Preliminary Characterization of Soil Texture and Organic Matter Thickness in 52 ha of Lowland Mixed Dipterocarp Forest, Lambir Hills National Park, Sarawak Malaysia

Peter A. Palmiotto

Yale University, School of Forestry and Environmental Studies
New Haven, CT USA

ABSTRACT

Previous research in the mixed dipterocarp forests of the Lambir Hills National Park in Sarawak has shown the forests to be one of the most tree species rich in the Old World. A major focus of ecological research has been the explanations for such high species richness. One of the earliest proposed and most likely candidates to be a principle factor in maintaining species richness in tropical forests is habitat heterogeneity. In contrast to previous research that has examined this question on relatively homogeneous sites the establishment of the 52 ha plot at Lambir across diverse topography and soil types allows us to examine the ecological heterogeneity that exists. To characterize edaphic heterogeneity in the 52 ha plot at Lambir the spatial distribution of soil texture classes and the patterns of organic layer thickness were mapped during July and August 1992. Soil texture was determined in the field, along with measurements of litter depth, root mat thickness and percent canopy cover. Seven soil textural classes from clay to sandy loam were mapped. Sandy loam soils dominated the plot covering 17.4 ha, sandy clay loam soils covered 15.1 ha, clay loam soils covered 10.2 ha and loam soils covered 6.5 ha. Both leaf litter thickness and rootmat thickness increased with increasing coarseness of soil texture. Mean organic matter thickness on clay loam soils was 1.1 ± 0.3 cm while on sandy loam soils it was 6.1 ± 0.4 cm. Canopy density did not vary significantly between soil textural classes.

INTRODUCTION

A major focus of ecological research has been the search for principle factors that explain the maintenance of large number of tree species in species rich tropical forests. One of the earliest proposed and most likely candidates in the maintenance of tree diversity in tropical forests is habitat heterogeneity. Previous research has examined this question using data from relatively homogenous sites, thereby controlling for habitat heterogeneity. However, to begin to answer diversity questions, with habitat heterogeneity as the underlying hypothesis for a portion of its explanation, research needs to be conducted in forests that exemplify heterogeneity.

The mixed dipterocarp forests growing on the Lambir hills in northwest Sarawak, Malaysia is such a forest. Lambir's variable lithology has given rise to soils which vary in depth, sand content, and nutrient concentrations (Ashton, 1964). On the younger, sandstone-dominated hills towards the north, shallow spodosols predominate on the ridges. Lower sandstone cuestas and dip slopes bear deep soils of nutrient poor, yellow leached ultisols with a distinct surface horizon of densely rooted raw humus (humult)(USDA, 1975). In contrast, in the south and southwest deep yellow-red ultisols (udult), with a relatively high nutrient content are present (USDA, 1975).

Forest structure and species composition have been observed to reflect the large-scale edaphic variability. Heath forests of variable stature correspond to the sandstone ridges to the north while Mixed Dipterocarp forests grow elsewhere (Whitmore, 1984; P. Ashton, 1973 unpubl. report). Previous research at Lambir has broadly described patterns of floristic variation in relation to varying site factors (Ashton, 1964; Austin et al., 1972; Baillie and Ashton, 1983), as well as variation in forest structure and dynamics at the level of the whole stand for trees over 10 cm dbh (Hall, 1991; Ashton and Hall, 1992).

In collaboration with the Sarawak Forest Department, researchers from Harvard University and colleagues from the Plant Ecology Laboratory of Osaka City University, established a 52 ha plot at Lambir to encompass the variability exhibited by forests growing on the ultisols characteristic of the region. The south-central section of the plot consists of a broad ridge of soft shale, dissected at its margins by steep ravines and bearing udult soils with relatively high nutrient concentrations (for the region) of the main limiting nutrients, P and Mg (Ashton, 1973; Baillie et al., 1987; Ashton and Hall, 1992). This ridge extends northwest where, over a distance of 50 to 100 m, the udult soils are replaced by humult soils. The northwest three-quarters of the plot consist of an undulating dip slope on the west and a steep scarp on the east (Figure 1). Within this plot is a diversity of habitats that make it ideal for addressing questions of tree species diversity.

To begin to address species diversity and correlate it to habitat heterogeneity, in particular soil heterogeneity, a finer scale characterization of the habitats within the plot has to be described. This paper reports the results of a preliminary survey of edaphic heterogeneity within the 52 ha plot.

