2021 Soil quality monitoring – drystock

Contents

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Overview

Greater Wellington (GW) monitors soil quality as part of its State of the Environment programme, to meet the requirements of section 35 of the Resource Management Act (1991) and to provide information to measure Regional Plan policy effectiveness.

The soil quality monitoring programme consists of approximately 100 monitoring sites on a range of soils across the region under different land uses. The frequency of sampling is dependent on the intensity of the land use; dairying, cropping and market garden sites are sampled every 3-4 years, dry stock, horticulture and exotic forestry sites are sampled every 5-7 years, while indigenous vegetation sites are sampled every 10 years. This years' report summarises monitoring results for dry stock sites.

Monitoring objectives

1. Provide information on the physical, chemical and biological properties of soils;
2. Provide an early-warning system to identify the effects of primary land uses on long-term soil productivity and the environment;
3. Track specific, identified issues relating to the effects of land use on long- term soil productivity;
4. Assist in the detection of spatial and temporal changes in soil quality; and
5. Provide information required to determine the effectiveness of regional policies and plans.

Monitoring indicators

Monitoring indicators are used to assess soil chemistry and fertility, and to understand soil physical condition. The indicators used are as follows:

- Soil chemistry and fertility - total carbon (C), total nitrogen (N), anaerobic mineralisable nitrogen, soil pH, Olsen phosphorus (P), and total recoverable trace elements.
- Physical condition - bulk density and macroporosity.

Measured indicator values at each monitoring site are benchmarked against relevant guidelines for monitoring soil health. See the methods page for more information.

Monitoring sites and indicator breaches

Each monitoring site is shown by the map circles below, with the total number of indicators breached during the for the 2021 monitoring season displayed by colour of the circle.

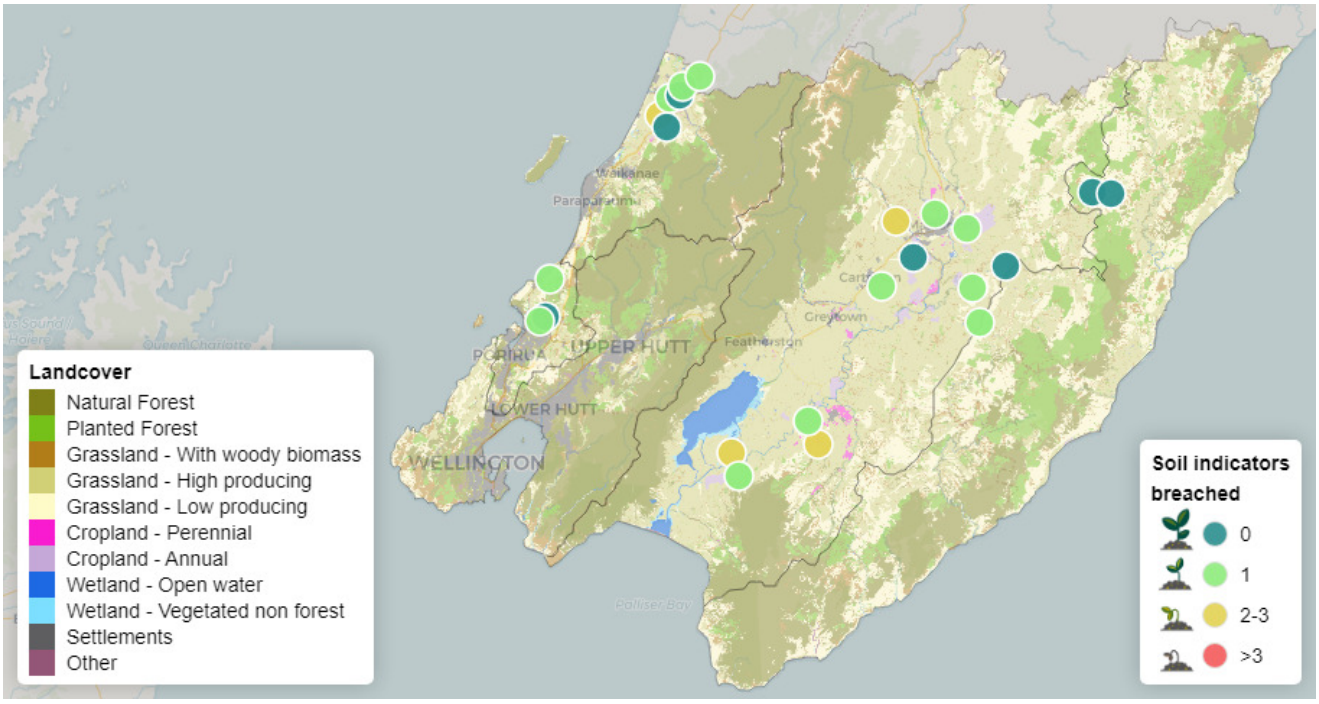

Figure 1: Soil quality monitoring sites rated by the total number of soil quality indicators breached. See the results sections for which indicators were breached, and LUCAS 16 landcover for more information on the classifications shown. Whaitua (main river catchments) are outlined by thin grey lines.

Note that site coordinates have been moved slightly throughout the report for visualisation and confidentiality purposes.

Proportion of total sites that breached indicators

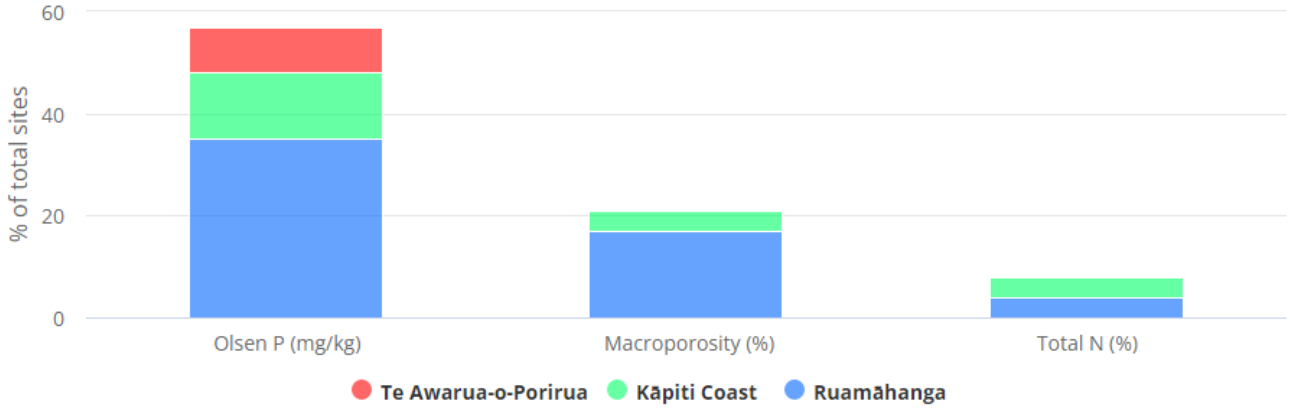

Figure 2: Percentage of total soil quality monitoring sites that breached each soil quality indicator, coloured by Whaitua.

Methods

Analytical methods

Analyses of the soil chemistry and soil physics indicators were completed at the Landcare Research laboratory. Trace element analyses were undertaken at Hill Laboratories in Hamilton. Where necessary, samples were stored at 4°C until analysis.

Soil macroporosity was determined at the Landcare Research soil physics laboratory in Hamilton. The Land Monitoring Forum specifies that macroporosity should be measured at a matric potential of -10 kPa. Macroporosity is the percentage of pores > 30 microns in diameter, when measured at -10 kPa. Ambiguity may arise with other terms (e.g. air-filled porosity) or macroporosity measured at other matric potentials (Drewry et al. 2008; 2015).

Olsen P measurements analysed at Landcare Research were undertaken using a gravimetric (weight) method to avoid the influence of soil bulk density. In New Zealand several large commercial laboratories measure soil received in the laboratory by volume prior to Olsen P chemical extraction. The fertiliser industry guidelines for Olsen P measurement are based on a volumetric method. Further information and explanation is available from Drewry et al. (2013; 2015).

Indicator	Method
Bulk density	Measured on a sub-sampled core dried at 105°C.
Total-C content	Dry combustion method. Using air-dried, finely ground soils using a Leco 2000 CNS analyser.
Total-N content	Dry combustion method. Using air-dried, finely ground soils using a Leco 2000 CNS analyser.
Mineralisable-N	Waterlogged incubation method. Increase in NH_4^+ concentration was measured after incubation for 7 days at 40°C and extraction in 2M KCl.
Soil pH	Measured in water using glass electrodes and a 2.5:1 water-to-soil ratio.
Olsen P	Bicarbonate extraction method. Extracting <2mm air dried soils for 30 minutes with 0.5M $NaHCO_3$ at pH 8.5 and measuring the PO_4^{3-} concentration by the molybdenum blue method.
Trace elements	Total recoverable digestion. Nitric/hydrochloric acid digestion, USEPA 2002.

Benchmarking

Green shaded columns indicate **soil quality target ranges**, follow the referenced links for more information.

Bulk density (t/m^3)

Table 1: Target range is 'Loose' to 'Compact' (Hill and Sparling, 2009).

Soil order	Very loose	Loose	Adequate	Compact	Very compact
Semi-arid, pallic and recent	≤0.40	>0.40-0.90	>0.90-1.25	>1.25-1.40	>1.40
Allophanic	≤0.30	>0.30-0.60	>0.60-0.90	>0.90-1.30	>1.30
Organic	≤0.20	>0.20-0.40	>0.40-0.60	>0.60-1.00	>1.00
All other	≤0.70	>0.70-0.80	>0.80-1.20	>1.20-1.40	>1.40

Macroporosity (% v/v at -10kPa)

Table 2: Target range is 'Adequate' (Hill and Sparling, 2009).

Land use	Very low	Low	Adequate	High
Pastures, cropping and horticulture	≤6	>6-10	>10-30	>30
Forestry	≤8	>8-10	>10-30	>30

Total Carbon (% w/w)

Table 3: Target range is 'Depleted' to 'Ample' (modified from Hill and Sparling, 2009 to have no upper bound on the ample category). *Organic soils excluded as by definition these soils have ample total carbon content.

Soil order	Very depleted	Depleted	Normal	Ample
Semi-arid, pallic and recent	≤2	>2-3	>3-5	>5
Allophanic	≤3	>3-4	>4-9	>9
Organic*				
All other	≤3	>3-4	>4-7	>7

Total nitrogen (% w/w)

Table 4: Target range is 'Depleted' to 'Ample', (Hill and Sparling, 2009). *Cropping and horticulture excluded as ranges would depend on specific crops grown.

Land use	Very depleted	Depleted	Normal	Ample	High
Pasture	≤0.25	>0.25-0.35	>0.35-0.65	>0.65-0.70	>0.70
Forestry	≤0.10	>0.10-0.20	>0.20-0.60	>0.60-0.70	>0.70

Mineralisable nitrogen (mg/kg)

Table 5: Target range is 'Low' to 'High' (Hill and Sparling 2009).

Land use	Very low	Low	Adequate	Ample	High	Excessive
Pasture	≤50	>50-100	>100-200	>200-200	>200-250	>250
Cropping and horticulture	≤20	>20-100	>100-150	>150-150	>150-200	>200
Forestry	≤20	>20-40	>40-120	>120-150	>150-175	>175

Soil pH

Table 6: Target range is 'Slighly-acidic' to 'Optimal' (Hill and Sparling, 2009). *Forestry on organic soils excluded as this combination is unlikely in real life due to windthrow.

Land use & soil order	Very acidic	Slightly acidic	Optimal	Sub-optimal	Very alkaline
Pastures on all except Organic	>4-5	>5-6	>6-6	>6-7	>7-9
Pastures on Organic	>4-5	>5-5	>5-6	>6-7	>7
Cropping & horticulture on all except Organic	>4-5	>5-6	>6-7	>7-8	>8-9
Cropping & horticulture on Organic	>4-5	>5-5	>5-7	>7-8	>8
Forestry on all except Organic	≤4	>4-4	>4-7	>7-8	>8
Forestry on organic soils*					

Olsen P (mg/kg)

Table 7: Target ranges are set for different land use and soil orders (see the revised targets of McKay et al 2013). Note that 'Market gardening' refers to the cropping of Celery, Leeks, Winter Lettuce, Onions, Early Potatoes, and Winter Spinach. Note also that lifestyle blocks are included in 'Pastures, [other] cropping, and horticulture'.

Land use	Soil order	Range
Forestry	All Soils	>5-50
Indigenous	All Soils	>0-50
Market gardening	Recent and Pallic Soils	>45-55
Market gardening	Brown, Gley, Melanic, Organic, Pumice, Semi arid and Ultic Soils	>55-75
Market gardening	Allophanic, Granular and Oxidic Soils	>75-90
Pasture, cropping and horticulture	Andisols	>35-60
Pasture, cropping and horticulture	Pumice Soils	>35-60
Pasture, cropping and horticulture	Organic Soils	>35-50
Pasture, cropping and horticulture	Recent Soils and Podzols	>20-50
Pasture, cropping and horticulture	Raw Soils	>10-25
Pasture, cropping and horticulture	Other Soils	>25-50

Trace elements - draft eco-soil guidelines (mg/kg)

Table 8: Target range is less than the soil guideline value (Cavanagh, 2019). Note: Other values may apply for non-agricultural land uses, soils and circumstances.

