders were also asked to share their opinions by ranking their level of interest for using the Beaty green roof for a number of hypothetical activities.

We received a total of 235 responses from the questionnaire, which have been separated into primary and secondary stakeholders. Primary stakeholders refer to occupants of either of the two buildings that surround the Beaty green roof, the Biodiversity Research Center (BRC) or the Aquatic Ecosystems Research Laboratory (AERL). Secondary stakeholders refer to non-occupants of BRC and AERL. The questionnaire results are presented in this paper, as well

as a *conflict and synergy analysis* that explores whether or not more than one function of the green roof can coexist.

Methodology

Public Questionnaire

Using the UBC Survey Tool, we administered a questionnaire to gain information on the following:

1. Demographics of stakeholders
2. Primary location of stakeholders
3. Current understand and perception of the Beaty green roof
4. Current usage of the Beaty green roof
5. Suggested future uses of the Beaty green roof

The questionnaire was distributed via email to the BRC, AERL, and EOAS' Department mailing lists as well as through a link shared on social media. The questionnaire was also distributed by approaching random individuals on campus. During the period of February 27 to March 3 2017, 235 stakeholders (undergraduate and graduate students, faculty, and staff) completed the questionnaire.

The responses were extracted from the UBC Survey Tool and was analyzed using MicroSoft Excel and NVIVO.

Plant Survey

Following the methods of Bauer (1943), we divided the green roof into 42 plots (4.1m x 2.5m), by staking the four corners of each plot and using rope to connect the stakes. Using a measuring tape, wooden stakes were marked every 2.5m along the east and west edges, and marked every 4.1m along the north and south edges. Orange flags were then placed inside the grid mark off the remaining corners, creating 42 plots. As a team we walked through and observed each plot and recorded the percent cover of each plant species. Species were identified using *Flora of the Pacific Northwest* (Hitchcock & Cronquist, 1973) and various volumes of *The Flora of North America* (eFloras, 2008).

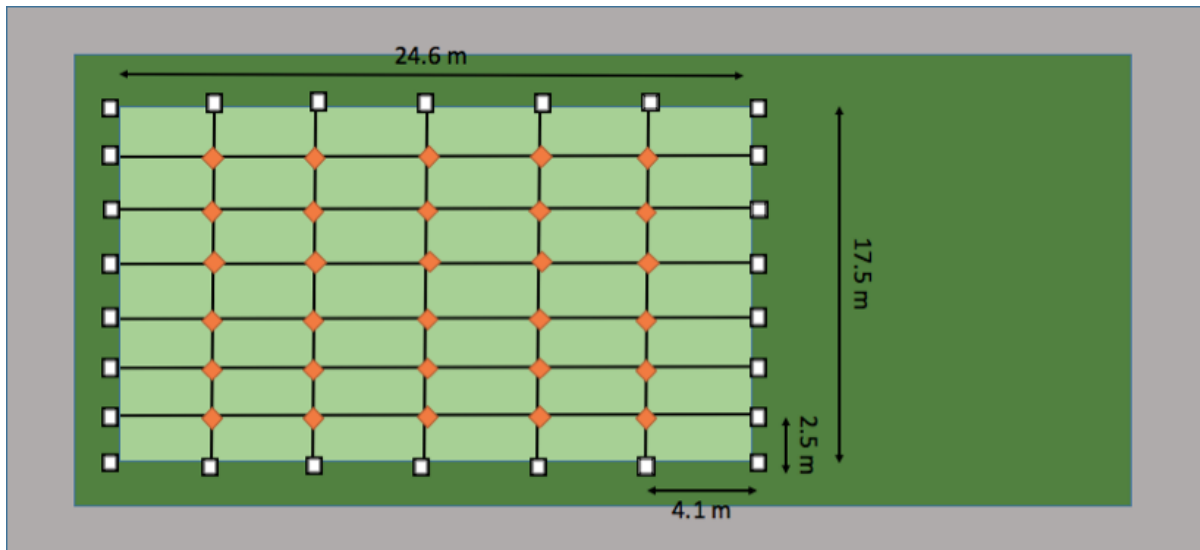


Figure 2. A representation of the 42 plots at the Beaty green roof, where the grey area represents the walkway, the white squares represent wooden stakes, and the orange diamonds are orange flags.

Results

Survey Summary

A total of 235 completed questionnaire responses were received:

- 33% of the responses came from *primary stakeholders*
- 67% of the responses came from *secondary stakeholders*
- 78% of the responses identified as a part of the Faculty of Science
- 32% of the responses came from undergraduate students
- 67% of the responses came from faculty/researchers/professors, UBC staff, or graduates
- 4% of the responses identified as “other” for their occupation

