HUNTER
REPORT

**Land Capability Survey
of Tasmania**

R M MORETON
Department of Primary Industries, Water and Environment
Prospect Offices
2001

Hunter Report
and accompanying 1:100 000 scale map

DEPARTMENT *of* PRIMARY INDUSTRIES, WATER *and* ENVIRONMENT
Tasmania

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Accompanies 1:100 000 scale map titled 'Land Capability Survey of Tasmania. Hunter' by R. M. Moreton, Department of Primary Industries, Water and Environment, Tasmania, Australia, 2001.

Contents

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SUMMARY

This report and map describes and classifies the privately owned and leased Crown land resources occurring within the limits of the 1:100 000 scale Hunter map (Sheet No. 7916). This region is referred to throughout this report as the Hunter area. It is located in far north west Tasmania and includes the small agricultural centres of Marrawah, Montagu, Redpa, Togari and Brittons Swamp. This area is well known for its dairy and sea fisheries industries, as well as a range of nature conservation and heritage values.

With a total area of 107 154 ha the survey area is dominated in the north western parts by a large, gently undulating coastal plain that stretches to over 20km inland in some places. High basalt escarpments occur on the western coastline at Cape Grim and Marawah, while older sediments form hill ranges in the east and south of the area. 32% of this area is represented by exclusion areas and has not been mapped.

This wide variety of landscapes and rock types has resulted in a wide range of soils. The better agricultural areas are confined to the Tertiary and Cambrian volcanic materials where structurally robust red and brown Ferrosol soils have formed. Other areas of agricultural significance include the alluvial basins at Brittons Swamp, Togari and parts of the vast sandy coastal plain that have been cleared of native heath vegetation predominantly for intensive grazing of dairy cattle. The poorest areas occur on wetter sites with extremely poor drainage, on sediments of Precambrian age or where erosion risk or depth of soil severely restricts agricultural use.

Land use in the area is dominated by grazing enterprises, dairy farming being the dominant activity. Beef cattle and sheep production as well as plantation forests are other large components of primary production in the region.

Despite receiving moderate to high average annual rainfall (900-1400mm/annum) most of the rain occurs in winter and therefore necessitates the use of irrigation of both crops and dairy pastures during the drier summer period to achieve optimum yields. Farmers have reported that the lack of suitable dam sites to store irrigation water is a major restriction in this area. Only relatively small quantities are therefore currently stored for irrigation of crops. A combination of bore water and small on farm dams constitute the supply for livestock and dairies. The regularity of rainfall throughout the area during spring and early autumn results in soils becoming too wet for land managers to prepare their paddocks or harvest crops. This often leads to frustrating waits, late planting and late harvests.

The land has been classified according to the land capability classification system for Tasmania as described by Noble 1992a and Grose (in prep) and boundaries have been determined by a combination of field investigation, aerial photo interpretation and computer modelling.

Land capability is based on the ability of the land to sustainably produce agricultural goods without impairing the long-term, productive potential of the land. The system categorises land into seven capability classes with increasing degree of limitation for agricultural production or decreasing agricultural versatility as the system progresses from Class 1 to Class 7. Classes 1 to 4 are considered suitable for all agricultural activities especially cropping activities, Classes 5 and 6 suitable for pastoral activities only and Class 7 is considered unsuitable for agricultural use.

Complex units have been mapped where two land classes have been identified but cannot be usefully separated at the scale of mapping. Within each complex the first land class identified is dominant and occupies 50-60% of the unit, while the second class occupies 40-50%.

Within the Hunter area the best agricultural areas (Class 2 and 3 land) occur where deep soils have formed from volcanic rocks of Tertiary and Cambrian age and erosion risk is low (slopes less than 18%). Despite the good quality of this land the dominant landuse still remains pasture production for dairy and beef cattle. Most of this high quality land is found in the Marrawah and Redpa area, and small areas in the north, near Montagu. It represents the most versatile and most intensively used agricultural land within the Hunter area and represents 3.8% of the area mapped.

Where poorer drained land, shallow soils and topographic constraints occur, the land is used predominantly for grazing purposes with only occasional opportunistic cash crops grown. Most of this land is identified as Class 4 and requires much higher levels of management to prevent degradation. The major limitation for most of this land is restricted soil drainage and high groundwater tables that result in short windows for working the land, even within areas that have been intensively drained.

The largest land capability class identified is Class 5, making up just over 50% of the study area (including land within Complex map units). This land is mostly found on the poorer drained sandy alluvial plains that are very wet for most of the year (too wet for cropping activities apart from fodder crops). Drainage of this land is essential to produce the highest quality dairy pasture and to reduce the impact of grazing saturated soil. Hump and hollow is currently a popular technique on this land type but other forms of drainage have been successfully implemented. Poorly drained Class 5 land is also found at Togari and Redpa where the soils formed from Cambrian mudstone are shallow or are very clayey. Class 5 areas also include the steep and rocky slopes of the coastal escarpments found in the western part of the survey area. More Class 5 land is found in combination with Classes 4 and 6 and mapped as a complex.

A significant proportion of the Hunter area is comprised of Class 6 land. This land is predominantly found on steeper coastal escarpments and plateaux, in drainage depressions on the low coastal plains, areas with shallow soils overlying rock or areas surrounding the mobile dune systems on the west coast. Shallow soils, poor drainage, rock outcrop and erosion risk imposes physical limitations on this land restricting its agricultural use to rough or seasonal grazing with low stocking rates.

Land unable to sustain agricultural use (Class 7) is found mainly on the highly erodible frontal dunes and coastal swamps and mudflats where highly fragile landforms occur. Other small areas are found on extremely rocky terrain with shallow soils such as at White Rock Ridge (Robbins Island) or on the cliffs and headlands at Mt Cameron West. Agricultural use of these areas can lead to unsustainable levels of degradation and, in the case of the sand-blow and dunes areas, the reactivation of currently stabilised dunes. Other areas of Class 7 occur in combination with Class 6 land on hill slopes with extremely high erosion risk and shallow soils (south of Marrawah) or surrounding the dunes and headlands near Green Point, Three Mile Sand and Back Banks on Robbins Island.

The major limitations to agriculture in the Hunter area are:

- **Soil drainage** - poorly drained soils, high groundwater levels
- **Erosion risk –** wind, rill and sheet
- **Topographic complexity** - irregular and fragmented microrelief

Other minor but locally significant limitations include:

- **Poor soil condition** - stoniness, poor soil structure, shallow topsoil depth.
- **Climate –** In areas with good volcanic soil the frequency of rainfall in spring and autumn, during sowing and harvest, restricts the window of suitability for working and trafficking, the range of crops that can be grown and the frequency of crop rotations. Exposure to strong winds, high relative humidity, salty seas spray and high evaporation rates also combine to restrict the range of crops that can be grown on land close to the coast. In some inland locations damage by severe frost is also a consideration to land managers.

Table 1 shows the amount of each land capability class and each complex identified within the Hunter area together with its proportion of the total map area.

Land Capability Class	Area (ha)	% of Hunter Map
1	0	0
2	181	0.17
2+3	584	0.55
3	1 367	1.28
3+2	1 924	1.80
3+4	76	0.07
4	2 517	2.35
4+5	5 067	4.73
5	48 438	45.20
5+4	5 060	4.74
5+6	345	0.32
6	4 146	3.87
6+5	699	0.65
6+7	971	0.91
7	1 802	1.68
E	33 977	31.71
TOTAL	107 154	100.00

Table 1. Extent of land classes and land class complexes on Hunter map.

1. INTRODUCTION

1.1 Background

This report continues a series of land capability reports published by the Department of Primary Industries, Water and Environment as part of a 1:100 000 scale land capability survey of Tasmania's agricultural land which began in 1989. The report and accompanying map describes the land capability classes found within the agricultural land of the Hunter area (Figure 1). It evaluates the land capability of private freehold and leased Crown land only. Other areas are considered non-agricultural and are mapped as exclusion areas.

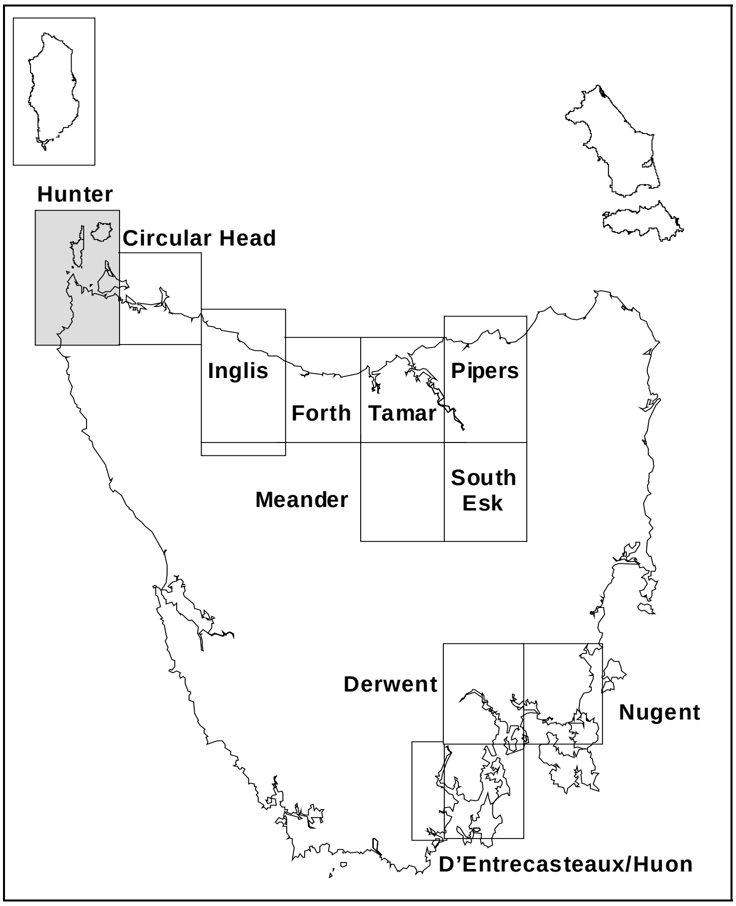


Figure 1. Circular Head survey location and previous land capability surveys in Tasmania.

The land capability project aims to: a) identify and map the extent of different classes of agricultural land in order to provide an effective base for land use planning decisions; and b) ensure that the long-term productivity of the land is maintained at a sustainable level, through the promotion of compatible land uses and management practices. It undertakes to achieve these aims through a program of mapping activities and associated extension and awareness programs such as the Farmwi$e program. It also supports the State Policy on the Protection of Agricultural Land (2000) by identifying areas of Prime Agricultural Land (Classes 1, 2 and 3).

The land capability classification system for Tasmania comprises a seven class classification and is based on the capability of the land to support a range of agricultural uses on a long-term sustainable basis.

The evaluation system takes into account only the land's capability to support sustained agricultural production and does not consider suitability for individual crops, forestry, orchards, vineyards or other non-agricultural uses.

Much of Tasmania's agricultural land has limitations that restrict its agricultural versatility. The land capability classification system recognises these limitations and uses the physical characteristics of the land and the local climatic characteristics to evaluate the area and classify it accordingly.

The information printed here and in the accompanying map is intended for use at a regional planning level and has limited use at the farm scale. The system can however, be applied at any level (see Section 3).

Surveys undertaken to date indicate that the agricultural areas of Tasmania only have a small percentage of high quality, 'Prime' agricultural land (Class 3 or better) in proportion to the total area (Table 2). It also shows that the southern region of the State has much less Prime agricultural land compared to the north.

1:100 000 scale Land Capability Map	**Class 1** (ha)	**Class 2** (ha)	**Class 3** (ha)	**Total Prime Land on map** (ha)	**Agricultural Land on map** (ha)	**% of Agric. land mapped as Prime at 1:100000 scale.**
Pipers	0	898	3459	4357	150930	2.89
Tamar	42	629	8958	9629	135626	7.10
Meander	0	127	12859	12986	106698	12.17
South Esk	0	0	8661	8661	216487	4.00
Forth	880	7149	16861	24890	113173	21.99
Inglis	748	3868	17533	22149	188051	11.78
Circular Head	1336	5023	5756	12115	56196	21.56
Hunter	0	1301	2801	4102	73177	5.56
Derwent	0	0	144	144	173564	0.08
D'entrecasteaux/Huon	0	0	98	98	102711	0.10
Nugent	0	0	336	336	122079	0.28
Total (to date)	**3006**	**18995**	**77466**	**99467**	**1438692**	**6.91**

Table 2. Prime agricultural land statistics for land capability maps produced to date. (based on current GIS measurements)

With ever increasing demands placed on our agricultural land to produce greater yields per unit area and the continuing uptake of good agricultural land for urban development and subdivision, the incidence of degradation and the loss of Tasmania's prime agricultural resource has been escalating. The acknowledgment of this has come in the form of legislation (State Policy on the Protection of Agricultural Land, 2000) which sets out to protect prime land in order to prevent its loss to non-agricultural uses.

By determining the location and extent of Tasmania's better quality agricultural land we are better able to protect it from loss to non-agricultural use or degradation through inappropriate land management practices.

2. HOW TO USE THIS MAP AND REPORT

This publication comprises a report and map. It is important that the land capability map be used in conjunction with the accompanying report. By referring to the map, and locating the area of interest, the land capability class assigned to that area can be determined. This is indicated on the map by a class number (1 to 7) and an associated colour shade. Definitions of the land capability classes are given on the side legend of the map and in Section 3 of the report. Further details about each of the land capability classes occurring within the Hunter area are given in Section 6.

2.1 Limitations of Scale

Special attention needs to be paid to the limitations imposed by the scale of mapping. It is important that the map is used at the scale at which it is published (1:100 000). **The map should not be reproduced at a larger scale (eg 1:25 000)**. The land capability boundaries found on this map are accurate only at the published scale of 1:100 000. Errors in interpretation will occur if the map is enlarged. If more detail is required, the area of interest should be remapped at a more suitable scale for the end use, rather than enlarging this map.

Gunn *et al* (1988) indicate that, at a scale of 1:100 000, the standard minimum area for a map unit which can be adequately depicted on the map is approximately 64ha. Landon (1991) suggests a wide range of "minimum areas" are currently in use. For the purposes of this work however, unit areas of less than 25ha have been mapped only where they are identifiable on the basis of clearly visible boundaries (usually topographic) or where they link with larger areas on adjacent map sheets or within exclusion areas. Impurities in map units will occur where land class changes are a result of less obvious changes in land characteristics or qualities.

In any mapping exercise there are always areas which are physically too small to delineate accurately at a given map scale and in such cases these areas are absorbed into surrounding units. The map units shown on this map will therefore often contain more than the one land capability class or subclass. The map units are assigned the dominant land capability class within them but it should be recognised that some map units may contain up to 40% of another class.

Complex map units (eg 4+5) have been identified in a number of areas where, due to the complexity of the soils and topography, two land classes have been identified. Each occupies between 40% and 60% of the total unit area, but cannot be adequately distinguished at the scale of mapping. Such areas are shown as striped units on the map. The first digit of a complex map unit label represents the dominant land capability class and is represented by the slightly wider of the two coloured stripes on the map. Further discussion of complexes and the method of labelling these map units are found in Sections 3 and 4.

The accuracy of the land capability class boundaries depends on a number of factors including the complexity of the terrain, soils and geology. Where topography or other visible features change abruptly, the class boundaries may be well defined. Alternatively, changes may be gradual and more difficult to assess such as with a change in soil depth, some soil types, slope, or extent of rockiness. In these cases the boundary is transitional and therefore can be less precisely plotted on the map.

The majority of the exclusion boundaries for this survey have been supplied in digital format by Forestry Tasmania and are deemed to be accurate to 2000. Some areas less than 25ha have been removed to improve legibility of the map and absorbed into the adjacent land capability units.

2.2 Interpretation of the Land Capability Information

The scope and range of applications of the land capability information depends on the scale at which the surveys are carried out. This map has been produced at 1:100 000 scale and is targeted for use at the district or regional planning level.

Larger scale maps such as those at 1:5 000 or 1:10 000 are more suitable for whole farm planning purposes, to plan farm layouts and identify appropriate land uses, soil conservation and land management practices. A scale of 1:25 000 is more appropriate for catchment planning, although this is a guide only for the scale used will often be determined by the size of the catchment to be surveyed and the amount of time that is allocated for mapping it.

The information within both the report and map is targeted mainly at planning consultants and officers of local government, regional and State land use planning authorities. The information at this scale is **not** intended to be used to make planning decisions at farm level, although the information collected does provide a useful base or benchmark for more detailed studies. The 100 000 scale survey methodology does however apply to all scales of mapping and can be utilised equally well by local landowners, local, regional or State planning authorities.

Examples of other potential uses of land capability information at 1:100 000 scale are:

- Identifying broad areas of prime agricultural land (Classes 1 to 3) for retention for agricultural use.
- Rational planning of urban and rural subdivisions.
- Identifying areas for new crops, enterprises or major developments.
- Identifying areas for expansion of particular land uses.
- Planning of new routes for highways, railways, transmission lines, etc.
- Identifying areas of land degradation, flooding or areas that may require special conservation treatment.
- Identifying areas of potential erosion hazard.
- Resolving major land use conflicts.
- Integrated catchment management (depending on catchment size).

Combining land capability information, with other resource data using a GIS (Geographic Information System), can greatly enhance its use, accessibility and interpretation.

While intended for use by regional and State planning authorities, the information supplied by this map and report can still be used at the farm level to give a general indication of the land quality at a particular location. For example, a newcomer to an area wishing to purchase good quality land for cropping could look to the map to find where Class 1, 2 and 3 has been identified.

The land capability maps and reports do not purport to have legal standing as documents in their own right, nor should they attempt to stand alone in planning decisions without being supported by other relevant land resource, economic, social or conservation considerations. The information is intended as a guide to planning development and, where more detailed planning is required, for farm planning or route alignment for example, further fieldwork at a more appropriate scale needs to be undertaken.

Section 3 of this report provides more information about land capability classification and definitions for the individual land capability classes, while Section 4 discusses the survey methodology used. A general description of the survey area, including climate, geology, topography, soils, vegetation and land use appears in Section 5, while a detailed account of land capability classes found is presented in Section 6.

2.3 Copyright

The maps, reports and digital information stored on the DPIWE databases are copyright, and the data is solely owned by the Department of Primary Industries, Water and Environment, Tasmania. Every encouragement is given to individuals and organisations who wish to use the information contained in this report and accompanying map to assist with property management or regional planning activities. However, commercial organisations or individuals wishing to reproduce any of this information, by any means, for purposes other than private use, should first seek the permission of the Secretary, Department of Primary Industries, Water and Environment.

2.4 Availability of Land Capability Publications in this Series

An Index of the land capability maps (based on the TASMAP 1:100 000 Series) is shown on the rear cover of this report. The locations of maps available to date are indicated in Figure 2 and the prices (including GST) of the land capability publications are listed below.

Pipers, Tamar reports and maps	$16.50
Meander Report and Map	$22
Land Capability Maps and Reports (Colour maps and photos) **South Esk, Forth, Inglis, Derwent, Circular Head, Hunter, Nugent and D'Entrecasteaux/Huon**	$33
Land capability Handbook	$11
Land Capability Classification in Tasmania, Information Leaflet	No Charge

All listed items may be viewed and ordered at DPIWE reception desks or telephone 1300 368 550 State wide or Service Tasmania on 1300 366 173. DPIWE land resource assessment staff welcome constructive comment and criticism of all reports and accompanying maps and, in the event that significant errors in classification are identified (at a scale appropriate to the level of mapping), they can be reported to DPIWE staff and documented appropriately.

3. LAND CAPABILITY CLASSIFICATION

Land capability classification is an internationally recognised means of land evaluation used to determine the capability of land to support a range of land uses on a long-term, sustainable basis.

For the Tasmanian classification system, agricultural land uses only are considered, and are defined as broad scale grazing and cropping uses. Land capability ratings for specific land uses are not evaluated, nor is the capability of land for forestry use incorporated into the classification system.

Land capability may be defined as a rating of the ability of land to sustain a range of land uses without degradation of the land resource. It is an interpretive and somewhat subjective assessment based on the physical limitations and hazards of the land, potential cropping and pastoral productivity, and the versatility of the land to produce a range of agricultural goods (Figure 2).

