Ecological Integrity Assessment of Naturally Managed Areas in Vancouver Parks

Case study of Jericho Beach Park

Final Report

EVSC 400 Environmental Science Capstone

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Background

Access to green spaces in urban areas offers many benefits to residents. These urban forests provide residents with a more stress-free environment (Grahn & Stigsdotterthe, 2003) and bring economic benefits in the form of tourism, associated jobs, and business opportunities (Headwaters economics, 2018). Looking through this anthropocentric lens, it can be seen how important the preservation of urban green spaces is to the residents of Vancouver. When ecological integrity is disrupted, the ecological function and ecological services of an ecosystem can be diminished. Therefore, an assessment of ecological integrity is essential in Vancouver.

This project aims to provide a quantitative method that can comprehensively assess the ecological condition of Vancouver Park Board Naturally Managed Areas (NMAs). Through our developed method, the ecological condition of the selected variable(s) can be evaluated, allowing for restoration and management recommendations to be made and carried out.

Objectives

This report provides a methodology for the ecological integrity assessment of the natural managed areas (NMA) within Jericho Park. By conducting field experiments, analyzing and interpreting the obtained data, we have developed management recommendations for this site. The physical condition, species composition and biodiversity, and external disturbances are assessed and assigned different weights according to their relative importance to the park's ecological integrity and overall quality. Our approach covers a wide range of parameters that are critical factors in most NMAs and focuses on providing a holistic assessment for developing management strategies.

Methodology

For our assessment of the ecological condition of the NMA we focused on five factors that were both significant indicators of health as well as easily applicable to a variety of parks. These factors include water, soil, noise, species composition, and air quality. For the testing of water quality, measurements of turbidity, pH, temperature and total dissolved solids were taken intermittently from the initial discharge into the park to the pond and final pooling location in the marsh. When measuring noise pollution, sound samples were taken from areas of high noise pollution and areas behind tree cover and compared to determine the sound reduction capabilities of the park. Species composition data was gathered through the use of quadrats and consisted of an assessment of biodiversity and invasive species density in comparison to past data. The physical conditions were all measured and compared to quality guidelines established within the literature. These factors were then assigned a score from 1 – 3, 1 indicating low priority and 3 indicating high priority based on their effect on ecological health and the condition determined in the results. Our rationale for our rating system within Jericho beach park was majorly determined by the priorities specific to Jericho park as an urban center.

Results
For the results on water quality turbidity, pH, temperature, and Total dissolved solids were all found at satisfactory conditions. Despite most of the soil in Jericho park being fill, soil was found to be rich. Noise levels significantly decreased further into the park majorly due to the sound reduction ability of the trees indicating low disturbance to the wildlife and residents using the park. Biodiversity was measured within multiple quadrats and showed a slight decrease from the previous assessment conducted in Jericho park Baseline Inventory (2014). On the other hand invasive species density was high throughout all of our study areas. Our overall results are illustrated further in the following table.

Table 1 Assessment result table

	Water	Soil	Biodiversity	Invasive Species	Noise	Air
Score	3	3	1.5	2	3	3
Weight (%)	20%	8%	24%	20%	12%	16%
Final Factor Score	0.6	0.24	0.36	0.4	0.36	0.48
Site Overall Score	Between Moderate and Good (2.44)					

Recommendations
Going forward we think that the continual protection of native late-successional growth and the removal of invasive species will be urgent in ensuring Jericho parks ecological integrity. It was evident in our data that Jericho Park's primary issue was its poor biodiversity. Invasive species such as English Ivy, threaten the diversity of other plant species and reduce the resilience of the ecosystem. Therefore, invasive species must be controlled to ensure the long term sustainability of the park.

Report Authors

Kyree is a fourth-year environmental science student from earth-system concentration. For elective courses selection, he studied geographic information science (GIS) and spatial analysis, which provide him with useful tools to evaluate the spatial distribution and extract spatial information from the study area.

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Sijin is a fourth-year environmental science student with a concentration in the Environmental Earth System. Her background enables her to assist the team, as well as work independently effectively. In academic studies, she has gained knowledge in Environmental Law, Environmental Assessment procedures, as well as remediation strategies. She was allowed to develop field sampling and laboratory analysis skills by working at a research centre under Agriculture and Agri-Food Canada. During her 8-months internship, she was trained to accurately conduct different sampling methods, including soil, water and air. She is always enthusiastic about learning and exploring the natural environment and committed to high quality and detail-oriented work.

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1. Introduction

1.1. Background

As a group of undergraduate environmental scientists, we were tasked with the assessment of the naturally managed areas within Jericho Beach Park; one of the urban forests that the parks board has had a focus on since 2010. Jericho Park has had a long history as a perturbed environment due to urban development. This has put the ecological integrity at risk, and therefore an assessment of its overall condition is essential for future management strategy development.

1.2. Objectives

For this project, we created a comprehensive framework for determining the ecological condition of the NMA within Jericho Park. By developing a methodology applicable to Jericho as well as other urban parks, we seek to holistically assess the ecological integrity of the park as well as in contrast to other parks within the city of Vancouver.

1.3. Description of study area

Jericho Park is located at West Point Grey and makes up a 46.71 ha area preceding Jericho beach. The park offers multiple recreational facilities and provides tremendous ecological benefits. Jericho Park contains several natural areas and biodiversity zones (Figure 1). The forested region of Jericho Park is undergoing a secondary transition. This region of land is also transitioning back into a productive ecological zone after anthropogenic use.

