State of the Park Report for the Ecological Integrity of Stanley Park

October 2020

Unceded xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səl̓ílwətaʔɬ (Tsleil-Waututh) Territory

Vancouver, British Columbia

STANLEY PARK ECOLOGY SOCIETY

Executive Summary

Vancouver's iconic Stanley Park is one of the world's largest natural urban parks, yet it is a small remnant of the forest, wetlands, and seashores that once covered the region encompassed by the traditional, ancestral, and unceded territory of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səl̓ílwətaʔɬ (Tsleil-Waututh) Nations. Bordered by downtown Vancouver and surrounded by ocean, Stanley Park faces the stressors of recreation, pollution, and climate change. To protect the Park's habitat and biodiversity, it is crucial to understand the impact of these stressors and how the ecosystems are changing.

In 2010, Stanley Park Ecology Society (SPES) published its first *State of the Park Report on the Ecological Integrity of Stanley Park* (SOPEI 2010). The report provided extensive information on the biophysical aspects of Stanley Park, evaluated its ecological integrity, and identified knowledge gaps. Still to this day, this comprehensive resource is highly informative and has informed several management strategies and plans for the Park. SOPEI 2020 (this report) is intended to build upon SOPEI 2010, rather than to replace it.

The objectives of this report are to:

1) Evaluate the ecological integrity of Stanley Park

SPES has developed a long-term monitoring program to evaluate the ecological integrity of Stanley Park over time. The format of this "snapshot" evaluation is based on Parks Canada's *State of the Park* reports. We evaluated four ecological integrity indicators through the assessment of strategic measures. For each measure, thresholds were developed to indicate the current status (in good, fair, or poor condition), and the trend (improving, stable, or declining). Because this is the first report using these quantitative measures, the trend for each indicator will be evaluated in subsequent reports.

Climate and Atmosphere **Current Status: Fair**

The current status of Climate and Atmosphere in Stanley Park is considered fair. Our analysis revealed an increase in annual air temperature, a probable decrease in summer precipitation, and an increase in sea level. Air quality is considered good and improving. Based on local and global predictions, climate change is expected to impact freshwater, intertidal, and terrestrial ecosystems. The main effects of climate change expected to impact Stanley Park are rise in sea level, precipitation increase in the fall, winter, and spring, precipitation decrease in summer, and increase in air temperature. The development of appropriate management strategies is crucial to mitigate the impacts of these changes.

Freshwater Ecosystems **Current Status: Poor**

The current status of Freshwater Ecosystems is rated as poor and is a main area of concern. Dissolved oxygen and water temperatures have reached alarming levels for aquatic life in Lost Lagoon and Beaver Lake. Special attention should be dedicated to management of the Park's lakes, wetlands, and streams.

Intertidal Ecosystems **Current Status: Not Rated**

SPES recently developed a monitoring program to assess Intertidal Ecosystems; therefore, the current status and trend for this indicator will be assessed in subsequent reports.

Terrestrial Ecosystems **Current Status: Good**

Based on tree cover, Bald Eagle productivity, and a bird community index, Terrestrial Ecosystems are in good condition. The huckleberry productivity and soil decay rate measures were recently developed, so their assessment will be presented in subsequent reports.

2) Provide recommendations for future research directions

Based on our ecological integrity evaluation, we listed recommendations for future research. The purpose of these recommendations is to create a more robust understanding of the Park's ecological conditions. The report does not evaluate whether resources may permit the accomplishment of all recommendations, but can be useful to prioritize actions.

We recommended activities that will improve accuracy and continuity of data collection (e.g. installation of an air quality station), continue the hosting of citizen science projects (e.g. Bioblitzes), measure the success of restoration efforts (e.g. survival rate of planted species), examine water flow, develop research of intertidal ecosystems, and complement studies with Traditional Ecological Knowledge (TEK).

3) Track achievements in habitat restoration and enhancement

Following SOPEI 2010, SPES, the Vancouver Board of Parks and Recreation (VPB), and collaborators have strategically planned and accomplished many goals that have enhanced the ecosystems of the Park. The motivation for these stewardship efforts is to benefit native biodiversity and reduce environmental stressors. Examples include replacing invasive plants with native plant species, installing nest boxes for cavity nesters such as tree swallows and wood ducks, and enhancing wetland habitat through the installation of elevated boardwalks. In partnership with the VPB, we tracked the progress of the proposed actions of the *Stanley Park Ecological Action Plan* (SPEAP 2011). This has helped to identify milestones and obstacles in reaching the action plan's goals, and we intend for it to provide guidance for revisiting prioritized actions.

We aim that SPES's *State of the Park* reports continue to help guide management decisions that support the Park's ecosystems. SPES is dedicated to assessing, supporting, and raising awareness of the ecological health of Stanley Park on a continual basis.

Stanley Park Ecology Society's Mission

Stanley Park Ecology Society promotes awareness of and respect for the natural world through collaborative leadership in environmental education, research, and conservation in Stanley Park.

Stanley Park is a peninsula connected to downtown Vancouver and surrounded by ocean. Photo: Ariane Comeau, 2020

Acknowledgments

We gratefully acknowledge that our work takes place on the traditional, ancestral, and unceded territory of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səl̓ílwətaʔɬ (Tsleil-Waututh) Nations. The study of Stanley Park that we present here is incredibly young compared to the long history of Traditional Ecological Knowledge of the land held by these three Nations.

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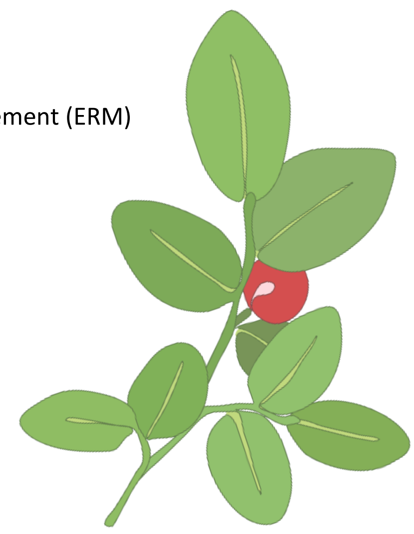

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Table of Contents

Introduction

Stanley Park is a 400-hectare forested peninsula located on the traditional, ancestral, and unceded territory of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səl̓ílwətaʔɬ (Tsleil-Waututh) Nations. Situated in the midst of Vancouver's urban landscape, Stanley Park is known worldwide for its accessibility to diverse ecosystems, wildlife, and plants.

Stressors

Since the beginning of colonization in the 1860's, Stanley Park's natural ecosystems have faced many local, regional, and global pressures. Stressors include loss and fragmentation of natural areas, degradation of water quality, the introduction and proliferation of non-native species, park operations, vehicular and pedestrian traffic, and climate change (SPES 2010). In 2006 and 2007, hurricane-force windstorms severely impacted the Park, felling more than 10,000 trees and breaking sections of the 7 km perimeter seawall. At Stanley Park Ecology Society (SPES), the subsequent restoration planning raised awareness for the importance in gathering information about the ecology of the Park, which would help better understand the impacts that stressors such as windstorms have on the Park.

2010's State of the Park Report for the Ecological Integrity of Stanley Park (SOPEI)

In 2010, SPES published the first *State of the Park Report for the Ecological Integrity of Stanley Park* (SOPEI). The report provided a comprehensive overview of the Park's history, management, and biophysical characteristics and included an initial assessment of the Park's ecological integrity (SPES 2010). The biophysical inventory was compiled through a review of scientific literature, Park-specific monitoring data, and local knowledge. A qualitative assessment of the ecological integrity of Stanley Park was conducted through the analysis of environmental indicators. This process provided a crucial preliminary understanding of the ecological integrity of Stanley Park and what issues should be prioritized for action planning. Following the report, SPES began long-term monitoring programs to assess ecological integrity through quantifiable measures.

2011's Stanley Park Ecological Action Plan (SPEAP)

The information presented in SOPEI 2010 was also key for establishing the *Stanley Park Ecological Action Plan* (SPEAP) (VPB 2011), a comprehensive direction for the management of five prioritized areas of the Park: 1) Beaver Lake's rapid infilling, 2) Lost Lagoon's water quality, 3) invasive plant species, 4) habitat fragmentation, and 5) species of significance.

SOPEI 2020 Objectives

This report (SOPEI 2020) provides an opportunity to reflect on the current state of the natural environment and to identify trends and potential issues as they emerge. Additionally, it offers knowledge-based context to help guide park management activities and conservation and stewardship efforts. The report has been developed with guidance from the *Consolidated Guidelines for Ecological Integrity Monitoring in Canada's National Parks* (Parks Canada 2011) and the *Ecological Integrity Monitoring Program* (Parcs Québec 2014), and has taken recommendations provided in SOPEI 2010 (SPES 2010).

In the report, we present

1) an assessment of the ecological integrity of Stanley Park
2) recommendations for future research directions
3) restoration and habitat enhancement highlights since SOPEI 2010, including tracking of the implementation of the actions recommended in SPEAP 2011


N
North
Vancouver
Forest Ecosystems
Freshwater Ecosystems
Intertidal Ecosystems
Stanley Park
Beaver Lake
Lost Lagoon
0
0.5
1 Km
Data Sources: SPES, City of Vancouver,
District of North Vancouver

1. Ecological Integrity Assessment

This section evaluates ecological integrity through the assessment of **indicators**, which provide a broad representation of the ecosystems that occur in the Park. The four indicators are Climate and Atmosphere, Freshwater Ecosystems, Intertidal Ecosystems, and Terrestrial Ecosystems. We strategically selected 17 **measures** (e.g. water temperature) for their ability to represent key ecosystem attributes or processes.

Data were gathered from a variety of sources, including on-the-ground monitoring (by SPES staff, interns, and community volunteers), academic collaborations, and open data inventories (e.g. DataBC). Appendix 1 presents the schedule and timeline of when the data were collected.
For each measure, we compared data to reference **threshold values**. These thresholds indicate if the data for a given measure are within an ideal range, a fair range, or a concerning range. The threshold values are established based on existing standards, provincial climate trends, and predictions, developed through professional consensus, or may require time to establish through monitoring (Parks Canada 2011). With this information, the current **status** of a measure is scored as **good**, **fair**, or **poor** (Table 1). The **trend** of a measure is based on a change in the current state from a previous state and is categorized as **improving**, **stable**, or **declining** (Table 2). Appendix 2 provides further explanation on how the status and trend for each measure and indicator are calculated.

Although SPES set baseline evaluations of the ecological integrity in 2010 (SPES 2010), the assessment was qualitative and did not correspond to the same approach utilized in this report. As a result, some measures were established in the making of this report and will be assessed when sufficient data is collected.

Table 3 summarizes the results for each indicator and measure.

Table 1. Terms and Symbols Used to Evaluate Current Status

Term	Definition	Symbol
Good	The condition of the measure or indicator is satisfactory	●
Fair	There is concern regarding the state of the measure or indicator	◆
Poor	The condition of the measure or indicator is unsatisfactory	■
Not rated	There is insufficient information to determine the condition of the measure or indicator	n/r

Source: Parks Canada (2011)

Table 2. Terms and Symbols Used to Evaluate Trends

Term	Definition	Symbol
Improving	The condition of the measure or indicator has improved since the last assessment	↑
Stable	The condition of the measure or indicator has not changed since the last assessment	↔
Declining	The condition of the measure or indicator has worsened since the last assessment	↓
Not rated	There is insufficient information to determine the trend of the measure or indicator	n/r

Source: Parks Canada (2011)

Table 3. Ecological indicators and measures selected to evaluate the ecological integrity of Stanley Park, with their current status and trend. Trends for the indicators will be determined in following reports**.**

Indicator	Status	Measure	Status	Trend
Climate and Atmosphere	Fair	Air quality	Good	Improving
		Air temperature	Fair	n/r
		Precipitation	Good	n/r
		Sea level rise	Fair	n/r
Freshwater Ecosystems	Poor	Water temperature	Poor	Stable
		Dissolved oxygen	Poor	Stable
		pH	Fair	Stable
		Stream invertebrate rating	Fair	Declining
		Amphibian richness	Good	Stable
Intertidal Ecosystems	n/r	Marine algae abundance and richness	n/r	n/r
		Sessile invertebrate abundance and richness	n/r	n/r
		Limpet size	n/r	n/r
Terrestrial Ecosystems	Good	Tree cover	Good	n/r
		Bird community index	Fair	Stable
		Bald Eagle productivity	Good	Stable
		Huckleberry productivity	n/r	n/r
		Soil decay rate	n/r	n/r

Status: Good (circle) — Fair (diamond) — Poor (square) — n/r Not Rated

Trends: Improving (↑) — Stable (↔) — Declining (↓) — n/r Not Rated

For each indicator and measure, the context, methods, and results are described below. The results reflect data collected up to and including the year 2019 when available.

Climate and Atmosphere

With sea level rising, Stanley Park coastal habitats are expected to reduce in size, experiencing "coastal squeeze". Currently, winter king tides are occasionally flooding the west side of the Seawall. These flooding events are expected to become more frequent and the waves to become stronger (NHC 2014). Photo: Frank Lin, 2020

Background

The UN Intergovernmental Panel on Climate Change (IPCC) has concluded that the global atmosphere is warming (Masson-Delmotte et al. 2018). Most of the warming observed over the last 60 years can be attributed to human activities that release greenhouse gases into the atmosphere (BC MOE 2016a). Atmospheric warming affects all parts of the climate system, which in turn influence other related physical systems.

Climate plays a fundamental role in shaping the environment of Stanley Park. SPES regularly examines governmental data on air quality, temperature, precipitation, and sea level rise to better understand the impacts of climate change on the Park's ecosystems and species. Although park management cannot directly control how the climate and atmosphere are changing, it can adapt to maximise the resiliency of the Park to climate change. In 2019, the Vancouver City Council approved the *Climate Emergency Response Report*, which identified "six big moves" including reducing Vancouver's carbon pollution and developing "negative emission" by restoring forest and coastal ecosystems (City of Vancouver 2019). The City assessed coastal flood risk using a probability modelling methodology, identified at-risk zones (some are in Stanley Park), and recognized the need to adapt flood mitigation strategies for future sea level conditions (NHC 2014, 2015).

For our evaluation of the Climate and Atmosphere indicator, it is difficult to gauge the impact that climate change has on the ecosystems of Stanley Park and to detect actual climate trends with the limited datasets that we have. For these reasons, we took a different approach to discuss the Air Temperature, Precipitation, and Sea Level measures. It is globally predicted that these three measures are changing, and small changes can have great impacts on ecosystem balance. Therefore, we presented the data that exist for Stanley Park, and rated the measures based on how the data compare to local governmental predictions and guidelines (Ausenco Sandwell 2011, BC MOE 2016b, Metro Vancouver 2016a). We discuss how these predicted changes and trends may affect Stanley Park ecosystems. For the four measures of Climate and Atmosphere, we used governmental data available in open inventories (Figure 1).

Summary

The current status for the **Climate and Atmosphere indicator is evaluated as fair**. Data showed a possible increase in air temperature, no annual change in total annual precipitation, a possible decrease in total summer precipitation, and an increase in sea level. We presume that the ecological integrity of Stanley Park is under a certain stress caused by these changes. These changes exhibited in the data were not as pronounced as governmental predictions and guidelines. However, the data that we analysed was not taken from a long enough period of time to truly represent the trends of these measures, so our results should be interpreted conservatively and will become more reliable in subsequent reports. The air pollutants nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) have been decreasing over the last two decades. Air quality is currently considered in good condition and improving.

These changes are expected to have growing consequences over time on the ecosystems of Stanley Park. While challenging, it is crucial that adequate measures are put in place to mitigate the impacts of sea level rise, seasonal precipitation changes, and increasing air temperatures.

Decreasing summer precipitation combined with increasing air temperature is expected to have various concerning ecological effects, such as reducing soil moisture which will increase erosion and tree mortality, increasing frequency and severity of forest fires, increasing evaporation of wetlands creating stressful conditions for aquatic species, and increasing spread of invasive species (BC MOE 2016b).