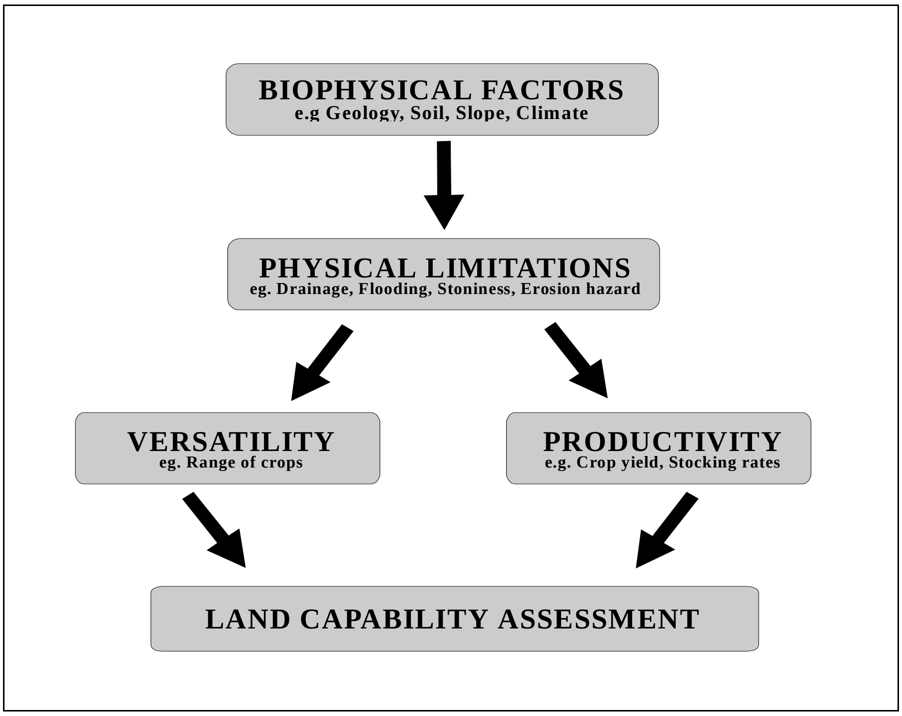


Figure 2. Factors in land capability assessment.

Land capability assessment takes into account the physical nature of the land (eg geology, soils, slope) plus other factors (eg climate, erosion hazard, land management practices) which determine how that land can be used without destroying its long-term potential for sustainable agricultural production. It also takes into account limitations that might affect agricultural use, eg stoniness, drainage, salinity or flooding. Land capability assessment is therefore based on the permanent biophysical features of the land (including climate), and does not take into account the economics of agricultural production, distance from markets, or social or political factors.

Land capability assessment should not be confused with land suitability assessment which, in addition to the biophysical features, may take into account economic, social and/or political factors in evaluating the 'best' use of a particular type of land. Land capability classification gives a grading of land for broad scale agricultural uses, whereas land suitability is applied to more specific, clearly defined land uses, such as land 'suitable' for growing carrots, and usually defines specific management systems. The basic principle of land capability brings together both land conservation and protection of land as well as its potential for broad scale agricultural production, in other words, the balance between use of the land and the risk of degradation of the land resource.

3.1 Features of the Tasmanian Land Capability Classification System

The Tasmanian system of land capability classifies land into seven classes according to the land's capability to produce agricultural goods. The system is modelled on the USDA (United States Department of Agriculture) approach to land capability (Klingbiel and Montgomery, 1961) and is described in full by Noble (1992) and Grose (in prep). A summary of the system is presented here to assist with the interpretation of the report and accompanying map. The classification does not attempt to portray specific land uses, or rank the value of any particular agricultural land use above another. Neither does it attempt to give an indication of land values.

The Tasmanian land capability classification system is based on agricultural production (cropping and pastoral productivity). It is based on cultivation of the land for cropping purposes and not other land use systems which can sustain 'crops' on steeper land with longer rotations and less risk of erosion (eg perennial horticulture, silviculture).

The classification relates primarily to the three permanent biophysical features of the landscape - soil, slope and climate. These three factors have a major influence in determining the capability of the land to produce agricultural goods. Other factors which must be taken into account include rock type, erosion hazard, range of crops that can be grown, management practices, soil conservation treatment, risk of flooding and past land use history.

A valid criticism of the land capability classification process is that it is a very subjective system. In order to improve this aspect of the system a revised set of guidelines has been produced by Grose. This handbook is designed for DPIWE field officers and sets out more quantitative guidelines for assessing some land attributes. While the guidelines will improve the consistency between different surveyors, a certain amount of subjectivity still remains in the determination of cut-offs for each land class.

Considerations of the system

The system assesses the versatility of the land to produce a range of agricultural goods that are considered typical for Tasmania, and not just those that are specific or suited to localised areas. For example, small scale intensive activities like soft fruit orchards and floriculture are not considered when evaluating the versatility of an area. Opportunities for silviculture are another activity that the system does not consider. The main agricultural land uses that are considered when evaluating land include cereals, poppies, broad acre vegetable production (potatoes, peas, beans, onions etc), pyrethrum and essential oils, dairy, beef, lamb and wool production.

The system considers degradation of the soil resource and does not take into account the possible effects of agricultural land use on water quality, aesthetics, wildlife, etc except where it might impact on the quality of the agricultural resource.

The classification, in particular at the unit level, takes into account the management strategies and soil conservation requirements the land may need in order to maintain a level of production without long-term degradation.

For 1:100 000 scale surveys the issue of irrigation and its impact on land capability classification has created much discussion. While it is recognised that some areas of the State have the potential to attain an improved land capability ranking through the application of irrigation water, the extent of beneficial effects from irrigation on land capability will vary considerably depending upon such factors as water quality, economics and the skill of the property manager. These factors all require assessment on an individual property basis, a procedure inappropriate at this level of mapping. As well, it is beyond the scope of this survey to identify areas where irrigation water might be available. Land capability is therefore assessed on the ability of the land to support rain fed agriculture except where irrigated agriculture is considered normal practice and water is readily available from on farm water storage.

Assumptions

As with most land classification systems certain assumptions are necessary. These include:

(a) A moderately high level of management is being applied to the land.

(b) Appropriate soil and land conservation measures have been applied.

(c) Where it is reasonable and feasible for an individual farmer to remove or modify physical limitations (eg surface and subsurface drainage, stoniness, low fertility) the land is assessed assuming the improvements have been made.

(d) Assessments are based on the capability of the land for sustained agricultural productivity, since use of the land beyond its capability can lead to land degradation and permanent damage.

(e) For the purpose of this work "*agriculture*" does not include forestry operations.

Main features of the system

- The land capability classification is an interpretive classification based on the permanent biophysical characteristics of the land.

- Land capability assessments of an area can be changed by major schemes that permanently change the nature and extent of the limitations (eg drainage or flood control schemes).

- The land capability classification is not a productivity rating for specific crops, although the ratio of inputs to outputs may help to determine the land capability class.

- Land capability does not take into account economic, social or political factors and is not influenced by such factors as location, distance from markets, land ownership, or skill of individual farmers.

- Present and past uses of the land (or similar land elsewhere) are guides to potential, in that they can indicate the limits of the capability of the land. Present land use and vegetation cover are not always good indicators of land capability class. The system of land capability is aimed at assessing the potential sustainable productivity of land rather than current productivity.

- The feasibility of irrigated landuse is not considered when evaluating land capability. However, in areas where irrigation is standard agricultural practice the capability of the land is assessed assuming irrigation is used.

- The system is consistent across the State.

It is important to remember that the land capability of an area can change as a result of improved farming practices, changes in crop variety, technical innovations or just a better understanding of the relationships between soils, farming and the natural environment. The information in this report has a limited lifespan and care should be given to its interpretation in future years. Farming practices that today are only available for the advanced or innovative farmer may become common practice in the future.

3.2 The Classification Hierarchy

Three levels are defined within the Tasmanian land capability classification:

- ***Class*** - which gives an indication of the general degree of limitation to use;
- ***Subclass*** - which identifies the dominant kind of limitation, and
- ***Unit*** - which differentiates between land with similar management and conservation requirements, productivity characteristics, etc.

The levels are also shown in Figure 3.

The land capability system can be used and applied at various scales by mapping to the class, subclass and unit levels. The level at which the mapping is undertaken and presented depends on the purpose and scale of the survey.

Class

The classification system comprises seven classes ranked in order of increasing degree of limitation, and in decreasing order of versatility, for agricultural use. The system is hierarchical. Class 1 land is identified as the best land and can produce a wider variety of crops and pastures at higher levels of production with lower costs, or with less risk of damage to the land, than any of the other classes of land. Class 2 land is similarly superior to Classes 3 to 7, and so on.

A range of land may occur in any one, land capability class. Thus it is often possible, for example, to identify good and poor quality Class 4 land in a Class 4 area on the map. While the intensity of 1:100 000 scale mapping cannot differentiate between these areas the land capability methodology does allow this when mapping at a more detailed level by the use of a unit level (see Figure 3).

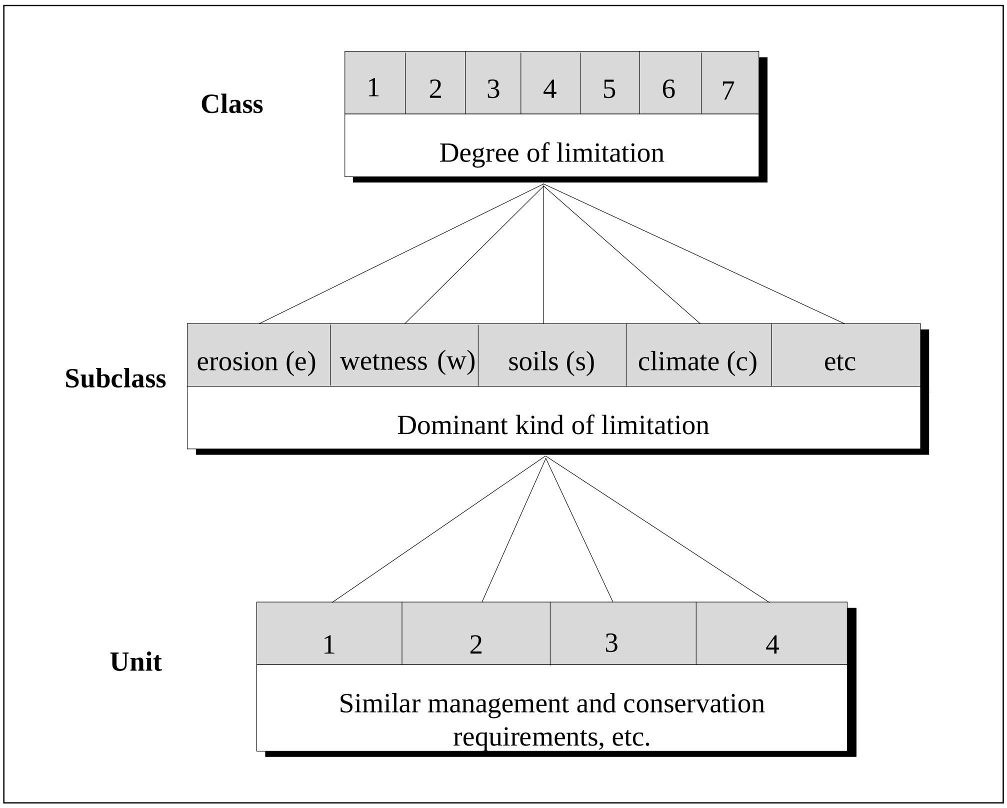


Figure 3. Levels of the land capability classification system.
(Adapted from: National Water and Soil Conservation Organisation, 1979, Our Land Resources. (NWASCO), Wellington, New Zealand.)

Classes 1-4 only are considered capable of supporting cropping activities on a sustainable basis; Classes 5 and 6 are more suited to grazing activities only although occasional fodder cropping and pasture improvement may be possible on Class 5 land, while grazing of unimproved pastures or other resident vegetation only is appropriate for Class 6 land. Class 7 land is unable to support any form of sustainable agricultural activity.

Definitions

CLASS 1

Land well suited to a wide range of intensive cropping and grazing activities. It occurs on flat land with deep, well drained soils, and in a climate that favours a wide variety of crops. While there are virtually no limitations to agricultural usage, reasonable management inputs need to be maintained to prevent degradation of the resource. Such inputs might include very minor soil conservation treatments, fertiliser inputs or occasional pasture phases.

Class 1 land is highly productive and capable of being cropped eight to nine years out of ten in a rotation with pasture or equivalent without risk of damage to the soil resource or loss of production.

CLASS 2

Land suitable for a wide range of intensive cropping and grazing activities. Limitations to use are slight and can be readily overcome by management and minor conservation practices. However the level of management is greater, and the variety and/or number of crops that can be grown is marginally more restricted than for Class 1 land. This land is highly productive but there is an increased risk of damage to the soil resource or of yield loss. The land can be cropped five to eight years out of ten in a rotation with pasture or equivalent during 'normal' years, if reasonable management inputs are maintained.

CLASS 3

Land suitable for cropping and intensive grazing. Moderate levels of limitation restrict the choice of crops or reduce productivity in relation to Class 1 or Class 2 land. Soil conservation practices and sound management are needed to overcome the moderate limitations to cropping use.

Land is moderately productive, requiring a higher level of management than Classes 1 and 2. Limitations either restrict the range of crops that can be grown or the risk of damage to the soil resource is such that cropping should be confined to three to five years out of ten in a rotation with pasture.

CLASS 4

Land well suited to grazing but which is limited to occasional cropping or to a very restricted range of crops. The length of cropping phase and/or range of crops are constrained by severe limitations of erosion, wetness, soils or climate. Major conservation treatments and/or careful management are required to minimise degradation.

Cropping rotations should be restricted to one to two years out of ten in a rotation with pasture or equivalent to avoid damage to the soil resource. In some areas longer cropping phases may be possible but the versatility of the land is very limited.

CLASS 5

This land is unsuitable for cropping, although some areas on easier slopes may be cultivated for pasture establishment or renewal and occasional fodder crops may be grown. The land may have slight to moderate limitations for pastoral use. Applying appropriate soil conservation measures and land management practices may reduce the effects of these limitations on grazing potential.

CLASS 6

Land marginally suitable for grazing because of severe limitations. This land has low productivity, high risk of erosion, low natural fertility or other limitations that severely restrict agricultural use.

CLASS 7

Land with very severe to extreme limitations which make it unsuitable for agricultural use.

E - Exclusion Areas

Land with tenure other than private freehold or leased crown land according to 1998 Forestry Tasmania data. Exclusion areas include urban centres and other obvious non-agricultural areas such as National Parks, State Forests, Reserved land and large water bodies within the map area.

The length of cropping phase given for Classes 1-4 is intended as a general guide only. Past experience has shown that there is some confusion and concern regarding the figures given. While some land will just not support production beyond the intensity recommended (due to the risk of erosion or soil structure decline), other areas are limited by the risk of loss occasioned by such factors as adverse climatic conditions or

Notes on the Class Definitions

flooding.

For example, some parts of the survey area are subject to a significant flood risk. Due to rainfall patterns in recent years it has been possible to cultivate these areas more frequently than might 'normally' be achieved. By cultivating these areas farmers are accepting a high risk of failure or damage to crops from flooding, and whether or not a crop is planted in any particular year is dependent, in part, on just how much risk an individual farmer is prepared to accept. In other areas the soils are such that significant periods of cultivation without a break can lead to severe structure decline, hindering germination, water infiltration, and soil aeration and increasing the likelihood of erosion.

Also, the classification system takes into account the *variety* of crops that can be grown. Thus Class 4 land might incorporate areas where a relatively wide range of crops could be grown but the risk of damage to the resource is such that cropping should **only** be undertaken one or two years out of ten. Conversely, other areas may support a more limited range of crops but production may be sustainable over a longer period.

It should be noted that capability classes have not been defined on the basis of productivity. This is partly due to problems in comparing the relative value of different agricultural practices and partly due to the lack of data regarding just what is sustainable for each land class. As well, within any particular land class, there is likely to exist a range of land and, at a more detailed level of mapping, it may be possible to distinguish, for example, between good Class 4 land and poor Class 4 land.

Figure 4 summarises the main features of the land capability classes.

Subclass

Within each class it may be possible to identify a number of limitations that restrict agricultural use. Limitations may be defined as physical factors or constraints that affect the versatility of the land and determine its capability for long-term sustainable agricultural production. Where limitations are found a class may also be allocated a subclass code indicating the nature of the dominant limitation or hazard that exists. Subclass codes are a single letter that is added directly after the Class. For example an area identified as Class 4 that is limited by water erosion risk is coded 4h. A range of subclass codes exists. The four basic subclass codes are (c)-Climate, (s)-Soil, (e)-Erosion and (w)-Wetness. This list of four codes has in recent times been subdivided and added to by Grose (in prep), in an attempt to make each subclass code more informative (see Table 3).

In practice it may be possible to identify more than one limitation that restricts the use of an area of land. When mapping, every attempt should be made to record the dominant limitation although it may occasionally be necessary to record a maximum of

CLASS		LIMITATIONS	CHOICE OF CROPS	CONSERVATION PRACTICES
1	Under cultivation	Very minor	any	Very minor
2	Under cultivation	Slight	Slightly reduced	Minor
3	Under cultivation	Medium	Reduced	Major
4	Under cultivation	Severe	Restricted	Major + careful management
5	Under pastoral use	Slight to moderate	Grazing	Major + careful management
6	Under pastoral use	Severe	Grazing	Major + careful management
7	Under pastoral use	Very severe to extreme	No, or very minor agricultural value	Major + careful management

Figure 4. Features of land capability classes

two subclass codes. If more than two limitations are evident they should be grouped according to the broad limitation code under which they fall (e, w, s, or c).

Unit

Unit codes may be added to the *Class* and *Subclass* classification when conducting a detailed land capability study at the farm scale. Unit codes help to distinguish between similar areas that have different management or conservation requirements. They may also be used to separate areas that have slightly different productivity characteristics that may not be significant in a broader scale study. For example, an area identified as 5h may be further divided into land requiring conservation practices appropriate for gully erosion 5h1 and land requiring conservation practices appropriate for sheet erosion 5h2. Unit codes are not considered in a 1:100 000 scale study.

• **e** (erosion) Unspecified erosion limitation (both current and potential). – **a** (aeolian) Erosion caused by the effects of strong wind. Usually affects sandy or poorly aggregated soils and can occur on slopes of very low gradient. – **h** (water) Erosion resulting from the effects of rainfall, either directly through raindrop impact or through secondary effects of overland flow and surface run off (including stream bank erosion). – **m** (mass movement) Landslip, slumping, soil creep and other forms of mass movement. • **w** (wetness) Unspecified wetness limitation. – **f** (flooding) Limitations created through the surface accumulation of water either from overbank flow from rivers and streams, run-on from upslope areas or because the area lies in a topographic depression. – **d** (drainage) Limitations resulting from the occurrence of a ground watertable, or restricted or impeded permeability within the soil profile, leading to the development of anaerobic conditions. • **x** (complex topography) Limitations caused by irregular, uneven or dissected topography which limit ease of management or divide land into parcels difficult to manage individually at the paddock scale.	• **s** (soils) Unspecified soil limitations. – **g** (coarse fragments) Limitations caused by excess amounts of coarse fragments (particles of rock 2 - 600mm in size), including gravel, pebbles and stones, which impact on machinery, damage crops or limit growth. Coarse fragments may occur on the soil surface or throughout the profile. – **r** (rockiness) Limitations caused by boulders or outcrops of bedrock material greater than 600mm in size (cf coarse fragments, above). – **k** (conductivity) Land at risk from salinity (as indicated by high electrical conductivity readings of a 1:5 ratio soil:water paste). – **l** (limiting layer) Rooting depth or depth to some limiting layer. • **c** (climate) Unspecified climatic limitations. – **p** (precipitation) Limitations resulting from insufficient, excess or uneven distribution of rainfall. – **t** (temperature) Limitations caused by frost risk or by reduced length of growing season due to low temperatures. • More than one subclass may be recorded by listing the dominant subclass first eg Class 5 (a,c,f).

Table 3. Subclass codes and their definitions

4. SURVEY METHODOLOGY

The land capability map is produced through a combination of fieldwork and aerial photo interpretation (API). Fieldwork commenced in October and concluded in December 2000. A review of all existing relevant land resource information was also undertaken to provide a background for field investigation.

Resource Information used

Resource information that has been utilised by this study has been referenced within the relevant sections of this report. Other information data sets have been used to determine relationships between landform, geology, soil and the associated land capability and are listed below.

Computer generated slope maps developed by the DPIWE GIS section from 1:25 000 scale contour information (10m contour intervals) and spot heights, interpret slope from a digital elevation model. These maps have a resolution of 50m. This information has proved invaluable in locating class boundaries where access has been difficult or in areas that are extensively covered by forest. While these slope class maps have assisted in boundary placement some underestimation of slope angle was occasionally found. This is attributed to the scale or resolution used to create the digital elevation model.

Black and white aerial photos at a scale of 1:42 000 and 1:100 000 Land Systems information have been utilised to determine boundaries where access has been difficult or where topography and landform have been the major determinant of the boundary (eg ridges or steep valleys). The location of detailed soil profile description sites has also been recorded on these photos. In an area where soil pattern was complex and access difficult due to plantation forestry, colour aerial photographs at a scale of 1:20 000 were obtained from Forestry Tasmania. These helped to determine the dominant soil types and in some areas soil boundaries.

While most of the area has at best reconnaissance and regional scale land resource information available, the Montagu Swamp area at Togari has a very detailed soil map (approx 1:15 833 scale, Hubble 1958) and accompanying report (Hubble 1944). This information has proved invaluable in assisting with the determination of land capability boundaries by providing information on soil drainage, soil texture and workability.

