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Trail width and epiphyllous coverage of Chamaedorea spp

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ABSRACT

Epiphylls are bryophytes and lichens that grow on the leaves of other trees. These plants are dependent on water for survival and reproduction. Lichens are often used as bioindicators of climate change and pollution. The purpose of this study was to find out if trail width sufficiently changed the microclimate and alter epiphyll cover on trailside leaves. I hypothesized that epiphylls could be used as bioindicators of changing microclimate by trails from a control area. Liverwort and lichen cover were measured on leaves of *Chamaedorea* spp. (Arecaceae) in the Monteverde Biological Cloud Forest Preserve on five different trail types. Wider trails had decreased epiphyllous growth more compared to narrower trails, with reductions of 82% to 89% on wide trails and 28% reductions on narrow trails. Epiphylls have shown that they can be used as bioindicators of small changes in sunlight due to trail widths. Epiphyll cover is declining linearly with trail widths. These effects can be warning signs for others plants that are harder to see the effects of.

RESUMEN

Las epífilas son briófitas y líquenes que crecen en las hojas de otros árboles. Estas plantas dependen del agua para su supervivencia y reproducción. Los líquenes son utilizados con frecuencia como bioindicadores de cambio climático y contaminación. El propósito de este estudio fue determinar si la amplitud de los senderos cambia el microclima y altera la cubrierta de epífilas en las hojas a la orilla del sendero. Se propuso la hipótesis de que las epífilas briofíticas como los líquenes se podrían utilizar como bioindicadores de cambiobios en el microclima de los senderos en un área de control. Se determinó el porcentaje de cubierta de las hepáticas y líquenes en *Chamaedorea spp*. (Arecaceae) en la Reserva Biológica Bosque Nuboso de Monteverde, en cinco categorías diferentes de senderos. Se demostró que los senderos más anchos disminuyeron el crecimiento de epífilas más que los senderos más estrechos, con reducciones del 82% al 89% en senderos amplios. Se demostró que las epífilas pueden ser utilizadas como bioindicadores de cambios pequeños en la luz solar debido a la anchura del sendero.

INTRODUCTION

Bryophytes (Division Bryophyta) are nonvascular, photosynthetic plants that are usually small and slow growing. They are heavily dependent on water for survival and reproduction. (Moore et al. 1995). Bryophytes are important to a community because they increase the moisture in areas that are colonized by them. This is especially important in forest understories. Byrophyes help epiphytes to colonize on trees by acting as substrates (Gradstien, 2000). Bryophytes are also more susceptible to losing water as fast as they retain it (Schofield, 2001).

Epiphylls are plants, most of which are bryophytes, which live on leaves of other plants. These plants are most often found in tropical, humid forests. The most common epiphylls are Lejeuneaceae (Division Bryophyta, Order Sphaerocarpales) liverworts and lichens (Bates, 2000; Morales, 2000). Spores of Lejeuneaceae are short lived and are only dispersed short distances (Tan and Pocs, 2000). Epiphylls are commonly found on leaves that have a smooth surface, which promotes better reproduction and establishment (Morales, 2000). Most epiphylls only use their host plant for establishment; however, they are not host specific.

Most scientists are in agreement that epiphylls do not significantly reduce the photosynthetic output of the colonized leaves because the most heavily colonized leaves tend to be older ones, which no longer have an important input in the photosynthetic production of the plant (Morales, 2000). Also, Epiphylls can actually form a mutualistic relationship with their hosts; many epiphylls can deter herbivores from feeding on leaves of plants. Nutrient movement has also been documented for some species of epiphyllous liverworts, with the plant receiving nitrogen-fixing cyanobacteria (Bates, 2000; Morales, 2000). Epiphylls are conspicuous parts of tropical forests and contribute greatly to their biodiversity. The host plants of epiphylls may also have enhanced fitness due to colonization. Epiphylls may also be important and benefit ecosystem processes (Zartman, 2003).

