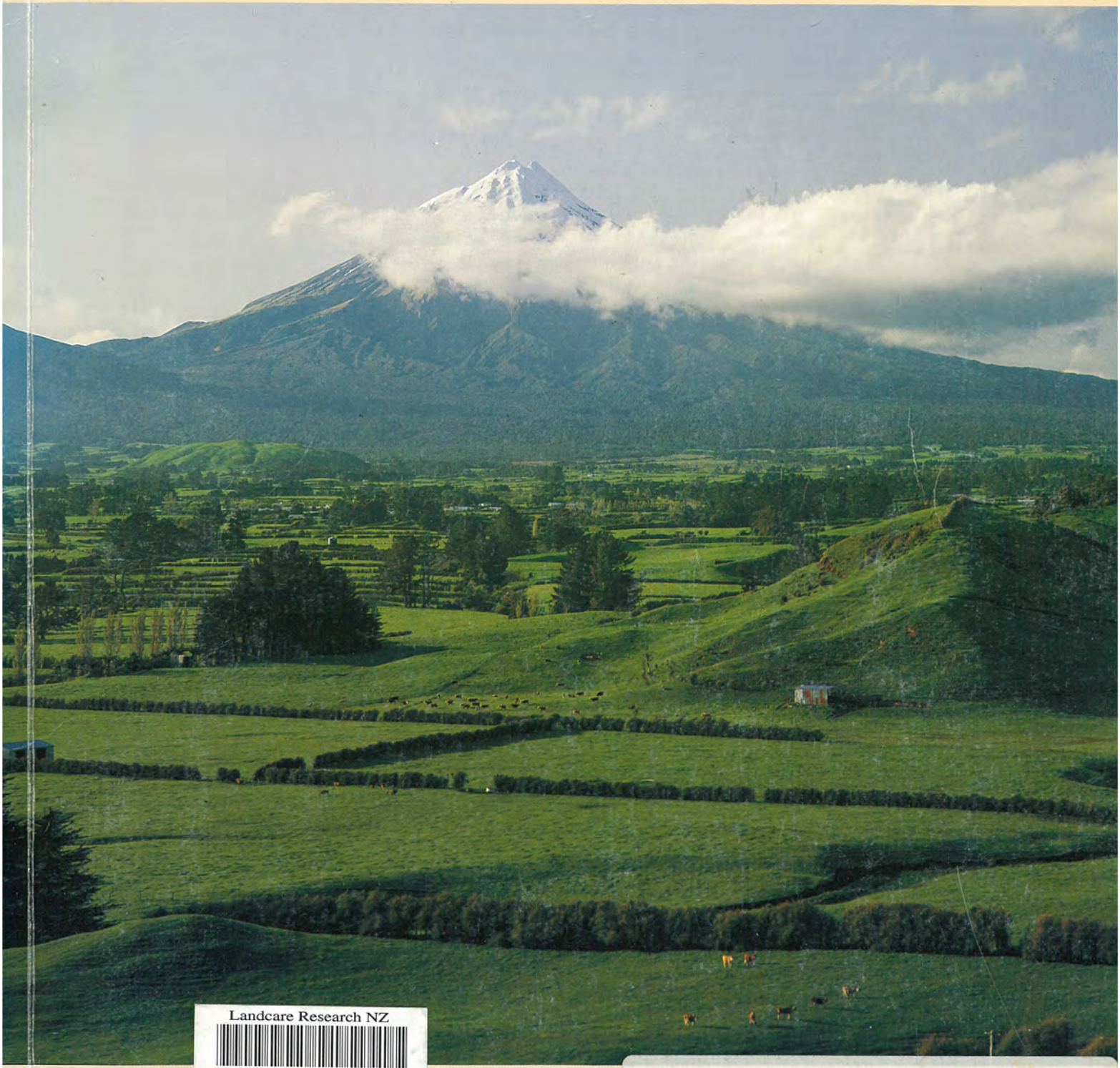
WATER & SOIL MISCELLANEOUS PUBLICATION NUMBER 110

Land Use Capability Classification of the Taranaki-Manawatu Region



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Land Use Capability Classification of the Taranaki-Manawatu Region: a bulletin to accompany the New Zealand Land Resource Inventory Worksheets

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This bulletin describes the land use capability classification of the Taranaki-Manawatu region, an area of 24 000 km² in the south-west of the North Island, New Zealand. This region is one of eleven mapped during the New Zealand Land Resource Inventory (NZLRI) survey by the Water and Soil Directorate of the Ministry of Works and Development for the National Water and Soil Conservation Authority. The NZLRI provides a physical land resources inventory and a land use capability (LUC) assessment at a scale of 1:63,360 (1 inch to 1 mile). This bulletin is intended for users of this data.

The 13 700 map units recognised in the region were grouped into 150 LUC units: these were arranged into 26 groups of related LUC units (known as LUC suites or subsuites).

The bulletin provides a detailed description of each LUC suite and subsuite, covering its climate, physiography, rock types, soils, erosion, vegetation, agricultural and forestry productivity, and land use and management. LUC units within each LUC suite and subsuite are also described and illustrated by photographs.

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CONTENTS

INTRODUCTION

This publication is one of a series accompanying the New Zealand Land Resource Inventory (NZLRI). The NZLRI provides a unified coverage of physical land resource information for New Zealand, for the purposes of land resource and land use planning. The information is published as a series of Land Resource Inventory Worksheets at a scale of 1:63,360 (1 inch to 1 mile), (NWASCO 1975–79), together with supporting documents. It is also available as a computer data base using the retrieval program LADEDA (van Berkel & Eyles 1981). The survey has been prepared on behalf of the National Water and Soil Conservation Authority by the Land Resources Group from the Water and Soil Directorate of the Ministry of Works and Development, based at NWASCA research centres in Palmerston North and Christchurch.

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

1) An inventory of five physical factors (rock, soil, slope, erosion, and vegetation) which are basic to the assessment of land resources.

2) An evaluation of the long-term potential for sustained agricultural production, in the form of land use capability (LUC) assessment. Further information on the methods of mapping and assessment, interpretation and application of the NZLRI are found in the Land Use Capability Survey Handbook (Soil Conservation and Rivers Control Council 1969) and in NWASCO (1979).

For the NZLRI the North Island was divided into ten regions (Figure 1), each with its own land use capability classification. Accompanying the Land Resource Inventory Worksheets for each region is an extended legend to the land use capability units of that region. A correlation of land use capability units in all ten North Island NZLRI regions has recently been prepared (Page 1985) (Appendix 4).

The Taranaki-Manawatu region (Figure 2) is one of ten North Island NZLRI regions. Preparation of NZLRI worksheets in this region began in 1978, incorporating previous work that had been carried out in the King Country and Ruahine Ranges in 1976. All worksheets for the region were published by 1979.

Twelve scientists participated in the preparation of worksheets in the region. Figure 1 shows the boundaries and numbers of worksheets, while Appendix 3 lists the worksheets, their authors, dates of field work and date of publication. Field checking and correlation of all worksheets in the region was carried out by J R Fletcher, M J Page, and G O Eyles. The regional LUC classification and extended legend was prepared by J R Fletcher.

The principal aim of this publication is to explain the basis of the land use capability classification adopted for this region and to describe the land use capability units delineated. It supplements the extended legend for the region (Fletcher 1981) which summarises much of the resource information for each land use capability unit. It places more emphasis on explaining relationships between different land use capability units, and special features of the classification which could not be easily summarised in the extended legend format. To show the relationship between land use capability units, the concept of groups of related units (called LUC suites) has proved to be very useful and has been given special emphasis in this publication.

The main part of the publication is a detailed description of each land use capability suite and its constituent land use capability units, dealing with physical factors, land use, and land use capability. This is preceded by a description of the region and a summary of its physical resource factors as they relate to the NZLRI. This is not intended to be an exhaustive resource document, although it does aim to refer the interested user to some of the more detailed literature available relating to land resources of the region.

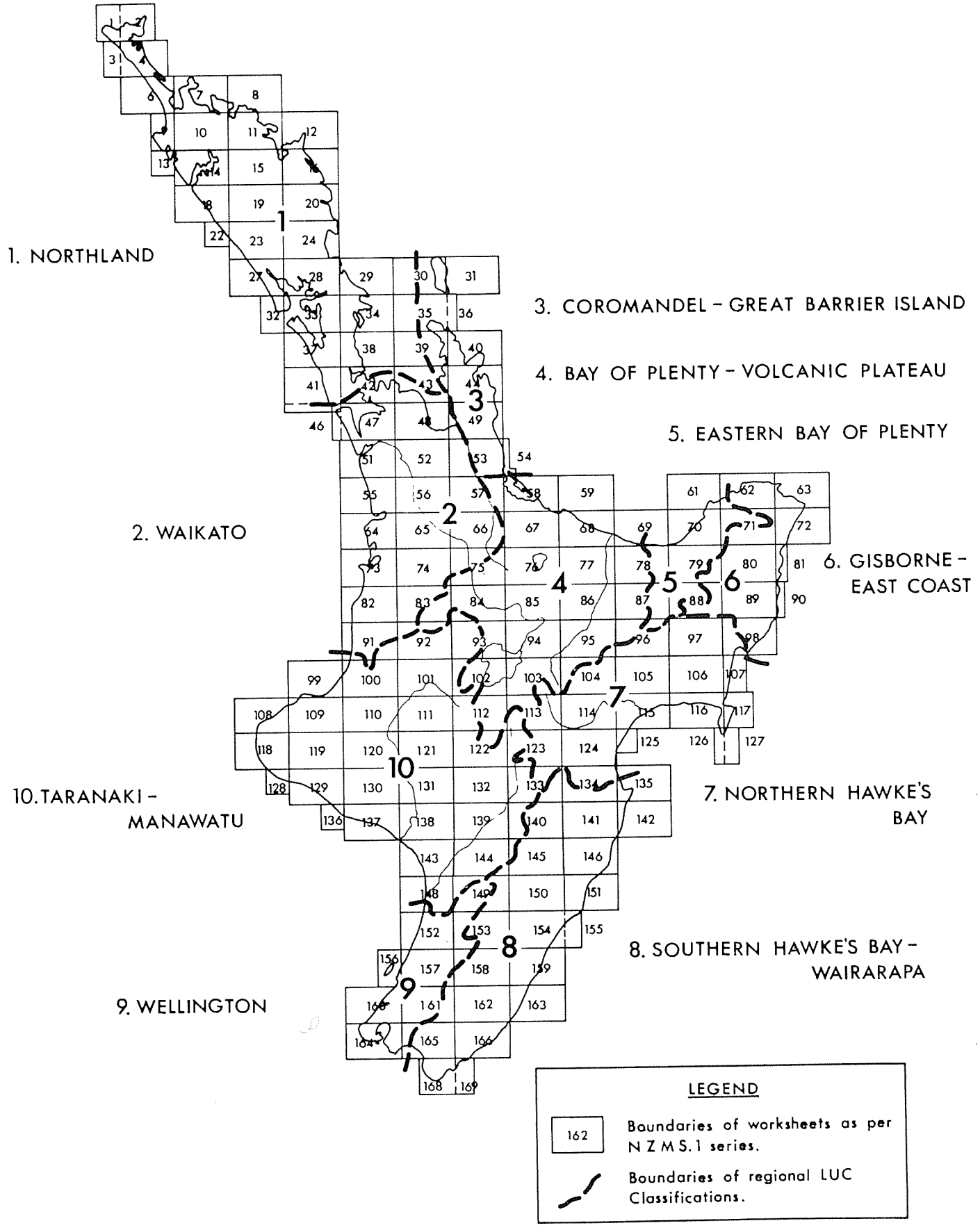


Figure 1: North Island NZLRI Regions.

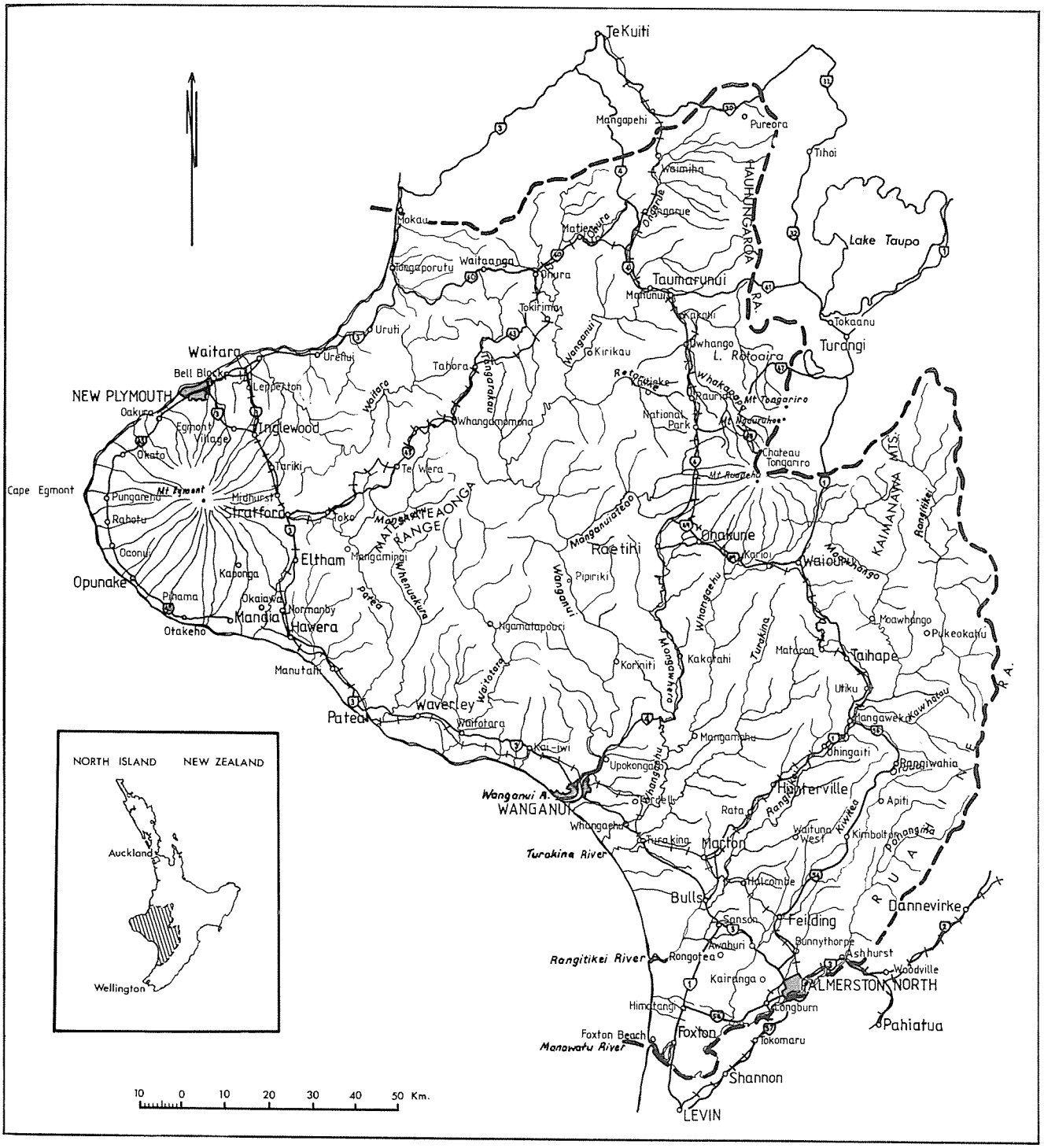


Figure 2: Location and main physical features of the Taranaki-Manawatu Region. Regional boundary is shown as heavy dashed line.

DESCRIPTION OF THE TARANAKI-MANAWATU REGION

Location and Boundaries

The Taranaki-Manawatu region, as delineated in the NZLRI, has an area of 24,010 km^2 and is located in the south-west of the North Island (Figure 1). The region includes virtually all but the northern margin of Taranaki Province and includes the Wanganui, Manawatu, Rangitikei and Waimarino districts of Wellington Province and the southern 'King Country' portion of Auckland Province.

The region is defined mainly by catchment boundaries. In the north the boundary runs from the north Taranaki coast along the northern boundary of the Mohakatino and Wanganui catchments. From there it runs south and east along the divide that separates the Wanganui, Whangaehu and Rangitikei Catchments from the Waikato catchment (including the Lake Taupo Catchment). The boundary then runs south along the eastern boundary of the Rangitikei catchment and the summit of the Ruahine Range to the Manawatu Gorge. The regional boundary then follows the course of the Manawatu River to the coast at Foxton.

Physical Features

The main physical features of the region are shown in Figure 2. A series of mountain ranges and mountains form the eastern margin of the region. These comprise the Hauhungaroa Range in the north-east, the volcanoes of the Tongariro National Park, the Kaimanawa Range, and the Ruahine Range in the south-east. Mt Egmont* is the dominant feature in the west of the region. Land within the region rises from sea level to an altitude of 2797 m on Mt Ruapehu. The Kaimanawa and Ruahine ranges have crests that are generally between 1100–1700 m while the crest of the Hauhungaroa Range is mainly at about 900 m but rises to 1165 m in the north. The Matemateonga Range, which extends from central Taranaki east to the Wanganui River, rises to about 700 m and is the most elevated area in the Taranaki-Wanganui hinterland.

River systems are a prominent feature of the region. There are eight major rivers that are longer than 100 km (the Wanganui, Rangitikei, Manawatu, Patea, Turakina, Whangaehu, Waitotara and Waitara). Of these the Wanganui River (290 km) and Rangitikei (241 km) are the 3rd and 5th longest respectively in New Zealand. With the exception of the Waitara River (which flows into the Tasman Sea in the North Taranaki Bight) all rivers enter the Tasman Sea on the 140 km of coastline between Patea and Foxton.

Physiography

Within the Taranaki-Manawatu region nine major physiographic zones can be recognised (Figure 3).

1. Hill country: This extensive physiographic unit covers some two thirds of the region. It is deeply dissected with narrow ridge crests and mainly moderately steep to steep slopes. Streams and rivers are deeply incised and have narrow flood plains. Small areas of rolling land occur particularly on the margins of the unit, and in the north on what is considered to be the remnant of a former peneplain. To the north-east this physiographic unit extends into a lower altitude basin in the King Country where interfluves in the north-east may be capped with ignimbrite sheets that are now dissected to give escarpments with characteristic flat tops.

2. Mountainlands: This comprises the Kaimanawa and Ruahine mountain ranges on the eastern margin of the region. The mountains are of greywacke rock. They are very steep and rugged and generally occur between 1300 and 1700 m a.s.l. The climate is severe with high annual rainfall (1500–5000 mm p.a.) and cold winter temperatures.

*The Geographic Board ruled in 1986 that the names Mt Egmont or Mt Taranaki can be used for the mountain peak dominating the Taranaki landscape.

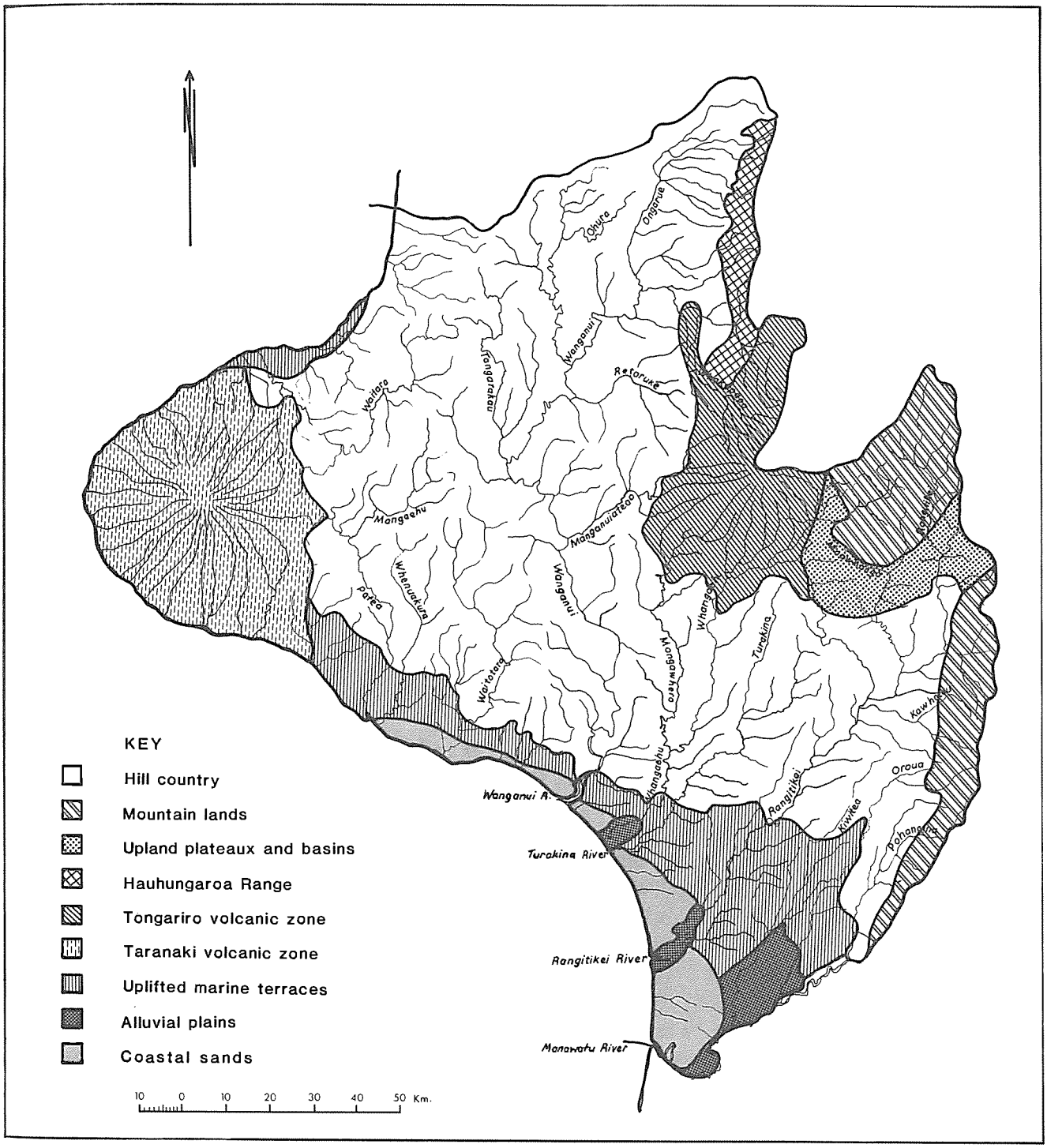


Figure 3: Major physiographic zones in the Taranaki-Manawatu Region.

3. Upland plateaux and basins: This zone occurs between the Kaimanawa and Ruahine Ranges and extends north-west to the Tongariro volcanic zone. It occurs at about 1000 m a.s.l. and comprises plateaux, basins and associated hill country underlain by greywacke and Tertiary aged rock and mantled with deep tephra.

4. Hauhungaroa Range: The Hauhungaroa Range forms the north-east boundary of the region. It consists of greywacke of the Mesozoic era, with Tertiary aged sandstones and siltstones in the south. Altitude ranges between 800 and 1100 m resulting in a cooler climate than the adjacent hill country.

5. Tongariro Volcanic Zone: This comprises the andesite volcanoes of Mts Ruapehu (2797 m), Ngauruhoe (2291 m) and Tongariro (1968 m) and their volcanic ring plains.

6. Taranaki Volcanic Zone: Occurs in the west of the region and consists of the andesite cones of Mt Egmont (2518 m) and the older Pouakai and Kaitake cones together with their ring plains.

7. Uplifted marine terraces: Extend from North Taranaki south along the coast and inland to Marton and Palmerston North. The most extensive of these are the Rapanui and Brunswick terraces which slope gently seaward and are separated by old coastal cliffs.

8. Alluvial Plains: These occur in the Manawatu. Extensive areas of alluvial deposition have accumulated from the Manawatu, Oroua and Pohangina rivers draining the hinterland. The topography is flat with an elevation of <15 m.

9. Coastal sands: Comprises a complex of dunes, sand plains and swamps which extend continuously from near Hawera to the Manawatu River. It is most extensive south of Wanganui (extending to 19 km inland), where the coast is actively prograding.

Cultural Features

The main settlements in the region are shown in Figure 2. The largest urban areas (1984 estimates) are Palmerston North (69,100), Wanganui (39,700) and New Plymouth (45,800). Other important centres are Feilding (12,700), Hawera (11,400), Taumarunui (6630), Waitara (6420), Stratford (5570), and Marton (4830). Inglewood, Eltham, Patea, Opunake, Manaia, Waverley, Ohakune, Raetihi, Waiouru, Taihape, Bulls and Foxton are smaller towns with populations greater than 1000.

The North Island Main Trunk Railway runs through the region via Palmerston North, Marton, Waiouru, Ohakune and Taumarunui. A branch line which runs from Marton via Wanganui and Stratford to New Plymouth, is also connected to the Main Trunk railway by a rail link from Stratford to Taumarunui. A fourth railway line runs from Palmerston North by way of the Manawatu Gorge to Hawke's Bay and Gisborne.

Three major highways traverse the region: SH1 from Foxton through Bulls and Waiouru to Turangi; SH3 from Mokau through New Plymouth, Hawera, Palmerston North and Woodville; and SH4 from Te Kuiti to Wanganui via Taumarunui and Raetihi. Intensively farmed areas have a dense network of mainly sealed roads. Roads are sparse and expensive to maintain in hill country because of the steep terrain and lack of suitable roading aggregate.

Administratively the region covers 21 counties and districts grouped into five Regional or United Councils: Taranaki, Wanganui, Manawatu, Tongariro and Waitomo. For water and soil conservation purposes four catchment authorities operate within the region: the Waikato Valley Authority (headquarters at Hamilton with an office at Taupo), Taranaki Catchment Commission (headquarters at Stratford), Rangitikei-Wanganui Catchment Board (headquarters at Marton with offices at Wanganui, Taihape and Taumarunui, and the Manawatu Catchment Board (headquarters at Palmerston North).

History of Land Settlement

Organised European settlement in the region began in 1841 with the establishment of settlements at New Plymouth and Wanganui. Settlement progressed slowly along the coastal lowlands adjacent to these centres but it was not until after the Land Wars that population

expansion occurred on a large scale. In 1850 farming commenced in the lower Rangitikei between the Turakina and Rangitikei Rivers.

In the 1880s the railway between New Plymouth, Palmerston North and Wellington was completed which gave considerable impetus to farming along the rail route. Because of the small size of holdings dairying was the most attractive type of farming on most arable land, with wheat also grown in the drier Wanganui and Rangitikei areas. The first cooperative dairy factories opened in 1885 in Taranaki, and their number increased to 46 in 1891 and to 116 by 1896. In 1900 the Taranaki landscape (and indeed much of the landscape in the region) "revealed leafless, branchless, half burnt tree trunks left standing after the bush fires, at the foot of them the bric-a-brac of fallen branches and trunks, over which newly sown grasses were growing" (McLintock 1966).

Settlement of the interior proceeded slowly until the construction of the North Island Main Trunk railway line. The railway reached Taumarunui in 1903 and Taihape in 1904 but it was not until 1909 that the two lines were joined at Pokaka, north of Raetihi. Most of the forests were simply felled and burned to enable pastoral farming. In some areas that were settled later, improvements in transport encouraged sawmilling. This industry was particularly important in the Waimarino and King Country until the 1940s.

Forest clearance in steep hill country received another boost after World War I when returned servicemen were encouraged to take up land for farming. In some instances farming was not successful, particularly in remote, high rainfall areas because of reversion, erosion, and low product prices.

After the trees were felled a hot burn was essential to destroy the forest completely and to generate sufficient heat to destroy seed and fern spores (Levy 1970). However, because of the wet conditions a hot white ash burn was rarely secured. The result was that within 6–8 weeks of the burn plants such as fern and secondary growth shrubs were competing with newly sown grasses. This reversion was encouraged by the practice of set stocking with sheep. Much of the regrowth could have been controlled with cattle but financial constraints usually precluded their use.

In 1925 a government-appointed committee to investigate deteriorated Crown Lands in the King Country, Taranaki and Wanganui regions, estimated that of the 874,700 areas of Crown holdings (not all of which would have been developed for farming), 232,500 acres had reverted to second growth after being felled and grassed, and that 4.9% of the area in Crown holdings had been abandoned by settlers (Bullard *et al.* 1925). Most of this reverted land would have been on high rainfall LUC units.

Development of land on lower rainfall units was more successful. Because of the lower rainfall, excellent burns were obtained and grass established more readily. Secondary growth was not as vigorous and was readily controlled by secondary growth burns. The high cost of maintaining road access was the determining factor leading to the abandonment of farming in the Mangaparua, Mangatiti and Aotuhia districts. At Mangaparua major storms in 1931, 1933, 1935, 1936, 1939, 1940 and 1942 caused considerable erosion. Despite heavy reliance on unemployed labour, Government expenditure on the Mangaparua Road totalled $298,436 between 1921 and when the settlement was abandoned in 1942 (Bates 1981).

Present Land Use

Pastoral farming is the most important land use. The region covers 9% of New Zealand but carries 20% of the nation's dairy cattle, 16% of the beef cattle and 13.5% of the sheep.

Dairying remains the dominant land use on the Taranaki volcanic ring plain and is also very important in the Manawatu. The number of dairy farms in the King Country and Waimarino has reduced significantly and now only supply the local town milk supply market. Throughout the region rationalisation of dairy companies is occurring with large multi-product factories producing a range of products such as butter, cheese, milk powders and casein. A large complex at Longburn serves suppliers in the Manawatu and lower Rangitikei

areas, while in Taranaki dairy factory amalgamations have resulted in only three major dairy companies.

Sheep and cattle are fattened on arable land and easier hill country throughout the region while store stock are carried on the steep hill country. Present farming practice in hill country is directed toward more intensive use of subdivision fencing, regular fertiliser use and rotational grazing to improve soil fertility and pasture species composition. High cattle to sheep ratios and goats are utilised, particularly in high rainfall areas, to prevent reversion of pasture to fern and scrub.

There are freezing works within the region at Taumarunui, Waitara, Wanganui, Feilding and Longburn. Fertiliser works are situated at New Plymouth and Wanganui.

Cash cropping is concentrated mainly in the Manawatu, Wanganui and Marton areas. The main crops are barley, wheat, oats, maize, peas and grass seed. Interest in these crops has increased in recent years in response to a need for stock feed grains and to supply a malting factory at Marton. In the 1982/83 season the region produced 54,000 tonnes of barley and 25,000 tonnes of wheat which was 15.5% and 8.0% respectively of New Zealand's total production. Potatoes are grown in the Manawatu, with seed potatoes at higher altitudes such as the Kimbolton and Apiti districts. Potatoes for processing are grown near Rata and Marton.

Market gardening is well established in the Ohakune-Raetihi area where over 700 ha is in vegetable production. The main crops produced are carrots, parsnips, cabbages, cauliflowers, brussel sprouts, swedes and potatoes. Market gardening is also carried out adjacent to Palmerston North and to a lesser extent near New Plymouth, Wanganui and Hawera. A wide range of subtropical fruit, citrus fruit and ornamentals are grown in the New Plymouth area and kiwifruit is proving to be a successful crop particularly near New Plymouth and Wanganui. 200 ha of asparagus was grown adjacent to the south Taranaki coast in 1985.

Exotic forestry occupies about 25,000 ha (<1% of the region). State exotic forests are sited mainly on the coastal sand country (Santoft, Motuiti, Tangimoana); and the central plateau (Karioi, Erua and Tongariro), in addition to the Lismore Forest at Wanganui and Te Wera Forest in Taranaki. Smaller areas of exotic forestry have been established in the Wanganui area and by Winstones Ltd, near Raetihi. The 1981 NZ Forestry Conference set a target of 16,900 ha of exotic forest plantings to be established in the combined King Country, Taranaki, Wanganui and Manawatu regions between 1981 and 1990. It was envisaged that much of this would occur through an expansion of farm forestry, however this diversification of land use does not appear to be occurring at the rate expected so it is unlikely that the planting targets will be achieved.

Undeveloped land occupies about 35% of the region. Much of this is steep forested land (often State Forest) whose main function is watershed protection. Scrub occurs mainly on extensively farmed or unoccupied hill country. The most significant scrub cover is manuka, mixed indigenous scrub, gorse, hard fern and bracken fern. Other major undeveloped areas in the region include the Egmont National Park, the Tongariro National Park and the Kaimanawa and Ruahine State Forest Parks.

Future trends will see a greater diversification of land use within the region. Many opportunities given for diversification in Taranaki (Taranaki United Council 1985) also have application in other areas of the region. LUC Classes I and II land at present used for intensive grazing is increasingly used for cropping and horticulture. With the likelihood of greater New Zealand exports of frozen vegetables it is predicted that the area of process peas in the Manawatu will increase significantly. This, together with a continuing demand for feed grains and wheat for flour milling, will see cropping expand in the Manawatu, Marton and Wanganui areas. Intensification of pastoral production will occur on both arable and hill country pastoral land with further diversification to goats, deer and farm woodlots. Some marginal LUC Class VII hill country particularly in remote locations is unlikely to prove economic for pastoral farming and could revert to scrub and fern. This would repeat a cycle of land development followed by reversion, that may have already occurred once or twice previously on the same piece of land.

PHYSICAL RESOURCE FACTORS IN THE REGION

The physical land resource inventory component of the NZLRI is recorded in the form of an inventory code for each map unit. It contains information on rock type, soil unit, slope, erosion severity and type, and vegetation. The inventory code is set out in the following format.

$$\frac{\text{Rock Type—Soil Unit—Slope Group}}{\text{Erosion severity and type—Vegetation Cover}}$$

These inventory factors, together with climate and the effects of past land use, provide the basis for determining the land use capability of each map unit. In the homogeneous unit area approach to recording data, as used in the NZLRI (Eyles 1977), the five factors are mapped simultaneously within the limitations of the 1:63,360 scale. This section provides a brief summary of physical resource factors of the region, as mapped on the NZLRI, and also includes notes on climate. More details on these physical factors are given in the descriptions of LUC suites and LUC units.

Climate

Although climate is not recorded in the inventory it is assessed as 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.

Climatic data for the region was obtained from a variety of sources including "The Climate and Weather of": The Taranaki Region (Thompson 1981), Wanganui Region (Maunder and Browne 1972) and Tongariro Region (Thompson 1984). 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).

Climatic regions for the Taranaki-Manawatu region as defined in NZ Meteorological Service (1983b) (Figure 4) are climate types A_2, C_3, D_1 and M. Rainfall varies between 900 and 1300 mm in the south and south-west of the region and increases to between 1300–2500 mm in the west and north. The region generally has warm summers and mild winters although in high rainfall mountain climates temperatures vary greatly with altitude and exposure. The prevailing wind is from the westerly quarter.

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 in Taranaki and the King Country helped confirm the validity of the LUC classification in these areas.

Further information on the effects of climate on land use capability is given in the description of LUC suites.

Rock Types

Rock type is recorded using the North Island Rock Type Classification prepared specifically for use in the NZLRI (Crippen and Eyles 1985). This classification designed specifically for soil conservation purposes groups rocks with similar erosion susceptibilities and characteristics.

Table 1 lists the rock types recorded in the region and their areas. The most important underlying rocks are the sedimentary sandstones and mudstones (particularly massive sandstone and coarse siltstone) and indurated greywacke. However, most rocks in the region can

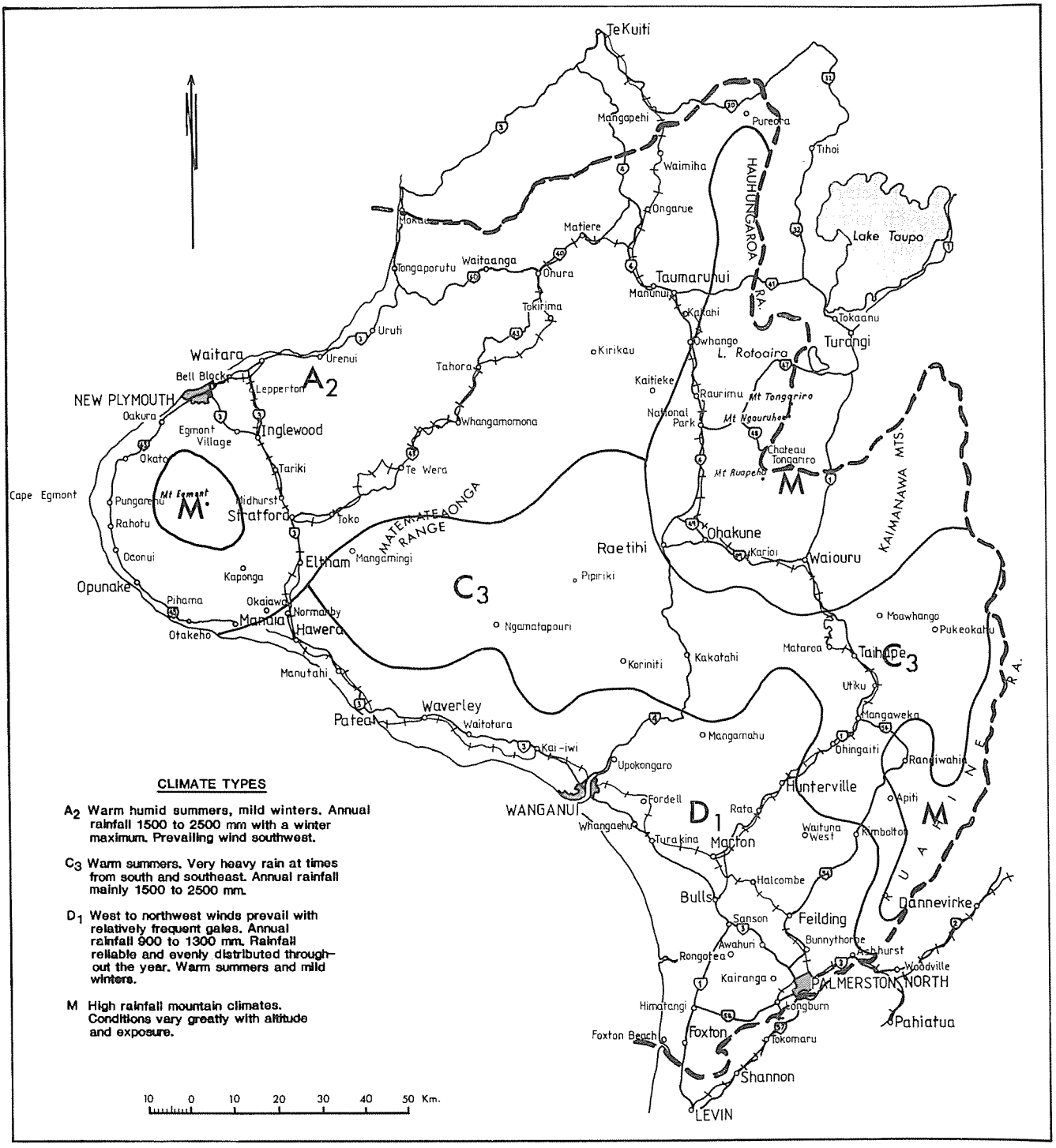


Figure 4: Climatic regions of the Taranaki-Manawatu Region (from NZ Meteorological Service 1983b).

Table 1: Areas of each rock type in the Taranaki-Manawatu Region (in hectares)

	Sole and dominant rock type	Forms a complete cover over underlying rock	Forms a patchy cover over underlying rock	Covered by tephra and lahar	Covered by loess	Covered by Wb, Pt etc	As an interlayer*	TOTAL	% of region
Ngauruhoe tephra	490	43310	15940	–	–	–	–	59740	2.5
Taupo tephra	–	141280	38270	2310	–	–	–	181860	7.5
Tephras older than Taupo tephra	203500	359450	224590	231050	–	–	145890	1164480	48.3
Lapilli	3690	2990	2630	–	–	–	–	9310	0.4
Taupo flow and water-sorted tephra	33890	3690	1070	1750	–	–	–	40400	1.7
Lahars	29800	970	–	86170	–	–	3630	120570	5.0
Lavas, ignimbrite, 'hard' volcanic rocks	8910	–	–	71590	–	–	–	80500	3.3
Peat	6740	–	1230	–	–	–	–	7970	0.3
Loess	6985	62930	33170	–	–	–	–	165950	6.9
Sands—windblown	78110	2830	–	–	–	–	–	80940	3.4
Gravels	10300	–	420	430	28350	16020	–	55520	2.3
Alluvium	104060	16780	–	2810	1110	–	–	124760	5.2
Unconsolidated lithologies	25190	–	–	8930	6970	–	–	41090	1.7
Sandstone or coarse siltstone—massive	647100	–	–	346410	56920	3250	–	1053680	43.7
Mudstone or fine siltstone—massive	113300	–	–	46240	2550	760	–	162850	6.7
Mudstone or fine siltstone—jointed	27120	–	–	–	–	–	–	72370	3.0
Mudstone or fine siltstone—banded	10700	–	–	–	–	–	–	64090	2.6
Greywacke	57570	–	–	–	200	1230	–	145920	6.0

*Occurs as an interlayer between an upper cover unit and a lower unit

Individual areas are not mutually exclusive and therefore percentages total greater than 100%.

also be overlain by surficial rock types such as volcanic tephra, alluvium, loess, and wind-blown sand.

Because the NZLRI inventory only recognises rock types that directly influence surface morphology and land use, the underlying and basement rock is often not recorded. This is particularly so on rolling to moderately steep land which may have significant depths of cover deposits. For example Mo is often the basal recorded rock type on flat and rolling land in Taranaki and the Waimarino.

Volcanic tephra is a particularly significant rock type in the region. The following five tephras were recorded in the region:

a) Ngauruhoe tephra (Ng). Ngauruhoe tephra (Topping 1973) is a recent airfall tephra stratigraphically above the Taupo Pumice Formation (Healy 1964).

b) Taupo tephra (Kt). Comprises rhyolitic airfall tephra of the Upper Taupo Sub-group (1000–2000 yrs BP).

c) Taupo flow and water sorted tephra (Tp). Comprises Taupo flow (deposited by nuees ardentes) and Taupo water-sorted tephra. (Taupo volcanic alluvium). Although intended exclusively for rhyolitic tephra the definition has had to be widened in the Taranaki-Manawatu Region to include andesitic tephric alluvium from Mt Egmont.

d) Tephras older than Taupo Pumice (Mo). This is principally andesitic tephra from the Taranaki volcanic centres and all but the youngest Formation of the Tongariro Sub-group (Topping 1973). Also included are older brown ashes occurring in the King Country.

e) Lapilli (Lp). Lapilli of the Burrell Formation (Druce 1966) is the only lapilli recorded in the region.

Table 2: Geological surveys used in the Taranaki-Manawatu Region

Survey number (Fig.5)	Map name	Author and date
1	Geological map of NZ 1:250,000 Sheet 4 Hamilton	Kear 1960
2	Geological map of NZ 1:250,000 Sheet 5 Rotorua	Healy *et al.* 1964
3	Geological map of NZ 1:250,000 Sheet 7 Taranaki	Hay 1967
4	Geological map of NZ 1:250,000 Sheet 8 Taupo	Grindley 1960
5	Geological map of NZ 1:250,000 Sheet 10 Wanganui	Lensen *et al.* 1959
6	Geological map of NZ 1:250,000 Sheet 11 Dannevirke	Kingma 1962
7	Geological map of NZ 1:250,000 Sheet 12 Wellington	Kingma 1967
8	Geological map of NZ 1:50,000 Sheets P19, P20, P21 New Plymouth, Egmont and Manaia	Neall 1979
9	The Geology of Wanganui Subdivision 1:63,360	Fleming 1953

The limit of three rock type symbols in the inventory code, while necessary in the interests of clarity, meant that significant rock types sometimes had to be omitted. This is particularly the case where a series of thin depths of tephra overlie a basement rock. For example Kt is not recorded in the stratigraphic sequence Ng/Kt/Mo/Gw.

Geological surveys used in the NZLRI are given in Figure 5 and Table 2. In most areas basic geological information was obtained from the NZ Geological Survey 1:250,000 Geological Map of New Zealand series. However these maps use a stratigraphic classification that is not particularly suited for the mapping of rock type especially in areas of Tertiary lithology and surficial deposits such as loess and tephra. Published information from other sources was also consulted [Henderson and Ongley (1923); Grange (1927); Gregg (1960) and Te Punga (1952)]. All information was supplemented by extensive field observation.

Soils

The soil information on the worksheets is based on published or publicly available soil surveys provided by Soil Bureau DSIR. The Taranaki-Manawatu Region at the time of NZLRI mapping was covered by 14 soil surveys: these are listed in Table 3 and their coverage shown in Figure 6.

Where soils information was only available at 1:253,440 scale (from the General Survey), more detail was required for the NZLRI. In obtaining this extra detail, the objective was not to prepare a 1:63,360 soil map, but to accurately record, within NZLRI map units, soil sets which were already recognised in the General Survey. For a given area the relevant sheet of the General Survey was consulted to see which soil sets had been mapped. Using these sets, as defined in the extended legend, together with detailed air photo and field interpretation, boundary detail appropriate to the 1:63,360 scale was recorded. During field work, soil profiles were checked to ensure that the correct soil set had been recorded (Hawley and Leamy 1980).

Table 3: Soil surveys used in the Taranaki-Manawatu Region

Survey number*	Survey name	Author and date	Scale
1	General Survey of the soils of the North Island, New Zealand	NZ Soil Bureau 1954	1:253,440
2	Soils of Stratford County	Aitken *et al.*1978	1:63,360
3	Soils of Waimate West County	Campbell and Wilde 1969	1:63,360
4	Soils of Egmont and part Taranaki Counties	Palmer *et al.*1981	1:63,360
5	Soils of part Waitotara County	Wilde 1976	1:63,360
6	Soils of part Wanganui County	Campbell 1977	1:63,360
7	Soils of Rangitikei County	Campbell 1979	1:63,360
8	Soils of Pohangina County	Rijkse 1977	1:63,360
9	Soils of Kairanga County	Cowie 1972	1:63,360
10	Soils of Manawatu County	Cowie and Rijkse 1977	1:63,360
11	Soils of the Manawatu-Rangitikei Sand Country	Cowie *et al.* 1967	1:63,360
12	Soils and some related agricultural aspects of Mid Hawke's Bay	Pohlen *et al.* 1947	1:63,360
13	Soils of Taupo County	Rijkse (in prep)	1:63,360
14	Provisional Soil Map of the King Country	Rijkse and Wilde 1977	1:63,360

*Refer Figure 6.

It should be noted that the soil information recorded is not a new soil map. Because soils are only one of the five inventory factors recorded within a 'homogeneous' map unit, boundaries of map units need not necessarily correspond exactly to soil boundaries of soil maps covering the same area.

Typical soils recorded for each LUC unit are listed in the Taranaki-Manawatu Region Land Use Capability Extended Legend. For more detailed soils description and interpretation, users should consult the appropriate soil maps and associated reports. These are listed on the legends of the individual worksheets. Additional information can be obtained from local Soil Bureau pedologists.

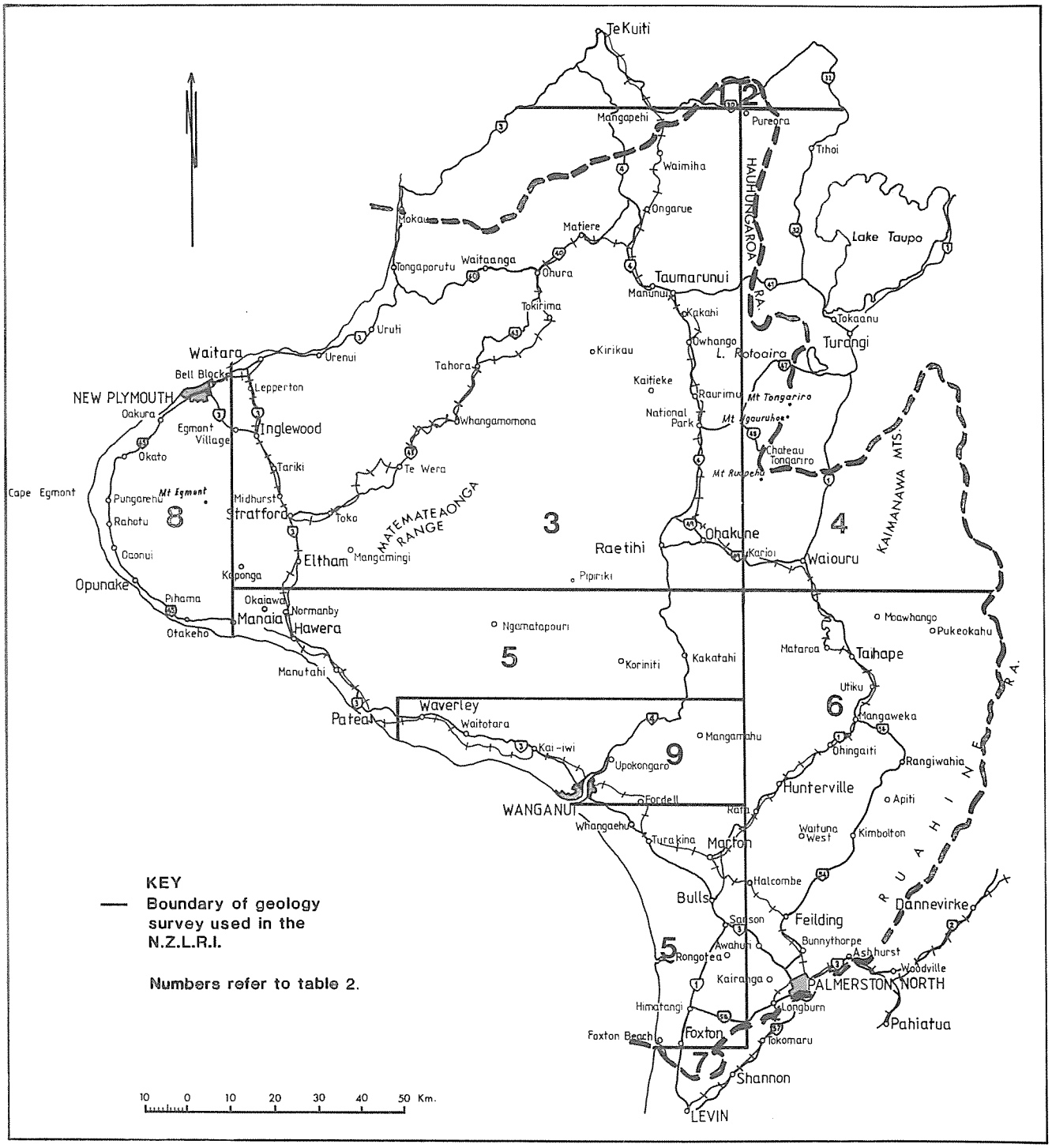


Figure 5: Geological surveys used in the Taranaki-Manawatu Region.

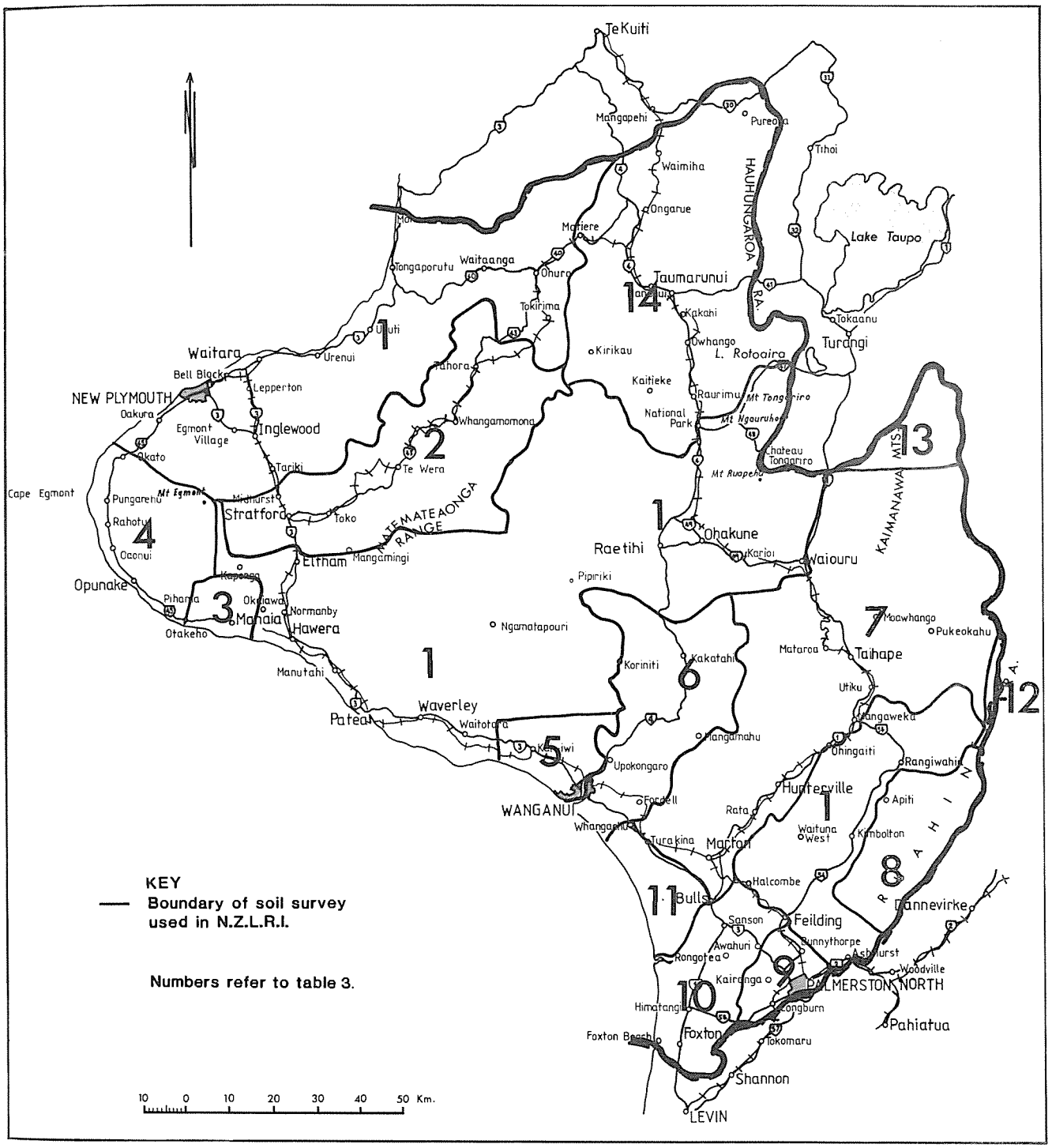


Figure 6: Soil surveys used in the Taranaki-Manawatu Region.

General information about the properties of soils within the region can also be obtained from a number of sources such as NZ Soil Bureau (1968), National Resources Survey (1971, 1973), and Gibbs (1980). Much information is also to be found in the unpublished series "Soil Groups of New Zealand", produced by the NZ Society of Soil Science.

Slopes

The slope groupings recorded for each map unit are standard for land use capability mapping (SCRCC 1969). Slope angles are measured with an clinometer, or estimated visually in the field and/or from aerial photographs. Slopes recorded are those areally dominant in each map unit. Complex slopes where more than one major slope grouping occurs (e.g., A+B), compound slopes which are borderline between two slope groupings (e.g., A/B), and dissected slopes (e.g., A') are also recorded.

The dominant slope groups in the region and the proportion of the various slope groups in the North Island is given in Table 4. A comparison of information in the table shows that the Taranaki-Manawatu Region has proportionately more flat and gently undulating land, and also more very steep land than the rest of the North Island.

Table 4: Areas of dominant slope groups recorded in the Taranaki-Manawatu Region

Dominant slope group	Area (ha)	% region	% North Island
A (0–3°)	422,300	17.5	14.8
B (4–7°)	192,800	8.0	6.4
C (8–15°)	135,800	5.6	8.9
D (16–20°)	212,300	8.8	12.8
E (21–25°)	517,800	21.5	24.5
F (26–35°)	759,300	31.5	22.8
G (>35°)	148,100	6.1	7.6
Unmapped	21,040	1.0	2.2

Erosion

Erosion mapping is based on the NZLRI erosion classification (Eyles 1985). For each map unit, erosion severity and type was assessed. These assessments were based on aerial photograph interpretation and field work, aided by knowledge of rock, soil and climate factors affecting the erosion pattern.

The types of erosion recorded in the region are shown in Table 5 together with the total area of map units within the region affected by each type of erosion. It is important to realise that the methods used to record most types of erosion in the NZLRI *do not give actual areas of erosion*: because erosion is assessed within a map unit whose boundaries reflect a combination of physical factors, only *areas of map units in which erosion of specified severity occurs* can be obtained.

With surface 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 = 0–1%, 1 = 1–10%, 2 = 11–20%, 3 = 21–40%, 4 = 41–60%, 5 = >60%. An approximate area of erosion could therefore be calculated in these cases; however this has not been done in this bulletin. Mass-movement and fluvial erosion severity is assessed according to the following scale: 0 = insignificant, 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 and "erosion associations" for the region are mapped at 1:250,000 scale in the "Erosion Map of New Zealand". Most of the region is covered by Sheets 7, 8, 10 and 11 (Robins 1974a, Page and Steel 1982, Fletcher 1976, Noble and Fletcher 1984), with very small parts of the region occurring also on Sheets 4, 5 and 12 (Robins 1974b, Steel 1982, Page and Trustrum 1982).

The only significant erosion mapping in the region prior to the publication of the NZLRI and the Erosion Map of New Zealand was that by Cumberland (1944) and Grange and Gibbs

(1947). Cumberland grouped all of the moderately steep to very steep land in the region into either the Taranaki-Wanganui Tertiary Hinterland Region or the North Island Mountain Axis Region. Erosion occurring in these two regions was broadly described, with all the Tertiary hinterland considered to have "soil erosion apparent" or be covered in indigenous forest.

Grange and Gibbs recognised the relationship between lithology and erosion when they mapped classes of soil erosion at 1:500,000 scale in the southern North Island. Four classes of erosion were recognised: no erosion, wind erosion, slip erosion, and undifferentiated sheet and slip erosion. No erosion was recorded on most flat and undulating land and easier hill country with yellow-brown loam soils. The coastal sand country, Kaimanawa mountains and yellow-brown pumice soils were mapped as having wind erosion. The effect of rock type was recognised by differentiating hill and steep slopes with slip erosion into the following categories.

Slips expose soft rock, vegetation establishes quickly	a) mudstone b) sandstone c) crumbly mudstone.
Slips expose hard rock, vegetation establishes slowly.	a) sandy mudstone b) sandstone
Slips expose rock, erosion of the rock follows.	a) shattered greywacke b) soft sandstone

The NZLRI has further defined those links between lithology and erosion for the Taranaki-Manawatu Region. The LUC Classification is based on the relationships that exist between lithology, soils, erosion, slope and climate, and the potential for sustainable agricultural production.

Most erosion research in the region has been in mountain ranges where geological, morphologic and climatic factors including high intensity rainfall, and the effects of animals on vegetation are given as causes of erosion. Cunningham and Stribling (1978) have described in detail the erosion problem in the Ruahine Range. To date very little research has been carried out in the Tertiary hill country. Stout (1977) and Thompson (1982) have carried out work on deep seated landslides in the Taihape area which are affecting communications and urban areas while Fleming (1953) and O'Byrne (1961) have investigated the relationship between lithology and erosion near Wanganui. Recent work by Trustrum *et al.*(1984) aims to quantify the effect of erosion on potential pasture productivity. Other erosion research in the region is reviewed in the description of LUC suites.

Table 5: Types of erosion occurring in the Taranaki-Manawatu Region

Erosion type	Area of map units affected (ha)*	(% of region)*
Soil slip (sSl)	807,000	20.1
Sheet (Sh)	739,100	18.4
Debris avalanche (daF)	241,210	6.0
Wind (W)	118,000	2.9
Streambank (Sb)	104,200	2.6
Scree (Sc)	96,800	2.4
Earthflow (eF)	78,900	2.0
Gully (G)	57,700	1.4
Slump (Su)	9,100	0.2
Earthslip (eSl)	4,900	0.1
Deposition (D)	2,900	0.1
Rill (R)	1,500	0.0
No erosion recorded (0)	1,761,192	43.8

* Adds up to more than total of region because each erosion type recorded within a map unit (up to 3 allowed) is counted separately for that map unit.

Vegetation

Vegetation cover was assessed for each map unit, using a classification of 45 vegetation classes arranged in five major groups: grassland, cropland, scrubland, forest, and miscellaneous (Hunter and Blaschke 1986). Up to three vegetation classes were recorded in each map unit, in descending order of percentage cover. Information on vegetation cover was derived from aerial photograph analysis and field work, supplemented by published maps and descriptions for forested areas.

Several general vegetation descriptions are available including for the Kaimanawa Range (Elder 1962), Hauhangaroa Range (McKelvey 1963), Ruahine Range (Elder 1965), Egmont National Park (Druce 1976), Tongariro National Park (Esler 1965), and inland Taranaki (Nicholls 1956). Many of these authors have also discussed the effect on vegetation of long-term climatic changes, drought, volcanic activity, and the influence of man and browsing animals. The modification of vegetation in the Ruahine Range is reviewed by Cunningham and Stribling (1978).

Pasture is the most important vegetation category being the dominant vegetation over 58% of the region. High producing pasture, comprising a high proportion of ryegrass and white clover, is most important on arable and rolling land where dairying and other forms of intensive grazing are practised. Hill country has mostly low producing pastures in which browntop, sweet vernal and danthonia are important constituents. Red tussock grassland is significant in the Tongariro National Park and the southern Kaimanawa and northern Ruahine Ranges.

Forest is the dominant vegetation on map units covering 24% of the region. Lowland podocarp-hardwood forest occurs in lower altitude areas of the region. Rimu and miro are the most common podocarps, and tawa and kamahi the principal hardwoods. Kahikatea commonly occurs on valley floors. In almost all cases podocarps have been heavily logged. In forested areas of inland Taranaki beech trees tend to be confined to ridges with hard beech in North Taranaki and black beech in South Taranaki. Above the upper limit of rimu (approx 900 m a.s.l.) mid altitude podocarp-hardwood forest occurs, which extends to the forest line in the Egmont National Park. Predominant trees include kaikawaka, Hall's totara, mountain toatoa, and kamahi. As altitude increases on mountain slopes elsewhere in the region red beech is commonly associated with kaikawaka before merging with mountain beech that extends to the upper limit of forest. Exotic forest comprising mainly *Pinus radiata* occurs on about 20,000 ha (<1% of the region).

Scrubland comprises the dominant vegetation in approximately 14% of the region. Leatherwood scrub is significant in the southern Ruahine Range and the Egmont National Park, while *Dracophyllum* sp occurs in subalpine areas throughout the region. The most widespread occurrence of scrub and fernland is the result of human modification of vegetation resulting in species such as manuka, broadleaved shrubs, bracken fern, hard fern, and tree ferns; and the introduction of scrub weeds such as gorse and blackberry.

LAND USE CAPABILITY CLASSIFICATION

PRINCIPLES OF LAND USE CAPABILITY CLASSIFICATION

The land use capability (LUC) classification of an area is an assessment of the land in terms of its capacity for 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 and the effects of past land use.

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

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 forestry but is best used for catchment protection. Areas and percentages of the eight LUC classes mapped in the Taranaki-Manawatu region are shown in Table 6, together with comparative data for the North Island.

Table 6: Area of LUC Classes of the Taranaki-Manawatu Region, compared with the North Island

LUC Class	Area (ha)	% of Region		% of North Island	
I	64,300	2.7		1.3	
II	178,600	7.4	27.3	6.3	27.8
III	211,700	8.8	(Arable land)	8.9	(Arable land)
IV	201,500	8.4		11.3	
V	41,500	1.7	62.0	0.8	61.1
VI	733,800	30.5	(Non arable	35.2	(Non arable
VII	717,050	29.8	land)	25.1	land)
VIII	239,550	9.9	9.9 (Protection land)	8.7	(Protection land)
Unmapped	20,090	0.8	2.4		

Land Use Capability Subclass

The LUC subclass is a subdivision of the LUC class according to the main kind of physical limitation or hazard to use. The four kinds of limitation recognised are:

e erodibility
w wetness
s soils limitations within the rooting zone
c climate.

Only the dominant limitation is recorded in symbol form, and is identified by a lower case letter in the land use capability code. Information on other limitations is recorded in the Taranaki-Manawatu Region LUC extended legend.

Land Use Capability Unit

The LUC unit is the most detailed component of the LUC classification system. The LUC subclasses are subdivided into a number of LUC units (represented by an arabic number at the end of the LUC coding).

A LUC unit groups together inventory map units which respond similarly to the same management, are adapted to the same kinds of crops, pastures, and forest species, have

about the same potential yield, and require the application of the same conservation measures (SCRCC 1969)

An example of the LUC nomenclature is given for LUC unit VIe3: VI is the class, VIe is the subclass, VIe3 is the unit.

Within each LUC class, LUC units are arranged in approximate order of decreasing versatility of use and increasing degree of physical limitation.

A total of 150 LUC units were recognised in the region and are described in the NZLRI LUC extended legend (Fletcher 1981). They are listed together with their areas in Appendix 2. A correlation of these LUC units with similar LUC units in adjacent NZLRI regions is given in Appendix 4, (from Page 1985).

Land Use Capability Suite

The traditional numerical ranking of LUC units based on decreasing versatility and capability, as shown in the LUC extended legends, 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 follows:

A group of LUC units which, although differing in land use capability, share a definitive physical characteristic which unites them in the landscape.

The "definitive physical characteristic" may vary from region to region. LUC suites may be divided into subsuites according to secondary criteria. The arrangement of LUC units into LUC suites and subsuites in the Taranaki-Manawatu region is given in Table 9 and Appendix 1.

PREVIOUS LUC SURVEYS IN THE REGION

Prior to the commencement of the NZLRI in the region in 1978, five LUC surveys had been carried out in the region by the LUC survey team of the Water and Soil Division MWD, the forerunner of the present Land Resources Group.

The first LUC survey in the region (and in the North Island) was the Soil Conservation Survey of part of the Pohangina and Oroua Catchments (Greenall *et al.* 1951). This survey and the soil conservation survey of the Porewa Stream Catchment (Sutherland 1953) were both at a 1:15,840 scale. More recently LUC surveys were made of the Wanganui River catchment (Nairn *et al.* 1967), the Lake Taupo catchment (Toohill and Fletcher 1971) and the Aotuhia District (Robins *et al.* 1975). None of the surveys and reports were published, but were important sources of information for the NZLRI Regional LUC classifications in the Bay of Plenty-Volcanic Plateau, and Taranaki-Manawatu regions. The Lake Taupo LUC Survey was also a major input into the Lake Taupo Catchment Control Scheme. (Waikato Valley Authority 1973). In addition staff of all three catchment authorities in the region have prepared many LUC surveys of areas under their jurisdiction for use in farm plans and in the design and operation of catchment control schemes.

Limited numbers of interim NZLRI worksheets and LUC extended legends were printed for the King Country area and made available to the interdepartmental land use study of the King Country (Department of Lands and Survey 1978). These interim worksheets resulted from field work and map compilation carried out in the King Country land use study area between August and November 1976. Subsequently, in 1978 interim NZLRI worksheets were produced for Taumarunui County and then reprinted as NZLRI worksheets in 1979. These incorporated changes in rock, soil and vegetation symbols and a renumbering of LUC units according to the NZLRI land use capability classification used in the Taranaki-Manawatu Region.

ASSESSMENT OF PASTORAL AND EXOTIC FORESTRY POTENTIAL

An important extension of the original NZLRI data base has been the addition of pastoral and forestry potentials for each LUC unit. This is expressed in terms of stock carrying capacity in stock 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 the description of LUC units in this publication and is included in the LUC extended legend of the Taranaki-Manawatu Region. The computer data base also incorporates this pastoral and forestry productivity data for all of the 925 LUC units mapped throughout New Zealand on the NZLRI.

The information has the advantage of enabling LUC units to be more closely defined by enumerating land performance, as well as dramatically increasing the applicability of the NZLRI information for regional and district planning purposes.

Data on stock carrying capacity was collected in 1980 as a combined project with Ministry of Agriculture and Fisheries advisory staff from Te Kuiti, New Plymouth, Stratford, Hawera, Wanganui, Taihape and Palmerston North. Representative sites of each LUC unit were visited and assessments of present average, top farmer, and potential carrying capacity were made. An assessment of fertiliser and trace element requirements for establishment and maintenance of pasture was also made at the time of field inspection. Correlation of the stock-carrying capacity data was carried out by the NZLRI regional supervisor and MAF sub-regional advisory officers and the regional advisory officer. Potential stock-carrying capacity figures can be ranked (Table 7).

Table 7: Potential stock carrying capacity groupings

Potential stock carrying capacity ranking	Potential stock carrying capacity (stock units/ha)
Very high	>25
High	21–25
Moderately high	16–20
Medium	11–15
Low	6–10
Very low	1–5
Sparse	<1

Present average, top farmer and potential stock carrying capacity data for all LUC units in the region is given in Appendix 5.

Site index data were collected in 1980 with the Senior Forester, New Zealand Forest Service, Palmerston North. Representative sites of each LUC unit were visited in the field, and an assessment of site index given, based either on plot record information or on field observations of shelterbelts or plantations in the vicinity. The site index data were correlated by the NZLRI regional supervisor and the Senior Forester. Site index figures can be ranked (Table 8). Appendix 6 gives the site index data of *P. radiata* for all LUC units in the region.

Table 8: *P. radiata* site index groupings

Exotic forest growth potential	Site Index for *P. radiata*
Very high	>35
High	30–35
Medium	25–29
Low	20–24
Very low	<20

NZLRI DATA IN DISTRICT AND REGIONAL PLANNING

This publication together with the 35 NZLRI worksheets and regional land use capability extended legend provides a comprehensive physical land resource data base for the Taranaki-Manawatu region. Further, all NZLRI data is computer stored. This provides the versatility to produce data (including maps of various scales) in response to specific user requests.

The NZLRI data is widely used by local territorial authorities, Government departments, companies, consultants and other agencies involved in planning rural land use. Examples of this information assisting local territorial authorities with district and regional planning include the location of:

1. Hazardous areas that are highly erodible or liable to flooding.
2. High producing land.
3. Non arable land.
4. Land with scenic value.
5. Areas that can physically sustain pastoral farming.
6. Areas that can physically sustain production forestry.
7. Vegetation cover to indicate existing land uses.

The NZLRI data should only be used at 1:63,360 or smaller scales. Under no circumstances should it be used for more detailed land use planning. The areas of LUC units mapped in the Taranaki United Council are given in Appendix 7 and for the Wanganui United Council in Appendix 8. Similarly, Appendix 9 provides areas of LUC units mapped in Taumarunui, Kiwitea, Pohangina, Oroua, Manawatu and Kairanga counties. Appendix 10 presents a summary of LUC class as a percentage of each county in the region.

It should be noted that NZLRI information is a planning tool not a plan. It is only one input into a district or regional scheme and as such can be used as a physical base on which social and economic implications of land uses can be considered.

LAND USE CAPABILITY SUITES IN THE REGION

Thirteen LUC suites (Table 9) have been recognised in the Taranaki-Manawatu Region. The primary factor used to distinguish these LUC suites is soil parent material. Four suites occur on tephra, four on Tertiary aged rock types, and one each from alluvium, loess, volcanic lahars, and coastal sand. One suite is on mountainlands.

Eight of the 13 LUC suites were subdivided into varying numbers of subsuites. The main distinguishing criteria are the depth and texture of tephra, the strength and hardness of rocks, climate and slope. In total 34 LUC suites or subsuites are described for the region—they are listed in Table 9. A list of LUC units grouped into LUC suites and subsuites, together with areas is given in Appendix 1.

It should be recognised that although the concept of LUC suites is emphasised in this bulletin 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 number of LUC units which do not fit exactly into one LUC suite or subsuite. For example LUC unit IIc1 occurring in both the Waimarino and Apiti areas is placed in the yellow-brown loams suite at Waimarino and the loess suite at Apiti.

Table 9: LUC suites and subsuites in the Taranaki-Manawatu Region

LUC Suite/Subsuite number	LUC suite/subsuite
1.	Yellow brown loams
1a	Waimarino
b	King Country
c	Inland plateaux
d	Taranaki
2.	Lahars in Taranaki
3.	Coastal sand country
4.	Alluvium
4a	Wide flood plains and river valleys
b	Narrow river valleys
5.	Loess
5a	Low rainfall
b	High rainfall
6.	Taupo airfall tephra
6a	Shallow Taupo airfall tephra
b	Deep Taupo airfall tephra
7.	Taupo flow tephra and water sorted tephra
8.	North-east uplands
8a	Shallow Taupo and/or Ngauruhoe tephra
b	Deep Taupo and/or Ngauruhoe tephra
9.	Mudstone
9a	Jointed mudstone
b	Banded mudstone
10.	Siltstone
10a	Siltstone
b	Urenui siltstone
11.	Sandstone
11a	Unconsolidated
b	Moderately consolidated
c	Moderately consolidated with slump and earthflow erosion
d	Consolidated
e	Hard consolidated
12.	Deep-seated earthflow and slump erosion
13.	Mountainlands

1. LUC SUITE ON YELLOW-BROWN LOAMS

This suite comprises deep well drained yellow-brown loam soils developed on volcanic tephra. The suite comprises 31 LUC units and covers 375,350 ha (15.5%) of the Region. Yellow-brown loams have excellent physical characteristics for plant growth and their physical and chemical properties are shaped by amorphous clay (chiefly allophane) rather than crystalline constituents dominating the clay fraction. They are very friable and free draining. The soils have a high porosity yet have a moderate to high retention of water that is available for plant growth. They have a high phosphorus requirement because, although they have moderate levels of phosphorus, much of it is unavailable to plants.

The land use capability of yellow-brown loam soils has been briefly discussed by Fletcher and Jessen (1982). On yellow-brown loam soils within this suite it is climate together with slope angle that determines the suitability and versatility of land for cropping, pastoral and forestry use, and hence land use capability. Yellow-brown loams dominated by wetness or soil limitations are included in the lahar suite.

Within the yellow-brown suite the following four LUC subsuites are recognised:

a. LUC Subsuite in the Waimarino District.

b. LUC Subsuite in the King Country.

c. LUC Subsuite on inland plateaux.

d. LUC Subsuite in Taranaki.

1a LUC Subsuite on Yellow-brown Loams in the Waimarino District

This subsuite occurs on the Mt Ruapehu ring plain, between Pokaka and Tangiwai, and on adjacent hill country and river terraces. The subsuite comprises six LUC units IIc1, IIIc1, IIIe5, IVc1, IVe6 and VIc1 which are differentiated on altitude and slope. Together they cover 73,500 ha (3.0%) of the region. The distribution of the subsuite is shown in Figure 7.

It is generally more elevated than other yellow-brown subsuites in the Taranaki area, and accordingly has a lower cropping versatility.

Physiography

The majority of the subsuite comprises flat and undulating slopes on the western and southern areas of the Mt Ruapehu ring plain. The ring plain has a maximum altitude of 1000 m at Pokaka in the north, reducing gradually to about 350 m a.s.l. in the south. Also included in the subsuite are hill slopes mantled with andesitic tephra, to the west and south of the ring plain. Within this hill country arable LUC units are mapped on high and medium level terraces of the Wanganui, Mangawhero, Whangaehu, Turakina and Hautapu Rivers.

Climate

Rainfall increases with altitude from approx 1000 mm p.a. on LUC unit IIc1 to over 2000 mm p.a. on LUC unit IVc1 (Table 11). This rainfall is spread fairly evenly throughout the year except for a dry period between January and March.

Frosts can occur at any month of the year. The Ohakune climatological station (610 m a.s.l.) on LUC unit IIIc1, had on average 106 ground frosts and 4.3 days of snow per year between 1961 and 1974 (NZ Met Service 1983a). The mean air temperature at Ohakune is 10.1°C.

Rock Type

The rock type is andesitic tephra successively erupted from the Tongariro volcanic centre. This tephra overlies lahars of the Mt Ruapehu ring plain (Grindley 1960), or Tertiary aged sediments of the hill country further west and south. Topping (1973) has included in the Tongariro Subgroup (Table 10) all andesitic tephra erupted within the Tongariro volcanic centre from 13800 years B.P.

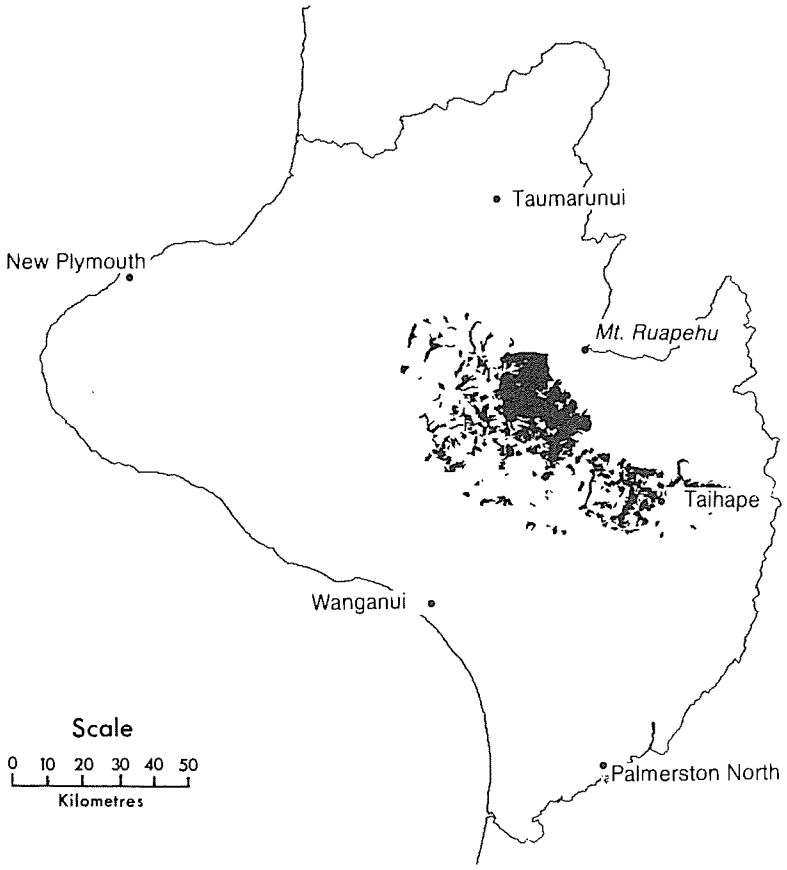


Figure 7: Location of LUC subsuite 1a: yellow-brown loams in the Waimarino district.

Table 10: Stratigraphic column for andesitic tephras of Tongariro Sub-group (Summarised from Topping 1973)

Tephra Formation	C^{14} Age in years before 1950
Ngauruhoe Tephra	1819 ± 17 to present
Mangatawai Tephra	2500 ± 200
Unnamed bed	
Papakai Tephra	3420 ± 70
Mangamate Tephra	9700 ± 210
	9780 ± 160
Okupata Tephra	9790 ± 160
Rotoaira Lapilli	13,800 ± 300

Isopach maps (Gregg 1960) indicate that the 5 cm depth of Ngauruhoe tephra in the vicinity of Ohakune thins markedly to the west and to the south; and the Mangatawai Tephra is absent. Tephra underlying the Mangatawai tephra are described as the youngest beds of the Tongariro shower (Grange 1931, Grange and Taylor 1931) or Tongariro Ash (Gregg 1960). In this bulletin the andesitic tephra comprising the soil parent material of this subsuite are referred to as Tongariro Ash.

Soils

Soils were recorded on NZLRI map units in Waimarino County using information from the NZ Soil Bureau (1954) survey. Elsewhere, in Rangitikei County and Wanganui County 1:63,360 soil survey information (Campbell 1977, 1979) was used.

Ohakune, Pokaka, and the Kakatahi series are the dominant soils recorded. Ohakune soils occur on flat to strongly rolling slopes mantled with 1–3 m of tephra, and the Ohakune hill soils on strongly rolling to moderately steep hill slopes. The Ohakune bouldery loam is recorded where laharic stones and boulders were present. The Pokaka series is mapped in the

north where thin Taupo tephra (<15 cm) overlies the Tongariro Ash (Wilde 1982). The Kakatahi series occurs in the Whangaehu and Mangawhero River valleys, on high terraces of fine gravelly volcanic alluvium derived from lahars.

Erosion

This subsuite does not have a potential for serious erosion. Forty five percent of the subsuite area (LUC units IIc1, IIIc1 and IVc1) have flat and undulating slopes and no significant erosion hazard under pasture or cultivation. Rolling slopes (LUC unit IIIe5) have a potential for slight to moderate sheet and rill erosion when cultivated while strongly rolling slopes (LUC unit IVe6) have a potential for severe sheet and rill erosion if cultivated. The remaining 25.5% of the subsuite area (LUC unit VIc1) has strongly rolling to moderately steep slopes which have a potential for slight slip and sheet erosion.

