REPORT ON THE LAND UNITS OF SELECTED AREAS

by

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The following is a supplementary report to be used in conjunction with the "Report on the Land Units of the Katherine-Douglas Area, N.T., 1970" by J.M. Aldrick and C.S. Robinson. The reader should also be familiar with the "General Report on Lands of the Tipperary Area, N.T., 1961", C.S.I.R.O. Land Research Series No. 13.
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**ACKNOWLEDGEMENTS:** The authors wish to thank Mr P. McLeod and Mr R. Savage for their technical assistance and Mr R.L. Henderson for the drawing of figures.
1. INTRODUCTION

Manbulloo Station covers an area of 3,855 sq. km., the centre of which is located approximately 45 km due south of Katherine (Figure 1).

Due to the relatively large size of the station and limited time available for field work, the survey was mainly restricted to those areas with the greatest potential for agricultural development. These areas were identified and separated from more marginal lands using the land system map of the area (Speck et al 1961).

Two major sections of Manbulloo Station have been mapped (Figure 1). Both areas are adjacent to the Victoria Highway and are accessible throughout the year. The more northern section is located within an area between the King River and the Stuart Highway and is bounded to the west by the Katherine River and to the east by the boundary of Mataranka Station. This section is approximately 490 sq. km in area and is comprised mainly of Kimbyan, Tagoman, Budbudjong and Blain land systems. (Figure 2a). The remaining section of approximately 860 sq. km lies between the King River and the station's western boundary.

The study area lies within the Daly Basin, most of which has been surveyed to land unit level by officers of this section (Aldrick and Robinson, 1972). The land units used by Aldrick and Robinson were found to adequately describe most facets of land within the Manbulloo area, hence permitting continuity in mapping within the drainage basin.
Figure 2a  Land Systems of the Northern Survey area, Manbulloo Station

Key to the Land Systems
1. Mullaman
2. Yujullowan
3. Woggaman
4. Wallingin
5. Chinaman
6. Claravale
7. Blain
8. Tagaman
9. Budbudjung
10. Kimbyan
11. Karaman
12. Banyan

Scale 1:250,000
Figure 2b Land Systems of the Southern Survey area, Manbulloo Station

Key to the Land Systems

1. Yujullowan
2. Yungman
3. Jindara
4. Woggoman
5. Wallingin
6. Chinaman
7. Claravale
8. Wriggley
9. Blain
10. Tagoman
11. Budbudjong
12. Kimbyan
13. Keraman
14. Wongalla
15. Banyan
2. PREVIOUS MAPPING

Manbulloo Station has been mapped by the Commonwealth Scientific and Industrial Research Organization as far south as 15° latitude, as part of the Land Systems Survey of the Tipperary area. This mapping was at a scale of 1:250,000 and covered the structural entity known as the Daly River Basin. Since Manbulloo Station's southern boundary is at approximately 15° 7½' latitude an area the full length of this boundary and approximately eight miles north was unsurveyed.

A land system is defined by Christian and Stewart (1953) as "an area or groups of areas, throughout which there is a recurring pattern of topography, soils and vegetation". It is a large scale mapping concept designed to be used at the regional planning level. The C.S.I.R.O. map provides a valuable guide as to where the more detailed land unit surveying should be concentrated. The larger scale mapping unit, the land unit, may then facilitate property planning in more detail.
3. DEVELOPMENTAL LIMITATIONS AND POTENTIAL LAND USE

In defining and mapping the land units of the Katherine-Douglas area Aldrick and Robinson endeavoured to place objective limitations ratings on each unit, and by reference to these limitations propose a suitable land use for each unit. Both the limitations and the proposed forms of land use are applicable to the land units of the Manbulloo area.

The limitations that have been considered are relief and microrelief, soil depth, gravel content, stoniness, presence of rock and stone, erodibility, susceptability to flooding or inundation, drainage, permeability, available soil water storage capacity, topsoil consistency, soil reaction, clearing difficulty and weediness. Because many of these limitations interact the dominant limitation is frequently the only one mentioned in the land unit description. For example in rugged areas where severe rock, erodibility and soil depth limitations occur, the severe relief limitation overrides all others.

A description of the resources and inherent limitations of each land unit provides a factual basis on which an assessment of the agricultural capability of an area can be made. The term "land category" refers to this assessment. The land categorisation* used herein was developed by Aldrick and Robinson with present agricultural and pastoral management systems in mind. The land categories 1-8 are briefly:

(1) Arable with only slight limitations : suitable for cash crops
(2) Arable with moderate limitations : suitable for cash crops
(3) Arable with definite limitations : more suitable for fodder crops than cash crops
(4) Marginally arable with serious limitations : more suitable for improved pasture
(5) Non arable : suitable for permanent improved pasture
(6) Non arable : marginally improvable grazing land
(7) Unimprovable rough grazing land
(8) Land unsuitable for pastoral production.

The extrapolation of these subjective capability assessments from the Katherine-Douglas to the Manbulloo area is generally valid since both areas lie within the same drainage basin and possess similar geological and geomorphological features.

* based on the U.S.D.A. system.
To interpret the land unit maps of the northern and southern survey areas in terms of relatively productive and unproductive land, the land categories devised by Aldrick and Robinson have been grouped into four broad classes as follows:

A: Arable areas with slight or moderate limitations i.e. categories 1,2.

B: Arable or marginally arable areas with definite or serious limitations i.e. categories 3,4.

C: Non arable areas: improvable: i.e. categories 5,6.

D: Unimprovable, i.e. categories 7,8.

The approximate areas of land in each of these classes are shown in Table 1.

The results indicate that approximately 120 sq. km or 9% of the total area surveyed is potentially arable with only slight or moderate developmental limitations. A further 267 sq. km or 20% of the area is arable or marginally arable although definite limitations do exist. The remaining 964 sq. km or 71% of the area has been designated as non arable. It is considered that of this remainder 572 sq. km or 42% is improvable and 392 sq. km or 29% is unimprovable.
TABLE 1. Areas of land occurring in each of four land category groupings on Manbulloo Station.

<table>
<thead>
<tr>
<th>Land Category Grouping</th>
<th>Southern Section</th>
<th>Northern Section</th>
<th>Total Area Surveyed</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Area (km²)</td>
<td>Area (km²)</td>
<td>Area (km²)</td>
</tr>
<tr>
<td></td>
<td>% of Total</td>
<td>% of Total</td>
<td>% of Total</td>
</tr>
<tr>
<td>A</td>
<td>68.44</td>
<td>50.94</td>
<td>119.38</td>
</tr>
<tr>
<td></td>
<td>8.0</td>
<td>10.4</td>
<td>8.8</td>
</tr>
<tr>
<td>B</td>
<td>184.38</td>
<td>82.75</td>
<td>267.13</td>
</tr>
<tr>
<td></td>
<td>21.4</td>
<td>16.9</td>
<td>19.8</td>
</tr>
<tr>
<td>C</td>
<td>343.38</td>
<td>228.88</td>
<td>572.26</td>
</tr>
<tr>
<td></td>
<td>39.9</td>
<td>46.7</td>
<td>42.4</td>
</tr>
<tr>
<td>D</td>
<td>264.13</td>
<td>127.38</td>
<td>391.51</td>
</tr>
<tr>
<td></td>
<td>30.7</td>
<td>26.0</td>
<td>29.0</td>
</tr>
<tr>
<td>Total</td>
<td>860.33</td>
<td>489.95</td>
<td>1350.28</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>100</td>
<td>100</td>
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</table>
4. DESCRIPTION OF LAND UNITS

The land units described in this report are essentially the same as those described by Aldrick and Robinson (1972). Variability in vegetation and in a few cases soils from those described by Aldrick and Robinson is apparent in some areas. This has necessitated the use of some complex land units which possess a combination of soil, vegetation, or topographical attributes normally belonging to two separate units (as per Aldrick and Robinson). For example the designation 3d/3f would indicate that the land unit contains dominantly loamy red earth soils interspersed with some loamy yellow earths.

Throughout this section the heading 'Occurrence' refers to the CSIRO land systems in which the land unit most commonly occurs. The term 'Land Category' refers to the subjective assessment of the agricultural capability of the unit.

1. HIGH LEVEL PLATEAUX
Land unit la.
Occurrence: Mainly Mullaman; some Yujullowan.
Topography: Flat to gently sloping with marginal rocky slopes to 10%.
Soils: Generally shallow Cockatoo and Lateritic Podzolics with frequent outcrop of laterite or sandstone.
Vegetation: Open forest (E.* miniata, E. tetradonta, E. bleezeri); frequently dense understory shrubs; and Spinifex/annual Sorghum.
Limitations: Rocky, shallow soils.
Potential Land Use: Mainly inaccessible; very limited rough grazing; watershed protection.
Land Category: 7.

