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Lichen Abundance and Diversity in Relation to Host Tree Species and Lakeshore Proximity

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Abstract

Lichens have been recognized and used as biological indicators for a variety of environmental conditions over the past several decades. This is because they are highly susceptible to a number of factors that affect their growth, diversity, and abundance. As global climate and weather patterns rapidly change, gaining a better understanding of the factors that affect lichen growth, abundance, and diversity will be an indispensable tool for researchers in the years to come. In this study, epiphytic lichens on the lower two meters of trees were sampled at three near-shore sites along the upper peninsula of Michigan. For each tree sampled, species, distance from lakeshore, percentage of bark covered by lichen, and number of lichen species present were all recorded. The findings showed weak to no relationship between lichen abundance and diversity relative to lakeshore proximity, but showed significant differences between deciduous and conifer species in both lichen coverage and lichen diversity. Deciduous trees had a mean cover of 23.67% and a mean diversity of 4.61 species, while conifers had a mean cover of 7.73% and a mean diversity of 3.15 species. The results revealed a strong relationship between host tree species and the abundance and diversity of epiphytic lichen.

Introduction

Lichens have long been used as biological indicators for air pollution, acid rain, nitrogen deposition, and a number of other environmental conditions. Due to their strategy of obtaining water and nutrients directly from the surrounding air, lichens are highly susceptible to changes in air quality and climate, as well as temporal and spatial hydration sources (Gauslaa 2014). As global climate and weather patterns change, understanding the effects these changes will have on the structure, function, and composition of ecosystems will be invaluable (Jonsson et al. 2008). Lichen's physiological traits, ecological characteristics, and wide global distribution offer an opportunity to gain a better understanding of these changes as they develop (Matos et al. 2015). Therefore, understanding the various factors that affect lichen abundance and diversity is an important tool in monitoring such changes in the coming years.

Lichens have a number of overlapping environmental and site-specific factors that affect their abundance, distribution, and diversity (Hauck 2011). Of these factors, air pollution, nitrogen deposition, and aridity/ humidity have been extensively studied and monitored over the past several decades (Niemi and McDonald 2004). Latitude and elevational gradients have also become areas of interest when trying to use lichen diversity as a means to predict the effects of changing climate conditions (Bässler et al. 2016). A study by Marini et al. concluded that the diversity of lichen in response to environmental change depends on their photosynthetic partners, known as photobionts. Lichens with cyanobacteria as their photobionts showed a positive correlation between species diversity and amount of rainfall, while those with the filamentous algae *Trentepohlia* as the photobiont increased in abundance and diversity with increasing temperatures (Marini et al. 2011).

With so many factors affecting epiphytic lichen growth patterns, this study aimed to test how host tree species and near-shore proximity to Lake Superior influence their abundance and diversity. Gaining a thorough understanding of the factors determining lichen abundance and diversity can help researchers more accurately employ them as bio indicators for monitoring, assessing, and predicting changes in environmental conditions.

Materials and Methods

This study was conducted at Little Presque Isle Recreation Area, eight miles northwest of Marquette, Michigan. The three sites that were chosen for this study (Wetmore Landing, Freeman Landing, and Little Presque Isle Point) are on the Lake Superior shoreline, exposed to the lake towards the east (Figure 1). To determine whether relative humidity could be a factor in lichen abundance and diversity, preliminary humidity readings were carried out along four transects at the Wetmore Landing site with a Flexzion Digital Hygrometer. The transects were each 100 meters (m) in length, running perpendicular to the lakeshore. Each transect was placed 100 m to the north of the preceding transect, starting at an arbitrary point chosen as the reference point for the Wetmore Landing site.

Figure 1: Study sites shown in red (top to bottom: Little Presque Point, Freeman Landing and Wetmore Landing). All sites are within the Little Presque Isle Recreation Area in Marquette, Michigan.

