STANLEY PARK ECOLOGY SOCIETY

Beaver Lake Bog Restoration Report

Date: 24 January 2012

Table of Contents

Figures and Tables

Beaver Lake Bog Background

The small bog adjacent to Beaver Lake on its southern edge is representative of a rare and sensitive habitat. In a 1997 report from the Beaver Lake Bog Committee of BLEEP, the bog's boundary was defined as the area covered by Labrador tea (*Ledum groenlandicum).* The bog was then 15.25 m by 34.35 m in area and approximately 2 m deep (BLEEP, 1997). It was said to have three small paths running through it and contained mainly salal, Labrador tea, hardhack (*Spireae douglassii*), sphagnum moss, and characteristic round-leaved sundew.

Studies by Capilano College Environmental Science students the following year were aimed at providing baseline data for long-term monitoring of the bog. They carried out a sampling program to determine plant species composition and soil water characteristics such as depth and pH (Worcester, et al., 1998). Despite the presence of bog plants throughout their three study areas, the students determined that it was not a true 'bog' but more of a 'mire' according to the Canadian Wetland Classification System. This was due to the fact that the area is supplied with water from the lake and not solely from rainwater, and because of the underlying layers of decomposed plant material rather than the typical base of fibrous peat (Worcester, et al., 1998). They concluded that what now exists at Beaver Lake is the remnant of a larger bog that once existed (prior to the Causeway being built). This is supported by earlier consultants' pollen core samples which show a decrease in sphagnum production over time (Worcester, et al., 1998). The students also found that the area of the bog that contained unsanctioned trails had major differences from those sites that did not. The trails had negative impacts such as the compaction of sphagnum moss and the matting of the shrub layer, as well as the positive effects of creating light openings that allowed for the growth of round-leaved sundew plants (Worcester, et al., 1998). In fact, the trail edges were the only place where sundew was found. The groups also found that the bog was disappearing from encroachment by terrestrial species such as trees and shrubs. The group made several recommendations including:

- the use of boardwalks as an interpretive opportunity and a way to stop unsanctioned trails while maintaining sundew habitat,
- the completion of future monitoring using similar techniques to assess the disappearing bog.

Today these sections of the bog are still intact, but at risk of disappearing due to the influx of small trees and other terrestrial plants such as salal. Round-leaved sundew, Labrador tea and sphagnum moss are still present, but salal and western hemlock are becoming the dominant species. Future enhancement efforts should include the removal of some of the western hemlock trees as well as salal to prevent the bog from turning into a forested habitat.

The State of the Park Report for the Ecological Integrity of Stanley Park (SOPEI) released by SPES in 2010 indicated that sections of the bog were still intact, but still at risk of disappearing due to the influx of small trees and other terrestrial plants such as salal. In 2009, SPES staff created three small restoration test patches to see if sundew growth would increase with the removal of competing salal and Labrador tea. After a couple growing seasons it seems that the test patches were working well and had helped improve conditions in those areas.

In January 2011, the Vancouver Park Board approved the Ecological Action Plan for Stanley Park created as a result of the SOPEI report, and which included the restoration of Beaver Lake's bog. At the meeting, 12 year old Young Naturalist Club member, Maja Lampa, spoke in support of the plan along with Laurence Brown, a representative from the Camosun Bog Restoration group. They both expressed interest in helping out with the restoration efforts. Since that meeting, SPES staff met with Park Board staff, Maja, and the Camosun Bog Restoration group to plan the restoration process which began in the spring of 2011.

Project Summary

This project will accomplish restoration of the Stanley Park Bog, a sphagnum-peat ecosystem hidden off the southwest corner of Beaver Lake that supports rare species that are integral to wetland biodiversity. As well as direct, manual restoration work that includes removing encroaching species, and subsequently repopulating with native bog plants, the project will deliver a comprehensive abiotic and biotic inventory; will engage community with education and skills-training; will produce baseline mapping and a monitoring strategy and best-management plans for species for the broader watershed. The breadth of the project activities will be to:

1. Work strategically with the Vancouver Park Board (VPB) to accomplish first actions of the newly approved Stanley Park Ecological Action Plan.
2. Restore Stanley Park bog's size and habitat values by removing encroaching trees and shrubs and by planting and transplanting bog plants.
3. Prepare the bog site for a boardwalk.
4. Create current map layers and make them available for management and restoration purposes.
5. Undertake a detailed inventory and photo documentation of the bog to gather baseline information and track changes in its extent and ecological health since earlier surveys. Document as a report.
6. Involve community groups and individuals in hands-on bog restoration and educate public, youth and students through walks, displays and social media.

Project Rationale

In April 2010, culminating two years of extensive research and analysis, SPES released the first ever State of the Park Report for the Ecological Integrity of Stanley Park (SOPEI), which describes everything thus far known of the biotic and abiotic ecosystems of Stanley Park, trends in its ecological integrity, and relevant stress factors. It was clear that aquatic systems are in trouble and in decline.

Informed by the clarity of the SOPEI report, the Vancouver Park Board Commissioners tasked their staff to identify priority areas of concern with actions for remediation. Since July 2010, therefore, SPES has been integral to a park staff working group to identify five key restoration areas, the largest and most critical of which pertains to the reclamation of Stanley Park's aquatic systems, and most specifically Beaver Lake and its rare Bog environment. This unique heritage watershed of the city provides recreational, aesthetic, spiritual, educational, and historical benefits among other human-centric values, as well as critical habitat for a tremendous biodiversity of wildlife including fish, aquatic insects, amphibians and reptiles, aquatic and terrestrial flora, songbirds, birds of prey, and even mammals such as otters and beavers.

Studies done by external consultants in the 1990's and confirmed by recent aerial photos indicate that rapid infilling of the lake by organic invasive plants and/or inorganic materials introduced by human-induced factors including trail edging and the creation of the Causeway in the 1930's will cause Beaver Lake to succumb to a marsh and meadow environment within the next 10-20 years if not intercepted, and the Bog is disappearing even more quickly. As Stanley Park is now an island wilderness that cannot repopulate through natural species immigration and migration, if we lose this most important of Vancouver's wetlands, we will lose irreplaceable biodiversity.

The global issue facing bogs/peatlands is their destruction. Over 50% of the earth's wetlands are bog ecosystems, yet they are internationally considered threatened (International Mire Conservation Group, 1984). On the global scale, bogs are tremendously significant as carbon sinks, and act to mitigate Climate Change. In 2007, at a meeting organized by the "Ramsar Convention on Wetlands and the Convention of Biological Diversity (CBD), it was concluded that investments in conservation and restoration of peatlands (ie sphagnum bogs) can be up to 100 times more cost effective than other carbon sequestration measures." (Ahmed Djoghlaf, Executive Secretary of the CBD. Source: UN Press Release, 2007)

Restoring every little piece of sphagnum bog is critical to our planet's survival. In the Lower Mainland, machines are working through unprotected Burns Bog and returning carbon to the atmosphere and destroying habitat for rare and endangered wildlife.

Under Vancouver's Greenest City Action Plan: Restoring Ecological Services, a priority is given to the restoration and protection of wetlands, protection of endangered ecosystems and programs to control harmful invasive species. "Restoration of the Stanley Park peat bog will put the City of Vancouver in step

with governments in Ireland and the European Union which are spending millions of Euros in restoring and rewetting cutover peatlands" (Eliza Olson, President, Burns Bog Conservation Society).

