ER 390 Final Project Report

Forest Understory Monitoring Protocols
For Stanley Park Ecology Society
Vancouver, BC

Prepared for Restoration of Natural Systems Program
University of Victoria

Megan Spencer
Student # V00754774

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Abstract

The integrity of native forest vegetation in Stanley Park (Vancouver, B.C.) is threatened by anthropogenic stressors and climate change. While preparing the second *State of the Park Report* for Stanley Park, the non-profit organization Stanley Park Ecology Society (SPES) identified the need to implement ecological monitoring protocols to assess the productivity and phenology of native vegetation. In partnership with SPES, the author identified two established protocols: the ‘red huckleberry productivity’ protocol and the ‘salmonberry first bloom’ protocol. In April and October 2017, locations for long-term monitoring plots were surveyed and selected for both protocols. Methods included review of a forest strata and roads/trails map and field surveys to assess topographic and man-made features. In June 2017, year 1 data was collected in a pilot of the red huckleberry protocol. Trends in native plant productivity and phenology can be interpreted using standard statistical tests after at least five years of data collection. Four next steps are recommended: (1) reselect shorter stem segments for the red huckleberry protocol and discount year 1 data; (2) purchase permanent ID tags and monitoring equipment; (3) provide training sessions for citizen science volunteers; and (4) monitor and respond to changes in site conditions.

Acknowledgements

The author would like to thank Maria Egerton and Kari Pocock, staff with Stanley Park Ecology Society’s conservation department, for their support for this project and for lending survey equipment; Tory Stevens, BC Parks’ Long-term Ecological Monitoring Program Coordinator, for her insight and assistance with adapting the BC Parks red huckleberry protocol; and Bill Stephen, an urban forester with the Vancouver Park Board, for granting permission to tag individual plants in Stanley Park.

1. Introduction

The integrity of native forest vegetation in Stanley Park (Vancouver, B.C.) is threatened by anthropogenic stressors and climate change. Forested areas in the park are fragmented by roads and trails and degraded by recreational use by humans and competition with invasive exotic vegetation (SPES, 2010). Climate change is also impacting the blooming times of native flowering plants, which will have systemic impacts (Lantz and Turner, 2003; Beaubien and Freeland, 2000). Understanding how these stressors impact the health and productivity of Stanley Park's native vegetation is critical. Healthy forests provide food and shelter for wildlife, maintain vital ecosystem processes and services, and provide economic opportunities for nature education and tourism (SPES, 2010).

The non-profit organization Stanley Park Ecology Society (SPES) facilitates ecological restoration and monitoring in Stanley Park. While preparing the second *State of the Park Report* for Stanley Park, SPES identified the need to implement ecological monitoring protocols to assess the productivity and first bloom dates of native forest vegetation. As a fulfilment of the University of Victoria's ER 390, this project intended to identify and pilot two forest understory monitoring protocols in Stanley Park: the red huckleberry productivity protocol and the salmonberry first bloom protocol.

1.1 Goal

Identify and pilot two ecological monitoring protocols to assess native forest vegetation in Stanley Park in partnership with Stanley Park Ecology Society.

1.2 Objectives

1.2.1 Identify two ecological monitoring protocols to assess native forest productivity and the first bloom dates of a native flowering plant

1.2.2 Establish long-term monitoring plots and/or sites

1.2.3 Pilot the protocols in Stanley Park

1.3 Why implement monitoring protocols?

SPES staff can interpret the data collected through the monitoring protocols to determine trends in the productivity of native forests and the phenology of native flowering plants. An understanding of these trends will enrich the pool of biophysical information collected through SPES' ecological monitoring program (SPES, 2010). The trends will provide baseline information on ecosystem change in Stanley Park, and can be used as the basis for intervention activities (such as ecosystem enhancement or restoration) and can be compared with other parks and protected areas that monitor the same indicators.

1.3.1 Why monitor the productivity of red huckleberry?

Red huckleberry (*Vaccinium parvifolium*) often dominates the shrub layer in the moist temperate rainforests of the Pacific Northwest. In mid-summer, the shrub produces globe-shaped red berries, a seasonal delicacy for humans and wildlife.

Like most berry-producing shrubs, the quantity of huckleberries produced by a given shrub will naturally vary from year to year (Turner, 2014, p. 8). Variation in the productivity of huckleberry bushes can be correlated with variation in temperature and rainfall during the growing season. Cool spring temperatures coupled with high daytime temperatures in July are thought to maximize huckleberry productivity (Holden et al., 2012). Monitoring red huckleberry productivity over time provides a proxy for understanding how changes in local climate are impacting coastal forests.

1.3.2. Why monitor the first blooms of salmonberry?

In early spring throughout the Pacific Northwest, thickets of salmonberry (*Rubus spectabilis*) awaken moist forests with nodding blooms of magenta flowers. As one of the first deciduous shrubs to flower each year, salmonberry blossoms are considered a harbinger of spring. In the phenological knowledge of Northwest Coast peoples, the ripening of its berries is attributed to the return and spring song of the Swainson's thrush (*Hylocichla ustulata)* (Lantz and Turner, 2003, p. 266).

The date of the first salmonberry bloom depends on the preceding years' winter temperatures. In the Pacific Northwest, warmer and shorter winters are the new normal (Lantz and Turner, 2003, p. 265; Beaubien and Freeland, 2000). Monitoring the first bloom date of salmonberry provides a proxy of how changes in local climate are impacting coastal forests (Clayoquot Biosphere Trust, n.d.).

1.4 Citizen science and ecological monitoring

In order to successfully implement the two monitoring protocols discussed in this report, a committed and well-trained group of citizen science[1] volunteers is required. In the last few decades citizen science programs have grown in popularity, attracting the scrutiny of critics and researchers. In Stanley Park, citizen science volunteers contribute to many of SPES' ecological monitoring programs, from bald eagle nest surveys to freshwater quality sampling.

[1] Citizen science can be defined as science conducted by individuals who are not professional scientists, but are trained to carry out basic scientific research.

A warranted critique of citizen science is that non-professionals cannot provide reliable data of sufficient quality. A study by Crall et al. (2011) investigated the accuracy of citizen scientist plant identification skills for common invasive plants, while Fuccillo et al. (2015) examined the ability of citizen scientists to identify phenophases of common plants. Both studies found that citizen scientists generally provided accurate observations; however, data quality varied. There are many ways to improve data quality in citizen science initiatives: use protocols that are professionally-designed, standardized, and field-tested with citizen scientists (Delaney et al., 2008; Fuccillo et al., 2015) and conduct skills testing, follow-up training, and monitor performance (Danielsen et al., 2005; Bonney et al., 2009). Such measures can help citizen science gain credibility and legitimacy as a model to monitor ecological change.

