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A soil-landscape model for Mahurangi Forest, Northland, New Zealand

H.S. Jones[A], D.J. Lowe[A], W.C. Rijkse[B], C.D.A. McLay[A] and T.W. Payn[C]
[A]Department of Earth Sciences, University of Waikato, Private Bag 3105, Hamilton, New Zealand. [B]Landcare Research, Private Bag 3127, Hamilton, New Zealand. [C]Forest Research, Private Bag 3020, Rotorua, New Zealand.
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Abbreviation: NZSC = New Zealand Soil Classification

Introduction

Exotic plantation forestry is an important land use of both economic and environmental significance in Northland and elsewhere in New Zealand. It is therefore of considerable importance that forestlands be managed sustainably by employing approaches such as site-specific management. The establishment of site-specific forest management practices requires information regarding the distribution of key soil properties (Turvey and Poutsma, 1980). Quantitative modelling to predict key soil properties from landscape features may be an effective approach to mapping forestlands. A study investigating the efficacy of such an approach is being conducted within Mahurangi Forest, Northland, New Zealand. As a pilot to the study, a detailed qualitative soil-landscape model was developed in order to gain a greater understanding of the soil-landscape relationships and soil pattern of the area. The qualitative soil-landscape model developed in the pilot study is presented here.

Material and Methods

The soil-landscape model was developed using the land systems approach (Lynn and Basher, 1994), within representative training windows and extrapolated across southern Mahurangi Forest. The soils occurring on representative landforms within the training windows were described according to the method of Milne et al. (1995) and classified using the New Zealand Soil Classification system (Hewitt, 1998). The investigation of soil class distribution within the training window, and the later validation of the soil-landscape model, were conducted by auger observation. A soil class map was produced using the geographic information system ARC/INFO (Environmental Systems Research Institute, 1997).

Results and Discussion

Three orders of the NZSC were represented within southern Mahurangi Forest: Ultic, Gley, and Raw Soils (Table 1). However, Ultic Soils dominated, with the Mottled Yellow Ultic subgroup accounting for the majority of observations. Therefore, it can be considered that there is little taxonomic diversity within the forest.

Table 1. Soil classes of the NZSC and soil series identified in southern Mahurangi Forest.

Order	Group	Subgroup	Series	NZSC class codes
Ultic	Yellow	Mottled	Whangaripo	UYM (Wr)[1]
			Puhoi	UYM (Pb)[2]
		Typic		UYT
	Perched-gley	Typic		UPT
Gley	Orthic	Acidic		GOA
Raw	Fluvial			WF
	Orthic			WO

[1]Abbreviation for the Whangaripo series.
[2]Abbreviation for the Puhoi series.

The difference between the soil classes (with the exception of the Raw Soils) is essentially related to a natural drainage sequence ranging from the well or moderately well drained Typic Yellow Ultic Soils to the poorly drained Gley Soils. The drainage of the soil can have a marked influence on tree growth and can impact on harvesting operations. Therefore, despite the lack of taxonomic diversity, differences between the soils potentially have significant implications for forest management decision making.

The drainage of the soil appears to be controlled mainly by a combination of topographic position and the nature of the underlying parent material. The parent material is almost exclusively clay derived from strongly weathered Tertiary sandstone and mudstone (Waitemata Group), which is red weathered in places.

The relationships between observable landscape features (landforms) and soil classes are listed in Table 2. The Typic Yellow Ultic Soils occupy topographic positions from which water is readily removed (e.g. narrow ridge summits) and/or locations where the red-weathered regolith occurs in close proximity to the soil surface (within 50 cm). Gley Soils occur on topographic positions where water accumulates (e.g. narrow valley floors). In those topographic positions where water residence is intermediate (e.g. broad ridge summits), the imperfectly drained Mottled Yellow Ultic Soils occur, unless the red-weathered regolith occurs close to the surface—in this case the soil will be better drained. Some Mottled Yellow Ultic soils are slightly more-imperfectly drained than others; the better-drained soils are identified as the Whangaripo series whereas the more-imperfectly drained soils are assigned to the Puhoi series. The Typic Yellow Ultic Soils and the Mottled Yellow Ultic Soils (Whangaripo series) correspond to the Typic Paleudults of Soil Taxonomy whereas the Mottled Yellow Ultic Soils (Puhoi series) correspond to the Aeric Paleaquults (Soil Survey Staff, 1996).

Table 2. Relationships between soil classes and landscape features.

Landscape features	Dominant soil class	Subdominant soil class(s)
Flat/narrow ridge summit	UYT	UYM (Wr)
Broad/sloping ridge summit	UYM (Wr)[1]	UYM (Pb)
Ridge hillock	UYT	UYM (Wr)
Ridge saddle	UYM (Pb)[2]	UYM (Wr)
Backslope	UYM (Wr)	UYM (Pb), UYT, WO
Footslope	UPT	
Narrow valley floor	GOA	
Broad valley floor	WF	

[1]Abbreviation for the Whangaripo series.
[2]Abbreviation for the Puhoi series.

The depth below the soil surface at which the red-weathered regolith occurs is only weakly associated with the present topography. It tends to be close to the surface on flat ridge summits and ridge hillocks but can also occur near to the surface on other landforms. Therefore, a degree of uncertainty exists that limits the success with which the soil-landscape model can predict the soil class distribution at the subgroup level. However, at the order and group levels of the classification, the predictive success was improved due to the lack of taxonomic diversity. The fourth level of the NZSC, the soilform (Clayden and Webb, 1994), was not found to be useful in this study because all of the described soil pedons had very similar soilform designations.

Conclusions

Although there is little taxonomic diversity within southern Mahurangi Forest, the differences evident between the soil classes may have significant implications for forest management.

The soils of southern Mahurangi Forest can be described in terms of a drainage sequence that is controlled primarily by the complex interplay of topographic position and the nature of the parent material, which is strongly weathered.

The success with which the soil-landscape model predicts the distribution of the NZSC subgroups is limited by the weak correlation between the present topography and the nature of the parent material.

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