Table 3.3: Area of pasture on erosion-prone hill country by region between 1997 and 2002.

Region	Erosion-prone area (ha) in pasture in 1997 (LCDB1)	Erosion-prone area (ha) in pasture in 2002 (LCDB2)	Percentage of total regional land area (%)	Area (ha) change from pasture (LCDB2)	Percentage change (%)
Northland	67.723	65.832	5.10	-1.691	-2.50
Auckland	13.101	12.988	2.49	-53	-0.40
Bay of Plenty	27.000	25.855	2.20	-1.104	-4.09
Waikato	116.049	112.315	4.58	-3.680	-3.17
Gisborne	169.141	158.382	19.01	-8.151	-4.88
Hawke's Bay	113.128	110.416	7.80	-2.537	-2.24
Manawatu	230.585	223.535	10.08	-6.793	-2.95
Taranaki	40.580	38.444	5.30	-2.136	-5.26
Wellington	54.281	51.387	6.33	-2.794	-5.15
Nelson	1.612	1.535	3.52	-76	-4.74
Tasman	24.249	22.697	2.39	-1.012	-4.17
Marlborough	75.042	71.946	6.84	-3.107	-4.14
Canterbury	113.995	113.770	2.52	-220	-0.19
West Coast	4.623	4.592	0.20	-16	-0.35
Otago	101.531	101.236	3.17	-294	-0.29
Southland	26.083	25.437	0.80	-646	-2.48
North Island	829.587	799.154	N/A	30.433	-3.67
South Island	347.134	341.213	N/A	-5.291	-1.71
Total	**1.176.721**	**1.140.367**	**N/A**	**-36.354**	**-3.09**

Notes:
1. Figures rounded to the nearest 200 hectares.
2. Pasture classes from the erosion risk data used for this analysis limited to the Land Cover Database 'Primarily Pastoral' classes for reporting.
Data: Landcare Research, from MFE, 2007.

3.1.3 HOW DO WE COMPARE?

The Ministry for the Environment has compared areas of erosion susceptible land in New Zealand and the at-risk area being farmed by region by comparing satellite images between 1997 (LCDB1) and 2002 (LCDB2)[9]. According to the Ministry's analysis, Taranaki has 5.3% of its region in erosion-prone land in pasture, compared to neighbouring regions such as Waikato (4.6%) or Manawatu-Wanganui (10%) (Table 3.3). The amount of erosion-prone land in pasture recorded in 2002 decreased nationally by 36,000 hectares. In Taranaki there was a 5.4% reduction in the amount of erosion-prone pasture land between 1997 and 2002 (this figure differs to that determined through the Council's own monitoring due to the different methodology used but is still of a similar magnitude and in the same direction). This was the highest percentage of change recorded for all the regions, followed by the Wellington region (showing 5.2% reduction in erosion-prone pasture land) and the Gisborne region (which demonstrated a 4.9% reduction).

East Taranaki hill country.

3.2 SOIL HEALTH

3.2.1 WHAT IS THE CURRENT STATE OF SOIL HEALTH IN TARANAKI?

(A) INDICATORS

Soil health refers to the biological, chemical and physical state of the soil and the maintenance of soil ecosystems. It includes aspects such as the structure of the soil, the levels of organic matter, nutrients and trace elements and levels of any contaminants. Ecological processes

9 Ministry for the Environment. 2007. *Environment New Zealand 2007.* Note: LCDB = Land Cover Database.

Table 3.4: Indicators used for soil quality assessment.

	Measures	What this tells us about soil health
Physical properties	Dry bulk density	Compaction
	Particle density	Porosity and available water
	Macroporosity	Soil compaction, root environment, aeration
Chemical properties	Total carbon content	Organic matter status
	Total nitrogen content	Organic nitrogen reserves
	Olsen P	Plant available phosphate
	Cadmium and zinc concentration	Level of trace metal contaminants
Biological properties	Mineralisable nitrogen	Organic nitrogen that can be mineralised to a plant available form
	Microbial biomass	Amount of living microbes in soil
	Soil respiration	Total activity of aerobic soil organisms
	Soil nematode populations	Diversity and numbers of soil nematodes

SOURCE: Sparling and Stevenson, 2008.

are important for productive soil, such as the breakdown of organic material and the release of nutrients for plant growth. Other indicators of soil health include concentrations of various chemicals – indicators of nutrients available for plant growth, and various biological properties that provide an indication of the 'healthy' functioning of the soil (Table 3.4).

