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Ranking of Auckland Soils' Susceptibility to Degradation

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Reviewed by:

Name: Amy Taylor

Position: Project Leader Land

Organisation: ARC

Date: 1/04/09

Approved for ARC Publication by:

Name: Grant Barnes

Position: Group Manager Monitoring & Research

Organisation: ARC

Date: 1/04/09

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Ranking of Auckland Soils' Susceptibility to Degradation

D. L. Hicks

Prepared for
Auckland Regional Council

By
Ecological Research Associates
Box 170, Orewa

Contents

1 Introduction

These rankings have been prepared to help ARC Environment design its environmental monitoring programme in a way that is consistent with Section 35 of the Resource Management Act. S35(2) states:

Every local authority shall monitor:

(a) the state of the whole or any part of the environment of its region or district to the extent that is appropriate to enable the local authority to effectively carry out its functions under this Act; and

(b) The suitability and effectiveness of any policy statement or plan for its region or district; and

(c) The exercise of any functions, powers or duties delegated or transferred by it; and

(d) The exercise of the resource consents that have effect in its region or district, as the case may be –

(e) and take appropriate action (having regard to the methods available to it under this Act) where this is shown to be necessary.

2 Background

A scoping paper commissioned by ARC Environment ("Monitoring sustainability of soil resources: an approach for Auckland", Hicks 1994) has suggested that the Council could meet its RMA monitoring responsibilities with respect to soils and land use, by adopting a soils-based approach. This would entail identifying areas of land where issues of soil use arise and result in adverse environmental effects, as opposed to other areas where they do not. A soils-based approach would have four stages:

1. Define issues of soil use, soil degradation, and consequential adverse environmental effects.
2. Delineate areas of land within the region, where issues of soil use could arise.
3. Identify the soils that are susceptible to adverse effects from use, and where sustainability of the soil resource could be threatened by adverse effects (n.b. the two are not the same).
4. Identify current location of uses likely to cause degradation, to an extent that adverse effects threaten sustainability of the resource.

ARC Environment staff have indicated in subsequent discussions that:

- Stage 1 is being addressed by the draft Regional Policy Statement, and any plans prepared pursuant to it e.g. sediment control,
- Stage 2 is being addressed by the district planning process. Rural land use zones from the relevant maps can probably be extracted and input to ARC's geographic information system by Council staff, if need be assisted by temporary workers.
- Stage 3 is the current priority, and is seen as a pre-requisite for any monitoring of soil, relative to land use and its off-site effects in the region.
- Stage 4 is the next priority, but will be deferred until an arrangement is reached with other ARC sections (and possibly territorial local authorities) about sharing the cost of satellite images or aerial photographs.

This report, together with appended tables (and maps to be commissioned) constitutes ARC Environment's implementation of Stage 3.

3 Progress

A shortlist of land uses in the Auckland region, likely to cause degradation if they are practised on susceptible soils, has been prepared by D. Hicks of Ecological Research Associates in consultation with ARC Environment's soil conservator H. Moodie (Table 1). It is based on issues identified in Chapter 13 (Soil Conservation) of ARC Environment's Regional Policy Statement (1994).

Auckland soils that are susceptible to the three main types of degradation i.e. structural breakdown, nutrient loss and erosion have been provisionally identified by D. Hicks, consulting soil maps and publications listed in the scoping paper. Information has been examined for individual soils, and summarised as rankings indicating low, moderate or high susceptibility (Appendices 1 to 3). These identifications have been verified independently by two recognised experts in soil physics and chemistry, G. Shepherd and R. Parfitt of Landcare Research. While confirming many rankings, in some instances they have assigned a higher or dual ranking. Very few rankings have been lowered.

Table 1 Short-list of land uses likely to cause degradation on susceptible soils, Auckland region

Structural breakdown	
Horticulture (market gardens, orchards, vineyards)	Partic. on heavy soils
Continuous cropping (grain or fodder)	Partic. on heavy soils
Intensive livestock grazing (dairy farming)	Partic. on heavy or poorly drained soils
Extensive livestock grazing (beef, sheep, deer, goats)	Poorly drained soils, and stream margins
Timber harvest (plantation forest)	Access tracks and stream margins
Nutrient loss in course of primary production	
Horticulture (market gardens, orchards, vineyards)	Partic. on permeable soils
Continuous cropping (grain or fodder)	Partic. on permeable soils
Intensive livestock grazing (dairy farming)	Partic. on permeable soils, and watercourse margins
Erosion	
Horticulture (market gardens, orchards, vineyards)	Heavy soils prone to surface erosion
Continuous cropping (grain or fodder)	Heavy soils prone to surface erosion
Intensive livestock grazing (dairy farming)	Heavy soils prone to surface erosion or gullies when over-grazed
Extensive livestock grazing (beef, sheep, deer, goats)	Mass movement erosion on steep land; wind erosion on sand soils
Timber harvest (plantation forest)	Surface erosion and gullying, partic. access tracks and stream margins

4 Further development

The rankings could be supplemented by adding any data that is available on soil properties relevant to degradation; by tabulating areas of each soil; and by producing maps that show location and extent of soils at risk.

Data for Auckland soils can be produced by asking Landcare Research to supply print-outs from its National Soils Database. However the NSD is not in a condition to supply a consistent body of data (H.Wilde and M. McLeod, pers. comms.) Of some 100 soils mapped in the Auckland region, 47 have profile descriptions in the database. Many of these are for sites outside the region's boundary. All 47 have chemical data recorded, but few have data about physical structure or mineralogy. Most of the analytical data has already been tabulated in published reports and papers. In short, data from the NSD is unlikely to be a useful addition.

Tabulated areas of soil are given (by numeric code and old county boundary) in a published Soil Bureau report (Roberts and Jarman 1979). Decoded and totalled, these can give a close approximation to areas of each soil present in rural areas within the current ARC boundary. As an extra column in Appendices 1 to 3, they could enable areas subject to a similar risk of degradation to be quickly added, for any desired combination of land use and degradation type (this is being done as part of the current contract).

A set of base maps, showing Auckland soils at standard scale, can be produced a number of ways. 1:125,000 soil maps commissioned by ARA from DSIR Soil Bureau in 1981 could be digitised (Option A). These already contain region–wide boundaries, reduced from unpublished 1:63,360 and 1:25,000 maps. Alternatively 1:50,000 soil maps could be generated from boundaries of NZLRI map units already stored in ARC's geographic information system (Option B). A third possibility would be to commission Landcare Research to supply a digital map at standard scale, by amalgamating various published and unpublished soil maps (Option C). Any of these options can provide maps that satisfactorily depict location and extent of soils susceptible to degradation. Which proceeds, will depend on cost (presently being evaluated by ARC staff).

5 Sources of data and their interpretation

The sources of information previously available to ARC Environment have been rankings of soils' suitability for food production, or soils' limitations for various land uses, in various published and unpublished reports produced by NZ Soil Bureau or Water and Soil Division, MWD in the 1970s-1980s (see references).