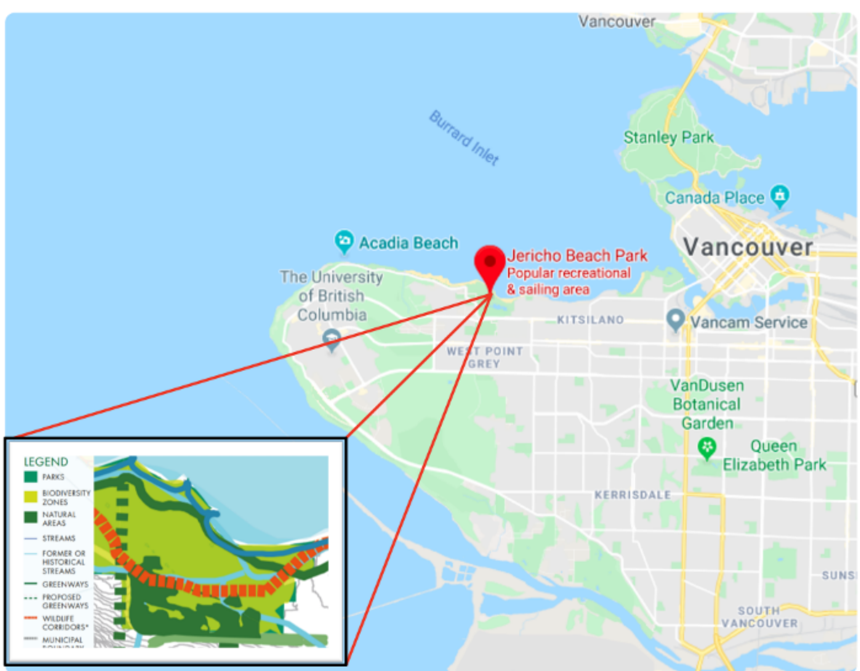

Figure 1 Map of natural area inventory of Jericho park and beach and its location in Vancouver

2. Literature Review

2.1. Introduction

Ecological integrity serves as the fundamental concept to ensure an ecosystem can function properly and can be managed holistically (Angermeier and Karr, 1994). Ecological integrity provides the most comprehensive guidance in terms of ecological management (Ordóñez & Duinker, 2012). Thus, aiming to achieve ecological integrity is vital for urban forest management as it can bring a well-functioning ecosystem from various aspects.

In our report, we will create a methodology based on ecological integrity for monitoring the ecological integrity of green space like Jericho Park, an area that has experienced multiple ecological disturbances throughout its history, with the final goal of restoration and rehabilitation. With the aid of multiple scholarly articles and reports, we constructed methods that assess the physical conditions, species composition, biodiversity, and external disturbances, generating a quantitative value that will indicate the ecological health of our site. This literature review gives the rationale for each of the parameters that we measure to assess ecological health.

2.2. *Soil and Site Productivity*

Soil provides structural support for the growth of plants and animals. It is critical to assess soil quality and its ability to support the ecological functions of its environment (Vincent et al., 2018). Green and Klinka (1994) proposed the Site Series method that describes a site's productivity based on three primary factors: Climate, Soil Nutrient Regime (SNR) and Soil Moisture Regime (SMR). Once those three parameters are determined, the method categorizes the study sites into different zones providing detailed information about the vegetation covering, site productivity and competition potential of the area (Green & Klinka, 1994). Instead of assessing the physical properties of the soil, this method focuses more on assessing site productivity. In urban forests, the ecosystem and the soil have been disturbed to some extent, thus the physical properties of the soil will not provide an accurate reflection of the ecological health of a location such as Jericho Park. Another benefit of using this method is that it was developed in British Columbia, using field data collected locally, making it compatible with our study site.

2.3. Water & Pond Quality Assessment

Water is a key component of an environment and has wide-reaching effects on the ecosystem as a whole. Due to water's ecological significance, evaluating its quality provides insight into the environmental health of a region. As water temperature increases, animals experience increased levels of stress and become more vulnerable to contaminants, parasites, and contagious diseases (The Pacific Streamkeepers Federation, 2013). Algae blooms caused by fertilizers entering bodies of water consume oxygen and create an anoxic environment (The Pacific Streamkeepers Federation, 2013). Turbidity affects light penetration in water, which affects algal growth and photosynthesis efficiency (The Pacific Streamkeepers Federation, 2013). Streamkeepers handbook (2013) provides a useful framework for evaluating temperature conditions and dissolved oxygen, which can be modified for our methodology to cover some of our considered parameters. Using BC Hydro's classification of turbidity, we can design a turbidity condition table based on the same units and durations BC Hydro uses (2019).

Water quality is also essential when it comes to human health, as pH levels and total dissolved solids (TDS) in the water can have adverse effects on a person's well being (Government of Canada, 2018). Therefore, the assessment of water quality should be constructed with human health as a key factor. The neutral pH level for water is around 7. However, due to the complicated process that occurs in the lake or pond, such as stratification, healthy freshwater lakes, ponds and streams usually have a pH of 6.5 - 9.0 depending on the surrounding soil and bedrock (CCME, 2014). By moderating these levels with the human pH tolerant range of 4-11 (pH of water, 2020), a pH scaling table can be created to evaluate healthy pH conditions. TDS is one of the essential parameters in water quality assessment because the drinkability of water emphasizes the harmonious coexistence of humans and nature. Based on Canadian drinking water guidelines that water with less than 500 ppm TDS is considered drinkable water and with more than 1000 ppm considered unacceptable, an assessment table is carried out to test the water quality (Government of Canada, 2018).

Using temperature, total dissolved oxygen, turbidity, pH and TDS as parameters and averaging the quantitative values of these parameters, an accurate overall site water quality can be determined. Additionally, by using 5 distinct parameters we can reduce variability and increase accuracy.

