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Land Use Capability Classification of the Southern Hawke's Bay-Wairarapa Region

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Land Use Capability Classification of the Southern Hawke's Bay-Wairarapa Region: a bulletin to accompany New Zealand Land Resource Inventory Worksheets

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This bulletin describes the land use capability classification of the Southern Hawke's Bay-Wairarapa Region which is situated in the south-east of the North Island and covers 1 422 600 ha. This region is one of ten regions classified in the North Island section of the New Zealand Land Resource Inventory survey, prepared by scientists of the Water and Soil Directorate of the Ministry of Works and Development for the National Water and Soil Conservation Authority. The survey covers New Zealand at the 1:63,360 scale, and records a physical resource inventory and an assessment of land use capability. The bulletin is intended for users of the land use capability data; it provides a description of the land use capability units in the Southern Hawke's Bay-Wairarapa Region.

The classification for this region contains a total of 71 land use capability (LUC) units. These units have been grouped into ten land use capability "suites"—a grouping of LUC units which, although differing in land use capability, share a definitive physical characteristic which unites them in the landscape.

Within this region, rock type and climate are the most important physical factors determining the long term land use capability, and these factors formed the basis for subdivision of the LUC units into suites.

Each suite is described and illustrated (where appropriate) by photographs and diagrams. Each LUC unit is described in detail with a summary of parent material, soils, slope, erosion characteristics and potential, climate, present and potential land uses, land management and agricultural and forestry productivity data.

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CONTENTS

INTRODUCTION

The New Zealand Land Resource Inventory (NZLRI) contains physical land resource information for New Zealand. This information is published as Land Resource Inventory worksheets at a scale of 1:63,360 (NWASCO, 1975-79), and stored as a computerised data base (van Berkel and Eyles, 1981). The survey was carried out for the National Water and Soil Conservation Organisation (now National Water and Soil Conservation Authority (NWASCA)) by scientists from the Water and Soil Directorate of the Ministry of Works and Development, at the request of the Soil Conservation and Rivers Control Council (SC&RCC). Field mapping and office compilation of the Southern Hawke's Bay-Wairarapa Region began in 1976 and was completed in 1978.

Two sets of data were mapped:

(1) An inventory of five physical factors (rock type, soil unit, slope group, erosion type and degree, and vegetation) (SC&RCC, 1971; NWASCO, 1979).

(2) An assessment of the long-term potential for sustained productivity in the form of a land use capability classification (SC&RCC, 1971; NWASCO, 1979).

The Southern Hawke's Bay-Wairarapa Region is one of ten North Island land resource survey regions (Figure 1.), each with its own land use capability classification (Page, 1985).

The aim of this bulletin is to provide a detailed description of both the land use capability (LUC) units and the capability classification of the Southern Hawke's Bay-Wairarapa Region, based on the NZLRI.

A 'suite' approach has been used to group together land use capability units. This approach has been used to allow the physical relationship between units within each suite to be clearly illustrated.

The description of the LUC suites and their component LUC units are preceded by a brief description of physical resource factors of the region. It is not intended that this publication be an exhaustive resource document for the Southern Hawke's Bay-Wairarapa Region; instead it describes the LUC classification of the region. Readers are referred to other documents referenced in the text for more detailed resource information.

The regional LUC classification and descriptive extended legend were prepared by K. E. Noble, regional supervisor of the survey (Noble, 1979). Field checking and correlation of worksheets was carried out by K. E. Noble and G. 0. Eyles. Appendix I lists the worksheets mapped within the Southern Hawke's Bay-Wairarapa Region, together with names of authors and dates of field work. All photographs are by the author, K. E. Noble, unless otherwise stated.

The regional LUC classification extended legend (Noble, 1979) summarises much of the data presented in this bulletin and should be referred to by those using worksheets in this region. Maps showing the distribution of LUC suites are computer generated using NZLRI data.

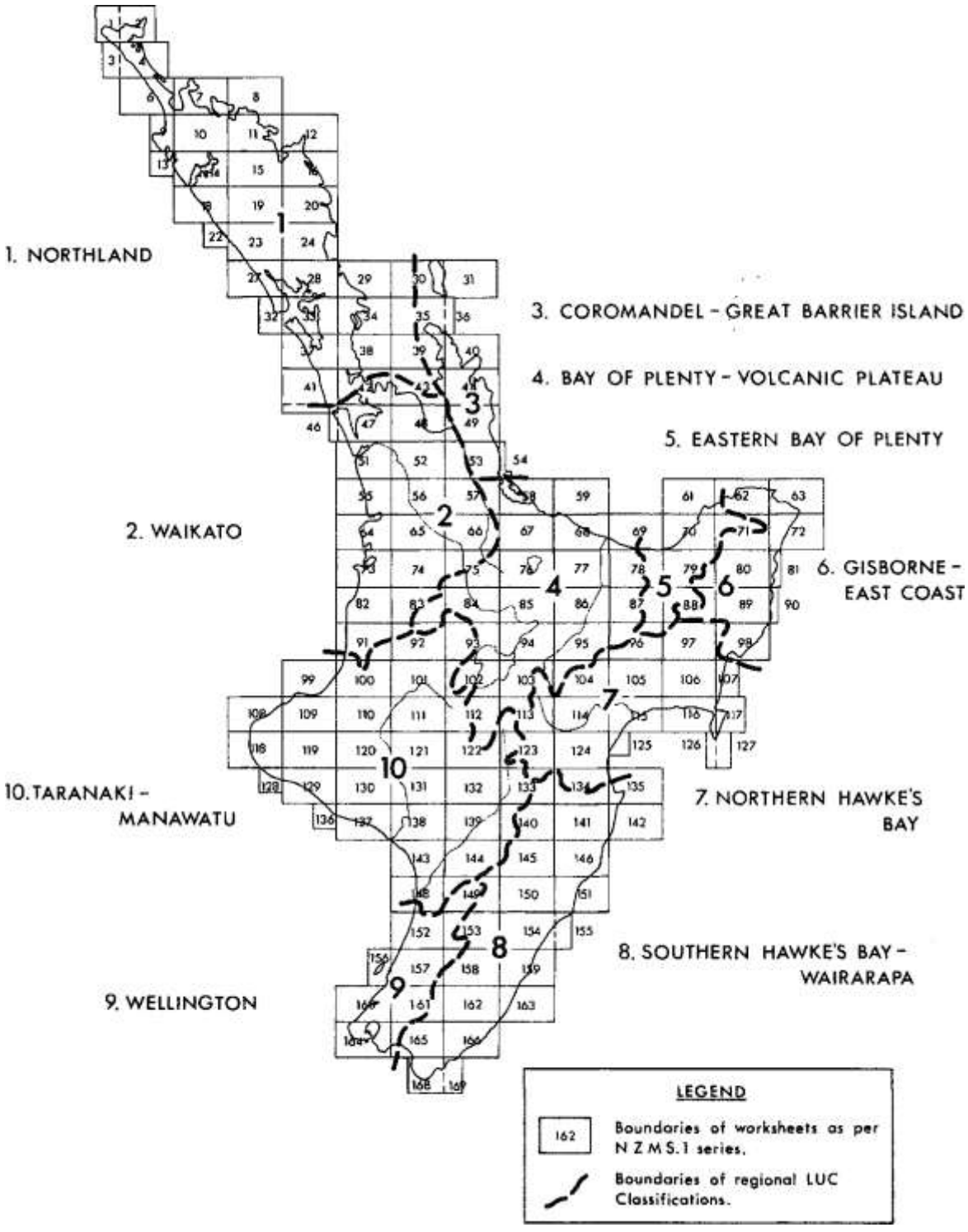


Figure 1: North Island land resource survey regions

THE SOUTHERN HAWKE'S BAY-WAIRARAPA REGION

The Southern Hawke's Bay-Wairarapa Region, as delineated in the NZLRI survey, comprises 1 422 600 hectares in the south-east of the North Island (Figure 2). It extends from the Ngaruroro River in the north to Cape Palliser in the south, its western boundary follows the summit of the Ruahine Range and the eastern foothills of the Tararua and Rimutaka Ranges. The Pacific Ocean forms the eastern boundary.

The major servicing centres are Hastings, Dannevirke and Masterton, with smaller rural towns (e.g., Waipawa, Waipukurau, Woodville, Greytown, Martinborough) throughout the central lowlands. The major rivers are the Ngaruroro (which forms the northern boundary of the region), Tukituki, Manawatu and Ruamahanga Rivers.

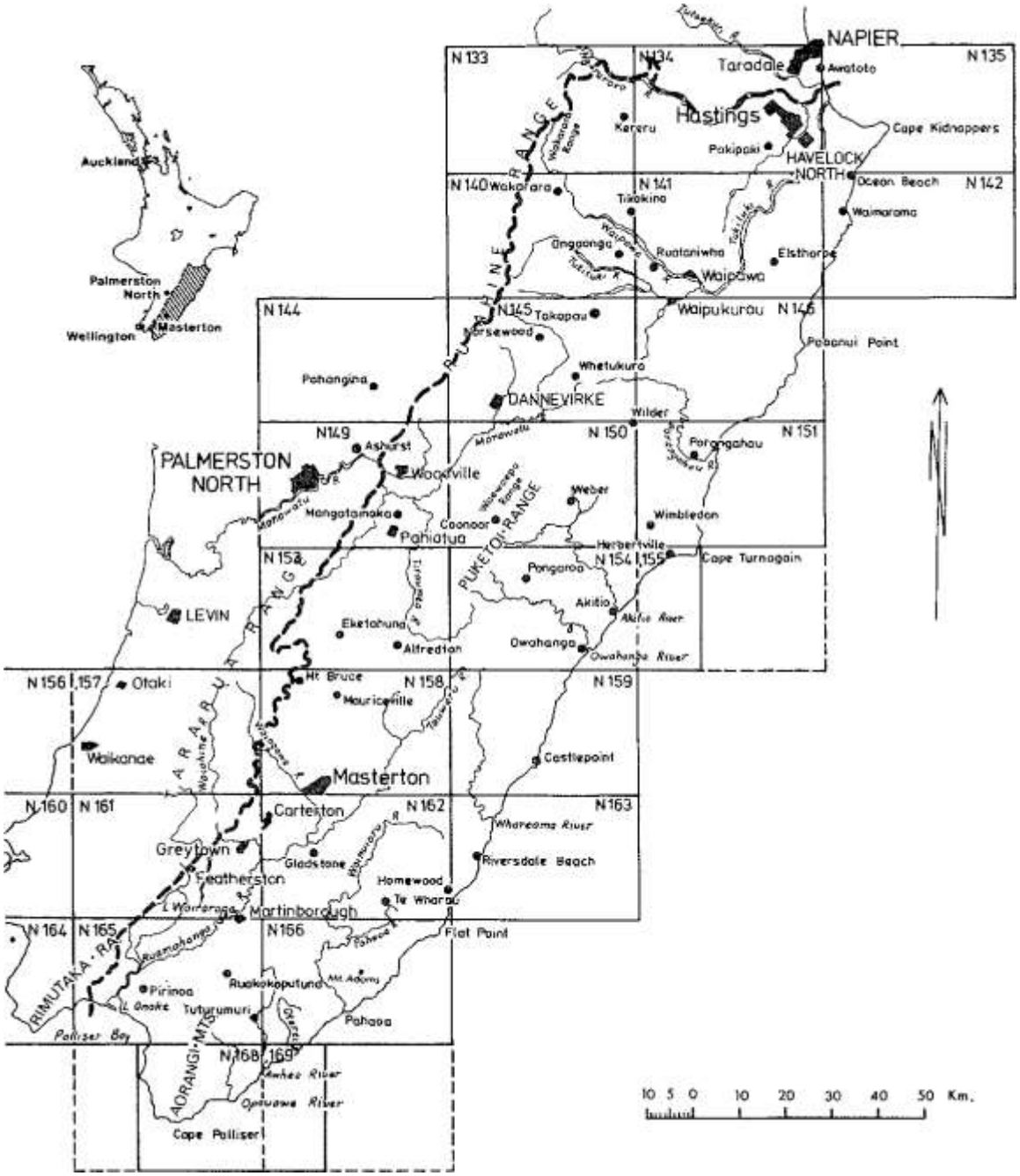


Figure 2: Location of the Southern Hawke's Bay-Wairarapa Region

Past and Present Land Use

Prior to European settlement, much of the region was covered in indigenous forest, scrub, fern and swamp vegetation. Settlement began in the late 1840s with extensive areas of the plains and coastal districts subdivided into large stations, many of which still remain. The main hindrance to the settlement of the Wairarapa from Wellington, was the physical barrier presented by the Tararua and Rimutaka Ranges. Before 1843, when a walking track was established across the Rimutakas to Lake Wairarapa, the early settlers followed the coastline east from Wellington (Bagnall, 1976). After 1850 when graziers arrived from the Wairarapa, the Hawke's Bay was divided into large sheep stations (National Resources Survey, 1971). Access to the coastal stations remained almost entirely by sea until after the turn of the century. Two large areas of forest, called the '70 mile bush', around Waipukurau and Dannevirke, and the '40 mile bush', between Mauriceville and Woodville, also discouraged settlement, and were physical barriers to overland communication between Hawke's Bay and Wellington. In the 1870s Government schemes attracted large numbers of Scandinavian settlers to these forested areas. Sawmilling became an important industry, and now only a few small areas of indigenous forest remain.

Today, agriculture is the most important industry, with 85 percent of the region being in pasture.

The axial foothills in the western part of the region are used for sheep and cattle breeding. Dairy farming is carried out on flatter areas which border the Ruahine, Tararua and Rimutaka Ranges, e.g., around Dannevirke, Woodville, Pahiatua and Greytown, where rainfalls are generally over 1200 mm/annum. Dairy factories are situated at Te Rehunga and Maharahara (near Dannevirke), Woodville, Mangatainoka, Pahiatua, Dalefield (near Carterton), Greytown and Featherston. Little cropping occurs on dairy farms because year round growth of pasture is sufficient with efficient pasture management (Advisory Services Division, Dannevirke, 1979). The pattern of farming has changed markedly in recent years, from dairying to sheep and beef fattening, cropping and horticultural production.

The major area of intensive horticulture and process cropping is centred on the Heretaunga Plains, near Hastings. The high sunshine hours and relatively low humidity make the area well suited to orchard, process crop and market garden production. The largest fruit assembly depot in New Zealand is situated at Hastings (New Zealand Apple and Pear Board). It handled 99 268 tonnes in the 1980-81 season (Glenny, 1982). Fruit varieties include apples, pears, apricots, cherries, nectarines, peaches, plums, citrus, kiwifruit, grapes, feijoas, avacados, and berryfruit (boysenberries, strawberries, raspberries, blackcurrants). The main vegetable crops are asparagus, beans, beetroot, cabbage, carrots, cauliflower, celery, kumara, lettuce, onion, parsnip, peas, sweetcorn, tomatoes and pumpkin (Glenny, 1982).

In the Wairarapa, horticultural production is centred around Masterton, Carterton, Greytown and Martinborough. Here, it is not as extensive or important an industry as in the Hawke's Bay area, due principally to less favourable climatic conditions. Major crops grown in this area are vegetables, berryfruits, pip and stone fruit, and grapes.

Away from these areas of intensive horticulture, the central lowlands support a diversity of farming systems — sheep and cattle breeding and fattening (with occasional barley crops grown during pasture renewal or after winter feed crops on fattening farms), and dairy farming (in the higher rainfall areas). More intensive cropping of wheat, barley, ryegrass seeds, maize, process peas, potatoes and some oats, is also carried out. Barley is the main cash crop, with choumoellier the most important winter feed crop. Maize is grown for summer green feed or silage. Most cereal cropping is confined to the Ruataniwha and Takapau Plains. In recent years process pea growing has also moved into,this area. Some cereal grains are processed locally for stock feed, but the majority is exported.

The eastern coastal hill country supports sheep and cattle farming, both breeding and fattening, with occasional cash crops grown on valley floors. Recently, with the introduction of the Land Development Encouragement Loan Scheme and the Livestock Incentive Scheme, there has been renewed interest in the development of large areas of this hill country.

Freezing works are situated at Waingawa (south of Masterton), Oringi (south of Dannevirke), Takapau, and three on the outskirts of Hastings (at Tomoana and Whakatu).

Fertiliser works are located at Waingawa, Mangatainoka, Waipawa and Napier, and lime works at Pakipaki, Hatuma (south of Waipukurau), Woodville, Mauriceville, Masterton and Martinborough.

Physiography

The physiography of the region is determined largely by rock type and structural trends. Part of the region is contained within the 'East Coast Fold Belt' (Katz, 1976) or alternatively named the 'East Coast Deformed Belt' (Sporli, 1980) — a complex and active tectonic zone, with a pronounced north-east south-west regional structural alignment, which affects all major landforms. One of the major faults is the Wairarapa Fault, which runs from Palliser Bay in a north-easterly direction, along the eastern side of the Rimutaka and Tararua Ranges, to east of Woodville. Numerous parallel faults, some presently active (Kingma, 1962; Kingma, 1967), and all with a predominant NE-SW alignment, occur throughout the region. Major tectonic melange and crushed zones are associated with areas that have been thrust-faulted (Pettinga, 1982). It is these areas that are particularly susceptible to mass movement erosion.

Three natural physiographic regions can be identified (see also Kamp, 1982; Kamp and Vucetich, 1982):

(a) *Axial mountain ranges and foothills* — Of the axial ranges, only the eastern side of the Ruahine Range is included within the region. These greywacke ranges are very steep and rugged, with peaks rising to over 1500 m a.s.l.

(b) *Central lowlands* — These comprise a central trough of plains, terraces and low hill country, formed from very young (Quaternary) sedimentary rocks. The major rivers have built up broad fertile plains including the Heretaunga, Ruataniwha and Wairarapa Plains. The Wairarapa Valley is separated from the northern Pahiatua Basin by the Mount Bruce basement high, an area of steep greywacke hill country (Kamp and Vucetich, 1982).

(c) *Eastern hill country* — This comprises rolling to steep hill country to the east of the central lowlands, below 600 m a.s.l., and formed of Cretaceous and Tertiary sedimentary rocks. Steeper mountain ranges are also included in this area, e.g., the Waewaepa Range, greywacke (760 m a.s.l.), the Puketoi Range, capped by limestone (800 m a.s.l.), and the Aorangi Mountains, greywacke (980 m a.s.l.).

The coastline is mostly rugged, comprising hill country and cliffs of Cretaceous and Tertiary rocks. Active coastal erosion is primarily in response to tectonic uplift, the crushed nature of some lithologies, and the presence of bentonitic lithologies in places. Small areas of sand dunes occur along the coast, e.g., at Riversdale, Porangahau, Waimarama and Ocean Beach.

PHYSICAL RESOURCE FACTORS

The physical resource inventory is recorded in the form of a standard code which contains five sets of physical information in symbol form. These are rock type, soil unit, slope, erosion degree and type, and vegetation. The standard layout of an inventory code is:

$$\frac{\text{Rock type} \quad — \quad \text{Soil unit} \quad — \text{ Slope}}{\text{Erosion degree and type} \quad — \text{ Vegetation}}$$

The inventory factors (together with climate and effects of past land use), provide the basis for determining the capability for long term use for each map unit. In the homogeneous unit area approach to recording data, as used in the NZLRI (Eyles, 1 977), the five factors are mapped simultaneously within the limitations of scale. The minimum map unit area is approximately 20 ha. Further information on general aspects, and interpretation of the NZLRI is available in Howard and Eyles (1979), in 'Land Use Capability Survey Handbook', (SCRCC, 1971) and in 'Our Land Resources' (NWASCO, 1979). Brief comments follow on the inventory factors and climate as they apply to the region.

Rock type

Rock types in the Southern Hawke's Bay-Wairarapa Region are sedimentary. The sedimentary pattern is one of the most complex in New Zealand. Accumulation, consolidation or induration of sands, silts and muds have resulted in lithologies ranging from Quaternary alluvial and aeolian deposits, Tertiary mudstones, siltstones, sandstones and limestones, to Mesozoic argillites and greywackes. Greywacke forms the axial ranges, the Aorangi, Waewaepa and Wakarara Ranges, and areas of the coastal 'taipo'* country. Tertiary sediments of sandstone, siltstone, mudstone or limestone comprise the majority of the hill country, especially in eastern parts of the region. River terrace systems are comprised of recent gravels and alluvial flood plain deposits. Part of the region is covered by loessial deposits which mantle, either wholly or in part, the underlying sediments. The four most extensive rock types, which together comprise 53 percent of the region, are loess, jointed mudstone, greywacke and alluvium. A summary of the areas of different rock types (recorded as the dominant lithology in a map unit), is shown in Table 1.

Rock type mapping

Rock type mapping is based on the North Island Rock Type Classification prepared specifically for use in the NZLRI (Crippen and Eyles, 1985). This classification was designed specifically for mapping rock types for soil conservation purposes. Emphasis was placed on grouping those rock types with similar erosion susceptibilities and characteristics.

The complexity of deformation (e.g., from faulting, folding and compression) in the East Coast Deformed Belt makes delineation of different rock types in this area difficult.

When the rock type classification was first introduced, siltstone was recorded as a separate rock type. The erosion characteristics of fine siltstones are similar to those of mudstones. Coarse grained lithologies, e.g., sandstones and coarse siltstones, also appear to have similar erosion characteristics. The classification was therefore modified so that siltstone was grouped either with mudstone or sandstone, depending on its erosion susceptibility and characteristics (Crippen and Eyles, 1985).

Geological surveys and related studies referenced in the NZLRI for the Southern Hawke's Bay-Wairarapa Region are shown in Figure 3 (refer Appendix 2 for full bibliographic references).

"Taipo'—a Maori name meaning 'Little Devil'. Hutton (1872} introduced the name 'Taipo Beds', and the name was later used for rocks of Tertiary and Pre Tertiary age, that form conspicuous rugged hills, commonly called 'taipos'.

Table 1: Areas of dominant lithologies recorded within map units in the Southern Hawke's Bay-Wairarapa Region

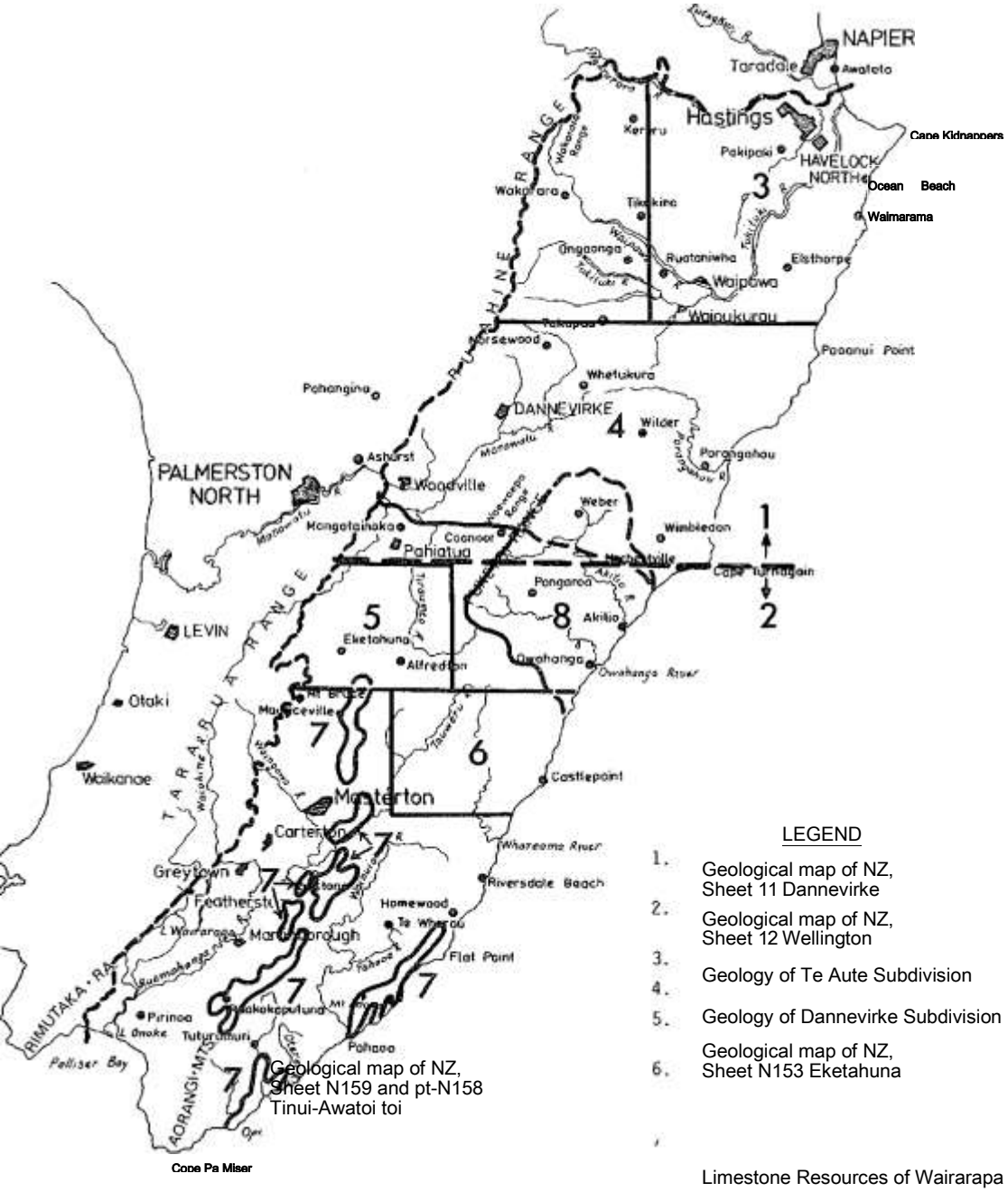
SYMBOL	LITHOLOGY	AREA (ha)	PERCENT OF REGION
Lo	Loess	6 330	0.5
Lo/	Loess (complete cover), over various lithologies	160 970	11.3
(Lo)/	Loess (significant in patches), over various lithologies	91 780	6.5
Mj	Mudstone or fine siltstone—jointed	202 430	14.2
Gw	Greywacke	152 440	10.7
Al	Undifferentiated floodplain alluvium	125 030	8.8
Al/	Undifferentiated floodplain alluvium (complete cover), over various lithologies	19 990	1.4
Sm	Sandstone or coarse siltstone—massive	118 600	8.3
Gr	Gravels	93 820	6.6
Gr/	Gravels (complete cover), over various lithologies ..	9 340	0.7
(Gr)/	Gravels (significant in patches), over various lithologies	1 810	0.1
Ac	Argillite—crushed	104 070	7.3
Ar	Argillite	71 810	5.0
Mb	Mudstone or fine siltstone—banded	64 710	4.6
Li	Limestone	53 530	3.8
Mo	Ashes older than Taupo ash	160	0.0
Mo/	Ashes older than Taupo ash (complete cover), over various lithologies	16 680	1.2

Soil unit

The soil information on the worksheets is based on published or publicly available soil surveys provided by New Zealand Soil Bureau, DSIR. In areas which had only 'General Survey of the Soils of North Island' coverage (at 1:253 440 scale), the objective was not to prepare a '1 mile to 1 inch soil map' (1:63 360) but to record, within the map units, soil sets which were already recognised by New Zealand Soil Bureau. Where the 'General Survey of the Soils of North Island' (New Zealand Soil Bureau Bulletin (n.s.)5) at a scale of 4 miles to 1 inch has been used, names and descriptions of the existing soil sets have been obtained from the soil map in that area. Using these defined soils, together with detailed aerial photograph interpretation and field mapping, boundary detail appropriate to the 1:63 360 scale was recorded. Field checks on soil profiles were made to ensure that the correct soil set had been recorded (Hawley and Leamy, 1980).

Thirteen soil surveys were used. Of these only eight were published surveys. (Refer Figure 4 for location map, and Appendix 3 for full bibliographic reference to soil surveys used.)

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 map unit, these boundaries need not necessarily correspond exactly to soil mapping unit boundaries of soil maps of the same area.



Geological map of NZ, Sheet N159 and pt-N158 Tinui-Awatoi toi

Cape Pa Miser

LEGEND

1. Geological map of NZ, Sheet 11 Dannevirke
2. Geological map of NZ, Sheet 12 Wellington
3. Geology of Te Aute Subdivision
4. Geology of Dannevirke Subdivision
5. Geology of Dannevirke Subdivision
6. Geological map of NZ, Sheet N153 Eketahuna

Limestone Resources of Wairarapa

{Refer Appendix 2 for full bibliographic references)

10 5 O 10 30 40 50 Krr

Luil . I

Figure 3: Location of geological surveys used in the Southern Hawke's Bay-Wairarapa Region of the NZLRI.

For a more detailed soil description and interpretation, users should consult the appropriate soil maps. These are listed on the legends of the individual worksheets. Additional information may also be obtained from consultation with the local Soil Bureau pedologist.

A listing of soils (by survey) recorded in the region has been prepared by K. E. Noble and M. J. Page, and is available on request from the Scientist in Charge, Soil Conservation Centre, Aokautere.

Typical soils recorded for each LUC unit are listed in the Southern Hawke's Bay-Wairarapa Region Land Use Capability Extended Legend.

Slope

The slope groupings used are standard for land resource mapping (SCRCC, 1971). Refer Appendix 4 for details of slope groupings used.

Slope angles are estimated with an abney level, or estimated visually either in the field or from aerial photographs.

Slopes recorded are those areally dominant in each map unit. Compound slopes (where more than one major slope grouping occurs in an otherwise uniform unit, e.g., A + B), slopes which are borderline between two slope groupings (e.g., A/B) and dissected slopes (e.g., A') are also recorded.

An analysis of the dominant slope groups is given in Table 2.

Table 2: Areas of dominant slope groups recorded in the Southern Hawke's Bay-Wairarapa Region

DOMINANT SLOPE GROUPS	AREA (ha)	PERCENT OF REGION
A (0- 3°)	292 630	20.6
B (4- 7°)	50 200	3.5
C (8-15°)	54 060	3.8
D (16-20°)	168 730	11.9
E (21-25°)	534 030	37.5
F (26-35°)	246 880	17.3
G (> 35°)	51 970	3.7
Areas not mapped (rivers	24 120	1.7

Erosion

A feature of this region is the extent and diversity of erosion. This can be partly attributed to tectonic activity. Many faults have wide crush zones associated with them and these areas are particularly susceptible to severe mass movement erosion. In general, the type and severity of erosion may be related to a combination of the following factors: regional structure, tectonism, lithology (bedrock and regolith properties, including depth to bedrock), soil properties, slope characteristics (angle, shape, aspect), vegetation cover and climatic conditions (Stephens, 1975; Pettinga, 1980; Crozier *et al.,* 1980, 1982b; Marden, 1981; Crozier *et al.,* 1982a; Grant, 1983; Trustrum *et al.,* 1984).

