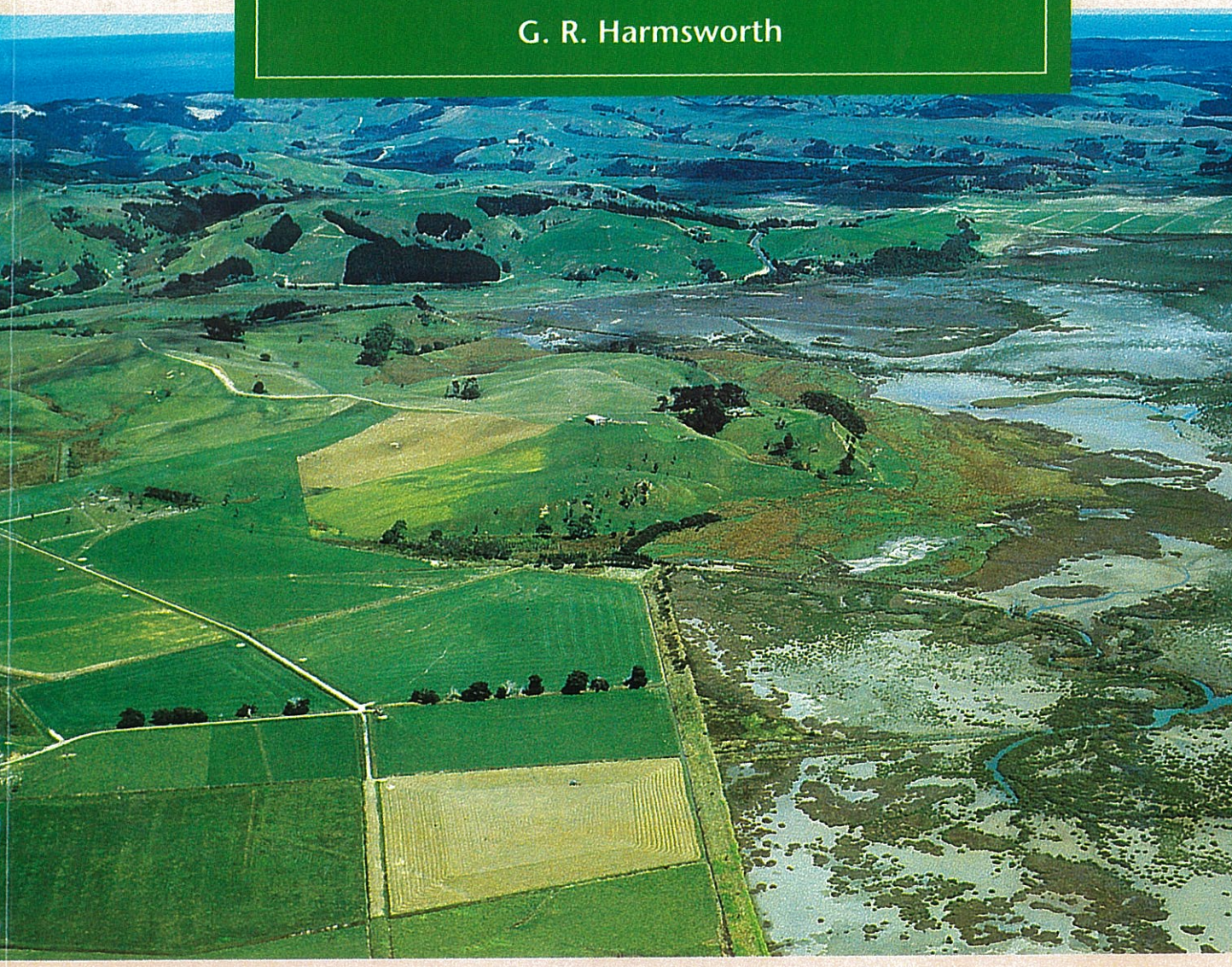
# Land Use Capability Classification of the Northland Region

G. R. Harmsworth



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# Land use capability classification of the Northland region:

## A report to accompany the second edition New Zealand Land Resource Inventory

G. R. Harmsworth

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*Cover:*
View west across the Kaipara Harbour, towards the southern Kaipara sand barrier north of Helensville. The sand country is bounded by Rangtira beach on the seaward side, and by the Kaipara Harbour, Omokoiti Flats on the inner harbour side. The estuarine flats in the foreground are classified as land use capability (LUC) units IIIw2 and IVw2 with gleyed Kaipara and gleyed slightly saline Takahiwai soils. In the background are LUC units IIIe5, IVe9, the steeper sand-country LUC units VIe6, VIIe9, and the more unstable VIIe10 on the horizon.

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# Summary

The report describes the second-edition Land Use Capability (LUC) classification of the Northland region, an area of 1 582 698 ha (15 827 km²) in the north of the North Island, New Zealand. This region is one of 11 in the New Zealand Land Resource Inventory (NZLRI). The NZLRI provides a physical-resource inventory for land-resource and land-use planning, particularly for evaluating the potential of land for sustained production, using the Land Use Capability system of land classification.

Fieldwork for the second-edition worksheets at 1:50 000 scale began in 1985 and was completed in 1990. A total of 11 718 inventory map units were delineated in the Northland region. These map units were grouped into 91 LUC units on the basis of their management requirements, soil conservation needs and land-use potential. The LUC units have been arranged into eight LUC suites – groupings of LUC units which, although differing in capability, share a definitive physical characteristic that unites them in the landscape. Within LUC suites, LUC units are further grouped into LUC subsuites according to features such as micro-topography, rock-type characteristics (e.g. composition, age) soil type, erosion potential, wetness, and management.

A description of Northland region's physical land resources is provided, as well as a key to the recognition of LUC units in LUC suites, and descriptions of each LUC unit.

# Introduction

## Purpose

The purpose of this report is to explain the basis of the second edition New Zealand Land Resource Inventory (NZLRI) Land Use Capability (LUC) classification of the Northland Region, and to describe the land use capability units delineated. The report accompanies 26 worksheets (maps) of the Northland region at 1:50 000 scale.

## New Zealand Land Resource Inventory (NZLRI)

The NZLRI is a national database of physical land-resource information. All NZLRI data are stored on a computer in a geographic information system managed by Landcare Research. This provides the versatility to produce worksheets (maps) of various scales and tables in response to specific requests from users.

Two sets of data are on the Land Resource Inventory Worksheets:

1. An inventory of the five physical factors (rock, soil, slope, erosion and vegetation) that are basic to the assessment of land resources. The physical factors are represented by symbols, in a standard layout:

$$\frac{\text{Rock type – Soil unit – Slope group}}{\text{Erosion degree and type – Vegetation cover}}$$

A homogenous unit-area approach is used to record the physical resource data (Eyles 1977), with the five factors being mapped simultaneously to an appropriate level of detail in relation to the scale of mapping being undertaken.

2. A land use capability rating of each map unit based on an assessment of the ability of the five physical factors, together with climate and the effects of past land use, to provide sustained agricultural production.

Detailed information on general aspects and interpretation of the NZLRI has been given by Howard and Eyles (1979), and is available in the *Land Use Capability Survey Handbook* (Soil Conservation and Rivers Control Council 1971) and in *Our Land Resources* (National Water and Soil Conservation Organisation 1979).

The NZLRI was initially prepared for the National Water and Soil Conservation Organisation (NWASCO), later the National Water and Soil Conservation Authority (NWASCA), by the Water and Soil Division, Ministry of Works and Development, and later by DSIR Land Resources, Palmerston North and Christchurch. Present-day upgrading is carried out by Landcare Research under contract to the Foundation for Research, Science and Technology.

This report is not intended to be an exhaustive description of the land resources of the region; rather it describes the region's physical resources in terms of land use capability. A number of earlier publications have fully documented the physical and social resources of the region, for example the *Northland Regional Development Resources Survey* (Northland Regional Development Council and Northland Regional Planning Authority 1978a,b).

NZLRI information was first published as a series of first-edition Land Resource Inventory worksheets at a scale of 1:63 360 (1 inch to 1 mile) (NWASCO 1975–79), together with supporting documents.

Many first-edition NZLRI worksheets have been updated or remapped as second-edition worksheets at 1:50 000 scale, which correspond with New Zealand Mapping Series (NZMS) 260 series topographic maps. Where the 1:50 000 base was not available, the second-edition worksheets were prepared at 1:63 360 scale. At 1:63 360 scale, an inventory map unit can be delineated to about 100 ha in size; at the 1:50 000 scale, an inventory map unit can be delineated to about 60 ha. When mapping at the scale of 1:50 000, the smallest practical area size determined in the NZLRI for a hooked (that is, joined by a vinculum) inventory map unit equates to approximately 15 hectares. Northland was the first region to be remapped.

## Application of the NZLRI

The NZLRI data have been widely used by local territorial authorities such as regional councils, government corporations, government departments, private companies, consultants and other agencies involved in planning rural land use or management of natural resources. Examples of the types of information which can be generated

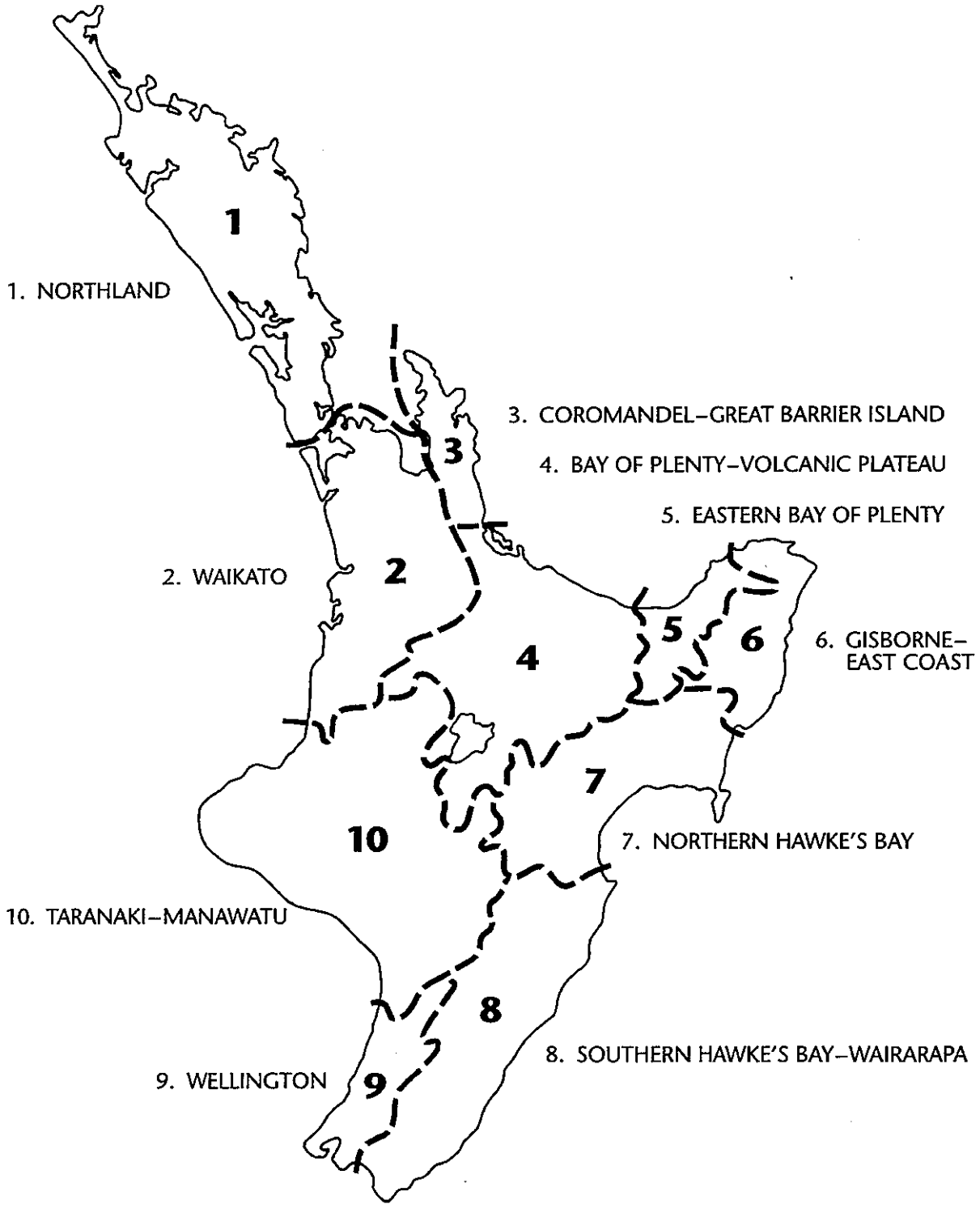



*Figure 1.*
*North Island NZLRI regions.*

for district and regional planning include the location of:

- hazardous areas that are highly erodible or liable to flooding (such as land physically unsuited to urban development),
- high-producing land,
- non-arable land,
- land with scenic value,
- areas that can physically sustain pastoral farming,
- areas that cannot physically sustain pastoral farming or have severe limitations for pastoral use,
- areas that can physically sustain production forestry,
- vegetation cover to indicate existing land uses,
- land physically suited to urban development.

NZLRI data should only be used at the published or smaller scales but under no circumstances for more detailed land use planning. NZLRI information is a planning tool not a plan: It is only one input into district or regional schemes, where it can be used as a physical base on which social and economic implications of land use can be considered.

## Northland region

The Northland region is one of 10 North Island land-resource survey regions (Figure 1), each with its own land use capability classification. The region has an area of 1 582 698 hectares and is located in the northernmost part of the North Island of New Zealand (Figure 2). It extends from Manakau Heads and Auckland City, to Cape Reinga and the most northern part of the Aupouri Peninsula, Surville Cliffs. The land mass is a naturally defined isthmus surrounded by the Tasman Sea to the west, the Pacific Ocean to the north and east, and the Hauraki Gulf in the southeast. The regional boundary is defined by the extensive coastline and by Auckland City in the south (Manukau and Waitemata Harbours).

## Second-edition (1993) Northland region worksheets

Fieldwork in the Northland region commenced in 1985 and was completed in 1990. The accompanying report was completed by the end of 1990.

The region is covered by all or part of 26 NZLRI worksheets (corresponding with NZMS 260 sheets – Figure 2). Appendix 1 lists the NZLRI worksheets together with names of authors and dates of fieldwork and compilation. Survey numbers of aerial photographs used in the compilation of the NZLRI worksheets are given in Appendix 2. Field checking follows quality-control procedures discussed by Harmsworth (1988), and was carried out by G. R. Harmsworth, K. E. Noble, M. R. Jessen and G. O. Eyles. Checks were also carried out periodically through field and office discussion with the Northland Catchment Commission staff based in Whangarei and with Auckland Regional Water Board (ARWB) staff. The regional LUC classification and extended legend were prepared by G. R. Harmsworth in 1989 and made available as DSIR Land Resources Technical Record 3 (version 2.1) (Harmsworth 1991a).

In total, 11 718 inventory map units were delineated in the second-edition NZLRI for Northland region; the average area for a map unit is 125 ha. In the first-edition NZLRI, 69 LUC units were defined for the region whilst 91 LUC units have been defined for the second-edition classification. A correlation between the first- and second-edition classifications is given in Appendix 3.

Copies of the 26 worksheets covering Northland region are available from Landcare Research, Palmerston North. All data are also stored on a geographic information system.

In describing the Land Use Capability Classification, this report emphasises the relationships between different LUC units by grouping related units into LUC 'suites'. The description of each suite emphasises the similarities between LUC units, while the descriptions of the LUC units themselves emphasise the differences. The suites are described in detail in a later section (page 36).

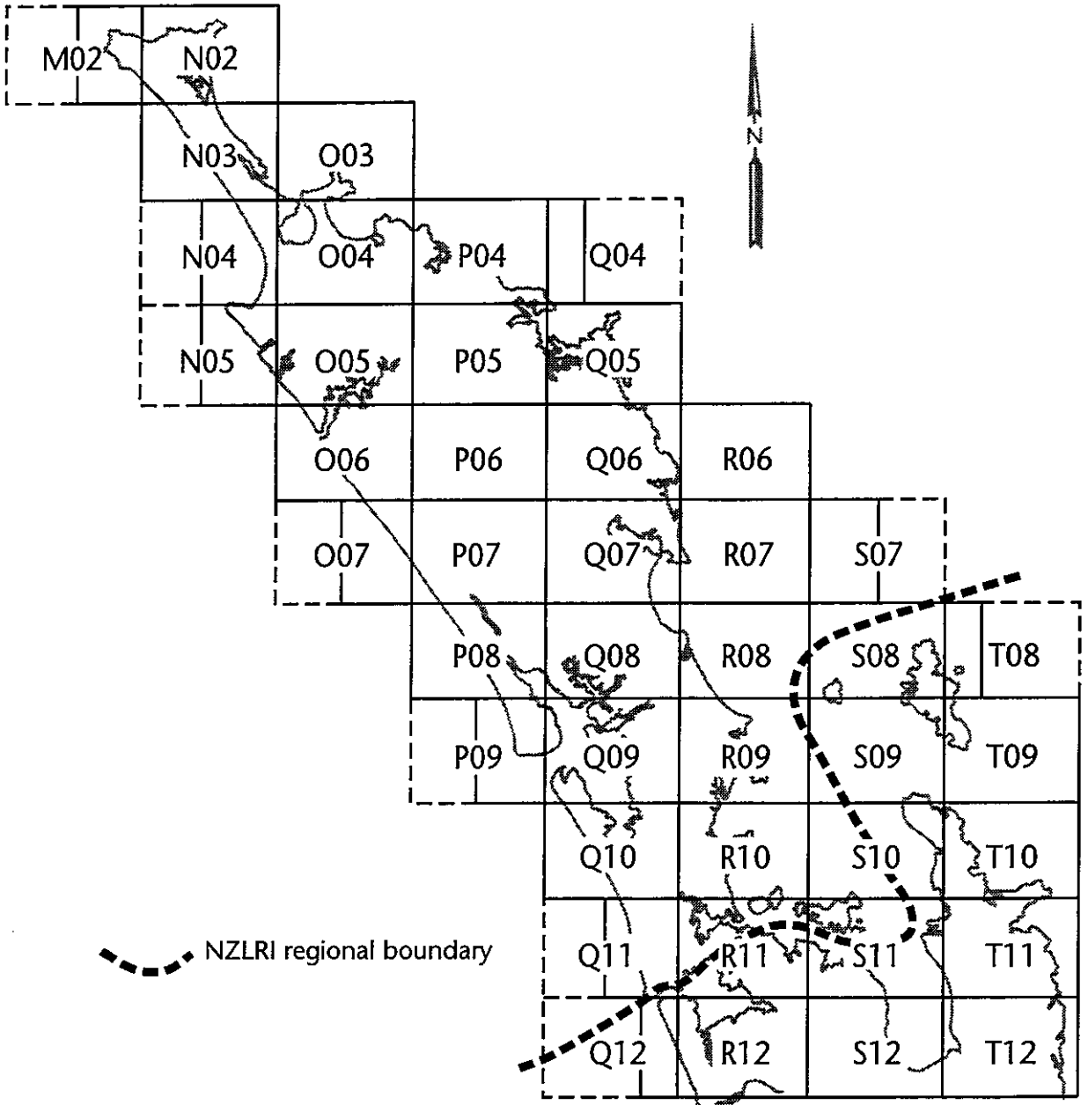



*Figure 2.*
*Location of the Northland region (NZLRI region 1), showing position of NZMS 260 map series.*

# Physical resources of the Northland region

This section provides a brief description of the region's physiography and climate, and a summary of the physical resources of the region, as mapped in the NZLRI, including a brief description of the method of mapping each inventory factor. More details on the physical resource factors are given in the individual LUC unit descriptions.

The warm, humid, almost subtropical climate, the complex, deeply weathered soils and rock types, and the unique flora and fauna together make the region dissimilar from the rest of New Zealand.

## Physiography

The general pattern of relief, landform expression, soils, and erosion types largely reflects the gross underlying geological structure. Soil patterns and soil characteristics also show a strong relationship to the natural vegetation and climate. Two of the most conspicuous physiographic features are the relatively subdued nature of the terrain and the distinctive coastline. The main physical features are shown in Figure 3, and all major rivers are shown in Figure 4.

The extensive coastline is highly irregular on the east coast, indented with numerous bays and inlets, deepwater harbours, rock promontories, sandy bays, and mangrove swamps. Prominent harbours in the east include the Waitemata, Whangarei, Bay of Islands and Whangaroa. In contrast, the west coast is more linear with vast expanses of sand dune terrain (windswept beaches) stretching for hundreds of kilometres. These extensive west-coast sand deposits are interrupted by tidal entrances to the large Manukau, Kaipara, Hokianga, and Whangape Harbours, and also by steep volcanic terrain, bluffs, and steep sand-dune landforms in the Waitakere, Waipoua (such as Maunganui Bluff) and Ahipara areas. The Kaipara and Hokianga Harbours extend well into the interior, almost reaching the eastern coastline near Maunga-turoto. Mangrove swamps have developed over large areas in the shallower, more inland reaches of harbours, intertidal estuaries and inlets. As a result of the extent of west-coast harbours and an indented east coast, no part of the Northland region is more than 40 km from the sea.

Slow-moving sediment-laden streams and rivers, and extensive fingerlike estuaries, are characteristic of the region. Most rivers and streams flow east to west and discharge into large harbours and mangrove-covered estuarine areas. Major rivers (Figure 4) include the Wairoa, which originates in the Hikurangi–Mangakahia area and flows southwest into the Kaipara Harbour. The Mangakahia, Wairua, and Manganui Rivers converge into the Wairoa in the central part of the region and flow southwest and west respectively into the Kaipara Harbour. The Wairoa river system represents one of the largest catchments in the region, and drains the Hikurangi swamp. Other major river systems include the Kaihu near Dargaville, the Awanui near Kaitaia which drains into the Rangaunu Harbour, the Kaeo River which enters the Whangaroa Harbour, and the Kerikeri and Waitangi Rivers which enter the Bay of Islands. Smaller rivers include the Waima which drains into the Hokianga Harbour, and the Awaroa which drains into the Whangape Harbour. In the southern part of the region rivers are generally smaller and include the Hoteo and Kaipara which both enter the Kaipara Harbour, and the Puhoi River which runs east reaching the coast at Waiwera. Lakes of limited size are a particular feature of the sand country along the west coast, and are more occasionally located within volcanic terrain in the central part of the region. The largest natural lakes are Lake Omapere near Kaikohe (formed by basalt lava obstruction) and the well known Kai-iwi Lakes – Taharoa, Waikere, and Kai-iwi – within the sand country north of Dargaville.

A number of hilly and mountainous areas are conspicuous. These include the Maungataniwha Range in the far north, the Parataiko and Whirinaki Ranges (Waima Forest) near Hokianga, the Tutamoe and Tutamoa Ranges just south of the Hokianga Harbour but north of Dargaville, the Tangihua Range west of Whangarei, the Brynderwyn Hills between Whangarei and Wellsford in the south, and the Waitakere Range in the south, on the northern side of the Manukau

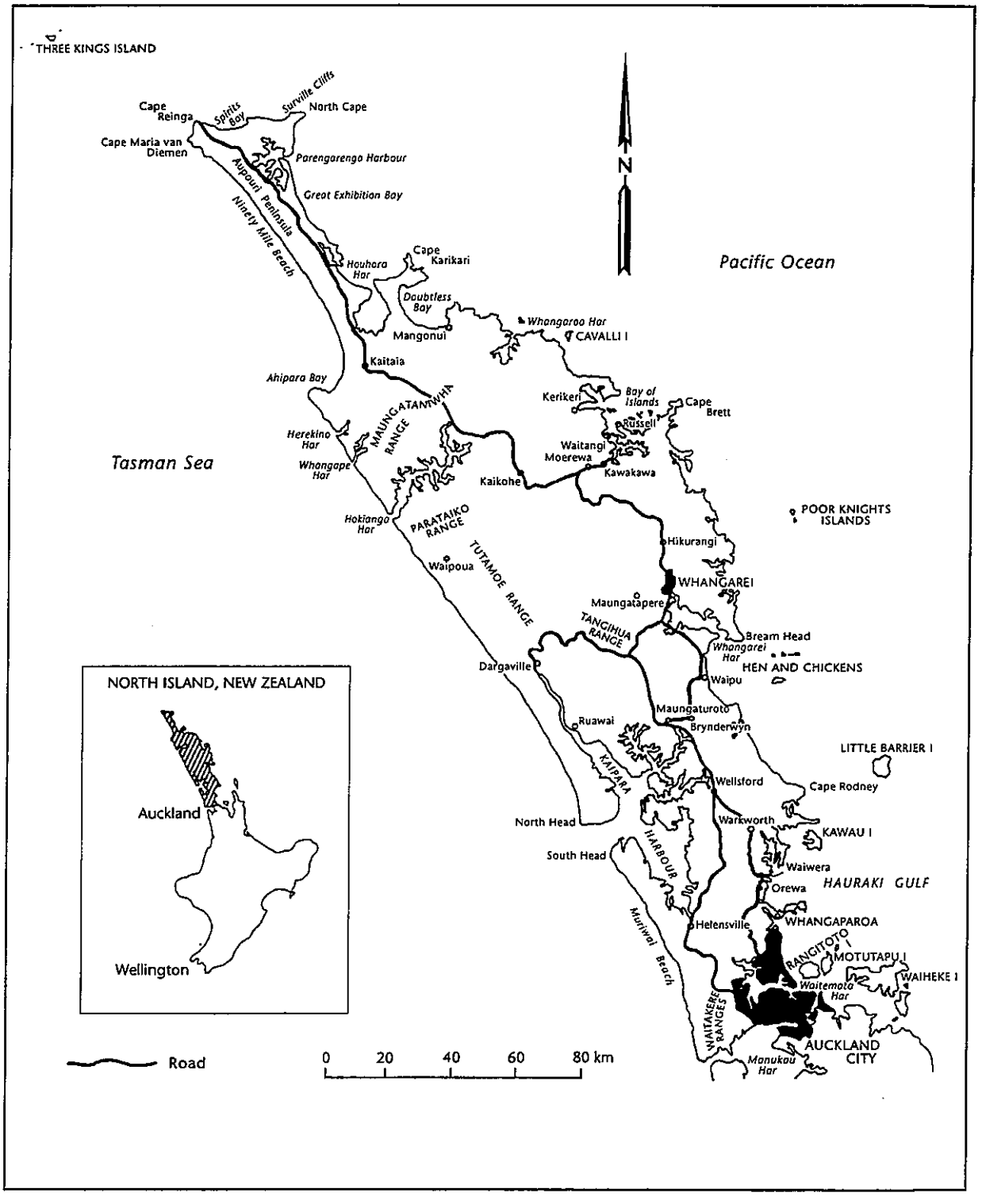



*Figure 3.*
*Main locations and physical features of the Northland region. Auckland City marks the southern boundary of the region.*

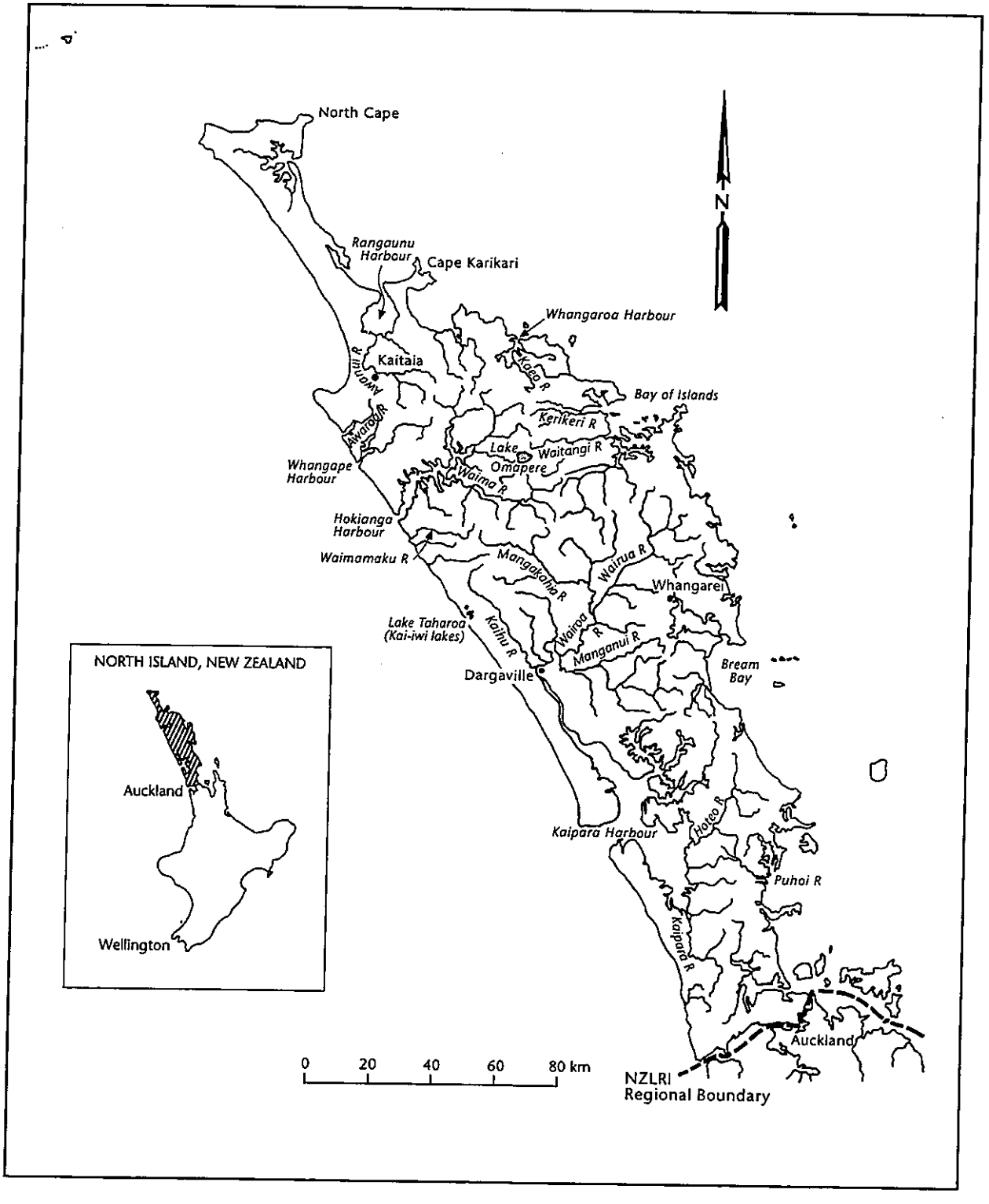



*Figure 4.*
*Major rivers and lakes of the Northland region. The regional boundary is shown as a heavy dashed line.*

Harbour. These higher areas have altitudes ranging between 300 m and about 800 m above sea level (a.s.l.). Some of the highest elevations are in the Waipoua–Hokianga area and in the Maungataniwha Range, and include the summits Tutamoe (770 m), Ngapukehaua (762 m), and Raetea (744 m).

The typical inland landscape is one of low, rolling hill country usually below 400 m a.s.l., and few mountain ranges or even isolated peaks rise more than 600 m a.s.l. This hilly and rolling landscape is incised in many places by an interfingering pattern of rivers, streams, inlets and harbours (Figure 4). With the exception of the Wairoa and Wairua, rivers and streams are generally short and slow flowing. There are only limited areas of extensive flat, low-lying land; generally these are wide floodplains and low terraces formed on fluvial and estuarine alluvium. They include the Ruawai/Dargaville plains, the Kaitaia/Awanui plains, and the Parakai/Waimauku flats adjacent to the Kaipara River. Other significant flat lowland areas comprise swamp land, such as the Hikurangi and Kaitaia swamps, which can become quite productive when drained.

Eight distinct physiographic units can be recognised (Figure 5):

### *1. Sand-country terrain – coastal sands*

This physiographic unit comprises extensive sand-country terrain along both the western and eastern coastlines (sand deposits have accumulated mainly during the last 2 million years BP) and includes windswept beaches, sand dunes, coastal terraces, and sand plains. Most of the sands have accumulated on the high-energy western coast, extending from Muriwai Beach in the south to Cape Maria Van Diemen in the north. Other major occurrences are at Karikari in the north. On the eastern side of the region the sand country is less extensive, with principal areas south of Whangarei at Marsden Point, and extending south to Waipu, Mangawhai and Leigh. Other main areas on the east coast include Omaha, Matapouri and Whananaki.

### *2. Floodplains, coastal plains, swamps, and estuarine flats*

Low-lying floodplains, coastal plains and estuarine flats commonly occur around inner harbour areas, bays and inlets, and near the mouths of streams and rivers. The most extensive flat areas are between Ruawai and Dargaville, Kaitaia and Awanui south of Rangaunu Harbour extending towards Victoria Valley, and in the Auckland district between Parakai and Helensville, extending south to Woodhill. Other notable but less extensive flat areas are situated around Kaeo, south of Whangaroa Harbour, south of Whangarei to Waipu, and east of Warkworth around the Omaha area. Swamp land, such as the Hikurangi swamp, is also significant in parts of the region.

### *3. Older terraces*

A number of terrace levels occur on unconsolidated to firm (or compact) alluvial and marine sediments of Quaternary age, along streams and rivers. These terraces are more extensive when adjacent to larger low-lying alluvial flats and less extensive in inland sites nearer to the headwaters of streams and rivers. Quaternary-aged terraces are characteristic features in the Auckland district from the Waimauku–Huapai areas to Albany up to Dairy Flat.

### *4. Undulating to very steep sedimentary terrain excluding greywacke*

This physiographic unit represents between 40 and 50% of the total land area mapped in Northland. The landscape is generally subdued, with very few steeply rising hills or mountains. It comprises stratified sandstones and mudstones, shattered argillites, frittered mudstones, limestone, and massive mudstone and sandstone. The majority of landforms have developed on a number of 'soft' sedimentary lithologies, namely shattered and sheared mudstones, sandstones, fine-grained limestones, shales, and argillites. Many of these rocks belong to the Northland Allochthon and Onerahi Chaos breccia. Allochthonous deposits are defined as having been substantially moved or displaced from their original site of deposition/emplacement, such as rock units subject to gravity-sliding on the sea floor. Since being redeposited (about 25 million years BP), much of the Northland Allochthon has been removed by erosion processes (particularly in the east) or buried beneath younger rocks.

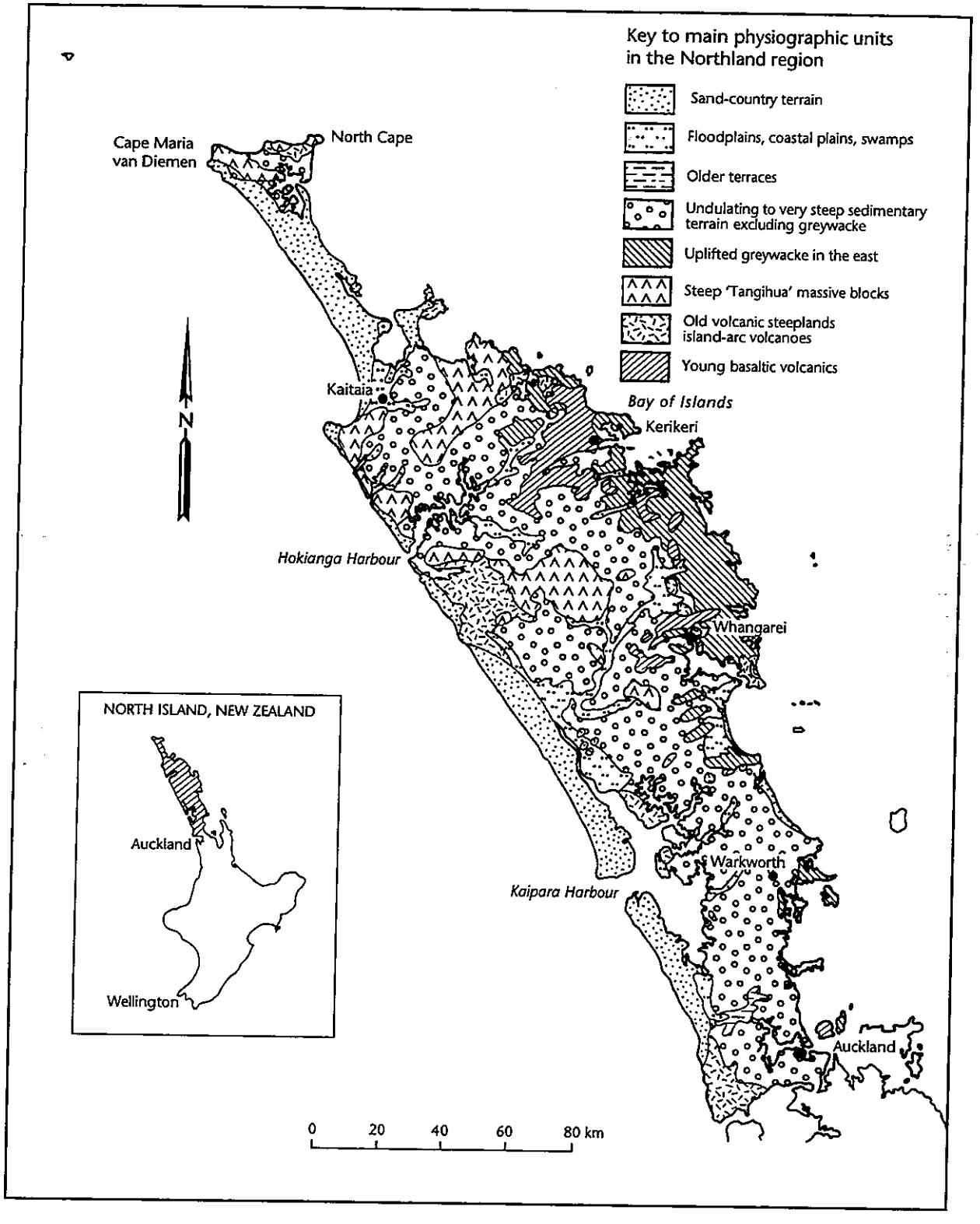



*Figure 5.*
*Major physiographic units (generalised) in the Northland region of New Zealand.*

In the southern part of the region, younger stratified sandstones and mudstones (marine sediments) are predominant, and form a homogeneous well-dissected landscape of moderate slopes.

These rocks were deposited (about 22–15 million years BP) between two chains of island-arc volcanoes, on either side of the present region. Stratified rocks were subsequently uplifted and broken into tilted blocks along major, steeply inclined faults, some 15 million years BP when the eastern portion of the Northland peninsula rose. Many of these sedimentary rocks dip gently to the north, while giving rise to steep cliffs, waterfalls, and scarp and dip–slope profiles on more southerly aspects. Long rolling to moderately steep slopes dipping to the north, abutted against short, steep to very steep slopes on the southerly part of each block, are a feature of this landscape.

In some localities, such as Waiwera northward, the landforms on these stratified deposits are much steeper, with higher ridges and cliffs, reflecting an increased resistance to erosion. This is attributed to a higher proportion, and general northward increase, in volcanic minerals contained in the sedimentary rock.

### *5. Uplifted greywacke*

This physiographic unit is extensive on the eastern side of Northland, and comprises uplifted greywacke rock (Triassic–Jurassic in age). These old, hard, and complexly deformed greywackes (indurated or very hard sandstones and mudstones) were block-faulted and tilted westward, approximately 15 million years BP. Tilting of these blocks along major, steeply inclined faults has clearly controlled the evolution of the greywacke landscape (well shown in the zone between Brynderwyn and Whangarei).

Landform expression is typically rolling to very steep with steep faces to the south and gently sloping surfaces to the north. Most Northland greywackes are deeply weathered and show a susceptibility to chemical weathering. Deeply weathered zones may extend more than 10 metres below thick clay-rich soils at the surface. Thus erosional processes usually act on the thick mantle of deeply weathered rock, not on the unweathered greywacke which is at depth and seldom exposed. This gives rise to a homogeneous landscape of close-set, steep-sided valleys.

### *6. Steep 'Tangihua' massive blocks*

This unit comprises ancient volcanics of mainly Cretaceous age and represents some of the steepest and most rugged terrain (rising to between 700 and 800 m), in sharp contrast to the surrounding low-lying subdued landforms on sedimentary rock.

The Tangihua volcanics are often referred to as fault-bounded massifs. They include the following mountain ranges and upland areas: Maungataniwha, Ahipara uplands, Mangamuka, Whirinaki, Parataiko, and Tangihua. These very steep landforms reflect the highly resistant nature of the old Cretaceous volcanic rock and usually form steeply rising, isolated, bush-covered mountain ranges and steep hills. Their present isolation as 'piles' of hard volcanic rock reflects their original break-up into blocks about 25 million years BP, during a subterranean sliding process, that deposited them as large volcanic remnants. Layers of hard lava within these old volcanic blocks often give rise to numerous bluffs and waterfalls. This unit occurs particularly in the northwest in areas such as North Cape, Kaitaia to Hokianga, south of the Hokianga Harbour to the Tutamoe Range, and between Dargaville and Whangarei.

### *7. Old volcanic steeplands from island-arc volcanoes*

This unit represents old, mainly Miocene-aged (about 27–15 million years BP) arc-type volcanic rock and intrusive igneous rock, and comprises steep, rugged, bush-covered terrain, mainly on the western side of Northland. Landforms developed on two spatially separate volcanic complexes, one on the eastern and the other on the western side of the region. The western belt is more basaltic while the eastern belt is dominated by andesites, dacites (for example, Parahaki dacite) and their intrusive equivalents. The western belt includes the Waitakere and Tutamoe Ranges which, because of their variation in form, are further separated into two distinct physiographic subunits: those landforms occurring in steep, rugged areas such as the Waitakere Ranges on old Miocene-aged volcanic

and plutonic rocks (dominated by volcanic breccias), and those areas such as the Tutamoe Range, comprising Miocene-aged plateau forming (sheet) basalts. The western belt, or Waitakere volcanic chain, left voluminous deposits of lava, breccia, and conglomerate on the western side (also referred to as the western volcanic chain) of the region, some 22 to 15 million years BP. These volcanic deposits extend northward from the Waitakere hills and around the sides of the Kaipara Harbour (Tokatoka, Hukatere) to Waipoua forest in the north. The eastern belt extended from the Coromandel up into Northland about 22 to 15 million years BP and is at present seen only in a few remaining areas in the region: Hen and Chicken Islands, Whangarei Heads, Whangaroa Harbour, Karikari, and North Cape.

Landforms on these Miocene-aged volcanics strongly reflect the volcanic emplacement processes of the underlying geology. These volcanic/plutonic complexes are commonly referred to as volcanic breccia and conglomerate 'sheets', in contrast to the volcanic 'piles' of the older Tangihua rocks (Ballance and Williams 1982).

The landforms developed on the Waitakere volcanic chain are characterised by high vertical bluffs, very steep slopes, and prominent sharp ridge crests. Vertical joints in the flat-lying layers of volcanic rock have prescribed the present landform pattern, and a number of large isolated pillars of rock remain in several localities throughout the region. Striking landscapes of high, vertical dark-coloured cliffs are developed on this type of rock in the southern Waitakere hills and around the Whangaroa harbour. A few large pillar-like remnants are also seen around the fringes of the Kaipara Harbour.

A variation on the volcanic breccia sheets of the Waitakere volcanic chain occurs in the Waipoua Forest where, instead of being dominated by volcanic breccias, the rocks are mostly sheets of solid lava. They dip gently to the southwest and give rise to the high, southwest-sloping tableland of Waipoua Forest (Ballance and Williams 1982). The very flat-looking landform on the Waipoua basalts contrasts markedly in surface form to that seen in the Waitakere Ranges and has been described as a *separate physiographic subunit.*

### *8. Young basaltic volcanics*

This physiographic unit comprises landforms largely on Quaternary-aged basaltic volcanics, and typically occurs in the Whangarei, Kerikeri, Kaikohe, and Auckland districts. Volcanic activity has occurred intermittently during the past in several locations, and basalts from these eruptive events have been distinguished mainly on the basis of landscape form and degree of weathering. The earliest period of basaltic volcanic activity (mainly during the Pleistocene) occurred in two main areas: in the north from Whangarei to beyond the Bay of Islands and as far west as Kaikohe, and south of the present Auckland City. Later activity began in the Whangarei–Kerikeri district during the late Pleistocene and Holocene, and in the south within the vicinity of the now highly populated Auckland City.

Landforms reflect the age and the intermittent nature of the volcanic fields, and in each area volcanism was both spasmodic and shifting. Eruptions occurred every few hundred or few thousand years, each fresh eruption or series of eruptions taking place from a new vent. The eruptions were of two main types: either explosions (usually with a mixing of water), producing circular craters surrounded by rings of tuff (volcanic ash mixed with pulverised country rock), or by a combination of lava fountains ('fire fountains') and lava flows.

These varying eruptive styles during the last one million years have contributed to the development of a range of young volcanic landforms, each 'type' reflecting the process of its volcanic origin. Included in these are steep scoria cones, and terraces formed on flat sheets of hard lava. Volcanic cones reflect processes during the early eruption phase, when pressurised molten lava is ejected high into the air from a central pipe. After settling and subsequent cooling, the lava builds steep-sided cones of scoria (fragmentary, highly vesiculated basaltic rock) with a central crater, marking the eruption pipe. Lava flows were mainly erupted from fissures.

As eruptions took place, the landscape was built up by consecutive layers of flowing basaltic lavas which solidified to form a relatively hard, dark-coloured and often dense rock. More recent eruptions (those less than 500 years BP) have resulted in relatively unweathered landforms,

such as Rangitoto Island where a small circular shield volcano has been formed.

## Climate

Although climate is not recorded in the inventory it is an integral physical factor in the assessment of land use capability. Climate determines the suitability of land for horticulture, cropping, pastoral and forestry use, and also affects erosion processes and possible soil conservation options.

Climate data for the region were obtained from a variety of sources, including *The Climate and Weather of Northland* (de Lisle and Kerr 1964). Other sources included the 1:500 000 isohyet map of New Zealand (NZ Meteorological Service 1978), the 1:2 000 000 map of climatic regions (NZ Meteorological Service 1983b), rainfall normals (NZ Meteorological Service 1984) and climatological records from individual stations (NZ Meteorological service 1983a), and papers and reports, including those of Sparrow (1968), and Waugh (1970, 1978).

Climatic regions for Northland are defined by the NZ Meteorological Service (1983b) as climate types A1 and A2. The proximity of the sea, combined with an almost subtropical latitude, results in a climate characterised by warm, humid summers, and relatively mild winters. Maximum rainfalls are in winter. Prevailing winds tend to be from either the southwest or west and occasionally from the southeast. The climate is very variable, temperatures vary greatly with altitude and exposure, and droughts occur periodically within different areas or districts, most often during summer months. Heavy rainfalls are often localised and can cause flooding and erosion in a relatively short space of time. The Northland Peninsula is often affected by intense 'cyclonic'-type rainstorms which often originate near, or in, tropical belts to the north of the region. Storms usually occur during the months of November through to April.

The mean annual rainfall varies between 1000 and 1500 mm in the south and north and increases to between 1500 and 2500 mm in the centre (Dargaville across to Whangarei and north to Kaitaia–Kaeo), particularly where altitude is greater than 300 m a.s.l. The west tends to be slightly wetter than the east, and inland hillier areas are wetter than those near the coast. Hilly terrain on the east coast margin (greywacke) is particularly prone to drought during summer months.

The mean annual rainfall can vary significantly from area to area. The annual rainfalls for low-lying coastal districts are often between 1000 and 1400 mm, while for upland areas above 400 m a.s.l. they are often between 1600 and 2500 mm. Some high-elevation areas (>600 m a.s.l.), such as the Tutamoe Plateau, receive annual rainfalls greater than 2500 mm. Approximately one-third of the yearly rainfall total falls in the three winter months of June, July and August, and only one-fifth in summer months. On average, rainfalls are recorded on 125 to 200 days per year, with areas of high elevation towards the western side receiving rain on the greatest number of days. The region is subject to high-intensity rains and, as many of the rivers and streams have flat gradients, flood rises can be spectacular and flood damage serious. Intense short-duration rainfalls, thunderstorms and hail can be a periodic problem affecting horticultural areas, particularly in the district immediately north of Auckland (Sparrow 1968; Waugh 1978).

Mean annual temperatures range from about 15.5°C in the far north to 14°C in the southwest coastal districts, giving the region the highest mean annual temperatures in New Zealand. Although there are other districts in the North Island that have higher February mean temperatures than those found here, nowhere further south are the July mean temperatures as high. The daily and annual temperature variations are also low. Many of the soils, having a high clay contents, dry out in summer months, making grass and animal production difficult. Light frosts are common in winter, particularly in southern parts, but are not usually severe, and do not generally have an adverse affect on plant growth. Soil temperature and degree day totals are two climatic parameters that are of particular importance in assessing the suitability and versatility of land for plant growth. Data from soil temperature maps at 1:2 000 000 scale (NZ Meteorological Service 1983c) and generalised maps of degree day totals helped confirm the validity of the LUC classification. Further information on the effects of climate on land use capability is given in the description of LUC suites.

## Rock type

Rock types were recorded for each map unit, using the Rock Type Classification for the New Zealand Land Resource Inventory (Lynn and Crippen 1991). The classification is listed in Appendix 12, and was designed basically for soil conservation purposes, grouping rocks with similar erosion susceptibilities and similar compositional and structural characteristics. In the NZLRI, the rock-type factor is used to record both the underlying and basement rocks, and also the surficial rock types or cover deposits such as alluvium, airfall tephra, and wind-blown (aeolian) sand. Only those rock types that directly influence surface (landform) morphology and land use are recorded. Because no more than three rock types are recorded per map unit, rock types known to be present, but representing limited areas, may not always appear in the inventory.

The major geological surveys used in the NZLRI are given in Appendix 9. In most areas, basic geological information was obtained from the New Zealand Geological map series at the scale of 1 : 250 000. The region is covered by Sheet 1 North Cape (Kear and Hay 1961), Sheet 2A Whangarei (Thompson 1961), and Sheet 3 Auckland (Schofield 1967). These maps record rocks as time–stratigraphic units.

The other major source of geological information was the Lands and Survey (Department of Survey and Land Information) single-factor NZMS 290 series maps at the scale of 1 : 100 000 (13 maps cover the region), fully referenced in Appendix 9. These maps were highly suited to land use capability mapping as they identified and defined lithological rock units. Provisional geological maps covering the NZMS 260 Whangaparaoa sheet area and the NZMS 260 Helensville sheet area (Schofield 1989) at 1 : 50 000 scale were also used. A large amount of published and unpublished information from other sources was also consulted (e.g. Hayward 1975, 1983a). All information was supplemented by extensive field investigation.

## Soils

The second edition LUC classification of the Northland region was completed before the New Zealand Soil Classification (NZSC) (Hewitt 1993) was published. Assignment of soil groups to their NZSC equivalents can be done through the National Soils Database, which is maintained and developed by Landcare Research. [These details can be obtained by contacting Landcare Research in Palmerston North or in Lincoln, Canterbury.]

Soil mapping units are defined by Cox et al. (1983) as 'Soil Series' (for example, the Wharakohe series); 'Soil Sets' on defined parent materials within one soil suite, such as Wharakohe soils on claystone, mudstone, and shale (that is, Wharakohe podzols of the Omu suite) which includes Wharakohe silty loam, Wharakohe silty loam with pan, Wharakohe silty loam with brown subsoil; and 'Soil Types', the basic mapping unit within a soil suite (for example, Wharakohe silty loam of the Omu suite).

The 'Genetic Soil Groups' of Northland are subdivided into 29 'Soil Suites' by Cox et al. (1983). Most of the suites have been termed 'coarse suites', which include a range of parent materials, and each suite reflects one or a number of similar parent materials from which the soils were formed. Further subdivision of 'coarse suites' into 'finer (purer) suites' was based on more detailed separation of parent materials. Subdivision of genetic soil groups into subgroups was generally related to the degree of leaching. The 'Soil Suite' approach (Cox et al. 1983) relates very closely to the resulting physiographic–management unit subdivisions made in the NZLRI. The conceptual approach of subdividing soils into soil suites is practical and has worked very well given the complexity of the soil pattern.

General information about the properties of soils can be obtained from a number of sources, such as *Soils of the North Island* (NZ Soil Bureau Bulletin 5, 1954), NZ Soil Bureau Bulletin 26, and the Northland Regional Development Resources Survey (Cox 1978). A general account of the soils of Northland is given in *Soils of Northland* by H.S. Gibbs (1964), in *National Resources Survey Part III – Northland Region* by the Town and Country Planning Branch, Ministry of Works (1964), and by Molloy (1988).

More detailed information on individual soils is given in a number of papers (Gradwell 1971; Metson et al. 1977), and is available from Landcare Research New Zealand. Further information is also detailed in the unpublished series *Soil Groups*

*of New Zealand* (Cox 1977), produced by the NZ Society of Soil Science.

The level of detail and quality of soil maps at the scale of 1:100 000 and 1:63 360 was highly suited for incorporation into the NZLRI database at the scale of 1:50 000. Extensive field investigation during the NZLRI mapping and assessment scrutinised all soils data which were checked in accordance with recorded rock-type data. It should be noted that the soils data collected do not constitute a new soil map. Because soils are only one of the five inventory factors recorded within a 'homogenous' map unit, the NZLRI inventory map unit boundaries need not necessarily correspond exactly to the soil map unit boundaries (from soil maps) covering the same area. For more detailed soil description and interpretation, users should consult the appropriate soil maps and associated reports. These are listed on the legends of the individual NZLRI worksheets.

Typical soils are given for each LUC unit in the land use capability unit descriptions (page 36).

The soils generally have clay-rich profiles over deeply weathered rocks. A number of factors have contributed to the high degree of chemical and physical weathering of the rocks:

- a relatively warm humid climate
- the marked influence of vegetation on soil formation
- the domination of forests by species such as kauri, taraire, puriri, mangaeo and pohutakawa
- subdued and old topography, with little rejuvenation of the landscape by Pleistocene glaciations
- the paucity of tephras.

In particular, the effect of vegetation type on soil formation has been significant. The poor physical properties, such as podzolisation and gleyisation, seen in many of the region's soils can be largely attributed to the deep layers of highly acidic kauri litter (During 1984; Molloy 1988).

The most common parent materials are:

- underlying or basement sedimentary rocks: sandstone, mudstone, siltstone, argillite–shale, limestone, and greywacke; underlying or basement volcanic rocks: andesitic rock flows, basalt, dolerite, and dacite
- surficial rock types or cover deposits: alluvium, wind blown (aeolian) sand, peat, and airfall tephra.

Soil map units for Northland have been arranged on the basis of parent material (soil suites) and defined accordingly in genetic soil group sequences (Cox et al. 1983). Most soils are more easily described in terms of their leaching sequences, which are closely related to topography. Soils in steeper environments are generally less leached while those on easier slopes are often strongly leached or podzolised. Major genetic soil groups are as follows:

### *Yellow-brown sands*

Soils ranging from weakly leached to strongly leached are developed from accumulations of young (Pliocene to Holocene age) aeolian (windblown) sands along a wide coastal zone which forms an outer perimeter bordering most of the region. Parent materials range from unconsolidated to firm or compact, particularly along the west coast. Original vegetative cover on these soils included manuka/kanuka, swamp vegetation, coastal forest in inland areas, and sand-dune vegetation towards the coast.

### *Recent and gleyed recent soils from alluvium*

Formed from sedimentary and/or volcanic (i.e. mainly doleritic and andesitic rocks) alluvium. Alluvium derived from sedimentary rocks reflects a range of source lithologies, from dune sands near the coast, to mudstones, sandstones, argillites, and greywackes throughout the interior and on the east coast. The main source areas for volcanic detritus throughout western and interior parts are the older volcanics of Cretaceous (about 135 million years BP) to Lower Miocene (about 25–15 million years BP) age, namely the volcanic/plutonic complexes of the old Tangihua, and younger Waitakeres and Waipoua volcanics. Other important source areas for volcanic alluvium are the younger, mostly Quaternary-aged basaltic volcanics in the Kerikeri, Kaikohe, and Whangarei areas.

### *Gley soils*

These are developed from fluvial and estuarine alluvium (clays and sands), terrace alluvium, and lacustrine deposits, and they typically form in wetland environments. They are further

subdivided into finer subgroups of slightly saline gley soils and podzolised gley soils.

### *Organic soils*

Formed from peat and alluvium where peat was derived from plant remains accumulating in swamp environments, such as areas with a high watertable.

### *Yellow-brown earths and related steepland soils*

These are extensively recorded, and are mainly clays and clay loams. Subsoils have strongly developed coarse nut structures and show leaching sequences from weakly to strongly leached or weakly podzolised. Main clays are kaolin and vermiculite. Strongly leached soils (often developed where podocarp forest was dominant) have poorer drainage, greyer subsoils (with mottles), higher acidity, and a higher proportion of halloysitic clay (Molloy 1988). Yellow-brown earths are developed on a range of sedimentary and volcanic rock types. Sedimentary rocks include interbedded or massive sandstones, mudstones, argillite–shales (occasionally referred to as claystone), limestones and greywacke. These rocks are often deeply weathered and highly sheared. Yellow-brown earths may also be developed from volcanic and intrusive igneous (plutonic) rocks such as dacite, rhyolite and granodiorite. Landforms are typically rolling to steep. During the formation of these soils, vegetation was primarily lowland podocarp–broadleaved forest and kauri (conifer) forest.

### *Podzolised yellow-brown earths*

These earths are clay rich and have prismatic subsoils breaking down into coarse blocks. Generally they have poor internal drainage and are prone to various forms of erosion. Subsoils have grey colours with distinct mottling, indicating reducing conditions, coupled with low pH (less than 5). The main clay is smectite. These soils are developed on a range of lithologies, principally sandstones, mudstones, argillite–shale (claystone) and alluvium but also include greywacke, quartzite, dacite, rhyolite and granodiorite. They typically occur on undulating to rolling landscapes. Original vegetation was lowland podocarp–broadleaved forest and kauri (conifer) forest.

### *Podzols*

Podzols occur extensively, typically on flat to gently rolling landforms underlain by sedimentary rocks. Infertile soils with bleached top horizons and very poor structure, podzols are often described as silt to sandy loams with dark grey topsoils and white grey subsoils, often with a dark-grey hardpan at depth. Developed on sedimentary lithologies such as sandstones and mudstones, or on old deeply weathered sands such as those of aeolian and fluviatile origin, podzols are also formed on deeply weathered volcanic rocks such as dacite and rhyolite. Landforms within sand terrains include truncated dunes and coastal terraces. Kauri and lowland podocarp forest was the original vegetative cover.

### *Rendzinas and associated soils*

These soils are formed from limestone, often where limestone rock is exposed at the surface, and are associated or complexed with yellow-brown earths. They are heavy, relatively fertile soils with dark grey to black clays. They have high cation-exchange capacities and base saturation, and also high contents of well-decomposed humus and montmorillonitic clay. Landforms are typically undulating to strongly rolling, and moderately steep to very steep. Lowland podocarp–broadleaved forest, broadleaved forest and kauri forest were the original cover, and soil properties and drainage are poorer where soils have developed under kauri or podocarp forest. In some areas these soils have deteriorated, with the alteration of montmorillonitic clays, under a warm humid climate and acid vegetative litter. With the application of phosphatic fertilisers, this land is highly productive and suited to pastoral land uses.

### *Red loams*

Developed from Quaternary-aged basaltic scoria and ash. These relatively young soils are generally friable and free draining, with good structure and quite high fertility. Older soils are clay rich and have high contents of kaolin-type clays or allophane, depending on the degree of leaching,

and crystalline oxides of aluminium (gibbsite) and iron (goethite, haematite). Red loams occur mainly in the Whangarei, Kaikohe, and Kerikeri districts. Broadleaved (puriri and taraire) and podocarp–broadleaved forests originally covered the landscape.

### *Brown loams*

Developed from Quaternary-aged basalt flows and ash. These soils generally have good structure and most are friable, granular and free draining with bouldery subsoils. The brown loams usually have high contents of kaolin-type clays or allophane (depending on degree of leaching) and crystalline oxides of aluminium (gibbsite) and iron (goethite, haematite). More strongly leached soils have high acidity, high contents of iron/aluminium oxides (often as nodules) and accumulation of kaolin, and are of lower fertility than less leached soils. Brown loams are recorded extensively in the Kerikeri, Kaikohe and Whangarei districts. Original vegetation was broadleaved forest (puriri and taraire) and podocarp–broadleaved forest.

### *Brown granular clays and loams and related steepland soils*

These soils occur on undulating to steep landforms underlain by volcanic rocks such as the Tangihua volcanics, the Waitakere Group volcanics and the Waipoua basalts. They often have nutty to coarse granular structures and high clay contents (mainly kaolin) and are relatively high in iron oxides and occasional manganese oxides. The following parent materials have been recorded: shattered dolerites, breccias and tuffs, andesitic agglomerates and breccias, andesitic flows, and alluvium derived from volcanic rocks.

Brown granular loams and clays have low natural fertility levels and dry out readily in summer months. They have particular deficiencies in molybdenum, and require in addition high inputs of superphosphate, lime, and potash fertilisers. Podocarp–broadleaved forest and some kauri forest were once very extensive. Where kauri was predominant, the soils are more strongly leached.

### *Podzolised brown granular clays*

Moderately to strongly podzolised soils of limited area are more typically mapped in high-elevation areas such as on plateaux or upland environments receiving higher rainfalls (e.g. >1800 mm/year). These soils tended to form under predominantly kauri forest.

### *Soil complexes*

Soil complexes are formed where parent materials and soils, often with different degrees of leaching, are complexed or closely associated, particularly in one area. Parent materials can be categorised in two main groups: the first includes mixtures of airfall and reworked volcanic ash, organic soils, alluvium, limestone and/or mudstone such as in the north Auckland area. The second includes associations or complexes of volcanic and sedimentary rock, including andesitic flows, breccias, tuffs, dolerites, agglomerates, mudstones, sandstones, and argillite. Soil complexes C1, CIA, C4, C5 (Haunga complex), C8 (Onetai complex), and C9 (Waimamaku bouldery complex) are all defined for the region (Cox et al. 1983). The C1 complex, recorded mainly in the north Auckland district, contains a number of soil groups such as yellow-brown loams, podzolised yellow-brown loams, podzolised yellow-brown earths, and organic soils. Where the second group of parent materials is recorded, soil groups are typically brown granular loams and clays complexed with yellow-brown earths.

## Slope

Slope is recorded as one or a combination of slope groups defined in the NZLRI standard classification shown in Appendix 13. The slopes recorded are the dominant or controlling slopes, or the most commonly occurring slopes within a particular delineated landform–management unit (inventory map unit). Slopes are initially measured in degrees and then recorded in the NZLRI inventory as a standard code representing each slope group. Slope groups range from A to G. The total number of separate slope-group categories recorded in the inventory is limited to a maximum of three. Slope groups are recorded in the NZLRI in descending order of dominance so that the first slope expressed is always the most dominant.

Slopes are typically measured in the field

using an inclinometer, and measurement is generally given as an angle, expressed in degrees. If required, slope angles and slope groups can be translated into percentages. With experience (when observing large areas of similar terrain) slope measurements may be estimated in the field and on aerial photographs. Estimated measurements can be continually checked and verified during field assessment. Slope comparators can also be used during stereo aerial photograph interpretation to check slopes. Additional codes are often recorded in conjunction with the slope group codes to give additional information on the type of slope or slope-group association (i.e. complex slopes, compound slopes, dissected slopes). These additional codes are shown in Appendix 13.

## Erosion

The recording of erosion type and severity for each inventory map unit is based on the NZLRI erosion classification (Appendix 14; Eyles 1985). These assessments were mainly derived from interpretation of stereo-aerial photographs at a scale of 1:25 000, and from extensive fieldwork, aided by knowledge of the rock, soil, slope and climate factors which have a direct influence on the erosion characteristics and the pattern of distribution. Vegetation may also be indicative of this erosion pattern or, in combination with other physical factors, may exert some influence, such as degree of wetness on slope.

It is important to realise that the methods used to record mass movement and fluvial types of erosion in the NZLRI do not give actual areas of erosion, as erosion is recorded within defined landform–management units (inventory units) whose boundaries reflect a combination of physical factors. Only the areas of specified inventory map units containing information on erosion type or severity can be given. However, because surficial erosion is recorded initially as an areal percentage, it can be calculated to give an approximate area within defined or specified inventory map unit areas.

With surficial erosion types (sheet, wind, and scree creep erosion) the assessment of severity (or alternatively, degree) of erosion relates to a percentage of bare ground on the following basis: 0 = <1%, 1 = 1–10%, 2 = 11–20%, 3 = 21–40%, 4 = 41–60%, 5 = >60%. The severity measurement of mass-movement and fluvial erosion is derived in a more complex, subjective way, based on a combination of factors in addition to area, including rate and depth of movement, frequency of erosion event, and cost of control. It is assessed according to the following scale: 0 = not significant, 1 = slight, 2 = moderate, 3 = severe, 4 = very severe, 5 = extreme. No calculations of the actual areas of erosion can be made.

Present and potential erosion derived from the first edition NZLRI of the region at the scale of 1 : 63 360, along with an interpretation of erosion associations, are produced at a scale of 1:250 000 in the 'Erosion Map of New Zealand'. The Northland Region is covered by Sheets 1, 2 and 3 (Whiley and Wood 1977, 1979; Trustrum and Walsh 1976).

The main studies of erosion in Northland before publication of papers, the NZLRI and the Erosion Map of New Zealand, were those by Cumberland (1944), Ward (1966), and Visser (1969), and also unpublished reports by the Northland Catchment Commission (NCC), 1968–1975. Other notable, more recent studies, include those of Schouten and Hambuechen (1976), and Fitzwilliam and Whiley (1976). The most significant paper giving an overview of erosion in the region was the *Soil Conservation Survey of the Northland Catchment Area*, published in 1968 by Burridge and Cathcart of the Northland Catchment Commission. This was further added to by surveys of the North Kaipara and Mangawhai Catchments of the Otamatea County by Fitzwilliam and Whiley of the NCC. Other works include the unpublished report 'Northland: A report to accompany Erosion Sheets 1 and 2' prepared by the Ministry of Works and Development (1975), and an unpublished report by Wood (1975) on the northern parts of the region. All this work has been summarised in the chapter 'Soil Conservation and Erosion Control' in the 1978 report *Northland Regional Development Resources Survey* (Northland Regional Development Council and Northland Regional Planning Authority).

The main conclusion derived from these papers was that "at this stage of Northland development, erosion is not generally severe throughout the region, but there are isolated problem areas."

Authors of these reports also recognised the relationship between erosion and the following factors: the erodible nature of many of the soils; the inherent unstable characteristics of many rock types (e.g. weak structural and sheared nature of many rocks); the deeply weathered character of rock types; and the intensity of rainstorms which affect the region.

The LUC Classification in both the first-edition NZLRI (at a scale of 1:63 360) and the second-edition NZLRI (at a scale of 1:50 000) is based on the relationships that exist between lithology, soils, erosion, slope and climate, and the potential for sustainable agricultural production. The causes of erosion, however, are complex and may include combinations of the following: general nature of the rock type such as rock strength; geological composition, age and structure; depth and degree of weathering of soil and rock; soil properties, soil texture and structure; slope characteristics (angle, shape, aspect); drainage and moisture conditions; vegetation cover; land-use practices; and climatic factors (rainfall intensity and duration, or strong or persistent winds). A large amount of evidence (Northland Regional Development Council and Northland Regional Planning Authority 1978a,b; NCC, pers. comm.; Northland Regional Council, pers. comm.; NZLRI survey, second edition) shows links between the intensive development of land, where grassland and to a lesser extent scrub has replaced forest or dense scrub, and increasing erosion, both in terms of present and potential erosion. Erosion may be locally severe or widespread under certain conditions, mainly related to a combination of land type (such as the potential or susceptibility of land to be eroded) and certain climatic parameters. A number of authors therefore stated in earlier reports that unless long-term sustainable strategies are incorporated into land-use management systems, intense or widespread erosion and flooding, along with declining productivity levels, can be increasingly expected.

Erosion control and soil conservation planning in the region came under the Resource Management Act in 1991; before this, all soil conservation works were carried out under the Soil Conservation and Rivers Control Act 1941. Before 1989, when new local government legislation was introduced into New Zealand under the Local Government Amendment Act 1974, soil conservation works were carried out principally by the Northland Catchment Commission in the northern half of the region, and the Auckland Regional Authority in the southern half of the region (north Auckland). Replacing these two organisations were the Northland Regional Council and the Auckland Regional Council which came in to being in late 1989. These two councils administer basically similar territorial areas to those existing before 1989 and, along with a number of separate district councils in the region, collectively administer the regulatory functions concerning soil conservation under the statutory framework of the Resource Management Act of 1991.

Generalised relationships between lithology–terrain type and predominant erosion type are shown in Table 1. The table shows the main physiographic areas where both present and potential erosion problems are identified using NZLRI data and physical data from earlier surveys (also summarised in the report by Burridge and Cathcart 1968). A more detailed account of erosion types and potential erosion for different types of land is given for each LUC suite and LUC subsuite in a later section (pages 36–104). Present and potential erosion and severity rankings are given there for each LUC unit in the Land Use Capability unit descriptions, pages 105 to 234.

## Vegetation

Vegetative cover was assessed for each inventory map unit, using a classification of 50 vegetation classes, arranged in five major groups: grassland, cropland, scrubland, forest and herbaceous (Appendix 15). Up to three vegetation classes were recorded in each inventory map unit, in descending order of percentage cover, and each vegetation class was recorded to the nearest 10%. The method of recording vegetation distribution within inventory map units is described in Appendix 15.

The vegetation classification used in the second-edition NZLRI for Northland (Page 1987) was adapted from an earlier classification (Hunter and Blaschke 1986) which was used in the first-edition mapping of the region. A correlation of these two classifications has been given by Harmsworth (1990).

*Table 1: Relationships between lithology–terrain and erosion for the Northland region. Adapted from Cathcart 1978.*

| | Lithology/terrain types | Erosion types |
|---|---|---|
| (a) | Sand country (LUC Suite 1) | Prone to wind and sheet. Potentially highly erodible on both coasts. |
| (b) | Alluvial plains (LUC Suite 2) | Locally severe streambank. Silting and flooding may be a serious problem in some areas. |
| (c) | Steep (>20°) terrains on the stratified/ interbedded sandstones and mudstones (e.g. Southern Northland) (LUC Suite 4) | Prone to soilslip, earthslip, and tunnel gully. |
| (d) | The rolling/strongly rolling 'clay' hill country on a range of sedimentary rock types (LUC Suite 4) | Prone to tunnel gully, earthflow, earthslip, soilslip, gully. |
| (e) | Deep argillaceous limestone and associated complex soils (LUC Suite 4) | Among the most erodible soils in the region. Prone to gully, tunnel gully, earthflow and slump. |
| (f) | 'Gumlands'/Podzolised soils (LUC Suite 4) | Serious problems when mismanaged. Prone to tunnel gully, gully, and sheet. |
| (g) | Crushed argillite terrains (LUC Suite 4) | Severe to very severe gully and rill erosion. Also prone to sheet and soilslip. |
| (h) | The greywacke hill country (LUC Suite 5) | Prone to earthslip and soilslip , and minor debris avalanche. |
| (i) | Older volcanic soils and steep volcanic hill country (LUC Suite 7) | Have suffered mismanagement. Under pasture are prone to sheet, wind and gully. Steep areas are also prone to soilslip, earthslip and debris avalanche. |

Information on vegetation cover was derived from fieldwork and interpretation of aerial photographs. This was supplemented by published maps and associated reports and papers.

Several general vegetation descriptions are available, and vegetation maps from the Department of Survey and Land Information Lands and Survey (formerly Lands and Survey Department) NZMS 290 series at 1:100 000 scale also provided useful background information. Full bibliographic references are given in Appendix 11.

A brief summary on the vegetative cover for each LUC suite is given later (pages 36–104). The broad vegetation pattern of the region, and vegetation group and class areas, are described in the section on present land use (page 27).

At least 15 years have elapsed between the current second-edition NZLRI mapping at the scale of 1:50 000 (1985 to 1990) and the first-edition mapping at the smaller scale of 1:63 360

as part of the NZLRI programme between 1973 and 1975. During this time some significant changes in vegetation have occurred, principally increases in areas of exotic forest, such as extensive plantings on the sand country along the west coast, on the steeper volcanic terrains between Hokianga/Dargaville/Whangarei and the Bay of Islands, and in the southeast sector of the region around the Brynderwyns and south to Dome Valley.

The patterns and areas of horticultural, orchard, and vegetable crops and nurseries have also increased dramatically during the last 15 years, particularly in the Kerikeri, Whangarei and Kaikohe districts, on free-draining and friable volcanic soils, and in the north Auckland district from Huapai–Kumeu to Silverdale. Other areas of noticeable change extend within the sand country, for example from Dargaville to Pouto, from Parakai to South Head, and from Kaitaia extending up through the Aupouri Peninsula (Pukenui). Horticultural expansion in the Kerikeri and Whangarei districts has been largely in response to improved irrigation and increased markets. Other major changes have been the clearance of scrub from many areas, with increasing inputs into pastoral farming and the development of high-producing pastures. In many areas, however, the reverse has occurred, with scrub replacing pasture. A number of noxious weeds and plants are recorded, and are noticeably more widespread in western areas. Some of the most common are: Australian sedge (*Carex longibrachiata*), pampas grass (*Cortaderia jubata* and *Cortaderia selloana*), tobacco weed or woolly nightshade (*Solanum mauritianum*), gorse (*Ulex europaeus*), blackberry (*Rubus fruticosus*), tree privet (*Ligustrum* spp.), and wild ginger (*Hedychium gardnerianum* and *H. flavescens*).

Other significant changes in land use have resulted from improved drainage systems, such as those draining swampland and floodplains (Hikurangi flats, and on land surrounding Dargaville) and the extensive reclamation of estuarine and tidal flats. Stopbanks, such as those on the flats adjacent to the Wairoa river, have also extended land development in a number of areas.

# Present land use

Pastoral farming and exotic forestry are the most widespread land uses in Northland. Although large areas of land have been increasingly used for productive purposes such as pastoral farming, exotic forestry, and horticulture, there are still significantly large areas which are under utilised, such as multiple-use, flat to rolling land covered in scrub. There is enormous potential for horticultural development to expand further in the region with intensification or diversification into other types of crops. The main restriction on this expansion in the future, however, will be poor soil conservation management in some areas, requirements for irrigation, and the threat of increasing urbanisation. Many of the most versatile soils in the region are being increasingly removed for urbanisation or seriously degraded under repeated cultivation.

Northland covers 6.0% of New Zealand but, as at 30 June 1988, carried 17% of the nation's dairy cattle, 17.5% of beef, 4% of sheep, 14% of pigs, 8.5% of deer, and 14% of goats. It also produces 19% of New Zealand's total fruit, vegetable and nursery crops, and 12% of the nation's exotic timber plantations. Horticulture and other forms of cropping have become increasingly important during the last 20 years and, together with orchards and nurseries, and vegetable crops, currently cover approximately 12 000 hectares. Horticulture is restricted to the most versatile soils, usually the most fertile, and the gentlest slopes (Kumeu–Huapai, Whangarei, Kerikeri districts) or, in the case of viticulture, the most appropriate soils and climate.

## Exotic forestry

Exotic forest (mainly *Pinus radiata*) occupies about 160 000 ha (10% of the region), with much of the land which has been planted having a moderate to extreme potential for erosion. Forests have been planted on a range of land types. Exotic forest is extensive on coastal sand country, particularly on the western side of the region, from Woodhill in the south extending to the Hokianga area in the north, and on the northern side of the Hokianga Harbour. Other plantings cover the sand country along the Aupouri Peninsula, and on sedimentary/volcanic terrains with podzolised soils near North Cape. On the eastern side of the peninsula, forests are extensive on the sands in the Mangawhai area.

Important areas include forests in the north Auckland district on moderately leached to podzolised yellow-brown earths on interbedded sandstones and mudstones and conglomerate, which extend from Riverhead up to Dome Valley. These were some of the first areas planted in exotic forest after intensive fertiliser application. Exotic forest is now extensive on the infertile argillite–shale and mudstone and minor limestone country near Kaikohe, such as the area from Kaikohe to Ngawha and south to Pipiwai. Plantings have increased in the last 10 to 20 years on steep hill country from the Waipoua and Mangakahia areas across to Whangarei. In Whangarei, much of the land in the west is on volcanic terrain with brown granular clays and loams, for example Waipoua basalt and Tangihua volcanics, while land further to the east is underlain by argillites, mudstones, and greywacke. Large areas of forest cover volcanics, greywacke, and argillites in the north, such as Omahuta forest up to Mangonui and Whangaroa. Exotic forest is grown extensively on the greywacke terrains on the eastern side of the region from the Brynderwyns in the south to Whangarei, and north to the Bay of Islands. Hardwoods such as eucalyptus and acacia species make up a very small component (<0.1%) of exotic forest in Northland and are mainly recorded in sand-country areas or occasionally on greywacke. Agroforestry is limited, such as seen in the area from Dargaville to Pouto.

## Horticulture

Some of the main crops include: citrus, such as mandarins, oranges and tangelos; pip fruit, such as nashi (asian pears) and limited areas of apples; stone fruit, such as peaches and plums mainly in the Auckland area; berry fruit, such as strawberries, blueberries, and raspberries, also mainly in the Auckland area; and subtropicals, including avocados, feijoas, kiwifruit, persimmons, tamarillos, and grapes. Grapes make up a signifi-

cant proportion of crops in the Auckland district, particularly around Kumeu to Waimauku and Riverhead to Albany. They are grown on a limited scale in locations north of the Auckland district, such as Whangarei. Kiwifruit cropping increased markedly in the 1970s and 1980s, mainly in the Auckland, Whangarei and Kerikeri districts, but popularity has since decreased because of economic and market constraints. A number of vegetable crops are grown on the more fertile soils in the region, mainly on the recent soils on alluvium, organic soils, and at a more limited scale on the weakly to moderately leached soils of the red and brown loams, yellow-brown earths, and brown granular loams and clays. Market gardening of both vegetables and fruit crops is well established in the north Auckland district around Kumeu–Waimauku and up to Albany, and also around Kerikeri, Whangarei, Ruawai to Dargaville, and Kaitaia. Kumara are grown in the Ruawai–Dargaville area on the alluvial plains, and to less extent on alluvial/peat areas near Kaitaia.

Grain cropping is limited because of the warm subtropical climate. However, barley and maize, along with fodder crops, swedes and rape are grown to a limited extent for stockfeed.

## Pastoral farming

Dairying remains one of the dominant pastoral agricultural land uses, generally on flat to gently rolling country on a range of rock types, but most commonly on sedimentary rock with strongly leached to podzolised soils, or on alluvium with a range of soil types. The more strongly leached and podzolised soils generally require quite high fertiliser and trace-element inputs. Dairying extends largely from Albany (Dairy Flat) in the south, to the Kaitaia–Aupouri area in the north. It is also significant in the sand-country areas such as the wide floodplains, and the more deeply weathered dunes and terraces, from Parakai in the south to Dargaville and Waipoua in the north.

Beef cattle and sheep are usually run on steeper sedimentary and volcanic country. These livestock are common on much of the drier, hillier, greywacke country in the east, on steeper country on mudstones and sandstones, and on the volcanic country in central and northern parts, areas such as Waipoua–Hokianga up to Kaitaia, and the northern parts of the Aupouri Peninsula.

Many steeper, high-rainfall areas are currently reverting to fern and scrub because of declining stocking rates, reduced fertiliser inputs and the subtropical nature of the climate, which stimulates vigorous plant growth. Weeds and noxious plants, such as tobacco weed or woolly nightshade, privet, Australian sedge, blackberries, gorse, and pampas grass are a common problem in areas which have a high potential for scrub reversion. Gorse is predominant on less fertile soils, such as on strongly leached to podzolised soils on greywacke, argillite and alluvium. Reversion to gorse is also common on shallow, infertile soils on basalts.

Deer and goat farming have greatly increased since the 1970s. Deer farming has concentrated on less steep areas in the region such as the sand country north of Woodhill to South Head and north of Kaitaia, and also on flat to rolling land on alluvium, on older sedimentary rock such as sandstones such as around Helensville, and on a range of volcanic terrains. Goat farming has been more common on steeper (strongly rolling to very steep) land requiring careful management to avoid land degradation. Goat farming is small scale and localised and occurs on a range of sedimentary and volcanic terrains – for example, extending from Waipoua to Hokianga, and across to Whangaroa, in limited areas within the Auckland district, and in the sand country south of Dargaville.

## Undeveloped land

Undeveloped land (native forest, scrub, wetland vegetation, sand-dune vegetation, unvegetated land) occupies about 415 000 ha or 26% of the region. Much of this is steep land covered in scrub and/or native forest.

