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Quantitative Characterization of Field-estimated Soil Nutrient Regimes in the Coastal Forest

Introduction

One of the key factors in the site classification of the biogeoclimatic ecosystem classification is soil nutrient regime. Soil nutrient regime (SNR) represents the amount of essential soil nutrients available to plants over a period of several years. SNRs classes are assessed based on field identifiable (qualitative) criteria, not using quantitative measures. There have been several studies that attempted to quantitatively characterize regional soil nutrient gradients in the Coastal Western Hemlock (CWH) zone. In the study summarized here, the soils are influenced by a perhumid cool mesothermal climate. The objective of the study was to examine relationships between soil chemical properties and field-estimated SNRs.

Study Stands and Procedure

One hundred and fifty two study stands were selected in seven locations on south-western Vancouver Island over a wide range of sites. The stands were 35 years old and established after cutting old-growth stands, slashburning, and planting. The canopy cover ranged from 40% to 90%. The SNR of each stand was estimated using an heuristic procedure that integrated a number of easily observable soil morphological properties and indicator plants.

In each of the study stands, a 0.01 ha sample plot was established. On all sample plots, a composite sample was taken from 15 randomly selected points. At each sample point the entire forest floor and the first 30 cm of the mineral soil were sampled. The samples were air-dried, prepared for laboratory analysis, and analysed for the following chemical properties: pH, total C (tC), total N (tN), mineralizable-N (min-N), extractable Ca (eCa), Mg (eMg), K (eK), P (eP), and S (eSO_4-S), and C:N ratio was calculated. All properties were expressed as concentration on a dry mass basis.

Using the field identified SNR classes, the mean chemical properties for each class were calculated and compared by one-way analysis of variance. Then the chemical measures that differentiate best between field identified SNR classes were selected and the results were compared to other studies in this zone.

Results and Discussion

Most of the forest floor and mineral soil chemical properties showed a trend with the field identified SNR gradient (Table 1, Figure 1 and Figure 2). However, it should be noted that the sample size for very poor sites was quite low (n = 4); therefore, even large differences between very poor soils and soils in the other SNR classes may not be statistically significant. For both forest floor and mineral soil pH, tN, and min-N increased and C:N decreased from very poor to very rich soils. Beside the above mentioned properties in the case of forest floor eMg showed a decreasing trend, and for mineral soil tC, eK, and eP showed an increasing trend along the SNR gradient.

Mineral soil min-N was the only property for which the mean values in all five SNR classes were significantly different. The mean min-N values increased exponentially across the SNR gradient. Mineral soil tN distinguished most of the SNR classes with the exception of very poor which was not significantly different from poor. On the other hand, forest floor eK and eP (for both mineral soil and forest floor) showed no significant differences between any SNR classes.

Table 1. Means and standard deviations (in parentheses) of selected forest floor and mineral soil (0 - 30 cm) chemical properties for plots stratified by field-identified soil nutrient regimes. Values in the same row with the same letter superscript are not significantly different (α = 0.05).