These documents were used to compile preliminary rankings. Quite a number of changes were made in the light of more recent information, again from a mix of published and unpublished sources (see references). Comments on the utility of sources, and how they have been interpreted, are offered below.

5.1 Structural breakdown

Rankings of Rodney County soils' limitations for cropping, horticulture, grazing and forestry are contained in an unpublished Soil Bureau report by J.E. Cox and A.W Wilson (c. 1979). The rankings can be cross-referenced with the 1:100,000 Soil Map of Northland. They are alphanumeric in form i.e. 1 denotes slight limitation, 2 moderate and 3 severe; while a, b, etc. denote the nature of limitation (drainage, slope, nutrient, structure). The structural suffix can be used to identify soils at risk of breakdown in the event of poor management. However it must be interpreted with reference to profile descriptions, as on some soils it may indicate structural problems unrelated to management e.g. excessive permeability, stoniness.

Rankings of Franklin County soils' versatility for food production in a published Soil Bureau Report by G. Orbell (1977) offer similar guidance about structural limitations, and can be cross-referenced with the 1:63,360 Soil Map of Franklin County. The Franklin rankings are alphanumeric, similar to (but not the same as) those for Rodney. With care, they can be differentiated according to land use, by cross-reference with an unpublished MAF report on horticultural potential of Auckland soils (1983). The latter contains maps identifying horticultural (i.e. vegetable production, orchards and vineyards), arable (i.e. field crop) and non-arable soils. Soil boundaries on these maps are reduced from the 1:63,360 NZ Land Resource Inventory.

An unpublished report accompanying the 1:20,000 Manukau map (Purdie et al 1981) contains tables identifying the principal structural limitation of each Manukau soil for cropping, horticulture, and grazing. Limitations are denoted by complex alphanumeric rankings which can on àly be deciphered by cross-referencing four sets of tables. It is simpler to apply the Franklin rankings to the Manukau soils (most of the soil types are common, and the few which are not, can be correlated).

Rankings of susceptibility to structural breakdown, for lowland soils depicted on the 1:1,000,000 Soil Map of New Zealand, were compiled by G. Shepherd and D. Hicks for MAF Policy in 1994. These enable a check on rankings for cropping, horticulture and grazing, for most of the lowland soil types named in the older maps and reports.

With reference to this, and unpublished data held by G. Shepherd, the old alphanumeric rankings (1a, 2b, etc.) have been converted to rankings of low, moderate or high requirement for soil management to avoid structural breakdown. These terms are essentially the same as used by Shepherd and Hicks (1994). Apart from being descriptive, they also convey that:

- The rankings are relative, not quantitative. Alphanumeric rankings can give the impression of measurements - which they are not.
- Structural breakdown is not automatic, even if a soil is highly susceptible. Breakdown is a consequence of excessive cultivation, inappropriate machinery or injudicious timing.
- Even on a highly susceptible soil, breakdown can be avoided by good management. Where it has already occurred, it can also be rectified by management.

5.2 Soil nutrient loss

In any soil, the nutrients essential for plant growth are present in different quantities. They are released in plant-available form at different rates, taken up by plants at variable rates depending on time of year, and partly returned to the soil as litter, crop residue or animal dung and urine. Returned nutrients can be immobilised, leached to water bodies, or released to the air. Rating a soil's susceptibility to nutrient loss is, therefore, conceptually difficult.

For this reason, the Soil Bureau rankings of Rodney and Franklin soils' suitability for food production, or their limitations to use, do not provide a great deal of guidance. They clearly identify a few high-fertility soils where no nutrient deficiency is likely (though these identifications assume regular application of fertiliser containing the principal plant nutrients N, P, S, K, Mg and Ca, to compensate for losses in harvested plant or animal produce). Likewise they identify a few low-fertility soils where one or more of these nutrients is so grossly deficient that it is unlikely to be remedied by fertilisation at an economic level. For most Auckland soils, rankings as 1, 2 or 3 at best indicate whether natural fertility is high, medium or low. They simply do not identify the extent ¬ to which specific nutrient deficiencies are likely to arise if various land uses are practised.

The approach adopted for ARC Environment's new rankings has been to avoid implying that loss of one or more nutrients is a "risk" or a "bad thing". The reality is that there will be losses, which can be rectified by fertilisation. Whether the level of fertilisation a particular soil requires is economic, will determine whether the use, and the plant-available nutrient supply, can be sustained. Accordingly soils have been ranked as having a low, moderate or high fertiliser requirement for maintaining plant-available nutrient supply under pasture, plantation forest, field crops or horticulture respectively. A soil with a high fertiliser requirement under a particular use can be regarded as highly susceptible to depletion of one or more plant nutrients, in the absence of regular fertilisation.

Rankings for pasture have been made by checking fertiliser recommendations for Auckland soils discussed in During's publication "Soils and Fertilisers in New Zealand Farming", Second Edition 1984. They can be extended to similar soils not discussed by During, by cross-reference to an unpublished correlation of northern soils by Taylor et al (1952), and to Orbell's (1977) legend of

South Auckland soils. These are based on parent material and degree of weathering, so are good guides to nutrient status after prolonged weathering, likelihood of nutrient immobilisation, and hence availability of nutrients in soil solution. For soils on flat to rolling land, two rankings are generally given. The higher indicates maintenance fertiliser requirement for dairying, and the lower, for beef and sheep grazing.

Rankings for plantation forestry have been made by referring to fertiliser recommendations for radiata pine on broad groups of soils, contained in the FRI Bulletins by Will et al (1985) and Hunter et al (1991). Auckland soils in each group have been identified by cross-referencing with Taylor's soil correlation chart and Orbell's legend. The small-scale maps in Hunter et al (1991) are sufficiently detailed to be a useful check on rankings, for many soil types that are extensive in area. It should be noted that forestry rankings are comparable with agricultural rankings as single applications. Over a thirty year forest rotation, repeat applications will only be required once or twice cf. pasture applications (every 1 to 3 years) or cropping/horticulture applications (annual or even bi-annual). On a long time scale, the maintenance fertiliser requirements of all soils could be ranked as low under forest.

Rankings for field crops were initially made by assuming that soils identified as 1(few limitations for cropping) in the Soil Bureau reports have a low requirement for fertiliser to maintain enough plant-available nutrients for field cropping. Soils identified as 2 (moderate limitations) were assumed to have a moderate requirement; while soils identified as 3 (severe limitations) were assumed to have a high maintenance fertiliser requirement. These assumptions correspond fairly well with published data about natural nutrient status of the soils e.g. tables in Soil Bureau Bulletins 5(1952) and 26(1968). Under cropping, actual levels of fertiliser application to these soils appear fairly uniform (R. Parfitt, pers. comm). All rankings for cultivable soils were therefore changed to moderate, on the grounds that farmers' current applications indicate the level of fertilisation required to maintain crop yields.