Some important impacts that sea level rise will directly contribute to in Stanley Park are the loss of intertidal habitats (coastal squeeze) and increasing salinity in Lost Lagoon through flooding. Some graduate students have developed interesting restoration strategies to mitigate and adapt to the impacts of sea level rise in Stanley Park, for the west coastline of the Park, and for the future of Lost Lagoon (bringing it back to a mudflat ecosystem, for the latter) (Canning 2017, MacKinnon 2018).

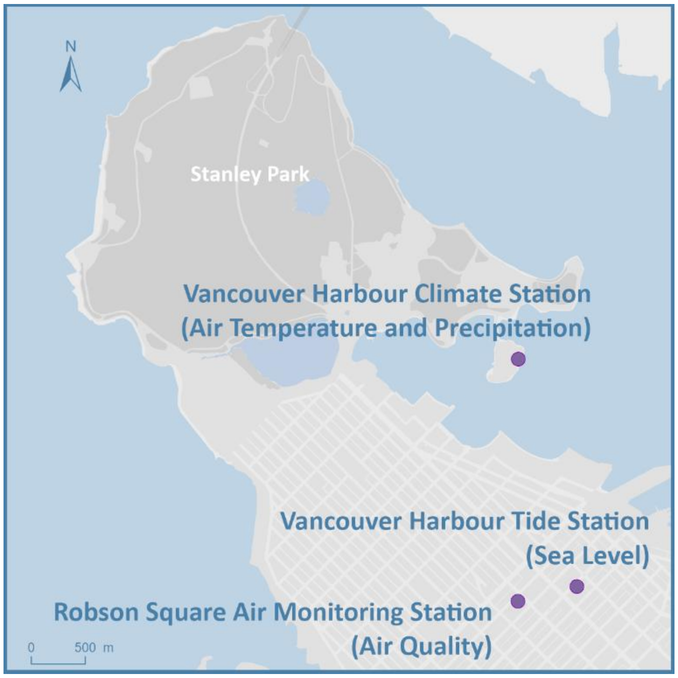


Figure 1. The data used for the Climate and Atmosphere measures was collected at three governmental stations.

Measure: Air Quality

Status: Good (average of three pollutants)

Trend: Improving

Thresholds (Concentration in ppb)	Annual peak[1]	Annual average	
	Ground-level ozone (O3)	Nitrogen dioxide (NO2)	Sulphur dioxide (SO2)
Poor	> 65	> 22	> 12
Fair	50 – 65	3 – 22	3 – 12
Good	< 50	< 3	< 3

[1] Annual peak (4th-highest) of the daily maximum 8-hour average concentration

Context

Air quality can deteriorate due to the presence of air pollutants (ECCC 2018). Ground-level ozone (O_3) is a secondary pollutant formed in the air from other contaminants with the highest concentrations of ozone occurring during hot sunny weather. Sulphur dioxide (SO_2) is formed primarily by the combustion of fossil fuels containing sulphur, such as marine vessels and the petroleum products industry. Road vehicles and other transportation are the primary source of nitrogen dioxide (NO_2) emissions, with the highest average concentrations measured in high-traffic areas (CCME 2017a).

Method

SPES inferred the ambient air quality of Stanley Park from the nearest monitoring station in Robson Square operated by Metro Vancouver. The station provides long-term hourly data for multiple air pollutants. Thresholds for Stanley Park were defined by regional, provincial, and federal pollutant-specific objectives and standards (BC MOE 2016a, Metro Vancouver 2016b, CCME 2017b).

Results

To ensure an unbiased summary of the measure's status, we equally weighted each pollutant (Parks Canada 2011). The overall current status of the air quality measure is **good**. Mann-Kendall tests found a significant monotonic decreasing trend in NO_2 and SO_2 since 2000 (for NO_2, $z = -4.46$, $p < 0.001$, slope of - 0.50 ppb/year; for SO_2 $z = -4.16$, $p < 0.001$, slope of - 0.26 ppb/year). For O_3, Mann-Kendall tests showed a significant monotonic increasing trend over time ($z = 1.98$, $p < 0.05$, slope of 0.30 ppb/year). While O_3 increased over time, it remained within the good thresholds since 2000 (Figure 2). Based on the trends of the three pollutants, the trend for air quality is **improving**. This reflects national strategies to reduce NO_2 and SO_2 emissions (CCME 2017a).

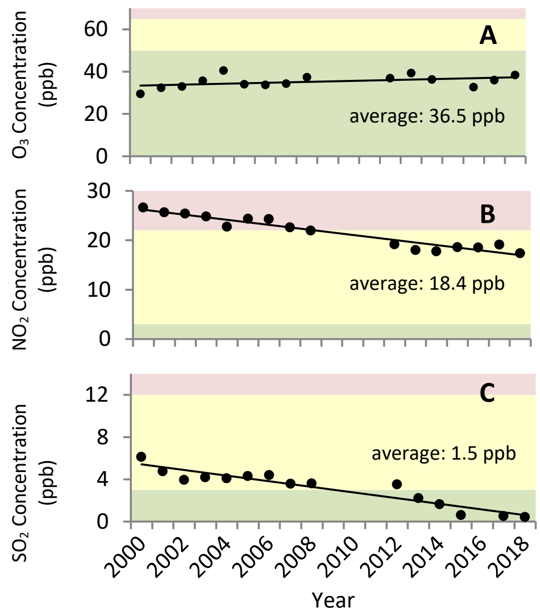


Figure 2. Air pollutant concentrations from 2000 and 2018. A. Annual peak (4th-highest daily maximum 8-hour average) of ground-level ozone (O_3) concentrations; B. Annual average of hourly concentrations of nitrogen dioxide (NO_2); C. Annual average of hourly concentrations of sulphur dioxide (SO_2). The green, yellow, and red areas represent the good, fair, and poor thresholds, respectively. The average concentration from 2012 to 2018 for each pollutant is indicated over each graph and is used to assess the current status of this measure. All data was collected at the Vancouver Robson Square monitoring station (BC MOE 2020). Years that did not satisfy the data completeness criteria were not considered valid for inclusion and have not been presented.

Since the evaluation of this measure is based on data collected at the Robson Square monitoring station in downtown Vancouver, it may not reflect what is happening in Stanley Park. Tree leaves uptake air pollutants such as O_3, NO_2, and SO_2 (Nowak et al. 2014), so we presume the concentration of these pollutants would be lower in Stanley Park than downtown Vancouver. Installing an air quality monitoring station in Stanley Park would provide a more accurate assessment for the Park.

Measure: Air Temperature

Status: Fair (appears to be increasing)

Trend: Not rated

Thresholds Average annual increase in air temperature	
Poor	> 0.045 °C/year
Fair	> 0 – 0.045 °C/year ≤
Good	no significant change

(adapted from BC MOE 2016b predictions)

Context and Impacts on Ecosystems

Warming may drive broad-scale shifts in the distribution of ecosystems and species (BC MOE 2016b). In Stanley Park, it may ease the spread of invasive species, reduce air moisture contributing to soil erosion, increase evaporation of wetlands, create stressful conditions for aquatic species, and increase the frequency and severity of forest fires. The Georgia Depression region warmed by 0.8 °C between 1900 and 2013; this is similar to the global average rate of 0.9°C per century (BC MOE 2016b). Regional climate change scenarios predict an increase from historical normal (1971-2000) in mean annual temperature of 2.9 °C by the 2050s across Metro Vancouver (Metro Vancouver 2016a).

Method

SPES examined data recorded through the Vancouver Harbour climate station (#1108446) located on Deadman's Island in Stanley Park (Government of Canada 2020). The climate station has recorded air temperature since 1976 and became automated in 1995 (G. Bramwell, Environment and Climate Change Canada, Personal Communication 2017). To ensure consistency within the dataset, only information collected from 1996 and onwards is presented.

Results

Between 2010 and 2019, the annual average temperature in Stanley Park was 11.6 °C, which is 0.5 °C above the previous decade of 2000-2009. Although not significant, annual average temperatures at the Vancouver Harbour climate station appear to be increasing from 1996 to 2019 ($z = 1.52$, $p > 0.05$) (Figure 3). This is reflective of regional, provincial, and global temperature trends. Considering that the possible increase in air temperature is lower than the predictions, and that the average annual air temperature was higher during this decade than the previous one, we evaluate the current status of this measure as **fair**.

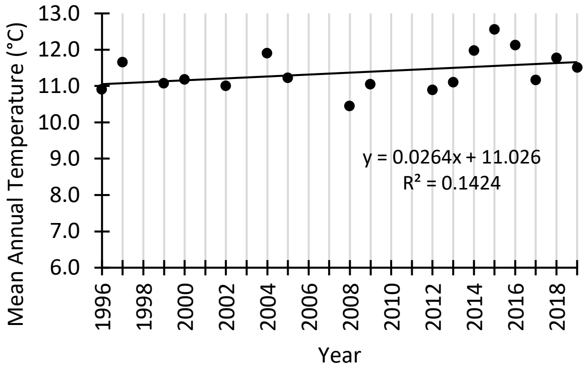


Figure 3. Annual average air temperature per year from 1996 to 2019 at Deadman's Island in Stanley Park. There is no significant trend exhibited in air temperature over time, but it appears to be increasing. Years that did not satisfy the data completeness criteria were not considered valid for inclusion and have not been presented. Data source: Historical Data (Government of Canada 2020).

This analysis will become more reliable when more data will be collected and analysed. An increase in air temperature in Stanley Park may become more evident over time, such as observed on the regional, provincial, and global scales (BC MOE 2016b). We will assess the trend of this measure in subsequent reports.

Measure: Precipitation

Status: Good (No significant change)

Trend: Not rated

Thresholds Total precipitation change in annual or in one season	
Poor	Change greater than prediction rate
Fair	Change less than or equal to prediction rate
Good	No significant change
Predicted change in precipitation over years and seasons (%) (adapted from Metro Vancouver 2016b)	
Annual	+ 0.08 to 0.12 % per year
Winter	+ 0.08 to 0.15 % per year
Spring	+ 0.12 to 0.13 % per year
Summer	- 0.30 to - 0.31 % per year
Fall	+ 0.17 to 0.21 % per year

Context and Impacts on Ecosystems

Regional precipitation projections predict a 5% increase in total annual precipitation by the 2050s and a larger increase of 11% by the 2080s, as well as wetter winters and drier summers, relative to the baseline period of 1971 to 2000 (Metro Vancouver 2016a). Increased year-to-year variability in precipitation may have adverse impacts on wetlands and other ecosystems and make water planning more complex (BC MOE 2016b).

In Stanley Park, we would expect wetter winters to create more and worse flooding events, which can:

- Erode the gravel paths surrounding Lost Lagoon, Beaver Lake, and streams. This impacts aquatic habitats of fish, invertebrates, amphibians, and other organisms.
- Lead people to walk around puddles, which may steer them to outside paths and lead to trampling plants, habitats, and small organisms.
- Flood buildings and infrastructure around Lost Lagoon more often during king tide events.
- Generate high water flow in Beaver Creek that continuously aggravates the head cut (at the outflow of Beaver Lake) and collapses the adjacent walking path.

Drier summers are expected (but not limited) to:

- Reduce soil moisture in the summer, resulting in decline of tree growth, increase of tree mortality, and less aquatic and moist terrestrial habitat for amphibians and other organisms.
- Reduce rainwater level in lakes and streams of the Park. Continuing to add municipal water to Stanley Park watershed would be beneficial for the ecosystems; however, water conservation efforts may no longer permit that as a potential source of fresh water. Municipal water needs will increase for drinking water due to drier summers and due to anticipated growing population.
- Increase risk, frequency, and severity of forest fires and human-caused fire events, leading to decreased air quality from smoke.

Method

We used data recorded by the Vancouver Harbour climate station (#1108446) located on Deadman's Island in Stanley Park for this analysis (Government of Canada 2020). The climate station has recorded precipitation since 1976 and became automated in 1995 (G. Bramwell, Environment and Climate Change Canada, Personal Communication 2017). To ensure consistency within the dataset, only data collected from 1996 and onwards were presented. When data were missing for some days at the station, SPES used data (1.7% of total dataset) from the Vancouver INTL A climate station (#1108395) (Government of Canada 2020). Years that still did not satisfy the data completeness criteria were not considered valid for inclusion and are not presented.

Results

From 1996 to 2019, the wettest year was 2010 and the driest year was 2019, and summer months varied more than the other seasons in total precipitation year after year (Figure 4 and Figure 5). Because no significant trends were detected, annually or seasonally, the current status for precipitation is considered **good.** However, this analysis will become more reliable when more data will be collected and analysed. Changes in total precipitation in Stanley

Park may become more evident over time, such as observed on the regional, provincial, and global scales (BC MOE 2016b).

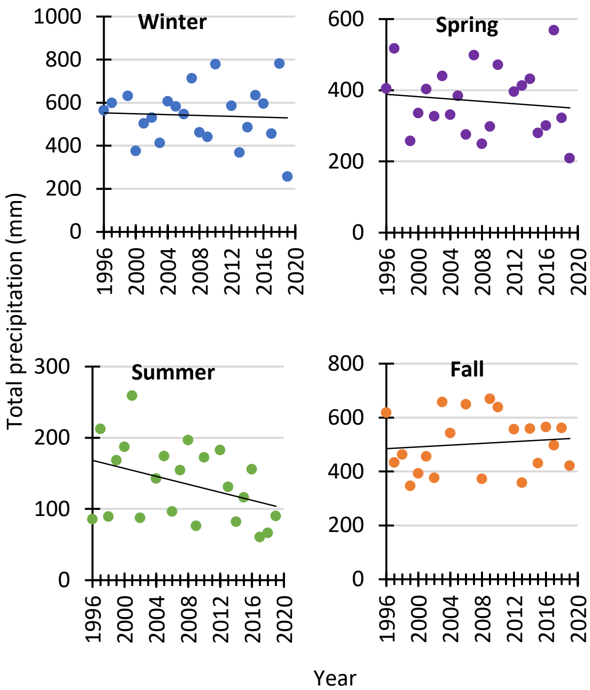


Figure 4. Total seasonal precipitation (mm) from 1996 to 2019. No significant trend was detected, but summer precipitation seems to be decreasing. Data source: Historical Data (Government of Canada 2020)

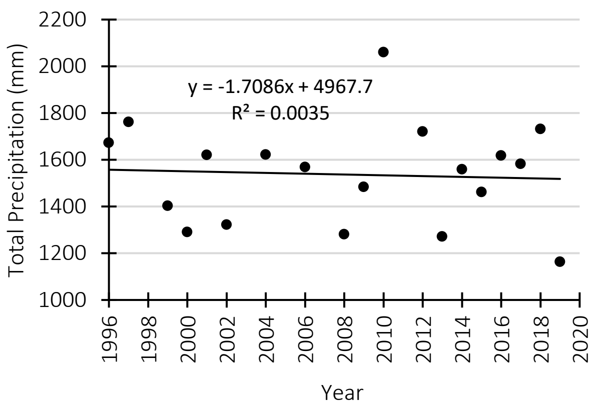


Figure 5. Total annual precipitation (mm) from 1996 to 2019. No statistically significant trend was detected. Data source: Historical Data (Government of Canada 2020).