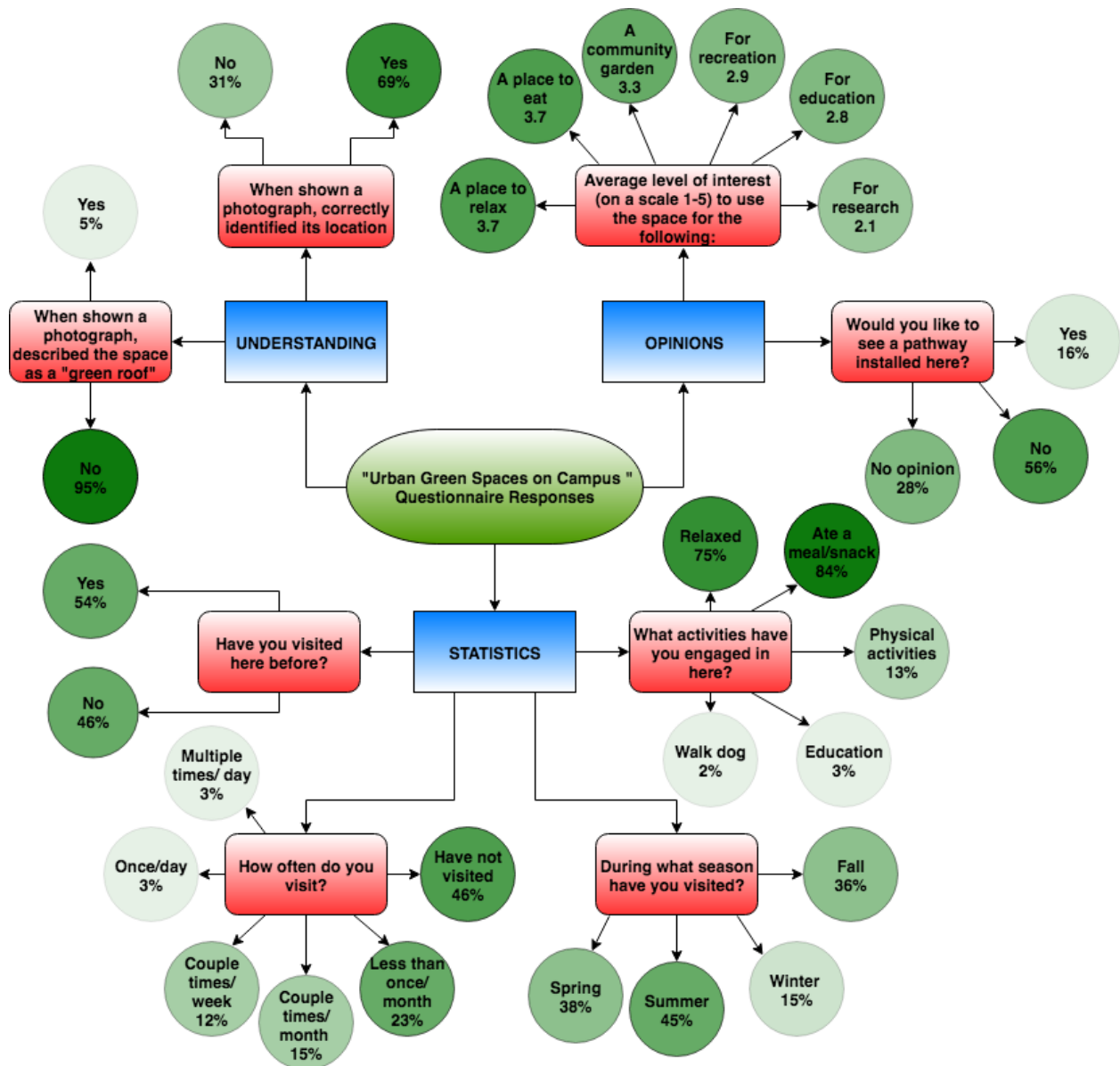


Figure 3. Summary of results from 235 questionnaire responses.

Understanding

To determine whether participants were able to identify the Beaty green roof, they were asked two consecutive questions: "Are you familiar with this space?" and "If yes, where is this located?" Of the 235 participants, 54 stated that they were unfamiliar with the space while 181 participants stated that they were. Responses that identified the location using any of the following words: *Aquatic Ecosystems Research Laboratory, Beaty Biodiversity, Beaty, Beaty Biodiversity Museum, Whale, Skeleton, Research Centre/Center, Beaty Museum, Biodiversity Centre/Center* were taken to be correct. 167 participants (69% of total participants) correctly identified the location of the picture.

Figure 4 A and B illustrates the response when participants were asked to write down “term(s) to define this green area” while accompanied with a photograph of the Beaty green roof.

Term(s) to Define This Green Area

A



B



Figure 4. A) Illustration of common terms used to describe the Beaty green roof, generated using NVIVO. B) Illustration of subjective adjectives used to describe the Beaty green roof, generated using MS Excel.

Of the individuals who were familiar with the photograph and location of the Beaty green roof, we were interested to see how many individuals used the term “green roof” to define the area. Of the 235 questionnaire responses, the term “green roof” was referenced 12 times (3.32%), and the term “green space” was referenced 9 times (2.03%).

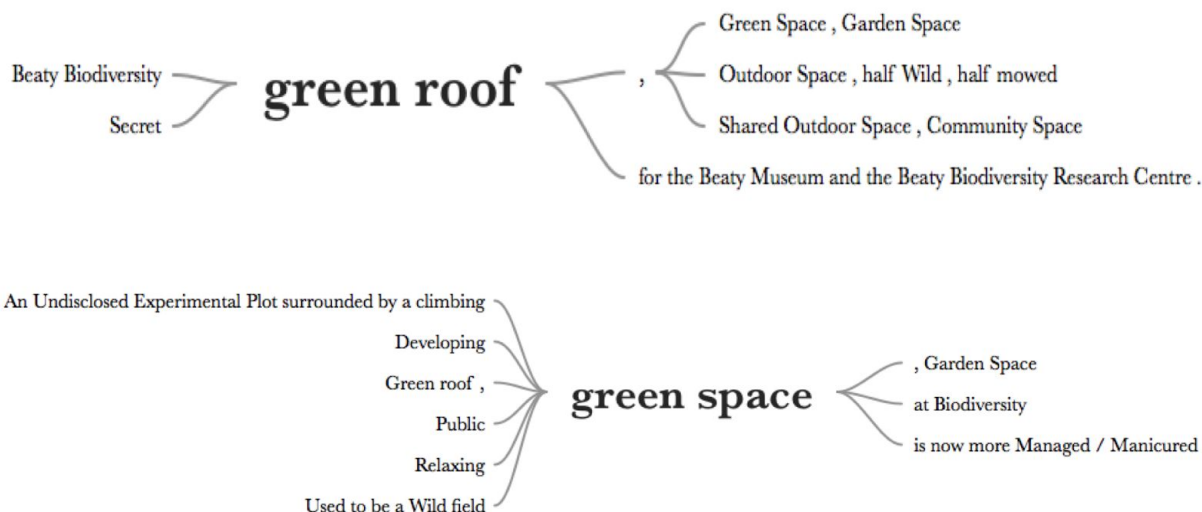


Figure 5. Represents the context in which the terms "green roof" and "green space" were used in the questionnaire responses. The analysis was conducted using NVIVO.

Opinions

To analyze stakeholder’s understanding of the Beaty green roof, they were asked the following question: “What do you think the Beaty Biodiversity Green Roof is used for?” The results are shown in figure 6.

What Do You Think the Beaty Biodiversity Green Roof is Used For?



Figure 6. Illustration of the most common terms used to describe participants’ thoughts on how the Beaty green roof is currently used. The analysis was conducted using NVIVO.