Rankings for horticulture were similarly made by assuming that soils identified as 1 (few limitations to horticulture), 2 (moderate limitations) and 3 (severe limitations) in the Soil Bureau reports have low, moderate and high requirements for fertiliser to maintain the plant nutrients needed for market gardening or orchards. Again, this accords approximately with natural nutrient status of soils recorded in Bulletins 5 and 27. However, actual applications of fertiliser are high under horticultural use, and do not appear to be differentiated by soil type (R. Parfitt, pers. comm). Accordingly all rankings for cultivable soils were changed to high.

The uniform ranking of soils' fertiliser requirements as moderate under cropping, and high under horticulture, undoubtedly masks some soils where lower applications could sustain these uses (albeit at lower yields per hectare). The rankings should therefore be taken as indicating the levels of application that are required to maintain plant-available nutrients at current intensities/yields.

5.3 Erosion risk

The principal sources of information have been the Land Resource Inventories of Northland and South Auckland-Waikato (1st and 2nd editions).

Arable soils, including soils marginal for cultivation, have been ranked as being at low, moderate or high risk of surface erosion under cropping, horticulture, grazing and forestry. "Surface erosion" covers sheetwash and rilling, also windblow on sand soils.

Non-arable soils i.e. hill and steepland phases have been similarly ranked for risk of either surface erosion or mass movement. "Mass movement" covers soil slips, earth slips, earthflows and subsoil gullies. Rankings indicate the higher of the two risks; generally mass movement, as surface erosion is a slight risk on most of these soils so long as dense grass or tree cover is maintained. Exceptions are podsols and sand soils; two non-arable soil groups on flat to rolling land. Here the rankings indicate surface erosion risk.

A single ranking for each soil should suffice, bearing in mind that it denotes surface erosion risk on arable soils/flat to rolling non-arable land; and mass movement erosion on hill/steepland soils. Specifying risks separately for individual erosion types, while useful when planning soil conservation measures on a farm, would be excessively complex for S35 monitoring region-wide.

Cropping and horticulture rankings are based on actual erosion types recorded on maps, and potential erosion severity if cultivated, as described in the relevant land use capability legend. The horticulture ranking is appropriate for market gardening, but not for orchards or vineyards with grass ground cover. Here, the rankings for pasture are probably more appropriate.

Pasture rankings are similarly based on actual erosion types and potential erosion severity; if pasture is depleted by drought or excessive grazing on lowland soils; and if it is subject to heavy rain or prolonged wet weather on hill and steepland soils.

For forestry, the extended legends do not offer other than very generalised statements that potential erosion under pasture may be reduced by conversion of Class 6 or 7 land to trees. Forestry rankings have been made by assuming firstly that if the risk under pasture is low, it is low under trees also; secondly that if the risk under pasture is moderate, it is low under trees; thirdly that if the risk under pasture is high, then it is moderate under tree cover. Except that under plantation or native forest, erosion recorded on NZLRI maps is generally absent or slight to moderate, these assumptions are unsupported by field data collected for specific soils in the Auckland region. However they are consistent with comparative surveys of mass movement erosion under different land uses at a number of sites in the North Island (see summary by Clough and Hicks 1993).

6 Priority soils for monitoring

To aid prioritisation, Auckland soils have been divided into four categories: lowland soils under intensive use (I), lowland soils under low-intensity use (L), hill soils (H) and steepland soils (S). Within each category, soils have been grouped according to their susceptibility to different kinds of degradation, as indicated by Appendices 1 to 3 for various present or potential land uses. Statements attached to each group indicate specific uses, under which the risk of a particular kind of degradation is high, and the kinds of soil management needed to counteract it.

I3, L3, H3 and S3 soils are at risk from physical erosion, structural breakdown and nutrient loss, under most of the land uses that are practised on these soils. Risks are generally high for all three forms of degradation. The intensively used I3 and H3 categories in particular are the highest priority for checking if land uses likely to ¨ cause degradation are being practised, for monitoring soil condition where they are, and for encouraging landowners to implement management techniques which can control degradation.

I2, L2, H2 and S2 soils are at risk under fewer of the uses that are likely to be practised. There are high risks of structural breakdown and nutrient loss; physical erosion is also possible but the risk is low to moderate. While degradation is less likely on these soils, it may be of concern particularly on the productive I2 and H2 categories.

I1 and H1 soils are at risk under intensive uses. The risk of nutrient loss is high, but only if they do not receive adequate maintenance fertiliser to replace what is removed in produce. Risks of structural breakdown or physical erosion while possible are low to moderate. The I1 and H1 categories are least likely to cause concern as regards on-site degradation of soil's productive capacity. -

7 Groups

I: lowland soils under intensive uses e.g. vegetable crops, grain crops, orchards, vineyards, dairying or intensive sheep and beef cattle fattening.

Group I1a 42,794 hectares

Arable soils with few limitations to any use, but which require adequate maintenance fertiliser to avoid nutrient loss, when in vegetable crops, grain crops, or intensively grazed pasture.

Otao	470
Hobsonville	3939
Karaka	18954
Mauku	inc. in Karaka
Flat Bush	2361
Papatoetoe	1844
Weymouth	1967
Orere	1747
Pollok	799
Patumahoe	10600
Pukekohe	inc. in Patumahoe
Helvetia	inc. in Patumahoe
Onewhero	inc. in Patumahoe
Kapu	113

Group I1b 16,119 hectares

Arable soils with limitations for vegetable cropping, orchards and vineyards, but few limitations to other intensive uses such as grain crops or intensively grazed pasture. Require adequate maintenance fertiliser to avoid nutrient loss under these uses.

Whakapara	10821
Mangakahia	439
Whareora	1474
Otonga	910
Ardmore	2322
Piako	inc. in Kaipaki
Kaipaki	153

Group I2a 24,515 hectares

As for I1a. Also require care in timing and nature of cultivation to avoid structural breakdown, and soil conservation practices to control surface erosion, when in vegetable or grain crops. Additionally require care in timing and duration of grazing, to avoid structural breakdown when intensively grazed pasture.

Waitemata	11647
Koheroa	inc. in Torehape
Torehape	2094
Waipuna	322
Albany	inc. in Waitemata
Coatesville	inc. in Waitemata
Hamilton	3711
Bombay	224
Pukekapia	inc. in Hamilton
Ararimu	3349
Hunua	1282
Opita	238
Matakawau	1648

Group I2b 9,500 hectares

As for I1b. Also require care in timing and nature of cultivation to avoid structural breakdown, and soil conservation practices to control surface erosion, when in grain crops. Additionally require care in timing and duration of grazing, to avoid structural breakdown when intensively grazed pasture.

Waipu	2526
Kaipara	4305
Clevedon	2669
Hauraki	inc. in Clevedon

Group I3a 10,129 hectares

As for I2a. Also require soil conservation practices to control wind erosion if in vegetable, grain or fodder crops; and care in pasture management to control wind erosion if grazed.