Since the last state of the environment report[10] the Council has continued soil quality investigations and monitoring projects to ascertain whether there are any threats or emerging trends in Taranaki relating to soil compaction, depletion of soil nutrients and residual soil contamination. Results from the following studies inform us of the state of soil health and will be discussed further below:

1. 2008 soil study: A study was repeated into the biological, chemical and physical characteristics of soil on properties representative of the major agricultural land uses and soil types within Taranaki[11]. This study updated a national monitoring project implemented in 1999-2001 (the '500 Soils' project). Sites are illustrated in Figure 3.8.
2. 2007 long term study: A separate study looked at how soil health has changed over a longer time frame[12]. This involved re-sampling seven sites sampled 20-30 years ago, and included data from eight additional sites re-sampled in 2005. All sites were dairy farms except for one beef farm.
3. Two new trials explored the possible effects of livestock intensification upon soil and pasture quality for several years. The locations of these research farms are illustrated in Figure 3.8.

(B) PHYSICAL PROPERTIES OF SOIL

Taranaki's soils, particularly its volcanic and organic soils, are generally more resistant to compaction than other soil types, although they are not altogether immune to damage. In relation to soil compaction, 97% of Taranaki soils are in the moderately vulnerable to very resistant categories, with 52% in the very resistant category[13]. Taranaki's volcanically-based soils have a naturally high resistance to structural damage and are generally able to withstand intensive land uses while maintaining essential soil physical qualities. Other types of soils such as those found on river and stream margins, coastal sandy soils, or alpine and sub-alpine soils are very vulnerable to soil compaction but comprise only 3% of Taranaki soils.

Soil compaction leads to reduced aeration, a tendency for soils to turn 'sour', decreased water infiltration and retention capacity, and accelerated run-off. It is linked to adverse effects on pasture productivity. Other short-term effects of compacted soil include increased erosion potential, emissions of nitrous oxide (a greenhouse gas), and leaching of nitrate.

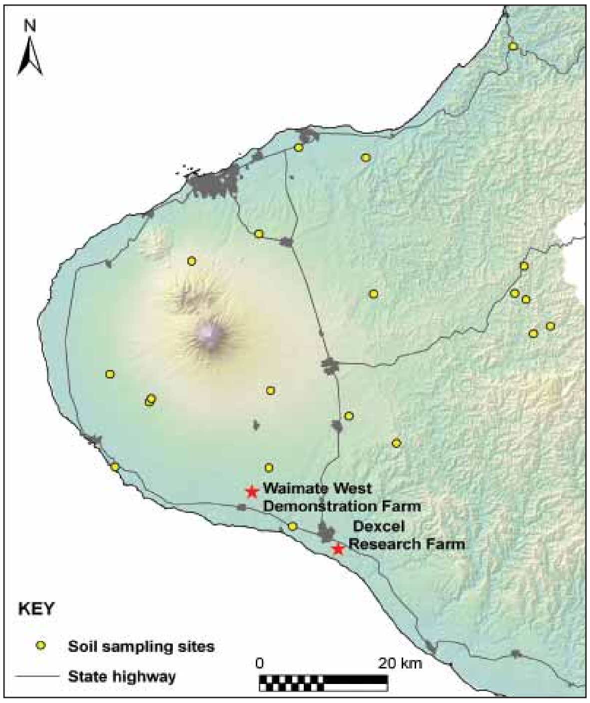

Figure 3.8: Sites sampled for soil health monitoring and the location of research farms, the sites of trials.

10 Taranaki Regional Council. 2003. *Taranaki – Our Place, Our Future. Report on the State of the Environment of the Taranaki Region.*
11 Sparling, G; Stevenson, B. 2008. *Soil Quality in Taranaki Region: Characteristics of new sites, and current status of previously sampled sites.* Prepared by Landcare Research for the Taranaki Regional Council.
12 Parfitt, R,L and Ross C. 2007. *Soil Profile Resampling for Carbon, Nitrogen and Phosphorus after 21 to 31 years.* Prepared by Landcare Research for the Taranaki Regional Council.
13 Hewitt, AE, 1998. *Structural Vulnerability of Taranaki Soils.* Prepared by Landcare Research for the Taranaki Regional Council.

Taranaki soils are naturally resilient to compaction.

Notwithstanding the generally good soil structure found in Taranaki soils, the original '500 soils' study identified some evidence of soil compaction at 16 of the 32 dairy farm sites investigated[14]. In the 2008 soil study, 60% of the sites sampled showed soil compaction problems with six of seven dairying sites and four of five drystock sites showing soil compaction over target levels. However, it should be noted sites were sampled at the end of winter, a 'worst case' situation.

The most likely cause of increased soil compaction has been identified as the 'pugging' of soil by cattle during wet weather (when the soil is saturated), with paddocks either excessively stocked or left stocked for extended periods. Compaction is generally reversible. The rate of recovery depends on subsequent pasture and stock management, climate and soil type factors[14].

