

Environmental Indicators for Land : Overall Soil Quality in the Waikato Region 1998 - 2004

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Summary

Project and Client

Environment Waikato monitors soil quality in the Waikato region each year, following the protocols and interpretation established by the 500 Soils Project (Hill et al. 2002; Lilburne et al. 2004). The annual monitoring data are published as a series of annual reports (e.g., Sparling 2004). As part of those reports and as separate documents, overviews of soil quality in the region are produced, classified by land uses and soil orders. The information is also displayed on the Environmental Indicators pages of the Environment Waikato website (<http://www.ew.govt.nz/enviroinfo/indicators/index.htm>). Those pages were created in 2002, and at that time insufficient data had been collected on the cropping land uses to provide reliable estimates of quality. Environment Waikato has continued to accumulate data on cropping and other land uses in the intervening time. Landcare Research was contracted to update the overview of soil quality in the region, and to prepare data in suitable format for updating of the website pages.

Objective

- Update the soil quality indicator following the protocols and methodology used for the initial SQ indicator.
- Update data sheets and recalculate existing soil quality information for all land uses currently presented. For resampled sites, calculate direction and rate of change into the soil quality indicator.
- Work with EW staff to revise indicator presentation as required. Revise supporting documentation (data report and technical information cards).
- Provide EW with revised electronic files data and text (WORD or WORD compatible) containing the supporting technical information as required.

Methods

- Soil quality monitoring data from published reports were combined and sorted into 5 major land-use categories: dairy pasture, sheep-beef pastures, crops and horticulture, forestry, and indigenous vegetation.
- Seven key soil quality indicators were used to estimate the quality status of the soils and to determine whether the measured values fell within target ranges specific to that soil and land use. The number of times a value failed to meet the target range was recorded.
- For each land-use category the proportion of sites meeting or not meeting soil quality targets was calculated and used to estimate the proportion of total land area in the Waikato that was “satisfactory” or “of concern” for soil quality status.
- To provide further detail for sites “of concern”, the proportion of sites not meeting the target ranges suggested for the 7 indicators, soil pH, total C, total N, mineralisable N, Olsen P, bulk density, and macroporosity, were calculated.

Results

- Data from a total of 133 sites were analysed, comprising 44 dairy pastures, 36 sheep-beef pastures, 26 horticulture and cropping, 18 plantation forests, and 8 indigenous vegetation. Weighting factors based on actual area under each land use were derived to correct for bias in the data set

- Over all land uses, 34% of the sites met all the soil quality targets, 66% had one or more indicators outside the target range.
- Proportions of sites in the “satisfactory” category were greatest for cropping soils 54%, followed by forestry (44%), drystock (36%), and least for dairy (27%). There are still too few examples (8) of indigenous vegetation for the results to be considered representative.
- Main sources of soil quality concern were the compaction and excessively high fertility levels of dairy and sheep-beef pastures, the high fertility level, low organic matter, and compaction under horticulture and cropping, and the low fertility levels and excessive porosity under some plantation forests.

Conclusions

- The number of soil quality characteristics that met target criteria (86%) was similar to that of previous years.
- Data expressed on a per site basis suggested that about one third of the sites met the soil quality targets.
- Moderate soil compaction under pastures was widespread across the Waikato region.
- About one quarter of pastoral farms and some cropping sites had very high fertility levels (high Olsen P levels) that were above current recommendations.
- Recommendations
- The summary data of soil quality in the Waikato region are used by Environment Waikato for public information about soil quality in the region, and to update the Environmental Indicators (Land) web pages.
- Through user group meetings, pastoral land managers be made aware of the widespread extent of soil compaction within the region, and that fertiliser levels on some farms may be above current agronomic recommendations.