Flood risk information within the Montagu Catchment Management Plan (Sinclair Knight Merz 1999) also helped to determine land capability boundaries in this area.

The Mapping Process

Fieldwork proceeded along public roads and private property when needed, to assess land capability on-site and to check soil types, geological boundaries etc. Soil investigations have been made by hand auger and spade, as well as examination of soil exposures in ditches or road cuttings to determine depth of soil horizons and other important soil properties (Photo 1).

Photo 1. Describing profile characteristics in the field.
(GR E 319550, N 5475350)

A combination of aerial photo interpretation and field assessment was used to determine land capability boundaries. These boundaries were then recorded onto 1:50 000 scale field maps before being transferred to base maps for digitising. In line with standard mapping practice not all map units have been visited, rather informed assumptions have been made about some map units based on the knowledge of similar areas and the information extrapolated from these sites. For example soil transect mapping was undertaken in the vast coastal plain areas to determine the range of soils and their limitation. This information was then extrapolated to other areas to assist in determining land capability boundaries.

Interpretations of existing land information including geological information, vegetation, soil maps and reports, aerial photographs and land systems maps and reports have also been used to help determine land capability. This approach is necessary to reduce the time required to produce an end product and is appropriate where a good understanding of the relationships between soil, geology, landform etc and land capability exists. This is consistent with 1:100 000 scale mapping methodology and such interpretation has been made in areas with limited access.

In assessing land capability, consideration has been given to a wide range of land factors, together with information supplied by local farmers, land managers and agricultural advisers within and outside DPIWE.

Storage of the data

All map information has been captured and stored in the Arc Info GIS at the government offices at Prospect in Launceston. This information was digitised from

Photo 2. Discussion of soil properties and potential agricultural uses with landholders and agricultural advisers is an integral part of land capability fieldwork. (GR E 307400, N 5495500)

1:50 000 scale base maps and also includes some subclass label information for the map units.

Site descriptions recorded in the field have been entered into the Department's Soil and Land Capability Database for reference and quality control purposes. This database includes a range of site information relevant to evaluating land capability and holds both land capability class and subclass information.

Complex Map Units

In some parts of the survey area the complexity of topography or soils make it impossible to separate pure land capability classes at the scale of mapping. In such instances 'complex' map units have been identified.

Considerable effort is made to map areas of a single land class but inevitably some complex units are unavoidable.

The complex areas identified within the Hunter area could be separated into their relevant land classes at a more detailed level of mapping.

Use of Subclass Codes

Although the published map does not display subclass codes, an attempt has been made to identify the dominant limitations (subclass) to agriculture within each map unit during the course of this survey. No attempt has been made to determine the boundaries between each of the subclasses however. As mentioned above the subclass information is stored by DPIWE. This information can be requested by contacting the resource assessment staff at Prospect Offices in Launceston.

Where a number of limitations are found within a large land capability map unit multiple subclass codes are recorded (eg 4es) in order of dominance within that area.

Reliability of the Data

Site information from fieldwork and other studies has been used as reference sites for this survey giving a total of 212 reference sites. Figure 5 provides an indication of the distribution of these sites.

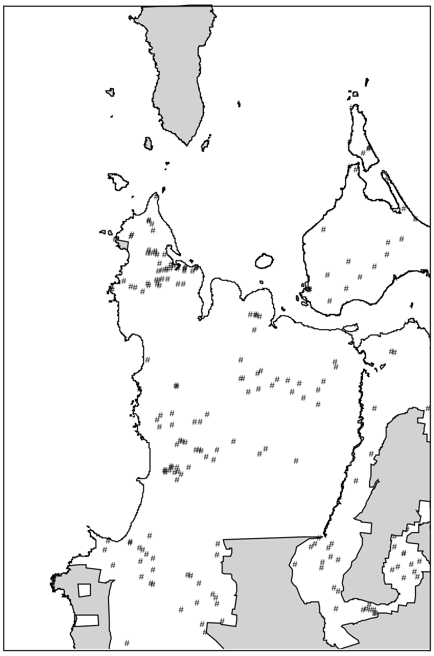


Figure 5. Distribution of land capability reference sites for the Hunter study area.

5. THE HUNTER SURVEY AREA

5.1 Introduction

The study area lies on the far north west coast of Tasmania (see Figure 2). It includes the small farming communities of Marrawah, Montagu, Redpa, Togari and Brittons Swamp. The total area is 107 154 ha of which just under 32% is identified as exclusion areas which comprise State Forest, Forest Reserves, Crown Reserves, Conservation Areas and Aboriginal Sites.

The area has a range of landforms, climatic regions and associated land uses that are discussed in the sections below.

5.2 Climate

The climate of the Hunter survey area is considered temperate maritime with relatively cool dry summers and mild wet winters. Climatic conditions change only slightly across the Hunter area due to the regions coastal situation and low relief. Where variations do occur, they are attributable to relative coastal proximity, elevation, local topography and aspect.

5.2.1 Precipitation

The amount of rainfall received within the survey area increases from the north to the south. The north west coastal areas are typically the driest recording marginally less than 950mm rainfall annually. Conversely, the south east regions are the wettest with Togari receiving 1288 mm per annum. Figure 6 shows a simplified rainfall isohyet diagram for the survey area. This information as been created using ESOCLIM modelling software, and the results closely reflect previous work by the HEC (1986).

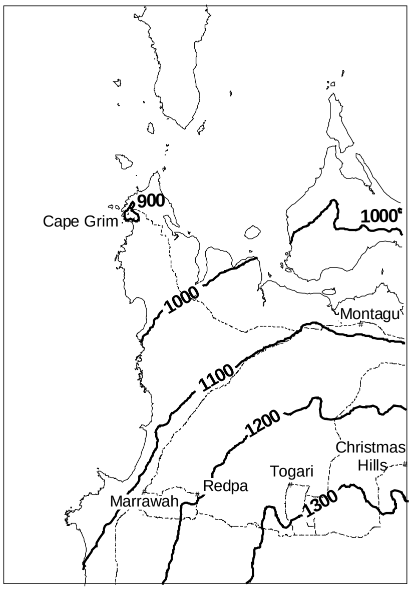


Figure 6. Simplified rainfall isohyet diagram (mm/year)
for the Hunter survey area. (ESOCLIM)

A selection of stations has been chosen throughout the survey area to show average monthly rainfall and the variations that occur with changes in elevation and latitude (Figure 7). In all cases, precipitation is winter dominant with mean monthly rainfall figures for the winter months double those of the summer. Maximum monthly rainfall reaches 170mm at Togari in July, whilst the minimum of 38mm occurs at Cape Grim in January.

Snowfall on the coast is unknown with hailstorms occurring infrequently. At inland locations both are rare and are usually confined to areas of higher elevation.

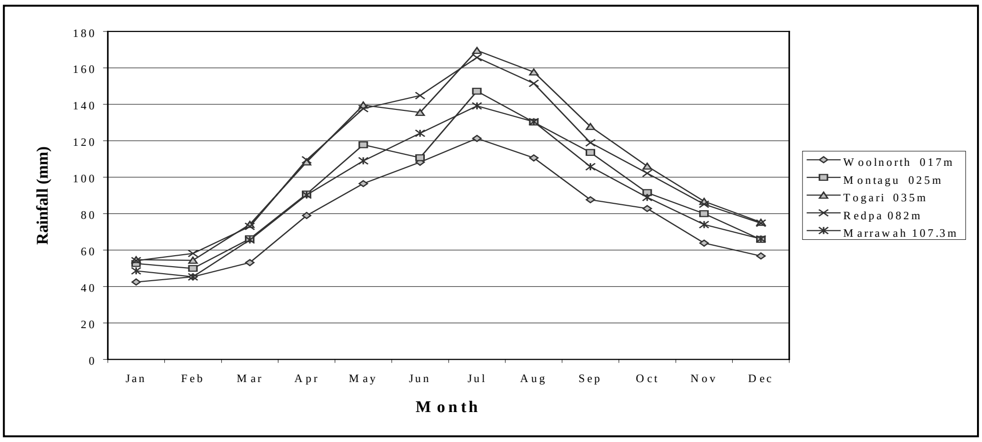


Figure 7. Average monthly rainfall for selected stations
(Source: Bureau of Meteorology, unpublished data, 2001)

5.2.2 Evaporation

No stations monitor evaporation within the Hunter survey area. Evaporation figures for respective areas have therefore been devised using modelling software (Table 4). Coupled with actual rainfall values, it is possible to infer the number of months in which evaporation exceeds rainfall and a moisture deficit occurs. The spatial variation in the number of months per year in which a moisture deficit occurs is shown in Figure 8.

	NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cape Grim	Rainfall	38	47	48	77	96	94	115	102	85	79	62	53
	Evaporation	161	139	105	66	45	32	36	47	62	91	116	140
Welcome R	Rainfall	46	53	58	89	111	115	137	126	99	92	75	62
	Evaporation	161	139	105	66	45	33	37	47	63	92	117	140
Marrawah	Rainfall	49	55	63	96	113	126	142	133	104	100	75	63
	Evaporation	156	135	101	63	43	31	34	45	59	88	112	135
Montagu	Rainfall	46	53	58	91	113	114	141	132	102	96	80	64
	Evaporation	162	140	106	67	45	33	37	48	64	93	119	142
Redpa	Rainfall	52	57	65	99	123	132	156	144	110	102	81	70
	Evaporation	159	137	103	65	44	32	36	46	61	90	115	138
Togari	Rainfall	56	60	70	106	135	140	168	157	121	110	89	75
	Evaporation	159	137	104	65	44	32	36	47	62	91	117	139

Table 4. Average monthly evaporation (modelled using ESOCLIM) and recorded annual rainfall figures for selected stations. Shaded areas indicate months where a moisture deficit occurs ie where evaporation exceeds rainfall.

From the modelled data it is apparent that evaporation is consistent throughout the survey area and the minor differences apparent in the incidence of moisture deficits and the degree of these deficits, are determined by variations in precipitation. In all areas of the study area a moisture deficit occurs over the five months between November and March inclusive, aside from the area immediately surrounding Cape Grim which experiences a deficit from October.

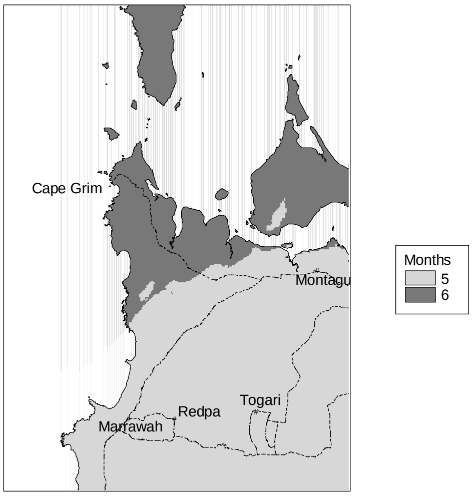


Figure 8. Number of months that evaporation exceeds rainfall in the Hunter survey area (ESOCLIM).

5.2.3 Temperature

A limited number of stations record temperatures within the Hunter survey area. Mean daily maximum and minimum temperatures for selected stations exhibit a distinct seasonality. Figure 9 illustrates the seasonal variation in temperature.

January and February are the warmest months in all locations whilst July and August are the coolest. The coastal influence moderates temperature extremes in the Hunter area to the extent that the difference between mean daily minimum and maximum temperatures does not exceed eight degrees during the year. Coldest temperatures are likely to occur in the elevated inland areas in the south east of the study area. Of the stations that do record temperature Redpa is the coldest location and the least coastal with an average monthly minimum of 6 degrees in July and maximum of 18 degrees in January. Marrawah is the warmest in the summer months with an average maximum of 21 degrees.

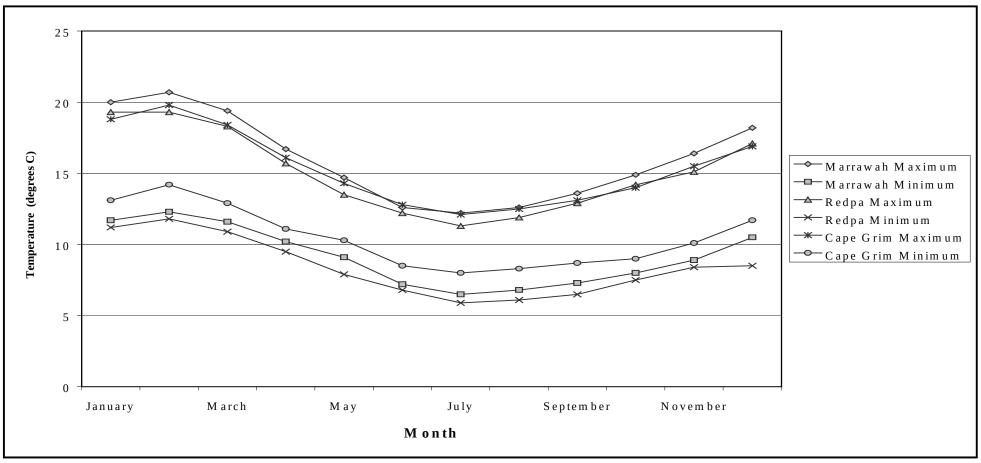


Figure 9. Mean monthly maximum and minimum temperature for stations within the Hunter survey area. (Source: Bureau of Meteorology, unpublished data 2001).

Table 5 shows the average frequency of frost days per month for the two available stations. From this table it is possible to observe that both areas experience infrequent frost events even during the winter months, with the frequency increasing with distance from the coast.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Marrawah	0	0	0	0	0.1	0.7	1.1	0.6	0.5	0.1	0	0
Redpa	0	0	0	0.1	0.7	1.7	2.3	2.4	1	0.8	0	0

Table 5. Mean number of days per month with frost.
(Source: Bureau of Meteorology, unpublished data, 2001)

5.2.4 The Influence of Climate upon Agricultural Activity

All areas within the Hunter map area occur below 180m asl which is the first altitude limit that the State land capability system uses to identify increased frost risk. From a temperature point of view all areas have a Class 1 climate. It would therefore seem to indicate that no risk to crops exists in the Hunter area from low temperatures or frost especially during the traditional growing period of September through to April. However localised effects from cold air drainage and relief have been reported by landholders to result in regular frost occurrence in the Togari and Brittons Swamp area. Hubble (1944) has also documented frost damage and reduction in vegetable crop yield in this area. This therefore highlights that damaging frosts do occur, and are likely to be more frequent and have a significant impact on agricultural activities at inland locations compared to the coastal locations listed in Table 5.

Other climatic conditions that have a marked affect on agricultural activities in the Hunter survey area relate to the seasonal distribution and frequency of rainfall. This was especially noted in the Marrawah and Redpa areas (Figure 10).

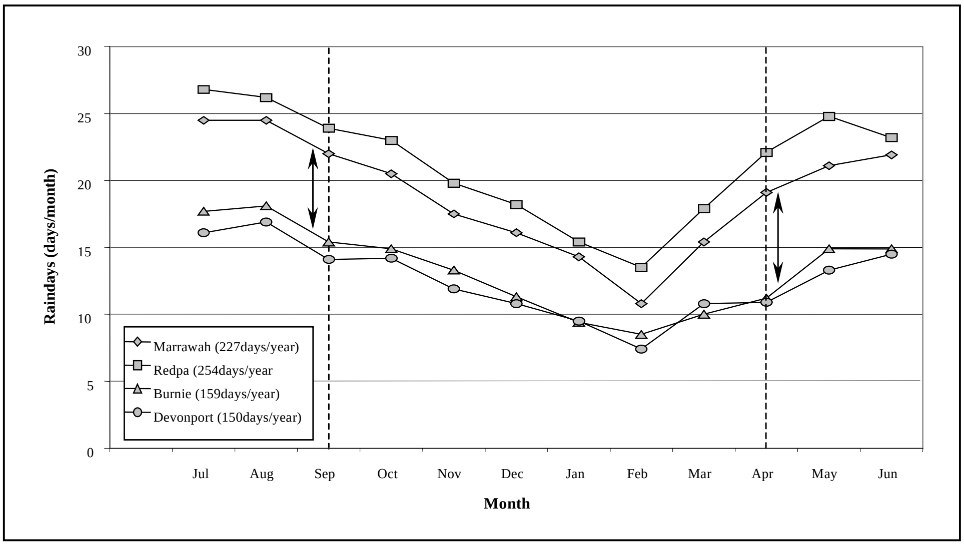


Figure 10. Comparison of rainday frequency during the traditional cropping season between sites within the study area and other sites in other intensive cropping regions.
(Rainday = a day that receives more than 2mm of rainfall (Bureau of Meteorology)).

Figure 10 compares the number of raindays per month at Marrawah and Redpa to that of the intensive cropping centres of Burnie and Devonport. Total rainday figures indicate that the two west coast locations generally receive up to 100 raindays more per year than Devonport and Burnie.

It is also possible to see that Marrawah and Redpa receives significantly more raindays per month than Burnie and Devonport (nearly 10 raindays more) in September and April. With low evaporation rates and approximately 7 rainy days out of 10 occurring at these locations during these months management of the land becomes very difficult. Even though these areas possess the best soils and have the most freely draining land delays to paddock preparation in the spring and the risk of soil degradation and crop losses from water logging late in the season pose very real management problems for farmers.

In the summer management is also difficult due to low rainfall and high evaporation rates at these locations. A significant period of moisture deficit period occurs coinciding with the traditional growing season. Application of supplementary irrigation during these times in these areas is necessary to guarantee yield and quality for cropping farmers. The expansion of dryland poppies within the district partly reflects this moisture availability characteristic. While relying upon rainfall prior to December, dryland poppies benefit from the natural period of moisture deficit to help concentrate alkaloid content within their capsules.

On the lowland plains the lack of drainage outfall and high winter rainfall impacts more severely and result in shorter windows of operation for farmers as well as limiting management and cropping options. These wet conditions also impact upon the growth and development of pastures and prevent timely access to perform paddock preparation and harvest activities. For areas with even poorer drainage characteristics due to heavy clay soils, such as some near Woolnorth, Togari and Brittons Swamp, increased risk of soil degradation from compaction and smearing exist. Consequently growing seasons and working windows are significantly shortened at these locations in spring and autumn. These restricted growing seasons effectively reduce the range of crops that can be successfully grown in the area and hence the land capability is poorer in these areas than for areas in other parts of the state where rainfall is lower but soil and topographic characteristics are similar.

Relative humidity is considered by some landowners in some coastal areas to prevent commercial cereal production. Little information is available on this subject however. It is reported that the high humidity near to the coast prevents the grain from fully drying before harvest, thus further limiting the range of potential crops for the area.

5.3 Geology

The majority of the survey area is covered by a 1:50 000 Geological Survey of Tasmania Sheet 7816s WOOLNORTH (1992), the remaining area to the north is covered by the Geological Atlas 1:250 000 Series SK55-1 KING ISLAND. This geological information has been combined, grouped and draped over a digital terrain model in Figure 11 to show the relationship between the geology types and the topography across the Hunter survey area. From this it is possible to visualise the area and the wide diversity of rock types covering a substantial geological time-span. Rock ages range from the Precambrian (older than 570 million years) to very recent dune and alluvial deposits of the Quaternary period (less than 2 million years).