Trace element	Guideline (mg/kg)	Soil orders rated
Arsenic (mg/kg)	<20	All soil
Cadmium (mg/kg)	<1.5	All soil
Chromium (mg/kg)	<300	All soil
Copper (mg/kg)	<150	Sensitive soil
Copper (mg/kg)	<340	Tolerant soil
Copper (mg/kg)	<220	Typical soil
Lead (mg/kg)	<530	All soil
Nickel (Ni)	Not determined	
Zinc (mg/kg)	<130	Sensitive soil
Zinc (mg/kg)	<265	Tolerant soil
Zinc (mg/kg)	<190	Typical soil

Trace elements - adapted from NZWWA (mg/kg)

Table 9: Target range is less the the soil limit value (NZWWA, 2003). Note: the suggested values by Alloway (2008) suggested for copper deficiency (≤ 5 mg/kg) and zinc deficiency (≤ 10 mg/kg) may be of interest depending on circumstances and type of farm production.

Trace element	Soil limit (mg/kg)
Arsenic (mg/kg)	<20
Cadmium (mg/kg)	<1
Chromium (mg/kg)	<600
Copper (mg/kg)	<100
Lead (mg/kg)	<300
Nickel (mg/kg)	<60
Zinc (mg/kg)	<300

Cadmium - Tiered Fertiliser Management System (mg/kg)

Table 10: Target ranges depend on the choice and rate of phosphate fertiliser application, see the Fertiliser Association Tiered Fertiliser Management System for Soil Cadmium for more detail.

Tier	Concentration (mg/kg)
0	>0.0-0.6
1	>0.6-1.0
2	>1.0-1.4
3	>1.4-1.8
4	>1.8

Soil chemistry & fertility results

The following sections present maps of soil quality monitoring results benchmarked against relevant indicator guidelines, see Appendix 2: Data tables for tabulated results.

Organic resources

Total carbon (C)

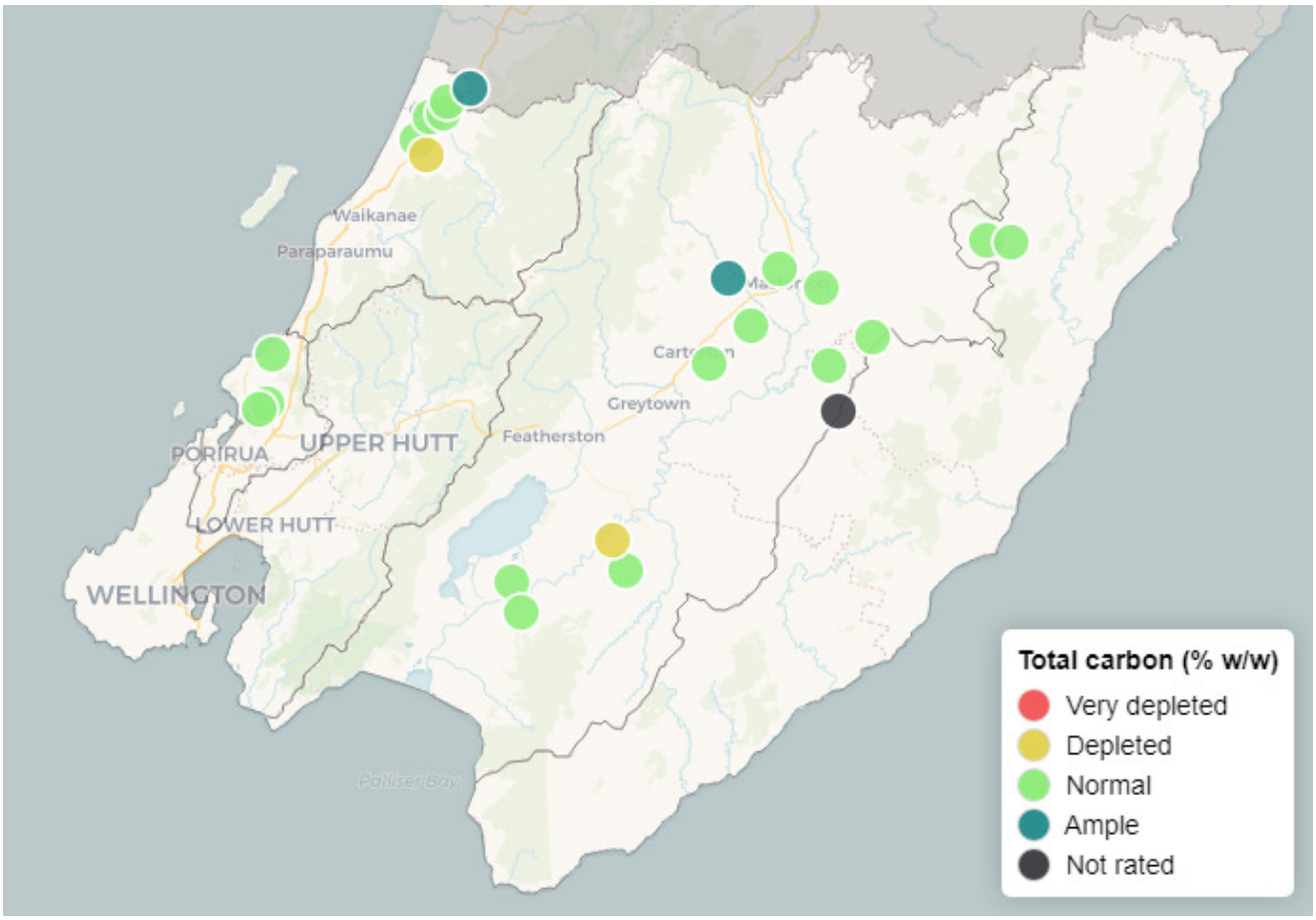

Figure 3: Total carbon is an estimate of the amount of organic matter. Organic matter helps soils retain moisture and nutrients, and gives good soil structure for water movement and root growth. It can be used to address the issue of organic matter depletion and carbon loss from the soil. The target range is **'Depleted' to 'Ample'**, see benchmarking for more information.

Total nitrogen (N)

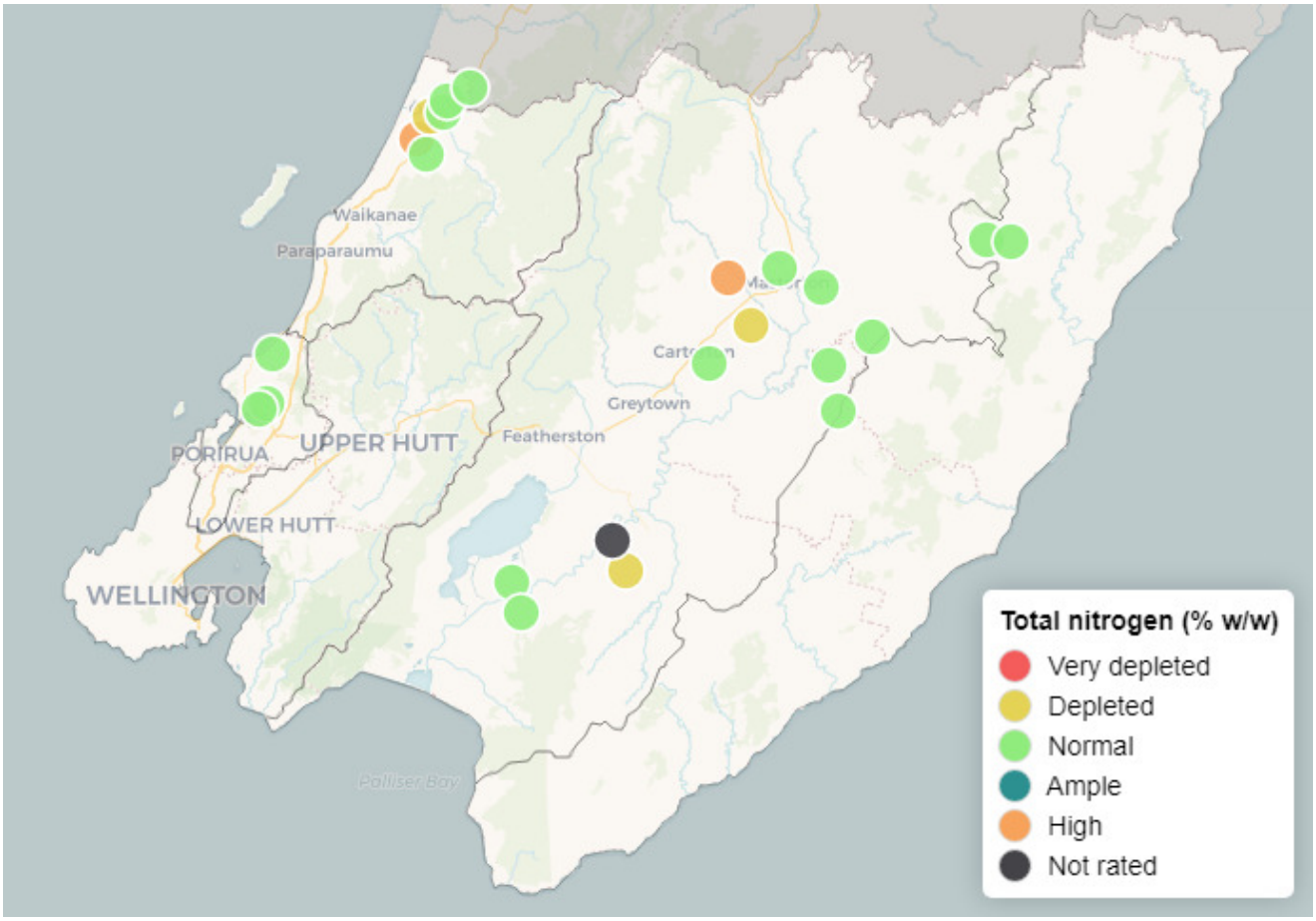

Figure 4: Most nitrogen in soil is present within the organic matter fraction, and total nitrogen gives a measure of those reserves. It also provides an indication for the potential of nitrogen to leach into underlying groundwater. The target range is **'Depleted' to 'Ample'**, see benchmarking for more information.

Mineralisable nitrogen (N)

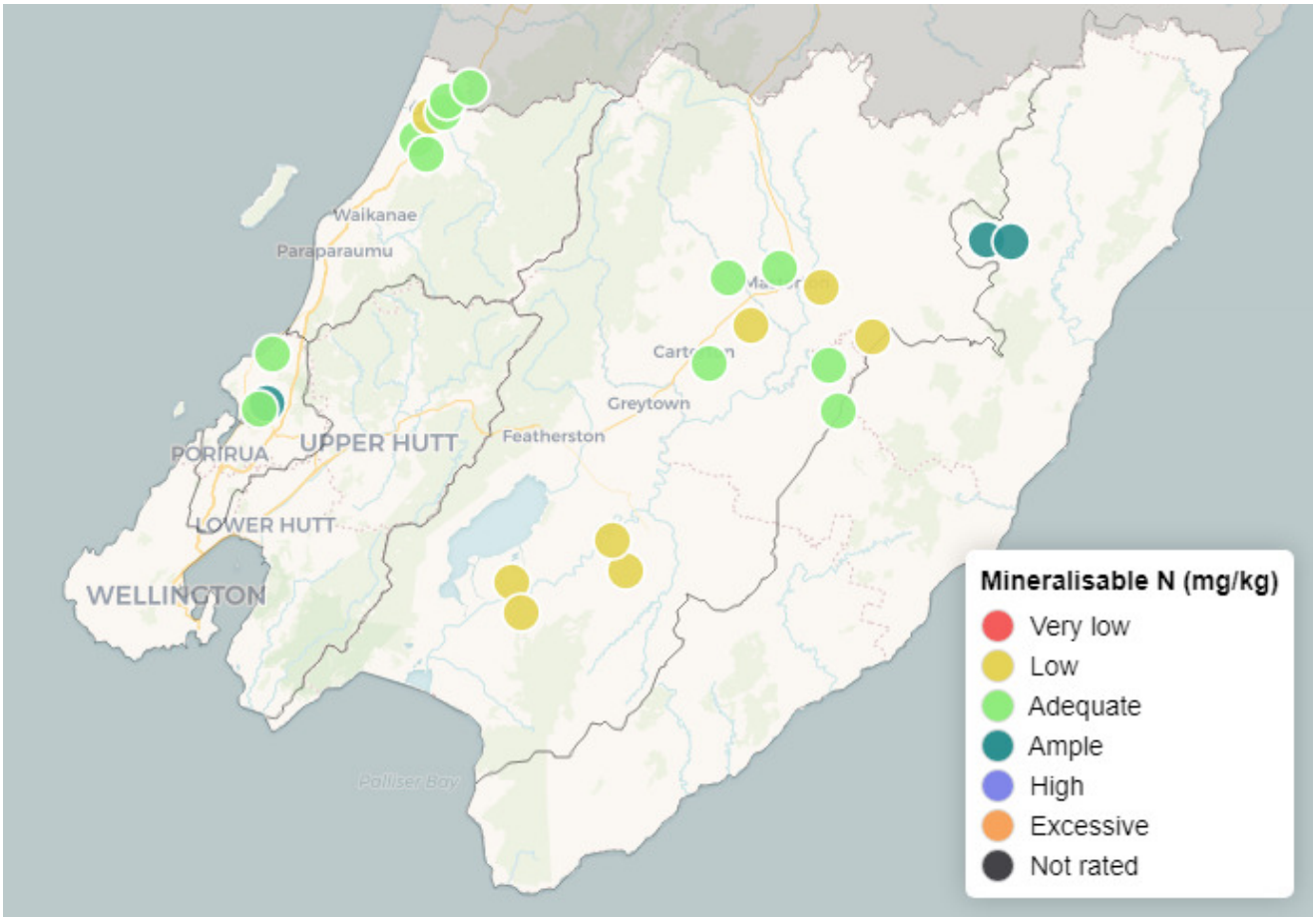

Figure 5: Not all nitrogen can be used by plants; soil organisms change nitrogen to forms that plants can use. Mineralisable N gives a measure of how much organic nitrogen is available to plants, and the potential for nitrogen leaching at times of low plant demand. Mineralisable nitrogen is also used as a surrogate measure of the microbial biomass. The target range is **'Low' to 'High'**, see benchmarking for more information.