Unvegetated land (26 854 ha) is mainly restricted to sand dunes, or very steep areas, including rocky cliffs along the coast. Wetland vegetation (15 898 ha) includes swamp vegetation and scattered podocarps and *Cordyline australis* in low-lying areas, and sand-dune vegetation (9690 ha) includes sand-binding grasses and lupins. The largest undeveloped areas are covered by native forest and scrub (about 362 700 ha or

23% of the region). Scrub covers approximately 189 000 ha or 12% of the region. Its distribution is usually one of two main types: either extensive continuous scrub cover (over entire hillsides), or less extensive scattered cover intermixed with grassland.

Scattered scrub is very common throughout the region on extensively farmed, unoccupied, or untended rolling to steep hill country. The most dominant types of scrub include manuka, mixed indigenous scrub, native scrub with tree fern, gorse, cassinia, tauhinu (erica), hard fern, and bracken fern.

Native forest covers approximately 173 000 ha or 11% of the region. Dominant types of native or indigenous forest are lowland podocarp–broadleaved forest, broadleaved forest, kauri forest and podocarp forest. Nearly all the podocarp–hardwood forest has been cut over, and most of the kauri forest has been logged at some stage. These trees now cover only small or discontinuous areas and are mainly confined to some forest parks and reserves.

Coastal forest, mainly growing on, or adjacent to steep to very steep slopes on the coast, represents only 3301 ha (0.2%) of the region. Lowland podocarp–broadleaved forest, with regenerating podocarps, makes up the largest component within native forest, and covers 130 358 ha (8.2%) of the region, or 75% of native forest. Broadleaved forest represents 25 336 ha or 14.6 % of native forest areas. Kauri forest at present covers 14 280 ha or 0.9% of the region. Dominant podocarp forest occupies 1170 ha or 0.07% of the total region. Kahikatea is recorded sparsely on alluvial plains and footslopes, generally in wetter areas. More extensive areas covered in native forest include Waipoua Kauri Forest and Tutamoe Range, Puketi Forest, Maungataniwha Range, Waitakere Ranges, and Bay of Islands to Russell.

Large areas have poor-producing pastures or are currently reverting to scrub, particularly on infertile or poorly drained soils. Within pasture, reversion to rushes and sedges or increasing scrub areas is common, and can be partly attributed to the warm, humid nature of the climate, the extent of clay soils, and to reversion on neglected or poorly maintained land. Economic constraints are important factors for this increased scrub reversion.

## Future trends

Future trends should see a greater diversification of different land uses. In particular, land assessed as LUC Classes I, II and III, at present under an intensive grazing regime, is increasingly being developed for horticulture and cropping. Sustainable land-use planning is recommended, with agroforestry on Class IV and VI land. With current predictions for a growing horticultural and timber export industry in New Zealand, in line with expanding overseas markets, areas covered in horticulture and forestry should increase before the year 2000. Multiple-use land, and more versatile types of land with fertile soils, is under increasing pressure from urban development, particularly in the Auckland district. It will be important, therefore, to plan these areas effectively so that a balance between agricultural, urban and recreational demand can be maintained. Pastoral production should be intensified on both arable and hill country pastoral land with further diversification to mixed farming of livestock such as deer, cattle and sheep, and silvo-pastoral, two-tier or other multi-tier farming with farm woodlots. Much LUC Class VIe and LUC Class VIIe land has been planted in exotic conifers, particularly in the sand country, steeper inland hills and mountainous country. Forestry operations in these forested catchments should be carefully planned and monitored to reduce degradation of water quality, mitigate flooding risk, and reduce long-term ecological damage in downstream areas, harbours, and bays.

Undeveloped land, often under-utilised pastoral hill country, occupies a large percentage of the region (about 26%) and much land could be either better utilised or retired. Marginal Class VII land and some of the more unstable Class VI land is unlikely to prove economic for pastoral farming and could be planted in exotic trees or allowed to revert back completely to indigenous scrub and forest.

# Land Use Capability classification

The Land Use Capability (LUC) system of land classification assesses land in terms of its capacity for long-term sustained productive use, taking into account physical limitations, management requirements and soil conservation needs. The LUC assessment in the NZLRI is based on an interpretation of the physical information in the land-resource inventory, supplemented with information on climate, flood risk, land-use practices (e.g. information on present and past land use) and erosion history.

The LUC classification has three components – class, subclass and unit – each of which is represented by a number or symbol.

An example of the LUC nomenclature is given for LUC unit VIe1: VI is the class, VIe is the subclass, VIe1 is the unit.

LUC units within subclasses are arranged in approximate order of decreasing versatility to land use and increasing degree of physical limitation to land use, e.g. VIe8 has a higher land use capability than VIe11, but not as high as VIe2.

The relationship between the three components of the classification is illustrated in Figure 6.

## Land Use Capability class

The LUC class is the broadest category in the Land Use Capability classification. It is an assessment of the versatility of land for sustained agricultural production, taking into account its physical limitations. There are eight LUC classes – represented by roman numerals – with limitations to use increasing, and versatility of use decreasing, from class I to class VIII. Classes I–IV are suitable for arable use and may also be suitable for pastoral or forestry use, while classes V–VII are not suitable for arable use, but are suitable for pastoral or forestry use. The limitations reach a maximum with class VIII land, which is unsuitable for agriculture or production forestry but is best managed for catchment protection (which may include some recreational uses). Areas and percentages of the eight LUC classes mapped in Northland are shown in Table 2, together with comparative data for the North Island.

## Land Use Capability subclass

The LUC subclass is a subdivision of the LUC class according to the main kind of physical

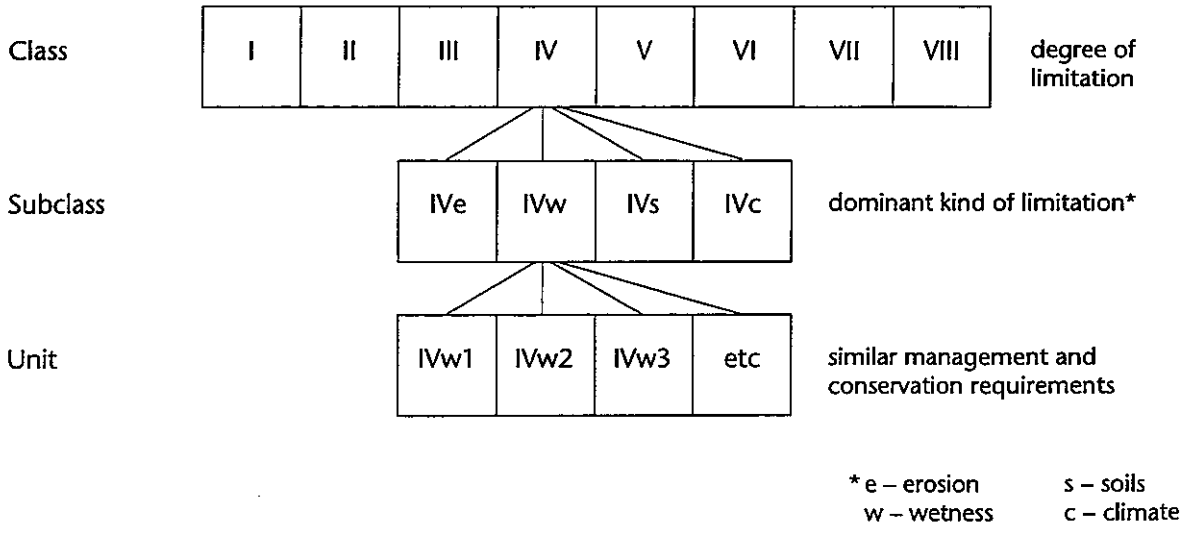



*Figure 6.*
*Components of LUC classification.*

*Table 2: Area of LUC classes of the Northland region, compared with the North Island.*

| LUC class | General suitability | Area (ha) region | % of mapped† region | % of total | % of total North Island |
|---|---|---|---|---|---|
| I | *Arable land* | 435 | 0.03 | 0.03 | 1.3 |
| II | *Arable land* | 52 615 | 3.48 | 3.32 | 6.3 |
| III | *Arable land* | 133 008 | 8.80 | 8.40 | 8.9 |
| IV | *Arable land* | 365 339 | 24.16 | 23.08 | 11.3 |
| V | *Non-arable land* | 8 327 | 0.55 | 0.53 | 0.8 |
| VI | *Non-arable land* | 731 842 | 48.40 | 46.24 | 35.2 |
| VII | *Non-arable land* | 181 785 | 12.02 | 11.48 | 25.1 |
| VIII | *Protection land* | 38 613 | 2.55 | 2.44 | 8.7 |
| Total of mapped areas | | 1 511 965 | 100 | 95.53 | 97.6 |
| Unmapped areas (towns, rivers, lakes, estuaries, etc.) | | 70 733 | | 4.47 | 2.4 |
| Total of mapped and unmapped areas | | 1 582 698 | | 100 | 100 |
| **SUMMARY** | | | | | |
| Total arable land | | 551 397 | 36.46 | 34.84 | 27.8 |
| Total non arable land | | 921 954 | 60.98 | 58.25 | 61.1 |
| Protection land | | 38 613 | 2.55 | 2.44 | 8.7 |

† that area exclusive of towns, rivers, lakes, estuaries, quarries, etc.

limitation or hazard to use. Four kinds of limitation are recognised: erodibility (e), wetness (w), soil limitations within the rooting zone (s), and climate (c). The initial letter of each limitation is used to identify the subclass (e.g. IIe, IIw, IIs, IIc,). Only the dominant limitation is identified in the land use capability code. Other limitations may also exist, and these are described under LUC unit descriptions (pages 105 to 234).

The area of each of the four subclass limitations in the Northland region, both in hectares and as a percentage, is given in Table 3. More detailed data are given in Appendix 1.

## Land Use Capability unit

The LUC unit is the most detailed component of the LUC classification. LUC subclasses are subdivided into a number of LUC units which are identified by arabic numerals at the end of the LUC code: "...the unit groups those inventory map units that respond similarly to the same management, are adapted to the same kind of crops, pastures and forest species, have about the same potential yield, and require the application of the same conservation measures." (SCRCC 1971).

In total, 91 LUC units have been identified in Northland and are described in the LUC extended legend of the second-edition NZLRI (Harmsworth 1991a). They are listed together with their areas in Appendix 1 and 2.

For a detailed description of the Land Use Capability classification, refer to the *Land Use Capability Survey Handbook* (Soil Conservation and Rivers Control Council 1971).

*Table 3: Areas of LUC subclass limitations mapped in the Northland region.*

| LUC subclass limitations | | Area (ha) | % of mapped† region | % of total region |
|---|---|---|---|---|
| Erodibility | (e) | 1 201 026 | 79.43 | 75.88 |
| Wetness | (w) | 177 493 | 11.74 | 11.21 |
| Soil limitations | (s) | 122 636 | 8.11 | 7.75 |
| Climate | (c) | 10 801 | 0.71 | 0.68 |
| Total of mapped areas | | 1 511 965 | 100 | 95.53 |
| Total of unmapped areas (towns, rivers, lakes, estuaries, etc.) | | 70 733 | | 4.47 |
| Total of region (mapped and unmapped areas) | | 1 582 698 | | 100 |

† that area exclusive of towns, rivers, lakes, estuaries, quarries, etc.

## Land Use Capability suite

The traditional numerical ranking of LUC units, based on decreasing versatility and capability, as shown in the section on LUC unit descriptions (pages 105 to 234), gives no direct indication of the relationships between LUC units in their actual landscape setting. To enable these relationships to be better understood and to aid interpretation of the worksheets and extended legends, related LUC units are arranged into groups, called LUC suites. A LUC suite is defined as *a group of LUC units which, although differing in land use capability, share a definitive physical characteristic which unites them in the landscape.*

These 'definitive physical characteristics' may vary from suite to suite. The use of LUC suites as a tool in landscape assessment is discussed by Blaschke (1985). The 91 LUC units have been arranged into eight suites and these suites are described in the section on LUC suites (pages 36 to 104). LUC suites may be subdivided into LUC subsuites according to secondary criteria. The arrangement of LUC units into LUC suites and LUC subsuites is given in Table 4 and Appendix 2.

## Productivity data

An important extension of the original first-edition NZLRI database has been the addition of pastoral and forestry potentials for each LUC unit (Harmsworth 1991b,c,d). This is expressed in terms of livestock-carrying capacity in livestock units per hectare, and site index for *Pinus radiata* (mean top height or predominant mean top height in metres at age 20 years). These data are given in Appendices 4 and 5 (with rankings for productivity figures). All data are included in the LUC extended legend of the Northland Region (Harmsworth 1991a, and in the LUC unit descriptions, pages 105 to 234). The NZLRI computer database incorporates the pastoral and forestry productivity data for all of the 925 LUC units mapped throughout New Zealand.

These production estimates provide a quantitative link between land use capability and agriculture and forestry. They take the NZLRI beyond the physical description or composition of land and provide a measure of land performance.

### *Stock-carrying capacities*

Data on livestock-carrying capacity was collected for each LUC unit between 1988 and 1990 as a joint exercise between MAFTech and DSIR. Methods for collecting these data were described by Harmsworth (1991c). Three levels of stock-

carrying capacity were assessed (expressed in terms of stock units per hectare): present average, top farmer, and attainable physical potential. One stock unit is equivalent to a breeding ewe (55 kg at mating) weaning one lamb. It can also be expressed in terms of a dry-matter intake of 550 kg/year (MAF Soil Fertility Service 1988). These assessments were made by field inspection of a number of representative sites for each LUC unit.

Stock-carrying capacity figures for each LUC unit are given in Appendices 4a and 5, and rankings for stock-carrying capacity are given in Appendix 4b. Fertiliser requirements (PKS) for top-farmer and attainable physical potential have been additionally derived for each LUC unit. This information is given by Harmsworth (1991c) and can be obtained from the NZLRI computer database and used for the establishment and maintenance of pasture and to formulate strategies for sustainable land uses.

### *Forestry site indices*

Site index data were collected during 1989–1990 as a joint exercise between DSIR and MOF (Kaikohe). Site index was chosen as the most suitable measure of forest growth and was defined as 'the mean top height or predominant mean height in metres of *Pinus radiata* at age 20 years'. Methods for collecting these data are given by Harmsworth (1991d). These assessments were made by collating plot record information and field assessment.

Because of the site variation within LUC units, caused mainly by the complex soil and rock type pattern, site index data were recorded as a range rather than a single figure (Appendices 4 and 5). Rankings for site index figures are given in Appendix 4c.

## Previous LUC surveys in the Northland region

Before the NZLRI remapping and updating programme at the scale of 1 : 50 000 (second edition) during 1985 to 1990, the whole of Northland had been surveyed, between 1973 and 1975, at the smaller scale of 1 : 63 360 (first edition). The update of the NZLRI in the region has provided new and improved physical-resource information at the more detailed scale of 1 : 50 000 and also greater emphasis on geomorphic delineation. Changes to the rock-type and vegetation classification have also been incorporated into the updated NZLRI (see Appendices 12–15). In the first-edition 1 : 63 360 NZLRI, 69 LUC units were defined for the region, while 91 LUC units have been defined for the second-edition NZLRI at the scale of 1 : 50 000 (Appendix 3). The change in scale from 1 : 63 360 to 1 : 50 000 has enabled a greater level of detail to be achieved. At the 1 : 50 000 scale of mapping, an unhooked inventory map unit (i.e. with no vinculum) can theoretically be delineated to an area approximating 60 ha. [Note: 100 ha = 1 $km^2$ or 1000 m by 1000 m.]

## NZLRI data in district and regional planning

This publication, together with the 26 NZLRI worksheets and a regional Land Use Capability extended legend (Harmsworth 1991a and pages 105–234 in this report), provides a comprehensive physical land-resource database for Northland. Further, all NZLRI data are stored on computer in a Geographic Information System (GIS) database. This provides the versatility to produce data (including maps at various scales) in response to specific requests from users.

The NZLRI data can be widely used by local territorial authorities such as regional councils, and government corporations and departments, private companies, consultants and other agencies involved in planning rural land use or managing natural resources. Examples of the types of information that can be generated for district and regional planning include the location of:

- hazardous areas that are highly erodible or liable to flooding (such as land physically unsuited to urban development, or land of potentially high flood risk)
- high-producing versatile land
- non-arable land
- land with scenic value
- areas that can physically sustain pastoral farming
- areas that cannot physically sustain pastoral farming or have severe limitations for pastoral use

*Table 4: LUC suites, subsuites, and component LUC units in the Northland region.*

| LUC suite number | LUC suite name | | LUC subsuite name | Component LUC units |
|---|---|---|---|---|
| 1. | Coastal sand country | 1a | Young unstable sand dune complex. | VIe15, VIIe10, VIIIe1 |
| | | 1b | Old stable sand dunes on unconsolidated to compact sands. | IIIe5, IIIs4, IVe9, VIe6, VIIe9 |
| | | 1c | Old stable podzolised terraces and escarpments on unconsolidated to compact Pleistocene sands. | IVe10, IVs5, VIe14, VIs4, VIIe9 |
| 2. | Alluvial and estuarine plains and low terraces | 2a | Well drained floodplains and low terraces. | IIw1, IIIw1 |
| | | 2b | Alluvial and estuarine plains with gley soils. | IIw2, IIIw2 |
| | | 2c | Poorly drained floodplains and low terraces. | IVw1, VIw1, VIIw1 |
| | | 2d | Mudflats with saline soils. | IIIw3, IVw2, VIw2 |
| | | 2e | Peats. | IIIw4, IVw3, VIw3, VIIw2 |
| 3. | Quaternary terraces with complex soils | – | | IIe2, IIw3, IIs2, IIIe2, IIIs3 |
| 4. | Sedimentary rock terrain excluding greywacke | 4a | Interbedded and massive sandstone and mudstone. | IIIe3, IVe5, VIe1, VIe8, VIIe4 |
| | | 4b | Older shattered and sheared argillites and sandstone. | IVe6, VIe7 |
| | | 4c | Sheared mixed lithologies. | IVe8, VIe12, VIIe2 |
| | | 4d | Crushed argillite. | VIe19, VIIe8 |
| | | 4e | Limestone. | IIIs5, IVe1, Vc1, VIs3, VIe3, VIIe3 |
| | | 4f | Limestone complexed with other sedimentary deposits. | IIIe4, IVe4, VIe5 |
| | | 4g | Podzols on sedimentary rock. | IVe12, IVs4, IVw4, VIs5 |
| 5. | Greywacke terrain | – | | IVe7, VIe9, VIe10, VIe17, VIc1, VIIe5, VIIe6 |
| 6. | Young basalt volcanic terrain | – | | Ic1, IIe1, IIs1, IIIe1, IIIs1, IIIs2, IVe2, IVsl, IVs2, Vs1, VIs1, VIe4, VIIIs2 |
| 7. | Old volcanic terrain | 7a | Landforms on old stable basalt–andesite volcanics with brown granular loams and clays. | IVe3, IVs3, Vc2, VIe2, VIe16, VIc1, VIIe1 |
| | | 7b | Landforms on volcanic/sedimentary complexes. | VIs2, VIe11, VIe13 |
| | | 7c | Acid to intermediate igneous volcanics and plutonics. | IVe11, VIe18, VIIe7 |
| 8. | Cliffs and precipitous slopes | – | | VIIIe2, VIIIe3, VIIIs1 |

- areas that can physically sustain production forestry
- vegetation cover to indicate existing land uses
- land physically suited to urban development.

NZLRI data for Northland are designed to be used at scales of 1 : 50 000 (the scale of the second-edition NZLRI mapping) or smaller. Only under special circumstances should the data be used for more detailed land-use planning.

It should be noted that the NZLRI information is a planning *tool* and not a plan. It is only one input into district and regional schemes, and as such should be used as a physical base on which social and economic factors, and their implications, can be considered.

# Land Use Capability suites

Eight LUC suites (Table 4) have been defined for Northland:

| | |
|---|---|
| LUC suite 1: | Coastal sand country (page 36) |
| LUC suite 2: | Alluvial and estuarine plains and low terraces (page 45) |
| LUC suite 3: | Quaternary terraces with complex soils (page 54) |
| LUC suite 4: | Sedimentary-rock terrain, excluding greywacke (page 60) |
| LUC suite 5: | Greywacke terrain (page 74) |
| LUC suite 6: | Young basaltic volcanic terrain (page 81) |
| LUC suite 7: | Old volcanic terrain (page 87) |
| LUC suite 8: | Cliffs and precipitous slopes (page 100) |

The primary factors used to group LUC units into LUC suites were rock type, soil (series, group, and subgroup), and landform, although other factors such as erosion type, slope and climate are integral components of the suite definition. Within LUC suites, variations in factors such as microtopography (slope angle, slope profile), rock-type characteristics (composition, age), erosion potential, wetness, stoniness and management were used to group LUC units further into LUC subsuites.

Of the eight LUC suites, five LUC suites are defined on sedimentary rock types (LUC suites 1, 2, 3, 4, 5), two on volcanic rock types (LUC suites 6 and 7), while one is recorded on the basis of steepness and may occur on either sedimentary or volcanic rock types (LUC suite 8). LUC suite 2 is also defined on alluvial and estuarine deposits of both sedimentary and volcanic origin.

It should be recognised that although the concept of LUC suites is emphasised here, and was implicit in the design of the LUC classification and extended legend for the region, LUC suites were not formally defined at the time of mapping. For this reason there are a few LUC units which do not fit well into a LUC suite. There are also LUC units which are described in two LUC suites: areas classified as a particular LUC unit have been divided into two component areas, each of which is described in a different LUC suite.

## Keys to recognition of Land Use Capability units

At the end of each section on Land Use Capability suites is a decision pathway for keying out and recognising individual Land Use Capability units within that suite. The decision or logic pathway is grossly simplified and uses the minimum amount of data possible for recognising individual LUC units.

Key physical attributes and unique associations of attributes are isolated within decision trees – providing a further aid to the rapid recognition of units. While this approach is not 'pictorial', it has the advantage of allowing both the mapper and interpreter to examine clearly the internal discrimination logic of the classification. It does this by stripping away all factors from those which are identified as definitive for the LUC unit. Note, however, that the stripped-away factors are still very important in understanding the classification – particularly in the role of 'evidence corroborators'.

The decision pathway is a set of vertically tiered questions with answers, 'Yes' or 'No'. A 'Yes' answer may either lead the enquirer to an appropriate solution (i.e. a LUC unit), or give an instruction to proceed to another identified question. A 'No' answer is followed by a number that identifies the question that the enquirer should proceed to.

The enquirer should be sufficiently familiar with the Northland environment to identify key physiographic areas or the rudiments of Land Use Capability suites: if the land is within sand dunes and coastal terraces go to page 36, if the land is within alluvial and estuarine plains go to page 45, and so on.

## LUC Suite 1: Coastal sand country

The sand country comprises coastal sediments which have formed a complex of dunes and terraces, mainly during a period of overall sea-level fall from the Pliocene through to the Quaternary (Brothers 1954; Schofield 1970, 1975, 1989).

Beach deposits, sand dunes, sand plains and coastal terraces (Pliocene to Recent age) have developed on both the western and eastern sides of the Northland region, but are most extensive on the exposed, high-energy, western coast from Muriwai in the south to Cape Reinga in the north. North of the Manukau Harbour (Figure 3) there are three major occurrences of sand – the South Kaipara Barrier, the Northern Kaipara Barrier, and the Aupouri–Karikari tombolos (Cox 1977; Hicks 1977). In these areas sands reach a maximum elevation of approximately 200 m. On the eastern side of the region, beaches occur intermittently along a more irregular coastline, and the most extensive sand-country areas are recorded from Marsden Point just south of Whangarei, extending south to Waipu and Mangawhai.

The sequence of dune sands can be differentiated by surface morphology, degree of dissection, rock type, soils and vegetation. There are 12 LUC units recorded on the coastal sand deposits within this suite: IIIe5, IIIs4, IVe9, IVe10, IVs5, VIe6, VIe14, VIe15, VIs4, VIIe9, VIIe10, VIIIe1; together they cover 197 878 ha (12.5%) (Figure 7). An idealised cross section of LUC Suite 1 is shown in Table 5.

On the basis of more detailed geomorphic and management criteria, LUC units can be placed in the following subsuites:

**1a.** Beaches and young sand-dune formations on unstable recent windblown sands adjacent to the coast (LUC units VIe15, VIIe10, VIIIe1).

**1b.** Older more stable dune formations on compact to semi-consolidated dune sands further inland from the coast (LUC units IIIe5, IIIs4, IVe9, VIe6, VIIe9).

**1c.** Old coastal terraces on semi-consolidated sands and gravels with podzolised soils (LUC units IVe10, IVs5, VIe14, VIs4, VIIe9).

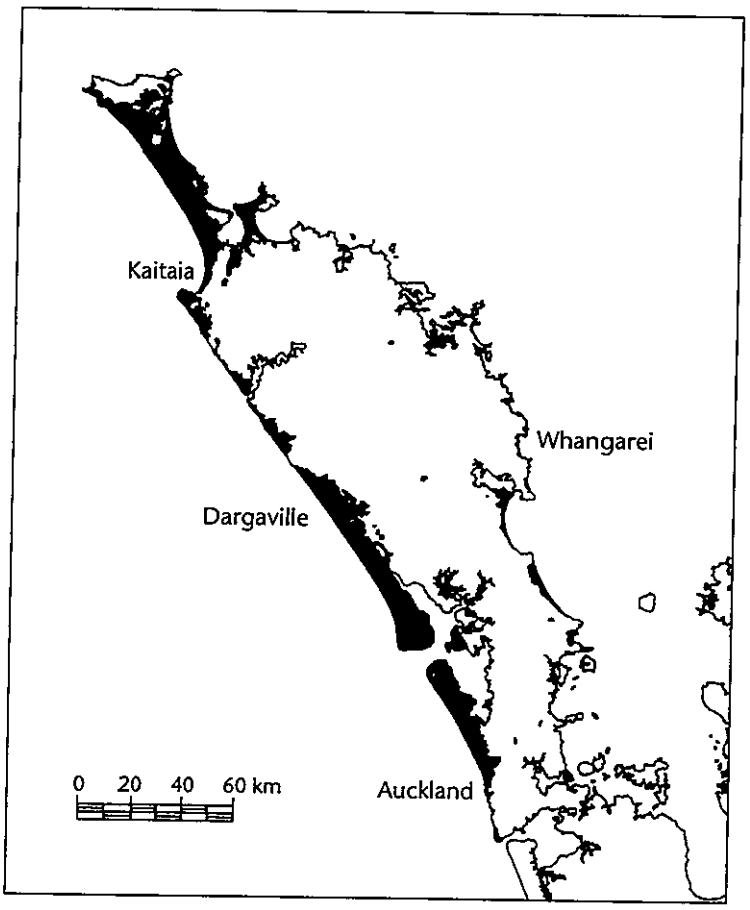



*Figure 7. Location of LUC suite 1. Coastal sand country.*

*Table 5. Idealised cross-section showing relationship between LUC units within LUC Suite 1, on coastal sand country.*

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Typical dominant slope(s) (degrees) | 0–>20 | 0–25 | 4–25 | 16–25 | 16–>35 | 8–20 | 7–15 | 0–7 | 8–25 | 16–>35 | 8–20 | 0–15 | 0–15 |
| NZLRI slope group | A–D | A–E | B–E | D, E D+E | D–F | C, C+D | B+C | A+B | C–E | D–F | C, C+D | A–C | B, A, C |
| Typical altitudinal range (m a.s.l.) | 0–60 | 0–100 | 0–100 | 0–200 | 0–200 | 0–200 | 0–200 | 0–200 | 0–200 | 0–200 | 0–200 | 0–200 | 0–200 |
| Typical rainfall range (mm) | 1000–1400 | 1000–1200 | 1000–1200 | 1000–1400 | 1000–1400 | 1000–1400 | 1000–1400 | 1000–1400 | 1000–1400 | 1000–1400 | 1000–1400 | 1000–1400 | 1000–1400 |
| Present erosion (NZLRI codes) *see Appendix 14* | 2-5 W 1-3 G | 0-3 W, Sh, G | 1-2 W, Sh. 0-1 G, Ss | 0-2-Sh, W, Ss. 0-1 G | 1-3 Sh, W, G. 0-2 Ss | 1-2 Sh, W. 0-1 G | 0-1 Sh, W, G | 0-1 W, Sh | 1-2 Sh, W, G, Ss | 1-3 Sh, W, G. 0-2 Ss | 1-2 Sh, W, G, R | 0-1 Sh, W, G, T | 0-1 Sh, G, R |
| Potential erosion (NZLRI codes) | 5 W 4G | 4-5 W 4 Sh, G | 2-3 W, Sh, G. 2 Ss | 2 Sh, W, Ss, G | 4-5 Sh, W, G 2-3 Ss | 1-2 Sh, W, G. 2 Sh, W, R, G | 1 Sh, R, G, 1-2 W, Sh, R | 1-2 W, Sh | 2-3 Sh, W. 2 G, Ss | 4-5 Sh, W, G 2-3 Ss | 1-2 Sh, G, R, W. 2-3 R, G, W, Sh | 1-2 G, T, Sh. 2 Sh, W, R, G | 2-3 G, R, Sh |
| Soils *(generalised)* | nil | nil | nil to Y-B sand | Y-B sand | Y-B sand | Y-B sand | Y-B sand | Y-B sand + organic | podz. Y-B sand | podz. Y-B sand | podz. Y-B sand + podz. | podz. | podz. |
| Lithology (NZLRI codes) *see Appendix 12* | Wb | Wb | Wb | Us | Us | Us | Us | Us+Pt Us+Pt | Us | Us | Us | Us | Us |
| LUC unit | VIIIe1 | VIIe10 | VIe15 | VIe6 | VIIe9 | IVe9 | IIIe5 | IIIs4 | VIe14 | VIIe9 | IVe10 | IVs5 | VIs4 |

These land types generally form zones running north to south. Broad valley and gully systems infilled with fine alluvium and/or peat typically dissect and transect west to east through the sand dunes and coastal terraces.

### *Geomorphology and rock type*

The sand country is largely made up of a composite of sand-dune and terrace landforms of Quaternary to Recent age. On a geomorphological basis this country can be subdivided into three main zones of land corresponding to developmental age. A range of landform types exists in each zone:

- The youngest zone includes beaches, young irregular foredune topography, transverse dunes, parabolic dunes, blow-out dunes, arcuate dunes (all categorised as unstable dune sands) mainly of Holocene age. It includes migrating or moving dune sands that can be described as active or potentially active. Five distinct dune belts were recognised by Schofield (1975).

- A second more inland zone (central strip) includes older, rolling to steep, dune topography (more stable dune sands) mainly of Pleistocene age. Dune sands are usually more highly weathered and cemented. Landforms comprise old dune complexes, truncated dunes, and high terraces, with the level of dissection on these dunes and terraces generally increasing with age (Brothers 1954; Schofield 1975).

- Coastal terraces, usually on the more inland side of barrier complexes or tombolos, have developed on undifferentiated dune, fluviatile, and estuarine sediments and have formed at a number of levels or steps (ranging from 2 m to approximately 100 m above local base level) on the interfluves between streams. These terraces probably represent remnants of high-level, partly fluviatile, partly estuarine, partly marine-cut surfaces formed during periods of sea level 'stillstands' (Schofield 1989). The best-preserved terrace remnants are those up to about 70 m above sea level (Brothers 1954; Schofield 1989). The level of dissection, as with the dune topography, generally increases with age. Where terrace landforms are mapped, the older dune topography has often been truncated during sea-level change, while more preserved dune topography (of rolling to strongly rolling dune hills), is commonly recorded at higher elevations towards the seaward side of the terraces.

Other types of land within the sand country include interdune swamps, backswamps, and floodplains. Because of the different management requirements for land with a dominant wetness limitation (e.g. areas at risk to flooding or having prolonged wetness) these areas are separated out and placed in LUC suite 2: Alluvial and estuarine plains and low terraces (see page 45).

The main rock types recorded in the sand country are unconsolidated to compact sands and gravels and windblown sands:

- Unconsolidated to compact sands (aeolian, fluviatile, estuarine) are typically exposed at the sides of coastal terraces, old dune hills and rolling land (Awhitu sand: Schofield 1989). They are usually of Pleistocene age, and are defined in the NZLRI rock-type classification (Lynn and Crippen 1991) as loose to compact, very thickly to very thinly bedded (usually crossbedded or horizontally bedded), sands and gravels and minor silts and clays. They range from weakly weathered to highly weathered, and locally hardened layers occur as a result of cementation and iron-pan formation. Distinct brown to orange striations (e.g. liesegang weathering) are particularly conspicuous throughout the top 2 to 5 m of most exposures. At the sides of coastal terraces, the soil profile above the unconsolidated to compact sands typically shows a bleached silica-rich horizon caused by podzolisation.

- Windblown sands (aeolian) are exposed in younger, more unstable, dune complexes nearer the coast (Mitiwai sand: Brothers 1954; Schofield 1989). They are generally of Holocene age and comprise very loose to loose, massive or bedded sand, with subordinate gravel and mud. A number of distinct periods of dune development (progradation) have been recognised in the region. For example, on the South Kaipara Barrier Schofield (1989) identified that these periods or sequences of deposition could be distinguished by dune form and in order of increasing age and altitude (up to 200 m above sea level) as: irregular, partially vegetated dunes; transverse, non-vegetated dunes; vegetated parabolic dunes; and parabolic dunes that often bury fossil cliffs.

• Younger Holocene dunes tend to have a more transverse form, while older vegetated Holocene dunes are more longitudinal. The more 'freshly' deposited younger Holocene dune sands (Mitiwai sands: Schofield 1989) often lie on or around inliers of the highly weathered Pleistocene dune sands (Awhitu sands: Brothers 1954; Schofield 1989). On the South Kaipara Barrier (Schofield 1989) the older Holocene longitudinal dunes have buried an old fossil cliff which was cut into the Pleistocene 'Awhitu' sand during the early Holocene rise in sea level.

### *Climate*

In general, climate is characterised by warm humid summers and relatively mild winters. The prevailing wind is generally from the southwest and west, with the west coast of the region being exposed to relatively strong southwesterly and westerly winds for much of the year. Northwesterly winds may also become more prevalent during spring. Occasional strong gales and heavy rains from the east or northeast may affect coastal districts, mainly during summer and autumn months, in the form of tropical cyclones or intense rainstorms.

In spring and winter the percentage of southwest winds is greatest but in summer and autumn the number of winds from an easterly quarter is, in many places, about equal to the number of southwest winds. Spring is the windiest season, while the greatest number of calm periods occur in late summer and autumn. Mean daily wind speed is 11 to 15 km/h in most areas. Wind gusts may reach 64 km/h or greater on 30 to 40 days of the year, while on one or two days a year wind gusts of 96 km/h may occur in any month from either an easterly or westerly quarter.

Mean annual temperatures range from about 14°C to 15.5°C in southwest coastal districts to 16°C in districts north of Kaitaia. The mean annual temperature range is between 7.2°C and 8.3°C. These represent some of the highest mean annual temperatures recorded in New Zealand, and nowhere south of Auckland city are the July mean temperatures as high.

Rainfall is variable but shows a winter maximum and a summer minimum. Approximately one third of the rain falls in the three winter months June, July, and August. Mean annual rainfall ranges from 1000 to 1400 mm in low-lying coastal districts.

In eastern coastal districts rain falls on approximately 125 to 150 days per year, increasing to 150 to 200 days per year in more exposed western districts. Droughts are common in some areas during summer and autumn months and have a significant impact on land use because of the low moisture-holding capacity of the sands.

### *Soils*

Soils are mainly yellow-brown sands, podzolised yellow-brown earths, gley soils and podzols from the Pinaki soil suite (Cox et al. 1983). The Pinaki suite refers to a range of soils from relatively young, unconsolidated sands to old, bleached, very acid sandy loams (During 1984). Organic soils from the Ruakaka and Otonga soil suites (Cox et al. 1983), gley soils on alluvium, and podzolised gley soils from alluvium may also be recorded in some areas.

Parent materials are dominantly windblown (aeolian) in origin, but fluviatile and estuarine sediments are also commonly recorded. Generally, both topography and rock type are closely related to genetic soil subgroups:

*Young unstable sand dune complexes*

Weakly to moderately leached, weakly weathered, yellow-brown sands (Pinaki, Marsden, Whananaki and occasional Ohia) or areas of little or no soil development or weak soil development are recorded on the younger more unstable dune complexes nearer the coast, developing primarily on windblown sands (LUC units VIe15, VIIe10, VIIIe1).

*Older more stable dunes*

The moderately to strongly leached, moderately weathered, yellow-brown sands (Houhora and Red hill soils), and sometimes weakly weathered yellow brown sands (e.g. Ohia), tend to occur on the older more stable dunes, where the surface dune topography is well preserved on mainly unconsolidated sands (LUC units IIIe5, IIIs4, IVe9, VIe6, VIIe9).

*Old coastal terraces*

The weakly to moderately podzolised yellow-brown earths, podzolised yellow-brown sands, gley podzol soils and podzols on the sand country

occur mainly on terraces where the dune topography is either poorly preserved or not preserved (e.g. truncated dunes) and terraces are formed on aeolian, fluvial and estuarine sediments (LUC units IVe10, IVs5, VIe14, VIs4, VIIe9).

### *Erosion*

The stability of the sand country depends largely on vegetative cover. In areas of active dune movement a permanent and extensive vegetative cover should be maintained so as to avoid or reduce the effect of dune migration or sand drift.

*Young unstable sand dune complexes*

Windblown sands forming young dunes are recorded nearer the coast and comprise LUC units VIIIe1, VIIe10, and VIe15. They are highly susceptible to wind and sheet erosion. Wave action, particularly during storms and spring tides, can also remove large quantities of sand from beaches and foredunes nearer the high-tide water mark along exposed coastlines, harbours and estuarine areas. The potential severity of wind erosion generally decreases away from the coast as sands under sand-dune vegetation and grasses become more compact and weathered, and the residual strength of deposits increases inland.

*Older more stable dunes*

In more inland areas on older relatively more stable dunes (e.g. where Red hill and Tangitiki soils are recorded – LUC units IIIe5, IIIs4, IVe9, VIe6, VIIe9) predominant erosion types include sheet, wind, soil slip, rill and gully. Wind erosion is less severe on more stable dune terrains and is usually recorded in association with sheet erosion. Large, broad, historic gully features with deep gully sides (up to 100 metres deep in some areas) are often recorded running east to west through the older dune landscapes with gully size progressively decreasing towards younger more unstable dune sands that have lower residual strength. Moderate to severe sheet and wind erosion is often recorded on steep gully sides.

Soil slip erosion is more commonly recorded following intense, localised high-intensity rainstorms (e.g. on the Red hill and Tangitiki hill soils on the Poutu peninsula) on moderately steep (21–25°) to very steep (>35°) slopes on older dune hills and at the sides of terrace landforms where the slip surface is compact or semi-consolidated sands. Because of lack of residual strength, hill sides and gully sides often collapse when the more unconsolidated sands become saturated.

Where bare ground has been initiated, for example through livestock camps, further exposure to wind and sheet erosion over time often results in the removal of large quantities of soil and regolith and subsequent rapid enlargement of bare-ground areas, as can be seen with the Houhora sands on the Aupouri Peninsula. This is particularly evident on steeper slopes affected by droughts, or where pastures on older dune surfaces, such as dune hillslopes and ridges, have been overgrazed or stock trampled. At these sites sheet erosion is often recorded in conjunction with wind, and it is difficult to determine the dominant process.

*Old coastal terraces/ truncated dunes*

Erosion on coastal terraces (LUC units IVe10, IVs5, VIe14, VIs4, VIIe9) can be discussed separately for the terrace surface and for the terrace sides.

When cultivated, under poor-quality pasture, or under some form of environmental stress, for example if overgrazed or affected by drought, flat to gently rolling terrace surfaces become increasingly prone to sheet and wind erosion on flat (0–3°) to rolling slopes (e.g. 6–12°). Slight to moderate rill and gully erosion can develop when more saturated conditions affect the outer steeper edge of the terrace.

Steeper slopes (e.g. >18°), including escarpments at the sides of terraces, and gully sides, are prone to sheet, shallow soil slip and wind erosion. Land at the sides of terraces and gullies shows, to varying degrees, extensive areas of bare ground. Regenerating and often patchy scrub cover, consisting of heath and manuka, offers some protection to an increasingly eroded landscape. Most of these steep areas have a low potential productivity. On rolling (8–15°) to strongly rolling slopes (16–20°) at the sides of terraces, particularly where the soils are podzolised and the underlying sand is more compact or consolidated, small gullies, almost linear in form and similar to tunnel gully, are commonly recorded incising back towards the terrace surface. They often

represent areas of runoff and may have formed under more saturated conditions or during heavy rainfall, and enlarged during stock trampling and pugging.

### *Vegetation*

Exotic conifer forest now covers a large proportion (about 80%) of the younger more unstable sand dune complex on windblown sand near the coast. Trees are mainly *Pinus radiata*, with minor areas of *Eucalyptus* being planted in more protected areas. The more exposed seaward areas along the coast are affected by strong salt-laden winds, and for much of the year strong westerly winds affect the western side of the region. Trees that are planted on these young foredunes and sandplains have a stunted appearance but provide an environmental protection or buffer zone sheltering more inland forests.

Other important vegetative types recorded on the younger more unstable dunes are marram grass, lupins, pingao and spinifex, which all bind the sand particles and reduce sand movement. Lupin, being a legume, adds nitrogen to the sand.

On the older dune topography (e.g. Red hill and Tangitiki hill soils) the dominant vegetation is kikuyu grass, which has been recorded as improved pasture (gI) in the NZLRI because of its vigorous growth and suitability to the drier and drought-prone areas of the sand country where soils are well to excessively drained. On flat to undulating and rolling sides of coastal terrace surfaces, where it is often intergrown with clover grasses, kikuyu grass is also dominant. Some exotic conifer forest, *Eucalyptus* and naturalised exotic conifer forest are also recorded on the older dune country.

On steeper sides of terraces and sides of old gullies the vegetation cover is mainly scrub including manuka, kanuka, heath (*Erica* species), cassinia and exotic scrub varieties (hakea).

Improved pasture (gI) is the main type of vegetation recorded on flat to rolling coastal terrace surfaces. This pasture includes large areas of dominant clover grasses.

### *Land use and land management*

Exotic forestry, mainly the exotic conifer *Pinus radiata* and smaller areas of *Eucalyptus*, currently cover about 80% of the younger, more unstable wind-blown sands in the region. During the 1920s, encroachment of sand on to productive farmland, particularly on the western side of Northland, was a major problem. Sand migration buried fences and covered pastures, and deposition increasingly threatened lakes and transport links. A programme to stabilise these drifting sands was initiated by the Public Works Department in the Woodhill area, north of Auckland, in the 1930s. Stabilisation began with the planting of marram grass (*Ammophila arenaria*). By 1952, however, the problem had worsened. At this stage the Forest Service assumed responsibility, and today about 95% of the total area of windblown sand in the Woodhill area has been stabilised. Once techniques for afforestation were established in this area, unstable areas in other parts of the region were in turn stabilised and afforested: Aupouri and Mangawhai in 1962, and Pouto in 1972. Afforestation also had the prime objective of encouraging regional development and lowering unemployment in the area.

The older rolling to moderately steep dune country (e.g. Red hill and Houhora soils) is currently dominated by pasture, and both kikuyu and clover grasses are grown mainly for dairy and beef cattle farming with deer farming becoming more prominent in some areas. Horticultural crops are also recorded, on a very limited scale, on flat to gently rolling slopes in more sheltered areas on the older sand dune and terrace country (moderately to strongly leached yellow-brown sands, weakly to moderately podzolised yellow-brown earths and associated organic soils). The full potential of the older sand country areas for horticulture has not been fully established. The more podzolised soils on the terraces and terrace sides are mainly in pasture and the most appropriate land uses at present are dairy cattle and beef cattle farming. Many gully areas and the steeper sides of terraces are often planted in exotic conifer forest, mainly *Pinus radiata*. Where they are not, the land is usually in a state of scrub reversion and vegetation includes heath, manuka, cassinia, exotic scrub, and wind dispersed naturalised exotic conifer forest.

## Decision pathway for recognising LUC units within the coastal sand country

1. **Does the land comprise windblown sands with little or no soil development?**

   Yes → go to 2 | No → go to 5

2. Is this the most seaward land within 400 m inland of the high tide mark, with a potential for extreme wind erosion?

   Yes → **VIIIe1** | No → go to 3

3. Is this land adjacent to the coast, immediately inland of LUC unit VIIIe1 with a potential for moderate to severe wind erosion?

   Yes → **VIIe10** | No → go to 4

4. Is this land immediately inland of LUC unit VIIe10, with some soil development and a potential for slight to moderate wind and sheet erosion?

   Yes → go to 5 | No → go to 5

5. Where soil development is present, are soils weakly to moderately leached yellow-brown sands?

   Yes → **VIe15** | No → go to 6

6. Are soils strongly leached to podzolised yellow-brown sands?

   Yes → **VIe15** | No → go to 7

7. Is the rock type Wb?

   Yes → **VIe15** | No → go to 8

8. **Is the rock type dominantly Us?**

   Yes → go to 9 | No → go to 9

9. **Does the land have moderately weathered, moderately to strongly leached yellow-brown sands of the Pinaki suite?**

   Yes → go to 10 | No → go to 17

10. Are slopes A or B?

    Yes → go to 11 | No → go to 13

11. Are the soils Red Hill sandy clay loam?

    Yes → **IIe2** | No → go to 12

12. Are the slopes dominantly A and B and may organic deposits be part of the parent material?

    Yes → **IIIs4** | No → go to 13

13. Are the slopes dominantly B or B and C?

Yes → **IIIe5** No → go to 14

14. Are the slopes dominantly C and D?

Yes → **IVe9** No → go to 15

15. Are the slopes dominantly D and E?

Yes → **VIe6** No → go to 16

16. Are the slopes greater than E?

Yes → go to 23 No → go to 17

17. **Does the land have podzolised yellow-brown earths, gley soils, or podzols of the Pinaki suite?**

Yes → go to 18 No → go to LUC suite 2, (page 51)

18. Are the slopes dominantly A or B where the degree of podzolisation does not preclude arable use?

Yes → **IVs5** No → go to 19

19. Are the slopes dominantly A , B or gentle C where the degree of podzolisation excludes arable use?

Yes → **VIs4** No → go to 20

20. Are the slopes dominantly C or B+ where slope angle is an extreme limitation to arable use but where podzolisation does not preclude arable use?

Yes → **IVe10** No → go to 21

21. Are the slopes dominantly C, or C and D where the degree of podzolisation precludes arable use?

Yes → **VIe14** No → go to 22

22. Are the slopes dominantly D, or D and E?

Yes → **VIe14** No → go to 23

23. Are the slopes E, or greater than E, and the landforms gullies, scarps and bluffs?

Yes → **VIIe9** No → go to LUC suite 2, (page 51)

## LUC Suite 2: Alluvial and estuarine plains and low terraces

This suite is characterised by low-lying flat to undulating landforms such as floodplains, valley plains, low terraces and tidal mudflats with soils formed on alluvium and/or peat. The alluvium is derived mainly from sedimentary and volcanic rocks of mainly Miocene to Tertiary age which include sandstones, mudstones, greywackes, argillites, and andesitic and basaltic volcanic rocks. The suite comprises 14 LUC units: IIw1, IIw2, IIIw1, IIIw2, IIIw3, IIIw4, IVw1, IVw2, IVw3, VIw1, VIw2, VIw3, VIIw1, VIIw2; and together they cover 171 770 ha (10.8%) of the region (Figure 8). An idealised cross-section of LUC suite 2 is shown in Table 6. LUC units generally occur below 100 m a.s.l. and are usually near sea level. On the basis of more detailed geomorphic, soils, and management criteria, units can be placed into the following subsuites:

**2a.** Well drained flood plains and low terraces (LUC units IIw1, IIIw1).

**2b.** Alluvial and estuarine plains with gley soils (LUC units IIw2, IIIw2).

**2c.** Poorly drained floodplains and low terraces (LUC units IVw1, VIw1, VIIw1).

**2d.** Mudflats with saline soils (LUC units IIIw3, IVw2, VIw2).

**2e.** Peats (LUC units IIIw4, IVw3, VIw3, VIIw2).

Most of the units in this suite are either limited by high watertables, particularly during winter, or by poor soil drainage, or are at risk from flooding. They are therefore subdivided according to the degree to which wetness is a limitation to productive use. Most of the land in this suite is at present under pasture or a combination of pasture/rushes or pasture/podocarp trees/wetland vegetation. Flood damage in the absence of stopbanks is a serious limitation to agricultural potentials, particularly cropping and horticulture. This dominant physical limitation of wetness increases from class II to class VII. From a land management point of view, the level and duration of a permanently high water table and the frequency of surface flooding are very important considerations when assessing land use capability. Inherent soil wetness characteristics are also considered to be very important, and information on the physical properties of these younger soils, including their permeability, oxygen diffusion rate, clay content or structural characteristics, is often required.

### *Geomorphology and rock type*

Most of the land is flat to undulating, forming alluvial and estuarine floodplains, levees, low lying terraces, tidal mudflats, and peat swamps. Soils are generally young and are developed on deposits consisting predominantly of fine-grained alluvium (i.e. sand, silt, and clay) of mainly fluvial origin. Peat was commonly recorded in swamps and natural depressions – main areas included depressions between sand dune hills near the coast, narrow valleys, depressions on terrace surfaces, and on plains often behind dunes or saline mudflats.

Fine-grained alluvium, consisting of sands, silts, and clays, was recorded extensively in low-lying areas throughout the region, and derived principally from either sedimentary rocks or deeply weathered volcanic rocks. Recently deposited stream and river alluvium (fluvial and/or estuarine) was usually unconsolidated and often variable in colour (pale brown mottled to grey) and texture, but uniformly water saturated, soft, with low compressive and shear strengths.

Coarse alluvium, such as gravels and boulders (>2 mm), was less commonly recorded and usually confined to the headwaters of catchments surrounded by more indurated rock types such as andesites, basalts, and greywacke.

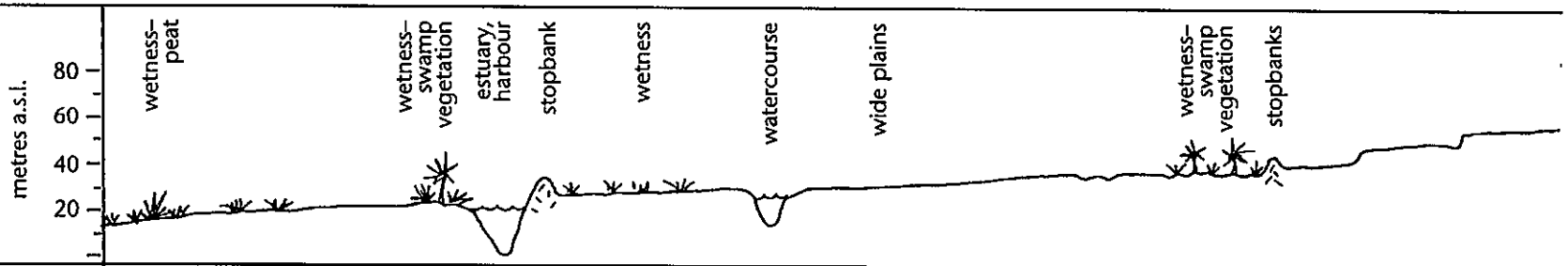
Windblown (aeolian) sand was recorded nearer the coast in association with fine alluvium or peat.

Peat was commonly recorded in poorly drained or historically wet sites, such as natural depressions and valley floors.

Floodplains and low-lying terraces have been mainly formed during the last 10 000 years. Higher terraces at the sides of floodplains are typically of late Pleistocene age. The alluvial deposits were derived from a range of mainly Mesozoic and Tertiary rock types, including sandstones, mudstones, greywackes, argillites, and volcanic rocks such as andesites, dolerites and basalts.

A large proportion of the alluvium on floodplains and terraces on the western side of the Northland region is derived from volcanic

*Table 6. Idealised cross-section showing relationship between LUC units within LUC Suite 2, on alluvial and estuarine plains and low terraces.*




| Wetness | High water table | Wet-drained | Wet-drained | High water table | High water table | Wet-drained | Wet-drained | Some occ. flooding | Occ. flooded | Occ. to freq. flooded | Freq. flooded HWT | Freq. flooded HWT | Occ. to freq. flooded | Occ. flooded-drained | Well drained |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Typical dominant slope(s) (degrees) | 0–3 | 0–7 | 0–7 | 0–3 | 0–3 | 0–3 | 0–3 | 0–3 | 0–3 | 0–7 | 0–3 | 0–3 | 0–3 | 0–7 | 0–3 (A) 4–7 (B) |
| NZLRI slope group | A | A, B | A, A+B | A | A | A | A | A | A | A, A+B | A | A | A | A, A+B | A, A+B |
| Typical altitudinal range (m a.s.l.) | 0–100 | 0–100 | 0–100 | 0–100 | 0–20 | 0–20 | 0–20 | 0–60 | 0–60 | 0–100 | 0–100 | 0–100 | 0–100 | 0–100 | 0–100 |
| Typical rainfall range (mm) | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1000–1400 | 1000–1400 | 1000–1400 | 1200–1400 | 1200–1400 | 1200–1600 | 1200–1800 | 1200–1800 | 1200–1600 | 1200–1600 | 1200–1600 |
| Present erosion (NZLRI codes) *see Appendix 14* | 0-1 D | 0-1 Sb, D. 0-1 G | 0 | 0-1 W, Sh, G | 0 | 0 | 0-1 D | 0 | 0-1 Sb, D | 0-2 Sb, 0-1 D | 0-2 Sb, D | 0-1 Sb, D | 0-2 Sb, 0-1 D | 0-1 Sb, D | 0-1 Sb |
| Potential erosion (NZLRI codes) | 1-2 D. 1-2 Sb | 1 Sb, D. 2 D, 1-2 G | 0-1 W | 1-2 W, Sh, D. 1 G | 1-2 D | 1 W, Sh | 0-2 D, 1 W | 0-1 Sb, D | 1 Sb, D | 2 Sb, D | 1-3 Sb, D | 1-3 Sb, D | 2 Sb, D | 1-2 Sb, 1-2 D | 1 Sb, D |
| Soils *(generalised)* | Organic | Organic | Organic | Organic | Saline gley | Saline gley | Saline gley | Gley | Gley | Recent Gley | Recent Gley | Recent Gley | Recent Gley | Recent | Recent |
| Lithology (NZLRI codes) *see Appendix 12* | Pt | Pt | Pt | Pt, Af | Af | Af | Af | Af | Af | Af | Af | Af | Af | Af | Af |
| LUC unit | VIw3 | IVw3 | IIIw4 | VIIw2 | VIw2 | IVw2 | IIIw3 | IIw2 | IIIw2 | IVw1 | VIw1 | VIIw1 | IVw1 | IIIw1 | IIw1 |

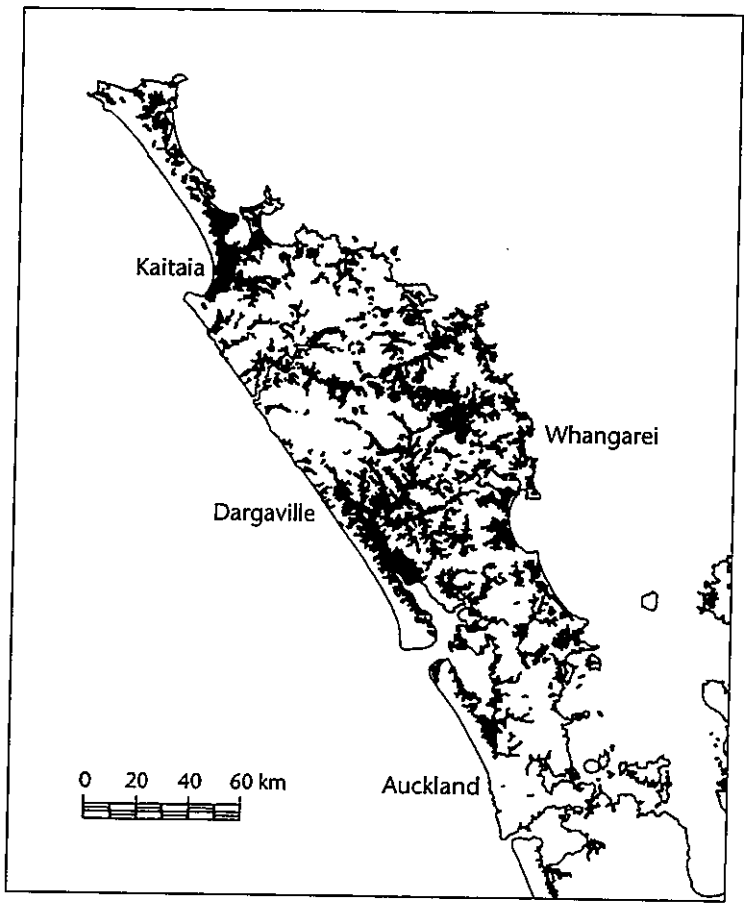



*Figure 8. Location of LUC suite 2. Alluvial and estuarine plains and low terraces.*

uplands such as hilly and mountainous land underlain by Cretaceous and Miocene volcanics. In central and southern parts of the region, alluvial sediments originate from a range of Cretaceous–Tertiary sedimentary rock types. On the eastern side of Northland, Triassic–Jurassic greywackes are a major source of sediment. Other major source areas in the central and northeastern parts of the region are Quaternary aged basalt volcanics.

## *Climate*

The climate varies markedly from area to area. In general the suite is characterised by warm, humid summers and relatively mild winters with few frosts. Prevailing winds are generally from the southwest and west, but northwesterlies may become more prevalent during spring. Occasional strong gales and heavy rain from the east or northeast may also occur during the year, particularly tropical cyclones or intense rainstorms in summer and early autumn.

Mean daily wind speed is between 11 and 13 km/h in most areas. Spring is the windiest season, while the greatest number of calm periods occur in summer and autumn. Wind gusts may reach 64 km/h or greater on 30 to 40 days of the year while wind gusts of 96 km/h may occur on one or two days a year in any month from either an easterly or a westerly quarter.

Mean annual temperatures are typically between 13.5°C and 15.5°C, and the mean annual temperature range is 7.2°C to 8.3°C.

Rainfall is extremely variable but shows a winter maximum and a summer minimum. Rainfall variability in Northland averages 16% (being the average of the differences of the annual

totals from the long-period mean, expressed as a percentage of the mean). Topography and airflow are two major factors affecting the overall rainfall pattern in the region. The eastern side of the region is generally drier than the western side. Low-altitude areas on or near the coast are typically drier than higher-altitude areas. Eastern coastal districts average about 125 to 150 raindays per year, whereas other areas generally experience between 150 to 200 raindays per year, the highest being in the western uplands.

Mean annual rainfall is generally between 1000 and 1800 mm. Rainfall exceeds 1400 mm in most inland valleys. Mean annual rainfalls can be broken down for individual LUC subsuites. Rainfall is commonly between 1000 and 1500 mm for well drained floodplains. It is often slightly higher, between 1200 and 1600 mm, for poorly drained floodplains and low terraces. This may increase to 1800 mm in some inland areas. Alluvial and estuarine plains with gley soils receive approximately 1000 to 1300 mm near the coast which increases to 1400 mm in more inland areas. Mudflats and saline soils are generally recorded in coastal localities around bays and harbours which receive a mean annual rainfall of between 1000 and 1300 mm. Rainfall can be up to 1400 mm in more inland areas.

Areas on peat with mainly organic soils, including drained and undrained swamps, typically receive mean annual rainfalls of between 1000 and 1500 mm. Rainfalls can be up to 1800 mm in more inland sites.

During normal weather patterns, periods of drought from spring to late autumn are common.

The major physical limitation in this LUC suite is one of wetness. Northland is often affected by high-intensity rainfalls and although most rivers are relatively short, flooding is always a major problem. Floods can occur in any month but are more likely in winter.

## *Soils*

Soils have developed either from fine-grained (<2.0 mm) alluvium derived from sedimentary or volcanic rocks, or from peat, and are characteristic of floodplain, valley plain, levee, and low-lying terrace environments. Soils are often deep. The main soil groups represented are recent soils, yellow-brown earths, brown granular loams and clays, gley soils, and organic soils. Podzolised gley soils are separated out from soils in this suite and are included with podzolised soils on sand country.

Soils on floodplains and low terraces typically range from well drained to very poorly drained. The degree of wetness is reflected by the amount of gleying or mottling, by the height of the water table and by soil texture. Soil wetness increases as textures change from sandy loams and silt loams to clay loams and peaty loams. There is often a narrow pattern of well drained soils on the levee with more poorly drained soils away from the levee.

### *Floodplains and low to intermediate terraces*

The most commonly recorded soils are those belonging to the Whareora and Kohumaru soil suites (Cox et al. 1983). They include mainly recent soils, and, to a lesser degree, moderately leached to weakly podzolised yellow-brown earths and moderately leached to strongly leached brown granular loams and clays. Podzolised yellow-brown earths and strongly to very strongly leached brown granular loams and clays are separated out from the soils recorded in this suite and are contained in other suites.

### *Gley soils*

The main gley soils belong to the Kaipara, Waipu and Waipapa soil suites, and are commonly recorded on floodplains, estuarine plains and valley plains in low-lying, usually poorly drained areas. Soils in the Kaipara suite have formed on estuarine clays, sands and alluvium and are subdivided into gley soils (e.g. Kaipara series, Tawharanui series) and slightly saline gley soils (e.g. Takahiwai series).

### *Mudflats with saline soils*

Slightly saline gley soils from the Kaipara soil suite (e.g. Takahiwai series) are recorded on drained and stopbanked mudflats bordering harbours, bays, estuaries and lagoons. Underlying sediments have accumulated in tidal and intertidal environments.

### *Organic soils*

Organic soils of the Ruakaka and Otonga suites (Cox et al. 1983) are commonly recorded on peats in low-lying, poorly drained areas.

### *Erosion*

Streambank erosion and deposition were recorded throughout the region, with the potential for streambank erosion increasing in narrow and constricted valleys and at the sides of terraces. Most major rivers and streams are subject to minor to moderate bank erosion.

There is a constant risk of flooding and deposition in many low-lying areas, such as alluvial flats, particularly during and immediately following intense long-duration rainstorms and 'flash' floods. On major plains such as in the Ruawai–Dargaville, Hikurangi and Kaitaia areas, flooding and deposition are largely controlled by a system of stopbanks, ponding areas, overflow channels and drains. Swamps in the region play a major part in the detention/ponding of floodwaters and the regulation of watertables.

Present erosion is usually negligible to slight on units in LUC subsuites 2a, 2b, 2d and 2e, while often slight to severe on LUC units in LUC subsuite 2c. Streambank erosion and deposition is locally severe and often difficult and expensive to repair and control. LUC units recorded on broad plains (LUC subsuite 2a, 2b), often without significant streams, were more typically drained by small channels and drains and showed negligible erosion.

A significant amount of all sediment in streams and rivers in the region can be traced back to bank erosion (e.g. the Wairoa, the Mangakaihia). Another major source of sediment is runoff from hillslopes, with increased debris/sediment entering watercourses during or after major storms, as can be seen in the Kaihu Valley. Most streams in the region are undersized for the catchments they drain and many streams and rivers are affected by tidal influence.

The clearance of large tracts of forest – native forest since about 1850 and exotic forest since about 1950 – has contributed greatly towards increases in runoff and discharge. Deforestation has therefore had a major impact on the land in this suite during approximately the last 100 years. As land has become stripped of its dense vegetative cover it has been mainly replaced by grasses for pastoral farming. It must be noted that many hillslopes in Northland are of an inherent geologically 'unstable' nature, and that deforestation and undercutting the base of slopes (e.g. by streams) increases instability and erosion.

Greater runoff and more direct discharge of detritus and sediment has generated large volumes of silt and clay which have entered watercourses and often led to aggradation of channels. The increase in sediment loads, enlargement of streams and increased discharge has greatly increased the risk of flooding and deposition (silting) of downstream areas, often with deleterious effects to low-lying highly productive pastoral and cropping land. Flood protection schemes and drainage have therefore been essential prerequisites for productive land use in this suite.

Potential erosion can range from slight to very severe. Units in subsuite 2a generally have a low flooding risk, present erosion is negligible to slight, and the land is generally moderately well to well drained. Subsuite 2b also has a low risk for flooding but soils are more poorly drained and land in this subsuite does occasionally flood. In contrast, the risk of flooding is much higher on units in subsuite 2c which have high watertables or are more frequently flooded (poorly drained floodplains and low terraces). Flooding risk is also high on all Class IV, Class VI, and Class VIII land, where potentials for streambank erosion and deposition are often moderate to very severe.

Units in subsuite 2e, on peat and peat and sand, also have the potential for slight to severe streambank erosion and deposition, particularly where they drain units in the sand country. Gullying may also be recorded on more erodible types of land on peat and alluvium.

### *Vegetation*

Much of the land is covered in improved pasture, improved pasture with scattered rushes and sedges, or semi-improved pasture with scattered rushes and sedges. Areas with high watertables, are usually poorly drained or frequently flooded, and are typically covered in rushes and sedges in association with wetland vegetation.

Swamps are usually densely covered in rushes with scattered or clumped wetland vegetation. Wetland vegetation includes toetoe, raupo, and cabbage trees (*Cordyline australis*). Podocarps such as kahikatea are often found growing in scattered clumps throughout pasture, or scattered throughout swamps.

Some of the better drained and less frequently flooded areas on peats and alluvium are being used for horticulture or vegetable cropping.

### *Land use and land management*

Drainage and flood control have been essential requirements for the development of this land and its conversion into productive land uses such as dairying and cropping. Open drains and stopbanks have been used extensively on broad plains such as in the Ruawai–Dargaville areas, the northern Wairoa catchments which include the Hikurangi swamp, and the Kaitaia plains. Intensive open and subsurface drainage is often used in smaller areas to maximise cropping and pastoral potentials. Narrow or constricted valleys, floodplains and terraces are subject to runoff from surrounding hills, and drains and diversion channels are required at the base of hills (e.g. colluvial footslopes) to channel water away from terrace surfaces.

Most of the land has been developed for agriculture, with dairying the main type of farming. Land consists almost entirely of high-producing pasture, and in wetter areas pasture with scattered podocarps and rushes, and smaller areas of wetland vegetation. Cropping on better-drained soils and less floodable land includes vegetables, horticulture and nurseries. Drainage, irrigation and shelter are essential for horticultural development. Vegetable cropping, such as kumara, is a dominant land use on the gley soils, particularly in the Dargaville–Ruawai area.

Flooding is a significant problem in a number of areas. Of particular concern is land within and downstream of the northern Wairoa catchments which collectively drain between 3000 km$^2$ and 4000 km$^2$ including the Mangakahia Valley and the Hikurangi swamp, and land extending south to the Wairoa River (e.g. Tangiteroria). The Kaihu Valley north of Dargaville represents another area of high risk. Highly productive farming and cropping land, adjacent to the northern Wairoa and its tributaries, is currently protected by a comprehensive system of stopbanks, ponding areas, drains, and channels. The northern Wairoa River is tidal for about 100 kilometres from Kaipara Heads, and this tidal influence, together with intense rainfalls, can result in rapid flood rises. The spread of exotic grasses such as *Zizonia latifolia* (Manchurian wild rice) into main drains and channels has also created further management problems in the lower reaches of the northern Wairoa catchment. Other low-lying areas with the potential for flood damage are in the far north, adjacent to the Awanui River and the Victoria River valley, extending to the Kaitaia–Awanui plains. Low-lying areas in the northeast of the region which have been affected by occasional but significant flood events are those adjacent to the Kerikeri River and the Waipapa Stream (affected by flood damage and severe erosion in 1981), the Waitangi River, and the Kaeo River, where the potential for flood damage is considered to be high.

Flood control, reclamation, and drainage of low-lying areas have involved major work schemes, usually at the district and regional planning level. The largest and most successfully developed area adjacent to the northern Wairoa River is the broad plains of the Ruawai flats, where about 8200 ha of highly productive land has been reclaimed from tidal and swampland. With continued drainage and reclamation the total area of the floodplains and swamp will reach about 16 000 ha. Initial reclamation in the early 1900s was carried out by the Department of Lands and Survey. In 1905 reclamation and drainage work was taken over by the Raupo Drainage Board and continued, more recently, in collaboration with the now disestablished Northland Catchment Commission. Isolated flood control works are continuously undertaken along the northern Wairoa as part of an overall river control scheme now administered by the Northland Regional Council. Any rise in sea level would pose further problems to the development and management of these areas.

Drainage of swamps has been imperative for land development and increasing productivity in the region. Settlers drained many swamps for farming and as part of gum-digging operations in the late 1800s and early 1900s. The Kaitaia swamp, which was formed mainly by sand dunes forcing the Awanui River northward to discharge into the Rangaunu harbour, was drained in 1913, forming the Kaitaia drainage area covering 25 000 ha; the Hikurangi swamp was drained in 1934, forming the Hikurangi drainage area covering approximately 20 000 ha. On the eastern side of the region, the swamp at Mangawhai and

the low-lying land northwards towards Whangarei were also drained. Many areas just inland of the sand country, on both the western and eastern coasts, were drained and reclaimed where land was adjacent to harbours and estuaries. After drainage of the Hikurangi swamp, the area continued to be flooded regularly because of its high watertable and constricted outlet formed by an old lava flow and narrow outlet through limestone. The area was therefore unable to cope with increased flows, particularly during intense rainstorms. Water continued to pond in the swamp and other low-lying land for long periods, particularly in winter months. Drainage throughout the swamp was gradually improved but, because of the constricted outlet, a major flood control scheme was the only option for effective drainage. Initial planning for such a scheme was initiated by the Northern Wairoa Watershed Committee who intended extensive development of the swamp which would require planning for the whole river system and larger catchment area. In 1962 the Northland Catchment Commission was established to proceed with planning such a scheme and was given an administrative area covering the old Hobson and Whangarei Counties. This administrative area was later extended to the Hokianga and Mangonui Counties, and in 1967 the Northland area from Wellsford–Maungaturoto north was included. The Hikurangi swamp drainage and flood control scheme was largely completed by 1980 and included river straightening, stopbanking, and the construction of a number of pumping stations for different sections (approximately seven main sections were identified) of the swamp to regulate internal drainage. The scheme is designed to cope with floods with return periods of five years. Although the Hikurangi swamp is still occasionally flooded by intense rainfalls, it has brought an extensive area of land into production and greatly improved the potential for pastoral farming and cropping in better drained areas, with identifiable economic benefits to the region.

A range of management techniques includes bank protection works, re-afforestation of critical headwater areas and flood detention techniques (swamps are often used for ponding or regulating flows into the downstream drainage system). These are used to control river and stream flows, floodflows and erosion within catchments. Channel modification and enlargement can be a problem, particularly where there is increased siltation and bank erosion, as in the siltation of newly constructed channels in the Kaipara District.

Management of the channel bed and channel size includes bank protection by planting trees such as willows. It is also necessary to remove and maintain clearance of obstructions, such as vegetation, from within channels. Other techniques include construction of gabions, brushwork, and control of any degradation or aggradation of the channel bed by closely monitoring sediment deposition and transport. Gully erosion usually caused by the construction of drains on grades too steep in relation to the type of material and the catchment size (Cathcart 1978) is another land management difficulty. The potential for erosion is often related to land use.

## Decision pathway for recognising LUC units within alluvial and estuarine plains and low terraces

1. **Are the soils of the Whareora or Kohumaru suites?**

   Yes → go to 2 No → go to 11

2. Are the soils podzols?

   Yes → go to 3 No → go to 5

3. Are the soils podzolised to such an extent that arable use is precluded?

   Yes → **VIs5** No → go to 4

4. Are soils podzolised but arable use is not precluded?

   Yes → **IVs4** No → go to 5

5. Are soils recent, or weakly to strongly leached yellow-brown earths?

   Yes → go to 6 No → go to 11

6. Are the soils free draining and land rarely flooded?

   Yes → **IIw1** No → go to 7

7. Does the land have imperfectly to moderately well drained soils suitable for arable use?

   Yes → **IIIw1** No → go to 8

8. Does the land have continuing severe wetness or flooding limitation but the degree of limitation does not preclude arable use?

   Yes → **IVw1** No → go to 9

9. Is the land subject to flooding and/or a high watertable which precludes arable use, and drainage would require a small-scale local drainage scheme?

   Yes → **VIw1** No → go to 10

10. Is the land a swamp or depressed area subject to severe flooding or a continuously high watertable which requires a large-scale district flood control and/or drainage scheme?

    Yes → **VIIw1** No → go to 11

11. **Are the soils organic and developed on peat, or peat and alluvium?**

    Yes → go to 12 No → go to 16

12. Does the land have only moderate physical limitations to arable use?

    Yes → **IIIw4** No → go to 13

13. Does the land have severe physical limitations for arable use but limitations do not exclude cropping?

    Yes → **IVw3** No → go to 14

14. Does the land have physical limitations which preclude arable use?

    Yes → **VIw3** No → go to 15

15. Is the land a swamp with a permanently high watertable or is it subject to frequent floods which restrict agricultural use?

    Yes → **VIIw2** No → go to 16

16. **Are the soils gleyed and slightly saline and developed on mudflats adjacent to harbours, tidal estuaries, and lagoons?**

Yes → go to 17 No → go to 21

17. Has the land been reclaimed for more than 10 years and intensively drained?

Yes → **IIIw3** No → go to 18

18. Has the land been reclaimed for between 5 and 10 years but still has a continuing wetness limitation?

Yes → **IVw2** No → go to 19

19. Has the land been reclaimed in the last 5 years and requires extensive drainage?

Yes → **VIw2** No → go to 20

20. Is the land covered in mangroves or subject to tidal flooding and requires stopbanks?

Yes → **VIIw1** No → go to 21

21. **Are the soils gleyed?**

Yes → go to 22 No → go to LUC suite 3, (page 58)

22. Are the soils fertile and suitable for cropping?

Yes → **IIw2** No → go to 23

23. Are the soils fertile but have a moderate wetness problem?

Yes → **IIIw2** No → go to 24

24. Does this land have a continuing wetness or flooding limitation but physical limitations do not exclude arable use?

Yes → **IVw1** No → go to 25

25. Is the land subject to flooding or a continuously high watertable precluding arable use, and drainage would require a small-scale local flood control or drainage scheme?

Yes → **VIw1** No → go to 26

26. Is this land a swamp or depressed area subject to severe flooding or a continuously high watertable and requires a (or is part of a) large-scale district flood control and/or drainage scheme?

Yes → **VIIw1** No → go to LUC suite 3, (page 58)

## LUC Suite 3: Quaternary terraces with complex soils

A complex of soil groups and soil subgroups, including yellow-brown earths, yellow-brown loams, brown granular loams and clays, podzolised yellow-brown earths and podzolised yellow-brown loams, podzols and organic soils, is recorded on undulating to gently rolling slopes on mainly Quaternary-aged terraces. Other soil groups, such as rendzinas, may occasionally be associated with this type of land. The suite is mainly represented immediately north of Auckland, in the Dairyflat–Riverhead–Kumeu area but also in a number of small isolated areas north of Orewa to Whangarei. The suite typically occurs in valleys where Quaternary alluvium, volcanic ash and reworked tephras form or mantle alluvial terraces.

The suite comprises five LUC units: IIe2, IIw3, IIs2, IIIe2, IIIs3, together covering some 22 003 ha (1.4%) of the region (Figure 9). An idealised cross-section of LUC suite 3 is shown in Table 7.

### *Geomorphology and rock type*

The topography within this LUC suite comprises relict terraces or fluviatile plains with flat to gently rolling slopes dissected by small streams and broad, shallow valleys. It therefore forms a subdued relief of gently inclined surfaces. Terraces consist mainly of Quaternary-aged alluvium exposed in remnants of high-level fluviatile plains. Terrace levels range from 2 to 85 m above local base level. Stream alluvium, mainly clay, is exposed below terraces over 85 m above sea level and between 34 and 64 m, 14 and 27 m, and 2 and 14 m above local base level (Schofield 1989). Coarse sand in some deposits near Riverhead could represent near-coastal sand development when sea level was about 25 m above present (Schofield 1989). The highest level of fluviatile clay occurs below moderately well preserved remnants of a plain up to 115 m above sea level near Riverhead, just north of Auckland, suggesting higher sea levels during the Quaternary than at present (Schofield 1989).

Various Quaternary-aged deposits are exposed below the series of relict terraces. These deposits are described as surface or near-surface (surficial deposits).

The main rock type recorded in this suite is unconsolidated clays and silts (Uf), largely originating from stream alluvium (Pleistocene fluviatile deposits). These deposits commonly contain reworked tephric material. They comprise alluvial clays, silts, and sands with occasional organic-rich deposits and are typically derived from local weathering products. In the north Auckland area they are principally the redeposited weathered regoliths and bedrock from Waitemata Group rocks.

Quarternary-aged deposits are very thinly to thinly bedded, often multi-coloured, although most often pale grey, white, or pale brown (often mottled near surface) with interbeds of peaty material and/or sands. The thickness of the deposits is variable but usually no greater than 8 m. When moist the deposits are very soft to soft, forming soft plastic clays and silty clays of low strength (especially when remoulded).

The presence of the clay mineral allophane, comprising roughly 7% of the clay fraction (Whyte 1982), and the occurrence of pumiceous silts in some localities indicate that rhyolitic tephric materials were derived from outside the basin of deposition. The last phase of deposition included the addition of a thin and discontinuous cover of water-sorted tephra, which on weathering and soil formation gives yellow-brown loam soils.

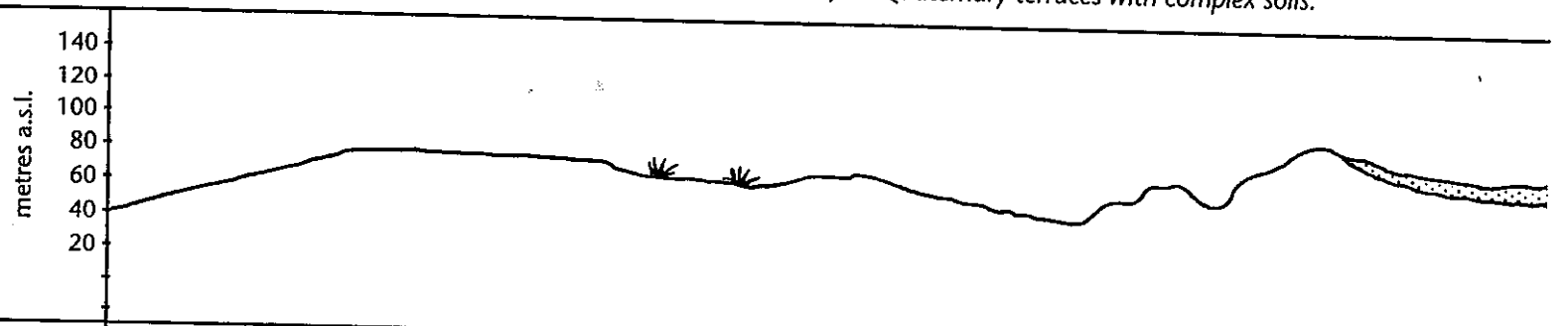
Throughout the region, Quaternary-aged alluvial deposits are associated with or derived from deeply weathered *in situ* or redeposited sedimentary lithologies including the regolith material of sandstones, mudstones, and/or limestones. In the north Auckland area these Quaternary-aged deposits rest unconformably on Waitemata Group interbedded sandstones and mudstones (including conglomerates) of mainly Miocene age. In the more northern parts of the region they overlie a range of mainly Tertiary-aged sedimentary lithologies including sandstones, mudstones, limestones and argillites.

In many areas unconsolidated clays and silts of Quarternary age are associated with younger Holocene aged alluvium (Af), where the younger Af deposits either overlie or form lower terrace levels next to Uf deposits.