Some arable map units in the Karioi and Rangataua areas have a component of Taupo airfall tephra which gives a potential for wind erosion when cultivated.

Land Use

Early settlers initially felled and burnt the existing forest to develop pastoral farms. The completion of the Main Trunk railway in 1909 opened up outside markets for timber and resulted in a considerable increase in saw milling (Saunders 1968). During the peak period of 1920–1924 there were 50 mills operating within 8 miles of Ohakune and Raetihi. Market gardening was started by Chinese settlers between 1910–1914, and a system of 5 year leases evolved whereby the land was cleared, used to grow vegetables for 4 years, then sown in grass before it was returned to the owner.

Land use is now dominantly sheep and cattle farming with market gardening important on LUC unit IIIc1. Pasture growth is mainly in late spring and during summer, however cool temperatures restrict pasture production for the remainder of the year necessitating supplementary feed crops and hay. Dairying was once a major land use but now there are only 430 dairy cows in Waimarino County (Dept of Statistics 1984), most of them in the Ohakune area.

The combination of favourable climate and suitable soils make flat and gently undulating slopes very well suited to root and brassica vegetable crops and potatoes. Carrots, parsnips, swedes, cauliflower, cabbages and brussel sprouts are the main vegetable crops grown. Root crops can remain in the ground over winter, providing an almost continuous supply of these vegetables throughout the year. The total area of vegetable crops and potatoes is approx 700 ha. Of this area about 50% is in carrots. When this is compared with the 54,000 ha of arable land in this subsuite, it is evident that the production of these crops could be increased substantially. Lack of markets however is the main constraint to achieving this.

LUC units IIc1, IIIc1, IIIe5 and IVe6 are mainly in high producing pasture with minor amounts of low producing pasture, forest or scrub. IVc1 is mostly covered by forest or scrub. Pasture dominates on VIc1 although cut-over hardwood forest, mixed native scrub associations and manuka can be significant particularly in the hill country west of Raetihi.

Page and Blaschke (1981) estimate an extra 81,000 stock units would be supported in Waimarino County, if all scrub was removed from LUC units IIc1, IIIc1, IVc1, IIIe5 and IVe6 and replaced by pasture.

In the following section individual LUC units of this subsuite are briefly discussed in two groups. Firstly, LUC units IIc1, IIIc1 and IVc1 are described. This is followed by a description of LUC units IIIe5, IVe6 and VIc1. A climosequence is demonstrated in the first group, and in the second group slope steepness is important.

LUC UNITS ON FLAT AND UNDULATING SLOPES

LUC unit IIc1 (1700 ha)

Terraces with deep yellow-brown loam soils on flat and undulating slopes between 350–550 m a.s.l. in the Mangawhero, Whangaehu, Turakina and Hautapu river valleys are

mapped as LUC unit IIc1. Rainfall ranges from 1000 to 1400 mm p.a. and the climate is suited to a wider range of crops than LUC unit IIIc1 (Table 11).

A further 7450 ha of IIc1 mapped in the lower Rangitikei and Apiti districts is described in more detail in the loess suite. IIc1 is therefore mapped on similar land in two widely separated locations with the same slope, similar climates and soils. The management and soil conservation requirements are the same as are the range of potential crops. The potential stock carrying capacity (26 su/ha) and forestry site index (30–33 m) are also the same in both areas.

LUC unit IIIc1 (21,200 ha)—Figure 8

This unit is mapped on deep well drained yellow-brown loams on flat and undulating slopes between 550–750 m a.s.l. It occurs mostly on the volcanic ring plain in the Ohakune and Raetihi districts but also south of Karioi and north-west of Taihape. Flat river valleys below 550 m a.s.l., with yellow-brown loam soils, such as the Manganui-a-te-ao valley are included in this unit because cold air drainage down the valley gives a climate similar to higher altitude IIIc1's.

The LUC unit is well suited to the growing of brassica and root and vegetable crops, and potatoes and peas. Wheat, oats and barley are not well suited to IIIc1 because of the high rainfalls (1400–1700 mm p.a.) and short growing season. The potential stock carrying capacity is 22 su/ha and the site index for *P. radiata* is 27–28 metres. Areas of imperfectly drained gley soils (Rahotu loam) occurring within IIIc1 are mapped as LUC unit IIIw3.

LUC unit IVc1 (9700 ha)—Figure 9

LUC unit IVc1 occurs between 750–1000 m a.s.l., principally in the Horopito and Pokaka localities. The severe climate limits the range of crops grown to root and brassica vegetable crops, potatoes and root and green fodder crops. Occasional crops of barley and oats can be grown but they must be artificially dried.

Pasture is the dominant vegetation on map units covering only 15% of IVc1. The remainder is mostly indigenous forest (principally cut-over lowland podocarp-hardwoods and lowland beech forest).

The potential stock carrying capacity of 16 su/ha reflects the lower land use capability of this unit (IIIc1 has a potential carrying capacity of 22 su/ha). Similarly the site index of IVc1 drops to 23–24 m compared to 27–28 m on IIIc1.

Included within IVc1 are areas with a shallow depth of tephra overlying stony or bouldery lahars which restrict cultivation and impede subsoil drainage. In these situations soils are mapped as the Ohakune bouldery silt loam.

LUC unit IIIw3 (1050 ha)—Figure 10

Also included in the Tongariro tephra suite are 1050 ha of LUC unit IIIw3 with gley soils developed on Tongariro tephric alluvium and airfall tephra.

IIIw3 is mapped in two situations:

1) flat valley floors in areas of Tertiary aged hill country where gleyed recent soils are developed on alluvium and colluvium.
2) low lying areas where the volcanic ring plain abuts the sedimentary hill country. Here, drainage is difficult because of the lack of drainage outlets.

The Rahotu loam and small areas of Raumati silt loam are the dominant soils.

Almost all of IIIw3 has been developed into pasture, and rushes are significant in many places. Permanent wetness and climatic limitations restrict the cropping versatility to brassica and root vegetable crops and root and green fodder crops. The potential stock carrying capacity is 24 su/ha. Because of a permanent high water table IIIw3 is considered unsuitable for exotic forestry.

Figure 8: Growing of carrots on IIIc1 (600 m a.s.l.) near Ohakune. N121 835504 looking NE.

Figure 9: IVc1 (750 m a.s.l.) north of Horopito. N121 893653 looking W.

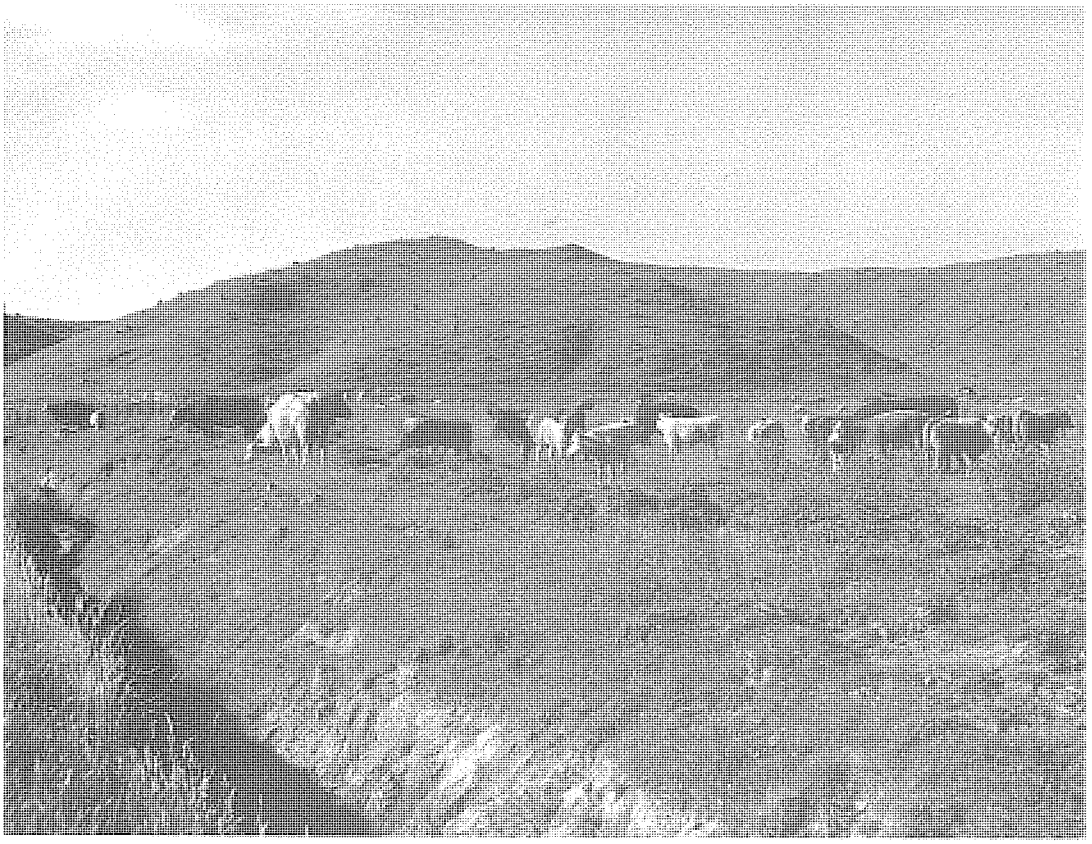


Figure 10: IIIw3 on poorly drained valley floor. VIc1 on hills Pakihi Rd, near Raetihi. N121 850451 looking N.

Figure 11: IIIe5 on rolling slopes. IVe6 on strongly rolling slopes in foreground. Near Ohakune. N121 946480 looking SW.

Figure 12: IVe6. Near Raetihi. N121 808425 looking NW.

LUC UNITS ON ROLLING TO MODERATELY STEEP SLOPES

LUC units IIIe5, IVe6 and VIc1 are differentiated on slope angle.

LUC unit IIIe5 (9700 ha)—Figure 11

This unit is mapped on 8 to 15° slopes which have a potential for slight to moderate sheet and rill erosion when cultivated but have an insignificant erosion potential when in pasture. Intensive grazing and vegetable cropping are the main land uses. The potential stock carrying capacity is 21 su/ha and the site index for *P. radiata* is 27–28 m.

LUC unit IVe6 (11,950 ha)—Figures 11, 12

LUC unit IVe6 differs from LUC unit IIIe5 by occurring on steeper slopes, and having a greater erosion potential. Slopes are dominantly between 16 and 20° with a potential for severe sheet and rill erosion when cultivated, although there is negligible erosion risk when in pasture. Soil erosion can be minimised by maintaining the LUC unit in pasture for long periods and cultivating along the contour. IVe6 is seldom utilised for vegetable cropping. Intensive grazing is the dominant land use although in hill country some IVe6 is undeveloped or has reverted to manuka scrub. The potential stock carrying capacity is 21 su/ha and the site index values for *P. radiata* are 27–28 m.

LUC unit VIc1 (18,200 ha)—Figure 10

This comprises strongly rolling to moderately steep rounded slopes with yellow-brown loam soils developed on Tongariro tephra mantling stable Tertiary aged lithologies or Quaternary lahars. VIc1 occurs at 550–650 m a.s.l. in two main areas:

1) the low rounded hills south of Ohakune and Raetihi;

2) the ridge crests of hill country west of Raetihi.

Table 11: Relationship between LUC, slope, rainfall, altitude and potential cropping, pastoral and forestry use on the yellow-brown loam subsuite in the Waimarino district

LUC Unit	Slope	Rainfall (mm pa)	Altitude (m asl)	Potential cropping uses	Potential stock carrying capacity (su/ha)	*P. radiata* Site Index (m)	Erosion when cropped	Potential under pasture
IIc1	0–3°	1000–1400	350–550	Wheat, barley, oats, peas. Root and brassica vegetable crops, potatoes. Root and green fodder crops	26	30–33	0	0
IIIc1	0–3°	1400–1700	550–750	Root and brassica vegetable crops, potatoes, peas. Root and green fodder crops. (Wheat, oats, and barley marginal).	22	27–28	0	0
IVc1	0–3°	1700–2000	750–1000	Root and brassica vegetable crops, potatoes. Root and green fodder crops. (Barley and oats marginal).	16	23–24	0	0
IIIe5	8–15°	1400–1700	Mostly 600–650	Same as IIIc1	22	27–28	Slight sheet & rill	0
IVe6	16–20°	1400–1700	Mostly 600–650	Same as IIIc1	22	27–28	Severe sheet & rill	0
VIc1	16–25°	1400–1700	Mostly 550–650	N/A	17	26	N/A	Slight slip & sheet

Although VIc1 is not suited to cultivation for cropping it is potentially the most productive pastoral hill country LUC unit in the Waimarino district. The potential stock carrying capacity is 17 su/ha and the site index for *P. radiata* 26 m. There is a potential for slight soil slip and sheet erosion.

1b LUC Subsuite on Yellow-brown Loams in the King Country

This subsuite occurs mainly in the Ohura area and discontinuously between Ohura, Matiere and Otangiwai. Also between Ohura and the Wanganui River in the vicinity of Kirikau. These areas are beyond the influence of Taupo airfall tephra which dominates LUC on flat to moderately steep slopes elsewhere in the King Country. This subsuite comprises LUC units IIs4, IIIe1, IVe1 and VIs1 which together account for 10,500 ha (0.4%) of the region. The distribution of the subsuite is shown in Figure 13.

Because the climate is relatively uniform throughout the subsuite, land use capability units are differentiated on slope angle as this is the principal factor determining land use and the range and intensity of soil conservation measures required. This contrasts with other LUC units in the yellow-brown loam suite which are differentiated principally on climatic factors related to rainfall and altitude.

A greater proportion of this subsuite comprises rolling to moderately steep land than on other yellow-brown loam subsuites. Only 600 ha (5.7%) is flat or gently undulating compared with 45% in the Waimarino subsuite.

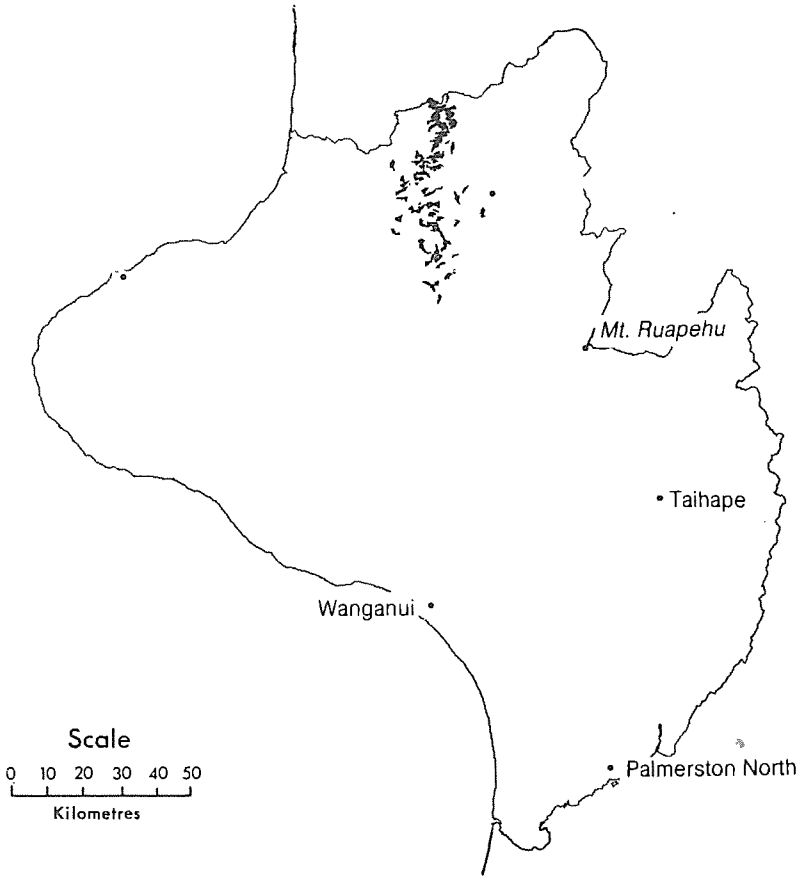


Figure 13: Location of LUC subsuite 1b: yellow-brown loams in the King Country.

Physiography

This subsuite comprises mainly rolling to moderately steep slopes mantled with andesitic tephra. The tephra covers a variety of landforms, the most significant being long dip slopes of banded mudstone aligned subparallel to the bedding plane. Most of the subsuite occurs

between about 300–500 m a.s.l. with limited areas also of flat river terraces at about 150 m a.s.l.

Climate

The Ohura rainfall station, (152 m a.s.l.) records an average annual rainfall of 1900 mm.p.a. (Thompson 1984) with the wettest months (May, June and July) receiving 31% of the annual total. In contrast January, February and March together receive 18% of the annual total and experience periodic soil moisture deficits. Temperatures are typical of inland locations in the King Country with characteristically warm day time temperatures in summer and relatively cool night time temperatures during winter.

Soils

The yellow-brown loam soils which characterise this subsuite are developed on weathered andesitic tephra (Rijkse and Wilde 1977).

Soils recorded were from the Provisional soil maps of the King Country Land Use Study (Scale 1:63,360). In this survey soils were subdivided into the following soil series according to the underlying rock type (Rijkse and Wilde 1977).

1) Aria series developed on andesitic tephra on mixed alluvium.
2) Waihuka series developed on andesitic tephra on indurated sandstone or silty fine sandstone.
3) Tangitu series on andesitic tephra on banded mudstone or sandstone.
4) Matiere series on andesitic tephra on mudstone.

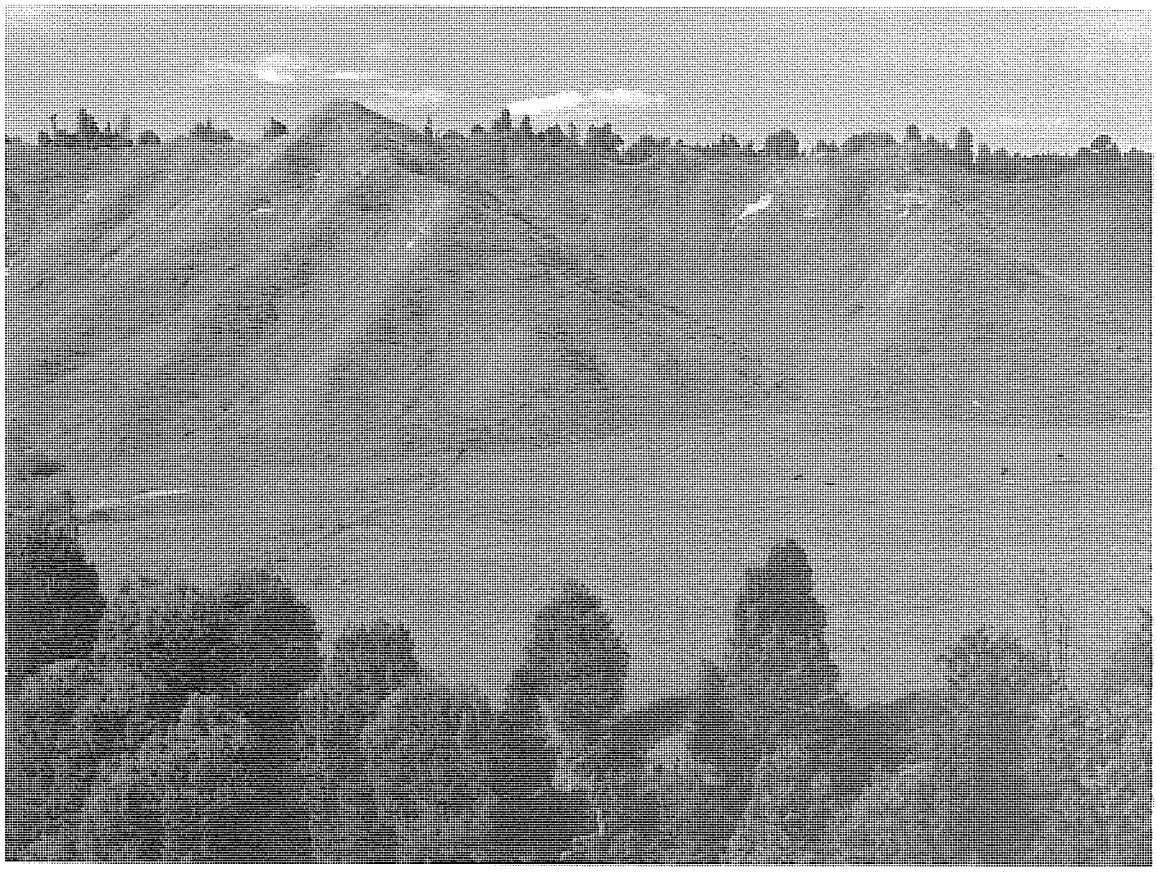


Figure 14: IIs4 on river terrace with VIe10 (LUC subsuite 10a) in distance. Wanganui River Rd, Kirikau district. N111 635990 looking N.

Erosion

Erosion is not a significant problem on this subsuite.

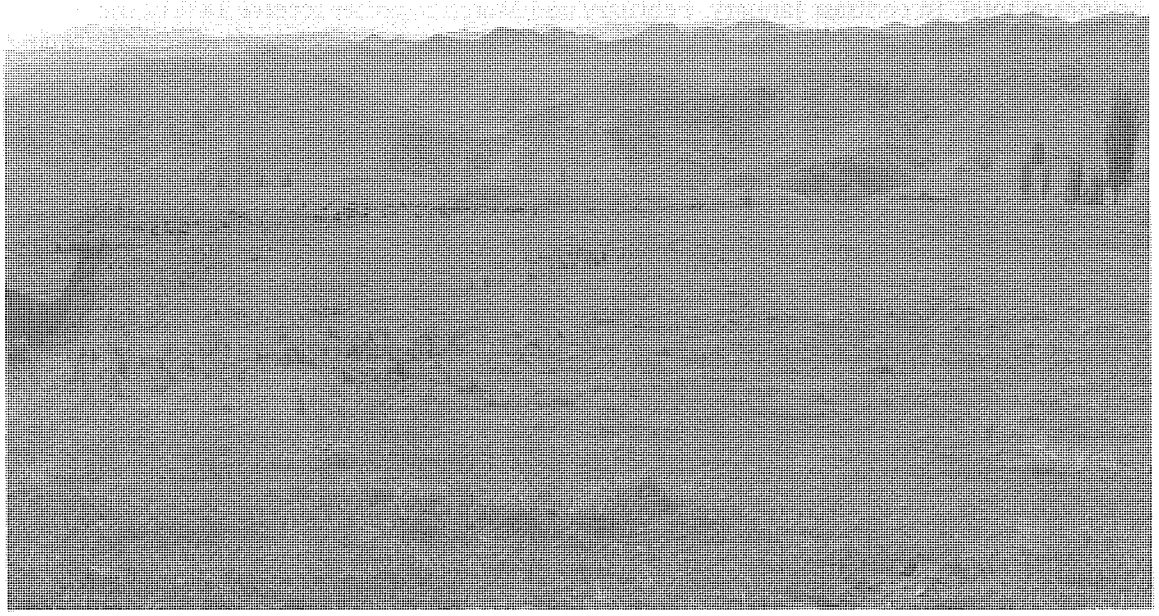


Figure 15: IIIe1 (foreground) VIe17 (LUC subsuite 11e) in distance. Otuiti Rd, Tokirima district. N101 609061 looking N.

Figure 16: VIs1 south of Ohura. N100 513171 looking NW.

Land Use

Dairying was previously an important land use particularly in the Ohura and Matiere areas, however the dominant land use is now intensive sheep and cattle farming. Isolation, and lack of knowledge on the suitability of potential crops appear to be the main constraints precluding intensive cropping and horticultural use.

LUC unit IIs4 (600 ha)—Figure 14

This unit occurs on terraces and gently undulating colluvial slopes, adjacent to the Wanganui River between Kirikau and Tawhata, and beside the Otuiti Stream near Koiro. The Aria series soils are recorded.

IIs4 is suited to intensive cropping and horticulture. The recent establishment of a kiwifruit orchard on this unit indicates the potential for intensification and diversification of land use, however virtually all is at present used for intensive grazing and occasional cereal and root and green fodder crops. In some instances the Wanganui River or deeply incised streams have posed access difficulties and only rough grazing is possible. The potential stock carrying capacity is 24 su/ha. This unit also has a high suitability for exotic forestry (site index for *P. radiata* 30–32 m.)

LUC unit IIIe1 (1400 ha)—Figure 15

This unit occurs on rolling tephra-mantled slopes south and east of Ohura, particularly in the Tokirima, Aukopae, Koiro and Otangiwai areas. The principal soils mapped on IIIe1 are the Matiere and the Aria series. IIIe1 is suited to horticulture and to cropping uses with the constraint of slight to moderate sheet and rill erosion when cultivated. This can however be minimised by soil conservation measures such as contour cultivation. The potential stock carrying capacity is 22 su/ha and the site index for *P. radiata* is 30–32 m.

LUC unit IVe1 (3200 ha)

This unit occurs on strongly rolling downlands which mainly occur between Ohura, Matiere and Otangiwai; south of Ohura, between Ohura and the Wanganui River, and east of Tawhata. The dominant soils are the Matiere and Tangitu series. When cultivated the unit has a severe sheet and rill erosion potential. This can be minimised by cropping occasionally and using contour cultivation, or zero tillage techniques.

IVe1 has a potential stock carrying capacity of 20 su/ha and the site index for *P. radiata* is 30–32 m.

LUC unit VIs1 (5300 ha)—Figure 16

This unit comprises strongly rolling to moderately steep hills with yellow-brown loam soils, occurring mainly north of Ohura, particularly between Ohura and Matiere, and in the Otangiwai district. Dominant soils are the Waihuka, Tangitu and Matiere series developed on approximately 45 cm of andesitic tephra over varying Tertiary aged rock types.

The rock types underlying the tephra include banded mudstones or siltstones, massive mudstones and fine siltstones and massive sandstones or siltstones. Each of these rock types has different erosion characteristics and gives rise to soils with differing natural fertility but the presence of the andesitic tephra 'masks' these effects. As a result VIs1 is the most stable and among the most productive of the hill country LUC units in the King Country.

Most of VIs1 has been developed for pastoral farming. About 70% is dominantly in pasture while the remainder is grassland-forest or grassland-scrub. The potential stock carrying capacity is 18 su/ha and the site index for *P. radiata* is 27–29 m.

1c LUC Subsuite on Yellow-brown Loams Occurring on Inland Plateaux

This subsuite comprising LUC units IVw3 and VIe22 is mapped on plateaux in the Waitaanga and Mt Damper areas of inland Taranaki. VIe22 is more extensive, being mapped

also in the vicinity of the Kiwi and Mangatoro Roads in Taranaki, in the Matemateaonga Range, and in the Ruatiti-Erua area of the Waimarino district. The distribution of this subsuite is shown in Figure 17. High rainfall and cool temperatures associated with a generally high altitude limit cropping, pasture and forestry productivity and distinguish it from other yellow-brown subsuites in the region. The subsuite covers 14,800 ha (0.6%) of the region.

Physiography

This subsuite comprises the remnants of an old uplifted peneplain surface which is gently tilted to the west and south. The landscape is characterised by strongly rolling to moderately steep slopes which in Taranaki are interspersed with basin areas that have undulating to rolling slopes.

Climate

This subsuite occurs between 300–700 m a.s.l. and has a rainfall of approximately 2000–3000 mm p.a. At this altitude cool winter temperatures (including occasional snowfalls) restrict winter pasture growth. The only specific climatic data available are from the Mt Damper rainfall station (320 m a.s.l.) where the annual rainfall normal is 2200 mm p.a (NZ Met Service 1984).

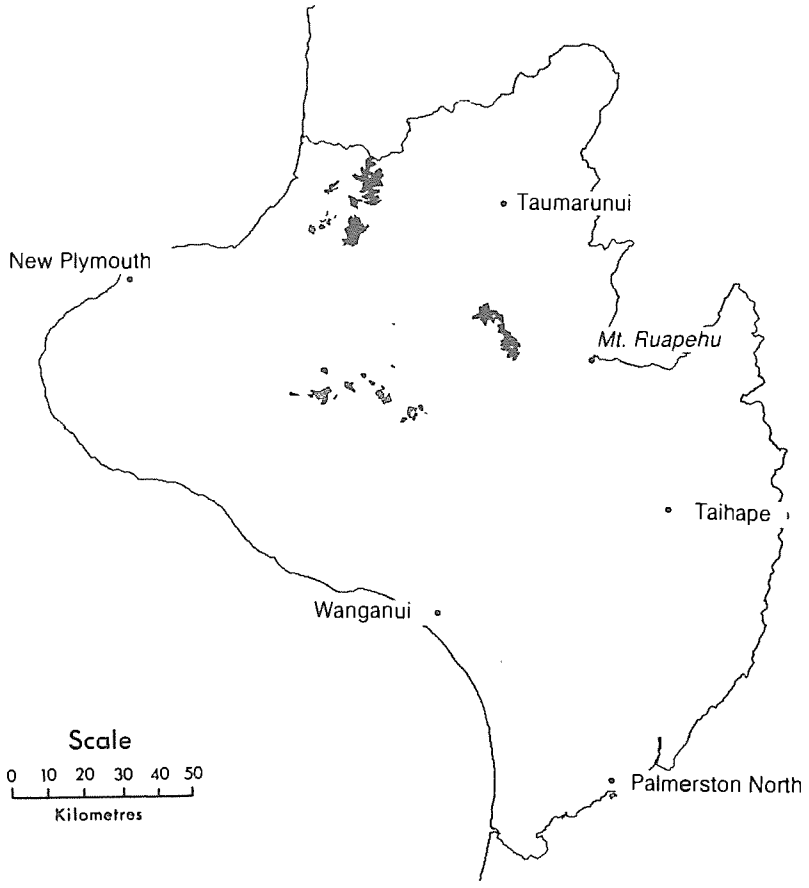


Figure 17: Location of LUC subsuite 1c: yellow-brown loams on inland plateaux.

Soils

The yellow-brown loam soils in this subsuite are developed on andesitic tephra from two main sources. In Taranaki the New Plymouth series occur on andesitic tephra from Mt Egmont, while in the Waimarino district the Ohakune series are developed from Tongariro tephra. The Pokaka series is recorded where there is a thin mantle of Taupo tephra over Tongariro tephra. The Mapiu series from weathered rhyolitic and andesitic tephra was recorded in the Waitaanga area. These soils have also been classified as Marokopa—Onaio

soils (yellow-brown earths) (Orbell 1973). Future, more detailed soil surveys may reveal that these soils in the Waitaanga area have physical and chemical properties very similar to those of the New Plymouth series mapped some 10 km south-west in the Mt Damper area. Gley soils on IVw3 are mapped as the Kaikarangi series in the Mt Damper area, or the Wairua series near Waitaanga.

Although the soils on this LUC subsuite occur on other subsuites of lower rainfall and altitude, IVw3 and VIe22 were established in the classification to take account of the harsher climate and lowered agricultural productivity. For example IVw3 has a potential stock carrying capacity of only 16 su/ha. This compares with 20 su/ha on both IVe7 (New Plymouth series) and IVe1 (Mapiu series), and 18 su/ha on IVw2 (also with Kaikarangi series soils).

Erosion

Erosion is only a minor constraint to agricultural and forestry use. IVw3 was assessed as having negligible erosion, although undulating and rolling slopes have a potential for slight sheet and rill erosion when cultivated for cropping or pasture renewal. There is a potential for slight to moderate soil slip erosion on VIe22.

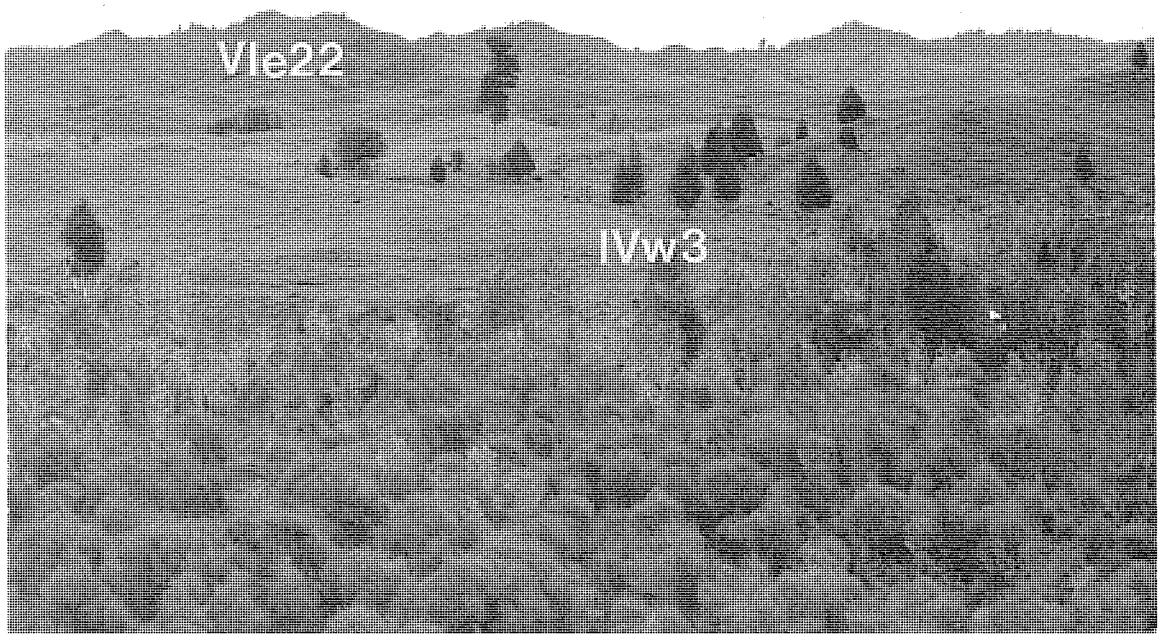


Figure 18: IVw3 (at 350 m a.s.l.) comprising a complex of undulating to rolling slopes with yellow-brown loam soils and flat poorly drained areas with gley soils. VIe22 in distance. Mt Damper, north of Tahora. N 100 321075 looking W.

Land Use and Vegetation

This subsuite occurs in isolated areas with difficult access. For these reasons and because the indigenous forest had comparatively low volumes of merchantable timber, forest milling commenced later than in other areas. Much of the subsuite remains in forest although in more accessible areas the forest has been logged and then cleared for farming.

A major problem on farmed land is reversion to fern and scrub, inadequate subdivision and fertiliser use, and poor grazing management. The Lands and Survey Department acquired

2050 ha of marginal farm units in the Mt Damper area in 1960. These were settled as four sheep and beef farms in 1982. A small *P. radiata* forest has been established on IVw3 adjacent to Waitaanga North Road.

LUC unit IVw3 (4700 ha)—Figure 18

This LUC unit is a complex of undulating to rolling slopes with yellow-brown loam soils and flat, low lying, poorly drained land with gley soils. It occurs on flat to rolling plateau areas at 300–400 m a.s.l. in the Waitaanga and Mt Damper areas.

Pasture is the dominant vegetation, and small areas are dominated by cutover lowland podocarp-hardwood forest or manuka scrub and fern.

Root and green fodder crops and root and brassica vegetable crops are suited to the undulating to rolling components of this unit although excess wetness would be a restriction in low lying areas. Effective drainage of the gley soils is difficult because of low gradients and lack of drainage outlets. The potential stock carrying capacity is 16 su/ha and the site index for *P. radiata* is 25–27 m.

LUC unit VIe22 (10,100 ha)—Figure 18

This unit occurs between 300 and 700 m a.s.l. on strongly rolling and moderately steep slopes where sandstone or siltstone lithologies are mantled with andesitic tephra.

Thirty eight percent of VIe22 is dominantly pasture. The remainder is mainly fern, scrub or cut-over forest. The 3150 ha of VIe22 in the Matemateonga Range is almost exclusively in podocarp-hardwood forest.

VIe22 cannot be safely cultivated for cropping, although some slopes could be occasionally cultivated for pasture renewal. Slight soil slip or sheet erosion was recorded on map units covering 22% of the total VIe22 area. The potential erosion severity is assessed as slight to moderate. Areas susceptible to soil slip erosion should be open planted with erosion control trees and adequately protected from animal damage.

The potential stock carrying capacity of VIe22 is 13 su/ha and the site index for *P. radiata* is 25–27 m.

1d LUC Subsuites on Yellow-brown Loams in Taranaki

Eighteen LUC units are recognised in this subsuite and are differentiated on the following slope criteria (Table 12):

1) LUC units on flat to undulating slopes. Climate is the dominant limitation
2) LUC units on undulating to very steep slopes. Erosion is usually considered the dominant limitation.

Together the 18 LUC units in the subsuite cover 276,550 ha (11.5%) of the region. The distribution of the subsuite is shown in Figure 19.

Physiography

The yellow-brown loam subsuite in Taranaki occur on all three physiographic units recognised by Neall (1982). These comprise the volcanic landforms associated with the Mt Egmont, Pouakai and Kaitake volcanic cones; the uplifted marine terraces of north and south Taranaki; and the fluvially dissected hill country of eastern Taranaki. On the first two landforms the landscape rises gently from sea level to an altitude of 1200 m on the lower slopes of Mt Egmont (2518 m a.s.l.). These dominantly flat and undulating slopes are dissected by streams flowing in a dominantly radial drainage pattern. Stream dissection is quite shallow on the upper ring plain but can become more deeply incised closer to the coast.

Climate

There is a considerable variation in rainfall in the subsuite. Mt Egmont, and to a lesser extent the Pouakai and Kaitake Ranges have a major influence on the rainfall pattern. Strong moisture laden winds from the Tasman Sea are forced to ascend these mountains, producing

Table 12: The relationship between climate, slope and LUC on the yellow-brown loam subsuite in Taranaki

SLOPE	CLIMATIC ZONES WITH APPROX RAINFALL AND ALTITUDE LIMITS					
	<1600 mm p.a.	1000–1400 mm p.a. within 5 km of coast	1600–2000 mm p.a. 60–250 m a.s.l.	2000–2500 mm p.a. 250–400 m a.s.l.	2500–3000 mm p.a. 400–500 m a.s.l.	3000–5000 mm p.a. 500–1200 m a.s.l.
SUBSUITE ON FLAT TO UNDULATING SLOPE						
Flat to undulating	Ic1, Ic3, Iw2	IIc2	IIc3	IIIc4	IVc3	N/A
SUBSUITE ON UNDULATING TO VERY STEEP SLOPES						
Undulating	IIe1	N/A	IIe1	N/A	N/A	N/A
Undulating to rolling	IIIe2	IIIe2	IIIe2	IIIe6	IIIe6	VIc5
Rolling to strongly rolling	IVe2	IVe2	IVe2	IVe7	IVe7	VIe25
Strongly rolling to moderately steep	N/A	N/A	Vc1	Vc1	Vc1	VIe25
Moderately steep	VIe1	VIe1	VIe1	VIe6	VIe6	VIe25
Steep and very steep	N/A	N/A	N/A	N/A	N/A	VIIe18

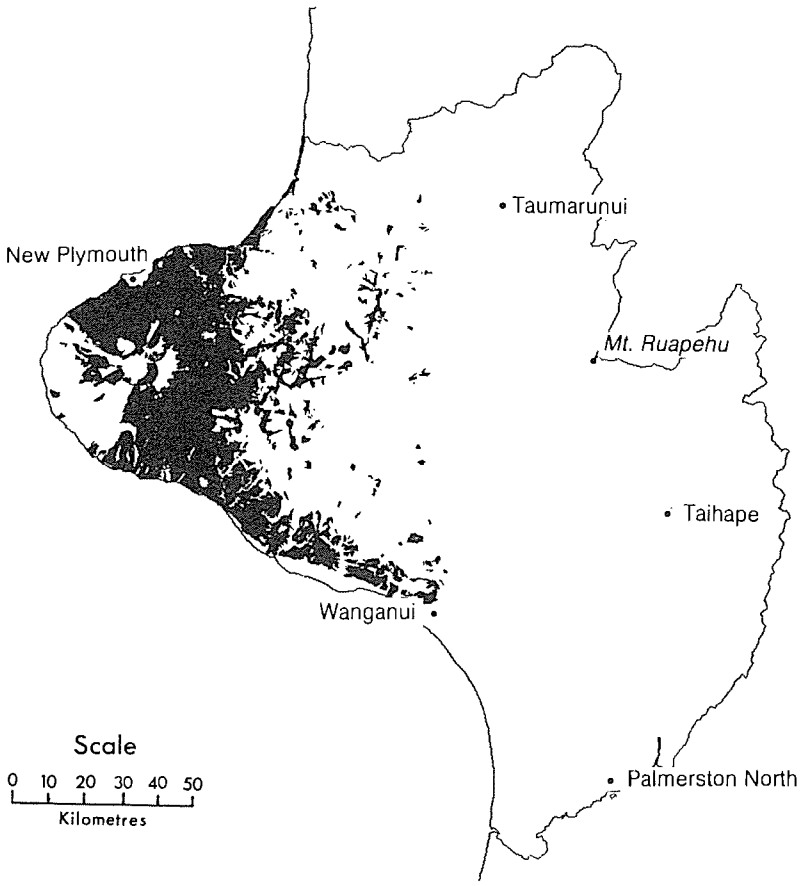


Figure 19: Location of LUC subsuite 1d: yellow-brown loams in Taranaki.

condensation. This results in rainfall as low as 1100 mm p.a. on the coast which increases inland to an estimated 8000 mm p.a. on the upper slopes of Mt Egmont (2518 m a.s.l.).

Temperature is the most important climatic variable determining the suitability of land for crops. Temperatures decrease inland with increasing altitude and rainfall. The diurnal range is between 7°–8°C depending on the season (Table 13). This relatively narrow range indicates the mildness of the Taranaki climate and the absence of extremes in temperature.

Coastal Taranaki experiences few frosts but frosts become more frequent and severe inland (Table 14).

Table 13: Annual temperature means and mean daily temperature range of stations in Taranaki (Source Taranaki Catchment Commission 1981 and Coulter 1976)

Mean	Mean (°C)	Mean maximum daily (°C)	Mean mimimum daily (°C)	Daily range (°C)
New Plymouth	13.6	17.1	9.9	7.2
Patea	13.3	17.2	10.3	6.9
New Plymouth Aerodrome	13.1	17.3	9.3	8.0
Manaia Demonstration Farm	12.5	16.7	8.8	7.9
Stratford Demonstration Farm	11.4	15.9	7.5	8.4
Stratford Mountain House	8.5	13.0	5.0	8.0

Table 14: Average screen frost occurrence of stations in Taranaki (Source NZ Meteorological Service 1973 and Coulter 1976)

Location	Days with Frost												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
New Plymouth							0.1	0.1					0.2
New Plymouth Aerodrome						0.7	0.9	0.3	0.1				2.0
Manaia Dem. Farm				0.8	2.5	1.4	3.3	2.1	0.9	0.2			11.2
Stratford Dem. Farm				0.2	1.0	2.4	4.8	2.5	1.4	0.4	0.1		12.8
Stratford Mt. House*	0.1		0.1	0.6	3.9	10.3	13.6	10.5	5.3	4.1	0.8	0.2	42.9

*Air Frosts

Average annual sunshine hours are available for only three locations. New Plymouth (2102 hours), Manaia Demonstration Farm (2026 hours) and Stratford Demonstration Farm (2026 hours) (Taranaki Catchment Commission 1981). These figures indicate that sunshine hours on the arable units in these subsuites are adequate for outdoor horticultural production.

In coastal areas, especially on LUC unit IIc2 in south Taranaki, the effects on strong wind and salt spray is a constraint to agricultural and forestry use. Boxthorn hedges are extensively used for shelter on pastoral properties. It is particularly important that shelterbelts for horticulture be of a high standard.

Rock Type

The principal soil forming tephras are the "Stratford Shower", a group of pumiceous lapilli showers of Holocene age but not accurately dated; the Oakura Tephra (7170 ± 110 years BP) and the Okato Tephra (between 12950 ± 150 and 16,600 ± 300 years BP). On flat and undulating slopes these tephra overlie up to 30 m of weathered tephra which has accumulated very slowly over the last 100,000 years (Neall 1981).

The Burrell lapilli (1655 AD) and Newall tephra (dated between 1500–1550 AD) are localised and only significant on LUC units IVc3, VIc5, VIe25 and VIIe18. The Burrell Formation ranges in thickness from about 20 cm above Stratford Mountain House to less than 10 cm 2 km beyond the eastern edge of the Egmont National Park boundary. The Newall Formation was deposited as a series of "nuee ardente" type eruptions. Within this Formation the 5 cm isopach of the Waiweranui Ash and the 7.5 cm isopach of the Newall Ash (Neall 1976b) are on some units of VIIe18 occurring within 5 km and 4 km respectively of the Mt Egmont summit. The two lapilli members are most extensive north west of the Mt Egmont summit on LUC suite 2.

Soils

Soils were recorded using information from the soil surveys of Waimate West, Egmont and part Taranaki, and Stratford Counties, and the General Soil Survey.

The distribution of yellow-brown soils in Taranaki has been outlined by Neall (1982). He grouped the soil series on the basis of soil parent materials and physical and chemical properties into those occurring at low, intermediate, and high elevations.

At low elevations on LUC units Ic1, Ic3, IIc2 and IIc3, the principal soils are the Egmont and New Plymouth series. The Egmont series, mapped on the coastal plain in South Taranaki, is developed on andesitic tephra and tephric loess while the New Plymouth series occurs on the north Taranaki coastal plain on deep andesitic tephra.

At intermediate elevations on LUC units IIIc4, IVc3, IIIe6 and IVe7 annual rainfall ranges between 2000 and 3000 mm approx.—depending on altitude. This results in moderately to strongly leached soils with a low pH. The Inglewood, Lowgarth and Rowan series which are sandy textured occur in an arc between Mt Egmont and Inglewood and Stratford. In contrast, the Stratford series is developed on fine textured tephra, and occurs further east.

Within the Egmont National Park at higher elevations annual rainfall increases from approx. 3000 mm on LUC units VIc5 and VIe25 to as much as 7000 mm on VIIe18. Patua and Tahurangi series mapped here are strongly leached. Where only General Soil Survey

information was available the Patua soil set was recorded on undulating to moderately steep slopes, and the Te Kie soil set on steep and very steep slopes.

Erosion

Erosion is not a significant problem on these subsuites.

Non arable units were recorded as having negligible to slight erosion although periodic high intensity rainstorms can result in moderate erosion on Class VI units (Robins 1971). Soil slip, earth slip and sheet are the dominant erosion types on Class VI, while debris avalanche erosion is also significant on long steep forested slopes classified as LUC unit VIIe18 within the Egmont National Park.

Land Use

Dairying is by far the most important land use. The large proportion of small holdings and the high rainfall made dairying an attractive proposition from the time of early settlement. Since the opening of the first cooperative dairy factory in 1885 dairying increased rapidly, so that in 1983 510,000 dairy cattle (16.3% of New Zealand's total) are now carried in Taranaki (Dept of Statistics 1984). Dairying is based on an all-grass farming system using high quality pasture, rotational grazing and high rates of fertiliser application.

There is, however, considerable potential for horticulture particularly on LUC Classes I and II land although in some areas there could be insufficient water for irrigation (Taranaki Catchment Commission 1981). If land on the volcanic ring plain was developed to its highest attainable stock carrying capacity an increase of approximately 50% in the amount of water currently being used for dairying will be required (Jardine 1984).

In the hill country on LUC units VIe1 and VIe6 sheep and beef farming is the dominant land use. Intensive management is necessary to enable high fertility pastures to successfully compete against the natural reversion to low fertility demanding pasture species, and fern and manuka. LUC units VIc5, VIe25 and VIIIe18 are in the Egmont National Park and therefore are not used for pastoral or forestry production.

Vegetation

High producing pasture or cropland dominates LUC units Ic1, Ic3, IIe2, IIc2, IIc3, IIIe2 and IIIe6. On the remaining LUC units scrub and indigenous forest vegetation become increasingly important with increasing slope angle, altitude and rainfall. For example, IIIc4 has a combination of grassland-scrub, grassland-forest or forest dominant on map units covering only 9.0% of the IIIc4 area. This compares with IVc3 where forest, grassland-scrub, or grassland-forest predominate on map units covering 28% of the LUC unit. LUC units IVe2 and IVe7 have 85% and 66% respectively of their map unit areas in pasture. As slopes increase to become moderately steep to steep on LUC units VIe1 and VIe6 the proportions of the map unit areas dominantly in pasture drop to 43% and 29% respectively.

All of LUC units VIc5, VIe25 and VIIe18 are within the Egmont National Park. The vegetation on these varies with altitude. Lowland podocarp-hardwood forest, and broadleaf forest occur at lower elevations (VIc5 and VIe25). This grades into mid altitude podocarp-hardwood forest and finally subalpine scrub with increasing altitude (VIIe18). The vegetation of the Egmont National Park is described by Druce (1976) and for the Kaitake Range by Clarkson (1985).

LUC UNITS ON FLAT AND UNDULATING SLOPES IN TARANAKI

This comprises a climosequence of seven LUC Units (Figure 20) mapped on deep, well drained yellow-brown loams in Taranaki. In this sequence, LUC units Ic1, Ic3, IIc2, IIc3, IIIc4 and IVc3 are mapped on flat and undulating slopes, and VIc5 on undulating to rolling slopes. Together the seven LUC units cover 137,400 ha (5.7%) of the region.

Within the climosequence the effect of rainfall on LUC is illustrated in Table 15. Slope, parent material and erosion type and degree are relatively uniform while rainfall is the

principal climatic variable. Within this rainfall range temperatures are mild although frosts become more frequent inland and with increasing altitude. As rainfall increases from <1400 mm p.a. (Ic1) to >3000 mm p.a. (VIc5), there is a decrease in the range of crops and in the potential for pastoral and forestry production.

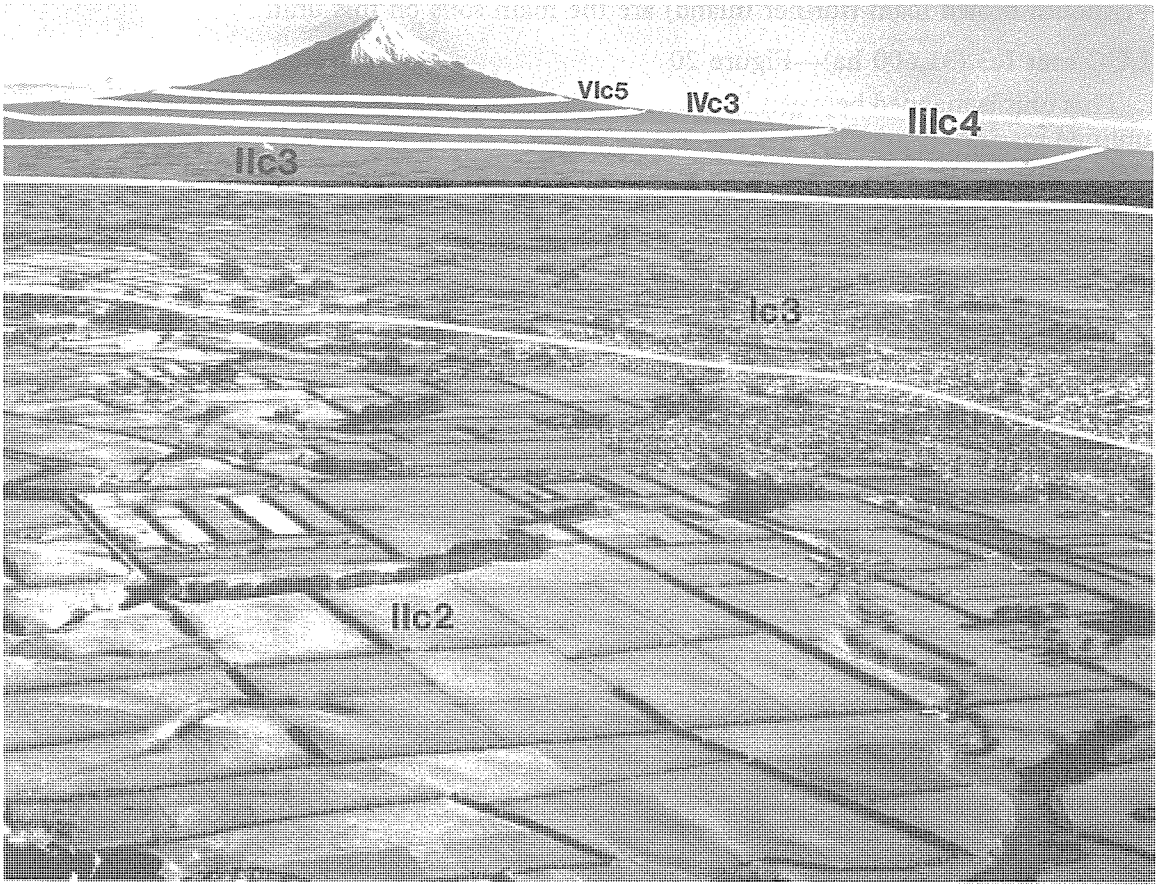


Figure 20: A climosequence of LUC units on the south Taranaki ring plain. N129 830240 looking N.

Photo: NZ Aerial Mapping

Table 15: The relationship between climate and land use capability on a sequence of LUC units occurring on flat and undulating slopes on deep well drained yellow-brown loams in Taranaki

LUC unit	Rainfall (mm p.a.)	Climatic factors	Potential cropping uses	Potential su/ha	Site index (m)
Ic1	1400–1600		Subtropical fruit; citrus fruit;	30	27–30
Ic3	1100–1400		berry fruit; nurseries; vegetables; potatoes; cereals (incl. maize); root and green fodder crops.	30	29–32
IIc2	1100–1400	Occurs within 5 km of the coast. Shelterbelts required to minimise effect of prevailing SW winds and salt spray on crops.	Berry fruit; nurseries; vegetables; potatoes; cereals; root and green fodder crops.	28	20–28
IIc3	1400–2000	Increasing altitude results in cooler winter temperatures and a shorter growing season.	Berry fruit; nurseries; vegetables; potatoes; cereals; root and green fodder crops.	30	27–30
IIIc4	2000–2500		Vegetables (brassica and root crops only); potatoes; root and green fodder crops.	25	27–32
IVc3	2500–3500		Root and green fodder crops.	21	23–27
VIc5	3500–4500		Unsuitable	16	22–23

LUC unit Ic1 (8750 ha)

This unit is mapped between Okato and Pukearuhe on uplifted marine terraces and remnants of the Pouakai ring plain. Ic1 is below 60 m a.s.l. and receives an annual rainfall of between 1400–1600 mm p.a. The New Plymouth black loam (near the coast) and the New Plymouth brown loam (further inland) are the main soils on this unit.

LUC unit Ic3 (31,600 ha)—Figure 20

This unit is mapped between Pihama and Wanganui on areas of the Egmont ring plain and uplifted marine terraces that are between 5–15 km inland from the coast. It was differentiated from Ic1 because of the greater hazard from wind and its effect on cropping, (land within 5 km of the south Taranaki coast is classified as IIc2). Climatically Ic3 also differs from Ic1 by having a lower rainfall of about 1100–1400 mm p.a.

The dominant soil is the Egmont brown loam developed on andesitic tephra and tephric loess. Also included are the Westmere soils which are developed on a mixture of tephric and quartzo-feldspathic loess. These are classified as intergrades between yellow-brown loams and brown granular loams (Wilde 1976) but have similar physical properties to yellow-brown loams.

On both Ic1 and Ic3 shelterbelts are essential for the successful growing of horticultural crops. However shelterbelts can be difficult to establish and artificial shelter may be necessary. Although Ic1 and Ic3 have the potential to grow the same crops Ic3 requires more intensive shelterbelt planting to overcome the limitations imposed by its greater susceptibility to wind. Ic1 and Ic3 both have potential stock carrying capacities of 30 su/ha. The site index (S.I.) values however differ between units. On LUC unit Ic1 the S.I. is 27–30 m while on LUC unit Ic3 it varies between 29–32 m depending on distance from the coast.

LUC unit IIc2 (12,050 ha)—Figures 20, 21

This unit is mapped within approximately 5 km of the south Taranaki coast where prevailing strong south-westerly winds and accompanying salt spray limit plant growth. Shelterbelts are essential if maximum crop yields are to be obtained. This climatic effect results in a reduced range of cropping uses and a slight reduction in potential stock carrying capacity to 28 su/ha from the 30 su/ha on LUC units Ic1, Ic3 and IIc3. The Site Index for *P. radiata* increases from 20 metres at the coast to 28 metres 5 km inland, further indicating the influence of wind and salt on plant growth. The Egmont black loam and Egmont brown loam are the main soils.

LUC unit IIc3 (28,000 ha)—Figures 20, 22

This unit differs from IIc2 by having a generally higher rainfall of between 1400 and 2000 mm p.a. and not being adversely affected by strong south-westerly winds and salt spray. IIc3 occurs in three distinct areas; in north Taranaki, south Taranaki, and on the uplifted marine terraces between Hawera and Kai-iwi.

In north Taranaki, IIc3 occurs immediately inland of Ic3, between 60–170 m altitude. In south Taranaki, the unit is most extensive between 170–270 m altitude which is principally in a zone that extends from west of Riverlea and Kaponga east to Eltham.

On the uplifted Brunswick and Kaiatea marine terraces IIc3 occurs immediately inland of Ic3 and IIc2 at an altitude of 150–250 m and with a rainfall of between 1100 and 1400 mm p.a. In this area IIc3 is more exposed to strong winds than elsewhere in Taranaki.

Although IIc3 is mapped in different locations with slightly differing climate it has the potential to grow similar crops. The potential stock carrying capacity is 30 su/ha, while the site index for *P. radiata* varies between 27 and 30 m depending on exposure to wind, and altitude. The dominant soils are the New Plymouth, Egmont and Stratford series.

LUC unit IIIc4 (34,950 ha)—Figure 20

This unit is mapped where rainfall is between approximately 2000–2500 mm p.a. The largest area of IIIc4 occurs on the ring plain between Inglewood and Stratford. However it is

Figure 21: IIc2 adjacent to the south Taranaki coast. Note the boxthorn hedge shelterbelts. Raine Rd near Manaia. N129 764293 looking SW.

Figure 22: IIc3 (at 200 m a.s.l.) Skeet Rd, near Kaponga. N119 730400 looking N.

also mapped in other areas at a slightly higher altitude closer to Mt Egmont and within the eastern Taranaki hill county. These areas have higher rainfall, cooler temperatures, greater frequency of frost and a shorter growing season than LUC Classes I and II in this subsuite. This results in a restricted range of potential crops (Table 15) and a reduction in potential stock carrying capacity to 25 su/ha. The site index for *P. radiata* is 27–32 m. The dominant soils on IIIc4 include the Stratford, Inglewood, Lowgarth, Patua and Kahui series.

LUC unit IVc3 (19,700 ha)—Figure 20

This unit has a rainfall of 2500–3000 mm p.a. and occurs at an altitude of between 400–500 m a.s.l. adjacent to the Egmont National Park boundary. The high rainfall and lower temperatures at this altitude result in IVc3 having an even shorter growing season than IIIc4. The reduction in winter pasture production necessitates later calving and earlier drying off of dairy cows, and reduces the potential stock carrying capacity to 21 su/ha. The site index for *P. radiata* varies between 23 and 27 m according to altitude and the degree of exposure. The cropping potential is limited to root and green fodder crops. The Patua, Rowan and Stratford series are the dominant soils.

LUC unit VIc5 (800 ha)—Figure 20

This unit differs from other LUC units in this climosequence by occurring on undulating to rolling slopes and having climatic limitations that are so severe that arable cropping is precluded.

As it lies within the Egmont National Park, all of VIc5 is undeveloped. Cool temperatures, high rainfall (4000 mm p.a. approx.) and low sunshine hours limit the growing season. It has a low site index of 22–23 m for *P. radiata* and a potential stock carrying capacity of 16 su/ha. Large inputs of fertiliser would be required to establish and maintain pastures.

Soils are mainly strongly leached yellow-brown loams of the Rowan and Patua series and recent soils of the Newall series. In some areas the soils are stony but climate is still considered the dominant limitation.

LUC unit Iw2 (1,550 ha)

Within the area mapped as Ic3 are 1000 ha in the Oeo-Manaia and 550 ha in the Westmere area with mottled soils. These are mapped as Iw2. This unit occurs on flat to gently undulating slopes which require artificial drainage for intensive cropping use. Even after drainage a continuing very slight wetness limitation may result in Iw2 being slightly less versatile for cropping than Ic3. The stock grazing capacities and exotic forest growth potentials are, however, the same as for Ic3. The dominant soils are the Westmere mottled silt loam and the Egmont brown loam, strongly mottled subsoil phase. A further 300 ha also classified as Iw2 occurs in the Marton area in the high rainfall loess suite.

LUC UNITS ON UNDULATING TO VERY STEEP SLOPES

The following ten LUC units are recognised on undulating to very steep slopes: IIe1, IIIe2, IIIe6, IVe2, IVe7, Vc1, VIe1, VIe6, VIe25 and VIIe18. Together they cover 139,050 ha (5.7%) of the region.

These LUC units can be further grouped (Table 12) into three climatic zones as follows:

1. Rainfall below 2000 mm p.a. and altitude generally below 250 m a.s.l. (LUC units IIe1, IIIe2, IVe2, VIe1).
2. Rainfall between 2000 and 3000 mm p.a. and altitude between 250 and 500 m a.s.l. (LUC units IIIe6, IVe7, Vc1, VIe6).
3. Areas in the Egmont National Park with rainfall 3000–6500 mm p.a. (LUC units VIe25 and VIIe18).

The rationale for reducing the number of climatic zones and hence the possible number of LUC units on undulating to very steep slopes compared to flat and undulating slopes is as follows:

1. Most of the map units with undulating to very steep slopes occur in hill country or the Egmont National Park, where detailed climatic data are not available.
2. There is considerable micro-climate diversity related to relief.
3. Eighty percent of the map units with undulating to very steep slopes are either unsuitable or have severe limitations for arable use.
4. The range of crops able to be grown on IIe2, IIIe2 and IIIe6 is constrained by slope and erosion hazard as well as by climate.

LUC unit IIe1 (10,050 ha)

This unit is mapped below 250 m a.s.l. on undulating slopes in North and South Taranaki that receive annual rainfalls of less than 2000 mm p.a. Egmont brown loam soils predominate in south Taranaki while in north Taranaki the New Plymouth black loam is mapped near the coast and New Plymouth brown loam further inland.

There is a potential for negligible erosion under pasture and slight sheet and rill erosion when cultivated.

At present most of this unit is used for dairying; although there is some horticulture particularly subtropical fruit, nurseries, berry fruit, and vegetable cropping. Cereals (including maize) are also grown. The range of potential crops is the same as for LUC units Ic1, Ic3, IIc2 or IIc3 depending on the microclimate in which individual IIe1 map units occur. The potential stock carrying capacity is 28 su/ha and the site index for *P. radiata* is 27–30 m.

LUC unit IIIe2 (9,300 ha)—Figure 23

This unit occurs on undulating to rolling slopes generally below 250 m a.s.l. in areas with an annual rainfall of less than 2000 mm.

IIIe2 differs from IIe1 by having steeper slopes, contributing to a greater potential (slight to moderate) for sheet and rill erosion when cultivated. Dairying is the predominant land use although there is a potential for some horticultural and arable crops. The potential stock carrying capacity is 23 su/ha and the site index for *P. radiata* is 27–30 m.

The dominant soils are the New Plymouth and Egmont series.

LUC unit IIIe6 (7150 ha)

This unit is similar to IIIe2 in that it occurs on undulating to rolling slopes and has a potential for slight to moderate sheet and rill erosion when cultivated. However, it differs by being located at a higher altitude (approx. 250–500 m a.s.l.) and having greater annual rainfall (approx. 2000–3000 mm p.a.). These climatic constraints reduce the range of potential crops to potatoes, root and brassica vegetable crops and root and green fodder crops. Very little cropping however is practised and dairying is the dominant land use. The potential stock carrying capacity is 22 su/ha and the site index for *P. radiata* is 29–32 m.

The dominant soils are the Inglewood, Stratford, Lowgarth, Rowan and Kahui series. These soils are moderately to strongly leached. On the eastern side of Mt Egmont they also tend to be coarse textured.

LUC unit IVe2 (11,150 ha)—Figure 24

This unit is mapped on rolling to strongly rolling downlands with an annual rainfall between 1000–2000 mm and an altitude of less than 250 m a.s.l.

Negligible erosion was recorded throughout the unit as it is almost wholly in pasture, however if cultivated, moderate to severe sheet and rill erosion could occur making it marginal for cropping. This erosion could be minimised by intensive soil conservation measures such as contour cultivation, and minimum tillage. Dairying is the main land use, with cropping normally restricted to root and green fodder crops. The potential stock carrying capacity is 21 su/ha and the site index for *P. radiata* is 27–30 m. The dominant soils are the New Plymouth and Egmont series.

Figure 23: IIIe2 on rolling slopes. Tatanga Rd, near Hawera. N129 872273 looking N.

LUC unit IVe7 (21,750 ha)—Figure 25

This unit is similar to IVe2 as it also occurs on rolling and strongly rolling slopes, but because of its higher altitude (250–500 m a.s.l.) and increased rainfall (2000–3000 mm p.a.), IVe7 has greater climatic limitations.

The erosion potential is similar to that of IVe2. The combination of erosion hazard and climatic limitations make this unit marginal for cropping, therefore generally only root and green fodder crops are grown as part of a pasture renewal programme. Dairying is the dominant land use. The potential stock carrying capacity is 20 su/ha and the site index for *P. radiata* varies between 25 m and 32 m depending on the altitude and exposure of individual map units. The dominant soils recorded are the Lowgarth, Rowan, Patua, Inglewood and New Plymouth series.

LUC unit Vc1 (31,000 ha)—Figures 26, 28, 113

This unit comprises low hills with strongly rolling to moderately steep slopes. It occurs on two different rock types and locations in Taranaki:

1) In the Toko area on Tertiary aged sandstone mantled with >1 m of tephra.
2) On deep tephra on the volcanic ring plain; including the redeposited tephra of the Katikara Formation (Neall 1975).

Because of the slope angle, friable soil consistency and high rainfall (approx. 2000 mm p.a.), Vc1 has an extreme potential for sheet and rill erosion hazard when cultivated. However, with application of soil conservation measures such as contour cultivation or zero tillage, Vc1 could be cultivated for pasture renewal. With pastoral land use there is a potential for only slight sheet and soil slip erosion.

Potentially this one of the most productive non arable LUC units in the region, as it has a potential stock carrying capacity of 19 su/ha and a site index for *P. radiata* of 27–29 m.

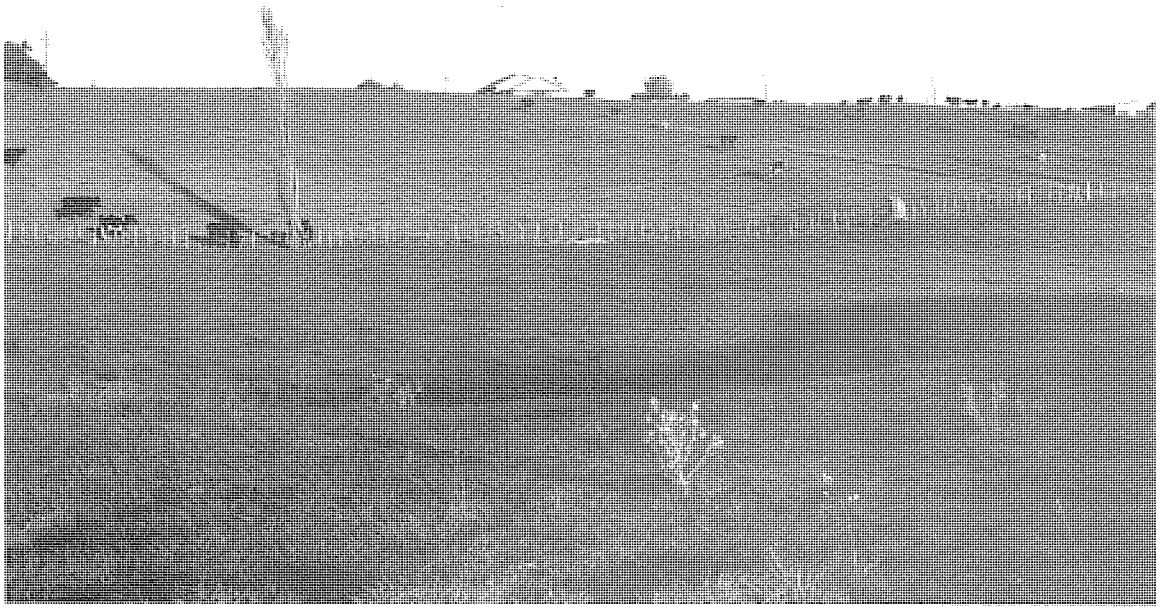


Figure 24: IVe2 on rolling and strongly rolling slopes. Austin Rd, near Hawera. N129 865345 looking SE.

Dairying is the dominant land use, although sheep and beef farming are also important. The dominant soils are the New Plymouth, Egmont and Stratford series.

LUC unit VIe1 (10,200 ha)—Figure 27

This unit comprises moderately steep slopes mantled with yellow-brown loam soils in areas with less than 2000 mm p.a. rainfall. It is mapped on short hill slopes on the western margins of the Taranaki hill country and on scarps of dissected areas of the volcanic ring plain. Characteristically slopes are slightly steeper and do not have the rounded form of Vc1.

Map units covering 42.0% of VIe1 are dominantly in pasture, with pasture and scrub, particularly manuka and mixed native scrub associations on the remainder. There is therefore considerable potential for pastoral and forestry expansion on this LUC unit. The dominant soils are the Egmont and New Plymouth series.

Thirty-nine percent of VIe1 is recorded as having negligible erosion. Slight erosion (principally soil slip, earth slip and sheet) occurs on the remainder of VIe1. Erosion can be minimised by the planting of soil conservation trees on sites susceptible to mass-movement erosion. Dairying is the predominant land use although sheep and beef farming are also important especially in the hill country. The potential stock carrying capacity is 18 su/ha and the site index for *P. radiata* is 27–30 m.

LUC unit VIe6 (28,000 ha)—Figure 113

This unit is found on the same landforms as VIe1, but has a higher rainfall (approx. 2000–2500 mm p.a.). It occurs on moderately steep, short hill slopes in the Taranaki hill country and on scarps of the dissected volcanic ring plain close to Mt Egmont and the Pouakai Range.

Figure 25: IVe7 on rolling and strongly rolling slopes. IIIw3 with organic soils. Cross Rd, near Midhurst. N119 873650 looking W.

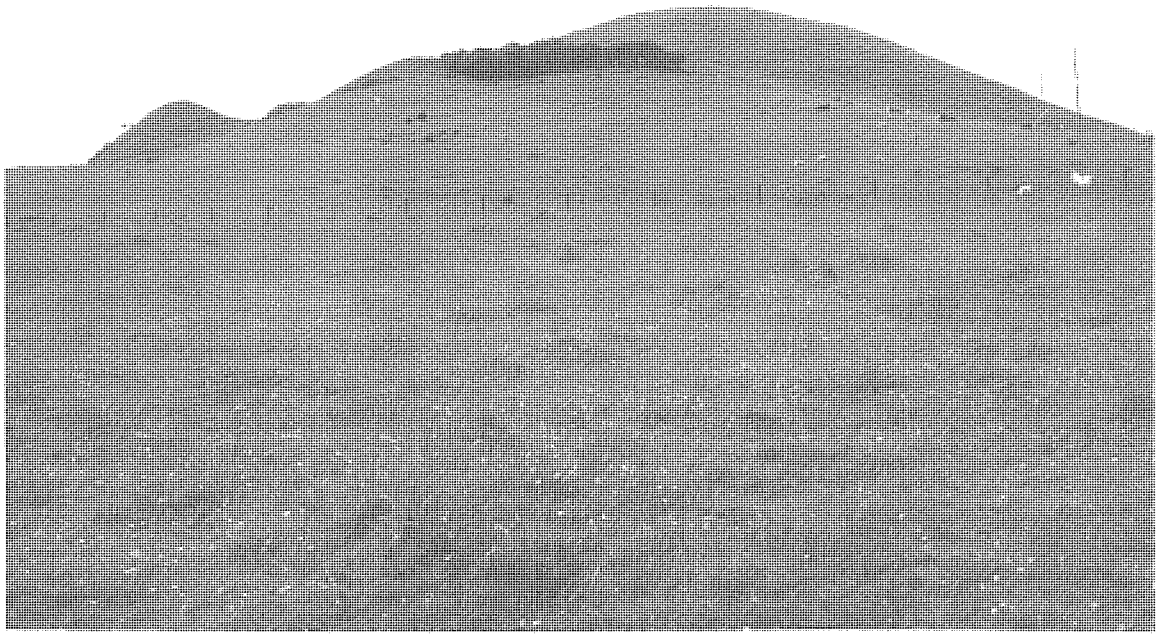


Figure 26: Vc1 in distance. Beaconsfield Rd, near Stratford. N119 905590 looking S.

Figure 27: VIe1 Ararata Rd, NE of Hawera. N129 920337 looking N.

The principal soils are the Patua series adjacent to Mt Egmont, and the Stratford, New Plymouth and Egmont series in the hill country. The latter two soils are also mapped on VIe1 but they are more leached and have higher fertiliser requirements.

VIe6 has a greater component of scrub and fern than VIe1. Only 28% of VIe6 is dominantly in pasture compared with 42% of VIe1. This is because of higher annual rainfall, and VIe6 generally being situated in more remote areas, with the consequent additional costs of maintaining adequate fertiliser levels and intensive subdivisional fencing. These two inputs are both essential to maintain vigorous high producing pastures and to prevent the natural reversion to low-fertility-demanding pasture species, fern and manuka.

There is a potential for moderate soil and earth slip erosion, however because of the considerable area of scrub and fern there is a low incidence of present erosion. Forty eight percent of VIe6 has slight erosion with negligible erosion on the remainder. This contrasts with VIe1 which has a greater proportion of its area in pasture and is therefore more prone to mass-movement erosion.

Most of VIe6 occurs in the Taranaki hill country where sheep and beef farming is the dominant land use. The potential stock carrying capacity is 17 su/ha. The LUC unit is well suited to forestry as the site index for *P. radiata* is 27–29 m. Rapid fern regrowth is a major problem in new forest plantings, however at Te Wera forest this is being successfully controlled with herbicide sprays and grazing.

In the hill country the subsuite is not mapped on slopes above 25° because on such slopes most tephra has been removed by erosion. In these situations LUC is determined by the degree of consolidation and the texture of the Tertiary aged rock, and VIe6 most commonly grades into VIe23, VIe10 and VIe17.

On the Egmont, Pouakai and Kaitake volcanic cones deep andesitic tephra is present (even on steeper slopes). In these locations VIe25 and VIIe18 are mapped.

LUC unit VIe25 (4000 ha)—Figure 28

This unit occurs between approx. 450–800 m a.s.l. on the lower flanks of mountains in the Egmont National Park. The majority occurs on the Kaitake and Pouakai Ranges with a smaller area on Mt Egmont. Slopes are dominantly moderately steep to steep but with inclusions of rolling land (not separated at the scale of mapping). The average annual rainfall is between 3000 and 5000 mm.

The soils are strongly leached. Hill soils were not recognised by NZ Soil Bureau (1954), therefore the Patua soil set was recorded on slopes of up to 25° and the Te Kie soil set on steeper slopes.

All of this unit is in either hardwood forest with some mixed native scrub associations or lowland podocarp forest. As it is situated within a National Park none has been developed.

Ninety five percent of VIe25 has negligible erosion while the remainder has slight soil slip. There is a potential for moderate soil slip erosion. Soil conservation measures would include care in the siting of recreational tracks to minimise erosion by run off, and the control of possums and goats.

LUC unit VIIe18 (6550 ha)—Figure 28

Areas mapped as VIIe18 are principally between 800–1,200 m a.s.l. have a rainfall of between 4,000–6,500 mm p.a., and occur on steep to very steep slopes on Mt Egmont and the Pouakai and Kaitake Ranges.

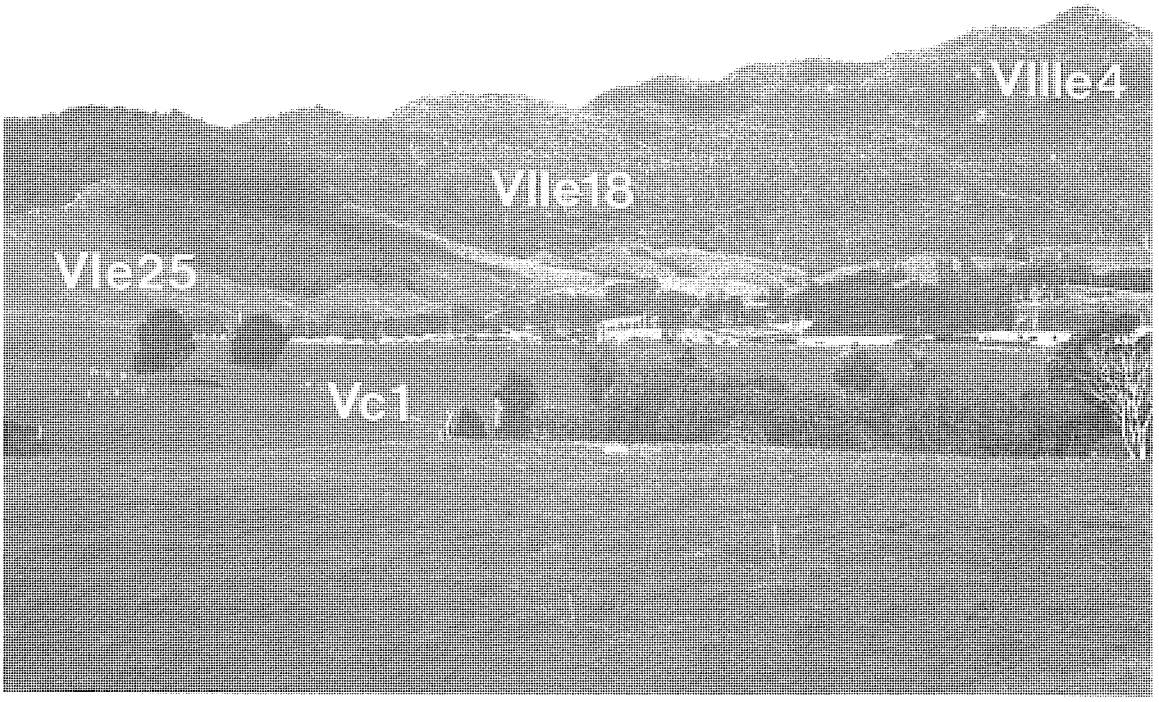


Figure 28: LUC units VIe25, VIIe18 and VIIIe4 Kaitake Range. Foreground to middle distance includes Vc1 on strongly rolling to moderately steep slopes and Ic1 on flat slopes. Okato district. N108 500780 looking E.

All of this LUC unit has a vegetation of scrub or native forest, particularly mid altitude podocarp-hardwood forest and sub-alpine scrub associations. The soils are strongly leached. The principal soils are the Patua series, and the Te Kie soil set. On the western side of Mt Egmont VIIe18 is mapped on the Maero series, a recent soil developed from young debris

flows. Above 1,100 m a.s.l. the Tahurangi soil series is mapped on the Tahurangi Formation of c. 1755 A.D. (Aitken *et al.* 1978).

Soil slip and debris avalanche are the dominant erosion types. About 70% of VIIe18 has negligible erosion recorded. There is a potential for severe erosion. Soil conservation measures include controlling goats and possums so as to maintain the existing vegetation cover, and the revegetation of eroded areas with appropriate species. Care is required in the siting of recreational tracks to minimise erosion.

Steeper slopes at higher altitude are mapped as VIIIe4, VIIIe7, VIIIe8 or VIIIe9 and are described in the Mountainland suite.

1170 ha on the southern slopes of Mt Ruapehu are also mapped VIIe18.

2. LUC SUITE ON LAHARS IN TARANAKI

This suite occurs in Taranaki, on a volcanic ring plain built up of laharic* material originating from Mt Egmont. Seven LUC units (IIs3, IIw3, IIIs3, IIIs5, IIIw5, Vs1, VIs3) were recognised on the basis of the depth of tephra mantling laharic breccia, slope angle, and soil wetness. In addition three LUC units (IIIs1, IVs1 and VIs6) are mapped on flat and undulating slopes in lahar terrain where there are alluvial sediments and coarse textured or bouldery soils. Map units of IIIw3 occurring elsewhere in Taranaki were also included in this suite. Together the 11 LUC units in this suite total 79,100 ha (3.3%) of the Region. Figure 29 shows their distribution in the region.

