DNRQ980091

Land Resources Bulletin

Soils and Agricultural Land Suitability of the Atherton Tablelands North Queensland

D.T. Malcolm, B.K.A. Nagel
I. Sinclair and I.J. Heiner
Resource Management

NATIONAL LANDCARE PROGRAM

Department of Natural Resources
Queensland

NATURAL RESOURCES Queensland

Land Resources Bulletin

Soils and agricultural land suitability of the Atherton Tablelands

North Queensland

D. T. Malcolm, B.K.A. Nagel,
I. Sinclair and I. J. Heiner

Department of Natural Resources,
Brisbane 1999

DNRQ980091
ISSN 1327-5763

This publication is for general distribution. The information in this report is derived from 1:50 000 scale land resource mapping which is an adequate scale for planning purposes. In assessing individual applications for subdivision a detailed assessment of land resources is usually necessary. Explicit evaluation of economic factors such as the size of production units or crop viability have not been included in the suitability assessment as they are not considered relevant to the quality of the land resource (State Planning Policy 1/92).

QUEENSLAND
GOVERNMENT

Department of Natural Resources
Locked Bag 40
Coorparoo DC Qld 4151

Contents

List of figures

List of tables

List of maps

In back of report

In Back Pocket of report

Acknowledgements

National Landcare Program for funding Support
Doug Smith for guidance throughout the project and major role in writing section five
Peter Wilson (Mareeba) for writing the GIS section
Rob Lait Operations Manager Mareeba for writing the hydrology section
Peter Hocroft CSO Mareeba for his major role in setting up the suitability framework
Ian Webb for compiling chemistry data from other sources and organising some PAWC data
Sue Laurance CSIRO Atherton for a copy of her remnant native vegetation work
Val Eldershaw editing
Dennis Baker for editing the soil chemistry section
GIS officers Mareeba
John Kilpatric principal agronomist Kairi
Horticulture extension officers Mareeba (Terry Campbell, Noel Ainsworth, Irene Kernot)
Soil conservation extension staff Atherton and Kairi (Peter lazzarini)
Dairy Extension officers Malanda
John Armour, Agricultural chemistry Mareeba
John Clarkson and John Neldner, botany staff Mareeba
Queensland Department of Forestry officers, Atherton
Agricultural chemistry staff, Indooroopilly
Peter Warner
Neil Enderlin
Diane Bray, Land Resources Publications, Indooroopilly, for final editing and publication of this report

Summary

The land resources of approximately 160 000 hectares of the Atherton Tableland, North Queensland was surveyed at a medium intensity scale of 1:50 000. Soils were mapped according to their geological parent material and topographical position.

The climate of the area is predominantly humid subtropical with the majority of rain falling in the summer. Five climatic zones have been identified across the survey area.

The topography becomes increasingly steeper from gently sloping rises around Tolga in the North to steeply sloping low hills and hills around Millaa Millaa in the south.

Soils in the study area have formed from five major parent materials - basalt, granite, rhyolite, schist and quaternary alluvium. Soils derived from basalt are by far the most dominant, covering 56% of the survey area. Soils derived from granite account for 23% of the area whilst soils derived form rhyolite and schist cover 12% and 7% respectively. The alluvial soils which include some organic peats only cover 2% of the survey area.

Over 2000 site descriptions were made identifying 34 different soil profile classes (SPC's). All major soils were sampled for chemical analysis. Morphological and physical soil properties pertinent to the assessment of land suitability for agriculture were also recorded.

The suitability of land for 19 agriculturally sustainable land uses has been assessed according to a range of limitations. Basaltic derived soils were found to have the best potential for agriculture. Soils formed on the other parent materials are generally of poorer quality and as such are restricted in their suitability for agriculture. The nutrient status of all soils is generally low due to leaching induced by high rainfall.

1. Introduction

The Atherton and Evelyn Tablelands of North Queensland are high rainfall areas with a diversity of land uses. These include national parks, world heritage areas, forestry, dairying, tourism, beef and cropping.

The Atherton Tablelands soil and land suitability project was jointly funded by the National Land Care Program and the Department of Natural Resources. The project was initiated due to the need for more detailed land resource information in the area. The mapping detail of previous land resource surveys did not allow the accurate assessment of land suitability for agriculture and land use planning. The information gathered in this survey will therefore benefit state and local authorities, landholders and industry bodies.

Location of survey area

The study area extends from Walkamin in the Northwest to the Lamb range in the north east, (including Tinaroo Dam). The western boundary runs south west of Atherton to Herberton and follows the Wild River to Kaban. The southern most point is Mt Koolmoon at the edge of the Ravenshoe 1:100 000 topographic map. The eastern boundary of the project approximates the escarpment of the Atherton Tableland (Figure 1).

Project objectives

The main objectives of this project were:

- to map the soils of the Atherton Tablelands at 1:50 000 scale and produce a Geographical Information System (GIS) coverage.
- assess the suitability of the area for a range of sustainable agricultural land uses.
- increase the capability of state and local government agencies to address emerging land use and rezoning issues.
- to provide information to land care and other community groups.

Summary of methodology

Land resource mapping of approximately 160 000 ha was undertaken at 1:50 000 scale in order to characterise the soils and assess their suitability for a range of sustainable agricultural uses.

Soil, landform, geology and vegetation patterns were identified using current 1:25 000 scale air photographs. A reference making phase was undertaken to collect information on soil, topography, vegetation and lithology across a representative range of landforms using the procedures and codes of McDonald *et al* (1990). Soil profile classes were then developed based on Laffan (1988) for the Atherton Tablelands and studies of adjacent areas by Heiner and Grundy (1995) and Malcolm and Heiner (1996).

A free survey technique (Reid, 1988) was then used to map the soils and landforms. Ground observation sites were selected to characterise mapping units into the soil profile classes identified in the reference making phase.

Approximately 2000 sites were recorded, which in addition to some 500 sites from previous surveys provided an average intensity of 1 site per 60 hectares. Site intensity varies according to intensity of land use.

- In cropping areas 1 site per 50 hectares.
- In grazing areas 1 site per 100 hectares.
- In steep forested areas 1 site per 170 hectares.

These observations included information on soil morphology, geology, landform and vegetation. Thirteen profiles of agricultural importance were sampled for chemical and physical analysis.

Each occurrence of a mapping unit is known as a unique map area (UMA). Each mapping unit is named after the dominant soil profile class. Any associated soils along with a percentage estimate of their occurrence is also listed in the UMA file. The information recorded in the UMA file is available upon request from the Resource Management Group, Department of Natural Resources, Mareeba.

Each Soil Profile Class (SPC) is described in Appendix 1. The distribution of these soils is shown on the accompanying soils map. Soil profile classes have been grouped by geology, landform and topography.

Assessing the suitability of the area for sustainable agriculture, involved a number of steps. Firstly the requirements of the crops are determined so that their limitations can be ascertained. For example if a crop is intolerant of waterlogging, then wetness is a limitation. Major limitations to agriculture in the study area were found to be: climate, moisture availability, soil nutrient supply, wetness, flooding, landscape complexity, soil physical condition, topography, rockiness and water erosion.

UMA's were assigned a value for each limitation (known as limitation subclasses) and then these values were rated on a 1 to 5 scale for individual land uses. The most limiting factor determines the overall suitability rating for that UMA.

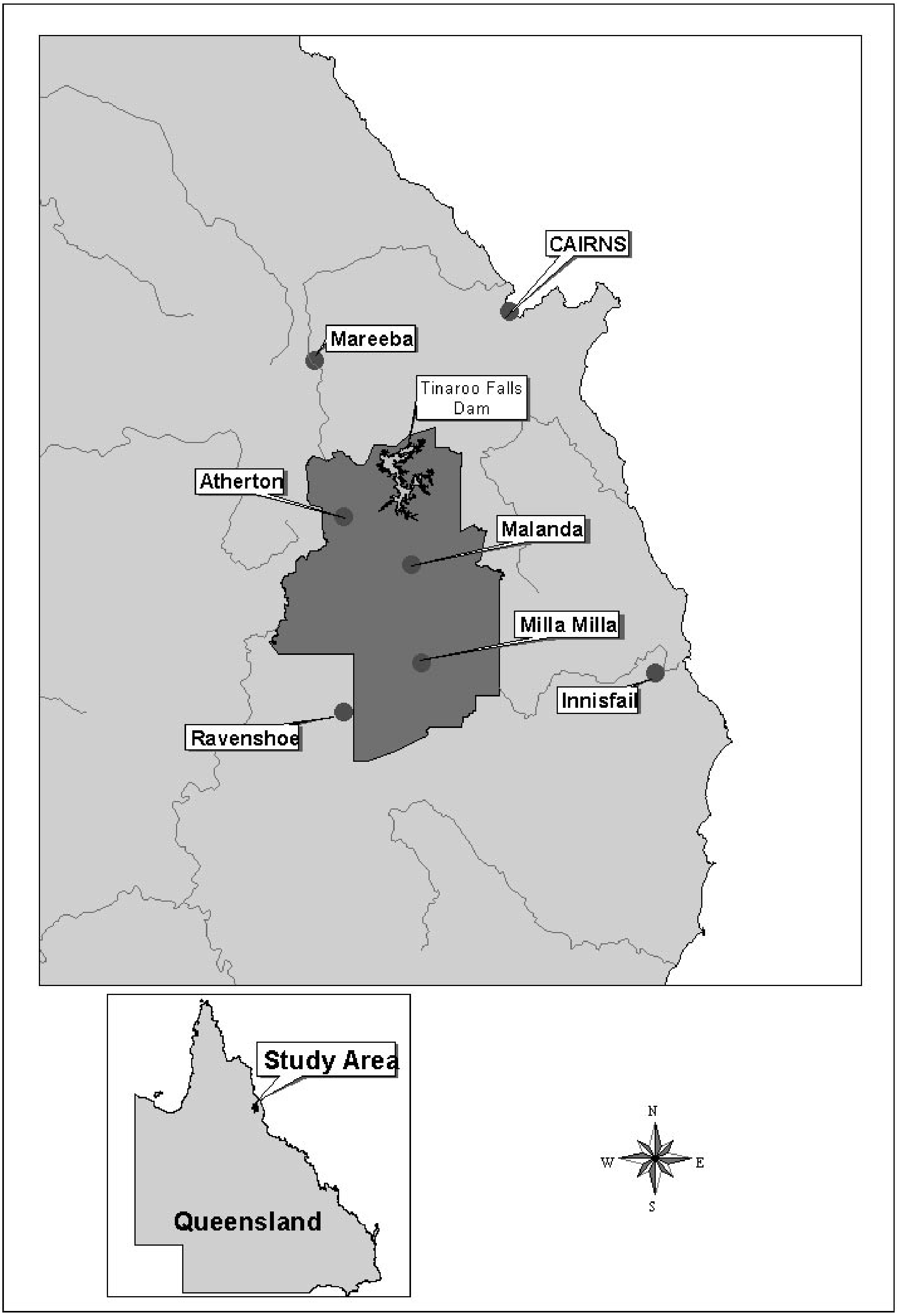


Figure 1 Location and boundary of Atherton Tablelands survey

Geographical Information System (GIS)

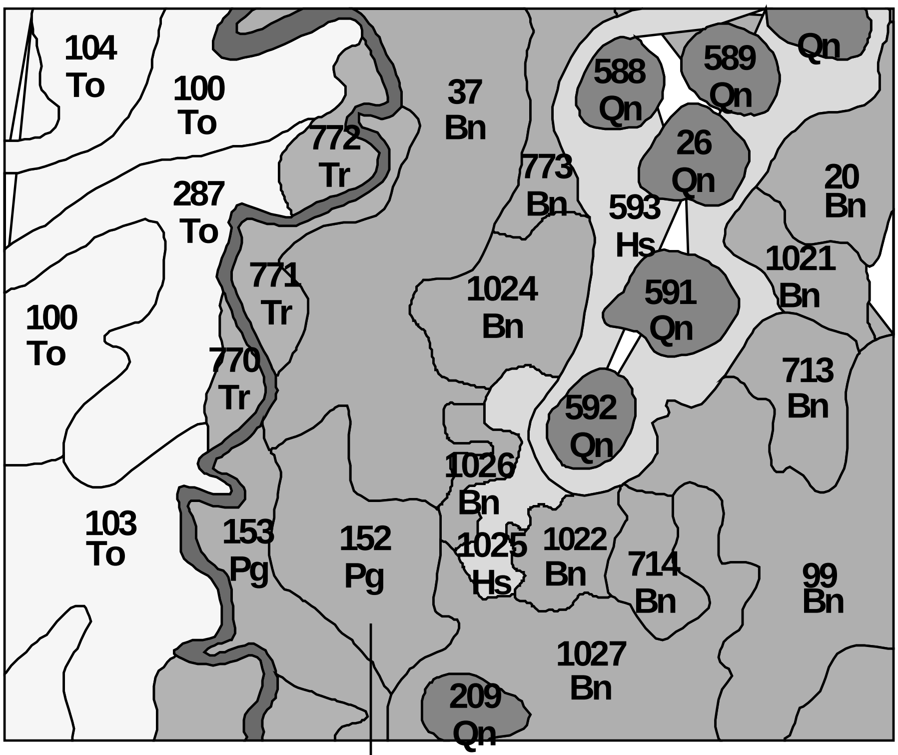
Much of the information collected during the survey is stored digitally in a computerised Geographic Information System (GIS). A GIS allows information to be readily analysed and maintained so that any future improvement in, or additions to, the knowledge base can be incorporated. The GIS has been developed using ARCINFO software. Map line work was transferred using an Artiscope from interpreted aerial photographs to cadastral and topographic base maps and digitally captured through a combination of hand digitising and scanning.

The GIS contains the spatial (map) information, stored as a series of lines (vectors) which represent the interpreted boundaries between areas (polygons) of different soil or landform characteristics (Figure 2). These boundaries do not necessarily show an abrupt natural change, but most commonly represent a line within a landscape continuum around which change is maximised (ie, soils in the real world rarely change abruptly).

The GIS also stores an associated set of data base tables (Figure 2) which hold various data relating to the individual unique map areas (UMA's). The data tables contain information on the basic soil and landform characteristics of the UMA. In addition, these tables also contain a number of interpreted values for the limitation factors which have been taken into account when assessing the reported land use suitabilities.

Whilst the accompanying hard copy soils and suitability maps accompanying this report provide a valuable and comprehensive overview of the basic information, the full potential of the GIS is in the ability to interrogate and display the vast amount of data and information collected and interpreted throughout this survey. For example, displays for individual farms can be produced which show not just the dominant soil but also the assessed values of limiting factors (such as erosion risk, nutrient status or water holding capacity). This will more clearly illustrate the suitability of a particular UMA for a particular land use. Also the GIS can be used to overlay other data sets, such as cadastral or topographic information, or local authority zoning plans, to help assess the likely impacts of proposed developments.

GIS data sets can be made available to anyone requiring part or all of the captured digital data. Departmental extension officers can assist with access to and interpretation of these data sets.



Unique Map Area (UMA) polygons showing UMA Number and code for dominant soil type

UMANo	Soil1	SoilP1	Geology	LfElem	LfPat
149	Pg	10	Cza	PLA	LAV
150	To	10	Cza	HSL	LAV
151	Pg	10	Cza	HSL	RIS
152	Pg	10	Cza	HSL	RIS
153	Pg	10	Cza	HSL	RIS
154	Pg	10	Cza	HCR	LOW
155	Pg	10	Cza	HSL	RIS

Primary data table which is conected to the spatial data represented by the map layer

UMANo	LandUse	SuitClass
155	Macadamia	3
155	Heavy Veg	3
155	Temperate Pasture	1
155	Maize	3
155	Custard Apple	3
155	Mango	4
155	Citrus	4
155	Navy Beans	3
155	Salad Veg	3
155	Irrigated Sugar	3
155	Forestry	2
155	Sorghum	3

Other data tables containing land use suitability and other information can be linked to the primary data table

Figure 2. Example of GIS map and data tables

Previous resource assessments

Previous land resource assessment work in and adjacent to the area includes :

- Atlas of Australian soils (Isbell *et al*., 1968).
- Evaluation of agricultural land in Atherton and Eacham Shires (Kent and Tanzer, 1983).
- Soils of Kairi Research Station (Warrell et al., 1984).
- Soils and land use on the Atherton Tableland (Laffan., 1988).
- Land management field manual for Atherton/. Mareeba districts (Shepherd *et al*., 1989).
- Soils of Walkamin Research Station (Malcolm and Heiner,1996).
- Land resources of the Ravenshoe, Mount Garnet area, north Queensland. Vol I (Heiner and Grundy, 1996).
- Land Resources of the Ravenshoe-Mount Garnet area, north Queensland land suitability. Vol II (Grundy and Heiner in prep).
- Land resources of the Einasleigh-Atherton dry tropics. (Grundy and Bryde, 1989)
- the mineralogy of soils from basalt (Simonett and Bauleke, 1963),
- the plant nutrient status of soils (Kerridge *et al*., 1972)
- the morphological, chemical and mineralogical studies of red basaltic soils (Isbell *et al.*, 1976).

2. Land resource assessment

Climate

The climate of the Atherton Tablelands is predominantly humid subtropical modified by the elevation (700 - 900 m above sea level). Hot humid summers and mild dry winters are the norm, but the higher altitude areas around Milla Milla and Topaz receive extended periods of drizzle during the winter whilst frosts are common around Herberton and Kaban.

Five broad climatic zones have been developed using existing work by Kent and Tanzer (1984) and consultation with departmental staff. Parameters considered included rainfall, temperature, extent of drizzle and the presence or absence of frost. These zones are shown in Figure 3. Local variation to these zones can occur due to small changes in topography.

Rainfall

Mean annual rainfall is highly variable across the Tablelands. There is a clear gradient from Southeast (3600 mm at Topaz) to the Northwest (1350 mm at Tolga). Mean annual rainfall totals for 15 centres across the Tablelands are shown in Table 1. Figure 4 shows the mean monthly rainfall distribution for these centres.

Table 1. Mean annual rainfall totals for selected centres

Location	Total (mm)	Years of data
Tolga	1350	40
Tinaroo	1292	34
Atherton	1417	73
Kairi	1273	58
Danbulla	1645	59
Lake. Barrine	1444	35
Yungaburra	1404	62
Peeramon	1677	56
West. Barron	1450	6
East. Barron	1494	35
Upper Barron	2100	41
Malanda	1682	73
Milla Millaa	2643	71
Topaz	4352	9
Herberton	1145	101

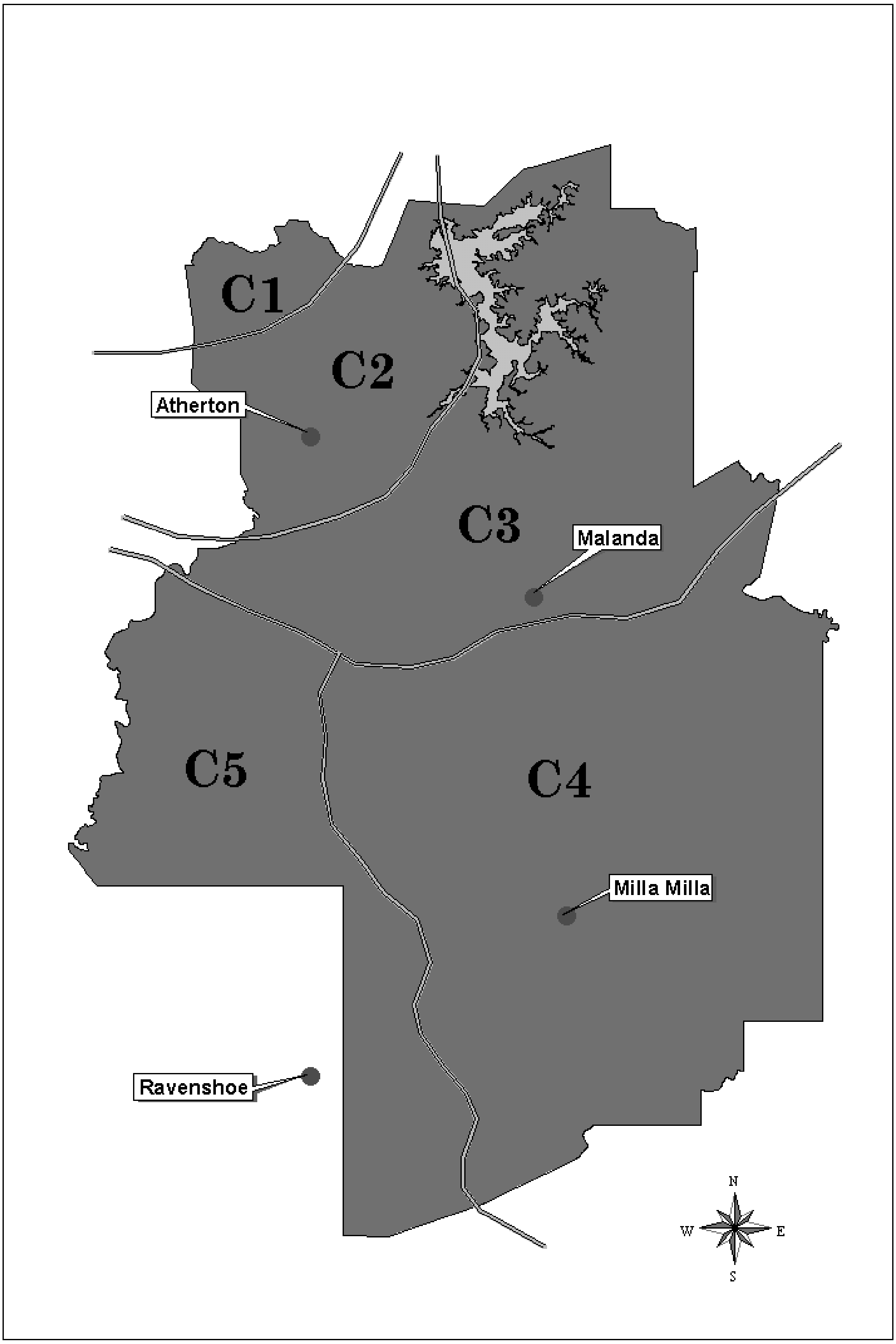


Figure 3. Climatic zones within the Atherton Tablelands survey area

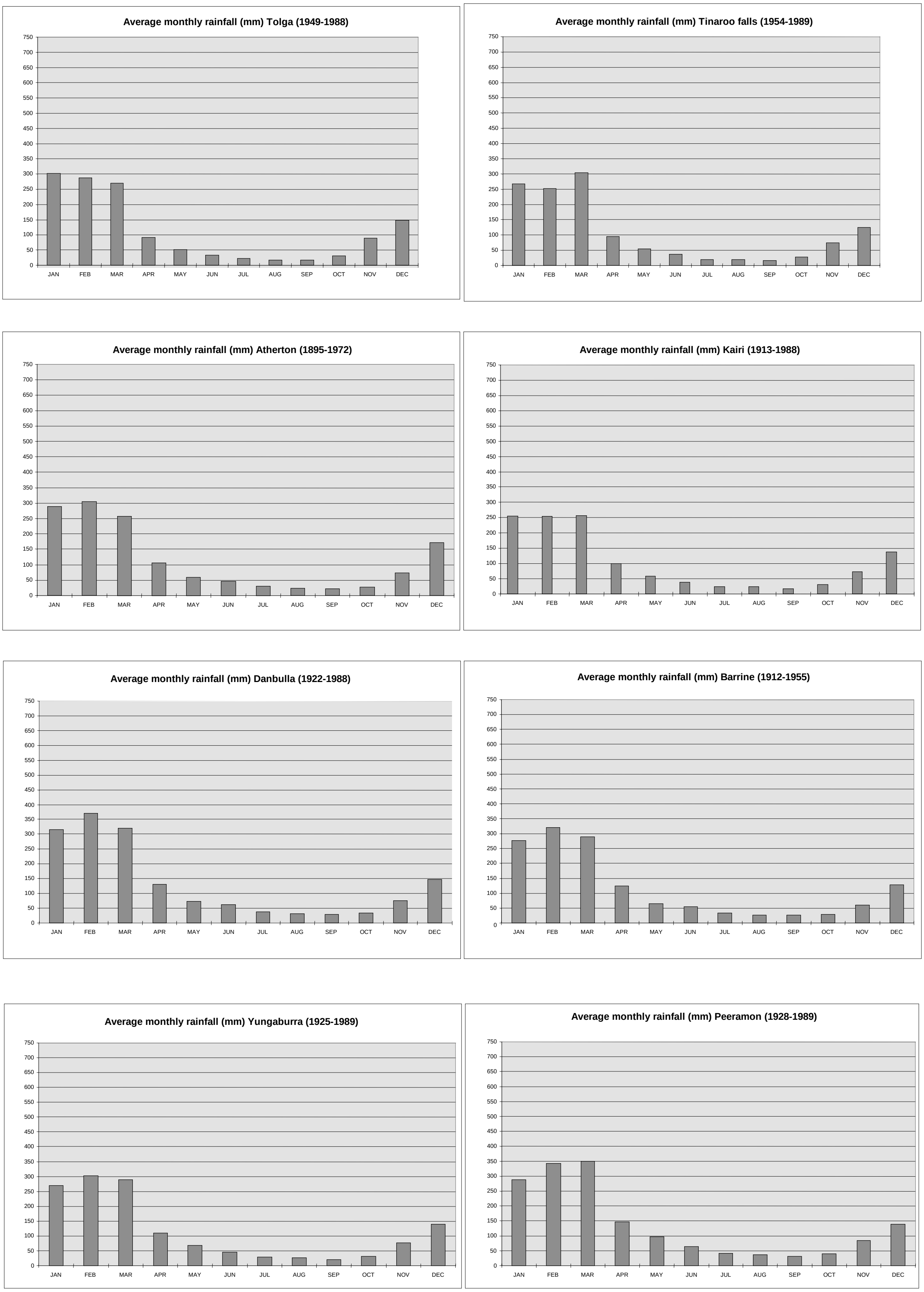
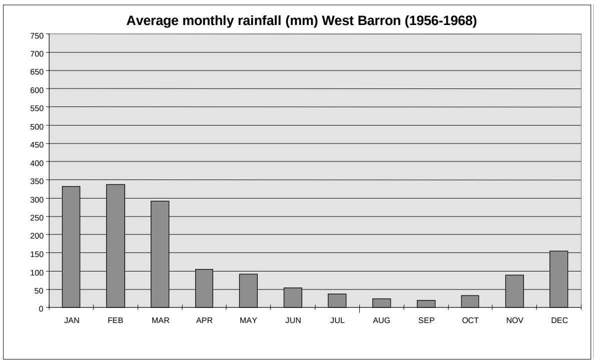
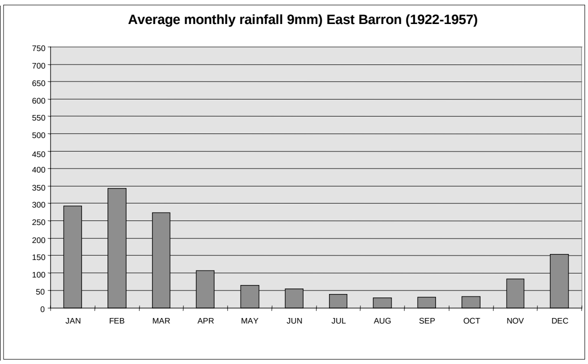
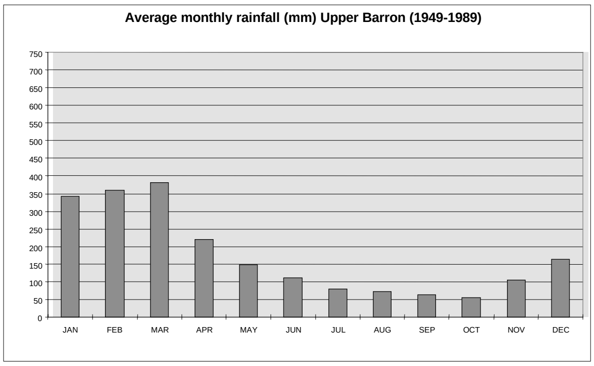
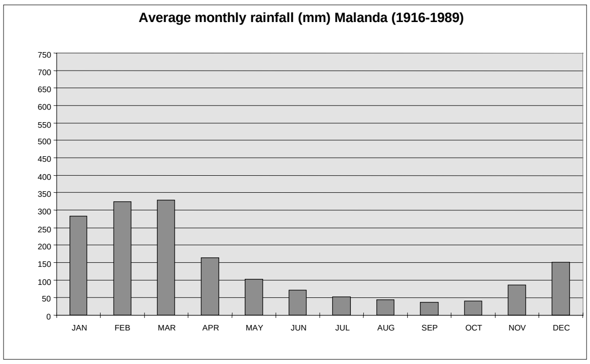


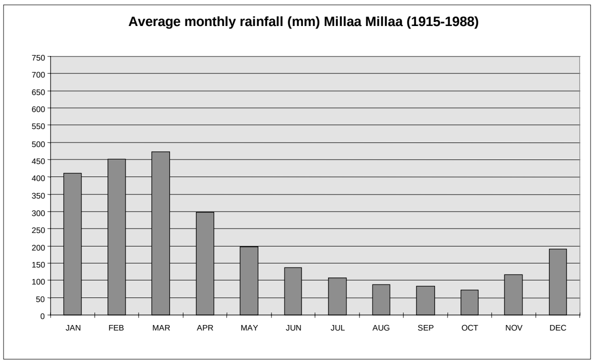
Figure 4 Average monthly rainfall graphs for selected centres

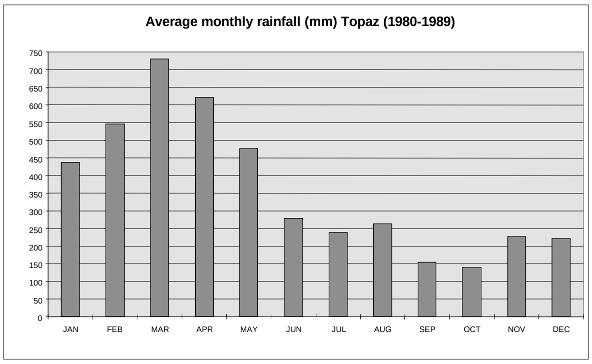












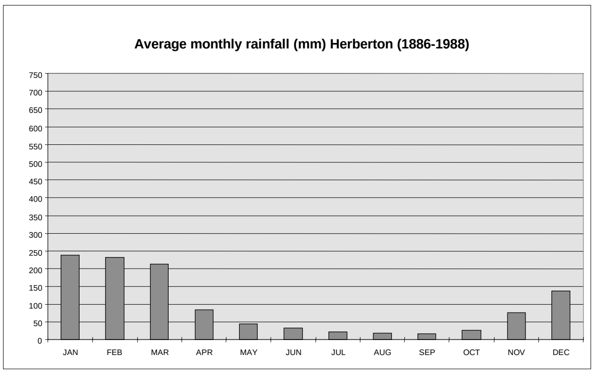


Figure 4 (cont.)

Mean monthly rainfall shows a distinct seasonal distribution. Most rain falls in the summer months December to March particularly during high intensity, short duration thunderstorms. The six months of May to October are relatively dry receiving less than 25% of the total yearly rainfall (Laffan, 1988). Topaz is one of the wettest places in Australia and the highest rainfall recorded for a 24 hour period (1300mm)in Australia occurred on nearby Mount Bellenden Kerr.

Soil water deficits (evaporation exceeds rainfall) occur in most areas during winter, however they are most severe in the drier northern and north-western and western parts around Tolga, Walkamin and Herberton. Additionally the area is affected by tropical depressions and cyclones on average once every 5 years. These may produce a significant proportion of the summer rainfall and affect large areas with destructive winds and flooding.

Work undertaken by Kershaw (1974) analysing pollen samples from crater lakes in the area has shown that the current climate has only existed for the last 7000 years. For the 30 000 years prior to this, Kershaw suggests that the rainfall was considerably lower as indicated by the dominance of *Eucalyptus* and *Casuarina* species.

Temperature

Mean maximum and minimum temperature ranges for selected centres are shown in Table 2.

Table 2 - Mean maximum and minimum temperature ranges for selected centres

Centre	Maximum range	Minimum range
Walkamin	28.2 - 20.6	20.0 - 12.2
Tolga	29.4 - 21.2	18.3 - 10. 0
Atherton	29.0 - 22.0	18.1 - 10.2
Malanda	27.6 - 19.9	18.6 - 10.7
Millaa Millaa	29.9 - 19.9	19.2 - 12.1
Herberton	28.2 - 21.2	18.2 - 9.3

Generally the mean maximum and minimum temperatures decrease with increasing elevation.

Evaporation

Huda *et al* (1991) have cited an annual average pan evaporation for Atherton of 1650 mm. Data for other centres is not available but figures are likely to decrease moving from north to south.

Frost

Information collected during the survey from landholders as well as Department of Natural Resources and Department of Primary Industries personnel indicates that on average Herberton, Malanda and Atherton receive three to six frosts per year (climate zones 2, 3 and 5. See appendix 3 for more details). Of these frosts two are deemed to be heavy and three to four are considered mild. This reduces the number of crops and pastures that could be grown during winter.

Solar radiation and cloud cover

Cloud cover limits the hours of sunshine received each day and affects light distribution and temperature. In the drier northern and western parts of the region, cloud cover is greatest during the wetter summer months and decreases during the winter. It is also generally greater during the afternoon. South and east of Malanda however, low cloud and drizzle occur for extended periods during winter and, together with the high rainfall, conditions are considered unfavourable for commercial production of most agricultural ad horticultural crops (Laffan, 1988).

In the south and Southeast (Malanda, Millaa Millaa, Topaz) cloud and drizzle often occur for extended periods during winter. Combined with high rainfall during summer, solar radiation is reduced to such an extent that conditions become unfavourable for most commercially grown horticultural and agricultural crops. (Huda, *et al*., 1991)

Geology

Best (1962) and de Keyser (1964) have mapped and described the geology of the area at 1:250 000 scale.

The most common rock types identified are basalt, granite, schist, phyllite and rhyolite (Table 3). A map showing the distribution of the rock types can be seen in Appendix 5 (page 169).

The oldest rocks in the area are the Barron river metamorphics (Pzb) found in the north east of the region. They were formed when previously laid down sedimentary material was metamorphosed during a major orogeny of the Carboniferous period approximately 280-345 million years ago (Table 4) and cover 7.4% of the study area (Table 3).

In the late Carboniferous to early Permian period (Table 4), the Mareeba (Pgm), Tully (Pgb) and Elizabeth Creek (Pgz) granites were implaced in the northern, western and southern margins making up approximately 23% of the study area (Table 3). Some of the granitic magma made it to the surface and formed the acid volcanic rocks of the Walsh Bluff Volcanics (Ph) and Glen Gordon Volcanics (Pl). These rocks dominate the western margin of the study area comprising 11.7% of the total (Table 3).

The Atherton basalts (Cza) are the most extensively occurring geology in the region and cover approximately 56% (Table 3) of the total study area extending from Rocky Creek on the northern boundary of the study area to Ravenshoe and Maalan in the south. The lava flows have originated from approximately 40 eruptive centres across the Tablelands (de Keyser, 1964). These include shield volcanoes (Bones Knob), cinder cones (Seven Sisters), maars (Lake Eacham, Lake Barrine, Bromfield swamp) and a diatreme (Hypipamee Crater) (de Keyser and Lucas, 1968).

It is estimated that the lavas of the major volcanoes are of early Pliocene to Pleistocene age (Table 4) whilst pyroclastic deposits from the cinder cones are of late Pleistocene to early Holocene age (Stephenson et al 1980).

Table 3 Areas of major rock types

Geology	**area(ha)**	**% of total area**
basalt	90800	56
granite	37195	22.9
rhyolite	18924	11.7
schist, phyllite	12022	7.4
alluvial	3200	2.0

Table 4 Major geological periods

Geological Period	Era	Age (millions years)
Quaternary	Holocene	0.01
	Pleistocene	2
Tertiary	Pliocene	5
	Miocene	23
	Oligocene	38
	Eocene	54
	Palaeocene	65
Cretaceous		136
Jurassic		190
Triassic		225
Permian		280
Carboniferous		345
Devonian		395
Silurian		430
Ordovician		500
Cambrian		570
Precambrian		4600

Geomorphology and soil forming environments

The varying climate of the Atherton Tablelands, differing geologies and large scale volcanic activity have combined to produce a large range of landforms. These landforms can be grouped into three major types. The first is the steeply (20-35%) to very steeply (>35%) sloping low hills (30-90m) and hills (90-300m) of the southern, eastern and western areas. The second is the gently sloping (3-12%) to moderately sloping (12-20%) rises (9-30m) of the central areas from Malanda to Atherton. The third is the very gently sloping (1-3%) to gently sloping (3-12%) rises in the northern areas around Tolga and Kairi.

By far the most dominant land forming factor is the volcanic activity which produced the vast lava flows that have covered approximately 56% of the study area.

Volcanoes, cinder cones, lava flows, alluvial terraces and floodplains

Landforms created by volcanic activity are represented in all three major geomorphic groups. The young geological age of the cinder cones has meant that they have only been weakly weathered. This has meant that they have retained much of their original shape. Generally they are steeply to very steeply sloping low hills and hills.

On the upper slopes of these cinder cones, high contents of scoriaceous gravels have combined with the steep gradients to form shallow, *insitu* soils that are very well drained. On lower slopes and footslopes, well drained colluvial material has accumulated. The surrounding lava plains are comprised of gently sloping rises. Lack of weathering has combined with large amounts of pyroclastic material and volcanic bombs to produce very rocky, dark coloured profiles.

Where craters remain (Quincan Crater, Bromfield Crater and Lynches Crater), swamps have formed creating ideal conditions for plant growth. Decaying plant material has built up over long periods to create organic soils. These conditions are also found where recent basalt flows have cut off stream channels causing water to accumulate for long periods (Nyleta area). Basalt flows from older much larger volcanoes cover vast areas. Landforms within these flows vary from very gently sloping rises to very steeply sloping low hills.

In the southern areas around Millaa Millaa, higher annual rainfall and higher rainfall intensities combined with increased altitude have caused strong dissection of the basaltic lavas. This has produced to very steep low hills and hills. Soils have formed *in situ*, are predominantly brown in colour and contain decomposing basalt.

From Malanda to Atherton landforms are gently to moderately sloping. Deep weathering has been the major soil forming factor in these areas and thus the lava flows have weathered to very deep, highly permeable red soils with little or no rock. Further north around Tolga and south-west around Herberton the basalt lavas have weathered to very gently and gently sloping rises. Profiles are deep and red with varying amounts of rock. On level plains and on very gently undulating rises which are lower in the landscape, seasonal water tables produce imperfectly drained yellow soils similar to the red ones.

At the edges of very recent basalt flows, walls of basalt rock are prevalent. Just above these walls in poorly drained depressions accumulations of fine sediments have produced poorly drained heavy clay soils. At the edges of these walls, shallow rocky soils have developed in the weakly weathered basalt. Soil morphology and landform suggest that the lavas in the southern areas are older than those of the cinder cones but younger than the flows that occurred to the north around Atherton and Tolga. However interpretations of age relationships between different lava flows are complicated by the effects of climate, landform dissection and the rejuvenation of parent materials on steeper slopes (Laffan, 1988). Features such as pH, abundance of manganese nodules and abundance of rock are indicators that climate has also been an important factor in the formation of the different soils on the Tablelands.

Granitic and acid volcanic hills, low hills and footslopes

The higher granitic outcrops Southeast of Malanda, east of Millaa Millaa and east of Herberton were too high to be covered by the basalt flows that emanated from the many surrounding volcanoes.

On the steep hillslopes in the drier western areas, gravelly, sandy, shallow soils have developed *in situ* reflecting the weakly weathered parent material and high erosion of this landscape (Heiner and Grundy, 1994). Deep sandy soils have formed in areas of sediment accumulation within the steep landscape.

In the eastern and north eastern areas, higher rainfall has caused deeper insitu weathering which has resulted in deeper soils of higher clay content in the steeper areas. In down-slope positions where drainage is poorer profiles are predominantly yellow in colour.

In the steeper drier areas on weakly weathered rhyolite shallow gravelly soils have formed *insitu.* Where the rhyolite is more strongly weathered, deep well drained soils occur. In the wetter regions as with the granites, the higher rainfall has produced deeply weathered well drained red soils on upper slopes and moderately deep but poorer drained yellow soils on lower slopes. Below these soils accumulation of finer sediments has produced poorly drained grey soils of high clay content.

Metamorphic low hills and rises

The metamorphic landforms are found in the wetter eastern and north eastern areas. This has produced deep *in situ* weathering. Well drained red soils can be found on upper slopes with yellow poorer drained soils in lower landscape positions.

Alluvial and colluvial landforms

Alluvial and colluvial landforms are not dominant on the Atherton Tablelands reflecting the highly permeable young landscape. On the very gently sloping river and creek terraces that flow through the basaltic landscape, deposits of clay eroded from surrounding basalts have produced well drained soils. In some areas, recent volcanic activity has interrupted drainage lines, causing deposition of stream load and accumulation of water resulting in poorly to very poorly drained soils.

Streams flowing out of the granitic and acid volcanic hills west and south-west of Atherton have deposited clay and sands in alluvial and colluvial fans. This material has produced poorly drained, grey coloured soils.

Natural Vegetation

Although now mostly cleared the original vegetation of the Atherton Tableland was dominated by rainforest with sclerophyll woodland in the drier areas where mean annual rainfall is less than 1400mm (Kershaw, 1974). Isbell *et al* (1976) also noted the 1400mm isohyet as a boundary between the rainforest and sclerophyll forests. This boundary occurs around Tolga in the north; Kaban in the south and the Herberton range area to the west.

Most of the forests on lower sloping areas were cleared around the turn of the century for agriculture. By 1980 over 76,000 ha of forest had been removed (Winter *et al*., 1987), leaving only scattered forest fragments ranging from 1 to 600 ha in area (Laurance 1991).

Tracey and Webb (1975) mapped rainforest and woodland types at a scale of 1:100 000. Species composition and their relation to climate, altitude and soil parent material was investigated by Tracey (1982), with rainforest deemed to include complex mesophyll vine forest, mesophyll vine forest, complex notophyll vine forest and simple microphyll vine forest. Sclerophyll woodland includes tall open forest dominated by *Eucalyptus spp*, *Casuarina spp* and *Acacia spp* with mixed communities of closed-vine forest with sclerophyll species and co-dominants occurring in transition zones.

In pollen samples from cores taken from Lynches Crater, Quincan Crater and Lake Euramoo, Kershaw (1970, 1971 and 1974) found that the current rainforest species have only dominated for the last 7000 years. Previous to this, up until 25 700 years before present *Eucalyptus* and *Casuarina* species dominated due to much drier climatic conditions. Prior to this rainforest dominated again.

Water resources

Surface hydrology

Two major catchments drain the study area. The Barron River catchment drains the area north of Malanda whilst the North and South Johnston River catchments drain the area south of Malanda.

Other major rivers throughout the survey area include: The Beatrice River and the Wild River. The Beatrice River flows into the Johnston just south east of Millaa Millaa. The Wild River has its headwaters near Herberton. From there it flows in a south-westerly direction. All of the rivers on the Atherton Tableland appear to have had their course altered at some stage by lava flows and volcanic activity.

The major water resource in the study area is Tinaroo Dam located on the Barron River at the northern end of the study area, which supplies water to the Mareeba Dimbulah Irrigation Area and Atherton township.

Subsurface hydrology

The main geological regimes in which groundwater occurs in the area are

- The Carboniferous Barron River Metamorphics
- The Carboniferous Mareeba and Tully Granite
- The Tertiary Atherton Basalt
- Minor Alluvium

Extensive outcrops of acid volcanic rocks also occur within the area but these are generally massive and rarely contain usable supplies of groundwater.

Barron River Metamorphics

The main lithologies of the Barron River metamorphics are shale, schist, slate, greywacke and basic volcanics. The formation is of marine origin and outcrops to the north and east of Tinaroo Dam. It has been extensively faulted and folded and metamorphosed in places. Groundwater occurs in quartz veins which have infilled fractures and between bedding planes.

Groundwater is generally located at depths of between 40 and 60 m and supplies range from less than 1 L/s to 10 L/s with the average being 2.5 L/s. Water quality from this formation is generally adequate for stockwatering, domestic and irrigation purposes where sufficient internal drainage exists.

Mareeba and Tully Granite

Groundwater occurs in the upper zones of this formation at depths of less than 30 m. It is generally located in fractures which develop close to the surface. Supplies from these fractures are usually of the order of 2 to 5 L/s depending on the extent of the fracture system intersected. Minor supplies (<0.25 L/s) are found in decomposed granite.

The Mareeba Granite forms elevated terrain throughout to the north of Tinaroo Falls Dam, whilst the Tully Granite forms elevated terrain southeast of Malanda and east of Millaa Millaa. Few water bores have been drilled in these granites owing to ready availability of alternative surface water supplies especially around Tinaroo Dam. Consequently, little is known about regional water level behaviour in these aquifer units. Water quality is very good.

Atherton Basalt

The majority of the groundwater used in the study area is produced by this formation. The Atherton Basalt occurs mainly in a roughly triangular-shaped area bounded by the towns of Malanda, Atherton and Mareeba although tongues of basalt extend to the north, south and east. The formation is comprised of horizontal layers of blocky and vesicular basalt. It is thickest beneath the town of Tolga (100m) and thinnest towards its lateral boundaries.

Supplies from this formation range from 5 to 50 L/s depending on the thickness of basalt available at the site of the borehole. The average depth to which water bores are drilled in this formation is around 60 m. The quality of water from the Atherton Basalt is excellent and suitable for all purposes. This aquifer unit is very porous and permeable and, consequently very dynamic. It is recharged by direct infiltration of rainfall and seasonal variations of water level in the aquifer can be as much as 20 m.

The main use of groundwater from this unit is for irrigation of crops in the Atherton, Tolga and Kairi area (about 12 000 ML/annum). Other uses include town water supplies, stock watering and minor industrial purposes.

Alluvium

Minor alluvial sequences are associated with the larger watercourses in the area (the Barron and Walsh Rivers). Alluvium, consisting predominantly of granite-derived quartz sand and silt derived from finer-grained rocks, extends for distances of about 250 m from these rivers.

Groundwater Regulation

Licences for the extraction of groundwater are required only within the Atherton Shire as the Atherton Basalt is the primary groundwater resource of the area. The remainder of the study area is not proclaimed as an area of sub-artesian supply. No licence is required if the water is to be used for domestic purposes only.

3. Soils

The subtropical climate of the Tablelands has generally produced deep, well drained soils. The soils of the study area have been mapped and described at a scale of 1:50 000. In the survey area, thirty two soil profile classes, a variant and a phase have been identified. Table 5 shows areas of individual soils. Figures 5a, 5b and 5c show the soils in relation to each other and the landscape. Appendix 1 describes details of individual soil profile classes.

Table 5 Areas of individual soil profile classes on the Atherton Tableland

Geology	Soil Profile Class	Area (ha)	% of total area
Basalt	Maalan	36 198	22.3
	Quincan	562	0.4
	Heales	704	0.4
	Pin Gin	32621	20.1
	Barron	3174	2.0
	Tolga	14 105	8.7
	Kaban	2779	1.7
	Millstream	197	0.1
	Walkamin	159	0.1
	Walkamin Grey Phase	87	0.05
	Morgan	87	0.05
	Snider	127	0.08
Granite	Utchee	21 683	13.4
	Severin	12 415	7.6
	Nettle	335	0.2
	Gowrie	801	0.5
	Gillies	1760	1.1
	Expedition	201	0.1
Rhyolite	Umala	10 027	6.2
	Umala Rocky Phase	2004	1.2
	Bally	680	0.4
	Whelan	4335	2.7
	Worsely	351	0.2
	Flaggy	554	0.3
	Sylvia	949	0.6
	Mazlin	24	0.1
Schist	Galmara	8055	5.0
	Bicton	3967	2.4
Alluvial	Wongabel	539	0.3
	Carrington	567	0.3
	Tranters	787	0.5
	Gwynne	768	0.5
	Peterson	290	0.2
	Nyleta	249	0.2
	Total	162141	100

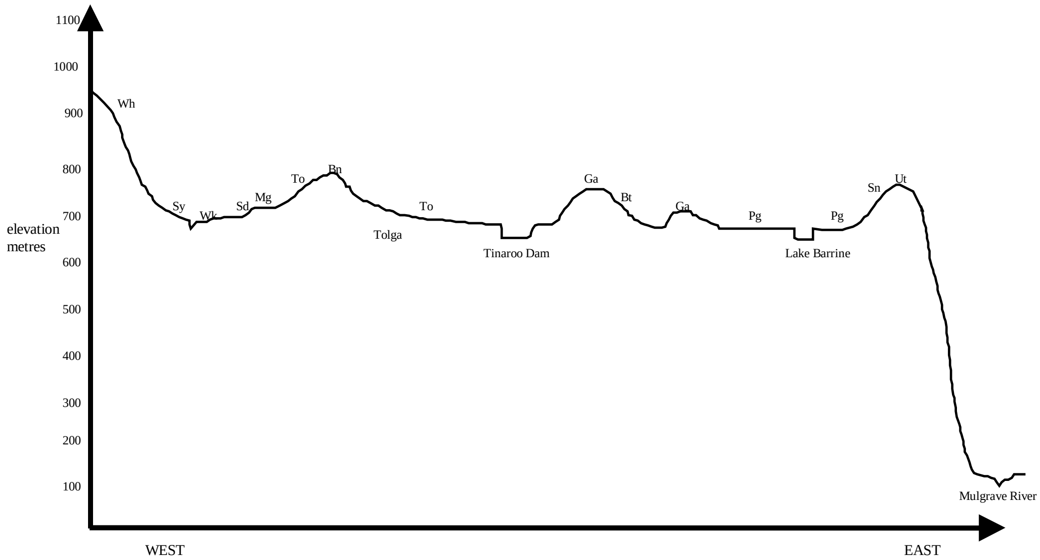


Figure 5a Tolga to Lake Eacham Barrine (not to scale)

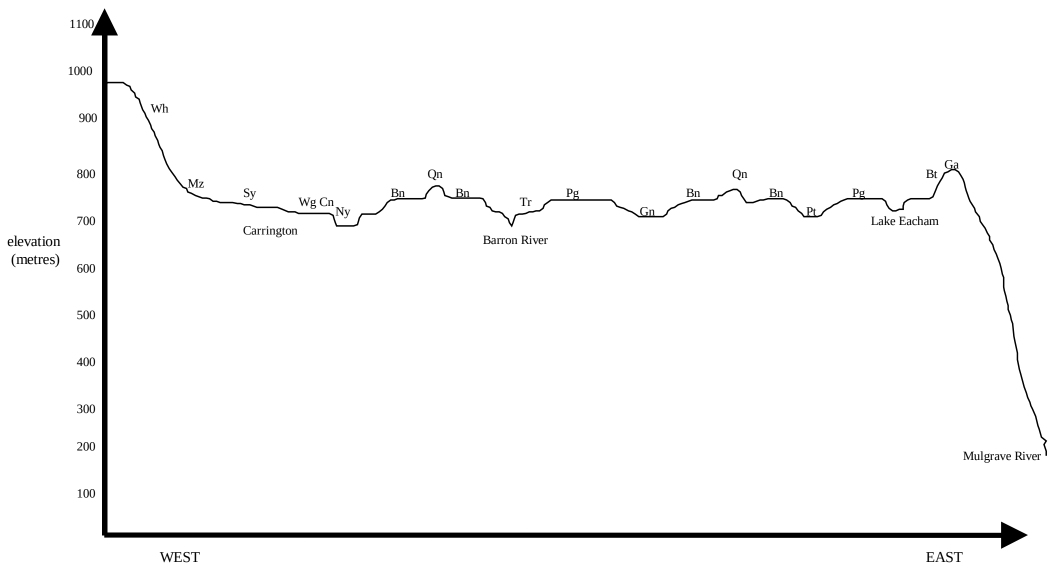


Figure 5b Carrington to Lake Eacham (not to scale)

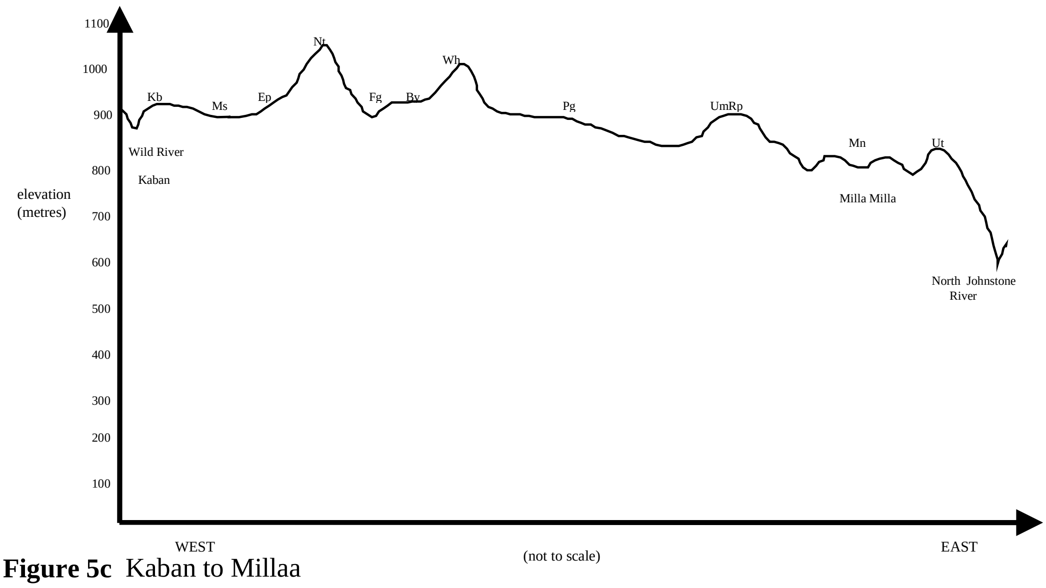


Figure 5c Kaban to Millaa

Morphology and classification

Soils derived from basaltic rocks

Maalan soil is a major SPC covering 36 198 ha. They are Red and Brown Ferrosols which have formed on older, strongly weathered and dissected lava flows in the higher rainfall areas around Millaa Millaa. Basalt rock and boulders can be found on the surface and weathered basalt is common lower in the profile. Profiles are deep and well drained. They consist of pedal brown/red-brown clay A horizons, over pedal red brown clay B2 horizons, grading to brown clay B3 horizons with weathering basalt fragments. Soil reaction trend is acid.

Quincan soil covers 562 ha. They are Brown Dermosols which have formed on the slopes of weakly weathered cinder cones (Mt Quincan, Seven Sisters) and contain considerable amounts of basaltic scoria gravels. Profiles are moderately deep and well drained. They consist of pedal brown/red-brown fine sandy clay loam A horizons containing scoria gravels over pedal red-brown fine sandy clay loam to clay B2 horizons with scoria gravels and manganese nodules, grading to brown fine sandy clay loam B3 horizons with increasing amounts of scoria gravels and manganese nodules, grading to a C horizon of scoria gravels. Soil reaction trend is neutral.

Heales soil covers 704 ha. They are Red Ferrosols which have formed on the footslopes of cinder cones (Mt Quincan, Seven Sisters) downslope from the Quincan soils and contain considerable amounts of basaltic scoria gravels. Profiles are very deep and well drained. They consist of pedal red-brown/red clay A horizons containing some scoria gravel, over pedal red/red-brown clay B2 horizons containing scoria gravel, grading to mottled brown clay BC horizons with considerable amounts of scoria gravel. Soil reaction trend is neutral.

Pin Gin soil is a major SPC covering 32 621 ha. They are Red Ferrosols which have formed on older highly weathered basalt flows between Atherton, Malanda and Millaa Millaa. Profiles are very deep and well drained. They consist of pedal dark or red clay A horizons, over pedal red clay B2 horizons. Soil reaction trend is acid.

Barron soil covers 3174 ha. They are Brown Ferrosols which have formed on the basalt flows from the younger volcanic vents and cinder cones such as the Seven Sisters, Mt Quincan. These soils are probably the most fertile in the study area due to their young age and relatively weakly weathered state. Profiles are deep and well drained. They consist of pedal brown/dark clay A horizons, over pedal brown/dark clay B2 horizons containing basalt rock, grading to pedal brown/dark clay B3 horizons containing basalt rock, grading to C horizons of basalt at depth. Soil reaction trend is neutral.

Tolga soil is a major SPC covering 14 105 ha. They are Red Ferrosols which have formed on basalt flows originating from Bones Knob (a large shield volcano immediately west of Tolga). Profiles are very deep and well drained. They consist of pedal dark or red clay A horizons over pedal red clay B2 horizons. Soil reaction trend is neutral and manganese nodules are common throughout the profile. Basalt rock is common however it appears that it is predominantly on the surface. Most farmers pick the rock and pile it usually along edges or in the centres of paddocks.

Kaban soil covers 2779 ha. They are Red Ferrosols which have formed on basalt flows originating from shield volcanoes to the south. They are the major agricultural soil in the Herberton area. Profiles are very deep and well drained and are similar to the *Tolga* series however they generally contain larger amounts of manganese nodules and have an apedal B1 horizon. Soil reaction trend is neutral.

Millstream soil covers 197 ha. They are Yellow Dermosols which have formed south of Herberton and are very similar to the *Walkamin* series except they contain more ferromanganese nodules and basalt coarse fragments and have an acid soil reaction trend.

Walkamin soil covers 159 ha. They are Brown Dermosols which have formed on the lower slopes of the lava flows of Bones Knob immediately below the Tolga soils. They are seen as the poorer drained equivalents of the Tolga soils. Profiles are deep and imperfectly drained with mottles and ferromanganese nodules throughout. They consist of pedal dark clay A1 horizons, grading to pedal mottled brown or yellow brown clay B horizons, grading to C horizons of weathering basalt. Soil reaction trend is neutral. A *Walkamin grey phase* has also been mapped. It occurs in conjunction with the Walkamin soils usually in lower, poorer drained situations

Morgan soil covers 87 ha. They are Brown Vertosols which have formed in depressions just above the basalt walls formed at the edge of lava flows. They are most prevalent in the drier northern part of the region north of Tolga. Profiles are deep and imperfectly to poorly drained. Cracking is also evident in drier times. They consist of pedal brown clay A horizons, over pedal mottled brown clay B2 horizons containing some carbonate nodules, grading to pedal mottled yellow brown clay B3 horizons containing basalt rock. Soil reaction trend is alkaline.