Houhora	468
Red Hill	9661

Group I3b 2,446 hectares

As for I2b. Also require soil conservation practices to control wind erosion if in grain or fodder crops; and care in pasture management to control wind erosion if grazed.

Horea	307
Tangitiki	2139

L: lowland soils used for extensive sheep and beef cattle grazing or plantation forestry. Significant areas (mainly wetlands and sand dunes) are also used for conservation of scenery, indigenous vegetation or wildlife habitat

Group L2 10,472 hectares

Frequent waterlogging (and salinity on some soils) is likely to preclude horticulture and cropping, and may also restrict grazing and forestry. Require care in timing and duration of grazing to avoid structural breakdown, and adequate maintenance fertiliser to avoid nutrient loss, if in pasture.

Mercer	300
Kara	3088
Tawharanui	796
Miranda	194
Takahiwai	4316
Akaaka	32
One Tree Point	464
Parore	345
Ruakaka	937
Te Kopuru	not recorded

Group L3 26,268 hectares

Wind erosion hazard is likely to preclude horticulture or cropping. Require care in pasture management to control wind erosion if grazed. Additionally require adequate maintenance fertiliser to avoid nutrient loss, under both pasture and forestry.

Marsden	167
Parore	783
Whananaki	964
Pinaki	22027
Red Hill	2327

H: hill soils. Footslope phases are generally under intensive dairying or sheep and beef cattle fattening, and at some localities, orchards and vineyards. Hill phases are used principally for extensive sheep and beef cattle grazing or plantation forestry. Significant areas of the hill phase soils (mainly reverting scrub and bush remnants) are also used to conserve scenery, indigenous vegetation and wildlife habitat.

Group H1a 9,013 hectares

Footslope phases. Soil structure and surface erosion hazard preclude vegetable or grain cropping. Where there is no drainage limitation, these soils can be used for orchards or vineyards if fertiliser is applied to counteract nutrient loss. May be used for occasional fodder crops but soil conservation practices are needed to control surface erosion. Few limitations to dairying or sheep and beef cattle fattening, but require some maintenance fertiliser to avoid nutrient loss when in intensively grazed pasture.

Arapohue	565
Motatau	154
Whaka	-
Te Tio	-
Whirinaki	1
Te Hihi	923
Manurewa	4737
Puhoi	427
Papakauri	70
Bald Hill	-
Awapuku	1914
Bream	222

Group H1b 25,244 hectares

Footslope phases. Management requirements as for H1a, but require higher levels of maintenance fertiliser to counteract nutrient loss when under intensively grazed pasture.

Omu	2474
Aponga	4347
Brookby	1722
Whangaripo	9330
Waiotira	363
Marua	2436
Tikipunga	330
Waiotu	139

Mangonui	-
Dome Valley	-
Parau	4103

Group H2a 27,983 hectares

Footslope phases. Management requirements as for H1b. Also require care in timing and duration of cultivation, to avoid structural breakdown, if used for occasional fodder crops. Particularly require care in timing and duration of grazing to control this form of degradation, when in intensively grazed pasture.

Dairy Flat	1613
Maungaturoto	165
Warkworth	16806
Mt. Rex	687
Okaka	2417
Rangiora	1424
Opaheke	190
Rangiuru	951
Cornwallis	3730

Group H2b 27,753 hectares

Footslope phases. Management requirements as for H2a. Additional requirement for adequate maintenance fertiliser to avoid nutrient loss under extensive grazing. May require long-term fertiliser application under forestry.

Rockvale	766
Waikare	8419
Mahurangi	17279
Hukerenui	1147
Wharekohe	142
Maramarua	not recorded
Omaiko	-

Group H3a 79,679 hectares

Hill phases of H1 soils. Erosion hazard precludes all forms of horticulture and cropping. Maintenance fertiliser requirements if under pasture are similar to H1a and H1b respectively. These soils also require conservation practices to control mass movement erosion.

Arapohue	205
Motatau	-
Whaka	-
Te Tio	-
Whirinaki	-
Te Hihi	356
Manurewa	-
Puhoi	13139
Papakauri	-
Bald Hill	10
Awapuku	420
Bream	-
Omu	865
Aponga	558
Brookby	5945
Whangaripo	35863
Waiotira	1792
Marua	15199
Tikipunga	-
Waiotu	261
Mangonui	2266
Dome Valley	979
Parau	1821

Group H3b 30,239 hectares

Hill phases of H2 soils. Erosion hazard precludes all forms of horticulture and cropping. Maintenance fertiliser and structural management requirements if under pasture are similar to H2a and H2b respectively, and the soils additionally require conservation practices to control mass movement erosion.

Dairy Flat	-
Maungaturoto	-

Warkworth	14394
Mt. Rex	-
Okaka	950
Rangiora	3376
Opaheke	3372
Rangiuru	522
Cornwallis	642
Rockvale	-
Waikare	618
Mahurangi	5829
Hukerenui	-
Wharekohe	-
Maramarua	not recorded
Omaiko	566

Group H3c 17,414 hectares

Hill phases of Group I soils. Erosion hazard precludes all forms of horticulture and cropping. When in pasture, maintenance fertiliser requirements and grazing management requirements to control structural breakdown and/or wind erosion are the same as for the respective I categories. Additional conservation measures are also needed to control mass movement erosion.

Patumahoe	231
Kapu	111
Pollok	581
Hamilton	524
Bombay	127
Matakawau	3419
Houhora	1122
Red Hill	9546
Horea	1633
Tangitiki	120

S: skeletal and steepland soils. Most areas are under reverting scrub or remnant bush, and are used for conservation or as water supply catchments. The balance is in extensively grazed pasture or plantation forest.

Group S2 26,374 hectares

Skeletal soils. Stoniness and excessive drainage preclude all forms of horticulture or cropping, and may also restrict grazing and forestry.

Rangitoto	4067
Ohaeawai	125
Whatitiri	649
Dolerite	not recorded
Waitakere	21533

Group S3 55,230 hectares

Steepland soils. Shallow depth and mass movement erosion hazard preclude all forms of horticulture or cropping, are also likely to preclude long-term grazing, and may restrict forestry. These soils additionally require adequate maintenance fertiliser to avoid nutrient loss, when in pasture or forestry.

Atuanui	10899
Te Ran	26486
Tangatara	1587
Te Kie	9031
Huia	7227

8 Areas

The draft report (December 1995) contained areas for each soil type from old Soil Bureau tables (Roberts and Jarman 1979). Areas from a GIS sort of the same soil names, as stored in ARC Environment's subset of the NZLRI, differed remarkably; to a far greater extent than could be accounted for by the NZLRI mappers' practice of recording a dominant soil type on map units where more than one soil is present. A check of source data for each revealed that:

Soil areas tabulated by Roberts and Jarman are derived from the General Soil Survey of the North Island (Taylor et al 1952). These maps in turn were derived from unpublished provisional soil surveys, principally the North Auckland survey by Taylor et al (1947-1952).

