Distribution and Abundance of Epiphytic Bryophytes in Pacific Spirit Park

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Abstract

The diversity and abundance of bryophytes on the north, west, east and south sides of four different species of trees (Douglas-fir, Bigleaf Maple, Western Hemlock and Western Redcedar) are investigated. Sunlight and bark composition are considered as main determining factors of the orientation of moss and liverworts on trees. Since more sunlight hits the southern side of trees it is expected that the north side retains more moisture and therefore has a higher abundance of bryophytes. Abundance is measured by percent cover of a quadrat on each of the four sides of twenty-four trees. Sixteen different species of bryophytes are measured and identified with a dichotomous key. The three coniferous species have similar assortments of bryophyte species while the Bigleaf Maples have a different subset of species. Bigleaf Maples also have the highest average percent coverage of the tree species sampled. It is found that 54% of all surveyed trees, including 67% of all sampled conifers have the largest percent cover on the north facing side. Bigleaf Maple showed no correlation between compass direction and bryophyte coverage. The diversity of bryophytes on the tree species is analyzed using Simpson's Diversity Index scores. Possible factors influencing the observed patterns of bryophyte distribution, including bark pH, structure, and moisture are discussed.

Introduction

The Bryophyte assemblage includes an ancient and highly diverse array of organisms, consisting of mosses, hornworts, and liverworts. Currently, 958 species are described for British Columbia, many of which are localized in the moist temperate rainforests of Coastal British Columbia (Schofield, 2004). In these forests, mosses are adapted to exploit specialized substrate niches, and many species are particularly adapted to grow epiphytically: on the surface of other plants (Kenkel, 1981). This study focuses on the epiphytic moss diversity present on the lower trunks of four common tree species in the Coastal Douglas-fir forest of Pacific Spirit Park, Vancouver. These four tree species are the conifers Western Hemlock *(Tsuga heterophylla)*, Douglas-fir *(Pseudotsuga menziesii)*, Western Redcedar *(Thuja plicata)*, and the deciduous Bigleaf Maple (*Acer macrophyllum).* The species were selected because they represent the dominant tree species in the area, far outnumbering other tree species. Surveying multiple tree species allows the bryophyte composition of each tree type to be compared, allowing the assessment of the specificity of each bryophyte species.

Bryophytes include a paraphyletic assemblage of basal land plants lacking a vascular system and employing spores in reproduction. In this study, both true mosses (Division Bryophyta) and liverworts (Division Marchantiophyta) were surveyed. For the purposes of this paper, "bryophyte" will refer to the traditional paraphyletic combination of both mosses and liverworts.

Bryophytes are non-vascular plants, lacking a conducting network to transport water, instead absorbing moisture directly from their surroundings (Reitz, 2012). As such, they lack a water-retaining cuticle, and are more susceptible to desiccation than are vascular plants (Reitz, 2012). This restricts the growth of many species to shaded, moist areas.

It is a popularly held belief that in the forest, orientation may be determined by observing on which side of a tree moss grows: as the sun moves in a southeast-to-southwest path in the Northern Hemisphere, the north sides of trees

receive the lowest levels of solar radiation, and thus less moisture will be lost to evaporation. This moist microhabitat would then be most conductive to bryophyte growth. This experiment tests this belief, comparing the percent coverage of mosses on the north, south, east, and west sides of four species of trees.

This study hypothesized that the moss abundance would be greatest on the north side of trees, in accordance with the popular belief. It was also possible that there would be no significant difference: in the understory of the temperate rainforest the canopy is heavily covered by vegetation, possibly limiting the effects of the sun's orientation on relative moisture evaporation rates. In addition, this study predicted that the deciduous Bigleaf Maple *(Acer macrophyllum)* would contain a higher diversity and abundance of mosses than the coniferous trees. This prediction was supported by cursory informal observations of the trees. The trees also differ in bark structure, and the chemical composition of the bark is different between the species. Coniferous trees contain acidic chemicals (USDA, 2014), which may affect the growth ability of epiphytes. Mosses have been shown to be sensitive to changes in pH, which may restrict the range of habitats in which they can thrive (Wiklund 2004).