Snider soil covers 127 ha. They are Brown Dermosols which have formed at the edges of basalt flows. Profiles are moderately deep and imperfectly to well drained and contain considerable amounts of basalt rock. They consist of pedal dark or brown clay A1 horizons containing basalt rock, over pedal mottled brown clay B horizons containing basalt rock, grading to C horizons weathering basalt. Manganese nodules are also found throughout the profile. Soil reaction trend is neutral.

Soils derived from granitic rocks

Utchee soil is a major SPC covering 21 683 ha. They are Red Dermosols found mostly in the wetter areas east of Millaa Millaa and southeast of Malanda. Profiles are deep and well drained. They consist of pedal brown sandy clay A1 horizons, over pedal red-brown/brown sandy clay A2 horizons, grading to pedal red/red-brown sandy clay B2 horizons often grading to pedal mottled red sandy clay B3 horizons. Quartz pebbles are common throughout these soils. Soil reaction trend is acid.

Severin soil is a major SPC covering 12 415 ha. They are Yellow Dermosols and can be found in conjunction with the Utchee soils often downslope in slightly poorer drained situations. Profiles are deep and imperfectly drained. They consist of pedal dark or grey sandy clay A1 horizons, over yellow-brown sandy clay A2 horizons, over pedal mottled yellow-brown sandy clay B2 horizons, grading to mottled yellow-brown sandy clay BC horizons of decomposing granite. Quartz pebbles are prevalent throughout the profile. Soil reaction trend is acid.

Nettle soil is a very minor SPC covering 335 ha. They are Brown Kandosols which have formed in the drier areas around Herberton. Profiles are shallow and well drained. They consist of brown or dark apedal sandy loam A1 horizons, over apedal yellow-brown coarse sandy loam AC horizons with 50-90% granite fragments over C horizon of decomposing granite. Soil reaction trend is acid.

Gowrie soil is a minor SPC covering 801 ha. They are Red Kandosols which have formed on or around the northern edge of Tinaroo Dam and west of Atherton. Profiles are very deep and well drained. They consist of pedal dark or red-brown sandy clay loam A2 horizons over apedal red or red-brown sandy clay B2 horizons. Quartz pebbles are common throughout. Soil reaction trend is acid.

Gillies soil is a minor SPC covering 1760 ha. They are Tenosols which have generally formed in conjunction with the Gowrie soils. Profiles are deep and rapidly drained. They consist of apedal brown loamy sand A1 horizons, over apedal brown sandy loam A2 horizons, over yellow sandy loam B2 horizons, grading to sandy clay loam B3 horizons containing decomposing granite. Quartz pebbles are prevalent throughout the profile. Soil reaction trend is acid.

Expedition soil is a very minor SPC covering 201 ha. They are Red Kandosols which have formed on footslopes around the Herberton, Ravenshoe area. Profiles are deep and well drained. They consist of apedal brown or red-brown sandy loam A1 horizons, over apedal pale sandy loam A2 horizons, over apedal red-brown sandy clay B horizons. Soil reaction trend is acid.

Soils derived from acid volcanic rocks

Umala soil is a major SPC covering 10 027 ha. They are Brown Dermosols found in the south-west of the study area. Profiles are very deep and moderately well drained. They consist of pedal dark or brown sandy clay A1 horizons, over pedal brown light clay A2 horizons, over pedal mottled red-brown clay B2 horizons, grading to pedal mottled red brown sandy clay B3 horizons containing weathered rhyolite. Soil reaction trend is acid. An *Umala rocky phase* has been mapped in steeper areas. These contain more rock on the surface and in the profile.

Bally soil is a minor SPC covering 680 ha. They are Red Dermosols found in the south-west between Millaa Millaa lookout and Kaban. Profiles are very deep and well drained. They consist of pedal dark or reddish brown clay loam A1 horizons, over red or brown clay loam A2 horizon, grading to pedal red clay B2 horizons. Soil reaction trend is acid.

Whelan soil is a relatively major SPC covering 4335 ha. They are Brown Kandosols which have formed along the western margins of the area. Profiles are shallow and well drained. They consist of apedal grey brown sandy clay loam A1 horizons, over apedal conspicuously bleached sandy clay loam A2 horizons, grading to apedal grey or yellow-brown sandy loam BC horizons, grading to C horizon of decomposing rhyolite. Fragments of rhyolite are common throughout the profile. Soil reaction trend is acid.

Worsley soil is a minor SPC covering 351 ha. They are Yellow Dermosols which have formed along the western margins of the area. Profiles are deep and imperfectly to moderately well drained. They consist of pedal dark or grey-brown silty clay loam A1 horizons, over pedal brown or grey silty clay loam A2 horizons, over pedal mottled yellow-brown sandy clay B2 horizons, grading to yellow sandy clay B3 horizons containing decomposing rhyolite. Fragments of rhyolite are common throughout the profile. Soil reaction trend is acid.

Flaggy soil is a minor SPC covering 554 ha south of Herberton. They are Yellow Kandosols which have formed on footslopes of the hills and low hills south of Herberton. Profiles are deep and imperfectly to moderately well drained. They consist of pedal grey sandy clay loam A1 horizons, over apedal pale sandy clay loam A2 horizons, over apedal yellow-brown sandy clay B2 horizons, grading to C horizons of decomposing rhyolite. A few manganese nodules and quartz pebbles can be found throughout the profile. Soil reaction trend is acid.

Sylvia soil is a minor SPC covering 949 ha. They are Grey Chromosols which have formed to the west and south-west of Atherton on footslope and fan material. Profiles are deep and poorly drained. They consist of apedal grey sandy clay loam A1 horizons, over apedal conspicuously bleached clay loam A2 horizons, over pedal mottled grey dense clay B2 horizons, grading to pedal yellow grey B3 horizons of decomposing rhyolite. Soil reaction trend is acid.

Mazlin soil is a very minor SPC covering just 24 ha. They are Brown Dermosols which have formed on footslopes of the hills and low hills south-west of Atherton. Profiles are very deep and well drained. They consist of pedal grey or dark silty clay A1 horizons, over a pedal brown silty clay loam A2 horizons, over pedal mottled red brown clay B2 horizons, grading to mottled grey clay B3 horizons dominated by weathering rhyolite. Soil reaction trend is acid.

Soils derived from metamorphic rocks

Galmara soil is a major SPC covering 8055 ha. They are Red Dermosols which have formed to the east of Tinaroo dam.. Profiles are deep and moderately well to well drained. They consist of dark fine sandy clay loam A1 horizons, over a pedal red-brown or brown fine sandy clay loam A2 horizons, over pedal red or red-brown fine sandy light clay B2 horizons, grading to mottled yellow-brown clay loam B3 horizons, and C horizons of weathering schist. Quartz pebbles are common throughout the profile and soil reaction trend is acid.

Bicton soil is a major SPC covering 3967 ha. They are Yellow Dermosols which have formed in conjunction with the Galmara soil, usually in slightly poorer drained landscape positions. Profiles are deep and imperfectly drained. They consist of pedal brown or grey fine sandy clay loam A1 horizons, over pedal yellow-brown fine sandy clay loam A2 horizons, over pedal mottled yellow or yellow-brown clay B2 horizons, grading to pedal mottled yellow or yellow-brown clay loam fine sandy B3 horizons, grading to a C horizon of weathering schist. Quartz pebbles are common throughout the profile and soil reaction trend is acid.

Soils formed on alluvium derived from basalt

Tranters soil is a minor SPC covering 787 ha. They are Brown Dermosols which have formed on very gently sloping (1-3%) creek and river terraces. Profiles are very deep and well drained. They consist of pedal dark or brown clay loam (sometimes sandy) A1 horizons, over pedal brown sandy clay B2 horizons, over (where present) pedal mottled grey clay D horizons. Soil reaction trend is acid.

Gwynne soil is a minor SPC covering 768 ha. They are Brown Dermosols which have formed on level (0-1%) to very gently sloping (1-3%) floodplains and back plains. Profiles are very deep and imperfectly drained. They consist of pedal dark clay A1 horizons, over pedal mottled brown clay B2 horizons, grading to pedal mottled grey clay B3 horizons. Manganese nodules are common throughout the profile. Soil reaction trend is acid.

Peterson soil is a minor SPC covering 290 ha. They are Grey Vertosols which have formed in the alluvium of Peterson Creek between Yungaburra and Peeramon. Profiles are very deep and very poorly drained. They consist of pedal grey-brown clay A horizons, over pedal mottled grey or brown clay B2 horizons, grading to mottled grey or gleyed horizons. Soil reaction trend is acid to neutral.

Soils formed on alluvium derived from granitic and acid volcanic rocks

Wongabel soil is a minor SPC covering 539 ha. They are Yellow Dermosols found on very gently (1-3%) sloping alluvial/colluvial fans south of Atherton. Profiles are deep and imperfectly to poorly drained. They consist of apedal dark or grey sandy clay loam A1 horizons, over apedal yellow-brown sandy clay loam A2 horizons, over apedal mottled yellow-brown sandy clay B2 horizons, grading to yellow-brown sandy clay D horizons containing quartz pebbles. Quartz fragments are also common throughout the profile. Soil reaction trend is acid.

Carrington soil is a minor SPC covering 567 ha. They are Redoxic Hydrosols found in depressions on the lower slopes of alluvial/colluvial fans. Profiles are deep and very poorly drained. They consist of pedal dark or grey clay A1 horizons, over pedal mottled grey clay A2 horizons, over mottled grey or grey-brown sandy clay B2 horizons, grading to mottled grey sandy clay loam D horizons. Soil reaction trend is acid.

Organic Soils

Nyleta soil is a minor SPC covering 249 ha. They are Organosols which have formed in drainage depressions and volcanic craters such as Quincan Crater, Lynches Crater and Bromfield Crater, or where a stream has been cut off often by a basalt flow. Profiles are moderately deep and comprise of dark clay peat P1 and P2 horizons, grading to mottled dark clay B1 horizons, grading to mottled dark clay B2 horizons. Soil reaction trend is acid.

Comparisons with other work

Previous soil mapping did not have sufficient detail to assess land suitability throughout the area. This caused problems in the assessment of good quality agricultural land for local authorities who needed the information in their assessment of rezoning applications.

Generally the major soil boundaries identified by Laffan (1988) were correct. The extra detail of the current Tableland survey however allowed further refinement of these boundaries and the soils within them. For example the boundary between the *Tolga* and *Pin Gin* soil has been moved south of Atherton identifying another 5000 ha of *Tolga* soil. Around Kairi small patches of *Galmara* soil were identified in areas mapped as *Tolga*.

Larger areas previously mapped as complexes (mixtures of SPCs) were also refined into discrete units with one dominant soil profile class. The main complexes were the *Pin Gin-Utchee* (Malanda to Millaa Millaa), *Pin Gin-Galmara* (Lake Barrine to Malanda) and *Maalan-Utchee* (Millaa Millaa to Maalan). In these areas a further 6500 ha of *Utchee* soils; 1200 ha of *Galmara* soils and 10 000 ha of *Maalan* soils were identified.

Ten soil profile classes, a phase (*Umala rocky phase*) and a variant (*Walkamin grey variant*) were added to those of Laffan (1988). The *Coolabbi* soil mapped by Laffan (1988) only covered approximately 40 ha. It was decided to remove this soil profile class and amalgamate it with the *Umala* soils as differences between the two were hard to distinguish. Of the soils added seven were taken from the work of Heiner and Grundy (1994) who mapped the soils of the Ravenshoe 1:100 000 sheet area and three from the mapping of Walkamin Research Station (Malcolm and Heiner, 1996). Both of these areas are adjacent to the Atherton Tableland study area.

The *Kaban* soils of Grundy and Heiner (1994) are very similar to the *Tolga* soils with the main difference being that the Kaban has formed in a drier environment and contains larger amounts of manganese nodules. These soils are also similar to the *Mape*e soils described by Shepherd and Macnish (1989) and later by Malcolm and Heiner (1996). The *Millstream* soils of Grundy and Heiner (1994) are very similar to the *Walkamin* SPC. The *Pin Gin, Galmara* and *Bicton* soils of Murtha (1986) are identical to those used in this report.

The soils of Kairi Research Station which lies within the Atherton Tableland survey area were mapped in much more detail by Warrell *et al.* (1984). Their soil profile classes relate to the Atherton survey as follows

Bolygum = Galmara
McDonald = Galmara
Kairi = Pin Gin
Drysdale = Tolga
Godfrey = Tolga
Pope = Tolga
Yungaburra = Tolga

Soil chemical properties

Data used in the interpretation of the chemical properties of the soils of the Atherton tableland was drawn from four sources. Thirteen profiles were sampled as part of this investigation (Appendix 2). These were seen as soils with major agricultural importance. Chemical analysis for remaining SPC's were reported in Laffan (1988), Heiner and Grundy (1994) and Malcolm and Heiner (1996).

Several sites were analysed for those SPC's which had significance in land use and which covered large parts of the study area. Paired samples were also taken from the Tolga SPC to find any differences between virgin and cleared sites.

To facilitate discussion, the soils have been placed into six groups according to the parent material from which they were derived.

Table 6 summarises selected analytical data of Appendix 2 for use in this section.

The groups are as follows.

1. Soils derived from basaltic rocks
   Pin Gin, Maalan, Tolga, Kaban, Millstream, Walkamin, Barron, Heales, Quincan, Snider, Morgan

2. Soils derived from granitic rocks
   Utchee, Severin, Gowrie, Gillies, Expedition, Nettle

3. Soil derived from acid volcanic rocks (rhyolite)
   Umala, Bally, Whelan, Worsley, Flaggy, Sylvia, Mazlin

4. Soils derived from metamorphic rocks (schist and phyllite)
   Galmara, Bicton

5. Soils derived from alluvium
   Tranters, Gwynne, Peterson Wongabel, Carrington

6. Organic soils
   Nyleta (not sampled)

Although there were some differences in laboratory methods between CSIRO work and that of the Department of Natural Resources analytical centre, most results were compatible. In some instances there has been duplication of analysis between DNR and CSIRO. Where important, any differences between the two data sets have been highlighted.

Table 6. Summary of selected chemical data from appendix 2											
Soil group	**SPC**	**O.C wtb B0–0.1m**	**Total N KJEL B0–0.1m**	**Available Phosphorus B0–0.1m**	**Available Potassium 0–10 cm**	**Total S XRF B0–0.1m**	**ECEC m.eq/100g**	**Al sat % profile range**	**EC dS/m**	**pH H2O profile range**	**Cit–dith Fe %**
1	Pin Gin	v.high	high	low	med	v.high	30	69–97%	v.low	4.7–5.1	14
1	Maalan	v.high	high	high	med	v.high	41	80%	v.low	5.4–5.1	13
1	Tolga R.F	v.high	v.high	high	v.high	high–v.high	59	–	v.low	6.8–7.6	11
1	Tolga E.	high	high	med	high	high–v.high	18	–	v.low	6.6–5.9	11
1	Tolga P.	med	med	low	high	high–v.high	20	–	v.low	5.7–6.2	11
1	Kaban	high	low	high	v.high	med–low	29	–	v.low	6.6–6.0	*
1	Walkamin	high	na	med	na	na	26	–	v.low	6.0	*
1	Millstream	med	low	low	med	high–low	62	–	v.low	6.4–6.8–6.0	*
1	Barron	v.high	v.high	v.high	v.high	v.high–med	57	–	v.low	7.0–6.5	8
1	Heales (ns)							–	v.low	7.0	
1	Quincan	high	high	v.high	na	na	106	–	v.low	7.0–8.0	4
1	Morgan	med	na	v.low	na	na	74	–	v.low	6.6–6.9	*
1	Snider	med	na	low	na	na	53	–	v.low	6.2–6.9	*
2	Utchee	high	med	v.low	low	high–med	21	88–97%	v.low	5.3–5.0	*
2	Severin	v.high	high	low	high	m	25	31–78%	v.low	4.7–5.2	1
2	Gowrie	high	low	low	low	l	17	–	v.low	5.5	2
2	Gillies	high	low	v.low	v.high*	l	12	2–30%	v.low	6.3–6.2	*
2	Expedition	low	low	v.low	low	l	14	–	v.low	6.5–6.9	*
2	Nettle	low	v.low	v.low	med	l	3	–	v.low	6.3	*
3	Umala	v.high	high	low	v.low	high–med	33	41–88%	v.low	4.9–5.0	2
3	Bally	high	med	v.low	high	high-v.high	21	16–30%	v.low	5.3–4.9	*
3	Whelan	v.high	med	v.low	high	low–v.low	13	22–39%	v.low	5.3–5.5	*
3	Worsley	high	low	v.low	high	low–v.low	14	26–30%	v.low	5.6–6.1	1
3	Sylvia	low	low	v.low	high	v.low	18	62–48%	v.low	5.0–6.2	1
3	Mazlin	low	low	v.low	med	v.low	19	51–71–23	v.low	5.4–6.0	1
4	Galmara	high	med	low	high	high–med	15	8–86%	v.low	5.5–5.3	3
4	Bicton	high	high	low	high	med	11	80–65%	v.low	4.9–5.7	3
5	Tranters	high	high	v.high	v.high	high-med	41	–	v.low	6–8–66	4
5	Gwynne	high	high	med	low	high	28	6–80%	v.low	5.3	4
5	Peterson	v.high	v.high	med	low	v.high	110	–	low	5.4–7.5	1
5	Wongabel	med	low	v.low	v.high*	low	9	5	v.low	5.5 – 5.9	*
5	Carrington	high	high	med	high	high	23	34–50–.5	v.low	5.0–5.6	
6	Nyleta (ns)										

ns Not Sampled na not analysed * total Potassium used

Soil pH and variable charge characteristics

Soil pH is an important soil characteristic in the highly leached acid soils of the Tablelands which possess variable charge. The term ‘variable charge soil’ refers to a soil in which a significant proportion of charge on the particle surfaces, responsible for cation retention, is dependent upon the pH, concentration, and composition of the soil solution. These functional groups are situated on the edge of kaolinite clay minerals and on oxide surfaces, ie. minerals that are residual following extreme weathering (Gillman, 1983).

Due to the dependence of variable charge soils on pH, there is a particular pH (pH0) where the net charge of the variable charge surface is zero, ie. where the cation exchange capacity and anion exchange capacity on the variable charge surfaces are equal and any net negative charge present would be associated with constant charge surfaces in the soil. (Uehara and Gillman, 1981).

From the difference between the soil pH in a solution of calcium chloride and in a very dilute electrolyte (water), the sign of the net surface charge can be determined ie $\Delta pH = pH (CaCl) - pH (H_20)$. If the difference in soil pH is positive, zero or small negative (>0.5) then the values generally indicate soils dominated by variable charge minerals. Anion retention is likely. Where values are large negative nothing can be said whether charge is variable or permanent (Warrell *et al*, 1984) however a high surface negative charge density is indicated and cation retention assumed. Therefore the range of ΔpH for variable charge soils is $0 > \Delta pH > -0.5$.

Group 1

Profile soil reaction trends vary considerably amongst the soils derived from basalt. Basaltic soils formed in the wetter areas in the south east of the study area (*Pin Gin* and *Maalan*), have strongly acid (pH<5.5) soil reaction trends (Appendix 2). The soils in the drier areas to the west and north (*Tolga*, *Barron*, *Kaban*, *Quincan* and *Heales*) have neutral reaction trends (Appendix 2), whilst the *Walkamin* and *Millstream* have slightly acid reaction trends due to their positions lower in the landscape.

Three *Maalan* soils were analysed representing three separate basalt flows. The low pH values and high kaolin contents of these soils indicate the high rainfall and therefore high leaching environment. ΔpH values in the profiles of these soils indicate that two of the soils have variable surface charge subsoils around 50cm. Both of these soils were from areas where annual rainfall is 2500–3000mm. The other *Maalan* site was from an area which receives 1500mm per year. Liming will be required to improve these soils before addition of fertilisers.

The *Pin Gin* soil showed slightly negative ΔpH from 80cm indicating variable surface charge. Anion retention is expected in both the *Maalan* and *Pin Gin* soils and this is indicated by the total sulfur contents which increase down the profile,.(Appendix 2). The fact that these soils show very low amounts of cations in their subsoils highlights the important role of organic matter in maintaining modest amounts of cations in the surface layers (Gillman and Sumpter, 1986).

The other basaltic soils had high negative ΔpH values indicating net negative charge and therefore cation retention. However of the three *Tolga* soils sampled the soil under the improved pasture site did display variable charge characteristics below 1.4 metres. This should not be of concern for most agricultural activities.

Group 2

All granitic derived soils are mildly to strongly acid (Appendix 2). Like the basaltic soils found in the higher rainfall areas the *Utchee* and *Severin* are strongly acid with pH<5.5. Again this is indicative of a high leaching environment. ΔpH values of the sampled soils were high negatives and therefore do not indicate any variable charge. Net negative charge is however indicated and therefore cation retention is expected.

Group 3

The acid volcanic derived soils again show a similar trend to the granitic soils in that the soils of the wetter zones namely the *Umala* and the *Bally* have strongly acid soil reaction trends (pH<5.5) (Appendix 2). ΔpH values indicate net negative charge and therefore cation retention.

Group 4

Both of the metamorphic derived soils have strongly acid reaction trends (pH<5.5) (Appendix 2) and very low levels of soluble salts. ΔpH values indicate net negative charge and therefore cation retention. Corresponding soils on the wet tropical coast exhibit variable charge characteristics (Gillman and Abel, 1987).

Group 5

The alluvial soils have varying reaction trends probably reflecting the different parent materials and drainage conditions. Generally the basaltic derived alluvium has acid to neutral pH whilst the granitic/acid volcanic derived alluvium is acid to strongly acid (Appendix 2). No variable charge characteristics were evident

Cation exchange capacity, exchangeable cations and exchange acidity

CEC (Cation Exchange Capacity) measures the ability of the soil to adsorb cations in exchangeable forms. It corresponds to the negative charge of the soil and is normally expressed in milli equivalents per 100 grams of soil. Baker and Eldershaw (1993) state that a minimum CEC of 5 meq/100g is required. Below this infertility problems are likely to occur. They also state the following minimum percentage requirements of total CEC for exchangeable cations in acid to neutral soils provided levels are above sufficiency.

- calcium 65–80%
- magnesium 10–15%
- potassium 1–5%
- sodium 0–1%
- aluminium <5%

Effective cation exchange capacity (ECEC) is the method used for highly leached acid soils. This method also measures hydrogen and aluminium (exchange acidity) as well as calcium, magnesium, potassium and sodium at a pH similar to that of the soil. Soils with slightly acid to neutral pH values have minimal levels of exchange acidity and therefore it is not determined.

Group 1

All soils derived from basalt have ECEC values greater than 5 meq/100g in the surface (Table 7). This can probably be attributed to high clay and organic matter contents. Nutrient holding capacity should therefore be adequate provided organic matter contents are preserved .

In Appendix 2 it can be seen that ECEC values generally decrease with depth to a point where they remain fairly constant. Only the *Tolga* eucalypt (2meq/100g), *Tolga* pasture (3meq), Kaban (3meq) and *Walkamin* (3meq/100g) soils have ECEC levels less than 5 meq/100g lower down the profile. Very high ECEC values are evident in the *Quincan* (35meq/100g) and *Morgan* (31meq/100g) soils reflecting the young age of the *Quincan* and heavy clay textures of the *Morgan*.

Using the minimum exchangeable cation figures of Baker and Eldershaw (1993), all group one soils have adequate levels of exchangeable calcium in surface soils (Table 7). The only exceptions are the *Pin Gin* (16%)and *Maala*n soils (20%) which reflect their highly leached status. Similar results were found by Isbell *et al*. (1976). A strong association between high levels of organic carbon and exchangeable calcium for surface soils derived from Atherton basalt was found by Warrel *et al* (1984).

Exchangeable magnesium levels are sufficient in surface soils (Table 7) according to the figures of Baker and Eldershaw (1993). Exchangeable sodium and potassium are also at adequate levels.

Table 7 shows percentages of all major cations (including exchange acidity) for surface 0–10cm and 20–30cm which represents the top of the subsoil horizons. It can be seen that exchangeable acidity (hydrogen and aluminium) make up to 90% of the effective cation exchange capacity in the *Pin Gin* (90%) and *Maalan* (97%) soils. Due to their low pH (<5.5) there is a strong possibility of aluminium toxicity in sensitive plants on these soils (Heiner and Grundy, 1994). Liming would be recommended.

Group 2

The ECEC values of the granitic derived soils are generally adequate in the surface 0–10 cm (Table 6). Only the *Expedition* and *Nettle* soils have values less than 5 meq/100g. This can be related to high sand contents of 85 to 90% and low organic matter contents of 0.6-1.0%.Nutrient holding capacity of these soils will be poor. *Gillies* has reasonable ECEC (12 meq/100g) in the surface but declines rapidly with depth. Organic matter in the surface layers is the most likely explanation of this. The high sand contents and low clay contents in these soils mean reduced charged sites to which cations can be attached. These soils are highly leached and therefore will only retain a small percentage of added nutrients.

Exchangeable calcium and magnesium levels are adequate in the surface of all group two soils (Table 7). The *Utchee* is the only exception having very low calcium levels. This soil has high sand contents (Appendix 2) and is highly leached. Exchangeable sodium and potassium levels are high especially in the *Severin*. This may reflect the high potassium levels of the granitic parent material.

Hydrogen and aluminium dominate the exchange complex of the *Utchee* (80%), *Severin* (63%) and *Gowrie* (50%) soils reflecting the high rainfall and high leaching environment these soils are in. Like the *Pin Gin* and *Maalan* soils, the *Utchee* and *Severin* have pH values below 5.5 and therefore aluminium toxicity is a possibility.

Group 3

The soils developed on acid volcanic rocks have very similar ECEC and exchangeable cation values as the granitic derived soils (Table 7). In the *Mazlin* and *Sylvia* soils, magnesium exceeds calcium at all depths. Except for the *Bally*, all of these soils are likely to have unstable subsoils prone to erosion as well as nutrient disorders. Exchangeable acidity is also high dominating the exchange of the *Umala*, *Sylvia* and *Mazlin* soils (60-70%).

Group 4

The two soils formed from metamorphic rock were similar in that their surface ECEC values were adequate (Table 1). However their exchangeable cation levels were substantially different (Table 7). The *Galmara* was found to be dominated by calcium on the exchange whilst the *Bicton* was dominated by magnesium. Warrel *et al* (1984) found similar results on *Bolygum* and *McDonald* soils which correspond to the *Galmara* of this survey.

Exchange acidity increased down the profile of the *Bicton* to very high levels (80%) making aluminium toxicity a possibility in sensitive plants (Table 7). The Galmara did not exceed 50% throughout the profile

Group 5

The alluvial soils have CEC (Table 1) and exchangeable cation levels (Table 7) that generally correspond to the parent materials from which they were derived. The *Tranters*, *Gwynne* and *Peterson* soils all have similar values to those of the basaltic soils whilst the *Wongabel* and *Carrington* have high levels of exchangeable magnesium and potassium typical of their acid volcanic and granitic counterparts.

Table 7 Exchangeable cations (%) and exchangeable acidity (%) at 0–10cm and 20–30cm

SOIL	**Ca 0–10**	**Ca 20–30**	**Mg 0–10**	**Mg 20–30**	**Na 0–10**	**Na 20–30**	**K 0–10**	**K 20–30**	**H+Al 0–10**	**H+Al 20–30**
Pin Gin	16	2	12	8	1	1	4	2	69	90
Maalan	6	1	6	3	1	1	2	1	80	97
Tolga Rf	80	86	15	8	0.2	0.3	3	5	–	–
Tolga E	64	21	27	29	1	2	10	5	–	–
Tolga P	65	83	25	18	2	0.3	14	2	–	–
Kaban	64	50	21	30	2	3	10	14	–	–
Walkamin	70	47	24	49	0.4	1	5	3	–	–
Millstream	69	69	23	29	1	1	3	2	–	–
Barron	75	75	20	20	0.5	0.6	4	6	–	–
Quincan	75	79	18	14	0.2	0.4	6	7	–	–
Morgan	68	53	27	43	1.5	3	2	1	–	–
Snider	64	65	32	27	0.3	6	4	1	–	–
Utchee	3	0.5	6	1	1	1	2	1	88	80
Severin	52	26	10	7	0.3	0.7	4	63	31	63
Gowrie	56	18	26	23	0.7	1	10	8	6	50
Gillies	74	3	21	2	0.2	0.3	3	1	2	33
Expedition	60	55	25	41	1	2	6	12	–	–
Nettle	77	na	21	na	1	na	10	na	–	–
Umala	51	5	18	14	2	2	4	3	23	70
Bally	41	30	28	26	3	4	11	11	16	28
Whelan	30	11	32	36	2	2	13	10	22	39
Worsley	37	7	27	46	3	5	7	10	26	32
Sylvia	4	1	19	26	3	3	13	8	61	63
Mazlin	13	1	25	19	3	2	9	5	51	71
Galmara	50	37	34	27	2	3	11	15	1	20
Bicton	1	1	8	14	2	3	4	5	85	78
Tranters	64	63	27	32	1	1	9	8	–	–
Gwynne	70	61	18	27	3	0.6	4	0.6	6	1
Peterson	52	49	44	50	1	0.6	2	0.3	0	–
Wongabel	21	7	15	14	3	3	8	2	53	68
Carrington	34	23	24	25	1	3	6	4	34	50

Soil Organic Carbon and Total Nitrogen

Group 1

The majority of soils developed on basalt have moderate to very high levels of organic carbon in the surface 0–10cm (Table 6). These range from 1.9% in the *Morgan* to 5.7% in the *Maalan* and *Barron* soils (Table 8).

Values were found to be higher under rainforest where the soil surface is covered by a dense layer of leaf litter and conditions are ideal for decomposition. On the other hand soils under eucalypt forest surface cover and conditions are generally drier. Isbell *et al*. (1976) found similar values for soils in the same area attributing the results to the higher frequency of fires in the eucalypt forests compared to the rainforest. These fires having the effect of reducing organic matter. The low levels in the *Tolga* pasture site (1.9%) is typical of other cleared sites where practices such as intensive cropping and seasonal burning result in long term breakdown of organic carbon Baker and Eldershaw (1993). The *Morgan* and *Millstream* soils were not disturbed but were from drier areas where vegetation was sparse.

Table 8 Organic carbon, total nitrogen and carbon to nitrogen ratios for basaltic soils

SPC	Vegetation	O.C %	Total N %	C:N ratio
Pin Gin	rainforest	5.1	0.43	12
Maalan	rainforest	5.7	0.42	13
Tolga rainforest	rainforest	5.2	0.51	10
Tolga eucalypt	eucalypt	4.1	0.29	14
Tolga pasture	pasture	1.9	0.19	10
Kaban	eucalypt	2.8	0.14	20
Walkamin	eucalypt	3.5	not analysed	
Morgan	eucalypt	1.9	not analysed	
Millstream	eucalypt	2.3	0.10	23
Barron	rainforest	5.7	0.51	11
Quincan	rainforest	4.9	0.40	12

Total nitrogen content for surface soils shows a similar pattern to organic carbon with values ranging from low (0.10 %) in the *Millstream* to very high (0.51 %) in the *Barron*. Isbell *et al*. (1976) found total nitrogen to be related to rainfall and vegetation. They found that soils in with higher rainfall and denser vegetation generally have higher levels of nitrogen and organic carbon.

Carbon to nitrogen ratios vary between 10 and 14 (Table 8). Generally speaking, the lower the value the more nitrogen will be mineralised making it available for plant growth (Baker and Eldershaw 1993). The highest value found was 23 in the *Millstream* which was analysed during the Ravenshoe Mt Garnet soil and land suitability survey. Analysis from other projects show values of 17–25. These higher values were generally found in areas of less than 1400mm rainfall. Thus nitrogen deficiency is likely to be a common problem in the *Kaban* and *Millstream* soils.

Group 2

Like the basaltic soils in the wetter areas, the granitic soils such as the *Utchee* and *Severin* have high to very high organic carbon levels, ranging from 2.7% to 5.3% respectively (Table 9) due to the denser rainforest vegetation that grows in these areas.

Table 9 Organic carbon, total nitrogen and carbon to nitrogen ratios for granitic soils

Soil	O.C%	Total N%	C:N ratios
Utchee	2.7	0.16	17
Severin	5.3	0.33	16
Gowrie	2.9	0.11	26
Gillies	3.5	0.12	29
Expedition	1.0	0.05	20
Nettle	0.6	0.04	15

The organic carbon levels of the *Gowrie* and *Gillies* soils which form at the edge of the wetter areas are high whilst the *Expedition* and *Nettle* soils from the drier areas around Herberton have low levels 1.0% and 0.6% respectively, (Heiner and Grundy, 1994).

Total nitrogen levels are low for all group 2 soils except for the *Utchee* which was high and *Severin* which had very high levels. Other group two soils have levels around 0.1% which indicates potential problems for plant growth. (Baker and Eldershaw, 1993). The low clay contents , low organic matter contents and high sand contents are a reason for this. Kerridge *et al*. 1972 found similar levels of total nitrogen in *Utchee* soils around Tarzali.

Carbon to nitrogen ratios are high (Table 9) ranging from 15 in the *Nettle* to 29 in the *Gillies*. These values reflect the low nitrogen levels found in these soils. The high values >14 indicate that a lot of nitrogen currently available to plants will be converted to unavailable organic forms and a deficiency will result.

Group 3

Organic carbon and total nitrogen levels in the surface of soils formed from acid volcanic rocks are similar to the granitic soils. This is probably because they form in corresponding climatic zones and landform positions and from parent material of similar mineral composition. Again rainfall and vegetative cover seem to determine the levels of organic carbon and nitrogen (Table10). The *Sylvia* and *Mazlin* soils which have formed under drier conditions to the west of Atherton and *Tolga* have high sand contents and low clay contents in the surface soils. Like the granitic soils of group 2, this can cause low nitrogen levels because of the reduced number of sites for nutrients to cling to.

Carbon to nitrogen ratios are high indicating a net immobilisation of nitrogen and therefore a nitrogen deficiency. This is particularly the case in the *Worsley, Whelan* and *Bally* soils.

Table 10 Organic carbon, total nitrogen and carbon to nitrogen ratios for soils derived from acid volcanic rocks

Soil	**O.C%**	**N%**	**C:N ratios**
Umala	5.8	0.34	17
Bally	4.9	0.2	25
Whelan	5.7	0.24	24
Worsley	3.7	0.13	29
Sylvia	1.5	0.08	19
Mazlin	1.5	0.08	19

Group 4

Both of these soils have formed on metamorphic parent material. Organic carbon levels are high and total nitrogen levels range from medium in the *Galmara* to high in the *Bicton*. (Table 11). Carbon to nitrogen ratios suggest reasonable amounts of nitrogen will be available for plant growth with the *Bicton* being slightly better (Table 11). Vegetation in the area was predominantly Acacia species.

Table 11 Organic carbon, total nitrogen and carbon to nitrogen ratios for metamorphic soils

Soil	O.C%	N%	C.N ratios
Galmara	2.7	0.22	12
Bicton	3.5	0.33	10

Warrell *et al.* (1984) found soils similar to the *Galmara* in their mapping of Kairi Research Station. Under improved pastures, levels of organic carbon and nitrogen in the surface soils were low. On similar soils on the wet tropical coast under much higher rainfall, Gillman and Abel (1987) found similar levels of organic carbon.

Group 5

The alluvial soils vary considerably in their surface organic carbon and nitrogen levels. This is not surprising given the wide variety of parent materials and drainage of these soils. These range from 2.1% organic carbon in the *Wongabel* to 13% in the *Peterson* soils (Table 12). The low levels in the *Wongabel* could probably be attributed to their sparse Eucalypt/Acacia vegetation which has been predominantly been cleared as well as high sand and low clay contents. The Peterson on the other hand has formed in poorly drained areas where grass cover is dense. The surface layers also have much higher clay contents than the *Wongabel*. According to Wild (Ed) (1988), the anaerobic conditions slow the 'humification' process causing a lot of partially decomposed plant material to remain.

The carbon to nitrogen ratio of the *Peterson* is lower than the *Wongabel* due to the much higher nitrogen levels in the Peterson. A possible reason for this is the higher clay and organic matter content.

Table 12 Organic carbon, total nitrogen and carbon to nitrogen ratios for alluvial soils

Soil	O.C%		N%		C:N ratios
Peterson	13		0.8		16
	V.HIGH		V.HIGH		
Tranters	2.9	H	0.3	H	10
Gwynne	4.8	H	0.4	H	12
Wongabel	2.1	M	0.1	L	21
Carrington	4.8	H	0.3	H	16

Phosphorus and Potassium

Group 1

Available phosphorus levels range from medium to very high for all basalt derived soils (Table 1), except the *Pin Gin* (16ppm), *Tolga* (pasture) (14ppm), *Millstream* (19ppm) and *Morgan* (4ppm) soils. All of these soils have high contents of iron and aluminium oxides which have the ability to adsorb large amounts of phosphorus making it unavailable to plant (*Wild (Ed), 1988*). Kerridge *et al (1972)* found that Krasnozems of the Atherton Tableland required two and a half times more phosphorus than the metamorphic soils for plant response due to the high levels of sesquioxides. The free iron content was very high in all group one soils in which it was analysed. Levels ranged from 8.4 % in the

Barron to 14% in the *Pin Gin.* Isbell *et al* (1976) also found similar levels, regarding them to be very high when compared to other sesquioxidic soils of the region.

It is notable (Table 6) that the *Tolga* (pasture) (14ppm) site had significantly less available phosphorus than the samples taken from under Rainforest (59ppm) and eucalypt forest (105ppm). Baker and Eldershaw (1993) have stated that when virgin or pasture soils are cultivated, organic matter is destabilised and the contribution of organic phosphorus may be significant in the short term. These soils will require added phosphorus for suitable growth of crops and pasture once cleared and disturbed.

Total phosphorus levels (Appendix 2) were very high for all group one soils confirming the findings of Wild (1958). This relates to the phosphorus content of the basalt parent material (Norrish and Rosser, 1983).

Thompson and Beckman (1959) have noted that the level of total phosphorus can be used to infer degree of weathering. The very high total phosphorus value (4000 mg/kg) of the *Barron* soils indicates that they are one of the youngest soils on the tableland.

Loader (1987) reported on the fertiliser practices used on peanuts on the Atherton Tableland. He found virgin sites on the Tolga and Pin Gin soils to have comparatively low levels of phosphorus compared to cultivated sites and may therefore respond to phosphatic fertiliser application. On the other hand soils with a cropping and fertiliser history have higher levels of total phosphorus and are less likely to respond to added fertiliser.

Available potassium levels range from moderate to high in all (Table 6) soils derived from basalt. These results are in agreement with those found by Warrell *et al,* (1984) and other previously mentioned authors. Rayment (1977) has suggested that a response to potassium is unlikely in tropical legumes on these soils.

Group 2

Available phosphorus levels in the granitic derived soils were all low to very low (Table 6). Kerridge *et al* (1972*)* had similar findings. Thus responses to phosphorus are likely. The low to medium levels of total phosphorus are probably related to low levels in the parent rock.

Available potassium levels are low to medium (Table 6) in the Utchee (0.14meq%), Expedition (0.19meq%) and *Nettle* (0.24%) soils. Values were not available for *Severin, Gowrie* and *Gillies*, but they could be expected to also be low to medium. Total potassium values shown in Appendix 2 are not a good indicator of potassium availability.

Group 3

Available phosphorus levels are low for all acid volcanic soils (Table 6). This is probably directly related to the low phosphorus content in the rhyolitic parent material. Kerridge et al (1972) found good responses to added phosphorus in these soils. Laffan (1988) also noted that these soils had high phosphate retention.

On the *Bally* soils Heiner and Grundy (1994) found low levels of available phosphorus for cropping species and marginal to low levels for pasture species grown in the wetter areas.

Available potassium and total potassium levels were moderate to high except for the surface of the *Umala* which showed very low levels (0.32meq%). Heiner and Grundy (1994) found that levels of potassium were sufficient for crop growth in the *Bally*, whilst Kerridge et al (1972) found good responses of acid volcanic soils in the wetter southern areas to potassium fertiliser.

Group 4

Available phosphorus is low (<20 ppm), in both of the metamorphic derived soils (Table 6). Warrell *et al* (1984) found similar results for their *Bolygum* and *McDonald* soils on Kairi Research Station and suggested that phosphorus application would be required for successful tropical legume growth.

Potassium levels were high in the *Galmara* (0.65%) with levels being substantially higher than most other soils mapped. This is in accord with the high total potassium content in the parent material (schist) (Kerridge *et al* 1972).

Warrell *et al* (1984) found the metamorphic derived soils on Kairi Research Station to have significantly higher total potassium levels than soils derived from basalt. However, they did not find this to be true for available potassium.

Group 5

Of the alluvial soils, the *Tranters* (115ppm) had the highest levels of extractable phosphorus and replaceable potassium (1.1meq%). The *Gwynne* (33ppm), *Peterson* (35ppm) and *Carrington* (34ppm) had moderate levels of extractable phosphorus. This is not surprising considering that all of these soils are derived from basalt and phosphorus is known to adhere well to soil particles and move with them during erosion (Table 6).

The *Wongabel* has low levels (7ppm) of extractable phosphorus probably due to the higher sand content and low organic matter contents in surface horizons. Responses to fertiliser applications of both elements would be expected.

Sulfur

Group 1

Total sulphur in the basalt derived soils is generally high to very high in surface soils and decreases with depth (Table 6, Appendix 2). The exceptions to this are the *Pin Gin* and *Maalan* in which total sulfur content increases with depth. This can be related to the high degree of weathering that these soil have been subjected to. A positive charge on the clay surfaces caused by the effect of low pH (<5.0) on variable charge clays leads to anion retention.

There seems to be a correlation between rainfall and sulphur contents down the profile with the wetter soils having increasing sulphur contents down the profile and the drier sites having decreasing amounts. Isbell *et al (1976)* found similar results for the Tolga (rainforest) soil. He attributed the differences to the vegetation growing on these sites. The drier sites are vegetated by Eucalypt species which would have been subjected to a lot more fires than the rainforest areas. The fires cause the sulfur to diminish with any remaining being tied up in organic forms. In the rainforest sulfur is added continuously by rainfall and is leached down the profile where it is adsorbed onto sesquioxides. Kerridge *et al (1972)* recognised that sulfur responses should not be overlooked on the drier basalts.

Group 2

Apart from the *Utchee* soils which are found in higher rainfall areas and contain sesquioxides, the soils derived from granite are low in total sulfur content (Table 6, Appendix 2). Laffan (1988) found similar results for the *Utchee* soils. Kerridge *et al (1972)* suggested that the "possibility of responses to added sulfur on the lighter textured granites should not be overlooked" (ie *Gowrie, Gillies, Nettle* and *Expedition*).

Group 3

Of the soils formed from acid volcanic rocks, both the Bally (0.08%) and Umala (0.08%) have high levels of total sulfur only decreasing slightly down the profile (Table 6). This is indicative of high leaching and high levels of sesquioxides. Laffan (1988) found generally low levels of total sulfur of soils formed from weakly weathered acid volcanic rocks.

Group 4

Both soils formed from metamorphic parent material have high to moderate levels of total sulfur (Table 6). Kershaw *et al (1972)* stated that response to sulfur should not be overlooked in these soils.

Group 5

The alluvial soils generally reflected the total sulfur content found in the parent materials from which they were derived.

Micronutrients – iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn)

As can be seen in Table 13, levels of extractable manganese, copper and zinc are at moderate to very high levels in the majority of soils. Low levels of copper and zinc were found in *Utchee* (0.14, 0.15ppm) and *Expedition* soils (0.3, 0.3ppm) whilst the *Nettle* had only low levels of zinc (0.3ppm). Teitzel and Bruce (1971) found severe copper deficiencies on soils formed on granite on the same geology in a higher rainfall zone (3000–4500 mm) on the coast. Heiner and Grundy (1994*)* found low to very low levels of both of these micronutrients in the *Expedition* and *Nettle* soils.

Loader (1989*)* found that onion growth on the *Tolga* and *Pin Gin* soils was reduced when extractable manganese exceeded 43 mg/kg. Onion plant death occurred at 50 mg/kg. He found that manganese toxicity symptoms also appeared in peanuts and maize at levels greater than 43 mg/kg, whilst potatoes showed no effects until levels exceeded 50 ppm. Death of both peanuts and potatoes occurred at levels above 100 mg/kg.

Looking at Table 13 all of the group one soils except for the Maalan and Morgan have extractable manganese levels exceeding 50 mg/kg. The Morgan soil just exceeds 43 ppm. Of the granitic soils, three out of six soils exceed 50 mg/kg. Results were similar for the acid volcanic soils whilst of the metamorphic soils the Bicton has levels of 50 mg/kg. Of the alluvial soils, the Tranters is the only soil that does not exceed 43ppm. Results for Wongabel and Carrington were not obtained.

All soils with levels greater than 50 mg/kg could be susceptible to manganese toxicity if pH drops below 5.5. (Baker and Eldershaw, 1993). This can occur from the over use of nitrogenous fertilisers.

The extremely high levels of manganese in the *Gwynne* and *Quincan* soils is not likely to be a problem as these soils have other physical constraints which would prevent them from being cropped.

Extractable copper levels are generally adequate in all soils (Table 13), ranging from 1.3mg/kg in the *PinGin* to 77mg/kg in the *Quincan*. The only exceptions are the *Utchee* (0.14), *Expedition* (0.3) and Whelan (0.3) soils which are low and may show some response to added copper. High buffering capacity reduces the likelihood of copper toxicity (Baker and Eldershaw 1993).

Extractable zinc levels were moderate to high in all soils ranging from 0.8 mg/kg in the *Kaban* to 188 mg/kg in the *Quincan* (Table 13). Exceptions were the three granitic soils – *Utchee* (0.15), *Expedition* (0.3) and *Nettle* (0.3).

Table 13 Micronutrient levels in surface soils

Group	Soil	Fe mg/kg	Mn mg/kg	Cu mg/kg	Zn mg/kg
1	Pin Gin	97	52	1.3	1.3
1	Maalan	110	5.9	1.8	1.7
1	Tolga RF E P	12 10 11	180 130 76	4.7 3.6 2.6	240 1.8 1.6
1	Kaban	49	198	2.4	0.8
1	Walkamin	59	89	1.2	3.8
1	Millstream	48	87	4.2	3.3
1	Barron	49	160	3.1	7.1
1	Quincan	na	1600	77	92
1	Morgan	56	47	1.9	1.2
1	Snider	97	69	1.0	1.5
2	Utchee	4.7	4.7	0.14	0.15
2	Severin	na	180	5	31
2	Gowrie	na	620	10	27
2	Gillies	na	310	5	16
2	Expedition	10	18	0.3	0.3
2	Nettle	5	15	0.5	0.3
3	Umala	110	4.3	0.08	0.53
3	Bally	78	18	0.4	1
3	Whelan	76	15	0.3	1.3
3	Worsley	na	120	5	35
3	Sylvia	na	190	7	20
3	Mazlin	na	50	8	20
4	Galmara	350	16	0.8	2.5
4	Bicton	na	50	7	17
5	Tranters	97	28	1.5	3.5
5	Gwynne	na	3030	64	188
5	Peterson	na	490	53	68
5	Wongabel	NS	–	–	–
5	Carrington	NS	–	–	–

Electrical Conductivity and Salinity

Electrical conductivity values were low for all soils meaning negligible salinity risk.

Soil physical properties

The physical attributes of the soils found during the survey have been discussed in the same order as those in the chemical section.

Particle Size Analysis

Group 1

These soils have uniform clay texture profiles ranging from 60% clay in surface horizons to 80% in B horizons. (Appendix 2). The *Barron* has slightly lower clay contents (50-60%) and higher silt contents (30%) indicating it is less weathered and therefore a much younger soil than the other basaltic soils. Good soil structure combined with the high clay contents relate to these soils having good moisture retention and plant growth capabilities.

Group 2

The most weathered granite derived soils have 30-40% clay contents and 30-40% coarse sand contents (Appendix 2). This is due to the high resistance to weathering of quartz minerals found in granite parent material. The high clay contents mean that moisture holding capacities are good. The *Nettle* soils have 60-70% coarse sand indicating they have formed in a drier, less weathering environment on steeper slopes. This high sand content relates to poor moisture and nutrient holding capacity.

Group 3

The acid volcanic derived soils from the wetter areas such as *Bally* and *Umala* have very similar clay contents to the basaltic soils (Appendix 2). Coarse sand and fine sand contents are slightly higher however; 5-13% and 10-15% respectively. In the drier areas, the *Whelan*, *Sylvia* and *Mazlin* have up to 40% fine sand and silt contents. This can be attributed to steeper slopes, less weathering environment and high silica content of the rhyolitic parent material. Combined with high magnesium levels the *Sylvia* and *Mazlin* will become unstable upon wetting causing erosion, surface sealing and crusting. This will cause problems with plant seedling emergence and root elongation (Baker and Eldershaw, 1993).

Group 4

Fine sand dominates the particle size analysis results of the soils derived from schist (40-50%). Coarse sand and clay make up approximately 20% each (Appendix 2). The high sand contents will result in lower moisture and nutrient holding capacities than the basaltic soils.

Group 5

The particle size analysis of the alluvial soils reflects the material from which the alluvium originated from. The *Wongabel* contains up to 40% coarse sand reflecting dominantly granitic origin whilst the *Carrington* contains more silt and fine sand reflecting a dominantly rhyolitic origin. (Appendix 2). The *Tranters* contains a mix of clay, fine sand and coarse sand from granite, rhyolite and basaltic parent material. The *Gwynne* and *Peterson* soils however contain up to 80% clay because they are derived solely from basalt.

Clay activity ratios

The clay activity ratio (ratio of CEC to % clay) has been found to be closely linked to clay mineralogy (Baker and Eldershaw, 1993), ie <0.2 for kaolinite; 0.3-0.5 for illite and other non expanding clays and >0.6 for expanding montmorillonite clays. All but two soils found had clay activity ratios of <0.2 in B horizons indicating a dominance of non cracking kaolinite clays. The *Snider* had a clay activity ratio of 0.4 indicating a dominance of less weathered non cracking illite clays and the *Morgan* had a value of 0.6 indicating cracking montmorillonite clays.

Plant available water content (PAWC)

There was a range of data collected to estimate PAWC. Most of the major agricultural soils were sampled and analysed for -1500kpa to estimate permanent wilting point and -10kpa for field capacity. Neutron moisture meters were installed in 5 SPC's *(Pin Gin, Maalan, Utchee, Galmara,* and Tolga) with repetitions on Pin Gin and Maalan to cover the variations in rainfall of the areas these soils are found in. These were monitored for two years with the highest and lowest values being recorded for estimation of PAWC (Table 14).

Table 14 Estimates of PAWC for selected soils derived from neutron moisture meter readings

SPC	PAWC (mm/m)
Pin Gin (Upper Barron)	280
Pin Gin (Hallorans Hill)	240
Maalan (Upper Barron)	260
Maalan (Lamins Hill)	230
Tolga	150
Tolga (Yadjin forest)	110
Utchee (Bartletts Hill)	280
Galmara (Maroobi Creek)	180

As can be seen in Appendix 2 the estimates found in Table 14 correlate well with those measured in the laboratory. The low values of the *Tolga* were not expected however they may be explained by the finer grade of structure which reduces pore size. Other possible reasons include the high rate of compaction found in the upper layers of these soils and the often considerable amounts of manganiferous nodules both of which reduce the amount of plant available water.

4. Land use on the Atherton Tablelands

The Atherton Tablelands supports a diverse range of agricultural activities, including the growing of peanuts and potatoes, horticultural tree crops such as macadamias and avocados, and the grazing of beef and dairy cattle. The spatial distribution of each land use is strongly influenced by the soil, the climate and the topography.

Peanuts

Peanuts have been commercially grown on the Atherton Tablelands since 1919 however at this time the crop was considered secondary to the maize and dairy industry

It wasn't until 1927 when all produce was brought under the control of the Queensland Peanut Board (and growers were compelled to rail their produce to Kingaroy for treatment) that the industry became an important part of agriculture on the Tablelands. A receiving depot was built at Atherton in 1933; however a new one was built in Tolga in 1974, and operations then ceased at Atherton.

The crop is planted around November–December and harvested six months later. Generally the crop is rain fed, but the use of irrigation is gaining popularity and can result in higher yields. Diseases such as CBR are a major problem, making crop rotation essential. Currently the industry is worth around 7 million dollars to the local community with 2,500–3000 ha under the crop. One hundred farmers were involved in the 1994/95 harvest.

Maize

Maize has been grown on the Atherton Tablelands for nearly 100 years, with the early crops produced for sale to the dry inland mining centres which often needed to import fodder to feed the horses, mules and bullocks essential to the mining industry. Most of this was grown by Chinese farmers, and between 1890 and 1899, the area producing maize increased from 492 to 1252 hectares in the Atherton district consisting of over 300 Chinese maize farms.

After WW1, the leases of the Chinese farmers were terminated and the land resumed by the government for the settlement of ex–servicemen. In 1923 the farmers involved in the industry formed a marketing board which constructed and opened silos in Atherton, Kairi and Tolga. Six vertical bins were added to Atherton in 1934 and in 1968 a bulk shed was added.

Currently maize is grown on over 110 farms, and is an important part of a rotation which includes peanuts, potatoes and pasture grass. The grain is stored and milled at the Athmaize Producers Co–operative Association in Atherton, and sold as feed throughout the North Queensland region with export markets to Malaysia and Hong Kong.

The 1994/5 crop was worth 3.5 million dollars to the local economy with thirty–five people presently employed at the Athmaize Silos in Atherton. Disease such as rusts and smuts have been a problem in the past, but using suitable varieties and good husbandry has overcome many problems.

Horticultural Tree Crops

Horticultural tree crops such as avocados, mangoes and macadamias are grown throughout the Atherton Tablelands. These trees have been grown in the backyard of tableland houses for many years, producing fruit of varying quality, but it wasn't until the early seventies that commercial production began. Some of these early orchards were established for taxation reasons but the majority were owner/grower operations. The first plantings of avocados were around Malanda but problems with root rot were soon encountered and activity shifted to the Tolga area. The earliest varieties were Fuerte, which was not really suitable to the damp and overcast conditions, and Hass is now the dominant variety. There was an increase in the size of orchards; in the early seventies, planting numbers were around 400 800 trees. By the early 1980's orchard size grew to 1000 trees. The industry formed the Atherton Tableland Avocado Growers Association (ATAGO) with 36 members. The produce is sold to the eastern capitals and a small amount to the Adelaide market.

Around the same period there was a similar establishment of a macadamia industry, but on a smaller scale.. Mangoes were also introduced in the later part of this decade. There are currently over 30 avocado, 20 mango and 15 macadamia producers on the Tablelands.

Other horticultural crops include lychee (6 producers), and citrus (10 producers). Many of the farms are operated on a part–time basis, with the owner having a full time occupation and living off farm. The produce is sold at local markets, and also at the markets in Brisbane, Sydney and Melbourne.

Potatoes

The potato industry has been in the area since before WW2, but it was only in 1949 that there were moves to organise the local industry. By 1963 there were signs that the local market was beginning to be over–supplied. In response the Atherton Tableland Potato Growers Co–operative was registered. Initial membership numbered 30 growers, with 30 000 tons of potato sold. The co–operative is still operating but growers are selling to other outlets. Export of potatoes to overseas markets, especially to south east Asia are increasing and providing some price stability in an industry where prices have been known to range from $4 to $50 a bag.

Potatoes can be grown year round on the Tablelands, but most growers aim to harvest in spring, when the best prices are received. On the lower Tablelands, conditions are unsuitable due to high temperatures and excessive humidity.

Pasture seed and hay

Pasture seed and hay production has been an important part of many farm rotations on the Atherton Tablelands since the 1960's. After many years of maize monoculture the need for a rotation crop to add nitrogen, and to improve soil structure, was recognised. This was a major reason for the introduction of a pasture rotation on the Atherton Tablelands.

Initially legumes such as glycine and desmodium were grown to add nitrogen to the soil and improve soil structure. The demand for pasture seed and longer crop rotation periods however led to the changeover to grass species.

There are between 30–45 growers involved, with around one quarter or one third of farm area involved in pasture production at any one time. Species grown for pasture seed production include Callide Rhodes, other Rhodes species, *Brachiaria decumbens,* (Signal grass), *Setaria sphecalata* (Nandi), *Panicum maximum* (Green Panic); and *Bothriochloa insulphton* (Bisset). The pasture is commonly left in for around three years, although there is considerable variation on the extent and range of farm rotations.

The pasture industry is worth approximately $1.5m to the local economy. The seed is sold to a number of seed merchants, including Selected Seeds, Heritage, Rightson and locally to Southedge Seeds. The seed is also exported to a number of countries, such as the Middle East, Vanuatu, the Philippines, and to South America. However, most is used in Australia. There is a limited amount of grazing on the pasture, thus removing the need for fences etc. The baling and selling of the hay is a productive sideline, and the development of round bales, which simplified handling, greatly increased this section of the industry.

Dairy

Maize was the dominant land use until 1913, when the area under sown pasture for dairy exceeded the maize acreage for the first time. The early settlers discovered that paspalum thrived on the Tablelands, though there was some concern over the way feed dried off over the winter months.

The industry continued to expand, with the first butter factory built just outside Atherton at Tumbare in 1909 and then relocated to Atherton in 1914. A co–operative was then formed to run this factory, and a branch at Malanda was opened. The headquarters were transferred to Malanda and in 1929 the Atherton factory closed down due to economic reasons.

Tropical pasture species such as Setaria, Kikuyu and Green Panic are now commonly used throughout the Tablelands while irrigated temperate pasture species such as rye grass and clovers are annually sown in late autumn for winter feed. Legumes including glycine and desmodium are used extensively. The main breed is the Holstein Friesian; other breeds include Illawarra, Jersey and small numbers of Brown Swiss.

Today the Dairy industry on the Tablelands injects over 70 million dollars into the local economy through the sale of the Malanda brand products. There are 201 dairy farms throughout the Tablelands, with an average herd size of 110 animals and an average farm size of 150ha.

Tea

Tea was first grown in Queensland at Bingil Bay, near Tully late last century, but the plantation was abandoned in 1918 following a major cyclone. In 1936, the Queensland Department of Agriculture and Stock (now the QDPI) planted an experimental plot at South Johnstone Research station. Commercial production commenced in the late 1950's at Nerada near Innisfail.

