Patterns of Invasive Species and Associated Management Options for Stanley Park

Tara L. Bergeson

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Abstract

Stanley Park is located within the Coastal Western Hemlock zone, and is mostly in the subzone dry maritime (CWHdm), with a small fraction occurring in the very dry maritime subzone (CWHxm). The most frequent and troublesome invasive species were: English Ivy (*Hedera helix L.*), Himalayan Blackberry (*Rubus discolor* Weihe & Nees), European Holly (*Ilex aquifolium L.*), and Japanese Knotweed (*Fallopia japonica*). Each poses a serious threat to maintaining native species diversity and should be properly eliminated to prevent further contamination. The purpose of this research was to examine key variables related to invasive species prevalence across Stanley Park and develop recommendations for invasive species management. The variables chosen for analysis were based on literature review and analysis of collected plot data collected during the summer of 2008, along with input from the Vancouver Parks Board (VPB) and Stanley Park Ecological Society (SPES), where applicable. The initial theory was that proximity to trails, low basal area, the number of rootwad pits (indicative of newly disturbed area) and a low volume of woody debris would contribute to the abundance of invasive species. I found that a slight relationship existed between only one of the variables and invasive cover; that as the volume of woody debris increased, the amount of invasive cover decreased. Based on this and the other findings which demonstrated no relationship, the recommendation for park staff was to use an integrated pest management system which utilizes several approaches for invasive control.

Key words: invasive species, Stanley Park, English Ivy, Himalayan Blackberry, European Holly

Introduction

Stanley Park is located in Vancouver, British Columbia and is the third largest urban park in North America. At approximately 400 hectares (ha), it has numerous maintained and multi-use trails including the famous Seawall. There are two main roads for vehicle access; the Causeway, which allows direct passage to the Lion's Gate Bridge and North Vancouver and a scenic route which roughly follows the perimeter of the park (Figure 1). Stanley Park hosts an estimated 8 million visitors per year who enjoy the various events and amenities including Prospect Point, the Sequoia Grill, the Rose Garden, historical landmarks (Totem poles, 9 o'clock gun), and abundant recreational activities (lawn bowling, Second Beach pool). Many of the visitors are nearby residents who use the park on a daily basis and feel strongly about its protection and management.