Project Goals

To prevent the disappearance of the Beaver Lake bog, a unique habitat in Stanley Park and in Vancouver, and to protect and enhance the diversity of species and habitats currently existing in the Park.

1. Document the current state of the Stanley Park Bog and associated watershed components. The current state of the bog, including its extent and vegetation, will be documented through detailed surveys and photos prior to and following the restoration work. Maps and data collection will track the changes in the bog and the surrounding watershed so that restoration efforts can be measured and evaluated.

2. Restore the Stanley Park Bog. The aim is to repair this fragile ecosystem which is disappearing mainly due to human impacts on the surrounding landscape. Ecosystem Restoration will involve the removal of encroaching trees and shrubs and the planting and transplanting of native bog species into cleared areas by volunteers from established community groups as well as members of the public.

3. Educate the community and Park Managers about watershed values. Integral to this project is the goal of gaining community and park management support and involvement in the project. This will be done in part through educational programming and meetings that bring awareness to conservation issues concerning bogs and other watershed values and how our actions affect the ecosystems that support our community.

Project Objectives

1. Stop the incursion of non-bog plants into the existing bog area and remove trees and shrubs that have become established over time to the detriment of the integrity of the bog.

2. Increase the bog's size as much as possible given the constraints of its existing location and historic extent to maximize its valued habitat functions.

3. Gain more detailed information about the current bog status as a baseline of information to compare to following restoration efforts to be conducted by SPES and its volunteer base.

4. SPES intends to maintain and monitor the restoration work in the bog as part of its ongoing mandate to ensure the ecological integrity of Stanley Park.

5. To leverage project funding to attract matching funds from other sources for the betterment of the park.

Key Staff and Project Partners

- Robyn Worcester, SPES Conservation Programs Manager, has a diploma in BCIT's Resource Management: Fish, Wildlife, and Recreation program, a BSc in Biology from SFU, and is a Registered Professional Biologist (RPBio).

- Brian Titaro, SPES Conservation Technician, has credentials including Bachelor of Environmental Studies (Honours) in Environment and Resource Studies, a Diploma of Excellence in Ecological Restoration and Rehabilitation, and a Diploma of Environmental Assessment all from the University of Waterloo. He has an Environmental Professional in Training (EPt) certification from CECAB with specializations in Fisheries & Wildlife and Education & Training.

- Laurence Brown, BSc (Strathclyde), PhD (Glasgow) was a Professor in Materials Engineering at UBC from 1963-1992. He studied botany on retirement, receiving the Ney Award from Nature Vancouver in 2001. He co-founded the Camosun Bog Restoration Group in 1995 and has advised/assisted in a number of other bogs, including Langley Bog, Rithets Bog, Blaney Bog, Burns Bog, Lulu Island Bog.

- Maja Lampa, a 14 year old Young Naturalist who has successfully secured a City Green Action Award for Youth, which she submitted as a project to support the restoration & renewal of the Stanley Park Bog, with action and education for youth, in particular. Her mother, Kristine Webber, MSc Biology, is the Executive Director of Young Naturalists' Club of BC.

Project Supervisor:

- Alan Duncan, Environmental Planner for Vancouver Park Board. Author of Stanley Park Ecological Action Plan.

Part 1: Baseline Bog Inventory Report and Photo Documentation

Project Deliverable: Update baseline of information on the bog to monitor how it has changed over the past 10 years (since the first survey was conducted) and subsequent to the proposed restoration activities.

Prepared by: Robyn Worcester, SPES Conservation Programs

Date: by June 30, 2011

Studies by Capilano College Environmental Science students in 1998 aimed at providing baseline data for long-term monitoring of the bog. They carried out a sampling program to determine plant species composition and soil water characteristics such as depth and pH. They concluded that what now exists at Beaver Lake is the remnant of a larger bog that once existed (prior to the Causeway being built) (Worcester, et. al., 1998). The students also found that the area of the bog that contained unsanctioned trails had major differences from those sites that did not. The trails had negative impacts such as the compaction of sphagnum moss and the matting of the shrub layer, as well as the positive effects of creating light openings that allowed for the growth of round-leaved sundew plants. The groups also found that the bog was disappearing from encroachment by terrestrial species such as trees and shrubs (Worcester, et. al., 1998)..

Bog laurel in bloom June 2011.

Follow up surveys were conducted at the bog in June of 2011 by SPES staff along with Young Naturalist Maja Lampa. We could not conduct the quadrat surveys using the same methods and reference location as the previous group, because they forgot to include the compass bearing in their report. Instead we attempted to replicate the vegetation map of the bog they had made using manual techniques (see Figure 1).

The round-leaved sundew is a carnivorous plant that derives most of its nutrients from trapping and consuming insects such as this damselfly. These plants appear adapted to grow in places where the soil is poor in nutrients, especially nitrogen.