### *Climate*

The climate is warm and humid with mild winters

*Table 7. Idealised cross-section showing relationship between LUC units within LUC Suite 3, on Quaternary terraces with complex soils.*




| | | | | | | |
|---|---|---|---|---|---|---|
| Typical dominant slope(s) (degrees) | 0–7 | 0–7 | 0–3 | 0–7 | 8–15 | 0–7 |
| NZLRI slope group | B, B+A | A, A+B | A | B, B+A | C | A, A+B |
| Typical altitudinal range (m a.s.l.) | 0–100 | 0–100 | 0–100 | 0–100 | 0–100 | 0–100 |
| Typical rainfall range (mm) | 1200–1500 | 1200–1500 | 1200–1500 | 1200–1500 | 1200–1500 | 1200–1500 |
| Present erosion (NZLRI codes) *see Appendix 14* | 0 | 0 | 0 | 0 | 0-1 Sh, R | 0 |
| Potential erosion (NZLRI codes) | 1 Sh, R | 0-1 Sh, R | 0-1 Sb | 1 Sh, R | 1 Sh, R, G.2 R, G (when cultivated | 0-1 R, Sh |
| Soils *(generalised)* | Complex | Complex | Complex, organic | Complex | Complex | Complex |
| Lithology (NZLRI codes) *see Appendix 12* | Uf | Uf | Uf + Pt | Uf | Uf, Uf/Sb | Uf, Uf/Mx, Uf/Li*Sb |
| LUC unit | IIe2 | IIs2 | IIw3 | IIe2 | IIIe2 | IIIs3 |

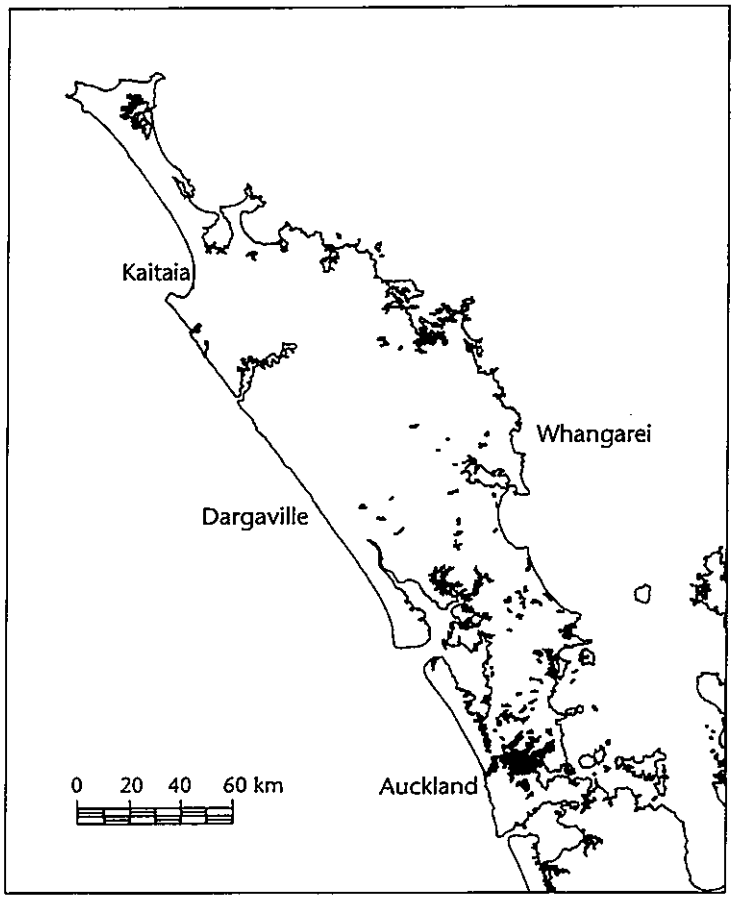



*Figure 9. Location of LUC suite 3. Quaternary terraces with complex soils.*

and few frosts. Prevailing winds are from the southwest and west with occasional strong gales and heavy rains from the east or northeast, particularly during summer and autumn (e.g. tropical cyclones, intense rainstorms). Northwesterlies may also become more prevalent during spring. Spring is the windiest season, while the greatest number of calm periods are in summer and autumn. Mean daily windspeed is between 11 and 13 km/h. Wind gusts may reach 64 km/h or greater on 30 to 40 days of the year while wind gusts of 96 km/h may occur on one or two days a year in any month from either an easterly or a westerly quarter.

The mean annual temperatures are typically between 13.5°C and 15.5°C and the mean annual temperature range is commonly between 7.2°C and 8.3°C . These represent some of the highest mean annual temperatures recorded in New Zealand and nowhere south of Auckland City are the July mean temperatures as high. The average of 2000 sunshine hours is adequate for the growth of a wide range of crops. The climate has been described as almost subtropical in some areas.

Rainfall is variable but shows a winter maximum and a summer minimum. Areas tend to experience on average 125 to 150 days of rain a year near the coast and on the eastern side of the region, while further inland and towards the west 150 to 200 days a year may be more common.

The mean annual rainfall is typically between 1200 and 1500 mm. Mean annual rainfall in the north Auckland area, where most of this suite occurs, is 1426 mm, with a spatial variation from 1600 mm/year in more western higher elevation areas to about 1200 mm/year in eastern more sheltered areas. The most reliable rainfall is in the winter and spring months, while the period November to March is particularly drought-prone. This latter period is also frequented by

intense tropical rainstorms. Water balance studies described by Smith (1983) show the significance of these rainfall patterns. The key to further intensification of horticulture will be the availablity of water for irrigation during these spring and summer dry periods.

### *Soils*

Soils have formed on flat to gently rolling land (terraces and plains) on a variably thick and often patchy cover of reworked, mainly rhyolitic airfall tephra. Tephric deposits are incorporated within, or form a veneer over, fine-grained alluvium (unconsolidated silts and clays) of Quaternary age. They are mainly from the Waitemata suite, the Otonga suite and Whareora suite (Cox et al. 1983).

Peats are also recorded in some low-lying areas, usually in natural depressions. Deeply weathered sandstone, mudstone, conglomerate rock, and limestone may be recorded at the outer margins of the flat to gently rolling terraces.

Because of the spatial complexity of parent materials, mainly due to differences in composition and thickness, the distribution of soil types is also very complex. With the soil pattern being so variable, soils have had to be arranged into soil complexes rather than individual soil types or soil series, and designated with the symbols C1 and C1A. Soil groups and subgroups represented in these soil complexes are yellow-brown loams, brown granular loams, podzolised yellow-brown loams, weakly to strongly leached yellow-brown earths, podzolised yellow-brown earths, organic soils, and podzols.

### *Erosion*

There is no immediate erosion hazard for units of this suite. There is, however, a potential for streambank erosion along low-lying terraces bordering streams, and for sheet erosion on the steeper sides of terraces. There is also a potential for sedimentation/deposition when terraces in this suite are excavated.

Although terraces are stable in an *in situ* state, some instability can occur on disturbance of bedded sediments. For example, Jessen (1983) refers to a highly dispersive layer, between 0.3 m and 1.0 m thick, of loosely consolidated yellow sands and loamy sands which occurs within Quaternary terrace deposits and provides little resistance to running water.

Under a grassland cover, soils do not generally erode. On cultivated slopes above 2°, however, there is a potential for slight to moderate rill, sheet and wind.

### *Vegetation*

Improved pasture and horticultural crops (e.g. grapes and berryfruit, vegetables, nurseries, subtropical fruit, kiwifruit, pip and stonefruit) are the dominant vegetation types recorded. On the rolling to steep sides of terraces or escarpments improved pasture, often associated with mixed indigenous scrub, manuka or gorse, are commonly recorded. On flat to rolling terrace surfaces and on downlands such as the Albany–Riverhead area, high-producing pasture is progressively being replaced by intensive cropping, which has dramatically increased in area in the last 20 years, particularly in the Kumeu and Huapai areas. Smaller areas of root and green fodder crops are also grown, usually on undulating to rolling slopes.

### *Land use and land management*

Because of the complex pattern of soils, a large spatial variation in drainage types and soil fertility is found. Clay, volcanic and peat soils often occur over short distances – even on one property. Profiles may also be difficult to predict. A peat or volcanic soil may be shallow, with a poorly drained clay underneath. These spatial variations are more apparent at scales between 1 : 1000 to 1 : 5000, but are collectively called soil complexes at the mapping scales of 1 : 63 360 and 1 : 50 000.

Present land use is mainly cropping on flat to undulating slopes and grazing on steeper slopes. The suite covers one of Auckland's main vegetable growing areas, and includes land near Kumeu, Huapai, Waimauku, and Hobsonville. Smaller areas of vegetables are also grown in Henderson and Albany. Much of the production is on small, blocks of about 4 ha. Over the last 20 years the Auckland region has been one of the fastest-growing cropping districts in New Zealand. Because of a favourable 'growing' climate and close proximity to markets, some of this production is on less fertile soils with poor soil structure.

Grapes are extensively grown, although production has fallen in the last 15 years and there has been a general move from white grapes to red. Smaller wineries have increased in the north Auckland area. Production of grapes can often be affected by a seasonal rainfall pattern which will damage crops late in the season. This has seen diversification to export glasshouse grapes.

Vegetable crops include potatoes, and smaller areas of carrots, cauliflower, cabbage, and broccoli, as in the Riverhead area. Fruit crops include pipfruit and stonefruit, particularly in the Riverhead/Kumeu area, and smaller areas of citrus.

Kiwifruit is extensively grown, particularly in the Kumeu/Waitakere area extending into the Rodney District. Kiwifruit has replaced dairy farming in many areas, especially on seasonal supply dairy farms.

Berryfruit, particularly strawberries and smaller areas of blueberry, and boysenberry are also common. Large-scale production of blueberries is limited because of the lack of peaty soils in the north Auckland area.

Subtropicals have increased markedly over the last 15 years, with avocado, babaco, feijoa, Asian pear (nashi), and persimmon being grown. Melons are also grown as specialist crops on a very small scale.

Greenhouse and ornamental crops have also increased, with plants being grown almost all the year round. Many crops are now grown in greenhouses. These include vegetable crops such as tomatoes, cucumbers and beans, and flower crops such as carnations and chrysanthemums. Cutflowers and ornamentals are now major export crops. Outdoor ornamental crops, open ground and container nurseries have also expanded in recent years.

## Decision pathway for recognising LUC units within Quaternary terraces with complex soils

1. Are the soils developed on fluvial sands, silts and clays of mainly Quaternary age?

   Yes → go to 2 | No → go to LUC suite 4 (page 71)

2. Are the soils developed on alluvium from sedimentary rocks?

   Yes → go to 3 | No → go to 16

3. Are the soils moderately to strongly leached yellow-brown earths of the Whareora suite?

   Yes → go to 4 | No → go to 6

4. Are the soils free draining and land rarely flooded?

   Yes → **IIw1** | No → go to 5

5. Does the land have imperfectly to moderately drained soils but is occasionally flooded?

   Yes → **IIIw1** | No → go to 7

6. Are the soils Waipuna clay or Albany silt loam?

   Yes → **IVw1** | No → go to 7

7. **Are the soils of the C1 or C1A complex and mainly from the Waitemata suite?**

Yes → go to 8 | No → go to 14

8. Does the land include small areas of soils developed on interbedded sandstones and mudstones?

Yes → go to 9 | No → go to 11

9. Is the land on A, B or gentle C slopes?

Yes → go to 10 | No → go to 16

10. Are the soils a complex of Waitemata suite soils and soils from other suites?

Yes → **IIIs3** | No → go to 17

11. Are the soils reasonably fertile and slopes predominantly A?

Yes → **IIs2** | No → go to 12

12. Are the soils reasonably fertile and slopes predominantly B?

Yes → **IIe2** | No → go to 13

13. Are the slopes predominantly C?

Yes → **IIIe2** | No → go to 14

14. **Are the soils organic?**

Yes → go to 15 | No → go to 17

15. Are the slopes A or B?

Yes → **IIw3** | No go to 16

16. **Are the soils on volcanic alluvium?**

Yes → go to 17 | No → go to LUC suite 4 (page 71)

17. **Are the soils of the Kohumaru suite?**

Yes → go to 18 | No → go to LUC suite 4 (page 71)

18. Are the soils moderately to strongly leached?

Yes → go to 19 | No → go to 23

19. Are slopes A or A and B?

Yes → go to 20 | No → go to 22

20. Is this land free draining and rarely flooded?

Yes → **IIw1** | No → go to 21

21. Is this land occasionally flooded and/or has imperfectly to moderately well drained soils?

Yes → **IIIw1** No → go to 22

22. Are slopes C or B and C?

Yes → **IIIe1** No → go to 23

23. Are soils strongly to very strongly leached?

Yes → go to 24 No → go to 26

24. Are slopes A or B?

Yes → **IVs3** No → go to 25

25. Are slopes C, C and D or D?

Yes → **IVe3** No → go to 26

26. Are soils moderately to strongly podzolised but the degree of podzolisation does not preclude arable use?

Yes → **IVs3** No → go to LUC suite4 (page 71)

## LUC Suite 4: Sedimentary rock terrain (excluding greywacke)

This suite on sedimentary rock terrain (excluding greywacke) comprises 25 LUC units: IIIe3, IIIe4, IIIs5, IVe1, IVe4, IVe5, IVe6, IVe8, IVe12, IVw4, IVs4, Vc1, VIe1, VIe3, VIe5, VIe7, VIe8, VIe12, VIe19, VIs3, VIs5, VIIe2, VIIe3, VIIe4, VIIe8. Together these cover 604 328 ha (38.2%) of the region (Figure 10). An idealised cross-section of LUC suite 4 is shown in Table 8. On the basis of more detailed geomorphic and management criteria, units can be placed into the following subsuites:

**4a.** Interbedded and massive sandstone and mudstone (LUC units IIIe3, IVe5, VIe1, VIe8, VIIe4).

**4b.** Older shattered and sheared argillites and sandstone (LUC units IVe6, VIe7).

**4c.** Sheared mixed lithologies (LUC units IVe8, VIe12, VIIe2).

**4d.** Crushed argillite (LUC units VIe19, VIIe8).

**4e.** Limestone (LUC units IIIs5, IVe1, Vc1, VIe3, VIs3, VIIe3).

**4f.** Limestone complexed with other sedimentary deposits (LUC units IIIe4, IVe4, VIe5).

**4g.** Podzols on a range of sedimentary rock types (LUC units IVe12, IVw4, IVs4, VIs5).

### *Geomorphology and rock type*

LUC units are formed on a range of sedimentary rock types, with the land generally forming a mixture of undulating to rolling terrain, downlands, hills and steep hills.

The sedimentary landscape as a whole shows only subtle landform and microrelief differences, giving an impression of uniformity or continuity. However, more detailed observation (e.g. slope profiles, erosion features, drainage) using photo-interpretation and field assesssment indicates small but discernable differences in slope morphology and texture, and soil erosion, which are related to changes in the spatial distribution of rock type. The soil type also reflects these changes in rock type. In many areas in Northland landforms are underlain by a complex mixture of rock types or an inter-digitating pattern of rock types in close association, seldom having

distinct boundaries. On a geomorphic basis, using landform and soil characterisation, and on consideration of management and soil conservation requirements, the sedimentary landscape has been subdivided into seven main landtypes referred to as LUC subsuites in this report (see above). Each subsuite is closely related to rock type, except one landtype – LUC subsuite 7 – which separates out areas with podzolised soils on a range of rock types (see soils section below).

Six individual rock-type groupings are described with their characteristic geomorphic expression and erosion types:

- Interbedded sandstones and mudstones (flysch), and occasional massive sandstones, mudstones and conglomerate of mainly Miocene age, and typically those of the Waitemata Group. Landforms have undulating to very steep slopes, giving mainly rolling, hilly and steepland terrain. The terrain is some of the most stable of that on the sedimentary rock types. The characteristic erosion forms are soil slip, earth slip, tunnel gully and minor earthflow.

- Shattered and deformed sedimentary rocks, comprising a mixture of argillites (e.g. siliceous shales, hard mudstones) and massive or banded sandstones in varying proportions, and occasional minor mudstone. Mudstones are generally hard and include massive, banded or jointed/fritttered forms. Rocks are typically Cretaceous to Miocene in age and typically belong to the Raukumura, Mata, Dannevirke, Arnold, and Landon series. They include large areas within that mapped as Northland Allochthon (Ballance and Spörli 1979) and occasional Onerahi Chaos breccia (Kear and Waterhouse 1967) where argillite, argillite and sandstone, sandstone and argillite, and minor mudstone are typically recorded.

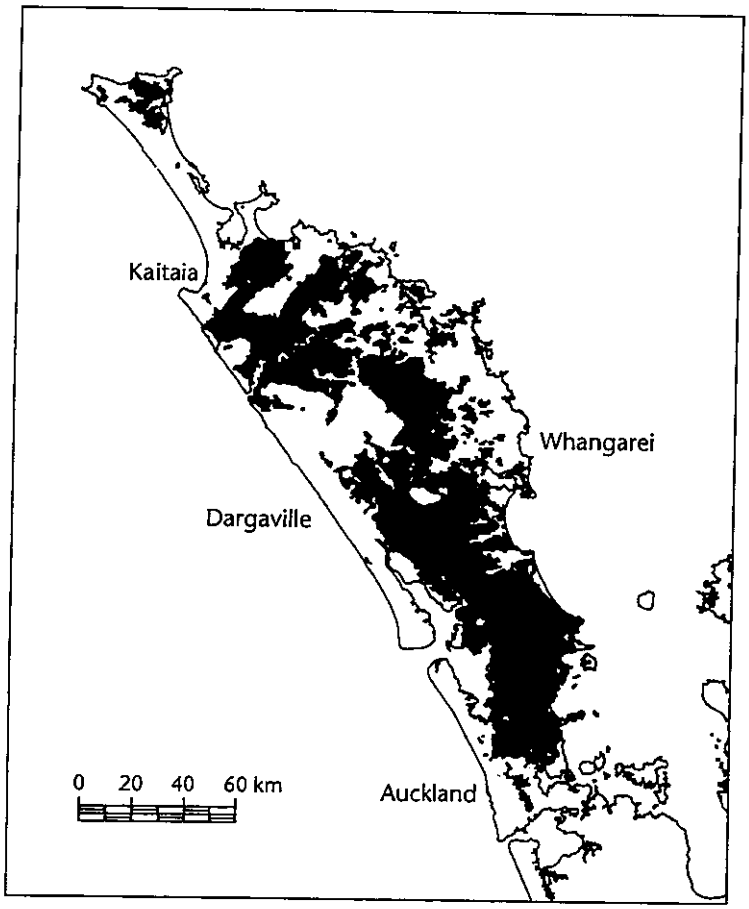
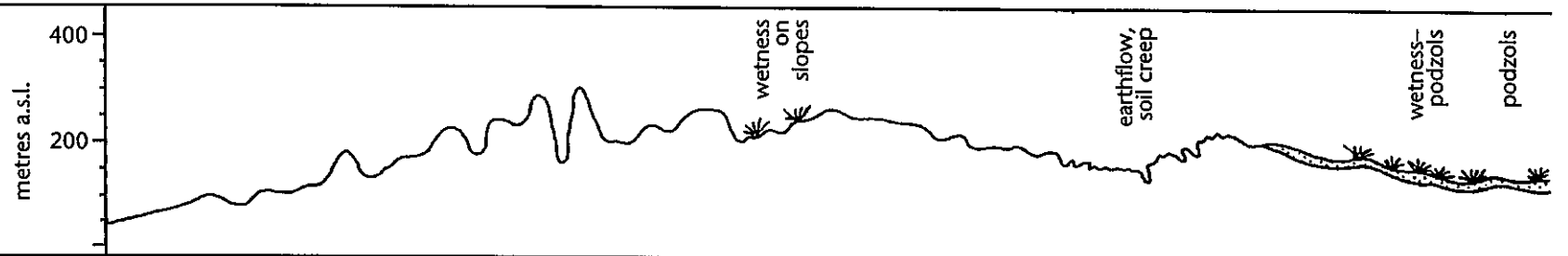


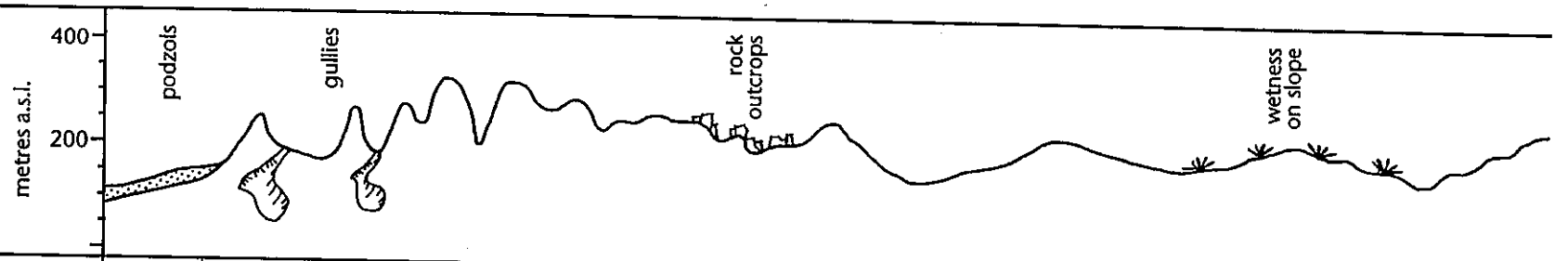

*Figure 10. Location of LUC suite 4. Sedimentary rock terrain (excluding greywacke).*

*Table 8. Idealised cross-section showing relationship between LUC units within LUC Suite 4, on sedimentary rock terrain (excluding greywacke).*




| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Typical dominant slope(s) (degrees) | 4–15 | 8–20 | 16–25 | 21–35 | 26–>35 | 21–35 | 16–25 | 8–20 | 8–20 | 8–25 | 8–25 | 8–20 | 3–15 | 0–15 |
| NZLRI slope group | B+C, C+B, C | C, C+D | D, E, D+E | E, F | F, F+G | E, F | D+E E+D | C, C+D | C, C+D | C, D, E | C, D, E | C, C+D | B, B+A B+C | A-C |
| Typical altitudinal range (m a.s.l.) | 0–400 | 0–400 | 0–400 | 0–400 | 0–400 | 0–400 | 0–400 | 0–400 | 0–400 | 0–400 | 0–600 | 0–400 | 0–400 | 0–400 |
| Typical rainfall range (mm) | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1400–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1400–1800 | 1200–1600 | 1200–1600 | 1200–1600 |
| Present erosion (NZLRI codes) *see Appendix 14* | 0-1 Sh, R | 0-1 Sh, R, Ss, T, G, Ef | 0-2 Sh, Ss, T, G, Es | 1-2 Sh, Ss. 1 Ef, G. 0-1 T | 1-3 Ss, Sh. 0-1 T, Ef, G. Es | 1-2 Sh, Ss. 1 Ef, G. 0-1 T. | 1-2 Sh, Ss, Es, Ef, T. 0-1 G | 1 Sh, G, T, Ss, Ef | 1-2 G, Ef. 0-1 Sh, R, Ss, T | 1-2 Ef, G, T. 0-1 Sh, Ss, Es | 2-3 Ef, G. 0-2 Es, Ss, Sh | 1-2 T, Sh. 1 Ef, G | 0-1 T Sh, G, Ef | 0-1 Sh, G |
| Potential erosion (NZLRI codes) | 1 Sh, R, G. 2 R, Sh, G | 1-2 Sh, Ss, T, Ef, R. 1-2 R, G, 2-3 Sh | 2 T, Ss, Es, Sh, G. 1 Su, Ef | 2 Sh, Ss, G, Ef. 1 T | 2-3 Ss, Sh, Es. 2 T, G | 2 Sh, Ss, G, Ef. 1T | 2 Ef, G, Ss, T, Es. 3 Sh | 2 Sh, G, T, Ss, Es, Ef. 2-3 Sh, R, G | 2 Ef, G. 1-2 Sh, Ss, T, 2-3 Sh, R, G | 2-3 Ef, G. 2 T, Sh, Ss, Es | 3-4 Ef, G. 2 Es, Ss, Sh | 2 Ef, Ss, T, Sh, G. 2-3 Sh, R, G | 2 Sh, R, T, G. 1 Ef, 2 Sh, R. 1 G | 2 G, T. 1-2 Sh, R, G |
| Soils *(generalised)* | Y-B earth | Y-B earth | Y-B earth | Y-B earth | Y-B earth + steepland soils | Y-B earth | Y-B earth | Y-B earth | Y-B earth | Y-B earth | Y-B earth + BG loams, clays | Podzols | Y-B earth, podzols | Podzols |
| Lithology (NZLRI codes) *see Appendix 12* | Sb, Sm, Mb, Mm | Sb, Sm, Mb, Mm | Sb, Sm, Mb, Mm | Sb, Sm, Mb, Mm | Sb, Sm, Mb, Mm | Sb, Sm, Mb, Mm | Ar, Ar+Sm Sm+Ar | Ar, Sm | Mx, xst | Mx, xst | Mx, In | Mx, Sm, Ar, xst | xst, Li | xst, Af, Uf |
| LUC unit | IIIe3 | IVe5 | VIe1 | VIe8 | VIIe4 | VIe8 | VIe7 | IVe6 | IVe8 | VIe12 | VIIe2 | IVe12 | IVw4 | IVs4 |

*Table 8 (continued).*




| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Typical dominant slope(s) (degrees) | 4–15 | 16–25 | 21–35 | 26–>35 | 16–25 | 4–35 | 16–25 | 8–20 | 4–15 | 7–15 | 8–20 | 16–25 |
| NZLRI slope group | B, B+A B+C | E, D | E, E+F | F, F+G, G+F | E+D, E | B-F | D, E | C, D | B, C | B, B+C | C, C+D | D+E, D |
| Typical altitudinal range (m a.s.l.) | 0–400 | 0–500 | 0–500 | 0–400 | 0–400 | 0–400 | 0–400 | 0–400 | 0–400 | 0–400 | 0–400 | 0–400 |
| Typical rainfall range (mm) | 1400–1800 | 1200–1800 | 1200–1800 | 1400–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 |
| Present erosion (NZLRI codes) *see Appendix 14* | 0-2 Sh, G, R. 0-1Ss | 1-3 G, Sh, Ss, Es | 1-3 G, Sh, 0-3 Ss, Es, R | 1-2 Ss, Sh, 0-1G | 0-1 Sh, Ss, G | 0-1 Sh, Ss, T, G | 0-1 Sh | 0-1 Sh, G, Ss | 0-1 G | 0-1Sh, G | 0-1 Sh, G, Ss, T, Ef | 0-2 Ss, Sh, Ef, G, Es |
| Potential erosion (NZLRI codes) | 2-3 Sh, G, R. 1 Ss | 3 G, Sh, Ss, Es | 5 G. 4 Sh, Ss. 2 Es, R. 1 Ef | 2-3 Ss, Sh, 1 G | 2 Ss, Sh, G | 1-2 Sh, Ss, G. 2-3 T | 1 Sh, Ss | 1 Sh, G, Ss, 2 Sh, G | 0-1 G. 0-2 Sh. R | 1 Sh, R, G. 2 R, Sh. 1 W | 1 Sh, Ss, 1-2 G, T, Ef. 2-3 Sh, R, G | 2 Ss, Sh, Ef, Es |
| Soils *(generalised)* | Podzol | Y-B earth Podzol | Y-B earth Podzol | Rendzina + steepland soils | Rendzina | Rendzina | Rendzina | Rendzina | Rendzina | Rendzina + Y-B earth | Rendzina + Y-B earth | Rendzina + Y-B earth |
| Lithology (NZLRI codes) *see Appendix 12* | xst, Ac | Ac | Ac | Li | Li | Li | Li | Li | Li | Li + xst xst + Li | Li + xst xst + Li | Li + xst xst + Li |
| LUC unit | VIs5 | VIe19 | VIIe8 | VIIe3 | VIe3 | VIs3 | Vc1 | IVe1 | IIIs5 | IIIe4 | IVe4 | VIe5 |

Landforms have rolling to hilly slopes which are comparatively more unstable than rock-type group 1. The characteristic erosion forms are earthflow, tunnel gully, and minor soil slip and earth slip.

• Shattered and sheared sedimentary rocks, often more than four discernable lithologies, mixed together and containing a high proportion of mudstone or highly weathered shales, and, sometimes, a mixture of highly weathered volcanic deposits (e.g. Tangihua volcanics). Described in the NZLRI rocktype classification (Lynn and Crippen 1991) as sheared mixed lithologies, mainly multi-coloured mudstones and limestone with minor argillite and sandstone. The rock type is very stiff to weak, and probably Cretaceous to Tertiary in age. It includes unstable areas or gently sloping areas within the Northland Allochthon (Ballance and Sporli 1979; Schofield 1983) and Onerahi Chaos breccia (Kear and Waterhouse 1967, 1977) where mudstone or mudstone and limestone (or calcareous argillite) are predominant.

Landforms are undulating to rolling. In the sedimentary landscape they are comparatively very unstable rock types in which creep occurs at slope angles as low as 4° (Whyte 1982). The characteristic erosion forms are tunnel gully, gully, earthflow and sheet. Because the rock is weak, slopes are very seldom more than rolling. Land associated with this rock type, as with rock-type group 2, is noted for its prevalence in roadside bank collapse.

• The siliceous claystone or siliceous shale is referred to as crushed (closely jointed and sheared) argillite in the NZLRI rock type classification (Lynn and Crippen 1991). It includes large areas of the Ngatuturi claystone (Hay 1960). The argillite has various angular (approximately 1 to 5 cm) rock fragments and in unweathered form these fragments can be moderately strong to extremely strong, although weathering to loose or soft clayey fragments. The structure of the rock is very sheared and deformed.
The landform which typically has strongly rolling to steep hills shows conspicuous large amphitheatre gully erosion forms and is particularly prone to sheet erosion.

• Limestone rock, containing 50% or more calcium carbonate, is common throughout the Northland Region, with strengths ranging from weak to very strong. This rock-type group represents those areas of dominant limestone which can be separated out at the mapping scale of 1 : 50 000. It is often associated with rocks in the Northland Allochthon (Ballance and Spörli 1979) and the Onerahi Chaos breccia (Kear and Waterhouse 1967). The limestones are mainly of Tertiary age and typically Oligocene to Paleocene in age. They include the Mahurangi limestone (Waterhouse 1966), and argillaceous and crystalline limestones of the Mangakahia Group, Motatau Group and Opahi Formation (Hay 1960; Thompson 1961).

Slopes range from undulating to very steep, but most of the terrain is typically undulating to hilly. Erosion is often negligible except on moderate to very steep slopes where soil creep and sheet erosion can become moderate to severe. Tunnel gully and gully may occur in some areas on gentler slopes.

• Limestone and argillaceous limestone is often closely associated with, or complexed with, a number of other sedimentary lithologies such as mudstone and sandstone. This rock-type group represents those areas (inventory map units) which are recorded as spatially complex at the mapping scale of 1 : 50 000, with mixtures of both limestone and other sedimentary rock types. Mudstone, micaceous sandstone, and greensands are often dominant secondary components. It is often associated with the Northland Allochthon (Ballance and Spörli 1979) and the Onerahi Chaos breccia (Kear and Waterhouse 1967).

Slopes typically range from undulating to steep with most terrain being undulating to rolling. In comparison with rock-type group 5, there is a more unstable, hummocky and irregular appearance, probably indicating soil creep or earthflow, and more seepage and wet zones. Erosion types include tunnel gully and gully on gentler slopes and sheet and soil slip on steeper slopes. The recorded soils on this land are more likely to be rendzinas associated with, or complexed with, yellow-brown earths.

### *Climate*

In general the suite is characterised by warm, humid summers and relatively mild winters.

Prevailing wind is generally from the southwest and west with northwesterlies prevalent in spring. Occasional strong gales and heavy rains from the east or northeast may occur during the year, particularly tropical cyclones and intense rainstorms in summer and early autumn.

Spring is the windiest season, while the greatest number of calm periods occur in summer and autumn. Mean daily wind speed is between 11 and 13 km/h. Wind gusts may exceed 64 km/h on 30 to 40 days of the year and 95 km/h on one or two days of the year in any month, from either an easterly or a westerly quarter.

Mean annual temperatures are typically between 13.5°C and 15.5°C and the mean annual temperature range is commonly between 7.2°C and 8.3°C.

Rainfall is extremely variable but shows a winter maximum and summer minimum. The average rainfall variability is 16% (this being the average of the differences of the annual totals from the long-period mean, expressed as a percentage of the mean). Topography and airflow are two major factors affecting the overall rainfall pattern. The eastern side of the region is generally drier than the western side. Low-altitude areas on the coast are typically drier than high-altitude areas further inland. Eastern coastal districts have on average about 125 to 150 raindays per year, whereas other areas generally experience between 150 to 200 raindays, the highest number being recorded in the western uplands.

The mean annual rainfall is between 1200 and 1800 mm. Coastal districts on the eastern side of the region receive lower rainfalls, typically between 1000 to 1400 mm, while western districts receive greater rainfalls on average and some inland sites receive approximately 1600 to 1800 mm.

## Soils

Soils have developed on a range of sedimentary rock types. The main parent materials are sandstones, mudstones, argillites (shale), and limestones, and in some areas deeply weathered volcanic rock may also be complexed or associated with the sedimentary rock types. Because of this complex and variable spatial pattern of rock types, many of the soils form complexes or spatially complex associations. Yellow-brown earths are recorded extensively, as are rendzinas and associated soils which are typically recorded on limestone, calcareous argillite, or calcareous mudstone.

Soils range from weakly to strongly leached, and weakly podzolised to podzolised.

*Yellow-brown earths*

Within the soil group yellow-brown earths, the main soil suites recorded were the Puhoi, Waiotira, Omu, Omanaia, Purua, and Omaiko suites (Cox et al. 1983).

*Rendzinas*

The soil group rendzinas and associated soils comprises three main soil suites: Arapohue, Maungaturoto, and Konoti (Cox et al. 1983).

*Podzols*

Because podzolised soils have a profound influence on land management and land use they are recorded separately. Podzols are formed on various sedimentary rock types, with the podzolised nature of the soil having a more overriding influence on land use capability rather than the rock type or landform. Within the sedimentary landscape four LUC units (IVe12, IVs4, IVw4, VIs5) are recorded on podzolised soils. Podzols, podzolised yellow-brown earths, and podzolised yellow-brown loams commonly occur on flat to rolling terrains such as footslopes and downlands of the sedimentary hill country.

## Erosion

Erosion is discussed for each of the subsuites defined within LUC suite 4. Erosion characteristics and the potential for erosion are largely related to differences in rock type and landform, particularly factors such as slope angle, wetness, depth of regolith and depth and degree of weathering of rock type. These differences are often indicated by changes in soil type.

*Interbedded and massive sandstone and mudstone (LUC units IIIe3, IVe5, VIe1, VIe8, VIIe4)*

Slopes generally range from 4° to above 35°. Characteristic erosion forms are soil slip, earthslip, sheet, tunnel gully and occasionally gully. Debris avalanche is limited to slopes above 25°. Potential for erosion can be generally described as moderate to severe.

The potential for soil slip increases with slope

angle, and slip frequency increases greatly above slope angles of 21°. Most soil slips are relatively shallow, <1 m deep, with shear planes typically occurring along the contact between soil and bedrock. Deeper soil slips (>0.5 m deep) and earthslips (>1.0 m deep) are more evident on deeply weathered sandstones, often on midslope and lower slope positions, where the failure surface is often concave rather than parallel to the surface. A deep failure surface is typically recorded on the Whangaripo soils, where slipping occurs within the red weathered regolith on deeply weathered sandstones.

This subsuite includes the more 'stable' areas on Waiotira soils, whereas the more 'unstable' areas, because of lithologic composition and degree of weathering, are placed in subsuite 2 on older shattered lithologies.

Sheet erosion is common on steep slopes, particularly above 20° where shallower soils have less moisture-holding capacity. Where these slopes are in pasture, overgrazing and drought conditions, during summer months, can promote sheet erosion by reducing pasture cover, exposing the soil to surficial erosion processes.

Tunnel gully often occurs on footslopes, or lower slopes typically below 18°. This erosion form is particularly characteristic on the Waiotira soils and also occurs on the Riponui, Puhoi and Whangaripo soils. Gully erosion is occasionally recorded on incised lower slopes and footslopes.

*Old shattered and sheared argillite and sandstone (LUC units IVe6, VIe7)*

Slopes seldom exceed 26°. The main erosion types are soil slip/earthslip, sheet, tunnel gully, earthflow and gully. Occasional slump may also be recorded. The potential for erosion varies depending mainly on erosion type, slope angle, depth of weathering and lithologic composition, but is generally described as moderate to very severe. Underlying rocks are often shattered and sheared and often closely associated with rocks recorded as sheared mixed lithologies. This subsuite includes the more unstable areas on Waiotira soils either where sandstones become increasingly deformed, principally by shearing, or where sandstones are mixed with argillites.

Soil slips and earthslips tend to occur on steeper slopes above 16° and are often deeper than those on subsuite 1 largely because of the deep weathered and sheared nature of the older rocktypes. Soil slips/earthslips are often associated with slump and earthflow erosion.

Slopes in general are more disrupted in appearance and shorter than slopes in subsuite 1. The irregularity of the slope profile and soil variability down the length of the slope because of erosion and deposition, along with colluvial deposition and reworking of regolith deposits on the lower slopes, indicates a long and continuous history of erosion, with greater reactivation on the mid to lower slope areas.

Earthflow erosion and large seepage areas are often characteristic on lower slopes or slopes below 20°, with 'wet' zones typically indicated by high concentrations of rushes. Earthflows are often associated with slump and gully erosion in these areas.

Sheet erosion is common on steeper slopes, particularly above 20°, and becomes more pronounced where argillite content increases or becomes more dominant. Soils on these steeper sites, particularly on argillaceous rocks, have low moisture-holding capacities and are prone to drying out in summer months.

Tunnel gully often occurs on lower slopes or footslopes, typically below 18°. This erosion form is particularly evident on the Waiotira soils.

Gully erosion is often associated with earthflow and is occasionally recorded on incised lower slopes and footslopes where channels tend to drain excess water away from earthflows.

Because the predominant clay soils on these rock types dry out in summer months, the development of cracks and fissures on these slopes is often a means for deeper penetration of water during rainstorms. Wetting and drying of soils throughout the year is therefore often paralleled by periods of decreasing stability with increased wetness, followed by periods of increased stability as soils dry out.

*Sheared mixed lithologies (LUC units IVe8, VIe12, VIIe2)*

Most slopes are low angle, i.e. less than 20°, with principal erosion types comprising earthflow, (slump/earthflow) tunnel gully, gully and sheet. Occasional soil slip or earthslip, with associated slump may be recorded on steeper slopes. The potential for erosion can generally be described as moderate to very severe; locally, however, the

potential can be extreme. Underlying rocks are deeply weathered and pervasively sheared, mudstone, argillaceous limestone, and deeply weathered volcanic rock, which are collectively recorded as sheared mixed lithologies (refer to rock type section for detail). Rock types are inherently low strength and generally have a high potential for swelling and shrinkage. They are therefore susceptible to earthflow, slump and gully erosion. Earthflow and soilcreep, sometimes with associated slump, occur on mudstone and argillaceous limestone on slopes as low as 4–7° (Whyte 1982). The clay mineral assemblage of these deeply weathered rocks is dominated by smectite and illite.

Slope profiles are hummocky or irregular, and pressure mounds or pressure ridges are often developed near the foot of the slope, or in series up the slope. Hollows are also common features. Soils are often exposed by deep cracks or fissures. The broken nature of the surface, together with poor internal drainage, contribute to deep-seated earthflow and slump erosion (surface profiles become more broken or disrupted as land progresses from Class IV to Class VII). Slopes typically comprise large seepage areas covered in scattered rushes, and 'wet' depressed areas. Small gullies on low angle slopes are often initiated in depressions or associated with earthflows.

Earthflows may be passive or active features, and their estimated depth to the failure surface is uncertain, but likely to be variable. Their activity is increased where water is incorporated or where they are undercut at their base by streams or channels. Features commonly associated with earthflows on this type of land include head scarps, tension cracks, localised failures, pressure ridges, and gullies.

This type of land (along with land in LUC subsuite 2) is often associated with earthflow and slumping adjacent to roads and tracks.

Tunnel gully was typically recorded on slopes below 16°, in slight depressions where there is a concentration of water. Tunnel development in these areas is related to subsurface drainage (Ward 1966; Visser 1969). Tunnel gully was particularly prevalent where argillaceous limestone or sandstone was complexed with shales and mudstones.

Gullying was often recorded in association with earthflow, particularly where channelling of water had caused incision and often gullying or undercutting of slopes had instigated downslope movement or reactived earthflow areas. Slump/flow erosion is often triggered by undercutting of the slope or by gullying. In some areas gullying was probably initiated through overgrazing and pugging of natural depressions by livestock.

Sheet erosion was often recorded on all slopes where repeated tracking and pugging from livestock had reduced pasture cover. This type of land is very susceptible to surficial erosion, rill and gully erosion, when cultivated.

Areas considered most susceptible to slump/flow erosion are those on the multi-coloured mudstones, such as the green and chocolate mudstones of the Waiomio and Opahi Groups (Hay 1960) which slump readily. Multi-coloured shales with flints were also considered highly susceptible to mass movement.

*Crushed argillite*
*(LUC units VIe19, VIIe8)*

Slopes are typically between 14° and 35°. The main erosion types are gully, sheet and soil slip. Minor earthflow and slump may be recorded on lower slopes. This type of land is highly susceptible to gully and sheet erosion and the potential for both these erosion types ranges from severe to extreme.

Underlying rocks are shattered and sheared, comprising mainly of shales or siliceous claystones, and recorded in the NZLRI as crushed argillite. These rocks often have high concentrations of sulphides, and when exposed they become highly acidic in a weathered state. The high level of acidity and the infertile nature of the soils on these rock types is a major limitation for plant growth and revegetation, and represents a significant problem for gully mitigation and repair.

Rills and gullies form rapidly on these rock types. Water readily permeates down through strongly leached and podzolised soils, particularly where subsoils have a well developed prismatic or columnar structure which allows water to enter fissures at depth.

Mature gullies form large amphitheatre shapes with steep walls typically to 40 m deep, 100 m wide, and between 200 m and 2 km in length. During enlargement a large amount of coarse

sediment is generated from the gully head and wall and deposited as a series of thick, gently sloping beds (about 1–8°) on the gully floor, often forming detrital fans at the mouth of the gully. Gully floors are often further incised and patterned by rills and channels.

Gullying is characteristic near Kaikohe, particularly between Ngawha and Waiomio, and between Pipiwai and Titoki. It is also commonly recorded southwest of the Whangarei harbour between Maungatapere and Oakleigh (Cathcart 1978).

Crushed argillite or claystones generally have sharp ridges with abrupt concave-planar slopes scarred by slips, and valley heads have masses of slumped debris. Soil slips/slumps tend to occur most frequently in midslope to upper slope areas typically on slopes steeper than about 20°. Occasional earthflow may occur on lower slopes or slopes below about 20°, usually at the head of valleys where there is a concentration of runoff or high watertable.

Sheet erosion is significant, particularly on grassed slopes above 18°, and was observed to have been initiated where shallow soils had low moisture-holding capacities, where pasture cover was sparse or thin, and where slopes were dry during summer months. It was often exacerbated by a combination of overgrazing and low soil moisture retention on these slopes.

*Limestone*
*(LUC units IIIs5, IVe1, Vc1, VIs3, VIe3, VIIe3)*
Slopes range from 4° to above 35°. Underlying rock types are often referred to as 'stable' limestones, as mapped for example in the Arapohue and Kaiwaka areas. The main types of erosion are soil slip, sheet and occasional gully. Sinkholes are also a feature within limited areas (e.g. mainly on crystalline limestone).

The potential for erosion ranges from negligible to slight on slopes below about 20°, and slight to moderate on greater slopes. Erosion becomes more pronounced on the more 'unstable' limestones such as argillaceous limestones complexed with mudstones, shales and sandstones (refer to subsuite 6). Slope profiles below about 20° on 'stable' limestones are generally long and smooth, and have a stable appearance.

The frequency and distribution of erosion may increase where runoff from steeper hill country is a factor.

Shallow soil slips (<0.5 m deep) may occur more commonly on slopes above 20°, and more frequently on slopes above 25°. Grassed slopes above about 20° are often more susceptible to slipping during or after localised rainstorms. Soil creep to depths of about 40 cm was recorded on slopes typically greater than 20°, exposing bedrock, and in many places the turf mat was broken indicating downslope movement. Soil creep may to some degree be facilitated by repeated stock treading or overgrazing of livestock, but is particularly accentuated on steep to very steep slopes.

Sheet erosion is characteristic on steeper slopes above 16°, and is often associated with livestock tracking, broken pasture cover, or dry slopes.

Gully erosion is occasionally recorded on footslopes and lower slopes of hill-country terrain and on downlands. Gullies on limestone are relatively small narrow features and often associated with depressions and areas where there is a concentration of runoff, such as swales. They are often associated with argillaceous limestones and jointed mudstones.

Because of the high percentage of expanding clays, soils should not be overworked or overcultivated particularly at high moisture levels. Soils generally are wet and less permeable during winter and crack badly during drier months in summer as they dry out.

*Limestone mixed with other sedimentary deposits*
*(LUC units IIIe4, IVe4, VIe5)*
Slopes are typically between 4° and 26°. Underlying rock is often referred to as 'unstable' limestone, of lower strength than 'stable' limestone, and landforms, such as those mapped in the Maungaturoto and Kaiwaka areas, are inherently more unstable than those on 'stable' limestones. Rocks are typically recorded as complexes of argillaceous limestone, crystalline limestone, calcareous and non-calcareous mudstone, shales, and minor sandstone.

These more unstable terrains are commonly adjacent to or proximal to more 'stable' limestone terrains. Slope profiles are more irregular, often have minor corrugations (due to creep) and typically have large seepage areas and 'wet' depressed areas.

Major erosion forms are gully, sheet, tunnel gully and earthflow. Soil slip, often associated with slump, is occasionally recorded on slopes above 16°. Soil creep also occurs mainly on slopes generally above 16°. Slumping tends to occur in areas which have been undercut.

Gully erosion occurs on easier slopes usually below 20° where runoff and water concentrate. Gullies are generally small and sinuous.

Tunnel gully mainly occurs on slopes below 16°. Development can be attributed to subsurface drainage (Ward 1966; Visser 1969). The potential for tunnel gully is moderate to severe.

Sheet erosion is more conspicuous on steeper slopes, or on slopes affected by repeated tracking of livestock.

Earthflow was recorded on lower slopes, footslopes and was often associated with slump and gully.

*Podzolised soils on a range of sedimentary rock types (LUC units IVe12, IVs4, IVw4, VIs5)*

Slopes are typically between 0° and 20°. Major erosion forms are gully, sheet, earthflow, tunnel gully, and soil slip may occur on slopes steeper than 12°. Large drainage depressions, seepage zones, colluvial footslopes, and long gentle slopes covered in scattered rushes are characteristic of landforms. Podzols are formed on a range of lithologies of varying strengths, rock types are commonly shattered and sheared and include marine sandstones, siltstones, claystones, greywacke, rhyolite, dacite, and alluvium derived from erosion of these rocks.

Soils have poor structure and low fertility; they are extremely wet during winter and pug badly under repeated tracking by livestock during wet conditions. At most undisturbed sites, for example under Kauri forest, moric organic horizons cover, and to some degree protect, the more indurated and massive sandy or silty horizons. In contrast, under a pastoral or cropping regime, where soils have been disturbed, the 'more' massive and often structureless silt-sand horizons are extremely susceptible to erosion. The columnar structure of the subsoil also allows deep penetration of water, particularly during drier months when there is enlargement of fissures and cracks, thus increasing the potential for erosion.

These 'gumland' soils rapidly break down to structureless fine sand or silt when overcultivated and rill and gully can be moderate to very severe under cultivation. Gullies can be initiated on relatively gentle slopes where runoff or a concentration of water penetrates the soil to bedrock.

Earthflow and soil creep commonly occur on mudstones and argillaceous limestones on slopes as low as 4–7° (Whyte 1984).

Sheet erosion, easily identified by the characteristic white colour of 'bleached' soil horizons in disturbed areas, has the potential to become severe to very severe. It is much more pronounced on slopes affected by repeated tracking of livestock, and on cultivated slopes than on undisturbed pasture. It is commonly associated with other erosion forms such as gully and rill.

Tunnel gully occurs where runoff or water concentrates in gently depressed areas usually on midslope to lower-slope positions on a range of sedimentary rock types including argillaceous limestone, crystalline limestone, jointed mudstone and sandstone.

## Vegetation

High-producing pasture is the principal cover on land within this suite, while large areas of exotic conifer forest (mainly *Pinus radiata*) and scrub also exist. Manuka, gorse, mixed indigenous scrub and mixed indigenous scrub with tree fern were the dominant scrub types.

Indigenous forest, largely lowland podocarp–broadleaved forest, is recorded throughout the region in small, usually isolated, pockets. Rushes and sedges commonly occur on poorly drained land with podzolised soils and landforms on shattered and sheared mudstones and argillites, i.e. siltstone, claystone. Exotic conifer forest covers much of the crushed argillite terrain where large areas were initially planted for erosion control. Extensive areas of scrub including manuka, heath and gorse were also commonly recorded on this rock type.

Space and block planting of conservation trees such as poplars and block planting of exotic conifer forest (*Pinus radiata*) is common on the more unstable terrains on shattered and sheared rocks, argillite, crushed argillite, mudstone and mixed lithologies.

### *Land use and land management*

Most of the land types included in this suite have been deforested, with most deforestation occurring in the last 50–150 years.

Major land uses are pastoral farming and exotic forestry. Cropping is generally unsuitable. Undeveloped areas, particularly on the podzolised terrains, are also locally extensive and show various stages of scrub reversion, with vegetation classes such as manuka, mixed native scrub and gorse dominating.

Many of the landtypes are highly suited to pastoral farming, but fertiliser application is necessary to counter nutrient deficiencies and increase and sustain production. Steeper areas, slope angles above 25°, are generally more suited to forestry.

The weakly to moderately leached northern yellow-brown earths and the northern rendzina soils support excellent pasture with light to moderate applicatons of phosphate and lime. Under good management, land on the interbedded sandstones and mudstones, on limestones, and on older shattered sandstones and mudstones, shows high levels of productivity. Land underlain by argillite is often more difficult to manage and is prone to several forms of erosion, sheet and gully being the most conspicuous forms under a pastoral regime.

More intensive management is required on those northern yellow-brown earths which are strongly leached or podzolised and on the podzols within this suite. These more infertile soils (e.g. Waikare soils) are often difficult to farm because of their high requirements for fertilisers and lime, their susceptibility to seasonal moisture deficiencies particularly during drought, and their poor soil structure resulting in their relatively high potential for erosion. However, high levels of productivity can be achieved and maintained with sustained, intensive management. The podzolised northern yellow-brown earths and podzols require a combination of phosphorus, potassium and trace elements (e.g. boron) as well as lime.

Much of the land is susceptible to various degrees of erosion which can be difficult to manage. Many landtypes on mixed lithologies including unstable limestone complexes, and on old shattered and sheared mudstones, argillites and sandstones, are inherently unstable. The crushed argillite terrains are particularly prone to gully erosion while many of the terrains on old shattered and sheared sedimentary rocks are prone to earthflow, slump and soil slip. Tunnel gullies may also disrupt farming operations on mixed lithology/unstable limestone terrains.

The potential for erosion is related to a number of causal factors which include: unstable often low-strength rock types which have been deformed by pervasive shearing and are deeply weathered; high clay contents in deeply weathered soils and regolith; poor soil structure which has high potential for accelerated erosion on the podzol soils with shallow weakly aggregated A horizons; and high available moisture in deep subsoils. Land, particularly with podzolised soils, becomes extremely wet during winter months because of poor or slow subsoil drainage. Gullying can often be instigated through repeated compaction by livestock trampling in natural depressions which pug badly during winter. Careful planning and good livestock management is therefore essential. Much of the land with podzolised soils, often referred to as 'gumland', has had a history of mismanagement since deforestation and many areas show evidence of up to 50 cm of soil loss from their original profiles (Cathcart 1978).

Exotic conifer forest covers a relatively large part of this suite, including extensive areas on terrains underlain by crushed argillite, banded sandstone and mudstone, and older shattered and sheared argillites, sandstones and mudstones, and to a lesser degree on the steeper limestone country, north and west of Whangarei. Much of the land on the northern yellow-brown earths is highly suited to exotic forestry, mainly *Pinus radiata*. These soils generally have high available moisture in deep subsoils and a steady but slow supply of nutrients. Tree growth responds well to fertiliser application (e.g. phosphate and lime and additional fertilisers, trace elements) and improvements in drainage. However, on the more podzolised yellow-brown earths and podzols, tree growth may be slower and establishment generally requires more preparation, higher inputs of fertiliser and lime, and better maintenance of silvicultural management.

Good soil conservation management is essential on all units in this suite. Many erosion

problems in the past have been caused by inadequate planning, often involving operations such as earthworks and inappropriate land clearance (i.e. deforestation), particularly on steepland. Hill country and steepland areas are highly susceptible to damage from high-intensity rainstorms.

Potentially unstable sites should remain either in scrub or forest for catchment protection or, if already cleared, should be planted in suitable tree species. Many sites require dewatering of slopes, and tree planting should be considered in these areas. Erosion is largely regarded as an on-site problem on land in this suite. However, with increasing runoff from pastoral land, any erosion is likely to lead to increases in sediment yield, mainly fine sediment such as clays, silts and fine sand, and subsequent increases in deposition in downstream areas. This can exacerbate flooding problems, disrupt farming operations and increase flooding risk.

Because many streams within these terrains are undersized, sediment generation is often very noticeable. The deterioration is caused by suspended sediments which, by degrading water quality, have a deleterious effect on the downstream ecology.

A whole-catchment approach should therefore be adopted for environmental and resource planning for all land in this suite.

## Decision pathway for recognising LUC units within the sedimentary rock terrain (excluding greywacke)

1. **Are the soils podzols or moderately podzolised yellow-brown earths on a sedimentary lithology or range of sedimentary lithologies?**

   Yes → go to 2 | No → go to 7

2. Are slopes either A, B, or gentle C?

   Yes → go to 3 | No → go to 6

3. Do the physical limitations preclude arable use?

   Yes → **VIs5** | No → go to 4

4. Are podzolised soils recorded, but the degree of podzolisation does not preclude arable use; however, there are extreme limitations to arable use?

   Yes → **IVs4** | No → go to 5

5. Is land permanently wet in winter because of soil character, runoff, or a high watertable, and are rendzina soils recorded in complex?

   Yes → **IVw4** | No → go to 6

6. Are slopes C or C and D?

   Yes → **IVe12** | No → go to 7

7. **Is the rock type interbedded or massive sandstones and mudstones?**

   Yes → go to 8 | No → go to 14

8. Are the soils weakly leached to moderately podzolised yellow-brown earths of the Puhoi or Waiotira suites?

Yes → go to 9 No → go to 14

9. Are the slopes dominantly C and B?

Yes → **IIIe3** No → go to 10

10. Are the slopes dominantly C and D?

Yes → **IVe5** No → go to 11

11. Are the slopes dominantly D and E?

Yes → **VIe1** No → go to 12

12. Are the slopes dominantly E and F?

Yes → **VIe8** No → go to 13

13. Are the slopes dominantly F?

Yes → **VIIe4** No → go to 14

14. **Is the rocktype older sheared or shattered argillites and sandstones?**

Yes → go to 9 No → go to 18

15. Are the soils weakly leached to moderately podzolised yellow-brown earths of the Waiotira, Omanaia, Omu or Purua suites?

Yes → go to 16 No → go to 18

16. Are slopes dominantly C and D?

Yes → **IVe6** No → go to 17

17. Are the slopes dominantly D and E?

Yes → **VIe7** No → go to 18

18. Are slopes dominantly E or E and F?

Yes → **VIe8** No → go to 19

19. **Is the rocktype a mixture of multi-coloured pervasively sheared lithologies, with a high proportion of mudstone and argillaceous limestone?**

Yes → go to 20 No → go to 24

20. Are soils weakly leached to moderately podzolised yellow-brown earths of the Omu, Omanaia, Purua or Waiotira suites?

Yes → go to 21 No → go to 24

21. Are slopes dominantly B, C, D, or E with a potential for severe earthflow, soil creep, or gully?

Yes → **VIIe2** No → go to 22

22. Are slopes dominantly C?

Yes → **IVe8** No → go to 23

23. Are slopes dominantly D or C and D with a potential for moderate earthflow, soil creep, or gully?

Yes → **VIe12** No → go to 24

24. **Is the rock crushed argillite (siliceous claystone)?**

Yes → go to 25 No → go to 28

25. Does the land have a potential for severe to extreme sheet and gully?

Yes → go to 26 No → go to 28

26. Are slopes dominantly D or E?

Yes → **VIe19** No → go to 27

27. Are slopes dominantly E or F?

Yes → **VIIe8** No → go to 28

28. **Is the rocktype limestone?**

Yes → go to 29 No → go to LUC suite 5 (page 79)

29. Are soils a complex of rendzinas and yellow-brown earths?

Yes → go to 30 No → go to 35

30. Is the rock a complex of limestone and another sedimentary rock type such as mixed lithologies?

Yes → go to 31 No → go to 35

31. Are slopes dominantly C or C and B?

Yes → **IIIe4** No → go to 32

32. Are slopes dominantly C and D?

Yes → **IVe4** No → go to 33

33. Are slopes predominantly D, D and E, or E?

Yes → **VIe5** No → go to 34

34. Are slopes F or greater than F?

Yes → go to 44 No → go to 35

35. Are the dominant soils recorded rendzinas of the Arapohue, Maungaturoto, or Konoti suites?

Yes → go to 36 No → go to LUC suite 5 (page 79)

36. Do rocky outcrops preclude all arable land use?

Yes → go to 37 No → go to 38

37. Are slopes dominantly A, B, C, or D?

Yes → **VIs3** No → go to 42

38. Are rock outcrops or large areas of stones rare?

Yes → go to 39 No → go to 42

39. Are slopes predominantly B, B and C or C?

Yes → **IIIs5** No → go to 40

40. Are slopes predominantly C and D?

Yes → **IVe1** No → go to 41

41. Are slopes predominantly D or D and E precluding arable use but with nil potential for erosion?

Yes → **Vc1** No → go to 42

42. Are slopes D, E, F or G with a slight to moderate potential for erosion?

Yes → go to 43 No → go to LUC suite 5 (page 79)

43. Are slopes D, D and E, or E?

Yes → **VIe3** No → go to 44

44. Are slopes F or greater than F?

Yes → **VIIe3** No → go to LUC suite 5 (page 79)

## LUC Suite 5: Greywacke terrain

The major unifying feature of this suite is the rock type. Greywacke covers an extensive area on the eastern side of Northland, approximately from Leigh and Waiheke Island in the south, to Whangaroa in the north, and greywacke remnants are also recorded in many central parts of the region. Dominant soils are northern yellow-brown earths. Land use is mainly pastoral farming and exotic forestry, but large areas are undeveloped and are either in indigenous forest or have reverted to a dominant scrub cover (e.g. manuka, gorse or indigenous mixed scrub).

Land use capability is assessed on the basis of underlying lithology, soil type, erosion potential, slope and climate. The suite comprises seven LUC units: IVe7, VIe9, VIe10, VIe17, VIc1, VIIe5, and VIIe6, which together cover some 164 797 ha

(10.4%) of the region (Figure 11). An idealised cross-section of LUC suite 5 is shown in Table 9. LUC units VIe10 and VIIe5 occur in a drier climate along the eastern coastal margin, and on offshore islands where droughts are common, soils dry out for longer periods during summer and autumn months, and soils appear to be shallower and more prone to scree and sheet erosion.

## *Geomorphology and rock type*

The term 'greywacke' has been used to describe indurated sandstones, siltstones and mudstones which are deeply weathered and often shattered and deformed. They were formed about 230 and 130 million years ago (Spörli 1978). These rocks belong mainly to the Waipapa Group and were laid down as part of the Torlesse Supergroup (Suggate et al. 1978). Greywacke rock represents an extensive area on the uplifted eastern side (a series of large uplifted blocks all dipping towards the west) of the Northland region, forming a large part of the eastern uplands. The greywacke is the oldest rock type in the region and forms the basement rock for the other lithologies recorded in the region.

Landforms on the greywacke range from undulating downlands to steep hilly terrain. Much of the terrain is either strongly rolling (16–20°) to moderately steep (21–25°) with a repetitive pattern of broad convex ridges or interfluves, separated by shallow valleys and small streams, or moderately steep (21–25°) to steep (26–35°) hills with occasional very steep (>35°) hillslopes. The terrain is moderately to finely dissected.

At depth, the greywacke rock consists of hard to very hard, dark grey marine sediments comprising indurated mudstone or argillite, greywacke-type sandstone, layered cherts, spilitic rocks, and occasional marble. It can be differentiated into blue-grey quartz–feldspar

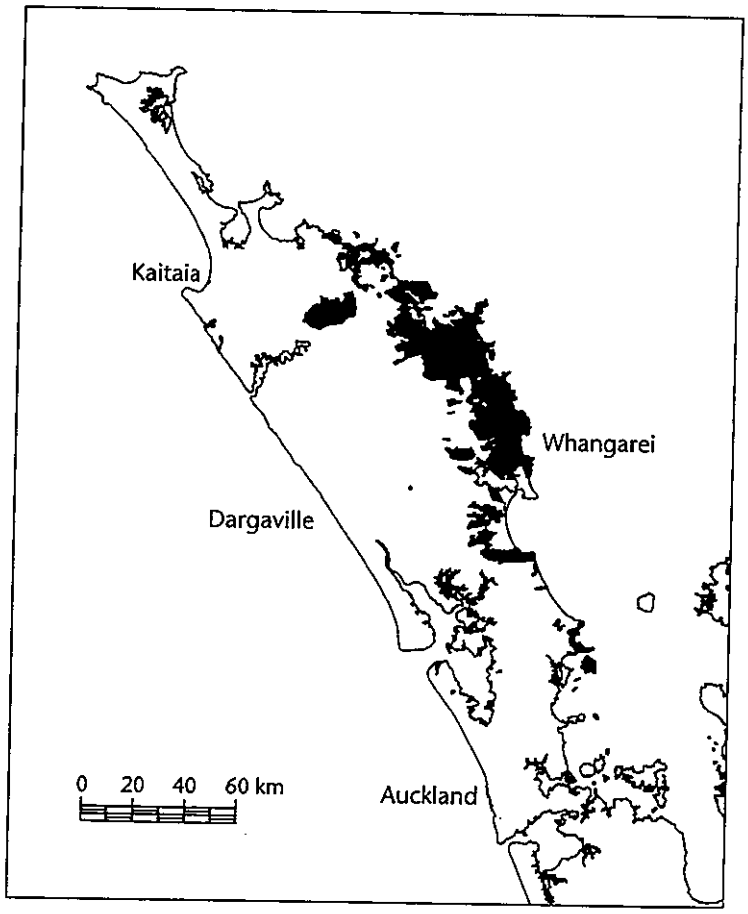
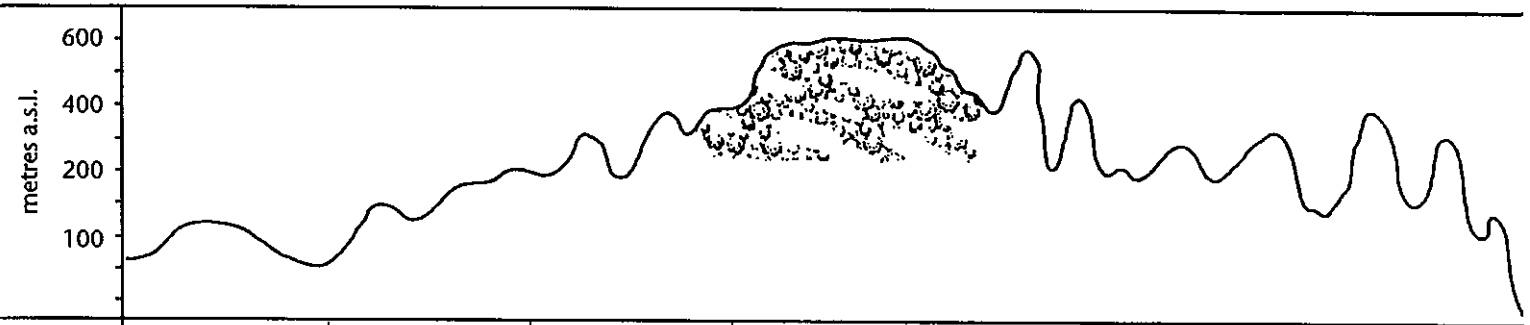



*Figure 11. Location of LUC suite 5. Greywacke terrain.*

*Table 9. Idealised cross-section showing relationship between LUC units within LUC Suite 5, on greywacke terrain.*




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Typical dominant slope(s) (degrees) | 8–20 | 16–25 | 21–35 | 4–18 | 26–35 | 16–35 | 26–>35 |
| NZLRI slope group | C, D | D+E | E+F, F | B, C, C+D | F, G | D, E, F | F, G |
| Typical altitudinal range (m a.s.l.) | 0–400 | 0–400 | 0–600 | >~600 | 0–600 | 0–200 | 0–200 |
| Typical rainfall range (mm) | 1200–1600 | 1400–1600 | 1400–>~2000 | 1800–>~2000 | 1400–1800 | 1000–1200 + <~1000 | 1000–1200 + <~1000 |
| Present erosion (NZLRI codes) *see Appendix 14* | 1 Sh, G, Ss | 1-2 Ss, Sh, Ef, G, Es | 1-2 Ss, Sh, G. 0-1 Es | 0-1 Sh, G | 1-3 Ss, Sh, Da. 0-2 G, Es | 1-2 Sh, Ss, Sc. 0-1, W | 1-2 Sh. 0-2 Sc, Ss. G |
| Potential erosion (NZLRI codes) | 1-2 Ss, Es, Sh, G. 2 Sh, R, G | 2 Ss, Es, Sh, Ef, G | 2 Ss, Sh, G. 1 Es | 1-2 G, Sh | 3-4 Ss, Da. 2-3 Sh, G, Es | 2 Sh, Ss, Sc, G. 1 W | 2-3 Sh, Sc, Ss. 2 G |
| Soils *(generalised)* | Y-B earths | Y-B earths | Y-B earths | Y-B earths – podz. Y-B earths | Y-B earths + steepland soils | Y-B earths | Y-B earths + steepland soils |
| Lithology (NZLRI codes) *see Appendix 12* | Gw | Gw | Gw | Gw | Gw | Gw | Gw |
| LUC unit | IVe7 | VIe9 | VIe17 | VIc1 | VIIe6 | VIe10 | VIIe5 |

greywacke sandstone which is thinly to thickly interbedded with dark grey argillite mudstone. Most of the greywacke rock is closely fractured and quartz veined, and locally siliceous with minor chert or quartzite. Large areas of greywacke have been regionally metamorphosed (Elliot 1968a,b; Black 1989). In most areas, the greywacke, under a warm, humid climate, has become deeply weathered to a soft brown sandy clay, often to depths of 30 m.

### *Climate*

The climate is characterised by warm humid summers and relativelty mild winters. Prevailing winds are from the southwest and west. Northwesterlies also become more prevalent during spring. Occasional strong gales and heavy rain from the east or northeast may occur during the year, particularly in summer and early autumn (e.g. 'tropical' cyclones, intense rainstorms). Spring is the windiest season, while most calm periods occur in summer and autumn. Mean daily wind speed is between 11 and 13 km/h. Wind gusts may reach 64 km/h or greater on 30 to 40 days of the year while wind gusts of 96 km/h may occur on one or two days a year in any month from either an easterly or a westerly quarter (Lisle and Kerr 1964).

Mean annual temperatures are typically between 13.5°C and 15.5°C and the mean annual temperature range is commonly between 7.2°C and 8.3°C. This range may be higher in some inland valleys and higher-altitude areas above 400 m.

Rainfall is extremely variable but shows a winter maximum and a summer minimum. The average rainfall variability in Northland is 16% (defined as the average of the differences of the annual totals from the long-period mean, expressed as a percentage of the mean), and topography and airflow are two major factors affecting the overall rainfall pattern. The eastern side is generally drier than the western side, while low-altitude areas on the coast are typically drier than higher-altitude inland areas. Eastern coastal districts have on average about 125 to 150 raindays per year, whereas other areas generally experience between 150 to 200 days of rain a year, the highest number of raindays being recorded in the western uplands.

Mean annual rainfall ranges between 1200 and 1800 mm with extremes of 1800 to 2500 mm in more inland higher-altitude areas (above 400 m a.s.l.). Coastal districts on the eastern side of the region typically receive lower rainfalls, between 1000 and 1400 mm.

### *Soils*

Soils are usually formed on the deeply weathered greywacke and occasionally on hard, less weathered greywacke. Soils are yellow-brown earths and belong principally to the Marua suite (Cox et al. 1983).

In conjunction with the hill and steepland soils of the Marua soil suite, minor areas of red loams of the Manganese and Maungakohatu soil suites may occasionally be recorded. Soils from quartzite, of the Omaiko soil suite, are also recorded in some areas but these soils are separated out, where possible, to be grouped with soils on highly siliceous rock types from other LUC suites.

### *Erosion*

Land is prone to earthslip and soil slip, which usually occurs following long wet periods when the ground becomes deeply saturated. Hillslopes typically collapse short distances, leaving a series of scarps. Soil slip and earthslip, generally to depths between 0.5 and 3 metres, are often initiated during high-intensity rainstorms. Observations of greywacke terrain over a number of years have indicated that the more mature soils tend to be more prone to slipping when under a poor scrub cover than when under improved, well topdressed pasture, exotic forest or indigenous forest (Cathcart 1978).

Present erosion is not extensive and is generally of slight to moderate severity. However, this assessment is largely based on areas covered by extensive and often dense forest and scrub, including indigenous mixed scrub, gorse, manuka, indigenous forest and exotic conifer forest. Large areas of pastoral land are also recorded as currently reverting to scrub and gorse. With the removal of forest or scrub the potential exists for erosion of a similar magnitude to that occurring in other suites on strongly rolling to steep terrain. Generally, more extensive and severe erosion occurs in response to intense rainstorms, and is usually localised.

The major erosion types are soil slip, earthslip and sheet, and occasional debris avalanche, scree and gully. Soil slip, earthslip, and sheet erosion are more common on steeper slopes above about 20° with a cover of pasture or scrub.

Scree erosion is commonly recorded nearer the coast typically on slopes above 20° on shallow soils where the greywacke rock is generally less weathered and harder. Under an indigenous forest cover much of the erosion is the result of intense rainfalls but introduced animals such as goats and possums may also be contributing factors.

Debris avalanches usually occur on steep to very steep, forested slopes. This type of erosion is most commonly initiated during high-intensity or long-duration rainstorms and forms rapid flows or slides. Narrow tracks often result from scouring and removal of large amounts of regolith. The speed of movement and weight of debris normally ensures that the debris avalanche continues until it reaches the base of the slope, where the debris usually enters the watercourse, often choking the channel. The debris is usually removed during the storm event or later events. The scour remaining is often subsequently eroded further by sheet, rill or gully erosion (Eyles 1985), which may lead to the development of scree erosion.

### *Vegetation*

Dominant vegetation types include improved pasture, semi-improved pasture, exotic conifer forest, indigenous forest, manuka/kanuka, mixed indigenous scrub, fern, and rushes and sedges. Improved pasture is commonly recorded on flat to moderately steep terrain.

Moderately steep to steep terrain is usually covered in exotic forest, scrub (e.g. manuka/kanuka, gorse) and indigenous forest (e.g. lowland podocarp–broadleaved forest, and kauri forest) with pasture being less extensive. In steepland areas covered in indigenous forest, kauri tend to dominate on the ridges and spurs while podocarps grow mainly between the ridges on the more concave wetter slopes.

### *Land Use and Land Management*

Principal land uses include pastoral farming and exotic forestry, but many areas are still undeveloped or are reverting to scrub.

Many of the land management problems evident on the greywacke terrain are similar to those described for LUC suite 4 on the younger sedimentary terrains.

Along the eastern side from Whangaroa to Whangarei, the greywacke hill country represents some of the more extensive undeveloped hill-country areas in the region. There has also been a gradual change in many areas from pastoral farming to forestry. Good farming practice or forest management is essential to minimise both onsite and offsite effects of erosion. Small uneconomic holdings, noxious weeds and lack of finance have in many districts prevented sustainable farming strategies from being successfully employed. Development on this land should be discouraged unless resources are available for continued, sustained use.

Forestry operations, if not properly planned, can initiate erosion through hillside disturbance and modification, from machinery, tracks, thinning, burning slash, hauling, and debris landings. This results in increased runoff and sediment generation from catchments, enlargement of areas of bare ground, and increased bedload and suspended sediment in streams which causes discoloration of water. Increases in sedimentation inevitably lead to a decrease in water quality and impacts on downstream ecological habitats such as in littoral and estuarine habitats. Increased runoff from deforested areas, with associated high levels of suspended and bedload sediment, often gives rise to higher flood peaks in many catchments. Because of the proximity of many exotic and native forests to the coast, such as Whangaroa, Bay of Islands district, future logging activities will have to be carefully planned and monitored so that impacts on coastal environments are minimised. Increased sedimentation from any type of land disturbance could create major problems such as pollution of the littoral or inshore coastal areas.

## Decision pathway for recognising LUC units within the greywacke terrain

1. **Are the soils moderately podzolised yellow-brown earths and podzols?**

   Yes → go to 2 | No → go to 7

2. Are slopes either A, B or gentle C?

   Yes → go to 3 | No → go to 6

3. Do the physical limitations preclude arable use?

   Yes → VIs5 | No → go to 4

4. Are podzolised soils recorded, and while the degree of podzolisation does not preclude arable use, there are extreme limitations to arable use because of the dominant soil limitation?

   Yes → IVs4 | No → go to 5

5. Is land permanently wet in winter with a dominant wetness limitation due to clay mineralogy in soil, runoff, or a high watertable, and podzolised soils are complexed with rendzina soils?

   Yes → IVw4 | No → go to 6

6. Are slopes C or C and D?

   Yes → IVe12 | No → go to 7

7. **Are soils moderately leached to moderately podzolised yellow-brown earths of the Marua suite?**

   Yes → go to 8 | No → go to LUC suite 6 (page 85)

8. Is the land on a high plateau above 400 m a.s.l.?

   Yes → go to 12 | No → go to 10

9. Are slopes A, B or C?

   Yes → VIc1 | No → go to 13

10. Are the slopes B, or B and C and soils moderately to strongly leached?

    Yes → IIIe3 | No → go to 11

11. Are slopes B, or B and C and soils weakly podzolised to moderately podzolised?

    Yes → IVs4 | No → go to 12

12. Are slopes predominantly C or D?

    Yes → IVe7 | No → go to 13

13. **Are slopes D, E or F?**
Yes → go to 14 No → go to 23

14. Is land adjacent to the coast and receiving less than 600 mm of rain per year?
Yes → go to 15 No → go to 16

15. Does land have potential for scree and sheet erosion?
Yes → **VIe10** No → go to 16

16. Does land have potential for soil slip, sheet, and debris slide?
Yes → go to 17 No → go to LUC suite 6 (page 85)

17. Are slopes D or E?
Yes → **VIe9** No → go to 18

18. Are slopes E and F, or F?
Yes → go to 19 No → go to 23

19. Is land adjacent to the coast and receiving less than 1000 mm of rain per year?
Yes → go to 20) No → go to 21

20. Does land have potential for scree and sheet erosion?
Yes → **VIIe5** No → go to 21

21. Does land have potential for soil slip, sheet and debris slide?
Yes → go to 22 No → go to LUC suite 6 (page 85)

22. Are slopes E or F?
Yes → **VIIe6** No → go to 23

23. Are slopes greater than F?
Yes → go to LUC suite 6 No → go to LUC suite 6 (page 85)

## LUC Suite 6: Young basalt volcanic terrain

This suite comprises young (approximately Quarternary) basalt volcanic terrain with brown and red loam soils. Land use capability is assessed mainly on the basis of soil type, slope, erosion potential, stoniness and climate. The suite comprises 13 LUC units, ranging from class I to class VIII: Ic1, IIe1, IIs1, IIIe1, IIIs1, IIIs2, IVe2, IVs1, IVs2, Vs1, VIs1, VIe4, and VIIIs2; and together they cover approximately 70 512 ha (4.5%) of the Region (Figure 12). An idealised cross-section of LUC suite 6 is shown in Table 10.

### *Geomorphology and rock type*

Intermittent basaltic volcanic activity occurred in Northland during the Pliocene and Pleistocene, and during more recent times, in the Holocene.

A number of characteristic landforms have developed on this young basalt. These include lava terraces and plains, scoria cones, and lava domes. The topography is generally flat to gently rolling, with gently sloping surfaces bounded by short steep escarpments. Volcanic cones and domes with moderately steep (21–25°) to very steep (>35°) slopes occur intermittently throughout these flat to rolling surfaces. The more flat to rolling landforms were developed when lava flows moved down existing valleys and invaded the mouths of tributary streams, giving rise to the present series of stepped terrace forms and plains. This has resulted in some areas having an almost plateau-like appearance above the lower floodplains and alluvial terraces. The older Horeke basalts initially filled broad, relatively deep valleys on old sedimentary rocks and are now exposed in terraces up to 200 m a.s.l. The younger Taheke basalts continued to fill depressions such as valley floors, and sub-

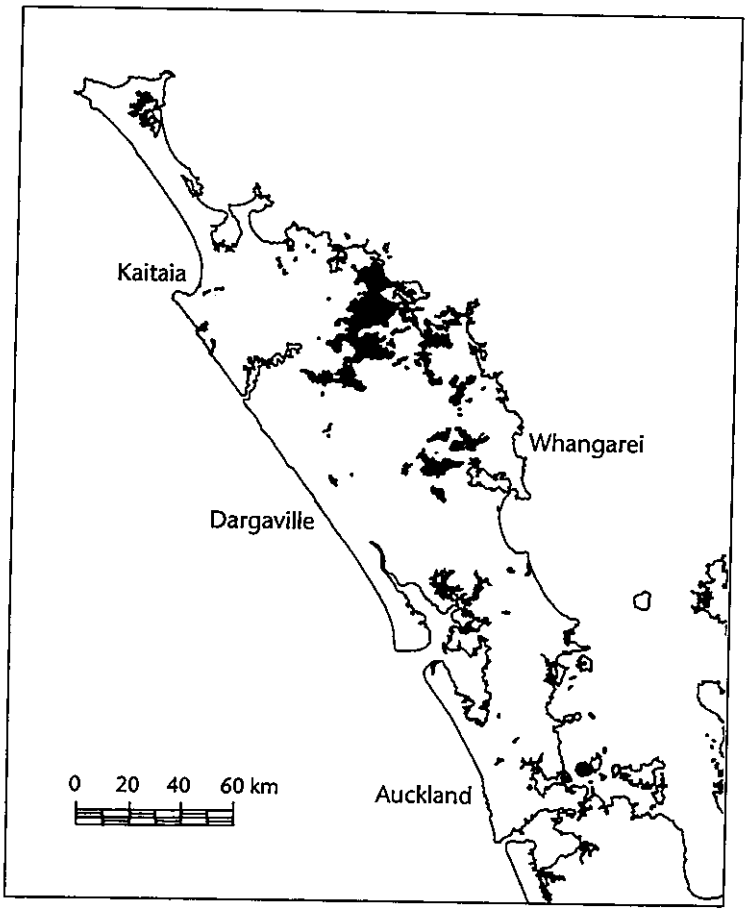
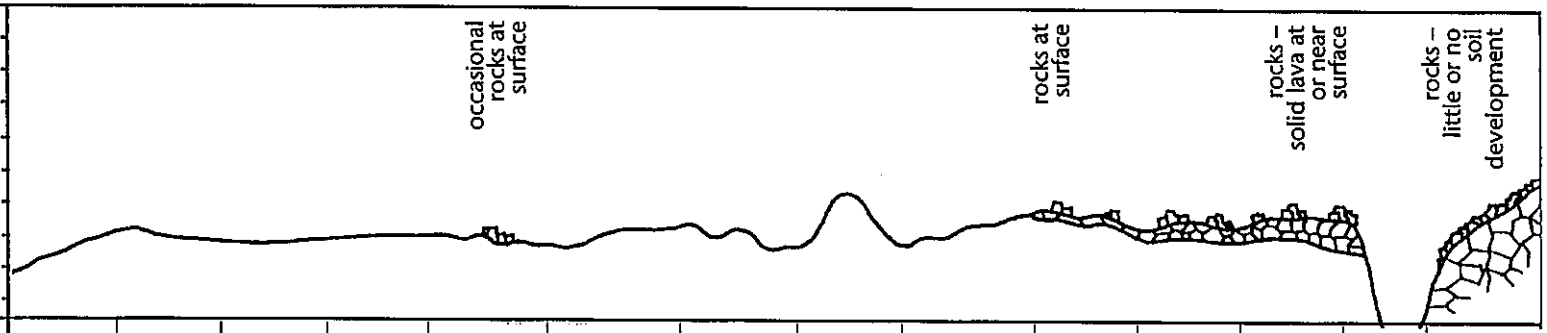



*Figure 12. Location of LUC suite 6. Young basalt volcanic terrain.*

*Table 10. Idealised cross-section showing relationship between LUC units within LUC Suite 6, on young basalt volcanic terrain.*




| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Typical dominant slope(s) (degrees) | 4–15 | 0–7 | 0–7 | 0–7 | 0–7 | 0–7 | 8–20 | 16–25 | 0–7 | 0–15 | 0–15 | 0–25 | | 4–25 |
| NZLRI slope group | B+C, C+D | A+B, B | A, A+B | A, A+B | A, B | A, B | C, C+D | D, D+E E, (F) | A, A+B, B | A, B, C | A-C | A-E | | B-E |
| Typical altitudinal range (m a.s.l.) | 0–400 | 0–200 | 0–200 | 0–200 | 0–200 | 0–200 | 0–400 | 0–400 | 0–400 | 0–400 | 0–400 | 0–400 | | 0–280 |
| Typical rainfall range (mm) | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | 1200–1600 | | 1000–1200 |
| Present erosion (NZLRI codes) *see Appendix 14* | 0-1 Sh | 0 | 0 | 0 | 0 | 0 | 0-2 Sh. 0-1 Ss, G, R, W | 0-1 Ss, Sh, 1 G | 0-1 Sh, G | 0-1 Sh | 0 | 0-1 Sh, G | | 0-1 Sh, G |
| Potential erosion (NZLRI codes) | 1 Sh, R, G. 2 R, G | 0-1 W, Sh. 1 R | 0-1 Sh, R | 0-1 W Sh | 1 W, Sh, R | 1 Sh, R | 1-2 Sh, Ss, R, W. 2-3 Sh, R, G | 1-2 Ss, Sh. 1 G | 1-2 R, Sh | 2 Sh, 1 W, T, R, Sh, W | 1-2 Sh | 1 Sh G | | 1-2 Sh, G, W |
| Soils *(generalised)* | B + R loams | R + B loams | R + B loams | R + B loams | B + R loams | B + R loams | B + R loams | R + B loams | B + R loams | B + R loams | B + R loams | B + R loams | | Recent |
| Lithology (NZLRI codes) | Vo, Sc | Vo, Sc | Vo, Sc | Vo, Sc | Vo, Sc | Vo, Sc | Vo, Sc | Sc, Vo | Vo, Sc | Vo, Sc | Vo, Sc | Vo, Sc | | Sc, Vo |
| Other features | fertile | fertile | fertile | highly fertile | slight to mod. stony | mod. to strongly leached | rolling–mod. steep | steep | strongly leached | stony | stony | stony | | bare rock |
| LUC unit | IIIe1 | IIe1 | IIs1 | Ic1 | IIIs1 | IIIs2 | IVe2 | VIe4 | IVs2 | IVs1 | Vs1 | VIs1 | | VIIIs2 |

sequently formed both scoria cones and lava flows. This basaltic deposition caused ponding of upstream areas and the formation of extensive swamps. In many areas waterfalls have been created at the edge of basalt flows.