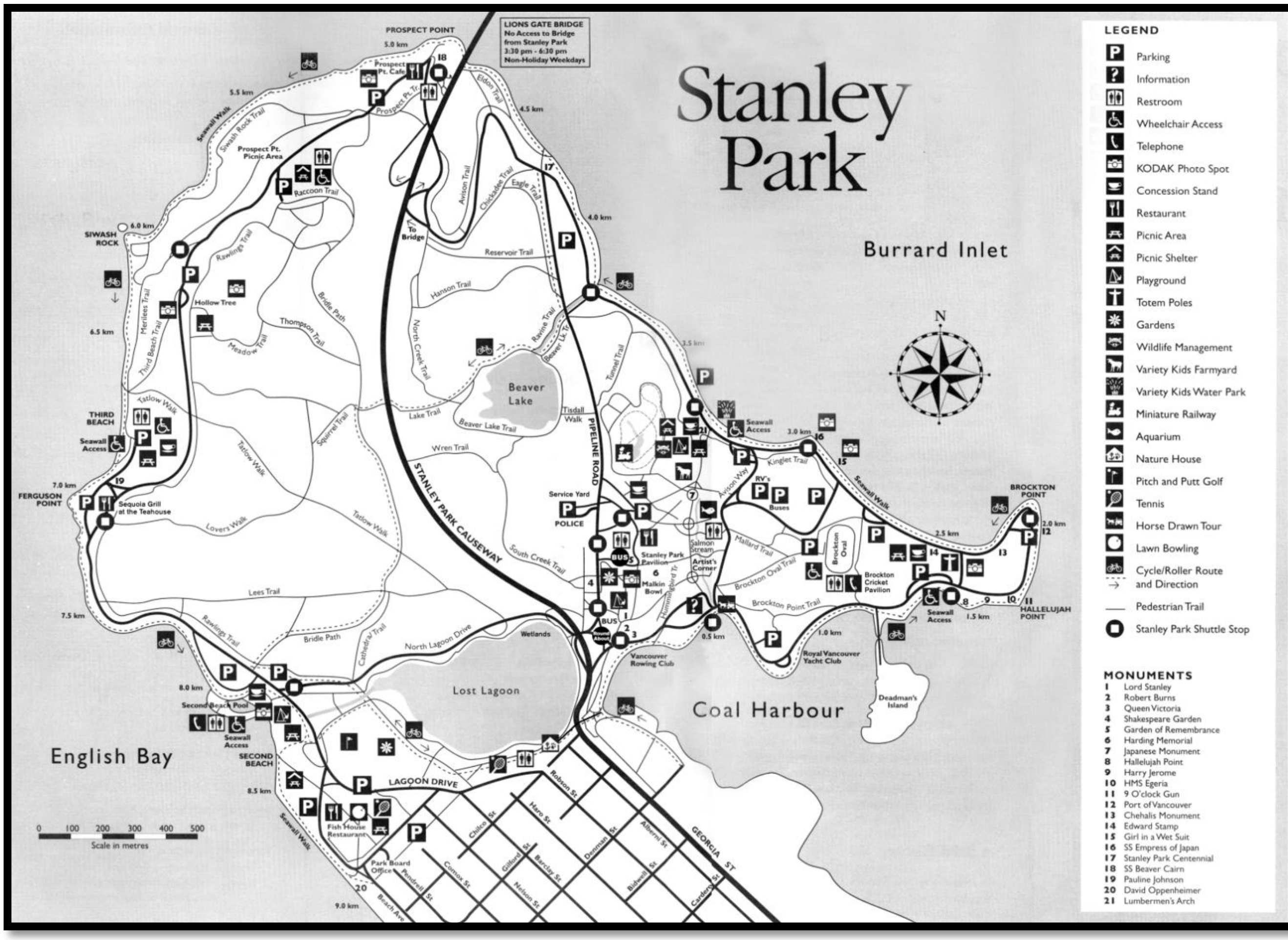

Figure 1: Overview map of Stanley Park

The Vancouver Parks Board (VPB) and the Stanley Park Ecological Society (SPES) are both dedicated to the sustainable management of the approximately 250 ha of forested area in the park. In the winter of 2006/2007, several devastating storms left about 30% of the forested area with varying levels of damage, the worst being near Prospect Point. For this and other ecological reasons, VPB began the laborious task of creating a forest management plan for the park. Heavy visitor use was a key issue to be addressed in this plan, with implications for fire risk, garbage/littering, danger tree assessment, etc. Another consequence of proximity to an urban centre is the transfer of invasive species from nearby seed source (gardens, yards, etc) through direct means (seed dispersal or vegetative propagation) or unintentional means like on shoes or tires as people and vehicles move throughout the park. An invasive can be defined as a 'non-indigenous species[1] that negatively affects the habitats it invades, through economical, environmental and/or ecological means' (IUCN 2009). These plants can reproduce quickly, are resilient and may overwhelm existing native vegetation.

There are several invasives of concern for Stanley Park, including: English Ivy (*Hedera helix L.*), Himalayan Blackberry (*Rubus discolour*), English Holly (*Ilex aquifolium L.*), Japanese Knotweed (*Fallopia japonica*) and Creeping Buttercup (*Ranunculus repens*). The most established are ivy, blackberry and holly so this paper focused on the current management, abundance and attributes of these species. In order to best document the current infestation of invasives and plan for future intervention, the presence and percent cover of each species were included in a four month vegetation inventory of Stanley Park conducted during the summer of 2008. In this paper I briefly review the literature concerning these species, present the results of the data collection and analysis, and make recommendations for management.

Species Characteristics and Current Management

English Ivy dominates sheltered areas like the understory layer of shady, moist sites (Metcalfe 2005), both as a thick ground cover and as a climbing vine up trees or other surfaces. It favours open, disturbed areas to establish and typically does not colonize well in occupied forest. Reproductive shoots are found on vertical stems, which produce seed-containing berries between August and November. These shoots therefore facilitate the long-distance

[1] A non-indigenous species, for the purpose of this report, is one in which does not naturally inhabit BC ecosystems.

transfer of ivy by bird dispersal (Metcalfe 2005). Immature shoots are the ones which facilitate local vegetative propagation, the primary method which allows ivy to quickly take over small patches of open area. Current management practices include large scale ivy pulls by 'Ivy Busters', a volunteer program run by SPES, and the target of vertically growing stems on trees. To allow Ivy Busters, SPES and the VPB better target problem areas and speculate where new infestations may occur, analysis will attempt to determine important correlations between ivy and predictor variables.

Himalayan blackberry is commonly found on disturbed areas in a variety of soil types and light conditions though best growth occurs under full light (IPC 2008a). It is a biennial plant that can reproduce by seed in the berries, which are eaten by birds or mammals and later distributed. Blackberry also has several asexual vegetative methods, including rooting stem tips to form daughter plants, stem/root fragments and regrowth from the root stalk (Hoshovsky 2000). Capable of growing up to six m/yr (Hoshovsky 2000), blackberry quickly overtakes native low growing vegetation through shading and accumulation of dead leaves and stems. The rapid formation of dense thickets bearing large, sharp prickles makes blackberry a major barrier to the movement of animals and trail maintenance (IPC 2008a). There are several integrated pest management[2] options for controlling blackberry including prevention, mechanical mowing and/or tillage, manual removal and chemical use. At this point, prevention is limited to further contamination of unaffected sites and care should be taken so not to knowingly transfer seed, such as brushing trails while berries are out. Mechanical and manual methods are effective

[2] Integrated pest management (IPM) is, "a decision making process that includes identification and inventory of invasive plant populations, assessment of the risks that they pose, development of well-informed control options that may include a number of methods, site treatment and monitoring" (IPC 2008a).

options, if maintained over several years (IPC 2008a) and include the removal of both above and below ground plant parts (especially root collar). Chemical use is not a feasible option in Stanley Park at this point due to proximity to water and/or social acceptance. At the time of data collection, little effort was being given to the control of blackberry by the VPB, though SPES had conducted some pulling of colonizing stems in blowdown areas. It is presumed that a formal regime will begin when the forest management plan is initiated.