1 Introduction

The Resource Management Act (1991) Section 35 requires Regional Councils to report on the “life supporting capacity of soil” and whether current practices will meet the “foreseeable needs of future generations”. Protocols for monitoring land and soils were established by a 6- year trial commonly known as the 500 Soils Project (Hill et al. 2002; Sparling et al. 2004), and an interpretive framework for reporting at a regional scale was developed (Lilburne et al. 2004). Environment Waikato supported and participated in the trial and has applied the approach to report on soil quality within the Waikato Region. Environment Waikato monitors soil quality in the Waikato each year, and the annual data are published as a series of annual reports (e.g., Sparling 2004). Summaries of soil quality in the region are produced, classified by land uses and soil orders. The information is also displayed on the Environmental Indicators pages of the Environment Waikato website (<http://www.ew.govt.nz/enviroinfo/indicators/index.htm>). Those pages were created in 2002; at that time insufficient data had been collected to provide reliable estimates of quality on the cropping land uses. Since then, Environment Waikato has collected more data on horticulture and cropping soils and continued to accumulate data on other land uses. In addition, some sites have been resampled to check whether there had been any change in soil quality during the intervening period. Landcare Research was contracted to provide an overview of soil quality in the region using all the currently available data collected from 1995 to 2004, and to summarise the data in suitable format for updating of the website pages

2 Objectives

- Update the soil quality indicator following the protocols and methodology used for the initial SQ indicator.
- Update data sheets and recalculate existing soil quality information for all land uses currently presented. For resampled sites calculate direction and rate of change into the soil quality indicator.
- Work with EW staff to revise indicator presentation as required. Revise supporting documentation (data report and technical information cards).
- Provide EW with revised electronic files data and text (WORD or WORD compatible) containing the supporting technical information as required.

3 Methods

Soil quality monitoring data from published Landcare Research contract report to Environment Waikato were combined and sorted into 5 major land use categories: dairy pasture, sheep-beef pastures, crops and horticulture, forestry, and indigenous vegetation.

Seven key soil quality indicators (soil pH, total C, total N, mineralisable N, Olsen P, bulk density and macroporosity) were used to estimate the quality status of the soils. The target ranges, specific to soil order and land use, were taken from the provisional values suggested by Sparling et al. (2003). For each site, the number of times a value failed to meet the target range was recorded.

Data were grouped by land use category. For each land-use category, the proportion of sites meeting or not meeting soil quality targets was calculated using the formula

$$P = C/N \times 100,$$

where P is the proportion (5) of sites not meeting targets, C is the count of sites exceeding the target range on one or more indicators, and N is the total number of sites sampled.

The proportion of the Waikato Region under the 5 land-use categories (dairy pasture, sheep-beef pasture, horticulture and cropping, plantation forests and indigenous vegetation) was supplied by Environment Waikato. The proportion of concern can then be calculated by multiplying by P derived as above.

$$Ac = P \times At,$$

where Ac is the area of concern, P is the proportion of sites of concern, and At is the total area. The calculation was completed for each land use individually, and also using all land uses combined to obtain a figure for the whole region.

To provide further detail for sites “of concern”, for each land use, the proportion of sites not meeting the target ranges suggested for each of the 7 indicators were calculated.

$$Pi = Ic / Ni \times 100,$$

where Pi is the proportion of sites not meeting the target for that particular indicator, Ic is the count of sites exceeding the target range, and Ni is the total number of sites sampled for that indicator.

4 Results

4.1 Dairy Land Use

Forty-four sites were analysed from dairy farms. Twelve of the farms (27%) met all the soil quality targets. Moderate soil compaction. (indicated by low macroporosity) was the main source of concern, occurring on half of the farms in the sample (Fig 1).

