14 LAND AND SOILS

Summary

RPS Objectives

- The maintenance, and where possible, enhancement of the life-supporting capacity of soils, especially those which have potential to support intensive primary production.
- The protection of the soil resources, including soil quality and soil quantity, from degradation or loss as a result of unsustainable land uses and land use practices.
- The safeguarding of the life-supporting capacity of water and ecosystems from the adverse effects of unsustainable land uses and land use practices.
- The avoidance, remedying or mitigation of the adverse effects of plant and animal pests on the use of land, including its potential for primary production and natural ecosystems.

Pressures

- Approximately half of the region's land is used for intensive pastoral farming, with about 367,000 dairy cattle, 496,000 beef cattle and 534,000 sheep in Northland in 2006. A change to more intensive farming can lead to decreased water quality in waterways and reduced soil health.
- About 375,000 tonnes of fertiliser in total (including 212,000 tonnes of lime) was applied in Northland in the year ending 30 June 2002.
- Over half (720,000 ha) of Northland's land area is erosion prone land (i.e. has a Land Use Capability (LUC) erosion class of either 6e or 7e).
- There is an increased risk of unwanted organisms entering the region, partly as a result of climate change, which will continue to impact on agriculture, horticulture and natural ecosystems.
- Based on subdivision data supplied by the region's three district councils, (different year periods for each district) about 9% of Northland's prime soils for horticultural and agricultural (includes land resource inventory soil classes 1c1, 2e1, 2w1, 2s1, 3e1, 3s1 and 3s2) have been subdivided into 2,209 lots over approximately the last six years, particularly around Whangarei and Kerikeri (refer to section 14.2 for more information).

State

- Soil chemical properties at the 25 sites sampled in 2007 were generally good, however the physical properties at about half of the 25 sites indicated soil compaction was occurring. At these 25 sites, all heavy metals tested were within recommended guidelines.

- Approximately 30% of Northland's erosion prone land (land with LUC erosion class of 6e or 7e) had pastoral land cover in 2002. The majority of this land is being used and managed in a way that does not cause widespread or large scale erosion. There is also anecdotal evidence that some areas of erosion prone land in Northland have reverted from pasture to scrub or gorse over the last decade, as some farmers have moved away from using 'marginal' land for pastoral farming.
- The occurrence and extent of most pest plants in the Regional Pest Management Strategy (RPMS) for Northland have been greatly reduced, with many ahead or on target for meeting the objectives in the RPMS.

Doing well

- Progress towards meeting the targets in the Northland Regional Action Plan for the Dairying and Clean Streams Accord is well underway.
- 21 Community Pest Control Areas have been established, or proposed for Northland, with 650 people engaged in biosecurity action on their own land, working cooperatively together, with over 22,000 hectares of private land under some form of pest management.
- The emphasis of biosecurity action is changing from managing established pests to meeting new pressures and recognising the potential damaging effects of new insect species, marine species and wind-borne diseases.
- Approximately 200 people from 50 different Northland companies attended erosion and sediment control workshops held by the Regional Council in 2006 and 2007.

Areas for improvement

- There were significant amounts of soil conservation research and work carried out in Northland in the 1970s and 1980s, such as dune protection through forestry planting. However, this soil conservation work has reduced in the last two decades. This coupled, with intensification of farming, has lead to an increased risk of erosion occurring on erosion prone land used for pastoral farming. There is some anecdotal evidence of poorly managed erosion prone pastoral land, but there is a lack of quantitative information on the extent of the problem.

- Much of the data used for this Land and Soils chapter was collected for national databases at five yearly intervals. For example, the most recent data available for the Land Cover Database was captured over the 2001/2002 summer and the last full census for the Agriculture Production Statistics was in 2002. Also the scope of the data, that is the range of parameters surveyed or tested, while adequate for national databases, is insufficient to enable catchment or even district-wide trends to be assessed and fully understood. Therefore more data and information is needed on land use in Northland to improve the accuracy and frequency of assessment at a catchment, district and regional scale. This would include increased routine monitoring of land use, health and density of vegetation cover, and soil quality on a greater number of soil types within the region to assess whether Northland's land and soils are being sustainably managed.

- Increased promotion and implementation of soil conservation are needed, particularly on erosion prone land.
- More joint agency plans and response to mitigate the effects of introduced plants, insects and animals, with support from crown agencies such as Biosecurity New Zealand, are needed.

14.1 Introduction

Northland is a long narrow peninsula with a land area of approximately 1.25 million hectares, making it the eighth largest region in NZ based on land area. The region consists of a wide variety of landforms, soil types and associated land uses. Landforms range from young active sand dunes along the coast to relatively old greywacke, and volcanic peaks and hills in inland areas. There are no mountain ranges in Northland, with all ranges less than 800 metres above sea level.

The low relief, absence of ash deposits from recent ash showers, warm moist climate and the original vegetation, have resulted in Northland soils being dominated by strongly leached, mature, heavy clays. Generally, topsoils are thin and subsoils are of low fertility. The main exceptions are the fertile volcanic soils, young alluvial deposits and the young soils developing on unstable steep slopes.

The cover of the original indigenous forest has strongly influenced soil properties. Trees with acidic litter, such as kauri, totara and rimu, have produced strongly leached soils, while broadleaf trees, such as puriri, kohekohe and taraire, have returned the nutrients to the soil through rapid decomposition of leaves and branches to give fertile top soils.

Northland's economy is largely agricultural with approximately half of the region's land used for dairy, beef and sheep farming. Therefore as a region, Northland is heavily dependant on the environment and the state of soil and land resources for its economy.

Regional Policy Statement objectives

The objectives relating to Northland's land and soils resources in the Regional Policy Statement (RPS) for Northland (NRC 2002) are:

- The maintenance, and where possible, enhancement of the life-supporting capacity of soils, especially those which have potential to support intensive primary production.
- The protection of the soil resources, including soil quality and soil quantity, from degradation or loss as a result of unsustainable land uses and land use practices.
- The safeguarding of the life-supporting capacity of water and ecosystems from the adverse effects of unsustainable land uses and land use practices.
- The avoidance, remedying or mitigation of the adverse effects of plant and animal pests on the use of land, including its potential for primary production and natural ecosystems.

Environmental results anticipated

The following are the anticipated environmental results after the implementation of the policies for soil conservation and land management in the Regional Policy Statement:

- Continued availability of highly versatile soils for primary production.
- Reduction in the damage caused to soils and natural features from pest animals and plants.
- Safer use, storage and disposal of pesticides and other agricultural chemicals and reduced risk of soil contamination.
- More widespread adoption of soil conservation practices within land use and subdivision proposals.
- Reduction of erosion in high risk areas.
- Reduction in the volumes of soil and other contaminants entering surface water bodies.

14.2 What are the pressures on our soil and land resources?

Land use

Northland's land cover is dominated by grassland (Land Cover Database 2) and therefore presumably pastoral farming, with 48% of the region in grassland (predominantly high production grassland), as shown in table 1 (below). There were only small percentage changes in land use between 1997 and 2002 (also shown in table 1).

Table 1: Proportion of different land uses in Northland in 1997 and 2002 based on the land cover classes in LCDB1 and 2 and the percentage difference between 1997 and 2002. Data source: LCDB, Ministry for the Environment.

	LCDB1 (1997)		LCDB2 (2002)		
Land use based on land cover	**Area (Ha)**	**% of region**	**Area (Ha)**	**% of region**	**% differ**
High production pastoral farming	599709	46.4	593169	45.9	-1.1
Low production pastoral farming	26812	2.1	26394	2.0	-1.6
Exotic forestry	172411	13.3	181761	14.1	5.4
Other exotics	10385	0.8	10182	0.8	-1.9
Horticulture	9264	0.7	9265	0.7	0.0
Indigenous forest	274761	21.3	273434	21.1	-0.5
Other native (scrub etc)	119298	9.2	118501	9.2	-0.7
Urban area	7406	0.6	7439	0.6	0.5
Water (rivers, lakes & estuaries)	72122	5.6	72026	5.6	-0.1
Other land cover classes	669	0.1	665	0.1	-0.6

Currently the most recent land use data available for Northland is the Land Cover Database 2 (LCDB2) data that was created from satellite imagery captured over the 2001/2002 summer. However it is hoped that Ministry for the Environment will continue to ensure that this data is collected regularly at a national level and made available to regional councils.

The other land use data available for Northland is the Agricultural Production Statistics collected by Statistics New Zealand. There is land use data for Northland for six years from 1994 to 2006, as shown in table 2 (below). Note: caution should be taken interpreting the results as the population size is inconsistent for each year.

Table 2: Land use in Northland at 30 June of each year for various years from 1994 to 2006, based on the results from Agricultural Production surveys conducted by Statistics New Zealand.

	Area (000 Hectares)					
Land use	**1994[a]**	**1995[b]**	**1996[b]**	**2002[a]**	**2003[b]**	**2006[b]**
Grazing, arable, fodder and fallow land	616	621	607	516	486	488[c]
Horticultural land	6	6	7	5	5	NA
Planted production forest	148	NA	NA	193	174	158
Other land	98	83	90	121	126	126
Total land	867	861	855	836	794	782

[a] In 1994 and 2002 full Agricultural Production Censuses were carried out.
[b] In 1995, 1996, 2003 and 2006, sample surveys were carried out which are subject to sampling errors.
[c] This figure for 2006 only includes the area in grassland, it excludes the area in grain, seed and fodder crop.

This data shows an increase in forestry area in Northland in this 12 year period and a decrease in the amount of grazing, arable, fodder and fallow land.

Agriculture

Pastoral farming is still the predominant land use in Northland. Over recent decades there has been a movement away from sheep production and an increase in dairying. Decreases in stock numbers have been offset to an extent by increases in productivity across all parts of the pastoral sector, both in terms of production per animal and production per hectare. Despite these productivity gains, sheep and beef model farm data (MAF 2005) shows that productivity and profitability of Northland farms was low on a per hectare basis when compared with other regions.

The number of sheep in Northland has greatly decreased over the last 18 years, from about 1.3 million in 1990 to 534,000 in 2007, as shown in figure 1 (below). The number of beef cattle decreased up to 2004, since then the number has increased slightly, with an overall decrease of about 100,000 in the 18-year period from 1990 to 2007. The number of dairy cattle in Northland has fluctuated slightly over the last 18 years but stayed relatively stable with an average of 375,000. The decrease in sheep numbers and slight decrease in beef cattle is consistent with elsewhere in New Zealand. However dairy cow numbers for all of New Zealand have increased by 24% in the 10 years from 1996 to 2006 (MFE 2006).

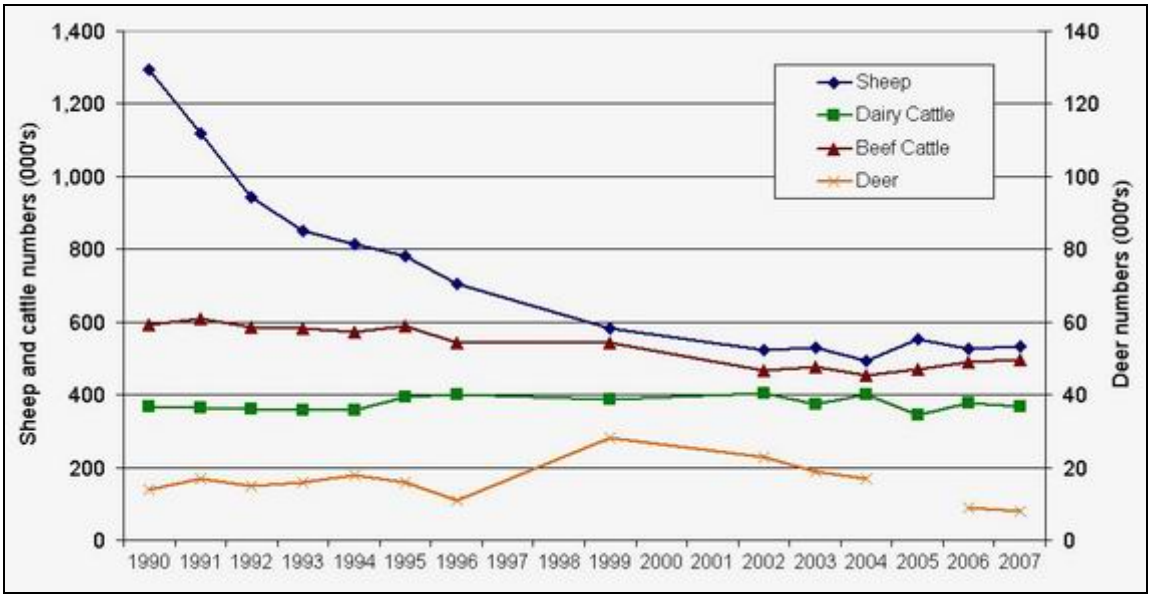

Figure 1: Stock numbers in Northland, including sheep and dairy and beef cattle (left axis) and deer (right axis) at 30 June of each year. Note: data is not available for some years. Data source: Statistics New Zealand.

As farming becomes more intensive it can result in a reduction of water quality, soil health and an increase in some greenhouse gas emissions (MFE 2008). Intensification of pastoral farming has lead to a greater area of fodder and grain cropping in Northland, particularly maize (Doug Foster, Northland Regional Council, *pers. comm*.). This can lead to long term deep soil compaction and damage to soil structure when either long maturing varieties or late plantings are harvested with heavy equipment late in autumn, when soil conditions are too wet.