Drier summers can reduce soil moisture, resulting in decline of tree growth and increase of tree mortality. As Western redcedars have increasingly been observed declining and dying in larger numbers in the last couple of years, in 2020, Diamond Head Consulting Ltd conducted a preliminary study for the VPB to quantify and measure the severity of declining Western redcedars in Stanley Park (Diamond Head Consulting Ltd 2020). Photo: Ariane Comeau, 2020

Measure: Sea Level

Status: Fair (increase of 0.0053 m/year)

Trend: Not rated

Thresholds Average annual increase in sea level	
Poor	> 0.01 m/year
Fair	> 0 – 0.01 m/year ≤
Good	no significant change

(Adapted from Ausenco Sandwell 2011, NHC 2014 predictions)

Context and Impacts on Ecosystems

Coastal hazards associated with sea level rise include coastal flooding, erosion, and loss of intertidal habitat (The Arlington Group Planning + Architecture Inc. et al. 2013). Sea level rise policy for BC recommends assuming a one meter rise in global mean sea level between 2000 and 2100 (Ausenco Sandwell 2011). The City of Vancouver's *Coastal Flood Risk Assessment* (NHC 2014) modelled different scenarios predicting 0.6 m and 1.0 m sea level rise by the year 2100. The City predicts that sea level rise will directly impact Stanley Park shorelines. With permanent inundation due to higher sea levels, the intertidal zone will shrink, resulting in reduced habitat for mussels, snails, young fish, which will affect the food chain and the mammals and birds that feed in the intertidal zone (City of Vancouver 2018). Wave modelling shows that the west side of Stanley Park is the most exposed side and will be subject to the largest waves, resulting in more seawall breakage, undercuts, and flooding.

Method

Annual average sea level data for Stanley Park were inferred from the nearby Vancouver Harbour Tide Station (#175), which is operated and governed by the Canadian Hydrographic Service, Fisheries and Oceans Canada.

Results

Between 2010 and 2019, the annual average sea level was 7.139 m, which is 0.060 m above the 2000-2009 average. It represents an increase of 0.0053 m per year (5.3 mm/year). Mann Kendall tests indicated a significant increasing trend in sea level between 2000 and 2019 ($z= 2.79$, $p < 0.01$) Figure 6. Because there is a significant trend in sea level, which we presume to affect the ecological integrity of the Park, and that the changing rate is slower than the predictions, we consider the current status for sea level to be **fair**.

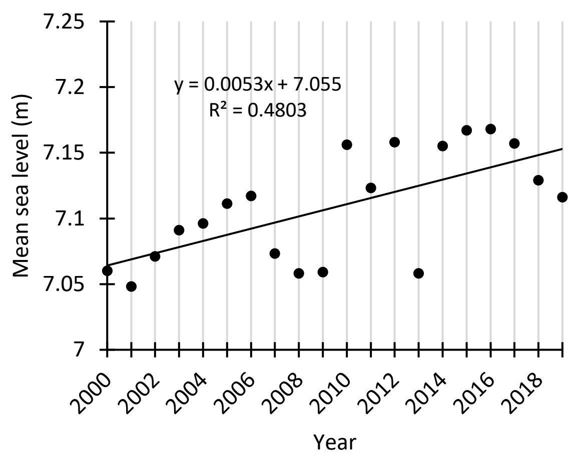


Figure 6. Annual mean sea level (m) from 2000 to 2019, at Vancouver Harbour near Stanley Park. In the last two decades, sea level is increasing at a rate of 0.0053 m per year (5.3 mm/year). Data source: Permanent Service for Mean Sea Level (PSMSL 2019).

The trends observed at the Vancouver Harbour Tide Station are reflective of global, provincial, and regional trends. Between 1993 and 2013, the rate of global sea level rise increased to around 0.003 m/year (3 mm/year) (The Arlington Group Planning + Architecture Inc. et al. 2013). On the BC coast, sea level rise has occurred in most locations, but at a lower rate than the global average. In Vancouver, average sea level rose at a rate of 0.0004 m/year (0.4 mm/year) over the last century (Province of BC 2017).

Freshwater Ecosystems

Beaver Lake is a place of ecological and cultural importance. However, its resilience to facing severe stressors such as invasive species, infilling, and climate change is uncertain. Photo: Michael Schmidt, 2015

Background

Freshwater ecosystems are a subset of aquatic ecosystems, and include lakes, ponds, streams, springs, and wetlands. Although they occupy less than one per cent of the Earth's surface, freshwater ecosystems support an estimated 12 per cent of all animal species (Abromovitz 1996). However, freshwaters are losing a greater proportion of their species and habitat than any other ecosystem (Revenga and Mock 2000, Ormerod et al. 2010). Threats to species in freshwater ecosystems are widespread and include habitat degradation, pollution, climate change, and the introduction of non-native species (Pacific Rivers Council 2007, Ormerod et al. 2010).

Essential freshwater components of Stanley Park consist of Beaver Lake, Lost Lagoon, Ceperley Meadow, several streams, and ephemeral ponds. They provide critical habitat for aquatic and semiaquatic species, including species at risk. Since the late 1800s, Beaver Lake and Lost Lagoon have gone through significant human-caused alterations. Both Beaver Lake and Lost Lagoon are infilling at rapid rates due to alteration to the watershed and its hydrology over the last century from logging, fragmentation caused by trails and roads, and invasive species, especially the fragrant water lilies covering most of Beaver Lake's surface in the summer (more information on the lakes and watershed history in SOPEI 2010 (SPES 2010)).

Beaver Lake is one of Vancouver's last natural wetlands, but is infilling at a rapid rate due to invasive plant species, road construction, and fluctuating seasonal water levels. In 2011, the rapid infilling and accelerated succession of Beaver Lake was identified as a top priority for short-term restoration and enhancement in the *Stanley Park Ecological Action Plan* (SPEAP 2011) (VPB 2011). It was evaluated that without intervention, it would risk losing its

open water by 2020. In 2013, a team of consultants led by AquaTerra Environmental Ltd. was engaged to assess the issue and develop a vision for Beaver Lake. In 2014, *the Ecological and Culturally Sensitive Enhancement Plan for Beaver Lake* was produced (VPB and AquaTerra Environmental Ltd. 2014) and was open to public review (VPB 2014). The goal of this project was "to create a diverse and healthy ecosystem that provides passive recreation opportunities for the public, maximizes native biodiversity, respects cultural significance and requires minimal ongoing interventions to maintain its integrity" (VPB and AquaTerra Environmental Ltd. 2014). Even though the enhancement project was identified as a top priority in SPEAP 2011, there have been considerable delays in the implementation of the enhancement plan, mostly due to lack of funding from the city's Capital Plan (City of Vancouver 2020a). In 2020, Beaver Lake still had open water, and beavers have played an important role in keeping deep water in the lake. Further information on the progress of this project is provided in Appendix 3 and on the City of Vancouver's website (City of Vancouver 2020a).

Lost Lagoon was originally an intertidal mud flat which was separated from Coal Harbour in 1916 by the construction of the Stanley Park Causeway and has since been a freshwater lake with saltwater intrusion (SOPEI 2010). Today it is a eutrophic system with little submergent vegetation and mostly inhabited by invasive species such as common carp and yellow flag iris. Nonetheless, Lost Lagoon is an important destination for birds migrating along the Pacific Flyway and is a refuge for a great number of overwintering and breeding birds. The biofiltration pond of Lost Lagoon, built in 2001, filtrates pollutants from the Causeway and provides wildlife habitat. Improving the water quality of Lost Lagoon was identified as a short term priority in SPEAP 2011, but, similarly to the Beaver Lake enhancement project, it is facing delays. The VPB is contemplating the option of transitioning Lost Lagoon back to a mud flat, which would be a more productive and healthy ecosystem and mitigate increasing flooding events due to sea level rise (NHC 2014, MacKinnon 2018).

SPEAP 2011 directed that seasonal freshwater top ups (potable city water) would continue to maintain water depths, cool waters, and oxygen in the Park's lake and the Jubilee Fountain in Lost Lagoon would continue operation in order to aerate the Lagoon. However, policies have shifted and most municipal water in the Park's watershed has been shut down since 2015 for water conservation. The Jubilee Fountain was significantly damaged by a flood in 2016 and estimated costs to fix it has increased. Alternative freshwater sources are being investigated (Alan Duncan, personal comm. 2020).

To evaluate the current status of the Freshwater Ecosystems indicator for Stanley Park, SPES monitors water temperature, dissolved oxygen, pH, stream invertebrate rating, and amphibian richness (Figure 7).

Summary

The current state of the **Freshwater Ecosystems indicator is evaluated as poor**. The current status for water temperature and for dissolved oxygen (DO) is poor and stable. High summer water temperatures were regularly recorded in both Beaver Lake and Lost Lagoon and DO reached incredibly low levels in Beaver Lake. These conditions reached lethal levels to aquatic fish and amphibians and may explain the low number of fish species inhabiting the lakes. The current status for pH is fair and stable. Water quality in Beaver Creek was evaluated through stream invertebrate ratings, and the status is fair and declining. Amphibian richness is considered good and stable.

Other recent studies evaluated heavy metals in Beaver Lake and Lost Lagoon, both exhibiting elevated amounts of metal in the water column and sediment, exceeding provincial and federal quality guidelines for aquatic life (Faugeraux and Bendell 2011, VPB and AquaTerra Environmental Ltd. 2014, MacKinnon 2018).

These inadequate aquatic conditions were identified prior to our assessment in several studies. They have negative effects on aquatic life and will likely continue to decline without intervention. Management strategies such as the proposed actions identified as priorities and approved by the VPB in SPEAP 2011 are essential to bring freshwater ecosystems of Stanley Park back to appropriate conditions for aquatic life.

Currently, water temperature, DO, and pH is measured once every other week by SPES staff and volunteers. Installing water quality and water level data loggers in Lost Lagoon and Beaver Lake would provide a more continuous and intensive sampling for parameters of interest.

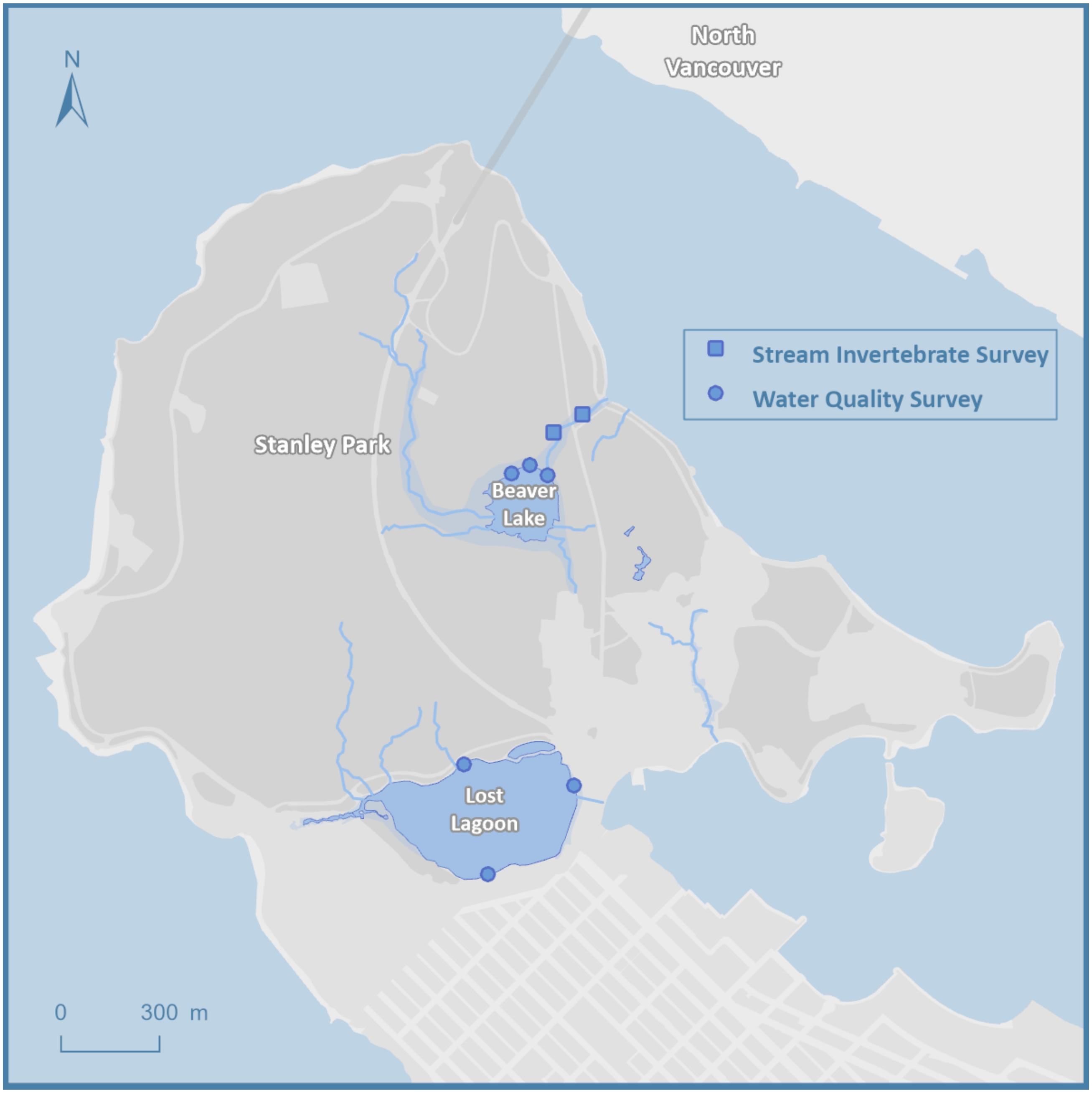


Figure 7. Sites for Freshwater Ecosystems data collection.

Measure: Water Temperature

Status: Poor (maximum 26.9 °C)

Trend: Stable

Thresholds Maximum water temperature (°C)		
Poor	**Fair**	**Good**
> 21	18 - 21	< 18

Context

Water temperature in lakes is an important environmental factor, playing a pivotal role in the development, growth, and reproduction of aquatic organisms (MELP 2001).

Method

Since 2016, SPES has monitored water temperatures in summer months (between June 1 and September 30) in three locations in Beaver Lake and three locations in Lost Lagoon, near the shore using a YSI Professional Plus Meter. Prior to these years, water temperatures were collected with different methods, by SPES and other groups. Due to limited data, we include those measurements here even if collection was inconsistent. This assessment provides an indication of stress that aquatic organisms might experience, especially during low water and drought conditions. SPES established water temperature thresholds based on the instant upper lethal water temperature for Northern red-legged frog egg survival, at 21 °C and for juvenile and adult salmonid rearing, between 22 and 24 °C (Licht 1971, MELP 2001, COSEWIC 2002).

Results

Between 2011 and 2019, the maximum water temperature measured in Beaver Lake ranged from 18.5 °C to 22.9 °C, while the maximum water temperature measured in Lost Lagoon has ranged from 24.3 °C to 26.9 °C (Figure 8). For both lakes, the maximum water temperature exceeded the 21 °C threshold every year observed, indicating that the current status for water temperature is **poor**. In 1984, the maximum water temperature measured in Beaver Lake was 22 °C (Hatfield Consultants Limited 1984), and in 2010 in Lost Lagoon SPES measured a maximum temperature of 25 °C. No significant trend was detected in either Lost Lagoon or Beaver Lake maximum water temperatures, therefore the trend is considered **stable**. However, given that both lakes are infilling at a relatively rapid rate and becoming shallower (SPES 2010, VPB and AquaTerra Environmental Ltd. 2014), we expect water temperatures to increase.

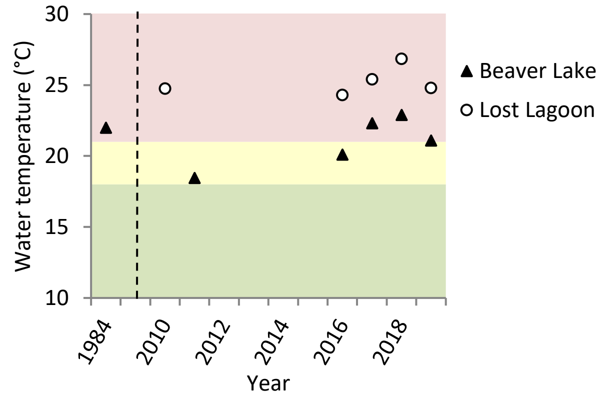


Figure 8. Maximum water temperature (°C) recorded per year in Beaver Lake and Lost Lagoon. The green, yellow, and red areas represent the good (< 18 °C), fair (18-21 °C), and poor (> 21 °C) thresholds respectively. 1984 data was collected by Hatfield Consultants Limited and the remaining data was collected by SPES.

