Hands-on Curriculum-based Field Trip Module for BC Grade 8 to 10 Students at the Delta Nature Reserve

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Executive Summary

The goal of this project was to develop an educational environmental science field trip module for BC high school students in grades 8 to 10 at the Delta Nature Reserve in Burns Bog, located in Delta, British Columbia (Fig. 1). This module will be used by high school teachers and the Burns Bog Conservation Society to engage students in place-based learning and introductory scientific research. Recent changes to the BC high school curricula emphasize the importance of outdoor learning, a connection to land and place, and Indigenous content. With these changes, there exists the opportunity to update the current field trips provided by the Burns Bog Conservation Society and to make them more grade-specific, introduce field-based research techniques, and emphasize the history of Canadian Indigenous peoples at Burns Bog. We have developed a field trip module divided into three parts, with worksheets and activities to guide high school teachers, field trip leaders, and students before the field trip, during the field trip, and after the field trip.

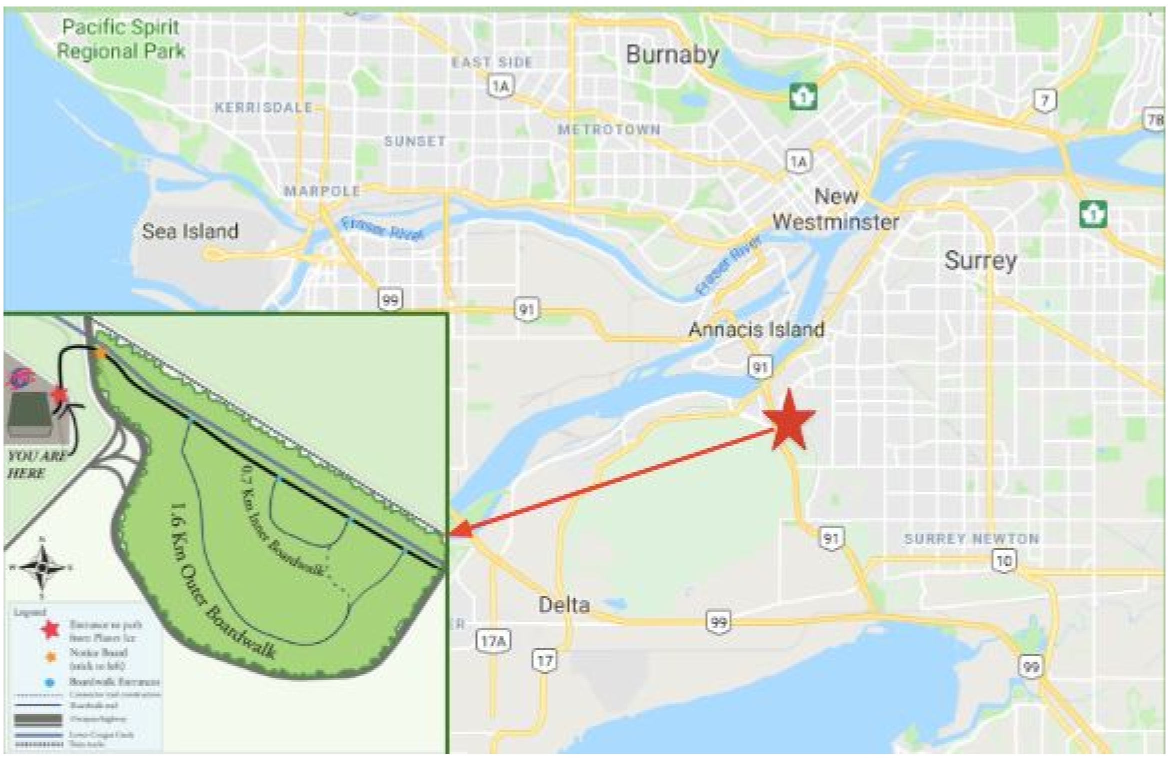

Figure 1. Location of the Delta Nature Reserve in Delta, British Columbia; field trips will be conducted at this location through the Burns Bog Conservation Society. From Google Maps (2018) and the Burns Bog Conservation Society (2018).

The new British Columbian Science curricula have many shared learning aspects, such as the aforementioned emphasis on place-based learning, but each grade has its own specific requirements as well. In eighth grade, students focus more on chemistry, as well as receive a simple introduction to research. In ninth grade, students focus on sustainability of ecosystems and are gradually introduced to more complex methods of research and analysis. By tenth grade, students are focusing on natural selection and anthropogenic impacts on ecosystems, and should be capable of performing more rigorous research and analysis. We consulted with education experts from the University of British Columbia and conducted searches into education literature and the new BC curricula to design our field trip modules. We then generated matrices to analyze how well our field trip components align with the curricula requirements for each grade; for example, the different parts of our module align well with the grade 10 Science learning goals (Fig. 2).

Grade 10 Science Learning Goals	Field Trip Components		
	Pre-field trip Worksheet	Data Collection + Analysis (ie. Plant and Soil Survey)	Outdoor Experience
Planning and Conducting Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data		✓	
Collaboratively and individually plan, select, and use appropriate investigation methods, including field work and lab experiments, to collect reliable data (qualitative and quantitative)		✓ *Students will not plan experiments*	
Assess risks and address ethical, cultural and/or environmental issues associated with their proposed methods and those of other		✓	
Processing and Analyzing Data and Information Experience and interpret the local environment		✓	✓
Apply First Peoples perspective and knowledge, other ways of knowing, and local knowledge as sources of information	✓		✓
Seek and analyze patterns, trends, and connections in data, including describing relationships between variables (dependent and independent) and identifying inconsistencies		✓	
Construct, analyze and interpret graphs (including interpolation and extrapolation), models and/or diagrams		✓	
Use scientific understandings to identify relationships and draw conclusions	✓	✓	
Analyze cause-and-effect relationships	✓	✓	
Evaluating Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled		✓	
Demonstrate an awareness of assumptions, question information given, and identify bias in their own work and secondary sources		✓	
Consider social, ethical, and environmental implications of the findings from their own and others' investigations		✓	
Critically analyze the validity of information in secondary sources and evaluate the approaches used to solve problems			
Applying and Innovating Contribute to care for self, others, community, and world through personal or collaborative approaches			✓
Contribute to finding solutions to problems at a local and/or global level through inquiry		✓	
Transfer and apply learning to new situations		✓	
Communicating Communicate scientific ideas, claims, information, and perhaps a suggested course of action, for a specific purpose and audience, constructing evidence-based arguments and using appropriate scientific language, conventions, and representations	✓	✓	
Express and reflect on a variety of experiences, perspectives, and worldviews through place	✓	✓	
Content First Peoples perspectives on energy: energy use and conservation include generational roles and responsibilities	✓		
Implications: positive and negative impacts, including environmental, health, economic	✓		

Figure 2. A chart showing how the field trip components in our project align with the BC Grade 10 science and social studies curricula. The chart is meant to be utilized by teachers or field trip leaders to identify which components of the curriculum are being incorporated into the field trip module. The chart shows that the majority of the learning goals outlined in the Grade 10 curriculum will be addressed in at least one aspect of the field trip module.

The proposed field trip activities adhere to the place-based learning approach, which promotes learning that is rooted in the unique history, ecology, and culture of Burns Bog. Our aim was to provide students with the opportunity to develop relevant skills related to environmental science, such as data collection and analysis, the use of scientific equipment, and critical thinking. A series of hands-on activities encourage the development of a scientific skill set designed to provide students with a base understanding of research that they can take forward into future studies.

Specific activities include soil testing and plant identification, both of which can be modified to increase complexity for higher grades. Soil testing will take place at different accessible locations throughout the Delta Nature Reserve to highlight the various ecosystem types within the reserve and provide opportunities to critically analyze these differences (Fig. 3).