2.4. Vegetation Successional Trajectory

The history of Jericho Park has been defined by disruption and development. The history of the park is made up of multiple environmental disturbances. Currently the park's soil is mostly composed of unknown fill, which has allowed for growth; however, this growth mainly consists of generalist plant species with higher tolerances for changing conditions. At this stage in the park's development, it is predicted to stay in this early/intermediate state of succession, which is important when considering the preservation of certain native species and the management of vegetative growth (Montreuil, 2014).

Ecological theory suggests that after a significant disturbance, pioneer species that are able to establish in perturbed conditions first settle, then facilitate the settlement of early successional species, that in time will allow later successional species, and finally a climax community (Connell et al., 1977). Jericho Park remains in an early successional stage, with a minority of late intermediate growth (Montreuil, 2014). The establishment of late-successional vegetation requires a certain level of complexity in both diversity of species and soil richness. An example of this is the presence of complex mycorrhizal diversity that old-growth relies on for survival (Koske et al., 1997). Though Jericho Park does house small patches of late succession shade-intolerant plants, it lacks the qualities of an older native forest baring further progression (Montreuil, 2014). In some ways, Jericho Park is an artificial ecosystem, as many of the species are exotic and the area has been anthropogenically altered in the past. The establishment of late-successional forests can take around ~200 years; 200 years that the area has yet had unperturbed by urban development (Montreuil, 2014). Urban development has put a freeze on vegetative succession within the park and would require either further ecological restoration efforts or time for the forest to progress. Though we are not conducting any assessment of succession in Jericho Park, this information will contribute our final recommendations for ecological restoration in light of future trends.

2.5. Biodiversity

Biodiversity is defined by the richness of plant and animal species as well as the ecological systems that support the ecosystem in which these species exist (Vancouver Board of Parks and Recreation, 2016). Biodiversity plays a key role within the city Vancouver providing the area and its residence with many ecological services. Natural areas provide both physical and mental health benefits to residents, while natural spaces like coastal wetlands and forests clean the air, acting as sinks for large amounts of carbon (Vancouver Board of Parks and Recreation, 2016). When measuring biodiversity within Jericho Park, we opted to measure only species richness of plant species, as we could not find a reliable metric for measuring and scoring the abundance of animal species in the park. The Jericho Park Baseline Inventory report by Montreuil and Ballin (2014) measures biodiversity in Jericho Park by combining species richness and species evenness to calculate the Shannon-Wiener Index. We intend to use a similar method, acquiring data on species richness and species evenness using the quadrat method. Collecting data at five sample sites will allow us to calculate a quantitative value for biodiversity using the Shannon-Wiener index formula. Through the value produced by the Shannon-Wiener index formula, we can judge the strength of Jericho Park's biodiversity, with large values indicating a large amount of biodiversity and small values indicating a lack of biodiversity. Unfortunately, the report by Montreuil and Ballin (2014) does not provide a clear standard about the Shannon index's scale, making it hard to determine whether biodiversity is low or high. Nonetheless, their report can give us a good reference standard for measuring plant biodiversity in Jericho Park.

2.6. Invasive Species

Invasive species are an important indicator of park ecology (Fraser Basin Council, 2003). The main invasive species in urban forest parks are plants. Invasive species replace native plants that wildlife depends on, alter the park's hydrology, increase fire risk, and contain toxic substances (Fraser Basin Council, 2003). In the study of invasive species, we will use the quadrat method to investigate the types and abundance of invasive species in the park and compare them with the risk level of invasive species provided by the province of BC to determine their significance (Priority Invasive Species 2020). In our report, we use different methods to determine invasive species distribution than in the report by Catt (2014). Using orthographic imaging, they marked the distribution and frequency of invasive species making their future removal more comfortable. In our report, we conducted an assessment of the distribution and species richness, but lack a section including plans for future removal of invasive species. Additionally, due to the lack of criteria for invasive species risk assessments, we constructed our method for comparing the risk of invasive species in our park.

2.7. Noise Pollution

Noise pollution has detrimental effects on both the physical and mental health of both residents and species (Australian Academy of Science, 2020). Therefore, it is essential that not only an assessment of noise level be conducted to reveal the ecological condition but to demonstrate a process by which a green space can be constructed where humans and nature can co-exist (Vanplay, 2020). Birds' sensitivity to environmental change makes it easy to compare and interpret collected data and examine their response to changes in a predictable manner, making them a great indicator of environmental health (Hill, 2020). Birds can hear a narrow range of frequencies, from 1kHz to 4 kHz, but with only one-third sensitivity specific sound frequency than humans (Beason, 2004). Beason proposed a table about species-specific sensitivities to frequencies, which can be modified as the foundation of the noise level assessment.

Conducting only noise level assessment will be inadequate to evaluate the noise pollution for the park because of the presence of tree species. Tekeykhah and his colleagues (2019) found that tree species can reduce the noise value by 20-30dB, and the magnitude of noise reduction is based on the leaf density and canopy width. The researchers proposed a table containing how distance from the noise source, with a frequency of (1000 Hz), affects attenuation caused by different tree species (Tekeykhah et al., 2019). The table shows that the noise reduction is the most significant and with least variability between species within a 10-meter distance to the sound source. It has a strong application potential that once the spatial distribution of species over one place is obtained by maps or geographic analysis, the determination of the noise belt coverage of the area becomes feasible.