* Throughout this report E. refers to Eucalyptus species.
2. RUGGED TERRAIN

Land unit 2a.

Occurrence: Mullaman, Yujullowan, Woggaman, Chinaman and Jindara.

Topography: Rugged terrain with slopes in general greater than 40%; boulder strewn slopes and rocky crests.

Soils: Very shallow or skeletal with outcrop.

Vegetation: Variable, but general occurrence of dense thickets of *Acacia shirleyi* and local areas of *E. umbrawarrensis* to the edge of breakaways. Stunted *E. tectifica*, *Erythrophleum*, *Cochlospermum*, *Brachychiton paradoxum* and *Hakea* are also common as low shrubland to low woodland associations. Sparse annual grass cover.

Limitations: Shallow rocky soils.

Potential Land Use: Usually inaccessible; watershed protection; catchment reserves; unsuitable for pastoral production.

Land Category: 8.

Land unit 2b.

Occurrence: Mullaman, Yujullowan, Woggaman, Chinaman and Jindara.

Topography: Rugged terrain with slopes 15-40%; boulder strewn slopes and rocky crests.

Soils: Very shallow or skeletal with outcrop.

Vegetation: Generally similar to land unit 2a, however associations dominated by *Acacia shirleyi* and *E. umbrawarrensis* are less frequently observed.

Limitations: Shallow rocky soils.

Potential land use: Usually inaccessible; watershed protection; catchment reserves; unsuitable for pastoral production.

Land Category: 8.

Land unit 2c.

Occurrence: Mullaman, Yujullowan, Woggaman, Chinaman, Jindara and Claravale.
Plate 1.

Land unit 2b.  Rugged terrain with slopes 15-40\%, skeletal soils.

Plate 2.

Land unit 2e.  Undulating terrain with slopes \(<\) 5\%, stony skeletal soils.
Topography: Hilly terrain with slopes 5-15%; rocky and boulder strewn.

Soils: Generally shallow or skeletal.

Vegetation: Very variable, generally stunted open woodland to low open woodland dominated by E. tectifica and/or E. terminalis. E. clavigera and stunted Lysiphyllum, E. miniata and Erythrophleum may also be present. Grass cover is usually very poor with Sorghum sp (annual) and Plectrachne sp. dominant.

Limitations: Shallow, rocky soils; very erodible situations.

Potential Land Use: Limited rough grazing.

Land Category: 7.

Land unit 2d.

Occurrence: Budbudjong and Kimbyan.

Topography: Massive limestone ridges with frequent rocky sinks.

Soils: Very poorly developed Red Earths; large areas of bare rock surface.

Vegetation: Mainly deciduous non-Eucalypt low woodland and scrub; sparse grasses.

Limitations: Extremely rocky.

Potential Land Use: Inaccessible areas.

Land Category: 8.

3. FLAT TO GENTLY UNDULATING TERRAIN

Land unit 2e.

Occurrence: Mainly Woggaman, Jindara and Claravale.

Topography: Gently undulating crests and upper slopes up to 5%.

Soils: Either very shallow and gravelly, or sandy with frequent exposures of sandstone or laterite.

Vegetation: Open woodland to low woodland of E. tectitica with stunted E. foelscheana in areas of deeper soils. On shallow gravelly soils a low tree to shrub understory similar to that for land units 2a, 2b and 2c exists. E. dichromophloi, E. terminalis and E. bleezeri may also occur; mainly Spinifex and annual Sorghum grass cover.
Limitations: Shallow soils, rocky, poor waterholding capacity; frequently erodible.

Potential Land Use: Poor rough grazing.

Land Category: 7.

Land unit 3a.

Occurrence: Kimbyan, Tagoman and Budbudjong.

Topography: Very gentle slopes less than 2% on Kimbyan and Budbudjong; undulating and dissected terrain on Tagoman; severe limestone pavement or outcrop on Kimbyan and Budbudjong; frequent linear outcrops of intermixed limestone and sandstone on Tagoman.

Soils: Small pockets of very shallow Red Earths; some yellow podzolics (Florina).

Vegetation: Low woodland to low open woodland of E. tectifica and/or E. foelscheana. A low tree to shrub understory of species including Cochlospermum, Brachychiton, Hakea, Lysiphyllum and Croton arnhemicus normally occurs. Grass cover is usually poor and includes Sorghum sp annual, Sehima and Chrysopogon fallax.

Limitations: Severe rock outcrop; shallow soils in small pockets, highly erodible on Tagoman.

Potential Land Use: Very limited rough grazing; severely restricted accessibility.

Land Category: 7.

Land unit 3b.

In general similar to 3a. Rock outcrop less severe on Kimbyan and Budbudjong or terrain more gentle and less dissected on Tagoman. Areas are trafficable with difficulty. Areas without rock are generally more extensive and the soils deeper. Suitable for rough grazing with small areas suitable for improved pasture.

Plate 3.

Land unit 3a. This unit is characterized by severe limestone pavement rendering it almost unusable.

Plate 4.

Land unit 3b. This unit contains generally less rock outcrop and deeper soils than unit 3a.
Land unit 3c.

Occurrence: As 3a.

Topography: Flat to gently sloping (less than 2%) with scattered limestone pavement or outcrop.

Soils: Loamy Red Earths, deep with minor outcrop, or shallow (30-45 cm deep) with small amounts of surface stone and gravel.

Vegetation: Woodland to low open woodland generally dominated by E. tectifica and/or E. foelscheana. A low tree-shrub understory of Hakea, stunted Erythrophleum, Gardenia and/or Terminalia platyptera may occur in some areas. Grass cover is usually dense and mixed with such species as Sehima, Chrysopogon fallax and Themeda.

Limitations: Slight rock; soils sometimes shallow (hence poor waterholding capacity); generally slightly erodible on Tagoman where slopes are greater than 1%.

Potential Land Use: Improved pastures with high carrying capacity; often arable but more suitable for forage crops than for cash crops.

Land Category: 3.

Land unit 3d.

Occurrence: Extensive on Kimbyan, small areas on Tagoman, Jindara and Wriggley.

Topography: Flat to gently sloping (less than 2%) with indistinct drainage floors.

Soils: Generally deep Loamy Red Earths (Tippera) with very minor inclusions of Yellow Podzolics.

Vegetation: Woodland to low open woodland dominated by E. foelscheana and E. tectifica. Sparse Erythrophleum, E. confertiflora and/or E. patellaris may occur in drainage situations. Dense grass cover is usually dominated by Sehima, Themeda and/or Chrysopogon fallax.

Limitations: Slight erosion on slopes greater than 0.5% more severe on drainage floors; dense hard surface with low permeability; narrow available moisture range.

Potential Land Use: Arable; suitable for cash cropping; not easily ploughed when dry; continuous cultivation leads to insidious sheet erosion.

Land Category: 1 with small areas of 3 (sloping erodible areas adjacent to Chinaman track linking Manbulloo airstrip with King River).
Plate 5.

Land unit 3c. Generally flat areas of deep loamy red earths, with E. tectifica, E. foelscheana woodland. Some slight limestone outcrop is present.

Plate 6.

Land unit 3d. Generally flat areas of deep loamy red earths (Tippera), with E. foelscheana, E. tectifica woodland. Absence of rock outcrop. Areas are arable and suitable for cash cropping.
Land unit 3dl.

Occurrence: Kimbyan.

Topography: As 3d.

Soils: Deep Loamy Red Earths, (Tindall) with subsoil concretions high in manganese.

Vegetation: Dense low woodland to tall shrubland with perennial grasses; same species as 3d.

Limitations: As 3d and in addition a probable nutrient imbalance.

Potential Land Use: As 3d depending on severity of the nutrient disorder.

Land Category: 2.

Land unit 3d2.

Occurrence: Jindara in the north of the area.

Topography: Lower slopes and drainage floors; undulating with short and variable slopes.

Soils: Loamy Red Earth (Emu), often shallow.

Vegetation: As 3d on lower slopes; E. miniata open forest with perennial grasses including Coelorhachis and Heteropogon triticeus on drainage floors.

Limitations: Very erodible; small, scattered areas.

Potential Land Use: Native pastures and grassed waterways with controlled grazing.


Land unit 3e.

Occurrence: Tagoman and Jindara; very limited in extent.

Topography: Undulating terrain with slopes up to 5%; generally at distinct breaks of slope or at heads of drainage systems; frequently used by cattle and horses for camp sites.

Soils: Loamy Red Earths usually shallow and eroded.
Vegetation: Low very open woodland with many dead trees; sparse perennial grasses and Brachyachne, frequent bare areas and gullies.

Limitations: Very erodible; small, scattered areas.

Potential Land Use: Rough grazing; possibly improvable.


Land unit 3f.

Occurrence: Kimbyan, in particular adjoining major river alluvials.

Topography: Almost flat (less than 1%).