Treading by grazing animals can have a significant adverse effect on soil properties and on plant growth under wet soil conditions (Ussher 2004). The most severe treading is when pasture and soil are reduced to a visual muddy mess with pugging damage. This is common on Northland's heavy clay soils, particularly in late autumn and winter. This treading/pugging damage can lead to reduced yield, shallow rooting and nutrient loss from the pasture, damage to the physical, chemical and biological properties of the soil and increased run-off into waterways (Ussher 2004).

Approximately 375,000 tonnes of fertiliser was applied in Northland in the year ending 30 June 2002 (Statistics NZ), as shown in table 3 (below). This is predominantly lime with approximately 212,000 tonnes applied in the 2001/2002 year. Lime application is important for maintaining soil condition and has minimal risk of adverse effects on the environment (Bob Cathcart, NRC, *pers. comm*.). This equates to approximately 730 kg of total fertiliser per hectare (including 410 kg of lime) based on the area of grazing in Northland at 30 June 2002, as shown in table 3. Note: this does not include horticultural and forestry land uses, which also use these fertilisers but to a much lesser extent.

Table 3: Fertiliser (including lime) applied in Northland in the year ending 30 June 2002 (tonnes) and the amount applied per land in pasture (kg/ha) for the amount of grazing, arable, fodder and fallow land use in Northland at 30 June 2002 (Agricultural Production Census 2002, Statistics NZ).

	Fertiliser applied (tonnes)	**Amount per area of pasture (kg/ha)**
Land area in grazing, arable, fodder and fallow (ha)	516,000	
Urea	17,732	34
Di-ammonium phosphate (DAP)	5,712	11
Ammonium sulphate	2,267	4
All other Nitrogen containing fertilisers	16,231	31
Lime	211,758	410
Phosphatic fertilisers	84,507	164
Potassic fertilisers	36,909	72
Total	375,116	**727**

Regional trends in fertiliser usage can be estimated from national usage. Total fertiliser applied in NZ has increased significantly in the last 20 years, as shown in figure 2 (right).

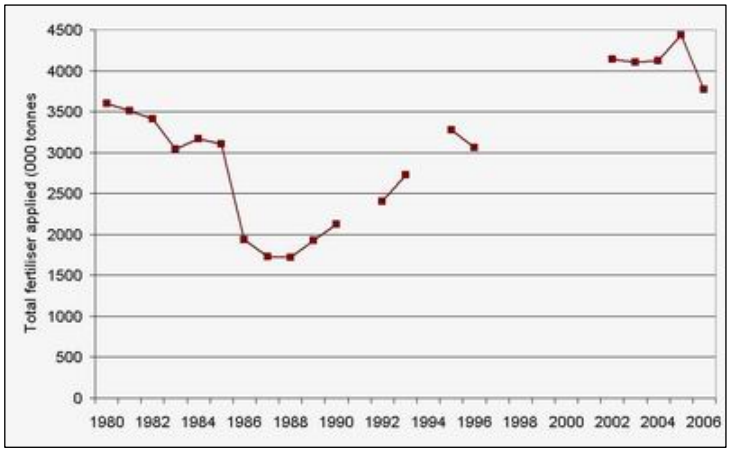

Figure 2: Total fertiliser (including lime) applied in New Zealand (000's tonnes) from 1980 to 2006. Data: Statistics NZ.

Other land uses

Exotic forestry has positive effects on soil erosion and subsequent water quality when the trees are growing and fully established. However, during harvesting short periods of increased erosion occur due to the loss of vegetative cover. In the long term however, the positive effects of exotic forestry on soil conservation outweigh the negative effects of short-term erosion during harvesting.

The region has a well developed horticultural industry, centred mainly on the growing of avocados, citrus, kiwifruit, kumara, squash and flowers. In 2002 approximately 5,100 ha of Northland was used for horticulture and a further 3,000 ha was used for arable and fodder crop land (Stats NZ 2002). If not managed correctly, cropping can result in soil loss and degradation.

Since 1994 there has been a significant increase in the area planted in avocados and grape vines and a significant decrease in the area planted in squash and apples, as shown in table 4 (below). Again, caution should be taken interpreting the results as the population size is inconsistent for each year. The increase in the area planted in avocados and grape vines and decrease in the area of apples is consistent with national figures.

Both viticulture and avocado orchards have the potential to have detrimental effects on the environment, particularly soil health (Everett and Timudo-Torrevilla 2006; Gabzdylova et al. 2006). Copper is the only fungicide registered to control avocado rots in orchards and there are concerns about the impact of copper on the environment because it does not readily degrade (Everett and Timudo-Torrevilla 2006). Copper levels in New Zealand soils can approach levels that are detrimental for the environment (Guernsey et al. 2004). There is currently national research being carried out to reduce copper use in avocado orchards (Everett and Timudo-Torrevilla 2006; Guernsey et al. 2004).

Table 4: Areas planted for some crops in Northland at 30 June of each year. Note: data for many crops is not available such as kumara and citrus and therefore the sum of the data for each year in table 2 is not the total area of Northland in horticultural land use. Data source: Statistics NZ.

Total area planted in (ha)	1994	2002	2003	2005	2007
Apples	118	71	47	NA	30
Avocados	331	939	1013	1001	1325
Kiwifruit	715	605	601	520	634
Olives	NA	146	NA	NA	231
Onions	38	NA	NA	NA	NA
Potatoes	102	NA	NA	11	31
Squash	952	104	102	NA	25
Wine grapes	27	53	53	72	121

Mining of non-metallic minerals is a significant contributor to the regional economy. High quality ceramic clay operations are based at Matauri Bay. Limestone is recovered for agricultural purposes and cement manufacturing. The Portland quarry and associated cement works south of Whangarei is the largest in the country. The extraction of aggregate for roading and concrete manufacturing is the region's largest mining industry, with 2.5 million tonnes produced in Northland in 2006 (MED 2006).

Subdivision development

In recent years large areas of land in Northland with prime soils for agricultural and horticultural land use (i.e. rich, free-draining volcanic soils) have been subdivided into lifestyle blocks and for urban development. In most cases this renders it unavailable for sustainable horticultural and agricultural land uses. This is obvious in the areas of Maunu, Kamo and Glenbervie in Whangarei and around Kerikeri in the Far North. Prime soils for horticultural and agricultural land uses include soils classed as 1c1, 2e1, 2w1, 2s1, 3e1, 3s1 or 3s2 in the land resource inventory (Harmsworth 1994; Clarke et al. 1996).

Based on resource consent data for land subdivision from January 2001 to October 2006 for Whangarei District, from June 2002 to February 2007 for Far North District and up to July 2005 for Kaipara District, approximately 9% of Northland's prime soils have been subdivided into 2,209 lots over the last six years, with an average lot size of about two hectares, as shown in table 5 (below).

Table 5: Area of prime soils by district, with the number of resource consents approved for subdivision within these areas, and the number of lots and area associated with these consents.

	Area of prime soils (ha)	No. of resource consents	No. of lots	Average no. of lots	Total area of lots (Ha)	Average lot size (ha)
Whangarei	12,068	279	830	2.9	1833	2.2
Kaipara	3,643	12	46	3.83	NA	NA
Far North	33,168	347	1333	3.84	2530	1.9
Total	48,879	990	2,209			

Future development

Whangarei District Council carried out and reported on a detailed analysis of development trends in the Whangarei District (WDC 2007). The report states that subdivision activity in the district over the past five years has been high and is likely to continue into the future.

The report shows schematic images of what three coastal areas are estimated to look like in the future, based on lots that have already been subdivided but not necessarily built on today (2007), all being occupied in the future. Examples of the images are shown below for One Tree Point in 2007 (figure 3) and in the future (figure 4).

As can be seen from the images the visual attributes of One Tree Point and other similar areas undergoing extensive subdivision development will be significantly altered once all lots are occupied. There will be effects on the natural character, open space, visual amenity and ecological values, as well as significant implications relating to the provision of infrastructure (WDC 2007).

Figure 3: Approximate housing development in One Tree Point, Whangarei in 2007. Source: WDC 2007, pg 26.

Figure 4: Estimated housing development in One Tree Point, Whangarei in the future (based on subdivision lots already created all being occupied). Source: WDC 2007, pg 27.

The detailed report on development trends in Whangarei district is available on the Whangarei District Council's website at the following link:

http://www.wdc.govt.nz/customerservice/?lc=reader&m=tssd&i=3754

Land use consents

Land use consents can give an indication of the main types of pressures on soil conservation and quality. Land disturbance consents in Northland are mainly sought for excavation, extraction or vegetation clearance work and the placement of structures. Land use consents for these latter types of activities are required when there is the potential to cause:

- An increase in erosion
- Significant or long term degradation of water quality
- Increased flood risk

At 1 January 2007 there were 902 land use consents in Northland as shown in figure 5 (right).

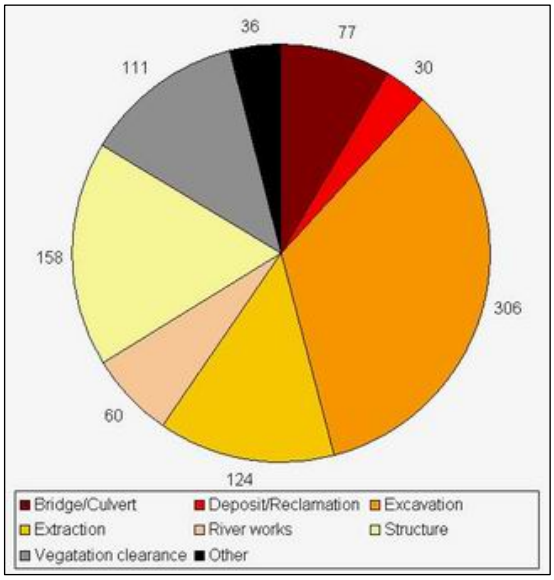

Figure 5: Land use consents at 1 January 2007 (right).

The number of current land use consents in Northland has steadily increased since 1997 as shown in figure 6 (below). This is likely to be a result of increasing economic activity in the region and therefore an increase in consent applications being received by the Council for land use activities such as subdivisions, roading and quarries.

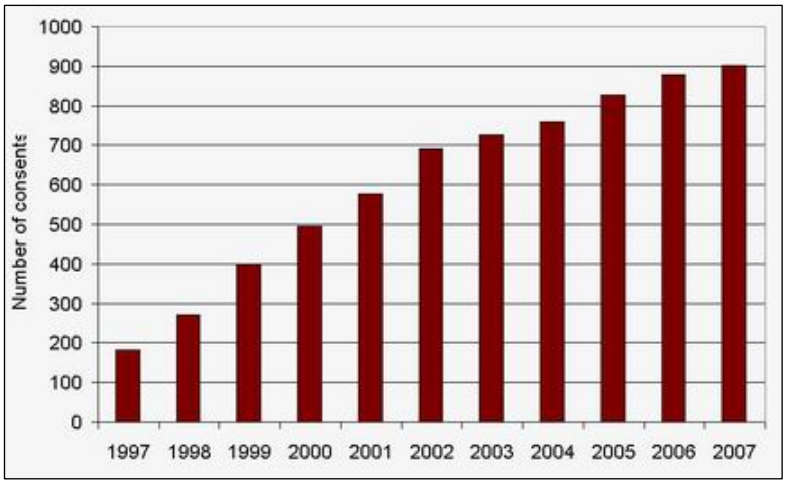

Figure 6: Number of land use consents current at 1 January of each year in the Northland region.

The percentage of significant non-compliance for land use consents (including vegetation clearance, earthworks, quarries and bridge/culvert construction) has decreased over the last four years, as shown in figure 7 (below). This is likely as a result of increased environmental awareness amongst consent holders, forestry companies and earthworks operators, through the Council taking formal enforcement action on non-compliance and carrying out education in the form of workshops, field days, site visits and publications.