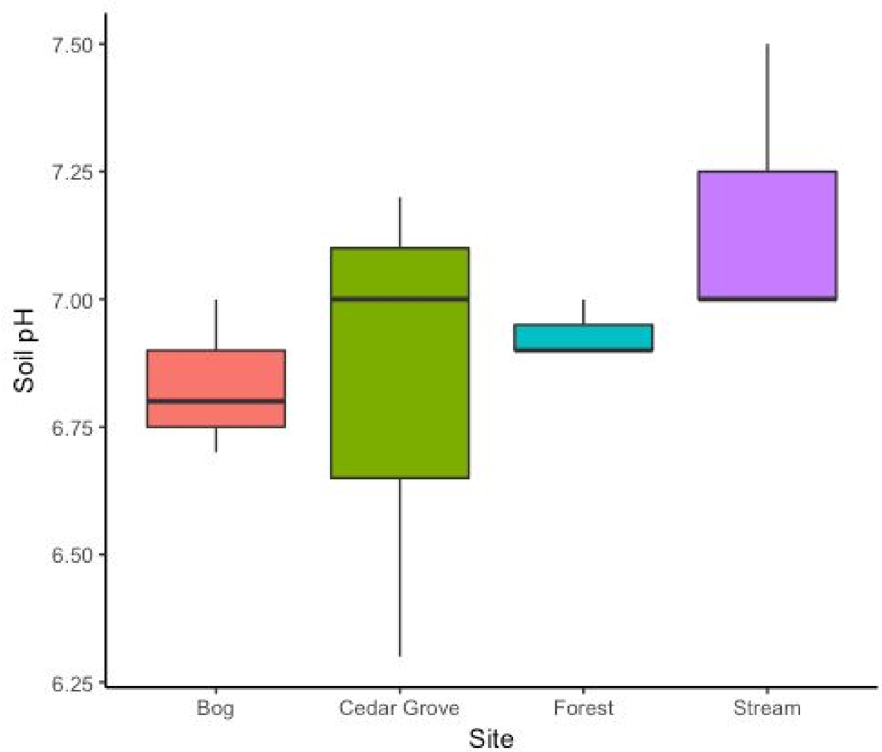

Figure 3. Expected results and range of soil pH values in four ecologically distinct areas within the Delta Nature Reserve: a bog, a cedar grove, a mixed forest, and a streamside area. Results are from our own preliminary sampling, and students will collect data and generate similar graphs. They will then draw conclusions based on the figures, statistics run on the figures, their personal observations at Burns Bog, and what they learned during and before their field trip.

By focusing on Indigenous land use and history in the pre-field trip activities and during the field trip itself, students will learn the stories of the people who depended on the environment. This can encourage students to develop more personal connections to their community and natural environment and foster stewardship and a sense of responsibility. In combination with place-based learning, this will promote student learning and engage students with Indigenous content on a level they may not otherwise be able to in the classroom.

The modules require minimal instructor or student preparation, as appropriate pre-trip and post-trip activities are already formulated. This allows the educator to focus more on the learning of the students, as opposed to still being engaged in the generation of educational material. In addition, the cost of the field trip is very reasonable, especially if sufficient students attend and each contribute to a small portion of the travel costs.

Overall, our field trip module offers students a hands-on, curriculum-based, outdoor educational experience in the Delta Nature Reserve. By introducing research activities (ie. soil pH and plant identification) and emphasizing placed-based learning, our module builds on curriculum requirements and encourages students to develop a more personal connection to their local environment. Our field trip also highlights cultural and ecological aspects of Burns Bog, through the inclusion of information on Indigenous perspectives in the pre-field trip activity, observation of plant interactions in the plant identification activity, and soil chemistry changes in the soil pH measurement activity. The nature of this field trip design is meant to help promote collaboration between students, encourage critical thinking and data analysis, and to emphasize the significance of natural ecosystems in a way that is specific to the learning needs of BC Grade 8 to 10 science students and their teachers.

Author Biographies

Andrea Le - I am a fifth year Bachelor of Science student majoring in Environmental Sciences with a focus on Land, Air, and Water. I participated in the Science Co-op program, completing twelve months of work in a commercial environmental testing lab and in zooplankton taxonomy research, and have had exposure to programs such as R, ArcGIS, and Matlab. I also have previous experience in education as an assistant tutor for students in Preschool to Grade 12. I enjoy learning in the outdoors, and was drawn to this project as it was a way to bridge education and environmental science.

Darren Tong - I am a fifth year Bachelor of Applied Science student majoring in Engineering Physics, with a minor in Environmental Science. Although my academic life is mostly Engineering or Physics related, I have a strong interest in biology and ecology, and have completed two capstone projects in related fields. These projects include the design and fabrication of an automated stem cell incubator, as well as a quality control system for the 3D printing of human tissues. My technical experience accumulated through work terms with the UBC Quantum Devices Group allowed me to provide a unique perspective to this project.

Heather Reid - I am a fifth year Bachelor of Science student majoring in Environmental Sciences with a focus on Ecology and Conservation. I participated in the Science Co-op program, completing sixteen months of work with oyster aquaculture, freshwater toxicology, and salt marsh restoration. For my senior project I am working in intertidal ecology, focusing on the cold tolerance and winter microhabitat use of a Littorinid snail. With these professional and research experiences I have had extensive opportunities to conduct fieldwork and lab work, and am comfortable performing research and working with programs like R. For this project I brought my knowledge of fieldwork and research to the design of student activities and worksheets.

Vanessa Lim - I am a fifth year Bachelor of Science student majoring in Integrated Sciences. My diverse background and knowledge has contributed an unique approach to solving novel problems. I have a passion for environmental science and educating the youth about more sustainable practices. My previous experience in the education field assisted in the design of this field trip module and the content within it. As an avid hiker, I enjoy being outdoors and encouraging others around me to consider using nature as an education tool for younger students.

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I. Introduction

The primary objective of this project was to develop an educational environmental science field trip module for BC high school students in grades 8 to 10 at the Burns Bog Delta Nature Reserve for use by our community partner, the Burns Bog Conservation Society. The Society currently leads generalized field trips meant for all ages through the Delta Nature Reserve, which provide a general overview of the importance of bog ecosystems, the common animal and plant species in the area, and the threats to the peatlands. With this project, we were tasked with updating the existing field trip module to become more grade-specific to students in grades 8 to 10, and adapted to fit the new redesigned BC science curriculum. We aimed to incorporate more hands-on field trip activities that highlight important ecological aspects of Burns Bog and the impacts of anthropogenic activities on the ecosystem in order to complement the existing field trip module and also provide students an opportunity to practice relevant skills related to environmental science, such as data collection and analysis, the use of scientific equipment, and critical thinking.

The full transition to British Columbia's newly redesigned curricula for Kindergarten to Grade 10 will take effect by September 2018 (British Columbia Ministry of Education, n.d.). Specific changes include the integration of more information on Indigenous culture and ways of knowing, and place-based learning into all core school subjects, with a greater emphasis on ecology and environment in the Science curriculum (British Columbia Ministry of Education, n.d.).

Each grade level also has its own curriculum requirements and focuses. Environment-related content in the Grade 8 Science curriculum emphasizes important life processes at the cellular level (e.g. photosynthesis, characteristics of life), while the Grade 9 Science curriculum focuses on sustainability, matter cycles, and impact of anthropogenic activities on natural systems (British Columbia Ministry of Education, 2016a; 2016c). Grade 10 Science involves natural and artificial selection, local and global energy transformation (e.g. habitat destruction, carbon dioxide output), and encourages students to draw connections and conduct deeper analysis than in the previous grades (British Columbia Ministry of Education, 2016a).

Moreover, Indigenous perspective and knowledge of the natural world is highly stressed in the new curriculum, and it is expected that Indigenous material be incorporated with other academic subjects like Science (British Columbia Ministry of Education, 2016a). The motivation behind the inclusion of these new learning objectives is to expose students to a diverse range of ways of knowing, and to allow them to use local knowledge as sources of information (British Columbia Ministry of Education, 2016a). Burns Bog has historically been occupied and used by a number of Indigenous groups, including the Tsawwassen, Semiahmoo, Sto:lo and Katzie bands (Jackson, 2007). With this rich history, a field trip module at Burns Bog that respectfully includes Indigenous content provides an ideal opportunity for teachers to meet curriculum requirements and for students to learn and connect with the material on location.