Quaternary-aged basalts are the main rock type recorded in this LUC suite. The most extensive area of basaltic volcanics is formed by the Horeke and the Taheke basalts, which outcrop in the Whangarei and Kerikeri districts. The Horeke basalts represent the older Pliocene to late Pleistocene volcanics comprising basalt flows without scoria cones. The Taheke basalts are younger, late Pleistocene to Holocene, and consist of scoria cones and lava flows. Older Pliocene-aged Ti Point basalts are less extensive and comprise olivine basalt forming flows, cones, dikes, and sills. These older Pliocene-aged basalts are recorded in central parts of the region with some outcrops recorded near the coast, northeast of Warkworth.

Younger basalts (e.g. Taheke) form scoria flows and cones consisting of very fine-grained to medium-grained crystalline basalt, with interbedded scoria, and are moderately fractured and hard to very hard. This younger basalt and/or scoria rock, although usually unconsolidated and unweathered, can be weathered to a soft brown clay to depths of 10 m in some areas. The older basalts, such as Horeke and Ti Point, form flows and cones of glassy and fine-grained to medium-grained crystalline basalt, which is usually hard and dense and moderately fractured. Depending on the age of the surface, the older basalt rock in some areas is occasionally weathered to a soft brown clay to depths of 20 m.

### *Climate*

This suite is characterised by warm humid summers and relatively mild winters with few frosts.

The prevailing wind is generally from the southwest or west, with northwesterlies becoming more prevalent in spring. Occasional tropical cyclones and intense rainstorms from the east or northeast may affect the region, particularly in summer and early autumn. In spring and winter the percentage of southwest winds is greatest but in summer and autumn the number of winds from an easterly quarter is, in many places, about equal to the number of southwest winds. Spring is the windiest season, while the greatest number of calm periods is in summer and autumn. Mean daily wind speed is between 11 km/h and 13 km/h. For the region as a whole wind gusts may reach 64 km/h or greater on 30 to 40 days of the year, while wind gusts of 96 km/h or more may occur on one or two days a year in any month from either an easterly or a westerly quarter.

Mean annual temperatures are typically between 13.5° and 15.5°C with a mean annual temperature range of 7.2°C to 8.3°C.

Rainfall is variable but shows a winter maximum and summer minimum, with droughts common during summer months. Many of the LUC units that are suitable for horticulture require irrigation during summer months. Rainfall variability is about 16% for the region, this being defined as the average of the differences of the annual totals from the long-period mean, expressed as a percentage of the mean. LUC units on the eastern side of the region are generally drier than those in the west, and in eastern coastal districts there are typically about 125 to 150 days a year which experience rain, whereas more inland and high-altitude areas experience about 150 to 200 days of rain.

The mean annual rainfall is generally between 1200 and 1600 mm. This may be slightly higher, up to 1800 mm, in more inland areas often at higher altitude.

### *Soils*

Red and brown loam soils have formed on basalt flows and ash, and basaltic scoria and ash under a warm humid climate and a predominantly mixed broadleaf–podocarp forest. The red loams are formed from scoriaceous basalt on the sides of volcanic cones and free-draining plains and terraces. Brown loams are formed from massive basalt lava, and while some have developed on the sides of cones, they are most extensive on the flat to rolling land on the lava flows. Soils recorded in this suite belong to two main soil suites (Cox et al. 1983): the Kiripaka suite which comprises brown loams, and the Papakauri suite which comprises red loams.

The Kiripaka suite soils have developed from basalt flows and ash over a long period, and range from weakly to strongly leached. Three

main stages are recognised and represented by the Kiripaka, Ruatangata, and the Okaihau soils. In the early stage (Kiripaka) the soils are weakly to moderately leached, containing 30% to 50% clay. The clays are mixtures of kaolin and gibbsite with small amounts of micas, vermiculite and amorphous oxides. Older soils such as the Ruatangata friable clay are moderately to strongly acidic, strongly leached of cations, and contain between 50% and 80% clay. The clays are dominantly kaolin and gibbsite. On the very old and stable undulating plains and plateaux the brown loams such as the Okaihau soils are moderately to strongly acidic, very strongly leached of cations and contain between 30% and 50% clay. Clays mainly comprise gibbsite with some kaolin, and nodules are often present. These nodules are mainly oxides of iron, aluminium and manganese.

The red loams are distinctly red in profile and are moderately acidic and weakly to moderately leached of cations. The Papakauri suite soils are developed from basaltic scoria and ash and range from weakly to strongly leached (Gibbs 1980).

### *Erosion*

Present erosion on these young basalt volcanics ranges from negligible to moderate. The potential for erosion increases on slopes above 16°, or when flat to rolling slopes are cultivated. Main forms of erosion are sheet, soil slip and gully, with sheet, rill and wind the main types when cultivated.

Slopes are relatively stable and revegetate quickly, and even on slopes above 21° revegetation is rapid because of the high natural fertility of the soils. Younger scoria cones tend to have soft friable soils which can be tracked badly if heavy cattle are stocked, and therefore adequate spelling and careful siting of fencelines and gates are required to avoid these problems. The flat to gently rolling slopes in the Kaikohe and Kerikeri areas and Whangarei–Maungatapere area are well suited to arable farming and horticulture. Careful planning is often required to control and prevent soil loss on steeper slopes under cultivation. Soil loss from sheet erosion and rilling can usually be reduced by planning contour cultivation, and diverting runoff to interception zones, and construction of grassed waterways.

### *Vegetation*

This suite is mainly covered by high-producing pasture and extensive areas of horticultural crops (kiwifruit, subtropicals, citrus) and vegetables. On the less fertile strongly leached or shallow soils a scrub cover of gorse and manuka often predominates or is scattered throughout pasture. Where soils are less well drained, such as on the poorly drained soils belonging to the Otaha series, rushes may be more prolific throughout pasture. Broadleaved forest and lowland podocarp–broadleaved forest is commonly recorded as either scattered or clumped vegetation in many areas, particularly on steeper slopes (>20°). Partly because of the high fertility of the soils, puriri is often the dominant tree species recorded on the red and brown loams.

### *Land use and land management*

The weakly to moderately leached red and brown loams are used mainly for horticulture, vegetable cropping and intensive pastoral grazing. The strongly leached red and brown loams are used mainly for intensive pastoral grazing and some forestry, such as exotic conifer forest. Often more infertile strongly leached volcanic soils or those which are stony or shallow are covered in improved and semi-improved pasture with rushes/sedges and scrub, or are in a state of reversion to scrub and gorse. By using fertilisers and trace-element supplements and good soil-conservation management practices the potential for erosion can be minimised. Because of the excellent physical properties and the free-draining nature of these soils, they are well suited to horticulture and cropping use. However, on the strongly and very strongly leached soils, cropping is restricted by the high requirement for nutrients and by the wide fluctuation in the soil moisture, which varies from deficient to excessive during the year. These limitations apply to a lesser degree under a pastoral farming regime which is the dominant present land use on these soils. Alternative uses include forestry, but this land use is often limited because of the wide variations in soil properties, the small areal extent of the red and brown loam soils and the complex spatial distribution of more infertile soils.

Brown loams and red loams have very good structural characteristics, but these can often be

quickly lost because of poor land husbandry. Over-cultivation of these soils when either too dry or too wet can cause their structure to deteriorate, resulting in a dusty soil with a low moisture-holding capacity. Suitable crop rotations with greencrops are needed to build up organic matter content and to spell the soil if productivity is to be maintained. Higher levels of organic matter help buffer the effects of dry summers by improving the soil's ability to store and maintain moisture levels from applied irrigation. Minimum cultivation techniques for crop establishment and strip cropping are also advised.

It is important, when subdividing this land for horticultural units, that due planning consideration is given to controlling runoff and disposing of surface water in uncultivated or grassed waterways, and also to the need to store water or to have access to water for irrigation of crops. It is also important to site boundaries for shelterbelt development.

## Decision pathway for recognising LUC units within young basalt volcanic terrain

1. **Is the land on basaltic volcanic rocks of Pliocene to Holocene age?**
   Yes → go to 2 | No → go to LUC suite 7 (page 98)

2. Are the soils brown or red loams of the Kiripaka or Papakauri suites respectively?
   Yes → go to 3 | No → go to LUC suite 7 (page 98)

3. **Are stones or rocky outcrops a dominant limitation for agricultural use?**
   Yes → go to 4 | No → go to 11

4. Are slopes A, B, or gentle C?
   Yes → go to 5 | No → go to 7

5. Are stones or rock outcrops scattered over 10% to 20% of the land area, but land is suited for arable use?
   Yes → **IIIs1** | No → go to 6

6. Are stones or rock outcrops scattered over 20% to 30% of the land area, but land is suited for arable use?
   Yes → **IVs1** | No → go to 7

7. Are slopes less than E?
   Yes → go to 8 | No → go to 28

8. Do stones or rock outcrops preclude arable use but productivity for pastoral farming remains high?
   Yes → **Vs1** | No → go to 9

9. Are stones or rock outcrops numerous, affecting 30% to 50% of land area and precluding arable use?

Yes → **VIs1** No → go to 10

10. Are physical limitations extreme for all types of agricultural use and land has little soil development and numerous rocky outcrops?

Yes → **VIIIs2** No → go to 11

11. **Are the soils weakly to moderately leached?**

Yes → go to 12 No → go to 23

12. Is the land on A or B slopes with slight soils limitation and less than 5% stones in the top 20 cm?

Yes → **IIs1** No → go to 13

13. Does the land have physical limitations for agricultural use other than stoniness and rock outcrops?

Yes → go to 14 No → go to 25

14. Does the land have a potential for erosion under cultivation?

Yes → go to 15 No → go to 21

15. Are slopes C and D, or D, and soils weakly to strongly leached?

Yes → go to 16 No → go to 17

16. Is there a potential for extreme sheet erosion under cultivation?

Yes → **IVe2** No → go to 17

17. Are slopes B and C, or C, and soils weakly to strongly leached?

Yes → go to 18 No → go to 19

18. Is there a potential for moderate sheet erosion under cultivation?

Yes → **IIIe1** No → go to 19

19. Are slopes A and B, or B, and soils weakly to moderately leached?

Yes → go to 20 No → go to 23

20. Is there a potential for slight sheet erosion under cultivation?

Yes → **IIe1** No → go to 21

21. Is the land on A or A and B slopes with no physical limitation to arable use within the Northland environment?

Yes → **Ic1** No → go to 22

22. Is the basalt rock relatively old and deeply weathered?

Yes → go to 23 No → go to 24

23. Are soils strongly to very strongly leached?

Yes → go to 23 No → go to 25

24. Are slopes A or B or gentle C?

Yes → go to 25 No → go to 28

25. Is there a dominant physical limitation to arable use because of soil properties?

Yes → go to 26 No → go to 28

26. Is the limitation moderate?

Yes → **IIIs2** No → go to 27

27. Is the limitation regarded as severe because of the strongly leached and deeply weathered nature of the soils?

Yes → **IVs2** No → go to 28

28. Are slopes greater than E?

Yes → **VIe4** No → go to 29

29. Are slopes predominantly D?

Yes → **VIe4** No → go to 30

30. Are slopes greater than F?

Yes → go to LUC suite 7 (page 98)

## LUC Suite 7: Old volcanic terrain

This suite covers an extensive area of mainly old, Miocene–Cretaceous, upland volcanics which are particularly conspicuous on the western side of the region from the Manukau Harbour in the south to North Cape in the far north. It consists of a combination of flat to gently rolling, deeply weathered landscapes, and steep landforms and bluffs on hard volcanic deposits. Brown granular clays and loams and associated steepland soils are the dominant soil group. Land use is largely indigenous forest (only limited areas of kauri forest remain) and pastoral farming. Pastoral farming is typically semi-extensive to extensive while more intensive grazing is confined to the flat to gently rolling slopes. The other dominant land use is exotic forestry.

The suite comprises 13 LUC units: IVe3, IVe11, IVs3, Vc2, VIe2, VIe11, VIe13, VIe16, VIe18, VIs2, VIc1, VIIe1, and VIIe7; and together they cover approximately 271 339 ha (17.1%) of the region (Figure 13). An idealised cross-section of LUC suite 7 is shown in Table 11. On the basis of more detailed geomorphic and management

criteria, units can be placed into the following subsuites:

7a. Landforms with brown granular loams and clays and related steepland soils on a range of old relatively stable basic-intermediate volcanic rock including dolerite, breccias and tuffs, andesitic agglomerate and breccias, andesite flows, and dolerite, and andesitic alluvium. (LUC units IVe3, IVs3, Vc2, VIe2, VIe16, VIc1, VIIe1.)

7b. Landforms on volcanic/sedimentary complexes (LUC units VIs2, VIe11, VIe13), for example, around the periphery of Tangihua massifs, or at the edge of volcanic/plutonic complexes.

7c. Landforms on acid to intermediate igneous volcanics and plutonics including dacites, rhyolites, granodiorites. Dominant soils are yellow-brown earths. (LUC units IVe11, VIe18, VIIe7.)

### *Geomorphology and rock type*

A number of distinctive 'older' Miocene–Cretaceous volcanic landform types are recognised in Northland, and volcanics of Tertiary and Cretaceous age have been placed together in this suite. They are generally greater than about 5 million years old, in contrast to the younger volcanics less than about 5 million years old described earlier in LUC suite 6. High to intermediate Pleistocene-aged alluvial terraces with strongly weathered soils are associated with these older volcanics and are included in this suite. Older volcanics include extensive areas of basic to intermediate volcanic rocks, such as dolerite, andesite and basalt, which principally have brown, granular loam and clay soils and related steepland soils. Smaller isolated areas of 'silica-rich' igneous rocks and plutonics, such as dacites, rhyolites, granodiorites, are separated out as a distinct subsuite.

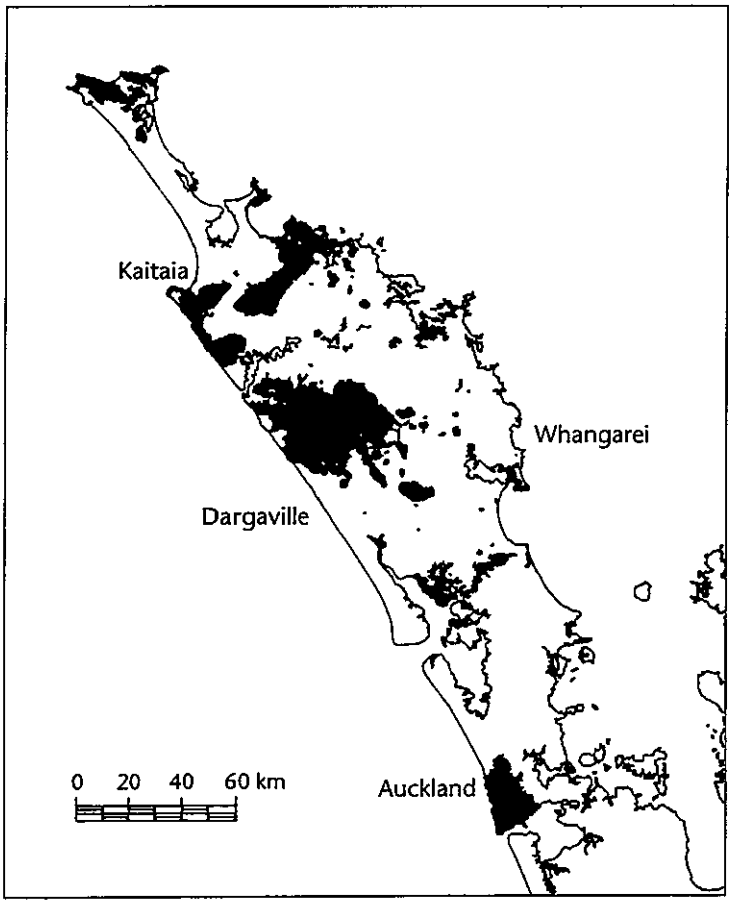
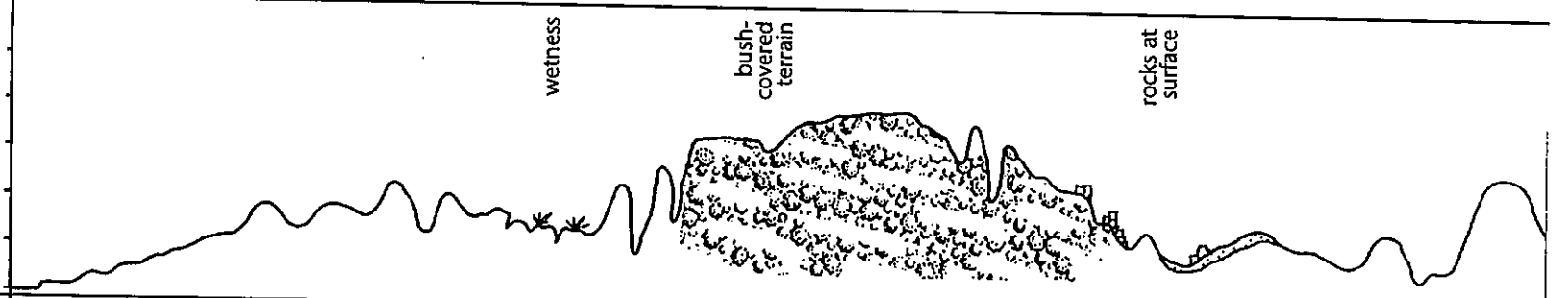



*Figure 13. Location of LUC suite 7. Old volcanic terrain.*

*Table 11. Idealised cross-section showing relationship between LUC units within LUC Suite 7, on old volcanic terrain.*




| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Typical dom. slope(s) (degrees) | 0–3 (A) 4–7 (B) 8–15 (C) | 8–15 (C) 16–20 (D) 4–7 (B) | 16–20 (D) 21–25 (E) | 21–25 (E) 26–35 (F) | 16–25 | 26–>35 | 0–3 (A) 4–7 (B) 8–15 (C) | 8–15 (C) 16–20 (D) | 26–>35 | 16–25 | 4–15 | 8–20 | 16–25 | 21–>35 |
| NZLRI slope group | A+B, B+A, B+C, C+B | C, C+D, C+B | D, D+C, D+E | E, E+F, F+E, (F) | D, E | F, F+G | A, B, A+B, B, B+C, C+B | C, C+D | F, F+G | D, E | B, B+C, C | C, C+D | D, E, D+E | E+F, F, F+G |
| Typical altitud. range (m a.s.l.) | <~600 | <~600 | 0–~800 | 0–~800 | 0–~600 | 0–~600 | >~500 >~600 | >~600 | 0–~800 | 0–~400 | 0–~600 | 0–300 | 0–400 | 0–400 |
| Typical rainfall range (mm) | ~1400–<~1800 | ~1400–<~1800 | 1200–>~2000 | ~1400–>~2000 | 1200–>~2000 | ~1400–>~2000 | 1600–>~2000 | 1800–>~2000 | ~1400–>~2000 | ~1400–~1800 | ~1400–>~2000 | 1000–1600 | 1000–1800 | 1000–1800 |
| Present erosion (NZLRI codes) *see App.14* | 0-1 Sh, G | 0-1 Ss, Sh, W, R, G, Ef | 0-2 Ss, Sh, G, Es | 1-3 Sh, Ss. 1-2 G, Es, Da | 1-2 Ef, Ss, Es, G. 0-1 Sh | 1-3 Sh, Ss, Es, G, Da | 0-1 Sh, T | 0-1 Sh, G, T | 1-3 Sh, Ss, Es, G, Da | 0-1 Sh, Ss, G, Es | 0-1 Sh, G | 1-2 Sh, W, G, R | 1-2 Sh, Ss, G | 1-4 Sh. 1-3 R, G. 0-3 W, Ss |
| Potent. erosion (NZLRI codes) | 1 G, 1 R, Sh | 1-2 Ss, Sh, W, R, G, Ef. 2-3 Sh, R, G | 2 Ss, Sh, G, Es. 1 Ef | 2-3 Sh, Ss, Es. 2 G, Da | 2-3 Ef, Es. 2 G, Ss, Sh | 3 Ss, Da. 2 G, Sh, Es | 1 Sh, R, G, T | 1–2 G, T. 1 Sh | 3 Ss, Da. 2 G, Sh, Es | 2 Sh, Ss, G. 1 Es | 1 Sh, G | 1-3 Sh, G, R, W. 2-3 Sh, R, G. 0-1 Ss | 2-3 Sh, Ss, G | 2-4 Sh, R. 2-3 G, Ss. 1-3 W |
| Soils *(generalised)* | B-G loams and clays | B-G loams and clays | B-G loams and clays +steepland soils | B-G loams and clays +steepland soils | B-G loams and clays + stpl + Y-B earth | B-G loams & clays + stpl | B-G loams and clays | B-G loams and clays | B-G loams and clays | B-G loams and clays + Y-B earths | B-G loams and clays + Y-B earths | Y-B earths | Y-B earths | Y-B earths |
| Lithology (NZLRI codes) *see App.12* | Uf, wVo | Uf, wVo | wVo, In | wVo, In | wVo, In | wVo, In | wVo, In | wVo, In | wVo, In | wVo, In complex with sed. rocks | wVo, In complex with sed. rocks | wVo (acid) | wVo (acid) | wVo (acid) |
| LUC unit | IVs3 | IVe3 | VIe2 | VIe16 | VIe11 | VIIe1 | Vc2 | VIc1 | VIIe1 | VIe13 | VIs2 | IVe11 | VIe18 | VIIe7 |

Landforms on volcanic/igneous masses, *in situ* volcanic/plutonic rock, and volcanic alluvium, range from flat terrace surfaces and undulating downlands to steep to very steep, rugged land including mountain ranges and volcanic cones. At the sides of floodplains, intermediate to high terraces on volcanic alluvium of mainly Pleistocene age are recorded near or adjacent to these old volcanic terrains. Soils, such as Pakotai clay, on these relatively high terraces have similar physical and chemical characteristics to many of the soil types recorded on the old volcanic deposits of dolerite–andesite–basalt rocks.

The physiography is dominated by the central highlands of the Tangihua volcanics which form rugged, mountainous terrain rising to between 700 and 800 m a.s.l. Much of this land on the Tangihuas is covered in dense podocarp–broadleaved forest. The streams have steep headwaters with waterfalls and gorges, the interfluves are generally sharp, indicating that erosion has reached only an early stage in maturity. Landforms and rocktypes are discussed for the three subsuites defined within this LUC suite.

*Old stable basalt–andesite volcanics*

This type of land is recorded extensively throughout the region and contains large areas of mountainous terrain. The most extensive areas recorded are those of the Tangihua volcanics (Hay 1960), the Whangakea volcanics (Kear and Hay 1961), the Waipoua andesites and basalts (Kear and Hay 1961), the Waitakere Group volcanics (Hayward 1976), and the Wairakau andesites (Kear and Hay 1961). In the central and northern parts, the Tangihua volcanics form prominent mountain ranges often referred to as the Tangihua massifs. A number of detached ranges and hills encircle these steep, igneous masses.

This subsuite also includes relatively high alluvial terraces of Pleistocene age with sediments derived from mainly doleritic and andesitic rocks.

Landforms within the subsuite range from flat to undulating land on terraces in low-lying areas and downlands, to very steep, rugged, mountainous terrain in upland areas. Slopes range from flattened tops to steep terrain, often moderately to finely dissected by streams and rivers which have become entrenched forming gorges and precipitous slopes.

A typical generalised cross-section (Table 11) through these volcanic terrains progresses in the following order: dissected alluvial terraces; rolling (8–15°) to strongly rolling (16–20°) downlands; strongly rolling to moderately steep (21–25°) hills; moderately steep to steep (26–35°) hills; moderately steep to very steep (>35°) mountain ranges with areas of high almost vertical bluffs and gorges. Often at the top of these upland mountainous areas are flat to strongly rolling slopes, forming plateau-like topography.

Steep, prominent uplands on old resistant volcanic rock often form a striking contrast to the surrounding land formed on old sedimentary rocks, which are generally low-angle and subdued. For example, the Tangihua volcanics, being highly resistant, have not been worn down to the same degree as the adjacent sedimentary rock, even though they are of similar age. As the sedimentary landforms were denuded at a faster rate than the more resistant volcanics, their relief became more subdued and the old volcanic Tangihua massifs became more prominent. This is also true to some extent for the younger Miocene-aged Waitakere Group volcanics which form the Waitakere Ranges.

The Tangihua and Whangakea volcanics (Hay 1960; Ballance and Williams 1982) have originated from submarine or sea-floor volcanics, such as volcanic seamounts, oceanic crust, and mid-ocean ridge basalts, and in the NZLRI are referred to as 'ancient volcanics' (In). Minor areas of ultramafics (Um) are also recorded. These old volcanics are commonly referred to as volcanic piles or massifs, particularly in the central and western parts of the region from Maungaturoto north. They are of probable Cretaceous age (120–65 million years BP) and are closely related to the sedimentary deposits of the Northland Allochthon, both in age and by their probable allochthonous mode of deposition, and appear to have been displaced from their original site of deposition further to the north. It is likely that these igenous/volcanic masses moved from their original site of deposition during the Miocene (30–15 million years BP).

Tangihua volcanic masses mainly comprise basaltic pillow lavas and flows, basalt and dolerite breccias, dolerite dikes, gabbros, ultramafic rock

and minor tuffs. They generally weather to soft clay with moderately soft fragments to depths of 20 m. Volcanic deposits may often be mixed with sedimentary rock types, such as blocks of sandstone.

The western and eastern sides of Northland became volcanically active during the Miocene, 27 million to 10 million years ago, producing voluminous deposits of lava, breccia and conglomerate on the western side of the region. These Miocene volcanic rocks have been referred to as island arc volcanic/plutonic complexes (Spörli 1989) and include the Waitakere Group volcanics (Hayward 1976), the Waipoua basalts and andesites (Hayward 1975; Wright 1980) and the Wairakau andesites (Kear and Hay 1961). These rocks are recorded as lavas (Vo), indurated volcanic breccias (Vb), and indurated fine-grained pyroclastics (Tb) in the NZLRI. The western volcanic chain extended from the present Waitakere Ranges and hills in the southwest of the region to the Waipoua–Hokianga district in the north. The eastern volcanic chain extended from the Coromandel region to Whangarei and north to Whangaroa and North Cape. The Miocene-aged volcanics in general produced volcanic breccia and conglomerate sheets, in contrast to the volcanic massifs or piles of the Tangihua and Whangakea volcanics.

These Miocene-aged volcanics principally comprise basalts, andesites, rhyolites and dacites and their intrusive equivalents. Dacites and rhyolites, mainly from the eastern volcanic chain, form characteristic landforms (Bowen 1974) which have been separated out from this LUC subsuite and placed in LUC subsuite 7c.

The Waitakere Group volcanics (Hayward 1976, 1979) on the western side of the region are dominated by andesitic lavas, breccias, andesitic agglomerate, pillow lavas and dikes. Part of this western volcanic chain, the Waipoua basalts, consist of plateaux-forming basalt–andesite lavas. They are hard massive flows of very fine dense crystalline basalt, thickly interbedded with tuff, scoria and minor breccia in places. Often moderately fractured with curved jointing, they weather to soft reddish-brown clay to depths of 30 m. Typical landforms include dissected, high (over ~400 m a.s.l.) upland plateaux (plateaux with extensive flat to rolling surfaces, and minor rolling to strongly rolling slopes) bounded by steep escarpments and bluffs, and hilly terrain. They are mainly represented by the Tutamoe plateau, formed of basaltic and andesitic flows or sheets. The basalt sheet appears to be around 100–200 m thick. This elevated (~200 to ~700 m a.s.l.), mainly flat to strongly rolling land surface is bounded by relatively long steep slopes forming an almost continuous escarpment around the edge of the basalts. The plateau surface is covered mainly in dense indigenous forest, along with extensive swamps which have formed under conditions of high rainfall (more than ~1800 mm per year).

The escarpment around the edge of the plateau originated with the sapping back of the edge of the extensive basalt sheet, and subsequent undercutting of the underlying softer, older, sedimentary rocks (mainly sandstones and argillites) which were preserved under the lava extrusion. This was probably most extensive in the west, owing to the westerly dip of the sediments, and may have been accelerated by wave attack on underlying sediments. Slumping of the basalt is a conspicuous feature in the Kaihu and Waimamaku valleys, north of Dargaville, near Waipoua. Earthslip, debris slide and debris flow are common features on steep slopes at the edge of the deeply weathered plateau basalts under saturated conditions.

The Wairakau andesites (Kear and Hay 1961) are mainly andesitic breccia. Typical landforms include resistant necks, plugs and domes.

*Volcanic/sedimentary complexes*

This type of land is mainly formed on shattered, old, volcanic rock (e.g. Tangihua volcanics) or a complex association of volcanic (e.g. basic to intermediate volcanic rocks or acid igneous rocks) and sedimentary rock such as sandstone, mudstone or argillite in which volcanics usually make up the greatest proportion of the complex. These complexes are often deeply weathered. They are recorded in the NZLRI as mixtures or associations of rock types, for example, ancient volcanics (In) and sheared mixed sedimentary lithologies (Mx), or lavas (Vo) and sandstone (Sm) with minor argillite (Ar), or indurated volcanic breccias (Vb) and mudstone (Mb) with minor limestone (Li). Younger volcanics (e.g. volcanics such as basalts less than ~5 million years BP) may also be included in this group

where they are complexed with older sedimentary rocks (usually Cretaceous–Tertiary-aged rocks). Ancient volcanics (In), by definition, comprise a number of volcanic and sedimentary lithologies, with sandstone often being a major component.

This subsuite represents those areas where the volcanics, because of their greater proportion in complexes, usually dictate the geomorphic expression of the land but where the sedimentary rocks because of their composition and weaker nature impart a certain structural influence over the landform expression (i.e. residual strength, and erosion characteristics). This close association between the volcanics and sedimentary lithologies may be where the volcanics are relatively thin and overlie the sedimentary rock, where the volcanics intrude into the sedimentary rock, or where volcanics are mixed with, or interdigitate with, the sedimentary deposits.

This type of land is often found at the edge of, or on the periphery of, steep volcanic hills and mountainous terrain, such as the Tangihua massifs, or where volcanic rock has intruded into and displaced old sedimentary rocks, for example the Miocene volcanics north of Maungaturoto just east of the Kaipara Harbour. Many of the landforms at the edge of steep volcanic masses are often more unstable than those in the main, thickest part of the volcanic masses where the land is usually more stable and more resistant in nature and appearance. The more unstable areas characteristically show a more irregular hummocky slope profile, and earthflow, gully erosion and large seepage areas are often recorded.

On other types of land in this subsuite large areas of scattered volcanic detritus such as boulders and stones, often recorded as VIs2, are usually indicative of some type of volcanic intrusion or emplacement of volcanics into or adjacent to the sedimentary rock. The stablity of land covered in volcanic debris may vary from site to site. Therefore land is differentiated as more 'stable' (LUC unit VIe13 and VIs2) or 'relatively unstable' (LUC unit VIe11). The more 'stable' areas are usually mapped around or near volcanics of Miocene age, such as Waitakere Group volcanics and Wairakau andesites, but can include Tertiary-aged plutonic rocks such as granodiorite. The latter, more 'unstable' types of land, usually occur around or near Cretaceous to Eocene volcanics, for example Tangihua volcanics.

Weakly to moderately podzolised yellow-brown earth soils on rhyolites and dacites on flat to rolling slopes near the edge of sedimentary terrain, represent a very small area in LUC suite 7 and are therefore included in this subsuite (i.e. LUC unit VIs2 ). Where podzols are recorded as dominant on rolling to steep slopes on dacites and rhyolites, and where the land is regarded as having a dominant erosion limitation, the podzols are placed with podzols in the sedimentary units (see sedimentary rocks).

*Acid to intermediate igneous volcanics and plutonics*

The land in this subsuite is mainly formed on 'acid' igneous rocks and plutonic rocks (e.g. dacite, rhyolite, granodiorite) and typically forms conspicuous volcanic domes and volcanic masses on dacite or rhyolite. These rocks are recorded as lavas (Vo) and plutonics (Gn) in the NZLRI, and are often recorded as deeply weathered. Dominant soils are yellow-brown earth and related steepland soils (see below). The subsuite is of limited area but is recorded on a number of characteristic and often very prominent volcanic landforms, such as steep volcanic domes on Parahaki dacite, which occur intermittently throughout the eastern side of the region from approximately Wellsford in the south to Karikari Peninsula and Mt Camel in the north.

## Climate

This suite has warm, humid summers and relatively mild winters, giving an almost subtropical climate. The prevailing wind is generally from the southwest and west. Occasional tropical cyclones and intense rainstorms from the east or northeast may also occur during the year, particularly in summer and early autumn. Droughts may be particularly common during summer months, particularly north of Kaitaia and in the Karikari and Mangonui areas, and strong winds are common in all exposed coastal areas. In spring and winter the percentage of southwest winds is greatest but in summer and autumn the number of winds from an easterly quarter is, in many places, about equal to the number of southwest winds. Spring is the windiest season, while the greatest number of calm periods occur in summer and autumn.

The mean daily wind speed is between 11 and 13 km/h. Wind gusts may reach 64 km/h or greater on 30 to 40 days of the year, while wind gusts of 96 km/h may occur on one or two days a year in any month from either an easterly or a westerly quarter (Lisle and Kerr 1964).

Mean annual temperatures are typically between 13.5° and 15.5°C and the mean annual temperature range is generally between 7.2° and 8.3°C. This temperature range may vary considerably and may be higher in inland valleys.

The average sunshine hours a year range from 1700 hours on the western flanks of the Tutamoe range to 2000 hours in most other areas. This is approximately 50% of the possible total sunshine hours per year.

Topography and airflow are two major factors affecting the overall rainfall pattern. The eastern side of the region is generally drier than the western side. Low-altitude areas on the coast are typically drier than higher-altitude inland areas, and eastern coastal districts have on average about 125 to 150 days a year which experience rain, whereas other areas generally experience 150 to 200 days of rain a year, the highest being in the western uplands.

Rainfall is extremely variable but shows a winter maximum and summer minimum. The average rainfall variability is 16%, being defined as the average of the differences of the annual totals from the long-period mean, expressed as a percentage of the mean. In general, mean annual rainfall is between 1400 and 2000 mm, with around 1200 mm rainfall averages near the coast, and up to 3000 mm in inland high-altitude areas above 600 m a.s.l. However, in many inland areas, above 400 m a.s.l., such as the hilly and mountainous area between Kaitaia and Dargaville, rainfalls are commonly between 1800 and 2500 mm. Thunderstorms may affect the region at any time of the year, particularly in winter months. They are more common in the central uplands, which experience on average 15 to 20 per year, the most frequent being on the Tutamoe range. Land requires approximately 25 to 30 mm of rain a month to maintain pastures in midwinter, and about 100 to 120 mm in January. If, during dry periods, soil moisture is used up to the equivalent of 75 mm of rainfall, the growth of the pasture starts to show serious signs of retardation. North of Hokianga Harbour such dry conditions occur in about half of the growing seasons. For the rest of the region dry conditions occur in approximately one-third of the growing season (Lisle and Kerr 1964).

### *Soils*

Soils on 'old' volcanic rocks are discussed for the three main defined subsuites:

- Soils are generally brown granular loams and clays and related steepland soils which have formed on basic to intermediate igneous rocks and typically belong to the Te Kie, Huia, Katui, and Kohumaru soil suites (Cox et al. 1983). These soils are recorded on LUC units IVe3, IVs3, Vc2, VIe2, VIe16, VIc1, and VIIe1.

- Soils are usually brown granular loams and clays complexed with or associated with yellow-brown earths or brown or red loams complexed with or associated with yellow-brown earths. This type of complex association of soils is more often recorded on LUC units VIs2, VIe11, and VIe13. For example, brown granular clays and loams and yellow-brown earths often form complex associations or soil complexes on a range of volcanic and sedimentary rock types around the periphery of Tangihua massifs (Tangihua volcanics). The volcanic soils are usually spatially dominant in the association or complex. Brown granular clays and loams are from the Te Kie, Huia, Katui, and Kohumaru soil suites while the yellow-brown earths are typically from the Waiotira, Omanaia, Omu, Purua, and Maungarei soil suites (Cox et al. 1983).

Brown or red loam/yellow-brown earth soil complexes or complex associations are less frequently recorded, and this type of variable soil pattern is only recorded within isolated inventory map units.

Small areas of podzolised yellow-brown earths and podzols from the Maungarei suite are also recorded in this subsuite on flat to rolling slopes, mainly on dacites and rhyolites, and are classified as unit VIs2. This unit is often recorded at or near the edge of volcanic deposits where volcanic/plutonic complexes form a relatively thin layer over sedimentary rocks, or are of minimal area.

- Soils are generally yellow-brown earths and related steepland soils. Soils are typically of the Maungarei soil suite (Cox et al. 1983). These soils

are recorded on LUC units IVe11, VIe18, and VIIe7.

### *Erosion*

Erosion is discussed for the three defined subsuites:

*Landforms on old stable basalt–andesite volcanics with brown granular loams and clays*

The main erosion types recorded in this subsuite are soil slip, earthslip, debris avalanche, sheet, wind, and minor gully. Slump and earthflow may also occur in some areas.

Soil slip and earthslip are mainly recorded on slopes above ~18° and debris avalanche above ~25°. Soil slip and earthslip are common on deeply weathered volcanic terrains, and erosion processes usually include an instantaneous slipping phase which removes large quantities of soil, forming the slip scar (for example, if it is assumed that the average size of a slip was about100 $m^2$ with an average depth of about 30–50 cm, this equates to an average of about 30–50 $m^3$ of soil lost per slip site on Tangihua volcanics), and a subsequent soil flow or earth slip/debris flow phase which forms the debris tail. Slip and avalanche erosion forms can be locally severe to very severe, especially where land is damaged by localised high-intensity rainstorms, such as debris avalanches on forest covered slopes steeper than about 25° around Parengarenga Harbour and in the Puketi forest. However, regeneration of the vegetative cover tends to be quite rapid on these old volcanic terrains, particularly where annual rainfall is between about 1600 mm and greater than 2000 mm, as in the Waipoua–Hokianga district, but soils remain shallow. Relatively deep earthslip and slumping often occurs on the Waimatenui soils.

The most damaging erosion type on steep to very steep terrain is debris avalanche, largely recorded on steep to very steep slopes with an indigenous forest or mixed indigenous scrub cover. Debris avalanches are rapid flows or slides which scour a narrow track through vegetation, removing the regolith. As water becomes incorporated, they may be divided into three phases – a debris fall, a debris slide and a debris flow. The speed of movement and weight of debris normally ensures that a debris avalanche continues until it reaches the base of the slope, where the debris enters a stream and often chokes the channel. The scar is often eroded further by sheet, rill, wind and gully erosion (Eyles 1985), which inhibits revegetation on these sites. Numerous tracts of old and new scars, resulting from debris avalanches, are evident in localised areas throughout hilly and mountainous terrain on these old volcanics.

Sheet and wind erosion are frequently recorded on brown granular clays and loams and related steepland soils. They are obvious forms of accelerated erosion in areas where indigenous forest has been replaced by pasture or scrub, and it is common to find about 20–30% of the hillslope area in bare ground in some coastal locations such as North Cape or Mangonui. Areas of bare ground attributed to sheet and wind are significantly higher during summer months when soils have dried out and soil moisture is at a minimum, and they increase in percentage area/hillslope in drier, coastal environments. The granular and crumb structure of the brown granular soils makes them very susceptible to both sheet and wind erosion. Wind erosion is generally assessed as moderate (~11–20% of map unit) to severe (~21–40% of map unit) in areas exposed to strong coastal winds, such as hills with slopes mainly above about 10° in the North Cape–Waitiki area, and other areas adjacent to Mangonui Harbour.

Severe sheet erosion (~21–40% bare ground) is only recorded in the most exposed areas and is typically the result of soils or regolith drying out and not revegetating because of reactivation of surface erosion processes and/or heavy or continuous grazing on some slopes. These sites often show a considerable loss of topsoil (scar sites typically have average areas of about 25 $m^2$, and depths of about 20 cm, equating to a total soil loss of about 5 $m^3$ per scar site). Once the subsoil is exposed to erosion it often remains bare, being denuded further by both wind and water erosion (Cathcart 1978).

Gully erosion is recorded in a number of areas and is more common on slopes steeper than about 20°. It is often associated with sheet and wind erosion, which makes it difficult to control. Gully erosion includes "plunge-pool type" gullying.

The older (more strongly weathered) soils

from volcanic materials are more prone to erosion than the younger, less weathered soils recorded on similar rock types. These old volcanic soils have extremely friable topsoils, overlying crumbly but often dense subsoils. If the topsoil is lost and subsoil exposed, revegetation becomes extremely difficult. Subsoils tend to be nutrient-deficient, and dry out markedly in summer. The balance of nutrients in the subsoil is not generally conducive to plant growth. Scars are easily identified by distinct red to chocolate brown subsoils against the darker deeply weathered surrounding slopes. The Rangiuru soils (e.g. in the Te Paki area) and the Mangonui soils (e.g. in the Mangonui area) have been subjected to localised severe sheet and wind erosion which exposes their red subsoils. Revegetation of bare-ground areas on these soils, particularly the dry subsoil, will continue to be a major problem in this suite.

Because this subsuite mainly comprises relatively stable and resistant terrains, most erosion types are assessed as having an erosion severity of slight to moderate, even on slopes above about 21°. However, this assessment largely reflects the high proportion (more than about 40%) of forest or scrub cover within the subsuite. Large areas (more than about 50%) have slopes in excess of about 21°, forming hilly and mountainous terrain, and (particularly under pasture) were highly susceptible to soil slip, earthslip, and sheet. On terrains with an indigenous forest cover, mass-movement erosion is largely the result of high-intensity rainstorms in combination with other factors such as slope.

Sediment generated from these areas has the potential to become a major pollutant in watercourses in Northland. Brown granular clays and loams and related steepland soils tend to have a high clay content and therefore a potential for a high colloidal or suspended sediment concentration in water. The initiation of erosion and subsequent generation of sediment into streams and rivers can therefore lead to considerable discoloration of waterways. The location and distribution of these soils in the headwaters of river and stream catchments is an important consideration with any sustainable land use/management planning.

On these old volcanic soils it is important to retain a complete and permanent vegetative cover such as dense forest or well maintained, well fertilised pasture. When indigenous vegetation is removed from land within this subsuite it significantly alters the ecological balance which exists under the forest cover. Without that balance, the potential for severe to very severe sheet and wind erosion and severe mass movement is high, particularly on moderately steep to very steep slopes.

*Landforms on volcanic/sedimentary complexes*
The main erosion types recorded are earthflow, gully, earthslip and sheet.

Shattered and sheared volcanic material and colluvium (including a high proportion of breccia) often occur at the base or periphery of steep, skeletal volcanic masses on Tangihua, Wairakau and occasional Waitakere Group volcanics. Deeper forms of mass movement can be expected in the deeply weathered complex geologies around the peripheries of these masses, especially where old shattered volcanic rocks are found. Many areas, depending on volcanic composition and structure, have similar erosion potentials and erosion types to those described in subsuite 7a.

This type of land is particularly prone to gully erosion with secondary slump, and earthflow erosion. Erosion becomes more active when slopes are undercut.

*Acid to intermediate igneous volcanics and plutonics*
The main erosion types recorded are sheet, wind, gully, soil slip and earthslip. Sheet and wind erosion can be a significant problem in some areas, particularly with deforestation or scrub clearance, such as on Karikari Peninsula. The potential for mass movement can be very high on deeply weathered deposits like Parahaki dacite.

## Vegetation

This suite is mainly covered in indigenous forest and scrub, together with improved and semi-improved pasture. Many areas on footslopes and downlands comprise pasture and scattered rushes. Rushes throughout pasture are particularly common on unit VIe11, where the land has formed on shattered and often complex volcanic and sedimentary lithologies.

Exotic conifer forest (mainly *Pinus radiata*) is

also extensive on brown granular clay and loam soils and related steepland soils, and on some of the yellow-brown earths-steepland soils and podozolised soils on the dacites and rhyolites.

A significant proportion of the suite, particularly slopes above 20°, is covered in indigenous forest, predominantly lowland podocarp–hardwood forest, kauri forest, broadleaved forest, and podocarps such as totara and kahikatea. Much of the land could be considered for catchment protection, principally because of its steepness, its position in relation to major catchments, and its extensive indigenous forest cover. Many areas are at present under scrub or reverting to scrub, such as manuka, kanuka, indigenous scrub with tree fern, or exotic scrub such as tobacco weed.

### *Land use and land management*

Historically, between 1840 and 1950 land use practices on this suite have included extensive logging of both kauri and native softwoods (podocarps,) with conversion of forest to pasture occurring mainly during the last 100 years. Present land use includes undeveloped land (where indigenous forest remains) extensive to semi-extensive grazing of sheep and cattle on hill and steep land areas, more intensive farming on gentler slopes, and widespread exotic conifer forest. The milling of native forest has reduced appreciably in the last 60 years because of the reduced supply of available indigenous forest. Most of the remaining native forest is cutover. In the last 10–20 years there has been a marked increase in the area of pasture planted in *Pinus radiata* for production forestry and in areas of pasture reverting to scrub (manuka, mixed indigenous scrub). Many of the pastoral areas being planted in exotic forest had been previously affected to varying degrees by localised rainstorms which caused considerable mass movement on steeper slopes.

Scrub reversion, because of the humid, subtropical climate, is rapid and can be a major problem for maintaining pasture. Burning is a common way of controlling scrub regrowth but the method requires strict controls.

Noxious animals such as possums and goats pose a serious threat to the health of indigenous forests, and to the soil mantle underneath them. Possums have proliferated in the past 20 years, and while there have been repeated attempts to control numbers, populations remain very high in areas such as the Waipoua forest, Puketi forest, and Bay of Islands. Goat farming was popular in the late 1970s and early 1980s but lost popularity because of the economic recession in the later 1980s. Many of these animals escaped from poorly enclosed paddocks, and feral goats could increasingly become a problem in reserves and parks, particularly in the Waipoua, Puketi and Bay of Islands areas. Fitch farming has also declined in popularity in the last 10 years, and controls on the numbers of these animals must also be imposed. Possums, goats, ferrets, and stoats pose a serious threat to flora and fauna, and in time any damage to the vegetation cover may have an adverse effect on slope stability.

Pasture includes mainly clover and ryegrass. The brown granular loams and clays on the older volcanics, although reasonably fertile, are amongst the most difficult soils to farm. They are prone to drying out in summer and commonly have strongly leached granular topsoils. Bare-ground areas can be very difficult to revegetate, particularly once the dense red-brown clay subsoils are exposed. Maintenance of a complete and permanent vegetative cover is essential to prevent the initiation of sheet and wind erosion and consequent enlargement of bare-ground areas (often caused by poor vegetative cover and overstocking of cattle and sheep). Stock tracking along fencelines and ridges can be avoided by careful siting of fences, gates, troughs and access roads and by using mob stocking rather than set stocking. Where red-brown subsoils are exposed, revegetation requires heavy liming, both to raise pH and to help balance nutrient levels offset by high levels of iron and aluminium in the subsoil. Initial heavy dressings of phosphate and appropriate trace elements are needed, with subsequent regular maintenance dressings to avoid loss of phosphate by iron and aluminium fixation.

Many areas, particularly at the foot of steep slopes and on volcanic/sedimentary complexes, require drainage and tree planting. To establish and maintain high-producing pastures, improved management in these areas should be encouraged and combined with strategic planting of erosion control trees such as poplars and natives. Many

gully and sheet erosion problems are initiated by repeated tracking and compaction by livestock, which can lead to pugging in natural drainage depressions.

Steeper land components in this suite, particularly at the head of major catchments, should be increasingly considered for catchment protection and retirement. Much of this land is at present covered in indigenous forest, and protection of environmentally sensitive areas is essential for countering the effects of degrading water quality in critical headwaters and downstream zones. Selective logging of indigenous forest still occurs on a limited scale in many areas, such as Whangaroa and Whangarei.

On steeper land, particularly where there is a moderate to very severe potential for erosion or where there is a serious weed problem, forestry may be a more sustainable and economic land use. The high costs in maintaining the steeper class VI and VII land in pasture are often greater than the actual return, making it more profitable to re-establish in trees. In the last 10–15 years, large areas of pasture have been planted in mainly *Pinus radiata* for production forestry. Exotic forest crops require initial topdressing for successful establishment and production. The largest areas of exotic forestry include the Mangakahia–Waipoua area and between Mangonui to Mangamuka. Steepland areas, such as those with Te Kie steepland soils, have shallow topsoils that are prone to sheet and slip erosion under pastoral use but which represent excellent soils for forestry. Logging operations, both exotic and indigenous, should be designed in such a way as to minimise erosion hazard.

Forestry operations, if not properly planned, can initiate erosion through hillside disturbance and modification (from machinery, tracks, thinning, burning slash, hauling, debris landings) resulting in increased runoff and sediment generation from catchments, enlargement of bare-ground areas, and increased bedload and suspended sediment in streams and discoloration of water. This inevitably leads to a decrease in water quality and has an impact on downstream ecological habitats. Increased runoff from deforested areas, such as from log landing areas or roads, is often associated with high levels of suspended and bedload sediment, and can result in higher flood peaks in many catchments, for example in the Mangakahia catchments (Water Resources, DSIR and Northland Regional Council, pers. comm.). Because of the proximity to the coast of many exotic and native forests, future logging activities should be carefully planned and monitored so that impacts on coastal environments are minimised. Increasing sedimentation from any type of land disturbance could create major problems such as pollution of littoral or inshore areas.

Any form of earthworks on these old volcanics should include adequate battering of slopes, return of topsoil, adequate topdressing with lime and fertiliser and sowing or planting, and continued maintenance of suitable ground-cover species. Particular attention should be made to dispose of water from culverts and runoff at the top of embankments, to maintain watertable levels, to protect drainage depressions, and to ensure frequent and adequate culverting of tracks and roads. Caution should be exercised when doing any form of excavation, particularly when constructing drains or similar earthworks on potentially erodable soils and in upper valleys of catchments; where feasible, wide parabolic, trapezoidal, or V-shaped drains should be constructed in preference to steep-sided channels. V-shaped drains should be revegetated and pair-planted with willows to prevent further degradation (Cathcart 1978).

Areas of shattered rock, breccia, and colluvial material at the foot of steep Tangihua massifs, Waitakere volcanic complexes and Wairakau andesitic volcanics are naturally prone to gully erosion, with secondary slump and earthflow erosion. Other erosion problems on this type of terrain, as in LUC unit VIe11, can be caused by unwise earthworks, such as the construction of drains on steep grades, or by excessive earthworks undercutting potentially unstable slopes, such as the removal of the toe of the slope by roadworks or quarries. Other potential problems may be caused by the construction of farm dams and roads with insufficient regard for overflows, spillways, and culvert outlets (Cathcart 1983).

## Decision pathway for recognising LUC units within old volcanic terrain

1. **Are soils developed on old basalt and andesite volcanics such as the Tangihua volcanics, Manakau breccia, and Waipoua flood basalts?**
   Yes → go to 2 No → go to 12

2. Are soils brown granular loams and clays?
   Yes → go to 3 No → go to 12

3. Are soils of the Te Kie, Huia, Katui, or Kohumaru suites?
   Yes → go to 4 No → go to 12

4. Are slopes C or D?
   Yes → **IVe3** No → go to 5

5. Are slopes D or E?
   Yes → **VIe2** No → go to 6

6. Are the slopes E or F?
   Yes → **VIe16** No → go to 7

7. Are slopes F or F and E?
   Yes → **VIIe1** No → go to 8

8. Are slopes greater than F?
   Yes → go to suite 8 (page 104)

9. Are slopes B or C?
   Yes → go to 10 No → go to 12

10. Are soils moderately to strongly leached and of the Kohumaru suite?
    Yes → **IIIe1** No → go to 11

11. Are the soils moderately leached to strongly podzolised?
    Yes → **IVs3** No → go to 12

12. **Are soils developed on dacitic or rhyolitic volcanics or plutonics such as granodiorite?**
    Yes → go to 13 No → go to 22

13. Are soils yellow-brown earths?
    Yes → go to 14 No → go to 22

14. Are the soils of the Maungarei suite?
    Yes → go to 15 No → go to 22

15. Are the slopes C or C and D?

Yes → **IVe11** No → go to 16

16. Are the slopes D or D and E?

Yes → **VIe18** No → go to 17

17. Are the slopes greater than E but less than G?

Yes → **VIIe7** No → go to 18

18. Are slopes above G?

Yes → go to suite 8 (page 104) No → go to 19

19. Are the slopes A or A and B?

Yes → go to 20 No → go to 22

20. Is arable use precluded because of the nature of the soils, such as podzolisation?

Yes → **VIs5** No → go to 21

21. Are there severe limitations to arable use because of the nature of the soils, such as podzolisation?

Yes → **IVs4** No → go to 22

22. **Are rocks a complex of volcanic and sedimentary rock?**

Yes → go to 23 No → go to LUC suite 8 (page 104)

23. Are soils a complex of brown granular clays and loams and yellow-brown earths?

Yes → go to 27 No → go to 24

24. Are soils a complex of red loams and yellow-brown earths?

Yes → go to 27 No → go to 25

25. Are soils a complex of brown loams and yellow-brown earths?

Yes → go to 27 No → go to 26

26. Are soils brown granular clays and loams from more than one soil suite?

Yes → go to 27 No → go to suite 8 (page 104)

27. Are slopes D or greater than D and showing potential for earthflow and gully?

Yes → **VIe11** No → go to 28

28. Are slopes a very broken C and occasional D and showing potential for earthflow and gully?

Yes → **VIe11** No → go to 29

29. Are slopes C or C and D where steepness or erosion hazard does not preclude arable use?

Yes → **IVe6** No → go to 30

30. Are slopes dominantly B, C, or D but stoniness and rock outcrops preclude arable use?

Yes → **VIs2** No → go to 31

31. Are slopes D, or E, or F, relatively stable, but steepness precludes arable use?

Yes → **VIe13** No → go to LUC suite 8 (page 104)

## LUC Suite 8: Cliffs and precipitous slopes

This suite includes very steep slopes in mountainous areas, and precipitous slopes adjacent to the coast. The suite comprises three LUC units, VIIIe2, VIIIe3, and VIIIs1, which together cover 14 129 ha (0.9%) of the region (Figure 14). An idealised cross-section of LUC suite 8 is shown in Table 12. The units are differentiated on the basis of slope, soil depth, the amount of rock exposed (bare ground), erosion type, potential erosion severity, and extent of vegetative cover.

In terms of management, the dominant physical limitation on this suite is slope. Precipitous slopes are recorded as steep to very steep slope groups in the NZLRI. Rock type and soil are considered secondary factors.

### *Geomorphology and rock type*

Units in this suite form the steepest parts of land both near the coast and in inland areas where landforms are typically mountainous or precipitous. The main landforms are bluffs, cliffs, escarpments at the sides of terraces and gullies, and escarpments around the edge of plateaux.

An intricacy of harbours, bays and headlands or promontaries have formed along a rocky coastline separated by sandy beaches. Many of these areas represent drowned valleys. Mudflats, tidal estuaries, lagoons and peat swamps are often formed at the base of these steep terrains in low-energy environments where fine-grained alluvium and peat have infilled low-lying areas. Coastal cliffs are common along the extensive coastline bordering the region, and form prominent features on all hard or indurated lithologies such as interbedded Waitemata Group sandstones and mudstones, Waipapa Group greywacke, Wairakau andesites in the area of Whangaroa Harbour, indurated hard 'ancient volcanics' of the Tangihua and Whangakea volcanics, and very steep slopes on Waipoua basalt around Maunganui bluff. Indurated lithologies are also exposed in offshore islands, craggy heads and prominences, and sea stacks.

In inland areas, cliffs and bluffs are common features on deeply dissected rugged mountainous terrain, where streams have steep to very steep headwaters with many bluffs, gorges and waterfalls.

Very steep (precipitous) volcanic plugs, domes, dykes or stocks, have also been delineated where possible at the mapping scale of 1:50 000 in several areas, and include the Wairakau andesites near Whangaroa in the northeast and the Waitakere Group volcanics near Tokatoka on the western side of Northland.

Hard or indurated, resistant rock types principally recorded in this suite include volcanic

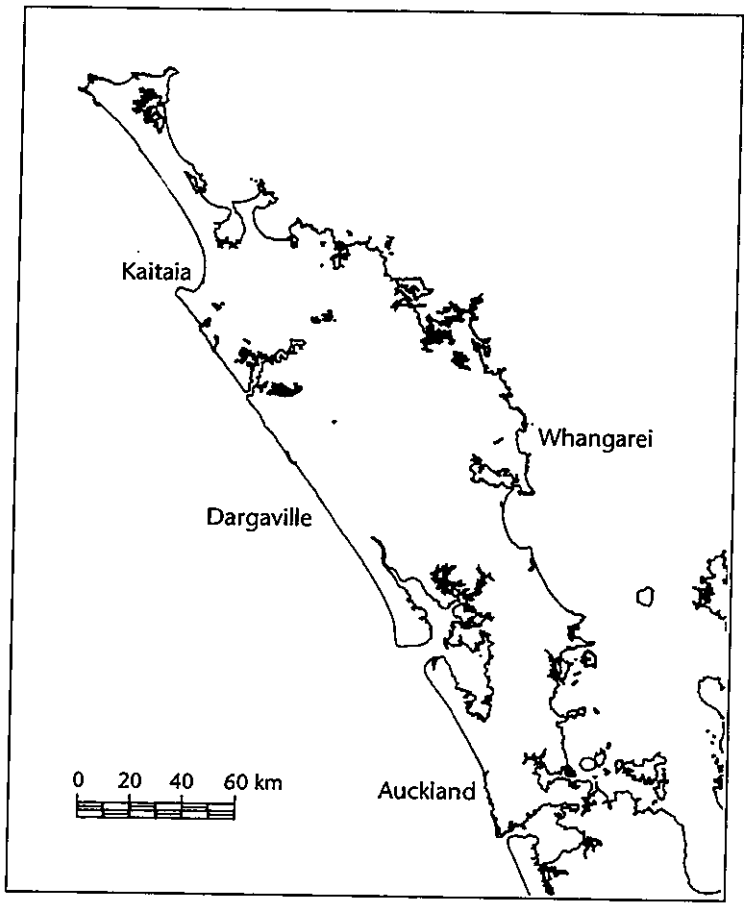



*Figure 14. Location of LUC suite 8. Cliffs and precipitous slopes.*

rock such as dolerite, andesite, basalt, rhyolite, and dacite, which are recorded in the NZLRI as Vo, Vb, Tb and In (see Appendix 11), and sedimentary rock types such as greywacke and interbedded sandstones and mudstones, recorded in the NZLRI as Gw and Sb or Mb respectively. Other hard lithologies, forming precipitous slopes such as escarpments, include sedimentary rocks such as limestone, and Quarternary- and Pliocene-aged volcanic rocks such as basalt.

## *Climate*

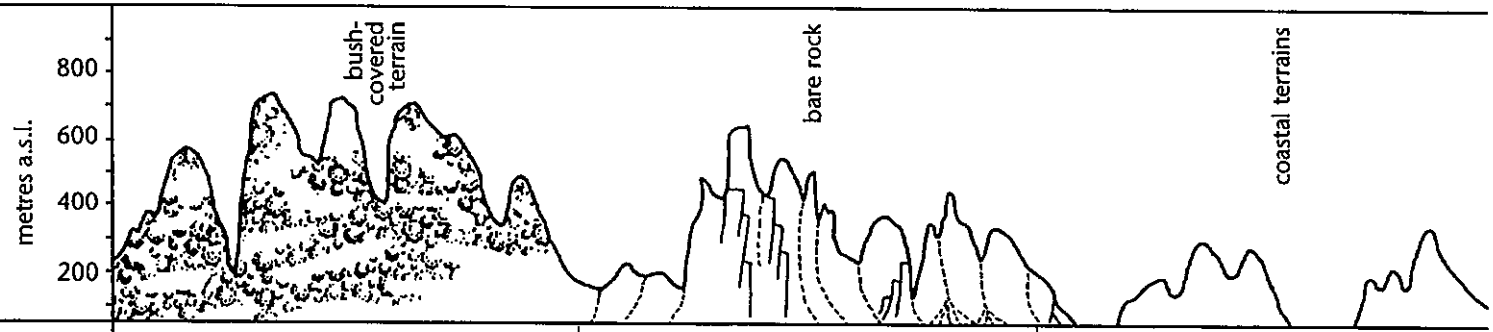
In general, the suite is characterised by warm humid summers and relatively mild winters. Dry conditions often prevail during summer months. The prevailing wind is mainly from the southwest and west. Occasional tropical cyclones and high-intensity rainstorms from the east or northeast may also occur during the year, particularly in summer and early autumn. In spring and autumn the percentage of southwest winds is greatest but in summer and autumn the number of winds from an easterly quarter is, in many places, about equal to the number of southwest winds.

Spring is the windiest season, while the greatest number of calm periods occur in summer and autumn. Mean daily wind speed is between 11 and 13 km/h. Wind gusts may reach 64 km/h or greater on 30 to 40 days of the year, while wind gusts of 96 km/h may occur on one or two days a year in any month from either an easterly or a westerly quarter (Lisle and Kerr 1964). In addition, units on the coast are exposed to salt-laden winds.

Mean annual temperatures are typically between 13.5° to 15.5°C and the mean annual temperature range is often between 7.2° and 8.3°C.

Topography and airflow are two major factors

*Table 12. Idealised cross-section showing relationship between LUC units within LUC Suite 8, on cliffs and precipitous slopes.*




| | | | |
|---|---|---|---|
| Typical dominant slope(s) (degrees) | >35 | >35 | >35 |
| NZLRI slope group | G | G | G |
| Typical altitudinal range (m a.s.l.) | 0–800 | 0–800 | 0–200 |
| Typical rainfall range (mm) | 1400–2000 | 1200–1800 | 1000–1400 |
| Present erosion (NZLRI codes) *see Appendix 14* | 0-2 Sh. 1-4 Ss, Da. 1-2 Da on In, Vo | 1-2 Sh, Sc. 0-1 Da, Ss | 1-4 Sh, Sc, Da, Ss |
| Potential erosion (NZLRI codes) | 2-5 Ss, Da. 2-4 Sh | 4 Sh, Sc. 1-2 Da, Ss | 3-5 Sh, Sc. 2-3 Da, Ss |
| Soils *(generalised)* | Steepland (shallow) | Bare rock – occasional steepland | Steepland (shallow) |
| Lithology (NZLRI codes) *see Appendix 12* | In, Gw, indurated rocks | In, Gw, Sb, Mb, Vo, Vb, Gn, Um | Gw, In, Sb, Mb, Vo, Vb, Gn, Um |
| LUC unit | VIIIe2 (inland) | VIIIs1 | VIIIe3 (coastal) |

affecting the overall rainfall pattern in Northland. The eastern side of the region is generally drier than the western side. Low-altitude areas on the coast are typically drier than higher-altitude inland areas. Eastern coast districts experience rain on average about 125 to 150 days a year, while other areas generally experience 150 to 200 days of rain a year, the western uplands experiencing the highest.

Rainfall is extremely variable but shows a winter maximum and a summer minimum. Variability in the region is on average 16%, this variability being defined as the average of the differences of the annual totals from the long period mean, expressed as a percentage of the mean.

The mean annual rainfall typically ranges from 1200 to 2500 mm. For coastal units on the eastern side of the region, rainfalls between 1000 and 1400 mm are common, and this could be as low as 800 mm in some sheltered areas. For coastal units exposed to prevailing winds from troughs and depressions on the western side of the region the mean annual rainfall is generally higher, commonly between 1200 and 1600 mm. Depending on altitude, inland units receive much higher rainfalls. Those above 400 m a.s.l. typically receive rainfalls between 1800 and 2500 mm, which becomes as high as 3000 mm in more rugged mountainous areas.

### *Soils*

Because of the steepness of the land, soils are typically shallow. Large areas of bare rock may also be recorded on precipitous slopes with little or no soil cover.

Where soil is present, a number of soil groups and subgroups are recorded on a range of lithologies on steep to very steep slopes. They include steepland and hill soils related to brown granular loams and clays, steepland and hill soils related to yellow-brown earths, and steepland and hill soils related to rendzinas and associated soils.

Also occasionally included on less steep slopes are hill soils related to the brown loams and red loams.

Soil suites (Cox et al. 1983) belonging to the brown granular loams and clays and related steepland soils include steepland soils of the Te Kie, Huia and Katui soils suites, particularly in western areas.

Soil suites (Cox et al. 1983) belonging to the yellow-brown earths and related steepland soils include steepland soils of the Puhoi, Marua and Maungarei soil suites are often recorded in central and eastern coastal districts. Occasionally associated with steepland and hill soils of the Marua soil suite are red loams of the Manganese and Maungakohatu soil suites. Soils of the Omanaia, Waiotira, Omu, Purua, and Omaiko soil suites may be recorded in small areas or in association with the yellow-brown earth soil suites mentioned above.

Other soil suites occasionally recorded are the rendzinas and associated soils of the Arapohue and the Konoti suites, and brown loams of the Kiripaka suite.

### *Erosion*

Present erosion is typically slight to moderate sheet, soil slip, and debris avalanche. Potential erosion on most land units is severe soil slip and debris avalanche and very severe sheet.

Coastal cliffs (often shallow soil or bare rock) with sparse vegetation cover generally have a potential for moderate to very severe sheet and soil slip–rock fall, debris fall and occasional debris avalanche. Factors contributing to erosion along the coast include very steep slopes, wave attack, strong winds and lack of vegetation. Erosion potential may be very severe to extreme in limited areas, particularly where coastal erosion such as bank or cliff retreat is evident.

In inland areas, many of the steepest slopes are covered in dense vegetation such as indigenous forest or scrub, which reduces the potential for erosion or erosion hazard.

### *Vegetation*

Much of the land, being steep to very steep, has a sparse vegetative cover, and many areas are recorded as being either unvegetated or partially vegetated. This is particularly the case on coastal cliffs, where vegetation is usually scattered or in discrete, 'clumped' areas, but seldom extensive. In inland areas vegetation may form a more dense and extensive cover or canopy.

The most dominant vegetation classes

recorded include coastal forest, coastal scrub, lowland podocarp–hardwood forest, broadleaved forest, kauri, scrub with tree ferns, manuka and kanuka.

### *Land use and land management*

Most of the land is undeveloped. It includes coastal cliffs on a range of hard or indurated sedimentary lithologies, such as interbedded sandstones and mudstones of the Waitemata Group, steep to very steep slopes on old volcanics, such as the Tangihua volcanics and Waitakere Group volcanics, and steep to very steep slopes on Waipapa Group greywacke. The suite is of limited area. Because of its unfavourable physical characteristics, precipitous slopes, shallow soil depth, low fertility, and harsh climate, it has been largely retired from use. Class VIII land on very steep slopes in inland areas is often borderline between class VIII and class VII. Class VIII land on the coast is more easily defined because of its limitations, with slopes above about 35°, and a potential for severe to very severe sheet and soil slip. Where there is adequate soil depth, or regolith depth, there is a potential for debris avalanche during high-intensity rainstorms in steep to very steep catchment areas, particularly within mountainous land on Tangihua volcanics. A vegetative cover on steep to very steep areas and coastal cliffs should be maintained, particularly on those slopes forming steep hilly land and mountainous land on old volcanics and on greywacke. A vegetative cover is essential for catchment protection, cliff protection, and to reduce sediment generation and deposition in downstream watercourses and in estuaries, harbours, and bays.

Various degrees of possum damage to the vegetative cover is evident throughout the region. Coastal forest and pohutakawa trees are particularly affected, and many inland areas covered in dense indigenous forest show signs of severe canopy damage.

## Decision pathway for recognising LUC units within cliffs and precipitous slopes

1. Are slopes greater than F?
   Yes → go to 2 No → go to LUC suite 1 (page 43)

2. Is the land adjacent to the coast?
   Yes → go to 3 No → go to 5

3. Does the land have some soil development?
   Yes → go to 4 No → go to 5

4. Does the land form coastal cliffs?
   Yes → **VIIIe3** No → go to 6

5. Does the land have bare rock recorded and forms bare rock cliffs?
   Yes → **VIIIs1** No → go to 6

6. Is the land very steep on any lithology?
   Yes **VIIIe2** No → go to LUC suite 1 (page 43)

# Land Use Capability unit descriptions

This section provides descriptions of each of the 91 LUC units that were mapped during the updating of the New Zealand Land Resources Inventory (NZLRI) 1985–90 in the Northland region of New Zealand. This region is defined by Auckland City, which marks the southermost boundary of the region, and extends northwards to North Cape where Cape Reinga and Surville Cliffs mark the northernmost part of the region (Figure 3).

The association and grouping of Land Use Capability (LUC) units within respective LUC suites and LUC subsuites is given at the top of each description page. Symbols in brackets, such as Vo, A+B, or Sh, denote the dominant NZLRI classification symbols written in the inventory code on the NZLRI worksheets/maps and entered onto the Geographic Information System (GIS) as attributes of each map unit.

See Appendix 9 and Appendices 11–15 for a full description of the physical attributes used in the NZLRI.

Where slopes are recorded, the *first slope given* is always *dominant*. For example, if slopes are A+B or C+D, A and C are the dominant slopes respectively. Where A, A+B is given, A slopes (0–3°) are dominant and A+B slopes together are considered secondary.

## LUC unit: Ic1 (435 ha)

**LUC suite:** 6. Young basalt volcanic terrain:
(LUC units Ic1, IIe1, IIs1, IIIe1, IIIs1, IIIs2, IVe2, IVs1, IVs2, Vs1, VIs1, VIe4, VIIIs2)

**Description:** Highly fertile free-draining friable red and brown loam soils on flat to gently undulating slopes on young basaltic scoria, basaltic lava flows and occasional ash. Land classified as Ic1 has only minimal limitations to use. This unit has negligible physical limitations, relatively deep soils, and high natural fertility. Climate is considered to be the main restricting factor for growing a wide range of crops.

**Type location:** PO5/895509 State Highway 1 near Ohaeawai

**Altitudinal range:** 0–200 m

**Slope:** Flat to gently undulating (A, A+B), 0–7°

**Landform:** Flat land on lava terraces and plains.

**Rock type:** Basaltic lavas (Vo). Basaltic scoria (Sc). Older ashes or tephras (Mo).

**Soils:** Red and brown loams on basaltic scoria and ash and basaltic flows and ash. Weakly to moderately leached red loams of the Papakauri suite (MU, WM). Weakly to moderately leached brown loams of the Kiripaka suite (KB, KBe, WG, WP) may be included where physical limitations are assessed as negligible.

**Erosion:** *Present:* Negligible (0)
*Potential:* Negligible (0) to slight (1) wind (W) and sheet (Sh) if repeatedly cultivated

**Vegetation:** Improved pasture (gl), subtropical fruit (cS), kiwifruit (cK).

**Annual rainfall range:** 1200–1600 mm

**Land use:**

| | | | |
|---|---|---|---|
| *Present:* | Grazing | – | Intensive grazing incl. beef breeding |
| | | – | Present average carrying capacity (s.u./ha) = 21 |
| | | – | Top farmer carrying capacity (s.u./ha) = 26 |
| | Cropping | – | Horticulture |
| *Potential:* | Cropping | – | Horticulture |
| | Grazing | – | Attainable physical potential carrying capacity (s.u./ha) = 30 |
| | Forestry | – | Production – site index for *Pinus radiata* = 34–37 |

**Soil conservation management:**
- Negligible erosion under pasture. Because of light friable nature of soils, overcultivation can have an adverse effect on soil structure and result in soil degradation. There is a potential for wind and sheet erosion when poorly managed.
- Seasonal irrigation may be required in some areas particularly under horticultural land use.
- Shelterbelts are recommended for pastoral and horticultural land use.
- When cultivating, contour cultivation practices are recommended.

**Comments:** Limited area, occasionally includes Class II land (e.g. Unit IIe1) which was not able to be differentiated at the 1:50 000 scale of mapping.

## LUC unit: IIe1 (2890 ha)

**LUC suite:** 6. Young basalt volcanic terrain:
(LUC units Ic1, IIe1, IIs1, IIIe1, IIIs1, IIIs2, IVe2, IVs1, IVs2, Vs1, VIs1, VIe4, VIIIs2)

**Description:** Fertile, free-draining red and brown loam soils developed on gently undulating to undulating slopes on young basaltic scoria, basaltic lava flows and occasional ash. Soils are generally deep. IIe1 is suited to a wide range of crops, but due to a slight increase in slope from that recorded in LUC units Ic1 and IIs1, a slight erosion limitation exists under cultivation.

**Type location:** Q07, pt R07/242064

**Altitudinal range:** 0–200 m

**Slope:** Flat to undulating (A+B, B), 0–7°

**Landform:** Flat to undulating land on lava terraces and plains which have developed from basaltic scoria, basalt flows and occasional ash. Also mapped on low-angle slopes near the base of low domes and cones.

**Rock type:** Basaltic lavas (Vo). Basaltic Scoria (Sc). Older ashes or tephras (Mo).

**Soils:** Red and brown loams on basaltic scoria, basalt flows and ash. Weakly to moderately leached red loams of the Papakauri suite (PK, PKe, MU, WM, AT). Weakly to moderately leached brown loams of the Kiripaka suite (KB, KBe, OW, WG, WP, WPe).

**Erosion:** *Present:* Negligible (0)
*Potential:* Negligible (0) to slight (1) wind (W) and sheet (Sh) if repeatedly cultivated
Slight (1) rill (R) if repeatedly cultivated

**Vegetation:** Improved pasture (gI), subtropical fruit (cS), kiwifruit (cK).

**Annual rainfall range:** 1200–1600 mm

**Land use:**

| | | | |
|---|---|---|---|
| *Present:* | Cropping | – | Horticulture |
| | Grazing | – | Intensive grazing – including dairying |
| | | – | Present average carrying capacity (s.u./ha) = 21 |
| | | – | Top farmer carrying capacity (s.u./ha) = 26 |
| *Potential:* | Cropping | – | Horticulture |
| | Grazing | – | Attainable physical potential carrying capacity (s.u./ha) = 30 |
| | Forestry | – | Production – site index for *Pinus radiata* = 34–37 |

**Soil conservation management:**
- Negligible erosion under well managed pasture. Would be subject to wind and sheet erosion if vegetative cover was sparse. Because of the light, friable nature of soils, overcultivation can have an adverse effect on soil structure and result in soil degradation. There is potential for sheet, wind and rill erosion under poor management.
- Seasonal irrigation may be required in some areas particularly under horticultural land use.
- Shelterbelts are recommended for pastoral and horticultural land use.
- When cultivating, contour cultivation is recommended.

**Comments:** Limited area. Differs from Ic1 in having sufficient slope to require specific management techniques to prevent sheet, wind and rill erosion when cultivated.
Occasionally includes Class I land (e.g. Ic1) and Class IIs (e.g. IIs1) which were not able to be differentiated at the 1:50 000 scale of mapping.

## LUC unit: IIe2 (7092 ha)

**LUC suite:** 3. Quaternary terraces with complex soils:
(LUC units IIe2, IIw3, IIs2, IIIe2, IIIs3)

**Description:** Undulating to gently rolling slopes on broad (well drained) terrace surfaces with a complex of soil types on Quaternary-aged alluvium. Includes extensive areas of water sorted tephra forming yellow-brown loams. Small areas of red hill sandy clay loam have also been incorporated into this unit because of similar physical potentials. This unit is highly suited to cropping but has slight physical limitations (i.e. erosion and soil) under intensive use. Much of this unit is mapped in the north Auckland district.

**Type location:** Q11/480900 Tawa Road, Kumeu

**Altitudinal range:** 0–100 m

**Slope:** Undulating (B, B+A), 0–70°

**Landform:** Flat to undulating land on broad terrace surfaces and plains at a range of heights.

**Rock type:** Unconsolidated clays and silts (Uf). Unconsolidated clays and silts associated with fine alluvium (Uf + Af). Unconsolidated clays and silts associated with peat (Uf + Pt).

**Soils:** Complex of soil types on mainly airfall and reworked rhyolitic volcanic ash and alluvium including: yellow-brown loams, brown granular loams, podzolised yellow-brown loams and podzolised yellow-brown earths mainly of Waitemata suite (OL, OLm, HV, WE, WEm, CV), Otonga suite (OG, OGd, OGv), and Whareora suite (AB). Soil complexes expressed as C1 and C1A. Small areas of moderately weathered, moderately to strongly leached sandy clay loams of Pinaki suite (RL1) also recorded.

**Erosion:** *Present:* Negligible (0)
*Potential:* Slight (1) sheet (Sh) and rill (R) when cultivated

**Vegetation:** Improved pasture (gl), vegetables and nurseries (cV), grapes and berryfruit (cG), subtropical fruit (cS), kiwifruit (cK).

**Annual rainfall range:** 1200–1500 mm

**Land use:** *Present:*
Cropping – Horticulture. Orcharding. Viticulture. Market gardening
Grazing incl. dairying – Present average carrying capacity (s.u./ha) = 17
– Top farmer carrying capacity (s.u./ha) = 20

*Potential:*
Cropping – Horticulture
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 24
Forestry – Production – site index for *Pinus radiata* = 30–33

**Soil conservation management:**
- When cultivating, contour cultivation and minimum tillage practices are recommended.
- Seasonal irrigation may be required in some areas, particularly under horticulture.
- Shelterbelts are recommended for pastoral and horticultural land use.

**Comments:** Includes limited areas of moderately weathered, moderately to strongly leached yellow-brown sandy clay loams on sand country units. These soils have similar potentials and limitations to those on Quaternary alluvium.

## LUC unit: IIw1 (7185 ha)

**LUC suite:** 2. Alluvial and estuarine plains and low terraces

**LUC subsuite:** 2a. Well drained floodplains and low terraces: (LUC units IIw1, IIIw1)

**Description:** Flat, floodplains and low alluvial terraces with fertile free-draining recent soils on volcanic and sedimentary alluvium. Has slight wetness limitation because of potential for occasional flooding or an occasionally high watertable. This limitation restricts the range of crops grown.
Higher terraces of Pleistocene and Holocene age may also be included where soils are moderately leached, where a dominant wetness limitation and secondary soils limitation restricts use.