Based on the most frequent words used by stakeholders to describe what the Beaty green roof is used for, a text search query was used to analyze the context the term was used in. Refer to Appendix A, Table A1 to view the results, organized into seven vocations and an other category.

To determine the ideas that participants had for using the Beaty green roof, they were asked to express their thoughts in the comment section of the questionnaire. Overall, 110 stakeholders provided opinions for how the green roof should be used.

Ideas on how to use the green roof

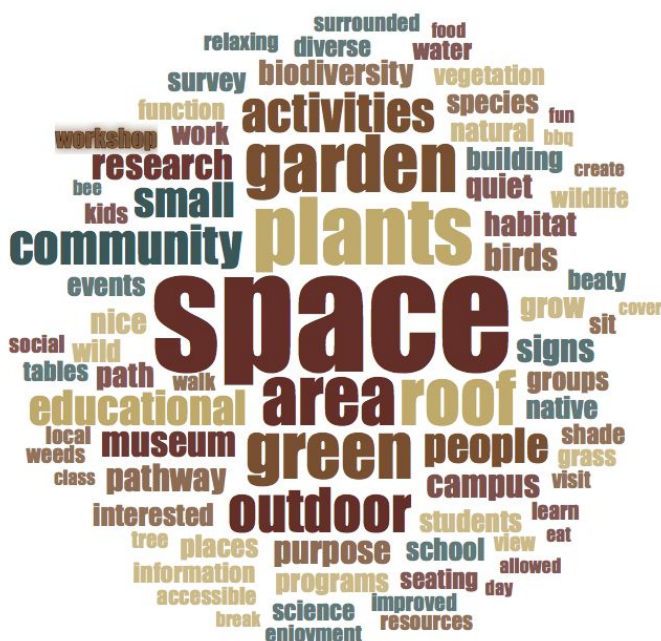


Figure 7. Illustration of the most common terms used to describe stakeholders' ideas on what the Beaty green roof should be used for. The analysis was conducted using NVIVO.

Based on the common themes of the responses, a text search query was used to understand the context of the words used. Refer to Appendix A, Table A2 to view the results organized into seven vocations and an other category.

Next, participants were asked to rate their level of interest for six proposed potential uses for the Beaty green roof. Figure 7 shows the average rankings for primary and secondary stakeholders, as well as an overall weighted average for all participants.

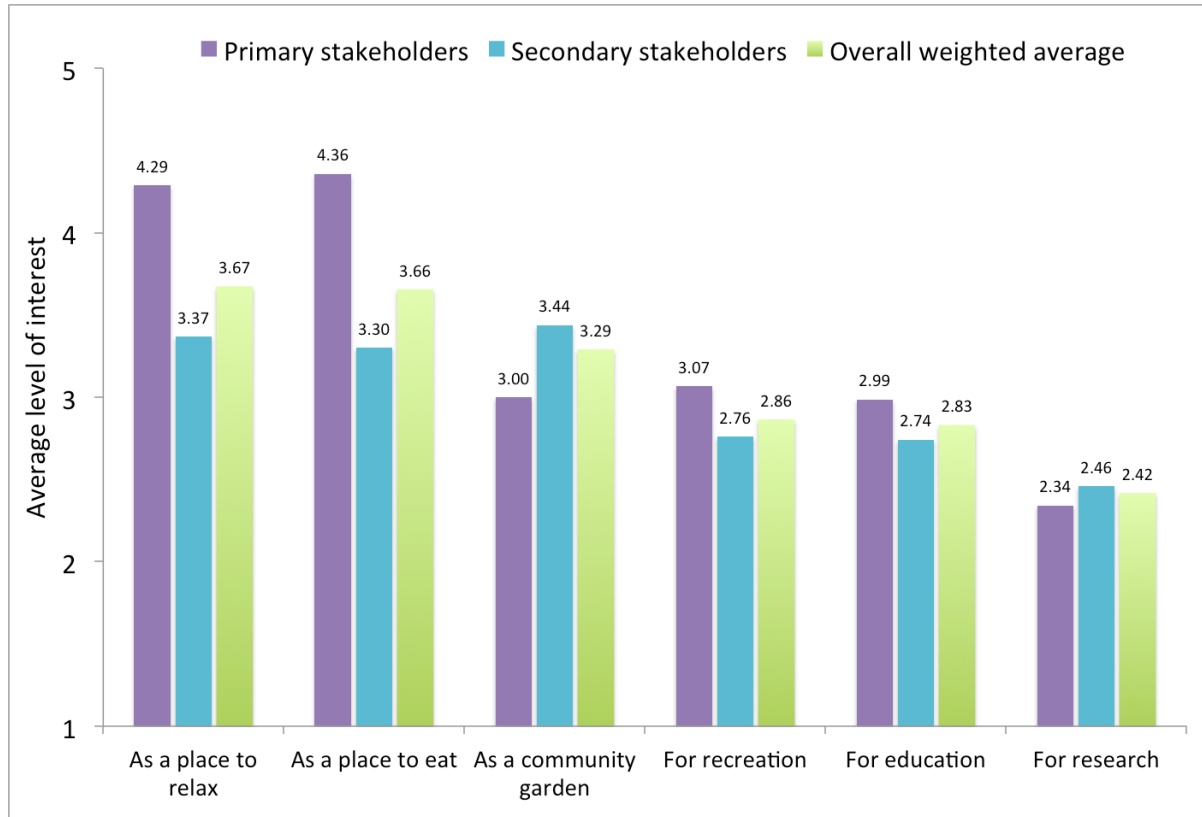


Figure 8. The average level of interest for using the Beaty green roof for six different functions, on a scale of 1 (not interested) to 5 (very interested). Averages were calculated from 78 primary stakeholder responses and 157 secondary stakeholder responses.

Figure 8 indicates secondary stakeholders have a higher interest to use the green roof for community gardening and research compared to primary stakeholders. Primary stakeholders have a higher interest to use the green roof for the remaining four proposed potential uses, and have a larger range in their average responses compared to secondary stakeholders.