Across all grades, the curricula state that students should learn to "contribute to care for self, others, community, and world through individual or collaborative approaches" and use Indigenous perspectives and knowledge on sustainability and interconnectedness of the local environment as sources of information (British Columbia Ministry of Education, 2016d). This concept, known as “place-based education”, was adopted from David Sobel’s book titled “Place-based Education: Connecting Classrooms & Communities” (Sobel, 2006). Sobel encourages integration of community activities into school curricula so that students can apply their knowledge and feel like they are making a real difference (Sobel, 2006). This was an important aspect for us to consider when integrating place-based learning techniques into our field trip design, which encourages students to develop more personal connections to their community and natural environment. Consequently, the establishment of these connections to nature can help foster stewardship values and a mindfulness for the environment. By focusing on place-based learning and incorporating other key aspects of the science curriculum, our goal was to create a field trip that meaningfully engages students with required curriculum content on multiple learning levels and makes these subjects more interesting.

Another major goal of our field trip module was to highlight significant ecological aspects of Burns Bog and express the importance of its conservation and restoration in the context of urban wetland management. Bogs are unique ecosystems where very few organisms can thrive without significant adaptations to low pH levels associated with the ecosystem engineer sphagnum moss (Jackson, 2007). Bacteria in these areas cannot fully decompose plant biomass, resulting in the accumulation of partially decayed matter known as peat (Hebda et al. 2000). Peat-bogs are the largest store of non-decayed carbon on the planet (Environment and Climate Change Canada, 2001) and Burns Bog contains both the greatest area of raised peatland in western North America, and the largest continuous undeveloped urban land area in Canada (Cowan, 2015). The bog provides habitat for a variety of plant and animal species, many of which are considered rare and endangered and are threatened due to land use changes (Hebda et al. 2000). In addition, the management policies at Burns Bog currently aim to be recognized for their education programs and scientific research (Jackson, 2007). An important social aspect to the current management policy is to provide opportunities for public education and encourage community involvement through stewardship activities (Jackson, 2007). Current field trips at Burns Bog provide some history of Burns Bog and emphasize relevant aspects of bogs, but there is potential for expansion of that discussion. Older grades are capable of understanding more complex material, and should be allowed to engage with and think about environmental issues on a deeper level than younger grades. Our field trip hopes to align with educational management goals and highlight the importance and possible challenges of protecting a bog ecosystem.

II. Methods

In order to develop activities that meet the requirements of the BC curricula while still engaging students, we consulted with education experts Dr. Hartley Banack and Dr. Sandra Scott from the UBC Department of Curriculum and Pedagogy and conducted research into science education literature. We sought information that highlights teaching techniques proven to be effective in helping students retain information, develop critical thinking skills, and feel motivated to see the bigger picture. By compiling a list of specific learning goals and content details of the new

BC Science curricula for grades 8 to 10, we compared our proposed activities to these goals in the form of a learning matrix in order to gauge the activities' potential effectiveness and alignment with the curriculum expectations.

Our field trip module was designed to take place within the Delta Nature Reserve (Fig. 1), which is connected to the Burns Bog ecosystem. We therefore had to develop a working knowledge of the ecology of both bogs in general and Burns Bog specifically. This included researching the roles of different animal and plant species that live within the area, how they interact, and other significant physical and chemical characteristics of the bog. This knowledge was sourced from research papers, our former community partner Hillary Rowe, experts at the Burns Bog Conservation Society, and from our own observations in the Delta Nature Reserve.

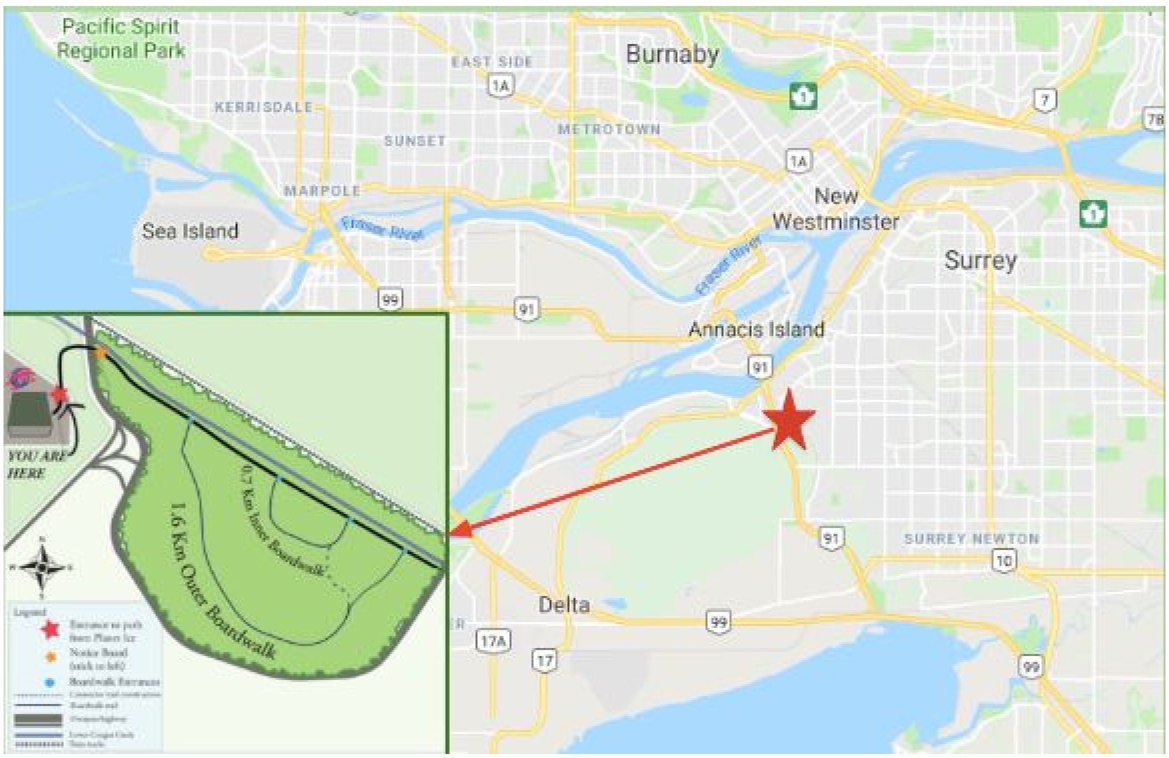

Figure 1. *A map indicating the location of the Delta Nature Reserve and an outline of the boardwalk. The field trip will take place in the reserve, where students will see how humans have impacted the surrounding environments. From Google Maps (2018) and the Burns Bog Conservation Society (2018).*

We familiarized ourselves with the physical environment and plant communities that exist within the bog and marked areas of significance on a map to indicate potential field activity sites (Fig. 2). In order to make environmental science interesting for high school students, studies suggest that educators need to draw connections from everyday life problems to larger environmental issues (e.g. global warming), and that hands-on interactions with wildlife is an effective learning strategy (Ballantyne & Packer, 2002; Breunig, Murtell & Russell, 2015). We therefore developed a module that uses real life environmental examples from the bog and meets BC Science teaching objectives through interactive learning.