Maps of the region showing present and potential erosion severity and types, at 1:250 000 scale, are presented in the 'Erosion Map of New Zealand' series, sheets 11 and 12 (Page and Trustrum, 1982; Noble and Fletcher, 1984).

LEGEND

1. General Survey of the Soils of North Island,NZ
2. Soils of Mid Hawke's Bay
3. Soils of Wairarapa Valley
4. Soils of Pohangina County
5. Soils of Heretaunga Plains
6. Soils of Whareama Catchment
7. Soils of Woodville County
8. Provisional Soil Map of Awhea and Opouawe Catchments
9. Provisional Soil Map of Pahiatua County
10. Provisional Soil Map of Eketahuna County

Provisional Soil Map of Mauriceville County

(Refer Appendix 3 for full bibliographic references)

Figure 4: Location of soil surveys used in the Southern Hawke's Bay-Wairarapa Region of the NZLRI.

Table 3 shows the area of all map units in the region affected by each of the erosion types.

Table 3: Area of map units affected by erosion

EROSION TYPE	CODE	AREA OF MAP UNITS AFFECTED* (ha)
Soil slip	sSl	525 370
Earthflow	eF	418 770
Sheet	Sh	213 880
Gully	G	143 030
Tunnel gully	T	120 640
Scree	Sc	90 800
Wind	W	84 280
Streambank	Sb	61 500
Debris avalanche ..	daF	27 860
Deposition	D	14 700

*The total area affected by erosion is different from the sum of the individual types, because up to 3 types can be recorded in a map unit.

Erosion codings and severities referred to in the text are described in Appendix 5.

Erosion control and soil conservation works are undertaken by three catchment boards in the region. The Hawke's Bay Catchment Board operates three catchment control schemes (Makara, Maungakuri, Puhokio-Waingongoro), the Upper Tukituki River Control Scheme, and the Tutaekuri-Waimate Drainage and Flood Control Scheme.

In that part of the Manawatu Catchment Board area east of the Manawatu Gorge, six schemes are in operation, at a cost of $350,000 for the 1982/83 year. They are the South Eastern Ruahine Management Scheme, Upper Manawatu Scheme, Eastern Manawatu Scheme, and the Mangatainoka, Tawaitai-Mangaone and Wainui Erosion Control Schemes.

In the Wairarapa, eight catchment control schemes covering the Owahanga, Matai-kona, Whakataki, Whareama, Homewood, Maungaraki, Awhea-Opouawe and Kaiwhata catchments, and the Lower Wairarapa Valley Scheme, are in operation. These involved an annual expenditure on erosion control work of $0.5 million (1982 values), mainly on fencing and tree planting. The tree planting programme involves 700,000 to 800,000 trees per annum (King, 1982).

Vegetation

Vegetation cover is assessed using a classification of 45 classes, arranged into five groupings — grassland, cropland, scrub and femland, forest, and miscellaneous. In the Southern Hawke's Bay-Wairarapa Region, 25 of the 45 different vegetation classes have been mapped. The classification and method of recording are set out in NWASCO (1 979). A summary of the dominant vegetation mapped in the five groupings is shown in Table 4.

Grassland is the most extensive vegetation cover in the region, comprising 85 percent of the total area, and occurring on the majority of flat and rolling land, and hill country. Isolated pockets of scrub and forest occur in the hill country, usually on the steeper valley sides. In the more isolated eastern areas of the Wairarapa hill country, large areas are under scrub, or are being cleared for redevelopment.

Table 4: Areas of dominant vegetation groups mapped

VEGETATION GROUP	AREA (ha)	PERCENT OF REGION
Grassland	1 202 940	84.6
Cropland	5 880	0.4
Scrubland	121 630	8.5
Forest	65 180	4.6

Areas of horticultural land are centred mainly on the Heretaunga Plains and the Wairarapa Valley, with root and green fodder crops grown throughout the region.

The Haurangi and Ruahine State Forest Parks have an indigenous forest cover, including some areas of scrubland. Outside the forest parks, other small remnant stands of the original forest cover remain, e.g., Puketoi, Mt Bruce, and Rocky Hills State Forests (New Zealand Forest Service, 1970, 1973, 1974). The removal of the original forest through 'slash and burn' has had disastrous effects in areas where repeated burnings have almost completely destroyed the vegetation cover, resulting in very severe erosion (e.g., Wakarara Range). Much of the remaining forest has been selectively logged, and is now regenerating. Forest comprises only 4.6 percent of the region, of which 46 780 ha are indigenous forest, 1030 ha are conservation plantings, and 17 370 ha are exotic forest. Three exotic forests administered by the New Zealand Forest Service occur in the region—Gwavas, Tinui and Ngaumu State Forests.

Climate

Climatic data, together with the inventory data, and effects of past land use, are necessary to assess the capability of land for permanent sustained production. Rainfall information was based on the Isohyetal Map of New Zealand (New Zealand Meteorological Service, 1978). Other climatic information was available in Coulter (1969), de Lisle and Patterson (1971), New Zealand Meteorological Service (1973, 1976-81 a, 1976-81 b), Kerr *et al.* (1981), and Thompson (1982).

The region experiences a range of climatic conditions, strongly dominated by orographic influences, and controlled to a large extent by the axial ranges.

There is considerable variation in annual rainfall recorded throughout the region, ranging from about 800 mm on the Heretaunga Plains and the Wairarapa Valley, to more than 2000 mm on the Puketoi Range and the Aorangi Mountains, and over 4000 mm recorded on the summit of the Ruahine Range. Most of the eastern coastal hill country has an annual rainfall between 1000 mm and 1400 mm but, as a result of the rain-shadow effect of the Ruahine and Tararua Ranges, it receives very little rain from the west. The eastern hills are exposed to persistently strong westerly winds, which deplete soil moisture reserves and retard pasture production. The coastal ranges cause a rain-shadow effect in inland areas from S-SE rain, and have an important orographic effect in localising rainfall. The effectiveness of rainfall is reduced by strong westerly winds in spring and late autumn.

Generally, the climate is hot and dry in summer, and cold and wet in winter. Summer temperatures frequently rise above 25 ° C in sheltered inland areas, and may exceed 32°C. Winter frosts may be recorded as low as —9°C.

Snowfalls occur during the winter and early spring on the Ruahine, Wakarara and Puketoi Ranges, Mt Bruce, the foothills of the Ruahine Ranges between Woodville and Norsewood, and on hill country above 450 m a.s.l.

Dry periods and drought in the central and eastern Hawke's Bay (north of Norsewood) and Wairarapa (south of Mt Bruce) often occur annually, and significantly reduce pasture growth in late spring, summer and autumn.

It is usual for the Wairarapa region to experience at least one period of low rainfall each year especially during the summer months (November to March), and it is common for very dry conditions to last about 19 or 20 days. During the period 1884 to 1981 there were 87 droughts (period of at least 15 consecutive days when there has been no measurable rainfall), and 151 dry spells (at least 15 consecutive days, none of which has 1.0 mm or more of rain) (Thompson, 1982).

In the Hawke's Bay area the monthly distribution and variability of rainfall result in moisture deficits frequently occurring from November to May. Deficits of 7.5 cm or more may occur.

In parts of the Heretaunga Plains, the dry conditions will occur in one year out of two, and on the average, last for at least four months. Away from the Plains, the lengths of the dry spells are much shorter. In the ranges only about one year in ten would a dry spell last for two months on end (de Lisle and Patterson, 1971).

The mean daily wind run is generally high throughout the region. Measured wind run data are scarce (see de Lisle and Patterson (1971) and Thompson (1982)).

The prevailing wind direction is from the west although, locally, winds are influenced by orography. Cook Strait and the Manawatu Gorge have the effect of funnelling air-streams, resulting in north-westerlies and south-westerlies prevailing east of the Manawatu Gorge, and the Rimutaka and Tararua Ranges respectively (Coulter, 1969). The Puketoi and Wakarara Ranges also have the effect of funnelling winds, so that they can often be gale force (up to 150 km/h) in these areas. Easterly and southerly winds usually bring rain and colder temperatures, and are more frequent in winter. Westerly winds predominate during the spring and autumn equinoxes, are occasionally of gale force and frequently strong enough to significantly affect plant growth through the rapid depletion of soil moisture. Northerly winds are generally hot and dry, desiccating north or north-westerly facing slopes, especially in the summer months. On exposed faces, the upper slopes and ridges tend to be more severely desiccated than the lower slopes. On dip and scarp topographies, the north-westerly facing dip slopes are exposed to the westerly winds, and experience wide seasonal variations in soil moisture, while the more sheltered south-westerly scarps are subject to far less moisture variation.

The effects of climate appear to divide the region into two broad climatic zones:

(a) Southern Hawke's Bay (north of both Norsewood, at the southern end of the Takapau Plains, and Porangahau at the coast). This zone has warm summers and mild winters and is generally less windy than the Wairarapa (except for areas near the Ruahine Range which experience strong, turbulent winds). Variable spring and summer rainfalls result in drought periods in most years.

(b) Wairarapa (south of Norsewood and Porangahau). Apart from the northern Wairarapa Plains area which is relatively sheltered, this zone experiences more wind than Southern Hawke's Bay. Wind is an agriculturally significant element of the Wairarapa climate. Rainfall is variable, with summer drought periods and winter flooding occurring. Colder winter temperatures, higher wind velocities, and a shorter growing season for some crops (Kerr ef *al.*, 1981) suggest that this zone is less versatile for cropping than the northern zone. The lower Wairarapa Valley is very exposed to cold winds from the south, making shelter necessary for horticulture.

The importance of recognising these two zones was not evident from the climatic data available at the time of the survey. However, the interpretive analysis of stock, forestry and cropping data collected after the survey was completed, indicated that the effects of climate were significant enough to influence productivity potentials of LUC units in each zone.

It is presumed that the lower levels of stock carrying capacity and forestry site index are related to the frequency of strong winds which appear to be more prevalent in the Wairarapa zone.

LAND USE CAPABILITY CLASSIFICATION

The Land Use Capability (LUC) classification is an assessment of land in terms of its capacity for sustained productive use, taking into account physical limitations, management requirements and soil conservation needs. The assessment is based on an interpretation of the physical information in the resource inventory, supplemented with information such as climate and the effects of past land use. The LUC classification has three basic components — class, subclass and unit — each of which is represented by a number or symbol.

Land Use Capability Class

The capability class is the broadest grouping of the capability classification. It is an assessment of the versatility of land for sustained production and gives the general degree of limitation to use, taking into account its physical limitations. There are eight 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 cropping, pasture or forestry, while classes V-VII are limited to pastoral or forestry use. The limitations reach a maximum with class VIII land, which is unsuitable for grazing or production forestry, and is best suited to catchment protection.

Areas of the eight LUC classes mapped in the region are given in Table 5.

Table 5: Areas of LUC classes mapped in the Southern Hawke's Bay-Wairarapa Region

LUC CLASS	AREA (ha)	PERCENT OF REGION	
1	18 000	1.3 1	
II	74 810	5.2 1	Arable land 28.9%
III	217 170	15.3 f	
IV	101 830	7.1 I	
V	29 640	2.1 1	
VI	620 480	43.6 }	Non arable land 65.8%
VII	285 620	20.1 J	
VIII	50 950	3.6	Protection land 3.5%

The most versatile land, classes I and II, which have only slight limitations to arable use, comprise 6.5% of the region.

Land Use Capability Subclass

The subclass groups units with the same kind of limitation or hazard. The four kinds of limitation recognised are:

e erodibility

w wetness

s soil 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 LUC extended legend.

Land Use Capability Unit

The LUC unit is the most detailed grouping, and is represented by an arabic number. It groups together land inventory units which require the same kind of management and

the same kind and intensity of conservation treatment, would grow the same kind of crops, pasture or forest species, and have about the same potential yield. Within each capability class, the LUC units are arranged in order of decreasing versatility of use and increasing degree of limitation to use.

A total of 71 LUC units were mapped in the region (Noble, 1979), and are listed together with their areas in Appendix 6. A correlation of these units with LUC units in adjacent Northern Hawke's Bay (Region 7), Wellington (Region 9), and Taranaki-Manawatu (Region 10) Regions is given in Appendix 7.

Additional Interpretive Data

Stock carrying capacities together with information on forest growth potential are necessary in the assessment of LUC units.

Stock Carrying Capacities

Three levels of stock carrying capacity and fertiliser data were collected in 1978-79 with the assistance of Ministry of Agriculture and Fisheries advisory staff from Hastings, Dannevirke and Masterton. Representative sites of each capability unit were visited in the field. Assessments of present average, top farmer, and potential carrying capacity were given for each of these sites. An assessment of fertiliser and trace element requirements was also made at the time of field inspection.

Correlation of the data was carried out by the Regional Advisory Officer. The stock carrying capacity data are presented in Appendix 8, and the fertiliser data are available on request from the Scientist in Charge, Soil Conservation Centre, Aokautere.

Forestry Site Indices

The forestry site index data of *Pinus radiata* for each LUC unit were collected in 1981 with the assistance of New Zealand Forest Service personnel from Palmerston North, Napier and Masterton. Representative sites of each capability unit were visited in the field, and an assessment of site index was given, based either on plot record information or on field observations of shelterbelts or plantations in the vicinity. The data were then correlated with the District Forester. Groupings for the site index data are given in Table 6.

Table 6: Forestry Site Index Groupings

FOREST GROWTH POTENTIAL (for *P. radiata)* (m)	SYMBOL	SITE INDEX
Very High	VH	>35
High ..	H	30-35
Medium	M	25-29
Low . .	L	20-24
Very Low	VL	<20

Variations in the site index between the same LUC units were noted over the region, with consistently lower figures being given in the lower half of the region. These lower figures result from the effects of wind depressing tree growth in more exposed sites and to the harsher southern Wairarapa climate.

The forestry site index data are given in Appendix 9.

LAND USE CAPABILITY SUITES

Traditionally, numerical ranking of LUC units, based on decreasing capability and versatility, has been used in the land use capability extended legends, which accompany each LUC survey. This ranking gives no indication of the relationship between units in a landscape setting. For ease of interpretation, LUC units which are related to each other have been arranged into groups, these being termed 'LUC suites'. A LUC suite may be defined as a group of LUC units which, although differing in land use capability, share a definitive physical characteristic, which unites them in the landscape.

In this region, rock type and climate are the basis for division of the 71 LUC units into ten suites (Table 7). Rock type is the most important factor which determines long term land use capability. It affects landforms, slopes, soils, erosion forms and soil conservation measures, land management and productivity. Within each suite, LUC units are ranked according to decreasing capability. LUC suites may be further divided into subsuites on the basis of secondary criteria.

Table 7: LUC suites, and LUC units occurring within each suite

LUC SUITE	LUC UNITS OCCURRING WITHIN SUITE
Alluvium and peat	Id, Iw1, IIw1, IIIwl, IIIw2, IVw1, Vlw1
Gravels	Iis 1, IIIs2, IVsI, Vls1, Vls4, VIlsl
Sand dunes	Vle14, Vls5, VIIe14, VIIIe4
Tephra and loess	Iid, IIIst, IIIel, IIIe2, IVe1, IVe2, Vle1, Vle4, Vle6
Mudstone or fine siltstone	IIIs3, IIIe3, IVe3, Vle2, Vle3, Vle7, Vle8, Vie 10, VIIel, VIIe2, VIIe8, VIIe12
Sandstone or coarse siltstone	Vle9, Vls2, VIIe4, VIIs2
Limestone	IVe4, Vs1, Vd, Vle5, Vld, Vlc2, VIIe3
Argillite	IIIs4, IVe5, Vle12, Vle13, VIIe6, VIIe7, VIIel 1, VIIe13
Greywacke	Vls3, Vle11, VIIe5, VIIelO, VIIIe5, VIIIe6, VIIIe7, VIIIe8, VIIIe9, VIIId
Miscellaneous	VIIe9, VIIIel, VIIIe2, VIIIe3

These LUC suites, and the units occurring within each suite are described more fully in the following sections.

Land Use Capability Suite of Units on Alluvium and Peat

Alluvium, totalling 128 260 ha, is widespread throughout the region on plains, terraces and valley bottoms (Figure 5). In this suite seven LUC units have been mapped, with LUC classes ranging from I to VI. The main criterion for the subdivision of these LUC units is the degree to which wetness is a limitation to productive use. This limitation increases from LUC class I to VI. Wetness is related to soil physical properties of texture and structure as they influence internal soil drainage characteristics. Water table levels and frequency of flooding are also taken into account in deciding the LUC unit (Table 8). Climate and relief influence wetness in terms of available water.

Table 8: Wetness characteristics related to LUC units on alluvium and peat.

LUC UNIT	WATER TABLE LEVELS	INTERNAL DRAINAGE CHARACTERISTICS	SOIL GROUPS	SURFACE FLOODING
Id	No effect on production	Well drained	Recent alluvial	Nil
Iw1	No effect on production	Well drained	Recent alluvial	Nil
IIw1	Subsoils permanently moist. Water table rises seasonally	Well drained	Recent alluvial Gley	Ponding after rain
IIIwl	Fluctuating	Moderately well drained to imperfectly drained	Recent alluvial Gley	Infrequent flooding (approx. 1 in 5 years)
IIIw2	Fluctuating	Imperfectly drained	Gley Organic	Infrequent flooding (approx. 1 in 5 years)
IVw1	At or near surface during wetter periods of year	Poorly drained	Gley Organic	Surface flooding each winter

LUC classes I and II contain the most versatile LUC units in the region. They occur on plains and terraces where soils and climate are most favourable for plant growth, e.g., the Heretaunga Plains and Wairarapa Valley, and large areas are used intensively for either horticulture or orcharding.

LUC class III occurs on terraces and in narrow valleys, while LUC classes IV and VI occur most frequently in low lying depressions and around lake margins. Because of the limitations of scale, no class VII or VIII has been mapped since these areas were too small to be separated out.

Soils range from free-draining deep alluvial soils on LUC classes I and II, to poorly drained gley and organic soils formed on alluvium and peat respectively on classes IV and VI.

Rainfalls are generally between 700 and 1200 mm/annum, although some units, e.g., **IIwl**, IIIwl and IIIw2, near Pahiatua, have annual rainfalls of up to 1600 mm.

Erosion is not a problem, apart from deposition on low terraces, and streambank erosion.

Figure 5: Location of LUC units on alluvium and peat.

LUC units that occur north of Norsewood have a slightly more favourable climate for a wider variety of crops to be grown than those to the south. As a consequence they have slightly higher potential production levels. However, in this survey, the difference is not recorded, because it was not identified until after the classification was completed and the productivity data collected. In the southern half of the region, shelter is necessary for all horticultural and orchard crops.

Production data for the LUC units on alluvium are shown in Table 9.

Table 9: Production data related to LUC units on alluvium and peat

LUC UNIT	POTENTIAL STOCK CARRYING CAPACITY (su/ha)*	SITE INDEX FOR *P. radiata* (m)t	CROPPING POTENTIAL
Id	32 29-33		Wide range, including subtropicals.
Iw1	30 29-33		
IIwl	28 28-33		Berryfruit, vegetables, cereals, root and green fodder crops, pip fruit, some stone fruit, and kiwifruit.
IIIwl	26 28-30		Green vegetables, some cereals, root and green fodder crops, grass seed.
HIw2	25 26-28		Some cereals, root and green fodder crops, grass seed.
IVw1	16	Unsuitable	Root and green fodder crops. Occasional barley.
Vlw1	15	Unsuitable	Unsuitable.

See Appendix 8 tSee Appendix 9

LUC UNIT Id (12 260 ha)-Figure 6

This unit is mapped on deep, fertile, free-draining soils on plains and river terraces that are not subject to flooding or erosion. The unit occurs on the Heretaunga Plains (5560 ha), Ongaonga-Waipukurau area (61 70 ha), and adjacent to Greytown (530 ha). Annual rainfalls are between 700 and 1200 mm. Soils mapped are the Manawatu silt loam, and Twyford and Hastings series soils. These are recent alluvial soils which have a high natural fertility, and free-draining silty and fine sandy loam textures. Soil depths are greater than 45 cm. Irrigation is required during summer drought periods for intensive horticulture, especially on the well drained, sandier soils. In the Wairarapa, the slightly colder temperatures and stronger winds result in the need for more intensive shelterbelt plantings. A wide range of horticultural, market gardening and orchard crops are presently grown on this unit. These include berry fruits, grapes, kiwifruit, pip fruit, stone fruit, process crops, and market garden vegetables. Cereal crops such as barley, wheat and maize could also be grown.

Only small areas are still used for intensive grazing with a present average stocking rate of 15 su/ha. The grazing potential is assessed as 32 su/ha. Forestry site index is medium to high, 29-33 m for *P. radiata.*

r-v

+ -

mm

Figure 6: LUC unit Id. Peach orchard, Raupare Road, near Hastings. N134/230248.*

*Grid references based on the thousand-yard grid of the 1:63 360 topographic map series (NZMS1)

LUC UNIT **Iw1** (5740 ha)-Figure 7

This unit is similar to LUC unit Ic1, occurmg on plains and river terraces with deep fertile, alluvial soils. However, soil wetness is a slight limitation. It occurs on the Heretaunga Plains, near Waipawa and Pahiatua, and in the Wairarapa Valley. Annual rainfalls are between 700 and 1200 mm.

The Manawatu silt loam, Greytown silt loam and Hastings series soils have a high natural fertility. They have slightly heavier textured subsoils which retain moisture for longer periods than those in LUC unit Id. This very slight wetness limitation does not restrict versatility, and the land is suitable for a wide range of horticultural crops. It is presently being used for intensive horticulture (market gardening, process vegetables, berryfruit, kiwifruit), orcharding (pip and stone fruit), and for intensive grazing. Cereal cropping may also be carried out. Present average stocking rate is 13 su/ha, with a potential of 30 su/ha. Forestry site index values for *P. radiata* are medium to high, ranging from 29 m in the Wairarapa to 33 m in Hawke's Bay.

Figure 7: LUC unit Iwi. Near Hastings. N134/296211.

LUC UNIT IIwl (37 810 ha)-Figure 8

This unit is mapped on plains and river terraces on the Heretaunga Plains, between Waipawa and Eketahuna, and in the Wairarapa Valley. In addition, small areas are mapped on river valleys in the hill country throughout the region. Annual rainfalls vary from 700 mm at Hastings to 1400 mm at Pahiatua. The flat river terraces have deep soils with a high natural fertility, but with slow natural drainage in the subsoils. A continuing slight wetness limitation to mainly horticultural land use remains after drainage. Water table levels rise seasonally, and areas of ponding can occur after heavy rain.

Both recent and gley soils have been mapped, typical soils being Kairanga silt loam, and Ahikouka silt loam.

A wide range of crops can be grown, and with appropriate drainage it is suitable for deeper rooting crops. Crops include berry fruit, market garden vegetables, asparagus, cereal crops (barley, maize, wheat), pip fruit, and root and green fodder crops. Some kiwifruit and stone fruit may be grown in sheltered or frost-free areas. Shelter is required for all cropping in the southern half of the region. Some areas of this unit south of Pahiatua, are presently used for dairying with a present average stocking rate of 1 2 su/ha. Potential stock carrying capacity is 28 su/ha, with forestry site index for *P. radiata* ranging from 28 to 33 m.

Erosion is not a problem, except near streams where streambank erosion may remove productive soils.

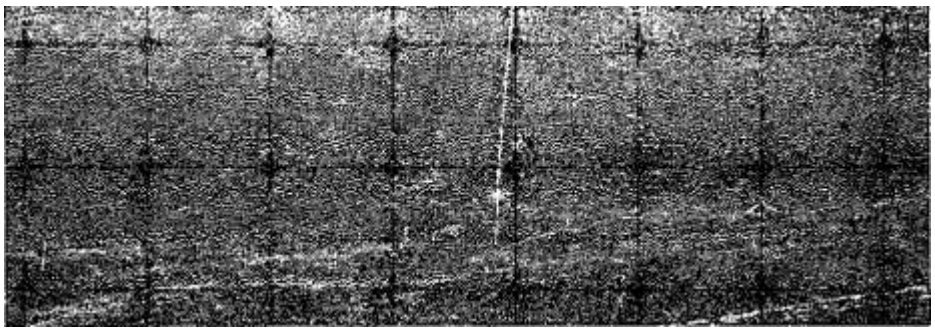


Figure 8: LUC unit IIw1, Near Martinborough, N161/945345

LUC UNIT IIIwl (44 750 ha)-Figure 9

This unit is mapped on narrow valley bottoms or on poorly-drained alluvial flats. These areas have moderately high and fluctuating water table levels, and a moderate wetness limitation continues even after drainage. Runoff from surrounding hill country and periodic flooding contribute to this continuing wetness limitation. Rainfalls range between 800 and 1600 mm/annum.

Soils are recent alluvial or gley soils, and include Kairanga silt loam, Ahikouka silt loam, and Kaiapo silt loam and heavy silt loam. These have developed under conditions of slow natural drainage, and subsoils are gleyed or mottled. These poor internal drainage characteristics restrict the potential for intensive cropping. Soil wetness also limits early cropping. This type of land is suitable for dairying, but winter feed crops for stock are limited because of practical difficulties in feeding out. Present cropping is mostly maize or fodder crops, hay, silage; grass seed, and less frequently cereals (in lower rainfall areas) and green vegetables.

Potential stock carrying capacity is 26 su/ha, although the present average rate is only 12 su/ha. The forestry'site index for P. *radiata* is estimated at 28 to 30 m.

Slight streambank erosion, flooding and deposition are potential hazards in narrow valley bottom situations.

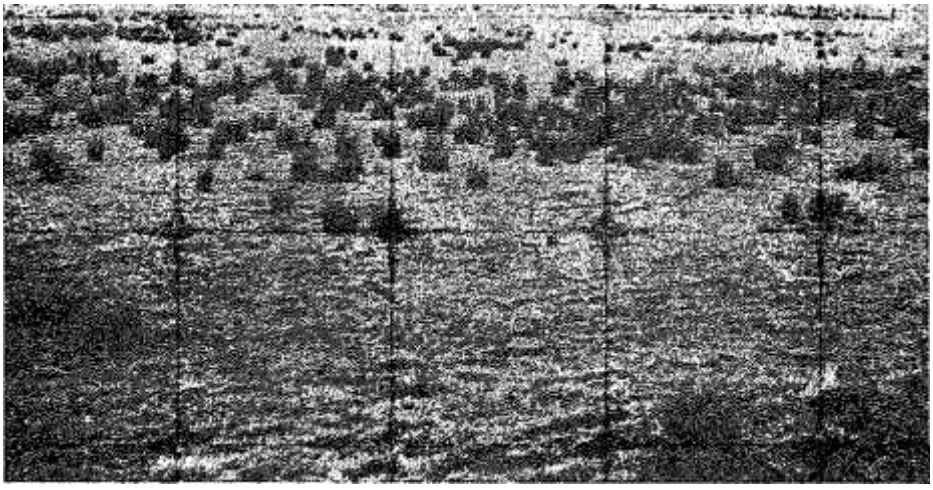


Figure 9: LUC unit IIIwl, Ihuraua, south-east of Eketahuna, N158/295885

LUC UNIT IIIw2 (15 910 ha)-Figure 10

This unit occurs on flat terraces and depressions which have poor internal drainage, or in areas where natural drainage outfalls are restricted. The gley and organic soils mapped on this unit are more difficult to drain effectively than soils on LUC unit IIIwl.

The heavy textured subsoils give rise to slow internal drainage and poor soil aeration. Typical soils include Arlington loam and Raumati silt loam. The impeded drainage and long periods of high water tables make this unit more suited to intensive grazing than cropping, although some maize, barley, grass seed, and summer forage cropping may be carried out. Some soils have the added limitation of stoniness, e.g., Moroa stony loam, where some profiles are stony to the surface. Areas of this unit south of Greytown are presently used for dairying. The unit includes small areas of wet sand plains near Porangahau and around the margin of Lake Wairarapa, which would be classified as a new LUC unit at more detailed mapping scales.

Present average stock level is 13 su/ha, and the potential stock carrying capacity is 25 su/ha. The forestry site index is rated as medium, 26 to 28 m for *P. radiata.*

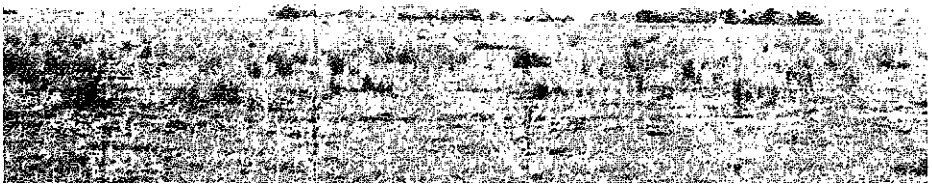


Photo: D. Harding

Figure 10: LUC unit IIIw2, Phillips Line, south-west of Greytown, N161/911392.

LUC UNIT IVW1 (8310 ha)-Figure 11

This unit occurs in flat, slow-draining depressions or adjacent to lake margins where water table levels are at or near the surface during wetter periods of the year. Because of the low-lying situation, drainage is difficult. The result is a more severe wetness limitation than the LUC class IIIw units.

Soils are gley, formed on alluvium, (e.g., Raumati heavy silt loam), or organic, formed on peat deposits, (e.g., Poukawa peaty loam).

The unit is better suited to intensive grazing, because the high water tables and periods of surface flooding limit cropping. However, occasional root and green fodder crops and barley may be grown.

The present average stocking rate is 9 su/ha, with a potential of 16 su/ha. Because of high water table levels, LUC unit IVw1 is unsuitable for production forestry of P. *radiata.*

Figure 11: LUC unit IVw1. Wards Line, south of Greytown. N161/928368.