To determine how important biodiversity on the Beaty green roof is to stakeholders, the questionnaire asked participants to express “*how important is it for the Beaty green roof to serve as a habitat for diverse plants and invertebrates?*,” on a scale of 1 (not important) to 5 (very important). The results in figure 9 show that majority of participants value biodiversity on the green roof, with primary stakeholders demonstrating a higher level of importance compared to secondary stakeholders.

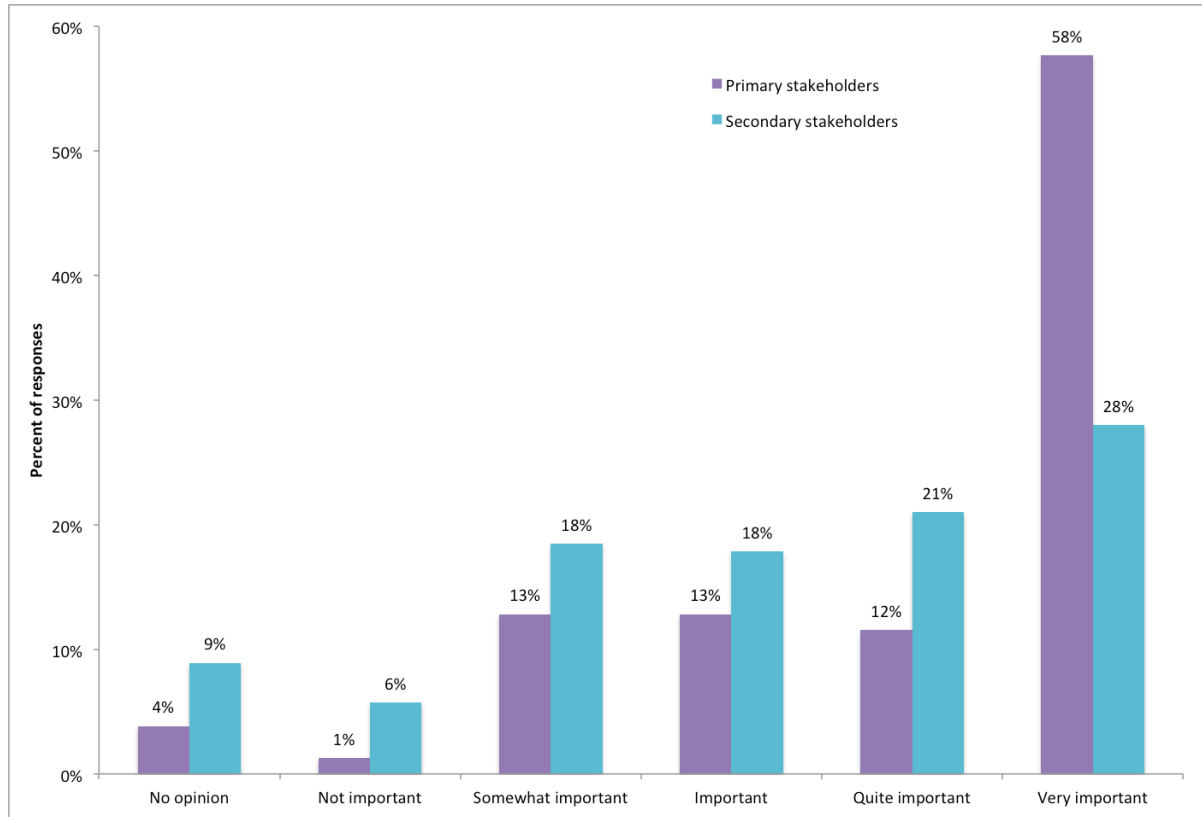


Figure 9. The average level of importance for biodiversity on the Beaty green roof according to primary and secondary stakeholders. Data is based on 78 primary stakeholder and 157 secondary stakeholder questionnaire responses.

To understand the current biodiversity of the Beaty green roof, a plant species composition survey was conducted. 28 unique species of plants were found and identified on the green roof, and of those identified, 8 were classified down to the genus level, and 20 were determined to the species level. 13 of the plant species were found to be exotic, with 7 of those being invasive. 8 species were native, and the remaining 7 could not have their status assessed, as they were only identified down to genus level. The green roof was predominantly covered with an unidentified grass. Of the identified plants, *Symphyotrichum* sp. had the highest percent cover, as shown in figure 10.

