# Comparing Percent Cover of Select Invasive Plant Species (*Rubus armeniacus, Ilex aquifolum*, and *Hedera helix*) at Salish Creek and Canyon Creek in Pacific Spirit Park

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## Abstract

Understanding the effect of invasive species is becoming increasingly important as they can directly impact the health of ecosystems. This study investigates the percent coverage of three select invasive species within Pacific Spirit Park: Himalayan Blackberry, English Holly, and English Ivy, specifically along Salish and Canyon Creek. Sampling was done by laying a transect line at the stream bank and at forest regions at both creeks, followed by calculation of percent cover for each species within random plots along the transect lines. No significant difference was found between the percent cover of invasive species at the two streams, with a p-value of 0.61927; yet data demonstrated that there was a significantly higher mean percent cover of invasive species within the forest at both creeks than at their respective streams, with a p-value of 0.01658. This can be explained by the similarity between Salish and Canyon environments and by the level of human activity between forests and streams and, implying that more disturbed sites (i.e. sites heavily affected by anthropogenic activity) are more susceptible to invasive species immigration. Thus, our findings suggest that removal efforts of invasive species at Pacific Spirit Park be focused on the forest regions.

## Introduction

It is well established that invasions of exotic species, in general, create profound alterations to the invaded ecosystems. A result of this is the reduction in plant biodiversity of the invaded ecosystem (Hejda et al., 2009). It seems that invasive plants can also indirectly decrease animal biodiversity, through a bottom-up mechanism (Gerber et al., 2008). That is to say, the loss of native species can be detrimental to primary consumers adapted to feed on these species, which then also affects species at higher trophic levels (Gerber et al., 2008). In addition, there are documented effects on soil and water quality. Woody and riparian invasive plants are severe water consumers (Pejchar and Mooney, 2009). The large uptake of water can decrease stream water level and decrease streamflow (Pejchar and Mooney, 2009). Moreover, invasive vines have weak root structures that do not bind soils well. The soils in these areas are thus subject to erosion, releasing sediments that accumulate in streams, decreasing water quality (“The Problem With Invasive Plants").

A mapping project of invasive species in the Pacific Spirit Park revealed about 17% of the forest surveyed were invaded (Jerowsky, 2016). One of the main causes was identified to be the continual disposal of yard waste into the forest for over 30 years

(Jerowsky, 2016). The three most common invasive species mapped are *Ilex aquifolium* (English Holly), *Hedera helix* (English Ivy) and *Rubus armeniacus* (Himalayan Blackberry). According the the Invasive Species Council of BC, all of these plants are known to thrive in moist soils along stream banks. They are also aggressive invasive plants. English Holly and Himalayan Blackberry are hardy, dense shrubs that outcompete native plants for ground cover, sunlight and water (Fotelli et al., 2005; ISCBC). English Ivy damages host trees because their added weight makes it easier for the wind to uproot the tree ("The Problem With Invasive Plants").

With this knowledge, we wish to compare the percent cover of invasive species collectively along different stream banks in Pacific Spirit Park. We also wish to compare the percent cover of invasive species collectively between forest and stream banks to determine if there is a preference for riparian habitats based on our findings in literature. Knowledge regarding the distribution of invasive species may be helpful for future efforts on invasive species removal. In addition, distribution patterns may indicate certain interactions between invasive species and the native ecosystem in Pacific Spirit Park, providing groundwork for further research.

**Methods and Procedure**

The two streams chosen for investigation were Salish and Canyon Creek, primarily due to their convenient location and ease of accessibility. They are given the designations Salish (consisting of Salish Creek and surrounding forests) and Canyon (consisting of Canyon Creek and surrounding forests).

At each site, the sampling is done at the stream as well as surrounding forests. There are 30 plots laid out at each site, making up 60 plots in total. Three transect lines mark out three areas for sampling within each site: one for stream side sampling and two for forest sampling. Each sampling area is 30 metres long. For each transect line laid, a random

number generator is used to generate 10 random whole numbers ranging from 0 to 30. Then, each number is located on the transect line. On each of these numbers, a 1-by-1 metre plot is placed so that the corner of the plot is positioned at the number. The three invasive species of interest (Himalayan Blackberry, English Holly and English Ivy) are identified within each plot. Using measuring tape, the length and width of the area occupied by each invasive species is measured and recorded in data tables. Within a plot, the percent cover for one species is calculated by dividing the area occupied by that species by the total area of the plot, which is $1m^2$ in this case (refer to Figure 1a).