LUC UNIT Vlw1 (3480 ha)-Figure 12

This unit occurs in similar situations to LUC unit IVw1, in slow-draining depressions or around lake margins e.g., around the shorelines of Lake Wairarapa. However the wetness limitation is greater than in other LUC units in this suite, because water table levels are permanently at or near the surface. Drainage is very difficult in these low-lying areas, due to the lack of natural outfalls. Surface flooding is frequent throughout the year.

Typical soils are poorly aerated organic soils formed on peat, e.g., Taratahi peat, Poukawa peaty loam.

Pastoral farming is the most suitable land use, with a potential stock carrying capacity of 1 5 su/ha. The present average stocking rate is 5 su/ha. The high water tables make this unit unsuitable for forestry.

Figure 12: LUC unit Vlw1. Eastern shoreline, Lake Wairarapa. N161/842348.

Land Use Capability Suite of Units on Gravels

LUC units on gravels have been subdivided into two subsuites:

1, Terraces and flood plains (Figure 13)—1 22 560 ha.
2. Maturely dissected gravel deposits forming stable hill country (Figure 14)-26 360 ha.

Figure 13: Typical gravel terraces.
Near Takapau.
N146/902784.

Figure 14: Typical gravel hill country.
Near Gwavas State Forest.
N133/888119.

Figure 1 5 shows the general distribution of LUC units on gravels.

1. Terraces and Flood Plains

Terraces and flood plains comprise flat to gently undulating Quaternary surfaces. These occur as low flood plain terraces and fans (e.g., Wairarapa Valley), present day river flats (e.g., Tukituki River), or as dissected terraces (e.g., Ruataniwha Plains). Soils are coarsely textured, free draining, stony, and prone to seasonal soil moisture deficiencies.

The LUC units in this subsuite are defined on the basis of:

1. Depth of soil above gravel or coarser material; determines rooting depth, and moisture and nutrient availability for plant growth.
2. Stoniness, both density and size of gravels, stones, or boulders; determines the ease of cultivation.

The LUC classes in this subsuite range from classes II to VII. Class I units have not been included; they are included within the alluvial suite of LUC units, due to their greater soil depth and stone-free profiles. At more detailed mapping scales (e.g.,

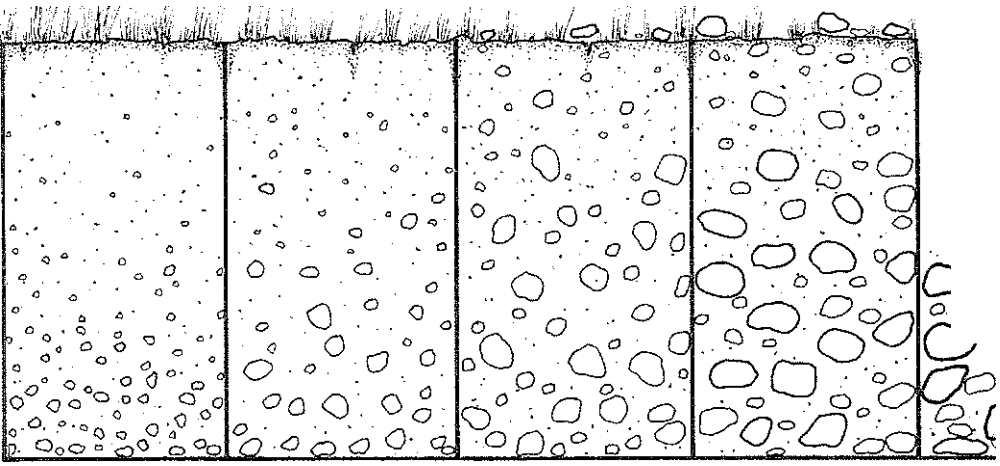
1:10 000), some small areas of class VIII (bouldery or very stony, flood-prone areas close to river courses) may also be identified.

Standard criteria, summarised in Table 10, and illustrated diagramatically in Figure 16, were used to separate the LUC units.

Table 10: Standard criteria used to identify LUC units on gravel terraces and flood plains.

LUC UNIT	DEPTH OF SOIL	DEGREE OF STONINESS	SUSCEPTIBILITY TO FLOODING
IIs1	45-90 cm	Gravel may be present in subsoil.	Nil
IIIs2	30-45 cm	Gravelly or stony subsoils. Gravel and small stones present throughout the profile.	Nil
IVs1	15-30 cm	Significant number of stones on the surface. Stones occur throughout the profile.	Low
Vls4	< 15 cm	Large stones often present on surface. Stones occur throughout the profile.	Medium
VIIsl	< 15 cm	Boulders on surface and throughout the profile.	High

Figure 15: Location of LUC units on gravels.



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IIs1 45 cm or greater depth of light - textured, fertile and well-drained soil. **IIIs2**	30-45 cm depth of soil, over gravels or stones. **IVs1** 15-30 cm	depth of light - textured, stony soil. Some stones are present on the surface. Vis4	Less than 15 cm ,depth of soil. Soil is vety I stony and shallow. Larger stones often present on the surface. **VIIs1**	Very stony and shallow soils. Boulders are present on surface and throughout profile.

Arable Units **4-Non Arable Units•**

Increase in size of stones, and number of stones on surface

Decrease in soil depth, and soil moisture holding capacity-

Figure 16: A diagrammatic representation of the relationship between LUC units on gravel terraces and flood plains.

LUC UNIT Us 1 (32 110 ha)-Figure 17

This unit occurs on flat river terraces and plains. Soils are moderately deep, with 45 to 90 cm of free-draining alluvium overlying gravels, e.g., Kopua series. These soils are light textured, and slightly more susceptible to summer drought than LUC class I units. However, with adequate soil moisture, summer irrigation in lower rainfall areas, and conservation measures to minimise the slight wind erosion potential (which exists under cultivation), a wide variety of crops can be grown. These include cereals, vegetables, asparagus, process peas, potatoes, berry fruit, pip and stone fruit, grapes, and root and green fodder crops. Kiwifruit may be grown given adequate shelter and irrigation. The versatility of this unit is not being fully utilised at present. The dominant land uses are intensive grazing, dairying, and root and green fodder cropping, rather than intensive cropping. Rainfalls range between 800 and 2000 mm/annum. The unit occurs mainly in the Wairarapa Valley and between Eketahuna and Tikokino.

The present average stocking rate is 12 su/ha, but grazing potential is high, 27 su/ha. The forestry site index figure for *P. radiata* is medium to high, 27-30 m.

Figure 17: LUC unit lis 1. Park Road, near Carterton. N162/034532.

LUC UNIT IIIs2 (55 890 ha)-Figure 18

This unit is mapped on flat terraces and plains that have 30-45 cm depth of free-draining, light-textured soils, over gravels and stones. Gravel and small stones may be present throughout the profile, but they are not a hindrance to cultivation.

This unit is more susceptible to summer drought and is therefore less versatile than LUC unit I Is **1**. This is due to shallower soil depth and light-textured topsoils and it generally occurs in areas where rainfalls are less than 1200 mm/annum. Porina and grass grub can be a problem on this unit.

Soils are intergrades between central yellow-brown loams and earths, e.g., Takapau series. They are susceptible to wind erosion when cultivated; however, with correct soil conservation management techniques, such as shelterbelt plantings, soil losses can be minimised. Large areas of the unit occur on the Takapau Plains, where, because of the wind erosion hazard, shelterbelts have been established in the past. With shelter, and irrigation where necessary, this unit is suitable for cereal crops, small seeds, process peas, lucerne, grapes, berry fruit, beans, tomatoes, and forage crops.

The present average stocking rate is 1 2 su/ha, while the potential stock carrying capacity is 25 su/ha. The forestry site index for *P. radiata* ranges between 26 and 30 m (medium to high).

Figure 18: LUC unit IIIs2. Cornwall Road, near Waingawa. N162/108589.

LUC UNIT IVs1 (20 820 ha)-Figure 19

This LUC unit is mapped on flat stony terraces. Annual rainfalls are generally less than 1200 mm. The shallow soil depth (15-30 cm) and the sandy textures of these soils, make this unit susceptible to drought. A typical soil is Takapau stony loam, which suffers long periods of seasonal soil moisture deficiency, particularly during summer months. Stones frequently occur on the soil surface, and in these areas stonepicking is beneficial. Areas of LUC unit IVs 1 adjacent to stream courses, may be subject to occasional flooding. (These areas would be identified as a separate unit at more detailed mapping scales.)

Because of the shallow soils and consequent drought-prone nature of the unit, crop versatility is limited, the land being suited only to occasional barley or root and green fodder cropping. Present average stocking rate is 5 su/ha. Potential stock carrying capacity (15 su/ha) is significantly lower than for LUC unit IIIs2, but the forestry site index is still rated as medium (27-29 m). Areas on coastal flats at Glenburn Station (south of Flat Point) and Pahaoa have been mapped as LUC unit IVs 1 because of the exposed nature of the coastline and the effects of salt spray and wind which limit cropping, although the soil profile is not as stony as a typical LUC unit IVs1 in other areas.

Figure 19: LUC unit IVs1, Swamp Road, north of Greytown, N161/952501.

LUC UNIT Vls4 (7510 ha)-Figure 20

This unit is mapped on very stony terraces or fans where the soils are less than 15 cm deep. These soils are not suitable for cropping because of the combination of shallow soil depth, numerous large stones, and susceptibility to drought. Typical soils are intergrades between central yellow-brown loams and earths, e.g., Tauherenikau stony silt loam, and recent soils from alluvium, e.g., Ruamahanga stony sand. Stones, often up to boulder size, are present throughout the soil profile and on the surface. Stone picking can provide a short term improvement, allowing occasional root and green fodder crops to be grown. However, repeated stone picking is required because further stones will be brought to the surface at each cultivation. Where this unit occurs on lower river terraces, it may be subject to short duration flooding.

Present average stocking rate is 4 su/ha, with a grazing potential of 15 su/ha, and the unit has a site index for *P. radiata* of 26-28 m.

Figure 20: LUC unit Vls4, Norfolk Road, Waingawa River terrace, N158/042679.

Sig. 3*

LUC UNIT VIIs 1 (6230 ha)-Figure 21

This unit is generally confined to bouldery flood plains or river courses subject to frequent flooding. Soil cover is patchy and less than 15 cm deep, with numerous boulders on the surface. A typical soil mapped is Tukituki stony gravel.

The size and frequency of boulders make stone picking uneconomic. However bull-dozer raking can be effective and may raise the capability to LUC unit VIs4.

This LUC unit is capable only of extensive grazing with a stock carrying potential of 5 su/ha, although the present level is as low as 1 su/ha. Vegetation cover is dominantly low producing pasture, with some tauhinu and conservation plantings for river protection. Forestry site index values are low to medium (24-25 m for *P. radiata),* on areas not subject to frequent flooding. On other areas, forestry is unsuitable.

Figure 21: LUC unit VIIsl. Old bed of Waipawa River, east of Waipawa. N141/065819.

2. Maturely Dissected Gravel Hill Country

The maturely dissected greywacke gravel deposits of Castlecliffian age comprise the second subsuite. This distinctive and stable landform occurs in a relatively confined area, around Gwavas, immediately east of the Wakarara Range. Relief is very regular, comprising a series of east-west trending valley systems, with subcatchments at right angles to these. One LUC unit, Vis 1, has been identified at the 1:63 360 mapping scale, as a result of the uniform nature of the terrain. The Gwavas State Forest is situated on this unit, and was established in 1944 as a source of timber for local supply. The site was most suited to forestry because lack of stock water hindered farm development and rabbits were a major problem.

LUC UNIT Vls1 (26 360 ha)-Figure 22

This unit is mapped on hill country with only a slight erosion risk. The landform consists of short, strongly rolling to moderately steep slopes between 1 6 and 25 °. The less steep slopes usually have a mantle of andesitic tephra from the Tongariro area. There is a potential for slight sheet erosion, which can be activated by stock camp activity. Soils are free draining, making the unit susceptible to summer droughts which frequently occur from November to March. During this period, pasture production is severely affected, with very low levels of dry matter production being attained. Grass grub infestations can be an additional problem, significantly affecting pasture production. A typical soil mapped is Gwavas sandy loam, an intergrade soil between central yellow-grey and yellow-brown earths. Present land uses are sheep grazing with a present average stocking rate of 12 su/ha and a potential stock level of 21 su/ha, and production forestry with an estimated site index of 28-30 m for *P. radiata.*

Figure 22: LUC unit Vls1. Kereru Road, near Gwavas State Forest. N133/882125.

Land Use Capability Suite of Units on Sand Dunes

The sand dune suite of LUC units which comprises sand dunes in two localities, has been divided into two subsuites:

1. Coastal dunes, in narrow isolated pockets along the eastern coastline (2790 ha).
2. Inland dunes, in a narrow inland strip along the eastern side of Lake Wairarapa (1680 ha).

Figure 23 shows the general distribution of LUC units on sand dunes.

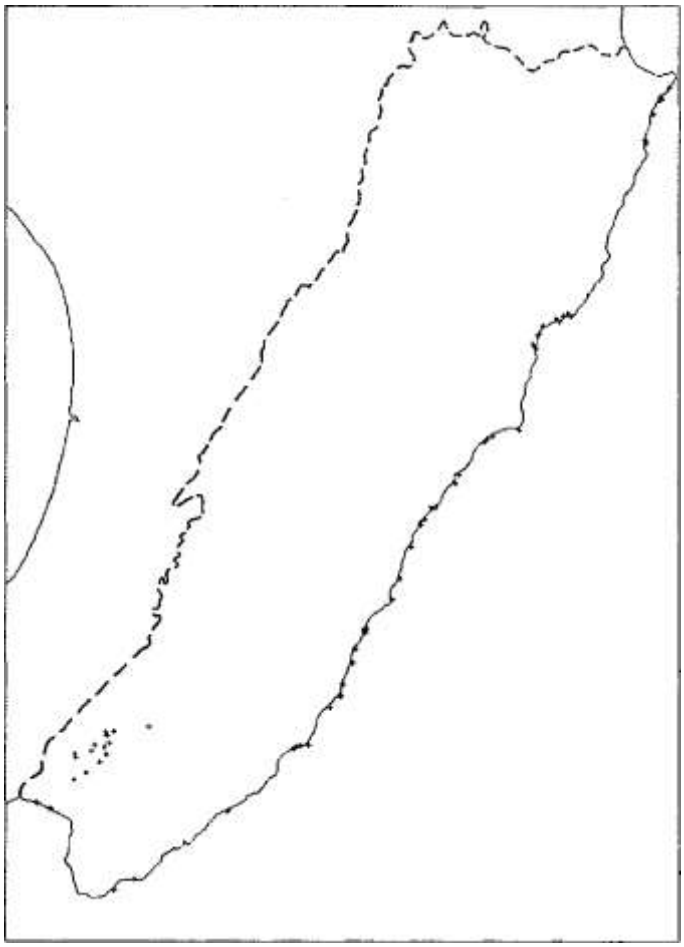


Figure 23: Location of LUC units on sand dunes.

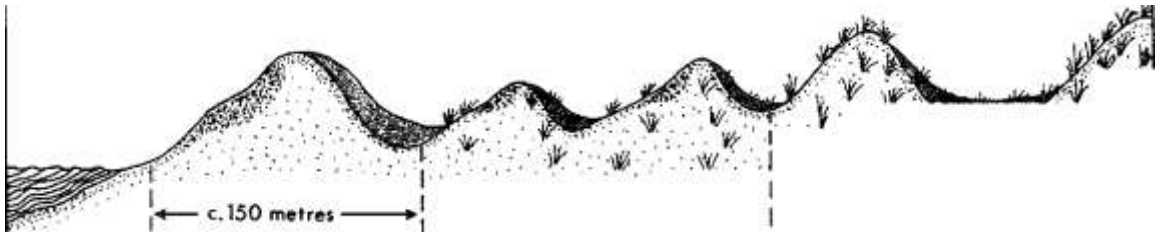
Soils in both dune areas are central yellow-brown sands. These soils are sandy textured, with a weakly developed structure. As a consequence the soils in this suite have a potential for severe soil moisture deficits, and for varying degrees of wind erosion. The main vegetation groups are the sand dune colonisers, e.g., pingao *(Desmoschoenus spiralis),* spinifex *(Spinifex hirsutus)* and marram *{Ammophila arenaria),* and low producing pasture species where dunes have been developed for grazing.

Erosion risk, exposure and degree of soil development, were the main criteria used in assessing the land use capability of these landforms.

1. Coastal Dunes

A complex of recent sand dunes and plains occur in small areas around existing river mouths (e.g., Riversdale, Porangahau, Waimarama, Ocean Beach). (This contrasts with the extensive dune belts along the west coast of the North Island.)

In general, the coastal dunes increase in stability, land use versatility and productive potential with increasing distance from the sea. This is related to the increased age of dunes further inland and therefore their degree of soil development, and a decrease in the extreme effects of wind and salt that are experienced along the foreshore. A diagrammatic representation of LUC units in the coastal dune subsuite is shown in Figure 24.



	beach zone	-Foredunes-		
erosion potential		Extreme wind	Extreme wind	Moderate wind
potential land Use		Protection forestry	Erosion control forestry	Production forestry, grazing
LUC unit		VIIIe 4	Vile 14	Vie 14

Figure 24: Relationships between LUC units on coastal dunes. (See Appendix 5 for erosion codings.]

Three LUC units have been identified on the coastal dune areas.

LUC UNIT VIIIe4 (440 ha)-Figure 25

This unit is mapped on the foredunes immediately inland from the beach zone. Climatic conditions (wind and salt spray) preclude any significant production potential. The inland boundary separates this protection land from potentially productive land. The recent windblown sands have very little soil development, a sparse vegetative cover, and an extreme wind erosion potential.

Management techniques on these dune areas need to concentrate on sand stabilisation by planting of marram *(Ammophila arenaria)* and spinifex *(Spinifex hirsutus),* followed by protection forestry. These plantings are necessary to combat the extreme erosion potential, and as a protection for the productive inland areas of LUC units VIIel 4 and VIe14.

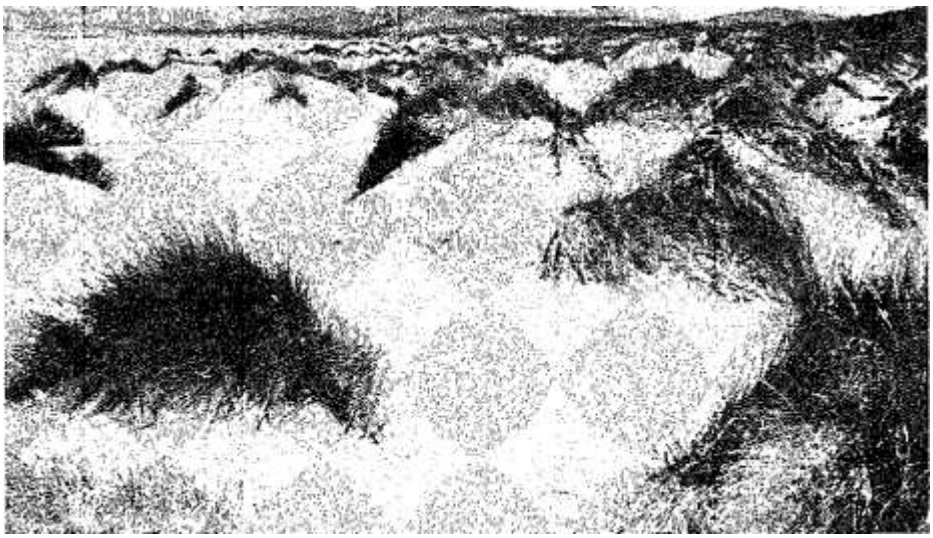


Figure 25: LUC unit VIIIe4, Blackhead Beach, N146/170502

LUC UNIT Vile 14 (1290 ha)-Figure 26

This unit is mapped on dune areas immediately inland from the Class VIII coastal foredunes. It comprises recent dune sands, usually with a more established vegetative cover than LUC unit VIIIe4. Environmental conditions here are less harsh than on the foredune areas and, although versatility is minimal and there is an extreme wind erosion hazard, a long term production potential does exist. Dune slopes are generally between 8 and 20 °. Soils are mapped as central yellow-brown sands, e.g., Patea sand. Because of the minimal soil development and the severe climatic conditions, extreme caution is needed in the management of this unit. If the vegetation cover is broken to expose the loose sand, blow-outs may result, often followed by dune migration.

Erosion control forestry is the most effective conservation land use; the forestry site index for P. *radiata* is estimated at between 23 and 26 m (low to medium). Potential stock carrying capacity is estimated at only 3 su/ha. This low grazing potential is reflected in the present land use pattern with many areas unfarmed. At the time of mapping, only 180 ha had been developed (170 ha into low producing pasture and 10 ha into exotic forestry).

*i.3**

J.

Figure 26: LUC unit Vile 14. Blackhead Beach. N146/160510.

LUC UNIT VIe14 (1060 ha)-Figure 27

This unit occurs inland from LUC unit VIIel4, on rolling to strongly rolling, semi-consolidated dunes, which generally have a stable vegetation cover. The sandy soils are free draining and have a more developed structure than those on LUC unit VIIel4, and are therefore better suited for pastoral use. Soils mapped are central yellow-brown sands, e.g., Patea sand. Present land use is extensive grazing of 700 ha, with the remainder undeveloped. However, with good management it has the potential for more intensive pastoral use. The present average stocking rate is 3 su/ha, and the potential stock carrying capacity is estimated at 11 su/ha. The forestry site index for P. *radiata* is 25-28 m.

It is important to strategically site tracks and fencelines to avoid concentrations of stock because this will break the turf mat, resulting in erosion of the loose subsoils. Shelterbelts minimise the wind erosion potential and encourage pasture growth.

Figure 27: LUC unit Vie14. Ocean Beach. N142/416086.

2. Inland Dunes

Inland dunes occur as a narrow strip along the eastern side of Lake Wairarapa. These dunes were formed in the late Pleistocene, and are therefore older and more stable than the recent coastal dunes. This subsuite is represented by only one LUC unit.

LUC UNIT **VIs5 (1680 ha)-Figure 28**

This unit is mapped on strongly rolling to moderately steep consolidated dunes. Soils are well developed central yellow-brown sands which support a productive pasture cover except during drought periods (good winter country). A typical soil mapped is Manihera sand. The susceptibility to drought, caused by the sandy free-draining soils and rainfalls less than 1200 mm/annum, is the dominant limitation to use, rather than erosion which is the dominant limitation on the coastal sand dune LUC units. Under good conservation management erosion will not be a significant problem. Management needs to ensure that soil moisture is maintained as far into drought periods as possible. This can be achieved through well designed and managed shelter belts and adoption of good pasture management techniques aimed at providing a healthy pasture cover. Care should be taken in the siting of fencelines and tracks to prevent stock concentration since this may lead to erosion. The majority of the unit (1320 ha) is in pasture with a present average stocking rate of 5 su/ha and a potential carrying capacity of 11 su/ha. The forestry site index for *P. radiata* is 26-28 m.

Figure 28: LUC unit VIs5. LUC unit IIIw2 on wet sand plains in foreground. Near Kahutara, eastern Lake Wairarapa. N165/848286.

Land Use Capability Suite of Units on Tephra and Loess

This suite is one of the largest in the region, covering 1 73 800 ha (Figure 29). Nine land use capability units, ranging from LUC class II to LUC class VI have been identified. The separation of units was based on a combination of limitations relating to climate, slope and erosion hazard.

The suite has been divided into two subsuites:

1. Landforms mantled by airfall tephra, and reworked loess derived from this tephra (tephric loess). This subsuite is mapped along the western foothills and terraces bordering the axial ranges. Annual rainfalls are greater than 1200 mm, and the area is subject to strong winds, frosts and cold winter temperatures. LUC units mapped in this subsuite are lie **1**, IIIe1, IVe1, Vie 1 and VIe6.
2. Landforms mantled by loess. This subsuite is mapped on terraces and hill country in the eastern part of the region. Annual rainfalls are less than 1200 mm, and frequent and severe summer droughts occur. LUC units mapped in this subsuite are IIIsl, IIIe2, IVe2 and VIe4.

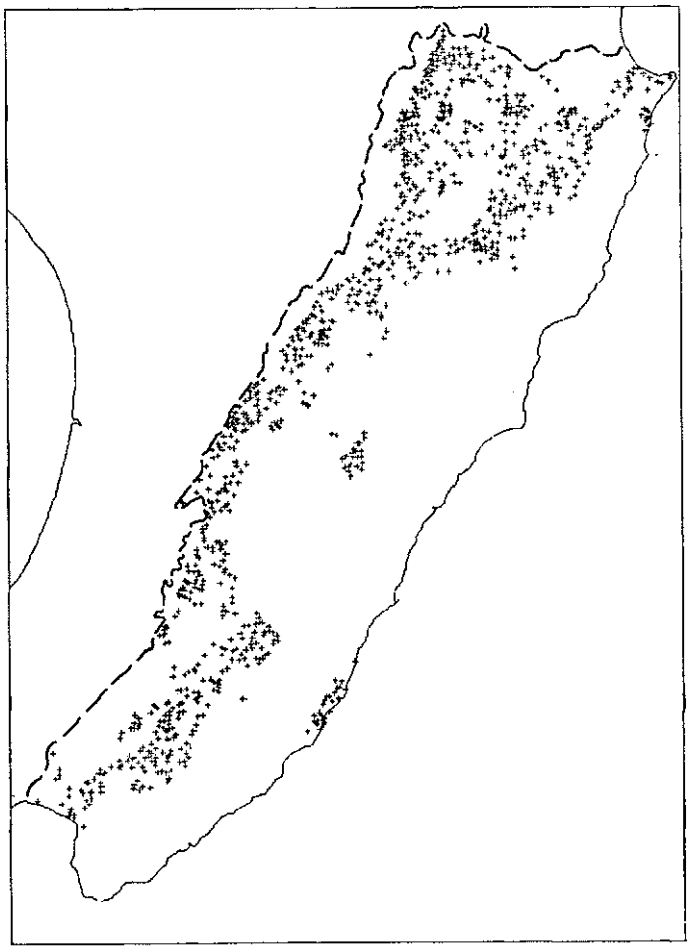


Figure 29: Location of LUC units on tephra and loess.

The LUC units and production figures for each subsuite are listed in Table 11

Table 11: Stock and forestry data for LUC units on tephra and loess

TEPHRA AND TEPHRIC LOESS: annual rainfall > 1200 mm			LOESS annual rainfall < 1200 mm		
Present average stock carrying	Potential stock carrying	Site index	Present average stock carrying	Potential stock carrying	Site index

Production figures are generally higher on the tephra subsuite than on the loess subsuite, because of the more naturally fertile and well structured soils, and the higher rainfalls.

1. Land Use Capability Units on Tephra and Tephric Loess in Areas with Annual Rainfalls above 1200 mm

Five LUC units are mapped in this subsuite, totalling 86 150 ha, with classes ranging from class II on flat terraces, to class VI on moderately steep hill country. These units occur immediately east of the axial ranges, as far south as Masterton. Annual rainfalls are generally between 1200 and 1600 mm, but range up to a high of 2000 mm immediately east of the ranges, e.g., at Kopikopiko, north-west of Eketahuna. Pasture production continues throughout the summer because of the evenly distributed rainfall pattern. However, strong winds, frosts and cold winter temperatures limit cropping versatility and winter pasture production. Shelter is necessary for horticulture and cropping to improve the yield and quality of the produce.

North of the Waipawa River, landforms are mantled by weathered, clay-rich, red-brown airfall tephras from the Taupo Volcanic Zone. (The zone is described in Healy, 1982.) The tephras in this area have been mapped as Mo (ashes older than Taupo ash). This tephra is deepest on flat terrace areas adjacent to the ranges, and the deposits thin towards the east, away from the source area. On steeper slopes, the tephra is patchy, reflecting the influence of past erosional history.

Between the Waipawa River and Woodville, it is considered that tephric loess forms the bulk of the soil parent material, and is reworked red-brown airfall tephra. These deposits have been mapped as loess (Lo). Tephric loess was not recognised by Rhea (1968) in his work on the late Quaternary stratigraphy of the Dannevirke district.

South of Woodville, and along the western Wairarapa Valley, the loess deposits are also considered to be of tephric origin, or a complex of loess and tephra. Loess has been locally derived from aggrading alluvial flood plains and valley floors, deposited mainly by southerly and easterly winds during glacials. This locally-derived loess is interbedded with distal tephric material originating from the Taupo Volcanic Zone (Kaewyana, 1980).

These tephra and loess deposits mantle a variety of underlying rock types, e.g., gravels, sandstones, siltstones, mudstones and greywacke. Soils mapped are central yellow-brown earths, and intergrades between central yellow-brown loams and yellow-brown earths. They have good physical properties for plant growth, but the light-textured and 'fluffy' topsoils are particularly susceptible to wind erosion. Wind erosion is a significant hazard, with risk increasing towards the ranges, especially in turbulent wind funnel areas where gusts can reach 150 kilometres per hour.

LUC UNIT He 1 (4890 ha)-Figure 30

This unit is mapped on flat or undulating terraces from Norsewood to Eketahuna which are sheltered from the prevailing strong westerly winds. Soils are intergrades between central yellow-brown loams and earths, e.g., Dannevirke silt loam. They are formed on deep tephric loess deposits (usually over 1 m deep) which overlie gravels, and are well drained. Topsoils are light-textured silt loams, which are susceptible to wind erosion when cultivated. In more exposed areas (e.g., west of State Highway 2 between Dannevirke and Takapau), the unit has been classified as LUC unit IIIe1 because of the increased erosion hazard. Rainfalls are between 1200 and 1600 mm/annum. Frequent winter frosts are a slight limitation to the cropping versatility of this unit. Shelter is essential for horticulture and cropping. A wide range of horticultural crops, including asparagus, pip fruit, root and brassica vegetable crops, potatoes, carrots, process peas, cereals and fodder crops may be grown, although at present cropping is limited mainly to root and green fodder crops, and some cereals. Summer rainfalls are limiting to cereal cropping, making grain drying necessary. Berry fruit is limited by wind, out of season frosts and winter temperatures, and summer rainfall during fruit ripening.

At present, most of this unit (together with LUC unit IIIe1) is used for dairying (west of State Highway 2 between Norsewood and Woodville), with a present average stock carrying capacity of 13 su/ha. Potential stock carrying capacity is as high as 27 su/ha. The unit is also suitable for production forestry, with a potential forestry site index for P. *radiata* of 27-29 m.

