SOIL HEALTH MONITORING IN THE TASMAN DISTRICT

Introduction:

In carrying out the Councils' duty to monitor the state of the region's environment, information is being collected and assessed on soil health under different land use activities. This collection of information is part of the SEM programme for land monitoring (2.2 in the 1999 Environmental Monitoring Programmes summary).

Soil health, or quality, is the soil's fitness to support crop growth without resulting in soil degradation or otherwise harming the environment. Soils can be degraded through compaction, nutrient depletion or excess and the reduction of biological activity and organic matter.

This Council had minimal information on soil quality and hence little opportunity to identify areas susceptible to degradation, and to monitor changes in the extent and severity of soil degradation.

Since 1995 several relevant research programmes were funded by the Ministry of the Environment and backed by some of the larger Regional Councils such as the Auckland Regional Council, Environment Waikato and Environment Canterbury. At that time central government desired information at a national level for State of the Environment Reporting to fulfil international treaty obligations and the Regional Councils were looking for an effective, affordable and hopefully nationally consistent programme.

Project 5001 "Trialing Soil Quality Indicators for the State of the Environment Monitoring" was completed in 1998. The result of this trial was a set of indicators based on responsiveness, reliability, cost and interpretation. This set of indicators was then used in the next programme: " Implementing soil quality indicators for land" and popularly known as the "500 Soils Project". This was funded by the Ministry of the Environment on a 60:40 split with participating Councils. The Tasman District Council joined the project in 2000.

Ten Regional and District Councils participated in the monitoring project. In each region the effects of land use on soil quality were examined on 10-25 sites selected on the basis of soil type and land use considered of relevance for the region.

Objectives:

- Identify field sites for targeted sampling.
- Describe the soils and sites and measure a set of soil chemical, physical and biological attributes to characterise the soils and assess the soil quality.
- Provide interpretation of soil characteristics in relation to previous samples and soils from other regions.
- Relate soil quality to land use.
- Integrate the soil quality data from all available regions into a national overview.

Methods:

- 10 Sites were selected in the Tasman region. The number was governed by the availability of finance. Sites were selected to cover a range of land uses that were perceived to pose the greatest risk to sustained soil health. Soil types under these land uses were selected that were representative of substantial areas. Some sites were selected where climatic conditions were perceived to compound soil health problems, ie high rainfall areas.
- The site location, current land use and brief history were recorded, the soil profile described, and surface samples collected along a transect to characterise the chemical, biochemical and physical attributes of the soil.
- A standard suite of 11 soil characteristics was used to assess soil quality of the various soil and land use combinations.
- Exceptional sites were identified by grouping soils under similar land uses and recording those sites that exceeded an expected range for that land use, and by comparison against expected values for that soil and land use.

Table 1. **Indicators used for soil quality assessment.**

Indicators	Soil Quality Information
Chemical properties	
Total C content	Organic matter content
Total N content	Organic N reserves
Exchangeable cation	Buffering and nutrient reserves
pH	Acidity or alkalinity
Olsen P	Plant available phosphate
Biological properties	
Potentially mineralisable N	Readily mineralised N reserves
Physical properties	
Dry bulk density	Compaction, volumetric conversions
Particle density	Used to calculate porosity and available water
Porosity	soil compaction, root environment, voids
Available water	Moisture for plant growth and soil biology
Aggregate stability	Strength of soil crumbs

Results for the Tasman District

- The ten sites selected fell into 4 soil orders (Recent, Brown, Podzol and Mixed Anthropic) and covered 3 land use categories (pasture, orchard and market gardening) in addition to 3 rehabilitated sites, previously used for either gold mining or gravel extraction.
- Chemical and physical indicator results for the 10 soils are shown in Tables 2 & 3.

Soil quality issues

- Sites TDC00.6 and TDC00.7 were historically used for long term market garden production. The latter site was used for gravel extraction and subsequently rehabilitated and sown in a grass/clover sward. Both sites have low total C and N levels, high bulk densities, low macroporosities and low aggregate stabilities. All these measurements suggest that both sites have become degraded. When soil aggregates are less than 1.5mm MWD, the soil is considered to be structurally degraded. This may limit crop production and increase the paddocks susceptibility to soil erosion. The low aggregate soil stabilities measured here suggest that structural degradation has occurred. The condition of the soil at the market garden site is probably the result of management practises typically associated with traditional intensive market gardening. These practises include intensive cultivation and minimal organic matter inputs.