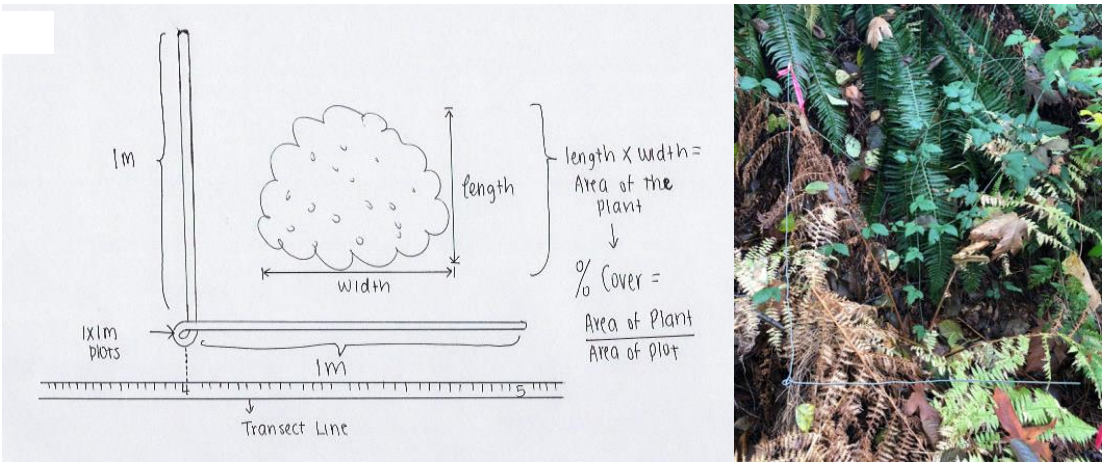


Figure 1. a) Schematic showing how a plot is laid out along the transect line and how percent cover was measured. b) Picture showing example of one of the plots.

At Salish, the transect line is laid out directly alongside the stream bank for streamside sampling. Forests on both sides of the creek are sampled for forest sampling (refer to Figure 3a). At the side touching the sidewalk, the transect line is laid out in the center of a patch of forest located uphill of the creek. The line runs parallel to the creek. At the other side, the line begins on higher grounds but then slopes back down until it is at the creek bank. This was done because the higher grounds became densely vegetated and the transect line was forced to curve around a large tree.

At Canyon Creek, the transect line is also laid out along the stream bank (refer to Figure 2a). Forest sampling is carried out at West and East Canyon trail (refer to Figure 3b). Canyon Creek is accessible by walking through the forest near the bridge located in West

Canyon trail. This forest is sampled along with the Creek. The transect line begins immediately after crossing the bridge (refer to Figure 2b). It then curves into the forest and is laid out straight through the middle of the forest floor, similar to the layout at Salish. The forest on the opposite side of the creek is heavily vegetated and inaccessible. Thus, sampling at the entrance of East Canyon trail is done in replacement. The transect line begins at the mouth of the East Canyon trail, directly past the crossroads between the two Canyon trails. The transect line is then laid out straight on the right edge of the trail. Although the line itself is laid out at the edge of the path, the plots are laid out about 1 meter into the forest floor. This is done because the forest in the East Canyon trail contained more bushy plants and ferns and it is harder to lay the transect line directly in the forest.

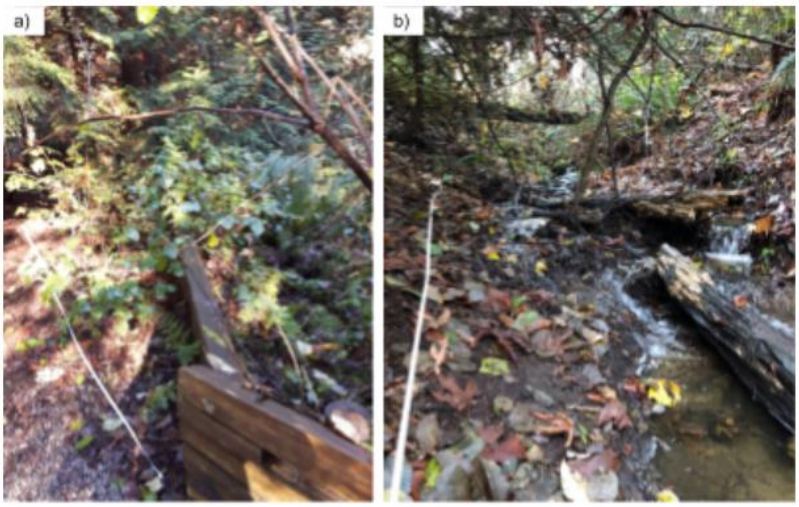


Figure 2. a) Picture of the beginning of the transect line along West Canyon trail, starting just past the bridge. b) Picture of part of the transect line along Canyon Creek


Figure 3. a) Rough estimate of sampled areas at Salish. b) Rough estimate of sampled areas at Canyon. For both graphs, the blue line represents the stream area and black lines represent forest areas.