Figure 30: LUC unit IIe 1. School Road, north-east of Norsewood. N145/702719.

LUC UNIT IIIe1 (18 960 ha)-Figure 31

This unit occurs on similar landforms to LUC unit Ie 1 but it is situated nearer the axial ranges on sites exposed to the prevailing strong westerly winds. Soils are intergrades between central yellow-brown loams and yellow-brown earths, e.g., Dannevirke silt loam, Mangatahi sandy loam. Although having well developed structure, the light-textured top soils have a moderate to severe wind erosion hazard when cultivated to a fine tilth. Windbreaks are an essential erosion control measure if cultivation is to be regularly practiced. Annual rainfalls are between 1200 and 1600 mm, and wind and frosts are a limitation to the range of crops grown. Potential crops include process peas, potatoes, carrots, asparagus, green vegetables, and root and green fodder crops. Cereals and berry fruit may be limited because of summer rainfalls. The unit also includes areas of rolling tephra-covered slopes (8-15°) which have a similar wind erosion hazard.

Present average stocking rate is 14 su/ha, with a potential stock^carrying capacity the same as for LUC unit Ie 1 (27 su/ha). Potential forestry site index is also similar, being 26-30 m for P. *radiata.*

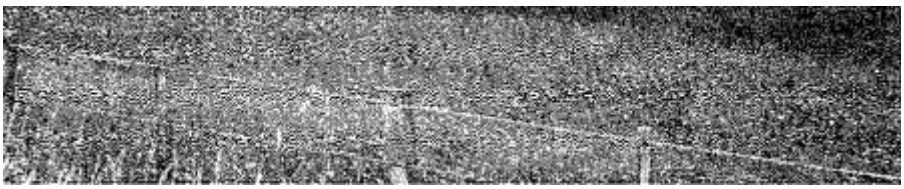


Figure 31: LUC unit IIIe1, School Road, north-east of Norsewood, N145/716715.

LUC UNIT IVe1 (23 750 ha)-Figure 32

This unit occurs in similar locations to LUC unit IIIe1, in lowland areas bordering the Ruahine and Tararua Ranges. However, slopes are steeper, between 16 and 20 °, forming a strongly rolling downland topography. Under cultivation, soils on these slopes are subject to a severe sheet and rill erosion hazard, and a moderate to severe wind erosion hazard. A typical central yellow-brown earth soil mapped is Matamau silt loam. Rainfalls are mostly between 1200 and 1 600 mm/annum, although they can be as high as 2000 mm/annum. The severe erosion hazard and the climatic limitations make this unit less versatile for cropping than LUC unit IIIe1, and it is more suited to intensive grazing. Present land uses are intensive grazing (dairying) with some forage crops grown. This unit is suitable for occasional root and green fodder cropping, but contour cultivation is needed to minimise the soil erosion risk. Windbreaks are also recommended.

Present average stocking rate is 12 su/ha. The potential stock carrying capacity of 25 su/ha is slightly lower than for LUC unit IIIe1. Potential forestry site index is rated as 27-30 m for P. *radiata.*

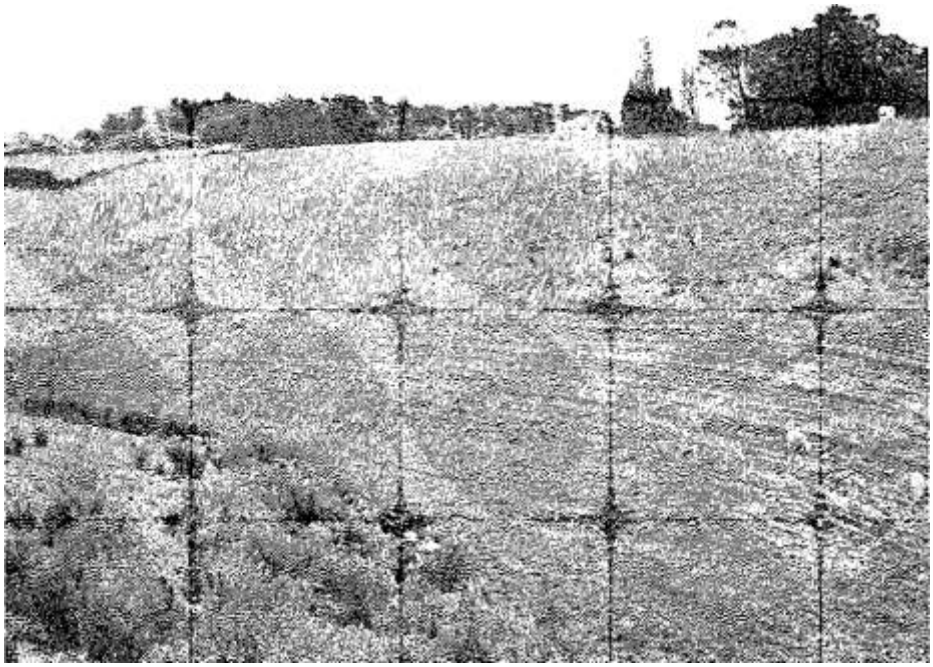


Figure 32: LUC unit IVe1, Third Line Road, near Norsewood, N145/653698.

LUC UNIT VIe1 (25 200 ha)-Figure 33

This unit comprises the best hill country in the region because of high potential pastoral productivity, adequate summer rainfalls, and a moderate erosion potential.

The unit is mapped on strongly rolling to moderately steep tephra-covered hill country in western areas, from south of the Waipawa River to west of Masterton. Slopes, which are steeper and longer than LUC unit IVe1, range between 16 and 25 °. Soils mapped are central yellow-brown earths formed on loess, e.g., Matamau series. The loess cover is thinner on the steeper slopes, which are most susceptible to soil slip and tunnel gully erosion. The moderate erosion potential can be minimised by open planting of soil conservation trees. The risk of surface erosion on these steeper slopes make this unit unsuitable for arable use. However, it is well suited to pastoral farmina.

Present stock level is 11 su/ha, with a potential carrying capacity of 20 su/ha. Dairying and intensive grazing are present land uses. The unit is also suitable for pro-

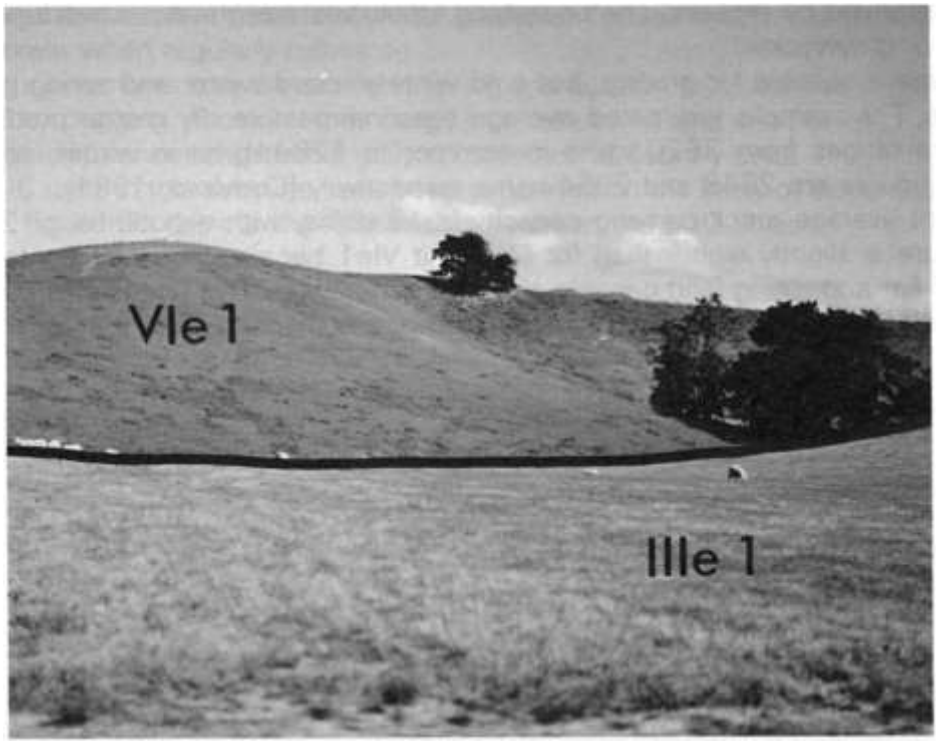


Figure 33: LUC unit VIe1. LUC unit IIIe1 on undulating slopes in foreground. Near Woodville. N149/380390.

LUC UNIT VIe1 (25 200 ha)-Figure 33

duction forestry, with a potential forestry site index of 26-29 m for *P. radiata.*

LUC UNIT Vle6 (13 350 ha)-Figure 34

This unit is mapped in the Mangleton Valley area between the Wakarara and Ruahine Ranges. It occurs on landforms ranging from flat terraces to moderately steep hill country. This area is a wind funnel zone which can experience winds of 150 km/h. Altitudes range between 500 m a.s.l. on lower terraces, to 750 m a.s.l. on the foothills bordering the ranges. Annual rainfalls range between 1200 and 1800 mm.

The area has a history of severe wind erosion, and significant depths of soil have been eroded in the past during periods of cultivation. Because of the potential for wind erosion, the land has been classified as unsuitable for arable use. In areas away from the wind-funnel zone, arable slopes would be mapped as LUC units IIIe1 or IVe1, depending on slope, and steeper slopes as Vle1.

Soils are intergrades between central yellow-brown loams and yellow-brown earths, developed on airfall tephra. Typical soils mapped are Mangatahi fine sandy loam, and Dannevirke silt loam. To protect the light-textured soils from erosion, maintenance of a complete pasture cover and the establishment of windbreaks are necessary measures. Recommended cultivation methods for pasture renewal include conservation tillage, chisel ploughing, stubble mulching, cross wind cultivation, or zero cultivation.

Slopes range up to 25 °, with slight soil slip erosion occurring on the steeper slopes. The tephra cover is thinner on the steeper slopes; and in some places has been completely removed by erosion. The underlying lithologies are gravels, sandstones, mudstones, or greywacke.

The unit is suitable for grazing, but cold winters retard winter and spring growth of-
pastures. For example, estimated average seasonal pasture dry matter production at
Wakarara ranges from 3620 kg/ha in summer to 1 284 kg/ha in winter; spring and
autumn figures are 2848 and 2954 kg/ha respectively (Crawford, 1981).

Present average stock carrying capacity is 12 su/ha, with a potential of 22 su/ha. This figure is slightly higher than for LUC unit Vle1 because this unit contains large areas of flat and rolling land capable of higher production. This unit is also suitable for production forestry, with the forestry site index rated as medium (27-29 m for P. *radiata).*

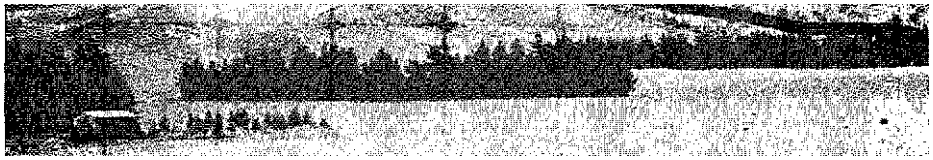


Figure 34: LUC unit Vle6 on flat and moderately steep slopes. The LUC units VIIIe5 and VIIIe6 are on greywacke. Gull Road, Mangleton Valley. N133/785248.

2. Land Use Capability Units on Loess in Areas with Annual Rainfalls Below 1200 mm

Four LUC units are mapped in this subsuite and they occur on a total of 87 650 ha. They occur on high, flat terraces (LUC unit IIIs'!), rolling downlands (LUC units 111 e 2 and IVe2) and moderately steep hill country (LUC unit Vle4). These units are mapped in lower rainfall areas (< 1200 mm/annum) of inland Southern Hawke's Bay (south of the Heretaunga Plains to Waipukurau), inland Wairarapa (east of the Wairarapa Valley) and on coastal terraces (between Homewood and Riversdale).

These units occur on loess deposits (mainly of greywacke origin) which have been derived from aggrading alluvial fans and flood plains, and deposited on older surfaces during glacials. Loess was also locally derived from lacustrine, estuarine and continental shelf deposits exposed during periods of low sea level (Palmer, 1982a, 1982b). The loess is of variable thickness, and mantles underlying lithologies such as gravels, silts and sandstones. Loess cover is deepest on flat terraces (over one metre thick), whereas on some steeper hill country areas the cover may be thin or patchy reflecting removal by erosion.

Annual rainfalls are low, and vary from less than 800 mm to 1000 mm. Summer droughts are common. Soils mapped are central yellow-grey earths and related hill soils. These have very compact and heavy-textured subsoils with fragipans which restrict internal drainage and result in periods of winter wetness. Topsoil structure is weak and liable to deteriorate when regularly cultivated.

High stock numbers may be carried in spring and autumn, but intensive winter grazing is limited by pugging. Erosion types range from sheet, rill and wind erosion on arable units to soil slip, sheet and tunnel gully on steeper hill country units.

The LUC units in this subsuite have been separated on the basis of slope and erosion

slope groupings	0-7°	8-15°	16-20°	21-25°
potential erosion	1W	2Sh,2R,2W	3Sh,3R,2W	2-3sSI,IT,ISh
LUC unit	IIIs 1	IIIe 2	IVe2	Vie 4

Figure 35: Relationship between slope and potential erosion of LUC units on loess, with annual rainfalls below 1200 mm. (See Appendix 5 for erosion codings.)

potential. Figure 35 depicts the relationship between the LUC units.

LUC UNIT IIIs 1 (33 060 ha)-Figure 36

This unit is mapped on flat, loess-covered terraces occurring in the drier inland areas of Central Hawke's Bay and the Wairarapa Valley. These terraces are older than present flood plains, and occur at higher elevations. Annual rainfalls range between 700 mm and 1000 mm. A marked dry season with prolonged periods of soil moisture deficiency can be expected to occur in summer. Soils are yellow-grey earths that have poor internal drainage and poor soil structure. Typical soils mapped are Martinborough loam, and Waipukurau sandy loam. The light-textured topsoils will not withstand continuous cultivation. Slow internal drainage, caused by the compact dense subsoil, together with poor soil structure and summer droughts, impose moderate cropping limitations on this unit and make it unsuitable for most permanent horticultural and orchard crops (except for grapes and strawberries). The range of crops grown is limited to some cereals (barley, oats, wheat, maize), peas, small seeds (ryegrass, clover, pea seed) grapes, and root and green fodder cropping. Some berry fruit (strawberries) may be grown in areas with more favourable climatic and drainage conditions. A slight wind erosion problem exists with regular cultivation, and the establishment of windbreaks is recommended. Intensive subsurface drainage (tile and mole) is essential to reduce wetness limitations, and to increase the cropping versatility of this unit.

Present average carrying capacity is 14 su/ha but with drainage and intensive grazing a potential of 23 su/ha exists. The unit is also suitable for forestry, with a site index value for *P. radiata* between 26 and 30 m.

Figure 36: LUC unit IIIs 1. LUC unit IIIe2 in foreground. East of Carterton. N162/100512.

LUC UNIT IIIe2 (17 320 ha)-Figure 37

This unit occurs in similar localities to LUC unit IIIsl, but is mapped on rolling slopes which have a significant surface erosion hazard when cultivated. It is located in areas of inland Hawke's Bay and Wairarapa with rainfalls between 700-1000 mm/annum and with marked seasonal drought periods.

The unit is mapped on dissected terraces and rolling downlands on slopes ranging between 8 and 1 5 °. These slopes have a moderate sheet, rill and wind erosion potential when cultivated. Contour cultivation and shelterbelts are recommended conservation measures. The unit is well suited to cereal cropping (barley, wheat, oats), peas, grapes (with summer irrigation), small seed production and root and green fodder cropping.

Soils are yellow-grey earths and have formed on a deep loess cover overlying Pleistocene gravels and silts. Typical soils mapped are Martinborough loam and Wharekaka fine sandy loam. They have poor internal drainage (caused by the presence of a fragipan), a weak soil structure and are subject to summer soil moisture deficiencies. Because of the greater slope angle, slightly better natural drainage exists than on LUC unit IIIsl, but subsurface drainage is still necessary to achieve the potential productivity.

The present average stocking rate is 13 su/ha, and the potential stock carrying capacity is the same as for LUC unit IIIsl (23 su/ha). Forestry site index is rated as 26-32 m for P. *radiata.*

Figure 37: LUC unit IIIe2. Tods Road, east of Waipawa. N141/095845.

LUC UNIT **IVe2 (18 870 ha)-Figure 38**

This unit is mapped in inland Hawke's Bay and Wairarapa Valley, on strongly rolling loess-covered downlands. Localities are similar to LUC unit IIIe2. Climatic conditions are the same; annual rainfalls are between 700-1000 mm, and prolonged summer droughts are common. Soils are yellow-grey earths with parent materials of loess overlying gravels and sandstones. Typical yellow-grey earth soils mapped are Wharekaka fine sandy loam, and soils of the Matapiro series. Slopes are steeper than LUC unit IIIe2, ranging between 16 and 20 ° . Natural drainage on these steeper slopes is better than on LUC unit IIIe2, but the heavy compact subsoils still impede drainage. Under grass, little or no erosion occurs, but a severe surface erosion potential exists under cultivation. Cropping use is marginal because of the increased erosion hazard, and the soil structure and climatic limitations. With contour cultivation and windbreaks to minimise soil loss, occasional cereal or root and green fodder cropping may be carried out. This unit is more suitable for intensive grazing, although high stock numbers over the winter period need to be avoided to minimise pugging.

The present average stocking rate is 11 su/ha. Potential carrying capacity is slightly lower than for LUC unit IIIe2, being assessed as 20 su/ha. The compact subsoils are a moderate limitation to forestry, although the potential site index is 27-30 m for *P. radiata.*

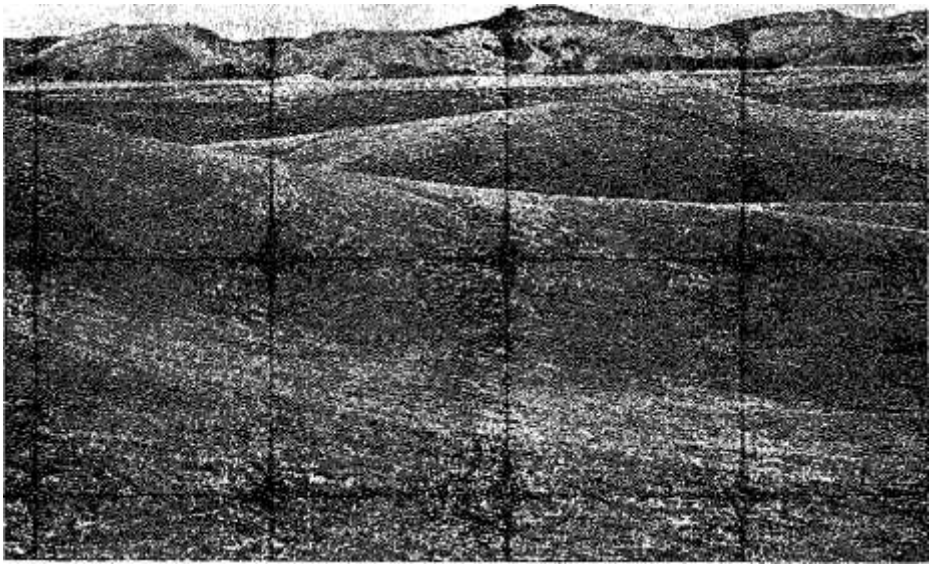


Figure 38: LUC unit IVe2, Wairarapa Valley, east of Masterton, N158/238622.

LUC UNIT VIe4 (18 400 ha)-Figure 39

This unit is mapped on loess-mantled hill country where erosion is a continuing hazard. Slopes range between 1 6 and 25 °. The unit is confined to the southern part of the region east of Masterton and Martinborough, where annual rainfalls are less than 1200 mm. Long periods of summer drought are common. Hill soils mapped are those related to central yellow-grey earths, e.g., Wharekaka hill soils and Gladstone hill soils. They are moderately well drained but have compact subsoils.

Present erosion forms are soil slip, sheet and tunnel gully. Soil slips occur in the upper slope profile, with long, narrow debris tails. Loess cover is variable, and in places has been completely removed to expose the underlying gravel and sandstone lithologies. Aspect has a marked effect on this unit. Hot dry northerly winds make establishment of traditional soil conservation trees difficult, especially on north and west facing slopes. Present research indicates that some eucalypt species are more suited to the harsher Wairarapa climate, and are able to withstand long periods of moisture stress. Although suitable for intensive grazing, stock numbers are limited because of summer soil moisture deficiencies. The present average stocking rate is 10 su/ha, while the potential stock carrying capacity is rated as 1 5 su/ha. Forestry site index is 26-28 m for P. *radiata.*

Figure 39: LUC unit VIe4, Near Martinborough, N166/020250.

Land Use Capability Suite of Units on Mudstone or Fine Siltstone

Areally, this is the largest LUC suite in the region. It is widespread throughout the eastern hill country, occurring over 384 620 ha (Figure 40). Rock types are Tertiary mudstones and fine siltstones. Erosion is the major limitation to long term use. Mass movement erosion forms range from shallow earthflow and soil slip, to deep-seated earthflow and slump.

Twelve LUC units are mapped. These are subdivided into two subsuites because of differences in land management and erosion control:

(1) LUC units with "shallow" erosion types, and

(2) LUC units with "deep-seated" erosion types.

Figure 40: Location of LUC units on mudstone or fine siltstone.

1. LUC Units Formed on Mudstone or Fine Siltstone with 'Shallow' Erosion Types

This subsuite comprises 10 LUC units covering 332 890 ha. They occur mainly in the dissected hill country in the east of the region. These 10 LUC units consist of three arable LUC units mapped on terraces and downlands, and seven non-arable LUC units on hill and steepland topographies. Rainfalls range from a low of 800 mm/annum in drier coastal areas to 1600 mm/annum further inland. Soil groups are intergrades between central yellow-grey and yellow-brown earths, or central yellow-brown earths, and related hill and steepland soils. They have a high natural fertility, but are heavy textured and poorly drained. Erosion scars regrass rapidly.

The major erosion types are soil slip, shallow earthflow and sheet. Sheet erosion occurs mainly in drier coastal areas, e.g., near Elsthorpe. Sheet and rill erosion are potential hazards when arable units are cultivated. On hill country landforms, earthflows tend to occur on the lower colluvial slopes, while soil slips occur on steeper areas nearer the ridge crests. Figures 41 and 42 demonstrate the relationship between the LUC units and slope, erosion and rainfall.

4-15 8-20

0-7

slope groupings

potential erosion (under cultivation)	ISb	2Sh,2R	3Sh,3R,le F
infall/a	800-1,600 mm	800-1,600mm	1,000-1,400 mm
LUC unit	IIIs 3	IIIe3	IVe 3

Figure 41: Relationship between arable LUC units and slope, erosion and rainfall. (See Appendix 5 for erosion codings.)

slope groupings	Strongly rolling to moderately steep hill country 16-25 i 16-25	Moderately steep to steep hill country 21-35 21-35	Steep to very steep hill country 26-35 ! >26	Over - steepened valley sides >26
potential erosion	2eF,1sSI] 2eF,2Sh,1sSI	2eF,2sSI] 2eF,2sSI,lSh	! 3sSI,2Sh, 3eF,2sSI,1G|]ef]Q	4Sh,4W, 4sSI,2G
rainfal^/ •'annum	>1,200mm 1 <1,200 mm	>1,200mm J <1,200mm	variable	>I,200mm
LUC unit	Vie 2 Vie 3	Vie 7 Vie 8	Vile 1 Vile 2	Vile 12

Figure 42: Relationship between non-arable LUC units and slope, erosion and rainfall. (See Appendix 5 for erosion codings.)

Climate is also an important variable in assessing the capability. Traditionally, the 1150 mm isohyet forms the boundary between yellow-grey and yellow-brown earths. Where detailed soil maps have been used, this boundary is reflected by these soil types. In areas where only the 'General Survey of the Soils of North Island' soil map was used, the boundary between units was approximated by the 1200 mm isohyet. This subdivision was made only on the class VI units because they cover such a large area (211 950 ha). It separates those areas which are prone to frequent summer droughts that limit plant growth from those areas which have regular summer growth. LUC units Vle£ and Vle7 are mapped where rainfalls exceed 1200 mm/annum; LUC units Vle3 and Vle8 are mapped where rainfalls are less than 1200 mm/annum. At more detailed mapping scales, class VII would be subdivided on this basis also. At the class VI level, rainfall was the most important factor for subdivision of the LUC units; however, on class VII other factors, especially erosion, are more important than climate.

The lower rainfall units (< 1200 mm annual rainfall), are subject to drying winds, summer drought periods and sheet erosion, resulting in a slightly lower potential stock carrying capacity (Table 12).

Table 12: Relationship between LUC units and production figures

LUC UNIT	PRESENT AVERAGE STOCK CARRYING CAPACITY (su/ha)	POTENTIAL STOCK CARRYING CAPACITY (su/ha)	SITE INDEX P. *radiata* (m)
IIIs3	.. 14	25	26-29
IIIe3	.. 11	25	27-32
IVe3	.. 10	22	28-30
Vle2 (> 1200 mm p.a. rainfall)	.. 10	22	27-30

LUC UNIT IIIs3 (17 470 ha)-Figure 43

This unit is mapped on flat, imperfectly drained high terraces or colluvial basins in the eastern hill country. Annual rainfalls range from 800 mm at Wanstead to over 1400 mm at Alfredton.

Soils are intergrades between central yellow-grey and yellow-brown earths, developed on colluvial or loess deposits, which mantle jointed mudstone or fine siltstone lithologies, or gravels. Typical soils are Bideford loam and Atua silt loam. Although naturally fertile, they have very compacted clay subsoils which restrict internal drainage. Subsurface drainage is required if cropping is to be successful. Crops include cereals, and root and green fodder crops. The predominant land use is intensive grazing (present average stocking rate of 14 su/ha), and root and green fodder cropping. Winter growth of pasture is inhibited because of pugging of winter-wet soils by cattle.

Potential stock carrying capacity is 25 su/ha, and the forestry site index for *P. radiata* is 26-29 m.

Figure 43: LUC unit IIIs3, Tiraumea Valley Road, N154/464977.

LUC UNIT **IIIe3 (10 120 ha)-Figure 44**

This unit is mapped on rolling colluvial terrace slopes, between 4 and 15 °. It differs from LUC unit IIIs3 by having a sheet and rill erosion hazard when cultivated. Annual rainfalls range between 800 mm north-east of Masterton to over 1400 mm at Weber. Soils are the same as those mapped on LUC unit IIIs3, typical soils being Atua silt loam, and Bideford loam. The heavy-textured subsoils which impede internal drainage are a moderate limitation to cropping use. Because of the slope angle, this unit is also susceptible to sheet and rill erosion when cultivated. Contour cultivation is recommended as a soil conservation measure. The range of crops is restricted. At present only root and green fodder crops are grown, although cereal crops may be grown. The predominant land use is intensive grazing, with an average stocking rate of 11 su/ha.

The grazing potential is 25 su/ha. Production forestry is an alternative land use, with the site index for P. *radiata* rated as 27-32 m.

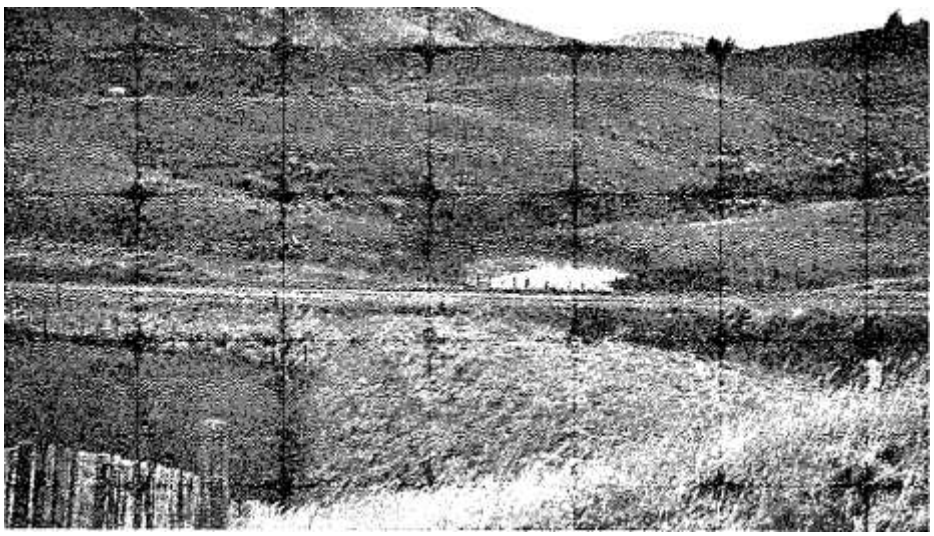


Figure 44: LUC unit IIIe3, Kaituna Road, north-east of Pongaroa, N154/697170.

LUC UNIT IVe3 (20 760 ha)-Figure 45

This unit is mapped on rolling to strongly rolling downlands throughout the eastern hill country. Annual rainfalls range between 1000 mm at Pongaroa to 1400 mm at Toi Flat (north of Weber).

Soils are intergrades between central yellow-grey and yellow-brown earths developed on mudstone or fine siltstone lithologies, e.g., Atua silt loam, Purimu silt loam.

The natural drainage of these soils is better than on LUC unit IIIe3, mainly because of the increased slope angle. The heavy subsoil textures still impede internal drainage and limit the cropping potential. On poorly drained sites such as colluvial fans, rushes are common.

The severe sheet and rill erosion potential when cultivated together with drainage, climate and soils limitations, makes this unit marginal for cropping. The unit is suitable only for occasional root and green fodder crops. Contour cultivation is a necessary conservation measure. The predominant land use is intensive grazing, with an average stocking rate of 10 su/ha.

Potential stock carrying capacity is 22 su/ha, while the forestry site index for *P. radiata* is medium, 28-30 m.

Figure 45: LUC unit IVe3, Kaituna Road, north-east of Pongaroa, N154/705172

LUC UNIT Vle2 (45 950 ha)-Figure 46

This unit occurs in hill country on jointed and banded Tertiary mudstones or fine siltstones. Slopes are generally between 21 and 25 ° , although easier slopes (between 1 6 and 20 °), have been included where they form a complex with the steeper slopes. Rainfalls range between 1200 mm and 1600 mm/annum.