SPES staff measuring water quality using a YSI Professional Plus Meter. Photo: Michael Schmidt, 2017

Measure: Dissolved Oxygen

Status: Poor (minimum 0.5 mg/L)

Trend: Stable

Thresholds Minimum dissolved oxygen in summer (mg/L)		
Poor	Fair	Good
< 6	6 - 8	> 8

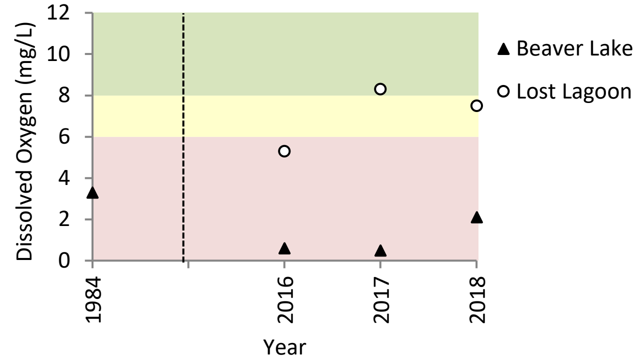
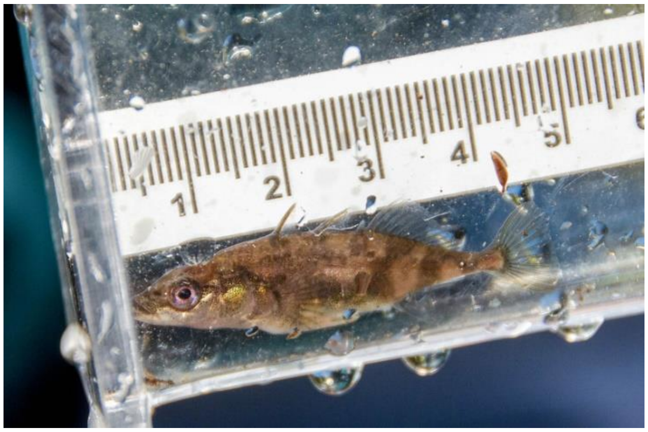


Figure 9. Minimum dissolved oxygen (DO, in mg/L) recorded per year in Beaver Lake and Lost Lagoon, between June 1 and September 30. The green, yellow, and red areas represent the good (8 mg/L), fair (6 – 8 mg/L), and poor (6 mg/L) thresholds respectively. 1984 Beaver Lake measurement was collected by Hatfield Consultants Limited (1984), and the remaining data was collected by SPES.



Threespine stickleback (*Gasterosteus aculeatus*) is one of very few species of fish living in Beaver Lake and Lost Lagoon; this is likely due to its tolerance to severe hypoxia (low oxygen condition) (Regan et al. 2017). Photo: Don Enright, 2014

Context

Dissolved oxygen (DO) is one of the most important parameters in assessing water quality because it determines whether or not aerobic aquatic organisms (require oxygen to live) will be able to survive and reproduce in the water (Zimmermann et al. 1999)(MELP 1997, Zimmermann et al. 1999).

Method

Since 2016, SPES monitors DO in the summer months (between June 1 and September 30) in three locations in Beaver Lake and three locations in Lost Lagoon, near the shore using a YSI Professional Plus Meter. It provides information on water quality when DO levels are at seasonal lows (the water capacity for DO is lower at warmer temperatures) (MPCA 2009). The DO thresholds for Beaver Lake and Lost Lagoon were established based on the recommended criteria for the protection of aquatic life (instantaneous minimum of 5 mg/L and 30-day mean of 8 mg/L) and other resources (Hatfield Consultants Limited 1984, MELP 1997, Franklin 2013).

Results

Beaver Lake and Lost Lagoon have reached DO values as low as 0.5 mg/L and 5.3 mg/L, respectively (Figure 9). Because both lakes have experienced reduction in DO to levels that are harmful for aquatic life, the current status for DO is **poor**. No trend was detected, and the poor status has not changed compared to data from 1984. We therefore consider the trend **stable**, and it is not expected to improve without restoration.

Measure: pH

Status: Fair (minimum 5.2 and maximum 8.4)

Trend: Stable

Thresholds Minimum and maximum pH in summer		
Poor	Fair	Good
< 5.0 or > 9.0	5.0 - 6.5 or 8.5 - 9.0	> 6.5 – 8.5 <

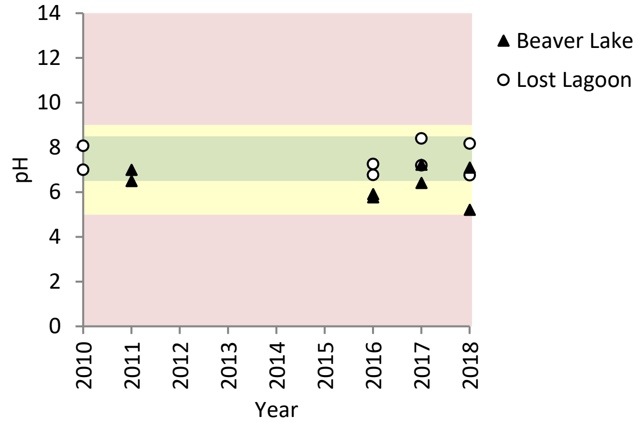


Figure 10. Maximum and minimum pH values recorded per year in Beaver Lake and Lost Lagoon between June 1 and September 30. pH is considered poor if under 5 or over 9 (red area), fair if between 5 and 6.5 or between 8.5 and 9 (yellow area), and good if between 6.5 and 8.5 (green area). Data was collected by SPES.

Context

Most aquatic organisms have a narrow range of pH tolerance. If the pH level is too high (too basic) or too low (too acidic), the organisms living within the waterbody become stressed. The pH level also affects the solubility and toxicity of chemicals and heavy metals in the water, with high and low pH levels causing toxic chemicals to become more mobile (Fondriest Environmental Inc. 2016).

Method

SPES has been monitoring pH levels intermittently since 2010 in Beaver Lake and Lost Lagoon. Monitoring pH between June 1 and September 30 provides information on water quality during the summer months when pH levels are at seasonal lows. We established pH thresholds for Stanley Park based on the provincial ambient water quality criteria for aquatic life (McKean and Nagpal 1991).

Results

The summer pH values for both Beaver Lake and Lost Lagoon were on average within the good threshold, but reached values within the fair thresholds, (minimum pH of 5.2 and a maximum pH of 8.4)(Figure 10). The current status for pH is therefore considered **fair**. Based on limited data, the trend for pH is likely **stable**, but further data collection will be required to confirm that trend.

Measure: Stream Invertebrate Rating

Status: Fair (1.9 rating)

Trend: Declining

Thresholds Stream invertebrate rating		
Poor	Fair	Good
< 1.3	1.3 – 2.7	> 2.7

Context

Stream macroinvertebrates are aquatic invertebrates living on the substrate of a body of water and are large enough to be seen with the naked eye (e.g. damselfly nymphs). Evaluating the abundance and variety of macroinvertebrates in streams provides an indication of water purity of that waterbody because invertebrates differ in their tolerance to pollution (Benetti et al. 2012, EPA 2016).

Method

Stream invertebrate ratings were taken from *The Streamkeepers Handbook Module 4: Stream Invertebrate Survey* (DFO 1995). SPES conducted surveys in 2014 and 2018 in Beaver Creek. In 2019, we began assessing North Creek, Zoo Creek, and Ceperley Creek as well. The surveys are conducted in two sites per creek, in spring and fall. In 1998, Capilano College students conducted a similar survey at Beaver Creek and North Creek (Benitah et al. 1998). While the survey was not conducted in the exact same way, we still consider their results in the analysis. For consistency, we will only analyse results for Beaver Creek.

Results

For Beaver Creek, between 2014 and 2019, the annual average stream invertebrate site rating was 1.8. The current status of this measure is **fair**. In 1998, the rating resulted as good (2.8 rating). The trend for this measure is considered **declining** (Figure 11). Further monitoring and of more creeks will strengthen the assessment and will confirm if the rating continues to decrease. Aquatic worms, aquatic sow bugs, caddisfly larvae, and midge fly larvae are the most abundant stream macroinvertebrates found in Beaver Creek.

Damselfly nymphs are abundant in Beaver Lake and are more tolerant to water pollution than caddisflies, stoneflies, and mayflies. Photo by Ariane Comeau, 2015

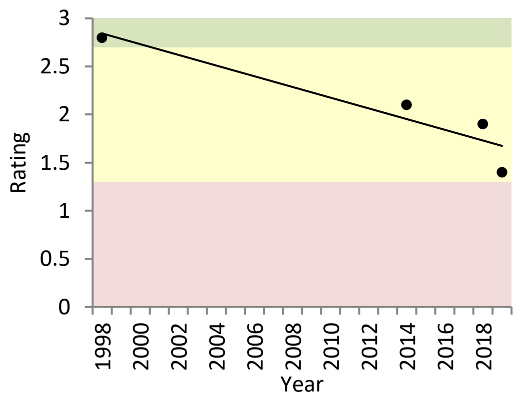


Figure 11. Stream invertebrate rating for Beaver Creek, Stanley Park in 1998, 2014, 2018, and 2019. The green, yellow, and red areas represent the good (> 2.7), fair (1.3 – 2.7), and poor (< 1.3) thresholds respectively. The current rating is on average 1.9 and considered fair, but declining. 1998 data was collected by Capilano College students (Benitah et al. 1998) and the remaining data was collected by SPES.

SPES volunteer identifying stream invertebrates in Ceperley Creek. Photo: Meghan Cooling, 2019

Measure: Amphibian Richness

Status: Good (4 native species)

Trend: Stable

Thresholds Number of native amphibian species detected		
Poor	Fair	Good
≤ 2	3	≥ 4

Context

Amphibians are particularly sensitive to water-borne pollutants and pathogens as they have moist, permeable skin. In addition, factors such as habitat loss, introduced species, and climate change are negatively impacting amphibian populations on a global scale (Meredith et al. 2016, Griffith 2017).

Method

SPES monitors terrestrial and pond-breeding amphibians by conducting auditory, capture, and visual encounter surveys every other year (RIC 1998, 1999). Pond-breeding surveys are done in lakes and ponds of the Park, early to late spring when amphibians are laying egg masses. The terrestrial surveys take place all year long, consisting of observing presence of terrestrial amphibians under a dozen coverboards placed within the forest of the Park. Other sightings outside of surveys are also recorded. We established thresholds based on the number of native amphibian species detected in the Park between 2000 and 2009.

Results

Since 2010, four native amphibian species were detected, all provincially yellow listed (species that is at the least risk of being lost/of least concern) (Table 4). The Northern Pacific treefrog made a comeback around 2015 and a full chorus can now be heard at Beaver Lake. The current status for amphibian richness is considered **good** and, comparing to the last assessment, the trend is **stable.**

Table 4. Native amphibian species documented in Stanley Park historically, between 2000 and 2009, and 2010 and 2020

English Name	Scientific Name	Historically[1]	2000 to 2009	2010 to 2019
Blue listed (in BC, species *of special concern*)				
Northern red-legged frog	*Rana aurora*	✓		
1-SC (in Canada, species *of special concern*)				
Western toad	*Anaxyrus boreas*	✓		
Yellow listed (in BC, species *of least concern*)				
Ensatina	*Ensatina eschscholtzii*	✓	✓	✓
Long-toed salamander	*Ambystoma macrodactylum*	✓		
Northern Pacific treefrog	*Pseudacris regilla*	✓		✓
Northwestern salamander	*Ambystoma gracile*	✓	✓	✓
Rough-skinned newt	*Taricha granulosa*	✓	✓	
Western red-backed salamander	*Plethodon vehiculum*	✓	✓	✓
Total Native Amphibian Species		**8**	**4**	**4**

[1]: Data from the Ministry of Environment (2020)

SPES believes that the reappearance of the Northern Pacific treefrog is most likely due to someone releasing individuals to Stanley Park. It is unlikely that the treefrogs made it back on their own as Stanley Park is highly isolated from other populations. We suspect that this may be the case for the one rough-skinned newt found in 2020 (Mike Mackintosh, personal comm. 2020), since the species was not detected for ten years.

The invasive American bullfrog (*Lithobates catesbeianus*) and green frog (*Lithobates clamitans*) are found within the lakes and ponds of the Park. Invasive species may coexist with some of the native species; however, they are known to prey on amphibians (Jancowski and Orchard 2013) and, along with changes in water temperature and DO, could be a factor of the disappearance of some of the historically occurring species. Examining abundance of native and invasive amphibian species would provide additional information on their populations.

Intertidal Ecosystems

SPES volunteers surveying intertidal invertebrates and algae. Photo: Meghan Cooling, 2019

Background

Marine ecosystems are a subset of aquatic ecosystems and include salt marshes, intertidal zones, estuaries, and lagoons as well as larger ocean bodies. Covering approximately two-thirds of the earth's surface area, the ocean is home to millions of species and plays an essential role as a global ecological and climate regulator (UNESCO 2016). However, stressors such as climate change, ocean acidification, pollution, and overuse of marine resources threaten the continued provision of these services (Doney et al. 2012, Wowk 2013).

Stanley Park is bound on three sides by the Pacific Ocean and associated intertidal habitat (SPES 2010). The intertidal zone is home to kelps and invertebrates such as sea stars, clams, mussels, marine worms, and barnacles, where larger animals are often observed foraging, such as diving ducks, Bald Eagles, river otters, and raccoons. Stanley Park is surrounded by the Seawall, which creates a barrier between the ocean and the land, limiting interactions between the ecosystems. With birds and wildlife feeding on shellfish and travelling from intertidal habitats to terrestrial habitats, important nutrient exchanges still exist between the ecosystems (Cox et al. 2019). Stanley Park is globally important for the conservation of bird populations and is recognised as an Important Bird and Biodiversity Area (IBA) (IBA Canada 2020).

The intertidal ecosystems of Stanley Park are facing various stressors including climate change, pollution, and recreational uses (SPES 2010). Sea level rise is expected to reduce the size of the coastal habitats around Stanley Park and increase breakage severity of the Seawall. The City of Vancouver is examining ways to mitigate these future impacts (NHC 2014, 2015). On a global scale, ocean acidification affects the development of marine and intertidal organisms and trophic dynamics (Fabry et al. 2008, Doney et al. 2012).

In April 2015, a substantial oil spill occurred in English Bay. The Marathassa oil leak came from a Panamax bulk grain carrier and it spread to the shorelines of Stanley Park by Siwash Rock. It was roughly estimated that a total of 2,800 L of fuel oil leaked and that approximately half of it was recovered (Canadian Coast Guard 2015). Not enough baseline data was available to capture how detrimental the oil spill was on the habitats of the Park. Collecting baseline information in the intertidal ecosystems will provide information on the impact of future stressors such as oil spills and climate change.

SPES is surveying the intertidal community to understand how it may change over time facing these stressors. So far, the intertidal habitats have been assessed intermittently; however, a monitoring program has been developed and regular surveys will be conducted to document changes in marine algae abundance and richness, sessile invertebrate abundance and richness, and sea surface temperature (Figure 12).

Summary

SPES initiated a long-term monitoring program for the Intertidal Ecosystems indicator in 2019. The data collected that year was used to established thresholds for each measure. The status and trend for the measures and indicator **will be assessed in subsequent reports** when data become available. Since we are currently working with only three measures, collaborating with local groups doing similar work would be beneficial to provide a stronger understanding of the intertidal ecosystems' conditions (e.g. for forage fish, seagrass).

Figure 12. Intertidal Ecosystems data is collected on six sites around Stanley Park. SPES surveys marine algae abundance and richness, sessile invertebrate abundance and richness, and limpet size along 24 random transects on these sites.