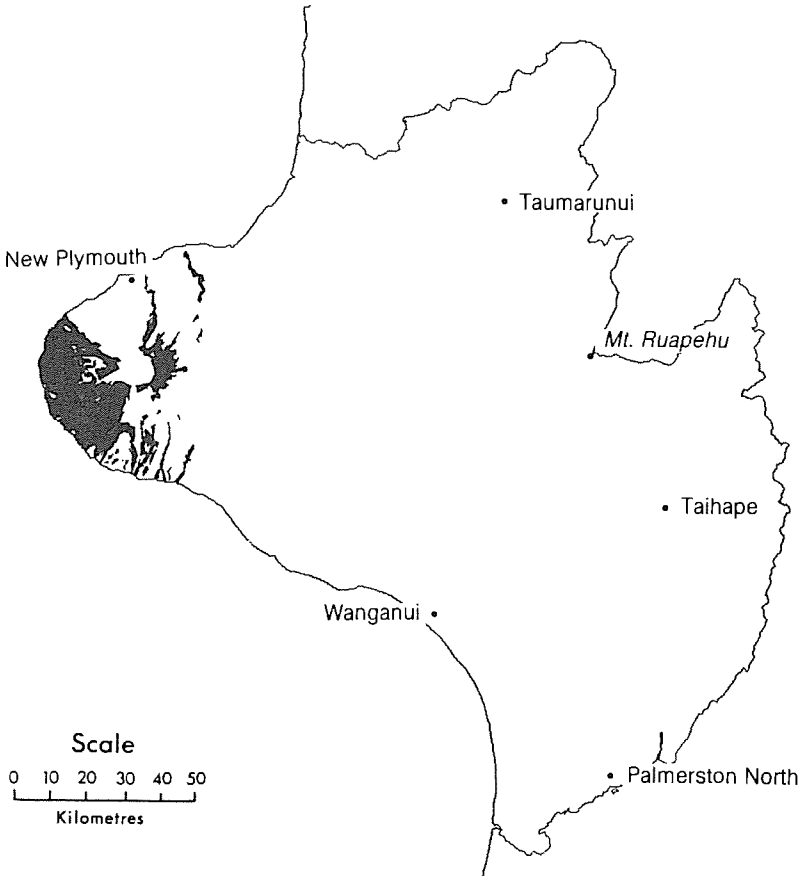


Figure 29: Location of LUC suite 2: lahars in Taranaki.

Lahars in Taranaki and elsewhere with a deep tephra (>1 m) mantle are commonly mapped in tephra suites. This is because a >1 m tephra mantle masks the effect on LUC of the underlying laharic material. Examples where tephra suites are mapped include the

*A lahar is defined as a large mudflow or debris flow mostly composed of volcaniclastic detritus, often including large blocks, on or surrounding the flanks of a volcano (Neall 1976a).

Opunake, Stratford and Lepperton lahars of Hay (1967) in Taranaki, the Waimarino, Murimotu, Rangipo and Hautapu lahars originating from Mt Ruapehu and Mt Tongariro, and the lahars of the Whangaehu Rivers (Grindley 1960). Terrain in which these lahars occur have most commonly been included in the yellow-brown loam LUC suite.

Physiography

This suite occurs on a landscape which rises gently from sea level to the slopes of Mt Egmont. The laharic terrain is characterised by numerous lahar mounds which are hemispherical or ellipsoidal in shape and vary in height from a few metres up to 40 m. In some areas the lahars can be differentiated into central and marginal phases (Palmer *et al.* 1981). In the central phase the lahar mounds are arranged very closely together and only a small proportion of the land is occupied by hollows or depressions. The proportion of mounds decreases towards the margins, until the landscape becomes flat or gently undulating.

Climate

Data compiled by the NZ Meteorological Service (1978) show that mean annual rainfall varies from 1000 mm at sea level and increases to approximately 4000 mm at 700 m elevation. Rainfall normals for 1951–1980 are available for rainfall stations at Cape Egmont, Warea, Opunake and Opua Road (Table 16).

Table 16: Rainfall normals (1951–80) for rainfall stations in the LUC suite on lahars (Source NZ Meteorological Service 1984)

Rainfall Station	Altitude (m)	Rainfall normal (mm)
Cape Egmont	8	1413
Warea	24	1406
Opunake	27	1328
Opua Road	204	1697

At Cape Egmont, Warea and Opunake between 31 and 32% of the annual rainfall is received in the three months of June, July and August. January, February and March, the months with least rainfall, account for 19% of the annual total. However, analysis of the rainfall data from Opua Road rainfall station indicates that at higher elevations the rainfall is distributed more evenly throughout the year.

Wind has a major effect on land use capability. Wind direction summary data for Cape Egmont (Thompson 1981) demonstrate that wind distribution is quite uniform with the dominant wind direction being south-east or south-west. In coastal areas, wind-driven salt spray has a detrimental effect on cropping and horticultural versatility as well as on pastoral and forestry production.

Mean air temperature can be expected to decrease by about 0.6°C for each 100 m increase in altitude. Occasional snowfalls can occur on land above 200 m a.s.l.

Rock Type

Assessment of land use capability is primarily dependent on the depth of tephra overlying laharic material (Table 18). The principal soil-forming tephra are the Okato Tephra (from 12,950 ± 150 to 16,600 ± 300 years B.P.) and the Oakura Tephra (7,170 ± 110 years B.P.) (Neall 1972). The Newall tephra erupted between 1500 and 1550 A.D. is a significant soil parent material in the north-west of the suite near the Stony River.

A pattern occurs in which the oldest lahars are mantled with the greatest depth of tephra while the most recent lahars have little or no tephra cover. The lahars and alluvial sediments of this suite have been mapped at a 1:50,000 scale and described by Neall (1979).

The greatest depth of tephra occurs on the Pungarehu Formation (23,700 ± 700 years B.P.) (Neall 1976b). This lahar formation pre-dates both the Oakura and Okato tephra. LUC units IIc3, IIIc4 and IVc3 and Vc1 (of the yellow-brown loam suite) are mapped on the Pungarehu Formation. The next greatest depth of tephra occurs on the Warea Formation (12,950 ± 150 and 16,600 ± 300 years B.P.). It is mantled with 30 cm to 1 m of tephra

(mainly Oakura). On the Warea Formation LUC unit IIs3 occurs on flat and undulating slopes, and Vs1 occurs on strongly rolling to moderately steep slopes.

On the Opua Formation lahars (7,320 + 110 years B.P.) there is little or no tephra cover below 400 m a.s.l. Here, IIIs3 or VIs3 are mapped.

The Kahui Debris Flows (7,000–12,000 years B.P.) occur mainly on the lower western slopes of Mt Egmont and also to the north-east along the Waiwhakaiho River. The larger debris flow units contain boulders up to 0.5 m across while the small debris flows were deposited as fine sands.

The Ngatoro Formation occurs over an extensive area on the north-east side of Mt Egmont. It contains large boulders up to 3 m across within coarse gravels.

Over the last 500 years at least 14 debris flows, collectively named the Maero Debris Flows, have occurred. Most were derived from collapses of the western crater rim and were channelled along river courses to form aggradational terraces at lower altitude. Following the destruction of vegetation by the Newall eruptions between 1500 and 1550 A.D. Maero Debris Flow surfaces became devoid of vegetation. Heavy rainfall and floods subsequently transported and restored some of the debris on the north-west and the north-east slopes to form the Hangatahua Gravels. These are dominantly of gravel and sand size texture and are most extensive in the Stony River catchment.

These debris flows may in turn be overlain by tephra. Some Oakura Tephra mantles the younger Kahui Debris Flows while the Ngatoro Formation is overlain by shallow depth of volcanic ashes. These include a grey lithic tuff at present named the Manganui Tephra (3110 ± 160 years and 3630 ± 80 years B.P.). Also present is an unnamed ash deposit containing many lithic lapilli described by Aitken *et al.* (1978) in Stratford County.

Ash and lapilli layers of the Newall Formation were deposited as a series of nuee ardente eruptions between 1500–1550 A.D. on the north-west side of Mt Egmont. The Waiweranui Lapilli and Newall Lapilli are the most easily recognised members. The 7.5 cm Newall lapilli isopach extends 6 km beyond the National Park boundary between Newall Road and the Stony River. Within the National Park VIs6 map units on the north-west side of Mt Egmont are likely to be included within the 15 cm Waiweranui Lapilli isopach.

On the eastern side of Mt Egmont, the Burrell Lapilli member of the Burrell Formation 1655 A.D. (Druce 1966) is a significant soil forming tephra.

Soils

Soil maps covering this subsuite are available at a 1:50,000 scale for Egmont and part Taranaki County (Palmer *et al.* 1981) and at a 1:63,360 scale for Stratford County (Aitken *et al.*1978) and Waimate West County (Campbell and Wilde 1969). Elsewhere NZ Soil Bureau (1954) information was used. Because of the complex soil pattern Palmer *et al.* used soil associations as mapping units. Each soil association comprises a number of kinds of soil on a common parent material. These soils form a predictable and repeated pattern in the landscape and are related to drainage and relief. Soil associations are named after the two most extensive members, although commonly three or more members will occur in an association.

Important physical attributes in defining the soil series and their relationship to land use capability are summarised in Table 17.

Erosion

Erosion is not a significant problem. There is a potential for slight sheet erosion to occur on the steeper lahar mounds.

Watercourses are the main areas of erosion hazard as channels are shallow, have steep gradients and frequently carry large volumes of water. There is a potential for deposition especially on VIs6. This can occur either when streams overflow their channels, or where the volume of debris flow detritus channelled along stream and rivercourses exceeds the capacity of the water course and becomes deposited on aggradational terraces.

Table 17: Relationship between soil series and LUC units on the lahar suite. (Adapted in part from Palmer *et al.* 1981)

Soil series	Parent material	Elevation range (m)	Degree of soil leaching	Typical LUC unit
YELLOW BROWN LOAMS				
Warea Wr	From thin to thick volcanic ash on Pungarehu and Warea Formations	Sea level to 165	Moderately leached	IIs3 Vs1 (WrH)
Kahui Kui	From thin to thick volcanic ash on Pungarehu, Warea, Ngatoro Formations and Kahui debris flows	165–430	Moderately to strongly leached	IIs3 Vsl (Kui H)
Opua Ou	From central phase Opua Formation	Sea level to 180	Moderately leached	VIs3
Te Kiri Tz	From central phase Opua Formation	165–335	Moderately to strongly leached	IIIs5 VIs3 (TzH)
Oaonui Oi	From central phase Opua Formation	Sea level to 335	Weakly gleyed	IIIs5
Pihama Pm	From marginal phase Opua Formation	Sea level to 165	Moderately leached	IIIs3
Wiremu Wir	From marginal phase Opua Formation	140–365	Moderately to strongly leached	IIIs3 VIs3 (WirH)
Skeet Sk	From marginal phase Opua Formation	Sea level to 400	Weakly gleyed	IIIs5
GLEY SOILS				
Glenn Gl	From thick volcanic ash on Opunake Formation	Sea level to 76	—	IIIw5
Awatuna At	From thin to thick volcanic ash on Pungarehu, Warea, Ngatoro Formations and Kahui debris flows	Sea level to 430	—	IIIw5
Punehu Pe	From central phase Opua Formation	Sea level to 335	—	IIIs5 IIIw5
Patiki Pat	From marginal phase Opua Formation	Sea level to 400	—	IIIs3 IIIs5
Rahotu Rh	From sandy andesitic alluvium associated with Opua Formation	Sea level to 165	—	IIIs5
>INTERGRADES BETWEEN YELLOW-BROWN LOAMS AND RECENT SOILS				
Hangatahua Hn	Recent sands and gravels from Hangatahua Gravels and Maero Debris Flows	Sea level to 450	—	IIIs1 IVs1 VIs6
COMPOSITE RECENT SOIL OVER YELLOW BROWN LOAM				
Newall N	Newall Formation on Oakura Tephra on Kahui Debris Flows	250–920 m	Strongly leached	VIs6
RECENT SOILS				
Maero Mae	Maero Debris Flows and Hangatahua Gravels	280–1000 m	Strongly to very strongly leached	IVs1 VIs6
Burrell Bl	Burrell Formation over older ash	460–1000 m	Strongly to very strongly leached	IVs1 VIs6

Land Use and Vegetation

Dairy farming is the dominant land use. Fat lamb and intensive beef farming are also significant, particularly in higher altitude areas nearer to Mt Egmont, and where there are extensive areas with strongly rolling to moderately steep slopes. Land use capability units at lower altitude and with lower rainfall nearer the coast have a potential for horticulture if given adequate shelter and irrigation. Most VIs6 map units are within the Egmont National Park.

Pasture is the dominant vegetation. The majority is high producing although low producing pasture, often in combination with gorse and blackberry, is significant especially on VIs3. Rushes and willow weed are significant on poorly drained sites between lahar mounds.

LUC Units

The principal factors determining land use capability are the depth of tephra overlying lahars, slope angle and soil wetness. Using these criteria LUC units are grouped as follows:

LUC UNITS ON FREE DRAINING SITES
LUC UNITS WITH DRAINAGE LIMITATIONS
LUC UNITS ON RECENT TEPHRIC ALLUVIUM AND DEBRIS FLOWS.

Because of the complex pattern of lahar mounds and intervening depressions much of the lahar suite has been mapped as a complex of LUC units (Jessen 1984).

LUC UNITS ON FREE DRAINING SITES

On free draining sites, land use capability is determined by slope angle and the depth of tephra overlying laharic breccia (Table 18). LUC units IIs3, IIIs3, Vs1 and VIs3 are included in the lahar suite, while the small areas of lahar terrain with >1 m of tephra (Vc1) are included in the yellow-brown loam suite.

Table 18: Relationship of land use capability to slope and depth of tephra in the lahar suite

Depth of Tephra	Typical lahar Formation	Dominant slope 0–7°	16–25°
<30 cm	Opua	IIIs3	VIs3
30 cm–1 m	Warea	IIs3	Vs1
> 1 m	Pungarehu	*	Vc1

* LUC unit IIc2, IIc3, IIIc4, or IVc3 (depending on altitude and rainfall) of the yellow-brown loam suite (LUC subsuite 1d)

LUC unit IIIs3 (6450 ha)—Figure 30

IIIs3 occurs on flat and undulating slopes. It has less than 30 cm depth of tephra overlying lahar.

The predominant soils are the Pihama and Wiremu series. These are free draining, coarse textured yellow-brown loams. Pasture is recorded as the dominant vegetation on map units covering 95% of IIIs3 while the remaining vegetation is grassland-forest or grassland-scrub. Dairying is the dominant land use, although with adequate shelter and irrigation there is a potential for horticulture. IIIs3 has a potential stock carrying capacity of 21 su/ha while the site index for *P. radiata* varies from 23 m near the coast to 26 m on more sheltered island sites. The unit does not have a potential erosion hazard.

LUC unit IIs3 (3950 ha)

IIs3 occurs on flat and undulating slopes and has between 30 cm–1 m of fine textured andesitic tephra overlying lahar. The soils are yellow-brown loams, predominantly of the Warea and Kahui series. They are deeper and have better physical characteristics for cropping than those on IIIs3. Despite the differences in soil depth both IIs3 and IIIs3 have very similar potentials for pastoral and forestry production, because they have similar climates. High producing pasture is the dominant vegetation on map units covering 94% of the LUC unit, the remainder has a grassland-forest vegetation. There is no present or potential erosion recorded.

The dominant land use is dairying although there is a potential for horticulture, given adequate shelter and irrigation. The potential stock carrying capacity is 22 su/ha while the site index for *P. radiata* varies from 23 to 26 m depending on distance inland from the coast.

Also occuring on flat and undulating slopes in the lahar terrain are LUC units IIc2, IIc3, IIIc4 and IVc3. These have >1 m of fine textured tephra and are described in the yellow-brown loam suite.

A similar sequence of LUC units related to depth of tephra occurs on the steeper lahar mounds.

LUC unit VIs3 (5600 ha)—Figures 30, 31, 32

This unit occurs on strongly rolling to moderately steep lahar mounds which have yellow-brown loam soils developed from < 30 cm of andesitic tephra.

The shallow and bouldery Opua, Wiremu and Te Kiri soils present preclude cultivation for pasture renewal and restrict pasture production. Because of these limitations LUC unit VIs3 is the least developed for agriculture in the lahar suite. Pasture is the only vegetation on map units covering 42% of VIs3, while on the remainder grassland occurs in combination with forest or scrub. The unit has a potential stock carrying capacity of 12 su/ha, and a site index for *P. radiata* which varies from 23 to 26 m depending on the degree of exposure to strong coastal winds.

Figure 30: IIIs3 in foreground. VIs3 in distance. IIs3 occurs on similar slopes to IIIs3. Kaweora Rd, NE of Opunake. N118 520480 looking NW.

LUC unit VIs3 is often used as a winter runoff for dairy cattle, however treading can damage the turf cover and may result in slight sheet erosion. Considerable areas have been mapped as a complex with LUC unit IIIs5–a LUC unit with a similar depth of tephra but occurring on flat and undulating slopes between the VIs3 lahar mounds.

Figure 31: VIs3. Bouldery, poorly sorted lahar deposits mantled with <30 cm depth of tephra. Kiri Rd. N118 582498.

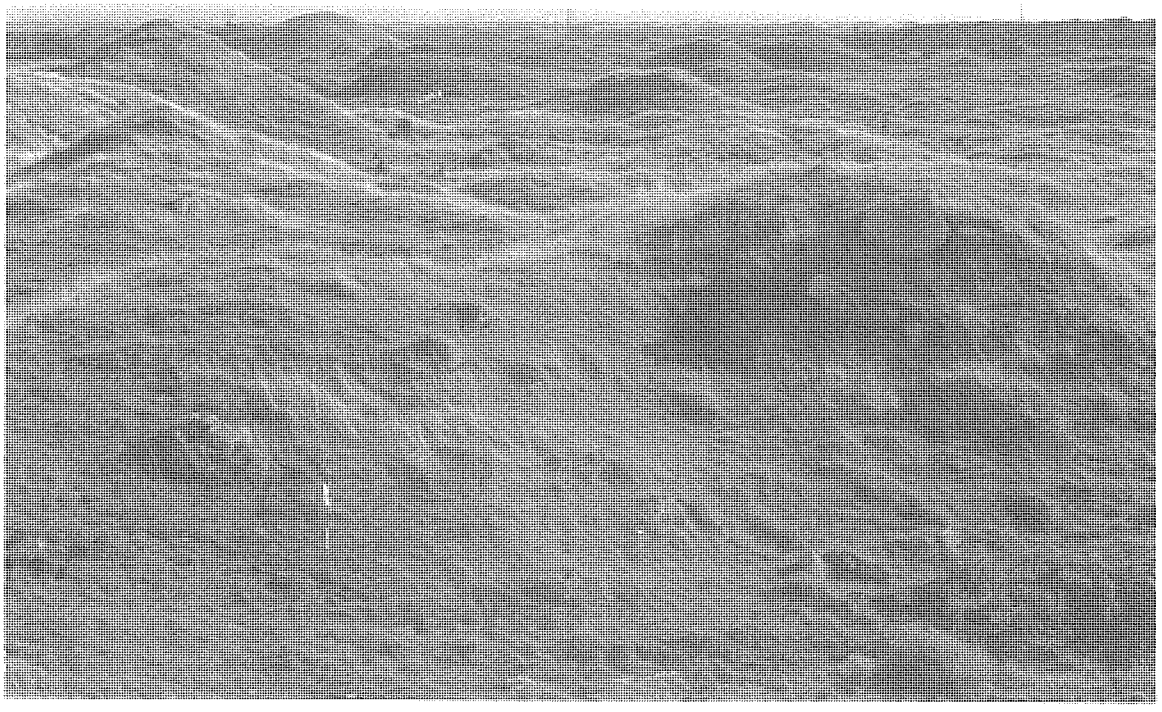


Figure 32: VIs3. Hummocky lahar terrain showing boulders at surface. Wiremu Rd. N118 553508 looking SW.

LUC unit Vs1 (8650 ha)—Figures 33, 34

This unit consists of strongly rolling to moderately steep lahar mounds mantled with 30 cm to 1 m depth of andesitic tephra. The predominant Warea and Kahui soil series have better physical characteristics than those on VIs3. They are sufficiently deep to enable cultivation for pasture renewal although in places this may be difficult where rocks outcrop.

LUC unit Vs1 has had greater pastoral development than VIs3. 71% of VIs3 is dominantly in pasture, with grassland-forest or grassland-scrub on the remainder. There is a potential for slight sheet erosion, although map units covering only 3.8% of the area were assessed as having present erosion of this severity.

The potential stock carrying capacity has increased to 14 su/ha compared to 12 su/ha on VIs3. This demonstrates the trend that potential pastoral productivity increases with increasing depth of tephra. The site index for *P. radiata* is the same as for VIs3 (23–26 m). This is also consistent with site index on this suite being related to soil wetness and exposure to wind rather than to soil depth.

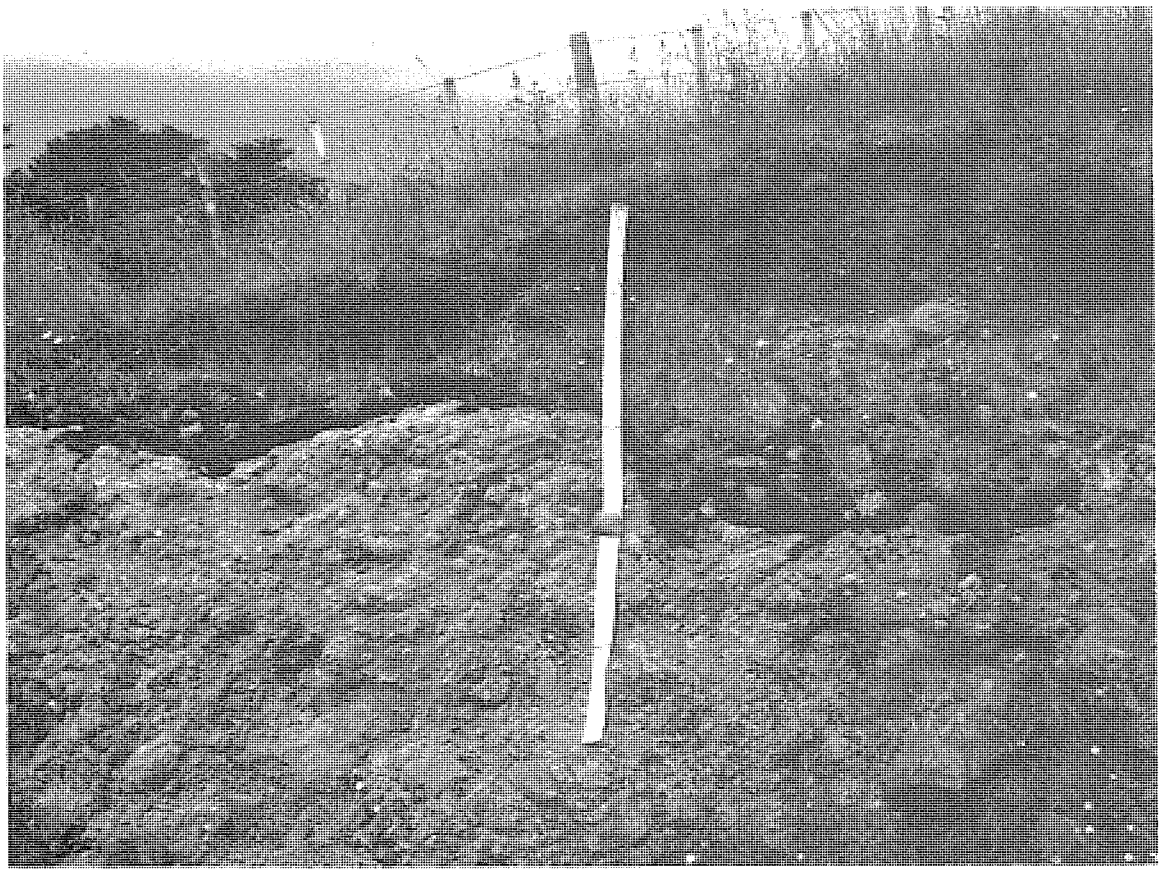


Figure 33: Vs1. Lahar material mantled with between 30 cm and 1 m of andesitic tephra. Opourapa Rd, east of Rahotu. N118 464598.

LUC unit Vs1 is often mapped in association with IIIw5, which occurs on low lying wet areas between the Vs1 lahar mounds. LUC unit Vc1 of the yellow-brown loam suite is mapped where the depth of fine textured andesitic tephra on strongly rolling to moderately steep lahar slopes is greater than 1 m.

LUC UNITS DETERMINED ON THE BASIS OF DRAINAGE LIMITATIONS

On flat low lying poorly drained areas between lahar mounds three LUC units are mapped. LUC units IIw3 and IIIw5 in deep andesitic tephra, and IIIs5 with gley soils developed from stony lahars. It is difficult to effectively drain these three LUC units because of the presence

of lahar mounds in the local topography. Iron ochre deposits in tile drains are an additional problem.

LUC unit IIw3 (450 ha)

This unit comprises flat areas south-east of Pihama, and west of Manaia with moderately gleyed yellow-brown loam soils of the Egmont series, or gley soils of the Glenn series.

All of this LUC unit is in high producing pasture. There are slight limitations for cropping due to continuing slight wetness after drainage, and the limiting effect of strong winds. Intensive drainage and the provision of shelter is necessary for horticultural development. This unit has a potential stock carrying capacity of 22 su/ha and a site index for *P. radiata* of between 23 and 26 m.

Because of its limited extent IIw3 has been correlated with LUC unit IIIw5 in the North Island NZLRI correlation (Page 1985).

LUC unit IIIw5 (9050 ha)—Figure 34

This unit comprises gley soils of the Glenn, Punehu and Awatuna series. Most of this unit occurs in the Pungarehu and Rahotu areas where it is mapped as a complex with Vs1.

IIIw5 differs from IIw3 by having more strongly gleyed soils, and greater constraints to drainage because of low gradients and the presence of lahar mounds. However, when drained there is a potential for some horticultural crops and root and green fodder crops. IIIw5 was assessed to have the same stock carrying and forestry site index potentials as IIw3.

IIIw5 has been highly developed for intensive grazing particularly dairying. Map units covering 95% of IIIw5 have pasture as the only vegetation, the remainder is grassland-forest or grassland-scrub.

LUC unit IIIs5 (10,650 ha)

This unit occurs on flat to undulating slopes with gley or weakly gleyed yellow-brown loam soils developed on stony lahars.

Subsurface drainage is impeded by a compact lahar layer while the presence of low undulating lahar mounds also poses difficulties for surface drainage methods. IIIs5 is usually mapped as a complex with VIs3.

Gley soils of the Patiki and Rahotu series occur in low lying areas and the Oaonui and Skeet series on undulating better drained sites. At present 83% of the LUC unit is dominantly in pasture and used for intensive grazing, the remainder is in grassland-forest or grassland-scrub.

Drainage, shelter and irrigation make this unit suitable for some horticultural crops and root and green fodder crops. The potential stock carrying capacity is 22 su/ha and the *P. radiata* site index varies between 23 and 26 m.

Included in the lahar suite are 3310 ha of organic soils on peat mapped as LUC unit IIIw3 on the eastern margin of the Egmont volcanic ring plain.

LUC unit IIIw3 (4650 ha)—Figure 25

This unit is recorded on peat deposits east of Eltham, Midhurst and Tariki where the eastern margin of the Egmont ring plain adjoins sedimentary hill country. The peats appear to have formed as a result of ponding during the formation of the Egmont ring plain (Aitken *et al.* 1978).

Most of IIIw3 has been developed into pasture, although rushes and kahikatea forest are significant in some areas. The dominant land use is intensive grazing particularly dairying. The potential stock carrying capacity is 24 su/ha. Some potato and root and green fodder crops are grown but the high rainfall (1600–2400 mm pa), together with frequent and severe frosts severely restrict the cropping versatility. Because of the presence of a permanent high water table IIIw3 is not considered suitable for exotic forest.

An important management requirement is the necessity to maintain the water table at a level which will prevent irreversible drying of soils. Organic soils developed on the peat are mapped as Eltham peaty loam in the Eltham area and the Piako and Taihaia soil sets further north. A small area of the Raumati soil set (a gley soil) is also included in this unit.

IIIw3 is also mapped on 1050 ha in the Waimarino district. These map units are discussed in the yellow-brown loams subsuite in the Waimarino district.

LUC UNITS ON RECENT TEPHRIC ALLUVIUM AND DEBRIS FLOWS

LUC unit IIIs1 (8100 ha)—Figure 34

This unit comprises recent andesitic tephric alluvium, on river terraces and levees on the lower Egmont ring plain. Most IIIs1 occurs in western Taranaki particularly adjacent to streams in the Puniho, Warea and Pungarehu areas. But IIIs1 is also significant on terraces of the Waitara and Waiwhakaiho rivers in north Taranaki and the Otakeho and Waingongoro Streams in south Taranaki.

The Hangatahua soil series was recorded in Egmont, Waimate West and Stratford counties. Elsewhere the Esk soil set was recorded. These soils have a coarse sandy texture and are developed on loose or weakly cemented tephric alluvium. Their free draining properties mean there is a tendency for soil moisture deficiencies to develop in summer. This is more of a problem in western and southern Taranaki where the annual rainfall is lower (approx. 1000 mm p.a.). In north-east Taranaki (rainfalls up to 2000 mm p.a.) soil moisture deficits are not a limitation to cropping or pastoral use.

Most IIIs1 occurs within 5 km of the coast and is therefore exposed to strong winds. If sufficient shelter is provided (in addition to irrigation) the unit would be suited to a wide range of horticultural crops but at present, most is in high producing pasture with dairying as the dominant land use. The potential stock carrying capacity is 22 su/ha while the site index for *P. radiata* varies between 23 and 28 m according to the distance from the coast.

IIIs1 is not subject to flooding, however streambank erosion can be a problem.

LUC unit IVs1 (6150 ha)

IVs1 differs from IIIs1 by having coarser textured soils and higher rainfall (2000–3000 mm p.a.). It occurs on high altitude areas of the Mt Egmont ring plain. IVs1 occurs on either well drained alluvial gravels, or more poorly drained debris flow deposits. There are numerous stones in the soil profile and on the surface.

The dominant vegetation is high producing pasture, however low producing pasture, rushes, blackberry, lowland podocarp-hardwood forest and mixed native scrub associations are a significant component of the vegetation in many areas. Some map units have slight streambank erosion. There is also a potential for moderate sheet and rill erosion when this unit is cultivated.

The limitations of climate, soil texture and in some areas wetness restricts cropping to occasional root and green fodder crops. IVs1 has a site index of 23 m and a potential stock carrying capacity of 18 su/ha.

LUC unit VIs6 (15,400)—Figure 35

This LUC unit has greater climatic and soil textural limitations than IVs1. VIs6 occurs at 500–700 m altitude in areas that are either adjacent or within the Egmont National Park. VIs6 receives an annual rainfall of 2500–4000 mm.

Most VIs6 is mapped on debris flows where the soils are of shallow depth, often poorly drained and have numerous boulders and gravels both within the profile and on the soil surface. The principal soils are the Maero, Burrell and Hangatahua series.

Within the Egmont National Park most of this unit is in forest. Outside the National Park boundary the dominant vegetation is low producing pasture, mixed native scrub associations, cut over lowland podocarp forest and blackberry. High producing pasture is only significant in small areas.

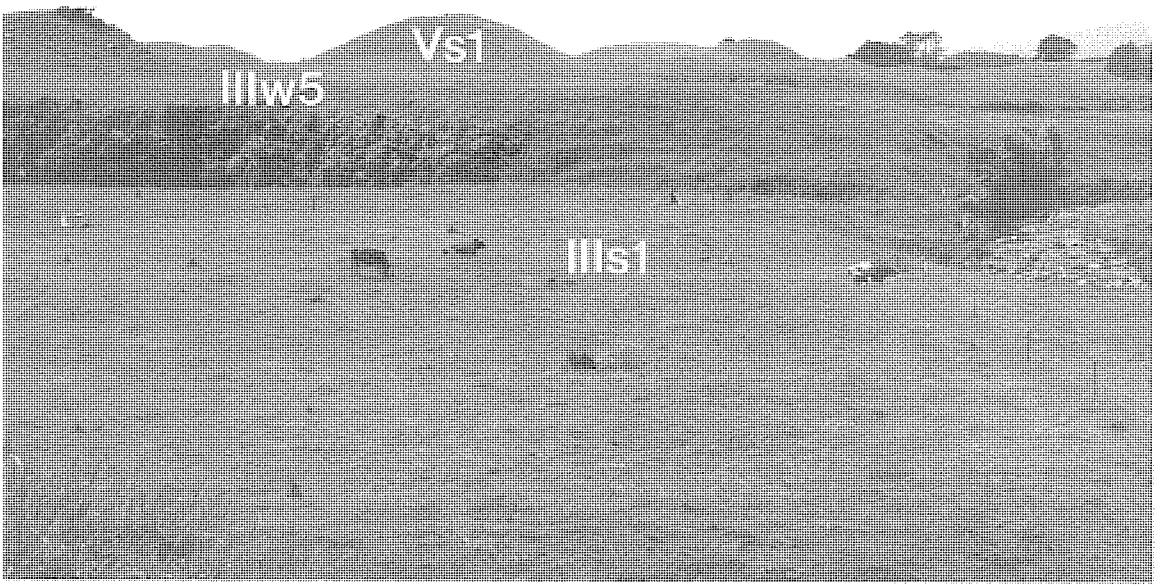


Figure 34: IIIs1 on tephric alluvium adjacent to Warea River. IIIw5 on flat higher terrace in distance. Lahar mounds are Vs1. Newall Rd, NE of Pungarehu. N118 440670 looking NE.

Figure 35: VIs6 on Maero Debris Flows, Upper Puniho Rd adjacent to Egmont National Park. Pouakai Range in distance. N118 540670 looking NE.

Areas that are farmed have a present average stock carrying capacity of 12 su/ha and a potential stock carrying capacity of 16 su/ha. The site index (23 m) is the same as for IVs1. Slight or moderate streambank erosion is a problem on some map units and there is also a potential for flood deposition.

3. LUC SUITE ON COASTAL SAND COUNTRY

The sand country suite comprises a complex of dunes, sand plains and swamps along the coastal fringe of the Region (Figure 36). It extends continuously from near Hawera in the north to the Manawatu River, and is most extensive between the Manawatu and Turakina Rivers, where it extends up to 19 km inland. North of Hawera the sand country is discontinuous and extends no further than 1 km inland.

The suite comprises six LUC units : IIIw4, IVe10, VIs4, VIe24, VIIe15 and VIIIe1. These are separated according to slope, depth to water table, erosion hazard, and potential for cropping, pastoral and forestry use (Table 22). The suite covers 81,950 ha (3.4%) of the region.

Physiography and Rock Type

The sand country can be broadly divided into plains and dunes.

A young unstable dune complex immediately behind the foredune is probably the result of a sudden influx of detritus on the coast following the Taupo eruptions of 131 AD. The more consolidated and older dune complex is probably related to the falling sea level of 5000 years BP (Heerdegen 1972). The dunes furthest inland tend to be orientated in a north west-south east direction which parallels the prevailing wind.

On the margins of the suite, sand overlies the alluvial terraces of the Manawatu, Rangitikei, Turakina, Whangaehu and Wanganui rivers, and the uplifted Rapanui and Brunswick terraces.

Climate

This suite is characterised by mild temperatures and high sunshine hours. The average daily temperature range is 7–10°C throughout most of the year. Sunshine data are available for Ohakea and Wanganui, with annual averages for these stations being 2064 hours and 2107 hours respectively (Maunder and Browne 1971). There is a low frequency of frosts, for instance Ohakea received an average (1948–70) of 20.6 days of ground frost per year and Wanganui (1937–70) an average of 10.9 days per year.

The annual rainfall is generally between 900–1000 mm in the Manawatu, Rangitikei and Wanganui areas, but further north, in Taranaki, it increases to about 1200–1300 mm p.a. The rainfall is fairly evenly distributed throughout the year with January to March being the driest months.

The most important climatic factor affecting land use capability is wind. Wind is the main erosive agent. Wind and associated salt spray also have a desiccating effect on pasture, reduce tree growth and are a major influence on the range of crops able to be grown.

Soils

Eight Soil surveys (Table 19) were used as a basis for recording soil.

The soils can be separated on the basis of relief and drainage into soils occurring on sand dunes, soils on dry sand plains and soils on wet sand plains. Soils developed on sand dunes are further differentiated according to the degree of profile development. Dunes nearest the coast have recent soils (Waiterere series) with little soil profile development. Further inland where the dunes are older, there is greater soil development and soils are classified as yellow-brown sands (Table 20).

Figure 36: Location of LUC suite 3: coastal sand country.

Table 19: Soil surveys used in the coastal sand country suite

Soil survey	Scale
Soils of the Manawatu-Rangitikei sand country	1:63,360
Soils of Manawatu County	1:63,360
Soils of Rangitikei County	1:63,360
Soils of part Wanganui County	1:63,360
Soils of part Waitotara County	1:63,360
Soils of Waimate West County	1:63,360
Soils of Egmont and part Taranaki Counties	1:50,000
General Survey of the Soils of the North Island	1:253,440

Table 20: Relationship between soils and physiography in the coastal sand country suite

Soil Group	Soil series		
	Dunes	Dry sand plains	Wet sand plains
Recent	Waiterere Castlecliff	Hokio	Hokio
Yellow-brown sands	Motuiti Mosston Foxton Patea	Himatangi Awahou	
Moderately gleyed yellow-brown sands	—	—	Pukepuke
Gley	—	—	Carnarvon
Organic	——	—	Omanuka

Dry sand plains suffer soil moisture deficiencies in summer. They have recent soils (Hokio series) on the younger sand plains and yellow-brown sands (Himatangi and Awahou series) on the older dry sand plains. Moderately gleyed yellow-brown sands (Pukepuke series), gleys (Carnarvon series) or organic soils (Omanuka series) occupy wet sand plains (low lying situations) where the water table is permanently near the ground surface.

Soil surveys in the sand country have used the concept of the soil association as a mapping unit. These are groupings of geographically associated soils whose differences are related mainly to drainage and topographic position. Soil associations were recorded in the NZLRI for this suite.

Erosion

Erosion in the Manawatu sand country has been outlined by Holland (1983), while the erosion problem, the LUC classification and soil conservation measures required are described for the Marahau-Wainui area by Clark *et al.* (1974) and for the Foxton-Tangimoana area by Thompson and Clark (1983). More recently Stephens (1985) has measured changes in the areal extent of bare sand dunes in the Manawatu, using digital image analysis.

Wind erosion is recorded on map units covering 52% of the suite. The erosion hazard is greatest on LUC units VIIe15 and VIIIe1. Fifty-eight percent of VIIIe1 has more than 60% bare ground affected by wind erosion. Table 21 summarises the relationship between LUC and bareground affected by wind erosion.

LUC unit IIIw4 is not affected by wind erosion. It owes this to a high ground water table and good pasture growth throughout the year. On all other LUC units wind erosion can be initiated when pastures are overgrazed. Overgrazing is usually not a problem, with dairy and beef cattle, however trampling by these animals will shear the turf mat on sand dunes and expose the dunes to erosion.

Table 21: The relationship between LUC and bare ground affected by wind erosion in the coastal sand country suite

	Percentage bare ground affected by wind erosion											
LUC Unit	Not significant ha	%	1–10% ha	%	11–20% ha	%	21–40% ha	%	41–60% ha	%	>60% ha	%
IIIw4	24,750	100										
IVe10	7,040	47	6,570	44	1,440	9						
VIs4	2,430	33	3,520	47	1,290	20						
VIe24	2,730	23	6,330	54	2,590	23						
VIIe15	2,320	11	6,050	30	7,190	35	2,920	14	570	3	1,330	7
VIIIe1	—				290	9	440	14	580	19	1,789	58
Suite Total	39,270	48	22,470	27	12,800	27	3,360	4	1,150	1	3,110	4

Land Use

The majority of this suite is in pastoral use. This requires a high standard of management to achieve production potentials, and at the same time minimise soil erosion. The key to this management is sufficient subdivision fencing to enable differential grazing of sand dunes and sand plains. On all LUC units, except IIIw4, the main pasture growth period is from April to October. Lambing is early, enabling most lambs to be fattened and removed from properties before pasture production declines in November.

Dairying is the dominant land use on the wet sand plains (LUC unit IIIw4), especially south of the Rangitikei River. Pasture productivity on the dry sand plains (LUC units IVe10 and VIs4) is limited by shallow topsoils, poor soil structure and susceptibility to drought. The establishment of lucerne in such situations dramatically increases feed production in summer and enables stock carrying capacities over the year to be increased by approximately 50%. However, damage from white fringe weevil has recently become a major problem in lucerne pastures, and without effective control this pest will severely limit the use of lucerne.

The dry sand plains have a considerable potential for some horticultural crops if shelter and irrigation are provided. This is because of the high sunshine hours and the ability to cultivate all year. However, excessive tillage can lead to a loss of organic matter, rapid deterioration in soil structure and a consequent increase in wind erosion potential.

The migration of dunes onto productive land has mostly been controlled by forest planting and other erosion control practices. 3,848 ha of this suite had been planted in exotic State Forest by 1985 (NZ Forest Service 1986). Additionally there are smaller areas of farm woodlots and private forestry company plantings.

Land use capability units in the sand country suite can be separated into those occurring on sand plains and those on sand dunes. Salient features of the LUC units are summarised in Table 22.

LUC UNITS ON SAND PLAINS

LUC unit IIIw4 (24,800 ha)—Figure 37

This unit comprises the wet sand plains in which the water table is near the surface all year. IIIw4 contrasts with the drier more elevated higher sand plains (LUC units IVe10 and VIs4) which have a lower water table and suffer extended periods of soil moisture deficiency. Soils mapped include the Pukepuke and Carnarvon series and gley soils such as the Carnarvon black loamy sand. Also included are small areas of swamp which could not be separated at the scale of mapping.

Dairying is the dominant land use. Supplementary feed crops such as chou-moellier, turnips, swedes and maize are grown, as well as occasional crops of barley and wheat. The potential stock carrying capacity is 25 su/ha while the site index for *P. radiata* is 30–33 m.

Management of this unit should always be related to adjacent areas. The danger is that by lowering the water table level in IIIw4 map units, neighbouring areas (IVe10 and VIs4) are likely to be adversely affected by lowered water tables. There is a slight wind erosion potential when IIIw4 is cultivated.

LUC unit IVe10 (15,050 ha)—Figure 38

This unit comprises the drier sand plains which have yellow-brown sand soils of low to moderate natural fertility and subject to long periods of summer drought. The dominant soils are the Himitangi, Awahou and Mosston series. There is a potential for slight wind erosion when in pasture but if cultivated the wind erosion potential is severe. Supplementary feed crops can be grown, in addition to barley and wheat. Such cropping is marginal because of the wind erosion risk, droughtiness, low soil nutrient levels and poor soil structure. Direct drilling of crops and the provision of shelterbelts is recommended. Lucerne enables a potential stock carrying capacity of 20 su/ha compared with 14 su/ha with pasture. The site index for *P. radiata* is 28–31 m.

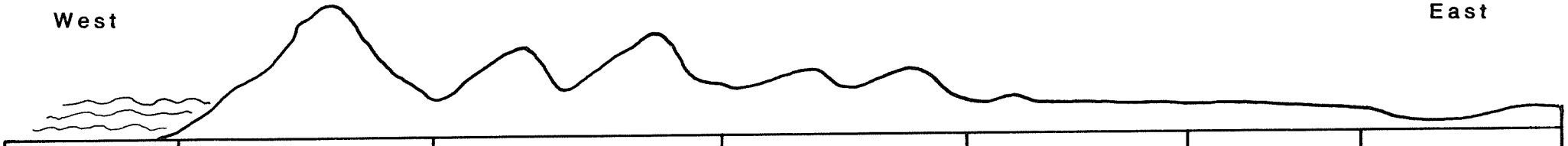
When irrigated (and with adequate shelter) this unit may have a potential for horticultural crops. Disadvantages are the strong winds (and accompanying salt spray) and low natural soil fertility. Suitable horticultural crops may include asparagus, watermelons, some vegetables, kiwifruit, grapes, pip fruit, stone fruit and berry fruit crops.

LUC unit VIs4 (7,250 ha)

This unit occurs predominantly on flat, dry sand plains but also includes some areas of low undulating sand dunes. The dominant soils are the Hokio, Himatangi, Mosston and Patea series.

This LUC unit is similar to IVe10 but water tables are deeper and soils are more prone to drought and to wind erosion. It is the increased wind erosion hazard and the consequent necessity to maintain a complete vegetative cover that makes this unit non-arable. Establishment of lucerne can lift the potential stock carrying capacity to 20 su/ha compared to 14 su/ha in pasture. VIs4 has a site index for *P. radiata* of 28–31 m and is well suited to production forestry.

Table 22: Relationship between LUC units in the coastal sand country LUC suite (idealised cross section)



L U C Unit	VIIIe1 (within c 400 m of the coast)	VIIe15	VIe24	VIs4	IVe10	IIIw4
Erosion Potential	Extreme wind	Extreme wind	Moderate wind	Slight wind	Nil to slight wind severe when cultivated	Nil
Site Index *P. radiata*	-	26-28	28-31	28-31	28-31	30-33
Potential su/ha	-	5 su/ha	14 su/ha	14 su/ha 20 su/ha	14 su/ha 20 su/ha	25 su/ha
Potential Land Use	Protection forest	Erosion control forestry	Production forestry Grazing	Intensive grazing Production forestry	Intensive grazing Horticulture cropping	Intensive grazing Horticulture cropping

Figure 37: IIIw4 in foreground and VIe24 on sand dunes. Prier Road, Mangawhata. N148 920303 looking SW.

Figure 38: IVe10 in foreground and VIIe15 on sand dunes. Wylie Road, Foxton. N148 777230 looking SE.

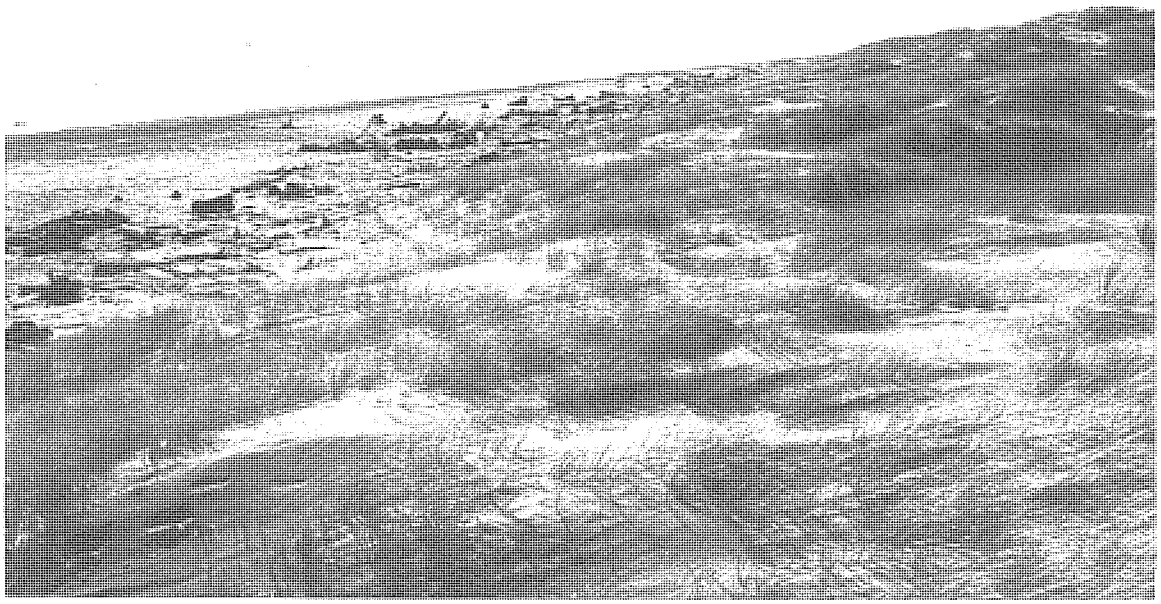


Figure 39: VIIIe1 on sand dunes within 400 m of the coast. Foxton Beach. N148 740230 looking N.

LUC UNITS ON SAND DUNES

LUC unit VIIIe1 (3100 ha)—Figure 39

This unit consists of a narrow strip extending up to 400 m inland from the coast. It comprises the foredune and adjacent unstable sand dunes and sand plains. All VIIIe1 map units are recorded as having between 10% and greater than 60% bare ground affected by wind erosion (Table 21).

The erosion hazard can be mainly attributed to the following harsh environmental conditions, all of which discourage plant growth.

1) Exposure to strong salt laden winds.
2) Unstable nature of the sand dunes.
3) Severe soil moisture deficiencies.
4) Very weak soil development.
5) Nitrogen deficiency.

Eroded areas require stabilisation with marram grass and lupin prior to the establishment of *P. radiata.* Soils are classified as recent, with Waiterere series on the dunes and Hokio series on the sand plains.

VIIIe1 is extremely sensitive to erosion induced by grazing and stock trampling and must be managed for protection. The most satisfactory method of achieving this is by protection forest planting which prevents sand dunes migrating inland. Urban development is undesirable because of the high risk of erosion.

LUC unit VIIe15 (20,500 ha)—Figure 38

This LUC unit is mapped on dunes more than 400 m inland from the coast. It is capable of both forestry or pastoral production. Soils are dominantly yellow-brown sands particularly on

the Motuiti, Castlecliff, Mosston and Patea series, although the Waiterere series (Recent soils) are also included in unstable areas.

Fifty-nine percent of VIIe15 has more than 10% of bare ground affected by wind erosion. Stabilisation of these areas is best achieved by planting in erosion control forestry which serves both a production and protection function. Some is suitable for strictly controlled grazing, however, fencing from adjacent LUC units is necessary to enable effective differential grazing which will minimise stock trampling and prevent overgrazing of the dunes. Erosion control forestry is a preferred land use in terms of minimising erosion and maximising the LUC unit's productive potential. Site index values for *P. radiata* are 26–28 m while the potential stock carrying capacity is 5 su/ha.

LUC unit VIe24 (11,250 ha)—Figure 37

This unit occurs on undulating to moderately steep stabilised dunes which are generally lower, less steep and further inland than dunes mapped as VIIe15 or VIIIe1. All map units on VIe24 are recorded as having less than 20% of bare ground affected by wind erosion.

The dominant soils are the Foxton, Motuiti, Waiterere, Castlecliff and Patea series. VIe24 has a site index for *P. radiata* of 28–31 m and is well suited for production forestry, although the majority is in pasture. The potential stock carrying capacity is 14 su/ha but the present average stocking rate is estimated at only 6 su/ha.

4. LUC SUITE ON ALLUVIUM

This LUC suite is characterised by its floodplain landform and alluvial soils. The alluvium, is derived mainly from greywacke, but also from sandstone, mudstone and loess with a volcanic tephra component. The LUC suite comprises 12 LUC units and covers 97,850 ha (4.1%) of the region.

On the basis of differences in soil texture and location, the LUC suite has been subdivided into two subsuites:

1. On wide flood plains and river valleys in the Manawatu and Rangitikei areas. (LUC units Iw1, IIw1, IIw2, IIw4, IIs1, IIIw1, IIIs2, IVs2 and VIs7.)
2. On narrow river terraces in hill country. (LUC units IIIw2, IVw1, IVw2).

4a LUC subsuite on wide flood plains and river valleys

This subsuite occurs on river terraces and floodplains of mainly the lower Rangitikei, Manawatu, Oroua, Pohangina and lower Turakina and Whangaehu River catchments (Figure 40). Most LUC units in this subsuite are highly developed for pastoral farming and cropping. This subsuite covers 77,750 ha and includes 34% of the LUC Classes I and II land in the Taranaki-Manawatu region.

Physiography

The Manawatu River rises east of the Ruahine and Tararua Ranges and flows westward through these ranges by way of the Manawatu Gorge, where it is joined by the Pohangina River at Ashhurst and the Oroua River at Rangiotu. The physiography of the Manawatu and Oroua River flats has been described by Cowie and Rijkse (1977). Within this subsuite the Manawatu River has a broad braided channel which becomes narrower with more developed meanders downstream. The higher and better drained levees of the Manawatu and Oroua rivers grade into lower lying more poorly drained areas, the largest of which is the shallow Taonui basin between the Manawatu and Oroua Rivers. The river flats adjacent to the Rangitikei, Turakina and Whangaehu Rivers are very much more limited in area, are at higher elevation and are usually better drained. Upper Pleistocene terraces corresponding in age to the Ohakea terrace occur further inland.

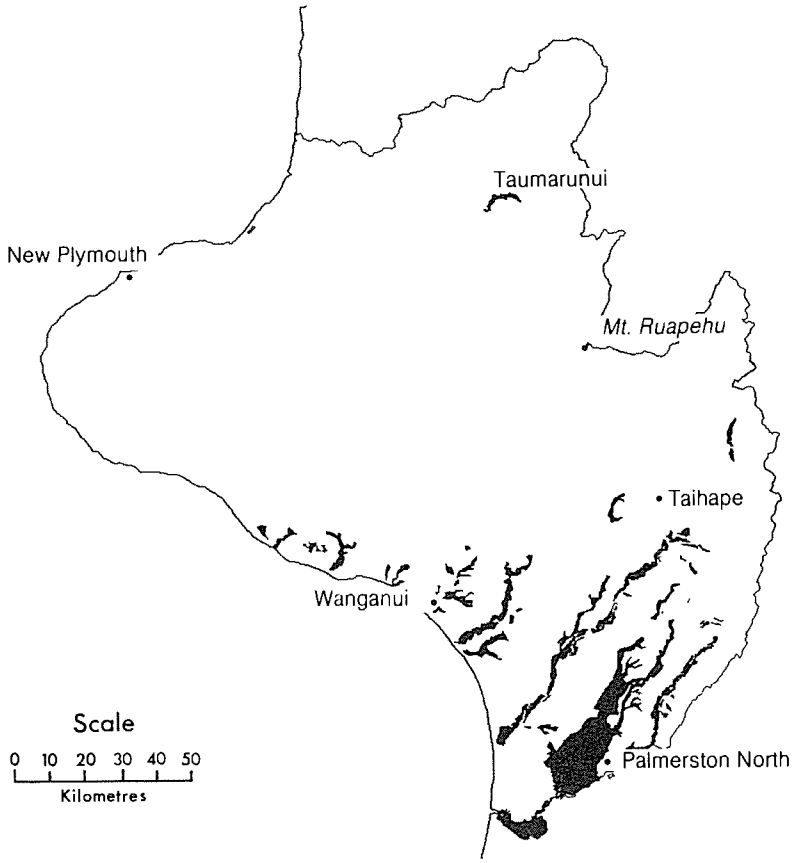


Figure 40: Location of LUC subsuite 4a: wide floodplains and river valleys.

Climate

Data from the Kairanga Climatological Station is representative of the subsuite on the lower Manawatu River floodplain, while information from the Ohakea climate station is representative in the lower catchments of the Rangitikei, Turakina and Whangaehu Rivers. At Kairanga (15 m a.s.l.) the mean annual rainfall is 936 mm. Rainfalls are lowest in January, February, April and November, while May and July have the highest monthly rainfalls. The mean air temperature is 12.9°C and an average of 50.7 days of ground frost occur annually. This compares with Ohakea (48 m a.s.l.) which is nearer the coast and has a lower annual rainfall and warmer temperatures. The subsuite is characterised by warm summers. This LUC suite also occurs inland at about 500 m a.s.l. in the Kawhatau Valley and 800 m a.s.l. in the mid Rangitikei Valley. Here temperatures are cool particularly in areas adjacent to the Ruahine Ranges.

Rock Type

On recent floodplains the rock type is quartzo-feldspathic alluvium. The alluvium is mainly silty textured but adjacent to the rivers textures are sandy to bouldery. In some low lying poorly drained areas peaty deposits are interbedded with alluvium.

On the Upper Pleistocene aged terraces soil parent materials are variable. They have been described as comprising greywacke gravels with alluvial sands overlain by a thin layer of loess and some volcanic ash (Rijkse 1977), also greywacke and volcanic alluvium with some volcanic ash (Campbell 1979). Cowie and Milne (1973) however, have considered that the loess cover is absent in almost all places and is nowhere more than 0.5 m thick.

Soils

Soils were recorded using information from the Kairanga, Manawatu, Pohangina, Rangitikei, and part Wanganui County soil surveys and the General Soil Survey.

Soil texture, drainage and frequency of flooding determine the properties of soils and LUC units in this subsuite.

The Manawatu and Karapoti series comprise recent soils which are the most fertile and versatile in the region. The Manawatu series occur on slightly higher and broader levees bordering the main rivers. The Karapoti series occur on higher and better drained areas that were formerly under scrub or forest. Within these two series textural differences are used to differentiate soil types e.g., Manawatu silt loam, Manawatu fine sandy loam and Manawatu sandy loam. Mottled types and stony or gravelly phases may also be recognised.

The Kairanga series and Te Arakura series are gleyed recent and gley soils respectively. The Kairanga series is restricted to imperfectly, poorly and very poorly drained sites. In the Kairanga series four soil types are recognised which are based on natural drainage and textural differences closely related to topographic position. The Kairanga fine sandy loam occurs on slightly higher areas. Where the land is lower the soils become heavier in texture and more poorly drained, so that the Kairanga silt loam grades through Kairanga heavy silt loam into Kairanga peaty silt loam. The Makerua series (an organic soil) occurs in low lying peaty swamps.

Other minor soil series in the subsuite are the Rongotea peaty loam and the Piako soil set (both organic soils), and the Opiki peaty silt loam, a gleyed recent soil.

Soils on the low level terraces are recent and of the Rangitikei series. Also included are the Tukituki and Esk soil sets and Tarata soils. All these soils are well drained, poorly structured and have a predominantly sandy texture although they can be bouldery particularly in the upper reaches of catchments.

On the intermediate level terraces the Ashhurst silt loam, shallow phase, is recorded in Pohangina County, and the Ashhurst stony sand loam in Rangitikei County. These soil types occur in areas with less than 1150 mm p.a. rainfall and are particularly susceptible to summer drought. In areas of higher rainfall the Kawhatau stony silt loam (1150–1400 mm p.a.) and the Kopua stony silt loam (>1400 mm p.a.) are recorded in both Pohangina and Rangitikei counties, while the Kawhatau stony silt loam and the Kopua stony loam soil sets are recorded in the Kiwitea County. All the soils on this terrace level have stony textures and are well drained. As rainfall increases the topsoils become more friable and have a more strongly developed structure.

Erosion

Some wind erosion occurs on this subsuite in the Rangitikei catchment. Streambank erosion is usually of only slight severity.

Land Use and Management

Most of this subsuite is highly developed for agriculture. Dairying and fat lamb farming are the major land uses. Although the rainfall is lower than in other major dairying areas, butterfat production per cow is generally above the NZ average. On LUC Class I land top farmers are carrying about 22 su/ha but have a potential to carry 30 su/ha. Supplementary crops including maize, choumoellier, mangolds, and turnips are grown on dairy and sheep farms to provide feed during periods of feed shortage.

A wide range of cash crops can be grown and this has resulted in a decline in the number of dairy cows and sheep carried. Wheat, barley, oats, peas, maize, grass seed and potatoes are all grown. In Kairanga County for example, most of the 815 ha of wheat, 800 ha barley, 380 ha maize (for grain), 250 ha peas and 40 ha oats grown in 1982–83 (Dept of Statistics 1984) were on this subsuite. It is expected that the expansion in cropping will continue. Barley is in strong demand, both as a feed grain and for malting. Predictions of a considerable increase in the area of wheat in the southern North Island should also expand wheat growing on this subsuite.

Horticulture, including vegetable growing, nurseries, berry fruit and pip fruit orchards is mainly on LUC unit Iw1 and to a lesser extent on all other units except IIIw1. However shelter and irrigation are essential for horticultural development.

The main constraint to the intensification of agricultural production is the requirement for drainage particularly on LUC units IIw2, IIIw1 and IIw4. Drainage involves both open drains and the installation of an integrated subsurface system involving both mole and tile drains. In some areas low grades and the difficulty of providing drainage outlets has necessitated the use of pumps and the provision of ponding areas. This is particularly so in the Taonui basin. Damage to pastures and soil structure caused by animal treading after heavy rainfall is a problem. This is minimised by the provision of runoffs in the nearby sand country, and more recently, the use of cattle pads for dairy and beef herds. Where there is a change in land use from pastoral farming to cropping, more intensive subsurface drainage is required to achieve maximum crop yields.

Flooding of the Manawatu River has been a major problem, however the completion of the lower Manawatu River Flood Control Scheme in 1963 provides adequate protection for most of the land in this subsuite. Ponding of water occurs for short periods on LUC unit IIIw1 when the Oroua and Manawatu Rivers are in flood.

LUC Units IVs2 and VIs7 occurring on low level river terraces are used mainly for rough grazing with alluvial deposition being a hazard particularly on VIs7. Intensive sheep farming with occasional cropping is the dominant use on LUC unit IIIs2.

LUC Units

The nine LUC units in this subsuite are differentiated on the basis of soil texture, soil depth, drainage properties and potential for flooding and deposition as follows:

- LUC units Iw1 and IIw1 have recent soils. These LUC units are distinguished by the degree of wetness limitation after drainage as it affects cropping.
- LUC unit IIs1 also has recent soils. But IIs1 has a sandy texture and is more freely drained than LUC units Iw1 and IIw1.
- LUC unit IIw4 is a complex of peat and alluvium.
- LUC units IIw2 and IIIw1 have gleyed recent and gley soils Intensive subsurface drainage is required. LUC unit IIIw1 is also affected by frequent water inundation.
- land use capability on units IIIs2, IVs2 and VIs7 is dependent on soil depth, soil texture and frequency of flooding.

LUC unit Iw1 (10,250 ha)—Figure 41

This unit occurs on alluvial floodplains in the south of the region, particularly those of the Rangitikei, Oroua, Manawatu and Pohangina Rivers.

Typical soils are the Manawatu silt loam, Manawatu fine sandy loam and Karapoti black silt loam, which are developed on fine textured undifferentiated floodplain alluvium. Soils are deep, with excellent physical properties and a high natural fertility. Although free draining they have a very slight wetness limitation in winter and spring after drainage.

Soils on Iw1 are capable of being almost continually cropped with consistently high yields. Horticultural uses include vegetable cropping, nurseries (both shrubs and flowers), berry fruit and pip fruit orchards. However the only area which is in intensive horticultural use is the Te Matai Road area near Palmerston North. Irrigation in summer is necessary to achieve the horticultural, cropping and pastoral potential of this unit.

Despite its suitability also for cereal cropping, the dominant land use is intensive grazing, particularly dairying and sheep and cattle fattening. The top farmer stock carrying capacity is 22 su/ha with an attainable potential of 30 su/ha. The site index for *P. radiata* is between 33–34 m, except in more exposed locations nearer the coast where it is as low as 30 m.

LUC unit IIw1 (1500 ha)—Figure 42

IIw1 has a slightly greater wetness limitation after drainage than LUC unit Iw1. It occurs closer to the river channel than Iw1, consequently there is a risk of flooding for short periods on average once every 3–5 years in some areas. Improvements in flood control works are minimising this hazard.

Typical soils are the Manawatu sandy loam, Manawatu mottled fine sandy loam and Karapoti sandy loam. These soils generally have sandier textures than those on Iw1. With irrigation, this unit is capable of growing the same kinds of crops as Iw1, although it is less suitable for permanent deep rooting orchard crops. The potential stock carrying capacity is 30 su/ha and the site index for *P. radiata* is 33–34 m.

LUC unit IIs1 (6100 ha)

This unit is mapped on river levees in the Manawatu and Rangitikei districts which are free of flooding and have recent, free draining, sandy textured soils.

Soils are the Manawatu and Karapoti series. The principal soil types within these series are the Manawatu sandy loam and the Karapoti sandy loam. These dry out slightly in summer, therefore irrigation is necessary to achieve the horticultural and pastoral potential of this unit. IIs1 does have the advantage of being better drained in winter and spring, than LUC units Iw1 and IIw1.

The dominant land use is intensive grazing particularly dairying, although horticulture, particularly market gardening and nurseries, are important in some areas. Asparagus, pip and stone fruits, berry fruit and kiwifruit are crops likely to be suitable for this unit. Other crops grown include maize, barley, lucerne and root and green fodder crops. The potential stock carrying capacity is 30 su/ha and the forestry site index for *P. radiata* is 32–35 m.

LUC unit IIw4 (2800 ha)—Figure 43

This unit is mapped on flat, low lying areas on the Manawatu and Oroua floodplains where peat and alluvium have accumulated, and are capable of being effectively drained.

The Kairanga peaty silt loam is mapped where there is a shallow accumulation of peaty material. Where peaty layers are more pronounced the Opiki silt loam is recorded. The Makerua series (organic soils) are mapped on low lying swamp areas where peat is the dominant parent material. An important management requirement is control of the water table. This needs to be kept at a level sufficient to maintain plant growth in summer. Where this unit has been over-drained, soils become dry in summer and very difficult to rewet. There is a potential for slight wind erosion if over-drained areas are cultivated.

Most has been drained and developed to high producing pasture. Dairying is the main land use, although potatoes, barley, wheat, process peas, maize, grass seed, sunflowers, vegetables and berry fruit are becoming increasingly important. The present average stock carrying capacity is 18 su/ha with a potential of 30 su/ha. The site index of *P. radiata* is 30–32 m, indicating a high suitability for exotic forest growth.

LUC unit IIw4 correlates with IIw2 of the Wellington Region LUC classification (Page 1985).

Included in IIw4 are 750 ha (27% of IIw4) of organic soils on flat valley floors that dissect terraces in the Rongotea and Waverley areas. In both these situations the parent material is a mixture of peat and colluvium, on which organic soils have developed. The Rongotea peaty loam occurs in the Rongotea area while the Piako soil set (108) is mapped in the Waverley district.

LUC unit IIw2 (39,700 ha)—Figure 44

This unit occurs on flat alluvial terraces with deep, fertile, gley, or gleyed recent soils, which have a slight wetness limitation remaining after drainage. This unit is most extensive on the wide floodplains of the Manawatu River but is also important on the floodplains of the lower Rangitikei, Whangaehu, Turakina and Waitotara rivers.

Figure 41: Iw1. Horticultural nursery Te Matai Rd near Palmerston North. N149 170370 looking SE.

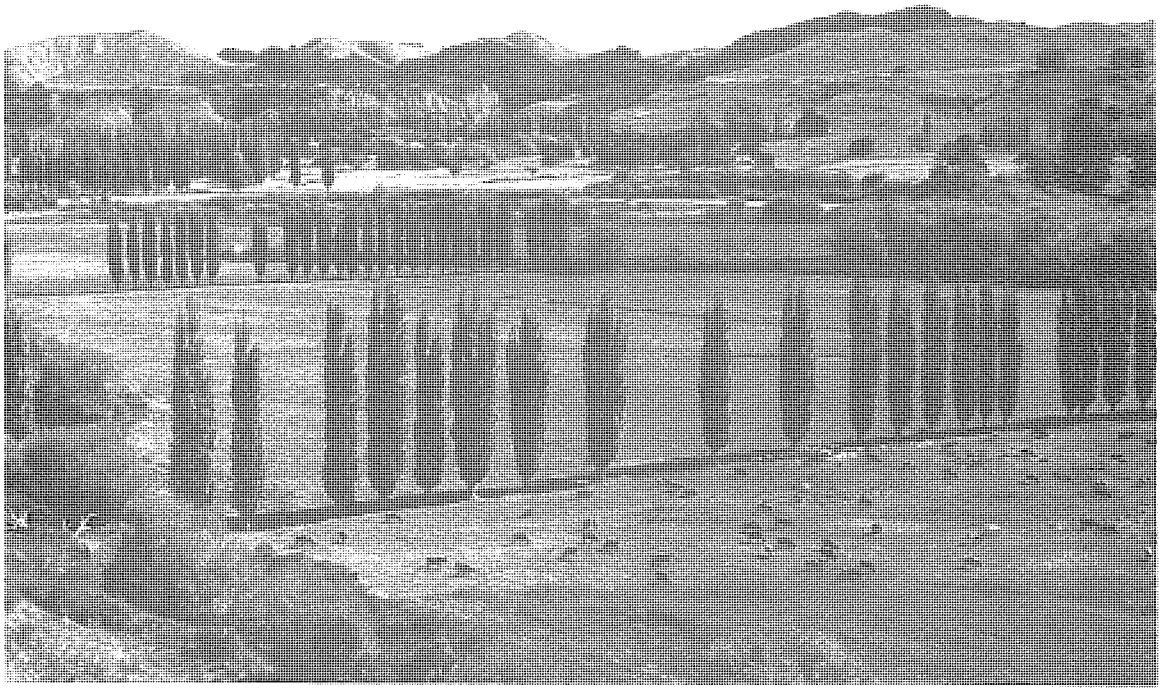


Figure 42: IIw1. Pohangina valley. N144 290570 looking N.

Figure 43: IIw4 on peat and alluvium. Market gardening near Kopane. N148 970411 looking S.

Figure 44: IIw2 on gley and gley-recent soils, Manawatu Plains. Intensive dairying near Kopane. N148 957414 looking SE.

The predominant land use is intensive grazing particularly dairying and sheep and cattle fattening. Subsurface drainage together with cattle pads and feeding platforms should be used to minimise soil pugging during wet periods. The potential stock carrying capacity is 30 su/ha and the site index for *P. radiata* is 33–35 m.

Provided there is adequate subsurface drainage and effective shelterbelts IIw2 is well suited to market garden crops, wheat, barley, maize, potatoes, process peas, beans, sweet corn, grass seed and root and green fodder crops.

The Kairanga series and the Te Arakura series are the principal soils recorded. Alluvial terraces in hill country with gley or gleyed recent soils are classified as LUC unit IIIw2 if the valley width is less than about 400–800 m.

Figure 45: Ponding of floodwaters on IIIw1. Kairanga district. N148 993307 looking W.

LUC unit IIIw1 (2600 ha)—Figure 45

This unit is mapped on areas of the lower Manawatu plains between Rangiotu and Karere that are designed to be used as ponding areas in the lower Manawatu River Flood Control Scheme. These areas can be inundated by water for periods of 1 to 2 days on average, up to 3 times a year. Ponding occurs when the Oroua River is in flood, and pumps discharging water from drainage schemes in the Taonui Basin into the river cannot cope with the available water.

Dairying is the predominant land use. This unit should be used in conjunction with adjacent areas of non-flooding IIw2 or adjacent sand country LUC units. Cattle pads and feeding platforms are necessary to minimise pasture damage during wet periods.

The potential stock carrying capacity is 28 su/ha. IIIw1 is unsuitable for *P. radiata.*

Because of the flooding risk IIIw1 is not suited to permanent horticultural crops, however barley, wheat, grass seed, maize and root and green fodder crops can be grown if the ponding risk is accepted.

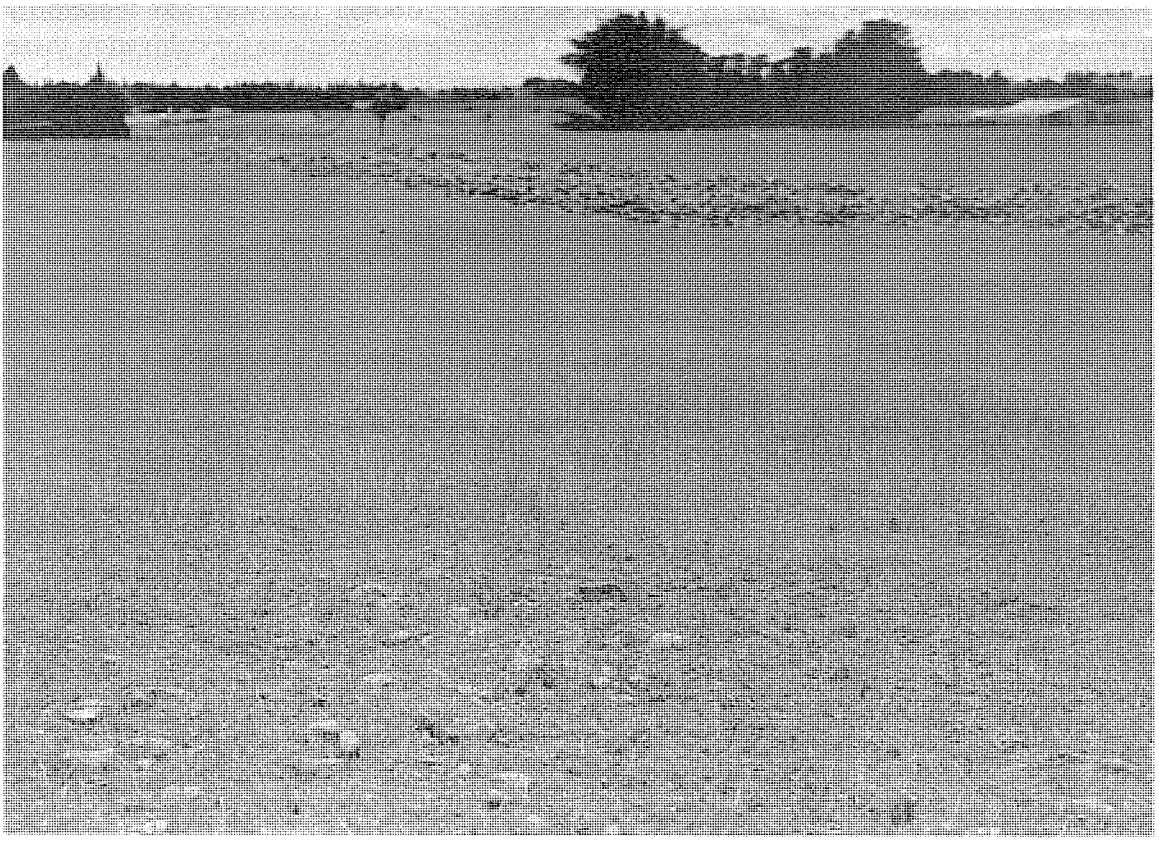


Figure 46: IIIs2. Porewa Rd near Marton. N143 978705 looking W.

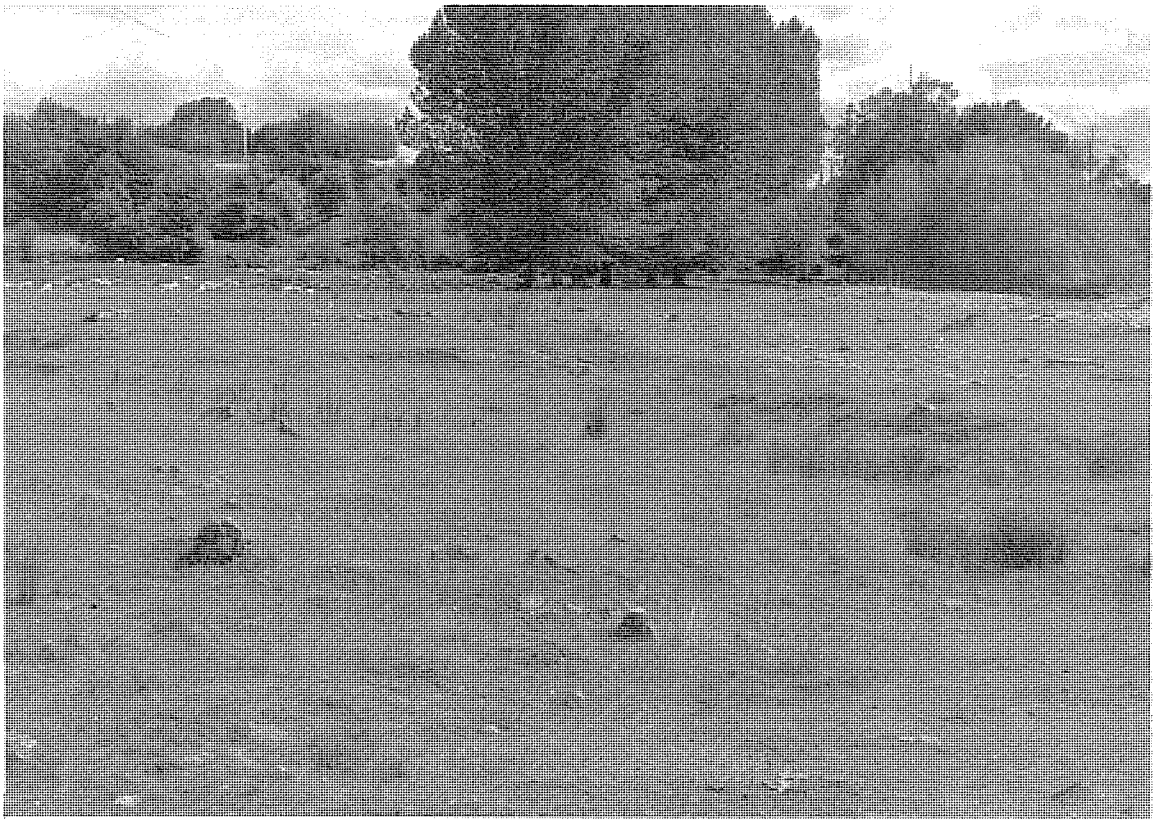


Figure 47: VIs7. Karewarewa, nearRangiwahia. N139 410943 looking W.

On the 1st edition N148 and N149 worksheets the Moutoa floodway was incorrectly mapped as IIIw1. Because of the flood hazard and consequent limitations for cultivation these map units will be amended to VIs7 on 2nd edition worksheets.

LUC unit IIIs2 (7850 ha)—Figure 46

This unit is mainly on Pleistocene aged terraces in hill country where loess, volcanic ash and/or fine textured greywacke and volcanic alluvium overly gravels. Stones within the profile and on the surface are generally small and do not significantly hinder cultivation, although the cropping potential could be improved by the use of stone picking machinery.

IIIs2 is used for intensive grazing and some cereal cropping. In hill country areas it is also important for the growing of root and green fodder crops and hay to be used for supplementary feed. Land use could be intensified with the use of shelterbelts and irrigation, to include more cropping and horticulture. The present average stocking rate is 16 su/ha, while the potential stock carrying capacity is 26 su/ha. The forestry site index for *P. radiata* varies between 29–32 m.

Also included in this unit are 950 ha of recent soils of the Rangitikei series on Holocene aged terraces of the Rangitikei River. These areas are considered to be free of flooding and to have only moderate limitations for cropping.

LUC unit IVs2 (3150 ha)

This unit is mapped where there are severe limitations to arable use. Constraints are shallow soil depth, sandy or stony texture, seasonal soil moisture deficits and risk of flooding.

The majority of IVs2 (85%) comprises recent soils adjacent to river and stream courses. The remainder consists of stony-textured soils on Pleistocene aged terraces.

IVs2 is only suited to occasional cereal or root and green fodder crops. The potential stock carrying capacity is 20 su/ha and the site index for *P. radiata* is 26–29 m. IVs2 is a broadly defined unit that could be subdivided into several LUC units in future NZLRI mapping at the 1:63,360 scale.

LUC unit VIs7 (3800 ha)—Figure 47

VIs7 comprises recent soils which are of sandy texture or are bouldery and may be frequently flooded. In the lower river catchments VIs7 occurs mainly on sandy textured soils of the Rangitikei series. These soils are droughty with little or no profile development. In upper catchments such as the Kawhatau the soil parent material is more bouldery with many large boulders at the surface.

The vegetation is dominantly scattered lupins or native scrub associations with low producing pasture in some areas. The potential stock carrying capacity is only 7 su/ha, with present average levels being about 3 su/ha. On areas not prone to flooding forestry production potentials are medium (SI 25–29 m).

River and streambank protection is required although bank erosion is generally of slight severity. VIs7 is a broadly defined LUC unit. In future remapping at the present scale, areas that are frequently flooded and subject to severe deposition, should be classified as class VIII or as part of the river channel. Other areas of this unit may be better classified as class VII.

4b LUC subsuite on narrow river valleys

This subsuite comprises LUC units IIIw2, IVw1, IVw2 on river terraces within Tertiary aged hill country. Valley floors are less than 800 m wide, and runoff from adjacent hills limits cropping. The subsuite covers 20,100 ha (0.8%) of the region. Its distribution is shown in Figure 48.

Physiography

This subsuite comprises mainly low level alluvial terraces but included in IIIw2 are areas of higher terraces mantled with colluvium from nearby valley slopes.

Climate

The climate over this subsuite is varied. In the Taumarunui, Taihape and southern Wanganui, Manawatu and Rangitikei hill country rainfall is between 1000–1200 mm p.a. The latter areas have a mild climate with few frosts. For example, Wanganui averages 10.7 days of ground frost per year and has a mean temperature of 13.6°C (NZ Met Service 1983a). Further inland, rainfall increases to as much as 2400 mm p.a. in inland Taranaki and frosts become more frequent and severe. For example, Te Wera has a mean temperature of 11.9°C and an average of 74 days of ground frost per year.