At each site, five transects were established for lichen sampling. To determine the locations of the transects, an arbitrary reference point was chosen at each site and a 100 m measuring tape was run in a northwestern direction, parallel to shore, along the near-shore tree line. Next, five numbers between 0-100 were generated using a random number generator. These numbers were then marked along the 100 m tape and used as the starting point for each of the transects. From each point, a 100 m tape measure was run perpendicular to the lakeshore. Along the transects, all trees whose center fell within one meter of either side of the transect line and whose diameter at breast height (DBH) was ≥ 15 cm were assessed.

To assess epiphytic lichen, the bottom two meters of each tree trunk that fit our parameters was sampled to determine species of lichen, percent cover for each species, and overall percent of lichen coverage. The percentage of cover was recorded separately for the side of the tree facing the lakeshore and the side of the tree facing away from the lakeshore; these percentages were later combined to determine total cover. A transparency grid with 100 squares, each 2x2 cm, was placed over the trunk and used to determine the percentage of cover. A modified Braun-Blanquet cover-abundance scale was used when recording and analyzing the percentage of cover for each tree. In addition to lichen coverage, the DBH, distance from lakeshore (m), and species were recorded for each tree sampled.

Statistical analysis was performed using IBM SPSS Statistics Data Editor Software. Microsoft Excel 2016 was used for calculations and arranging data.

Results

The preliminary readings of relative humidity revealed that there was no significant difference based on proximity to the lakeshore, eliminating that factor in our experiment.

In total, 159 trees were sampled across three sites, yielding fifteen species of lichens. A one-way ANOVA showed a significant difference in mean lichen cover between sites ($p=0.009$). A follow up Post-hoc test showed that the Freeman Landing and Little Presque Point sites were significantly different ($p= 0.039$), as were the Freeman Landing and Wetmore Landing sites ($p= 0.003$). There was no significant difference in lichen cover between the Little Presque Point and the Wetmore Landing sites ($p= 0.341$). The Freeman Landing site was dominated by eastern hemlock (*Tsuga Canadensis*), which represented 81.1% of the trees sampled. At the Little Presque Point and Wetmore Landing sites, red pine (*Pinus resinosa*) was the dominant tree species, comprising 57.8% and 51.9%, respectively.

The trees sampled ranged from 0.5-99 m from the near-shore tree line. A linear regression showed no relationship between epiphytic lichen coverage and lakeshore proximity ($r^2= 0.0282$) (Figure 2). A t-test showed a significant difference in mean lichen coverage between the ranges of 0-50 m and 50-100 m from the near-shore tree line (p= 0.001). The mean coverage was 7.37% in the 0-50 m range and 13.29% in the 50-100 m range. A linear regression showed no relationship between lichen diversity and lakeshore proximity (r^2= 0.0006) (Figure 3). A t-test showed no significant difference in mean lichen diversity between 0-50 m and 50-100 m from the near-shore tree line (p= 0.051). The mean number of lichen species was 3.35 per tree in the 0-50 m range and 3.45 in the 50-100 m range.

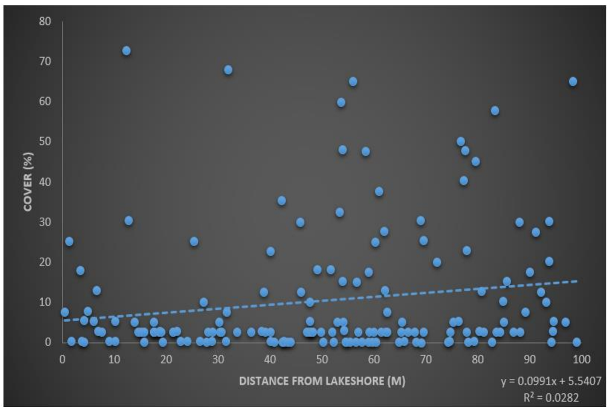

Figure 2: Scatter plot showing the relationship between percentage of epiphytic lichen cover and proximity to the Lake Superior shoreline. Data are from 159 trees that were sampled from November 8-13, 2017, at Little Presque Isle Recreation Area in Marquette, Michigan.