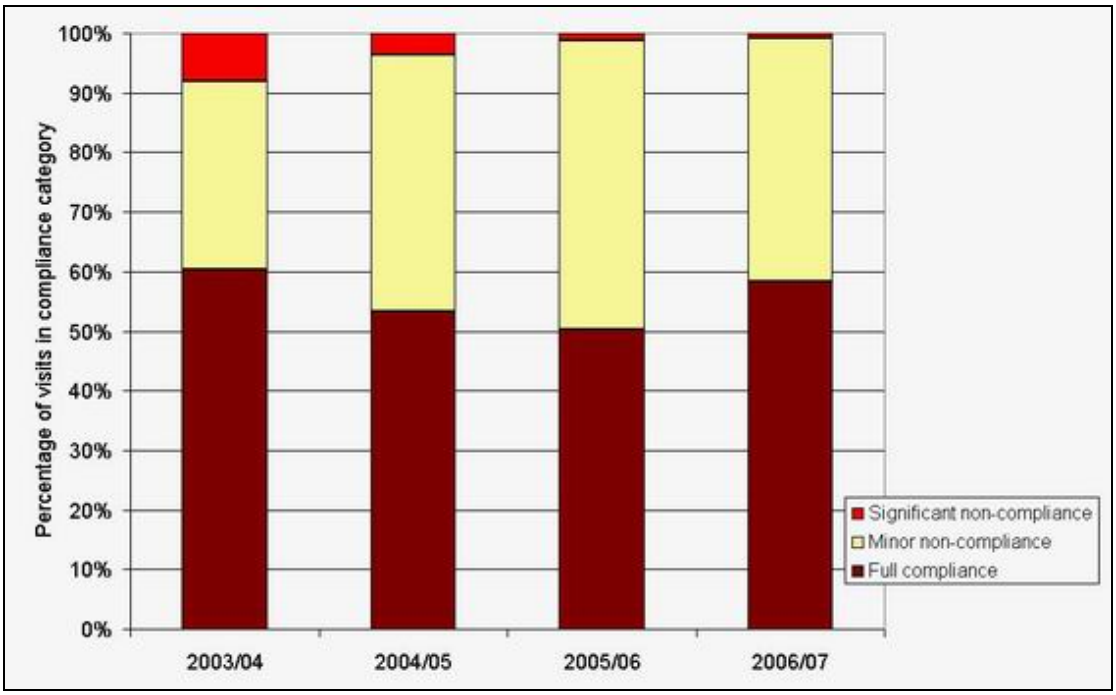

Figure 7: Consent compliance for land use consents

Soil contamination

Cadmium in Northland soils

Cadmium is a non-essential heavy metal that naturally occurs at low concentrations in the environment (MAF 2007). Naturally soils in New Zealand have average cadmium levels of 0.16 mg/kg soil (MAF 2007). Phosphate rock, from which phosphate fertilisers are made, contains cadmium, as a trace impurity, at higher levels than this. Ongoing addition of phosphate fertilisers leads to an accumulation of cadmium. Horticulture, cropping, forestry and pastoral agriculture in New Zealand are reliant upon the application of phosphate fertilisers to maintain economic levels of production.

The reason for monitoring cadmium levels stems from a primary concern over human health and possible economic impacts of losing markets if cadmium levels in primary produce exceed acceptable levels (MAF 2007). Low levels of cadmium in the diet can accumulate over a person's lifetime. The New Zealand Food Safety Authority has estimated the amount of cadmium in the diet of the average New Zealander is at a level far below that which would cause adverse health effects (MAF 2007). However there is evidence that cadmium levels in NZ soils, including Northland, are increasing.

A national study measured the cadmium level of 1,794 soils throughout NZ, including 24 samples from Northland (Taylor et al. 2007). The results indicate that land use was a key driver of topsoil cadmium concentrations. The average cadmium concentration for the Northland soils sampled was 0.33 mg/kg, while nationally the averages for other regions ranged from 0.17 to 0.66 mg/kg (Taylor et al. 2007).

The phosphate rock used in the manufacture of phosphate fertilisers for the New Zealand market has traditionally been from Nauru Island. This source had levels of cadmium that were high by international standards (MAF 2007). A voluntary industry limit on cadmium content in phosphate fertiliser has led to phosphate rock being sourced from other areas. Lower cadmium levels in fertiliser will reduce the rate of accumulation in soils.

The national study on cadmium levels in NZ soils recommended that monitoring of Northland soils is continued with an increase of sites to 50 and the monitoring of

fluorine levels as well as cadmium (Taylor et al. 2007). The working group also recommended that a national cadmium strategy should be developed, supported by all stakeholders in order to mitigate future risks from cadmium (MAF 2007).

For more information on contaminated sites in Northland refer to the Waste Hazardous Substances chapter of this report.

Environmental Incidents

All environmental incidents reported to the Council are categorised by what resource is affected as well as type. Some examples of types of incidents recorded as potentially affecting land resources in Northland are:

- Oil, diesel or hazardous substance spills, which can have significant impact on soil quality.
- Earthworks and vegetation clearance, which can increase erosion.

Fifteen percent or less of incidents impacting on land resources every year have a significant or large impact on Northland's soil and land resources, as shown in figure 8 (below) .

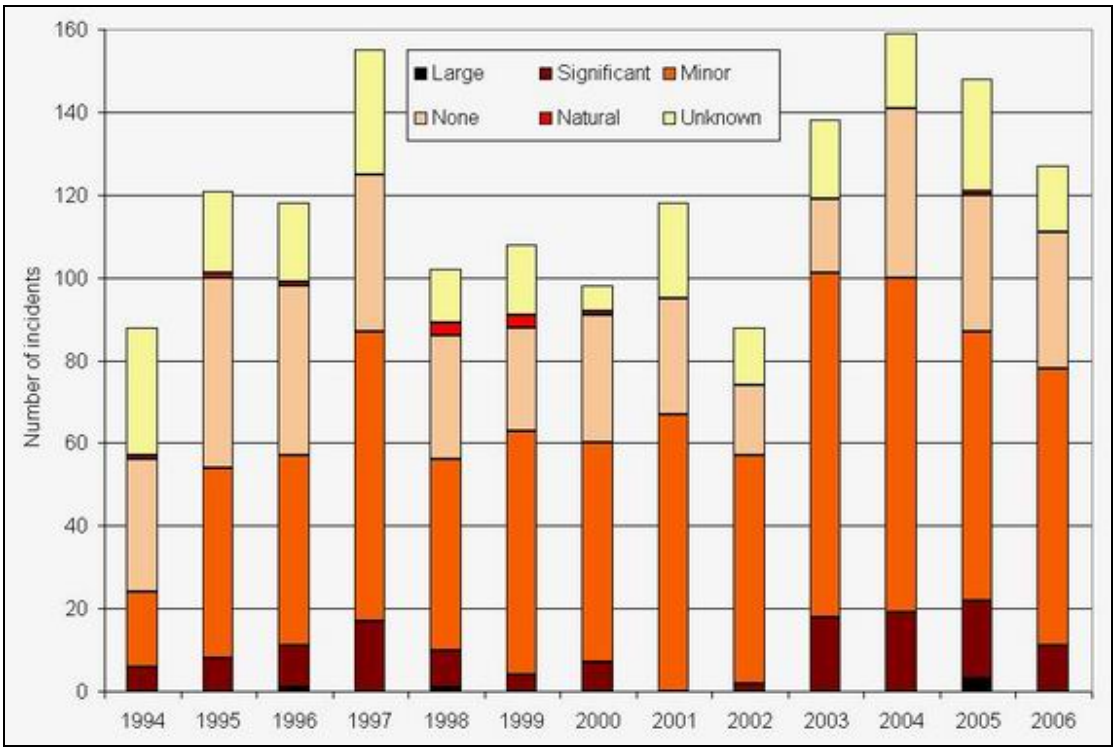

Figure 8: Number of land environmental incidents with their recorded impact on the environment from 1994 to 2006.

Earthworks and vegetation clearance incidents

Almost a third of incidents affecting land reported to the Council every year are incidents relating to earthworks and vegetation clearance, as shown in figure 9 (below). There has been a slight decrease in the number of earthworks and vegetation clearance incidents that affect land resources in Northland from 2004 to 2006. Again this is likely to be as a result of increased environmental awareness through Councils advocacy and education. Inappropriate land management practices when carrying out these activities can cause severe erosion, potentially resulting in land slides, increased sediment discharge and

reduced water quality or increased flood risk.

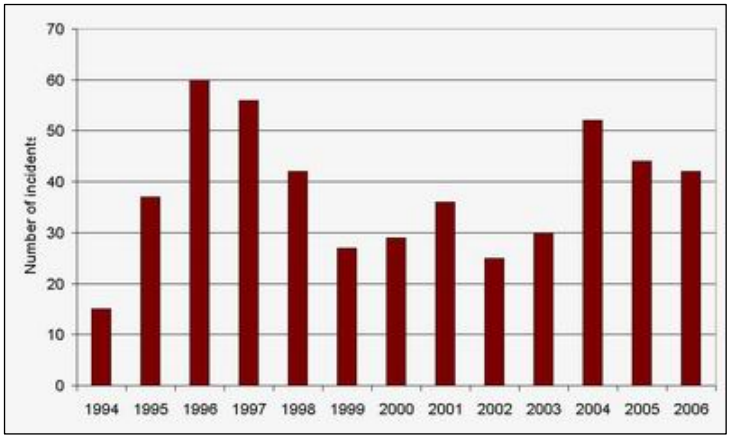

Figure 9: Earthworks and vegetation clearance incidents affecting land resources in Northland from 1994 to 2006.

Pests and weeds

Typically Northland is weedier than elsewhere in New Zealand due to earlier settlement (Bob Cathcart *pers. comm*.). In areas of early settlement in Northland, such as Mangonui, Whangaroa, Kohukohu, Rawene and Russell, garden plants have had longer to acclimatise and escape into the surrounding environment.

Northland's warm temperate climate and high rainfall also provides conditions that make it vulnerable to a wide range of animal pests and weeds. A wide range of pests and weeds are already established in the region. A predicted climate change forecast, which will see the region warming and becoming drier, will make the region more favourable for weed species. Already established weed and pest species and new organisms are impacting on agriculture, horticulture and the environment, such as tropical grass webworm and guava moth.

For more information on the impact of pests and weeds on Northland's indigenous biodiversity and ecosystems refer to the Indigenous Biodiversity chapter.

Weed species

There is a wide range of weed species present in Northland that impacts on productive land use and in some cases limits options for land use. Weeds can impact both economically and environmentally on farm performance. Weed species will compete with more desirable species for space, water and nutrients, some are poisonous to stock and prolific weed growth can lead to poor quality pasture which is more vulnerable to erosion.

On the other hand there is evidence that pasture weakened from overgrazing by sheep or damaged by insects (e.g. grass grub) can become infested by wind-blown species such as nodding thistle. A change in pasture management, such as from sheep to dairy cattle, can reduce the infestation of nodding thistle.

Most of the pest plants in Northland that have significant impacts on agriculture, horticulture and the environment are those identified in the Regional Pest Management Strategy (RPMS) for Northland (NRC 2003). At December 2007, this included 15 species with individual strategies, a strategy for five aquatic plants and a strategy for 12 surveillance plants ('*dirty dozen*').

The Regional Pest Management Strategies for pest plants are available on the Council website at the following link: http://www.nrc.govt.nz/Resource-Library-Summary/Plans-and-Policies/Pest-management/Northland-Pest-Management-Strategies---Pest-Plants/

The '*dirty dozen'* are 12 major pest plants, which are in other regions of NZ but not yet recorded in Northland, with the exception of the one site of evergreen buckthorn in Matakohe. It includes the following 12 surveillance plants from the RPMS (see section 5.15) that are unwanted in Northland:

1. eelgrass *(Vallisneria gigantea)*
2. senegal tea *(Gymnocoronis spilanthoides)*
3. hydrilla *(Hydrilla verticillata)*
4. nardoo *(Marsilea mutica)*
5. water poppy *(Hydrocleys nymphoides)*
6. needlegrass *(Stipa tenuissima)*
7. skeleton weed *(Chondrilla juncea)*
8. evergreen buckthorn *(Rhamnus alaternus)*
9. old man's beard *(Clematis vitalba)*
10. houttuynia *(Houttuynia cordata)*
11. entire marshwort *(Nymphoides geminata)*
12. fringed water lily *(Nymphoides peltata)*

They are all invasive species which can have detrimental effects on agriculture, horticulture and the environment. For example: senegal tea and nardoo are both poisonous aquatic plants; old man's beard smothers and kills other plants; skeleton weed is a major potential weed for crops, choking harvesting equipment; and needlegrass is a major potential weed of farmland, gardens and the coastal environment.

Table 6 (below) shows some of the invasive species in the RPMS with two scores that give an indication of the weed's relative importance: biological success rating and weediness rating (Esler et al. 1993). Biological success ratings are associated with the plant's ability to establish and spread (out of 21), while weediness (or weed status ratings) refers to the nuisance value of the plant (out of 24). For example, high scores in both would make a plant high priority for management as it can easily spread and establish in new areas and is of high nuisance value.

Table 6: Plants in Northland Pest Plant Management Strategy, (excluding the aquatic pest plants, plants that are controlled in a Community Pest Control Area and surveillance plants (dirty dozen)).

Pest plant	Biological success[1] (out of 21)	Weediness[1] (out of 24)	Problems caused
African feather grass (*Pennisetum macrourum*)	20	18	Invades poor pasture areas, roadsides and reserves. Can suppress other plants and restrict the movement of animals, people and machinery.
Bathurst bur (*Xanthium spinosum*)	10	8	Its burs devalue wool and its spines can injure stock, Young plants can also be toxic to stock. Dense stands can impede harvesting of crops
Broom (*Cystisus scoparius & Teline monspessulana*)	12	12	Invades pasture, plantation forests and regenerating native ecosystems.
Gorse (*Ulex* spp.)	15	19	Hardy; colonises new areas quickly, forming dense thickets. Provides cover for other pests and restricts the movement of stock and people.
Lantana (*Lantana camara* var. *aculeate*)	19	18	Forms dense impenetrable thickets. Invades pasture, roadside and bush edges, replacing other vegetation. Poisonous to stock and humans.
Manchurian ricegrass (*Zizania latifolia*)	19	18	Blocks drains, causes flooding and invades pasture, causing lowered livestock production.
Moth plant (Araujia sericifera)	15	13	Vigorous climbing plant, smothers trees and breaks their branches with its weight. Spreads over considerable distances.
Nassella tussock (*Stipa trichotoma*)	14	14	Invades pasture, reducing productivity and generally unpalatable to stock.
Pampas grass (*Cortaderia selloana* and *C. jubata*)	16	17	Forms dense impenetrable stands, excludes other vegetation, creates a fire risk and provides habitats for vermin.
Privet (*Ligstrum lucidum* and L. sinense)	11	13	Scent can impact on human health. Toxic to stock and can restrict native plant regeneration.
Ragwort (*Senecion jacobaea*)	15	14	Quickly invades land, reducing productivity and is toxic to stock.
Spartina (*Spartina alterniflora*, *S. anglica* and *S. x townsendii*)	15	15	Forms dense mats in harbours, which causes silt to accumulate and severely affects marine life. Can cause flooding.
Thistle (*Carduus nutans* and *Cirsium arvense*)	13 15	11 11	Invades pasture and is capable of total ground cover.
Wild ginger (*Hedychium garderianum* and *Hedychium flavescens*)	18 15	14 12	Forest invader, which smothers small plants and prevents forest regeneration. Can contribute to erosion on steep land.