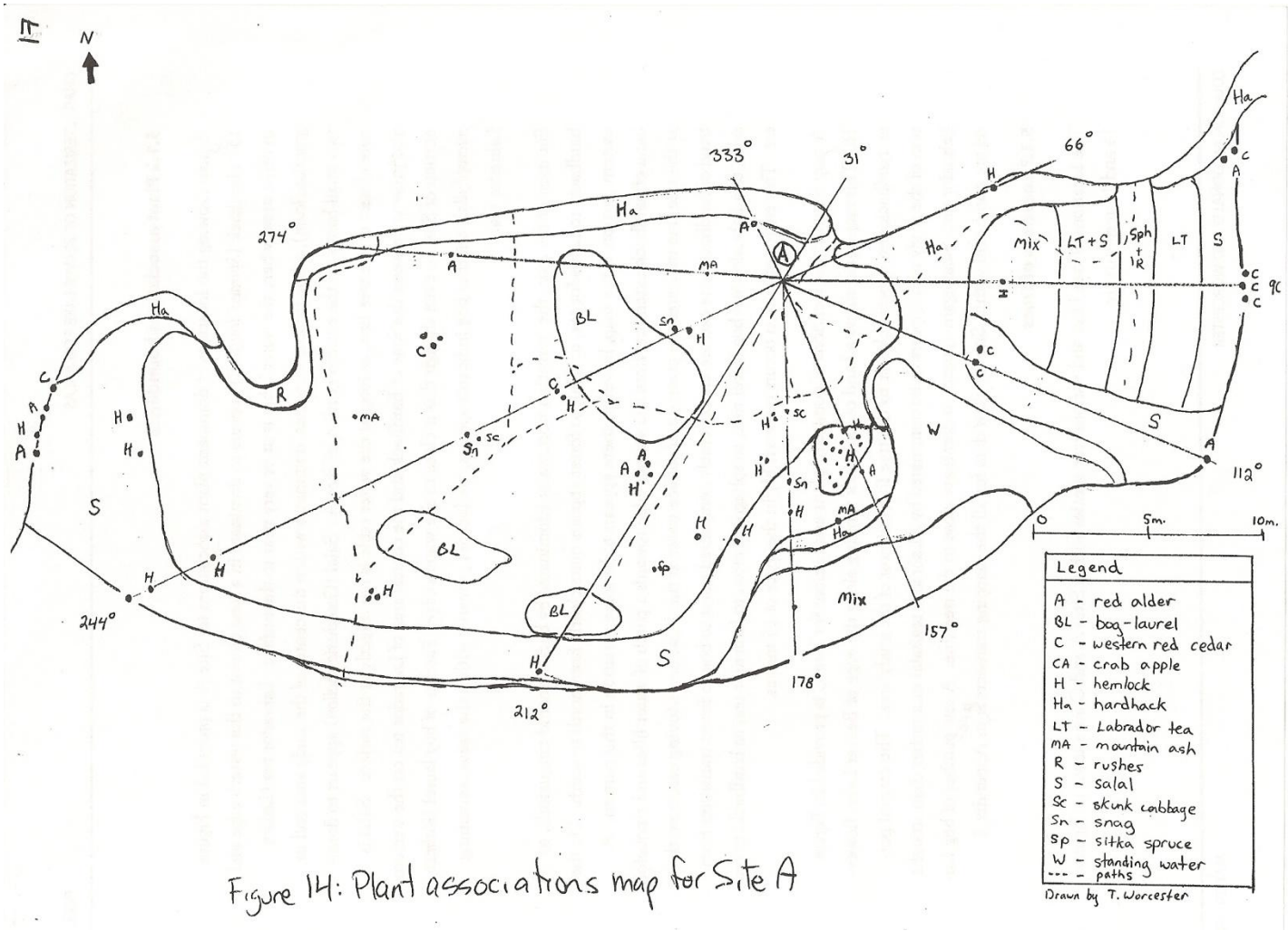


Figure 1: Bog area and vegetation map created in 1998 (Worcester, et. al., 1998).

We created a vegetation map, similar to the one done in 1998, to show the changes in the bog. We did this using a GPS unit and landmarks that were used in the original survey including larger trees and snags. The boarders of the bog were considered to be areas where the Labrador tea and sphagnum moss plants ended and terrestrial plants began. The majority of the bog, and all areas on the map that are not delineated as a particular type of vegetation, are a mix of Labrador tea, sphagnum moss, and encroaching salal plants (see Figure 2).

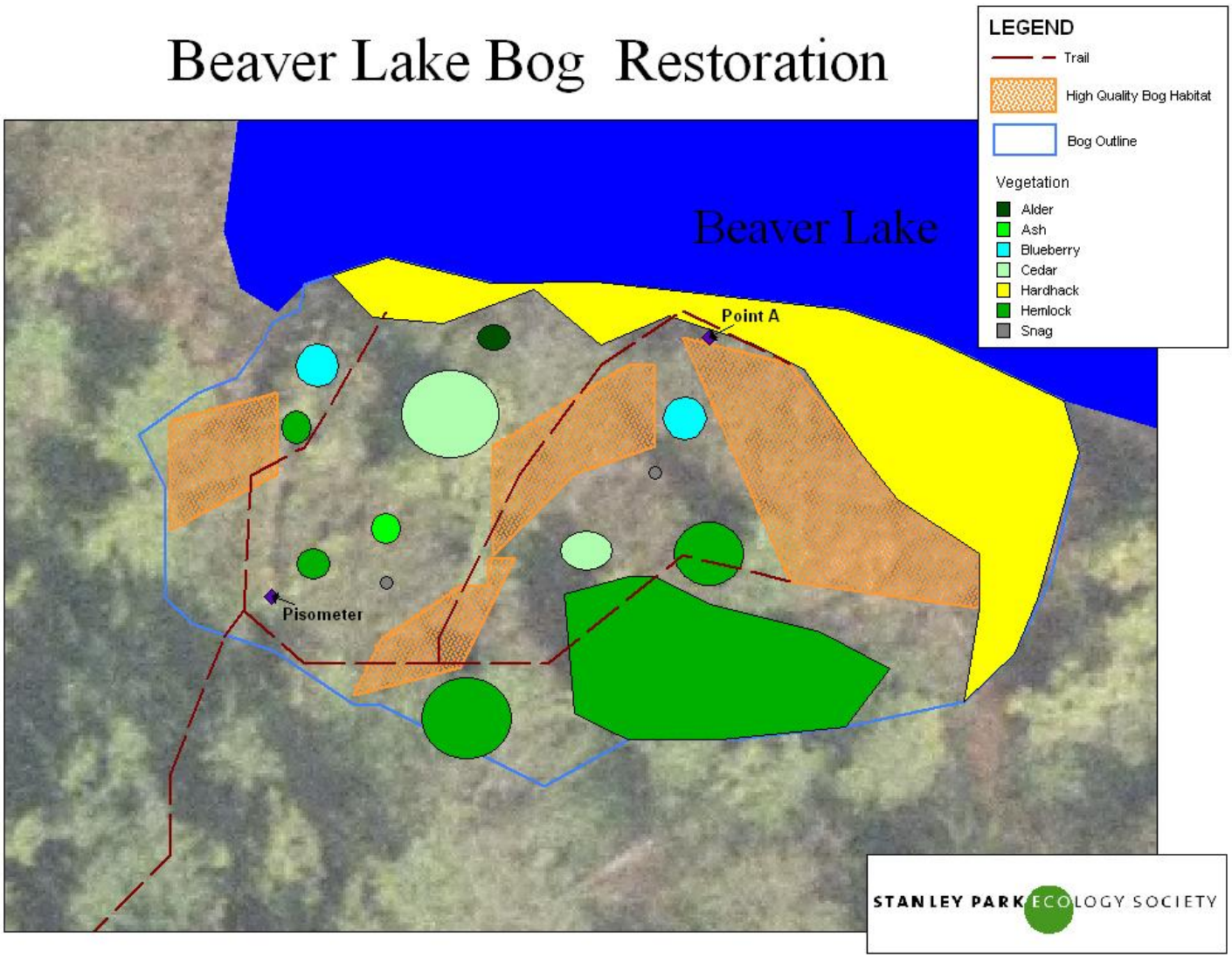


Figure 2: Bog area and vegetation map created in June 2011.

The current map of the bog as seen in Figure 2, shows some distinct changes to the bog area since the earlier study. In 1998, there were several large sections that contained predominantly bog laurel, but today there are only a small number of bog laurel plants scattered throughout those areas (see Figures 3 and 4). The 1998 map showed areas where there were several hemlock trees together on the southern edge of the bog, and today that area has been almost completely overtaken by a small stand of these trees (see Figures 5 and 6).

The southern edge of the bog, from which terrestrial salal plants are encroaching, has grown inward and the predominance of salal within the bog itself not believed to have been seen in 1998 (see figure 7 and 8). It is also believed that the hardhack on the eastern and northern edges of the bog has been encroaching. A full list of plant species observed can be found in Table 1.

Figure 3: View of bog, facing north, in 2002. Note the purple flowers of bog laurel and the white flowers of Labrador tea in the foreground.

Figure 4: View of bog, facing north, in 2011. Although the bog laurel was in bloom there are few plants left in this area.

Figure 5: View of bog, facing northeast, in 2002. Note the small cedar in the foreground.

Figure 6: View of bog, facing northeast, in 2011. Note the growth of hemlock trees, the increase in salal and the appearance of skunk cabbage.

Figure 7: View of bog, facing northeast, in 2002. Note that the predominant shrub vegetation is Labrador tea.

Figure 8: The same view of bog as in Figure 7 taken in 2011. Note that the predominant shrub vegetation is salal mixed with Labrador tea, the hemlock trees have filled in, and skunk cabbage has invaded (an indicator of nutrient rich soils uncharacteristic in bog habitats.