Understanding the specific microhabitat niches exploited by bryophytes and their degree of specificity is crucial to the understanding of species-specific bryophyte physiology and adaptation. This understanding is critical to assessing conservation status, predicting how their population and distribution may be affected by changing abiotic factors, and understanding the dynamics of bryophyte evolution. Bryophyte conservation is often overlooked in favour of more charismatic species. Currently, 88 species of moss are provincially red-listed as at risk of extirpation and 97 species are blue-listed as species of special concern in British Columbia (E-flora BC, 2015). The specificity and sensitivity of moss species to environmental changes may present a conservation challenge, and an understanding of niche requirements and current distribution is critical to the conservation of bryophyte biodiversity.

Figure 1. Visual representation of where the quadrats were placed, shown by the red bracket, located 3.33 feet above the base of the tree. Image from http://www.for.gov.bc.ca/hfp/silviculture/compendium/WesternLarch.htm

Materials and Methods

Fieldwork was conducted over the course of five prospecting visits to Pacific Spirit Park. Epiphytic bryophytes were surveyed around the circumference of trees in 2-foot intervals 3.33 feet above the level of the forest floor. Six of each tree species were randomly selected, all at approximately 5-20m from the main trail in Pacific Spirit Park. Although the trees were randomly selected, dead trees and trees with a circumference less than 9 inches were avoided. It was chosen to not go below

this minimum circumference because very young trees do not yet have as diverse and abundant amounts of bryophytes as more mature trees (Fritz, 2009). The exact geographical location of each surveyed tree was recorded as well as the diameter at breast height (the standard method of measuring tree diameter). Each survey zone was divided into north, south, east, and west facing quadrats using a compass. Within each quadrat, all bryophytes were identified and percent cover was determined. Voucher samples of each bryophyte species were collected for later identification and confirmation. These specimens were identified under a dissecting microscope by leaf, sporophyte, and cell morphological characteristics following a key by W. B. Schofield 1992 and cross-checked with the identification books *Mosses Lichens and Ferns of Northwest North America* by Vitt, Marsh and Bovey, and *Plants of Coastal British Columbia* by Pojar and Mackinnon. Surveys were conducted over a 39-day period from January 24 to March 4, 2015.

Survey Zone

The survey was conducted in Pacific Spirit Park, Vancouver, British Columbia. During each different field excursion trees were surveyed on a different trail, including the Cleveland, Salal, Deer Fern, Imperial, and Sasamat trails all within Pacific Spirit Park. The park is second-growth, located within the Coastal Douglas-fir biogeoclimatic zone (Roberta, 1948). The dominant tree species are Western Redcedar, Western Hemlock, and Douglas-fir. Bigleaf Maple, Vine Maple and Red Alder occur in scattered stands. The understory consists of dense Western Hemlock saplings, as well as Salmonberry, Dull Oregon-grape, and Salal. Sword Fern occurs abundantly, and there is a heavy supply of coarse woody debris. The forest floor contains moss mats, dominated by *Hylocomium splendens* and *Plagiothecium undulatum*. The area contains trails which are heavily used. Invasive species are abundant, including English Holly and English Ivy. Survey zone assessment was based on field observations.