1. Both the biological success rating and weediness rating are part of the Esler, Liefting and Champion Weediness Index (Esler et al. 1993).

Pest animals

Four pest animal species impact on farm production through both competing with stock for feed and making land more prone to erosion. Rabbits, goats, pigs and possums all potentially impact directly or indirectly. Overgrazing makes soil more vulnerable to erosion and increases the rate of sediment loss to waterways. Possums, goats and pigs all impact on the health of forest remnants, grazing on the understorey vegetation and

damaging mature trees, reducing the value of these areas as buffers during heavy rainfall events.

Overall rabbit numbers are relatively low in Northland when compared with other regions in NZ. They cause the most problems in areas with lighter volcanic or sandy soils and numbers fluctuate from year to year dependent upon weather conditions. Numbers build up through summer and drop off in winter. The worst affected areas are coastal sands where numbers can reach levels that seriously affect vegetation cover and can lead to sand drift erosion.

Pigs, possums and goats sometimes cause problems where grazing land adjoins areas of bush. The bush provides cover for the animals which then emerge onto the pasture to graze. Goat control work carried out in Northland in recent years has reduced the size of goat mobs and restricted them to a fewer areas, meaning that damage to pasture is currently rare. Pigs are most likely to cause damage to pasture in the winter months. Possums are being controlled where cooperating landowners work together in community pest control areas.

More information on these pest animals is available on the website at the following link: http://www.nrc.govt.nz/Resource-Library-Summary/Plans-and-Policies/Pest-management/Northland-Pest-Management-Strategies---Pest-Animals/

Pest insects

Pest insects can also have significant impacts on agriculture, horticulture and the environment. Some of the more significant pest insects found in Northland are the tropical grass webworm, Argentine ant and guava moth.

Severe infestations of the tropical grass webworm, *Herpetogramma licarsisalis*, were seen on the Aupouri Peninsula in March 1999. If there is a boom in webworm numbers severe damage can be caused to kikuyu pasture and the webworm population can quickly spreads to other pastures. There is usually a seasonal trend in topical grass webworms, with the population growth being related to climatic conditions, with numbers increasing dramatically in warm moist summers.

Argentine ants (*Linepithema humile)* are among the 100 most invasive species on earth. First discovered in New Zealand in 1990, they are believed to have reached Northland via potted plants, freight or wood and are now found throughout the region, especially in urban areas. Argentine ants can form super-colonies of immense size and threaten the region's environment and economy as well as the lifestyle Northlanders enjoy. In New Zealand Argentine ants threaten native insects, lizards and native birds, either attacking them directly or by competing for food like nectar and honeydew.

The guava moth (*Coscinoptycha improbana)* is a native of Australia. It was first found in Kaitaia in 1997 and is now found north of, and including, Whangarei City, Maungatapere and Whangarei Heads. The guava moth lays its eggs at the ends of fruit, from which the caterpillar hatches out and burrows into the fruit. The caterpillar feed within the ripening fruit producing excrement and encouraging the growth of fungus. Guava moth infests fruit all year round, including yellow guava, feijoa, citrus, plums, peaches, nashi pear and macadamia nuts.

More information on these pest insects is available on the Council website at the following link: http://www.nrc.govt.nz/Environment/Weed-and-pest-control/Pest-insects/

14.3 What is the state of our soil and land resources?

Soil quality

Twenty-five sites around Northland, of varying land uses and soil types, were initially sampled in 2001 as part of the national 500 Soils project. The main objective of this project was to establish a national baseline against which future trends in soil quality could be measured. These 25 sites were resampled in June 2007 (Stevenson 2007). The results from the 2007 sampling are shown in tables 9, 10 and 11 in appendix A.

Chemical properties in 2007

In general the chemical properties of most sites were good and within the recommended range for the different land use and soil types, as shown in table 9 in appendix A. However Olsen phosphorus (Olsen P) and pH were outside target ranges for several sites. Olsen P, which is a measure of phosphorus available for pasture production, was below the target range for three of the 25 sites, all of which were drystock sites. This could be as a result of lower rates of fertiliser application. Soil pH was below the target range for two sites (both dairy) and above for two sites. The two pH levels below the target range could be due to higher nitrogen fertiliser application and/or increased soil compaction under heavier stocking regimes.

Physical properties in 2007

Approximately half of the 25 sites had values outside the target ranges for macroporosity, particularly on pasture (dairy and drystock) sites, indicating compacted soils, as shown in table 10 in appendix A. This is consistent with findings elsewhere in New Zealand where sites in pasture are showing moderate compaction. Greater caution is needed in Northland, as Northland soils are more susceptible to compaction due to their higher clay content and to a generally wet winter.

Heavy metals in 2007

The levels of heavy metals in the soil samples varied across land uses, with no obvious differences between land use categories, as shown in table 11 in appendix A. Natural levels of metals can vary depending on the parent geology of a site. All heavy metal concentrations were within the suggested soil limits of the New Zealand Water and Wastes Association (NZWWA 2003), except one site. The orchard site (NRC25) had copper levels of 102 mg/kg, just above the suggested limit for copper of 100 mg/kg.

Changes in soil quality since 2001

Macroporosity had decreased for many sites, particularly at dairy and drystock pastoral sites, which is generally a result of intensification of these land use practices. Mineralisable nitrogen values were also significantly lower at most sites in 2007 compared to 2001. Otherwise there were few changes consistent across land uses.

Overall the majority of instances of poor soil quality could be reversed by appropriate management. Landcare Research has recommended that sampling should continue to determine the extent and direction of any long term changes in soil quality. They also

recommend increasing the number of sites, to gain more replicates for each different land use and to sample different soil types.

For more detailed information on the results from the 2007 sampling refer to the detailed report available on the Council website at the following link:

http://www.nrc.govt.nz/Resource-Library-Summary/Research-and-reports/Land-and-soils/

Land instability

Landslides can be a threat to life and property, with one fatality in Dargaville in 1998 and significant damage to property every year. In Northland the dominant trigger is intense or prolonged rainfall which initiates many landslides annually (Beetham et al. 2004). There are four main types of landslide hazards in Northland:

Debris avalanche

Many areas in Northland are susceptible to land instability of one form or another. The highest land within the region includes steep Tangihua volcanic ranges, such as Maungataniwha, Panguru, Waima and Tangihua Ranges. These, because of their steepness and exposure to high intensity short duration rainstorms, often suffer debris avalanches.

A debris avalanche is a slip containing a high proportion of water as well as logs, boulders and soil. It cuts a narrow path through surrounding forest and spill both into river systems and out onto surrounding land. This steep hill country is very susceptible to debris avalanches regardless of the health and extent of cover of native bush. Because a debris avalanche is likely to cut from the very top of a ridge to the valley floor, removing all bush in its path, it contributes large volumes of logs, boulders and sediment to river systems. Debris avalanches spilling down Mt Manaia in 1971 and the Panguru Range in 1999 destroyed buildings, roads and bridges in their path.

Because debris avalanches are unpredictable and very destructive, the only way of avoiding damage by debris avalanches is to avoid siting buildings or infrastructure in areas at risk.

Earth flows

The Waipoua and Tutumoe Plateaux is formed by a basalt flow (volcanic rock) capping and protecting softer underlying sandstone and mudstone. Water percolating through the volcanic rock filters through the more porous sandstone but is blocked by the mudstone. The water moves towards the edges of the plateau, seeping out along the interface between the two rock types and creating large landslides and earthflows on the middle slopes of the plateau. The movements occur in the Wekaweka valley and the catchments of the Otaua, Mangakahia, Tangowahine, Awakino and Kaihu Rivers are large enough to be recorded on the IGNS *landslides database*.

These movements are examples of geological erosion and while they cannot be prevented, they can be identified and avoided when siting roads, dwellings and infrastructure. The rate of movement on some can be slowed by planting deep-rooted trees and by strategic drainage.

Greywacke slips

The greywacke hill country extending down the eastern side of Northland from Whangaroa to Mangawhai is susceptible to slipping on slopes over 12^{o} (Professor Brothers, Auckland University, *pers. comm*.). The soil, 1 to 2 metres deep, overlies a weather rock or regolith. Water percolating through the soil transports clay and deposits it as a layer on top of the regolith, creating a slip plane. During extended periods of wet weather the soil becomes waterlogged and can move down the slope over the slip plane. This movement, in which the soil surface remains relatively intact, is evidenced by terracettes or a folded surface. In high intensity, short duration storms, the saturated soil slides off the slip plane resulting in widespread but usually shallow slips. Again, slipping occurs in high intensity storms almost regardless of the vegetative cover.

More susceptible sites can be identified using aerial photography and land resource inventory mapping. Strategic planting of deep-rooted trees on these more susceptible sites can reduce the incidence and extent of slipping. Careful siting of infrastructure and suitable dewatering and stabilisation of susceptible sites can reduce the damage caused by this slipping, both onsite and offsite (in respect of water quality).

Unstable mudstone

The Northland Allochthon swept a mass of crushed and soft rock over middle and western Northland from the North Hokianga to Kaiwaka, extending to the east coast around Whangarei Harbour. This material is very unstable, particularly where there are complexes of sandstone, mudstone and limestone and is susceptible to deep-seated earthflows and slumping, as well as surface erosion forms like gully erosion. This soft, crushed and moving material is one of the reasons for Northland's winding and poorly surfaced roads. Examples of the effect of particularly difficult road foundations can be seen on SH1 immediately south of Kaiwaka and at Umawera, and on SH14 between Kirikopuni and Tangowahine.

Again, identification of these areas of soft, crushed, and folded rock is very important when planning infrastructure. Remote sensing survey methods which penetrate the surface of the earth, commonly used to search for minerals, would provide valuable data. Once identified, the difficult sites could either be avoided, or extra measures including drainage and pre-stabilisation, could be used to reduce the rate of movement. Strategic planting of deep-rooted trees could also assist stability.

Land use on erosion prone land

Over half of Northland's land area (720,000 ha) is classed as erosion prone land (i.e. has a Land Use Capability (LUC) (Harmsworth 1996) erosion class of either 6e or 7e), as shown in table 6 and 7 (below). Almost half (43%) of this had indigenous vegetation cover in both 1997 and 2002, which with mature vegetation, has a low erosion risk. However 39% of the land classed as 6e, and 13% of the land classed as 7e, had pastoral land cover in 2002. Without careful management, appropriate soil conservation and erosion control methods, this land is at risk to erosion.

A significant portion of the erosion-prone land in Northland is also in pine forest. This land is most at risk to erosion during harvesting. Only a small area of the forestry on erosion prone land has been harvested since 1997.

Exotic forestry on Mount Tiger, Whangarei (right).

There was little change in the proportion of different land uses on erosion prone land between 1997 and 2002.

Table 6: Area (ha) and proportion (%) of 6e erosion prone land (based on LUC) in different land uses in 1997 and 2002 (based on LCDB1 and 2). Afforestation - planted in forest for the first time.

	1997		2002		
	6e land (ha)	% of total	6e land (ha)	% of total	Difference
Afforestation	16698	2.9	6334	1.1	-1.80
Indigenous vegetation	236839	41.2	235576	41.0	-0.22
Forest harvested	4237	0.7	7996	1.4	0.65
Exotic vegetation	6733	1.2	6623	1.2	-0.02
Pasture	228582	39.8	223146	38.8	-0.95
Orchard/crops	281	0.0	281	0.0	0.00
Pine forest	78724	13.7	92142	16.0	2.33
Urban area/infrastructure	752	0.1	750	0.1	0.00
Other land covers	2061	0.4	2057	0.4	0.00
Total area	574905		574905		

Table 7: Area (ha) and proportion (%) of 7e erosion prone land (based on LUC) in different land uses in 1997 and 2002 (based on LCDB1 and 2). Afforestation - planted in forest for the first time.

	1997		2002		
	7e land (ha)	% of total	7e land (ha)	% of total	Difference
Afforestation	4200	2.9	746	0.5	-2.38
Indigenous vegetation	76426	52.6	76319	52.5	-0.07
Forest harvested	1026	0.7	2147	1.5	0.77
Exotic vegetation	1374	0.9	1357	0.9	-0.01
Pasture	20115	13.8	19509	13.4	-0.42
Orchard/crops	24	0.0	24	0.0	0.00
Pine forest	37301	25.7	40410	27.8	2.14
Urban area/infrastructure	16	0.1	169	0.1	0.00
Other land covers	4738	3.3	4693	3.2	-0.03
Total area	145374		145374		

The need to get an economic return on farm investment, has led to a concentration of resource use on average to good pastoral land and the abandoning or selling off of more marginal land (Doug Foster, NRC, *pers. comm*.). This has had catchment-wide soil

conservation benefits as this marginal land, which is often land classed as erosion prone, has either reverted to gorse or scrub or been planted in production forest.