Rock Type

The source of soil parent materials are nearby hillslopes underlain by Tertiary aged rocks and mantled with tephra cover deposits.

Soils

Soils recorded were from the Stratford, Rangitikei, part Wanganui, and Pohangina County Soil Surveys, the King Country Survey, and the General Soil Survey.

Gleyed recent and gley soils developed on alluvium and/or colluvium are the largest group of soils in the subsuite. The most extensive of these are the Kairanga series, a gleyed recent soil. Other soils include the Kaikarangi silt loam—a strongly gleyed recent soil in inland Taranaki; the Raumati series, a gley soil developed on colluvium on high terraces particularly in the Wanganui and Rangitikei areas; and the Aratora series, also a gleyed recent soil. The Ohinemoa and Kokau are recent soils recorded on better drained situations in the King Country.

Erosion

Streambank erosion was the only significant erosion recorded. Recorded erosion was usually of a slight or moderate severity although severe streambank erosion was recorded on some IIIw2 map units particularly in the Waitotara and Moumahaki catchments.

Land Use and Management

Most of the subsuite is developed for farming. Map units covering 82% of the subsuite have pasture recorded, with grazing also possible on much of the remaining area which is in grassland-forest, grassland-scrub or swamp vegetation. Pastures comprise mainly high producing species but rushes are significant in poorly drained areas.

Sheep and cattle grazing are the dominant land use although dairying is important in north Taranaki. Being in a hill country situation the LUC units are particularly valuable for the growing of supplementary fodder crops and hay. However, this activity is made difficult mainly because of poor drainage, and the presence of meandering, often deeply incised streams and rivers which create access difficulties for cultivating and harvesting machinery. Ponding of surface water can occur after heavy rainfall, though the effects of this can be minimised by surface drainage. Diversion drains are often used to channel surface water away from the surrounding hill slopes. Intensive subsurface drainage is necessary to maximise cropping and pastoral potentials.

Flooding is a particular problem in the Waitara, Urenui, Uruti and Tongaporutu catchments in north Taranaki, and also the Waitotara catchment where major flooding is a 5 yearly event (Taranaki Catchment Commission 1982).

LUC unit IIIw2 (11,500 ha)—Figure 93

This unit comprises flat, narrow (400 to 800 m wide) valley floors.

Soil wetness, access difficulties and erosion hazard limit cropping. Runoff from adjacent hills results in a moderate wetness limitation even after drainage has been carried out. This reduces cropping versatility and limits periods available for crop planting. Access difficulties are caused by meandering streams or rivers which dissect the unit into small 'islands'.

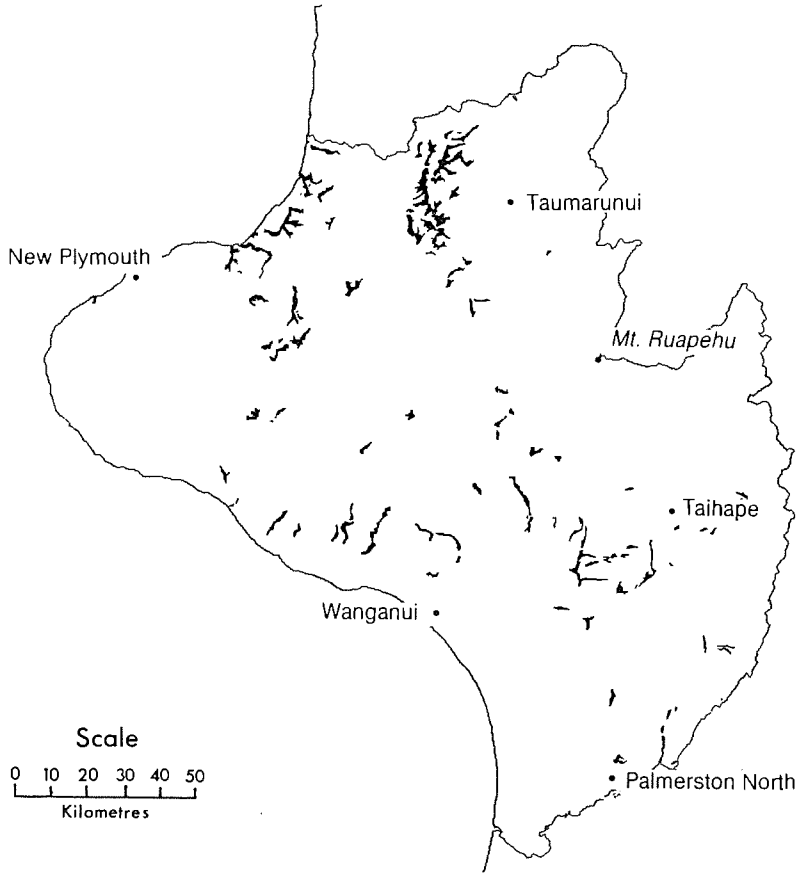


Figure 48: Location of LUC subsuite 4b: narrow river valleys.

In many areas however, IIIw2 is the only arable land in hill country farms and is therefore particularly valuable for the growing of supplementary feed crops. A high level of development has therefore been achieved with 86.5% of the map units in pasture or cropland. The remainder is grassland-forest or grassland-scrub. The main soils are the Kairanga, Raumati, Kaikarangi, Arotora, Ohinemoa and Kokau series.

This unit is most suited to root and green fodder crops, however cereals may also be grown in areas of lower rainfall. The potential stock carrying capacity is 25 su/ha and the site index for P. radiata is 28–30 m.

Most IIIw2 occurs on higher level terraces that are deeply incised by rivers or streams. Where IIIw2 occurs on lower level terraces streambank erosion, flooding and silt deposition is a problem. This is most evident in the Waitotara and Moumahaki catchments. There is a potential for slight sheet and rill erosion when gently sloping colluvial slopes are cultivated.

LUC unit IVw1 (6750 ha)—Figure 49

This unit comprises flat valley floors (less than about 400 m wide) that are subject to periodic flooding and/or runoff from adjacent hills.

This unit is restricted mainly to north Taranaki. There are severe limitations to cropping because of runoff from adjacent hills and the flooding of streams. Meandering streams which closely dissect this unit provide access problems for agricultural machinery and reduce the effective croppable area.

Dairying is the predominant land use although there is some sheep and cattle fattening. 74% of the LUC unit is in pasture, and grazing is also possible on much of the grassland-forest or grassland-scrub which covers the rest of this unit. The dominant soils recorded are the Kairanga and the Kokau series. Cropping is generally restricted to the growing of root

Figure 49: IVw1 on valley floor. Hillslopes are VIIe20 or VIIIe3 (LUC subsuite 10b) on 'Urenui' siltstone. Kaka Rd near Okoki, Urenui catchment. N109 089975 looking SW.

Figure 50: IVw2 on strongly gleyed recent soils. Te Wera. N110 140705 looking SE.

and green fodder crops. The potential stock carrying capacity is 19 su/ha and the site index for *P. radiata* is 27–29 m.

Flooding is a particular problem in the Ahititi and Uruti areas. For example extensive flooding in the Mimi and Uruti catchments occurred on 5 occasions in the 15 years between 1965 and 1980 (Taranaki Catchment Commission 1982). This can result in the closure of county roads and sometimes SH3 and SH40 also. Less extensive inundation of river flats occurs more frequently, probably on average once or twice a year. Measures to enable this unit to achieve its production potential include drainage, diversion banks to divert runoff from surrounding hills, stopbanks, protection planting of stream banks and removal of willow trees from stream channels. Complete flood protection of IVw1 may not be feasible because of the small areas involved.

LUC unit IVw2 (1850 ha)—Figure 50

This unit comprises flat, narrow valley floors which have a permanent high water table and are frequently inundated with surface water. This unit occurs principally in the Te Wera, Huiroa and Kohuratahi areas of inland Taranaki.

Eighty-five percent of the map unit has been developed into pasture. Most of the remainder is undeveloped and comprises predominantly kahikatea forest or swamp associations. The dominant soils recorded are the Kaikarangi and Kairanga series. The permanent high water table and frequent surface flooding limits cropping to occasional root and green fodder crops. A high standard of drainage is required to achieve a potential stock carrying capacity of 18 su/ha. This unit is unsuitable for exotic forestry, because of the permanently high water table.

5. LUC SUITE ON LOESS

This suite is characterised as occurring on terraces with soils developed on quartzofeldspathic loess from floodplains. There have also been intermittent additions of tephric loess and airfall tephra to the soil parent material.

The suite occurs mainly in the lower Rangitikei, Wanganui and Manawatu areas. It comprises 11 LUC units and occupies 149,950 ha (6.3%) of the region.

A low rainfall subsuite and a high rainfall subsuite have been recognised on the basis of climate and soil differences.

a) *Subsuite with low rainfall*

This subsuite occurs in areas with 800 to 1100 mm p.a. rainfall and a distinct dry season. Soils are yellow-grey earths. These soils are characterised by a compact fragipan which perches water, and the presence of gleying and mottles which become more pronounced with depth. The soils dry out in summer, become very wet in winter, and require subsurface drainage if high levels of production are to be achieved.

b) *Subsuite with high rainfall*

This subsuite occurs further inland where the rainfall is generally between 1150 and 1800 mm p.a. The soils differ from those in the low rainfall subsuite by having a greater component of tephra. They are deep, friable, well drained and have no fragipan. The soils are classified as intergrades between yellow-brown earths and yellow-brown loams, intergrades between yellow-brown loams and yellow-brown earths, or yellow-brown loams.

5a LUC Subsuite With Low Rainfall

The low rainfall subsuite occurs in the Taranaki-Manawatu region on uplifted marine and river terraces that are mainly between the lower Whangaehu and the Manawatu Rivers (Figure 51). Slopes are flat to strongly rolling with inclusions of moderately steep land where the terraces are incised by streams.

The subsuite comprises four LUC units (IIs2, IIIe4, IVe4 and VIe2). Slope angle differentiates the four LUC units. The subsuite covers 100,350 (4.2%) of the region.

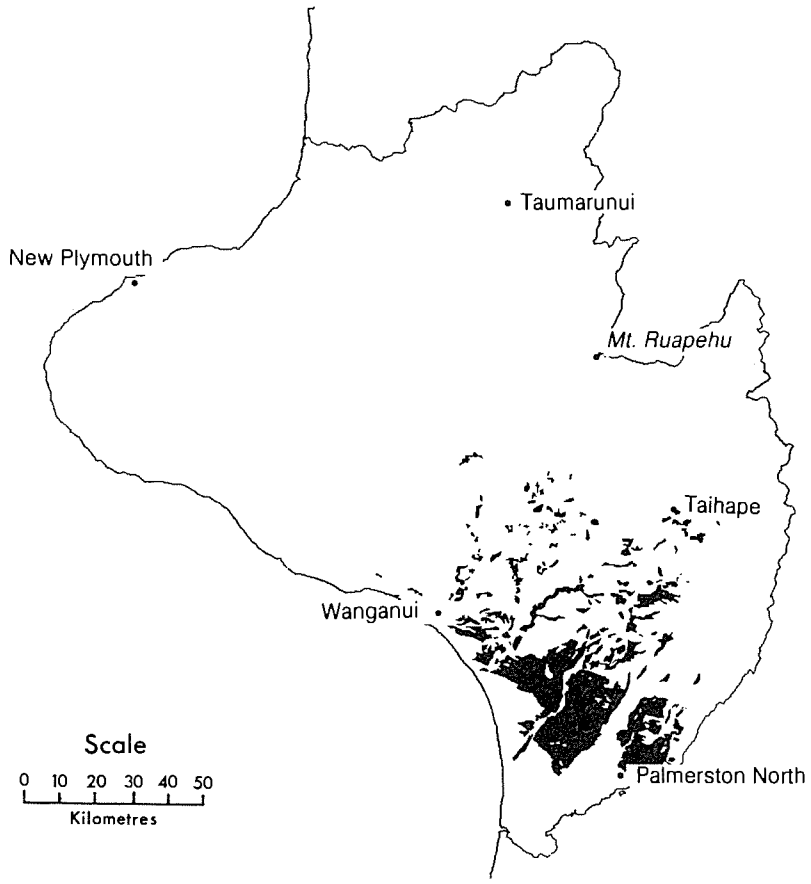


Figure 51: Location of LUC subsuite 5a: loess in low rainfall areas.

Physiography

The uplifted late Quaternary aged marine terraces on which most of this suite occurs are described by Fleming (1953). The oldest terrace (the Kaiatea Terrace) which occurs between 200–300 m a.s.l. has been extensively dissected and only scattered remnants remain. The younger Brunswick and Rapanui terraces are much more extensive. All three terraces are represented in the Wanganui-Marton area but in the Manawatu only the Rapanui terrace is recognised.

Climate

The subsuite has an annual rainfall of between 800 and 1150 mm with a distinct dry season in summer but rainfall is fairly evenly distributed throughout the remainder of the year.

All of the subsuite occurs within 40 km of the coast and is characterised by mild temperatures throughout most of the year. Climatic data from Ohakea show the mean air temperatures are 17.5°C in January and 8.4°C in June. On average 22.6 days of ground frost can be expected between April and November. An average of 2064 hours of sunshine are recorded annually at Ohakea.

Rock Type

Significant climatic fluctuations during the late Pleistocene together with regional uplift resulted in major periods of river aggradation and degradation to produce a series of terraces within the river valleys flowing through this suite. Quartzo- feldspathic loess has been blown from the aggrading river beds during cold and arid climatic phases onto the river terraces and uplifted marine terraces forming deposits 1 m or more thick. In addition there has been intermittent additions of tephric loess and/or airfall tephra of both rhyolitic and andesitic

origin. LUC subsuite 4b is mapped on the youngest set of terraces because the loess cover is absent or very thin.

The sequence of terrace surfaces and loess deposits on which the subsuite occurs have been described by Fleming (1953), Te Punga (1952), Cowie (1964b) and Milne (1973). The soil parent material comprises the upper two loess deposits (the Ohakea and Rata loess), but more particularly, the younger Ohakea loess. The main period of accumulation of the Ohakea loess is believed to have been during the aggradational phase of the Ohakea Terrace, between 25,000 and 12,000 years ago. Within the Ohakea loess the presence of the 20,000 year old Aokautere Ash marker bed correlates with the Oruanui Ash of the Taupo area (Cowie 1964a) and provides a permanent dating record of the geomorphic events of that time. [The Aokautere Ash has since been redesignated Kawakawa Tephra by Vucetich and Howarth (1976)]. The Rata loess appears to have been deposited between c. 40,000 and c. 30,000 years B.P. (Cowie and Milne 1973).

Soils

Soils in the subsuite were recorded using information from the following soil surveys:

1. Soils of Kairanga County (Cowie 1972).
2. Soils of Manawatu County (Cowie and Rijkse 1977).
3. Soils of Rangitikei County (Campbell 1979).
4. Soils of part Wanganui County (Campbell 1977).
5. Soils of Pohangina County (Rijkse 1977).
6. Soils of part Waitotara County (Wilde 1976).
7. General Survey of the Soils of the North Island (N.Z. Soil Bureau 1954).

The last named soil survey was used in the Oroua County.

Soils on arable LUC units are differentiated into the Ohakea, Milson, Marton, Halcombe or Tokomaru series on the basis of variation in the texture and depth of Ohakea loess. The Tokomaru series is developed on thick loess deposits occurring on the intermediate and high terraces bordering the eastern banks of the Rangitikei and Manawatu Rivers. The Milson series developed on thinner and finer textured loess in the Palmerston North and Feilding areas. The most widespread soil is the Marton series occurring to the north-west of major rivers where the depth of loess is thinner and the texture finer. It has a heavier subsoil and is more poorly drained than the Tokomaru and Milson series. The Ohakea series (the youngest yellow-grey earth in the region) occurs on lower terraces where the loess is mixed with colluvium washed from higher terraces and hills. The Halcombe series on rolling valley sides is developed on loess over sandstone while on moderately steep hill slopes and terrace scarps (LUC unit VIe2) Halcombe hill soils are recorded.

Erosion

Erosion is not a serious hazard. Map units covering 14% of the subsuite have negligible erosion recorded. Arable LUC units have a potential for slight to severe sheet and rill erosion when cultivated, depending on slope angle.

Land Use

Adequate subsurface drainage using mole and tile drains is necessary to achieve high levels of cropping or pastoral production.

Sheep farming has traditionally been the dominant land use. In recent years more intensive grazing management systems have been adopted and top farmers are now running up to 25 su/ha (Withell 1984). Fat lambs are drafted off farms by late January before pastures feel the full effect of summer soil moisture deficits. Beef cattle are also fattened, however there is only limited wintering of heavy beef cattle because of the risk of damage to pastures. In the Rongotea area dairying is the predominant land use. Even with intensive subsurface drainage, cattle pads and feeding platforms are recommended for use during wet weather.

A wide range of cash crops is grown. Approximately 2000 ha of feed and malting barley are grown each year on yellow-grey earths in the Manawatu alone (Withell 1984). Wheat is also an important crop. Intensive cropping rotations often comprise 2 years cereals, 1 year peas and 4–5 years pasture. Other cash crops include seed and process peas, grass seed and occasionally maize and potatoes. Root and green fodder crops are also produced.

The versatility of this subsuite for cropping is reduced by a seasonal wetness limitation which prevents early cultivation in spring. This can be minimised by more intensive subsurface drainage. The expansion of cropping on to land that was previously grazed will require a corresponding increase in the intensity of subsurface drainage if maximum crop productivity is to be achieved. A greater provision of shelterbelts would reduce cereal crop damage caused by frequent and, at times, strong westerly prevailing winds, as well as minimising evapotranspiration and desiccation of pastures during summer.

Land use trends will continue towards more intensive pastoral farming and a greater emphasis on cropping. Major increases in cropping will however require expansion of processing facilities which already exist for malting barley at Marton, potatoes at Rata and process peas at Feilding. A predicted increase in the area of wheat in the southern North Island should result in an expansion of wheat growing on the subsuite.

With drainage, irrigation and shelter there is also a potential for some horticultural crops. However there is unlikely to be a significant expansion into horticulture as there are large areas of more suitable land on LUC units such as Iw1, IIw4 and Ic2.

LUC Units

LUC unit IIs2 (55,950 ha)—Figures 52, 53, 55

This LUC unit occurs on 0–3° slopes although some slopes up to 7° are included. Most of the barley and wheat crops in the Rangitikei, Wanganui and Manawatu districts are on this LUC unit. The remainder is used for intensive pastoral production, mainly sheep farming with some dairying.

To achieve high levels of cropping or pastoral production, intensive subsurface drainage and the provision of shelterbelts and irrigation are necessary. When cultivated the potential for wind erosion can be minimised by the planting of shelterbelts and the use of strip cropping or minimum tillage techniques. The potential stock carrying capacity is 26 su/ha and the site index for *P. radiata* 29–34 m.

LUC unit IIIe4 (11,800 ha)—Figures 53, 54

IIIe4 ccurs on 8–15° slopes. These rolling slopes contribute to a slight to moderate potential for sheet and rill erosion when cultivated. This can be minimised by cultivating on the contour. The potential stock carrying capacity is 25 su/ha, and the site index for *P. radiata* is 29–30 m.

LUC unit IVe4 (11,800 ha)—Figure 54

IVe4 occurs on rolling to strongly rolling slopes (8–20°). There is a potential for moderate to severe sheet and rill erosion when cultivated. The erosion potential can be minimised by intensive soil conservation measures which include cultivating on the contour, strip cropping and minimum tillage techniques.

Because of its limitations for cropping IVe4 should remain in pasture for long periods. The potential stock carrying capacity is 21 su/ha and the exotic forest growth potential for *P. radiata* is 29–30 m.

LUC unit VIe2 (20,800 ha)—Figure 55

VIe2 occurs on strongly rolling to moderately steep (16–25°) hill slopes and terrace scarps which are too steep to cultivate for cropping, although some areas of easier contour can be cultivated for pasture renewal. When cultivated a pasture cover needs to be quickly established so as to minimise the potential for soil loss by sheet and rill erosion.

Figure 52: IIs2 with a wheat crop. Wightman Rd near Bulls N143 907553 looking SE.

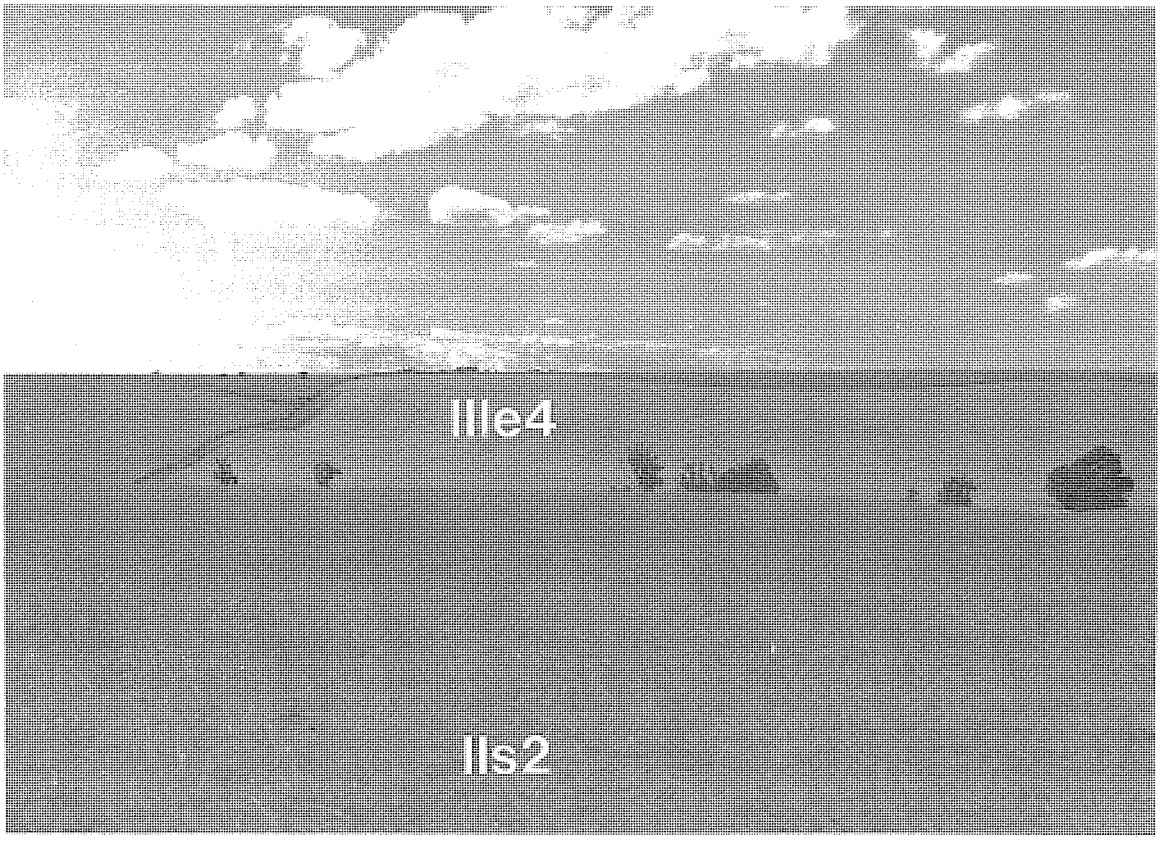


Figure 53: IIs2 on flat and undulating slopes with IIIe4 on rolling slopes near Feilding. N149 020476 looking N.

Figure 54: IIIe4 in foreground and IVe4 in distance. Te Rakehou Rd near Feilding. N143 993543 looking W.

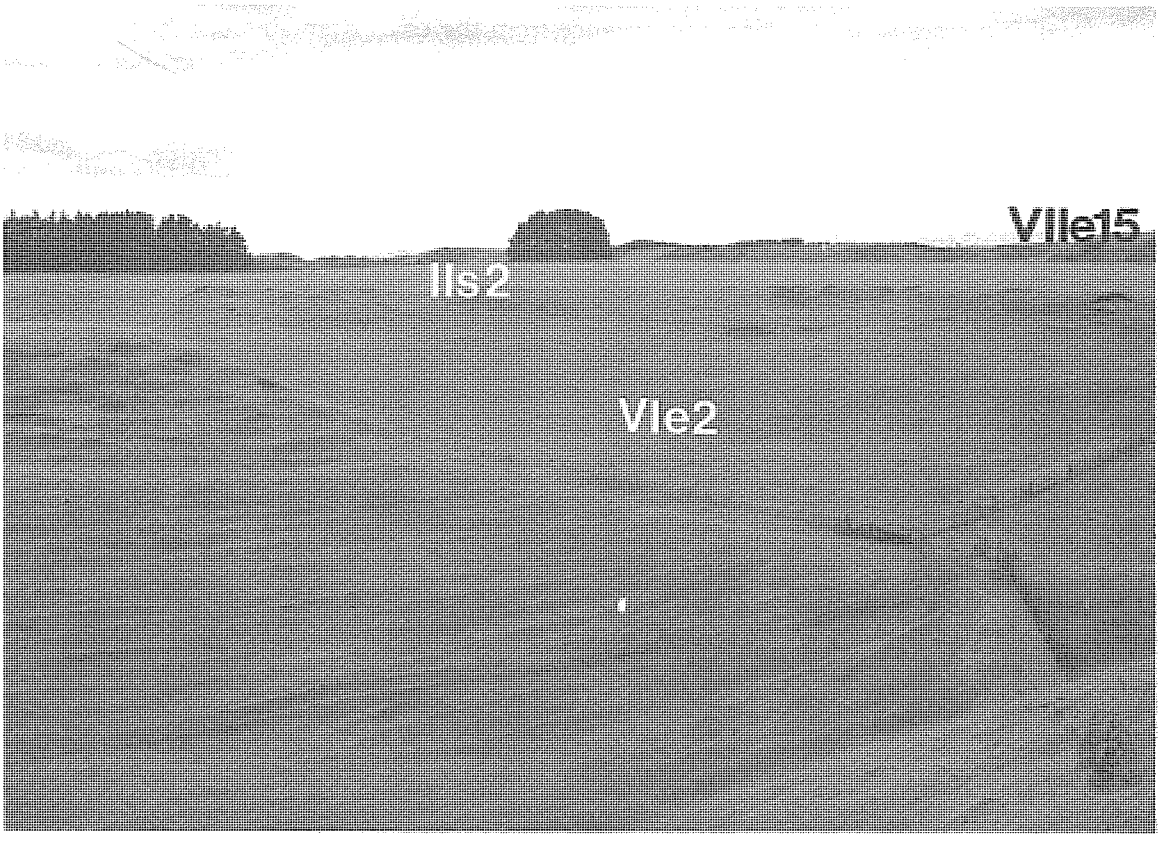


Figure 55: VIe2 on terrace scarps and IIs2 on terraces. Sand dunes in distance are VIIe15. Santoft Rd. N143 820638 looking SE.

The dominant soil is Halcombe silt loam, hill soil. Additionally, 1500 ha of Raumai sandy loam, hill soil (a yellow-grey earth—yellow-brown earth intergrade) is included because of its similar production potentials and soil conservation requirements.

This unit has a potential for slight sheet and soil slip erosion which can be minimised by good pasture and stock management, particularly the avoidance of overgrazing during periods of summer drought. Poplar poles should be open planted in areas that are susceptible to slip erosion, while the installation of diversion terraces on the terraces above this unit would prevent runoff which can cause erosion on the VIe2 terrace scarps.

VIe2 has a potential stock carrying capacity of 19 su/ha and a site index for *P. radiata* of 28–30 m.

5b LUC Subsuite With High Rainfall

In contrast to the low rainfall subsuite, this subsuite occurs in more elevated areas with greater rainfall. Soils are deep, friable, and well drained with stable aggregates capable of sustaining intensive cropping use.

The subsuite extends from Kai-iwi in the west to the western margins of the Ruahine Range between Kawhatau and the Umutoi district (Figure 56). The subsuite comprises seven LUC units which together cover 49,600 ha (2.1% of the region). A climosequence of LUC units Ic2, IIc1 and IIIc2 is mapped on flat and undulating slopes; LUC units IIe2, IIIe3 and IVe3 have erosion as the dominant limitation to cropping use. LUC unit VIc2 is mapped on non arable hill country.

Physiography

Most of this subsuite occurs on intermediate height, Upper Pleistocene aged terraces bordering the Rangitikei, Kawhatau, Oroua and Pohangina Rivers. The remainder is on high terraces, comprising the late Pleistocene Rapanui, Brunswick and Kaiatea marine terraces.

Climate

Rainfall increases with elevation and distance from the coast from about 1000 mm p.a. in the Wanganui and Kiwitea areas to about 1800 mm p.a. in the north-east near the Ruahine Ranges. The majority of the subsuite is between 200 and 550 m altitude and has a rainfall of between 1000 and 1300 mm p.a.

Rainfall data (N.Z. Met. Service 1984) for Te Awa, (LUC unit Ic2), Apiti (LUC unit IIc1) and Table Flat (LUC unit IIIc2) show monthly and annual rainfall totals increasing with altitude. For all three stations January, February and March are generally the months receiving the least rainfall with another period of significantly lower rainfall in September.

Temperature data (N.Z. Met. Service 1983a) for selected stations within or adjacent to this suite (Table 23) best represents the trend of decreasing air temperatures as altitudes increase.

Table 23: Mean air temperature for January and July, and average days of ground frost at Wanganui, Marton and Taihape

	Wanganui 1937–80	Marton 1947–66	Hiwi, Taihape 1911–70
Altitude	22 m	152 m	657 m
Mean air temp. °C			
January	17.8	16.3	15.1
July	8.7	7.4	5.4
Average days of ground frost p.a.	10.7	58.2	63.4

Rock Type

Soil parent materials can be grouped into those occurring on intermediate terraces and those on high terraces. Low terraces of recent alluvium are described in LUC suite 4.

Within the Pohangina County the soil parent materials on the Late Pleistocene terraces bordering rivers flowing from the Ruahine Range have been described as greywacke gravels with alluvial sands overlain by a thin layer of loess and some volcanic ash (Rijkse 1977).

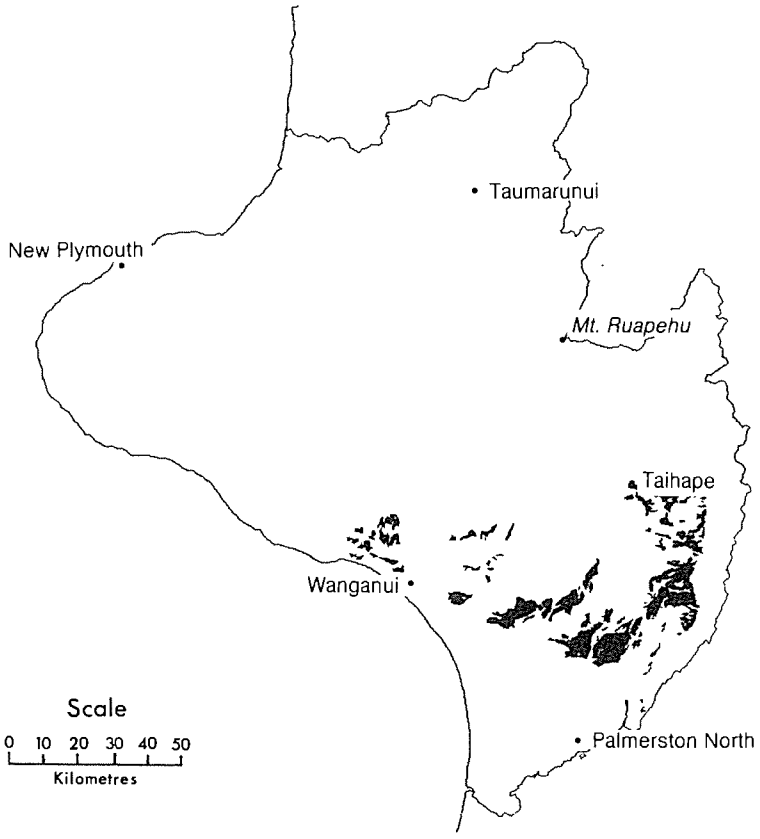


Figure 56: Location of LUC subsuite 5b: loess in high rainfall areas.

Cowie and Milne (1973) however consider that the loess cover is absent in almost all places and nowhere is more than 0.5 m thick. In the Rangitikei County Campbell (1977) describes the parent materials as greywacke and volcanic alluvium with some volcanic ash.

On the Brunswick and Kaiatea terraces near Wanganui the soil parent material is quartzofeldspathic loess mixed with fine-textured tephric loess from Taranaki. The tephric loess component becomes less significant east of Wanganui.

Soils

Soils were recorded using information from the following soil surveys:

1. Soils of Pohangina County (Rijkse 1977).
2. Soils of part Wanganui County (Campbell 1977).
3. Soils of Rangitikei County (Campbell 1979).
4. Soils of part Waitotara County (Wilde 1976).
5. General Survey of the Soils of the North Island (N.Z. Soil Bureau 1954).

The last mentioned survey was used in Kiwitea County where there was no detailed soil map available. Although the soils within the subsuite are classified as intergrades between yellow-brown earths and yellow-brown loams, intergrades between yellow-brown loams and yellow-brown earths, or yellow-brown loams they are all included in the same subsuite because of their excellent physical properties for plant growth.

The Kiwitea series is the most extensive soil recorded. It occurs on high terraces in the Kiwitea, Rangitikei and Pohangina Counties where the rainfall is approximately 1000–1400 mm p.a. The Dannevirke and Table Flat soils are mapped in the north-east of Pohangina County adjacent to the Ruahine Range where the rainfall and altitude are greater. The Dannevirke series occurs on high terraces south and north-east of Apiti where the rainfall is approximately 1300–1500 mm annually, while the Table Flat series is mapped where the

rainfall is approximately 1800 mm p.a. and the altitude approximately 700 m. Within this soil sequence the topsoil becomes more strongly developed and the subsoil increasingly massive with higher rainfall. The higher rainfall soils are also more strongly leached and have a greater allophane content.

The Westmere, Parakino and Kakatahi soil series are mapped on high terraces in the Wanganui region. The Westmere series occurs on the Brunswick and Kaiatea Terraces in the Fordell and Westmere districts. The Parakino series is developed on broad hill ridges at 250–450 m a.s.l. in the Parakino and Mangamahu areas where the soil parent material is volcanic ash over moderately consolidated sandstone. The Kakatahi series is developed on fine gravelly andesitic alluvium on high terraces in the Whangaehu and Mangawhero valleys. The dominant soils on LUC unit VIc2 are the Kiwitea hill soils, with the Umutoi hill soils also mapped within Pohangina County.

On intermediate level terraces in the Rangitikei, Kiwitea and Pohangina Counties the Kawhatau and Kopua series are recorded. The Kawhatau series occurs where the rainfall is between approximately 1150–1400 mm p.a. and the Kopua series where the rainfall increases to 1400–1800 mm p.a.

Map units with Ohakune soils on the Hautapu River terraces south of Taihape, are included in this subsuite because of similar altitude and rainfall, rather than the Waimarino yellow-brown loam subsuite in which the majority of Ohakune soils occur.

A map unit with any of the above soils dominant, occurring within the climatic parameters of the subsuite can be classified into one of the seven LUC units. For example, map units on flat and gently undulating slopes with Kiwitea soils can be classified as LUC units Ic2, IIc1 or IIIc2 depending on the climate. Steeper slopes with Kiwitea soils can be classified as IIe2, IIIe4 or IVe3 according to slope angle and climate, while non-arable hill country with Kiwitea hill soils is LUC unit VIc2.

Erosion

Erosion is not a major concern on this subsuite, as map units covering 98% of the subsuite have negligible erosion recorded. This low erosion severity can be attributed to the majority of the subsuite being in pastoral use. That part used for cropping (mainly Ic2, IIc1 and IIIc2) has a negligible erosion potential.

Land Use

The dominant land use is intensive sheep and cattle farming, with top farmers carrying up to 25 su/ha on Ic2. Previously, dairying was a major land use but it has declined significantly to the extent that it is now only important on the Oroua and Rangitikei River terraces.

This subsuite is well suited to vegetables, potatoes and some horticultural crops. However major expansion of these crops is unlikely unless export markets are available.

LUC Unit Descriptions

LUC units Ic2, IIc1 and IIIc2 form a climosequence on flat and undulating slopes (Table 24). As rainfall and altitude increase from Ic2 to IIIc2 the physical limitations to use increases and the range of crops able to be grown decreases.

A sequence of LUC units comprising LUC units IIe2, IIIe3 and IVe3 are mapped where slope increases from gently undulating to strongly rolling, with erosion risk, rather than climate, becoming the dominant limitation to cropping use. LUC unit VIc2 is mapped on non arable hill country.

LUC unit Ic2 (11,850 ha)—Figure 57

Ic2 occurs on flat and undulating terraces below 350 m a.s.l. Rainfall is 900 to 1100 mm p.a. The unit is mainly in the Kiwitea, Stanway-Beaconsfield, Porewa-Putorino and Fordell areas. The remainder is in the Whangaehu Valley near Mangamahu, the Mangawhero Valley south of the Parapara Road and in the Fern Flat and Mt Curl areas near Marton.

The principal soils are the Kiwitea and Westmere series on the high marine terraces and the Kakatahi loam on the terraces of the Mangawhero and the Whangaehu rivers.

Potatoes, barley, wheat, oats, grass seed and lucerne for hay are grown. At present vegetable cropping only occurs on a small scale in the Kiwitea area. Crops include onions, brussel sprouts, process peas, carrots, parsnips, swedes and turnips. There are small areas of kiwifruit, boysenberries and asparagus in the sheltered Whangaehu valley.

Irrigation and shelter is necessary if horticulture is to be expanded. However, it is likely that costly rural water supply schemes will be necessary to deliver water to the high Ic1 terraces. Irrigation would enable an expansion of vegetable production to include brassicas such as cabbages and cauliflower and realise the potential available for nurseries, cut flowers and bulbs.

Pastoral farming is principally sheep and cattle fattening. Stud stock breeding is also important and there is some dairying. The potential stock carrying capacity is 30 su/ha but a lack of available stock water is an impediment to reaching these levels of production on much of this unit. The site index for *P. radiata* is 29–32 m.

Ic2 has a negligible erosion potential. Nevertheless, good soil conservation management would avoid cultivating a fine tilth so to minimise the risk of wind and sheet erosion.

Within the area mapped as Ic2 are map units totalling 300 ha that have mottled soils. These are classified as Iw2. Iw2 map units require artificial drainage for intensive cropping use. Even after drainage a continuing very slight wetness limitation may result in Iw2 being slightly less versatile for cropping than Ic2. Stock grazing capacities and exotic forest growth potentials are the same as for Ic2.

Table 24: Relationship between altitude, rainfall and land use capability on a sequence of LUC units occurring on flat to gently undulating slopes on the high rainfall loess subsuite.

LUC unit	Altitude a.s.l.	Rainfall (mm p.a.)	Potential cropping use	Potential stock carrying cap. Su/ha	Site index *P. radiata*
Ic2	< 350 m	900–1100	Cereals Process & Fresh Vegetables Potatoes Berryfruit Kiwifruit Nurseries Cut flowers and bulbs Root & green fodder crops	30	29–32
IIc1	350–550	1000–1300	Cereals Vegetables (Root and Brassica crops only) Potatoes Berryfruit Nurseries Cut flowers and bulbs Root & green fodder crops	26	30–33
IIIc2	550–750	1400–1800	Cereals (marginal) Vegetables (Root and Brassica crops only) Potatoes Root & green fodder crops	25	29–30

LUC unit IIc1 (7450 ha)

IIc1 occurs on flat and gently undulating terraces that are between 350 and 550 m a.s.l. with a rainfall of 1000 to 1300 mm p.a. This is predominantly in the Waituna West, Kimbolton, Apiti, Mangaonoho and Rangiwahia districts although minor areas also occur on high terraces of the Rangitikei, Moawhango, Hautapu and Mangawhero rivers. The principal soils are the Kiwitea, Ohakune, Westmere, Kawhatau, Dannevirke and Kakatahi soils.

Figure 57: Ic2 on flat and gently undulating slopes. IVe3 in foreground. Coulters Line, Kiwitea. N144 210645 looking SE.

Figure 58: IIIc2 (at 670 m a.s.l.) Table Flat near Apiti. Ruahine Ranges in distance. N139 441835 looking E.

Pastoral farming, particularly intensive sheep and cattle farming and some dairying is the predominant land use. The potential stock carrying capacity of 26 su/ha reflects increasing climatic limitations compared with LUC unit Ic2. The site index for *P. radiata* is 30–33 m. There is a negligible erosion potential either under a grassland vegetation or when cultivated.

Wheat, barley, potatoes and root and green fodder crops are grown (grain drying facilities are usually necessary for cereals). IIc1 is also suitable for root vegetable growing. If irrigation water is available other horticulture crops such as berryfruit, nursery crops and brassica vegetables can be grown.

LUC unit IIIc2 (5950 ha)—Figures 58, 60

IIIc2 occurs on flat terraces adjacent to the Ruahine Ranges. Areas mapped as IIIc2 are between 1400 and 1800 mm. Occasional snowfalls, frequent and severe frosts and high rainfall result in IIIc2 having a reduced suitability for cropping compared with other LUC units in this subsuite. The principal soils are the Kiwitea, Dannevirke, Kopua, Kawhatau and Table Flat series. Crops grown are potatoes (including seed potatoes), root and green fodder crops and occasionally barley and wheat. There is also a potential for root and brassica vegetable crops. Pastoral use is essentially intensive sheep and cattle farming, with a small area of dairying at Marton Block, and at Table Flat.

LUC unit IIe2 (7500 ha)—Figure 59

IIe2 occurs on undulating (predominantly 4–7°) slopes in the same climatic zone as LUC unit Ic2. IIe2 is suitable for the same crops as Ic2, however, the greater slope causes harvesting difficulties. This may preclude process peas from some areas. Shelterbelts are recommended for horticulture. The potential stock carrying capacity is 28 su/ha while the site index for *P. radiata* is the same as LUC unit Ic2 (29–32 m).

No significant erosion was recorded although there is a potential for slight sheet and rill erosion with cultivation.

LUC unit IIIe3 (4,400 ha)—Figure 59

This unit occurs on undulating to rolling downlands. Most of IIIe3 occurs in the Ic2 climatic zone (i.e. < 350 m a.s.l.) particularly in the Kiwitea, Fern Flat—Mt Curl, and Fordell districts. In these areas IIIe3 will grow the same crops as Ic2 but the slope angle constrains cereal harvesting and precludes the growing of process peas. At higher altitude and rainfall such as in the Apiti and Hunterville districts the climate is more marginal for cereal cropping.

IIIe3 has a potential stock carrying capacity of 26 su/ha and a site index for *P. radiata* of 29–30 m. When cultivated there is a potential for slight to moderate sheet and rill erosion. This can be minimised by contour cultivation.

LUC unit IVe3 (4,150 ha)

This unit occurs on rolling to strongly rolling downlands, in the Fern Flats—Mt Curl, Kimbolton and Apiti areas, and inland from Kai-iwi. IVe3 has a potential stock carrying capacity of 24 su/ha and a site index for *P. radiata* of 29–32 m. It is used for intensive sheep and cattle grazing and some root and green fodder cropping, however it may also have a potential for some horticultural crops.

There is a potential for severe sheet and rill erosion when cultivated. This erosion can be minimised by intensive soil conservation measures including contour cultivation, strip cropping, and zero tillage techniques.

LUC unit VIc2 (8,000 ha)—Figure 60

LUC unit VIc2 occurs on strongly rolling to moderately steep hills between 600 and 800 m a.s.l. It is found adjacent to the Ruahine Ranges, particularly in the Rangiwahia and Apiti areas and east of Taihape. Generally this unit has a rounded topography with short slopes,

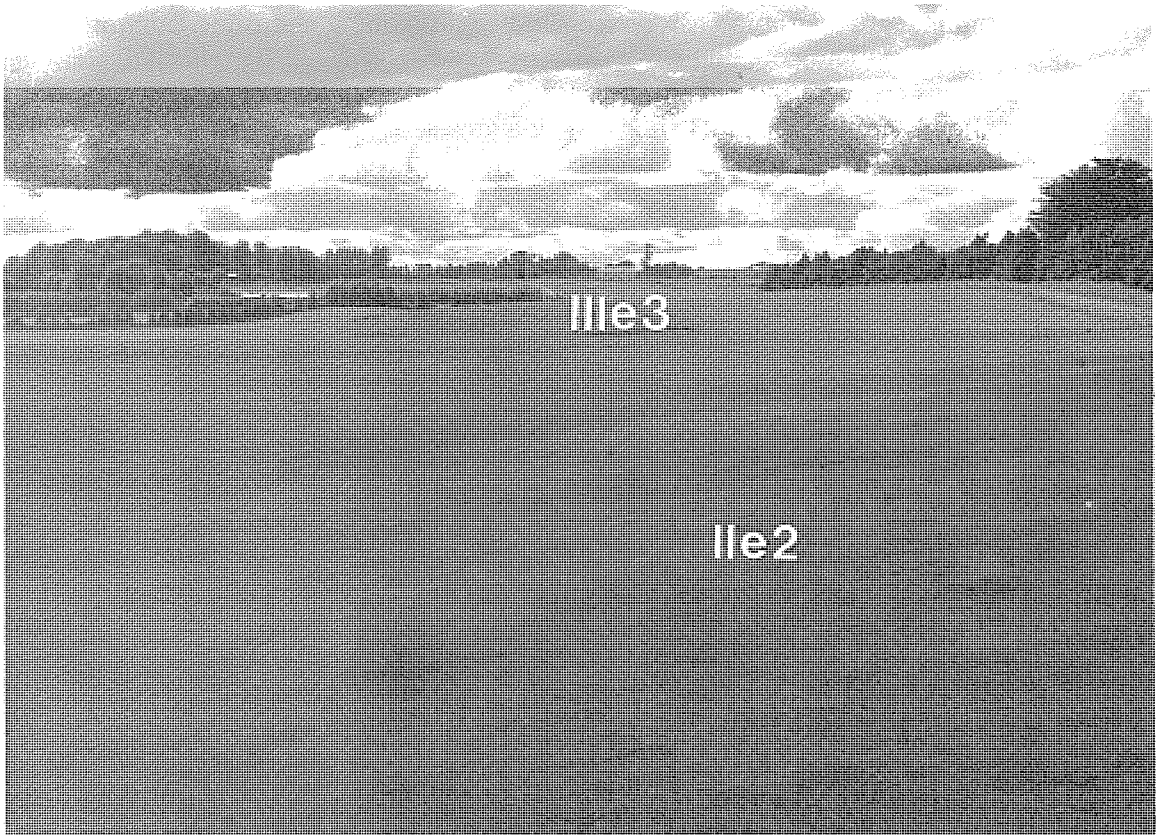


Figure 59: IIe2 and IIIe3. Kiwitea. N144 233667 looking S.

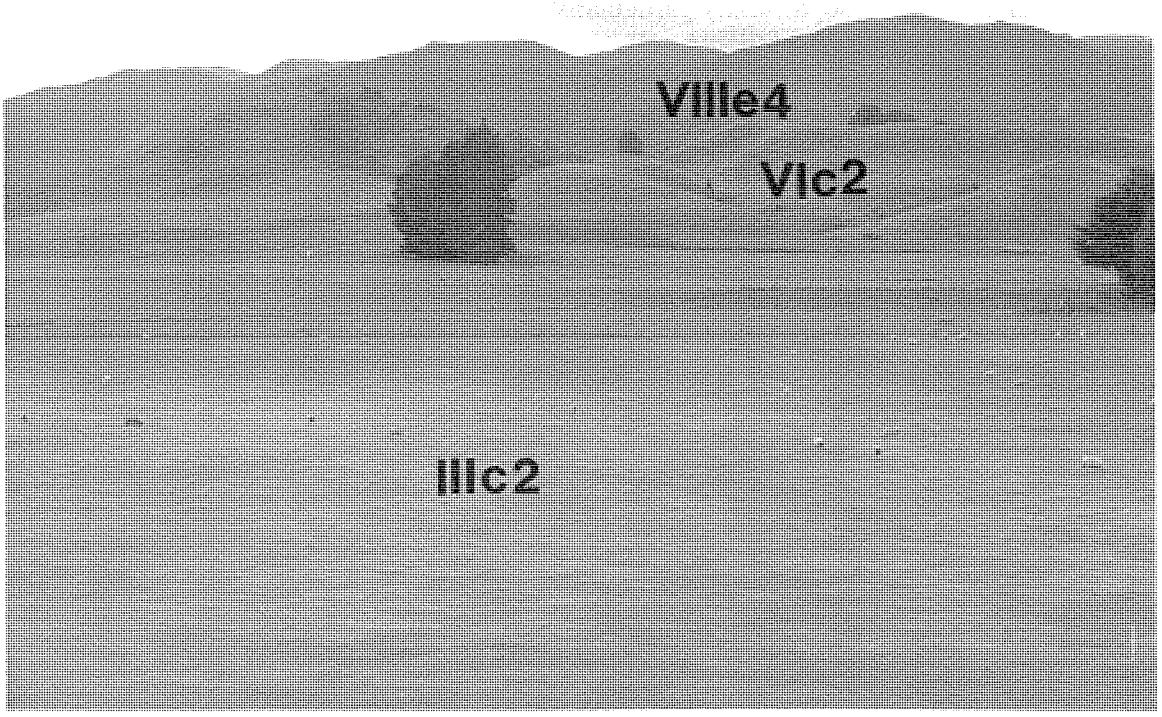


Figure 60: IIIc2 and VIc2. VIIIe4 of LUC subsuite 13 in distance. Near Rangiwahia. N139 431927 looking E.

and soils with very good physical characteristics for plant growth. Pastoral productivity is constrained by climate, which limits pasture growth for much of the year.

There is a potential for only slight soil slip and sheet erosion. The major soils are the Kiwitea hill soils, Umutoi hill soils, Dannevirke silt loam rolling phase and the Kiwitea fine sandy loam rolling phase.

The potential stock carrying capacity is 20 su/ha and the site index of *P. radiata* is assessed as 27–28 m. Reversion of pastures to fern is a problem. To combat this, easier slopes can be cultivated for pasture renewal.

6. LUC SUITE ON TAUPO AIRFALL TEPHRA

This suite is characterised by soils developed from Taupo airfall tephra of the Taupo Pumice Formation (Healy *et al.* 1964). The probable source of the Taupo eruption (1820 ± 80 years BP) is within Lake Taupo at Horomatangi Reefs (Froggatt 1981). Soils developed on this suite are characterised by coarse textures, a friable to loose consistency, a weakly developed structure, generally low nutrient levels and susceptibility to periods of soil moisture deficiency. These soil properties have a major effect on erosion potential and land use capability.

The Taupo airfall tephra suite is confined to the King Country, where it mainly occurs east of the National Park-Te Kuiti Highway (SH4). It occupies 89,900 ha (3.8%) of the total area of the region.

This suite comprises twelve LUC units differentiated into the following two subsuites:

a. LUC units with shallow Taupo airfall tephra (< 44 cm) (IVe5, Vs2, VIs2, VIe9, VIs8 and VIIs1).
b. LUC units with deep Taupo airfall tephra (> 44 cm) (IIIs4, IIIe7, IVe9, VIs5, VIe18, and VIIe8).

The two subsuites are differentiated according to the depth of Taupo tephra. The depth of Taupo tephra determines cropping potential and grazing and forestry production indices, and susceptibility and type of erosion. The physical impediment to pastoral and forestry land use of ignimbrite scarps is recognised in LUC units VIs8 and VIIs. LUC units within this suite correlate with similar LUC units in the Bay of Plenty-Volcanic Plateau Region (Appendix 4).

6a LUC Subsuite on Shallow Taupo Airfall Tephra

This subsuite is mapped where there is a significant depth of Taupo airfall tephra (< 44 cm) overlying older tephra on stable rock types. Soils are dominantly composite yellow-brown pumice soils on yellow-brown loams.

The presence of this depth of rhyolitic tephra is sufficient to significantly affect land use capability and give the LUC units of this subsuite erosion characteristics and pastoral productivity levels that are intermediate between those of the King Country yellow-brown loam subsuite and the subsuite on deep (>44 cm) Taupo tephra.

Physiography

This subsuite comprises mainly rolling to moderately steep Tertiary lithologies in the Taumarunui area. To the north-east the terrain increases in altitude to about 700 m a.s.l., where dissected ignimbrites flank the steep slopes of the Hauhungaroa Range, on the eastern margin of the region. The Hauhungaroa Range is an upthrust greywacke block with its summit mostly at about 900 m a.s.l. but reaching 1165 m at Pureora Trig in the north. Further south in the Owhango area the suite is mapped on lahars which have descended the Whakapapa River valley from the Tongariro volcanic centre.

Climate

The Taumarunui climate station at 171 m a.s.l. can be taken as representative of the climate on this subsuite. The annual rainfall normal (1951–80) is 1460 mm. This increases to 1844 mm (NZ Met Service 1984) at Pureora Forest (549 m a.s.l.) in the north and 1632 mm

at Owhango (457 m a.s.l.) on the southern margin of the suite. Soil moisture deficits can occur in January and March, the driest months, however for the remainder of the year rainfall is spread fairly evenly. In the Hauhungaroa Range the annual rainfall increases to approx. 2400 mm p.a., and temperatures are cooler. Snow falls occasionally.

Because of its inland location summer temperatures are characteristically warm, however night time temperatures during winter are relatively cold with frequent frosts (e.g., the mean number of days of ground frost for the period 1947–82 was 64 at Taumarunui and 87 at Pureora [Thompson 1984]). The lower areas are among the least windy in New Zealand with Taumarunui having a 65% frequency of calm weather. Taumarunui also has an average annual growing degree-day total (above a base of 10°C) of 1334, which indicates the climatic suitability of lower altitude areas within this suite for plant growth.

Rock Type

The cover deposit characterising this LUC suite is the Taupo Pumice Formation*, the stratigraphy of which has been discussed by Froggatt (1981). Isopach maps (Pullar and Birrell 1973) give thicknesses of approx. 100 cm on the Hauhungaroa Range thinning to about 30 cm in the west of the suite.

Underlying the Taupo pumice are significant depths of older tephras which thicken to the south and east. These include the Tongariro tephra (2500–13,800 yrs BP); the Rotoehu Ash (40,000 years BP) and undifferentiated brown tuffs thought to be between 75,000–150,000 years BP (Pullar and Birrell 1973).

Because of the deep tephra cover, underlying rocks were not usually recorded in the inventory on arable LUC units. They were recorded however on steeper Classes VI and VII slopes where the tephra cover thins. Underlying rocks are mainly sandstone and mudstone, although in the east ignimbrite and greywacke are important.

Soils

Soils were recorded using the Provisional soil survey of the King Country. In that survey a great number of soils were recognised on the basis of slope, nature of underlying rock, depth of tephra deposits, climatic factors etc. These soils are described by Cowie (1978).

Erosion

Slight or moderate erosion is recorded on map units covering 31% of the subsuite. The most common type is sheet, with soil slip also important on LUC Class VI and VII units. Rill and gully are minor erosion types but are potentially significant when arable areas are cultivated. These erosion types and severities contrast with those on the Taupo flow and water sorted tephra suite where gully and streambank were the dominant erosion types and 60% of the arable map unit area had erosion recorded.

Soil compaction following land development from natural vegetation to pasture leads to increased runoff. It is essential that a complete pasture cover is maintained and that runoff does not become channelised or major erosion problems will result. Soil conservation measures on arable units include the use of minimum cultivation techniques, cultivating only to a coarse tilth and the use of contour cultivation methods. On steep forested areas (particularly LUC unit VIIe8) it is necessary to comply with "Forest Operations" guidelines (NWASCO 1976).

Land Use

Indigenous forest and manuka or mixed native scrub associations cover more than 45% of the suite. Pasture occupies a further 22% and pasture-scrub-forest mixtures 33%. However, within the suite the shallow and deep Taupo tephra subsuites have distinctly different levels of development. The shallow Taupo tephra subsuite has 56% of its area in pasture, compared to only 16% in pasture on the deep Taupo tephra subsuite. These differences can be

*Recent research by Froggatt (1981) has shown that only Members 3–6 of the Taupo Pumice Formation (Healy 1964) i.e. Taupo lapilli, Rotongaio Ash, "putty ash" and Hatepe lapilli are airfall in origin. The Upper Taupo Pumice and rhyolitic block members which are widespread in this suite are in fact flow tephra deposits.

attributed to most of the deep Taupo tephra subsuite occurring in more remote locations adjacent to or within the Hauhungaroa Range. These areas also have high rainfall and pastures are more likely to revert to scrub and fern.

On arable units intensive sheep and cattle grazing is the dominant land use. Town supply dairying is also important between Taumarunui and Owhango. There is unlikely to be much expansion of cropping in the future except for supplementary feed crops to support more intensive pastoral use.

Exotic forestry is a minor land use. This contrasts with the LUC suite on Taupo Pumice in the Bay of Plenty-Volcanic Plateau Region where exotic forestry now occupies 40% of the suite area. Some exotic forest planting has occurred in and adjacent to the Hauhungaroa Range on scrub and fern covered areas and in areas where indigenous forest has been logged. It is only intended to plant 4,500 ha of exotic forest in the King Country between 1981–90 (NZ Forestry Conference 1981), therefore only minor expansion of exotic forest is expected on this suite mainly at the expense of areas which are at present dominantly in scrub and fern.

LUC Units

This subsuite comprises six LUC units: IVe5, Vs2, VIs2, VIe9, VIs8 and VIIs. Together they cover 12,950 ha (0.6%) of the region. Their distribution is shown in Figure 61.

The shallow Taupo airfall tephra subsuite has soils which are dominantly composite yellow-brown pumice soils on yellow-brown loams. The underlying more weathered tephra within the plant rooting zone reduces the erosion potential and gives pastoral and cropping potentials that are intermediate between yellow-brown pumice soils and yellow-brown loams. The majority of moderately steep and steep slopes occur on the eastern margin of the suite. Although these areas are closest to the Taupo Pumice source much of the Taupo Pumice has been eroded from the slopes.

LUC unit IVe5 (3100 ha)—Figure 62

IVe5 occurs on scattered areas of rolling downland between Taumarunui and the northern boundary of the Region. It includes areas at Echolands, Kakahi and Aramahoe Road near Taumarunui; south of Ongarue; in the Tapuiwahine Valley, east of Matiere and further south in the lower Retaruke Valley.

Typical soils are the Taumarunui, Mapara, Taringamotu, Ongawhao and Waione series which are classified as composite yellow-brown pumice soils on yellow-brown loams. IVe5 is at present used for intensive grazing with some root and green fodder cropping. With a potential stock carrying capacity of 28 su/ha and site index for *P. radiata* of 27–28 m it is rated as having a medium suitability for both pastoral and forestry production. The cropping potential is very limited as there is a potential for severe sheet and rill erosion. Contour cultivation and minimum tillage techniques are required to minimise soil losses.

LUC unit Vs2 (1850 ha)—Figures 63, 68

Vs2 is mapped on strongly rolling to moderately steep slopes which extend from south of Taumarunui west to Te Whakarae. Soils are developed on a thin mantle of Taupo airfall tephra on Tongariro tephra. These tephra overlie hard stable rocks particularly the Waimarino lahars (Hay 1967) which often outcrop at the surface. Where the Taupo tephra is >20 cm the soils are classified as Ongawhao series (composite yellow-brown pumice soils on yellow-brown loams) while the Kakahi series, a yellow-brown loam, is recorded where there is less than 20 cm of Taupo tephra (Rijkse and Wilde 1977).

Vs2 has a potential stock carrying capacity of 16 su/ha and a site index (*P. radiata*) of 27–28 m. There is no significant present erosion, and a potential for only slight sheet erosion.

LUC unit VIs2 (4050 ha)—Figure 62

VIs2 occurs on strongly rolling to moderately steep slopes principally in the Taumarunui area, particularly at Otunui, Opotiki Road, Taringamotu, Oruaiwi and the Taringamotu-

Figure 61: Location of LUC subsuite 6a: shallow Taupo airfall tephra.

Mangakahu Road areas. Other areas include the vicinity of Tapuiwahine Road in the north of the region, and west and south of Ongarue.

Although this unit also occurs on relatively stable slopes it has a lower LUC ranking than LUC unit Vs2 because of differences in soils, climate and erosion potential. Soils are composite yellow-brown pumice soils on yellow-brown loams, these are typically the Taumarunui, Taringamotu, Kokomiko and Mapara series on stable rock types (ignimbrite and banded mudstone and siltstone). The rainfall is slightly less than for LUC unit Vs2 and pastures are more likely to suffer soil moisture deficits in summer. There is a potential for slight soil slip and sheet erosion, but good pasture management can minimise erosion. Despite these physical differences the potential stock carrying capacity of 16 su/ha and the site index (*P. radiata*) of 26–27 m are both very similar to the figures given for Vs2.

LUC unit VIe9 (400 ha)—Figure 64

This unit occurs immediately west of Waimiha on slopes which are slightly steeper and have a slightly greater erosion potential than LUC unit VIs2.

VIe9 is mapped on moderately steep slopes with soils of the Piropiro and Waione series. There is a potential for moderate soil slip erosion. This can be minimised by open planting of soil conservation trees on susceptible sites. The majority of this unit is in pasture although there are also areas of fern and gorse. The potential stock carrying capacity is 16 su/ha and the site index for *P. radiata* is 26–27 m.

LUC UNITS ON IGNIMBRITE SCARPS

LUC units VIs8 and VIIs occur in the King Country, particularly in the Waimiha and Ongarue districts. Bare rock bluffs and boulders on colluvial footslopes are the dominant limitation to use.

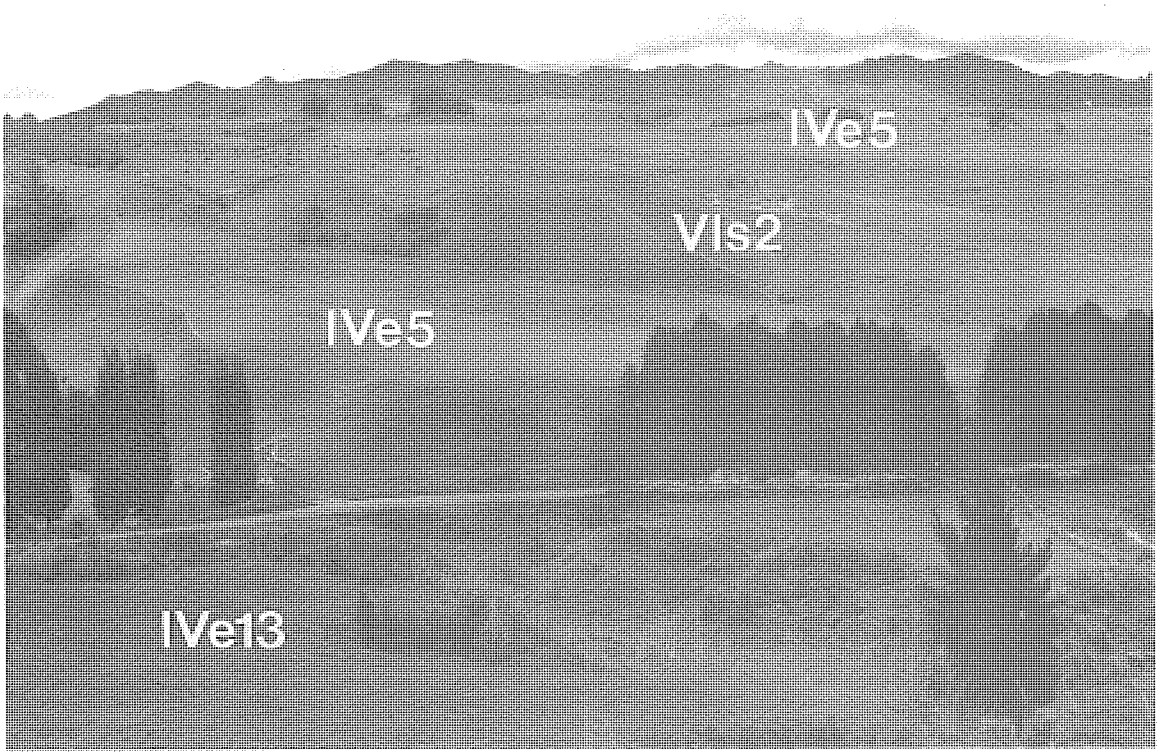


Figure 62: IVe5 (far side of road) dissected by steeper slopes of VIs2. Hills in background are VIIe9 (LUC subsuite 9b). IVe13 in foreground (LUC suite 7). Retaruke valley. N111 709902 looking S.

Figure 63: Vs2 on hills. In foreground is IVe13 of the Taupo flow tephra and water-sorted tephra suite (LUC suite 7). Makokomiko Rd, near Taumarunui. N101 831079 looking N.

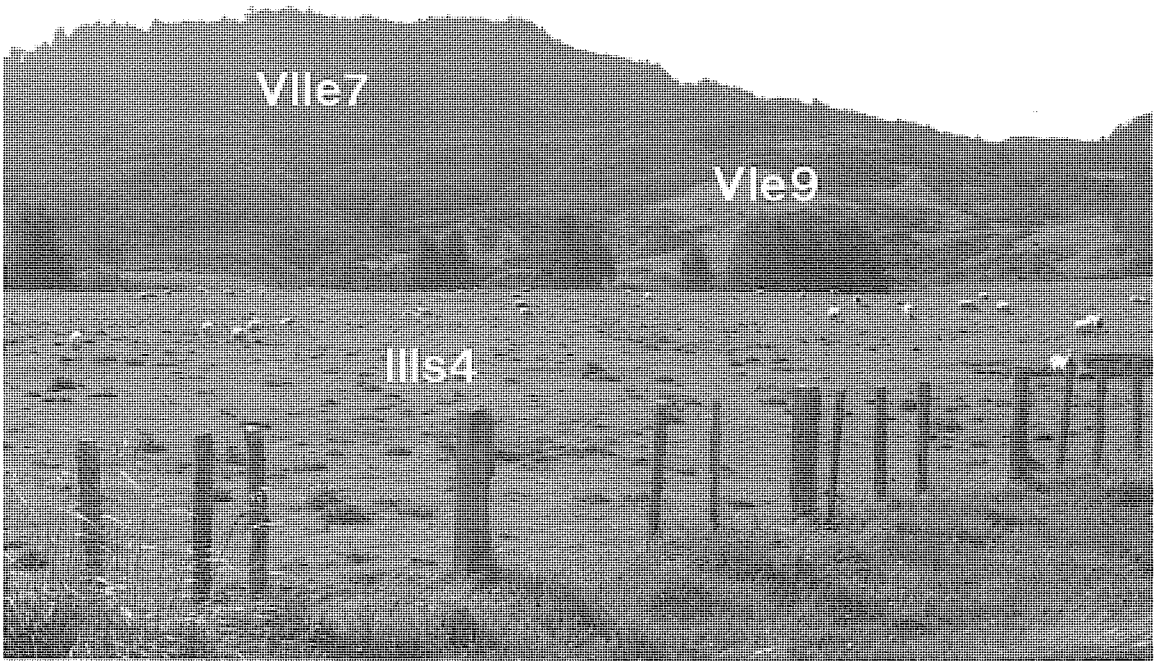


Figure 64: VIe9 on hills in middle distance and VIIe7 in background. Terrace in foreground is IIIs4 (LUC subsuite 6b). Near Waimiha. N92 833466 looking NW.

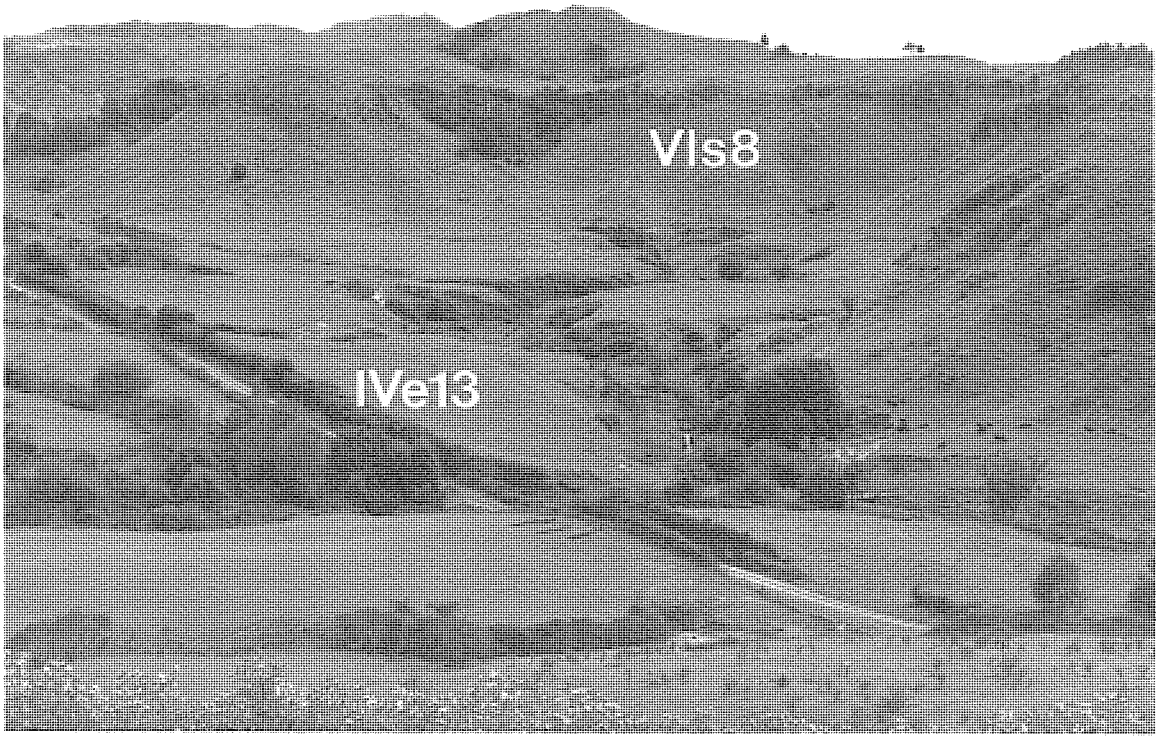


Figure 65: VIs8 on ignimbrite scarps. Stream terraces are IVe13 (LUC suite 7). Paraketu Rd, near Waimiha. N92 793432 looking NW.

LUC unit VIs8 (1850 ha)—Figure 65

This unit comprises moderately steep to steep slopes mantled with a varying depth of Taupo airfall tephra over older weathered tephra on ignimbrite. Most is mapped in the Ongarue River valley, the Paraketu Road area near Waimiha and further south in the Taringamotu Valley.

Dominant soils are hill soils of the Kokomiko, Piropiro and Ongarue series, and the Mangakahu and Mahorehore series steepland soils. Grassland or a combination of grassland and scrub (including fern) is the dominant vegetation on map units covering 79% of the LUC unit. The remainder is indigenous or exotic forest and scrub. VIs8 has a potential stock carrying capacity of 9 su/ha. The site index for *P. radiata* is 25–26 m, however bare rock scarps are not suitable for forestry, and the dislodging of large boulders may constitute a hazard during logging operations.

Slight sheet and/or soil slip erosion is recorded on map units covering 41% of VIs8.

Where bare rock bluffs and boulders are not a significant physical limitation LUC unit VIe18 is mapped.

LUC unit VIIs1 (1700 ha)—Figure 66

VIIs1 comprises steep to very steep slopes on ignimbrite scarps. Most VIIs1 occurs in the Ongarue and Waione valleys, the headwaters of the Waimiha Stream, and in the vicinity of the Upper Ongarue Stream road and Upper Kokomiko road.

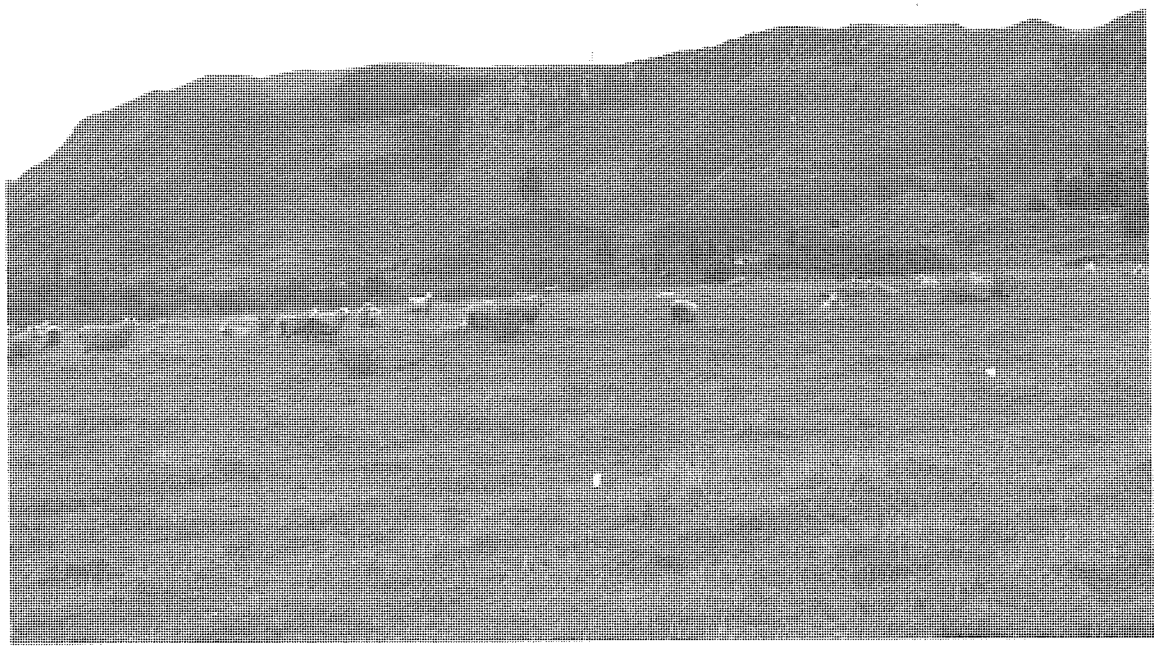


Figure 66: VIIs1 on ignimbrite scarps. Foreground is IIIs6 on Taupo flow and water-sorted tephra (LUC suite 7). Ongarue-Waimiha Rd. N92 820402 looking SW.

Slight soil slip erosion is recorded on 33% of VIIs1 with negligible erosion on the remainder. There is a potential for only slight soil slip and sheet erosion. Soils are recorded as the Mangakahu and Mahorehore steepland series.

Slopes are steeper and longer than on VIs8, with a greater proportion of bare rock bluffs. These limitations reduce the potential stock carrying capacity to 5 su/ha. The site index for *P. radiata* is the same as that for VIs8 but there are considerable areas of bare rock bluffs, very steep slopes, and boulders on colluvial slopes that are not suited to forestry.

6b Subsuite on deep Taupo airfall tephra

This subsuite is mapped where the depth of Taupo airfall tephra exceeds 44 cm. Soils are mostly yellow-brown pumice soils. It usually occurs further east than the previous subsuite

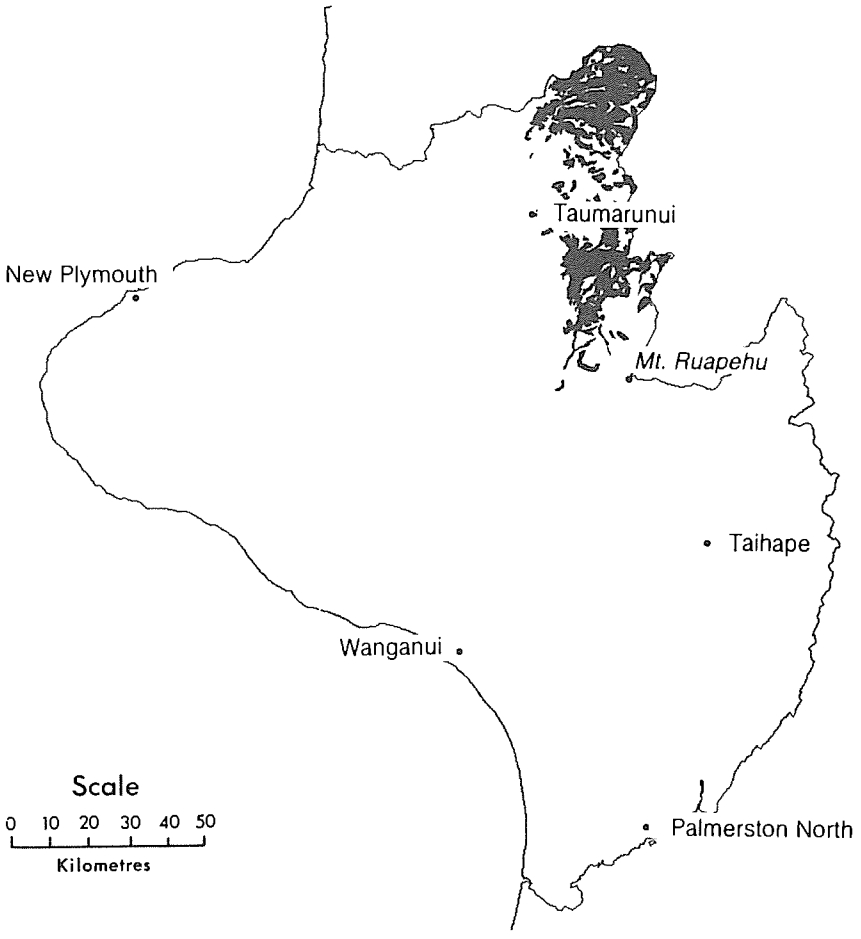


Figure 67: Location of LUC subsuite 6b: deep Taupo airfall tephra.

and closer to the source of the Taupo tephra (Figure 67). Six LUC units are defined: IIIs4, IIIe7, IVe9, VIs5, VIe18 and VIIe8. Together they cover 76,950 ha (3.2%) of the region.

The subsuite on deep Taupo airfall tephra has a physiography and climate similar to the subsuite on shallow Taupo airfall tephra. The increased depth of Taupo airfall tephra results in a greater level of physical limitations. This is reflected in lower pastoral and forestry productivity levels and a greater erosion hazard. These differences between the deep and shallow tephra subsuites are summarised in Table 25.

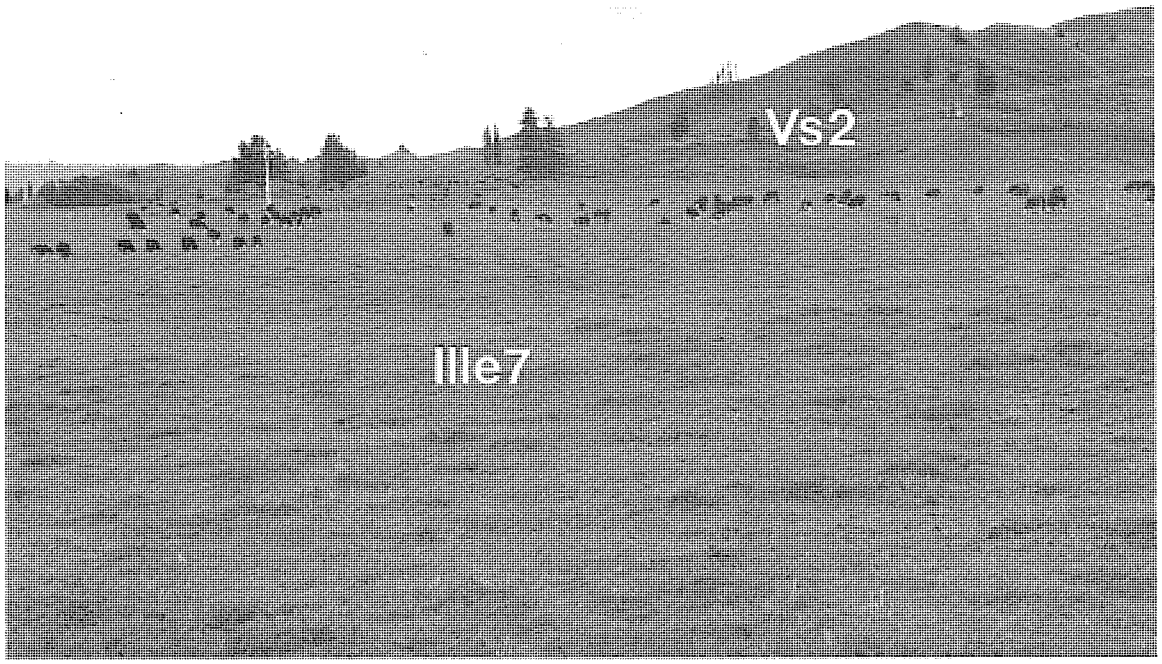


Figure 68: IIIe7 in foreground. Vs2 on hills. Near Owhango. N101 854075 looking S.