Acidity - soil pH

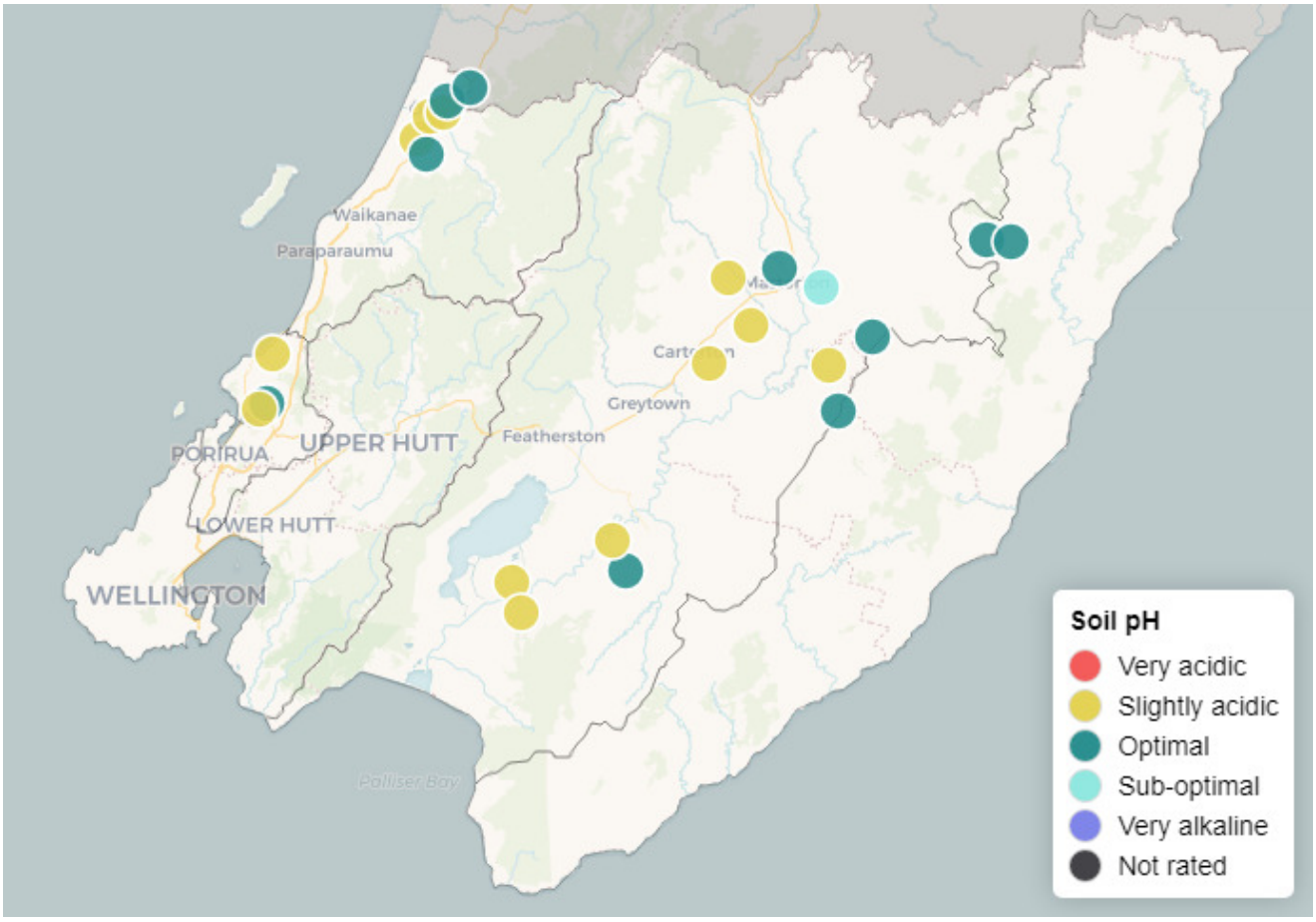

Figure 6: Most plants have an optimal pH range for growth. The pH of a soil influences the availability of many nutrients to plants and the solubility of some trace elements. Soil pH is influenced by the application of lime and some fertilisers. The target range is **'Slightly-acidic' to 'Optimal'**, see benchmarking for more information.

Fertility - Olsen P

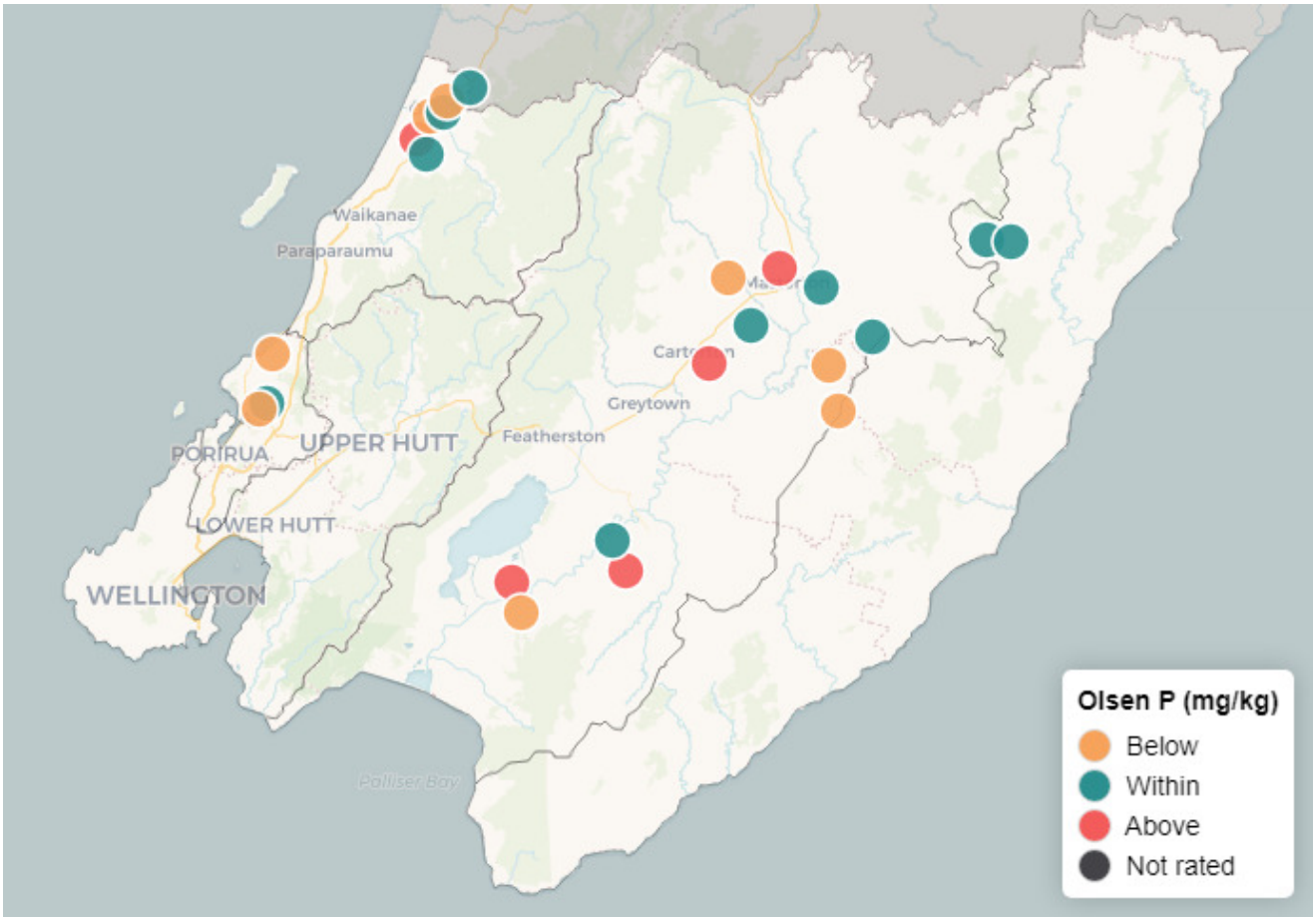

Figure 7: Phosphorus (P) is an essential nutrient for plants and animals. Olsen P is a measure of the amount of phosphorus that is available to plants. Levels of P greater than agronomic requirements can increase P losses to waterways, and therefore contribute to eutrophication (nutrient enrichment). The target range depends on land use and soil order, see benchmarking for more information.

Trace elements

Some trace elements are essential micro-nutrients for plants and animals. Both essential and non-essential trace elements can become toxic at high concentrations. Trace elements can accumulate in the soil from various common agricultural and horticultural land use practices.

Arsenic (As)

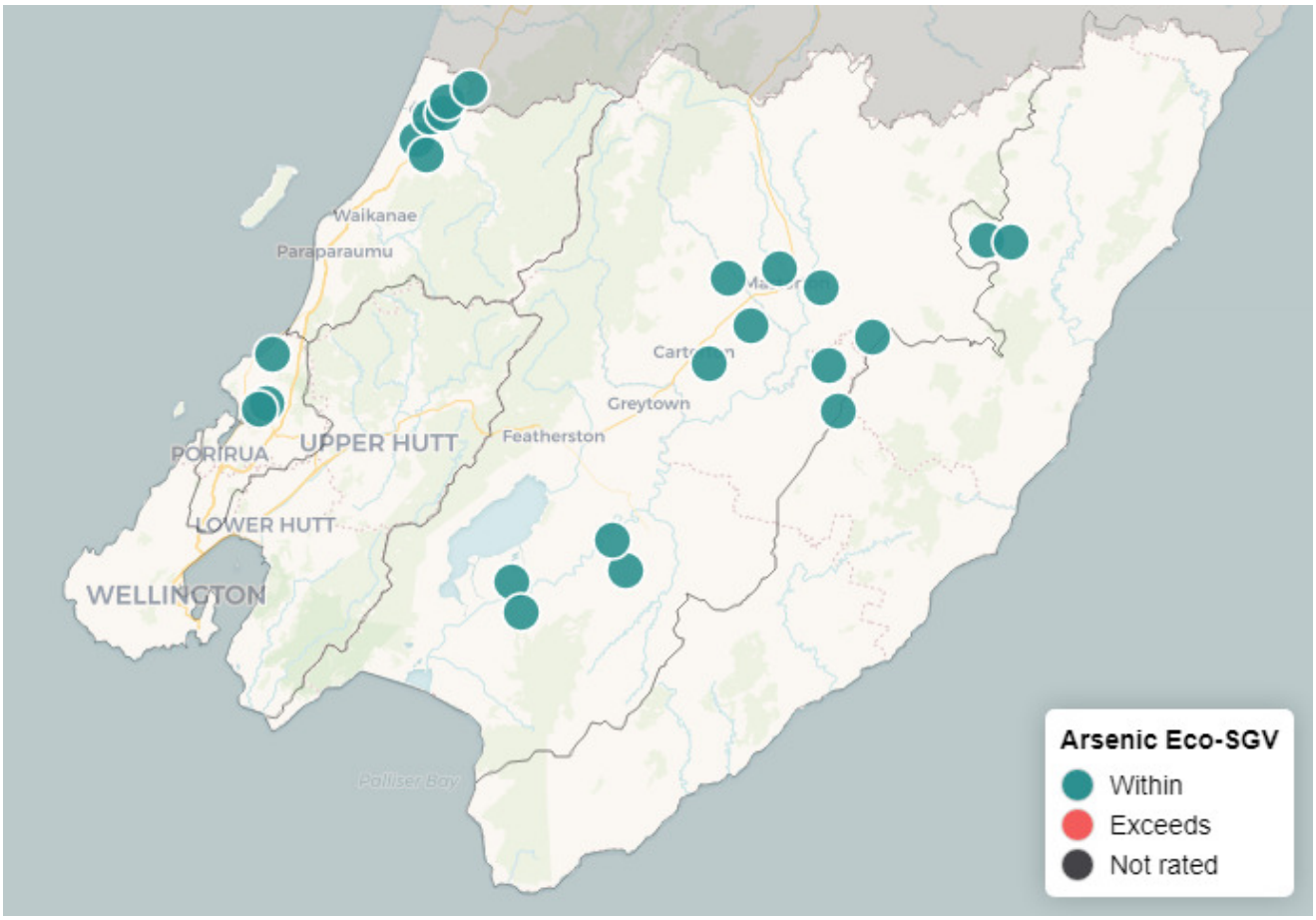

Figure 8: Arsenic results are compared against draft eco-soil guideline values (Eco-SGVs), see benchmarking for more information.