2. Study Area

Figure 1: Study area (Stanley Park, Vancouver, B.C.) with three long-term monitoring plots and features. Plot layer: created by the author in Google Earth. Base map: Google Earth

2.1 Overview

Stanley Park is a 395 ha. urban park located on the northwest peninsula of City of Vancouver, B.C. (see Figure 1). The natural areas of the park consist of deciduous and coniferous forest, rocky outcrops, and marshy areas in the Coastal Western Hemlock (CWHdm) biogeoclimatic zone. Stanley Park is managed by Vancouver Park Board and the non-profit organization Stanley Park Ecology Society (SPES) provides education, conservation and restoration programs. About sixty-five percent of the park’s total area is forested, which is fragmented by 27 km of trails and roads (SPES 2010, pp. 5-6).

2.2 First Nations and settler history

Stanley Park is situated in the Coast Salish territories of the Squamish, Musqueam, and Tsleil-waututh. Until the arrival of European settlers to Vancouver in the 1850s, these lands and waters were managed by the Coast Salish. Selective harvesting of resources, prescribed burns, and other management activities were practiced to enhance the natural productivity of the land and sea (Bakewell, 1980).

In the 1850s and 1860s, European settlers arrived to Vancouver and began selective timber harvest operations. At first, the most valuable trees located near coastal edges were felled for easy removal by water. Later, interior trees were felled and removed by oxen along skid roads, and some areas were clear-cut and burned to favour habitat for the high value species Douglas-fir (*Pseudotsuga menziesii*). Timber harvest ended after the 1880s, but major windstorms in 1934, 1962, and 2006 caused significant blowdown that required tree removal and replanting (SPES, 2010, pp. 44-45).

Invasion by insects, fungal disease, and invasive plants have greatly altered the natural trajectory of Stanley Park's forests. Insect and fungus invasions between the 1910s and 1960s prompted the Vancouver Park Board to cut down and burn large stands of infected trees, clear underbrush and debris, and replant with Douglas-fir. Invasive plants have also increased in diversity and abundance (SPES, 2013); partially attributable to the increase in the park's infrastructure and fragmented forest cover. Roads and trails, originally for fire control purposes, were constructed between the late 1880s and early 1920s. A network of water mains and fire hydrants were also installed at this time. The Lions Gate Bridge and Stanley Park Causeway, which divide the park in half, were constructed in the 1930s (SPES, 2010, p. 45). Forest cover is estimated to have declined by 25% between 1930 and 1980 (Bakewell, 1980).

2.3 Modern land-use status

The City of Vancouver developed several strategies that advocate for the enhancement of natural areas in Stanley Park, including the *Biodiversity Strategy* (2016), the *Vancouver Bird Strategy* (2015), and the *Urban Forest Strategy* (2014). Two of the strategies are most applicable to this report: the *Stanley Park Ecological Action Plan* (Vancouver Park Board, 2011) and the *Ecological and Culturally Sensitive Enhancement Plan for Beaver Lake* (AquaTerra et al., 2014).

The *Stanley Park Ecological Action Plan* was released in 2011 by the Vancouver Park Board after extensive consultations with the public, experts, and First Nations. It was prompted by the public's "outpouring of support and lively discussion" following the 2006 windstorm (SPES, 2010, p. 24). The plan sets out a path to foster a resilient coastal forest in Stanley Park. Priority management actions following the storm included efforts to: wind firm and create 'soft' forest edges, minimize fuel loads for forest fires, survey snags and wildlife trees, and monitor for disease and insect outbreaks (Stephen, 2016).

Over 15,000 trees and some understory vegetation were planted following the storm (Stephen, 2016). Ten years after the action plan was released, the Vancouver Park Board reported that ninety percent of planted trees are still alive and that the number of nesting birds in snags was retained throughout the restoration efforts. A legacy fund of $650,000 remains for future windstorm forest restoration in Stanley Park (Stephen, 2016).

A top priority identified in the *Stanley Park Ecological Action Plan* was to restore the sensitive wetland, bog and riparian areas around Beaver Lake (Vancouver Park Board, 2014). In 2013, Stanley Park Ecology Society initiated a team of consultants and academics to work collaboratively with other stakeholders and First Nations to develop a plan to achieve the long term ecological viability of Beaver Lake (LEES+Associates, 2016; Vancouver Park Board, 2014). After extensive field work and consultations, the *Ecological and Culturally Sensitive Enhancement Plan for Beaver Lake* was accepted by the Vancouver Park Board in 2014. Nine management objectives set a pathway to enhance the environmental conditions at Beaver Lake (Vancouver Park Board, 2014). A concept design was approved to enhance wetland and bog habitat around the lake and create a boardwalk (Amon and Duncan, 2016).

3. Methods

3.1 Site selection and field visits

3.1.1 Huckleberry productivity protocol

This protocol arose from a literature review of potential environmental monitoring protocols for coastal forests, consultation with an ecosystem monitoring expert at BC Parks, and project meetings and field visits with SPES staff and volunteers. The plot establishment techniques and protocol was lightly adapted, with permission, from the red huckleberry/soapberry production protocol used in BC Parks' Long-term Ecological Monitoring Program (BC Parks, n.d.; T. Stevens, pers. comm. April 11, 2017).

A base map with two feature layers was created by the author with ArcOnline software and used to generate general areas for field visits: forest strata (dry conifer areas selected)[2] and roads and trails (areas ~10m away selected). Additional assessments were made and recorded during three field reconnaissance visits by the author and a volunteer on April 10th, 18th and 20th, 2017. Sites where red huckleberry visibly grew in abundance were targeted, and the number of 'robust' plants[3] within a 10m plot diameter were noted.

[2] Red huckleberry grows in dry to moist coniferous forests; dry conifer areas were targeted to standardize the surveyed areas.
[3] 'Robust' plants is a subjective term used in BC Parks' red huckleberry protocol. The author interpreted 'robust' as huckleberry plants that are 2m (+) tall with widely branching stems.

Potential plots were identified on zonal sites: areas with gentle slope (<25%) and middle mesoslope position (Terrestrial Ecosystems Task Force, 1998, p. 18).[4] Slope was assessed using a Suunto clinometer and aspect was assessed using a Suunto compass. Canopy cover was estimated using the canopy cover schematic provided in *Describing Ecosystems in the Field* (Ministry of Environment, Lands and Parks, 1990, p. 112). Relative abundance of coarse woody debris and forest duff was noted.[5] Evidence of human impacts (garbage) and distance from unsanctioned trails were also recorded and included as site selection criteria. The site characteristics for each plot are recorded in Table 1 (see Results section).

3.1.2 Salmonberry first bloom protocol

This protocol arose from a literature review of potential environmental monitoring protocols for coastal forests project meetings with SPES staff, and field visits by the author. The plot establishment techniques and the protocol itself were inspired by the native flowering plant phenology protocol used by the Government of Canada's EMAN Ecosystem Monitoring Partnership (EMAN, n.d.) and the salmonberry phenology protocol used by Clayoquot Biosphere Trust (Clayoquot Biosphere Trust, n.d.).