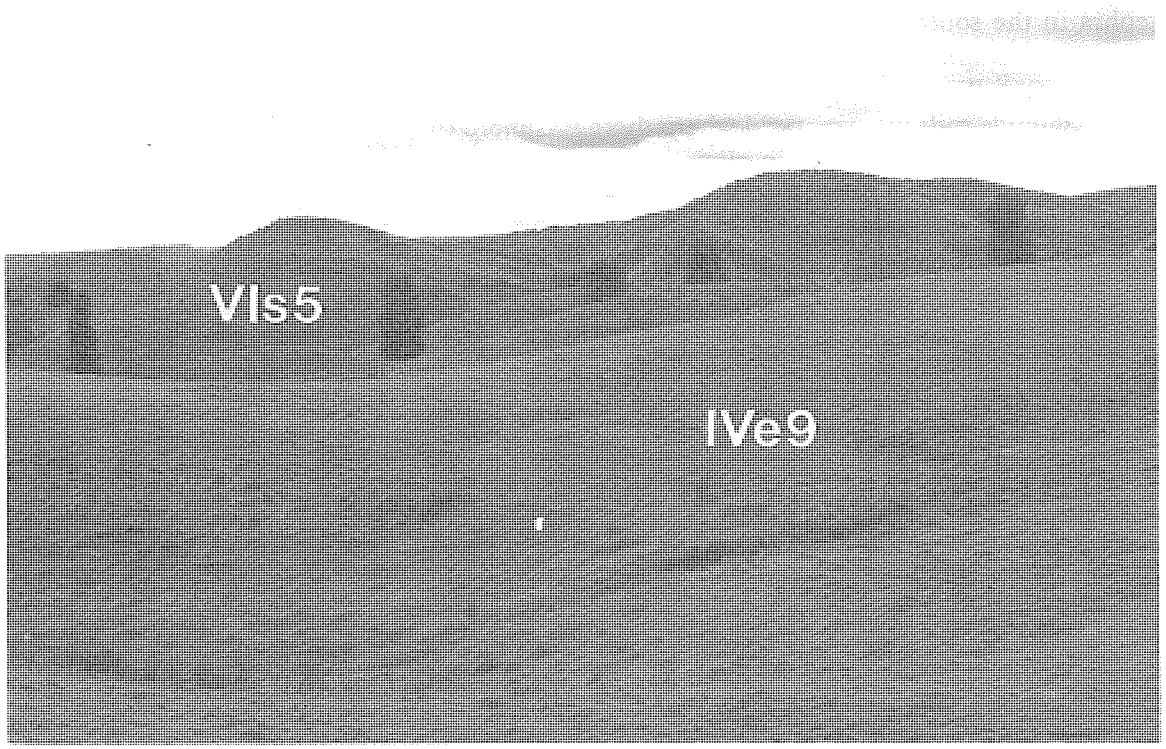


Figure 69: IVe9 in foreground. VIs5 on hills in the background. Deep Taupo airfall tephra on Tongariro tephra. Waihuka Rd, near Waimiha. N92 793432 looking E.

Table 25: Summary of erosion potentials and potential pastoral and forestry productivities of LUC units in the Taupo airfall tephra suite

LUC unit	Erosion potential when cultivated	Erosion potential under grassland	Pastoral potential su/ha	Forestry potential S.I.
Subsuite < 44 cm Taupo Airfall Tephra				
IVe5	3	0	18	27–28
Vs2	N/A	1	16	27–28
VIs2	N/A	1	16	26–27
VIe9	N/A	2	16	26–27
VIs8	N/A	1	9	25–26†
VIIs1	N/A	1	5	25–26†
Subsuite > 44 cm Taupo Airfall Tephra				
IIIs4	0	0	22 *	27–29
IIIe7	2	1	21 *	27–29
IVe9	3	0	18	27–28
VIs5	N/A	1	14	26–28
VIe18	N/A	2	13	25–27
VIIe8	N/A	3	9	17–22†

*With lucerne.
†Some unsuitable.

LUC unit IIIs4 (1650 ha)—Figure 64

This unit is mapped on flat terraces where yellow-brown pumice soils have developed on Taupo airfall tephra, overlying older tephra. A large proportion of this LUC unit (1000 ha) occurs in the Ongarue River catchment, east of Waimiha, where terraces are derived from tephric alluvium originating from the Hauhungaroa Range. The remainder occurs in the vicinity of Owhango where Taupo and Tongariro tephras overly Waimarino lahars (Hay 1967).

These two areas have climatic differences. Map units at Waimiha are at approximately 275 m a.s.l. and have an average annual rainfall of approximately 1600 mm. Soils are the Waimiha series (yellow-brown pumice soils). However, further south at Owhango (450 m a.s.l.) the average annual rainfall is approximately 1900 mm. The depth of Taupo airfall tephra in the southern area is less. Rijkse and Wilde (1977) map the soils in the Owhango area as a complex of Owhango series (yellow-brown pumice soils) and Ongawhao series (composite yellow-brown pumice soils on yellow-brown loams). In that soil survey yellow-brown pumice soils were mapped where there was more than 50 cm depth of Taupo pumice. However, despite differences in climate and soils between LUC unit IIIs4 at Waimiha and Owhango, both areas were assessed by MAF and NZFS as having very similar stock and forestry potentials. Because their cropping and erosion potentials were also similar they were classified in this survey as the same LUC unit.

IIIs4 is suitable for cereals, root and green fodder crops and some horticultural crops including asparagus and berryfruit. At present it is almost exclusively in high producing pasture and has a potential stock carrying capacity of 16 su/ha in pasture, and 22 su/ha in lucerne. The site index for *P. radiata* is 27–29 m. There is no significant present or potential erosion hazard.

LUC unit IIIe7 (4650 ha)—Figure 68

This unit occurs on undulating slopes where erosion is the dominant long-term limitation to arable use. Sixty two percent occurs from Kakahi south through Owhango and Oio almost to Raurimu. The remainder is on the margins of the Hauhungaroa Range particularly in the vicinity of Pureora. The climate is similar in both locations with average rainfalls of approximately 1800–2000 mm p.a.

Typical soils include the Owhango series with the Tihoi series (a podzolised yellow-brown pumice soil) mapped in the higher rainfall areas adjacent to the Hauhungaroa Range. The potential stock carrying capacity is 16 su/ha under pasture but increases to a potential of 21 su/ha with lucerne. The site index for *P. radiata* is 27–29 m.

There is a potential for slight sheet, gully and tunnel gully erosion under pasture and moderate sheet, rill and gully erosion when cultivated. This erosion can be minimised by cultivating on the contour and minimum tillage techniques.

LUC unit IVe9 (17,400 ha)—Figure 69

This unit occurs on rolling slopes which have a greater erosion hazard than IIIe7. It is mapped in the following areas:

1) the north-west margin of the Hauhungaroa Range;
2) east of Ongarue and Waimiha;
3) between Kakahi and Raurimu;
4) The Tongariro State Forest between Owhango and Raurimu, and east to the vicinity of Taurewa.

Rainfall varies from about 1600 mm p.a. near Waimiha and Ongarue to approximately 2400 mm p.a. in the Hauhungaroa Range and the Tongariro State Forest.

Typical soils are the Owhango, Rangipo and Waimarino series classified as yellow-brown pumice soils and Mangatepopo series which are podzolised yellow-brown pumice soils. There is a potential for severe sheet, rill and gully erosion when cultivated, requiring intensive erosion control techniques such as cultivation on the contour, minimum tillage and the installation of graded banks.

The unit is considered to have severe limitations for cropping (suitable for root and green fodder crops only). The potential stock carrying capacity is 18 su/ha and the site index for *P. radiata* is 27–28 m.

NON ARABLE LUC UNITS

LUC units VIs5, VIe18 and VIIe8 occur on the western flanks of the Hauhungaroa Range, in the Tongariro State Forest and also east of Waimiha and Ongarue. These areas have an annual average rainfall of approximately 1500–2500 mm.

LUC unit VIs5 (20,000 ha)—Figure 69

VIs5 comprises strongly rolling and moderately steep slopes. These occur as plateaux east of Waimiha and Ongarue or as ridges below 800 m a.s.l. in the Hauhungaroa Range.

There is considerable scope to expand pastoral and forestry development because map units covering 66% of the LUC unit are exclusively in forest and scrub. The dominant soils are the Rangipo, Tihoi, Raurimu and Mangatepopo series.

The potential stock carrying capacity is 14 su/ha (compared to 16 su/ha on VIs2) and the site index for *P. radiata* is 26–28 m. There is a potential for slight sheet erosion which can be minimised by good pasture management. At present map units covering 26% of the VIs5 area have slight erosion recorded.

LUC unit VIe18 (21,800 ha)—Figure 70

VIe18 is mapped on moderately steep to steep slopes which have a potential for moderate sheet erosion. Podocarp-hardwood forest was the dominant vegetation on this unit but most podocarps have now been logged. Pasture in combination with forest or scrub, occurs on map units covering 25% of the LUC unit. Forest covers a further 23% and the remainder is in scrub. Dominant soils mapped are the Tihoi, Mangatepopo, Waimarino, Rangipo, Taurewa and Ongawhao Series.

A high level of management is necessary to prevent reversion of pastures to fern and scrub. Care is required in the siting of tracks, fence lines and troughs to minimise stock induced erosion. Map units covering 33% of VIe8 have slight erosion recorded while map units covering a further 7% have moderate erosion. VIe18 has a potential stock carrying capacity of 13 su/ha and a site index for *P. radiata* of 25–27 m.

Figure 70: VIe18 with IVe13 (LUC suite 7) on stream terraces. East of Piropiro. N93 030505 looking NE.

Photo: P R Stephens

LUC unit VIIe8 (11,300 ha)

This unit occurs on moderately steep and steep slopes of longer length than those on VIe18. VIIe8 is found in the same locations as VIs5 and VIe18 and is also mapped on lower forest covered slopes in western areas of the Tongariro National Park (for example, the lower slopes of Mt Hauhungatahi).

All of this unit, apart from a very small area in pasture east of Waimiha has a forest or scrub vegetative cover. Steepland soils related to yellow-brown loams are mapped on steep slopes. These include the Mangakahu, Otamawairua, Weraroa, Pihanga, Kaimanawa and Moeatoa series. On moderately steep slopes where the Taupo tephra is deeper, yellow-brown pumice soils such as the Tihoi and Mangatepopo series dominate.

There is a potential for moderate soil slip and severe sheet erosion although soil slip and debris avalanche is the dominant erosion recorded. High levels of pasture management and care in the siting of fence lines, tracks and troughs is necessary to minimise erosion. The unit has a site index for *P. radiata* of 17–22 m, although steeper slopes are generally unsuitable for forestry due to access, establishment and logging difficulties. Exotic forest plantings should be principally for erosion control purposes. The potential stock carrying capacity is 9 su/ha.

7. LUC SUITE ON TAUPO FLOW TEPHRA AND WATER-SORTED TEPHRA

This suite comprises all LUC units that occur on Taupo flow tephra (also known as Taupo breccia or Taupo ignimbrite), and Taupo water-sorted tephra (Taupo volcanic alluvium) derived from the Taupo eruptions. *'Nuee ardente'* (glowing avalanche eruptions) gave rise to the flow tephra. These flowed rapidly over the land surface, settling mainly in low-lying areas.

Taupo flow tephra comprises poorly sorted ash, lapilli and block materials often with charcoal. Taupo water-sorted tephra comprises flow tephra together with airfall tephra which has been deposited by water. Taupo flow tephra and water-sorted tephra has been given the symbol Tp on the NZLRI.

The suite comprises 40,900 ha (1.7%) of the Taranaki-Manawatu Region. It occurs mainly in the Wanganui River catchment upstream of Taumarunui, but small areas also occur in the upper Moawhango River catchment, west of Lake Rotoaira and in the Waiouru area (Figure 71).

Major differences between this suite and the suite of LUC units on Taupo airfall tephra are:

1) A high potential for gully erosion.

2) Less soil profile development and weaker soil structure.

3) A low natural fertility.

4) A greater susceptibility to drought because of coarser soil texture.

Arable LUC units within the suite have been differentiated on the basis of soil texture. LUC units with finer textured soils have higher natural fertility, improved soil structure, greater profile development, and increased water holding capacity making them more suited to cropping than units with coarse textured soils. The arable units are further divided (Table 26) according to the intensity and depth to which they have been dissected by watercourses.

Figure 71: Location of LUC suite 7: Taupo flow tephra and water-sorted tephra.

On non-arable land where the separation into coarse and fine textured soils is not so critical LUC units have been differentiated on the intensity and depth of dissection and the associated erosion hazard. A further grouping within the suite recognises non arable LUC units in poorly drained areas which if drained would have similar erosion problems to other LUC units in the suite.

In summary, the 12 LUC units in this suite (Table 26) can be grouped as follows:

1. Arable land with finer textured soils (IIIs6, IIIe8 and IVe13).
2. Arable land with coarser textured soils (IVs3 and IVe14).
3. Non-arable land (VIe26, VIIe19, VIIIe2 and VIIIe10).
4. Poorly drained areas (IVw4, VIw1 and VIIIw1).

Table 26: Relationship between LUC units in the Taupo flow tephra and water-sorted tephra suite

Soil Parent Material	LUC units increasing intensity and depth of dissection →	
	Arable	Non-arable
Predominantly fine-textured Tp	IIIs6–IIIe8–IVe13	VIe26–VIIe19–VIIIe2–VIIIe10
Predominantly coarse-textured Tp	IVs3–IVe14	
Peat/Tp	IVw4	VIw1 VIIIw1

Physiography

Taupo flow and water-sorted tephra forms extensive relatively flat areas in the vicinity of Lake Rotoaira. Most of the subsuite occurs further from the tephra source where it has infilled large valley systems particularly in the Wanganui River catchment. In these situations flat to rolling terrace slopes are deeply incised by streams and rivers or more shallowly dissected by ephemeral waterways.

Climate

This suite generally occurs in two differing areas each with distinctively different climates. LUC units IIIs6, IIIe8 and IVe13 were mainly mapped in the Wanganui River catchment between Waimiha and Taumarunui, and further south in the Retaruke catchment. These areas are at approximately 150–250 m a.s.l. In contrast LUC units IVe14 and IVs3 occur between 700–1000 m a.s.l. in the Taurewa and Lake Rotoaira area, and IVw4 at Waiouru. The non arable LUC units VIe26, VIIe19, VIIIe2, VIw1 and VIIIw1 occur in both climatic areas. The only exceptions to this pattern are LUC units IIs5 and VIIIe10 mapped respectively, near Wanganui, and at high altitude in the Moawhango River headwaters.

Data from the Taumarunui climate station (171 m a.s.l.) (Thompson 1984) can be taken as representative of the climate on the lower altitude units. The annual rainfall normal (1951–80) is 1460 mm, with the driest months in January, February and March together receiving 18% of the annual total. Rainfall is spread fairly evenly during the remainder of the year. Because of its inland location, summer temperatures are characteristically warm e.g., Taumarunui can expect 41 days annually with a maximum temperature in excess of 25°C, while winter temperatures are relatively cold.

The climate at Taurewa and the Chateau is indicative of the higher altitude units, IVs3 and IVe14. The annual rainfall normal (1951–80) for Taurewa rainfall station (975 m a.s.l.) is 2565 mm with the driest months of January, February, March and April together receiving 26% of the annual total. The monthly rainfall totals for the remainder of the year are between 219–260 mm. The Chateau, at a slightly higher altitude (1119 m a.s.l.) and 14 km distant from Taurewa has an average of 142 days of ground frost and 16 days of snow per year (NZ Meteorological Service 1983a).

The cropping suitability can be interpreted in part from the number of growing degree-days. Average annual growing degree-day totals above a base of 10°C of 1334 for Taumarunui and 249 for the Chateau (Thompson 1984), show the effect of altitude in drastically reducing the growing degree-days.

Rock Type

Within the suite Taupo flow tephra and Taupo water-sorted tephra were not separated because of the difficulty of field recognition. In general deposits close to source were more

likely to be primary flow tephra and coarse textured, while deposits distant from source (such as in the middle Wanganui River catchment) were more likely to be water-sorted and have finer textures. However in the Lake Rotoaira area close to source Topping (1973) found that both flow tephra and water-sorted tephra of the Taupo Pumice Formation occurred and that the distribution pattern was very complex. There has been some peat development on poorly drained areas.

Soils

Most of the suite occurs within the area mapped by the Provisional Soil Survey of the King Country. However soils outside this survey area were recorded using the General Survey of the soils of the North Island (Maraeroa, Rangipo and Waimarino soil sets), Soils of part Wanganui County (Putiki series) and Soils of Rangitikei County (Murimotu series).

The majority of the soils are classified as yellow-brown pumice soils with minor areas also of Recent and Organic soils. Cowie (1978) has differentiated soils in the King Country survey on the basis of:

1) Soil texture.

2) Depth of soil parent material

3) Degree of leaching of plant nutrients, or degree of podzolisation, as conditioned by rainfall and vegetation.

4) The temperature regime as conditioned by altitude.

5) The presence or absence of the more recent andesitic Ngauruhoe ash in the surface layers. These physical factors differentiating the soils are summarised in Table 27.

Erosion

Gully and streambank are the dominant erosion types in this suite. Of the 18,120 ha of arable land, map units comprising 49% of the suite had slight erosion, and 11% moderate erosion, while negligible erosion was recorded on the remaining 40%. On non arable land only LUC units VIw1 and VIIIw1 had no present erosion. On the remaining LUC units erosion severity increases with decreasing LUC ranking, resulting in 54% of VIIIe2 having severe erosion and all of VIIIe10 having extreme erosion.

Erosion control measures on this suite are designed to prevent or control gully erosion. It is critical to ensure that runoff does not become channelised as this can initiate gully erosion. It is also necessary to ensure that a complete pasture cover is maintained and fences, tracks and water troughs are correctly located to minimise stock concentrations and areas of bare ground. Other soil conservation requirements include retirement of gullies and permanent water-courses, planting and strengthening of gully heads and gully sides liable to erosion and the maintenance of vegetative cover on ephemeral watercourses.

Land Use

Pastoral farming is the most important land use. However intensive grazing comprising mainly sheep and cattle breeding and fattening, with some dairying in the vicinity of Taumarunui, is only important on LUC units IIIs6, IIIe8 and IVe13. On other LUC units there is a significant reduction in grazing suitability as land use capability decreases from Class IV to Class VII. In terms of production potentials and erosion hazard under pastoral farming (Table 28) exotic forestry can be considered a more suitable use than pastoral farming on non arable LUC units. However at present exotic forestry is only significant west of Lake Rotoaira, although there is a trend towards more farm forestry in some areas.

Table 27: Physical characteristics of the dominant soils in the Taupo flow tephra and water-sorted tephra suite. (Adapted from Cowie 1978)

Soil Mapping Unit	Texture	Altitude (m a.s.l)	Rainfall (mm p.a.)	Dominant LUC units
YELLOW-BROWN PUMICE SOILS from very thick redistributed Taupo Pumice				
Atiamuri	Coarse	420–450	1650	IVe14,VIe26,VIIe19
Manunui	Coarse friable	170–230	1600	IIIs6,IIIe8,IVe13 VIe26,VIIe19,VIIIe2
Maraeroa	Coarse	300–400	1500	IIIe8
Benneydale	Coarse	200–300	1700	IIIs6,IIIe8,IVe13, VIe26,VIIe19,VIIIe2
from Ngauruhoe Ash on very thick redistributed Taupo Pumice				
Turangi	Coarse	400–800	1400–2200	IVe14
Turangi soils, peaty phase		550–700	2000–2400	VIw1,VIIIw1
Moerangi	Coarse	450–700	1800–2400	IVe14, IVs3, VIe26 VIIIe2
PODZOLISED YELLOW-BROWN PUMICE SOILS from very thick redistributed Taupo Pumice				
Kaama	Coarse	200–550	1900	VIIIe2
RECENT SOILS from pumice alluvium				
Ohinemoa	Coarse	150–250	1700	VIIIe10
ORGANIC SOILS from peat on redistributed Taupo Pumice				
Mokai	Fine	450–480	1300–1500	VIw1
from peat and Ngauruhoe Ash on redistributed Taupo Pumice				
Waikune	Fine	720–920	2200+	VIw1, VIIIw1

Most of Class VIII and much of Classes VI and VII are undeveloped, being mainly in manuka, *Dracophyllum* heathland or red tussock vegetation, with wetland vegetation on LUC units IVw4, VIw1 and VIIIw1.

Table 28: Summary of erosion potentials and potential pastoral and forestry productivity of LUC units in the Taupo flow tephra and water-sorted tephra suite

LUC Unit	Erosion pot. when cultivated	Erosion pot. under grassland	Pastoral potential (su/ha)	*P. radiata* site index
IIIs6	1	0-1	20	28
IIIe8	2	0-1	20	28
IVe13	3	1	18	28
IVe14	3	1-2	10	23-24
IVs3	1	0	12	23-24
IVw4	1	1	15	Unsuitable
VIe26	–	2-3	9	23–28
VIw1	–	2	8	Unsuitable
VIIe19	–	3	9	23-28
VIIIw1	–	5	Unsuitable	Unsuitable
VIIIe2	–	5	"	"
VIIIe10	–	5	"	"

FREE-DRAINING LUC UNITS

LUC unit IIIs6 (9340 ha)—Figure 66

This unit occurs in the Wanganui River catchment on flat, wide river and stream terraces with fine textured soils. It is most extensive in the Taumarunui area, particularly between Taumarunui and Piriaka, Manunui and Ngapuke, Taumarunui and Te Maire and in the Taringamotu valley. It also occurs in the Kaitieke and Retaruke valleys and in the vicinity of Waimiha and Ongarue. Much IIIs6 occurs as a complex with VIe26 and VIIIe2.

The predominant soils are the Manunui and Benneydale series. To minimise erosion soils should not be cultivated to a fine tilth and care must be taken to control surface water runoff.

Almost all of this unit is at present used for intensive grazing but horticultural crops, cereals, and root and green fodder crops could be grown. The potential stock carrying capacity is 20 su/ha with lucerne pastures. Irrigation may be required to achieve these cropping and pastoral potentials. The site index for *P. radiata* is 28 m.

LUC unit IIIe8 (1930 ha)

IIIe8 is mapped on gently undulating and slightly dissected terraces with fine textured soils. It is more limited in area than LUC unit IIIs6, being mapped particularly in the Tapuiwahine area in the north, adjacent to the Wanganui River at Kakahi and in the Kawautahi valley in the south.

The dominant soils are the Benneydale and Manunui series with the Maraeroa series significant in some areas. IIIe8 has the same cropping, pastoral and forestry production potentials as IIIs6 but has been differentiated because of its higher erosion potential, due to steeper slopes and more intensive dissection. There is a potential for negligible to slight gully and streambank erosion when in pasture and moderate sheet, rill and gully erosion when cultivated. This erosion can be minimised by cultivating on the contour and maintaining a complete vegetation cover on ephemeral watercourses.

LUC unit IVe13 (5020 ha)—Figures 62, 63, 65

This LUC unit has fine textured soils on undulating slopes in valley systems that are dissected by shallow ephemeral waterways. IVe13 is slightly steeper and more dissected than LUC unit IIIe8. IVe13 is widespread in valleys throughout the King Country occurring particularly in the northern Hauhungaroa Range, at the Te Koura, Ngapuke, Kirikau and Upper Taringamotu localities in the Taumarunui district, and in the Retaruke, Kawautahi and Whakapapa valleys. Small areas are also mapped outside the King Country at Tangiwai and adjacent to the Aorangi Stream (north of the Taihape-Napier road).

The Benneydale and Manunui series are the dominant soils. There is a potential for slight sheet, streambank and gully erosion when cultivated. To minimise stock induced erosion, care is required in the siting of fences, tracks and troughs. To reduce gully and streambank erosion permanent watercourses should be fenced off and retired from grazing and a complete vegetative cover should also be maintained on ephemeral watercourses and above gully heads. Because of the erosion hazard IVe13 is only suited to occasional cropping. The potential stock carrying capacity is 18 su/ha and the site index for *P. radiata* is 28 m.

LUC unit IVe14 (1750 ha)

This unit has a similar landform to LUC unit IVe13 but is mapped at higher altitudes (700–900 m a.s.l.) west of Lake Rotoaira and near Taurewa. The soils are dominantly the Atiamuri, Moerangi and Turangi series, which are coarser textured, and more drought prone than soils on IVe13.

IVe14 has a 'frost flat' microclimate with a natural vegetation of *Dracophyllum* and tussock. Although it is classified as an arable LUC unit, it is marginal for this purpose, being suitable for occasional root and green fodder crops. The potential stock carrying capacity is 10 su/ha and the site index for *P. radiata* is 23–24 m which gives LUC unit IVe14 a low potential for both grazing and forestry. IVe14 has the same erosion potentials and requires the same soil conservation measures as LUC unit IVe13.

LUC unit IVs3 (50 ha)—Figure 87

This unit comprises a single map unit on the Taurewa Land Development Block. It differs from LUC unit IVe14 by having flat undissected slopes which have a potential for only slight sheet erosion when cultivated. Soils are the Moerangi series.

The high altitude (820 m a.s.l.) and rainfall (2400 mm p.a.) depresses plant growth and results in a short annual growing season and a potential stock carrying capacity of only 12

su/ha. IVs3 is marginal for cropping, being suited to only root and green fodder crops. The site index for *P. radiata* is 23–24 m which gives this unit also a low suitability for forestry production.

Where the degree of dissection by ephemeral and permanent water-courses or gullies is such that cultivation for cropping is not advisable, the land is classified as non arable. Using this criterion three LUC units (VIe26, VIIe19 and VIIIe2) were differentiated on the basis of increasing depth and width of dissection, the susceptibility to and potential severity of gully erosion, and pastoral and forestry potentials. Soils mapped on these three units include the Benneydale, Atiamuri, Manunui, Moerangi and Kaama series.

LUC **unit VIe26 (1200 ha)**—Figure 72

VIe26 is mapped on strongly dissected flat and undulating terraces on which the degree of dissection and erosion potential precludes cultivation for cropping. This unit occurs in the King Country area of the Wanganui River catchment, often as a complex with LUC unit IIIs6. The potential stock carrying capacity is 9 su/ha while the site index for *P. radiata* of between 23 and 28 m varies with altitude. Slight erosion was recorded on map units covering 61% of VIe26, with moderate erosion on another 9%.

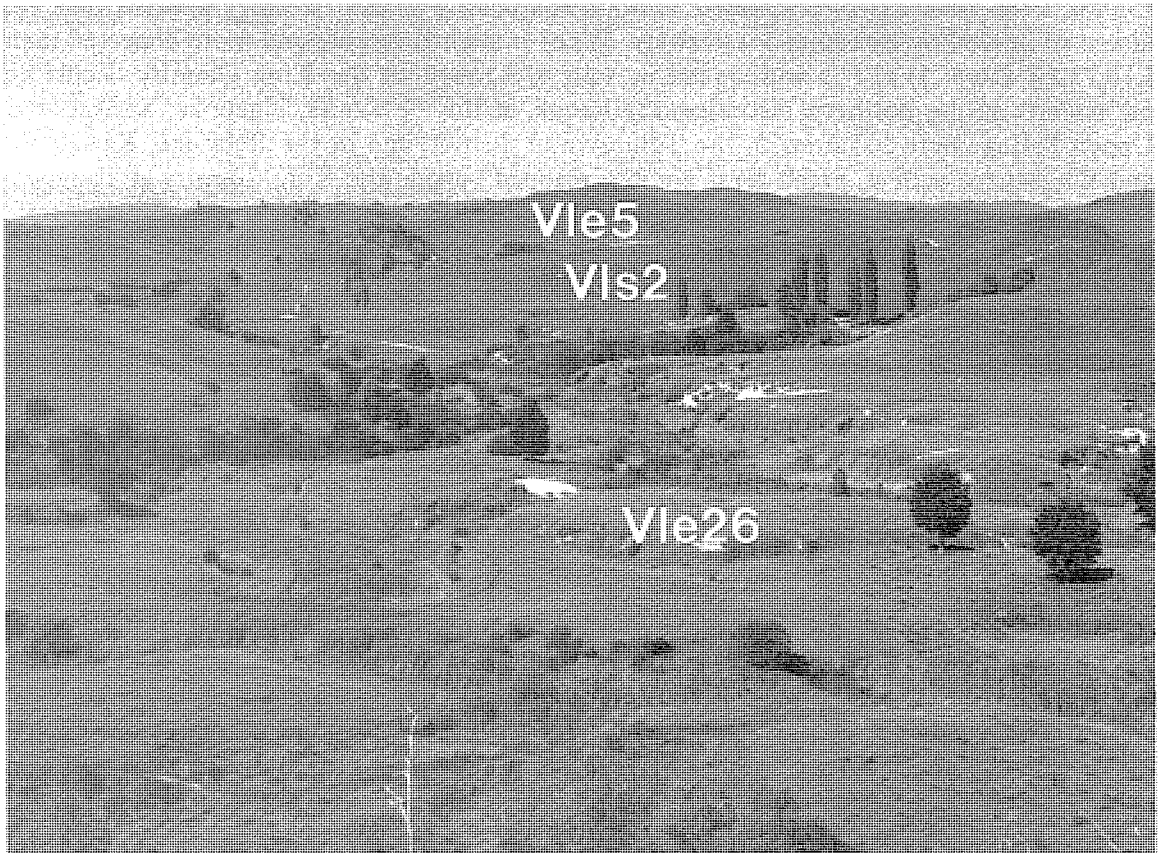


Figure 72: VIe26 (foreground). VIs2 (LUC subsuite 6a) in distance with VIe5 (LUC subsuite 9b) in far distance. SW of Taumarunui. N101 730082 looking E.

There is a potential for moderate to severe gully erosion together with moderate streambank and sheet erosion. Soil conservation measures include care in the siting of fences, tracks and troughs to minimise stock induced erosion. Permanent watercourses need to be retired and a vegetative cover on them maintained.

LUC unit VIIe19 (1550 ha)

VIIe19 is similar to LUC unit VIe26 but is more deeply dissected and has a greater erosion potential, especially for gully erosion. It is mapped in the Mangakahu and Hikumutu catchments near Taumarunui, in the Retaruke valley, and near Taurewa.

Although VIIe19 has the same pastoral and forestry potentials as VIe26 it is classified as Class VII because of the potential for very severe gully and streambank erosion, and severe sheet erosion. At present map units covering 58% of VIIe19 has slight erosion recorded. 36% has moderate erosion and 6% negligible erosion. Erosion control measures are the same as for VIe26 but need to be more intensively applied as the closer dissection makes erosion control more difficult.

LUC unit VIIIe2 (2800 ha)—Figure 87

This unit identifies the most intensively and deeply dissected areas adjacent to stream channels and ephemeral watercourses. VIIIe2 has a potential for extreme gully, streambank and sheet erosion. It is mainly mapped along watercourses in the Hauhungaroa Range, the Mangatepopo, Retaruke and Whakapapa valleys, the Taurewa area, and also in the Moawhango and Mangamaire catchments of the southern Kaimanawa Range. Because of its extreme erosion potential and physical limitations VIIIe2 is only suited for catchment protection.

Another 2,330 ha in the Manawatu-Wanganui area is also mapped as VIIIe2 on the basis that similar erosion processes are involved. The area is underlain by unconsolidated sedimentary rocks and has a potential for extreme gully erosion. These map units are discussed in the unconsolidated sandstone subsuite (LUC subsuite 11a).

LUC unit VIIIe10 (220 ha)

Two hundred hectares of Taupo flow and water-sorted tephra occurring at 1100–1300 m a.s.l. in the upper Moawhango catchment in the southern Kaimanawa Range have been included in this suite. This unit has extreme wind erosion which has removed the surface mantle of Ngauruhoe tephra to leave a pavement of course pumice blocks. The majority of VIIIe10 (4,830 ha) was mapped on areas of extreme wind erosion in the Rangipo desert and is described in LUC suite 8b.

LUC UNITS WITH A WETNESS LIMITATION

Three LUC units (IVw4, VIw1 and VIIIw1) are mapped on organic soils within Taupo flow and water-sorted tephra. High water table levels are a persistent problem for cropping, pastoral or forestry use.

LUC unit IVw4 (2250 ha)—Figure 73

IVw4 comprises poorly drained depressions with organic soils occurring between 700 and 1000 m a.s.l. The most extensive areas are the Ngamatea swamp at Waiouru and smaller swamps near Irirangi, Tangiwai and Karioi.

In Rangitikei County, organic soils of the Murimotu series are recorded, while "islands" with flat to rolling slopes have yellow-brown loams of the Moawhango series. Soils in the Waimarino County are the Pongakawa peaty loam or Rahotu loam.

The lack of suitable drainage outlets, the high potential for gully erosion following drainage, and the need to control the water table level are other constraints to the use of this unit. Most is undeveloped but when fully developed the potential stock carrying capacity is 15 su/ha. Climatic limitations and the presence of a permanent high water table preclude exotic forestry.

LUC unit VIw1 (1650 ha)—Figure 74

VIw1 includes swamps and developed areas with a high water table. Most occurs between 700 and 900 m a.s.l. in the National Park, Waikune to Erua area and adjacent to the Hauhungaroa Range. The remainder is at lower altitude elsewhere in the King Country.

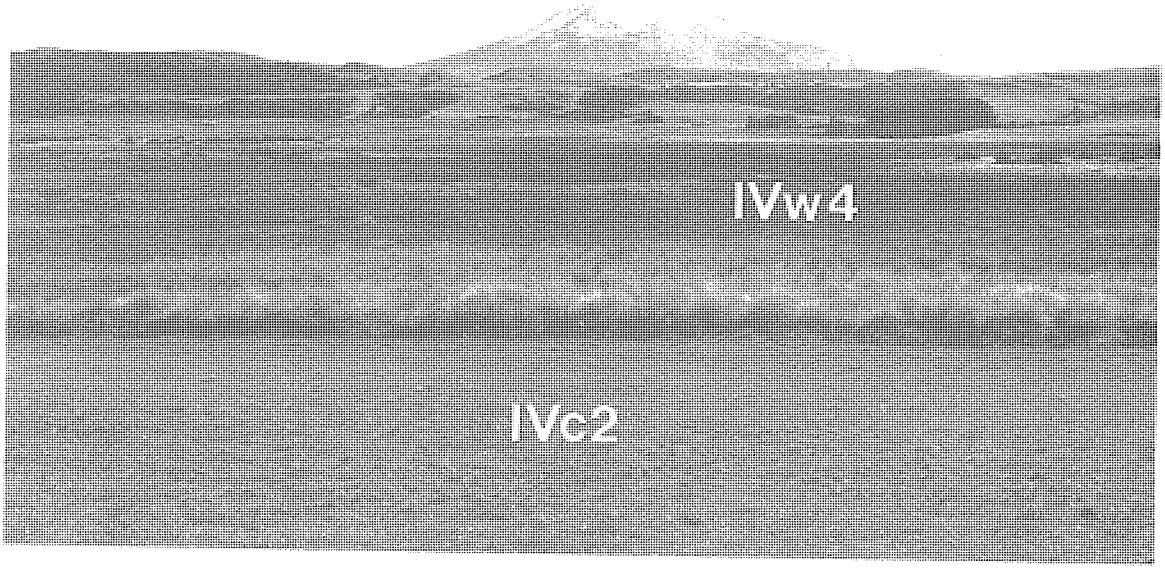


Figure 73: IVw4 in centre of photograph. IVe12 and VIe27 on hills and IVc2 in foreground are LUC subsuite 8a. In the distance is Mt Ruapehu. Near Irirangi. N132 155340 looking N.

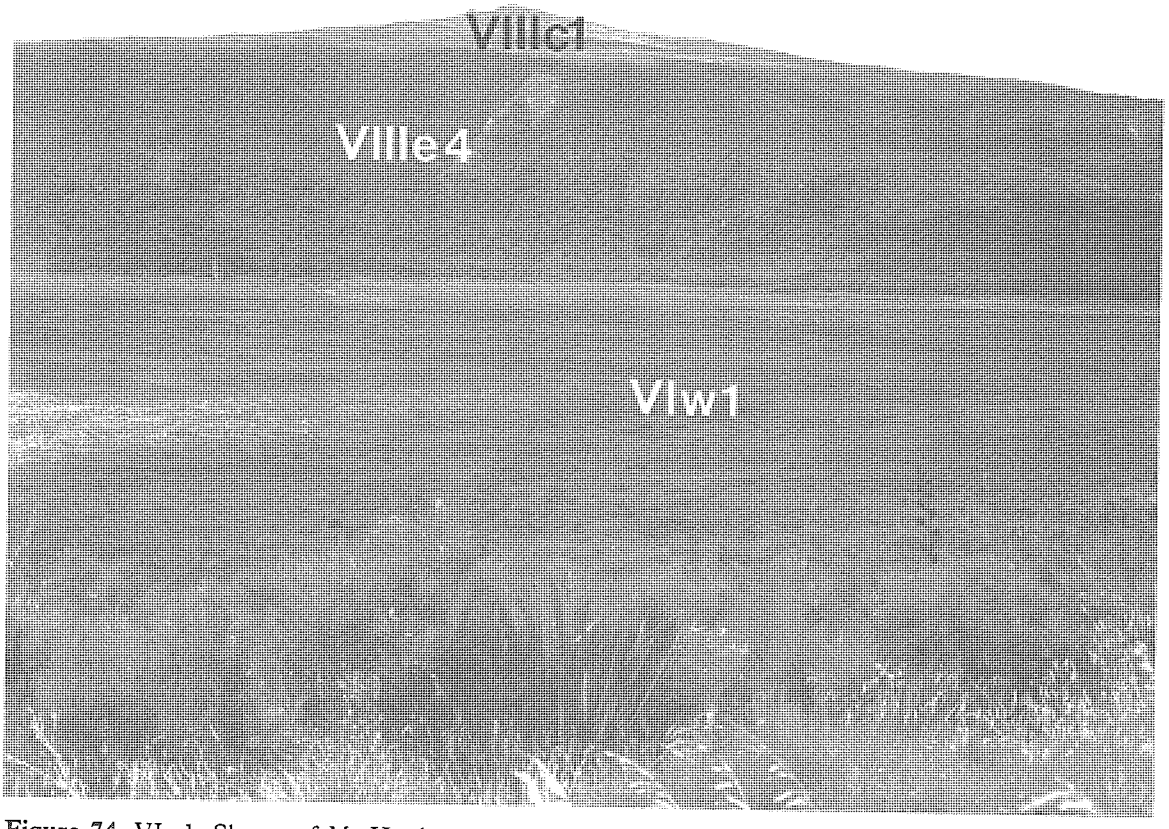


Figure 74: VIw1. Slopes of Mt Hauhungatahi (1519 m a.s.l.) classified as VIIIe4 and VIIIc1. Tongariro National Park. N111 940775 looking S.

The unit is mostly undeveloped with a wetland vegetation cover. Soils recorded include the Waikune and Mokai series (organic soils) and the Turangi series, peaty phase. When drained there is a potential for moderate gully and streambank erosion. However drainage can be difficult as VIw1 is often locally closely associated with undulating slopes, such as those of IVe11, IVc4, or VIc4). In many cases drainage would probably not be justified in terms of cost, technical difficulty, erosion potential, its scattered and local distribution, and habitat conservation values. The potential stock carrying capacity is 8 su/ha, but the high water table makes it unsuitable for exotic forestry.

Fifty hectares of saline soils mapped on river flats at the mouths of the Mokau and Mohakatino Rivers on the north Taranaki coast were also included in VIw1 but would be classified as a separate LUC unit in more detailed mapping.

LUC unit VIIIw1 (150 ha)

VIIIw1 is mapped on areas of peat swamp occurring on Taupo flow tephra or water-sorted tephra where there is a potential for extreme gully erosion if drained.

VIIIw1 occurs north-west of National Park township and north-west of Lake Rotoaira. Because of the potential for extreme erosion it must not be drained and should remain in its present wetland vegetation.

Figure 75: IVe11 on valley floor and in foreground. The valley floor is predominantly Taupo flow tephra and water-sorted tephra while the foreground is mostly Taupo airfall tephra. Hills in the distance are mainly IVe9. East of Benneydale. N93 010595 looking E.

(A further 220 ha of peat and tephric alluvium—but not overlying Tp, occurs within the Egmont National Park—is also mapped as VIIIw1 in this survey.)

LUC UNITS THAT ARE A COMPLEX OF TAUPO AIRFALL TEPHRA, AND TAUPO FLOW AND WATER-SORTED TEPHRA

Two LUC units (IVe11 and VIIe26) are mapped where undulating and rolling slopes mantled with Taupo airfall tephra occur as a complex with flat and undulating areas infilled with Taupo flow and water-sorted tephra. These two LUC units combine the erosion characteristics, and agricultural and pastoral suitabilities of LUC units developed on both Taupo airfall tephra and Taupo flow and water-sorted tephra.

LUC unit IVe11 (7250 ha)—Figure 75

This unit occurs mainly in the Tiroa and Barryville areas near Pureora, from Waikune to south of Erua, and west of Lake Rotoaira. These areas are at an altitude of approximately 450–700 m a.s.l. and have an annual rainfall of 2000 to 2800 mm.

On slopes with airfall tephra the Rangipo, Waimarino and Tihoi series occur. The Atiamuri and Bennydale series are the principal soils on Taupo flow tephra and water-sorted tephra. IVe11 has a potential stock carrying capacity of 13 su/ha and a site index for *P. radiata* of 26–27 m. Only slopes mantled with airfall tephra are suited to occasional root and green fodder crops. The erosion hazard varies according to the lithology. Slopes with airfall tephra have a potential for severe sheet, rill and gully erosion when cultivated, while the flow and water-sorted tephra has a potential for severe gully erosion along watercourses. Soil conservation measures include contour cultivation, taking care in the siting of fences, tracks and troughs to minimise stock induced erosion and maintaining a vegetative cover along watercourses.

IVe11 closely correlates with IVe13 of the Bay of Plenty-Volcanic Plateau Region.

LUC unit VIIe26 (3900 ha)—Figure 76

This unit occurs at 1100–1200 m a.s.l. in inland basins at the headwaters of the Moawhango River Catchment.

The undulating to rolling slopes have Waimarino Series soils developed on 15 cm of Ngauruhoe tephra over Taupo tephra. The flat areas of Taupo flow and water-sorted tephra are mantled by >20 cm of Ngauruhoe tephra and have a potential for severe wind erosion. The soils were recorded as Otamatea series, a droughty yellow-brown pumice soil, although the definitions of yellow-brown pumice soils (Rijkse 1974) would see them classified as Ngauruhoe sand, a recent soil.

Red tussock with some subalpine scrub associations is the dominant vegetation. Soil conservation measures should be directed at maintaining this vegetative cover by eliminating burning, preventing overgrazing and restricting vehicles to properly maintained tracks.

VIIe26 has severe climatic and erosion limitations. The nearest climatic data is from Waiouru (25 km distant and 300 m lower altitude). The Moawhango headwaters has considerably more snow and frost than Waiouru. The annual rainfall is estimated at about 2400 mm p.a. (NZ Met Service 1978). Because of the severe climate and erosion potential this unit should not be cultivated for pasture renewal. VIIe26 unit is estimated to have a potential stock carrying capacity of 1 su/ha and is only suited to light summer grazing. It is not suited to production forestry.

MISCELLANEOUS LUC UNIT

LUC unit IIs5 (800 ha)—Figure 77

This unit is included in the Taupo flow tephra suite because of its parent material, however it does not have the erosion characteristic of other LUC units in the suite.

IIs5 comprises flat terraces of Taupo water-sorted tephra bordering the lower Wanganui River in the vicinity of Wanganui City. The most extensive areas are in urban use. Outside the city IIs5 is mapped on an almost continuous 0.2–1 km wide strip bordering the Wanganui river upstream to Kaiwhaiki. Above this point scattered areas occur particularly in the Parakino area and as far upstream as Atene.

Figure 76: VIIe26. A complex of Taupo flow tephra and water-sorted tephra with Taupo airfall tephra. VIIIe8 in the distance. Headwaters of Aorangi Stream, Waiouru Military Reserve. N122 417535 looking N.

Figure 77: IIs5 on terraces of Taupo water-sorted tephra. Wanganui River at Kaiwhaiki. N138 610998 looking NE.

On river levees the pumice deposits are coarse-textured. However away from the river the alluvium thins and becomes fine-textured, being dominantly silt and sand sized (Campbell 1977). In most places these finer textured deposits have been buried by sedimentary alluvium and colluvium. Soils are mapped as the Putiki sandy loam.

IIs5 is at present used for sheep and cattle fattening, dairying and horticulture including nurseries, pip fruit, viticulture and kiwifruit. Because of its free draining soils, favourable climate and generally sheltered location a wide range of horticultural crops can be grown. However irrigation is required to achieve both the horticultural and pastoral potential of this unit. With a potential stock carrying capacity of 30 su/ha and a site index for *P. radiata* of 33–35 m, IIs5 is also highly suitable for both pastoral and forestry use.

8. LUC SUITE ON THE NORTH-EAST UPLANDS

This suite is characterised by its occurrence at high altitude and the presence of a mantle of Ngauruhoe and Taupo tephra over Tongariro tephra.

The suite occupies 155,650 ha (6.5% of the region). It mainly occurs in the Karioi-Waiouru area, the Defence Department Military Reserve north-east of Waiouru, and the "Inland Patea".* Also included are areas in and adjacent to the western and southern areas of the Tongariro National Park.

The suite comprises 14 LUC units which are subdivided into the following two subsuites on the basis of the depth of Taupo and/or Ngauruhoe tephra overlying Tongariro tephra:

a. Subsuite with shallow Taupo and/or Ngauruhoe tephra overlying Tongariro tephra (IIIc3, IVc2, IVe12, VIc3, VIe27, VIIe21, VIIe22, VIIe23).

b. Subsuite with deeper Taupo and/or Ngauruhoe tephra overlying Tongariro tephra (IVc4, VIc4, VIIc, VIIe24, VIIe25 and VIIIe10).

Steep and very steep slopes in the Kaimanawa and Ruahine Ranges and mountains of the Tongariro volcanic centre, as well as flat and rolling slopes above 1300 m a.s.l. are mapped as LUC Class VIII and are described in the mountainland suite.

Physiography

This LUC suite which occurs between 550–1300 m a.s.l. can be considered as comprising the following three physiographic units:

1) volcanic terrain, including the flanks of the andesitic cones of Mt Tongariro, Ngauruhoe and Ruapehu, together with the laharic ring plain extending to National Park township and south to Pokaka.

2) the depression between the Tongariro volcanic centre and the Kaimanawa Range which is infilled with lahar material to as far south as Waiouru.

3) To the east and south-east are greywacke and tertiary sediments which tilt gently to the south.

Sixty-seven percent of slopes are dominantly flat to rolling, the majority of steeper land is in the east and south-east where slopes are more dissected.

Climate

Cool temperatures characterise the climate of this suite. Frosts are frequent in winter but can occur at any season.

Climatic data for Taurewa and the Chateau which represent the climate on the western margin of the suite is outlined in the previous suite.

The only other meteorological station is on the southern margin of the suite at Waiouru. This station averaged 15.8 days of snow and 100.6 days of ground frost per year between 1960–1980 (NZ Met Service 1983a). At Waiouru the mean air temperature is 8.9°C.

*The Inland Patea refers to the area in the vicinity of the Taihape-Napier Road between Moawhango and Timahanga. It extends southward to include Mangaohane Station and north to the Kaimanawa Ranges.

The prevailing winds from the west and north-west bring most of the rain, however the mountains of the Tongariro National Park have a rain shadow effect on the Rangipo Desert, Waiouru, southern Kaimanawas and Inland Patea areas. The Ruahine Ranges similarly shield these areas from the south, while to the east the Huiarau and Kaweka Ranges act as a screen from easterly winds which can give heavy rainfalls in Hawke's Bay (Elder 1962). Annual rainfall at about 800 m altitude is indicated by rainfall normals (1951–80) for Waiouru of 1059 mm and Erewhon 1024 mm. Rainfalls increase with altitude to the south-east and the north so that at Burma Road rainfall station (1330 m a.s.l.) on the northern margin of the suite, the average annual rainfall over a 5 year period between 1962 and 1968 was 2290 mm.

Rock Type

This suite is characterised by the presence of Ngauruhoe, Taupo and Tongariro tephra.

Ngauruhoe ash, a recent tephra which is still accumulating (Topping 1973), is most significant on flat and gently undulating slopes on the western flanks of Mt Ngauruhoe and within about 30 km to the south-east of the Mt Ngauruhoe summit.

Taupo airfall tephra is significant as a soil forming parent material within and adjacent to the western and north-western areas of the Tongariro National Park. South of National Park township the depth of Taupo tephra thins away from source so that south of Pokaka the Waimarino yellow-brown loam suite is mapped on Tongariro tephra. In the Waiouru and Inland Patea areas Taupo tephra remains significant as a soil parent material in areas north of a line extending from Waiouru ENE to Ngamatea Station homestead.

To the south, Tongariro tephra is the principal soil parent material although traces of Taupo tephra are also present. On moderately steep to steep slopes where the depth of Ngauruhoe and Taupo tephra thin considerably (depending on distances from source) Tongariro may be the only tephra recorded above the underlying greywacke, siltstone or sandstone rock.

Only three lithologies in a stratigraphic sequence were recorded. The Tongariro and greywacke or Tertiary aged lithologies were normally recorded because of their significant effect on land use capability. Whether Ngauruhoe or Taupo tephra were recorded depended on the depth of the former, however in practice resorting by wind often made it difficult to determine whether Ngauruhoe or Taupo tephra was dominant.

Soils

Soils were recorded using the Rangitikei County Survey, the Provisional Soil Survey of the King Country and the Interim Soil Map of Taupo County. Information from the General Soil Survey was used in Waimarino County. Six soil groups, together with some related steepland soils are recorded.

Yellow-brown loams are mapped where the Tongariro tephra is mantled with a trace of Taupo tephra. Soils are principally the Moawhango series(the most extensive in the suite). At altitudes above 1100 m a.s.l. the Titapu series are recorded on the same soil parent material.

Where there is a trace of Ngauruhoe tephra over thin Taupo tephra on Tongariro tephra, composite yellow-brown pumice soils on yellow-brown loams of the Ngamatea series occur.

Yellow-brown pumice soils are principally the Waimarino and Mangatepopo soils of the King Country and the General Soil Survey, and the Taupo and Rangipo soils of the General Soil Survey. The Makahu hill soils occur in the north of the suite in Taupo County. Within the Rangitikei County the Otamatea series occurs on Taupo pumice alluvium, and the Taruarau series where there is a trace of Ngauruhoe tephra on Taupo and Tongariro tephras.

The remaining three soil groups are in the north-east of the suite. East of the Tongariro volcanic centre the thickness of both the Ngauruhoe and Taupo tephras increase towards the northern boundary of the region. This results in a progression from composite recent soils on yellow-brown pumice soils on yellow-brown loams (Waiouru series), to composite recent soils on yellow-brown pumice soils (Waimarino series), and recent soils from Ngauruhoe ash (Ngauruhoe series).

In Rangitikei County, moderately steep to steep slopes on greywacke (VIIe22) have steepland soils related to composite recent soils on yellow-brown pumice soils on yellow-brown loams (Kaimanawa or Kaweka soils). Similar slopes on Tertiary aged lithologies (VIIe21 and VIIe23), are mainly Irirangi soils which are steepland soils related to yellow-brown loams.

Erosion

Map units covering 38% of the suite have erosion recorded. The severity of erosion varies from negligible on LUC unit IIIc3 to extreme on map units covering 86% of VIIIe10 (Table 29). Wind and sheet erosion is recorded on 90% of the suite. Soil slip and debris avalanche erosion is significant on moderately steep to steep slopes. Present and potential erosion severities are the least on LUC units with flat to rolling slopes at lower altitude (IIIc3, IVc2, IVc4, IVe12, VIc3 and VIc4).

In recent years much of the higher altitude and steeper land has been destocked or is now only lightly grazed and the frequency of burning has been reduced. However fires still occur in the Waiouru and Inland Patea areas. A major fire occurred between 2–8 February 1983 on Ohinewairua and Ngamatea Stations. This fire which resulted from a controlled burn travelled 26 km to the north-east and burnt 15,000 ha of pasture, tussock and grassland. Burning the vegetation cover exposes the highly erodible Ngauruhoe and Taupo tephras to wind and water action and may result in a bare pavement of more compact Tongariro tephra (or, in extreme cases, the underlying greywacke or Tertiary aged rocks). Re-vegetation of such areas is hampered by frost heave which detaches soil and rock particles and allows them to be transported by wind or water. A wind funnel effect accentuates the wind erosion hazard on steep slopes of deeply incised river valleys.

Table 29: Present Erosion as a Percentage of LUC unit area, in the north-east upland suites

LUC Unit	Area (ha)	Present erosion severity as percentage of LUC Unit area 0	1	2	3	4	5
IIIc3	1,330	100					
IVc2	8,840	85	15				
IVc4	7,170	92	8				
IVe12	10,770	86	14				
VIc3	27,310	86	14				
VIc4	17,050	95	5				
VIe27	26,000	45	40	15			
VIIe21	8,920	22	71	4	3		
VIIe22	7,420	19	28	41	10	2	
VIIe23	8,090	3	59	38			
VIIe24	8,248		87	13			
VIIc	14,891	100					
VIIe25	4,550	71	26	3			
VIIIe10	5,040	2	—	2	10	—	86

Land Use

Large pastoral properties dominate areas which are not in National Park or State Forest.

Sheep have extensively grazed the red tussock grasslands of the Inland Patea since their introduction in 1868. By the 1880s sheep were grazed in the western areas of what is now the Tongariro National Park and in the Taurewa and National Park areas.

The Inland Patea originally comprised 3 vast holdings Owhaoko (now Ngamatea), Mangaohane and Erewhon (Oruamatua) totalling some 200,00 ha (Newton 1969). These have since been subdivided. The principal stations now are Ngamatea (48,000 ha), Mangaohane (12,800 ha), Ohinewairua (12,000 ha), Otupae (9,200 ha), Erewhon (4,800 ha) and Springvale (2,000 ha). Waiouru Station and the Lands and Survey Development Blocks at National Park and Taurewa comprise the principal remaining areas in pasture.

Back boundaries are largely unfenced on the largest stations. On Ngamatea Station, for example, it was necessary to muster to the crest of the Makorako Range (1727 m) and as far north as Mt Dowden (1562 m), a total area of about 100,000 ha. More recently higher

altitudes (above about 1300 m a.s.l.) have been excluded from grazing so in 1970 Ngamatea Station was no longer officially putting sheep on Makorako, Mt Dowden or in the Mangamaire (Lethbridge 1971). The long history of grazing in the Inland Patea and Waiouru areas together with the effects of fires and rabbits have caused a deterioration of the tussock and beech forest cover. However a significant reduction of grazing in higher altitude erosion-prone areas, the continued effective control of rabbits, and a reduction in the frequency of fires has resulted in an improvement in the vegetation cover.

Most land below 900 m a.s.l. used for pastoral farming has been converted to high producing pasture although in some areas such as on Mangaohone Station high-producing pasture has been established as high as 1100 m a.s.l.

LUC units IIIc3, IVc2, IVc4 and IVe12 are suited for arable use but little cropping is undertaken. Oats, barley and wheat are occasionally grown particularly on IIIc3. Yields can be high, for example 92 hectares of barley grown at about 1000 m a.s.l. on Otupae Station yielded 225 bushells to the hectare (Newton 1969). However the short growing season, the difficulty of getting suitable moisture conditions for harvesting necessitating artificial drying, and the remote location with associated high transport costs are likely to preclude the expansion of grain cropping. During the short November to February growing season large quantities of grass are saved as hay or silage for winter use. The 4,800 ha Erewhon Station grows 200 ha of choumoullier and swedes, and produces 1800 tonnes of silage, and 25–30,000 bales of hay annually for supplementary feed (Newton 1969). During the summer some of the higher country may be utilised for grazing.

Vegetation

Considerable areas comprise National Park, Defence Department Military Reserve, or Crown lease. These forms of land ownership together with the generally high altitude results in a low proportion of this LUC suite being in improved pasture or production forest.

The vegetation (Table 30) comprises mainly tussock grassland, scrubland (predominantly manuka) and forest (particularly mountain beech).

Table 30: Areas of dominant vegetation on the LUC suite on the north-east uplands

Dominant Vegetation	Percentage of map unit area in the LUC suite
Improved pasture	21
Forest	20
Tussock grassland	17
Scrubland	3
Combination of scrub tussock and forest	39

Improved pasture is the dominant vegetation on map units covering more than 50% of LUC units IIIc3, IVc2, and IVe12 and also comprises a considerable area of LUC units IVc4, VIc3, VIe27 and VIIe23. Red tussock varies with the intensity of burning and grazing from a closed community almost shoulder high to more widely spaced and stunted specimens (Elder 1962). Between 1912 and 1923 heather was planted in and adjacent to the western side of the Tongariro National Park (Bagnall 1982) and is now widespread in red tussock grassland on LUC units IVc4, VIc4 and VIIc in these areas.

Similarly *Pinus contorta* has spread from the Karioi State Forest to the Waiouru Military Reserve and threatens adjacent areas of the Tongariro National Park.

8a LUC Subsuite With Shallow Taupo and/or Ngauruhoe Tephra Overlying Tongariro Tephra

The soil parent material comprises a thin mantle of Taupo airfall tephra and Ngauruhoe tephra (together generally less than 50 cm), overlying Tongariro tephra. On steep slopes the Taupo and Ngauruhoe tephra may be very thin or absent so soils are developed on Tongariro

tephra alone. Soils are mainly yellow-brown loams, and composite yellow-brown pumice soils on yellow-brown loams.

This subsuite covers 98,950 ha (4.1%) of the region and occurs at 550 to 1300 m a.s.l. to the east and south-east of the Waimarino yellow-brown loam LUC suite. It is bounded by the Karioi State Forest in the west, Ngamatea Station in the east, the northern boundary of the region, and the Pukeokahu and Rangiwaea Junction areas in the south (Figure 78).

Map units in the Waiouru-Desert Road areas have a significantly lower forestry productivity and a slightly reduced agricultural potential than map units occurring at similar altitude elsewhere in the subsuite. This is probably due to more severe climatic limitations although these cannot be quantified because there are no climatic stations in the subsuite other than at Waiouru. The greater depth of Taupo and Ngauruhoe tephra in the vicinity of Waiouru and the Desert Road is probably also a factor. These productivity differences which apply mainly to LUC units IVc2, IVe12, VIc3 and VIe27 were not considered to be sufficient to warrant the formation of separate LUC units for the Waiouru-Desert Road areas.

Eight LUC units are differentiated on the basis of slope, altitude and the nature of the underlying rock (Table 31).

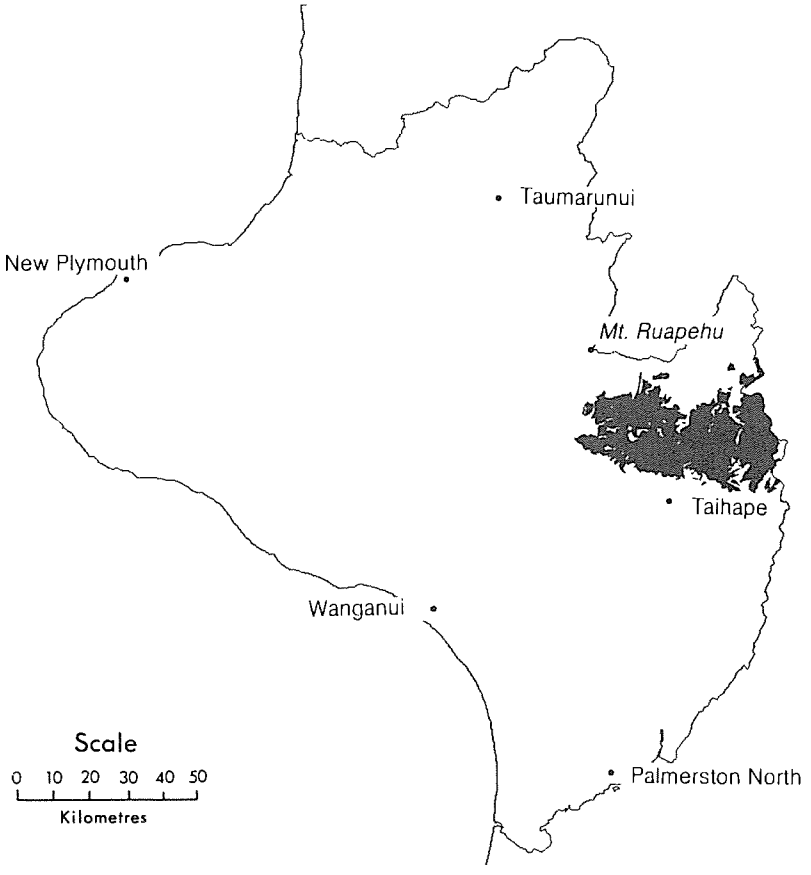


Figure 78: Location of LUC subsuite 8a: shallow Taupo and/or Ngauruhoe tephra on the north-east uplands.

LUC unit IIIc3 (1,650 ha)—Figure 79

This unit comprises flat to undulating slopes between 550 and 750 m a.s.l. in the Tangiwai, Rangiwaea Junction and Pukeokehu areas. Map units covering 71% of the LUC unit area have cropland or improved pasture recorded while indigenous forest occupies most of the remaining area. Soils of the Moawhango series predominate. The moderate climatic limitations restrict the range of crops to root and brassica vegetable crops, potatoes, barley, wheat, oats and root and green fodder crops. Vegetable cropping is only likely in map units in the Tangiwai area because of their proximity to the vegetable growing areas of Ohakune.

The potential stock carrying capacity is 20 su/ha. This unit is also suited for production forestry, having a site index for *P. radiata* of 27–30 m. There is a potential for slight wind erosion when cultivated.

LUC unit IVc2 (8,800 ha)—Figures 80, 82, 84

This unit comprises flat to undulating slopes between 750 and 1000 m a.s.l. in the Waiouru, Irirangi and Mangaohane Station areas.

Cropland or improved pasture is recorded on map units covering 47% of IVc2. The remainder is mainly tussock and indigenous forest. The dominant soils are those of the Moawhango series.

Severe climatic limitations limit cropping as well as pasture and tree growth. Cropping is restricted mainly to the growing of barley and root and green fodder crops although there is the potential also for potatoes, oats, wheat, and root and brassica vegetable crops. LUC unit IVc2 has a potential stock carrying capacity of 16 su/ha and a site index for *P. radiata* of 24–26 m.

When cultivated there is a potential for slight to moderate wind erosion with a potential also for slight to moderate sheet and rill on undulating slopes. This erosion can be minimised with minimum cultivation techniques and the establishment of wind breaks.

LUC unit IVe12 (10,750 ha)—Figures 79, 81

This unit occurs on rolling slopes between 550 and 900 m a.s.l. in the Tangiwai-Irirangi, east of Hihitahi, Pukeokahu, and Taihape-Napier Road areas. 68% of IVe12 has improved pasture or cropland. The dominant soils are those of the Moawhango, Ngamatea and Waiouru series.

Cropping is severely limited by the short growing season and the potential for severe sheet, wind and rill erosion when cultivated. Soil conservation measures include minimum cultivation techniques, contour cultivation and avoiding cultivating to a fine tilth.

There is the potential for occasional vegetable and cereal crops, however because of the physical limitations of this unit cropping is best restricted to root and green fodder crops.

The potential stock carrying capacity is 16 su/ha and the site index for *P. radiata* varies between 22–28 m according to altitude and degree of exposure.

LUC unit VIc3 (27,300 ha)—Figure 81

This unit occurs on rolling to strongly rolling slopes in the Waiouru, Desert Road, 'Inland Patea', and between Mangaohane Station and Pukeokahu. These areas are mostly between 750–1000 m a.s.l. but occur down to 650 m altitude in the Pukeokahu area.

Improved pasture is recorded on 30% of VIc3. Large areas, particularly in the Defence Department Military Reserve at Waiouru have a tussock vegetation and are not used for grazing. The dominant soils are the Moawhango and Ngamatea series.

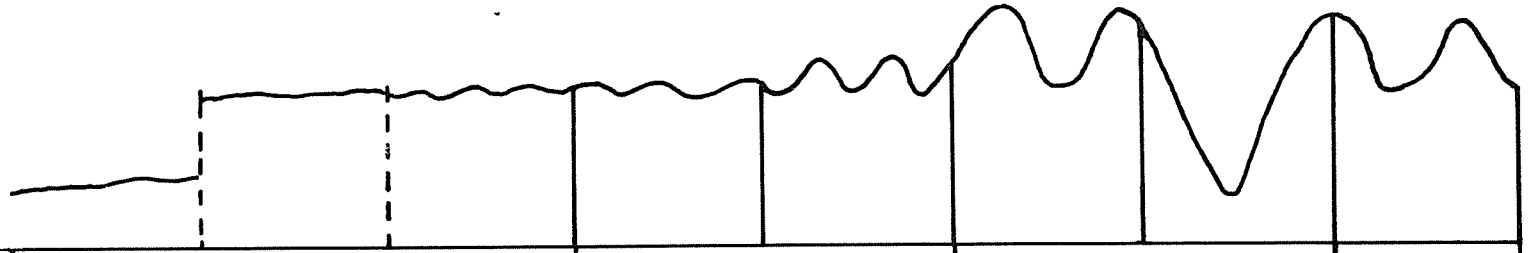
The potential stock carrying capacity is 13 su/ha. The site index for *P. radiata* varies between 22–28 m in the Inland Patea and Pukeokahu areas to less than 20 m in the Waiouru area. There is a potential for only slight sheet and wind erosion, however with poor management practices such as burning and overgrazing this potential would be greater.

LUC unit VIe27 (26,000 ha)—Figures 80, 82

This unit occurs on moderately steep slopes between 750 m and 1100 m altitude in the Waiouru, Desert Road and Inland Patea areas. Pasture is recorded on map units covering 29% of VIe27. The remainder is mostly tussock vegetation. Soils vary with the depth of Ngauruhoe and Taupo tephra and include the Moawhango, Waiouru, Ngamatea, Waimarino, Taruarau and Mangatepopo series.

The potential stock carrying capacity is 12 su/ha. Site index values vary with altitude and exposure and range from 23–26 m in the Inland Patea to less than 20 m in the Waiouru and Desert Road area. Present erosion severities are greater than for LUC unit VIc3 (Table 31).

Table 31: Relationship between L.U.C. unit in subsuite comprising shallow Taupo and/or Ngauruhoe tephra overlay overlying Tongariro tephra



Underlying Lithology	Tongariro tephra			Greywacke or Tertiary aged rocks		Tertiary aged rocks		Greywacke
Altitude (m a.s.l.)	550–750	750–1000	550–900	750–1000	750–1100	750–1300	700–1000	750–1300
Slope	0–7°	0–7°	8–15°	8–20°	21–25°	21–35°	26– 35°	21–35°
Present erosion	e	e	e	e	e–1Sh, w. sSl.	1sSl, daf 1–3w, Sh	1Sh, w, daf sSl	e–3w,Sh.
Potential erosion	1w when cultivated	1–2w , Sh R. when cultivated	3w, Sh, R when cultivated	1w, Sh	2w, Sh sSl	2sSl, daf 3w,Sh	2Sh, w, daf 3sSl	2sSl, daf 3w, Sh, Sc
Potential su/ha	20	16	16	13	12	3	8	3
Site Index, *P. radiata*	27-30	24-26	22-28	20-28	20-26	Unsuitable	24-26	Unsuitable
L U C unit	IIIc3	IVc2	IVe12	VIc3	VIe27	VIIe21	VIIe23	VIIe22

Figure 79: IIIc3 (670 m a.s.l.) in foreground. IVe12 in middle distance and VIe27 in background. Tangiwai. N122 080425 looking SE.

Figure 80: IVc2 (800 m a.s.l.) with VIe27 in the distance. Waiouru. N122 160400 looking W.

Figure 81: IVe12 on rolling slopes and VIc3 on strongly rolling slopes. Ohinewairua Station, Taihape-Napier Rd. N132 391353 looking N.

Figure 82: IVc2, VIe27 and VIIe21 Home Valley Road, Waiouru Military Reserve. N122 235429 looking NE.

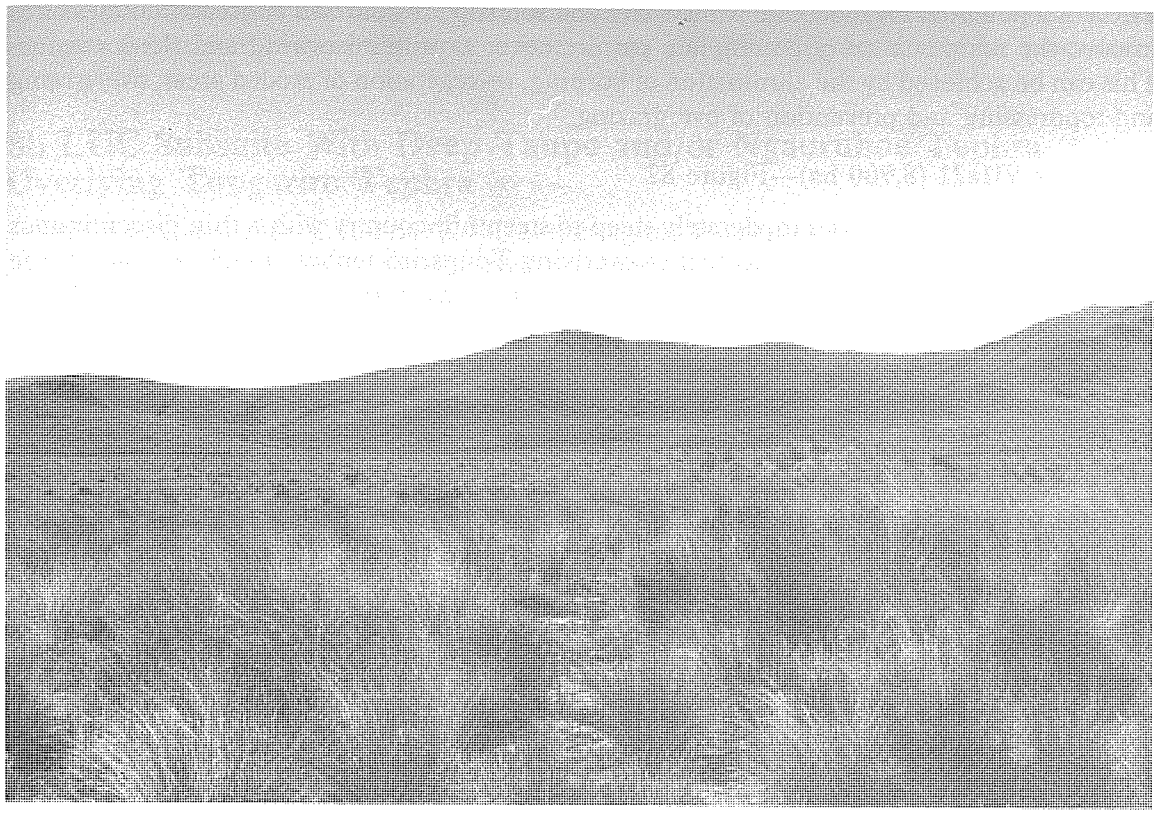


Figure 83: VIIe22 on hills. VIIc1 (LUC subsuite 8b) foreground (1050 m a.s.l.). Paradise Valley Rd, Waiouru Military Reserve. N122 253598 looking S.

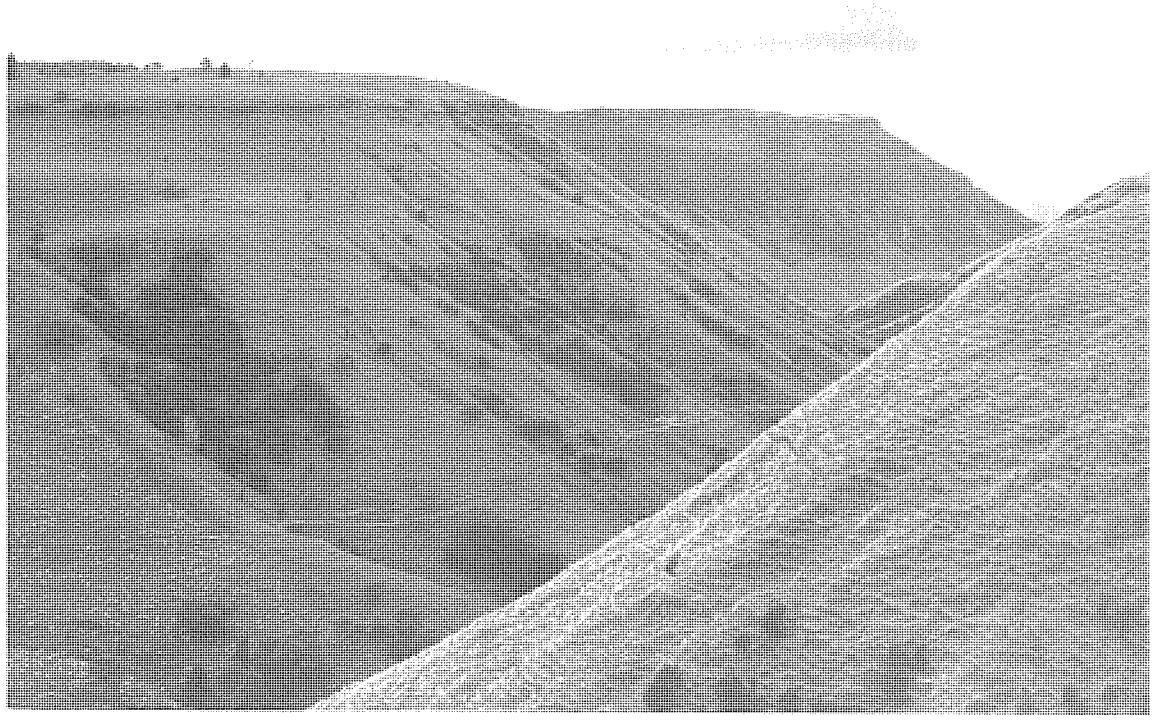


Figure 84: VIIe23 on scarps with IVc2 on plateaux (800 m a.s.l) Moawhango River, Taihape-Napier Rd. N132 360338 looking N.

There is a potential for moderate wind, sheet and soil slip erosion. Soil conservation measures involve the maintenance of a complete pasture cover to minimise wind and sheet erosion. This can be achieved by the elimination of burning, re-vegetation of eroded areas, oversowing and topdressing and prevention of overgrazing.

LUC unit VIIe21 (8,900 ha)—Figure 82

This LUC unit comprises moderately steep to steep hill country with a thin discontinuous mantle of Ngauruhoe and Taupo tephra overlying Tongariro tephra, which in turn overlie Tertiary aged sedimentary rock. It occurs up to 1300 m a.s.l. between Waiouru and Ngamatea Station and also on Mangaohane and Otupae Stations adjacent to the Ruahine Range. Improved pasture is only dominant on map units covering 9% of the LUC unit. On the remainder the dominant vegetation is red tussock grassland, manuka and *Dracophyllum* scrub. Dominant soils are the Moawhango and Titapu series, with the Irirangi series in steepland areas.

Extensive sheep grazing is the dominant land use, however because of the severe winter climate the potential stock grazing capacity is only 3 su/ha. VIIe21 is assessed as being unsuitable for production forestry.

Map units covering 40% of the LUC unit have wind and sheet erosion recorded. Erosion is dominantly of a slight or negligible severity (Table 31). Wind and sheet are the main erosion types with soil slip on steeper slopes and debris avalanche on steep forested slopes. Soil conservation measures would include prevention of overgrazing and burning, re-vegetation of eroded areas, oversowing and topdressing of pastures and restricting vehicles to properly maintained tracks.

LUC unit VIIe22 (7,400 ha)—Figure 83

VIIe22 has similar relief to LUC unit VIIe21 but differs by occurring on greywacke lithologies which have a potential for scree creep erosion. It occurs between 750 and 1300 m a.s.l. on the Defence Department Military Reserve east of the Desert Road. The Otupae and Kaweka soil series are recorded on the steepest slopes where little tephra remains, while the Waiouru and Taruarau series are on easier slopes with a greater depth of tephra.

VIIe22 has the same pastoral and *P. radiata* production potentials as VIIe21. Erosion is dominantly of negligible to moderate severity (Table 31). Wind and sheet are the dominant erosion forms. There is also a potential for soil slip, debris avalanche and scree creep erosion. Soil conservation measures are the same as for LUC unit VIIe21.

LUC unit VIIe23 (8,100 ha)—Figure 84

LUC unit VIIe23 comprises steep to very steep hill country between 700–1000 m a.s.l. Slopes are long (up to 350 m) and underlain by Tertiary aged sedimentary rocks. It includes long scarp slopes between Waiouru and the Rangitikei River and in the Hihitahi and Moawhango areas. A feature of this unit is the presence of numerous sandstone bluffs on upper hillslopes. These bluffs reduce the available productive area.

Improved pasture is the dominant vegetation on 50% of VIIe23, with mostly red tussock or manuka scrub on the remainder. Irirangi soils are recorded where there is a significant depth of Tongariro tephra while the Waiaruhe soils occur where the Tongariro tephra is not significant.

Slight sheet, wind and debris avalanche erosion, and slight to moderate soil slip is recorded. There, there is a potential for moderate sheet, wind and debris avalanche, and severe soil slip erosion. Soil conservation measures include open planting of conservation trees in areas that are susceptible to mass-movement erosion, and the maintenance of a complete vegetation cover by revegetating eroded areas, eliminating burning and preventing overgrazing.

The potential stock carrying capacity is 8 su/ha. Lower slopes have a site index for *P. radiata* of 24–26 m, however steeper upper slopes are generally unsuitable for production forestry.

8b LUC Subsuite With Deep Taupo and/or Ngauruhoe Tephra Overlying Tongariro Tephra

This subsuite covers 56,700 ha (2.3%) of the region. Its distribution is shown in Figure 85. In comparison to the previous to the previous subsuite, this subsuite has a greater depth of Taupo and Ngauruhoe tephra. This is because it occurs on flat to strongly rolling slopes and is often closer to the tephra source. The depth of Taupo and Ngauruhoe tephra is variable but is generally between 50 cm and 1 m. This greater depth of Taupo and Ngauruhoe tephra results in LUC units with a lower productivity and greater erosion hazard than in the previous subsuite. Soils are dominantly yellow-brown pumice soil or recent soils. Six LUC units are differentiated (Table 32).

LUC unit IVc4 (7,100 ha)—Figure 86

This LUC unit occurs on flat plateaux at 900–1000 m altitude between National Park township and Taurewa.

Map units covering 20% of IVc4 are dominantly in improved pasture and are farmed by the Department of Lands and Survey. The remaining areas have a vegetation of cut-over indigenous forest or occur in the Tongariro National Park where the dominant vegetation is red tussock grassland, with *Dracophyllum* scrub and heather, or beech forest. Soils are podzolised yellow-brown pumice soils, principally of the Mangatepopo and Waimarino series.

A severe winter climate and a rainfall of 2000–2500 mm p.a. limit cropping to root and green fodder crops. The potential stock carrying capacity of 10 su/ha, and the site index for *P. radiata* of 23–24 m gives IVc4 a low suitability for both pastoral and forestry use. There is negligible erosion.

LUC unit VIc4 (17,050 ha)—Figure 87

This unit is mapped on undulating to strongly rolling slopes on plateaux between 900–1100 m altitude. Although LUC unit VIc4 occurs at a similar altitude to LUC unit IVc4 it is differentiated because of steeper slopes which preclude cultivation for cropping. The unit is mapped principally on the western margins of the Tongariro National Park but small areas also occur in the Tongariro State Forest and the Hauhungaroa Range.

Improved pasture is dominant on map units covering only about 4% of VIc4. Soils are principally of the Waimarino, Mangatepopo and Raurimu series. Climatic limitations result in a potential stock carrying capacity of only 9 su/ha. The site index for *P. radiata* of 23–24 m is also low. VIc4 has a negligible erosion hazard when in pasture.

LUC unit VIIc1 (12,900 ha)—Figures 83, 88

This unit comprises undulating to strongly rolling plateaux between 900–1300 m a.s.l. with severe climatic limitations for pastoral and forestry production. LUC unit VIIc1 occurs in two distinct areas:

1) Western and southern areas of the Tongariro National Park from the Mangatepopo Track to north of Ohakune. Included also are ridges at the crest of the Hauhungaroa Range.
2) Eastern areas between the Desert Road and Ngamatea Station, and adjacent to the Ruahine Ranges. Here the extremely erodible Ngauruhoe tephra is deeper and land management practices result in a greater erosion potential than in western areas.

This unit is undeveloped being mainly in red tussock grassland or beech forest. Soils vary according to the depth and type of tephra as well as climate, and include the Moawhango, Titapu, Taruarau, Mangatepopo, Tihoi, Waimarino and Waiouru series.