Table 1: Beaver Lake Bog Plant Inventory

Bog plants	***Terrestrial Plants***	***Wetland Plants***
Labrador tea *(Ledum groenlandicum)*	Western red cedar (*Thuja plicata)*	Skunk cabbage *(Lysichiton americanus)*
Bog-laurel *(Kalmia polifolia)*	Western hemlock *(Tsuga heterophylla)*	Yellow flag iris *(Iris pseudacorus) **invasive species*
Round-leaved sundew *(Drosera rotundifolia)*	Red alder *(Alnus rubra)*	Rushes *(Juncus sp)*
Peat moss *(Sphagnum sp.)*	Pacific crab apple *(Malus fusca)*	Marsh Cinqufoil *(potentilla-pallutris)*
	Hardhack (*Spiraea douglasii*)	
	Salal *(Gaultheria shallon)*	
	Alaskan blueberry *(Vaccinium alaskensis)*	
	European mountain ash *(Sorbus aucuparia)*	
	Horsetail sp. *(Equisetum sp.)*	

Trails existing in the bog were also mapped. We found that some of the trails identified on the earlier map had grown in, while new trails had emerged. Similar to the previous study, we found that Round-leaved Sundew plants grew mainly around the areas where trails had trampled the larger vegetation. These areas were identified as having particularly high habitat value and sensitivity to human disturbance and so were delineated in the field using flagging tape attached to stakes and are shown on the map in Figure 2 as “High Quality Bog Habitat”. These areas will be restored more sensitively than the surrounding Labrador tea-salal dominated areas.

In addition to mapping the vegetation our team also installed a piezometer to monitor changes in the water table. Soil pH and nutrient levels will also be monitored throughout the project. Table 2 outlines out current list of wildlife species using the bog.

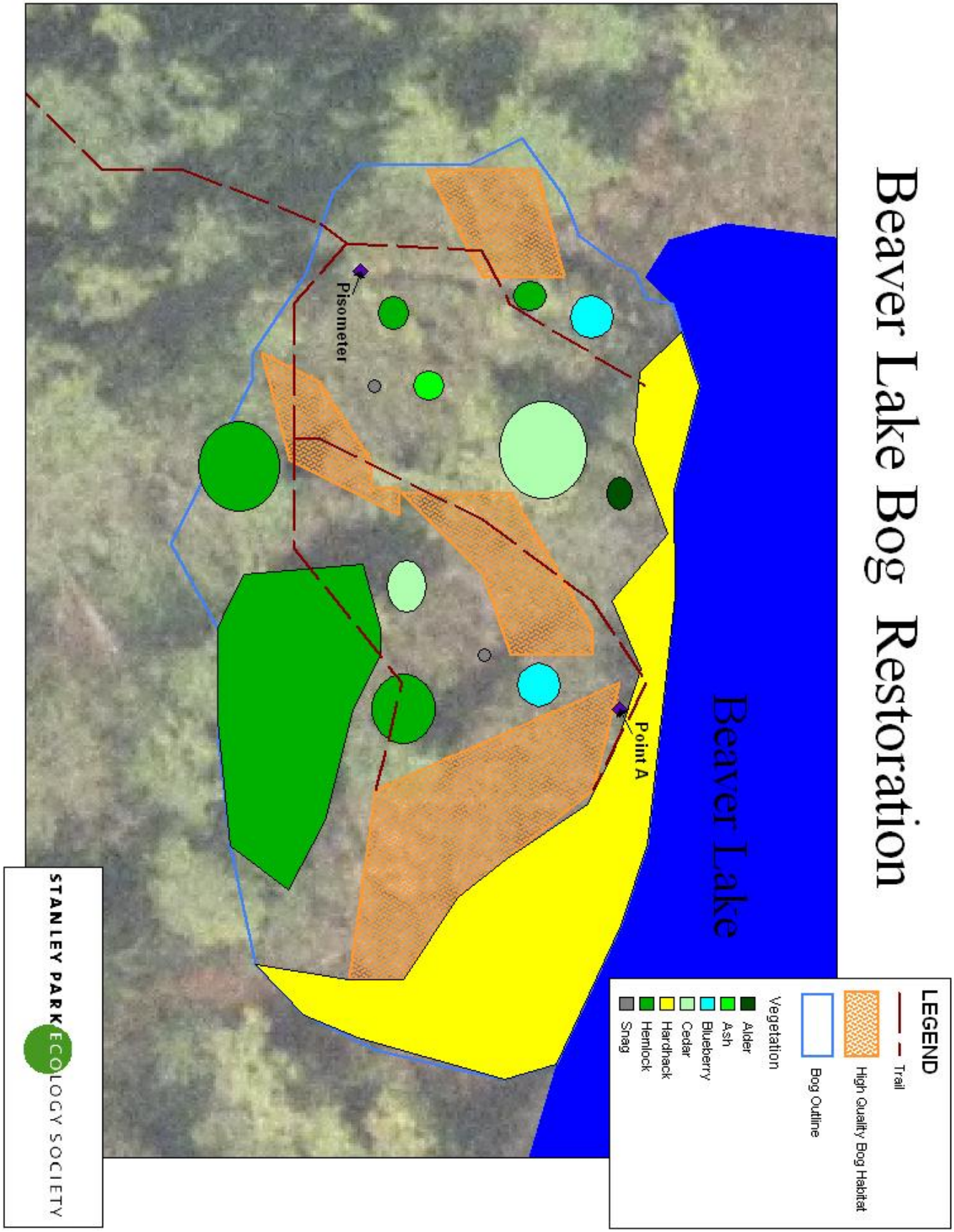
Young Naturalist and Generation Green Award recipient, Maja Lampa, checking water levels in the piezometer.

Table 2: Beaver Lake Bog Animal Inventory

Mammals	*Birds*	*Invertebrates*
American mink	American goldfinch	blue dasher
raccoon	American robin	Bumble bee
	black-capped chickadee	Damselfly sp.
	black-headed grosbeak	Dragonfly sp.
	black-throated grey warbler	orb-weaver spider
	brown creeper	Pacific forktail
	cedar waxwing	Syrphids
	chestnut-backed chickadee	
	hairy woodpecker	
	Pacific slope flycatcher	
	Pacific wren	
	pine siskin	
	red-breasted nuthatch	
	red crossbill	
	rufous hummingbird	
	song sparrow	
	spotted towhee	
	Swainson's thrush	
	Wilson's warbler	

Bog restoration partner, Maja Lampa, has created an excellent blog to track her work, which can be found at http://www.wix.com/maja132/bogger.

A hoverfly (*Syrphid* spp.) feeding on marsh cinquefoil.
Photo by Peter Woods



Bog vegetation map created by SPES in June 2011.

Part 2: Bog Restoration methodology

Project Deliverables:

- Restore disappearing habitat by removing encroaching trees and shrubs.
- Transplant bog plants into damaged areas to restore the bog's historic diversity and size
- Photo documentation of all stages of the project

Prepared by: Brian Titaro, SPES Conservation Programs

Date: January 2012

1. Felling and Removing Conifers

Within the project site, defined as the 'bog' (see Figure 1 above), areas of conifers (in particular western hemlock) have become established as growing conditions developed to favour terrestrial plants. However, because of the generally wet and nutrient-poor nature of the peat below the organic layer that had accumulated, these patches were isolated and the trees themselves were relatively small.

Through the in-kind service of the Vancouver Park Board forestry staff, trees in the bog that had been identified by SPES as negatively influencing the bog by shading out bog species and occupying bog habitat were felled by chainsaw, and bucked up for removal (see Figure 9). The felled and bucked trees were left on site.

After the trees were felled, a community group was brought into the bog by SPES to manually remove the material to areas outside of the bog. Parts of these felled trees were used to build temporary bridges and access paths throughout the bog to allow easier access for future restoration work and to minimize trampling of the sensitive bog species.