METHODS AND ANALYSIS

To characterize edaphic heterogeneity in the 52 ha plot at Lambir the spatial distribution of soil types and the patterns of organic layer thickness were mapped during July and August 1992. Soil texture was determined in the field, along with measurements of litter depth, root mat thickness and percent canopy cover. Approximately 600 points were surveyed on a 20 x 40 meter grid in the lower part of the plot (0 -140 m), and on a 40 x 40 meter grid above the 140 m line. Each point was located 5 m west of each quadrate's southeast corner. At each sampling point a field determination of soil texture class was made. Field determinations were regularly checked in the lab using a LaMotte Chemical soil texture kit. Litter layer depth, root mat depth (to the nearest cm), and canopy density (using a spherical densiometer) were also measured at each point. Depth of litter was categorized as 'trace' when at least 25% of the ground was visible through the leaves, as 'present' when the ground was completely covered by leaves, but litter depth was less than 1 cm (i.e. single layer of leaves) and measured to the nearest cm when the leaf litter was 1 cm or thicker. Rootmat thickness was categorized as 'trace' when roots were present but no root mat existed, as 'present' when a rootmat was present but was less than 1 cm thick, and measured to the nearest cm when it was 1 cm or thicker

To analyze the litter and rootmat depths, values of 0.1 and 0.5 were assigned to categories of 'trace' and 'present.' Data was analyzed using Statview statistical package. Spatial representation of the soil texture map and the corresponding area was created using IDRISI (version 4.0) geographic information software. Using the Thiessen command IDRISI constructs polygons around each control point (soil texture class collected in the field). The polygons define the regions which are dominated by each point (Eastman, 1992). The Area command was then used to calculated the area (ha) of the polygons that had a value of each texture class.

RESULTS

Seven soil textural classes from clay to loamy sand were mapped in the 52 ha plot. As expected finer textural classes (i.e. clay and clay loam soils) dominated the south central section of the plot with distinct patches occurring along the eastern border (Figure 2). Coarser textured, highly erodable soils (i.e. sandy loam and sandy clay loam soils) dominated the remaining 2/3 of the plot. Sandy loam soils dominated the plot covering 17.4 ha, sandy clay loam soils covered 15.1 ha, clay loam soils covered 10.2 ha (Table 1). Figure 3 shows the percent particle size in the different textural classes of soil samples tested in the lab.

Both leaf litter thickness and rootmat thickness increased with increasing coarseness of soil texture , agreeing with previously accepted trends observed in other tropical forests (Figure 4). Mean organic matter thickness (root mat and litter layer) on clay loam soils was 1.1 ± 0.3 cm while on sandy loam soils it was 6.1 ± 0.4 cm. Canopy density did not vary significantly between soil textural classes (mean = 94.0%, range: 67.3 - 99.8%).

Table 1. Number of hectares represented by each soil texture class in Lambir's 52 ha plot. (IDRISI software, using Thiessen and Area commands on point data, n=597).

Texture	Hectares
clay	2.2
clay loam	10.2
loam	6.5
loamy sand	0.1
sandy clay loam	15.1
sandy loam	17.4

DISCUSSION

With the correlation of organic matter thickness to coarseness of soil texture it is tempting to look at the soil texture map and attempt to delineate different soil types (i.e. udult and humult soils). Unfortunately, this can not be done as soil texture alone can not determine soil type. Soils on steep slopes that are actively eroding are likely not ultisols, but some form of Entisols (USDA, 1975). Short of chemical analysis, a combination of slope angle and organic matter thickness is needed to construct a soil type map of the 52 ha plot. The data presented here is preliminary. I am currently conducting a second survey examining the soil texture, organic matter thickness, slope angle and disturbance history for each 20 x 20 quadrate in the plot.

However, even the results of this preliminary survey shows that the distribution of soil textural classes (i.e. the edaphic heterogeneity) that exists in the 52 ha plot is on a scale of 10's of meters. In combination with the undulating terrain and steepness of slope the soil nutrient and moisture heterogeneity at a microsite scale is likely high. The addition of biotic factors (i.e. soil macro fauna) and disturbance regimes (i.e. tree fall gaps and landslides) further increases the habitat heterogeneity within the plot. The current survey will describe this heterogeneity in detail, which in turn will be used to examine the distribution of tree species in the plot. Habitat heterogeneity, one of the oldest explanations of species diversity, is not likely to explain the demographic patterns of all 1100 species in the plot, but even if 10% can be explained by this factor it would be substantial because no previous evidence exists at this scale.

ACKNOWLEDGMENTS

I would like to thank the State Secretary for permission to conduct research in Sarawak and the Director of Forests and Assistant Director of Research (Sarawak Forest Department) for their sponsorship. Funding for this project came from Tropical Resources Institute, Yale University, School of Forestry and Environmental Studies, and the Conservation, Food and Health Foundation Inc.

REFERENCES

Ashton, P.S. 1964. Ecological studies in the mixed dipterocarp forests of Brunei state. *Oxford Forestry Memoirs*. No. *25*.

Ashton, P.S. 1973. Report on research undertaken during the years 1963-72 on the ecology of mixed dipterocarp forest in Sarawak. Sarawak Forest Department, Mimeo. 412 p.