Figure 2. *Isothecium stoloniferum*

Results

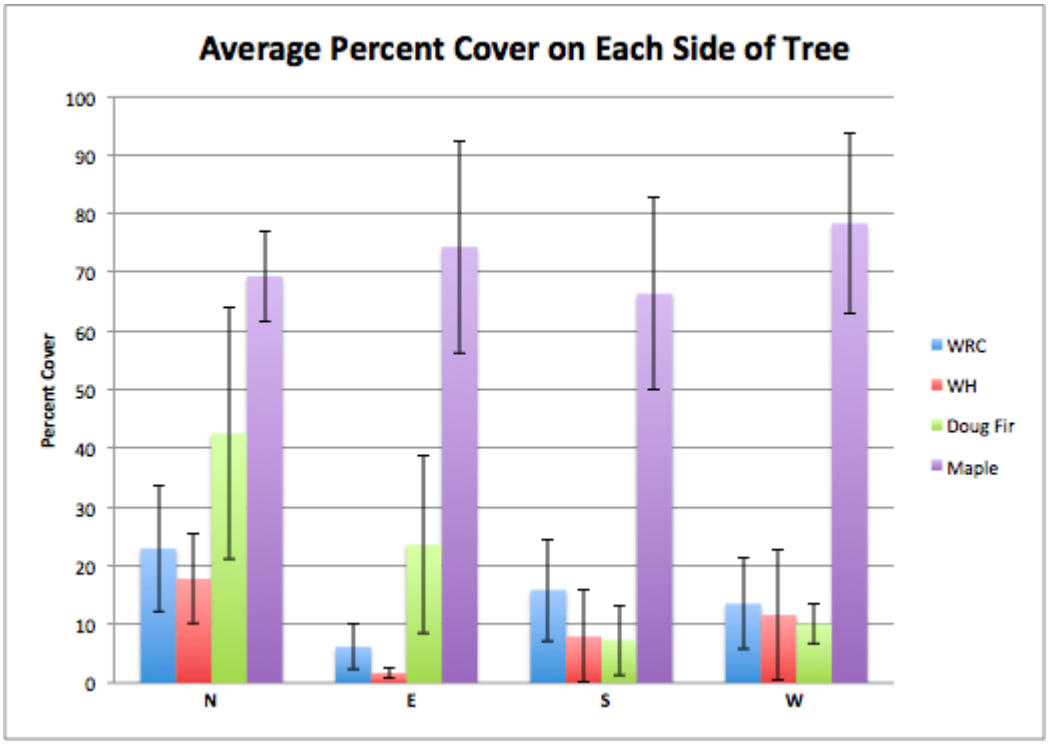

Figure 3. The average percent cover on the north, east, south and west facing sides of Western Redcedar, Western Hemlock, Douglas-fir and Bigleaf Maple. The error bars represent standard deviation of the mean. Note that Bigleaf Maple consistently has a much higher percent cover than all other tree species sampled. Also note that on all tree species excluding Bigleaf Maple the north side has the highest average percent cover compared to all other sides of the respective trees.

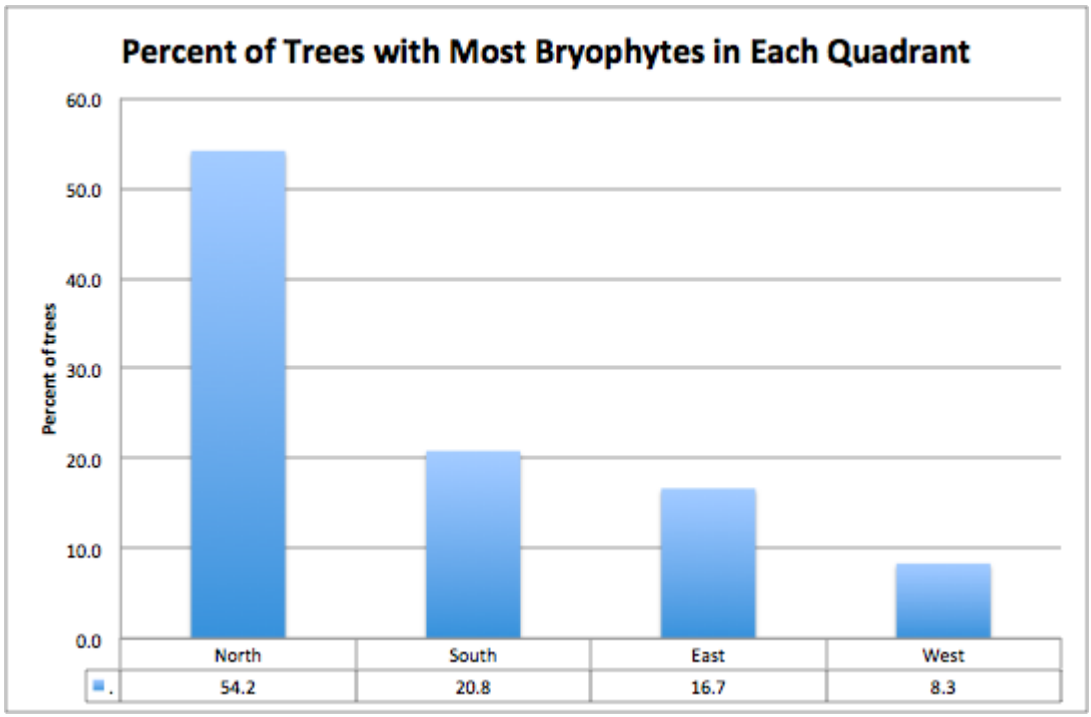

Figure 4. The percentage of trees that had the largest percent cover of bryophytes on the different sides of a tree. Note that more than half of all surveyed trees had the most bryophytes occurring on their north side.