The stocking rate intensification trial showed that paddocks left unstocked had the best soil health in terms of soil compaction. Interestingly, different stocking rates did not show any difference in compaction rates. One trial showed soil structure improving regardless of stocking rate as good pasture management was put in place. The biggest effect on soil compaction, irrespective of stocking rate, occurred when paddocks were grazed during heavy rainfall. Under these circumstances, moderate pasture damage occurred as a result. These trials indicate that pasture management regimes had a far greater potential effect on pasture quality and soil health than stocking intensity. It was noted during the experiment that increased stocking rates led to increased loss of vegetative cover on the pasture[15]. This affects the potential for soil erosion and sedimentation due to run-off.

Thus soil health can be mitigated by adopting appropriate farm management techniques such as rapid movement of cattle from susceptible paddocks, grazing cattle on higher ground during heavy rain fall and not over-grazing paddocks.

(C) CHEMICAL PROPERTIES OF SOIL

Organic matter

Organic matter in the soil is important for soil moisture and nutrient retention, soil structure, availability of trace elements, and plant growth. Popular perception is that pastoral farming depletes the organic content and nutrient levels of soil.

However, the 2008 soil study showed that the carbon content of the dairying soils was actually overall higher than for the two sites in native bush, indicating that no or little 'carbon mining' is taking place and that the reverse may actually be occurring, and that there was no overall trend of decreasing carbon values for pasture as has been observed in some other regions of New Zealand with different soil types[16].

The 2007 long-term soil study of sites first analysed 30 and 20 years ago, found that on average, the total soil organic matter and the carbon:nitrogen ratio had not changed. The common soil type in Taranaki is derived from volcanic rocks. The soil particles with volcanic content may bind to the organic matter and so prevent the loss of organic matter from the soil. The finding that levels of organic carbon in soil in Taranaki are being maintained under pastoral livestock management, has implications not only for the aim of protecting the quality and fertility of these soils, but also for 'carbon crediting' in greenhouse gas emission inventories.

Phosphate levels

Phosphates are nutrients important for plant growth. The 2008 soil study found that phosphate levels were below levels recommended for productivity at forestry and drystock sites surveyed, indicating production is likely to be sub-optimal at such sites, and that productivity on Taranaki's hill country farms could be enhanced by judicious use of phosphate fertilisers[16].

While the studies show that over a 20-30 year time frame phosphate levels have increased significantly in Taranaki soils (68% average), over the past ten years the increase has in fact been negligible. This is consistent with fertiliser sales data showing a sharp decline in recent years. Phosphate levels on almost all dairy farms reported on in the two studies are considered appropriate.

Nitrogen levels

Nitrogen is another nutrient important for plant growth. Soil nutrient depletion can be an issue. However, excessive nitrogen levels (which may arise through excessive fertiliser application or importation of feed) can lead to nitrate leaching into either surface water or groundwater. It is also an economic cost to farmers.

Nutrient levels are important for pasture production.

14 Sparling, G. 2001. *Interpretation of Taranaki Region Soil Health Data from the 500 Soils Project, 1998-2000.* Prepared by Landcare Research for the Taranaki Regional Council.
15 Unpublished data.
16 Sparling, G and Stevenson, B 2008. *Soil Quality in Taranaki Region.* Prepared by Landcare Research for the Taranaki Regional Council.

The 2008 study found that total nitrogen levels were above recommended levels on almost all dairy farms and that the average total nitrogen level on dairy farms had slightly increased over the past 10 years[16]. While soluble nitrogen fell, this may reflect the influence of the timing of the sampling (winter's end). However, the 2007 long-term soil study found that total soil nitrogen in the dairy farm sites probably has not changed when assessed against 30 or 20 years ago[17].

Nitrogen in soil is predominantly in the organic form. When it decomposes it may contribute to increased nitrate leaching but the majority of nitrate leaching comes from fertiliser and animal excreta, not the decomposition of organic nitrogen. High total nitrogen reflects conditions with vigorous root growth of pasture, which is to be encouraged. Nutrient levels in cropping/gardening soils were generally among the highest of all land use classes.

The stocking rate intensification trials found there was no significant difference in loss of nutrients and trace elements (total nitrogen, calcium, and magnesium) via leaching, even though stocking rates and the amount of feed imported increased. For the duration of these trials it was apparent that higher stocking rates do not necessarily lead to an increase in leaching to groundwater, but rather the issue is more one of balancing nutrient application and uptake by pasture. The studies showed that appropriate farm management could improve soil quality (structure and chemistry) even at higher stocking rates, and that more highly stocked soils can be as good as those stocked at a lower rate[18].

(D) RESIDUAL SOIL CONTAMINATION

Cadmium and zinc

There is considerable interest in the question of whether cadmium (a contaminant found in phosphate rock) and zinc (an animal remedy) are accumulating in pasture soils to an extent that poses an environmental risk such as toxicity in produce. To this end, the Council has reviewed data from national and specific Taranaki studies[19,20].