Cadmium (Cd)

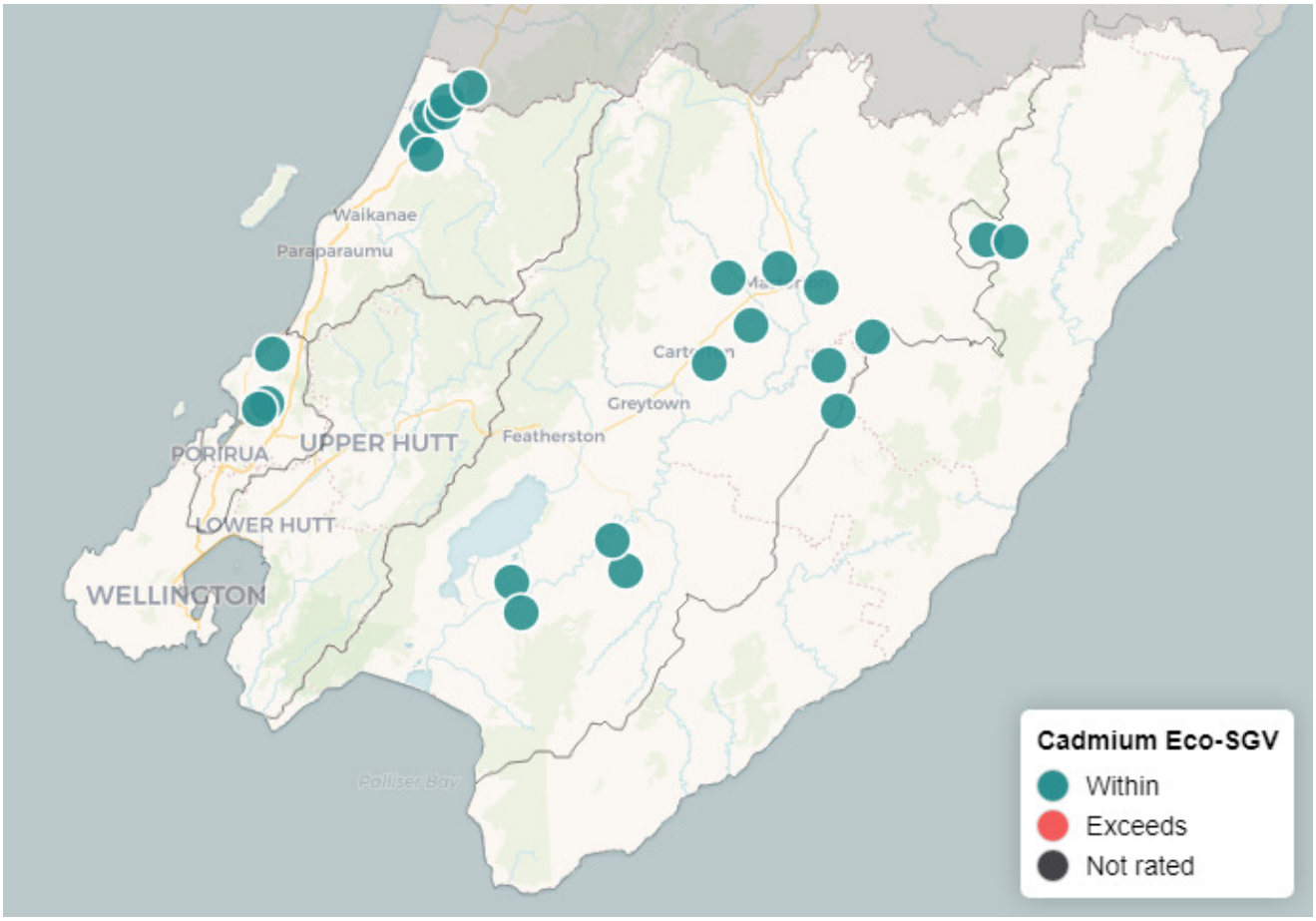

Figure 9: Cadmium results are compared against draft eco-soil guideline values (Eco-SGVs) on the map and trigger values from the tiered fertiliser management system (TFMS) also in the table, see benchmarking for more information.

Chromium (Cr)

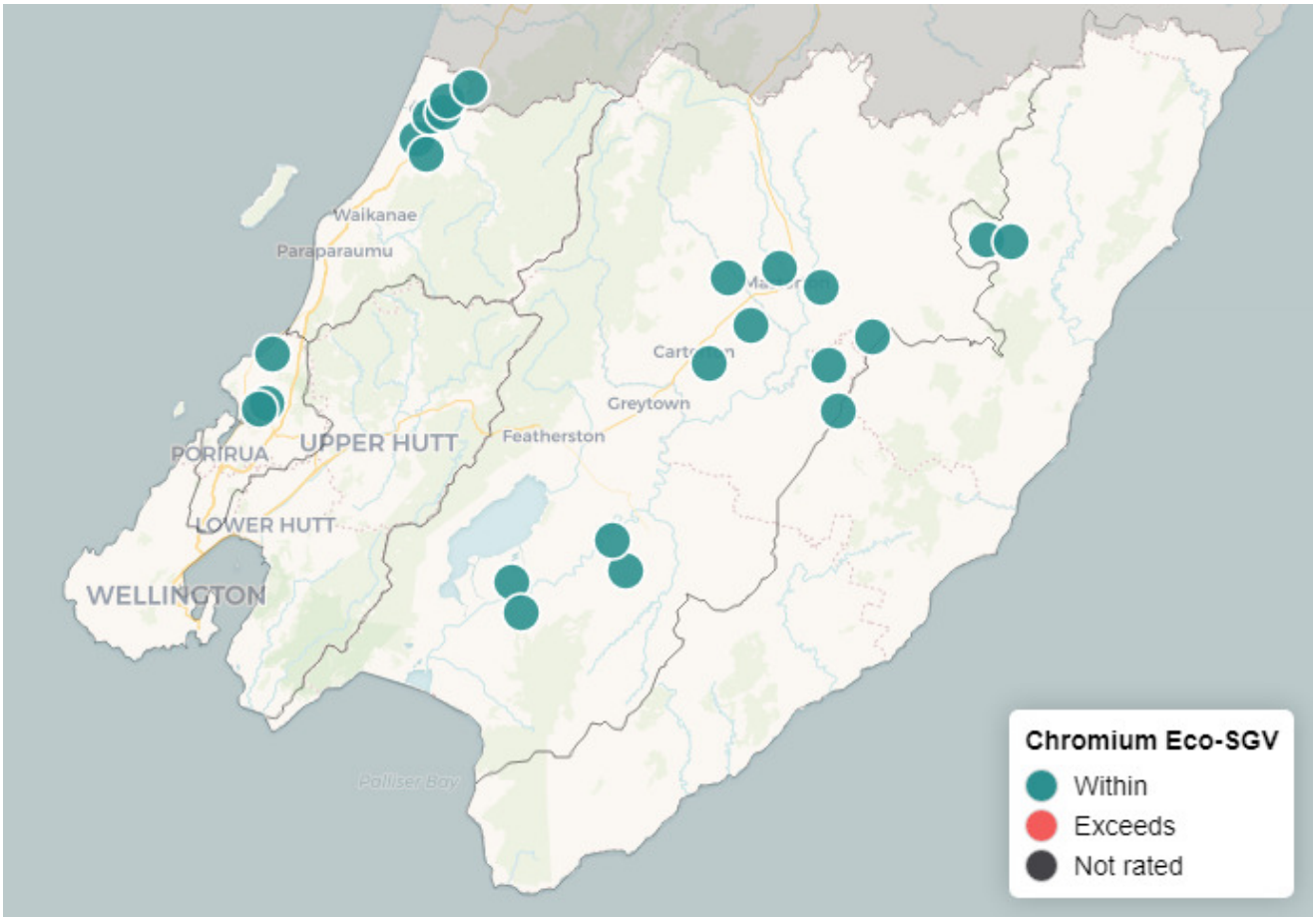

Figure 10: Chromium results are compared against draft eco-soil guideline values (Eco-SGVs), see benchmarking for more information.

Copper (Cu)

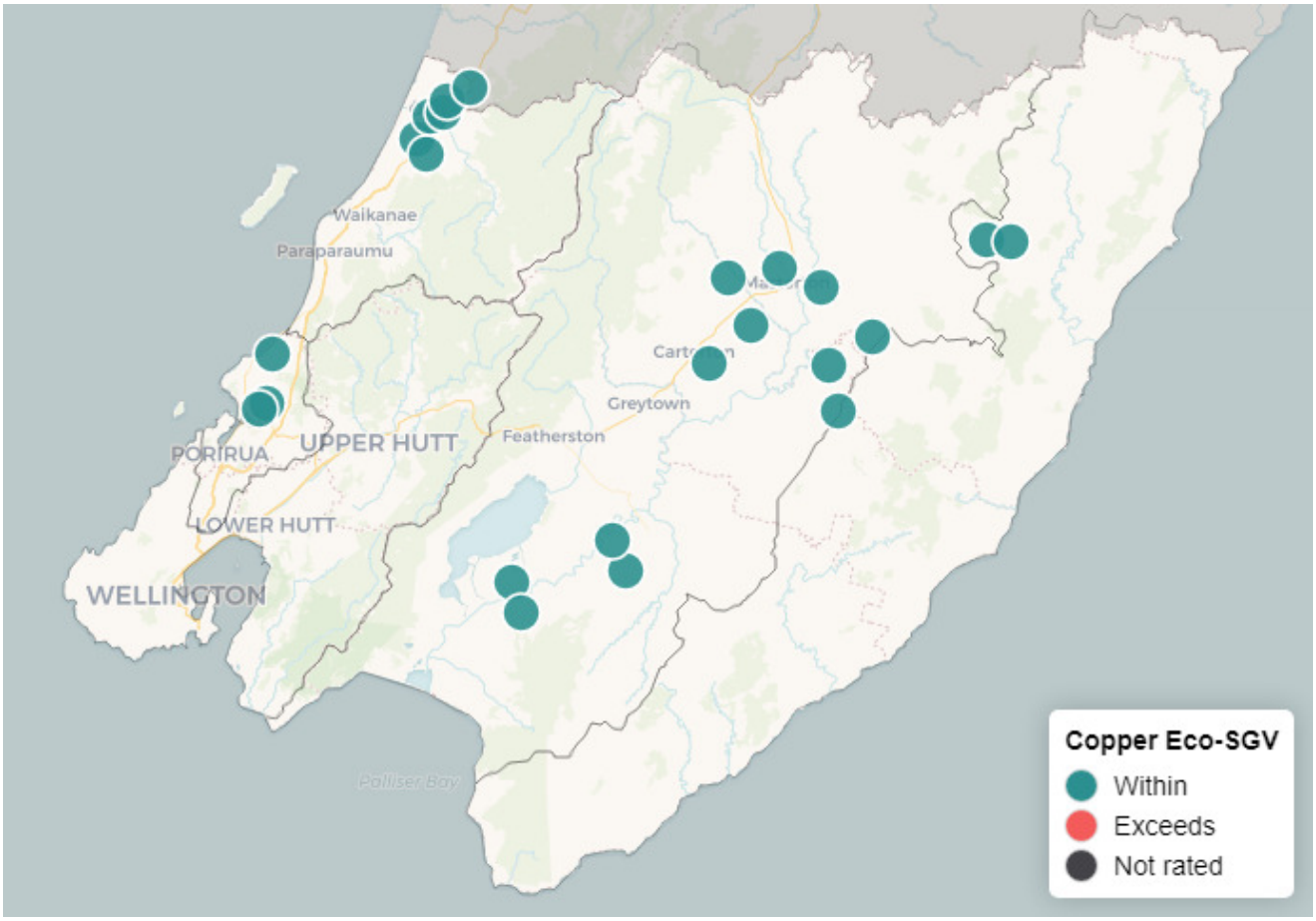

Figure 11: Copper results are compared against draft eco-soil guideline values (Eco-SGVs), see benchmarking for more information.