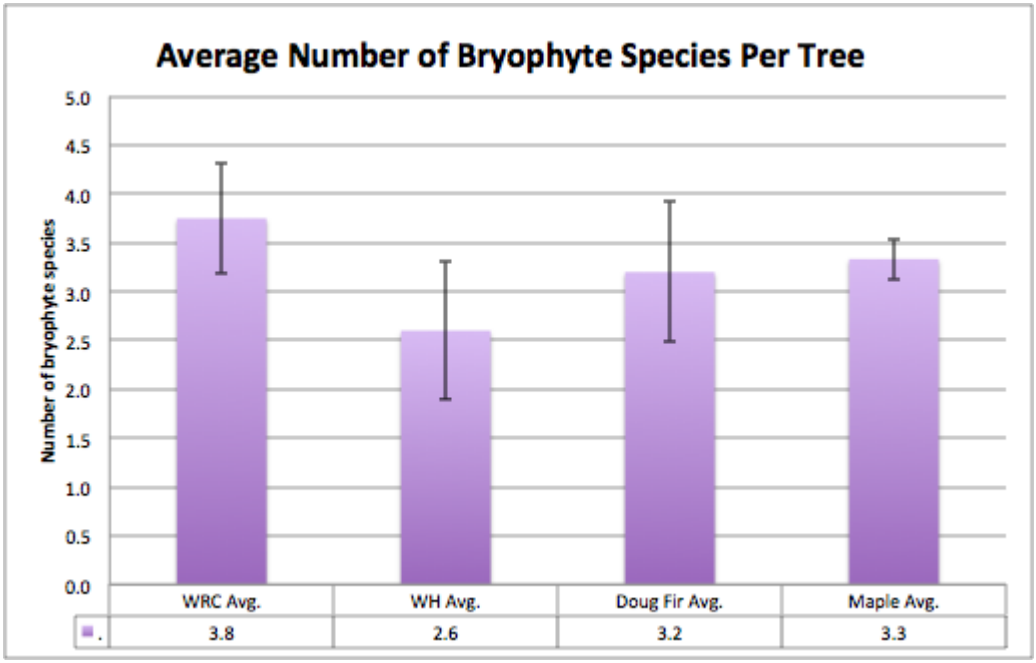

Figure 5. The diversity of Western Redcedar, Western Hemlock, Douglas-fir and Bigleaf Maple is shown here by the average number of different species of bryophytes found on each tree. The error bars are the standard deviation of the mean of the number of bryophyte species.