2.8. Air pollution

The relationship between air pollution and forest health is complicated and interactive, especially under an urban context. The insufficient combustion processes of vehicle engines cause air pollutants, producing carbon dioxide, nitrogen oxides, hydrocarbons, carbon monoxide and fine particulate material. These pollutants diffuse into nearby soil and water and have a negative effect on the ecosystem as a whole (Bohemen & Janssen Van De Laak, 2003). While forests actively remove air pollutants like sulphur dioxide (SO2), nitrogen dioxide (NO2), and ozone (O3) (Yang et al., 2005), studies have shown that air pollution would impose a threat to forest health and potentially lead to a decline in tree and plant species (McLaughlin & Percy, 1999; Oszlanyi, 1997). However, due to objects of those studies being more on generalizing and predicting forest health in relation to air pollution on a global scale, they failed to provide accurate measurements of evaluating the impact of air pollution on an adjacent local forest.

2.9. Conclusion

Multiple literature pieces were key in providing a framework for developing the methods incorporated into our own assessment. For soil, Green and Klinka (1994) defined both the parameters that describe soil conditions and the regimes to measure them. The Streamkeepers handbook (2013) and the work conducted by Tekeykhah and his colleagues on noise in urban forests describe the "safe space" on which the guidelines we employ for noise and water quality are based. The Jericho Baseline inventory (Montreuil, 2014) provided much of our current data for species composition and biodiversity for the park since it was conducted reasonably recently and gave a holistic description of its conditions. Our review of the literature gave us the background needed to support our assessment, along with the specific information needed for evaluating the perturbed urban conditions of Jericho Park.

3. Methodology

3.1. Overview

Our proposed methodology for evaluating the ecological condition of Natural Managed Areas (NMA) is focused on five factors (water, soil, species composition, noise, and air) within three classes (physical conditions, species composition, and external disturbance). Soil and water represent the physical condition of the area because soil provides structural support to the growth of plants and animals and water is the origin of life. The biodiversity and invasive species are essential to species composition because the richness of species represents the resilience and resistance ability of an ecosystem, whereas invasive species indicates the negative effect on local organisms. Noise pollution and air pollution as the result of anthropogenic activities represent the external disturbance to the ecosystem. Each factor may involve several subfactors in order to average out the dominant result in a single parameter assessment.

The ecological condition assessment table (Table 1) for the NMA contains four steps: (1) collecting field data, (2) match field data with the correct range to obtain a score, (3) calculatethe weighted score for each sub-parameters and averaging out the final factor score (see Factor Weighting), (4) add up the final score for each factor to obtain site overall score.

Table 2 Ecological condition assessment table

Factors	Categories	Good (3)	Moderate (2)	Poor (1)	Result	Score	Weight (%)	Factor Final Score
Water	Temperature (°C)	5°C-13°C	13°C-20°C	>20 °C	8.175°C		20%	
	pH	6.5-9	5-6.5 or 9-11	<5 or >11	8.075			
	Turbidity	Change from background of 8 NTU at any one time for a duration of 24 h in all waters during clear flows or in clear waters	Change from background of 2 NTU at any one time for a duration of 30 d in all waters during clear flows or in clear waters	Change from background of 5 NTU at any time when background is 8 - 50 NTU during high flows or in turbid waters	Unable to obtain the instrument to conduct the experiment. By observing at surface, the water is **clear**			
	Dissolved Oxygen (mg/L)	9.5-12 mg/L	6.5-9.5 mg/L	<6.5 mg/L	No result			
	TDS (ppm)	0-500 ppm	500-1000ppm	>1000 ppm	138.5 ppm			
Soil	Moisture regime	Moist to wet	Slightly dry - fresh	Very dry - Moderate dry	Moist to wet		8%	
	Site Productivity	Above average	Average	Below average	No result			
	Nutrient regime	Rich to very rich	Medium	Very poor-poor	Rich			
Species	Biodiversity	Observed biodiversity > 2014 reported biodiversity	Observed biodiversity = 2014 reported biodiversity	Observed biodiversity < 2014 reported biodiversity	Comparing the biodiversity from three quadrats to 2014 data, biodiversity declined		24%	
	Invasive species	0-35	35-70	>70	52.5		20%	
Noise	Intensity (kHz)	1kHz- 4kHz	4kHz- 8kHz	8kHz- 12kHz	No result		12%	
	Sound reduction (dB)	20-30dB	15-20dB	<15 dB	20 dB			
Air	Air Quality Health Index	Low Risk (1-3)	Moderate (4—6)	High Risk> 7	2.8		16%	
Overall Site Score								

3.2. Factor weighting

A unique component of our assessment is the addition of a weighting system. Using the weighting system, the impact that a factor's score (water, air, noise, etc.) has on the final score of an NMA can be altered to meet the priorities of different regions. In our assessment of Jericho Park, because the park was an urban forest frequently visited by residents, we weighted our factors from an anthropocentric viewpoint. Due to this viewpoint, factors that had a negative effect on both the environment and resident's enjoyment of the park were weighted more heavily than factors that mainly affected just the environment. To determine the weight each factor carried a number from 1 to 3 was assigned to each, 1 indicating low priority and 3 indicating high priority. Once a priority was assigned, a rationale for the priority was for each factor. Once all priorities were set, all values were added up to find the total value and then the priority value of each factor was divided by the total value to find the percent weight of each factor. The percent weights determined through this process were then used to find the final score for each factor as well as the overall site score (Table 1).

3.3. Priority Rationale

3.3.1. Soil (1) 8%

In the context of Jericho Park we weighted the health of the soil as low priority as the goal for restoration of urban forests such as Jericho Park is not to return them to a pristine forest environment, but to make them healthy enough to remain productive in urban environments where local residents can enjoy them. This prioritization leads us to believe that high quality soil is not as important as other factors.

3.3.2. *Air (2)16%*

We weighted air as a moderate priority, as air quality negatively affects the health of not just local species but residents visiting the park as well.