Marine Algae n/r

Status: Not rated

Trend: Not rated

Thresholds 1. Algae relative abundance (%)		
Poor	**Fair**	**Good**
< 16.5	16.5 – 24.75	> 24.75
2. Algae richness (number of species)		
Poor	**Fair**	**Good**
< 1.15	1.15 – 1.73	> 1.73

Sessile Invertebrates n/r

Status: Not rated

Trend: Not rated

Thresholds 1. Sessile invertebrate relative abundance (%)		
Poor	**Fair**	**Good**
< 7.0	7.0 – 10.5	> 10.5
2. Sessile invertebrate richness (number of species)		
Poor	**Fair**	**Good**
< 0.75	0.75 – 1.13	> 1.13

Limpet Size n/r

Status: Not rated

Trend: Not rated

Thresholds Limpet shell length (mm)		
Poor	**Fair**	**Good**
< 3.5	3.5 – 5.25	> 5.25

Context

Several biological communities are associated with the rocky intertidal habitat surrounding Stanley Park, including a diversity of algae and invertebrate species (SPES 2010). Marine algae and invertebrate species are vulnerable to physical and chemical changes in the marine environment, which makes them useful indicators for detecting environmental change (El Shoubaky 2013). Shifts in species abundance and distribution are expected in response to climate change, ocean acidification, pollution, and over use of marine resources, although it is unclear how invertebrate communities respond to warming ocean temperatures (Clark et al. 2016, Loiacono 2016).

Method

An intertidal habitat monitoring program has been developed for SPES by Environmental Resources Management (ERM 2018). SPES began conducting yearly surveys in 2019 to document changes in abundance and richness of marine algae and sessile invertebrates, as well as change in limpet size. Sessile invertebrates such as barnacles, anemones, and mussels are immobile and attached to substrate for at least a part of their life cycle. Limpets are aquatic snails with conical shells. Their body size and dimensions exhibit variation and are influenced by environmental factors. Limpets could thus potentially be used as sensitive indicators of temperature and salinity change (Hobday 1995). We conduct surveys at six sites distributed around Stanley Park (Figure 12).

For the thresholds of each measure, we established that changes less than 25% from the baseline will indicate a stable community structure while changes greater than 50% would signal significant change (ERM 2018).

Results

In 2019, the average relative abundance at the surveyed sites was 33% coverage for algae and 14% for sessile invertebrates. The average number of species per quadrats (richness) was 2.3 for algae and 1.5 for sessile invertebrates. The average limpet length was 7.0 mm. We will use these numbers as baselines and the **status and trend for each measure will be assessed in future reports**.

Terrestrial Ecosystems

Forest of Stanley Park. Photo: Michael Schmidt, 2011

Background

Approximately one third of the earth's land is covered in forest and these terrestrial ecosystems contain over 80% of terrestrial biodiversity (Aerts and Honnay 2011). Both the extent and quality of forest habitat continues to decrease, with primary threats including habitat loss and degradation, climate change, invasive species, and pollution (Malcolm and Pitelka 2000, Coristine and Kerr 2011). Climate change will affect terrestrial biodiversity and ecosystems; however, ecosystems are complex and it is difficult to model and predict how they will respond (Malcolm and Pitelka 2000).

More than half of Stanley Park is comprised of forested habitat, which has been altered over time by natural and anthropogenic influences (SPES 2010). The forest of Stanley Park is composed of various ecological communities (site associations), most of them provincially listed as "ecosystems at risk" (VPB 2009a, SPES 2012c). It is important to understand and safeguard these various vegetation compositions, as they support particular flora and fauna communities. Several invasive plant species are impacting the integrity of those communities. SPES has developed a mapping program and management plan for invasive plants in Stanley Park to assess the impacts of invasive species, guide stewardship actions, and monitor the success of those actions (SPES 2013).

Climate change is expected to affect terrestrial ecosystems of Stanley Park, largely through warming temperatures and decreasing summer precipitation. This is expected to result in reducing air and soil moisture, increasing erosion, declining tree growth and increasing tree mortality, promoting the spread of invasive species, and

increasing risk, frequency, and severity of human-caused fires (BC MOE 2016b). In the late 2010s, Park goers and Park staff started noticing a greater number of declining Western redcedars, which could be related to drier summers and increase in air temperature. To create a baseline of information, a preliminary study was conducted by Diamond Head Consulting Ltd on declining Western redcedars in Stanley Park (Diamond Head Consulting Ltd 2020).

To provide a snapshot of the Terrestrial Ecosystems condition, SPES established five measures: tree cover, a bird community index (BCI), Bald Eagle productivity, huckleberry productivity, and soil decay rate (Figure 13).

Summary

The **Terrestrial Ecosystems indicator has been rated as good** based on tree cover, the BCI, and Bald Eagle productivity. To look at total tree cover in Stanley Park, we used LiDAR data from the City of Vancouver, which indicated an increase of 8 % from 2013 to 2018. The current status for tree cover is good and the trend will be assessed when more data become available. Since 2007, SPES has been surveying breeding birds at 22 forest sites throughout the Park. This allowed us to develop a bird community index, calculating a score based on the ratio of specialist and generalist bird species breeding in spring. The current status for breeding birds is considered fair and the trend to be stable. Several Bald Eagles breed in Stanley Park and their productivity's current status is considered good and stable. The huckleberry productivity and soil decay rate measures were implemented in 2019; therefore, their status and trend will be assessed in subsequent reports.

Although we rated the Terrestrial Ecosystems indicator as good, several natural and anthropogenic stressors continue to have significant impacts, such as climate change, off-trail activities, and the spread of invasive plants. It is essential to understand the impacts of these stressors on the terrestrial ecosystems in order to best mitigate them. For information on ecological restoration efforts since 2010, see Section 3 (2010-2019 Ecological Restoration and Habitat Enhancement) and Appendix 3 (Implementation Tracking of 2011's Stanley Park Ecological Action Plan (SPEAP 2011)).

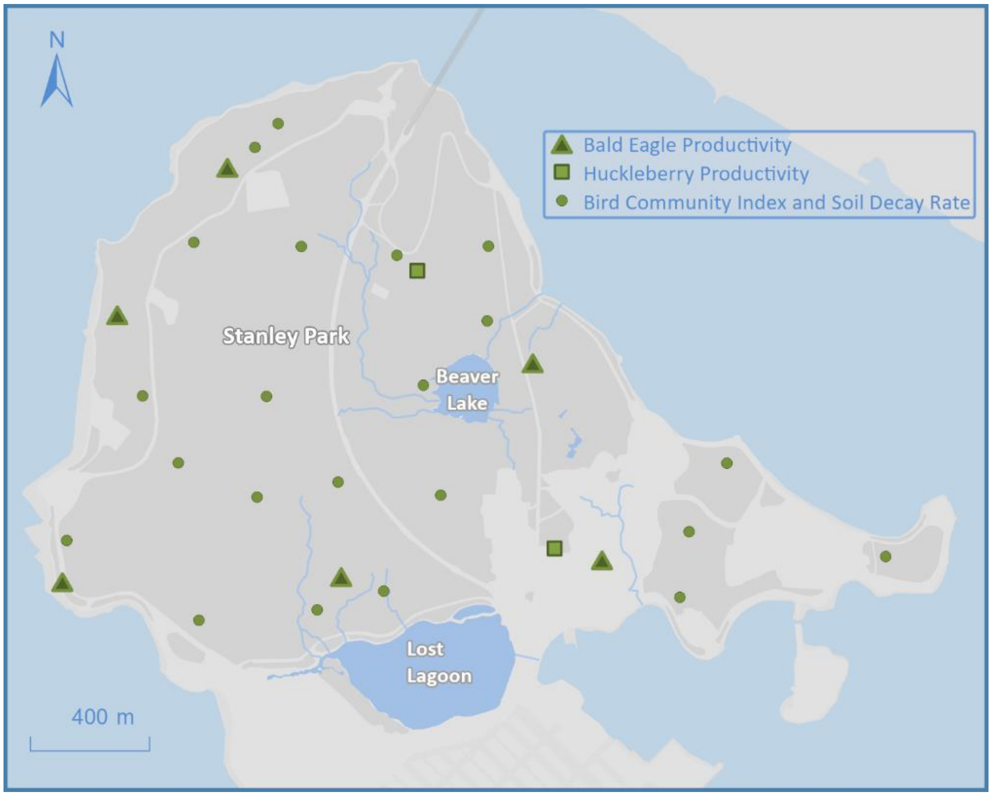


Figure 13. Terrestrial Ecosystems data is collected throughout Stanley Park.

Measure: Tree Cover

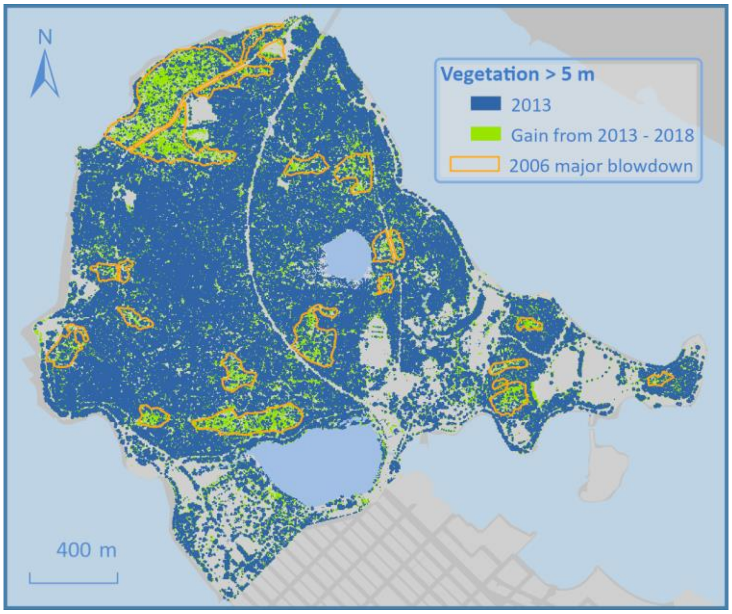
Status: Good (+1.6 % tree cover per year)

Trend: Not rated

Thresholds	
Poor	> 1% loss of tree cover per year
Fair	≤ 1% loss of tree cover per year
Good	no loss or increase in tree cover

Context

Stanley Park's forest provides several environmental and economic benefits, including climate regulation and valuable ecosystem services. Tree cover loss can have significant implications for ecosystem functioning, habitat integrity, climate change mitigation, and other environmental services (Yale University and Columbia University 2018). In Stanley Park, the natural forest has been impacted by anthropogenic and natural events over time, such as logging from the 1860s to the 1880s, creation of roads, widening of those roads, powerful windstorms, and mown grass areas for recreational purposes (SPES 2010). Monitoring tree cover allows tracking changes resulting from forest loss, reforestation, and afforestation, shedding light on forest health.



Method

SPES calculated percentage (%) change in tree cover in Stanley Park between 2013 and 2018 using Light Detection and Ranging (LiDAR) data, available through the open data catalogue of the City of Vancouver (City of Vancouver 2020b). We considered five metres as the minimum height of tree cover to ensure that tree saplings and the other types of vegetation are excluded from the calculation (Matasci and Coops 2017). The area of the park with trees above this height was compared between years to obtain a value for canopy cover. It is, however, important to note that the 2013 data was collected in February, while 2018 data was collected in August. This is not ideal given that foliage increases canopy cover. Therefore, the percentage increase between 2013 and 2018 is believed to be amplified due to seasonal timing of the data collection. Also, since this report is our baseline for this measure, the status thresholds are provisional and may be revisited in future reports. For now, we are considering any positive tree cover change as good.

Results

The total tree cover was 65.0 % of the Park in 2013 and 73.0 % in 2018 (Figure 14). Because tree cover increased during that period (average of 1.6 % per year), the current status is considered **good**. Again, the results would be more accurate if LiDAR data was collected in the same month or season each year. The trend is **not rated** and will be assessed when more years of data become available.

Figure 14. Comparison of tree cover in Stanley Park between 2013 and 2018. 1 by 1 m cells where canopy is at least 5 m in height or more is coloured. Blue cells represent tree cover in February 2013, and the green cells represent the gain in tree cover between February 2013 and August 2018 (2018 layer is behind 2013 layer). Gains in canopy cover are present throughout the forest of the Park. Notably, there are major increases in the blowdown areas of the 2006 windstorms where 15,000 trees and shrubs were planted in the two subsequent years to help the forest recover. Tree growth is also visible in other planting sites where invasive plants were removed and native trees and understory plants planted through SPES stewardship events, notably the Brockton Oval edge.

Measure: Bird Community Index

Status: Fair (score of 2.6)

Trend: Stable

Thresholds Bird Community Index (BCI) Score		
Poor	Fair	Good
> 4.0	2.0 – 4.0	< 2.0

Context

Some bird species survive better than others in changing environments. Generalist species thrive in a wide range of environmental conditions, while specialist species require specific conditions to thrive. Bird communities provide an indication of environmental change because they respond to increasing development in predictable patterns, with specialist species becoming less common and generalist species becoming more widespread and abundant (Goodwin and Shriver 2014).

Method

SPES developed a bird community index (BCI), which uses the health and diversity of Stanley Park's bird community as an indicator of forest ecosystem health. Higher BCI scores (represented by lower numbers) describe a community where specialists are well-represented relative to generalists, indicating higher ecological integrity. We developed the BCI for Stanley Park based on O'Connell et al.'s study (1998). We have conducted breeding bird point count surveys intermittently since 2007, between May and July, at eight to 22 forest habitat stations throughout the Park.

Results

Since 2007, the annual scores have ranged between 1.9 (good) and 3.3 (fair), with the majority of annual BCI scores ranking as **fair** (Figure 15). Comparing the BCI from surveys conducted from 2007-2009 to 2010-2019, the trend in the breeding bird community is **stable**. The stations that had the highest BCI score (represented by lower numbers) were in coniferous-dominated forest (VPB 2009a), closer to the centre of the Park (Figure 16).

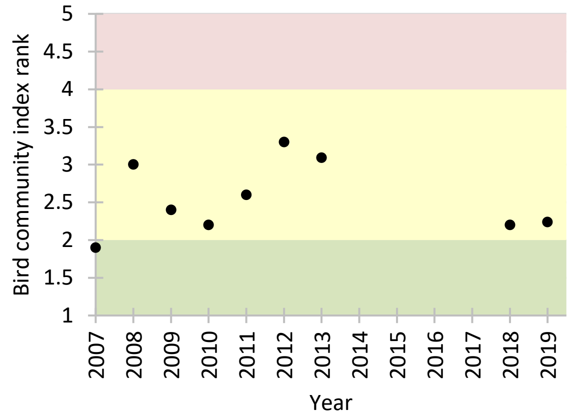


Figure 15. Bird community index (BCI) Score per year. The green, yellow, and red areas represent the good (< 2.0), fair (2.0 - 4.0), and poor (> 4.0) thresholds respectively.

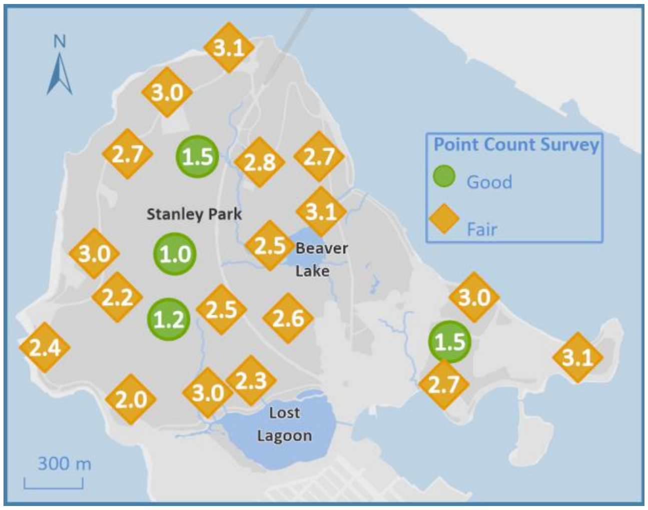


Figure 16. Map of the 22 breeding bird point count stations ranked by their 2007-2019 average BCI score. "1.0" is the station with the highest score, and "3.1" the lowest. The green circles indicate the stations with a *good* BCI, and in yellow, a *fair* BCI score. No stations were scored *poor*.