Table 2: Soil Physical Characteristics of Sites Sampled in the Tasman District: 2000-2001[1]									
Code	**Land Use**	**Soil Type**	**Bulk Density mg/m^3**	**Particle Density mg/m^3**	**Total Porosity % v/v**	**Macro Porosity % v/v**	**Readily Available Water % v/v**	**Total Available Water % v/v**	**Aggregate Stability MWD mm**
TDC00.1	Pasture(Collingwood)	Karamea silt loam	0.89	2.54	65.1	4.8	7.5	38.2	2.58
TDC00.2	Pasture (Aorere)	Ikamatua silt loam	1.00	2.55	60.7	6.5	7.8	27.5	2.80
TDC00.3	Pasture (Rockville)	Onahau silt loam	0.85	2.08	58.9	3.7	9.5	34.3	2.54
TDC00.4	Orchard (Appleby)	Waimea clay loam	1.03	2.66	61.3	19.7	5.3	18.4	2.30
TDC00.5	Orchard (Mapua)	Mapua sandy clay loam	**1.51**	2.60	**43.0**	5.3	5.4	17.1	2.13
TDC00.6	Market garden (Appleby)	Waimea silt loam	**1.61**	2.72	**40.9**	4.8	4.9	14.4	**0.72**
TDC00.7	Rehabilitated site (Appleby)	Waimea silt loam (anthropic)	**1.63**	2.73	**40.6**	6.2	4.8	17.6	**0.59**
TDC00.8	Rehabilitated site (Waimea West)	Waimea silt loam (anthropic)	**1.46**	2.69	**45.9**	6.0[2]	14.4[2]	26.2[2]	1.91
TDC00.9	Rehabilitated site (Matakitaki)	Ikamatua gritty silt loam (anthropic)	1.32	2.65	50.3	9.4	6.8	18.9	1.78
TDC00.10	Pasture (Matakitaki)	Hokitika loamy sand	1.39	2.65	47.4	9.4	9.1	25.7	2.16

[1] Site means of samples are shown; full data in Appendix II.
[2] Values not corrected for stone content at site TDC00.8.

Table 3 : Soil Chemical Characteristics of Sites Sampled in the Tasman District: 2000-2001														
Code	**Land Use**	**Soil Type**	**Total C mg/cm^3**	**Total N mg/cm^3**	**C:N Ratio**	**AMN[3]**	**Olsen P Φg/cm^3**	**pH**	**Base sat. %**	**CEC cmol/10^3/cm^3**	**Exchangeable Cations cmol/10^3/cm^3**			
											Ca	Mg	K	Na
TDC00.1	Pasture	Karamea silt loam	45.4	5.58	8.1	97	46.0	5.85	59	13.8	7.2	0.51	0.33	0.11
TDC00.2	Pasture	Ikamatua silt loam	64.8	5.48	11.8	136	33.5	5.57	42	18.4	5.9	1.14	0.44	0.19
TDC00.3	Pasture	Onahau silt loam	83.5	5.67	14.7	127	18.1	5.66	85	17.7	13.5	0.99	0.41	0.12
TDC00.4	Orchard	Waimea clay loam	36.4	3.31	11.0	59	89.5	5.92	82	25.4	15.1	4.54	1.17	0.09
TDC00.5	Orchard	Mapua sandy clay loam	31.7	2.58	12.3	69	85.7	6.57	100	19.0	19.9	1.64	0.96	0.15
TDC00.6	Market garden	Waimea silt loam	**20.9**	2.00	10.5	44	69.8	6.45	100	23.1	12.2	11.51	0.52	0.15
TDC00.7	Rehabilitated site	Waimea silt loam (anthropic)	**15.5**	1.27	12.2	58	39.5	**7.83**	100	16.2	34.1	4.14	0.90	0.19
TDC00.8	Rehabilitated site	Waimea silt loam (anthropic)	**16.3**	1.64	9.9	38	13.1	6.82	94	16.1	8.3	6.12	0.58	0.13
TDC00.9	Rehabilitated site	Ikamatua gritty silt loam (anthropic)	33.0	2.32	14.3	46	14.7	5.82	33	18.3	5.1	0.45	0.46	0.11
TDC00.10	Pasture	Hokitika loamy sand	26.6	2.40	11.1	74	36.8	5.84	76	10.0	6.8	0.54	0.19	0.05

- A comparison of sites TDC00.6 and TDC00.7 suggests that the rehabilitation of site TDC00.7 has not been particularly successful. Pasture management is commonly used to restore soils degraded by long-term intensive cultivation or to rehabilitate mining and gravel extraction sites. Five years of pasture management is normally sufficient to significantly improve soil organic levels. However after 5 years of pasture management, TDC00.7 maintains relatively low total C and N levels, and similar aggregate stability levels to those measured on the adjacent market garden site (TDC00.6). TDC00.7 is also highly alkaline (high soil pH) This may reduce pasture performance, leading to an increased risk of weed infestation.