Currently the industry is made up of three large company operated plantations, and ten smaller family owned and operated units. The company plantations range in size from about 100–200 ha, while the family units range from 2–40ha (majority 15–30ha). The family operated units grow tea in conjunction with a range of other activities including sugar cane (2), beef cattle (6) and tropical fruit (2). Total tea production in 1992/93 was about 1.5 million kg, and since then has increased to around 2 million kg due to young plantings coming online.

Tea requires fairly specific growing conditions; namely deep, well drained acid soils on a moderate slope, frost free, with a high relative humidity for much of the growing season. On the Tablelands these conditions are found in the Butchers Creek/ Malanda area. The total area growing tea in North Queensland is approximately 750 ha, mostly on the Atherton Tablelands. The value of the industry is around 1.5 million dollars (bulk made tea). All tea is harvested mechanically.

5. Land suitability assessment methodology

Land suitability studies have two distinct phases: a land resource description and assessment phase, and an agricultural land evaluation phase. The information gathered in the first phase is driven by the requirements of the agricultural land evaluation phase, ie it is to create the suitability framework.

The land was evaluated according to how the properties of discrete parcels of land fulfil the requirements of selected land uses. These properties affect plant growth, machinery use and land degradation management. Land assessed 'suitable for a land use', means that it can sustain profitable production on a long term basis with minimal degradation to the land resource (assuming medium term cost structures, current technology and average management inputs).

Land resource description phase

Land resource description on the Atherton Tablelands was based on the Australian standard methodology (Gunn *et al.*, 1988; McDonald *et al.*, 1990). This descriptive stage produced a map comprising units which are discrete parcels of land that are relatively homogenous in terms of SPC, topography, climatic properties and natural vegetation (if present), and referred to as Unique Map Areas (UMA's). The variability of the UMA is recorded in a database for further interpretations. The UMA data file encompasses information on SPCs and properties, topography, vegetation and climate as well as interpreted agricultural land suitability information and current land use data. This data is available from Resource Management, Department of Natural Resources, Mareeba.

Land suitability studies usually require additional assessment of soil/land properties to be carried out in association with the soil survey. This survey included field and laboratory testing of soil physical and chemical properties, including bulk density, particle size analysis and available water capacity.

Agricultural land evaluation phase

Selection and assessment of key land properties

The land evaluation stage aims to classify each UMA according to its suitability for the selected land uses. To do so, the first step is to define the requirements of each land use and then select and assess the land properties. The potential of each UMA was assessed for the following land uses: maize, peanuts, sorghum, navy beans, salad vegetables, heavy vegetables, tea, sugar, avocados, macadamias, lychees, longans, custard apples, stone fruit, mango, citrus, tropical pasture and temperate pasture.

Detailed information on the land uses selected for this study and their requirements is provided in Appendix 3 and 4. For example, the requirement that lychees have for dry soil conditions to initiate fruiting is determined by soil drainage properties. These inherent properties of land that are assessed to determine agricultural land suitability are referred to as land use limitations, shortened to limitations. Ten limitations were selected from a comprehensive list of land use requirements and related limitations used in Queensland, provided in *Guidelines for Agricultural Land Evaluation in Queensland. (*Land Resources Branch, 1990). These are as follows:

Climate ("c" limitation)

Variations in climate characteristics across the study area have a significant impact on plant performance and adaptation. Five climatic zones have been defined each of which can be distinguished in terms of its effect on at least one land use (Appendix 3)**.** Rainfall, temperature, frosting and the amount of sunshine hours are the major diagnostic attributes that define the five zones. Not being a soil specific limitation, a range of soils can be found in each zone.

Water availability ("m" limitation)

Effective seasonal water supply to plants is primarily a function of the available soil water storage capacity and the two sources of water supply — rainfall and groundwater supply to the root zone either directly and/or through capillary rise.

Attributes which determine available soil water include: amount and type of clay in the soil, amount and grade of structure, organic matter, depth of soil, infiltration rate, permeability, salinity, sodicity, compaction, amount of rock and the effective rooting depth of the plant.

Plant available water capacity (PAWC) has been used to determine this limitation. Plant available water determinations involved -10kPa and/or drained soil determination using undisturbed samples for field capacity estimates and -33kPa for wilting point (Rayment *et al* 1992)**.** Volumetric calculations were made using bulk density data from undisturbed samples. A range of soils were treated and extrapolations made to the remainder. Six subclasses were determined (Appendix 3) Refer to the soil physical and chemical section for further detail.

Soil nutrient supply ("n" limitation)

Modern fertilisers enable most soil nutrient problems to be ameliorated. Tea is the only crop on the Tablelands that has a specific soil and climatic requirement ie well drained soil with pH less than 5.5 and rainfall greater than 2000 mm (Wilson et al 1988). Therefore soils have been assessed for their effect on tea growth due to pH. This is restricted to the southeastern corner of the tableland on mainly Pin Gin and *Maalan* soils. Five subclasses have been determined. (Appendix 3)

Wetness ("w" limitation)

Waterlogged soil conditions occur because of impeded soil permeability and/or the presence of a water table controlled by local hydraulic gradients. The majority of soils in the survey do not have significant chemical or physical internal drainage impediments such as sodicity. The exceptions are the *Sylvia* and *Mazlin* which have highly dispersive subsoils due to excess magnesium and sodium. When the lower horizons of these soils become wet, the magnesium and sodium ions cause the soil to deflocculate and disperse causing severe erosion. Upon drying these soils set hard.

The *Nyleta* soils are poorly drained due to its landscape position of drainage depressions whilst the *Walkamin*, *Millstream*, *Gwynne*, *Carrington*, *Peterson*, *Wongabel* and *Morgan* soil are found lower in the landscape position where they receive water from upper slope positions.

The assessment of wetness is based on the degree of expression of various morphological indications such as mottling, presence of segregations and soil colour. Landscape factors are also taken into consideration. These factors determine the ease with which artificial drainage can be affected.

Soil physical condition (“p” limitation)

Adverse soil physical condition effect germination, soil workability and the ability to harvest crops such as peanuts and potatoes. Seven subclasses have been used based on soil adhesiveness, moisture range and ability to set hard. This limitation is of most concern in the following soils: *Carrington, Peterson, Morgan, Flaggy, Mazlin, Wongabel, Whelan* and *Sylvia.*

Rockiness (“r” limitation)

The surface rockiness of an area describes the presence of a rock outcrop or coarse fragments. Stony or rocky soils impede cultivation and can damage ploughing and harvest implements. High amounts of small rock reduces the amount of soil for roots to forage in and therefore reduces the availability of moisture. Rockiness levels are based on five size and four abundance categories

Surface rock can be a major limitation in the following soils: *Tolga, Maalan, Barron, Heales, Quincan, Kaban, Snider, Utchee, Severin, Gillies, Umala rocky phase, Whelan* and *Worsley*.

Flooding (“f” limitation)

Floods are not a significant problem on the Atherton Tableland and therefore only the alluvial soils and the *Nyleta* soils have been downgraded. Frequency of flood events determine the effect on a particular land use.

Topography (“t” limitation)

This limitation primarily applies to the use of farm machinery. The safety and manoeuvrability of farm machinery is adversely affected by increasing slope. Two slope limits have been determined for all year round machinery use. The first is 20% for horticultural tree cropping. The second is 35% for the beef and dairy industry.

Water erosion (“e” limitation)

Slope and attributes of soil type such as surface texture, structure and permeability are the main attributes that determine soil erosion by water. Six slope categories have been determined. The basaltic soils have higher slope limits for agriculture than soils formed on other parent materials due to their good drainage and permeability as well as their stable chemical and physical nature. Slope categories have been calculated using the recommendations of the land conservation section of the Department of Natural Resources. These recommendations incorporate the use of soil conservation measures and structures.

Landscape complexity (“x” limitation)

This limitation is determined by the size of contiguous areas of land as some crops require minimum sized parcels of land to be viable. Six categories have been used although this is only a minor limitation. In a strict sense, the above limitations are not true limitations unless, in the context of a land use, their level of expression has a limiting effect on plant growth or crop management or has implications for the sustainability of the agricultural practice by increasing degradation risk.

Land attribute levels

The next step in land evaluation is to record, for each UMA, a value for the level of each of the selected limitations, using the information obtained in the land resource description and agricultural assessment stage. For those limitations that are SPC related such as wetness, physical condition, water holding capacity and nutrient supply, the UMA is allocated a value according to its dominant SPC. There is a constant value for such a limitation for each SPC ie. a *Tolga* always has a physical condition value of P0 (no restriction), irrespective of location. For those limitations such as rockiness and slope that commonly vary independently of SPC, the value comes from field data recorded in each UMA. In this survey, most UMA's have been field checked and have a dominant soil which represents at least 60% of the UMA. The remaining 40% may contain up to two minor soils. The limitation expression values are recorded in a UMA data file.

Limitations are usually not recorded directly, but rather through surrogate indicators termed attributes. For example, soil drainage, termed "wetness" is a limitation which can be assessed by attributes such as soil colour, abundance of mottles and permeability. One or more attributes may be used to assess a limitation. The chosen attributes are termed diagnostic land attributes (DLAs). They are the means by which inherent properties of land are assessed to determine its suitability for agriculture and other uses.

The measurement of DLA's is a means of expressing the range of occurrence of each limitation across all soils/land types in the study area. For example, one means of assessing the moisture supply limitation is to measure the soils plant available water content (PAWC).

Soil series limitations

Land use limitation attribute levels (Table 15) apply to each of the soils described in the study area. The limitations are given as diagnostic land attribute codes, eg R2c is the rockiness attribute code for 2-10% of 60-200 mm cobble. The limitation attribute level codes are explained in the suitability framework (Appendix 4).

In some SPCs, limitations such as topography, erosion and rockiness vary in expression across the landscape. In Table 15, the range of expression within the particular SPC is given. It should be noted however, that when UMA data is recorded, the actual attribute level present in an individual UMA is entered in the data base.

Table 15 Limitation attribute levels of individual soil profile classes

SPC	C[1]	m	n	w	p	r	f	t	e	x
Bally	C4, 5	M1	N1	W2m	P0	R0	F0	T1-3	E2-5a	X0
Barron	C1-4	M2	N3	W2h	P0	R0;2g;2-5c;2-5s	F0	T1-2,4	E2-6,8b	X0
Bicton	C3,4	M2	N2	W4m	P2	R0	F0	T1-4	E3-6m	X0
Carrington	C2-5	M1	N2	W5l	P3	R0	F2	T1	E1	X0
Expedition	C5	M3	N3	W2h	P1	R0;2,4c	F0	T1-2	E3-4g	X0
Flaggy	C5	M3	N3	W4m	P5	R0;2g;2,4c;3s;	F0-1	T1-2	E1-4a	X0
Galmara	C1-4	M2	N1	W3m	P2	R0;2-4g;3-5c;	F0	T1-4	E1-6m	X0
Gillies	C1-3,5	M5	N2	W1h	P0	R0;2-3g;3-4c	F0	T1-4	E3-6g	X0
Gowrie	C2-3,5	M2	N2	W2h	P0	R0;2-3g	F0	T1-3	E1-5g	X0
Gwynne	C3-4	M1	N1	W4m	P1	R0	F2	T1	E1-2b	X0
Heales	C2-3	M1	N3	W2h	P0	R0;3-4g;1-3c;4s	F0	T1,3-4	E2-8b	X0
Kaban	C5	M1	N3	W2h	P0	R0;2-4g;2-5c;3-5s;4b	F0	T1-4	E1-8b	X0
Maalan	C3-5	M1	N1	W2h	P0	R0; 2g;2-4c;2-4s	F0	T1-4	E1-8b	X0,1
Mazlin	C2	M2	N1	W3m	P5	R0	F0	T1	E3m	X0
Millstream	C5	M1	N2	W4m	P1	R0;3s	F0	T1	E2-4b	X0
Morgan	C1	M1	N4	W5m	P4	R0	F3	T1	E2b	X0
Nettle	C5	M6	N2	W2h	P1	R3g	F0	T1-3	E3-5g	X0
Nyleta	C2-5	M1	N1	W6l	P2	R0	F3	T1	E1b	X0
Peterson	C3	M1	N2	W5m	P3	R0	F3	T1	E1b	X0
Pin Gin	C2-5	M1	N1	W2h	P0	R0;2g;2-3c;2s	F0	T1-4	E1-8b	X0
Quincan	C2-3,5	M2	N3	W2h	P0	R0;3g;3-5c;4s	F0	T2-4	E6-8b	X0
Severin	C2-3,5	M1	N1	W4m	P2	R0;2-4g; 2,4c;2,4s;5b	F0	T1-4	E2-6g	X0
Snider	C1-2,5	M2	N3	W3m	P0	R03-4c;6s	F0,1	T1-2,4	E5,6,8b	X0
Sylvia	C1-2,5	M4	N1	W5l	P6	R0;2g	F1	T1-2	E1-2,4-5a	X0
Tolga	C1-2	M1	N3	W2h	P0	R0; 2g;2-4c; 4s	F0	T1-2	E1-6b	X0
Tranters	C2-5	M1	N2	W2m	P0	R0;2s	F1	T1	E1-2b	X0
Umala	C4-5	M1	N1	W3m	P2	R0;2-3c;	F0	T1-4	E2-6a	X0
Umala Rp	C4	M1	N1	W3m	P2	R4s	F0	T4	E6a	X0
Utchee	C2-5	M1	N1	W2m	P2	R0;2g;2-4c;2-4s;2,4b	F0	T1-4	E2-6g	X0
Walkamin	C1,3	M1	N1,3	W4m	P1	R0	F0	T1	E1-3b	X0
Walk Gv	C1	M1	N1	W4m	P0	R0;2g	F2	T1	E1-2b	X0
Whelan	C1-2,5	M6	N2	W2h	P5	R0;4-5c;5s	F0	T2-4	E4-6a	X0
Wongabel	C2-3,5	M2	N2	W4l	P5	R0	F2	T1	E1-2	X0
Worsley	C1-2,5	M2	N2	W4m	P2	R0;2-3g;2-4c;4s	F0	T1-4	E1,4-6a	X0

[1]Codes used for the attribute levels are shown in Appendix 3

Determining the effect of the limitation

The next step in land evaluation is to determine what effect each limitation will have on the land uses being assessed, as each land use will vary in tolerance of each limitation. For example, horticultural tree crop production is more tolerant of rock than peanut production. A five class system was used to express the effect or impact of each limitation on every land uses. **Classes 1 to 3** indicate an increasing adverse effect up to a level beyond which the land is marginal **(class 4)** or unsuitable **(class 5).** This rating system is based on average, medium term cost structure and/or current technology of the land use being assessed.

A simplified schematic example of data recorded in a UMA file for a UMA is shown in Table 16 Only three of the eleven limitations are shown in the example. They are moisture supply, rockiness and erosion potential. The critical limitation for the land uses listed is rockiness; the suitability class is 4 for peanuts and potato (r4), 3 for avocado (r3) and 2 for pasture (r2). However, if the area was rock picked, then the limitation class for these land uses would be reduced to r1. The next most limiting factor then determines the overall suitability. In this case it is erosion for peanuts and potatoes (e3). The overall suitability class would become 1 for avocados and pasture (m1 ,r1, and e1)

Table 16 Relationship between UMA limitation level and limitation classes for four land uses

Simplified description of UMA	**Limitation levels[1]**	**Limitation Classes[2]**			
		Peanut	**Potato**	**Avocado**	**Pasture**
Soil Series: Tolga (Red Ferrosol)	Pedal, uniform medium textured soil (M1)	m1	m1	m1	m1
	Rockiness: 20-50% cobble (R4c)	r4	r4	r3	r2
	Erosion: 8-12% slope Eg3	e3	e3	e1	e1
	Overall UMA Suitability Class for crop	**4**	**4**	**3**	**2**

1. The respective limitation level codes (upper case), indicate the degree of expression of respective limitations present in the UMA.
2. Limitation classes by convention are in lower case.

The critical step in this process is to determine the attribute level which approximates the cut-off point between suitable and unsuitable for a particular land use (the class 3/4 boundary). This attribute level equates to a sustainable production level at the margin of profitability based on average cost-price structures and on the limit of current technological capability. For example, 20% slope is the upper limit to tropical tree crop production with respect to safe machinery usage, hence T3 (slope >20%) represents topographic limitation class 4 for tropical tree crops on the Atherton Tableland. It is then a matter of determining the point where the attribute level changes from having little or no effect to having a significant effect on production or management difficulty etc. This is the **class 1-2** boundary. The **class 2-3** boundary is then a matter of interpolation.

Suitability class determination

The final step is to allocate an overall suitability class to the UMA for each land use. The overall suitability classification for a particular land use is determined by the most severe limitation, as shown in the last row of (Table 16). There are five suitability classes which equate to the five limitation classes. The classes are described as follows:

Class 1: Suitable land with negligible limitations requiring only basic management practices to maintain economic production.

Class 2: Suitable land with minor limitations which either reduce production or require more than simple management practices of Class 1 to maintain economic production.

Class 3: Suitable land with moderate limitations which either further lower production or require more than those management practices of Class 2 land to maintain economic production.

Class 4: Marginal land with severe limitations which will make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long term.

Class 5: Unsuitable land with extreme limitations that preclude its use.

Land is considered less suitable as the severity of limitations for a land use increase. Increasing limitations may reflect either (a) reduced potential for production and/or (b) increased inputs to achieve an acceptable level of production and/or (c) increased inputs required to prevent land degradation. The first three classes are considered suitable for a specified land use as the benefits from using the land for that use should outweigh the inputs required to initiate and maintain production.

Class 4 land is considered presently unsuitable as it is doubtful that the inputs required to achieve and maintain production outweigh the benefits in the long term. Additional studies are needed to determine whether the effect of the limitation(s) can be reduced to achieve sustained production.

Class 5 is considered unsuitable having limitations that in aggregate are so severe that the benefits would not justify the inputs required to initiate and maintain production in the long term. It would require a major change in economics, technology or management expertise before the land could be considered suitable for that land use. Some class 5 lands however, such as escarpments, will always remain unsuitable for agriculture.

6. Results of land suitability assessment

The results of the suitability component are based upon the natural resource information collected earlier in this project. Inaccuracies may occur due to the scale of the information gathered (in this case 1:50 000). It should also be noted that these results reflect current technologies and management techniques. If technology changes, eg. a harvester is developed which can safely operate on slopes greater than 20%, then an area, previously considered unsuitable for horticultural tree crops due to the topographic limitation, could become suitable. The use of a GIS and computer database provides the flexibility for upgrades to reflect such changes in technology. As mentioned in the previous section class 1 to 3 are considered suitable with class 4 and 5 being considered unsuitable.

On the Tablelands, the Tolga to Kairi area is extremely versatile with a combination of good soils, favourable climate and the availability of irrigation water allowing the growth of most crops. Land further south in the project area is less versatile mainly due to steep slopes and a cool wet climate. This means that landowners in these areas are generally restricted to pasture production, either for dairy or beef purposes.

For the purposes of local government (Atherton and Eacham Shires) strategic planning, the land suitability results have been reinterpreted to aid in the identification of good quality agricultural land (GQAL). Table 17, shows the areas of each class found in the study area. Maps showing the spatial extent of those classes can be found in the back of this report.

In Atherton and Eacham Shire all areas suitable for one or more field crops or horticultural tree crops are considered to be GQAL. In addition to the above mentioned land uses, those areas which have been identified as suitable for pastures are considered to be GQAL as this recognises the importance of the dairy industry to the local economy.

Table 17 Areas of Good Quality Agricultural Land

Land class	**Area ha**
A1	15 324.5
A2	52455
A4	901
B1	28752
B2	9800
C2	29361
D	31336
Total	167929ha

Suitability results for field crops (peanuts, maize, sorghum potatoes, sugarcane, navy beans and salad vegetables).

Of the field crops, peanuts are probably the most sensitive to environmental limitations. They are virtually restricted to the friable basaltic derived red soils (which allow good nut development) in the drier regions of the Tableland so as to avoid being wet during the drying stage. These two requirements reduce the land suitable for peanuts to approximately 14 000 ha compared to approximately 30 000 ha for maize, sorghum, potatoes, sugar, navy beans and salad vegetables.

Class 1 Suitable land with negligible limitations

There is approximately 1800 ha (Table 18–23) of land rated class 1 for all of these crops except for potatoes *Tolga* SPC.

Class 2 Suitable land with minor limitations

This is a larger area of approximately 9000–12 000 ha (Table 18–23) of the *Tolga* SPC and includes most of the remaining areas around Atherton, Tolga and Kairi that are not class 1. The major factor that downgraded these areas from class 1 to class 2 was climate ie. a slightly higher incidence of drizzle which can effect the drying of peanuts and can cause premature germination of the seed in the head of sorghum. This is however only a minor limitation. Small areas of other SPC's are also class 2 for some or all of these crops. These SPC's are *Pin Gin, Heales, Kaban, Utchee, Maalan* and *Tranters*.

Class 3 Suitable with moderate limitations

There is approximately 20 000 ha of class 3 land (Table 18–23) for field crops with the exception of peanuts (3000 ha). *Tolga* and *Pin Gin* soils dominate again. There is also a broad range of other SPCs that are suitable particularly for sugar cane and navy beans. The major limitations that downgrade these areas to class 3 are climate, erosion, topography, rockiness, moisture availability and wetness.

Class 4 Marginal land with severe limitations and class 5 Unsuitable land

Approximately 140 000–150 000 ha of land to the south and south-west of Malanda is considered marginal or unsuitable for field cropping (Table 18–23). Climate (too wet and cold), water erosion (slopes too steep for cultivation) and topography (slopes too steep for machinery use) are the major limitations to field crops in these areas.

Table 18 Peanut suitability

Suitability class	Area (ha)	UMA total
1	1828	8
2	9028	59
3	3234	33
4	55018	562
5	98820	400

Table 19 Maize, sorghum suitability

Suitability class	Area (ha)	UMA total
1	1828	8
2	10444	87
3	18615	200
4	39137	379
5	97904	388

Table 20 Potato suitability

Suitability class	Area (ha)	UMA total
1	Nil	Nil
2	12273	95
3	18590	199
4	38246	368
5	98820	400

Table 21 Sugar suitability

Suitability class	Area (ha)	UMA total
1	1828	8
2	9033	60
3	22732	268
4	37950	352
5	96386	374

Table 22 Navy bean suitability

Suitability class	Area (ha)	UMA total
1	1828	8
2	10482	89
3	20528	230
4	37186	347
5	97904	388

Table 23 Salad vegetable suitability

Suitability class	Area (ha)	UMA total
1	1828	8
2	10444	87
3	18615	200
4	39137	379
5	97904	388

Suitability results for horticultural tree crops (macadamia, lychee, custard apple, stone fruit, mango, citrus, avocado).

The total area of land suitable (class 1 to 3) for horticultural tree crops varies considerably with 66 000 ha suitable for macadamias; approximately 50 000 ha suitable for avocado, custard apples and stone fruit and approximately 16 000 ha suitable for lychee mangoes and citrus.

Class 1 suitable land with negligible limitations

This category consists of approximately 2100 ha (Table 24-30) of the *Tolga* SPC, and is the same areas as the class 1 land for field crops with the exception of stone fruit and citrus, this area is ideal for horticultural tree crops.

Class 2 suitable land with minor limitations

This area of *Tolga* SPC is approximately the same (Table 24-30) as the Class 2 land for field crops (10 000 ha), with the major exception of mangoes, citrus, and lychee which only have small areas of class 2 land (200 ha) available due to climatic restraints). Small areas of *Heales, Pin Gin, Tranters* and *Utchee* are also class 2 for varying horticultural tree crops.

Class 3 suitable land with moderate limitations

There are 13 000 to 14 000 ha of Class 3 land for lychees, mangoes and citrus due to cooler temperatures and winter drizzle which lead to disease and 30 000 to 50 000 ha rated Class 3 for avocados, macadamias, custard apples and low chill stone fruit, (Table 24-30).

Class 4 marginal land with severe limitations and Class 5 unsuitable land

Like the field crops, most of the southern areas are marginal or unsuitable for horticultural tree crops due to low winter temperatures and periods of winter drizzle which lead to lower amounts of solar radiation for plant growth (Table 24-30).

Table 24 Avocado suitability

Suitability class	Area (ha)	UMA total
1	2184	13
2	11719	84
3	52317	545
4	38780	172
5	62927	248

Table 25 Macadamia suitability

Suitability class	Area (ha)	UMA total
1	2184	13
2	11609	75
3	34754	347
4	56453	379
5	62927	248

Table 26 Lychee suitability

Suitability class	Area (ha)	UMA total
1	2184	13
2	208	5
3	13613	113
4	51240	468
5	100682	463

Table 27 Custard apple suitability

Suitability class	Area (ha)	UMA total
1	2184	13
2	11700	83
3	37632	399
4	53484	319
5	62927	248

Table 28 Low chill Stone fruit suitability

Suitability class	Area (ha)	UMA total
1	Nil	Nil
2	18238	186
3	33278	309
4	53484	319
5	62927	248

Table 29 Mango suitability

Suitability class	Area (ha)	UMA total
1	2184	13
2	326	7
3	14396	116
4	51290	470
5	99731	456

Table 30 Citrus suitability

Suitability class	Area (Ha)	UMA total
1	Nil	Nil
2	2392	18
3	13594	112
4	89014	684
5	62927	248

Suitability results for tea

Previous work of Wilson (1991) has identified areas which are suitable for tea. This project determined that there was no Class 1 land suitable for tea production. There is a total of 18400 ha (Class 1-3) of land suitable for tea. This is made up of 722 ha of Class 2 land and 1700 ha of Class 3 land (Table 31) around the Malanda area.. The major limitations to tea growing on the Tablelands are climate (tea requires rainfall >2500 mm per year) and soil pH (tea requires soil pH values <pH5.5).

Table 31 Tea suitability

Suitability class	Area (ha)	UMA total
1	Nil	Nil
2	723	12
3	17696	157
4	34156	282
5	115352	611

Suitability results for temperate and tropical pastures

Table 32 and 33 show the areas suitable for temperate and tropical pastures. It can be seen that unlike field and tree crops, the bulk of the Tablelands is suitable for pastures. This is due to the wider climatic and soil morphological tolerances of grasses. A total of approximately 135 000 ha of land is deemed suitable for temperate and tropical pastures.

Table 32 Temperate pasture suitability

Suitability class	Area (ha)	UMA total
1	22359	215
2	62627	384
3	49169	298
4	27674	135
5	6097	30

Table 33 Tropical pasture suitability

Suitability class	Area (ha)	UMA total
1	14072	99
2	34669	295
3	87850	515
4	25238	123
5	6097	30

7. Soil conservation practices

Maintenance of the soil resource is fundamental to the continued productivity of agricultural lands. On the Atherton Tablelands, the majority of land has been cleared of native vegetation for the establishment of pastures and cultivated land. The result is an increased incidence of erosion causing substantial soil losses, particularly in the cropping lands. Rainfall events recorded in 1985 revealed soil losses of 60 t/ha on land slopes of less than 3% and up to 400 t/ha on slopes up to 8% (East, 1986). Structural works such as contour banks and waterways have been shown to be effective in reducing soil loss from arable lands.

Controlling erosion caused by water involves two important techniques. The first is to maintain adequate levels of vegetative cover on the soil surface. In grazing lands and some cropping lands this may be all that is necessary to achieve satisfactory levels of erosion control. Secondly, in some situations on mainly sloping cropping lands (generally over 2%), it is also necessary to control run-off by the use of structures such as contour banks and waterway systems. Contour banks may be required for land under 2% if the slope length is excessive.

The major run-off control structures used in the Atherton Tablelands district include: waterways, contour banks, diversion banks, drop structures and rock and sod chutes. When designing soil conservation structures, an estimate of the peak flow rate or discharge is necessary. The design of structures used to convey run-off, such as contour banks, waterways and dam bywashes, requires an estimate of the peak rate of run-off (that is, the volume of run-off per unit time m^3/sec). Soil conservation structures are usually designed for a 1 in 10 year run-off event. A 1 in 10 year run-off event refers to the intensity of a rainfall event, eg. a storm you would expect to experience once every ten years. Run-off estimates are obtained using mathematical calculations in conjunction with meteorological data.

As at 30/04/94, the total area in the extensive croplands[1]; across these three shires protected[2] by contour banks amounted to 10 475 hectares (Queensland department of Primary Industries, 1994). Table 34 shows the area protected and the percentage of area covered by soil conservation works in the above mentioned shires.

Table 34 Soil conservation statistics for the Atherton Tableland

Shire	Cropping area	Land use	Area protected	% of area
Atherton	15 618 ha	croplands	5564 ha	36
Eacham	4306 ha	croplands	1166 ha	27
Herberton	6085 ha	croplands	3745 ha	62
Total	26 009 ha	croplands	10 475 ha	40

[1] The term ‘extensive croplands’ refers to areas under maize/peanut rotations, including those lands under pasture which are suitable for cropping.

[2] The term ‘protected’ defines land which has contour banks, waterways, diversion banks or run-off coordination works implemented.

Soil erosion

Soil erosion occurs on most of the cultivated land in the district. The degree of erosion varies according to land use, soil type, topography, climate, crop type and management practices. Raindrop impact, splash and rill erosion can be severe in the maize and peanut areas where continuous cropping and cultivation have reduced soil organic matter and depleted soil structure. The susceptibility of the cropping lands to erosion increases dramatically during the land preparation stage due to the relatively low level of surface protection and the increased incidence of seasonal high intensity rainfall events.

Preventing soil erosion is more effective than the remedial works often associated with repairing damaged land, therefore, planning farm layouts, especially along creeks and streams, prior to clearing will help minimise erosion. Streambank erosion can be controlled by fencing both sides of the stream so as to exclude livestock. Strategic positioning of watering points and stock crossings will help minimise damage caused by hoofed animals. Stream and creek stability can then be maintained for long periods.

Over clearing

The southern parts of the Tableland, around Malanda and Millaa Millaa, are generally steep lands where slopes can exceed 50%. Most of the land south of Malanda has been cleared for dairying. The steeper areas have been adversely affected by over clearing. The major effects of over clearing on steep slopes are:

- Woody weed invasion: e.g. Lantana (*Lantana camara*), Wild Tobacco (*Nicotinia spp*) and Bracken fern (*Pteridium spp*).

- Landslip occurs on steep slopes where vegetation has been removed. Mass movement of this nature renders the effected land unproductive and is costly if not impossible to rectify. Areas where a layer of basalt covers granite or metamorphic rocks or where the soil is shallow over underlying rock are particularly susceptible to landslip.

- Streambank erosion: occurs when over cleared streambanks and heads become unstable and start to erode again resulting in the advance of the gully head and widening of the bed. Further gully advance results in the loss of valuable cropping and grazing land. Both stream bank and gully erosion occur throughout the tablelands area. Stream bank erosion occurs in most grazing and cropping areas.

- Gully erosion: occurs where run-off water is concentrated into unstable outlets eg. where relatively flat cropping lands drop into existing creeks and streams. Major gully erosion occurs at catchment outlets and can cause down stream siltation. Gullies are very expensive to rectify and active gully heads can be difficult to control. Common methods of gully stabilisation include:
    - -controlling the amount of water the gully carries
    - -battering gully sides and heads
    - -replacing topsoil in small gullies eg. rills
    - -planting trees
    - -gully control dams
    - -chutes (sod and masonry)
    - -drop structures
    - -terracettes

Conservation cropping

Cultivation of the soils in association with the seasonal distribution and erosivity of high intensity rainfall, predispose the area to serious erosion. Conservation cropping practices and sound management techniques are required to both control and reduce the amount and concentration of run-off and soil loss. Agronomic erosion control practices that could be used on the Atherton Tableland are listed below :

- crop rotation
- crop pasture rotation
- opportunity cropping
- stubble mulching
- use of tyned implements and rod weeders
- zero tillage and reduced tillage
- timing of cultivation
- fertiliser applications at planting (rather than disturbing the soil post plant)
- chemical weed control
- controlled traffic technology
- winter stubble retention for soil protection

8. References

Baker, D.E. and Eldershaw V.J. (1993). *Interpreting soil analyses - for agricultural land use in Queensland*, Queensland Department of Primary Industries, Brisbane.

Best, J.G. (1962). *Atherton, Queensland 1:250 000 Geological Series.* Bureau of Mineral Resources Australia, Explanatory Notes E/55-5.

Carey, B.W. (1995). *(DRAFT) Technical Handbook for the Design of Soil Conservation Structures,* Queensland Department of Primary Industries, Brisbane.

Coughlan, K.J., McKenzie, N.J., McDonald, W.S. and Cresswell H.P. (1995). *Soil Physical Measurement and Interpretation for Land Evaluation.* Penultimate Draft ed. In Australian Soil and Land Survey Handbook, 5. Canberra: Australian Collaborative Land Evaluation Program.

De Keyser, F. (1964). *Innisfail, Queensland 1:250 000 Geological Series.* Bureau of Mineral Resources, Geology and Geophysics, Australia

East, G. (1986). *Erosion Survey of Cropping Areas in the Atherton and Herberton Shires after the storm events of the 21/11/85 to 26/11/85,* Queensland Department of Primary Industries.

Frawley, K.J. (1983). *A history of forest and land management in Queensland with particular reference to the north Queensland Rainforest.* A report to the Rainforest Conservation Society of Queensland, Brisbane.

Frawley, K.J. (1987). *The Maalan group settlement north Queensland 1954 - An Historical Geography*, Department of Geography and Oceanography, University College, Australian Defence Force Academy, Canberra.

Gillman, G.P and Abel, D.J. (1987). *A Summary of Surface Charge Characteristics of the major soils of the Tully - Innisfail area, North Queensland.* CSIRO Division of Soils report number 85.

Greacen, E.L. (1983). Physical Properties and Water Relations - Soil Mechanical Properties and Water Movement. *Soils: an Australian viewpoint.* Editors CSIRO, 502-530: Melbourne; Academic Press: London.

Grundy, M.J. and., Heiner, I.H. (1994). *Land resources of the Ravenshoe - Mt Garnet area North Queensland. Volume 2 - land suitability*. in prep. Queensland Department of Primary Industries. Land resources bulletin.

Gunn, R.H., Beattie, J.A., Reid, R.E. and van de Graff R. (1988). *Australian Soil and Land Survey Handbook: Guidelines for Conducting Surveys.* Inkata Press, Melbourne.

Heiner, I.H. and Grundy, M.J. (1994). *Land resources of the Ravenshoe - Mt Garnet area North Queensland. Volume 1 - land resource inventory,* Queensland Department of Primary Industries. Land resources bulletin.

Hield, D. and Topaz, H. (1977). Simulation of Soil Water Dynamics in Layered Soils. *Journal of Soil Science* 123: 54-62.

Huda, A.K.S., Cogle A.L. and Miller C.P. (1991). *Agroclimatic analysis of selected locations in north Queensland.* Queensland Department of Primary Industries. Bulletin.

Isbell, R. F. (1996). *The Australian Soil Classification.* CSIRO Publishing, Australia.

Isbell, R.F., Stephenson, P.J., Murtha, G.G. and Gillman, G.P. (1976). *Red Basaltic Soils in North Queensland*, CSIRO, Australia.

Isbell, R F., Webb, A.A. and Murtha, G.G (1968). *Atlas of Australian Soils,* CSIRO and Melbourne University Press.

Kent, D.J. and Tanzer, J.M. (1983). *Evaluation of Agricultural Land in Atherton Shire North Queensland*, Division of Land Utilisation, Queensland Department of Primary Industries, Brisbane.

Kent, D.J. and Tanzer, J.M. (1983). *Evaluation of Agricultural Land in Eacham Shire North Queensland*, Division of Land Utilisation, Queensland Department of Primary Industries, Brisbane.

Kerridge, P.C., C.S. Andrew, and G.G. Murtha. (1972). Plant nutrient status of soils of the Atherton Tableland, North Queensland. *Australian Journal Experimental Agriculture and Animal Husbandry,* No. 12, 59: 618-627.

Kershaw, A.P. (1970). A pollen diagram from Lake Euramoo north east Queensland Australia, *New Phytologist* 69: 785-805.

Kershaw, A.P. (1971). A pollen diagram from Quincan Crater north east Queensland Australia *New Phytologist*, 70: 669-681

Kershaw, A.P. (1974). A long continuous pollen sequence from north eastern Australia. *Nature* (London), 251: 222-223.

Laffan, M.D. (1988). *Soils and Land Use on the Atherton Tableland, North Queensland,* CSIRO Division of Soils.

Loader, L.R. (1987). *Fertilization practices for peanuts on the Atherton Tableland, North Queensland.* Queensland Department of Primary Industries project report

Loader, L.R. (1989). *Trace element toxicity of onions on the Atherton tableland* Queensland Department of Primary Industries project report.

Loveday, J. (1974). *Methods for Analysis of Irrigated Soils*. Commonwealth Agricultural Bureaux, England.

Land Resources Branch (1990). *Guidelines for Agricultural Land Evaluation in Queensland,* Queensland Department of Primary Industries, Brisbane.

Laurance, W.F. (1991). Ecological correlates of extinction proneness in Australian tropical rain forest mammals. *Conservation Biology,* 5: 79-89.

Malcolm, D.T. and Heiner, I.J. (1996). *The soils of Walkamin Research Station. North Queensland.*

McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J and Hopkins, M.S (1990). *Australian Soil and Land Survey Field Handbook (2nd Edition).* Inkata Press, Melbourne.

Mohr, E.C.J., van Baren, F.A. and van Schuylenborgh, J. (1972). *Tropical Soils: A Comprehensive Study of their Genesis*. The Hague: Mouton.

Murtha, G.G.(1986). *Soils of the Tully-Innisfail area North Queensland*. CSIRO Division of Soils divisional report.

Norrish, K. and Rosser, H. (1983). Mineral phosphate, *In Soils: An Australian viewpoint*, CSIRO 335-364: Melbourne; Academic press: London.

Northcote, K.H. (1979). *A Factual Key for the Recognition of Australian Soils*. South Australia: Rellim Technical Publications Pty. Ltd.

Queensland Department of Primary Industries (1994). *Land Conservation Report - Statistics for Atherton Tableland*, Queensland Department of Primary Industries.

Rayment, G.E. and Higginson F.R. (1992). *Australian Laboratory Handbook of Soil and Water Chemical Methods.* Inkata Press, Melbourne.

Reid, R.E. (1988) Ed. Soil survey specifications. In Gunn, R.H., Beattie, J.A., Reid, R.E and van de Graff, R. Ed (1988). *Australian Soil and Land Survey Handbook: Guidelines for Conducting Survey.* Inkata Press, Melbourne.

Sheperd, R.N. and Macnish, S.E. (1989). *Land Management Field Manual Atherton/Mareeba District*, Queensland Department of Primary Industries, Brisbane.

Simonett, D.S. and Bauleke, M.P. (1963). Minerology of Soils on Basalt in North Queensland. *Proceedings of the Soil Science Society of America,* 27: 205.

Stace, H.C.T., Hubble, G.D., Brewer, R., Northcote, K.H., Sleman, J.R., Mulcahy, M.J. and Hallsworth, E.G. (1968). *A Handbook of Australian Soils*. Rellim Technical Publications, South Australia.

Stanton, J.P. (1992). *Integrated Management for the Johnstone River Habitat Management Plan (Preliminary Report).* Report to Department of Primary Industries.

Taylor, R.M., McKenzie, R.M., Fordham, A.W. and Gillman, G.P. (1983). Oxide Minerals. *In Soils: an Australian viewpoint.* CSIRO, 309-334. Melbourne; Academic Press: London.

Thompson, C.H., Moore, A.W. and Northcote, K.H. (1983). Soils and Land Use. *In Soils: an Australian viewpoint.* CSIRO, 757-76. Melbourne; Academic Press: London.

Tracey, J.G. (1982). *The Vegetation of the Humid Tropical Region of North Queensland.* CSIRO, Melbourne.

Tracey, J.G and Webb, L.J. (1975). *Vegetation of the humid tropical region of north Queensland.* CSIRO Australia, Long Pocket Labs, Indooroopilly.

Warrell, L.A., Thompson, W.P. and Cannon, M.G. (1984). *Soils of the Kairi Research Station, Atherton Tableland*, Queensland Department of Primary Industries, Brisbane.

Webb, L.J. (1966). The identification and conservation of habitat types in the wet tropical lowland of north Queensland. *Proceedings of Royal Society of Queensland*, 78: 59-86.

Wild, A. (Ed) (1988). *Russel's soil conditions and plant growth.* 11th Edition. Longman Scientific and Technical, UK.

Willett, I.R. (1983). Oxidation - Reduction reaction. *In Soils: an Australian viewpoint.* CSIRO, 417-426. Melbourne; Academic Press: London.

Wilson, P.R. (1991). *Agricultural land suitability of the wet tropical coast. Mossman to Julatten area.*, Queensland Department of Primary Industries, Brisbane.

Wilson, P.R., and Baker, D.E. (1990). *Soils and Agricultural Land Suitability of the Wet Tropical Coast of North Queensland: Ingham Area*. Queensland Department of Primary Industries, Brisbane.

Winter, J.W., Bell, F.C., Pahl, L.I. and Atherton, R.G. (1987). Rainforest clear felling in Northeastern Australia. *Proceedings of the Royal Society of Queensland,* 98: 41-57.

Wood, A.W. (1985). Soil degradation and management under intensive sugarcane cultivation in North Qld. *Soil Use and Management,* No 1, 4: 120-124.

9. Glossary

Acid volcanic rock - light coloured, fine grained rock containing small crystals of quartz. Classified as acid as it contains more than 66% silica. Contains low levels of Iron (Fe), Magnesium (Mg) and Calcium (Ca).

Australian Soil Classification - A new classification scheme developed over the last five years. The order names end in 'ol' eg.

- Dermosol: is a well structured soil and does not have a clear or abrupt boundary between the A and B horizon;
- Ferrosol: has a structural B horizon which is high in Iron (and therefore red), and lacks a major change in texture between the A and B horizon.

Basalt - fine grained basic volcanic rock; the most common volcanic rock.

Boundaries - the distance over which the soil changes from one horizon to the underlying horizon.

- a <u>sharp</u> boundary has a width of 5mm,
- an <u>abrupt</u> boundary has a width of 5-20mm,
- a <u>clear</u> boundary 20-50-mm and a
- <u>a gradual</u> boundary 50-100mm.

Clay - soil material consisting of particles less than 0.002mm in diameter.

Coarse fragments - are particles greater than 2 mm in diameter which are remnants of parent material; the size categories used are:

- <u>gravels</u> 2-60 mm; (<u>scoria</u> gravels red in colour with a rough surface);
- <u>cobbles</u> 60-200 mm
- <u>stones</u> 200-600 mm diameter.

The percentage of coarse fragments in each horizon varies;

- "few" coarse fragments is equivalent to 0-10% of the horizon made up of coarse fragments;
- "some" coarse fragments 2-20%;
- "many" 20-50%;
- "abundant" 50-90%.

Cultivation slope limit - the maximum slope at which cultivation can occur on an area which is protected by soil conservation measures (ie. contour banks, grassed waterways), without causing soil erosion.

Great Soil Group - a group of soils with similar features and generally having similar agricultural suitability. There are over forty Great Soil Groups recognised in Australia. This soil classification scheme has been used for over twenty years and is being replaced by the Australian Soil Classification Scheme.

Hill - area of relief 90-300 metres high with gentle to precipitous slopes.

Horizon - is a layer of soil approximately parallel to the land surface, with properties differing from layers above and/or below.

- The *A horizon* is the surface horizon; usually darker in colour (due to organic material) than the underlying horizons. It is often sub-divided into A_1, A_2 and A_3
    - The A_2 *horizon* is lighter in colour than the overlying A_1 and can be bleached white.

  - The A_3 *horizon* is a transitional horizon between the A and B horizons, but is more like the A horizon than the B horizon.
- The *B horizon* differs from the A horizon by a range of properties including stronger colours and a higher percentage of clay. The B horizon consists of one or more layers *(B_1, B_2, B_3).*
  - The B_1 *horizon* is a transitional horizon between the A and B horizons, but is more like the B horizon than the A horizon.
  - The B_2 *horizon* is the major part of the soil profile and is further sub-divided by minor differences in some properties e.g colour, texture, into B_{21}, B_{22}, B_{23}
  - The B_3 *horizon* is a transitional horizon between the *B* and *C horizon* with the properties of the B horizon dominant but some properties of the *C* horizon evident.
- The *C horizon* is material below the B horizon which is partially weathered and may be the parent material from which the soil was formed.

Limitations - are factors that restrict the land use options available to a landowner eg. the farm may be in an area which is heavily frosted, therefore the landowners choice of crop is restricted to frost tolerant crops.

Metamorphic rock - is material which has been chemically and physically altered by heat and pressure. Schist and quartzite are two common types.

Mottles - are spots, blotches or streaks differing from the main colour of the profile. Mottles generally indicate a fluctuating water table. The percentage of mottles in each horizon varies;
- "a few" mottles is equivalent to 0-10% of the horizon made up of mottles;
- "some" mottles 2-20%;
- "many" 20-50%; and
- "abundant" 50-90%.

Nodules - are small irregularly shaped segregations in the soil resulting from the concentration of an element. Manganese (Mn) nodules are black; Ferromanganiferous nodules are a combination of iron (Fe) and manganese and are reddish-black. Both fizz on application of H_2O_2 (peroxide); manganese nodules more strongly. The Mn contained in these nodules are unavailable to plants unless pH drops below 5.5.

PAWC (Plant Available Water Capacity) - ability of the soil to store water which is available to plants.

Pedal - a characteristic of the soil: a pedal soil has observable peds (see *Structure*).

Permeability - the ease in which water moves through the profile.

pH - this property affects the availability of nutrients. The optimum pH is 6-7.
- A very acid soil has a pH less than 5.5;
- moderately acid 5.5-6.5;
- weakly acid 6.5-7;
- neutral 7.

Phenocrysts - small crystals resembling sand, found in the soil. These are formed when the magma cools slowly, enabling a few crystals to develop; conditions change and the magma is then cooled quickly, preventing other crystals developing.

Principal Profile Form - is a coded description of the soil profile. This is part of the Northcote Soil Classification Scheme, the third major scheme used in Australia. Use of this classification scheme is declining. For further detail see “A Factual Key For The Recognition of Australian Soils.” (Northcote, 1979).

Rise - is a small hill of elevation 9-30 metres with very gentle to steep slopes.

Safe machinery limit - maximum steepness of slope on which machinery can be safely driven without major risk of machinery overturning.

Silt - soil material with a diameter between 0.002 and 0.02 mm.

Slopes - a 1% slope has a rise of 1 in 100; a 10% slope a rise of 10 in 100. Categories used are:
- *level* 0-1%
- *very gentle slopes* 1-3%
- *gentle* 3-10%
- *rolling* 10-20%
- *steep* 20-30
- *very steep* >30%.

Structure - refers to the distinctness, size and shape of peds. A ped consists of a number of primary particles and is an individual soil aggregate. Peds with:
- *prismatic* structure have flat vertical sides and flat tops
- *columnar* structure have flat vertical sides and domed tops.
- *blocky* structure have six roughly flat faces.

A soil with good structure has better drainage than a soil with poor structure. Soil structure influences pH and other soil characteristics. A soil with poor structure has an earthy appearance and can be broken in any direction.

Texture - the proportion of sand, silt and clay in a soil. A soil with a higher percentage of clay is generally more fertile than a soil with a low clay content, although this is affected by the parent material.
- *clay loam* has 30-35% clay;
- *light clay* 35-40%, and
- *medium clay* 45-55%.

Vegetation - is described as consisting of several layers.
- The *upper storey* is the upper most layer of leaves (the canopy).
- The *mid-storey* is the middle layer.
- The *understorey* is comprised of grasses and low shrubs.

Terms used to describe vegetation include;
- *Complex* - indicates an abundance of epiphytes (eg. staghorns), lianas, and buttresses on trees.
- *Mesophyll* - leaf size ranges from 125-250mm. Leaf size is affected by climate and soil fertility and is an important descriptive tool when classifying rainforests.
- *Vine forests* - a type of rainforest where vines, twining or scrambling plants drape the tallest trees, covering at least 60% of the exposed surface.

Appendix 1

Soil Profile Classes

Soil Profile Class : BICTON (Area 3 967 ha)

Concept : Moderately deep[g], mottled[g] yellowish–brown, pedal[g] gradational[g] soils with acid reaction trend[g], formed on rolling and steep low hills[g] of schist and phyllite.

Australian Classification : Dystrophic Brown Dermosol

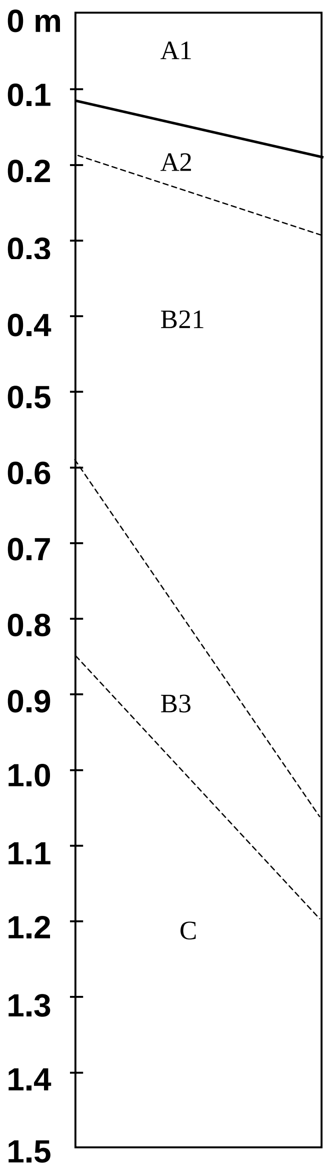
Great Soil Group : No Suitable Group affinities with Xanthozem

Principle Profile Form : Gn3. 74, Gn3. 71, Gn3. 94

Landform : rolling low hills (20–32%) and steep low hills (>32%)

Geology : Barron River Metamorphics

Vegetation : Rainforest species and *Casuarina* spp.



A1 : 0.12–0.18m Brown or grey (10YR3–4 /2–3);(7. 5YR4–5/2–4); Clay loam fine sandy to fine sandy light clay; moderate to strong 2–5mm granular; Field pH 6.0–6. 5; Clear change to :

A2 : 0.19–0.26m Yellow–brown or grey (10YR4–5/2–4); Silty clay loam to light clay; <2–10% 6–20mm quartz pebbles; moderate to strong 2–5mm granular; Field pH 5. 8–6.0; Clear or gradual change to :

B21 : 0.60–1.10m Yellow or yellow–brown (10YR5–6/4–6); 10–20% 5–15mm distinct red and orange mottles; silty light clay to light medium clay; 2–10% 6–20mm quartz pebbles; moderate 2–5mm subangular blocky; Field pH 5. 5–6.0; Gradual to diffuse change to :

B3 : 0.84–1.20m Yellow or yellow–brown (10YR5–7/4–6); 10–20% 5–30mm distinct orange and red mottles; clay loam fine sandy to clay loam; 50–90% schist and phyllite fragments; weak 2–5mm subangular blocky; Field pH 5.0–6.0.

C : 1.00m onwards parent material of schist and phyllite.

Soil Profile Class : BARRON **(Area 3 174 ha)**

Concept : Deep[g] ,brown or dark, pedal[g], uniform[g] soils with neutral reaction trend[g], formed on gently sloping rises[g] of younger basaltic flows containing significant amounts of basalt rock.

Australian Classification : Eutrophic Brown Ferrosol

Great Soil Group : Prairie Soil

Principle Profile Form : Uf6. 31

Landform : Gently sloping rises (3–10%)

Geology : Atherton basalt of late Pleistocene age

Vegetation : Rainforest species. some *E. clarksoniana* and *E. tereticornis*

A1 : 0.05–0.20m Brown or dark (7. 5YR 3/2– 3); light to light medium clay; 2– 10% 2– 6mm basalt pebbles; moderate to strong 2– 5mm granular; Field pH 6.5–7.5; Clear change to :

B21 : 0.40–0.70m Brown or dark 7. 5YR3/4, 5YR3/2–4); light medium clay; 2–10% 20–60mm basalt pebbles; moderate 2–5mm polyhedral; Field pH 6. 5–7. 5; Gradual or diffuse change to :

B22 : 0.80–1.20m Brown (7. 5YR3/3–5); light medium clay; 2–50% 6–60mm basalt pebbles; moderate 2–5mm polyhedral; <2% 2–6mm manganiferous nodules; Field pH 6. 2–7. 5; Gradual change to :

B3 : 0.90–1.30m Brown or dark (7. 5YR3/4, 5YR3/4); light medium clay; 20–50% 20–60mm basalt pebbles; moderate 2 –5mm polyhedral; Field pH 6. 5–7. 5; Gradual change to :

C : 1.00–1.50m Brown or dark (7. 5YR3/4, 5YR3/4); light medium clay; 50 to 90% basalt pebbles; moderate 2–5mm polyhedral; <2% 2–6mm manganese nodules; Field pH 6. 5–7. 5

Comments : Rock levels vary considerably

Soil Profile Class : CARRINGTON (Area 567 ha)

Concept : Moderately deep[g], mottled[g] grey, pedal[g] , uniform[g] soils with acid reaction trend[g] , formed in depressions at the lower end of alluvial/colluvial fans[g] derived from granite and rhyolite.

Australian Classification : Dermosolic Redoxic Hydrosol

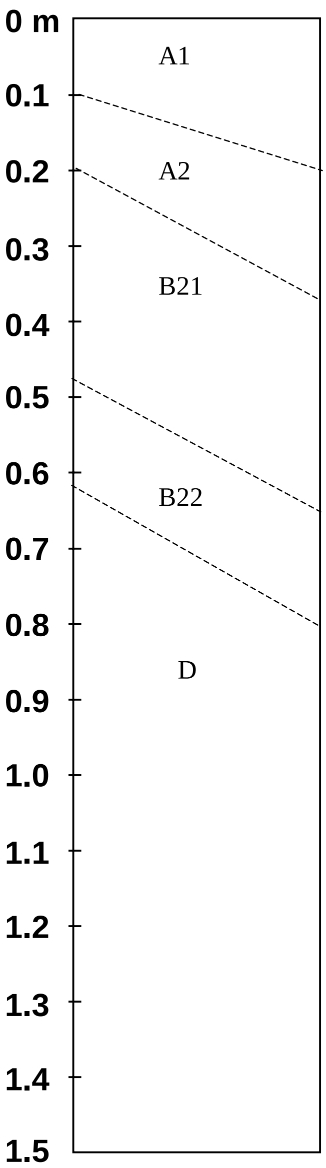
Great Soil Group : Humic Gley

Principle Profile Form : Uf6. 41, Uf4. 2, Uf6. 7, Gn2. 41

Landform : Depressions at the lower end of alluvial/colluvial fans (0–1%)

Geology : Quaternary alluvium

Vegetation :*Melaleuca* spp. *Lophostomen suaveolens, E. tereticornis*



A1 : 0.12–0.17m Dark or grey (10YR3–5/1); 2–10%, 5–15mm distinct orange mottles; light to medium clay; moderate 2–5mm granular; Field pH 5. 5–6. 5; Diffuse change to :

A2 : 0.20–0.36m Grey (10YR4–6/1–2); 2–20%, 5–15mm distinct orange mottles; light clay to medium clay; weak to moderate 2–5mm granular; Field pH 5. 5–5. 8; Gradual change to :

B21 : 0.48–0.63m Grey–brown or grey (7. 5YR4/1, 10YR6/1–3); 2–20%, 5–15mm distinct orange mottles; fine sandy light clay to sandy light medium clay; moderate 2–50mm subangular blocky or lenticular or prismatic; Field pH 5. 5; Gradual change to :

B22 : 0.66–0.80m Grey–brown or grey (7. 5YR4–5/1, 2. 5YR6/1); 2–20%, 5–30mm distinct orange mottles; sandy medium clay to medium clay; moderate 2–50mm prismatic or lenticular; Field pH 5.0–5. 5; Gradual change to :

D : 0.90–1.30m Grey (10YR4–6/1); 10–20%, 5–15mm distinct orange mottles; sandy clay loam to sandy light medium clay; massive; Field pH 5.5–6.0

Soil Profile Class : **GALMARA (Area 8 055 ha)**

Concept : Deep[g], red, pedal[g], gradational[g] soils with acid reaction trend[g] , formed on gently sloping rises to steeply sloping low hills[g] of schist and phyllite.

Australian Classification : Mesotrophic Red Dermosol

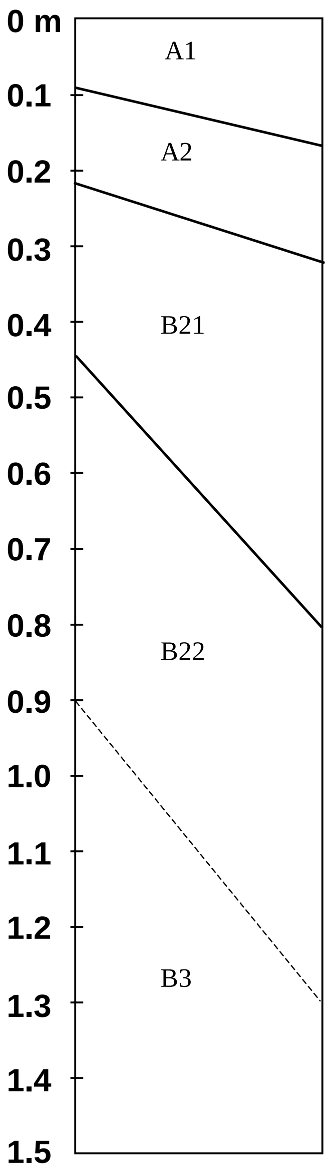
Great Soil Group : No Suitable Group affinities with Red Podzolic

Principal Profile Form : Gn3.14, Gn3.74, Uf4.41

Landform : Gently sloping rises to steep low hills (3–>32%)

Geology : Barron River Metamorphics;

Vegetation : *E. clarksoniana, E. acmenoides, Accacia* spp., *Casuarina* spp., *Xanthorhoea* spp.