Figure 9: This is the area once occupied by hemlock trees in the bog. Once the trees were

felled, the underlying area devoid of vegetation became exposed.

2. Removal of Invading Plant Species

The Beaver Lake bog restoration is a unique management project in that many of the plant species that require removal are native to southwestern BC, in particular salal (*Gaultheria shallon*) and Labrador tea (*Rhododendron groenlandicum*). Salal is not a bog related species and the removal of it will not negatively impact the bog. However, Labrador tea is native to bogs but its abundance (along with salal) is outcompeting sensitive bog species such as peat moss (*Sphagnum sp*.), bog laurel (*Kalmia polifolia*) and round-leaved sundew (*Drosera rotundifolia*).

Removal of salal and Labrador tea are performed by voluntary work groups of youth and adults brought into the bog by SPES staff. Groups of 6-10 individuals at a time are ideal to minimize trampling of sensitive areas and species. Once the plant material has been removed from the bog it is stored nearby in the forest. After several sessions the plant material is brought to Beaver Lake trail where it is picked up by the Park Board staff for disposal (see Figures 10 and 11 for before/after photos of shrub removal).

The rational for removing these plant species is to create growing conditions that favour a diversity of native bog species in existing bog areas and to restore areas that have become degraded. Removal techniques vary based on the species being removed and the surrounding sensitive plants and are as follows:

Skunk cabbage (*Lysichiton americanus*): Grows from rhizomes that can measure over 30 cm in length, and 2.5 to 5 cm in diameter and must be completely removed to eradicate the plant from the site (Pojar & MacKinnon, 2004).

- To begin, the upper leaves and seed head of the plant is removed using hand pruners.
- A transplanting shovel is used to dig out and remove the onion-like rhizome (Laurence Brown, pers. comm.).
- Complete removal is required to ensure that the plant does not regenerate. Since there are only a few skunk cabbage plants present in the bog, the sites where they have been removed will be flagged and monitored to ensure that the entire plant was removed and to eradicate any remains early next season before it flowers and spreads throughout the site.

Salal and Labrador tea: Take care in identifying the Labrador tea as bog laurel is also present and the two can be easily confused.

- Using hand pruners, clip several centimeters above the ground to remove the top of the plant and expose the ground below.
- If sphagnum hummocks are present:
    - gently pull out the stems and roots, trying not to displace large chunks of the fragile moss.

- If this is not possible then leave the hummocks as they are with the clippings exposed.
- This will require future maintenance as the clippings will sprout new leaves, but the sphagnum is now exposed to better growing conditions (sun exposure).

- Once the hummocks have better established themselves and the clippings have been continuously pruned (after about one year) the remaining stems and roots can be manually removed.
- If no sphagnum hummocks exist below the salal and Labrador tea then mattocks and Pulaski's can be used to remove the entire plant to ensure that it does not recolonize the site (Laurence Brown, pers. comm.).

Figure 10: Before and after pictures showing a work group's progress at removing invading salal and Labrador tea and exposing the sphagnum hummock below. Note the pink flagging tape (red arrow) as a reference.

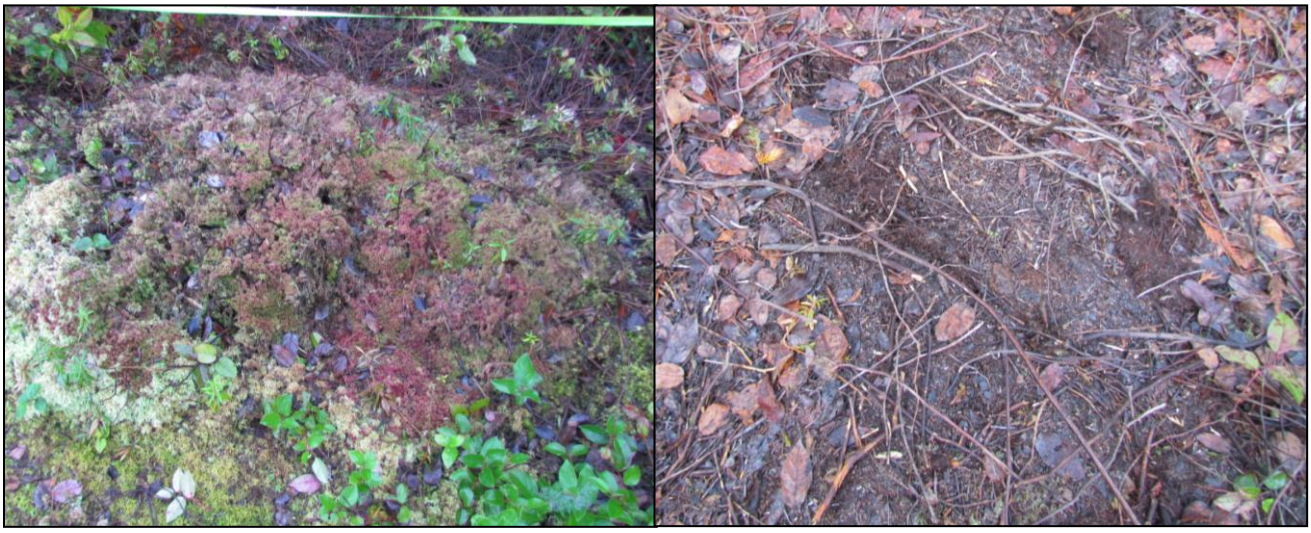


Figure 11: Below the salal and Labrador tea we find either exposed moss hummocks (left) or accumulated organic debris (right).

3. Removal of Organic Debris

Below much of the salal and Labrador tea is a layer of organic debris (between 1-15cm thick) that has accumulated over time from the salal, Labrador tea and hemlock trees. While this layer provides nutrients through decomposition, this is detrimental to a bog environment that is characterized by its low nutrient level. Native bog plants such as sphagnum moss, round-leaved sundew and bog laurel have a difficult time establishing and outcompeting invading terrestrial plants on this platform of nutrient rich organic debris (Laurence Brown, pers. comm.).

To create ideal growing conditions for native bog plants this layer of organic matter must be removed to expose the slowly decomposing and waterlogged sphagnum below (see Figure 12). This is most easily accomplished by the use of the Pulaski axe.

- Using the axe end of the tool cut down into the organic debris until the peat is reached.
- Continue cutting a line at this depth for a total length of about 30 cm and then proceed to make an additional cut parallel to this about 45cm apart.
- Connect the two at the top of these incisions with another cut so that you've cut in 3 sides of a square or rectangle.
- Using the pick end of the tool pry under the top cut and work at peeling the organic debris back in a large section much like rolling up a carpet.
- The layer of organic debris, while heavy, should peel back from the peat fairly easily as it is only resting on top of it (Laurence Brown, pers. comm.).

Figure 12: Area where the organic debris has been removed down to the layer of peat.

4. Water Level Monitoring

Water levels in the bog have been monitored for several months by SPES staff using a piezometer. Figure 13 below shows the water levels in the Beaver Lake bog from June to late October. When these measurements are compared to the Camosun bog water levels, it appears that the Beaver Lake bog shows much less dramatic changes in its seasonal water levels as demonstrated below in Figure 14 (Laurence Brown, pers. comm.).

