SPATIAL DISTRIBUTION OF SOIL NUTRIENTS IN THE FOREST DYNAMIC PLOT AT SINHARAJA

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Introduction

Rain forests supply much information about high plant diversity compared to other tropical forests. The main resource available in Sri Lanka for an illustration for a rain forest is Sinharaja lowland rainforest. A Forest Dynamic Plot (FDP) is established at Sinharaja, which covers an area of 25 ha (500 x 500 m). There is little information available on the spatial scale and pattern of below ground resources in lowland rain forests. According to Robert *et al*., (2006) soil nutrients show non-uniform patchy distribution that are often correlated with topographical features such as slope and elevation suggesting that such physical processes are important in determining spatial variation in soil characteristics. Changes in the magnitude and scale of spatial dependence in soil nutrients may reflect changes in the cover, composition or size of plants over the succession. The present study was designed to address the spatial soil resource heterogeneity in lowland rainforest with the help of a research project carried out by the third co-author of this article. The study area includes a valley, lying in-between two slopes, a steeper higher slope facing the southwest and a less steep slope facing the northeast. The Sinharaja FDP were divided into 8 topographic habitats depending on three physical parameters, elevation, slope and convexity (Gunatilleke *et al*., 2005).

Soils were sampled by using a regular grid pattern which yielded 253 soil samples in total. Soil samples were analyzed for Al, Ca, Fe, K, Mg (mg/kg), pH and soil moisture (%) using standard analytical procedures. Geostatistics were used to quantify the scale and pattern of soil variability and to discriminate between large trends in the data. The spatial variations of Al, Ca, Fe, K, Mg, P, and pH and soil moisture were analyzed using semivariograms and coefficient of variations were taken for the consideration to confirm heterogeneity.

Methodology

A Box-cox transformation (Lambda restricted to 0, 0.5, 1.0) is used to normalize the soil nutrient data (mg/kg), and performed polynomial trend-surface regressions. Empirical variograms were computed using the residuals of the regression to remove the spatial trend in the data across the site. Since the data were relatively sparse, isotropy is assumed, and variogram models were fitted to the calculated empirical variograms. Using ordinary kriging the spatial predictions for 20 $\times$ 20 m blocks were obtained. The trend was then added back to the kriged means, and the values were back transformed to the original scale. Geostatistical analyses were carried out mainly by using the R package "gstat" version 0.9-59 (http://www.gstat.org/) in the R programming environmental version 2.8.1 (http://www.R-project.org).

Results and Discussion

When comparing the means, standard deviations and coefficient of variation(CV) of the variables, it was noted that Mg was the most variable property (CV=1.48), and pH had the least CV value. Though Ca and Fe had nearly equal values for average contents, standard deviation of Ca was two times that of Fe. All the calculated sample correlation values were statistically significant at 5 % level except pH with soil moisture, Fe, K, Mg and P, Mg with soil moisture, Al, Ca, Fe and K. Since the variables that have been used are chemicals, obviously there may be some multiple correlations between them. Seven different measurements on multiple correlations (ranging between 0.24 - 0.85) indicted that there were significant interactions between measured soil properties. Semivariograms were drawn, and variogram models were fitted for soil properties. An exponential model provides a significant fit to the semivariograms for all soil properties except for P. Spherical model was the most preferable model to describe the spatial correlation for P (Table 1- see Appendix). Parameter values of the fitted variograms models were used to estimate spatial predictions for 20 × 20 m quadrates and to generate spatial soil maps. Using these estimated predictions, descriptive statistics, mean, Standard deviation (SD) and Coefficient variation (CV), of the soil variables (Table 2- see Appendix), and the relationships with topographic features (Table 3- see Appendix) were obtained. Observed means and the predicted means were similar in some extent for Al, Fe, K, P, pH and soil moisture. However, the estimated standard deviations were narrow than the measured values. This study showed that the Mg was the most variable soil property in 25-ha FDP, Sinharaja (CV = 1.04). P was the second most variable nutrient in the sampled area (CV = 0.36). A similar value (CV = 0.31) was obtained for Ca. Block averages of soil properties in 20 × 20 m quadrates were correlated with mean elevation, slope and convex of these quadrates. All correlations except those indicated in bold were statistically significant (p-value < 0.05), but the correlations were usually weak as indicated by the numbers in the table.

Conclusion

The pair-wise correlation coefficient of Al with soil moisture, Ca with K and Ca with P were 0.602, 0.592 and 0.458 respectively. Al and pH showed a moderate negative relationship (-0.451). Since the variables that have been used are chemicals there can be some multiple correlations. The results of seven different measurements (0.24 - 0.85) on multiple correlations indicate there were significant interactions between soil properties. Topographic variables, elevation and slope related with Al, Ca, K and P. All the values of the correlation coefficients were ranging between 0.217-0.285 when discard the sign. Mg was the most variable soil property measured in this study with a coefficient of variation equal to 1.04. Soil pH and soil moisture are the least variable among all other parameters.

References

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Appendix

Table 1. Variogram models

	Lambda	Trend order	Model	Nugget	Partial sill	Range (m)
Al	1	2	Exponential	10832.98	25370.43	42.2760
Ca	0.5	2	Exponential	48.2361	46.2131	30.4098
Fe	0	2	Exponential	0.0180	0.0786	16.6954
K	0.5	2	Exponential	3.1723	2.5112	14.7288
Mg	0	3	Exponential	0.0878	1.0726	43.9433
P	0.5	2	Spherical	0.4358	0.5634	48.2188
pH	0	3	Exponential	0.0014	0.0056	20.9340
Soil Moisture	0	2	Exponential	0.0102	0.0239	17.6390

Table 2. Univariate statistics for spatial predictions

	Al	Ca	Fe	K	Mg	P	pH	Soil moisture
Mean	939.71	156.38	176.03	22.11	26.06	1.78	4.49	0.24
SD	99.41	47.99	23.19	2.99	27.16	0.63	0.2	0.02
CV	0.11	0.31	0.13	0.14	1.04	0.36	0.04	0.07

Table 3. Kendall correlation coefficients of soil nutrients and topographic variables

	Al	Ca	Fe	K	Mg	P	pH	Soil moisture
Elevation	0.217	0.217	-0.096	0.285	0.064	-0.234	0.133	0.194
Slope	0.057	0.093	-0.171	0.07	**-0.01**	-0.234	0.127	**-0.018**
Convex	0.145	**-0.02**	**0.024**	0.108	**-0.017**	-0.109	-0.11	0.156