Occurrence and extent of pest plants

Every year the Council reviews and produces an annual report on the Councils' performance towards implementing the annual Operational Plans prepared under section 85 of the Biosecurity Act.

Table 8 (below) presents the status in 2006-2007 of most of the pest plants included in the RPMS for Northland (NRC 2003), which was reported to the July 2007 meeting of the NRC Landcare Committee. In most cases the Council is well ahead or on target for meeting the objectives for each pest plant in the RPMS (NRC 2003).

Table 8: Occurrence and extent of major pest plants, including most plants from the Regional Pest Management Strategy for Northland, in Northland in 2006-2007

Pest plant	Occurrence and extent in 2006 - 2007
Manchurian ricegrass	• 76 sites throughout the region all outside the main infestation area are included in the control programme. • 16 of the 76 sites had no evidence of any regrowth. 42 sites had regrowth of less than 10% of the original infestation level. The remaining had regrowth of between 10% and 50%.
African feathergrass	• More than half of the sites had a clear status (33 of 63 sites had no new plants). • It is predicted that within four years over 90% of sites will be free of infestation.
Spartina	• Covers approximately 100 ha of Northland's harbours, however 80 ha is currently under active management. • Density is being reduced by approximately 80% per annum on all Mid and Far North sites. All spartina will be under management by the end of next year (2008), with all known sites either eradicated or remaining areas negligible in a further four years.
Lantana	• The continued control in urban centres (over 800 sites in 2006/07) is halting its spread, along with a targeted campaign to stop this pest plant reaching the Far North reserves.
Nassella tussock	• 39 properties are recorded as having nassella tussock with a total of 54 plants. This is an increase of 21 plants since 2005/2006. • 24 properties which have had nassella tussock controlled have remained clear for four years.
Evergreen buckthorn	• There is only one known site in Northland at Matakohe, which has been progressively reduced in size over the last 10 years and now covers about 1 ha.
Bathurst bur	• 81 sites were inspected by NRC staff at least once in 2007-2008 to ensure that property owners achieved complete control of all plants.
Nodding thistle	• 72 sites were inspected at least once during the year to ensure that property owners achieved complete control of all plants.
Californian thistle	• Five sites were inspected during 2006-2007. There are currently 24 known sites but new populations are continuing to be found. • While the infestation levels in Northland are low compared with other parts of New Zealand, Californian thistle can still rapidly invade open pasture and infest neighbouring clean farms if left uncontrolled.

Spartina

A salt tolerant plant, spartina spreads mainly by underground rhizomes, bits of which break off when exposed by erosion on tidal stream banks or when grazing stock pull the whole plant out of the harbour sediment. It forms dense mats which act as sediment traps on exposed mud banks and under mangroves, catching sand, mud, shells and debris.

The main species in Northland, *Spartina alterniflora,* does not flower or produce viable seed. It varies in height from about 0.4 to 1.5 metres and has a dense interwoven root mat about 0.3 metres thick.

Spartina alterniflora was introduced to the North Island and Northland in the early 1950s because of the disappointing performance of other species and was actively promoted by the Department of Agriculture in the 1950s and 1960s to protect stopbanks, as stock forage, and in combination with drainage, aid in the conversion of tidal mud flats to farmland. As a result, the area and number of sites increased dramatically with some plantings being made in Northland as recently as the early 1990s despite planting being banned by the Government in the mid-1960s.

Prior to the Council commencing control operations in the Kaipara Harbour in 2003, major infestations totalling over 100 hectares were recorded in the Kaipara, Hokianga and Parengarenga Harbours. Smaller infestations were present in the Bay of Islands, Houhora, Rangaunu, Mangonui and Whangaroa Harbours and the Taipa River. Individual sites ranged in size from a few square metres to one site of approximately 15 hectares. Northland-wide surveys were carried out in 1992 and again in 2002. It was found that patches of spartina not contained by dense mangroves, stop banks or tidal channels had, in some cases, spread and increased in size by up to 200 times their original cover over the 10 year period.

Spartina control is effective using a five year programme of annual herbicide application. Eradication of individual sites can generally be achieved within this time however extensive ranging is needed to locate all outlying sites and individual plants that may have spread from the initial source. Aerial spraying with the herbicide Gallant is the only practical and cost-effective method for initial control of most large sites due to location and accessibility. Aerial spraying is required for three years by which time the infestation has been reduced to a size that it can be controlled by ground-based methods. Ground-based methods can be used for initial control of small sites.

The Council gained resource consent and commenced a large-scale eradication programme in the Kaipara in 2003. The Regional Pest Management Strategy for Spartina was revised in 2003 and a 15-year programme to eradicate spartina Northland-wide was approved by the Council in 2004. The long term (15 year) goal is to completely eradicate spartina from Northland. The short term (five year) goal is to control the spread of the plant in the Kaipara, Hokianga, Rangaunu and Parengarenga Harbours and reduce

infestation levels by 50%, and in conjunction with the Department of Conservation, eradicate other small and isolated infestations.

Progress towards the long term goal of Northland-wide eradication is ahead of schedule. At February 2008 all except three of the 150 plus known sites in Northland, totalling over 100 ha, had been sprayed at least once. 50 ha now has nil or very minor re-growth (98-100% reduction in density). The three sites (totalling 2.5 ha) not yet sprayed are covered by Memorandums of Understanding with the adjoining landowners delaying their control to give them the opportunity to implement alternative erosion control measures.

Occurrence and extent of pest animals and insects

Wild deer

Wild deer pose a serious threat to the valuable farming industry of Northland, as they have been confirmed as an efficient vector of Bovine Tuberculosis to domestic animals. Northland currently has a Tb-free status (DOC 2007). If left unchecked, wild deer populations will increase and damage Northland's unique ecosystems. The potential environmental costs of deer to Northland, although difficult to separate out from those already accruing to goats, are estimated to be at least $538,000 per year, while potential economic costs are estimated to be in the range of $185,000 to $6 million (Sweetaple 2006).

Representatives of Northland's farmers, the Northland Regional Council, Agriquality New Zealand, the Animal Health Board, and the Department of Conservation, have been working together as part of a multi-agency plan to eradicate wild deer and reduce the risk of farm escapes. Northland is the only region in New Zealand that has successfully controlled the threat of wild deer and the programme has the confidence of farmers and pest agencies.

Although farm escapes continue to occur these deer are captured or culled and all wild red, fallow or wapiti deer have been eradicated. The illegal release of wild sika deer in Russell forest has also been targeted and this campaign aimed at total eradication is nearing completion. The future success of the plan will rely on sustaining the lessons learnt, and the relationships between joint agencies and farmers.

Table 9: Summary of deer escapes recorded as part of a 10 year plan to eradicate wild deer from Northland. Source: DOC 2007.

Year	Number of escape events (Confirmed & suspected)	Number dispatched or recovered
1998/99	4	36
1999/00	3	13
2000/01	5	125
2001/02	5	8
2002/03	8	61
2003/04	6	47
2004/05	10	86
2005/06	4	13
2006/07	16	93

Tropical grass webworm

There is usually a seasonal trend in topical grass webworms, with population growth being related to climatic conditions. Moths emerge at the end of January, with a small peak in larval numbers in February, followed by another significant emergence of moths in early to mid March, as shown in figure 10 (below) and concurrent larval feeding damage throughout March and April.

Since the initial outbreak in 1999, damage from populations of larval TGW has never been as widespread. However, severe feeding damage to kikuyu pasture by TGW as high as that recorded in 1999 has occurred in localised areas in autumn of 2000, 2001, 2002 and 2007.

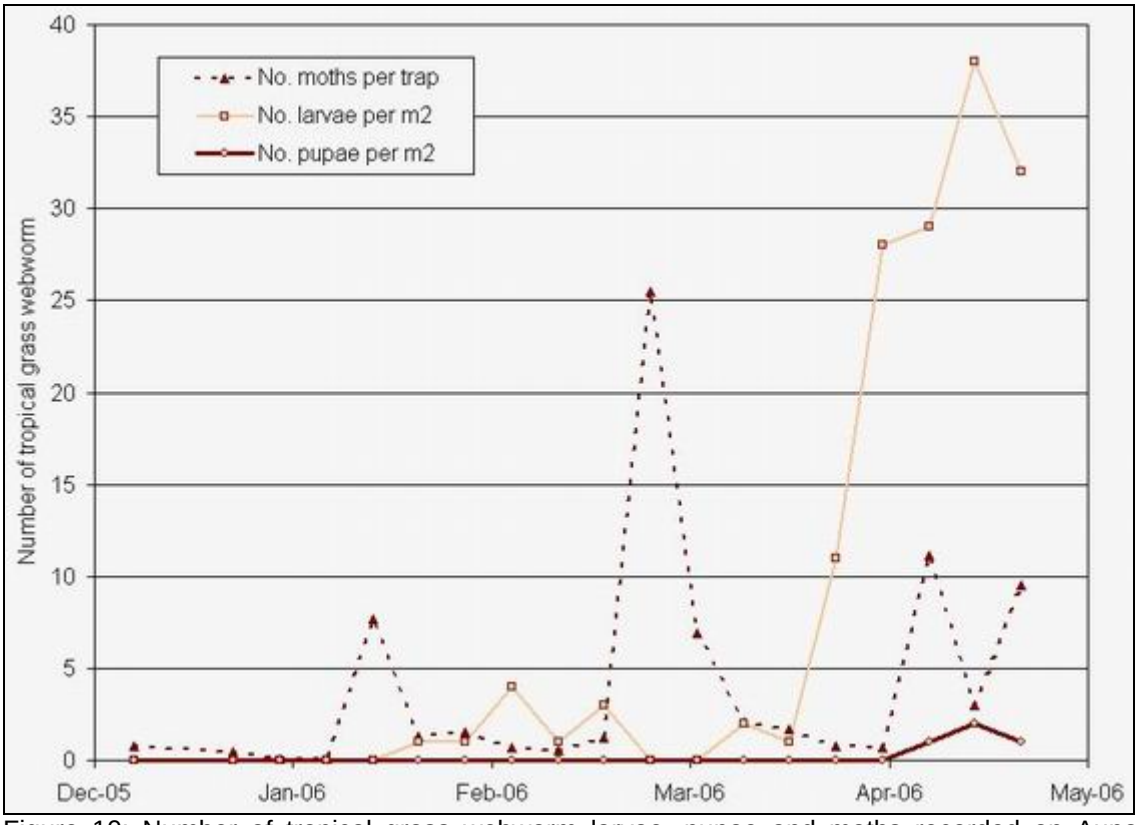

Figure 10: Number of tropical grass webworm larvae, pupae and moths recorded on Aupouri Peninsula from December 2005 to May 2006 (Dymock 2007).

The years in which significant damage did not occur were characterised by either cooler temperatures and/or significant spells of dry weather at crucial stages in the TGW life cycle, particularly in February and March. In addition to these climatic factors influencing TGW build-up each year, the continued presence of parasitoids attacking TGW larvae and pupae (*Meteorus pulchricornis*, *Lissopimpla excelsa*, *Pales* sp.) may now be exerting increased control of TGW.

For the latest results of the tropical grass webworm monitoring refer to the following link on the Regional Council website:

http://www.nrc.govt.nz/Environment/Weed-and-pest-control/Tropical-Grass-Webworm-monitoring/

Argentine ants

Argentine ants (*Linepithema humile*) are widespread throughout Northland. In March 2007 Argentine ant free areas included much of the Far North and all Crown administered offshore islands. Up to March 2007 there were no reports of Argentine ant populations spreading into the larger Crown administered forests such as Waipoua and Puketi-Omahuta Forests, although populations of the species are present on the margins of some forests.

There are Argentine ant populations in urban areas throughout the rest of the region, particularly on the east and west coasts. Where coordinated control is undertaken by community groups successful reduction in Argentine ant populations can be achieved.

Indigenous vegetation cover

In 2002 approximately 416,900 hectares (33%) of Northland's land area was covered in indigenous vegetation (LCDB2). There was a slight decrease in the land area covered in indigenous vegetation from 1997 to 2002, which was approximately 419,100 ha in 1997. This is mostly through a decrease in the following native land covers: broadleaved indigenous hardwoods, indigenous forest and manuka/kanuka. However since 2002 it is possible that this trend has stabilised or turned with the significant amounts of protection and enhancement of indigenous biodiversity that is being carried out in Northland.

Of the 416,900 ha of indigenous vegetation land cover in Northland in 2002, approximately 36% of it was legally protected in 2006 as either Department of Conservation reserves, QEII covenants, WDC covenants, wildlife refuge or District Council reserves, where the land has been set aside as a reserve for the protection of flora, fauna or wildlife reasons. The native land cover protected in Northland in 2006 was predominately indigenous forest and manuka/kanuka.

For more information on the extent and protection of indigenous vegetation in Northland refer to the Indigenous Biodiversity chapter.

14.4 What is being done?

Policy documents

The Regional policy Statement (RPS) for Northland sets out objectives for the maintenance and enhancement of soil and land resources in Northland, including mitigating the effects of land use on water quality and the control of pest plants and animals.