English Holly is a woody shrub (or small tree) that colonizes well drained areas, in either sun or shade. It has high water requirements, and can therefore be a threat to nearby native vegetation. Holly also reproduces through berry consumption and distribution by birds; however the berries are poisonous to humans, making this species a potential hazard to the public. It also asexually suckers from cut stumps and layers through branches. Despite its extent, holly was receiving no control treatment as of August 2008. It also is to be included in the new forest management plan.

It was predicted that proximity to trails, low basal area, low volume of woody debris and the number of rootwad pits (indicative of newly disturbed area) would all contribute to an increase in the percent cover of invasives. This theory is based on studies that suggest disturbed, more open sites facilitate the introduction of invasive species (IPC 2008a, Metcalfe 2005, Lake and Leishman 2004).

Materials and Methods

A Geographic Information System (GIS) file of forested and non-forested areas was provided by VPB for Stanley Park. This was used to incorporate a grid system for mapping purposes. The Universal Transverse Mercantor (UTM) Zone 10, North American Datum (NAD) 83 system was used for location of axis and a 100 metre (m) by 100 m grid was added to the GIS file (Figure 2). By using the known forested vs. non-forested areas, acceptable points within the forested area could be located for plot placement. In total, approximately 235 points were identified as potential plots locations and numbered accordingly. Due to time constraints, 180 fixed-area plots were randomly chosen to be carried out and the other potential sampling points were reserved for use at a later date if possible. A systematic grid pattern was chosen rather than random sampling to ensure an even distribution of coverage per hectare across the park.

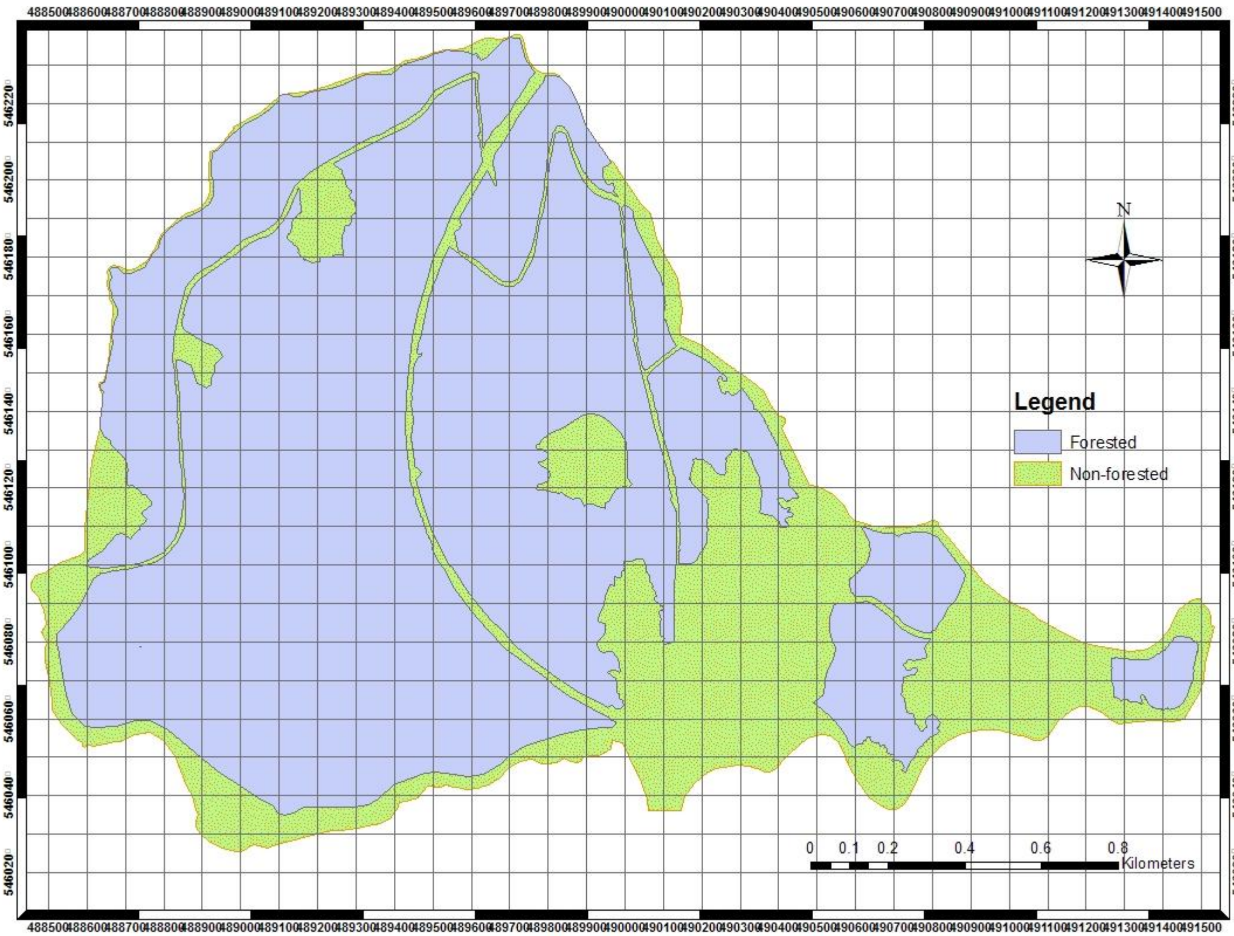

Figure 2: Grid overlay on Stanley Park

Of the chosen plot locations, 130 were designated as temporary sample plots (TSPs) and the remaining 50 as permanent sample plots (PSPs). The distinction of allocating a plot as either a TSP or PSP was done through random selection. The implementation of a PSP included placement of a steel marker so that these plots could be re-measured on a periodic basis. In addition, PSPs were assessed for extra information (Appendix A). Plot locations were identified in the field using Global Positioning System (GPS) coordinates. Several plotcards were created based on the information desired by VPB, SPES, and the University of British Columbia (UBC).