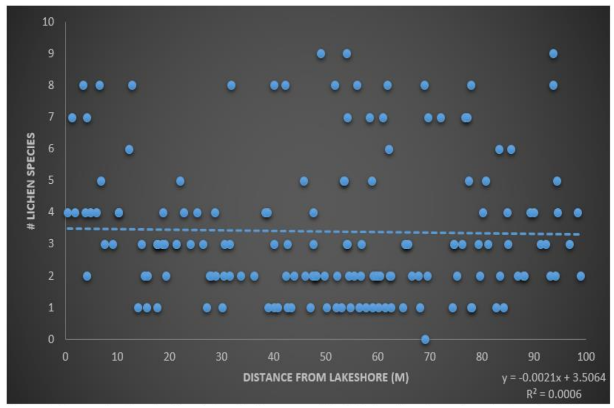

Figure 3: Scatter plot showing the relationship between epiphytic lichen diversity and proximity to the Lake Superior shoreline. Data are from 159 trees that were sampled from November 8-13, 2017, at Little Presque Isle Recreation Area in Marquette, Michigan.

The 27 white pines (*Pinus strobus*) sampled ranged from 1.3-94.4 m from the near-shore tree line. A linear regression, considering only white pines, showed no relationship between lichen coverage and lakeshore proximity (r^2= 0.0113) (Figure 4). A t-test showed no significant difference in mean lichen coverage on white pines between 0-50 m and 50-100 m from the near-shore tree line (p= 0.416). The mean coverage, on white pines, was 22.18% from 0-50 m and 23.89% from 50-100 m. A linear regression showed no relationship between lichen diversity on white pines and lakeshore proximity (r^2= 0.1966) (Figure 5). A t-test showed no significant difference in mean lichen diversity between 0-50 m and 50-100 m from the near-shore tree line (p= 0.193). The mean number of lichen species per white pine was 6.36 from 0-50 m and 5.63 from 50-100 m.

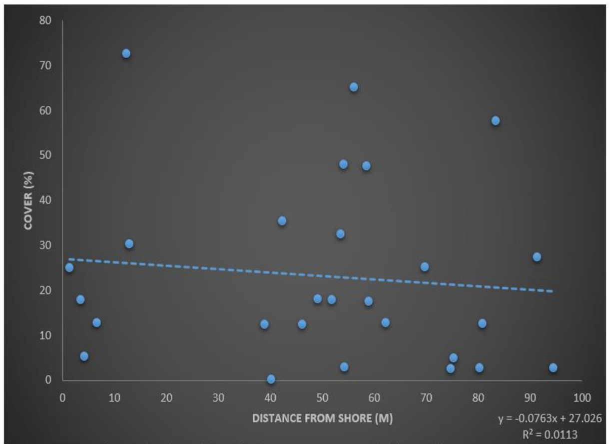

Figure 4: Scatter plot showing the relationship between percentage of epiphytic lichen cover on white pines (*Pinus strobus*) and proximity to the Lake Superior shoreline. Data are from 27 trees that were sampled from November 12-13, 2017, at Little Presque Isle Recreation Area in Marquette, Michigan

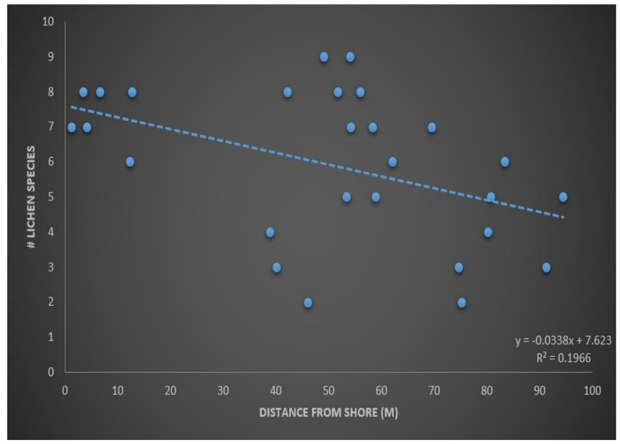

Figure 5: Scatter plot showing the relationship between epiphytic lichen diversity on white pines (*Pinus strobus*) and proximity to the Lake Superior shoreline. Data are from 27 trees that were sampled from November 12-13, 2017, at Little Presque Isle Recreation Area in Marquette, Michigan.