**Type location:** 005/428695 Akahue Road

**Altitudinal range:** 0–100 m

**Slope:** Flat to undulating (A, A+B), 0–7°

**Landform:** Floodplains, low terraces.

**Rock type:** Fine alluvium (Af).

**Soils:** Recent soils on volcanic and sedimentary alluvium. Recent soils of Kohumaru suite (MF, MFm) and to a lesser extent of Whareora suite (WF, WFm). Moderately to strongly leached brown granular loams and clays of Kohumaru suite (KM, KMm) and moderately to strongly leached yellow-brown earths of Whareora suite (WO, WOa).

**Erosion:** *Present:* Negligible (0) to slight (1) streambank (Sb)
*Potential:* Slight (1) streambank (Sb) and deposition (D)

**Vegetation:** Improved pasture (gl), pip and stone fruit (cP), vegetables, nurseries (cV), manuka, kanuka (sM).

**Annual rainfall range:** 1200–1600 mm

**Land use:**

| | | | |
|---|---|---|---|
| *Present:* | Grazing | – | Intensive grazing including dairying |
| | | – | Present average carrying capacity (s.u./ha) = 21 |
| | | – | Top farmer carrying capacity (s.u./ha) = 26 |
| *Potential:* | Cropping | – | Horticulture, vegetables |
| | Grazing | – | Attainable physical potential carrying capacity (s.u./ha) = 30 |
| | Forestry | – | Production – site index for *Pinus radiata* = 26–29 |

**Soil conservation management:** Generally a low flood risk. To reduce flooding risk of floodplain and low terrace areas, suitable flood protection should be carefully planned, on long-term basis, and management considered over broader catchment area.
- Stopbanks may be required in some areas adjacent to this unit.
- Drainage may be required, particularly for more intensive pastoral, cropping, and horticultural subdivision. Maintain condition of drains.
- Shelterbelts are recommended in some areas.
- Maintain clearance of vegetation within stream and river channels.

**Comments:** Suited to a wide range of crops but has potential to be affected by occasional flooding, although this is generally of low risk.

## LUC unit: IIw2 (22054 ha)

**LUC suite:** 2. Alluvial and estuarine plains and low terraces

**LUC subsuite:** 2b. Alluvial and estuarine plains with gley soils:
(LUC units IIw2, IIIw2)

**Description:** Flat to gently undulating areas within alluvial plains, valley plains and low terraces, with fertile, gley, soils formed on estuarine and alluvial deposits. Unit represents those naturally 'wet' areas which have been systematically drained, resulting in land having a high potential for sustained arable and pastoral production. This unit is extensively mapped in the Ruawai–Dargaville area, on the flats near Kaitaia, and just south of Whangarei.

**Typical location:** P08/030650 Ruawai

**Altitudinal range:** 0–60 m

**Slope:** Flat to gently undulating (A), 0–3°

**Landform:** Floodplains, low terraces. Includes plains formed on estuarine and alluvial sediments.

**Rock type:** Fine alluvium (Af).

**Soils:** Gley soils on estuarine clays, sands and alluvium. Gley soils of the Kaipara suite (KP, KPy, KA, KAy, TZ, TZy) and Waipu suite (YUa, YUay, YU, YUy, YA).

**Erosion:** *Present:* Negligible (0)
*Potential:* Negligible (0) to slight (1) streambank (Sb) and deposition (D)

**Vegetation:** Improved pasture (gl), vegetables, nurseries (cV).

**Annual rainfall range:** 1200–1400 mm

**Land use:**

| | | | |
|---|---|---|---|
| *Present:* | Grazing | – | Intensive grazing incl. dairying |
| | | – | Present average carrying capacity (s.u./ha) = 21 |
| | | – | Top farmer carrying capacity (s.u./ha) = 26 |
| | Cropping | – | Vegetables. Root and green fodder cropping |
| *Potential:* | Cropping | – | Cereals. Root and green fodder crops. Horticulture. |
| | Grazing | – | Attainable physical potential carrying capacity (s.u./ha) = 30 |
| | Forestry | – | Production – site index for *Pinus radiata* = 25–28 |

**Soil conservation management:**
- Drainage required in some areas. Maintain condition of drains.
- Suitable flood protection should be considered on long-term basis. Stopbanks may be necessary in some areas.
- Shelterbelts recommended in some areas particularly under arable land use, cropping.
- Timing of cultivation, tillage, may be important consideration. Avoid cultivating saturated soils (e.g. near field capacity).

**Comments:** Usually mapped in association with IIIw2, which is usually less effectively drained, often associated with areas of peat, and occasionally receives runoff from rolling and hill-country areas.

## LUC unit: IIw3 (1926 ha)

**LUC suite:** 3. Quaternary terraces with complex soils: (LUC units IIe2, IIw3, IIs2, IIIe2, IIIs3)

**Description:** Flat to gently undulating areas within alluvial plains and low terraces on Quaternary-aged alluvium and peat. Includes water-sorted tephra in places. Soils dominantly organic or represent less well drained parts of C1 and C1A soil complexes. Includes organic soils which are of sufficient areal extent to be delineated at the 1:50 000 scale of mapping. Peaty soils on low terraces and alluvial plains with adequate drainage outfall included in this unit. Has only slight limitations to wetness and can be effectively drained.

**Altitudinal range:** 0–100 m

**Type location:** R10/512908 Kumeu area

**Slope:** Flat to gently undulating (A), 0–3°

**Landform:** Flat to undulating land on broad terrace surfaces and plains, at a range of heights. Principally where organic soils (peats) are mapped, or less well drained parts of C1 and C1A soil complexes. Floodplains, low terraces.

**Rock type:** Peat (Pt). Peat and fine alluvium (Pt + Af). Peat and unconsolidated clays and silts (Pt + Uf).

**Soils:** Organic soils on peat or peat and sand. Organic soils of Otonga suite included in C1 and C1A soil complexes (OG, OGd, OGv). Poorly drained areas of C1 and C1A soil complexes (e.g. natural depressions).

**Erosion:** *Present:* Negligible (0)
*Potential:* Negligible (0) to slight (1) streambank (Sb)

**Vegetation:** Improved pasture (gl), grapes and berry fruit (cG), vegetables, nurseries (cV), pip and stone fruit (cP).

**Annual rainfall range:** 1200–1500 mm

**Land use:**

*Present:*
- Cropping – Horticulture
- Cropping – Viticulture
- Grazing – Intensive
- Grazing – Present average carrying capacity (s.u./ha) = 17
- Grazing – Top farmer carrying capacity (s.u./ha) = 20

*Potential:*
- Cropping – Horticulture
- Grazing – Attainable physical potential carrying capacity (s.u./ha) = 24
- Forestry – Production – site index for *Pinus radiata* = 24–27

**Soil conservation management:**
- Drainage required in some areas. Maintain condition of drains.
- Shelterbelts recommended in some areas particularly under arable land use, e.g. cropping, or horticultural land use.
- Optimum water tables for specific land uses should be regulated and water allocation managed.

**Comments:** Important to maintain and monitor groundwater levels, particularly when under horticultural use.

## LUC unit: IIs1 (7575 ha)

**LUC suite:** 6. Young basalt volcanic terrain:
(LUC units Ic1, IIe1, IIs1, IIIe1, IIIs1, IIIs2, IVe2, IVs1, IVs2, Vs1, VIs1, VIe4, VIIIs2)

**Description:** Fertile, free-draining brown and red loams developed on flat to undulating slopes on young basaltic lava flows, basaltic scoria, and occasional ash. Mainly mapped in association with units Ic1, IIe1, IIIe1, IIIs1 and IIIs2. Soils are of lower fertility, have less favourable physical characteristics, and are often shallower, than those recorded in Unit Ic1. Is suited to wide range of crops but has slight soils limitation.

**Type location:** P05/960612 Kerikeri

**Altitudinal range:** 0–200 m

**Slope:** Flat to undulating (A, A+B), 0–7°

**Landform:** Flat to undulating land on basaltic lava terraces and plains. Also mapped on low-angle slopes near base of low domes and cones.

**Rock type:** Basaltic lavas (Vo). Basaltic scoria (Sc). Older ashes or tephras (Mo).

**Soils:** Brown and red loams on basalt flows, scoria and ash. Weakly to strongly leached brown loams of Kiripaka suite (KE, YO, RT, PG, WP, WPe, KB, OW) and weakly to strongly leached red loams of Papakauri suite (PKe, MUb).

**Erosion:** *Present:* Negligible (0)
*Potential:* Negligible (0) to slight (1) sheet (Sh) and rill (R) when cultivated

**Vegetation:** Improved pasture (gl), subtropical fruit (cS), kiwifruit (cK).

**Annual rainfall range:** 1200–1600 mm

**Land use:**

*Present:*
- Cropping – Horticulture, Viticulture
- Grazing – Intensive
  - Present average carrying capacity (s.u./ha) = 21
  - Top farmer carrying capacity (s.u./ha) = 26

*Potential:*
- Cropping – Horticulture
- Grazing – Intensive
  - Attainable physical potential carrying capacity (s.u./ha) = 30
- Forestry – Production – site index for *Pinus radiata* = 35–37

**Soil conservation management:**
- Negligible erosion under pasture. Would be exposed to wind and sheet erosion if vegetative cover was sparse. Because of light friable nature of soils, overcultivation can have adverse effect on soil structure and result in soil degradation.
- Seasonal irrigation may be required in some areas, particularly under horticultural land use.
- Shelterbelts recommended for pastoral, cropping, and horticultural land use.

**Comments:** Differs from Ic1 in that soils are slightly less fertile, often shallower, and generally have less favourable physical characteristics.

## LUC unit: IIs2 (3891 ha)

**LUC suite:** 3. Quaternary terraces with complex soils: (LUC units IIe2, IIw3, IIs2, IIIe2, IIIs3)

**Description:** Flat to undulating slopes on broad, well-drained Quaternary terrace surfaces on alluvium. Surficial deposits include extensive areas of water sorted tephra. Complex of soil types, including yellow-brown loams on reworked tephra, yellow-brown earths, brown granular loams, and organic soils, are recorded. Has slight soils limitation due to complex pattern of soils and highly variable soil properties.

**Type location:** Q10/465910 Huapai

**Altitudinal range:** 0–100 m

**Slope:** Flat to undulating (A, A+B), 0–7°

**Landform:** Flat to undulating land on broad terrace surfaces and plains at range of heights.

**Rock type:** Unconsolidated clays and silts (Uf). Unconsolidated clays and silts associated with fine alluvium (Uf+Af). Unconsolidated clays and silts associated with peat (Uf+Pt).

**Soils:** Complex of soil types on mainly airfall and reworked rhyolitic volcanic ash and alluvium including: yellow-brown loams, brown granular loams, podzolised yellow-brown loams, podzolised yellow-brown earths, and organic soils, of Waitemata Suite (OL, OLm, HV, WE, WEm, CV), Otonga suite (OG, OGd, OGv), and Whareora suite (AB). Soil complexes expressed as C1 and C1A.

**Erosion:** *Present:* Negligible (0)
*Potential:* Negligible (0) to slight (1) sheet (Sh) and rill (R) when cultivated

**Vegetation:** Improved pasture (gl), grapes and berryfruit (cG), pip and stonefruit (cP), vegetables, nurseries (cV), kiwifruit (cK).

**Annual rainfall range:** 1200–1500 mm

**Land use:** *Present:*
Cropping – Horticulture, Viticulture
Grazing – Intensive
– Present average carrying capacity (s.u./ha) = 17
– Top farmer carrying capacity (s.u./ha) = 20

*Potential:*
Cropping – Horticulture
Grazing – Intensive
– Attainable physical potential carrying capacity (s.u./ha) = 24
Forestry – Production – site index for *Pinus radiata* = 30–33

**Soil conservation management:**
- Contour cultivation and minimum tillage practices recommended when cultivating. Care needed to avoid structural degradation of soils with intensive, regular cultivation.
- Seasonal irrigation may be required in some areas particularly under horticultural land uses.
- Shelterbelts recommended for pastoral cropping, and horticultural land use.
- Water allocation should be investigated and regulated for specific land uses.

**Comments:** Because of spatial complexity of the soils recorded (i.e. high variability of physical and chemical properties) at the 1:50 000 scale of mapping, this land has been classified as Class II, but at more detailed scales of mapping (e.g. 1:10 000) elements of Class I, Class II, and Class III would be differentiated. For detailed assessment, mapping of soils at scales between 1:1000 and 1:10 000 is recommended.

## LUC unit: IIIe1 (5620 ha)

**LUC suite:** 6. Young volcanic basalt terrain:
(LUC units Ic1, IIe1, IIs1, IIIe1, IIIs1, IIIs2, IVe2, IVs1, IVs2, Vs1, VIs1, VIe4, VIIIs2)

**Description:** Undulating to rolling slopes on young basaltic lava flows, basaltic scoria and occasional ash with brown and red loam soils. Smaller areas of moderately leached brown granular loam and clay soils on volcanic alluvium may be included on undulating terrace surfaces, often proximal to old andesitic–basaltic volcanics (e.g. Tangihua volcanics) and mountainous terrain. Has moderate limitations for arable use, largely due to potential for slight to moderate sheet and rill erosion when cultivated, limitations related to soil characteristics and seasonal soil moisture deficit. When cultivated, erosion on these slopes regarded as dominant physical limitation.

**Type location:** P05/925540 Waimate North

**Altitudinal range:** 0–400 m

**Slope:** Undulating to rolling (B+C, C+B), 4–15°

**Landform:** Flat to gently rolling surfaces on basalt lava terraces, low domes, and plains. Also mapped on low-angle slopes near base of scoria cones.

**Rock type:** Basaltic lavas (Vo). Basaltic scoria (Sc). Older ashes or tephras (Mo).

**Soils:** Brown and red loams on basalt flows, scoria and ash. Weakly to strongly leached brown loams of Kiripaka suite (WG, WP, WPe, YO, MC, TG, KE, RT, PG). Moderately to strongly leached red loams of Papakauri suite (AT) may also be recorded. Less extensive areas of moderately leached brown granular loams and clays of Kohumaru suite (KM) are recorded.

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh)
*Potential:* Slight (1) sheet (Sh), rill (R), and gully (G). Moderate (2) sheet (Sh), wind (W), rill (R) and gully (G) when cultivated

**Vegetation:** Improved pasture (gI), subtropical fruit (cS), lowland podocarp–broadleaved forest (fO), manuka, kanuka (sM).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*
Cropping – Horticulture
Grazing – Intensive
– Present average carrying capacity (s.u./ha) = 21
– Top farmer carrying capacity (s.u./ha) = 26

*Potential:*
Cropping – Horticulture
Grazing – Intensive
– Attainable physical potential carrying capacity (s.u./ha) = 30
Forestry – Production – site index for *Pinus radiata* = 30–33

**Soil conservation management:**
- When cultivating, contour cultivation and minimum tillage practices are recommended.
- Control runoff using appropriate techniques such as grassed waterways and diversion banks.
- Shelterbelts are recommended for pastoral, cropping, and horticultural land use (shelterbelts are important for micro-climatic control).
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking).
- Seasonal irrigation may be required in some areas particularly under horticultural land uses.

**Comments:** Physical limitations include slight to moderate potential for erosion and seasonal soil moisture deficits. Irrigation can greatly increase versatility.

## LUC unit: IIIe2 (4743 ha)

**LUC suite:** 3. Quaternary terraces with complex soils: (LUC units IIe2, IIw3, IIs2, IIIe2, IIIs3)

**Description:** Gently rolling to rolling slopes on broad, well-drained, Quaternary terraces on alluvium. Surficial deposits include extensive areas of water sorted tephra. Complex of soil types, including yellow-brown earths, yellow-brown loams, podzolised yellow-brown earths, and brown granular loams are mapped. Moderate limitations for arable use.

**Type location:** Q11/471889 Tawa Road, Kumeu

**Altitudinal range:** 0–100 m

**Slope:** Rolling (C), 8–15°

**Landform:** Rolling land on broad terrace surfaces and plains at a range of heights.

**Rock type:** Unconsolidated clays and silts (Uf).

**Soils:** Complex of soil types on mainly airfall and reworked rhyolitic volcanic ash and alluvium, including: yellow-brown loams, brown granular loams, podzolised yellow-brown loams, podzolised yellow-brown earths, and organic soils of Waitemata suite (OL, OLm, HV, WE, WEm, CV), Otonga suite (OG, OGd, OGv), and Whareora suite (AB). Soil complexes expressed as C1 and C1A.

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh) and rill (R)
*Potential:* Slight (1) sheet (Sh), rill (R), gully (G). Slight (1) to moderate (2) sheet (Sh), rill (R) and gully (G) when cultivated

**Vegetation:** Improved pasture (gI), grapes and berryfruit (cG), subtropical fruit (cS), kiwifruit (cK), pip and stone fruit (cP).

**Annual rainfall range:** 1200–1500 mm

**Land use:** *Present:*
- Grazing – Intensive, incl. dairying
  - Present average carrying capacity (s.u./ha) = 17
  - Top farmer carrying capacity (s.u./ha) = 20
- Cropping – Root and green fodder cropping. Horticulture. Viticulture. Berryfruit.

*Potential:*
- Cropping – Root and green fodder cropping. Horticulture.
- Grazing – Intensive
  - Attainable physical potential carrying capacity (s.u./ha) = 24
- Forestry – Production – site index for *Pinus radiata* = 29–32

**Soil conservation management:**
- When cultivating, contour cultivation and minimum tillage practices are recommended.
- Avoid structural degradation of soils under intensive, regular cultivation.
- Control runoff using appropriate techniques such as grassed waterways and diversion banks.
- Shelterbelts recommended for pastoral, cropping and horticultural land uses. May be useful for micro-climate control, for reducing wind speeds and minimising wind erosion.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking).
- Seasonal irrigation may be required in some areas particularly under horticultural land use.

**Comments:** Soils are spatially complex. For detailed assessment, mapping of soils at scales between 1:1000 and 1:10 000 is recommended.

## LUC unit: IIIe3 (19 935 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke:

**LUC subsuite:** 4a. Interbedded and massive sandstone and mudstone: (LUC units IIIe3, IVe5, VIe1, VIe8, VIIe4)

**Description:** Gently rolling to rolling slopes on deeply weathered interbedded sandstones and mudstones with occasional massive sandstones and mudstones. Sandstones and mudstones sometimes partially veneered by reworked rhyolitic tephra and Quaternary-aged unconsolidated clays and silts. Soils are yellow-brown earths, and weakly podzolised yellow-brown earths. Moderate limitations for arable use. Moderate potential for sheet, rill and gully when cultivated.

**Type location:** Q09/450209 Warkworth, West Coast Road

**Altitudinal range:** 0–400 m

**Slope:** Undulating to rolling (B+C, C+B, C), 4–15°

**Landform:** Gently rolling, occasionally undulating surfaces on downlands, footslopes of hills, steeper components of undulating terrace surfaces, sides of terraces.

**Rock type:** Interbedded sandstones and mudstones (Sb, Mb). Massive sandstone (Sm). Massive mudstone (Mm).

**Soils:** Yellow-brown earths on stratified and massive sandstones and mudstones. Yellow-brown earths of the Puhoi suite (WA, AY, AYf, MU, OU), Waiotira suite (YC, YCr, YCe, RP, RPa, PV) and Omu suite (MAr, MA, AP).

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh) and rill (R).
*Potential:* Slight (1) sheet (Sh), rill (R), and gully (G). Moderate (2) rill (R), sheet (Sh), and gully (G) when cultivated

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), Gorse (sG), root and green fodder crops (cR), grapes and berryfruit (cG).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*
Grazing – Intensive incl. dairying
– Present average carrying capacity (s.u./ha) = 13
– Top farmer carrying capacity (s.u./ha) = 15
Cropping – Root and green fodder crops. Horticulture. Viticulture. Berryfruit.

*Potential:*
Cropping – Root and green fodder crops, limited horticulture, viticulture
Grazing – Intensive
– Attainable physical potential carrying capacity (s.u./ha) = 18
Forestry – Production – site index for *Pinus radiata* = 29–32

**Soil conservation management:**
- Contour cultivation and minimum tillage practices recommended when cultivating.
- Avoid structural degradation of soils under intensive, regular cultivation.
- Control runoff using appropriate techniques such as grassed waterways and diversion banks.
- Shelterbelts recommended for pastoral and horticultural land use. May be useful for micro-climate control, for reducing wind speed and wind erosion.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking).
- Seasonal irrigation may be required in some areas, particularly under horticultural land use.

## LUC unit: IIIe4 (4724 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4f. Limestone complexed with other sedimentary deposits: (LUC units IIIe4, IVe4, VIe5)

**Description:** Gently rolling slopes on shattered, sheared limestone complexed with deeply weathered sandstones, mudstones and/or Quaternary alluvium. Soils spatially complex within a subdued rolling landscape. Moderate limitations for arable use. Moderate potential for sheet and rill erosion, and slight wind erosion, when cultivated.

**Type location:** Q09/412453 Port Albert Road

**Altitudinal range:** 0–400 m

**Slope:** Undulating to rolling (B, B+C), 7–15°

**Landform:** Undulating to easy rolling downlands.

**Rock type:** Limestone (Li) complexed with range of sedimentary lithologies such as jointed mudstone (Mj), and/or sheared mixed lithologies (Mx), and/or massive sandstone (Sm), and/or argillite (Ar), expressed as Li+Mj, Li+Mx, Li+Sm, Li+Ar respectively.

**Soils:** Complex of rendzinas and yellow-brown earths on limestone, mudstone and sandstone. Weakly to moderately leached rendzinas of Konoti suite (KN, KNr), Arapohue suite (AU, AUd, MT), and Maungaturoto suite (MO). Weakly leached to weakly podzolised yellow-brown earths of Omu suite (OM, AP, OA).

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh) and gully (G)
*Potential:* Slight (1) sheet (Sh), rill (R), and gully (G). Moderate (2) rill (R) and sheet (Sh) when cultivated. Slight (1) wind (W) when cultivated

**Vegetation:** Improved pasture (gl) manuka, kanuka (sM).

**Annual rainfall range:** 1200–1600 mm

**Land use:**

| | | | |
|---|---|---|---|
| *Present:* | Cropping | – | Root and green fodder crops |
| | Grazing | – | Intensive incl. dairying |
| | | – | Present average carrying capacity (s.u./ha) = 13 |
| | | – | Top farmer carrying capacity (s.u./ha) = 15 |
| *Potential:* | Cropping | – | Root and green fodder crops, limited horticulture |
| | Grazing | – | Attainable physical potential carrying capacity (s.u./ha) = 18 |
| | Forestry | – | Production – site index for *Pinus radiata* = 28–31 |

**Soil conservation management:**

- Contour cultivation and minimum tillage practices recommended when cultivating.
- Avoid structural degradation of soils under intensive regular cultivation. Avoid excessive pugging of soils by heavy stock in winter.
- Timing of cultivation important. Avoid cultivating saturated soils (e.g. near field capacity).
- Control runoff using appropriate techniques such as graded banks and grassed waterways. Minimise sheet and rill erosion by planning runoff interception zones.
  Shelterbelts recommended for pastoral and horticultural land use (micro-climatic control e.g. reducing wind speeds and wind erosion).
- Space plant trees in erosion prone areas (e.g. mass movements such as soil slip, soil creep).
- Control grazing by avoiding overstocking and concentrated stock

movement, such as repeated tracking.
- Seasonal irrigation may be required in some areas, particularly under horticultural land use, treecrops, forestry.

**Comments:** Medium to high natural fertility. Soils may require some subsurface drainage. Parts of this unit, too small to be delineated at the 1:50 000 scale of mapping, may be susceptible to mass movement/soil creep, and would be classified as Class IV.

## LUC unit: IIIe5 (6598 ha)

**LUC suite:** 1. Coastal sand country

**LUC subsuite:** 1b. Old stable sand dunes on unconsolidated to compact sands: (LUC units IIIe5, IIIs4, IVe9, VIe6, VIIe9)

**Description:** Undulating to rolling slopes on old coastal dune landforms with yellow-brown sands on unconsolidated to compact dunesands i.e. aeolian sands. Potential for slight to moderate sheet, rill and wind erosion when cultivated. Soils moderately deep and well drained to somewhat excessively drained.

**Type location:** Q09/120419 Pouto Road

**Altitudinal range:** 0–200 m

**Slope:** Undulating to rolling (B+C), 7–15°

**Landform:** Interdune, swales, elevated terrace surfaces on dunesands.

**Rock type:** Unconsolidated sands and gravels (Us).

**Soils:** Yellow-brown sands on aeolian sands. Moderately weathered, moderately to strongly leached yellow-brown sands of Pinaki suite (HO, RLa, RL, RLl).

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh), wind (W) and gully (G)
*Potential:* Slight (1) sheet (Sh), rill (R) and gully (G). Slight (1) to moderate (2) wind (W), sheet (Sh), and rill (R) when cultivated

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM).

**Annual rainfall range:** 1000–1400 mm

**Land use:**

| | | | |
|---|---|---|---|
| *Present:* | Grazing | – | Intensive |
| | | – | Present average carryng capacity (s.u./ha) = 13 |
| | | – | Top farmer carrying capacity (s.u./ha) = 15 |
| | Cropping | – | Horticulture |
| *Potential:* | Cropping | – | Horticulture. Root and green fodder crops. Cereals. |
| | Grazing | – | Intensive |
| | | – | Attainable physical potential carrying capacity (s.u./ha) = 18 |
| | Forestry | – | Production – site index for *Pinus radiata* = 27–30 |

**Soil conservation management:**

- When cultivating, contour cultivation and minimum tillage practices recommended. Need to minimise surficial erosion.
- Avoid structural degradation of soils under intensive, regular cultivation.
- Shelterbelts essential for minimising wind and sheet erosion under pastoral and horticultural land use. Cultivated areas should not be left exposed to sheet and wind erosion and unprotected for long periods. Shelterbelts may also be useful for maintaining soil moisture levels.
- Maintain complete vegetative cover and good pasture quality.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking, particularly near gates, fencelines, and around troughs).
- Irrigation important, particularly for horticulture.

**Comments:** Moderate limitations for arable use, largely due to potential for erosion when cultivated; limitations due to soil characteristics and seasonal soil moisture deficit.

## LUC unit: IIIw1 (30 252 ha)

**LUC suite:** 2. Alluvial and estuarine plains and low terraces

**LUC subsuite:** 2a. Well drained floodplains and low terraces: (LUC units IIw1, IIIw1)

**Description:** Flat to undulating floodplains, valley plains and low to intermediate terraces with recent soils, and occasional yellow-brown earths and brown granular loams and clays, on sedimentary and volcanic alluvium. Runoff from surrounding hills and moderately high watertable increase the wetness limitation. Areas may be prone to occasional flooding, and slight to moderate streambank erosion and deposition. IIIw1 occurs throughout region.

**Type location:** P05/960425 Ngapipito Road near Moerewa

**Altitudinal range:** 0–100 m

**Slope:** Flat to undulating (A, B), 0–7°

**Landform:** Floodplains, valleys plains, low terraces.

**Rock type:** Fine alluvium (Af).

**Soils:** Recent soils on sedimentary and volcanic alluvium. Recent soils of Whareora suite (WF, WFm, WFa) and Kohumaru suite (MF, MFm). Less extensive areas of moderately to strongly leached yellow-brown earths of Whareora suite (WOa, WO), and moderately to strongly leached brown granular loams and clays (KM, KMm).

**Erosion:** *Present:* Negligible (0) to slight (1) streambank (Sb) and deposition (D)
*Potential:* Slight (1) to moderate (2) streambank (Sb). Slight (1) to moderate (2) deposition (D)

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM), podocarp forest (fP), rushes, sedges (hR).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*

| | | |
|---|---|---|
| Grazing | – | Intensive |
| | – | Present average carrying capacity (s.u./ha) = 21 |
| | – | Top farmer carrying capacity (s.u./ha) = 26 |
| Cropping | – | Root and green fodder crops. Vegetables. Cereals. Horticulture. |

*Potential:*

| | | |
|---|---|---|
| Grazing | – | Intensive |
| | – | Attainable physical potential carrying capacity (s.u./ha) = 30 |
| Cropping | – | Root and green fodder crops. Cereals. Horticulture. Vegetables. |
| Forestry | – | Production – site index for *Pinus radiata* = 23–26 |

**Soil conservation management:**

- Has potential for occasional flooding and greater flood risk than on IIw1. Suitable flood protection should be carefully planned and management should be considered over broader catchment area.
- Streambank protection may be required and stopbanks are recommended in some areas. Occasional flooding (deposition and erosion) may occur on land not protected by stopbanks. Erosion can be locally severe and difficult and expensive to repair or control.

- Drainage recommended, particularly for more intensive pastoral, cropping, and horticultural subdivision. Maintain condition of drains. Maintain clearance of vegetation within stream and river channels.
- Shelterbelts should be considered for watertable control or micro-climatic control.

**Comments:** Flood risk slightly higher than on IIw1. Because of increased flooding risk, vegetables and horticultural crops should be grown on intermediate to high terraces, or in flood-protected areas. Has moderate wetness limitation for arable use.

## LUC unit: IIIw2 (19 394 ha)

**LUC suite:** 2. Alluvial and estuarine plains and low terraces

**LUC subsuite:** 2b. Estuarine plains with gley soils:
(LUC units IIw2, IIIw2)

**Description:** Poorly drained flat areas within floodplains, valley plains and on low terraces with gley fertile soils developed on sedimentary and volcanic alluvium. Has moderate wetness limitation for arable use, but can be effectively drained.

**Type location:** P08/887775 Notorious West Road

**Altitudinal range:** 0–60 m

**Slope:** Flat (A), 0–3°

**Landform:** Floodplains, plains.

**Rock type:** Fine alluvium (Af).

**Soils:** Gley soils on estuarine clays, sands and alluvium. Gley soils of Kaipara suite (KP, KPy, KA, KAy, TZ, TZy), Waipu suite (YUa, YUay, YU, YUy, YA) and Waipapa suite (KO, KOr, KOl, KOy, YF).

**Erosion:** *Present:* Negligible (0) to slight (1) streambank (Sb) and deposition (D)
*Potential:* Slight (1) streambank (Sb) and deposition (D)

**Vegetation:** Improved pasture (gl), rushes, sedges (hR), vegetables, nurseries (CV).

**Annual rainfall range:** 1200–1400 mm

**Land use:**

| | | | |
|---|---|---|---|
| *Present:* | Grazing | – | Intensive incl. dairying |
| | | – | Present average carrying capacity (s.u./ha) = 17 |
| | | – | Top farmer carrying capacity (s.u./ha) = 20 |
| | Cropping | – | Root and green fodder crops. Cereals. |
| *Potential:* | Cropping | – | Root and green fodder crops. Cereals. Vegetables. Horticulture. |
| | Grazing | – | Intensive |
| | | – | Attainable physical potential carrying capacity (s.u./ha) = 24 |
| | Forestry | – | Production – site index for *Pinus radiata* = 18–21 |

**Soil conservation management:**
- Potential for occasional flooding. Suitable flood protection should be carefully planned; management should be considered over broader catchment area.
- Drainage required for management of watertable levels. Maintain condition of drains.
- Streambank protection may be necessary in some areas.
- Stopbanks recommended close to flood prone areas.
- Maintain clearance of vegetation within stream and river channels.

**Comments:** Some horticulture on Waipapa suite soils if deep drained.

## LUC unit: IIIw3 (1158 ha)

**LUC suite:** 2. Alluvial and estuarine plains and low terraces

**LUC subsuite:** 2d. Mudflats with saline soils:
(LUC units IIIw3, IVw2, VIw2)

**Description:** Flat land on reclaimed tidal mudflats and estuarine plains with slightly saline gley soils on alluvium. Occurs at margins of harbour areas, bays, lagoons, intertidal creeks and streams. Has moderate wetness limitation for arable use. Stopbanks and drainage have enabled saline levels and watertables to be reduced progressively.

**Type location:** Q09/380268 Omaumau Road

**Altitudinal range:** 0–20 m

**Slope:** Flat (A), 0–3°

**Landform:** Plains, mudflats on margins of harbours, estuaries, lagoons, intertidal creeks and streams.

**Rock type:** Fine alluvium (Af).

**Soils:** Slightly saline gley soils of Kaipara suite (TCa, TC, TCy, TCya) on coastal mudflats. Parent materials include estuarine clays, sands and alluvium.

**Erosion:** *Present:* Negligible (0) to slight (1) deposition
*Potential:* Negligible (0) to moderate (2) deposition. Slight (1) wind (W) when cultivated

**Vegetation:** Improved pasture (gl), rushes, sedges (hR).

**Annual rainfall range:** 1000–1400 mm

**Land use:** *Present:*

| | | |
|---|---|---|
| Grazing | – | Intensive incl. dairying |
| | – | Present average carrying capacity (s.u./ha) = 17 |
| | – | Top farmer carrying capacity (s.u./ha) = 20 |
| Cropping | – | Root and green fodder crops |

*Potential:*

| | | |
|---|---|---|
| Grazing | – | Intensive |
| | – | Attainable physical potential carrying capacity (s.u./ha) = 24 |
| Cropping | – | Root and green fodder crops. Cereals. Horticulture. |
| Forestry | – | Production – site index for *Pinus radiata* = 18–21 |

**Soil conservation management:**

- Drainage required for management of watertable levels. Maintain condition of drains.
- Stopbanks required near tidal affected areas.
- Watertable levels should be monitored, salinisation could be a potential problem in some areas. Saline and pH levels can affect cropping suitability.
- Deposition may be problem where flood discharge is high or where tidal influences occur in lower reaches of channels and estuarine areas.
- Maintain dense vegetative cover to minimise sheet and wind erosion, particularly in areas affected by concentrated stock movement.
- Treeplanting and other suitable vegetation grown on either side of major drains can act as windbreaks, protect and stabilise drains, control watertable levels, stockcontrol, etc.

**Comments:** Much land has been effectively drained and progressively reclaimed. Salinity of soils has been reduced over time to levels which make cropping possible.

## LUC unit: IIIw4 (13 375 ha)

**LUC suite:** 2. Alluvial and estuarine plains and low terraces

**LUC subsuite** 2e. Peats:
(LUC units IIIw4, IVw3, VIw3, VIIw2)

**Description:** Flat to undulating land with organic soils on alluvial and estuarine plains, terraces, and in interdune areas. Land types include poorly drained valley floors on peat and sand within older sand dune environments and peaty areas on surface of Quaternary-aged terraces. In sand country isolated pockets of podzols on lacustrine sediments, too small to be separately delineated, may be included with soils in this unit. Watertables may be near the surface in winter months. Has moderate wetness limitation for arable use.

**Type location:** 004/315342 Spains Road, Sweetwater

**Altitudinal range:** 0–100 m

**Slope:** Flat to undulating (A, A+B), 0–7°

**Landform:** Peat areas on terraces, alluvial plains, swamps, valley floors, valley plains. Often mapped in depressions between sand dunes.

**Rock type:** Peat (Pt) often intercalated with fine alluvium (Af), e.g. Pt/Af, Pt+Pt/Af.

**Soils:** Organic soils on peat or peat and sand. Organic soils of Ruakaka suite (OT, PZ, RK, RKu, RKd, RKv, RKl) and Otonga suite (OG, OGd, OGv, OR, ORd).

**Erosion:** *Present:* Negligible (0)
*Potential:* Negligible (0) to slight (1) wind (W) when cultivated

**Vegetation:** Improved pasture (gl), rushes, sedges (hR), vegetables, nurseries (cV), subtropical fruit (cS), manuka, kanuka (sM), root and green fodder crops (cR).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*
- Grazing – Intensive
  - Present average carrying capacity (s.u./ha) = 17
  - Top farmer carrying capacity (s.u./ha) = 20
- Cropping – Root and green fodder crops. Cereals.

*Potential:*
- Grazing – Intensive
  - Attainable physical potential carrying capacity (s.u./ha) = 24
- Cropping – Root and green fodder crops. Cereals. Horticulture.
- Forestry – Production – site index for *Pinus radiata* = 19–22

**Soil conservation management:**
- Drainage required in some areas to control/manage watertable levels. Maintain condition of drains. Optimum watertables for specific land uses should be regulated and water allocation planned and monitored.
- Suitable flood protection should be carefully planned and management considered over broader catchment area. Stopbanks may be necessary in some areas.
- Shelterbelts recommended in some areas particularly under arable land use, e.g. cropping, or horticultural land use, to help regulate watertable levels and for micro-climatic control.

**Comments:** Occasional logs/organic debris requires removal for horticulture/cropping particularly in the sand country. Can be effectively drained for high-producing pasture and arable land (e.g. horticulture).

## LUC unit: IIIs1 (3676 ha)

**LUC suite**

6. Young volcanic basalt terrain:
(LUC units Ic1, IIe1, IIs1, IIIe1, IIIs1, IIIs2, IVe2, IVs1, IVs2, Vs1, VIs1, VIe4, VIIIs2)

**Description:**

Flat to rolling slopes on relatively young basalt rocks with numerous stones, gravels and boulders scattered over surface and throughout soil profile. Soils are usually free-draining, light textured and often range from 30–90 cm deep over hard weathered basalt rock. Gravels and boulders typically comprise 10–35% by volume of soil profile. Stoniness and shallow soil depth are regarded as moderate limitation to arable use. Requires irrigation to maintain crops during dry periods thus limiting range of crops able to be grown.

**Type location:**

P05/855509 Pua Road and State Highway 1 just east of Lake Omapere

**Altitudinal range:**

0–200 m

**Slope:**

Flat to undulating (A, B), 0–7°

**Landform:**

Flat to undulating surfaces on basalt lava terraces, low domes, and plains. Also mapped on low-angle slopes near base of scoria cones and mounds.

**Rock type:**

Lavas (Vo). Scoria (Sc).

**Soils:**

Brown and red loams on basalt flows, scoria and ash. Weakly to moderately leached brown loams of Kiripaka suite where a bouldery phase is often recorded (KB, KBb, KBe, KBeb, OW, OWb, YOb, MCb, KEb, RTb). Moderately to strongly leached red loams of Papakauri suite may be recorded (MUb).

**Erosion:**

*Present:* Negligible (0)
*Potential:* Slight (1) wind (W) sheet (Sh) and rill (R) when cultivated

**Vegetation:**

Improved pasture (gI), subtropical fruit (cS), kiwifruit (cK), semi-improved pasture (gS).

**Annual rainfall range:**

1200–1600 mm

**Land use:**

*Present:*
Cropping – Horticulture
Grazing – Intensive
– Present average carrying capacity (s.u./ha) = 21
– Top farmer carrying capacity (s.u./ha) = 26

*Potential:*
Cropping – Horticulture. Root and green fodder crops.
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 30
Forestry – Production – site index for *Pinus radiata* = 33–36

**Soil conservation management:**

- Minimum tillage practices are recommended when cultivating.
- Avoid structural degradation of soils under intensive, regular cultivation.
- Irrigation necessary for arable use, particularly horticulture.
- Shelterbelts recommended for pastoral, cropping and horticultural land uses; may be useful for micro-climatic control, e.g. reducing wind speeds, minimising wind erosion, maintaining soil moisture levels.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking).

**Comments:**

Soils may be affected by seasonal soil moisture deficits. Soils relatively fertile but stoniness and shallow soil depths are moderate limitations for arable use.

## LUC unit: IIIs2 (11 661 ha)

**LUC suite**

6. Young volcanic basalt terrain:
(LUC units Ic1, IIe1, IIs1, IIIe1, IIIs1, IIIs2, IVe2, IVs1, IVs2, Vs1, VIs1, VIe4, VIIIs2)

**Description:** Flat to undulating slopes on deeply weathered basalt rocks and occasional ash. Soils moderately to strongly leached brown loams. Soils of lower fertility than those of Class II units, have poorer drainage characteristics and are subject to seasonal soil moisture deficiencies, giving moderate limitations for arable use.

**Type location:** P05/945673 Kapiro Road, Kerikeri

**Altitudinal range:** 0–200 m

**Slope:** Flat to undulating (A, B). 0–7°

**Landform:** Flat to gently rolling surfaces on basalt lava terraces, low domes, and plains. Also mapped on low-angle slopes near base of scoria cones and mounds.

**Rock type:** Lavas (Vo). Scoria (Sc). Older ashes or tephras (Mo).

**Soils:** Brown and red loams on basalt flows, scoria and ash. Moderately to very strongly leached brown loams of Kiripaka suite (KE, RT, PG, TA, OKu, OK).

**Erosion:** *Present:* Negligible (0)
*Potential:* Slight (1) sheet (Sh) and rill (R) when cultivated

**Vegetation:** Improved pasture (gl), subtropical fruit (cS), kiwifruit (cK), pip and stone fruit (cP).

**Annual rainfall range:** 1200–1600 mm

**Land use:**

| | | | |
|---|---|---|---|
| *Present:* | Grazing | – | Intensive |
| | | – | Present average carrying capacity (s.u./ha) = 13 |
| | | – | Top farmer carrying capacity (s.u./ha) = 15 |
| | Cropping | – | Horticulture |
| *Potential:* | Grazing | – | Intensive |
| | | – | Attainable physical potential carrying capacity (s.u./ha) = 18 |
| | Cropping | – | Horticulture. Root and green fodder crops. |
| | Forestry | – | Production – site index for *Pinus radiata* = 33–36 |

**Soil conservation management:**

- Contour cultivation on undulating slopes and minimum tillage practices recommended when cultivating.
- Avoid structural degradation of soils under intensive, regular cultivation.
- Irrigation necessary for arable use, particularly for horticulture.
- Shelterbelts recommended for pastoral, cropping, and horticultural land uses; may be useful for micro-climatic control, e.g. reducing wind speeds, minimising wind erosion, maintaining soil moisture levels.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking).

**Comments:** Soils range from moderate to low fertility, and together with seasonal soil moisture deficiencies and poorer drainage characteristics than in Class II units, moderate soil limitation exists for cropping. Often large amount of spatial variation in soil properties. When topdressed with phosphate, moderate to high yields of vegetable crops, dairying pastures or forestry can be expected. Production often limited by high retention of phosphorus.

## LUC unit: IIIs3 (4351 ha)

**LUC suite:** 3. Quaternary terraces with complex soils: (LUC units IIe2, IIw3, IIs2, IIIe2, IIIs3)

**Description:** Flat to gently rolling slopes on intermediate to moderately high Quaternary terraces and plains on alluvium associated with other sedimentary lithologies, such as limestone, sandstone and mudstone. Surficial deposits include water sorted tephras. Soils spatially complex, and include yellow-brown loams, yellow-brown earths, podzolised yellow-brown earths, brown granular loams, and rendzinas. Has moderate soils limitation due to the highly variable soil characteristics and includes high-fertility to low-fertility soils. Drainage characteristics may change greatly over a small area.

**Type location:** R10/625951 Bush Road, Albany

**Altitudinal range:** 0–100 m

**Slope:** Flat to undulating (A, A+B), 0–7°

**Landform:** Flat to undulating land on broad terrace surfaces and plains at a range of heights.

**Rock type:** Unconsolidated clays and silts (Uf), occasional interbedded sands (Us), often overlying bedded sandstone (Sb) or limestone (Li).

**Soils:** Complex of soil types on mainly airfall and reworked rhyolitic volcanic ash and alluvium including: yellow-brown loams, yellow-brown earths, brown granular loams, podzolised yellow-brown loams, podzolised yellow-brown earths, and rendzinas, mainly of Waitemata suite (OL, OLm, HV, WE, WEm, CV), Maungaturoto suite (DF), Arapohue suite (MT), and Omu suite (YK, WK). Soil complexes expressed as C4 and C1A.

**Erosion:** *Present:* Negligible (0)
*Potential:* Negligible (0) to slight (1) rill (R) and sheet (Sh) when cultivated

**Vegetation:** Improved pasture (gl), rushes, sedges (hR), vegetables, nurseries (cV).

**Annual rainfall range:** 1200–1500 mm

**Land use:**

*Present:*
- Grazing – Intensive
  - Present average carrying capacity (s.u./ha) = 17
  - Top farmer carrying capacity (s.u./ha) = 20
- Cropping – Horticulture

*Potential:*
- Grazing – Intensive
  - Attainable physical potential carrying capacity (s.u./ha) = 24
- Cropping – Horticulture. Root and green fodder crops.
- Forestry – Production – site index for *Pinus radiata* = 28–31

**Soil conservation management:**
- When cultivating, contour cultivation and minimum-tillage practices recommended.
- Avoid structural degradation of soils under intensive, regular cultivation. Mulching required on some soils.
- Drainage required in some areas depending on soil/regolith characteristics.
- Irrigation necessary on some soil types, particularly for horticulture.
- Shelterbelts recommended for pastoral, cropping, and horticultural landuses (shelterbelts for micro-climatic control).
- Control runoff using appropriate techniques such as graded banks and grassed waterways. Minimise sheet and rill erosion by planning runoff interception zones.

**Comments:** Soils spatially complex. For detailed assessment, mapping of soils at scales between 1:1000 and 1:10 000 is recommended.

## LUC unit: IIIs4 (5986 ha)

**LUC suite:** 1. Coastal sand country

**LUC subsuite:** 1b. Old stable sand dunes on unconsolidated to compact sands: (LUC units IIIe5, IIIs4, IVe9, VIe6, VIIe9)

**Description:** Flat to undulating slopes on valley floors, swales, and sandplains, between old coastal dune hills (interdune areas). Soils well drained to somewhat excessively drained yellow-brown sands often associated with poorly drained organic soils. Yellow-brown earths also occasionally recorded. Yellow-brown sands are subject to seasonal soil moisture deficiencies. Has moderate soils limitation for arable use.

**Type location:** Q10/303086 South Head Road

**Altitudinal range:** 0–200 m

**Slope:** Flat to undulating (A+B), 0–7°

**Landform:** Interdune areas, sandplains, valley floors filled with aeolian and alluvial sands, silts and occasional peat.

**Rock type:** Unconsolidated sands (Us).

**Soils:** Yellow-brown sands and organic soils on aeolian sand. Moderately weathered, moderately to strongly leached yellow-brown sands of Pinaki suite (HO, RLa, RL, RLl) and weakly to moderately podzolised yellow-brown earths of Pinaki suite (TT), commonly associated with smaller areas of organic soils of Ruakaka suite (PZ, OT, RK, RKu, RKd, RKv, RKl).

**Erosion:** *Present:* Negligible (0) to slight (1) wind (W) and sheet (Sh)
*Potential:* Slight (1) to moderate (2) wind (W) and sheet (Sh) when cultivated

**Vegetation:** Improved pasture (gl), rushes, sedges (hR).

**Annual rainfall range:** 1000–1400 mm

**Land use:**

| | | | |
|---|---|---|---|
| *Present:* | Grazing | – | Intensive |
| | | – | Present average carrying capacity (s.u./ha) = 13 |
| | | – | Top farmer carrying capacity (s.u./ha) = 15 |
| | Cropping | – | Root and green fodder crops. Horticulture. |
| *Potential:* | Grazing | – | Intensive |
| | | – | Attainable physical potential carrying capacity (s.u./ha) = 18 |
| | Cropping | – | Root and green fodder crops. Horticulture. |
| | Forestry | – | Production – site index for *Pinus radiata* = 23–26 |

**Soil conservation management:**
- Contour cultivation and minimum-tillage practices recommended when cultivating.
- Avoid structural degradation of soils under intense, regular cultivation.
- Shelterbelts essential for minimising wind and sheet erosion. Under horticultural use, shelter essential for micro-climatic control and maintaining soil moisture levels.
- Maintain complete vegetative cover and good pasture quality.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking).

**Comments:** Well drained yellow-brown sands with weak structures, prone to seasonal soil moisture deficit. Require irrigation for arable use. Where clay contents/ organic contents are higher, soils generally have improved structure and higher fertility.

## LUC unit: IIIs5 (1535 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4e. Limestone:
(LUC units IIIs5, IVe1, Vc1, VIs3, VIe3, VIIe3)

**Description:** Undulating to gently rolling slopes on limestone, usually within a subdued rolling landscape. Typical soils are rendzinas and associated soils. Soils have high natural fertility but may require some subsurface drainage, particularly during winter months. Occurs throughout region but mapped extensively near Dargaville–Arapohue, west of Whangarei–Kaikohe, and near Kaiwaka–Maungaturoto. Has moderate limitations for arable use.

**Type location:** P08/047705 Rehia Road

**Altitudinal range:** 0–400 m

**Slope:** Undulating to rolling (B, C), 4–15°

**Landform:** Undulating to rolling surfaces within a subdued limestone landscape. Downlands.

**Rock type:** Limestone (Li).

**Soils:** Rendzinas and associated soils on limestone. Weakly to moderately leached rendzinas of Arapohue suite (AU, AUd, MT), moderately to strongly leached rendzinas of Maungaturoto suite (MO, DF).

**Erosion:** *Present:* Negligible (0) to slight (1) gully (G)
*Potential:* Negligible (0) to slight (1) gully (G). Negligible (0) to moderate (2) sheet (Sh) and rill (R) when cultivated

**Vegetation:** Improved pasture (gI), manuka, kanuka (sM), lowland podocarp–broadleaved forest (fO).

**Annual rainfall range:** 1200–1600 mm

**Land use:**

*Present:*
- Grazing – Intensive, incl. dairying
- Grazing – Present average carrying capacity (s.u./ha) = 13
- Grazing – Top farmer carrying capacity (s.u./ha) = 15

*Potential:*
- Grazing – Intensive
- Grazing – Attainable physical potential carrying capacity (s.u./ha) = 18
- Cropping – Root and fodder crops. Viticulture. Horticulture.
- Forestry – Production – site index for *Pinus radiata* = 27–30

**Soil conservation management:**
- Contour cultivation and minimum-tillage practices recommended when cultivating.
- Avoid structural degradation of soils under intensive, regular cultivation. Avoid excessive pugging of soils by heavy stock in winter.
- Timing of cultivation, tillage, may be an important consideration. Avoid cultivating saturated soils (e.g. near field capacity).
- Control runoff using appropriate techniques such as grassed waterways, graded banks.
- Shelterbelts useful in regulating soil moisture levels.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking).
- Seasonal irrigation required in some areas, particularly under horticultural land use, tree crops, forestry.

**Comments:** Heavy soils, with very high cation-exchange capacity and base saturation and high content of well decomposed humus and of montmorillonitic clay. With phosphate topdressing, rendzina and associated soils make excellent pastoral land.

## LUC unit: IVe1 (5132 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4e. Limestone:
(LUC units IIIs5, IVe1, Vc1, VIs3, VIe3, VIIe3)

**Description:** Rolling to strongly rolling slopes on limestone, usually within a subdued rolling landscape. Typical soils are rendzinas and associated soils. Severe limitations for arable use related to potential for erosion on increased slopes from those recorded in unit IIIs5. Secondary limitations related to soil characteristics. Potential for moderate sheet, rill and gully erosion when cultivated. Occurs throughout region, but mapped extensively near Dargaville–Arapohue, west of Whangarei–Kaikohe, east of Kaitaia, and near Kaiwaka–Maungaturoto.

**Type location:** P08/964795 Arapohue

**Altitudinal range:** 0–400 m

**Slope:** Rolling to strongly rolling (C, D), 8–20°

**Landform:** Rolling to strongly rolling terrain. Downlands.

**Rock type:** Limestone (Li). Muddy and fine grained argillaceous limestone.

**Soils:** Rendzinas and associated soils on limestone. Weakly to moderately leached rendzinas of Arapohue suite (AU, AUd, MT), moderately to strongly leached rendzinas of Maungaturoto suite (MO, DF).

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh), gully (G) and soil slip (Ss).
*Potential:* Slight (1) sheet (Sh), gully (G) and soil slip (Ss). Moderate (2) sheet (Sh), rill (R), and gully (G) when cultivated.

**Vegetation:** Improved pasture (gl), lowland podocarp–broadleaved forest (fO) podocarp forest (fP), broadleaved forest (fB), root and green fodder crops (cR).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:* Grazing – Intensive
– Present average carrying capacity (s.u./ha) = 13
– Top farmer carrying capacity (s.u./ha) = 15
*Potential:* Grazing – Intensive
– Attainable physical potential carrying capacity (s.u./ha) = 18
Cropping – Root and green fodder crops
Forestry – Production – site index for *Pinus radiata* = 27–30

**Soil conservation management:**
- When cultivating, contour cultivation and minimum-tillage practices recommended.
- Avoid structural degradation of soils under intensive, regular cultivation.
- Timing of cultivation, tillage may be an important consideration. Avoid cultivating saturated soils (e.g. near field capacity).
- Runoff should be channelled away from steeper slopes. Control using appropriate techniques such as grassed waterways, graded banks.
- Maintain good-quality pasture cover.
- Shelterbelts may be useful in regulating soil moisture levels.
- Space plant trees in erosion-prone areas (e.g. mass movement). Tree planting may be limited to wetter sites. Pair plant trees in gullies.

- Control grazing by avoiding overstocking, and concentrated stock movement (e.g. repeated tracking). Controls may include closer subdivision, rotational grazing, adequate spelling of pastures. Avoid excessive pugging of soils by heavy stock in winter.

**Comments:** Heavy soils with very high cation-exchange capacity and base saturation and high content of well decomposed humus and of montmorillonitic clay. With phosphate topdressing, rendzina and associated soils make excellent pastoral land. Some subsurface drainage may be required as soils become very wet during winter months.

## LUC unit: IVe2 (11,648 ha)

**LUC suite:** 6. Young basalt volcanic terrain: (LUC units Ic1, IIe1, IIs1, IIIe1, IIIs1, IIIs2, IVe2, IVs1, IVs2, Vs1, VIs1, VIe4, VIIIs2)

**Description:** Rolling to strongly rolling slopes on young basaltic rock and ash. Soils strongly leached brown and red loams which may be affected by moisture deficiencies, particularly during summer months. There is a potential for moderate to severe sheet, rill, wind and gully when cultivated.

**Type location:** P05/892680 Pungaere

**Altitudinal range:** 0–400 m

**Slope:** Rolling to strongly rolling (C, C+D), 8–20°

**Landform:** Rolling to strongly rolling sides of lava plains, terraces and domes.

**Rock type:** Lava (Vo). Basaltic lava.

**Soils:** Brown and red loams on basalt flows, scoria and ash. Moderately to strongly leached brown loams of Kiripaka suite (PG, RT, RTb, KE, KEb). Strongly to very strongly leached brown loams of Kiripaka suite (TA, OKu, OK, OKg). Occasional weakly to moderately leached brown loams of Kiripaka suite (KB, KBH, KBb, KBe, KBeb). Moderately to strongly leached red loams of the Papakauri suite (MUH, MU, ATH, AT).

**Erosion:** *Present:* Negligible (0) to moderate (2) sheet (Sh). Negligible (0) to slight (1) soil slip (Ss), gully (G), rill (R), and wind (W)

*Potential:* Slight (1) to moderate (2) sheet (Sh), soil slip (Ss), rill (R), gully (G), and wind (W). Moderate (2) to severe (3) sheet (Sh), rill (R), wind (W) and gully (G) when cultivated

**Vegetation:** Improved pasture (gl), manuka, kanuka (sM), lowland podocarp–broadleaved forest (fO).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*

| | | |
|---|---|---|
| Grazing | – | Intensive to semi-intensive |
| | – | Present average carrying capacity (s.u./ha) = 17 |
| | – | Top farmer carrying capacity (s.u./ha) = 20 |

*Potential:*

| | | |
|---|---|---|
| Grazing | – | Attainable physical potential carrying capacity (s.u./ha) = 24 |
| Cropping | – | Root and green fodder crops. Horticulture. |
| Forestry | – | Production – site index for *Pinus radiata* = 28–30 |

**Soil conservation management:**

- Contour cultivation and minimum-tillage practices recommended when cultivating. Need to minimise surficial erosion.
- Control runoff using appropriate techniques such as grassed waterways and graded banks. Avoid sheet and rill erosion by planning runoff interception zones.
- Shelterbelts recommended for pastoral, cropping and horticultural land use. Useful for micro-climatic control, reducing wind speeds, minimising wind erosion and maintaining soil moisture levels.
- Seasonal irrigation may be required, particularly under horticultural land uses.
- Maintain good-quality pasture cover.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking, tracking near fencelines, troughs). Bare ground difficult to revegetate on soils in this unit.

**Comments:** Soils well drained and may be affected by moisture deficiencies during summer months. High content of sesquioxides causes high phosphate retention. Time of application and placement of fertilisers important on soils.

## LUC unit: IVe3 (35 124 ha)

**LUC suite:** 7. Old volcanic terrain

**LUC subsuite:** 7a. Landforms on old stable basalt–andesite volcanics with brown granular loams and clays:
(LUC units IVe3, IVs3, Vc2, VIe2, VIe16, VIc1, VIIe1)

**Description:** Rolling to strongly rolling slopes typically below ~600 m a.s.l., within rolling downlands, hills, and at sides of plains and terraces, on old 'basic' volcanics (e.g. dolerite, andesite, basalt) including ancient volcanics (e.g. Tangihua volcanics) and volcanic breccia. Includes some areas on older volcanic alluvium. Soils brown granular loams and clays which may be affected by moisture deficiencies particularly during summer months. Potential for moderate to severe sheet, rill, wind and gully erosion when cultivated.

**Type location:** 004/631889 Mangonui area

**Altitudinal range:** 0–600 m

**Slope:** Rolling to strongly rolling (C, C+D), 8–20°

**Landform:** Rolling to strongly rolling terrain. Downlands, sides of plains, terraces. Rolling land on plateau surfaces.

**Rock type:** Lavas (Vo), Indurated volcanic breccias (Vb), indurated fine-grained pyroclastics (Tb), ancient volcanics (In), ultramafics (Um).

**Soils:** Brown granular loams and clays on old volcanics. Weakly to strongly leached brown granular loams and clays of Te Kie suite (YN, MN, RU, RUr, AW, TU, AK), Huia suite (YT, PA, DV, CW, Hl, Hlg, HU, BM), Katui suite (YP, WT, TO, AR, KT), Kohumaru suite (PCr, PC, PCm, PLy, PL).
Parent materials include shattered dolerites, breccias and tuffs, andesitic agglomerates, and breccias and andesitic flows.

**Erosion:** *Present:* Negligible (0) to slight (1) soil slip (Ss), sheet (Sh), wind (W), rill (R), gully (G) and earthflow (Ef)
*Potential:* Slight (1) to moderate (2) soil slip (Ss), sheet (Sh), wind (W), rill (R), gully (G) and earthflow (Ef). Moderate (2) to severe (3) sheet (Sh), rill (R), wind (W) and gully (G) when cultivated

**Vegetation:** Improved pasture (gl), lowland podocarp–broadleaved forest (fO), manuka, kanuka (sM).

**Annual rainfall range:** 1400–1800 mm

**Land use:** *Present:*
Grazing – Intensive to semi-intensive
– Present average carrying capacity (s.u./ha) = 13
– Top farmer carrying capacity (s.u./ha) = 15

*Potential:*
Grazing – Intensive
– Attainable physical potential carrying capacity (s.u./ha) = 18
Cropping – Root and green fodder crops
Forestry – Production – site index for *Pinus radiata* = 29–32

**Soil conservation management:**
- Contour cultivation and minimum-tillage practices recommended when cultivating. Need to minimise surficial erosion.
- Control runoff using appropriate techniques such as grassed waterways. Avoid sheet and rill erosion by planning runoff interception zones.

- Shelterbelts are recommended for pastoral, cropping and horticultural land use. Useful for micro-climatic control, reducing wind speeds and minimising wind erosion and maintaining soil moisture levels.
- Seasonal irrigation may be required, particularly under horticultural land uses.
- Maintain good-quality pasture cover.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking, tracking near fencelines, troughs). Bare ground difficult to revegetate on soils in this unit.

**Comments:** Soils generally well drained. Topsoils have strongly developed granular, nutty structures, hold little moisture and are liable to sheet erosion. Establishment and maintenance of pastures may be difficult in some areas. Fixation of phosphorus less than in brown loams but greater than on the yellow-brown earths.

## LUC unit: IVe4 (17 869 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4f. Limestone complexed with other sedimentary deposits: (LUC units IIIe4, IVe4, VIe5)

**Description:** Rolling to strongly rolling slopes within a subdued rolling landscape on limestone complexed with other sedimentary or volcanic lithologies. Intermediate unit between IVe1 and IVe8 having a more irregular slope form and a greater potential for erosion than IVe1, soils are spatially complex and include rendzinas, yellow-brown earths and podzols. Potential for moderate to severe sheet, rill and gully erosion when cultivated.

**Type location:** Q09/386435 Tauroa – Port Albert Road

**Altitudinal range:** 0–400 m

**Slope:** Rolling to strongly rolling (C, C+D), 8–20°

**Landform:** Rolling terrain. Downlands.

**Rock type:** Limestone (Li), complexed with a range of sedimentary lithologies such as jointed mudstone (Mj), and/or sheared mixed lithologies (Mx), and/or massive sandstone (Sm), and/or argillite (Ar). Expressed as, Li+Mj, Li+Mx, Li+Sm, Li+Ar respectively.

**Soils:** A complex of rendzinas and yellow-brown earths on limestone, mudstone and sandstone. Weakly to moderately leached rendzinas of Konoti Suite (KN, KNr), Arapohue suite (AU, AUd, MT), and Maungaturoto suite (MO). Weakly leached to weakly podzolised yellow-brown earths of Omu suite (OM, AP, OA), and Whaka suite (RV, RVe).

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh), gully (G), soil slip (Ss), tunnel gully (T) and earthflow (Ef)

*Potential:* Slight (1), sheet (Sh) and soil slip (Ss). Slight (1) to moderate (2) gully (G), tunnel gully (T) and earthflow (Ef). Moderate (2) to severe (3) sheet (Sh), rill (R) and gully (G) when cultivated

**Vegetation:** Improved pasture (gI), manuka, kanuka (sM), Lowland podocarp–broadleaved forest (fO), root and green fodder crops (cR).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*

| | | |
|---|---|---|
| Grazing | – | Intensive to semi-intensive, incl. dairying |
| | – | Present average carrying capacity (s.u./ha) = 13 |
| | – | Top farmer carrying capacity (s.u./ha) = 15 |

*Potential:*

| | | |
|---|---|---|
| Grazing | – | Intensive |
| | – | Attainable physical potential carrying capacity (s.u./ha) = 18 |
| Cropping | – | Root and green fodder crops |
| Forestry | – | Production – site index for *Pinus radiata* = 28–31 |

**Soil conservation management:** Good soil conservation management essential.

- Contour cultivation and minimum-tillage practices recommended when cultivating.
- Avoid structural degradation of soils under intensive, continuous cultivation or repeated compaction.
- Timing of cultivation, tillage may be an important consideration. Avoid

cultivating saturated soils (e.g. near field capacity).
- Runoff should be channelled away from steeper slopes. Control runoff using appropriate techniques such as grassed waterways, graded banks.
- Space plant trees in erosion-prone areas (e.g. mass movements). Limited tree planting and subsurface drainage in "wetter" areas. Pair plant trees in gullies, tunnel gullies.
- Maintain good-quality pasture cover.
- Shelterbelts may be useful in regulating soil moisture levels.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking). Adequate farm subdivision necessary. Allow spelling of some pastures. Avoid excessive pugging of soils by heavy stock in winter.
- Carefully plan all earthworks such as roads, drains and dams. Avoid potentially unstable sites.
- Attention to subsurface drainage.

**Comments:** Identified as an 'unstable' limestone unit with greater potential for erosion than IVe1. Drainage characteristics can change greatly over a small area. Soil fertility may be lower than in IVe1.

## LUC unit: IVe5 (58 507 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4a. Interbedded and massive sandstone and mudstone: (LUC units IIIe3, IVe5, VIe1, VIe8, VIIe4)

**Description:** Rolling and strongly rolling slopes within subdued rolling to hilly landscape e.g. lower hillslopes, downlands on strongly weathered interbedded and occasionally massive sandstones and mudstones. Soils typically weakly to moderately podzolised yellow-brown earths. Excludes land on limestone and greywacke. Potential for moderate to severe sheet, rill, and gully erosion when cultivated. Usually mapped in association with IIIe3 and VIe1, throughout the region.

**Type location:** R09/622334 Warkworth Leigh Road

**Altitudinal range:** 0–400 m

**Slope:** Rolling to strongly rolling (C, C+D), 8–20°

**Landform:** Rolling to strongly rolling terrain. Downlands.

**Rock type:** Bedded sandstone (Sb), bedded mudstone (Mb), less extensive areas of massive sandstone (Sm) and massive mudstone (Mm) are also recorded.

**Soils:** Yellow-brown earths on stratified and massive sandstones and mudstones. Weakly to strongly leached and weakly to moderately podzolised yellow-brown earths of Puhoi suite (WA, AY, AYf, MV, OU), Waiotira suite (YC, YCr, YCe, RP, RPa, PV) and Omu suite (MAr, MA, AP).

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh), rill (R), soil slip (Ss), tunnel gully (T), gully (G) and earthflow (Ef). Slight to moderate terracette creep

*Potential:* Slight (1) to moderate (2) sheet (Sh), soil slip (Ss), tunnel gully (T), earthflow (Ef) and rill (R). Slightly (1) to moderate (2) rill (R) and gully (G) and moderate (2) to severe (3) sheet (Sh) when cultivated

**Vegetation:** Improved vegetation (gI), manuka, kanuka (sM), gorse (sG). Exotic conifer forest (fF).

**Annual rainfall range:** 1200- 1600 mm

**Land use:** *Present:*

Grazing – Intensive to semi-intensive incl. dairying
– Present average carrying capacity (s.u./ha) = 13
– Top farmer carrying capacity (s.u./ha) = 15
Forestry – Production – exotic spp.
Reversion to scrub

*Potential:*

Grazing – Intensive
– Attainable physical potential carrying capacity (s.u./ha) = 18
Cropping – Root and green fodder crops. Horticulture.
Forestry – Production – site index for *Pinus radiata* = 29–32

**Soil conservation management:**

- Contour cultivation and minimum-tillage practices recommended when cultivating.
- Avoid structural degradation of soils under intensive, continuous cultivation.
- Runoff should be channelled away from steeper slopes. Control runoff using appropriate techniques (e.g. grassed waterways, diversion banks).

- Maintain good-quality pasture cover.
- Space plant trees in erosion-prone areas (e.g. mass movements). Pair plant trees in gullies.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking, tracking along fencelines, gates, around troughs).
- Shelterbelts may be useful in regulating soil moisture levels.
- Seasonal irrigation may be required for some crops.

**Comments:** Heavy soils, but support excellent pastures. Require light to moderate applications of phosphate and lime.

## LUC unit: IVe6 (43 341 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4b. Old shattered and sheared argillites and sandstone: (LUC units IVe6, VIe7)

**Description:** Gently rolling to strongly rolling slopes within a subdued rolling to hilly landscape on fractured and sheared argillites, sandstones and mudstones. Occasionally complexed with shattered and sheared volcanic deposits. Soils yellow-brown earths and occasionally associated with brown granular loams and clays or brown loams. Soils generally have less favourable drainage characteristics than those in IVe5. Potential for moderate to severe sheet, rill and gully erosion when cultivated.

**Type location:** P08/099761 Bond Road

**Altitudinal range:** 0–400 m

**Slope:** Rolling to strongly rolling (C, D), 8–20°

**Landform:** Rolling to strongly rolling terrain. Downlands.

**Rock type:** Argillite (Ar) and massive (Sm) which has been shattered. Argillite (Ar) complexed with massive sandstone (Sm), and/or crushed argillite (Ac) and/or jointed mudstone and/or ancient volcanics (In), expressed as Ar+Sm, Sm+Ar, Ar+Sm+Ac, Ar+Sm+Mj, Ar+In, Ar+Sm+In.

**Soils:** Yellow-brown earths on shattered argillites and sandstones. Weakly to strongly leached and weakly podzolised yellow-brown earths of Omu suite (OM, AP, OA, PX), Omanaia suite (WN, ON, ONe, AE, AEe, KW, YR, HW) and Purua suite (PU, TN, TNa, OC). Yellow-brown earths occasionally complexed with minor brown granular loams and clays or brown loams.

**Erosion:** *Present:* Slight (1) sheet (Sh), gully (G), tunnel gully (T), soil slip (Ss) and earthflow (Ef)
*Potential:* Moderate (2) sheet (Sh), gully (G), tunnel gully (T), soil slip (Ss), earthslip (Es) and earthflow (Ef). Moderate (2) to severe (3) sheet (Sh), rill (R), and gully (G) when cultivated

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM), gorse (sG), exotic conifer forest (fF), exotic scrub (sE), lowland podocarp–broadleaved (fO).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*
Grazing – Intensive to semi-intensive
– Present average carrying capacity (s.u./ha) = 13
– Top farmer carrying capacity (s.u./ha) = 15
Reversion to scrub
Forestry – Production – exotic spp.

*Potential:*
Grazing – Intensive
– Attainable physical potential carrying capacity (s.u./ha) = 18
Cropping – Root and green fodder crops
Forestry – Production – site index for *Pinus radiata* = 30–33

**Soil conservation management:** Good soil conservation management essential.
– Contour cultivation and minimum-tillage practices essential when cultivating.

- Avoid structural degradation of soils under intensive, regular cultivation or repeated compaction. Avoid cultivating saturated (e.g. near field capacity) soils.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking, tracking along fencelines, gates, around troughs). Controls may include closer subdivision, rotational grazing, adequate spelling of pastures. Avoid excessive pugging of soils by heavy stock in winter.
- Runoff should be channelled away from steeper slopes. Control runoff using appropriate techniques such as grassed waterways, graded banks.
- Space plant trees in erosion-prone areas (e.g. mass movements). Limited tree planting and subsurface drainage in "wetter" areas. Pair plant trees in gullies.
- Maintain good-quality pasture cover.
- Shelterbelts may be useful in regulating soil moisture levels.
- Carefully plan all earthworks such as roads, drains, and dams. Avoid potentially unstable sites.

**Comments:** Soils often imperfectly drained to poorly drained.

## LUC unit: IVe7 (18 461 ha)

**LUC suite:** 5. Greywacke terrain:
(LUC units IVe7, VIe9, VIe10, VIe17, VIc1, VIIe5)

**Description:** Gently rolling to strongly rolling slopes within subdued rolling to hilly landscape (e.g. downlands) on greywacke. Soils are yellow-brown earths. Potential for moderate to severe sheet, rill, wind and gully when cultivated.

**Type location:** P05/015680 Rangitane Road

**Altitudinal range:** 0–400 m

**Slope:** Rolling to strongly rolling (C, D), 8–20°

**Landform:** Rolling to strongly rolling terrain. Downlands.

**Rock type:** Greywacke association of rocks (Gw). Predominantly that extensive area of rocks belonging to Waipapa Group.

**Soils:** Yellow-brown earths on greywacke and argillite. Moderately to strongly leached and weakly podzolised yellow-brown earths of Marua suite (MRr, MR, MRu, RA, RAl).

**Erosion:** *Present:* Slight (1) sheet (Sh), gully (G) and soil slip (Ss)
*Potential:* Slight (1) to moderate (2) soil slip (Ss), earthslip (Es), sheet (Sh) and gully (G). Moderate (2) to severe (3), sheet (Sh), rill (R), wind (W) and gully (G) when cultivated

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM), gorse (sG), exotic conifer forest (fF).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*
Grazing – Intensive to semi-intensive
– Present average carrying capacity (s.u./ha) = 13
– Top farmer carrying capacity (s.u./ha) = 15
Reversion to scrub
*Potential:*
Grazing – Intensive
– Attainable physical potential carrying capacity (s.u./ha) = 18
Cropping – Root and green fodder crops
Forestry – Production – site index for *Pinus radiata* = 28–31

**Soil conservation management:**
- Contour cultivation and minimum-tillage practices recommended when cultivating.
- Avoid structural degradation of soils under intensive, continuous cultivation or repeated compaction. Avoid cultivating saturated (e.g. near field capacity) soils.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking, tracking along fencelines, gates, around troughs). Controls may include closer subdivision, rotational grazing, adequate spelling of pastures. Avoid excessive pugging of soils by heavy stock in winter.
- Runoff should be channelled away from steeper slopes. Control runoff using appropriate techniques such as grassed waterways, graded banks.
- Space plant trees in erosion-prone areas (e.g. mass movements). Pair plant trees in gullies.
- Maintain good-quality pasture cover.
- Shelterbelts may be useful in regulating soil moisture levels.

**Comments:** Heavy soils, but support excellent pastures. Require light to moderate applications of phosphate and lime. Soils may be susceptible to soil moisture deficits in summer months.

## LUC unit: IVe8 (23 445 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4c. Sheared mixed lithologies:
(LUC units IVe8, VIe12, VIIe2)

**Description:** Gently rolling to rolling slopes within subdued rolling landscape on relatively unstable fractured and sheared mixed sedimentary lithologies, with high proportion of mudstone, e.g. multi-coloured mudstones. Land surface is typically hummocky and irregular with broken terrain caused by mass movement. Typical soils are yellow-brown earths and podzolised yellow-brown earths. Potential for moderate to severe sheet, rill, and gully when cultivated. Soils have poor internal drainage characteristics. Soil fertility may be quite spatially variable and range from low to medium.

**Type location:** 005/634565 State Highway 1 near Rangiahua

**Altitudinal range:** 0–400 m

**Slope:** Gently rolling to strongly rolling (C, D), 8–20°

**Landform:** Rolling to strongly rolling terrain. Downlands.

**Rock type:** Sheared mixed lithologies (Mx). Fractured and sheared multicoloured mudstones sandstones, argillites and argillaceous limestone.

**Soils:** Yellow-brown earths, podzolised yellow-brown earths and rendzinas on sheared mixed sedimentary lithologies. Weakly to strongly leached and weakly podzolised yellow-brown earths of the Omu suite (OM, AP, OA, PX), Omanaia suite (WN, ON, ONe, AE, AEe, KW, YR, HW) and Purua suite (PU, TN, TNa, OC). Rendzinas of the Konoti suite (KN, KNr), Maungaturoto suite (MO, DF), Arapohue suite (AU, AUd, MT) may be complexed with yellow-brown earths but are of limited area.

**Erosion:** *Present:* Slight (1) to moderate (2) gully (G) and earthflow (Ef). Negligible (0) to slight (1) sheet (Sh), rill (R), soil slip (Ss) and tunnel gully (T)

*Potential:* Moderate (2) earthflow (Ef) and gully (G). Slight (1) to moderate (2) sheet (Sh), soil slip (Ss), and tunnel gully (T). Moderate (2) to severe (3) sheet (Sh), rill (R), and gully (G) when cultivated

**Vegetation:** Improved pasture (gl), rushes, sedges (hR), root and green fodder crops (cR), semi-improved pasture (gS), podocarp forest (fP), erosion control trees such as exotic broadleaved forest (fR) and exotic conifer forest (efF), exotic conifer forest (fF).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*
Grazing
- Intensive to semi-intensive
- Present average carrying capacity (s.u./ha) = 13
- Top farmer carrying capacity (s.u./ha) = 15

Reversion to scrub

*Potential:*
Grazing
- Intensive
- Attainable physical potential carrying capacity (s.u./ha) = 18

Cropping – Root and green fodder crops

Forestry – Production – site index for *Pinus radiata* = 30–33

**Soil conservation management:** Good soil conservation management is essential
- Contour cultivation and minimum-tillage practices essential when

cultivating.

- Avoid structural degradation of soil under intense, continuous cultivation or repeated compaction. Avoid cultivating saturated (e.g. near field capacity) soils.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking, tracking along fencelines, gates around troughs). Controls may include closer subdivision, rotational grazing, adequate spelling of pastures. Avoid excessive pugging of soils by heavy stock in winter.
- Runoff should be channelled away from steeper slopes. Control runoff using appropriate techniques such as grassed waterways, graded banks.
- Space plant trees in erosion-prone areas (e.g. mass movements). Limited tree planting and subsurface drainage in "wetter" areas. Pair plant trees in gullies, tunnel gullies.
- Carefully plan all earthworks such as roads, drains, stock ponds, and dams. Avoid potentially unstable sites and excavation of the toe of the slope.
- Maintain good-quality pasture cover/application of fertiliser.
- Attention to subsurface drainage.

**Comments:** Associated with creeping earthflows, road bank collapse, terracette creep and large seepage zones. At the 1:50 000 scale of mapping, podzolised soils have been separated from this unit where possible and placed in IVe12.

## LUC unit: IVe9 (8619 ha)

**LUC suite:** 1. Coastal sand country

**LUC subsuite:** 1b. Old stable sand dunes on unconsolidated to compact sands: (LUC units IIIe5, IIIs4, IVe9, VIe6, VIIe9)

**Description:** Rolling to strongly rolling slopes on old (Pleistocene) coastal dune landforms, e.g. interdune valleys and dune hills. Formed on unconsolidated to compact dunesands i.e. aeolian sands. Typical soils are yellow-brown sands. Potential for moderate sheet, wind, rill and gully when cultivated.

**Type location:** P08/920660 Red Hill/Te Maire Road

**Altitudinal range:** 0–200 m

**Slope:** Rolling to strongly rolling (C, C+D), 8–20°

**Landform:** Rolling to strongly rolling older duneforms.

**Rock type:** Unconsolidated sands (Us). Strongly weathered unconsolidated to compact sands.

**Soils:** Yellow-brown sands on aeolian sand. Moderately weathered to strongly leached yellow-brown sands of Pinaki suite (HO, RLa, RL, RLI, HOH, RLaH, RLH, RLIH).

**Erosion:** *Present:* Slight (1) to moderate (2) sheet (Sh) and wind (W). Negligible (0) to slight (1) gully (G)

*Potential:* Slight (1) to moderate (2) sheet (Sh), wind (W) and gully (G). Moderate (2) sheet (Sh), wind (W), rill (R) and gully (G). when cultivated

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM), heath (sH), coastal scrub (SO).

**Annual rainfall range:** 1000–1400 mm

**Land use:** *Present:*

| | | |
|---|---|---|
| Grazing | – | Intensive to semi-intensive |
| | – | Present average carrying capacity (s.u./ha) = 13 |
| | – | Top farmer carrying capacity (s.u./ha) = 15 |

*Potential:*

| | | |
|---|---|---|
| Grazing | – | Intensive |
| | – | Attainable physical potential carrying capacity (s.u./ha) = 18 |
| Cropping | – | Root and green fodder crops |
| Forestry | – | Production – site index for *Pinus radiata* = 27–30 |

**Soil conservation management:**

- When cultivating, contour cultivation and minimum-tillage practices essential.
- Shelterbelts required on this type of land for minimising wind and sheet erosion, under pastoral and horticultural land use. Cultivated areas should not be left exposed and unprotected for long periods (e.g. exposed to wind erosion). Shelterbelts may be useful in regulating soil moisture levels.
- Maintain complete vegetative cover and good pasture quality.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking, particularly near gates, fencelines and around troughs).
- Irrigation is important in some areas, particularly for horticulture.

**Comments:** Soils are well drained to somewhat excessively drained and subject to seasonal soil moisture deficiencies. With regular topdressing of phosphate and potash the Houhora and Red Hill soils give excellent pastures. Lime may not be required on soils.

## LUC unit: IVe10 (17 405 ha)

**LUC suite:** 1. Coastal sand country

**LUC subsuite:** 1c. Old stable podzolised terraces and escarpments on unconsolidated to compact sands:
(LUC units IVe10, IVs5, VIe14, VIs4, VIIe9)

**Description:** Rolling to strongly rolling slopes at the sides of old coastal terraces and low hills. Formed on semi-consolidated sands and gravels. Soils show varying degrees of podzolisation, and are typically podzols, gley podzols and podzolised yellow-brown earths. Soils are generally quite infertile (low in nutrients). Potential for moderate to severe rill, gully, wind and sheet when cultivated.

**Type location:** P08/908752 Te Kopuru area

**Altitudinal range:** 0–200 m

**Slope:** Rolling to strongly rolling (C, C+D), 8–20°

**Landform:** Rolling to strongly rolling land on and at sides of coastal terraces and older dune forms.

**Rock type:** Unconsolidated sands (Us). Strongly weathered unconsolidated to compact sands.

**Soils:** Podzolised yellow-brown earths and podzols on aeolian sand. Weakly to moderately podzolised yellow-brown earths of Pinaki suite (TT, TTH), podzolised gley soils of Pinaki suite (TEKm) and podzols of Pinaki suite (TX, TXp, TEK, TEKy).

**Erosion:** *Present:* Slight (1) to moderate (2) sheet (Sh), wind (W), gully (G) and rill (R)
*Potential:* Slight (1) to moderate (2) sheet (Sh), gully (G), rill (R) and wind (W). Moderate (2) to severe (3) rill (R), gully (G), wind (W), and sheet (Sh) when cultivated

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM), cassinia (sC), heath (sH), exotic conifer forest (fF), exotic scrub (SE).

**Annual rainfall range:** 1000–1400 mm

**Land use:** *Present:*
Grazing – Intensive to semi-intensive
– Present average carrying capacity (s.u./ha) = 11
– Top farmer carrying capacity (s.u./ha) = 13
Reversion to scrub
Forestry – Production – exotic spp.