Four cards (Appendix A) were used to describe each of:

- Plot center data (1.78 m radius)
- Understory level data (11.28 m radius), including invasive species percent cover
- Tree level data (11.28 m radius)
- Line Intersect Sampling (LIS) data (2 x 20 m lengths) for large woody debris

Each plot was of fixed-area, the size of which differed depending on the information that was being collected. The smaller center plot was used to keep counts of germinants to a reasonable number while the larger plots allowed for a more representative observation of trees, understory vegetation and the Biogeoclimatic Ecosystem Classification (BEC) site series[3]. Numerous instruments were used to gather data (Table 1), with the exception of estimating percent invasive cover and other vegetation percent coverage.

[3] Site series are areas within a BEC zone or subzone that have very similar environmental properties and associated vegetation which typify late seral or climax stages of forests.

Table 1: Description of data collection procedures

	Equipment	Measurement Procedure	Unit	Precision
Center				
Plot Location	Garmin® GPS	Travel to plot center	Metres (m)	± 2-6 m
Slope Grade	Clinometer	Used equal height on assistant at distance of 15 m	%	± 1 %
Aspect	Compass	Took reading directly up/down hill		Accurate[a]
Basal Area	BAF Prism	Counted all trees of size	BAF 8	Accurate
BEC	N/A	As outlined in Green and Klinka 1994	Site Series	Accurate
Germinants	N/A	Counted	Number	Accurate
Pits	N/A	Counted	Number	Accurate
Area 1/2[b]	N/A	Determined by measurement and calculation on site	%	Accurate
Understory (by species)				
Bryophytes	N/A	Estimated percent cover over plot area	%	Accurate
Herbs	N/A	Estimated percent cover over plot area	%	Accurate
Shrubs	N/A	Estimated percent cover over plot area	%	Accurate
Natural Regen	N/A	Estimated percent cover over plot area	%	Accurate
Invasives	N/A	Estimated percent cover over plot area	%	Accurate
Tree				
Species	N/A	Identified species	N/A	Accurate
Azimuth	Compass	Took reading from plot center to tree center	Degrees (°)	± 2°
Distance	Measuring Tape	Measured distance from plot center to tree center (pith)	m	± 2 cm
DBH[c]	Diameter Tape	Measured tree diameter at 1.3 m above ground	cm	± 0.5 cm
Line Intersect Sampling				
Azimuth	Compass	Took reading from plot center along transect	°	± 2°
Length	Measuring Tape	Measured transect and debris lengths	m	± 2 cm
Diameter	Diameter Tape	Measured diameters at points along logs	cm	± 0.5 cm

(a) 'Accurate' denotes estimated/subjective activities which were consistently carried out but precision could not be calculated.
(b) Differing areas within a plot (i.e. % trail or road)
(c) Diameter at Breast Height (DBH)

Once data collection was complete, the plot data was entered into Microsoft Excel© as flat files[4] and then run through Statistical Analysis Software (SAS)[5]. Each record was summarized to the plot level, correlation graphs and basic statistical information were produced and then the records were exported to Excel for subsequent analysis. Pearson correlations were calculated and further examination of the best predictor and response variable(s) was done via regression analysis.

[4] A flat file is one in which data for an entire record is kept to one row in the dataset for the purpose of further use in subsequent programs. Variables are contained in columns, also called 'fields'.
[5] http://www.sas.com/technologies/analytics/statistics/stat/

It was theorized that the following predictor variables would be of importance: overstory tree basal area, volume of woody debris, number of rootwad pits and proximity to maintained trails[6]. The response variable was total percent cover of invasives. Examination of the scatterplot graphs of response and individual predictor variables provided initial insight about relationships, many of which were tenuous at best. At this point, it was decided to look more closely at each invasive species with respect to these predictor variables. Each total percent cover for blackberry, ivy and holly were plotted against main tree species, woody debris volume, total basal area, and stems per hectare.

Results

Of the surveyed plots, 35% had ivy with an average 14% cover. If extrapolated over the 250 ha of forested area, an approximate 12 ha of ivy cover is present. Blackberry was found on 16% of plots with an average coverage of 13% for an estimated total of 5 ha across the park. Holly was present on over half of visited sites (53%) making it the most widely distributed, and had an average cover of 4% for a total of about 5 ha.

There was only one significant relationship found between predictor and response variables; total invasive cover per plot (referred to as 'invasive cover') and the volume of woody debris (Table 2), with a Pearson product-moment correlation coefficient of -0.15 (denoted by *r*) and a p-value[7] of 0.0455. It indicates a slight decrease in invasive cover as the volume of woody

[6] Proximity to trails was determined by the percent of fixed plot area (11.28 m) that was taken up by a trail. This was measured and calculated on site.