Bewick's Wrens are a specialist species: they require a tree cavity for nesting and are insectivores. Photo: Mark White, 2012

Measure: Bald Eagle Productivity

Status: Good (1.00 fledgling per active nest per year)

Trend: Stable

Thresholds Annual average number of fledglings per active nest per year		
Poor	**Fair**	**Good**
< 0.48	0.48 – 0.70 <	≥ 0.70

Context

Bald Eagle (*Haliaeetus leucocephalus*) populations across North America went through declines in the last century due to several factors, including loss of habitat, DDT poisoning, rodenticides, and human disturbance. They have successfully recovered due to conservation actions targeting their protection (U.S. Fish and Wildlife Service, Interior 2007), but they continue to be susceptible to many of these stressors. Monitoring productivity of Bald Eagles provides information on the sustainability of a population and may indicate if habitat requirements for breeding and feeding are adequate for this top predator. Here we use Bald Eagle productivity as a measure for Terrestrial Ecosystems, but as fish-eating birds, they can also shed light on the aquatic ecosystems.

Methods

From January through August, SPES monitors Bald Eagle nests in Stanley Park to identify the number of active nests and number of fledglings produced every year. We established thresholds based on the previous assessment period (2004-2009) and on what is considered a sustainable Bald Eagle population (average of 0.7 fledglings per nest) (Sprunt et al. 1973).

Results

From 2004 to 2019, three to five pairs of Bald Eagles were breeding in the Park every year, and in 15 years produced over 50 fledglings. On average, 0.64 fledglings per active nest were produced per year from 2004 to 2009, and 1.00 from 2010 to 2019 (Figure 17). The Bald Eagle population of the Park is considered sustainable and the status for this measure is **good**. No trend was detected, so it is considered **stable**.

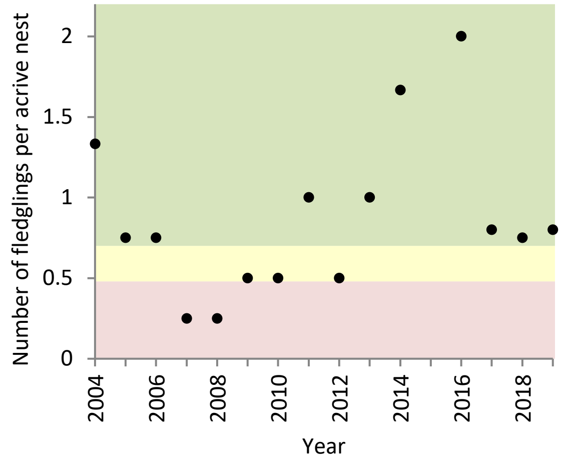


Figure 17. Bald Eagle productivity in Stanley Park from 2004 to 2019. Bald Eagle populations are considered sustainable if the average number of fledglings per active nest per year is at least 0.7 (Sprunt et al. 1973). On average 0.64 fledglings per active nest were produced per year between 2004 and 2009, and 1.00 between 2010 and 2019. The green, yellow, and red areas represent the good (≥ 0.70), fair (0.48 – 0.70 <), and poor (< 0.48) thresholds, respectively.

Two Bald Eagle eaglets being raised in a tall Douglas fir near the Malkin Bowl. Photo: Michael Schmidt, 2015

Measure: Huckleberry Productivity n/r

Status: Not rated

Trend: Not rated

Thresholds Average annual berry weight (g)		
Poor	**Fair**	**Good**
< 0.08	≥ 0.08 – 0.10 <	≥ 0.10

Huckleberries are counted and weighted to measure annual productivity. Photo: Brian Grover, 2011

Context

Changes in berry production are correlated with variations in climate, particularly temperature (Holden et al. 2012). Berry monitoring can be an indicator of changes in local climate that might affect local forest productivity.

Method

A red huckleberry survey was derived from methods developed by BC Parks to infer ecosystem productivity through soapberry survey (Spencer 2017, BC Parks n.d.). The study consists of selecting ten robust red huckleberry plants that will be surveyed yearly in June and July. Each year two stems per selected plant are chosen, on which we count and weigh ripe berries, to measure the annual berry weight average. We selected preliminary thresholds based on a first year of data collected.

Results

SPES commenced surveys in 2019, in which the average berry weight was 0.11 g (n=142). Because this was the first year of data collection for the Park, the thresholds were established from that baseline data, using it as the reference. Therefore, the current status and trend are **not rated** and will be evaluated after 5 years of data collection.

Measure: Soil Decay Rate

n/r

Status: Not rated

Trend: Not rated

Thresholds Average mass loss of wood sticks buried for one year (%)		
Poor	Fair	Good
> 24%	20 – 24%	< 20%

Context

Rates of decay are influenced by many factors including climate, temperature, moisture, substrate type, nutrient concentrations and availability, litter type and size, and soil organisms (Environment Canada 2004). Changes in decay rates and soil processes are associated with climate change effects. An increase in temperature can increase the rate of decomposition, which would then cause an accelerated release of carbon into the atmosphere. Tracking decomposition in soils over a long period of time will provide information about the impacts of climate change on soil health and productivity (Environment Canada 2004).

Method

SPES follows the federal decay rate protocols developed by the Ecological Monitoring and Assessment Network (EMAN) (Environment Canada 2004). This SPES survey consists of burying wooden sticks (chopsticks and dowel sticks) under the soil surface at selected locations throughout the Park and retrieving them one year later, dry them, and measure their weight loss. We selected preliminary thresholds based on a first year of data collected.

Results

Wood sticks were buried at two sites in October 2018 and retrieved in October 2019 to be weighed. On average, 16% of the original sticks' mass decayed (n=16). This survey was expanded to include five additional forested sites in 2019. Because this is the first round of data collection for this survey and the thresholds are based on this data, the current status and trend for this measure are **not rated** and will be determined in future reports.

SPES volunteer buries wood sticks to be retrieved and weighed a year later. Photo: Ariane Comeau, 2018

2. Recommendations for Future Research Directions

SPES recommends future research projects to uncover gaps in ecological information and to measure stressors of Stanley Park's ecosystems. The ecological integrity assessment in Section 1 is a snapshot of what is happening among the ecosystems of Stanley Park; therefore, these recommendations aim to refine our understanding of the ecological conditions in the Park. In addition to this list, many recommendations listed in SOPEI 2010 are still applicable (SPES 2010). The ability to pursue these recommendations will be contingent on resources. Overall, continuing to collaborate with other groups makes these projects possible.

Improving accuracy and continuity of data collection

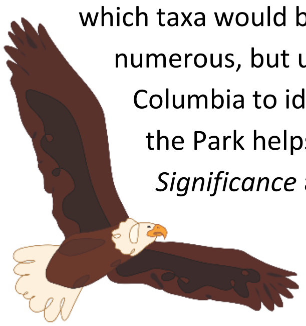
Additional methods for continuous data collection would benefit long term monitoring for Stanley Park. Currently, for our air quality analysis, we use data collected at the closest air quality station, which is at the Robson Square in downtown Vancouver. Air quality at this urban location is not an accurate representation of the conditions of the more natural and forested Park, where air quality is expected to be better. If resources permit, it would be valuable to **install stations recording air quality, pollutants, weather, noise, and light pollution in the Park**, especially near the Stanley Park Causeway where disturbance is higher.

For water quality and water temperature, SPES staff and volunteers are collecting data once every other week during summer months in Beaver Lake and Lost Lagoon. Complementing the effort by **installing water quality and water level data loggers** would provide a more continuous and intensive sampling for parameters of interest, including measuring hourly changes. Additionally, monitoring more water quality parameters would enable us to use the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) and provide a more robust water quality measure. Again, this would be dependent on resource availability.

We are currently using LiDAR data collected by the City of Vancouver to analyse tree cover in the Park. Since the data in 2013 and 2018 were not collected in the same season, the true annual change in tree cover may not be accurately represented here. If the City collects **LiDAR data on the same month** every time, this will prevent seasonal changes and provide a more accurate analysis.

Continuing to host citizen science projects to identify species

There is a great interest from the community to get involved in citizen science. Since 2011, SPES has hosted a handful of **Bioblitzes**, during which experts and the public came together to identify as many species as possible. SPES has been using the iNaturalist website and App as a platform to host the identification of species and counts. These events are very educational and help us keep the Stanley Park life list (Appendix 4) updated and identify which taxa would benefit from focussed research. For example, insects and other arthropods are very numerous, but under identified. In July 2019, SPES partnered with the Entomological Society of British Columbia to identify as many insects as possible. Knowing what native and exotic species are present in the Park helps inform park management, like SPES's *Best Management Practices for Species of Special Significance* and the *Invasive Plant Management Plan* (SPES 2012c, 2013).



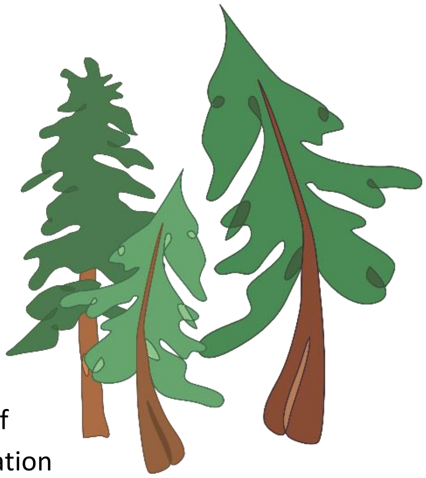
The **Stanley Park species life list** will be online to allow for more interactivity and accessibility for all citizens (public, students, researchers), and currency of information.

People will be able to see what species have not been seen recently, but still thought to be present in the Park, especially the species listed as "possible" in the life list (Appendix 4).

Environmental DNA (eDNA) is still an expensive method to identify aquatic or semiaquatic species, but it is gaining in popularity. This is a powerful tool **to detect the presence of rare species or migrating birds living in water**. Some currently undetected species at risk or amphibians could be detected by eDNA studies. This type of study in Stanley Park may be possible through larger research done by universities or governmental groups.

We use amphibian richness as a measure for the freshwater indicator, but we do not necessarily know if the population of each species is truly healthy. For example, there was one incidental sighting of rough-skinned newt in January 2020. More extensive **research on the abundance of amphibian and reptiles** should be done and could be a student project.

Measuring success of restoration efforts

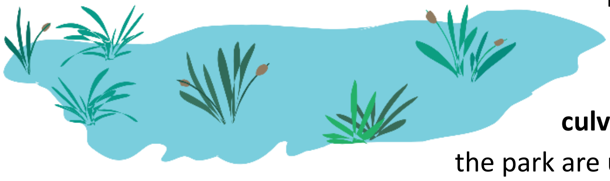


One of the main stewardship efforts of SPES is to remove invasive plants to restore the natural habitat of the Park and for native plants to thrive again. To be able to quantify the success of the restored sites, we started to **measure regrowth of invasive plants** in previous work, **resiliency of native plants**, **survival rate of planted species**, and **bird richness and abundance** before and after restoring a site. SPES and volunteers continue to map invasive plants in Stanley Park on the edges of the trails. Measuring percentage cover of invasive species and their ecological effect within the Park permits SPES to identify areas of the Park to prioritise for restoration efforts, and to measure the success of restoration efforts (manual removal, native species planting, chemical control of giant hogweed and Japanese knotweed) (SPES 2013). Additionally, the VPB is working with the Musqueam, Squamish, and Tsleil-Waututh First Nations to create an invasive plant management plan for all of Vancouver Parks.

To mitigate forest fragmentation, one of the proposed actions in SPEAP 2011 is for the VPB to obstruct unofficial trails with fallen trees in conjunction with forest thinning and maintenance (VPB 2011). It would be valuable to **measure the effectiveness of the obstructions of unofficial trails**, as well as the effectiveness of replanting encampment sites.

Examining water flow and the importance of streams

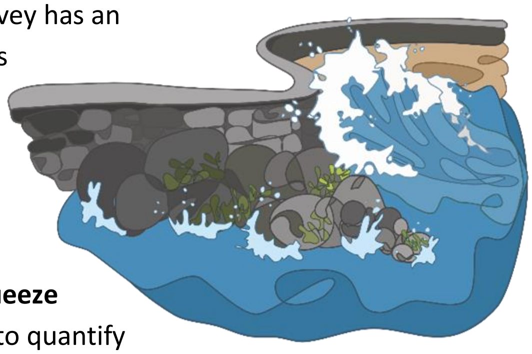
Since 2015, most of municipal water input into the Park's watershed was shut down (Alan Duncan, personal comm. 2020). A study should be conducted, potentially by university students, to **determine how eliminating municipal water input affects the watershed** and its aquatic inhabitants. With summers becoming drier, this may become an increasing concern for water levels in the lakes and creeks.



Another valuable study would be on the **water flow through the culverts of the Park's watershed**. Many of the culverts throughout the park are undersized and are thought to be challenging for vertebrates desiring to cross them. A few culverts were widened at Cathedral Trail and it would be valuable to study how water flow changes through the seasons and examine how corridors are used by vertebrates. This would identify which culverts are not facilitating adequate water flow and thus which to prioritize for widening.

Developing research for intertidal ecosystems

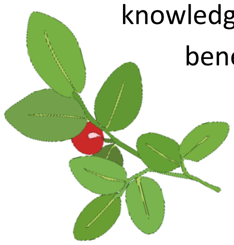
Our evaluation of the Intertidal Ecosystems indicator (Section 1) is currently based on three measures. Developing an **additional measure for intertidal ecosystems** would strengthen the evaluation. We started collaborating with BCIT to survey mussel abundance and size and we plan to use this survey has an additional measure. Partnering with local organizations that also focus on intertidal and ocean research would be a great option.



Sea level rise is expected to significantly affect the coastal habitats of the Park in the next decades (NHC 2014). While our Intertidal Ecosystems measures are expected to indirectly represent the impact of climate change and sea level rise, **measuring long-term coastal squeeze over time** should be examined. Remote sensing data might be useful to quantify the change in the total area of the intertidal zones.

Complementing ecological science with Traditional Ecological Knowledge (TEK)

In this report, we evaluate the ecological integrity of the Park based on metrics from a Western science perspective. This is an incredibly young study of Stanley Park compared to the long history of Indigenous knowledge of the land held by the Musqueam, Squamish, and Tsleil-Waututh Nations. SPES would benefit from an increase in Indigenous relationship building. Future iterations of this report will strive to build knowledge based on the complementarity of Traditional Ecological Knowledge (TEK) and Western science in order to understand past ecological integrity and how ecosystems are changing today.



3. 2010-2019 Ecological Restoration and Habitat Enhancement

In the first *State of the Park Report* (SOPEI 2010), SPES identified areas of concern and recommended several conservation projects that would benefit the Park's ecosystems (SPES 2010). Following the release of the report, the Vancouver Board of Parks and Recreation (VPB) in close collaboration with SPES created a *Stanley Park Ecological Action Plan* (SPEAP) (VPB 2011). Appendix 3 tracks the implementation of the 2011 Action Plan.

Here, we highlight notable ecological restoration and habitat enhancement projects that have been implemented since 2010. These projects were possible thanks to invaluable partnerships and collaborations between SPES, the VPB, and many other groups. These projects not only enhance the natural habitats and native biodiversity of Stanley Park, but also provide unique opportunities for the community to engage and learn about this culturally and environmentally significant place.