- The other two rehabilitation sites, (TDC00.8 and TDC009) also demonstrate levels of degradation from what would be typical for the soil types. It was not possible to obtain intact cores from TDC00.8 due to the stoniness of the site; hence it is unclear how accurately the macroporosity measurements indicate true field values. Soils structural improvements at sites TDC00.6, TDC00.7 and TDC00.8 may be further suppressed due to low aeration and infiltration. The values for these sites lie outside the suggested target range for environmental criteria. In addition, site TDC00.8 had Olsen P levels below the suggested optimum range.

- Relatively few soil quality issues related to the orchard sites. The Olsen P level at site TDC00.4 was slightly above the suggested upper limit for horticultural crops which may lead to P leaching from the site. The other orchard site, TDC00.5 had a high bulk density and low macroporosity outside the suggested optimum range. With an associated slope of 12 degrees, there is a risk of surface runoff at this site if irrigation is applied at a rate greater than the infiltration rate of this soil.

- The results for soil quality overall were good at the pasture sites used for dairy production and the rehabilitated ex-goldmining site. The bulk density measures at site TDC00.9 and TDC00.10 were relatively high, possibly due to heavy grazing or grazing during wet conditions. However, the associated macroporosity value of 9.4% for both sites suggests long-term treading damage has been minimal.

Results for New Zealand

- A total of 511 sites across 10 regions were sampled using comparable methodology. There was a strong bias towards the more intense land uses of greatest concern to the regions. Simply, sampling was targeted to efficiently use limited resources.

Structural Decline

- Bulk density and macroporosity measurements provide evidence of structural degradation. More than half the soils under dairy farming (121 sites sampled) had macroporosity levels below which poor soil aeration results in reduced pasture growth. Soil structural degradation was common under arable cropping with more than half the soils from the 17 sites showing low aggregate stability.

- The widespread loss of macroporosity under dairy farming was examined in more detail to see if it was localised in one soil order or region. The alternative land use of forestry was used for comparison. In all soils, macroporosity was less under farming than in the same soil under forestry. The same pattern occurred across all regions where comparisons could be made.

Nutrient Saturation

- Instances of high nutrient status were found in dairy pasture, horticulture and arable cropping. Unless the high levels of the available nutrients are matched by high plant demand, there is an increased risk of nutrient being leached and affecting water quality.

Biological Activity

- Mineralisable N content was measured to indicate microbial biomass and activity. Results showed that mineralisable N were highest under pastures and lowest under cropping regimes. (High levels indicate healthy soils.)

Forestry, nutrient depletion and soil acidity

- There are concerns that plantation forestry, mainly for radiata pine, may be causing soil acidification. Comparisons of data were made between plantation and indigenous forestry and pasture. There was no evidence that the overall pH of the sites under pine plantations was any lower than under indigenous vegetation. Both indigenous and plantation forests were of lower pH than pastures, reflecting the history of liming to establish and improve pasture production.

- Soil nutrient levels were generally lower under pine plantations than other land uses. The reason for and possible consequences of the lower nutrient levels are currently not known.

Future requirements

- The results both regionally and nationally show that there are issues that need some attention. The degradation of soil physical properties highlighted on the market garden site will require further investigation. Simply, we have information from only one site. Obviously the results highlight an issue but do not indicate a trend for all market garden sites in the district. Further investigations are necessary to gain an accurate picture.

  The degradation of soil physical properties highlighted on the rehabilitation sites associated with gravel extraction will come under further investigation. Land productivity trials will be set up at both sites as part of their consent requirements. The information gained to date will be helpful when assessing any applications for earthworks where rehabilitation of soil is required.

- The number of sites sampled in our district is not enough to give the Council a reasonable picture of soil health. A programme is currently being developed that will be adequate to give the Council the confidence to know what is happening over the whole district. The programme takes into consideration those trends showing up on a national level, such as the compaction problems on dairy farms. The programme is based on a targeted sampling process picking specific land uses on specific soil types as this is the only affordable method in which this could be achieved. It will mean that some land uses on some soil types will never be sampled. But, if there is confidence that the threat of soil deterioration is low, due to either the inherent nature of the soil type or land use, or, that trends on those areas will be picked up and readily extrapolated from other monitoring sites, then sampling of those sites is not warranted.

  Through the 500 Soils project, the relevance and usefulness of the parameters being used was assessed. As a consequence some modification of the sampling procedure could easily be made that would incur some cost savings. One of the benefits that the 500 Soils Project has brought to soil health monitoring in New Zealand is in providing a standard monitoring design nationwide. Consequently extrapolation of all the data collected throughout New Zealand is made easier. This benefit needs to be ongoing and can only be achieved by working with the other Regional Councils and agreeing to a standardised sampling design.

  The 500 Soils project was set up not merely to assess soil health at a particular point in time in New Zealand. One of the main outcomes of the project was to be able to monitor trends over time and compare trends between landuses. This would involve going back and sampling at the same site on a regular basis. The time frame for re-sampling may be anything between 5 and 15 years dependent on the perceived or measured rates of change.

  Recommendation

  That the report be received