In these studies, the average cadmium concentration in dairying soils in Taranaki was in the range 0.52-0.66 mg/kg, and for all soils the averages were 0.47-0.66 mg/kg. Very few results lay above 1.0 mg/kg,

Pip Gerard, of AgResearch, with one of the mites brought to Taranaki.

IRISH ALIEN TACKLES ROOT WEEVIL

It's the stuff of horror movies – but in terms of the health of Taranaki's soil, it's a story that has a happy ending in sight.

The protagonist, an Irish wasp called *Microctonus aethiopoides*, injects its egg into the target, the clover root weevil called *Sitona lepidus*. When the egg hatches, the weevil is firstly sterilised then dies as the mature larva bursts out of the abdomen.

The stakes here rival a blockbuster's box-office takings. Healthy clover is a low-cost, natural source of nitrogen, with the value of its fixed nitrogen pasture yield, high-quality forage, seed production and honey production put at $3 billion nationally. The root weevil can cut clover pasture production by a third or more. This not only takes a direct economic toll, but forces farmers to apply more nitrogen fertiliser which can potentially compromise the health of both soil and waterways.

The weevil, a native of Europe and North America, was first discovered in New Zealand in 1996. By the early part of this decade it had made its way into Taranaki and had also won infamy as one of the nation's worst pasture pests.

Enter the *Microctonus aethiopoides*, a natural enemy of the weevil and brought to New Zealand by AgResearch in 2005 to fight the weevil under an overall programme funded through Dairy NZ and Meat and Wool NZ. It was introduced to this region in the summer of 2006-07, under a project funded by the Taranaki Regional Council.

It got off to a roaring start at two Taranaki trial sites. After the release of 5,000 weevils carrying the wasp egg, parasitism rates of 64% had been established at Lepperton and 23% at Stratford within six months.

That was encouraging evidence that the Irish wasp would be able to increase its numbers rapidly in Taranaki, and plans were made for widespread dispersal of parasitised weevils among the region's famers during the summer of 2007-08.

Nature intervened, however, with the summer drought hitting pastures hard. While parasitism levels were good, only one site produced enough weevils for collection, and dispersal sites were limited to a couple of farms with good irrigation and plenty of clover.

Another 58 vials of infected weevils have been given to Taranaki farmers in 2008, along with background information and instructions for release.

With more favourable weather expected for the summer of 2008-09, wider dispersal of the weevils is planned, along with a publicity campaign.

It may not be an Oscar-winner, but the wasp-versus-weevil story is a gripping one for Taranaki landowners.

17 Parfitt, R,L and Ross C. 2007. *Soil Profile Resampling for Carbon, Nitrogen and Phosphorus after 21 to 31 years.* Prepared by Landcare Research for the Taranaki Regional Council.
18 Unpublished data.
19 Taranaki Regional Council. 2005. *Cadmium in Taranaki Soils: An assessment of cadmium in Taranaki soils from the application of superphosphate fertiliser.*
20 Sparling, G. 2001. *Interpretation of Taranaki Region Soil Health Data from the 500 Soils Project, 1998-2000.* Prepared by Landcare Research for the Taranaki Regional Council.

Aerial topdressing.

with the highest reported in any study 1.7 mg/kg. Generally cadmium levels were highest on grazed pastures (but there was little distinction between pastoral soils and plantation soils), and lowest within indigenous forestry soils. Internationally, guideline values for cadmium in agricultural soils (including beef, sheep, and horticultural soils) are in the range 1-12 mg/kg, with the lower values being used for triggering the need for further investigation (1.0-1.4 mg/kg). The majority of Taranaki sites were about half the lower guideline values.

At the average rate of increase found in some of these studies, it would be approximately 100 years before the average for dairy sites exceeds the guideline values and triggers the need for further investigation. Modelling of cadmium accumulation predicts that soil concentrations of cadmium will in fact reach a limiting value around 1.3 mg/kg or a little higher, depending upon phosphate fertiliser application rates[21]. It should also be noted that the current rate of application of superphosphate (2007) is now less than what it was in the preceding four decades (Figure 3.9)[22], and the current cadmium concentration in superphosphate is less than half of what it was over that period. These factors would considerably extend the period before levels were reached that would necessitate further investigations. A national working party is examining options for controlling cadmium accumulation in agricultural soils. The working party also advises that, in any case, 'dairy (milk), muscle meat and fruit products are unlikely to be at risk of high cadmium levels, due to the low capacity of these products to store cadmium'[23].