After data collection, the percent covers of all three species at each site are compiled together and averaged, giving the mean percent cover of all invasive species at each site. The goal is to compare percent cover of invasive species between the two sites as well as between forest and stream environments. To accomplish this task, a two-way ANOVA test is used, with two factors of interest: stream banks versus forest areas and Salish versus Canyon, and one response variable: percent cover of all invasive species.

**Results**

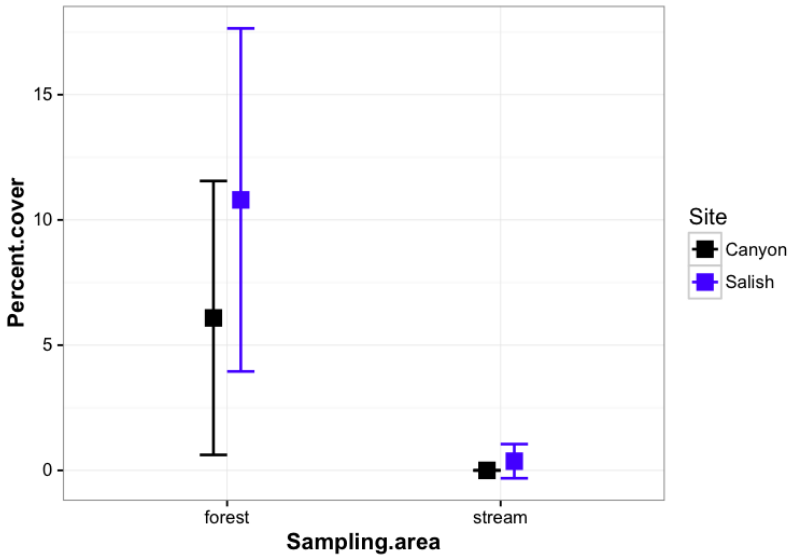


Figure 4. The average percent cover of 3 invasive plants with sites and sampling areas

The error bars in Figure 3 represents the 95% confidence interval of the sample mean percent cover of invasive plant species. The blue and black square represent Salish and Canyon respectively.

The p-value for the comparison between sites is 0.61927, while the p-value for the interaction term is 0.79981. This is less than 0.05, so the results are significant at the 5% significance level. The p-value between forests and streams, however, is 0.01658, which is smaller than the standard alpha value of 0.05. So these results are not significant at the 5% significant level.

The boxplot in Figure 3 explores the average percent cover of invasive plants between sites and sampling areas. It is interesting to note that the average percent cover at the streamside at Canyon and Salish creek is similar, with the average percent cover at the streamside at Canyon creek being 0$m^2$, and approximately 0.1$m^2$ at the streamside at Salish creek. Also, at both Canyon and Salish creek, invasive species in the forest regions have a significantly higher average percent cover than at their respective streamside regions.

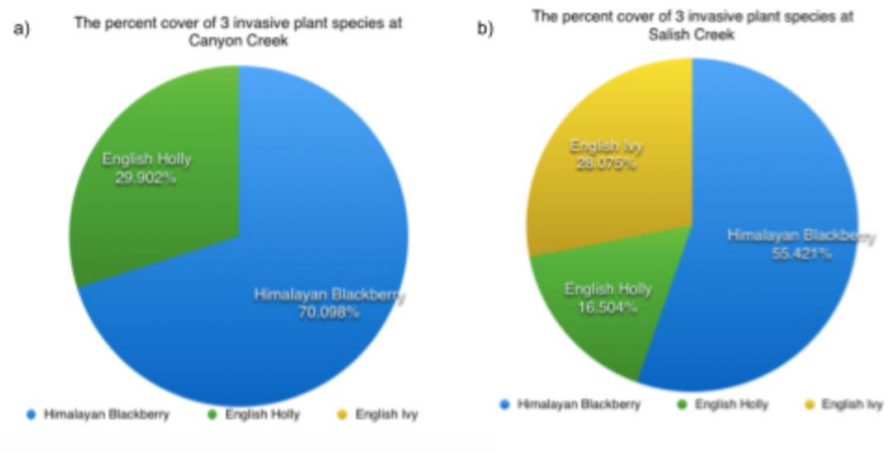


Figure 5. a) Mean percent cover of each invasive species at Salish b) Mean percent cover of each invasive species at Canyon.