Lichens are also known to colonize on living leaves as well and are therefore epiphylls. Lichens are a mutualistic relationship between green algae or cyanobacteria and a fungus, with both partners gaining nutrients. Lichens are completely reliant on water for production; in dry conditions photosynthesis stops and the lichen is inactive. There organisms are extremely adapted to taking up water and nutrients through diffusion, and it is because of this that they are used as bioindicators; because if there is a change in climate or pollution they are the first to be affected and to disappear (Brodo et al. 2001; Purvis, 2000).

In a study done in central Amazonia, C. Zartman (2003) found that fragmentation had negative effects on epiphyll coverage. Zartman found that fragmentation reduced species abundance and richness of epiphyllous bryophytes. Fragmentation also increased the chance of species becoming locally extinct. The purpose of my study was to find out, specifically, if trail width changed the microclimate and had an affect on the percent coverage of epiphyllous growth. I am arguing that epiphyllous bryophytes and lichens can be used as bioindicators of changing microclimate, as well, with the hypothesis that trails that have wider widths will have a decrease in epiphyllous coverage due to an increase in evaporation. Epiphylls, since they receive water and nutrients in a similar way as lichens, should be able to be used as bioindicators as well. Epiphylls have short life cycles and colonization periods. These plants are highly sensitive to amount of water, light, and nutrients that are present in an ecosystem. There should be a quicker response to these plants from changes in abiotic factors than slower growing, vascular plants. These vascular plants may respond in much the same way, however, with little notice. Epiphylls are found in areas of high diversity (easily quantified with limited taxonomy) and fast turnover rates, and are spatially delineated. These are also signs of good bioindicators. The increase in trail width should increase the trail edge effects, increasing light, and therefore evaporation, of the plants that are right on the trail.

METHODS

This study took place in the Monteverde Biological Cloud Forest Preserve in Monteverde, Costa Rica. Over 70,000 tourists visit the Reserve each year. The Reserve does limit the number of people that are in the trail system at one time to between 120 and 135 people (CCT). This study looked at the impact of all of these people in the area of the Reserve through its trail system. The trails examined were: Sendero El Camino, Sendero El Roble, Sendero Wilford Guindon, Sendero Bosque Nuboso, and a research trail. Samples of epiphyll coverage were only taken on *Chamaedorea* (Arecaceae) palms. I only used trees at the edge of the trail were used as samples in order to control for distance from trail edge. Also, in order to control for age, only the middle pinna on the left side of the second oldest frond was taken as a sample. A sample was taken off of the trails in order to have a set of control data that was not affected by trails or trail edge effects.

A transparency herbivory grid was used in order to measure the percent epiphyllous coverage of the pinnae. Only squares that were covered 50% or more with epiphylls were recorded for the percentage. That number was then divided by the total number of squares of the pinna for the total percent covered. In this experiment, both liverworts and lichens were measured for the total percent coverage. A tape measure was used in order to measure the width of the trails in meters.

Once the data were collected they were grouped into five different trail types, according to their width and substrate. In this experiment, substrate was assumed to determine trail width. Type 1 "trails" were the control data that were taken away from trails. Type 2 trails were trails that had substrates of wood cookies or concrete bricks of one brick wide. These trails had a width between one and two meters. Type 3 trails were constructed of concrete bricks of two or three bricks wide. These trails had a width between two and three meters wide. Type 4 and type 5 trails were the multipurpose road/trail, El Camino, which runs through the Reserve to the Continental Divide. This trail was split according to width. Trail type 4 had widths between four and five meters, while trail type 5 had widths between five and seven meters.

