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EXPLORING LICHEN PREFERENCE ON HARDWOOD VERSUS SOFTWOOD TREES

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ABSTRACT

This research focused on the microhabitat preference of lichens in Huntingdon, PA, USA. The research plan was built on anecdotal evidence in the form of stories (word of mouth), blogs, and well-known facts about lichens. Lichens often occur on trees with which they have a symbiotic or commensal relationship. They do not obtain nutrients from trees but from photosynthetic algae or cyanobacteria which cover the surface of the lichen whose base is composed of fungus. This survey's primary objective was to determine whether lichens prefer to grow on hardwood or softwood trees observed in the forest behind the Juniata Paul E. Hickes Observatory. A tape measure was used to record the diameter of the tree. Photos were taken of the trees and lichen to identify their species. The results showed that lichen have a strong, statistically significant preference for hardwood trees ($P < 0.001$).

Keywords: coniferous trees, deciduous trees, fungus, lichens, symbiosis

INTRODUCTION

Lichens are some of the most resilient and long-lived organisms in the world. With over 20,000 named species and thousands more unnamed found on almost every biome on the planet, lichens are an incredibly complex and diverse set of organisms (Hawksworth, 2021). Each lichen is composed of at least two symbiotic organisms: a fungus, and either green algae or cyanobacteria. The photosynthetic partner (algae or cyanobacteria) is responsible for supplying the fungus with sugars while the fungus offers a structural place for the photosynthetic partner to live and obtain condensed water (Hawksworth, 2021). Although lichens are characterized and named for their fungal partner, the photosynthetic partner is just as important. In fact, many lichen spores will include their photosynthetic partner's reproductive cells when being dispersed. Additionally, once a fruiting body is established, lichens can provide cover and camouflage for insects (Lichens 2024).

Lichens are not only spectacular in form and function, but also by the role they play in ecosystems. Lichens are a pioneer species, being some of the first to colonize bare landscapes after a major disturbance and paving the way for other plant and animal species to follow. Additionally, lichens benefit the trees and forests in which they inhabit. They, along with saprophytic fungi, break down and recycle the nutrients dead trees offer, benefiting young and growing trees (Daniel & Polanin, 2013). Lichen are also efficient carbon sinks as their photosynthetic partners absorb and metabolize carbon dioxide. Specific lichen species can have integral impacts on their ecosystems. In the taiga, lichens are important food for caribou and reindeer while in other places lichen offer camouflage to insects such as moths. In addition, lichens have been beneficial to humans in the dye, perfume, decoration, and medicinal industry (Hawksworth, 2021).

Due to the wide variation of traits that lichens display based on their location, there is a plethora of topics one could study. This study's aim was to investigate differences in lichen distribution and

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presence on softwood (gymnosperms) versus hardwood (angiosperm) trees. We hypothesized that lichens prefer to grow on hardwood trees especially because they are relatively stable, well-lit environments. Lichens require a stable environment with optimal access to sunlight and rain. Since deciduous trees have a relatively slow growth rate and drop their leaves, there is little competition for nutrients and habitat stability (changing of the bark due to growth) is generally minimized in these trees.

Additionally, other studies have mentioned microhabitat preferences lichens tend to exhibit. While lichen microhabitat preference varies between species, generally there are some overarching patterns most lichen species follow. First, the pH of the bark can be a limiting factor for lichen distribution. Conifers tend to have acidic bark, with a pH ranging from 3.0-4.5 (Hauck, 2011). Additionally, lichen densities on coniferous trees have been seen to decrease in the presence of high concentrations of sulfur dioxide, which causes acid rain, further lowering the pH of the bark. Due to the already low pH level, conifers lack a natural buffer to these human-caused changes in pH in rainwater or soil. As lichens prefer a neutral pH, this can cause lichens to have a lower survival rate on coniferous trees and would lead them to prefer hardwood trees (Lõhmus et al., 2023). In a location like central Pennsylvania, which has a history of acidic rain events, this could certainly play a role in lichen distribution.

The morphology-dependent presence of shade year-round could also lead to observed differences. With few exceptions, conifers maintain foliage all year which can increase shade to their trunk and divert water off branches rather than down the trunks. Presence of any foliage — pines or leaves — deters lichens as they have limited access to direct sunlight. Additionally, winter temperatures can decrease the viscosity of water which can impact lichens on conifers specifically due to higher manganese concentrations in the bark. This can cause build up frigid water or ice which can be fatal for many lichens (Hauck, 2011). These two factors suggest that lichens, their fruiting portion especially, could be impacted by seasonal conditions. This study was conducted in March and April 2025, after the winter period of freezing temperatures and a lack of foliage on deciduous trees. With this knowledge, it is possible that the lack of sunlight or build-up of manganese could be a confounding factor affecting lichen densities on hardwood and softwood trees in this study.