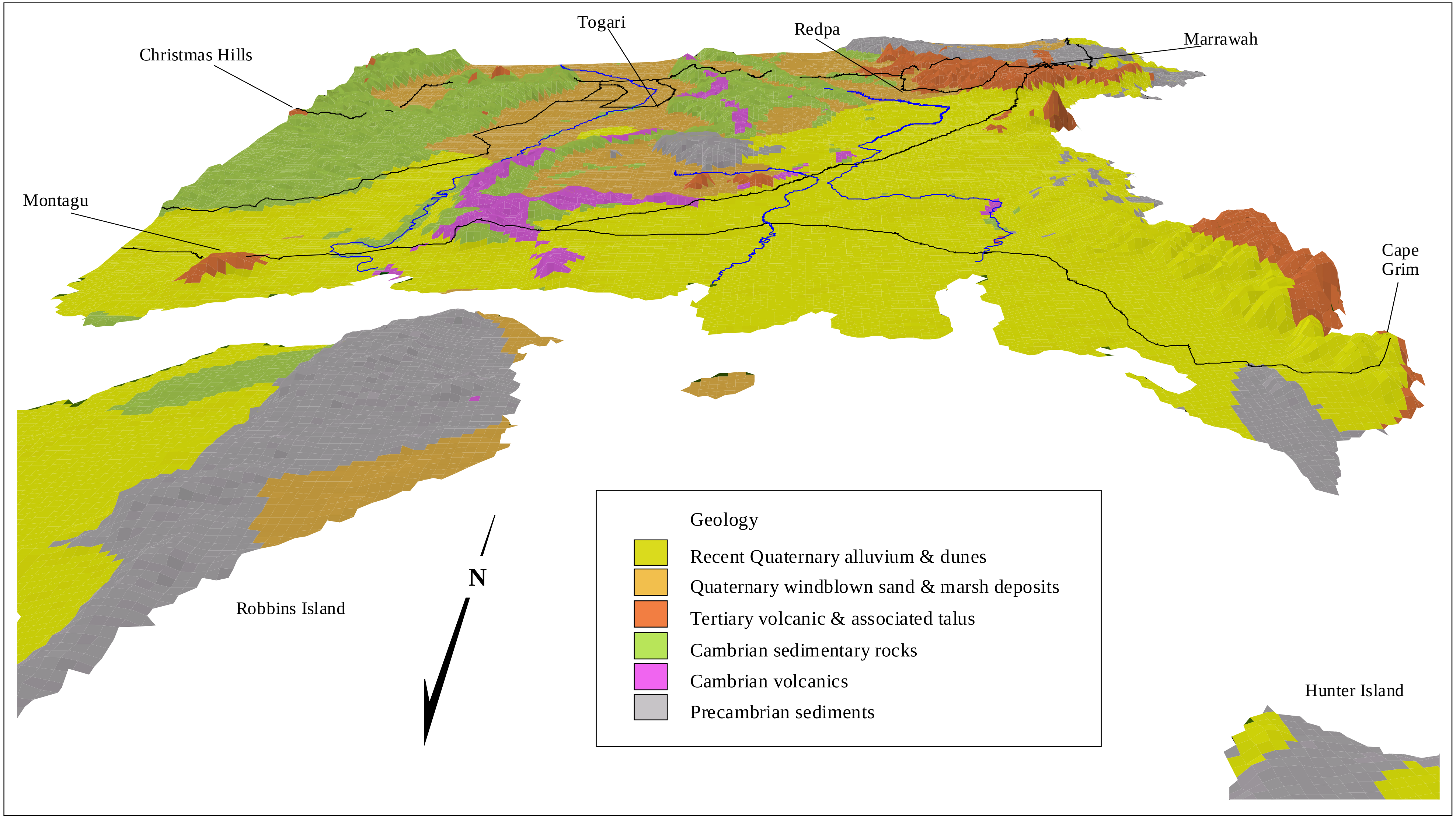


Figure 11. Digital elevation model and simplified geology of the Hunter area.

Figure 11 also clearly shows the group of low lying Quaternary sediments that represent the extent of inundation by the sea during periods of higher sea level. Hills and plateaux formed from Tertiary volcanic lavas are prominent in south western and western areas while ridges of older materials can be seen bisecting the landscape forming valleys that have subsequently been infilled by Quaternary sediments to form large sand plains.

Only a summary of the major rock types and their main form are presented in the next few pages. While no explanatory report is available for the Hunter area reference has been made to the explanatory report for the area immediately to the east (Brown, 1989), that shares much of the same geology. Readers that require more detailed information are therefore directed to this text.

Rock types are described in order of their age beginning with the oldest rocks within the survey area. Appendix A contains a geological time scale indicating relative ages of the following rock types.

Precambrian Rocks

Precambrian rock types occupy high landscape positions within the Hunter survey area. They include finely laminated siltstones, very fine sandstone, mudstone, quartzite, orthoquartzite, conglomerates, chert and dolomite. These materials are some of the oldest found within Tasmania and most have been faulted and folded during an early period of mountain building (the Penguin Orogeny). A product of this mountain forming period was a number of geanticlines that have revealed some of the oldest basal bed sequences. These have been heavily eroded, dissected or covered by more recent sediments of Cambrian and Quaternary age. Main areas occur south of Marrawah, Jims Plain and on both Walker and Robbins Island.

The oldest of the Precambrian rock types is a suite of highly siliceous sediments ranging to 5000m thick in places and collectively termed the Rocky Cape Group. This group has been described by Gee (1971) in the Table Cape area. He subdivides this suite of rocks into four subgroups, two of which have been identified within the Hunter survey area. These are the Cowrie Siltstone and the Detention Quartzite. These rocks have a wide range of lithology ranging from laminated and uniform siltstones, slate, impure quartzite, greywacke and sandstone. They are often hard and resistant to weathering due to both metamorphism and strong silica cementing (Turner, 1989).

The Detention Quartzite is faulted and folded in nature, which result in ridges and steep rocky landforms. These areas are easily identifiable by their stunted vegetation species and white colouring of the bare bedrock material. On windward slopes especially, windblown sands of Quaternary age have partially covered these landforms. The Cowrie Siltstone however, occurs mainly as flatter platforms and plateaux, some of which have also been partially buried by windblown sand or by accumulations of peat in drainage depressions.

Overlying the Rocky Cape Group are a younger set of Precambrian sediments including the Forest Conglomerate. This is found only in minor occurrences south east of Maxies point and West Point.

Cambrian Rocks

Four main Cambrian rock types occur in the Hunter area. These include older Eocambrian conglomerates and siltstones, associated volcanic lavas containing pyroclastic material, dolomite and a younger siltstone/mudstone unit.

The oldest sequences are found in the central part of the area, extending in a ridge-like formation the whole length of the survey area, from Bonds and Hays Tier in the south through to Denium Hill in the north. These sediments have been folded and represent an eroded fold apex, with strata dipping to the east so as to disappear below the Quarternary Sediments of the Montagu drainage basin.

The grey to yellow conglomerates and siltstones are the dominant rock types in this area but on flatter plateau tops the volcanic rock become more abundant especially in northern locations surrounding West Montagu. This volcanic unit mapped as basalt lava emulates similar materials on a similar ridge formation south of Smithton where the rocks have been described as breccias, spilites and pillow lavas. The other commonality between these areas is also the formation of better red agricultural soils on gently sloping land and plateaux.

Conformably overlying and underlying these sediments are correlates of the Smithton and Black River Dolomites. Although rarely observed in large exposures they underlie a large portion of the Montagu and Welcome drainage basins now covered by Quaternary sediments. Similar dolomite rocks are commercially quarried for agricultural fertiliser near Smithton and Roger River.

The youngest sedimentary rocks of Cambrian age consist of finely textured mudstone, siltstone and greywacke of varying colours ranging from purple, red brown through to yellows and greys. They are often laminated and sometimes fossiliferous. These sediments make up most of the forested hills along the eastern map boundary, including the Christmas Hills and the area known locally as the Togari Forest Block to the east of the Montagu River basin. Areas with Tertiary basalt lavas have been identified in locations within these sediments, perhaps indicating that there was once a greater capping of the Cambrian sediments by Tertiary lavas.

Tertiary Volcanic Rocks and other sediments

Tertiary volcanic materials occur in several regions of the Hunter area. They can be divided into two main types – i) volcanics that include pyroclastic material, breccias, pillow lavas, and ii) pillowed or non-pillowed olivine basalt lava. The former is the most abundant and can be found at Marrawah, Redpa, Studland Bay, Flat Topped Bluff and Slaughter Bay areas. Olivine basalt lavas are found at Harcus Hill, Bens Hill and Mount Cameron West.

The mineralogy of these Tertiary volcanics is such that they weather to form the best agricultural soils in the area. These materials have been logged to 50m thick within the Port Hills, west of Marrawah. In places they cap other older sediments and are associated with Tertiary limestone deposits in the south of Redpa as well as a range of predominantly Cambrian rock types elsewhere.

Basalt hill slopes are commonly sites for springs and water seepage to occur. Water percolates through this fractured bedrock and may flow laterally along the contact zone with underlying less permeable sediments or through very permeable lenses within the substrate, to then exit at mid-slope or lower slope positions. The risk of landslip and erosion in these locations can be high.

Quaternary Sediments

These materials are by far the most abundant within the Hunter area. Geologists have distinguished between the younger alluvium deposited within the Holocene and older deposits that took place in the Pleistocene.

The younger or most recent alluvium include the upper catchment drainage basins of the Welcome, Montagu and Harcus Rivers where sediments are derived from rock types that form the surrounding hillslopes, as well as from those found higher in the catchment. These sediments vary from silty, clayey or sandy in nature. Their spatial distribution is also as varied being dictated by the lithology of, and proximity to the surrounding hills and feeder creeks as well as the influence from both aeolian and fluvial processes in these areas.

Other young sediments include those predominantly found along the coast in the form of mud and sand flats and beach and dune sand.

Older Quaternary alluvium within the Hunter map includes the extensive sand plains that dominate the north and north western lowlands. These plains indicate roughly the extent of previous sea levels that once covered this area during the interglacial periods and have been mapped to roughly approximate the 30m contour. Remnant dunes, terraces and strandline deposits indicate old shorelines near Montagu as well as in the north and western areas. This material is predominantly sand with some gravel and conglomerates derived from local sources.

A small area of Quaternary talus derived from Cambrian hills occurs in the Brittons swamp area and has been quarried mainly for construction purposes.

5.4 Topography and Geomorphology

Figure 11 provides a simplified overview of the topography and respective landforms as well as the geological units that occur within the area. Readers may wish to refer to more detailed studies by Edwards (1941), Gill and Banks (1956) and Davies (1961).

The land within the Hunter area has three distinct topographic regions and related geomorphology. The area generally is characterised by a large coastal sand plain that extends inland along river valleys. This plain occurs mostly below 25m above sea level (asl) and rarely exceeds 30m asl. It receives sediment and drainage waters from the catchment areas above as well as from surrounding hills. Rolling hills, escarpments, ridges and plateaux rise above the coastal plain in the central, south western and north western parts. These features are, in places, heavily eroded and dissected where river and creek systems have cut their course. The highest point is found in the south at Seymour Hill (134m asl).

Coastal Dunes and Sand Plain

A number of mobile dune systems occur on the western coastline within the Hunter areas. These have been formed by strong and relatively constant prevailing westerly winds. The large "sand blows" on the western coastline remain active and are slowly migrating inland.

Smaller stabilised dune systems are found behind and parallel to the longer beaches and are commonly flanked by swales. These areas form a barrier to drainage outflow and impede land drainage at inland positions by holding up sub surface through flow resulting in poorly drained land and marshes or swamps at some locations.

The sand plain itself is composed of windblown alluvium of both marine and freshwater origin and grades very gently towards the sea resulting in very slow run off rates for surface waters. This plain is part of an emergent shore platform that extends for much of the north coast of Tasmania (Edwards 1941) and is the result of eustatic sea level changes during glacial and post-glacial periods. It is likely that parts of Robbins and Walker Island also emerged from the sea during these times.

Other features of interest in this coastal environment include barchan lunettes, terrace systems, bays and inlets, tidal marshes and many small closed drainage depressions.

Escarpments, Headlands and Plateaux

Escarpments and cliffs form much of the coastal topography on the western coastline. These represent the areas of more resistant rock types or reclaimed islands and sea cliffs that have been shaped by the erosive forces of the sea and wind. The escarpments at Marrawah and Cape Grim are the largest examples and have been partially covered by wind blown sands on the windward slopes. On the plateau inland of Marrawah erosion and dissection by creeks has formed gently to steeply sloping hill country.

Steep Hills and Ridges

Steep dissected hills and ridges occur in the south and eastern areas of the map where Tertiary basalt hills, Cambrian Ridges and Precambrian platforms influence the landscape. Mass movement, resistant rock types, high rainfall and dissection by watercourses have played a large part in the formation of these environments. The existence of a large fold in the underlying geology has exposed a suite of Cambrian materials in the central and eastern areas. These areas form the steep ridges and valley sides to the large alluvial basins and impact greatly upon the direction of local watercourses. Outcrops of Precambrian rock that are partially covered by wind blown sand, as well as old erosion surfaces in the south of the survey area, grade steeply to the plain below.

Major Rivers and Hydrology

The major river systems in the area are the Welcome, Harcus and Montagu. All trend in a northward direction, after negotiating local obstructions, and enter the sea on the northern coast. Many feeder creeks and water courses, including artificial drainage channels, occur which flow into the major rivers or find their own course to the sea. Some underground drainage paths occur where the Welcome River disappears and appears to follow Karst formations within limestone rocks.

This complex and mainly dendritic pattern of river and creek systems, together with high winter rainfall and low rates of run off, concentrates water onto the very flat lowland areas resulting in high ground water levels. This has required the implementation of an intensive drainage network to overcome near surface seasonal groundwater tables and provide an outflow to the sea. The creation of drainage trusts in the Brittons Swamp and Togari area as well as the use of Hump and Hollow drainage has also seen areas brought into higher levels of agricultural production than were once possible before such drainage was implemented.

Draining the lowland areas has lead to a number of environmental issues in the area, and although they are not the focus of this report, management of the surrounding agricultural areas can affect their severity. High leaching rates in most of the soils that occur in these areas result in high nutrient loads within the network of drainage channels and waterways at certain times of the year. These levels have been reported to have had impacts upon wetland areas near the coast and also contribute to higher nutrient loads in the more sheltered coastal waters. Fertilisers and animal wastes are the largest source of these contaminants. Land managers are therefore encouraged to tailor their nutrient application to minimise the leaching of nutrients into the drainage system. Where practical, the application of smaller amounts more regularly, during the drier periods of the year, (especially for the more soluble nutrients such as nitrogen) is advisable. Whilst this practices protects watercourse habitat it also can prove more cost effective over time.

Recent discoveries of very acid water (pH 2) in drainage lines at Togari as well on the coastal plains, are suspected to be caused by leachate from acid sulfate soils. Appropriate water management practices and monitoring are required in these areas especially if the water is to be used for stock drinking purposes. Additional comment on acid sulphate soil is made in Section 5.5.2.

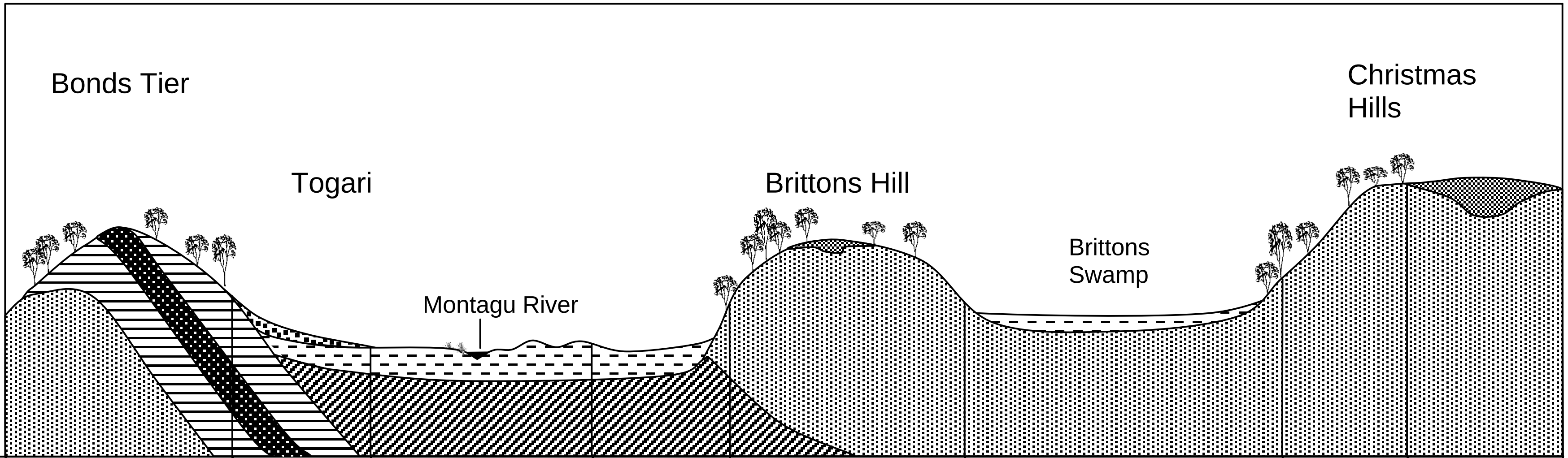
Stylised cross sections have been created for parts of the survey area and presented in Figures 12, 13 and 14. These transects represent the dominant landforms present within the Hunter survey area and aim to display the interrelationships between landform, geology, soil and land capability.

5.5 Soils

5.5.1 Background and Previous Studies

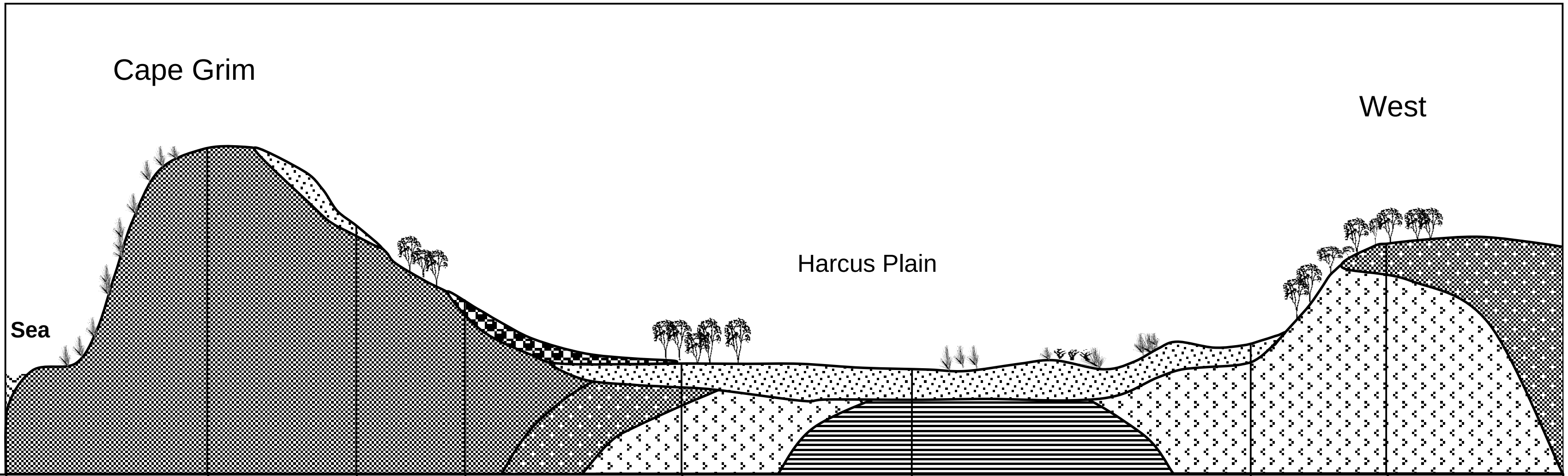
The agricultural potential of the north west coast of Tasmania has attracted primary producers to the area since the early days of settlement. The Van Diemens Land Company, with its pioneering interests in this part of the State, was one of the early investors who recognised the combination of favourable climatic conditions and good grazing and cropping lands. Agricultural development and expansion followed as the red friable soils were targeted for cropping and mixed grazing at Marrawah and Redpa, while the plains were cleared and a number of drainage trusts established to drain the swamps and marsh lands.

A number of early studies have been undertaken aimed at understanding soil distribution, bedrock geology, soil formation, soil nutrient status, pasture production and drainage. Despite this early work a detailed soil map does not exist for the whole of the Hunter area.