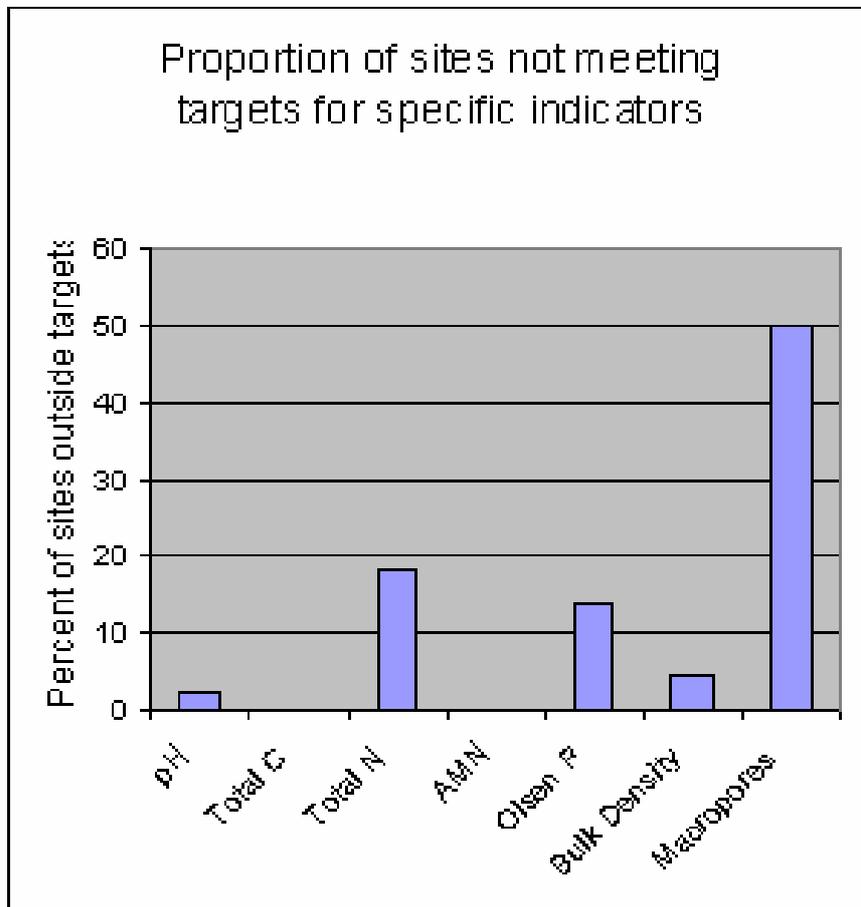


Figure 1: Soil quality concerns for dairy pastures

4.2 Sheep-Beef Land Use

Thirty-six sites were analysed from drystock (sheep and beef cattle) farms. Twelve of the farms (36%) met all the soil quality targets. Of those sites not meeting the targets, Olsen P contents above recommended levels (39% of farms) and moderate soil compaction (33% of farms) were the main indicators of concern (Fig 2).