All these reasons provide important context and background for this study. However, little or no research has been carried out on lichens in Huntingdon, PA, including their preference for hardwood and softwood trees. This study will shed further light on the microhabitat distribution of lichens. As mentioned above, lichens are important parts of a forest ecosystem, and therefore knowing their distribution may provide important information contributing to maintaining thriving lichens in our area.

METHODS AND MATERIALS

The sample area chosen for this study was a diverse area of forest located at Juniata College, behind the Brumbaugh Academic Center and Paul E. Hicks Observatory. This area is roughly four and a half acres. Our surveys were done during two separate sessions, one week apart. The physical materials used to collect data were a tape measure and a phone camera. The sample size was approximately 5-6% of the total number of individual trees within the patch of land. This number was figured out using an aerial survey on Google Maps. 5-6% of the total number of trees was found to be about forty trees. So, the sample size for the study was twenty hardwood trees and twenty softwood trees.

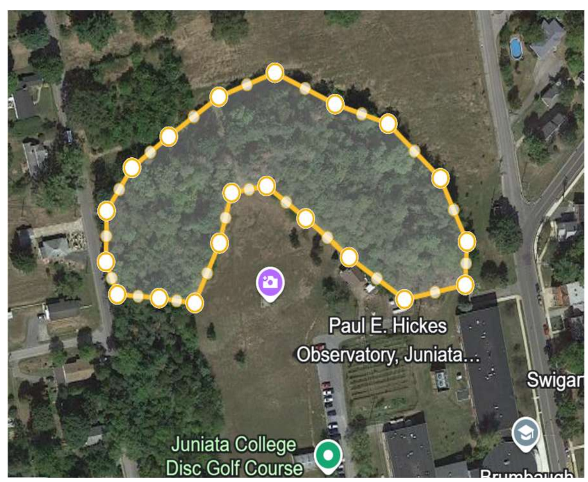

Figure 1. Aerial photo of sampling area showing approximately where observations were made.

To collect samples, trees were chosen at random, making sure to move across the field site from one end to another and taking photos of each tree to ensure no samples were repeated. Trees were noted to be hardwood or softwood, and the circumference of each tree was measured using the tape measure. From these measurements, the diameter of each tree was calculated. The size of the trees sampled was varied intentionally to remove any possible size bias. Photographs were taken of each tree sampled along with any lichen, if present, to assist in identification later in the process. Each sample was categorized as either having lichens present or absent on each tree, and by location (trunk or branch). It is important to note that due to restrictions on sampling, the upper trunk and branches of the trees sampled were not visible in most cases. Because of this, the observations are taken from only the estimated lower twenty feet of each tree sampled. Lichen density was measured through visible observation as a percentage, with 0% being no visible lichen fruiting body present, and 100% being the entire visible tree space covered. Another important factor which could be a possible fallacy in our data is the presence on some trees of only the fungus, which grows under the surface of the bark. In these cases, the lichen is not visible to the naked eye and would not be noted as present. After samples were collected, both tree and lichen species were identified using a combination of the photos taken and internet resources. This ensured that specific tree species did not have an influence on the presence or lack of lichen.

RESULTS

The observations yielded 14 different species of trees and 8 different species of lichen. There were 5 softwood species: White Pine (*Pinus strobus*), Spruce (*Picea*), Red Pine (*Pinus resinosa*), Pitch Pine (*Pinus rigida*), and Eastern Hemlock (*Tsuga canadensis*). And there were 9 hardwood species: White Oak (*Quercus alba*), White Ash (*Fraxinus americana*), Tulip Tree (*Liriodendron tulipifera*), Sugar Maple (*Acer saccharum*), Red Maple (*Acer rubrum*), Red Oak (*Quercus rubra*), Hawthorn (*Crataegus* spp.), Black Locust (*Robinia pseudoacacia*), and Beech (*Fagus grandifolia*). These species were identified to the best accuracy possible with the time and resources available, however, inaccuracies in species identification are possible. Figure 1 shows all the tree species observed and their subsequent frequencies. As the chart shows, Pitch Pine and Red Maple were the two most frequently sampled tree species, with half of the softwoods sampled being Pitch Pines.