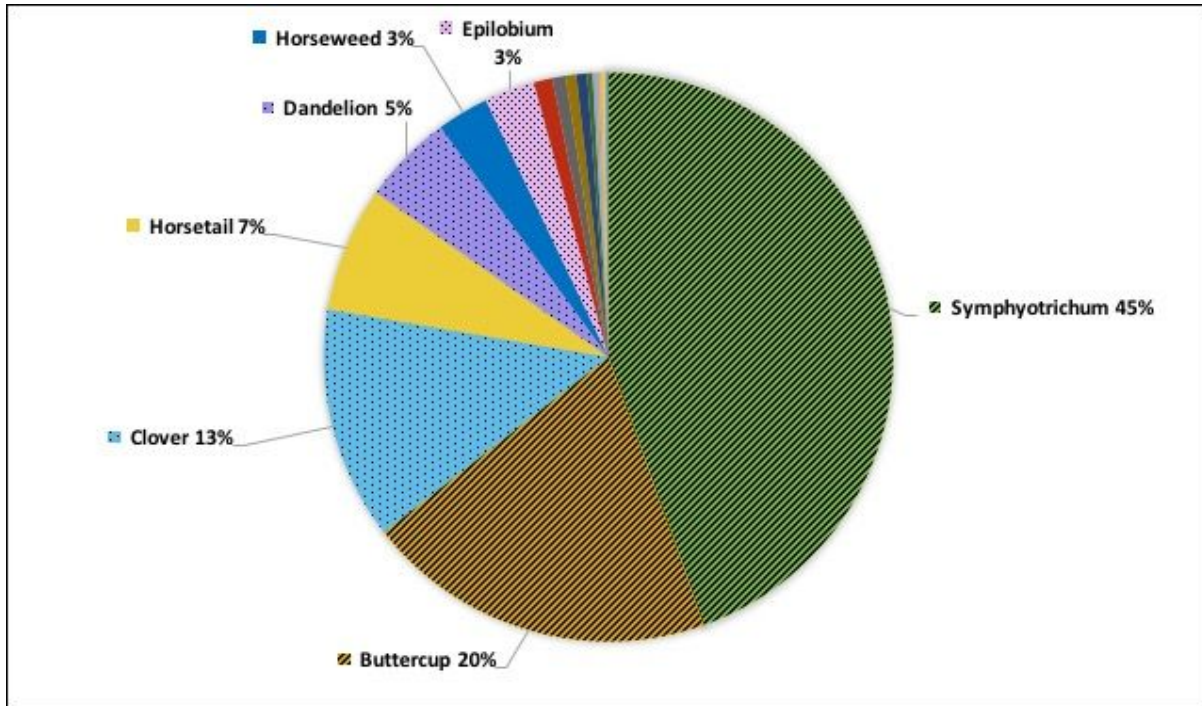


Figure 10. Average percent cover of plant species in the Beaty green roof. Dashed lines indicate invasive species, dotted lines indicate exotic species, and no pattern indicates native species. Labels for species with less than 3% average percent cover are not shown for visual simplicity. Data was collected on October 23, 2016 at the Beaty Biodiversity Museum, University of British Columbia. Values represent the calculated average of each species' percent cover over 42 plots (2.5 m x 4.1 m).

Of the identified species, invasive plants had a much higher percent cover than native plants (figure 10). Areas of over 50% invasive species cover were found near the corners of the green roof, as shown in figure 11.

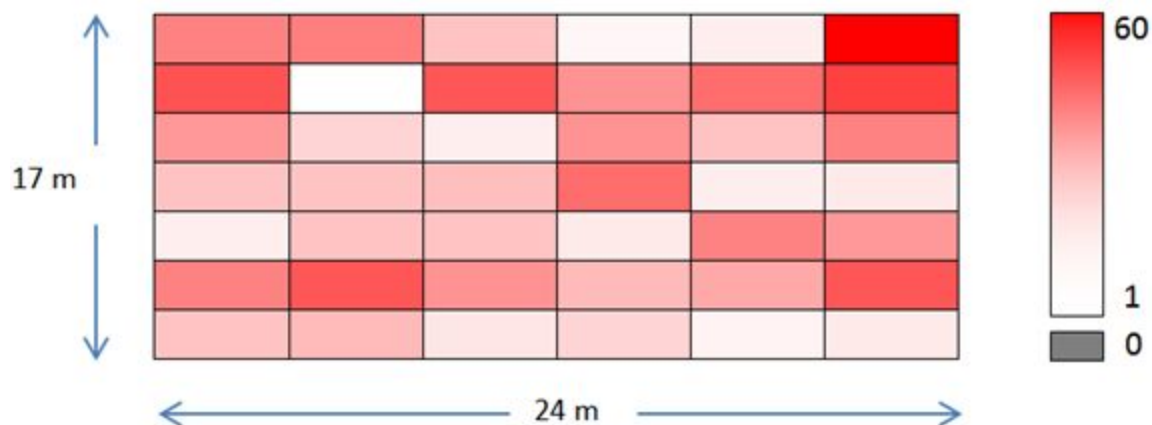


Figure 11. Distribution of invasive plant species on the Beaty green roof based on percent cover per 2.43 m x 4 m plot sampled (n = 42). Maximum percent found = 60%. Data was collected on October 23, 2016 at the Beaty Biodiversity Museum, University of British Columbia.

Four invasive species found were of particular interest: *Cirsium arvense*, *Rubus armeniacus*, *Hypochaeris radicata*, and *Calystegia sepium* as they are often cited on invasive species lists (Invasive Species Council of British Columbia, n.d.; Province of British Columbia, n.d.). Given the wide range of invasive and exotic plant species, and a high importance level to stakeholders, it is imperative to manage the green roof based on native BC plants.

Native plants had much fewer areas of high percent cover, with some plots being completely devoid of native plant cover, as shown in figure 12.

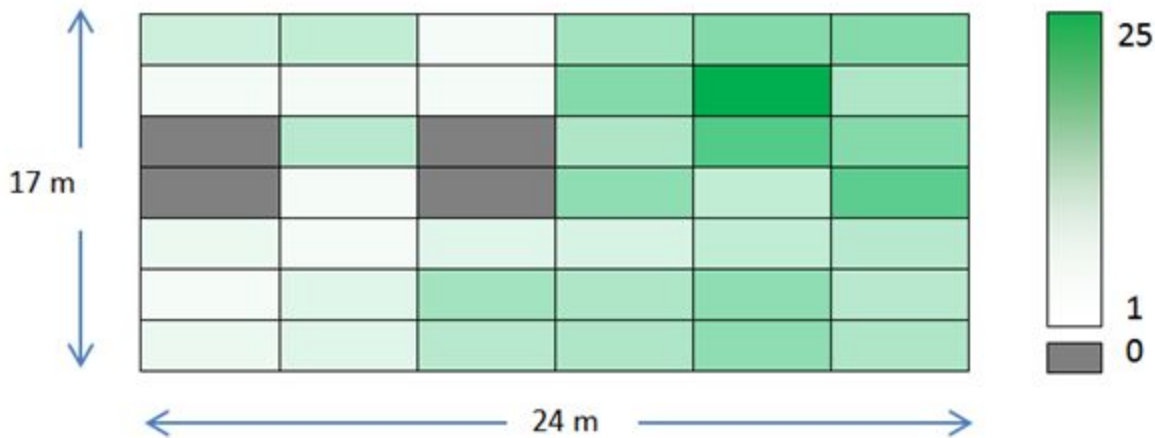


Figure 12. Distribution of native plant species on the Beaty green roof based on percent cover per 2.43 m x 4 m plot sampled (n = 42). Maximum percent found = 25%. Data was collected on October 23, 2016 at the Beaty Biodiversity Museum, University of British Columbia.

To determine the ideas that participants had for using the Beaty green roof, they were asked to express their thoughts in the comment section of the questionnaire. Overall, 110 stakeholders provided opinions for how the green roof should be used.

Discussion

Comparison of Stakeholders' Top Interests

“Passive activities” was a top choice for both primary and secondary stakeholders, showing that all participants placed higher importance on using the green roof as a place to eat and relax. Being that the questionnaire was distributed mainly to working and studying individuals, this response could be explained by the green roof’s potential health benefits. Kinomura & Shimomura (2008) explains that users often feel comfort when connected to nature, which is correlated to reduced stress and health complaints.