3.3.3. *Water (2.5) 20%*

Water Quality was weighed moderately as it has a significant impact on visitors, wildlife, and vegetation. Our assessment is based on urban guidelines and general water conditions. Jericho Park has multiple streams, a pond, and marsh habitats that make up a large area of the NMA. This predominance makes it an important factor in our assessment.

3.3.4. Biodiversity (3) 24%

Biodiversity play an important role in delivering the ecosystem service visitors expect from the park. Additionally, biodiversity enhances ecosystem reliability, where reliability refers to the probability that a system will provide a consistent level of performance over a given unit of time.

3.3.5. *Invasive Species (2.5) 20%*

Ecological perturbations caused by invasive species have been identified as a growing threat to global sustainability. Invasive alien plants species (IAPS) are considered to be one of the major drivers of biodiversity loss and thereby altering the ecosystem services and socio-economic conditions through different mechanisms

3.3.6. Noise (1.5) 12%

Our weighing of noise disruption in Jericho Park was relatively low. Guidelines for noise levels are based on disruption to wildlife and focus on absolute measurements of frequency and intensity that would be harmful to park inhabitants. This would make the threshold quite high and unlikely to be exceeded. Another major factor is the reduction of noise due to tree cover. Because the NMA makes up the forested portion of the park, urban noise is reduced protecting the area, making it a low concern.

3.4. Results

Table 3 Assessment results table

Factors	Categories	Good (3)	Moderate (2)	Poor (1)	Result	Score	Weight (%)	Factor Final Score
Water	Temperature (°C)	5°C-13°C	13°C-20°C	>20 °C	8.175°C	3	20%	0.6
	pH	6.5-9	5-6.5 or 9-11	<5 or >11	8.075	3		
	Turbidity	Change from background of 8 NTU at any one time for a duration of 24 h in all waters during clear flows or in clear waters	Change from background of 2 NTU at any one time for a duration of 30 d in all waters during clear flows or in clear waters	Change from background of 5 NTU at any time when background is 8 - 50 NTU during high flows or in turbid waters	Unable to obtain the instrument to conduct the experiment. By observing at surface, the water is **clear**	3		
	Dissolved Oxygen (mg/L)	9.5-12 mg/L	6.5-9.5 mg/L	<6.5 mg/L	No result	N/A		
	TDS (ppm)	0-500 ppm	500-1000ppm	>1000 ppm	138.5 ppm	3		
Soil	Moisture regime	Moist to wet	Slightly dry - fresh	Very dry - Moderate dry	Moist to wet	3	8%	0.24
	Site Productivity	Above average	Average	Below average	No result	N/A		
	Nutirent regime	Rich to very rich	Medium	Very poor-poor	Rich	3		
Species	Biodiversity	Observed biodiversity > 2014 reported biodiversity	Observed biodiversity = 2014 reported biodiversity	Observed biodiversity < 2014 reported biodiversity	Comparing the biodiversity from three quadrats to 2014 data, biodiversity declined	1.5	24%	0.76
	Invasive species	0-35	35-70	>70	52.5	2	20%	
Noise	Intensity (kHz)	1kHz- 4kHz	4kHz- 8kHz	8kHz- 12kHz	No result	N/A	12%	0.36
	Sound reduction (dB)	20-30dB	15-20dB	<15 dB	20 dB	3		
Air	Air Quality Health Index	Low Risk (1-3)	Moderate (4—6)	High Risk> 7	2.8	3	16%	0.48
Overall Site Score								More moderate than Good (2.44)

3.4.1. Water

The results on Turbidity, pH, temperature, and TDS, were all determined to score a 3 in our assessment, indicating the overall site water quality as "good". As water flows from the entrance to the creek, marsh, and eventually reaching the pond, the TDS was observed to decrease monotonically along the path. Additionally, the pH was seen to be lowest at the entrance discharge of the park among the four sampling sites. The extremely low TDS observed in all sites implies that the water passes urban quality guidelines.

3.4.2. *Soil*

Jericho Park belongs to the Coastal Western Hemlock with a variation of dry sub maritime (CWHds 1) under the Biogeoclimatic Unit System. We also determined that the relative Soil moisture Regime (SMR) was between 5-7 and the actual SMR was from moist to wet. For the soil nutrient regime, we have determined that soil quality was from rich to very rich. By combining these three parameters, we were able to identify the site was most likely to be 07 Devil's club. In this site, the soil has relatively good moisture and nutrient content. However, there is a high potential for competition in vegetation. The site productivity is not addressed in our experiment due to technical limitations. However, future assessment of on-site productivity is encouraged.

3.4.3. *Biodiversity*

Comparing the biodiversity from our three quadrats assessment to biodiversity from an assessment conducted in 2014, we concluded that biodiversity had declined. However, due to the small sample size, the likelihood of our data being accurate is low. Thus the future repetition of larger sample size assessment will be necessary to determine the quality of biodiversity in the park accurately. Nonetheless, these results show that future monitoring of biodiversity is necessary to ensure the health of the park.

3.4.4. *Invasive Species*

A total of four invasive species are found in Jericho Park. They are Himalayan blackberry, Scotch broom, English holly and English ivy. The total coverage of those four invasive plants took up 51% of all vegetation covering. Himalayan blackberry and Scotch broom are listed as "Regional Containment/Control" in BC's invasive plant priority list. The latter two invasive plants can be put with less effort as they are widely spread across the province. However, a more effective management practice towards all four invasive plants is needed.

3.4.5. *Noise*

The noise reduction ability for tree species is around 20 dB to 30 dB. The observed average sound intensity between the edge of the forest and near the pond area has a difference of 9 dB. Given that the data was taken in the evening when the traffic was inactive, the maximum records are also valuable as it represents the rush hour traffic noise. The maximum difference in sound intensity is 20 dB, which implies that there is the noise belt is full coverage and the noise reduction for the park is excellent.