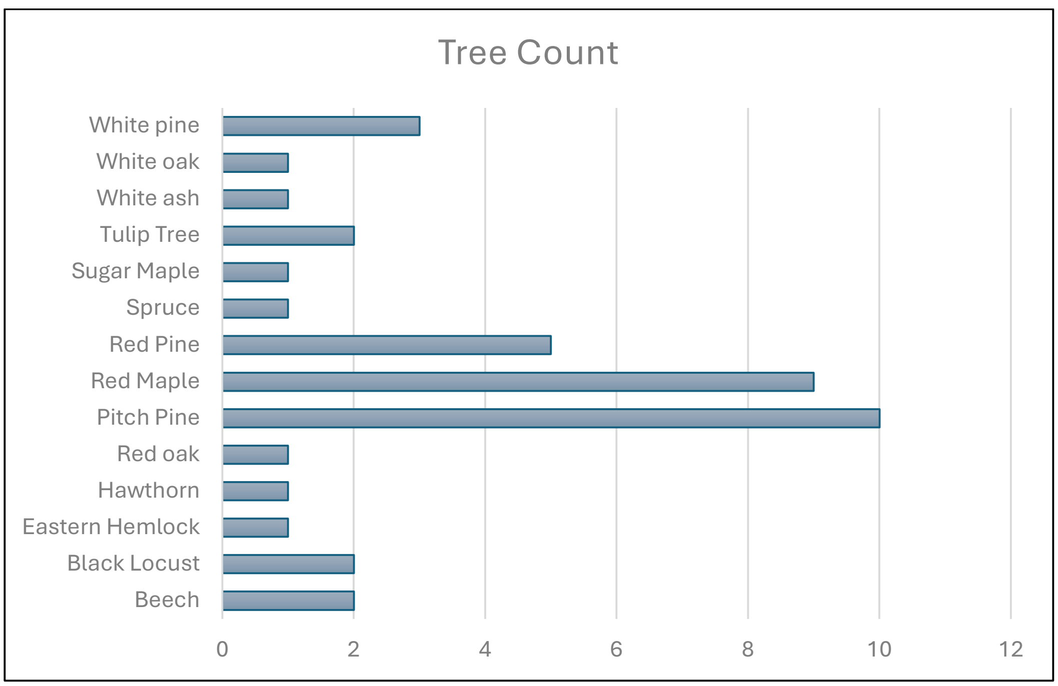

Figure 2. Shows the count of trees for each species as well as all the 14 different species of trees observed.

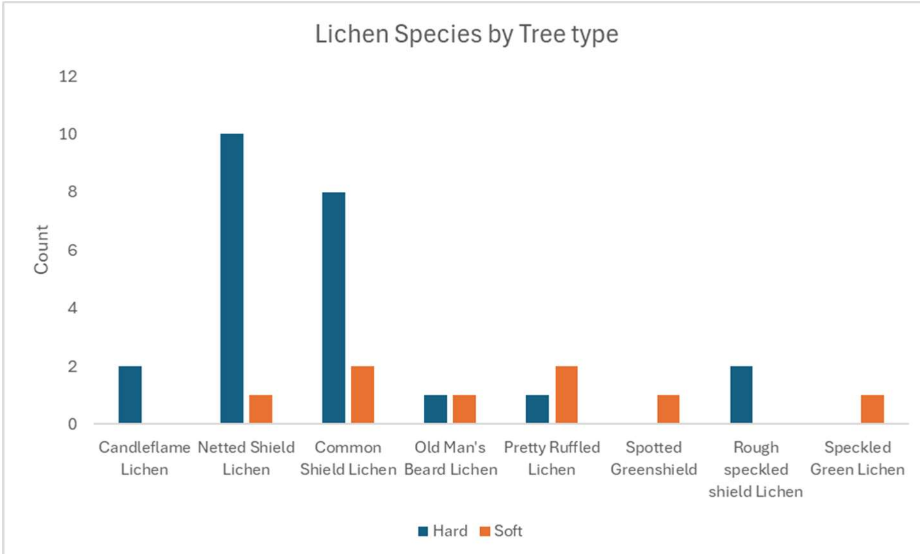

Figure 3. Bar chart showing the 8 lichen species and their frequencies on hardwood and softwood trees. Orange bars denote softwood counts and blue bars are for hardwood counts.

As for the lichen species, Candleflame (*Candelaria concolor*), Netted Shield (*Parmelia sulcata*), Common Shield (*Parmelia saxatilis*), Old Man's Beard (*Usnea spp*.), Pretty Ruffled (*Parmotrema stuppeum*), Spotted Greenshield (*Flavoparmelia caperata*), Rough Speckled Shield (*Punctelia rudecta*), and Speckled Green (*Punctelia subrudecta*) lichens were all observed. Figure 2 shows the distribution of the different lichen species presence (not density) with a separation for softwoods and hardwoods. This table accounts for the fact that on some trees multiple species of lichen were found and due to this may seem inconsistent with the contingency table (Table 1) discussed later. This figure shows that overall, there were a lot more lichen observed on hardwoods than on softwoods, however lichen species seem to be somewhat evenly dispersed considering this fact. Four of the lichen species were found on both hardwoods and softwoods whereas 4 were found on just one type, however counts are too low to really consider any statistically important results. Netted and Common shield lichens were by far the most common with 10+ counts each where other lichen species were counted under 3 times.