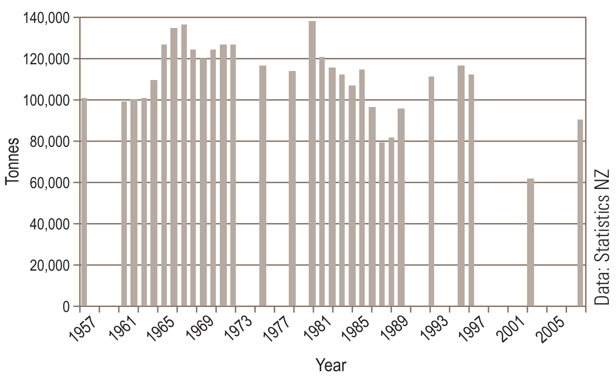

Figure 3.9: Tonnes of superphosphate-based fertiliser used in Taranaki (see note below on data used).

Zinc concentrations at all sites were far below guideline limits. While the highest soil concentration was found in one dairy pasture site, generally levels were similar in all land uses surveyed: indigenous bush, plantation forest and beef pasture sites.

Of note is that the forms of both cadmium and zinc that are readily available for uptake or ingestion by plants or animals were several orders of magnitude or more lower in concentrations than the total concentrations of these elements. This highlights that in Taranaki soils these metals are simply not readily available for plants or animals.

Agrichemicals

As part of the 2008 soil survey, samples were also collected for evidence of residual contamination by agrichemicals. All sites were tested for a suite of 18 different acidic herbicides (including acetochlor, chlorpyalid, dicamba, 2,4-D, haloxyfop, MCPA, MCPB, pentachlorophenol, picloram, 2,4,5-T, 2,4,5-TP, and triclopyr). Sites were also tested for a suite of 72 different chemicals that are used to control insects or fungus. These included acephate, atrazine and its derivatives, captan, chlorpyrifos, cyfluthrin, diazinon, dichlorvos, malathion, parathion, permethrin, simazine, trifluralin, and vinclozolin.

The limits of detection for the herbicides were in the range 0.008-0.02 mg/kg. The limits of detection for the pesticides were in the range 0.009-0.04 mg/kg.

Out of 72 pesticides tested for in 20 samples (1,440 results), 12 results returned a positive result (in each case, just on the limit of detection). That is, 99.17% of all results were negative for the presence of any pesticide. One sample had five positive detections, while a second had two. Perhaps unsurprisingly, these two sites were the two cropping sites tested. Otherwise each of the remaining five results occurred in a different sample, i.e. none of these five latter sites (two drystock farms and three forestry plots) had more than a single pesticide (out of 72) confirmed present.

No agrichemicals were detected in the soil at any dairy farm site, the predominant land use on the ring plain of Taranaki.

The herbicide acetochlor was detected at five sites (some drystock, market gardening, and indigenous forest sites), otherwise no agrichemical was detected at more than one site. Acetochlor is used for pre-emergent weed control in cropping. It is strongly absorbed by soil, with little leaching, and a half life of 8-18 days i.e. it degrades rapidly and is not persistent or cumulative.

On the basis of these results, there is no evidence of any issue of residual or cumulative agrichemicals in the soils of the region.

(E) BIOLOGICAL HEALTH

Soil biological health can be assessed from the soil microbial biomass and soil respiration. The diversity of the soil invertebrate community can be assessed by counting the numbers and types of soil nematodes (small worm-like animals). However, research on using these measures as indicators of soil health is in its preliminary stage and there is still

21 Taylor M et al, 2007. *Soil Maps of Cadmium in New Zealand.* Published by Landcare Research.
22 Note: Data on tonnes of superphosphate not available for all years. For 1957, and 1961-1980 Statistics New Zealand just records fertiliser used and tonnes of lime. Given that the main fertiliser used during those years, the graph uses this figure as the estimate for quantities of superphosphate used.
23 Cadmium Working Group. November 2007. *Summary of Risks from Cadmium in Agricultural Soils.*

little understanding of the consequences of changes in soil biodiversity[24]. The Council still chose to pursue this component of soil assessment because of the growing awareness of the need to safeguard ecological diversity within soil communities, and that soil health has a biological, as well as structural and chemical, component.

Popular perception is that soils under pastoral management tend to have lower diversity and ecological richness than plantation forestry and indigenous bush soils. The results of the 2008 soil survey do not bear this out. Soil biodiversity was poor only in cropped soils. These sites were also among those with the lowest quantity of microbial biomass. The report notes that cropping sites frequently have lower microbial biomass than pastures, because of repeated soil disturbance and reduced returns to soil. Forestry sites had invertebrate communities that reflected a damp environment with a high rate of organic decomposition.

The study findings will be used as a baseline for future studies and can also be revisited as expertise and experience in interpretation develops.