3.4.6. *Air*

The air quality at Jericho Park was evaluated based on the Air Quality Health Index (AQHI), the 7 days average of AQHI was 2.8. It indicates that Jericho Park is at a low risk of air pollution.

3.4.7. *Overall*

Based on our obtained results and self-developed weighting system, the overall site score is 2.44, indicating that the ecological condition of the NMA within Jericho Park is between moderate and good.

4. Limitation

The major limitations of our testing were to our assessment of biodiversity and invasive species. Initially, we had planned to measure more quadrats throughout the park; however, we were unable to go for subsequent data collections due to restrictions put in place following the COVID-19 pandemic. This would have allowed us to get a more representative assessment; however, our results were still useful as they showed the suspected trend of high invasive species density. We were also unable to collect subsurface soil samples due to policies against digging within the park, but collections were most likely unneeded as surface soils were satisfactory, and there is little exposure to subsurface soils within the park for wildlife and residence.

Due to the limited accessibility to the GIS software and spatial data, we were unable to perform geographic spatial analysis for the park to test the coverage of the noise belt. Therefore, we chose another approach to complete the assessment of noise reduction. We first lookup for the scientific evidence of noise reduction ability of tree species. Then we calculated the field data difference of sound intensity between inside the park and the edge of the park. Lastly, we compare the observed value to the experiment value to determine if the park meets the typical noise reduction level due to the appearance of tree species. The supposed geographic spatial analysis methodology will be presented in the appendix.

As we do not have the specific instrument to test sound frequency, and there is a limitation in converting frequency to sound intensity, we are unable to test the sound frequency subfactor of our noise assessment. Moreover, the dissolved oxygen levels in water quality assessment are also not conducted also due to lack of instruments.

5. Recommendations

Jericho Park is mostly dominated by early - intermediate successional stand growth, many of which are deciduous generalists. We concluded that the most significant threat facing Jericho Park is its large population of invasive species. English ivy is an invasive species that is extremely prominent throughout the Park, covering large areas of the forest floor and suffocating trees. Due to its extensive growth and the threat to the trees it is growing on, immediate action should be taken to remove it from trees and manage its spread on the forest floor. Other invasive species in the area do not pose the same level of risk and should take a back seat to the control of English Ivy. We think that these efforts will need to be focused on and around the new growth stands on the south end of the park so that these especially vulnerable trees are not choked out by the ivy. Additionally, many of the largest trees have ivy growth on their trunks that could be removed at the bottom to eliminate the vertical growth of ivy. Within our findings, air, water, soil, and noise quality were evaluated to be in good condition, and do not warrant any action at this time.

Our methodology was structured to generate site-specific recommendations but could easily be adapted to other parks. By altering the weighting system to reflect the priorities of other parks and conducting the test outlined in our methodology, our report can be repurposed to provide insight into the health of individual factors, as well as the overall health of other ecosystems. This could help others to make recommendations for the rehabilitation of their sites.

Acknowledgments

This project could not be completed without the effort and co-operation of our group members. We sincerely thank the instructor, Tara Holland, for her critical comments and guidance on our work throughout the course of this project. We would also like to express our gratitude to our client, Dana McDonald and the Vancouver Parks Board, for providing this opportunity and giving feedback and support throughout the project. In addition, we would like to thank Kelly Gardner and the CityStudio, for all the support. We also appreciate the help from Rebecca Ho, who helped us acquire lab equipment to conduct our assessment. Last but not least, we would like to acknowledge that we are fortunate to be able to gather on the unceded territory of the Musqueam, Tsleil-Waututh, and Squamish nations.

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Appendix 1: Technical Guidance

Soil Data Collection Technique
A soil sample with approximately 15 cm*15 cm*10 cm in size should be obtained in the field and exam in the lab for its physical properties. The Soil Nutrient Regime (SNR), Soil Moisture Regime (SMR) are keyed out according to Figure xx and Figure xx below. Site productivity should be determined according to The Field Guide by Green and Klinka (1994). To quantify the outcomes, an index value will be assigned to both the Soil Nutrient Regime (SNR), the actual Soil Moisture Regime (SMR) and site productivity. The conversions are shown in the Table 2 to Table 4.

Table 4 Scaling for soil moisture regime

Code	Class	Scale
VD	very dry	
MD	moderate dry	1
SD	slightly dry	
F	fresh	2
M	moist	
VM	very moist	3
W	wet	2

Table 5 Scaling for soil nutrient regime

Code	Class	Scale
A	very poor	
B	poor	1
C	medium	2
D	rich	
E	very rich	3

Table 6 Scaling for site productivity

Site productivity	Score
Below average	1
Average	2
Above average	3

Quadrat Techniques
Quadrats 2m by 2m were laid out with strings at various locations in the NMA that together were representative of the NMA as a whole. Once the quadrant was assembled, the number of distinct species were numbered and identified as either native or invasive species. Finally, the percent

composition of each species within the quadrat was predicted in order to help determine biodiversity within the quadrat.

Noise reduction technical guidance

1. Open ArcGIS and obtain the spatial data for Jericho park
2. Select all coordinates of tree species from the attribute table (this can be manually selected by pin point on the map)
3. Use buffering tool to create buffers for every selected point and set the distance to 10 meters
4. Exclude the buffers (this step is to exclude the overlapped areas which we think are covered with noise belts).
5. The uncovered area will be revealed and represents the gaps in the noise reduction belt.