Soil type names and areas recorded in the NZLRI are from the published soil maps of Northland (Taylor et al 1980-1985), Franklin (Orbell 1973), and the unpublished soil map of Manukau (Purdie et al 1981).

All three changed soil names on large numbers of map units cf. the 1947-1952 surveys. These were not just substitutions of local names for the ones used North Island-wide in the General Survey. Many units mapped at 1:63,360 in the North Auckland Survey have been assigned different names. The main changes are:

- 4800 hectares of Whareora re-mapped as Whakapara,
- 6000 hectares of Otonga soil included in the Waitemata complex,
- 8000 hectares originally mapped as Houhora, redesignated as Pinaki,
- About 7000 hectares of bare sand, remapped as bare sand-Pinaki associations,
- 11000 hectares of Omu, 2800 of Aponga and 6600 hectares of Puhoi soil remapped as Whangaripo or Warkworth,
- 5300 hectares of Rangiora and 7700 hectares of other soil types on greywacke redesignated as Te Ranga steepland soils,
- 31,000 hectares of Waikare clay, apparently re-distributed across a number of less podsolised soil types on sedimentary rocks,
- 11,400 hectares of Hukerenui and 3900 hectares of Wharekohe podsols remapped as Mahurangi.

A secondary cause has been that soil areas given by Roberts and Jarman for Franklin county are for the entire county area. These have been reduced by the NZLRI sort, which is only for those parts of the new Franklin district that are included in the Auckland region. The main changes here are decreases of 6800 hectares in area for Patumahoe, 3300 for Kapu, 6000 for Hamilton, 4100 for Orere and 5200 for Mercer soils.

A third factor is that areas given by Roberts and Jarman for Manukau county have been reduced by urbanisation (soils under urban use are excluded from the NZLRI). This has reduced the areas of Flat Bush, Papatoetoe and Weymouth soils by 800, 3500 and 2600 hectares respectively.

For all these reasons, soil areas produced by the GIS sort of NZLRI data correspond more closely to soil names and areas depicted on Soil Bureau maps of the Auckland region published from 1973 onwards, than do the tables in Roberts and Jarman. The NZLRI areas have been substituted on pp11-17 in the final report (April 1996), and it is suggested that ARC Environment use them in preference to areas given in Soil Bureau publications, in view of the discrepancies which can arise if the latter are cross-referenced with maps.

The main cause of the discrepancies i.e. different soil names used for the same area of soil mapped at two different dates, implies that differences between some of the soil types are minor. This tends to validate the approach taken when preparing the rankings on pp11-17 i.e. that soil with different names but similar properties can be grouped for management purposes.

9 Maps

The accompanying map depicts extent and location of each group, as a regional overview at 1:250000. It was produced by T. Batistich of ARC Environment's GIS Section, from a regional subset of the New Zealand Land Resource Inventory. NZLRI map units have been grouped by matching the dominant soil type recorded for each, with soil names in the rankings on pp11-17. This does not produce an exact replicate of the pattern on soil maps, as small areas of other soils are incorporated as subdominant soil types in many NZLRI units. However the overall pattern is very close, and has the advantage of being at a uniform scale. Larger-scale versions, corresponding to individual 1:50,000 NZMS 260 topographic maps/NZLRI worksheets, are being produced by the GIS Section.

On the maps, groups I1a and I1b are depicted as a single category I1; similarly for I2, I3 and H1. There are differences in the range of land uses that are likely on the a and b soils, but they have similar risks of degradation under any particular use. H2b soils are depicted separately from H2a, because they may have an additional risk of long-term nutrient loss under extensive grazing and forestry, but these soils are similar with respect to other degradation risks, and could well be amalgamated. H3a, b and c soils need to be depicted separately because while all are at risk from mass movement, there are differences in the other types of degradation that are likely to occur.

Two map keys are also attached. The first is a summary key indicating which forms of degradation each group of soils is susceptible to, under a range of uses. The second, more lengthy key provides some indication of the management needed to control degradation under each land use. For more detailed information about soil management, refer to:

- During (1984) for ways to reverse nutrient loss,
- Haynes (1995) for ways to remedy structural breakdown,
- Hicks (1995) for ways to reduce erosion.

10 Conclusion

Appendices 1 to 3 indicate that most soils in the Auckland region are at risk of nutrient depletion, structural breakdown, or physical erosion, under at least one and sometimes under several uses. However, ranking Auckland soils according to intensity of use and degree of risk (pp11-17) shows that:

- There are 48 soils, with an area of 221,405 hectares that are at risk under most of the land uses practised on them. The risk is generally high for all three forms of degradation. 38 of these soils, with a combined area of 139,907 hectares, are likely to be intensively used (groups I3 and H3); some of the rest are extensively grazed or afforested, but many are on land that is reserved for conservation and water supply.

- 39 soils, with an area of 126,597 hectares, are at risk under several of the land uses practised on them. On these soils the risk of nutrient loss and structural breakdown is usually high; that of erosion, low to moderate. 26 of the soils, with a combined area of 89,751 hectares, are likely to be under intensive use (groups I2 and H2). The balance is mainly on land that is used for extensive grazing or forestry.

- 34 soils, with an area of 93,170 hectares, are at risk only under intensive land uses. The risk is high for nutrient loss, but low to moderate for structural breakdown and erosion. Given their properties and location, almost all these soils are intensively used (groups I1 and H1).

It needs to be stressed that on all these soils, degradation is not an automatic consequence of use. Nutrient loss, structural breakdown and erosion are unlikely where land is under good management. Equally, it is very likely that one or more of these things will happen where land is badly managed.

The rankings on pp11-17 can be used to focus any future ARC Environment programme for monitoring soil degradation (and associated adverse environmental impacts) onto critical soils, and away from those of less concern.

A monitoring programme could be even more focussed, by identifying which areas on these soils are currently under the land use (or uses) for which they are ranked as being at risk. Ways to produce an up-to-date map of land use are discussed in the scoping paper by Hicks (1994), and ARC Environment is giving consideration to producing such a map in 1996 or 1997.

As regards evaluation of soil degradation indicators and a sampling design for their use on the soils identified, a pilot programme jointly funded by ARC Environment with MfE and Landcare Research will commence in 1996.

11 Acknowledgements

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Appendix 1: Ranking of soils' susceptibility to structural breakdown

G. Shepherd and D Hicks, December 1995

Management requirements to avoid structural breakdown are ranked as low (L), moderate (M) and high (H) for cropping (Crop.), horticulture (Hort.), pasture (Past.) and plantation forestry (For.) Refer to accompanying text for sources of information and method of interpretation.