[7] A p-value represents whether or not the sample supports the tested hypothesis and values range from 0 to 1. Usually p-values of less than 0.05 are deemed statistically significant, resulting in rejection of the Null Hypothesis.

debris increases. It is also important to note that this was the strongest correlation of all of the other initial predictor variables. There was no relationship for the basal area, number of windthrow pits or proximity to trails, nor to any other tested variable. The somewhat negative relationship between proximity to trail and invasive cover is surprising considering that trails are under continual disturbance. The number of disturbed windthrow pits was also negatively correlated with invasives, in contrast to the hypothesis. Increased overstory tree basal area somewhat influenced the percent of invasive cover as theorized, though this was not a significant relationship.

Table 2: Correlation coefficients between invasive cover and predictor variables

Pearson Correlation Coefficients, N = 181 Prob > |r| under H0: Rho=0							
	baha[a]	**pct_BD[b]**	**pct_road[c]**	**pct_trail[d]**	**pct_veg[e]**	**num_pits[f]**	**volha[g]**
total_pct_cover (p)	-0.06626 0.3755	-0.04601 0.5386	0.05608 0.4533	-0.07964 0.2866	0.04609 0.5379	-0.04633 0.5357	-0.14956 0.0445

(a) Basal area per ha
(b) Percent blowdown area in plot
(c) Percent road area in plot
(d) Percent trail area in plot
(e) Percent vegetated area (intact forest) in plot
(f) Number of rootwad pits in plot
(g) Volume of woody debris per ha (m^3)

The distribution of residuals[8] was highly erratic, reinforcing the fact that wide variability exists in the relationship between invasive cover and my chosen variables (Figure 3).

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[8] The residual of a sample is the difference between the sample and the sample mean or regressed (fitted) function; it is an observable estimate of the unobservable statistical error.

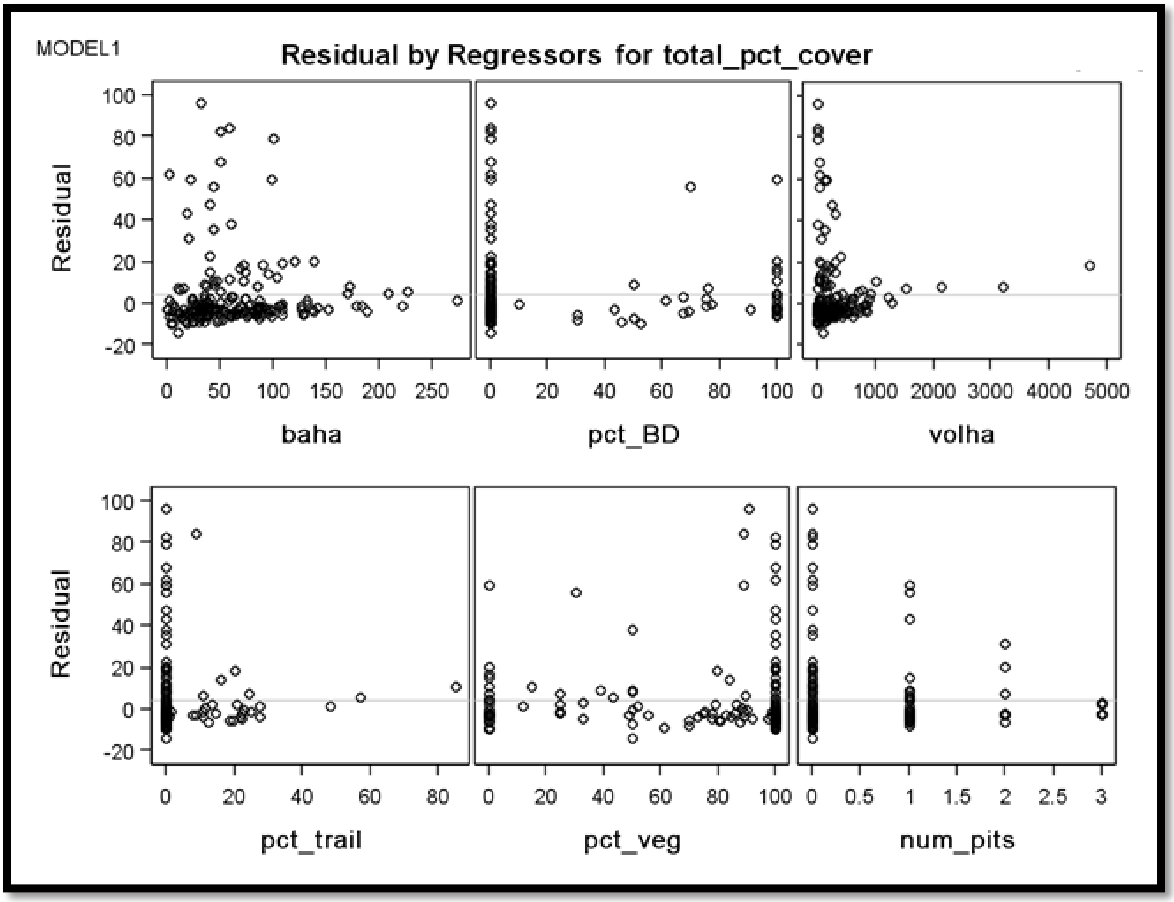

Figure 3: Residual distribution of preliminary predictor variables

In order to better assess the woody debris to invasive cover relationship, transformation of the two variables was done. The logarithms of each were taken and ran through SAS which produced a more even distribution of residuals (Figure 4). Several other conversions of data were done but produced no better results.