Figure 4 shows the mean percent cover of each invasive species at Salish and Canyon sites. In both sites, Himalayan Blackberry has the largest percent cover with 55.421% at Salish and 70.098% at Canyon. English Holly is the second largest in Canyon, but the least largest in Salish with 16.504% at Salish and 29.902% at Canyon. English Ivy is not present at all in Canyon, but is the second largest at Salish, with 28.075%.

**Discussion**

The results indicate there is no significant difference in the mean percent cover of invasive species between Salish and Canyon. This indicates the distribution of invasive species is fairly uniform across the two creeks. Qualitative observations agree as both sites were similar with dense canopy, and abundance in deciduous trees and ferns. The similarity between habitats may simply be due to how close, geographically, Salish and Canyon are to each other.

The forest percent cover is found to be significantly higher than the stream percent covers at both sites. This does not agree with what we expected based on the literature. However, by taking into consideration the disturbance of the ecosystems between forests and streams, we may be able to account for this. Disturbance, in this case, refers specifically to disturbance caused by human activity. It is proposed that invasive species are better able to dominate in weakened ecosystems (Macdougall and Turkington, 2005). Human activity can effectively weaken ecosystems. For example, after forest clearing for land development, native species have trouble re-establishing stable populations (Richardson et al., 1996). In addition, areas near trails and close to human settlements and are, consequently, frequented by people are also found to be more susceptible to domination by exotic plants (Super et al. 2007). Healthy forests, on the other hand, with a thriving native tree population can effectively prevent low-lying invasive plants, such as Himalayan Blackberry and English Holly, from establishing stable populations (Caplan and Yeakley, 2006; Valladares et al., 2005).

Accordingly, the forest areas sampled were indeed more disturbed than the stream areas. The forest sampled at Salish is located uphill of the Creek, bordering a sidewalk and elementary school, while the creek is nestled within farther within the forest. Similarly, most of Canyon Creek is located in a deep valley. The portion of the creek sampled, the only accessible area found, still required lots of effort to traverse due to the dense vegetation and steep slope down to the creek. There were also no direct trails because the creek passed under a bridge. The forest data, on the other hand, are directly collected along the two Canyon trails. So, perhaps, even though the invasive species investigated prefer riparian habitats, the undisturbed and well-established native flora at the streams may have prevented domination of these plants. Furthermore, Jerowsky identified the main cause for invasion due to dumping of yard waste into the park. As the forest sampled are generally

more accessible than the streams, there are also likely more yard waste dumped into the forest, making the forest more frequently exposed to potential invasive species than the streams.

One main source of error within this study is the fact that it took place in November, where temperatures drop during the autumn season in BC. Not only were there limited invasive species, there were limited plant species in general, as the ground was generally covered in dead foliage. In order to improve the study's results this research should be repeated in the spring and summer when plants are actively growing. Accessibility at each creek also introduced accidental bias as we were forced to lay transect lines at easily accessible areas for us, which is not representative of the creeks in their entirety. We also did not define our forest and stream habitats very clearly. In further studies, there needs to be a clear boundary that sets the forest habitat separate from the stream habitats. There is also always the possibility that some of the species were misidentified. Although English Ivy and English Holly is fairly distinctive, there are other blackberry plants with thorns and a similar leave shape to Himalayan Blackberry.

The results suggest more effort should be focused on removing invasive species in the forest. The streams are much less at risk because little to none were found at both creeks. Overall, Himalayan Blackberry is the most prominent invasive species found and English Holly is also present at both sites. Due to their aforementioned negative impact on the ecosystem, removal of these two invasive plants is essential.

This study provides numerous possibilities for future studies. To further investigate the relationship between salmon and invasive species in the surrounding ecosystem, an experimental based study must be done. To ascertain whether anthropogenic effect on the growth of invasive species played a part in the distribution obtained, measurements of invasive species can be done along trails, and deeper within less accessible parts of the forests for comparison. To improve confidence in conclusions obtained, more sampling must

be done at more streams, located farther away from each other and scattered evenly throughout the park.

## Conclusion

The present study finds no significant difference in percent cover of the select invasive species: English Ivy, English Holly and Himalayan Blackberry, between Salish and Canyon Creek within Pacific Spirit Park. There is significantly higher percent cover of the select invasive species, however, at the forest versus the stream bank at both sites, indicating that areas disrupted by human activity are more prone to the invasion of such exotic species. We hope our research will encourage further investigation into how these invasive species are impacting Pacific Spirit Park and, if necessary, what steps of action can be taken to remove them and prevent further spreading.