RESULTS

In total, 205 leaves were sampled from *Chamaedorea* palms on each of the five trail types. 30 samples were taken from trail type 1, 64 from trail type 2, 61 from trail type 3, 25 from trail type 4, and 26 samples from trail type 5. The data show that the wider trail type had less coverage of epiphylls than did the narrower trail types and the control. The average percent cover by trail type decreased in a linear regression with increasing trail widths. Trail type 1 (control) had an average coverage of 62.94%. As the average trail width increased from one to seven meters, the averages of the percent cover

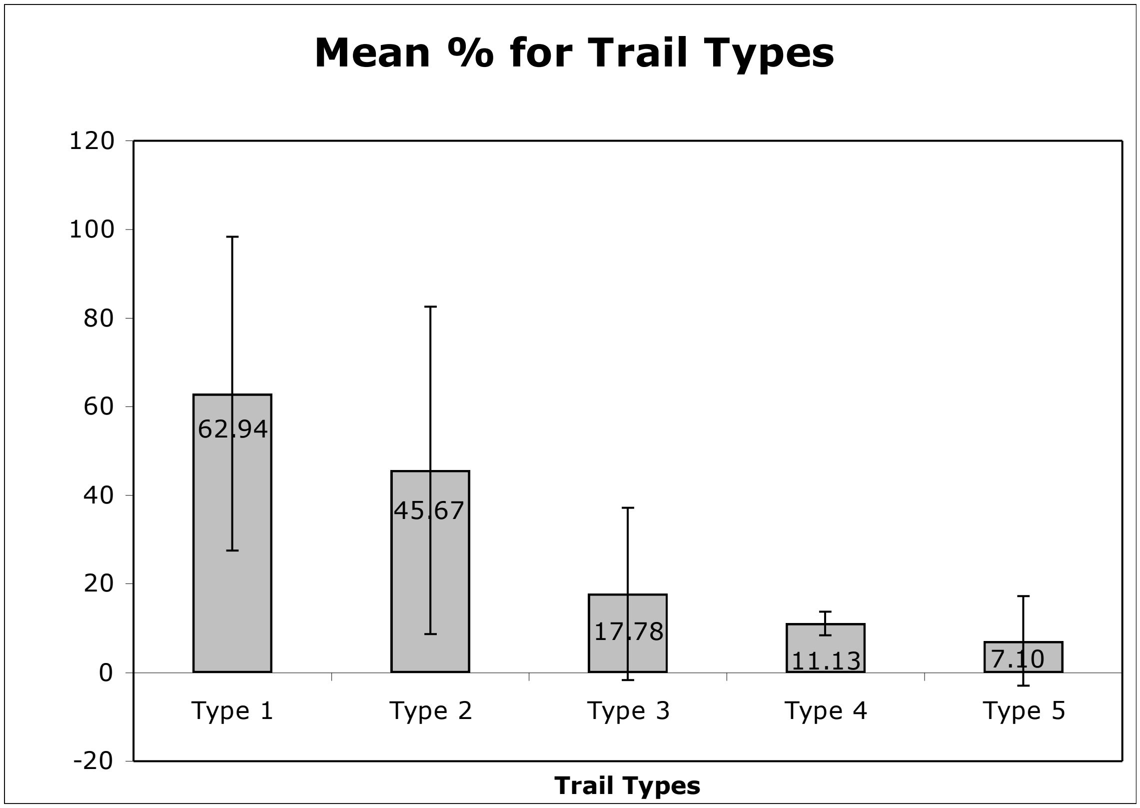

FIGURE 1. Mean % coverage of epiphylls on *Chamaedorea* palms in the Monteverde Biological Cloud Forest Preserve on five different trail types. The error bars are the standard deviation for each trail type. The percentage of epiphyllous coverage greatly decreases as the trail width increases.

decreased greatly. Trail type 2 had an average of 45.67% cover, with an average width of 1.48 meters. The average width of trail type3 was 2.87 meters and had a percent coverage of 17.78%. The widest trail types (ones with a multipurpose road as the substrate) had averages of percent coverage of 11.13% (trail type 4) and 7.1% (trail type 5) and 4.59 meters and 5.94 meters, respectfully (Figure 1). Trail types 1 and 2 had significantly more epiphyllous cover than trail types 3, 4, and 5 (Fisher's PLSD, $p < .0001$). Also, trail type 1 had significantly more epiphylls than trail type 2. Trail types 3, 4, and 5 were not significant from each other.