A1 : 0.10–0.15m Brown, dark or red–brown (5YR3–4/1–5, 7.5YR3–4/2–3); silty clay loam to fine sandy clay loam; 2–20% 6–20mm quartz pebbles; moderate to strong 2–5mm granular; Field pH 5.0–7.0; Clear change to :

A2 : 0.20–30m Brown or red–brown (5YR3–5/2–6, 7.5YR4–5/3–4); silty clay loam to fine sandy clay loam; 2–20% 6–20mm quartz pebbles; moderate to strong 2–5mm granular; Field pH 5.5–6.5; Clear change to :

B21 : 0.45–0.80m Brown or red–brown (5YR3–5/4–6, 2.5YR3–5/4–6); Silty light clay to fine sandy light clay; 2–20% 6–20mm quartz and schist pebbles; moderate 2–5mm subangular blocky; Field pH 5.8–6.0; Clear change to :

B22 : 0.90–1.30m Red or red–brown (5YR4–5 /4–6, 2.5YR3–5/5–7); 10–50% 5–15mm distinct yellow, or orange mottles; clay loam fine sandy to sandy light clay; 2–20% 6–60mm quartz and schist pebbles; weak to moderate 2–5mm subangular blocky; Field pH 5.5–6.5; Gradual change to :

B3 : 1.00–1.40m Red or red–brown (5YR4–5 /4–8, 2.5YR3–6/4–6); 10–50% 5–15mm distinct yellow or orange mottles; clay loam fine sandy; 50–90% 6–60mm quartz and schist pebbles; weak 2–5mm subangular blocky; Field pH 5.5–6.5.

Soil Profile Class : GWYNNE (Area 768 ha)

Concept : Deep[g], mottled[g] brown, pedal[g], uniform[g] soils with acid reaction trend[g] , and manganese nodules[g] formed on level to very gently sloping floodplains[g] of basaltic alluvium

Australian Classification : Mesotrophic Brown Dermosol

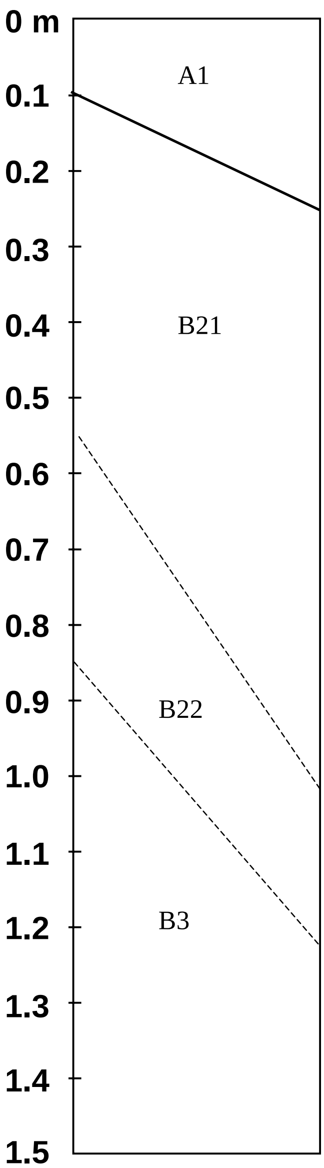
Great Soil Group : No Suitable Group affinities with Xanthozem

Principle Profile Form : Uf6.31, Uf6.4

Landform : Level to very gently sloping floodplains (0–3%)

Geology : Atherton Basalt

Vegetation : Improved pasture; *E.clarksoniana, E.tereticornis, Lophostomen suaveolens*



A1 : 0.10–0.24m Dark or brown (7.5YR3/ 2–3); <2%–10% <5mm faint orange mottles; light to light medium clay; moderate 2–5mm granular; <2%–10% 2–6mm manganiferous nodules; Field pH 5.5–7.0; Clear change to :

B21 : 0.55–1.00m Red–brown or brown (5YR3/4–5, 7.5YR3/4, 10YR4/4); 10–20% <5–15mm distinct orange mottles; light medium clay; moderate 2–5mm polyhedral; 2–10% 2–6mm manganese nodules and soft segregations; Field pH 6.0–6.5; Gradual change to :

B22 : 0.85–1.20m Red–brown or grey (5YR3/5–6, 10YR5/1); 10–50% 5–15mm prominent orange mottles; light medium to medium clay; moderate 2–5mm polyhedral; 2–10% 2–6mm manganese nodules; Field pH 5.5–6.2; Gradual change to :

B3 : 1.04–1.50m Brown or grey or yellow–brown (7.5YR4/4, 5YR4/4, 10YR5/1–3); 10–50%, 5–15mm distinct brown and orange mottles; light medium clay; weak to moderate 2–10mm prismatic or polyhedral;<2%–10%, 2 –6mm manganese nodules; Field pH 5.8–7.0.

Soil Profile Class : GOWRIE (Area 801 ha)

Concept : Deep[g], red, apedal[g], gradational[g] clay soils with acid reaction trend[g] , formed on moderately sloping low hills[g] of granite.

Australian Classification : Dystrophic Red Kandosol

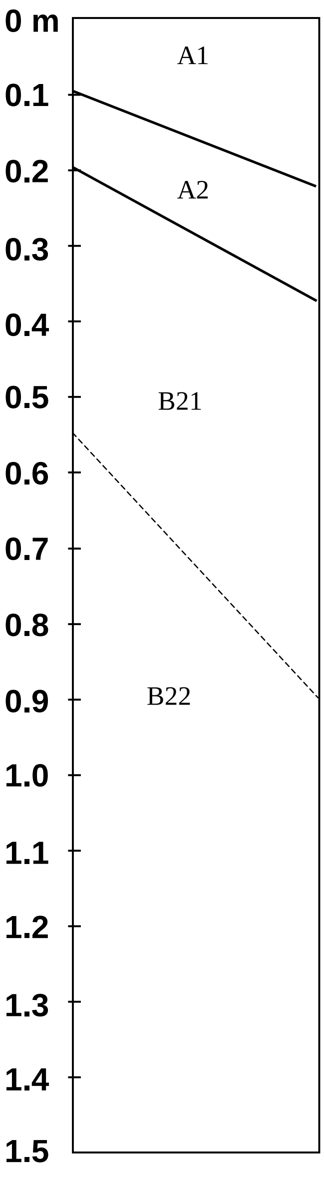
Great Soil Group : Red Earth

Principle Profile Form : Gn2.11, Um5.52

Landform : Moderately sloping low hills (10–32%)

Geology : Elizabeth Creek Granite, Mareeba Granite

Vegetation : *E. intermedia; E. acmenoides; Accacia* spp.;*Xanthorrhoea* spp*; Casuarina* spp



A1 : 0.10–0.21m Red–brown or dark (5YR2–3/1–3, 10YR3–4/2–4,7.5YR3/2); fine sandy clay loam to sandy light clay; <2%–10% 2–6mm quartz pebbles; weak 2–5mm granular; Field pH 5.5–6.3; Clear change to:

A2 : 0.19–0.30m Red–brown or brown (5YR2/4, 7.5YR4/4); sandy light clay; 10–20% 2–6mm quartz pebbles; weak to moderate 2–5mm granular; Field pH 6.0; Clear change to :

B21 : 0.55–0.90m Red,red–brown or brown (5YR3–4/4–6, 2.5YR3/3–4, 7.5YR4/6); clay loam fine sandy to sandy light medium clay; 10–20% 2–6mm quartz pebbles; weak 2–5mm polyhedral to massive; Field pH 6.0; Gradual change to :

B22 : 1.10–1.50m Red or brown (2.5YR3–4/4–6, 5YR5/6); clay loam to coarse sandy light clay; 10–20% 2–6mm quartz pebbles; weak 2–5mm polyhedral to massive; Field pH 5.5–6.0; Gradual change to :

Soil Profile Class : UTCHEE (Area 21 683 ha)

Concept : Very deep[g], red, pedal[g], gradational[g] soils with acid reaction trend[g], formed on moderately to steeply sloping low hills[g]of granite

Australian Classification : Red Dermosol

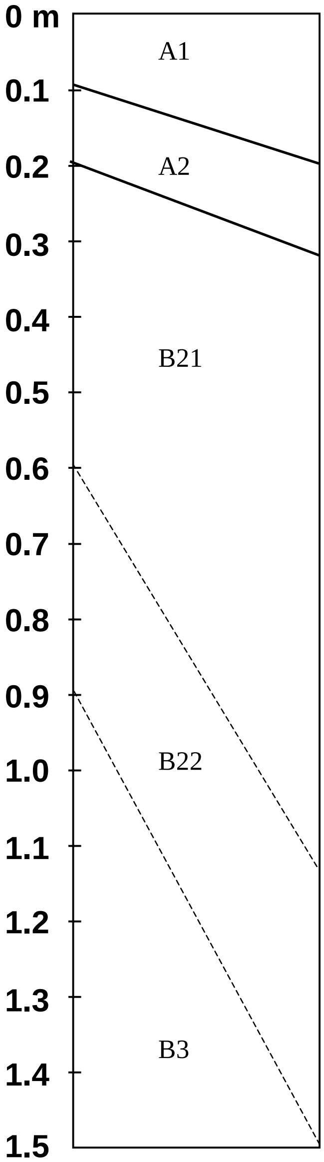
Great Soil Group : No Suitable Group affinities with Red Podzolic soil

Principle Profile Form : Gn3.11, Gn3.14, Gn3.74, Gn3.21

Landform : Moderately to steeply sloping low hills (20–>32%)

Geology : Tully Granite complex, Mareeba Granite, Elizabeth Creek Granite

Vegetation : Mainly rainforest spp.



A1 : 0.10–0.20m Red–brown or brown (5YR3–4/2–5, 7.5YR3–4/1–4); sandy light clay to sandy light medium clay; <2%–20% 2–6mm quartz pebbles; moderate to strong 2–5mm granular; Field pH 5.8–6.5; Clear change to :

A2 : 0.20–0.30m Red–brown or brown (5YR3–4/4–6, 7.5YR4–5/3–4); fine sandy light to sandy light medium clay;<2%–20% 2–6mm quartz pebbles; moderate to strong 2–5mm granular; Field pH 5.5–6.5; Clear change to :

B21 : 0.60–1.10m Red or red–brown (2.5YR4–5/4–7, 5YR3–5/4–8); 2–10% 5–30mm distinct orange, and yellow mottles; sandy light to sandy light medium clay; 10–20% 2–6mm quartz pebbles; moderate 2–10mm subangular blocky; Field pH 5.5–6.2; Gradual change to :

B22 : 0.90–1.50m Red or red–brown (2.5YR4–6/6–8, 5YR4–7/6–8); sandy light medium clay; 10–50%, 2–6mm quartz pebbles; moderate 2–5mm subangular blocky; Field pH 5.5–6.5; Gradual change to :

B3 : 1.20–1.60m Red or red–brown (2.5YR4–6/4–8, 10R4–5/6–7); 10–20% 5–30mm distinct orange and yellow mottles; coarse sandy light medium clay; 10–50% 2–6mm quartz and granite pebbles; moderate 2–10mm subangular blocky; Field pH 5.5–6.0.

Soil Profile Class : MAALAN (Area 36 198 ha)

Concept : Very deep[g], **r**ed–brown, pedal[g] ,uniform[g] soils with acid reaction trend[g] , formed on moderately to steeply sloping low hills[g] of basalt.

Australian Classification : Dystrophic Red Ferrosol

Great Soil Group : Krasnozem

Principle Profile Form : Uf6.31

Landform : Moderately to steeply sloping low hills (20–>32%)

Geology : Atherton basalt

Vegetation : Rainforest spp and improved pasture

A1 : 0.10–0.20m Red–brown or brown (5YR3–4/3–4, 7.5YR3–4/3–4); light clay to light medium clay; 2–10% 2–60mm basalt pebbles; moderate to strong 2–5mm granular; Field pH 5.5–7.0; Clear change to :

B21 : 0.65–0.90m Red–brown or brown (5YR3–4/3–6, 7.5YR3–4/3–4); light clay to light medium clay; 2–10% 2–20mm basalt pebbles; moderate 2– 5mm polyhedral; Field pH 5.8–7.0; Gradual change to :

B22 : 0.80–1.20m Red–brown or brown (5YR3–4/3–7, 7.5YR3–4/3–6); light clay to light medium clay; moderate to strong 2–5mm polyhedral; Field pH 5.8–6.5; Gradual change to :

B3 : 1.25–1.60m Red–brown or brown (7.5YR3–5/2–6, 5YR3–5/2–6, 10YR3–4 /3–4); light clay to light medium clay; 10–20%, 2–20mm basalt pebbles; moderate to strong 2–10mm polyhedral; Field pH 5.5–6.5

Soil Profile Class : PIN GIN (Area 32 621 ha)

Concept : Very deep[g], red, pedal[g], uniform[g] soils with acid reaction trend[g] , formed on gently sloping rises to moderately sloping low hills[g] of basalt.

Australian Classification : Dystrophic Red Ferosol

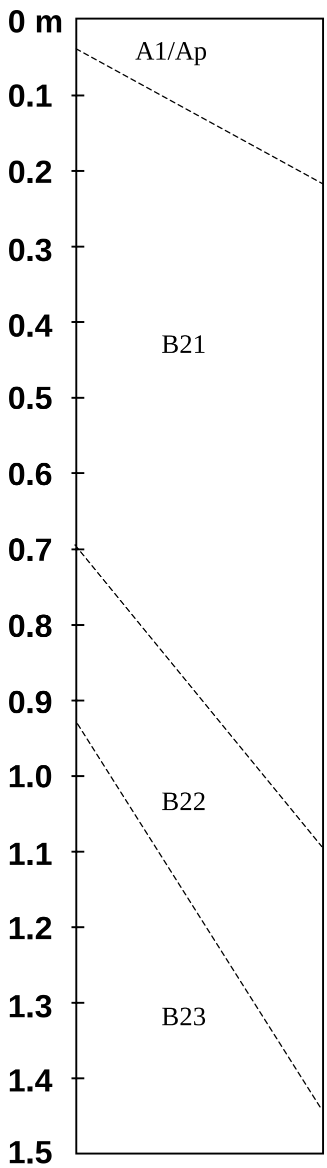
Great Soil Group : Krasnozem

Principle Profile Form : Uf6.31

Landform : Gently sloping rises to moderately sloping low hills (3–32%)

Geology : Atherton Basalt

Vegetation : Cropping, minor areas of rainforest, improved pastures



A1/Ap : 0.05–0.20m Dark or red (2.5YR2–3/2–6, 10R3/3–4); light clay; moderate to strong 2–5mm granular; Field pH 5.5–6.5; Clear to gradual change to :

B21 : 0.70–1.10m Red (2.5YR3/3–5, 10R3/3–5); light to light medium clay; moderate 2–5mm polyhedral; Field pH 5.8–6.5; Gradual change to :

B22 : 1.00–1.50m Red (2.5YR3/3–7, 10R3/3–5); light to light medium clay; moderate 2–5mm polyhedral; Field pH 5.8–6.5; Gradual or diffuse change to :

B23 : 1.30–1.80m Red (2.5YR3/3–7, 10R3–4/3–6); light clay to light medium clay; moderate to strong 2–10mm polyhedral; Field pH 5.8–6.5; Gradual or diffuse change to :

B3 : 1.50–1.80m (where present) Red or red–brown (2.5YR3–4/4–6, 10R3–5/3–5, 5YR3–4/3–8); light to medium clay; 2–50% 2–20mm basalt pebbles; strong 2–10mm polyhedral; Field pH 5.8–6.5

Soil Profile Class : WONGABEL (Area 539 ha)

Concept : Deep[g], yellow brown, weakly pedal[g], gradational[g] soils with acid reaction trend[g] , formed on very gently sloping alluvial/colluvial fans[g] derived from granite and rhyolite.

Australian Classification : Dystrophic Yellow Dermosol

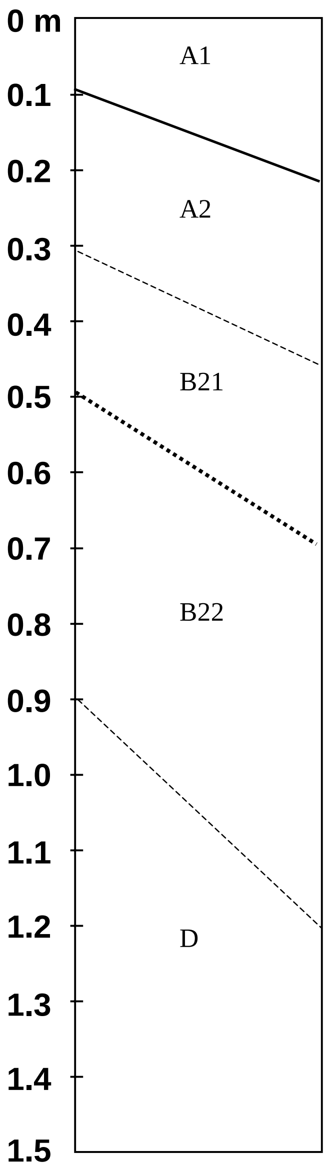
Great Soil Group : No Suitable Group affinities with Yellow Earth

Principle Profile Form : Gn2.44, Gn2.41, Um4.25, Uc5.11

Landform : Very gently sloping alluvial/colluvial fans (1–3%)

Geology : Quaternary alluvium

Vegetation : Improved pasture; *E. teriticornis, E. clarksoniana, Acacia* spp., *L. suaveolens; Alphitonia* spp., *M. quinquinervia*



A1 : 0.10–0.20m Dark or grey (10YR2–4/1–2); Sandy clay loam to clay loam; 2–20% 2–6mm quartz pebbles; weak to moderate 2–5mm granular; Field pH 5.8–6.0; Clear change to :

A2 : 0.30–0.45m Dark or grey or yellow–brown (10YR2–5/1–3); sandy clay loam to silty clay loam; 2–20% 2–6mm quartz pebbles; weak 2–5mm granular to massive; Field pH 5.5–6.0; Clear change to :

B21 : 0.50–0.70m Yellow or yellow–brown or grey (10YR5–7/2–4); sandy clay loam to sandy light medium clay; 2–50% 2–6mm quartz pebbles; weak to moderate 2–5mm subangular blocky; Field pH 5.3–6.8; Gradual change to :

B22 : 0.90–1.20m Yellow–grey, brown or grey (10YR4–7/2–3, 2.5Y6/3); 10–50% 5–30mm distinct orange and yellow mottles; fine sandy clay loam to sandy light medium clay; 20–40% 2–6mm quartz pebbles; weak 5–10mm prismatic or massive or single grain; Field pH 5.0–5.8; Gradual change to :

D : 1.00–1.70m Grey or yellow–brown 10YR4–7/1–2); 10–50% 5–30mm distinct yellow and orange mottles; loamy sand to light medium clay; 20–90% <2mm quartz pebbles; massive; Field pH 5.0–5.8.

Soil Profile Class : HEALES (Area 704 ha)

Concept : Very deep[g], red–brown, pedal[g], uniform[g] soils with neutral reaction trend[g], formed on gently to moderately sloping footslopes[g] of cinder cones. Profiles contain varying amounts of scoria.

Australian Classification : Red Ferrosol

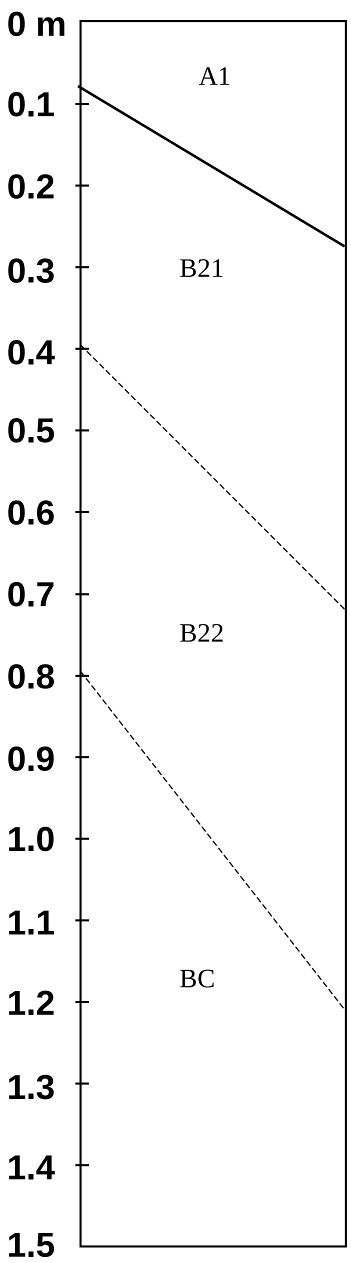
Great Soil Group : Euchrozem

Principle Profile form : Uf6.31

Landform : Gently to moderately sloping footslopes of cinder cones (3–20%)

Geology : Atherton Basalt of Late Pleistocene age

Vegetation : Rainforest, improved pasture



A1 : 0.08–0.26m Brown, red–brown or red (7.5YR3/4, 5YR3/2–3, 2.5YR3/3, 10R3/3); light to light medium clay; 2–10% 2–6mm scoria; moderate 2–5mm granular; Field pH 6.3–7.5; Clear change to :

B21 : 0.40–0.72m Red or red–brown (10R3/4, 2.5YR3/4, 5YR3/4); light medium clay; 2–20% 2–6mm scoria and basalt pebbles; moderate to strong 2–5mm polyhedral; Field pH 6.8–7.0, Gradual change to :

B22 : 0.80–1.20m Red or red–brown (10R3/5, 2.5YR4/3, 5YR3/5); light medium clay; 2–10% 2–6mm basalt pebbles; strong 2–5mm polyhedral; Field pH 6.8–7.5; Gradual change to :

BC : 0.90–1.50m Red, dark or red–brown (10R3/6, 2.5YR3/4, 5YR3–4/2–5); 2–20% 2–6mm distinct orange mottles; light to medium clay; 10–50% 2–20 mm scoria and basalt; moderate <2mm–5mm polyhedral; Field pH 7.0–7.5;

Comments : Scoria levels can vary considerably

Soil Profile Class : SYLVIA (Area 949 ha)

Concept : Deep[g], grey, pedal[g], duplex[g] soils with acid reaction trend[g], formed on gently sloping footslopes[g].derived from rhyolite.

Australian Classification : Magnesic Grey Chromosol

Great Soil Group : Soloth

Principle Profile Form : Dy2.41, Dy3.41, Gn3.04, Dy2.32

Landform : Gently sloping footslopes (3–10%)

Geology : Walsh Bluff Volcanics

Vegetation : *E. clarksoniana, E. alba, E. tessellaris, L. suaveolens, Casuarina* spp.; *M. viridiflora*

A1 : 0.09–0.20m Grey or grey–brown (10YR4–5/1–2, 7.5YR4–5/1–2); fine sandy loam to fine sandy clay loam; weak 2–5mm granular and cast; Field pH 5.5–6.3; Clear change to :

A2 : 0.20–0.35m Grey to grey–brown (10YR4–7/1–3) conspicuously bleached (dry); <2%–10% <5mm–15mm faint orange and yellow mottles; silty loam to silty clay loam; <2%–10% 2–6mm weathered rhyolite pebbles; massive; Field pH 5.5–6.3; Clear change to :

B21 : 0.50–0.80m Grey (10YR5–6/1–3, 2.5Y 5–7/1); 10–50% 5–30mm distinct orange and red mottles; silty light medium to medium heavy clay; strong 2–20mm angular blocky and prismatic; Field pH 5.8–6.0; Gradual change to :

B22 : 0.85–1.20m Grey or grey–brown (10YR5–6/1–2, 2.5Y7/2, 7.5YR4/1); 10–50% 5–30mm distinct orange and yellow mottles; silty light medium to medium heavy clay; strong 2–20 mm angular blocky; Field pH 5.8–6.0; Gradual change to :

B3 : 1.20–1.40m Grey or yellow (10YR3–6/3–8, 2.5Y7/2); 10–20% 5–15mm distinct orange mottles; silty clay loam to silty light medium clay; 2–50% 2–6mm rhyolite pebbles; moderate <2mm–5mm angular blocky; Field pH 5.8–6.0.

Soil Profile Class : TRANTERS (Area 787 ha)

Concept : Very deep[g], brown, pedal[g], uniform[g] soils with acid reaction trend[g], formed on very gently sloping terraces[g] of alluvium derived from basalt .

Australian Classification : Eutrophic Brown Dermosol

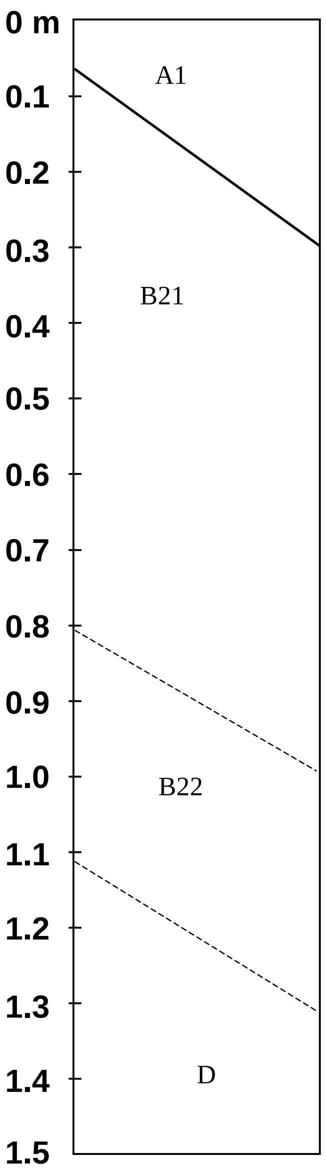
Great Soil Group : No Suitable Group

Principle Profile Form : Uf6.31, Uf6.4

Landform : Very gently sloping alluvial terraces (1–3%)

Geology : Atherton Basalt

Vegetation : Rainforest, improved pasture



A1 : 0.07–0.28m Dark or brown or red–brown (7.5YR3/2–3, 5YR3/3); 2–10% 5–15mm faint orange mottles; clay loam fine sandy to light clay; moderate 2–5mm granular; Field pH 5.5–6.8; Clear change to :

B21 : 0.80–0.97m Brown or red–brown (10YR4/4, 5YR3/3); clay loam fine sandy to light medium clay; moderate 2–5mm polyhedral; Field pH 6.0–7.0; Clear or gradual change to :

B22 : 1.10–1.30m Brown to grey (7.5YR4/3, 10YR5/1); clay loam fine sandy to light medium clay; moderate 2–5mm polyhedral; Field pH 5.8–7.0; Clear or gradual change to :

D : 1.40–1.80m (where present) Brown or grey (7.5YR4/3–4, N5/0); 10–20% 5–30mm distinct orange mottles; loamy sand to medium heavy clay; moderate to strong 5–20mm subangular blocky or prismatic; Field pH 6.5–7.0.

Soil Profile Class : WORSLEY (Area 351 ha)

Concept : Moderately deep[g], yellow–brown, pedal[g], gradational[g] soils with acid reaction trend[g], formed on moderately to steeply sloping low hills[g] of acid volcanic rocks (rhyolite).

Australian Classification : Mesotrophic Yellow Dermosol

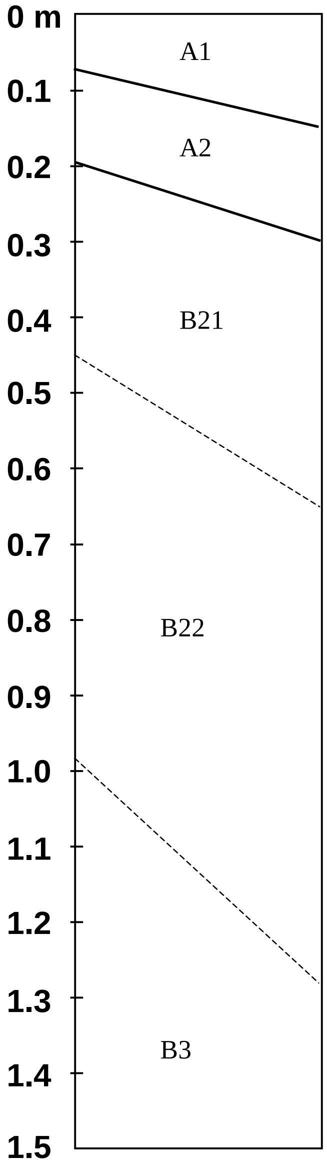
Great Soil Group : No Suitable Group affinities with Yellow Podzolic

Principle Profile Form : Gn.24, Gn2.21, Uf6.52

Landform : Moderately (20–32%) to steeply (>32%) sloping low hills

Geology : Walsh Bluff Volcanics and Glen Gordon Volcanics;

Vegetation : *Eucalyptus* and rainforest species



A1 : 0.08–0.15m Dark or grey–brown (7.5YR4/2, 10YR3/1); silty clay loam to fine sandy light clay; moderate 2–5mm granular; 10–20% 20–60mm rhyolite pebbles; Field pH 6.5; Clear change to :

A2 : 0.20–0.30m Brown, grey or pale (dry) (10YR4/4, 10YR5/1); silty clay loam to fine sandy light clay; weak 2–5mm granular; 10–20% 20–60mm rhyolite pebbles; Field pH 6.0; Clear change to :

B21 : 0.45–0.65m Yellow or yellow–brown (10YR5–6/3–5); 10–20%, 5–15mm distinct orange mottles; fine sandy light clay; weak to moderate 2–5mm angular blocky; 20–50%, 60–200mm subangular rhyolite; Field pH 6.0; Gradual change to :

B22 : 1.00–1.30m Yellow–brown (10YR6/4); 10–20% 5–15mm distinct orange mottles; fine sandy light clay; moderate 2–5mm subangular blocky; Field pH 6.0; Clear change to :

B3 : 1.10–1.50m Yellow (10YR7/5); sandy light medium clay; 50–90%, 20–60mm rhyolite pebbles; moderate 2–15mm angular blocky; Field pH 6.0.

Soil Profile Class : TOLGA(Area 14 105 ha)

Concept : Very deep[g], red, pedal[g], uniform[g] soils with neutral reaction trend[g], formed on very gently to gently sloping rises[g] of basalt.

Australian Classification : Mesotrophic Red Ferrosol

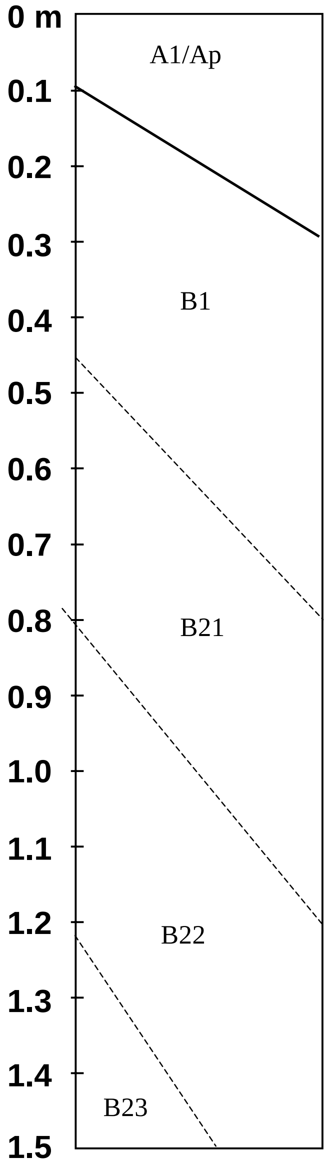
Great Soil Group : Euchrozem

Principle Profile Form : Uf6.31

Landform : Very gently sloping to gently sloping rises

Geology : Atherton Basalt

Vegetation : *E. clarksoniana; E tessalaris; E crebra; E.papuana; Lophostemon. suaveolens; Alphitonia* spp., *Grevillia glauca;* Rainforest species, cropping



A1Ap : 0.10–0.30m Red or dark (2.5YR2–3/2–3); light clay; moderate 2–5mm granular; 2%–10% 2–6mm manganese nodules; Field pH 6.0–7.0; Clear change to :

B1 : 0.46–0.80m (where present) Red (2.5YR3/3–4); light clay; weak 2– 5mm polyhedral; 2–10% 2–6mm manganese nodules; Field pH 6.2–7.5; Gradual change to :

B21 : 0.80–1.20m Red (2.5YR3/3–4); light clay; moderate 2–5mm polyhedral; 2–10% 2–6mm manganese nodules; Field pH 6.8–7.5; Gradual change to :

B22 : 1.20–1.60m Red (2.5YR3/3–5); light to light medium clay; moderate to strong 2–5mm polyhedral; 2–20% 2–6mm manganese nodules; Field pH 7.0–7.5; Gradual change to :

B23 : 1.60–1.80m Red 2.5YR/3–5); light to light medium clay; moderate to strong 2–10mm polyhedral; 2–20% 2–6mm manganese nodules; Field pH 7.0–7.5.

Soil Profile Class : UMALA (Area 12 031 ha)

Concept : Very deep[g], mottled[g] red, pedal[g], gradational[g] soils with acid reaction trend[g] , formed on moderately to steeply sloping low hills[g] of acid volcanics (rhyolite).

Australian Classification : Dystrophic Brown Dermosol

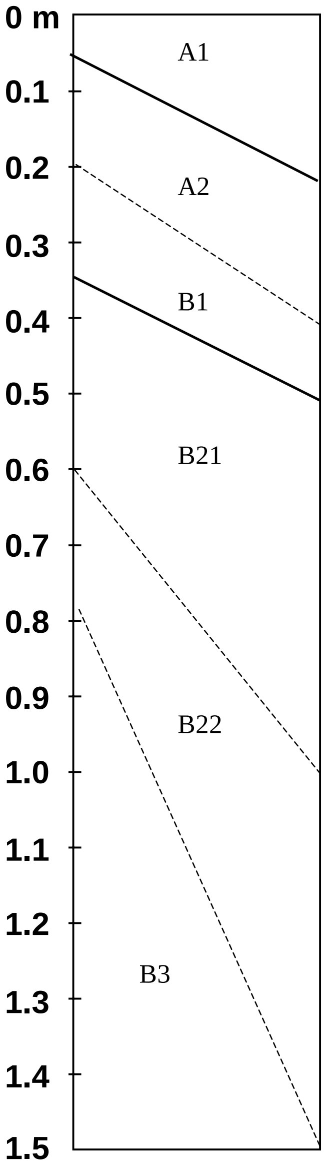
Great Soil Group : No Suitable Group affinities with Red Podzolic

Principle Profile Form : Gn3.11, Gn3.14, Gn3.21, Gn3.91

Landform : Moderately (20–32%) to steeply sloping (>32%) low hills

Geology : Glen Gordon Volcanics and Walsh Bluff Volcanics

Vegetation : Rainforest; *E. tereticornis, E. intermedia, Casuarina spp.; Acacia* spp.



A1 : 0.05–0.20m Red–brown, brown or dark (5YR3–4/4–5, 7.5YR4/3–4, 10YR2/2); 2–10% 5–15mm faint red mottles; clay loam fine sandy to light clay; moderate to strong 2–5mm granular; Field pH 6.0–7.0; Clear change to :

A2 : 0.20–0.40m Brown or red–brown (5YR4/4–6, 7.5YR4–5/5–6);light clay to light medium clay; moderate 2–5mm granular; Field pH 5.5–6.0; Gradual change to :

B1 : 0.35–0.50m Brown or red–brown (5YR4/5, 7.5YR4/5); 2–10% 5–15mm faint orange mottles; light medium clay; moderate 2–5mm subangular blocky; Field pH 5.8–6.5; Clear change to :

B21 : 0.60–1.00m Red–brown or brown (5YR3–4/6, 7.5YR5/4, 10YR6/3); 10–50% 5–30mm distinct orange and red mottles; light to medium heavy clay 2–10% 20–60mm rhyolite pebbles; moderate 2–5mm subangular blocky; Field pH 5.8–6.5; Gradual change to :

B22 : 0.80–1.50m Red–brown, brown or grey (5YR3–4/6–7, 7.5YR6/4, 10YR6/2); 10–50%, 5–30mm distinct orange and red mottles; fine sandy light medium to medium heavy clay; moderate to strong 2–20mm subangular blocky; Field pH 5.8–6.2; Gradual change to :

B3 : 1.20–1.80m Red–brown or red (5YR4–5/6–8, 2.5YR4/6); 10–50% 2–20mm distinct orange mottles; fine sandy medium to medium heavy clay; 20–50% 6–20mm rhyolite pebbles; strong 2–10mm subangular blocky; Field pH 5.8–6.2.

Soil Profile Class : PETERSON (Area 290 ha)

Concept : Very deep[g],grey, pedal[g], uniform[g] soils with acid reaction trend[g], formed on level floodplains[g] of alluvium derived from basalt.

Australian Classification : Redoxic Hydrosol

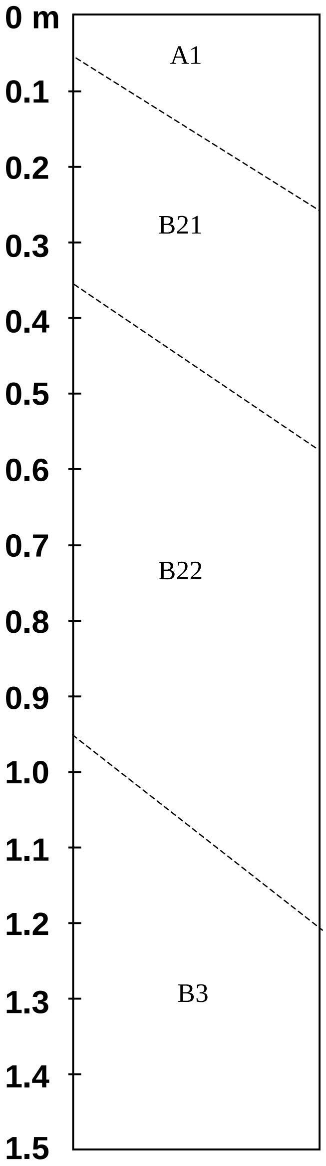
Great Soil Group : No Suitable Group affinities with Weisenboden

Principle Profile Form : Uf6.31, Uf6.41, Uf6.33, Uf6.2

Landform : Level floodplains

Geology : Quaternary Alluvium

Vegetation : Mainly grassland with *E. tereticornis; E. papuana*



A1 : 0.05–0.25m Grey–brown, brown or dark (7.5YR4/2–3, 10YR3–4/1–4); 2–20%, 5–15mm distinct orange mottles; light to medium clay; strong 2–5mm granular; Field pH 5.8–6.0; Clear or gradual to :

B21 : 0.35–0.55m Brown, red–brown or brown (5YR3/6, 7.5YR4/3, 10YR5/1); 2–20%, 5–15mm distinct orange mottles; light to medium clay; moderate 2–20mm polyhedral or prismatic or lenticular; Field pH 5.8–6.5; Gradual change to :

B22 : 0.95–1.20m Grey–brown or grey (7.5YR5/1–2, 10YR5/1); 10–20%, 5–30mm distinct orange mottle; medium to medium heavy clay; moderate 10–20mm prismatic or lenticular; Field pH 5.5–7.0; Gradual change to :

B3 : 1.40–1.60m Red or brown or grey or gleyed (10YR5/1, 10R3/6, 2.5YR4/7, 5BG4/1); 10–20% 5–30mm distinct orange, grey or brown mottles; light to medium heavy clay;moderate 5–20mm prismatic; Field pH 5.5–7.5.

Soil Profile Class : GILLIES (Area 1 760 ha)

Concept : Deep,[g] yellow, apedal[g], uniform[g] soils with acid reaction trend[g], formed on moderately sloping low hills[g] of granite.

Australian Classification : Orthic Tenosol

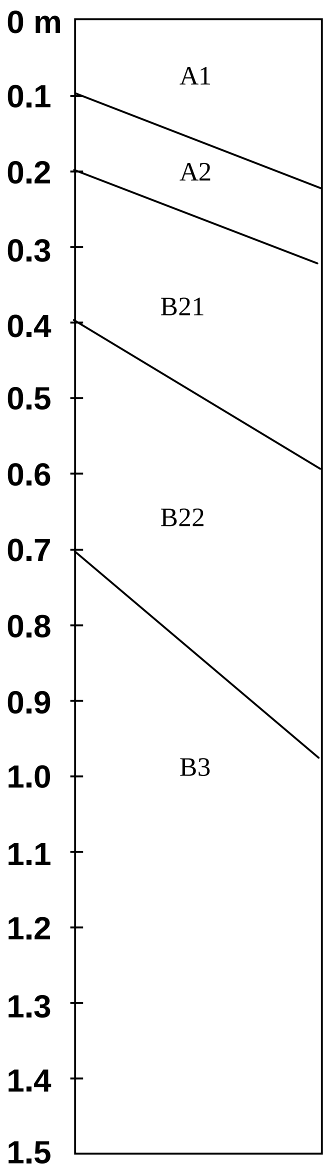
Great Soil Group : No Suitable Group affinities with Siliceous Sand

Principle Profile Form : Uc4.22, Uc4.21, Gn2.21

Landform : Moderately sloping low hills

Geology : Mareeba Granite and Elizabeth Creek Granite

Vegetation : *Eucalyptus* species



A1 : 0.10–0.20m brown (10YR3–4/2–3); loamy sand to sandy loam; 10–50% 2 –6mm quartz pebbles; weak 2–5mm granular; Field pH 5.5–6.5; Clear change to :

A2 : 0.20–0.30m Brown (10YR4/3); sandy loam; 10–50% 2–6mm quartz pebbles; massive to weak; Field pH 6.0– 6.5; Clear change to :

B21 : 0.40–0.60m Yellow (10YR5/5); sandy loam; 10–20% 2–6mm quartz pebbles; massive; Field pH 6.3–6.5; Clear change to :

B22 : 0.70–0.95m Yellow (10YR5/6); sandy loam; 20–50% 2–6mm quartz pebbles; massive; Field pH 6.3–6.8; Clear change to :

B3 : 1.00–1.5m Brown (7.5YR5/5); sandy clay loam; 20–50% 2–6mm quartz pebbles, 50–90% altered granite; massive; Field pH 6.3.

Soil Profile Class : SEVERIN (Area 12 415 ha)

Concept : Deep[g], mottled yellow, pedal[g], uniform[g] soils with acid soil reaction trend[g], formed on moderately to steeply

sloping hills and low hills[g] of granite .

Australian Classification : DystrophicYellow Dermosol

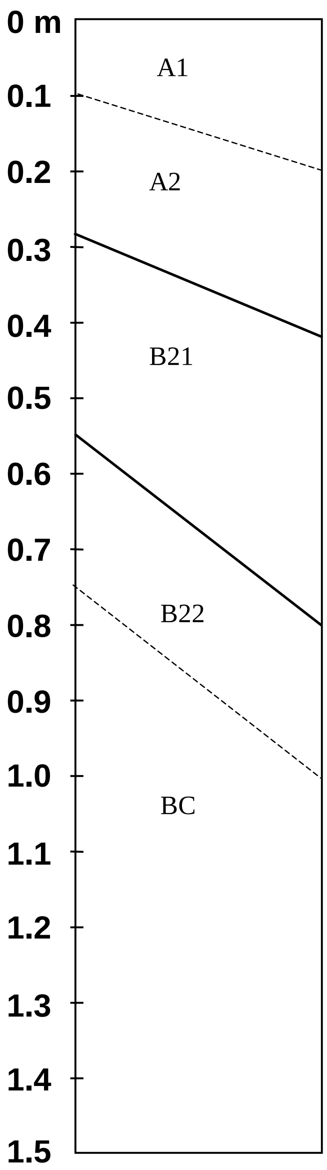
Grat Soil Group : No Suitable Group affinities with Xanthozem

Principle Profile Form : Uf4.42, Uf4.43, Uf6.33, Uf6.4

Landform : Moderately to steeply sloping hills and low hills (20–>32%)

Geology : Mareeba Granite and Elizabeth Creek Granite

Vegetation : Rainforest spp*; E. clarksoniana; E. tessellaris; Casuarina* spp*; Lophostemon suaveolens*



A1 : 0.10–0.20m Dark or grey (10YR2–4/1–2); sandy light clay to fine sandy light medium clay; 2–20% 2–10mm quartz pebbles; moderate 2–5mm granular; Field pH 5.5–6.0; Gradual change to :

A2 : 0.29–0.40m Grey, brown, dark or yellow–brown (10YR4–6/1–4); sandy clay loam to fine sandy light medium clay; moderate 2–5mm granular; Field pH 5.8–6.0; Clear change to :

B21 : 0.55–0.80m Yellow or yellow–brown (10YR5/3–7); 2–20% 2–10mm distinct orange and red mottles; sandy light to sandy light medium clay; 2–20% 2–10mm quartz pebbles; moderate 2–5mm subangular blocky; Field pH 5.8–6.0; Clear change to :

B22 : 0.75–1.00m Yellow or yellow–brown (10YR5–6/4–6); 10–50% 2–10mm distinct red mottles; sandy light medium clay; 2–20% 2–6mm quartz pebbles; moderate 2–5mm subangular blocky; Field pH 5.8; Gradual change to :

BC : 1.00–1.50m Yellow–brown or red–brown (2.5YR6/4, 10YR6/3–4); 10–50% 10–20mm distinct red mottle; sandy light to sandy light medium clay; 20–50% 2–6mm quartz pebbles; 50–90% decomposing granite; pH 5.5–5.8.

Soil Profile Class : QUINCAN (Area 562 ha)

Concept : Moderately deep[g], red–brown, pedal[g], uniform soils with neutral reaction trend, formed on moderately to steeply sloping cinder cones. Profiles contain significant amounts of scoria.

Australian Classification : Brown Dermosol

Great Soil Group : No Suitable Group affinities with Prairie Soil

Principle Profile Form : Uf6.31

Landform : Moderately to steeply sloping cinder cones (20–>32%)

Geology : Atherton basalt of recent or late Pleistocene age

Vegetation : Rainforest species

A1 : 0.05–0.20m Red–brown (5YR3/3, 7.5YR32, 10YR3–5/2); light clay; 10–20% 6–20mm basalt pebbles; strong 2–5mm granular; Field pH 6.5; Sharp change to :

B21 : 0.50–0.70m Red–brown (5YR3/5, 7.5YR33); light clay to light medium clay; 2–10% 6–20mm basalt pebbles; moderate 2–5mm polyhedral; Field pH 5.5–6.3; Gradual change to :

B22 : 0.80–0.90m Brown (7.5YR3/4); light clay; 20–50%, 6–20mm basalt pebbles; moderate 2–5mm polyhedral; 2–10% 2–6mm manganese nodules; Field pH 5.5; Gradual change to :

B3 : 1.00–1.10m Brown (7.5YR3/3); light clay; 10–20% 6–20mm basalt pebbles; strong 2–5mm polyhedral; 20–50% 2–6mm manganese nodules; Field pH 5.5–6.3; Gradual change to :

C : 1.10m onwards 50–90% basalt scoria.

Soil Profile Class : MAZLIN(Area 24 ha)

Concept : Deep[g], mottled[g] red–brown, pedal[g], gradational[g] soils with acid soil reaction trend[g], formed on moderately
loping footslopes[g] of acid volcanics (rhyolite).

Australian Classification : Magnesic Brown Dermosol

Great Soil Group : No Suitable Group affinities with Red Podzolic

Principle Profile Form : Gn 3.74, Dr 5.21

Landform : Moderately sloping footslopes (10–20%)

Geology : Walsh Bluff Volcanics

Vegetation : *E. clarksoniana; E. leptophleba; Acacia* spp

A1 : 0.12–0.18m Grey or dark (10YR3–5/1–3); silty clay loam; moderate 2–5mm granular; Field pH 5.8–6.0; Clear change to :

A2 : 0.18–0.35m Brown (7.5YR4/4); silty clay loam; moderate 2–5mm granular; Field pH 6.0–6.5; Clear change to :

B21 : 0.70–0.82m Red–brown (5YR3/6); 2–20%, 5–15mm distinct orange mottles light to silty light clay; moderate to strong 2–5mm polyhedral; Field pH 6.0; Gradual change to :

B22 : 0.90–1.00m(where present) red–brown (5YR3/6); 10–20%, 5–15mm distinct red mottles; silty light clay; strong 2–5mm polyhedral; Field pH 6.0; Gradual change to :

B31 : 1.00–1.50m Yellow–brown (10YR5/4) or grey (10YR6/2); 10–20% 15–30mm distinct red mottles; light medium clay; strong 5–10mm polyhedral; Field pH 5.8.

Soil Profile Class : NYLETA (Area 249 ha)

Concept : Deep[g], black, weakly pedal[g], organic soils with acid reaction trend[g], formed in drainage depressions[g] and volcanic craters from decaying organic materials overlying clay.

Australian Classification : Sapric Organosol

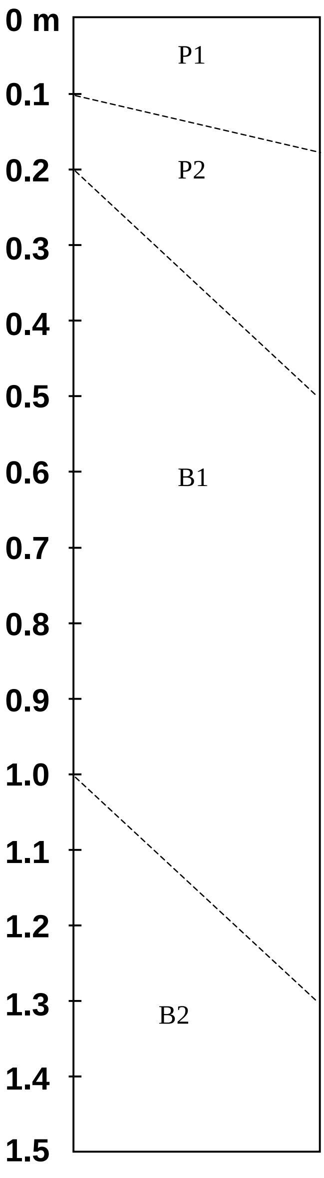
Great Soil Group : Acid Peat

Principle Profile Form : O

Landform : Drainage depressions and volcanic craters

Geology : Quaternary alluvium;

Vegetation : Mainly sedges, rushes and other hydromorphic tolerant plants.



P1 : 0.10–0.15m Dark (N20, 10YR3/1); clay loam to light clay; weak to strong 2–5mm granular; Field pH 5.0–5.5; Gradual change to :

P2 : 0.20–0.50m Dark (N20, 10YR2/1); light clay; moderate 2–5mm; Field pH 5.5; Gradual change to :

B1 : 1.00–1.30m Dark (N20, 10YR5/1); 10–20% 5–15mm distinct pale mottles; light medium to medium heavy clay; weak to moderate 2–5mm; Field pH 5.5–6.0; Gradual change to

B2 : 1.10–1.80m Dark (N20, 10YR5/1); 10–20%, 5–15mm prominent gleyed mottles; medium heavy to heavy clay weak to moderate 2–5mm; Field pH 5.5–6.5.

Soil Profile Class : BALLY (Area 680 ha)

Concept : Very deep[g], red, pedal[g], gradational[g] soils with acid reaction trend[g], formed on moderately to steeply sloping low hills[g] of acid volcanics (rhyolite)

Australian Classification : Mesotrophic Red Dermosol

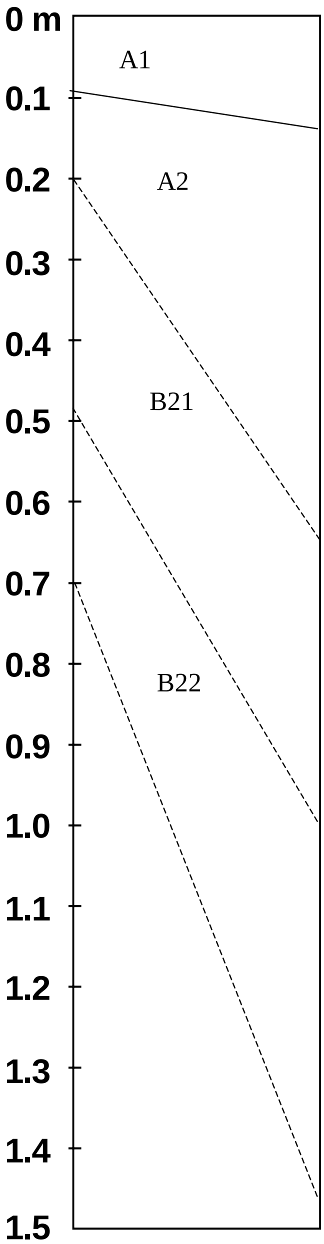
Great Soil Group : No Suitable Group affinities with Red Podzolic soil

Principle Profile Form : Gn3.11, Gn3.14

Landform : moderately to steeply sloping low hills (10–>32%)

Geology : Glen Gordon volcanics

Vegetation : Rainforest species and *E. erythrophloia*, *E. acmenoides*, *E. drepanophylla*



A1 : 0.10–0.15m Dark (2.5YR3/2) or reddish brown (5YR 3/4); clay loam; moderate 2–5mm granular. Field pH 6.0–6.5. Clear change to :

A2 : 0.20–0.65m.(Where present) Red (2.5YR4/8) Pale (dry); clay loam; strong 2–5 mm polyhedral; <2% 2–5mm manganese nodules. Field pH 5.5–6.0.Clear to gradual change to :

B21 : 0.50–1.00m Red (2.5YR3/4.6) or red–brown (5YR4–5/6); light to medium clay; 2–10% small quartz pebbles; moderate to strong <2–5mm polyhedral; 2–10% <5mm manganese nodules. Field pH 4.5–5.8; Diffuse change to :

B22 : 0.70–1.50m Red (2.5YR3/4) light to medium clay; 2–10% small quartz pebbles; moderate to strong 2–5mm polyhedral; 2–10% <5mm manganese nodules; Field pH 4.5–6.0.

Comments : B3 horizon can occur below 1.35 m.

Soil Profile Class : EXPEDITION (Area 201 ha)

Concept : Deep, red, apedal, gradational soils with acid reaction trend[g], formed on gently to moderately sloping footslopes derived from granite.

Australian Classification : Mesotrophic Red Kandosol

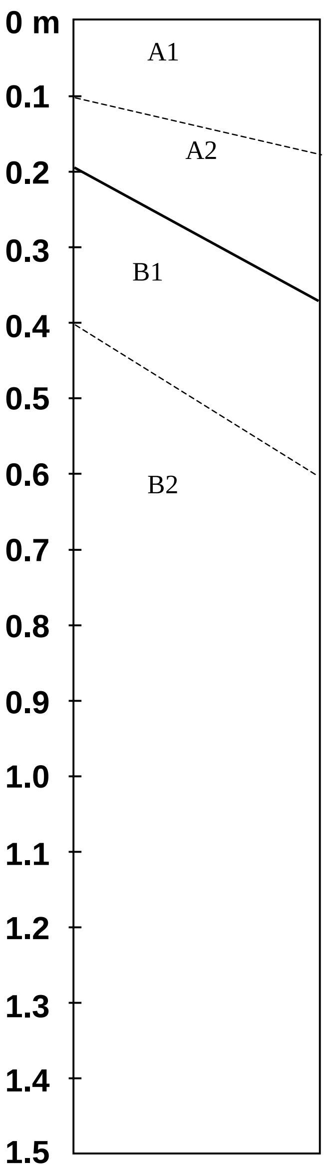
Great Soil Group : Red earth

Principle Profile Form : Gn2.15, Gn2.11, Dr4.61, Dr4.62

Landform : Footslopes or pediments of gently undulating to undulating low hills

Geology : Tully Granite

Vegetation : *E. drepanophylla; E. clarksoniana;* and *Acacia* spp.



A1 : 0.10–0.15m Brown (7.5YR3–4/3–4, 10YR3/3), red–brown (5YR3–4/3) or dark (5YR3/2); loamy coarse sand to sandy loam; single grain. Field pH 6.0–6.8; Clear to gradual change to :

A2 : 0.20–0.35m (where Present) Pale (dry) loamy coarse sand to sandy loam; single grain; Field pH 6.0–6.8; Clear change to :

B1 : 0.40–0.60m(where present) Red–brown (5YR3/3–6); coarse sandy loam to sandy clay loam; massive. Field pH 6.3–6.8; Gradual change to :

B2 : 0.65–1.50m Red (2.5YR3–4/6–8); clay loam sandy to coarse sandy light medium clay; massive to weak 5–10 mm angular blocky; Field pH 6.3–7.0.

Soil Profile Class : FLAGGY (Area 554 ha)

Concept : Deep[g], yellow, apedal[g] gradational[g] soils with acid reaction trend[g], formed on very gently to gently sloping lower footslopes[g] of colluvium derived from acid volcanic rocks (rhyolite).

Australian Classification : Yellow Kandosol

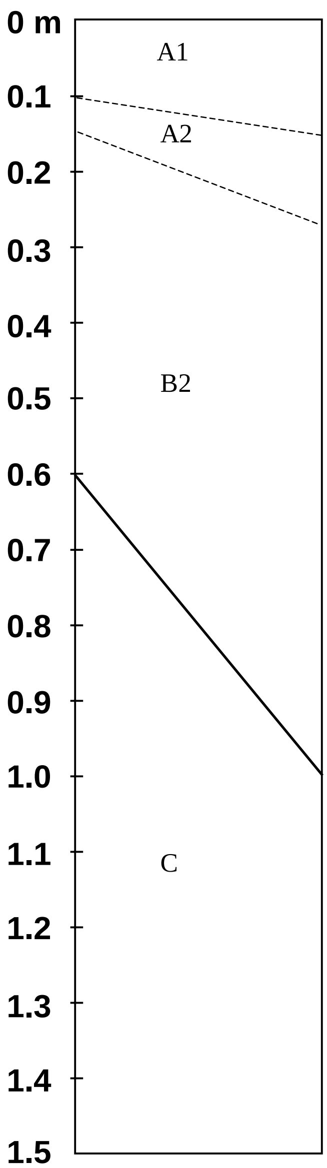
Great Soil Group : Yellow earth

Principle Profile Form : Gn2.31, Gn2.21, Gn2.22, Dy3.81

Landform : Slopes of level to gently undulating plains

Geology : Glen Gordon volcanics

Vegetation : *E. drepanophylla, E. papuana , E. clarksoniana*



A1 : 0.10–0.12m Dark (7.5YR2–3/2) or grey (10YR4/2); sandy clay loam to clay loam sandy; massive; 2–20% 5–20mm ferromanganese nodules; Field pH 5.7–6.5. Clear to gradual change to :

A2 : 0.15–0.25m (where present) Pale, sporadically or conspicuously bleached (dry) sandy clay loam to clay loam sandy; massive; 2–20% 5–20mm ferromanganese nodules; Field pH 5.7–6.5. Clear to gradual change to :

B2 : 0.60–1.00m Yellow (10YR5/5–6) or yellow–brown (10YR 5/4,7.5YR5/4); 2–20% 5–15mm distinct yellow or red mottles; sandy clay loam to light medium clay; massive; 20–50% 10–20mm ferromanganese nodules; Field pH 5.7–6.5. Sha rp to clear change to :

C : 0.80–1.20m Decomposing rhyolite.