	VP	P	M	R	VR
n	4	26	89[1]	17	16
Forest floor					
pH	4.0^{c}	4.2^{bc}	4.4^{b}	4.6^{a}	4.6^{a}
	(0.26)	(0.23)	(0.29)	(0.25)	(0.15)
Total C (g kg^{-1})	51.5^{a}	46.1^{ab}	46.1^{ab}	42.3^{b}	44.2^{ab}
	(1.42)	(5.62)	(5.82)	(3.66)	(2.74)
Total N (g kg^{-1})	1.11^{cd}	1.15^{d}	1.31^{bc}	1.45^{b}	1.78^{a}
	(0.11)	(0.19)	(0.21)	(0.25)	(0.29)
C/N ratio	47^{a}	41^{a}	36^{b}	30^{c}	25^{c}
	(4.0)	(6.2)	(5.9)	(5.0)	(3.3)
Mineralizable-N (mg kg^{-1})	275^{bc}	368^{c}	536^{bc}	709^{ab}	980^{a}
	(77)	(207)	(257)	(392)	(415)
Extractable Ca (mg kg^{-1})[2]	2483^{ab}	2546^{a}	2989^{a}	2995^{a}	1953^{b}
	(662)	(444)	(1414)	(1625)	(1281)
Extractable Mg (mg kg^{-1})	1128^{a}	878^{ab}	777^{b}	537^{c}	410^{c}
	(394)	(267)	(216)	(188)	(182)
Extractable K (mg kg^{-1})	415^{a}	459^{a}	410^{a}	442^{a}	423^{a}
	(147)	(157)	(129)	(73)	(124)
Extractable P (mg kg^{-1})	56.4^{a}	51.7^{a}	55.3^{a}	65.60^{a}	66.2^{a}
	(25.2)	(23.9)	(22.9)	(25.9)	(27.6)
Extractable SO_4-S (mg kg^{-1})	28.2^{a}	28.4^{a}	26.4^{a}	27.1^{a}	27.4^{a}
	(12.3)	(12.1)	(10.8)	(18.6)	(10.4)
Sum of extractable Ca, Mg,	4026^{ab}	3884^{a}	4176^{a}	3974^{a}	2776^{b}
and K (mg kg^{-1})[2]	(526)	(566)	(1495)	(1782)	(1515)
Mineral soil					
pH	4.4^{c}	4.6^{bc}	4.7^{b}	4.7^{ab}	4.7^{abc}
	(0.23)	(0.23)	(0.20)	(0.26)	(0.28)
Total C (g kg^{-1})	4.75^{c}	6.72^{c}	8.92^{b}	9.66^{b}	12.9^{a}
	(0.80)	(1.51)	(2.02)	(2.00)	(2.30)
Total N (g kg^{-1})	0.19^{d}	0.25^{d}	0.35^{c}	0.44^{b}	0.63^{a}
	(0.03)	(0.06)	(0.07)	(0.07)	(0.12)
C/N ratio	26^{ab}	28^{a}	25^{b}	22^{c}	21^{c}
	(2.1)	(3.1)	(3.1)	(1.5)	(1.6)
Mineralizable-N (mg kg^{-1})	15^{e}	41^{d}	85^{c}	173^{b}	322^{a}
	(6)	(13)	(26)	(29)	(74)
Extractable Ca (mg kg^{-1})[2]	43^{ab}	139^{b}	204^{ab}	328^{a}	280^{ab}
	(23)	(78)	(137)	(373)	(405)
Extractable Mg (mg kg^{-1})	35.0^{a}	58.7^{a}	66.4^{a}	62.6^{a}	62.1^{a}
	(12.2)	(29.2)	(34.7)	(33.1)	(35.1)
Extractable K (mg kg^{-1})	21.4^{d}	35.6^{cd}	44.4^{c}	55.5^{b}	74.4^{a}
	(4.6)	(11.0)	(15.9)	(10.0)	(14.8)
Extractable P (mg kg^{-1})	2.7^{a}	2.5^{a}	4.3^{a}	6.0^{a}	6.6^{a}
	(3.6)	(1.1)	(5.8)	(4.3)	(2.3)
Extractable SO_4-S (mg kg^{-1})	8.3^{d}	53.8^{bc}	71.1^{a}	35.2^{bc}	23.2^{cd}
	(6.4)	(53.4)	(40.4)	(28.6)	(21.1)
Sum of extractable Ca, Mg,	100^{ab}	233^{b}	315^{ab}	447^{a}	417^{ab}
and K (mg kg^{-1})[2]	(29)	(100)	(175)	(401)	(443)

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Figure 1. Direct measures of forest floor chemical properties stratified according to field-estimated SNRs. Error bar is one standard error of the mean. VP, P, M, R, and VR are very poor, poor, medium, rich and very rich, respectively.