Epiphyll cover was tested against the average trail width of the corresponding trail type. The data fit a linear regression ($r^2 = .297$, $p < .0001$). The data show, with significance, that there is a strong negative correlation between the widths of trails that the percent of epiphyllous coverage on *Chamaedorea* leaves. Therefore, the trends (Figure 2) show that, from the control, the percent coverage is being reduced greatly with trail width. The larger trails have a much greater effect on the percent coverage than do the narrower trails. Narrow trails have some effect, reducing the epiphyllous coverage an average of 28% from the control. The wider trails have a much greater reduction of epiphyllous coverage. Trail type 3 have reductions of 71% from the control samples. Trail types 4 and 5 have even greater effect, reducing the percent coverage 82% and 89%, respectively.

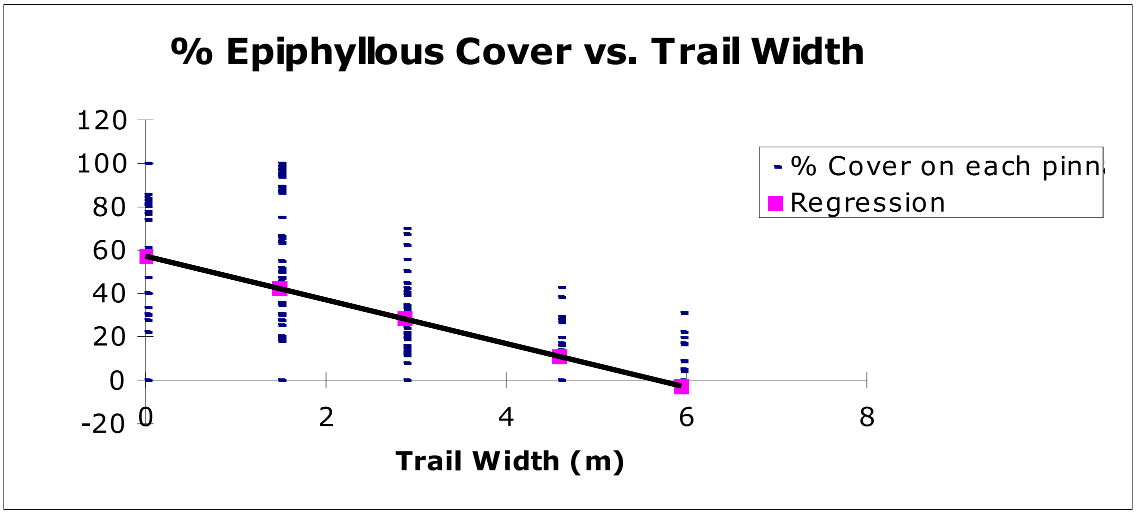

FIGURE 2 Percent coverage for each datum (circles) that was recorded compared to the average width of the corresponding trail. The regression points for the test (squares) and the regression line show that width affects epiphyllous coverage a great deal. The test proves this significantly with a p value of less than .05 ($p = 2.41e^{-17}$).

DISCUSSION

The results show that my hypothesis was accepted. Trail width does affect epiphyllous growth on plants. There is a strong negative correlation is shown between trail width and epiphyllous coverage. Having wider trail widths is changing the microclimate that epiphylls are living in. This change in microclimate is a result of wider trails increasing the trail edge effect that the forest is exposed to. I am also able to conclude from the results that in this case, epiphylls can be used as bioindicators for changing microclimates. Trail edge effect increases the amount of wind, light, and temperature, which in turns increases the amount of evaporation. The wider the trail width, the more pronounced the edge effects are.

Because of these trail edge effects, the epiphylls are drying out. Epiphylls are going to be more affected by trail edge effect because they are mostly bryophytes and lichens. These organisms to not have roots, so they are not able to receive water and nutrients from the ground; they have to absorb their water and nutrients directly from the air. In addition, bryophytes require water for reproduction; without water, the male gametes are not able to find the female gametes. Both bryophytes and lichens are more susceptible to desiccation, than are other plants.