Volunteers from TD Canada Trust are planting trees on the edge of Brockton Oval to expand the forest. Photo: Kari Pocock, 2017

Restoring Disturbed Areas

As a Park Partner of the VPB, SPES has a leadership role in environmental restoration. In ten years, over 8,000 m^3 of invasive plants were removed and replaced by more than 8,000 individual native trees, shrubs, and grasses. These plants were planted by various groups guided by SPES, such as hundreds of individual volunteers, community groups, school classes, indigenous youth, and volunteers of corporate companies. This is a separate count from the 15,000 trees and shrubs planted within the two years following the windstorms of 2006.

To mitigate forest fragmentation, the VPB has implemented log laying practices in unsanctioned trails, using trees needed to be cut down for public safety. This was mentioned as an objective of SPEAP 2011. The Park Rangers, the VPB, and SPES are currently working together for planting in areas of the forest fragmented by camp sites.

To stabilize and protect newly restored riparian areas and slopes, SPES has been working with the EartHand Gleaners Society to weave fences from upcycled bio-material to stabilize and protect restored riparian areas. During some of these events, SPES has had the honor to have Coast Salish First Nations Elders witness the work and generously share stories with the participants.

Tree swallows nesting at one of the nest boxes in Lost Lagoon. Photo: Frank Lin, 2019

Stanley Park bears several archeological sites. In 2016, the VPB hired an archeologist who informs SPES which sites are authorized for ecological restoration, so any disturbance to archeological sites is avoided.

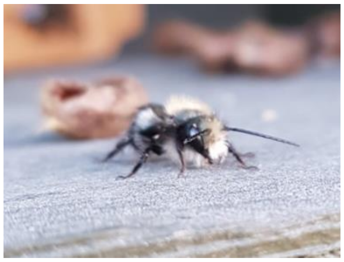
Increasing Breeding and Roosting Habitat for Wildlife

Bird Nest Boxes: In 2009, SPES implemented the nest box project with the goal of supporting vulnerable cavity nesting species in Stanley Park. Nest boxes for Tree Swallows (*Tachycineta bicolor*), Violet-green

Swallows (*Tachycineta thalassina*), and Wood Ducks (*Aix sponsa*) are installed in Lost Lagoon and Beaver Lake. In the past, some swallow nest boxes were installed on the Nature House wall, but these boxes were used by the invasive House Sparrows. Installing these nest boxes only over the water reduce competition between swallows and other bird species and provide protection from land predators such as raccoons and squirrels. These birds are adapted to nesting and take off over water. Currently, 15 swallow nest boxes and six Wood Duck nest boxes are installed at Lost Lagoon and Beaver Lake every spring. SPES volunteers, members, and donors have contributed to the construction, installation, cleaning, and monitoring of the boxes. These nest boxes provide ongoing environmental education and receive the attention of thousands of visitors, including local media.

Twelve bat boxes were installed in 2019 near Beaver Lake. Photo: Ariane Comeau, 2019

Bat Boxes: Stanley Park is home to at least six species of bats, including the federally endangered little brown myotis (*Myotis lucifugus*). It is key to the bats' survival to have access to a variety of roosts, so the right temperatures are available throughout the seasons. Installing bat boxes in various locations, some in the sun and some the shade, can provide the right temperature for bats on a given day or night (Lausen 2020). In 2019, SPES installed 12 new bat boxes by South Creek Trail and Ravine Trail, in addition to the other existing boxes on buildings and on trees of the forest. These bat boxes were provided by the VPB, the BC Community Bats Program (BCCBP), South Coast Bats (SCBats) and SPES donors, and some were built during community events with SPES. Every year, SPES, SCBats and the BCCBP monitor maternity roost of bats at the Stanley Park Pavilion, the Vancouver Rowing Club, and other potential roosts in the Park. Through emergence count surveys, in 2019, we counted 547 bats at the Stanley Park Pavilion, the highest number of bats counted since surveying started in 2010.


A male mason bee emerged from its cocoon at the Air Bee n Bee near the Nature House. Photo: Ariane Comeau, 2019

Mason Bees Condos: In recent years, there has been a rapid decline in native bee populations across North America, mainly due to habitat loss, fragmentation, and degradation of habitat, along with pesticide use (Potts et al. 2010). Every year, SPES installs and manages three manmade condos in Stanley Park for the blue orchard mason bee (*Osmia lignaria*), a remarkably effective pollinator, native to the region. The current bee condos are at the Stanley Park Pavilion, at Lost Lagoon near the Nature House, and at the Stanley Park Community Garden. The condos consist of wooden and plastic tunnels for the solitary bee to lay eggs in. The tunnels and bee cocoons are cleaned from parasites every fall, stored for the winter, and put back in early spring.

Lost Lagoon Islands and Logs: Eight islands around Lost Lagoon provide sheltered habitat for ducks and waterfowls. Invasive plant species, mostly bamboo, took over most of these islands. To provide better sheltered habitat for migrating and resident ducks and waterfowl, SPES worked with students, HSBC, and community volunteers to enhance three of those


Small islands in Lost Lagoon provide shelter for ducks and waterfowls. Photo: Brian Titaro, 2013

islands, by removing invasive plants, reorganizing rock alignment, adding liners, planting native species and adding perching logs.

Restoring Sensitive Ecosystems

Ceperley Meadow: Ceperley Meadow, located to the northwest side of Lost Lagoon, used to be a mowed grass area for people to use. Recently, SPES, the VPB, and sponsors such as HSBC partnered to re-establish the space as a wet meadow, a rare ecosystem remaining in Vancouver. Reducing mowing activity at the area permits the meadow to expand its habitat capacity. Grasses such as rushes and sedges were planted and are thriving in this water-saturated soil. Beavers, river otters, owls, hummingbirds, ducks, and many other species are often observed in this important wetland. The regular flooding events of Ceperley Creek is better retained with the restored meadow.

The Beaver Lake bog is home to plants such as round-leaved sundew, bog cranberry, bog laurel, Labrador tea, and various species of sphagnum. Photo: Brian Titaro, 2015

Beaver Lake Bog: The south side of Beaver Lake has boggy areas with sphagnum. Since 2011, SPES, with the support of the Camosun Bog Restoration Group, has been safeguarding 500 m^2 of the Beaver Lake bog area, where sphagnum, round-leaved sundew, bog laurel, Labrador tea and bog cranberry are thriving (SPES 2012b). To protect the bog, encroaching non-bog plants were removed and bog plants were transplanted into damaged areas to restore the bog's historic diversity and size. Liners were installed underground to minimize non-bog species encroachment over the bog, one on the edge of the forest and one along the water side. The VPB is working with consultants and SPES to design and install a boardwalk around the restored bog for visitors to experience this secretive yet astounding environment.

The first boardwalk in Stanley Park was installed at Cathedral Trail to reconnect a divided wetland. Photo: Patricia Thomson, 2013

Beaver Creek: Beaver Creek is the main outflow of Beaver Lake and has been impacted in various ways. To stabilize the steep and heavily eroded bank near Beaver Lake, the VPB installed a large fence. Further down Beaver Creek, also to stabilize the shore, SPES planted native plants such as salmonberry. This provides better habitat, especially for the Coho salmon that are released every spring by elementary classes through the DFO Salmonids in the Classroom program (DFO 2017). For information on the beaver baffler installed between Beaver Lake and Beaver Creek, see the section below on Co-existing with Wildlife.

Cathedral Trail's Boardwalk: In 2013, SPES assisted the VPB to install the first boardwalk in Stanley Park at Cathedral Trail, to reconnect a divided wetland, thus improving drainage, wildlife

passage, and pedestrian safety. The VPB engineered the boardwalk and SPES replanted the reclaimed, previous trail area.

Co-existing with Wildlife

Beavers: Two families of beavers are established and breed in Stanley Park; one in Beaver Lake since 2011 and one in Lost Lagoon since 2014. While the beavers take down some trees to build their lodges and to control water levels with dams, beavers have an incredible role in the health of freshwater ecosystems. At Beaver Lake, they have been creating channels and feeding on the invasive water lilies, providing deeper and cooler pools of water. This is highly beneficial to aquatic species such as fish, amphibians, invertebrates, and waterfowls. To foster coexistence with beavers in this urban park, SPES staff and volunteers install wire mesh around large trees that are protecting trails and shores from eroding. Nonetheless, native riparian trees such as aspens and willows are adapted to beavers and regrow rapidly after being chewed on.

The "beaver baffler" was installed in 2014 to reduce the damming activity of the beavers, which blocks the outflow of Beaver Lake into Beaver Creek. Due to lack of effectiveness, the baffler was removed in 2018. Photo: Robvn Worcester. 2014

At Beaver Lake, the activity of the beavers has been improving the lake's conditions for aquatic life, but also has been flooding surrounding trails and reducing water flow in Beaver Creek that bears Coho salmon. To regulate water flow at the main outflow and reduce maintenance, a "beaver baffler" was installed at Beaver Lake in 2014. Unfortunately, the device did not baffle the beavers. The beavers continuously dammed and blocked the water flow, and Park staff still had to remove the dam daily to let water flow down Beaver Creek. The VPB removed the beaver baffler in 2018 and is designing a new outflow to better mitigate the beavers' damming activities.

SPES volunteers installing predator guards at the heron colony. Photo: Dannie Piezas, 2020

Herons: The Pacific Great Blue Herons (*Ardea herodias fannini*) colony in Stanley Park has been active in its current location (near the VPB head office) since 2001 and regularly faces urban stressors. A natural one is raccoons who feed on heron eggs (SPES 2010). SPES installs predator guards on the trees of the colony, which has eliminated raccoon attacks on the nesting birds. The herons are very charismatic creatures and catch the attention of many visitors, including online through the live Vancouver Heron Camera (City of Vancouver 2020c). In 2018 and 2019, the renovation of the former Fish House heritage building into the Stanley Park Brewery raised concern for the existence of the heron colony, since the building is located within the 200 m "quiet" buffer zone recommended during heron breeding season (VPB 2006). Some nests are as close as 40 m from the building. Therefore, Bianchini Biological Services was contracted to monitor the colony activity during construction. During monitoring, no herons displayed stressed behavior or flushed from their nest due to the Brewery's construction (Bianchini Biological Services 2019).

Other notable events and documents from 2010 to 2019

2010	*State of the Park Report for the Ecological Integrity of Stanley Park* (SPES 2010)
2010	Smoking banned in Vancouver city parks (VPB 2010)
2011	*Stanley Park Ecological Action Plan* (VPB 2011)
2012	*Best Management Practices for Species of Significance in Stanley Park* (SPES 2012c)
2012	*Beaver Lake Bog Restoration Report* (SPES 2012b)
2012	*Stanley Park Cycling Plan* (VPB 2012)
2013	*Stanley Park Invasive Plant Management Plan* (SPES 2013)
2014	*Ecologically and Culturally Sensitive Enhancement Plan for Beaver Lake* (VPB and AquaTerra Environmental Ltd. 2014)
Mid 2010s	Recreational drones emerge on the scene creating disturbances to wildlife
Mid 2010s	Increase in marine mammal sightings around Stanley Park
2015	*Vancouver Bird Strategy* (VBAC 2015)
2015	Summer droughts cause cut offs for potable water to freshwater bodies
2015	Marathassa Oil Spill (Canadian Coast Guard 2015)
2015	Widening of the causeway sidewalks (VPB 2015)
2016	*Biodiversity Strategy* (VPB 2016)
2016	Canada's First municipal archeologist, Geordie Howe, hired by the VPB on the recommendation of the Musqueam, Squamish, and Tsleil-Waututh Nations
2016	Lost Lagoon Fountain is no longer functional
2017	Bird anti-collision window stickers installed at Park Board office (VPB 2017)
2018	*A Restoration Strategy for Lost Lagoon in Stanley Park, Vancouver, British Columbia* (MacKinnon 2018)
2018	*Urban Forest Strategy 2018 Update* (City of Vancouver and VPB 2018)
2018-2019	Major reparations to the seawall (City of Vancouver 2020d)
2019	Design of the Metro Vancouver's Stanley Park Water Supply Tunnel project (Metro Vancouver 2020)

In the last five years, there has been an increase in marine mammal sightings in the waters surrounding Stanley Park, including orcas, humpback whales, and porpoises. Photo: James Marks, 2015

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Appendix 1. Survey Schedule

Table 5. Annual survey schedule for measures including year, frequency, and seasonal timing

Measure	2018	2019	2020	2021	2022	Frequency	Timing
Climate and Atmosphere							
Air quality[1]	✓	✓	✓	✓	✓	-	-
Air temperature[1]	✓	✓	✓	✓	✓	-	-
Precipitation[1]	✓	✓	✓	✓	✓	-	-
Sea level[1]	✓	✓	✓	✓	✓	-	-
Freshwater Ecosystems							
Water temperature	✓	✓	✓	✓	✓	2 x / month	Jun 01 – Sep 30
Dissolved oxygen	✓	✓	✓	✓	✓	2 x / month	Jun 01 – Sep 30
pH	✓	✓	✓	✓	✓	2 x / month	Jun 01 – Sep 30
Stream invertebrate rating	✓	✓	✓	✓	✓	2 x / year	Spring and Fall
Amphibian richness[2]	✓		✓		✓	1 x / month	January - December
Intertidal Ecosystems							
Marine algae abundance & richness		✓	✓	✓	✓	1 x / year	May - June
Sessile invertebrate abundance & richness		✓	✓	✓	✓	1 x / year	May - June
Limpet size		✓	✓	✓	✓	1 x / year	May - June
Terrestrial Ecosystems							
Tree cover[1]	✓					Every 5 years	-
Bird community index	✓	✓	✓	✓	✓	2 x / year	April - July
Bald Eagle productivity	✓	✓	✓	✓	✓	1 x / week	January - August
Huckleberry productivity		✓	✓	✓	✓	1 x / year	June - August
Soil decay rate		✓	✓	✓	✓	1 x / year	October

[1] Data available through open data inventories (not collected by SPES)

[2] Terrestrial cover board surveys conducted monthly throughout the year, pond-breeding surveys conducted monthly between February and May, and acoustic surveys conducted monthly between March and July

Appendix 2. Method to Evaluate Status and Trends with Thresholds

SPES developed the ecological integrity assessment for Stanley Park by following the *Consolidated Guidelines for Ecological Integrity Monitoring in Canada's National Parks* (Parks Canada 2011). Below are guidelines to evaluate the status and trend of each measure and indicator via thresholds.

Status and Trend for Measures

The current status of a measure is scored as good, fair, or poor relative to the threshold values, which correspond to scores of two points, one point, and zero points, respectively (Environment Canada 2012, ECCC 2017).

If a measure is composed of several field measurements, the current state of each component is evaluated. If one third or more of the component measures are scored as poor, the measure is also scored as poor. If not, the overall measure score is determined by the average score of the components as determined by the following equation:

$$Measure\ Score = \frac{\sum Component\ Scores}{N} \times 50$$

where N is the number of components for a particular measure and a score of 0 – 33 is classified as poor, 34 – 66 is classified as fair, and 67 – 100 is classified as good (Parks Canada 2011). Although alternative weighting schemes may better reflect the ecological importance of different measures, equal weighting was chosen for simplicity (Environment Canada 2012).

The trend of a measure is based on a change in the current state from a previous state and are categorized as improving, stable, or declining (Environment Canada 2012). Trends can be evaluated statistically when sufficient time-series data is available (e.g., Mann-Kendall test). When there is not enough data available for statistical analysis, a simpler approach is used (Parks Canada 2011). Specifically, a value of ⅓ of the difference between the upper and lower threshold values (the critical range) is recommended as the criterion for change in a measure (Parks Canada 2011).

Status and Trend for Indicators

The current status for an indicator is determined from the status of its component measures (Parks Canada 2011, Environment Canada 2012). This is calculated using the same formula as described for measures, where each measure is scored and summed to provide an overall indicator score.

The assessment of the overall trend for an ecosystem indicator is based on a change in its current status from its previous status (Environment Canada 2012). We will evaluate indicator trends in the following reports when sufficient data will become available.