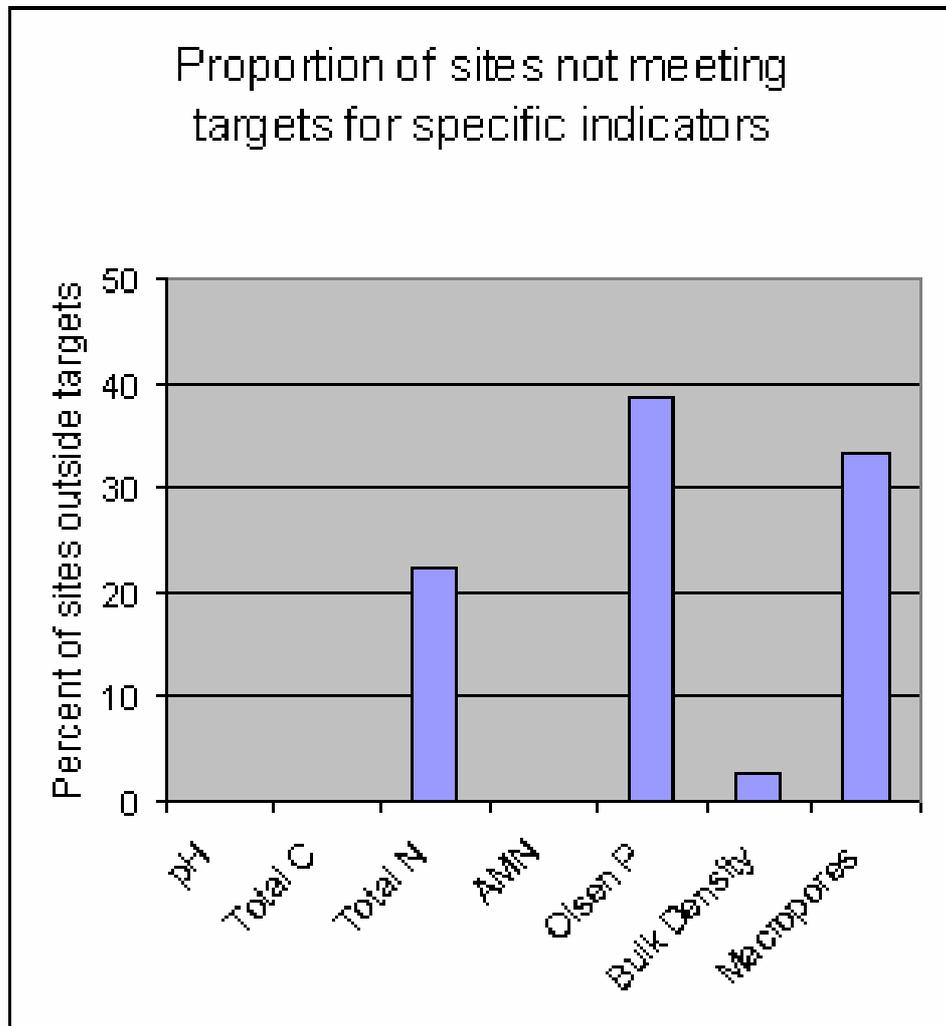


Figure 2: Soil quality concerns for drystock pastures

4.3 Horticulture and Cropping

Twenty-six sites used for horticulture or cropping land use were analysed. Fourteen of the sites (54%) met all the soil quality targets. Of those sites not meeting the targets the main source of concern was high fertility (high Olsen P) on 31% of the sites that were above recommended levels (Roberts & Morton 1999), low organic matter on 15% of the sites, and low macroporosity (compaction) on 12% of the sites (Fig. 3).

