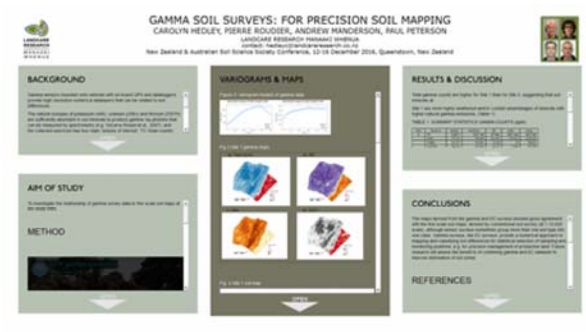
GAMMA SOIL SURVEYS: FOR PRECISION SOIL MAPPING



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BACKGROUND

Gamma sensors mounted onto vehicles with on-board GPS and dataloggers provide high resolution numerical datalayers that can be related to soil differences.

The natural isotopes of potassium (40K), uranium (238U) and thorium (232Th) are sufficiently abundant in soil minerals to produce gamma ray photons that can be measured by spectrometry (e.g. Viscarra Rossel et al., 2007), and the collected spectrum has four main 'regions of interest': TC (total counts), 40K, 238U and 232Th.

Soil minerals containing potassium and its isotope 40K are common, for example feldspars and micas. The less abundant uranium and thorium minerals typically also occur with feldspar and mica-bearing rocks, such as greywacke alluvium and gravels, and in some volcanic rocks. 232U is also introduced into soils, associated with Cd in phosphate fertilisers (Taylor, 2011).

Gamma survey data is used in digital soil mapping exercises to predict soil attributes, e.g. clay content (e.g. Piikki et al., 2013), and also in precision agriculture to classify soils into management zones for precision management (e.g. Rodrigues et al., 2015).

AIM OF STUDY

To investigate the relationship of gamma survey data to fine scale soil maps at two study sites.

METHOD

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Two Hawkes Bay farm sites (102 ha and 33 ha) WERE gamma surveyed. The mobile radiation detection system (Radiation Solutions RS-700) continuously recorded georeferenced values every second, with 8 m swath widths. The vehicle travelled at a speed of about 10 kph providing a high resolution dataset for the survey areas (Fig. 1). Raw data were pre-processed and then converted, using variogram analysis and ordinary block kriging, into four maps: TC, 40K, 238U, 232Th, using R (R Core Team, 2014). Block kriging estimates a value for a block in preference to a point, and this method provides better variance estimates and smooth interpolated results. A Dualem 1s sensor survey system was also used to collect apparent electrical conductivity (EC) data. This sensor has two depths of exploration: 0.5m (shallow) and 1.5 m (deep).

A fine-scale pedological survey was undertaken at both sites using visual observation of soil pits and auger samples, at an approximate scale of 1:10,000 (1 observation per ha). The field observations were supported by desktop analysis of a LIDAR-derived digital elevation map.