Ashton, P.S. and Hall, P. 1992. Comparisons of structure among mixed dipterocarp forests of north-west Borneo. *Journal of Ecology*. *80*: 459-481.

Austin, M.P., Ashton, P.S. and Grieg-Smith, P. 1972. The application of quantitative methods to vegetation survey. III. A re-examination of forest data from Brunei. *Journal of Ecology*. *60*: 305-324.

Baillie, I.C. and Ashton, P.S. 1983. Some aspects of the nutrient cycle in the mixed dipterocarp forests of Sarawak, East Malaysia. In: S. L. Sutton, T. C. Whitmore, A. C. Chadwick (ed.) *Tropical Rain Forest: Ecology and Management*. p. 347-356.. Blackwell Scientific Publications, Oxford.

Baillie, I.C., Ashton, P.S., Court, M.N., Anderson, J.A.R., Fitzpatrick, E.A. and Tinsley, I. 1987. Site characteristics and the distribution of tree species in mixed dipterocarp forest on tertiary sediments in Central Sarawak, Malaysia. *Journal of Tropical Ecology*. *3*: 201-220.

Eastman, J.R. 1992. *IDRISI, Technical Reference*. Clark University Worcester MA.

Hall, P. 1991. Structure, stand dynamics, and species compositional change in the mixed dipterocarp forests of northwest Borneo. Ph.D. thesis Vol I & II. Boston University.

U.S.D.A. 1975. *Soil Taxonomy. A basic system of soil classification for making and interpreting soil surveys*, Agricultural Handbook 436.

Watson, H. 1985. *Lambir Hills National Park Resource Inventory and Management Recommendations*. National Parks and Wildlife Office Forest Department Sarawak, Kuching.

Whitmore, T.C. 1984. *Tropical Rain Forest of the Far East*. 2nd, edn. Clarendon Press, Oxford.

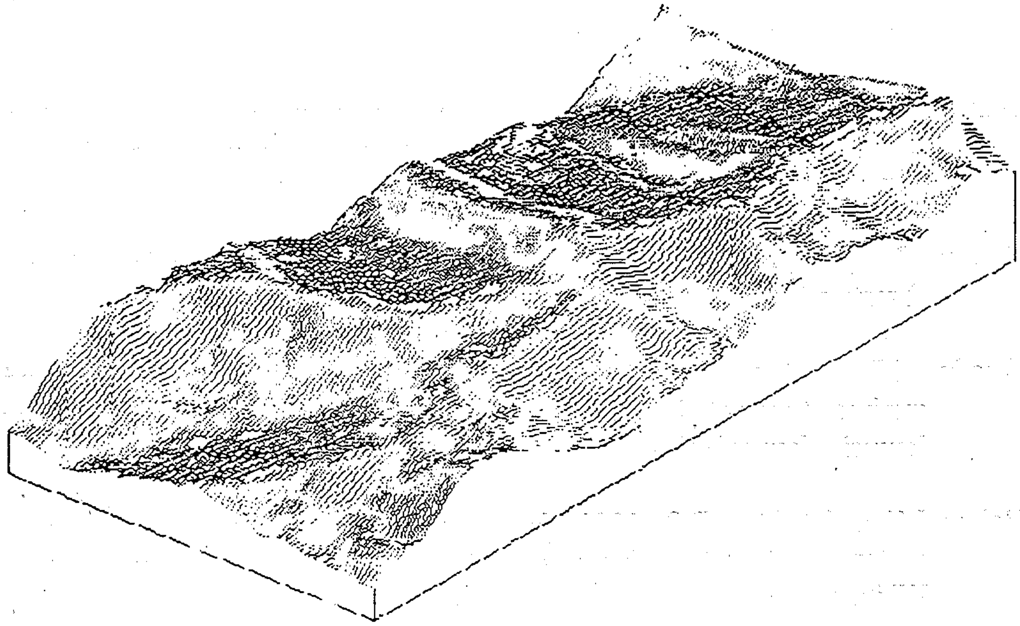
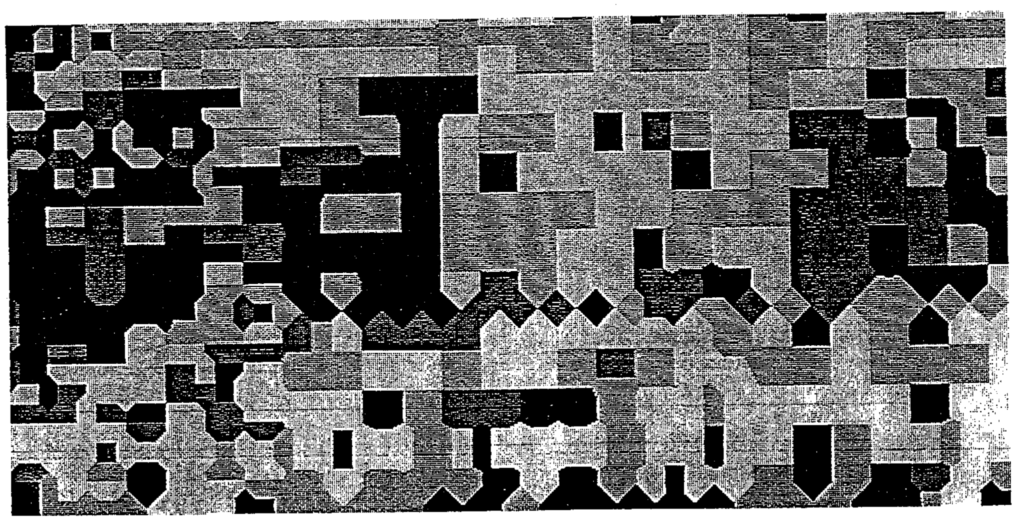