Soil Profile Class : KABAN (Area 2 779 ha)

Concept : Very deep[g], red, pedal[g], uniform[g] soils with neutral reaction trend[g], formed on very gently to gently sloping rises[g] of basalt. Profiles contain significant amounts of manganese nodules.

Australian Classification : Mesotrophic Red Ferrosol

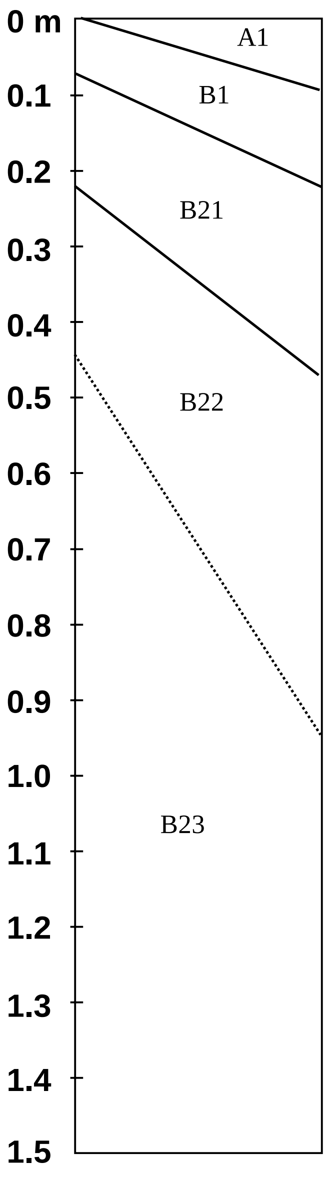
Great Soil Group : Euchrozem

Principle Profile Form : Uf6.31, Gn3.12

Landform : Very gently to gently sloping rises (1–10%)

Geology : Atherton Basalt

Vegetation : *E.intermedia, E. acmenoides*; often cropped



A1 : 0.10–0.15m Brownish black (5YR2/2), light clay; strong <2mm polyhedral; 10–20% 5–15mm manganese nodules; Field pH 6.6. Clear change to :

B1 : 0.20–30m Dark reddish brown (5YR3/3); light clay; weak 2–5mm polyhedral; 2–10% manganese nodules; Field pH 6.8; Clear change to :

B21 : 0.40–0.50m Dark reddish brown (2.5YR3/4); light clay; moderate 2–5mm polyhedral; 10–20% manganese nodules; Field pH 6.8; gradual change to :

B22 : 0.46–0.96m Dark reddish brown (2.5YR3/4) light medium clay Moderate 2–5mm polyhedral 10–20% manganese nodules; Field pH 6.8; Diffuse change to :

B23 : 0.96–1.50m Dark reddish (5YR3/4) light clay; strong 5–10mm polyhedral; 10–20% 5–15mm manganese nodules.

Soil Profile Class : MILLSTREAM (Area 197 ha)

Concept : Deep[g], yellow, pedal[g], uniform[g] soils with acid reaction trend[g], formed on very gently sloping footslopes of basalt

Australian Classification : Mesotrophic Yellow Ferrosol

Great Soil Group : Xanthozem

Principle profile Form : Uf6.34, Uf6.4, Gn3.21, Gn3.71, Gn3.74

Landform : Very gently sloping footslopes (1–3%)

Geology : Atherton basalt and McBride basalt

Vegetation : *E. leptophleba, E. drepanophylla* and *E. papuana*

A1 : 0.10–0.20m Dark (10YR2–3/2, 7.5YR2–3/2) or brown (10YR2–3/3, 7.5YR2–3/3); clay loam to light clay; moderate to strong 2–5mm granular; 2–50% 2–15mm ferromanganese nodules; Field pH 5.7–6.3. Gradual or diffuse change to :

B21 : 0.30–0.53m Yellow (10YR5/3–8, 6/4–6), brown (10YR4/4–6, 7.5YR4/3–6) or yellow–brown (7.5YR5/4–8); 2–20% <2mm–15mm distinct orange or red mottles; light to medium clay; moderate to strong 2–10mm polyhedral or angular blocky; 2–50% 5–15m manganese or ferromanganese nodules. Field pH 5.9 –7.0; Clear change to :

B22 : 0.70–0.90m Brown (7.5YR5/6); 2–10%, 5–15mm distinct red mottles; light medium clay; strong 2–5mm polyhedral; 20–50% manganese nodules. Field pH 6.5–7.0; Gradual change to :

D : 1.09–1.48m Brown 20–50% 5–15mm distinct brown and grey mottles; medium heavy clay; moderate 5–10mm angular blocky; <2%, 2–5mm ferromanganese nodules.

Soil Profile Class : NETTLE(Area 335 ha)

Concept : Shallow[g], yellow–brown, apedal[g], uniform[g] soils with acid reaction trend[g], formed on moderately to steeply sloping hills and low hills[g] of granite.

Australian Classification : Orthic Tenosol

Great Soil Group : No Suitable Group affinities with Lithosol

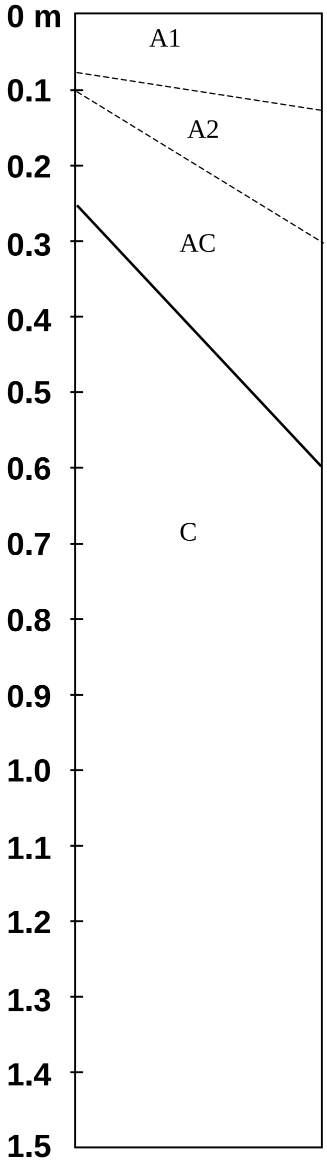
Principle Profile Form : Uc2.12, Uc1.42, Uc3.21, Uc5.11

Landform : Moderately to steeply sloping hills and low hills (20–>32%)

Geology : Elizabeth creek granite

Vegetation : *E. drepanophylla; E. pellita; E.erythophloia* and *Acacia* spp.

Surface condition : Firm to hardsetting



A1 : 0.08–0.12m Brown (10YR3–4/3, 7.5YR4–5/3–4) or dark (10YR3/2, 7.5YR3/2); coarse sand to coarse sandy loam, 10–20% 20–60mm granitic pebbles; single grained or massive; Field pH 6.0–6.7; Clear to gradual change to :

A2 : 0.10–0.30m conspicuously bleached (dry) coarse sand to coarse sandy loam; 10–20% 20–60mm granitic pebbles; single grained or massive; Field pH 5.7–6.3. Clear to Gradual change to

AC : 0.25–0.60m Yellow–brown (10YR6/3–4, 7–5YR5–6/6) or brown (5YR5/4); coarse sand to coarse sandy loam; 50–90% 20–60mm granitic fragments; massive or single grained. Field pH 5.5–6.0; Gradual change to :

C : Decomposing granite.

Variant : Pale, weakly developed A2 horizon.

Soil Profile Class : WHELAN (Area 4 335 ha)

Concept : Sha llow[g], yellow–brown, apedal[g], uniform[g] soils, with acid reaction trend[g] formed on moderately to steeply sloping hills and low hills[g] of acid volcanics (rhyolite).

Australian Classification : Orthic Tenosol

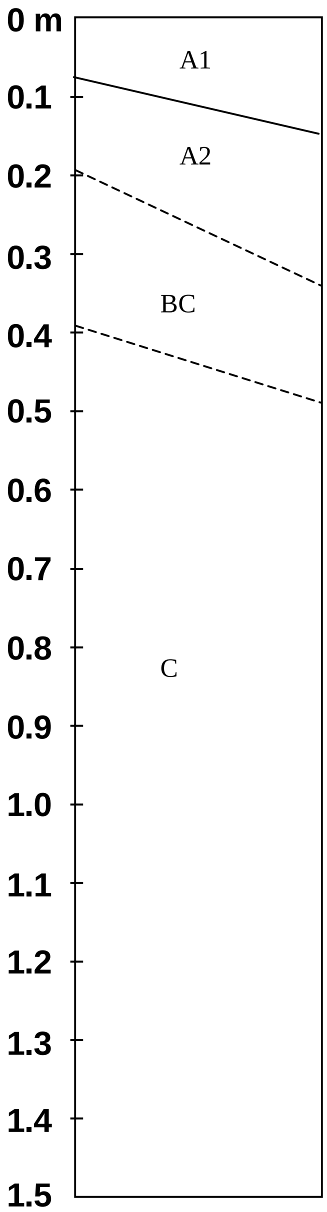
Great Soil Group : No Suitable group affinities with Lithosol

Principle Profile Form : 2.12, Uc2.21, Um4.23

Landform : Moderately to steeply sloping hills and low hills (20 – >32%)

Geology : Walsh Bluff Volcanics

Vegetation : *E. drepanophylla, E. clarksoniana, E. acmenoides* and *E. citriodora*



A1 : 0.08–0.13m Grey (10YR4–5/2–1) or brown (7.5YR4/4); loam; 10–20% 10–20mm rhyolite pebbles weak to moderate 2–5mm granular; Field pH 5.8–6.3; Clear change to :

A2 : 0.20–0.32m Grey (10YR6–7/2) brown (10YR6/3) pale (dry); sandy loam. Field pH 5.8–6.3; Gradual change to :

BC : 0.40–0.48m Yellow–brown (10YR6/3) or reddish brown sandy loam; to sandy clay loam; 50–90% 20–60mm pebbles or altered parent material. Field pH 5.5–6.0; Gradual change to :

C : 0.50–0.80m Decomposing rhyolite.

Soil Profile Class : WALKAMIN (Area 159 ha)

Concept : Deep[g], yellow–brown, pedal[g], uniform[g] soils with acid reaction trend[g] formed on gently sloping footslopes[g] of basalt.

Australian Classification : Dystrophic Brown Ferrosol

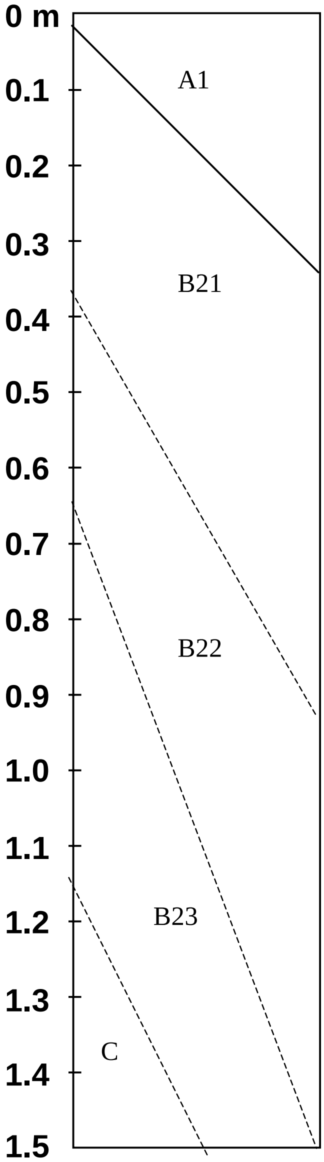
Great Soil Group : Xanthozem

Principle Profile Form : Uf 6.4, Uf 6.31, Uf 6.33, Uf 6.41

Landform : Gently sloping footslopes (1–3%)

Geology : Atherton Basalt

Vegetation :*E. leptophleba, E. platyphylla, M. nervosa, Lophostemon. suaveolens*



A1 : 0.10–0.22m Dark (10YR2–3/2–3, 7.5YR2–3/2–3);or brown (10YR2–4/3); light to light medium clay; weak to strong 2–5mm granular 2–10%, 5–15mm ferromanganese nodules or soft segregations; Field pH 6.0–7.0; Clear change to:

B21 : 0.50–0.85m Brown (10YR4/4–6, 7.5YR3–4/4–6); yellow (10YR5/5–6) yellow brown (10YR5/4–5); light to light medium clay; 0–50% 5–15mm distinct orange and red mottles; moderate 2–10mm polyhedral; 2–10% 2–6mm ferromanganese nodules. Field pH 6.5–7.0;Gradual change to:

B22 : 0.80–1.45m Brown (10YR4/4–6, 7.5YR4–5/4–); 6yellow brown (10YR5–6/3–4, 7.5YR5/5–6); yellow (10YR5–6/5–6); light to light medium clay 0–50% 5–15mm distinct orange and red mottles moderate 2–10mm polyhedral 2–50% 2–15mm ferromanganese nodules. Field pH 6.5–7.5; Gradual change to :

B23 : 1.10–1.60m Brown (10YR4–5/3–5); yellow brown (10YR4–6/3, 7.5YR5/6) grey (10YR4–6/2); 0–50% 2–30mm prominent red and orange mottles medium heavy clay; moderate 2–10mm polyhedral 2–50% 2–20mm ferromanganese nodules. Field pH 7.0–8.0; Gradual Change to :

C : 1.30–1.80m 50–90% decomposing basalt.

Variant : grey in colour

Soil Profile Class : SNIDER (Area 127 ha)

Concept : Shallow[g], black or brown, pedal[g], uniform[g] soils with neutral reaction trend[g], formed on gently sloping footslopes[g] of basalt. Profiles contain significant amounts of basalt rock.

Australian Classification : Eutrophic Brown Dermosol

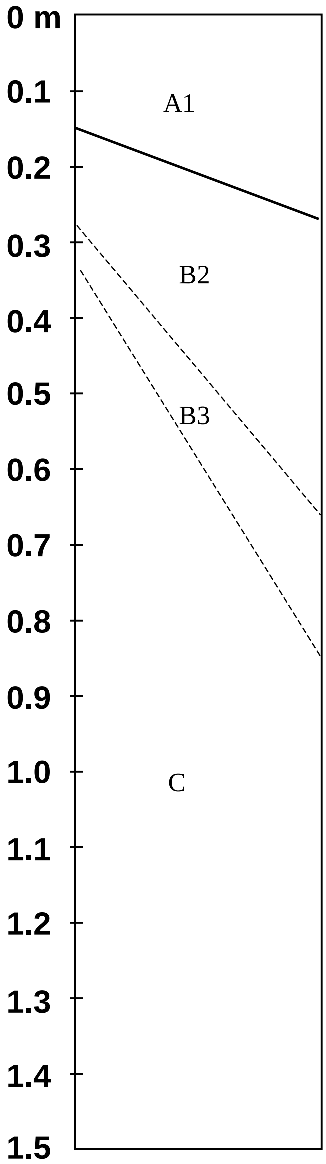
Great Soil Group : No Suitable Group affinities with Prairie Soil

Principle Profile Form : Uf 6.31

Landform : Gently sloping footslopes (3–10%)

Geology : Atherton basalt

Vegetation : *E. leptophleba, E. erythrophloia, E. platyphylla, Hakea persiehana*



A1 : 0.05–0.18m Dark (10YR2–3/2–3, 7.5YR2/2) or brown (10YR2–3/3) light to light medium clay; 0–20%, 6–20mm basalt pebbles; moderate 2–5mm granular; <2–10% ferromanganese nodules; Field pH 6.0–7.0; Clear change to :

B2 : 0.25–0.48m Brown (10YR3–4/3–4, 7.5YR4/3–4); 0–20%, <5–15mm faint orange, and red mottles, light to medium heavy clay, 20–50% 6–60mm basalt pebbles; moderate 2–5mm polyhedral; 0–20%, 2–6mm or ferromanganiferous nodules; Field pH 6.5–7.5.

B3 : 0.37–0.89m Brown (7.5YR4–5/4, 10YR3–4/4) or yellow brown (10YR5/3–4); 0–20%, <5–15mm distinct orange, red and yellow mottles; light to medium heavy clay; 20–50%, 6–60mm basalt pebbles; moderate 5–30mm angular blocky or lenticular breaking to angular blocky 0–10% 2–6mm manganese nodules; Field pH 7.5

C : 0.60–1.15m 90–100% basalt and altered basalt.

Soil Profile Class : MORGAN (Area 87 ha)

Concept : Deep, brown, pedal, uniform soils, with alkaline reaction trend, formed on very gently sloping lower fans off basalt.

Australian Classification : Brown Vertosol

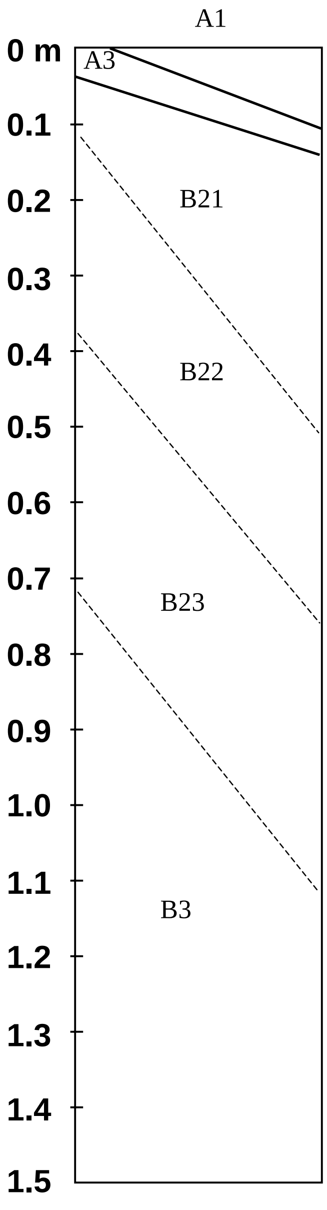
Great Soil Group : No Suitable Group affinities with Brown Clay

Principle Profile Form : Uf 6.31, Uf 6.33, Ug 5.32, Ug 5.3

Landform : Very gently sloping lower fans

Geology : Atherton basalt

Vegetation : *E. leptophleba, E. erythrophloia, E. crebra, hakea persiehana*



A1 : 0.04–0.15m Brown (10YR2–4/3, 7.5YR3/3) or dark (10YR2/1–2); 0–2%, <5mm faint orange mottles; light to medium heavy clay; weak to moderate 2–5mm granular; Field pH 6.0–6.5; Clear change to :

B21 : 0.30–0.60m Brown (10YR2–4/3–4, 7.5YR3–4/3–4); 0–10% <5–15mm faint to prominent orange, red or yellow mottles, light medium to medium heavy clay 0–10%, basalt stone; moderate 2–5mm polyhedral or 5 to 20mm lenticular; 0–10% size manganese nodules or soft segregations; Field pH 6.8–7.5; Gradual change to :

B22 : 0.45–0.83m Brown (10YR4/3–4, 7.5YR4/4) or grey (10YR4/1–2); 0–20%, <5–15mm prominent orange mottles, medium to medium heavy clay; 0–10%; 15–30mm basalt stone; moderate 2–20mm polyhedral, or lenticular; 2–20% 2–20mm manganese or calcium carbonate nodules; Field pH 7.0–8.0; Gradual change to :

B23 : 0.80–1.20m Grey (10YR4–5/1–2) yellow brown (10YR5/3), 0 to 20%, 5–15mm prominent orange mottles, medium heavy to heavy clay; 0–10% 6–20mm basalt stone moderate 10–20mm angular blocky or lenticular, 0–10% , 2–6mm manganese nodules; Field pH 7.5–8.5; Gradual change to :

B3 : 0.93–1.30m Yellow brown (10YR5/2) or grey (10YR34); 0–50% 15–30mm prominent mottles light clay to coarse sandy medium heavy clay; 10–20%, 20–60mm basalt stone, moderate 2–5mm angular blocky; Field pH 8.0–8.5.

Appendix 2

Morphological and analytical data for representative soil profiles

Conventions used in this Appendix are as follows:

A **soil profile class** is a group or class of soil profiles, not necessarily contiguous, grouped on their similarity of morphological characteristics. It is representative of a three dimensional soil body with similar substrate or parent materials, landforms and generally, but not always, vegetation communities.

Substrate Material as described in McDonald *et al.* (1990).

Landform Pattern Type and **Landform Element Type** as in McDonald *et al.* (1990).

Australian Classification as described by Isbell (1996), Third Approximation.

Great Soil Group as described by Stace *et al.* (1968).

Principal Profile Form (PPF) as defined by Northcote (1979).

Surface Coarse Fragments as in McDonald *et al.* (1990).

Vegetation Structural Form as in McDonald *et al.* (1990).

Profile Morphology as in McDonald *et al.* (1990).

Colour Codes are those of Oyoma and Takehara (1967).

LABORATORY DATA

The first three tables of laboratory data given for each of the profiles are the standard suite of analyses conducted for Land Resource Surveys in Queensland. Details of the methods used are given in Baker and Eldershaw (1993). Results are expressed on an air dry (40^{o}C) soil basis, except for particle size which is given on an oven dry (105^{o}C) soil basis. The Effective Cation Exchange Capacity (ECEC) is calculated as the sum of exchangeable basic cations (Ca, Mg, K, Na) plus exchange acidity, where pH is less than 6.0.

The final table provides additional soil physical data for major SPC's based primarily on undisturbed cores sampled from the main morphological horizons. Methods used for sampling, bulk density and moisture retention were based on Loveday (1974) and Coughlan *et al.* (in press). Plant Available Water Capacity (PAWC) is calculated here as the difference between moisture retained at a soil matrix potential of -10kPa (approximating to "Field Capacity") and -1.5mPa ("Wilting Point"). The PAWC results are expressed on a volumetric basis, corrected for gravel and stone content and in mm (water) per horizon, with a total value given for the top 1m of the soil profile. Unfortunately some results were considered unrealistic due to error and therefore have not been included

Chemical analysis results for the following soils are not included here, Bicton, Carrington, Gwynne, Gowrie, Wongabel, Heales, Sylvia, Worsley, Peterson, Gillies, Severin, Quincan, Mazlin and Nyleta but can be found in the report of Laffan (1988).

SOIL PROFILE CLASS: Bally:
SUBSTRATE MATERIAL: Rhyolite
A.M.G. REFERENCE: 339 600 mE 8 061 500 mN ZONE 55
LANDFORM ELEMENT TYPE: Hillslope
AUSTRALIAN CLASSIFICATION: Dystrophic, Red Dermosol
GREAT SOIL GROUP: No suitable group. Affinities with red podzolic soil
VEGETATION:
DOMINANT SPECIES: *Ficus* species, *Acacia* species
SURFACE COARSE FRAGMENTS:

SITE NO: S13
ANNUAL RAINFALL: 1512 mm
SLOPE: 18 %
LANDFORM PATTERN TYPE:
PRINCIPAL PROFILE FORM: Gn3.14
STRUCTURAL FORM: Tall open forest

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Loose, soft

HORIZON	DEPTH	DESCRIPTION
A0	.04 to .00 m	Moderately moist moderately weak. Clear to-
A1	.00 to .03 m	Dark reddish brown (2.5YR3/2) moist; clay loam; strong <2mm granular; moderately moist moderately weak. Gradual to-
A2	.03 to .22 m	Dark reddish brown (2.5YR3/4) moist, reddish brown (2.5YR4/6) dry; clay loam; strong <2mm granular; moderately moist moderately weak. Gradual to
B21	.22 to .45 m	Dark reddish brown (2.5YR3/6) moist; light clay; strong 2 to 5mm polyhedral; moderately moist moderately weak. Gradual to-
B22	.45 to .83 m	Dark red (10R3/6) moist; medium clay; very few coarse pebbles, subrounded rhyolite; strong 2 to 5mm polyhedral; moderately moist moderately firm. Gradual to-
B31	.83 to 1.02 m	Reddish brown (2.5YR4/6) moist; very few faint yellow mottles; light medium clay; very few coarse pebbles, subrounded rhyolite; strong 5 to 10mm polyhedral; moderately moist moderately firm. Gradual to-
B32	1.02 to 1.22 m	Reddish brown (2.5YR3/6) moist; common medium faint yellow mottles; light clay; few coarse pebbles, subrounded rhyolite; strong 5 to 10mm polyhedral; moderately moist moderately firm.

Depth	**1:5 Soil/Water or 0.1 CaCl2**				**Particle Size**				**Disp.**
cm	**pH CaCl2**	**pH Water**	**EC mS/cm**	**Cl %**	**CS % (oven dry soil)**	**FS**	**SI**	**C**	**ratio R1**
B.10		5.3	0.09	0.003					
0.1		5.3	0.07	0.001	5	8	26	57	0.16
0.33		5.3	0.04	0.002	4	9	24	64	0.18
0.6		5.2	0.04	0.002	3	9	23	67	0.13
0.9		5.0	0.03	0.001	4	7	18	73	0.10
1.2		4.9	0.03	0.002	5	7	17	74	

Depth	**Exchange properties (meq/100g soil)**							**Total Element %**		
cm	**ECEC**	**Ca**	**Mg**	**Na**	**K**	**Al**	**Acid**	**P**	**K**	**S**
0.1		2.80	1.90	0.18	0.76	0.9	1.1	0.083	0.127	0.075
0.33		1.40	1.20	0.17	0.50	1.1	1.3	0.062	0.089	0.042
0.6		0.95	0.94	0.11	0.41	1.0	1.2	0.055	0.109	0.044
0.9		0.55	0.63	0.08	0.26	0.7	0.9	0.054	0.057	0.057
1.2		0.29	0.61	0.08	0.23	0.5	0.6	0.060	0.044	0.073

Depth	**Org. C**	**Tot. N**	**Extract. P**	**Rep. K**	**DTPA extractable (mg/Kg)**				**Cit/Dith**
cm	**% (W & B)**	**%**	**mg/Kg (bic.)**	**meq %**	**Fe**	**Mn**	**Cu**	**Zn**	**Fe %**
B.10	4.9	0.21	5	0.58	78	18	0.4	1	

SOIL PROFILE CLASS: Barron:
SUBSTRATE MATERIAL: Basalt
A.M.G. REFERENCE: 348 450 mE 8 088 800 mN ZONE 55
LANDFORM ELEMENT TYPE: Hillslope
AUSTRALIAN CLASSIFICATION: Brown Ferrosol
GREAT SOIL GROUP: No suitable group. Affinities with Prairie soil
VEGETATION: Rainforest spp.
SURFACE COARSE FRAGMENTS: Abundant cobbles, sub-rounded basalt

SITE NO: 2478
ANNUAL RAINFALL: 1400 - 1700mm
SLOPE: 5.0 %
LANDFORM PATTERN TYPE: Lava plain
PRINCIPAL PROFILE FORM: Uf6.31
STRUCTURAL FORM:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Firm

HORIZON	**DEPTH**	**DESCRIPTION**
A11	0 to .10 m	Brown (7.5YR2/3); light medium clay; few large pebbles, basalt; strong 2-5mm granular. Clear to-
A12	.10 to .20 m	Brown (7.5YR3/2); light medium clay; few large pebbles, basalt; moderate 2-5mm granular. Gradual to-
B21	.20 to .70 m	Brown (7.5YR3/3); light medium clay; common large pebbles, basalt; moderate 2-5mm polyhedral. Gradual to-
B22	.70 to 1.40 m	Brown (7.5YR3/4); light medium clay; many large pebbles, basalt; moderate 2-5mm polyhedral. Gradual to-
BC	1.40 to 1.50 m	Brown (7.5YR3/4); many medium distinct grey mottles; medium clay; many large pebbles, basalt; moderate 2-5mm polyhedral.

LABORATORY DATA: SITE NO: 2478

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
0-B10	6.3	7.0	0.13	0.001					
0- 10	5.8	6.6	0.09	0.001	10	5	36	53	0.12
20- 30	5.7	6.5	0.04	0.001	2	5	32	65	0.11
50- 60	5.8	6.6	0.02	0.001	1	5	62	36	0.04
80- 90	5.8	6.5	0.03	0.001	1	5	23	74	0.07
110- 120	5.8	6.6	0.02	0.001	2	6	27	67	
140- 150	5.8	6.7	0.03	0.001					

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10	24	18	4.8	0.11	0.94			0.412	0.284	0.120
20- 30	12	9.0	2.5	0.07	0.67			0.323	0.237	0.072
50- 60	7	5.1	1.5	0.08	0.49			0.258	0.198	0.036
80- 90	7	5.1	1.6	0.10	0.50			0.255	0.199	0.033
110- 120	7	5.1	1.4	0.11	0.80			0.281	0.218	0.033
140- 150										

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	5.7	0.51	224	1.1	49	160	3.1	7.1	
50- 60									8.4

SOIL PROFILE CLASS: Expedition
SUBSTRATE MATERIAL: Granite
AMG REFERENCE: 305 400 mE 8 012 200 mN ZONE 55
LANDFORM ELEMENT TYPE: Hillslope
AUSTRALIAN CLASSIFICATION: Mesotrophic, Red Chromosol
GREAT SOIL GROUP: Red earth - red podzolic intergrade
VEGETATION: Eucalypt woodland

LOCATION: Ravenshoe
ANNUAL RAINFALL: 752mm
SLOPE: 4.9%
LANDFORM PATTERN TYPE: Undulating rises
PRINCIPAL PROFILE FORM: Dr4.62
SITE NO.: S8
STRUCTURAL FORM: Mid-high woodland

DOMINANT SPECIES: *Eucalyptus drepanophylla, Eucalyptus tessellaris, Eucalyptus clarksoniana, Petalostigma pubescens, Grevillea decora, Themeda triandra*
SURFACE COARSE FRAGMENTS: Common small pebbles, subangular quartz

PROFILE MORPHOLOGY:

CONDITIONS OF SURFACE SOIL WHEN DRY: Loose

HORIZON	**DEPTH**	**DESCRIPTION**
All	0 to .09m	Black (10YR2/1) moist; loamy coarse sand; very few small pebbles, subangular quartz; massive; dry very weak. Clear to-
A12	.09 to .17m	Brownish black (7.5YR3/2) moist; loamy coarse sand; few small pebbles, subangular quartz; massive; dry very weak. Gradual to -
A2	.17 to .51m	Dull reddish brown (5YR4/4) moist; loamy coarse sand; common small pebbles, subangular quartz; massive; dry very weak. Clear to -
B21t	.51 to 1.01m	Dark reddish brown (2.5YR3/6) moist; coarse sandy light medium clay; common small pebbles, subangular quartz; weak 2 to 5mm angular blocky; dry moderately weak; very few fine ferromanganiferous nodules. Diffuse to -
B22t	1.01 to 1.51m	Dark reddish brown (2.5YR3/6) moist; light medium clay; very few small pebbles, subangular quartz, very few coarse pebbles, subangular quartz; weak 2 to 5mm angular blocky; dry very weak; very few fine ferromanganiferous nodules. Clear to -
B3	1.51 to 1.60m	Reddish brown (5YR4/6) moist; few medium distinct yellow mottles; clay loam, coarse sandy; very few medium pebbles, subangular granite; massive; dry very weak; few fine ferromanganiferous nodules.

Site No TC s8

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
0-B10		6.9	0.03	0.001					
0- 10		6.6	0.01	0.001	69	19	4	8	0.62
20- 30		6.5	0.01	0.001	52	34	5	10	0.58
50- 60		6.7	0.01	0.001	47	16	5	33	0.39
80- 90		6.1	0.01	0.001	33	12	3	52	0.07
110- 120		6.6	0.01	0.001	32	13	4	52	
140- 150		6.9	0.01	0.001					

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10		1.8	0.75	0.02	0.17			0.011	1.660	0.011
20- 30		0.55	0.41	0.02	0.12			0.008	2.030	0.007
50- 60		1.2	0.89	0.02	0.19			0.017	1.650	0.009
80- 90		1.0	1.9	0.05	0.30			0.021	0.963	0.011
110- 120		1.2	2.3	0.05	0.31			0.021	0.889	0.011
140- 150										

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	1	0.05	3	0.19	10	18	0.3	0.3	
50- 60									

SOIL PROFILE CLASS: Galmara
SUBSTRATE MATERIAL: Schist
A.M.G. REFERENCE: 351 700 mE 8 091 300 mN ZONE 55
LANDFORM ELEMENT TYPE: Hillslope
AUSTRALIAN CLASSIFICATION: Red Dermosol
GREAT SOIL GROUP: No suitable group. Affinities with Red Podzolic soil
VEGETATION: Acacia spp.
SURFACE COARSE FRAGMENTS:

SITE NO: 2480
ANNUAL RAINFALL: 1400 - 1700mm
SLOPE: 30.0 %
LANDFORM PATTERN TYPE: Low hills
PRINCIPAL PROFILE FORM: Gn3.74
STRUCTURAL FORM:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Firm

HORIZON	**DEPTH**	**DESCRIPTION**
A1	0 to .05 m	Grey-brown (5YR4/2); fine sandy clay loam; very few medium pebbles, quartz; moderate 2-5mm granular. Clear to-
A2	.05 to .20 m	Grey-brown (5YR5/2); fine sandy clay loam; very few medium pebbles, quartz; moderate 2-5mm granular. Clear to-
B1	.20 to .30 m	Grey-brown (5YR5/4); fine sandy clay loam; few medium pebbles, schist; moderate 2-5mm subangular blocky. Clear to-
B2	.30 to .55 m	Red-brown (5YR5/6); fine sandy light clay; few medium pebbles, schist; moderate 2-5mm subangular blocky. Gradual to-
BC	.55 to .70 m	Red (2.5YR5/6); fine sandy clay loam; many medium pebbles, schist; moderate 2-5mm subangular blocky.
C	.70 to 1.20 m	Red (2.5YR5/6); abundant medium pebbles, schist; weak 2-5mm subangular blocky.

LABORATORY DATA: SITE NO: 2480

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH CaCl2	pH Water	EC mS/cm	Cl %	CS % (oven dry soil)	FS	SI	C	ratio R1
0-B10	4.4	5.4	0.09	0.005					
0- 10	4.4	5.5	0.06	0.002	12	50	17	24	0.46
20- 30	4.3	5.4	0.04	0.002	18	45	13	26	0.76
50- 60	4.7	5.7	0.03	0.002	22	47	19	20	0.60
80- 90	4.5	5.3	0.04	0.003	21	54	11	13	0.26
110- 120	4.3	5.3	0.02	0.002	20	54	14	13	

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10	5	2.5	1.7	0.09	0.56	0.30	0.40	0.039	1.95	0.061
20- 30	3	1.1	0.82	0.08	0.46	0.50	0.60	0.026	2.26	0.032
50- 60	3	1.4	0.81	0.08	0.24	0.20	1.10	0.035	3.04	0.025
80- 90	2	0.54	0.82	0.06	0.11	0.40	0.80	0.044	2.28	0.026
110- 120	2	0.14	0.68	0.07	0.05	1.20	1.00	0.031	2.19	0.025

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	2.7	0.22	12	0.65	350	16	0.84	2.5	
50-60									2.9

SOIL PROFILE CLASS: Kaban:
SUBSTRATE MATERIAL: Basalt
A.M.G. REFERENCE: 330 500 mE 8 062 900 mN ZONE 55
LANDFORM ELEMENT TYPE: Plain
AUSTRALIAN CLASSIFICATION: Mesotrophic Red Ferrosol
GREAT SOIL GROUP: Krasnozem
VEGETATION:
SURFACE COARSE FRAGMENTS:

SITE NO: S16
ANNUAL RAINFALL: 1219mm
SLOPE: 2.1 %
LANDFORM PATTERN TYPE: Gently undulating plains
PRINCIPAL PROFILE FORM: Uf6.31
STRUCTURAL FORM:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Self mulching

HORIZON	DEPTH	DESCRIPTION
A1n	0 to .08 m	Brownish black (5YR2/2) moist; light clay; strong <2mm polyhedral; moderately moist moderately firm; common medium manganiferous nodules, few medium argillaceous nodules. Clear to-
B1	.08 to .21 m	Dark reddish brown (5YR3/3) moist; light clay; moderate 2 to 5mm polyhedral; moderately moist moderately firm; few medium manganiferous nodules. Clear to-
B21n	.21 to .46 m	Dark reddish brown (2.5YR3/4) moist; light clay; weak 2 to 5mm polyhedral; moist moderately weak; very few medium manganiferous nodules. Clear to-
B22n	.46 to .96 m	Dark reddish brown (2.5YR3/4) moist; light medium clay; weak 5 to 10mm polyhedral secondary, parting to moderate 2 to 5mm polyhedral primary; moderately moist moderately firm; many coarse manganiferous nodules. Diffuse to-
B23n	.96 to 1.50 m	Dark reddish brown (5YR3/4) moist; light clay; strong 5 to 10mm polyhedral secondary, parting to strong 2 to 5mm polyhedral primary; moderately moist moderately firm; common medium manganiferous nodules.

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH CaCl2	pH Water	EC mS/cm	Cl %	CS % (oven dry soil)	FS	SI	C	ratio R1
B.10		6.6	0.04	0.002					
0.1		6.6	0.06	0.004	22	13	15	50	0.26
0.31		6.4	0.03	0.002	20	10	11	61	0.23
0.6		6.1	0.04	0.006	16	8	10	71	
0.9		5.8	0.04	0.006	17	7	9	70	
1.17		5.9	0.03	0.005	9	5	7	80	
1.5		6.0	0.02	0.002					

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0.1		9.0	3.0	0.21	1.40			0.190	0.246	0.044
0.31		2.6	1.5	0.13	0.71			0.114	0.190	0.022
0.6		1.3	1.2	0.10	0.38			0.090	0.160	0.009
0.9		1.2	1.3	0.10	0.31	0.1	0.1	0.112	0.116	0.005
1.17		1.7	1.4	0.38	0.34	0.1	0.1	0.100	0.091	0.005

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
B.10	2.8	0.14	50	1.4	49	198	2.4	0.8	

SOIL PROFILE CLASS: Maalan:
SUBSTRATE MATERIAL: Basalt
A.M.G. REFERENCE: 362 400 mE 8 077 900 mN ZONE 55
LANDFORM ELEMENT TYPE: Hillslope
AUSTRALIAN CLASSIFICATION: Red Ferrosol
GREAT SOIL GROUP: No suitable group. Affinities with Krasnozem
VEGETATION: Rainforest spp.
SURFACE COARSE FRAGMENTS:

SITE NO: 2481
ANNUAL RAINFALL: 1700 - 4400mm
SLOPE:
LANDFORM PATTERN TYPE: Low hills
PRINCIPAL PROFILE FORM: Uf6.31
STRUCTURAL FORM:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Firm

HORIZON	**DEPTH**	**DESCRIPTION**
A1	0 to .11 m	Dark (5YR3/2); light clay; strong 2-5mm granular. Clear to-
B21	.11 to .35 m	Red-brown (5YR3/3); light clay; moderate 2-5mm polyhedral. Gradual to-
B22	.35 to .60 m	Red-brown (5YR3/4); light medium clay; very few medium pebbles, angular basalt; moderate 2-5mm polyhedral. Gradual to-
B23	.60 to .84 m	Red-brown (5YR3/5); medium clay; very few medium pebbles, angular basalt; moderate 2-5mm polyhedral. Gradual to-
B31	.84 to 1.80 m	Brown (7.5YR3/4); light medium clay; common medium pebbles, angular basalt; moderate 2-5mm polyhedral.

LABORATORY DATA: SITE NO: 2481

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
0-B10	4.6	5.6	0.05	0.001					
0- 10	4.4	5.4	0.03	0.001	7	7	22	59	0.13
20- 30	4.7	5.4	0.01	0.001	2	9	23	69	0.06
50- 60	4.8	5.2	0.02	0.002	6	14	24	58	0.08
80- 90	4.7	5.1	0.02	0.002	5	19	26	49	0.19
110- 120	4.6	5.1	0.01	0.001	4	21	28	45	
140- 150	4.5	5.2	0.01	0.001					

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10	3	0.90	0.89	0.11	0.27	0.70	10.80	0.217	0.080	0.122
20- 30	BL	0.07	0.19	0.06	0.05	0.10	6.80	0.193	0.076	0.093
50- 60	BL	0.03	0.07	0.09	0.10	0.10	4.70	0.184	0.053	0.119
80- 90	BL	0.12	0.10	0.13	0.03	0.20	6.10	0.184	0.030	0.139
110- 120	1	0.13	0.11	0.13	0.07	0.30	7.80	0.185	0.026	0.120
140- 150										

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	4.3	0.32	12	0.23	84	7.5	2.7	19	
50- 60									11

Horz. No.	Horizon Depth (cm)	Bulk Density (g/cm^3)	Total Porosity	Coarse Mat. (>2mm) (% of O.D.soil)	Moisture Retention (cm^3/cm^3) -10kPa	Moisture Retention (cm^3/cm^3) -1.5MPa	Available Water Capacity cm^3/cm^3	Available Water Capacity mm per horizon	Available Water Capacity mm per upper m.
1	0-10	0.90	0.674	0	0.572	0.234	0.338	33.8	
2	10-20	0.92	0.668	0	0.489	0.238	0.251	25.1	
3	20-35	1.09	0.606	0	0.491	0.283	0.208	31.2	
4	35-90	1.14	0.599	5	0.496	0.282	0.214	117.5	
5	90-120	1.22	0.573	0	0.539	0.329	0.210	21.0	
Total	0-100								**229**

SOIL PROFILE CLASS: Maalan:
SUBSTRATE MATERIAL: Basalt
A.M.G. REFERENCE: 341 600 mE 8 073 450 mN ZONE 55
LANDFORM ELEMENT TYPE: hillslope

SITE NO: 2484
ANNUAL RAINFALL: 1700 - 4400mm
SLOPE: 47.0 %

AUSTRALIAN CLASSIFICATION: Red Ferrosol
GREAT SOIL GROUP: No suitable group. Affinities with Krasnozem
VEGETATION: Rainforest spp.
SURFACE COARSE FRAGMENTS:

LANDFORM PATTERN TYPE: Lava plain
PRINCIPAL PROFILE FORM: Uf6.31
STRUCTURAL FORM:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY:

HORIZON	**DEPTH**	**DESCRIPTION**
A1	0 to .10 m	Red-brown (5YR3/3); light clay; strong 2-5mm granular. Clear to-
B21	.10 to .59 m	Red-brown (5YR3/4); light medium clay; moderate 2-5mm polyhedral. Gradual to-
B22	.59 to .98 m	Red-brown (5YR4/4); medium clay; moderate 2-5mm polyhedral. Gradual to-
B31	.98 to 1.65 m	Red-brown (5YR4/3); medium clay; moderate 5-10mm polyhedral.

LABORATORY DATA: SITE NO: 2484

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
0-B10	4.6	5.4	0.06	0.002					
0- 10	4.4	5.3	0.04	0.001	5	8	19	65	0.15
20- 30	4.3	5.0	0.02	0.001	3	10	18	70	0.12
50- 60	4.4	5.2	0.01	0.001	2	16	21	61	0.13
80- 90	4.4	5.3	0.01	0.001	1	22	22	54	0.08
110-120	4.4	5.4	0.01	0.001	1	25	25	48	
140-150	4.3	5.3	0.01	0.001					

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10	4	1.00	1.20	0.13	0.32	1.20	1.40	0.195	0.214	0.096
20- 30	2	0.05	0.17	0.10	0.08	1.40	1.40	0.185	0.046	0.076
50- 60	1	0.03	0.16	0.13	0.02	1.00	1.00	0.178	0.031	0.060
80- 90	1	0.15	0.11	0.13	0.04	0.90	1.00	0.176	0.029	0.082
110-120	2	0.10	0.45	0.21	0.03	1.00	1.00	0.175	0.027	0.095
140-150										

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	5.6	0.42	28	0.34	110	5.9	1.8	1.7	
50- 60									9.8

SOIL PROFILE CLASS: Maalan
SUBSTRATE MATERIAL: Basalt
A.M.G. REFERENCE: 352 850 mE 8 064 600 mN ZONE 55
LANDFORM ELEMENT TYPE: Plain
AUSTRALIAN CLASSIFICATION: Red Ferrosol
GREAT SOIL GROUP: No suitable group. Affinities with Krasnozem
VEGETATION: Rainforest spp.
SURFACE COARSE FRAGMENTS: Few large pebbles , basalt

SITE NO: 2485
ANNUAL RAINFALL: 1700 - 4400mm
SLOPE: 3.0 %
LANDFORM PATTERN TYPE: Lava plain
PRINCIPAL PROFILE FORM: Uf6.31
STRUCTURAL FORM:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Firm

HORIZON	**DEPTH**	**DESCRIPTION**
A1	0 to .18 m	Red-brown (5YR3/3); light clay; strong 2-5mm granular. Clear to-
B21	.18 to .75 m	Red-brown (5YR3/4); light clay; moderate 2-5mm polyhedral.. Gradual to-
B22	.75 to 1.20 m	Red-brown (5YR4/4); light medium clay; moderate 2-5mm polyhedral. Gradual to-
B31	1.20 to 1.70 m	Brown (7.5YR3/4); common coarse distinct brown mottles; medium clay; moderate 2-5mm polyhedral.

LABORATORY DATA: SITE NO: 2485

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
0-B10	4.4	5.4	0.10	0.002					
0- 10	4.3	5.3	0.06	0.002	16	5	15	61	0.17
20- 30	4.9	5.2	0.03	0.002	9	7	13	74	0.11
50- 60	5.1	5.1	0.03	0.002	8	8	14	72	0.18
80- 90	5.4	5.0	0.03	0.002	12	7	20	64	0.19
110- 120	5.5	5.1	0.03	0.002	10	9	33	51	
140- 150	5.6	5.0	0.02	0.001					

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10	2	0.39	0.56	0.11	0.19	0.80	0.80	0.333	0.066	0.132
20- 30	BL	0.05	0.07	0.04	0.03	0.10	0.10	0.335	0.053	0.120
50- 60	BL	0.04	0.03	0.02	0.02	0.10	0.10	0.320	0.053	0.117
80- 90	BL	0.05	0.02	0.01	0.01	0.10	0.10	0.297	0.060	0.167
110- 120	BL	0.20	0.05	0.01	0.02	BL	BL	0.328	0.048	0.203
140- 150										

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	5.8	0.42	42	0.24	230	32	2.3	0.75	
50- 60									13

SOIL PROFILE CLASS: Millstream
SUBSTRATE MATERIAL: Basalt
AMG REFERENCE: 331 400 mE 8 048 400 mN ZONE 55
LANDFORM ELEMENT TYPE: Plain
AUSTRALIAN CLASSIFICATION: Mesotrophic, Brown Ferrosol
GREAT SOIL GROUP: Xanthozem
VEGETATION:
DOMINANT SPECIES: *Eucalyptus tereticornis, Themeda triandra, Heteropogon contortus*
SURFACE COARSE FRAGMENTS: Common medium pebbles, rounded basalt

SITE NO: S18
ANNUAL RAINFALL: 908mm
SLOPE: 1.4%
LANDFORM PATTERN TYPE: Lava plain
PRINCIPAL PROFILE FORM: Uf6.4
STRUCTURAL FORM: Tall isolated trees

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Firm

HORIZON	**DEPTH**	**DESCRIPTION**
A11	0 to .11m	Brownish black (10YR3/2) moist; light clay; moderate <2mm granular; wet very weak; very few fine ferromanganiferous nodules. Clear to-
A12	.11 to .26m	Dark brown (10YR3/3) moist; light clay; moderate 2 to 5mm granular; wet very weak; very few fine ferromanganiferous nodules. Clear to -
B21n	.26 to .53m	Brown (10YR4/6) moist; light clay; strong 2 to 5mm polyhedral; wet very weak; common medium ferromanganiferous nodules. Gradual to -
B22n	.53 to .85m	Bright brown (7.5YR5/6) moist; few medium distinct grey mottles, few medium distinct red mottles; light medium clay; strong 2 to 5mm polyhedral; wet moderately weak; many fine ferromanganiferous nodules. Gradual to -
D1n	.85 to 1.09m	Bright brown (7.5YR5/6) moist; many medium prominent red mottles, few medium distinct grey mottles; medium heavy clay; weak 10 to 20mm polyhedral secondary, parting to moderate <2mm polyhedral primary; wet moderately firm; common fine ferromanganiferous nodules. Gradual to -
D2	1.09 to 1.37m	Greyish brown (7.5YR6/2) moist; many medium distinct brown mottles, few medium distinct grey mottles; medium heavy clay; moderate 5 to 10mm angular blocky; wet moderately firm; few fine ferromanganiferous nodules. Gradual to -
D3	1.37 to 1.48m	Yellowish brown (10YR5/6); medium heavy clay; weak; wet moderately firm; few fine ferromanganiferous nodules.

Site No: TC s18

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
0-B10		6.4	0.04	0.010					
0- 10		6.6	0.05	0.002	38	10	13	38	0.26
20- 30		6.8	0.02	0.002	27	12	9	52	0.30
50- 60		6.7	0.02	0.001	29	8	10	56	0.01
80- 90		6.5	0.03	0.002	26	5	8	62	0.01
110- 120		6.0	0.06	0.004	8	10	9	73	
140- 150		5.9	0.06	0.008					

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10		11	3.6	0.15	0.49			0.183	0.108	0.048
20- 30		6.9	2.9	0.14	0.15			0.105	0.063	0.024
50- 60		2.2	2.7	0.13	0.09			0.092	0.087	0.008
80- 90		2.2	7.2	0.31	0.40			0.048	0.037	0.006
110- 120		4.4	15	0.79	0.23			0.016	0.033	0.005
140- 150										

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	2.3	0.10	25	0.29	48	87	4.2	3.3	

SOIL PROFILE CLASS: Morgan
SUBSTRATE MATERIAL: Atherton Basalt
A.M.G. REFERENCE:

LOCATION: Walkamin Research Station
SITE NO:
ANNUAL RAINFALL: 1030mm

LANDFORM ELEMENT TYPE: Gently undulating rise
AUSTRALIAN CLASSIFICATION: Brown Dermosol
GREAT SOIL GROUP: No suitable grouping affinities with Brown clay
VEGETATION: *Eucalyptus* spp., *Hakea* spp.
SURFACE COARSE FRAGMENTS:

SLOPE: 2.5%
LANDFORM PATTERN TYPE:
PRINCIPLE PROFILE FORM: Uf 6.4
STRUCTURAL FORM:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Firm to self mulching

HORIZON	DEPTH	DESCRIPTION
A1	0-10cm	Dark (10YR2/2) medium heavy clay; 10-20% 6-20mm subrounded basalt; strong 2-5mm granular;
B21	10-40cm	Brown (10YR4/3) 10-20% <5mm distinct red mottles; medium heavy clay; 10-20% 20-60mm subrounded basalt; moderate 10-20mm lenticular.
B3	40-58cm	Grey (10YR4/1) 10-20% <5mm distinct orange mottles; medium clay; 50-90% 20-60mm subrounded basalt; moderate 5-10mm angular blocky; 10-20% 6-20mm manganese nodules.
C	58-80cm	>90% weathering basalt.

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
B0-10		6.2	0.04						
0-10		6.3	0.02		27	15	15	43	
20-30		6.6	0.02		21	16	16	47	
40-50		6.9	0.03		34	22	18	26	

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0-10	13.55	9.32	3.72	0.21	0.30					
20-30	28.56	15.16	12.16	0.96	0.28					
40-50	30.52	15.72	12.80	1.80	0.20					

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
B0-10	1.85		4		56	47	1.9	1.2	

SOIL PROFILE CLASS: Nettle
SUBSTRATE MATERIAL: Granite
A.M.G. REFERENCE: 292 500 mE 8 037 500 mN ZONE 55
LANDFORM ELEMENT TYPE: Hillslope
AUSTRALIAN CLASSIFICATION: Paralithic Leptic Rudosol
GREAT SOIL GROUP: Lithosol
VEGETATION:

LOCATION:
SITE NO: S6
ANNUAL RAINFALL: 797 mm
SLOPE: 16 %
LANDFORM PATTERN TYPE: Rolling low hills
PRINCIPAL PROFILE FORM: Uc1.42
STRUCTURAL FORM: Mid-high woodland

DOMINANT SPECIES: *Eucalyptus peltata, Eucalyptus drepanophylla, Grevillea decora, Eucalyptus melanopholoia*
SURFACE COARSE FRAGMENTS: Common coarse pebbles, subangular granite

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Hard setting

HORIZON	**DEPTH**	**DESCRIPTION**
A1	0 to .04 m	Brownish black (10YR3/2) moist; loamy coarse sand; common medium pebbles, subangular quartz; single grain; dry very weak. Clear to-
AC	.04 to .25 m	Dull yellowish brown (10YR5/4) moist; loamy coarse sand; many medium pebbles, subangular quartz, common coarse pebbles, subangular granite; single grain; dry very weak.

Depth Cm	1:5 Soil/Water or 0.1 CaCl2 pH CaCl2	pH Water	EC mS/cm	Cl %	Particle Size CS % (oven dry soil)	FS	SI	C	Disp. ratio R1
B.10		6.3	0.01	0.001					
0.1		6.2	0.01	0.001	57	29	6	8	0.46

Depth cm	Exchange properties (meq/100g soil) ECEC	Ca	Mg	Na	K	Al	Acid	Total Element % P	K	S
0.1		2.3	0.62	0.04	0.29			0.015	4.730	0.015

Depth cm	Org. C % (W & B)	Tot. N %	Extract. P mg/Kg (bic.)	Rep. K meq %	DTPA extractable (mg/Kg) Fe	Mn	Cu	Zn	Cit/Dith Fe %
B.10	0.6	0.04	2	0.24	5	15	0.5	0.3	

SOIL PROFILE CLASS: Pin Gin
SUBSTRATE MATERIAL: Basalt
A.M.G. REFERENCE: 357 600 mE 8 092 750 mN ZONE 55
LANDFORM ELEMENT TYPE: Hillslope
AUSTRALIAN CLASSIFICATION: Red Ferrosol
GREAT SOIL GROUP: Krasnozem
VEGETATION: Rainforest spp.
SURFACE COARSE FRAGMENTS:

SITE NO: 2479
ANNUAL RAINFALL: 1400 - 1700mm
SLOPE: 11.0 %
LANDFORM PATTERN TYPE: Lava plain
PRINCIPAL PROFILE FORM: Uf6.31
STRUCTURAL FORM:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Firm

HORIZON	**DEPTH**	**DESCRIPTION**
A1	0 to .10 m	Red (2.5YR3/3); light clay; strong 2-5mm granular. Clear to-
B21	.10 to .40 m	Red (2.5YR3/4); light clay; moderate 2-5mm polyhedral. Gradual to-
B22	.40 to 1.10 m	Red (2.5YR3/5); light medium clay; moderate 2-5mm polyhedral.. Gradual to-
B31	1.10 to 1.60 m	Red-brown (5YR4/4); medium clay; moderate 2-5mm polyhedral.

LABORATORY DATA: SITE NO: 2479

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
0-B10	4.1	4.7	0.11	0.002					
0- 10	4.1	4.8	0.09	0.002	8	6	18	63	0.23
20- 30	4.4	5.0	0.04	0.002	3	6	19	72	0.06
50- 60	4.5	5.1	0.04	0.003	3	7	16	76	0.08
80- 90	4.6	5.0	0.04	0.004	2	7	15	77	0.08
110- 120	4.9	4.9	0.03	0.002	1	9	16	76	
140- 150	4.8	5.1	0.03	0.003					

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10	5	1.30	0.95	0.11	0.31	2.20	5.5	0.125	0.070	0.129
20- 30	2	0.10	0.39	0.07	0.11	1.20	4.5	0.112	0.058	0.088
50- 60	1	0.03	0.66	0.10	0.05	0.50	4.3	0.099	0.058	0.094
80- 90	1	0.03	0.24	0.10	0.03	0.20	5.8	0.097	0.057	0.099
110- 120	BL	0.06	0.10	0.06	0.03	0.10	5.7	0.103	0.045	0.124
140- 150										

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	5.1	0.43	16	0.29	97	52	1.3	1.3	
50- 60									14

Horz.	Horizon	Bulk	Total	Coarse Mat.	Moisture Retention		Available Water Capacity		
No.	Depth	Density	Porosity	(>2mm)	(cm^3/cm^3)		cm^3/cm^3	mm per	mm per
	(cm)	(g/cm^3)		(% of O.D.soil)	-10kPa	-1.5MPa		horizon	upper m.
1	0-5	1.07	0.614	0	0.498	0.277	0.221	11.0	
3	5-15	1.13	0.589	0	0.471	0.295	0.177	17.7	
3	15-55	1.21	0.571	0	0.472	0.301	0.171	68.2	
4	55-80	1.31	0.540	0	0.504	0.354	0.149	37.4	
5	80-140	1.35	0.526	0	0.502	0.406	0.096	19.3	
Total	0-100								**154**

SOIL PROFILE CLASS: Pin Gin
SUBSTRATE MATERIAL: Basalt
AMG REFERENCE: 338 500 mE 8 063 100 mN ZONE 55
LANDFORM ELEMENT TYPE: Hillslope
AUSTRALIAN CLASSIFICATION: Dystrophic, Red Ferrosol
GREAT SOIL GROUP: Krasnozem
VEGETATION:

SITE NO: S15
ANNUAL RAINFALL: 1512mm
SLOPE: 24%
LANDFORM PATTERN TYPE: Rolling low hills
PRINCIPAL PROFILE FORM: Uf6.31
STRUCTURAL FORM: Mid-high open tussock grassland

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Firm

HORIZON	DEPTH	DESCRIPTION
A1	0 to .12m	Dark reddish brown (2.5YR3/3) moist; light clay; strong <2mm granular; dry very firm. Gradual to-
B1	.12 to .31m	Dark reddish brown (2.5YR3/4) moist; light clay; weak 5 to 10mm angular blocky; dry moderately firm. Diffuse to-
B21	.31 to .59m	Dark reddish brown (2.5YR3/6) moist; light clay; moderate <2mm polyhedral dry very firm. Diffuse to-
B22	.59 to 1.31m	Dark reddish brown (2.5YR3/6) moist; light medium clay; strong 10 to 20mm angular blocky secondary, parting to strong 2 to 5mm polyhedral primary; dry very firm. Diffuse to-
B23	1.31 to 2.00m	Dark reddish brown (2.5YR3/6) moist; light medium clay; strong 5 to 10mm polyhedral secondary, parting to strong 2 to 5mm polyhedral primary; dry moderately strong.