In total, 131 of 159 trees sampled were conifers and the remaining 28 were deciduous. T-tests showed that there was a significant difference in both the lichen coverage (p= 0.000) and lichen diversity (p= 0.001) between conifers and deciduous trees. Conifers had a mean cover of 7.73% and a mean of 3.15 lichen species per tree. Deciduous trees had a mean cover of 23.67% and a mean of 4.61 lichen species per tree. A one-way ANOVA and Tukey's Post-hoc test showed significant differences in percentage of cover, as well as lichen diversity, between most of the five dominant tree species: red pine, eastern hemlock, white pine, red oak (*Quercus rubra*), and yellow birch (*Betula alleghaniensis*). Of the dominant tree species, red oak had the greatest mean coverage and number of species per tree at 37.27% and 7.00, respectively (Figures 6 and 7).

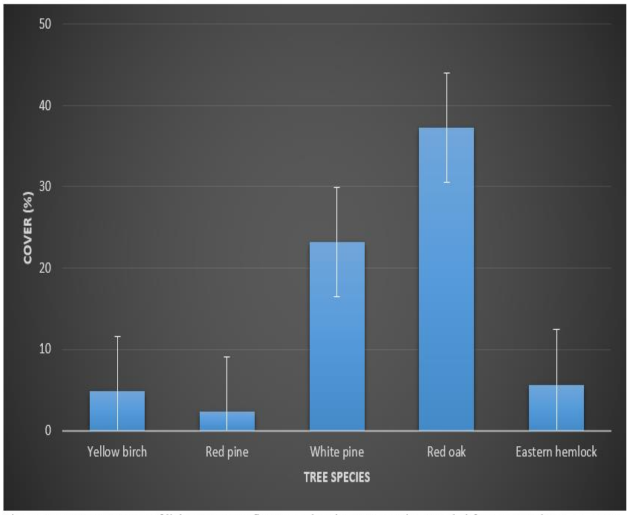

Figure 6: Mean percentage of lichen cover on five most abundant tree species sampled from November 8-13, 2017, at Little Presque Isle Recreation Area in Marquette, Michigan.

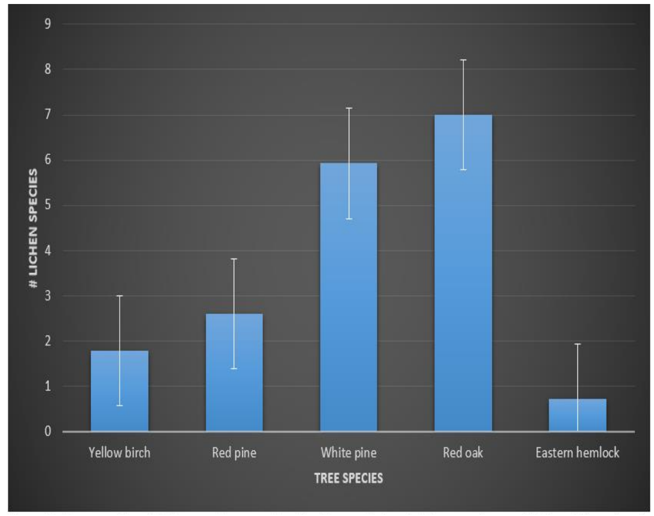

Figure 7: Mean number of lichen species present on the five most abundant tree species sampled from November 8-13, 2017, at Little Presque Isle Recreation Area in Marquette, Michigan.