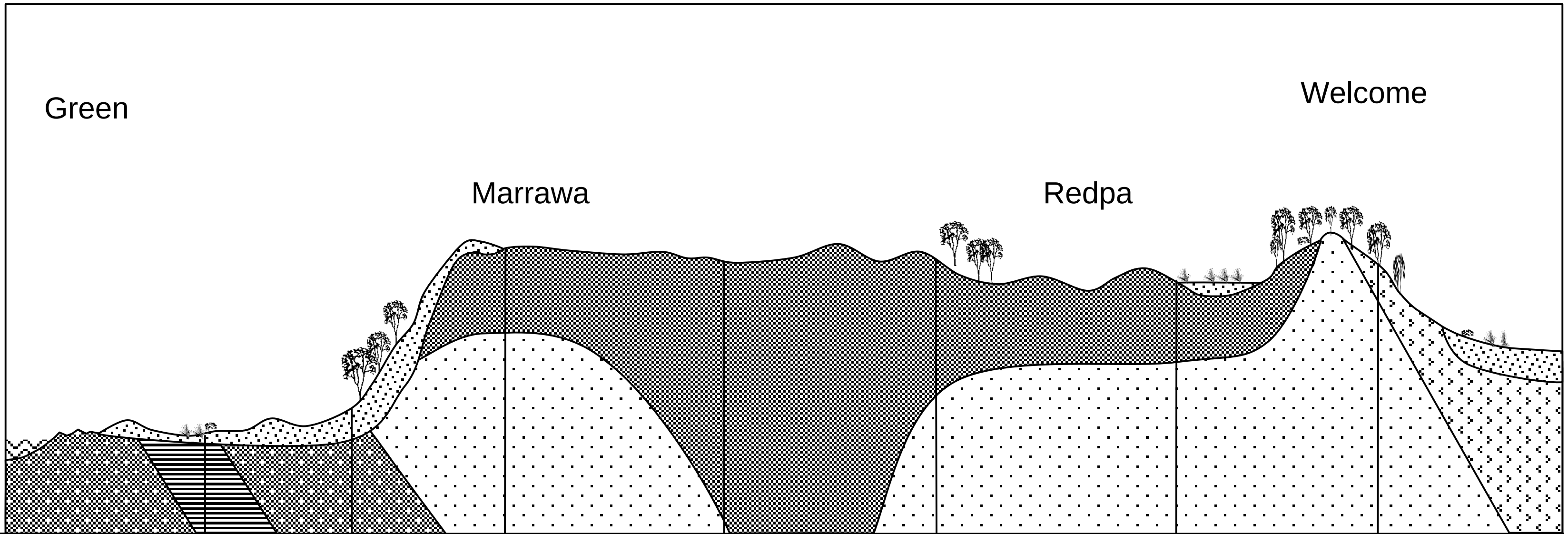
Typical Landform	Moderately steep to steep hills	Lower hill slopes and alluvial fans	Floodplain and sandy terraces	Alluvial basin	Moderately steep to steep hills	Alluvial basin	Moderately steep to steep hills	Gently sloping land
Geology	Cambrian sediments and volcanics	Cambrian sediments and Quaternary alluvium	Quaternary alluvium	Quaternary alluvium	Cambrian siltstone and mudstone	Quaternary alluvium (sourced from Cambrian sediment)	Cambrian siltstone and mudstone	Tertiary basalt
Soil Type	Dermosols, Chromosols (Silty and clay soils)	Kandosols (Clays and peat)	Podosols, Organosols (Woolnorth Sands)	Hydrosols, Dermosols, Kandosols (Clayey and silty soils)	Dermosols, Chromosols (Clay soils)	Kandosols, Hydrosols (Silty clay soils)	Hydrosols, Dermosols (Silty and clay soils)	Red Ferrosols
Slope Range	18-45%	0-5%	0-5%	Level	18-45%	0-3%	28-56%	<18%
Drainage Status	Moderate to poor	Imperfect	Poor to well	Imperfect to poor	Moderate to imperfect	Imperfect to poor	Moderate to poor	Well
Permeability	Moderate to slow	Slow	High	Slow	Moderate to slow	Moderate to slow	Moderate to slow	Moderate to high
Erosion Risk	Moderate to high	Low	High wind erosion risk in sandy areas	Low water – high wind erosion risk	Moderate to high	Low	Moderate to high	Low
Main Limitations	Soil depth (s), erosion risk (e).	Short working window due to poor drainage (d).	Flooding (f), poor drainage (d), wind (a) erosion.	Short working window due to poor drainage (d).	Soil depth (s), water (h) erosion.	Short working window due to poor drainage (d).	Soil depth (s), water (h) erosion.	Water (h) erosion.
Land Capability Classes	E	4	5	4 , 5	E	4 , 5	5	2 , 3

Figure 12. Stylised cross-section from Bonds Tier east to Christmas Hills.



Typical Landform	Coastal platform and extremely steep slopes	Steep hillslopes	Moderate to steep hills	Colluvial fan and alluvial plains	Alluvial sand plain	Aeolian sand plain, dunes and swamps	Steep hillslopes	Gently to moderately sloping hills
Geology	Tertiary basalt and volcanics	Tertiary basalt with some windblown sand	Tertiary basalt	Quaternary alluvium (clay)	Quaternary alluvium (sand)	Quaternary alluvium (sand)	Cambrian siltstone and volcanics	Cambrian volcanics
Soil Type	Red/Brown Ferrosols	Red/Brown Ferrosols	Red/ Brown Ferrosols	Hydrosols, Dermosols	Hydrosols, Podosols	Podosols, Hydrosols	Kurosol, Sodosol	Ferrosols
Slope Range	>56%	28-56%	18-28%	0-12 %	0-5%	0-5%	18-56%	0-18%
Drainage Status	Rapid to well	Well	Well	Moderate to imperfect	Poor	Well to poor	Moderate to well	Well
Permeability	High	High	High	Very slow to slow	High	High	Moderate	Moderate
Erosion Risk	Very high to extreme	High	Moderate	Low	High	High	Moderate to high	Moderate
Main Limitations	Water erosion (h), mass movement (m).	Water erosion (h), (a).	Water erosion (h), stoniness (g).	Drainage (d), stoniness (g).	Drainage (d), water erosion (h).	Wind (a) and water (h) erosion, drainage (d).	Water erosion (h), soil structure (s).	Soil structure (s), water erosion (h), stoniness (g).
Land Capability Classes	7	5	4	4	5	5	5 + 4	3

Figure 13. Stylised cross-section from Cape Grim east to West Montagu.



Typical Landform	Rocky headlands, dunes, wetlands and coastal plain	Alluvial sand plain, some older stabilised dunes	Steep escarpment and hills	Plateau with very flat to very gentle slopes	Plateau with gently undulating hills	Undulating to rolling hills	Alluvial plains and moderate to steep hills	Moderately steep hills and alluvial basins
Geology	Precambrian Orthoquartzite	Quaternary alluvium (sand)	Tertiary basalt/volcanics and windblown sands	Tertiary basalt/volcanics	Tertiary basalt/volcanics	Tertiary basalt/volcanics	Quaternary alluvium, Tertiary volcanics, Tertiary limestone and Cambrian sediments	Cambrian sediments and Quaternary alluvium
Soil Type	Rudosols, Podosols	Podosols, Hydrosols	Ferrosols	Ferrosols	Ferrosols	Ferrosols	Ferosols, Dermosols	Chromosols, Podosols, Hydrosols
Slope Range	<12%	0-5%	28-56%	0-12%	0-18%	8-12%	0-28%	<5%
Drainage Status	Well to poorly drained	Poor	Well	Well	Well	Well	Well to imperfectly drained	Moderately to poorly drained
Permeability	High	High	Moderate	Moderate to high	Moderate to high	Moderate to high	Moderate	Slow to very slow
Erosion Risk	High to extreme	Low to moderate	High to very high	Low	Low	Low to moderate	Moderate	Low on clay soils, moderate to high on sandy alluvium
Main Limitations	Rocky land (r), wave (h), and wind (a) erosion.	Drainage (d), and wind (a) erosion.	Water (e) erosion.	Climate (c) – short growing season through regular rainfall events (p).	Climate (c), water (h) erosion.	Water (h) erosion.	Water (h) erosion and imperfect soil drainage (d).	Imperfect and poor soil drainage (d).
Land Capability Classes	7, 6	5	5 ,	2	2 , 3	3	4	4 , 5

Figure 14. Stylised cross-section from Green Point east to Welcome Swamp.

In 1944 Hubble conducted reconnaissance investigations in the Montagu and Dismal Swamp areas to determine the potential for agricultural production. A map was later produced for the Montagu Swamp area at a scale of 1 inch to 20 chains. Hubble later undertook reconnaissance soil mapping of the coastal heath country and produced a map and accompanying report (Hubble 1951). The report provides comprehensive soil descriptions of the common soil types found. While the report has been extremely useful, the accompanying map provides only a very rough indication of soil boundary locations. This is due to poor correlation between the original base map used and modern day map base information.

Stephens (1967) surveyed an area to the north of Christmas Hills as well as Brittons Swamp producing a report for each area. Even though the author refers to maps within these reports, none have been located. Whilst most of the study near Christmas Hills is outside this study area, the soil descriptions within the report have proved useful for identifying soils in other areas on similar parent materials.

Another study originally undertaken by CSIRO Division of Soils in 1946 and later published by Hubble and Bastick (1991), is the Soils and Landuse of the Mowbray Swamp Area. This area was mapped at a scale of 3 inches to 1 mile (1:21 120) also with a view to describing and assessing agricultural potential of "undeveloped land" in the neighbouring Smithton district. This report has provided valuable soil chemistry data, assisted with the identification of soils types and provided excellent information on specific restrictions to agricultural production in areas of the Hunter area with similar soils.

The land systems report by Richley (1978) has also assisted with identifying soil properties that limit agricultural use of the land in areas where no other soil information is available.

The text, Forest Soils of Tasmania by Grant *et al* (1995) also aided in the identification of some soil types, especially those formed from Precambrian and Cambrian parent materials.

These studies have all been used to better understand the soil and landscape processes and assist with land capability boundary placement especially where land capability boundaries reflect change in soil properties. General characteristics of the major soils are described in the following section and readers are referred to the references above, if more detail is required.

The following sections refer to the major soil types by their local name or their classification according to the Australian Soil Classification (Isbell 1996). In some cases the classification terminology developed by Stace *et al* (1968) is also used.

5.5.2 Soils of the Hunter Area

Soils of the Coastal Dunes

A range of soils occur within this landform and have been described by Hubble (1951) and Richley (1978). They include soils with negligible profile development on the active dunes and sand blows and those with small accumulations of organic matter in the topsoil underlain by a deep leached horizon of pure sand (Rudosols). These soils are found immediately behind the beaches of the west coast and on the north western shores of Walker and Robbins Island.

In areas where sand has become stabilised, Tenosols occur. These soils have a dark sandy loam A1 horizon to approximately 30cm, overlying a highly leached light grey or yellow-grey sand. These soils correlate to the Warra sands described by Hubble (1951) and usually support native woody vegetation or have been partially cleared for grazing. An obvious fibrous root mat occurs in the A1 horizon as plant roots tap into the most fertile part of the soil profile. C horizons are often composed of fine shelly material with some secondary calcium carbonate that has been leached from above (Hubble 1951).

At inland locations, especially on the older stabilised dunes that once represented old shorelines, giant Podosols have formed (see Photo 3). Yellow brown sands with tongued Bhs horizons (accumulations of iron and organic material) are prominent characteristics of these soils. These soils are non-calcareous and are sometimes capped by more recent aeolian sand that appears to have filled in old root channels.

Photo 3. Giant podosols have developed on the older remnant dunes (GR E 305525, N 5468425).

In areas where the dunes are calcareous, due to the accumulation of shell fragments, more Tenosols are found. These soils have been described by Hubble (1951) and Nicholls (1955) as Pellree sands and are identified near Woolnorth Homestead. These soils have compacted and distinctly red brown, fine sandy loam topsoils directly overlying a light yellow, shelly sand. The distinct and sharp colour change between the red/brown upper portion of the soil profile and the underlying shelly horizon is believed to be caused by the pH gradient and its effect on the mobility of iron. pHs greater than 7 are common in the C horizon and this horizon is quarried for soil conditioning purposes by the land holder. Similar soils located in the depression have clay B horizons and are described by Richley (1978) within the "Homestead" Land System.

Soils of the Coastal Sandy Heathland

The soils of this group correlate to the "Sandy Heath" soils described by Hubble (1951) and by Hubble and Bastick (1991). They include a range of Aquic Podosols and Hydrosols, Organosols and soils described by Hubble (1951) as "Marsh" or “Meadow” soils that classify as Dermosols.

The dominant soil type within this landform is the Woolnorth Sand and Woolnorth Peaty Sand. The Woolnorth sand usually has a dark grey to black sandy loam A1 horizon to approximately 20cm over a bleached, grey, fine sandy A2 horizon that is often but not always underlain by a dense, humus rich Bh horizon. The origin of this horizon is considered to be organic material from higher in the soil profile, that has over time been transported down and accumulated just above the height of the groundwater table (Hubble 1951). Below the Bh saturated white, grey or brown sand generally occurs. Where sufficient organic material has accumulated to form a pan like structure within the soil, vertical soil drainage becomes impeded resulting in surface ponding. Waterlogging also frequently occurs due to high groundwater levels, especially after periods of heavy rainfall.

The Woolnorth Peaty Sand occurs in wetter landscape positions such as the small and often subtle depressions that are scattered through the plain environment. The accumulation of organic matter from swamp vegetation species at these locations has resulted in the characteristic peaty textures.In such areas improved for pasture production these depressions have been cleared of their native vegetation and cultivation has partly mixed the peaty layers with the underlying sands.

Another sandy profile identified in the area is the Lupari Sand. This soil is often found in linear sand ridges especially at the northern end of the Harcus road. The original route for this road in fact, followed the tops or sides of these ridges because their freely draining nature and raised position reduced the risk of vehicles becoming bogged. The Lupari sand can be easily distinguished from the Woolnorth Sand by the presence of a lighter coloured, less organic topsoil and a very deep underlying A2 horizon of highly leached sand. This horizon is highly erodible by both wind and water.

Other soils found within the coastal Heathland include shallow, sandy and often skeletal soils (Rudosols). These are found in areas where Precambrian parent materials occur close to the surface and have subsequently been covered by windblown sand. They correlate with the soils of the "Stony Heath" described by (Hubble1951). These soils tend to be highly susceptible to both wind and water erosion if disturbed, especially on small banks and where soils have developed thixotropic characteristics in the A2 horizon. In some areas deeper, gravelly variants may be found. Most areas are often characterised by stunted heath vegetation due to poor nutrient status, shallow rooting depth and low pH. In the small gullies better drained, deeper soils are indicated by groves of Eucalypts

Within the areas of stony heath soils, as well as in some locations of the sandy heath country, acid peaty soils (Organosols) occur in closed depressions and in areas with restricted drainage. These Organosols are similar to and correlate well with the Loira Peat, described by Hubble and Bastick (1991), in the area of the Mowbray Swamp near Smithton. Typically fibrous in nature these peat soils vary in depth depending upon the landform they occur in and often sharply overlie bleached raw sand or Precambrian rock, stones or gravels. A pH of 3.5 and 4 is not uncommon in these areas. Other areas formed under Manuka Swamp, such as Richardsons Flat, have deep peaty profiles but have slightly higher natural pH values of around 4.8 possibly reflecting the different vegetation from which the peat has formed.

Soils of the Inland Drainage Basins

These areas include the Montagu (Togari area) and Brittons Swamps lying in the south of the survey area as well as the large drainage depression lying between Grunter and Buckbys Roads. The publications by both Hubble and Stephens have provided a comprehensive list of major and minor soils of the Montagu and Brittons swamp area together with their identifying characteristics in these areas. The complexity of the soil pattern is noted by Hubble (1944) "There is considerable variation in the nature of the soils of the swamps from organic soils (peats) through to highly organic mineral soils to soils containing relatively little organic matter. Textures range all the way from sands to clays." It is due to this variety of soil types and the complexity of the pattern that the soils in these areas have been broadly grouped for the purpose of this report. Their topographic and landscape relationships, that are important to soil formation and their identification are addressed below.

At Brittons Swamp mainly clay soils are found. These soils have formed from sediments sourced from the surrounding mudstone hills as well as minor and localised volcanic intrusions. In the better drained locations such as small banks and rises, brown clay loam textured soils with imperfect soil drainage occur. These soils classify as Dermosols and Kandosols due to their deep clay B horizons with variable structure and sometimes very little topsoil development. These soils are often found in combination with heavier clay soils or silty clay soils in areas of poorer drainage (Hydrosols) such as in small depressions or at the base of the surrounding hill slopes in areas affected by run off waters from the hills (See Photo 4).

Photo 4. Intricate soil patterns are a feature in parts of Brittons Swamp (GR E 326200, N 5462350).

At Montagu Swamp, or Togari as it is known today, the soil types are even more varied and include sandy soils and profiles with silty clay topsoils. Closest to the hills where clayey alluvium has been deposited, heavy brown and grey clay soils have formed similar to those at Brittons Swamp (Dermosols and Kandosols). On the western side of the basin the clay soils have a deeper loamy topsoil than the eastern basin margin. The different mineralogy of the adjacent Cambrian sediments as well as aspect may be responsible for this difference. These soils correspond to the Scopus Clay soil described at Mowbray Swamp (Hubble and Bastick 1991). They have very low permeability and when combined with depressions in the landscape they become poorly drained (Hydrosols).

The Togari area is lower in elevation than Brittons Swamp and contains soil types associated with the sandy plain environment. Podosols such as the Woolnorth Sand are found on the flatter ground along side Lupari sands on the banks and rises. Some soils are underlain by clays or dolomite rock that severely impedes drainage and results in very high groundwater heights (Hydrosols).

In the lower areas of the now cleared swamp the soils are a mixture of peaty sands and peaty loams. Fen peat similar to the Mella Peat, (Hubble and Bastick 1991) is found in the northern parts. This soil type represents the best agricultural soil in the area and most likely indicates the heart of the swamp prior to improvement. This deep and sometimes fibrous soil can also have pH measurements of 7.5 and higher. Fen peat classifies as an Organosol.

Some of the peat soils in this area however have been found to contain pyritic materials (acid sulphate soils). Intensive drainage of these soils can lower water tables to a point where air reaches these materials causing oxidation of sulphides. A by-product of this oxidation process is sulphuric acid and pH's less than 3 have been recorded. The highly acidic leachate is often flushed into water ways and drainage ditches by rainfall especially after a long dry period, and can severely impact upon water quality for stock and for other downstream users. The extent of the sulphidic sediments in this and other areas of the Hunter survey area is currently unknown and detailed investigation is strongly recommended prior to any future drainage development.

Other naturally acid peats and sandy peaty soils (pH 4) occur to the north west in an area yet to be cleared of Button grass and heath species. These soils correlate to the Loira Peats of Mowbray Swamp that are also very poorly drained in their natural state. The presence or absence of pyritic materials in Loira Peats has yet to be determined.

Soils at the southern margins of the basin adjacent to Paceys and Eldridge Roads are siltier in texture and are poorly drained without intensive drainage. They have little natural structure and can hard set if careful stock and traffic management is not practiced.

Soils of the Tertiary Hills and Plateaux

Relatively deep, well structured and well drained soils have formed upon the Tertiary basalt hills and plateaux at Marrawah, Redpa, Christmas Hills and Flat Topped Bluff with some small areas occurring on Robbins Island. They include soils formed *in situ*, intergrade soils or soils formed from basaltic talus material. Most of these soils correlate well with the profiles described by Loveday and Farquhar (1958) and Stephens (1937) and these descriptions have been used in identifying similar soils found within the survey area.

Although these soils are similar to the Lapoinya clay loams described by Loveday and Farquhar (1958), some have formed from different parent materials other than in-situ volcanic lava flow basalts. The soils at Marrawah and Redpa are typical of this and have formed from mainly pyroclastic materials, breccias, ash and lavas that have erupted under the sea. These soils have a high proportion of weathered fragments throughout their subsoils and are therefore very highly permeable. The well drained soils have brighter, redder profile colours (Red Ferrosols) while those in wetter areas such as closed depressions or footslope positions have browner, duller colours with mottled clay subsoils with occasional manganiferous nodules (Brown Ferrosols). These soils are more favoured for grazing and occasional cropping purposes rather than solely intensive crop production due to the changeable nature of the topography, soil moisture and increased stone content. On the steeper basalt escarpments mass movement and slumping becomes a risk.

A small area with soils formed from Tertiary limestone occurs east of Fairview Road at the base of the large ridge that forms Coffeys Hill. Being strongly structured throughout the profile these soils classify as Dermosols. A typical profile has a clay loam topsoil over a medium clay subsoil. They have pH's approaching neutral and are characterised by sporadic rock outcrop and the abundance of weathered rock fragments within the soil profile.

Soils of the Cambrian Hills

A variety of soils developed from Cambrian material occur in the Hunter area, reflecting the range of parent material that occurs. They can be divided into two main groups: i) soils formed from volcanic material, and ii) those formed from sedimentary rock including siltstone, mudstone and greywacke.

The soils formed from Cambrian volcanic rocks are found in the West Montagu region and share many soil properties with soils developed from Tertiary volcanic materials. Found on gentle to moderately sloping land these soils have gradational, well drained profiles with good structure but their depth to clay subsoil or weathered rock is often shallower and more variable than their Tertiary relatives. They classify as Red Ferrosols and are very similar to the Minnow Soil and Gawler Profile classes described by Hill *et al* (1995).

Much of the land with soils formed from Cambrian siltstone, and greywacke tends to occur higher in the landscape. The soils that have developed generally have shallow topsoils and extremely compact subsoils (Kandosols). The soils include the Farnham and Fagan Soil Profile classes found also in the neighbouring forested areas by Grant *et al* (1995) and are described as podsolised clay soils by Hubble (1991). Many of these soils are to be found on Hays and Bonds Tier as well as the hills east of the Montagu River.

Elsewhere on toe slopes and fans, deeper, less stony, moderately structured soils occur. These are the best Cambrian soils formed from mudstone. They classify as Brown Dermosols and can intergrade quite intricately with the surrounding poorer soils described above. These soils are similar to the Castra soil association described by Hill *et al* (1995). Despite their good natural structure (in their native state) this structure soon degrades under agricultural activity.

Soils of the steep Precambrian Hills and Peneplain

Very poor soil depth and fertility are typical of soils from Precambrian age parent materials. A variety of soil types occur, with a wide diversity of topsoil depths, structure and profile textures.