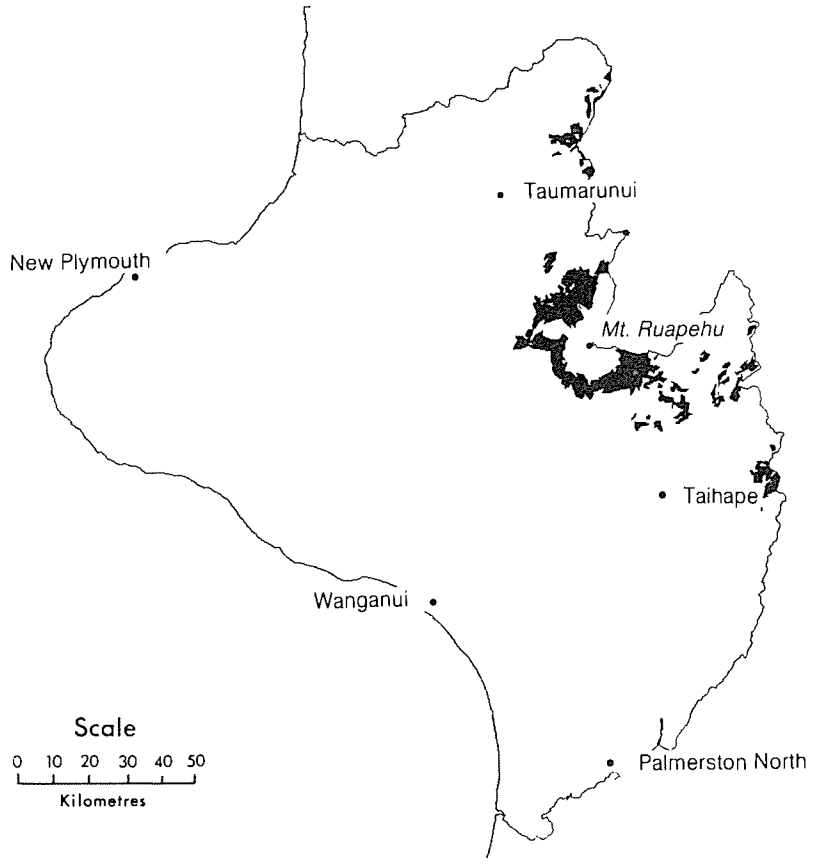


Figure 85: Location of LUC subsuite 8b: deep Taupo and/or Ngauruhoe tephra on the north-east uplands.

In eastern areas some of the tussock grassland is used for summer grazing, however the severe climate results in a potential stock carrying capacity of only 2 su/ha. The site index for *P. radiata* is 20 m making it only marginally suitable for production forestry. Present erosion is of negligible severity. The prime soil conservation requirement is to maintain the existing vegetation cover. This can be achieved through the elimination of burning, prevention of overgrazing and restricting vehicles to properly maintained tracks.

LUC unit VIIe24 (10,200 ha)

This unit occurs on the same relief and altitude range as LUC unit VIIc1 but differs in having a slight to moderate present erosion severity, and a potential for very severe sheet and wind erosion. It is restricted to areas between the Desert Road and Ngamatea Station and adjacent to the Ruahine Ranges.

The pastoral and exotic forestry potentials and soil conservation measures are the same as for VIIc1. Eroded areas should be revegetated, however this is difficult to achieve because of frost heave and consequent wind and sheet erosion.

LUC unit VIIe25 (4,500 ha)—Figure 89

This unit is mapped on undulating to strongly rolling slopes between 900 and 1300 m a.s.l. on the south-east flanks of Mt Ruapehu, where recent soils are developed on deep (>50 cm) Ngauruhoe tephra overlying lahars. Most occurs in the Karioi State Forest.

The presence of soils with loose consistence and fine to coarse soil texture in an area of severe climate results in a potential for extreme wind erosion. Present erosion however is of negligible to moderate severity (Table 32). Soil conservation measures are primarily concerned with maintaining a complete vegetation cover and in this respect erosion control forestry is a most suitable land use.

Figure 86: IVc4 (850 m a.s.l.) near National Park. Mt Tongariro and Mt Ngauruhoe in background. N111 925778 looking NE.

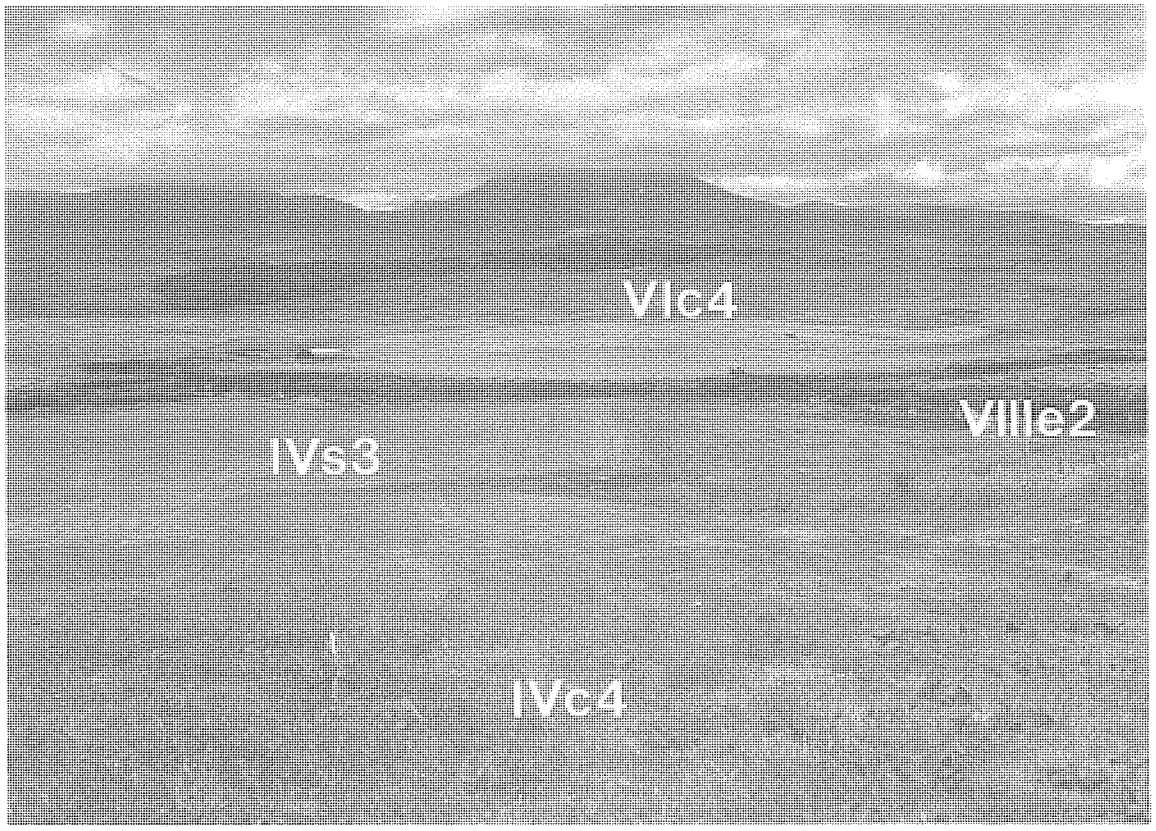


Figure 87: IVs3 and VIIIe2 (800 m a.s.l.) of the Taupo flow tephra and water-sorted tephra suite (LUC suite 7). IVc4 in foreground and VIc4 in distance occur in LUC subsuite on deep Taupo airfall tephra (LUC suite 6b). Taurewa Lands and Survey Block near National Park. N111 985845 looking E.

The site index for *P. radiata* varies between 22–26 m according to altitude and exposure. VIIe25 is unsuitable for pastoral use.

LUC unit VIIIe10 (4,850 ha)—Figures 89, 90

This unit occurs on the same materials and in a similar location as VIIe25 but differs in having severe to extreme present erosion. It occurs east of the Karioi Forest between 1000 and 1300 m a.s.l. on recent lahars in the Whangaehu River catchment.

LUC unit VIIIe10 consists of flat to rollng slopes with deep Ngauruhoe tephra on Tongariro tephra and bouldering laharic breccia, that is dissected by ephemeral watercourses. Wind erosion results in the Ngauruhoe tephra being overthickened in some areas and completely removed from others. Tongariro tephra is also eroded by freeze and thaw action and subsequent wind and sheet erosion. The majority of this unit has no vegetation recorded. Soil conservation measures include maintaining the small pockets of tussock grassland and subalpine scrub vegetation and the revegetation of eroded areas.

Two hundred and twenty hectares of extremely eroded Taupo flow and water-sorted tephra in the Upper Moawhango River basin also mapped as VIIIe10 are described in the Taupo flow and water- sorted tephra suite (LUC suite 7).

Figure 88: VIIc1 on valley floor (900 m a.s.l.). Steeper slopes are VIIIe5, VIIIe8 or VIIIe9 of LUC suite 13. Upper Rangitikei River catchment, Kaimanawa Ranges. N122 436560 looking NE.

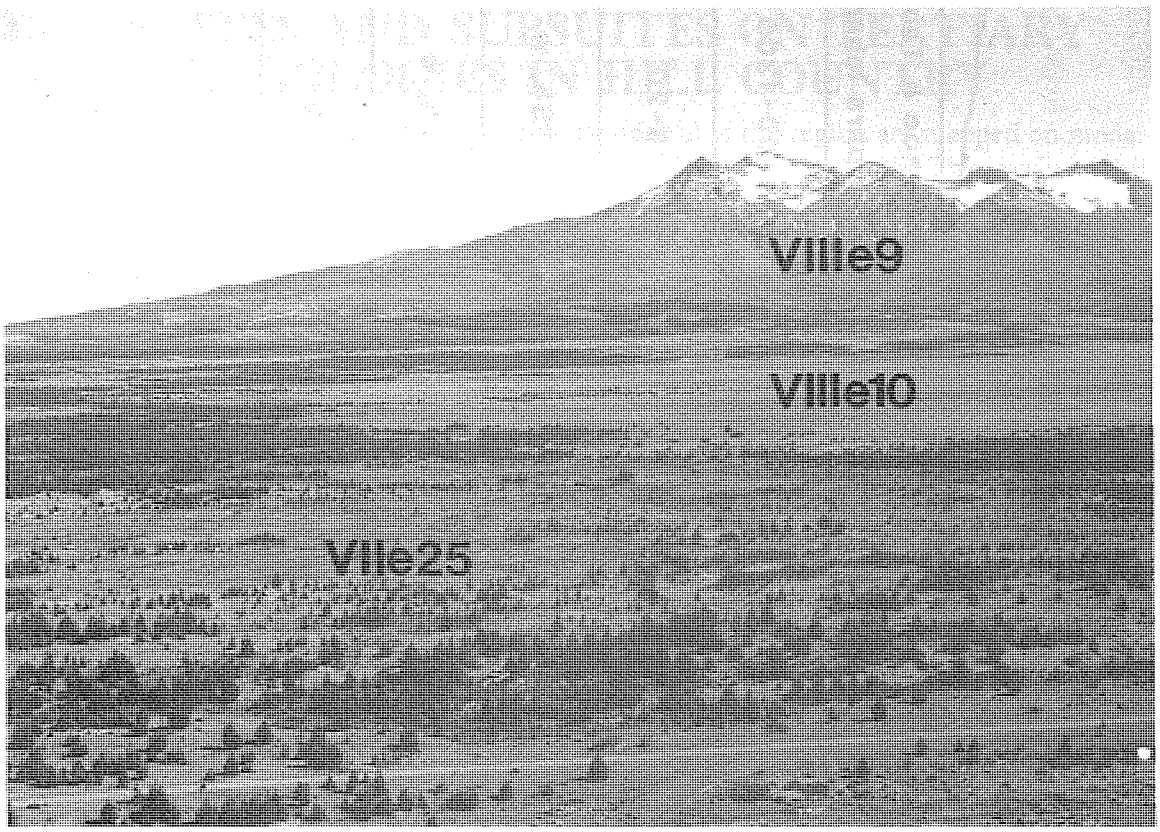
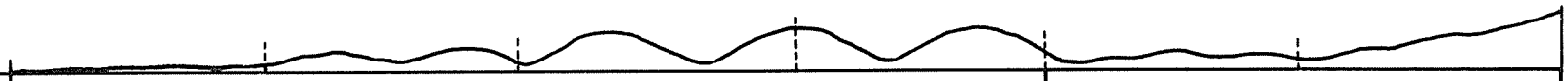


Figure 89: VIIe25 and VIIIe10 Rangipo Desert. VIIIe9 (LUC suite 13) on Mt Ruapehu (2797 m a.s.l.). N122 200548 looking NW.

Figure 90: VIIIe10. Wind erosion, Rangipo Desert. N122 220640 looking W.

Table 32: Relationship between LUC units in subsuite comprising deep Taupo and/or Ngauruhoe tephra overlying Tongariro tephra.



Lithology	50cm (approx.) Ngauruhoe & Taupo tephra on Tongariro tephra				50cm - 1m. Ngauruhoe & Taupo tephra on recent tephra lahars	
Altitude (m a.s.l.)	900-1000	900-1100	900-1300	900-1300	900-1300	1000-1300
Slope	0-3°	3-20°	3-20°	3-20°	3-20°	3-20°
Present erosion	0	0	0	1-2Sh, w	0-2Sh, w	4-5Sh, w
Potential erosion	1w, Sh when cultivated	1Sh, w	1Sh, w	4Sh, w	4Sh, w	5Sh, w
Potential su/ha	10	9	2	2	1	N.A.
Site Index *P. radiata*	23-24	23-24	20	20	22-26	N.A.
L U C unit	IVc4	VIc4	VIIc1	VIIe24	VIIe25	VIIIe10

LUC SUITES AND SUBSUITES ON TERTIARY AGED LITHOLOGIES IN HILL COUNTRY

Thirty-four LUC units totalling 1,114,550 ha (46.2%) of the region are mapped on moderately steep to very steep hill country underlain by Tertiary aged rocks. This excludes hill country mantled with significant depths of tephra, that are included in the Taupo tephra or yellow-brown loam suites.

LUC units on moderately steep to very steep slopes were separated on the basis of field observations of rock grain size into three LUC suites: the sandstone, siltstone, or mudstone LUC suite. Within these three LUC suites there is a relationship between the natural nutrient status of soils and the particle size distribution of the parent rock. The mudstone LUC suite has soils of high natural fertility. Soils on the sandstone suite are the least fertile. A fourth LUC suite comprises low-angle slopes, with mudstone or siltstone lithologies, and exhibits deepseated slump and earthflow erosion.

The sandstone, siltstone and mudstone LUC suites are subdivided further into LUC subsuites on the basis of erosion characteristics and susceptiblity, and rock strength and hardness. These criteria are recognisable in the field and are directly related to soil conservation requirements and the suitability of the LUC units for pastoral or forestry use.

Within each LUC subsuite, LUC units of the same class and subclass are further separated according to climatic differences (principally rainfall). These comprise:

1. LUC units with annual rainfall >1200 mm p.a. (generally between 1200–2400 mm p.a.)
2. LUC units with annual rainfall <1200 mm p.a. (generally between 900–1200 mm p.a.).

Lower rainfall LUC units occur nearer the coast. They have a seasonal soil moisture deficit which limits pasture growth in summer and autumn and may provide some difficulty for soil conservation tree establishment. In contrast higher rainfall LUC units occur further inland and at higher altitude. Higher rainfall LUC units usually have slightly higher potential stock carrying capacities, because although cooler temperatures depress pasture growth in winter there is good summer growth. Scrub and fern reversion occurs more readily on higher rainfall LUC units. This corresponds with observations by Levy (1970) who noted that in lower rainfall areas secondary growth was not as vigorous and was more readily controlled. Analysis of NZLRI vegetation data also confirms that high rainfall LUC units have a greater percentage of their area in scrub and fern than do low rainfall LUC units.

9. LUC SUITE ON MUDSTONE

The mudstone suite occurs on hill country in the King Country and inland Taranaki and Wanganui regions.

It is characterised by soils of high natural fertility, with the result that some LUC units have the highest pastoral productivity levels of any on hill country underlain by Tertiary aged rocks in the region.

The suite comprises six LUC units which occupy 160,950 ha (6.7%) of the region. These units are divided into two subsuites on the basis of lithology, landform and erosion:

a. LUC subsuite on jointed mudstone (VIe3, VIe4, VIIe1, VIIe2.)

b. LUC subsuite on banded mudstone (VIe5 and VIIe7).

9a LUC Subsuite on Jointed Mudstone

This subsuite comprises very closely spaced jointed, weak, soft mudstone. It is characterised by high natural fertility, and a potential for shallow earthflow and soil slip and sheet erosion.

It occupies 127,350 ha (5.3%) of the region particularly in the Taihape, upper Parapara Road, King Country and inland Taranaki areas (Figure 91).

Physiography

This subsuite occurs on Pliocene and Miocene aged mudstones. These have been strongly dissected so that moderately steep and steep slopes dominate. However, the topography lacks the characteristic V-shaped and intensively dissected appearance typical of the siltstone suite and consolidated sandstone subsuites.

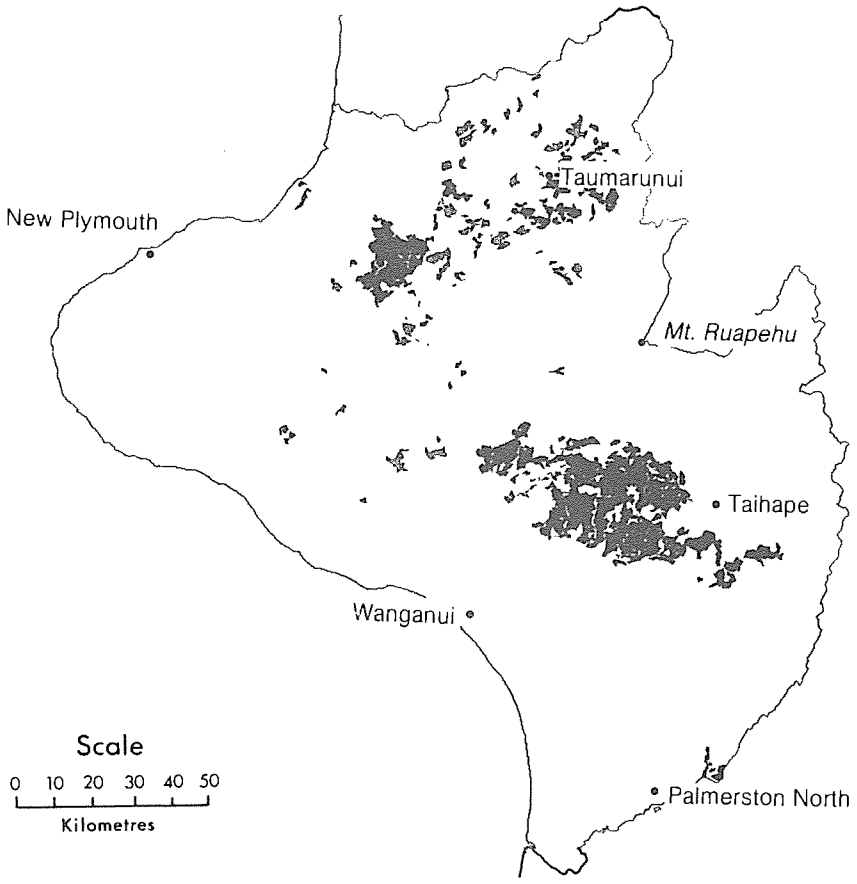


Figure 91: Location of LUC subsuite 9a: jointed mudstone.

Climate

The units of the subsuite have been grouped into two climatic zones (defined principally on rainfall) that influence seasonal pasture production.

Two thirds of the subsuite occurs in areas with >1200 mm p.a. rainfall. The remainder is in a lower rainfall (<1200 mm p.a.) area. There are no representative climatological stations on this subsuite.

Rock Type

This subsuite is mapped on mudstone that displays close-spaced fracturing or jointing when exposed to weathering. This results in a gradual transition between rock and soil. This is in contrast to the sharp separation between soil and parent rock that occurs on both the siltstone suite and consolidated sandstone subsuites.

Included also are areas south and east of Taumarunui on banded mudstone rocks where shallow earthflows occur on dip slopes. A significant depth of andesitic tephra may mantle strongly rolling and moderately steep slopes on higher rainfall LUC units.

Soils

Soils were recorded using information from the Rangitikei, part Wanganui, and Stratford County Surveys, the King Country Survey and the General Soil Survey. The dominant soils are the Mangatea, Atua and Kohuratahi hill soils, and the Turakina, Rangiwaea and Tahora

steepland soils. In the King country and Taranaki where mudstone is mantled by andesitic tephra, yellow-brown loam hill soils of the Matiere, Tangitu and New Plymouth series are recorded.

Erosion

Soil slip, sheet and shallow earthflows are the dominant erosion types. In contrast to mudstone LUC units elsewhere in the North Island, earthflow erosion is generally not a serious hazard. Earthflows are shallow and mainly occur on colluvial slopes. Soil slips revegetate rapidly particularly when jointed rock remains on the erosion surface. Sheet erosion is recorded mainly on lower rainfall units that are prone to drought.

Present erosion severities are mainly negligible to moderate. Erosion severity is similar to that of the subsuites on banded mudstone, siltstone, and consolidated sandstone but is significantly less than that on the Urenui siltstone subsuite. There is a potential for slight to moderate erosion on moderately steep slopes and severe erosion on steep and very steep slopes.

Land Use

The LUC units in this subsuite are the most productive of the classes VI and VII in hill country underlain by Tertiary aged rocks. Potential stock carrying capacities are 19 su/ha on LUC units VIe3 and VIe4 and 14 su/ha on LUC units VIIe1 and VIIe2. However there are seasonal differences in pasture growth between LUC units. On LUC units VIe3 and VIIe1 winter pasture growth is inhibited by cool winter temperatures while on LUC units VIe4 and VIIe2 summer pasture productivity is reduced by periods of soil moisture deficit.

Large areas are in scrub or forest while much of that which is farmed is producing at only 50% of its potential. In many cases this can be partially attributed to poor access and remote location.

LUC UNITS WITH RAINFALL GREATER THAN 1200 MM P.A.

LUC units VIe3 and VIIe1 are mapped on mudstone hill country where the rainfall is between 1200 and 2000 mm p.a. The most typical examples are in the Tahora and Kohuratahi areas of Taranaki and the Ohura and Kirikau areas in the King Country. Data from the Te Wera Forest climatological station which can be taken as best representing the higher rainfall LUC units, show a mean air temperature of 11.9°C and an average of 74 days of ground frost annually. Areas of less rainfall such as in the Upper Parapara Road, and the Upper Turakina and Waitotara Valleys have a climate that is transitional between those of the high and low rainfall mudstone LUC units.

VIe3 and VIIe1 conform to the pattern of higher rainfall LUC units, having a greater proportion of their area in forest or scrub than do lower rainfall LUC units.

LUC unit VIe3 (50,450 ha)

VIe3 comprises strongly rolling to moderately steep slopes, with a mantle of andesitic tephra. South of Mangaweka, however, the tephra has thinned to the extent that it is insignificant on the scattered areas of VIe3 mapped.

The dominant soil series are the Matiere, Tangitu, New Plymouth, Kohuratahi, Atua and Mangatea hill soils and the Tahora steepland soils.

VIe3 has a present average stock carrying capacity of 10 su/ha but a potential of 19 su/ha. The site index for *P. radiata* is 27–29 m. Significant increases in pastoral producton are possible both by increasing stocking rates and by clearing more land for grazing. At present pasture is dominant on map units covering only 39% of the LUC unit.

Erosion is not a significant problem as negligible to slight erosion is recorded on 93% of VIe3. The dominant erosion types are soil slip and earthflow erosion. Most erosion can be controlled by open planting of conservation trees. There is a potential for moderate soil slip and earthflow, and slight gully and sheet erosion.

LUC unit VIIe1 (29,100 ha)

This unit comprises steep to very steep slopes which are of longer length (approx. 150 m) and have thinner soils than those on VIe3.

The dominant soils on VIIe1 are the Tahora, Mahoenui and Turakina steepland soils. Pasture is dominant on 34% of VIIe1. The remainder is scrub or forest often with a minor component of pasture.

The present average stock carrying capacity is 8 su/ha with a potential of 14 su/ha. Lower and mid slopes have a site index for *P. radiata* of 25–27 m, however steeper upper slopes and steep slopes adjacent to incised streams are unsuitable for forestry because of access, establishment and logging difficulties.

VIIe1 has a potential for severe soil slip and moderate shallow earthflow erosion. There is also a potential for slight gully erosion near water courses and slight sheet erosion especially on sunny north facing slopes. Map units covering 23% of VIIe1 have moderate erosion and 14% have severe erosion. Soil conservation measures include the open planting of conservation trees in areas most susceptible to erosion and the oversowing and topdressing of soil slips. Gullies can be stabilised with pair and block planting and debris dams. Conservation planting must be adequately protected from damage by cattle, goats and possums.

LUC UNITS WITH RAINFALL LESS THAN 1200 MM P.A.

LUC units VIe4 and VIIe2 occur mainly in the hill country of the middle Turakina River Valley. Here the rainfall is between 1000 and 1200 mm p.a. A seasonal soil moisture deficit affects summer pasture production.

LUC unit VIe4 (24,900 ha)—Figures 92, 93

VIe4 occurs on strongly rolling to moderately steep slopes.

The dominant soils are the Mangatea hill soils and the Turakina steepland series. A very high level of development has been reached with pasture on 81% of the LUC unit. The remainder is mainly pasture-scrub or pasture-forest.

The potential stock carrying capacity is 19 su/ha, although the present average stock carrying level is assessed at 12 su/ha. The site index is 27–31 m which also gives it a medium to high suitability for *P. radiata* growth.

Moderate erosion is recorded on map units covering only 16% of the VIe4. There is a potential for slight tunnel gully, earthflow and sheet erosion, and moderate soil slip erosion. Erosion can be minimised by the planting of conservation trees in tunnel gullies and sites most susceptible to mass movement erosion forms. However, conservation tree establishment may be difficult due to seasonal soil moisture deficiencies.

LUC unit VIIe2 (22,900 ha)—Figure 93

VIIe2 comprises slopes which are steep to very steep and of longer length (up to 150 m) than those on VIe4.

Soils are typically the Turakina or Rangiwaea steepland soils. At present 73% of VIIe2 is dominantly in grassland with the remainder in grassland-forest or grassland-scrub.

VIIe2 has a potential stock carrying capacity of 14 su/ha, with a present average of 8 su/ha. The lower and mid slopes have a site index for *P. radiata* of 27–28 m although the steeper upper slopes are unsuitable for exotic forestry planting because of access, establishment and logging difficulties.

There is a potential for severe soil slip, moderate gully and sheet erosion and slight earthflow. Areas of severe soil slip erosion should be oversown and topdressed. Conservation trees can be open planted in areas most susceptible to erosion, however seasonal soil moisture deficits may make their establishment difficult. Pair and block planting and debris dam techniques can be utilised to stabilise gullies.

Figure 92: VIe4 showing earthflow erosion. Upper Whangaehu Valley. N131 955265 looking E.
Photo: G. O. Eyles

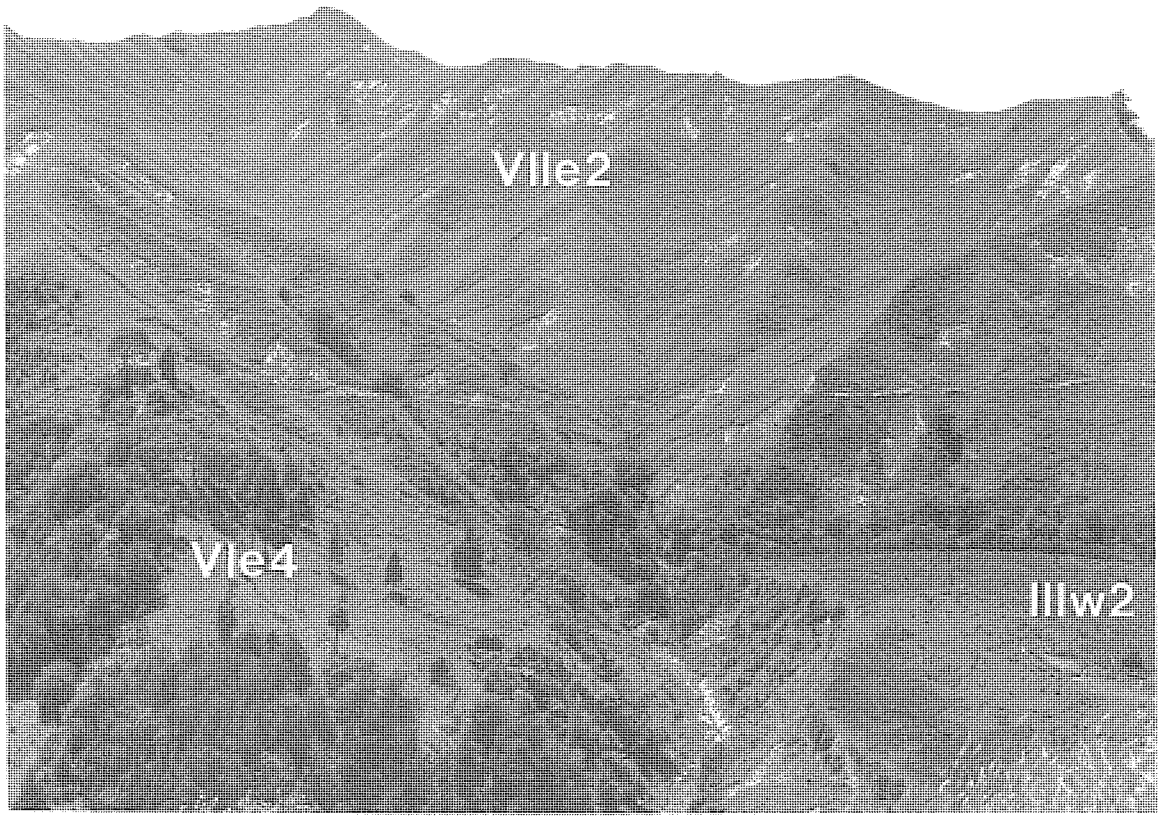


Figure 93: VIIe2 and VIe4 on hills of jointed mudstone. IIIw2 (LUC subsuite 4b) on river terraces. Upper Turakina Valley near Colliers Junction. N132 065245 looking W.

9b LUC Subsuite on Banded Mudstone

The lithology comprises sequences of mudstone interbedded with less dominant sandstone. The mudstone is weakly cemented, and on weathering develops close-spaced fracturing or jointing. This contrasts with the sandstone beds which are moderately hard to very hard and massive.

The banded mudstone subsuite is only mapped on moderately steep to very steep slopes that have a potential for soil slip and sheet erosion. Rolling to strongly rolling dip slopes with extensive deep-seated earthflow erosion, are mapped in the deep-seated earthflow and slump suite (LUC suite 12). Stable slopes that are strongly rolling and moderately steep with a mantle of airfall tephra are typically mapped as VIs1 of the Taupo airfall tephra suite.

LUC subsuite 9b is confined to the King Country. It comprises two LUC units (VIe5 and VIIe7) which together cover 33,600 ha (1.4%) of the region.

Sixty-four percent of the subsuite occurs in southern areas of the King Country, particularly on hill country west of Raurimu and Owhango (including the Kaitieke, Kawautahi and Hikumutu valleys) and between Te Maire and Taumarunui (Figure 94). The remainder occurs about 20 km to the north-west, in an area extending from Ohura north-east to Waimiha, including the Waitewhena, Matiere, Otangiwai and Mangapapa districts.

Physiography

The banded mudstone lithology has been intensively dissected resulting in a landscape with mainly moderately steep and steep slopes. In the Raurimu and Owhango areas the subsuite occurs up to 600 m a.s.l. Further north it is at about 300–450 m a.s.l. and slopes are generally steeper.

Climate

There is no climatological stations on this subsuite. Data from the NZ isohyet map (NZ Meteorological Service 1978) and rainfall normals from 1951–1980 (NZ Meteorological Service 1984) show that the annual rainfall ranges from 1400 to 2000 mm depending on altitude.

Temperatures are similarly related to altitude, with the subsuite having an average of between 600 and 1100 growing degree-days above a base of 10°C during the period October to April (Thompson 1984).

Rock Type

Lithologies are confined to the Mahoenui Formation (Hay 1967) and comprise mudstones interbedded with less dominant, thinner, coarser grained sandstone. The nature of these alternating beds of sandstone and mudstone was first recognised by Schofield (1954) and later described by Glennie (1959). Moderately steep and steep slopes in southern areas have a deep mantle of andesitic tephra from the Tongariro Volcanic Centre, which becomes progressively thinner to the north.

Soils

Soils were recorded using the King Country Soil Survey information. Soil series are differentiated on the basis of slope, and the depth of andesitic tephra overlying banded mudstone.

Yellow-brown loams of the Tangitu series are recorded on moderately steep to steep slopes in the south of the subsuite where there is a deep mantle of andesitic tephra. As the tephra becomes progressively thinner to the north of the region, soils of the Hiwi series (composite yellow-brown loams on yellow-brown earths) and Waitataura series (yellow-brown earths) are recorded. On steep and very steep slopes a similar sequence related to the depth of tephra occurs. The Kaitieke series (steepland soils related to yellow-brown loams) is dominant in southern areas while the Mahoenui series (steepland soils related to yellow-brown earths) is predominant in the north.

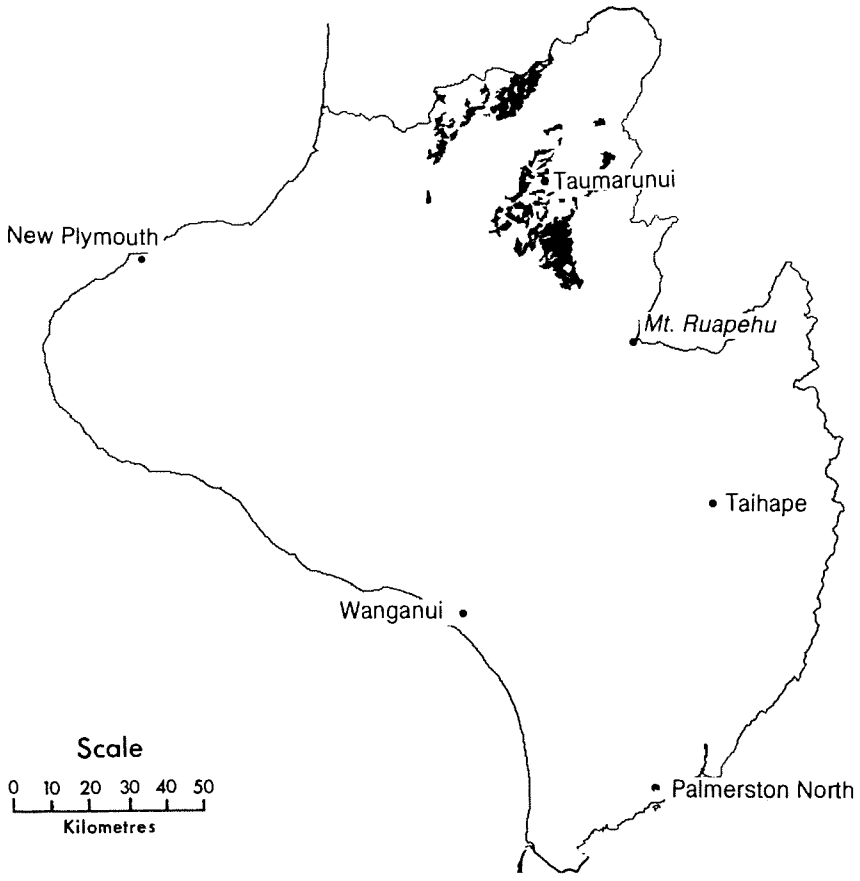


Figure 94: Location of LUC subsuite 9b: banded mudstone.

Erosion

Soil slip is the dominant erosion type, with sheet and earthflow erosion also significant on some map units. Present erosion is mainly of a negligible to slight severity, with only 15% of the subsuite having moderate or severe erosion. Erosion is related to slope angle. Moderately steep slopes have a potential for slight to moderate erosion while there is a potential for severe erosion on steep slopes. On over-steepened slopes with no vegetative cover, weathering of close-jointed mudstone beds dislodges mudstone fragments resulting in a talus (scree) slope. Continual weathering of the mudstone removes support from above and below the sandstone beds causing sandstone boulders to eventually dislodge and fall. Boulders falling onto roadways from oversteepened cuttings are a significant hazard to road traffic.

Land Use and Vegetation

This subsuite has been less developed for pastoral farming than has the jointed mudstone subsuite. Large areas remain in forest, scrub or fern, and present average and potential stock carrying capacity levels are lower.

The dominant land use is sheep and cattle farming with also some deer and goat farming. Exotic forestry is an insignificant land use. A high level of pasture management is required particularly in higher rainfall areas, to prevent reversion of pastures to scrub and fern.

LUC unit VIe5 (26,800 ha)—Figure 95

VIe5 is mapped on moderately steep to steep slopes, particularly in the southern King Country.

Much is either undeveloped or has reverted from pasture to scrub and fern. Only 27% of VIe5 is exclusively in pasture.

Figure 95: VIe5 on hills. Foreground is IIIs6 (LUC suite 7). Near Owhango. N111 865963 looking W.

Figure 96: VIIe7 in background. IIIs6 in foreground. Near Matiere. N92 700303 looking N.

The dominant soils are the Tangitu series. However, further north where the andesitic tephra is thinner the Hiwi series and Waitataura series are recorded.

The potential stock carrying capacity is 14 su/ha. This compares with 19 su/ha on LUC units VIe3 and VIe4. The site index for *P. radiata* is estimated at 26–28 m.

Erosion is not a major problem though map units covering 75% of VIe5 do have some erosion recorded. Most however is of only slight severity. There is a potential for moderate soil slip and slight sheet and gully erosion. Spaced planting of conservation trees is the most appropriate erosion control measure. Due to the fertility of the parent material slip scars rapidly regrass.

LUC unit VIIe7 (6,800 ha)—Figure 96

VIIe7 occurs on slopes which are steeper and of longer length than in LUC unit VIe5. Only 4% is exclusively in pasture (cf. 27% on VIe5) while 18% is forest and 4% forest and scrub. The remainder has a combination of pasture, scrub and forest. The Kaitieke and Mahoenui series are the dominant soils.

The potential stock carrying capacity is 12 su/ha, although the present average is 9 su/ha.

Erosion control forestry is an alternative (but at present insignificant) land use. The site index for *P. radiata* is rated as 25–27 m, however steeper slopes will generally be unsuited to forestry because of access, establishment and logging difficulties.

The unit has a potential for severe soil slip and slight sheet erosion, although present erosion is mostly of a slight or moderate severity. Block planting with trees is the most effective way to stabilise severely eroded sites, although wide spaced planting of conservation trees is recommended on areas with a lower erosion potential. Stock treading may continually reactivate erosion on soil slip surfaces. It is therefore recommended that cattle grazing should be restricted on steeper slopes during winter.

10. LUC SUITE ON SILTSTONE

This suite comprises moderately steep to very steep hill country with soils developed on very weak to weak siltstone. These soils support pastoral productivity levels that are intermediate between the more fertile mudstone suite and lower fertility sandstone suite. Similarly, erosion has the characteristics of both the mudstone and sandstone suites: predominantly soil slip and sheet, with tunnel gully and shallow earthflow on colluvial foot slopes. The siltstone suite occupies 174,900 ha (7.3%) of the region.

Seven LUC units are differentiated. They are grouped on the basis of their erosion severity and potential into the following two subsuites:

a. Siltstone subsuite (VIe7, VIe8, VIe10, VIIe4 and VIIe9).

b. Urenui siltstone subsuite (VIe21 and VIIe20).

10a LUC subsuite on siltstone

This subsuite occupies 145,800 ha (6.1%) of the region and comprises all siltstone LUC units within the region, excluding the Urenui siltstone subsuite in North Taranaki. Its distribution is shown in Figure 97.

LUC units are subdivided on the basis of climate (principally rainfall) as follows:

i. Higher rainfall LUC units (annual rainfall >1200 mm) VIe7, VIe10, VIIe9.

ii. Lower rainfall LUC units (annual rainfall <1200 mm) VIe8, VIIe4.

Physiography

This subsuite comprises intensely dissected marine sediments of the Wanganui and Taranaki series that become progressively older and more massive and homogeneous to the north. The strata are slightly tilted to the south and west and the landscape is strongly dissected with steep and very steep slopes and narrow sharply defined ridge crests.

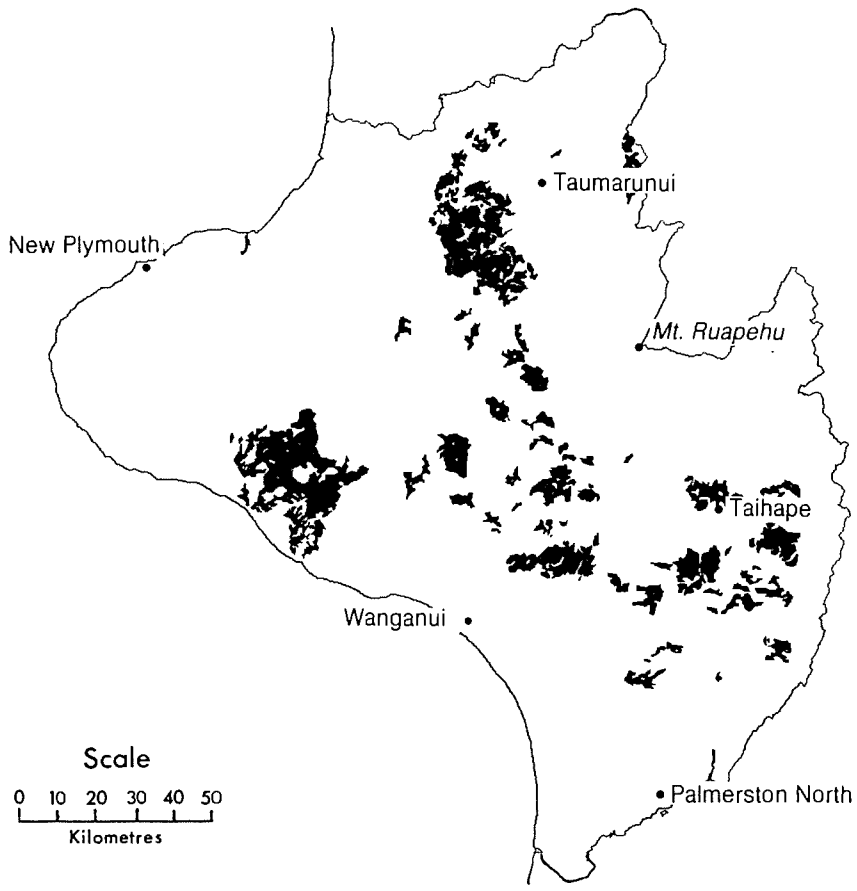


Figure 97: Location of LUC subsuite 10a: siltstone.

Climate

Data from the Hiwi climatological station (Taihape) is the most representative of the lower rainfall LUC units, while the Ohakune climate station best represents the higher rainfall LUC units. At Hiwi (657 m a.s.l.) the mean annual rainfall is 941 mm and the mean air temperature 10.4°C with an average of 63 days of ground frost annually. This compares with Ohakune (610 m a.s.l.) which has higher rainfall and cooler temperatures. At Ohakune the mean annual rainfall is 1320 mm, the mean air temperature 10.1°C, and an average of 106 days of ground frost occur annually. These climatic differences result in significant seasonal pastoral productivity differences between the higher and lower rainfall LUC units in this subsuite.

Rock Type

The subsuite is mapped on siltstones occurring within the Tangahoe mudstone, Matemateonga sandstone, Urenui siltstone and Mt Messenger sandstone (Hay 1967). Siltstones of this subsuite are very weak to weak, and non-cohesive to weakly cemented. Moderately steep slopes, on LUC unit VIe10 have a significant depth of andesitic tephra originating from Mt Egmont or the Tongariro Volcanic Centre.

Soils

Soils were recorded using soils information from the Rangitikei, part Wanganui, and Stratford county surveys, the King Country Survey and the General Soil Survey.

Yellow-brown loams of the Ohakune, Egmont, Stratford, Waihuka and Tangitu series were recorded on VIe10. Other hill soils include the Mangaweka, Atua and Wainui series. The dominant steepland soils are the Taihape, Pahiatua, Tirangi and Whangamomona series.

Erosion

Soil slip is the dominant erosion type with debris avalanche important in forested areas. Sheet erosion is significant in lower rainfall units while earthflow erosion is frequently mapped on colluvial footslopes.

Present erosion severities are dominantly of a negligible to moderate severity (Table 33), with 70% of the subsuite having slight erosion. This contrasts with the Urenui siltstone subsuite which has moderate erosion on map units covering 56% and severe erosion on a further 11.5%.

Table 33: Present erosion as a percentage of LUC unit area in the siltstone suite

LUC Unit	Area (ha)	Present Erosion Severity as Percentage of LUC Unit Area 0	1	2	3	4	5
VIe7	14,430	12	82.5	5.5	—	—	—
VIe8	17,330	—	5.5	82.0	12.5	—	—
VIe10	32,190	2.0	97.5	0.5	—	—	—
VIIe4	12,160	0.5	77.5	22.0	—	—	—
VIIe9	69,760	11.0	58.0	29.5	1.5	—	—

Within this subsuite the trend is for lower rainfall units to have a greater proportion of their area affected by erosion. This is probably because they have a larger percentage of their area in pasture.

Land Use

On lower rainfall LUC units seasonal soil moisture deficits affect summer pastoral production. This contrasts with higher rainfall units which have excellent pasture growth in summer.

The dominant land use is sheep and cattle farming with also some deer and goat farming. Exotic forestry is an insignificant land use. A high level of pasture management is necessary particularly in higher rainfall areas to prevent reversion to scrub.

LUC UNITS WITH RAINFALL GREATER THAN 1200 MM P.A.

LUC unit VIe7 (14,400 ha)

VIe7 comprises moderately steep to steep slopes on siltstone occurring between 600 and 900 m a.s.l. and where the annual average rainfall is between 1200 and 1600 mm. It is mapped in the Taihape and Parapara Road areas and adjacent to the Ruahine Range. Although cool temperatures reduce winter pasture growth, it is one of the most productive Class VI hill country units in the region.

Soils mapped on this unit include the Mangaweka, Atua and Mangatea hill soils and the Tirangi steepland soils. Silty mudstone in the Fields Track area have been mapped as LUC unit VIe7 instead of the mudstone LUC unit VIe3. The silty mudstone in this locality is prone to soil slip and sheet erosion, which is more typical of siltstone rather than mudstone. Map units covering 57.0% of the LUC unit have pasture as the dominant vegetation. Another 35% is grassland-forest or grassland-scrub.

The potential stock carrying capacity is 18 su/ha and the site index for P. radiata is 26–27 m. There is a potential for moderate soil slip and sheet erosion, with slight shallow earthflow and tunnel gully erosion on lower colluvial slopes. Erosion can be controlled with open planted conservation trees.

LUC unit VIe10 (32,200 ha)—Figure 98

VIe10 comprises moderately steep to steep slopes with a mantle of andesitic tephra on siltstone. Most of this unit occurs in an area extending from Tatu (south of Ohura) south-east across the Wanganui River to Whakahoro. Other major locations are the Tangahoe Valley, west of the Whenuakura River, and the Ngamatapouri, Orautoha and the upper Parapara Road areas. These locations have a rainfall between approx. 1600 and 2000 mm p.a.

In contrast to LUC unit VIe7 only 30% is in pasture with a further 55% in grassland-scrub or grassland-scrub-forest. This reduced proportion of pasture reflects higher rainfall and the generally more remote locations.

Yellow-brown loam soils are recorded where there is a significant depth of andesitic tephra. These include the Ohakune silt loam hill soils developed on Tongariro tephra and the Egmont brown loam and Stratford sandy loam hill soils developed on Taranaki tephras. In the King Country the Waihuka series (silty variant) and Tangitu series, both developed on older more weathered andesitic tephra were recorded. The dominant soils on steep slopes are the Tirangi and Whangamomona series.

LUC unit VIe10 has a potential stock carrying capacity of 13 su/ha, and a site index for *P. radiata* of 26–27 m. There is a potential for moderate soil slip and slight sheet erosion. Soil slip erosion can be reduced by open planting of conservation trees.

LUC unit VIIe9 (69,750 ha)—Figures 98, 99, 100

VIIe9 comprises slopes which are steep to very steep and of longer length (approx. 150 m) than the Class VI units in this suite. Very narrow ridge crests and deeply incised streams at the base of slopes provide additional constraints to pastoral and forestry use.

LUC unit VIIe9 principally occurs in the following areas. In the King Country it is mapped in the Tatu-Tokirima areas and south-east across the Wanganui River to Whakahoro, and on the lower slopes of the southern Hauhungaroa Range. In Taranaki it occurs between Mangamingi and the Whenuakura River. In the Wanganui-Rangitikei area it extends from Ngamatapouri in the Waitotara Valley east to the Wanganui River. It is also significant near Orautoha (NW of Raetihi), in the vicinity of the Parapara Road and south-east of Taihape.

Pasture covers only 12.0% of the LUC unit, a further 35.0% is in grassland-scrub or grassland-scrub-forest. The remainder is scrub or indigenous forest. Typical soils recorded include the Tirangi, Pahiatua and Taihape steepland soils. VIIe9 is one of the most potentially productive Class VII hill country units. It has a present average stock carrying capacity of 8 su/ha and a potential of 12 su/ha. Because of the difficulty in maintaining pastures much has reverted to scrub and fern. Lower slopes have a site index for *P. radiata* of 25–27 m, however steeper upper slopes are generally unsuited to production forestry because of access, establishment and logging difficulties.

There is a potential for severe soil slip and debris avalanche erosion. Areas susceptible to soil slips can be open planted with conservation trees. Debris avalanches which are most likely to occur in forested areas should revegetate naturally provided feral goats are controlled. There is also a potential for slight sheet erosion particularly where pastures have been heavily grazed to control reversion. On colluvial slopes there may also be a potential for slight earthflow erosion particularly where slopes have been undercut by streams or roads.

LUC UNITS WITH RAINFALL LESS THAN 1200 MM P.A.

LUC units VIe8 and VIIe4 occur on siltstone hill country in areas with an annual rainfall of less than 1200 mm. They are more likely to be affected by summer drought than are the higher rainfall units of this suite. VIe8 and VIIe4 occur mainly near Mangaweka, and in an area north of Taihape bounded by Mataroa, Hihitahi, Te Moehau Road, Wainui Junction and Taihape. They are also mapped adjacent to the lower Parapara Road (SH 4).

LUC unit VIe8 (17,300 ha)—Figure 100

This unit comprises moderately steep and steep slopes on siltstone where rainfall is less than 1200 mm p.a.

At present 63% of the LUC unit is in pasture with the remainder in grassland-scrub or grassland-forest. Soils include the Wainui, Mangaweka and Atua hill soils with the Taihape steepland soils on the steepest slopes. The potential stock carrying capacity is 17 su/ha and the site index for *P. radiata* is 27–31 m.

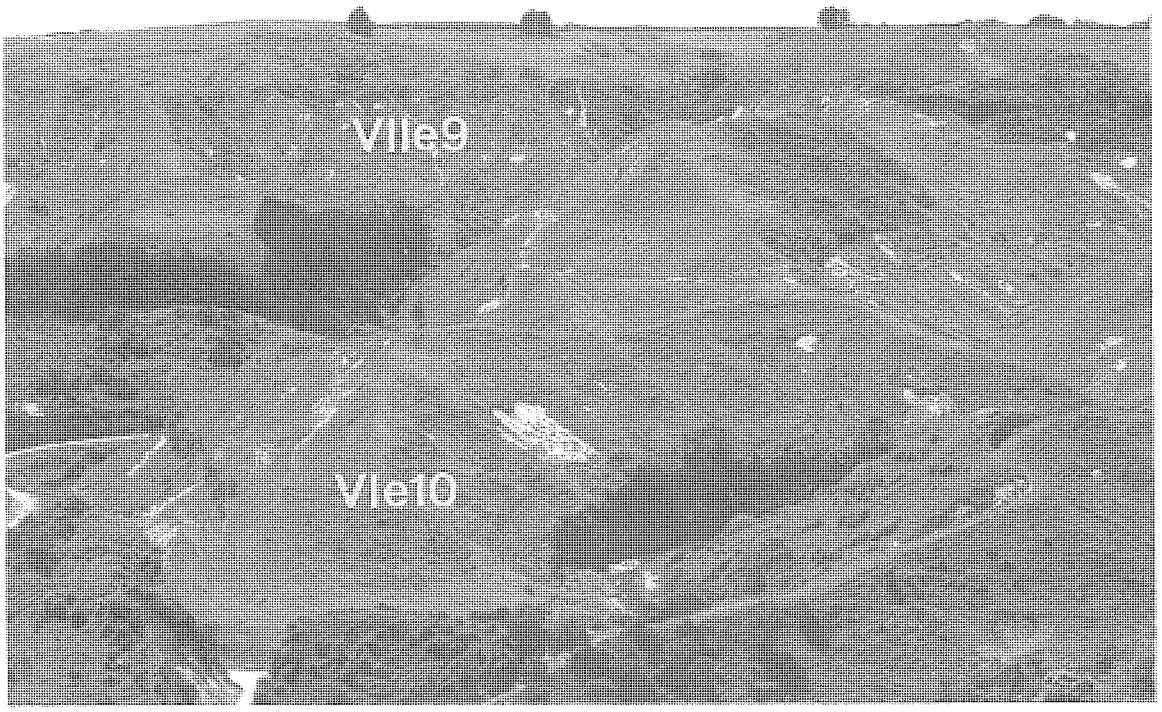


Figure 98: VIe10 (foreground) and VIIe9 on terrace scarps. Tangahoe valley NE of Hawera. N129 942342 looking NE.

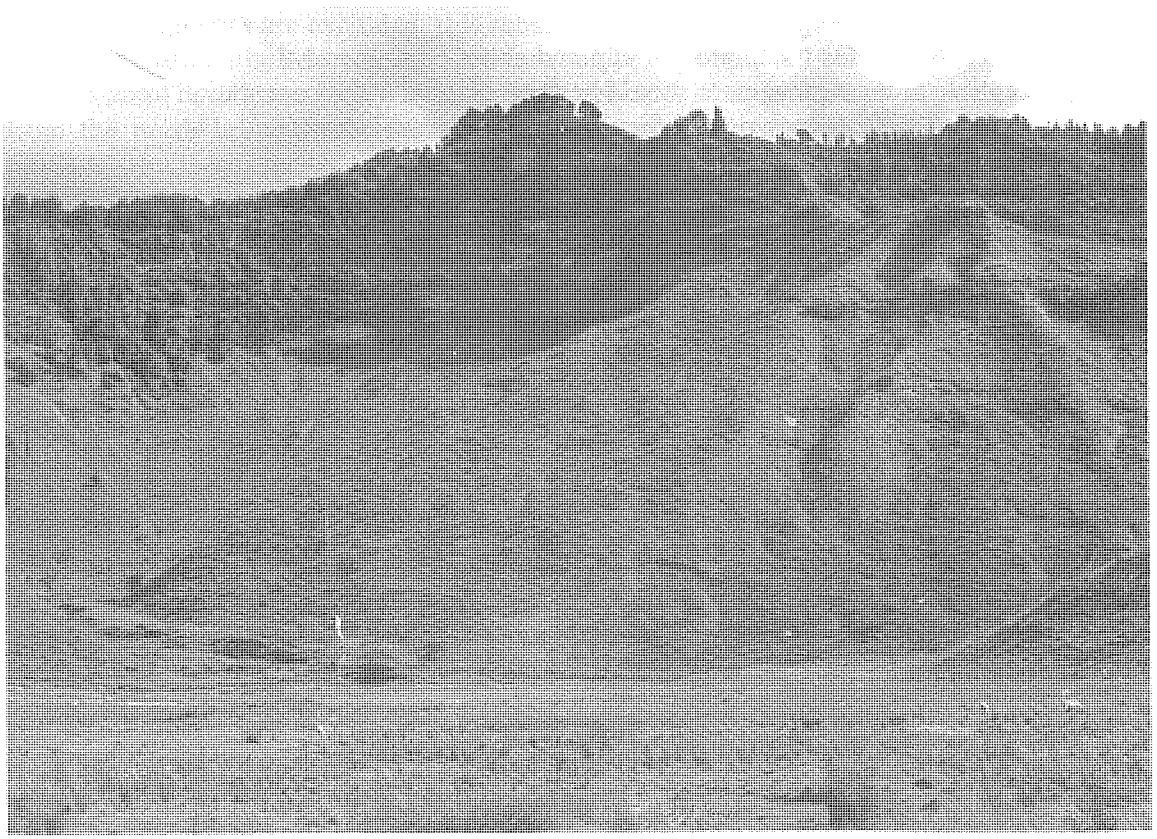


Figure 99: VIIe9. Very steep upper slopes are VIIIe3. Retaruke valley. N111 632850 looking S.

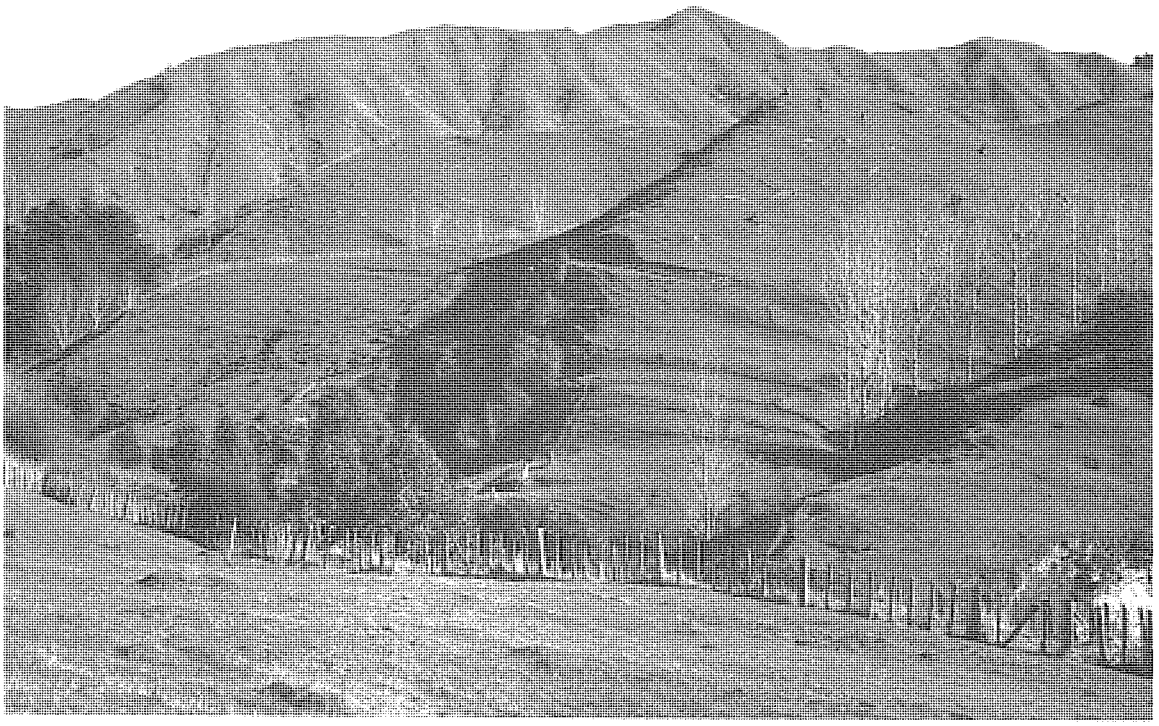


Figure 100: VIe8 (foreground) with VIIe9 in distance. SH1 North of Mangaweka. N139 280068 looking SW.

There is a potential for moderate soil slip and sheet erosion and slight earthflow erosion. Areas susceptible to mass movement should be open planted with conservation trees, however seasonal moisture deficits may pose difficulties in their establishment.

LUC unit VIIe4 (12,150 ha)

VIIe4 has greater physical limitations to use than LUC unit VIe8. These include steeper and longer slopes (up to 170 m long) resulting in shallower soils and a more severe erosion risk. These factors greatly increase management requirements and reduce productivity and land use options.

Pasture covers 61% of the LUC unit. The remainder is grassland-forest or grassland-scrub. The high proportion of pasture on VIIe4 contrasts with LUC unit VIIe9 which has only 11.5% of its area dominantly in pasture. The dominant soils are the Taihape and Pahiatua steepland soils.

VIIe4 has a present average stock carrying capacity of 8 su/ha with a potential of 12 su/ha. Lower and mid slopes have a site index for *P. radiata* of 25–27 m however steeper upper slopes are generally unsuitable for forestry due to access, establishment and logging difficulties.

There is a potential for severe soil slip and moderate sheet erosion; and slight tunnel gully and earthflow erosion on colluvial slopes. Conservation trees should be open planted in tunnel gullies and areas most susceptible to soil slip erosion, however establishment may be difficult due to seasonal soil moisture deficiencies. Sheet erosion which is a greater problem on north facing sunny slopes, can be minimised by oversowing and topdressing together with intensive subdivision fencing to enable better grazing management of sunny and shady slopes.

10b LUC Subsuite on Urenui Siltstone

The Urenui siltstone subsuite which comprises 29,100 ha (1.2%) of the region, is restricted to the Waitara, Onaero, Urenui and Mimi Catchments in North Taranaki (Figure 101). Although it is one of the smallest hill country subsuites it is unique for its high incidence of mass-movement erosion.

Physiography

The Urenui siltstone subsuite comprises hill country, immediately inland of a narrow coastal terrace. Slopes are moderately steep to steep but with significant areas of very steep slopes with scarps of bare rock. Ridge crests which are at about 150 m a.s.l. near the coast gradually increase in height to about 450 m in the east.

Climate

The climate of this subsuite is described (NZ Meteorological Service 1983b) as having warm humid summers and mild winters. Rainfall records which are the only climatic data available are given in Table 34.

Table 34: Rainfall normals (1951–80) for Uruti, Purangi, Kohuratahi and Okoki

Rainfall Station	Rainfall Normals 1951–80 (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Uruti	136	147	132	150	220	185	192	181	165	182	199	173	2062
Purangi	142	141	142	158	229	209	211	211	174	196	208	169	2190
Kohuratahi	132	139	113	145	177	170	190	161	161	156	165	141	1850
Okoki	191	157	172	178	254	202	240	214	175	244	268	205	2500

The annual rainfall is between 1600 and 2400 mm p.a. but all four stations have a distinct dry period in summer with about 20% of the annual total falling in the three months between January and March. The remainder of the year has a fairly evenly distributed rainfall.

If mountain areas are excluded, this subsuite receives the greatest amount of high intensity rainfall in the region. Between 160–200 mm can be expected in 24 hours with a return period of five years (Tomlinson 1980). Such rainfalls are most likely when a slow moving depression from the north brings heavy rains from the Tasman Sea to north Taranaki. These heavy rainfalls which can be up to three days duration (Thompson 1981) result in considerable erosion on this subsuite.

Rock Type

The subsuite is mapped on Miocene aged siltstone of the Urenui Siltstone Formation (Hay 1967). These had been previously referred to as the Urenui beds (Morgan and Gibson 1927) and Urenui beds or Group (Grange 1927). The rock is a very weak sandy siltstone. Moderately steep hillslopes have a discontinuous mantle of andesitic tephra.

Soils

Yellow-brown loam hill soils of the Egmont and New Plymouth series were recorded on slopes mantled with a significant depth of andesitic tephra. Soils of the Tirangi and Whangamomona series occur on steep slopes. Very steep slopes frequently have much bare rock with no soil.

Erosion

Predominant erosion types are soil slips with debris avalanche erosion on long, steep forested slopes. Earthflow erosion is also significant on colluvial slopes. Deep-seated earthflow and slump erosion occurring within the subsuite area is mapped as LUC units IVe8, VIe20 or VIIe14 of LUC suite 12.

Present erosion on the subsuite is mainly of moderate severity. The Erosion Map of New Zealand Sheet 7 (Robins 1974a) assesses LUC units VIIe9 and VIIIe3 as having a potential for extreme erosion under a grassland vegetation.

Figure 101: Location of LUC subsuite 10b: 'Urenui' siltstone.

Analysis of Class VII units occurring in high rainfall areas (>1200 mm p.a.) on both siltstone subsuites show that VIIe20 of the Urenui siltstone subsuite has a greater erosion severity than has VIIe9. Map units covering 81% of LUC unit VIIe20 have moderate to very severe erosion recorded in contrast to LUC unit VIIe9 which has 30% of its area with moderate erosion and 1% with severe erosion (Table 35).

Table 35: Percentage of LUC units VIIe20 and VIIe9 in each erosion category

	Erosion Severity (% of LUC unit area)					
	0	slight	moderate	severe	very severe	extreme
VIIe20	—	20	63	13	5	—
VIIe9	11	58	30	1	—	—

The greater incidence of erosion on the Urenui siltstone subsuite can be attributed to the periodic high intensity rainstorms which result in mass-movement erosion and flooding in north Taranaki. In the Onaero-Mohakatino Catchment Survey (Taranaki Catchment Commission 1978) erosion on Urenui siltstone was found to be more severe on north facing slopes which are exposed to the predominant rain direction.

Land Use

Map units covering 52% of the subsuite have a combination of dominantly low producing pasture with manuka scrub, mixed native scrub associations or fern. The remainder is indigenous forest, scrub or fern.

The dominant land use is sheep and cattle grazing, with some goat farming. Large areas of land cleared for farming have reverted to fern and scrub. To prevent this a high level of

pasture management, requiring regular fertiliser applications, subdivision fencing and rotational grazing is necessary to improve fertility and species composition. High cattle to sheep ratios are also necessary to control the growth of fern and scrub.

LUC unit VIe21 (3350 ha)

VIe21 is mapped on moderately steep and steep slopes. Yellow-brown loam hill soils of the Egmont and New Plymouth series are mapped on slopes with a significant depth of andesitic tephra. The Tirangi and Whangamomona series occur on steeper slopes.

Figure 102: VIIe20. Moderately steep and steep slopes with severe mass movement erosion. Okoki Rd, Urenui R catchment. N109 005988 looking S.

Analysis of the vegetation recorded on LUC unit VIe21 indicates that many areas in pasture are reverting to scrub or fern. A combination of pasture and scrub or forest covers 92% of the LUC unit. Areas in pasture have a present average stock carrying capacity of 7 su/ha although the attainable potential is 11 su/ha. The forestry site index for *P. radiata* is rated as 26 m.

Map units covering 82% of VIe21 have slight erosion recorded. The remainder has moderate or negligible erosion. There is a potential for moderate soil slip and sheet erosion with moderate earthflow on colluvial footslopes. Soil slip erosion can be reduced by open planting with poplars.

LUC unit VIIe20 (25,750 ha)—Figures 102, 120

VIIe20 is mapped on 'Urenui siltstone' where:

1. Slopes are steep and very steep, or
2. Slopes are moderately steep to steep with severe mass movement erosion.

Indigenous forest, particularly lowland podocarp-hardwood, lowland *Nothofagus* and hardwoods, is the dominant vegetation on 52% of VIIe20. The remainder is pasture, scrub and fern. Soils are the Tirangi and Whangamomona series.

Areas in pastoral use have a present average stock carrying capacity of 7 su/ha with a potential stock carrying capacity of 11 su/ha. Erosion control forestry is an alternative land use. However only lower slopes are suitable (having a site index for *P. radiata* of 25–26 m). Steeper upper slopes are generally unsuited to forestry because of access, establishment and logging difficulties.

Present erosion severities are dominantly slight to severe (Table 35). Areas in pasture and scrub have a potential for very severe soil slip erosion and moderate sheet erosion. There is also a potential for severe debris avalanche erosion on areas in indigenous forest. A severe earthflow hazard also exists on colluvial footslopes occurring within this unit. Although VIIe20 occurs on a naturally fertile rock type, erosion scars on steeper slopes are slow to revegetate because they are continually eroded by rainstorms.

Soil conservation measures include open planting of poplar trees in areas most susceptible to erosion. Areas with severe to very severe erosion should be block-planted. Goats and possums must be controlled in order to protect trees planted for soil conservation purposes and to maintain the vigour of indigenous vegetation on inclusions of class VIII within this unit.

11,200 ha of very steep long slopes within this lithology are classified as VIIIe3 because steepness and an extreme erosion potential preclude pastoral or forestry production. VIIIe3 is described in the consolidated sandstone subsuite (11d).

11. LUC SUITE ON SANDSTONE

The sandstone LUC suite comprises 16 LUC units that occupy 779,700 ha (32.2%) of the region. The 16 LUC units are differentiated into five subsuites (Table 36) on the basis of differences in rock strength and hardness, and erosion type. The subsuites have been named adopting non-standard terms (unconsolidated, moderately consolidated, and consolidated) to briefly indicate the rocks' field strength characteristics. The criteria for differentiating the subsuites are readily recognisable in the field. The characteristic sandstones occurring within the five subsuites are described as follows using terminology for soil and rock descriptions for engineering use (NZ Geomechanics Society 1985).

a. *Subsuite on unconsolidated sandstone:*
Comprises extremely weak, loose to compact, friable to very friable sands interbedded with extremely weak to very weak mudstones and sandstones. These lithologies were classified as unconsolidated to moderately consolidated clays, silts, sands, tephra and breccia (Crippen and Eyles 1985). The rock can be excavated by hand. This subsuite is characterised by its potential for gully erosion.

b. *Subsuite on moderately consolidated sandstone:*
This comprises extremely weak, loose to compact, friable to very friable sands interbedded with extremely weak to weak sandstones and siltstones. The rock can be excavated with varying difficulty, by spade. The dominant erosion is soil slip, sheet and tunnel gully erosion. Soil slips which are deeper than on other subsuites may develop characteristic rill erosion on the slip plane.

c. *Subsuite on moderately consolidated sandstone with a complex of slump and deep-seated earthflow erosion:*
This also comprises mainly extremely weak, loose to compact, friable to very friable sands interbedded with extremely weak to weak sandstones and siltstones. The subsuite has a complex of slump and deep-seated earthflow erosion as well as soil slip, sheet and tunnel gully.

d. *Subsuite on consolidated sandstone:*
Consists of weak, massive sandstone. Shallow indentations result from a firm blow with the point of a geological hammer. The dominant erosion is shallow soil slips and sheet erosion.

e. *Subsuite on hard sandstone:*
Comprises moderately strong to strong (or, moderately hard to very hard) rock. (The rock makes a 'ringing' noise when hit with a geological hammer.) The dominant erosion is shallow soil slips and sheet erosion.

Table 36: Summary of LUC units in the sandstone suite

	Low rainfall(800–1200 mm pa)				High rainfall(1200–2000 mm pa)			
LUC Subsuite	LUC unit	Potential erosion	Potential su/ha	*P. radiata* Site Index	LUC unit	Present erosion	Potential su/ha	*P. radiata* Site Index
11a	VIe14	1Sh; Tg; 2ssl	14	26–30	VIe12	2Sh, ssl, Tg	16	27–30
	VIIe16	2sh; 3ssl, G	9	27–30*				
	VIIIe2	5G, ssl, sh	—	—	VIIIe2	5G, ssl, sh	—	—
11b	VIe14	1Sh, Tg; 2ssl	14	26–30	VIe12	2sh, ssl, Tg	16	27–30
	VIIe5	1sh, Tg; 3ssl	9	26–28*	VIIe3	1G, 2Sh, 3ssl	10	26–28*
	VIIIe3	5ssl, daF, Sh	—	—	VIIIe3	5ssl, daF, sh	—	—
11c	VIe11	2sh, ssl, Su, Tg eF	19	27–29				
	VIIe6	1sh, Su; 2eF; 3ssl	16	27–29*				
11d	VIe15	1 Tg; 2sh, ssl	16	24–28	VIe13	1Sh, Tg; 2ssl	14	26–28
	VIIe13	1sh; 3ssl	11	24–26*	VIe23	1sh; 2ssl	13	26–28
	VIIIe3	5ssl, daF, sh	—	—	VIIe11	1sh, eF; 2daF; 3ssl	9	25–28*
					VIIIe3	5ssl, daF, sh	—	—
11e					VIe17	2sh, ssl, daF	11	25–27
					VIIe17	2–3sh; 3ssl, daF	6	25–27*
					VIIIe3	5ssl, daF, sh	—	—

*Site Index value applies only to less steep, lower hill slopes. Steeper slopes are generally unsuitable for production forestry

11a LUC Subsuite on Unconsolidated Sandstone

This subsuite is characterised by its occurrence on steep and very steep slopes comprising loose unconsolidated sandstone with a potential for severe to extreme gully erosion. The subsuite consists of LUC units (VIIe16 and VIIIe2) differentiated on slope angle and present and potential erosion severity. These two LUC units occur principally between Kai-iwi and Mangamahu, and in the Pohangina and Oroua Catchments (Figure 103). Together, VIIe16 and VIIIe2 comprise 16,850 ha (0.7% of the region).

Moderately steep to steep slopes are classified as VIe12 and VIe14. These two LUC units are also mapped on moderately consolidated sandstone lithologies, and are described in the subsuite on moderately consolidated sandstone (LUC subsuite 11b).

Physiography

Valley sides are steep to very steep and often expose loose unconsolidated sandstones. Ridge crests are wider and more rounded than those on consolidated lithologies.

Climate

Annual rainfall is mainly between 1000 and 1200 mm p.a. but increases to 1400 mm p.a. in inland areas of the Pohangina Catchment. All map units are below 300 m a.s.l. and consequently experience a mild climate. Other aspects of the climate which pertain to this subsuite are given in the climate section for LUC subsuite 11b.

Rock Type

The rock type comprises extremely weak, loose to compact, friable to very friable sands interbedded with extremely weak to very weak mudstones and sandstones. These 'Pohangina sands' which are dominantly marine sediments of the Castlecliffian Stage are described by Lensen *et al.* (1959) and Kingma (1962).

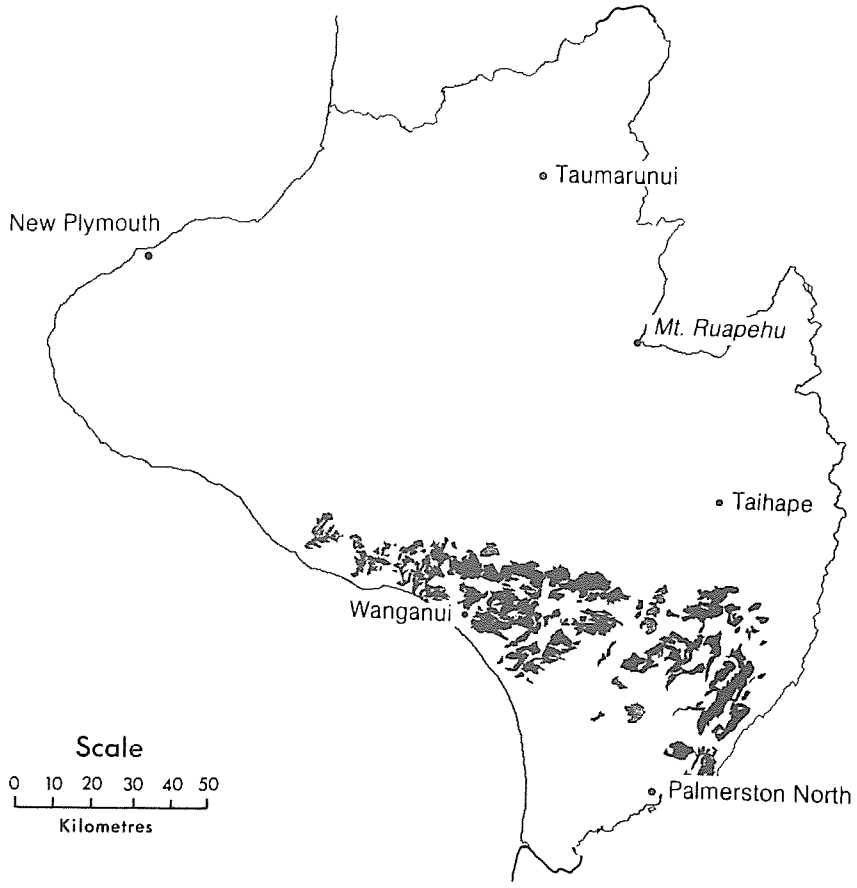


Figure 103: Location of LUC subsuite 11a: unconsolidated sandstone.

Soils

Soils were recorded using information from the Pohangina, part Wanganui, and part Waitotara County Surveys and the General Soil Survey. Soils are free draining, with a weakly developed structure and low nutrient status. They are subject to soil moisture deficits in summer. The Pohangina and Opawe steepland soil series are recorded, with very steep phases of both occurring where the average slope exceeds 40° (Rijkse 1977). The Opawe soils which occur on a similar parent material to the Pohangina steepland series, are confined to limited areas in the north of Pohangina County where the rainfall is between 1300 and 1400 mm p.a.

Erosion

Soil slip, tunnel gully, gully and sheet erosion are the dominant erosion types. A feature of the subsuite is the occurrence of gully erosion in drainage channels. If soil conservation measures are not effective, gullies can rapidly erode towards the valley heads. The potential for extreme gully erosion has resulted in 14% of the subsuite area being classified as Class VIII. The development of severe erosion on this subsuite resulted in the first LUC survey in the North Island being carried out in the Pohangina and Oroua Catchments in 1951 (Greenall *et al.* 1951). The benefits of soil conservation measures put in place after this survey are described by Glass (1957).

Land Use

The potentially productive land in this subsuite (LUC unit VIIe16) has the economic advantage of being located within 30 km of major agricultural servicing centres such as Wanganui, Feilding or Palmerston North. VIIe16 however has a low potential for pastoral use. Physical constraints to pastoral production include steepness of slope, soils of low nutrient status and poor structure, erosion hazard, summer drought and a lack of stock water in summer. Much VIIe16 land is suitable for erosion control forestry.

LUC unit VIIe16 (14,500 ha)—Figure 104

VIIe16 comprises steep slopes on extremely weak, loose to compact, friable to very friable sands. Approximately one third of the LUC unit occurs in the vicinity of Pohangina township. The remainder is mapped in the Wanganui area: the Karemu catchment near Kai-iwi, adjacent to the Wanganui River near Kaiwhaiki, the Lismore Forest, and Mangamahu.

Reversion of pastures to manuka scrub, gorse, mixed native scrub associations and fern is a major problem. 31% of VIIe16 is exclusively in pasture with a further 48% in grassland-scrub. Soils are the Pohangina or the Opawe series. The present average stock carrying capacity is 6 su/ha and the potential is 9 su/ha.

To achieve increased production better quality pastures, improved grazing management, increased fertiliser use, provision of stock water, and more subdivision to enable differential grazing of shady and sunny slopes are required.

In contrast to its low pastoral potential much of LUC unit VIIe16 has a medium to high site index for *P. radiata.* Exotic forest has been established particularly at the Lismore Forest, however some steeper slopes may be unsuitable for production forestry due to access, and logging difficulties.

Because much of VIIe16 has a medium site index, erosion control forestry may be a preferred land use provided measures are taken to minimise soil erosion and maintain water quality. These measures include the adherence to strict management guidelines when land is prepared for planting, roads are constructed, and logging takes place. Approximately 14% of VIIe16 has been planted in exotic forest, particularly the Lismore Forest near Wanganui.

Soil slip, tunnel gully and sheet are the dominant erosion types. Present erosion is dominantly of a slight to moderate severity with map units covering 74.0% of the LUC unit having slight erosion and 23.0% moderate erosion. There is however a potential for severe soil slip and gully, and moderate sheet erosion particularly during high intensity rainfalls. Soil conservation measures include the stabilisation of watercourses and drainage channels with block and pair planting, flumes and debris dams. Block planting is necessary in areas with severe erosion and spaced planting in sites that are most susceptible to erosion. At more detailed mapping scales very steep gullies within this unit would be delineated as LUC unit VIIIe2.

LUC unit VIIIe2 (2350 ha)—Figure 105

VIIIe2 comprises large (up to 110 m deep and 300 m wide) gullies with unstable perpendicular sides.

The majority of VIIIe2 in this subsuite* comprises large gullies in the Pohangina and Te Awa areas, and adjacent to the Rangitikei River south-east of Rata. Also mapped as VIIIe2 are 380 ha of very steep cliffs on unconsolidated sands adjacent to the Wanganui River at Kaiwhaiki. In this locality the presence of limestone bands makes some areas of VIIIe2 relatively stable and suited to forestry production.

There is a potential for extreme gully, streambank, soil slip and sheet erosion. All areas should be retired from pastoral and forestry production. To prevent the headward migration of gullies, gully heads should be stabilised with the use of flumes, debris dams and tree planting while adjacent areas should be planted in erosion control forestry to protect gully heads. Indigenous vegetation on this unit should be retained.

