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Soil Spatial Variability in Northern Manawatu, New Zealand

**A thesis presented in partial fulfilment of the requirements for
the degree of Doctor of Philosophy in Soil Science
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Massey University

Asoka Senarath

2003

*This Thesis is Dedicated to My Loving Mother and
to the Memory of My Loving Father.*

Abstract

A detailed soil survey (1:25,000 scale) was conducted in northern Manawatu, near Kiwitea village, covering 2000 ha of terraced lands having three major terraces; a low river terrace, a last-glacial intermediate terrace and loess covered upper terrace. The area is characterized by warm and dry summers and wet and mild winters. The annual rainfall ranges from 900-1200 mm and the mean annual temperature ranges from 12°-13.5°C.

The parent materials are recent alluvium for the soils of the lower terrace; a mixture of alluvium, colluvium, loess and tephra for the soils of the intermediate terrace and Ohakean loess intermixed with tephra for the soils of the upper terrace. The loess originated from the local alluvium. The alluvium is derived mainly from greywacke, which is non calcareous and quartzo-feldspatic in mineralogy, and local early Pleistocene sands and mud.

In the soil survey, soils with gley profile form are considered poorly drained; with mottled profile form are considered imperfectly drained; with redox-mottled horizon below 60 cm are considered moderately well drained and; with no reductimorphic horizon or redox-mottled horizon within 80 cm are considered well drained. According to these drainage criteria the Ohakea and Marton series are redefined. Five new soil series are identified. Thirteen soil types are mapped.

The soil survey revealed that there is little relationship between soil drainage and topography. Chemical and mineralogical analysis of the soils revealed that there is a strong relationship between soil drainage, clay mineralogy and phosphate retention (P-retention).

Three parameters important for soil management were studied in detail in a window area (2000 m by 300 m) selected from the intermediate terrace. These three parameters were drainage status, P-retention and penetration resistance (PR) of the topsoil.

When mapped at 1:25,000 scale the window area comprised three different soil map units having well, moderately well and imperfect drainage. A small window area

(300 m by 250 m) from each map unit was selected and again mapped at 1:10,000 (100 m by 100 m grid) and 1:5,000 (50 m by 50 m grid) scales.

The simple soil pattern represented at 1:25,000 scale map is more complex when mapped at 1:10,000 scale. At least three different soil types (drainage classes) were identified in each of the blocks at 1:10,000 scale. When mapped at 1:5,000 scale little new information was found, but the drainage class boundaries could be shown more accurately. P-retention and PR of the topsoil are highly variable within the soil map units at all different mapping intensities. Variability of PR is dependent on the soil type and the land use, whereas P-retention is influenced by soil type alone.

Soil maps at 1:25,000 or smaller scale are not capable of readily delineating drainage status of this particular soil complex. A 1:10,000 scale soil map is the smallest scale that portrays reliable information.

No clear relationship could be established between soil drainage and landscape features, or depth to underlying river gravels. Therefore, a grid method is most suitable for conventional soil surveys in the area. An electromagnetic sensor (Em38) linked to a GPS can successfully be used to map soil drainage classes reliably, rapidly and cost effectively.

There is a good relationship between P-retention and soil drainage. Low P-retention values are associated with poorly drained soil conditions whereas high P-retention values are associated with well-drained soil conditions. The relationship is not as strong with moderately well drained and imperfectly drained soils. A majority of the observations on the imperfectly drained soils have medium P-retention values whereas a majority of the observations on the moderately well drained soils have P-retention values that range from medium to high.

The relationship between P-retention and soil type allows soil maps to be used effectively to identify areas likely to have low and high P-retention in the field. Soil maps at 1:10,000 scale are more suitable for identifying the areas reliably. However, some uncertainty exists within imperfectly and moderately well drained areas.

There is a good relationship between the PR and soil types as for the P-retention. The PR of the topsoil is relatively low in poorly drained soils and gradually increases through imperfect, moderately well to well drained soils. Soil maps at 1:5,000 are the most suitable for delineating PR classes.

The spatial scale of the variability of the three soil properties was quantitatively investigated using variogram models. The spatial variability of the three soil properties is anisotropic over the intermediate terrace. The variability is greater across the terrace than along the terrace. The maximum variability occurs at shorter lags (100-200 m) across the terrace and at longer lags (250 – 500 m) along the terrace.

Soil drainage and the tephra mixed parent material are the driving force behind the spatial variability of the three soil properties. Under well drained conditions, volcanic glass present in the tephra weathers to allophane and kandite and under imperfect and poorly drained conditions into kandite alone. P-retention is high in allophane-rich, well-drained soils and low in kandite-rich imperfectly and poorly drained soils. Variability of soil drainage within short distances is attributed to the minor textural differences responsible for the different hydraulic conductivity properties in the original alluvial sediments from which the soils developed.

The implications of spatial scale of soil variability for soil mapping, land use, soil management and land suitability evaluation are discussed

A summary of the study, research findings, recommendations and further research needs are given.

A soil survey report of Kiwitea district including formation, distribution, properties, limitations and the management of soils is written in simple English for non-technical people and is included as an appendix.

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