After passive activities, the next top interest was “active activities” for primary stakeholders and “community garden” for secondary stakeholders. This distinction might be due to the benefits of these uses targeting different groups of people. Primary stakeholders likely prefer

passive and active activities because they provide *personal benefits* such as stress reduction and greater attentional focus (Dinnie et al. 2013). Secondary stakeholders, on the other hand, may be more inclined to uses that *benefit the community*, by bringing people on campus together. Specifically, a community garden would facilitate campus involvement, socialization, access to fresh food, and sustainability (Guitart et al. 2012).

Synergy and Conflict between Vocations

Burgess et al. (1988) claim that successful green spaces are those that appeal to individuals with urbanized landscapes and naturalistic environments. By integrating these two, it meets a variety of users’ expectations and ideals compared to spaces that serve a single function. To explore the possibilities of multiples uses, Power (2010) explains that tradeoffs between the supply of various ecosystem services exist and should be analyzed. Table 1 summarizes potential *areas of conflict* and *areas of synergy* that exist between proposed functions for the Beaty green roof.

		Main Focus						
		Physical Activities	Passive Activities	Education	Research	Biodiversity	Aesthetics	Community Garden
Secondary Focus	Physical Activities		+	+/-	-	-	-	-
	Passive Activities	+		+	+	+	+	+/-
	Education	+/-	+		+	+	-	+
	Research	-	+	+		+	-	+
	Biodiversity	-	+	+	+		+	-
	Aesthetics	-	+	+/-	-	+		-
	Community Garden	-	+/-	-	-	+	-	

Table 1. Hypothetical relationship between two coexisting uses for the Beaty green roof. The table predicts whether or not the secondary focus is conflicting (-) or is synergistic (+) with the main focus.

Can the top two vocations coexist on the Beaty green roof?

From the questionnaire responses, we have concluded the top 2 vocations of interest for primary stakeholders as *passive activities* and *physical activities*, and as *passive activities* and a *community garden* for secondary stakeholders.

By using the synergistic table (Table 1), if *passive activities* is the main focus for using the green roof compared to the secondary focus, *physical activities*, and vice versa, the top two vocations for primary stakeholders would be synergistic as both types of activities would use a similar space (ie. an open field) and would not interfere with each other. For instance, if the space is used for sports, other stakeholders may use the surrounding picnic tables and benches to relax and watch.

While comparing *passive activities* as a main focus to *community garden* as a secondary focus and vice versa, these top two vocations for secondary stakeholders can be synergistic, given that the garden would allow activities such as eating and relaxing, and the passive activities will not damage the garden plants. However, a conflict may arise between the two as using organic soil for plants may temporarily prevent stakeholders from using the space for relaxation.

Biodiversity and Invasive Species

Biodiversity is important to all stakeholders, yet invasive species are prominent on the green roof. This is an issue, as many invasive plants are weedy, possessing traits that allow them to grow and spread faster than native species. They use up resources and choke out native plants, thereby threatening native biodiversity (MacKinnon et al. 2014). If left unchecked, some of these species could grow to take over the entire green roof. For example, Himalayan blackberry grows quickly through underground rhizomes, aboveground shoots, and eventually by fruit (Gaire et al. 2015). The found shoots should be removed quickly before the rhizomes spread so far that a significant area of the green roof would need to be dug up. Although only a small amount of Himalayan blackberry was found, Beaty should deal with it as soon as possible.

Furthermore, some of the invasive species found on the green roof pose a health hazard. Himalayan blackberry and Canada thistle both have prickles that can damage skin on contact (Gaire et al. 2015; Moore 1975). As many visiting children enjoy running through and playing in the green roof meadow, these prickly plants should be removed to reduce the risk of someone falling onto them. In order to maintain or improve native biodiversity on the green roof, as well as keep visitors safe, these invasive species will need to be removed.

Range of Interest Levels

Primary stakeholders showed a wider range of interest levels compared to secondary stakeholders. While secondary stakeholders were on average moderately interested in the six uses proposed (average level of interest ranged from 2.46 - 3.37), primary stakeholders were

mildly interested in some uses, and very interested in other (average level of interest ranged from 2.34 - 4.36). The largest jump in interest level occurred between “research” and “passive activities”. Primary stakeholders preferred using the green roof for passive activities 39% more than they would for research, while secondary stakeholders preferred passive activities only 18% more than for research.

This difference in range of interest level may be due to each group’s relative investment in the green roof. Primary stakeholders are the current main users of the green roof and use it as part of their workplace, taking breaks, eating lunch, and socializing there. They rely more on the green roof, and therefore might have been more inclined to voice a strong opinion on the questionnaire. The secondary stakeholders likely do not have a strong personal investment towards green roof, as they likely have green areas near their own workplaces to use, or they are students who spend their days in many locations across campus. As a result, secondary stakeholders are likely to have a more neutral interest level.

Strengths and Limitations

Public Questionnaire Strengths

The mixture of qualitative and quantitative responses to the public questionnaire provided a more holistic representation. The questions asking for qualitative (text) responses provided personal and detailed information to analyze. This allowed an in depth understanding on how the Beaty green roof is perceived by stakeholders as well as the opportunity for participants to express their ideas openingly and anonymously. The questions using a quantitative (numeric) scale provided responses with a standard ranking scale in order to calculate averages.

Public Questionnaire limitations

The responses of the public questionnaire may be considered a limited stakeholder representation. The questionnaire was electronically distributed to the building mailing lists of the BRC, AERL and EOAS, thus a great number of responses belong to the Faculty of Science. Under the assumption that most green roof visitors are individuals who spend time nearby, the locations chosen to approach individuals to complete the questionnaire were buildings relatively close to the green roof.