Soils are mapped as either intergrades between central yellow-grey and yellow-brown earths, e.g., Atua silt loam, hill soil, or as central yellow-brown earths, in areas of higher rainfalls, e.g., Waipataki hill soils. The unit has a moderate potential for shallow earthflow erosion, although this can be minimised by good pasture management and space planting of conservation trees. Earthflow erosion is usually concentrated on the colluvial footslopes, while soil slip erosion occurs on the upper steeper slopes. Because of the fertility of the parent material, slip scars rapidly regrass.

Production values are high due to the natural fertility of the soils and the even distribution of rainfall. The unit is predominantly used for intensive grazing with a present average stocking rate of 10 su/ha. Potential stock carrying capacity is 22 su/ha, and the. forestry site index for *P. radiata* is estimated at 27-30 m.

Figure 46: LUC unit Vle2, Westmere Road, east of Gladstone, N162/230445.

LUC UNIT VIe3 (47 470 ha)-Figure 47

This unit is similar to LUC unit VIe2, occurring in hill country areas on jointed and banded Tertiary mudstones or fine siltstones. However, annual rainfalls are less than 1200 mm, and there are pronounced summer soil moisture deficiencies. Low summer rainfalls and the drying influence of winds result in rapid drying out of pastures.

Landforms, rock type and slope are the same as for LUC unit VIe2. The erosion hazard is also similar, but LUC unit VIe3 is more susceptible to sheet erosion because the drier conditions result in a less complete pasture cover. Typical soils mapped are the Atua soils, intergrades between central yellow-grey and yellow-brown earths.

The unit is well suited to either grazing (present average stocking rate of 11 su/ha) or forestry. Potential stock carrying capacity (20 su/ha) is slightly less than that of LUC unit VIe2 because of lower summer pasture production levels. Forestry site index for *P. radiata* is 27-30 m.

Figure 47: LUC unit VIe3. Near Elsthorpe. N141/248862.

LUC UNIT Vle7 (62 090 ha)-Figure 48

This unit occurs on the same rock type and in a similar climate to **LUC** unit Vle2 (> 1200 mm/annum rainfall). However, it has a lower land use capability ranking and potential productivity, because of steeper slopes (21-35°) and a greater erosion potential.

Soils are intergrades between central yellow-grey and yellow-brown earths, and related steepland soils, or central yellow-brown earths, e.g., Atua silt loam, hill soil, and Mangatea clay loam, hill soil. They have a high natural fertility, and are suited to either grazing or forestry. Present average stocking rate is 9 su/ha, and the potential grazing value is 19 su/ha. Forestry site index is 26-29 m for *P. radiata.*

Figure 48: LUC unit Vle7. LUC unit ills3 in foreground. Near Alfredton. N153/401981.

LUC UNIT VIe8 (56 440 ha)-Figure 49

This unit has similar landforms to LUC unit VIe7. However, it occurs in areas of lower rainfall, i.e., annual rainfalls less than 1200 mm. In these areas it is usually recorded together with LUC unit VIe3, but occurs on the steeper hill slopes (between 21 and 35°). Exposure to prevailing winds enhances the seasonal soil moisture deficiencies.

Soils include Atua silt loam, hill soil and Taihape silt loam. Erosion is the major long term limitation, with potentials for moderate earthflow and soil slip, and slight sheet erosion. For erosion control, open and block plantings of conservation trees are recommended.

The predominant land use is grazing, with a present average stocking rate of 10 su/ha. The potential stock level at 18 su/ha is slightly lower than that of LUC unit VIe7. This unit is also suited to production forestry, with the site index for *P. radiata* rated as 26-29 m.

Figure 49: LUC unit VIe8. Near Ocean Beach. N142/365095.

LUC UNIT VIIe1 (32 800 ha)-Figure 50

This unit is mapped on steep mudstone and fine siltstone (jointed and banded), hill country throughout the region, and under a range of annual rainfalls, up to 2000 mm. Slopes are steeper (26-35 °) and longer, and are generally more severely eroded than the related class VI units (Figure 42). Typical steepland soils mapped are Turakina silt loam and Taihape silt loam.

The present erosion severity and type on this unit is moderate to severe earthflow, and slight to moderate soil slip. A potential for severe shallow earthflow exists, together with a potential for moderate soil slip and slight gully erosion. More intensive soil conservation practices are needed to control the erosion — these include open planting of conservation trees on eroding areas, debris dams in gullies and de-watering and planting of earthflows. Block planting on areas of severe erosion may also be necessary.

The potential stocking rate is high at 16 su/ha, although cattle grazing in winter should be restricted to reduce pugging and to minimise instability. Present average stocking rate is 10 su/ha. Erosion control forestry is an alternative land use, with the site index for P. *radiata* rated as 25-30 m. The majority of this unit has been developed for grazing.

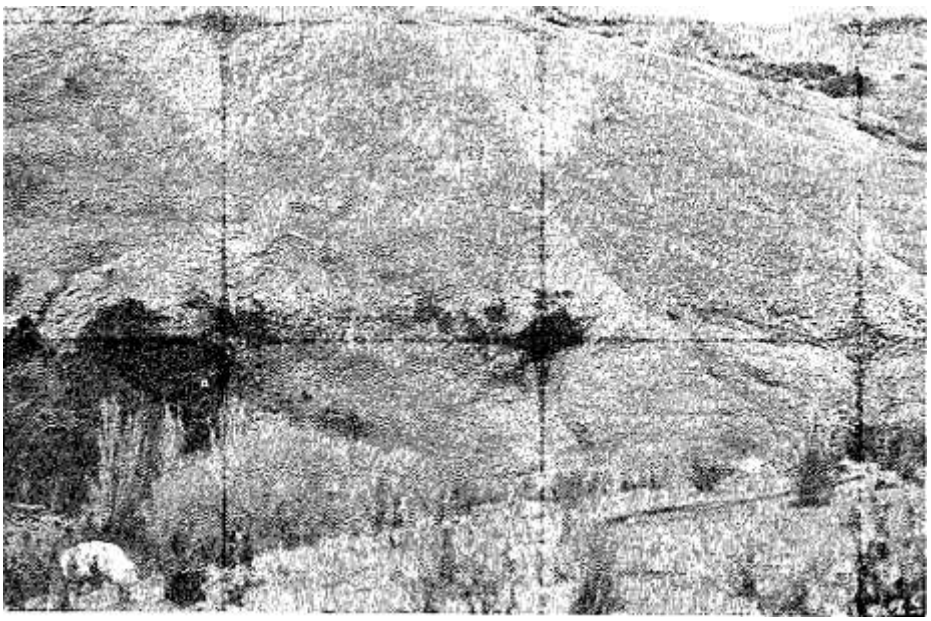


Figure 50: LUC unit VIIe1. Near Wimbledon. N150/892255.

LUC UNIT VIIe2 (34 490 ha)-Figure 51

This unit occurs throughout the Tertiary sedimentary hill country. It is similar to LUC unit **VIIel** because it occurs on steep to very steep massive and banded mudstone and siltstone slopes. However, it is more susceptible to soil slip erosion, and a potential for severe soil slip and moderate sheet erosion exists. Slight earthflow and gully erosion may also occur. The soil slips are shallow and expose the underlying bedrock. These bare slip surfaces are difficult to revegetate, because of continuing surface (sheet and rill) erosion. Typical steepland soils mapped include Taihape silt loam, Mahoenui silt loam and Pahiatua silt loam.

The majority of the unit has been developed into pasture, with a present average stocking rate of 7 su/ha. The potential stocking rate of 15 su/ha is slightly lower than for LUC unit **VIIel** (16 su/ha) due to the greater soil slip erosion potential and areas of bare erosion scars.

Erosion control forestry is a recommended land use on steeper and more erodible areas; the site index for P. *radiata* is rated at 25-29 m.

Figure 51: LUC unit VIIe2. Near Alfredton. N153/337990.

LUC UNIT VIIe2 (5300 ha)-Figure 52

This unit occurs on oversteepened valley sides on closely jointed siltstone and mudstone lithologies, between Wilder and Fiakaunui. Annual rainfalls are over 1200 mm. Slopes are steep to very steep (over 26°) and have a very severe erosion potential.

Steepland soils related to central yellow-brown earths are mapped, e.g., Rakaunui steepland soils, and Mahoenui silt loam.

The closely jointed lithologies are particularly susceptible to sheet, wind, soil slip and gully erosion. Large areas of the unit consist of bare erosion surfaces. Wind frittering is accentuated by strong winds which desiccate bare surfaces and dislodge loosened rock particles to form scree slopes. This is aided by erosion processes such as sheet wash. Stream action continually undercuts and oversteepens many slopes, often initiating further erosion. Intensive soil conservation treatment is needed, including block plantings of conservation trees and retirement of severely eroded areas. Revegetation of bared surfaces is extremely difficult. The predominant land use is extensive grazing (4990 ha), the remainder (285 ha) having a scrub cover.

The most appropriate land use for much of the unit is erosion control forestry. The present average stocking rate of this unit is 5 su/ha, although the potential stocking rate on uneroded areas is 10 su/ha. The forestry site index for *P. radiata* is rated at 24-26 m.

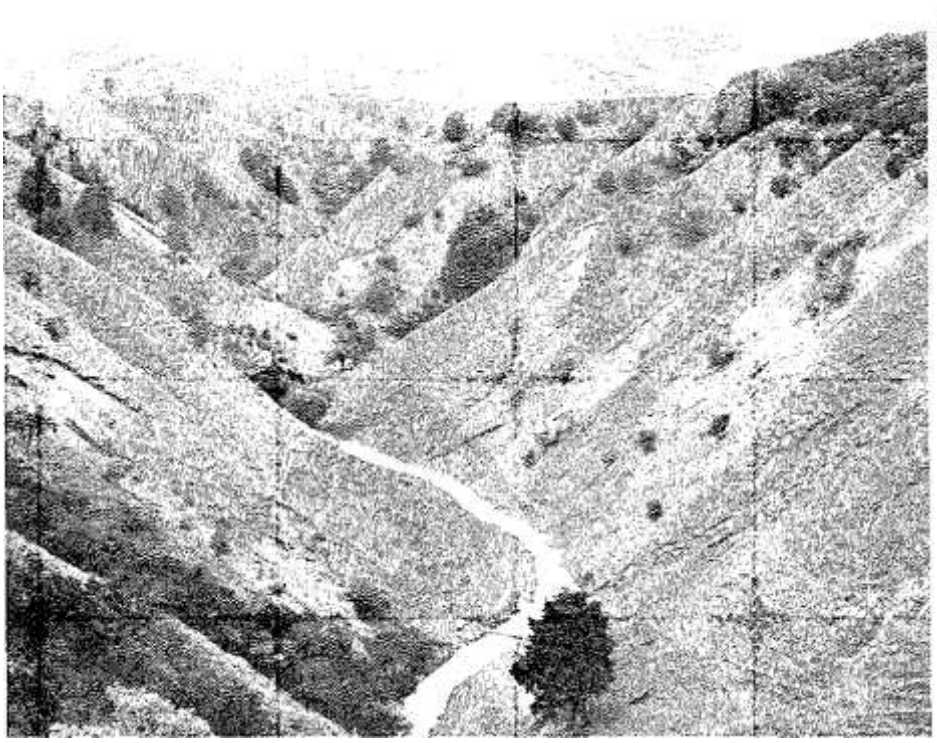


Photo: D. Harding

Figure 52: LUC unit VIIe12, Falls Road, Weber, N150/743268.

2. LUC Units Formed on Mudstones with 'Deep-Seated' Erosion Types

The two units in this subsuite occur throughout the eastern hill country on bentonitic mudstones, or on shattered (jointed) mudstones in crush or fault zones. Erosion, which is the major long term constraint, varies from having a severe potential on LUC unit Vie 10, to an extreme potential on LUC unit VIIe8. Areas of class VIII on bentonitic mudstones are classified as LUC unit VIIIe3, described under 'Miscellaneous land use capability units'. Erosion types are deep-seated earthflows, and gullies. Landforms are more subdued than other mudstone or fine siltstone units, forming strongly rolling to moderately steep hill country, broken by low-angled, hummocky earthflows. These earthflows are more extensive on LUC unit VIIe8 where there is often a continuing erosion hazard caused by either watercourses or streams undercutting the toe of the movement, or earthflows being activated by gully erosion in drainage channels. Large cracks, which allow water to concentrate in the regolith, or ponding in the head of the flow, further aid earthflow movement. Bentonitic mudstones have high proportions of montmorillinitic clays, and their shrinking and swelling properties facilitate downslope movement.

Soils are fertile, but the heavy subsoils impede drainage. Earthflows are deeper and more difficult to control than the shallow earthflows mapped on LUC units VIe2, 3, 7 and 8, therefore more intensive soil conservation treatments are needed for stabilisation. The two LUC units mapped in this group have been separated on the basis of erosion severity.

LUC UNIT VIe10 (34 440 ha)-Figure 53

This unit occurs on strongly rolling to moderately steep hill country, with a potential for severe deep earthflow erosion. Large areas occur around Herbertville and Wimbledon. Hills are characteristically rounded in appearance, with short slopes and broken by hummocky low-angled earthflows. These are deep-seated, and difficult to control. Conservation treatments include de-watering and block planting.

Typical soils are Wanstead clay loam, hill soil, and Atua silt loam, hill soil. Although these soils are naturally fertile, they have heavy clay subsoils which impede internal drainage. Pastures dry off slowly during dry periods due to the ability of the soil to retain moisture for long periods. Cattle grazing during winter should be restricted to avoid soil pugging. The majority of this unit is used for pastoral grazing. Present average stock level is 11 su/ha, with a stock carrying capacity potential of 18 su/ha. Production forestry is also a suitable land use, with a site index for P. *radiata* of 27-30 m.

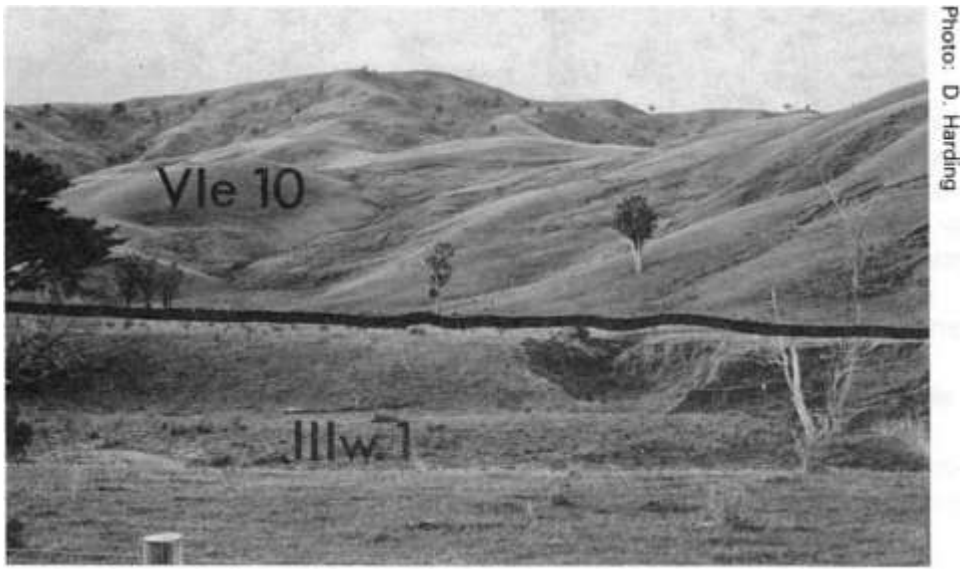


Figure 53: LUC unit Vie 10, LUC unit IIIw1 in foreground. Near Wimbledon. N151/974222.

LUC UNIT VIIe8 (17 290 ha)-Figure 54

This unit occurs on similar low angle slopes to LUC unit Vie 10, but earthflow erosion is far more extensive and there is an extreme erosion potential. The erosion severity limits production. Soils mapped are mtergrades between central yellow-grey and yellow-brown earths, e.g., Wanstead clay loam, hill soil.

Examples of this unit occur in coastal crush zones, e.g., near the Awhea and Pahaoa River mouths, and near Wimbledon.

Farm management is difficult because earthflows disrupt farm tracks, fencelines and public roads. Constant maintenance and intensive stabilising measures are necessary (Figure 54). Other problems include loss of stock, difficult access, and large areas of land being lost to production. The unit has a potential for extreme deep-seated earth-flow, moderate gully, and slight soil slip erosion. De-watering and open planting of poplars and willows on earthflows are necessary measures. Gully erosion is often present in stream channels which drain these flows, and block planting is recommended in these areas. Grazing is not a suitable long term use because of the erosion hazard and the intensive soil conservation inputs required to maintain stability. Cattle grazing during winter must be restricted. The present average stocking rate is 9 su/ha. Stock potential of 10 su/ha is lower than LUC unit Vie 10(18 su/ha) due to the greater erosion severity. Erosion control forestry is a more suitable long term use. The forestry site index for P. *radiata* is 25-29 m.

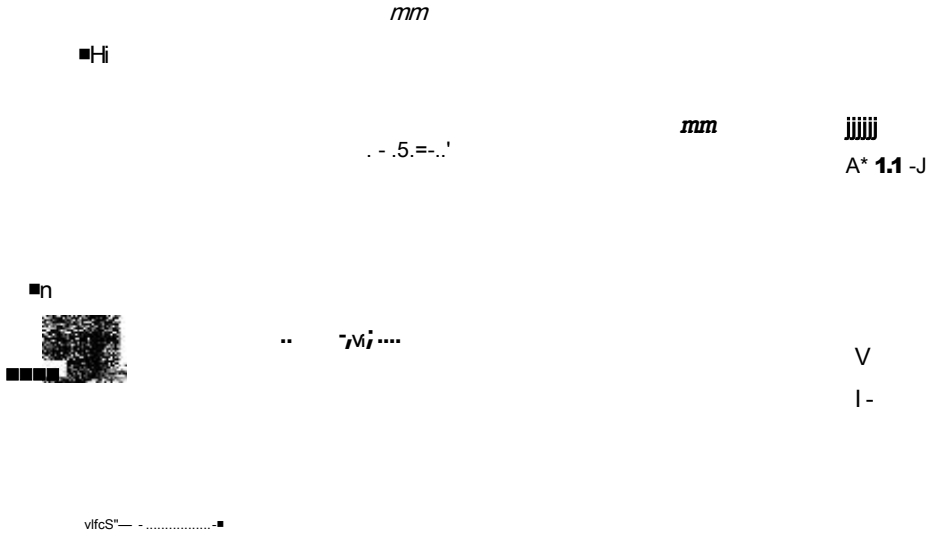


Figure 54: LUC unit VIIe8. Patangata. N141/155890.

Land Use Capability Suite of Units on Sandstone or Coarse Siltstone

LUC units on sandstone and coarse siltstone have been mapped on 109 400 ha of hill country throughout the region (Figure 55).

Figure 55: Location of LUC units on sandstone or coarse siltstone

The sandstone is Tertiary in age, and is either massive or banded. Coarse siltstones have been grouped with sandstones on the basis of erosion characteristics, while fine siltstones have been grouped with mudstones. This suite comprises moderately steep to steep hill country, with no significant areas of arable land. Annual rainfalls vary, but are mainly greater than 1200 mm. The degree of hardness of the sandstone has a significant effect on the land use capability. Two subsuites are recognised: —

(1) Moderately consolidated and consolidated sandstone or coarse siltstone with a significant erosion hazard (LUC units VIe9 and VIIe4).

(2) Consolidated and very hard sandstone or coarse siltstone with a negligible erosion risk (LUC units VIs2 and VIIs2).

Additional factors which further determine the LUC units within these two subsuites are the degree of weathering of the soil mantle, and depth and fertility of the soil.

1. Moderately Consolidated and Consolidated Sandstone or Coarse Siltstone

Within this subsuite two LUC units are mapped, which together total 88 160 ha. The weathered sandstone and coarse siltstone is susceptible to erosion.

LUC UNIT VIe9 (60 250 ha)-Figure 56

This unit is mapped throughout the region on massive and banded sandstone hill country. Slopes range between 21 and 35 ° . Moderate soil slip and tunnel gully, and slight gully and sheet erosion may occur on this unit. Soil slips are shallow and can be controlled by open planting of soil conservation trees. Pair planting of poplars and willows is recommended along eroding gullies, while tunnel gullies can be controlled by tree planting along tunnel lines. Typical soils mapped include Kumeroa and Whetukura hill soils (intergrades between central yellow-grey earths and yellow-brown earths, and central yellow-brown earths). Natural fertility is low. The present average stocking rate is 7 su/ha, with a potential for 17 su/ha. Forestry growth potential for P. *radiata* is medium, with a site index value of 26-28 m.

Figure 56: LUC unit VIe9. Maraetotara Road. N141/342070.

LUC UNIT VIIe4 (27 910 ha)-Figure 57

This unit is mapped on steeper (generally over 26 °), and longer slopes than LUC unit VIe9. The majority of the unit occurs in the central hill country east of Pahiatua and Eketahuna. Rainfall is generally above 1 200 mm/annum, although 6680 ha have been mapped in areas nearer the coast with rainfall less than 1200 mm/annum. Typical steepland soils mapped include Mangamahu silt loam and Pukeokahu silt loam. These are shallower and less well developed than the hill soils on LUC unit VIe9, and have a low natural fertility. Scrub reversion is a continuing problem. Exposure to north-westerly winds on some sites, make the establishment of soil conservation trees difficult. The unit has a potential for severe soil slip, moderate sheet, and slight tunnel gully erosion.

The present average stocking rate is 7 su/ha with a potential for 15 su/ha. Forest growth potential is rated as medium for P. *radiata* (25-28 m), although some steeper areas may be unsuitable because erosion and shallow soils make tree planting and harvesting very difficult or impossible.

Photo: M. S. Redpath

Figure 57: LUC unit VIIe4, Kaitawa Ridge Road, near Pahiatua, N153/383133.

2. Consolidated and Very Hard Sandstone or Coarse Siltstone

Two LUC units have been mapped in this group, totalling 21 240 ha. These sandstones are harder and form more upstanding and stable landforms than the moderately consolidated sandstones. Erosion risk is negligible, but low natural fertility and shallow soils are the main limitations to use.

LUC UNIT VIs2 (17 600 ha)-Figure 58

This unit is mapped on very stable hill country in the east of the region between Whetukura and the Pahaoa River. Rainfalls are generally between 1200 and 1400 mm/annum. Slope lengths are short, and slope angles range between 21 and 25 °. The soil type mapped is Ngaumu fine sandy loam, hill soil — a central yellow-brown earth of low natural fertility. Scrub reversion is a problem on these soils, and high fertiliser inputs are required if a good pasture cover is to be maintained.

Although this hill country is more stable than LUC unit VIe9, the shallow, lower fertility soils limit its productivity. The unit is well suited to pastoral farming although summer stock water is a problem. Although the present average carrying capacity is 7 su/ha, 15 su/ha may be carried if adequate fertiliser and appropriate management techniques are applied. 4500 ha are in high producing pasture, 6620 ha have a low producing pasture cover and 4240 ha have a dominant scrub cover. The forest site index figure for *P. radiata* is medium (26-27 m). 2100 ha of this unit occur within the Ngaumu State Forest which was established on these low fertility sites in 1947 as a regional supply forest. A further 140 ha are planted in exotic forest outside the Ngaumu State Forest boundary.

Figure 58: LUC unit VIs2. LUC unit IIIs3 in foreground. Ngatahuna Road, near Ngaumu State Forest. N162/367526.

LUC UNIT VIIs2 (3640 ha)-Figure 59

This unit has a very distinct hogback relief of steep, hard sandstone ridges. The sandstone is generally banded, with the very resistant and steeply dipping bands resulting in upstanding hogback ridges. The unit is mapped in two main localities: in the Waihoki district (south of Pongaroa), and along the Silver Range (near Elsthorpe).

These hogback landforms are very stable and often include significant areas of bare rock and sandstone bluffs (which would be classified as LUC class VIII at more detailed mapping scales). The skeletal soils are infertile, e.g., Silver sandy loam, a steepland soil related to central yellow-brown earths. Slopes are longer and steeper than those on LUC unit VIs2, being in excess of 26 ° . The steep slopes and shallow, infertile soils, make the unit suitable only for extensive grazing or limited production forestry. Present average carrying capacity is 4 su/ha with a potential for 6 su/ha. Forestry site index values are low to medium (24-25 m). Significant areas of the steeper slopes are unsuitable for forestry because of access difficulties, shallow rooting depths and difficulties of tree planting and harvesting on the very steep slopes. A slight soil slip erosion potential exists, with slipped areas being slow to revegetate. 1520 ha of this unit have a dominant scrub cover. The remaining 2120 ha is in pasture and is used for sheep grazing.

Figure 59: LUC unit VIIs2, Silver Range, near Elsthorpe, N141/203881.

Land Use Capability Suite of Units on Limestone

Limestone landforms have been grouped as a separate suite because of their distinctive physical characteristics, i.e., their stable nature, high natural fertility and distinct geomorphology.

LUC units in this suite are widespread throughout the region (Figure 60), and occur in a variety of climates. The total area of this suite is 86 970 ha.

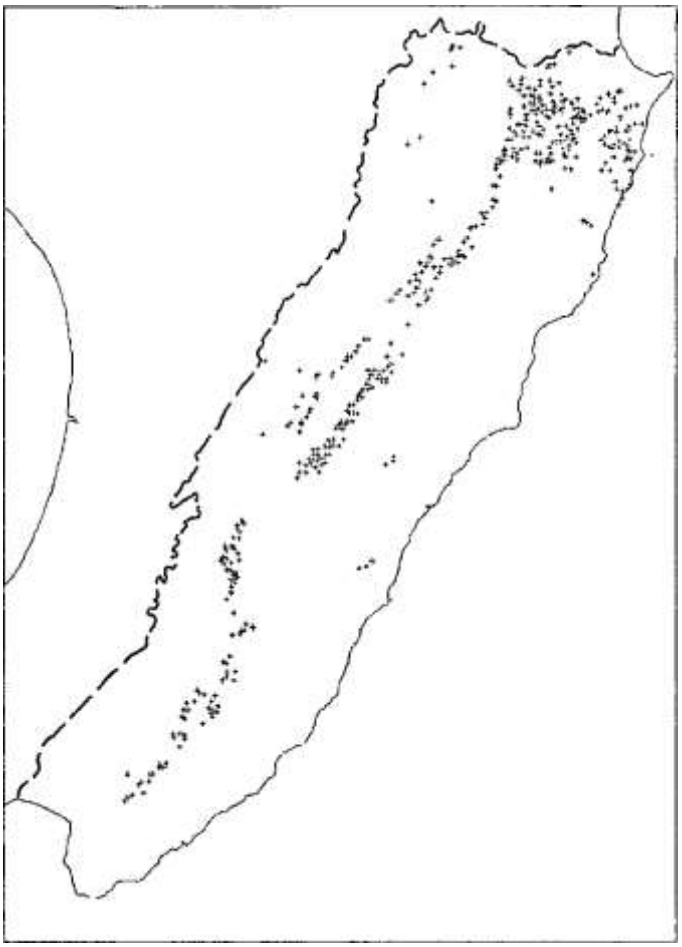


Figure 60: Location of LUC units on limestone.

The LUC units mapped have been subdivided on the basis of relief and rainfall into two subsuites:

1. Rocky landforms: generally occurring in areas where rainfalls exceed 1200 mm/annum (Figure 61).
2. Cuesta landforms: generally occurring in areas where rainfalls are less than 1200 mm/annum (Figure 62).

Figure 61: Typical rocky limestone landforms. Maraetotara Heights. N141/309991.

Figure 62: Typical loess-covered cuesta landforms. Near Takapau. N145/808742.

1. Rocky Landforms (16 760 ha)

Three LUC units are mapped on stable limestone landforms, a significant feature of which are limestone rock outcrops and sink holes. These units generally occur in areas where rainfalls exceed 1200 mm/annum, e.g., on the Maraetotara Heights (near Waimarama) and on the Puketoi Range (east of Pahiatua). These areas are very exposed, and have long cold winters (April to October) which restrict winter grass growth.

Two of the LUC units (IVe4 and Vs1) were differentiated on the basis of slope angle, and density of rock outcrops and sink holes, while the third (LUC unit Vlc2) was separated on the basis of climate.

LUC UNIT IVe4 (5410 ha)-Figure 63

This unit is mapped on rolling to strongly rolling slopes (8-20 °) on limestone plateaux and downlands. It occurs mainly on the Maraetotara Heights (an exposed plateau 300 m a.s.l. situated near Waimarama, south-east of Hastings), with rainfalls over 1400 mm/annum. The main diagnostic criteria are the frequent rock outcrops and sink holes which significantly reduce the area available for cultivation. Areas mapped north of Masterton and east of Gladstone with a thin loess cover and which receive lower annual rainfalls, are also included in the unit. Although soils have a high natural fertility and a well developed structure, because of the slope angle there is a potential for severe sheet and rill erosion when cultivated. This erosion potential, together with the rock outcrops and sinkholes, make the unit marginal for cropping. Root and green fodder crops may be grown. The erosion hazard can be minimised by the use of conservation management techniques such as contour cultivation. Soils mapped are central yellow-brown earths and intergrades between central yellow-brown earths and rendzinas. Typical soils are Kourarau silt loam, Waimarama sandy loam and Maraetotara sandy loam.

Under pasture, this unit is stable with a potential to sustain 25 su/ha. At present the predominant land use is intensive grazing with a present average grazing level of 10 su/ha. Production forestry is also a potential use with a site index for P. *radiata* of 26-28 m.

Figure 63: LUC unit IVe4, Waipoapoa Road, Maraetotara Heights, N141/305958

LUC UNIT Vs1 (2600 ha)-Figure 64

This unit differs from LUC unit IVe4 in that it occurs on steeper slopes and contains more numerous rock outcrops and sink holes. These factors combine to make it physically unsuitable for cultivation for cropping. However, this limestone hill country is well suited to either intensive grazing or to production forestry. Most of the unit occurs on the Maraetotara Heights; small areas occur in the Wairarapa, near Gladstone and Ruakokoputuna. Slopes are generally between 1 6 and 25 °. Erosion hazard is negligible. Soils are naturally fertile and include Kourarau silt loam, hill soil, and Waimarama sandy loam, hill soil.