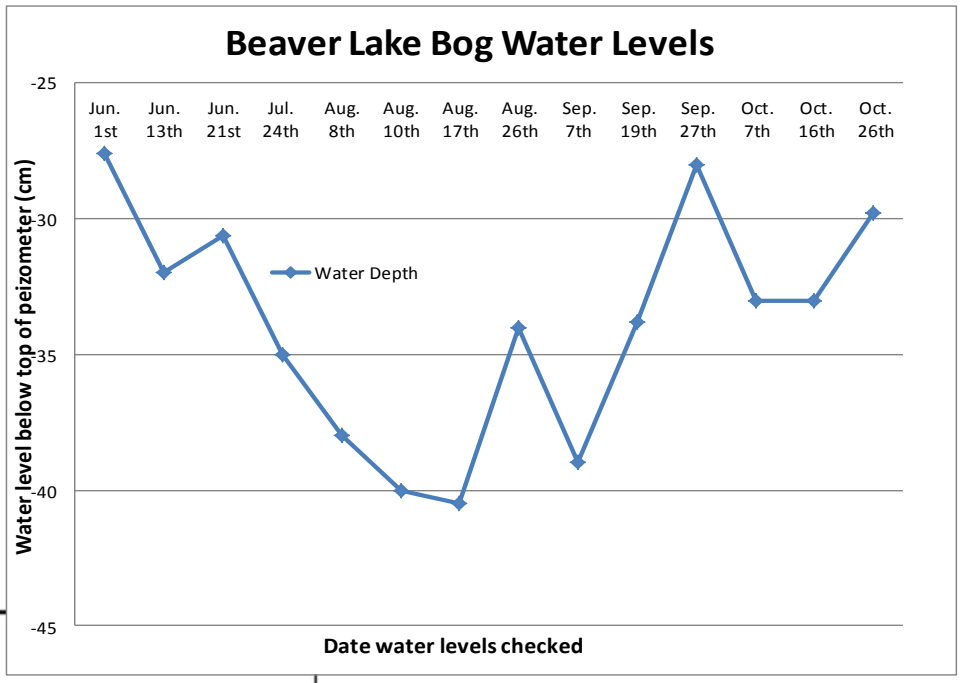


Figure 13: Beaver Lake bog water level trend from Jun-Oct 2011.

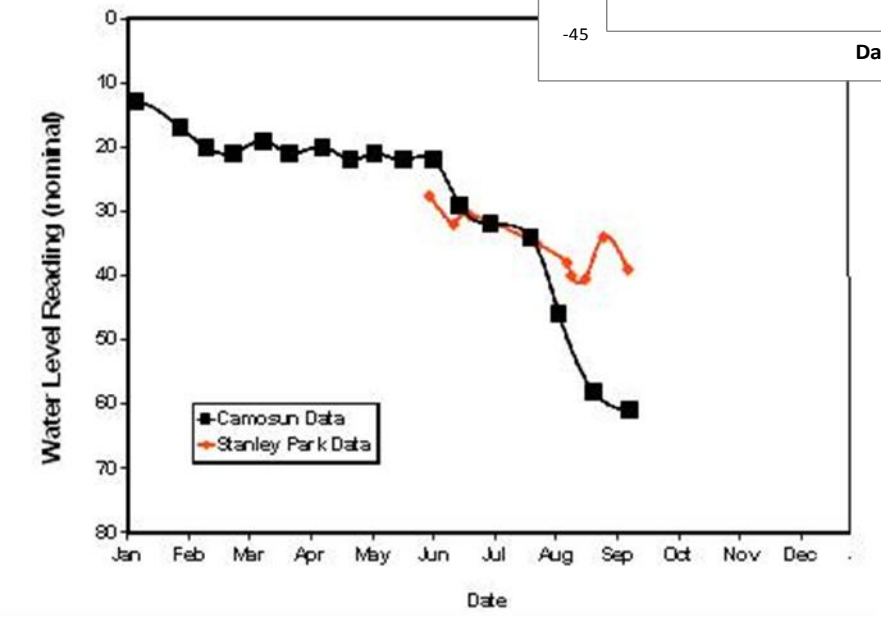
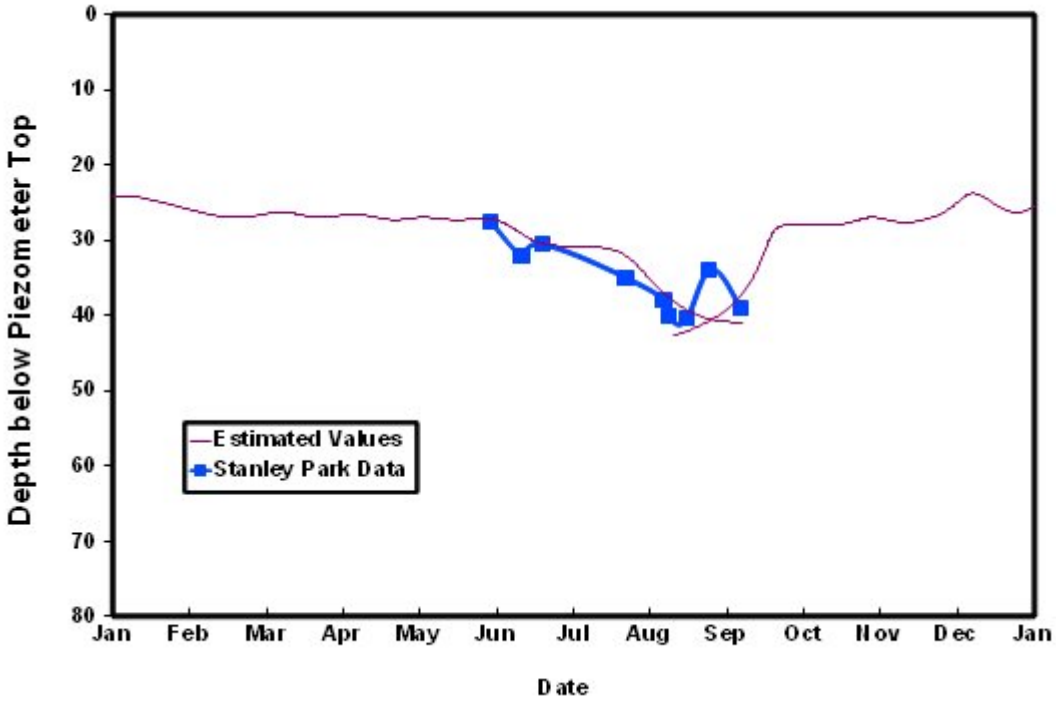


Figure 14: Water level trends of Camosun Bog compared to the Beaver Lake bog.

An estimate of the water level range for an entire year in the Beaver Lake bog is required to determine when the area will be most inundated and what the water level would be at that time. This was done by comparing the Camosun bog water levels from August 2010 to September 2011 and matching this to the smaller range found at the Beaver Lake bog. This is demonstrated below in Figure 15. The best fit was obtained assuming that the variation in the Beaver Lake bog is 35% of that in Camosun bog (Laurence Brown, pers. comm.).

Figure 15: Estimated annual water level changes in the Beaver Lake bog.



It should be emphasized that this is a very rough analysis but it does provide reasonable values for where water levels will be in the winter months in the Beaver Lake bog. It is estimated that the peat level should be at a height of a 26cm below the top of the Beaver Lake bog piezometer tube (Laurence Brown, pers. comm.). This number may change as longer term data is obtained at the Beaver Lake bog.