The RPS for Northland is available on the Council website at the following link:

http://www.nrc.govt.nz/Resource-Library-Summary/Plans-and-Policies/Regional-Policy-Statement/Regional-Policy-Statement/

The Regional Water and Soil Plan (RWSP) for Northland (NRC 2007) contains rules relating to land disturbance and vegetation clearance. The Council has targeted the most control on those areas at the greatest risk; steep land with high erosion potential, and the area adjacent to water bodies which has been defined as the "riparian management zone".

The RWSP for Northland is available on the Council website at the following link:

http://www.nrc.govt.nz/Resource-Library-Summary/Plans-and-Policies/Regional-plans/Regional-Water-and-Soil-Plan/

The Regional Pest Management Strategy (RPMS) for Northland (NRC 2003) is an action plan that describes why and how plant and animal pests will be controlled in Northland. Although RPM strategies are not compulsory, the Council has developed one for Northland because the benefits of doing so outweigh the costs (after taking into account the likely consequences of doing nothing).

The RPMS for Northland is available on the Council website at the following link:

http://www.nrc.govt.nz/Resource-Library-Summary/Plans-and-Policies/Pest-management/Northland-Pest-Management-Strategies/

National direction

Soil conservation

As a consequence of the 2004 floods and extensive soil erosion in the Wanganui, Rangatiki and Manawatu areas, the government has reviewed the administration of soil conservation in New Zealand. A national flood risk reduction strategy requiring a whole catchment approach to soil conservation and river management has been adopted by government. The Regional Council is currently reviewing its involvement in soil conservation in Northland.

Dairying and Clean Streams Accord

The national Accord, a contract between Fonterra, the government (MAF and MFE) and Local Government New Zealand (regional councils), aims to promote sustainable dairy farming in New Zealand. It focuses on reducing the impacts of dairying on the quality of New Zealand streams, rivers, lakes, groundwater and wetlands.

The six priorities for actions and national targets outlined in the national Accord are:

- Fonterra and regional councils to develop Regional Action Plans for the main dairying regions to implement this Accord by June 2004.

- Dairy cattle excluded from 50% of streams, rivers and lakes by 2007, 90% by 2012.
- 50% of regular crossing points to have bridges or culverts by 2007, 90% by 2012.
- 100% of farm dairy effluent (FDE) discharges to comply with resource consents and Regional Plans immediately.
- 50% of regionally significant wetlands to be fenced by 2005, 90% by 2007.
- 100% of dairy farms to have in place systems to manage nutrient inputs and outputs by 2007.

The Regional Council and Fonterra co-signed the Dairying and Clean Streams Accord Regional Action Plan for Northland in May 2004. The purpose of the Regional Action Plan is to identify local commitments and to support the national Accord principles of developing actions that are adapted for local conditions, practical, cost effective (whilst recognising the practical and financial constraints of implementing time frames) and that will make a real difference.

For more information on the Regional Action Plan, refer to the following link on the Regional Council website:

http://www.nrc.govt.nz/upload/2238/Dairy%20&%20Clean%20Streams%20Accord.pdf

In general farmers have progressed well towards meeting the targets, as shown in table 10 (below). There was a significant increase in the number of farmers meeting the nutrient management system target from 22% in 2005/2006 to 97% in 2006/2007. This is largely to increased advocacy and support by both Fonterra and the fertiliser companies who provide these nutrient management plans to the farmers.

Table 10: Progress towards meeting the performance targets contained in the Northland Regional Action Plan for the Dairying and Clean Streams Accord.

Target	2003/04 %	2004/05 %	2005/06 %	2006/07 %
50% of suppliers have stock exclusion from waterways by 2007 (includes suppliers with no waterways) and 90% by 2012[1]	70	78	83	91
90% of regionally significant wetlands fenced by 2007[1]	Not measured regionally or nationally at this stage			
100% of suppliers have a nutrient management system by 2007[1]	8	18	22	97
50% of regular stream crossings bridged or culverted by 2007 and 90% by 2012[1]	NA	NA	94	97
100% of FDE discharges to comply with resource consents and regional plans immediately[2]. Only significant non compliance % shown[3]	51	40	28	23

1 – Data source: Fonterra.
2 – Date source: NRC.
3 – Refer to surface water quality chapter for more information on FDE discharge compliance

This data is collected by Fonterra during their on-farm Environment and Animal Welfare Assessment carried out annually with every supplier (MFE 2006). It should be noted that farmer participation in the assessment is voluntary (however there is a 99% participation rate) and most of the answers to the assessment are based on the farmer's response. Therefore there is the chance for inconsistencies between farmers. For example, what each farmer includes as a waterway or what they believe is an appropriate stock exclusion method or stock crossing may vary. Fonterra have however carried out independent auditing, which has shown that the survey method used provides robust data (MFE 2006).

It also should be highlighted that this only includes waterways that are wider than a stride, deeper than a red band gumboot and permanently flowing, under the definition of a waterway in the Regional Action Plan for the Accord. Many small streams in Northland do not fall into this definition and therefore are not included. For example, if all the streams on a farm are narrower than a stride, than this farmer most likely responded in the assessment as having no waterways on their farm. However these streams are still classed as waterways in the RWSP and RMA.

National reporting on the Dairying and Cleans Stream Accord targets is available at the following link on the Ministry for the Environment's website:

http://www.mfe.govt.nz/publications/land/

Weed management

Intensification of pastoral farming and increased availability of improved herbicides has resulted in a general reduction of pest plants in most pastoral farming areas. Retirement or changes to land use on marginal pastoral land has reduced the economic impacts of weeds in these areas (Doug Foster, NRC, *pers. comm*.).

The Northland Regional Council employs a number of tools to manage the risks presented by weeds in the region. Pest management strategies exist for the weeds that are considered to pose the greatest risks. The particular approach taken with each weed is outlined in the individual pest management strategies.

In addition to the regulatory approach outlined in the pest management strategies the Council is also involved in programmes to release biocontrol agents and supporting the establishment of Community Pest Control Areas (CPCAs). Over the last five years 21 Community Pest Control Areas have been established in the region that focus on weed management, such as wild ginger and mothplant control. These CPCAs cover an area of 22,000 hectares of private land and include the involvement of over 600 ratepayers.

More information on CPCAs is available on the Council website at the following link:

http://www.nrc.govt.nz/Environment/Weed-and-pest-control/Community-Pest-Control-Areas/

Recent research on new and emerging weeds for Northland identified 32 species which are established in Northland and could pose a new threat to the environment or economic values of the region. Included are species such as Phoenix palm (*Phoenix canariensis*), which is spreading rapidly into forests close to urban areas, and Giant reed (*Arundo donax*), which is colonising the margins of our roadways. A review of the pest species managed under the Regional Pest Management Strategy is underway and control of new weed threats will be considered an important part of the process.

Pest control

Ongoing control work for a wide range of pest animals, including rabbits, goats, possums and mustelids is being carried out by individuals, community groups (with and without the assistance of the Council) and other government agencies. The resurgence of the use of possum fur in the clothing industry has provided added incentive for possum control. The fur recovered from possum control indicates that at least an average of 11,000 possums per month and an estimated 0.5 million have been killed over the last four years in Northland (Scott Candy, Basically Bush Limited, *pers. comm*.).

Rabbits, goats, possums and mustelids are all covered by individual pest management strategies for Northland, which are available on the Council website at the following link:

http://www.nrc.govt.nz/Environment/Weed-and-pest-control/Animal-pests/

Rabbit Calicivirus Disease (RCD) is present in Northland and adds a biological control option for managing rabbits. NRC has been involved with targeted releases of the virus in Northland. For the virus to be effective it is important that it released at the correct time and in the correct manner. For further information please contact Council biosecurity staff.

Monitoring

Twenty-five sites around Northland, of varying land uses and soil types, were initially sampled in 2001 as part of the national 500 Soils project. These 25 sites were resampled in June 2007 for chemical and physical properties including heavy metals.

For more detailed information on the results from the 2007 sampling refer to the detailed report (Stevenson 2007) available on the Council website at the following link:

http://www.nrc.govt.nz/Resource-Library-Summary/Research-and-reports/Land-and-soils/

Nutrient budgets and nutrient management

A nutrient management plan is a tool that can help land owners to utilise nutrients on the farm, effectively leading to an increase in both financial and environmental performance. One of the key components of a nutrient management plan is the nutrient budget for the property. Fertiliser companies and farm consultants are able to work with land owners to develop a nutrient budget for the property using the Overseer computer program developed by AgResearch. The computer program allows the modelling of fertiliser inputs and outputs for a number of different scenarios on a farm. It will identify where nutrient applications are above or below what is optimum for a given situation.

Use of a nutrient budget can lead to more efficient use of fertiliser resulting in less nutrient loss to waterways and greater farm profitability. The Cleans Streams Accord has encouraged all dairy farmers in the region to develop nutrient budgets for their properties. An increasing number of sheep and beef farmers are also starting to adopt nutrient budgets.

During the 2005-2006 the Council employed an independent consultant to audit the development and implementation of nutrient management plans prepared by fertiliser companies for farms within the Lake Omapere catchment. The findings were used to help the companies improve the standard of their service.

Earthworks workshops

The Regional Council has held eight erosion and sediment control workshops for developers, earthwork contractors and planners in 2006 and 2007. The aim of the workshops was to increase understanding on best management practices to reduce adverse effects on the environment from earthworks.

The workshops covered the erosion and sediment control standards required by the Resource Management Act and Regional Council plans, the skills needed to ensure staff and subcontractors meet these standards and how contractors can improve their site compliance record. Some of the many topics covered during the course include:

- the extent of sediment run off and erosion in Northland,
- what impact sediment has on the environment,
- dust nuisance and air quality,
- tactics and tools for dust, erosion and sediment control,
- legal requirements and potential penalties,
- and overall site management

So far approximately 200 people from 50 different companies/organisations have attended. Very positive feedback has been received from attendees and there is still significant interest from contractors who have not yet been able to attend due to courses being fully booked. More workshops will be held in the future as required.

Other responses

Envirolink research projects

The Envirolink scheme funds research organisations to provide regional councils with advice and support for research on identified environmental topics and projects.

The Northland Regional Council has initiated a number of Envirolink research projects that are associated with land use in Northland. Reports completed as part of the Envirolink scheme are available at the following government website:

http://www.envirolink.govt.nz/reports/index.htm

Northland Pastoral Farming Development Group

The Northland Pastoral Farming Development Group comprises representatives from the Council, pastoral farmers, service and supply companies and training providers. The group has a mandate to give effect to the pastoral farming component of Northland's strategy for sustainable economic development *Northland Forward Together - Kokiri Ngatahi Taitokerau.* The group is involved in a number of projects that centre on promoting research that is beneficial to pastoral production and promoting the dissemination of new and existing research material in a form useful to Northland farmers.

Environmental Landcare groups

There are currently more than 55 Landcare and community groups operating in Northland, many of which are involved in a range of biodiversity focused projects from small scale possum and pest insect control and plant pest eradication, to large ecosystem protection projects.

Regional Council Environment Fund

The Northland Regional Council's Environment Fund is a contestable fund that was established to assist land owners and community groups carry out work that assists with the protection or enhancement of indigenous biodiversity. Often this protection or enhancement work also has further benefits to landowners and the community, such as:

- increased pastoral productivity by retiring unsuitable pastoral land and improving grazing management on the farm,
- keeping stock out of waterways reducing the risk of stock getting waterborne diseases and parasites as well as the risk of stock getting stuck in waterways,
- stock exclusion, riparian planting and fencing off waterways thereby improving water quality which makes the water more suitable for stock drinking water use,
- the control of pest plants and animals reducing the damage and invasion of productive land
- increased land value through enhancing the natural appearance of properties.

Applications are accepted through an annual funding round; the fund will meet a percentage of the project costs of successful applications. A range of different projects are eligible for funding including pest and weed control, bush protection, riparian protection and enhancement, coastal protection and re-vegetation projects. Since 1996 $1.5 million has been allocated from the fund to various projects.

Soil monitoring workshops and kits

Visual Soil Assessment (VSA) is a means of monitoring soil quality that can be used in the field by landowners. VSA is based on the visual scoring of key bio-physical indicators of soil quality. The soil indicators are supported by plant 'performance' indicators that link soil condition to crop and pasture production. The system allows landowners to monitor changes that are occurring to the soil over time as well as getting a better understanding of how to visually assess the health of their soil.

Northland Regional Council has run, in conjunction with industry groups, VSA workshops for landowners throughout the region. The field guides and score sheets are currently being updated and reprinted. Once available the Council will run another series of workshops.

14.5 Where to from here?

Policy documents

The permitted activity rules in the Regional Water and Soil Plan for Northland do not specify or offer any guidance on good husbandry measures expected of land managers, such as planting potentially unstable areas on pastoral land with poplar and willow trees. The Council needs to look at options for addressing this, ideally that promote more involvement from the three district councils. Possible options include more education and promotion of soil conservation or the development of a soil conservation and erosion policy document. However, if the permitted activity rules continue to be inadequate then a review and plan change may be needed, which may lead to tighter rules on erosion prone land. For example, pastoral farming could become a controlled activity on erosion prone land.

A review of the Regional Pest Management Strategies will be undertaken during 2008-2009. This process will provide an opportunity for the public to have input on what pests should be considered, review control tactics and how new pest threats can be addressed.

Land use information

This chapter highlights that there is limited up-to-date information on land use within Northland. Currently the most recent land use data available for Northland is the Land Cover Database 2 (LCDB2) data that was created from satellite imagery captured over the 2001/2002 summer. Ministry for the Environment is the steward for the national land cover database, which it plans to maintain in a five yearly update cycle.