Water quality assessment technical guideline

There are several subfactors contained in the water quality assessment, the guidelines for each subfactor are listed below as the same order in the score table. If there are multiple water sources, measurement at each resource needs to be taken and the average results of all water resources are representative of the site water quality.

Temperature

1. Set the Temperature/pH/Conductivity/TDS Tester to measure Temperature.
2. Insert the Temperature/pH/Conductivity/TDS Tester to a 10 cm depth below the surface of the water and keep it submerged for two minutes. -
3. Read the temperature while the thermometer is still in the water or press the HOLD button to keep the measurement from the water.
4. Record

pH

1. Set the Temperature/pH/Conductivity/TDS Tester to measure ph.
2. Insert the tester 10 cm below the surface and wait for two minutes.
3. Read the pH while the tester is still in the water or press the HOLD button to keep the measurement from the water.

Turbidity

1. Set nephelometer with the detector to the side of the light beam
2. Insert the tester below the surface and start the test.
3. Read the NTU
4. Record the time it takes to change the NTU in all waters during clear flows or in clear waters, then fill out the score table

TDS

1. Set the Temperature/pH/Conductivity/TDS Tester to measure pH。
2. Insert the tester 10 cm below the surface and wait for two minutes.
3. Read the TDS while the tester is still in the water or press the HOLD button to keep the measurement from the water.

Dissolved oxygen

1. Set the dissolved oxygen Tester to measure ph.
2. Insert the tester 10 cm below the surface and wait for two minutes.
3. Read the numbers while the tester is still in the water or press the HOLD button to keep the measurement from the water.
4. Using the unit converting graph to obtain the percentage, then comparing it to the range table to obtain results

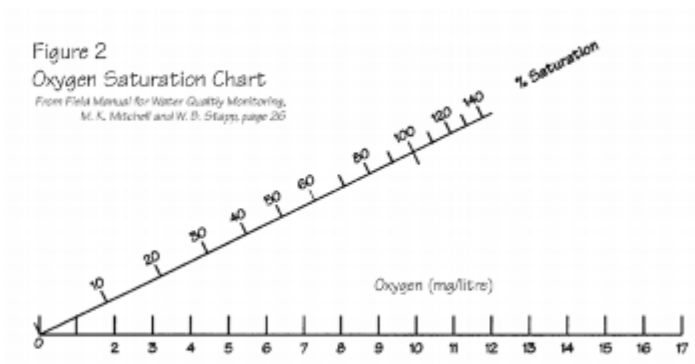

Figure 2 A converting unit chart for dissolved oxygen

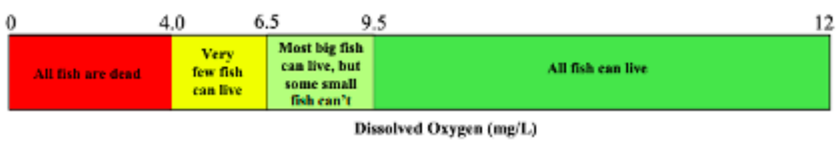

Figure 3 A range table of dissolved oxygen for species living status

Appendix 2: Figures and Tables

Table 1. Assessment results table

	Water	Soil	Biodiversity	Invasive Species	Noise	Air
Score	3	3	1.5	2	3	3
Weight (%)	20%	8%	24%	20%	12%	16%
Final Factor Score	0.6	0.24	0.36	0.4	0.36	0.48
Site Overall Score	Between Moderate and Good (2.44)					

Table 2. Ecological condition assessment table

Factors	Categories	Good (3)	Moderate (2)	Poor (1)	Result	Score	Weight (%)	Factor Final Score
Water	Temperature (°C)	5°C-13°C	13°C-20°C	>20 °C	8.175°C		20%	
	pH	6.5-9	5-6.5 or 9-11	<5 or >11	8.075			
	Turbidity	Change from background of 8 NTU at any one time for a duration of 24 h in all waters during clear flows or in clear waters	Change from background of 2 NTU at any one time for a duration of 30 d in all waters during clear flows or in clear waters	Change from background of 5 NTU at any time when background is 8 - 50 NTU during high flows or in turbid waters	Unable to obtain the instrument to conduct the experiment. By observing at surface, the water is **clear**			
	Dissolved Oxygen (mg/L)	9.5-12 mg/L	6.5-9.5 mg/L	<6.5 mg/L	No result			
	TDS (ppm)	0-500 ppm	500-1000ppm	>1000 ppm	138.5 ppm			
Soil	Moisture regime	Moist to wet	Slightly dry - fresh	Very dry - Moderate dry	Moist to wet		8%	
	Site Productivity	Above average	Average	Below average	No result			
	Nutrient regime	Rich to very rich	Medium	Very poor-poor	Rich			
Species	Biodiversity	Observed biodiversity > 2014 reported biodiversity	Observed biodiversity = 2014 reported biodiversity	Observed biodiversity < 2014 reported biodiversity	Comparing the biodiversity from three quadrats to 2014 data, biodiversity declined		24%	
	Invasive species	0-35	35-70	>70	52.5		20%	
Noise	Intensity (kHz)	1kHz- 4kHz	4kHz- 8kHz	8kHz- 12kHz	No result		12%	
	Sound reduction (dB)	20-30dB	15-20dB	<15 dB	20 dB			
Air	Air Quality Health Index	Low Risk (1-3)	Moderate (4—6)	High Risk> 7	2.8		16%	
Overall Site Score								