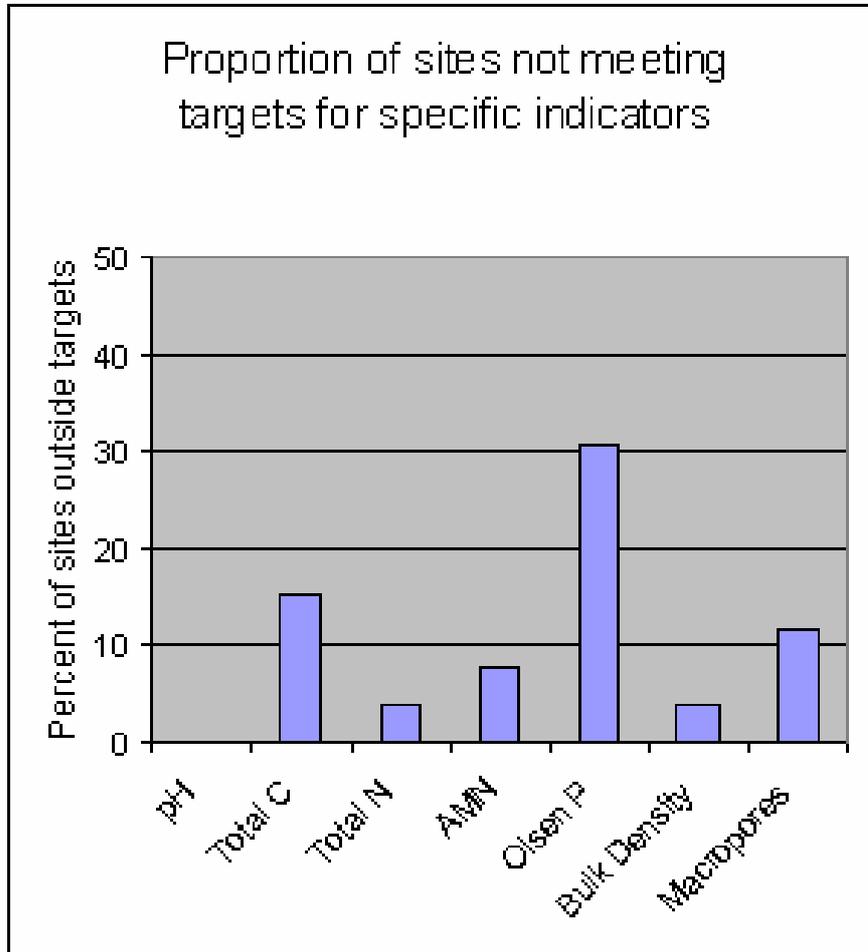


Figure 3: Soil quality concerns for horticultural and cropping soils

4.4 Plantation Forests

Eighteen sites were analysed, and 8 of these (44%) met soil quality targets for that land use. Of those sites not meeting targets, some failed to meet the targets for several indicators. The main indicators of concern were low Olsen P contents, very low bulk density, and excessive macroporosity, suggesting the soils could be infertile and susceptible to drought and erosion. The soil quality indicators are not well developed for forest soils, and Olsen P is not the preferred measure of long term P availability for trees. While there is a reasonable agreement between Olsen P and Bray P (often used by foresters) it is likely that the target ranges may be modified in the future. The revision will probably be downward, which will mean that most of the present forest sites will fall within target criteria. Although the bulk densities on some sites were high, the sites are mostly in high rainfall areas, so despite being well and excessively well drained, they are unlikely to shown water stress.