Soils: Loamy Yellow Earths (Elliott), normally deep with slight internal drainage impedance.

Vegetation: Woodland, rather taller than on 3d, otherwise similar with frequent occurrence of E. patellaris; dense perennial grasses usually dominated by Themeda, Sehima or Chrysopogon fallax.

Limitations: Slow subsoil permeability causes poorer drainage than 3d.

Potential Land Use: Arable, suitable for cash cropping although water tolerant varieties may be required, lower yields may be expected on locally waterlogged areas; some areas may be untrafficable during wet periods.

Land Category: 2 with areas of minor 3 (imperfectly drained, erodible areas adjacent to Chinaman track linking Manbulloo airstrip with King River).

Land unit 4al.

Occurrence: Blain, Kimbyan and Wriggley.

Topography: Long gentle slopes up to 2% and broad drainage floors; scattered rock outcrop or pavement, normally limestone.

Soils: Usually deep Sandy Red Earths with firm surface horizons of sandy loam to sandy clay loam (Ooloo with some Killuppa).

Vegetation: Low woodland to woodland with E. tetradonta and Terminalia grandiflora on Blain and Wriggley and as 3d on Kimbyan; perennial grasses.
Plate 7.
Land unit 3f. Similar potential to 3d, but characterized by deep loamy yellow earths (Elliot).

Plate 8.
Land unit 4a1 Similar potential to both 3d and 3f but with deep sandy red earth soils with firm surface horizons.
Limitations: Subject to erosion particularly under conditions of continuous cultivation; probable compaction and surface sealing problems.

Potential Land Use: Arable; crop responses expected to be similar to 3c.

Land Category: 1.

Land unit 4a2.

Occurrence: Blain and Wriggley.

Topography: Long gentle slopes up to 2%; occasional sandstone outcrop.

Soils: Deep Sandy Red Earths with soft surface horizons of sand to loamy sand (Blain with some Killuppa).

Vegetation: Woodland to sparse open forest often with E. tetradaonta or E. miniata dominant, Terminalia grandiflora and Erythrophleum often form part of the association. Grass cover usually dominated by Sorghum which may occur with Sehima, Chrysopogon fallax or Themeda.

Limitations: Subject to severe erosion; seedling establishment difficulties due to low waterholding capacity of topsoil and surface sealing.

Potential Land Use: Improved pastures; possibly suitable for deep rooted fodder crops.

Land Category: 3.

Land unit 4b1.

Occurrence: Blain and Claravale.

Topography: Broad drainage floors up to 1 Km wide and with longitudinal slopes of up to 2%. Occasional sandstone outcrop.

Soils: Deep Sandy Red Earths with firm surface horizons of sandy loam to sandy clay loam (Ooloo and Killuppa).

Vegetation: Open forest almost exclusively dominated by tall E. tetradaonta (up to 25 m) with subordinate Ironwood and E. foelscheana; predominantly perennial grasses (Sehima).

Limitations: Subject to severe erosion if cultivated; probable surface sealing and possible compaction problems; high cost of clearing; probable sucker regrowth problems.
Potential Land Use: Arable but favouring deep-rooted crops; probably suitable for forestry use as well as agricultural.

Land Category: 3.

Land unit 4b2.

Occurrence: Blain and Claravale.

Topography: Lower slopes and floors in gently undulating terrain; slopes up to 3%; occasional sandstone outcrop.

Soils: Deep Sandy Red Earths with soft surface horizons of sand to loamy sand (Killuppa and Blain with some Cockatoo).

Vegetation: Open forest dominated by E. tetradonta with some E. miniata, subordinate Ironwood and E. foelscheana; dominant annual Sorghum; occasional Spinifex in the south.

Limitations: Subject to periods of severe water stress; moderately erodible on steeper slopes; severely erodible if cleared and cultivated.

Potential Land Use: Mainly suitable for improved pastures; generally non-arable.

Land Category: 5.

Land Unit 4c.

Occurrence: Blain and Claravale; mainly close to major rivers and creeks.

Topography: Gently undulating terrain often adjoining, or at least close to river backplains, slopes up to 3%; often slight limestone outcrop at breaks of slope.

Soils: Deep Sandy Red Earths with sand or loamy sand surfaces (Killuppa with some Blain).

Vegetation: Woodland to open forest dominated by Ironwood, E. tetradonta and E. papuana; large well-formed trees, rather widely spaced with much Bauhinia understory; mixed perennial grasses and annual Sorghum.

Limitations: Subject to severe erosion if cultivated; probable water stress and surface sealing problems; slight rock.
Plate 9.
Land units 4b2. Deep sandy red earths with soft surface horizons distinguish this unit from 4a1.

Plate 10.
Land unit 4cl. Deep sandy red earths carrying E. papuana and Ironwood are characteristic of this unit.
Potential Land Use: Improved pastures with selective clearing; proximity to perennial waters and their content of excellent shade trees makes these areas most valuable for grazing.

Land Category: 5.

Land unit 4cl.

Occurrence: Kimbyan; mainly adjacent to Daly River below its junction with Stray Creek.

Topography: Gently undulating terrain adjoining river backplains or old river channels, slopes up to 5%; some ferruginous outcrops at breaks of slope.

Soils: Deep Sandy Red Earths with sand to sandy loam surfaces (Killuppa with some Blain).

Vegetation: Woodland to open forest dominated by E. papuana with Erythrophleum, Gyrocarpus, or Terminalia grandiflora as co-dominants. Some Canarium, Brachychiton diversifolium or Lysiphyllum may be present. Grass cover of mixed perennials and Sorghum sp. annual. Some Hyptis present.

Limitations: Subject to severe erosion if cultivated; probable water stress and surface sealing problems; slight rock.

Potential Land Use: Improved pastures on lower slopes with selective clearing; proximity to perennial waters and their content of excellent shade trees increases the value of these areas for grazing.

Land Category: 5.

Land unit 4d.

Occurrence: Claravale and to a small extent Blain.

Topography: Upper and middle slopes in undulating terrain; slopes up to 5% occasionally up to 8%.

Soils: Mainly deep Earthy Sands (Cockatoo), sometimes light Sandy Red Earths (Blain) and Siliceous Sands (Cypress); often occurs in association with Claravale soils.

Vegetation: Open forest dominated by E. tetradoanta and E. miniata. E. ferruginea frequently occurs with a dense Bossiaea understory. Elsewhere a dense shrub layer of Acacia and Petalostigma frequently occurs. Sorghum sp. annual is the dominant grass cover, Plectrachne, Setaria, Aristida and Sehima also occur.
Plate 11.

Land unit 4d. Soils of this unit are very sandy (Cockatoo, Blain or Cypress) and hence subject to severe water stress.
Limitations: Severe water stress; very loose sandy surface; highly erodible under intensive use.

Potential Land Use: Mainly rough grazing; largely unimprovable; lacking natural stock waters.


Land unit 4dl.
Occurrence: Generally limited to certain areas within Claravale and locally round sandstone hills.
Topography: Lower slopes and floors generally associated with areas of strong relief.
Soils: Siliceous Sands (Cypress) with some Cockatoo and Claravale.
Vegetation: As 4d with some areas, particularly in the south, dominated by Cypress Pine with little or no grass.
Limitations: Very severe water stress; extremely loose and boggy sandy surface; highly erodible; very infertile.
Potential Land Use: Very limited rough grazing.

Land unit 5a.
Occurrence: Claravale and small areas in Jindara and Woggaman.
Topography: Mainly crests and upper slopes up to 4%; frequent laterite outcrop on crests on Claravale land system.
Soils: Lateritic Podzolics (Claravale); some Cypress and Cockatoo.
Vegetation: Stunted woodland to low open woodland dominated by E. miniata often with E. ferruginea as a low tree understory. The grass layer is usually dominated by Sorghum sp and/or Plectrachne. A well developd shrub layer is frequently present. Vegetation generally lower and more open on Jindara.
Limitations: Very low waterholding capacity; erodible on slopes steeper than 1% if the surface is disturbed; very loose soil surface; very infertile.
Potential Land Use: Mainly rough grazing; some slight improvement might be possible on flatter areas; lacking natural stock waters.
Land unit Sb.

Occurrence: Claravale, Jindara and Woggaman.

Topography: Crests and upper slopes, sometimes containing minor drainage lines; frequent laterite outcrop.

Soils: Lateritic Podzolics (shallow Claravale).

Vegetation: Woodland, dominated often exclusively by *E. bleeseri* with very poor Spinifex dominated pastures with much of the low shrub *Petalostigma haplocladum*.

Limitations: Very shallow, gravelly and drought affected soils; subject to high amounts of sheetwash and very erodible if disturbed.

Potential Land Use: Very poor rough grazing; unimprovable; useful source of gravel.

Land Category: 7.

Land unit Sc.

Occurrence: Claravale and rarely Banyan.

