Impacts of conversion from forestry to pasture on soil physical properties of Vitrands (Pumice Soils) in central North Island, New Zealand

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Introduction

Tens of thousands of hectares of land have been converted from plantation forest to pasture in the central North Island of New Zealand between 2000 and 2010. The land use change was driven by the perceived better long term returns from dairy farming compared with forestry. Pumice Soils (NZ Soil Classification, equivalent to Vitrands in *Soil Taxonomy*) in the central North Island are formed on pumice deposited mainly from the AD 232 ± 5 Taupo volcanic eruption. The texture of Pumice Soils (Figure 1) varies from silt to coarse gravel and they have weak structure and erode easily when disturbed. Water holding capacity may be low but increases as the organic matter content of the topsoil is built up.

Figure 1. Upper part of soil profile on Pumice Soil, central North Island, New Zealand

When forests are cleared for pasture (Figure 2) the soil may undergo changes in soil structure affecting physical properties including the water infiltration rate and moisture holding capacity. Soil physical characteristics influence plant growth rates, soil erosion, and infiltration runoff, and therefore, flood occurrence in the catchment.

Soil organic matter (SOM) content is widely recognised as a factor that influences a number of soil physical properties (Bauer *et al.* 1992). De Oliviera *et al.* (2008) found that forest to pasture conversion caused lower organic carbon content (SOM). Steffens *et al.* (2008) similarly suggested that organic carbon, total N and total S concentrations decreased with increasing grazing intensity. However, recent findings from New Zealand showed a significant increase in soil organic matter in the first 5 years after conversion from plantation forest to dairy pasture on Pumice Soils (Hedley *et al.* 2009).

Figure 2. Land conversion from plantation forest (*Pinus radiata*) to dairy pasture near Taupo in the Central North Island of New Zealand

Pasture production on the Pumice Soils in summer is often limited by moisture availability. Because of increasing pressure on water resource use in the area an enhanced understanding of soil moisture holding capacity will contribute to our ability to manage plant available moisture. The plant root depth of much of the pasture on farms recently converted from forest was relatively shallow (about 10 cm), thus making pasture especially prone to moisture stress during dry periods. It is suggested that if we can identify causes of the shallow root depths and find a means to counteract the problem, root depth could be doubled from 10 to 20 cm, which would increase the moisture available to plants during dry periods and could conservatively give an overall 10% increase in pasture production.

The overall objective of this study was to investigate changes in soil physical properties in Pumice Soils following land use change from forest to pasture. Specific objectives were: (1) to investigate the consequences of conversion from forest to pasture on the soil moisture retention, plant rooting depth, aggregate stability, soil dry bulk density, and hydrophobicity; and (2) to determine the relationship between soil organic matter and the soil physical properties measured.

Site identification and experimental design

Four soil landscape units were identified: two near Tokoroa (Maxwell Farms) and two near Taupo (Wairakei Estate) (figure 3). On each soil landscape unit, seven sites were identified including current plantation pine forest, pasture established 1, 3, 4, and 8 years since forest-to-pasture conversion, long-term sheep pasture, and long-term dairy pasture.

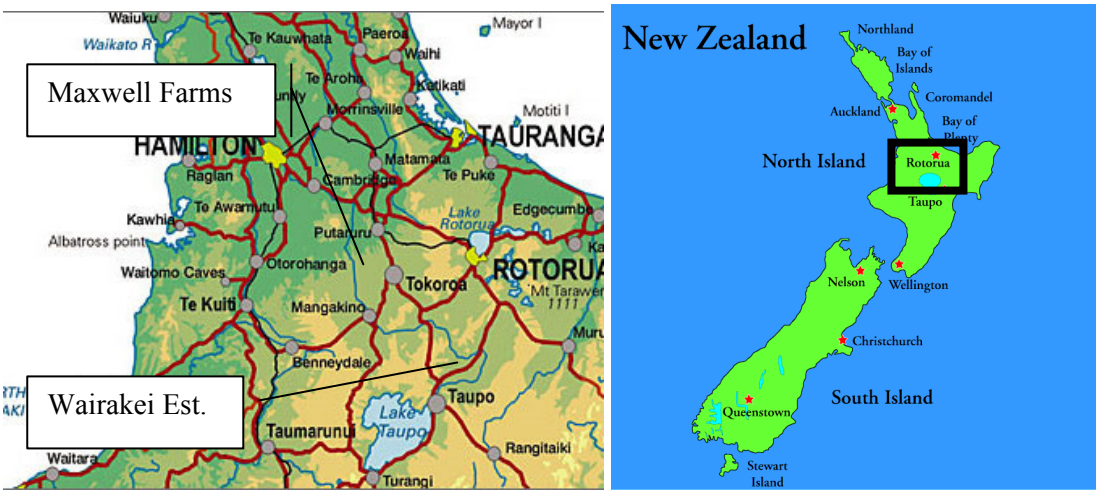

Figure 3. Location of study sites at Maxwell Farms and Wairakei, Central North Island New Zealand

Undisturbed soil cores were taken in triplicate from each site at a range of depths. Soils were analysed for unsaturated hydraulic conductivity, moisture release characteristics, readily and total-available water, particle density, and particle-size distribution. Soil water repellency or hydrophobicity was measured using the water

drop penetration time. Total carbon and total nitrogen were determined in a parallel project (Lewis *et al*. 2010).

Discussion and conclusion

At the time of writing sampling is underway. Initial observations show that there are marked differences between forested, recently converted and long term pasture sites in terms of soil bulk density or soil structure and aggregation particularly in near surface soil horizons.

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