The present average stocking rate is 11 su/ha. The potential stock carrying capacity is high with a rate of 22 su/ha attainable in higher rainfall areas where summer pasture production is not limited by drought. Forestry site index is medium (28-29 m for P. *radiata)* with production forestry providing an alternative land use to-intensive grazing.

Photo: P. R. Stephens

Figure 64: LUC unit Vs1, Maraetotara Heights, N141/340015

LUC UNIT Vlc2 (8750 ha)-Figure 65

Although this unit has similar physical characteristics to LUC unit Vs1, it occurs in areas where a severe climate provides the dominant constraint to land use.

The unit is situated along the west-facing dip slopes of the Puketoi Range (east of Pahiatua), between an altitude of 600 and 900 m a.s.l. Annual rainfalls exceed 1600 mm, and the unit is exposed to strong winds which have a detrimental effect on plant growth. The prevailing winds are from the west and are strongest during the equinoxes (often gale force and lasting several days on end). The 'Puketoi gale' is a feature of the local climate. Snow and sleet can occur for short periods in winter. Slopes range from 1 6 to 20 ° and contain numerous rock outcrops and sinkholes. Soils mapped are central yellow-brown earths and related steepland soils, e.g., Waimarama sandy loam, hill soil and Pukeokahu silt loam. Also included in this unit are small areas of similar landforms east of Eketahuna.

The severe climate significantly limits production. The present average stocking rate is 6 su/ha. The potential carrying capacity is 11 su/ha. The forestry site index for P. *radiata* ranges from 24 to 28 m (low to medium).

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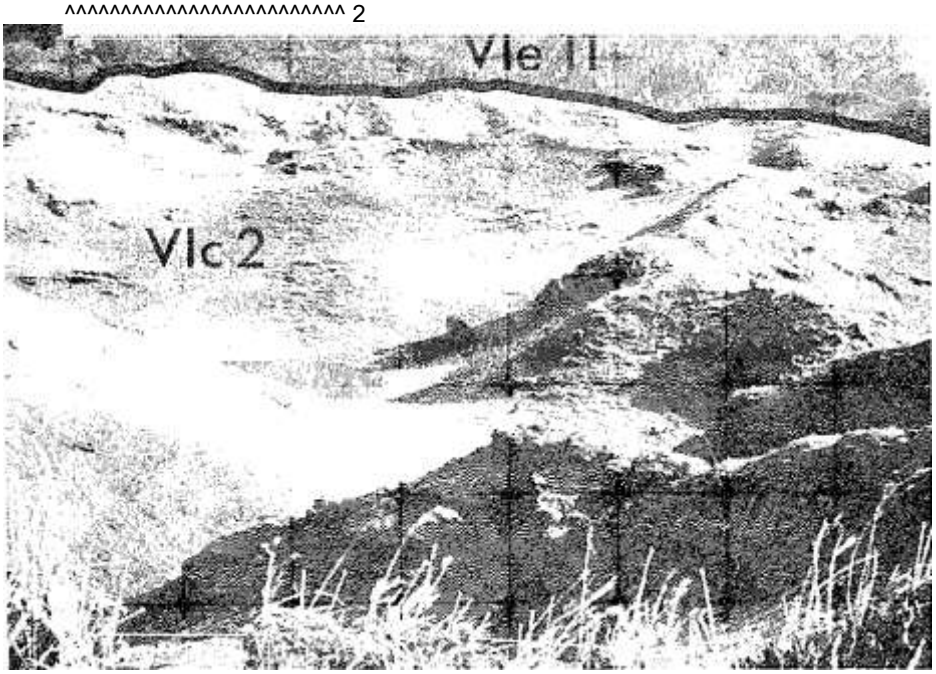

Figure 65: LUC unit Vlc2. Puketoi Range, near Coonoor. LUC units Vie 11 and Vlle5 on Waewaepa Range (greywacke) in background. N150/593272.

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2. Cuesta Landforms (70 210 ha)

Cuestas are asymmetrical landforms consisting of resistant dipping rock strata, and steeper, more erodible scarp slopes.

Four LUC units are described:

(a) Two on the dip slopes (LUC units Vc1 and Vic 1). These are generally north-westerly facing, stable limestone slopes with varying amounts of loess cover.

(b) Two on the scarp slopes (LUC units Vle5 and Vlle3). These are generally south-easterly facing slopes, which are formed on bedded sedimentary strata, underlying a limestone cap.

LUC units mapped on these landforms generally occur in areas where annual rainfalls are below 1 200 mm/annum. The relationship between the LUC units is illustrated in Figure 66.

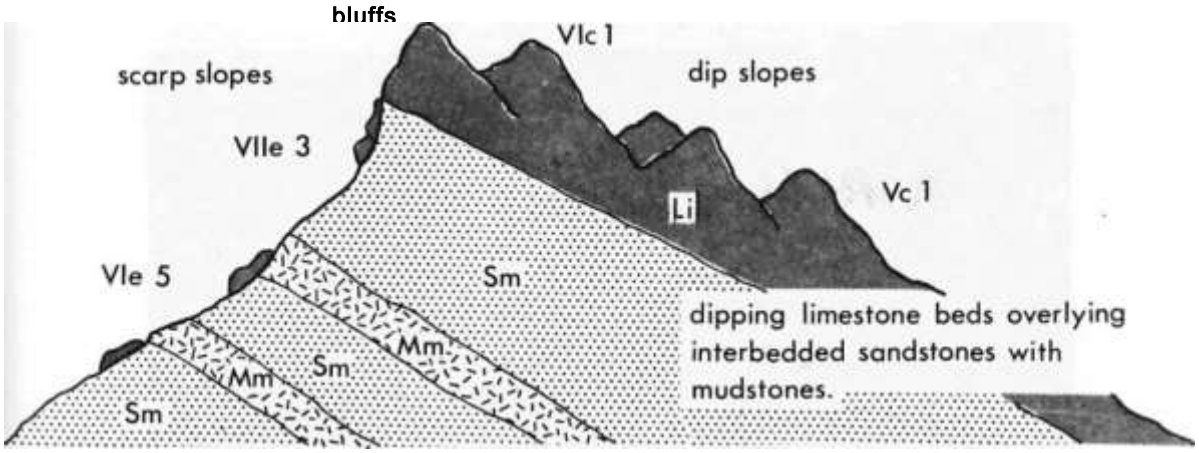

Figure 66: Cross section of a cuesta landform showing the relationship between LUC units mapped on dip and scarp slopes.

(a) LUC units on dip slopes

The two LUC units mapped on the stable, generally north-westerly facing dip slopes, are **Vc1** and **Vic 1** (Figure **66).** Both units are too steep for cultivation for cropping. Exposure to the prevailing desiccating westerly winds severely limits pasture production early in most summers. Frequent droughts occur between mid November and March. The susceptibility to summer drought is the overriding climatic constraint to production.

LUC UNIT Vc1 (27 040 ha)-Figure 67

This unit occurs in areas of hill country south of the Heretaunga Plains, and east of the Wairarapa Valley. It is mapped on short and stable slopes which range between **21** and **25 ° .** Typical soils are yellow-grey earths, formed on a loess cover over banded limestone and sandstone, e.g., the Matapiro soil series. Erosion hazard is slight, with a potential for slight sheet erosion on ridges during drought periods when the grass cover is sparse. Long periods of summer drought limit pasture production, but the unit is well suited to intensive spring and autumn grazing, with a present average stocking level of **1** 1 su/ha, and a potential stocking rate of **20** su/ha. Production forestry is also a suitable land use with the site index value for *P. radiata* ranging from **26** to **29** m.

Figure 67: LUC unit Vc1, Poukawa Road, N141/171049.

LUC UNIT VIc1 (8100 ha)-Figure 68

This unit is similar to LUC unit Vcl, but it occurs on longer and steeper slopes, which range between 21 and 35 ° . The slopes are more exposed with generally shallow soils. These factors result in the unit being prone to longer periods of summer drought, which reduces its capability.

The unit occurs mainly in Hawke's Bay, but it is also mapped east of the Wairarapa Valley.

Soils are yellow-grey earths and steepland soils related to rendzinas. Typical soils mapped are the Matapiro series and Te Mata sandy loam. Erosion risk is slight, with a potential for slight sheet erosion occurring on ridges.

Potential stock carrying capacity is 14 su/ha with a present average grazing level of 9 su/ha. The forestry site index is rated as medium, 25-27 m for P. *radiata,* but some steeper areas are unsuitable for forestry because of shallow soil depths.

oto: D. Harding

Figure 68: LUC unit VIc1, Near Pakipaki, south of Hastings, N134/204119.

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(b) LUC units on scarp slopes

Two LUC units (Vle5 and Vlle3), are mapped on the south-easterly facing scarp slopes of cuesta landforms (Figure 66). Soils on these slopes retain moisture for longer periods than soils on the north-westerly facing dip slopes because they are protected from the drying north-westerly winds.

These two units have a mass movement erosion potential. The scarp slopes expose the banded sedimentary strata beneath the limestone cap. These strata consist of a variety of rock types including bands of limestone, sandstone, jointed mudstone and fine siltstone. The weaker lithologies are preferentially eroded. Past erosion scars indicate an active erosion history on these units.

LUC UNIT Vle5 (30 410 ha)-Figure 69

This unit is mapped on moderately steep to steep slopes, on bedded limestone, sandstone and siltstone lithologies. The unit has also been mapped on dip slopes where underlying sediments have been exposed by incised drainage patterns. Areas of shallow loess may be present.

There is a potential for moderate soil slip erosion but this can be controlled by open planting of conservation trees such as poplars. Erosion scars rapidly regrass. Soils mapped include the Crownthorpe and Matapiro series mapped on hill slopes, and Te Mata soils mapped on steepland areas. Intensive grazing, with appropriate soil conservation and management measures, can achieve a potential carrying capacity of 1 7 su/ha. Present average stocking rate is 10 su/ha. Production forestry has a medium

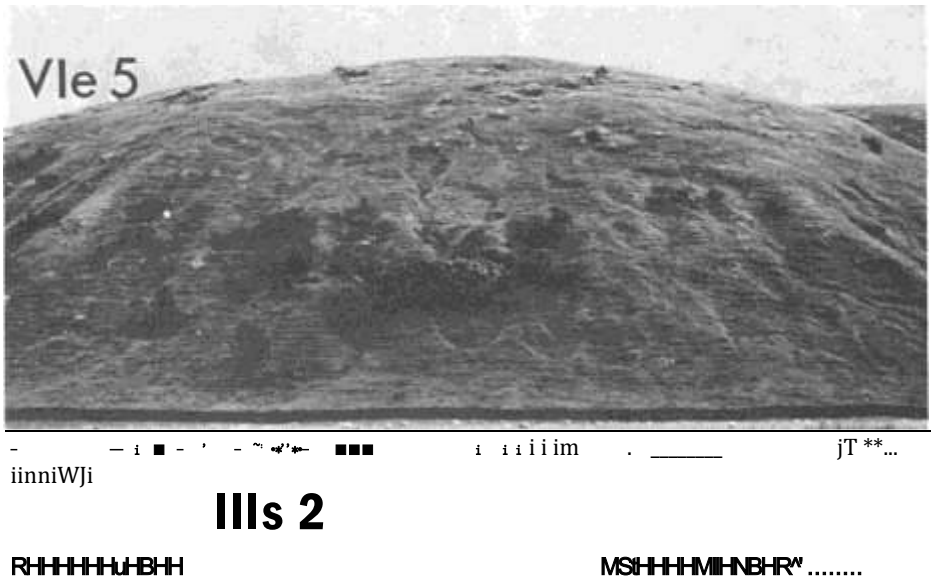

Figure 69: LUC unit Vle5, LUC unit IIIs2 in foreground, West of Hastings, N134/122222.

(b) LUC units on scarp slopes

site index of 26-29 m for P. *radiata*.

LUC UNIT VIIe3 (4660 ha)-Figure 70

This unit is mapped on steeper and more erosion prone scarp slopes than those of LUC unit VIe5. It occurs on steep to very steep scarp slopes (over 25 °); these often contain significant areas of limestone bluffs. A typical example of this unit are the scarp slopes at Te Mata Peak, south-east of Havelock North. The unit often contains a complex of very steep class VIII bluffs, and less steep class VII and VI land; these would be separated out at more detailed mapping scales.

Typical steepland soils are Bluff loam, Pukeokahu silt loam, and Te Mata sandy loam. The unit has a moderate potential for soil slip and sheet erosion. The present average grazing level is 7 su/ha and the potential grazing capacity is 15 su/ha. The forestry site index value for P. *radiata* is rated as medium (25-28 m).

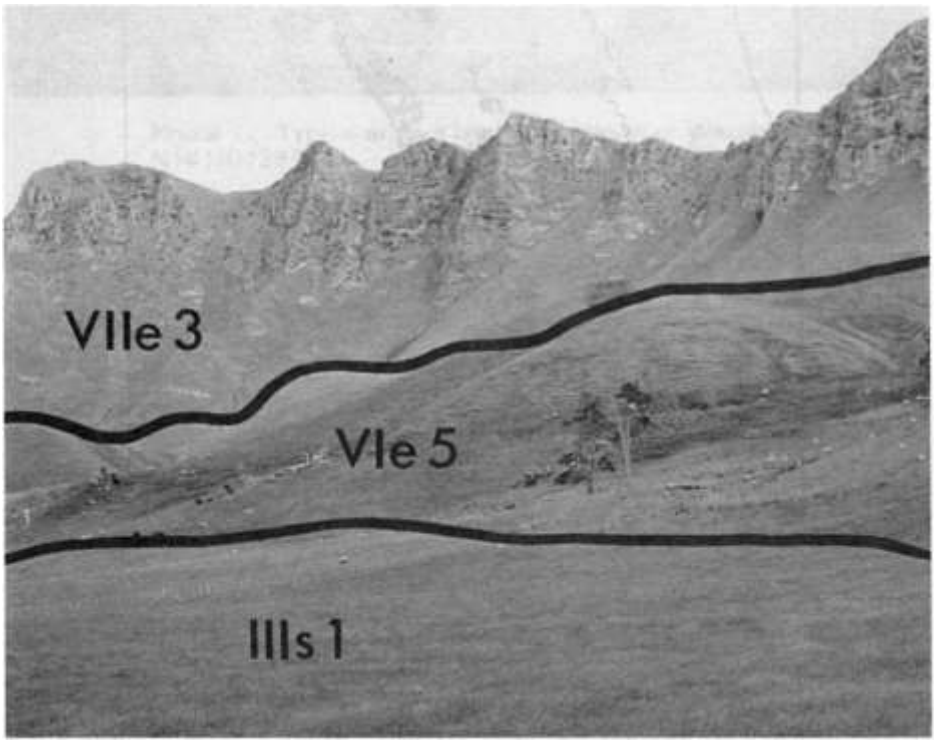

Figure 70: LUC unit VIIe3, LUC units IIIs 1 and VIe5 in foreground, Te Mata Peak, N134/323140.

Land Use Capability Suite of Units on Argillite

LUC units on argillite have been mapped on 183 710 ha, mainly in eastern hill country areas (Figure 71).

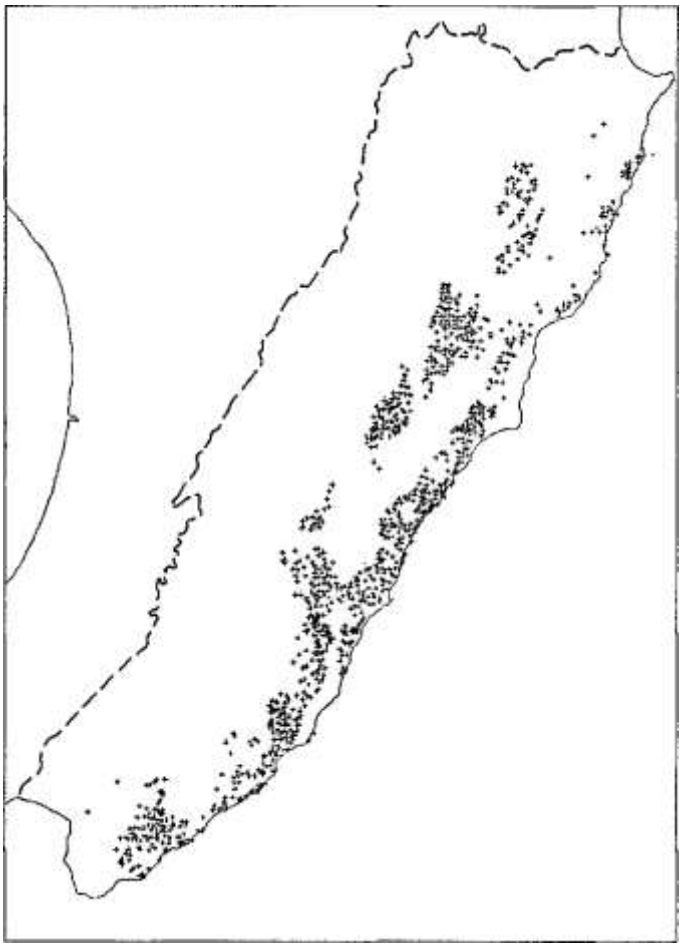

Figure 71: Location of LUC units on argillite.

Two subsuites of LUC units have been identified within the suite, based on the strength and stability of the argillite rock. This is related to the degree of deformation caused principally by faulting, folding and compression. The different types of argillite are:

(1) Argillite (Figure 72)

(2) Crushed argillite (Figure 73).

These two types of argillite form different landscapes with characteristic erosion and drainage patterns. Each requires specific erosion control techniques and soil conservation measures to minimise erosion and to maximise long term production.

Figure 72: Typical argillite landscape. North of Waipawa. N141/012898.

Figure 73: Typical crushed argillite landscape. Te Apiti Road, south of Waimarama. N141/349933.

1. LUC Units on Argillite

74 990 ha of well consolidated argillite is mapped. The argillite consists of:

(a) 'White' argillite of the Whangai Formation (upper Cretaceous), e.g., the Whangai Range, east of Dannevirke, and

(b) 'Grey' argillite, (lower Cretaceous to Jurassic), e.g., areas along the south-eastern coastline, north of Cape Palliser.

Four LUC units have been identified. Two have been mapped on arable land and are separated on the basis of slope — LUC unit IIIs4 (0-7 °) and LUC unit IVe5 (8-20 °). Two non-arable units (LUC units VIe13 and VIIe1 1) are also identified on the basis of slope angle and potential erosion severity. Soils are generally shallow and infertile, and susceptible to summer droughts. Soils are central yellow-grey earths, intergrades between central yellow-grey and yellow-brown earths and related steepland soils. Erosion forms are sheet, wind, soil slip and gully.

LUC UNIT IIIs4 (3690 ha)-Figure 74

This unit has been mapped on flat and undulating alluvial terraces in the Wilder depression (near Porangahau), and near Horoeka (near Weber). These terraces are formed from argillaceous alluvium derived from the surrounding 'white' argillite hill country. The soil type mapped is Wilder silt loam, a weakly structured intergrade soil between central yellow-grey and yellow-brown earths with low natural fertility, and prone to summer drought. These properties are the main physical limitations to cropping. Shelter and summer irrigation are necessary for cropping, and cereals and root and green fodder crops may be grown.

Annual rainfalls are in the vicinity of 1000 mm. Strong westerly winds funnelled by the Puketoi Range are a major desiccating influence and a significant erosion hazard. These winds are strongest during the equinoxes. However, with the establishment of windbreaks, and the use of appropriate conservation tillage methods, the potential for moderate wind erosion under cultivation can be minimised. Some areas south of Weber that are particularly exposed to the 'Puketoi gale' may be more correctly assessed as class IV, but are very limited in area.

Present average grazing level is 7 su/ha, with a potential for 19 su/ha. Production forestry is also an optional land use with a site index of 26-27 m for P. *radiata.*

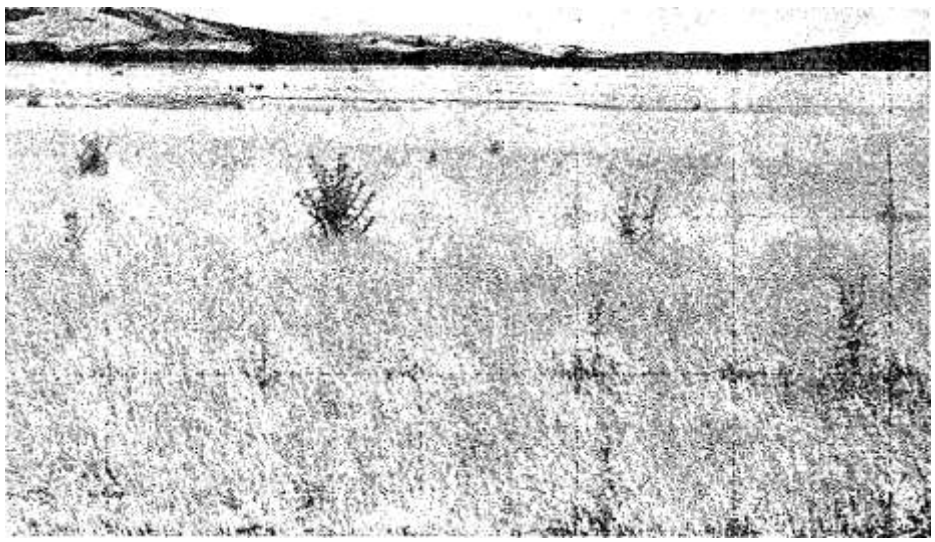

Figure 74: LUC unit IIIs4, Wilder, N151/934466.

LUC UNIT IVe5 (3910 ha)-Figure 75

This unit describes rolling and strongly rolling downlands (8-20 ° slopes) on 'white' argillite. Examples occur north of Waipawa township. Rainfall generally varies between 800 and 1000 mm/annum. Typical central yellow-grey earth soils are Mangatarata silt loam and Whangai silt loam. These have a low natural fertility and are subject to severe soil moisture stress during summer drought periods. Wind, sheet and rill erosion are all potential erosion hazards when the unit is cultivated. These hazards can be minimised by conservation practices such as contour cultivation and windbreak establishment. The range of crops able to be grown is limited by the erosion hazard, wind (especially in mid-spring), lack of available soil moisture, and summer drought. Crops include cereals and root and green fodder crops. The predominant land use on this unit is intensive grazing.

There is a potential for the stocking rate to be increased from the present average of 9 su/ha to a potential of 19 su/ha. Production forestry is an added land use option; the site index for P. *radiata* is 26-28 m.

Figure 75: LUC unit IVe5, LUC unit IIIsl in foreground, Racecourse Road, near Waipawa, N141/060879.

LUC UNIT Vle13 (38 850 ha)-Figure 76

This LUC unit describes moderately steep to steep hill country formed on 'white' argillite. Large areas are mapped near Waipawa, and on the Whangai Range, east of Dannevirke. Typically, annual rainfalls are less than 1200 mm but some LUC units mapped on the Whangai Range and near Weber have rainfalls of up to 1400 mm/annum. Summer droughts significantly reduce the potential of this unit for pasture production. Typical central yellow-grey earth soils mapped are the Waipawa silt loam, hill soil and Whangai silt loam, hill soil. The landform is generally stable, with only slight present sheet erosion. However, a moderate erosion potential exists for sheet, soil slip and gully, with a slight potential for wind erosion. Prevention of summer overgrazing to maintain a complete pasture cover is essential if sheet and wind erosion are to be minimised. Conservation trees are necessary to control areas of erosion.

The present average stocking rate is 10 su/ha. Potential stock carrying capacity is 16 su/ha. The forestry site index for P. *radiata* is rated as medium (25-27 m). The difficulty of maintaining high producing pastures on the low fertility, drought prone soils, is evidenced by the present state of development — over 21 000 ha has a vegetative cover of a mixture of low producing pastures and scrub.

Figure 76: LUC unit Vie 13. Near Waipawa. N141/995885.

LUC UNIT VIIel 1 (28 540 ha)-Figure 77

This unit occurs on steep, argillite ('white' and 'grey') landforms located along the eastern coastline and in the Whangai Range area. It differs from **LUC** unit Vie 13 in that slopes are steeper (over 25 °) and longer, with characteristic narrow ridges. Soils mapped are steepland soils related to intergrades between central yellow-grey and yellow-brown earths. Typical steepland soils are Mataikona silt loam and Opouawe stony silt loam. They have a low natural fertility and are very prone to summer drought, which is accentuated by the drying effect of north-westerly winds, making pasture establishment difficult.

Soil slip, gully, sheet and wind erosion occur on this unit. Scree erosion is present where stony subsoils have been exposed, resulting in an accumulation of rock fragments downslope. The potential for wind and scree erosion is severe. Erosion control forestry is the recommended land use on severely eroded areas. Some areas with very steep slopes, shallow rooting depth and severe erosion are unsuitable for production forestry due to establishment and harvesting problems. On less steep areas that are more suitable for production forestry, e.g., Ngahape district, site index values for P. *radiata* are rated low to medium (24-26 m). The present average stocking rate is 5 su/ha. The stock carrying capacity on less eroded areas has a potential for 10 su/ha. Scrub reversion is a major problem on this unit, with over 60 percent of the total area having a scrub or forest cover. The remaining areas are developed into pasture and used for extensive grazing.

Figure 77: LUC unit VIIel 1, Near Weber, N150/769282.

2. LUC Units on Crushed Argillite

108 720 ha have been mapped on crushed argillite in the eastern coastal hill country. Landforms are more subdued than those formed on the hard argillite, with lower angled slopes and rounded interfluves, broken by earthflow erosion.

Crushed argillite refers to argillite that has been crushed or sheared to various degrees giving the material a pervasive weakness (Crippen and Eyles, 1985). Rocks are upper Cretaceous to lower Tertiary, and are dominated by the alternating sandstones and carbonaceous mudstones of the Raukumara Formation (Lillie, 1953), although some areas of Whangai argillite are also included (Pettinga, 1980).

Four LUC units are mapped on crushed argillite; all are non-arable hill country units on moderately steep and steep slopes. Potential erosion severity is the main criterion used to separate the units. Earthflow erosion is the dominant erosion type. Soils are central yellow-brown earths, intergrades between central yellow-grey and yellow-brown earths, and related steepland soils. Soils are more fertile than those mapped in the argillite group, but internal drainage is slow. Stock management needs to be carefully controlled in winter months to reduce the effects of pugging. On units where earthflow erosion is significant, de-watering, diversion banks and conservation plantings are needed to control movement. On units where gully erosion is the dominant erosion process, control is more difficult; retirement planting is often the only available cure.

LUC UNIT Vie 12 (44 590 ha)-Figure 78

This unit is mapped on moderately steep hill country with significant earthflow erosion, throughout the eastern part of the region.

Soils are naturally fertile, e.g., Whakaroro hill soils, but have heavy clay textures with slow internal drainage. This unit is less drought prone than LUC unit Vle13 because the heavier soils retain moisture for longer periods. In exposed coastal areas winds can have a severe drying influence. This unit has a relatively high grazing potential (18 su/ha), although the present average carrying capacity is only 10 su/ha. However, care must be taken to prevent overstocking because soil pugging in winter and spring can decrease infiltration and this together with soil cracking in dry periods further activates earthflow erosion.

The forestry site index for *P. radiata* is medium (26-29 m).

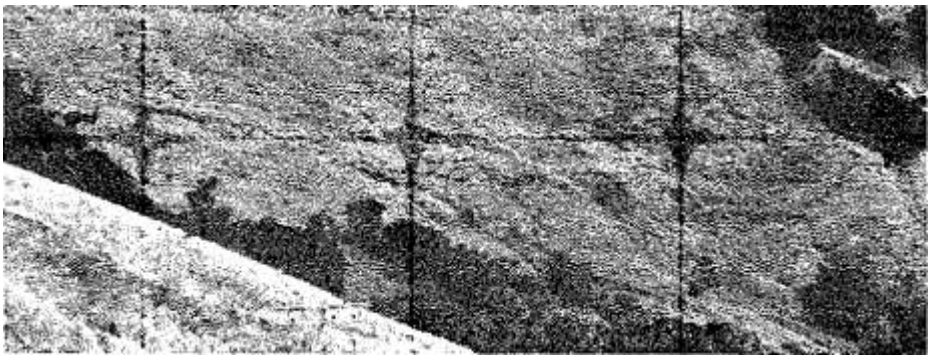

Figure 78: LUC unit Vie 12, White Rock Road, N165/993133

LUC UNIT VIIe6 (31 800 ha)-Figure 79

This unit is mapped in the eastern part of the region on moderately steep to steep crushed argillite hill country which has a greater potential for earthflow erosion than LUC unit Vie 1 2. Under pasture, the unit has a potential for very severe earthflow, moderate gully, and slight soil slip. Erosion control forestry is the recommended erosion control measure on areas with very severe erosion, while de-watering of earthflows and open planting of conservation trees are necessary control measures on the less severely eroding areas.

Typical yellow-brown earth soils include Whakaroro hill soils and Akitio hill soils. These are naturally fertile soils, but are heavy textured, and prone to pugging, therefore cattle grazing should be restricted during winter.

The stock carrying capacity can be raised to 13 su/ha from a present average of 9 su/ha, if the erosion can be controlled. The forestry site index for *P.aadiata* is medium (26-28 m) although problems such as butt malformation (caused by earthflow movement) are common. The problems caused by erosion are reflected in the current state of development with 21 000 ha having a low producing pasture cover and a further 9700 ha partially cleared and developed into pasture. The remaining 1100 ha has an indigenous scrub or exotic forest cover.

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Figure 79: LUC unit VIIe6, Te Apiti Road, south of Waimarama, N142/354939

LUC UNIT VIIe7 (27 000 ha)-Figure 80

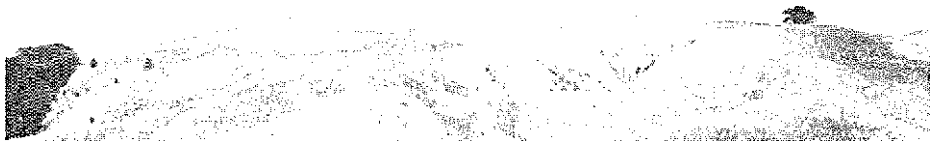
This moderately steep to steep hill country unit is a complex of argillite ridges with significant sheet and wind erosion, and basins of crushed argillite dominated by earth-flow erosion. At more detailed mapping scales, LUC units VIIel 1 (ridges) and VIIe6 (valley basins), would be separated out. Soils mapped are those occurring on LUC units VIIe6 and VIIel 1, i.e., Whakaroro hill soils and Mataikona silt loam, steepland soil respectively.

