Effect of Terrain Gradient on Litter Depth, Humus Depth, Root Density, & Above Ground Biomass in a Mixed Dipterocarp Forest

Jesse Hiestand
Charlie Ryland
Tim Treuer

ABSTRACT

In this study we sought to determine the relationships between topography, litter and humus depth and root density in diverse, primary, lowland Dipterocarp rainforest. Though known to be important for rainforest ecology, minimal research on how these factors are codependent is available. Varying slope gradient in a 52 ha plot in the Lambir Hills National Forest showed a negative correlation to both root density and above ground woody basal area in the surrounding trees. While the limited scope of our project prevents extensive application of our results, we were still able to demonstrate two important principles: (1) that great heterogeneity exists in tropical rainforests at both large and small scales and (2) that even local variation in an abiotic factor, such as topography, can have large ecological implications.

Introduction

Forest-growth is impacted by a wide range of factors, including topography and nutrient availability.[1,2,3] Due to ready soil erosion and frequent rainfall, these factors are widely varied throughout Lambir Hills National Park in Sarawak. We are interested in observing the relationships found between some of these factors by examining the effects of terrain gradient, leaf litter depth, and humus depth on root densities and basal area. In this study, we have sampled a number of random plots under various controls in order to examine the possibility of correlation between such variables as terrain gradient, humus depth, leaf litter depth, root density and above ground woody biomass.

Given the high levels of rainfall and the associated erosion and leaching of leaf litter and humus on varied sloped terrain, we hypothesized that high terrain gradient will correlate with decreased humus and leaf litter depth. Furthermore, we hypothesized that decreased humus and leaf litter depth would be correlated with increased root density and decreased relative woody basal area. We believed that the plants would need higher root densities to gather the requisite amount of recycled nutrients from the top soil layers and that this allocation of resources would result in less above ground plant development.

Methods

Using data previously collected by the Center for Tropical Forest Science over a 52 hectare plot in Lambir Hills National Park, 30 trees in separate 20m by 20m plots were selected. Despite being selected randomly, controls for minimum DBH, soil type, species composition and terrain gradient were used. Of these 30 trees, the first four usable sites were selected in each of three slope categories: those with a slope between 0 and 15 degrees, between 15 and 30 degrees, and between 30 and 45 degrees. At each site, we verified the slope of the terrain using a clinometer and surveyed the relative woody plant basal area using an anthropomorphic angle gauge. To measure root density at each site, three 10cm by 10cm by 5cm holes were dug, removing a fixed amount of soil. From these samples, the roots were then sorted, cleaned and weighed. Additionally, measures of leaf litter and humus depth were taken from each hole.

The statistical software R[4] was used to analyze our data. We first created a correlation matrix of our multiple variables by performing a Pearson test of correlation (Fig. 1), then further tested paired variables to verify causation. The data was further analyzed via a principle components analysis (Fig. 2).

Results

After testing each combination of pairs of variables for correlation, we found only three to be significant: leaf litter depth to humus depth (n = 36, p-value = .007), slope to root density (n = 36, p-value = .033), and slope to relative woody basal area (n = 12, p-value = .005).

	Slope	Leaf Litter Depth	Humus Depth	Root Density	Basal Area
Slope	--	-0.1198156	-0.24758100	-0.3561912	-0.45698196
Leaf Litter Depth	--	--	0.44359846	0.3029687	-0.25883490
Humus Depth	--	--	--	0.3154255	0.05660693
Root Density	--	--	--	--	0.17288437
Basal Area	--	--	--	--	--

Fig. 1
Correlation coefficient for each pair of observed variables

Following the analysis of correlation, the principle components plot illustrated a clear divide between plots with extreme slope and plots with great relative basal area, reinforcing the negative correlation between gradient and basal area.