The best soils are formed from argillaceous Precambrian sediments on peneplain and lower slopes of the steep hills south of Marrawah. Shallow yellow clay soils support stunted eucalypt forests at these locations. The soils have been described by Richley (1978) as brown duplex soils developed on Mudstone and by Nicholls (1955), in a study further south, as yellow podzolics. They range in their classification from Kurosols to Tenosols and Chromosols. These soils occur under native vegetation at Black Bull Scrub and Jim Crowe Scrub, adjacent to the Arthur River Road, while north of Buckety Flats they have been at least partly cleared for grazing and timber. The most common soil found has fine silty topsoil that is grey in colour and very shallow. Sometimes topsoil was found to be absent due to water erosion most probably occurring after fire or clearing. Below, a yellow brown, slowly permeable clay poses a tough barrier for deep root development.

Poorer soils occur on the hills and ridges of Robbins and Walker Islands and in a small coastal area south west of Marrawah (near Coles Lookout). Here a thin capping of windblown sand has covered highly eroded Precambrian siltstone formations. These areas are highly susceptible to wind and water erosion should vegetation be removed or burnt and the landscape is characterised by sporadic rock outcrop.

5.6 Vegetation

Much of the vegetation information below has been prepared from observations and identifications made during the fieldwork. Texts by the Launceston Field Naturalists Club (1992) as well as Kirkpatrick and Backhouse (1997) have assisted in field identification. Some general facts and climatic relationships have been noted from personal communications with landholders and from Richley (1978).

Whilst the expanses of unstable coastal dunes remain largely un-vegetated, the calcareous sandy soils of the coast support a range of species typical of open heath; namely Scented Paper-bark *(Melaleuca squarrosa*), Smithton peppermint *(Eucalyptus Nitida)*, Bracken (*Pteridium esculentum*), Honey-suckle *(Banksia marginata)*, Coastal Tea Tree (*Leptospermum laevigatum)*, Scrambling coral fern and Currant bush (*Leucopogon parviflorus*). In many places small swamps occur immediately behind active dune systems and on the coastal plains and are defined by bands of closed paperbark scrub.

Growth of vegetation on the numerous bluffs along the coast, the most significant of which is Bluff Point, is severely inhibited by the forceful prevalent westerly winds. Despite this, Paperbark (*Melaleuca spp.)* occupy most of these sites and Eucalypts and Bracken are observed to grow in areas of better-drained or deeper soils.

On the extensive sand plain landform, typically open heath and sedge communities are found. The vegetation here includes *Melaleuca squarrosa*, Manuka (*Leptospermum scoparium), Leptocarpus tenax*, Tassel cord rush, Juncus spp. with some areas of Button Grass (*Gymnoschoenus sphaerocephalus*) in poorly drained sites (Photo 5). Within more

Photo 5. Buttongrass, sedges and heath are found in the wettest depressions while on better drained rises Eucalypt species and low scrubby heath predominates (GR E 321900, N 5472900).

elevated areas, and upon better drained sandy soils, open forests of *Eucalyptus nitida*, Swamp gum (*Eucalyptus ovata)* and White Gum (*Eucalyptus viminalis*) occur. Nearer to the coast and over the expanses of tidal flats the salt tolerant shrub *Arthrocnemum aruscula* and *Sueda australis* prevail.

On the areas formed from tertiary basalt, namely the north-east of Robbins Island, Bluff Point and the area immediately surrounding the settlement of Marrawah, much of the native vegetation has been cleared to facilitate agricultural activity, particularly grazing. It is possible to infer from the small remnants that the original vegetation included a closed scrub of *Melaleuca spp.* in poorer drained areas, and *Eucalyptus* forest on Robbins Island. Around Marrawah it is apparent that the natural vegetation comprised of areas of Stringybark (*Eucalyptus delegatensis)* forest with an understorey of Blackwood (*Acacia melanoxylon*) and Dogwood (*Pomaderris apetala)*, while on the poorly drained soils *Eucalyptus ovata* dominated.

Further inland in areas of soils formed on Cambrian rock sequences, and typically in areas of relatively high rainfall tall forests of *Eucalyptus delegatensis* occur above an understorey of *Acacia melanoxylon*, Lancewood (*Phebalium squameeum)*, Myrtle (*Nothofagus cunninghamii***)**, and Sassafras (*Atherosperma moschatum*) with Soft Tree Fern occurring in drainage lines.

On the north-south ridges of Precambrian quartzite and siliceous strata extending from Robbins Island and appearing in isolated instances further south, open heath dominates. Stunted *Leptospermum nitidum*, *Gymnoschoenus sphaerocephalu*, *Xyris operculata, Leptocarpus tenax* and *Sprengelia incarnata* are common.

5.7 Land Use and Major Industries

Agricultural activities dominate land use within the Hunter area and also represent the most significant sector of the regional economy. Grazing activities, forestry and occasional cropping account for most of the areas' revenue, while secondary industrial activities occur infrequently and on a small scale. A recent growth in the tourism industry is increasingly contributing to the regional economy.

Dairying is by far the largest of the grazing activities in the region. Beef and some sheep production also occur. Large portions of land are still being developed through clearing of native vegetation together with improvements to land drainage. Hump and hollow drainage has been implemented throughout large parts of the study area in order to maximise the use of what would otherwise be seasonally waterlogged land.

Commercial cropping activities occur occasionally in areas of low relief and better soils. Principally these areas surround the settlements of Marrawah, Montagu, Togari and Woolnorth. Short growing seasons and the cost of establishing infrastructure to support cropping has limited the success of cropping in the region. Other influences that have affected the decisions of landholders whether to engage in cropping include the availability of irrigation water, traditional attitudes and the contractual policies of large processing companies. In the past, commercial crops of potatoes, peas and beans have been grown, though poppies are now grown most widely. All agricultural produce is transported by road to markets outside the study area.

Forestry areas comprise much of the south east of the survey area and their use includes both plantation and native forest. Recent trends have seen increased use of private land to establish plantations. Logs are generally processed for timber or pulp in Smithton and Burnie respectively.

This part of the north west coast offers a variety of recreation activities including surfing, fishing, camping. With this has emerged a growth in the tourism industry for the region. A number of other attractions for visitors exist and include a number of conservation areas, the Arthur Pieman Protected Area and the Dismal Swamp Nature Area. Areas with heritage values include West Point aboriginal area and Preminghana.

6. LAND CAPABILITY CLASSES OF THE HUNTER MAP

The following sections of this report describe the different classes of land that have been identified during the course of the survey. General information on the nature of the land, soil type and geology are given together with an indication of the major limiting factors and any other information that is considered relevant. Each class is described according to broad geological groups found within it.

For each class of land a simple diagram is presented indicating the distribution of that land class across the map together with a table listing the total hectares that each occupies. These diagrams and tables include all complexes that occur in combination with that class.

Figure 16 shows the spread of land capability classes recorded within the Hunter area together with their proportion of total map area. Class 5 land is the most abundant making up 50.4% of the Hunter area. No Class 1 land was identified within the area and Class 2 represents the smallest class (1.2%).

In calculating the class percentages for Figure 16, complex areas where two capability classes are identified have been split 60:40 and the relative proportion of each combined with the appropriate class. For example, the total area of Class 2 land equals "the total area of Class 2 + (60% of the area of Class 2+3) + (40% of the area of Class 3+2)".

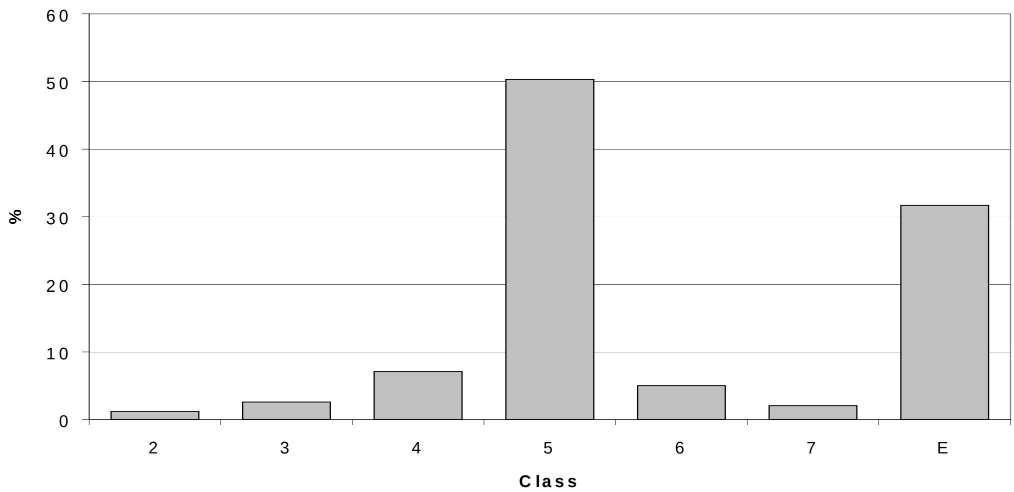


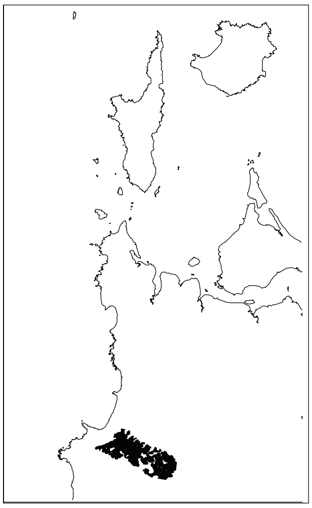
Figure 15. Percentage of each land capability class identified within the Hunter area.

6.1 CLASS 1 LAND

No Class 1 land was identified within the Hunter due to the high risk of soil degradation.(s). This elevated risk is the result of a significant number of rainy days occurring during the year (see page 22) causing the soil to be above the ideal plastic limits for cultivation, planting and harvest machinery for longer periods of the year.

6.2 CLASS 2 LAND

Class 2	181ha
Class 2+3	584 ha
Class 3+2	1924 ha



Class 2 land is found in an area immediately east of Marrawah extending to Station Hill in the west. Here the terrain ranges from level to gently sloping (<12%) at an elevation of approximately 100-110m. Minimal frost risk and deep, freely draining fertile soils result in these areas being suited to intensive agricultural uses. The relatively long growing season allows for a wide range of crops but is impacted by the high frequency of rainfall events that make timely paddock preparation and harvesting difficult to achieve. The main limitation for this area is therefore dominantly a climatic one ((p) rainfall frequency), but sheet and rill erosion risk (h) also occur on the steeper hillslopes.

Class 2 Land on Tertiary Volcanics

Areas of Class 2 land on Tertiary basalt occur on gently sloping land (<12%) east and north east of Marrawah, adjacent to the Comeback and Harcus River roads. This land is characterised by almost level ground and the occurrence of Red and Red/Brown Ferrosol soils often containing some weathered fragments of parent material that pose no problem to the cultivation of this land.

The main limitation for these areas is a climatic one. In early spring and up to mid October farmers experience frustrating interruptions and delays to planting activities from the occurrence of regular rainfall events. This is a characteristic for this part of the West Coast. These rains raise soil moisture levels above the limit that allows machinery to operate without resulting in wheel spin, smearing and structural degradation of the soil. Due to the regularity of these rain events a farmer may wait a number of days some times weeks for paddocks to dry out as moisture levels keep getting "topped up" with each successive rain event. A similar climatic limitation also occurs at the end of the season resulting in delays to harvesting.

Much of this land is used for grazing activities that do not reflect the high land capability rating. This reduced intensity of use can be attributed to a shortage of water, lack of suitable dam sites for irrigation water storage, social preference and current commodity prices. The fact that vegetable companies will not contract for potatoes without the availability of irrigation water is another reason for the under utilisation of this land. These factors, although important in determining the use of this land, all fall outside the scope of this study and are therefore ignored in the classification process. This Class 2 land is an area currently used below its agricultural capability and represents one area that could accommodate possible expansion of the cropping industry should the above influencing factors alter in the future.

Where slopes are steeper (5-12%) paddocks become susceptible to sheet and rill erosion (h) at times when vegetative cover is absent such as before crop emergence, particularly when erosion minimisation measures have not been implemented. Such areas are found at the fringes of the flatter Class 2 land. (Photo 6)

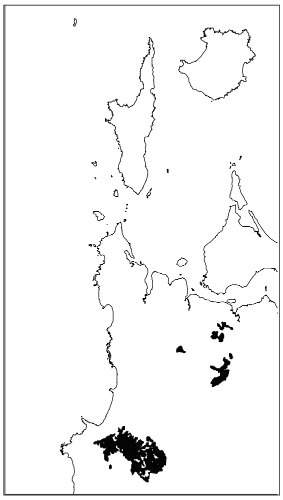
Complexes (2+3)

Areas of Class 2 and Class 3 land on tertiary volcanics are found intermingled on the Hunter map. The main areas occur south and south east of Marrawah and near Dunns Road at Christmas hills. These complex units are predominantly found on rolling hill country where the risk of sheet and rill erosion, caused by short, changeable slope gradients ranging from 5-18%, influence agricultural use. Class 2+3 land is also found where drainage status of the soil changes frequently over a relatively small area. These areas have mainly been identified in low landscape positions where land with moderately drained soils (d) is found adjacent to land with better drainage and limited to Class 2 by high rainfall frequency (p) (Photo 6).

In some areas the changeable nature of the topography (x) also impacts agricultural land use by making cultivation and the passage by planting and harvesting machinery awkward. This terrain also makes the implementation of erosion minimising structures very difficult to achieve. The implementation of such structures is necessary if cropping of this land is intended.

6.3 CLASS 3 LAND

Class 3	1367 ha
Class 3+2	1924 ha
Class 2+3	584 ha
Class 3+4	76 ha



Class 3 land has been identified on both Tertiary and Cambrian volcanic parent materials which have weathered to form deep, freely draining soils. Landforms tend to be gentle to moderately steep and rolling, with slopes ranging up to 18%. The dominant limitations to agriculture in these areas are erosion (h) gravelly soil (g) and topographic variability (x). The majority of the Class 3 land in the Hunter area is found in combination with Class 2 land.

Class 3 Land on Tertiary Volcanics

Small areas of Class 3 land on Tertiary basalt occur south of Marrawah and Redpa. Here land is limited by erosion risk (h) (see Photo 6), topographic complexity (x) and stoniness (r) (see Photo 7). A small area of Class 3 land also occurs east of the Bass Highway and Arthur River Road junction. At this location red soils with sandy loam to sandy clay loam topsoils occur on slopes exceeding 12%. The combination of this soil texture characteristic and the slope gradient increases the risk of water and wind erosion should this land be cultivated. Retention of organic matter and minimum tillage techniques are recommended if working this land even for pasture restoration.

Areas of Class 3 with red clay loam soils are found along Hortons Road and to the south east where a thin cap of volcanic material covers the underlying Cambrian sediments. These areas are often stony (g) and have a topographic limitation (x) due to the

complexity of slope gradients. Both these characteristics impact upon cropping machinery and make working this land more difficult.

In areas surrounding Kings Road an expanse of flat to gently sloping land effected by restricted drainage conditions (d) due to its low landscape position and proximity to the steeper hillslopes to the west. This delays early paddock preparation in most years.

Other land with red clay loam soil but overlying quartzite rock is found south of Chequers Road. These areas also suffer from stoniness (g) and topographic limitations (x), and from rock outcrop (r). Other land limited by water erosion risk (h) is also found on the steeper slopes. This combination of limitations requires land mangers to carefully plan paddock layouts to avoid the poorer areas. Within steep and stony paddocks that are to be used for cropping the construction of erosion prevention structures aimed at handling surface run-off, as well as undertaking further stone picking, is advisable in order to minimise soil erosion and wear on machinery.

Class 3 Land on Cambrian Parent Material

Land inland of West Montagu in the vicinity of Buckbys, Boundary and Redbank Roads has also been classified as Class 3. These areas occur on Cambrian basalts and other related volcanic material that have weathered to form well draining, red clay loam soils on gently to moderately sloping land <18%). While little published information exist regarding these soils they appear to be somewhat shallower than their tertiary basalt relatives with and increased abundance of stone fragments through out the lower portion of the soil profile. These stones create wear on tillage implements but do not prevent tillage from occurring. Where soil profiles are stone free and slopes increase over 12% water erosion risk (h) becomes the dominant limitation. The relative high quality of the land in this area has already been recognised both by local farmers at West Montagu and plantation forestry companies further inland.

Complex Classes (3+2 & 3+4)

In some areas such as south of Redpa, Class 3 land on Tertiary volcanics that is limited by erosion risk (h) and by general topographic complexity (x) has been mapped as a complex with Class 2(h) land that occurs on gentler more uniform slope gradients. At Kings road Class 3 land with a moderate soil drainage limitation has been mapped as a complex with better drained Class 2 land limited by the high frequency of rainfall which inturn causes management problems.

At Caseys Road and immediately west of Harcus Hill a complex of Class 3+4 land is identified where slope gradients vary between 12 and 45%. In these areas it is usually the gentler footslopes which comprise the better agricultural land (Class 3).

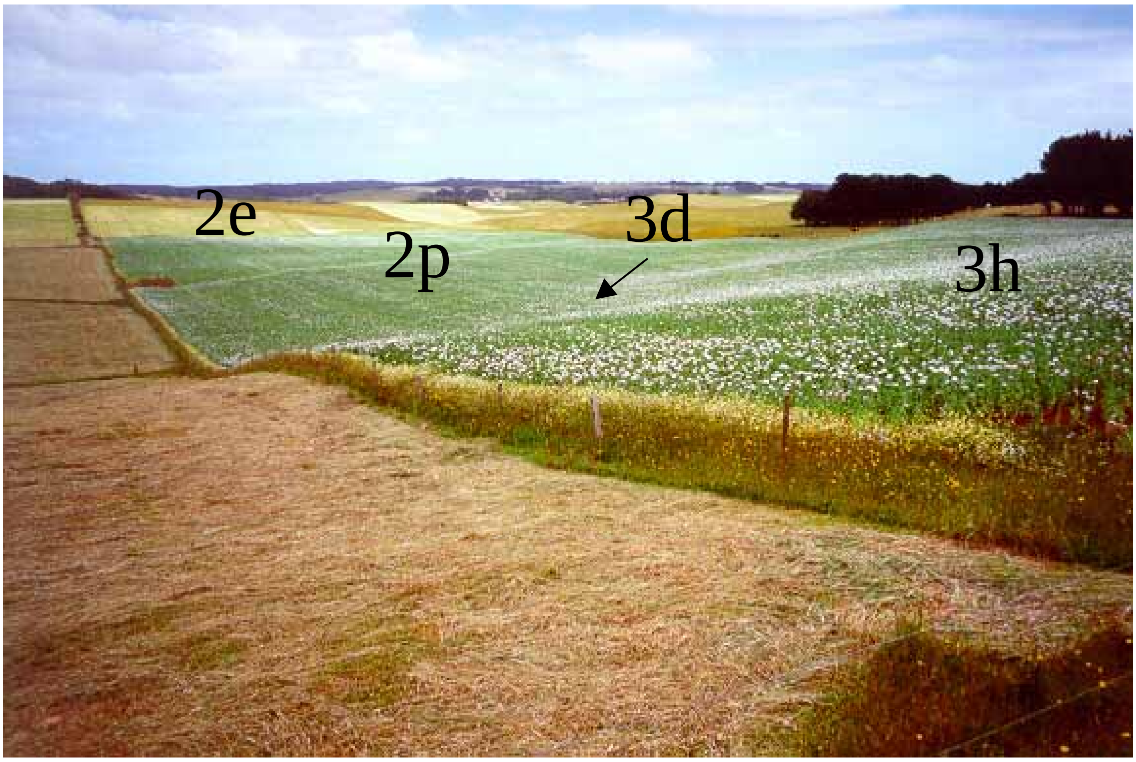
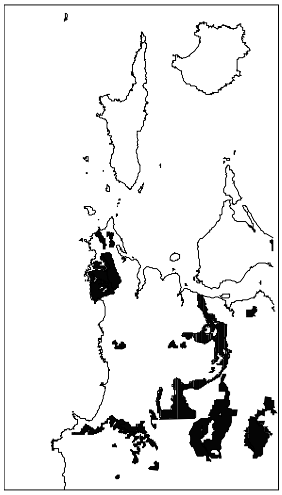


Photo 6. Examples of Class 2 and Class 3 land on Tertiary volcanics, and their respective limitations. (GR E 307500, N5467000)

Photo 7. Stony Class 3 land on Tertiary volcanics (3g).
(GR E 310650, N 5465525).

6.4 CLASS 4 LAND

Class 4	2517 ha
Class 3+4	76 ha
Class 4+5	5067 ha
Class 5+4	5060 ha



Class 4 land is found in the north of the study area near Woolnorth homestead, Montagu, Christmas Hills and in the Redpa region. It is found on a range of parent materials comprising Tertiary basalt, Quaternary Alluvium and Cambrian sediments. A substantial area of Class 4 land has been mapped with Class 5 land where the topography is complex and where the soil and drainage characteristics are of a very changeable nature.