The lack of explicit definitions for key terms such as ‘*community garden*’ and ‘*recreation*’ was a limitation to our questionnaire. Participants may interpret these terms differently, as community gardens may be solely used to produce fruits and vegetables, or flowers, or a mixture of both. Additionally, recreation may be subjectively viewed as either passive or physical activities, or a combination of both. This may lead to misinterpretations, loss or

addition of meanings and variations in perceptions that cannot be distinguished. As analyzers of the results, unknowingly, this may lead to a confirmation bias towards a particular vocation. As well, the potential uses listed in the questionnaire were not detailed. For example, people were asked to rate their level of interest in a broad “*physical activities*” category, but individual activities were not specified. Various activities would synergize and conflict differently, thus no clear conclusions on how to use the green roof can be made. However, the main areas of general interest found by this study should be noted, and used in future surveys for public interest, therefore the best specific uses can be determined.

Furthermore, for the question, ‘*How important is it for the Beaty green roof to serve as a habitat for diverse plants and invertebrates?*’ the ranking scale available for participants may be skewed towards being important. The scale presented is: *not important, somewhat important, important, quite important, very important*. If stakeholders feel that biodiversity is “*somewhat not important*” this option is not available. In future questionnaires, responses available to stakeholders should reflect an equal amount of choices for favorable and unfavorable ranks.

Plant Survey Limitations

As the plant survey was done in the middle of the fall season, key reproductive features such as flowers and fruits were not present, causing difficulty, and possibly error, in identifications. Additionally, with poor weather conditions, heavy rain caused longer grasses to cover small plants closer to ground level, leading to variations in percent cover and error in finding different plant species.

The timing of the survey also inhibited us from identifying spring plants, such as Camas lily. To create a more accurate plant species list, plant surveys should be done throughout the growing season (spring through summer) to capture dynamic compositions from species that have different growing or flowering times.

Conclusion

This questionnaire provided valuable data on social perception of the green roof, as well as plant composition and biodiversity on the green roof. Given the vocations that stakeholders provide the most and least interest in, this may provide sufficient background information for a follow-up study to understand the popular choices of activities users’ would like to participate in. Depending on these choices, management strategies will be designed accordingly. Thus, limitations of this study should be considered before applying the data. Using the questionnaire response data and a synergistic approach to determine the trade-offs between vocations will allow the Beaty Museum to determine how to engage primary and/or secondary stakeholders in the future use of the green roof.

Acknowledgements

We would like to thank Sara Harris, Bernardo Ranieri, Jackie Chambers, and Catherine Ouellet-Martin for their input and support throughout the project. We would also like to thank Jamie Fenneman and Karen Needham for their advice on plant identification and invertebrate identification, respectively. A kind thank you to Michael Meitner for feedback on designing our urban green space questionnaire.

References

- Au, A. Y. T. (2007). A planning tool of urban greenroofs (M.A.Sc.). Ryerson University (Canada), Canada.
- Board of Governors. "The University of British Columbia for Information." (n.d.): n. pag. 4 Dec. 2012. Web.
<http://bog2.sites.olt.ubc.ca/files/2012/11/6.5a_2012.12_Board-4-Beaty-Biodiversity-Centre.pdf>.
- Burgess, J., Harrison, C. M., & Limb, M. (1988). People, parks and the urban green: A study of popular meanings and values for open spaces in the city. *Urban Studies*, 25(6), 455-473.
- Dinnie, E., Brown, K. M., & Morris, S. (2013). Reprint of "Community, cooperation and conflict: Negotiating the social well-being benefits of urban greenspace experiences". *Landscape and Urban Planning*, 118, 103-111.
- eFloras. *eFloras*. Missouri Botanical Garden, St. Louis, MO & Harvard University Herbaria, Cambridge, MA., 2008. Web. 07 Apr. 2017. <<http://www.efloras.org>>.
- Gaire, R., Astley, C., Upadhyaya, M.K., Clements, D.R., Barga, M. 2015. The Biology of

Canadian Weeds. 154. Himalayan blackberry. *Can. J. Plant Sci.* 95, 557 - 570.
doi:10.4141/CJPS-2014-402

Glover, T. D. (2004). Social Capital in the Lived Experiences of Community Gardeners. *Leisure Sciences*, 26(2), 143–162. <https://doi.org/10.1080/01490400490432064>

Guitart, Daniela, Catherine Pickering, and Jason Byrne. "Past results and future directions in urban community gardens research." *Urban Forestry & Urban Greening* 11.4 (2012): 364-373.

Hitchcock, C. L., & Cronquist, A. (1973). *Flora of the pacific northwest: An illustrated manual*. Seattle: University of Washington Press.

Invasive Species Council of British Columbia. 2014. Invasive Plants. Accessed online
<<http://bcinvasives.ca/invasive-species/identify/invasive-plants>>

Kinomura Y., & Shimomura T. (2008). Questionnaire Study on Actual Situation and Future of Green Roofs Used as Office Worker's Relaxation Spaces. *Journal of The Japanese Institute of Landscape Architecture*, 71(5), 827–832.
<https://doi.org/10.5632/jila.71.827>

Mackinnon, E.D., Pratt, R.B., Jacobsen, A.L. 2014. Functional trait differences between weedy and non-weedy plants in southern California. *Madrono*, 61(4), 328-338.
<http://dx.doi.org/10.3120/0024-9637-61.4.328>

Mastrangelo, M. E., Weyland, F., Villarino, S. H., Barral, M. P., & Nahuelhual, L. (2014). *Landscape ecology: Concepts and methods for landscape multifunctionality and a*

unifying framework based on ecosystem services. Springer.
doi:10.1007/s10980-013-9959-9

Moore, R. J. 1975. The biology of Canadian weeds. 13. *Cirsium arvense* (L.) Scop. *Can. J. Plant Sci.*, 55, 1033-1048.