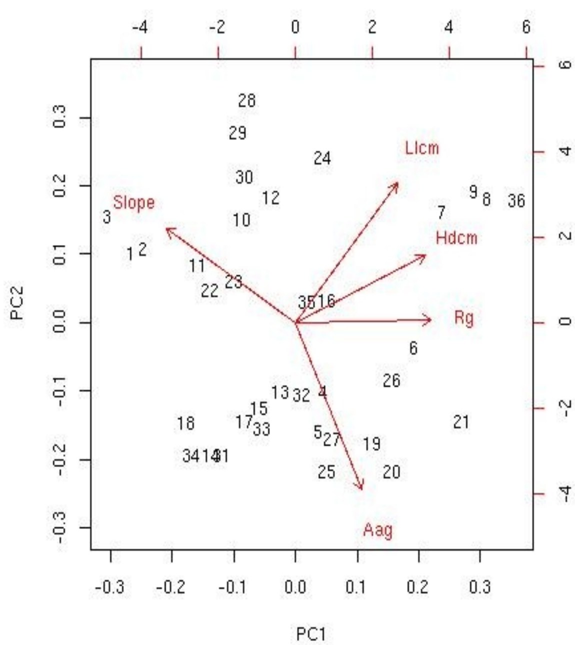

Fig. 2
Principle Components plot illustrating a pattern of clustering driven by slope and above ground biomas

Discussion

At the outset of this project, we made several predictions about the connectedness of various factors in forest ecology. Though none of the exact correlations made in our hypotheses proved significant, our results provide evidence for several interesting conclusions. To begin, we found that gradient played an important role in the density of roots laid down by the trees. Specifically, we have found that with steeper slope there is seen less root density, thus showing that terrain has a definite impact on the morphology of the trees. Secondly, we found that terrain gradient was negatively correlated to above ground woody biomass, showing that terrain can also influence the over-all structure of the forest.

Contrary to our original hypothesis, we also found that there were many high angle slopes with significant leaf litter, as illustrated in our principle component plot. In addition, there was great variation in root density and leaf and humus depth even within a given plot. For example, the samples with the greatest and least humus depth were found within the same plot. Both of these observations are evidence to the fact that rainforest ecosystems are incredibly heterogeneous, even in their abiotic factors and at the scale of just a few meters.

The extrapolation of these results to all tropical forests is limited due to the relatively small scope of the study, as it sampled only a few plots on one soil type from a single 52 ha region of the tropics. More significant relationships between the variables may have been found with a greater number of samples, exercising more control over confounding variables, and by analyzing some of our factors in different ways. Additional insight into the affect of slope and humus layer depth on root density may have been uncovered by looking at the density of the fine roots found in only the humus layer. By expanding the scope and breadth of this project, more powerful and applicable conclusions could be reached.

Despite these limitations, this project is able to demonstrate, at least to a limited extent, two very important principles of rainforest ecology. First, that they have incredible heterogeneity[5] at both large and small scales, in the variation of the micro-habitats they occupy and factors to which they have morphological responses. Second, even seemingly minor factors, such as micro-variation in topography, can influence overall forest ecology.

References

1. Harrison, R. 'Figs and the Diversity of Tropical Rainforests', BioScience 55(12), 1053-1064.
2. Davies, S.; Palmiotto, P.; Ashton, P.; Lee, H. & Lafrankie, J. (1998), 'Comparative ecology of 11 sympatric species of Macaranga in Borneo: tree distribution in relation to horizontal and vertical resource heterogeneity', Journal of Ecology 86(4), 662-673.
3. Baillie, I.; Ashton, P.; Chin, S.; Davies, S.; Palmiotto, P.; Russo, S. & Tan, S. (2006), 'Spatial associations of humus, nutrients and soils in mixed dipterocarp forest at Lambir, Sarawak, Malaysian Borneo', Journal of Tropical Ecology 22(05), 543-553.
4. R version 2.5.1 (2007-06-27). Copyright (C) 2007 The R Foundation for Statistical Computing. ISBN 3-900051-07-0
5. Kitayama, K. & Aiba, S. (2002), 'Ecosystem structure and productivity of tropical rain forests along altitudinal gradients with contrasting soil phosphorus pools on Mount Kinabalu, Borneo', Journal of Ecology 90(1), 37-51.