*Potential:*
Grazing – Intensive
– Attainable physical potential carrying capacity (s.u./ha) = 15
Cropping – Root and green fodder crops
Forestry – Production – site index for *Pinus radiata* = 24–30

**Soil conservation management:**
- When cultivating, contour cultivation and minimum-tillage practices essential. In some areas deep ripping required as pretreatment because of hardpans in subsoil.
- Correct siting of drainage channels to prevent initiation of gullies.
- Shelterbelts and tree planting recommended to minimise wind erosion, to improve soil structure and drainage, and increase organic matter in soils.

- Maintain complete vegetative cover and good pasture quality.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking, particularly near gates, fencelines and around troughs).
- Irrigation important in some areas, particularly for horticulture.

**Comments:** Pastures, or exotic forest are difficult to establish and maintain on low-fertility soils. Land is quite productive with moderate to high applications of lime and other fertilisers.

## LUC unit: IVe11 (1231 ha)

**LUC suite:** 7. Old volcanic terrain

**LUC subsuite:** 7c. Acid to intermediate igneous volcanics and plutonics: (LUC units IVe11, VIe18, VIIe7)

**Description:** Rolling to strongly rolling slopes within rolling to hilly landscapes, and at sides of steep volcanic masses, on 'acid' to 'intermediate' igneous rocks (e.g. dacite, rhyolite) and plutonics (e.g. granodiorite). Soils are typically strongly leached to podzolised yellow-brown earths. Potential for moderate to severe sheet, rill, and gully erosion when cultivated. Soil fertility is generally low and bare-ground areas are often difficult to revegetate.

**Type location:** 003/510060 Karikari Peninsula

**Altitudinal range:** 0–300 m

**Slope:** Rolling to strongly rolling (C, C+D), 8–20°

**Landform:** Rolling to strongly rolling terrain. Usually lower hillslopes at sides of old volcanic complexes such as volcanic cones and domes, and on downlands of hill country. Could be mapped on some old coastal terraces, marine benches.

**Rock type:** Plutonics (Gn). Lavas and welded ignimbrites (Vo). Dacite, rhyolite and granodiorite.

**Soils:** Yellow-brown earths on dacite, rhyolite and granodiorite. Moderately to strongly leached and weakly to moderately podzolised yellow-brown earths of Maungarei suite (ME, PF, PM).

**Erosion:** *Present:* Slight (1) to moderate (2) sheet (Sh), wind (W), gully (G) and rill (R)
*Potential:* Slight (1) to severe (3) sheet (Sh), gully (G), rill (R) and wind (W). Moderate (2) to severe (3) sheet (Sh), rill (R) and gully (G) when cultivated. Negligible (0) to slight (1) soil slip (Ss)

**Vegetation:** Manuka, kanuka (sM), semi-improved pasture (gl), exotic conifer forest (fF).

**Annual rainfall range:** 1000–1600 mm

**Land use:** *Present:*
Grazing – Semi-intensive
– Present average carrying capacity (s.u./ha) = 13
– Top farmer carrying capacity (s.u./ha) = 15
Undeveloped land
Reversion to scrub
Forestry – Production – exotic spp.
*Potential:*
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 18
Cropping – Root and green fodder crops
Forestry – Production – site index for *Pinus radiata* = 21–24

**Soil conservation management:** Good soil conservation management essential.
- Contour cultivation and minimum-tillage practices essential when cultivating. Cultivation should be confined to easier slopes.
- Avoid structural degradation (e.g. compaction) of soils under intensive, regular cultivation.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking, tracking along fencelines, gates

around troughs). Controls may include closer subdivision, rotational grazing, adequate spelling of pastures. Avoid excessive pugging of soils by heavy stock in winter.

- Runoff should be channelled away from steeper slopes and controlled using appropriate techniques such as grassed waterways, graded banks.
- Space plant trees in erosion-prone areas (e.g. mass movements). Limited tree planting in natural depressions (e.g. wetter sites). Pair plant trees in gullies, tunnel gullies. Windbreaks, shelterbelts useful in some areas for minimising wind erosion and regulating soil moisture levels.
- Carefully plan all earthworks such as roads, dams, drains and stock ponds. Avoid potentially unstable sites.
- Maintain good-quality pasture cover/apply adequate fertiliser levels.
- Attention to subsurface drainage.

**Comments:** Pastures, or exotic forest, are difficult to establish and maintain on low-fertility soils. Land is quite productive with moderate to high applications of lime and other fertilisers.

## LUC unit: IVe12 (14 630 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4g. Podzols on sedimentary rock:
(LUC units IVe12, IVs4, IVw4, VIs5)

**Description:** Gently rolling to strongly rolling slopes within subdued rolling landscape with podzolised soils. Unit generally occurs on the lower slopes of downlands. Typical gumland. Slopes formed on a range of sedimentary lithologies. Potential for moderate to severe sheet, rill and gully erosion when cultivated. Natural soil fertility generally very low.

**Type location:** P05/945585 Wiroa Road

**Altitudinal range:** 0–400 m

**Slope:** Rolling to strongly (C, C+D), 8–20°

**Landform:** Rolling to strongly rolling terrain. Subdued topography.

**Rock type:** Massive sandstone (Sm), massive mudstone (Mm), jointed mudstone (Mj), bedded sandstone (Sb), bedded mudstone (Mb), argillite (Ar), crushed argillite (Ac) association of rocks, sheared mixed lithologies (Mx), lavas and welded ignimbrites (Vo).

**Soils:** Podzols on various sedimentary lithologies. Podzols of Puhoi suite (WKf, WKfp), Waiotira suite (WKa, WKap) Omu suite (WK, WKp, WKr), Maungarei suite (PR, PRp). Moderately podzolised yellow-brown earths of Puhoi suite (HKf, MV, OU), Waiotira suite (HKa, PD, PW) Omu suite (HK, HKg, YK, YKl, OP) Marua suite (HKr), Maungarei suite (PM), Omanaia suite (HW).

**Erosion:** *Present:* Slight (1) to moderate (2) tunnel gully (T) and sheet (Sh). Slight (1) earthflow (Ef), and gully (G)

*Potential:* Moderate (2) earthflow (Ef), soil slip (Ss), tunnel gully (T), sheet (Sh) and gully (G). Moderate (2) to severe (3) sheet (Sh), rill (R) and gully (G) when cultivated

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM), rushes, sedges (hR).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*

Grazing
- Intensive to semi-intensive
- Present average carrying capacity (s.u./ha) = 13
- Top farmer carrying capacity (s.u./ha) = 15

Reversion to scrub
Undeveloped land

*Potential:*

Grazing
- Intensive
- Attainable physical potential carrying capacity (s.u./ha) = 18

Cropping – Root and green fodder crops
Forestry – Production – site index for *Pinus radiata* = 28–32

**Soil conservation management:** Good soil conservation management essential.
- When cultivating, contour cultivation and minimum-tillage practices essential. Cultivation should be confined to easier slopes.
- Avoid structural degradation of soils under repeated cultivation and compaction, especially when saturated.

- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking, tracking along fencelines, gates, around troughs). Include closer subdivision, rotational grazing, adequate spelling of pastures. Avoid excessive pugging of soils by heavy stock in winter.
- Runoff should be channelled away from steeper slopes. Control runoff using appropriate techniques such as grassed waterways, graded banks.
- Space plant trees in erosion-prone areas (e.g. mass movements). Limited tree planting in "wetter" areas. Pair plant trees in gullies, tunnel gullies.
- Carefully plan all earthworks such as roads, dams, drains, and stock ponds. Avoid potentially unstable sites.
- Maintain good-quality pasture cover/apply adequate fertiliser levels.
- Attention to subsurface drainage.

**Comments:** Pastures, or exotic forest are difficult to establish and maintain on low-fertility soils. Land is quite productive with moderate to high applications of lime and other fertilisers.

## LUC unit: IVw1 (35 423 ha)

**LUC suite:** 2. Alluvial and estuarine plains and low terraces

**LUC subsuite:** 2c. Poorly drained floodplains and low terraces: (LUC units IVw1, VIw1, VIIw1)

**Description:** Flat to gently undulating areas on floodplains, valleyplains and low terraces on alluvium, with continuing severe wetness or flooding limitation to arable use. Severe limitations to cropping because of runoff from adjacent hills, flooding of streams and high watertables. Potential for moderate streambank erosion and deposition. Recent soils on alluvium characteristic of this unit. Weakly to strongly leached yellow-brown earths and brown granular loams and clays with severe wetness limitations recorded on higher terraces. Waipuna clay on higher terraces included because of continuing wetness due to poor internal drainage of soils. Areas assessed as requiring on-farm drainage.

**Type location:** Q06/pt R06/217305

**Altitudinal range:** 0–100 m

**Slope:** Flat to undulating with limited areas of undulating land (A, B), 0–7°

**Landform:** Floodplains and low terraces.

**Rock type:** Fine alluvium (Af). Undifferentiated fine-grained alluvium, floodplain alluvium (Af), and fine alluvium intercalated with organic-peat deposits (Af + Pt).

**Soils:** Recent soils on sedimentary and volcanic alluvium. Recent soils of Whareora suite (WFa, WF, WFa) and Kohumaru suite (MF, MFm). Moderately to strongly leached yellow-brown earths of Whareora suite (WU). Moderately to strongly leached brown granular loams and clays of Kohumaru suite (KM, KMm). Gley soils of Kaipara suite (TZ, TZy, KP, KPy, KA, KAy), Waipapa suite (KO, KOr, KOl, KOy, YF), Waipu suite (YUa, YUay, YU, YUy, YA) included where wetness is considered a severe limitation to arable use.

**Erosion:** *Present:* Negligible (0) to moderate (2) streambank (Sb). Negligible (0) to slight (1) deposition (D). Some areas may show moderate (2) to severe (3) deposition after floods

*Potential:* Moderate streambank (Sb) and deposition (D)

**Vegetation:** Improved pasture (gl), rushes, sedges (hR), wetland vegetation (hW), gorse (sG), manuka, kanuka (sM).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*

| | | |
|---|---|---|
| Grazing | – | Intensive |
| | – | Present average carrying capacity (s.u./ha) = 17 |
| | – | Top farmer carrying capacity (s.u./ha) = 20 |
| Cropping | – | Root and green fodder crops |

*Potential:*

| | | |
|---|---|---|
| Grazing | – | Intensive |
| | – | Attainable physical potential carrying capacity (s.u./ha) = 24 |
| Cropping | – | Root and green fodder crops |
| Forestry | – | Production – site index for *Pinus radiata* = 20–23. |

**Soil conservation management:** These areas may be prone to occasional flooding (deposition and erosion). Suitable flood protection such as drainage and stopbanks should be

considered on a long-term basis, management should be directed over whole catchment.

- On-farm drainage required. Maintain condition of drains.
- Stopbanks should be constructed in flood prone areas and their condition maintained.
- Streambank protection may be required. Erosion can be locally severe and difficult and expensive to repair or control.
- Maintain clearance of vegetation within stream and river channels.
- Watertables need to be monitored and controlled.

**Comments:** Soils may range from well to poorly drained. Much land can be effectively drained, but high watertables, periodic flooding, and runoff from surrounding hills add to the drainage difficulty. Many areas require stopbank protection.

## LUC unit: IVw2 (5506 ha)

**LUC suite:** 2. Alluvial and estuarine plains and low terraces

**LUC subsuite:** 2d. Mudflats with saline soils:
(LUC units IIIw3, IVw2, VIw2)

**Description:** Flat reclaimed tidal mudflats, estuarine plains, with slightly saline gley soils on alluvium. Extensive flat areas formed on estuarine and sedimentary alluvium. Extreme wetness limitation to arable use. These areas have high watertables and soils have relatively high salinity levels. Occurs at margins of harbour areas, bays, intertidal creeks and streams.

**Type location:** P04/770790 State Highway 10, Whangaroa

**Altitudinal range:** 0–20 m

**Slope:** Flat (A), 0–3°

**Landform:** Tidal mudflats, margins of lagoons, estuaries, floodplains.

**Rock type:** Fine alluvium (Af). Undifferentiated alluvium, fluvial and estuarine deposits.

**Soils:** Slightly saline gley soils on coastal mudflats. Slightly saline gley soils of the Kaipara suite (TCa, TC, TCy, TCya). Parent materials include estuarine clays, sands and alluvium.

**Erosion:** *Present:* Negligible
*Potential:* Slight (1) wind (W) and sheet (Sh) when cultivated

**Vegetation:** Semi-improved pasture (gS), rushes, sedges (hR), improved pasture (gI).

**Annual rainfall range:** 1000–1400 mm

**Land use:**

| | | | |
|---|---|---|---|
| *Present:* | Grazing | – | Intensive, incl. dairying |
| | | – | Present average carrying capacity (s.u./ha) = 13 |
| | | – | Top farmer carrying capacity (s.u./ha) = 15 |
| | Cropping | – | Root and green fodder crops |
| *Potential:* | Grazing | – | Intensive |
| | | – | Attainable physical potential carrying capacity (s.u./ha) = 18 |
| | Cropping | – | Root and green fodder crops |
| | Forestry | – | Production – site index for *Pinus radiata* = <18 |

**Soil conservation management:** Areas may be prone to occasional tidal flooding. Suitable flood protection required, management should be considered over broader catchment/coastal area.

- Stopbanks required. Their condition should be maintained.
- Drainage required. Maintain condition of drains.
- Watertables need to be monitored and controlled.
- Deposition may be a problem where flood discharge is high or where tidal influences occur in lower reaches of channels and in estuarine areas.
- Maintain dense vegetative cover to minimise sheet and wind erosion/bare-ground areas, particularly areas affected by concentrated stock movement.
- Tree planting and other suitable vegetation grown on either side of major drains can act as windbreaks, protect and stabilise drains, control watertable levels, stock control, etc.

**Comments:** Much of this land can be effectively drained and reclaimed. With continued drainage and reduction in saline levels this unit may eventually progress towards a IIIw subclass.

## LUC unit: IVw3 (11 358 ha)

**LUC suite:** 2. Alluvial and estuarine plains and low terraces

**LUC subsuite:** 2e. Peats:
(LUC units IIIw4, IVw3, VIw3, VIIw2)

**Description:** Flat to gently undulating slopes with organic soils on peat and alluvium. Typically narrow peat-filled valleys with continuing severe wetness limitation subject to occasional flooding. Includes areas of peat with continuing severe wetness limitation on plains and terraces, and interdune swamps where peats have accumulated within valleys in sand country. Extreme wetness limitation to arable use. Watertables may be near or at surface in winter months. High watertable, periodic flooding and runoff from surrounding hills add to drainage difficulty.

**Type location:** P08/950668 Near Dargaville–Taingaehe Road

**Altitudinal range:** 0–100 m

**Slope:** Flat to undulating (A, B). 0–7°

**Landform:** Low-lying land on peat such as plains, swamp-filled valleys, floodplains.

**Rock type:** Peat (Pt) and peat/sand complex (Pt+Af).

**Soils:** Organic soils on peat or peat and sand. Organic soils of Ruakaka suite (PZ, OT, RK, RKu, RKd, RKv, RKl), and Otonga suite (OG, OGd, OGv, OR, ORd).

**Erosion:** *Present:* Negligible (0) to slight (1) streambank (Sb) and deposition (D). Negligible (0) to slight (1) gully in valleys on peat and sand within the sand country

*Potential:* Slight (1) streambank (Sb) and deposition (D). Some areas may show moderate (2) deposition (D) after floods. Slight (1) to moderate (2) gully on some deposits, particularly in the sand country

**Vegetation:** Improved pasture (gI), manuka, kanuka (sM), rushes, sedges (hR).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*

| | | |
|---|---|---|
| Grazing | – | Intensive |
| | – | Present average carrying capacity (s.u./ha) = 17 |
| | – | Top farmer carrying capacity (s.u./ha) = 20 |
| Cropping | – | Root and green fodder crops |

*Potential:*

| | | |
|---|---|---|
| Grazing | – | Intensive |
| | – | Attainable physical potential carrying capacity (s.u./ha) = 24 |
| Cropping | – | Root and green fodder crops |
| Forestry | – | Production – site index for *Pinus radiata* = <18 |

**Soil conservation management:** Affected by high watertables and may be prone to occasional flooding. Suitable flood protection and drainage should be carefully planned in context of wider area.

- Drainage required. Maintain condition of drains.
- Watertables need to be monitored and controlled.
- Deposition may be a problem where flood discharge is high or where tidal influences occur in lower reaches of channels and in estuarine areas.
- Stopbanks are required. Their condition should be maintained.
- Tree planting and other suitable vegetation grown on either side of major drains can protect and stabilise drains, control watertable levels, stock control, etc.

- Maintain clearance of vegetation within stream and river channels.
- Streambank protection may be required. Erosion can be locally severe, and difficult and expensive to repair or control.
- Gully erosion can be a problem in sand country areas.

**Comments:** Soils poorly to very poorly drained. Much of this land can be effectively drained and relcaimed. Pastures require topdressing with phosphate, potash and lime. Small amounts of copper may be required to offset high molybdenum levels.

## LUC unit: IVw4 (3797 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4g. Podzols on sedimentary rock:
(LUC units IVe12, IVs4, IVw4, VIs5)

**Description:** Long undulating to gently rolling slopes within subdued rolling landscape on a range of sedimentary lithologies e.g. fractured and sheared mixed sedimentary lithologies, limestone occasionally veneered by colluvium and alluvium. Spatially complex soils include rendzinas, yellow-brown earths and podzols. Typical gumland unit has continuing severe wetness limitation to arable use. Typically mapped on soils with poor internal drainage characteristics where wetness is considered a dominant physical limitation to sustainable use.

**Type location:** R10/570035 Dairy Flat, North Auckland

**Altitudinal range:** 0–400 m

**Slope:** Flat to gently rolling (B, B+A, B+C), 3–15°

**Landform:** Undulating to easy rolling land within subdued landscape. Includes 'wet' areas such as poorly drained slopes, alluvial fans.

**Rock type:** Argillite (Ar), limestone (Li), mixed lithologies (Mx) jointed mudstone (Mj), massive sandstone (Sm), bedded sandstone (Sm), massive mudstone (Mm), unconsolidated clays and silts (Uf).

**Soils:** Complex of soils, including rendzinas, yellow-brown earths and loams, and podzols on various sedimentary rocks. Weakly to moderately podzolised yellow-brown earths and podzols complexed with rendzinas and soils of C4 complex. Weakly to moderately podzolised yellow-brown earths of Omu suite (YK, YKl, OP), Puhoi suite (MV, OU, HKf), rendzinas of the Maungaturoto suite (DF) and Arapohue suite (MT), C4 complex soils (DF, MT, YK, WK, OL, OLm). Includes areas of strongly leached Y-B earths of Omu suite (OA, PX), and podzols of Omu suite (WK).

**Erosion:** *Present:* Negligible (0) to slight (1) tunnel gully (T), sheet (Sh), gully (G), and earthflow (Ef)

*Potential:* Moderate (2) sheet (Sh), rill (R), tunnel gully (T) and gully (G). Slight (1) earthflow (Ef). Moderate (2) sheet (Sh) and rill (R) when cultivated. Slight (1) gully (G) when cultivated

**Vegetation:** Improved pasture (gl), rushes, sedges (hR).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*
- Grazing – Intensive, incl. dairying
  - Present average carrying capacity (s.u./ha) = 13
  - Top farmer carrying capacity (s.u./ha) = 15

*Potential:*
- Grazing – Intensive
  - Attainable physical potential carrying capacity (s.u./ha) = 18
- Cropping – Root and green fodder crops
- Forestry – Production – site index for *Pinus radiata* = 20–24

**Soil conservation management:** Good soil conservation management is essential.
- Contour cultivation and minimum-tillage practices essential. Avoid structural degradation of soils under saturated conditions.

- Attention to subsurface drainage necessary.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking, tracking along fencelines, gates around troughs). Controls may include closer subdivision, rotational grazing, adequate spelling of pastures. Avoid excessive pugging of soils by heavy stock in winter.
- Pugging of soils is major problem.
- Control runoff using appropriate techniques such as grassed waterways, graded banks. Space plant trees in erosion-prone areas (e.g. mass movements) and pair plant trees in gullies, tunnel gullies.
- Carefully plan all earthworks such as roads, dams, drains, and stock ponds. Avoid channelling into gullies. Avoid potentially unstable sites (for example, undercutting the toe of slopes).
- Maintain good-quality pasture cover/apply adequate fertiliser levels.

**Comments:** Soils have poor internal drainage.

## LUC unit: IVs1 (2656 ha)

**LUC suite:** 6. Young basalt volcanic terrain:
(LUC units Ic1, IIe1, IIs1, IIIe1, IIIs1, IIIs2, IVe2, IVs1, IVs2, Vs1, VIs1, VIe4, VIIIs2)

**Description:** Flat to rolling slopes on young basalt rock with numerous stones, gravels and boulders scattered over land surface and throughout soil profile. Soil depths often range from 15 to 60 cm over hard weathered basalt rock. Surface characterised by outcrops of basalt boulders often forming hummocky mounds. Gravel/boulder content in some areas can be greater than 35% by volume of soil profile. Stoniness and shallow soil depth are severe limitation to arable use. Soils prone to seasonal soil moisture deficiencies in drier months. Often mapped at the edge of basalt lava flows e.g. terraces and plains.

**Type location:** P05/996522 Oromahoe

**Altitudinal range:** 0–400 m

**Slope:** Flat to rolling (A, B, C), 0–15°

**Landform:** Flat to gently rolling surfaces on basalt lava terraces, low domes, and plains. Also mapped on low angle slopes near base of scoria cones and mounds.

**Rock type:** Lavas (Vo), Scoria (Sc).

**Soils:** Brown and red loams with a stony or bouldery phase on basalt flows, basalt scoria and ash. Weakly to moderately leached brown and red loams with boulders and stones. Weakly to moderately leached brown loams of Kiripaka suite (KB, KBb, KBe, KBeb, OWb), moderately to strongly leached brown loams of Kiripaka suite (YOb, MCb, KEb, RTb). Red loams of Papakauri suite (MUb) may be included.

**Erosion:** *Present:* Negligible (0) to slight (1) sheet
*Potential:* Moderate (2) sheet (Sh). Slight (1) wind (W). Slight (1) rill (R), sheet (Sh) and wind (W) when cultivated

**Vegetation:** Improved pasture (gl), podocarp forest (fP) commonly scattered through pasture, manuka, kanuka (sM), gorse (sG).

**Annual rainfall range:** 1200–1600 mm

**Land use:**

| | | | |
|---|---|---|---|
| *Present:* | Grazing | – | Intensive |
| | | – | Present average carrying capacity (s.u./ha) = 21 |
| | | – | Top farmer carrying capacity (s.u./ha) = 26 |
| *Potential:* | Grazing | – | Intensive |
| | | – | Attainable physical potential carrying capacity (s.u./ha) = 30 |
| | Cropping | – | Root and green fodder crops. Horticulture. |
| | Forestry | – | Production – site index for *Pinus radiata* = 28–30 |

**Soil conservation management:**
- When cultivating, contour cultivation and minimum-tillage practices recommended.
- Removal of stones and boulders is required at many sites.
- Irrigation may be necessary, particularly for horticulture.
- Shelterbelts recommended for pastoral, cropping and horticultural land uses to minimise surficial erosion, maintain soil moisture levels.
- Control grazing by avoiding overstocking and concentrated stock movement (repeated tracking). Bare ground difficult to revegetate on these soils when topsoil depleted.
- Maintain good pasture cover/apply adequate fertiliser levels.

**Comments:** Soils prone to seasonal soil moisture deficiencies, particularly during summer months.

## LUC unit: IVs2 (4142 ha)

**LUC suite:** 6. Young basalt volcanic terrain:
(LUC units Ic1, IIe1, IIs1, IIIe1, IIIs1, IIIs2, IVe2, IVs1, IVs2, Vs1, VIs1, VIe4, VIIIs2)

**Description:** Flat to undulating slopes on deeply weathered basalt rock. Soils strongly leached brown loams, generally of low fertility and may be poorly drained in places. Internal drainage in some areas may be impeded by underlying basalt.

**Type location:** P05/870635 Mangararetu Road

**Altitudinal range:** 0–400 m

**Slope:** Flat to undulating (A, A+B, B), 0–7°

**Landform:** Flat to gently rolling surfaces on basalt lava plains, terraces, and low domes.

**Rock type:** Lavas (Vo), scoria (Sc).

**Soils:** Brown loams on basalt flows and ash. Strongly to very strongly leached brown loams of Kiripaka suite (TA, OKu, OK, OKg, ODg, OD, PG, RT).

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh) and gully (G)
*Potential:* Slight (1) to moderate (2) rill (R) and sheet (Sh) when cultivated

**Vegetation:** Improved pasture (gI), manuka, kanuka (sM), rushes, sedges (hR), subtropical fruit (cS).

**Annual rainfall range:** 1200–1600 mm

**Land use:**

| | | | |
|---|---|---|---|
| *Present:* | Grazing | – | Intensive |
| | | – | Present average carrying capacity (s.u./ha) = 13 |
| | | – | Top farmer carrying capacity (s.u./ha) = 15 |
| *Potential:* | Grazing | – | Intensive |
| | | – | Attainable physical potential carrying capacity (s.u./ha) = 18 |
| | Cropping | – | Root and green fodder crops. Horticulture. |
| | Forestry | – | Production – site index for *Pinus radiata* = 26–28 |

**Soil conservation management:**
- When cultivating, contour cultivation and minimum-tillage practices recommended.
- Soils strongly leached and deficient in some nutrients, adequate fertiliser/trace element applications required to counter nutrient deficiencies.
- Maintain good pasture cover and pasture quality.
- Shelterbelts, tree planting recommended for pastoral, cropping and horticultural land uses to minimise surficial erosion, maintain soil moisture levels, increase organic matter.
- Irrigation may be necessary, particularly for horticulture.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking). Bare ground difficult to revegetate when topsoil depleted.

**Comments:** Soils prone to seasonal soil moisture deficiencies, particularly during summer months. Soils generally of low natural fertility and drainage may be impeded in some localised areas. Soils require phosphate and lime for pastoral purposes. Citrus and subtropical crops may be grown but require careful management in locations such as Kerikeri.

## LUC unit: IVs3 (10 407 ha)

**LUC suite:** 7. Old volcanic terrain

**LUC subsuite:** 7a. Landforms on old stable basalt–andesite volcanics with brown granular loams and clays:
(LUC units IVe3, IVs3, Vc2, VIe2, VIe16, VIc1, VIIe1)

**Description:** Flat to gently undulating slopes on old deeply weathered 'basic to intermediate' volcanic rock (e.g. dolerite, andesite) and volcanic alluvium. Rock types recorded in NZLRI include ancient volcanics, In; volcanic breccia, Vb; volcanic alluvium, Uf. Soils brown granular loams and clays. Areas include flat to gently rolling slopes on terraces, plains and high plateaux. Severe soils limitation to arable use due to the low fertility and poor drainage characteristics.

**Type location:** 004/700853 State Highway 10, near Mangonui

**Altitudinal range:** 0–600 m

**Slope:** Flat to undulating (A, B), 0–7°. Includes gently rolling areas (B+C, C+B) >300 m a.s.l. and <600 m a.s.l.

**Landform:** Flat to gently rolling surfaces on old terraces, plains, uplands or plateaux, rolling downlands.

**Rock type:** Ancient volcanics (In), unconsolidated clays and silts (Uf), indurated volcanic breccias (Vb), indurated fine-grained pyroclastics (Tb), lavas and welded ignimbrites (Vo), ultramafics (Um).

**Soils:** Brown granular loams and clays on old volcanic rocks and alluvium. Strongly to very strongly leached brown granular loams and clays of Kohumaru suite (PCr, PC, PCm, PCy, PL), Huia suite (CW, Hl, Hlg), Te Kie suite (RUr, RU, AW, TP), Katui suite (AR). Includes moderately to strongly leached brown granular loams and clays of Katui suite (YP, WT, TO), Huia suite (DV, PA, YT), Te Kie suite (YN, MN). May include some areas of weakly to moderately leached brown granular loams and clays.
Parent materials include volcanic alluvium, shattered dolerites, breccias and tuffs, andesitic agglomerates and breccias and andesitic flows.

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh) and gully (G)
*Potential:* Slight (1) gully (G). Slight (1) rill (R) and sheet (Sh) on undulating to rolling slopes when cultivated

**Vegetation:** Improved pasture (gl), manuka, kanuka (sM), lowland podocarp–broadleaved forest (fO), root and green fodder crops (cR).

**Annual rainfall range:** 1400–1800 mm

**Land use:**

| | | | |
|---|---|---|---|
| *Present:* | Grazing | – | Intensive |
| | | – | Present average carrying capacity (s.u./ha) = 13 |
| | | – | Top farmer carrying capacity (s.u./ha) = 15 |
| *Potential:* | Grazing | – | Intensive |
| | | – | Attainable physical potential carrying capacity (s.u./ha) = 18 |
| | Cropping | – | Root and green fodder crops. Horticulture. |
| | Forestry | – | Production – site index for *Pinus radiata* = 24–27 |

**Soil conservation management:** – When cultivating, contour cultivation and minimum-tillage practices are recommended.

- Soils moderately to strongly leached, and deficient in some nutrients, adequate fertiliser/trace element applications required to counter nutrient deficiencies.
- Maintain good pasture cover and pasture quality.
- Shelterbelts/tree planting recommend for pastoral, cropping and horticultural land uses minimise surficial erosion, maintain soil moisture levels, increase organic matter.
- Irrigation may be necessary, particularly for horticulture.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking). Bare ground difficult to revegetate when topsoil depleted.

**Comments:** Soils prone to seasonal soil moisture deficiencies, particularly during summer months. At high altitudes (>400 m a.s.l.) soils have particularly poor internal drainage characteristics. Heavy topdressing with phosphate, potash, lime, and trace elements needed to establish and maintain pastures. Exotic conifer forest may be limited at higher elevations by higher rainfalls and poor drainage.

## LUC unit: IVs4 (21 753 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4g. Podzols on sedimentary rock:
(LUC units IVe12, IVs4, IVw4, VIs5)

**Description:** Flat to undulating slopes within a subdued rolling landscape where podzols and podzolised yellow-brown earths have developed on alluvium, colluvium and/or a range of sedimentary lithologies including fractured and sheared sedimentary lithologies, and deeply weathered massive sedimentary deposits. Typical gumland. Soils generally of very low natural fertility and have poor structure. Extreme limitations for arable use.

**Type location:** R10/560065 Pine Valley Road, Silverdale

**Altitudinal range:** 0–400 m

**Slope:** Flat to rolling (A-C), 0–15°

**Landform:** Flat to rolling surfaces within subdued landscape. Includes surfaces within downlands, terraces, and plains.

**Rock type:** Fine alluvium (Af) or unconsolidated clays and silts (Uf), sheared mixed lithologies (Mx). A mixture of shattered and sheared sedimentary lithologies (Mx), often associated with alluvium (Af), unconsolidated clays and silts (Uf), or argillite (Ar).

**Soils:** Podzols and podzolised yellow-brown earths on various sedimentary rocks. Podzols of Whareora suite (KRa, KR, KRy, KRe), Puhoi suite (WKf, WKfp), Waiotira suite (WKa) Omu suite (WK, WKr), Maungarei suite (PR). Moderately podzolised yellow-brown earths of Puhoi suite (HKf, MV, OU), Waiotira suite (HKa, PD, PW), Omu suite (HK, HKg, YK, YKl, OP), Marua suite (HKr), Maungarei suite (PM), Omanaia suite (HW).

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh) and gully (G)
*Potential:* Moderate (2) gully (G) and tunnel gully (T) under pasture. Slight (1) to moderate (2) sheet (Sh) rill (R) and gully (G) when cultivated

**Vegetation:** Improved pasture (gl), rushes, sedges (hR), podocarp forest (fP), lowland podocarp–broadleaved forest (fP), commonly scattered in pasture, manuka, kanuka (sM), gorse (sG).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*
Grazing
- Intensive to semi-intensive, incl. dairying
- Present average carrying capacity (s.u./ha) = 13
- Top farmer carrying capacity (s.u./ha) = 15

Undeveloped land

*Potential:*
Grazing
- Intensive
- Attainable physical potential carrying capacity (s.u./ha) = 18

Cropping – Root and green fodder crops
Forestry – Production – site index for *Pinus radiata* = 26–30

**Soil conservation management:** Good soil conservation management is essential.
- When cultivating, contour cultivation and minimum-tillage practices are essential to minimise sheet and rill erosion. Avoid structural degradation of soils under saturated conditions. Deeper cultivation may be necessary to break up hard layers at depth.

- Surface drains required. Maintain condition of drains.
- Attention to subsurface drainage necessary in some areas.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking, tracking along fencelines, gates, around troughs). Controls may include closer subdivision, rotational grazing, adequate spelling of pastures. Avoid excessive pugging of soils by heavy stock in winter.
- Pugging of soils is a major problem.
- Control runoff using appropriate techniques such as grassed waterways, graded banks.
- Maintain good-quality pasture cover/apply adequate fertiliser–trace-element levels.

**Comments:** Soils strongly acid, very strongly leached, have poor structure and are gleyed in low-lying areas. Drainage generally poor and biological activity very low. Soils can maintain good pastures for pastoral farming, with moderate applications of lime and plant nutrients, but light stocking in winter is essential to prevent surface pugging.

## LUC unit: IVs5 (14 885 ha)

**LUC suite:** 1. Coastal sand country

**LUC subsuite:** 1c. Old stable podzolised terraces and escarpments on unconsolidated to compact sands:
(LUC units IVe10, IVs5, VIe14, VIs4, VIIe9)

**Description:** Flat to undulating slopes on coastal terraces, plains and marine benches. Soils are podzols, gley podzols, and podzolised yellow-brown sands on unconsolidated to compact sands and gravels. Soils are generally of very low natural fertility and have poor structure. Extreme limitations for arable use.

**Type location:** P08/915715 Turkey Flat Road

**Altitudinal range:** 0–200 m

**Slope:** Flat to gently rolling (A-C), 0–15°

**Landform:** Coastal terraces, low-lying dunes, marine benches. Flat to gently rolling slopes on terrace surfaces. A range of terrace heights exists.

**Rock type:** Unconsolidated sands and gravels (Us).

**Soils:** Podzols and podzolised yellow-brown earths on coastal sands. Podzols, gley soils and weakly to moderately podzolised yellow-brown earths of Pinaki suite (TEK, TEKy, TX, TXp, TEKm, TT). Podzolised gley soils of Kaikino suite (KK) may be included.

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh), wind (W), gully (G), tunnel gully (T)
*Potential:* Slight (1) to moderate (2) gully (G), tunnel gully (T) and sheet (Sh) under pasture. Moderate (2) sheet (Sh), wind (W), rill (R) and gully (G) when cultivated

**Vegetation:** Improved pasture (gl), manuka, kanuka (sM), heath (sH), rushes, sedges (hR).

**Annual rainfall range:** 1000–1400 mm

**Land use:** *Present:*
Grazing – Intensive
– Present average carrying capacity (s.u./ha) = 13
– Top farmer carrying capacity (s.u./ha) = 15
Undeveloped land
Forestry – Production – exotic spp.
*Potential:*
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 18
Cropping – Marginal, root and green fodder crops
Forestry – Production – site index for *Pinus radiata* = 20–23

**Soil conservation management:**
- When cultivating, contour cultivation and minimum-tillage practices essential. In some areas deep ripping required as pretreatment because of hardpans in subsoil.
- Correct siting of drainage channels to prevent initiation of gullies.
- Shelterbelts and tree planting recommended for wind protection, to improve soil structure and increase organic matter in soils.
- Maintain complete vegetative cover and good pasture quality/apply adequate fertiliser–trace-element levels.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking, particularly near gates, fencelines and around troughs).
- Irrigation important in some areas, particularly for horticulture.

**Comments:** Podzols have indurated silica, humus and iron pans which cause wide fluctuations in moisture and consequently limit plant growth and farming use. Soils have low nutrient content and require moderate to high applications of lime and plant nutrients to maintain pastures for pastoral farming. Arable use usually requires breaking of subsurface pans.

## LUC unit: Vs1 (2760 ha)

**LUC suite:** 6. Young basalt volcanic terrain:
(LUC units Ic1, IIe1, IIs1, IIIe1, IIIs1, IIIs2, IVe2, IVs1, IVs2, Vs1, VIs1, VIe4, VIIIs2)

**Description:** Undulating to gently rolling slopes on relatively young basalt rock with numerous stones, gravels and boulders scattered over land surface and throughout the soil profile. Soil depths may be less than 20–30 cm in some areas, and gravels and boulders often comprise greater than 35% by volume of soil profile. Stoniness and shallow soil depth regarded as dominant limitations precluding arable use, but pasture production under pastoral use can be high. Considered intermediate between units which could sustain arable use and those suited to non-arable land uses.

**Type location:** P04/879780 Matauri Bay Road/Taraire Road

**Altitudinal range:** 0–400 m

**Slope:** Undulating to rolling (A-C), 0–15°

**Landform:** Flat to gently rolling surfaces on basalt lava terraces and plains.

**Rock type:** Lavas (Vo), scoria (Sc).

**Soils:** Weakly to strongly leached brown and red loams containing stones and boulders. Weakly to moderately leached brown loams of Kiripaka suite (KB, KBb, KBe, KBeb, OWb). Moderately to strongly leached brown loams of Kiripaka suite (YOb, MCb, KEb, RTb).

**Erosion:** *Present:* Negligible (0)
*Potential:* Slight (1) to moderate (2) sheet (Sh)

**Vegetation:** Improved pasture (gl) podocarp forest (fP), broadleaved forest (fB) often scattered through pasture, gorse (sG).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:* Grazing – Intensive
– Present average carrying capacity (s.u./ha) = 17
– Top farmer carrying capacity (s.u./ha) = 20
Reversion to scrub
Undeveloped land
*Potential:* Grazing – Intensive
– Attainable physical potential carrying capacity (s.u./ha) = 24
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 24–27

**Soil conservation management:**
- For more intensive development irrigation may be required in some areas, particularly in the dry season.
- Shelterbelts may be necessary as windbreaks and may minimise soil moisture loss and surficial erosion.
- Control grazing by avoiding overstocking and concentrated stock movement (repeated tracking). Bare ground is difficult to revegetate on these soils when topsoil depleted.
- Maintain good pasture cover/apply adequate fertiliser levels.

**Comments:** Drainage may be impeded by underlying basalt. Soils susceptible to seasonal soil moisture deficits, particularly during summer months.

## LUC unit: Vc1 (4125 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4e. Limestone:
(LUC units IIIs5, IVe1, Vc1, VIs3, VIe3, VIIe3)

**Description:** Strongly rolling to moderately steep, long slopes on limestone, with weakly to moderately leached rendzina and associated soils. Slopes considered too steep for arable use but under pastoral use erosion remains negligible to slight.

**Type location:** P08/063697 Rehia Road

**Altitudinal range:** 0–400 m

**Slope:** Strongly rolling to moderately steep (D, E), 16–25°

**Landform:** Strongly rolling, largely concave surfaces within downlands and hilly terrain. Long, regular slopes.

**Rock type:** Limestone (Li). Crystalline and fine-grained muddy limestone.

**Soils:** Rendzinas and associated soils on limestone. Weakly to moderately leached rendzinas of Arapohue suite (AU, AUd, MT, AUH, MTH). Moderately to strongly leached rendzinas of Maungaturoto suite (MO, DF).

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh)
*Potential:* Slight (1) sheet (Sh) and soil slip (Ss)

**Vegetation:** Improved pasture (gI), manuka, kanuka (sM), lowland podocarp–broadleaved forest (fO) often scattered through pasture.

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*
Grazing
- Intensive to semi-intensive
- Present average carrying capacity (s.u./ha) = 13
- Top farmer carrying capacity (s.u./ha) = 15

Undeveloped land
Reversion to scrub

*Potential:*
Grazing
- Intensive
- Attainable physical potential carrying capacity (s.u./ha) = 18

Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 27–30

**Soil conservation management:**
- Control runoff and channel away from steeper slopes.
- Subsurface drainage required under pasture or exotic forestry.
- Control grazing by avoiding overstocking and concentrated stock movement (repeated tracking, particularly near gates, fencelines and troughs in winter months).
- Avoid excessive pugging of soils by heavy stock in winter. Monitor soil creep on slopes and minimise with adequate destocking measures including spelling some paddocks/pastures.
- Maintain good-quality pasture cover/apply adequate fertiliser–trace-element levels.
- Under a warm climate, rates of revegetation (native vegetation, scrub and fern) can be rapid.

**Comments:** Soils generally have high natural fertility levels.

## LUC unit: Vc2 (1441 ha)

**LUC suite:** 7. Old volcanic terrain

**LUC subsuite:** 7a. Landforms on old stable basalt–andesite volcanics with brown granular loams and clays:
(LUC units IVe3, IVs3, Vc2, VIe2, VIe16, VIc1, VIIe1)

**Description:** Flat to gently rolling slopes above ~600 m a.s.l. on volcanic plateaux formed on old deeply weathered andesite, basalt, dolerite volcanics. Soils brown granular loams and clays. Climate regarded as dominant severe limitation affecting arable land use. Potential productivity for pastoral farming and some types of forestry relatively high. Poor soil drainage can be problem in some areas, particularly for *Pinus radiata* plantings. Rainfall generally high, 1600–>2000 mm; strong westerly winds common.

**Type location:** 006/634280 Tutamoe

**Altitudinal range:** ~ 600–800 m

~ >500 m where rainfall >1800 mm

**Slope:** Flat to gently rolling slopes (A, A+B, B+A, B+C, C+B), 0–7°, 8–15°. >600 m a.s.l.

**Landform:** Upland. Almost horizontal plateau or elevated (high-altitude) surface. Long, relatively even, flat to gently rolling slopes.

**Rock type:** Lavas (Vo), indurated volcanic breccias (Vb).

**Soils:** Brown granular loams and clays on old volcanic rocks. Moderately to strongly leached brown granular loams and clays of Katui suite (YP, WT, TO, AR). Parent materials include andesitic flows.

**Erosion:** *Present:* Negligible (0) to slight (1), sheet (Sh) and tunnel gully (T)
*Potential:* Slight (1) sheet (Sh), rill (R), gully (G) and tunnel gully (T)

**Vegetation:** Lowland podocarp–broadleaved forest (fO), kauri forest (fK), improved pasture (gl), manuka, kanuka (sM).

**Annual rainfall range:** 1600–>2000 mm

**Land use:** *Present:* Undeveloped
Grazing – Semi-intensive to intensive
– Present average carrying capacity (s.u./ha) = 13
– Top farmer carrying capacity (s.u./ha) = 15
*Potential:* Grazing – Attainable physical potential carrying capacity (s.u./ha) = 18
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 21–24

**Soil conservation management:**
- Control runoff. Attention to subsurface drainage.
- Control grazing by avoiding overstocking and concentrated stock movement (repeated tracking, particularly near gates, fencelines and troughs in winter months). Avoid excessive pugging of clay soils by heavy stock in winter.
- Maintain good-quality pasture cover/apply adequate fertiliser, trace element levels.
- Shelterbelts, windbreaks required.
- Space plant trees in some areas to remove excess water from some sites. Monitor soil moisture levels.
- Under a warm climate, rates of revegetation (native vegetation, scrub and fern) can be rapid.

**Comments:** Soils often have poor drainage characteristics, may require some form of subsurface drainage for pastoral or forestry development. Erosion negligible on flat to gently rolling slopes.

## LUC unit: VIe1 (101 635 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4a. Interbedded and massive sandstone and mudstone: (LUC units IIIe3, IVe5, VIe1, VIe8, VIIe4)

**Description:** Strongly rolling to moderately steep slopes forming hilly terrain on interbedded and occasionally massive sedimentary lithologies excluding greywacke and limestone. Rock types include sandstones, mudstones and conglomerate. Soils are yellow-brown earths. Mapped where at least 80% of the map unit area is sandstone, bedded mudstone, or massive mudstone. Minor argillite or jointed mudstone may be included where rock types are complexed or closely associated with interbedded sandstone and mudstone, or massive sandstone. Potential for moderate soil slip, sheet and tunnel gully erosion.

**Type location:** Q10/445145 Makarau Road, Kaukapakapa area

**Altitudinal range:** 0–400 m

**Slope:** Strongly rolling to moderately steep (D, E), 16–25°

**Landform:** Hill country. Hilly terrain.

**Rock type:** Bedded sandstones (Sb), mudstones (Mb), massive sandstone (Sm), massive mudstone (Mm).

**Soils:** Yellow-brown earth hill soils on stratified sandstones and mudstones. Weakly to strongly leached yellow-brown earth hill soils of Puhoi suite (PBH, PBuH, TMH, WRH, WReH, OFH, MXH, WAH, AYH, AYfH) associated with limited areas of Y-B earths on rolling land (PB, PBu, TM, WR, WRe, OF, MX, WA, AY, AYf). Weakly to strongly leached yellow-brown earth hill soils of Waiotira suite (YCgH, YCH, YCrH, YCeH, RPH, RPaH, PVH) associated with limited areas of Y-B earths on rolling land (YC, YCr, YCe, RP, RPa, PV).

**Erosion:** *Present:* Negligible (0) to moderate (2) sheet (Sh), soil slip (Ss), tunnel gully (T), gully (G) and earthslip (Es)

*Potential:* Moderate (2) tunnel gully (T), soil slip (Ss), earthslip (Es), sheet (Sh), and gully (G). Slight (1) slump (Su) and earthflow (Ef)

**Vegetation:** Improved pasture (gl), rushes, sedges (hR), manuka, kanuka (sM), lowland podocarp–broadleaved forest (fO).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*

Grazing – Semi-intensive to intensive
– Present average carrying capacity (s.u./ha) = 8
– Top farmer carrying capacity (s.u./ha) = 10

Undeveloped land

*Potential:*

Grazing – Attainable physical potential carrying capacity (s.u./ha) = 12
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 31–34

**Soil conservation management:** Stable hill country, good soil conservation management is essential.

- Maintain good-quality pastures/apply adequate fertiliser levels. Major elements and trace element requirements.
- Open plant soil conservation trees on areas susceptible to mass movement. Block planting of trees (indigenous scrub and forest, exotic

forest) should be considered on steepest slopes.
- Maintain complete vegetative cover on steeper slopes. Oversow and fertiliser slip scars.
- Pair plant soil conservation trees in tunnel gullies and gullies.
- Control runoff.
- Control grazing by avoiding overstocking and concentrated stock movement.

**Comments:** The more stable Waiotira hills (dominantly sandstone) are included in this unit. Tunnel gully often occurs on Waiotira soils.

## LUC unit VIe2 (92 605 ha)

**LUC suite:** 7. Old volcanic terrain

**LUC subsuite:** 7a. Landforms on old stable basalt–andesite volcanics with brown granular loams and clays:
(LUC units IVe3, IVs3, Vc2, VIe2, VIe16, VIc1, VIIe1)

**Description:** Strongly rolling to moderately steep slopes forming hilly terrain on old 'basic' to 'intermediate' volcanics, e.g. dolerite, andesite, basalt incl. andesitic–basaltic volcanics, ancient volcanics, volcanic breccias. Soils are brown granular loams and clays. There is a potential for moderate soil slip and sheet erosion.

**Type location:** 004/644905 Mangonui area

**Altitudinal range:** 0–800 m

**Slope:** Strongly rolling to moderately steep (D, E), 16–25°, 0–800 m a.s.l. – includes strongly rolling and rolling slopes (D+C, D), 16–20° above 600 m a.s.l.

**Landform:** Hill country. Hilly terrain.

**Rock type:** Ancient volcanics (In), indurated volcanic breccias (Vb), indurated fine-grained pyroclastics (Tb), lavas and welded ignimbrites (Vo), ultramafics (Um).

**Soils:** Brown granular loam and clay hill soils on old volcanic rocks. Weakly to strongly leached brown granular loams and clays of Te Kie suite (TUH, TWH, AKH, C5H, YNH, MNH, RUrH, RUH) associated with limited areas of BG loams and clays on rolling land (TU, AK, C5, YN, MN, RUr, RU).
Weakly to strongly leached brown granular loams and clays of Huia suite (HUH, BMH, PTH, DVH, PAH, YTH, CWH) associated with limited areas of BG loams and clays on rolling land (HU, BM, DV, PA, YT, CW, Hl, Hlg).
Weakly to strongly leached brown granular loams and clays of Katui suite (KTH, YPH, WTH) associated with limited areas of BG loams and clays on rolling land (KT, YP, WT).
Parent materials include shattered dolerites, breccias and tuffs, andesitic agglomerates, and breccias and andesitic flows.

**Erosion:** *Present:* Negligible (0) to moderate (2) soil slip (Ss), sheet (Sh), gully (G) and earthslip (Es)
*Potential:* Moderate (2) soil slip (Ss), sheet (Sh), gully (G), and earthslip (Es). Slight (1) earthflow (Ef). Localised severe (3) soil slip (Ss) and earthslip (Es) can occur under high-intensity rainstorms

**Vegetation:** Improved pasture (gl), semi-improved pasture (gS), lowland podocarp–broadleaved forest (fO), manuka, kanuka (sM).

**Annual rainfall range:** 1400–1800 mm

**Land use:** *Present:*
Grazing – Semi-intensive to intensive
– Present average carrying capacity (s.u./ha) = 7
– Top farmer carrying capacity (s.u./ha) = 8
Forestry – Production – exotic spp.
Undeveloped land
*Potential:*
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 9
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 30–33

**Soil conservation management:**

Stable hill country, good soil conservation management is essential.

- Maintain good-quality pastures/apply adequate fertiliser levels. Major elements and trace element requirements.
- Open soil conservation trees on areas susceptible to mass movement. Block planting of trees (indigenous scrub and forest) should be considered on steeper slopes and gullies. Forest crops also require topdressing for establishment.
- Maintain complete vegetative cover particularly during drier months. Sheet and wind erosion can be a serious problem and bare-ground areas are difficult to revegetate. Oversow and fertilise slip scars and bare-ground areas.
- Control grazing by avoiding overstocking and concentrated stock movement, particularly in summer months.
- Control runoff.
- Measures required to minimise soil erosion and maintain water quality. Strict management guidelines should be followed when land is prepared for tree planting, road construction, drains and culverts (all earthworks), logging (harvesting), deforestation, scrub clearance.
- Control noxious weeds (tobacco weed) as part of pasture maintenance.

**Comments:**

Old volcanics often difficult to farm. Generally strongly leached soils with granular topsoils – prone to drying out in summer. Difficult to revegetate eroded areas. Revegetation requires liming to raise pH (i.e. high levels of Fe and Al in subsoil). Fertiliser required:

- heavy initial dressings of phosphate, trace elements;
- lower applications of fertiliser for pasture maintenance;
- avoid loss of phosphate by iron and Al fixation.

## LUC unit: VIe3 (2726 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4e. Limestone:
(LUC units IIIs5, IVe1, Vc1, VIs3, VIe3, VIIe3)

**Description:** Moderately steep and strongly rolling slopes forming hilly terrain on limestone rocks. Typical soils are rendzinas and associated soils. Potential for moderate soil slip and sheet erosion.

**Type location:** 004/475735 Panther Road

**Altitudinal range:** 0–400 m

**Slope:** Strongly rolling to moderately steep (E+D, E), 16–25°

**Landform:** Hill country. Hilly terrain.

**Rock type:** Limestone (Li). Crystalline and fine-grained muddy limestone.

**Soils:** Rendzinas and associated soils on limestone. Weakly to moderately leached rendzinas of Arapohue suite (AUH, MTH).

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh), soil slip (Ss) and gully (G)
*Potential:* Moderate (2) soil slip (Ss) – soil creep, sheet (Sh), and gully (G)

**Vegetation:** Improved pasture (gl). Lowland podocarp–broadleaved forest (fO), podocarp forest (fP).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:* Grazing – Semi-intensive to intensive
– Present average carrying capacity (s.u./ha) = 7
– Top farmer carrying capacity (s.u./ha) = 8
Undeveloped land
*Potential:* Grazing – Attainable physical potential carrying capacity (s.u./ha) = 9
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 27–30

**Soil conservation management:**
- Maintain good-quality pastures/apply adequate fertiliser levels. Major element and trace element requirements.
- Open plant soil conservation trees on areas susceptible to mass movement.
- Maintain dense vegetative cover (indigenous scrub or forest) on steeper slopes.
- Pair plant soil conservation trees in tunnel gullies and gullies.
- Control runoff away from steeper slopes.
- Control grazing by avoiding overstocking and concentrated stock movement, particularly in wetter months.

**Comments:** High percentage of expanding clays in soil. Soils typically wet in winter and dry in summer months.

## LUC unit: VIe4 (9131 ha)

**LUC suite:** 6. Young basalt volcanic terrain:
(LUC units Ic1, IIe1, IIs1, IIIe1, IIIs1, IIIs2, IVe2, IVs1, IVs2, Vs1, VIs1, VIe4, VIIIs2)

**Description:** Strongly rolling to steep slopes on basalt flows and basaltic scoria. Includes scoria cones, mounds, lava domes, and escarpments bordering terraces and plains. Underlying basalts range from Pliocene to Holocene age. Potential for moderate soil slip and sheet erosion.

**Type location:** P05/890620 Puketotara Road

**Altitudinal range:** 0–400 m

**Slope:** Strongly rolling to moderately steep (D, D+E, E, F), 16–25°, occasional 26–35°

**Landform:** Hill country. Hilly terrain. Includes basalt (scoria) cones and domes, low domes usually surrounded by lava plains and terraces.

**Rock type:** Lava (Vo), scoria (Sc)

**Soils:** Brown and red loam hill soils on basalt scoria and flows. Brown loams of Kiripaka suite (KBH, YOH, MCH). Red loams of Papakauri suite (PKH, RKeH, MUH, ATH).

**Erosion:** *Present:* Negligible (0) to slight (1) soil slip (Ss), sheet (Sh). Slight (1) gully (G)
*Potential:* Slight (1) to moderate (2) soil slip (Ss) and sheet (Sh). Slight (1) gully (G)

**Vegetation:** Improved pasture (gI). Lowland podocarp–broadleaved forest (fO), manuka, kanuka (sM), gorse (sG), broadleaved forest (fB).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:* Grazing – Semi-intensive to intensive
– Present average carrying capacity (s.u./ha) = 13
– Top farmer carrying capacity (s.u./ha) = 15
Undeveloped land
*Potential:* Grazing – Attainable physical potential carrying capacity (s.u./ha) = 18
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 27–30

**Soil conservation management:** Stable hill country, good soil conservation management essential.
- Maintain good-quality pastures/apply adequate fertiliser levels – major elements and trace element requirements.
- Maintain dense vegetative cover (indigenous scrub or forest) on steeper slopes. Maintain complete pastures particularly in drier months.
- Revegetate landslide scars and eroded (bare ground) sites by oversowing and topdressing. High natural fertility of soils allows rapid revegetation of eroded sites.
- Control grazing by avoiding overstocking and concentrated stock movement. Younger soils on scoria cones can be tracked badly if heavy cattle are stocked, particularly with repeated tracking.
- Adequate spelling of pastures by subdivision and careful siting of fencelines and gates.
- Control runoff away from steeper areas, care in siting earthworks.

## LUC unit: VIe5 (6445 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4f. Limestone complexed with other sedimentary deposits: (LUC units IIIe4, IVe4, VIe5)

**Description:** Strongly rolling to moderately steep slopes forming hilly terrain on limestone rock complexed/mixed or associated with other sedimentary lithologies such as argillite, jointed mudstone, sandstone and sheared mixed lithologies, and to a lesser degree, with volcanic rock such as ancient volcanics (In) and volcanic breccia (Vb). Soils typically rendzina/yellow-brown earth complexes and associations. Potential for moderate soil slip and sheet erosion, and slight earthflow and gully on lower slopes.

**Type location:** 004/418788 Snelgar Road; and Q08/183748

**Altitudinal range:** 0–400m

**Slope:** Strongly rolling to moderately steep (D+E, D), 16–25°

**Landform:** Hill country. Hilly terrain.

**Rock type:** Limestone (Li), crystalline and fine-grained muddy limestone (Li) complexed or closely associated with argillite (Ar), sandstone (Sb, Sm), mudstone (Mb, Mm), jointed mudstone (Mj), mixed lithologies (Mx).

**Soils:** Complex of rendzinas and yellow-brown earths on limestone, mudstone, and sandstone. Rendzinas of Arapohue suite (AUH, MTH), Konoti suite (KNH, KNrH) and Maungaturoto suite (MO). May include yellow-brown earths of Omu suite (OMH, APH, OAH).

**Erosion:** *Present:* Negligible (0) to moderate (2) soil slip (Ss), sheet (Sh), earthflow (Ef), gully (G), and earthslip (Es)

*Potential:* Moderate (2) soil slip (Ss), sheet (Sh), earthflow (Ef), gully (G) and earthslip (Es)

**Vegetation:** Improved pasture (gl), manuka, kanuka (sM), lowland podocarp broadleaved forest (fO).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*

Grazing
- Semi-intensive to intensive
- Present average carrying capacity (s.u./ha) = 11
- Top farmer carrying capacity (s.u./ha) = 13

Undeveloped land

*Potential:*

Grazing – Attainable physical potential carrying capacity (s.u./ha) = 15

Cropping – Unsuitable

Forestry – Production – site index for *Pinus radiata* = 28–31

**Soil conservation management:**
- Maintain good-quality pastures/apply adequate fertiliser levels – major elements and trace element requirements.
- Open planting of soil conservation trees on areas susceptible to mass movement.
- Pair plant soil conservation trees in tunnel gullies and gullies.
- Control runoff away from steep slopes and potentially unstable sites.
- Control grazing by avoiding overstocking particularly during winter months; avoid excessive pugging of soils by heavy stock. Adequate spelling of pastures recommended.
- To minimise soil erosion and maintain water quality, carefully plan all earthworks, excavations. Avoid undercutting slopes.

**Comments:** High percentage of expanding clays in soil. Soils typically wet in winter and dry in summer months.

## LUC unit: VIe6 (13 510 ha)

**LUC suite:** 1. Coastal sand country

**LUC subsuite:** 1b. Old stable sand dunes on unconsolidated to compact sands: (LUC units IIIe5, IIIs4, IVe9, VIe6, VIIe9)

**Description:** Strongly rolling to moderately steep slopes forming rounded hills on old more stable, weathered dunesands. Sands are unconsolidated to compact. Soils are yellow-brown sands. Potential for moderate soil slip, sheet and wind erosion.

**Type location:** P08/869735 Red Hill – Oturei Road

**Altitudinal range:** 0–200 m

**Slope:** Strongly rolling to moderately steep (D, E), 16–25°

**Landform:** Hilly land, rounded hills (dune hills).

**Rock type:** Unconsolidated to compact sands (Us) deposited by aeolian processes.

**Soils:** Yellow-brown sand hill soils on aeolian sand. Moderately weathered, moderately to strongly leached yellow-brown sands of Pinaki suite (HOH, RLaH, RLH, RLIH).

**Erosion:** *Present:* Negligible (0) to moderate (2) sheet (Sh), wind (W), soil slip (Ss). Negligible (0) to slight (1) gully (G)

*Potential:* Moderate (2) sheet (Sh), wind (W), soil slip (Ss) and gully (G)

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM), heath (sH), cassinia (SC), exotic conifer forest (fF).

**Annual rainfall range:** 1000–1400 mm

**Land use:** *Present:*

Grazing
- Semi-intensive
- Present average carrying capacity (s.u./ha) = 11
- Top farmer carrying capacity (s.u./ha) = 13

Undeveloped land

*Potential:*

Grazing – Attainable physical potential carrying capacity (s.u./ha) = 15

Cropping – Unsuitable

Forestry – Production – site index for *Pinus radiata* = 26–29

**Soil conservation management:**

- Maintain good-quality pastures/apply adequate fertiliser levels – major elements and trace element requirements. Topdress to maintain pastures, oversow with clover.
- Control runoff away from steep slopes and potentially unstable sites. Gullying can occur in drainage depressions.
- To minimise soil erosion and maintain water quality, carefully plan all earthworks and excavation of roads, drains, dams.
- Control grazing by avoiding overstocking and concentrated stock movement. Carefully site fencelines, stock ponds, gates, etc., to avoid repeated tracking. Minimise sheet and wind erosion as bare-ground areas can be difficult to revegetate. Adequate spelling of pastures recommended, particularly in summer months.
- Shelterbelts, windbreaks are recommended.
- Gullies (VIe9) traversing this unit should be retired, fenced off and revegetated. Access roads and tracks should be carefully planned.
- Maintain dense vegetation cover on steeper slopes.

## LUC unit: VIe7 (128 894 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4b. Old shattered and sheared argillites and sandstone: (LUC units IVe6, VIe7)

**Description:** Strongly rolling to moderately steep slopes forming hilly terrain. Shattered and sheared argillite complexed with sandstone, bedded mudstone. Minor constituents of crushed argillite (siliceous claystone) and/or jointed mudstone also recorded. Sandstones and mudstones often deformed showing evidence of shearing, shattering. Faulting or folding often proximal to land on sheared mixed lithologies (e.g. Northland Allochthon). Soils are yellow-brown earths. Potential for moderate soil slip, gully and tunnel gully erosion, and severe sheet erosion. Also potential for moderate earthflow on lower slopes.

**Type location:** 005/453568 Buchanan Road and 004/640736 Otangaroa Road

**Altitudinal range:** 0–400 m

**Slope:** Strongly rolling to moderately steep (D+E, E+D), 16–25°

**Landform:** Hilly terrain with tunnel gully, earthflow and gully.

**Rock type:** Argillite (Ar), massive sandstone (Sm), interbedded sandstone (Sb), massive mudstone (Mm), interbedded mudstone (Mb), jointed mudstone (Mj), crushed argillite (Ac).

**Soils:** Yellow-brown earth hill soils on shattered argillites and sandstones. Weakly to strongly leached and weakly podzolised yellow-brown earths of Omanaia suite (WHN, ONH, AEH, AEeH, KWH, HWH), Purua suite (PUeH, TNH, TNaH, OCH), Waiotira suite (YCgH, YCeH, YCH, YCeH, RPH, RPaH, PVH, PDH, PWH) and Omu suite (TFH, OMH, APH, OAH, PH).

**Erosion:** *Present:* Slight (1) to moderate (2) sheet (Sh), soil slip (Ss), earthslip (Es), earthflow (Ef) and tunnel gully (T). Negligible (0) to slight (1) gully (G)

*Potential:* Moderate (2) earthflow (Ef), gully (G), soil slip (Ss), tunnel gully (T) and earthslip (Es). Severe (3) sheet (Sh)

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), rushes, sedges (hR), mixed indigenous scrub (sX), manuka, kanuka (sM), exotic scrub (SE), lowland podocarp–broadleaved forest (fO), gorse (sG).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*

Grazing – Semi-intensive
- Present average carrying capacity (s.u./ha) = 11
- Top farmer carrying capacity (s.u./ha) = 13

Undeveloped land

Reversion to scrub

Forestry – Production – exotic spp.

*Potential:*

Grazing – Attainable physical potential carrying capacity (s.u./ha) = 15

Cropping – Unsuitable

Forestry – Production – site index for *Pinus radiata* = 32–35

**Soil conservation management:**
- Maintain good-quality pastures/apply adequate fertiliser levels – major elements and trace element requirements.
- Open plant conservation trees on areas susceptible to mass movement.

- Block planting of trees may be required for stabilising severely eroded sites or sites with high erosion potential, whereas wide space planting is recommended on areas with lower erosion potential.
- Pair plant soil conservation trees in tunnel gullies and gullies.
- Oversow and fertilise slip scars.
- Control runoff away from steep slopes and potentially unstable sites.
- Maintain permanent vegetation cover on runoff channels to prevent gully erosion.
- Control grazing by avoiding overstocking. Stock treading may continually reactivate erosion on soil slip/flow surfaces. Earthflow areas may pug badly in winter under heavy stock.
- To minimise soil erosion and maintain water quality, carefully plan all earthworks and excavation of roads, drains, dams. Avoid undercutting slopes.

**Comments:** Sheet erosion is a particular problem on drier slopes on "argillaceous" terrains and adequate spelling from stock is recommended on these slopes. Bare ground can be minimised by oversowing and topdressing together with more intensive subdivision fencing.

## LUC unit: VIe8 (61 022 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4a. Interbedded and massive sandstone and mudstone: (LUC units IIIe3, IVe5, VIe1, VIe8, VIIe4)

**Description:** Moderate to steep slopes forming hilly to steepland terrain where interbedded sandstones and mudstones are dominant lithologies with less extensive areas on massive sandstones, mudstones and conglomerate. Rock types, often of Miocene age, may be associated with minor constituents of argillite and jointed mudstone. Steeper version of VIe1 and VIe7. Potential for moderate soil slip, earthslip, and sheet erosion and slight tunnel gully erosion.

**Type location:** Q09/435265 Glorit – Kaipara Hills Road

**Altitudinal range:** 0–400 m

**Slope:** Moderately steep to steep (E, F), 21–35°

**Landform:** Steep hills, escarpments.

**Rock type:** Interbedded sandstones (Sb), massive sandstones (Sm), interbedded mudstones (Mb), massive mudstones (Mm), argillite (Ar), jointed mudstone (Mj).

**Soils:** Yellow-brown earth hill soils on stratified sandstones and mudstones. Yellow-brown earths of Puhoi suite (PBH, PBuH, TMH, WRH, WReH, OFH, MXH, WAH, AYH, AYfH) and Waiotira suite (WCS, YCgH, YCH, YCrH, RPH, RPaH, PVH).

**Erosion:** *Present:* Slight (1) to moderate (2) sheet (Sh) and soil slip (Ss). Slight (1) earthflow (Ef) and gully (G). Negligible (0) to slight (1) tunnel gully (T)

*Potential:* Moderate (2) sheet (Sh), soil slip (Ss), gully (G) and earthflow (Ef). Slight (1) tunnel gully (T)

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM), mixed indigenous scrub (sX), mixed indigenous scrub with tree fern (sT), lowland podocarp–broadleaved forest (fO), exotic conifer forest (fF), rushes, sedges (hR), kauri forest (fk).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*

Grazing – Present average carrying capacity (s.u./ha) = 7
– Top farmer carrying capacity (s.u./ha) = 8

Undeveloped land

Forestry – Production – exotic spp.

Reversion to scrub

*Potential:*

Grazing – Attainable physical potential carrying capacity (s.u./ha) = 9

Cropping – Unsuitable

Forestry – Production – site index for *Pinus radiata* = 31–34

**Soil conservation management:**

- Maintain good-quality pastures/apply adequate fertiliser levels – major elements and trace element requirements.
- Open plant soil conservation trees on areas susceptible to mass movement. Block planting of trees (indigenous scrub and forest and exotic trees) should be considered on steepest slopes or potentially unstable sites.

- Maintain dense vegetative cover on steeper slopes. Oversow and fertilise slip scars.
- Pair plant soil conservation trees in tunnel gullies and gullies.
- Control runoff away from steep slopes and potentially unstable sites.
- To minimise soil erosion and maintain water quality, carefully plan all earthworks and excavation of roads, drains, dams.
- Control grazing by avoiding overstocking and concentrated stock movement (repeated tracking).
- Control feral (noxious) animals in forested areas. Protect conservation planting adequately from damage by cattle, goats, possums.

## LUC unit: VIe9 (62 289 ha)

**LUC suite:** 5. Greywacke terrain:
(LUC units IVe7, VIe9, VIe10, VIe17, VIc1, VIIe5, VIIe6)

**Description:** Strongly rolling to moderately steep slopes forming hilly terrain on deeply weathered greywacke and greywacke. Soils are yellow-brown earths. Potential for moderate soil slip, earthslip and sheet erosion.

**Type location:** P05/980692 Purerua Road

**Altitudinal range:** 0–400 m

**Slope:** Strongly rolling to moderately steep (D+E), 16–25°

**Landform:** Hilly terrain.

**Rock type:** Greywacke association of rocks (Gw).

**Soils:** Yellow-brown earth hill soils on greywacke and argillite. Moderately to strongly leached yellow-brown earths of Marua suite (MRrH, MRH, MRuH, RAH, RAlH).

**Erosion:** *Present:* Slight (1) to moderate (2) soil slip (Ss), sheet (Sh), earthflow (Ef), gully (G) and earthslip (Es)
*Potential:* Moderate (2) soil slip (Ss), earthslip (Es), sheet (Sh) earthflow (Ef), and gully (G)

**Vegetation:** Improved pasture (gl), manuka, kanuka (sM), mixed indigenous scrub (sX), mixed indigenous scrub with tree fern (sT), gorse (sG), exotic conifer forest (fF), lowland podocarp broadleaved forest (fO), rushes, sedges (hR).

**Annual rainfall range:** 1400–1800 mm

**Land use:** *Present:*
Grazing – Present average carrying capacity (s.u./ha) = 8
– Top farmer carrying capacity (s.u./ha) = 10
Forestry – Production – exotic spp.
Undeveloped land
Reversion to scrub
*Potential:*
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 12
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 30–33

**Soil conservation management:**
- Maintain good-quality pastures/apply adequate fertiliser levels – major elements and trace element requirements.
- Open plant soil conservation trees on areas susceptible to mass movement. Block planting of trees (indigenous scrub and forest or exotic trees) should be considered on steepest slopes or potentially unstable sites.
- Maintain dense vegetative cover particularly on steeper slopes. Oversow and fertilise slip scars.
- Pair plant soil conservation trees in gullies.
- Control runoff away from steep slopes and potentially unstable sites.
- To minimise soil erosion and maintain water quality, strict management guidelines should be followed when preparing for tree planting, road construction, drains and culverts (all earthworks), logging (harvesting), deforestation, scrub clearance.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking).
- Control feral (noxious) animals in forested areas. Protect conservation planting adequately from damage by cattle, goats, possums.

## LUC unit: VIe10 (5981 ha)

**LUC suite:** 5. Greywacke terrain:
(LUC units IVe7, VIe9, VIe10, VIe17, VIc1, VIIe5, VIIe6)

**Description:** Strongly rolling to steep slopes forming hilly terrain on greywacke adjacent to coast, and exposed to dry coastal climate. Rainfall on average less than ~1200 mm and less than 1000 mm at some locations. Has shallow yellow-brown earth soils developed on hard greywacke rock, and potential for moderate sheet, soil slip and scree erosion.

**Type location:** P04 and Q04/965885 Cavalli Islands

**Altitudinal range:** 0–200 m

**Slope:** Strongly rolling to steep (D, E, F), 16–35°

**Landform:** Hilly terrain near the coast.

**Rock type:** Greywacke association of rocks (Gw).

**Soils:** Yellow-brown earth hill soils and steepland soils on greywacke and argillite. Moderately to strongly leached yellow-brown earths of Marua suite (MRrH, MRH, MRuH, RAH, RAlH, TRS, TRuS).

**Erosion:** *Present:* Slight (1) to moderate (2) sheet (Sh), soil slip (Ss) and scree (Sc). Negligible (0) to slight (1) wind (W)
*Potential:* Moderate (2) sheet (Sh), soil slip (Ss), scree (Sc) and gully (G). Slight (1) wind (W)

**Vegetation:** Improved pasture (gI), manuka, kanuka (sM), mixed indigenous scrub (sX), lowland podocarp–broadleaved forest (fO), coastal forest (fC), gorse (sG).

**Annual rainfall range:** 1000–1200 mm Some areas may receive less than 1000 mm

**Land use:** *Present:*
Grazing – Present average carrying capacity (s.u./ha) = 8
– Top farmer carrying capacity (s.u./ha) = 10
Undeveloped land
Reversion to scrub
Forestry – Production – exotic spp.
*Potential:*
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 12
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 30–33

**Soil conservation management:**
- Maintain good-quality pastures/apply adequate fertiliser levels – major elements and trace element requirements.
- Open plant soil conservation trees in areas susceptible to mass movement and surficial erosion.
- Maintain complete dense vegetation cover. Oversow and fertilise slip scars and areas of bare ground. Areas of sheet and scree erosion difficult to revegetate. Hillslopes dry out readily in summer months.
- Control grazing by avoiding overstocking and concentrated stock movement (repeated tracking).
- Control runoff. To minimise soil erosion and maintain water quality, strict management guidelines should be followed when preparing for tree planting, road construction, drains and culverts (all earthworks), logging (harvesting), deforestation, scrub clearance.
- Control feral (noxious) animals in forested areas. Protect conservation planting adequately from damage by cattle, goats, possums.

## LUC unit: VIe11 (12 052 ha)

**LUC suite:** 7. Old volcanic terrain

**LUC subsuite:** 7b. Landforms on volcanic/sedimentary complexes:
(LUC units VIs2, VIe11, VIe13)

**Description:** Strongly rolling to moderately steep slopes forming hilly terrain on fractured and sheared old volcanics (e.g. ancient volcanics comprising basic to intermediate volcanic rock such as basalt, andesite, dolerite) often complexed with various sedimentary lithologies. Soils often spatially complex but comprise mainly brown granular loams and clay and occasional yellow-brown earths. Often mapped around the periphery of large mountainous volcanic blocks or massifs.
Relatively unstable when compared to other volcanic terrains; potential for moderate soil slip, earthslip, gully and earthflow erosion.

**Type location:** 005/460699 Te Rore Road

**Altitudinal range:** 0–600 m

**Slope:** Strongly rolling to moderately steep (D, E), 16–25°

**Landform:** Hilly terrain. Broken slopes, irregular and often gullied slope surfaces.

**Rock type:** Ancient volcanics (In), indurated volcanic breccias (Vb), indurated fine grained pyroclastics (Tb), lavas and welded ignimbrites (Vo). One or more volcanic rock types form dominant lithological component in complex with various sedimentary lithologies, such as massive sandstone (Sm), jointed mudstone (Mj), sheared mixed lithologies (Mx), argillite (Ar).

**Soils:** Brown granular loams and clays complexed with or associated with yellow-brown earths, where BG loams and clays are dominant. Include those complexes of Te Kie suite (C5H, C8, C9H) and BG loams and clays of Te Kie suite (TUH, TWH, AKH, YNH, MNH, RUrH, RUH) Huia suite (HUH, BMH, PTH, PAH, YTH) and Katui suite (KTH, YPH, WTH) which are recorded along with yellow-brown earths of Omu, Omanaia, Purua and Waiotira suites.

**Erosion:** *Present:* Slight (1) to moderate (2) earthflow (Ef) soil slip (Ss), earthslip (Es), and gully (G). Negligible (0) to slight (1) sheet (Sh)
*Potential:* Moderate (2) to severe (3) earthflow (Ef) and earthslip (Es). Moderate (2) gully (G), soil slip (Ss), and sheet (Sh)

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), rushes, sedges (hR), manuka, kanuka (sM), lowland podocarp–broadleaved forest (fO), exotic scrub (sE), gorse (sG), mixed indigenous scrub (sX), mixed indigenous scrub with tree ferns (sT).

**Annual rainfall range:** 1400–1800 mm

**Land use:** *Present:*
Grazing – Present average carrying capacity (s.u./ha) = 8
– Top farmer carrying capacity (s.u./ha) = 10
Undeveloped land
Reversion to scrub
Forestry – Production – exotic spp.
*Potential:*
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 12
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 31–34

**Soil conservation management:**

- Maintain good-quality pastures/apply adequate fertiliser levels – major elements and trace element requirements.
- Open plant soil conservation trees on areas susceptible to mass movement (slips, slumps). Block planting of trees may be required for stabilising severely eroded sites or sites with high erosion potential. Space planting recommended on areas with lower erosion potential. Planting of gullies (pair or block planting) recommended.
- Oversow and fertilise slip scars.
- Control runoff. Maintain a permanent vegetation cover on runoff channels. Control grazing by avoiding overstocking and concentrated stock movement. Stock treading may continually reactivate erosion on soil slip/flow surfaces. Earthflow areas may pug badly in winter under heavy stock.
- To minimise soil erosion and maintain water quality, carefully plan all earthworks and excavation of roads, drains, dams. Avoid undercutting slopes.
- Control feral (noxious) animals in forested areas, conservation planting adequately from damage by cattle, goats, possums.

**Comments:**

At foot of steep skeletal Tangihua and Wairakau volcanics, land prone to gully, secondary slump and earthflow erosion, and soil creep, particularly if slopes are undercut. Land suited to pastoral and forestry land use.

## LUC unit: VIe12 (15 114 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4c. Sheared mixed lithologies:
(LUC units IVe8, VIe12, VIIe2)

**Description:** Gently rolling to moderately steep slopes form rolling to moderately steep (hilly) terrain on fractured and sheared mixed lithologies, often a complex of multi-coloured sedimentary rock types (e.g. argillite, sandstone, mudstone) and minor volcanic rock (e.g. ancient volcanics). Rock types often allochthonous, with relatively high proportion of mudstone.
Terrains are characteristically unstable showing hummocky slope profiles with earthflow, gully, soil creep and soil slip erosion forms. Potential for moderate to severe earthflow and gully exists. Soils are mainly yellow-brown earths.

**Type location:** R10/599059 Silverdale, 005/653553 State Highway 1 near Rangiahua

**Altitudinal range:** 0–400 m

**Slope:** Gently rolling to moderately steep (C, D, E), 8–25°

**Landform:** Strongly rolling to hilly terrain. Earthflow, soil creep common.

**Rock type:** Sheared mixed lithologies (Mx). May include mixture of sedimentary and old volcanic lithologies where sedimentary lithologies are proportionately dominant, or a mixture of various sedimentary lithologies.

**Soils:** Yellow-brown earths of gently rolling, rolling and hill phases. Occasionally complexed with brown granular loams and clays and/or rendzinas. Include weakly to strongly leached yellow-brown earths of Omu suite (OMH, APH, OAH), Omanaia suite (WNH, WN, ONH, ON, ONe, AEH, AE, AEeH, AEe, kWH, KW, YR), Waiotira suite (YCeH), Purua suite (PUeH, TNH, TNaH).

**Erosion:** *Present:* Slight (1) to moderate (2) earthflow (Ef), gully (G), and tunnel gully (T). Negligible (0) to slight (1) sheet (Sh), soil slip (Ss), earthslip (Es). Underlying weathered shatterered and sheared rocks highly susceptible to earthflow, slump, and gully erosion. Channel deformation often occurs at foot of slopes
*Potential:* Moderate (2) to severe (3) earthflow (Ef) and gully (G). Moderate (2) tunnel gully (T), sheet (Sh), soil slip (Ss) and earthslip (Es)

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), rushes, sedges (hR), mixed indigenous scrub (sX), manuka, kanuka (sM), exotic scrub (sE), exotic conifer forest (fF), erosion control trees, exotic broadleaved forest (efR), lowland podocarp–broadleaved forest (fO).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:* Grazing – Present average carrying capacity (s.u./ha) =11
– Top farmer carrying capacity (s.u./ha) = 13
Undeveloped
*Potential:* Grazing – Attainable physical potential carrying capacity (s.u./ha) = 15
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 28–31

**Soil conservation management:**
- Maintain good-quality pastures/apply adequate fertiliser – major elements and trace element requirements.
- Open plant soil conservation trees in areas susceptible to mass

movement (slips, earthflows, natural drainage depressions). Block planting of trees may be necessary on more critical earthflow areas. Pair plant soil conservation trees in tunnel gullies and gullies. Revegetate, plant trees to stabilise gully head and walls. Dewatering of slopes may be necessary: spring tapping, smoothing of earthflows, reduce infiltration rates, etc.

- Control runoff with graded banks, diversion channels, grassed waterways.
- Attention to subsurface drainage on easier slopes.
- Control grazing by avoiding overstocking and concentrated stock movement. Stock treading may continually reactivate erosion on soil slip/flow surfaces. Earthflow areas become saturated during winter months posing problems for stock. Broken surface together with poor internal drainage are limitations to pasture production. Where earthflows are undercut at their base by streams, stream or river bank planting is necessary.
- To minimise soil erosion and maintain water quality, carefully plan all earthworks and excavation of roads, drains, dams. Avoid undercutting slopes.

## LUC unit: VIe13 (2362 ha)

**LUC suite:** 7. Old volcanic terrain

**LUC subsuite:** 7b. Landforms on volcanic/sedimentary complexes: (LUC units VIs2, VIe11, VIe13)

**Description:** Strongly rolling to moderately steep slopes forming rolling to hilly terrain on a complex of volcanic and sedimentary lithologies. Unlike VIe11, VIe13 is relatively stable with landforms being result of volcanic intrusion, as in areas surrounding domes, plugs, dykes, and sheets of lava. Soils are typically yellow-brown earths and brown granular loams and clays often spatially complex. Slopes littered with volcanic boulders and stones. Mapped where erosion is considered to be dominant physical limitation, and stoniness and shallow soil depth are considered secondary. Potential for moderate soil slip, gully and sheet erosion.