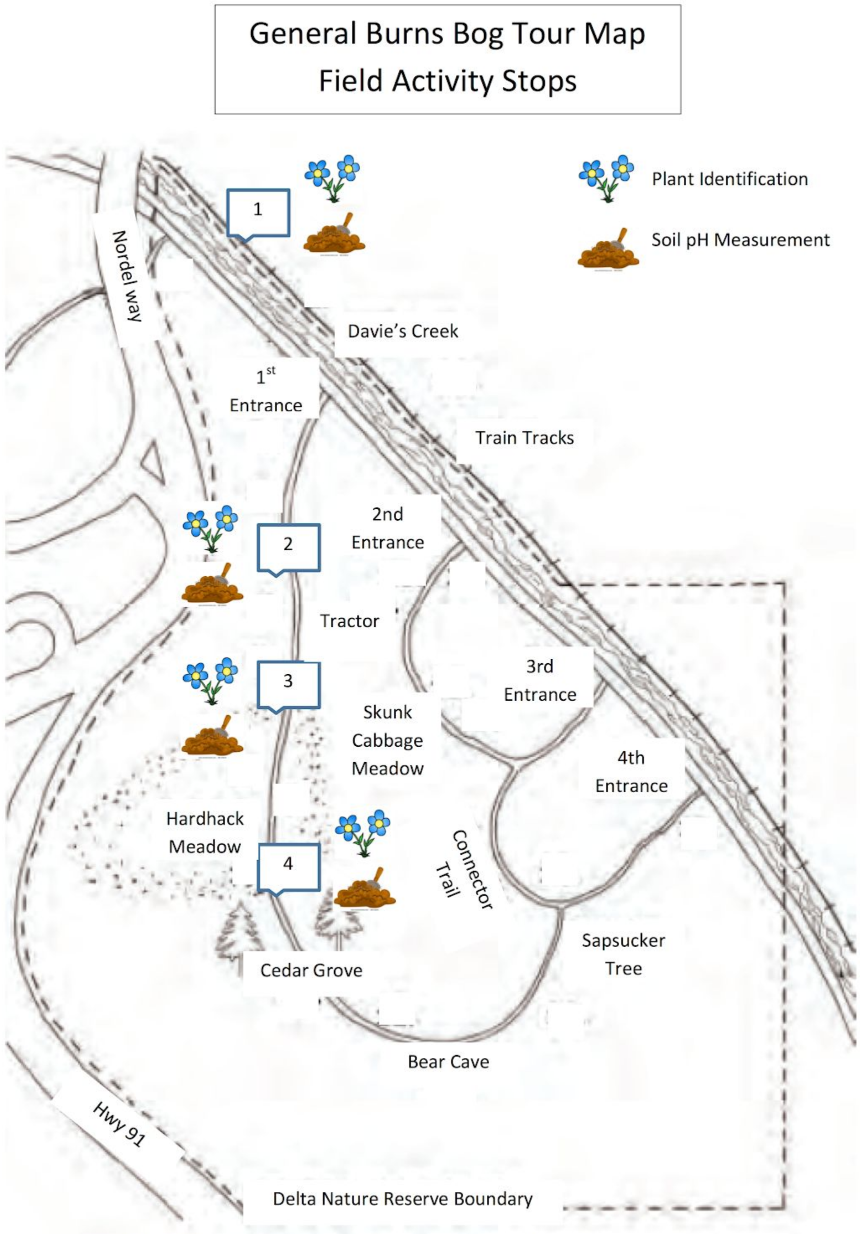

Figure 2. *Tour map of the Delta Nature Reserve boardwalk to be used by the Burns Bog field trip leader, outlining the field trip activity stops (1: Stream, 2: Forest, 3: Bog, and 4: Cedar Grove) we have added for students to conduct soil pH testing and plant identification.*

In the field trip we developed, students will be conducting various field activities, including an investigation in soil pH changes throughout the bog and a plant identification survey. We designed worksheets for these activities (Appendix Figs. A-E) with the intention of promoting collaboration between students (through group data collection activities) and connections to the local environment as intended with place-based learning (Sobel, 2006). Our activities are designed to require minimal supplies, and can be done in all weather types year-round. Our goal was to keep financial costs low, to allow for convenient transport of supplies for the field trip coordinator, and to ensure that participating schools would be able to receive consistent opportunities to do the activities regardless of the time of visit.

The field activities like soil pH sampling will require students to use a soil probe (TOPELEK pH and Moisture Soil Sensor Meter) and plant field guides (Appendix, Fig. C) at marked locations (Fig. 2). With these activities, students can analyze how certain physical and ecological characteristics change throughout the bog. We developed a protocol for conducting soil testing and plant surveys from our own collection trips to acquire preliminary data and determine the effectiveness of the methodology. Students are capable of following the methods we developed during a field trip, and the focus on hands-on experience is encouraged by the curriculum (British Columbia Ministry of Education, 2016b). We graphed some of our preliminary results to determine the feasibility of analysis and identify any issues. This data will be further discussed below in the Results.

III. Results

Our field trip module consists of three parts: *pre-field trip activity, post-field trip activity,* and the *field trip itself*. The pre-field trip activity includes a worksheet (Appendix Fig. A) that briefly discusses the history and ecological importance of Burns Bog as well as the importance of the area to multiple Indigenous groups. This activity also briefly introduces the experiments that students will be conducting during the field trip, and gives teachers a sense of the the activities to be conducted. The field trip component is where place-based learning techniques are to be executed by the Burns Bog field trip coordinator and students can conduct both a plant identification activity and soil pH sampling (Appendix Figs. B-E). During the field trip, students are to be guided by the field trip coordinator on how to use equipment, have discussions about the ecology of the bog, and continue to learn about the historical significance of the area to Indigenous groups. These activities were designed with consideration for how well they correspond to the BC science curricula.

IIIa. Grade 8 Field Trip Module

Each grade has different curriculum requirements; for example, the grade 8 curriculum introduces students to broad characteristics of life and experimental techniques (British Columbia Ministry of Education, 2016c). Students are expected to begin learning how to identify basic cause-and-effect relationships and learn about Indigenous knowledge of significant local geological events and formations (British Columbia Ministry of Education, 2016c). Our goal was to have different aspects of our field trip module target a variety of the Grade 8 learning goals. Based on our learning matrix (Fig. 3), most key Grade 8 learning goals are fulfilled by our field trip module.

Grade 8 Science Learning Goals	Field Trip Components		
	Pre-field trip Worksheet	Data Collection + Analysis (ie. Plant and Soil Survey)	Outdoor Experience
Planning and Conducting Observe, measure, and record data (qualitative and quantitative) using equipment with precision and accuracy		✓	
Collaboratively plan a range of investigation types, including field work and experiments, to answer their questions or solve problems they have identified		✓ *Students will not plan experiments*	
Consider social, ethical, and environmental implications of findings		✓	✓
Processing and Analyzing Data and Information Experience and interpret the local environment		✓	✓
Apply First Peoples perspective and knowledge, other ways of knowing, and local knowledge as sources of information	✓		✓
Construct and use a range of methods to represent patterns or relationships in data, including tables, graphs, keys, models, and digital technologies as appropriate		✓	
Use scientific understandings to identify relationships and draw conclusions		✓	
Evaluating Reflect on their investigation methods, including the adequacy of controls on variables (dependent and independent) and the quality of the data collected		✓	
Identify possible sources of error and suggest improvements to their investigation methods		✓	
Demonstrate an understanding and appreciation of evidence (qualitative and quantitative)		✓	
Applying and Innovating Contribute to care for self, others, community, and world through personal or collaborative approaches			✓
Co-operatively design projects			
Communicating Communicate ideas, findings, and solutions to problems, using scientific language, representations, and digital technologies as appropriate	✓	✓	
Content First Peoples knowledge of: - Local geological formations - Significant local geological events	✓		✓
Major geological events of local significance			
Characteristics of life	✓	✓	✓
Photosynthesis and cellular respiration			

Figure 3*. A matrix showing how the field trip components in our project align with the BC Grade 8 curricula (British Columbia Ministry of Education, 2016c). The chart is meant to be used by teachers or field trip leaders to identify which components of the curriculum is being incorporated into the field trip they will take at the Delta Nature Reserve. Through self-assessment, the chart shows that the majority of the learning goals outlined in the Grade 8 curriculum will be addressed in at least one aspect of the field trip.*

IIIb. Grade 9 Field Trip Module

The grade 9 Science curriculum highlights sustainability of systems and how matter and energy are connected through their interactions in the environment (British Columbia Ministry of Education, 2016b). Students are expected to learn how to collect and record data, while identifying and analyzing relationships and trends (British Columbia Ministry of Education, 2016b). Furthermore, the curriculum encourages students to learn about Indigenous perspectives on sustainability (British Columbia Ministry of Education, 2016e). Students in this grade are being exposed to more complicated research techniques and analysis, and are expected to engage with material on a deeper level than in previous grades. We demonstrated how aspects of our field trip align with Grade 9 curriculum needs in the learning matrix located below (Fig. 4).