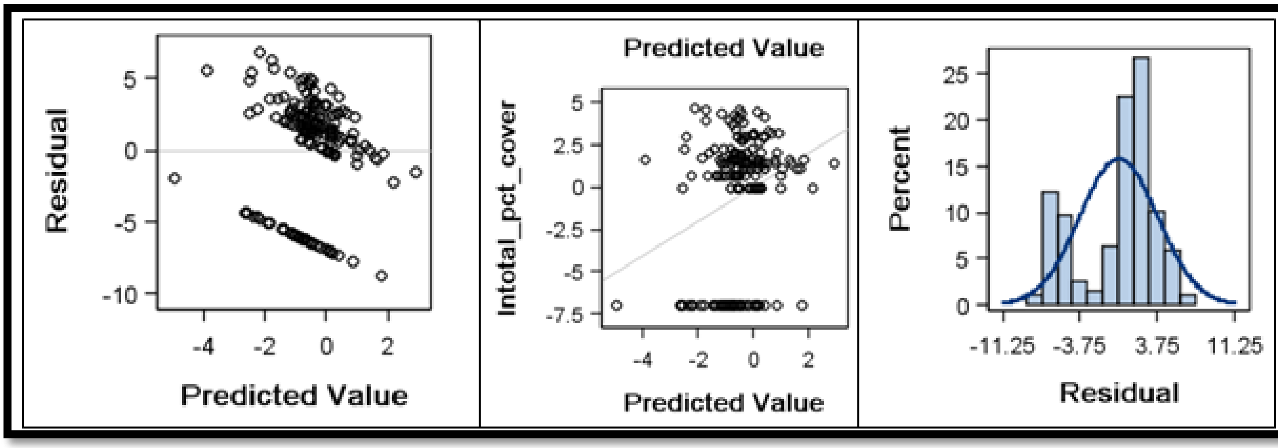

Figure 4: Residual distribution of transformed predictor variable

Alternatively, some interesting associations between specific overstory species (as a site indicator of long-term nutrient and water regimes) and invasive species were identified through other investigations (Figures 5, 6 & 7).