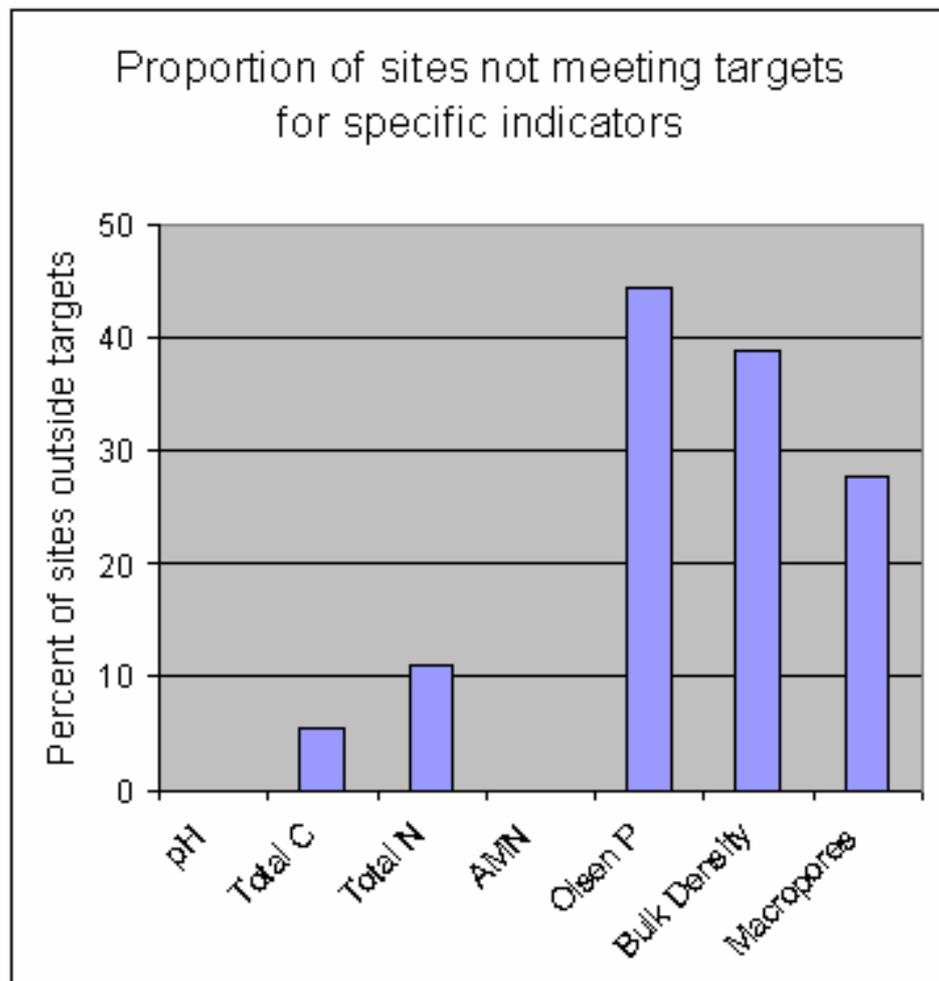


Figure 4: Soil quality concerns for plantation forest soils

4.5 Indigenous Vegetation

Only 8 sites under indigenous vegetation have been sampled to date. I consider the number too low to provide a reliable assessment of soil quality under indigenous vegetation. Further, soil quality target values for this land use are still poorly defined, and need to cover such diverse indigenous vegetation classes such as peat wetlands, native forest and scrublands. These targets will be the topic of on-going CRI research projects.

4.6 Overall Soil Quality in the Waikato (All Land Uses)

The overall soil quality for the region was calculated in two ways: (1) by the total number of **sites** where all indicators met the specified the target range, and (2) by the proportion of all **indicators** that met the target range.

Total number of sites

A total of 133 sites were sampled, but this sample is biased towards the more intensive land uses such as cropping and horticulture, which form 19.5% of the data but only 0.06% of the regional land area (Table 1).

Table 1:

Regional land are under different uses (000 ha)			Proportion of different land uses in the data set		
Land use	Total area	Percentage	Land use	Number	Percentage
Dairy	482	20.6	Dairy	45	33.8
Sheep/beef	895	38.2	Drystock	36	27.1
Crop	1.5	0.06	Crop/hort	26	19.6
Forestry	288	12.3	Forestry	18	13.5
Indigenous	675	28.8	Indigenous	8	6.0
Total	2341	100.0	Total	133	100.0

An overall regional soil quality assessment was obtained by summing the proportion of land area meeting soil quality targets for each of the 5 land uses.

- This calculation suggested 34.1% of the regional land area met soil quality targets, 65.9% did not. This latter figure was dominated by the large proportion of pasture sites that showed moderate compaction.

A summary graph of the 4 land-use categories (excluding indigenous) is shown in Figure 5. The area of the horticulture and cropping category was too small an area to show to be visible at this scale.