The combination of the two landform components and their associated erosion forms means intensive conservation measures are required to minimise the erosion hazard. Erosion control forestry is recommended on more severely eroding areas.

The present average stocking rate is 9 su/ha, and the potential stock carrying capacity is 11 su/ha. The forestry site index for P. *radiata* is medium (25-26 m), but some areas are unsuitable for production forestry because of the erosion hazard. 55 percent of this unit has been developed into low producing pasture and the remainder still has a dominant scrub or forest cover.

Figure 80: LUC unit VIIe7. Near Wimbledon. N150/892234.

LUC UNIT VIIe7 (27 000 ha)-Figure 80



LUC UNIT VIIel3 (5330 ha)-Figure 81

This unit is mapped on moderately steep to steep hill country scarred by large, deep and active gully erosion. It occurs predominantly in the Awhea-Tuturumuri area in southern Wairarapa. The unit occurs along crush zones which have shattered and weakened the argillite rock. Once gully erosion has started, control is often difficult, with some of the larger gullies developing to more than 5 ha. Erosion debris causes severe downstream problems by choking and raising stream beds, the disruption and destruction of roads, bridges, farm buildings and fencelines, and lost production of fertile river flats. Retirement of gullied areas and erosion control forestry planting are the only practical control measures. At more detailed mapping scales, the gullies would be classified as LUC class VIIIe3, and the more stable areas (with soil slip and earthflow erosion) would be classified as LUC classes Vie 1 2 or VIIe6.

The present average stocking rate of 6 su/ha is the same as the^potential carrying capacity of this unit, and the forestry site index for P. *radiata* is 24-26 m (low to medium).

Severe aggradation of the Awhea and Opouawe River beds and tributaries led to the approval in 1959 of the Awhea and Opouawe Catchment Control Scheme, covering an area of 400 km^2 (Poole, 1983). Large areas of this unit are contained within the scheme area, and remedial conservation works (including retirement fencing, conservation planting, debris dams, retards, groynes and siltation banks) have been carried out by the Wairarapa Catchment Board.

Figure 81: LUC unit VIIel3. LUC unit Vie 12 in foreground. Near Tuturumuri. N165/984082.

Land Use Capability Suite of Units on Greywacke

Ten greywacke units totalling 159 690 ha are mapped throughout the region on moderately steep hill country and on steep to very steep mountain lands (Figure 82).

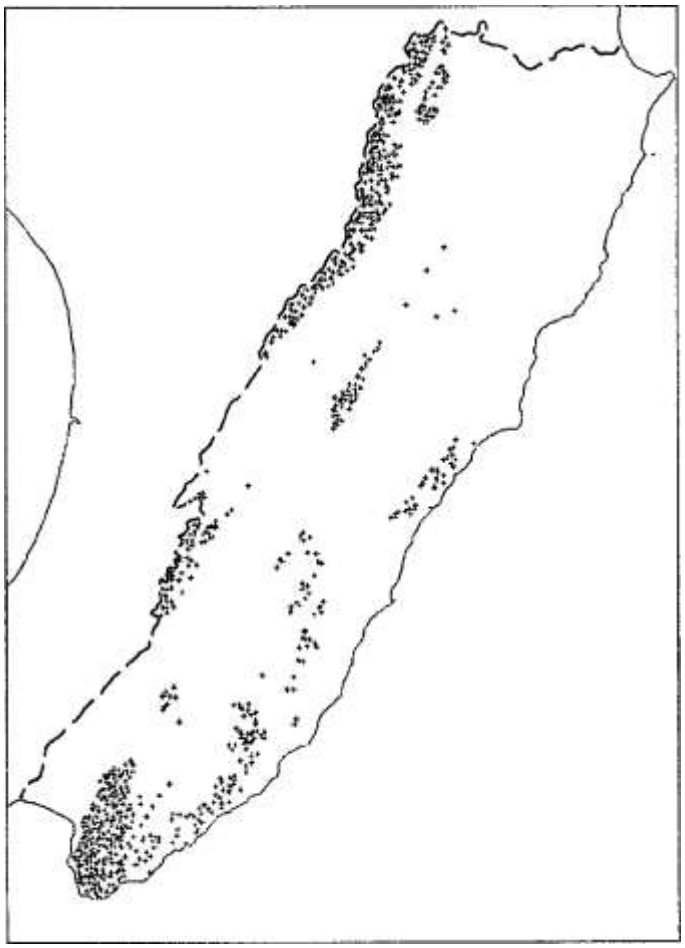


Figure 82: Location of LUC units on greywacke

The greywacke suite contains LUC classes VI, VII and VIII. However, at more detailed mapping scales, arable land would be delineated on lower footslopes. The LUC units have been subdivided into two subsuites on the basis of location, relief and rainfall:

(1) Mountain landforms, occurring in areas where rainfalls exceed 1200 mm/annum (Figure 83).

(2) Taipo landforms, occurring in eastern areas where rainfalls are less than 1400 mm/annum (Figure 84).

Figure 83: Typical greywacke mountain landforms. Ruahine Range. N145/496556.

Figure 84: Typical greywacke taipo landforms. Near Stronvar. N162/387477.

1. Mountain Landforms (109 420 ha)

Eight LUC units have been mapped on greywacke landforms where annual rainfalls are over 1 200 mm/annum. The units are mapped on the Ruahine Ranges, and on outlying greywacke ranges (Aorangi, Waewaepa and Wakarara Ranges). The susceptibility to erosion is related to a variety of factors including slope angle, crush zones and rainfall intensities. (Stephens, 1975; Cunningham and Stribling, 1978; Marden, 1981; Grant, 1983). The relationships between the LUC units and slope, altitude (above or below tree line) and present erosion severity are shown in Figure 85.

LUC units Vie 11 and VIIel0 have a long term productive capacity, while the LUC class VIII units are suitable only for protection purposes.

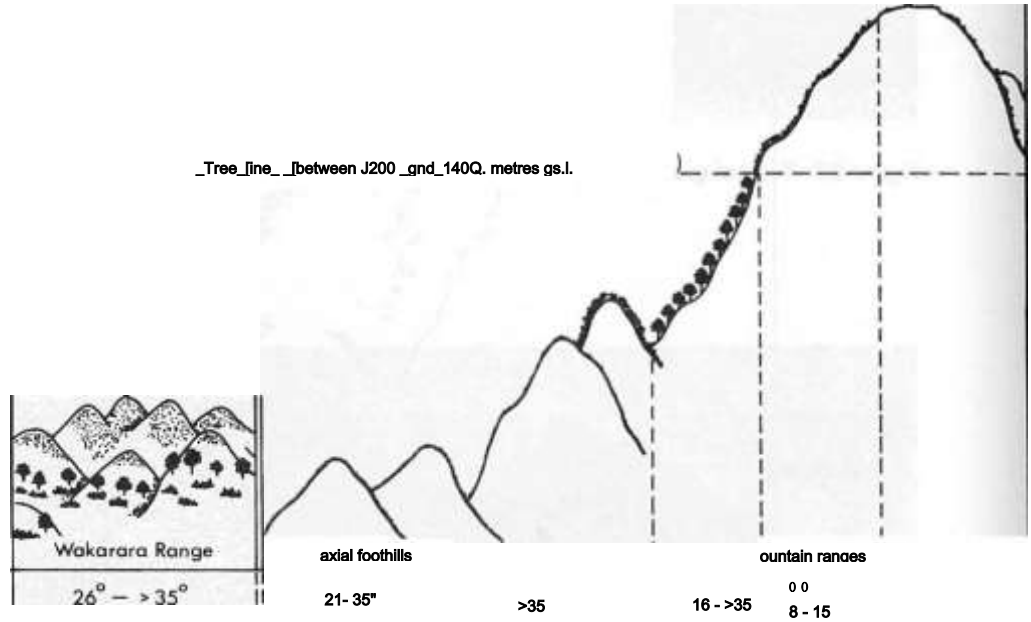


Figure 85: Relationships between LUC units mapped on greywacke mountain landforms. (See Appendix 5 for erosion codings.)

LUC UNIT VIe11 (32 050 ha)-Figure 86

This unit is mapped on greywacke hill country, along the foothills of the axial ranges, and lower slopes of the Waewaepa and Aorangi Ranges. Slopes are between 21 and 35 °. Soils are central yellow-brown earths and associated steepland soils, e.g., Korokoro silt loam, hill soil and Makara stony loam. They have a low natural fertility and stony subsoils, but pastures respond to fertiliser applications. Rainfall is sufficient to maintain pasture growth throughout the year. Scrub reversion can be a problem unless regular fertiliser applications and appropriate grazing management are maintained. The unit has a potential for moderate sheet, scree and soil slip erosion.

Present average carrying capacity is 7 su/ha, with a potential for 14 su/ha. The forestry site index for P. *radiata* is rated as medium (25-28 m).

Figure 86: LUC unit VIe11, Tamaki West Road, near Dannevirke, N145/497627.

LUC UNIT VIIelO (37 320 ha)-Figure 87

This unit occurs on similar landforms to LUC unit Vie 11, but slopes are steeper (over 25 °) and longer. The unit is mapped along the foothills of the axial ranges, and in the Aorangi, Waewaepa and Wakarara Ranges. High rainfalls (> 1200 mm/annum) have resulted in leached and podzolised soils which have a low natural fertility. Typical steepland soils related to central yellow-brown earths are the Rimutaka stony loam and Ruahine stony silt loam. Erosion is a major hazard with sheet, wind, soil slip, scree, gully and debris avalanche erosion all occurring. Scrub reversion is a problem on this unit. Only a small area has been developed (present average stocking rate of 4 su/ha); the remainder is either undeveloped with an indigenous forest cover or has reverted to scrub.

The potential stock carrying capacity is 9 su/ha, while the forestry site index for *P. radiata* ranges from low to medium (23-28 m).

Because of the erosion hazard on this unit, management measures should include erosion control forestry.

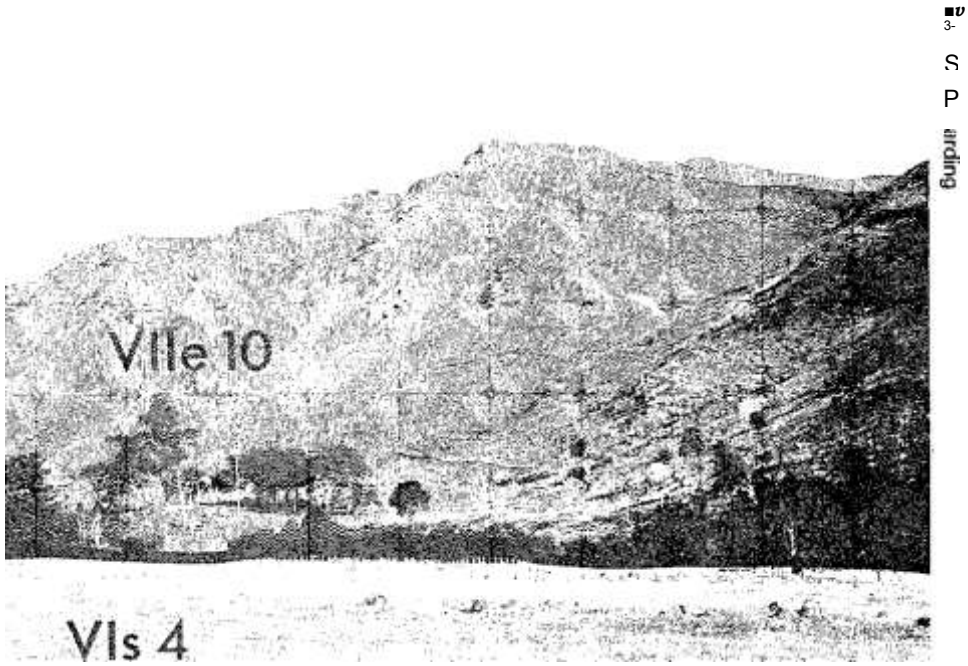


Figure 87: LUC unit VIIelO. LUC unit VIs4 in foreground. Mt Holdsworth Road. N158/003685.

LUC UNIT VIIIe5 (20 830 ha)-Figure 88

This unit is mapped below the tree line (between approximately 1200 and 1400 m a.s.l.) on long, very steep mountain slopes (over 35 °) which have only a slight to moderate degree of present erosion.

Steepland soils are related to podzolised central yellow-brown earths, e.g., Ruahine stony silt loam. Debris avalanche, scree, soil slip and sheet erosion are all present on this unit. The potential for erosion is very severe but this can be minimised if the vegetation cover is maintained in a healthy condition by effective control of browsing animals.

Eighty percent of the unit is covered by indigenous forest (lowland podocarp-hardwood and beech) with the remainder in mixed native scrub.

Photo: P. R. Stephens

Figure 88: LUC unit VIIIe5, Upper Smith Stream, Ruahine Range, N140/627954.

LUC UNIT VIIIe6 (10 790 ha)-Figure 89

This unit occurs on forested mountain slopes and is similar to LUC unit VIIIe5 except that present erosion is severe to very severe. The increased erosion severity is associated with crush zones (where the greywacke rock has been shattered and weakened by fault activity) and by the effect of localised storm events (Stephens, 1 975; Marden, 1981; Grant, 1983).

Particular care is needed to maintain the indigenous forest and scrub cover in a healthy state by ensuring animal control is maintained, and eroded areas should be revegetated.

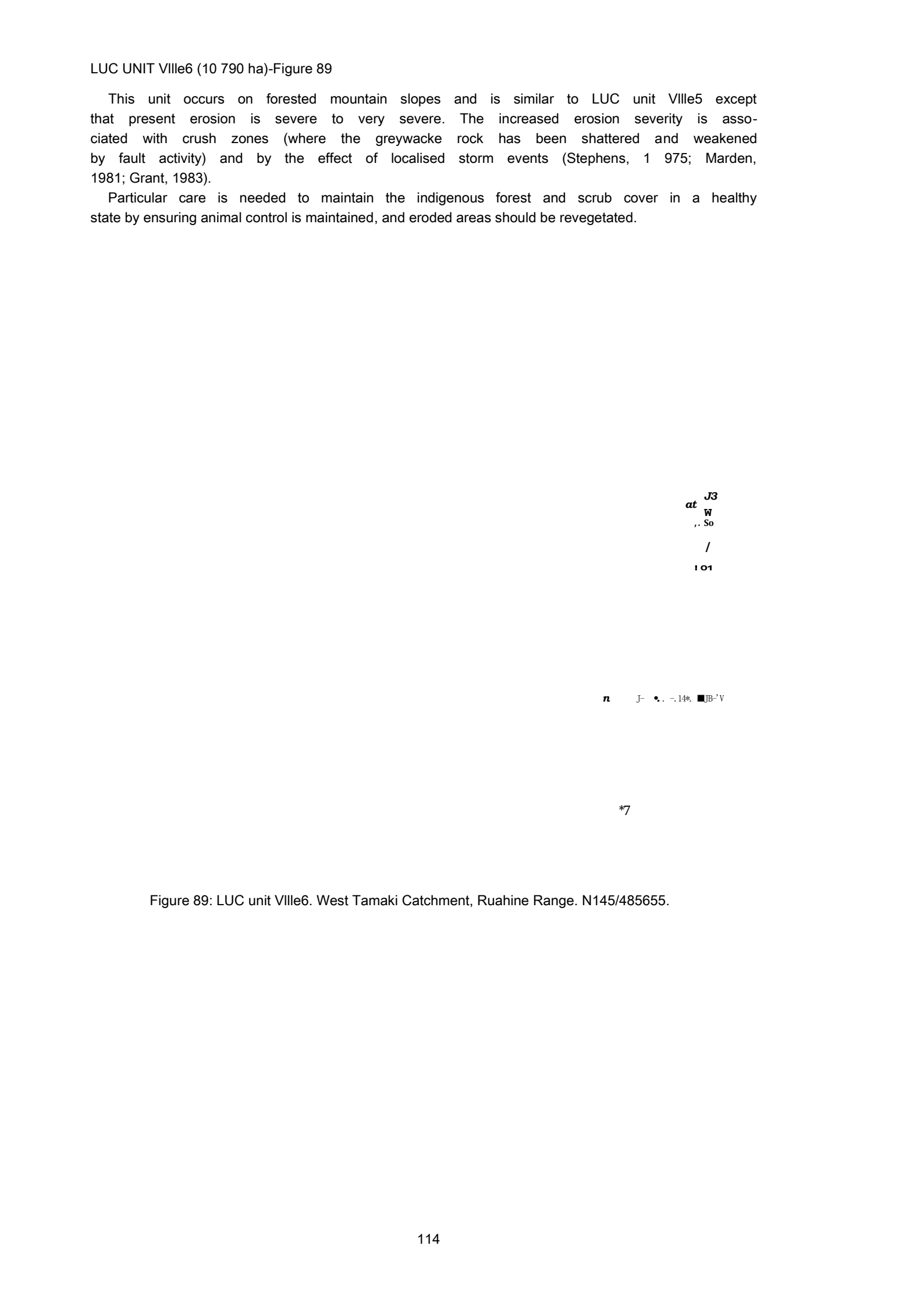


Figure 89: LUC unit VIIIe6. West Tamaki Catchment, Ruahine Range. N145/485655.

LUC UNIT VIIIe7 (6290 ha)-Figure 90

This unit occurs on long, steep to very steep slopes in the Wakarara Range, which have severe to extreme present erosion. Altitude ranges between 700 and 980 m a.s.l. and annual rainfall is between 1400 and 1800 mm. The unit is exposed to very strong westerly winds and cold winter temperatures. Past land use (forest clearance by burning followed by overgrazing) has resulted in erosion of the tephra mantle. The unit is subject to severe to extreme sheet and wind erosion; where this has exposed the underlying greywacke bedrock, extensive areas of severe to extreme scree occur. Other erosion processes occurring include gully and debris avalanche. Typical soils mapped are the severely and moderately eroded complexes of Ruahine silt loam.

Vegetation cover consists of a combination of manuka, mixed native scrub, lowland beech and exotic forest species planted for erosion control. This unit should remain under indigenous forest cover or exotic protection forestry.

The unit has also been mapped on severely eroded areas of the Aorangi Range, which are exposed to strong south-westerly winds.

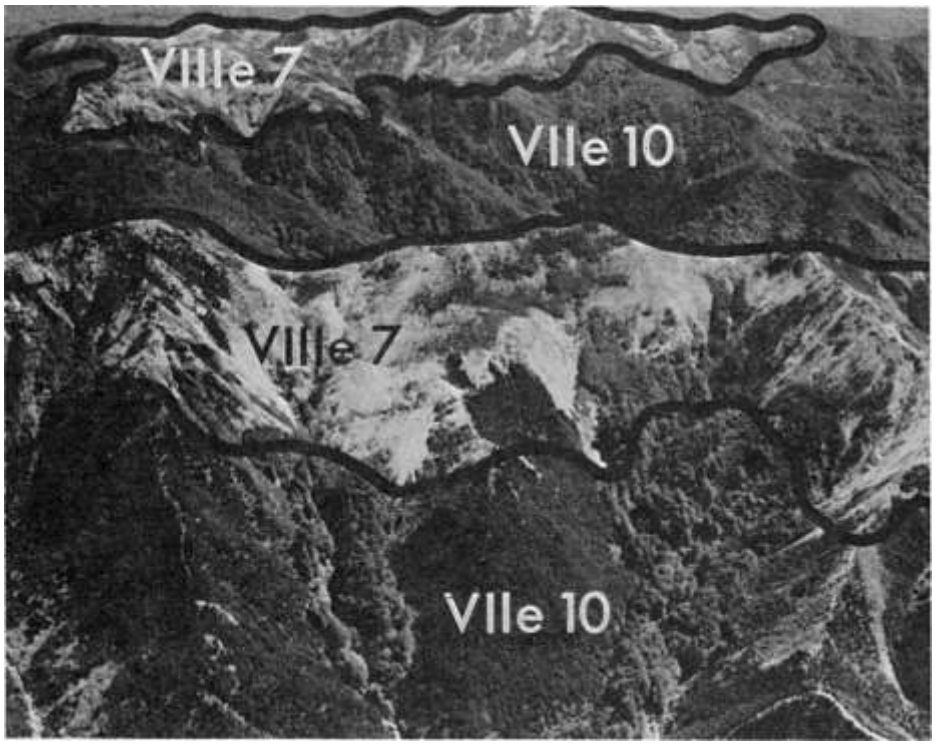


Figure 90: LUC unit VIIIe7. LUC unit VIIe10 in foreground. Wakarara Range. N140/778095.

LUC UNIT VIIIe8 (780 ha)-Figure 91

This unit is located above the tree line (between approximately 1200 and 1400 m a.s.l.) in the Ruahine Range, on areas which have only a slight present erosion severity. Because of the harsh climate (sub-zero winter temperatures, annual snowfalls and gale force winds) an extreme erosion potential exists. Erosion types occurring are scree, debris avalanche, sheet and wind. Slopes range between 16 and 35 ° . Soils mapped are subalpine organic soils (Takapari hill soil) and steepland soils related to podzolised central yellow-brown earths (Ruahine silt loam). Management must ensure that the present vegetative cover is maintained, and any bare areas revegetated. Vegetation consists mainly of tussock, and subalpine scrub and herb associations.

Figure 91: LUC unit VIIIe8, mapped within LUC unit VIIIe9. Ruahine Range, near Rangioteatua Trig. N140/598990.

LUC UNIT VIIIe9 (1290 ha)-Figure 92

This unit occurs in similar locations to LUC unit VIIIe8; however it is very severely to extremely eroded. Erosion types are scree, debris avalanche, gully, sheet and wind. Erosion control is very difficult due to the severe climatic conditions. Management measures need to prevent the enlargement of existing erosion surfaces, and to encourage revegetation.

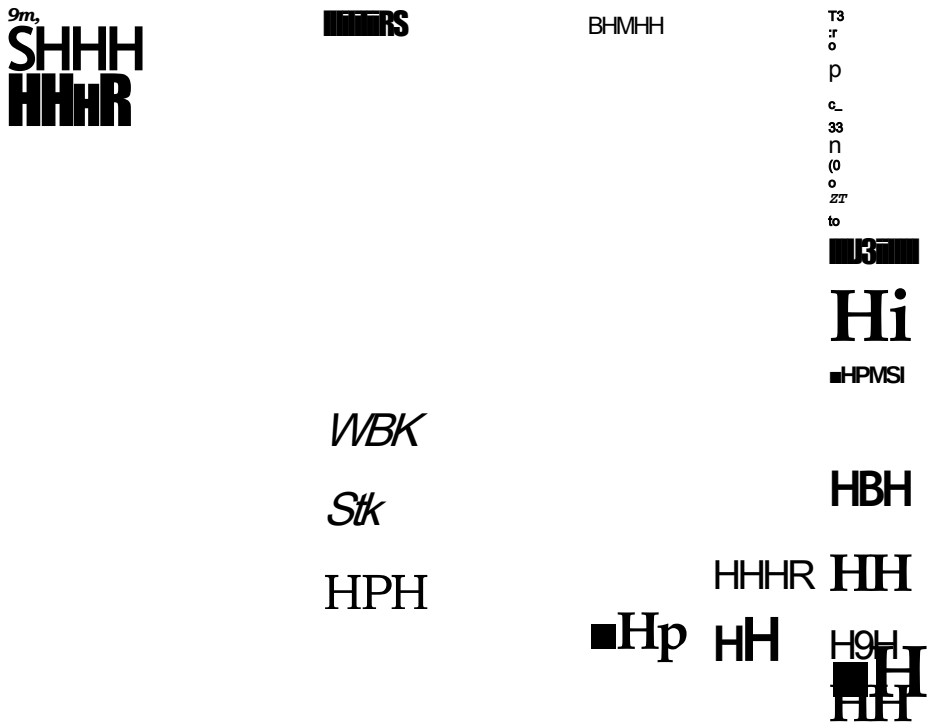


Figure 92: LUC unit VIIIe9, Broken Ridge, Ruahine Range, N140/592975.

LUC UNIT VIIIe 1 (70 ha)-Figure 93

This unit describes the flat to rolling slopes with no significant present erosion, above the tree line, along the summit of the Ruahine Range. Subalpine organic soils (e.g., Takapari peaty loam) are developed on peat overlying greywacke. Present erosion hazard is negligible under the existing subalpine scrub cover. However, when the vegetative cover is broken, there is a potential for moderate sheet and wind erosion. Management needs to be aimed at protecting the vegetative cover from damage by noxious animals.

Only a small portion of this unit has been mapped in the Southern Hawke's Bay-Wairarapa Region. The majority occurs along the summit of the Ruahine Range as LUC unit VIIIe 1 in the adjacent Taranaki-Manawatu Region (Fletcher, 1981).

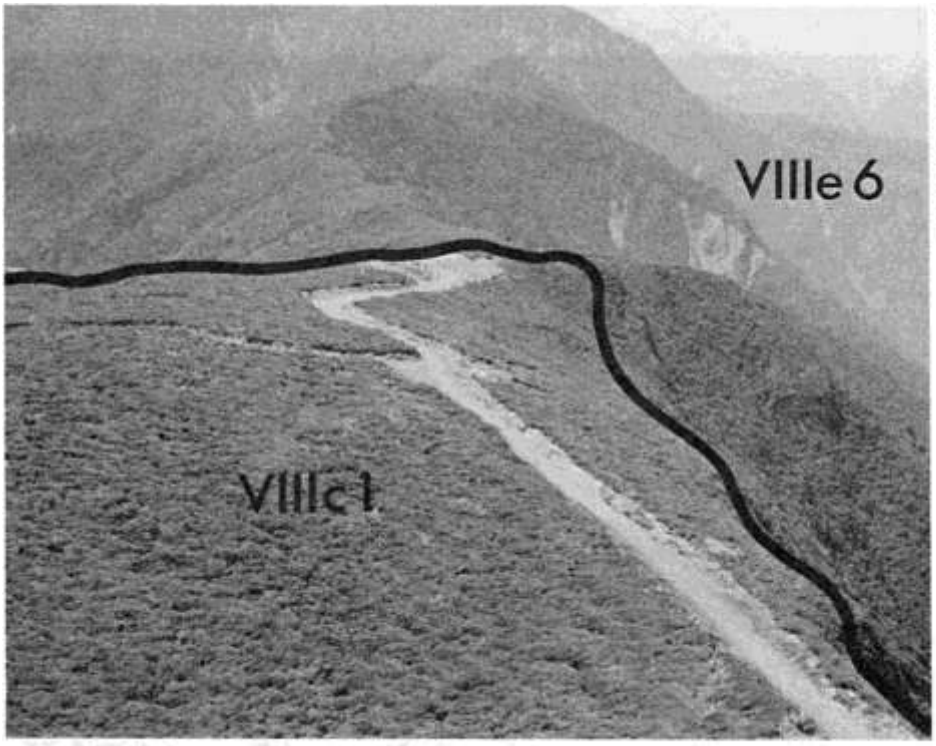


Figure 93: LUC unit VIIIc1. LUC unit VIIIe6 behind. Ruahine Range. N145/489673.

2. Taipo Landforms (50 270 ha)

Two LUC units are mapped on greywacke taipo landforms. Annual rainfalls are between 1000 and 1400 mm/annum. The units occur on the northern Wakarara and Waewaepa Ranges, near Akitio and Owahanga, in the Carswell-Stronvar-Ngahape-Te Wharau districts (east of Masterton), near Martinborough, from Mt Adams to the south of the Opouawe River, and on the foothills of the Aorangi Mountains.

The LUC units are separated on the basis of slope angle and erosion potential. LUC unit VIs3 is mapped on moderately steep, stable slopes with a slight erosion potential, while LUC unit VIIe5 occurs on longer, steeper slopes which have a moderate erosion potential. Both units are susceptible to periods of summer drought, and areas nearer the coast are exposed to drying winds.

LUC UNIT Vls3 (36 450 ha)-Figure 94

This unit is mapped on hill country with slopes between 21 and 25 °. These slopes are stable with only slight sheet and scree erosion occurring. The major limitations are those caused by the shallow infertile soils (e.g., Maungapakeha hill soil), and the susceptibility to drought, reflected by the 's' subclass. Rock outcrops and stony subsoils contribute to the low moisture holding capacity of the soils.

This type of land is suitable for either grazing or production forestry. Present average stock carrying capacity is 7 su/ha, with a potential for 12 su/ha. 70 percent of this unit has been developed for farming; the remainder has a complete scrub or forest cover. The forestry site index ranges from 25 to 28 m for *P. radiata.*

LUC UNIT Vlle5 (13 820 ha)-Figure 94

This unit is mapped on longer and steeper slopes with a more significant erosion hazard than LUC unit Vls3. Soils are shallow with many rock outcrops. They have a low natural fertility, and are particularly prone to the effects of drought. Typical soils mapped are Pahaoa silt loam and Makara stony loam. Erosion forms include sheet, scree and soil slip. The dominant limitations to use are the moderate potential for erosion and the susceptibility to drought.

The present average stock carrying capacity is 5 su/ha with a potential figure of 10 su/ha. Of this unit 9420 ha have a dominant low producing pasture cover, while 4400 ha are covered in indigenous scrub and forest. The forestry site index rankings for *P. radiata* are low to medium (23-26 m), but some steeper and rocky areas are unsuitable for production forestry.

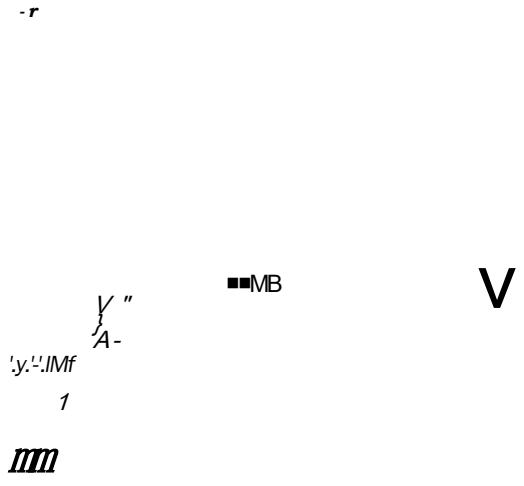


Figure 94: LUC units Vls3 and Vlle5. Near Stronvar. N162/388478.