A base map with two feature layers was created by the author with ArcOnline software and used to generate general areas for field visits: forest strata (wet conifer areas selected)[6] and roads and trails (areas near a trail but away from roads selected). Additional assessments were made during field visits by the author on October 24th and 27th, 2017. Sites where salmonberry visibly grew in abundance were targeted and the number of distinguishable, 'robust' plants were noted.[7] Slope and aspect were estimated visually; only flat areas were surveyed as per the protocol. Canopy cover was estimated using the canopy cover schematic provided in *Describing Ecosystems in the Field* (Ministry of Environment, Lands and Parks, 1990, p. 112). Proximity to built infrastructure (e.g. culverts, concrete pads) and streetlights was also noted.[8] The site characteristics for each plot are recorded in Table 2 (see Results section).

[4] Criteria was based on the plot establishment criteria used in BC Parks' red huckleberry protocol (see: http://www.env.gov.bc.ca/bcparks/partnerships/ltem/docs/protocols/forest/BerryProtocol.pdf?v=1508428463557) as well as additional advice from a BC Parks ecological monitoring expert (T. Stevens, pers. comm. April 3, 2017)

[5] Red huckleberry requires coarse woody debris for germination and growth (Lofroth, 1998) and plants are more productive on sunny aspects with soils that are acidic and have a thick organic layer.

[6] Salmonberry grows in moist to wet forests. Wet conifer areas were targeted to standardize the surveyed areas.

[7] 'Distinguishable' plants refers to salmonberry plants that are clearly visible at the base (i.e. no heavy brush or vegetation) and that appear to be separate, individual plants. 'Robust' plants is a subjective term used in BC Parks' red huckleberry protocol, also used here for the salmonberry protocol. The author interpreted 'robust' as salmonberry plants that are 2m (+) tall with thick, widely branching stems.

[8] Criteria was based on the plot establishment criteria used in the Government of Canada's EMAN Ecosystem Monitoring Partnership plant phenology monitoring instructions, see: http://publications.gc.ca/collections/collection_2014/ec/En14-161-2003-eng.pdf

3.2 Long-term monitoring plots

3.2.1 Huckleberry productivity protocol

The author and a volunteer revisited HK-8 (the selected long-term plot) on May 16th, 2017. The author selected ten robust red huckleberry plants for tagging. With the help of the volunteer, temporary identification tags[9] were tied loosely around the base of each plant and on two central branches. Identification codes were written on the tags for each individual plant (e.g., HK-8-1) and individual branches (e.g., HK-8-1-1 and HK-8-1-2). Photos were taken of the plot location entrance and of the identification tags (see Results section).

3.2.2 Salmonberry first bloom protocol

The author revisited SB-4 and SB-5 (the selected long-term plot) on October 27th, 2017. The author selected four robust salmonberry plants (two at each site) for tagging. Temporary identification tags[10] were tied loosely around the base of each plant. Identification codes were written on the tags for each individual plant (e.g., SB-4-1). Photos were taken of the plot location and of the identification tags (see Results section).

3.3 Pilot surveys

3.3.1 Huckleberry productivity protocol

The author revisited HK-8 on June 10th, 2017. For the ten selected plants, berry abundance per stem and stem diameters were recorded on a data sheet (see Appendix 1 for the protocol description and materials required, Appendix 2 for a template data sheet, and Appendix 7 for the June 10th data sheet). Photos were taken to show berry size and maturity, for reference in future years (see Results section).

3.3.2 Salmonberry first bloom protocol

Since salmonberry flowers emerge in early spring, the author was unable to conduct the pilot survey for this protocol before submitting this report. In the spring, the author aims to lead year one data collection, recording the first bloom and mid-bloom dates on a data sheet (see Appendix 3 for the protocol description and materials required and Appendix 4 for a template data sheet). Photos will be taken to show relative openness of the flowers for reference in future years.

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[9] Aluminum or stainless steel tags are desired, however as the protocol is in a pilot stage, temporary tags were used in case re-tagging is needed next year. Tags were made of folded black electricians tape, and labelled with a silver permanent marker.
[10] See footnote 9.

4. Results

4.1 Site selection and field visits

4.1.1 Huckleberry productivity protocol

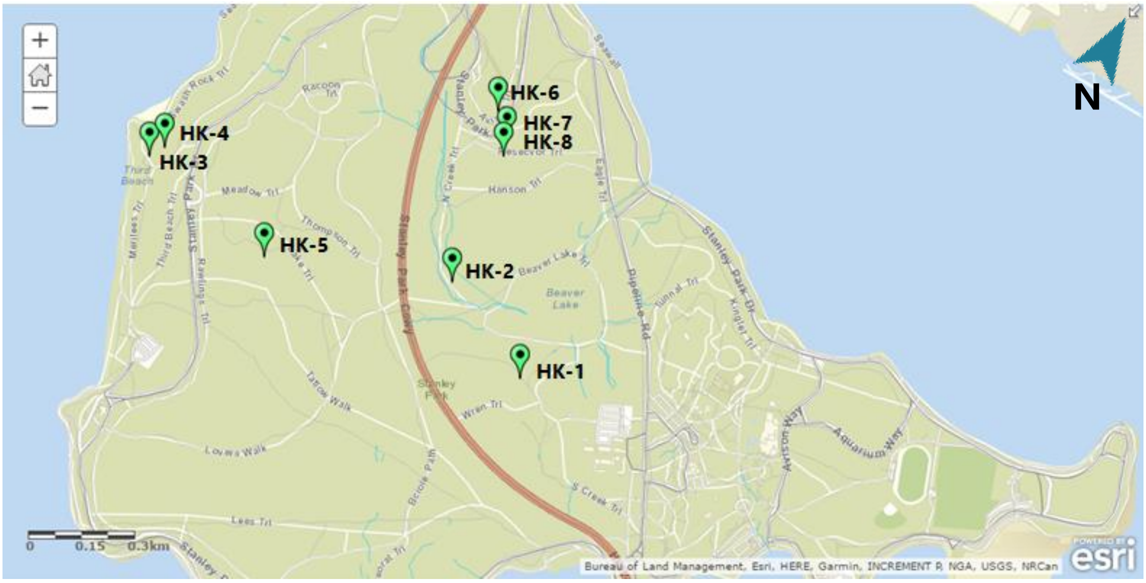


Figure 2: Locations of eight potential areas for permanent red huckleberry monitoring plots.
Plot layer: created by the author in ArcOnline. Basemap: SPES

After the map analysis and field visits, eight potential areas for permanent monitoring plots were identified (see Figure 2). The site characteristics for each plot are recorded in Table 1. Site characteristics were further reviewed and compared by the author and HK-8 was selected as the permanent monitoring site. The site is located approximately halfway along Reservoir Trail and about 10m along an overgrown, unsanctioned trail at the coordinates 489728E, 546171N (see Appendix 5). Ten robust huckleberry plants at this site were selected for the protocol. The site is situated on a southeast aspect, with minimal canopy cover and abundant coarse woody debris (CWD) and a thick layer of duff.