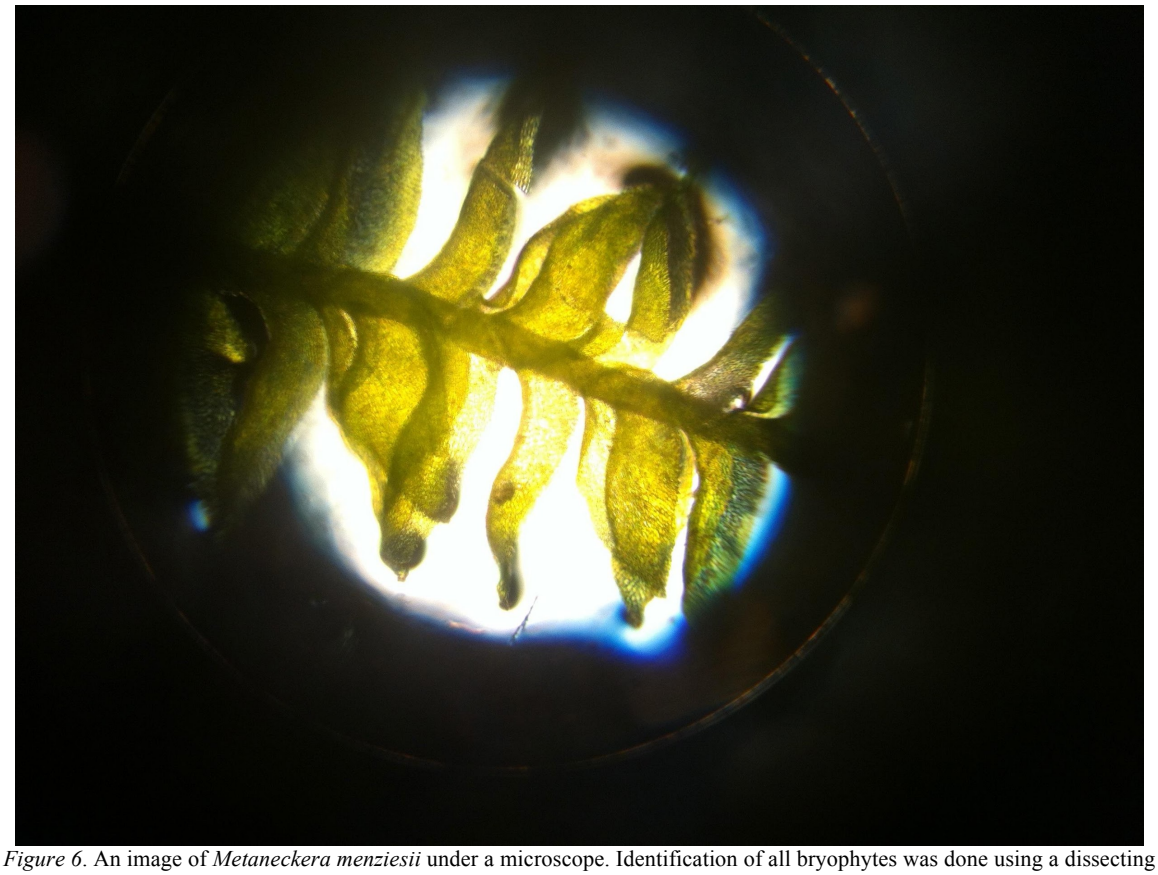

Figure 6. An image of *Metaneckera menziesii* under a microscope. Identification of all bryophytes was done using a dissecting microscope. Here the individual leaves of a single branchlette are visible.

Species of Bryophyte	Type of Tree Found On	How Many of that Tree it Appeared On
Scapania bolanderi	Western Hemlock	4
	Douglas Fir	4
	Western Red Cedar	3
Dicranum fuscescens	Western Hemlock	4
	Douglas Fir	4
	Western Red Cedar	5
Hypnum circinale	Western Hemlock	4
	Douglas Fir	4
	Western Red Cedar	5
Lepidozia reptans	Western Hemlock	3
	Douglas Fir	2
	Western Red Cedar	2
Drepanocladus uncinatus	Douglas Fir	1
	Western Red Cedar	2
Isothecium stoloniferum	Western Hemlock	2
	Western Red Cedar	2
Rhizomnium glabresncens	Western Red Cedar	1
Neckera douglasi	Bigleaf Maple	1
Homalothecium nuttallii	Bigleaf Maple	3
	Douglas Fir	1
	Western Hemlock	2
Heterocladium procurrens	Bigleaf Maple	6
	Western Red Cedar	1
	Western Hemlock	2
Antitrichia curtipendula	Bigleaf Maple	1
Rhytidiadelphus loreus	Bigleaf Maple	1
Riccardia multifida	Bigleaf Maple	3
Brachythecium frigidum	Bigleaf Maple	3
Kindbergia oregana	Bigleaf Maple	1
Metaneckera mensiesii	Bigleaf Maple	1

Table 1. The 16 species of bryophytes surveyed and identified, on which trees they were found, and on how many different trees each bryophyte was found.

Results

A total of 24 trees, including six of each species were sampled. Over all of the trees sampled, a total of 16 different species of bryophytes (13 mosses and 3 liverworts) were found within the survey quadrats (see Table 1). According to *Some Common Mosses of British Columbia* there are 27 common mosses that occur on tree trunks in British Columbia, 13 of which were encountered. All the coniferous trees had a fairly common assortment of bryophytes while the Bigleaf Maple trees contained a very different set of bryophytes. Results show that 54% of all trees surveyed had the largest amount of coverage on the north side (see *Figure 4)*. When Bigleaf Maple is excluded from the data set, this percentage increases to 67%. Western Redcedar, Western Hemlock, and Douglas-fir had the greatest average coverage on the north side, while Bigleaf Maple showed little difference between the sides. A Simpson's Diversity Index was calculated for each tree and averaged for each of the four species, representing the likelihood that any two randomly selected bryophytes will be the same species. Douglas-fir received the most diverse score, at 0.29, followed by Western Redcedar at 0.34. Western Hemlock and Bigleaf Maple were the least diverse with scores of 0.44 and 0.42 respectively.