**Type location:** P05/830570 Near Waiare Road

**Altitudinal range:** 0–400 m

**Slope:** Strongly rolling to moderately steep (D, E), 16–25°

**Landform:** Rolling downlands and moderately steep hills.

**Rock type:** Lavas and welded ignimbrites (Vo), indurated volcanic breccias (Vb), indurated fine-grained pyroclastics (Tb) and ancient volcanics (In). Sedimentary lithologies may include massive sandstone (Sm), bedded sandstone (Sb), limestone (Li), jointed mudstone (Mj), and argillite (Ar).

**Soils:** Weakly to strongly leached brown granular loams and clays, brown loams, red loams, complexed with, or associated with, yellow-brown earths and/or rendzinas.

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh), soil slip (Ss), gully (G), and earthslip (Es)
*Potential:* Moderate (2) sheet (Sh), soil slip (Ss), and gully (G). Slight (1) earthslip (Es)

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM), podocarp forest (fP), lowland podocarp–broadleaved forest (fO), mixed indigenous scrub with tree fern (sT).

**Annual rainfall range:** 1400–1800 mm

**Land use:** *Present:*
Grazing – Present average carrying capacity (s.u./ha) = 8
– Top farmer carrying capacity (s.u./ha) = 10
Undeveloped
*Potential:*
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 12
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 30–33

**Soil conservation management:** Land is relatively stable. Slopes may be littered with stones and boulders.

- Maintain good-quality pastures/apply adequate fertiliser levels – major elements and trace element requirements.
- Open plant soil conservation trees on areas susceptible to mass movement. Pair plant trees in gullies.
- Maintain dense vegetative cover on steeper slopes particularly during summer months. Surficial erosion processes can lead to large areas of bare ground.
- Control grazing by avoiding overstocking and concentrated stock movement.
- Control runoff.
- To minimise soil erosion and maintain water quality, carefully plan all earthworks, excavation of roads, drains, dams. Avoid undercutting slopes.

## LUC unit: VIe14 (28 246 ha)

**LUC suite:** 1. Coastal sand country

**LUC subsuite:** 1c. Old stable podzolised terraces and escarpments on unconsolidated to compact sands:
(LUC units IVe10, IVs5, VIe14, VIs4, VIIe9)

**Description:** Rolling to moderately steep slopes at the sides of old coastal terraces, terrace escarpments and hills on semi-consolidated, compact, sand and gravels. Soils include podzols, gley podzols, and podzolised yellow-brown earths. Potential for moderate to severe sheet and wind erosion and moderate soil slip and gully erosion.

**Type location:** P08/950655 Scarrot Road

**Altitudinal range:** 0–200 m

**Slope:** Rolling to moderately steep (C-E), 8–25°

**Landform:** Steeper sides, escarpments of coastal terraces and dune hills.

**Rock type:** Unconsolidated sands (Us).

**Soils:** Podzolised yellow-brown earth hill soils developed on coastal sands. Weakly to moderately podzolised yellow-brown earths (TTH) and podzols (TEK) of Pinaki suite.

**Erosion:** *Present:* Slight (1) to moderate (2) sheet (Sh), wind (W), gully (G) and soil slip (Ss)
*Potential:* Moderate (2) to severe (3) sheet (Sh) and wind (W). Moderate (2) gully (G), and soil slip (Ss)

**Vegetation:** Semi-improved pasture (gS), improved pasture (gI), exotic conifer forest (fF), manuka, kanuka (sM), heath (sH), cassinia (sC), naturalised exotic trees, exotic conifer forest (nfF), mixed indigenous scrub (sX).

**Annual rainfall range:** 1000–1400 mm

**Land use:** *Present:*
Grazing – Present average carrying capacity (s.u./ha) = 8
– Top farmer carrying capacity (s.u./ha) = 10
Reversion to scrub
Undeveloped land
Forestry – Production – exotic spp.
*Potential:*
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 12
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 28–31

**Soil conservation management:**
- Maintain good-quality pastures/apply adequate fertiliser levels – major elements and trace element requirements. Revegetate eroded sites by oversowing.
- Maintain dense vegetative cover (indigenous scrub or forest, exotic forest) on steeper slopes. Maintain complete dense pastures particularly in summer months.
- Control grazing by avoiding overstocking and concentrated stock movement. Adequate spelling of some hillslopes should be considered.
- Control runoff. Avoid enlargement of bare-ground areas, gullying, etc.
- Minimise soil erosion and maintain water quality. Follow strict management guidelines when land is prepared for tree planting, road construction, drains and culverts (all earthworks) logging (harvesting) deforestation, scrub clearance.

## LUC unit: VIe15 (15 716 ha)

**LUC suite:** 1. Coastal sand country

**LUC subsuite:** 1a. Young unstable sand dune complex:
(LUC units VIe15, VIIe10, VIIIe1)

**Description:** Sand dunes and sand plains on recent relatively unstable windblown (aeolian) sands usually further inland from VIIe10 in more sheltered environments, where younger sands are recorded adjacent to old dune sands. Soils weakly developed and mainly weakly weathered, weakly to moderately leached yellow-brown sands. Potential for moderate to severe wind and sheet erosion.
Vegetation comprises kikuyu grass and lupins, exotic forest, and lesser sand dune vegetation. Pasture is usually low producing and grazing extensive.

**Type location:** Q10/256108 Wilson Road. Near Lake Kareta

**Altitudinal range:** 0–100 m

**Slope:** Undulating to moderately steep (B-E), 4–25°

**Landform:** Sand plains and sand dune hills with typically hummocky surface form. Landform generally undulating to strongly rolling; slopes can range from flat to moderately steep generally below 15°.

**Rock type:** Windblown sand (Wb).

**Soils:** Weakly weathered yellow-brown sands on aeolian sand. Weakly weathered, weakly to moderately leached yellow-brown sands of Pinaki suite (PNH, PN, MDH, MD, WD) and weakly weathered, strongly leached to podzolised yellow-brown sands of Pinaki suite (OE, OEy).

**Erosion:** *Present:* Slight (1) to moderate (2) wind (W) and sheet (Sh). Negligible (0) to slight (1) gully (G) and soil slip (Ss)
*Potential:* Moderate (2) to severe (3) wind (W) and sheet (Sh) and gully (G). Moderate (2) soil slip (Ss)

**Vegetation:** Exotic conifer forest (fF), semi-improved pasture (gS), improved pasture (gI), sand dune vegetation (gD), manuka (SM), coastal scrub (SO), lupins (sL).

**Annual rainfall range:** 1000–1200 mm

**Land use:** *Present:*

| | | |
|---|---|---|
| Forestry | – | Production – exotic spp. |
| Undeveloped | | |
| Grazing | – | Limited |
| | – | Present average carrying capacity (s.u./ha) = 7 |
| | – | Top farmer carrying capacity (s.u./ha) = 8 |

*Potential:*

| | | |
|---|---|---|
| Grazing | – | Attainable physical potential carrying capacity (s.u./ha) = 9 |
| Cropping | – | Unsuitable |
| Forestry | – | Production – site index for *Pinus radiata* = 27–30 |

**Soil conservation management:** Prevent surface disturbance. Capable of productive use if conservation measures applied. Permanent vegetative cover is advised. Reduce the risk of wind erosion; wind breaks recommended. Erosion control forestry on VIIe10 on the seaward side of unit provides shelter and improves the soil moisture regime of adjacent inland sites.
- Grazing should be monitored and controlled. Avoid overstocking and concentrated stock movement, and take care in siting tracks, fencelines, troughs, etc.

**Comments:** Pasture growth and quality limited by long periods of soil moisture deficit. Summer droughts common.

## LUC unit: VIe16 (49 091 ha)

**LUC suite:** 7. Old volcanic terrain

**LUC subsuite:** 7a. Landforms on old stable basalt–andesite volcanics with brown granular loams and clays:
(LUC units IVe3, IVs3, Vc2, VIe2, VIe16, VIc1, VIIe1)

**Description:** Moderate to steep slopes forming steep hilly terrain on old 'basic' to 'intermediate' volcanics including andesites, basalts, and dolerites. Soils brown granular loams and clays and related steepland soils. Unit represents steeper version of VIe2. Potential for moderate to severe soil slip and sheet erosion, and for moderate debris avalanche.

**Type location:** 004/660835 Paroanui

**Altitudinal range:** ~ 0–800 m

**Slope:** Moderately steep to steep (E, F), 21–25°

**Landform:** Hilly to steep hilly terrain.

**Rock type:** Ancient volcanics (In), lavas and welded ignimbrites (Vo), indurated volcanic breccias (Vb), indurated fine-grained pyroclastics (Tb), conglomerate and breccia of volcanic origin (Cg).

**Soils:** Brown granular loam and clay hill and steepland soils on old andesite–basalt volcanics. Weakly to strongly leached brown granular loams and clays of Te Kie suite (TUH, TWH, AKH, C5H, YNH, MNH, RUrH, RUH, TES, TEuS, TErS), Huia suite (HUH, BMH, PTH, DVH, PAH, YTH, CWH, HAS, HAlS), and Katui suite (KTH, YPH, WTH).
Parent materials include shattered dolerites, breccias and tuffs, andesitic agglomerates and breccias, and andesitic flows.

**Erosion:** *Present:* Slight (1) to severe (3) sheet (Sh), and soil slip (Ss). Slight (1) to moderate (2) gully (G), earthslip (Es), and debris avalanche (Da)
*Potential:* Moderate (2) to severe (3) sheet (Sh), soil slip (Ss), and earthslip (Es). Moderate (2) gully (G) and debris avalanche (Da)

**Vegetation:** Lowland podocarp–broadleaved forest (fO), kauri forest (fK), manuka, kanuka (sM), mixed indigenous scrub with tree fern (sT), mixed indigenous scrub (sX), exotic conifer forest (fF), semi-improved pasture (gS), improved pasture (gI).

**Annual rainfall range:** 1400–>2000 mm

**Land use:** *Present:* Undeveloped
Grazing – Present average carrying capacity (s.u./ha) = 7
– Top farmer carrying capacity (s.u./ha) = 8
Forestry – Production – exotic spp.
*Potential:* Grazing – Attainable physical potential carrying capacity (s.u./ha) = 9
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 30–33

**Soil conservation management:**
- Maintain good-quality pasture / apply adequate fertiliser levels – major elements and trace element requirements.
- Open planting of soil conservation trees on areas susceptible to mass movement. Block planting of trees (indigenous forest or exotic forest)

should be considered on steeper slopes and gullies. Forest crops require topdressing for establishment, etc.

- Maintain complete vegetative cover particularly during summer months. Sheet and wind erosion can be serious problem and bare-ground areas are difficult to revegetate. Oversow and fertilise slip scars and bare-ground areas.
- Control grazing by avoiding concentrated stock movement (repeated tracking, along fencelines, tracks).
- Control runoff. Measures required to minimise soil erosion and maintain water quality. Follow strict management guidelines when land is prepared for tree planting, road construction, drains and culverts (all earthworks), logging (harvesting), deforestation, scrub clearance.
- Control feral (noxious) animals in forested areas. Conservation planting must be adequately protected from damage by cattle, goats, possums.

**Comments:**

Old volcanics often difficult to farm. Generally strongly leached soils with granular topsoils – prone to drying out in summer. Difficult to revegetate eroded areas particularly where slipping or debris avalanche has removed soil down to bedrock. Revegetation requires liming to raise pH (high levels of Fe and Al in subsoil).

Fertiliser required:

1. heavy initial dressings of phosphate, trace elements,
2. lower application of fertiliser for pasture maintenance,
3. avoid loss of phosphate by iron and aluminium fixation.

## LUC unit: VIe17 (42 062 ha)

**LUC suite:** 5. Greywacke terrain:
(LUC units IVe7, VIe9, VIe10, VIe17, VIc1, VIIe5, VIIe6)

**Description:** Moderate to steep slopes forming steep hilly terrain on greywacke rock, and occasional deeply weathered greywacke. Soils yellow-brown earths and related steepland soils. A steeper version of VIe9. Potential for moderate soil slip, sheet and gully erosion.

**Type location:** Q08/458720 Waipu Cove area

**Altitudinal range:** 0–600 m

**Slope:** Moderately steep to steep (E+F, F), 21–35°

**Landform:** Steep hilly terrain.

**Rock type:** Greywacke association of rocks (Gw).

**Soils:** Yellow-brown earth hill and steepland soils on greywacke and argillite. Moderately to strongly leached yellow-brown earths of Marua suite (MRrH, MRH, MRuH, RAH, RAlH, TRS, TRuS). May include small areas of yellow-brown earths of Omaiko suite (TVH, TVrH), and small areas of red loams of Manganese suite (MZH), and Maungakohatu suite (MGH).

**Erosion:** *Present:* Slight (1) to moderate (2) soil slip (Ss), sheet (Sh) and gully (G). Negligible (0) to slight (1) earthslip (Es)
*Potential:* Moderate (2) soil slip (Ss), sheet (Sh) and gully (G). Slight (1) earthslip (Es)

**Vegetation:** Semi-improved pasture (gS), improved pasture (gI), exotic conifer forest (fF), lowland podocarp–broadleaved forest (fO), manuka, kanuka (sM), gorse (sG), mixed indigenous scrub (sX), broadleaved forest (fB).

**Annual rainfall range:** 1400>~2000 mm

**Land use:** *Present:*

| | | |
|---|---|---|
| Forestry | – | Production – exotic spp. |
| Undeveloped | | |
| Grazing | – | Present average carrying capacity (s.u./ha) = 7 |
| | – | Top farmer carrying capacity (s.u./ha) = 8 |

*Potential:*

| | | |
|---|---|---|
| Grazing | – | Attainable physical potential carrying capacity (s.u./ha) = 9 |
| Cropping | – | Unsuitable |
| Forestry | – | Production – site index for *Pinus radiata* = 30–33 |

**Soil conservation management:**

- Maintain good-quality pastures/apply adequate fertiliser levels – major elements and trace element requirements.
- Open planting of soil conservation trees on areas susceptible to mass movement. Block planting of trees (indigenous scrub and forest, exotic trees) should be considered on steepest slopes or potentially unstable sites.
- Maintain dense vegetative cover particularly on steeper slopes. Oversow and fertilise slip scars.
- Pair plant soil conservation trees in gullies.
- Control runoff away from steep slopes and potentially unstable sites.
- Minimise soil erosion and maintain water quality. Follow strict management guidelines when land is prepared for tree planting, road construction, drains and culverts (all earthworks), logging (harvesting), deforestation, scrub clearance.
- Control grazing by avoiding overstocking and concentrated stock movement (e.g. repeated tracking).
- Control feral (noxious) animals and forested areas. Conservation planting must be adequately protected from damage by cattle, goats, possums.

## LUC unit: VIe18 (4586 ha)

**LUC suite:** 7. Old volcanic terrain

**LUC subsuite:** 7c. Acid to intermediate igneous volcanics and plutonics: (LUC units IVe11, VIe18, VIIe7)

**Description:** Strongly rolling to moderately steep slopes forming steep hilly and mountainous terrain on 'acid' to 'intermediate' igneous rocks (e.g. dacite, rhyolite) and plutonics (e.g. granodiorite). Occurs at the sides of the old volcanic domes and masses. Soils yellow-brown earths with minor related steepland soils. Potential for moderate to severe sheet, soil slip and gully erosion.

**Type location:** 003/488031 Karikari Peninsula

**Altitudinal range:** 0–400 m

**Slope:** Strongly rolling to moderately steep (D, E), 16–25°

**Landform:** Hilly and steep hilly terrain, often part of volcanic complexes where volcanic cones and domes are dominant landforms.

**Rock type:** Plutonics (Gn), lavas and welded ignimbrites (Vo).

**Soils:** Yellow-brown earth hill and steepland soils on dacite, rhyolite and granodiorite. Moderately to strongly leached, and weakly podzolised yellow-brown earths of Maungarei suite (MEH, MEbH, KUH, PFH, PMH, PES, POS).

**Erosion:** *Present:* Slight (1) to moderate (2) sheet (Sh), soil slip (Ss) and gully (G)
*Potential:* Moderate (2) to severe (3) sheet (Sh), soil slip (Ss) and gully (G)

**Vegetation:** Manuka, kanuka (sM), semi-improved pasture (gS), exotic conifer forest (fF), gorse (sG).

**Annual rainfall range:** 1000–1800 mm

**Land use:** *Present:*
Undeveloped land
Reversion to scrub
Forestry – Production – exotic spp.
Grazing – Present average carrying capacity (s.u./ha) = 7
– Top farmer carrying capacity (s.u./ha) = 8

*Potential:*
Forestry – Production – site index for *Pinus radiata* = 24–27
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 9
Cropping – Unsuitable

**Soil conservation – management:**

- Maintain good-quality pastures/apply adequate fertiliser and lime levels major elements and trace element requirements.
- Open plant soil conservation trees on areas susceptible to mass movement. Consider block planting of trees (indigneous forest or exotic forest) on steeper slopes and gullies. Forest crops require topdressing for establishment and good silvicultural management.
- Initial treatments before establishment of pasture or forest may include:
  (i) ripping or cultivation of soils;
  (ii) fertiliser application and lime (topdressing);
  (iii) nitrogen fixation, planting legumes;
  (iv) techniques for increasing soil organic matter (mulching).
- Maintain complete vegetative cover particularly during summer months.

Sheet and wind erosion can be a serious problem and bare-ground areas are difficult to revegetate. Oversow and fertilise slip scars and bare-ground areas.

- Control grazing by avoiding concentrated stock movement (repeated tracking, along fencelines, tracks, etc.).
- Control runoff. Measures are required to minimise soil erosion and maintain water quality. Strict management guidelines should be followed when land is prepared for tree planting, road construction, drains and culverts (all earthworks), logging (harvesting), deforestation, scrub clearance.
- Control feral (noxious) animals in forested areas. Conservation planting must be adequately protected from damage by cattle, goats, possums.

## LUC unit: VIe19 (36 128 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4d. Crushed argillite:
(LUC units VIe19, VIIe8)

**Description:** Rolling to moderately steep slopes forming steep hilly terrain on fractured and sheared – 'crushed' – argillites, commonly referred to as siliceous shale or siliceous claystone.
Soils podzolised yellow-brown earths, and also podzols on dacite–rhyolite rock.
Potential for severe gully and sheet erosion, and for moderate to severe soil slip and earthslip erosion.

**Type location:** 005/646530 Happy Valley Road

**Altitudinal range:** 0–500 m

**Slope:** Moderately steep and strongly rolling (E, D), 16–25°

**Landform:** Steep hilly terrain. Acute (sharp) narrow ridges and concavo–convex and concave hillslopes often scarred by slips with debris masses on lower slopes and in streams.

**Rock type:** Crushed argillite association of rocks (Ac).

**Soils:** Strongly leached and podzolised yellow-brown earth hill soils on shales. Strongly leached to moderately podzolised yellow-brown earths of Omu suite (PPH, HKH, HKgH, YKH, OPH). May include areas of moderately podzolised yellow-brown earths on quartzite of Omaiko suite (OVH, OV, OVp) and moderately podzolised yellow-brown earths and podzols of Maungarei suite (PR, PRp).

**Erosion:** *Present:* Slight (1) to severe (3) gully (G), sheet (Sh), soil slip (Ss) and earthslip (Es)
*Potential:* Severe (3) gully (G), sheet (Sh), soil slip (Ss) and earthslip (Es)

**Vegetation:** Manuka, kanuka (sM), exotic conifer forest (fF), gorse (sG), semi-improved pasture (gS), lowland podocarp–broadleaved forest (fO).

**Annual rainfall range:** 1200–1800 mm

**Land use:** *Present:*
Undeveloped land
Reversion to scrub
Forestry – Production – exotic spp.
Grazing – Present average carrying capacity (s.u./ha) = 7
– Top farmer carrying capacity (s.u./ha) = 8

*Potential:*
Forestry – Production – site index for *Pinus radiata* = 26–32
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 9
Cropping – Unsuitable
Land suited ideally to forestry/agroforestry/pastoral land uses.
Forestry recommended particularly on slopes above 15°.

**Soil conservation management:**
- Maintain good-quality pastures/apply adequate fertiliser and lime levels. Major elements and trace element requirements.
- Graded banks, protected waterways required to control runoff.
- Open planting of soil conservation trees on areas susceptible to mass movement.

- Block planting of trees (indigenous forest or exotic forest) recommended on steeper slopes. Forest crops require topdressing for establishment and good silvicultural management.
- Initial treatments before establishment of pasture or forest may include:
  (i) ripping or cultivation of soils;
  (ii) fertiliser application and lime (topdressing);
  (iii) nitrogen fixation, planting legumes;
  (iv) techniques for increasing soil organic matter (mulching).
- Maintain a complete vegetative cover. Minimise sheet erosion and control runoff.
- Gully erosion is serious. Gullies should be retired and block planted. Recommended treatments include:
  (i) diversion of runoff water away from gully head;
  (ii) stabilise areas within gully and at gully head with debris dam structures, flumes, and tree planting. Sediment traps required;
  (iii) gully plugs;
  (iv) revegetation (pair and block planting).
- Erosion control forestry should be considered.
- Maintain permanent vegetative cover on runoff channels to prevent enlargement of gullies.
- Minimise soil erosion and maintain water quality. Strict management guidelines should be followed when land is prepared for tree planting, road construction, drains, culverts (all earthworks), logging (harvesting), deforestation, scrub clearance.
- Control feral (noxious) animals. Conservation planting must be protected from damage by cattle, goats, possums.

## LUC unit: VIw1 (11 577 ha)

**LUC suite:** 2. Alluvial and estuarine plains and low terraces

**LUC subsuite:** 2c. Poorly drained floodplains and low terraces: (LUC units IVw1, VIw1, VIIw1)

**Description:** Low lying, flat to gently undulating land within floodplains, valley plains, low terraces, and narrow valleys on alluvium with a continuing severe wetness limitation. Subject to frequent flooding or a permanently high watertable. Typical soils, often mottled, are recent soils and yellow-brown earths. Assessed as requiring a community drainage scheme.

**Type location:** Q08/264729 Mareretu

**Altitudinal range:** 0–100 m

**Slope:** Flat to undulating (A), 0–3°

**Landform:** Floodplains. Low terraces.

**Rock type:** Fine alluvium (Af).

**Soils:** Recent soils on sedimentary and volcanic alluvium. Recent soils of Whareora suite (WFa, WF,WFm) and Kohumaru suite (MF, MFm). Gley soils of Kaipara, Waipapa and Waipu suites may be included where wetness is considered severe or prolonged and this precludes arable use.

**Erosion:** *Present:* Negligible (0) to moderate (2) streambank (Sb) and deposition (D)
*Potential:* Moderate (2) to severe (3) streambank (Sb) and deposition (D)

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), rushes, sedges (hR), wetland vegetation (hW). Podocarps (fP).

**Annual rainfall range:** 1200–1800 mm

**Land use:** *Present:*
Grazing – Present average carrying capacity (s.u./ha) = 13
– Top farmer carrying capacity (s.u./ha) = 15
Undeveloped land
*Potential:*
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 18
Forestry – Production – site index for *Pinus radiata* = <18
Cropping – Unsuitable

**Soil conservation management:**
- Severe wetness limitation because of runoff from adjacent hills, potential for frequent flooding, and high watertables throughout much of the year. Suitable flood protection (drainage and stopbanks) should be considered on long-term basis and management planning should be directed over whole catchment.
- Stopbanks are recommended.
- Drainage is required, planning at community level.
- Erosion (stream/river bank and deposition) can be locally severe and difficult and expensive to repair/control. Bank protection is required in some areas (stopbanks and vegetation planting).
- Avoid disturbance/modification of channels, channel beds (control aggradation or degradation). Control earthworks adjacent to channels.
- Maintain clearance of vegetation within stream and river channels. Avoid tree felling and deposition of slash in channels.
- Flood detention techniques required in some areas, for example, management of swamp areas, construction of detention dams.

**Comments:** These areas would be greatly affected by any rise in sea level or base level changes (aggradation) within channels. High watertables throughout the year, together with a potential for frequent flooding, make these areas unsuitable for cropping or forestry.

## LUC unit: VIw2 (2410 ha)

**LUC suite:** 2. Alluvial and estuarine plains and low terraces

**LUC subsuite:** 2d. Mudflats with saline soils:
(LUC units IIIw3, IVw2, VIw2)

**Description:** Flat, recently (<10 years) reclaimed tidal mudflats, estuarine plains, with slightly saline gley soils on alluvium. These areas have an extreme wetness limitation due to high watertables throughout the year, are prone to flooding and subject to receiving runoff from surrounding hills, and affected by tidal influence. Soils generally have high salinity levels. Occur at margins of harbours, bays, lagoons, intertidal creeks and streams.

**Type location:** Q09/315435 Oneriri Road

**Altitudinal range:** 0–20 m

**Slope:** Flat to gently undulating (A), 0–3°

**Landform:** Tidal mudflats, margins of lagoons, estuaries, floodplains.

**Rock type:** Fine alluvium (Af).

**Soils:** Slightly saline gley soils of Kaipara suite (TCa, TC, TCy, TCya) on coastal mudflats.
Parent materials include estuarine clays, sands and alluvium.

**Erosion:** *Present:* Negligible (0)
*Potential:* Slight (1) to moderate (2) deposition

**Vegetation:** Semi-improved pasture (gS), improved pasture (gI), saline vegetation (hS), rushes, sedges (hR), manuka, kanuka (sM). Small areas of mangroves (sV).

**Annual rainfall range:** 1000–1400 mm

**Land use:** *Present:* Undeveloped land
Grazing – Present average carrying capacity (s.u./ha) = 8
– Top farmer carrying capacity (s.u./ha) = 10
*Potential:* Grazing – Attainable physical potential carrying capacity (s.u./ha) = 12
Cropping – Unsuitable
Forestry – Unsuitable

**Soil conservation management:**
- Areas have permanently high watertables, or prone to flooding attributed to runoff/discharge and tidal influence. Long-term suitable flood protection should be considered and management/planning should be directed over broader catchment/coastal area
- Stopbanks required. Maintain condition of stopbanks.
- For productive use, drainage and control of watertable levels necessary.
- Avoid increasing siltation/deposition in lower channels and areas adjacent to estuaries and harbours.
- Maintain good-quality pastures/apply adequate fertiliser levels. Minimise surficial erosion in drier months.

## LUC unit: VIw3 (3251 ha)

**LUC suite:** 2. Alluvial and estuarine plains and low terraces

**LUC subsuite:** 2e. Peats:
(LUC units IIIw4, IVw3, VIw3, VIIw2)

**Description:** Flat to gently undulating land with organic soils on peat and alluvium. Includes low-lying flats, narrow valleys, plains, interdune swamps, etc. Areas on peat often drained and reclaimed but have continuing or prolonged wetness limitation due to flooding or permanently high watertable. Many areas are swampland.

**Type location:** Q06/pt R06/170214 Otakairangi Road

**Altitudinal range:** 0–100 m

**Slope:** Flat to undulating (A), 0–3°

**Landform:** Low-lying flat land on peat such as plains, swamp-filled valleys, floodplains.

**Rock type:** Peat (Pt) or peat complexed with fine alluvium (Pt + Af).

**Soils:** Organic soils of Ruakaka suite (PZ, OT, RK, RKu, RKd, RKy, RKl) and Otonga suite (OG, OGd, OGv, OR, ORd) on peat or peat and sand.

**Erosion:** *Present:* Negligible (0) to slight (1) deposition (D)
*Potential:* Slight (1) to moderate (2) deposition (D). Slight (1) to moderate (2) streambank (Sb)

**Vegetation:** Semi-improved pasture (gS), rushes, sedges (hR), manuka, kanuka (sM), wetland vegetation (hW), exotic broadleaved forest (fR).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:* Undeveloped land
Grazing – Present average carrying capacity (s.u./ha) = 13
– Top farmer carrying capacity (s.u./ha) = 15
*Potential:* Grazing – Attainable physical potential carrying capacity (s.u./ha) = 18
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = <18
– may suit hardwoods

**Soil conservation management:**
- Areas prone to flooding or have permanently high watertables. Mainly suited to pastoral farming, grazing. Suitable flood protection should be considered on long-term basis, management/planning should be directed over the whole catchment.
- Management of watertable levels required for productive use.
- Stopbanks recommended.
- Drainage planning at the community level required.
- Erosion (stream/river bank and deposition) locally severe, difficult and expensive to repair/control. Bank protection required in some areas (tree planting).
- Avoid disturbance/modification of channels, chanel beds (control aggradation and degradation). Control earthworks adjacent to channels.
- Maintain clearance of vegetation within stream and river channels. Avoid tree felling and deposition of slash, debris in channels.
- Areas often necessary for flood detention and require careful management.

**Comments:** Areas would be greatly affected by any rise in sea level or base level changes within channels/harbour areas.

## LUC unit: VIs1 (5982 ha)

**LUC suite:** 6. Young basalt volcanic terrain:
(LUC units Ic1, IIe1, IIs1, IIIe1, IIIs1, IIIs2, IVe2, IVs1, IVs2, Vs1, VIs1, VIe4, VIIIs2)

**Description:** Flat to rolling slopes on relatively young basalt flow terrains with numerous stones, gravels and boulders scattered over land surface and throughout soil profile. Soil depths commonly less than 30 cm over hard weathered basalt rock, and gravels and boulders typically comprise greater than 35% by volume of soil profile. Stoniness and shallow soil depth preclude arable use. Soils mainly brown loams. Often mapped at edge of basalt lava flows, for example, terrace and plains.

**Type location:** P05/889503 Ohaeawai

**Altitudinal range:** 0–400 m

**Slope:** Typically flat to rolling, however strongly rolling and moderately steep slopes may also be recorded (A, B, C, D, E), 0–25°

**Landform:** Flat to gently rolling surfaces on basalt lava terraces and plains.

**Rock type:** Lavas and welded ignimbrites (Vo).

**Soils:** Weakly to strongly leached brown and red loams with a bouldery or stony phase on basalt flows, scoria and ash. Weakly to moderately leached brown loams of Kiripaka suite (KB, KBb, KBe, KBeb, OWb), moderately to strongly leached brown loams of Kiripaka suite (YOb, MCb, KEb, RTb). Red loams of Papakauri suite (MUb) can be included where boulders and stones preclude arable use.

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh) and gully (G)
*Potential:* Slight (1) sheet (Sh) and gully (G)

**Vegetation:** Semi-improved pasture (gS), improved pasture (gI), gorse (sG), podocarp forest (fP), lowland podocarp–broadleaved forest (fO), manuka, kanuka (sM).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:*
Grazing – Present average carrying capacity (s.u./ha) = 17
– Top farmer carrying capacity (s.u./ha) = 20
Undeveloped land
Reversion to scrub
*Potential:*
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 24
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = <18

**Soil conservation management:** Land, although relatively stable, requires intensive management for productive use.
- Maintain good-quality pastures/apply adequate fertiliser levels – major elements and trace element requirements.
- Control of noxious weeds (gorse) required as part of pasture maintenance.
- Management may involve stone removal.
- Soils often shallow and experience moisture deficiencies in drier months. Irrigation may be required for intensive use.

- Shelterbelts, windbreaks recommended for minimising surficial erosion (sheet and wind) and improving the soil moisture regime.
- Techniques for increasing soil organic matter should be considered.
- Some areas (isolated swamp patches) may require drainage.
- Control grazing by avoiding overstocking and concentrated stock movement (repeated tracking) along fencelines, tracks and around troughs, etc.

**Comments:** Soils often suffer from seasonal soil moisture deficits. Underlying basalt may impede drainage in some areas during wetter months.

## LUC unit: VIs2 (803 ha)

**LUC suite:** 7. Old volcanic terrain

**LUC subsuite:** 7b. Landforms on volcanic/sedimentary complexes: (LUC units VIs2, VIe11, VIe13)

**Description:** Gently undulating to rolling slopes on complex of volcanic and sedimentary rock often forming downlands at edges of volcanic intrusions. Land has dominant soils limitation where stoniness or shallow soil depth preclude arable use, or soils are podzolised (on rhyolite and dacite rock). Typical soils are yellow-brown earths and podzolised yellow-brown earths.
Mapped where soils limitation due to stoniness, shallow soil depth, or poor soil structure or infertility is considered the dominant physical limitation, and erosion secondary. In areas where stoniness or shallow soils are dominant characteristic, slopes often littered with volcanic boulders and stones.

**Type location:** P05/903558 end of Whakataha Road

**Altitudinal range:** 0–600 m

**Slope:** Undulating to rolling (B, B+C, C), 4–15°

**Landform:** Gently rolling to rolling downlands, moderately steep hills. Hill country.

**Rock type:** Ancient volcanics (In), lavas and welded ignimbrites (Vo), indurated volcanic brreccias (Vb), complexed with various sedimentary lithologies (Ar, Mj, Sm).

**Soils:** Complex or association of brown granular loams and clays and yellow-brown earths, or brown or red loams and yellow-brown earths. Rendzinas may also be included. Strongly leached yellow-brown earths to moderately podzolised yellow-brown earths of Maungarei suite (PF, PM, PMH, PR) may be included in this unit.

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh) and gully (G)
*Potential:* Slight (1) sheet (Sh) and gully (G)

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), lowland podocarp–broadleaved forest (fO), podocarp forest (fP), manuka, kanuka (sM), mixed indigenous scrub (sX).

**Annual rainfall range:** 1400–>2000 mm

**Land use:** *Present:*
Grazing – Present average carrying capacity (s.u./ha) = 13
– Top farmer carrying capacity (s.u./ha) = 15
Undeveloped land
Reversion to scrub

*Potential:*
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 18
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 28–30

**Soil conservation management:**
- Maintain good-quality pastures/apply adequate fertiliser levels – major elements and trace element requirements. Control of noxious weeds (gorse) is required.
- Management may involve stone removal.
- Soils often shallow and stony, or have poor soil structure and are infertile, and experience moisture deficiencies in drier months. More infertile land suited to forestry, both block planting and agroforestry, with forestry establishment requiring initial periods of topdressing.
- Shelterbelts recommended on more stony soils to reduce soil moisture deficiencies and wind erosion.
- Techniques for increasing soil organic matter should be considered. Less stony areas should be deep ripped, followed by fertiliser application and planting of legumes.

## LUC unit: VIs3 (209 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4e. Limestone:
(LUC units IIIs5, IVe1, Vc1, VIs3, VIe3, VIIe3)

**Description:** Undulating to steep slopes within hilly and rolling terrain on limestone. Soils are rendzinas and associated soils. Shallow soils and numerous rocky outcrops preclude arable use. Pasture production may be high if well managed.

**Type location:** 005/627702 Iwitaua Road

**Altitudinal range:** 0–400 m

**Slope:** Undulating to steep (B-F), 4–35°

**Landform:** Lowlying hilly terrain, downlands. Karst landscape, rock outcrops.

**Rock type:** Limestone (Li).

**Soils:** Rendzinas and associated soils on limestone. Weakly to moderately leached rendzinas of Arapohue suite (AUH, AU, AUd, MTH, MT). Moderately to strongly leached rendzinas of Konoti suite (KNH, KN, KNrH, KNr).

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh), soil slip (Ss), tunnel gully (T), and gully (G)
*Potential:* Slight (1) to moderate sheet (Sh), soil slip (Ss), and gully (G). Moderate (2) to severe (3) tunnel gully (T)

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), manuka, kanuka (sM), podocarp forest (fP), lowland podocarp–broadleaved forest (fO), rushes, sedges (hR).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:* Grazing – Present average carrying capacity (s.u./ha) = 11
– Top farmer carrying capacity (s.u./ha) = 13
Undeveloped land
*Potential:* Grazing – Attainable physical potential carrying capacity (s.u./ha) = 15
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 24–27

**Soil conservation management:**
- Maintain good-quality pastures/apply adequate fertiliser levels – major element and trace element requirements.
- Control noxious weeds (tobacco weed, Australian sedge) as part of pasture maintenance programme.
- Control grazing by avoiding overstocking and concentrated stock movement (repeated tracking) particularly in wetter months. Avoid excessive pugging of soils by heavy stock and activation of soil or terracette creep and other types of mass movement erosion.
- Open plant soil conservation trees on areas susceptible to mass movement. Pair planting of trees in tunnel gullies and gullies.
- Control runoff away from steeper slopes, gullies and tunnel gullies.
- Maintain dense vegetative cover (indigenous scrub or forest) on steeper slopes and gully/tunnel gully areas.
- Good fencing required to avoid stock loss and control animal movements by keeping animals away from pot holes, caves, etc.

**Comments:** High percentage of expanding clays in soil. Soils typically wet in winter and dry in summer months.

## LUC unit: VIs4 (2586 ha)

**LUC suite:** 1. Coastal sand country

**LUC subsuite:** 1c. Old stable podzolised terraces and escarpments on unconsolidated to compact sands:
(LUC units IVe10, IVs5, VIe14, VIs4, VIIe9)

**Description:** Flat to gently rolling slopes on coastal terrace surfaces, marine benches, and plains, formed on dune, estuarine, and fluviatile sands and gravels. Soils podzols, gley podzols, and podzolised yellow-brown earths. Unit represents those coastal areas where podzolisation precludes arable use. Soils of very low natural fertility (nutrient deficient) and have poor structure.

**Type location:** M02, N02/998452 Spirits Bay Road

**Altitudinal range:** 0–200 m

**Slope:** Flat to gently rolling (B, A, C), 0–15°

**Landform:** Coastal terraces, lowlying dunes, marine benches. Flat to gently rolling slopes on terrace surfaces. Range of terrace heights exist.

**Rock type:** Unconsolidated to compact sands (Us).

**Soils:** Podzols on coastal sands. Podzols and gley soils of Pinaki suite (TEKm, TX, TXp, TEK, TEKy).

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh), gully (G), and rill (R)
*Potential:* Moderate (2) to severe (3) gully (G), rill (R) and sheet (Sh)

**Vegetation:** Manuka, kanuka (sM), heath (sH), cassinia (sC), mixed indigenous scrub (sX), semi-improved pasture (gS), exotic conifer forest (fF), rushes, sedges (hR), dracophyllum (sD).

**Annual rainfall range:** 1000–1400 mm

**Land use:** *Present:* Undeveloped
Grazing – Present average carrying capacity (s.u./ha) = 8
– Top farmer carrying capacity (s.u./ha) = 10
Reversion to scrub
*Potential:* Grazing – Attainable physical potential carrying capacity (s.u./ha) = 12
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = <18
Land suited ideally to forestry/agroforestry/pastoral land uses.

**Soil conservation management:** Podzolised soils difficult to manage, often have hard pan at depth.

- Maintain good-quality pastures/apply adequate fertiliser levels – major elements and trace element requirements. Control of noxious weeds (gorse) and scrub (manuka) required as part of pasture maintenance. Initial treatments prior to establishment of pasture or forest may include:
  (i) deep ripping, cultivation (improve plant rooting depth);
  (ii) fertiliser application and lime (topdressing);
  (iii) nitrogen fixation, planting legumes;
  (iv) techniques for increasing soil organic matter (mulching).
- Waterlogged soils require drainage. Forestry requires subsoil drainage and good silvicultural management.
- Control runoff away from erodible sites. Prevent gullying.
- Control grazing by avoiding overstocking and concentrated stock

movement (repeated tracking). Soils can pug badly in wetter months.
- Carefully plan all earthworks (drains, roads, etc.) to minimise soil erosion and maintain water quality.

**Comments:** Soils very nutrient deficient. For pasture establishment and maintenance, fertiliser application should include phosphate, potash, cobalt and molybdenum.

## LUC unit: VIs5 (10 626 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4g. Podzols on sedimentary rock:
(LUC units IVe12, IVs4, IVw4, VIs5)

**Description:** Flat to gently rolling slopes, typically on lower slope margins of downlands, broad convex ridges, flattened crests on hills, on a range of sedimentary lithologies (sandstones, mudstones, argillites). Typical soils are podzols, and unit represents areas where podzolisation precludes sustainable arable use. Soils of very low natural fertility (nutrient deficient) and have poor structure.

**Type location:** P04/878749 State Highway 10, near Matauri Bay Road turn-off

**Altitudinal range:** 0–400 m

**Slope:** Flat to gently rolling (B, B+A, B+C), 4–15°

**Landform:** Flat to gently rolling slopes usually within hill country and downlands. Occasionally recorded in upland, plateau like areas.

**Rock type:** Range of sedimentary lithologies recorded which are often veneered by colluvium and/or alluvium: jointed mudstone (Mj), argillite (Ar), sandstone (Sm, Sb), fine alluvium (Af), unconsolidated clays and silts (Uf). May include small areas of volcanics (Vo).

**Soils:** Podzols on various sedimentary lithologies. Podzols of Puhoi suite (Wkfp, WKf), Waiotira suite (WKap, WKa), Omu suite (Wkp, WKr). Podzols on alluvium of Whareora suite (KRp, KRap) and podzols on dacite, rhyolite and granodiorite of Maungarei suite (PRp) can be included.

**Erosion:** *Present:* Negligible (0) to moderate (2) sheet (Sh), gully (G) and rill (R). Negligible (0) to slight (1) soil slip (Ss)
*Potential:* Moderate (2) to severe (3) sheet (Sh), gully (G) and rill (R). Slight (1) soil slip (Ss)

**Vegetation:** Manuka, kanuka (sM), rushes, sedges (hR), exotic conifer forest (fF), semi-improved pasture (gS), mixed indigenous scrub (sX), cassinia (sC).

**Annual rainfall range:** 1400–1800 mm

**Land use:** *Present:*
Undeveloped
Grazing – Present average carrying capacity (s.u./ha) = 13
– Top farmer carrying capacity (s.u./ha) = 15
Forestry – Production – exotic spp.
Reversion to scrub
*Potential:*
Forestry – Production – site index for *Pinus radiata* = 20–24
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 18
Cropping – Unsuitable
Land suited ideally to forestry/agroforestry/pastoral land uses.

**Soil conservation management:** Podzolised soils difficult to manage: often have a hardpan at depth.
- Maintain good-quality pastures/apply adequate fertiliser and lime levels. Major elements and trace element requirements. Control of noxious weeds (gorse) and scrub (manuka) required as part of pasture maintenance. Initial treatments before establishment of pasture or forest may include:
  (i) deep ripping, cultivation (improve plant rooting depth);
  (ii) fertiliser application and lime (topdressing);

(iii) nitrogen fixation, planting legumes;
(iv) techniques for increasing soil organic matter (mulching).

- Waterlogged soils require drainage. Forestry requires subsoil drainage and good silvicultural management.
- Control runoff away from erodible sites. Prevent gullying.
- Control grazing by avoiding overstocking and concentrated stock movement (repeated tracking). Soils can pug badly in wetter months.
- To minimise soil erosion and maintain water quality carefully plan all earthworks (drains, roads, etc.).

**Comments:** Soils very nutrient deficient. For pasture and forestry establishment and maintenance, fertiliser application should include superphosphate and lime. Combinations of phosphorus, potassium and trace elements such as boron required.

## LUC unit: VIc1 (4800 ha)

**LUC suite:** 7. Old volcanics terrain

**LUC subsuite:** 7a. Landforms on old stable basalt–andesite volcanics with brown granular loams and clays:
(LUC units IVe3, IVs3, Vc2, VIe2, VIe16, VIc1, VIIe1)

**Description:** Gently to strongly rolling slopes which form high or elevated surfaces typically above 600 m a.s.l. on old volcanic rock (plateau) and flat to rolling slopes above 400 m a.s.l. on greywacke rock, where climate is considered the dominant physical limitation affecting land use. Strongly leached brown granular loams and clays on volcanics or strongly leached to moderately podzolised yellow-brown earths on greywacke are typical.
Rainfall generally high (1800–>2000 mm ) and evapotranspiration very low. Areas exposed to strong westerly winds.

**Type location:** P05/817679 Omataroa Ridge Road

**Altitudinal range:** 600–>800 m a.s.l. on old volcanic rock (Tangihua volcanics, Waipoua basalt). >400 m a.s.l. on greywacke association of rock

**Slope:** On old volcanics – gently rolling to strongly rolling slopes (C, C + D), 8–20° >600 m a.s.l. On greywacke – flat to rolling slopes (A, B, C), 0–15° >400 m a.s.l.

**Landform:** Upland plateau or elevated (high-altitude) surface which is almost horizontal. Long, relatively even, undulating to strongly rolling slopes.

**Rock type:** Lavas and welded ignimbrites (Vo), ancient volcanics (In), greywacke (Gw), indurated volcanic breccias (Vb).

**Soils:** Brown granular loams and clays and occasional yellow-brown earths on high plateaux. Moderately to strongly leached brown granular loams and clays of Katui suite (TO, WT). Strongly leached to weakly podzolised yellow-brown earths of Marua suite (RA, RAl) and associated moderately podzolised Y-B earths (HKr).

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh), gully (G), and tunnel gully (T)
*Potential:* Slight (1) to moderate (2) gully (G), and tunnel gully (T). Slight (1) sheet (Sh)

**Vegetation:** Lowland podocarp–broadleaved forest (fO), kauri forest (fK), manuka, kanuka (sM), broadleaved forest (fB), mixed indigenous scrub (sX), exotic conifer forest (fF).

**Annual rainfall range:** 1800–>2000 mm

**Land use:** *Present:* Undeveloped
Grazing – Present average carrying capacity (s.u./ha) = 13
– Top farmer carrying capacity (s.u./ha) = 15
Reversion to scrub
*Potential:* Grazing – Attainable physical potential carrying capacity (s.u./ha) = 18
Cropping – Unsuitable
Forestry – Production – site index for *Pinus radiata* = 29–32

**Soil conservation management:**
- Establishment and maintenance of pasture or exotic forestry may be difficult under high rainfalls, low evapotranspiration, and strong winds. Many areas poorly drained (waterlogged soils) and large areas covered in native vegetation.

- Subsurface drainage required for establishment of pasture or exotic forestry.
- Under pasture, grazing should be controlled. Avoid excessive pugging of soils by heavy stock.
- Control runoff, avoid development of gully, tunnel gully erosion.
- Under a warm climate, vegetation regeneration rates (native scrub and fern) can be rapid.

## LUC unit: VIIe1 (53 299 ha)

**LUC suite:** 7. Old volcanic terrain

**LUC subsuite:** 7a. Landforms on old stable basalt–andesite volcanics with brown granular loams and clays:
(LUC units IVe3, IVs3, Vc2, VIe2, VIe16, VIc1, VIIe1)

**Description:** Steep to very steep slopes forming steep, hilly and mountainous terrain on old 'basic' to 'intermediate' volcanic rock (dolerite, andesite, basalt).
Soils are typical steepland soils related to brown granular loams and clays. A steeper version of VIe16 and VIe2. Potential for severe soil slip and debris avalanche erosion, particularly during high-intensity rainstorms, and for moderate sheet and gully erosion.

**Type location:** 004/668913 Stoney Creek Road

**Altitudinal range:** 0–800 m

**Slope:** Steep to very steep (F, F+G), 26–>35°

**Landform:** Steep hill country and mountainlands. Includes steep rugged landforms on large fault-bounded blocks, igenous complexes often referred to as massifs (Tangihua massifs), and steep sides of plateau forming basalts (Tutamoe Plateau).

**Rock type:** Ancient volcanics (In), lavas and welded ignimbrites (Vo), indurated volcanic breccia (Vb), indurated fine-grained pyroclastics (Tb), ultramafics (Um), conglomerate and breccia of volcanic origin (Cg).

**Soils:** Brown granular loam and clay steepland and hill soils on old volcanics. Weakly to strongly leached brown granular loams and clays of Te Kie suite (TES, TEuS, TErS, AKH), Huia suite (HAS, HAlS), and Katui suite (KTH, YPH, WTH).
Parent materials include shattered dolerites, breccias and tuffs, andesitic agglomerates and breccias, and andesitic flows.

**Erosion:** *Present:* Slight (1) to severe (3) sheet (Sh), soil slip (Ss), earthslip (Es) gully (G), debris avalanche (Da)
*Potential:* Severe (3) soil slip (Ss) and debris avalanche (Da). Moderate (2) gully (G), sheet (Sh) and earthslip (Es)

**Vegetation:** Semi-improved pasture (gS), exotic conifer forest (fF), lowland podocarp–broadleaved forest (fO), broadleaved forest (fB) mixed indigenous scrub with tree fern (ST), mixed indigenous scrub (sM), improved pasture (gI).

**Annual rainfall range:** 1400–2000 mm

**Land use:** *Present:*
Undeveloped
Forestry – Production – exotic spp.
Grazing – Present average carrying capacity (s.u./ha) = 7
– Top farmer carrying capacity (s.u./ha) = 8
Reversion to scrub
*Potential:*
Forestry – Production – site index for *Pinus radiata* = 29–32
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 9
Cropping – Unsuitable
Ideally suited to forestry, erosion control forestry (exotic and native) and catchment protection.

**Soil conservation management:**

- Maintenance of complete vegetative cover essential. Maintain good-quality pasture / apply adequate fertiliser levels. Oversow and fertilise slip scars and bare-ground areas.
- Retire steepest slopes. Retain indigenous forest particularly on steepest slopes, allow regeneration on steeper slopes and gully areas.
- Management should consider whole catchment.
- Open planting of soil conservation trees on areas susceptible to mass movement. Block planting of either exotic trees or indigenous trees should be considered on areas assessed as having a high susceptibility to erosion. Pair plant or block plant trees in gullies.
- Control runoff. Measures required to minimise soil erosion and maintain water quality. Follow strict management guidelines when preparing land for tree planting, road construction, drains and culverts (all earthworks), logging (harvesting), deforestation, scrub clearance.
- Control feral (noxious) animals in forested areas. Conservation planting must be adequately protected from damage by cattle, goats, possums.
- Control grazing.

## LUC unit: VIIe2 (1050 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4c. Sheared mixed lithologies:
(LUC units IVe8, VIe12, VIIe2)

**Description:** Gently rolling, undulating and occasional moderately steep slopes forming hilly and rolling terrain on complex of fractured and sheared sedimentary and volcanic lithologies with relatively high mudstone content. Rocks are often multicoloured. Spatially complex soils typically include yellow-brown earths and/or brown granular loams and clays. Slope profiles irregular with broken or hummocky surface form. Unit represents more unstable or potentially unstable form of VIe12. Potential for severe to very severe earthflow, and gully erosion, and for moderate earthslip, soil slip and sheet erosion. Poor internal drainage and saturated on-slope conditions often features.

**Type location:** P06/747292 Mataraua

**Altitudinal range:** 0–600 m

**Slope:** Gently rolling to moderately steep (C, D, E), 8–25°

**Landform:** Unstable low angle hillslopes. Long broken slopes.

**Rock type:** Sheared mixed lithologies (Mx), argillite (Ar), jointed or frittered mudstone (Mj), sandstone (Sm, Sb). Sedimentary lithologies are dominantly recorded but sometimes complexed with ancient volcanics (In).

**Soils:** Yellow-brown earths and yellow-brown earth / brown granular loam and clay complexes on various sedimentary / old volcanic lithologies. Includes weakly to strongly leached yellow-brown earths of Omu suite (OMH, APH, OAH), Omanaia suite (WNH, WN, ONH, ON, ONe, AEH, AE, AEeH, AEe, KWH, KW, YR), Waiotira suite (YCeH), Purua suite (PUeH, TNH, TNaH). Weakly to strongly leached brown granular loams and clays of Te Kie suite (C8, C9H, C9).

**Erosion:** *Present:* Moderate (2) to severe (3) earthflow (Ef) and gully (G). Negligible (0) to moderate (2) earthslip (Es), soil slip (Ss) and sheet (Sh)
*Potential:* Severe (3) to very severe (4) earthflow (Ef) and gully (G). Moderate (2) earthslip (Es), soil slip (Ss) and sheet (Sh)

**Vegetation:** Improved pasture (gI), semi-improved pasture (gS), rushes, sedges (hR), exotic conifer forest (fF), manuka, kanuka (sM), lowland podocarp–broadleaved forest (fO).

**Annual rainfall range:** 1400–1800 mm

**Land use:** *Present:*

| | | |
|---|---|---|
| Grazing | – | Present average carrying capacity (s.u./ha) = 8 |
| | – | Top farmer carrying capacity (s.u./ha) = 10 |
| Forestry | – | Production – exotic spp. |
| | – | Erosion control forestry |

*Potential:*

| | | |
|---|---|---|
| Forestry | – | Erosion control and production |
| | – | site index for *Pinus radiata* = 26–29 |
| Grazing | – | Attainable physical potential carrying capacity (s.u./ha) = 12 |
| Cropping | – | Unsuitable |

Ideally suited to erosion control forestry (exotic and native) and catchment protection.

**Soil conservation management:**

Good soil conservation management essential because of earthflow and gully erosion.

- Slope profiles hummocky. Broken nature of surface and poor internal drainage are limitations to pastoral use and productivity.
- Open planting or block planting of trees (conservation or exotic forestry) required to promote dewatering of slopes. Other treatments may involve spring tapping, smoothing of earthflows or drainage (tubes) at foot of slopes.
- Bank planting necessary where streams or rivers undercut earthflow bases.
- Minimise soil erosion and maintain water quality. Carefully plan all earthworks and excavation (roads, drains, dams). Avoid undercutting slopes.
- Control runoff, e.g. diversion channels.

## LUC unit: VIIe3 (933 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4e. Limestone:
(LUC units IIIs5, IVe1, Vc1, VIs3, VIe3, VIIe3)

**Description:** Steep to very steep slopes forming steep hilly terrain on limestone rock. Includes scarps of dipping limestone blocks with numerous rock outcrops and shallow soils. Steepland and hill soils related to rendzinas and associated soils. Represents steeper version of VIe3. Potential for moderate to severe soil slip (soil creep), sheet erosion, and for slight gully erosion on less steep slopes.

**Type location:** 005/633695 Iwitau Road, Mangamuka

**Altitudinal range:** 0–400 m

**Slope:** Steep to very steep (F+G, G+F, F, G), 26–>35°

**Landform:** Steep hill country. Fault scarps and escarpments. Typically long slopes.

**Rock type:** Limestone (Li).

**Soils:** Rendzinas and associated soils on limestone. Weakly to moderately leached rendzinas of the Arapohue suite (MTH, AUH).

**Erosion:** *Present:* Slight (1) to moderate (2) soil slip (Ss), and sheet (Sh). Negligible (0) to slight (1) gully (G)

*Potential:* Moderate (2) to severe (3) soil slip (Ss) and sheet (Sh). Slight (1) gully (G)

**Vegetation:** Semi-improved pasture (gS), manuka, kanuka (sM), lowland podocarp–broadleaved forest (fO), rushes, sedges (hR), podocarp forest (fP), improved pasture (gI).

**Annual rainfall range:** 1400–1600 mm

**Land use:** *Present:*

Grazing – Present average carrying capacity (s.u./ha) = 7
– Top farmer carrying capacity (s.u./ha) = 8

Undeveloped

Forestry – Production – exotic spp.

*Potential:*

Forestry – Production and erosion control
– site index for *Pinus radiata* = 24–27

Grazing – Attainable physical potential carrying capacity (s.u./ha) = 9

Cropping – Unsuitable

Ideally suited to forestry, erosion control forestry (exotic and native) and catchment protection.

**Soil conservation management:**

- Maintenance of complete vegetative cover essential. Maintain good-quality pasture / apply adequate fertiliser levels. Oversow and fertilise slip scars and bare-ground areas.
- Retire steepest slopes. Retain indigenous forest particularly on steepest slopes, allow regeneration on steeper slopes.
- Management should consider the whole catchment.
- Open planting of soil conservation trees on areas susceptible to mass movement. Block planting of either exotic trees or indigenous trees should be considered on areas assessed as having high susceptibility to erosion. Pair plant or block plant trees in gullies.
- Control runoff. Measures required to minimise soil erosion and maintain water quality. Strict management guidelines should be followed when land is prepared for tree planting, road construction, drains and culverts (all earthworks), logging (harvesting), deforestation, scrub clearance.
- Control feral (noxious) animals in forested areas. Conservation planting must be adequately protected from damage by cattle, goats, possums.
- Control grazing.

## LUC unit: VIIe4 (10 540 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4a. Interbedded and massive sandstone and mudstone:
(LUC units IIIe3, IVe5, VIe1, VIe8, VIIe4)

**Description:** Steep to very steep slopes forming steep hilly and mountainous terrain predominantly on interbedded and massive sandstones and mudstones. Includes land formed from steeper sides and scarps (and erosion scarps) of fault blocks. Steepland and hill soils related to yellow-brown earths. Represents steeper version of VIe8 and VIe1. Potential for moderate to severe soil slip and sheet erosion, and moderate tunnel gully and gully erosion on lower slopes.

**Type location:** Q09/460292 Mainland Road

**Altitudinal range:** 0–400 m

**Slope:** Steep to very steep (F, F+G), 26–>35°

**Landform:** Steep hill country and mountainous terrain. Steep sided valleys with historic slump features.

**Rock type:** Bedded sandstone (Sb), bedded mudstone (Mb), massive sandstone (Sm), massive mudstone (Mm).

**Soils:** Yellow-brown earth steepland and hill soils on stratified sandstones and mudstones. Weakly to strongly leached yellow-brown earths of Puhoi suite (ANS, PBH, PBuH, TMH) and Waiotira suites (WCS, YCgH, YCH, YCrH).

**Erosion:** *Present:* Slight (1) to severe (3) soil slip (Ss) and sheet (Sh). Negligible (0) to slight (1) tunnel gully (T), earthflow (Ef) gully (G), and earthslip (Es)
*Potential:* Moderate (2) to severe (3) soil slip (Ss), sheet (Sh) and earthslip (Es). Moderate (2) tunnel gully (T) and gully (G)

**Vegetation:** Semi-improved pasture (gS), lowland podocarp–broadleaved forest (fO), manuka, kanuka (sM), exotic conifer forest (fF), improved pasture (gI), rushes, sedges (hR).

**Annual rainfall range:** 1400–1600 mm

**Land use:** *Present:*
Grazing – Present average carrying capacity (s.u./ha) = 7
– Top farmer carrying capacity (s.u./ha) = 8
Undeveloped
Reversion to scrub
Forestry – Production – exotic spp.
*Potential:*
Forestry – Production – site index for *Pinus radiata* = 30–33
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 9
Cropping – Unsuitable
Ideally suited to forestry, erosion control forestry (exotic and native) and catchment protection.

**Soil conservation management:**
- Maintenance of complete vegetative cover essential. Maintain good-quality pasture / apply adequate fertiliser levels. Oversow and fertilise slip scars and bare-ground areas.
- Retire steepest slopes. Retain indigenous forest or allow regeneration on steeper slopes.

- Management should consider the whole catchment.
- Open plant of soil conservation trees on areas susceptible to mass movement. Block plant either exotic or indigenous trees on areas assessed as having high erosion susceptibility. Pair plant or block plant trees in gullies.
- Control runoff. Measures required to minimise soil erosion and maintain water quality. Follow strict management guidelines preparing for tree planting, road construction, drains and culverts (all earthworks), logging (harvesting), deforestation, scrub clearance.
- Control feral (noxious) animals in forested areas. Conservation planting must be adequately protected from damage by cattle, goats, possums.
- Control grazing.

## LUC unit: VIIe5 (2997 ha)

**LUC suite:** 5. Greywacke terrain:
(LUC units IVe7, VIe9, VIe10, VIe17, VIc1, VIIe5, VIIe6)

**Description:** Steep to very steep slopes forming steep hilly and mountainous terrain on hard greywacke near coast. Exposed to dry coastal climate, generally receiving on average less than 1200 mm rain and less than 1000 mm some locations. Soils shallow, steepland and hill soils related to yellow-brown earths, prone to sheet, scree, and shallow slip erosion. Represents steeper, coastal, version of VIe10 and VIe17. Potential for moderate to severe sheet, soil slip and scree erosion. Potential for moderate gully erosion exists on lower slopes.

**Type location:** Q05/292640

**Altitudinal range:** 0–200 m

**Slope:** Steep to very steep (F, G), 26–>35°

**Landform:** Steep hill country and mountainous terrain with steep sided valleys adjacent to coast or within coastal zone. Fault-bounded and tilted blocks of greywacke form prominent landforms particularly on eastern side region.

**Rock type:** Greywacke association of rocks (Gw).

**Soils:** Yellow-brown earth steepland and hill soils on coastal greywacke. Moderately to strongly leached yellow-brown earths of Marua suite (TRS, TRuS, MRrH, MRH, MRuH). May include small areas of yellow-brown earths of Omaiko suite (TVH, TVrH) and small areas of red loams of Manganese suite (MZH), and Maungakohatu suite (MGH).

**Erosion:** *Present:* Slight (1) to moderate (2) sheet (Sh). Negligible (0) to moderate (2) scree (Sc), soil slip (Ss), and gully (G)

*Potential:* Moderate (2) to severe (3) sheet (Sh), scree (Sc) and soil slip (Ss). Moderate (2) gully (G)

**Vegetation:** Semi-improved pasture (gS), manuka, kanuka (sM), gorse (sG), mixed indigenous scrub (sX), exotic conifer forest (fF), coastal forest (fC), improved pasture (gI).

**Annual rainfall range:** 1000–1200 mm. Some areas may recieve less than 1000 mm

**Land use:** *Present:*

Grazing – Present average carrying capacity (s.u./ha) = 7
– Top farmer carrying capacity (s.u./ha) = 8
Forestry – Production – exotic spp.
Undeveloped

*Potential:*

Forestry – Production – site index for *Pinus radiata* = 25–29
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 9
Cropping – Unsuitable
Ideally suited to erosion control forestry (exotic and native) and catchment protection.

**Soil conservation management:**

- Maintenance of dense and complete vegetative cover essential. Maintain good-quality pasture / apply adequate fertiliser levels. Oversow and fertilise slip scars and bare-ground areas.
- Retire steepest slopes. Retain indigenous forest particularly on steepest slopes, allow regeneration on steeper slopes and gully areas.

- Management should consider the whole catchment.
- Open plant soil conservation trees on areas susceptible to mass movement. Block plant either exotic or indigenous trees on areas highly susceptible to erosion. Pair plant or block plant trees in gullies.
- Control runoff. Measures required to minimise soil erosion and maintain water quality. Follow strict management guidelines preparing for tree planting, road construction, drains and culverts (all earthworks), logging (harvesting), deforestation, scrub clearance.
- Control feral (noxious) animals in forested areas. Conservation planting must be adequately protected from damage by cattle, goats, possums.
- Control grazing.

## LUC unit: VIIe6 (28 207 ha)

**LUC suite:** 5. Greywacke terrain:
(LUC units IVe7, VIe9, VIe10, VIe17, VIc1, VIIe5, VIIe6)

**Description:** Moderately steep to very steep slopes forming steep hilly and mountainous terrain on greywacke. Includes scarps and bluffs. Steepland and hill soils related to yellow-brown earths. Represents steeper version of VIe9 and VIe17. Potential for severe to very severe soil slip and debris avalanche erosion, particularly during high-intensity rainstorms. Also potential for moderate sheet, gully and earthslip erosion.

**Type location:** Q08/340758 Finlayson Brook Road. West of Waipu.

**Altitudinal range:** 0–600 m

**Slope:** Steep to very steep (F, G), 26–35°

**Landform:** Steep hill country and mountainous terrain with steep sided valleys. Fault-bounded, tilted blocks of greywacke form prominent landforms particularly on eastern side of region.

**Rock type:** Greywacke association of rocks (Gw).

**Soils:** Yellow-brown earth steepland and hill soils on greywacke and argillite. Moderately to strongly leached yellow-brown earths of Marua suite (TRS, TRuS, MRrH, MRH, MRuH). May include small areas of yellow-brown earths of Omaiko suite (TVH, TVrH) and small areas of red loams of Manganese suite (MZH), and Maungakohatu suite (MGH).

**Erosion:** *Present:* Slight (1) to severe (3) soil slip (Ss), sheet (Sh), debris avalanche (Da). Negligible (0) to moderate (2) gully (G) and earthslip (Es)
*Potential:* Severe (3) to very severe (4) soil slip (Ss) and debris avalanche (Da). Moderate (2) to severe (3) sheet (Sh), gully (G) and earthslip (Es)

**Vegetation:** Lowland podocarp–broadleaved forest (fO), semi-improved pasture (gS), mixed indigenous scrub (sX), mixed indigenous scrub with tree fern (sT), manuka, kanuka (sM), exotic conifer forest (fF), improved pasture (gI), gorse (sG).

**Annual rainfall range:** 1400–1800 mm

**Land use:** *Present:* Undeveloped
Grazing – Present average carrying capacity (s.u./ha) = 7
– Top farmer carrying capacity (s.u./ha) = 8
Forestry – Production – exotic spp. Limited native spp.
*Potential:* Forestry – Production – site index for *Pinus radiata* = 25–29
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 9
Cropping – Unsuitable
Ideally suited to erosion control forestry (exotic and native) and catchment protection.

**Soil conservation management:**
- Maintenance of complete vegetative cover essential. Maintain good-quality pasture / apply adequate fertiliser levels. Oversow and fertilise slip scars and bare-ground areas.
- Retire steepest slopes. Retain indigenous forest particularly on steepest slopes, allow regeneration on steeper slopes and gully areas.
- Management should consider the whole catchment.
- Open plant soil conservation trees on areas susceptible to mass

movement. Block plant either exotic or indigenous trees on areas highly susceptible to erosion. Pair plant or block plant trees in gullies.

- Control runoff. Measures required to minimise soil erosion and maintain water quality. Follow strict management guidelines preparing for tree planting, road construction, drains, and culverts (all earthworks), logging (harvesting) deforestation, scrub clearance.
- Control feral (noxious) animals in forested areas. Conservation planting must be adequately protected from damage by cattle, goats, possums.
- Control grazing.

## LUC unit: VIIe7 (3538 ha)

**LUC suite:** 7. Old volcanic terrain:

**LUC subsuite:** 7c. Acid to intermediate igneous volcanics and plutonics: (LUC units IVe11, VIe18, VIIe7)

**Description:** Moderately steep to very steep slopes forming hilly and mountainous terrain including volcanic cones, domes, etc., on old deeply weathered acid to intermediate igneous rocks (dacite, rhyolite) and plutonic rocks (granodiorite). Typically mapped at sides of old volcanic cones and domes (Parahaki Dacite). Steepland and hill soils related to yellow-brown earths. Represents steeper version of VIe18. Potential for moderate to very severe sheet and rill erosion, and severe wind erosion. Also potential for moderate to severe soil slip and gully erosion.

**Type location:** N03/260090 Mt Camel; Q08/405645 State Highway 1 near Pukekaroro

**Altitudinal range:** 0–400 m

**Slope:** Moderately steep to very steep (E+F, F, F+G), 21–35°

**Landform:** Steep hill country and mountainous terrain. Prominent volcanic complexes with landforms such as volcanic cones and domes.

**Rock type:** Plutonics (Gn), Lavas (Vo).

**Soils:** Yellow-brown earth steepland and hill soils on dacite, rhyolite and granodiorite. Moderately to strongly leached yellow-brown earths of Maungarei suite (PES, POS, MEH, MEbH, KUH, PFH).
Parent materials include dacite, rhyolite, and granodiorite.

**Erosion:** *Present:* Slight (1) to very severe (4) sheet (Sh). Slight (1) to severe (3) rill (R) and gully (G). Negligible (0) to severe (3) wind (W) and soil slip (Ss)
*Potential:* Moderate (2) to very severe (4) sheet (Sh) and rill (R). Moderate (2) to severe (3) gully (G), soil slip (Ss). Slight (1) to severe (3) wind (W)

**Vegetation:** Manuka, kanuka (sM), gorse (sG), heath (sH), kauri forest (fK), semi-improved pasture (gS), exotic conifer forest (fF), lowland podocarp–broadleaved forest (fO).

**Annual rainfall range:** 1000–1800 mm

**Land use:** *Present:* Undeveloped
Grazing – Present average carrying capacity (s.u./ha) = 7
– Top farmer carrying capacity (s.u./ha) = 8
Forestry – Production – exotic spp.
*Potential:* Forestry – Production – Site index for *Pinus radiata* = 21–24
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 9
Cropping – Unsuitable
Ideally suited to erosion control forestry (exotic and native) and catchment protection.

**Soil conservation management:**
- Maintenance of dense and complete vegetative cover is essential. Highly susceptible to sheet and wind erosion, bare ground difficult to revegetate.
- Retire steepest slopes. Retain indigenous forest particularly on steepest slopes, oversow and fertilise slip scars and bare-ground areas where possible, allow regeneration on steeper slopes.

- Management should consider the whole catchment.
- Open plant or block plant soil conservation trees on areas susceptible to mass movement.
- Erosion control forestry recommended. Block plant trees in gullies.
- Control runoff. Measures required to minimise soil erosion and maintain water quality. Follow strict management guidelines preparing for tree planting, road construction, drains, and culverts (all earthworks) logging (harvesting), deforestation, scrub clearance.
- Control feral (noxious) animals in forested areas. Conservation planting must be adequately protected from damage by cattle, goats, possums.
- Control any grazing on easier slopes.

**Comments:** Soils are shallow and of low fertility.

## LUC unit: VIIe8 (10 213 ha)

**LUC suite:** 4. Sedimentary rock terrain excluding greywacke

**LUC subsuite:** 4d. Crushed argillite:
(LUC units VIe19, VIIe8)

**Description:** Moderately steep to steep slopes, often with repeated pattern of incision, forming steep hilly and mountainous terrain on fractured and sheared-crushed argillites (siliceous claystone). Typically has acute (sharp) narrow ridges and abrupt, steep hillslopes prone to sheet and gully erosion. Hillslopes are often scarred by slips, and stream heads have masses of slumped debris. Typical soils are podzolised yellow-brown earths. Represents steeper or more erodible parts of VIe19. Potential for severe to extreme gully erosion, and very severe sheet and soil slip erosion. Also potential for moderate earthslip/slump erosion, particularly in the head of catchments; and rill erosion, particularly on bare ground surfaces.

**Type location:** 005/520680 Rangiahua Road

**Altitudinal range:** 0–500 m

**Slope:** Moderately steep to steep (E, E+F), 21–35°

**Landform:** Steep hill country and mountainous terrain. Acute (sharp) narrow ridges and concavo–convex and concave hillslopes.

**Rock type:** Crushed argillite (Ac).

**Soils:** Yellow-brown earth hill and steepland soils on shales. Strongly leached to moderately podzolised yellow-brown earths of Omu suite (PPH, HKH, HKgH, YKH, OPH). May include areas of moderately podzolised yellow-brown earths on quartzite of Omaiko suite (OVH, OV, OVp).

**Erosion:** *Present:* Slight (1) to severe (3) gully (G), and sheet (Sh). Negligible (0) to severe (3) soil slip (Ss), earthslip (Es) and rill (R)
*Potential:* Extreme (5) gully. Very severe (4) sheet (Sh) and soil slip (Ss). Moderate (2) earthslip (Es) and rill (R). Slight (1) earthflow (Ef)

**Vegetation:** Exotic conifer forest (fF), manuka, kanuka (sM), semi-improved pasture (gS), gorse (sG). Lowland podocarp–broadleaved forest (fO).

**Annual rainfall range:** 1200–1800 mm

**Land use:** *Present:*
Forestry – Production – exotic spp.
Undeveloped
Grazing – Present average carrying capacity (s.u./ha) = 7
– Top farmer carrying capacity (s.u./ha) = 8
*Potential:*
Forestry – Production and erosion control
– site index for *Pinus radiata* = 25–28
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 9
Cropping – Unsuitable
Ideally suited to erosion control forestry (exotic and native) and catchment protection.

**Soil conservation management:**
– Maintenance of dense and complete vegetative cover essential. Highly susceptible to gully and sheet erosion. Bare ground and gully areas difficult to revegetate. Columnar structure of soils allows deep penetration of water to underlying shattered and sheared rock types.

- Erosion control forestry recommended.
- Forest crops require adequate fertiliser and lime application (topdressing with superphosphate lime and trace elements) for establishment, and good silvicutural management necessary.
- Control runoff. Measures required to minimise soil erosion and maintain water quality. Follow strict management guidelines preparing for tree planting, road construction, drains, and culverts (all earthworks), logging (harvesting), deforestation, scrub clearance.
- Gullies should be retired and block planted. Recommended treatments include:
  (i) diversion of runoff water away from gully head;
  (ii) stabilise sides and heads of gullies with debris dam structures, flumes, and tree planting. Sediment traps required;
  (iii) gully plugs;
  (iv) revegetation (pair and block planting).
  Essential to maintain a permanent vegetative cover on runoff channels to avoid enlargement of gullies, and enlargement of bare-ground areas affected by sheet and rill erosion processes.
- Control feral (e.g. noxious) animals.

**Comments:** Soils are shallow and of low fertility.

## LUC unit: VIIe9 (9633 ha)

**LUC suite:** 1. Coastal sand country

**LUC subsuite:** 1b. Old stable sand dunes on unconsolidated to compact sands: (LUC units IIIe5, IIIs4, IVe9, VIe6, VIIe9)

**Description:** Strongly rolling to very steep slopes forming sides of gullies, narrow valleys, low steep hills, and terrace scarps, on unconsolidated to compact sands and gravels, e.g. aeolian sand. Typical soils are steepland and hill soils related to yellow-brown sands and podolised yellow-brown earths. Potential for very severe to extreme sheet and wind erosion and very severe gully erosion and also for moderate to severe soil slip erosion particularly during high-intensity rainstorms.

**Type location:** P08/949631 Koremoa Road

**Altitudinal range:** 0–200 m

**Slope:** Strongly rolling to steep (D-F), 16–35°

**Landform:** Very steep hillslopes, escarpments, usually formed at the sides of gullies which have incised (dissected) dune landforms and coastal terraces.

**Rock type:** Unconsolidated to compact sands (Us).

**Soils:** Steepland soils related to yellow-brown sands and podzolised yellow-brown earths on coastal sand. Moderately weathered, moderately to strongly leached yellow-brown sands of Pinaki suite (RLIH, RLH, RLaH, HOH) and weakly to moderately podzolised yellow-brown earths of Pinaki suite (TTH).

**Erosion:** *Present:* Slight (1) to severe (3) sheet (Sh), wind (W) and gully (G). Negligible (0) to moderate (2) soil slip (Ss)

*Potential:* Very severe (4) to extreme (5) sheet (Sh), wind (W) and gully (G). Moderate (2) to severe (3) soil slip (Ss)

**Vegetation:** Manuka, kanuka (sM), heath (sH), cassinina (sC), exotic scrub (sE), coastal scrub (sO), semi-improved pasture (gS), naturalised exotic trees, exotic conifer forest (nfF), exotic conifer forest (fF). Mixed indigenous scrub (sX).

**Annual rainfall range:** 1000–1400 mm

**Land use:** *Present:* Reversion to scrub
Undeveloped
Grazing – Present average carrying capacity (s.u./ha) = 7
– Top farmer carrying capacity (s.u./ha) = 8
Forestry – Erosion control and production – exotic spp.

*Potential:* Forestry – Production and erosion control
– site index for *Pinus radiata* = 18–27
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 9
Cropping – Unsuitable
Ideally suited to erosion control forestry (exotic and native) and catchment protection. Retain native vegetation where possible.

**Soil conservation management:**
- Maintenance of dense and complete vegetative cover essential. Highly susceptible to sheet, wind, and gully erosion. Bare ground difficult to revegetate.
- Erosion control forestry recommended.
- Retain native vegetation where possible.

- Control grazing. Retirement and fencing off of parts of unit required. Control feral animals (goats).
- Control runoff. Measures required to minimise soil erosion and maintain water quality. Follow strict management guidelines preparing for tree planting, road construction, drains, and culverts (all earthworks), logging (harvesting) deforestation, scrub clearance.
- Gullies should be retired and block planted. Recommended treatments include:
  (i) diversion of runoff water away from gully head and gully sides;
  (ii) stabilise gully walls and gully head with vegetation (tree planting or allow revegetation of scrub) and debris dam structures, flumes, sediment traps, etc.;
  (iii) gully plugs.

Revegetate bare-ground areas exposed to sheet and wind erosion. Oversowing and fertiliser application should be considered as pretreatments at favourable times of year.

## LUC unit: VIIe10 (52 547 ha)

**LUC suite:** 1. Coastal sand country

**LUC subsuite:** 1a. Young unstable sand dune complex:
(LUC units VIe15, VIIe10, VIIIe1)

**Description:** Sand dunes and sand plains immediately inland (generally more than 400 m from the mean high-water mark) from VIIIe1, where the dunes are slightly more stable. Land formed on recent unconsolidated windblown (aeolian) sands and includes 'active' sand dunes. A very conspicuous unit on the western side of Northland, exposed to strong salt-laden winds. Has potential for very severe to extreme wind and sheet erosion. Soils if present are weakly developed and excessively drained. Since 1920s extensive plantings of sand dune vegetation and exotic forest have greatly minimised erosion on unstable sands and protected inland areas. Much exotic forest cover but large areas of bare ground recorded with sparse scattered vegetation. Smaller areas covered in sand-dune vegetation, lupins, coastal scrub and kanuka. Limited grazing basically restricted to further inland sites. Erosion mostly negligible under extensive exotic forest cover but potential for very severe to extreme wind erosion; careful management required.

**Type location:** Q10/340960 Inland Road, Woodhill State Forest

**Altitudinal range:** 0–100 m

**Slope:** Flat or undulating to moderately steep (A-E), 0–25°

**Landform:** Old foredunes, coastal deflation zones, sand plains, old truncated dune fields. Younger transverse dunes, parabolic dunes. Slopes commonly under 15° but may steepen away from coast with increasing compaction and aging of sands and increasing soil development. Level of dissection of dunes generally increases with age.

**Rock type:** Windblown sands (Wb).

**Soils:** Little or no soil development on aeolian sands. Developed soil is weakly to moderately leached and weakly weathered. Yellow-brown sands of Pinaki suite (PNH, MDH, PN, MD, WD) are occasionally recorded.

**Erosion:** *Present:* Negligible (0) to severe (3) wind (W), sheet (Sh), and gully (G)
*Potential:* Very severe (4) to exteme (5) wind (W). Very severe (4) sheet (Sh) and gully (G)

**Vegetation:** Sand dune vegetation (gD), exotic conifer forest (fF), lupin (sL), coastal scrub (sO), Exotic broadleaved forest (fR).

**Annual rainfall range:** 1000–1200 mm

**Land use:** *Present:*
Forestry – Production and erosion control – exotic spp.
Undeveloped
Grazing – Present average carrying capacity (s.u./ha) = 2
– Top farmer carrying capacity (s.u./ha) = 3

*Potential:*
Forestry – Erosion control and production
– site index for *Pinus radiata* = 21–26
Grazing – Attainable physical potential carrying capacity (s.u./ha) = 5
Cropping – Unsuitable
Ideally suited to erosion-control forestry.

**Soil conservation management:**

Prevent surface disturbance. Unit capable of productive use if conservation measures applied.

- Permanent vegetative cover advised. Measures should be taken to stabilise dunes in 'active' areas (migrating sands) with sand-binding species. Stabilisation of these areas best achieved by planting in erosion control forestry which serves both a production and protection function. Planting programmes usually carried out in the following sequence:
  1. planting of sand-binding species such as marram, spinifex, pingao;
  2. planting of lupins for nitrogen enrichment;
  3. Exotic forest species such as *Pinus radiata* planted when conditions are suitable.
- Grazing should be controlled and fencing is important.

## LUC unit: VIIw1 (4277 ha)

**LUC suite:** 2. Alluvial and estuarine plains and low terraces

**LUC subsuite:** 2c. Poorly drained floodplains and low terraces: (LUC units IVw1, VIw1, VIIw1)

**Description:** Low-lying, flat areas on floodplains and low terraces (riverflats) with watertables at or near surface. Includes mainly alluvial river flats and swamps with continuing severe wetness limitation and subject to frequent flooding or permanently high watertable. Recent soils, often mottled, on alluvium or alluvium and peat. Represents areas difficult to drain, land used for flood retention, and areas generally of high flood risk.

**Type location:** P06/036342 Motatau Road

**Altitudinal range:** 0–100 m

**Slope:** Flat to undulating (A), 0–3°

**Landform:** Floodplains, levees, swamps, margins of estuaries.

**Rock type:** Fine alluvium (Af).

**Soils:** Recent soils on sedimentary and volcanic alluvium. Recent soils of Whareora suite (WFm, WF, WFa) and Kohumaru suite (MFm, MF). Gley soils of Kaipara, Waipapa, and Waipu suites may be included where wetness is considered severe or prolonged.

**Erosion:** *Present:* Negligible (0) to slight (1) streambank (Sb) and deposition (D)
*Potential:* Slight (1) to severe (3) streambank (Sb) and deposition (D)

**Vegetation:** Wetland vegetation (hW), rushes, sedges (hR), semi-improved pasture (gS), podocarp forest (fP).

**Annual rainfall range:** 1200–1800 mm

**Land use:** *Present:* Undeveloped – Wetland vegetation, rushes, sedges
*Potential:* Undeveloped
Grazing – Extensive

**Soil conservation management:** Areas prone to flooding or permanently high watertables. Often inundated by surface water and have swamp vegetation. Management should be considered on long-term basis and planning should take the whole catchment into account. High value ecologically and for catchment protection.