11b LUC Subsuite on Moderately Consolidated Sandstone

This subsuite is moderately steep to very steep hill country comprising extremely weak, loose to compact, friable to very friable sands interbedded with extremely weak to weak sandstones and mudstones. For simplicity these lithologies have been conveniently described

*Also mapped as LUC unit VIIIe2 are 2800 ha of Taupo flow and water-sorted tephra with a potential for extreme gully erosion. These areas occur in the King Country and are discussed in the suite of LUC units on Taupo flow tephra and water-sorted tephra (LUC suite 7).

Figure 104: VIIe16. Near Pohangina. N144 265580 looking NE.

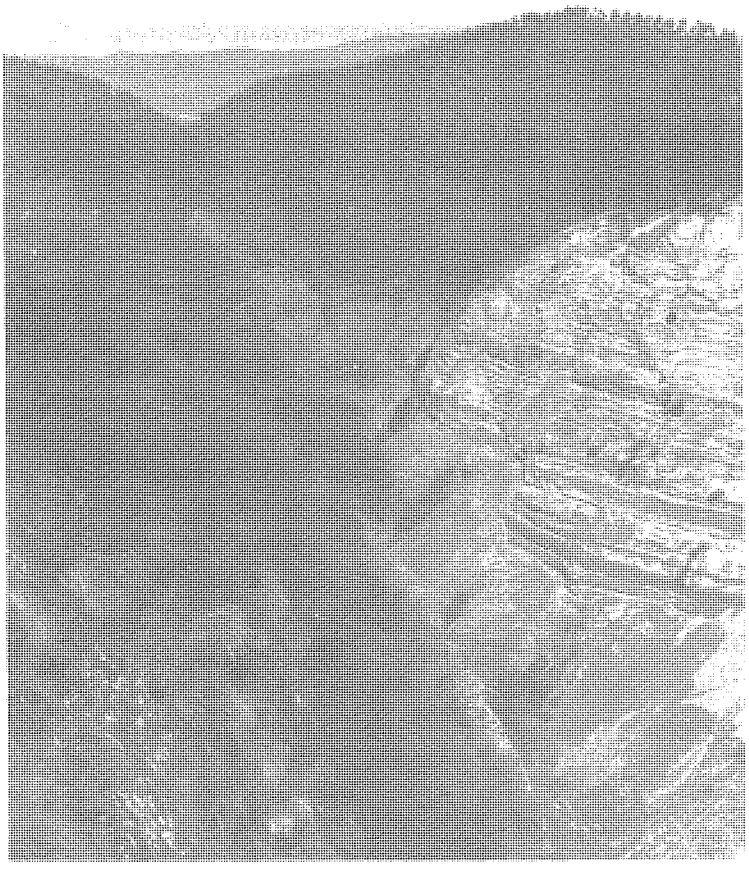


Figure 105: VIIIe2 on unconsolidated 'Pohangina sands' near Pohangina. Extreme gully erosion. N144 290667 looking E.

as moderately consolidated sandstone. There is a potential for sheet, tunnel gully and moderately deep soil slip erosion.

The subsuite comprises four LUC units that are differentiated on slope, erosion potential and climate (principally rainfall):

1. LUC units with annual rainfall >1200 mm p.a. (VIe12, VIIe3)
2. LUC units with annual rainfall <1200 mm p.a. (VIe14, VIIe5). The majority of map units occur south of a line extending from Waverley in the west through Hunterville and Rangiwahia to the Ruahine Range (Figure 106).

LUC units VIe12 and VIe14 also occur on loose unconsolidated sandstone. They are described in the moderately consolidated sandstone subsuite as this is the lithology on which the majority of VIe12 and VIe14 map units occur.

Figure 106: Location of LUC subsuite 11b: moderately consolidated sandstone.

Physiography

Landforms tend to have a shallower depth of dissection and be more rounded in appearance with wider ridge-tops than areas of consolidated sandstone. Slopes are dominantly moderately steep to steep. Slope length varies from less than 20 m where some Class VI map units are mapped on short terrace scarps to a maximum of about 150 m on Class VII units.

Climate

Data from the New Zealand isohyet map (NZ Meteorological Service 1978) and rainfall normals 1951–1980 (NZ Meteorological Service 1984) show that the annual rainfall on the subsuite ranges from about 900 mm p.a. on the coast to 1500 mm p.a. at inland locations in the north-east.

The only climatalogical station on the subsuite is at Wanganui. Data from this station is representative of the lower rainfall LUC units and also indicates the main features of the climate on adjacent higher rainfall LUC units. At Wanganui (22 m a.s.l.) the rainfall normal

(1951–1980) is 891 mm (NZ Meteorological Service 1983). Of this total 21.5% falls in the three months of January, February and March while the wettest months are May, June, July and December which each receive between 80 and 90 mm rainfall.

Temperatures are mild throughout the year. At Wanganui the mean annual air temperature is 13.6° and a mean of 2087 hours of sunshine occur annually. Wanganui has an average of 10.7 days of ground frost but further inland the frequency of frost increases to an average of over 50 per year at Marton and 68 per year at Taihape. At Marton (141 m a.s.l.) the mean air temperature of 12.1°C also indicates the overall reduction in temperature with increasing altitude and distance from the coast.

Rock Type

This suite is mapped on hill country comprising lithologies of the Upper Wanganui Series (early Pleistocene), and Hawera Series rocks (middle Pleistocene). These lithologies which extend from the coast to about 60 km inland are mapped and briefly described by Lensen *et al.*1959) and Kingma (1962). In addition Fleming (1953) has mapped and described in detail the geology of the area covered by the NZMS1 Topographic Sheets N137 and N138.

The Upper Wanganui series rocks are very variable in their lithology and degree of consolidation. They include sandstones, siltstones, limestones, shell beds and greywacke gravels. The Hawera series rocks comprise uplifted marine terraces of the late Quaternary period. The most important of these are the Rapanui, Ngarino, Brunswick and Kaiatea terraces (Fleming 1953, Dickson *et al.* 1974) which owe their origin to eustatic changes in sea level combined with tectonic uplift of the coastline. These terraces comprise beach deposits, dune sands with cover deposits of quartzo-feldspathic loess, and andesitic tephric loess, with some primary airfall tephra in the west. However erosion has removed most of the loess and tephra from steep slopes.

The rock types are more stable than those in the unconsolidated sandstone subsuite because the unconsolidated or loose beds are interspersed with more consolidated lithologies.

Soils

Soils were recorded using information from the part Waitotara, part Wanganui, Rangitikei, and Pohangina county surveys and the General Soil Survey. Soils included the Whangaehu steepland soils and Kumeroa hill soils on moderately consolidated silty sandstone and the Pohangina and Opawe steepland soils and Raumai and Oroua hill soils on weakly consolidated sandstone. The Westmere, Kiwitea and Halcombe hill soils are developed on loess derived from quartzo-feldspathic and volcanic materials. The Porewa steepland soils and the Hunterville hill soils, both developed on moderately consolidated sandy siltstone were also included because their erosion features are typical of this subsuite.

Erosion

This subsuite is characterised by soil slip, sheet and tunnel gully as the dominant erosion types, with soil slips being generally deeper than on other sandstone subsuites. Erosive action by water often results in characteristic rills on exposed slip surfaces. Re-vegetation of soil slips is more easily achieved than on the consolidated sandstone or very hard consolidated sandstone subsuites. Tunnel gullies are commonly found in colluvial slopes particularly on the lower rainfall LUC units (VIe14 and VIIe5).

Present erosion is dominantly of a negligible to moderate severity. There is a moderate potential for soil slip erosion on moderately steep to steep slopes, and a severe potential for soil slip erosion on steep and very steep slopes. There is also a potential for gully erosion within thick beds of loose, unconsolidated sandstone. The establishment of soil conservation trees may be difficult on LUC units VIe14 and VIIe5 because of summer soil moisture deficits.

Land Use

In comparison to other hill country subsuites underlain by Tertiary aged sedimentary rocks this subsuite has a high level of development. It is moderately well suited to both agriculture and forestry and is located near major rural servicing centres. Forty three percent is exclusively in pasture with a further 50% having a combination of grassland with scrub and/or forest. In constrast the consolidated sandstone subsuite which has a lower pastoral and forestry potential has pasture as the exclusive vegetation on only 11.5% of the subsuite, (Table 37) with a further 29% in pasture with scrub and/or forest.

On developed areas the dominant land use is sheep and cattle farming with some forestry. Summer soil moisture deficits affect pastoral production on lower rainfall LUC units (VIe14 and VIIe5). This contrasts with the higher rainfall LUC units (VIe12 and VIIe3) which have pasture growth throughout the summer, although winter pasture production is reduced due to cooler temperatures. For this reason VIe14 is assessed as having a lower pastoral potential than LUC unit VIe12 (potential stock carrying capacity of 14 su/ha compared to 16 su/ha). Reversion of pastures to gorse is a problem especially on lower rainfall LUC units.

Table 37: Percentage of moderately consolidated sandstone subsuite and consolidated sandstone subsuite in each of five vegetation categories

Sandstone Subsuite	Vegetation category as percentage of Subsuite area				
	Forest	Scrub	Forest/ Scrub	Grassland	Grassland/Forest and/or Scrub
Mod. consolidated (11b)	1.3	3.5	1.8	43.3	50.1
Consolidated (11d)	37.7	12.7	9.1	11.5	29.0

On the basis of site index and potential stock carrying capacity some LUC units in this subsuite have been ranked significantly higher for forestry production than for pastoral production (Fletcher 1984). All LUC units have a medium to high site index for *P. radiata* while pastoral potentials are medium on LUC units VIe12 and VIe14 and low on LUC units VIIe3 and VIIe5. It should be noted however that some steeper slopes on LUC units VIIe3 and VIIe5 will not be suitable for production forestry.

Exotic forestry is a significant land use. In the Wanganui area on the moderately consolidated sandstone subsuite and the unconsolidated sandstone subsuite is the Lismore Forest with a planted area of 4473 ha (NZFS 1986) and more than 3000 ha of private forest (Moore pers. comm.). An increase in forestry (particularly on Class VII units) may be the best land use for areas with a low pastoral productivity and requiring costly inputs for erosion control, fertilisers and weed control. Alternatively, farm woodlots and agroforestry can also maximise the productive potential of this subsuite.

LUC UNITS WITH RAINFALL BETWEEN 1200–1500 MM P.A.

LUC Unit VIe12 (21,250 ha)

VIe12 comprises moderately steep to steep slopes of moderately consolidated sandstone in areas where the rainfall is between approximately 1200 and 1500 mm p.a. VIe12 occurs at about 350–700 m a.s.l. in the Rangiwahia, Tapuwae, Apiti area and at about 180–270 m a.s.l. inland of Maxwell, Kai-iwi and Wanganui.

Mainly low producing pasture covers 53% of VIe12 while a further 42% is a combination of low producing pasture and manuka, mixed native scrub associations or fern. The dominant soils are the Kiwitea and Oroua hill soils.

In inland locations cool winter temperatures inhibit pasture growth. There may also be occasional winter snowfalls. Overall this unit has a more favourable climate for pasture growth than LUC unit VIe14 which is affected to a greater extent by summer drought. The potential stock carrying capacity is 16 su/ha and the site index for *P. radiata* is 27–30 m.

Soil slip, sheet and tunnel gully are the main erosion types but their effect is minor with slight erosion recorded on map units covering 76% of the LUC unit, and negligible erosion

on the remainder. There is however a potential for moderate erosion. This can be minimised by maintaining a good vegetative cover and to erosion. It is essential to maintain a permanent vegetative cover on runoff channels to prevent gully erosion.

LUC Unit VIIe3 (14,700 ha)

This unit comprises steep and very steep slopes of moderately consolidated sandstone in areas where the rainfall is between approximately 1200 and 1500 mm p.a. VIIe3 occurs in similar areas to VIe12, except in the Oroua and Pohangina River catchments where steep and very steep slopes are mainly on unconsolidated sandstone and are classified as LUC unit VIIe16.

Dominant soils are the Opawe and Pohangina steepland soils and the Oroua hill soils.

Pastoral farming occurs on map units which are in grassland-scrub or grassland-scrub-forest. These cover 80% of the LUC unit. The potential stock carrying capacity is 10 su/ha and the present average is 5 su/ha. The forestry site index for *P. radiata* is 26–28 m although some steeper slopes may be unsuited to production forestry because of access, and logging difficulties.

Present erosion is more severe than on VIe12. Slight erosion is recorded on map units covering 67% of the LUC unit area, and moderate erosion on 28%. There is a potential for severe soil slip and slight sheet and tunnel gully erosion. This can be minimised by maintaining a good pasture cover, oversowing and topdressing soil slips and planting soil conservation trees in tunnel gullies and on sites most susceptible to erosion. Because of the erosion hazard and low pastoral potential this unit is best suited to erosion control forestry.

LUC UNITS WITH RAINFALL BETWEEN 900–1200 MM P.A.

LUC Unit VIe14 (54,500 ha)—Figure 107

This unit comprises moderately steep and steep slopes of dissected Pleistocene aged terraces and moderately consolidated sandstone hill country in areas where the rainfall is between approximately 900–1200 mm p.a. The terraces occur between Waitotara and Feilding while the hill country is further inland at about 150–400 m a.s.l. in the Hunterville-Ohingaiti, Waituna West, and Pakihukura areas.

A vegetation of dominantly low producing pasture covers 50% of the LUC unit with the remainder comprising a mixture of pasture, manuka, gorse and mixed native scrub associations. Reversion of pastures to gorse is a major problem on both this and the related LUC unit VIIe5. Dominant soils include the Raumai, Halcombe, Kumeroa and Hunterville hill soils.

Soil moisture deficits are a limitation to pastoral production during summer. The potential stock carrying capacity is 14 su/ha and the site index for *P. radiata* is 26–30 m.

Erosion is not a major problem. Slight erosion is recorded on map units covering 92% of VIe14. There is a potential for moderate soil slip, sheet and tunnel gully erosion. This can be minimised by maintaining a healthy vegetative cover and by open planting of soil conservation trees in areas most susceptible to erosion. However seasonal soil moisture deficits may pose difficulties in tree establishment.

LUC Unit VIIe5 (14,500 ha)—Figure 108

VIIe5 comprises steep and very steep slopes of moderately consolidated sandstone in areas where the rainfall is between approximately 900 and 1200 mm p.a. Most VIIe5 comprises terrace scarps between Waverley and Makirikiri, and hill country in the lower Turakina catchment and north of Hunterville.

There has been a high level of land development with 44% of the LUC unit in low producing pasture, and a combination of low producing pasture and scrub on another 45%. Exotic forest is recorded on the remainder. The dominant soils are the Whangaehu steepland soils.

Summer soil moisture deficits contribute to VIIe5 having a slightly lower potential stock carrying capacity (9 su/ha) as compared with 10 su/ha on the higher rainfall LUC unit VIIe3.

Figure 107: VIe14 on Pleistocene terrace scarps near Kai-iwi. N137 454979 looking E.

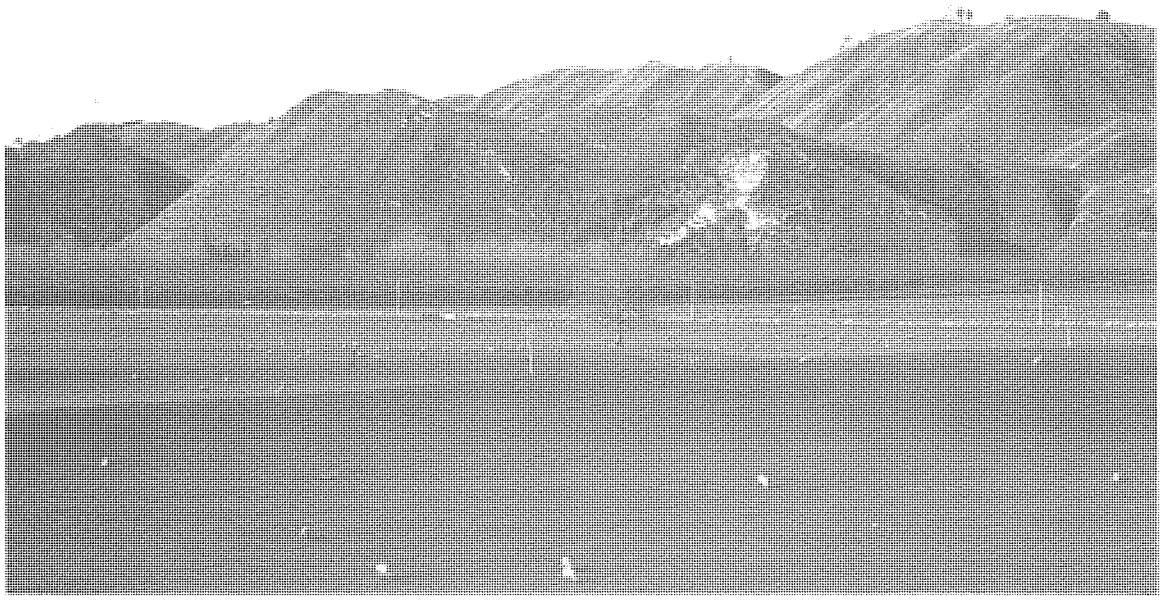


Figure 108: VIIe5. Whangaehu Valley SW of Mangamahu. N138 799962 looking SE.

The site index for *P. radiata* is 26–28 m although some steeper slopes may be unsuitable for production forestry because of access, and logging difficulties.

At present erosion is not a major problem. Slight erosion is recorded on map units covering 70% of the LUC unit and moderate erosion on 17%, the remainder has negligible erosion. There is a potential for severe soil slip and slight sheet and tunnel gully erosion. This can be minimised by maintaining a good vegetative cover. Soil slips should be oversown and top-dressed. Tunnel gullies and sites most susceptible to erosion should be planted with soil conservation trees however, these may be difficult to establish because of summer soil moisture deficits.

11c LUC subsuite on moderately consolidated lithologies with earthflow and slump erosion

This subsuite comprises moderately steep to steep slopes of moderately consolidated, predominantly sandstone lithologies. These are characterised by earthflow and slump erosion, as well as soil slip, sheet and tunnel gully erosion. The presence of earthflow and slump erosion differentiates this subsuite from the other subsuite on moderately consolidated sandstone. Two LUC units (VIe11 and VIIe6) are separated on steepness, length of slope, present erosion severity and erosion potential. Together they occupy 33,550 ha (1.4%) of the region. Most of the subsuite is near Wanganui in the Makirikiri and lower Turakina catchments (Figure 109). Some also occurs near Pakihukura and Rangiwahia.

Physiography

This subsuite occurs on rocks of the Maxwell, Kai-iwi and Okehu Groups which have deep-seated slump and earthflow erosion. Streams flowing in a westerly direction have dissected these sediments to give a hill country landscape which is of more subdued relief than other sandstone subsuites. This results in a topography in which deep-seated slump and earthflow occurs mainly on shady low angle south-facing slopes, while north-facing slopes are steeper with soil slip, sheet and tunnel gully erosion.

Climate

Most of this subsuite is between 60 and 300 m a.s.l. although some inland areas are at about 500 m a.s.l. Annual rainfalls range from about 900 mm near the coast to about 1200 mm at inland locations. Other applicable climatic data are given in the climate section of the other subsuite on moderately consolidated sandstone.

Rock Type

This subsuite occurs on the Maxwell, Okehu and Kai-iwi Groups which are described in detail for the Wanganui area by Fleming (1953), and also mapped and described for the lower Whangaehu and Turakina catchment areas by O'Byrne (1961). These rocks are mainly extremely weak, loose to compact, friable to very friable sands interbedded with thin siltstone, mudstone or claystone bands.

Soils

Soils were recorded using information from the part Waitotara, part Wanganui, Rangitikei and Pohangina county surveys and the General Soil Survey. Soils recorded were principally the Kumeroa hill soils and Whangaehu steepland soils on moderately consolidated silty sandstone. The Wilford hill soils and Okoia steepland soils developed on moderately consolidated sandy mudstone were also recorded as their erosion features are typical of this subsuite. The remaining soils were principally the Raumai hill soils in Pohangina County and the Atua soils of the General Soil Survey.

Erosion

It is considered that thinly interbedded impervious clays and silts (which perch water), with thickly bedded sands of little strength contribute to mass-movement failures in this subsuite. Slumps are most extensive in the Maxwell group which has many clay bands or lamina

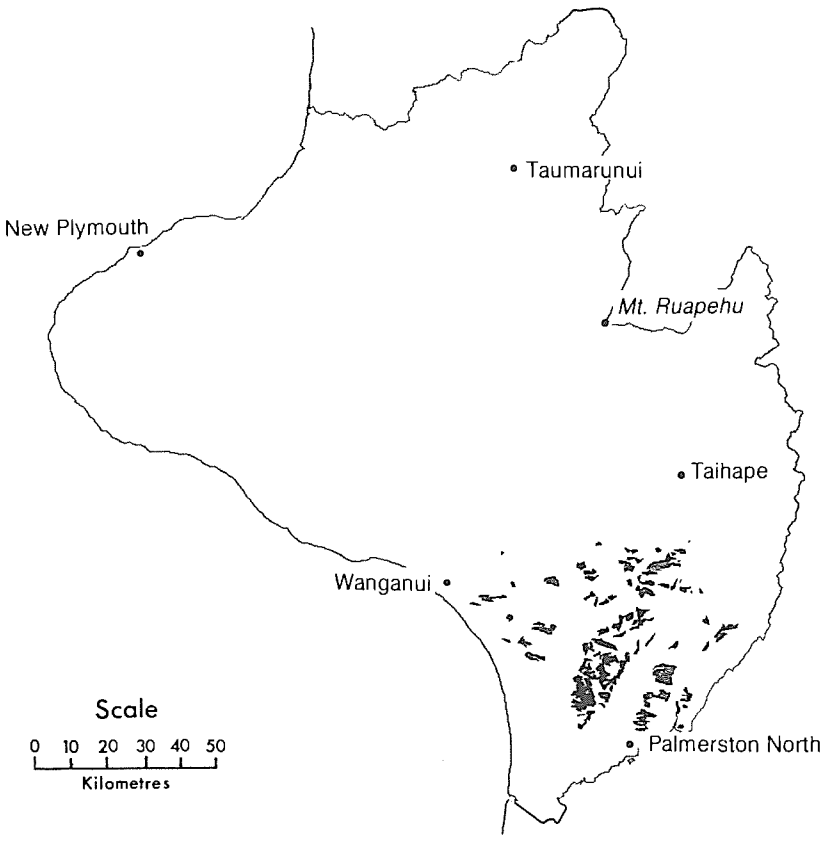


Figure 109: Location of LUC subsuite 11c: moderately consolidated sandstone with earthflow and slump erosion.

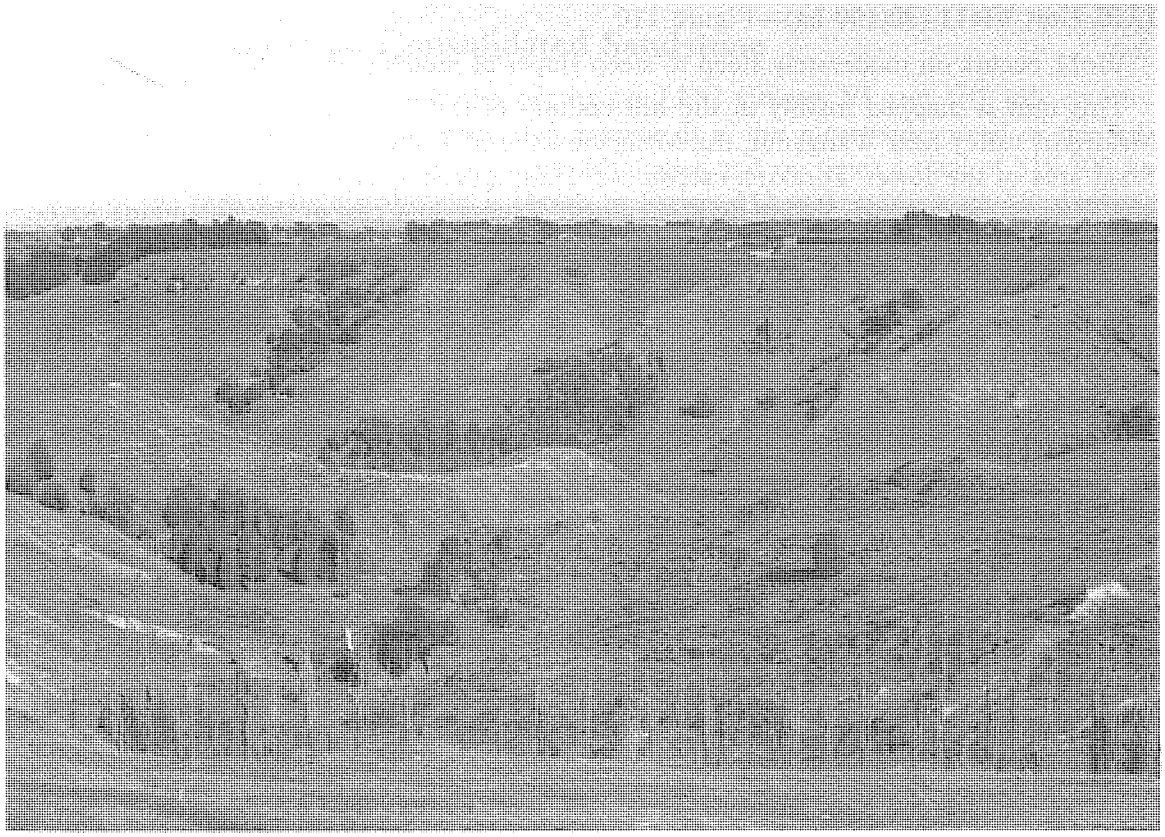


Figure 110: VIe11 slump and earthflow erosion on south facing slopes and sheet and soil slip erosion on steeper north facing slopes. Ic3 (LUC subsuite 1d) on flat terraces in the distance. Brunswick district near Wanganui. N138 580980 looking S.

interbedded with muddy sands (O'Byrne 1961). Sliding of unconsolidated sands overlying a contact of solid clays takes the form of a large slump movement, usually along the dip slope. The overlying Okehu and Kai-iwi Groups also have slumps which occurred during the dissection of the landscape following repeated uplift during the Hawera epoch. However, most of these slumps are considered dormant. Soil slip, sheet and tunnel gully erosion occur on steep slopes.

Present erosion severities are higher than for the other moderately consolidated sandstone subsuite. Slight erosion is recorded on map units covering 66% of the subsuite with moderate erosion on a further 30%. Where map units are exclusively a complex of slump and deep-seated earthflow erosion, they are classified as LUC units VIe19 or VIIe12 of the slump and deep- seated earthflow suite (LUC suite 12).

Soil conservation measures include surface smoothing to dewater earthflows and slumps, with debris dams and pair and block planting also required to stabilise stream channels. Soil conservation trees need to be open planted on steep slopes susceptible to soil slip erosion, and in tunnel gullies. However, soil conservation tree establishment may be difficult particularly on drier north-facing slopes because of the likelihood of soil moisture deficiencies. Areas of severe soil slip should be oversown and topdressed.

Land Use

Sheep and cattle grazing is the dominant land use. There is a high level of pastoral development with 66% of the subsuite in pasture, and the remainder a combination of pasture and scrub or forest. Land use capability units are ranked as medium for both potential stock carrying capacity (16–19 su/ha) and *P. radiata* site index (27–29 m). Although this subsuite has less than 1200 mm p.a. rainfall, only steeper slopes experience soil moisture deficits in summer as areas with slump and earthflow erosion retain sufficient soil moisture to maintain summer pasture growth.

LUC Unit VIe11 (30,100 ha)—Figure 110

VIe11 occurs on moderately steep to steep slopes of moderately consolidated sandstone.

This unit is mapped mainly in the hill country of the Westmere and Kai-iwi areas, the Makirikiri valley near Wanganui, the Mangahowhi and Mangakara valleys and the Taurimu Road area of the lower Turakina catchment. Further east VIe11 occurs in the Pakihukura and Kiwitea catchments, Valley Road area near Raumai and east of the Pohangina River.

At present pasture is the dominant vegetation on 67% of the LUC unit while the remainder is in pasture and scrub, particularly manuka scrub, gorse and mixed native scrub associations. The dominant soils are the Kumeroa, Wilford and Raumai hill soils.

VIe11 is one of the most productive hill country LUC units. It has a potential stock carrying capacity of 19 su/ha and a site index for *P. radiata* of 27–29 m.

Slight erosion is recorded on map units covering 69% of the LUC unit and moderate erosion occurs on the remainder. There is a potential for moderate soil slip, sheet, tunnel gully, earthflow and slump erosion.

LUC Unit VIIe6 (3450 ha)

VIIe6 occurs on steep slopes which have a potential for severe erosion. It occurs mainly in the lower Turakina Catchment north of the Mangahowhi and Mangara Streams but small areas are also mapped near Pakihukura and in the Pohangina catchment.

Pasture is the exclusive vegetation on 53% of the LUC unit—the remainder is a combination of pasture and scrub vegetation. The dominant soils are the Whangaehu and Okoia steepland soils. The potential stock carrying capacity is 16 su/ha and the site index for *P. radiata* is 27–29 m although steeper slopes are generally unsuited to production forestry.

Present erosion is of slight to severe severity, with a potential for severe soil slip, moderate earthflow and slump and slight sheet and tunnel gully erosion.

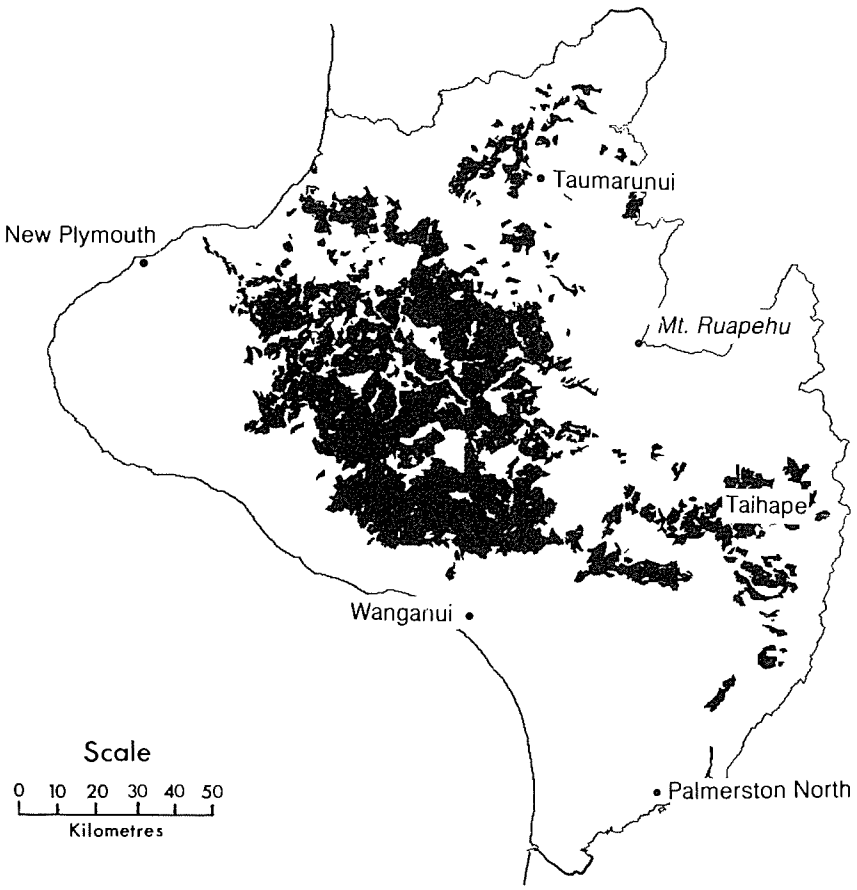


Figure 111: Location of LUC subsuite 11d: consolidated sandstone.

11d LUC Subsuite on Consolidated Sandstone

The consolidated sandstone subsuite occurs on LUC Classes VI and VII hill country particularly in the Taranaki and Wanganui regions. It is the most widespread of the hill country subsuites underlain by Tertiary aged lithologies and occupies a total of 519,300 ha (21.4%) of the region. Its distribution is shown in Figure 111.

This subsuite comprises weak, massive sandstone, which may contain interbedded siltstone in some areas. It is characterised by low soil fertility and bare rock scars marking the sites of past erosion. Revegetation of eroded sites is slow because the rock is compact, has a low natural fertility and weathers very slowly. Pastoral productivity levels are among the lowest of the hill country LUC units.

Five LUC units are differentiated on the basis of slope, erosion potential and climate (principally rainfall) as follows:

1. LUC units with rainfall > 1200 mm p.a. (VIe13, VIe23, VIIe11)
2. LUC units with rainfall < 1200 mm p.a. (VIe15, VIIe13).

For descriptive purposes LUC unit VIIIe3, which occurs on a variety of Tertiary aged rock types, is also included with this subsuite.

VIIe11 is the only unit in the subsuite to correlate with others in the North Island. It correlates with LUC units in the Gisborne-East Coast, Northern Hawkes Bay and Bay of Plenty-Volcanic Plateau Regions (Page 1985).

Physiography

The landscape is strongly dissected with steep and very steep slopes and narrow sharply defined ridge crests. Valley slopes are up to 150 m in length and often have very steep upper

slopes with conspicuous scarps. Ridges reach an altitude of about 700 m a.s.l. in the Taihape area and the Matemateonga Range.

Climate

Data from the New Zealand isohyet map (NZ Meteorological Service 1978) and Rainfall Normals 1951–80 (NZ Meteorological Service 1984) show that annual rainfall is between approximately 900 and 1100 mm p.a. on lower rainfall LUC units and between approximately 1400 and 2000 mm p.a. on higher rainfall LUC units. Climatological data from Hiwi, Taihape and Te Wera best represent the climate of the lower rainfall and higher rainfall LUC units respectively.

At Hiwi, Taihape (657 m a.s.l.) the 1951–1980 rainfall normals show that the 928 mm annual rainfall is fairly evenly spread through the year with the least rainfall in February, March and April. The mean air temperature is 10.4°C, and an average of 63.4 days of ground frost and 12.3 days of snow occur each year.

Rainfall normals (1951–1980) for representative stations on higher rainfall LUC units include Whangamomona 1971 mm, Te Wera 1846 mm, Mangaparua Landing (Wanganui River) 1992 mm and Orautoha (NW of Raetihi) 1437mm. All those stations receive approximately 20% of annual rainfall in the three driest months of January, February and March, while on average about 29% of annual rainfall occurs in the three wettest months of May, June and July. Te Wera has a mean air temperature of 11.9°C and receives an average of 74.1 days of ground frost per year. This station is however situated on a valley floor at 180 m a.s.l. so upper valley slopes and ridge crests commonly occurring at about 400–500 m a.s.l. will tend to have cooler temperatures and be more exposed.

Rock Type

LUC units of this subsuite occur on massive sandstones of the Waitotaran and Opoitian Stages of the Wanganui Series rocks, and the Kapitean and Tongaporutuan Stages of the Taranaki Series. These are described by Lensen *et al.* (1959), Kingma (1962) and Hay (1967). In northern areas moderately steep slopes may have a significant depth of andesitic tephra originating from Mt Egmont or the Tongariro Volcanic Centre.

Soils

Soils were recorded using information from the soil surveys of Rangitikei, part Wanganui, Stratford and Pohangina Counties and the King Country and General Soil Survey. Steepland soils have shallow profiles which pass abruptly into parent rock.

Moderately steep slopes with a significant andesitic tephra mantle (LUC unit VIe23) have yellow-brown loam hill soils of the Ohakune, Egmont, Stratford and New Plymouth series. Other soils recorded on high rainfall LUC units (VIe13 and VIIe11) include hill soils of the Umutoi series and steepland soils of the Whangamomona, Moumahaki, Timi and Otamawairua series. On the lower rainfall LUC units (VIe15 and VIIe13) soils include hill soils of the Whetukura, Rawea, Ashcott, and Ohutu series and steepland soils of the Mangamahu and Waiaruhe series.

Erosion

Soil slip, debris avalanche, sheet, tunnel gully and earthflow erosion are all recorded on this subsuite. Soil slip and sheet erosion predominate on pastoral land, with soil slip and debris avalanche in forested areas. Tunnel gully erosion appears to be important on colluvial slopes in lower rainfall areas. Lower colluvial slopes on LUC units VIIe11 and VIIe13 may also have slight earthflow erosion particularly where slopes are undercut by streams.

Present erosion is dominantly of a negligible to moderate severity with map units covering 17% of the subsuite having negligible erosion, 69% slight erosion and 14% moderate erosion.

Moderately steep to steep slopes have a potential for moderate soil slip and slight sheet erosion, with a potential for slight debris avalanche in forested areas and slight tunnel gully on colluvial slopes on lower rainfall LUC units. On steep and very steep slopes the erosion

potential increases to severe soil slip, moderate debris avalanche and slight sheet, with slight earthflow erosion also on colluvial slopes.

The pattern is for lower rainfall LUC units to have a greater proportion of their area affected by erosion. This is probably because they have a higher percentage of their area in pasture which is more likely to erode, than the extensive areas of scrub, fern and forest vegetation which dominates on higher rainfall LUC units.

Soil slip and debris avalanche erosion on this subsuite have similar characteristics to those of the siltstone suite. Water infiltrates through the soil profile to a depth where flow becomes impeded by low permeability consolidated sandstone rock. Interflow along the soil/rock interface decreases the shearing resistance and contributes to soil slip and debris avalanche erosion. Erosion scars take longer to revegetate than those on the more fertile siltstone suite. In contrast the mudstone suite and the moderately consolidated sandstone subsuite have a parent rock that is less consolidated and more permeable, on which vegetation can establish more rapidly.

Land Use

LUC units VIIe11, VIe23 and VIe13 epitomise the "hard hill country" of inland Taranaki-Wanganui. Large areas cleared of forest between 1880 and 1920 have now reverted so that almost 60% of the subsuite is exclusively in forest or scrub vegetation. Only 11.5% is in pasture, with another 29.0% dominantly in pasture with manuka scrub, fern, mixed native scrub associations or forest. The dominant land use is sheep and cattle farming with also some deer and goat farming.

Reversion of pastures to hard fern and scrub is a particular problem on higher rainfall LUC units but on lower rainfall LUC units secondary growth is not as vigorous and is more easily controlled. Present farming practice is directed toward more intensive use of subdivision fencing, regular fertiliser use and rotational grazing with high cattle to sheep ratios to improve soil fertility and pasture species composition, and prevent reversion.

LUC UNITS WITH RAINFALL GREATER THAN 1200 MM P.A.

The three LUC units within this grouping (LUC units VIe13, VIe23 and VIIe11) together total 396,750 ha. Two of them: LUC unit VIIe11 (316,000 ha) and LUC unit VIe23 (68,200 ha) are the two largest LUC units in the Taranaki-Manawatu region.

LUC unit VIe13 (12,550 ha)—Figure 112

VIe13 comprises moderately steep and steep hill slopes on consolidated sandstone where the annual rainfall is between 1200–1600 mm. It is mapped adjacent to the Ruahine Ranges and in the Wanganui, Rangitikei and Manawatu districts.

This unit is generally located at between 600–900 m a.s.l. where cool winter temperatures with associated frosts and occasional snowfalls depress winter growth. However there is sufficient rainfall to maintain pasture growth during the summer period. Reversion of pastures to scrub or fern is a major problem but not as serious as on VIe23 or VIIe11.

37% of the LUC unit is exclusively pasture with another 54% grassland-scrub or grassland-scrub-forest. Typical soils include the Umutoi, and Whetukura hill soils and Mangamahu steepland soils. The present average stock carrying capacity is 10 su/ha with a potential of 14 su/ha. Forest growth potentials for *P. radiata* are medium with a site index value of 26–28 m.

There is a potential for moderate soil slip and slight sheet and tunnel gully erosion. This erosion can be controlled by open planting of soil conservation trees and the planting of trees along tunnel gullies.

LUC unit VIe23 (68,200 ha)—Figure 113

This unit comprises steep hill country on consolidated sandstone, with a discontinuous mantle of andesitic tephra. It has a higher rainfall (1600–2400 mm p.a.) and milder climate than LUC unit VIe13. VIe23 occurs mainly in the inland Taranaki-Wanganui area and parts

of the King Country. It covers the largest area of any Class VI LUC unit in the region and is usually mapped in conjunction with LUC unit VIIe11. In remote areas much of the LUC unit has reverted to scrub and fern, however where there is good access reversion is more likely to be controlled.

Only 11% of VIe23 is exclusively in pasture with 59% a combination of grassland-scrub or grassland-scrub-forest. The remainder is forest or scrub and fern. Soils recorded on LUC unit VIe23 include hill soils of the Ohakune, Egmont, Stratford and New Plymouth series and steepland soils of the Whangamomona and Moumahaki series. Steeper and longer slopes are classified as LUC unit VIIe11, while easier slopes with a greater depth of tephra are mapped as either LUC unit VIe6 or LUC unit VIe22.

The present average stock carrying capacity is 6 su/ha with a potential for 14 su/ha. At Te Wera some areas of LUC unit VIe23 have been planted in exotic forest. The site index for *P. radiata* is 26–28 m.

There is a potential for moderate soil slip erosion on pasture and scrubland, and slight debris avalanche on forested slopes. This can be controlled by open planting of conservation trees on pasture areas, however they must be adequately protected from goats, cattle and possums. There is also a potential for slight sheet erosion particularly where pastures on steep slopes have been heavily grazed.

LUC unit VIIe11 (316,000 ha)—Figures 113, 114

VIIe11 comprises steep and very steep slopes on consolidated sandstone where the annual rainfall is between 1200 and 2000 mm p.a. Slopes are steeper and longer (approximately 150 m) than in LUC unit VIe23, and ridge crests are narrow and streams deeply entrenched. It is the most extensive LUC unit in the Taranaki-Manawatu region, and the dominant hill country LUC unit in much of inland Taranaki, the Waitotara River Catchment, Waimarino County and parts of the King Country.

There are severe physical limitations to pastoral and forestry use due to severe erosion hazards, steep and very steep slopes, and shallow infertile soils.

Typical soils include the steepland soils of the Whangamomona, Moumahaki, Timi and Otamawairua series. Sandstone bluffs with no soil development are recorded as bare rock.

Much of VIIe11 has not been cleared for farming and remains largely in indigenous forest. Pasture is primarily in areas with the best access. However extensive areas that were developed for farming have now reverted to scrub and fern. Pasture is the exclusive vegetation on map units covering only 3% of VIIe11 although grazing also occurs on another 22% that has pasture with forest or scrub. The remainder is recorded as forest (49%), scrub (15%) and forest-scrub (11%).

Physical land use constraints are demonstrated by the potentials for pastoral and forestry use. The average stock carrying capacity is 5 su/ha with a potential of 9 su/ha. Lower slopes have a medium suitability (SI 25–28 m) for *P. radiata* growth, but the steeper upper slopes are generally unsuitable for forestry because of access, establishment and logging difficulties. Difficult access is a major constraint to use. Numerous deeply incised gorges require expensive bridging and the cost of maintaining county roads is high.

The unit has a potential for severe soil slip and moderate debris avalanche erosion. Eroded sites need to be oversown and topdressed, however establishment of vegetation on the low fertility sandstone can be difficult. Conservation trees, adequately protected from goats, cattle and possums should be open planted in areas most susceptible to erosion, and indigenous vegetation should be maintained on inclusions of Class VIII. There is also a potential for slight sheet erosion particularly when north facing sunny slopes are over-grazed. Lower colluvial slopes may have a slight earthflow potential particularly if undercut by streams.

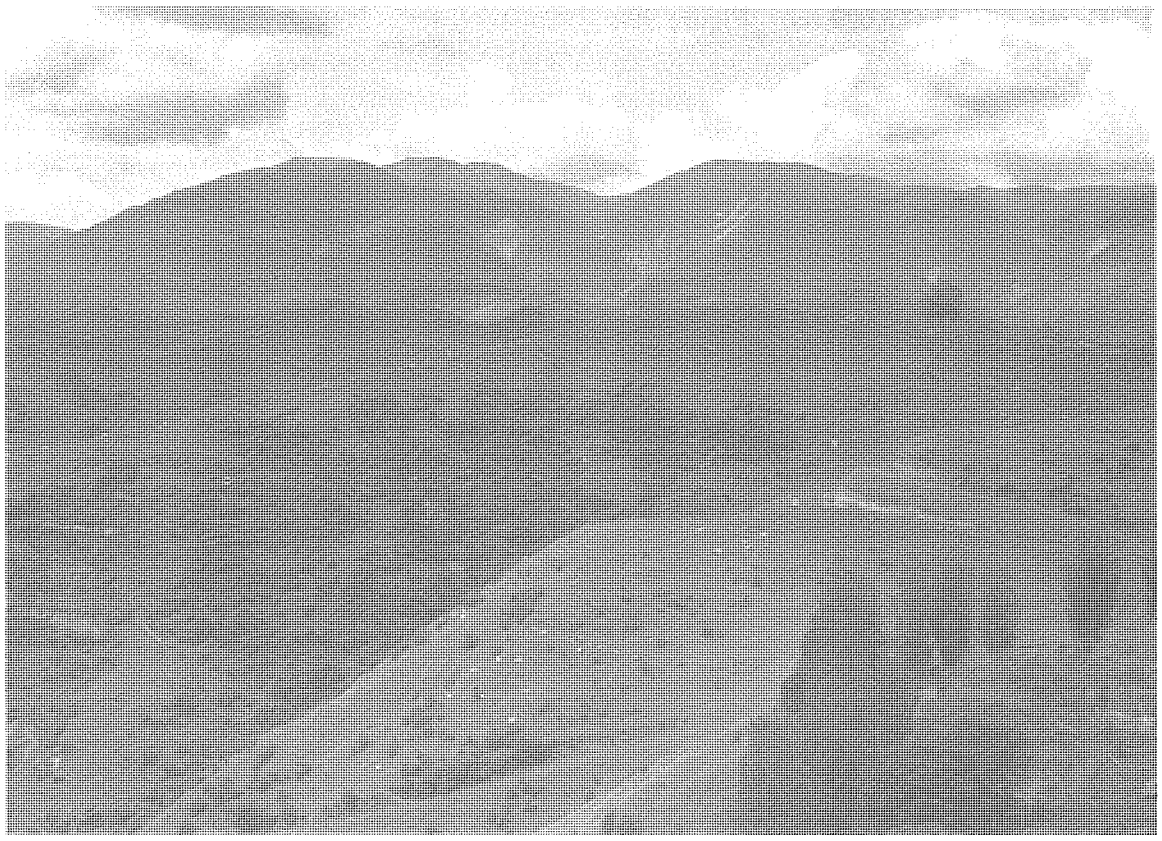


Figure 112: VIe13. Ruahine Ranges in distance. Auputa Rd, NE of Rangiwahia. N139 428968 looking E.

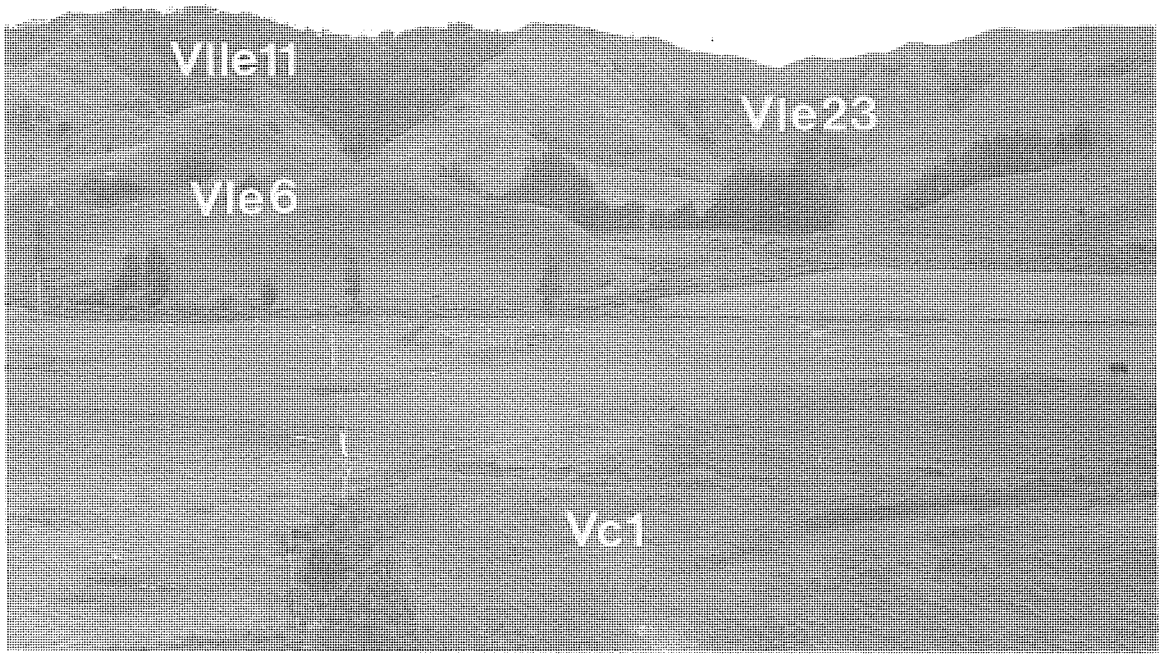


Figure 113: Vc1 right foreground. LUC units VIe6, VIe23 and VIIe11 in the distance. 3 km east of Douglas. N119 059623 looking W.

LUC unit VIIIe3 (77,000 ha)—Figure 99

Also included in this subsuite is LUC unit VIIIe3. VIIIe3 comprises gorges and very steep slopes of Tertiary age lithologies, particularly of the consolidated sandstone, hard consolidated sandstone and 'Urenui' siltstone LUC subsuites. Most VIIIe3 occurs in high rainfall areas especially in the Wanganui, Waitotara, Waitara and Urenui River catchments.

Soils are typically the Whangamomona, Moumahaki, Tirangi, Mohakatino and Mokau steepland soils. Bare rock bluffs are common. All of VIIIe3 is undeveloped and has indigenous forest or scrub vegetation. There is a potential for extreme soil slip, debris avalanche and sheet erosion. Existing vegetation should be maintained. This can primarily be achieved by feral and noxious animal control.

LUC UNITS WITH RAINFALL LESS THAN 1200 MM P.A.

The two LUC units in this climatic zone (VIe15 and VIIe13) differ from LUC units VIe13 and VIIe11 by having:

a) A seasonal soil moisture deficit which limits pasture growth in summer and may provide some difficulties for soil conservation tree establishment.

b) A slightly higher potential stock carrying capacity.

c) Reversion is normally less of a problem and is mainly to manuka scrub rather than to manuka scrub, hard fern and bracken fern.

LUC unit VIe15 (23,250 ha)

VIe15 comprises moderately steep to steep hills of consolidated sandstone occuring in areas of the Wanganui, Rangitikei and Manawatu hill country where the rainfall is between approximately 900 and 1200 mm p.a. VIe15 is most significant between Taihape and the Rangitikei River, south of the Kawhatau Valley, and in the Utuwai district.

Soils include hill soils of the Ashcott, Ohutu, Rawea and Whetukura series, and steepland soils of the Mangamahu series. Most has been developed for pastoral farming. Pasture is the dominant vegetation on 72% of VIe15. The remainder is mainly grassland with scrub or forest as subdominant. The potential average stock carrying capacity is 16 su/ha and the site index for *P. radiata* is 24–28 m.

There is a potential for moderate soil slip and slight sheet and tunnel gully erosion. Soil conservation measures should include open planting of conservation trees in areas most susceptible to erosion. Tunnel gully erosion can be controlled by tree planting along tunnel lines.

LUC Unit VIIe13 (22,300 ha)—Figure 115

VIIe13 comprises steep and very steep slopes on consolidated sandstone where the rainfall is between approximately 900 and 1200 mm p.a. Most VIIe13 occurs east of Taihape and near Mangamahu.

The dominant soils recorded are steepland soils of the Mangamahu and Waiaruhe series.

Most of VIIe13 is used for extensive sheep and cattle grazing. 51% of VIIe13 is exclusively in pasture with 35% in grassland- forest, grassland-scrub or grassland-scrub-forest. The high proportion of pasture on LUC unit VIIe13 contrasts with LUC unit VIIe11 on the same parent material but with higher rainfall, which has 25% in pasture or pasture-scrub or pasture-forest.

Pastoral productivity figures are lower than on adjacent Class VII units occurring in a similar climate on other more naturally fertile rock types. The present average stock carrying capacity is 6 su/ha with a potential of 11 su/ha. Forest growth potentials are rated as medium for *P. radiata* (24–26 m) although steeper upper slopes are generally unsuitable because of access, establishment and logging difficulties.

There is a potential for severe soil slip and slight sheet and tunnel gully erosion. However shallow soil depths and soil moisture deficits in summer may make soil conservation tree establishment difficult. Soil slips should be oversown and topdressed.

Figure 114: VIIe11. Ahuahu Valley, inland Wanganui. N130 520222 looking NE.

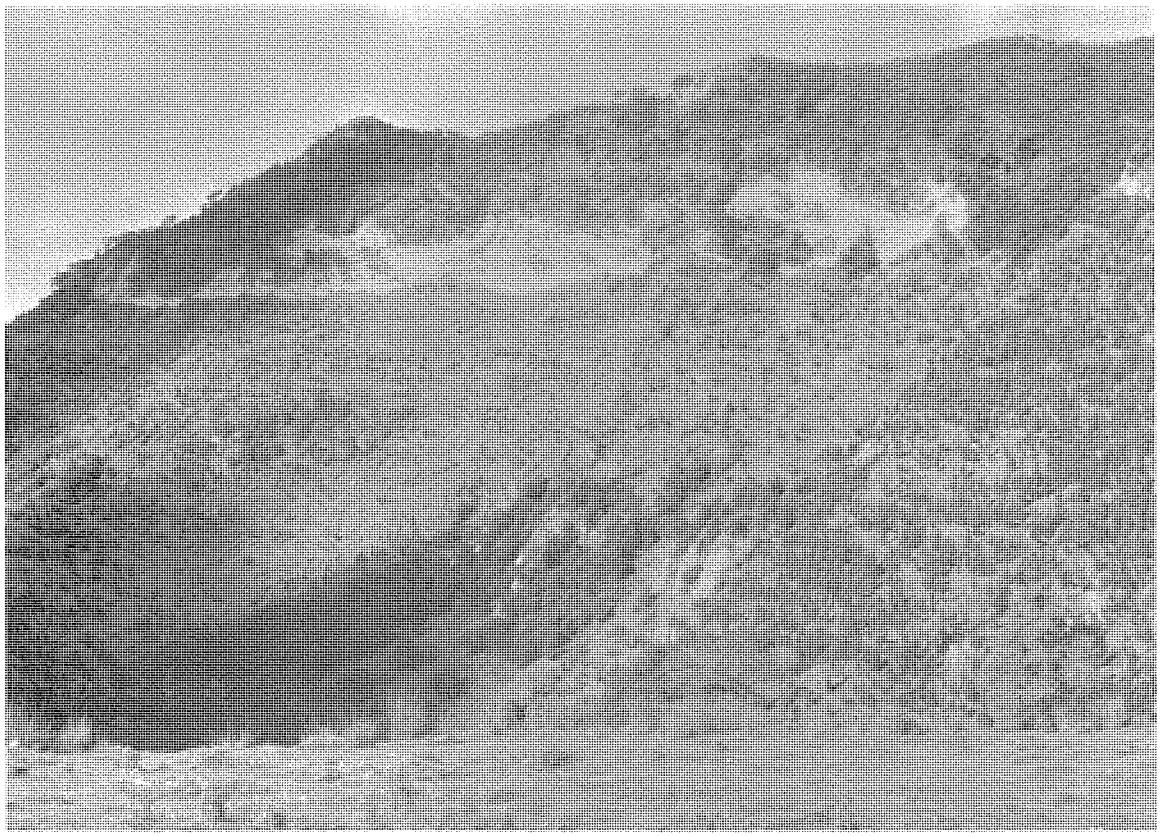


Figure 115: VIIe13. Creek Rd, near Mangamahu. N138 920037 looking E.

11e LUC Subsuite on Hard Sandstone

This subsuite comprises moderately steep to very steep hill country with soils developed on moderately hard to very hard sandstone. Bluffs are a distinctive feature on very steep slopes. The subsuite occupies 105,050 ha (4.3%) of the region. Its distribution is shown in Figure 116.

The subsuite comprises two LUC units, VIe17 and VIIe17. They are differentiated on the basis of slope steepness and the length of slope, erosion potential and the presence of sandstone bluffs. Pastoral productivity levels for LUC unit VIIe17 are the lowest for Class VII land in the sandstone suite. Extensive areas with very steep slopes and prominent sandstone bluffs are mapped as VIIIe3.

Physiography

Streams and rivers within this subsuite have dissected deeply into sediments of an old uplifted surface which is gently tilted to the west and south. The landscape has a strongly dissected appearance with narrow sharply defined accordant ridges that are at about 600 m elevation in the east and 250 m a.s.l. in the west and south. Narrow alluvial terraces within this subsuite are closely dissected by streams and are typically mapped as LUC unit IVw1.

Climate

Data from 1951–1980 Rainfall Normals (NZ Meteorological Service 1984) and the isohyet map of Taranaki (Thompson 1981) show that rainfall on this suite is between approximately 1800 and 2500 mm p.a. The Kotare rainfall station situated within the subsuite area has a rainfall normal (1951–80) of 1989 mm. Of this total 30% falls in May, June and July, 19.0% in January, February and March, and the remainder is fairly evenly spread throughout the rest of the year. There is sufficient rainfall to maintain good pasture growth during summer. Mean air temperature decreases inland with increasing altitude so that in the Retaruke area the average number of growing degree-days above base 10°C during October to April is estimated to be about 800 (Thompson 1981).

Rock Type

LUC units of this subsuite occur on sandstones of the Mohakatino and Mokau groups and the Tongaporutuan Stage (Hay 1967). The nature and extent of these rocks have been previously described within the subsuite area by Henderson and Ongley (1923) and Grange (1927).

The rocks of this subsuite which are called very hard consolidated sandstones in the NZLRI regional extended legend (Fletcher 1981) would be more correctly described as moderately strong to very strong (or, moderately hard to very hard) rock. Very hard sandstone exposed in sandstone bluffs cannot be scratched or gouged with a geological hammer point.

Moderately steep slopes on VIe17 have a significant depth of andesitic tephra originating from Mt Egmont and the Tongariro Volcanic Centre.

Soils

Soils were recorded using information from the General Soil Survey, the King Country soil survey, and the soil survey of Stratford County.

Yellow-brown loam soils are mapped on moderately steep slopes with a significant depth of andesitic tephra. These are typically the New Plymouth series in Taranaki and the Waihuka and Pokaka series in the King Country. On steeper slopes where there is a patchy or insignificant tephra cover over sandstone, typical steepland soils include the Moumahaki, Mohakatino, Tongaporutu and Mokau series. On VIIe17 in particular, there are significant areas of bare sandstone bluffs with no soil development.

Erosion

Erosion is dominantly soil slip with debris avalanche also in forested areas. Earthflow erosion can be significant on colluvial slopes as well as sheet erosion on grazed areas. Present

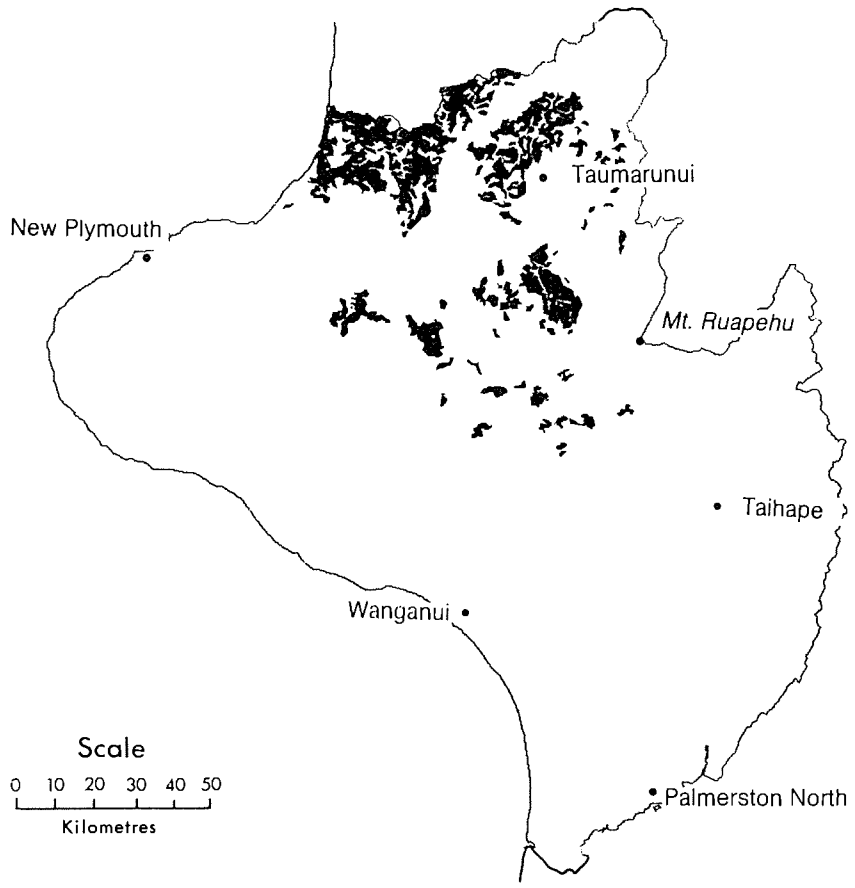


Figure 116: Location of LUC subsuite 11e: hard sandstone.

erosion is dominantly of slight severity with map units covering 23% of the subsuite area having negligible erosion, 68% slight erosion, 8% moderate erosion and <1% severe erosion. This contrasts with the Urenui siltstone subsuite also occurring in North Taranaki which has moderate erosion recorded on map units covering 56% of its subsuite area. These differences in erosion severity can be attributed to the more southerly location of the Urenui siltstone subsuite and its consequent greater exposure to heavy rains which come mainly from the north over the North Taranaki Bight. In comparison LUC units VIe17 and VIIe17 tend to be more sheltered from the effects of heavy rainfalls by hill country to the north of the subsuite.

Land Use

Only 5% of the subsuite is exclusively in pasture. Grazing is also possible on a further 30% which is dominantly low producing pasture with manuka scrub, mixed native scrub associations, fern or forest. The remainder is exclusively indigenous forest, scrub or fern.

Sheep and cattle grazing is the dominant land use in addition to some goat farming. Considerable areas of land previously cleared for farming have reverted to fern and scrub. This can be avoided by employing a high level of pasture management: regular fertiliser applications, subdivision fencing and rotational grazing (necessary to improve fertility and pasture species composition), and high cattle to sheep ratios (necessary to control the growth of fern and scrub).

LUC unit VIe17 (46,000 ha)

VIe17 occurs on moderately steep and steep slopes which are shorter in length and do not have the very prominent sandstone bluffs that are a feature of LUC unit VIIe17.

Only 11% of VIe17 is exclusively in pasture with another 46% in grassland-scrub, grassland-forest or grassland-scrub-forest vegetation. The remainder is principally indigenous forest, or scrub and fern with small areas also of exotic forest.

The dominant soils are the New Plymouth, Waihuka and Pokaka series hill soils, and the Moumahaki, Mohakatino, Tongaporutu and Mokau steepland soils.

The present average stock carrying capacity is 8 su/ha with a potential stock carrying capacity of 11 su/ha. The site index for *P. radiata* is 25–27 m. Areas of bare rock or very shallow soils overlying hard sandstone are not suited to production forestry use. The only significant exotic forestry plantings on VIe17 have been carried out by the Justice Department, and a private company in the Waitaanga area.

There is a potential for moderate soil slip and sheet erosion and moderate debris avalanche erosion in forested areas. Conservation trees can be open planted on sites most susceptible to mass movement erosion, however they must be adequately protected from damage by possums, goats and cattle.

LUC unit VIIe17 (59,050 ha)—Figure 117

VIIe17 is mapped on steep and very steep slopes which are much longer (up to 350 m) and steeper than those of VIe17. Sandstone bluffs on very steep upper slopes reduce the available productive area of this unit, therefore pastoral and forestry production is generally only feasible on the less steep lower colluvial hill slopes.

Typical soils are the Moumahaki, Mohakatino, Mokau and Tongaporutu steepland soils. Significant areas of bare sandstone bluffs with no soil development are mapped on the NZLRI as bare rock. LUC unit VIIIe3 is mapped on very steep slopes with many bare rock bluffs.

Figure 117: VIIe17. SH40 east of Ahititi. N100 260140 looking S.

Pastoral farming is confined to 16% of the area which is classified as grassland-scrub and grassland-scrub-forest vegetation. The present average stock carrying capacity of areas in pasture is 4 su/ha with a potential for 6 su/ha. The small proportion of pasture on this LUC unit also highlights the problem of pastures reverting to manuka scrub, hard fern and bracken fern. High cattle to sheep ratios are normally carried to minimise pasture reversion. Poor

quality pasture, insufficient subdivision, low fertility soils and inadequate fertiliser usage are other factors limiting the stock carrying capacity. The steeper upper slopes and bluff areas are generally unsuitable for forestry as shallow soils overlying impenetratable sandstone preclude successful tree establishment. Very steep slopes with numerous bluffs and very narrow ridges present considerable difficulties for access and logging operations. The lower colluvial slopes however have a site index for *P. radiata* of 25–27 m.

On steep and very steep slopes there is a potential for severe soil slip and debris avalanche erosion. Where steeper areas have been cleared for grazing there is also a potential for moderate to severe sheet erosion. Earthflow erosion on colluvial footslopes initiated by stream undercutting, can result in problems with road and track maintenance. Soil conservation measures include open planting of poles in areas most susceptible to erosion and block planting of severely eroded sites. It is very difficult (or impossible) to revegetate soil slips or debris avalanches that expose the underlying rock. Indigenous vegetation should be maintained on sandstone bluffs. Soil conservation trees must be adequately protected from possum damage and browsing by goats and cattle and these animals should also be controlled in forest and scrub areas.

12. LUC SUITE ON DEEP-SEATED EARTHFLOW AND SLUMP EROSION

This suite is characterised by rolling to moderately steep slopes affected by deep-seated earthflow and slump erosion. This suite is one of the most erosion prone yet naturally fertile of the hill country suites. This is largely explained by the presence of mudstone or fine siltstone lithologies (commonly mantled with andesitic tephra). It is widely distributed in most parts of the region (Figure 118).

The following five LUC units are mapped: IVe8, VIe19, VIe20, VIIe12 and VIIe14. Together these LUC units cover 46,000 ha (1.9%) of the Region. The non arable LUC units have been grouped on the basis of annual rainfall:

1. Low rainfall $<$ 1200 mm p.a. (VIe19, VIIe12).
2. High rainfall $>$ 1200 mm p.a. (VIe20, VIIe14).

The high rainfall LUC units tend to be mapped at higher altitude and in inland locations where mudstone or fine siltstone lithologies are usually mantled with andesitic tephra. In contrast the lower rainfall LUC units occur at lower altitudes, include massive and unconsolidated sandstone and coarse siltstone lithologies, and do not normally have an andesitic ash cover.

Physiography

This suite occurs on low angle slopes within generally steep hill country. In the Wanganui area large-scale slumping has altered the drainage pattern to form swamps and lakes. The suite occurs over a wide altitude range, from 200–300 m a.s.l. in the Wanganui and Taranaki regions to about 700–800 m a.s.l. on the southern margin of the Waimarino plateau. Further north in the Taumarunui area the suite is generally between 300–500 m a.s.l. but increases to about 700 m a.s.l. at the northern boundary of the region.

Climate

Because this suite is widely scattered the climate is very variable. Generally however, map units tend to be in sheltered locations with a more favourable micro-climate than the surrounding hill country.

Rock Type

This suite is mainly on mudstone or fine siltstone lithologies, with minor areas on massive or unconsolidated sandstone and coarse siltstone. Jointed mudstone or fine siltstone, massive mudstone or fine siltstone, and banded mudstone or fine siltstone respectively comprise 55%, 18% and 14% of the suite. The remainder of the suite comprise massive sandstone or coarse

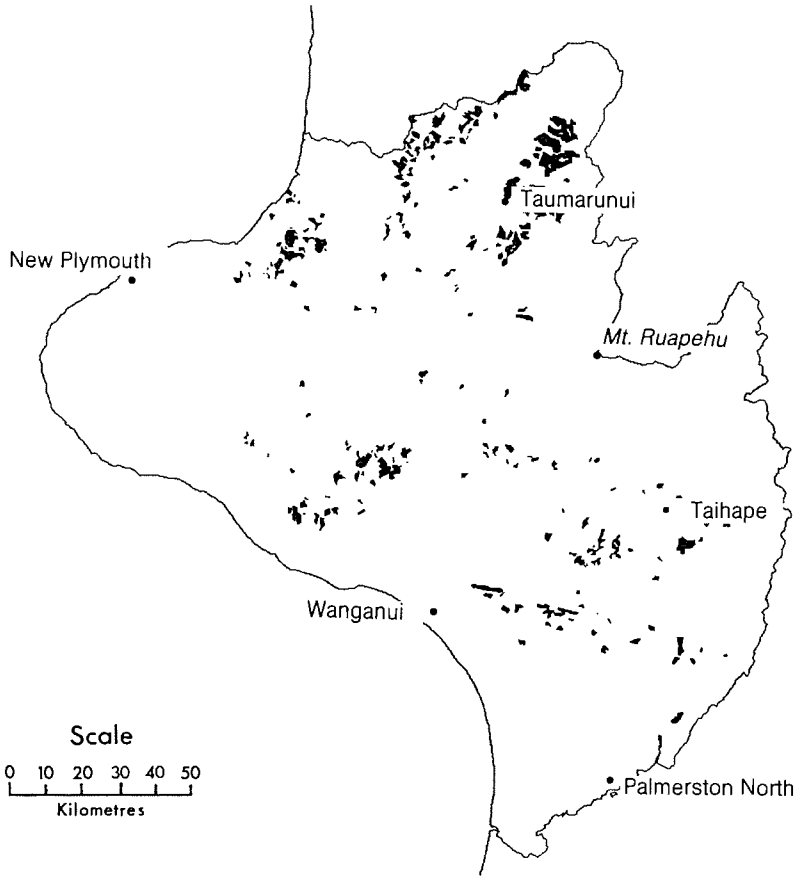


Figure 118: Location of LUC suite 12: deep-seated earthflow and slump erosion.

siltstone, and unconsolidated sandstones and siltstones. These latter lithologies occur mainly in the Wanganui district on the Maxwell, Okehu and Kai-iwi Groups (Fleming 1953).

Andesitic tephra (and sometimes rhyolitic tephra) mantles 60% of the suite particularly in the King Country, Taranaki and Taihape areas.

Soils

Soils are influenced by the depth of tephra and the nature of the Tertiary aged rock. The dominant soil groups are yellow-brown loams (New Plymouth, Egmont and Ohakune series). In the King Country the Matiere series occur where weathered andesitic tephra overlies jointed mudstone, and the Tangitu series where the weathered andesitic tephra mantles banded mudstone. Other soils mapped on the high rainfall areas include the Hiwi series and Waitataura series on banded mudstone and the Kohuratahi series on jointed mudstone. On low rainfall areas, soils include the Mangatea, Owhakura and Wilford soils on jointed mudstone and the Kumeroa soils on moderately consolidated sandstone.

Erosion

The diagnostic features of this suite are large, presently active, slumps and deep-seated earthflow erosion complexes. Ancient slump structures, not considered to be presently active but which may possibly become sites of renewed activity, are not included in this suite. Soil slip and sheet erosion is also significant, particularly in the head scarp area of major erosion features. Streambank erosion is frequently recorded where streams undercut the toes of movements.

Erosion severities vary between negligible and very severe. 50% of the suite has slight erosion, 25% moderate erosion, 4% severe erosion and 1% very severe erosion. The remainder is unaffected by present erosion.

It appears that the presence of clay layers in failure zones, together with undercutting of the toe by streams and overloading by weight of water during periods of heavy rainfall contribute to erosion on this suite. Some of the large-scale slump features may have resulted from seismic activity. In the Wanganui area Fleming (1953) suggests that most slumps pre-date European settlement, although some may have rejuvenated after deforestation. Near Wanganui slumping on a large scale is characteristic on sediments of the Kai-iwi, Okehu and Maxwell Groups. The Kai-iwi and Okehu Groups contain pumice members as well as silt and mud members (Fleming 1953). The Maxwell Group comprises unconsolidated sands which form a contact on clay (O'Byrne 1961).

On the Utiku landslide (covering about 18 ha), movement takes place along a thin montmorillonite clay seam at the base of the slide (Stout 1977). On the Mahoenui Formation in the Porootarao area and east of Taumarunui, Luckman *et al.* (1981) suggest that montmorillonite clay contributes to the slope instability. Movement is essentially of a seasonal nature being related largely to the amount of precipitation. Luckman *et al.* (1981) found that for sites monitored east of Taumarunui the average downslope surface velocity was 29 cm/year, while measurements within the Utiku slide (Stout 1977) recorded a displacement of up to 7.6 cm/day. Thompson (1982) postulates that the Utiku slide and numerous other large-scale slope failures in the area have been active for at least the last 11,000–20,000 years. On other large ancient slumps earthflow erosion on the lower portion has the potential to reactivate the entire structure.

Erosion on this suite has resulted in major problems with road and railway communications. Reactivation of the Utiku slide in 1964 caused the North Island Main Trunk railway line to be displaced by up to 7.6 cm/day and resulted in the realignment of State Highway 1 and a county road. Similar problems have affected the NI Main Trunk railway at Porootarao, SH3 at Mt Messenger, and SH41 east of Taumarunui. Movement has also affected county roads, displaced power and telephone lines and temporarily blocked rivers. On farms, damage includes displaced fence lines, and damage to tracks, houses and buildings.

Soil conservation measures are determined by the erosion severity and the need to protect communications or other assets. Tree planting alone is likely to have no significant stabilising effect but in conjunction with mechanical smoothing (to prevent water ponding in hollows and entering tension cracks), and graded banks can be very effective. Reducing stocking rates and/or retiring areas from cattle grazing may also be beneficial. Pair and block planting of conservation trees on slopes adjacent to streams and drainage channels will minimise slope instability.

Land Use

Despite the inherent erosion hazard LUC units on this suite are generally more pastorally productive than those on adjacent hill country suites. Slopes are rolling to moderately steep which favours deep soil development, and on the low rainfall subsuite areas of impeded drainage enable soils to retain moisture for longer periods during summer.

The potential for medium to high stock carrying capacities has resulted in virtually all of this suite being developed for pastoral farming. Both high and low producing pastures occur, with rushes also common in poorly drained areas.

LUC unit IVe8 (5,950 ha)—Figure 119, 120

IVe8 has a negligible to slight present erosion severity and a sufficiently smooth surface to enable cultivation for cropping. About one third of IVe8 occurs in North Taranaki principally in the Uruti and Kaka road areas, and west of Ohura. The remainder is further south in the Wanganui-Rangitikei areas. This includes the Makirikiri valley, Turakina valley, Utiku, Omatane, Pohonui, Upper Parapara road and the Makakaho and Taumatatahi areas of the upper Waitotara valley.

There is a potential for only slight to moderate slump, earthflow and gully erosion, and a potential for moderate to severe sheet and rill erosion if cultivated. Despite the erosion risk it

is one of the most productive of the Class IV LUC units. The potential stock carrying capacity is 24 su/ha, and the site index for *P. radiata* is 28–32 m.

Class VI LUC Units

On LUC units VIe19 and VIe20 cultivation for cropping is not possible due to hummocky micro-relief, slightly steeper slopes and the presence of slump and earthflow erosion which is mainly of slight and moderate severity (Table 38). Present erosion is slight gully and soil slip erosion with slump or earthflow where slopes are incised by drainage channels. Both LUC units have a potential for moderate earthflow, slump and gully and slight soil slip erosion.

LUC unit VIe19 (5450 ha)—Figure 121

VIe19 has less than 1200 mm p.a. rainfall and frequently experiences seasonal soil moisture deficits in summer.

It occurs mainly in the Utiku, Taoroa Junction, Wainui Junction and Tiriraukawa areas near Taihape, but also between the Makirikiri valley and Mt Curl, near Hunterville and Pakihikura, and adjacent to the Ruahine Range.

The potential stock carrying capacity is 19 su/ha and the site index for *P. radiata* is 28–30 m.

LUC unit VIe20 (31,600 ha)

This LUC unit has more than 1200 mm p.a. rainfall. It comprises 68% of the entire suite and occurs mainly in the King Country and Taranaki. 25% of the unit is mapped in the Ongarue district particularly near Porootarao and in the Mangakahu, Waione and Waikoura Stream catchments draining from the Hauhungaroa Range. Elsewhere in the King Country this unit is significant east and south-west of Taumarunui, west of Ohura, near Tatu and in the Kawautahi and Retaruke valleys. In north Taranaki VIe20 is mapped in conjunction with IVe8 and VIIe14 particularly in the vicinity of the Moki, Kaka and Rerekino roads. Further south it occurs inland from Waverley and in the upper Waitotara valley.

High rainfall, with cooler temperatures and more frequent frosts result in LUC unit VIe20 having a lower overall pasture productivity than LUC unit VIe19. This is reflected in a potential stock carrying capacity of 16 su/ha compared to 19 su/ha on LUC unit VIe19. The site index for *P. radiata* is 27–30 m.

Table 38: Present erosion as a percentage of LUC units in the deep seated earthflow and slump erosion suite.

LUC unit	Area (ha)	Present Erosion Severity as Percentage of LUC Unit Area					
		0	1	2	3	4	5
IVe8	5 950	26.5	73.5	–	–	–	–
VIe19	5 450	5.0	44.0	51.0	–	–	–
VIe20	31 500	23.0	52.0	23.5	1.5	–	–
VIIe12	1 450	–	–	66.0	34.0	–	–
VIIe14	1 950	–	–	30.0	50.0	20.0	–

Class VII Units

LUC units VIIe12 and VIIe14 occur on similar slopes to VIe19 and VIe20 but erosion is more extensive and severe (Table 38). Intensive soil conservation measures are required. Forest plantings are essentially for erosion control purposes because although site index figures for *P. radiata* are medium to high, earthflow erosion can result in malformed trees.

At more detailed mapping scales it is possible to differentiate Class VIII units particularly on areas of very severe earthflow erosion occurring at the toe of large-scale movements.

LUC unit VIIe12 (1450 ha)—Figure 121

VIIe12 is mapped at Kaiewe Junction and the junction of Te Moehau Road with State Highway 1. Also at Utiku and north-west of Tapuwae (north of Feilding).

Figure 119: IVe8 with headscarp of slump in distance. Moki Rd, SE of Uruti. N100 116033 looking SE.

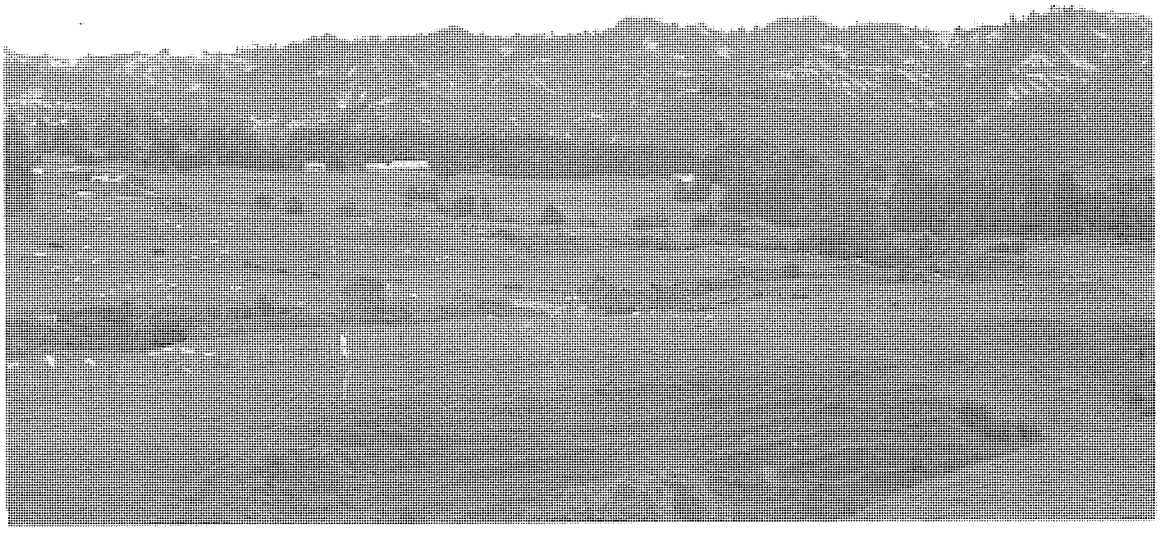


Figure 120: IVe8, Uruti Rd. Erosion by the Uruti Stream (middle distance) contributes to instability on this LUC unit. VIIe20 on 'Urenui' siltstone (LUC subsuite 10b) in distance. N100 116033 looking SW.