Table 1: Site characteristics for red huckleberry long-term plot site visits on April 10, 18, 20, 2017

Plot	Easting	Northing	# of 'robust' plants[11]	Canopy Cover	Slope	Aspect	Distance from trail (~)	Human evidence (garbage)	CWD and duff layer
HK-1	489046	5461386	8	5%	15%	NE	10m	No	Good CWD; good duff
HK-2	489582	5461312	12	5%	8%	S	7m	No	Good CWD; thin duff
HK-3	488717	5461672	8	15%	15%	E	10m	No	Good CWD; thin duff
HK-4	488762	5461699	8	20%	30%	NE	15m	Yes	Some CWD; thin duff
HK-5	489046	5461386	9	40%	0%	flat	7m	No	Some CWD; good duff
HK-6	489714	5461799	10	25%	25%	NW	5m	Yes	Some CWD; good duff
HK-7	489738	5461716	13	5%	5%	SE	5m	No	Some CWD; thick duff
HK-8	489728	5461671	15	<5%	10%	SE	10m	No	Good CWD; thick duff

[11] 'Robust' plants is a subjective term used in BC Parks' red huckleberry protocol. The author interpreted 'robust' as plants 2m (+) tall with widely branching stems.

4.1.2 Salmonberry first bloom protocol

Figure 3: Locations of five potential areas for permanent salmonberry monitoring plots
Plot layer: created by the author in ArcOnline. Basemap: SPES

After the map analysis and field visits, five potential areas for permanent monitoring plots were identified (see Figure 3). The site characteristics for each plot are recorded in Table 2. Site characteristics were further reviewed and compared by the author and SB-4 and SB-5 were selected as the permanent monitoring sites (see Appendix 6). SB-4 is located on the western branch of Beaver Lake trail, about 30m from the junction with Lake Trail, at the coordinates 489692E, 5461210N. SB-5 is located on North Creek trail, about 15m north from the junction with Lake Trail, at the coordinates 489617E, 5461243N. Two robust salmonberry plants were selected for the protocol at each site. Both sites are situated on a flat aspect and are easy to access from SPES offices (~13 minute walk) with minimal canopy cover and a good distance from roads and built infrastructure.

Table 2: Site characteristics for salmonberry long-term plot site visit on October 24, 2017

Plot	Easting	Northing	# of 'robust' plants[12]	Canopy Cover	Slope	Aspect	Distance from trail / road (~)	Close to built infrastructure?	Walking distance to SPES office?
SB-1	490051	5461204	5	<5%	flat	flat	2m / 80m	No	8 minutes (600m)
SB-2	489657	5461230	10	5%	flat	flat	1m / 210m	No	14 minutes (1.1km)
SB-3	489634	5461223	7	5%	flat	flat	1m / 200m	No	14 minutes (1.1km)
SB-4	489692	5461210	10	5%	flat	flat	2m / 260m	No	13 minutes (1km)
SB-5	489617	5461243	5	10%	flat	flat	1m/ 250m	No	14 minutes (1.1 km)

[12] See footnote 9.

4.2 *Long-term monitoring plots*

4.2.1 Huckleberry productivity protocol

During the May 16th site visit, the author noted that the huckleberry bushes were in leaf-out, and flowers were just beginning to form into berries. The below photos show the HK-8 plot location entrance and a sample identification tag.

Figure 4: (left) Plot location entrance for the long-term plot Figure 5: (right) Sample ID tag on a red huckleberry plant. Photos by Megan Spencer.

4.2.2 Salmonberry first bloom protocol

During the October 24th and 27th site visits, the author noted that the salmonberry bushes were entering winter dormancy, although some leaves remained. The below photos show plants from SB-4 and SB-5 and a sample identification tag.

Figure 6 (left): plant SB-4-2, notice the ID tag and distinguishable 'Y' split at base (red outlines), Figure 7 (centre): plant SB-5-1 (red outline) Figure 8 (right): sample ID tag on salmonberry plant

4.3 Pilot surveys

4.3.1 Huckleberry productivity protocol

During the June 10th site visit, the author noted that the berries were the ideal size for the berry abundance survey: still green but full-size. The below photos show berry size and maturity. The results of the year one pilot survey for berry abundance and stem diameters are provided in Appendix 7.


Figure 9 and Figure 10: Full-size green berries present on red huckleberry bushes in HK-8 plot on June 10, 2017 (red outlines). Photos by Megan Spencer.

The berry weight survey, which occurs later in the summer once the berries are fully ripe, was not conducted. After the berry abundance survey, the author reviewed the berry count data and observed that some of the counts were very high (200-300+ berries/stem) in comparison to counts conducted by BC Parks at nearby parks (20-100 berries/stem) (see Appendix 8 and 9 for results of berry counts at Mt. Seymour Provincial Park and Golden Ears Provincial Park). To address this issue, shorter stem segments of previously tagged branches should be selected (see Recommendations section). Since the berry weight survey uses the same bushes and stems as the berry count survey, the author decided not to conduct the berry weight surveys until after the stems are retagged.

4.3.2 Salmonberry first bloom protocol

Since salmonberry flowers emerge in early spring, the author was not able to conduct the pilot survey for this protocol before submitting this report.

5. Discussion

5.1 Overview and Context of Results

A consideration for the design of the huckleberry protocol was whether to establish two long-term plots to represent “blowdown” and “non-blowdown” areas. “Blowdown” areas are the regions of Stanley Park that were moderately or severely impacted by two recent major windstorms: Hurricane Freida in 1962 and the 2006 windstorm. SPES staff, the BC parks monitoring expert, and the author thought it may be interesting to represent blowdown and non-blowdown areas, to allow future comparisons in the relative productivity of red huckleberry between the two site types. This approach was discounted for several reasons. In walks throughout the park, the author has observed that the non-blowdown regions of Stanley Park are often middle-aged forests (structural class 5-6) with single or two storied canopies. Minimal light penetrates the canopy in these stands, and thus shrubby understory vegetation is sparse or in some cases absent (Terrestrial Ecosystem Task Force, 1998, pp. 22-23; SPES, 2010, p. 42). Also, human and temporal resources are not guaranteed for this protocol in the long-term, and collecting data from one plot versus multiple plots is considered sufficient for statistical purposes (T. Stevens, pers. comm. April 23, 2017). The author decided that one plot to represent blowdown forest productivity was more realistic, economical, and still statistically valid.