Topography: Either valley floors or lowlying seepage areas in sandy country; frequently abutt drainage lines or backplains.

Soils: Siliceous Sands (Stray), alluvial Red Earths (Umbrawarra) and Yellow Podzolics (Douglas), the latter on flattest areas.

Vegetation: Woodland to open woodland generally dominated by *E. polycarp*. *E. bigalerita* or *E. grandifolia* occur in less well drained situations. An understory of *Petalostigma* or *Melaleuca viridiflora* commonly occurs in these areas. A mixed grassland of *Themeda, Aristida, Plectrachne* and *Chrysopogon fallax* is also present.

Limitations: Very wet and untrafficable in the wet season; highly erodible if disturbed.

Potential Land Use: Very poor rough grazing, though may provide a green pick later in the dry season than most areas; may be improvable in parts but drainage floors should be treated as grassed waterways.

Land Category: 6, and 7 in drainage floors.
Plate 12.

Land unit 5b. Uniform *E. bleeseri* is commonly found on the shallow gravelly lateritic podzolic soils of this unit.
Land unit 5d.

Occurrence: Mainly Jindara; minor occurrence in Wriggley and Woggaman.

Topography: Undulating terrain; slopes generally less than 3%.

Soils: Rather variable but typically Lateritic Podzolics (Jindare) and Yellow Podzolics (Ejong);

Vegetation: Low woodland to low open woodland usually dominated by stunted E. tectifica. Erthrophleum, or E. bigalerita may occur as subdominants with a low tree-shrub understory of Petalastigma and/or Melaleuca viridiflora. Grass cover dominated by Plectrachne.

Limitations: Impeded drainage; wet and untrafficable in the wet season; low waterholding capacity; very erodible if disturbed.

Potential Land Use: Non-arable but mainly suitable for improved pastures for dry season use.

Land Category: 5.

Land unit 5e.

Occurrence: Kimbyan and Wriggle.

Topography: Generally rather flat (slopes less than 1%).

Soils: Yellow Podzolics (Florina and some Ejong); often associated with areas of Tippera; frequent pig wallows.

Vegetation: Similar to the low woodland of 3d; both trees and perennial grasses have a more uneven appearance; scattered shrubs (Grevillea heliosperma and Terminalia ferdinandiana) may also be present.

Limitations: Impeded drainage; boggy in the wet season.

Potential Land Use: May be arable but poor drainage could make cultivation difficult and lower yields, good improved pastures.

Land Category: 4.

Land unit 5fl.

Occurrence: Woggaman.

Topography: Undulating terrain; slopes less than 4%; intense drainage pattern.
Plate 13.
Land unit 5d. Stunted E. tectifica commonly occurs on the lateritic and yellow, podzolic soils of this unit.

Plate 14.
Land unit 6a. Extensive open, grassland areas occur over grey and brown clay soils.
Soils: Variable, shallow and poorly drained. Yellow Podzolics (mainly Ejong, some Lateritic Podzolics).

Vegetation: Tall shrubland to stunted woodland with scattered low emergent trees. In areas of Yellow Podzolics Petalostigma and Terminalia pterocarpa are dominant over E foelscheana, E. ferruginea and Erythrophleum emergents. On Lateritic Podzolic soils E. tetradonta and E. bleeseri emergents also occur. Generally poor grass cover of Sorghum sp annual.

Limitations: Very shallow, droughty and poorly drained soils of low fertility, very erodible if disturbed.

Potential Land Use: Very marginal country often well supplied with large creeks with almost perennial waterholes, such that low quality improved pastures could be considered with careful stock management.


Land unit 5f2.

Occurrence: Woggaman.

Topography: Lower slopes and drainage floors associated with 5fl.

Soils: As 5fl but seriously affected by waterlogging.

Vegetation: Dense tall shrubland, characteristically Melaleuca viridiflora, and/or Petalostigma.

Limitations: As 5fl with very serious waterlogging.

Potential Land Use: Very poor rough grazing at best.

Land Category: 7.

Land unit 5g.

Occurrence: Jindara; often lower slopes of Mullaman.

Topography: Undulating terrain, slopes of up to 4%; frequent unchannelled drainage floors.

Soils: Yellow Podzolics (Ejong with some Florina); usually with very dense low pointed termitaria.

Vegetation: Rather open low woodland (E. tectifica, E. latifolia) with low uneven perennial grasses (Chrysopogon fallax and Themeda).
Limitations: Seriously impeded drainage; moderate to severe erosion risk; probable low waterholding capacity.

Potential Land Use: Mainly suitable for improved pastures.

Land Category: 5.

Land unit 6a.

Occurrence: Chinaman and Woggaman.

Topography: Undulating terrain; slopes up to 5% rarely 10%; generally associated with rugged terrain.

Soils: Grey and Brown Clays (Banyan and Cununurra) with surface stone.

Vegetation: Grassland dominated by Chrysopogon fallax with occasional Acacia affin. bidwillii, Terminalia pterocarp a, E. platyp tera and Lysiphyllum emergents.

Limitations: Highly erodible, stony and strongly gilgaied.

Potential Land Use: Rough grazing.

Land Category: 7.

Land unit 6b.

Occurrence: Kimbyan and Budbudjong.

Topography: Small internal drainage depressions; almost flat; often at the base of massive limestone ridges.

Soils: Grey and Brown Clays (Banyan) with moderate to severe limestone outcrop or pavement.

Vegetation: Perennial grassland with scattered trees.

Limitations: Moderate to severe rock; severe gilgai; very wet.

Potential Land Use: Limited rough grazing.

Land Category: 7.

Land unit 6c.

Occurrence: Karaman and Chinaman.

Topography: Almost flat plains with endoreic drainage; ponded in the wet season.

Soils: Grey and Brown Clays (Banyan and Cununurra), usually the more poorly drained series.
Severely gilgaid soils render this unit suitable only for rough grazing land.

Almost flat, poorly drained plains carrying *Terminalia* spp and *Lysiphyllum* are characteristic.
Vegetation: Open shrubland to low open woodland dominated by Terminalia platyptera, Terminalia pterocarpa or Lysiphyllum E. prunosa, and Acacia affin bidwillii are also common. Tall perennial grasses including affin. Alloteropsis sp. Chrysopogon fallax, Aristida and Themeda are present.

Limitations: Strongly gilgaied; very poorly drained; periodically subjected to shallow inundation.

Potential Land Use: Limited dry-season rough grazing.

Land Category: 7.

4. TRIBUTARY CREEKS, DRAINAGE FLOORS AND BACK PLAINS

Land unit 7a1

Occurrence: Banyan, as drainage lines, may traverse many other land systems.

Topography: Major river backplains or tributary drainage flats.

Soils: Grey and Brown Clays (Banyan with some Cununurra and Coolibah).

Vegetation: Open woodland dominated by E. microtheca, E. patellaris and/or E. papuana, usually with dense Themeda and/or Chrysopogon fallax grassland.

Limitations: Poor drainage; inundated for long periods during the wet season; subject to occasional flooding; moderate to severe gilgai, usually alkaline subsoils; possibly saline.

Potential Land Use: At present only rough grazing; pasture improvement given suitable pasture species may be practicable in the future; irrigated pastures may be possible but further study is required.


Land unit 7a2.

Occurrence: Banyan, as drainage lines, may traverse other land systems.

Topography: Slightly elevated areas of major river backplains, and drainage floors in the lower reaches of some tributary creeks.

Soils: Grey and Brown Clays (Coolibah with some Banyan).
Plate 17.

Land unit 7a1. Major river back plains of grey and brown clay soils supporting E. papuana open woodland and dense Themeda grassland.

Plate 18.

Land unit 7d. Broad drainage flats with deep loamy red earths and commonly with E. papuana.
Vegetation: Woodland (E. tectifica, E. grandifolia and Tristania) with perennial grasses; increasing E. papuana and weed species close to main rivers; tributary drainage floors have very scattered trees (E. papuana) with very dense perennial grasses usually dominated by Themeda.

Limitations: Poor drainage; isolated at times by floodwaters.

Potential Land Use: Marginally arable; suitable for improved pastures used in conjunction with native pastures of 7al.

Land Category: 4.

Land unit 7a3.
Occurrence: Banyan, usually associated with Kimbyan.
Topography: Almost flat plains up to 1.5 Km wide; scattered limestone outcrop.
Soils: Rendzinas (Ingrid and Phillips), some Cununurra.
Vegetation: Either grassland (Sorghum plumosum), or very open woodland with large scattered Tristania suaveolens.
Limitations: Impeded drainage and periods of inundation; often shallow and possibly droughty; very high pH.
Potential Land Use: Rough grazing; may be improvable with pasture species able to tolerate waterlogging and alkaline conditions.