Grade 9 Science Learning Goals	Field Trip Components		
	Pre-field trip Worksheet	Data Collection + Analysis (ie. Plant and Soil Survey)	Outdoor Experience
Planning and Conducting Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data		✓	
Collaboratively and individually plan, select, and use appropriate investigation methods, including field work and lab experiments, to collect reliable data (qualitative and quantitative)		✓ *Students will not plan experiments*	
Assess risks and address ethical, cultural and/or environmental issues associated with their proposed methods and those of other		✓	
Processing and Analyzing Data and Information Experience and interpret the local environment		✓	✓
Apply First Peoples perspective and knowledge, other ways of knowing, and local knowledge as sources of information	✓		✓
Seek and analyze patterns, trends, and connections in data, including describing relationships between variables (dependent and independent) and identifying inconsistencies		✓	
Construct, analyze and interpret graphs (including interpolation and extrapolation), models and/or diagrams		✓	
Use scientific understandings to identify relationships and draw conclusions	✓	✓	
Analyze cause-and-effect relationships	✓	✓	
Evaluating Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled		✓	
Demonstrate an awareness of assumptions, question information given, and identify bias in their own work and secondary sources		✓	
Consider social, ethical, and environmental implications of the findings from their own and others' investigations		✓	
Applying and Innovating Contribute to care for self, others, community, and world through personal or collaborative approaches			✓
Contribute to finding solutions to problems at a local and/or global level through inquiry		✓	
Communicating Communicate scientific ideas, claims, information, and perhaps a suggested course of action, for a specific purpose and audience, constructing evidence-based arguments and using appropriate scientific language, conventions, and representations	✓	✓	
Express and reflect on a variety of experiences, perspectives, and worldviews through place	✓	✓	
Content Matter cycles within biotic and abiotic components of ecosystems		✓	
Sustainability of systems	✓	✓	
First Peoples knowledge of interconnectedness and sustainability	✓	✓	

Figure 4. *A chart showing how the field trip components in our project align with the BC Grade 9 curricula (British Columbia Ministry of Education, 2016b). The chart is meant to be used by teachers or field trip leaders to identify which components of the curriculum is being incorporated into the field trip they will take at the Delta Nature Reserve. Through self-assessment, the chart shows that the majority of the learning goals outlined in the Grade 9 curriculum will be addressed in at least one aspect of the field trip.*

IIIc. Grade 10 Field Trip Module

Students in this grade learn about the concept of natural selection as well as the classification of native and invasive species (British Columbia Ministry of Education, 2016a). Research and fieldwork skills are expected to be more developed at this age (British Columbia Ministry of Education, 2016a). Students are encouraged to work both collaboratively and individually, be able to identify and explore more complex relationships in data, and communicate their findings using appropriate scientific language (British Columbia Ministry of Education, 2016a).

There is also an emphasis on Indigenous perspectives on energy use and conservation (British Columbia Ministry of Education, 2016d). We demonstrated how aspects of our field trip align with the more complex Grade 10 curriculum needs in the learning matrix located below (Fig. 5).

Grade 10 Science Learning Goals	Field Trip Components: Pre-field trip Worksheet	Data Collection + Analysis (ie. Plant and Soil Survey)	Outdoor Experience
Planning and Conducting Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data		✓	
Collaboratively and individually plan, select, and use appropriate investigation methods, including field work and lab experiments, to collect reliable data (qualitative and quantitative)		✓ *Students will not plan experiments*	
Assess risks and address ethical, cultural and/or environmental issues associated with their proposed methods and those of other		✓	
Processing and Analyzing Data and Information Experience and interpret the local environment		✓	✓
Apply First Peoples perspective and knowledge, other ways of knowing, and local knowledge as sources of information	✓		✓
Seek and analyze patterns, trends, and connections in data, including describing relationships between variables (dependent and independent) and identifying inconsistencies		✓	
Construct, analyze and interpret graphs (including interpolation and extrapolation), models and/or diagrams		✓	
Use scientific understandings to identify relationships and draw conclusions	✓	✓	
Analyze cause-and-effect relationships	✓	✓	
Evaluating Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled		✓	
Demonstrate an awareness of assumptions, question information given, and identify bias in their own work and secondary sources		✓	
Consider social, ethical, and environmental implications of the findings from their own and others' investigations		✓	
Critically analyze the validity of information in secondary sources and evaluate the approaches used to solve problems			
Applying and Innovating Contribute to care for self, others, community, and world through personal or collaborative approaches			✓
Contribute to finding solutions to problems at a local and/or global level through inquiry		✓	
Transfer and apply learning to new situations		✓	
Communicating Communicate scientific ideas, claims, information, and perhaps a suggested course of action, for a specific purpose and audience, constructing evidence-based arguments and using appropriate scientific language, conventions, and representations	✓	✓	
Express and reflect on a variety of experiences, perspectives, and worldviews through place	✓	✓	
Content First Peoples perspectives on energy: energy use and conservation include generational roles and responsibilities	✓		
Implications: positive and negative impacts, including environmental, health, economic	✓		

Figure 5. *A chart showing how the field trip components in our project align with the BC Grade 10 curricula (British Columbia Ministry of Education, 2016a). The chart is meant to be used by teachers or field trip leaders to identify which components of the curriculum is being incorporated into the field trip they will take at the Delta Nature Reserve. Through self-assessment, the chart shows that the majority of the learning goals outlined in the Grade 10 curriculum will be addressed in at least one aspect of the field trip.*

IIId. Post-Field Trip Analysis

The post-field trip worksheet (Appendix Fig. D) includes analysis of the students' soil pH measurements. Preliminary results show that pH in the bog portion of the Delta Nature Reserve is quite low, but there is overlap with other areas and variation can be quite high, especially in the cedar grove near the bog (Fig. 6). Analyzing these data in isolation could be insufficient to teach students about soil chemistry and the larger picture of the bog itself, but identifying patterns in the area, informed by plant surveys and knowledge of how bogs function, could still provide valuable insight into relationships between environmental variables. Contributing to a long-term data set, including data from multiple schools and grades, would provide the opportunity for more rigorous analysis of results and evaluation of seasonal patterns, human error and more. More details on the establishment of a collective database will be discussed below in the Discussion. As it is, this aspect of the module is currently focused on allowing students to conduct scientific testing and surveying, critically analyzing their results in light of all they learned during and before the field trip, and incorporating necessary aspects of specific science curricula.