Soils suited to cultivation

a) Low to moderate requirements for management to avoid structural problems

	Crop.	Hort.	Past.	For.
Yellow-brown loams on waterlaid ash				
Karaka	L	L	L	L
Papatoetoe	L-M	L-M	L	L
Flat Bush	L-M	L-M	L	L
Yellow-brown loams on mix of ash and alluvium from sedimentary rocks				
Otao	L	L	L	L
Torehape	L	L	L	L
Hobsonville	L-M	L-M	L	L
Waitemata	L-M	L-M	L	L
Koheroa	L-M	L-M	L	L
Peats with admixture of ash				
Otonga	L	L	L	L
Ardmore	L	L	L	L
Piako	L	L	L	L
Kaipaki	L	L	L	L

Brown granular loams and clays from airfall ash and basalt

Patumahoe	L-M	L-M	L	L
Pukekohe	L-M	L-M	L	L
Helvetia	L-M	L-M	L	L
Mauku	L-M	L-M	L	L
Onewhero	L-M	L-M	L	L
Ohaeawai	L-M	L-M	L	L
Whatitiri	L-M	L-M	L	L
Weymouth	L-M	L-M	L	L

b) Moderate to high requirements for management to avoid structural problems

	Crop.	Hort.	Past.	For.
Yellow-brown earths on alluvium from sedimentary rocks				
Whakapara	H	H	M	M
Whareora	M-H	M-H	M	M
Gley soils on alluvium				
Waipu	H	H	M	M
Gley soils on admixture of ash and alluvium				
Clevedon	M-H	M-H	M	M
Topehahae	M-H	M-H	M	M
Brown granular loams from ash and basalt				
Mangakahia	H	H	M	M
Orere	M-H	M-H	M	M
Brown granular loams and clays from airfall ash and basalt				
Bombay	M	M	M	M
Hamilton	M	M	M	M
Pukekapia	M	M	M	M
Kapu	M	M	M	M

Pollok	M	M	M	M
Rendzinas from limestone				
Motatau	M-H	M-H	M	M
Dairy Flat	M-H	M-H	M	M
Whaka	M-H	M-H	M	M
Rockvale	M-H	M-H	M	M

Soils marginal for cultivation

Poor natural drainage or rolling slopes restrict cultivation.

a) Low to moderate requirements for management to avoid structural problems

	Crop.	Hort.	Past.	For.
Yellow-brown loams from waterlaid ash				
Akaaka	L-M	-	L	-
Gleys from mix of peat and alluvium				
Parore	L	-	L	-
Ruakaka	L	-	L	-
Gleys from sand				
Tawharanui	M	-	M	-
Miranda	M	-	L-M	-
Yellow-brown sands				
Red Hill	L-M	-	L	L
Brown loams and granular clays from volcanic rocks				
Tikitohe	L-M	-	L	L
Bald Hill	L-M	-	L	L

b) **Moderate to high requirements for management to avoid structural problems if cropped; moderate under pasture and forestry**

	Crop.	Hort.	Past.	For.
Yellow-brown earths on alluvium from sedimentary rocks				
Waipuna	H	-	M	M
Yellow-brown loams from waterlaid ash				
Mercer	M-H	-	M	-
Brown granular loams on alluvium from volcanic rocks				
Churchill	M-H	-	M	M
Gleys from estuarine sediment				
Takahiwai	H	-	M	-
Kaipara	H	-	M	-
Hauraki	H	-	M	-
Yellow-brown sands				
Houhora	M-H	-	M	M
Yellow brown earths from sedimentary rocks				
Albany	M-H	-	M	M
Coatesville	M-H	-	M	M
Puhoi	M-H	-	M	M
Manurewa	M-H	-	M	M
Te Tio	M-H	-	M	M
Marua	M-H	-	M	M
Brown granular loams and clays overlying sedimentary rocks				
Ararimu	M	-	M	M
Matakawau	M	-	M	M

Hunua	M-H	-	M	M
Opita	M-H	-	M	M

Brown loams and granular clays from volcanic rocks

Awapuku	M-H	-	M	M
Cornwallis	M-H	-	M	M

Rendzinas from limestone

Arapohue	M-H	-	M	M

Soils unsuited to cultivation

Steep slopes, erosion hazard or poor drainage prevent use for cropping or horticulture.

a) Weathered soils with moderate requirement for management to avoid structural breakdown

	Crop.	Hort.	Past.	For.
Yellow-brown earths from sedimentary rocks				
Whangaripo	-	-	M	M
Waiotira	-	-	M	M
Brookby	-	-	M	M
Aponga	-	-	M	M
Omu	-	-	M	M

Brown loams and granular clays from volcanic rocks

Waiotu	-	-	L	L
Dome Valley	-	-	M	M
Parau	-	-	M	M

Rendzinas from limestone

Konoti	-	-	M	M

Yellow-brown sands				
Tangitiki	-	-	M	M
Horea	-	-	M	M

b) Strongly weathered soils with moderate to high requirement for management to avoid structural breakdown

	Crop.	Hort.	Past.	For.
Yellow-brown earths from sedimentary rocks				
Warkworth	-	-	M-H	M-H
Mt. Rex	-	-	M-H	M-H
Te Hihi	-	-	M-H	M-H
Waikare	-	-	M-H	M-H
Okaka	-	-	M-H	M-H
Rangiora	-	-	M-H	M-H
Opaheke	-	-	M-H	M-H
Brown granular clays from volcanic rocks				
Rangiuru	-	-	M-H	M-H
Waitakere	-	-	M-L	M-L

Soils marginal for grazing

Due to steep slopes, erosion hazard or impeded drainage

a) With low to moderate requirement for management to avoid structural breakdown

	Crop.	Hort.	Past.	For.
Steepland yellow-brown earths				
Te Ranga	-	-	L-M	L-M
Atuanui	-	-	L-M	L-M
Steepland brown granular clays				
Huia	-	-	L-M	L-M
Te Kie	-	-	L-M	L-M

Brown loams				
Rangitoto	-	-	L	L
Yellow-brown sands				
Pinaki	-	-	L	L
Whananaki	-	-	L	L
Marsden	-	-	L	L

b) With moderate to high requirement for management to avoid structural breakdown

	Crop.	Hort.	Past.	For.
Podsols				
Mahurangi	-	-	M-H	M-H
Wharekohe	-	-	H	H
Hukerenui	-	-	H	H
Kara	-	-	H	H
Te Kopuru	-	-	H	H
One Tree Pt.	-	-	M-H	M-H

Appendix 2: Ranking of soils' susceptibility to loss of plant-available nutrients

R Parfitt and D Hicks, December 1995

Fertiliser requirements to maintain plant-available nutrients are ranked as low (L), moderate (M) and high (H) for cropping (Crop.), horticulture (Hort.), pasture (Past.) and plantation forestry (For.) Refer to accompanying text for sources of information and method of interpretation.