By comparing the number of trees which had the highest percent cover on each side (see *Figure. 4*) a χ^2 of 48.6 was obtained, which is much higher than the critical χ^2 (p= 0.01) of 11.34, which lends very strong support to the hypothesis of more moss growing on the north side of trees.

Discussion

This study observed that moss grew most abundantly on the north side of trees. The calculated χ^2 value is much higher than the calculated critical value, providing support to the hypothesis. This does not appear to be universally true for all tree species, however, as Bigleaf Maple showed no significant difference between the compass directions. Instead, the immediate environment seemed to be a more reliable predictor of moss abundance for this species. Where the tree was leaning to one side, the underside had significantly lower percent cover of bryophytes, regardless of compass direction. In all observed trees where the inclination was more than 15° in any direction, a significant decrease in bryophyte diversity was observed on the sheltered side of the tree, with no exceptions observed in this data set. This may be because the covered side of the tree is blocked from rain and sunlight, limiting photosynthetic and growth potential. In addition, sides of the trunks growing in very close proximity to other trunks, such as in the case of trees with double trunks, showed lower moss coverage, likely due to the same factors of sunlight and rain blockage. The three conifer species show a very straight, upright leading trunk, while Bigleaf Maple has a tendency to branch near the base into multiple leading trunks (field observation).

Unlike maple, the three conifer species showed significantly more moss coverage on the north side of the trees. The conifer species also showed a much lower average percent coverage of moss than maple. This may suggest that the chemical environment of coniferous trees is less conducive to bryophyte growth, to the extent that epiphytic mosses are under greater environmental pressure. In this case, the microclimate difference between the north and south sides may become significant enough to cause a distribution shift, as mosses are able to survive on the north side, but do not colonize the south to as great an extent. In maples, the favourable environment may make any difference between north and south insignificant for percent cover, as mosses are able to survive and colonize on any side.

Despite having a significantly greater total coverage of moss species and the second highest average number of species, Bigleaf Maple received a low overall diversity score on the Simpson's Diversity Index. This shows that while the total number of species found on Bigleaf Maples was higher than the total found on other species, the species evenness was very low. It was found that within the survey zone, the Bigleaf Maples were dominated by *Heterocladium procurrens* and *Brachythecium frigidum*, with the other species occurring in patches scattered within the *Heterocladium* and *Brachythecium* mats.

It was observed that Bigleaf Maple contained a species subset that was different from the other trees, while the three conifers displayed significant overlap in bryophyte diversity. The most common bryophyte species on the conifers, *Hypnum circinale, Lepidozia reptans, Dicranum fuscescens, and Scapania bolanderi* were common on all species of conifer, but scarce or absent on Bigleaf Maple. Similarly, the common Bigleaf Maple epiphytes, including *Heterocladium procurrens, Brachythecium frigidum, Homalothecium*

nuttalli, *Rhytidiadelphus loreus, Neckera douglasi* and *Kindbergia oregana* were scarce or absent on conifers. This suggests that bryophytes possess adaptations specific to their preferred host tree type. These differences may include bark structure, pH, and moisture retention. A study by Kenkel and Bradfield in southern British Columbia (1981) measured an average bark pH of 4.4 for Western Hemlock and Western Redcedar, and an average pH of 4.2 for Douglas-fir. In contrast, a 1986 study by the same authors measured an average bark pH of 6.76 for Bigleaf Maple. This marked difference between the conifers and maple may explain some of the observed differences in species composition, as species adapted to grow within a specific pH range may not be able to survive outside of that range.

The extensive cover on Bigleaf Maple suggests that competition for space is a limiting factor, and multiple bryophyte individuals were often found to be growing over top of each other. It was observed that the maple-specific species *Heterocladium procurrens* and *Homalothecium nuttalli* were occasionally found growing in small numbers on conifers with three occasions each. No other overlap between the conifer and maple species sets was observed. Competitive exclusion may be a factor in preventing conifer-type moss from colonizing Bigleaf Maple. In contrast, competition exclusion is likely less significant than abiotic factors in preventing maple-type moss from colonizing conifers, in part due to the more acidic substrate (Kenkel, 1986). Future experiments may include a further investigation of the chemical difference between deciduous and coniferous tree bark and the effects this may have on moss growth and survival.