Appendix 3. Implementation Tracking of 2011's Stanley Park Ecological Action Plan (SPEAP 2011)

The 2011's *Stanley Park Ecological Action Plan* (SPEAP 2011) was developed by the Vancouver Board of Parks and Recreation (VPB) in close collaboration with SPES. It prioritizes proposed actions from SOPEI 2010 and provides a comprehensive direction for the management of the Park (VPB 2011). Five priority areas were identified for restoration and enhancement activities:

- Beaver Lake's rapid infilling
- Lost Lagoon's water quality
- Invasive plant species
- Fragmentation of habitat
- Species of Significance

Table 6 to Table 10 track the status (Complete, On Track, Ongoing, Not Started, Paused) of the proposed actions in SPEAP 2011 up to 2019, and identify the project lead (VPB and/or SPES). The areas of SPEAP that were led and completed by the VPB were reported to SPES by Alan Duncan, VPB Environmental Planner.

Table 6. Status on SPEAP 2011-proposed actions for Beaver Lake's rapid infilling

Proposed actions for Beaver Lake's rapid infilling	Status	Lead	Additional information
1. Undertake a consultancy to A) conduct assessment of Beaver Lake's environment	Complete	VPB	AquaTerra Environmental Ltd completed wildlife and vegetation assessments of Beaver Lake in the spring and summer of 2013. They created recommendations on how to enhance Beaver Lake.
B) Develop a public visioning process to inform the future of the lake	Complete	VPB	An open house was held to review and comment on options developed by the consultant team. Summary of comments available here: https://vancouver.ca/files/cov/beaver-lake-enhancement-nov-2013-open-house-comments.pdf
C) Recommend vision and strategy	Complete	VPB	The project team reviewed the commentary and developed a preferred concept that the Park Board approved in October 2014. The plan called for dredging the lake, creating islands for mammal and fish habitat, and building viewing platforms and a boardwalk (VPB and AquaTerra Environmental Ltd. 2014).
2. Implementation of the approved plan	Not Started	VPB	Reconstructing the outflow areas with beaver deterring features and fish ladder to begin in 2020. Further works contingent on funding.

Proposed actions for Beaver Lake's rapid infilling	Status	Lead	Additional information
3. Update baseline information on the Beaver Lake bog and monitor changes	On Track	SPES	SPES produced a baseline information report and restoration summary (SPES 2012b) and continues to monitor changes.
4. Install a boardwalk, viewing platform, and signage at bog	Ongoing	VPB + SPES	Postponed due to technical challenges and effects of beaver activity on the surrounding forest.
5. Restore bog's size and habitat value	On Track	SPES	SPES continues to manage the bog's integrity with support from the Camosun Bog Restoration Group by removing encroaching non-bog species.
6. Continue to maintain water levels with municipal water until alternative sources found	Paused	VPB	Most municipal water has been shut down since 2015 for water conservation and temporarily turned on in 2016. Alternative sources are being investigated.
7. Develop strategy for invasive plant species management during and following lake restoration	Not Started	VPB + SPES	First phase of lake restoration and associated interventions must be completed before implementation.
8. Develop a maintenance strategy to control the rate of infilling	Not Started	VPB	The design will minimize infilling and major maintenance. Likely need to conduct sediment core samples over time.

Table 7. Status on SPEAP 2011-proposed actions for Lost Lagoon's water quality

Proposed actions for Lost Lagoon's water quality	Status	Lead	Additional information
1. Undertake a consultancy to A) conduct assessment of Lost Lagoon water quality parameters, bottom profile, etc.	Ongoing	VPB	A bathymetry and topographic survey were completed in 2018. Additionally, a student project provided water quality data, heavy metal data, and a restoration strategy (MacKinnon 2018).
B) Develop short-term options for remediation	Not Started	VPB	Experience with Beaver Lake may affect drafting. Option of returning Lost Lagoon to tidal mud flat or to some combination of habitats is being considered.
C) Develop long-term solutions to improve water quality, enhance wildlife habitat and aesthetics, and reduce reliance on potable water (e.g. dredging, creating habitat islands, large-scale riparian restoration, redirecting storm water)	Not Started	VPB	
D) Provide recommended strategy and plan	Not Started	VPB	
2. Conduct 10-year forebay sediment removal and water quality testing in existing biofiltration pond	Complete	VPB	Sediment removal conducted in 2013. Recommend cleaning forebay again in September 2024. A genomic study was performed in 2015-2016 to survey the effectiveness of the biofiltration water and sediment treatment (LeNoble 2017)

Proposed actions for Lost Lagoon's water quality	Status	Lead	Additional information
3. Undertake implementation of 1. D	Not Started	VPB + SPES	Requires completion of 1.D
4. Continue ongoing restoration of existing shoreline vegetation (invasive plant removal and native willow planting)	Ongoing	VPB + SPES	Through volunteer opportunities, SPES leads events on an ongoing basis to remove invasive species and plant native species on the shoreline of Lost Lagoon. Two islands were cleared of invasive bamboo to increase their value for wildlife.
5. Maintain Jubilee Fountain and water levels with municipal water until alternative sources found	Not Started	VPB	The Jubilee Fountain was significantly damaged due to a flood in 2016. Contemporary requirements have increased the estimated costs for repairs. Plans to reconnect Lost Lagoon to Coal Harbour may also affect the future of the fountain.
6. Develop protocols to prevent sedimentation from trail and road runoff and operational activities	Not Started	VPB	May be informed by the findings of the Beaver Lake consultant team and by the ultimate decision on reconnecting Lost Lagoon to Coal Harbour.

Table 8. Status on SPEAP 2011-proposed actions for invasive plant species

Proposed actions	Status	Lead	Additional information
1. Purchase equipment for chemical control of hogweed and knotweed	Complete	VPB	Contractors treat and remove these species. Hogweed and knotweed are still present in Stanley Park, but are controlled.
2. Update mapping of invasive species in Stanley Park and develop operational systems to allow consistent map updates	Complete	SPES	SPES provided an invasive species mapping report in 2012 (SPES 2012a) and an invasive plant management plan for Stanley Park in 2013 (SPES 2013). SPES continues to map invasive species on a regular basis, which inform areas to prioritize. The VPB is working with the Musqueam, Squamish, and Tsleil-Waututh Nations to develop a city-wide invasive species management strategy.
3. Develop a program to increase awareness within the Park's stakeholders about invasive plant management	Complete	SPES	Posters were created and distributed to strategic locations within Park offices and work rooms.
4. Provide material support for SPES' efforts to control most species	Complete	VPB + SPES	SPES possesses the material and equipment required for manual removal.
5. Use Best Management Practices outlined in the Forest Management Plan for the control of other invasive plants in the Park (VPB 2009b)	On Track	VPB + SPES	Best Management Practices are followed by SPES and VPB.

Table 9. Status on SPEAP 2011-proposed actions for fragmentation of habitat

Proposed actions	Status	Lead	Additional information
1. Replace gravel section of Cathedral Trail with a raised boardwalk for environmental enhancement and improved pedestrian safety	Complete	VPB	A small raised boardwalk on a section of Tunnel Trail was also completed by SPES and VPB to protect large tree roots.
2. Replace 50 existing undersized culverts with culverts large enough to better facilitate the flows of both water and wildlife	Ongoing	VPB + SPES	SPES identified 15 priority sites and a few culverts at Cathedral Trail were replaced.
3. Increase vigilance against off-trail bicycle usage and introduce bicycle barriers in particularly sensitive habitats	Ongoing	VPB + SPES	This proposed action is also referenced in the Stanley Park Cycling Plan (VPB 2012).
4. Obstruct unofficial trails with fallen trees in conjunction with forest stand thinning operations and as part of routine forest maintenance	Ongoing	VPB	Fallen trees have been used to block some unofficial trails, and it is planned to use logs or fencing after replanting in these areas.
5. Report on downgrading North Pipeline Road to trail status, potentially using dredged materials from other projects in the Park for planting medium	Not Started	VPB	Option for use of the road for Beaver Lake dredging disposal, in conjunction with Beaver Lake project and Cycling Plan recommendations. May also be needed for staging for Cap 5 Water Main construction.

Table 10. Status on SPEAP 2011-proposed actions for Species of Significance

Proposed actions	Status	Lead	Additional information
1. Produce Best Management Practices (BMPs) for each group of Species of Significance	Complete	SPES	Report produced (SPES 2012c)
2. Develop a program to increase awareness within Park Board staff and contractors to prevent unintentional harmful behaviours and to integrate BMPs into operations	Complete	VPB + SPES	SPES created a phenological calendar (needs to be redistributed again) and presents on BMP for Species of Significance during Park staff crew talks
3. Review and report on the roles and responsibilities of the Park Board in wildlife management	Not Started	VPB	A report has not yet been produced

Appendix 4. Stanley Park Species Life List

One of the largest known colonies of Barn Swallows in BC is in Stanley Park with over 80 nests. In 2019, 163 Barn Swallow fledglings were born at the colony. Barn Swallows are a species at risk and their nests are protected all year by the Migratory Birds Convention Act. Photo: Frank Lin, 2019

SPES maintains a Species Life List for Stanley Park (summary: Table 11 and Table 13) (SPES 2020). It is generated from a variety of sources including literature, online citizen database monitoring programs (e.g. eBird, iNaturalist), Bioblitzes, experts, students, and incident sightings reported by the public, naturalists, volunteers, and staff. When available, the year a given species was last documented is indicated to help track which species are still present in the Park and which ones require more information (e.g. invertebrates).

Since 2010, 1030 native species were confirmed present in the Park, including 20 species listed federally under the Species at Risk Act (SARA), and 41 species listed blue or red by the B.C. Conservation Data Centre (CDC) (Table 11). The species at risk confirmed in Stanley Park since 2010 are listed in Table 12. In 2012, SPES created the *Best Management Practices for Species of Significance in Stanley Park* report to provide background information on species and ecosystems at risk present in the Park, as well as what can be done to limit impacts on them during Park operations and other human activities (SPES 2012c). SPES implemented monitoring programs for species of special significance that are breeding in the Park, such as for Pacific Great Blue Heron, Bald Eagles, Barn Swallows, various bat species, and North American beavers. Monthly bird counts and coastal waterbird surveys provide information on other species at risk.

Table 11. Number of native species documented in Stanley Park listed by category

Category	Presence confirmed (2010 to 2020)	Possibly present (last confirmed between 1980 – 2009)	Unlikely, extirpated or unknown (not confirmed after 1979)	Total
Total native species	1030	272	248	1550
Red listed (provincially at risk)	10	3	6	19
Blue listed (prov. of special concern)	31	4	10	45
Yellow listed (prov. of least concern)	479	31	66	576
SARA 1-E (federally endangered)	3	1	2	6
SARA 1-T (federally threatened)	6	0	0	6
SARA 1-SC (fed. of special concern)	11	1	5	17
Birds	239	34	13	286
Mammals	27	2	28	57
Fish	18	5	54*	77
Reptiles	2	1	2	5
Amphibians	5	1	2	8
Invertebrates and Zooplankton**	325	199	83*	607
Vascular Plants	149	1	18	168
Mosses & Liverworts	99	0	10	109
Algae and Phytoplankton	55	29	11*	95
Fungi & Lichens	111	0	27*	138

*Some of the species in this category are suspected to be present but have not been detected recently.

**Some of the arthropod species counted might be introduced.

Table 12. List of Species at Risk observed in Stanley Park, BC, from 2010 to 2020

Scientific Name	Common Name	BC List	Species at Risk Act (SARA)
Arthropods			
Pachydiplax longipennis	Blue Dasher	Blue	
Birds			
Aechmophorus occidentalis	Western Grebe	Red	Special Concern
Ardea herodia; ssp fannini	Pacific Great Blue Heron	Blue	Special Concern
Botaurus lentiginosus	American Bittern	Blue	
Brachyramphus marmoratus	Marbled Murrelet	Blue	Threatened
Branta bernicla	Brant	Blue	
Buteo lagopus	Rough-legged Hawk	Blue	
Butorides virescens	Green Heron	Blue	
Chordeiles minor	Common Nighthawk	Yellow	Threatened
Clangula hyemalis	Long-tailed Duck	Blue	
Coccothraustes vespertinus	Evening Grosbeak	Yellow	Special Concern
Columba fasciata	Band-tailed Pigeon	Blue	
Contopus cooperi	Olive-sided Flycatcher	Blue	Threatened
Coturnicops noveboracensis	Yellow Rail	Red	Special Concern
Cygnus columbianus	Tundra Swan	Blue	
Cypseloides niger	Black Swift	Blue	Endangered
Falco peregrinus	Peregrine Falcon	No Status	Special Concern
Hirundo rustica	Barn Swallow	Blue	Threatened
Hydroprogne caspia	Caspian Tern	Blue	
Larus californicus	California Gull	Blue	
Megascops kennicottii; ssp kennicottii	Western Screech Owl	Blue	Threatened
Melanitta americana	Black Scoter	Blue	
Melanitta perspicillata	Surf Scoter	Blue	
Numenius phaeopus	Whimbrel	Red	
Nycticorax nycticorax	Black-crowned Night-Heron	Red	
Pelecanus erythrorhynchos	American White Pelican	Red	
Phalacrocorax auritus	Double-crested Cormorant	Blue	
Phalacrocorax penicillatus	Brandt's Cormorant	Red	
Phalaropus lobatus	Red-necked Phalarope	Blue	Special Concern
Podiceps auritus	Horned Grebe	Yellow	Special Concern
Podiceps nigricollis	Eared Grebe	Blue	
Progne subis	Purple Martin	Blue	
Setophaga virens	Black-throated Green Warbler	Blue	
Stercorarius parasiticus	Parasitic Jaeger	Red	
Synthliboramphus antiquus	Ancient Murrelet	Blue	Special Concern
Uria aalge	Common Murre	Red	
Herbs			
Oxalis oregana	Redwood Sorrel	Blue	
Fish			
Oncorhynchus clarkii; ssp clarkii	Coastal Cutthroat Trout	Blue	
Mammals			
Eschrichtius robustus	Grey Whale	Blue	Special Concern
Megaptera novaeangliae	Humpback Whale	Blue	Special Concern
Myotis lucifugus	Little Brown Myotis	Yellow	Endangered
Orcinus orca pop. 3	Orca (Transient population)	Red	Threatened
Phocoena phocoena	Harbour Porpoise	Blue	Special Concern
Mosses & Liverworts			
Frullania franciscana	Woodsman's Eczema	Blue	
Metzgeria temperata	*Metzgeria temperata*	Blue	
Reptiles			
Chrysemys picta pop. 1	Painted Turtle - Pacific Coast Pop.	Red	Endangered

Many introduced species are present in Stanley Park, including 89 invasive species of plants and animals confirmed in the last decade (summary: Table 13) (SPES 2020). SPES developed and follows an *Invasive Plant Management Plan* to mitigate the spread and impacts of invasive plant species in the Park (SPES 2013).

Table 13. Number of introduced species documented in Stanley Park listed by category. The number of invasive species is in parentheses.

Category	Presence confirmed (2010 to 2020)	Possibly present (last confirmed between 1980 – 2009)	Unknown (more surveys needed)	Total
Total introduced species (invasive species in parenthesis)	200 (89)	16 (0)	365 (8)	581 (97)
Birds	7 (6)			7 (6)
Mammals	3 (3)		1 (1)	4 (4)
Fish	2 (2)			2 (2)
Reptiles	3 (2)			3 (2)
Amphibians	2 (2)			2 (2)
Invertebrates	42 (8)	16 (0)	2 (0)	60 (8)
Plants	142 (66)		361* (7)	503 (73)

*Many plant species are ornamental and found in the gardens of the Park; their presence needs to be re-confirmed.

Italian arum (*Arum italicum*) is an exotic plant that was introduced to Stanley Park as an ornamental plant and is currently present in a mown grass area south of Lost Lagoon. While it is not currently listed as an invasive species in BC, it is recognised as invasive in Oregon and Washington and is difficult to eradicate. Photo: Jeannine Johnstone, 2019