An overlooked consideration for the red huckleberry protocol was for the author to clarify the approximate length/size of tagged branches. The author should have previously reviewed the Mt. Seymour or Golden Ears berry count data, or taken it on initial field visits. She could have cross-checked the berry counts with the BC Parks data *while* collecting year 1 data and caught the discrepancy. Then she could have re-selected shorter stem segments in the field, so as not to compromise year 1 data. Besides this oversight, the author believes that the methods used in this project are sound: they adhere to methods set out in established protocols for red huckleberry productivity and native flowering plant bloom times.

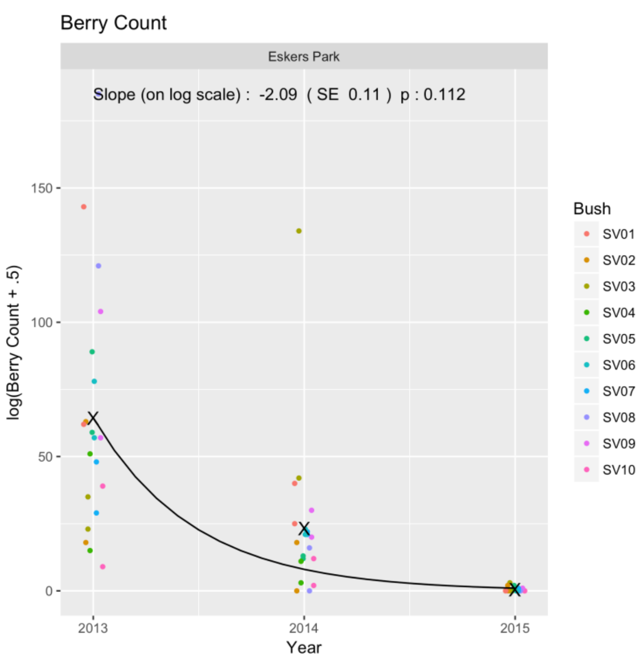
As part of the review process for the second *State of the Park Report* for Stanley Park, SPES received some feedback on its ecological monitoring indicators from a monitoring expert. The expert identified "meteorological noise" as a potential issue in the red huckleberry protocol, and noted that it would have to be filtered out. Indeed, huckleberry production, and native berry production in general, responds acutely to changes in weather and temperature (Turner, 2014, p. 8). It is this characteristic that makes red huckleberry an excellent indicator species for climate change.

The author brought the issue of “meteorological noise” to the attention of Tory Stevens, the BC Parks monitoring expert who she consulted earlier in this project. Stevens clarified that this concept was intentionally part of the design of the BC Parks long-term ecological monitoring program, and by extension the red huckleberry protocol (T. Stevens, pers. comm., October 4, 2017).

Since BC Parks monitors red huckleberry productivity in sites across the province, they anticipate that there will be inter-site differences due to different weather and climates. In time, BC Parks will identify the outliers based on "noise" (T. Stevens, pers. comm., October 4, 2017). Since SPES intends to bridge their red huckleberry dataset with the BC Parks dataset, any meteorological noise in SPES' data can be identified in statistical analyses and data interpretation.

5.2 Statistical Analyses and Data Interpretation

Since only year one data was collected for the red huckleberry protocol, there is not enough data to analyse results or trends. Sample statistical analyses for BC Parks' berry monitoring datasets (2011-2016) were completed in March 2017 by a statistician and are publically available on GitHub.[13] Graphs for two of these analyses are provided below for reference. They demonstrate two statistical tests that can be used to illustrate trends in berry production and berry weight within and between sites.



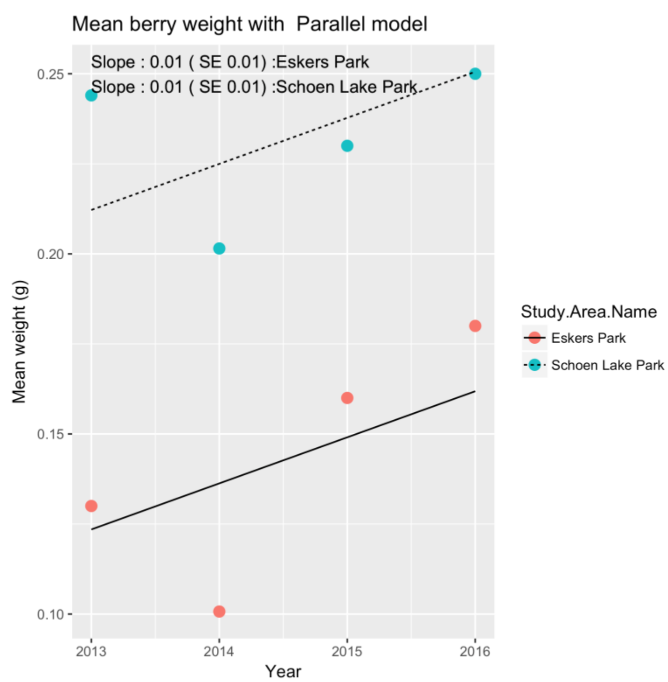


Figure 11 (left): Logistic regression of annual berry counts at Eskers Provincial Park (2013 to 2015), Figure 12 (right): Linear regression of mean berry weights at Eskers Provincial Park and Schoen Lake Provincial Park (2013 to 2016). Source: BC government public profile on GitHub.

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[13] See: https://github.com/bcgov/LTEM-sample-analyses/tree/master/Berries

Statistical analyses are not readily available for trends in salmonberry bloom dates. However a record salmonberry phenological observations is available through the "Phenology Observational Portal," an open-source database managed by the USA National Phenology Network, with contributions from diverse academic and non-profit partners across the United States and Canada.[14] A large dataset of observations (2012 - present) of various phenophases for salmonberry is available through the Portal, including numerous observations from British Columbia and Washington state. Data collected in Stanley Park can be compared to this dataset. Standard bar graphs or line plots can be used to chart trends in bloom dates observed in Stanley Park and between Stanley Park and observations from other provinces and states.

As data collection for the protocols continues, datasheets should be charted for each year, using Excel or similar software. After five or more years, trends can be interpreted with the assistance of BC Parks or SPES staff. For the red huckleberry protocol, comparisons can be made to data collected by BC Parks. For the salmonberry protocol, comparisons can be made to observations recorded in the Phenology Observational Portal.

After at least five years of collecting data through the monitoring protocols, SPES can analyse this information to determine trends in huckleberry productivity, as a proxy for native forest productivity, and the first bloom dates of salmonberry, as a proxy for the phenology of native flowering plants. An understanding of trends in these three areas will enrich the pool of biophysical information collected through SPES' ecological monitoring program.

6. Recommendations

6.1 Reselect shorter stem segments for the red huckleberry protocol

To simplify the huckleberry count for future years, the author recommends that year one data for the berry count is discounted, and that shorter stem segments from previously tagged branches are reselected. As part of the protocol, bushes and branches can be reselected and given new identification numbers at any time. For the sake of having data collection start from the same year, discounting year one data and starting fresh in spring/summer 2018 is recommended.