If this database is maintained as the Ministry initially intended, then an updated Land Cover Database based on 2007 satellite imagery should be available within a few years. Once this data is available the findings of this 2007 report that used LCDB1 and LCDB2 will be updated.

More information on the land cover database is available on the Ministry for the Environment's website at the following link:

http://www.mfe.govt.nz/issues/land/land-cover-dbase/index.html

There is also the option of using the LCDB in conjunction with other GIS databases such as AgriBase, which is a land use database created and maintained by AsureQuality. The Council will investigate this option further in the future.

Monitoring

The Council needs to consider increasing its routine monitoring of soil quality, so it can accurately measure trends in soil health throughout the region and assess whether land use activities are sustainable. This includes expanding the number of sites monitored in Northland to incorporate a greater regional spread, more soil types and greater sample sizes for the different land uses. This routine monitoring should be repeated at each site at least every five years.

The Council may also need to consider carrying out more site visits to assess whether land is being sustainably managed under its current land use. The LUC classification of Northland was an assessment made at the time of mapping. More frequent monitoring of soil health parameters will either confirm the original assessments or indicate a need for a review of the LUC classification, so that the classification is a better indicator of long term

sustainability.

The Council needs to improve its recording and reporting on the extent of unsustainable land management within Northland. This includes recording incidents of poor soil conservation and land management practices in a database, being more consistent with following up on these incidents and reporting on these on a regular basis. This will improve the amount and quality of information available for future reporting on the state of Northland's land and soil resources.

Education and promotion

The Council will continue to work with the Northland Pastoral Development Group to investigate ways to increase the amount of information from new research and to distribute current knowledge in a manner that makes it more available to the community and landowners.

The Council may also consider incentives to landowners for carrying out soil conservation work. One possible option is to establish an annual contestable fund for Northland, similar to the NRC Environment Fund that landowners can apply to for financial assistance to undertake soil conservation work

14.6 What can you do to help?

There are several ways you can help maintain and enhance soil quality and land resources in Northland.

On the farm:

- Exclude stock from waterways.

Where stock have direct access to streams, lakes and estuaries they cause damage in a number of ways, including fouling of the water, stirring up sediment and damaging stream banks and lake margins. Just erecting a temporary electric fence to keep stock out of the water can have major benefits.

A permanently fenced and planted riparian strip is more expensive and requires ongoing maintenance but will have additional benefits. Riparian plants provide shade that reduces water temperature, thus allowing the water to carry more oxygen. The shade also reduces the amount of weed and algae that will grow in the waterway and along the margins. A well designed and managed riparian margin can also help to capture nutrients before they enter the waterways. The plantings will also provide habitat for wildlife. It is important that plantings are well planned in terms of species selection and siting in order to prevent problems with stream bank collapse and blocking of waterways as the plants mature.

Further information is available in the booklets *Clean Streams* and *A Planters Handbook for Northland Natives* available from the Northland Regional Council. Land management staff at the Council are also able to give free advice.

- Develop a nutrient management plan for your property

A nutrient management plan can have both economic and environmental benefits. It includes a nutrient budget for the property but also looks at a range of other factors such as winter management, offal management, type and timing of fertiliser application and measuring fertility. Effective nutrient management will lead to improved financial returns as well as reduced loss of fertiliser to waterways through run-off and leaching.

Additional information on nutrient management plans is available from farm consultants and fertiliser company representatives.

- Develop a farm plan that helps to best match land use to capability.

The plan will highlight the suitability of various areas for particular land uses based on factors such as soil type and slope. The plan will also identify “hot spots”, such as waterways, wetland, seeps and steep sidings, where environmental protection efforts are best spent, the plan will also identify those areas best suited to further development. A nutrient management plan will be one important part of a whole farm plan.

- Plant trees to reduce erosion.

Erosion has negative impacts on both production and the wider environment. Sediment is the major pollutant of Northland waterways and loss of topsoil reduces the productive capacity of the land. Where pastoral farming is taking place on steep, erosion prone land then the use of suitable tree species can have multiple benefits. It is important to be aware that any plantings require ongoing maintenance in order to maximise long-term benefits.

Further information is available in the booklet *Trees for the Land* available from the Northland Regional Council. Land management staff at the Council are also able to give free advice.

- Attend industry monitor farm days.

Dairy NZ and Meat and Wool NZ both run regular workshops and field days throughout the region. These days provide a good opportunity to observe what is happening on other farms and receive up-to-date information on a range of subjects including pasture and soil management.

- Undertake regular weed and pest control.

It will help prevent the spread of undesirable species from one farm to another as well as preventing small problems escalating to large ones on your farm. The Northland Regional Council pest management strategies outline the situations where the landowner has a legal obligation to carry out control work.

Anyone can:

- Join a landcare group.

There are more than fifty landcare groups active in Northland. These community groups have been established by locals to provide solutions to local issues. A number of groups focus on pest and weed control, while others are based around managing production issues such as kikuyu management, clover root weevil and tropical grass webworm.

For more information contact New Zealand Landcare Trust or refer to their website: www.landcare.org.nz

- Report incidents of poor land management

Report incidents of poor soil conservation and land management that are having a detrimental effect on the environment to the Regional Council on 0800 002 004.

14.7 Case study 1: Lake Omapere integrated catchment management

The Lake Omapere Trustees (LOT) and the Northland Regional Council (NRC) received funding from the Ministry for the Environment's Sustainable Management Fund. This funding was provided to undertake a restoration and management project in regard to Lake Omapere from 2004 to 2006.

The project included the development and implementation of a voluntary lake management strategy that will work towards improving the health of Lake Omapere while re-establishing the role of the Lake Trustees as kaitiaki. The Lake Omapere Trust and Northland Regional Council's Chairman formally signed the 'Restoration and Management Strategy for Lake Omapere' on 29 September 2006, at a ceremony held at the Parawhenua Marae near the lake. The strategy incorporates aquatic weed management and integrated catchment management programmes, as well as biodiversity enhancement and regular monitoring of water quality.

The integrated catchment management included the development of farm management plans for farms in the lake catchment and encouraging and supporting fencing and plantings within the catchment.

Farm management plans

One of the activities being supported by the Council within the catchment of Lake Omapere is the preparation and implementation of farm management plans. The objective is to reduce the "loss" of nutrients from farming activities and the consequent impact of such nutrients on water quality within the lake. The plan includes detailed soil and slope maps and a nutrient budget (prepared by fertiliser companies).

Regional Council staff and Lake Omapere Trustees discussing land management with one of the catchment landowners (right).

In January 2006, 13 of the 19 farms which are in, or partly in, the Lake Omapere catchment had been mapped by Regional Council land management staff. This covers 93% of the surface water catchment area.

To ensure that the nutrient budgets meet the needs of the Council, the Council has, with the support of the fertiliser companies, agreed to audit the plans that have been prepared, the way farmers interpret the plans and how they are being implemented. An independent consultant employed by the Council visited four farmers during December 2005 to discuss their fertiliser programmes, to verify the information gathered by the fertiliser company representatives, to assess the farmer's understanding of the contents of the budgets and how he or she is using the budget.

Fencing

At January 2006, 41 km of fencing to exclude stock from waterways including the lake, has been undertaken within the catchment. Note that there is an error margin of approximately 10% due to most figures being calculated from aerial photography.

It has been calculated that a further 44 km of fencing is required to complete works to exclude stock from all waterways (including drains) and the lake margin. Of this 44 km, four landowners have committed to completing 4.8 km of fencing fully at their own cost. Of the remaining 39.2 km of fencing, 22.5 km is on one property.

At the end of 2006-2007 approximately 85% of the margin of Lake Omapere was fenced to exclude stock from the lake (NRC 2007 – Annual Report).

Seed collection and propagation

In order to maximise the success of planting undertaken on the lake margins, the plants will be grown from locally sourced seeds. A seed collection programme was undertaken for the following plants: toe toe, harakeke, totara, ti kouka, kahikatea, manuka, taraire, kauri, kuta, raupo and puriri.

A nursery on the lake edge was successfully completed, with the help of funding from the NRC Environmental Fund and the FNDC Significant Natural Areas Fund.

Currently plants are being propagated at this lakeside nursery and the Department of Conservation volunteer nursery in Kerikeri. The largest farm, which covers 20% of the catchment area, is developing its own nursery area for propagated plants for their planting programme.

Planting

Every year successful community days have been held with over 10,000 native trees and flaxes planted up to the end of 2006-2007 (NRC 2007 – Annual Report). There have also been significant contributions from Ngawha Correction Facility inmates, landowners and local schools.

Ongoing work

The aim is to have the entire lake margin protected with harakeke, raupo, kuta and *Carex secta*. This will mean ongoing stock exclusion from the lake margins and further planting in the future in between the areas planted in 2006 and 2007.

For more information on recent work carried out in the Lake Omapere catchment or the current state of the lake check out the following link on the Regional Council website:

http://www.nrc.govt.nz/Your-Council/Council-Projects/Lake-Omapere-Restoration-Project/

14.8 References

Clarke, A.D., Thacker, J., Barber, R.F. and Lyford, P.B. (1996). *Horticulture soils, economics and opportunities for the Far North: A resource management perspective.* Report produced for Far North District Council.

DOC. (2007). *Wild deer in Northland: Annual report – year 10.* Department of Conservation Internal Report.

Dymock, J. (2007). *A summary of Tropical Grass Webworm populations on the Aupouri Peninsula, Far North 1999 – 2007.* Report prepared for the Northland Regional Council. Available on the Regional Council website at the following link:

http://www.nrc.govt.nz/Resource-Library-Summary/Research-and-reports/Land-and-soils/

Esler, A. E.; Liefting, L. W. and Champion, P. D. (1993). *Biological success and weediness of the noxious plants of New Zealand.* Ministry of Agriculture and Fisheries, Wellington, New Zealand.

Everett, K.R. and Timudo-Torrevilla, O.E. (2006). *Reducing Copper use in avocado orchards: results of laboratory and postharvest testing of alternative fungicides and biological products.* New Zealand Avocado Grower's Association Annual Research Report Vol 6: 81 – 90. Available on the New Zealand Avocado Grower's Association website at the following link:

http://www.nzavocado.co.nz/2006%20Research%20Report/Reducing%20copper%20use%20in%20avocado%20orchards%20results%20of%20laboratory%20and%20postharvest%20testing%20of%20alternate%20fungicides%20and%20biological%20products.pdf

Gabzdylova, B., Raffensperger, J. F. and Castka, P. (2007). *Corporate Social Responsibility: Environmental Concern in New Zealand's Wine Industry.* Paper presented to Australian and New Zealand Marketing Academy Conference 2007. Available on the University of Otago website at the following link:

http://www.anzmac07.otago.ac.nz/anzmacCD/papers/B%20Gabzdylova_1a.pdf

Guernsey, S., Pearson, A. and Manktelow, D. (2004). *Inorganic agrichemicals: sustainable use in New Zealand horticultural industries.* Research report commissioned by Marie Dawkins Management Ltd on behalf of the horticultural industry groups participating in the SFF project. HortResearch Client Report No. 13290.

Harmsworth, G. R. (1994) *New Zealand Land Resource Inventory Land Use Capability Extended Legend of the Northland Region – 2nd Edition*, DSIR, Land Resources, Palmerston North.

Harmsworth, G.R. (1996) *Land Use Capability Classification of the Northland region.* Landcare Research Science series No. 9.