Lead (Pb)

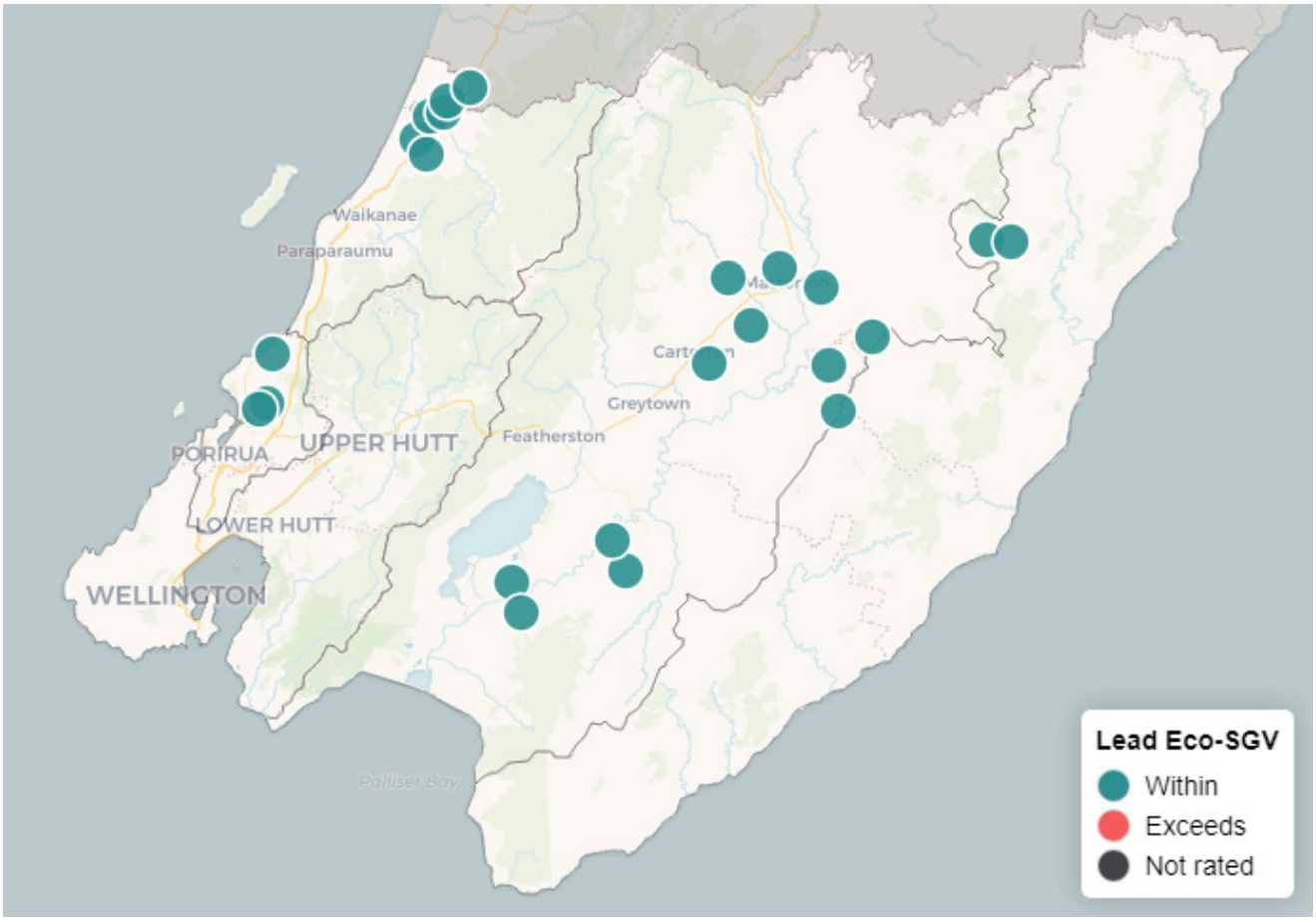

Figure 12: Lead results are compared against draft eco-soil guideline values (Eco-SGVs), see benchmarking for more information.

Nickel (Ni)

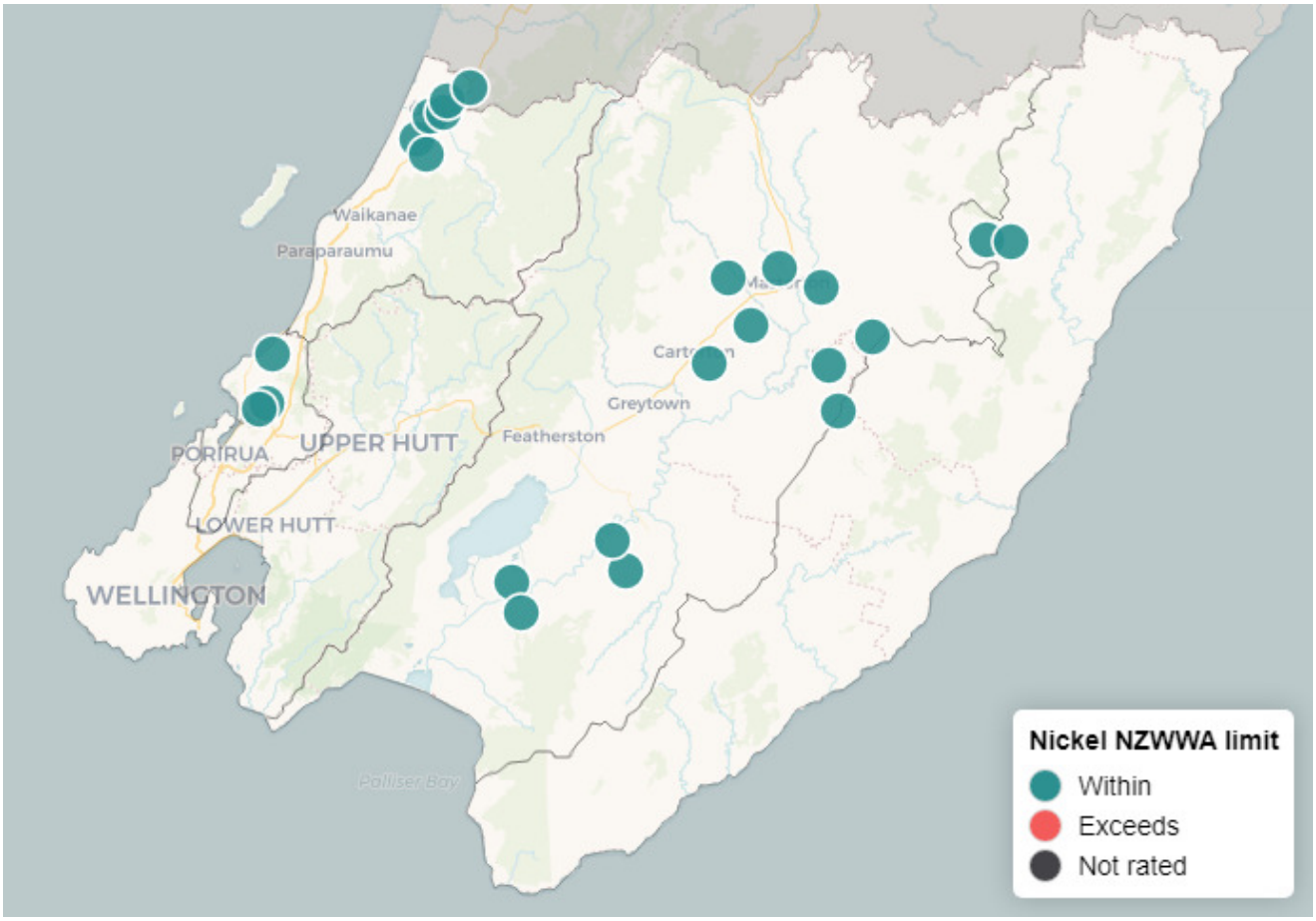

Figure 13: Nickel results are compared against New Zealand Water and Wastes Association (NZWWA) limits, see benchmarking for more information.

Zinc (Zn)

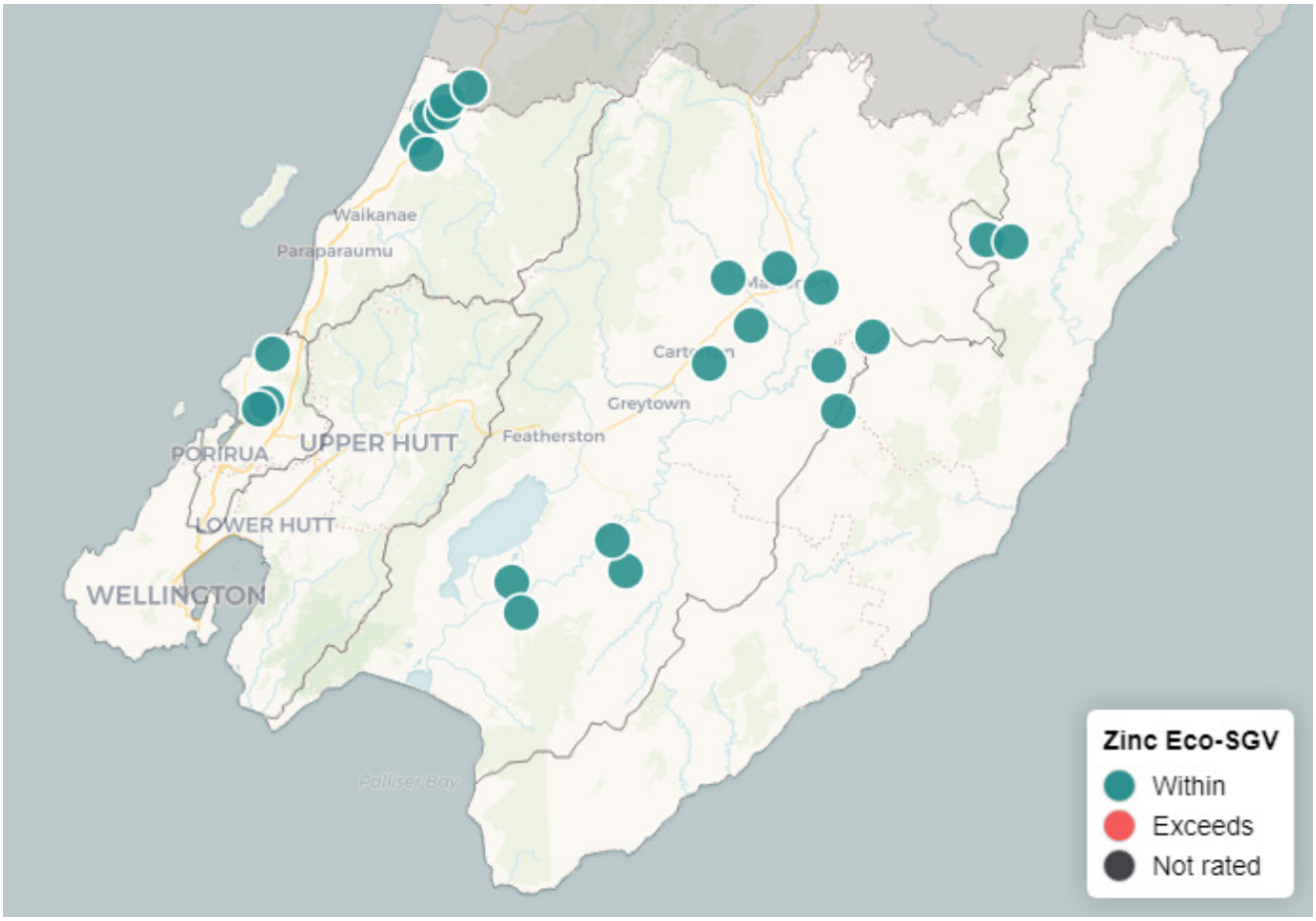

Figure 14: Zinc results are compared against draft eco-soil guideline values (Eco-SGVs), see benchmarking for more information.

Physical condition results

The following sections present maps of soil quality monitoring results benchmarked against relevant indicator guidelines, see Appendix 2: Data tables for tabulated results.

Bulk density

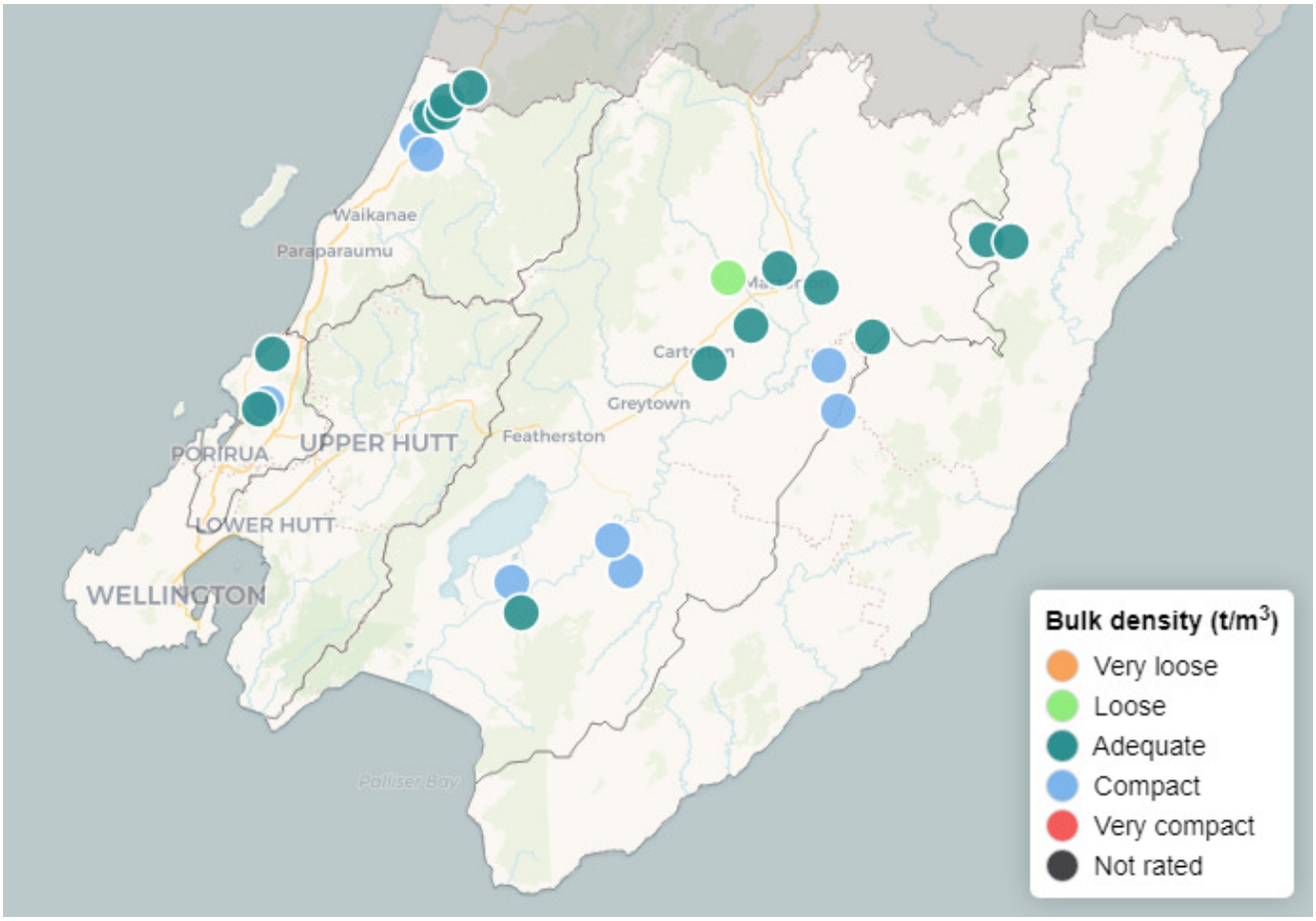

Figure 15: Bulk density is a measure of soil density. A high bulk density indicates a compacted or dense soil. Movement of water and air through soil pores is reduced in compacted soils. High soil bulk density can restrict root growth and adversely affect plant growth. There is also potential for increased run-off and nutrient loss to surface waters in compacted soils. The target range is 'Loose' to 'Compact', see benchmarking for more information.