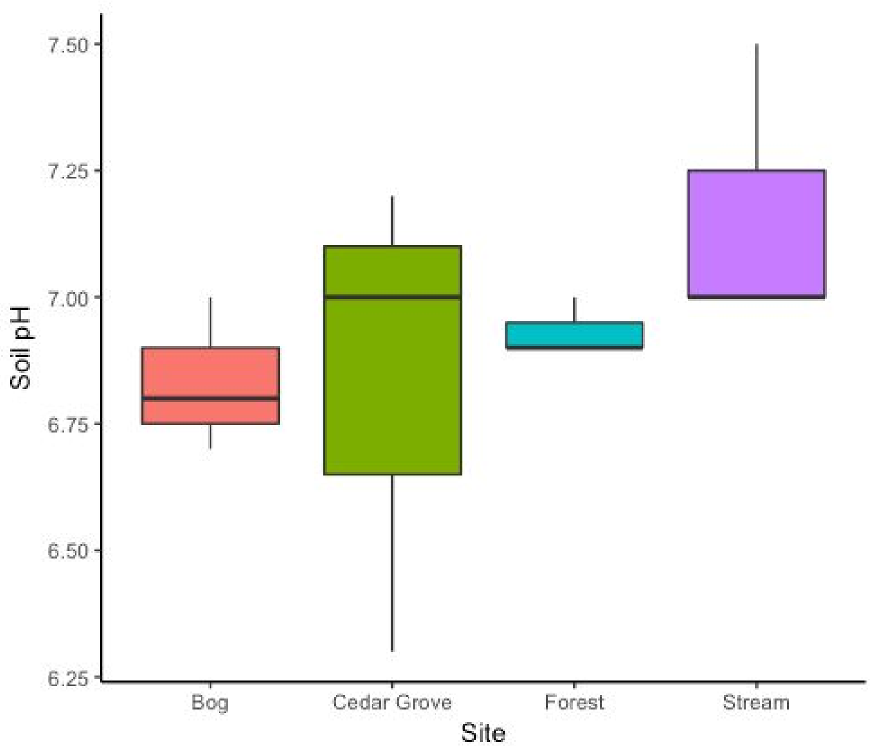

Figure 6. *Preliminary data from our own soil sampling from different sites along the Delta Nature Reserve boardwalk, depicting a range of soil pH values at the four sites in Figure 2. These sites depict four ecologically distinct areas: a bog, a cedar grove, a mixed forest, and a streamside area. Students will use the data they collect during the field trip to formulate graphs like this with the help of their teacher. They will then draw conclusions based on the figures, statistics run on the figures, their personal observations at Burns Bog, and what they learned during and before their field trip. Creating and analyzing these figures will give students the opportunity to think critically about their findings, as well as contribute to a larger database shared amongst high schools, while linking the results of soil testing with plant surveying results and their learning at the bog to enhance their understanding of the different systems and the biology/ecology of Burns Bog.*

IV. Discussion

Overall, our field trip module aligns with a majority of environment-related themes specified in the curricula for grades 8 to 10 (Figs. 3-5). In terms of content, our soil testing activity covers topics such as the effect on chemistry on nutrients (Grade 8) and the importance of sustaining the conditions of an ecosystem (Grade 9). Our plant identification activity addresses themes of natural selection, such as adaptations and invasive species (Grade 10). Both field activities encourage accurate data collection and analysis, identification of patterns, and reflection on the implication of student findings, all of which are key curricular competencies outlined in Science 8, 9 and 10. In addition, the discussion prompts included in the worksheets are based on suggestions from BC's Ministry of Education educational resource, "Shared Learnings: Integrating BC Aboriginal Content K-10" (BC Ministry of Education, 2006) on how to incorporate Indigenous ways of knowing into the BC Science curriculum, and the pre-field trip worksheet includes an activity adapted from Henley (1996) that incorporates Indigenous perspective. Combining scientific techniques with Indigenous content gives students both research experience and a personal connection to the area in which they conducted that research, which could foster future interest.

Preliminary data collection (Fig. 6) conducted by us (ie. the authors) using our proposed methods, supplies, and worksheets along the Delta Nature Reserve boardwalk indicate that students will be able to access and collect data at the locations we have chosen (Fig. 2). The four selected locations are meant to highlight the variation in the ecosystem as students transition from the forested part of the reserve into the bog proper, and to help promote observation and discussion about the causes of the change in the environment. Some expected student observations as the class moves closer to the bog proper include a decline in forest canopy, shorter trees, spongy soil, change in the dominance of certain plant species, and more acidic soil pH. By focusing on soil science and plant surveys, students are able to conduct real science alongside the standard tour, and ideally become interested in scientific fields. With affordable equipment, generous prices provided by the Burns Bog Conservation Society and integral curriculum content, this module should appeal to high school teachers throughout the Lower Mainland.

Future steps for our field trip module design that will extend beyond the timeline of the course include further data collection at our field activity sites, potentially using different types of soil meters to evaluate the effectiveness and accuracy of our proposed equipment. In addition, there may be future opportunities to pilot our field trip design with different high school classes from the Lower Mainland area to gauge student interest and level of understanding of the content being delivered.

The soil measurement results from our post-field trip worksheets and the data collected by students during the field trip can also be further developed into a shared database that can be utilized by the Burns Bog Conservation Society and participating high school classes. This could allow science teachers to access greater quantities of data that could be used for post-field trip analyses back in the classroom. This could give students the opportunity to observe variables such as soil pH patterns both spatially and temporally as field trips occur throughout the year. The Burns Bog Conservation Society can also use the data collected as a means of monitoring soil conditions over different periods of time. There is currently a plant monitoring program at Burns Bog, where observations of plant species and their life cycle stage as well as weather conditions and sun exposure can be submitted online into a spreadsheet (http://www.burnsbog.org/plantmonitoring/). This could serve as a potential platform on which to base the design of our proposed soil pH database and the way in which information can be submitted and accessed by different schools. Other potential database creation tools may include a simple shared Google Drive, or the utilization of other file sharing software such as 'Samepage' (https://www.samepage.io/), 'Tresorit' (https://tresorit.com/), 'Box' (https://www.box.com), and 'Citrix ShareFile' (https://www.sharefile.com), depending the budget and needs of the Burns Bog Conservation Society.

V. Conclusion

Our field trip module design appears to align with environment-related content and skills outlined in the BC curricula for grades 8 to 10, as determined through our self-assessed matrix analysis comparing the information in our field trip activities to specific learning objectives from the curriculum. Our field trip activities provide students with opportunities to engage hands-on with scientific concepts through our soil pH sampling and plant identification in various locations at the Delta Nature Reserve. The field trip highlights cultural and ecological aspects of Burns Bog through the inclusion Indigenous perspectives in the pre-field trip worksheet, observation of native and invasive plant species in the plant identification field activity, and soil chemistry changes in the soil pH measurement activity. Lastly, our field trip involves the use of place-based learning, a concept also highlighted in the redesigned BC curricula, through the implementation of field activities that give students opportunities to interact with an aspect their local environment (i.e. the bog ecosystem).

The results of our project imply that our field trip design is able to meet the learning standards set by the BC Ministry of Education, specifically for students in grades 8 to 10, and has the potential to engage students with ecological and Indigenous cultural aspects of Burns Bog. However, our greatest uncertainty is that our field trip has not yet been piloted with students in our target grade levels. To be able to do so would allow us to better gauge student interest in our proposed activities. Nevertheless, the benefits associated with our field trip include providing students with the opportunity to learn about the characteristics of a bog ecosystem and the significance of Burns Bog to the Indigenous groups that historically occupied the land. In addition, students are introduced to data collection using scientific equipment as well as data analysis and critical thinking. We believe that the minimal required supplies, low cost, and interactive nature of our design will make the field trip accessible and appealing to both educators and students. Overall, our general recommendation is that utilizing the activities and worksheets we have provided will help make the current generalized field trip presented by the Burns Bog Conservation Society more targeted towards the needs of BC students in grades 8 to 10.

VI. Acknowledgements

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VIII. Appendix

Name:_______________
Date:_______________

Pre-Field Trip Worksheet for Grade 8

Learning goals:

- Introduce the ecosystem of Burns Bog, highlighting its ecological and historical importance.
- Acknowledge First Nations history and land rights in Burns Bog and share knowledge (provided with permission where necessary) on Aboriginal uses for bog plants and stories associated with Burns Bog.
- Introduce field activities to be performed during the field trip.