Class 4 Land on Tertiary Volcanics

Class 4 land on Tertiary basalt has been identified where slope gradients are between 18 and 28%. These include the steeper hillslopes west of Fairview Road, Seymour Hill near Redpa as well as small areas of the Prospect Hills at Woolnorth. These hills are limited by erosion risk (h) and represent areas where occasional cropping could be undertaken but only with the implementation of appropriate soil conservation measures. If used for cropping these areas require erosion control structures to be established within the crop to control water erosion and special attention to paddock layout, with respect to the passage of cultivation, planting and harvesting machinery. Some areas also have quantities of stone within the soil profile or isolated rock outcrop that may cause wear to cultivation machinery.

Other Class 4 land on Tertiary basalt include the hillslopes surrounding and to the north of Kings Hill. While these hills also contain some steep gradients (>18%) this land is restricted by the complex nature of the topography (x). This "broken country" makes paddock planning and preparation for cropping almost impossible and was indicated by local farmers as "almost impractical".

A small area of Class 4 land has been identified at Bens Hill. While this area has been identified as a Tertiary basalt outcrop, the only soil property that resembles the clay loam Red Ferrosols found elsewhere is the red colour. The soil that occurs has a fine sandy loam texture and is highly erodible (h) by water movement on slopes of 5-12%. Evidence of soil accumulation against fences at the base of the slopes was noted at a number of locations. With these lighter textured soils this land also is limited by a wind erosion risk (a) due to its level of exposure to strong prevailing wind

While most slopes are within the 5-12% range, small areas of flatter land and those in more sheltered positions classify as Class 3 but are too small to represent at this scale of mapping, these therefore have been amalgamated within the Class 4 map unit.

Class 4 land on Quaternary alluvium

A large area of Class 4 land on clay textured alluvium occurs on the Woolnorth property (Photo 8). It is found on the plains on the eastern side of Prospect Hills extending more or less to the Woolnorth Road and airstrip. This area is almost entirely level with the occasional and subtle sandy rise. These clay soil areas are very fertile and have previously grown excellent crops. However, their drainage characteristics delay access in early spring resulting in risky late harvests in the following autumn. Severe soil compaction and loss of soil structure results in further restriction to soil drainage after wet working these areas. Short rotation crops are more suited to this land to avoid degradation. Grazing of this land during the wettest winter months should be minimised to retain soil structure and minimise damage from pugging.

Photo 8. Class 4d land on Quaternary clay alluvium.
(GR E 309000, N 5490000)

Another Class 4 area on Woolnorth property includes an area of deep peaty sand at Red Marsh (Photo 9). These soils are generally limited by poor drainage but cropping on large raised beds have improved drainage and has enabled poppies to be grown, but not without some losses from wetness.

Large areas of Class 4 land on Quaternary alluvium occur at Brittons swamp and within the Togari area. At Brittons Swamp areas of imperfectly drained red/brown soil with clay subsoils occur on the slightly raised banks throughout the area. Their clay subsoils impede drainage through the soil profile and causes surface ponding leaving the land wet, often well into spring.

At Togari areas of alkaline to neutral peat soils and imperfectly drained soils with clay textures occur interspersed within the low lying land with sandy soils. These soils represent the better drained and more productive land in this area. The largest extent is found at the margins of the Togari basin below the surrounding hill slopes, while the peat occurs mostly north of Renison Road.

Photo 9. Class 4d on Quaternary alluvium (peaty sand).
(Gr E 309050, N 5479400)

Factors that compound drainage further in this area are the low gentle gradients, high winter rainfall (c) and high ground water (d), all of which keep soils wet for very long periods of the year. Land managers therefore have only a short working window each year to prepare the ground and sow crops, at a time that will allow an early and successful harvest. Many farmers have described years when delays to paddock preparation in the spring have resulted in late harvesting and crop losses from water logging. Some at times have had to resort to hand harvesting (in the case of potatoes) to avoid entire crop loss.

Other smaller areas of Class 4 land on Quaternary alluvium include those near Redpa adjacent to the Welcome Swamp Road, south east of Hortons Road, a small area on Bucketty Flat and east of Bowood Hill. Imperfectly drained soils and their associated short window of opportunity for paddock preparation and harvest also impact these areas.

Class 4 Land on Cambrian Siltstone, Mudstone and Greywacke

On the gently sloping hills and footslopes of Hays and Bonds Tier, as well as those of Brittons Hill and the Christmas Hills, Class 4(s) and (d) have been mapped. In these areas brown to yellow/brown Dermosols with moderately structured clay to clay loam textures occur. Slowly permeable clay subsoils combined with over 1300mm of rain annually result in these soils being wet for much of the year. Surface run-off from the surrounding hills also compounds the drainage problems in these areas. While some areas have produced good crop yields in the past, these areas have soils with fragile structure, which is easily broken down by regular cropping.

Both degraded soil structure and soil drainage combines to impact upon paddock preparation and harvesting. Land managers need to wait for this land to dry out before working the soil type found on this land. Wet years have prevented some areas from being cropped and reports of crop failure due to the land being too wet to harvest have also been reported.

Where slopes increase to over 18% and where watercourses and gullies dissect the landform, erosion risk (e) takes over from soil drainage as the dominant limitation. This land class includes small areas of Class 5 land limited by erosion where gradients exceed 28%. Maintaining vegetation cover and diverting surface run off water safely into watercourses and drainage channels are all practices that are necessary to keep this land in good condition and prevent degradation through erosion.

Other Class 4 land on this parent material is identified on the very gentle slopes near Riseborough Road. These areas have shallow silty topsoils overlying heavy clay or are underlain by rock at shallow depth, making them only suited to growing the occasional shallow rooting crop.

Other Class 4 Land

Two small areas of Class 4 land are mapped north of the Woolnorth homestead. Here red soil with sandy loam topsoils occurs on very gently undulating land. This land has a high risk of wind erosion (a) and is limited by the lack of reliable rainfall (p) during the growing season. Both these limitations make intensive cropping use of this land risky. The long term sustainability of this land depends upon sound erosion minimisation techniques being implemented during cropping use. This includes minimum tillage, stubble retention and direct drill planting procedures. Yield losses from the droughty nature of these areas occur on a regular basis.

Complex Classes (4+5)

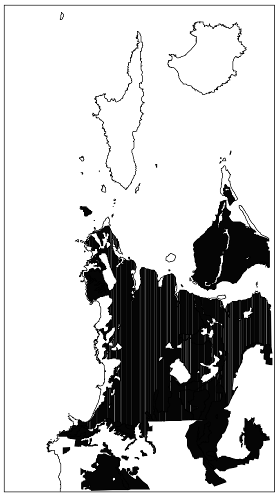
Two main areas of Class 4+5 occur on the Hunter map. The largest is found in the Togari and Brittons Swamp area where drainage trusts have created a highly modified and improved environment for agriculture, and also near Marrawah and Redpa.

In these areas Class 4 land on Quaternary alluvium with imperfectly drained soils is found in association with Class 5 land with poorly drained soil types. In some areas this imperfectly drained Class 4 land is found with Class 5 land limited by highly erodible, sandy soil types.

Other areas of Class 4+5 complex have been identified near Port Hills at Marrawah as well as at Station, Redpa and Mortyn's Hills. Here land with variable erosion risk, rock outcrop and stony soil profiles combine in a intricate fashion.

6.5 CLASS 5 LAND

Class 5	48438 ha
Class 4+5	5067 ha
Class 5+4	5060 ha
Class 5+6	345 ha
Class 6+5	699 ha



Class 5 land is the largest land capability class in the Hunter area. It occurs predominantly on the low alluvial plains of Quaternary age, but also has been identified on all other geological units in the area, either as a single class or within a complex land capability map unit. The dominant limitation to agricultural use of this land is poor drainage (d). Other limitations include wind (a) and water (h) erosion, and other soil quality related limitations such as rockiness (r) and shallow soil depth (l).

Class 5 Land on Quaternary Alluvium

Class 5 on alluvium occurs on the low gently undulating plains that once were entirely covered by heath or swamp vegetation. Clearing and sowing down these areas to pasture has been occurring since early settlement of the region but in recent times modern techniques have resulted in more rapid clearing and draining of these areas mainly for dairy uses but also for beef and sheep production. This land includes most of Robbins Island, the lower catchment areas of the Welcome River, Jims Plain and Swan Bay Plain and a large portion of the Montagu catchment to the east as well as some smaller areas in the south east of the map area.

Due to their low position in the landscape, degree of gradient and number of outflows to the sea, these areas remain extremely wet for all but the driest summer months. High annual rainfall in the upper catchment and run-off from these areas compounds already high water tables on the plain. Cleared areas have utilised open ditch drainage as the standard soil drainage method. Much investment has recently been made in hump and hollow drainage, a method that has seen dramatic results for pasture production mainly due to the creation of greater soil depth which distances the root zone from high water tables and provides enough gradient to shed surface waters. Even with improved drainage the soils of these areas are wet for most of the year resulting in water logging and short working windows (Photo 10).

Class 5 land on alluvium has also been identified where the risk of erosion is high due to the presence of light sandy soils. Wind erosion can and does remove large quantities of soil from paddocks especially during the drier months on sandier soil types if little vegetative cover is left on paddocks. Water erosion also removes large amounts of soil material during rainfall events, especially on land that has higher slope gradients, such as the footslopes of the surrounding hills.

Photo 10. Class 5d on Quaternary alluvium.
(GR E 310450, N 5474800)

These areas also are effected by rapid and regular flushing of nutrients and administered fertilisers from the soil profile due to the high permeability of the soil and the proximity of the water table (s limitation). This constant drain on the fertility and naturally acid characteristic of the soils in these areas requires land managers to top dress with lime and fertilisers regularly to maintain quality pastures.

An emerging concern that will require consideration especially if new drainage works are to be undertaken in these areas, is the potential for some locations to develop acid sulphate soils. If drainage ditches lower the water table sufficiently to allow oxidation of pyritic materials found within the soil, extremely acid drainage waters (<3.0 pH) can result. The drainage outflows from these areas can and have impacted upon water quality at Mella. Early investigations at Togari also indicate a similar risk in this area.

An area of Class 5 land limited by drainage (d) south of Togari and Brittons swamp is characterised by low landscape position and silty loam soils. This area has been less intensively drained by the drainage trusts, or lies outside the drainage trust boundaries. It therefore has not benefited from the improvements evident in the surrounding areas and the soils remain poorly drained. This also includes areas adjacent to the river that are prone to flooding (f) or areas with erosion prone (a) sandy rises.

Poorer areas of Class 5 land on alluvium containing small pockets of Class 6 land that suffer from wind erosion risk (a) or severe drainage impediments (d) are found throughout the Class 5 areas. These areas of Class 6 are too small to map out due to their relative size and have been absorbed into the Class 5 land. These areas containing Class 6 inclusions occur where aeolian sandbanks, dunes and swampy depressions are found in increased numbers such as the highly erodible sandy bank and remnant dunes adjacent to Harcus River Road. (Photo 11)

Photo 11. Class 5 land limited by drainage (d) with areas limited by wind erosion (a)
GR E 3072(00, N 5469125)

Class 5 Land on Precambrian Materials

Class 5 land on this parent material usually has a covering of wind blown sand overlying the parent material. It therefore shares many of the same limitations as Class 5 land on Quaternary alluvium, ie poor drainage (d) due to perched water tables, water erosion (h) and wind erosion (a). This land however, proportionally has more areas where soil limitations such as shallow (l), stony (g) soils or extensive rock outcrop (r) limit the land to grazing activities only (Photo 12). Much of this land occurs south of Marrawah east of the Arthur River Road and also on Robbins and Walker Islands.

Other Class 5 land on Precambrian land occurs in the surrounding hills where the soil types have a shallow silty clay topsoil overlying a clay subsoil with poor structure. These areas represent some of the poorest Class 5 land due to shallow topsoil and rooting depth limitation (l).

Other Class 5 Land

In the centre of the map a ridge aligned north-south extends from West Montagu through to Bonds Tier in the south. This structure contains both Cambrian sediments and volcanic materials and together these rock types produce land with a variety of soil types. The dominant soil type however is formed from Cambrian siltstone. Its shallow duplex nature (s), silty erodible topsoil (h), bleached A2 horizon (s) combined with steep sloping hills up to 45% make this land unsuited to regular cultivation.

Steep land (28-45%) or land with a capping of sandy soil with slopes between 18 and 45% on either Cambrian and Tertiary basalt volcanics or Tertiary Limestone material has been identified as Class 5.

Photo 12. Class 5ra on Precambrian quartzite with Quaternary alluvial deposits.
(GR E 303200, N 5467750)

These areas are considered too steep and erodible for regular tillage other than to cultivate for pasture establishment and renewal. Examples include the steep hillslopes surrounding Brittons Swamp, Port Hills, Prospect Hills and Cape Grim as well as Seymour, Station, Redpa and Mortyn's Hills. Similar areas have been identified on Trefoil Island using aerial photo interpretation techniques.

Complex Classes *(Class 5+4 & Class 5+6)*

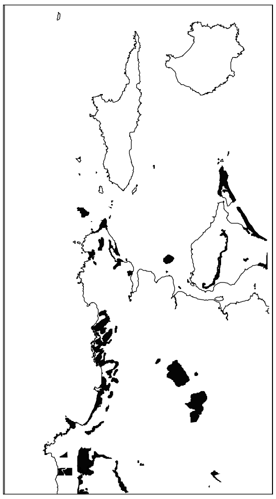
Class 5 land is mapped in association with both Class 4 and Class 6 land. The complexes of Class 5+4 typically occur due to variable erosion risk resulting from variations in the soil type and slope gradient. Examples of this land occur along a ridge containing Cambrian age material between Bonds Tier and Buckbys Road.

On Robbins Island poorly drained land on Quaternary alluvium is found together with very poorly drained closed depressions and swamps creating a complex of Class 5+6.

Additional areas of Class 5+6 land are found south of Redpa where areas with a combination of shallow slowly permeable soils (Class 5 land) and areas with very shallow soil depth, including rock outcrop (Class 6 land), limit agricultural use to grazing only.

6.6 CLASS 6 LAND

Class 6	4146 ha
Class 5+6	345 ha
Class 6+5	699 ha
Class 6+7	971 ha



Class 6 land has been identified where limitations restrict agricultural uses to limited or seasonal grazing activities. Class 6 land has been mapped in high erosion risk areas such as steep slopes or on stabilised sand dune material, or where rock outcrop, soil depth and abundance of stone prevents establishment and improvement of pastures. Areas that have very poorly drained soils or are at frequent risk from flooding or inundation by river or seawater are also identified as Class 6. This land requires the strictest management in order to prevent degradation occurring.

Class 6 Land on Quaternary Sediments

Areas with very poorly drained soils, usually under native vegetation, occur in coastal plain locations. These areas are predominantly found near the coast in swampy depressions behind estuarine mud and sand flats. Here the land is extremely low lying and subject to long periods of wetness due to high groundwater levels and inundation. Inundation from major storm events and spring tides occurs from time to time and combines with sea spray to produce highly saline conditions. When cleared of native vegetation some areas have been sown down to pasture, but these rarely thrive and commonly become dominated by sedges, rushes and other salt tolerant plant species. Due to prolonged high groundwater levels, limited grazing during the drier months is the only sustainable landuse on these poor pastures.

Class 6 land on Quaternary sediments may be found at Shoal and Welcome inlets as well as on Robbins and Kangaroo Island. A small inland area also limited by high ground waters and risk of inundation occurs on the Montagu River.

Class 6 land has also been mapped on the stabilised dunes where vegetation has stabilised sand movement (Photo 13). The prevailing strong westerly wind combined with light textured soils result in wind (a) and water (h) erosion being the major risk to agricultural use at these locations resulting in land that can only sustain light stocking rates. Careful management in order to minimise damage to the shallow organic topsoils and prevent sand blow is recommended in these areas. Examples of such areas are found on the west coast adjacent to the large sand dunes and sand "blow outs" between Studland Bay and Maxies Point as well as a small area south east of Cape Grim and Walker Island.

Class 6 Land on Precambrian Materials

Areas of Class 6 land on Precambrian material have been mapped where the land has very shallow soil (s), is extremely stony (g) or where steep ridges have rock outcrop (r). Both water and wind erosion risk can also become the main limitation in these areas where vegetation has been disturbed.

Photo 13. Class 6 land on low gradient, stable sand dunes on Robbins Island. (GR E 328500, N 5497500).

The largest areas of Class 6 land on Precambrian material are found east and west of the Arthur River Road south of Marrawah, at Jims Plain, Woolnorth Point and on Robbins and Walker Islands. All these areas require careful management and regulation of stock numbers, if used for rough grazing purposes, to avoid degradation. Establishment of improved pastures is all but impossible due to the high erosion risk and stony nature of the soil.

Other Class 6 Land

Small areas of land on both Cambrian and Tertiary volcanics have been identified as Class 6 in areas where very shallow, and extremely stony soils occur or where land is very poorly drained. These areas are found inland of Mount Cameron West, (Preminghana), on hills and ridges that outcrop on the Quaternary plain. The soil depth, drainage status and amount of stone found at these locations prevents land improvement using tillage machinery and restricts land use to rough grazing. Most areas are therefore found left under native vegetation.

Complex Classes (6+5 & 6+7)

Land with complexes of Class 6 and Class 5 land has been identified at Seventeen Mile Plain in the Montagu River catchment. Here a combination of both very poorly drained land dominated by button grass (Class 6d) and land with marginally better drainage covered by heath vegetation (Class 5 land) cannot be separated at the scale of mapping used. North of "Westmore" and at Bucketty Flats, it is the changeable nature of the Precambrian soil type that result in a complex of Class 6+5 being identified. Here soil types with variable stone content and soil depths limit agricultural use.

Trefoil Island is identified as Class 6+5 due to its combination of very steep land exceeding 45% and more gentler land that, with effort, could be improved for pasture production and grazing activities.

Complexes of classes 6 and 7 have been mapped on Robbins Island, Two Mile Sand beach, Green Point and Pavement Point where fragile dune systems occur in association with extremely rocky foreshores and rock platforms. While collectively this area of Class 6+7 is capable of enduring light/seasonal, forage grazing they demand high management inputs with respect to fencing, appropriate stocking rates and duration of grazing. The freely draining nature of the sands also results in these areas being nutrient deficient and very "droughty" in summer. Over grazing and fire in these area has shown to result in severe degradation in other locations of the west coast (Davies 1965).

6.7 CLASS 7 LAND

Class 7	1802 ha
Class 6+7	971 ha

Class 7 land in the Circular Head area represents land that is unable to support agricultural activities on a sustainable basis. Class 7 land has been identified in a number of locations on the Hunter map. Most are associated with sand dunes, steep or rocky land and in estuarine areas adjacent to the mouths of rivers and inlets. The dominant limitation for this land is erosion (wind and water). Other limitations preventing agricultural use include drainage, saline inundation, and rock outcrop. Other areas of Class 7 also exist throughout the Hunter area but are often too small to identify at this scale of mapping these while small are extremely important to acknowledge. They include riparian zones along streams and water courses, rock outcrops and extremely wet, closed depressions or tidal areas.

Class 7 Land on Quaternary Sediments

This land is composed of large unconsolidated and sparsely vegetated beach, sand dune or estuarine environments. These areas support fragile, natural ecosystems that cannot tolerate disturbances that may occur from browsing stock or land clearance.

Active sand dunes, or those that are extremely steep but have been stabilised by native vegetation, are considered too sensitive for any form of agricultural use and have been classified as Class 7(a). Even light grazing of the steep stabilised areas leads to vegetation decline and disturbance of the sandy topsoils, increasing the risk of wind erosion and dune migration. The importance of maintaining native vegetative cover at these locations is paramount. Dune stabilisation is a costly, labour intensive and a rarely successful activity once dune migration has begun. These areas have been identified at Studland Bay and Maxies Point.

Other areas of Class 7 on Quaternary alluvium include those very poorly drained areas on the northern coast adjacent to small inlets and in very low landscape positions. These areas are subject to inundation by water being impeded or "backed up" in drains and watercourses by spring tides and poor drainage outflow. This land supports tussock, sedge and salt tolerant vegetation species that provide little or no feed value for stock. These plants are also very easily damaged if used for forage purposes with may lead to bare ground and erosion. This land is found near the outflows of the Welcome, Harcus and Montagu Rivers, Montagu Island and Swan Bay

Class 7 Land on Precambrian Quartzite

Steep ridges and escarpments of Precambrian age with shallow sandy or stony soils and/or rock outcrop have been mapped as Class 7 land. Severe erosion risk and almost no rooting depth make sustainable agricultural use of this land impossible. These areas occur at Eagle Rock south of Marrawah and White Rock Ridge on Robbins Island.

Other Class 7 Land

This land includes the extremely steep coastal escarpments, sea cliffs and rocky foreshores (Photo 14). Mostly found in the north west of the map area, between Victory Hill and Bluff Point with a small area surrounding Mount Cameron West, these areas are unsuited to agricultural uses due to their extreme gradients and active erosion.