Knowing that the data involves a good spread of lichen and tree species for a small sample size of 40 is important to attempting to avoid bias wherein one lichen species may affiliate with one tree species or type. With this is mind, the statistical test used to answer the question of whether there is a difference between lichen frequencies between hardwood angiosperm) and softwood (gymnosperm) trees. To do this a contingency table (Table 1.) was constructed showing that on 16 hardwoods lichen was found where there was only 6 softwoods with lichen. This table was used to perform a chi-square test which resulted in a p-value of less than 0.001 (Table 2), indicating a significant difference between lichen counts on hardwood and softwood trees

Table 1. Contingency table showing the frequencies of lichen presence on hardwood and softwood

Tree Type	Lichen	No Lichen	Total
Hardwood	16	4	20
Softwood	6	14	20
Total	22	18	40

Table 2. Table of Chi-square and Mann-Whitney U test statistics and p-values.

	Test Statistic	df	p
$\chi 2$	10.1	1	<0.001
N	40		
Mann-Whitney U	44.5		<0.001

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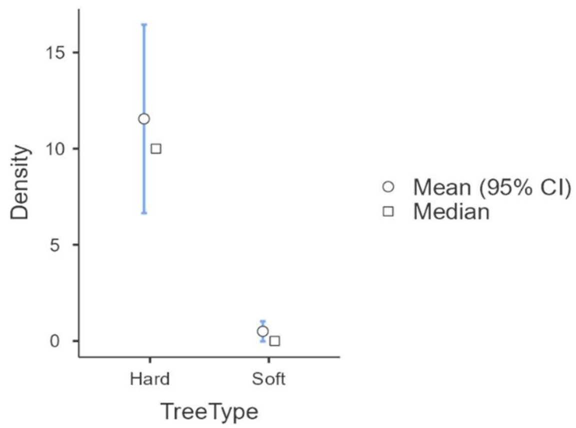

Figure 4. Plot showing the mean, 95% confidence interval and median (square)density of lichens on hardwood versus softwood trees.

This difference is further shown when comparing average densities of lichens on softwood and hardwood trees. The average density for hardwoods was 11.6% while softwoods was only 0.50%. Since the data were non-parametric, a Mann-Whitney U test was performed on the averages resulting in a p-value of less than 0.001 (Table 1). Once again this indicates a significant difference between not only presence, but the amount of lichen covering tree trunks on hardwood versus softwood trees.

DISCUSSION

Our study was conducted due to the lack of empirical research currently available on lichen preference for hardwood versus softwood trees. The sources that can be found about this topic mainly rely on anecdotal evidence claiming that lichens more commonly grow on hardwood trees. Our data displays a significant difference between the number of hardwood trees with lichen and the number of softwood trees with lichen and the corresponding lichen densities. This supports our hypothesis that lichens favor hardwood trees.

Despite the statistically significant results of our research, there is a large amount of further research that can be done on this topic. This study can be repeated in other areas to see if the data stays consistent, as well as performing it on a larger scale with a larger sample size. Other studies can be done to gain a better understanding of why this phenomenon may occur. For example, does this occur due to the acidity of bark or is there any seasonal differences in lichen distributions. Lichens are a crucial, yet often-overlooked species commonly found all over the world, so, for clarity on their distribution and environmental needs, studies that account for more confounding variables are needed.

Lichens have and will continue to have a profound impact on the environments they inhabit. For being some of the most prolific pioneer species to surviving trips to outer space, lichens are likely to survive as long as life is on this planet. Nevertheless, specific lichen species have their tolerance ranges and the stark difference of lichen species on hardwood and softwood trees shows this. Additionally, the effect sulfur dioxide pollution has had on lichen distributions in Europe is another example of how humans have affected lichen distributions (Hauck, 2011). This explains how, despite their general durability, understanding the more nuanced and specific climatic, nutrient, and environmental tolerations, such as was considered in this study, lichens are fragile in the face of climate change.

These factors, paired with the understanding that lichen species tend to be very region specific, of which the mechanism for is not known (Lõhmus et al., 2023), illustrate this importance of studies designed to understand the present distribution of Huntingdon lichen species and how future human impacts may affect them.

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