Site No: TC s15

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
0-B10		5.5	0.04	0.002					
0- 10		5.4	0.04	0.002	5	6	25	63	0.14
20- 30		5.1	0.02	0.001	1	6	22	73	0.08
50- 60		5.0	0.02	0.002	1	10	21	70	0.09
80- 90		4.9	0.01	0.001	1	10	21	71	0.09
110- 120		5.0	0.01	0.001	1	18	25	61	
140- 150		4.9	0.01	0.001					

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10		3.10	2.4	0.09	0.47	0.5	0.7	0.294	0.057	0.082
20- 30		0.54	0.40	0.06	0.12	0.6	0.8	0.272	0.016	0.058
50- 60		0.20	0.51	0.10	0.10	0.8	1.0	0.193	0.003	0.036
80- 90		0.10	0.60	0.05	0.08	1.0	1.2	0.179	0.003	0.039
110- 120		0.09	0.75	0.06	0.18	1.4	1.7	0.137	0.011	0.036
140- 150										

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	4.9	0.23	21	0.22	53	41	2.5	1.8	
50- 60									

SOIL PROFILE CLASS: Snider
SUBSTRATE MATERIAL: Atherton Basalt
A.M.G. REFERENCE:
LANDFORM ELEMENT TYPE: Undulating rise
AUSTRALIAN CLASSIFICATION: Brown Dermosol
GREAT SOIL GROUP: No suitable group affinities with Prairie soil
VEGETATION: *Eucalyptus* spp., *Hakea* spp.
SURFACE COARSE FRAGMENTS:

LOCATION: Walkamin Research Station
SITE NO:
ANNUAL RAINFALL: 1030mm
SLOPE: 4.0%
LANDFORM PATTERN TYPE:
PRINCIPLE PROFILE FORM: Uf6.31
STRUCTURAL FORM:

PROFILE MORPHOLOGY:‘

CONDITION OF SURFACE SOIL WHEN DRY**:** Firm

HORIZON	**DEPTH**	**DESCRIPTION**
A1	0-08cm	Dark (10YR2/2) sandy light medium clay; <2% 2-6mm angular basalt; moderate 2-5mm granular 2-10% 2-5mm ferromanganese nodules.
B2	08-30cm	Brown (10YR3/3) medium clay; 10-20% 6-20mm subrounded basalt; weak 2-5mm polyhedral 2-10% 2-6mm manganese nodules.
B3	30-50cm	Brown (10YR4/3) 2-10% 5-15mm distinct red and yellow mottles; medium heavy clay; 20-50% 20-60mm subrounded basalt; moderate 10-20mm angular blocky; 10-20% 2-6mm manganese nodules.
C	50-60cm	Grey (10YR5/1) 10-20% <5mm distinct orange mottles; heavy clay; 50-90% 20-60mm subangular basalt; moderate 10-20mm lenticular; 10-20% 2-6mm manganese nodules.

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
B0-10		6.2	0.04						
0-10		6.3	0.04		39	19	15	27	
20-30		6.5	0.01		28	16	15	42	
45-55		6.9	0.04		30	18	14	38	

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0-10	10.53	6.72	3.32	0.03	0.46					
20-30	14.92	9.7	4.06	0.94	0.22					
45-55	27.32	13.68	12.08	1.4	0.16					

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
B0-10	1.77		10		97	69	1	1.5	

SOIL PROFILE CLASS: Tolga
SUBSTRATE MATERIAL: Basalt
A.M.G. REFERENCE: 341 500 mE 8 096 400 mN ZONE 55
LANDFORM ELEMENT TYPE: Plain
AUSTRALIAN CLASSIFICATION: Red Ferrosol
GREAT SOIL GROUP: Euchrozem
VEGETATION: Eucalypt spp.
SURFACE COARSE FRAGMENTS:

SITE NO: 2475
ANNUAL RAINFALL: 1250 - 1400mm
SLOPE: 0.5 %
LANDFORM PATTERN TYPE: Lava plain
PRINCIPAL PROFILE FORM: Uf6.31
STRUCTURAL FORM:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Firm

HORIZON	DEPTH	DESCRIPTION
A11	0 to .05 m	Dark (2.5YR3/2); light clay; strong 2-5mm granular; very few medium manganiferous nodules. Clear to-
A12	.05 to .20 m	Dark (2.5YR3/2); light clay; moderate 2-5mm granular; very few medium manganiferous nodules. Gradual to-
B1	.20 to .50 m	Red (2.5YR3/3); light clay; moderate polyhedral; few medium manganiferous nodules. Gradual to-
B21	.50 to 1.00 m	Red (2.5YR3/4); light clay; moderate 2-5mm polyhedral; few medium manganiferous nodules. Gradual to-
B22	1.00 to 1.80 m	Red (10R3/4); light clay; moderate 2-5mm polyhedral; few medium manganiferous nodules.

LABORATORY DATA: SITE NO: 2475

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
0-B10	5.8	6.6	0.09	0.002					
0- 10	5.4	6.3	0.05	0.002	11	22	14	49	0.28
20- 30	5.4	5.8	0.04	0.003	7	18	11	63	0.07
50- 60	5.4	5.5	0.02	0.002	5	14	9	71	0.06
80- 90	5.6	5.6	0.01	0.002	5	10	6	78	0.06
110- 120	5.8	5.9	0.01	0.001	5	9	11	75	
140- 150	5.8	5.9	0.01	0.001					

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10	10	6.4	2.7	0.12	1.00			0.178	0.288	0.066
20- 30	3	2.1	0.87	0.05	0.15	0.10	4.00	0.130	0.252	0.040
50- 60	1	0.73	0.44	0.08	0.05	0.10	4.40	0.106	0.299	0.028
80- 90	2	1.0	0.44	0.07	0.05	BL	3.30	0.113	0.334	0.028
110- 120	2	1.5	0.38	0.13	0.03	BL	3.00	0.116	0.274	0.028
140- 150										

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	4.1	0.29	33	1	10	130	3.6	1.8	
50- 60									9.3

Horz. No.	Horizon Depth (cm)	Bulk Density (g/cm^3)	Total Porosity	Coarse Mat. (>2mm) (% of O.D.soil)	Moisture Retention (cm^3/cm^3) -10kPa	-1.5MPa	Available Water Capacity cm^3/cm^3	mm per horizon	mm per upper m.
1	0-15	1.06	0.616	0	0.358	0.244	0.114	17.1	
2	15-32	1.13	0.590	0	0.381	0.249	0.132	22.5	
3	32-50	1.21	0.575	0	0.367	0.267	0.100	18.0	
4	50-120	1.29	0.546	0	0.408	0.291	0.117	58.5	
Total	0-100								**116**

SOIL PROFILE CLASS: Tolga
SUBSTRATE MATERIAL: Basalt
A.M.G. REFERENCE: 343 250 mE 8 089 600 mN ZONE 55

SITE NO: 2476
ANNUAL RAINFALL: 1250 - 1400mm

LANDFORM ELEMENT TYPE: Hillslope
AUSTRALIAN CLASSIFICATION: Red Ferrosol
GREAT SOIL GROUP: Euchrozem
VEGETATION:
SURFACE COARSE FRAGMENTS:

SLOPE: 4.0 %
LANDFORM PATTERN TYPE: Lava plain
PRINCIPAL PROFILE FORM: Uf6.31
STRUCTURAL FORM:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Firm

HORIZON	DEPTH	DESCRIPTION
A11	0 to .10 m	Dark (2.5YR3/2); light clay; strong 2-5mm granular; very few medium manganiferous nodules. Clear to-
A12	.10 to .25 m	Dark (2.5YR3/2); light clay; moderate 2-5mm granular; very few medium manganiferous nodules. Gradual to-
B1	.25 to .55 m	Red (2.5YR3/3); light clay; moderate 2-5mm polyhedral; few medium manganiferous nodules. Gradual to-
B21	.55 to 1.20 m	Red (2.5YR3/4); light medium clay; moderate 2-5mm polyhedral; few medium manganiferous nodules. Gradual to-
B22	1.20 to 1.60 m	Red (10R3/4); medium clay; moderate 2-5mm polyhedral; few medium manganiferous nodules.

LABORATORY DATA: SITE NO: 2476

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
0-B10	5.9	6.5	0.12	0.004					
0- 10	6.3	7.0	0.19	0.008	11	10	19	56	0.16
20- 30	5.7	6.8	0.05	0.003	6	10	19	65	0.14
50- 60	6.2	6.7	0.11	0.013	7	9	20	66	0.08
80- 90	6.5	7.0	0.09	0.009	6	7	11	76	0.12
110- 120	6.7	7.4	0.04	0.001	5	7	12	75	
140- 150	6.9	7.7	0.04	0.001					

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10	21	13	4.50	0.29	3.40			0.308	0.342	0.111
20- 30	11	7.9	1.30	0.14	1.20			0.283	0.200	0.074
50- 60	12	11	0.92	0.13	0.15			0.280	0.127	0.069
80- 90	7	6.5	0.61	0.05	0.09			0.237	0.111	0.044
110- 120	6	5.6	0.50	0.04	0.07			0.198	0.123	0.034
140- 150										

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	4.2	0.42	105	0.89	31	220	5.1	5.1	
0- 10									9.3
50- 60									11

SOIL PROFILE CLASS: Tolga
SUBSTRATE MATERIAL: Basalt
A.M.G. REFERENCE: 340 100 mE 8 089 150 mN ZONE 55
LANDFORM ELEMENT TYPE: Hillslope
AUSTRALIAN CLASSIFICATION: Red Ferrosol
GREAT SOIL GROUP: Euchrozem
VEGETATION: Improved pasture
SURFACE COARSE FRAGMENTS:

SITE NO: 2486
ANNUAL RAINFALL: 1250 - 1400mm
SLOPE: 6.0 %
LANDFORM PATTERN TYPE: Low hills
PRINCIPAL PROFILE FORM: Uf6.31
STRUCTURAL FORM:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Firm

HORIZON	**DEPTH**	**DESCRIPTION**
Ap	0 to .35 m	Dark (2.5YR3/2); light clay; moderate granular; very few fine manganiferous soft segregations. Clear to-
B21	.35 to 1.05 m	Red (2.5YR3/3); light clay; moderate 2-5mm polyhedral; very few fine manganiferous soft segregations. Gradual to-
B22	1.05 to 1.50 m	Red (2.5YR3/4); light medium clay; moderate 2-5mm polyhedral; very few medium manganiferous nodules.

LABORATORY DATA: SITE NO: 2486

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
0-B10	5.7	6.5	0.12	0.002					
0- 10	5.3	6.0	0.12	0.003	5	10	14	71	0.19
20- 30	5.2	5.9	0.04	0.003	3	9	15	75	0.07
50- 60	6.2	6.7	0.02	0.001	2	7	12	82	0.06
80- 90	6.4	6.9	0.01	0.001	2	6	12	82	0.06
110- 120	6.4	6.8	0.02	0.001	2	7	17	74	
140- 150	6.2	6.5	0.02	0.001					

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10	6	3.9	1.50	0.09	0.85			0.169	0.132	0.069
20- 30	4	3.3	0.72	0.01	0.10	0.10	3.70	0.156	0.098	0.064
50- 60	3	2.7	0.60	0.01	0.05			0.117	0.112	0.032
80- 90	4	2.9	0.63	0.01	0.04			0.125	0.143	0.035
110- 120	3	2.4	0.75	0.01	0.04			0.113	0.141	0.040
140- 150										

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	1.9	0.19	14	0.87	11	76	2.6	1.6	
50- 60									11

Horz.	Horizon	Bulk	Total	Coarse Mat.	Moisture Retention		Available Water Capacity		
No.	Depth	Density	Porosity	(>2mm)	(cm^3/cm^3)		cm^3/cm^3	mm per	mm per
	(cm)	(g/cm^3)		(% of O.D.soil)	-10kPa	-1.5MPa		horizon	upper m.
1	0-25	1.21	0.563	0	0.467	0.289	0.178	44.5	
2	25-60	1.28	0.551	0	0.410	0.332	0.078	27.2	
3	60-95	1.30	0.542	0	0.490	0.365	0.125	43.7	
4	95-130	1.30	0.544	0	0.500	0.325	0.175	8.7	
Total	0-100								**124**

SOIL PROFILE CLASS: Tolga
SUBSTRATE MATERIAL: Basalt
A.M.G. REFERENCE: 338 300 mE 8 093 300 mN ZONE 55
LANDFORM ELEMENT TYPE: Plain
AUSTRALIAN CLASSIFICATION: Red Ferrosol
GREAT SOIL GROUP: Euchrozem
VEGETATION: Rainforest spp.
SURFACE COARSE FRAGMENTS:
SITE NO: 2487
ANNUAL RAINFALL:1250 - 1400mm
SLOPE: 2.0 %
LANDFORM PATTERN TYPE: Lava plain
PRINCIPAL PROFILE FORM: Uf6.31
STRUCTURAL FORM:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Firm

HORIZON	**DEPTH**	**DESCRIPTION**
A11	0 to .10 m	Dark (2.5YR3/2); light clay; moderate 2-5mm granular; very few fine manganiferous soft segregations. Clear to-
A12	.10 to .20 m	Red (2.5YR3/3); light clay; moderate granular; very few fine manganiferous soft segregations. Gradual to-
B21	.20 to .75 m	Dark (10R3/2); light clay; moderate polyhedral; very few fine manganiferous soft segregations. Gradual to-
B22	.75 to 1.20 m	Red (10R3/3); light medium clay; moderate 2-5mm polyhedral; few fine manganiferous soft segregations. Gradual to-
B23	1.20 to 1.50 m	Red (10R3/3); light medium clay; moderate polyhedral; few fine manganiferous soft segregations.

LABORATORY DATA: SITE NO: 2487

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
0-B10	6.3	6.8	0.24	0.003					
0- 10	6.8	7.3	0.27	0.002	10	10	22	56	0.17
20- 30	6.8	7.6	0.07	0.001	4	11	18	69	0.17
50- 60	6.8	7.6	0.04	0.001	4	11	13	74	0.19
80- 90	6.8	7.5	0.03	0.001	3	9	12	78	0.06
110- 120	6.6	7.6	0.03	0.001	4	10	16	71	
140- 150	6.7	7.5	0.03	0.001					

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10	31	25	4.60	0.07	1.00			0.206	0.258	0.117
20- 30	11	9.5	0.88	0.03	0.59			0.155	0.226	0.055
50- 60	7	5.4	0.88	0.02	0.31			0.121	0.217	0.031
80- 90	5	4.2	0.72	0.01	0.31			0.112	0.237	0.028
110- 120	5	3.4	0.79	0.02	0.31			0.108	0.216	0.027
140- 150										

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	5.2	0.51	59	1.1	12	180	4.7	240	
50- 60									10

Horz. No.	Horizon Depth (cm)	Bulk Density (g/cm^3)	Total Porosity	Coarse Mat. (>2mm) (% of O.D.soil)	Moisture Retention (cm^3/cm^3) -10kPa	Moisture Retention (cm^3/cm^3) -1.5MPa	Available Water Capacity cm^3/cm^3	Available Water Capacity mm per horizon	Available Water Capacity mm per upper m.
1	0-10	0.88	0.682	0	0.434	0.255	0.179	17.9	
2	10-20	1.05	0.619	0	0.397	0.284	0.113	11.3	
3	20-75	1.22	0.572	0	0.460	0.293	0.168	92.2	
4	75-120	1.36	0.521	0	0.432	0.341	0.091	22.7	
Total	0-100								**144**

SOIL PROFILE CLASS: Tranters
SUBSTRATE MATERIAL: Basalt
A.M.G. REFERENCE: 345 050 mE 8 090 250 mN ZONE 55
SITE NO: 2477
ANNUAL RAINFALL: 1250 - 1400mm

LANDFORM ELEMENT TYPE: Terrace flat
AUSTRALIAN CLASSIFICATION: Brown Dermosol
GREAT SOIL GROUP: No suitable group Affinities with
VEGETATION: Rainforest spp.
SURFACE COARSE FRAGMENTS:

SLOPE: 1.0 %
LANDFORM PATTERN TYPE: Alluvial plain
PRINCIPAL PROFILE FORM: Uf6.31
STRUCTURAL FORM:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Firm

HORIZON	**DEPTH**	**DESCRIPTION**
A1	0 to .16 m	Red-brown (5YR3/4); fine sandy light clay; moderate 2-5mm granular. gradual to-
B21/d1	.16 to .60 m	Brown (7.5YR3/4); fine sandy light clay; weak 2-5mm polyhedral. gradual to-
B22/d2	.60 to 1.00 m	Brown (7.5YR3/5); silty light medium clay; moderate 2-5mm polyhedral. gradual to-
B23/d3	1.00 to 1.20 m	Brown (7.5YR3/5); silty medium clay; moderate 2-5mm polyhedral.

LABORATORY DATA: SITE NO: 2477

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
0-B10	6.0	6.8	0.11	0.001					
0- 10	6.0	6.9	0.07	0.001	23	34	12	24	0.39
20- 30	5.4	6.6	0.02	0.001	25	41	8	23	0.45
50- 60	5.1	6.3	0.02	0.001	21	43	7	24	0.50
80- 90	5.3	6.4	0.02	0.001	3	46	16	32	0.38
110- 120	5.5	6.6	0.02	0.001	14	19	15	43	

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10	12	7.7	3.2	0.09	1.10			0.170	2.06	0.067
20- 30	6	3.8	1.9	0.07	0.46			0.133	2.23	0.041
50- 60	6	3.9	1.5	0.05	0.38			0.135	2.13	0.038
80- 90	8	6.1	1.9	0.07	0.24			0.169	1.59	0.044
110- 120	9	6.3	2.2	0.09	0.07			0.179	1.53	0.039

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	2.9	0.29	115	1.1	97	28	1.5	3.5	
50- 60									3.7

SOIL PROFILE CLASS: Umala
SUBSTRATE MATERIAL: Acid Volcanic
A.M.G. REFERENCE: 341 800 mE 8 061 100 mN ZONE 55
LANDFORM ELEMENT TYPE: Hillslope
AUSTRALIAN CLASSIFICATION: Brown Dermosol
GREAT SOIL GROUP: No suitable group. Affinities with red podzolic soil
VEGETATION: Eucalypt forest??
SURFACE COARSE FRAGMENTS:

SITE NO: 2483
ANNUAL RAINFALL: 1100mm
SLOPE: 14.0 %
LANDFORM PATTERN TYPE: Low hills
PRINCIPAL PROFILE FORM: Uf4.43
STRUCTURAL FORM:

PROFILE MORPHOLOGY:
CONDITION OF SURFACE SOIL WHEN DRY: Firm

HORIZON	**DEPTH**	**DESCRIPTION**
A1	0 to .05 m	Brown (7.5YR3/2); light medium clay; moderate 2-5mm granular. Clear to-
A21	.05 to .21 m	Yellow-brown (7.5YR5/5); light medium clay; moderate 2-5mm granular. Gradual to-
B1	.21 to .30 m	Yellow-brown (7.5YR5/7); medium clay; moderate 2-5mm subangular blocky. Clear to-
B21	.30 to .56 m	Red-brown (5YR5/6); medium clay; moderate 2-5mm subangular blocky. Gradual to-
B22	.56 to .75 m	Red-brown (5YR5/7); few medium faint yellow mottles; medium heavy clay; moderate 5-10mm subangular blocky. Gradual to-
B3	.75 to 1.60 m	Red (2.5YR5/7); many coarse distinct yellow mottles; medium heavy clay; moderate 5-10mm subangular blocky.

LABORATORY DATA: SITE NO: 2483

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
0-B10	4.2	4.9	0.08	0.002					
0- 10	4.3	5.3	0.07	0.002	13	14	18	49	0.21
20- 30	4.4	5.2	0.02	0.001	8	15	16	57	0.31
50- 60	4.2	5.2	0.01	0.001	5	11	14	68	0.50
80- 90	4.0	5.1	0.01	0.001	4	11	13	67	0.45
110- 120	4.0	5.0	0.01	0.001	6	11	17	62	
140- 150	4.0	5.0	0.02	0.001					

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10	8	4.1	1.40	0.13	0.34	1.8	1.8	0.035	0.226	0.077
20- 30	4	0.2	0.54	0.07	0.10	2.6	2.6	0.022	0.224	0.050
50- 60	4	0.25	0.30	0.09	0.03	3.6	3.6	0.015	0.379	0.039
80- 90	8	0.27	0.33	0.09	0.04	6.8	6.9	0.013	0.572	0.042
110- 120	9	0.15	0.41	0.08	0.05	7.8	8.0	0.013	0.644	0.048
140- 150										

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	4.3	0.31	7	0.32	110	4.3	0.08	0.53	
0- 10									3.2

Horz.	Horizon	Bulk	Total	Coarse Mat.	Moisture Retention		Available Water Capacity		
No.	Depth	Density	Porosity	(>2mm)	(cm^3/cm^3)		cm^3/cm^3	mm per	mm per
	(cm)	(g/cm^3)		(% of O.D.soil)	-10kPa	-1.5MPa		horizon	upper m.
1	0-12	0.896	0.649	0	0.353	0.233	0.120	14.4	
2	12-22	1.160	0.545	0	0.476	0.296	0.180	18.0	
3	22-48	1.196	0.535	0	0.478	0.311	0.167	43.4	
4	48-62	1.282	0.503	0	0.494	0.346	0.148	77.0	
Total	0-100								**153**

SOIL PROFILE CLASS: Utchee
SUBSTRATE MATERIAL: Granite
A.M.G. REFERENCE: 353 550 mE 8 071 400 mN ZONE 55
LANDFORM ELEMENT TYPE: Hillslope
AUSTRALIAN CLASSIFICATION: Red Dermosol
GREAT SOIL GROUP: No suitable group. Affinities with red podzolic soil
VEGETATION: Rainforest spp.
SURFACE COARSE FRAGMENTS:

SITE NO: 2482
ANNUAL RAINFALL: 1700-4400mm
SLOPE: 35.0 %
LANDFORM PATTERN TYPE: Low hills
PRINCIPAL PROFILE FORM: Uf4.41
STRUCTURAL FORM:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Firm

HORIZON	**DEPTH**	**DESCRIPTION**
A1	0 to .06 m	Brown (7.5YR3/4); coarse sandy light clay; common small pebbles, quartz; moderate 2-5mm granular. Clear to-
A2	.06 to .18 m	Red-brown (5YR4/4); coarse sandy light clay; common small pebbles, quartz; moderate 2-5mm granular. Clear to-
B21	.18 to .55 m	Red (2.5YR4/6); coarse sandy light medium clay; common small pebbles, quartz; moderate 2-5mm subangular blocky. Gradual to-
B22	.55 to 1.22 m	Red (2.5YR5/8); coarse sandy medium clay; common small pebbles, quartz; moderate 2-5mm subangular blocky. Gradual to-
B3	1.22 to 1.60 m	Red (10R5/6); common medium distinct orange mottles; coarse sandy light medium clay; many small pebbles, quartz; moderate 2-5mm subangular blocky.

LABORATORY DATA: SITE NO: 2482

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
0-B10	4.3	5.3	0.04	0.002					
0- 10	4.2	5.3	0.03	0.001	46	9	10	34	0.17
20- 30	4.3	5.1	0.01	0.001	37	9	8	47	0.29
50- 60	4.3	5.0	0.01	0.001	35	10	12	40	0.54
80- 90	4.3	4.8	0.01	0.001	40	9	12	36	0.77
110- 120	4.3	5.1	0.01	0.001	39	8	11	40	
140- 150	4.3	5.0	0.01	0.001					

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0- 10	2	0.16	0.35	0.05	0.12	1.10	5.30	0.042	0.081	0.068
20- 30	1	0.03	0.07	0.05	0.04	0.90	4.80	0.027	0.085	0.052
50- 60	1	0.03	0.03	0.05	0.03	1.10	2.80	0.019	0.083	0.042
80- 90	1	0.05	0.03	0.04	0.02	1.10	2.30	0.020	0.071	0.044
110- 120	1	0.05	0.03	0.04	0.02	1.10	3.00	0.021	0.080	0.048
140- 150										

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
0-B10	2.7	0.16	6	0.14	4.7	4.7	0.14	0.15	
50- 60									1.7

SOIL PROFILE CLASS: Walkamin (uncleared)
SUBSTRATE MATERIAL: Atherton Basalt
A.M.G. REFERENCE:
LANDFORM ELEMENT TYPE: Footslope
AUSTRALIAN CLASSIFICATION: Brown Dermosol
GREAT SOIL GROUP: Xanthozem
VEGETATION: *Eucalypt*., *Hakea* spp., *Lophostemon* spp
SURFACE COARSE FRAGMENTS:

LOCATION: Walkamin Research Station
SITE NO:
ANNUAL RAINFALL: 1030mm
SLOPE: 0.5%
LANDFORM PATTERN TYPE: Lava plain
PRINCIPLE PROFILE FORM: Uf6.4
STRUCTURAL FORM:

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Firm

HORIZON	**DEPTH**	**DESCRIPTION**
A11	0-08cm	Brown (7.5YR3/3) light clay; moderate 2-5mm granular; 2-10% 2-6mm ferromanganese nodules.
A12	08-20cm	Brown (7.5YR3/4) <2% <5mm faint orange mottles light clay; moderate 2-5mm granular; 10-20% 2-6mm ferromanganese nodules.
B21	20-70cm	Brown (10YR4/6) 2-10% <5mm distinct orange mottles; light clay; moderate 2-5mm polyhedral; 10-20% 2-6mm ferromanganese nodules.
B22	70-140cm	Yellow (10YR5/6) 2-10% <5mm distinct orange mottles; light clay; moderate 2-5mm polyhedral; 10-20% 2-6mm ferromanganese nodules.

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
Cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
B0-10		6.1	0.06						
0-10		6.2	0.07		28	17	21	34	
20-30		6.4	0.02		16	15	15	54	
50-60		5.9	0.03		16	9	10	64	
80-90		5.9	0.03		18	8	10	65	
110-120		6.1	0.03		18	6	12	65	
140-150		6.3	0.03						

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0-10	13.58	9.52	3.30	0.06	0.70					
20-30	4.00	1.88	1.95	0.04	0.13					
50-60	2.13	0.26	1.82	0.02	0.03					
80-90	3.21	0.27	2.82	0.10	0.02					
110-120	3.32	0.26	2.90	0.14	0.02					

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
B0-10	3.48		29		59	89	1.2	3.8	

SOIL PROFILE CLASS: Whelan
SUBSTRATE MATERIAL: Rhyolite
A.M.G. REFERENCE: 334 100 mE 8 062 200 mN ZONE 55
LANDFORM ELEMENT TYPE: Hillslope
AUSTRALIAN CLASSIFICATION: Fluvic, Orthic Tenosol
GREAT SOIL GROUP: No suitable group. Affinities with lithosol
VEGETATION:

SITE NO: S12
ANNUAL RAINFALL: 1512 mm
SLOPE: 11 %
LANDFORM PATTERN TYPE: Rolling low hills
PRINCIPAL PROFILE FORM: Um4.23
STRUCTURAL FORM: Tall open forest

DOMINANT SPECIES:*Eucalyptus acmenoides, Eucalyptus citriodora, Eucalyptus drepanophylla, Acacia species, Casuarina torulosa*
SURFACE COARSE FRAGMENTS: Abundant stones, subangular rhyolite

PROFILE MORPHOLOGY:

CONDITION OF SURFACE SOIL WHEN DRY: Hard setting

HORIZON	**DEPTH**	**DESCRIPTION**
A1	0 to .13 m	Brown (7.5YR4/4) moist; loam; common coarse pebbles, subangular rhyolite; strong 2 to 5mm granular; dry moderately firm. Gradual to-
A2	.13 to .32 m	Brown (7.5YR4/6) moist, dull brown (7.5YR6/3) dry; loam; few coarse pebbles, subangular rhyolite; massive; dry moderately firm. Gradual to-
BC	.32 to .48 m	Bright reddish brown (5YR5/6) moist; clay loam; many medium pebbles, subangular rhyolite; massive; dry moderately firm. Clear to-
C	.48 to .80 m	Very abundant boulders, subangular rhyolite.

Depth	1:5 Soil/Water or 0.1 CaCl2				Particle Size				Disp.
Cm	pH	pH	EC	Cl	CS	FS	SI	C	ratio
	CaCl2	Water	mS/cm	%	% (oven dry soil)				R1
B.10		5.3	0.04	0.001					
0.1		5.5	0.03	0.002	15	12	46	23	0.63
0.3		5.5	0.02	0.001	10	12	50	27	0.63
0.48		5.5	0.02	0.001	13	13	48	26	0.57

Depth	Exchange properties (meq/100g soil)							Total Element %		
cm	ECEC	Ca	Mg	Na	K	Al	Acid	P	K	S
0.1		1.50	1.60	0.10	0.65	0.9	1.1	0.021	3.120	0.019
0.3		0.44	1.30	0.08	0.36	1.1	1.4	0.015	3.160	0.012
0.48		0.08	1.70	0.07	0.30	1.0	1.4	0.012	3.160	0.009

Depth	Org. C	Tot. N	Extract. P	Rep. K	DTPA extractable (mg/Kg)				Cit/Dith
cm	% (W & B)	%	mg/Kg (bic.)	meq %	Fe	Mn	Cu	Zn	Fe %
B.10	5.7	0.24	4	0.58	76	15	0.3	1.3	

Appendix 3

Current Land Use Documentation

Tomatoes, Capsicums, Cucurbits

Location
Walkamin/Tolga/Atherton. Also Ravenshoe area.

Planting
April/May through to July/August. Most vegetables 3 month cycle.

Harvesting
Late plantings harvested early November (to avoid December storms and wet season).

Fertiliser
Amount and type applied varies for different soil types and crops. Common treatment is 800 1000 kg/ha/crop of Q5, applied at planting. Application by side dressing common practice. Dolomite applied to modify pH and add Ca and Mg to soil. Trace elements such as Zn and B applied every 3-4 years as foliar spray; also Mo to cucurbits, lettuce. Trellises are used to lift tomato crop off ground to prevent fruit spoilage. Use of plastic as ground cover and trickle irrigation used on Tablelands, particularly for strawberries.

Potatoes

Location
Upper Tablelands, grown in a pasture rotation. Around Atherton, Yungaburra, Upper and East Barron grown in mixed farming enterprise; dairying or beef in south and maize/peanuts/pasture in north.

Planting
Upper tablelands: from late July to following March. Lower area: April to August.

Harvesting
Peak at August, September and October when prices highest. On middle and lower Tablelands, summer potatoes not grown due to hot and wet conditions.

Yields
20 - 45 tonnes/hectare.

Fertiliser
Heavy applications needed to produce profitable crop. N, P, and K are major nutrients added. Most fertiliser applied as band at planting, with side-dressing of nitrogen within three weeks of planting.

Varieties
Sebago, Atlantic, Pontiac.

Irrigation
All tableland potato crops irrigated. Most widely used system is solid set pipes and sprinklers. Centre pivot and lateral shift increasing in popularity with bigger producers.

Erosion control
Required on Upper Baron/Evelyn Tablelands when grown in summer on steep slopes.

Weed control
Mechanical and chemical methods. Chemicals are sprayed by boom and/or plane depending on crop maturity and grower preference.

Insect control
Aphids, potato tuber moth and white fringed weevil larvae are serious problems in potato industry. Control by spraying with insecticide and rotations.

Disease control
Target spot, seed piece decay, blackleg and rhizoctinia significant problems. Control by spraying and good agronomic practices.

Maize

Location
Around Atherton, Kairi, Tolga, Walkamin and Kaban grown as part of rotation with peanuts. In wetter areas (Yungaburra, East and Upper Barron), grown in rotation with pasture. Optimum rainfall levels are 450 to 550 mm in the growing season; on Atherton Tablelands often exceeded. Yield decline occurs when levels over 1000 mm mainly due to cloudy weather reducing energy input.

Planting
Late November to late January.

Harvesting
Approximately 160 days after planting; affected by planting date and weather. Commences late May and finishes late August. Contractors carry out most harvesting as private ownership of harvester uneconomic.

Storage
Stored and dried at depots owned by Atherton Tableland Maize Co-op and private stockfeed manufacturer. No on-farm driers.

Yields
2.5 to 9.0 t per hectare. Northern growing area, average yield 6 t/hectare; south 3.5 t/hectare.

Fertiliser
Nitrogen and phosphorous applied at planting, as urea and DAP or Super 80 100 kg N/ha, 15 30 kg P/ha placed below and to side of seed, to avoid seed damage.

Varieties
Change regularly due to ongoing breeding program.

Erosion control
Zero/minimum tillage, conservation banks, contour planting.

Weed control
By physical, chemical methods. Inter row cultivation not done after day 28 as crop damage will occur. Atrazine used as pre and post emergent to control broad and narrow leaf species.

Insect control
Rarely reach levels at which it is economic to spray; corn ear worm, armyworms, weevils cause damage to maize crop. Current hybrids good resistance to such pests due to tight husk cover restricting access to cob.

Disease control
Resistant hybrids developed so losses due to rust and other diseases, eg. head smut and kernel rot are reduced.

Peanuts

Location
Tolga/Kairi/Atherton area. Grown on red friable basalt soils on slopes less than 10%.

Planting
Optimum time December to mid January; reduces likelihood of poor weather during harvest.

Harvesting
Crop matures in about 20 weeks. Harvesting consists of cutting plant just below level of nuts; plant inverted, placed into windrows to dry.

Drying
In field lasts between 3 to 14 days, until moisture content of pods about 13%. Threshing separates nuts from plant; nuts then tipped into bin for transport to drying shed. Nuts delivered to Peanut Marketing Board (PMB) when at safe storage moisture content.

Yield
2 to 5 tonnes/ha.

Fertiliser
No nitrogen fertiliser required. Phosphorous promotes vigorous plant growth; little yield response recorded.

Varieties
NC7, Florunner, Shulant, Streeton.

Erosion control
Surface stubble, conservation banks, contour planting

Weed control
Combination of physical and chemical methods. Interrow cultivation must not throw soil onto plant, otherwise fungal diseases occur. Pre-planting, pre and post emergent chemicals used.

Insect control

Minor concern, except when high population levels reached. *Heliothis* sp. can cause damage when in high populations (over 6 per metre of row). Roots and pods damaged by cane grubs, false wireworms and larvae of white fringed weevil. Sap sucking insects eg jassids need to be controlled to prevent virus transmission.

Disease control

Major problem in peanut industry main diseases leaf spot and rust. Sprayed with fungicides; crop rotation and correct timing of fungicide application important to achieve maximum control. Soil borne diseases CBR, Sclerotinia, white mould serious problem; little control. Variety resistance being researched.

Dairy

Location

South of Atherton to Millaa Millaa; east to Topaz, west to Ravenshoe. Mainly tropical pasture on slopes ranging up to 40%. Small number farmers in Atherton and East Barron area also grow potatoes, peanuts or maize. Average farm size approximately 150 ha; 100 milking animals. All milk sent to Atherton Tableland Cooperative Dairy Association.

Pastures (tropical)

Millaa Millaa, Topaz and Butchers Creek area Nandi, Norok and Solander Setaria. Around Ravenshoe Kikuyu main species; East and Upper Barron area Guinea Grass and Green Panic. Tropical pastures last up to 25 years; planted December. Some pastures undersown with oats in February/March.

Pastures (temperate)

Irrigation water required. Species rye grass and/or clover. Planted mid April to mid May; ground preparation 1-2 passes with disc plough, offset discing then harrowing. Reduced tillage techniques for rye grass of pasture mulcher with rye grass sown directly into mulched material becoming more common. No cultivation in this process.

Pastures (legumes)

Used where possible. In Ravenshoe area Haifa White Clover and Safari Clover are sown; around Millaa Millaa, Topaz and Butchers Creek Malawi Glycine and Greenleaf Desmodium are sown. Tinaroo Glycine sown around East and Upper Barron. Amarillo Pinto Peanut new legume showing promising results in Millaa Millaa area.

Supplementary feeding

This is a standard practice; proprietary grain/concentrate mixes used. Small amount of home milling carried out. Molasses commonly used, cotton seed increasing in use. Heifers supplementary fed with high energy/high protein concentrate to achieve sufficient live weight gain to calve at 2 years old. Amount of shade and water very important. Heat load affects high producing cows. Use of shade belts and sun cloth over yards give immediate improvements in milk yields and reproductive performance.

Yields

Average 5055 litres/cow/year. Butterfat 3.7%/cow, 189 kg fat/cow; protein 3.1%/cow; 283 days lactation.

Breeds

Holstein Friesian; other breeds include Illawarra, Jersey, small numbers of Brown Swiss.

Fertiliser
Maintenance applications of N to tropical grass 200-300 kg N/ha/year. Phosphorous applied 20-40 kg P/ha/year. Potassium applied at 60-120 kg/ha/year. No micro-nutrients applied.

Pest control
Army and web worms sporadic problem and damage pastures; sprayed when in high numbers. Cows routinely sprayed to control ticks and buffalo flies.

Weed control
Regular part of farm management. Species include lantana, wild tobacco and bracken. Chemical and physical control methods used.

Macadamias

Location
Atherton /Tolga area; most southerly area just outside Malanda. Further south, lack of sunlight, frosts and/or excessive drizzle prevent development.

Harvesting
Trees begin yielding after year five; reach peak production after year eight. Harvesting of nuts occurs three to four times, March until May. Nuts swept into rows and picked up by tractor driven vacuum harvester.

Yields
Mature trees yield up to 20 kg/tree.

Fertiliser
Rate and timing of fertiliser application important. Young trees, aim is to maximise vegetative growth. Organic fertilisers and synthetics used. Fertiliser applied every two months, starting at 100g of a 15:4:11 fertiliser, working up to 400g in fourth year. Mature trees, aim is to maximise production. Application of 4kg of 14:4:11 mixture/year. Applied from April to October. Other elements applied mainly in Spring. Phosphorous important in formation of root systems, flower initiation and nut set. Potassium required for production of high quality kernel. Organic materials eg. poultry manure, nut husks applied after harvest to improve physical, biological characteristics of soil. Magnesium, calcium, zinc, copper and boron also applied.

Varieties
741, 344, 660 and 246. Number of varieties planted in blocks within orchard to promote cross fertilisation.

Windbreaks
Macadamias are very susceptible to wind damage. Species used include Tallowwood (*Eucalyptus microcorys*), Cadagi (*E. torelliana*), River She Oak (*Casuarina cunninghamiana*) and Pine tree (*Pinus caribbea*). Trees staked during first two years of growth to prevent limb breakage from winds.

Pruning
Improves machinery access to tops of trees and promotes branching; removal of suckers and branches at ground level, and thinning out of branches done during early years of growth. Grassed inter-row slashed and material used as mulch, not placed directly against trunk otherwise collar rot will occur.

Disease control
Husk spot, trunk canker and root rot. Control by copper oxychloride and metalaxyl.

Pest control
Three main insect pests of macadamia tree: banana spotting bug, macadamia flowering caterpillar and macadamia nut borer. Banana spotting bug sprayed approximately every fortnight from start of nut formation to harvest. Nut borer pest of mature fruit and sprayed 2-3 times. Flowering caterpillar affects only flower, mainly around July. Most chemicals applied with misting equipment due to height of tree. Chemicals used are Endosulphan (for banana spotting bug control) and Carbaryl or methidathion to control nut borer, and Acephate. Control of minor insect pests occurs when tree is sprayed for main pests.

Avocados

Location
Eighty avocado producers on Atherton Tablelands (includes hobby farmers); orchards are located Malanda, Lake Eacham, Upper Barron, Atherton and Kairi areas. Mature trees tolerate frost; young trees susceptible. Constant overcast and/or wet conditions limit growth; encourage diseases such as phytophthora (root rot) and anthracnose. Soils must be well drained.

Planting
Trees planted in September/October to avoid frost problems. Undertree mini sprinklers installed at planting. Plantings at low, medium or high densities. Main varieties grown on Tablelands Hass and Fuerte.

Harvesting
Trees begin to yield after two years. Harvest from January - May (fruit can remain on trees later). Fruit removed using secateurs or shears. High fruit removed using cherry pickers, ladders or picking poles.

Yield
Range from 12 kg/tree at year three to over 150 kg/tree at maturity.

Fertiliser
From November - March during summer leaf flush or after main fruit drop period. Rate depends on tree size and fruit load. Trees of 2m diameter canopy require about 50g N, 20g P, 50g K over three applications. Mature trees use about 1000g N, 400g P and 1200g K over a year. Fertiliser applied via irrigation system or by spreading. Foliar applications of Zinc and Boron used occasionally. Trace elements, Ca, Mg applied between May - July.

Disease control
Main diseases are phytophora (root rot) and anthracnose. Phythoptora controlled by foliar fungicide sprays or phosphorous acid injections at main root flushes in November and April. Anthracnose controlled with regular spray program from fruit set to harvest using copper based fungicides. Root rot controlled by application of Aliette at a rate of 400g/100L at monthly intervals from about September to April. The soil is kept covered by straw mulch.

Pest control
Fruit spotting bug, fruit fly, loopers, leaf rollers and mites. Spray program of endosulphan from fruit set to harvest controls spotting bug. Use of Dimethoate or Chlorpyrrfos bait sprays start for fruit fly control about six weeks before harvest. Other pests sprayed as required.

Pruning
Tip pruning to develop branching and compact shape carried out on young trees. Thinning of main branches to prolong orchard life occurs. Some growers staghorn (cutting back tree to low stump). Done in spring. Stumps painted with copper fungicide and white acrylic paint to prevent disease and sunburn. Staghorning done over whole block of trees, to prevent pruned trees being shaded out.

Sugar-cane

Location
From Malanda north. New crop on Tablelands. Frost sensitive.

Planting
April June, dependent on climate, variety and crop rotation. Grown from pieces (seeds or billets) and ratoon. Up to 6 ratoon crops. One or two offset discings to remove weeds and volunteer cane; 1-2 rippings; ploughed, then rotary hoed to form fine seed bed.

Harvesting
June until November.

Yields
South Johnstone 85 t/ha; Mossman 102-107 t/ha.

Fertiliser
High analysis NPK plus urea (plant cane); or single application of high analysis NPK (ratoon). Rates as per BSES recommendations. Applied sub-surface behind ripper tine.

Irrigation
Irrigation essential for profitable cane production. Bulk of growth occurs during wet season.

Erosion control
Conventional soil conservation measures, minimum tillage and surface management practices required.

Rotation sequence
Limited amount of legume (soy, mungbean) grown as cover crop, occasional watermelon, pumpkins

Varieties
As per BSES approved varieties.

Pest control
Cane grubs (controlled by suSCan, applied at planting); wireworms (Lorsban applied at planting).

Disease control
Ratoon stunting; Pineapple disease; Rust; *Pachymetra* root rot. Control by resistant varieties, fungicide application at planting (pineapple disease), and sterilisation of equipment and planting material (ratoon stunting).

Tea

Location
Butchers Creek, Topaz, south of Milla Milla. Requires >2000 mm annual rainfall. Frost sensitive. Grown on very strongly to strongly acid (pH 4.5 to 5.5) soils. Tolerates pH 4 - 6. Requires moderately well drained to rapidly drained soils.

Planting
May June (seed); February May (transplanting). Inter-row width 1.8-3.6 metres. 12000-25000 plants/ha. Land preparation only at beginning of long crop cycle (100+years). No specific varieties used. Variety selection presently under evaluation.

Harvesting
About 15 - 20 times a year. Can commence 2 years after planting.

Yields
Range from 2,700 4000 kg/ha made tea (ie. dry weight). 10-20 t/ha (green leaf).

Fertiliser
Applied in single pass mix of 28% N, 2% P, 12% K and 3% S; 3 times a year.

Erosion control
Basic management includes surface drains, levelling.

Disease control
No major diseases.

Pest control
No major pests.

Weed control
Major problem. No herbicides registered for use.

Appendix 4

Land suitability assessment framework

CLIMATE (C)

Changes in climatic characteristics across the study area have a significant impact on plant performance and crop selection. Five climatic zones have been defined, each of which can be distinguished in terms of an effect on at least one land use.

C1 The area immediately to the south of Mapee Road. This area has a relatively low, summer dominant rainfall, with higher temperatures than the other zones. Frosts are extremely uncommon. Agricultural activities include grain and horticultural and vegetable crops.

C2 This zone ranges from Carrington to the Seven Sisters to Lake Tinaroo. The higher rainfall and frost events makes unsuitable for horticultural tree crops (except avocado and custard apples) due to disease and fruit setting problems.

C3 This area includes the northern half of the Eacham Shire and the eastern area around Lake Tinaroo. Increasing rainfall, frost incidence and the high number of rain days make this area marginal for most agricultural practices with the exception of tropical and temperate pastures, maize, peanuts and heavy vegetables.

C4 This zone includes the southern half of the Eacham Shire. A further increase in rainfall and a high number of rain days provide conditions suitable only for pastures, tea, and heavy vegetables. Frosts are generally very uncommon due to the increased cloud coverage but common in isolated patches.

C5 This zone mostly consists of the Evelyn Ranges. The cold temperatures, high frost incidence and low rainfall create conditions suitable only for pastures, heavy vegetables and maize.

Effect
Periods of extremely high rainfall together with extended drizzle during the winter months create conditions which limit photosynthesis for plant growth and cause disease and fruit setting problems. Frosts can either kill or severely restrict growth.

Assessment
High temperatures, high rainfall and extended drizzle either precludes or diminishes production, or reduces the quality of certain crops in parts of the Atherton Tablelands. Frosts are also common occurrences in some areas. Climatic data and local experience has been used to distinguish between zones.

Diagnostic land attributes
The distribution and amount of annual rainfall as an indication of available sunshine hours, mean monthly maximum and minimum temperatures and frost incidence, have been used to define five climatic zones.

Limitation class determination
Crop tolerance data and local experience have been matched with climatic data.

Climatic zones

C1 Mean annual rainfall < 1250mm;
Range maximum temperature 24 to 34
Range minimum temperature 13 to 22
Frosts very uncommon

C2 Mean annual rainfall 1250-1400mm
Range maximum temp. 20-29
Range minimum temp. 10-18
Frost incidence earliest 2 April, latest 2 Oct.
Frost incidence common

C3 Mean annual rainfall 1400-1700
Range maximum temp. 20-28
Range minimum temp. 10-19
Frost incidence common

C4 Mean annual rainfall 1700-4400
Range maximum temp. 20-30
Range minimum temp. 12-19
Frost incidence very uncommon (common in small areas).

C5 Mean annual rainfall 1100
Range maximum temp. 21-28
Range minimum temp. 9-18
Frost incidence earliest 20 May; latest 12 Sept
Frost incidence very common

Land Attribute Level	**Limitation classes for selected land uses**											
	Maize Sorghum Navy Bean Salad	Peanut	Heavy Vegetable	Tea	Sugar	Avocado Longan Custard Apple	Macadamia	Lychee Mango	Stone Fruit	Citrus	Tropical Pasture	Temperate Pasture
C1	1	1	2	5	1	1	1	1	2	2	1	3
C2	2	2	2	4	2	2	2	3	2	3	1	2
C3	3	4	3	3	3	3	3	4	3	4	2	1
C4	4	4	4	2	4	4	3	5	4	4	3	1
C5	2	4	2	5	3	3	3	4	2	4	3	3

WATER SUPPLY (M)

Plant yield will be decreased by periods of water stress during critical crop growth periods. Availability of suitable irrigation water is critical for certain crops.

Assessment
Soil morphological properties together with measured PAWC have been used to assess plant water supply and irrigation frequency.

Diagnostic land attributes
Soil texture and pedality. Measured PAWC for certain soils. Modelling information.

Limitation class determination
The 3/4 boundary was determined by:
- Simple monthly water balance based on mean rainfall
- Complex modelling using the PERFECT model
- Local consultation.

M1 - Pedal, uniform and gradational medium to heavy textured soils

M2 - Pedal, uniform and gradational medium to heavy textured soils B3/C horizon <1m

M3 - Non pedal uniform and gradational medium textured soils

M4 - Duplex soils with medium textured A horizons <0.4 m and heavy textured magnesic B horizon

M5 - Apedal light textured soils often shallow

M6 - Apedal uniform sands

Land Attribute Level	**Limitation classes for selected land uses**						
	Maize Peanut Sorghum	Navy Bean	Salad Heavy Vegetable Tea	Sugar	Avocado Macadamia Lychee Custard Apple Stone Fruit Mango Citrus	Tropical Pasture	Temperate Pasture
M1	1	1	1	1	1	1	1
M2	2	1	2	1	1	1	1
M3	2	2	3	2	2	1	1
M4	3	3	3	3	3	1	2
M5	4	4	4	4	3	2	3
M6	4	4	4	3	4	3	4

SOIL NUTRIENT SUPPLY (N)

Almost all soils on the Atherton Tableland study area require maintenance fertiliser for successful production irrespective of the original vegetation. The majority of nutrients in rainforest soils are held in the biomass, so a rapid decline in fertility occurs following clearing.

The soils of the Atherton Tablelands differ in nutrient status. Soils of granitic origin require greater quantities of the major elements and micronutrients when being developed for improved pasture. There is less difference in maintenance applications of fertiliser between the soil types as this demand is based on replacement of nutrients removed by harvesting/stock. This difference is not a significant cost factor and hence this classification system assumes standard fertiliser rates for all land users, so the majority of soils have not been downgraded on the basis of nutrient supply.

Soil pH has declined due to the effects of agriculture and applied N. Some soils on the Atherton Tableland with low pH require liming to raise the pH and prevent A1 and/or Mn toxicity problems. This is a widespread practice and no soils have been downgraded on this basis. Tea is a major land use on the Atherton Tablelands and the optimum soil pH for tea growing is 4.5 - 5.5. Rapid acidification of subsoil pH is difficult and most areas have, as a result, been classified as unsuitable for tea growing.

High levels of organic matter (around 9%) have been correlated to very high levels of P fixation on the Wet Tropic Coast (Smith 1994). Levels of P fixation of up to 1000 ppm have been recorded and hence require significantly higher fertiliser application rates (Probert *et al.*, 1990). This has not been recorded on the Atherton Tablelands, and the only soil series with such high organic matter levels are Nyleta and Paterson, both of which are found in very limited areas and due to other limitations such as wetness are not used for agriculture. High levels of exchangeable Aluminium are found in soils derived from acid volcanic (rhyolite) parent material.

Effects
Reduced plant growth associated with a shortage or oversupply of nutrients.

Assessment
Based on the need for fertiliser treatment additional to standard application rates and practices. High pH soils have been downgraded according to the effect on tea growth as no effective economic treatment is available. Apart from tea this assumes pH and nutrients can be ameliorated.

Diagnostic Land Attributes
pH, ECEC, Exchangeable Al,

Limitation class determinations
pH: Documented data relating high pH to growth suppression in tea.

Land Attribute Level		**Limitation classes for Tea**
	pH	**Tea**
N1	<5.5	1
N2	5.5-6.0	2
N4	6.0-6.5	3
N4	6.5-7.0	4
N5	>7.0	5

WETNESS (W)

Waterlogged soil conditions occur because of impeded soil profile permeability and/or the presence of a high water table. The combination of the region's geology and topography has resulted in the formation of a majority of soils which are i) moderately to well drained and ii) have medium to high permeability. The soil series to which this limitation applies include the Worsley, Bicton, Walkamin, Gwynne, Wongabel, Carrington, Sylvia, Peterson and Nyleta which combined cover only a small area of the Atherton Tablelands.

Effect
Waterlogged soils reduce plant growth and delay effective machinery operations.

Assessment
Internal and external drainage are assessed. Indication attributes of internal drainage (ie permeability) include texture, pedality and grade of structure, colour, mottle segregation and impermeable layers. Groundwater observations from piezometers are available for selected soils. Slope and topographic position are the indication attributes for external drainage (ie drainage class) capability.

Diagnostic land attributes
Drainage class and soil permeability modified by plant rooting depth requirement. Groundwater data for selected soils.

Limitation class determination
Consultation and crop tolerance information relating growth suppression to economic yield. Severity of effect concerning delays in machinery operation.

This accounts for all aspects of internal (permeability) and external drainage in the existing state. The ease of drainage is also considered in the final assessment. The assessment considers permeability (the ease with which liquids pass through a layer of soil) and drainage (ease of disposal of excess water).

Permeability	Drainage Class
l low permeability	6. Very poorly drained
m medium permeability	5. Poorly drained
h high permeability	4. Imperfectly drained
	3. Moderately well drained
	2. Well drained
	1. Rapidly drained

Land Attribute Level	**Limitation classes for selected land uses**									
	Maize Sorghum Salad Heavy Veg	**Peanut Tea**	**Navy Bean**	**Sugar**	**Avocado**	**Lychee, Custard Apple Macadamia, Longans**	**Stone Fruit**	**Mango**	**Citrus**	**Tropical Temperate Pasture**
W1h	1	1	1	1	1	1	1	1	1	1
W2h	1	1	1	1	1	1	1	1	1	1
W2m	2	2	2	2	2	2	2	2	2	1
W3m	3	3	2	2	3	3	3	2	3	1
W4m	4	4	3	3	4	3	3	3	3	2
W4l	5	5	4	3	5	4	4	3	5	2
W5m	5	5	3	3	5	4	4	3	4	2
W5l	5	5	5	4	5	5	5	3	5	2
W6l	5	5	5	5	5	5	5	5	5	2

FLOODING (F)

Flooding can damage crops by moving water or submersion by standing water. Periods of standing water (inundation) cause damage by creating anaerobic conditions deleterious to both plant and soil micro-organisms. Flowing water can physically damage the crop, expose roots, cover the crop with silt, cause serious erosion or damage infrastructure. On the Atherton Tablelands the topography, soil type and relatively even distribution of rainfall create a condition whereby flooding occurs only in very limited areas, on a small number of soil series. These soil series include the Flaggy, Gwynne, Wongabel, Carrington, Peterson, Nyleta, Tranters, and Sylvia. The area involved is approximately 5% of the Atherton Tablelands. Flooding occurrence is therefore irregular and sporadic on the Atherton Tablelands.

Effect
Field reduction and plant death caused by anaerobic conditions and/or high water levels and/or silt deposition during submersion, as well as physical removal or damage by flowing water.

Assessment
The effect of flooding on individual UMA's is difficult to predict. Flooding frequency has been used to distinguish between suitable and unsuitable land in extreme frequency situations only for intolerant crops.

Diagnostic land attribute
Flooding frequency, and Topographic position.

Limitation class determination
Consultation.

Land Attribute Levels	**Limitation classes for selected land uses**				
	Maize Peanut Sorghum Navy Bean Salad & Heavy Vegetable Sugar	Tea	Avocado	Macadamia Lychee Custard Apple Stone Fruit Mango Citrus	Tropical & Temperate Pasture
F0 No Flooding	1	1	1	1	1
F1 Flooding frequency < 1 in 10 years	1	4	4	2	1
F2 Flooding frequency between 1 in 10 and 1 in 5 years	3	5	5	5	2
F3 Flooding frequency exceeds 1 in 5 years	4	5	5	5	3

LANDSCAPE COMPLEXITY (X)

A unique mapping area may contain a number of managerially different soils which cannot be mapped at the operative map scale, or have dissected topography. A farmer will use the management system which is optimal for the dominant soil type in the production area. This may be suboptional or unsuitable for the minor soil type(s) in that production area.

Effect
An area of suitable land may be too small to justify its use as a separate management unit for a particular land use. This occurs where there is considerable soil complexity and/or topographic dissection.

Assessment
Once limitation classes for each UMA are determined, UMA's with one or more of the following are assessed:

- . Area of suitable contiguous suitable soil less than minimal production area.
- . Dissected topography.

When the area of contiguous suitable soil in a UMA is less than a minimum production area, the area of any contiguous suitable soil in adjacent UMA is also considered on the assessment.

Diagnostic Land Attribute
Production area size

Limitation class determination
The minimum production areas for each land use are determined by consultation.

1. Minimum production area: The minimum area of land which is practicable to utilise for a particular land use.

Land Attribute Level	**Limitation classes for selected land uses**					
Production Area (ha)	Peanuts Maize Sorghum Navy Beans Tea	Avocado Mango Citrus Custard Apple Stone Fruit Lychee	Heavy Vegetable	Tropical Temperate Pasture	Macadamia	Salad Vegetable
>10	1	1	1	1	1	1
5 to 10	1	1	1	1	2	1
2.5 to 5	4	2	2	2	3	1
1.5 to 2.5	4	3	2	2	4	2
1 to 1.5	4	4	3	4	4	3
<1.0	4	4	4	4	4	4

SOIL PHYSICAL CONDITION (P)

Soil structure influences germination rate, soil workability and the ease of extracting clean underground harvest material such as peanuts and potatoes. On the Atherton Tablelands the inherent good structure of soils derived from basalt and granite has resulted in sporadic occurrence of this limitation.

Effect

1. Germination and seedling development problems associated with adverse conditions of the surface soil such as hand setting, coarse aggregates and clays with strong consistency (ps)
2. Difficulties in achieving favourable tilth with machinery on soils with a narrow moisture range for working (pm)
3. Harvesting difficulty and quality of subsurface harvest material affected by soil adhesiveness (pa)

Assessment

1. Soils are evaluated in the context of local experience or knowledge of plant characteristics, for example, seed size, tuberous roots.
2. Local experience indicates problems associated with certain soils, for example narrow moisture range for working.

Diagnostic land attributes

Texture, structure, consistency, soils with a narrow moisture range for working.

Limitation class determination

1. Plant tolerance limits and requirements in relation to germination and harvesting are matched with soil properties and supported by local experience.
2. Local opinion of the severity of the problem of narrow moisture range.

Land Attribute Level		Limitation classes for selected land uses							
		Maize Sorghum Navy Bean	Peanut	Salad Vegetable	Heavy Vegetable	Tea	Sugar	Avocado Macadamia Lychee Custard Stone Fruit Mango Citrus	Tropical & Temperate Pasture
P0	**No restriction**	1	1	1	1	1	1	1	1
P1	**Slightly adhesive**	1	2	1	2	1	1	1	1
P2	**Moderatelyadhesive**	1	3	1	2	1	1	1	1
P3	**Strongly adhesive**	1	4	1	4	1	2	1	1
P4	**Narrow moisture range**	3	4	3	3	1	2	1	1
P5	**Hardsetting massive soil**	3	4	2	4	2	2	2	2
P6	**Hard setting soils with narrow moisture range**	4	4	2	4	2	3	2	2

TOPOGRAPHY (T)

This limitation is used to identify areas where the safe and efficient operation of machinery is restricted by the topography. The safety and manoeuvrability of farm equipment is adversely affected by increasing slope. On complex slopes soil conservation layouts (contour banks and grassed waterways) frequently result in short rows and sharp curves which impede farm machinery use.