3.2.2 HOW IS SOIL HEALTH MANAGED IN TARANAKI?

(A) REGIONAL PLANS

The Council addresses soil health through the *Regional Soil Plan for Taranaki* and the *Regional Fresh Water Plan for Taranaki*. The Soil Plan's soil health objective, policies and methods focus on non-regulatory methods. Through the plan, monitoring systems have also been put in place to monitor and gather information on the long-term effects of land use activities on soil health. The *Regional Fresh Water Plan* includes objectives, policies, and methods (including rules) addressing the effects of discharges of contaminants to land, whether from animals, effluent treatment, or applications of fertiliser and pesticides.

In implementing the plans the Council seeks to raise public awareness of soil health issues, optimise soil productivity and promote the adoption of practices by farmers that will avoid or minimise soil structure degradation, soil nutrient depletion, or residual soil contamination problems.

(B) RESOURCE CONSENTS

The Taranaki Regional Council issues consents for discharges to land, in accordance with the rules set out in the *Regional Fresh Water Plan*. At the end of June 2008, there were 875 consents for the discharge of agricultural wastes to land, 817 from farm dairy discharges, and 298 for the discharge of non-agricultural wastes to land. 75% of all discharges to land, were for the land application of farm dairy effluent. The total number and the proportion of such discharges directly to land instead of to water is steadily increasing in the region – a product of increased amalgamation of dairy farms, increased environmental awareness and recognition of the fertiliser benefit of discharging to land.

Over half of all the consents for the discharge to land of non-agricultural wastes have been granted within the past five years.

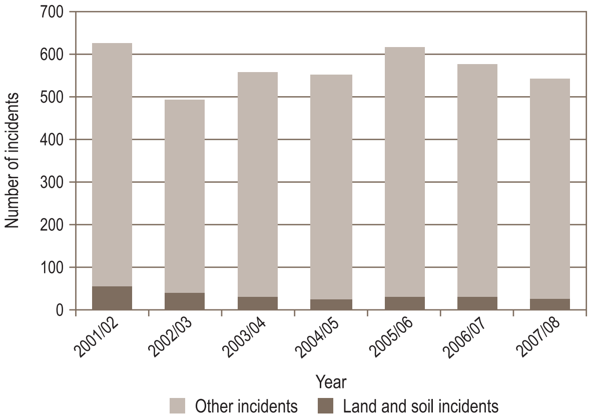

Figure 3.10: Number of land related incidents over time compared to the number of incidents reported each year.

These predominantly relate to discharges of sediments associated with earthworks, septic tank soakage systems, cleanfills, stormwater and hydrocarbon exploration sites discharging to land soakage, and the land incorporation of drilling wastes and fluids.

(C) UNAUTHORISED INCIDENTS

The Council maintains a register of complaints, and follows these up. The number of incidents related to land compared with the total number of other complaints is illustrated in Figure 3.10. Over the past six years these have largely arisen from complaints about dairy farms (29%), cleanfills (15%), meatworks and transport operators.

(D) INFORMATION, EDUCATION AND ADVICE

The Council responds to all requests from the public for information on soil health. The provision of information and advice can raise awareness of issues and problems and provide simple cost-effective solutions enabling land users to make well-informed decisions to prevent or minimise the effects of their land use practices on soil health.

The Council also promotes the use of guidelines, codes of practice, and standards, particularly on the application of pesticides, fertilisers and other agricultural compounds. This applies especially for those developed by the industry for the agricultural sector such as the *Code of Practice for Nutrient Management* [25] and the *Spreadmark Programme* [26].

The *Dairying and Clean Streams Accord* [27] is part of a range of activities to promote sustainable dairy farming in New Zealand. One of the six priorities for action adopted by the region includes the effective management of nutrients[28]. The *Regional Action Plan for Taranaki* sets a target of 100% of dairy farms to have a nutrient budget in place by 2007. By June 2008, 99.1% of dairy farms had a nutrient budget in place. This was up from 22% in 2004-05[29]. With Fonterra proposing financial penalties for farms that do not have a nutrient budget, it is anticipated that by the 2008-09 dairy season all supply farms will have nutrient budgets, a quadrupling within four years and a very positive situation for the health of Taranaki's soil resources.

24 Sparling, G and Stevenson, B 2008. *Soil Quality in Taranaki Region*. Prepared by Landcare Research for the Taranaki Regional Council.
25 Fert Research, 2007. *Code of Practice for Nutrient Management*.
26 New Zealand Groundspread Fertilisers Association. 1994. *Spreadmark Programme*.
27 Fonterra Co-operative Group, regional councils, unitary authorities, the Ministry for the Environment, and the Ministry of Agriculture and Forestry, 2003. *Dairying and Clean Streams Accord*.
28 Taranaki Regional Council, 2004. *Regional Action Plan for Taranaki*.
29 Taranaki Regional Council, 2008. *Dairying and Clean Streams Accord. Annual Report 2007-08*.