Land Unit 7b.
Occurrence: Woggaman; as drainage lines, may traverse other land systems.
Topography: Drainage lines with transverse slopes up to 1%; may be channelled but the channel is small and well defined; occasional small high-level plains.
Soils: Gleyed Podzolics (Marrakai) and Yellow Podzolics (Ejong) with minor Solodics, generally shallow with a well-developed hard pan.
Vegetation: Either open woodland (E. tectifica, E. latifolia) or Melaleuca shrubland with short annual Sorghum and Eriachne pastures.
Limitations: Severely impeded internal drainage; surface water flow; highly erodible if disturbed.

Potential Land Use: Permanent grassed waterways with strictly controlled grazing.

Land Category: 7, with some 6 (high level plains).

Land unit 7c.
Occurrence: Woggaman, Claravale.
Topography: Ill-defined depositional drainage lines; rare channels, intermittent and ill-defined.
Soils: Immature and unstable sandy alluvium with small areas of Marrakai, Ejong and Douglas.
Vegetation: Extremely variable; frequent occurrence of Melaleuca scrub and frontage grasses.

Limitations: Highly erodible and prone to flooding and flood deposition.

Potential Land Use: Strictly controlled rough grazing; permanent grassed waterways.

Land Category: 7.

Land unit 7d.
Occurrence: Tagoman, Kimbyan and Jindara.
Topography: Broad drainage flats or seasonally ponded areas with very slight slopes; rarely channelled.
Soils: Loamy Red Earths (Tippera) with alluvial and colluvial surface horizons.
Vegetation: Open woodland to open forest dominated by E. patellaris, E. foelscheana and/or E. papuana with dense grass cover of Themeda and Chrysopogon fallax.

Limitations: Highly erodible if disturbed; subject to periods of surface water flow.

Potential Land Use: Grassed waterways; useful grazing which should be strictly controlled; should not be cleared or cultivated.

Land unit 7dl.

Occurrence: Kimbyan.

Topography: Broad drainage flats or temporarily ponded areas with very slight slopes; rarely channelled.

Soils: Yellow Earths (Elliott) with alluvial and colluvial surface horizons.

Vegetation: Very open woodland, usually dominated by *E. papuana* with local thickets of *Tristania*; mixed annual Sorghum and *Themeda* with local swamp grasses.

Limitations: Erodible if disturbed, especially when subject to periods of surface water flow.

Potential Land Use: Grassed waterways; useful grazing which should be strictly controlled; should not be cleared or cultivated.


Land unit 7e.

Major creeks and severely gullied tributaries; contain permanent and ephemeral water supplies; severe risk of erosion, particularly headward gullying, at access points; careful control and regulation of stock numbers at these watering points is necessary.

Land Category: 8.

5. MAJOR RIVER ALLUVIALS

Land unit 8a.

Occurrence: Banyan, Karaman.

Topography: Younger river levees with back slopes up to 6% where the levee is narrow, 2-3% where wider; rarely over 200 meters wide.

Soils: Alluvial Red Earths (Manbulloo and Daly); occasional rock (quartzite) outcrop indicates shallow soils in area traversing sandy land systems.

Vegetation: Variable woodland or open forest with *E. papuana* a frequent species; generally short annual grasses infested more or less badly with weeds (*Hyptis, Acanthospermum*).
Plate 19.

Land unit 7d1. Similar to unit 7d but with deep loamy yellow earth soils.

Plate 20.

Land unit 8b. Alluvial red earths of the younger river levees and back slopes carry a variable woodland frequently with E. papuana.
Limitations: Weeds; high erosion risk on steeper slopes, stream bank erosion on river side of unit; low waterholding capacity; frequent risk of isolation by floodwaters.

Potential Land Use: These soils offer scope for spray irrigation of fruit and vegetable crops or pastures; normal erosion control measures must be considered even on moderately sloping areas.

Land Category: 3.

Land unit 8b.

Occurrence: Banyan.

Topography: Younger river levees with backslopes rarely in excess of 2%; up to 1 Km wide.

Soils: Alluvial Red Earths (Katherine, Edith); deep.

Vegetation: Variable woodland frequently with E. papuana; mixed perennial and short annual grasses with frequent bare patches; more or less badly infested with weed species.

Limitations: Weeds; slight erosion risk, with stream bank erosion; occasional flooding possible.

Potential Land Use: Arable for crops or pastures and suitable for irrigation.

Land Category: 1.

Land unit 8c.

Occurrence: Banyan, Kararnan.

Topography: Low-lying areas behind the younger levees, older levees, or minor drainage floors within the younger levees; slopes generally very slight.

Soils: Alluvial Red Earths (Belbowlie, or poor drained phases of Katherine and Edith).

Vegetation: Woodland (E. foelscheana, E. patellaris) with dense perennial grasses (Themeda).

Limitations: Drainage impedance; flooding and possibly periods of inundation; levee drainage floors highly erodible.
Potential Land Use: Arable if extensive and flat, but more suited for fodder crops or improved pasture; irrigation might be considered but some form of artificial drainage would be necessary; levee drainage lines should be left as grasses waterways.

Land Category: 3 and 4 with some 6 (levee drainage floors).

Land unit 8d.

Swamps, more or less permanent, either paperbark or freshwater mangrove with *Eleocharis* and *Oryza*. These areas should be considered as refuges for waterfowl or watering places for stock.

Land Category: 7.

Land unit 8e.

All severely eroded areas associated with the major river alluvials. These are usually deep and active gully systems which require careful protection, particularly from stock using them for access to water.

Land Category: 8.
6. GEOLOGY

Detailed geological mapping of the Katherine area was commenced by the Bureau of Mineral Resources in 1951 and a map and explanatory notes published in 1962 and 1963. Any previous mapping of the area was of an exploratory or reconnaissance nature, usually involving detailed mapping of mining areas only.

The geology of the Manbulloo area is relatively simple and is comprised mainly of the recently deposited Lower Cretaceous sandstone and siltstone sediments of the Mullaman beds and the later Quaternary alluvial deposits associated with the Katherine and King River systems. Older, Middle Cambrian limestones, sandstone and siltstone of the Daly River Group also occur throughout the area.

The geological relationships within the area surveyed are shown in Figure 3 and described briefly below.

PALEOZOIC

Middle Cambrian : Daly River Group

(i) Manbulloo Limestone Member :
This consists of silicified to flaggy limestone which overlies the basal unit of the Daly River Group, Tindall limestone.

(ii) Jinduckin Formation :
These sediments consist of ferruginous quartz sandstone and siltstone with halite pseudomorphs and some marl and limestone. This formation is the lateral equivalent of the Manbulloo Limestone Member since it also overlies the Tindall limestone.

(iii) Ooloolo Limestone :
This is the uppermost formation in the Daly River Group and consists of silicified limestone which is cherty in places.

MESOZOIC

Lower Cretaceous

(i) Mullaman Beds :
These sediments are widespread and unconformably overlie units of the Daly River Group. They consist of sandstone, siltstone, grit, conglomerate and some porcellanite.
Figure 3  Geology of survey area, Manbulloo Station

Key
- Alluvium
- Mulloman Beds
- Oollao Limestone
- Jinduckin Formation
- Manbulloo Limestone Member

River
Katherine
King
River
CAINOZOIC

Quaternary Alluvial Deposits:
These consist of alluvium, soil, residual sand and ferruginous material.

Geological control of major landscape developments formed on the Daly River Group is generally not marked within the Manbulloo area. This has been due to both the absence of contrast to erosion resistance within the group together with the masking of underlying lithologies by both widespread deep lateritic weathering and extensive alluvial and colluvial deposition, (Mabbutt, J.A., 1965). A comparison of figures 3 with figures 2a and 2b reveals however, that amongst the land systems of greatest agricultural potential i.e. Blain and Kimbyan, there is some degree of correlation with geology. Blain land system is generally formed on the extensive colluvial/alluvial mantle of the Mullaman beds. Because these deposits are arenaceous, almost horizontal and fairly thick, the soils tend to be uniform and sandy. A high degree of soil uniformity has resulted in the occurrence of reasonably large land units within this land system. Kimbyan land system generally occurs on broad, flat plains containing frequent exposures of Cambrian limestones either as pavement, floaters or massive outcrop. The land units within this land system are characteristically less extensive in area.
7. SOILS

The majority of soils encountered in the area surveyed of Manbulloo Station fit the general soil descriptions and classification contained in Aldrick and Robinson's report. Detailed descriptions of representative profiles of each of the major soil families located in the Manbulloo area are given in Appendix 1. Some of the soil families quoted in the land unit descriptions were not sampled and described during this survey but occur as a result of the extrapolation of land units from adjacent areas previously described by Aldrick and Robinson (1972). Detailed profile description of those families are given in that report. A brief outline of the major soil groups*, the soil families and their distribution within the various land systems and land units of the survey area is as follows.