Soils suited to cultivation

All have a high requirement for fertiliser to maintain plant-available nutrients if used for horticulture. If under grain or fodder crops, fertiliser requirement is moderate.

a) Young soils, with low to moderate maintenance fertiliser requirements under grazing and forestry

	Crop.	Hort.	Past.	For.
Yellow-brown loams on waterlaid ash				
Karaka	M	H	M	L
Papatoetoe	M	H	M	L
Flat Bush	M	H	M	L
Yellow-brown loams on mix of ash and alluvium from sedimentary rocks				
Otao	M	H	M-L	L
Hobsonville	M	H	M-L	L
Yellow-brown earths on alluvium from sedimentary rocks				
Whakapara	M	H	M-L	L
Gley soils on alluvium				
Waipu	M	H	M-L	L
Gley soils on admixture of ash and alluvium				

Clevedon	M	H	M-L	L
Topehahae	M	H	M-L	L

Brown granular loams and clays from airfall ash and basalt

Patumahoe	M	H	M	M
Pukekohe	M	H	M	M
Helvetia	M	H	M	M
Mauku	M	H	M	M
Onewhero	M	H	M	M
Ohaeawai	M	H	M	M
Whatitiri	M	H	M	M

Rendzinas from limestone

Dairy Flat	M	H	M-L	L
Motatau	M	H	M-L	L

b) Weathered soils, with moderate maintenance fertiliser requirement under grazing or forestry

	Crop.	Hort.	Past.	For.

Yellow-brown earths on alluvium from sedimentary rocks

Whareora	M	H	M-L	L

Yellow-brown loams on mix of ash and alluvium from sedimentary rocks

Waitemata	M	H	M-L	L
Torehape	M	H	M-L	L
Koheroa	M	H	M-L	L

Brown granular loams on waterlaid ash or alluvium derived from volcanic rocks

Mangakahia	M	H	M	L
Orere	M	H	M	L
Weymouth	M	H	M	L

Peats with admixture of ash				
Otonga	M	H	M-L	-
Ardmore	M	H	M-L	-
Piako	M	H	M-L	-
Kaipaki	M	H	M-L	-
Brown granular clays from airfall ash or basalt				
Bombay	M	H	M	M
Hamilton	M	H	M	M
Pukekapia	M	H	M	M
Kapu	M	H	M	M
Pollok	M	H	M	M
Rendzinas from limestone				
Whaka	M	H	M-L	L
Rockvale	M	H	M-L	L

Soils marginal for cultivation

Poor natural drainage or rolling slopes restrict cultivation. All have a high requirement for fertiliser to maintain plant-available nutrients if used for horticulture. Fertiliser requirement under grain or fodder crops is moderate.

a) **Young soils with poor drainage. Moderate maintenance fertiliser requirement if cropped; low to moderate if grazed.**

	Crop.	Hort.	Past.	For.
Yellow-brown loam from waterlaid ash				
Mercer	M	-	M	-
Akaaka	M	-	M	-
Gleys from estuarine sediment				
Takahiwai	M	-	M-L	-
Kaipara	M	-	M-L	-

Hauraki	M	-	M-L	-

Gleys from mix of peat and alluvium

Parore	M	-	M-L	-
Ruakaka	M	-	M-L	-

Gleys from sand

Tawharanui	M	-	M-L	-
Miranda	M	-	M-L	-

b) Weathered soils on rolling slopes. Moderate fertiliser requirement if cropped; low to moderate under grazing and forestry

	Crop.	Hort.	Past.	For.

Yellow-brown earths on alluvium derived from sedimentary rocks

Waipuna	M	-	M-L	L

Brown granular clays from volcanic alluvium

Churchill	M	-	M	M

Yellow brown earths from sedimentary rocks

Albany	M	-	M-L	L
Coatesville	M	-	M-L	L
Puhoi	M	-	M-L	L
Manurewa	M	-	M-L	L
Te Tio	M	-	M-L	L
Marua	M	-	M-L	L

Brown granular loams from ash overlying sedimentary rocks

Ararimu	M	-	M	M
Hunua	M	-	M	M
Matakawau	M	-	M	M
Opita	M	-	M	M

Brown loams and granular loams from volcanic rocks

Tikitohe	M	-	M	M
Bald Hill	M	-	M	M
Awapuku	M	-	M	M
Cornwallis	M	-	M	M

Yellow-brown sands

Houhora	M	-	M-L	M
Red Hill	M	-	M-L	M

Rendzinas from limestone

Arapohue	M	-	M-L	L

Soils unsuited to cultivation

Cropping and horticulture are prevented by steepness of slope, erosion hazard, or impeded drainage.

a) **Weathered soils with low to moderate requirement for maintenance fertiliser under grazing and forestry**

	Crop.	Hort.	Past.	For.
Yellow-brown earths from sedimentary rocks				
Whangaripo	-	-	M-L	L
Waiotira	-	-	M-L	L
Brookby	-	-	M-L	L
Aponga	-	-	M-L	L
Omu	-	-	M-L	L
Rendzinas from limestone				
Konoti	-	-	M-L	L

b) **Strongly weathered soils with moderate maintenance fertiliser requirements under grazing; low to moderate under forestry.**

	Crop.	Hort.	Past.	For.
Yellow-brown earths from sedimentary rocks				
Warkworth	-	-	M	M-L
Mt. Rex	-	-	M	M-L
Te Hihi	-	-	M	M-L
Waikare	-	-	M	M-L
Okaka	-	-	M	M-L
Rangiora	-	-	M	M-L
Opaheke	-	-	M	M-L
Brown clays and granular clays from volcanic rocks				
Waiotu	-	-	M	M
Dome Valley	-	-	M	M
Parau	-	-	M	M
Rangiuru	-	-	M	M-L
Waitakere	-	-	M	M-L
Yellow-brown sands				
Tangitiki	-	-	M	M
Horea	-	-	M	M

Soils marginal for pasture

Livestock grazing is restricted by steep slope, erosion hazard, or impeded drainage.

a) With low to moderate maintenance fertiliser requirements under grazing and forestry

	Crop.	Hort.	Past.	For.
Steepland brown granular clays				
Huia	-	-	M-L	L
Te Kie	-	-	M-L	L

Brown loams				
Rangitoto	-	-	M-L	L
Yellow-brown sands				
Pinaki	-	-	M	M
Whananaki	-	-	M	M
Marsden	-	-	M	M

b) Soils with moderate to high maintenance fertiliser requirement under grazing and moderate under forestry

	Crop.	Hort.	Past.	For.
Steepland yellow-brown earths				
Te Ranga	-	-	M-H	M
Atuanui	-	-	M-H	M
Podsols				
Mahurangi	-	-	M-H	M
Wharekohe	-	-	M-H	M-H
Hukerenui	-	-	M-H	M-H
Kara	-	-	M	M
Te Kopuru	-	-	M-H	M-H
One Tree Pt.	-	-	M	M

Appendix 3: Ranking of soils' susceptibility to erosion

D Hicks, December 1995

Management requirements to control erosion are ranked as low (L), moderate (M) and high (H) for cropping (Crop.), horticulture (Hort.), pasture (Past.) and plantation forestry (For.) Refer to accompanying text for sources of information and method of interpretation.