Taking soil samples.

(E) MONITORING AND INVESTIGATIONS

Since its *1996 State of the Environment Report,* the Taranaki Regional Council has undertaken investigative monitoring and participated in the national '500 soils' project (including its own continuing investigations based on the '500 soils' methodology) in order to first 'benchmark' and then track trends in soil health indicators. Future monitoring will be based on the '500 soils' Project (which, subject to review, will be continued at five-yearly intervals).

The Council supports work investigating the effects on soil health of different stocking rates with supplementary feeding regimes at two research farms. Research into the biodiversity and ecological richness associated with the varying stocking intensities, the effects on soil characteristics of nitrogen inhibitors, validation of soil nutrient modeling and the effects on soil structure from cropping and pasture renewal has been commissioned.

For example, during 2007-08, the Council investigated the impacts of higher dairy stocking rates on soil biodiversity. Plant, nematode, earthworm and invertebrate abundance and diversity were compared between paddocks with different stocking intensities. This found that higher stocking rates led to paddocks with higher proportions of bare ground. Higher stocking rates had little impact on overall nematode density or on species diversity, probably because the higher stocking rates had little effect on soil bulk density as Taranaki soil is generally resistant to soil compaction damage. There were no significant effects of increased stocking rates on earthworm species' richness, or on earthworm densities, with the exception of *Aporrectodea longa*, a useful deep burrowing species, which was found to be more abundant in the highly stocked paddocks. This increase was not surprising as this species of earthworm feeds on the surface where there was more food (more dung from the higher stocking rate). It might even be that this earthworm helped offset impacts of stock compacting the soil to a small extent.

During the 2007-08 year the Council also investigated the effects of disposing of oil drilling wastes onto land on the soil biology. Earthworm densities were compared between areas that had and had not been subject to various types of drilling waste application. Preliminary results indicate that applying drilling wastes to land in a manner that complies with consent conditions does have negative impacts on earthworm numbers, but these impacts subside with time and populations are able to recover over the long term. Further studies are planned to investigate the reasons for these negative impacts and to investigate ways to improve the ways in which drilling wastes are disposed to land.

(F) SUMMARY OF PROGRESS

Progress on implementing regional objectives and policies on soil health is summarised in Table 3.5.

3.2.3 HOW DO WE COMPARE?

Two studies have recently been completed looking at soils across New Zealand. One study looked at changes in total carbon and nitrogen in pastoral soils over the past 17-30 years[30]. It found that on average, soils had lost statistically significant amounts of both carbon and nitrogen. This loss of organic material from soils was attributed primarily to grazing, distinct from erosion or leaching. Of the Taranaki sites in the study, half showed increases in carbon and nitrogen in contrast with the national trends, and those sites that did show a loss of carbon or nitrogen showed smaller losses than sites elsewhere in the country.

As part of the '500 soils' Project, six key measures of soil health were monitored across seven major land-use categories in New Zealand[31,32]. These were reported on in the national state of the environment report[33]. Interestingly, of all land use types, the soil used for dairying and drystock

Table 3.5: Summary of progress: implementing regional objectives and policies on soil health.

Issue	What do we want to achieve?	What are we doing about it?	Where are we at?
Soil health	• No adverse change in soil structure on privately-owned land. • No adverse depletion in the nutrient levels of soils on privately-owned land. • No adverse increase in residual contaminant levels in soils on privately -owned land.	• Implementing the *Regional Soil Plan.* • Providing advice and information. • Advocacy. • Soil health investigations and research. • Monitoring.	• *Regional Soil Plan* made operative in October 2001 • Monitoring shows soil compaction at some sites but no evidence to date of long term change in soil structure. • Further research into soil structure and nutrient soil levels management commissioned. • No adverse depletion of soil nutrients or organic content. • No adverse increase in residual contamination from diffuse activities.

30 Schipper, L et al. 2007. Large losses of soil C and N from soil profiles under pasture in New Zealand during the past 20 years. *Global Change Biology* 13:6 pp.1138-1144
31 Sparling, G, and Schipper, L. 2004. Soil quality monitoring in New Zealand: trends and issues arising from a broad scale survey 1995–2001. *Agriculture, Ecosystems and Environment* vol 104, pp 545–552.
32 Sparling, G. 2007. *Land: Soil Quality Assessed from the 500 Soils Project*, unpublished, prepared for the Ministry for the Environment. Wellington: Ministry for the Environment.
33 Ministry for the Environment. 2007. *Environment 2007.*

had the highest carbon and nitrogen levels of all land use types, well above (for example) native forestry or tussock. In this work, the average levels of carbon and nitrogen in Taranaki's dairying soils were 22% and 24%, respectively, higher than the national average for dairying soils.