Introduction to Burns Bog

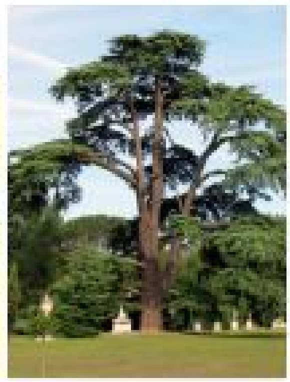
Burns Bog is the largest raised peat bog on the West Coast of North America and is situated on the delta of the Fraser River. It is a globally unique ecosystem that acts as a major regulator of regional climate and air quality, earning it the nickname "the Lungs of the Lower Mainland". At 3,000 ha, Burns Bog eight times the size of Stanley park and is the largest undeveloped urban wilderness in North America!

Ecological Importance

Burns Bog is home to many rare and endangered species, such as the Great Sandhill Crane and Southern Red-backed Vole. The Bog provides natural corridors and refuge for wide-ranging species, such as birds - so they can rest, nest, or digest food in a safe place. The plants and animal species that reside in the Bog contribute to its biodiversity. Due to its acidic and nutrient poor soil, the Bog can only support the growth of certain organisms that cannot survive elsewhere. In this field trip, we will exploring the soil chemistry throughout the Bog and looking at different types of plants that thrive under these conditions.


An image of a Great Sandhill Crane (Left) and a Southern Red-backed Vole (Right).

The Delta Nature Reserve is meant to be representative of Burns Bog, which is itself inaccessible in order to protect its environmental integrity. Within the reserve, there is not only bog, which contains plants such as Labrador tea and sphagnum moss, but also stream environments, a cedar grove, and other forested areas. The diversity of plant communities found in such a relatively small area provide ideal learning opportunities.



An image of sphagnum moss (left) and a cedar tree (right).

First Nations and Burns Bog

Historically, the bog was within the traditional use areas of multiple First Nations groups that used the land to hunt large mammals for food, and gather plants for medicinal and ceremonial purposes. Aboriginal groups that historically used the land are the Tsawwassen, Semiahmoo, Musqueam, Katzie and Sto:lo bands. A close connection to the land permeated all aspects of life for these groups, and they used plants for food, medicinal purposes and to craft clothing, canoes and shelters. In addition to the many uses for plants and animals in the bog, Aboriginal groups forged connections to the land through storytelling.

Activity #1: Aboriginal Storytelling

With permission, an elder or knowledgeable person from one of the Aboriginal groups mentioned above may provide a story about Burns Bog either in person or through video. No story is currently available to include in this worksheet, but providing one to students will ideally deepen their sense of place, get them interested in Burns Bog and make them care more about the bog and the environment overall.

Activity #2: Plants and Associations

Aboriginal groups used many different kinds of plants found within Burns Bog for medicinal purposes, including Labrador tea, western bog laurel and sphagnum moss. They also used plants for a variety of other uses, and

Break the class into groups, and ask them to discuss the following questions:

- How Aboriginal peoples knew which plants and roots to use and how to use them?
- What are some other uses for plants found in Burns Bog beyond food and medicine?
- How might the ways Aboriginal peoples viewed a bog or forest differ from how you see these places?

Bring the class back together and ask them to share their answers, leading a discussion focusing on the sense of place Aboriginal peoples experienced and how important many different aspects of the bog could be to people.

Then ask the students to think of answers for the following association list. The way this game works is that you provide a description of something; for example, something that squirrels eat. The students then must come up with things in a bog that squirrels eat, which could be acorns, mushrooms or berries. Students must use their imaginations, and can look for their answers during the field trip itself. Answers before the field trip may be generic, and they may not be able to come up with all the correct answers. Encourage students to keep this activity in mind during the field trip, encourage questions, and potentially provide a follow-up after the field trip to see what students learned. A suggested list, with potential answers in brackets, is provided.

- Something squirrels eat (mushrooms, berries, acorns, seeds)
- Materials that can be used to make canoes and paper (cedar, birch)
- Something that holds water like a sponge (sphagnum moss)
- Structures that perform photosynthesis (leaves, needles)
- A plant whose leaves can be made into a tea to help cure colds (Labrador tea)
- Something that engineers the bog ecosystem (sphagnum moss)
- Places where animals can make their homes (holes in trees, holes in the ground, logs)
- Places where you can find insects (everywhere, but especially streams and logs)
- Something of zero value (nothing natural!)

Field Trip Preparation

During the field trip, students will be asked to perform soil testing (pH) and conduct plant identification surveys. Provide the students with the sheets they will use in the field (see below), and walk them through the sampling protocol, answering any questions. Demonstrate how to use a soil probe, and walk them through common plants in Burns Bog.

Figure A. *A pre-field trip worksheet for grade 8, to be completed in class some time before going on the field trip to Burns Bog. Students can work in groups to discuss questions and form associations, and will be well-informed about the history of Indigenous presence in Burns Bog. The Plants and Associations activity is developed from an activity listed in Rediscovery: Ancient Pathways, New Directions (Outdoor Activities based on Native Traditions) by Thom Henley (1996).*

Name:______________________

Date:______________________

Field Activity: Plant Identification Worksheet

Learning Objectives:

- Allow students to practice relevant skills related to biology and environmental science (ie. plant identification, data collection)
- Observe, measure, and record data (qualitative and quantitative) on native and invasive species
- Experience and interpret the local environment and identify any significant relationships between organisms within it.

Definitions:

Native Species:

Invasive Species

Identify: Pictures of the plants are located on the last page of this worksheet for some guidance.

Native Species

Plant #	Plant Name	Location	Description (ie: colour, height, flowers, berries, thickness, hairy)
1.	Salal (*Gaultheria shallon*)		

2.	Labrador Tea (*Ledum groenlandicum*)		
3.	Skunk Cabbage (*Lysichiton americanum*)		
4.	Hardhack (*Spirea douglasii*)		
5..	Salmonberry (*Rubus spectabilis*)		

Invasive species

Plant #	Plant Name	Location	Description (ie: colour, height, flowers, berries, thickness, hairy)
1.	Himalayan Blackberry (*Rubus discolor*)		

2.	Bittersweet Nightshade (*Solanum dulcamara*)		
3.	Himalayan Balsam (*Impatiens glandulifera*)		

Discussion Questions:

1) Why do you think some areas have more invasive plants than others? How did this pattern emerge?

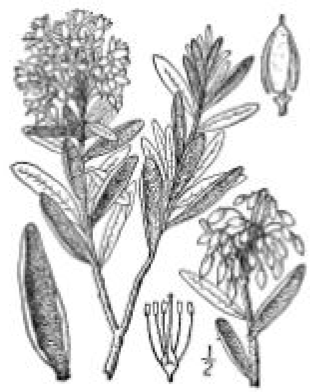
2) What do you think are some long-term consequences of invasive species continuing to grow unchecked?

3) What possible solutions can you suggest about how to/mitigate the impact of invasive species on the bog ecosystem?

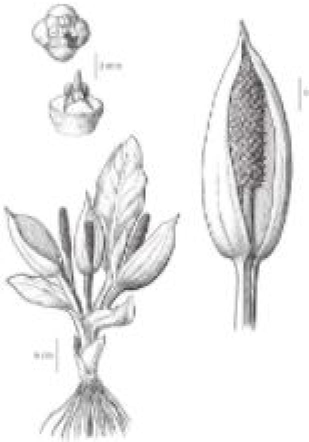
4) What might be a reason for some patterns you see in the plant life distribution? Patterns include abrupt changes in dominant plant species within a region.

<u>Pictures</u>
Native Species

1.



2.



3.

4.

5.

Invasive Species

Himalayan blackberry
Rubus armeniacus

1.

Solanum Dulcamara

2.

3. *Impatiens glandulifera*

Figure B. *The plant identification worksheet that will be supplied to students. Students will fill out the charts and use the pictures in this worksheet to help identify native and invasive species located around different areas of Burns Bog.*

Name:____________________
Date:____________________

Field Activity Data Collection Sheet: Soil Composition

Instructions: With your group, go to each site and take measurements of the soil pH using the probes given to you. Make sure to record the transect and point numbers. Write down additional comments about the characteristics of the soil (ie. What plants are growing there? What colour is it? Texture? etc.)