Soils suited to cultivation

a) Low requirement for management to control erosion under any use

	Crop.	Hort.	Past.	For.
Yellow-brown earths on alluvium from sedimentary rocks				
Whakapara	L	L	L	L
Whareora	L	L	L	L
Yellow-brown loams on mix of ash and alluvium from sedimentary rocks				
Torehape	L	L	L	L
Koheroa	L	L	L	L
Yellow-brown loams on waterlaid ash				
Papatoetoe	L	L	L	L
Karaka	L	L	L	L
Flat Bush	L	L	L	L
Brown granular loams on alluvium from ash and volcanic rocks				
Mangakahia	L	L	L	L
Peats with admixture of ash				
Otonga	L	L	L	L

Ardmore	L	L	L	L
Piako	L	L	L	L
Kaipaki	L	L	L	L

Gley soils on alluvium

Waipu	L	L	L	L

Gley soils on admixture of ash and alluvium

Clevedon	L	L	L	L
Topehahae	L	L	L	L

Rendzinas from limestone

Motatau	L	L	L	L
Dairy Flat	L	L	L	L

b) Low to moderate requirement for management to control erosion under cropping and horticulture

	Crop.	Hort.	Past.	For.

Yellow-brown loams on mix of ash and alluvium from sedimentary rocks

Otao	L-M	L-M	L	L
Hobsonville	L-M	L-M	L	L
Waitemata	L-M	L-M	L	L

Brown granular loams on alluvium from ash and volcanic rocks

Weymouth	L-M	L-M	L	L
Orere	L-M	L-M	L	L

Brown granular loams and clays from airfall ash and basalt

Patumahoe	L-M	L-M	L	L
Pukekohe	L-M	L-M	L	L
Helvetia	L-M	L-M	L	L

Mauku	L-M	L-M	L	L
Onewhero	L-M	L-M	L	L
Ohaeawai	L-M	L-M	L	L
Whatitiri	L-M	L-M	L	L
Bombay	L-M	L-M	L	L
Hamilton	L-M	L-M	L	L
Pukekapia	L-M	L-M	L	L
Kapu	L-M	L-M	L	L
Pollok	L-M	L-M	L	L
Rendzinas from limestone				
Whaka	L-M	L-M	L	L
Rockvale	L-M	L-M	L	L

Soils marginal for cultivation

Poor natural drainage or rolling slopes restrict cultivation.

a) Low requirement for management to control erosion

	Crop.	Hort.	Past.	For.
Yellow-brown loams from waterlaid ash				
Mercer	L	-	L	-
Akaaka	L	-	L	-
Gleys from mix of peat and alluvium				
Parore	L	-	L	-
Ruakaka	L	-	L	-
Gleys from estuarine sediment				
Takahiwai	L	-	L	-
Kaipara	L	-	L	-
Hauraki	L	-	L	-

Gleys from sand

Tawharanui	L	-	L	-
Miranda	L	-	L	-

b) Low to moderate requirement for management to control erosion

	Crop.	Hort.	Past.	For.
Yellow-brown earths on alluvium from sedimentary rocks				
Waipuna	L-M	-	L	L
Yellow brown earths from sedimentary rocks				
Albany	L-M	-	L	L
Coatesville	L-M	-	L	L
Manurewa	L-M	-	L	L
Rendzinas from limestone				
Arapohue	L-M	-	L-M	L
Yellow-brown sands				
Red Hill	L-M	-	L-M	L

c) Moderate to high requirement for management to control erosion if cropped. Low to moderate requirement if in pasture.

	Crop.	Hort.	Past.	For.
Brown granular clays from volcanic alluvium				
Churchill	M-H	-	L	L
Yellow brown earths from sedimentary rocks				
Puhoi	M-H	-	L-M	L
Te Tio	M-H	-	L-M	L
Marua	M-H	-	L-M	L

Brown granular loams and clays overlying sedimentary rocks

Ararimu	M-H	-	L-M	L
Hunua	M-H	-	L-M	L
Opita	M-H	-	L-M	L
Matakawau	M-H	-	L-M	L

Brown loams and granular clays from volcanic rocks

Tikitohe	M-H	-	L-M	L
Bald Hill	M-H	-	L-M	L
Awapuku	M-H	-	L-M	L
Cornwallis	M-H	-	L-M	L

Yellow-brown sands

Houhora	M-H	-	L-M	L

Soils unsuited to cultivation

Steep slopes, erosion hazard or poor drainage prevent use for cropping or horticulture.

a) Low to moderate requirement for management to control erosion under pasture. Low requirement under forest.

	Crop.	Hort.	Past.	For.
Yellow-brown earths from sedimentary rocks				
Whangaripo	-	-	L-M	L
Waiotira	-	-	L-M	L
Brookby	-	-	L-M	L
Aponga	-	-	L-M	L
Omu	-	-	L-M	L
Warkworth	-	-	L-M	L
Mt. Rex	-	-	L-M	L
Te Hihi	-	-	L-M	L
Waikare	-	-	L-M	L

Okaka	-	-	L-M	L

Rendzinas from limestone

Konoti	-	-	L-M	L

b) Moderate to high requirement for management to control erosion under pasture. Low to moderate requirement under forest.

	Crop.	Hort.	Past.	For.
Yellow-brown earths from sedimentary rocks				
Rangiora	-	-	M-H	L-M
Opaheke	-	-	M-H	L-M
Brown loams and granular clays from volcanic rocks				
Waiotu	-	-	M	L
Dome Valley	-	-	M	L
Parau	-	-	M-H	L-M
Rangiuru	-	-	M-H	L-M
Waitakere	-	-	M-H	L-M
Yellow-brown sands				
Tangitiki	-	-	M	L
Horea	-	-	M	L

Soils marginal for grazing

Due to steep slopes, erosion hazard or impeded drainage

a) Low to moderate requirement for management to control erosion under pasture. Low requirement under forest.

	Crop.	Hort.	Past.	For.
Brown loams				
Rangitoto	-	-	L-M	L

Podsols				
Mahurangi	-	-	M	L
Wharekohe	-	-	M	L
Hukerenui	-	-	M	L
Kara	-	-	L-M	L
Te Kopuru	-	-	L-M	L
One Tree Pt.	-	-	L-M	L

b) Moderate to high requirement for management to control erosion under pasture. Low to moderate requirement under forest.

	Crop.	Hort.	Past.	For.
Steepland yellow-brown earths				
Te Ranga	-	-	M-H	L-M
Atuanui	-	-	M-H	L-M
Steepland brown granular clays				
Huia	-	-	M-H	L-M
Te Kie	-	-	M-H	L-M
Yellow-brown sands				
Pinaki	-	-	M-H	L-M
Whananaki	-	-	M-H	L-M
Marsden	-	-	M-H	L-M