A. Siliceous Sands

The majority of these soils which were sampled belonged to the Cypress family. Their occurrence is limited in the area, mainly within land unit 4dl and occasionally units 5c and 4d of Claravale land system.

B. Earthy Sands

These soils occur mainly within Blain and Claravale land systems, land unit 4d and less commonly 4b2. Although these soils belong to the Cockatoo family, they tend to be lighter in texture than those described by Aldrick and Robinson. Their light texture is a result of the arenaceous nature of the underlying geology of these land systems.

C. Red Earths

As in the Katherine-Douglas area, the Red Earths are the most common soils in the area surveyed of Manbulloo Station. A revised classification of the Red Earths in the "Top End" of the Territory is currently under way (Day, K.J. and van-Cuylenburg, H.R.M.) and preliminary results suggest that some classification differences may occur when compared to the system proposed by Aldrick (1972).

(i) Sandy Subgroup
On Manbulloo the majority of these soils occur in Blain and Claravale land systems, within units 4b2, 4a2, 4c, 4cl and 4d. Soils with duplex texture profiles belonging to the Blain family were very common while those with gradational texture profiles of the Killuppa (previously Venn) family were marginally less common.

* Stace et al (1965)
(ii) Loamy subgroup
These soils are generally considered to possess a high potential for agricultural use within the Manbulloo area. They frequently occur however in association with varying amounts of limestone in Kimbyan, Tagoman, Wriggley and Budbudjong land systems. This has necessitated the use of "mixed units" e.g. 3c/3d in many cases. The majority of these soils belong to the Tippera family.

(iii) Alluvial subgroup
The majority of Alluvial Red Earths in this area belong to the Manbulloo family and occur within Banyan and Karaman land systems. Several representatives of the Katherine family were also encountered.

D. Yellow Earths

The occurrence of Yellow Earths is far more common in the Manbulloo area than in the Katherine-Douglas area. Aldrick and Robinson in their report of the latter area have described two families, Elliott and Elizabeth, but only the Elliott family is mentioned in the land unit descriptions. The majority of Yellow Earths in the Manbulloo area belong to the Elliott Family, however some areas do contain Elizabeth soils. To avoid establishing a new land unit, all yellow earths have been mapped together into either land unit 3f or 7dl, depending on topography. Yellow Earths of the Elizabeth family are generally associated with more sandy areas and are often found interspersed with Yellow Podzolics. In the Manbulloo area Yellow Earths were found to occur within Kimbyan and Wriggley land systems.

E. Yellow Podzolics

These soils are reasonably common in the Manbulloo area, particularly within Woggaman and Claravale land systems. The majority belong to the Douglas family.

F. Lateritic Podzolics

These soils are common within Claravale, Jindara and Woggaman land systems, and like the Earthy Sands have slightly sandier textures than those described in the Katherine-Douglas region. The majority belong to the Claravale family.

G. Grey and Brown Clays

These soils occur commonly within Chinaman, Woggamar, Kimbyan and Budbudjong land systems. The majority of these soils are gilgaied and belong to either the Cununurra or Banyan families.
H. Lithosols

These soils are generally shallow and gravelly and were found over a considerable proportion of Mambulloo, most commonly on slopes greater than 5%.
8. VEGETATION

The classification of vegetation communities used for this survey is based on that adopted by Specht (1970), (Table 2). A complete list of all botanical species observed in the survey area is given in Appendix II.

During the survey a certain degree of variation was encountered between recorded vegetation types and associations, and those summarised in the "Report of the Land Units of the Katherine-Douglas Area". (Aldrick J.M. and Robinson C.S. 1972). This variability is to be expected when land unit descriptions are extrapolated over large areas where some climatic, geological and soil differences are likely to occur. To more correctly describe the actual vegetation existing in the land units of the Manbulloo area, the vegetation summary within the land unit descriptions has been modified from that occurring in Aldrick and Robinson's report.

To aid any future botanical work in the Manbulloo area further detail on the vegetation types and their associations have been compiled separately as "Botanical Notes on some species collected in the Manbulloo area, 1976" (C.R. Gibbs 1977).
Table 2. Structural Forms of Vegetation in Australia (adapted from Specht, 1970).

<table>
<thead>
<tr>
<th>Life form and height of tallest stratum</th>
<th>Projective foliage cover of tallest stratum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dense (&lt;70-100%)</td>
</tr>
<tr>
<td>Trees 20 m</td>
<td>Tall closed-forest</td>
</tr>
<tr>
<td>Trees 10-20 m</td>
<td>Closed-forest</td>
</tr>
<tr>
<td>Trees 5-10 m</td>
<td>Low closed-forest</td>
</tr>
<tr>
<td>Shrubs 2-8 m</td>
<td>Closed-scrub</td>
</tr>
<tr>
<td>Shrubs 0-2 m</td>
<td>Closed-heath</td>
</tr>
</tbody>
</table>
REFERENCES


GIBBS, C.R. (1977) "Botanical Notes on some species collected in the Manbulloo Area 1976" an unpublished paper held at the Land Conservation Section, Forestry Fisheries and Land Conservation Branch, Department of the Northern Territory.


APPENDIX I. DESCRIPTIONS OF REPRESENTATIVE SOIL PROFILES.

Great Soil Group: Siliceous Sands

Soil Family: Cypress

Factual Key*: Uc4.21

Drainage: Well drained

Parent Material: Uncertain, but probably detrital laterite, and/or pallic-zone sandstones.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1cm</td>
<td>Pale pinkish or yellowish washed quartz sand, loose. Brown (10YR 3/3) or dark brown (10YR 5/3) sand or loamy sand, loose; sandy fabric; pH 6.5.</td>
</tr>
<tr>
<td>1-15cm</td>
<td>Brown (10YR 3/3) or dark brown (10YR 5/3) sand or loamy sand, loose; sandy fabric; pH 6.5.</td>
</tr>
<tr>
<td>15-60cm</td>
<td>Strong brown (7.5YR 5/6, 3/8) or brownish yellow (10YR 6/6) sand or loamy sand, loose; sandy fabric; pH 6.0. This horizon is an incipient unbleached A2.</td>
</tr>
<tr>
<td>60-100cm</td>
<td>Yellowish red (5YR 4/8, 5/8) loamy sand or clayey sand, slightly moist and very friable or dry and soft; sandy fabric; pH 6.0.</td>
</tr>
<tr>
<td>100-150cm</td>
<td>Red (2.5YR 4/8, 5/8) or yellowish red (5YR 4/8) loamy sand or light sandy loam, moist and friable; earthy fabric; pH 6.0. A few ferruginous nodules may occur in this horizon.</td>
</tr>
</tbody>
</table>

Great Soil Group: Earthy Sands

Soil Family: Cockatoo

Factual Key: Uc5.21 (Gn2.11,.12)

Drainage: Well drained

Parent Material: Colluvial sandy accumulations, or sandstone.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15cm</td>
<td>Dark reddish brown (5YR 3/3, 3/4) or rarely dark brown (10YR 3/3) sand or loamy sand, loose or soft; sandy/earthy fabric; pH 6.5.</td>
</tr>
<tr>
<td>15-45cm</td>
<td>Dark red (2.5YR 3/6) or red (2.5YR 4/6, 4/8) loamy sand soft or slightly hard; sandy/earthy fabric; pH 6.0-7.0. Rarely this horizon is an incipient unbleached A2.</td>
</tr>
<tr>
<td>45-150cm</td>
<td>Dark red (2.5YR 3/6) or red (2.5YR 4/6) sandy loam, slightly hard or moist and friable; earthy fabric; pH 6.0-7.0.</td>
</tr>
</tbody>
</table>

* Northcote K.H. (1971)
Great Soil Group: Red Earths

Soil Family: Blain

Factual Key: Dr4.51,.52

Drainage: Well drained

Parent Material: Unknown, but probably colluvial accumulations from weathering red sandstones or other arenaceous rocks.

0-10cm Dark reddish brown (5YR 3/3) or rarely dark brown (10YR 3/3) sand or loamy sand, soft; sandy fabric; pH 6.0.

10-55cm Red (2.5YR 4/6) or dark reddish brown (2.5YR 3/4) sand to loamy sand, slightly hard; sandy/earthy fabric; pH 6.0-7.0.

55-80cm Red (2.5YR 4/6) or dark red (2.5YR 3/6) silty loam or sandy clay loam, hard; earthy fabric; pH 6.5-7.0.

80-150cm Dark red (2.5YR 3/6) or red (10R 4/6) sandy clay loam or clay loam, dry hard to moist firm; earthy fabric; pH 6.5-7.0.

Great Soil Group: Red Earths

Soil Family: Killuppa

Factual Key: Gn2.11,.12

Drainage: Well drained

Parent Material: Unknown, but probably colluvial accumulations from weathering red sandstones or other arenaceous rocks.