FACT:
Sphagnum moss grows in acidic conditions and makes its conditions more acidic as it grows and multiples! How do you think this affects the soil pH?

Group Number: ____________________________
Date and Time: ____________________________
Weather (ie. sunny, cloudy, light rain): ____________________________________

Site 1 (Stream Area)

Transect #	Point #	Soil pH	Observations

Site 2 (Between 1st Entrance and Hardhack Meadow)

Transect #	Point #	Soil pH	Observations

Site 3 (Hardhack Meadow)

Transcect #	Point #	Soil pH	Observations

Site 4 (Cedar Grove)

Transect #	Point #	Soil pH	Observations

Discussion Questions

1. Compare and contrast the soil pH at all four sites:

2. What do you notice about the pH readings across the four sites? Is there a trend?

Figure C. *This worksheet accompanies the soil pH activity and will be distributed to students during the field trip. The worksheet contains charts that help organize the students' answers through charts and contains discussion questions to help encourage critical thinking.*

Name: ____________________

Date: ____________________

Post-Field Trip Worksheet

1. Using the data that you collected on soil pH, determine the average soil pH for all four locations. Put your answers in the chart below.

Location	Average soil pH
1	
2	
3	
4	

2. Graph your data. Do you notice any trends in soil pH throughout different locations in the Bog?

Figure D. *A post field trip worksheet that students will be asked to complete in class. Students will take the average of their soil pH readings, graph their findings, and determine is any trends are present.*

FIELD TRIP SOIL SAMPLING OVERVIEW
Activity #1: Soil pH

Overview:
In groups, students will be given soil probes and instructed to collect pH and moisture readings in several locations throughout the bog. They will then evaluate their results and analyze patterns in their findings.

Objectives:
- Give students the opportunity to conduct scientific testing in an outdoor education setting.
- Use appropriate equipment to systematically and accurately collect data related to soil properties in the Bog.
- Analyze patterns, trends, and connections in data and identify inconsistencies.
- Use scientific understanding to identify relationships and draw conclusions about soil properties in the bog.

Required Materials:
- Soil pH probes
- Data collection sheet printed on “Rite in the Rain” paper

Timeline:
During the activity (Total: 60 minutes):
- 15 minutes: Introduction to activity, explanation of instructions, and distribution of instruments
- 30 minutes: Data collection at 4 locations
- 15 minutes: Discussion of findings

Introduction to activity, explanation of instructions, and distribution of instruments (15 minutes)

Here we will stop to begin our first data collection activity: Soil pH Measurements.

Please split into groups of 5 or 6. Each group will receive a soil probe and data collection sheet.

This device is meant to take measurements of different characteristics of soil, such as pH and moisture level. The pH scale (a range of numbers from 0 to 14) is a measure of how *acidic* or *basic* a liquid is. In this case, the liquid we are measuring is the water found within the soil.
Ask students to give examples of acids and bases (e.g. stomach acid, battery acid, orange juice, baking soda, cleaners, detergents, etc.)

A pH between 0 and 6 indicates that the soil water is more acidic, and a pH between 8 to 14 indicates the soil water is more basic. A pH of 7 indicates that the soil water is neutral, like drinking water.

We will be stopping at 4 different locations during this field trip for you to take soil measurements. At each stop, your group will measure the pH of the soil using their probe.
Demonstrate how probe works: ensure knob is switched to pH, insert probe into few inches into soil, and read the pH shown by the needle on the probe’s dial

Besides recording the pH, also make observations about the characteristics of the soil (e.g. colour, texture, moisture) and its surroundings (e.g. what kinds of plants and trees are growing in it). As we continue along the field trip, keep an eye out for any changes you may see in pH or the types of plants you see.

Data Collection at 4 Locations (30 minutes)

Discussion of findings (15 minutes)

To ask after last soil measurement site: (Stop 4)

1. Do you see a trend in the pH values, and how does this pattern tie in with what you have already learned about bogs in general?

Ideally, should see soil becoming more acidic as we get closer to the bog proper; bogs are known to be acidic, wet and low in nutrients (info presented at stop 1)

2. What do the acidic characteristics of the soil mean for vegetation residing in the bog?

Plant growth and most soil processes, including nutrient availability and microbial activity, are favoured by a soil pH range of 5.5 – 8. Acid soil, particularly in the subsurface, will also restrict root access to water and nutrients.

Types of vegetation we see in more acidic soil are limited to those that can survive acidic environments → concept of adaptation (in curriculum)

3. What are 2 consequences of human activities on peatlands, such as Burns Bog? Explain why each consequence is an issue.

Artificial drainage, the draining of moisture from the saturated peat, is commonly practiced on peatlands. Draining is generally regarded as the first essential activity before attempting to develop the peatland in any way. The main long-term effect of drainage is to re-shape the bog itself, with major implications for water, carbon and biodiversity, yet this reshaping is rarely recorded or monitored. (peatlands hold 550 gigatonnes of carbon globally)

Tree plantations also have impacts on the biodiversity of peatlands not merely through direct habitat loss, but also through modification of adjacent habitat (the edge effect) and through the introduction of alien predators.

FIELD TRIP PLANT IDENTIFICATION OVERVIEW
Activity #2: Plant Identification

Overview:
Students will practice how to identify native and invasive plant species located throughout the bog and record their findings on an identification worksheet.

Objectives:
- Give students the opportunity to experience and interpret the local environment.
- Use scientific understanding to identify relationships and draw conclusions.

Required Materials:
- Data Collection Worksheet
- Plastic Bag

Introduction

Over the course of the field trip, we will also be doing a plant identification activity. Please take note of the different types of plants shown on your worksheet before we embark and keep an eye out for these plants. As we make our different stops along the trip today, be sure to write down the location of the plants that are listed in the worksheet, make any notes about their appearance (e.g. colour, height, flowers) and come up with an estimate of their abundance (ie. Are there a lot of this particular plant relative to the surrounding/other plants?). Near the end of the field trip, we will stop to discuss your observations, and make connections to the soil observations.

Please ask students to define the terms NATIVE and INVASIVE species

Native species: native species are species that have historically occurred as part of an ecosystem in a specific location

Invasive species: An invasive species is a plant, fungus, or animal species that is not native to a specific location (an introduced species), and that has a tendency to spread to a degree believed to cause damage to the environment, human economy or human health

Ask the questionnaire at stop 4.

Questionnaire:

1) Why do you think some areas have more invasive plants than others? How did this pattern emerge?

Invasive plants can outcompete native plants for resources (e.g. nutrients, light); once an invasive species is introduced to an area, it may possess certain characteristics that give it survival advantage over other natives species, allowing rapid proliferation.

2) What do you think are some long-term consequences of invasive species continuing to grow unchecked?

Eventually, invasive species may outcompete native species and cause local extinction of that native species. This may result in a loss of biodiversity within the area, and negatively impact other types of plants and animals that may rely on this native species for food or habitat.

3) What possible solutions can you suggest about how to mitigate the impact of invasive species on the bog ecosystem?

- Clean vehicles, equipment and gear (certain surfaces may be able to hold onto invasive plant seeds) to prevent the spread of seeds/spores
- Make living conditions less desirable for invasive plants (e.g. chemical or manual removal of invasive species and replanting with native species)
- Regular maintenance/monitoring of the area

4) What might be a reason for some patterns you see in the plant life distribution? Patterns include abrupt changes in dominant plant species within a region.

Although the soil conditions (pH or moisture) may change slowly and continuously, some species can only tolerate a particular range of conditions. Once the soil is no longer within this range, that particular species will no longer thrive outside the in-range zone, and we may see a drastic decrease in relative plant abundance for that species.

Figure E. *Shown above is a script that educators can use to guide the execution of the field activities contained in this project. For each activity, the educator is given an introduction to explain the activity to students, the learning objectives in relation to science curriculum needs, any required materials, and discussion questions to ask the students.*