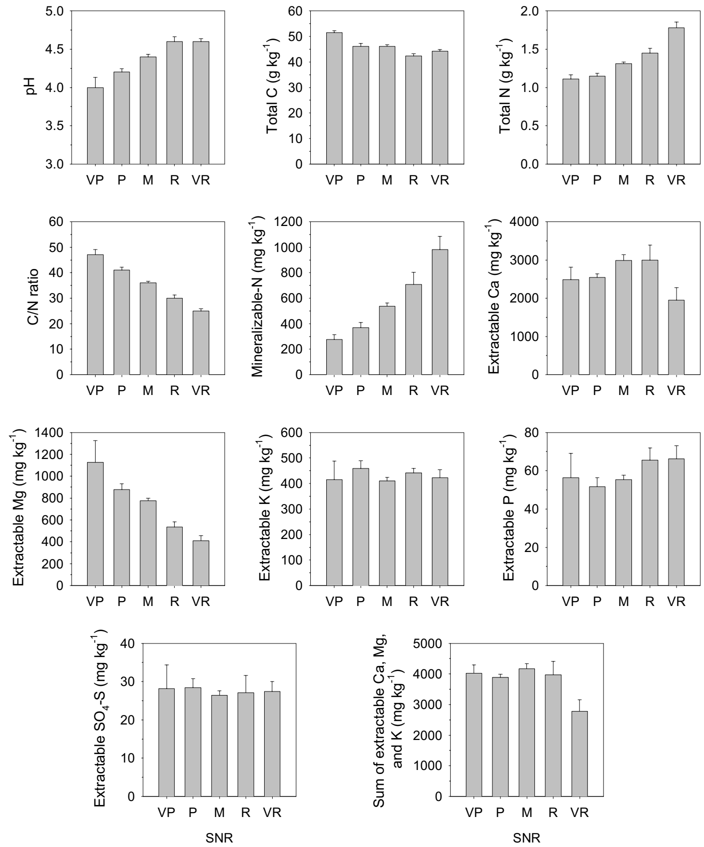
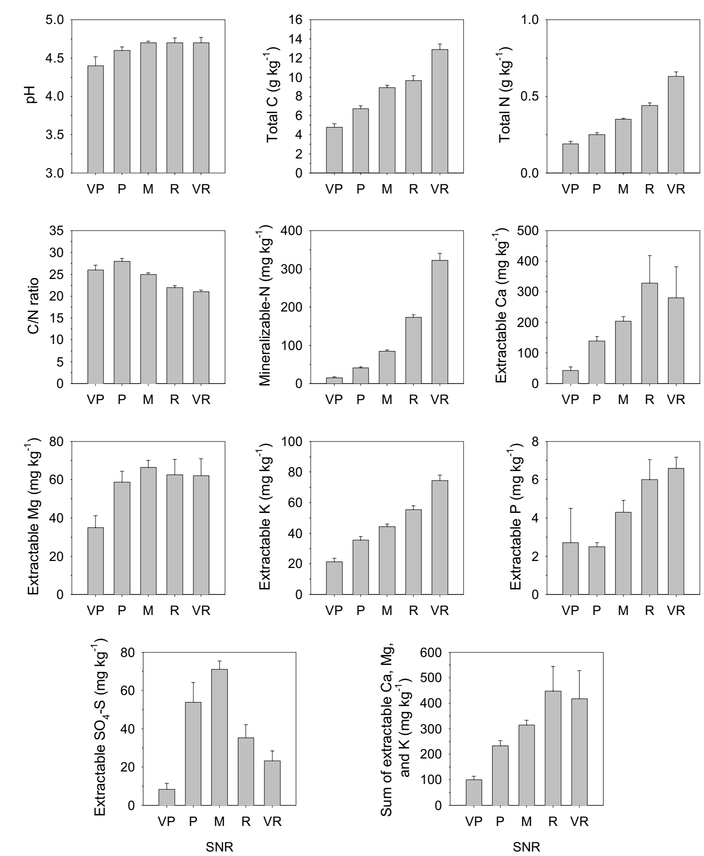


Figure 2. Direct measures of mineral soil chemical properties stratified according to field-estimated SNRs. Error bar is one standard error of the mean. VP, P, M, R, and VR are very poor, poor, medium, rich , and very rich, respectively.



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The other studies in the CWH zone also found that N-related measures (min-N and tN) distinguish best between field identified SNR classes. In each study the range of values increased from very poor to very rich, but the present study had the highest mean min-N values in all SNR classes compared to the other studies. When the min-N values from the different studies are combined, the ranges of values for almost all SNR classes overlapped.

The inconsistencies between the studies can be attributed to the use of concentrations instead of a volume basis for expressing the amount of min-N, and climatic differences of the study areas. Using concentrations does not provide a good indication of the available min-N in the soil for uptake by plants. Also the C and N concentrations in the soil increase with increasing precipitation.

Conclusions

Mineral soil min-N was the only property that differentiated between field identified SNR classes in the study stands. Other studies in the CWH zone also found that min-N and tN are the best measures for a quantitative classification of soil nutrients. However, there is quite a bit of overlap between soil N concentration values for field identified SNR classes.

Reference

Varga, P. and K. Klinka. 2001. Quantitative characterization of soil nutrient regimes in the CWHvm subzone of coastal British Columbia. (unpublished manuscript)

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