6.2 Purchase permanent ID tags and monitoring equipment

In the next few years, SPES should consider purchasing permanent plant identification tags for both protocols, ideally made of stainless steel or aluminum.[15] A few counters and a basic kitchen scale that measures in grams are also needed for the huckleberry protocol.

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[14] Available at: https://www.usanpn.org/data/observational

[15] Aluminum tags are an affordable option. Since aluminum is softer than stainless steel, the identification codes can be etched in rather than embossed (which requires a tapewriter kit). The 'Racetrack unnumbered' tags offered by Forestry Suppliers are recommended: http://www.forestry-suppliers.com/product_pages/Products.asp?mi=11481&itemnum=83024&title=Dymo%AE%20Rhino%99%20M1011%20Professional%20Tapewriter%20Kit

6.3 Provide training sessions for citizen science volunteers

Volunteer training session should be organized to recruit and train citizen scientists to conduct the protocols. They should occur in late March, a few weeks before salmonberry blooms emerge, and in late April, when red huckleberry flowers emerge. The classroom part of the session should review the protocol and methods used. Directions to the plot and clear photos of the plot locations and individual plants should be provided. The session should also include a field visit to the plots to ensure volunteers know how to locate the site. The salmonberry protocol field visit should clarify what branches are part of the individual plants, and which are not, to assist with future observations. The red huckleberry protocol field visit should identify each of the 10 bushes and 20 branches, have volunteers practice measuring branch diameter with calipers, and practice the berry count by having volunteers count huckleberry flowers using hand-held counters. Data sheets should be brought into the field and filled out as a group as a practice exercise. This hands-on training should help ensure that volunteers conduct the protocols using standard methods, and should help minimize future confusion or inaccurate counts.

6.4 Monitor and respond to changes in site conditions

The integrity of the condition of the monitoring sites should be monitored and recorded. Trampling or disturbance of vegetation, damage by browsing or insects, and other evidence of significant environmental, human or animal disturbance should be noted the annual surveys. The spread of invasive plants and competitive vegetation may also impact the desired site conditions. In such cases, SPES staff may decide to reselect individual plants or plots.

7. Conclusions

The goals and objectives of this project were generally met. However, a component of the third objective (to pilot the salmonberry protocol) was not possible due to timing conflicts. The author intends to conduct year one monitoring for the salmonberry protocol in spring 2018 and reselect stems for the red huckleberry protocol in summer 2018. The author also intends to host volunteer training sessions to recruit and train individuals to help conduct the protocols. Hopefully the training sessions and subsequent monitoring visits will stimulate volunteer interest in stewardship of native plants in Stanley Park, and/or provide experience in standard field skills for jobs in ecological monitoring.

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Appendices

Appendix 1: Protocol description and materials required: Red huckleberry productivity protocol

Appendix 2: Template data sheet: Red huckleberry productivity protocol

Appendix 3: Protocol description and materials required: Salmonberry phenology protocol

Appendix 4: Template data sheet: Salmonberry phenology protocol

Appendix 5: Description of HK-8 plot location and ten tagged red huckleberry plants

Appendix 6: Description of SB-4 and SB-5 plot locations and four tagged salmonberry plants

Appendix 7: Data sheet for red huckleberry count and stem diameters, Stanley Park, June 10, 2017

Appendix 8: Spreadsheet for red huckleberry count and stem diameters, Golden Ears Provincial Park

Appendix 9: Spreadsheet for red huckleberry count and stem diameters, Mt. Seymour Provincial Park

Appendix 1: Protocol description and materials required: Red huckleberry productivity protocol

Overview

The red huckleberry monitoring protocol is a standard indicator used to infer ecosystem productivity. The protocol outlined here was originally developed by the Government of Yukon and adapted by BC Parks. The protocol was taken with the permission of BC Parks with one small adjustment.[1] The protocol is simple to conduct and may be carried out by SPES staff or volunteers.

Site selection

Red huckleberry requires coarse woody debris for germination and growth (Lofroth, 1998) and plants are more productive on sites with acidic soils and a thick organic layer. Sunny locations and forest stands with canopy gaps are also favourable for berry productivity (Holden et al., 2012). Potential berry plots should be selected in sunny areas with an abundance of coarse woody debris and a thick layer of forest duff. Plots should be marked with a GPS and a location description should be recorded on a datasheet.

Data collection

In the first year, surveyors establish one or multiple plots of 10-12 robust red huckleberry plants. Identification tags are used to mark each plant and two central branches (termed 'stems') on each plant. Monitoring is then conducted annually. When the berries emerge, surveyors record berry abundance per stem and the stem diameters. When berries are ripe, surveyors collect samples and record average berry weights. Over time, plots, bushes, or individual branches may be reselected if a bush or branch is damaged (broken or dead) or extensive berry browsing occurs (BC Parks, n.d.).

Materials

- Data sheets, clipboard and pencils
- Garmin 60x GPS (SPES Conservation Department) to locate plots
- Electricians tape and Sharpie marker or aluminum tags to mark plants and branches
- Calipers to measure branch diameter
- Clickers for berry counts
- Container (glass preferred) to hold ripe berry samples
- Kitchen scale (measurements in grams) for berry weights

[1] The adjustment to the protocol is that if a bush or branch is damaged beyond use (i.e., broken or dead), the replacement should be given a different number rather than using the same one (T. Stevens, pers. comm., April 11, 2017).

References

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RED HUCKLEBERRY PRODUCTIVITY PROTOCOL DATA SHEET FOR STANLEY PARK
Modified from the data sheet used for BC Parks' soapberry/huckleberry production protocol

SURVEYOR INFORMATION
Name(s): Email(s):

Phone number(s): SPES volunteer(s)? (Yes/No):

PLOT INFORMATION
Site number: Coordinates:

SITE VISIT INFORMATION
Date: Time:

Weather in last few days: Weather at time of visit:

Bush number (*e.g., HK-8-1)*	Stem number (*e.g., HK-8-1-1)*	Stem diameter (mm)	Number of berries	Fate*	Berry weight** Avg. weight (g) of n= __	Comments (e.g. berry browse or branch damage, photos taken)

*Fate: 1 = OK, 2 = Partial branch, 3 = Unhealthy, 4 = Re-tagged (dead, broken)
** Average weight of ripe red berry. Collect n = 20-30 ripe berries where feasible

Appendix 3: Protocol description and materials required: Salmonberry first bloom protocol

Overview

Monitoring the first bloom date of native flowering plants is a common indicator used to infer the response of native vegetation communities to climate change. The protocol outlined here is a synthesis of the salmonberry protocols developed by Clayoquot Biosphere Trust and the Government of Canada's EMAN Ecosystem Monitoring Partnership. The protocol is simple to conduct and may be carried out by SPES staff or volunteers.