0-15 Dark reddish brown (5YR 3/3, 2.5YR 3/4) loamy sand or sandy loam, soft or slightly hard; earthy fabric; pH 6.5. Some loose pink sand may lie on the surface.

5-35cm Dark reddish brown (2.5YR 3/4), dark red (10R 3/6) or dusky red (10R 3/3, 3/4) sandy loam, slightly hard or hard; earthy fabric; pH 6.5.

35-65cm Dark reddish brown (2.5YR 3/4), dark red (10R, 3/6, 2.5YR 3/6) or dusky red (10R 3/3) light sandy clay loam, dry and hard; earthy fabric; pH 6.5.

65-150cm Dark red (2.5YR 3/6, 10R 3/6), dark reddish brown (2.5YR 3/4) or dusky red (10R 3/4), sandy clay loam, dry hard or moist friable; earthy fabric; pH 6.0-7.0.
Great Soil Group: Red Earths

Soil Family: Tippera

Factual Key: Gn2.11

Drainage: Well drained

Parent Material: Red siltstones, associated with either the Jinduckin formation or the Tindall limestones.

0-10cm Dusky red (2.5YR 3/2) or dark reddish brown (5YR 3/3, 3/4, 2.5YR 3/4) clay loam or fine sandy clay loam, very hard; earthy fabric; pH 6.0-6.5.

10-30cm Dark reddish brown (2.5YR 3/4, 5YR 3/4) or dark red (2.5YR 3/6) clay loam or light clay, very hard or extremely hard; earthy fabric; pH 6.0-6.5.

30-65cm Dark red (2.5YR 3/6, 10R 3/6) or dark reddish brown (2.5YR 3/4) light or medium clay, dry extremely hard or moist very firm; earthy fabric; pH 6.0-6.5. Some small ferruginous concretions and some clay skins.

65-150cm Dark red (10R 3/6, 2.5YR 3/6) or dark reddish brown (2.5YR 3/4) light clay, dry very hard or moist firm; earthy fabric; pH 6.0-6.5. Some small ferruginous concretions.

Great Soil Group: Red Earths

Soil Family: Manbulloo

Factual Key: Uc4.22 (Gn2.14)

Drainage: Well or excessively well drained

Parent Material: Coarse river alluvia, deposited from infrequent very high floods.

0-15cm Dark brown (7.5YR 3/2, 4/2), dark yellowish brown (10YR 3/4) or dark reddish brown (5YR 3/2, 3/3) sand or loamy sand, loose; sandy fabric; pH 6.0-6.5.

15-60cm Yellowish red (5YR 4/6, 5/8) or dark reddish brown (5YR 4/6, 5/8) or dark reddish brown (5YR 3/3, 3/4) sand or loamy sand, loose to slightly hard; sandy/earthy fabric; pH 6.0-7.0. This horizon is sometimes an incipient unbleached A2.

60-150cm Red (2.5YR 4/6, 4/8), yellowish red (5YR 4/6, 5/8) or rarely dark red (2.5YR 3/6) clayey sand to sandy loam, moist friable; earthy fabric; pH 6.0-7.0.
Great Soil Group: Red Earths

Soil Family: Katherine

Factual Key: Gn2.11..12

Drainage: Well or moderately well drained

Parent Material: River alluvia; often distinctly layered. These are not common soils.

<table>
<thead>
<tr>
<th>Depth Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10cm</td>
<td>Dark brown (10YR 3/3), brown (10YR 5/3) or dark yellowish brown (10YR 4/4) sand to light sandy loam, soft or slightly hard; earthy or sandy/earthy fabric; pH 6.0-7.0.</td>
</tr>
<tr>
<td>10-25cm</td>
<td>Reddish brown (5YR 4/4) or yellowish red (5YR 4/8) sand to sandy loam, soft or slightly hard; earthy fabric; pH 6.0-7.0. This horizon may be an incipient unbleached A2.</td>
</tr>
<tr>
<td>25-60cm</td>
<td>Red (2.5YR 4/6) or yellowish red (5YR 4/8, 5/8) sandy clay loam, dry hard or moist firm; earthy fabric; pH 6.0-7.0.</td>
</tr>
<tr>
<td>60-100cm</td>
<td>Red (2.5YR 4/6, 4/8) or dark red (2.5YR 3/6) clay loam, grading to sandy clay or light clay, dry hard or moist firm; earthy fabric; pH 6.0-7.0. A few yellow mottles may occur. This horizon is transitional to a buried soil, formed in an older layer.</td>
</tr>
<tr>
<td>100-125cm</td>
<td>Red (2-5YR 4/6) or dark red (2.5YR 3/6) light to medium clay or sandy clay, dry very hard or moist firm; earthy fabric; pH 6.0-7.0. A few yellow mottles may occur.</td>
</tr>
<tr>
<td>125-150cm</td>
<td>Red (10R 4/6) or dark red (2.5YR 3/6) light to medium clay or sandy clay, dry very hard or moist very firm; earthy fabric, with illuvial clay skins; pH 6.0-6.5. Yellow or whitish mottles are common.</td>
</tr>
</tbody>
</table>

Great Soil Group: Yellow Earths

Soil Family: Elliott

Factual Key: Gn2.61,.62(Gn2.21,.22)

Drainage: Moderately well to imperfectly drained

Parent Material: Unknown, but thought to be derived in situ from loamy Red Earths or red-bed shales.
Great Soil Group: Yellow Earths

Soil Family: Elizabeth

Factual Key: Gn2.21,.22(Gn2.24,.25)

Drainage: Moderately well or well drained

Parent Material: Unknown, but usually found in association with sandy Red Earths and may share their origin.

0-8cm Dark brown (10YR 3/3, 7/5YR 3/2), dark greyish brown (10YR 4/2) or very dark greyish brown (10YR 4/2) or very dark greyish brown (10YR 3/2) sand or loamy sand, loose to slightly hard; sandy/earthy fabric; pH 6.5-7.0.

8-30cm Strong brown (7.5YR 5/6), dark yellowish brown (10YR 4/4) or dark brown (7.5YR 4/4) sand or loamy sand, loose or slightly hard; sandy/earthy fabric; pH 6.5-7.0. A few (2%) small ferruginous concretions occur in some cases. This horizon may be an incipient unbleached A2.

30-50cm Yellowish brown (10YR 5/6, 5/8), strong brown (7.5YR 5/6, 5/8) or yellowish red (5YR 5/6) loamy sand or sandy loam, slightly hard or hard; earthy fabric; pH 6.0-7.0. Up to 5% small ferruginous concretions may occur.

50-90cm Strong brown (7.5YR 5/6, 5/8) or yellowish red (5YR 5/6, 5/8) sandy clay loam or light sandy clay, dry very hard or moist friable; earthy fabric; pH 6.0-7.0. From 10-20% small ferruginous concretions.
90-150cm  Yellowish red (5YR 5/6, 5/8) or red (2.5YR 5/6, 5/8) sandy clay loam, sandy clay or light clay, dry very hard or moist friable; earthy fabric; pH 6.0-7.0. Up to 30% small ferruginous concretions may occur and some profiles have common red or yellow mottles.

Great Soil Group:  Yellow Podzolics
Soil Family:  Douglas
Factual Key:  Gn2.74(Gn2.94,Dy5.81)
Drainage:  Imperfectly or very poorly drained
Parent Material:  Local sandy alluvia or colluvia, or rarely river alluvia. Drainage line or river backplain soils.

0-15cm  Very dark greyish brown (10YR 3/2), dark grey (10YR 4/1) or dark brown (10YR 4/3) sand or loamy sand, rarely sandy loam, loose or soft; sandy/earthy fabric; pH 6.0-7.0.

15-50cm  Pale brown (10YR 6/3), yellowish brown (10YR 5/8) or light brown (7.5YR 6/4) bleached A2 horizon of sand or loamy sand rarely sandy loam, soft or slightly hard; sandy/earthy fabric; pH 6.0-7.0. Faint organic or rusty mottling.

50-100cm  Light yellowish brown (10YR 6/4), pale brown (10YR 6/6) sandy clay loam or light sandy clay, dry hard or moist friable; earthy fabric; pH 5.5-6.5. This horizon is commonly mottled with red, yellow and grey and sometimes contains a few ferruginous concretions.

100-150cm  Pale brown (10YR 6/3), yellowish brown (10YR 5/6, 5/8) or strong brown (7.5YR 5/6) sandy clay, dry very hard or moist very firm; earthy fabric; pH 5.5-6.5. Many red, brown and grey mottles occur and much illuvial clay is present. The subsoil becomes impermeable between 100 and 175cm.