Discussion

The study showed that the most important factor in epiphytic lichen coverage and diversity is tree species. The results showed significant differences between tree species, with red oak and white pine being much higher in coverage and diversity than red pine, eastern hemlock, and yellow birch. One likely cause of low lichen counts on red pine and yellow birch is the characteristic shedding of bark that these two species routinely undergo. Another potential factor in lichen preference for tree species could be differences in bark acidity. The results also showed a difference in lichen cover and diversity between deciduous trees and conifers. Even though the white pine had the second highest mean cover and species diversity, the conifers had much less coverage and diversity overall. The differences in lichen cover between the Freeman Landing site and the other two sites sampled (Little Presque Point and Wetmore Landing), was likely due to the composition of tree species. The Freeman Landing site was dominated by eastern hemlock (81.1%) and yellow birch (15.1%) which together comprised 51 of the 53 trees sampled at the site. The sites at Little Presque Point and Wetmore Landing were dominated by red pine but had a greater diversity of trees than Freeman Landing, particularly red oak and white pine, which were the species with the greatest lichen cover and diversity.

Across all sites, there was no significant relationship between lichen cover and proximity to the lakeshore, with cover increasing only slightly with increased distance from shore. No relationship was found between species diversity and lakeshore proximity. In order to eliminate potential differences in lichen preference for particular tree species, some statistical tests were performed using only data from white pines. This species was chosen because it was well distributed from near-shore to away-from-shore and displayed both high lichen coverage and diversity. The relationship between lichen cover on white pines and proximity to lakeshore was also very weak and trended in the opposite direction of the data set as a whole, with greater coverage near-shore as opposed to away-from-shore. The relationship between lichen diversity and lakeshore proximity, on white pines, was more noticeable but still very weak, with a trend towards more species diversity near-shore.

Based on the results of this study, tree species were a much stronger factor in the diversity and abundance of epiphytic lichens than was proximity to the lakeshore. In a study performed in the Netherlands in 2010, Spier et al. concluded that tree species was the most important factor in lichen colonization. Further studies on the bark acidity in different species of trees could potentially lend more information on why epiphytic lichens prefer some trees to others. One such study concluded that lichens have a close relationship to the pH of the bark they inhabit, and that only a very low percentage of lichens were indifferent to the pH of their host trees (Pereira et al. 2014). Understanding the multiple factors that affect lichen growth and abundance is vital, due to their high value as biological indicator species. Findings from this study help build on the body of knowledge that will allow researchers to use epiphytic lichens more accurately when assessing, monitoring, and predicting changing environmental conditions in the years to come.

Literature Cited

Bässler, C., M. W. Cadotte, B. Beudert, C. Heibl, M. Blaschke, J. H. Bradtka, T. Langbehn, S. Werth, and J. Müller. 2016. Contrasting patterns of lichen functional diversity and species richness across an elevation gradient. Ecography 39:689–698.

Gauslaa, Y. 2014. Rain, dew, and humid air as drivers of morphology, function and spatial distribution in epiphytic lichens. The Lichenologist 46:1–16.

Hauck, M. 2011. Site factors controlling epiphytic lichen abundance in northern coniferous forests. Flora - Morphology, Distribution, Functional Ecology of Plants 206:81–90.

Jonsson, A. V., J. Moen, and K. Palmqvist. 2008. Predicting Lichen Hydration Using Biophysical Models. Oecologia 156:259–273.

Marini, L., J. Nascimbene, and P. L. Nimis. 2011. Large-scale patterns of epiphytic lichen species richness: Photobiont-dependent response to climate and forest structure. Science of The Total Environment 409:4381–4386.

Matos, P., P. Pinho, G. Aragón, I. Martínez, A. Nunes, A. M. V. M. Soares, and C. Branquinho. 2015. Lichen traits responding to aridity. Journal of Ecology 103:451–458.

Niemi, G. J., and M. E. McDonald. 2004. Application of Ecological Indicators. Annual Review of Ecology, Evolution, and Systematics 35:89–111.

Pereira, I., F. Müller, and M. Moya. 2014. Influence of Nothofagus bark pH on the lichen and bryophytes richness, Central Chile/Influencia del pH de la corteza de Nothofagus sobre la riqueza de líquenes y briófitos, Chile central. Gayana. Botanica; Concepcion 71:120–130.

Spier, L., H. van Dobben, and K. van Dort. 2010. Is bark pH more important than tree species in determining the composition of nitrophytic or acidophytic lichen floras? Environmental Pollution 158:3607–3611.