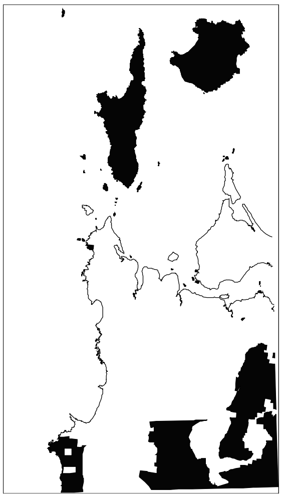
Complex Classes

No complex areas occur where Class 7 is the dominant land unit.

Photo 14. Class 7 land on Tertiary volcanics. (GR E 304000, N 5490000)

6.8 EXCLUSION AREAS

Exclusion areas 33977 ha



The Hunter area contains a considerable expanse of exclusion areas which are not included in the land capability survey. Exclusion areas are land parcels that are not private freehold or unallocated Crown land. The Exclusion areas are categorised into the following groups:

Land administered by the Forestry Commission

State Forest and Forestry Reserves constitute the vast majority of Exclusion Areas within the Hunter land capability map and are excluded from land capability classification. These areas include the Forest Reserves of Bond Tier, Dismal Swamp, Montagu Swamp, Duck River and the areas of State Forest that surround them.

Land administered by the National Parks and Wildlife Act

Several Nature Reserves and Conservation Areas occur within the survey area. The Arthur Pieman Protected Area in the extreme south west of the mapsheet is the most significant in terms of area. Smaller Reserves include the Dismal Swamp Nature Reserve, and the recreation area that exists at Stony Point in the north east.

Aboriginal Sites

The West Point Aboriginal Sites occurs within the survey area, and is excluded from the classification.

Land Administered under the Crown Lands Act

Numerous small reserves are found within the Hunter mapsheet and can be identified as schools, coastal reserves, river reserves, and lands administered by the Commonwealth. Examples include the Montagu River Reserve and the Cape Grim Baseline Air Pollution Station.

6.9 SUMMARY TABLES

A summary of the land capability classes, their land characteristics and the important land management issues for these classes are presented in Table 6. The Table is not intended as an exhaustive list of all the map units identified within the Hunter area. It contains the most common groups within each class and aims to display the link between land capability, the associated land features and the range of limitations that may be expected. The management practices necessary to keep the land within each land capability class in top condition as well as maximising productivity are indicated and a guide to the agricultural versatility of each land class is found in the last two columns of the table.

Land Capability Class	Land Characteristics						Land Management Issues		
	Geology	Slope	Topography and Elevation	Erosion Type and Severity	Climatic Limitation	Important Soil Properties	Main Limitation to Agricultural Use	Main Land Management Requirements	Agricultural Versatility
2	Tertiary volcanics.	0-5%	Gently inclined undulating rises.	Very minor sheet and rill erosion risk.	Minor risk of delays due to rainfall frequency.	Well drained.	Climate (c) rainfall frequency	Soil erosion control and soil conservation practices.	All annual crops and grazing.
2	Tertiary volcanics.	5-12%	Gently inclined undulating rises.	Minor sheet and rill erosion risk.	Minor risk of delays due to rainfall frequency.	Well drained. Some stone.	Erosion- sheet and rill (h).	Soil erosion control and soil conservation practices.	All annual crops and grazing.
3	Tertiary volcanics.	0-12%	Rolling hills and rises.	Slight sheet erosion risk.	Nil	Well to moderately well drained. Stony.	Stony soil (g).	Implementation of soil conservation practices. Stone picking.	Restricted range of crops. Grazing.
3	Tertiary volcanics (sandy topsoil).	0-12%	Moderately steep rolling hills and rises.	Moderate sheet and rill erosion.	Nil	Well to moderately well drained.	Erosion- water (h), wind (a), topographic complexity (x) undulating, broken terrain.	Implementation of soil erosion control and soil conservation practices.	Restricted range of crops. Grazing.
3	Tertiary volcanic	12-18%	Moderately steep hills	Moderate sheet and rill erosion risk	Nil	Some stone freely draining	Topographic complexity (x) changeable slope pattern, Erosion -sheet and rill (h)	Implementation of soil erosion control and soil conservation practices. Careful paddock planning.	Restricted range of crops. Grazing
3	Cambrian mudstone and Tertiary basalt intergrade.	0-12%	Gently sloping land, low topographic position.	Slight sheet and rill erosion risk	Nil	Slow drainage due to clay subsoil	Drainage (d)	Implementation of land drainage.	Restricted range of crops. Grazing.
3	Cambrian volcanics	0-18%	Gently sloping to moderately steep hills	Moderate sheet and rill erosion risk	Nil	Slow drainage due to clay subsoil.	Drainage (d), erosion- sheet and rill (h)	Implementation of soil erosion control and drainage structures	Restricted range of crops. Grazing.
4	Tertiary volcanics	12-18%	Moderate to steep hills	Moderate to high sheet and rill erosion risk	Nil	Freely draining soil , some stony profiles	Erosion- sheet and rill (h)	Implementation of soil erosion control and soil conservation practices including the implementation of surface drainage.	Restricted range and rotation for cropping. Grazing.
4	Quaternary alluvium	0-12	Low plains with sandy rises.	Minor sheet and rill erosion risk	Some localised frosts	Imperfect drainage caused by clay soil textures and slow internal drainage.	Drainage (d)	Surface drainage and good outlet provision	Restricted range of crops. Short working window for cropping activities.

Table 6. Characteristics of the main land capability classes identified in the Hunter survey area.

Land Capability Class	Land Characteristics						Land Management Issues		
	Geology	**Slope**	**Topography and Elevation**	Erosion Type and Severity	**Climatic Limitation**	**Important Soil Properties**	**Main Limitation to Agricultural Use**	**Main Land Management Requirements**	**Agricultural Versatility**
4	Quaternary Alluvium	0-5%	Plains, marshes and drainage depressions	Low erosion risk	Some localised frosts	Peat soils, some acid sulphate soils.	Drainage (d)	Careful drainage implementation.	Short working window for cropping activities. Grazing
4	Quaternary Alluvium	0-5%	Alluvial plain	Low erosion risk	Some localised frosts	Clay textured soils.	Drainage (d)	Careful drainage implementation.	Short working window for cropping activities. Grazing
4	Tertiary volcanics	12-28%	Moderate to steep hill.	Moderate to high risk of sheet and rill erosion	Nil	Freely draining soils, some stony soils	Topographic complexity (x) changeable slopes	Careful design of cropping paddocks, implementation of soil erosion control and soil conservation practices including surface drainage structures.	Restricted range of crops due to terrain constraints affecting the trafficking by planting and harvesting machinery.
4	Tertiary volcanics	5-12%	Moderately sloping hills.	High rill, sheet and wind erosion risk.	Nil	Sandy loam to sandy clay loam soil textures	Erosion sheet and rill (h) and wind (a)	Strict implementation of soil erosion control and soil conservation practices	Restricted range of crops. Grazing
5	Quaternary alluvium	0-12%	Low gently undulating plains and sandy rises.	Moderate wind erosion risk.	Some localised frosts.	High groundwaters.	Drainage (d), high groundwater levels (s).	Surface drainage and good outlet provision	Grazing. Occasional fodder crops.
5	Quaternary alluvium	0-5%	Drainage depressions and swamps.	Low sheet and rill erosion risk.	Nil	Very poorly drained soils, peat and some acid sulphate soils.	Drainage (d)	Careful drainage implementation and good outlet provision. Regular application of fertiliser.	Grazing. Occasional fodder crops
5	Quaternary alluvium	0-12%	Sand ridges and remnant dunes.	High wind and water erosion risk.	Nil	Freely draining soils , shallow topsoils with low underlying fertility.	Erosion- wind (a), sheet and rill (h), low fertility (s).	Implementation of erosion minimising and soil conservation practices	Grazing.
5	Precambrian Sediments	0-5%	Low lying land and drainage depressions.	Low sheet and rill erosion risk.	Nil	Shallow permeable soils	Waterlogging (d), due to perched watertables.	Drainage implementation and good outlet provision.	Grazing

Table 6. Continued.

Land Capability Class	Land Characteristics						Land Management Issues		
	Geology	Slope	Topography and Elevation	Erosion Type and Severity	Climatic Limitation	Important Soil Properties	Main Limitation to Agricultural Use	Main Land Management Requirements	Agricultural Versatility
5	Precambrian Sediments	0-18%	Low hills and undulating plains	Low sheet and rill erosion	Nil	Stony shallow soils	Soil depth (l), stony soils (g) rock outcrop (r)	Shallow tillage and Stone picking.	Grazing
5	Precambrian Sediments	18-45%	Hills covered by windblown sands.	Very high wind, sheet and rill erosion risk.	Nil	Shallow sandy topsoils.	Erosion, wind (a) and sheet and rill (h)	Minimum tillage for pasture establishment, vegetation and pasture management to prevent erosion.	Grazing
5	Cambrian and Tertiary volcanics and Tertiary limestone	18-45%	Moderate to steep hills, some with sand caps.	High Sheet and rill erosion risk	Nil	Erodible topsoil if surface is disturbed.	Erosion- sheet and rill (h)	Minimum tillage for pasture establishment, vegetation and pasture management to prevent erosion.	Grazing
6	Quaternary Alluvium	0-5%	Marshes , flood plains , swamps and drainage depressions	Low erosion risk except in floods where soil is bare	Nil	Poorly drained soils	Drainage (d), flooding (f) inundation by either river or sea waters.	Drainage implementation and good outlet provision.	Limited/seasonal grazing
6	Quaternary Alluvium	0-45%	Stabilised dunes and sandy rises.	Very high wind and water erosion risk.	Nil	Shallows topsoils and low fertility.	Erosion- (a) wind and (h) sheet and rill.	Careful vegetation and stock management	Limited/seasonal grazing
6	Precambrian Sediments and Cambrian and Tertiary volcanics	0-56%	Very steep hills and ridges.	Moderate to high sheet and rill erosion risk	Nil	Shallow soil depth to underlying material, stony soil.	Soil depth (l), stony soils (g) rock outcrop (r)	Careful vegetation and stock management. Soil conservation practices	Limited/seasonal grazing
7	Quaternary Alluvium	28-56%	Migrating coastal sand dunes and blowouts.	Very severe wind erosion risk	Nil	Loose soils, Very low nutrient status	Erosion (a) wind, soil fertility (s).	Avoid agricultural use	No sustainable agricultural use
7	Precambrian Sediments	>28%	Steep ridges and escarpments.	High water and wind erosion risk	Nil	Very little soil material, low fertility, shallow soil	Soil depth (l), stony soils (g) rock outcrop (r)	Avoid agricultural use	No sustainable agricultural use
7	Tertiary volcanics	>56%	Very steep cliffs and coastal rock platforms	Extreme erosion risk from mass movement, wave action	Nil	Bare rock, no soil material	Erosion risk -(h) water and (m) mass movement	Avoid agricultural use	No sustainable agricultural use

Table 6. Continued.

GLOSSARY

Acid sulfate soils: Soils containing iron sulphides which, when drained oxidise, to produce sulphuric acid.

Aeolian sediment: Sediments deposited after transport by wind.

Alluvial deposits/alluvium: Material transported by rivers.

Angular unconformity: An angular discordance between strata. The lower, older series of beds dip at a different angle to the younger, upper beds. This also includes the case where unfolded, younger strata rest upon folded, older, strata.

Argillaceous: Composed largely of clay.

Asl: Above sea level. eg 180m Asl

Barchan Lunette: Assymetrical crescent shaped dunes characterised by the points of the crescent extending downwind, and a convex windward slope of gentle gradient relative to that of the concave leeward face.

Bh Horizon: Horizon in which organic – aluminium compounds are dominant.

Breccias: Rocks comprised of angular fragments derived from a restricted source.

Clay: Soil particles <0.002 mm.

Coarse fragments: Particles (usually rock) found within soil that are >2 mm in size

Colluvial deposits: Weathered material transported by gravity.

Complex: The term complex is used to refer to a map unit where two land capability classes are identified but cannot be separated at the scale of mapping. In a complex unit the proportion of the two land classes is at least 60-40.

Conglomerate: A group of sedimentary rocks with particles greater than 2 mm which are rounded and subrounded and cemented together by a finer matrix.

Dendritic: From the Greek word dendron (tree) used to describe a branching drainage pattern made by rivers and streams.

Degradation: This is the deterioration of a resource through inappropriate or uncontrolled management or use.

Dispersive Soils: Refers to those soils which contain a high proportion of sodium on the exchange sites of the clay minerals. The high sodium content causes soil aggregates to break down as they absorb water. Dispersive soils are inherently unstable and easily eroded.

Drainage: How water drains from the soil profile. Rapid drainage will cause water to move past the root zone in a short period limiting water uptake by the plant, while slow drainage will cause the soil profile to become saturated with water. A saturated profile will exclude most of the oxygen from the soil which leads to root cell death and greatly reduced uptake of moisture by the plant. Drainage depends on landscape position (which controls external drainage eg. run-off and run-on), permeability of soil (texture, structure and distribution of pore spaces) and impediments in the profile to water movement such as hardpan and rock.

Duplex Soils: These soils contain a strong texture contrast between the A and B horizons. Strong texture contrast is defined according to the *Australian Soil Classification* (Isbell, 1996).

Erosion risk: The potential for wind, sheet, rill or gully erosion to occur on a land surface. The land surface is most prone to erosion when cultivated and/or when little or no vegetative cover is present. Land management to suit site conditions can minimise the severity, and often prevent most occurrences of water erosion. Erosion hazard depends on soil erodibility (loose, weakly structured soils are most at risk from wind erosion), amount of ground cover, slope gradient, rainfall (intensity and amount), and the amount of run-on received.

Ferrosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) as having a free iron content in the B2 horizon greater than 5%.

Fine sand: Particles from 0.06 to 0.1 mm, just visible with the naked eye and which feel similar to coarse flour or table salt.

Horizons: Layers within a soil profile which have morphological properties different from those above and below (Northcote 1979).

Igneous rocks: Rocks formed through the solidification of magma, they include; hypabyssal, plutonic, pyroclastic and volcanic rocks.

Imperfectly drained: (soil) Water is removed only slowly in relation to supply.

Land Suitability: Identifies the suitability of an area for a defined land use. Land suitability usually considers the economic and cultural suitability of a land use in addition to the land requirements. A comparison of land suitability evaluations for a range of different uses can identify the most suitable use for a particular area.

Limitation: Refers to the physical factors or constraints which affect the versatility of the land and determine its capability for long term agricultural development.

Limiting Layer: A layer within the soil profile that severely impedes or restricts the development of plant roots, eg bedrock, groundwater, heavy massive subsoils, iron pans or other cemented layers.

Lithology: The general characteristics of rocks and sediments.

Moisture availability: This is a measure or rating of the amount of moisture held in the soil which is available to the plant. It is defined as the difference between the field capacity of the soil and the wilting point. Field capacity occurs when the soil's large pores (>30 microns) have drained but when all the small pores and capillary channels are still filled with water. Wilting point is when the soil is dry to the point where the plants can extract no more water. Soil texture has the greatest effect on availability of water to the plant.

Permeability: A rock or layer is permeable if water or other liquid tends to pass through to a lower surface.

pH: Soil pH is a measure of the acidity or alkalinity. A pH of 7 denotes a neutral soil with a log scale of increasing alkalinity of pH 7 to 14, and a log scale of increasing acidity of pH 7 to 1.

Pillow Lava: Lava extruded underwater which has cooled rapidly to form pillow-like globular masses typically exhibiting a vesicular interior, a concentric structure and a finely grained exterior.

Plastic limit: The water content of a soil corresponding to an arbitrary limit at which it passes from a plastic state to a more or less rigid solid state; the state where a plastic soil begins to crumble.

Plateau: Elevated flat land limited by abrupt slopes on one or more sides.

Podosols: A soil order defined in the *Australian Soil Classification* (Isbell 1996) as being soils that have B horizons dominated by the accumulation of compounds of organic matter and aluminium, with or without iron.

Prime Agricultural Land: Areas identified as land capability Class 1, 2 or 3.

Pyritic: Containing the sulfide mineral FeS_2. Associated with igneous parent materials.

Quartzite: Metamorphosed rocks of sedimentary origin rich in silica.

Sedimentary: Rocks formed from material derived from pre-existing rocks.

Soil Association: A related group of soils that contains a dominant soil and a number of sub-dominant and minor soils within it.

Soil compaction: The development of a traffic (compaction) pan below the soil surface, usually 10 to 30 cm deep. Pans restrict root growth and drainage into the sub-soil. Pan development can occur in most soils. Yield responses can be obtained on some soils by deep ripping to break the traffic pan.

Soil structure decline: The degradation of soil structure. Soil aggregates may be destroyed by excessive cultivation/harvesting or trampling by stock, resulting in a compacted, massive or cloddy soil. Soils are particularly susceptible when wet.

Spilite: Basaltic rock type formed by volcanic lava flows that have flowed into or been extruded under the sea. Often found as pillow formations. Varies from other basalt by containing chlorite in lieu of augite and olivine and has albite as the plagioclase.

Strandline: Area in which material is deposited by wave action and subsequently stranded by receding sea levels.

Sustainable: The concept of sustainability in the agricultural context has given rise to considerable discussion. Very simply, *sustainable* land use implies a land use which can be continued in the long term without damage to the environment or the natural resource. It is generally agreed that agriculture inevitably results in some damage but for land use to be considered sustainable the damage has to be kept to an acceptable minimum and allow the continued long term use of that land.

Talus: Accumulation of rocks and boulders at the foot of a cliff or steep slope (also referred to as scree).

Thixotropic: Material which is solid when stationary but becomes mobile when affected by shearing stresses eg Quick clays

Tholeiitic, Tholeiite: A type of basalt consisting of basic plagioclase and pyroxene with interstitial glass or quartz-alkali feldspar intergrowths.

Transcurrent Fault: Also called a tear or wrench fault where movement is dominantly strike-slip (ie horizontal).

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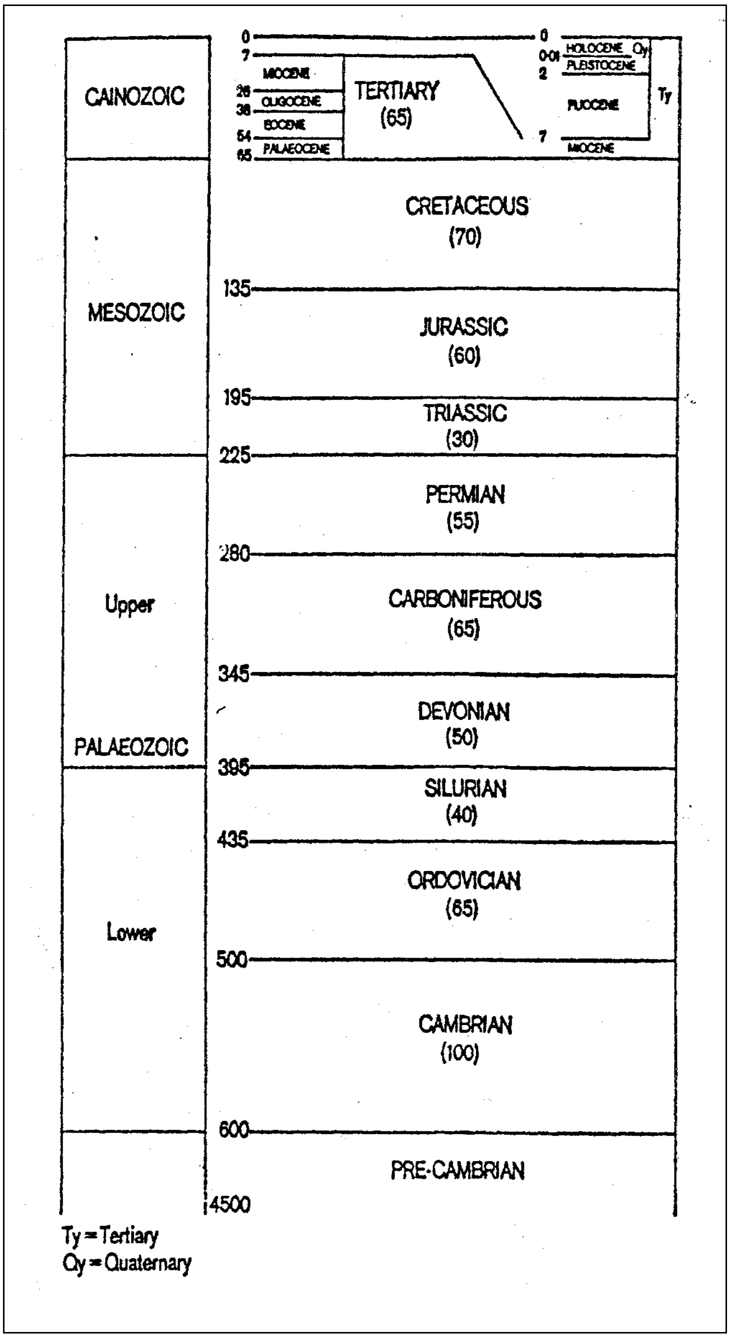
APPENDIX

Appendix A. Geological Timescale



*figures indicate millions (10^6) of years ago.