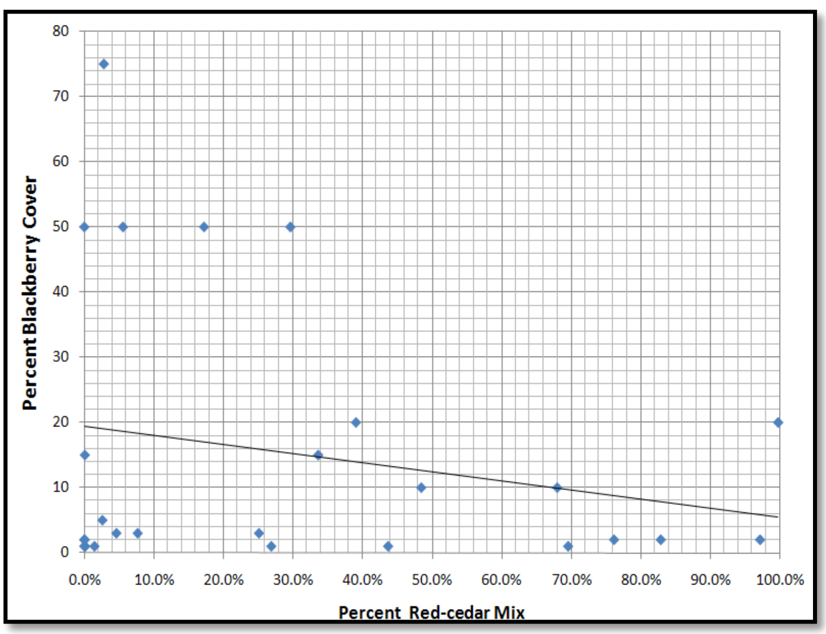

Figure 5: Trendline for Blackberry vs. Western red-cedar

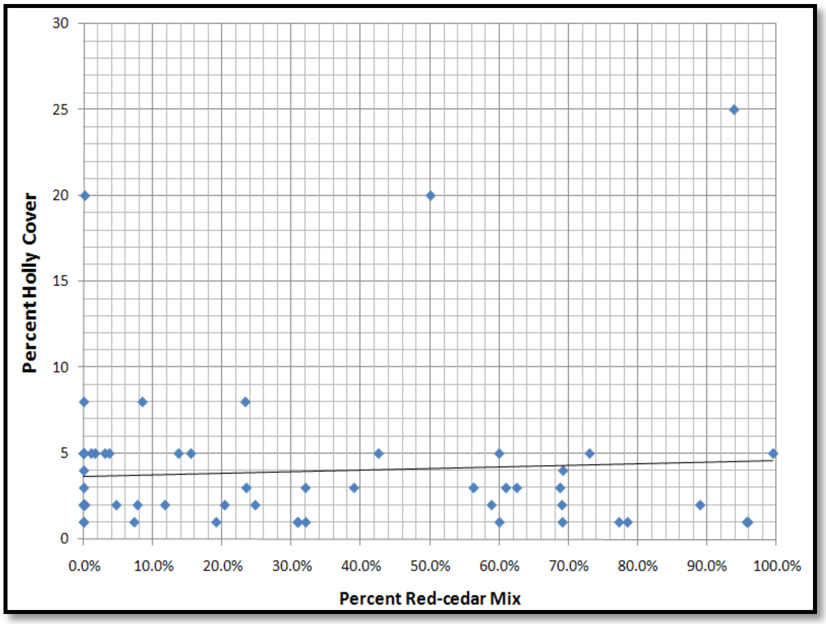

Figure 6: Trendline for Holly vs. Western red-cedar

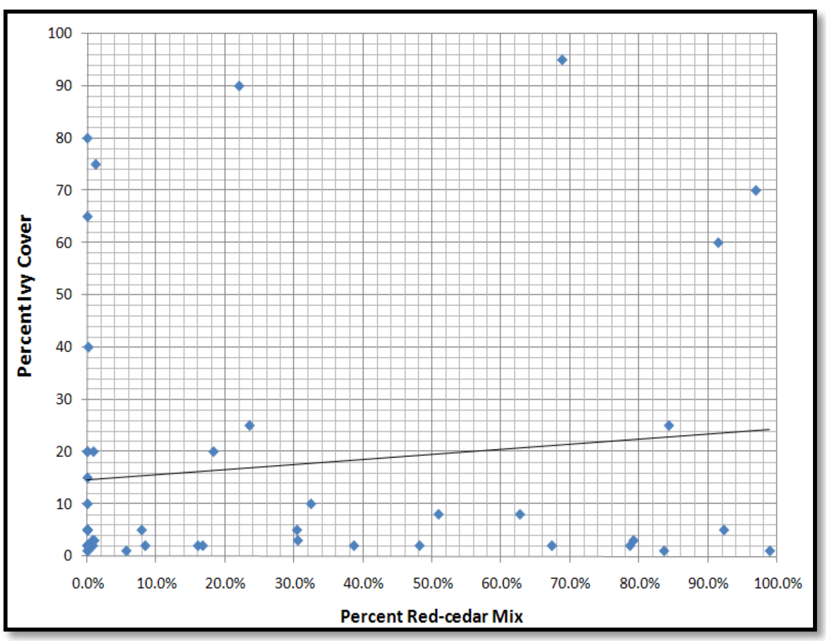

Figure 7: Trendline for Ivy vs. Western red-cedar

Discussion

There was little evidence to support the proposed theories, even with the best results. Therefore, the initial hypotheses and statistical procedures should be examined for soundness. The hypotheses were based on previous literature and/or observed conditions in the field. Borgmann and Rodewald (2005) found a positive correlation between proximity to urban influence and the cover of a local invasive species, which suggests that trails within an urban forest may increase the invasive cover. Another recent study looked at the contribution of disturbance to invasion (Lake and Leishman 2004), which in Stanley Park could be in areas of recent or historic windthrow (blowdown). These sites are typified by low basal area, a high volume of woody debris and an increased number of rootwad pits. During field work, there seemed to be an abundance of invasive cover along trails and open areas and so the predictor variables were chosen accordingly. The statistical analysis was limited to introductory methods, based on the experience of the researcher with SAS and time constraints. Careful consideration was given to ensuring that plot selection and location were unbiased, and that stringent and objective surveying techniques were used at every plot. Therefore, it can be concluded that the results are statistically sound.

The most evident finding was that of no relationship at all. The observed pattern might be explained through unmeasured factors. On the other hand, this lack of pattern is consistent with the definition of an invasive. In attempting to align these findings with available literature, several alternative scenarios surfaced which may better explain the invasive distribution and abundance. First, the propagation methods may clarify why holly (predominantly seed-dispersed) was found sparsely on over half the sites, many well within mature forest stands. In contrast, ivy and blackberry which take better advantage of vegetative propagation were found in dense clusters on fewer sites. This might aid in targeting eradication and prevention strategies by predicting where the invasive could be and where it is likely to spread to.

The results of this study may also be interpreted as is; no significant relationship could simply mean that no relationship exists. A forest manager could, and would, therefore expect to find invasives anywhere in the park, increasing the need for a vigilant monitoring program.

Conclusion and Recommendations

Ideally, the findings of this study will aid management staff in establishing a successful control and eradication regime for current invasive species and those that may be a problem in the future. Invasive species will continue to plague urban forests due to the diverse and heavy public use and their proximity to horticultural escapees.

Due to the finding of no relationship between invasive cover and predictor variables, it is suggested that management practices plan accordingly. The probability of finding these three invasives (at least) in any area of Stanley Park is high. A routine monitoring program by SPES volunteers or park employees could be implemented to identify new/existing patches of invasives. It would be beneficial to use a ranking scale for both current infestation and the potential vulnerability of a site (for example, low-medium-high). This would better situate the VPD to efficiently and progressively control invasive species.