Site selection

The first bloom dates of flowering plants are impacted by several factors in addition to winter and spring temperatures, such as drainage, aspect and light conditions. Monitoring sites should be located in easy-access areas, on a flat aspect and away from roads, paved areas, streetlights, concrete foundations, and buried pipes (EMAN, n.d.). Salmonberry thrives in moist soils and part-shade conditions (Pojar and Mackinnon, 2004), so these areas should be targeted. Plots should be marked with a GPS and a location description should be recorded on a datasheet.

Data collection

In the first year, surveyors establish one or multiple plots of individual or patches of robust salmonberry plants. Identification tags are used to mark each plant. Monitoring is then conducted annually in the spring. Surveyors should visit the plants every few days in early spring to monitor for emergent and swelling flower buds. Two phenomena should be monitored and recorded: 'date of first bloom,' when three flowers are open (revealing the stamens) on individual plants, and 'date of mid bloom,' when 50% of the flowers are open on individual plants. Environmental details, including weather conditions leading up to first bloom, should be recorded on the datasheet. Over time, plots or individual plants may be reselected if a bush or branch is damaged (broken or dead) (EMAN, n.d.; Clayoquot Biosphere Trust, n.d.).

Materials

- Data sheets, clipboard and pencils
- Garmin 60x GPS (SPES Conservation Department) to locate plots
- Electricians tape and Sharpie marker or aluminum tags to mark plants
- Digital camera, or high quality cellphone camera (for photographing relative 'openness' of the flowers, for reference after year 1)

References

Clayoquot Biosphere Trust. (n.d.) "Wanted: West Coast Salmonberry Sightings." Retrieved from http://clayoquotbiosphere.org/measuring-community-health/wanted-west-coast-salmonberry-sightings/

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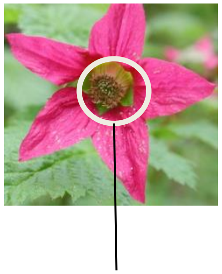
SALMONBERRY FIRST BLOOM PROTOCOL DATA SHEET FOR STANLEY PARK
Modified from salmonberry protocol data sheets by EMAN PlantWatch and Clayoquot Biosphere Trust



Location of stamens
(75-100 per flower)

SURVEYOR INFORMATION

Name(s): Email(s):

Phone number(s): SPES volunteer(s)? (Yes/No):

PLOT INFORMATION

Site number: Coordinates:

SITE VISIT INFORMATION

Date: Time:

Weather in last few days: Weather at time of visit:

PHOTO RECORD

Date: Camera or phone?: Number of photos:

Photographer name: Photographer email or phone number: Where are photos stored?

Bush number *(e.g., SB-4-1)*	First bloom date* (day-month-year)	Mid bloom date** (day-month-year)	Comments (e.g. branch damage; missed target bloom date)

**First bloom date: when three flowers are open (revealing stamens) on an individual plant
** Mid bloom date: 50% of flower buds are open on an individual plant

Appendix 5: Description of HK-8 plot location and ten tagged red huckleberry plants

HK-8 located approximately halfway along Reservoir Trail and about 10m down an overgrown, unsanctioned trail at the coordinates 489728E, 546171N. The unsanctioned trail is on the south side of Reservoir Trail the crest of a hill and is marked by a singular, large Western hemlock (*Tsuga heterophylla*). The site is situated on a SE aspect, with minimal canopy cover and abundance CWD and thick duff, and on the fringe of a 2006 “blowdown” area.

Ten robust huckleberry plants at this site were selected and tagged for the protocol:

- *HK-8-1:* next to large Douglas-fir (*Pseudotsuga menziesii*) in small clearing ~15m along trail
- *HK-8-2:* next to HK-8-1
- *HK-8-3:* across the path from above large Douglas fir, ~14m along trail
- *HK-8-4:* next to HK-8-3
- *HK-8-5:* next to HK-8-4
- *HK-8-6:* a few metres closer to Reservoir trail from HK-8-4, slightly off trail, ~10m along trail
- *HK-8-7:* next to HK-8-6
- *HK-8-8:* next to HK-8-7
- *HK-8-9:* a few metres closer to Reservoir trail from HK-8-6, on the trail, ~8m along trail
- *HK-8-10:* across the trail from HK-8-9

Appendix 6: Description of SB-4 and SB-5 plot locations and four tagged salmonberry plants

SB-4 is located on the western branch of Beaver Lake trail, about 30m from the junction with Lake Trail, at the coordinates 489692E, 5472326N. SB-4 is on the west side of Beaver Lake trail, in a thicket of salmonberry and lady fern (*Athyrium filix-femina*), about halfway between the trunks of two large Western hemlocks.

SB-5 is located on North Creek trail, about 15m north from the junction with Lake trail, at the coordinates 489617E, 5461243N. SB-5 is on the west side of North Creek trail, under the canopy of a few Western hemlock and vine maple (*Acer circinatum*). Both sites are situated on a flat aspect, and are easy to access from SPES offices (~ 13 minute walk) with minimal canopy cover and a good distance from roads and built infrastructure.

Two robust salmonberry plants ate each site were selected and tagged for the protocol:

- *SB-4-1:* in salmonberry and lady fern thicket between two hemlocks, ~2m tall bush
- *SB-4-2:* ~5m from SB-4-1, basal stem splits in a deep ‘Y’
- *SB-5-1:* ~4m from young hemlock tree, ~15m along trail
- *SB-5-2:* ~4m from SB-5-1, ~11m along trail

Appendix 7: Data sheet for red huckleberry count and stem diameters, Stanley Park, June 10, 2017

Soapberry Production Protocol

Protected Area Name: Stanley Park
Station location: HK-8 (Reservoir Trail)
Zone: —
Easting: —
Northing: —
Date: June 10, 2017 Weather: cloudy
Time: 11 10 am - 4 40 pm Temperature: 16°C
Observer: Megan S.
Page: ___ of ______
note: berries green and full-size.

Fate:
1 = OK
2 = Partial branch
3 = Unhealthy
4 = Re-tagged (natural death, breakage)

Note:
Each plant should be located within a 5 meter radius of a station. If plants are located farther from the station it is important to record a specific GPS reading of UTM coordinates for each plant.