Niachou, A., Papakonstantinou, K., Santamouris, M., Tsangrassoulis, A., & Mihalakakou, G. (2001). Analysis of the green roof thermal properties and investigation of its energy performance. *Energy and Buildings*, 33(7), 719–729.
[https://doi.org/10.1016/S0378-7788\(01\)00062-7](https://doi.org/10.1016/S0378-7788(01)00062-7)

Power, A. G. (2010). *Philosophical transactions. biological sciences: Ecosystem services and agriculture: Tradeoffs and synergies.* Royal Society. doi:10.1098/rstb.2010.0143

Province of British Columbia. Invasive Alien Plant Program (IAPP) Application Training.
Accessed online <<https://www.for.gov.bc.ca/hra/Plants/IAPPtraining.htm>>

Rode, J., Wittmer, H., Emerton, L., & Schroeter-Schlaack, C. (2016). *Journal for nature conservation: 'ecosystem service opportunities': A practice-oriented framework for identifying economic instruments to enhance biodiversity and human livelihoods.* Elsevier. doi:10.1016/j.jnc.2016.07.001

VanWoert, N., VanWoert, N.D., Rowe, D.B., Andresen, J.A., Rugh, C.L. (2005). Journal of environmental quality: Green roof stormwater retention: Effects of roof surface, slope, and media depth. *American Society of Agronomy.*

Young, R. F. (2010). *Managing municipal green space for ecosystem services. Urban Forestry & Urban Greening*, 9(4), 313–321. <https://doi.org/10.1016/j.ufug.2010.06.007>

Appendix A

Table A1. The ten most common terms taken from phrases or notes that participants stated in their knowledge or beliefs that the Beaty green roof is used for. These terms are: *space, lunch, museum, plants, green, people, research, area, education, recreation*. Frequent terms searched related back to the same comments repeatedly. Results are organized by vocation and other comments. Bolded comments indicate that it may be applicable to multiple vocations.

Vocation		
Physical Activities	<ul style="list-style-type: none"> - Frisbee - Volleyball - Play space for children - Events 	<ul style="list-style-type: none"> - For faculty, staff, and students, the community - Recreation
Passive Activities	<ul style="list-style-type: none"> - Meeting space - Picnicking - Socializing - Lunch or coffee break space - Outdoor space - Recreation 	<ul style="list-style-type: none"> - Barbeques - Relaxation - Events - For faculty, staff, and students, the community
Education	<ul style="list-style-type: none"> - Learning from the museum, studying - School groups - Museum outreach (bug hunts, pond poke, plant exploration) 	<ul style="list-style-type: none"> - Field trips - Outdoor exhibits - Native plant garden for education
Research	<ul style="list-style-type: none"> - Experiments - Comparison studies between the meadow and mowed sections 	<ul style="list-style-type: none"> - Research
Biodiversity	<ul style="list-style-type: none"> - Birds and insects - Native species habitat - Ecological development - Wild native grass garden 	<ul style="list-style-type: none"> - Plants and animal ecosystem - Habitat restoration - Maximizing conditions for the range of flora and fauna
Aesthetics	<ul style="list-style-type: none"> - Aesthetics 	<ul style="list-style-type: none"> - Garden
Food Production	<ul style="list-style-type: none"> - No comments 	<ul style="list-style-type: none"> - No comments
Other Comments	<ul style="list-style-type: none"> - Additional green space on campus, until there is a decision made for how to use it - Seems to be no function - seems to be growing wild 	<ul style="list-style-type: none"> - Temperature regulation, water quality remediation, mitigation and filtration - I didn't know it is a green roof, of its existence, it just seems to be 'there'

Table A2. Suggestions for how the Beaty green roof should be used in the future. Ideas are split between primary stakeholders and primary stakeholders, and were searched based on a text query search in the software, NVIVO. Responses were taken from February 27, 2017-March 3, 2017. Bolded comments indicate that it may be applicable to multiple vocations.

Function	Primary Stakeholders' Opinions	Secondary Stakeholders' Opinions
Active Activities	<ul style="list-style-type: none"> - Keep the area as a 'free space' to be used for various activities 	<ul style="list-style-type: none"> - Volleyball - Yoga - Sports that are not damaging to the grass or plant - Events
Passive Activities	<ul style="list-style-type: none"> - Keep the area as a 'free space' to be used for various activities - More seating areas (benches and tables) - Need quiet places on campus - Preferred as open space without much happening - No outdoor recreation as it might get too loud and disturb offices 	<ul style="list-style-type: none"> - Meetings when good weather conditions - Events - Barbeques, dinners - Performances, talks - Undercover or shading area for people to hangout and engage in the space when it is hot or under poor weather conditions - Bookable space for special events (research, social activities) - Outdoor reading - Relaxing, quiet enjoyment and views - Need more seating for outdoor lunch and breaks
Education	<ul style="list-style-type: none"> - Two spaces: mowed and meadow for learning - Outdoor classroom space - Museum should incorporate science for children (e.g. experimental plots) - Seminar space - Educational signs describing plants, animals, invertebrates found - Plant ID, pressing - Herbarium workshops for native plants 	<ul style="list-style-type: none"> - Seasonal talks - Species/wildlife identification - Bird watching - Student group work area - Outdoor informal lectures - Signage about the function of the green space
Research	<ul style="list-style-type: none"> - No comments 	<ul style="list-style-type: none"> - No comments
Biodiversity	<ul style="list-style-type: none"> - Two spaces: mowed and meadow for habitats - Campus is increasing manicured lawns as low-maintenance outdoor space - courtyard should be seen as habitat for birds, insects, etc with a focus on 	<ul style="list-style-type: none"> - Grow native plants, not invasive - Habitat for diverse plants or animals - More diverse vegetation to attract bees and birds

	<p>including local plants</p> <ul style="list-style-type: none"> - More spaces with plants of interest - Native garden - Add small woody cover to enhance year round use by bird community 	
Aesthetics	<ul style="list-style-type: none"> - Should be maintained as a natural meadow - Make it more accessible to those with mobility issues 	<ul style="list-style-type: none"> - Urban gardening - Look similar to the UBC rose garden - Leave the space alone in its natural state for habitat and human use - Have a company manage or define the purpose of the space (not researchers) - Preserve for calming and pleasing aesthetic - Should stay quiet and open for everyone to use (few are left on campus)
Food Production	<ul style="list-style-type: none"> - Community garden 	<ul style="list-style-type: none"> - No garden as other spaces on campus already have it - Garden for small portion to bring people together; support plant and insect diversity; grow herbs for educational component as well; grow food
Other Ideas	<ul style="list-style-type: none"> - No pathway is needed - Water features, long grasses and native plants on side of roof should function properly 	<ul style="list-style-type: none"> - No pathway - Rebuild the space to serve a purpose - Not many realize you're allowed to use the space as it seems kind of closed off - Rebuild the water system to help water the plants