Macroporosity

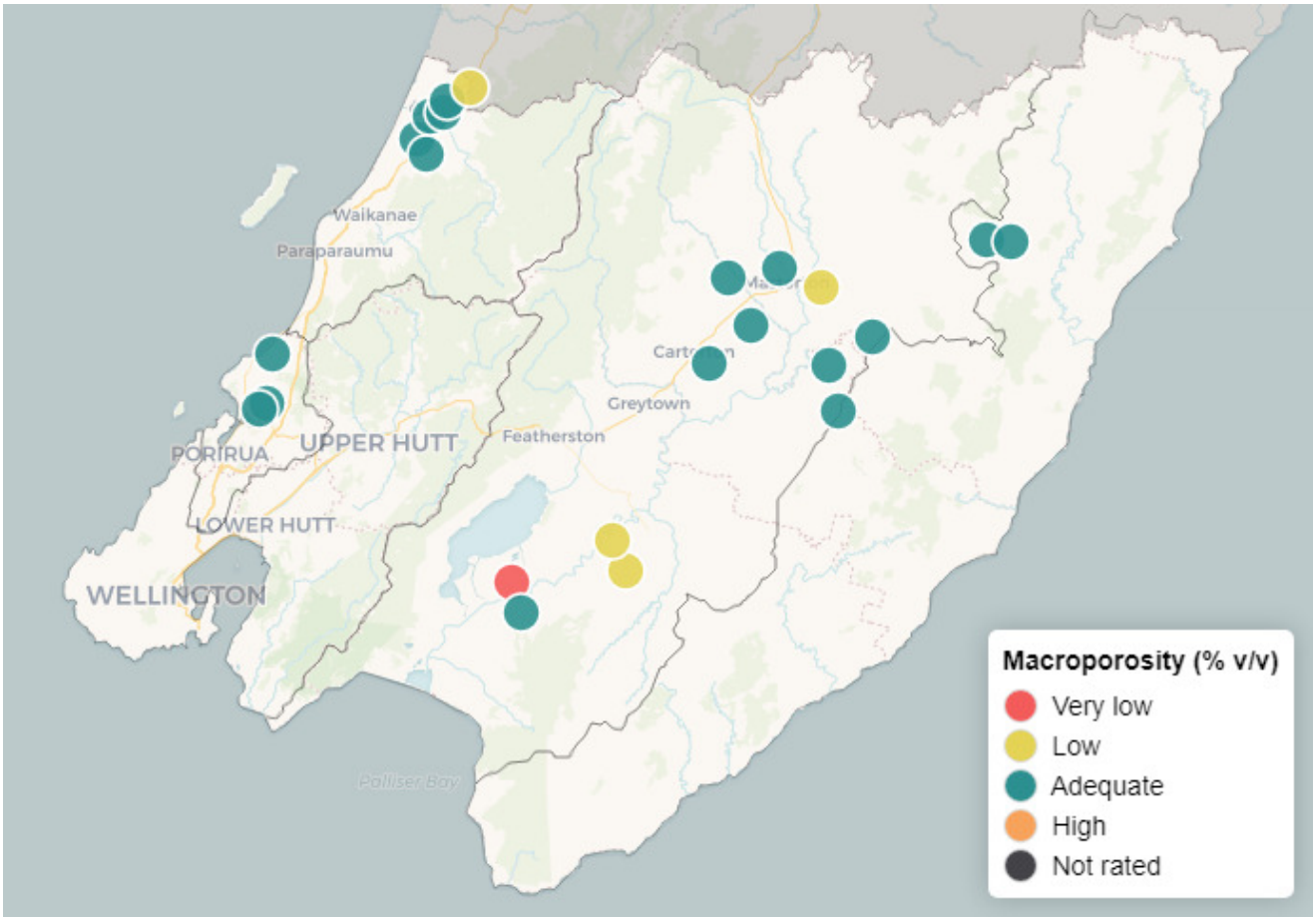

Figure 16: Macropores are important for soil air movement and drainage. Large soil pores are the most susceptible to collapse when soil is compacted. Low macroporosity adversely affects plant growth due to poor root environment, restricted air movement and N-fixation by clover roots. It also infers poor drainage and infiltration. The target is 'Adequate', see benchmarking for more information.

Resources

Useful links for managing soil quality

- Reducing the impacts of winter grazing on soil and water quality
- Soil compaction and pugging on farms
- Limiting Pugging and Compaction Damage
- Soil Fertility for Pasture
- Nitrogen Fertiliser
- Nutrient Management
- Beef and Lamb - Successful soil and fertiliser management
- Soil Characteristics Important to Management
- Managing our soils
- New Zealand Landcare Trust
- Soil Quality Indicators - A web-based tool designed to help you interpret the quality or health of a soil you have sampled

References

Alloway, BJ. 2008. *Copper and zinc in soils: too little or too much?* In: (Ed N. Kim) New Zealand Trace Elements Group conference. Hamilton. 10 p.

Cavanagh J. 2019. *UPDATED User Guide: Background soil concentrations and soil guideline values for the protection of ecological receptors (Eco-SGVs) – Consultation draft.* Envirolink Tools Grant: C09X1402. Prepared for Regional Waste and Contaminated Land Forum, Land Monitoring Forum and Land Managers Group. Update prepared for: Gisborne District Council. Landcare Research.

Drewry J., Cameron K. and Buchan G. 2008. *Pasture yields and soil physical property responses to soil compaction from treading and grazing: A review.* Australian Journal of Soil Research, 46: 237-256.

Drewry J., Taylor M., Curran-Cournane F., Gray C. and McDowell R. 2013. *Olsen P methods and soil quality monitoring: are we comparing 'apples with apples'? Accurate and efficient use of nutrients on farms. (Eds LD Currie and CL Christensen).* Occasional Report No. 26. Fertilizer and Lime Research Centre, Fertilizer and Lime Research Centre, Massey University.

Drewry, J., Curran-Cournane, F., Taylor, M., and Lynch, B. 2015. *Soil quality monitoring across land uses in four regions: implications for reducing nutrient losses and for national reporting.* In: Moving farm systems to improved nutrient attenuation. (Eds LD Currie and LL Burkitt). Occasional Report No. 28. Fertilizer and Lime Research Centre, Massey University.

Hill R. and Sparling G. 2009. *Soil quality monitoring. Land and soil monitoring: A guide for SoE and regional council reporting.* Land Monitoring Forum, New Zealand, pp. 27-86. Soil Quality SoE monitoring programme: Annual data report 2017/18 PAGE 23 OF 39

Mackay A., Dominati E., and Taylor M. 2013. *Soil quality indicators: the next generation.* Report prepared for Land Monitoring Forum of Regional Councils. AgResearch.

NZWWA. 2003. *Guidelines for the safe application of biosolids to land in New Zealand.* New Zealand Water and Wastes Association, Wellington.

Appendix 1: Monitoring site information

Table A1.1: 2021 dry stock monitoring sites with LUCAS 16 landcover classifications.

Whaitua	Site code	Land use	Soil order	Soil subgroup	Soil type	Landcover
Kāpiti Coast	GW002	Drystock	Brown	Typic Orthic Brown	Ashurst stony silt loam	Grassland - High producing
Kāpiti Coast	GW008	Drystock	Brown	Mottled Orthic Brown	Te Horo silt loam	Grassland - High producing
Kāpiti Coast	GW012	Lifestyle	Recent	Acidic Fluvial Recent	Rangitikei gravelly fine sandy loam	Wetland - Open water
Ruamāhanga	GW013	Drystock	Gley	Typic Recent Gley	Ahikouka silt loam	Grassland - High producing
Ruamāhanga	GW018	Drystock	Pallic	Argillic Perch-gley Pallic	Kokotau silt loam	Grassland - High producing
Ruamāhanga	GW026	Drystock	Recent	Acidic-weathered Fluvial Recent	Greytown silt loam	Grassland - High producing
Ruamāhanga	GW030	Drystock	Pallic	Mottled Immature Pallic	Martinborough loam	Grassland - High producing
Ruamāhanga	GW033	Drystock	Pallic	Typic Perch-gley Pallic	Bideford silt loam	Grassland - High producing
Ruamāhanga	GW037	Drystock	Pallic	Typic Argillic Pallic	Tauherenikau silt loam	Grassland - High producing
Ruamāhanga	GW040	Drystock	Pallic	Pedal Immature Pallic	Moroa silt loam	Grassland - High producing
Kāpiti Coast	GW043	Drystock	Recent	Typic Fluvial Recent	Manawatu silt loam	Settlements
Kāpiti Coast	GW050	Drystock	Gley	Acid Orthic Gley	Rahui silt loam	Grassland - High producing
Te Awarua-o-Porirua	GW054	Forestry	Brown	Typic Orthic Brown	Makara steepland soils	Planted Forest
Te Awarua-o-Porirua	GW056	Drystock	Brown	Typic Firm Brown	Korokoro hill soils	Grassland - Low producing
Te Awarua-o-Porirua	GW058	Drystock	Pallic	Mottled Argillic Pallic	Paramata hill soils	Grassland - High producing
Ruamāhanga	GW061	Drystock	Brown	Mottled Orthic Brown	Tinui hill soils	Grassland - High producing
Ruamāhanga	GW063	Drystock	Melanic	Weathered Rendzic Melanic	Kourarau hill soils	Grassland - High producing
Ruamāhanga	GW066	Drystock	Pallic	Mottled Argillic Pallic	Wharekaka hill soils	Grassland - Low producing
Wairarapa Coast	GW068	Forestry	Recent	Weathered Orthic Recent	Wharoama steepland soils	Grassland - Low producing
Wairarapa Coast	GW070	Forestry	Recent	Weathered Orthic Recent	Taihape steepland soils	Grassland - Low producing
Ruamāhanga	GW099	Drystock	Pallic	Mottled Immature Pallic	Kokotau silt loam	Cropland - Annual
Ruamāhanga	GW106	Cropping	Recent	Weathered Orthic Recent	Greytown silt loam	Cropland - Annual
Kāpiti Coast	GW114	Drystock	Pallic	Mottled Immature Pallic	Shannon silt loam	Grassland - High producing

Appendix 2: Data tables

Total carbon (C)

Table A2.1: Total carbon results benchmarked against the target range of **'Depleted' to 'Ample'**, see benchmarking for more information.

Whaitua	Site code	Land use	Soil order	Rating	Total carbon (%)
Kāpiti Coast	GW002	Drystock	Allophanic	Normal	8.15
Kāpiti Coast	GW008	Drystock	Allophanic	Depleted	3.97
Kāpiti Coast	GW012	Lifestyle	Semi-arid, pallic and recent	Normal	3.96
Ruamāhanga	GW013	Drystock	All other	Normal	5.48
Ruamāhanga	GW018	Drystock	Semi-arid, pallic and recent	Normal	3.40
Ruamāhanga	GW026	Drystock	Semi-arid, pallic and recent	Normal	4.20
Ruamāhanga	GW030	Drystock	Semi-arid, pallic and recent	Normal	3.39
Ruamāhanga	GW033	Drystock	Semi-arid, pallic and recent	Normal	3.90
Ruamāhanga	GW037	Drystock	Semi-arid, pallic and recent	Ample	9.14
Ruamāhanga	GW040	Drystock	Semi-arid, pallic and recent	Normal	4.57
Kāpiti Coast	GW043	Drystock	Semi-arid, pallic and recent	Normal	3.68
Kāpiti Coast	GW050	Drystock	All other	Normal	4.88
Te Awarua-o-Porirua	GW054	Forestry	Allophanic	Normal	4.63
Te Awarua-o-Porirua	GW056	Drystock	Allophanic	Normal	6.41
Te Awarua-o-Porirua	GW058	Drystock	Semi-arid, pallic and recent	Normal	4.71
Ruamāhanga	GW061	Drystock	Allophanic	Normal	6.09
Ruamāhanga	GW063	Drystock	Organic	Not rated	5.86
Ruamāhanga	GW066	Drystock	Semi-arid, pallic and recent	Normal	3.68
Wairarapa Coast	GW068	Forestry	Semi-arid, pallic and recent	Normal	4.08
Wairarapa Coast	GW070	Forestry	Semi-arid, pallic and recent	Normal	4.58
Ruamāhanga	GW099	Drystock	Semi-arid, pallic and recent	Normal	3.47
Ruamāhanga	GW106	Cropping	Semi-arid, pallic and recent	Depleted	2.34
Kāpiti Coast	GW114	Drystock	Semi-arid, pallic and recent	Ample	5.14

Mineralisable nitrogen (N)

Table A2.2: Mineralisable nitrogen results benchmarked against the target range of **'Low' to 'High'**, see benchmarking for more information.