Two topographic limits have been determined for safe use of machinery on the Atherton Tablelands. The first is a value of 20% slope for the horticultural tree cropping industry. This has been determined as the safe and efficient limit for year round machinery use in the prevailing climatic conditions. Year round trafficability is necessary because it must be possible to access these crops every day in wet or dry conditions to carry out disease control and other machinery based operations.

A higher value of 30% for the operation of farm machinery in the beef and dairy industry has been determined. The higher figure reflects the flexible nature of these two industries (compared to that of horticultural tree crops) - machinery operations can be deferred until drier conditions occur. In the cropping areas, the higher figure has been adopted; however due to the soil erosion limitation (E) these steeper slopes will be unsuitable for broad acre cropping so a defacto limit of 8% for metamorphic, acid volcanic and granite soils; and 12% for basalt soils has been adopted.

Effect

The safety and/or efficiency of farm vehicle operation is affected by:

Land slopes in relation to roll stability and side slip

Erosion control layouts with short rows and sharp curves in row crops with variability in degree and direction of slope (complex slopes).

Assessment

1. Steepness of slope in relation to safety and efficiency.
2. Variations in slope % causing short rows in erosion control layouts

Diagnostic land attributes

Slope % and Slope % variation

Limitation class determination

1. Land experience and consultation regarding the safe upper machinery slope limit for arable, horticultural tree crop and pasture land.
2. Farmer tolerance of short rows.

Land Attribute Level	**Limitation classes for selected land uses**		
	Maize Peanut Sorghum Navy Bean Salad & Heavy Vegetable Tea Sugar	Avocado Macadamia Lychee Custard Apple Stone Fruit Mango Citrus	Tropical & Temperate Pasture
T1 0-12%	1	1	1
T2 12-20%	4	2	1
T3 20-35%	5	4	2
T4 >35%	5	5	4

ROCKINESS (R)

The rockiness of an area describes the presence of a rock outcrop and/or coarse fragments. Stony or rocky soils deform underground plant parts, impede cultivation and damage machinery. The effects will vary with the size, content and distribution of coarse fragments. The presence of a high stone content in soils may also influence soil properties such as infiltration, erosivity, susceptibility to compaction and soil water storage.

Effect
Coarse (rock) fragments and rock[1] in the plough zone interfere with the efficient use of agricultural machinery. Rock in the plough zone also causes excess wear of tillage implements. Surface rock interferes with the harvesting of peanuts, soybean, potatoes, below ground vegetables and navy beans.

Assessment
Based on the size, abundance and distribution of coarse fragments in the plough layer; and with machinery and farmer tolerance of increasing size and content of coarse fragments.

Diagnostic land attributes
Size and abundance of coarse (rock) fragments (McDonald *et al.* 1990) in the plough layer.

Limitation class determination
Consultation, particularly related to farmer tolerance which are implicitly related to profitability and technological capability.

---

[1] By definition coarse fragments are particles greater than 2mm and are not continuous with underlying bedrock. Rock is defined as being continuos with bedrock.

Land Attribute Level	Limitation Classes For Selected Land Uses					
	Amount %	**Size**	Maize Sorghum Navy Bean Salad & Heavy Vegetable Tea Irrigated Sugar	Peanut Potato	Avocado Macadamia Lychee Custard Apple Stone Fruit Mango Citrus	Tropical & Temperate Pasture
R0			1	1	1	1
R1g	Very few (<2%)	20-60mm	2	3	1	1
R1c	"	60-200mm	1	1	1	1
R1s	"	200 to 600mm	2	2	1	1
R1b	"	>600mm	2	2	2	1
R2g	2-10	20-60mm	2	2	1	1
R2c	"	60-200mm	2	2	1	1
R2s	"	200 to 600mm	2	2	2	1
R2b	"	>600mm	2	2	2	2
R3g	10 to 20	20-60mm	3	3	2	1
R3c	"	60-200mm	3	3	2	1
R3s	"	200 to 600mm	3	3	3	2
R3b	"	>600mm	3	3	3	3
R4g	20 to 50	20-60mm	4	4	3	2
R4c	"	60-200mm	4	4	3	2
R4s	"	200 to 600mm	4	4	4	3
R4b	"	>600mm	4	4	4	4
R5g	50 to 100	20-60mm	5	5	4	4
R5c	"	60-200mm	5	5	4	4
R5s	"	200 to 600mm	5	5	4	4
R5b	"	>600mm	5	5	5	5

WATER EROSION (E)

Soil erosion on the Atherton Tablelands occurs on soils derived from all forms of parent material. However, soils derived from basalt are less susceptible to soil erosion than soils derived from metamorphic, granite and acid volcanic material. This is recognised by a down grading of soils of non basaltic origin for equivalent slopes of basalt soils. Soil erosion does occur under rainforest and permanent pasture, but considerably less than what occurs under cropping. Soil erosion rates on a sloping metamorphic soil under rainforest have been stated as 5-10 t/ha/year. Similar rates under pasture on similar slope and soil type have been recorded.

Effect
Land degradation and long term productivity decline will occur on unprotected arable land over 2% because of excessive soil erosion.

Assessment
Soil loss will depend on soil erodibility and land slope for a particular crop and surface management system. For each soil type there is a maximum slope above which soil loss cannot be reduced to acceptable levels by erosion control measures. This slope is determined in consultation with soil conservation and research personnel, research and extension agronomists, farmers and the use of computer models.

Diagnostic land attributes
Soil series and Slope

Limitation class determination
The difference between limitation class 3 and 4 is based on soil loss tolerance of approximately X tonnes/ha/year. (To judge the effectiveness of soil erosion control measures in bed research trials, modelling and where erosion control measures have been implemented on farms).

The implication of the limitation class for simple slopes[1] are:
E1 Surveyed row direction only required
E2 Conventional structures, surface management practices[2] and pastures phase
E3 E2 measures with a predominance of pasture phase.
E4 Predominance of pasture phase with occasional cropping.
E5 Non-arable land.

[1] Simple slopes - slopes with a constant fall and direction. Complex slopes with variable fall and direction are not suitable for conventional erosion control structures - a topographic (T) limitation has been applied to land with complex slopes.
[2] Surface management practices. A range of options aimed at minimum soil disturbance combined with retention of harvest residue material as a surface cover.

Land Attribute Level	Limitation classes for selected land uses			
	Slope %	**Maize Peanut Sorghum Potato Navy Bean Salad & Heavy Vegetable Tea Irrigated Sugar**	**Avocado Macadamia Lychee Custard Apple Stone Fruit Mango Citrus**	**Tropical & Temperate Pasture**
Granite, metamorphic & acid volcanic (rhyolite) soils				
E1a E1g E1m E1o	**0-1%**	1	1	1
E2a E2g E2m E2o	**1-5%**	2	1	1
E3a E3g E3m	**5-8%**	3	2	1
E4a E4g E4m	**8-20%**	4	2	2
E5a E5g E5m	**20-35%**	5	4	2
E6a E6g E6m	**>35%**	5	5	4
Basalt & alluvial soils				
E1b E1o	**0-1%**	1	1	1
E2b E2o	**1-3%**	1	1	1
E3b	**3-5%**	2	1	1
E4b	**5-8%**	3	1	1
E5b	**8-12%**	3	1	1
E6b	**12-20%**	4	3	2
E7b	**20-35%**	5	4	2
E8b	**>35%**	5	5	4

Appendix 5

A Soil Key for the Atherton Tablelands

Contents

List of figures

Acknowledgements

This key has been produced with the assistance of the National Landcare Program. The authors gratefully acknowledge the assistance given by Doug Smith DNR Resource Science Centre, Indooroopilly, Dr Ian Webb, DNR Mareeba, and Pieter Warnaar. The assistance by members of TREAT, staff at CSIRO Tropical Forest Research Centre and DoE at Atherton and Lake Eacham during field testing of this key is gratefully acknowledged.

1. Introduction

The Atherton Tablelands Soils and Land Suitability Study investigated the soils of the district - from just south of Walkamin to south of Millaa Millaa; east to the Bellenden Ker National Park, and west to Herberton. The study area is approximately 160 000 ha.

There are twelve major land uses occurring within the study area. The dominant land uses in the northern area are peanut and maize production, while in the southern area, around Malanda and Millaa Millaa, the dairy industry is the major land use. There is also a large area of land under the management of the Wet Tropics Management Authority.

Mapping work carried out by Departmental Officers Don Malcolm and Brett Nagel identified twenty - four different soil types, formed on basaltic, granitic, metamorphic and acid volcanic parent materials. Eight soils formed on alluvium derived from one or all of the above mentioned parent materials were also identified.

i) Soils of the Alluvial Flats and Fans generally occur in small areas to the north and northwest, with small scattered areas in the south.

ii) Basaltic derived soils formed on the Lava Flows and Cinder Cones make up over 50% of the soils and are found generally in the centre of the study area.

iii) Metamorphic derived soils are found in the eastern rim of the study area and to the east, immediately around Lake Tinaroo.

iv) Granite derived soils are found in three main areas - immediately north of Tinaroo Dam; the south-east area and central west of the study area.

v) Acid Volcanic derived soils are found in the south-west and north-west rim of the study area.

This key has been produced to assist landowners, students, and community groups to easily identify the soils in their area. The major feature of the key is the lack of technical soil descriptive phrases; rather the emphasis has been on those features of the soil which can be readily identified in the field by the non soil specialist. Some technical terms are used and these are explained in the glossary.

Correct identification of the soil will assist the landowner/community group in the sustainable management of their soils. The key is designed to be used in conjunction with Fact Sheets, which give further details regarding the soil and the opportunities associated for appropriate use with each soil type. These Fact sheets are available from the Development Extension Officer, DNR Mareeba. Technical descriptions, including detailed chemical and physical information, is contained in the report, which can also be obtained from the Development Extension Officer.

2. What you need

i) A **fresh** soil face; ie a road cutting, creek bank, a spade or an auger hole. A soil profile exposed to the elements loses colour quickly, so a fresh face will make the process easier. Where there is some doubt about the soil type, try nearby sites - you may be on a boundary between two or more soil types!

ii) A weak solution of peroxide (to identify nodules accurately) and an eye dropper is needed to identify nodules (refer to the **Glossary** located at the end of the key for further information).

3. How to use the key

i) Identify the parent material. Locate the area in question on the geology map (Figure 1) for the whole region and note which parent material(s) occur in the area.

ii) Turn to the page containing the questions on the relevant parent material. Where there is doubt on the correct parent material, try the questions for the adjacent parent materials. Look for surface rock in the immediate area. Boulders of granite or basalt are easily identifiable. There are occasionally small areas (outcrops) of older material amongst younger material. To assist the user to determine the amount of mottles, nodules and coarse fragments there are in the profile, a chart has been provided (see Figure 2). Avoid areas adjacent to roads or similar disturbance where there may be “introduced” rocks.

iii) Answer the questions until the soil association is determined. The questions refer to the most obvious characteristics which differentiate one soils association from another.

iv) A glossary is located at the back of the key to assist the user if a term is unfamiliar. This glossary is for use with the Soils Key and associated Fact Sheets.

Information on the properties of a soil association is gained from the key; additional information is available on the Fact Sheets and the report.

4. Table of soil and parent material

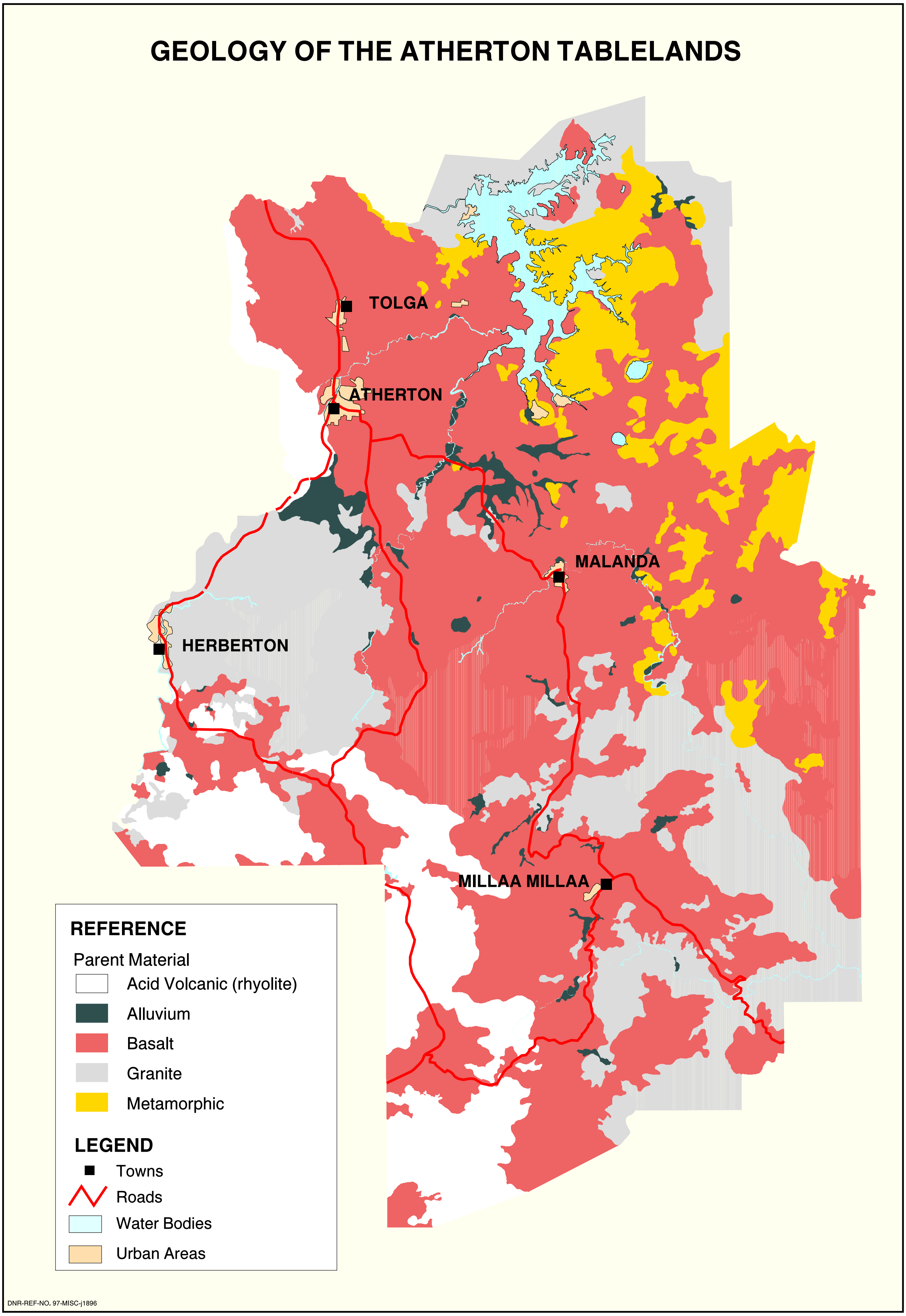
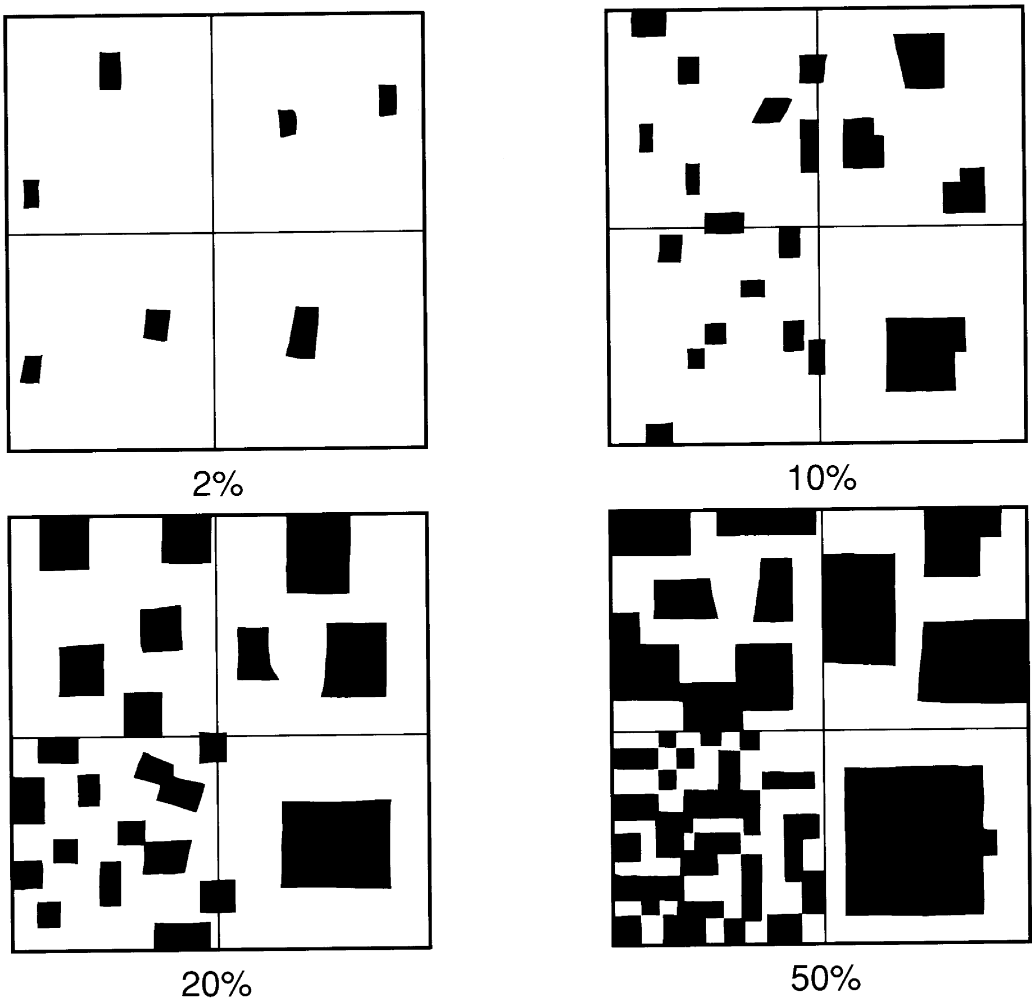


Figure 1 - Geology of the Study Area



Each quarter of any square has the same area of black

Chart for estimating abundance of

mottles and coarse fragments

Figure 2 Abundance Chart

5. Alluvial soils derived from basalt, granite, acid volcanic or metamorphic material

1. Dominant colour in B horizon

i) Grey, dark grey or black **2**
ii) Red-brown, brown, or dark brown **3**

2.

i) Soil consists of decomposing organic matter (Peat), very poorly drained ....**Nyleta**

ii) Very deep apedal clay soil. Coarse fragments absent; mottles present. No sand in profile; very poorly drained.. ....**Peterson**

iii) Deep apedal sandy soil becoming more clayey with depth. Some coarse fragments (quartz) throughout profile; mottles present; poorly drained .... **Wongabel**

iv) Deep pedal clay soil. Coarse fragments absent; mottles present. Sand generally present throughout profile; amount increases with depth; poorly drained.................. **Carrington**

3.

i) Very deep pedal clay soil. Well drained A few faint orange mottles in A horizon and in D horizon .... **Tranters**

ii) Very deep pedal clay soil. Manganese nodules present throughout profile. Poorly drained .... **Gwynne**

6. Soils derived from basalt

1. Dominant colour in B horizon

- i) Brown or dark brown **2**
- ii) Red **3**
- iii) Yellow brown **4**

2.

- i) Deep pedal clay soil with abundant basalt fragments on surface and throughout profile; often increasing with depth. May be a few manganese nodules in profile........... **Barron**
- ii) Moderately deep clay soil with many basalt scoria in profile. A few to many manganese nodules in profile. Formed on cinder cones eg Seven Sisters or Mt Quincan **Quincan**
- iii) Very deep pedal clay soil may have a few coarse fragments (basalt) in profile. Found south of Malanda .... **Maalan**
- iv) Deep pedal clay soil with mottles throughout profile. Some basalt stone may be present at depth. Found north of Tolga in depressions around basalt outcrops...............**Morgan**
- v) Deep pedal clay soil with manganese nodules and basalt fragments present throughout profile; found in and around basalt outcrops in north and west area .... **Snider**

3.

- i) Very deep pedal clay soil with some basaltic scoria throughout the profile. Found on the footslopes of cinder cones eg Seven Sisters or Mt Quincan .... **Heales**
- ii) Very deep pedal clay soil; basalt fragments may or may not be present at depth…………………………………………………………………….…**Pin Gin**
- iii) Very deep pedal clay soil, no basalt fragments. A few to many manganese nodules. Found on flat to gently sloping around Atherton and Tolga.................................….**Tolga**
- iv) Very deep pedal clay soil. No basalt fragments. A few to many manganese nodules. Found on flat to gentle rises in Wondecla area ....**Kaban**

4.

- i) Deep pedal clay soil. No basalt fragments. Mottles present in B horizon. Ferro-manganiferous nodules common throughout profile. Found in the Evelyn Tablelands ....**Millstream**
- ii) Deep pedal clay soil. Surface rock present, some coarse fragments (basalt) in mottled B horizon. Many ferro-manganiferous nodules. Found north of Tolga……….. **Walkamin**

NB Kaban, Tolga, Pingin, & Maalan Soils Kaban & Tolga soils are very similar; the difference being minor; a slight difference in the structure of the A1 and $B2_3$ horizon, and Kaban is slightly darker. "Kaban" was first used by the Ravenshoe Mt Garnet survey (Heiner and Grundy 1994); "Tolga" by the Laffan (1988) study of the Tablelands; both have neutral pH. A Pin Gin is similar to both but with acidic pH. A Maalan is generally similar to the other three except is a browner soil with acidic pH.

7. Soils derived from granite

1. Dominant colour in b horizon

i) Red or Yellow-red **2**
ii) Brown or Yellow-brown **4**

2.

i) Deep, pedal loamy soil becoming more clayey with depth. Some fine quartz present in profile. Found only in Herberton-Wondecla region ....**Expedition**

ii) Quartz pebbles in profile **3**

3.

i) Very deep apedal sandy soil becoming more clayey with depth. Mottles absent. Some coarse fragments of quartz. Sandy texture and structure ....**Gowrie**

ii) Very deep pedal sandy soil, becoming more clayey with depth. Mottles present at depth. Some coarse fragments of granite at depth. Well structured soil .... **Utchee**

4.

i) Deep pedal clay soil. Mottles present in B horizon. A few quartz pebbles throughout profile ....**Severin**

ii) Sandy soil **5**

5.

i) Very shallow apedal sandy soil with some coarse fragments of granite. Found only in Herberton-Wondecla region .... **Nettle**

ii) Very deep apedal sandy soil. Mottles absent. Many quartz pebbles throughout the profile ....**Gillies**

8. Soils derived from metamorphic material

1. Dominant colour in B horizon

i) Red **2**
ii) Yellow-brown **3**

2. Deep sandy soil becoming more clayey with depth. Mottles throughout the profile. Some coarse fragments of quartz and schist throughout the profile, amount increases with depth. Has a fine sandy feel. Found only on the eastern edge of study area .... **Galmara**

3. Very deep, sandy soil becoming more clayey with depth. Mottles throughout the B horizon. Some coarse fragments of quartz throughout the profile, amount increases with depth. Some schist and phyllite found at depth. Has a fine sandy feel. Found only on the eastern edge of study area ....**Bicton**

9. Soils derived from acid volcanic material

1. Dominant colour in B Horizon

I) Yellow-brown **2**
ii) Yellow-red **3**
iii) Red **4**
iv) Grey **5**

2.

i) Shallow apedal sandy soil with abundant rhyolite fragments on surface and throughout profile. .... **Whelan**

ii) Moderately deep pedal clay soil with rhyolite fragments throughout the profile amount increasing with depth. Some orange mottles in B horizon .... **Worsley**

iii) Deep apedal sandy soil with rhyolite fragments at depth. Mottles in B Horizon. Found in Herberton **-** Wondecla area .... **Flaggy**

3. Deep pedal soil with clay B horizon with some to many mottles and a few coarse fragments (rhyolite fragments) in the B horizon .... **Umala**

4.

i) Very deep pedal soil; no mottles; quartz phenocrysts throughout; very few coarse fragments (rhyolite) ....**Bally**

ii) Very deep soil with sandy A horizon and pedal clay B horizon. Mottles present in B horizon ....**Mazlin**

5. Deep soil with sandy A horizon and pedal clay B horizon. A few coarse fragments (rhyolite) in the B horizon. Mottles present in the B horizon .... **Sylvia**

10. Glossary

This terms in this Glossary were compiled and modified from the sources listed in the Reference section

Acid Volcanic Rock **-** pale coloured (white, pink or yellow), fine grained rock containing small crystals of quartz; also feldspar, biotite and/or hornblende. Also contains low levels of Iron (Fe), Magnesium (Mg) and Calcium (Ca). Classified as acid as it contains more than 66% silica. Most common form of acid volcanic rock in the project area is **rhyolite**.

Alluvial Soils - these are soils which are formed from the action of water. Material is carried by water and then deposited when the water slows down. This material is found only on low lying areas, eg along creek flats, and in depressions.

Australian Soil Classification **-** a new classification scheme developed over the last five years. The order names end in **ol** eg.

- Dermos**ol**: is a well structured soil and does not have a clear or abrupt boundary between the A and B horizon;
- Ferros**ol**: has a structural B horizon which is high in Iron (Fe and therefore red), and lacks a major change in texture between the A and B horizon.

Basalt **-** fine grained basic volcanic rock; the most common volcanic rock.

Boundaries **-** the distance over which the soil changes from one horizon to the underlying horizon.

- a **<u>sharp</u>** boundary has a width of 5mm,
- an **<u>abrupt</u>** boundary has a width of 5-20mm,
- a **<u>clear</u>** boundary 20-50-mm,
- **<u>gradual</u>** boundary 50-100mm.

Climatic Zones – The project
The project area has been divided into five climatic zones as outlined below.

<u>C1</u> The area immediately to the south of Mapee Road. This area has a relatively low (<1250mm), summer dominant rainfall, with higher temperatures than the other zones. Frosts are extremely uncommon. Agricultural activities include grain and horticultural and vegetable crops.

<u>C2</u> This zone ranges from Carrington to the Seven Sisters to Lake Tinaroo. The higher rainfall (1250 – 1400 mm) and frost events creates conditions unsuitable for horticultural tree crops (except avocado and custard apples) due to disease and fruit setting problems.

<u>C3</u> This area includes the northern half of the Eacham Shire and the eastern area around Lake Tinaroo. Increasing rainfall (1400 - 1700), high frost incidence and the high number of rain days make this area marginal for most agricultural practices with the exception of tropical and temperate pastures, maize, peanuts and heavy vegetables.

<u>C4</u> This zone includes the southern half of the Eacham Shire. A further increase in rainfall (1700 - 4400) and a high number of rain days provide conditions suitable only for pastures, tea, and heavy vegetables. Frosts are uncommon due to the increased cloud coverage.

<u>C5</u> This zone mostly consists of the Evelyn Ranges. The cold temperatures, high frost incidence and low rainfall (average 1100mm) create conditions suitable only for pastures, heavy vegetables and maize.

Coarse Fragments - are particles greater than 2 mm in diameter which are remnants of parent material; the size categories used are:

- **gravels** 2-60 mm; (**scoria** gravels red in colour with a rough surface and usually resemble honeycomb and are of light weight);
- **cobbles** 60-200 mm
- **stones** 200-600 mm diameter.
- **boulders** >600mm

The percentage of coarse fragments in each horizon varies; Appendix 1 is a guide to the visual estimation of abundance:

- "**a few**" coarse fragments is equivalent to 0-10% of the horizon made up of coarse fragments;
- "**some**" coarse fragments 2-20%;
- "**many**" 20-50%;
- "**abundant**" 50-90%.

Clay - soil material consisting of particles less than 0.002mm in diameter.

Colluvium - material which has moved from an upslope position and accumulated in a lower slope position by gravitational movement. Differs from ***alluvium*** which is material which has been moved by water and deposited in very gentle slopes.

Cultivation Slope Limit - the maximum slope at which cultivation can occur on an area which is protected by soil conservation measures (ie. contour banks, grassed waterways), without causing soil erosion. The slope limit for cultivation is 12% for basalt soils and 8% for acid volcanic, granite and metamorphic soils.

Granite - medium to coarse grained, light coloured, composed mainly of quartz, feldspar, biotite and/or hornblende.

Great Soil Group - a group of soils with similar features and generally having similar agricultural suitability. The most commonly used part of the Great Soil Group Classification Scheme. There are over forty Great Soil Groups recognised in Australia. This soil classification scheme has been used for over twenty years and is being replaced by the Australian Soil Classification Scheme.

Hil l- area of relief 90-300 metres high with gentle to precipitous slopes.

Horizon - is a layer of soil, approximately parallel to the land surface, with properties differing from layers above and/or below.

- The **A horizon** is the surface horizon; usually darker in colour (due to organic material) than the underlying horizons. Is often sub-divided into A_1, A_2 and A_3
    - A **bleached** A_2 is lighter than the overlying A_1.
    - The **A_3 horizon** is a transitional horizon between the A and B horizons, but is more like the A horizon than the B horizon.
- The **B horizon** differs from the A horizon by a range of properties including stronger colours and a higher percentage of clay. The B horizon consists of one or more layers (B_1, B_2, B_3).
    - The **B_1 horizon** is a transitional horizon between the A and B horizons, but is more like the B horizon than the A horizon.
    - The **B_2 horizon** is the major part of the soil profile and is further sub-divided by minor differences in some properties eg colour, texture, into B_{21}, B_{22}, B_{23}
    - The **B_3 horizon** is a transitional horizon between the B and C horizon with the properties of the B horizon dominant but some properties of the C horizon evident.

- The **C horizon** is material below the B horizon which is partially weathered and may be the parent material from which the soil was formed. (Northcote *et al.*, 1979)

Insitu **-** formed in place ie material that is formed insitu has not been transported anywhere; as opposed to an alluvial/colluvial soil which has formed where the material has been deposited.

Lava **-** magma which has flowed onto the earths surface.

Limitations **-** are factors that restrict the land use options available to a landowner eg. the farm may be in an area which is heavily frosted, therefore the landowners choice of crop is restricted to frost tolerant crops.

Magma **-** a hot liquid beneath the earths surface containing suspended crystals and dissolved gases; molten rock.

Metamorphic Rock **-** is rock which has been chemically and physically altered by heat and pressure. Schist and quartzite are two common types.

Mottles **-** are spots, blotches or streaks differing from the main colour of the profile. Mottles generally indicate a fluctuating water table. The percentage of mottles in each horizon varies;
- "**a few**" mottles is equivalent to 0-10% of the horizon made up of mottles;
- "**some**" mottles 2-20%;
- "**many**" 20-50%; and
- "**abundant**" 50-90%.

Nodules **-** are small irregularly shaped segregations in the soil resulting from the concentration of an element. **Manganese** (Mn) nodules are black; **Ferromanganiferous** nodules are a combination of iron (Fe) and manganese and are reddish-black. Both fizz on application of H_2O_2 (peroxide); manganese nodules more strongly. The Mn contained in these nodules are unavailable to plants unless pH drops below 5.5.

Orogeny **-** a mountain building period; when rock is pushed upwards by earth movement.

PAWC (Plant Available Water Capacity) **-** ability of the soil to store water which is available to plants.

Pedal - a characteristic of the soil; a pedal soil has observable peds (see ***Structure***). The opposite is *apedal*

Permeability **-** the ease in which water, gases, or plant roots moves through the soil. A soil with good structure has high permeability.

pH - The negative logarithm of the hydrogen ion activity of a soil. The pH of the soil measures the amount of available H+ ions in the soil. This property affects the availability of nutrients to plant growth. The optimum pH for most plants (ie when most nutrients are available for plants) is 6-7.
- A **very acid** soil has a pH less than 5.5
- **moderately** acid 5.5-6.5
- **weakly** acid 6.5-7
- **neutral** 7.
- **alkaline** >7.5

Phenocrysts **-** small crystals resembling sand, found in the soil. These are formed when the magma cools slowly, enabling a few crystals to develop; conditions change and the magma is then cooled quickly, preventing other crystals developing.

Quartz **-** clear or white coloured crystals of silica. Hard, with sharp edges. Very common mineral of rock. Chemical composition generally SiO_2.

Principal Profile Form **-** is a coded description of the soil profile. This is part of the Northcote Soil Classification Scheme, the third major scheme used in Australia. Use of this classification scheme is declining in favour of the much newer Australian Soil Classification Scheme. For further detail see "A Factual Key For The Recognition of Australian Soils, (Northcote *et al*.,1979).

Pyroclastic rocks **-** rocks formed by the accumulation of fragmental materials thrown out by volcanic explosions for example *scoria*.

Rhyolite **-** see ***Acid Volcanic Rock***

Rise **-** is a small hill of elevation 9-30 metres with very gentle to steep slopes.

Safe Machinery Limit **-** maximum steepness of slope on which machinery can be safely driven without major risk of machinery overturning. The safe machinery limit for machinery used in the horticulture industry is 20% (x0), and 35% for that used in the dairy/beef industry.

Sand **-** see **Texture**

Scoria **-** see ***Coarse Fragments***

Silt **-** soil material with a diameter between 0.002 and 0.02 mm.

Slopes **-** a 1% slope has a rise of 1 in 100; a 10% slope a rise of 10 in 100. Categories used are:
- **level** 0-1%
- **very gentle slopes** 1-3%
- **gentle** 3-10%
- **rolling** 10-20%
- **steep** 20-30
- **very steep** >30%.

Structure **-** refers to the distinctness, size and shape of peds. A ped consists of a number of primary particles and is an individual soil aggregate. Peds with:
- **prismatic** and **columnar** structure have flat vertical sides and flat (prismatic) or domed (columnar) tops.
- **blocky** structure have six roughly flat faces.

A soil with good structure has better drainage than a soil with poor structure. Soil structure influences pH and other soil characteristics. A soil with poor structure has an earthy appearance and can be broken in any direction.

Texture - the proportion of sand, silt and clay in a soil. A soil with a higher percentage of clay is generally more fertile than a soil with a low clay content, although this is affected by the parent material. A
- **clay loam** has about 30-35% clay;
- a **light clay** 35-40%, and
- a **medium clay** 45-55%.

A **sandy** soil has a gritty feel, with the sand particles visible. When rubbed close to the ear, the rubbing of the sand particles is heard.

***Vegetation* -** is described as consisting of several layers.

- The **upper storey** is the upper most layer of leaves (the canopy).
- The **mid-storey** is the middle layer.
- The **understorey** is comprised of grasses and low shrubs.

Terms used to describe vegetation include;

- **Complex -** indicates an abundance of epiphytes (eg. staghorns), lianas, and buttresses on trees.
- **Mesophyll -** a leaf size: ranges from 125-250mm. Leaf size is affected by climate and soil fertility and is an important descriptive tool when classifying rainforests.
- **Vine forests -** a type of rainforest where vines, twining or scrambling plants drape the tallest trees, covering at least 60% of the exposed surface.

Appendix 6

Land Type Sheets for the Atherton Tablelands

Contents

NATIONAL LANDCARE PROGRAM

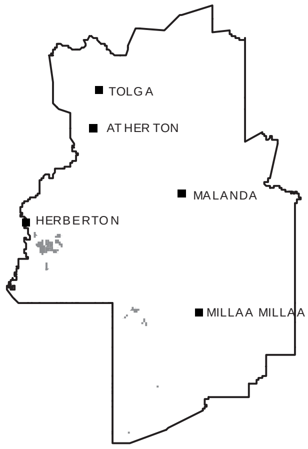
LAND TYPES OF THE ATHERTON TABLELANDS

BALLY (By) 680ha

NATURAL RESOURCES

Climate Zone

- annual rainfall 1700-4440 mm; frosts uncommon (C4)
- 1100mm; frosts very comon (C5)



Landform and Geology

- moderately to steeply sloping hills
- acid volcanic (rhyolite)

Vegetation

- tall open forst of *Euclyptus acmednoides, E grandis*
- medium and low woodlands of *E intermedia E citriodora*

vine forests with *E grandis, acacia melanoxylon*

Soil Characteristics

- very deep moderate structured
- acid (pH 4.5-6.0)
- red to red-brown
- a few fhyolitic fragments

Land Use Characteristics

Productive Features

- good moisture holding capacity
- good physical structure
- well drained soil

Limitations

- found in frost prone zone (C5)

Australian Soil Classification: Red Dermosol

Great Soil Group: No Suitable Group, affinities with Red Podzolic

Principal Profile Form: Gn3.11, Gn3.14

Horizon/Depth (cm)	Soil Description
A1: 10 - 15	Dark or reddish brown; clay loam; moderate 2-5 mm granular. Clear change to:
A2: 20 - 65	(Where present) Red pale (dry); clay loam; well structured; a few 2-5 mm manganese nodules. Clear to gradual change to:
B21: 50 - 100	Red or red-brown; light to medium clay; some small quartz pebbles; well structured; a few <5 mm manganese nodules. Diffuse change to:
B22: 70 - 150	Red; light to medium clay; a few small quartz pebbles; well structured; a few <5 mm manganese nodules;
B3:	Occasionally occurs below 1.35 m

Land Use Suitability

- Summer Crops: Maize, sorghum, navy beans, sugar
- Winter Crops: Salad and heavy vegetables mango & citrus
- Tropical & temperate pasture, tea (subject to climatic & topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needed on slopes slopes >2% (1.2^0)
- Cultivation on slopes >8% (4.5^0) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion slopes >2% (1.2^0)

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess QDPO Mackay

Author I. Sinclair QDPI Mareeba 1997

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

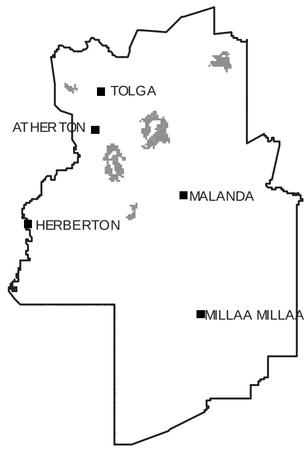
LAND TYPES OF THE ATHERTON TABLELANDS

BARRON (Bn) 3174 ha

NATURAL RESOURCES

Climate Zone

- annual rainfall >1250 mm (C1)
- 1250-1400 mm; frost common (C2)
- 1400-1700 mm; frosts common (C3)
- 1700-4400 mm; frosts uncommon (C4)



Landform and Geology

- gently undulating plains and undulating rises
- Atherton basalt of Pleistocene Age

Vegetation

- complex mesophyll vineforest
- rainforest regrowth *Melia azedarach* white cedar; *Neolitstia dealbata* grey bollywood
- open forest of *Eucalyptus clarksoniana* bloodwood, *E tereticornis blue gum*

Soil Characteristics

- brown, well structured clay soil
- amount of basalt pebbles increases with depth
- pH mildly acid to mildly alkaline
- may have abundant rock on surface

Land Use Characteristics

Productive Features

- pH suitable for a wide range of crops
- very well drained soil
- good soil moisture holding capacity

Limitations

- high amount of rock throughout profile interferes with pasture managment
- often found on steep slopes where erosion can occur if cultivated or overgrazed

Australian Soil Classification: Brown Ferrosol

Great Soil Group: Prairie Soil

Principal Profile Form: Uf6.31

Horizon/Depth (cm)	Soil Description
A1: 5 - 20	Brown or dark light to light medium clay; a few small basalt pebbles; well structured; Clear change to:
B21: 40 - 70	Brown or dark; light medium clay; a few basalt pebbles; well structured; Gradual or diffuse change to:
B22: 80 - 120	Brown; light medium clay; a few to many basalt pebbles; well structured; a few small manganiferous nodules; Gradual change to:
B3: 90 - 130	Brown or dark; light medium clay; many 20-60mm basalt pebbles; well structured; Gradual change to:
BC: 100 - 150	Brown or dark; light medium clay; very many basalt pebbles; well structured; a few 2-6mm manganese nodules.

Land Use Suitability

- Summer Crops: Maize, sorghum, navy beans, sugar cane
- Winter Crops: Salad and heavy vegetables mango & citrus
- Tree Crops: All tree crops, tea
- Tropical & temperate pastures (subject to climatic & topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needced on slopes >2% (1.2^0)
- Cultivation on slopes >8% (4.5^0) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

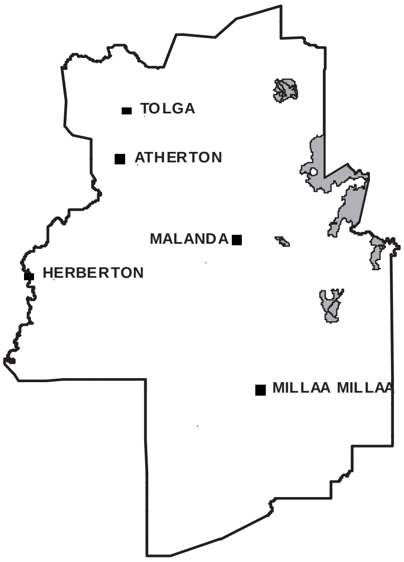
LAND TYPES OF THE ATHERTON TABLELANDS

BICTON (Bt) 3967ha

NATURAL RESOURCES

Climate Zone

- annual rainfall 1250-1400 mm; frost common (C3)
- 1700-4400 mm; frosts uncomon (C4)



Landform and Geology

- rolling low hills and steep low hills
- Barron River metamorphic

Vegetation

- complex mesophyll vine forest
- improved pasture: *Setaria* spp., *Brachiaria* spp., Tinaroo Glycine

Soil Characteristics

- yellow/yellow-brown sandy clay soil
- orange and red mottles in B horizon
- pH acid (5.5-6.5)

Land Use Characteristics

Productive Features

- Moderate moisture holding capacity
- pH suitable for a wide range of crops

Limitations

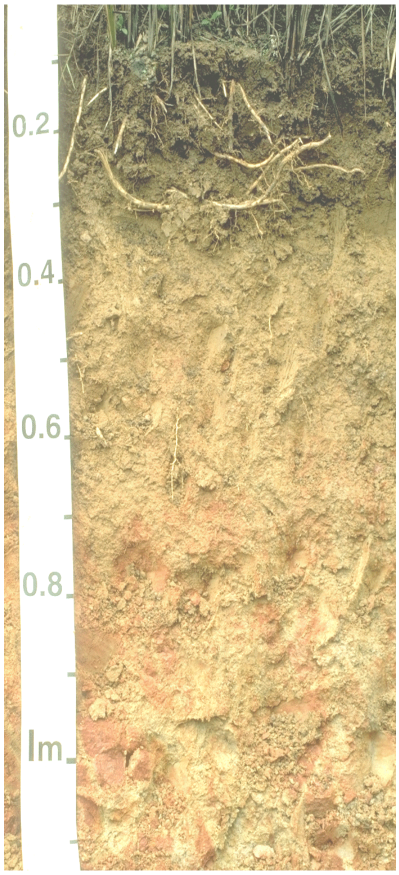
- Frosts common
- Imperfectly drained soil
- Moderately adhesive soil
- Susceptible to soil erosion on slopes greater than 2%

Australian Soil Classification: Brown Dermosol

Great Soil Group: No Suitable Group

Principal Profile Form: Gn3.74, Gn3.71, Gn3.94

Horizon/Depth (cm)	Soil Description
A1: 12 - 18	Brown or grey; clay loam to sandy light clay; well structured; Clear change to:
A2: 19 - 26	Yellow-brown or grey; silty clay loam to light clay; a few 6-20mm quartz pebbles; well structured; Clear or gradual change to:
B21: 60 - 110	Yellow or yellow-brown; a few 5-15mm distinct red and orange mottles; silty light clay to light medium clay; a few 6-20mm quartz pebbles; well structured; Gradual to diffuse change to:
B3: 84 - 120	Yellow or yellow-brown; a few 5-30mm distinct orange and red mottles; clay loam; 50-90% schist and phyllite fragments; weak structure.
C: 100 onwards	parent material of schist and phyllite.



Land Use Suitability

- Summer Crops: sugar cane
- Winter Crops: Nil
- Tree Crops: Macadamia, custard apple, stone fruit
- Tropical & temperate pastures (subject to climatic & topographic influences and variation in rock levels)

Management Recommendations

- Soil conservation measures needced on slopes >2% (1.2^0)
- Cultivation on slopes >8% (4.5^0) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources
- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess QDPI Mackay

Author I. Sinclair QDPI Mareeba 1997

NATURAL RESOURCES

LAND TYPES OF THE ATHERTON TABLELANDS

NATIONAL LANDCARE PROGRAM

NATURAL RESOURCES

CARRINGTON (Cn) 567ha

Climate Zone

- annual rainfall 1250-1400 mm; frosts common (C2)
- 1400-1700 mm; frosts comon (C3)
- 1100 mm; frosts very common (C5)

Landform and Geology

- flat to gently undulating alluvial plains
- Quaternary alluvium of granite and rhyolite

Vegetation

- low open forest *Melaleuca spp. Lophostemon suaveolens,*
- open forest: *Eucalyptus tereticornis*

Soil Characteristics

- mottles present throughout profile
- poorly drained
- pH acid (5.5-6.5)
- grey-brown or grey

Land Use Characteristics

Productive Features

- good moisture holding capacity
- pH suitable for a wide range of crops

Limitations

- very poorly drained soil
- strongly adhesive nature makes these soils unsuitable for below ground vegetables
- areas in which these soils occur are frequently flooded making these soils unsuitable for tree crops
- occurs in frost prone areas

Australian Soil Classification: Redoxic Hydrosol

Great Soil Group: Humic Gley

Principal Profile Form: Uf6.41, Uf4.2, Uf6.7, Gn2.41

Horizon/Depth (cm)	Soil Description
A1: 12 - 17	Dark or grey; a few 5-15mm distinct orange mottles; light to medium clay; well structured; Diffuse change to:
A2: 20 - 36	Grey; some 5-15mm distinct orange mottles; light clay to medium clay; moderate structure; Gradual change to:
B21: 48 - 63	Grey-brown or grey; some 5-15mm distinct orange mottles; fine sandy light clay to sandy light medium clay; moderate structure; Gradual change to:
B22: 66 - 80	Grey-brown or grey; some 5-30mm distinct orange mottles; sandy medium clay to medium clay; moderate structure; Gradual change to:
D: 90 - 130	Grey); some 5-15mm distinct orange mottles; sandy clay loam to sandy light medium clay; poor structure.

Land Use Suitability

- Summer Crops: Nil
- Winter Crops: Nil
- Tree Crops: Nil
- Tropical & temperate pastures (subject to climatic & topographic influences)

Management Recommendations

- Soil conservation measures needced on slopes >2% (1.2^0)
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess QDPI Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

LAND TYPES OF THE ATHERTON TABLELANDS

EXPEDITION

NATURAL RESOURCES

Climate Zone

- annual rainfall 110 mm; frosts very common (C5)

Landform and Geology

- Footslopes or pediments of gently to undulating low hills
- Tully Granite

Vegetation

- Medium and Low Woodlands

  Eucalyptus drepanophylla, E acmenoides, E clarksoniana understory of Acacia spp

Soil Characteristics

- Red/red-brown light textured soil
- pH slightly acid
- well drained

Land Use Characteristics

Productive Features

- pH suitable for a wide range of crops
- very well drained soil
- this soil only slightly adhesive
- majority of these soils ar rock free
- soils are flood free
- found on flat to sloping land

Limitations

- Soil found in a frost prone area
- not suitable for cultivation on slopes >8%

Australian Soil Classification: Red Kandosol

Great Soil Group: Red Earth

Principal Profile Form: Gn2.15, Gn2.11, Dr4.61, Dr4.62

Horizon/Depth (cm)	Soil Description
A1: 10 - 15	Brown red-brown or dark; loamy coarse sand to sandy loam; single grain. Clear to gradual change to:
A2: 20 - 35	(where present) Pale (dry) loamy coarse sand to sandy loam; single grain; Clear change to:
B1: 40 - 60	(where present) Red-brown; coarse sandy loam to sandy clay loam; apedal. Gradual change to:
B2: 65 - 150	Red; clay loam sandy to coarse sandy light medium clay; poor structure

Land Use Suitability

- Summer Crops: Maize, sorghum, potatoes, navy beans, sugar
- Winter Crops: Potatoes
- Tree Crops: Avacado, macadamia, custard apple, stone fruit
- Tropical & temperate pastures

Management Recommendations

- Soil conservation measures required on slopes >2%
- Should not be cultivated on slopes >8%

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess QDPI Mackay

Author I. Sinclair QDPI Mareeba 1997

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

LAND TYPES OF THE ATHERTON TABLELANDS

FLAGGY

NATURAL RESOURCES

Climate Zone

- annual rainfall 1100 mm; frosts very common (C5)

Landform and Geology

- Slopes of level to gently undulating plains
- Glen Gordon volcanics

Vegetation

- Medium and Low Woodlands

  Eucalyptus drepanophylla, E. clarksoniana, E. papuana

Soil Characteristics

- Red/red-brown light textured soil
- pH slightly acid
- well drained

Land Use Characteristics

Productive Features

- pH suitable for a wide range of crops

Limitations

- This soil found in a frost prone area
- This soils is not well drained
- Hardsetting, massive soil impedes germination
- Can contain high amounts of rock
- Flooding occurs infrequently
- these soils should not be cultivated on slopes >8%

Australian Soil Classification: Yellow Kandosol

Great Soil Group: Yellow earth

Principal Profile Form: Gn2.31, Gn2.21, Gn2.22, Dy3.81

Horizon/Depth (cm)	Soil Description
A1: 10 - 12	Dark or grey; sandy clay loam to clay loam sandy: massive; some 5-20mm ferromanganese nodules; Clear to gradual change to:
A2: 15 - 25	(where present) Pale, sporadically or conspicuously bleached (dry) sandy clay loam to clay loam sandy; massive; some 5-20mm ferromanganese nodules; Clear to gradual change to:
B2: 60 - 100	Yellow or yellow-brown; some 5-15mm distinct yellow or red mottles sandy clay loam to light medium clay; massive;many 10-20mm ferromanganese nodules; Sharp to clear change to:
C: 80 - 120	Decomposing rhyolite.

Land Use Suitability

- Summer Crops: Navy beans, sugar
- Winter Crops: Nil
- Tree Crops: Macadamia, stone fruit custard apple
- Tropical & temperate pastures

Management Recommendations

- Soil conservation measures required on slopes >2%

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess QDPI Mackay

Author I. Sinclair QDPI Mareeba 1994

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

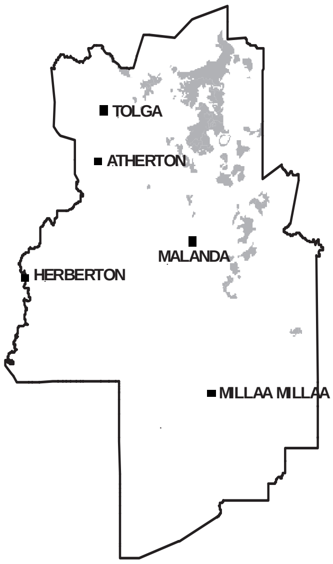
LAND TYPES OF THE ATHERTON TABLELANDS

GALMARA (Ga) 8055ha

NATURAL RESOURCES

Climate Zone

- annual rainfall 1250-1400 mm frosts common (C2)
- 1400-1700 mm; frosts common (C3)
- 1700-4400 mm; frosts uncomon (C4)



Landform and Geology

- undulating rises and rolling low hills
- Barron River metamorphic

Vegetation

- vineforest, *Eucalyptus and Acacia spp.*
- medium to low woodlands:
  upper story: Clarkson's Bloodwood *(Eucalyptus clarksoniana),* Yellow Stringybark *(E. acmenoides,)*
  mid story*: Acacia* spp.*; Casuarina* spp.,
  improved pastures: *Setaria spp., Brachiaria* spp., Tinaroo Glycine.

Soil Characteristics

- red/red-brown, clay soil
- schist and quartz pebbles throughout profile
- mottles present in B horizon
- pH acid (5.6-6.5)

Land Use Characteristics

Productive Features

- good moisture holding capacity
- frost, risk low
- well structured soil
- pH suitable for a wide range of soils
- moderately drained soil
- no salinity concern

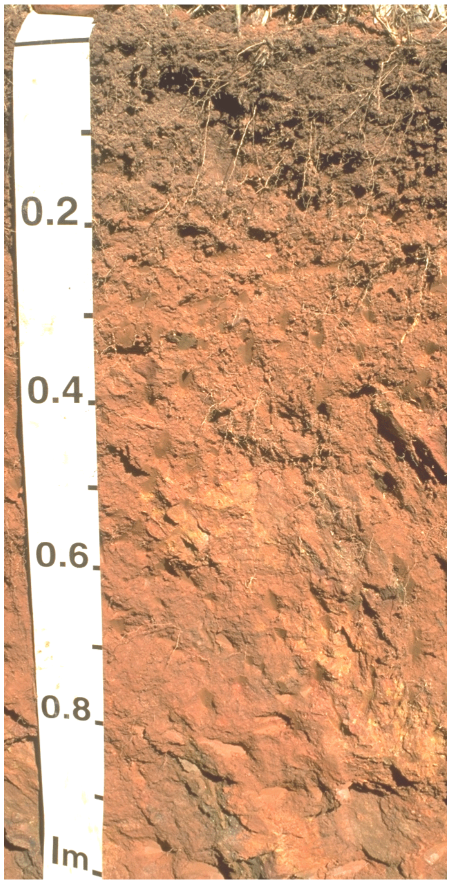
Limitations

- found in wide range of climates including frost prone and extensive drizzle areas
- safe machinery limit 35% (14^0)
- erodability: moderate
- cultivation slope limit 8% (4^0)
- hard wearing on tillage points due to abundant quartz fragments
- some areas may have extensive areas of rock throughout profile

Australian Soil Classification: Mesotrophic Red Dermosol

Great Soil Group: Red Podzolic

Principal Profile Form: Uf4.41, Gn3.14, Gn3.74



Horizon/Depth (cm)	Soil Description
A1: 0 - 15	Brown, dark or red-brown; silty clay loam to sandy clay loam; some 6-20 mm quartz pebbles; well structured; Clear change to:
A2: 15 - 45	Brown or red-brown; silty clay loam to sandy clay loam; some 6-20 mm quartz pebbles; well structured; Clear change to:
B21: 45 - 100	Brown or red-brown; light clay; some 6-20 mm quartz and schist pebbles; well structured; Clear change to:
B22: 75 - 130	Red or red-brown; distinct yellow or orange mottles; clay loam to sandy light clay; some 6-60 mm quartz and schist pebbles; moderate structure; Clear change to:
B3: 100 - 150	Red or red-brown; many orange mottles; clay loam; abundant 6-60mm quartz and schist pebbles; poor structure.

Land Use Suitability

- Summer Crops: Maize, peanut, sorghum, navy bean, salad and heavy vegetable
- Winter Crops: Salad and heavy vegetable
- Tree Crops: Avacardo, macadamia, lychee, custard apple, citrus, mango
- Tropical & temperate pastures (subject to climatic & topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needced on slopes >2% (1.2^{0})
- Cultivation on slopes >8% (4.5^{0}) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess QDPI Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

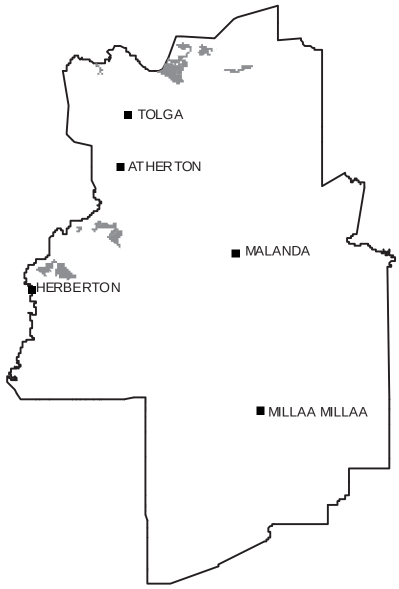
LAND TYPES OF THE ATHERTON TABLELANDS

GILLIES (Gi) 1760ha

NATURAL RESOURCES

Climate Zone

- annual rainfall >1250 mm frosts very uncommon(C1)
- 1250-1400 mm; frost common (C2)
- 1400-1700 mm; frosts common (C3)
- 1100 mm; frosts very common (C5)



Landform and Geology

- moderately sloping low hills
- Mareeba Granite and Elizabeth Creek Granite

Vegetation

- open forest *Eucalyptus spp., Lophostemon suaveolens, Casuarina spp.*

Soil Characteristics

- deep,yellow
- poorly structured
- acid pH (5.6-6.5)
- quartz pebbles throughout profile

Land Use Characteristics

Productive Features

- pH suitable for a wide range of crops

Limitations

- Shallow sandy soil with very low moisture holding capacity
- May contain significant amounts of gravel and cobble in profile
- Can occur in steep areas
- Generally found in frost prone areas

Australian Soil Classification: Tenosol

Great Soil Group: No Suitable Group affinities with Siliceous Sand

Principal Profile Form: Uc4.22, Uc4.21, Gn2.21

Horizon/Depth (cm)	Soil Description
1:10 - 20	Brown; loamy sand to sandy loam; some to many 2 -6mm quartz pebbles; poor structure; Clear change to:
A2:20 - 30	Brown; sandy loam; some to many 2-6mm quartz pebbles; poor structure; Clear change to:
B21:40 - 60	Yellow; sandy loam; some 2-6mm quartz pebbles; poor structure; Clear change to:
B22:70 - 95	Yellow; sandy loam; many 2-6mm quartz pebbles, poor structure; Clear change to:
B3:100 - 145	Brown; sandy clay loam; many 2-6mm quartz pebbles, abundant altered granite; poor structure.