5. Planting/Transplanting Native Bog Plants

Once the organic debris has been removed and the underlying peat has been exposed it is important to determine the appropriate thickness of peat above the water table. This will provide optimal growing conditions for sphagnum, the first plant species to be re-introduced into the bog. Sphagnum is most likely to survive after planting if it is inundated with water for some time during the winter months (Laurence Brown, pers. comm.). Earlier in the restoration process a small test area in the bog was cleared of invading plants and organic debris down to the peat. Additional peat was then removed to the water table in some areas and left several centimeters above the water table in others. This test area was then planted with sphagnum plugs at various heights above the water table and monitored for several months to determine which height lead to optimum growth.

In mid-December of 2011 members from the Camosun Bog Restoration Group examined the test site and helped to determine which level of peat height resulted in ideal growing conditions for the sphagnum. Once the ideal height was determined the remaining area was leveled to the same height. Work has since taken place by community groups to expand this area so that it can be planted with sphagnum plugs. All of the areas in the bog not colonized by sphagnum moss, bog laurel or round-leaved sundew will be cleared and leveled to this optimal growing height. This includes sphagnum hummocks that are colonized by

terrestrial plants. These hummocks will be torn down to the appropriate planting level, while the peat inside will be harvested and used for leveling other sites in the bog such as holes created through removing skunk cabbage, tree roots, etc. Once late winter temperatures are suitable enough to allow the bog to remain unfrozen but inundated with water, planting will begin in the newly leveled areas.

The original planting area has been expanded and levelled to the ideal height for transplanted sphagnum moss.

Sphagnum for transplanting into the bog will be harvested from source sites adjacent to the Beaver Lake bog as seen in Figure 16. At the harvest locations, a maximum of 30% of sphagnum will be taken throughout the source site so as not to negatively impact the harvest site's ability to recover. To do this effectively it is important to determine the correct amount of sphagnum to collect at the harvest site in comparison to the size of the restoration site. Typically this is represented as a ratio of 1:15, between the surface of the collection site to the surface of the restoration site. In other words we should be collecting enough sphagnum to cover 1/15th of the surface area of the restoration area. In practical restoration this ratio is closer to 1:10 as this difference accounts for losses in plant material and damage from transplanting (Quinty & Rochefort, 2003).

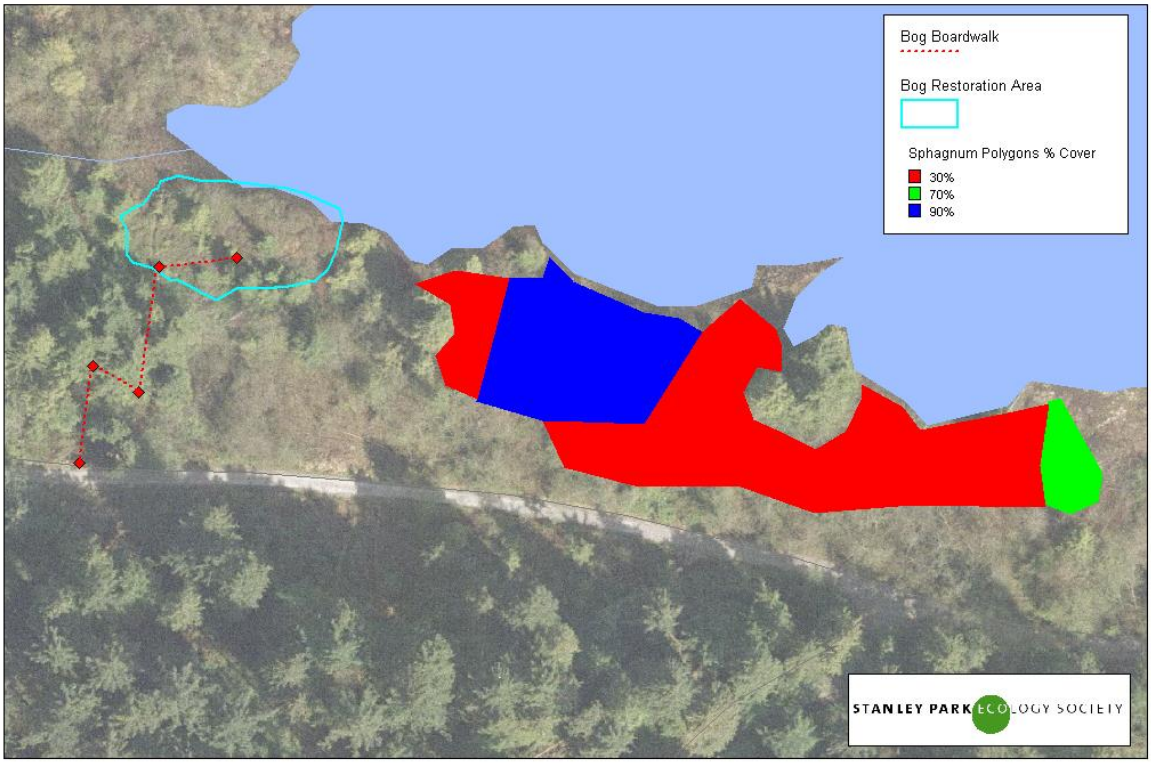


Figure 16: Map showing bog restoration area and adjacent peat 'source' areas delineated by % cover of sphagnum. This map also shows the proposed location of a future boardwalk.

Only the best sphagnum should be taken and introduced into the restoration site. Most sphagnum species are considered dead below 10cm from the surface and regeneration from sphagnum collected below 10cm is unlikely. Collecting only the top 10cm will result in the best moss being introduced into the restoration site, the highest probability of regeneration from the plugs and allows for rapid recovery of harvest sites (Quinty & Rochefort, 2003). Therefore, collection at the adjacent sites will consist of plugs with a 5 – 7cm depth and a diameter of 10cm. This plug size was based on practical experience gained from the Camosun Bog Restoration Group during their restoration process (Laurence Brown, pers. comm.). Sphagnum will be harvested by pushing a metal can with a 10cm diameter into the moss to a depth of 5cm to cut out a plug that can then be transplanted into the restoration site.

Once the sphagnum has been harvested the restoration site will be planted with sphagnum plugs in a grid pattern, as shown in Figure 17, to cover approximately 10 - 15% of the surface area (Quinty & Rochefort, 2003). To plant the sphagnum plugs the restoration area will be prepared by placing plywood directly onto the peat and lightly jumping on it to flatten the area underneath. A small indentation about 3 - 5cm deep is then made into the flattened and leveled peat and the plug is pushed into this depression ensuring that the moss is making direct contact with the saturated layer of peat (Laurence Brown, pers. comm.).