Whaitua	Site code	Land use	Rating land use	Rating	Mineralisable N (mg/kg)
Kāpiti Coast	GW002	Drystock	Pasture	Adequate	168.5
Kāpiti Coast	GW008	Drystock	Pasture	Adequate	113.6
Kāpiti Coast	GW012	Lifestyle	Pasture	Low	87.7
Ruamāhanga	GW013	Drystock	Pasture	Low	99.5
Ruamāhanga	GW018	Drystock	Pasture	Low	92.4
Ruamāhanga	GW026	Drystock	Pasture	Adequate	116.3
Ruamāhanga	GW030	Drystock	Pasture	Low	96.3
Ruamāhanga	GW033	Drystock	Pasture	Low	94.9
Ruamāhanga	GW037	Drystock	Pasture	Adequate	160.7
Ruamāhanga	GW040	Drystock	Pasture	Adequate	132.2
Kāpiti Coast	GW043	Drystock	Pasture	Adequate	165.3
Kāpiti Coast	GW050	Drystock	Pasture	Adequate	138.4
Te Awarua-o-Porirua	GW054	Forestry	Forestry	Ample	137.9
Te Awarua-o-Porirua	GW056	Drystock	Pasture	Adequate	165.3
Te Awarua-o-Porirua	GW058	Drystock	Pasture	Adequate	136.4
Ruamāhanga	GW061	Drystock	Pasture	Adequate	149.6
Ruamāhanga	GW063	Drystock	Pasture	Adequate	166.6
Ruamāhanga	GW066	Drystock	Pasture	Low	86.6
Wairarapa Coast	GW068	Forestry	Forestry	Ample	124.7
Wairarapa Coast	GW070	Forestry	Forestry	Ample	142.7
Ruamāhanga	GW099	Drystock	Pasture	Low	87.1
Ruamāhanga	GW106	Cropping	Cropping and horticulture	Low	80.0
Kāpiti Coast	GW114	Drystock	Pasture	Adequate	159.2

Acidity - soil pH

Table A2.3: Soil pH results benchmarked against the target range of **'Slightly-acidic' to 'Optimal'**, see benchmarking for more information.

Whaitua	Site code	Land use	Land use & soil order	Rating	Soil pH
Kāpiti Coast	GW002	Drystock	Pastures on all except Organic	Slightly acidic	5.14
Kāpiti Coast	GW008	Drystock	Pastures on all except Organic	Optimal	5.86
Kāpiti Coast	GW012	Lifestyle	Pastures on all except Organic	Slightly acidic	5.45
Ruamāhanga	GW013	Drystock	Pastures on all except Organic	Slightly acidic	5.46
Ruamāhanga	GW018	Drystock	Pastures on all except Organic	Slightly acidic	5.08
Ruamāhanga	GW026	Drystock	Pastures on all except Organic	Optimal	5.69
Ruamāhanga	GW030	Drystock	Pastures on all except Organic	Optimal	6.06
Ruamāhanga	GW033	Drystock	Pastures on all except Organic	Slightly acidic	5.46
Ruamāhanga	GW037	Drystock	Pastures on all except Organic	Slightly acidic	5.44
Ruamāhanga	GW040	Drystock	Pastures on all except Organic	Slightly acidic	5.47
Kāpiti Coast	GW043	Drystock	Pastures on all except Organic	Slightly acidic	5.40
Kāpiti Coast	GW050	Drystock	Pastures on all except Organic	Optimal	5.66
Te Awarua-o-Porirua	GW054	Forestry	Forestry on all except Organic	Optimal	5.33
Te Awarua-o-Porirua	GW056	Drystock	Pastures on all except Organic	Slightly acidic	5.33
Te Awarua-o-Porirua	GW058	Drystock	Pastures on all except Organic	Slightly acidic	5.21
Ruamāhanga	GW061	Drystock	Pastures on all except Organic	Slightly acidic	5.17
Ruamāhanga	GW063	Drystock	Pastures on Organic	Optimal	5.64
Ruamāhanga	GW066	Drystock	Pastures on all except Organic	Optimal	6.13
Wairarapa Coast	GW068	Forestry	Forestry on all except Organic	Optimal	5.71
Wairarapa Coast	GW070	Forestry	Forestry on all except Organic	Optimal	5.65
Ruamāhanga	GW099	Drystock	Pastures on all except Organic	Sub-optimal	6.32
Ruamāhanga	GW106	Cropping	Cropping & horticulture on all except Organic	Slightly acidic	5.43
Kāpiti Coast	GW114	Drystock	Pastures on all except Organic	Optimal	5.70

Fertility - Olsen P

Table A2.4: Phosphorus (P) results benchmarked against target ranges, see benchmarking for more information.

Whaitua	Site code	Land use	Soil order	Rating soil order	Rating	Olsen P (mg/kg)
Kāpiti Coast	GW002	Drystock	Brown	Other Soils	Above	85.77
Kāpiti Coast	GW008	Drystock	Brown	Other Soils	Within	27.29
Kāpiti Coast	GW012	Lifestyle	Recent	Recent Soils and Podzols	Below	9.95
Ruamāhanga	GW013	Drystock	Gley	Other Soils	Above	63.55
Ruamāhanga	GW018	Drystock	Pallic	Other Soils	Within	32.43
Ruamāhanga	GW026	Drystock	Recent	Recent Soils and Podzols	Above	67.18
Ruamāhanga	GW030	Drystock	Pallic	Other Soils	Above	69.31
Ruamāhanga	GW033	Drystock	Pallic	Other Soils	Below	24.32
Ruamāhanga	GW037	Drystock	Pallic	Other Soils	Below	21.85
Ruamāhanga	GW040	Drystock	Pallic	Other Soils	Above	64.16
Kāpiti Coast	GW043	Drystock	Recent	Recent Soils and Podzols	Within	47.65
Kāpiti Coast	GW050	Drystock	Gley	Other Soils	Below	15.12
Te Awarua-o-Porirua	GW054	Forestry	Brown	All Soils	Within	11.05
Te Awarua-o-Porirua	GW056	Drystock	Brown	Other Soils	Below	8.82
Te Awarua-o-Porirua	GW058	Drystock	Pallic	Other Soils	Below	14.17
Ruamāhanga	GW061	Drystock	Brown	Other Soils	Below	20.33
Ruamāhanga	GW063	Drystock	Melanic	Other Soils	Below	22.27
Ruamāhanga	GW066	Drystock	Pallic	Other Soils	Within	41.62
Wairarapa Coast	GW068	Forestry	Recent	All Soils	Within	13.24
Wairarapa Coast	GW070	Forestry	Recent	All Soils	Within	12.53
Ruamāhanga	GW099	Drystock	Pallic	Other Soils	Within	43.53
Ruamāhanga	GW106	Cropping	Recent	Recent Soils and Podzols	Within	42.46
Kāpiti Coast	GW114	Drystock	Pallic	Other Soils	Within	32.59

Arsenic (As)

Table A2.5: Arsenic results are compared against draft eco-soil guideline values (Eco-SGVs), see benchmarking for more information.

Whaitua	Site code	Land use	Soil order	Eco-SGV	Arsenic (mg/kg)
Kāpiti Coast	GW002	Drystock	Brown	Within	2.9
Kāpiti Coast	GW008	Drystock	Brown	Within	2.2
Kāpiti Coast	GW012	Lifestyle	Recent	Within	7.2
Ruamāhanga	GW013	Drystock	Gley	Within	5.1
Ruamāhanga	GW018	Drystock	Pallic	Within	2.7
Ruamāhanga	GW026	Drystock	Recent	Within	5.2
Ruamāhanga	GW030	Drystock	Pallic	Within	1.5
Ruamāhanga	GW033	Drystock	Pallic	Within	3.0
Ruamāhanga	GW037	Drystock	Pallic	Within	3.5
Ruamāhanga	GW040	Drystock	Pallic	Within	3.0
Kāpiti Coast	GW043	Drystock	Recent	Within	6.0
Kāpiti Coast	GW050	Drystock	Gley	Within	3.7
Te Awarua-o-Porirua	GW054	Forestry	Brown	Within	1.5
Te Awarua-o-Porirua	GW056	Drystock	Brown	Within	2.4
Te Awarua-o-Porirua	GW058	Drystock	Pallic	Within	3.7
Ruamāhanga	GW061	Drystock	Brown	Within	2.2
Ruamāhanga	GW063	Drystock	Melanic	Within	5.3
Ruamāhanga	GW066	Drystock	Pallic	Within	6.0
Wairarapa Coast	GW068	Forestry	Recent	Within	6.5
Wairarapa Coast	GW070	Forestry	Recent	Within	5.2
Ruamāhanga	GW099	Drystock	Pallic	Within	3.6
Ruamāhanga	GW106	Cropping	Recent	Within	5.3
Kāpiti Coast	GW114	Drystock	Pallic	Within	3.3

Cadmium (Cd)

Table A2.6: Cadmium results are compared against draft eco-soil guideline values (Eco-SGVs) on the map and trigger values from the tiered fertiliser management system (TFMS) also in the table, see benchmarking for more information.

Whaitua	Site code	Land use	Soil order	Eco-SGV	Cadmium (mg/kg)
Kāpiti Coast	GW002	Drystock	Brown	Within	0.36
Kāpiti Coast	GW008	Drystock	Brown	Within	0.11
Kāpiti Coast	GW012	Lifestyle	Recent	Within	0.09
Ruamāhanga	GW013	Drystock	Gley	Within	0.28
Ruamāhanga	GW018	Drystock	Pallic	Within	0.15
Ruamāhanga	GW026	Drystock	Recent	Within	0.20
Ruamāhanga	GW030	Drystock	Pallic	Within	0.21
Ruamāhanga	GW033	Drystock	Pallic	Within	0.20
Ruamāhanga	GW037	Drystock	Pallic	Within	0.38
Ruamāhanga	GW040	Drystock	Pallic	Within	0.16
Kāpiti Coast	GW043	Drystock	Recent	Within	0.09
Kāpiti Coast	GW050	Drystock	Gley	Within	0.29
Te Awarua-o-Porirua	GW054	Forestry	Brown	Within	0.16
Te Awarua-o-Porirua	GW056	Drystock	Brown	Within	0.27
Te Awarua-o-Porirua	GW058	Drystock	Pallic	Within	0.09
Ruamāhanga	GW061	Drystock	Brown	Within	0.21
Ruamāhanga	GW063	Drystock	Melanic	Within	0.51
Ruamāhanga	GW066	Drystock	Pallic	Within	0.23
Wairarapa Coast	GW068	Forestry	Recent	Within	0.16
Wairarapa Coast	GW070	Forestry	Recent	Within	0.06
Ruamāhanga	GW099	Drystock	Pallic	Within	0.28
Ruamāhanga	GW106	Cropping	Recent	Within	0.17
Kāpiti Coast	GW114	Drystock	Pallic	Within	0.29

Chromium (Cr)

Table A2.7: Chromium results are compared against draft eco-soil guideline values (Eco-SGVs), see benchmarking for more information.

Whaitua	Site code	Land use	Soil order	Eco-SGV	Chromium (mg/kg)
Kāpiti Coast	GW002	Drystock	Brown	Within	9
Kāpiti Coast	GW008	Drystock	Brown	Within	12
Kāpiti Coast	GW012	Lifestyle	Recent	Within	26
Ruamāhanga	GW013	Drystock	Gley	Within	26
Ruamāhanga	GW018	Drystock	Pallic	Within	13
Ruamāhanga	GW026	Drystock	Recent	Within	17
Ruamāhanga	GW030	Drystock	Pallic	Within	8
Ruamāhanga	GW033	Drystock	Pallic	Within	12
Ruamāhanga	GW037	Drystock	Pallic	Within	11
Ruamāhanga	GW040	Drystock	Pallic	Within	12
Kāpiti Coast	GW043	Drystock	Recent	Within	13
Kāpiti Coast	GW050	Drystock	Gley	Within	13
Te Awarua-o-Porirua	GW054	Forestry	Brown	Within	7
Te Awarua-o-Porirua	GW056	Drystock	Brown	Within	8
Te Awarua-o-Porirua	GW058	Drystock	Pallic	Within	10
Ruamāhanga	GW061	Drystock	Brown	Within	13
Ruamāhanga	GW063	Drystock	Melanic	Within	13
Ruamāhanga	GW066	Drystock	Pallic	Within	11
Wairarapa Coast	GW068	Forestry	Recent	Within	11
Wairarapa Coast	GW070	Forestry	Recent	Within	9
Ruamāhanga	GW099	Drystock	Pallic	Within	18
Ruamāhanga	GW106	Cropping	Recent	Within	18
Kāpiti Coast	GW114	Drystock	Pallic	Within	15

Copper (Cu)

Table A2.8: Copper results are compared against draft eco-soil guideline values (Eco-SGVs), see benchmarking for more information.