VARIOGRAMS & MAPS

Figure 2: Variogram models of gamma data

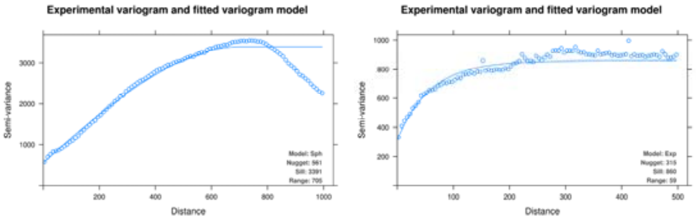


Fig.3 Site 1 gamma maps

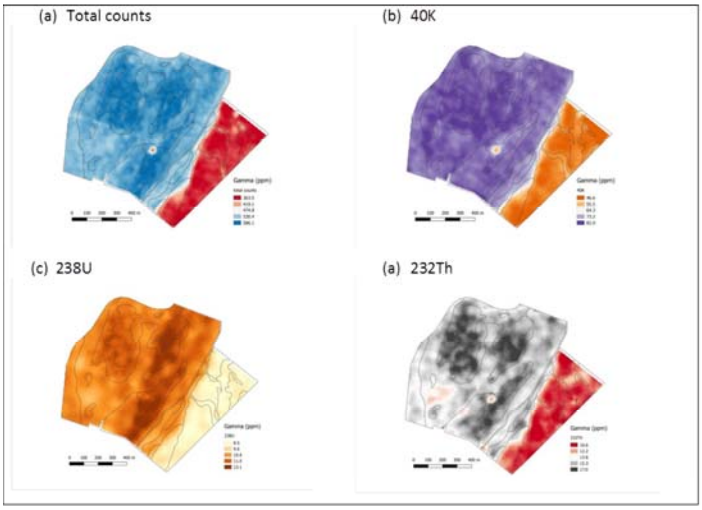


Fig. 4 Site 1 soil map

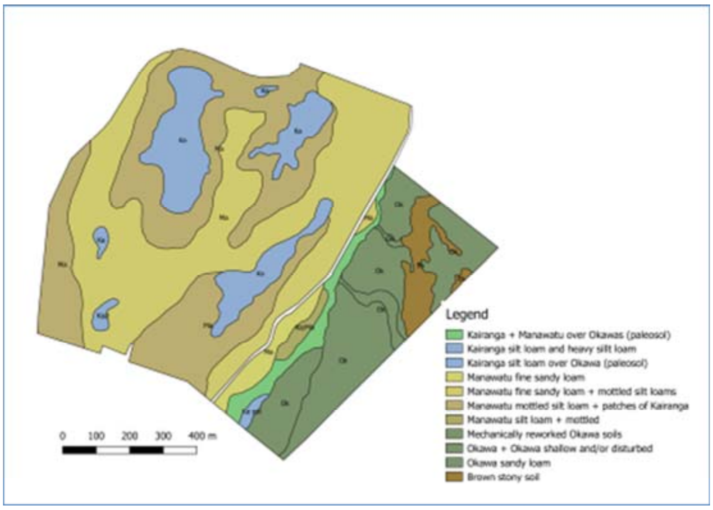


Fig. 5 Site 1 EC maps

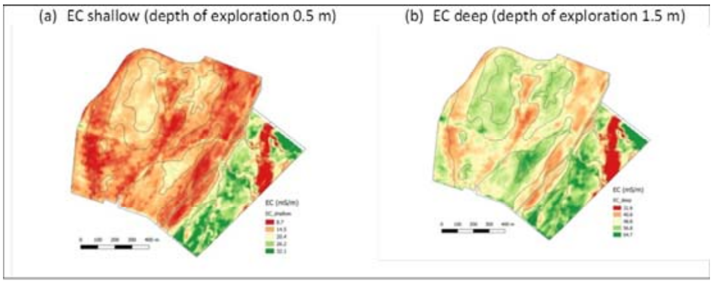


Fig. 6 Site 2 gamma maps

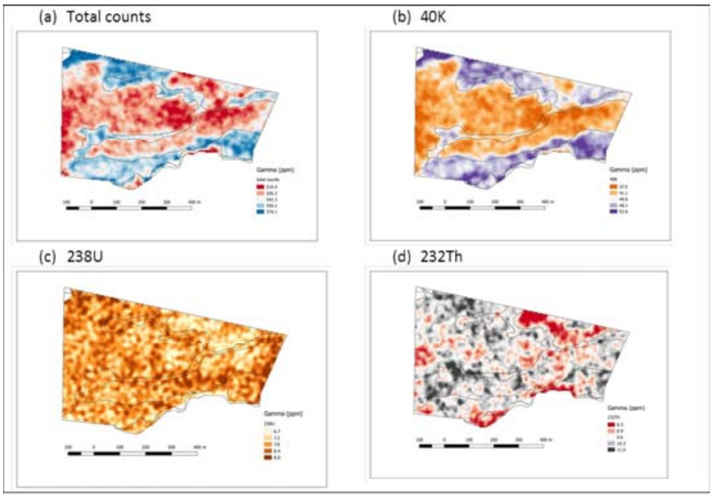


Fig. 7 Site 2 soil map

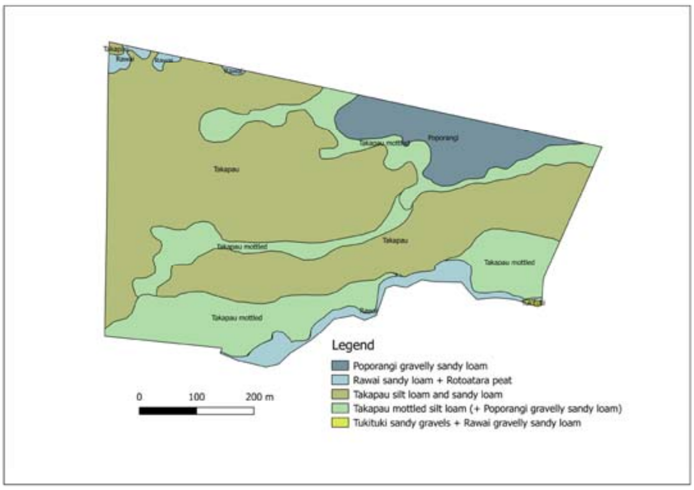
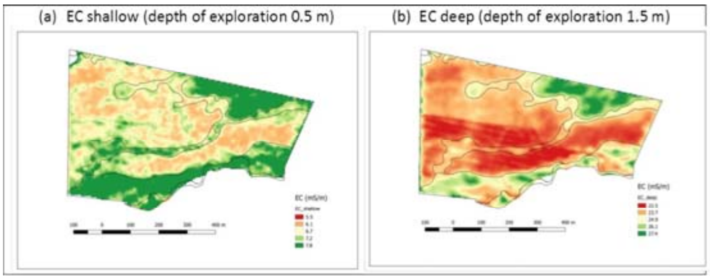


Fig. 8 Site 2 EC maps


(a) EC shallow (depth of exploration 0.5 m)
(b) EC deep (depth of exploration 1.5 m)
EC (mS/m)
EC (mS/m)

RESULTS & DISCUSSION

Total gamma counts are higher for Site 1 than for Site 2, suggesting that soil minerals at

Site 1 are more highly weathered and/or contain assemblages of minerals with higher natural gamma emissions, (Table 1).

TABLE 1: SUMMARY STATISTICS GAMMA COUNTS (ppm)

Site	Source	mean	median	sd	min	max
1	TC	528.7	547.38	67.86	307.18	667.60
	40K	74.14	76.08	13.66	23.01	126.10
	238U	11.17	11.01	3.58	0	28.02
	232Th	14.72	15.01	4.17	1.00	37.03
2	TC	336.82	337.10	28.99	196.01	450.18
	40K	43.44	43.03	7.94	17.01	75.07
	238U	7.72	8.00	2.86	0	20.01
	232Th	9.64	9.01	3.17	1.00	22.02

Variogram models (e.g. Fig. 2) provided parameters of spatial dependence for block kriging at 5m resolution to produce the gamma maps.

At Site 1, the gamma maps (Fig 3) differentiate between Recent soils and older soils (Fig. 4). They also distinguish soil type boundaries within the Recent soils, e.g. freely and imperfectly drained (Fig. 4). The EC maps (Fig. 5) also delineate these features.

At Site 2, gamma radiometrics (Fig 6) and EC maps (Fig. 8) differentiated the soil patterns, as described in the soil map (Fig. 7); although the spatial pattern of 238U data, and to a lesser extent 232Th, are not well expressed which is likely due to the low concentration of these isotopes in the soil minerals.

CONCLUSIONS

The maps derived from the gamma and EC surveys showed good agreement with the fine scale soil maps, derived by conventional soil survey (at 1:10,000 scale), although sensor surveys sometimes group more than one soil type into one class. Gamma surveys, like EC surveys, provide a numerical approach to mapping and classifying soil differences for statistical selection of sampling and monitoring positions, e.g. for precision management of productive land. Future research will assess the benefi ts of combining gamma and EC datasets to improve delineation of soil zones.

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