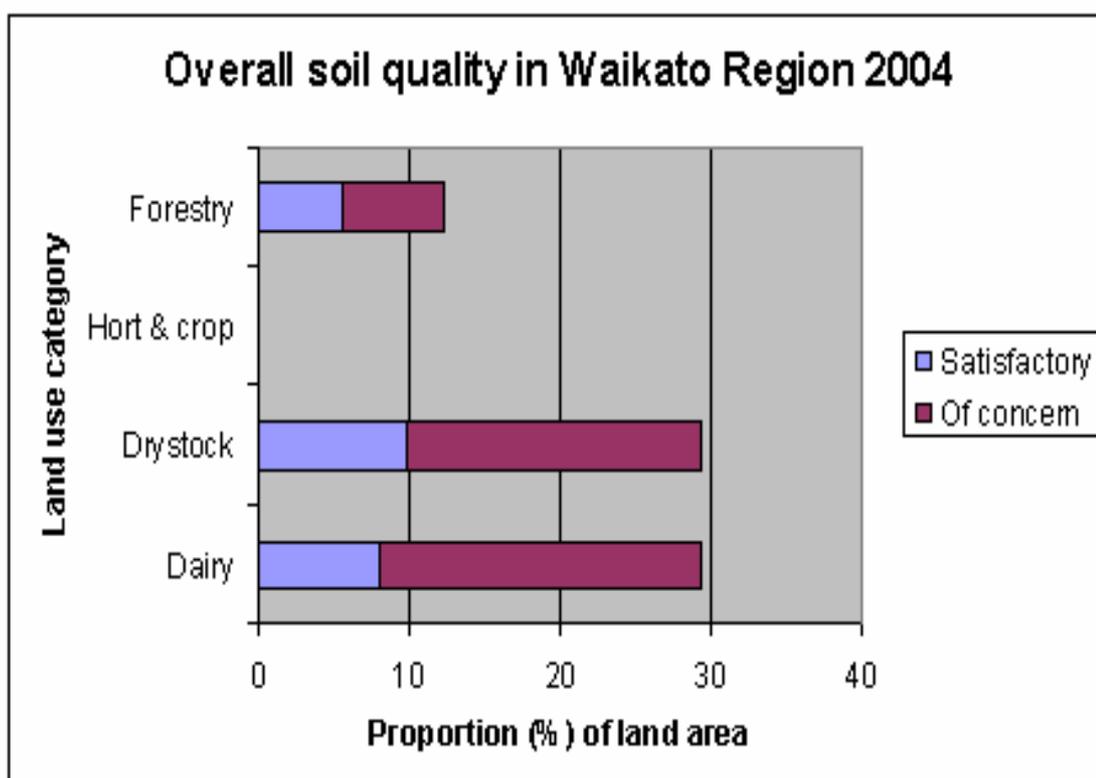


Figure 5: Proportions of land area for 4 land categories meeting “satisfactory” or “of concern” soil quality targets. The horticulture and cropping category was too small an area to show at this scale.

Proportion of all indicators

- A total of 906 soil characteristics were measured, of which 783 (86%) met the target ranges.

This figure should not be applied to calculate a proportion of land area affected, as some sites had more than one indicator that did not meet the target criteria, and there is a risk of masking sites of concern by a large number of “satisfactory” rankings. The proportion of “satisfactory” land area is much greater than that calculated using the number of sites, as that latter calculation ranks a site as “of concern” even if only one characteristic failed to meet the target value. The calculation using the number of sites is therefore much more conservative, but does not carry the risk that an “of concern” result can be masked by a large number of satisfactory results, such as is the case when assessing soil quality using the total number of indicators. A useful analogy may be a warrant of fitness on a car, where the vehicle must meet **all** the tests applied, and is failed if any one does not meet the specified target. I have applied the same criterion to assessing soil quality.

5 Conclusions

- The number of soil quality characteristics that met target criteria (86%) was similar to that of previous years.
- Data expressed on a per site basis suggested that about one third of the sites met the soil quality targets.
- Moderate soil compaction under pastures was widespread across the Waikato region.
- About one quarter of pastoral farms and some cropping sites had very high fertility levels (high Olsen P levels) which were above current recommendations.

6 Recommendations

- The summary data of soil quality in the Waikato region are used by Environment Waikato for public information on soil quality in the region, and to update the Environmental Indicators (Land) web pages.
- Through user group meetings, pastoral land managers are made aware of the widespread extent of soil compaction within the region, and that fertiliser levels on some farms may be above current agronomic recommendations.

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Appendices

Complete data sets, basis for calculations and the original figures are supplied as Word and Excel electronic files on the accompanying compact disk.