Miscellaneous Land Use Capability Units

Four of the LUC units mapped in the region cannot be described under a 'suite' approach because they do not form part of a sequence relating to rock type, erosion, climate, etc. Instead these units are unique landforms. They are therefore described separately in this section. These units are mapped on 18 660 ha, and their distribution is shown in Figure 95.

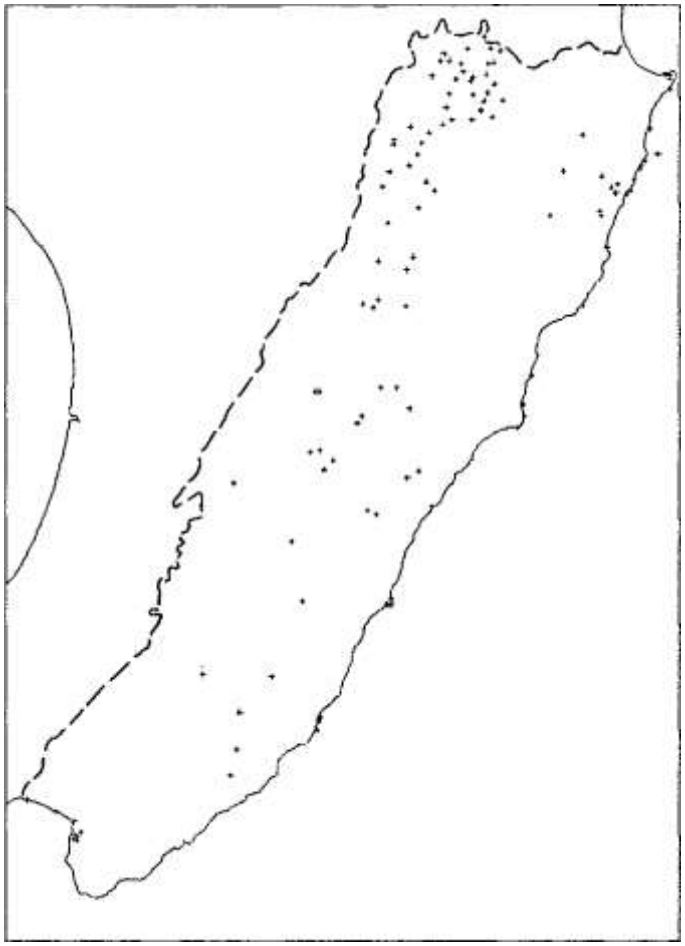


Figure 95: Location of miscellaneous LUC units.

Land classified as LUC units VIIe9, VIIIe 1, VIIIe2 or VIIIe3 comprise either steep sided river scarps, coastal cliffs or large scale slumps, earthflows or gullies. These units occur on a wide range of lithologies and under varying rainfalls. Soils are steepland soils related to yellow-grey earths, yellow-brown earths, and intergrades between central yellow-grey and central yellow-brown earths. Large areas of the class VIII units consist of bare rock faces.

Each of these units has severe to extreme erosion problems. LUC unit VIIe9 land has a potential for productive use only with intensive soil conservation measures, while the LUC class VIII units are suitable only for catchment protection purposes.

LUC UNIT VIIe9 (8200 ha)-Figure 96

This unit is mapped on valley sides which have a very severe slump or earthflow erosion potential. It is mapped along valley systems between Dannevirke and Kereru (e.g., Mangatera Stream). These areas are a complex of steep, presently stable slopes (over 25 °) interspersed with low-angled deep-seated earth movements which may be as large as 28 ha. Lithologies comprise banded formations of pumiceous sandstones, fine-grained lacustrine deposits, or thick beds of stony greywacke gravels. Shear planes or zones of deformation occur in these formations along which movement occurs. The surfaces of the movements are very broken, and natural drainage patterns are disturbed. Deep tension cracks allow surface water to be concentrated along the subsurface shear planes, which further lubricates the movement. The unit differs from LUC unit VIIe8 in that it occurs only on valley sides, and on different parent materials (i.e., no bentonitic influence).

Intensive erosion control measures such as land re-shaping, de-watering, block and space planting of conservation trees, and streambank protection are necessary if these areas are to be stabilised. Streams which continually undercut the toe of these deep-seated movements make erosion control on this unit very difficult to achieve. The most effective long term land use is erosion control forestry.

Because of the continuing erosion hazard, this unit has a limited potential for long term pastoral grazing. The present average stocking rate is 7 su/ha and the potential stock carrying capacity is 12 su/ha. The forestry site index is medium for P. *radiata* (25-28 m), but large areas of the unit are unsuitable for production forestry because of difficulty of access and continual earth movement.

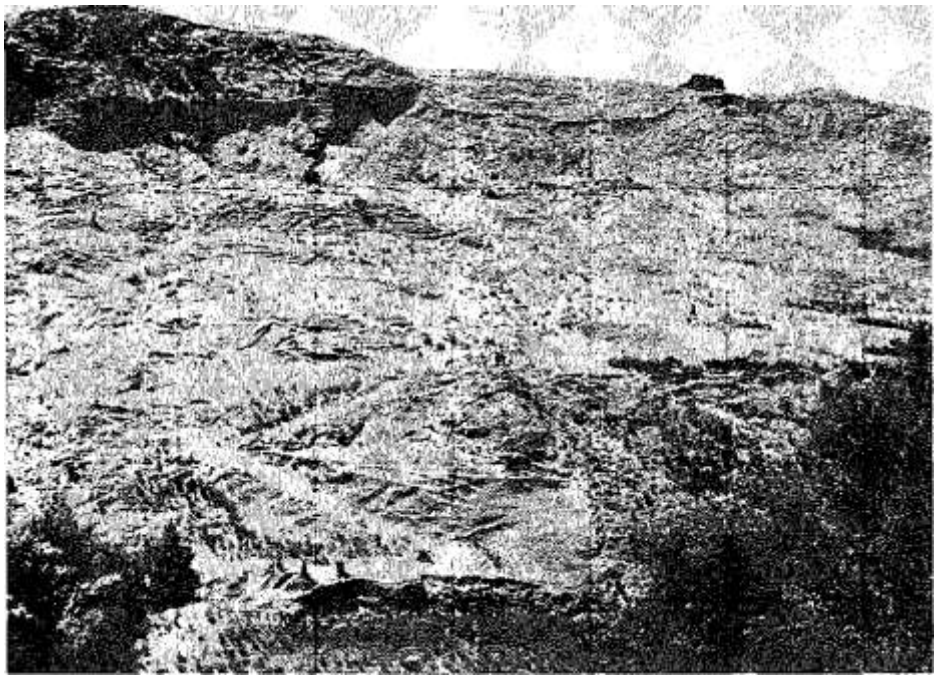


Figure 96: LUC unit VIIe9. Near Dannevirke. N145/608596.

LUC UNIT **VIIIel** (7500 ha)-Figure 97

LUC unit VIIIel occurs as scarps and cliffs along deeply incised river courses. This unit has a very severe to extreme erosion hazard. A variety of sedimentary lithologies such as mudstones, siltstones and sandstones are mapped on this unit. Typically, the steepland soils, such as the Kidnappers silt loam and Taihape silt loam, are very shallow and particularly susceptible to soil slip erosion. Present vegetation is low producing pasture with areas of scrub and forest, except on bare rock faces where natural regeneration is very slow.

Eroding stream channels have the potential to develop into serious gullies. Erosion is also accelerated by continual undercutting of streams at the base of scarp areas. Retirement fencing and protection plantings are necessary measures to minimise this erosion and to prevent runoff and sediment generation.

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Figure 97: LUC unit VIIIel. Poporangi Stream, near Kereru. N133/874256.

LUC UNIT **VIIIeI** (7500 ha)-Figure 97

LUC UNIT VIIIe2 (1410 ha)-Figure 98

This unit identifies the very steep coasta! cliffs along the eastern coastline which have severe soil slip, severe gully and moderate sheet erosion potential. Typical areas are the cliffs at Cape Kidnappers, Cape Turnagain and Palliser Bay. The eastern coastline is exposed to strong southerly gales, and the effects of exposure and salt spray severely limit revegetation. Vegetation cover consists mainly of salt tolerant herbaceous plants, tauhinu and manuka. Several rock types have been mapped, including sandstone, mud-stone and greywacke. Typical steepland soils are Taihape silt loam and Turakina silt loam, but there are large areas of bare rock outcrops. Undercutting by wave action results in continuing erosion. Because of the erosion potential and the extreme difficulty of control, the unit is suitable only for retirement for coastal protection.

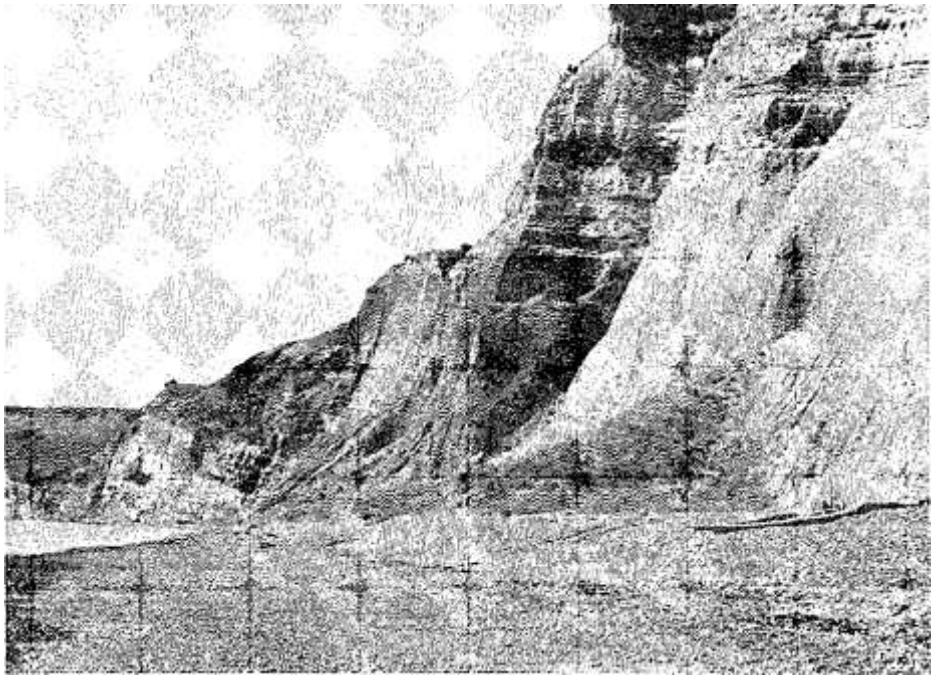

Figure 98: LUC unit VIIIe2, Near Clifton, N135/425202

LUC UNIT VIIIe3 (1550 ha)-Figure 99

LUC unit VIIIe3 describes areas of very severe to extreme earthflow, slump or gully erosion that are large enough to be separated out as individual map units. They occur on strongly rolling to very steep slopes on a variety of rock types.

Examples of this unit include:

(1) The Ponui slip, a massive slide failure (mapped as extreme slump erosion) occurring on the southern margin of the Maraetotara Heights. 25 ha of land were involved and approximately 2 000 000 m^3 of debris generated (Pettinga, 1980).

(2) The large bentonitic earthflows on the coast, south of Waimarama.

(3) The eroding gullies at Putangirua Pinnacles.

The extreme erosion potential of this unit makes it unsuitable for long term production. Erosion control measures involve retirement fencing and protection planting of eroding areas.

Figure 99: LUC unit VIIIe3. Ponui slip, near Elsthorpe. N141/312860.

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APPENDIX 1: AUTHORS AND DATES OF FIELD WORK OF THE NEW ZEALAND LAND RESOURCE INVENTORY WORKSHEETS FOR THE REGION.

WORKSHEET NUMBER	NAME	AUTHOR*	DATE
ptN133	Wakarara	P. R. Stephens, K. E. Noble	1976,
ptN134	Napier and Hastings	K. E. Noble	1976
N135 . .	Kidnappers	K. E. Noble	1976
ptN140	Ongaonga	P. R. Stephens, M. S. Redpath	1976,
N141	Waipawa	K. E. Noble	1976
N142..	Waimarama	K. E. Noble	1976
ptN144	Feilding	P. R. Stephens, P. M. Blaschke	1976,
ptN145	Dannevirke	P. R. Stephens, P. M. Blaschke, K. E. Noble	1976,
N146..	Waipukurau	P. R. Stephens	1976
ptN149	Palmerston North	P. R. Stephens, P. M. Blaschke	1976,
N150..	Weber	M. S. Redpath	1977
N151 . .	Porangahau	M. S. Redpath	1977
ptN153	Eketahuna	M. S. Redpath	1977

* Author and date of field work apply only to that part of the worksheet within the Southern Hawke's Bay-Wairarapa Region.

When quoting information from individual worksheets, the correct reference is: e.g., Noble, K. E. 1978: N134 Napier and Hastings. New Zealand Land Resource Inventory Worksheet, NWASCO. Wellington. Part sheets are referenced by the principal authors for that part of the worksheet.

N154, 155 . .	Pongaroa and Turnagain	M. J. Page	1977
pt N156, 157 . .	Otaki	A. J. Reid	1978
ptN158	Masterton	A. J. Reid	1977
N159..	Tinui	M. J. Page	1977
ptN161	Rimutaka	M. J. Page	1977
N162..	Wairarapa	K. E. Noble	1977
N163..	Whareama	M. J. Page, K. E. Noble	1977
ptN165	Onoke	A. J. Reid, M. S. Redpath	1977
N166..	Pahaoa	A. J. Reid	1977
N168, 169	Palliser	M. S. Redpath	1977

APPENDIX 2: BIBLIOGRAPHIC REFERENCES TO GEOLOGICAL MAPS AND RELATED STUDIES (Refer Figure 3).

Johnston, M. R. 1975: Sheet N159 and pt. N1 58 Tinui-Awatoitoi (1sted.). 'Geological Map of New Zealand, 1:63 360'. DSIR, Wellington, New Zealand.

Kingma, J. T. 1962: Sheet 11, Dannevirke (1 st ed.). 'Geological Map of New Zealand 1:250 000'. DSIR, Wellington, New Zealand.

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Lillie, A. R. 1953: The Geology of the Dannevirke Subdivison. *New Zealand Geological Survey Bulletin n.s. 46.* DSIR, Wellington, New Zealand.

Moore, P. R. 1975: The Limestone Resources of Wairarapa. *New Zealand Geological Survey Report NZGS 73.* DSIR, Wellington, New Zealand.

Neef, G. 1974: Sheet N153, Eketahuna (1st ed.). 'Geological Map of New Zealand 1:63 360'. DSIR, Wellington, New Zealand.

O'Byrne, T. N. 1968: Land Use Capability Survey of Akitio County and River Catchment. MWD, Palmerston North (Unpublished report). Scale 1:63 360.

APPENDIX 3: BIBLIOGRAPHIC REFERENCES TO SOIL SURVEYS (Refer Figure 4).

Gibbs, H. S. 1965: Soil Map of Whareama Catchment, Wairarapa, New Zealand. New Zealand Soil Bureau Map 4/1965.

DSIR 1939: Land Utilisation Report of the Heretaunga Plains. *DSIR Bulletin No. 70.*

DSIR 1966: Soil Map of Greytown District, North Island, New Zealand. Soil Bureau Map 5/1965. (This map was too detailed to use, but was referred to during field work and compilation).

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New Zealand Soil Bureau 1954: General Survey of the Soils of North Island, New Zealand. *New Zealand Soil Bureau Bulletin n.s. 5.* Sheets 7 and 8.

Pohlen, I. J.; Harris, C. S.; Gibbs, H. S.; Raeside, J. D. 1947: Soils and some related agricultural aspects of Mid Hawke's Bay. *DSIR Bulletin 94.*

Rijkse, W. C. 1974: Land Inventory Survey County series: Woodville County soils. Soil Bureau Map 95.

Rijkse, W. C. 1977: Soils of Pohangina County, North Island, New Zealand. *Soil Bureau Bulletin No. 42.*

In addition to these publicly available surveys, the following unpublished surveys were consulted and used. Where used, reference to these surveys are made on the side legend of the appropriate worksheet.

Gibbs, H. S. 1958: Provisional Soil Map of Awhea and Opouawe Catchments. Soil Bureau, DSIR.

Gibbs, H. S. 1959: Provisional Soil Map of Pahiatua County, Soil Bureau, DSIR.

Gibbs, H. S. 1959: Provisional Soil Map of Eketahuna County. Soil Bureau, DSIR.

Gibbs, H. S. 1959: Provisional Soil Map of Mauriceville County. Soil Bureau, DSIR.

O'Byrne, T. N. 1968: Land Use Capability Survey of Akitio County and River Catchment. MWD, Palmerston North (Unpublished report). (Note — this map was referred to but not referenced on the worksheets because it contains uncorrelated soils information).

In some areas where only the soil maps (sheets 7 and 8) accompanying 'General Survey of the Soils of North Island', (New Zealand Soil Bureau n.s. 5) were available, it was apparent that there was a need for some new soil sets to be mapped. As a result of consultation with staff of the Wairarapa Catchment Board and Mr D. J. Cowie, Soil Bureau, some ten new soil sets were recognised in the Wairarapa and Southern Hawke's Bay. These were also referenced where used, on the side legend of each worksheet concerned. Some of these names have been taken from existing soil surveys, e.g., Ngatahuna hill soils (29bH) from the Soil Map of Whareama Catchment.

These special soils are:

28cH	Whakaroro hill soil (clay loam)
28dH	Akitio hill soil (silt loam)
29bH	Ngatahuna hill soil
29g	Pongaroa clay loam
29gH	Pongaroa hill soil (clay loam)
35cH	Maungapakeha hill soil (silt loam)
113c	Tora silt loam
114e	Rakaunui steepland soil
114f	Taueru silt loam
114g	Motuwaireka steepland soil

APPENDIX 4: SLOPE GROUPINGS

SLOPE GROUPS	SLOPE IN DEGREES	RELIEF
A	0-3°	Flat to gently undulating
B	4-7°	Undulating
C	8-15°	Rolling
D	16-20°	Strongly rolling
E	21-25°	Moderately steep
F	26-35°	Steep
G	>35°	Very steep

APPENDIX 5: EROSION TYPES AND SEVERITIES

THE EROSION CLASSIFICATION USED IN THE NZLRI

Surface Erosion
- Sh —sheet
- W —wind
- Sc —scree

Recorded on areal basis

Mass Movement Erosion
- sSl —soil slip
- eSl —earth slip
- Su —slump
- daF—debris avalanche
- eF —earthflow
- mF — mudflow

Fluvial Erosion
- R -rill
- G —gully
- T — tunnel gully
- S — streambank
- b —deposition
- D

Recorded on basis of seriousness (a combination of rate and depth of movement, frequency of erosion events, feasibility and cost of control, economic effect)

EROSION SEVERITY RANKING USED IN THE NZLRI

EROSION RANKING	SURFACE EROSION (Estimated percentage of bare ground)	MASS MOVEMENT AND FLUVIAL EROSION (Seriousness)
0	< 1	none
1	1-10	slight
2	11-20	moderate
3	21-40	severe
4	41-60	very severe
5	>60	extreme

APPENDIX 6: AREAS OF LAND USE CAPABILITY UNITS MAPPED IN THE REGION

UNIT	UNIT TOTAL (ha)	SUBCLASS TOTAL (ha)	CLASS TOTAL (ha)	PERCENT OF REGION
Iw1	5 740	5 740		
Id	12 260	12 260	18 000	1.3
Ilw1	37 810	37 810		
lis 1	32 110	32 110		
lie 1	4 890	4 890	74 810	5.2
Ille1	18 960			
Ille2	17 320			
Ille3	10 120	46 400		
lllwl	44 750			
Illw2	15 910	60 660		
Ills 1	33 060			
Ills2	55 890			
Ills3	17 470			
Ills4	3 690	110 110	217 170	15.3
IVe1	23 750			
IVe2	18 870			
IVe3	20 760			
IVe4	5 410			
IVe5	3 910	72 700		
IVw1	8 310	8 310		
IVs1	20 820	20 820	101 830	7.1
Vs1	2 600	2 600		
Vc1	27 040	27 040	29 640	2.1
Vle1	25 200			
Vle2	45 950			
			620 480 43.6	

APPENDIX *6 — continued*

UNIT	UNIT TOTAL (ha)	SUBCLASS TOTAL (ha)	CLASS TOTAL (ha)	PERCENT OF REGION
VIIeI	32 800			
VIIe2	34 490			
VIIe3	4 660			
VIIe4	27 910			
VIIe5	13 820			
VIIe6	31 800			
VIIe7	27 000			
VIIe8	17 290			
VIIe9	8 200			
VIIeIO	37 320			
VIIeI 1	28 540			
VIIe12	5 300			
VIIe13	5 330			
VIIe14	1 290	275 750		
VIIsI	6 230			
VIIs2	3 640	9 870	285 620	20.1
VIIIeI	7 500			
VIIIe2	1 410			
VIIIe3	1 550			
VIIIe4	440			
VIIIe5	20 830			
VIIIe6	10 790			
VIIIe7	6 290			
VIIIe8	780			
VIIIe9	1 290	50 880		
VIIIeI	70	70	50 950	3.6
Area mapped	1 398 500			
Areas not mapped (rivers, lakes, urban areas, etc.).	24 120			1.7
TOTAL	1 422 620			100

APPENDIX 7: CORRELATION OF LUC UNITS MAPPED IN THE REGION, WITH LUC UNITS OF THE ADJACENT NORTHERN HAWKE'S BAY, WELLINGTON AND TARANAKI-MANAWATU REGIONS

(Refer Page, M. J. 1985: Correlation of North Island Regional Land Use Capability Units from the New Zealand Land Resource Inventory. Water and Soil Miscellaneous Publication No. 75.)

REGION 8 SOUTHERN HAWKE'S BAY-WAIRARAPA	REGION 7 NORTHERN HAWKE'S BAY	REGION 9 WELLINGTON	REGION 10 TARANAKI-MANAWATU
Iw1 (North of Waipukurau)			
Iw1 (South of Waipukurau)			
Id (North of Waipukurau)	Id		
Id (South of Waipukurau)			
Ilwl (North of Waipukurau)			
Ilwl (South of Waipukurau)			
lis 1			
lid			
Illel			
Ille2	Illel		
Ille3			
Illwl (North of Waipukurau)	part Illwl		
Illwl (South of Waipukurau)		Illwl	Illw2
Illw2 (North of Waipukurau)	part Illwl		
Illw2 (South of Waipukurau)			Illwl
Illw2 (sand plains)			Illw4
Illsl	Illsl	Illw2	Ills2
Ills2	Ills2		
Ills3		Ills2	
Ills4			
IVe1			IVe3
IVe2	IVe1	part IVe1	
IVe£			
IVe4			
IVe5			
IVw1	IVw1		IVw2
IVsl			IVs2
Vs1			
Vc1	Vc1	IVsl	
Vle1			
Vle2			
Vle3		part Vle1	
Vle4			
Vle5	Vle5		
Vle6			
Vle7	part Vle3		Vle3
Vle8	part Vle3		Vle4
Vle9 (> 1200 mm rainfall)			Vie 12
Vle9 (< 1200 mm rainfall)			Vie 14
Vie 10 (Bentonitic < 1200 mm rainfall)			
Vie 10 (Bentonitic > 1200 mm rainfall)	part Vie 10	Vle4	
Vie 10 (Non bentonitic < 1200 mm rainfall)			Vie 19
Vie 10 (Non bentonitic > 1200 mm rainfall)	part Vie 10		Vle20
Vie 11			Vie 16
Vie 12			
Vie 13			
		Vle9	

APPENDIX *7-continued*

REGION 8 SOUTHERN HAWKE'S BAY-WAIRARAPA	REGION 7 NORTHERN HAWKE'S BAY	REGION 9 WELLINGTON	REGION 10 TARANAKI-MANAWATU
Vle14	Vie 13	Vle6	Vlle7, Vlle9
Vlw1	Vlw1		
Vls1			Vlle4
Vls2			
Vls3			
Vls4 (Inland)			
Vls4 (Coastal)	Vls3, Vls1	Vls1, Vls4	Vlle3
Vls5			
Vlc1			Vlle5
Vlc2			
Vllel (> 1200 mm rainfall)			
Vllel (< 1200 mm rainfall)	part Vllel		Vile 12
Vlle2 (> 1200 mm rainfall)	part Vllel		VlleU
Vlle2 (< 1200 mm rainfall)	Vlle2		
Vlle3			
Vlle4 (> 1200 mm rainfall)			VllelO
			Vlle22
Vlle4 (< 1200 mm rainfall)			
Vlle5			
Vlle6			Vile 15
Vlle7			
Vlle8 (Non bentonitic < 1200 mm rainfall)			
Vlle8 (Non bentonitic > 1200 mm rainfall)			part Vllle3
Vlle8 (Bentonitic)	Vlle6		part Vllle3
Vlle9			Vllel
VllelO (Debris avalanche)			Vlle4
VllelO (Wind and sheet)			Vllle7
Vllel 1		Vlle2, part Vle5	VilleB
Vlle12			Vllle8
Vlle13	Vile 18		Vllle9
VlleU			Vlld
Vllsl (Inland)			
Vllsl (Coastal)	Vile 15	Vle4	
Vls2	Vlle13		
Vllllel	Vllsl	Vllsl	
Vllle2			
Vllle3		Vllle2	
Vllle4	Vllle2		
Vllle5	Vllle3	Vllllel	
Vllle6		Vllle3, part Vle5	
Vllle7	Vllllel	Vllle4	
Vllle8	Vllle5		
Vllle9	Vllle6	Vllle5	
Vlld	Vllle8	Vle24	
	Vllle9		
	VllllelO		
		Vls7, part lllwl	
		Vllel	
		Vlle2	

APPENDIX 8: STOCK CARRYING CAPACITY DATA

LUC UNIT	PRESENT AVERAGE (su/ha) POTENTIAL	TOP FARMER ATTAINABLE (su/ha) PHYSICAL	(su/ha)
Iw1	13	20	30
Id	15	20	32
IIw1	12	20	28
IIs1	12	18	27
Iid	13	19	27
Hid	14	19	27
IIIe2	13	16	23
IIIe3	11	13	25
IIIwl	12	14	26
IIIw2	13	16	25
iIIs 1	14	16	23
IIIs2	12	17	25
IIIs3	14	15	25
IIIs4	7	14	19
IVe1	12	17	25
IVe2	11	14	20
IVe3	10	15	22
IVe4	10	13	25
IVe5	9	12	19
IVw1	9	14	16
IVs1	5	10	15
Vs1	11	14	22
Vd	11	15	20
Vle1	11	15	20
Vle2	10	15	22
Vle3	11	15	20
Vle4	10	12	15
Vle5	10	12	17
Vle6	12	15	22
Vle7	9	12	19
Vle8	10	15	18
Vle9	7	14	17
Vie 10	11	16	18
Vie 11	7	14	14
Vie 12	10	14	18
Vie 13	10	15	16
Vie 14	3	3	11
Vlw1	5	15	15
Vls1	12	16	21
Vls2	7	12	15

Vls3	7	10	12
Vls4	4	5	15
Vls5	5	6	11
Vld	9	10	14
Vlc2	6	9	11
Vllel	10	11	16
Vlle2	7	12	15
Vlle3	7	10	15
Vlle4	7	12	15
Vlle5	5	7	10
Vlle6	9	11	13
Vlle7	9	9	11
Vlle8	9	9	10
Vlle9	7	7	12
VllelO	4	7	9
Vllel 1	5	7	10
Vlle12	5	5	10
Vlle13	6	6	6
VlleU	3	3	3
Vllsl	1	1	5
Vlls2	4	6	6

APPENDIX 9: SITE INDEX DATA FOR *PINUS RADIATA*

LUC UNIT	SITE INDEX (m)	SITE INDEX*	RANKING COMMENTS
Iw1	29-33	Lower figures obtained in Wairarapa due to effects of wind	
Id	29-33		
Ilwl	28-33		
	M-H	Lower figures obtained in Wairarapa due to effects of wind	
	M-H		
	M-H		
Ms 1	Vls5	27-30	27- 30
Iid	Vld	27-29	25- 28
Illel	Vlc2	26-30	26- 29
Ille2		26- 32	25-27
Ille3		27- 32	25- 28
Illwl		28- 30	Unsuitable
Illw2		26- 28	28- 30
Illsl		26- 30	26- 27
Ills2		26- 30	25- 28
Ills3		26- 29	26- 28
Ills4		26- 27	26-28
IVe1		27- 30	25-27
IVe2		27- 30	24-28
IVe3		28- 30	
IVe4		26-28	
IVe5		26- 28	
IVw1		Unsuitable	
IVsl		27- 29	
Vs1		28- 29	
Vd		26-29	
Vle1		26- 29	
Vle2		27- 30	
Vle3		27-30	
Vle4		26-28	
Vle5		26- 29	
Vle6		27- 29	
Vle7		26-29	
Vle8		26-29	
Vle9		26- 28	
Vle10			
Vie 11			
Vie 12			
Vie 13			
Vie 14			
Vlw1			
Vls1			
Vls2			
Vls3			
Vls4			

M-H
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M
M
M
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M

M-H
M
M
M
M
M
L-M Some areas unsuitable

"Refer Table 6 for site index rankings and symbols.

APPENDIX 143: SITE INDEX DATA FOR *PINUS RADIATA-continued*

LUC UNIT	SITE INDEX (m)	SITE INDEX*	RANKING COMMENTS
VIIeI	25-30	M-H	Some areas unsuitable
VIIe2	25-29	M	Some areas unsuitable
VIIe3	25-28	M	Large areas unsuitable. Harvesting may be a problem on some sites.
VIIe4	25-28	M	Some areas unsuitable
VIIe5	23-26	L-M	Some areas unsuitable
VIIe6	26-28	M	Earthflow movement could cause butt malformation
VIIe7	25-26	M	Some areas unsuitable
VIIe8	25-29	M	Earthflow movement could cause butt malformation.

•Refer Table 6 for site index rankings and symbols.

V. R. WARD, GOVERNMENT PRINTER, WELLINGTON, NEW ZEALAND— 1985

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