Whaitua	Site code	Land use	Soil order	Eco-SGV	Copper (mg/kg)
Kāpiti Coast	GW002	Drystock	Brown	Within sensitive limits	6
Kāpiti Coast	GW008	Drystock	Brown	Within sensitive limits	8
Kāpiti Coast	GW012	Lifestyle	Recent	Within sensitive limits	16
Ruamāhanga	GW013	Drystock	Gley	Within sensitive limits	19
Ruamāhanga	GW018	Drystock	Pallic	Within sensitive limits	7
Ruamāhanga	GW026	Drystock	Recent	Within sensitive limits	17
Ruamāhanga	GW030	Drystock	Pallic	Within sensitive limits	4
Ruamāhanga	GW033	Drystock	Pallic	Within sensitive limits	7
Ruamāhanga	GW037	Drystock	Pallic	Within sensitive limits	9
Ruamāhanga	GW040	Drystock	Pallic	Within sensitive limits	9
Kāpiti Coast	GW043	Drystock	Recent	Within sensitive limits	20
Kāpiti Coast	GW050	Drystock	Gley	Within sensitive limits	11
Te Awarua-o-Porirua	GW054	Forestry	Brown	Within sensitive limits	4
Te Awarua-o-Porirua	GW056	Drystock	Brown	Within sensitive limits	9
Te Awarua-o-Porirua	GW058	Drystock	Pallic	Within sensitive limits	8
Ruamāhanga	GW061	Drystock	Brown	Within sensitive limits	6
Ruamāhanga	GW063	Drystock	Melanic	Within sensitive limits	7
Ruamāhanga	GW066	Drystock	Pallic	Within sensitive limits	6
Wairarapa Coast	GW068	Forestry	Recent	Within sensitive limits	10
Wairarapa Coast	GW070	Forestry	Recent	Within sensitive limits	7
Ruamāhanga	GW099	Drystock	Pallic	Within sensitive limits	9
Ruamāhanga	GW106	Cropping	Recent	Within sensitive limits	14
Kāpiti Coast	GW114	Drystock	Pallic	Within sensitive limits	14

Lead (Pb)

Table A2.9: Lead results are compared against draft eco-soil guideline values (Eco-SGVs), see benchmarking for more information.

Whaitua	Site code	Land use	Soil order	Eco-SGV	Lead (mg/kg)
Kāpiti Coast	GW002	Drystock	Brown	Within	8.4
Kāpiti Coast	GW008	Drystock	Brown	Within	9.8
Kāpiti Coast	GW012	Lifestyle	Recent	Within	30.0
Ruamāhanga	GW013	Drystock	Gley	Within	22.0
Ruamāhanga	GW018	Drystock	Pallic	Within	9.7
Ruamāhanga	GW026	Drystock	Recent	Within	18.4
Ruamāhanga	GW030	Drystock	Pallic	Within	6.9
Ruamāhanga	GW033	Drystock	Pallic	Within	9.3
Ruamāhanga	GW037	Drystock	Pallic	Within	12.9
Ruamāhanga	GW040	Drystock	Pallic	Within	23.0
Kāpiti Coast	GW043	Drystock	Recent	Within	23.0
Kāpiti Coast	GW050	Drystock	Gley	Within	13.9
Te Awarua-o-Porirua	GW054	Forestry	Brown	Within	4.9
Te Awarua-o-Porirua	GW056	Drystock	Brown	Within	8.6
Te Awarua-o-Porirua	GW058	Drystock	Pallic	Within	9.7
Ruamāhanga	GW061	Drystock	Brown	Within	6.9
Ruamāhanga	GW063	Drystock	Melanic	Within	14.4
Ruamāhanga	GW066	Drystock	Pallic	Within	7.4
Wairarapa Coast	GW068	Forestry	Recent	Within	11.2
Wairarapa Coast	GW070	Forestry	Recent	Within	10.3
Ruamāhanga	GW099	Drystock	Pallic	Within	13.7
Ruamāhanga	GW106	Cropping	Recent	Within	16.7
Kāpiti Coast	GW114	Drystock	Pallic	Within	9.2

Nickel (Ni)

Table A2.10: Nickel results are compared against New Zealand Water and Wastes Association (NZWWA) limits, see benchmarking for more information.

Whaitua	Site code	Land use	Soil order	NZWWA limit	Nickel (mg/kg)
Kāpiti Coast	GW002	Drystock	Brown	Within	3.6
Kāpiti Coast	GW008	Drystock	Brown	Within	7.7
Kāpiti Coast	GW012	Lifestyle	Recent	Within	15.8
Ruamāhanga	GW013	Drystock	Gley	Within	24.0
Ruamāhanga	GW018	Drystock	Pallic	Within	8.2
Ruamāhanga	GW026	Drystock	Recent	Within	15.9
Ruamāhanga	GW030	Drystock	Pallic	Within	5.2
Ruamāhanga	GW033	Drystock	Pallic	Within	8.0
Ruamāhanga	GW037	Drystock	Pallic	Within	5.3
Ruamāhanga	GW040	Drystock	Pallic	Within	8.1
Kāpiti Coast	GW043	Drystock	Recent	Within	12.1
Kāpiti Coast	GW050	Drystock	Gley	Within	8.3
Te Awarua-o-Porirua	GW054	Forestry	Brown	Within	3.9
Te Awarua-o-Porirua	GW056	Drystock	Brown	Within	4.6
Te Awarua-o-Porirua	GW058	Drystock	Pallic	Within	5.5
Ruamāhanga	GW061	Drystock	Brown	Within	8.1
Ruamāhanga	GW063	Drystock	Melanic	Within	7.9
Ruamāhanga	GW066	Drystock	Pallic	Within	6.5
Wairarapa Coast	GW068	Forestry	Recent	Within	9.0
Wairarapa Coast	GW070	Forestry	Recent	Within	7.3
Ruamāhanga	GW099	Drystock	Pallic	Within	14.4
Ruamāhanga	GW106	Cropping	Recent	Within	17.2
Kāpiti Coast	GW114	Drystock	Pallic	Within	10.0

Zinc (Zn)

Table A2.11: Zinc results are compared against draft eco-soil guideline values (Eco-SGVs), see benchmarking for more information.

Whaitua	Site code	Land use	Soil order	Eco-SGV	Zinc (mg/kg)
Kāpiti Coast	GW002	Drystock	Brown	Within sensitive limits	41
Kāpiti Coast	GW008	Drystock	Brown	Within sensitive limits	48
Kāpiti Coast	GW012	Lifestyle	Recent	Within sensitive limits	106
Ruamāhanga	GW013	Drystock	Gley	Within sensitive limits	107
Ruamāhanga	GW018	Drystock	Pallic	Within sensitive limits	47
Ruamāhanga	GW026	Drystock	Recent	Within sensitive limits	73
Ruamāhanga	GW030	Drystock	Pallic	Within sensitive limits	37
Ruamāhanga	GW033	Drystock	Pallic	Within sensitive limits	43
Ruamāhanga	GW037	Drystock	Pallic	Within sensitive limits	45
Ruamāhanga	GW040	Drystock	Pallic	Within sensitive limits	74
Kāpiti Coast	GW043	Drystock	Recent	Within sensitive limits	69
Kāpiti Coast	GW050	Drystock	Gley	Within sensitive limits	48
Te Awarua-o-Porirua	GW054	Forestry	Brown	Within sensitive limits	24
Te Awarua-o-Porirua	GW056	Drystock	Brown	Within sensitive limits	49
Te Awarua-o-Porirua	GW058	Drystock	Pallic	Within sensitive limits	31
Ruamāhanga	GW061	Drystock	Brown	Within sensitive limits	45
Ruamāhanga	GW063	Drystock	Melanic	Within sensitive limits	35
Ruamāhanga	GW066	Drystock	Pallic	Within sensitive limits	48
Wairarapa Coast	GW068	Forestry	Recent	Within sensitive limits	53
Wairarapa Coast	GW070	Forestry	Recent	Within sensitive limits	42
Ruamāhanga	GW099	Drystock	Pallic	Within sensitive limits	68
Ruamāhanga	GW106	Cropping	Recent	Within sensitive limits	70
Kāpiti Coast	GW114	Drystock	Pallic	Within sensitive limits	58

Bulk density

Table A2.12: Bulk density results benchmarked against the target range of 'Loose' to 'Compact', see benchmarking for more information.

Whaitua	Site code	Land use	Soil order	Rating	Bulk density (t/m^3)
Kāpiti Coast	GW002	Drystock	Allophanic	Compact	0.90
Kāpiti Coast	GW008	Drystock	Allophanic	Compact	1.05
Kāpiti Coast	GW012	Lifestyle	Semi-arid, pallic and recent	Adequate	1.12
Ruamāhanga	GW013	Drystock	All other	Compact	1.27
Ruamāhanga	GW018	Drystock	Semi-arid, pallic and recent	Adequate	1.20
Ruamāhanga	GW026	Drystock	Semi-arid, pallic and recent	Adequate	1.07
Ruamāhanga	GW030	Drystock	Semi-arid, pallic and recent	Compact	1.27
Ruamāhanga	GW033	Drystock	Semi-arid, pallic and recent	Adequate	1.12
Ruamāhanga	GW037	Drystock	Semi-arid, pallic and recent	Loose	0.79
Ruamāhanga	GW040	Drystock	Semi-arid, pallic and recent	Adequate	0.96
Kāpiti Coast	GW043	Drystock	Semi-arid, pallic and recent	Adequate	1.09
Kāpiti Coast	GW050	Drystock	All other	Adequate	0.99
Te Awarua-o-Porirua	GW054	Forestry	Allophanic	Compact	0.92
Te Awarua-o-Porirua	GW056	Drystock	Allophanic	Adequate	0.80
Te Awarua-o-Porirua	GW058	Drystock	Semi-arid, pallic and recent	Adequate	0.99
Ruamāhanga	GW061	Drystock	Allophanic	Compact	0.92
Ruamāhanga	GW063	Drystock	Organic	Compact	0.97
Ruamāhanga	GW066	Drystock	Semi-arid, pallic and recent	Adequate	1.06
Wairarapa Coast	GW068	Forestry	Semi-arid, pallic and recent	Adequate	1.11
Wairarapa Coast	GW070	Forestry	Semi-arid, pallic and recent	Adequate	1.21
Ruamāhanga	GW099	Drystock	Semi-arid, pallic and recent	Adequate	1.23
Ruamāhanga	GW106	Cropping	Semi-arid, pallic and recent	Compact	1.37
Kāpiti Coast	GW114	Drystock	Semi-arid, pallic and recent	Adequate	0.97

Macroporosity

Table A2.13: Macroporosity results benchmarked against the target range of 'Adequate', see benchmarking for more information.

Whaitua	Site code	Land use	Rating land use	Rating	Macroporosity (% v/v)
Kāpiti Coast	GW002	Drystock	Pastures, cropping and horticulture	Adequate	16.8
Kāpiti Coast	GW008	Drystock	Pastures, cropping and horticulture	Adequate	11.0
Kāpiti Coast	GW012	Lifestyle	Pastures, cropping and horticulture	Adequate	19.5
Ruamāhanga	GW013	Drystock	Pastures, cropping and horticulture	Very low	4.6
Ruamāhanga	GW018	Drystock	Pastures, cropping and horticulture	Adequate	14.5
Ruamāhanga	GW026	Drystock	Pastures, cropping and horticulture	Adequate	14.2
Ruamāhanga	GW030	Drystock	Pastures, cropping and horticulture	Low	8.8
Ruamāhanga	GW033	Drystock	Pastures, cropping and horticulture	Adequate	14.0
Ruamāhanga	GW037	Drystock	Pastures, cropping and horticulture	Adequate	20.3
Ruamāhanga	GW040	Drystock	Pastures, cropping and horticulture	Adequate	18.3
Kāpiti Coast	GW043	Drystock	Pastures, cropping and horticulture	Adequate	14.8
Kāpiti Coast	GW050	Drystock	Pastures, cropping and horticulture	Adequate	14.0
Te Awarua-o-Porirua	GW054	Forestry	Forestry	Adequate	12.4
Te Awarua-o-Porirua	GW056	Drystock	Pastures, cropping and horticulture	Adequate	15.5
Te Awarua-o-Porirua	GW058	Drystock	Pastures, cropping and horticulture	Adequate	14.0
Ruamāhanga	GW061	Drystock	Pastures, cropping and horticulture	Adequate	22.6
Ruamāhanga	GW063	Drystock	Pastures, cropping and horticulture	Adequate	12.1
Ruamāhanga	GW066	Drystock	Pastures, cropping and horticulture	Adequate	13.2
Wairarapa Coast	GW068	Forestry	Forestry	Adequate	11.1
Wairarapa Coast	GW070	Forestry	Forestry	Adequate	14.0
Ruamāhanga	GW099	Drystock	Pastures, cropping and horticulture	Low	6.4
Ruamāhanga	GW106	Cropping	Pastures, cropping and horticulture	Low	7.2
Kāpiti Coast	GW114	Drystock	Pastures, cropping and horticulture	Low	7.4