THE DEVELOPMENT OF PROXIMAL SENSING METHODS FOR SOIL MAPPING AND MONITORING, AND THEIR APPLICATION TO PRECISION IRRIGATION

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Abstract

The potential of proximal soil sensing methods for high resolution investigation of soils in the landscape has been investigated. This addresses the need for improved environmental monitoring and management of soils within their environs. On-the-go electromagnetic (EM) mapping has been used to map soils, providing a high resolution (< 10m) spatially defined soil apparent electrical conductivity (EC_a) datalayer. Vis-NIR field spectroscopy has been trialled for in situ analysis of soil carbon, nitrogen and moisture.

The portable spectroradiometer has been used at 6 sites in the Taupo-Rotorua region for rapid, field analysis of soil carbon (R^2 calibration = 0.95, R^2 prediction = 0.75,) soil nitrogen (R^2 calibration = 0.95, R^2 prediction = 0.86) and moisture (R^2 calibration = 0.96, R^2 prediction = 0.70) by collecting reflectance spectra from the flat surface of a soil core; and at one Manawatu site for soil moisture (R^2 calibration = 0.79, R^2 prediction = 0.71), where the reflectance spectra were collected directly from a freshly cut in situ soil surface. EM mapping and Vis-NIR field spectroscopy were used in combination to spatially characterize soil moisture patterns at the Manawatu site.

Soil available water-holding capacity (AWC) of EC_a-defined zones has been assessed at six irrigated production farming sites. Two methods (predicted AWC v EC_a; estimated AWC v EC_a) have been used to relate soil EC_a to soil AWC to predict spatial AWC ($R^2 \geq$ 0.8 at 5 sites). Site-specific soil water balance models have been developed at all sites; and a wireless real-time soil moisture monitoring network has been trialled at two sites, to be used with the EC_a-AWC prediction model for the development of daily soil water status maps, for variable rate irrigation (VRI) scheduling. This digital, spatially defined soil water status information is available for upload to a sprinkler system modified for variable rate application.

The calculated water savings with VRI were 9–26% with equivalent energy savings and improved irrigation water use efficiency. Drainage and runoff were reduced by 0–55% during the period of irrigation, with the accompanying reduced risk of nitrogen

leaching. The reduction in virtual water content of product has also been assessed for VRI and compared with uniform rate irrigation (URI) at three study sites.

This study suggests that these proximal sensing methods provide a new improved way of monitoring and mapping soils. This facilitates soil inventory mapping, for example soil moisture and carbon mapping. In addition, these high resolution environmental monitoring and mapping techniques provide the information required for optimizing site-specific management of natural resources at the farm scale.

On-the-go electromagnetic (EM) mapping has enabled a step change in the pedological investigation of New Zealand soils. Resulting soil EC_a maps provide a tool for improving traditional soil map boundaries because they delineate soil zones primarily on a basis of soil texture and moisture in non-saline soils. In this study the maps have been used for site-specific irrigation management at the farm-scale, aiming to increase the energy efficiency of this land management operation. The study has developed a method for improved use of freshwaters by more accurate irrigation scheduling, based on high resolution characterization of spatial and temporal soil differences.

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irrigation evolved in my mind as a soil-based decision support tool, so (I think) it developed in Stu's mind as a modification of a centre-pivot or lateral irrigator with individual sprinkler control. Stu went on to form a new company, Precision Irrigation, with George Ricketts; and it became apparent to us all, at roughly the same time, that we could combine forces and come up with a potentially really useful new technology to help address New Zealand's emerging problem of insufficient freshwater to maintain supply to the ever increasing demands for irrigation in drought-prone parts of the country. We hope to continue and expand this collaboration.

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This thesis is dedicated

to the memory of

Alan McRae

18 November 1948 – 19 April 2008

Farm Consultant

Lochalsh Agriculture Ltd

A great friend and visionary

who introduced me to the concept of participatory research

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