- Flood detention and ponding often required, and should be carefully managed.
- Drainage control needs to be considered as part of district drainage, flood control scheme.
- Stopbanks required, essential in district schemes (Hikurangi swamp).
- Management of watertables should consider implications to surrounding areas.
- Control earthworks, harvesting of forests, adjacent to channels.

## LUC unit: VIIw2 (4550 ha)

**LUC suite:** 2. Alluvial and estuarine plains and low terraces

**LUC subsuite:** 2e. Peats:
(LUC units IIIw4, IVw3, VIw3, VIIw2)

**Description:** Peat-filled valleys, plains, and coastal swamps with watertables at or near the surface, areas frequently flooded, have continuing wetness limitation. Peat is strongly acid and very poorly drained. Organic soils typically recorded.

**Type location:** 004/324985 Kaimaumau Swamp

**Altitudinal range:** 0–100 m

**Slope:** Flat to undulating (A), 0–3°

**Landform:** Floodplains, swamps, backswamps, margins of estuaries.

**Rock type:** Peat (Pt), Peat and sand complex (Pt+Af).

**Soils:** Organic soils on peat or peat and sand. Organic soils of Ruakaka suite (PZ, OT, RK, RKu, RKd, RKy, RKv) and Otonga suite (OG, OGd, OGv, OR, ORd).

**Erosion:** *Present:* Negligible (0) to slight (1) wind (W), sheet (Sh) and gully (G)
*Potential:* Slight (1) to moderate (2) wind (W), sheet (Sh), and deposition (D). Slight (1) gully (G)

**Vegetation:** Wetland vegetation (hW), gorse (sG), manuka, kanuka (sM), heath (sH), semi-improved pasture (gS).

**Annual rainfall range:** 1200–1600 mm

**Land use:** *Present:* Undeveloped – Wetland vegetation, rushes, sedges, manuka, kanuka
Grazing – Extensive
*Potential:* Undeveloped
Grazing

**Soil conservation management:** Areas prone to flooding or permanently high watertables. Often inundated by surface water and have swamp vegetation. Long-term management should be considered and planning should take the whole catchment into account. High value ecologically and for catchment protection.

- Flood detention and ponding often required, and should be carefully managed.
- Drainage control needs to be considered as part of district drainage, flood control scheme.
- Stopbanks required.
- Management of watertables should consider implications to surrounding areas.
- Control earthworks, harvesting of forests, adjacent to channels.

## LUC unit: VIIIe1 (22 147 ha)

**LUC suite:** 1. Coastal sand country

**LUC subsuite:** 1a. Young unstable sand dune complex:
(LUC units VIe15, VIIe10, VIIIe1)

**Description:** Coastal foredunes, beaches and sand plains along narrow unstable belt of recent unconsolidated windblown (aeolian) sand along the coast. Typically extends up to 400 m inland of mean high-water mark and has little or no soil development. Land considered relatively 'active', and blowouts between sand dunes are common features. Most exposed to strong salt-laden winds, and together with rolling nature (and hummocky surface profile) of dunes, gives potential for extreme wind erosion.
Although exotic forest has been planted in many areas, large areas of bare sand still commonly exposed and vegetation is sparse, being restricted mainly to sand-dune vegetation types – spinifex, pingao, marram grass and lupins. Where *Pinus radiata* is planted, an environmental buffer zone of trees is grown along the most seaward part of the forest for protection of inland trees. Often stunted and malformed exotic trees occur in association with sand-dune vegetation and lupins.

**Type location:** Q10/330948 Muriwai Beach above mean high-water mark

**Altitudinal range:** 0–60 m

**Slope:** Typically flat to strongly rolling (A-D), 0–20°

**Landform:** Coastal foredunes, irregularly surfaced foredunes, beaches, sand plains. Moving, active, migrating dunes. Includes blowouts.

**Rock type:** Windblown sand (Wb), aeolian sands.

**Soils:** No soil development. Bare sand, on foredunes, beaches, sand hills, swales and plains. Windblown sand generally unstable or 'active'.

**Erosion:** *Present:* Moderate (2) to extreme (5) wind (W). Slight (1) to severe (3) gully (G)
*Potential:* Extreme (5) wind. Very severe (4) gully

**Vegetation:** Sand-dune vegetation (gD). Many areas are unvegetated (uV), coastal scrub (sO), lupin (SL).

**Annual rainfall range:** 1000–1400 mm

**Land use:**

| | | | |
|---|---|---|---|
| *Present:* | Undeveloped | – | Sand dune vegetation, lupin |
| | Forestry | – | Protection forestry and erosion control – exotic spp. *Pinus radiata*, marram grass, pingao, spinifex, lupin |
| *Potential:* | Undeveloped | – | Sand dune vegetation, lupin, pingao |
| | Forestry | – | Protection forestry and erosion control plantings |

**Soil conservation management:** Should be managed for protection purposes due to erosion hazard, not only for dunes but also to protect more productive or ecologically important areas inland. Areas of bare and eroding sand need stabilising by planting suitable sand-binding species such as spinifex, marram or pingao. Areas currently stable (covered by exotic forest) need careful management to minimise surface disturbance since underlying sand is highly susceptible to wind erosion. Sites need suitable preparation before tree planting, and high inputs of fertiliser and trace elements required. Erodible areas require stabilisation with marram and lupin (nitrogen fixation) before establishment of exotic forest species.

**Comments:** Land has severe soil moisture deficiencies and is extremely low in nitrogen, and molybdenum.
- Residential development undesirable because of high risk of erosion.
- Ensure recreational use does not damage vegetation cover.

## LUC unit: VIIIe2 (4563 ha)

**LUC suite:** 8. Cliffs and precipitous slopes: (LUC units VIIIe2, VIIIe3. VIIIs1)

**Description:** Very steep, precipitous slopes such as cliffs, bluffs, gorges and escarpments on a range of lithologies particularly old volcanic rock (ancient volcanics) and the greywacke association of rocks. Erosion regarded as dominant physical limitation because of insufficient soil and subsoil depth. This unit often recorded in mountainous terrain where rock types are consolidated or indurated. Steepland soils typical; however, bare rock recorded where there is little or no soil development. Potential for moderate to extreme soil slip erosion and moderate to very severe sheet erosion.

**Type location:** Q05/245460 Russell Forest

**Altitudinal range:** 0–800 m

**Slope:** Very steep or precipitous (G), >35°

**Landform:** Cliffs, bluffs, gorges, escarpments, very steep hillslopes.

**Rock type:** Ancient volcanics (In). Greywacke association of rocks (Gw).

**Soils:** Steepland soils on hard or indurated rock types. Steepland yellow-brown earths of Marua suite (TRS, TRuS), steepland brown granular loams and clays of Te Kie suite (TES, TEuS, TErS) and Huia suite (HAS, HAlS).

**Erosion:** *Present:* Negligible (0) to moderate (2) sheet (Sh). Slight (1) to very severe (4) soil slip (Ss) and debris avalanche (Da). Slight (1) to moderate (2) debris avalanche (Da) on volcanics

*Potential:* Moderate (2) to extreme (5) soil slip (Ss) and debris avalanche (Da). Moderate (2) to very severe (4) sheet (Sh)

**Vegetation:** Lowland podocarp–broadleaved forest (fO), broadleaved forest (fB), mixed indigenous scrub (sX), mixed indigenous scrub with tree fern (sT), kauri forest (fK).

**Annual rainfall range:** 1400–2000 mm

**Land use:** *Present:* Undeveloped

*Potential:* Undeveloped – indigenous forest, indigenous scrub

**Soil conservation management:** Principal soil conservation requirement is to retain and maintain the existing indigenous vegetation. On basis of steepness and catchment protection this unit should be retired from use. Where possible, eroded areas should be revegetated.

- All fires should be prevented.
- Control feral (noxious) animals such as possum and goats. Prevent browsing.

## LUC unit: VIIIe3 (4750 ha)

**LUC suite:** 8. Cliffs and precipitous slopes: (LUC units VIIIe2, VIIIe3, VIIIs1)

**Description:** Very steep, precipitous slopes adjacent to coast. Types of land include cliffs, bluffs and escarpments on range of lithologies, particularly old Miocene–Tertiary volcanics and greywacke, where steepness and erosion are dominant physical limitations and preclude productive use. Rock types consolidated or indurated. Areas have shallow and often patchy steepland soils with bare rock. Potential for severe to extreme sheet and scree erosion and moderate soil slip erosion.

**Type location:** R09/776350 Tawharanui Peninsula

**Altitudinal range:** 0–200 m

**Slope:** Very steep or precipitous (G), >35°

**Landform:** Cliffs, bluffs, escarpments, very steep hillslopes adjacent to coast or within coastal zone. Coastlines are often crenulate.

**Rock type:** Greywacke association of rocks (Gw), ancient volcanics (In), interbedded sandstones and mudstone (Sb, Mb), lavas (Vo), indurated volcanic breccias (Vb), plutonics (Gn), ultramafics (Um).

**Soils:** Steepland soils on hard or indurated rock types. Steepland yellow-brown earths of Marua suite (TRS, TRuS), Puhoi suite (ANS, PBH, PBuH, TMH). Steepland brown granular loams and clays of Te Kie suite (TES, TEuS, TErS) and Huia suite (HAS, HAlS).

**Erosion:** *Present:* Slight (1) to very severe (4) sheet (Sh), scree (Sc), debris avalanche (Da), and soil slip (Ss)

*Potential:* Severe (3) to extreme (5) sheet (Sh) and scree (Sc). Moderate (2) to severe (3) debris avalanche (Da), and soil slip (Ss)

**Vegetation:** Coastal forest (fC), lowland podocarp broadleaved forest (fO), unvegetated areas (uV), broadleaved forest (fB), mixed idigenous scrub (sX), gorse (sG), coastal scrub (sO).

**Annual rainfall range:** 1000–1400 mm

**Land use:** *Present:* Undeveloped

*Potential:* Undeveloped

**Soil conservation management:** Retain and maintain existing indigenous vegetation as principal soil conservation requirement. On basis of steepness, catchment protection and shoreline protection, unit should be retired from use. Where possible eroded areas should be revegetated.

- All fires should be prevented.
- Control feral (noxious) animals such as possum and goats. Prevent browsing.

## LUC unit: VIIIs1 (4816 ha)

**LUC suite:** 8. Cliffs and precipitous slopes: (LUC units VIIIe2, VIIIe3, VIIIs1)

**Description:** Very steep, precipitous slopes such as cliffs, bluffs, escarpments, gorges on range of lithologies where shallow soil depth, lack of soil, and steepness, are dominant physical limitations which preclude productive use. Surfaces may erode due to deep weathering of rock in places, and screes often occur at foot of slopes. Has extensive areas of bare rock, and developed soil is shallow, or patchy and associated with bare rock surfaces. Vegetation sparse in very steep areas. Rock types consolidated or indurated.

**Type location:** P04 and Q04/717880

**Altitudinal range:** 0–800 m

**Slope:** Very steep to precipitous (G), >35°

**Landform:** Cliffs, bluffs, volcanic rocks, volcanic plugs.

**Rock type:** Ancient volcanics (In), greywacke association of rocks (Gw), interbedded sandstones and mudstone (Sb, Mb), lavas (Vo), indurated volcanic breccias (Vb), plutonics (Gn), ultramafics (Um).

**Soils:** Steepland soils on hard or indurated rock types. Little or no soil development. May include limited areas of steepland yellow-brown earths of Marua suite (TRS, TRuS), steepland brown granular loams and clays of Te Kie suite (TES, TEuS, TErS) and Huia suite (HAS, HAlS).

**Erosion:** *Present:* Slight (1) to moderate (2) sheet (Sh) and scree (Sc). Negligible (0) to slight (1) debris avalanche (Da) and soil slip (Ss)
*Potential:* Very severe (4) sheet (Sh) and scree (Sc). Slight (1) to moderate (2) debris avalanche (Da) and soil slip (Ss)

**Vegetation:** Broadleaved forest (fB), mixed indigenous scrub (sX), unvegetated land (uV), lowland podocarp broadleaved forest (fO).

**Annual rainfall range:** 1200–1800 mm

**Land use:** *Present:* Undeveloped
*Potential:* Undeveloped

**Soil conservation management:** Retain and maintain existing indigenous vegetation. On basis of steepness, catchment protection and insufficient soil cover, unit should be retired from use. Where possible eroded areas should be revegetated.

- All fires should be prevented.
- Control feral (noxious) animals such as possum and goats. Prevent browsing.

## LUC unit: VIIIs2 (2336 ha)

**LUC suite:** 6. Young basalt volcanic terrain:
(LUC units Ic1, IIe1, IIs1, IIIe1, IIIs1, IIIs2, IVe2, IVs1, IVs2, Vs1, VIs1, VIe4, VIIIs2)

**Description:** Undulating to moderately steep slopes on very young basaltic scoria with little or no soil development. Includes basalt scoria cones, lava sheets, scoria mounds, shields, domes and plugs.

**Type location:** R11/762889 Rangitoto Island

**Altitudinal range:** 0–280 m

**Slope:** Undulating to moderately steep (B-E), 4–25°

**Landform:** Scoria cone surmounted by scoria mound.

**Rock type:** Scoria (Sc), lavas (Vo).

**Soils:** Recent soils from basaltic scoria and ash. Rangitoto gravelly sand, rangitoto bouldery loam and rock loam.

**Erosion:** *Present:* Negligible (0) to slight (1) sheet (Sh) and gully (G)
*Potential:* Slight (1) to moderate (2) sheet (Sh), gully (G), and wind (W)

**Vegetation:** Cassinia (sC), heath (sH), manuka, kanuka (sM), coastal scrub (sO).

**Annual rainfall range:** 1000–1200 mm

**Land use:** *Present:* Undeveloped
*Potential:* Undeveloped

**Soil conservation management:** Retain and maintain existing indigenous vegetation. On the basis of steepness, catchment protection and insufficient soil cover, unit should be retired from use. Where possible eroded areas should be revegetated.

- All fires should be prevented.
- Control feral (noxious) animals such as possum and goats. Prevent browsing.

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# Appendix 1.

List of all the LUC units in the region in the order in which they appear in the regional LUC extended legend (Harmsworth 1991 and pages 105–234 of this report). Areas in hectares* and as a percentage (%) for LUC units, LUC subclasses and LUC classes mapped in region.

| LUC unit | Area* (ha) | Subclass total (ha) | Class total (ha) | % of mapped† region | % of total region |
|---|---|---|---|---|---|
| Ic1 | 435 | 435 | 435 | 0.03 | 0.03 |
| IIe1 | 2 890 | | | | |
| IIe2 | 7 092 | 9 982 | | | |
| IIw1 | 7 185 | | | | |
| IIw2 | 22 054 | | | | |
| IIw3 | 1 926 | 31 165 | | | |
| IIs1 | 7 575 | | | | |
| IIs2 | 3 891 | 11 466 | 52 613 | 3.48 | 3.32 |
| IIIe1 | 5 620 | | | | |
| IIIe2 | 4 743 | | | | |
| IIIe3 | 19 935 | | | | |
| IIIe4 | 4 724 | | | | |
| IIIe5 | 6 598 | 41 620 | | | |
| IIIw1 | 30 252 | | | | |
| IIIw2 | 19 394 | | | | |
| IIIw3 | 1 158 | | | | |
| IIIw4 | 13 375 | 64 179 | | | |
| IIIs1 | 3 676 | | | | |
| IIIs2 | 11 661 | | | | |
| IIIs3 | 4 351 | | | | |
| IIIs4 | 5 986 | | | | |
| IIIs5 | 1 535 | 27 209 | 133 008 | 8.80 | 8.40 |
| IVe1 | 5 132 | | | | |
| IVe2 | 11 648 | | | | |
| IVe3 | 35 124 | | | | |
| IVe4 | 17 869 | | | | |
| IVe5 | 58 507 | | | | |
| IVe6 | 43 341 | | | | |
| IVe7 | 18 461 | | | | |
| IVe8 | 23 445 | | | | |
| IVe9 | 8 619 | | | | |
| IVe10 | 17 405 | | | | |
| IVe11 | 1 231 | | | | |
| IVe12 | 14 630 | 255 412 | | | |

* as at June 1992

† that area exclusive of towns, rivers, lakes, estuaries, quarries, etc.

*Appendix 1. (continued)*

| LUC unit | Area* (ha) | Subclass total (ha) | Class total (ha) | % of mapped† region | % of total region |
|---|---|---|---|---|---|
| IVw1 | 35 423 | | | | |
| IVw2 | 5 506 | | | | |
| IVw3 | 11 358 | | | | |
| IVw4 | 3 797 | 56 084 | | | |
| IVs1 | 2 656 | | | | |
| IVs2 | 4 142 | | | | |
| IVs3 | 10 407 | | | | |
| IVs4 | 21 753 | | | | |
| IVs5 | 14 885 | 53 843 | 365 339 | 24.16 | 23.08 |
| Vs1 | 2 760 | 2 760 | | | |
| Vc1 | 4 125 | | | | |
| Vc2 | 1 441 | 5 566 | 8 326 | 0.55 | 0.53 |
| VIe1 | 101 635 | | | | |
| VIe2 | 92 605 | | | | |
| VIe3 | 2 726 | | | | |
| VIe4 | 9 131 | | | | |
| VIe5 | 6 445 | | | | |
| VIe6 | 13 510 | | | | |
| VIe7 | 128 894 | | | | |
| VIe8 | 61 022 | | | | |
| VIe9 | 62 289 | | | | |
| VIe10 | 5 981 | | | | |
| VIe11 | 12 052 | | | | |
| VIe12 | 15 114 | | | | |
| VIe13 | 2 362 | | | | |
| VIe14 | 28 246 | | | | |
| VIe15 | 15 716 | | | | |
| VIe16 | 49 091 | | | | |
| VIe17 | 42 062 | | | | |
| VIe18 | 4 586 | | | | |
| VIe19 | 36 128 | 689 595 | | | |
| VIw1 | 11 577 | | | | |
| VIw2 | 2 410 | | | | |
| VIw3 | 3 251 | 17 238 | | | |
| VIs1 | 5 982 | | | | |
| VIs2 | 803 | | | | |
| VIs3 | 209 | | | | |
| VIs4 | 2 586 | | | | |
| VIs5 | 10 626 | 20 206 | | | |
| VIc1 | 4 800 | 4 800 | 731 839 | 48.40 | 46.24 |

* as at June 1992

† that area exclusive of towns, rivers, lakes, estuaries, quarries, etc.

*Appendix 1. (continued)*

| LUC unit | Area* (ha) | Subclass total (ha) | Class total (ha) | % of mapped† region | % of total region |
|---|---|---|---|---|---|
| VIIe1 | 53 299 | | | | |
| VIIe2 | 1 050 | | | | |
| VIIe3 | 933 | | | | |
| VIIe4 | 10 540 | | | | |
| VIIe5 | 2 997 | | | | |
| VIIe6 | 28 207 | | | | |
| VIIe7 | 3 538 | | | | |
| VIIe8 | 10 213 | | | | |
| VIIe9 | 9 633 | | | | |
| VIIe10 | 52 547 | 172 957 | | | |
| VIIw1 | 4 277 | | | | |
| VIIw2 | 4 550 | 8 827 | 181 784 | 12.02 | 11.48 |
| VIIIe1 | 22 147 | | | | |
| VIIIe2 | 4 563 | | | | |
| VIIIe3 | 4 750 | 31 460 | | | |
| VIIIs1 | 4 816 | | | | |
| VIIIs2 | 2 336 | 7 152 | 38 612 | 2.55 | 2.44 |
| Total of mapped areas | | | 1 511 965 | 100 | 95.53 |
| Total of unmapped areas (towns, rivers, lakes, estuaries, etc.) | | | 70 733 | | 4.47 |
| Total region (mapped and unmapped areas) | | | 1 582 698 | | 100 |

* as at June 1992

† that area exclusive of towns, rivers, lakes, estuaries, quarries, etc.

# Appendix 2. Areas in hectares and as a percentage for LUC suites, LUC subsuites and LUC units mapped.

| LUC suite | Area* (ha) | Area* (% of region) | LUC subsuite | Area* (ha) | Area* (% of region) | Component LUC units | Area* (ha) |
|---|---|---|---|---|---|---|---|
| 1 Coastal sand country | 197 878 | 12.50 | 1a Young unstable sand-dune complex | 90 410 | 5.71 | VIe15 | 15 716 |
| | | | | | | VIIe10 | 52 547 |
| | | | | | | VIIIe1 | 22 147 |
| | | | 1b Old stable sand dunes on unconsolidated to compact sands | 44 346 | 2.80 | IIIe5 | 6 598 |
| | | | | | | IIIs4 | 5 986 |
| | | | | | | IVe9 | 8 619 |
| | | | | | | VIe6 | 13 510 |
| | | | | | | VIIe9 | 9 633 |
| | | | 1c Old stable podzolised terraces and escarpments on unconsolidated to compact Pleistocene sands | 72 755 | 4.60 | IVe10 | 17 405 |
| | | | | | | IVs5 | 14 885 |
| | | | | | | VIe14 | 28 246 |
| | | | | | | VIs4 | 2 586 |
| | | | | | | VIIe9 | 9 633 |
| 2 Alluvial and estuarine plains and low terraces | 171 770 | 10.85 | 2a Well drained floodplains and low terraces | 37 437 | 2.36 | IIw1 | 7 185 |
| | | | | | | IIIw1 | 30 252 |
| | | | 2b Alluvial and estuarine plains with gley soils | 41 448 | 2.62 | IIw2 | 22 054 |
| | | | | | | IIIw2 | 19 394 |
| | | | 2c Poorly drained floodplains and low terraces | 51,277 | 3.24 | IVw1 | 35 423 |
| | | | | | | VIw1 | 11 577 |
| | | | | | | VIIw1 | 4 277 |
| | | | 2d Mudflats with saline soils | 9 074 | 0.57 | IIIw3 | 1 158 |
| | | | | | | IVw2 | 5 506 |
| | | | | | | VIw2 | 2 410 |
| | | | 2e Peats | 32 534 | 2.05 | IIIw4 | 13 375 |
| | | | | | | IVw3 | 11 358 |
| | | | | | | VIw3 | 3 251 |
| | | | | | | VIIw2 | 4 550 |

* as at June 1992

*Appendix 2. (continued)*

| LUC suite | Area* (ha) | Area* (% of region) | LUC subsuite | Area* (ha) | Area* (% of region) | Component LUC units | Area* (ha) |
|---|---|---|---|---|---|---|---|
| 3 Quaternary terraces with complex soils | 22 003 | 1.40 | – | 22 003 | 1.40 | IIe2 | 7,092 |
| | | | | | | IIw3 | 1 926 |
| | | | | | | IIs2 | 3 891 |
| | | | | | | IIIe2 | 4 743 |
| | | | | | | IIIs3 | 4 351 |
| 4 Sedimentary rock terrain excluding greywacke | 604 328 | 38.20 | 4a Interbedded and massive sandstone and mudstone | 251,639 | 15.90 | IIIe3 | 19 935 |
| | | | | | | IVe5 | 58 507 |
| | | | | | | VIe1 | 101 635 |
| | | | | | | VIe8 | 61 022 |
| | | | | | | VIIe4 | 10 540 |
| | | | 4b Older shattered and sheared argillites and sandstone | 172 235 | 10.88 | IVe6 | 43 341 |
| | | | | | | VIe7 | 128 894 |
| | | | 4c Sheared mixed lithologies | 39 609 | 2.50 | IVe8 | 23 445 |
| | | | | | | VIe12 | 15 114 |
| | | | | | | VIIe2 | 1 050 |
| | | | 4d Crushed argillite | 46 341 | 2.93 | VIe19 | 36 128 |
| | | | | | | VIIe8 | 10 213 |
| | | | 4e Limestone | 14 660 | 0.93 | IIIs5 | 1 535 |
| | | | | | | IVe1 | 5 132 |
| | | | | | | Vc1 | 4 125 |
| | | | | | | VIs3 | 2 726 |
| | | | | | | VIe3 | 209 |
| | | | | | | VIIe3 | 933 |
| | | | 4f Limestone complexed with other sedimentary deposits | 29 038 | 1.83 | IIIe4 | 4 724 |
| | | | | | | IVe4 | 17 869 |
| | | | | | | VIe5 | 6 445 |
| | | | 4g Podzols on sedimentary rock | 50 806 | 3.21 | IVe12 | 14 630 |
| | | | | | | IVw4 | 3 797 |
| | | | | | | IVs4 | 21 753 |
| | | | | | | VIs5 | 10 626 |

* as at June 1992

*Appendix 2. (continued)*

| LUC suite | Area* (ha) | Area* (% of region) | LUC subsuite | | Area* (ha) | Area* (% of region) | Component LUC units | Area* (ha) |
|---|---|---|---|---|---|---|---|---|
| 5 Greywacke terrain | 164 797 | 10.41 | – | | 164 797 | 10.41 | IVe7 | 18,461 |
| | | | | | | | VIe9 | 62 289 |
| | | | | | | | VIe10 | 5 981 |
| | | | | | | | VIe17 | 42 062 |
| | | | | | | | VIc1 | 4 800 |
| | | | | | | | VIIe5 | 2 997 |
| | | | | | | | VIIe6 | 28 207 |
| 6 Young basalt volcanic terrain | 70 512 | 4.45 | – | | 70 512 | 4.45 | Ic1 | 435 |
| | | | | | | | IIe1 | 2,890 |
| | | | | | | | IIs1 | 7 575 |
| | | | | | | | IIIe1 | 5 620 |
| | | | | | | | IIIs1 | 3 676 |
| | | | | | | | IIIs2 | 11 661 |
| | | | | | | | IVe2 | 11 648 |
| | | | | | | | IVs1 | 2 656 |
| | | | | | | | IVs2 | 4 142 |
| | | | | | | | Vs1 | 2 760 |
| | | | | | | | VIe4 | 9 131 |
| | | | | | | | VIs1 | 5 982 |
| | | | | | | | VIIIs2 | 2 336 |
| 7 Old volcanic terrain | 271 339 | 17.14 | 7a | Landforms on old stable basalt–andesite volcanics with brown granular loams and clays | 246 767 | 15.60 | IVe3 | 35 124 |
| | | | | | | | IVs3 | 10 407 |
| | | | | | | | Vc2 | 1 441 |
| | | | | | | | VIe2 | 92 605 |
| | | | | | | | VIe16 | 49 091 |
| | | | | | | | VIc1 | 4 800 |
| | | | | | | | VIIe1 | 53 299 |
| | | | 7b | Landforms on volcanic/sedimentary complexes | 15 217 | 0.96 | VIs2 | 803 |
| | | | | | | | VIe11 | 12 052 |
| | | | | | | | VIe13 | 2 362 |

* as at June 1992

*Appendix 2. (continued)*

| LUC suite | Area* (ha) | Area* (% of region) | | LUC subsuite | Area* (ha) | Area* (% of region) | Component LUC units | Area* (ha) |
|---|---|---|---|---|---|---|---|---|
| | | | 7c | Acid to intermediate igneous volcanics and plutonics | 9 355 | 0.59 | IVe11<br>VIe18<br>VIIe7 | 1 231<br>4 586<br>3 538 |
| 8 Cliffs and precipitous slopes | 14 129 | 0.89 | – | | 14 129 | 0.89 | VIIIe2<br>VIIIe3<br>VIIIs1 | 4 563<br>4 750<br>4 816 |
| Total of mapped areas† | 1 511 965 | 95.53 | | | 1 511 965 | 95.53 | | 1 511 965 |
| Total of unmapped areas (towns, rivers, lakes, estuaries, etc.) | 70 733 | 4.47 | | | 70 733 | 4.47 | | 70 733 |
| Total region | 1 582 698 | 100 | | | 1 582 698 | 100 | | 1 582 698 |

* as at June 1992

† areas exclusive of towns, rivers, lakes, estuaries, quarries, etc.

# Appendix 3. Correlation between first-edition (1979) and second-edition (1990) LUC classifications of the Northland region NZLRI.

| 2nd Edition | 1st Edition | 2nd Edition | 1st Edition |
|---|---|---|---|
| Ic1 | IIc1 | VIe1 | VIe1 |
| IIe1 | IIc1 | VIe2 | VIe2 |
| IIe2 | IIs1 | VIe3 | VIe3 |
| IIw1 | IIw1 | VIe4 | VIe4 |
| IIw2 | IIw2 | VIe5 | VIe3 |
| IIw3 | IIw3,IIw4 | VIe6 | VIe5 |
| IIs1 | IIc1 | VIe7 | VIe1,VIe6 |
| IIs2 | IIs1 | VIe8 | VIe6 |
| IIIe1 | IIIe1 | VIe9 | VIe7 |
| IIIe2 | IIIe2,IVe4 | VIe10 | VIe8 |
| IIIe3 | IIIe3 | VIe11 | VIe9,VIe2 |
| IIIe4 | IIIe3 | VIe12 | VIe10 |
| IIIe5 | IIIe4 | VIe13 | VIe9,VIe1,VIe6 |
| IIIw1 | IIIw1 | VIe14 | VIe11,VIe5 |
| IIIw2 | IIIw1 | VIe15 | VIe11 |
| IIIw3 | IIIw2 | VIe16 | VIe9 |
| IIIw4 | IIIw3 | VIe17 | VIe8 |
| IIIs1 | IIIs1 | VIe18 | VIe2,VIe8 |
| IIIs2 | IIIs2,IIIs1 | VIe19 | VIe10 |
| IIIs3 | IIIe3,(IVe4) | VIw1 | VIw1 |
| IIIs4 | IIIs3 | VIw2 | VIw2 |
| IIIs5 | IIIs4 | VIw3 | VIw1,IVw3 |
| IVe1 | IVe1 | VIs1 | VIs1 |
| IVe2 | IVe3,IVe6 | VIs2 | VIs2,VIe10,(VIe2) |
| IVe3 | IVe2,IVe9 | VIs3 | VIe3 |
| IVe4 | IVe1,(IVe4) | VIs4 | IVs5 |
| IVe5 | IVe5 | VIs5 | VIe10 |
| IVe6 | IVe5 | VIc1 | IVs4,VIe2 |
| IVe7 | IVe5 | VIIe1 | VIIe1 |
| IVe8 | IVe8 | VIIe2 | VIIe2,VIe10,(VIIe7) |
| IVe9 | IVe7 | VIIe3 | VIe3 |
| IVe10 | IVe10 | VIIe4 | VIIe3 |
| IVe11 | IVe5,(IVe9),(VIe1) | VIIe5 | VIIe4 |
| IVe12 | IVe8 | VIIe6 | VIIe5 |
| IVw1 | IVw1 | VIIe7 | VIIe6 |
| IVw2 | IVw2 | VIIe8 | VIIe7 |
| IVw3 | IVw3 | VIIe9 | VIIe8 |
| IVw4 | IVw4,IVe5,IVe8 | VIIe10 | VIIe9 |
| IVs1 | IVs1 | VIIw1 | VIIw1 |
| IVs2 | IVs2 | VIIw2 | VIIw3,(VIIw2) |
| IVs3 | IVs4 | VIIIe1 | VIIIe1 |
| IVs4 | IVs3,(IVe8) | VIIIe2 | VIIIe2 |
| IVs5 | IVs5 | VIIIe3 | VIIIe2,VIIIs1 |
| Vs1 | Vs1 | VIIIs1 | VIIIs1 |
| Vc1 | Vc1 | VIIIs2 | VIIIs2 |
| Vc2 | IVs4 | | |
| | **Total LUC units:** | 91 | 69 |

# Appendix 4a. Stock carrying capacity data and site index data for *Pinus radiata* for LUC units mapped.

| LUC unit | Area (hectares) | Stock unit carrying capacity (s.u./ha) | | | Site index (metres) |
|---|---|---|---|---|---|
| | | Present average PA | Top farmer TF | Attainable potential AP | |
| Ic1 | 435 | 21 | 26 | 30 | 34–37 |
| IIe1 | 2 890 | 21 | 26 | 30 | 34–37 |
| IIe2 | 7 092 | 17 | 20 | 24 | 30–33 |
| IIw1 | 7 185 | 21 | 26 | 30 | 26–29 |
| IIw2 | 22 054 | 21 | 26 | 30 | 25–28 |
| IIw3 | 1 926 | 17 | 20 | 24 | 24–27 |
| IIs1 | 7 575 | 21 | 26 | 30 | 34–37 |
| IIs2 | 3 891 | 17 | 20 | 24 | 30–33 |
| IIIe1 | 5 620 | 21 | 26 | 30 | 30–33 |
| IIIe2 | 4 743 | 17 | 20 | 24 | 29–32 |
| IIIe3 | 19 935 | 13 | 15 | 18 | 29–32 |
| IIIe4 | 4 724 | 13 | 15 | 18 | 28–31 |
| IIIe5 | 6 598 | 13 | 15 | 18 | 27–30 |
| IIIw1 | 30 252 | 21 | 26 | 30 | 23–26 |
| IIIw2 | 19 394 | 17 | 20 | 24 | 18–21 |
| IIIw3 | 1 158 | 17 | 20 | 24 | 18–21 |
| IIIw4 | 13 375 | 17 | 20 | 24 | 19–22 |
| IIIs1 | 3 676 | 21 | 26 | 30 | 33–36 |
| IIIs2 | 11 661 | 13 | 15 | 18 | 33–36 |
| IIIs3 | 4 351 | 17 | 20 | 24 | 28–31 |
| IIIs4 | 5 986 | 13 | 15 | 18 | 23–26 |
| IIIs5 | 1 535 | 13 | 15 | 18 | 27–30 |
| IVe1 | 5 132 | 13 | 15 | 18 | 27–30 |
| IVe2 | 11 648 | 17 | 20 | 24 | 28–30 |
| IVe3 | 35 124 | 13 | 15 | 18 | 29–32 |
| IVe4 | 17 869 | 13 | 15 | 18 | 28–31 |
| IVe5 | 58 507 | 13 | 15 | 18 | 29–32 |
| IVe6 | 43 341 | 13 | 15 | 18 | 30–33 |
| IVe7 | 18 461 | 13 | 15 | 18 | 28–31 |
| IVe8 | 23 445 | 13 | 15 | 18 | 30–33 |
| IVe9 | 8 619 | 13 | 15 | 18 | 27–30 |
| IVe10 | 17 405 | 11 | 13 | 15 | 24–30 |

*Appendix 4a. (continued)*

| LUC unit | Area (hectares) | Stock unit carrying capacity (s.u./ha) | | | Site index (metres) |
|---|---|---|---|---|---|
| | | Present average PA | Top farmer TF | Attainable potential AP | |
| IVe11 | 1 231 | 13 | 15 | 18 | 21–24 |
| IVe12 | 14 630 | 13 | 15 | 18 | 28–32 |
| IVw1 | 35 423 | 17 | 20 | 24 | 20–23 |
| IVw2 | 5 506 | 13 | 15 | 18 | <18 |
| IVw3 | 11 358 | 17 | 20 | 24 | <18 |
| IVw4 | 3 797 | 13 | 15 | 18 | 20–24 |
| IVs1 | 2 656 | 21 | 26 | 30 | 28–30 |
| IVs2 | 4 142 | 13 | 15 | 18 | 26–28 |
| IVs3 | 10 407 | 13 | 15 | 18 | 24–27 |
| IVs4 | 21 753 | 13 | 15 | 18 | 26–30 |
| IVs5 | 14 885 | 13 | 15 | 18 | 20–23 |
| Vs1 | 2 760 | 17 | 20 | 24 | 24–27 |
| Vc1 | 4 125 | 13 | 15 | 18 | 27–30 |
| Vc2 | 1 441 | 13 | 15 | 18 | 21–24 |
| VIe1 | 101 635 | 8 | 10 | 12 | 31–34 |
| VIe2 | 92 605 | 7 | 8 | 9 | 30–33 |
| VIe3 | 2 726 | 7 | 8 | 9 | 27–30 |
| VIe4 | 9 131 | 13 | 15 | 18 | 27–30 |
| VIe5 | 6 445 | 11 | 13 | 15 | 28–31 |
| VIe6 | 13 510 | 11 | 13 | 15 | 26–29 |
| VIe7 | 128 894 | 11 | 13 | 15 | 32–35 |
| VIe8 | 61 022 | 7 | 8 | 9 | 31–34 |
| VIe9 | 62 289 | 8 | 10 | 12 | 30–33 |
| VIe10 | 5 981 | 8 | 10 | 12 | 30–33 |
| VIe11 | 12 052 | 8 | 10 | 12 | 31–34 |
| VIe12 | 15 114 | 11 | 13 | 15 | 28–31 |
| VIe13 | 2 362 | 8 | 10 | 12 | 30–33 |
| VIe14 | 28 246 | 8 | 10 | 12 | 28–31 |
| VIe15 | 15 716 | 7 | 8 | 9 | 27–30 |
| VIe16 | 49 091 | 7 | 8 | 9 | 30–33 |
| VIe17 | 42 062 | 7 | 8 | 9 | 30–33 |
| VIe18 | 4 586 | 7 | 8 | 9 | 24–27 |
| VIe19 | 36 128 | 7 | 8 | 9 | 26–32 |
| VIw1 | 11 577 | 13 | 15 | 18 | <18 |
| VIw2 | 2 410 | 8 | 10 | 12 | unsuitable |

*Appendix 4a. (continued)*

| LUC unit | Area (hectares) | Stock unit carrying capacity (s.u./ha) | | | Site index (metres) |
|---|---|---|---|---|---|
| | | Present average PA | Top farmer TF | Attainable potential AP | |
| VIw3 | 3 251 | 13 | 15 | 18 | <18 |
| VIs1 | 5 982 | 17 | 20 | 24 | <18 |
| VIs2 | 803 | 13 | 15 | 18 | 28–30 |
| VIs3 | 209 | 11 | 13 | 15 | 24–27 |
| VIs4 | 2 586 | 8 | 10 | 12 | <18 |
| VIs5 | 10 626 | 13 | 15 | 18 | 20–24 |
| VIc1 | 4 800 | 13 | 15 | 18 | 26–28 |
| VIIe1 | 53 299 | 7 | 8 | 9 | 29–32 |
| VIIe2 | 1 050 | 8 | 10 | 12 | 26–29 |
| VIIe3 | 933 | 7 | 8 | 9 | 24–27 |
| VIIe4 | 10 540 | 7 | 8 | 9 | 30–33 |
| VIIe5 | 2 997 | 7 | 8 | 9 | 25–29 |
| VIIe6 | 28 207 | 7 | 8 | 9 | 25–29 |
| VIIe7 | 3 538 | 7 | 8 | 9 | 21–24 |
| VIIe8 | 10 213 | 7 | 8 | 9 | 25–28 |
| VIIe9 | 9 633 | 7 | 8 | 9 | 18–27 |
| VIIe10 | 52 547 | 2 | 3 | 5 | 21–26 |
| VIIw1 | 4 277 | – | – | 2 | unsuitable |
| VIIw2 | 4 550 | – | – | 3 | unsuitable |
| VIIIe1 | 22 147 | – | – | – | <18 |
| VIIIe2 | 4 563 | – | – | – | unsuitable |
| VIIIe3 | 4 750 | – | – | – | unsuitable |
| VIIIs1 | 4 816 | – | – | – | unsuitable |
| VIIIs2 | 2 336 | – | – | – | unsuitable |

Class VIII is unsuitable for livestock or forest production

## Appendix 4b. Stock carrying capacity ranking.

| Stock carrying capacity ranking | Stock units per hectare |
|---|---|
| very high | >25 |
| high | 21–25 |
| moderately high | 16–20 |
| medium | 11–15 |
| low | 6–10 |
| very low | 1–5 |
| sparse | <1 |

## Appendix 4c. *Pinus radiata* site index ranking.

| Site index ranking | Site index in metres |
|---|---|
| very high | >35 |
| high | 30–35 |
| medium | 25–29 |
| low | 20–24 |
| very low | <20 |

# Appendix 5.

Stock carrying capacity data and site index data for *Pinus radiata* for LUC units grouped into LUC suites and LUC subsuites (see Appendix 2 for LUC subsuite definition).

| LUC suite | Area (hectares of LUC suite) | LUC sub-suite | LUC unit | Area (hectares of LUC unit) | Stock unit carrying capacity (s.u./ha) | | | Site index for *Pinus radiata* (metres) |
|---|---|---|---|---|---|---|---|---|
| | | | | | Present average PA | Top farmer TF | Attainable potential AP | |
| 1. Coastal sand country | 197 878 | Ia | VIe15 | 15 716 | 7 | 8 | 9 | 27–30 |
| | | | VIIe10 | 52 547 | 2 | 3 | 5 | 21–26 |
| | | | VIIIe1 | 22 147 | – | – | – | <18 |
| | | 1b | IIIe5 | 6 598 | 13 | 15 | 18 | 27–30 |
| | | | IIIs4 | 5 986 | 13 | 15 | 18 | 23–26 |
| | | | IVe9 | 8 619 | 13 | 15 | 18 | 27–30 |
| | | | VIe6 | 13 510 | 11 | 13 | 15 | 26–29 |
| | | | VIIe9 | 9 633 | 7 | 8 | 9 | 18–27 |
| | | Ic | IVe10 | 17 405 | 11 | 13 | 15 | 24–30 |
| | | | IVs5 | 14 885 | 13 | 15 | 18 | 20–23 |
| | | | VIe14 | 28 246 | 8 | 10 | 12 | 28–31 |
| | | | VIs4 | 2 586 | 8 | 10 | 12 | <18 |
| | | | VIIe9 | 9 633 | 7 | 8 | 9 | 18–27 |
| 2. Alluvial and estuarine plains and low terraces | 171 770 | 2a | IIw1 | 7 185 | 21 | 26 | 30 | 26–29 |
| | | | IIIw1 | 30 252 | 21 | 26 | 30 | 23–26 |
| | | 2b | IIw2 | 22 054 | 21 | 26 | 30 | 25–28 |
| | | | IIIw2 | 19 394 | 17 | 20 | 24 | 18–21 |
| | | 2c | IVwl | 35 423 | 17 | 20 | 24 | 20–23 |
| | | | VIw1 | 11 577 | 13 | 15 | 18 | <18 |
| | | | VIIw1 | 4 277 | – | – | 2 | – |
| | | 2d | IIIw3 | 1 158 | 17 | 20 | 24 | 18–21 |
| | | | IVw2 | 5 506 | 13 | 15 | 18 | <18 |
| | | | VIw2 | 2 410 | 8 | 10 | 12 | |
| | | 2e | IIIw4 | 13 375 | 17 | 20 | 24 | 19–22 |
| | | | IVw3 | 11 358 | 17 | 20 | 24 | <18 |
| | | | VIw3 | 3 251 | 13 | 15 | 18 | <18 |
| | | | VIIw2 | 4 550 | – | – | 3 | – |
| 3. Quaternary terraces with complex soils | 22 003 | 3 | IIe2 | 7 092 | 17 | 20 | 24 | 30–33 |
| | | | IIw3 | 1 926 | 17 | 20 | 24 | 24–27 |
| | | | IIs2 | 3 891 | 17 | 20 | 24 | 30–33 |
| | | | IIIe2 | 4 743 | 17 | 20 | 24 | 29–32 |
| | | | IIIs3 | 4 351 | 17 | 20 | 24 | 28–31 |

*Appendix 5. (continued)*

| LUC suite | Area (hectares of LUC suite) | LUC sub-suite | LUC unit | Area (hectares of LUC unit) | Stock unit carrying capacity (s.u./ha) | | | Site index for *Pinus radiata* (metres) |
|---|---|---|---|---|---|---|---|---|
| | | | | | Present average PA | Top farmer TF | Attainable potential AP | |
| 4. Sedimentary rock terrain excluding greywacke | 604 328 | 4a | IIIe3 | 19 935 | 13 | 15 | 18 | 29–32 |
| | | | IVe5 | 58 507 | 13 | 15 | 18 | 29–32 |
| | | | VIe1 | 101 635 | 8 | 10 | 12 | 31–34 |
| | | | VIe8 | 61 022 | 7 | 8 | 9 | 31–34 |
| | | | VIIe4 | 10 540 | 7 | 8 | 9 | 30–33 |
| | | 4b | IVe6 | 43 341 | 13 | 15 | 18 | 30–33 |
| | | | VIe7 | 128 894 | 11 | 13 | 15 | 32–35 |
| | | 4c | IVe8 | 23 445 | 13 | 15 | 18 | 30–33 |
| | | | VIe12 | 15 114 | 11 | 13 | 15 | 28–31 |
| | | | VIIe2 | 1 050 | 8 | 10 | 12 | 26–29 |
| | | 4d | VIe19 | 36 128 | 7 | 8 | 9 | 26–32 |
| | | | VIIe8 | 10 213 | 7 | 8 | 9 | 25–28 |
| | | 4e | IIIs5 | 1 535 | 13 | 15 | 18 | 27–30 |
| | | | IVe1 | 5 132 | 13 | 15 | 18 | 27–30 |
| | | | Vc1 | 4 125 | 13 | 15 | 18 | 27–30 |
| | | | VIe3 | 2 726 | 7 | 8 | 9 | 27–30 |
| | | | VIs3 | 209 | 11 | 13 | 15 | 24–27 |
| | | | VIIe3 | 933 | 7 | 8 | 9 | 24–27 |
| | | 4f | IIIe4 | 4 724 | 13 | 15 | 18 | 28–31 |
| | | | IVe4 | 17 869 | 13 | 15 | 18 | 28–31 |
| | | | VIe5 | 6 445 | 11 | 13 | 15 | 28–31 |
| | | 4g | IVe12 | 14 630 | 13 | 15 | 18 | 28–32 |
| | | | IVw4 | 3 797 | 13 | 15 | 18 | 20–24 |
| | | | IVs4 | 21 753 | 13 | 15 | 18 | 26–30 |
| | | | VIs5 | 10 626 | 13 | 15 | 18 | 20–24 |
| 5. Greywacke | 164 797 | 5 | IVe7 | 18 461 | 13 | 15 | 18 | 28–31 |
| | | | VIe9 | 62 289 | 8 | 10 | 12 | 30–33 |
| | | | VIe10 | 5 981 | 8 | 10 | 12 | 30–33 |
| | | | VIe17 | 42 062 | 7 | 8 | 9 | 30–33 |
| | | | VIc1 | 4 800 | 13 | 15 | 18 | 26–28 |
| | | | VIIe5 | 2 997 | 7 | 8 | 9 | 25–29 |
| | | | VIIe6 | 28 207 | 7 | 8 | 9 | 25–29 |
| 6. Young basalt volcanic terrain | 70 512 | 6 | Ic1 | 435 | 21 | 26 | 30 | 34–37 |
| | | | IIe1 | 2 890 | 21 | 26 | 30 | 34–37 |
| | | | IIs1 | 7 575 | 21 | 26 | 30 | 34–37 |
| | | | IIIe1 | 5 620 | 21 | 26 | 30 | 30–33 |
| | | | IIIsl | 3 676 | 21 | 26 | 30 | 33–36 |

*Appendix 5. (continued)*

| LUC suite | Area (hectares of LUC suite) | LUC sub-suite | LUC unit | Area (hectares of LUC unit) | Stock unit carrying capacity (s.u./ha) | | | Site index for *Pinus radiata* (metres) |
|---|---|---|---|---|---|---|---|---|
| | | | | | Present average PA | Top farmer TF | Attainable potential AP | |
| | | | IIIs2 | 11 661 | 13 | 15 | 18 | 33–36 |
| | | | IVe2 | 11 648 | 17 | 20 | 24 | 28–30 |
| | | | IVs1 | 2 656 | 21 | 26 | 30 | 28–30 |
| | | | IVs2 | 4 142 | 13 | 15 | 18 | 26–28 |
| | | | Vs1 | 2 760 | 17 | 20 | 24 | 24–27 |
| | | | VIe4 | 9 131 | 13 | 15 | 18 | 27–30 |
| | | | VIs1 | 5 982 | 17 | 20 | 24 | <18 |
| | | | VIIIs2 | 2 336 | – | – | – | – |
| 7. Old volcanic terrain | 271 339 | 7a | IVe3 | 35 124 | 13 | 15 | 18 | 29–32 |
| | | | IVs3 | 10 407 | 13 | 15 | 18 | 24–27 |
| | | | Vc2 | 1 441 | 13 | 15 | 18 | 21–24 |
| | | | VIe2 | 92 605 | 7 | 8 | 9 | 30–33 |
| | | | VIe16 | 49 091 | 7 | 8 | 9 | 30–33 |
| | | | VIc1 | 4 800 | 13 | 15 | 18 | 26–28 |
| | | | VIIe1 | 53 299 | 7 | 8 | 9 | 29–32 |
| | | 7b | VIs2 | 803 | 13 | 15 | 18 | 28–30 |
| | | | VIe11 | 12 052 | 8 | 10 | 12 | 31–34 |
| | | | VIe13 | 2 362 | 8 | 10 | 12 | 30–33 |
| | | 7c | IVe11 | 1 231 | 13 | 15 | 18 | 21–24 |
| | | | VIe18 | 4 586 | 7 | 8 | 9 | 24–27 |
| | | | VIIe7 | 3 538 | 7 | 8 | 9 | 21–24 |
| 8. Cliffs and precipitous slopes | 14 129 | 8 | VIIIe2 | 4 563 | – | – | – | – |
| | | | VIIIe3 | 4 750 | – | – | – | – |
| | | | VIIIs1 | 4 816 | – | – | – | – |

# Appendix 6.

Authors and dates for fieldwork and compilation work during the updating programme (1985–1990) for the New Zealand Land Resource Inventory.

| NZMS260 1:50 000 sheet | Locality name of NZMS260 sheet | Fieldwork carried out by | Date of fieldwork | Date of compilation and author |
|---|---|---|---|---|
| M02, N02 | North Cape | Harmsworth, G.R. | 1986 | 1987–1988 Harmsworth, G.R. |
| N03 | Houhora | Harmsworth, G.R. | 1986 | 1987–1988 Harmsworth, G.R. |
| O03 | Karikari | Harmsworth, G.R. | 1986 | 1987–1988 Harmsworth, G.R. |
| N04 | Ahipara | Harmsworth, G.R. | 1986 | 1987–1988 Harmsworth, G.R. |
| O04 | Kaitaia | Harmsworth, G.R. | 1986 | 1987–1988 Harmsworth, G.R. |
| P04 and Q04 | Whangaroa | Hope, G.D. | 1986 | 1986 Hope G.D.<br>1988 Harmsworth, G.R. |
| N05 | Herekino | Harmsworth, G.R.<br>Hope, G.D. | 1986<br>1986 | 1987–1988 Harmsworth, G.R. |
| O05 | Rawene | Hope, G.D. | 1986 | 1986 Hope, G.D. |
| P05 | Kaikohe | Hope, G.D.<br>Crippen, T.F. | 1986<br>1987 | 1986 Hope, G.D.<br>1987 Crippen, T.F.<br>1988–1989 Harmsworth, G.R. |
| Q05 | Bay of Islands | Crippen, T.F. | 1987 | 1987 Crippen, T.F.<br>1988–1989 Harmsworth, G.R. |
| O06 | Waipoua | Harmsworth, G.R. | 1987 | 1989–1990 Harmsworth, G.R. |
| P06 | Mangakahia | Harmsworth, G.R.<br>Noble, K.E. | 1987, 1988<br>1987 | 1989–1990 Harmsworth, G.R. |
| Q06/R06 | Hukerenui | Noble, K.E.<br>Harmsworth, G.R. | 1987<br>1987 | 1989–1990 Harmsworth, G.R. |
| O07 | Aranga | Harmsworth, G.R. | 1987 | 1989–1990 Harmsworth, G.R. |
| P07 | Dargaville | Noble, K.E.<br>Harmsworth, G.R. | 1987, 1988<br>1987, 1988 | 1989–1990 Harmsworth, G.R. |
| Q07, pt R07 | Whangarei | Jessen, M.R.<br>Noble, K.E. | 1989<br>1989–1990 | 1989–1990 Jessen, M.R.<br>1989–1990 Harmsworth, G.R. |
| P08 | Ruawai | Harmsworth, G.R. | 1985 | 1985, 1988 Harmsworth, G.R. |
| Q08 | Maungaturoto | Crippen, T.F.<br>Jessen, M.R. | 1985<br>1988, 1989 | 1986–1988 Crippen, T.F<br>1989–1990 Jessen, M.R. |
| R08 | Mangawhai | Crippen, T.F. | 1985 | 1986, 1988 Crippen, T.F. |
| P09 | Rototuna | Harmsworth, G.R. | 1985 | 1985, 1988 Harmsworth, G.R. |
| Q09 | Kaipara | Noble, K.E.<br>Harmsworth, G.R. | 1985, 1987<br>1985 | 1986–1988 Noble, K.E.<br>1986 Harmsworth, G.R. |
| R09<br>Q10 | Warkworth<br>Helensville | Noble, K.E.<br>Harmsworth, G.R.<br>Hope, G.D. | 1985, 1987<br>1985–1986<br>1985 | 1987, 1988 Noble, K.E.<br>1985, 1986, 1988 Harmsworth, G.R. |

*Appendix 6. (continued)*

| NZMS260 1:50 000 sheet | Locality name of NZMS260 sheet | Fieldwork carried out by | Date of fieldwork | Date of compilation and author |
|---|---|---|---|---|
| R10 | Whangaparaoa | Harmsworth, G.R. | 1985, 1986 | 1986, 1988 Harmsworth, G.R. |
| Q11 | Waitakere | Hope, G.D. | 1985 | 1985, 1986 Hope, G.D.<br>1988 Harmsworth, G.R. |
| R11 | Auckland | Hope, G.D. | 1985 | 1985 Hope, G.D.<br>1988 Harmsworth, G.R. |

# Appendix 7. Bibliographic references for second edition NZLRI data at 1:50 000 on NZMS 260 sheets/NZLRI sheets.


**M02, N02:**
HARMSWORTH, G. R. 1990: M02, N02, North Cape (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**N03:**
HARMSWORTH, G. R. 1990: N03 Houhora (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**O03:**
HARMSWORTH, G. R. 1990: O03 Karikari (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**N04:**
HARMSWORTH, G. R. 1990: N04 Ahipara (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**O04:**
HARMSWORTH, G. R. 1990: O04 Kaitaia (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**P04 and Q04:**
HOPE, G. D. 1990: P04 and Q04 Whangaroa (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**N05:**
HARMSWORTH, G. R. 1990: N05 Herekino (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**O05:**
HOPE, G. D. 1990: O05 Rawene (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand

**P05:**
CRIPPEN, T. F.; HOPE, G. D. 1990: P05 Kaikohe (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**Q05:**
CRIPPEN, T. F. 1990: Q05 Bay of Islands (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**O06:**
HARMSWORTH, G. R. 1990: O06 Waipoua (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**P06:**
HARMSWORTH, G. R. 1990: P06 Mangakahia (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**Q06/R06:**
HARMSWORTH, G. R.; NOBLE, K. E. 1990: Q06/R06 Hukerenui (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**O07:**
HARMSWORTH, G. R. 1990: O07 Aranga (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**P07:**
NOBLE, K. E.; HARMSWORTH, G. R. 1990: P07 Dargaville (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**Q07, pt R07:**
JESSEN, M. R. 1990: Q07, pt R07 Whangarei (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**P08:**
HARMSWORTH, G. R. 1990: P08 Ruawai (2nd ed.) New Zealand Land Resource Inventory Worksheet, Mangawhai (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**Q08**
CRIPPEN, T. F.; JESSEN, M. R. 1990: Q08 Maungaturoto (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

*Appendix 7. (continued)*

**R08**
CRIPPEN, T. F. 1990: R08 Mangawhai (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**R09:**
HARMSWORTH, G. R. 1990: P09 Rototuna (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**Q09:**
NOBLE, K. E.; HARMSWORTH, G. R. 1990: Q09 Kaipara (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**R09:**
NOBLE, K. E. 1990: R09 Warkworth (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**Q10:**
HARMSWORTH, G. R. 1990: Q10 Helensville (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**R10:**
HARMSWORTH, G. R. 1990: R10 Whangaparaoa (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**Q11:**
HOPE, G. D. 1990: Q11 Waitakere (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

**R11:**
HOPE, G. D. 1990: R11 Auckland (2nd ed.) New Zealand Land Resource Inventory Worksheet, 1:50 000. DSIR Land Resources, Lower Hutt, New Zealand.

# Appendix 8. Aerial photographs used in the compilation of the second-edition 1:50 000 New Zealand Land Resource Inventory worksheets.

| NZMS 260 sheet/NZLRI worksheet | NZMS 260 sheet/NZLRI worksheet name | Date | Photographic scale | Survey no.* |
|---|---|---|---|---|
| M02, N02 | North Cape | 1979, 1980 | 1:25 000 | S.N. 5622 |
| N03 | Houhora | 1979, 1980 | 1:25 000 | S.N. 5622 |
| | | 1984 | 1:25 000 | S.N.C. 8379 |
| | | 1983 | 1:25 000 | S.N.C. 8233 |
| | | 1982 | 1:25 000 | S.N.C. 8098 |
| O03 | Karikari | 1984 | 1:25 000 | S.N. 8329 |
| | | 1981 & 1982 | 1:25 000 | S.N. 5932A |
| N04 | Ahipara | 1981 & 1982 | 1:25 000 | S.N. 5932A |
| O04 | Kaitaia | 1981 & 1982 | 1:25 000 | S.N. 5932A |
| P04/Q04 | Whangaroa | 1981 & 1982 | 1:25 000 | S.N. 5932A |
| N05 | Herekino | 1981 & 1982 | 1:25 000 | S.N. 5932A |
| O05 | Rawene | 1981 & 1982 | 1:25 000 | S.N. 5932A |
| P05 | Kaikohe | 1981 & 1982 | 1:25 000 | S.N. 5932A |
| Q05 | Bay of Islands | 1981 & 1982 | 1:25 000 | S.N. 5932A |
| O06 | Waipoua | 1977, 1979 | 1:25 000 | S.N. 5091 |
| | | 1961 | 1:63 360 | S.N. 1223 |
| | | 1956 | 1 inch:20.2 chains | S.N. 1011 |
| | | 1984 | 1:50 000 | S.N. 8328 |
| P06 | Mangakahia | 1977, 1979 | 1:25 000 | S.N. 5091 |
| | | 1984 | 1:50 000 | S.N. 8328 |
| Q06/R06 | Hukerenui | 1977, 1979 | 1:25 000 | S.N. 5091 |
| | | 1984 | 1:50 000 | S.N. 8328 |
| O07 | Aranga | 1977, 1979 | 1:25 000 | S.N. 5091 |
| | | 1984 | 1:50 000 | S.N. 8328 |
| P07 | Dargaville | 1977, 1979 | 1:25 000 | S.N. 5091 |
| | | 1984 | 1:50 000 | S.N. 8328 |
| Q07/R07 | Whangarei | 1977, 1979 | 1:25 000 | S.N. 5091 |
| | | 1984 | 1:50 000 | S.N. 8328 |
| P08 | Ruawai | 1982, 1983 | 1:25 000 | S.N. 8104 |
| Q08 | Maungaturoto | 1982, 1983 | 1:25 000 | S.N 8104 |
| R08 | Mangawhai | 1982, 1983 | 1:25 000 | S.N. 8104 |
| P09 | Rototuna | 1982, 1983 | 1:25 000 | S.N. 8104 |
| Q09 | Kaipara | 1982, 1983 | 1:25 000 | S.N. 8104 |
| | | 1980 & 1981 | 1:25 000 | S.N. 5783(a) |
| R09 | Warkworth | 1982, 1983 | 1:25 000 | S.N. 8104 |
| Q10 | Helensville | 1980 & 1981 | 1:25 000 | S.N. 5783(a) |
| R10 | Whangaparaoa | 1980 & 1981 | 1:25 000 | S.N. 5783(a) |
| Q11 | Waitakere | 1980 & 1981 | 1:25 000 | S.N. 5783(a) |
| R11 | Auckland | 1980 & 1981 | 1:25 000 | S.N. 5783(a) |

* New Zealand Aerial Mapping Ltd, Hastings.

# Appendix 9. Geological information referred to.

## *Geological Maps*

HAY, R. F. 1975: Sheet N7 – Doubtless Bay Geological map of New Zealand 1:63 360 (1st ed.). Map (1 sheet) and notes (24 p.). Department of Scientific and Industrial Research, Wellington.

HAYWOOD, B. W. 1983: Sheet Q11 – Waitakere. Geological map of New Zealand 1:50 000. Map and notes. Department of Scientific and Industrial Research, Wellington.

KEAR, D.; HAY, R. F. 1961: Sheet 1 – North Cape. Geological map of New Zealand 1:250 000 (1st ed.). Department of Scientific and Industrial Research, Wellington.

SCHOFIELD, J. C. 1967: Sheet 3 – Auckland. Geological map of New Zealand 1:250 000 (1st ed.). Department of Scientific and Industrial Research, Wellington.

SCHOFIELD, J. C. 1989: Sheets Q10 and R10 – Helensville and Whangaparaoa. Geological map of New Zealand 1:50 000. Map (2 sheets and notes. Department of Scientific and Industrial Research, Wellington.

THOMPSON, B. N. 1961: Sheet 2A – Whangarei. Geological map of New Zealand 1:250 000 (1st ed.). Department of Scientific and Industrial Research, Wellington.

## *NZMS 290 Rock Type Maps*

The following NZMS 290 maps were compiled from NZMS1 series 1:63 360 maps.

PETTY, D. R. 1982: North Cape – Houhora. NZMS 290 sheet N02/03, part sheet M02, 1:100 000. New Zealand Land Inventory, rock types. Department of Lands and Survey, Wellington.

PETTY, D. R. 1981: Ahipara – Herekino. NZMS 290 sheet N04/05, 1:100 000. New Zealand Land Inventory, rock types. Department of Lands and Survey, Wellington.

PETTY, D. R. 1982: Kaitaia – Rawene. NZMS 290 sheet O03/04/05, 1:100 000. New Zealand Land Inventory, rock types. Department of Lands and Survey, Wellington.

KERMODE, L. O. 1982: Whangaroa – Kaikohe. NZMS 290 sheet P04/05, 1:100 000. New Zealand Land Inventory, rock types. Department of Lands and Survey, Wellington.

PETTY, D. R. 1982: Bay of Islands. NZMS 290 sheet Q04/05, 1:100 000. New Zealand Land Inventory, rock types. Department of Lands and Survey, Wellington.

KERMODE, L. O. 1981: Waipoua – Aranga. NZMS 290 Sheet O06/07, 1:100 000. New Zealand Land Inventory, rock types. Department of Lands and Survey, Wellington.

MARKHAM, G. S. 1982: Mangakahia – Dargaville. NZMS 290 sheet P06/07, 1:100 000. New Zealand Land Inventory, rock types. Department of Lands and Survey, Wellington.

MARKHAM, G. S. 1981: Hukerenui – Whangarei. NZMS 290 sheet Q06/07, part sheet R06/07, 1:100 000. New Zealand Land Inventory, rock types. Department of Lands and Survey, Wellington.

KERMODE, L. O. 1981: Ruawai – Rototuna. NZMS 290 sheet P08/09, 1:100 000. New Zealand Land Inventory, rock types. Department of Lands and Survey, Wellington.

MARKHAM, G. S.; CRIPPEN, T. F. 1981: Maungaturoto – Kaipara. NZMS 290 sheet Q08/09, 1:100 000. New Zealand Land Inventory, rock types. Department of Lands and Survey, Wellington.

MARKHAM, G. S.; CRIPPEN, T. F. 1981: Mangawhai – Warkworth. NZMS 290 sheet R08/09, 1:100 000. New Zealand Land Inventory, rock types. Department of Lands and Survey, Wellington.

KERMODE, L. O. 1988: Helensville – Waitakere. NZMS 290 sheet Q10/11, 1:100 000. New Zealand Land Inventory, rock types. Department of Lands and Survey, Wellington.

# Appendix 10. Soil surveys used.

Cox, J. E. et al. 1978: compiled. The soil survey of Northland. Sutherland, C. F.; N. H. Taylor, N. H.; Wright A. C. S. 1937–1951. New Zealand Soil Bureau, Department of Scientific and Industrial Research, Wellington.

Cox, J. E.; Wilson, A. D. 1976: The soil surveys of Helensville, Waitakere area and Whangaparaoa–Auckland area. New Zealand Soil Bureau, Department of Scientific and Industrial Research.

The following NZMS 290 maps were compiled from NZMS 1:63 360 maps.

Cox, J. E.; Taylor, N. H.; Sutherland, C. F.; Wright, A. C. S. 1983: Northland Peninsula soil legend. New Zealand Soil Bureau, Department of Scientific and Industrial Research, Lower Hutt.

Sutherland, C. F.; Cox, J. E.; Taylor, N. H.; Wright, A. C. S. 1979: Soil map of North Cape–Houhora area. NZMS 290 sheet M02, N02/03, North Island, New Zealand, 1:100 000. New Zealand Soil Bureau map 180.

Sutherland, C. F.; Cox, J. E.; Taylor, N. H.; Wright, A. C. S. 1979: Soil map of Ahipara–Herekino area. NZMS 290 sheet N04/05, North Island, New Zealand, 1:100 000. New Zealand Soil Bureau map 181.

Sutherland, C. F.; Cox, J. E.; Taylor, N. H.; Wright, A. C. S. 1979: Soil map of Kaitaia–Rawene area. NZMS 290 sheet O03/04/05, North Island, New Zealand, 1:100 000. New Zealand Soil Bureau map 182.

Sutherland, C. F.; Cox, J. E.; Taylor, N. H.; Wright, A. C. S. 1980: Soil map of Whangaroa–Kaikohe area. NZMS 290 sheet P04/05, North Island, New Zealand, 1:100 000. New Zealand Soil Bureau map 183.

Sutherland, C. F.; Cox, J. E.; Taylor, N. H.; Wright, A. C. S. 1980: Soil map of Bay of Islands area. NZMS 290 sheet Q04/05, North Island, New Zealand, 1:100 000. New Zealand Soil Bureau map 184.

Sutherland, C. F.; Cox, J. E.; Taylor, N. H.; Wright, A. C. S. 1980: Soil map of Waipoua–Aranga area. NZMS 290 sheet O06/07, North Island, New Zealand, 1:100 000. New Zealand Soil Bureau map 185.

Sutherland, C. F.; Cox, J. E.; Taylor, N. H.; Wright, A. C. S. 1980: Soil map of Mangakahia–Dargaville area. NZMS 290 sheet P06/07, North Island, New Zealand, 1:100 000. New Zealand Soil Bureau map 186.

Sutherland, C. F.; Cox, J. E.; Taylor, N. H.; Wright, A. C. S. 1981: Soil map of Hukerenui–Whangarei area. NZMS 290 sheet Q06/07, R06/07, North Island, New Zealand, 1:100 000. New Zealand Soil Bureau map 187.

Sutherland, C. F.; Cox, J. E.; Taylor, N. H.; Wright, A. C. S. 1980: Soil map of Ruawai–Rototuna area. NZMS 290 sheet P08/09, North Island, New Zealand, 1:100 000. New Zealand Soil Bureau map 188.

Sutherland, C. F.; Cox, J. E.; Taylor, N. H.; Wright, A. C. S. 1981: Soil map of Maungaturoto–Kaipara area. NZMS 290 sheet Q08/09, North Island, New Zealand, 1:100 000. New Zealand Soil Bureau map 189.

Sutherland, C. F.; Cox, J. E.; Taylor, N. H.; Wright, A. C. S. 1980: Soil map of Mangawhai–Warkworth area. NZMS 290 sheet R08/09, North Island, New Zealand, 1:100 000. New Zealand Soil Bureau map 190.

Sutherland, C. F.; Wilson, A. D.; Cox, J. E.; Taylor, N. H.; Wright, A. C. S. 1985: Soil map of part Helensville–Waitakere area. NZMS 290 sheet Q10/11, North Island, New Zealand, 1:100 000. New Zealand Soil Bureau map 220.

Sutherland, C. F.; Wilson, A. D.; Cox, J. E.; Taylor, N. H.; Wright, A. C. S. 1985: Soil map of part Whangaparaoa–Auckland area. NZMS 290 sheet R10/11, North Island, New Zealand, 1:100 000. New Zealand Soil Bureau map 221.

# Appendix 11. Published vegetation maps referred to.

MITCHELL, N. D.; PARK, G. N. 1983: Indigenous forest map of North Cape–Houhora area, 1:100 000. NZMS 290 sheet M02, N02/03.

MITCHELL, N. D.; PARK, G. N. 1983: Indigenous forest map of Kaitaia–Rawene area, 1:100 000. NZMS 290 sheet O03/04/05.

MITCHELL, N. D.; PARK, G. N. 1983: Indigenous forest map of Ahipara–Herekino area, 1:100 000. NZMS 290 sheet N04/05.

MITCHELL, N. D.; PARK, G. N. 1983: Indigenous forest map of Whangaroa–Kaikohe area, 1:100 000. NZMS 290 sheet P04/05.

MITCHELL, N. D.; PARK, G. N. 1983: Indigenous forest map of Whangaroa–Bay of Islands area, 1:100 000. NZMS 290 sheet Q04/05.

MITCHELL, N. D.; PARK, G. N. 1983: Indigenous forest map of Waipoua–Aranga area, 1:100 000. NZMS 290 sheet O06/07.

MITCHELL, N. D.; PARK, G. N. 1983: Indigenous forest map of Mangakahia–Dargaville area, 1:100 000. NZMS 290 sheet P06/07.

MITCHELL, N. D.; PARK, G. N. 1983: Indigenous forest map of Hukerenui–Whangarei area, 1:100 000. NZMS 290 sheet Q06/07 and R06/07.

MITCHELL, N. D.; PARK, G. N. 1983: Indigenous forest map of Ruawai–Rototuna area, 1:100 000. NZMS 290 sheet P08/09.

MITCHELL, N. D.; PARK, G. N. 1983: Indigenous forest maps of Maungaturoto–Kaipara area, 1:100 000. NZMS 290 sheet Q08/09.

MITCHELL, N. D.; PARK, G. N. 1983: Indigenous forest maps of Mangawhai–Warkworth area, 1:100 000. NZMS 290 sheet R08/09.

# Appendix 12. NZLRI rock type classification.

## A. Igneous rocks

### (i) extremely weak to very weak igneous rocks

| | |
|---|---|
| Ng | Ngauruhoe tephra |
| Rm | Rotomahana mud |
| Ta | Tarawera tephra |
| Sc | Scoria |
| Lp | Pumiceous lapilli |
| Kt | Kaharoa and Taupo ashes |
| Tp | Taupo and Kaharoa breccia and pumiceous alluvium |
| Mo | Ashes older than Taupo ash |
| Ft | Quaternary breccias older than Taupo breccia |
| La | Lahar deposits |
| Vu | Extremely weak altered volcanics |

### (ii) weak to extremely strong igneous rocks

| | |
|---|---|
| Vo | Lavas and welded ignimbrites |
| Tb | Indurated fine-grained pyroclastics |
| Vb | Indurated volcanic breccias |
| In | Ancient volcanics |
| Gn | Plutonics |
| Um | Ultramafics |

## B. Sedimentary rocks

### (i) very loose to compact (very soft to stiff) sedimentary rocks

| | |
|---|---|
| Pt | Peat |
| Lo | Loess |
| Wb | Windblown sand |
| Af | Fine alluvium |
| Gr | Alluvial gravels |
| Cl | Coarse slope deposits |
| Gl | Glacial till |
| Uf | Unconsolidated clays and silts |
| Us | Unconsolidated sands and gravels |

### (ii) very compact (very stiff) to weak sedimentary rocks

| | |
|---|---|
| Mm | Massive mudstone |
| Mb | Bedded mudstone |
| Mf | Frittered mudstone |
| Me | Bentonitic mudstone |
| Sm | Massive sandstone |
| Sb | Bedded sandstone |
| Cw | Weakly consolidated conglomerate |
| Mx | Sheared mixed lithologies |
| Ac | Crushed argillite association of rocks |

### (iii) moderately strong to extremely strong sedimentary rocks

| | |
|---|---|
| Ar | Argillite |
| Si | Indurated sandstone |
| Cg | Conglomerate and breccia |
| Gw | Greywacke association of rocks |
| Li | Limestone |

*Appendix 12. (continued)*

**C. Metamorphic rocks**

| | |
|---|---|
| Sx | Semi-schist |
| Sy | Schist |
| Gs | Gneiss |
| Ma | Marble |

**D. Perennial ice and snow**

| | |
|---|---|
| I | Perennial ice and snow |

***Prefixes***

p denotes that the rock type is present only in patches, or of localised significance, e.g. In + pSm, ancient volcanics and patches of massive sandstone. Another example may include the symbol '/' (see below), e.g. pAf/Mx, patchy fine alluvium overlying sheared mixed lithologies.

w denotes a significant degree and depth of weathering such that the rock's physical characteristics are significantly different from its unweathered characteristics, e.g. wGw, weathered greywacke.

pw denotes patchy, and weathered, e.g. wGw + pwSm, weathered greywacke and patches of weathered massive sandstone.

***Combining symbols***

/ denotes stratigraphic sequence with the surface rock type first, e.g. Mo/Vo ashes older than Taupo ash cover over volcanic lavas. A maximum of two '/'s may be used in any one code.

+ denotes that there are two or more rock types present and the first one is dominant, e.g. Af+Pt, Fine alluvium and Peat. A maximum of two '+'s may be used in any one code.

* used in conjunction with '/', indicates that both rock types joined together are both overlain by the preceding rock type, e.g. Uf/Mb * Sb, unconsolidated clays and silts overlying both bedded mudstone and bedded sandstone. (This contrasts with Uf/Mb + Sb where the unconsolidated clays and silts overlie Mb only.)

For a complete description of the rock types used, refer to Lynn and Crippen (1991).

# Appendix 13. NZLRI slope classification.

| Slope groups | Slope angle (°) | Relief |
|---|---|---|
| A | 0–3 | Flat to gently undulating |
| B | 4–7 | Undulating |
| C | 8–15 | Rolling |
| D | 16–20 | Strongly rolling |
| E | 21–25 | Moderately steep |
| F | 26–35 | Steep |
| G | >35 | Very steep |

*Additional symbols:*
/ Average or compound slope between two slope groups, e.g. A/B
+ Complex slopes, first slope group is dominant, e.g. A+B
′ Dissected slopes, e.g. A′

The slope classification is described in the Land Use Capability Survey Handbook (Soil Conservation and Rivers Control Council 1971).

# Appendix 14. NZLRI erosion type and severity classification.

| Erosion type | | | Basis for recording |
|---|---|---|---|
| Surface erosion | | | |
| Sh | – | sheet | recorded on an areal basis |
| W | – | wind | |
| Sc | – | scree | |
| Mass movement erosion | | | recorded on a seriousness basis (a combination of rate and depth of movement, frequency of erosion events, feasibility and cost of control, economic effect, etc.). |
| Ss | – | soil slip | |
| Es | – | earth slip | |
| Su | – | slump | |
| Da | – | debris avalanche | |
| Ef | – | earthflow | |
| Fluvial erosion | | | |
| R | – | rill | |
| G | – | gully | |
| T | – | tunnel gully | |
| Sb | – | streambank | |
| D | – | deposition | |

| Ranking | | Seriousness: mass movement and fluvial erosion | Area: surficial erosion Sh, W, Sc (percentage bare ground) |
|---|---|---|---|
| 0 | – | negligible | <1 |
| 1 | – | slight | 1–10 |
| 2 | – | moderate | 11–20 |
| 3 | – | severe | 21–40 |
| 4 | – | very severe | 41–60 |
| 5 | – | extreme | >60 |

For a complete description of the NZLRI erosion classification, refer to Eyles (1985).

# Appendix 15. NZLRI vegetation classification.

The second-edition NZLRI vegetation classification (Page 1987) supercedes the vegetation classification (Hunter and Blaschke 1986) used in the first-edition 1:63 360 NZLRI worksheets.

Symbols have been changed, some of the classes have been subdivided or combined, and more detailed assessments of vegetation distribution have been incorporated.

A full description of the second-edition vegetation classification is given by Page (1987) and described in 'Physical resource classifications used for the Northland region.' *Department of Scientific and Industrial Research technical record 4.* (Harmsworth 1990).

| | | Previous classification |
|---|---|---|
| **Grass** | | |
| gI | Improved pasture | $P_1$ |
| gS | Semi improved pasture | $P_2$ |
| gU | Unimproved pasture | $P_2$ |
| gT | Short tussock grassland | $P_3$ |
| gW | Snow tussock grassland | $P_4$ |
| gR | Red tussock grassland | $P_5$ |
| gD | Sand dune vegetation | $P_6$ |
| **Crops** | | |
| cC | Wheat, oats, barley, etc. | $L_1$ |
| cM | Maize | $L_1$ |
| cP | Pip and stone fruit | $L_2$ |
| cG | Grapes and berry fruit | $L_2$ |
| cK | Kiwifruit | $L_2$ |
| cS | Subtropical fruit | $L_2$ |
| cR | Root and green fodder crops | $L_3$ |
| cV | Vegetables, nurseries | $L_4$ |
| **Scrub** | | |
| sM | Manuka, kanuka | $M_1$ |
| sC | *Cassinia* | $M_2$ |
| sD | *Dracophyllum* | $M_3$ |
| sF | Fern | $M_4$ |
| sS | Subalpine scrub | $M_5$ |
| sX | Mixed indigenous scrub | $M_{6a}$ |
| sT | Mixed indigenous scrub with tree ferns | $M_{6b}$ |
| sB | Broom | $M_7$ |
| sG | Gorse | $M_8$ |
| sK | Blackberry | $M_9$ |
| sW | Sweet brier | $M_{10}$ |
| sA | Matagouri | $M_{11}$ |
| sV | Mangrove | $M_{12}$ |
| sL | Lupin | $M_{14}$ |
| sH | Heath | $M_{15}$ |
| sO | Coastal scrub | $M_{16}$ |
| sE | Exotic scrub | $M_{17}$ |

*Appendix 15. (continued)*

| | | Previous classification |
|---|---|---|
| **Forest** | | |
| fC | Coastal forest | $N_1$ |
| fK | Kauri forest | $N_2$ |
| fP | Podocarp forest | $N_7$ |
| fB | Broadleaved forest | $N_5$ |
| fO | Lowland podocarp–broadleaved forest | $N_{3a}$ |
| fI | Highland podocarp–broadleaved forest | $N_{3b}$ |
| fD | Podocarp–broadleaved–beech forest | $N_{3c}$ |
| fW | Lowland beech forest | $N_{4a}$ |
| fG | Highland beech forest | $N_{4b}$ |
| fU | Beech forest, undifferentiated | $N_4$ |
| fF | Exotic conifer forest | $N_{6a}$ |
| fR | Exotic broadleaved forest | $N_{6b}$ |
| **Herbaceous** | | |
| hW | Wetland vegetation | $H_1$ |
| hR | Rushes, sedges | $H_2$ |
| hA | Alpine and subalpine herbfield/fellfield vegetation | $H_4$ |
| hS | Saline vegetation | $H_5$ |
| hP | Pakihi vegetation | $H_6$ |
| hM | Semi-arid herbaceous vegetation | $H_7$ |
| **Unvegetated** | | |
| uV | Unvegetated land | – |
| **Other Symbols** | | |
| *Placed before class:* | | |
| c | cutover | c |
| s | stunted | s |
| e | erosion control trees | – |
| n | naturalised exotic trees | – |
| *Placed after class:* | | |
| * | scattered (suffix) | |

The distribution of vegetation classes (e.g. sM, fO) *within inventory map units* is recorded as either 'clumped' or 'scattered'. Scattered vegetation classes are denoted by the use of an asterisk after the class symbol, e.g. sM*. There is no percentage of vegetative cover given for scattered vegetation.

Vegetation classes without an asterisk are 'clumped', e.g. gIsM, and are recorded to the nearest 10%. Therefore gIsM may be recorded as $gI_7sM_3$, where gI (improved pasture) is 70% and sM (manuka scrub) 30%.

Where the vegetation is scattered, the vegetation class will be scattered throughout the clumped vegetation class immediately preceding it in the vegetation code:

gIsM* – improved pasture with scattered manuka, or

gIsM*sG* – improved pasture with scattered manuka and scattered gorse,

and gIsM* and gIsM*SG* would be recorded as 100%.

Stunted vegetation is represented by the

symbol 's' before the class symbol; for example, stunted exotic conifer forest in coastal buffer zones would be recorded as sfF.

Erosion control trees are represented by the symbol 'e' before the class symbol; for example, exotic broadleaved trees, such as those planted for erosion control, scattered through the pasture, would be recorded as glefR*.

Naturalised exotic conifer trees are represented by the symbol 'n' before the class symbol; for example, naturalised exotic trees scattered through pasture would be recorded as glnfF*. This would describe a number of exotic conifers usually self-seeded and growing wild, usually without any form of silvicultural management, with trees representing a range of ages.