Figure 1: Steepness of slope in Lambir's 52 ha plot (southeast aspect, 45° viewing angle).



Legend

white = sandy loam
light gray = sandy clay loam
dark gray = loam
black = clay and clay loam

Figure 2: Spatial distribution of soil textural classes in Lambir's 52 ha plot. (IDRISI software, using Thiessen command on point data, n=597).

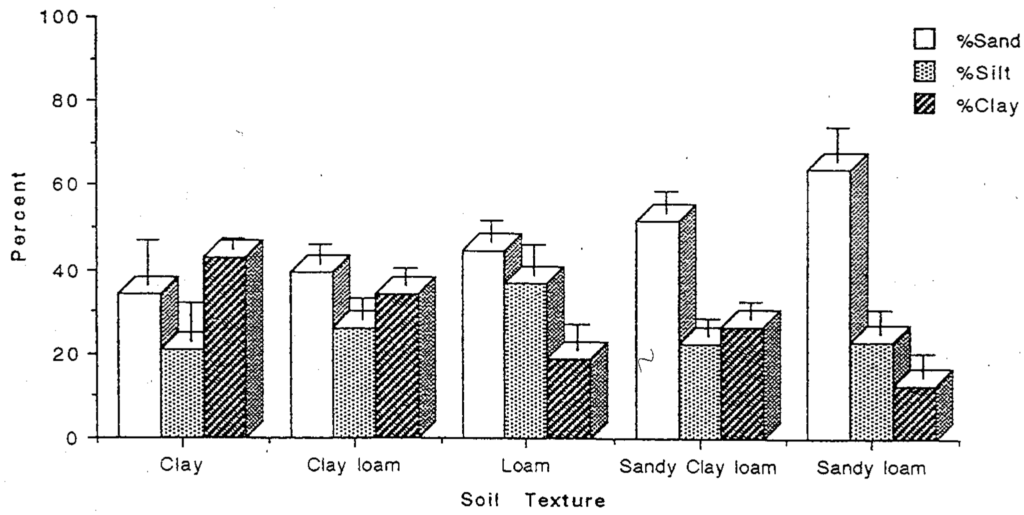


Figure 3: Mean percentage of particle size in dominant soil texture classes with standard deviation, from Lambir's 52 ha plot (n=146).

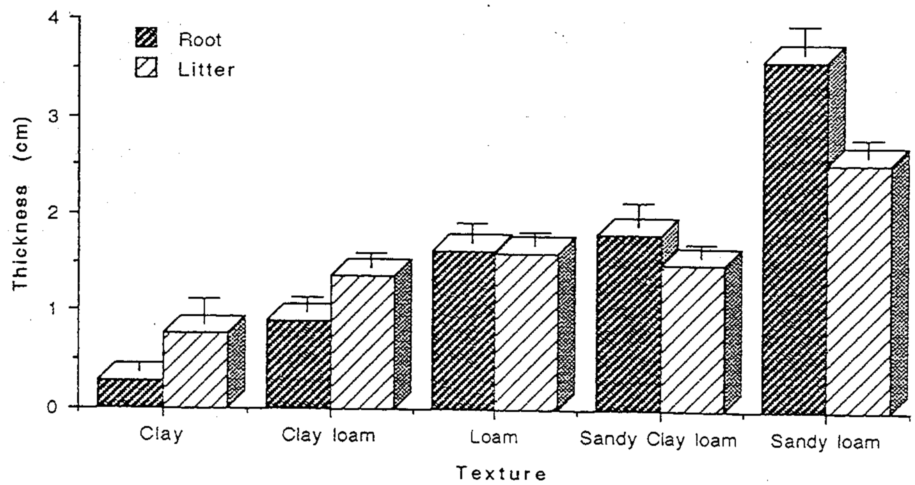


Figure 4: Mean depth of litter and rootmat over different soil textural classes with standard deviation, from Lambir's 52 ha plot (n=597).