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**Appendix**

Raw Data:

Salish Creek

Table 1. At stream bank:

| | Percentage cover (%) | | |
|---|---|---|---|
| Distance along transect line (m) | Himalayan Blackberry | English Holly | English Ivy |
| 2 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 |
| 8 | 0 | 0.9 | 0 |
| 9 | 0 | 0 | 10 |
| 10 | 0 | 0 | 0 |
| 11 | 0 | 0.12 | 0 |
| 13 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 |
| 29 | 0 | 0 | 0 |

Table 2. In forest on the side of Salish Creek facing the road:

| | Percentage cover ( %) | | |
|---|---|---|---|
| Distance along transect line (m) | Himalayan Blackberry | English Holly | English Ivy |
| 2 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 |
| 7 | 32 | 0 | 0 |
| 8 | 53.4 | 0 | 0 |
| 11 | 66.6 | 0 | 0 |
| 17 | 88 | 96.8 | 0 |
| 21 | 0 | 0 | 0 |
| 29 | 41 | 10.92 | 0 |

| | | | |
|---|---|---|---|
| 30 | 74.2 | 0 | 0 |

Table 3. In the forest on the other side of Salish Creek:

| | Percentage Cover (%) | | |
|---|---|---|---|
| Distance along the transect line (m) | Himalayan Blackberry | English Holly | English Ivy |
| 2 | 0 | 0 | 100 |
| 3 | 0 | 0 | 75 |
| 6 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 |
| 8 | One plant 50 cm tall | 0 | 0 |
| 11 | 0 | 0 | 0 |
| 17 | 0 | 0 | 0 |
| 21 | 0 | 0 | 0 |
| 29 | 0 | 0 | 0 |
| 30 | 0 | 0 | 0 |

Canyon Creek:

Table 4. At stream bank:

| | Percentage Cover (%) | | |
|---|---|---|---|
| Distance along transect line (m) | Himalayan Blackberry | English Holly | English Ivy |
| 2 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 |
| 12 | 0 | 0 | 0 |
| 13 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 |
| 21 | 0 | 0 | 0 |

| | | | |
|---|---|---|---|
| 22 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 |
| 25 | 0 | 0 | 0 |

Table 5. In forest along the entrance of West Canyon Trail:

| | Percentage Cover (%) | | |
|---|---|---|---|
| Distance along transect line (m) | Himalayan Blackberry | English Holly | English Ivy |
| 1 | 56 | 0 | 0 |
| 7 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 |
| 12 | 0 | 0 | 0 |
| 13 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 |
| 22 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 |
| 29 | 0 | 0 | 0 |

Table 6. In forest along the entrance of East Canyon Trail:

| | Percentage Cover (%) | | |
|---|---|---|---|
| The distance along transect line (m) | Himalayan Blackberry | English Holly | English Ivy |
| 1 | 0 | 0 | 0 |
| 7 | 0 | 63 | 0 |
| 8 | 0 | 1.5 | 0 |
| 11 | 100 | 5.7 | 0 |
| 12 | 0 | 0 | 0 |
| 13 | 0 | 0 | 0 |
| 19 | 0 | 39 | 0 |
| 22 | 0 | 0 | 0 |

| | | | |
|---|---|---|---|
| 23 | 0 | 0 | 0 |
| 29 | 100 | 0 | 0 |

Table 7. ANOVA Table (Type II tests) (Results figure)

| | Sum Sq | Df | F value | Pr(>F) |
|---|---|---|---|---|
| Bank | 1850 | 1 | 5.8520 | 0.01658* |
| Site | 78 | 1 | 0.2478 | 0.61927 |
| Bank: Site (Interaction) | 20 | 1 | 0.0645 | 0.79981 |
| Residuals | 55638 | 176 | | |

Sigif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 8. Means of percent cover of invasive species

| | Canyon | Salish |
|---|---|---|
| Forest | 21.16837 | 7.882 |
| Stream | 0 | 0.3673333 |

Standard deviations of percent cover of invasive species

| | Canyon | Salish |
|---|---|---|
| Forest | 21.16837 | 22.209973 |
| Stream | 0 | 1.826778 |

Samples size

| | Canyon | Salish |
|---|---|---|
| Forest | 60 | 60 |
| Stream | 30 | 30 |