Average wet weight of a ripe red berry: ____________ g (Average weight of n= _____)
(Collect 20-30 ripe berries where feasible)

Bush No.	Stem No.	Diameter (mm)	No. Berries	Fate	Comments
HK-8-1	HK-8-1-1	5	200	1	full sun, unobstructed
HK-8-1	HK-8-1-2	8	247	1	full sun, unobstructed, lots of 1st year growth
HK-8-2	HK-8-2-1	9	138	1	" "
HK-8-2	HK-8-2-2	12	207	1	" " + some leaves with bite marks
HK-8-3	HK-8-3-1	8	193	1	full sun unobstructed, some 1st year growth
HK-8-3	HK-8-3-2	5.5	44	2?	branch regenerating; small branch w/ lots of dead twigs present
HK-8-4	HK-8-4-1	3	83	1	small branch, partly shaded
HK-8-4	HK-8-4-2	6.5	62	1	Diameter taken above split with smaller branch (still near base); some leaf and berry mortality evident; partly shaded
HK-8-5	HK-8-5-1	4.5	56	1	near base of bush ∴ partly shaded; some 1st year growth
HK-8-5	HK-8-5-2	4	183	1	full sun, unobstructed
HK-8-6	HK-8-6-1	8	140	1	full sun, unobstructed, some 1st year growth
HK-8-6	HK-8-6-2	8	64	1	full sun, unobstructed, mostly 1st year growth
HK-8-7	HK-8-7-1	4	242	1	full sun, unobstructed, some 1st year growth
HK-8-7	HK-8-7-2	4.5	272	1	full sun, unobstructed, some 1st year growth
HK-8-8	HK-8-8-1	2.5	56	1	low branch, part-shade
HK-8-8	HK-8-8-2	2	81	1	part-shade
HK-8-9	HK-8-9-1	7.5	395	1	full sun, large bush
HK-8-9	HK-8-9-2	5.5	314	1	full sun, large bush. branch very tall - consider re-tagging
HK-8-10	HK-8-10-1	6	219	1	part-shade, some new growth
HK-8-10	HK-8-10-2	3	87	1	part-shade

12:20 - done tags
12:22 - 1:29 - diam + count for 1&2.

General comments:
Diameters taken at base/junction point of stem
Retag (counts too high/ branches high): HK-8-7/ HK-8-1/ HK-8-9/ HK-8-10-1

Appendix 8: Spreadsheet for red huckleberry count and stem diameters, Golden Ears Provincial Park

Golden Ears Provincial Park, red huckleberry count and stem diameters, June 20, 2014

Sample Station Label	Date	Surveyor	Species	Count	Berry count	Stem diameter (mm)
plant1-stem1	20-Jun-14	Iain Lunn	VACCPAR	1	114	17
plant1-stem2	20-Jun-14	Iain Lunn	VACCPAR	1	18	14
plant2-stem1	20-Jun-14	Iain Lunn	VACCPAR	1	24	6
plant2-stem2	20-Jun-14	Iain Lunn	VACCPAR	1	15	8
plant3-stem1	20-Jun-14	Iain Lunn	VACCPAR	1	8	9
plant3-stem2	20-Jun-14	Iain Lunn	VACCPAR	1	0	7
plant4-stem1	20-Jun-14	Iain Lunn	VACCPAR	1	22	13
plant4-stem2	20-Jun-14	Iain Lunn	VACCPAR	1	7	9
plant5-stem1	20-Jun-14	Iain Lunn	VACCPAR	1	25	6
plant5-stem2	20-Jun-14	Iain Lunn	VACCPAR	1	23	8
plant6-stem1	20-Jun-14	Iain Lunn	VACCPAR	1	50	8
plant6-stem2	20-Jun-14	Iain Lunn	VACCPAR	1	25	6
plant7-stem1	20-Jun-14	Iain Lunn	VACCPAR	1	34	10
plant7-stem2	20-Jun-14	Iain Lunn	VACCPAR	1	24	9
plant8-stem1	20-Jun-14	Iain Lunn	VACCPAR	1	55	10
plant8-stem2	20-Jun-14	Iain Lunn	VACCPAR	1	7	8
plant9-stem1	20-Jun-14	Iain Lunn	VACCINIUM	1	15	9
plant9-stem2	20-Jun-14	Iain Lunn	VACCINIUM	1	23	11
plant10-stem1	20-Jun-14	Iain Lunn	VACCPAR	1	26	9
plant10-stem2	20-Jun-14	Iain Lunn	VACCPAR	1	1	10

Table modified from BC Parks. (n.d.).

Reference

B.C. Parks (n.d.). “Get the Data!” BC Parks Long-term Ecological Monitoring Program. Available at http://www.env.gov.bc.ca/bcparks/partnerships/ltem/data.html

Appendix 9: Spreadsheet for red huckleberry count and stem diameters, Mt. Seymour Provincial Park

Mount Seymour Provincial Park, red huckleberry count and stem diameters, July 15, 2014

Sample Station Label	Date	Surveyor	Species	Count	Berry count	Stem diameter (mm)
plantH1-stem1	15-Jul-14	Joanna Hirner	VACCPAR	1	114	8.45
plantH1-stem2	15-Jul-14	Joanna Hirner	VACCPAR	1	19	8.45
plantH2-stem1	15-Jul-14	Joanna Hirner	VACCPAR	1	70	14.6
plantH2-stem2	15-Jul-14	Joanna Hirner	VACCPAR	1	60	12.3
plantH3-stem1	15-Jul-14	Joanna Hirner	VACCPAR	1	61	11.5
plantH3-stem2	15-Jul-14	Joanna Hirner	VACCPAR	1	11	8.1
plantH4-stem1	15-Jul-14	Joanna Hirner	VACCPAR	1	14	8.3
plantH4-stem2	15-Jul-14	Joanna Hirner	VACCPAR	1	33	9.05
plantH5-stem1	15-Jul-14	Joanna Hirner	VACCPAR	1	54	6.35
plantH5-stem2	15-Jul-14	Joanna Hirner	VACCPAR	1	34	7.2
plantH6-stem1	15-Jul-14	Joanna Hirner	VACCPAR	1	17	14.15
plantH6-stem2	15-Jul-14	Joanna Hirner	VACCPAR	1	85	8.75
plantH7-stem1	15-Jul-14	Joanna Hirner	VACCPAR	1	153	13.25
plantH7-stem2	15-Jul-14	Joanna Hirner	VACCPAR	1	2	9.05
plantH8-stem1	15-Jul-14	Joanna Hirner	VACCPAR	1	50	4.7
plantH8-stem2	15-Jul-14	Joanna Hirner	VACCPAR	1	64	8.35
plantH9-stem1	15-Jul-14	Joanna Hirner	VACCPAR	1	94	8.1
plantH9-stem2	15-Jul-14	Joanna Hirner	VACCPAR	1	25	7.4
plantH10-stem1	15-Jul-14	Joanna Hirner	VACCPAR	1	64	6.45
plantH10-stem2	15-Jul-14	Joanna Hirner	VACCPAR	1	81	6.8

Table modified from BC Parks. (n.d.).

Reference

B.C. Parks (n.d.). “Get the Data!” BC Parks Long-term Ecological Monitoring Program. Available at http://www.env.gov.bc.ca/bcparks/partnerships/ltem/data.html