However, this same study showed that soil compaction in Taranaki's dairying soils was worse than the average, scoring only 6.1% on the soil compaction measure used, compared to an average of 10.1% across the whole country, although it is worth noting that these were sampled at the end of winter, the worst-case timing. Nationwide, half of all dairy soil sites scored below 10% which is the threshold of adverse effects upon productivity.

In terms of cadmium levels, nationwide, the highest single soil cadmium level has been found in Waikato, with Bay of Plenty also having a high average along with Taranaki[34]. The highest results are associated with dairying, but orcharding had similar average values. Peat soils were found to have the highest potential for cadmium accumulation. These soils are rare in Taranaki. Beef and sheep farming sites had values very close to the national average.

3.3 CONTAMINATED SITES

Contaminated sites result from historical activities and industries where hazardous substances were inappropriately stored, used or disposed of, although these activities may well have been lawful at the time. Contamination may remain on-site in soil and/or move off site in surface water, groundwater or air discharges, posing a wider risk to both public health and the environment. Examples of land uses that could result in site contamination include landfills, engineering workshops, timber treatment sites, rail yards, gasworks, scrap metal yards and stock dips.

Present day activities and industries are much less likely to result in contaminated land, as those involving discharges to the environment are controlled under the RMA, while the storage and use of hazardous substances is controlled under the Hazardous Substances and New Organisms Act 1996 (HSNO).

3.3.1 WHAT IS THE STATE OF CONTAMINATED SITES IN TARANAKI?

In 1992 a report on potentially contaminated sites in New Zealand[35] was released, suggesting there might be 272 potentially contaminated sites in Taranaki. Given the desirability of a degree of certainty about the extent of any site contamination in the region, the Taranaki Regional Council embarked on a programme to investigate sites of interest, particularly timber treatment sites, sawmilling sites, landfills and rubbish dumps. This resulted in a number of extensive and thorough investigations and reports[36].

No national environmental standard currently exists on contaminants in soil. Sites are therefore classified on the basis of inspections and investigations carried out by the Council and a variety of currently available guidelines from both New Zealand and overseas.

The Council also developed a database, called the Register of Selected Land Uses (RSLU), to record information about sites in the region, where past or current activities may have resulted in contamination.

The RSLU includes information on sites which have been investigated for various reasons, including allegations of contamination. The total number of sites on the database does not indicate the number of contaminated sites, but rather the number of sites that have been investigated. There are 1,281 sites currently on the RSLU database (Table 3.6). The majority of sites (757), almost 60% of the total, have been investigated and no contamination has been found. A further 480 sites, or 37%, have had hazardous substances detected, but they pose no risk. Sixteen sites have been remediated, and there are no sites where the risk of the contamination means they are unable to be used.

Twenty eight sites remaining on the database require further investigation. These are generally low-risk sites, such as sites where notification has been received from the New Zealand Police regarding clandestine drug laboratories (previous investigations have shown that the land at such properties is not usually contaminated). The 28 sites also include those identified in the Moturoa oil field investigation[37],

Table 3.6: Status of sites on the Register of Selected Land Uses (RSLU).

No. of sites	Status	Comments
757	Hazardous substances not present - No identified contamination	Investigations have shown no contamination is present
480	Hazardous substances present - Risk acceptable for land use	Includes managed and remediated sites
16	Hazardous substances not present - Remediation undertaken	Remediated to background levels
0*	Hazardous substances present - Risk unacceptable for land use	Contaminated sites
28	Verified history of hazardous activity/industry	Low-risk sites unlikely to be contaminated, where further investigation is required to confirm status

*At the time of preparing this report, asbestos at the Pātea freezing works site had been stabilised, and so the site in the interim does not pose an unacceptable risk environmentally. Long-term remediation is still necessary.

34 Taylor M et al. 2007. *Soil Maps of Cadmium in New Zealand.* Published by Landcare Research.
35 Ministry for the Environment 1992. *Potentially Contaminated Sites in New Zealand: A broadscale assessment.* Prepared by Worley Consultants Ltd
36 Taranaki Regional Council. *Investigation of Possible Dieldrin Storage and Disposal Sites in Taranaki,* (1993); *Investigations of Past Refuse Dumping Sites in Taranaki,* (1995); *Investigations of Past Refuse Dumping Sites in Taranaki,* (1996); *Investigation of Timber Treatment and Sawmilling Sites in Taranaki,* (1995); *Site Investigations: Drycleaners, scrap metal yards, rail yards and gasworks,* (2000); and *Investigation of Alleged Agrichemical Waste Disposal Sites in New Plymouth,* (2001).
37 Taranaki Regional Council, Feb 2003. *Moturoa Oil Field Investigation: Stage 1.* Prepared by Transfield Worley Ltd