Great Soil Group:  Lateritic Podzolics
Soil Family:  Claravale
Factual Key:  Uc4.21
Drainage:  Moderately well or well drained
Parent Material:  Probably detrital laterite in association with weathered pallid-zone quartzite ('billy').
<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10 cm</td>
<td>Dark brown (10YR 3/3, 4/3), very dark greyish brown (10YR 3/2) or dark yellowish brown (10YR 3/4) slightly organic loamy sand, soft or loose; sandy/earthy fabric; pH 6.0-6.5. The soil surface may have a 5-10% cover of ferruginous nodules.</td>
</tr>
<tr>
<td>10-35 cm</td>
<td>Brownish yellow (10YR 6/6), yellowish brown (10YR 5/4, 5/6) or pale brown (10YR 6/3) A2 horizon of loamy sand, loose; sandy/earthy fabric; pH 6.0-7.0. From 2-15% ferruginous nodules may occur, the percentage increasing with depth.</td>
</tr>
<tr>
<td>35-75 cm</td>
<td>Yellowish brown (10YR 5/6, 5/8), pale brown (10YR 6/3) or strong brown (7.5YR 5/6) clayey sand or light sandy loam, slightly hard or hard; sandy/earthy fabric; pH 6.0-7.0. The percentage of ferruginous nodules increases to about 40%.</td>
</tr>
<tr>
<td>75-150 cm</td>
<td>Yellowish red (5YR 4/8) clayey sand or light sandy loam with high amounts (50-80%) of ferruginous nodules, and some faint red mottling. This overlies dense gravel or weak vesicular laterite.</td>
</tr>
</tbody>
</table>

**Great Soil Group:** Grey, Brown and Red Clays  
**Soil Family:** Cununurra  
**Factual Key:** Ug5.28 (.27)  
**Drainage:** Imperfectly or poorly drained  
**Parent Material:** Basalt or other basic finetextured rock, or transported weathering products of these rocks.

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10 cm</td>
<td>Dark greyish brown (2.5Y 4/2), very dark greyish brown (2.5Y 3/2, 10YR 3/2), very dark grey (5Y 3/1) or dark yellowish brown (10YR 4/4) silty medium or heavy clay, dry hard or moist firm; earthy or smooth-ped fabric; pH 6.0-7.5; granular or fine blocky structure ('self-mulching'). Some (5%) secondary carbonate nodules, and some manganiferous concretions.</td>
</tr>
<tr>
<td>10-35 cm</td>
<td>Dark greyish brown (2.5Y 4/2), very dark greyish brown (2.5Y 3/2) or very dark grey (5Y 3/1) silty medium or heavy clay, dry very hard or moist extremely firm; smooth-ped fabric; pH 7.5-8.5. Weak blocky structure, and up to 5% secondary carbonate nodules. Some manganiferous concretions.</td>
</tr>
<tr>
<td>35-90 cm</td>
<td>Dark greyish brown (2.5Y 4/2), dark grey (10YR 4/1) or dark olive grey (5Y 3/2) silty medium to heavy clay, dry extremely hard or moist extremely firm; smooth-ped fabric; pH 8.5-9.5. Up to 5% secondary carbonate nodules and sometimes fine amorphous carbonate.</td>
</tr>
</tbody>
</table>
90-150cm Dark greyish brown (2.5Y 4/2), olive grey (5Y 4/2) or yellowish brown (10YR 5/4) silty medium or heavy clay, dry extremely hard or moist extremely firm; smooth-ped fabric; pH 8.5-10.0. Up to 25% secondary carbonate which often forms a dense pan, and some fine amorphous carbonate which may impart a very pale colour to the sub-soil. Fragments of country rock are often encountered by 150cm.

Great Soil Group: Grey, Brown, and Red Clays.

Soil Family: Banyan.

Factual Key: Ug5.5.

Parent Material: River alluvia or fine textured basic rocks.

0-10cm Black (5Y 2/1), very dark greyish brown (10YR 3/2) or dark greyish brown (10YR 4/2) silty medium or heavy clay, earthy fabric; massive; pH 6.0-6.5. Some manganiferous concretions and secondary carbonate nodules and some rusty mottling.

10-35cm Dark greyish brown (2.5Y 4/2, 10YR 4/2) or black (2.5Y 2/1) silty medium or heavy clay, smooth-ped fabric; pH 6.5-7.5. Some manganiferous concretions and secondary carbonate nodules, and few yellowish mottles.

35-100cm Dark greyish brown (2.5Y 4/2, 10YR 4/2) light olive brown (2.5Y 5/4) or yellowish brown (10YR 5/4) medium or heavy clay, smooth-ped fabric; pH 8.5-9.0. Up to 5% secondary carbonate nodules and some manganiferous concretions. Common small yellow and grey mottles.

100-150cm Dark greyish brown (10YR 4/2), light olive brown (2.5Y 5/4) or yellowish brown (10YR 5/6) heavy clay, smooth-ped fabric; pH 8.5-9.5. Up to 10% secondary carbonate nodules and sometimes a carbonate pan of slow permeability. Common red, yellow and grey mottles in most profiles.
APPENDIX II

BOTANICAL CHECKLIST : Species observed in Manbulloo area with common names where appropriate.

(1) TREES

Acacia sp.  Wattle
Acacia affin. bidwillii  Wattle
A. sericata  Wattle
A. shirleyi  Lancewood
Brachychiton diversifolium  Kurrajong, northern
Buchanania obovata  kurrajong
Callitris intratropica  Green Plum
Casuarina cunninghamiana  Northern Cypress Pine
Croton arnhemicus  River Oak
Denhamia obscura
Dolichandrone filiformis
Erythrina vespertilio  Bat's-wing coral tree
Erythrina chlorostachyum  Ironwood
Erythroxylum ellipticum  Kerosene wood
Eucalyptus alba  Timor White Gum
E. bigalerita  Adelaide River White Gum
E. bleeseri  Smooth-barked Bloodwood
E. camaldulensis  River Red Gum
E. clavigera  Apple Gum
E. confertiflora  Carbeen Gum
E. affin. dichromophloia
E. dichromophloia  Red barked Bloodwood
E. ferruginea  Rusty Bloodwood
E. foelscheana  Fine leaved Bloodwood
E. grandifolia  Bastard Bloodwood
E. latifolia  Round leaved Bloodwood
E. microtheca  Coolabah, Desert Box
E. miniata  Wooly Butt
E. papuana  Ghost Gum
E. patellaris  Weeping Box
E. phoenicea  Scarlet Gum
E. polycarpa  Swamp Bloodwood
E. pruinosa  Silver leaved Box
E. affin. tectifica  McArthur River Box
E. tectifica  Gum small flowered Bloodwood
E. terminalis  Darwin Stringybank
E. tetrodonta  Mountain Blue Gum
E. umbrarwennis  Native Gardenia
Excaecaria parvifolia  Fern leafed Grevillea
Gardenia megasperma  Cooliman
Grevillea pteridiifolia  Native Bauhinia
Gyrocarpus americanus  Paperbark
Hakea arborescens  Emu apple
Lysiphyllum cunninghamii
Melaleuca viridiflora
Owenia vernicosa
Persoonia falcata
Petalostigma sp.
Terminalia (carpentaria?)
T. ferdinandiana
T. grandiflora
T. pterocarya
T. platypetra
T. volucris
Tristania grandiflora

(2) SHRUBS

Acacia decurrens
A. difficilis
A. dimidiata
A. holosericea
A. oncinoarpa
A. pachyphloia
Alphitonia excelsa
Bossiaea bossiaeoides
Brachychiton paradoxum
Cathormion umbellatum
Cochlospermum fraseri
Diospyros ferrea
Ficus opposita
Grevillea dimidiata
Grewia multiflora
Melaleuca alsophila
Pandanus sp.
Petalostigma pubescens
Planchonia careya
Strychnos lucida

(3) FORBS

Borreria sp.
Buchnera linearis
Drosera sp.
Evolvulus alsinoides
Gomphrena sp.
Grewia retusifolia
Hibiscus meraukensis
Hyptis suaveolens
Pachynema complanatum
Polycarpaea sp.
Pterocaulon glandulosum
Ptilotus exaltatus
Rhynchospora affinis
Tephrasia sp.
Trichodesma zeylanicum

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(4) **GRASSES**

Affin. Alloteropsis
Aristida sp.
Chrysopogon fallax
C. latifolius
Dichanthium fecundum
Enneapogon pallidus
Eragrostis sp.
Eriachne sp.
Heteropogon contortus
Panicum majusculum
P. mindanaense
Plectrachne pungens
Pseudoraphis spinescens
Schizachyrium fragile
Sehima nervosum
Setaria apiculata
Sorghum sp.
Sporobolus australasicus
Themeda australis

Wire Grass
Golden Beard Grass
Golden Beard Grass
Blue Grass, curty blue grass

Love Grass
Wanderrie Grass
Black Spear Grass
Panic, wild millet
Panic
Soft spinifex
Mud Grass
Red Spathe Grass
White Grass
Pigeon Grass
Sorghum
Rats-tail Grass
Kangaroo Grass