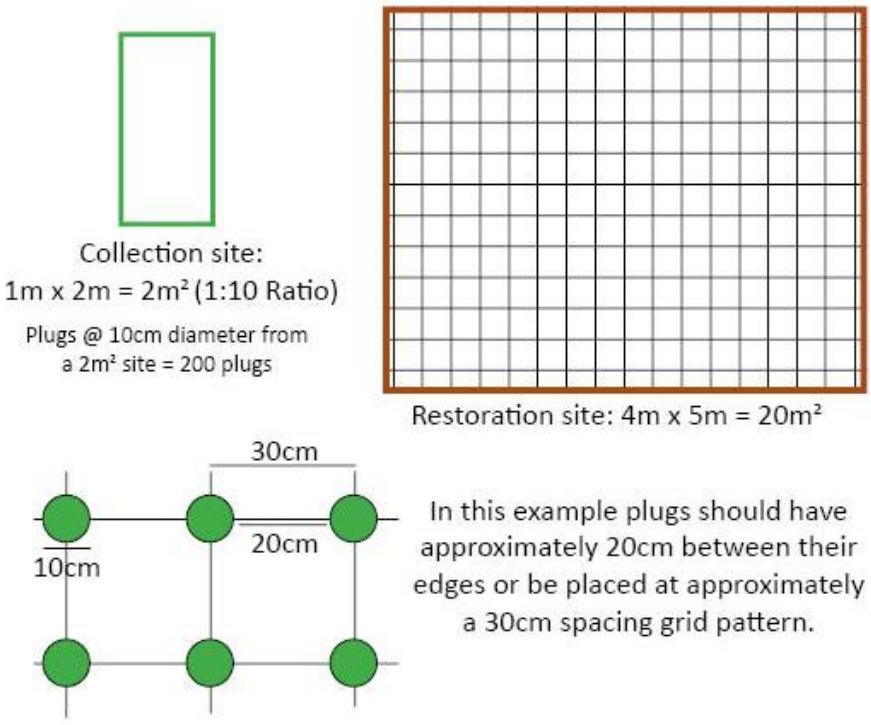


Figure 17: An example of a restoration site and the 1:10 ratio of the collection site.It also indicates the number of 10cm diameter plugs attainable from this ratio and the appropriate spacing for the plugs in the restoration site (Quinty & Rochefort, 2003).

As a result of the Beaver Lake bog's relatively stable water levels a "milkshake" method of planting may also be a suitable restoration technique (Laurence Brown, pers. comm.). This method involves spreading cut up pieces of sphagnum moss over the restoration site, in particular, in between the sphagnum plugs. This is done to encourage more rapid growth and coverage in the restoration site. Milkshake methods have been proven to be a successful way of performing bog restoration and are the primary method used for large scale peatland restoration. Almost all parts of sphagnum, except their almost microscopic leaves, can grow into new plants. Greenhouse experiments found that fragments as small as 0.5cm can grow successfully into new plants. When performing the milkshake method the sphagnum should be dispersed between the plugs to a thickness of 1cm for optimal coverage and probability of growth (Quinty & Rochefort, 2003). After the plugs have been planted if any sphagnum ren plugs through the process described above.

Volunteers at Camosun Bog transplant sphagnum plugs along a grid pattern. (Source: http://camosunblog.blogspot.com/)

References Cited:

Pojar J, MacKinnon A. 2004. Revised Plants of Coastal British Columbia including Washington, Oregon & Alaska. Lone Pine Publishing, Vancouver British Columbia.

Quinty, F. and L. Rochefort, 2003. Peatland Restoration Guide, second edition. Canadian Sphagnum Peat Moss Association and New Brunswick Department of Natural Resources and Energy. Québec, Québec.

Worcester T, Coulson J, McDonald B. 1998. Characterization of Beaver Lake bog areas in Stanley Park, Vancouver. In: Capilano College Environmental Science Program. Beaver Lake Ecological Studies: Stanley Park, Vancouver, B.C.

Appendix 1: Plants found in the Beaver Lake bog

Below is a list of all plants found in the Beaver Lake bog prior to the beginning of the restoration process in the summer of 2011. All plants found, and not only bog specific plants, are listed because they will likely be present in the bog for several years before they're completely eradicated. All non-bog specific plants are listed with an asterisk (*) next to their names (Pojar & MacKinnon, 2004).

Skunk Cabbage (*Lysichiton americanum*)*

General: Robust, hairless perennial 30 – 50 cm tall. Grows from a fleshy, upright underground stem. Gives off a skunky odour especially when flowering.

Leaves: In large basal rosette, lance-shaped to broadly elliptic, often huge (up to 1.5 m long and 0.5 m wide. Thin and net-veined, tapering to short, stout, winged stalks.
Flowers: Greenish-yellow; numerous in a spike on a thick, fleshy axis which is hooded by a bright yellow, large bract. Appearing before or with the leaves in early spring, and later overtaken by their exuberant growth.
Ecology: Found in swamps, fens, muskeg, wet forest, mucky seepage areas, wet meadows at low to middle elevations.

Salal(*Gaultheria shallon)
General: Creeping to erect; spreads by layering, suckering and sprouting. Height variable between 0.2-5m tall with hairy, branched stems.

Leaves: Alternate, evergreen, leathery, thick, shiny and egg shaped. 5-10cm long, sharply and finely toothed.
Flower/Fruit: White or pinkish urn shaped 7 – 10mm in length. 5 – 15 at the end of branches, flower stalks bend so that all flowers orient in same direction.
Ecology: Found in coniferous forests, rocky bluffs and near the sea shore at low to medium elevations.

Labrador Tea (*Rhododendron groenlandicum*)

General: An evergreen shrub, to 1 m tall, young twigs densely hairy, becoming smooth (glabrous) in older stems; flower bud large, terminal.

Leaves: Alternate, simple, 2-5 cm long and 0.5 to 2 cm wide, short-petioled, evergreen, fragrant when crushed. Blade oblong-elliptic, leathery-textured (coriaceous), dull and dark green above, lower surface covered at first with dense white hairs that become rusty-coloured in mature leaves; margins entire and strongly curved under (revolute).

Flowers: Rounded, umbel-like, terminal clusters; corolla white, about 1 cm wide, deeply 5-lobed, the lobes oblong and spreading; stamens 5-7, longer than the petal. Blooms in June to early July, slightly later than the flowers of bog laurel (Kalmia polifolia).

Ecology: Found in moist to wet, peaty soils, especially bogs and wet coniferous forests.

Western Bog Laurel (*Kalmia microphylla*)

General: Small, slender-branched evergreen, up to 0.5 m tall; spreads by layering and short rhizomes.

Leaves: Opposite, narrowly lance-shaped up to 4 cm long; margins rolled under; dark green and leathery above, conspicuously whitish and fine-hairy beneath. Compared to Labrador tea, bog laurel leaves tend to point more upwards, are darker green above and are less curled. The hairy/fuzzy underside of bog laurel is more whitish in appearance compared to Labrador tea which is browner underneath.

Flowers: Rose-pink, saucer shaped, above 2 cm across with 10 stamens.

Ecology: Found in bogs and wet mountain meadows.

Round-leaved sundew (*Drosera rotundifolia*)

General: Small, insect-eating perennial, 5 – 25cm tall. Appear to be covered in 'morning dew' at all times.

Leaves: Sticky, glandular, spreading in basal rosette 3 – 7cm long. Blades round to broadly egg shaped, at least as broad as long. Fringed with long, reddish, glandular hairs that exude drops of sticky fluid.

Flowers: Small white flower (petals 6 – 10mm long) that fully open only in strong sunlight. Form at the top of long stem well above the insect eating part of the plant. 3 – 10 at the end of a stem all on the same side.

Ecology: Found in sphagnum bogs, fens and wet meadows at low to middle elevations.

Peat Mosses (*Sphagnum spp.*)

The genus sphagnum (the peat mosses) contains about 40 separate species in coastal BC that live in forests, cliff-faces, bogs and fens. They have a number of different features that make their morphology distinct and their identification to the species level difficult.

The branches occur in clusters each with some branches spreading at 90 degree angles and the remainder hanging down the stem. The stems are upright and in addition to the clusters of branches, have stem leaves. These are critical to the identification of most species.

The branches are covered by concave leaves without midribs. The branch leaves are 1 cell thick and consist of a net like pattern of small, clear, dead cells.