In order to decrease the effects of trail edge, management plans should try to implicate making trails as narrow as possible. Narrow trails still do have some effect on epiphyllous growth, reducing the percent coverage to 28%. However, wider trails have a much greater impact than do the narrow trails. Compared to wider trails that reduce the epiphyllous coverage between 80% and 90%, narrower trails have a much less impact. In addition to the trails, management plans should be concerned about the amount of edge that comprises the perimeter of the area.

With the decline of epiphylls, some important relationships and interactions could be decreasing as well. Epiphylls have been known to deter herbivory on plants as well as supply nitrogen-fixing cyanobacteria, in some cases (Wanek and Portl, 2005). Bryophytes also increase humidity in colonized areas. With the absence of these bryophytes, these areas could be drying out even more because of this, in addition to the trail edge effects. This could affect the humidity level in the understory, as well the understory plants that depend on that humidity.

Also, in addition to this reduction from trail edge effects, many areas, such as Monteverde, Costa Rica, are being affected by larger scale factors, such as global warming. The amount of mist, and moisture in general, in Monteverde is declining. Combining the affects from global warming and edge effects could severely decrease the populations of these epiphylls. These plants that are common in tropical forests could start to become rare. Effects on other organisms from the increase in trail edge effect could be done as a future study; mosses, as well as other bryophytes, could be affected by trails as well. Also, researching how the loss of these epiphylls is affecting the community could be another future study. Elevation was not taken into factor for this study; however, this affects epiphylls as well.

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LITERATURE CITED

Bates, J.W 2000. *Mineral nutrition, substratum ecology, and pollution.* In: Bryophyte Biology, A. J. Shaw and B. Goffinet, eds. Cambridge University Press, Cambridge, UK, pp. 271-272.

Brodo, I. M., Sharnoff, S. D., Sharnoff, S. 2001. Lichens of North America. Yale University Press: 5-8, 38, 58

[CCT] Tropical Science Center. CCT homepage. www.cct.r.cr/en/menu_cct.html . Accessed 2005 May 18

Gradstien, S. R. 2000. *Bryophytes.* In: Monteverde: Ecology and Conservation of a Tropical Cloud Forest, N. M. Nadkarni and N. T. Wheelwright, eds. Oxford University Press. New York, New York. pp. 78-79.

Karnefelt, I. 1991. *Evolutionary rates in the Teloschistaceae*. In: Tropical Lichens: Their Systemics, Conservation, and Ecology, D. J. Galloway, ed. Oxford University Press: 119-120.

Moore, R; Clark, W.D.; Stern, K. 2000. *Botany.* Wm. C. Brown Publishers: 654-677.

Morales, M.I. 2000. *Plants Growing on Living Leaves.* In: Monteverde: Ecology and Conservation of a Tropical Cloud Forest, N. M. Nadkarni and N. T. Wheelwright, eds. Oxford University Press. New York, New York. pp. 80.

Proctor, M.C.F. 2000. *Physiology ecology.* In: Bryophyte Biology. A. J. Shaw and B. Goffinet, eds. Cambridge University Press, Cambridge, UK. pp. 225-248.

Purvis, W. 2000. Lichens. The Smithsonian Institution Press, Washington D.C.: 5-18.

Schofield, W. B. 2001. Introduction to Bryology. The Blackburn Press, Caldwell, New Jersey: 292-293.

Tan, B. C. and Pocs, T. 2000. *Bryogeography and conservation of bryophytes.* In: Bryophyte Biology. A. J. Shaw and B. Goffinet, eds. Cambridge University Press, Cambridge, UK. pp. 403-448.

Zartman, C.E. 2003. Habitat Fragmentation Impacts on Epiphyllous Bryophyte Communities in Central Amazonia. *Ecology* 84: 948-954.