Bark structure may also be an important factor. Bigleaf maple has a fairly thin bark, which is rarely thicker than 1.3 cm (Fryer, 2011). Western Redcedar has smooth bark structured into strips, and it was observed that moss most commonly grew in the grooves between the strips. This suggests that the roughness of the bark influences the ability of the bryophytes to adhere to the substrate or for the spores to settle. Douglas-fir and Western Hemlock each have rough, grooved bark. Within the conifer species, there were some differences between relative abundance, which may be influenced by bark structure. For example, the acrocarpous, tuft-forming species *Dicranum fuscescens* is much less common on Western Hemlock than on the other conifer species, by a factor of eight. The close-growing liverwort *Lepidozia reptans* was more than ten times more abundant on Douglas-fir than the other species, perhaps due to the rough bark providing an adequate surface to adhere to, or retaining moisture more readily than smooth-barked species. Another liverwort, *Scapania bolanderi,* was more than six times more abundant on Douglas-fir than Western Hemlock, and more than three times more abundant than on Western Redcedar.

The age of each tree, which was estimated by circumference, could also be a factor affecting bryophyte biodiversity and abundance. Although it was decided to not survey any tree with a circumference below 9 inches, the trees surveyed had a wide range of circumferences varying from 9 inches (a Western Hemlock) to 91 inches (a Douglas-Fir). A tree's bark chemistry and physical structure changes with age (Fritz, 2009), strongly influencing epiphytic bryophyte growth. Although from the data obtained no correlations were found between bryophyte diversity or abundance with tree

size, perhaps with a larger sample of surveyed trees a trend would begin to appear.

Possible sources of error in this study could include the ability of the researchers to accurately identify moss species in the field, as well as slight error in estimating percent cover within the quadrat. Error was minimized by careful analysis under a microscope, and agreement between both surveyors on the percent cover of each species. The highly variable nature of trees within the forest means that the data set does not represent a single controlled variable. Instead, the trees varied in many ways, including age, diameter, inclination, light exposure, and surrounding habitat structure. By considering multiple variables, experimental uncertainty is increased, but it allows a greater number of factors to be considered and analyzed.

Conclusion

It was found that epiphytic moss has a greater average abundance on the north side of coniferous trees. It was found that this correlation does not hold for Bigleaf Maple. It was observed that Bigleaf Maple and coniferous trees support separate subsets of epiphytic abundance and diversity.

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References

Bonady, D. 2014. USDA, Forest Service, Tannins, [online]. Available from http://www.fs.fed.us/wildflowers/ethnobotany/tannins.shtml [accessed 12 March 2015]

Fritz, Ö., Niklasson, M. and Churski, M. 2009. Tree age is a key factor for the conservation of epiphytic lichens and bryophytes in beech forests [online]. Applied Vegetation Science, **12**(1): 93–106. doi: 10.1111/j.1654-109X.2009.01007.x

Fryer, J. L. 2011. Acer macrophyllum. In: Fire Effects Information System, [online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available from http://www.fs.fed.us/database/feis/ [accessed 19 March 2015].

Ingerpuu, N., Vellak, K., and Tonu, M. 2009. Growth of Neckera pennata an epiphytic moss of old-growth forests [online]. The Bryologist, **110**(2): 309-318. doi: 10.1639/0007-2745(2007)110

Kenkel, N. C., and Bradfield, G. E. 1981. Ordination of epiphytic bryophyte communities in a wet-temperate coniferous forest [online]. Vegetation **45**(3): 147-154. doi: 10.1007/BF00054669

Kenkel, N. C., and Bradfield, G. E. 1986. Epiphytic vegetation on *Acer macrophyllum:* a multivariate study of species-habitat relationships [online]. Vegetation **68**(1): 43-53. doi: 10.1007/BF00031579

Parish, R. 1948. Tree Book. Ministry of Forests.

Schofield, Wilf. 2004. An introduction to bryophytes. E-Flora BC: Atlas of the Plants of British Columbia [online]. Available from www.eflora.bc.ca [accessed 13 March 2015]

Shackley, M., 2012. Bryophytes and Vascular Plants. doi:10.1007/978-1-4614-3339-2_7

Wiklund, K. 2004. Establishment, growth and population dynamics in two mosses of old-growth forests [online dissertation]. Available from ProQuest, UMI Dissertations Publishing [accessed 13 March 2015].