MED. (2006). *2006 Mining Production Statistics.* Available on the Ministry of Economic Developments' website at the following link:

http://www.crownminerals.govt.nz/cms/minerals/facts-and-figures

MAF (2005). *Sheep and beef monitoring report.* Published by the Ministry of Agriculture and Forestry. Available on the Ministry of Agriculture and Forestry website at the following link:

http://www.maf.govt.nz/mafnet/rural-nz/statistics-and-forecasts/farm-monitoring/

MAF. (2007). *Summary of risks from cadmium in agricultural soils: The Cadmium Working Group's Summary report one.* Published by the Ministry of Agriculture and Fisheries. Available on the Ministry of Agriculture and Fisheries website at the following link:

http://www.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/land-management/cadmium-in-nz/risks/index.htm

MFE. (2006). *The Dairying and Clean Stream Accord: Snapshot of progress – 2004/2005.* Report published by Ministry for the Environment, May 2006. Available on Ministry for the Environment's website at the following link:

http://www.mfe.govt.nz/publications/land/dairying-clean-streams-snapshot-may06/index.html

MFE. (2007). Environment New Zealand 2007. Published by Ministry for the Environment, Wellington. Available on the Ministry for the Environment's website at the following link:

http://www.mfe.govt.nz/state/reporting/enz-07.html

NRC. (2002). *Regional Policy Statement for Northland.* Produced by the Northland Regional Council. Whangarei: New Zealand. Latest version available on the Regional Council's website at the following link:

http://www.nrc.govt.nz/Resource-Library-Summary/Plans-and-Policies/Regional-Policy-Statement/Regional-Policy-Statement/

NRC. (2003). *Regional Pest Management Strategy for Northland.* Produced by the Northland Regional Council. Latest version available on the Regional Council's website at the following link:

http://www.nrc.govt.nz/Resource-Library-Summary/Plans-and-Policies/Pest-management/Northland-Pest-Management-Strategies/

NRC. (2007). Annual Report. Available on the Regional Council's website at the following link:

http://www.nrc.govt.nz/Resource-Library-Summary/Plans-and-Policies/Annual-Report/Annual-Report-2007/

NRC. (2007). *Regional Water and Soil Plan for Northland.* Produced by the Northland Regional Council. Whangarei: New Zealand. Latest version and current plan changes are available on the Regional Council's website at the following link:

http://www.nrc.govt.nz/Resource-Library-Summary/Plans-and-Policies/Regional-plans/Regional-Water-and-Soil-Plan/

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

Statistics NZ (2006). *Fertiliser Use in New Zealand.* Report published by Statistics New Zealand and available on their website at the following link:

http://www.stats.govt.nz/NR/rdonlyres/F8C0A446-864C-4AB1-B2C0-B095EC20F1F4/0/FertiliserUseandtheEnvironmentAug06.pdf

Statistics NZ (2002). *Agriculture Production Statistics.* Available on Statistics New Zealand website at the following link:

http://www.stats.govt.nz/products-and-services/info-releases/ag-prod-stats-info-releases.htm

Stevenson, Bryan. (2007). *Soil quality in Northland 2007: comparison with previous samplings in 2001.* Report produced for Northland Regional Council by Landcare Research. Available on the Regional Council website at the following link:

http://www.nrc.govt.nz/Resource-Library-Summary/Research-and-reports/Land-and-soils/

Sweetapple, P. J. (2006). Costs of deer in Northland. Report prepared for Northland Regional Council by Landcare Research. Envirolink funded report, contract number 128-NLRC5. Available on the Envirolink website at the following link:

http://www.envirolink.govt.nz/reports/index.htm

Taylor, M., Gibb, R., Willoughby, J., Hewitt, A. and Arnold, G. (2007). *Soil maps of cadmium in New Zealand.* Report published by Landcare Research. Available on the Ministry of Agriculture and Fisheries website at the following link:

http://www.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/land-management/cadmium-in-nz/maps/index.htm

Ussher, G. (2004). Managing soils on beef farms in Northland. Final report prepared on behalf of Northland Beef Farming Group for Sustainable Farming Fund project 01/148. Final report available on the Ministry of Agriculture and Forestry's website at the following link:

http://www.maf.govt.nz/sff/about-projects/search/01-148/final-report-01148.pdf

WDC. (2007). *State of the Environment Report: Development Trends. Report* published by Whangarei District Council. Available on the District Council's website at the following link:

http://www.wdc.govt.nz/customerservice/?lc=reader&m=tssd&i=3754

14.9 Appendix A: Soil characteristics of sites sampled in 2007

Table 9: Chemical characteristics of soil samples collected in 2007. Note results shown in bold are outside the recommended ranges for land use.

Site	Soil and land use	pH	Total C mg/cm^3	Total N mg/cm^3	C:N ratio	Olsen P µg/cm^3	NH_4-N µg/cm^3	NO_3-N µg/cm^3	Mineralisable N µg/cm^3
NRC00_1	Marua clay, drystock	5.43	60.9	5.9	10.4	25	40.9	29.0	144
NRC00_2	Marua clay, drystock	5.69	59.3	5.1	11.7	16	0.5	17.7	157
NRC00_3	Marua clay, drystock	5.32	66.6	5.8	11.5	52	13.6	18.2	162
NRC00_4	Waiotira clay, dairy	6.15	72.2	6.0	12.0	82	51.1	17.5	142
NRC00_5	Waiotira clay, dairy, irrigated	6.19	63.5	5.6	11.3	43	42.8	13.6	141
NRC00_6	Waiotira clay, indigenous forest	5.28	60.6	3.7	16.5	9	44.4	18.2	134
NRC00_7	Waiotira clay loam, drystock	6.49	65.8	5.8	11.4	**12**	44.0	18.5	138
NRC00_8	Waiotira clay loam, pines	5.07	57.6	3.4	17.2	16	5.0	16.1	47
NRC00_9	Waiotira clay, drystock	5.64	48.9	3.8	12.9	**8**	25.7	29.3	92
NRC00_10	Red Hill sandy loam, drystock	**7.20**	50.4	3.8	13.2	40	20.7	21.2	**41**
NRC00_11	Red Hill sandy loam, pines	6.36	40.6	2.2	18.2	6	0.9	14.5	55
NRC00_12	Red Hill loamy sand, dairy	6.09	50.9	5.0	10.2	56	64.8	24.5	101
NRC00_13	Red Hill loamy sand, drystock	5.77	59.7	5.1	11.6	**13**	42.2	34.3	108
NRC00_14	Wharekohe silt loam, dairy	**4.85**	57.2	4.6	12.5	58	107.5	35.9	116
NRC00_15	Wharekohe silt loam, dairy	**4.90**	51.0	4.3	11.7	56	83.7	27.3	110
NRC00_16	Wharekohe silt loam, pines	4.46	63.2	4.0	15.9	8	0.6	25.8	50
NRC00_17	Marua clay loam, pines	4.97	54.5	3.0	18.2	24	9.3	35.6	66
NRC00_18	Marua clay loam, indigenous forest	4.64	58.0	3.0	19.2	13	1.9	35.6	44
NRC00_19	Awarua clay loam, dairy	5.78	83.0	6.2	13.4	16	38.9	27.4	142
NRC00_20	Awarua clay loam, indigenous forest	4.84	99.5	5.2	19.1	7	12.0	36.7	132
NRC00_21	Awarua clay loam, dairy, irrigated	6.28	73.3	6.1	12.0	35	59.8	33.0	154
NRC00_22	Awarua clay loam, pines	4.98	80.0	3.4	23.7	18	0.0	37.1	90
NRC00_23	Kiripaka bouldery clay loam, drystock	5.53	75.0	6.8	11.1	45	68.0	16.6	164
NRC00_24	Kiripaka bouldery clay loam, indigenous	**6.48**	84.1	5.7	14.7	7	28.1	12.8	174
NRC00_25	Kiripaka bouldery clay loam, orchard	6.07	61.4	5.2	11.9	74	39.3	18.6	137

Table 10: Physical characteristics of soil samples collected in 2007. Note results shown in bold are outside the recommended ranges for land use.

Site	Soil and land use	Bulk density Mg m^3	Particle density Mg/m^3	Total porosity %v/v	Macro porosity %v/v	Moisture content @ -5 kPa %v/v	Moisture content @ -10 kPa %v/v
NRC00_1	Marua clay, drystock	0.84	2.44	65.7	12.4	53.3	51.6
NRC00_2	Marua clay, drystock	1.00	2.49	59.9	**9.2**	50.7	48.9
NRC00_3	Marua clay, drystock	1.02	2.51	59.4	**8.0**	51.4	49.6
NRC00_4	Waiotira clay, dairy	1.05	2.48	57.7	**4.2**	53.6	52.5
NRC00_5	Waiotira clay, dairy, irrigated	0.89	2.46	63.6	**6.2**	57.4	55.9
NRC00_6	Waiotira clay, indigenous forest	1.10	2.59	57.5	**6.9**	50.6	49.3
NRC00_7	Waiotira clay loam, drystock	0.88	2.49	64.6	12.2	52.4	50.9
NRC00_8	Waiotira clay loam, pines	0.94	2.47	62.4	22.9	39.5	38.6
NRC00_9	Waiotira clay, drystock	0.93	2.49	62.8	**7.6**	55.2	52.9
NRC00_10	Red Hill sandy loam, drystock	1.22	2.60	53.0	**5.2**	47.8	44.7
NRC00_11	Red Hill sandy loam, pines	0.80	2.56	68.9	**30.5**	38.4	30.8
NRC00_12	Red Hill loamy sand, dairy	1.04	2.54	59.2	**3.1**	56.1	53.9
NRC00_13	Red Hill loamy sand, drystock	0.86	2.50	65.7	13.9	51.9	46.1
NRC00_14	Wharekohe silt loam, dairy	0.79	2.40	67.0	10.7	56.3	53.7
NRC00_15	Wharekohe silt loam, dairy	0.73	2.36	69.0	**4.5**	64.5	61.6
NRC00_16	Wharekohe silt loam, pines	1.00	2.53	60.5	23.8	36.6	35.7
NRC00_17	Marua clay loam, pines	0.96	2.52	62.0	22.0	40.0	38.3
NRC00_18	Marua clay loam, indigenous forest	0.91	2.54	64.2	15.8	48.4	47.2
NRC00_19	Awarua clay loam, dairy	0.78	2.51	68.9	**7.7**	61.3	59.7
NRC00_20	Awarua clay loam, indigenous forest	0.80	2.62	69.6	12.0	57.6	56.2
NRC00_21	Awarua clay loam, dairy, irrigated	0.88	2.57	65.9	**7.7**	58.2	56.4
NRC00_22	Awarua clay loam, pines	0.84	2.69	68.8	14.3	54.5	53.4
NRC00_23	Kiripaka bouldery clay loam, drystock	0.94	2.49	62.2	10.1	52.1	50.3
NRC00_24	Kiripaka bouldery clay loam, indigenous	0.68	2.48	72.5	27.7	44.8	42.1
NRC00_25	Kiripaka bouldery clay loam, orchard	1.00	2.62	61.9	10.4	51.5	49.7

Table 11: Heavy metal concentrations in soil samples collected in 2007. * For means and standard deviations, values below detection limit (<0.5) were assumed to be ½ that of detection limit (0.25 mg/kg).

Site	Land use and soil class	As mg/kg	Cd mg/kg	Cr mg/kg	Co mg/kg	Cu mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
NRC00_4	Dairy, Brown	<0.5	<0.5	29.7	6.1	17.6	10.2	3.0	41.2
NRC00_5	Dairy, Brown	<0.5	<0.5	25.6	4.7	15.6	8.3	3.2	41.0
NRC00_12	Dairy, Allophanic	5.1	<0.5	15.2	4.6	6.1	8.4	3.5	49.9
NRC00_14	Dairy, Ultic	<0.5	<0.5	8.6	0.2	5.4	1.7	3.2	18.3
NRC00_15	Dairy, Ultic	<0.5	<0.5	8.5	1.1	10.6	3.6	21.4	29.4
NRC00_19	Dairy, Granular	<0.5	<0.5	58.8	11.2	30.1	32.7	0.9	43.9
NRC00_21	Dairy, Granular	<0.5	<0.5	47.1	11.2	31.6	27.1	1.7	133
	Mean ± 1SD	0.9±1.8	0.3±0.0	27.6±19.3	5.6±4.4	16.7±10.7	13.1±11.9	5.3±7.2	51.0±37.7
NRC00_1	Drystock, Granular	<0.5	<0.5	13.1	6.4	16.4	12.4	9.3	45.8
NRC00_2	Drystock, Granular	<0.5	<0.5	17.0	7.6	18.3	13.0	12.1	55.1
NRC00_3	Drystock, Brown	<0.5	<0.5	14.0	5.5	8.4	9.9	9.3	28.8
NRC00_7	Drystock, Brown	<0.5	<0.5	35.2	4.5	23.5	16.0	6.6	46.2
NRC00_9	Drystock, Brown	<0.5	<0.5	14.1	2.6	8.1	5.9	5.0	23.5
NRC00_10	Drystock, Allophanic	5.6	<0.5	16.0	5.1	7.9	8.7	3.9	31.2
NRC00_13	Drystock, Allophanic	10.5	<0.5	14.0	4.4	9.5	8.6	3.6	37.7
NRC00_23	Drystock, Allophanic	<0.5	<0.5	69.2	22.4	45.7	50.1	12.1	108
	Mean ± 1SD	2.2±3.8	0.3±0.0	24.1±19.6	7.3±6.3	17.2±12.9	15.6±14.3	7.7±3.5	47.0±26.7
NRC00_8	Plantation Forestry, Brown	<0.5	<0.5	14.2	3.2	9.4	7.4	6.7	30.0
NRC00_11	Plantation Forestry, Allophanic	5.7	<0.5	13.0	5.8	17.1	11.0	8.0	53.5
NRC00_16	Plantation Forestry, Ultic	<0.5	<0.5	5.7	1.6	5.3	3.6	3.6	9.2
NRC00_17	Plantation Forestry, Brown	12	<0.5	15.4	3.9	5.7	8.9	9.8	24.5
NRC00_22	Plantation Forestry, Granular	<0.5	<0.5	144.0	13.4	27.6	37.5	2.7	49.7
	Mean ± 1SD	3.6±5.1	0.3±0.0	38.5±59.1	5.6±4.6	13.0±9.4	13.7±13.6	6.2±3.0	33.4±18.4
NRC00_6	Indigenous, Brown	<0.5	<0.5	17.5	9.2	21.2	11.5	8.4	58.6
NRC00_18	Indigenous, Brown	<0.5	<0.5	11.8	5.0	11.3	9.5	9.5	29.5
NRC00_20	Indigenous, Granular	<0.5	<0.5	61.1	25.5	45.0	43.7	0.1	59.7
NRC00_24	Indigenous, Allophanic	<0.5	<0.5	73.2	27.3	41.9	46.0	11.1	91.2
	Mean ± 1SD	0.3±0.0	0.3±0.0	40.9±30.8	16.7±11.3	29.8±16.3	27.7±19.9	7.3±4.9	59.8±25.2
NRC00_25	Crop/Hort, Allophanic	<0.5	<0.5	67.8	27.9	102	40.3	11.9	80.5