Table 3. Assessment results table

Factors	Categories	Good (3)	Moderate (2)	Poor (1)	Result	Score	Weight (%)	Factor Final Score
Water	Temperature (°C)	5°C-13°C	13°C-20°C	>20 °C	8.175°C	3	20%	0.6
	pH	6.5-9	5-6.5 or 9-11	<5 or >11	8.075	3		
	Turbidity	Change from background of 8 NTU at any one time for a duration of 24 h in all waters during clear flows or in clear waters	Change from background of 2 NTU at any one time for a duration of 30 d in all waters during clear flows or in clear waters	Change from background of 5 NTU at any time when background is 8 - 50 NTU during high flows or in turbid waters	Unable to obtain the instrument to conduct the experiment. By observing at surface, the water is **clear**	3		
	Dissolved Oxygen (mg/L)	9.5-12 mg/L	6.5-9.5 mg/L	<6.5 mg/L	No result	N/A		
	TDS (ppm)	0-500 ppm	500-1000ppm	>1000 ppm	138.5 ppm	3		
Soil	Moisture regime	Moist to wet	Slightly dry - fresh	Very dry - Moderate dry	Moist to wet	3	8%	0.24
	Site Productivity	Above average	Average	Below average	No result	N/A		
	Nutrient regime	Rich to very rich	Medium	Very poor-poor	Rich	3		
Species	Biodiversity	Observed biodiversity > 2014 reported biodiversity	Observed biodiversity = 2014 reported biodiversity	Observed biodiversity < 2014 reported biodiversity	Comparing the biodiversity from three quadrants to 2014 data, biodiversity declined	1.5	24%	0.76
	Invasive species	0-35	35-70	>70	52.5	2	20%	
Noise	Intensity (kHz)	1kHz- 4kHz	4kHz- 8kHz	8kHz- 12kHz	No result	N/A	12%	0.36
	Sound reduction (dB)	20-30dB	15-20dB	<15 dB	20 dB	3		
Air	Air Quality Health Index	Low Risk (1-3)	Moderate (4—6)	High Risk> 7	2.8	3	16%	0.48
Overall Site Score								More moderate than Good (2.44)

Table 4. Scaling for soil moisture regime

Code	Class	Scale
VD	very dry	
MD	moderate dry	1
SD	slightly dry	
F	fresh	2
M	moist	
VM	very moist	3
W	wet	2

Table 5. Scaling for soil nutrient regime

Code	Class	Scale
A	very poor	
B	poor	1
C	medium	2
D	rich	
E	very rich	3

Table 6. Scaling for site productivity

Site productivity	Score
Below average	1
Average	2
Above average	3

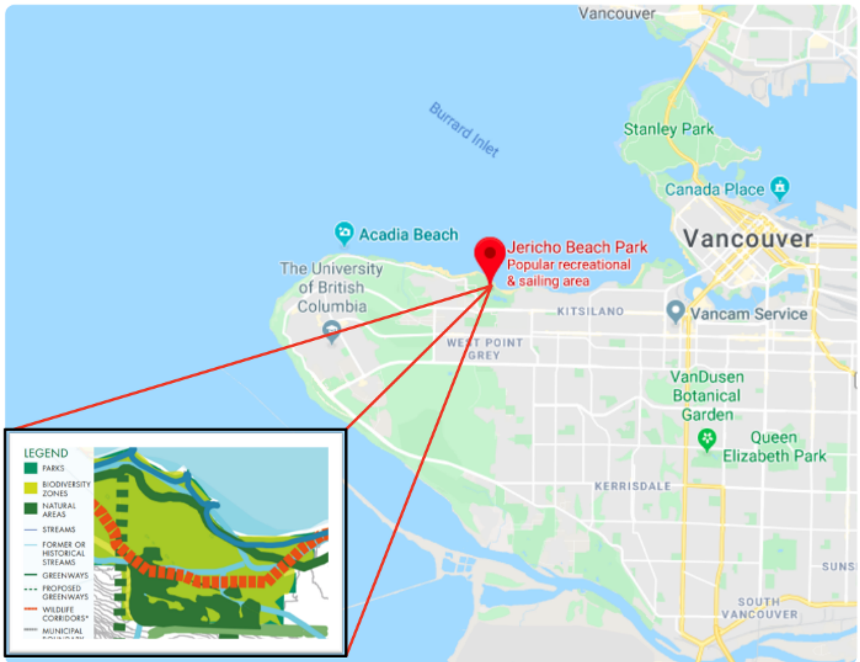

Figure 1 Map of natural area inventory of Jericho park and beach and its location in Vancouver

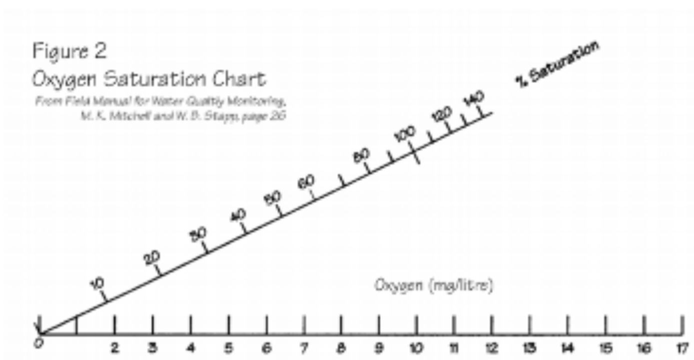

Figure 2. A converting unit chart for dissolved oxygen.

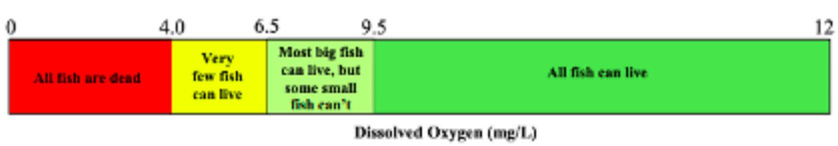

Figure 3. A range table of dissolved oxygen for species living status.