Figure 121: VIe19 and VIIe12. Deep-seated slump and earthflow erosion. Utiku, near Taihape. Rangitikei River in foreground. N139 324075 looking NE.

Figure 122: VIIe14, Slump and earthflow erosion on jointed mudstone. Kaka Rd, Waitara River catchment. N110 112969 looking S.

VIIe12 has less than 1200 mm p.a. rainfall and frequently experiences seasonal soil moisture deficits in summer.

It is potentially very productive (for a Class VII LUC unit) despite the constraints imposed on land management by erosion. The potential stock carrying capacity is 15 su/ha and the site index for *P. radiata* is 29–30 m.

LUC unit VIIe14 (1950 ha)—Figure 122

VIIe14 is similar to LUC unit VIIe12 but it occurs mainly in Taranaki and the King Country where rainfall is greater than 1200 mm p.a. Areas mapped as VIIe14 include deep-seated movements adjacent to Uruti and Rerekino roads and at Mt Messenger in Taranaki. In the King Country this unit is mapped south and east of Taumarunui and in the Mangaohutu and Retaruke valleys. VIIe14 also occurs at Makakaho in the upper Waitotara valley.

The potential stock carrying capacity is 13 su/ha and the site index for *P. radiata* is 27 m. This follows the general pattern of LUC units in the higher rainfall areas having a lower pastoral productivity than those in low rainfall areas.

13. LUC SUITE ON MOUNTAINLANDS

This suite occurs on the greywacke mountains of the Ruahine, Kaimanawa and Hauhungaroa Ranges and the higher slopes of the andesitic volcanic cones in the Egmont, and Tongariro National Parks (Figure 123). The suite comprises nine LUC units: VIe16, VIIe10, VIIIe4, VIIIe5, VIIIe6, VIIIe7, VIIIe8, VIIIe9 and VIIIc which together cover 155,370 ha (6.5% of the Region) and comprise 7 of the 12 Class VIII units in the Region. The LUC units are differentiated by slope, altitude, erosion severity and type, and vegetative cover (Table 40). Where there is a significant depth of tephra on greywacke or andesite, separate Class VI and VII units are recorded and included in the yellow-brown loam, Taupo airfall tephra or north-east upland suites.

Physiography

The main area of this suite is on the uplifted mountain blocks of the Ruahine and Kaimanawa Ranges, which form much of the eastern boundary of the Region. The Ruahine Ranges reach their greatest height in the middle of the range at Mangaweka (1733 m a.s.l.) on the Hikurangi Range, and Rangioteatua (1703 m a.s.l.) on the Main Range. Altitudes gradually decrease to 920 m a.s.l. at Wharite in the south and to 1300 m a.s.l. at the north of the Range.

To the north of the Ruahine Range the suite includes the Kaimanawa Ranges which lie east of the Desert Road and north of the Taihape-Napier Road. In the south the Kaimanawas rise to about 1400 m a.s.l. but further north they become steeper and more dissected and reach their greatest height at Makorako (1727 m a.s.l.). Ngapuketurua (1517 m a.s.l.) at the headwaters of the Rangitikei River forms a boundary between the Taranaki-Manawatu, Bay of Plenty-Volcanic Plateau, and Northern Hawkes Bay NZLRI Regions.

The other main areas of this suite are the andesitic cones of the Tongariro Volcanic Centre which rises to a height of 2797 m a.s.l. on Mt Ruapehu; and the volcanic cones of the Egmont National Park which reach a maximum of 2518 m on the summit of Mt Egmont.

The general relief pattern is one of long steep to very steep slopes with areas of undulating to strongly rolling slopes on ridges of the Ruahine and Kaimanawa Ranges.

Climate

The main climatic characteristics of this suite are its high annual rainfall and cool temperatures. Frosts are frequent and snow can fall at any time of the year and lie for several months at higher altitude.

Annual rainfalls over all of the suite is greater than 1600 mm, and the highest areas in the Egmont and Tongariro National Parks receive an estimated 8000 mm p.a. A significant feature of the rainfall in the Egmont National Park is that much of it falls as high intensity

Figure 123: Location of LUC suite 13: mountainlands.

rainstorms. On 11th August 1967 443 mm was recorded at Dawson Falls (945 m a.s.l.) and 427 mm at Stratford Mountain House (846 m a.s.l.). In the two days 10 and 11th August 1967 844 mm was recorded at Dawson Falls—the highest two day total recorded in NZ (Coulter 1976). 795 mm was also recorded on 23rd and 24th February 1971 at Stratford Mountain House.

In the Ruahines annual rainfall is about 5000 mm on the crest of the range where there are at least 250 rain days per year (Grant 1975). In the Kaimanawa Range annual rainfalls are estimated to be lower than in the Ruahines, but increase with altitude from approx. 1400 mm p.a. at 1000 m a.s.l. to an estimated 4000 mm p.a. at about 1700 m a.s.l. (NZ Met. Service 1978). Annual rainfalls are lower in the Hauhungaroa Range where they vary from approximately 2000 mm p.a. to in excess of 2400 mm p.a.

Gale force winds are a common feature. In the Kaimanawa Range and the mountains of the Tongariro National Park the frequency of wind speeds over 30 knots is about 20% and gales (i.e. wind speeds over 33 knots) can be expected on at least 100 days each year (Thompson 1984). The average wind speed on the upper slopes of Mt Egmont has been estimated at about 35 knots (Coulter 1976). The only climatological station on this suite is at Wharite Peak (914 m a.s.l.) in the Southern Ruahine Range. Here the mean daily temperature is 4.5°C and the average wind speed is 827 km/day. This compares with 262 km/day at Palmerston North (23 km distant), and makes Wharite one of the windiest places in New Zealand (Cunningham and Stribling 1978).

Rock Type

Greywacke and andesite are the two dominant rock types. They are often overlain by cover deposits which vary in depth according to distance from source and steepness of the slope, altitude and vegetative cover.

Greywacke occurs in the Ruahine, Kaimanawa and Hauhungaroa Ranges and comprises alternating argillites and sandstones, with some areas of Kaimanawa Schist (Grindley 1960) in the Kaimanawa Ranges. Andesites and associated lahar deposits comprise the rock type on the mountains of the Egmont and Tongariro National Parks. In the Egmont National Park these rocks are mantled by andesitic tephra. In the Hauhungaroa, Kaimanawa and Northern Ruahine Ranges and the volcanic cones of the Tongariro National Park the greywacke or andesite is often mantled with a significant depth of Tongariro tephra which in turn can be mantled with Taupo tephra. Ngauruhoe ash occurs in the vicinity of Mt Ngauruhoe and to the south-east on the Kaimanawa and northern Ruahine Ranges but is not usually of sufficient depth to be recorded. Also included are 350 ha of Tertiary aged sedimentary lithologies (LUC unit VIIIe6) in the north-west Ruahines. In the southern Ruahines loess rather than tephra becomes significant as a soil parent material on rolling and moderately steep slopes.

Soils

Soils of this suite were recorded using information from the soil surveys of Stratford County, Egmont and part Taranaki Counties, Rangitikei County, Pohangina County, King Country, and the General Survey. The largest area of this suite is covered by the soil map of Rangitikei County. The relationship between parent material and soil series for these areas of the Kaimanawa and Northern Ruahine Ranges within Rangitikei County is outlined by Campbell (1978).

The most extensive soil group comprises steepland soils related to yellow-brown earths. Examples are the Rimutaka series in the Ruahine Range and the Otanewainuku series in the Hauhungaroa Range. Where the soils are developed on a significant depth of andesitic tephra steepland soils related to yellow-brown loams occur. In the Ruahine Range these include the Irirangi series on sedimentary rock (VIIIe6) and Otupae series on greywacke. The Te Kie soils occur in the Egmont National Park. Soils are classified as steepland soils related to composite recent soils on yellow-brown pumice soils on yellow-brown loams (Kaimanawa series or Kaweka series) where there is a significant depth of Ngauruhoe tephra on Taupo overlying Tongariro tephra. The Urewera series, a steepland soil related to yellow-brown pumice soils is recorded on parts of the Kaimanawa Range within Taupo County (Rijkse, in prep). Steep and very steep slopes above the timberline have been classified as either subalpine soils or alpine steepland soils (Aitken *et al* 1978, Palmer *et al* 1981) or as Mountain Soils (NZ Soil Bureau 1954). Bare rock is widely recorded and perennial ice and snow is mapped on Mt Ruapehu.

On less steep areas other soil series are differentiated on the basis of soil parent material and altitude. In the Egmont National Park these include the Patua series (yellow-brown loams) and the Maero and Tahurangi soils (Recent soils). In the Southern Kaimanawas recent soils (Ngauruhoe series and Manukaiapu series) are developed on deep Ngauruhoe ash. As the depth of Ngauruhoe ash thins further from source, there is a sequence of composite recent soils on yellow-brown pumice soils (Waimarino series), and composite recent soils on yellow-brown pumice soils on yellow-brown loams (Waiouru series). As the depth of Taupo tephra also thins to the east and south, the following sequence of soils is recorded: yellow-brown pumice soils (Taruarau series), composite yellow-brown pumice soils on yellow-brown loams (Ngamatea series) and yellow-brown loams (Titapu series). In the central and southern Ruahines beyond the influence of the Tongariro tephra, yellow-brown earths of the Ramiha and Renata series and organic soils of the Takapari series are recorded.

Erosion

Map units covering 85% of the suite have erosion recorded. LUC units VIe16, VIIe10 and VIIIc are the least affected having either a negligible or one erosion ranking, while VIIIe7 and VIIIe9 have the highest erosion rankings (Table 39).

Erosion studies on this suite have been mainly in the Ruahine Ranges (particularly on the eastern side outside the Region). Studies conclude that a high rate of erosion can be expected

because the mountain range is so young, active and shattered. Severe erosion occurs where geological and geomorphic factors combine to produce the most favourable conditions i.e. weak lithology, strong deformation and favourable attitude of bedding combined with steep slope and rapid down cutting of streams (NZ Geological Survey 1978). Cunningham and Stribling (1978) have presumed that Ruahine Range erosion rates presently exceed 25m^3/ha/year while Mosely (1977) has stated that in the southern Ruahines "rates of erosion and sediment supply are comparable with the highest found almost anywhere in the world".

Table 39: Present erosion ranking as a percentage of LUC unit in the mountainland suite

LUC unit	Area of LUC Unit (ha)	Present Erosion Ranking as % of LUC Unit Area 0	1	2	3	4	5
VIe16	1,330	53	47	-	-	-	-
VIIe10	5,150	28	72	-	-	-	-
VIIIc	13,490	40	60	-	-	-	-
VIIIe4	56,930	24	44	32	-	-	-
VIIIe5	7,370	1	24	50	21	4	-
VIIIe6	340	-	83	-	17	-	-
VIIIe7	10,370	-	4	5	73	18	-
VIIIe8	40,840	4	34	56	6	-	-
VIIIe9	19,550	-	18	4	38	23	17
Area of LUC suite	155,370						

In the Pohangina Catchment the erosion surface exposed by mass-movement increased by 60% between 1947 and 1963 (James 1973), while Stephens (1975) calculated that in the No 1 Line Catchment the area of eroded slopes increased by 89% between 1946 and 1974.

Much of the erosion pavement areas in the Northern Ruahines and Southern Kaimanawas are considered to have resulted from burning and grazing. Zotov (1940) has also attributed some of the erosion at high altitudes in the Kaimanawa Ranges to deer treading breaking the vegetation and exposing the ground to wind, water and frost action. Throughout the Ruahine Ranges vegetation has been modified by possums, deer and goats (Logan 1971) while localised vegetation damage has been attributed to gale-force winds, and snow (Elder 1965) and insects (Logan 1971). This has resulted in slopes that are more prone to mass movement erosion, most commonly initiated by high intensity rainfalls. The bare surfaces continue to erode by freeze and thaw, rain splash and wind action.

The history of animals in the Egmont National Park is outlined by Mawhinney (1976). The effect of goats in the Egmont National Park are described as being the most serious in the lowland forest and montane scrub zone, however hunting operations are resulting in the recovery of damaged areas. On Mt Egmont heavy rainfall has initiated much erosion particularly where lava flows resting upon unconsolidated gravels have collapsed to form water based debris flows (Neall 1976b). On the Pouakai Range in the Egmont National Park most mass-movement erosion was considered to have been initiated by high intensity rainfall and occurred on slopes over 30°(Fletcher 1978). The presence of montmorillonite clays and lava outcrops were also considered contributing factors.

Land Use

Most of this suite is undeveloped and occurs in the Egmont or Tongariro National Parks, the Kaimanawa or Ruahine State Forest Parks, the State Forests of the Hauhungaroa Range or within the Waiouru Military Reserve north-east of Waiouru. 52% of the suite has indigenous forest as the dominant vegetation, 38% tussock grassland and 10% scrubland, mainly subalpine.

Possums, deer or goats have modified the forest and scrubland vegetation of this suite to a varying extent. This has been most pronounced in the Ruahine Range and in the Egmont National Park.

Much of the tussock grassland and manuka scrubland vegetation in the Kaimanawa and north-west Ruahine Ranges was probably fire induced prior to the arrival of early European runholders. However with the introduction of sheep in the 1870s on the tussock lands of the Inland Patea the regular burning of tussock resulted in much of the present erosion and affected the vegetation of practically all forest margins. The whole face of the Mangamaire up to the timberline of the Makorako Range has been burnt and the forest partly or completely replaced by subalpine scrub and tussock (Elder 1962). Ngamatea Station grazed sheep in the Mangamaire Catchment and up to Makorako (1727 m a.s.l.) and Mt Dowden (1562 m) until recently, and parts of the Mokai Patea Range have also been intermittently grazed. Pastoral farming is now confined to small areas of LUC units VIe16 and VIIe10 on the western margin of the Ruahine Ranges.

LUC unit VIe16 (1350 ha)—Figure 124

This unit is mapped on the western margins of the southern Ruahine Range on short moderately steep and steep valley sides at approximately 350 to 650 m altitude. Also included are short moderately steep slopes at 600 to 750 m asl on ridge crests between the Oroua Catchment and Wharite.

The dominant soils are the strongly leached Ramiha and Renata hill soils which are both strongly leached. The Renata hill soils occurring in areas of higher rainfall (1780–2300 mm p.a.) are also podzolised. There is potential for further pastoral development as pasture is the dominant vegetation on map units covering only 37.5% of the LUC unit. Most the remainder is mixed native scrub associations.

When the present average stock carrying capacity of 8 su/ha is compared with the 14 su/ha potential carrying capacity it is evident that there is also considerable potential to increase production from the existing farmed area. However high fertiliser levels and good grazing management are necessary to maintain pastures and prevent reversion. Cool winter temperatures and seasonal soil moisture deficiencies also limit pasture production.

The site index for *P. radiata* varies from 26 to 29 m depending on altitude and exposure. There is a potential for moderate soil slip and sheet erosion which can be minimised by maintaining a good pasture cover and open planting of conservation trees in areas most susceptible to erosion. However conservation tree establishment may be difficult because of seasonal soil moisture deficiencies, strong winds and browsing by possums.

LUC unit VIIe10 (5,150 ha)—Figure 124

This unit occurs on steep and very steep slopes between 500 and 800 m a.s.l. on the western side of the Ruahine Ranges. It differs from LUC unit VIe16 by being steeper, with longer slopes and shallower soils, and occurring at a higher altitude with a more severe climate.

The Ruahine and Rimutaka steepland soils occurring on this unit are shallow and drought prone with significant areas of bare rock outcrops with no soil development.

This unit has a potential stock carrying capacity of 9 su/ha. Lower and mid slopes have a site index for *P. radiata* of 24–27 m depending on altitude and exposure, however steeper upper slopes are generally unsuited to forestry because of access, establishment and logging difficulties.

There is a potential for severe sheet, scree creep, soil slip and debris avalanche erosion. Erosion control measures include topdressing and oversowing to improve pastures, block planting where necessary, and pair planting of watercourses. Planted areas must be adequately protected from damage by possums, goats, and deer.

800 ha of rolling and strongly rolling slopes on ridge crests at approximately 750–1000 m a.s.l. in the Delaware Ridge area of the southern Ruahine Range are also mapped as VIIe10. These have Renata silt loam and Takapari hill soils developed on loess with some volcanic tephra, overlying greywacke. Because of gentler slopes and generally more severe climatic limitations these map units could have been classified as a separate LUC unit. However, they

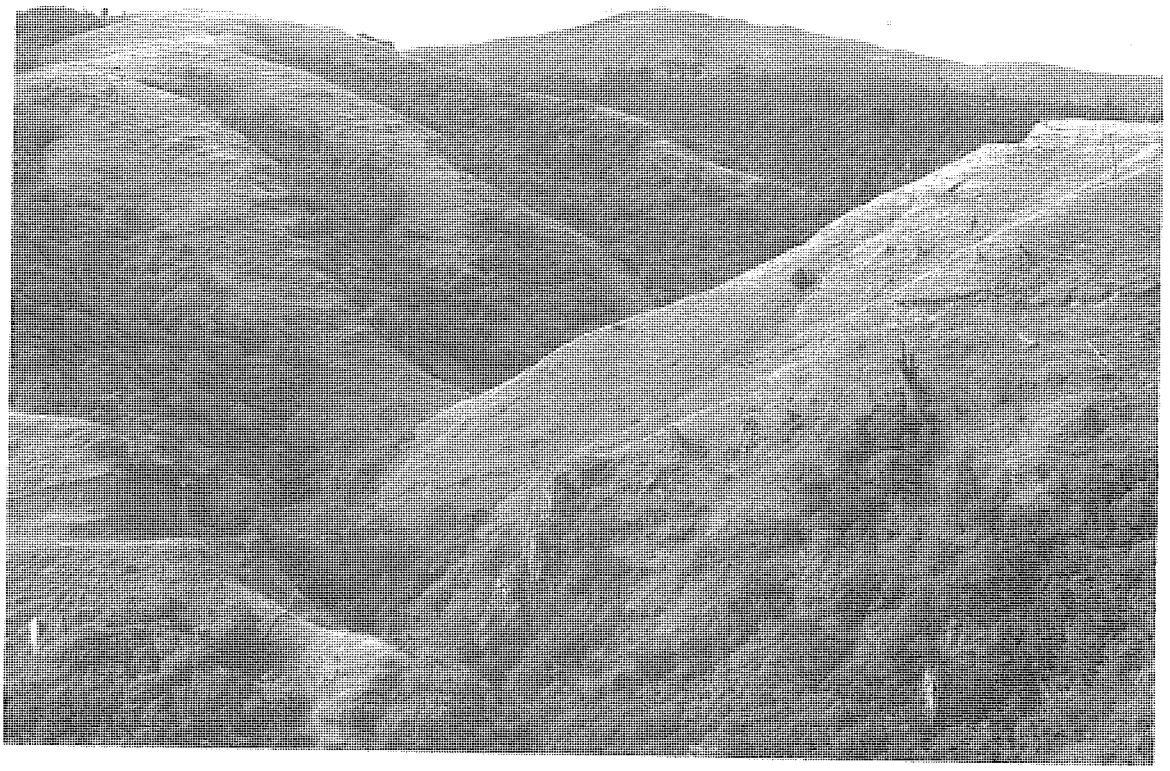


Figure 124: VIe16 in foreground. VIIe10 in distance on slopes of Mt Wharite (920 m a.s.l.). N149 303456 looking NE.

were included with VIIe10 because of the small area involved and the need to minimise the number of regional LUC units.

CLASS VIII UNITS

The seven Class VIII LUC units differentiated in this LUC suite can be grouped as follows:

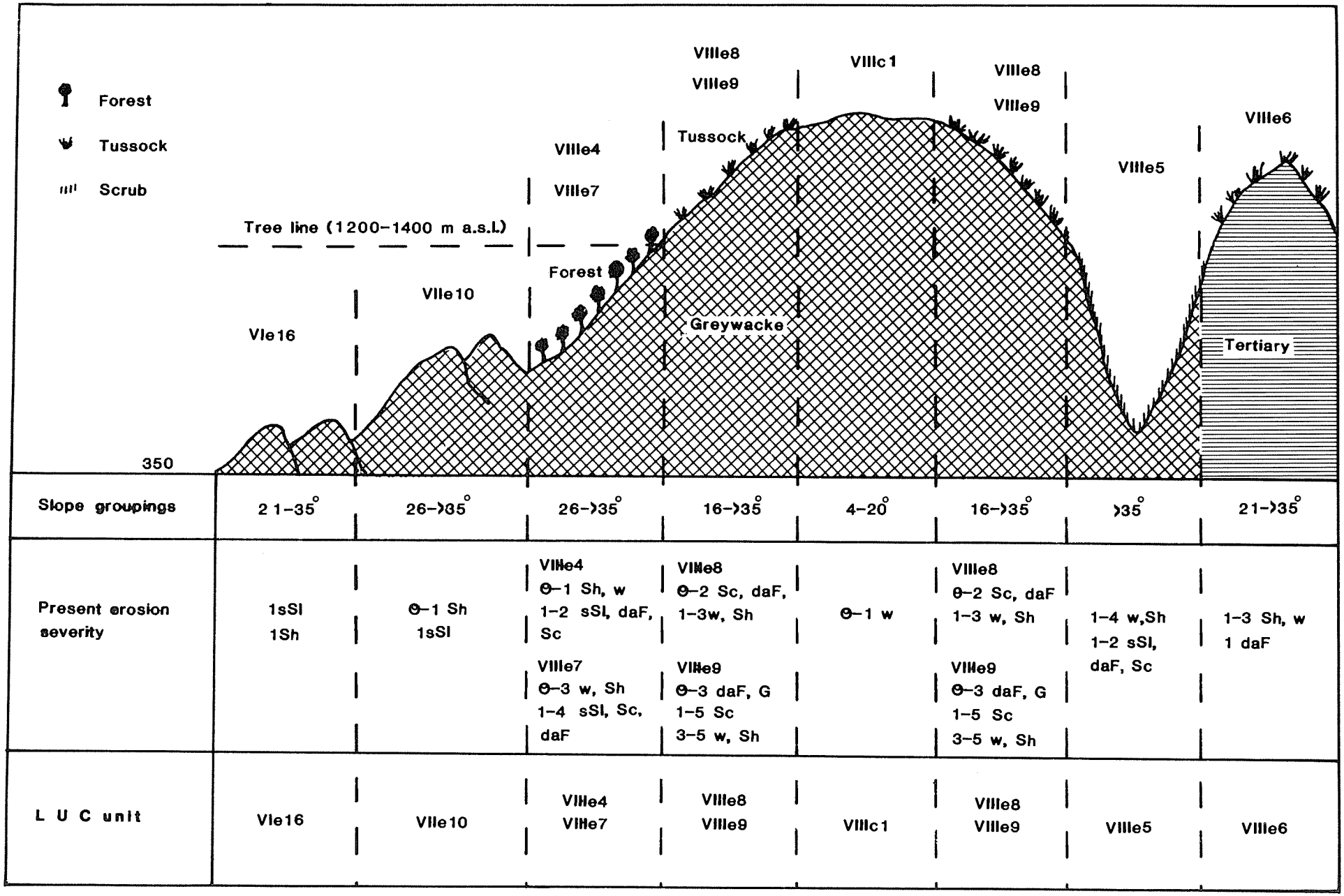
1. Steep and very steep forested land is classified as LUC units VIIIe4 or VIIIe7 depending on the present erosion.
2. Strongly rolling to very steep slopes above the timberline with a dominantly tussock vegetation are classified as LUC units VIIIe8 or VIIIe9 depending on the present erosion.
3. Very steep slopes between 700–1000 m a.s.l. with a potential for revegetation are classified as LUC unit VIIIe5.
4. LUC unit VIIIe6 is for sedimentary lithologies above 1,000 m a.s.l.
5. LUC unit VIIIIc comprises undulating to strongly rolling slopes above 1300 m a.s.l. with a slight erosion potential.

LUC UNITS WITH A FOREST VEGETATION

LUC unit VIIIe4 (56,950 ha)—Figure 74

This unit is mapped on steep and very steep forested slopes in the Kaimanawa, Ruahine and Hauhungaroa Ranges and on the mountains of the Egmont and Tongariro National Parks. Present erosion is of negligible to moderate severity with a potential for very severe to extreme erosion. The main erosion types are soil slip, and debris avalanche erosion.

Table 40: Relationships between LUC units mapped in the mountain land LUC suite



Slope groupings	21–35°	26–>35°	26–>35°	16–>35°	4–20°	16–>35°	>35°	21–>35°
Present erosion severity	1sSl 1Sh	Θ–1 Sh 1sSl	VIIIe4 Θ–1 Sh, w 1–2 sSl, daF, Sc VIIIe7 Θ–3 w, Sh 1–4 sSl, Sc, daF	VIIIe8 Θ–2 Sc, daF, 1–3w, Sh VIIIe9 Θ–3 daF, G 1–5 Sc 3–5 w, Sh	Θ–1 w	VIIIe8 Θ–2 Sc, daF 1–3 w, Sh VIIIe9 Θ–3 daF, G 1–5 Sc 3–5 w, Sh	1–4 w,Sh 1–2 sSl, daF, Sc	1–3 Sh, w 1 daF
L U C unit	VIe16	VIIe10	VIIIe4 VIIIe7	VIIIe8 VIIIe9	VIIIc1	VIIIe8 VIIIe9	VIIIe5	VIIIe6

LUC unit VIIIe7 (10,350 ha)—Figure 128

This LUC unit is similar to VIIIe4 but has severe to extreme present erosion. The principal erosion types are soil slip, debris avalanche and scree creep; with wind and sheet erosion also significant in some areas. Most VIIIe7 occurs in the Ruahine Ranges.

LUC UNITS WITH A TUSSOCK VEGETATION

Two LUC units, VIIIe8 and VIIIe9 are mapped on strongly rolling to very steep slopes with a dominantly tussock grassland vegetation.

In the Egmont National Park, southern areas of the Tongariro National Park and the Ruahine Range these LUC units occur above the timberline, which is generally at about 1250–1350 m a.s.l. However in much of the Tongariro National Park and in the southern Kaimanawa Range LUC units VIIIe8 and VIIIe9 occur down to 1000 m a.s.l.

The principal soil conservation requirement is to maintain the existing indigenous vegetation by preventing burning and controlling browsing animals. At this altitude the planting of soil conservation species would generally not be successful (R L Hathaway pers. comm.). Vehicles should be restricted to properly constructed and maintained tracks. LUC units VIIIe8 and VIIIe9 are differentiated by their present erosion ranking.

LUC unit VIIIe8 (40,840 ha)—Figures 125, 126, 127

This LUC unit has slight to severe wind and sheet erosion, and slight to moderate scree creep and debris avalanche erosion. There is a potential for extreme erosion to occur. Map units with severe to extreme erosion are mapped as LUC unit VIIIe9.

LUC unit VIIIe9 (19,550 ha)—Figure 128

VIIIe9 is similar to VIIIe8 but has severe to extreme wind, sheet and scree creep erosion. Severe gully and debris avalance erosion may also occur. LUC unit VIIIe9 is more widespread in the Tongariro National Park (Table 41) because there LUC Class VIII land above the timberline extends to a higher altitude than in other areas.

OTHER LUC UNITS

LUC unit VIIIe5 (7350 ha)—Figure 125

This unit is mapped on long very steep greywacke mountain slopes at 700–1000 m altitude in the Rangitikei River Catchment north of the Taihape-Napier Road.

VIIIe5 has slight to very severe wind and sheet erosion, which in some instances has completely removed the tephra, resulting in scree creep erosion on the exposed greywacke rock. Some areas are also susceptible to slight to moderate soil slip and debris avalanche erosion. Rock outcrops are a feature. Because of a previous history of burning this unit is now dominantly in manuka vegetation, although there are also significant areas with mountain *Nothofagus* forest. Soil conservation measures include prevention of burning, the control of browsing animals and the revegetation of eroded areas.

LUC unit VIIIe6 (340 ha)

This unit is mapped on moderately steep to very steep slopes underlain by Tertiary aged lithologies. It occurs between 1100 and 1300 m a.s.l. in the vicinity of the Ohutu Ridge and the Otupae Range in the north-west Ruahines.

Erosion is predominantly slight to severe sheet and wind. Unlike other LUC units in this suite the sheet and wind erosion types do not eventually result in scree creep. Soil conservation measures include the prevention of burning and the control of browsing animals to maintain the existing vegetation cover, and the revegetation of eroded areas.

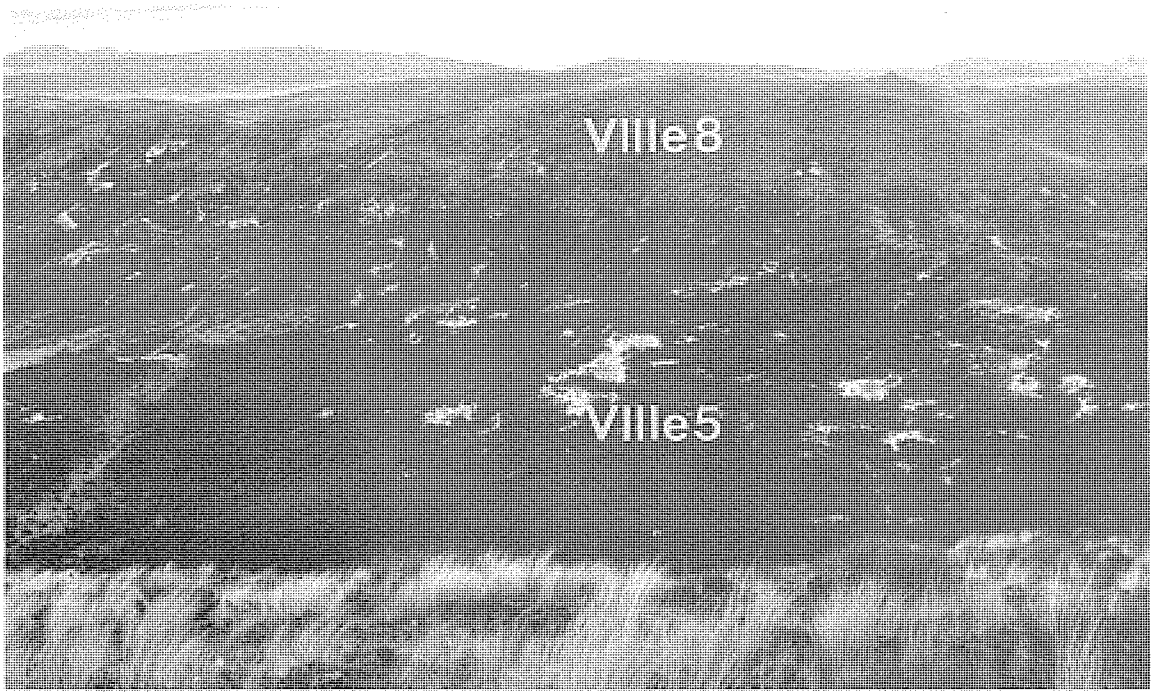


Figure 125: VIIIe5 and VIIIe8 Kaimanawa Range. Ngamatea basin in distance N122 435560 looking E.

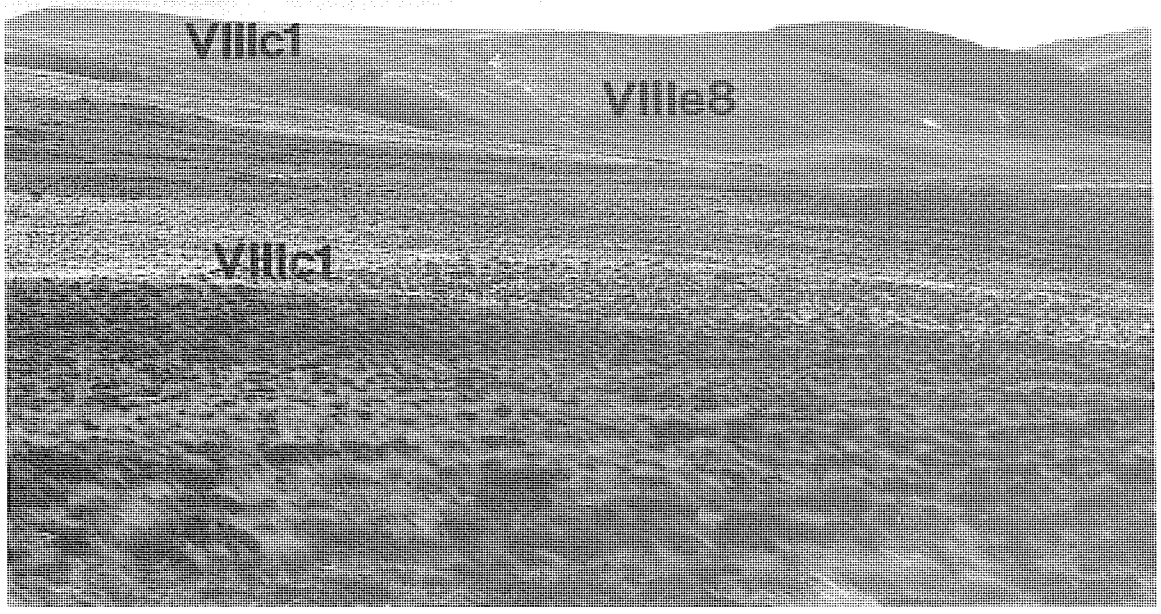


Figure 126: VIIIc1, VIIIe8 Stowman Range, Waiouru Military Reserve. N122 436560 looking S.

Figure 127: VIIIe8. Headwaters of Rangitikei R. catchment. Ngapuketurua 1517 m in distance. N113 490890 looking NE.

Figure 128: VIIIe7 and VIIIe9. Waikamaka R. catchment, Ruahine Ranges. N140 590070 looking SE. Photo: P.R. Stephens

Table 41: Percentage of LUC unit occurring in each of the five mountain areas in the mountainlands suite

LUC unit	Total area (ha)	Ruahines	Kaimanawas	Tong. Nt Pk	Egmont Nt Pk	Hauhungaroas	TOTAL %
VIe16	1,330	100	–	–	–	–	100
VIIe10	5,150	100	–	–	–	–	100
VIIIc	13,490	35	39.5	24.5	0.5	0.5	100
VIIIe4	56,930	45	28	17.5	2.5	7.0	100
VIIIe5	7,370	–	100	–	–	–	100
VIIIe6	340	100	–	–	–	–	100
VIIIe7	10,370	52.5	21.5	17	2	7	100
VIIIe8	40,840	17.5	42.5	37	3	–	100
VIIIe9	19,550	13.5	18.5	52	16	–	100
	155,370						

LUC unit VIIIc1 (13,500 ha)—Figures 74, 126

This unit comprises undulating to strongly rolling slopes above the timberline with negligible to slight erosion. These areas are normally above 1300 m a.s.l., with an extreme climatic limitation. Most VIIIc1 is mapped in the southern Kaimanawa mountains (e.g. Stowman Range, Three Kings Range), Ruahine Range particularly the Mokai-Patea Range and parts of the main Ruahine Range, and the west and south of the Tongariro National Park. Minor areas are also mapped in the Hauhungaroa Range, and the Pouakai Range in Egmont National Park.

Although present erosion is not serious there is a potential for extreme erosion if the indigenous vegetative cover is depleted. LUC units VIIIe6, VIIIe8 or VIIIe9 are mapped where the present erosion ranking is greater than slight.

VIIIc1 is undeveloped being principally in red tussock grassland and subalpine scrub associations. Some VIIIc1 map units in the southern Kaimanawas and the Ruahine Ranges have been used for summer grazing by adjacent stations, however because of the extreme physical limitations to pastoral use, VIIIc1 should only be used for catchment protection.

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APPENDIX 1: LUC Suites and Subsuites in the Taranaki-Manawatu Region.

LUC suite/ subsuite	LUC suite/subsuite name	LUC units	Area (ha) and percent of region			
			ha	%	ha	%
1	YELLOW-BROWN LOAMS					
1a	Waimarino	IIc1, IIIw3, IIIc1, IIIe5, IVe6, IVc1, VIc1	73,500	3.0		
1b	King Country	IIs4, IIIe1, IVe1, VIs1	10,500	0.4		
1c	Inland plateaux	IVw3, VIe22	14,800	0.6		
1d	Taranaki	Ic1, Ic3, Iw2, IIe1, IIc2, IIc3, IIIe2, IIIe6, IIIc4, IVe2, IVe7, IVc3, Vc1, VIe1, VIe6, VIe25, VIc5, VIIe18	276,550	11.5	375,350	15.5
2	LAHARS IN TARANAKI	IIw3, IIs3, IIIw3, IIIw5, IIIs1, IIIs3 IIIs5, IVs1, Vs1, VIs3, VIs6			79,100	3.3
3	COASTAL SAND COUNTRY	IIIw4, IVe10, VIe24, VIs4, VIIe15, VIIIe1			81,950	3.4
4	ALLUVIUM					
4a	Wide floodplains and river valleys	Iw1, IIw1, IIw2, IIw4, IIs1, IIIw1, IIIs2, IVs2, VIs7	77,750	3.3		
4b	Narrow river valleys	IIIw2, IVw1, IVw2	20,100	0.8	97,850	4.1
5	LOESS					
5a	Low rainfall	IIs2, IIIe4, IVe4, VIe2	100,350	4.2		
5b	High rainfall	Ic2, IIe2, IIc1, IIIe3, IIIc2, IVe3, VIc2	49,600	2.1	149,950	6.3
6	TAUPO AIRFALL TEPHRA					
6a	Shallow Taupo airfall tephra	IVe5, Vs2, VIe9, VIs2, VIs8, VIIs1	12,950	0.6		
6b	Deep Taupo airfall tephra	IIIe7, IIIs4, IVe9, VIe18, VIs5, VIIe8	76,950	3.2	89,900	3.8
7	TAUPO FLOW TEPHRA AND WATER SORTED TEPHRA	IIs5, IIIe8, IIIs6, IVe11, IVe13, IVe14, IVw4, IVs3, VIe26, VIw1, VIIe19, VIIe26, VIIIe2, VIIIe10, VIIIw1			40,900	1.7
8	NORTH-EAST UPLANDS					
8a	Shallow Taupo and/or Ngauruhoe tephra	IIIc3, IVe12, IVc2, VIe27, VIc3, VIIe21, VIIe22, VIIe23	98,950	4.1		
8b	Deep Taupo and/or Ngauruhoe tephra	IVc4, VIc4, VIIe24, VIIe25, VIIc1, VIIIe10	56,700	2.4	155,650	6.5
9	MUDSTONE					
9a	Jointed mudstone	VIe3, VIe4, VIIe1, VIIe2, VIIIe3	127,350	5.3		
9b	Banded mudstone	VIe5, VIIe7, VIIIe3	33,600	1.4	160,950	6.7
10	SILTSTONE					
10a	Siltstone	VIe7, VIe8, VIe10, VIIe4, VIIe9, VIIIe3	145,800	6.1		
10b	Urenui siltstone	VIe21, VIIe20, VIIIe3	29,100	1.2	174,900	7.3
11	SANDSTONE					
11a	Unconsolidated	VIe12, VIe14, VIIe16, VIIIe2	54,750	2.3		
11b	Moderately consolidated	VIe12, VIe14, VIIe3, VIIe5, VIIIe3	67,050	2.8		
11c	Moderately consolidated with slump and earth-flow erosion	VIe11, VIIe6	33,550	1.4		
11d	Consolidated	VIe13, VIe15, VIe23, VIIe11, VIIe13, VIIIe3	519,300	21.4		
11e	Hard consolidated	VIe17, VIIe17, VIIIe3	105,050	4.3	779,700	32.2
12	DEEP SEATED EARTHFLOW AND SLUMP EROSION	IVe8, VIe19, VIe20, VIIe12, VIIe14			46,400	1.9
13	MOUNTAINLANDS	VIe16, VIIe10, VIIIe4, VIIIe5, VIIIe6, VIIIe7, VIIIe8, VIIIe9, VIIIc1			155,400	6.5
Not mapped (rivers, urban etc)					21,050	0.8
TOTAL					2,409,050	100.0

APPENDIX 2:
Areas of Land Use Capability Units Mapped in the Region

LUC Unit	Unit Total (ha)	Subclass Total (ha)	Class Total (ha)	Percent of Region
Iw1	10,250			
Iw2	1,850	12,100		
Ic1	8,750			
Ic2	11,850			
Ic3	31,600	52,200		
			64,300	2.7
IIe1	10,050			
IIe2	7,500	17,550		
IIw1	1,500			
IIw2	39,700			
IIw3	450			
IIw4	2,800	44,450		
IIs1	6,100			
IIs2	55,950			
IIs3	3,950			
IIs4	600			
IIs5	800	67,400		
IIc1	9,150			
IIc2	12,050			
IIc3	28,000	49,200		
			178,600	7.4
IIIe1	1,400			
IIIe2	9,300			
IIIe3	4,400			
IIIe4	11,800			
IIIe5	9,700			
IIIe6	7,150			
IIIe7	4,650			
IIIe8	1,900	50,300		
IIIw1	2,600			
IIIw2	11,500			
IIIw3	5,700			
IIIw4	24,800			
IIIw5	9,050	53,650		
IIIs1	8,100			
IIIs2	7,850			
IIIs3	6,450			
IIIs4	1,650			
IIIs5	10,650			
IIIs6	9,300	44,000		
IIIc1	21,200			
IIIc2	5,950			
IIIc3	1,650			
IIIc4	34,950	63,750		
			211,700	8.8
IVe1	3,200			
IVe2	11,150			
IVe3	4,150			
IVe4	11,800			
IVe5	3,100			
IVe6	11,950			
IVe7	21,750			
IVe8	5,950			
IVe9	17,400			
IVe10	15,050			
IVe11	7,250			
IVe12	10,750			
IVe13	5,950			
IVe14	1,750	131,200		
IVw1	6,750			
IVw2	1,850			
IVw3	4,700			
IVw4	2,250	15,550		

LUC Unit	Unit Total (ha)	Subclass Total (ha)	Class Total (ha)	Percent of Region
IVs1	6,150			
IVs2	3,150			
IVs3	50	9,350		
IVc1	9,700			
IVc2	8,850			
IVc3	19,700			
IVc4	7,150	45,400		
			201,500	8.4
Vs1	8,650			
Vs2	1,850	10,500		
Vc1	31,000	31,000		
			41,500	1.7
VIe1	10,200			
VIe2	20,800			
VIe3	50,450			
VIe4	24,900			
VIe5	26,800			
VIe6	28,000			
VIe7	14,400			
VIe8	17,300			
VIe9	400			
VIe10	32,200			
VIe11	30,100			
VIe12	21,250			
VIe13	12,550			
VIe14	54,500			
VIe15	23,250			
VIe16	1,350			
VIe17	46,000			
VIe18	21,800			
VIe19	5,450			
VIe20	31,600			
VIe21	3,350			
VIe22	10,100			
VIe23	68,200			
VIe24	11,250			
VIe25	4,000			
VIe26	1,200			
VIe27	26,000	597,400		
VIw1	1,650	1,650		
VIs1	5,300			
VIs2	4,050			
VIs3	5,600			
VIs4	7,250			
VIs5	20,150			
VIs6	15,400			
VIs7	3,800			
VIs8	1,850	63,400		
VIc1	18,200			
VIc2	8,000			
VIc3	27,300			
VIc4	17,050			
VIc5	800	71,350		
			733,800	30.5
VIIe1	29,100			
VIIe2	22,900			
VIIe3	14,700			
VIIe4	12,150			
VIIe5	14,500			
VIIe6	3,450			
VIIe7	6,800			
VIIe8	11,300			
VIIe9	69,750			
VIIe10	5,150			
VIIe11	316,000			
VIIe12	1,450			

LUC Unit	Unit Total (ha)	Subclass Total (ha)	Class Total (ha)	Percent of Region
VIIe13	22,300			
VIIe14	1,950			
VIIe15	20,500			
VIIe16	14,500			
VIIe17	59,050			
VIIe18	6,550			
VIIe19	1,550			
VIIe20	25,750			
VIIe21	8,900			
VIIe22	7,400			
VIIe23	8,100			
VIIe24	10,200			
VIIe25	4,550			
VIIe26	3,900	702,450		
VIIs1	1,700	1,700		
VIIc1	12,900	12,900		
			717,050	29.8
VIIIe1	3,100			
VIIIe2	5,150			
VIIIe3	77,000			
VIIIe4	56,950			
VIIIe5	7,350			
VIIIe6	350			
VIIIe7	10,350			
VIIIe8	40,850			
VIIIe9	19,550			
VIIIe10	5,050	225,700		
VIIIw1	350	350		
VIIIc1	13,500	13,500		
			239,550	9.9
Area mapped	2,388,000			
Areas not mapped (rivers, urban areas etc)	21,050			0.8
TOTAL	2,409,050			100.0

APPENDIX 3:
Publication details of NZLRI Worksheets in the Region.

Worksheet Number	Name	Author(s)*	Date of Field Work	Date of Publication
83 pt.	Te Kuiti	P R Stephens	1976	1979
84 pt.	Whakamaru	P R Stephens	1976	1979
91 pt.	Mokau	A J Reid	1978	1979
		M S Redpath		
92 pt.	Ongarue	K E Noble	1976	1979
		M J Page		
		A J Reid		
93 pt	Waihaha	P R Stephens	1976	1979
99	Mimi	A J Reid	1978	1979
100 pt	Ohura	M R Jessen	1978	1979
		A J Reid		
101	Taumarunui	P R Stephens	1976	1979
		M R Jessen	1977	
102 pt.	Tokaanu	M R Jessen	1976	1979
108	New Plymouth	M R Jessen	1978	1979
109	Inglewood	M R Jessen	1979	1979
		A J Reid		
110	Whangamomona	A J Reid	1978	1979
111	Waimarino	M J Page	1976	1979
		K E Noble	1978	
		P M Blaschke		
		A M Campbell		
112 pt	Ngauruhoe	M R Jessen	1976	1979
		A M Campbell	1978	
113 pt	Kaweka	A M Campbell	1978	1979
118	Egmont	M R Jessen	1978	1979
119	Stratford	J R Fletcher	1978	1979
120	Matemateonga	A J Reid	1978	1979
121	Ohakune	P M Blaschke	1978	1979
122 pt	Ruapehu	A M Campbell	1978	1979
123 pt	Ngamatea	A M Campbell	1978	1979
128	Oeo	M R Jessen	1978	1979
129	Hawera	M R Jessen	1978	1979
130	Waitotara	M J Page	1978	1979
131	Kakatahi	P M Blaschke	1978	1979
		M J Page	1979	
132	Taihape	J R Fletcher	1978	1979
133 pt	Wakarara	J R Fletcher	1978	1979
136	Patea	J C van Amerongen	1978	1979
137	Waverley	J C van Amerongen	1978	1979
138	Wanganui	J C van Amerongen	1978	1979
139	Mangaweka	P M Blaschke	1979	1979
		T F Crippen		
		A J Reid		
140 pt	Ongaonga	P R Stephens	1976	1979
		M J Page	1979	
		A J Reid		
143	Marton	J C van Amerongen	1978	1979
144	Feilding	K E Noble	1976	1979
		P R Stephens	1978	
145 pt	Dannevirke	P R Stephens	1976	1979
		K E Noble	1978	
148	Tangimoana	J C van Amerongen	1979	1979
149 pt.	Palmerston North	K W Steel	1976	1979
		P R Stephens	1979	

*Applies only to that part of worksheet within Taranaki-Manawatu Region.

NOTE: Bibliographic reference for individual worksheets (example):
Jessen, M.R. 1979: N129 Hawera N.Z. Land Resource Inventory Worksheet. NWASCA Wellington.

APPENDIX 4:

Correlation of LUC Units Mapped in the Region, with LUC Units of the adjacent Bay of Plenty-Volcanic Plateau, Waikato, Northern Hawkes Bay, Southern Hawkes Bay-Wairarapa and Wellington Regions. This correlation is from Page (1985). It gives the correlation of each LUC unit to its North Island correlation unit (NICU). See Figure 1 for location of adjoining regions.

LUC unit	NICU	BOP	WKO	NHB	SHW	WLN
Iw1	1w5					Iw1
IIw2	2w10					IIw1
IIw4	2w12					IIw2
IIs1	2s10					IIs1
IIs2	2s11					IIs2
IIIe1	3e3		IIIe1			
IIIe4	3e16					IIIe1
IIIe7	3e26	IIIe8				
IIIe8	3e28	IIIe10				
IIIw1	3w5				IIIw2	
IIIw2	3w2				IIIw1	IIIw1
IIIw4	3w11				IIIw2	IIIw2
IIIs2	3s8			IIIs2	IIIs2	IIIs2
IIIs4	3s10	IIIs2				
IIIs6	3s20	IIIs6	IIIs1			
IVe1	4e2		IVe1			
IVe2	4e2		IVe1			
IVe3	4e7				IVe1	IVe1
IVe4	4e14					IVe1
IVe5	4e12	IVe4				
IVe9 (part)	4e25	IVe6				
IVe9 (part)	4e27	IVe8				
IVe9 (part)	4e43	IVe16				
IVe11	4e35	IVe13				
IVe12	4e42			IVe4		
IVe13	4e39	IVe15				
IVe14	4e45	IVe18		IVe5		
IVw2	4w2	IVw1	IVw1	IVw1	IVw1	
IVw4	4w7				IVw2	
IVs2	4s5				IVs1	IVs1
IVs3	4s12	IVs5		IVs2		
IVc4	4c4			IVc1		
VIe1	6e3		VIe1			
VIe2	6c4			VIe2		VIe1
VIe3	6e22		VIe9	VIe3	VIe7	
VIe4	6e23			VIe3	VIe8	
VIe9	6e19	VIe5	VIe20			
VIe11	6e55			VIe9		
VIe12	6e37				VIe9	
VIe14	6e51				VIe9	VIe4
VIe16	6e86				VIe11	VIe9
VIe17	6e88		VIe18			
VIe18	6e89	VIe9 VIe18				
VIe19	6e61				VIe10	
VIe20	6e62		VIe19	VIe10	VIe10	
VIe24	6e90			VIe13	VIe14	VIe6
VIe26	6e95	VIe24				
VIe27	6e96			VIe16		
VIw1 (part)	6w2	VIw1		VIs2		
VIw1 (part)	6w3	VIw2				
VIs2	6s1	VIs1				
VIs4	6s4					VIs3
VIs5	6s5	VIs1				
VIs7	6s15			VIs3	VIs4	VIs1

LUC unit	NICU	BOP	WKO	NHB	SHW	WLN
VIc3 (part)	6c10			VIc2		
VIc3 (part)	6c14	VIe23				
VIc4	6c12	VIc1				
VIIe1	7e2		VIIe5	VIIe1	VIIe1	
VIIe2	7e3			VIIe1	VIIe1	
VIIe3	7e10				VIIe4	
VIIe4	7e5				VIIe2	
VIIe5	7e11				VIIe4	
VIIe7	7e4			VIIe2	VIIe2	
VIIe8	7e31	VIIe6				
VIIe9	7e4			VIIe2	VIIe2	VIIe2
VIIe10	7e52				VIIe10	VIIe5
VIIe12	7e23				VIIe8	
VIIe14	7e24		VIIe4	VIIe6	VIIe8	
VIIe15	7e58			VIIe13	VIIe14	VIIe14
VIIe17	7e60		VIIe12			
VIIe19	7e61	VIIe12		VIIe16		
VIIe21	7e71			VIIe12		
VIIe22	7e74			VIIe18	VIIe10	
VIIe24	7e72			VIIe17		
VIIe25	7e73	VIIe15				
VIIs1	7s3	VIIe4	VIIs1			
VIIc1	7c1	VIIc1		VIIe17		
VIIIe1	8e1	VIIIe1	VIIIe4	VIIIe1	VIIIe4	VIIIe1
VIIIe2	8e5	VIIIe2		VIIIe4		
VIIIe3	8e3		VIIIe3	VIIIe3	VIIIe2	VIIIe2
VIIIe4	8e6	VIIIe3	VIIIe1	VIIIe5	VIIIe5	VIIIe3
VIIIe5	8e8			VIIIe8	VIIIe7	
VIIIe6	8e10			VIIIe7		
VIIIe7	8e7	VIIIe4		VIIIe6	VIIIe6	VIIIe4
VIIIe8	8e11	VIIIe6			VIIIe8	
VIIIe9	8e13	VIIIe7		VIIIe9	VIIIe9	VIIIe5
VIIIe10	8e9	VIIIe5				
VIIIw1	8w2	VIIIw2		VIIw1		
VIIIc1	8c1	VIIIc1		VIIIe10	VIIIc1	

APPENDIX 5:
Stock Carrying Capacity Data for LUC Units in the Region

LUC Unit	Present Average (su/ha)	Top Farmer (su/ha)	Attainable Physical Potential (su/ha)	
Iw1	15	22	30	
Iw2	20	25	30	
Ic1	20	25	30	
Ic2	20	25	30	
Ic3	20	25	30	
IIe1	17	23	28	
IIe2	15	26	28	
IIw1	15	22	30	
IIw2	19	25	30	
IIw3	15	19	22	
IIw4	18	25	30	
IIs1	13	22	30	
IIs2	14	24	26	
IIs3	17	20	22	
IIs4	12	16	24	
IIs5	18	20	30	
IIc1	15	22	26	
IIc2	17	23	28	
IIc3	18	25	30	
IIIe1	12	15	22	
IIIe2	16	21	23	
IIIe3	15	22	26	
IIIe4	14	21	25	
IIIe5	14	19	21	
IIIe6	16	21	22	
IIIe7	12	14	20	(16*)
IIIe8	12	14	20	(16*)
IIIw1	17	23	28	
IIIw2	16	18	25	
IIIw3	16	20	24	
IIIw4	15	18	25	
IIIw5	15	19	22	
IIIs1	17	20	22	
IIIs2	16	20	26	
IIIs3	16	19	21	
IIIs4	12	14	20	(16*)
IIIs5	16	19	22	
IIIs6	12	14	20	(16*)
IIIc1	14	19	22	
IIIc2	15	22	25	
IIIc3	14	16	20	
IIIc4	16	21	25	
IVe1	12	14	20	
IVe2	14	17	21	
IVe3	13	18	24	
IVe4	13	18	21	
IVe5	11	13	18	
IVe6	14	19	21	
IVe7	14	17	20	
IVe8	17	20	24	
IVe9	11	12	16	
IVe10	9	14	20	
IVe11	10	11	13	
IVe12	11	14	16	
IVe13	10	11	14	
IVe14	6	6	10	
IVw1	13	17	19	
IVw2	12	16	18	
IVw3	11	14	16	
IVw4	9	10	15	
IVs1	14	16	18	
IVs2	14	16	20	

LUC Unit	Present Average (su/ha)	Top Farmer (su/ha)	Attainable Physical Potential (su/ha)
IVs3	8	9	10
IVc1	7	12	16
IVc2	11	14	16
IVc3	14	17	21
IVc4	8	9	10
Vs1	10	12	14
Vs2	11	12	16
Vc1	14	18	19
VIe1	11	15	18
VIe2	10	14	19
VIe3	10	15	19
VIe4	12	16	19
VIe5	10	12	14
VIe6	10	15	17
VIe7	11	15	18
VIe8	10	13	17
VIe9	10	11	14
VIe10	9	12	13
VIe11	13	17	19
VIe12	10	14	16
VIe13	10	12	14
VIe14	9	11	14
VIe15	11	14	16
VIe16	8	10	14
VIe17	8	10	11
VIe18	8	10	11
VIe19	13	17	19
VIe20	11	13	16
VIe21	7	10	11
VIe22	10	12	13
VIe23	6	11	13
VIe24	6	10	14
VIe25	-	-	10
VIe26	8	8	9
VIe27	7	11	14
VIw1	6	6	8
VIs1	11	13	16
VIs2	11	12	16
VIs3	8	10	12
VIs4	9	14	20
VIs5	9	11	14
VIs6	12	14	16
VIs7	3	6	7
VIs8	8	8	9
VIc1	12	15	17
VIc2	13	17	20
VIc3	10	11	13
VIc4	8	8	9
VIc5	-	-	16
VIIe1	8	11	14
VIIe2	8	11	14
VIIe3	5	8	10
VIIe4	8	11	12
VIIe5	5	8	9
VIIe6	10	14	16
VIIe7	9	10	11
VIIe8	-	-	9
VIIe9	8	10	12
VIIe10	6	8	10
VIIe11	5	7	9
VIIe12	11	14	15
VIIe13	6	8	10
VIIe14	9	10	13
VIIe15	2	4	5
VIIe16	6	8	9
VIIe17	4	5	6

LUC Unit	Present Average (su/ha)	Top Farmer (su/ha)	Attainable Physical Potential (su/ha)
VIIe18	–	–	5
VIIe19	7	7	7
VIIe20	7	10	11
VIIe21	1	2	3
VIIe22	1	2	3
VIIe23	3	6	8
VIIe24	1	2	2
VIIe25	–	–	1
VIIe26	–	–	1
VIIs1	4	4	5
VIIc1	1	2	2

*This figure applies to a non lucerne grazing system.

APPENDIX 6:

Site Index Data (*Pinus radiata*) for LUC Units in the Region

LUC Unit	Site Index (m)	Comments
Iw1	30–34	
Iw2	29–32	
Ic1	27–30	
Ic2	29–32	
Ic3	29–32	
IIe1	27–30	
IIe2	29–32	
IIw1	33–34	
IIw2	33–35	
IIw3	23–26	Areas with difficult drainage unsuitable for production forestry
IIw4	30–32	
IIs1	32–35	
IIs2	29–34	
IIs3	23–26	
IIs4	30–32	
IIs5	33–35	
IIc1	30–33	
IIc2	20–28	If coastal dunes are present SI will be 24–28
IIc3	27–30	
IIIe1	30–32	
IIIe2	27–30	
IIIe3	29–32	
IIIe4	29–30	
IIIe5	27–28	
IIIe6	29–32	
IIIe7	27–29	
IIIe8	28	
IIIw1	Unsuitable	
IIIw2	28–30	
IIIw3	Unsuitable	
IIIw4	30–33	
IIIw5	23–26	
IIIs1	23–28	
IIIs2	29–32	
IIIs3	23–26	
IIIs4	27–29	
IIIs5	23–26	
IIIs6	28	
IIIc1	27–28	
IIIc2	29–30	
IIIc3	27–30	
IIIc4	27–32	The lower SI occurs in South and West Taranaki
IVe1	30–32	
IVe2	27–30	
IVe3	29–32	
IVe4	29–30	
IVe5	27–28	
IVe6	27–28	
IVe7	25–32	SI varies with altitude and exposure
IVe8	28–32	
IVe9	27–28	
IVe10	28–31	
IVe11	26–27	
IVe12	22–28	SI varies with altitude and exposure
IVe13	28	
IVe14	23–24	
IVw1	27–29	
IVw2	Unsuitable	
IVw3	25–27	
IVw4	Unsuitable	
IVs1	23	
IVs2	26–29	
IVs3	23–24	

LUC Unit	Site Index (m)	Comments
IVc1	23–24	
IVc2	24–26	
IVc3	23–27	
IVc4	23–24	
Vs1	23–26	
Vs2	27–28	
Vc1	27–29	
VIe1	27–30	
VIe2	28–30	
VIe3	27–29	
VIe4	27–31	
VIe5	26–28	
VIe6	27–29	
VIe7	26–27	
VIe8	27–31	
VIe9	26–27	
VIe10	26–27	
VIe11	27–29	
VIe12	27–30	
VIe13	26–28	Some areas unsuitable for production forestry
VIe14	26–30	
VIe15	24–28	Some areas unsuitable for production forestry
VIe16	26–29	
VIe17	25–27	Some areas unsuitable for production forestry
VIe18	25–27	
VIe19	28–30	
VIe20	27–30	
VIe21	26	
VIe22	25–27	
VIe23	26–28	
VIe24	28–31	
VIe25	22	
VIe26	23–28	SI varies with altitude
VIe27	23–26	
VIw1	Unsuitable	
VIs1	27–29	
VIs2	26–27	
VIs3	23–26	
VIs4	28–31	
VIs5	26–28	
VIs6	23	
VIs7	26–29	
VIs8	25–26	Some areas unsuitable for production forestry
VIc1	26	
VIc2	27–28	
VIc3	22–28	SI varies with altitude and exposure
VIc4	23–24	
VIc5	22–23	
VIIe1	25–27*	
VIIe2	27–28*	
VIIe3	26–28*	
VIIe4	25–27*	
VIIe5	26–28*	
VIIe6	27–29*	
VIIe7	25–27*	
VIIe8	17–22*	
VIIe9	25–27*	
VIIe10	24–27*	
VIIe11	25–28*	
VIIe12	29–30	Earthflow movement can cause stem curvature
VIIe13	24–26*	
VIIe14	27	Earthflow movement can cause stem curvature
VIIe15	26–28	
VIIe16	27–30*	
VIIe17	25–27*	
VIIe18	Unsuitable	

LUC Unit	Site Index (m)	Comments
VIIe19	23–28	Site index varies with altitude
VIIe20	25–26*	
VIIe21	Unsuitable	
VIIe22	Unsuitable	
VIIe23	24–26*	
VIIe24	20	
VIIe25	22–26	
VIIe26	Unsuitable	
VIIs1	25–26*	
VIIc1	20	

*Site Index value usually only applies to less steep lower hill slopes. Steeper slopes are generally unsuitable for production forestry due to difficulties with access and tree establishment, lower site index values and logging difficulties.

APPENDIX 7:
Areas of LUC units mapped in the Taranaki United Council

LUC Unit	County/District									Taranaki United Council (ha)
	Clifton (ha)	Taranaki (ha)	Inglewood (ha)	Stratford (ha)	Egmont (ha)	Waimate West (ha)	Eltham (ha)	Patea (ha)	Hawera (ha)	
Ic1	3920	4850								8770
Ic3						6570	20	9750	9320	25660
Iw2						990				990
CLASS TOTAL	3920 (3.5%)	4850 (8.0%)				7560 (39%)	20 (0%)	9750 (6.4%)	9320 (18.3%)	35420 (4.5%)
IIc2		220			1620	4320		2990	2900	12050
IIc3		3840		670		1660	13820	3310	3340	26640
IIe1	1290	1930				170	240	3810	1490	8930
IIs3		1590			2340	30				3960
IIw1	100							140		240
IIw2								1640		1640
IIw3					130	330				460
IIw4								440		440
CLASS TOTAL	1390 (1.2%)	7580 (12.5%)	(0%)	670 (0.3%)	4090 (6.5%)	6510 (33.4%)	14060 (26.2%)	12330 (8.2%)	7730 (15.2%)	54360 (6.9%)
IIIc4		2650	4690	22110	1350		3660	460		34920
IIIe2	2470	2440	340		100		790	1640	1380	9160
IIIe6	90	1390	1740	3280	120		550			7170
IIIs1	230	790	370	30	5020	1040			600	8080
IIIs3		180		120	5560	570				6430
IIIs5					10540	110				10650
IIIw2	800	120		420				1390	220	2950
IIIw3		130	950	240			3010			4330
IIIw4								400		400
IIIw5		60		1590	5090	2010	450	30	140	9370
Class III*	610									610
CLASS TOTAL	4200 (3.7%)	7760 (12.8%)	8090 (15.3%)	27790 (12.9%)	27780 (44.7%)	3730 (19.1%)	8460 (15.7%)	3920 (2.6%)	2340 (4.6%)	94070 (12.0%)
IVc3		1750	8870	3860	3930		1290			19700
IVe2	2540	2270	590		160	290	1240	1430	2610	11130
IVe7	1830	6120	3960	7630	450		950	120		21060
IVe8	1700							800		2500
IVe10		160			60			3170	30	3420
IVs1		2280	120	940	2320	480				6140
IVw1	2640		300				400			3340
IVw2				1330				130		1460
IVw3	60			1430						1490
CLASS IV*	260									260
CLASS TOTAL	9030 (7.8%)	12580 (20.1%)	13840 (26.1%)	15190 (7.0%)	6920 (11.0%)	770 (3.9%)	3880 (7.2%)	5650 (3.7%)	2640 (5.2%)	70500 (9.0%)
Vc1	2460	10890	7170	5680			2050	150	1890	30290
Vs1		430		290	7940					8660
CLASS TOTAL	2460 (2.1%)	11320 (18.6%)	7170 (13.5%)	5970 (2.8%)	7940 (12.7%)	0%	2050 (3.8%)	150 (0%)	1890 (3.7%)	38950 (5.0%)

LUC Unit	County/District									Taranaki United Council (ha)
	Clifton (ha)	Taranaki (ha)	Inglewood (ha)	Stratford (ha)	Egmont (ha)	Waimate West (ha)	Eltham (ha)	Patea (ha)	Hawera (ha)	
VIc5		150			480		180			810
VIe1	2320	960	100			170	1250	2620	2920	10340
VIe3				13530			130	490	220	14370
VIe6	260	1000	5600	17340			2170	220	700	27290
VIe7				60			90	290	1190	1630
VIe8								1330		1330
VIe10	150			770			690	1480	3800	6890
VIe11								160		160
VIe12								520		520
VIe13								840		840
VIe14								3010		3010
VIe17	6550			120						6670
VIe20	2640			400			70	5120	200	8430
VIe21	2910		340	100						3350
VIe22	1480			3460						4940
VIe23	2450		6130	29150			4930	1730	220	44610
VIe24	70	140			110	40		1520	20	1900
VIe25		3960	170	80			70			4010
VIs3					5590					5590
VIs4					40	80		390		510
VIs6		1650	4170	2970	5890	150	220			15050
CLASS VI*	1460									1460
CLASS TOTAL	20290 (17.6%)	7590 (12.5%)	16510 (31.1%)	67980 (31.5%)	12110 (19.3%)	440 (2.2%)	9800 (18.2%)	19720 (13.0%)	9270 (18.2%)	163710 (20.9%)
VIIe1				7310				1260	270	8840
VIIe3							60	3500		3560
VIIe5								740		740
VIIe9				2210			3410	16410	11410	33440
VIIe11	8830		3100	63000			11920	67390	4360	158600
VIIe12				150						150
VIIe14	630			170				100		900
VIIe15		390			490	70		2310	160	3420
VIIe17	16690			7580						24270
VIIe18		2260	720	1570	760		90			5400
VIIe20	17550		1340	6880						25770
CLASS VII*	490									490
CLASS TOTAL	44190 (38.4%)	2650 (4.4%)	5160 (9.7%)	88870 (41.1%)	1250 (2.0%)	70 (0.3%)	15480 (28.9%)	91710 (60.7%)	16200 (31.9%)	265580 (34.0%)
VIIIc1		60	20	80						160
VIIIe1								770		770
VIIIe3	26170	20	1000	8450		290		6290	670	42890
VIIIe4		700	150		510		10			1370
VIIIe7		900	660		200					1760
VIIIe8		880			260					1140
VIIIe9		400	210	1070	1340					3020
VIIIw		120								120
CLASS VIII*	3690									3690
CLASS TOTAL	29860 (26.0%)	3080 (5.1%)	2040 (3.8%)	9600 (4.4%)	2310 (3.7%)	290 (1.5%)	10 (0%)	7060 (4.7%)	670 (1.3%)	54920 (7.7%)

LUC Class in other NZLRI region.

APPENDIX 8:
Areas of LUC units mapped in the Wanganui United Council

	County				
LUC Unit	Wanganui (ha)	Waitotara (ha)	Waimarino (ha)	Rangitikei (ha)	Wanganui United Council (ha)
Ic2	1200			2950	4150
Ic3		5950			5950
Iw1	160	120		2560	2840
Iw2		560		290	850
CLASS TOTAL	1360 (1.1%)	6630 (5.0%)	- 0	5800 (1.3%)	13790 (1.5%)
IIc1	590		350	2860	3780
IIc3		1390			1390
IIe1		1110			1110
IIe2	290	1410		3430	5130
IIs1	2170			1250	3420
IIs2	4010	510		21800	26320
IIs5	610	190			800
IIw1		70		1020	1090
IIw2	2170	1030		5430	8630
CLASS TOTAL	9820 (7.7%)	5710 (4.3%)	350 (0.2%)	35790 (7.9%)	51670 (5.6%)
IIIc1	170	90	16930	3990	21180
IIIc2				750	750
IIIc3			980	690	1670
IIIe2		120			120
IIIe3	650	530		1190	2370
IIIe4	1870	340		2980	5190
IIIe5	990	30	6400	2230	9650
IIIs2				2820	2820
IIIw1				430	430
IIIw2	880	480	510	1990	3860
IIIw3	60		960		1020
IIIw4	410	1220		7880	9510
Class III*				60	60
CLASS TOTAL	5030 (3.9%)	2810 (2.1%)	25780 (12.6%)	25010 (5.5%)	58630 (6.4%)
IVc1			9410	290	9700
IVc2			3420	5420	8840
IVc4			880		880
IVe2		40			40
IVe3	300	1540		1340	3180
IVe4	1660	90	390	4000	6140
IVe6	1420	310	7070	2980	11780
IVe7		70			70
IVe8	560	220	710	1690	3180
IVe10	390	850		2530	3770
IVe12			2350	8420	10770
IVe13			1320	220	1540
IVw1	190	460		590	1240
IVw2		120	90		210
IVw4			890	1360	2250
IVs2				670	670
Class IV*				4040	4040
CLASS TOTAL	4520 (3.6%)	3700 (2.8%)	26530 (12.9%)	33550 (7.4%)	68300 (7.5%)
Vc1	1360	700			2060
CLASS TOTAL	1360 (1.1%)	700 (0.5%)			2060 (0.2%)

	County				
LUC Unit	Wanganui (ha)	Waitotara (ha)	Waimarino (ha)	Rangitikei (ha)	Wanganui United Council (ha)
VIc1		290	10100	6320	16710
VIc2				2940	2940
VIc3			6590	20720	27310
VIc4			3470		3470
VIe2	620	50		3580	4250
VIe3	5560	670	4580	840	11650
VIe4	4520		790	17110	22420
VIe6		470	190		660
VIe7	4360		360	3630	8350
VIe8	4480			9560	14040
VIe10		1290	8220		9510
VIe11	2060	1950		13550	17560
VIe12		5090	860		5950
VIe13	280	630	210	4400	5520
VIe14	12850	8410		1738	38640
VIe15	60		270	1899	19320
VIe17			3400		3400
VIe19	960			3350	4310
VIe20	100		390	120	610
VIe22		840	90		930
VIe23	310	5890	14990		21190
VIe24	350	1280		2840	4470
VIe27			3560	22430	25990
VIs4	90	890		1210	2190
VIs7				1580	1580
VIw1			360		360
Class VI*				12850	12850
CLASS TOTAL	36600 (28.8%)	27750 (21.0%)	58420 (28.5%)	163400 (36.2%)	286170 (31.2%)
VIIc1			4250	3840	8090
VIIe1	13280	90	3500	620	17490
VIIe2	6440		290	16150	22880
VIIe3	30	5510			5540
VIIe4	2440			7770	10210
VIIe5	5340	1750		6030	13120
VIIe6	60			1120	1180
VIIe8			200		200
VIIe9	2970	4490	5000	2970	15430
VIIe10				680	680
VIIe11	20490	52820	47810	3240	124360
VIIe12				760	760
VIIe13	5410	170	340	16390	22310
VIIe14			160	160	320
VIIe15	3280	2690		8060	14030
VIIe16	5480	1570		500	7550
VIIe17		2590	4830		7420
VIIe18			1170		1170
VIIe21			130	8790	8920
VIIe22				7410	7410
VIIe23			60	8030	8090
VIIe24				9680	9680
VIIe25			4210	250	4460
VIIe26				2990	2990
Class VII*				13010	13010
CLASS TOTAL	65020 (51.2%)	71680 (54.3%)	71950 (35.1%)	118450 (26.3%)	327100 (35.7%)
VIIIc1			1340	4850	6190
VIIIe1	410	270		1010	1690
VIIIe2	240	60		330	630
VIIIe3	1410	9730	3600	5360	20100

	County				
LUC Unit	Wanganui (ha)	Waitotara (ha)	Waimarino (ha)	Rangitikei (ha)	Wanganui United Council (ha)
VIIIe4			2340	11250	13590
VIIIe5				8030	8030
VIIIe6				350	350
VIIIe7			610	3920	4530
VIIIe8			4130	5110	9240
VIIIe9			4970	5120	10180
VIIIe10			4030	1020	5050
VIIIw1				100	100
Class VIII*				17610	17610
CLASS TOTAL	2060 (1.6%)	10060 (7.6%)	21020 (10.3%)	64150 (14.2%)	97290 (10.6%)

*LUC Class in other NZLRI region

APPENDIX 9:
Areas of LUC units (not in the Taranaki or Wanganui United Councils) on a County basis

LUC Unit	COUNTY (with area in hectares) Taumarunui	Kiwitea	Pohangina	Oroua	Manawatu	Kairanga
Ic1		7360	320			
Iw1		320	2180	2780	1130	970
Class I*						570
CLASS TOTAL		7680 (8.3%)	2500 (3.7%)	2780 (5.4%)	1130 (1.7%)	1540 (3.1%)
IIc1		2930	1870	580		
IIe2		2210			130	
IIs1		310	390	520	260	1520
IIs2		2370	710	14070	11530	1420
IIs4	540					
IIw1		150	110	220		40
IIw2	700	1360	430	5450	6840	14630
IIw4					2320	60
CLASS TOTAL	1240 (0.2%)	9330 (10.0%)	3510 (5.1%)	20840 (40.4%)	21080 (31.0%)	23080 (46.6%)
IIIc2		3350	1840			
IIIe1	1380					
IIIe3		1780	160	160		
IIIe4		810		5090	750	40
IIIe7	3270					
IIIe8	1730					
IIIs2		1720	1560	1540	30	160
IIIs4	1650					
IIIs6	9130					
IIIw1				90	680	1370
IIIw2	3870		430	160		100
IIIw4					14880	
Class III*	3500					2650
CLASS TOTAL	24530 (5.1%)	7660 (8.2%)	3990 (5.8%)	7040 (13.6%)	16340 (24.0%)	4320 (8.7%)
IVc4	6690					
IVe1	3190					
IVe3		500	470			
IVe4		260	270	2910	2110	130
IVe5	3100					
IVe6	160					
IVe7	580					
IVe8	270					
IVe9	13710					
IVe10					7860	
IVe11	4990					
IVe13	4320					
IVe14	1770					
IVs2		120	690	210	480	910
IVs3	70					
IVw1	2170					
IVw2					30	
IVw3	2490					
Class IV*	14800					1250
CLASS TOTAL	58310 (12.0%)	880 (0.9%)	1430 (2.1%)	3120 (6.0%)	10480 (15.4%)	2290 (4.6%)
Vs2	1840					
CLASS TOTAL	1840 (0.3%)					
VIc1	60					

LUC Unit	COUNTY (with area in hectares) Taumarunui	Kiwitea	Pohangina	Oroua	Manawatu	Kairanga
VIc2		2870	2170			
VIc4	13570					
VIe2		4090	2590	6340	3370	60
VIe3	23320					
VIe4		2400		80		
VIe5	26630					
VIe6	80					
VIe7	20	3220	1190			
VIe8		1950				
VIe9	400					
VIe10	15780					
VIe11		8760	1960	1640		
VIe12		7410	6540	540		
VIe13		4000	2200			
VIe14		8200	150	4530		
VIe15		2270	1670			
VIe16		1050				
VIe17	35920					
VIe18	19170					
VIe19		220	940			
VIe20	21780					
VIe22	4060					
VIe23	2020					
VIe24					4900	
VIe26	990					
VIs1	5270					
VIs2	4040					
VIs4				100	4540	
VIs5	14910					
VIs7		210	600	500	900	290
VIs8	1830					
VIw1	1230					
Class VI*	41710					8260
CLASS TOTAL	232790 (48.0%)	45600 (48.9%)	21060 (31.0%)	13730 (26.6%)	13710 (20.2%)	8610 (17.4%)
VIIc1	4830					
VIIe1	2660					
VIIe3		630	4300	470		
VIIe4		780		1380		
VIIe5		630				
VIIe6		1470	780			
VIIe7	6750					
VIIe8	10220					
VIIe9	20590		200			
VIIe10		440	3540			
VIIe11	30920	1300				
VIIe12		400	160			
VIIe14	610					
VIIe15					3060	
VIIe16			4760	70		
VIIe17	26260					
VIIe19	1380					
VIIs1	1550					
Class VII*	15150					2670
CLASS TOTAL	120920 (24.9%)	5650 (6.1%)	13740 (20.3%)	1920 (3.7%)	3060 (4.5%)	2670 (5.4%)
VIIIc1	4570		990			
VIIIe1					620	
VIIIe2	2110	30	1640	260		
VIIIe3	10070	2990	430			
VIIIe4	7720	8710	12650			
VIIIe7	500	840	2730			
VIIIe8	7400	3840	2570			

LUC Unit	COUNTY (with area in hectares) Taumarunui	Kiwitea	Pohangina	Oroua	Manawatu	Kairanga
VIIIe9	1350		700			
VIIIe10	60					
VIIIw1	150					
Class VIII*	10140					1010
CLASS TOTAL	44070 (9.1%)	16410 (17.6%)	21710 (32.0%)	260 (0.5%)	620 (0.9%)	1010 (2.0%)

*LUC Class in other NZLRI region

APPENDIX 10:
LUC Class as Percentage of the Area of each County in the Region

County	LUC CLASS I	II	III	IV	V	VI	VII	VIII	Unmapped
Clifton	3.4	1.2	3.7	7.8	2.1	17.6	38.3	25.9	-
Taranaki	8.0	12.5	12.8	20.1	18.6	12.5	4.4	5.1	6.0
Inglewood	-	-	15.3	26.1	13.5	31.1	9.7	3.8	0.5
Stratford	-	0.3	12.9	7.0	2.8	31.5	41.1	4.4	-
Egmont	-	6.5	44.7	11.0	12.7	19.3	2.0	3.7	0.1
Waimate West	39.0	33.4	19.1	3.9	0	2.2	0.3	1.5	0.6
Eltham	0	26.2	15.7	7.2	3.8	18.2	28.9	0	-
Patea	6.4	8.2	2.6	3.7	0	13.0	60.7	4.7	0.7
Hawera District	18.3	15.2	4.6	5.2	3.7	18.2	31.9	1.3	1.6
Taranaki United Council	4.5	6.9	12.0	9.0	5.0	20.9	34.0	7.7	
Wanganui	1.1	7.7	3.9	3.6	1.1	28.8	51.2	1.6	1.0
Waitotara	5.0	4.3	2.1	2.8	0.5	21.0	54.3	7.6	2.4
Waimarino	-	0.2	12.6	12.9	-	28.5	35.1	10.3	0.4
Rangitikei	1.3	7.9	5.5	7.4	-	36.2	26.3	14.2	1.2
Wanganui United Council	1.5	5.6	6.4	7.5	0.2	31.2	35.7	10.6	
Taumarunui	-	0.2	5.1	12.0	0.3	48.0	24.9	9.1	0.4
Kiwitea	8.3	10.0	8.2	0.9	-	48.9	6.1	17.6	-
Pohangina	3.7	5.1	5.8	2.1	-	31.0	20.3	32.0	-
Oroua	5.4	40.4	13.6	6.0	-	26.6	3.7	0.5	3.8
Manawatu	1.7	31.0	24.0	15.4	-	20.2	4.5	0.9	2.3
Kairanga	3.1	46.6	8.7	4.6	-	17.4	5.4	2.0	12.2

APPENDIX 11:
Glossary of Plant Names

beech	*Nothofagus* spp
black beech	*Nothofagus solandri* var. *solandri*
blackberry	*Rubus fruticosus*
bracken fern	*Pteridium esculentum*
brown top	*Agrostis tenuis*
contorta pine	*Pinus contorta*
danthonia	*Rytidosperma* spp
gorse	*Ulex europaeus*
hall's totara	*Podocarpus hallii*
hard beech	*Nothofagus truncata*
hard fern	*Paesia scaberula*
heather	*Calluna vulgaris*
kahikatea	*Podocarpus dacrydiodes*
kaikawaka	*Libocedrus bidwillii*
kamahi	*Weinmannia racemosa*
leatherwood	*Olearia colensoi*
lucerne	*Medicago sativa*
lupin	*Lupinus* spp
manuka	*Leptospermum scoparium*
marram grass	*Ammophila arenaria*
miro	*Podocarpus ferrugineus*
mountain beech	*Nothofagus solandri* var *cliffortiodes*
poplar	*Populus* spp
radiata pine	*Pinus radiata*
red beech	*Nothofagus fusca*
red tussock	*Chionochloa rubra*
rimu	*Dacrydium cupressinum*
rushes	*Juncus* spp
ryegrass	*Lolium* spp
sweet vernal	*Anthoxanthum odoratum*
tawa	*Beilschmiedia tawa*
tree fern	*Dicksonia* spp, *Cyathea* spp
white clover	*Trifolium repens*
willow	*Salix* spp
willow weed	*Polygonium persicaria*

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