Land Use Suitability

- Summer Crops: Nil
- Winter Crops: Nil
- Tree Crops: Avacado, macadamia, lychee, custard apple, stone fruit, mango, citrus
- Tropical & temperate pastures (subject to climatic & topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needced on slopes >2% (1.2^0)
- Cultivation on slopes >8% (4.5^0) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

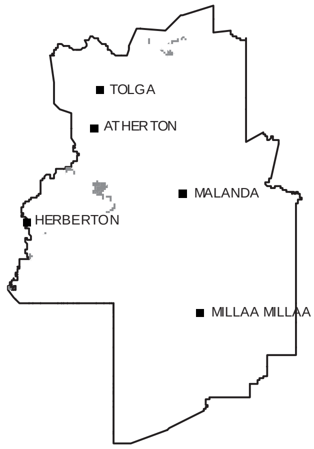
LAND TYPES OF THE ATHERTON TABLELANDS

GOWRIE (Gw) 801ha

NATURAL RESOURCES

Climate Zone

- annual rainfall 1250-1400 mm frosts common(C2)
- 1400-1700 mm; frosts common (C3)
- 1100 mm; frosts very common (C5)



Landform and Geology

- moderately sloping low hills
- Mareeba Granite and Elizabeth Creek Granite

Vegetation

- woodland *Euchalyptus intermedia; E. achmenoides, Casuarina spp.*

Soil Characteristics

- very deep, red/red-brown
- apedal
- acid pH (5.6-6.5)
- quartz pebbles throughout profile

Land Use Characteristics

Productive Features

- pH suitable for a wide range of crops
- Moderately well drained soil

Limitations

- Sandy clay soil with moderate moisture holding capacity
- May contain significant amounts of gravel in profile
- Occurs in frost prone areas

Australian Soil Classification: Red Kandosol

Great Soil Group: No Suitable Group; affinities with Red Earth

Principal Profile Form: Gn2.11 Um5.52 Uf4.2 Uf6.52,

Horizon/Depth (cm)	Soil Description
A1: 10 - 21	Red-brown or fine sandy clay loam to sandy light clay; a few 2-6mm quartz pebbles; poor structure; Clear change to:
A2: 19 - 30	Red-brown or brown; sandy light clay; some 2-6mm quartz pebbles; poor structure; Clear change to:
B21: 55 - 90	Red, red-brown or brown; clay loam fine sandy to sandy light medium clay; some 2-6mm quartz pebbles; poor structure; Gradual change to:
B22: 110 - 150	Red or brown; clay loam to coarse sandy light clay; some 2-6mm quartz pebbles; poor structure.

Land Use Suitability

- Summer Crops: Maize, sorghum, navy bean
- Winter Crops: Salad vegetable
- Tree Crops: Avacado, macadamia, lychee, custard apple, stone fruit, mango, citrus
- Tropical & temperate pastures (subject to climatic & topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needced on slopes >2% (1.2^{0})
- Cultivation on slopes >8% (4.5^{0}) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

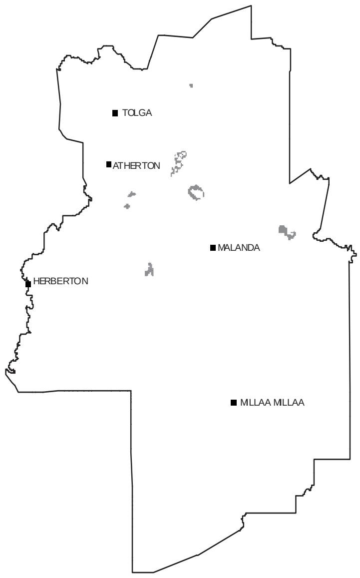
NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

LAND TYPES OF THE ATHERTON TABLELANDS

HEALES (Hs) 704ha

NATURAL RESOURCES



Climate Zone

- annual rainfall 1250-1400 mm frosts common (C2)
- 1400-1700 mm; frosts common (C3)

Landform and Geology

- moderately/steeply sloping cinder cones
- Atherton Basalt of Recent of Late Pleistocene Age

Vegetation

- complex mesophyll vine rainforest
- rainforest regrowth *Melia azedarach* White cedar; *Neolitsia dealbata* Grey Bollywood

Soil Characteristics

- deep, red/red-brown
- pedal, uniform
- neutral pH (6.5-7.0)
- basalt scoria throughout profile

Land Use Characteristics

Productive Features

- Good moisture holding capacity
- pH suitable for a wide range of land uses
- Well drained soil
- Good physical structure

Limitations

- High levels of rock may be present in profile
- Found predominantly in steep areas

Australian Soil Classification: Red Ferrosol

Great Soil Group: Euchrozem

Principal Profile Form: Uf6.31

Horizon/Depth (cm)	Soil Description
A1: 08 - 26	Brown, red-brown or red; light to light medium clay; some 2-6mm scoria; well structured; Clear change to:
B21: 40 - 72	Red or red-brown; light medium clay; some 2-6mm scoria and basalt pebbles; well structured; Gradual change to:
B22: 80 - 120	Red or red-brown; light medium clay; a few 2-6mm basalt pebbles; well structured; Gradual change to:
BC: 90 - 150	Red, dark or red-brown; some 2-6mm distinct orange mottles; light to medium clay; some to many 2-20 mm scoria and basalt; moderate structure.

Comment Scoria levels can vary considerably

Land Use Suitability

- Summer Crops: Maize, peanut, sorghum, navy beans, salad and heavy vegetable
- Winter Crops: Nil
- Tree Crops: Avacado, macadamia, lychee, custard apple, stone fruit, mango, citrus
- Tropical & temperate pastures (subject to climatic & topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needced on slopes >2% (1.2^0)
- Cultivation on slopes >8% (4.5^0) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

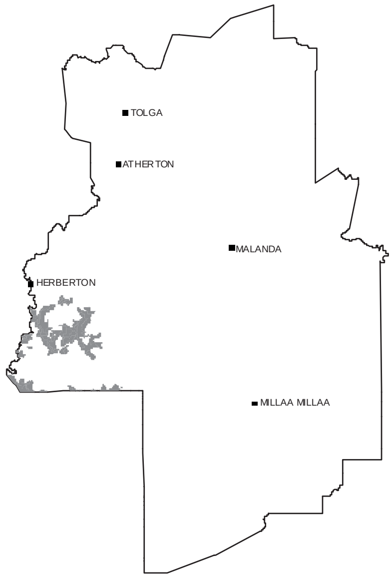
NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

LAND TYPES OF THE ATHERTON TABLELANDS

KABAN (Kb) 2779ha

NATURAL RESOURCES



Climate Zone

- annual rainfall 1100 mm;
  frosts very common (C5)

Landform and Geology

- level to gently undulating lava plains
- Atherton Basalt

Vegetation

- open forest of *Eucalyptus intermedia* red bloodsood; *E. achmenoides* white mahogony; *E. grandis* flooded gum

Soil Characteristics

- dark red-brown well structured
- manganese nodules present in profile
- pH acid (field test 6.6-6.8)

Land Use Characteristics

Productive Features

- Good moisture holding capacity
- pH suitable for a wide range of land uses
- Well drained soil
- Good physical structure

Limitations

- High levels of rock may be present in profile
- Found predominantly in steep areas

Australian Soil Classification: Red Ferrosol

Great Soil Group: Euchrozem

Principal Profile Form: Uf6.31, Gn3.12,

Horizon/Depth (cm)	Soil Description
A1: 10 - 15	Brownish black; light clay; well structured; a few 5-15mm manganese nodules; Clear change to:
B1: 20 - 30	Dark reddish brown; light clay; weak structure few manganese nodules; Clear change to:
B21: 40 - 50	Dark reddish brown; light clay moderate structure a few manganese nodules; Gradual change to:
B22: 46 - 96	Dark reddish brown; light medium clay Moderate polyhedral many manganese nodules; Diffuse change to:
B23: 96 - 150	Dark reddish; light clay; strong structure; some manganese.

Land Use Suitability

- Summer Crops: Maize, peanut, sorghum, salad and heavy vegetable
- Winter Crops: Nil
- Tree Crops: Avacado, macadamia, custard apple, stone fruit
- Tropical and Temperate pasture (subject to climatic and Topographic influences)

Management Recommendations

- Soil conservation measures needced on slopes >2% (1.2^0)
- Cultivation on slopes >8% (4.5^0) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources
- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

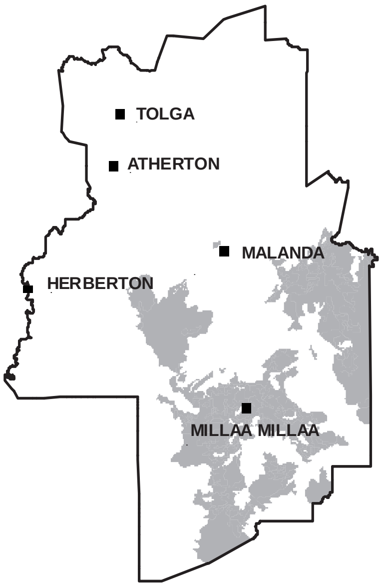
NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

LAND TYPES OF THE ATHERTON TABLELANDS

MAALAN (Mn) 36198ha

NATURAL RESOURCES



Climate Zone

- annual rainfall 1400-1700 mm; frosts common (C3)
- 1700-4400 mm; frosts uncommon (C4)
- 1100 mm; frosts very common (C5)

Landform and Geology

- gently undulating, undulating, rolling, and steep rises and hills
- Atherton Basalt

Vegetation

- rainforest: complex mesophyll vine forest
- improved pasture: Seteria spp. Kikuyu; Greenleaf Desmodium, Malawi Glycine

Soil Characteristics

- red-brown pedal, uniform claysoils
- basalt coarse fragments throughout profile
- pH acid to very acid (5.5-6.5)
- quartz pebbles throughout profile

Land Use Characteristics

Productive Features

- Excellent moisture holding capacity
- pH suitable for a wide range of uses
- Well drained
- Excellent structure
- No salinity potential

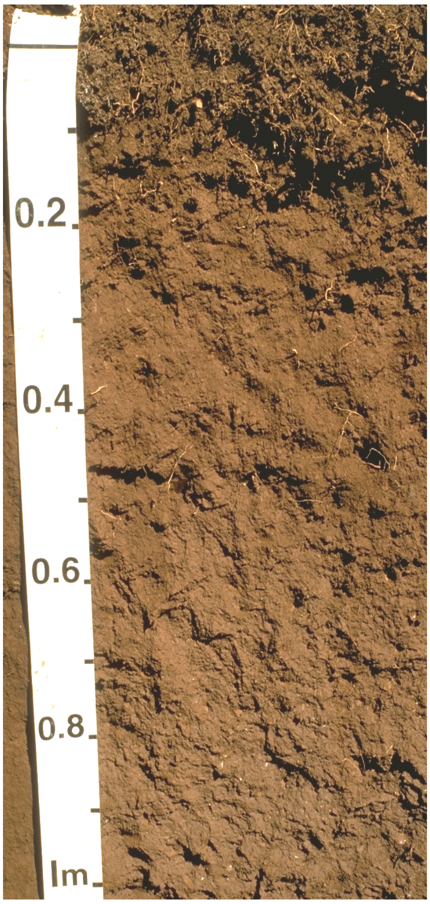
Limitations

- Seasonally low radiation levels
- Found in frost prone areas
- May be high level of rock in profile
- Erosion can occur if cultivated on slopes >12%

Australian Soil Classification: Red Ferrosol

Great Soil Group: Krasnozem

Principal Profile Form: Uf6.31



A1: 0 - 30 Red-brown or brown; light clay to light medium clay; a few 2-60mm basalt pebbles; well structured; Clear change to:

B21: 22 - 100 Red-brown or brown; light clay to light medium clay; a few 2-20mm basalt pebbles; well structured; Gradual change to:

B22: 60 - 140 Red-brown or brown; light clay to light medium clay; well structured; Gradual change to:

B3: 70 - 180 Red-brown or brown; light clay to light medium clay; basalt pebbles; well structured.

Land Use Suitability

- Summer Crops: Maize, sorghum, navy bean, potato, salad and heavy vegetable
- Winter Crops: Salad and heavy vegetable
- Tree Crops: Avacado, macadamia, custard apple, stone fruit
- Tropical & temperate pastures (subject to climatic & topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needced on slopes >2% (1.2^0)
- Cultivation on slopes >12% (6^0) not recommended due to erosion potential
- Retain vegetation along stream banks and in paddocks to prevent stream bank erosion and to provide shade
- Temperate pastures require irrigation

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

LAND TYPES OF THE ATHERTON TABLELANDS

MAZLIN

NATURAL RESOURCES

Climate Zone

- annual rainfall 1250-1400 mm; frosts common (C2)

Landform and Geology

- Moderately sloping footslopes
- Walsh Bluff volcanics

Vegetation

- Medium and Low Woodlands

  Eucalyptus tereticornis, E. acmenioides, Syncarpia glomulifera, Casuarina torulosa

Soil Characteristics

- Deep, pedal, red-brown
- pH acid
- mottled
- gradational

Land Use Characteristics

Productive Features

- Good moisture holding capacity
- pH suitable for a wide range of soils
- Moderately well drained

Limitations

- Hardsetting, massive soil creates emergence problems

Australian Soil Classification: Brown Dermosol

Great Soil Group: No suitable group: affinities with Red Podzolic

Principal Profile Form: Gn3.74, Dr5.21

Horizon/Depth (cm)	Soil Description
A1: 12 - 18	Grey or dark; silty clay loam; moderate structure; Clear change to
A2: 18 - 35	Brown; silty clay loam; moderate structure; Clear change to:
B21: 70 - 82	Red-brown; some 5-15mm distinct orange mottles, light to silty light clay; moderate to strong structure; Gradual change to:
B22: 90 - 100	(where present) red-brown; some 5-15mm distinct red mottles; silty light clay; strong structure; Gradual change to:
B3: 100 - 150	Yellow-brown or grey; some 15-30mm distinct red mottles; light medium clay; strong structure.

Land Use Suitability

- Summer Crops: Maize, sorghum, navy beans, salad vegetables
- Winter Crops: Nil
- Tree Crops: Macadamia, lychee, custard apple, stone fruit, mango, citrus
- Tropical & temperate pastures

Management Recommendations

- Soil conservation measures required on slopes >2%
- Cultivation >12% not recommended

NATIONAL LANDCARE PROGRAM

Information Sources
- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess QDPI Mackay

Author I. Sinclair QDPI Mareeba 1994

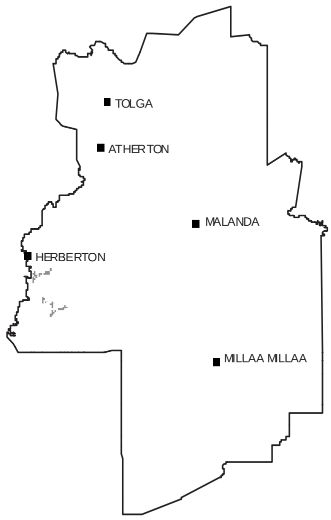
NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

LAND TYPES OF THE ATHERTON TABLELANDS

MILLSTREAM

NATURAL RESOURCES



Climate Zone

- annual rainfall 1100 mm; frosts very common (C5)

Landform and Geology

- footslopes of lava plains
- Atherton Basalt and McBride Basalt

Vegetation

- open forest of

  Eucalyptus leptophloeba, E. drepanophylla and *E. papuana*

Soil Characteristics

- yellow clay soil
- manganese nodules present in profile
- pH acid to neutral

Land Use Characteristics

Productive Features

- Good moisture holding capacity
- pH suitable for a wide range of crops
- Good physicl condition; soil only slightly adhesive

Limitations

- Occurs in a frost prone area
- Imperfectly drained soils
- Moderately high levels of rock may be found throughout profile
- Erosion can occur if cultivated on slopes >12%

Australian Soil Classification: Yellow Dermosol

Great Soil Group: Xanthozem

Principal Profile Form: Gn3.21, Gn3.71, Gn3.74 Uf6.34, Uf6.4

Horizon/Depth (cm)	Soil Description
A1: 10 - 20	Dark or brown; clay loam to light clay; well structured some 2-15mm ferromanganese nodules; Gradual to diffuse change to:
B21: 30 - 53	Yellowbrown or yellow-brown; a few <2mm-15mm distinct orange or red mottles; light to medium clay well structured a few to many 5-15m manganese or ferromanganese nodules; Clear change to:
B22: 70 - 90	Brown; a few 5-15mm distinct red mottles; light medium clay; well structured; some manganese nodules; Gradual change to
D: 109 - 148	Brown; some 5-15mm distinct brown and grey mottles; medium heavy clay; well structured; very few 2-5mm ferromanganese nodules.

Land Use Suitability

- Summer Crops: Navy beans, sugar
- Winter Crops: Nil
- Tree Crops: Macadamia, custard apple, stone fruit
- Tropical & temperate pastures

Management Recommendations

- Soil conservation measures required on slopes >2%

NATIONAL LANDCARE PROGRAM

Information Sources
- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES

LAND TYPES OF THE ATHERTON TABLELANDS

NETTLE (Nt) 335 ha

Climate Zone

- annual rainfall 1100 mm; frosts very common (C5)

Landform and Geology

- Moderately to steeply sloping hills and low hills
- Elizabeth Creek Granite

Vegetation

- medium and low woodlands

  Eucalyptus tereticornis, E acmenoides, E drepanophylla, Casuarina torulosa

Soil Characteristics

- shallow yellow-brown
- apedal
- sandy profile
- pH acid

Land Use Characteristics

Productive Features

- pH suitable for a wide range of crops
- Very well drained soil
- Low levels of gravel in profile

Limitations

- Occur in frost prone area
- Very low moisture holding capacity
- Soil erosion can occur when cultivated on slopes >8%

Australian Soil Classification: Brown Kandosol

Great Soil Group: No suitable grouping; affinities with Lithosol

Principal Profile Form: Uc2.12, Uc1.42, Uc3.21, Uc5.11

Horizon/Depth (cm)	Soil Description
A1: 08 - 12	Brown or dark; coarse sand to coarse sandy loam, some 20-60mm granitic pebbles; single grained or massive; Clear to gradual change to:
A2: 10 - 30	Conspicuously bleached (dry) coarse sand to coarse sandy loam; some 20-60mm granitic pebbles; single grained or massive; Clear to gradual change to
AC: 25 - 60	Yellow-brown or brown; coarse sand to coarse sandy loam; abundant 20-60mm granitic fragments; massive or single grained; Gradual change to:
C:	Decomposing Granite

Land Use Suitability

- Summer Crops: Sugar cane
- Winter Crops: Nil
- Tree Crops: Nil
- Tropical pasture

Management Recommendations

- Soil conservation measures needed on slopes >2% (1.2^0)
- Cultivation on slopes >8% (4.5^0) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources
- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

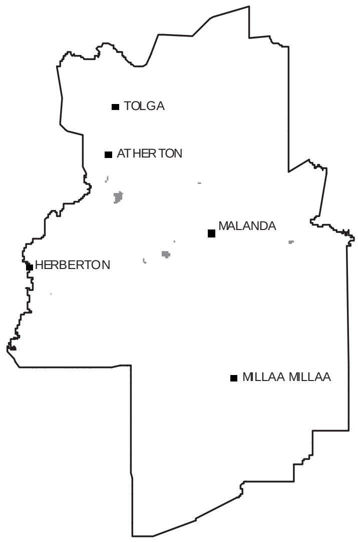
NATURAL RESOURCES

LAND TYPES OF THE ATHERTON TABLELANDS

NYLETTA (Ny) 249Ha

NATIONAL LANDCARE PROGRAM

NATURAL RESOURCES



Climate Zone

- annual rainfall 1250-1400 mm frosts common(C1)
- 1400-1700 mm; frost common (C3)
- 1700-4400 mm; frosts very uncommon (C4)
- 1100 mm; frosts very common (C5)

Landform and Geology

- drainage depressions and volcanic craters
- Quaternary alluvium

Vegetation

- hydromorphic tolerant plants eg sedges and rushes

Soil Characteristics

- deep, black organic soils
- acid pH trend

Land Use Characteristics

Productive Features

- good moisture holding capacity
- pH suitable for a wide range of crops
- no rock in profile

Limitations

- can occur in frost prone areas
- very poorly drained soil
- moderately adhesive soil
- frequently flooded

Australian Soil Classification: Organosol

Great Soil Group: Acid Peat

Principal Profile Form: O

Horizon/Depth (cm)	Soil Description
P1: 10 - 15	Dark; clay loam to light clay; weak to strong structure; Gradual change to:
P2: 20 - 50	Dark; light clay; moderate structure; Gradual change to:
B1:31 - 130	Dark; some 5-15mm distinct pale mottles; light medium to medium heavy clay; weak to moderate structure; Gradual change to:
B2: 110 - 180	Dark; some 5-15mm prominent gleyed mottles; medium heavy to heavy clay weak to moderate structure.

Land Use Suitability

- Summer Crops: Nil
- Winter Crops: Nil
- Tree Crops: Nil
- Tropical & temperate pastures

Management Recommendations

- Unsuitable for nearly all types of agriculture

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

LAND TYPES OF THE ATHERTON TABLELANDS

PETERSON (Pt) 290Ha

NATURAL RESOURCES

Climate Zone

- annual rainfall 1400-1700 mm; frost common (C3)

Landform and Geology

- level floodplains
- Quarternary alluvium

Vegetation

- grassland with *Eucalyptus tereticornis*

Soil Characteristics

- very deep, frey coloured
- pedal
- pH acid 5.5-6.5
- found on floodplains

Land Use Characteristics

Productive Features

- good moisture holding capacity
- pH suitable for a wide range of crops
- no rock in profile

Limitations

- occurs in areas where frosts are common
- poorly drained soil
- strongly adhesive soil which is unsuitable for below ground crops
- frequently flooded

Australian Soil Classification: Hydrosol

Great Soil Group: No suitable group; affinities with Weisenboden

Principal Profile Form: Uf6.31, Uf6.41, Uf6.33, Uf6.2

Horizon/Depth (cm)	Soil Description
A1: 05 - 25	Grey-brown, brown or dark; some 5-15mm distinct orange mottles; light to medium clay; well structured; Clear or gradual change to:
B21: 35 - 55	Brown, red-brown or brown; some 5-15mm distinct orange mottles; light to medium clay; moderate structure; Gradual change to:
B22: 95 - 120	Grey-brown or grey; some 5-30mm distinct orange mottle; medium to medium heavy clay; moderate structure; Gradual change to:
B3: 140 - 160	Red or brown or grey or gleyed; some 5-30mm distinct orange, grey or brown mottles; light to medium heavy clay, moderate structure.

Land Use Suitability

- Summer Crops: Nil
- Winter Crops: Nil
- Tree Crops: Nil
- Tropical & temperate pastures
  (subject to climate and topographic influences)

Management Recommendations

- Retain vegetation along stream banks and in paddocks to prevent stream bank erosion and provide shade

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

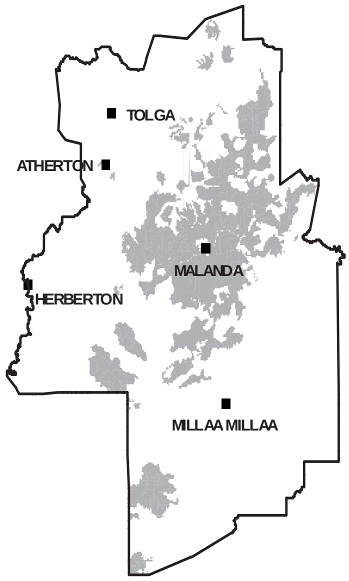
NATURAL RESOURCES

LAND TYPES OF THE ATHERTON TABLELANDS

NATIONAL LANDCARE PROGRAM

NATURAL RESOURCES

PINGIN (Pg) 32621ha



Climate Zone

- occurs in all climate zones

Landform and Geology

- level to gently undulating plains and gently undulating to undulating rises
- Atherton basalt

Vegetation

- rainforest: complex mesophyll vine forest
- open forest
  upper story: Clarkson's Bloodwood *(Eucalyptus clarksoniana);* Carbeen *(E. tessellaris)*, Ghost Gum *(E. papuana)*
  mid story: Soap tree/Sarsaparilla *(Alphitonia spp), Grevillea spp.*
- introduced pasture/cropping

Soil Characteristics

- brown, well structured clay soil
- amount of basalt pebbles increases with depth
- pH mildly acid to mildly alkaline
- may have abundant rock on surface

Land Use Characteristics

Productive Features

- excellent moisture holding capacity
- pH suitable for a wide range of crops
- very well drained soil
- excellent structure

Limitations

- erosion may occur if cultivated on slopes >12%
- can occur in frost prone areas
- may be high levels of rock in profile

Australian Soil Classification: Red Ferrosol

Great Soil Group: Kraznozem

Principle Profile Form: Uf6.31

Horizon/Depth (cm) **Soil Description**

A1/Ap 0-30: Dark or red; light clay; well structured; Clear to gradual change to:

B21: 30-155: Red; light clay to light medium clay; well structured; Gradual change to:

B22: 45-175: Red; light clay to light medium clay; well structured; Gradual or diffuse change to:

B23: 68-180: Red; light clay to light medium clay; well structured; Gradual or diffuse change to:

B3: 150-180 Red or red-brown; light clay to medium clay; well structured; a few to many 2-20 mm basalt pebbles.

Land Use Suitability

- Summer Crops: Maize, peanut, sorghum, navy bean, sugar, salad and heavy vegetables
- Winter Crops: potato, salad and heavy vegetables
- Tree Crops: Macadamia, avocado, citrus, mango, lychee, stone fruit, custard apple
- Tropical & temperate pastures (subject to climatic & topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needed on slopes >2% (1.2^{0})
- Soil conservation structures must be regularly maintained
- Use conservation cropping practices to avoid soil structure decline
- Use crop rotation to avoid pest and disease build-up

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

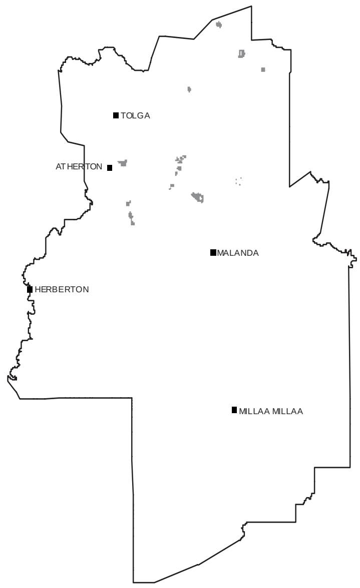
NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

LAND TYPES OF THE ATHERTON TABLELANDS

QUINCAN (Qn) 562ha

NATURAL RESOURCES



Climate Zone

- annual rainfall 1250-1400 mm; frosts common (C2)
- 1400-1700 mm; frosts common (C3)

Landform and Geology

- moderately/steeply sloping cinder cones
- Atherton Basalt of Recent of Late Pleistocene Age

Vegetation

- complex mesophyll vine rainforest
- rainforest regrowth *Melia azedarach* White cedar; *Neolitsia dealbata* Grey Bollywood

Soil Characteristics

- moderately deep red-brown
- pedal, uniform
- neutral pH (6.5-7.0)
- basalt pebbles throughout profile

Land Use Characteristics

Productive Features

- Good moisture holding capacity
- pH suitable for a wide range of crops
- Well drained soil

Limitations

- Can occur in frost prone areas
- May be high levels of rock in profile
- Soil erosion can occur on slopes >12%

Australian Soil Classification: Brown Dermosol

Great Soil Group: No suitable group; affinities with Prairie Soil

Principal Profile Form: Uf6.31

Horizon/Depth (cm)	Soil Description
A1: 05 - 20	Red-brown; light clay; some 6-20mm basalt pebbles strong structure; Sharp change to:
B21: 50 - 70	Red-brown; light clay to light medium clay; some 6-20mm basalt pebbles; moderate structure; Gradual change to:
B22: 80 - 90	Brown; light clay; many 6-20mm basalt pebbles; moderate structure; some 2-6mm manganese nodules; Gradual change to:
B3: 100 - 110	Brown; light clay; some 6-20mm basalt pebbles; strong structure; many 2-6mm manganese nodules; Gradual change to:
C: 110 onwards	abundant basalt scoria

Land Use Suitability

- Summer Crops: Nil
- Winter Crops: Nil
- Tree Crops: Avacado, macadamia, custard apple, stone fruit
- Tropical & temperate pastures (subject to climatic & topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needced on slopes >2% (1.2^{0})
- Cultivation on slopes >12% not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

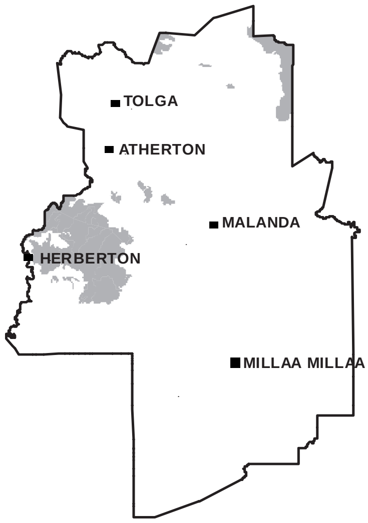
LAND TYPES OF THE ATHERTON TABLELANDS

SEVERIN (Sn) 12415ha

NATURAL RESOURCES

Climate Zone

- annual rainfall 1250-1400 mm; frosts common (C2)
- 1400-1700 mm; frosts comon (C3)
- 1100 mm; frosts very common (C5)



Landform and Geology

- undulating/rolling rises; steep low hills
- Mareeba Granite and Elizabeth Creek Granite

Vegetation

- rainforest interspersed with
- open forest: of *Eucalyptus clarksoniana* (Clarkson's bloodwood); *E. tessellaris,* Moreton Bay Ash; *Casuarina spp.*

Soil Characteristics

- yellow/yellow-brown sandy-clay soil
- quartz pebbles throughout profile
- pH acid (field test 5.5-6.0)

Land Use Characteristics

Productive Features

- Moderate moisture holding capacity
- pH suitable for a wide range of crops

Limitations

- Can occur in frost prone areas
- Imperfectly drained soil
- High levels of rock may be found in profile
- Erosion can occur on slopes >8%

Australian Soil Classification: Yellow Dermosol

Great Soil Group: No suitable group

Principal Profile Form: Uf4.42, Uf4.43, Uf6.33, Uf6.4

Horizon/Depth (cm)	Soil Description
A1: 10 - 20	Dark or grey; sandy light clay to fine sandy light medium clay; a few small quartz pebbles; moderate structure; Gradual change to:
A2: 29 - 40	Grey, brown, dark or yellow-brown; sandy clay loam to fine sandy light medium clay; moderate structure; Clear change to:
B21: 55 - 80	Yellow or yellow-brown; a few 2-10mm distinct orange and red mottles; sandy light to sandy light medium clay; a few 2-10mm quartz pebbles; moderate structure; Clear change to:
B22: 75 - 100	Yellow or yellow-brown; many 2-10mm distinct red mottles; sandy light medium clay; a few 2-6mm quartz pebbles; moderate structure; Gradual change to:
BC: 100 - 150	Yellow-brown or red-brown; some 10-20mm distinct red mottle; sandy light to sandy light medium clay;

Land Use Suitability

- Summer Crops: Navy bean, sugar cane
- Winter Crops: Nil
- Tree Crops: Macadamia, custard apple, stone fruit
- Tropical & temperate pastures (subject to climatic & topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needced on slopes >2% (1.2^0)
- Cultivation on slopes >8% (4.5^0) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources
- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess QDPI Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES

LAND TYPES OF THE ATHERTON TABLELANDS

SNIDER (Sd)127ha

NATIONAL LANDCARE PROGRAM

NATURAL RESOURCES

Climate Zone

- annual rainfall >1250 mm; frosts very uncommon (C1)
- 1200-1400 mm; frosts comon (C2)
- 1100 mm; frosts very common (C5)

Landform and Geology

- gently sloping footslopes
- Atherton Basalt

Vegetation

- medium to low woodlands: *Eucalyptus leptophleba* Red Box, *E platyphylla* poplar gum; *Hakea persiehana*

Soil Characteristics

- shallow, black or brown
- pedal uniform
- neutral pH (6.5-7.5)
- mottles, basalt pebbles

Land Use Characteristics

Productive Features

- good moisture holding capacity
- pH suitable for a wide range of crops
- moderately well drained

Limitations

- Can occur in frost prone areas
- High levels of rock may be found in profile
- Erosion can occur on slopes >8%

Australian Soil Classification: Brown Dermosol

Great Soil Group: No suitable group; affinities with Prairie Soil

Principal Profile Form: Uf6.31

Horizon/Depth (cm)	Soil Description
A1: 05 - 18	Dark or brown; light to light medium clay; some 6-20mm basalt pebbles; moderate structure; <2-10% ferromanganese nodules, Clear change to:
B2: 25 - 48	Brown; some <5-15mm faint orange and red mottles; light to medium heavy clay; many 6-60mm basalt pebbles; moderate structure; some 2-6mm or ferromanganese nodules.
B3: 37 - 89	Brown or yellow brown; some <5-15mm distinct orange, red and yellow mottles; light to medium heavy clay; many 6-60mm basalt pebbles; moderate structure a few 2-6mm manganese nodules.
C: 60 - 115	abundant basalt and altered basalt

Land Use Suitability

- Summer Crops: Maize, potato, sorghum
- Winter Crops: Potato
- Tree Crops: Avocado, macadamia, lychee, custard apple, citrus, mango
- Tropical & temperate pastures (subject to climatic & topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needed on slopes >2% (1.2^0)
- Cultivation on slopes >8% (4.5^0) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

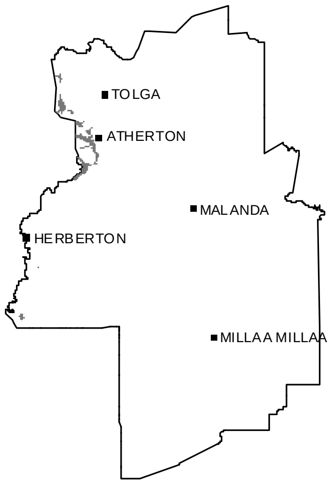
LAND TYPES OF THE ATHERTON TABLELANDS

SYLVIA (Sy) 949ha

NATURAL RESOURCES

Climate Zone

- annual rainfall >1250 mm (C1)
- 1250-1400 mm; frost common (C2)
- 1400-1700 mm; frosts common (C3)
- 1100 mm; frosts very common (C5)



Landform and Geology

- gently sloping footslopes
- Walsh Bluff Volcanics (rhyolite)

Vegetation

- medium and low woodlands
  Eucalyptus intermedia red bloodwood; *E. tereticornis* blue gum; *Casuarina torulosa, C. Littoralia; Syncarpia glomulifera*

Soil Characteristics

- deep, grey
- pedal, duplex
- acid trend 5.5-6.3
- orange and red mottles

Land Use Characteristics

Productive Features

- located on flat areas

Limitations

- poorly drained
- low permeability
- low water holding capacity
- hard setting soil
- prone to gully erosion

Australian Soil Classification: Grey Chromosol

Great Soil Group: Soloth

Principal Profile Form: Dy2.41, Dy3.41, Gn3.04, Dy2.32

Horizon/Depth (cm)	Soil Description
A1: 09 - 20	Grey or grey-brown; fine sandy loam to fine sandy clay loam; weak 2-5mm granular and cast; Clear change to:
A2: 20 - 35	Grey to grey-brown; conspicuously bleached (dry); a few <5mm-15mm faint orange and yellow mottles; silty loam to silty clay loam; a few 2-6mm weathered rhyolite pebbles; apedal; Clear change to:
B21: 50 - 80	Grey; some to many 5-30mm distinct orange and red mottles; silty light medium to medium heavy clay; well structured; Gradual change to:
B22: 85 - 120	Grey or grey-brown; some to many 5-30mm distinct orange and yellow mottles; silty light medium to medium heavy clay; well structured; Gradual change to:
B3: 120 - 140	Grey or yellow; some 5-15mm distinct orange mottles; silty clay loam to silty light medium clay; a few to many 2-6mm rhyolite pebbles; moderate structure

Land Use Suitability

- Summer Crops: Nil
- Winter Crops: Nil
- Tree Crops: Mango
- Tropical pasture (subject to climatic and topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needed on slopes >2% (1.2^{0})
- Cultivation on slopes >8% (4.5^{0}) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion slopes >2% (1.2^{0})

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

LAND TYPES OF THE ATHERTON TABLELANDS

TOLGA (To) 14105ha

NATURAL RESOURCES

Climate Zone

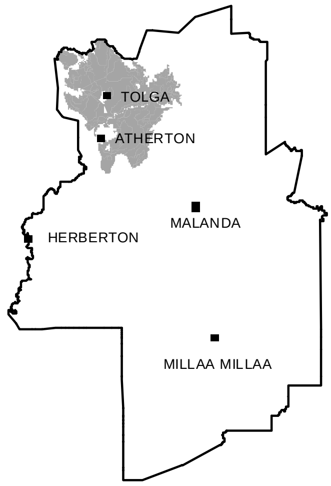
- annual rainfall >1250 mm (C1)
- 1250-1400 mm; frosts common (C2)

Landform and Geology

- level to gently undulating plains and gently undulating to undulaing rises
- Atherton Basalt

Vegetation

- rainforest: complex mesophyll vine forest
- open forest:
  upper story: Clarkson's Bloodwood *(Eucalyptus clarksoniana),* Carbeen (*E. tessellaris),* Ghost Gum *(E. papuana),* Swamp Box *(Lophostemon sauveolens);* mid story*: Eucalyptus* saplings, Bush Clothes *Peg* (Grevillea glauca)
- improved pasture/cropping



Soil Characteristics

- red structured, uniform clay soil
- manganese nodules in B horizon
- mottles present in B horizon
- pH neutral (6.0-7.5)
- very deep (>30 metres recorded)

Land Use Characteristics

Productive Features

- excellent moisture holding capacity
- pH suitable for a wide range of crops
- well structured
- well drained
- no salinity potential

Limitations

- can occur in frost prone areas
- may be high levels of rock in profile

Australian Soil Classification: Red Ferrosol

Great Soil Group: Euchrozem

Principle Profile Form: Uf6.31

Horizon/Depth (cm)	Soil Description
A1/Ap: 0 - 45	Red; light clay; well structured; a few 2-6 mm manganese nodules; Clear change to:
B1: 50 - 120	(where present). Red; light clay; moderate structure; a few 2-6 mm manganese nodules; Gradual change to:
B21: 45 - 180	Red; light clay; well structured; a few 2-6 mm manganese nodules; Gradual to diffuse change to:
B22: 50 - 180	Red; light clay to light medium clay; well structured; a few 2-6 mm manganese nodules; Gradual to diffuse change to:
B23: 100 -180	Red; light clay to light medium clay; well structured; a few 2-6 mm manganese nodules.

Land Use Suitability

- Summer Crops: Peanut, maize, and pasture, lablab, sugarcane, salad and heavy vegetable
- Winter Crops: Potato, pasture
- Tree Crops: Macadamia, avocado, citrus, custard apple, low chill stone fruit, mango, lychee (subject to climatic & topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needed on slopes >2% (1.2°)
- Use conservation cropping practices to avoid soil structure decline
- Use crop rotations to avoid pest and disease build-up
- Soil conservation structures must be regularly maintained to minimise failure from cracking and overtopping

NATIONAL LANDCARE PROGRAM

Information Sources
- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess QDPI Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

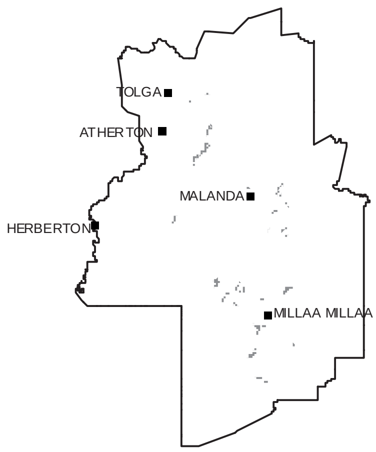
LAND TYPES OF THE ATHERTON TABLELANDS

TRANTERS (Tr) 787ha

NATURAL RESOURCES

Climate Zone

- annual rainfall 1200-1400 mm; frosts common (C3)
- 1400-1700 mm; frosts common (C3
- 1700-4400 mm; frosts commoons (C4)
- 1100 mm; frosts common (C5)



Landform and Geology

- very gently sloping alluvial terraces
- Atherton Basalt

Vegetation

- small pockets of complex mesophyll vine forests
- pasture

Soil Characteristics

- very deep, brown
- pedal, uniform clay
- pH trend neutral (6.5-7.0)

Land Use Characteristics

Productive Features

- Good moisture holding capacity
- pH suitable for a wide range of crops
- Well drained
- Workability is high

Limitations

- Can occur in frost prome areas

Australian Soil Classification: Brown Dermosol

Great Soil Group: No suitable group

Principal Profile Form: Uf6.31, Uf6.4

Horizon/Depth (cm)	Soil Description
A1: 07 - 28	Dark or brown or red-brown; a few 5-15mm faint orange mottles; clay loam fine sandy to light clay; moderate structure; Clear change to:
B21: 80 - 97	Brown or red-brown; clay loam fine sandy to light medium clay; moderate structure; Clear or gradual change to:
B22: 110 - 130	Brown to grey; clay loam fine sandy to light medium clay; moderate structure; Clear or gradual change to:
D: 140 - 180	(where present) Brown or grey; some 5-30mm distinct orange mottles; loamy sand to medium heavy clay; well structured.

Land Use Suitability

- Summer Crops: Maize, peanut, sorghum, navy bean, salad and heavy vegetable, sugar
- Winter Crops: Potato
- Tree Crops: Macadamia, avocado, custard apple, stone fruit, mango, citrus
- Tropical & temperate pastures (subject to climatic & topographic influences)

Management Recommendations

- Soil conservation measures needed on slopes >2% (1.2^0)
- Cultivation on slopes 8% (4.5^0) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

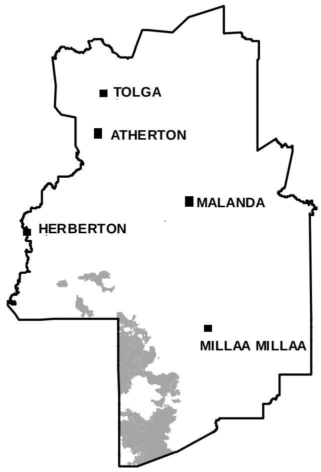
LAND TYPES OF THE ATHERTON TABLELANDS

UMALA (Um) 10027ha

NATURAL RESOURCES

Climate Zone

- annual rainfall 1700-4400 mm frosts uncommon(C4)
- 1100 mm; frosts very common (C5)



Landform and Geology

- Undulating and rolling rises and low hills
- Glen Gordon Volcanics and Walsh Bluff Volcanics; mainly Rhyolitye

Vegetation

- Rainforest: Complex Mesophyll Vine Forest
- Open Forest:
  - Blue Gum *(Eucalyptus tereticornis),*
  - Bloodwood *E. intermedia;*
  - Mid storey *Casuarina spp., Acacia spp.*
- Improved Pasture: *Setaria spp., Brachiaria spp.*

Soil Characteristics

- Red-brown/Brown clay soil
- Rhyolite pebbles in B horizon
- Orange and red mottles in B horizon
- Increasing clay content with depth
- pH acid (5.6-6.5)

Land Use Characteristics

Productive Features

- Good moisture holding capacity
- pH suitable for a wide range of crops
- Moderately well drained soil

Limitations

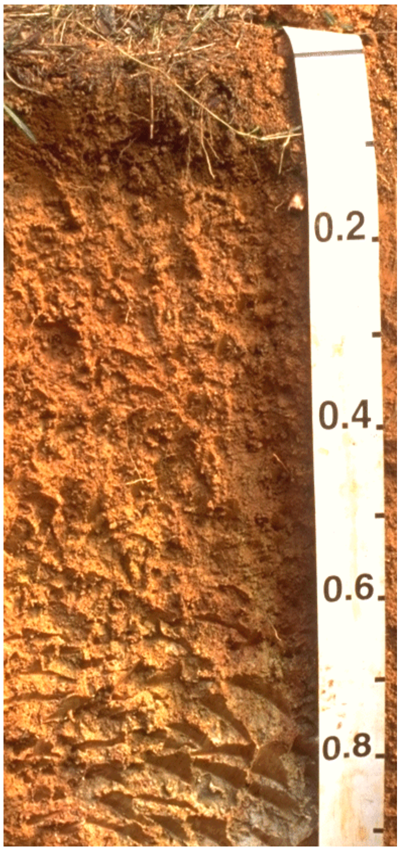
- Generally found in frost prone areas
- May be small amounts of rock in profile
- Soil erosion may occur if cultivated on slopes >8%
- Hard wearing on tillage points

Australian Soil Classification: Brown Dermosol

Great Soil Group: No suitable group; affinities with Red Podzolic Soil

Principle Profile Form: Gn3.11, Gn3.14, Gn3.21, Gn3.91

Horizon/Depth (cm)	Soil Description
A1: 0 - 25	Red-brown, brown or dark; a few 5-15mm faint red mottles; clay loam to light clay; well structured; Clear change to:
A2:20 - 40	Brown or red-brown; light clay to light medium clay; moderate structure; Gradual change to:
B1:45 - 50	Brown or red-brown; a few 5-15mm faint orange mottles; light medium clay; moderate structure; Clear change to:
B21:50 - 100	Red-brown or brown; a few to many 5-30mm distinct orange and red mottles; light to medium heavy clay; a few 20-60mm rhyolite pebbles; moderate structure; Gradual change to:
B21:50 - 100	Red-brown or brown; a few to many 5-30mm distinct orange and red mottles; light to medium heavy clay; a few 20-60mm rhyolite pebbles; moderate structure; Gradual change to:
B22:70 - 180	Red-brown, brown or grey; a few to many 5-30mm distinct orange and red mottles; medium to medium heavy clay; strong structure; Gradual change to:
B3:120 - 180	Red-brown or red; a few to many 5-20mm distinct orange mottles; sandy medium to medium heavy clay; many 6-20mm rhyolite pebbles; strong structure.



Land Use Suitability

- Summer Crops: Maize, sorghum, salad & heavy vegetables, irrigated sugar
- Winter Crops: Potato
- Tree Crops: Avocado, macadamia, custard apple, citrus, stone fruit
- Tropical & temperate pastures (subject to climatic & topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needed on slopes >2%
- Cultivation on slopes >8% (4.5^{0}) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

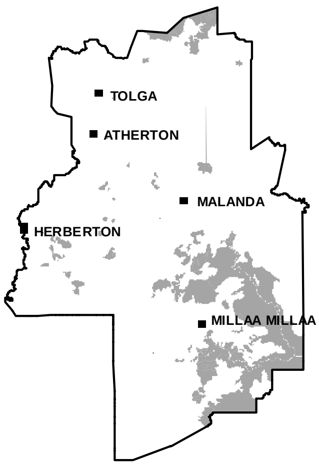
LAND TYPES OF THE ATHERTON TABLELANDS

UTCHEE (Ut) 21683ha

NATURAL RESOURCES

Climate Zone

- annual rainfall 1200-1400 mm; frosts common (C2)
- 1400-1700 mm; frosts common (C3)
- 1700-4400 mm; frosts uncommon (C4)
- 1100 mm; frosts very common (C5)



Landform and Geology

- undulating, rolling and steep rises
- Tully Granite Complex, Mareeba Granite, Elizabeth Creek Granite

Vegetation

- rainforest: complex mesophyll vine forests
- improved pasture: Kikuyu, *Setaria spp., Brachiaria spp.*

Soil Characteristics

- red-brown clay soil
- quartz pebbles throughout profile
- orange andyellow mottling in B horizon
- pH acid (5.5-6.5)

Land Use Characteristics

Productive Features

- moderate moisture holding capacity
- pH suitable for a wide range of crops
- moderately well drained soil
- low salinity potential
- moderate drainage

Limitations

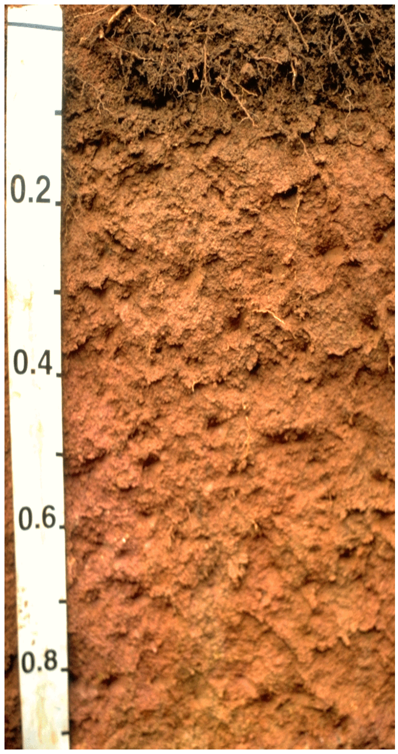
- can occur in frost prome areas
- safe machinery limit 35% (14^{0})
- cultivation slope limit 8% (4^{0})
- abundant quartz and granite pebbles in profile

Australian Soil Classification: Mesotrophic Red Dermosol

Great Soil Group: No suitable group; affinities with Red Podzolic soil

Principle Profile Form: Gn3.11, Gn3.14, Gn3.74, Gn3.21

Horizon/Depth (cm)	Soil Description
A1: 0 - 20	Red-brown or brown; sandy light clay to sandy light medium clay; a few 2-6mm quartz pebbles; well structured; Clear change to:
A2: 20 - 40	Red-brown or brown; fine sandy light to sandy light medium clay; a few 2-6mm quartz pebbles; well structured; Clear change to:
B21:40 - 110	Red or red-brown; with a few 5-30mm distinct orange and yellow mottles; sandy light to sandy light medium clay; some 2-6mm quartz pebbles; well structured; Gradual change to:
B22:90 - 150	Red or red-brown; sandy light medium clay; many 2-6mm quartz pebbles; well structured; Gradual change to:
B3: 100 - 180	Red or red-brown; some 5-30mm distinct orange and yellow mottles; coarse sandy light medium clay; many 2-6mm quartz and granite pebbles; well structured



Land Use Suitability

- Summer Crops: Maize, sorghum, salad and heavy vegetable, sugar cane
- Winter Crops: Potato
- Tree Crops: Avocado, macadamia, custard apple, stone fruit
- Tropical & temperate pastures (subject to climatic & topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needed on slopes >2% (1.2^0)
- Cultivation on slopes 8% (4.5^0) not recommended due to increased erosion risk
- Retain vegetation along stream banks and in paddocks to prevent stream bank erosion and to provide shade

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES

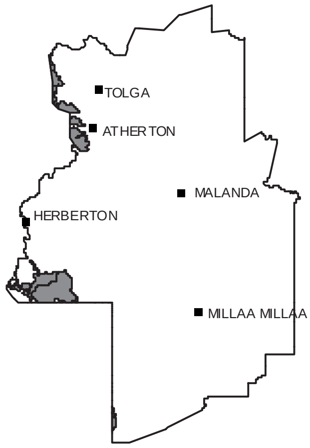
NATIONAL LANDCARE PROGRAM

LAND TYPES OF THE ATHERTON TABLELANDS

WHELAN (Wh) 4335Ha

NATURAL RESOURCES

Climate Zone
- annual rainfall >1250 mm; frosts very uncommon (C2)
- 1200-1400 mm; frosts common (C2)
- 1100 mm; frosts very common (C5)



Landform and Geology
- moderately to steeply sloping hills
- Walsh Bluff Volcanics

Vegetation
- tall open forests and tall woodlands
  Eucalyptys resinfera, E. acmenoides, Casuarine torulosa, Callitris macleayanus
- medium and low woodlands
  Eucalyptus cloeziana, E. acmenoides, E. tereticornis, Syncarpia glomuliferia

Soil Characteristics
- shallow, yellow-brown
- apedal, uniform texture
- abundant rhyolite pebbles in BC horizon
- pH mildly acid (5.5-6.3)

Land Use Characteristics

Productive Features
- pH suitable for a wide range of soils
- very well drained soil

Limitations
- occur in frost prone areas
- very low moisture holding capacity
- hardsetting, massive soil
- high levels of rock can be found in profile
- susceptible to erosion on slopes >8%

Australian Soil Classification: Brown Kandosol

Great Soil Group: No suitable group; affinities with Lithosol

Principal Profile Form: Uc2.12, Uc2.21, Um4.23

Horizon/Depth (cm)	Soil Description
A1: 08 - 13	Grey or brown; loam; some 10-20mm rhyolite pebbles poor structure. Clear change to:
A2: 20 - 32	Grey brown pale (dry); sandy loam. Gradual change to:
BC: 40 - 48	Yellow-brown or reddish brown; sandy loam to sandy clay loam; abundant 20-60mm pebbles or altered parent material; Gradual change to:
C: 50 - 80	Decomposing rhyolite.

Land Use Suitability

- Summer Crops: Nil
- Winter Crops: Nil
- Tree Crops: Nil
- Tropical pasture
  (subject to climatic & topographic influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needed on slopes >2% (1.2^0)
- Cultivation on slopes >8% (4.5^0) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

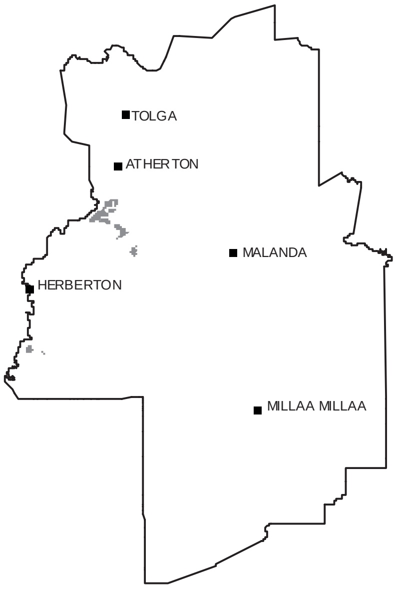
NATURAL RESOURCES

LAND TYPES OF THE ATHERTON TABLELANDS

WONGABEL (Wg) 539ha

NATIONAL LANDCARE PROGRAM

NATURAL RESOURCES



Climate Zone

- annual rainfall 1250-1400 mm; frosts common (C2)
- 1400-1700 mm; frosts common (C3)
- 1100 mm; frosts very common (C5)

Landform and Geology

- very gently sloping alluvial/colluvial fans
- Quarternary alluvium

Vegetation

- moderate and low woodlands
  Eucalyptys intermedia, E. tereticornis , Casuarine torulosa, C. littoralis, Banksia compar
- improved pasture

Soil Characteristics

- deep, yellow-brown
- gradational
- pH acid (5.6-6.8)
- quartz pebbles throughout profile

Land Use Characteristics

Productive Features

- Good moisture holding capacity
- pH suitable for a wide range of soils

Limitations

- Can occur in frost prone areas
- Poorly drained soil
- hardsetting, massive soil

Australian Soil Classification: Yellow Dermosol

Great Soil Group: No suitable group; affinities with Yellow Earth

Principal Profile Form: Gn2.44, Gn2.41, Um4.25, Uc5.11

Horizon/Depth (cm)	Soil Description
A1: 10 - 20	Dark or grey; Sandy clay loam to clay loam; some 2-6mm quartz pebbles; poor structure; Clear change to:
A2: 30 - 45	Dark or grey or yellow-brown; sandy clay loam to silty clay loam; some 2-6mm quartz pebbles; poor structure; Clear change to:
B21: 50 - 70	Yellow or yellow-brown or grey; sandy clay loam to sandy light medium clay; a few to many 2-6mm quartz pebbles; poor structure; Gradual change to:
B22: 90 - 120	Yellow-grey, brown or grey; some to many 5-30mm distinct orange and yellow mottles; fine sandy clay loam to sandy light medium clay; many 2-6mm quartz pebbles; poor structure; Gradual change to:
D: 100 - 170	Grey or yellow-brown; some to many 5-30mm distinct yellow and orange mottles; loamy sand to light medium clay; some to abundant <2m quartz pebbles; poor structure

Land Use Suitability

- Summer Crops: Irrigated sugar
- Winter Crops: Nil
- Tree Crops: Nil
- Tropical pasture

Management Recommendations

- Soil conservation measures needed on slopes >2% (1.2^0)
- Cultivation on slopes >8% (4.5^0) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources

- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES

NATIONAL LANDCARE PROGRAM

LAND TYPES OF THE ATHERTON TABLELANDS

WORSLEY (Wr) 351Ha

NATURAL RESOURCES

Climate Zone

- annual rainfall >1250 mm; frosts common (C2)
- 1400-1700 mm; frosts common (C3)
- 1100 mm; frosts very common (C5)

Landform and Geology

- moderately to steeply sloping low hills
- Walsh Bluff Volcanics and Glen Gordon volcanics

Vegetation

- simple microphyll vine-fern forest
- improved pasture

Soil Characteristics

- moderately deep, yellow-brown
- well structured, gradational texture profile
- acid pH (6.0)
- orange mottles and rhyolite in profile

Land Use Characteristics

Productive Features

- Good moisture holding capacity
- pH suitable for a wide range of soils

Limitations

- Can occur in frost prone areas
- Imperfectly drained
- Moderately adhesive soil
- High levels of rock may be found in profile
- Erosion can occur if cultivated on slopes >8%

Australian Soil Classification: Yellow Dermosol

Great Soil Group: No Suitable Group affinities with Yellow Podzolic soil

Principal Profile Form: Gn.24, Gn2.21, Uf6.52

Horizon/Depth (cm)	Soil Description
A1: 08 - 15	Dark or grey-brown; silty clay loam to fine sandy light clay; moderate structure; some 20-60mm rhyolite pebbles; Clear change to:
A2: 20 - 30	Brown, grey or pale (dry); silty clay loam to fine sandy light clay; poor structure; some 20-60mm rhyolite pebbles; Clear change to:
B21: 45 - 65	Yellow or yellow-brown; some 5-15mm distinct orange mottles; fine sandy light clay; poor structure; many 60-200mm rhyolite fragments; Gradual change to:
B22:100 - 130	Yellow-brown; some 5-15mm distinct orange mottles; fine sandy light clay; moderate structure; Clear change to:
B3: 110 - 150	Yellow; sandy light medium clay; abundant 20-60mm rhyolite pebbles; moderate structure;

Land Use Suitability

- Summer Crops: Navy beans, irrigated sugar
- Winter Crops: Nil
- Tree Crops: Macadamias, lychee, custard apple, stone fruit, mango, citrus
- Tropical and temperate pasture
  (subject to climatic & topographical influences & variation in rock levels)

Management Recommendations

- Soil conservation measures needed on slopes >2%
- Cultivation on slopes >8% (4^0) not recommended due to increased erosion risk
- Retain vegetation along stream banks to prevent stream bank erosion

NATIONAL LANDCARE PROGRAM

Information Sources
- DPI Staff at Mareeba, Kairi, and Malanda
- Atherton and Malanda Land Care Groups
- Jon Burgess DNR Mackay

Author I. Sinclair DNR Mareeba 1997

NATURAL RESOURCES