To minimize further spread and new colonization of invasives, consideration should be given to the timing and method of trail maintenance, especially around seed production time. Mowing, tilling and pulling are good ways of removing the three invasives outlined here, but require consistent treatment by VPB and/or volunteers through SPES. Incorporation of an integrated pest management program where detection and prevention is made a high priority could help in reducing the length of a treatment regime. It is especially important to inform the public of the park about all invasives they may encounter, how and why they are a problem for biodiversity and what steps they can take to prevent infestation (removing from home gardens, etc). All available resources should be employed to facilitate the eradication of invasives to help maintain a healthy, biologically diverse Stanley Park for users to enjoy.

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Appendix A: Plotcards for vegetation inventory of Stanley Park with associated metadata

Center and Germinant (1.78m) Plotcard

				Soil			Slope					Germinants (# stems)									
Plot	w	n	Humus	Texture	Color	Depth	Grade %	Aspect	BA	Site Series							Pits	Area 1	Area 2	Hazards	Comments

Depth: to root restricting layer
BA: Basal area (m^2/ha)
Pits: number of rootwad pits
Area 1: % area in main strata
Area 2: % area in second strata (ex. trail)
Hazard: # of tree/public safety hazards to follow up on
**germinants counting >50/species are designated 50+

<u>humus</u>
M: mors
Mo: moder
Mu: mull

<u>texture</u>
S: sandy
SL: sandy loam
SiL: silty loam
CL: clay loam

<u>color</u>
G: gleying present
F: ferric dominant
H: humic dominant

<u>CWH site series</u>
02 FdPl-Cladina
03 FdHw-Salal
04 Fd-Swordfern
01 Hw-Flat moss
05 Cw-Swordfern
06 HwCw-Deerfern
07 Cw-Foamflower
11 Pl-Sphagnum
12 CwSs-Skunk Cabbage

Understory Plotcard (11.28m) **Plot ID** **w** **n**

	Species										**% layer**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**cover**
Bryophytes	X	X	X	X	X	X	X	X	X	X	
Herbs											
spp. % cover											
avg height											
Shrubs											
spp. % cover											
avg height											
Nat Regen < 1.3m											XX
# stems											XX
avg height											
Invasives											XX
% cover											XX

<u>herbs</u>
Br: bracken
Wf: western fescue
Sw: sword fern
Sp: spiny wood fern
De: deer fern
La: lady fern
3L: 3-leaved foamflower
Bu: bunchberry
Sc: skunk cabbage
Fa: false-lily-of-the-valley

<u>shrubs</u>
Sl: salal
Rh: red huckleberry
Og: dull oregon-grape
Vm: vine maple
Sa: salmonberry
El: elderberry
Al: alaskan blueberry
Dv: devil's club

<u>regen</u>
Hw: western hemlock
Cw: western red cedar
Mb: bigleaf maple
Dr: red alder
Bg: grand fir
Ss: sitka spruce

<u>invasives</u>
Hg: hogweed
Kt: knotweed
Bb: blackberry
Mg: morning glory
Sb: scotch broom
Sj: st. john's wort
Dp: daphne
Ivy: english ivy
Ho: holly

Tree Plotcard (11.28m) **Plot #** **w** **n**

Tree #	Species	Azimuth	Distance	DBH	Height	HBLC	Decay Class	Other

Height: total height (m)
HBLC: height to base live crown (m)

<u>other</u>

R: conks
F: forking
M: mistletoe
W: wildlife use
BN: birds nests
S: stumps 10cm-1.3m
C: Cut stump
SB: spring board holes
B: charcoal/fire scar
CMT: cultural modification
L: leaning
LB: live, broken top

<u>decay classes (BCMOF classes)</u>

1	Live/healthy
2	Live/unhealthy
3	Dead (w/twigs or needles, roots sound)
4	Dead (no twigs/needles, loose bark)
5	Dead (most bark gone, some internal decay)
6	Dead (approx 2/3 ht, roots softening)
7	Dead (approx 1/2 ht, roots decomposed)
8	Dead (approx 1/3 ht, hollow)

LIS Plotcard (20 m transects) ** lower limit for CWD is 7.5 cm diameter at intersect point

Plot	w	n	Trans	Azimuth	Log	Length	IntsctDia	TopDia	TopEnd	BotDia	BotEnd	Species	Decay Class	Other

Trans: transect 1 or 2
IntsctDia: diameter where line intersects log
TopDia: diameter at top end of log
BotDia: diameter at bottom end of log

<u>TopEnd/BotEnd condition</u>

C	cut
B	broken
N	unbroken - natural top
R	rootwad

<u>decay Class (USDA)</u>

I	elevated on support pts, bark intact, twigs present
II	sagging on pts, bark intact, twigs absent
III	sagging near ground, trace of bark, lg pieces
IV	tree on ground, no bark, small pieces
V	red rot, soft and powdery

<u>species</u>

Xc: unknown conifer
Xh: unknown hardwood
X: unknown

<u>other</u>

F	beetle frass
W	woodpecker feeding
B	charcoal/fire scar
CMT	cultural modification
T	trail present along intersect

<u>other Notes:</u>

Ephemeral pools (GPS location)
Archaeological sites