SOILS OF THE C.S.I.R.O. EXPERIMENTAL AREA,
MANBULLOO STATION

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Figure 1. Land units within, and surrounding C.S.I.R.O. experimental site.

Scale 1:50 000

(part of Scott 5268 II Sheet covering Manbulloo Station, Gibbs et al. 1978)
Plate 1. Land Unit 3c.
INTRODUCTION

In October 1973, a survey was conducted by officers of Land Conservation Section to select a suitable site for a large scale grazing experiment on Manbulloo Station. This grazing experiment was to be conducted by C.S.I.R.O. Division of Tropical Crops and Pastures. A site of approximately 2 000 ha was chosen immediately north of the Victoria Highway, 53 km south-west of Katherine. Variation mainly in soil and vegetation parameters was investigated and the proposed site mapped into "land units"* at a scale of 1:16 000. The area consisted largely of land unit 3c (Plate 1) which is characterized by flat or gently sloping terrain (slopes less than 2 per cent) with scattered limestone pavement and outcrop. Loamy Red Earths with variable amounts of subsoil gravel were found to be the dominant soils. Small areas of land units 3f and 3b were also found within the selected area (Figure 1).

After the experiment was established, C.S.I.R.O. requested a more detailed evaluation of the soils on the experimental site, to enable better extrapolation of results from the trial to other areas of the Daly Basin. In response to this request an intensive soil survey based on the interpretation and evaluation of photopattern at a large scale (1:5 000) was conducted in June 1977. The following report details the methodology and results of that survey.

* A land unit is described as an area of relatively uniform landform, soil and vegetation which thereby exhibits a uniform pattern on aerial photographs. The land units referred to herein are those described by Aldrick, J.M. and Robinson, C.S. (1972) in their "Report on the Land Units of the Katherine-Douglas Area, N.T. 1970."
METHODOLOGY

The survey technique was based upon aerial photograph interpretation followed by an intensive field survey. The approach used for this work differed from that of the previous land unit mapping in two ways. Firstly, the mapping scale (1:5 000), allowed the delineation of soils at "soil type" and "soil phase" levels rather than at the more comprehensive "soil family" level. Secondly, descriptions of the structure and composition of vegetation within each of the mapping units are not provided.

Photopatterns were delineated from four sets of aerial photographs covering the experimental area. They were as follows:

(a) Colour Photographs (high level) 1 524 m Scale 1:10 856
(b) Colour Photographs (low level) 762 m Scale 1: 6 175
(c) False Colour Infra Red Photographs 884 m Scale 1: 5 597
(d) Black & White Photographs (from Infra Red) 884 m Scale 1: 5 597

A comparison was made of the patterns delineated from each type of photography and sites where chosen for field inspection from representative areas of each photopattern.

The field survey involved sampling and description of soils by two teams of pedologists working concurrently. Soils were sampled at 129 sites using a mechanical coring device to a depth of 150 cm where possible. Characteristics which were recorded include the following: horizon colour, depth, texture, consistence, structure, fabric, pH, and stone and gravel content. Presence or absence of mottling and surface rock occurrence were also recorded. Soil properties such as permeability and internal drainage, which largely describe the field behaviour of soils were inferred from this data. The soils were described in as factual a manner as possible largely in accordance with Northcote (1971). Importance was placed on classifying soils on the basis of their total visual appearance. In order to achieve this separation, properties such as profile gravel content, depth, soil colour and surface limestone occurrence were given prominence in the delineation of mapping units.
RESULTS

Comparison of Aerial Photography.

It was found that the low level colour photography was most easily interpreted and that photopatterns reflected such properties as surface limestone occurrence, soil depth, gravel and surface colour. Both false colour infra red and black and white (from infra red) photography were found to be very difficult to interpret and the patterns did not consistently correlate with any particular site or soil property. It is suggested that these photographs may have been more useful in distinguishing meaningful soil relationships if they were of a smaller scale and flown prior to the imposition of experimental treatments. The final soil mapping of the area was done using the low level colour photography (762 m; 1:6 175).

Presentation of Data.

Soil data gathered in the field have been correlated manually and the results presented in the form of a comprehensive soils map. Mapping units are designated by a letter/number code consisting of three divisions to explain the relevant soil and site parameters considered to be homogeneous within each unit. These parameters include major soil groupings (based on colour and texture), soil family, depth, profile gravel distribution and surface limestone occurrence. Characteristics such as soil reaction trend, consistence and surface gravel (type and amount) were recorded but not found to correlate with interpreted photopatterns.

A series of maps or overlays which display certain individual site and soil parameters have also been prepared to enable any parameter to be studied either separately or in combination with any others to distinguish correlations. The following overlays are provided:

(a) Major soil groups
(b) Soil families and texture variants
(c) Soil profile gravel distribution
(d) Soil depth
(e) Surface limestone occurrence.
Together, this series of overlays combine to form the comprehensive soils map. Trial plot fence boundaries have not been shown on each of these overlays but may be observed by superimposing the relevant overlay on the base map showing the experimental layout as the scales are identical.

The three divisions which comprise the letter/number code for each mapping unit are described below.

1ST DIVISION

This describes the major grouping to which the soil belongs and is based on the dominant texture and colour of the soil. There are four major soil groups found to occur in the survey area. Their coding is as follows:

- Lr : loamy red earth
- Lb : loamy brown earth
- Sr : sandy red earth
- Ly : loamy yellow earth.

According to the great soil group nomenclature of Stace et al. (1968) the first three of these groups are Red Earths and the latter a Yellow Earth. In order to achieve a greater taxonomic separation the brownish coloured or red-yellow intergrade soils (B Horizon 5YR 4/6, 4/8) have been called brown earths, similar to those described in Northcote et al. (1975).

The sandy red earth soils have surface (A horizon) textures belonging to texture group one (Northcote 1971) which varies from sand to clayey sand. The maximum B horizon texture in these soils usually ranges from clay loam to fine sandy clay loam (texture group 4). In contrast the loamy soils have surface textures belonging to texture group two (sandy loam to light sandy clay loam) or finer, and their maximum B horizon textures are usually of groups four or five.

2ND DIVISION

The coding in this division indicates the soil family, soil depth and the distribution of gravel throughout the profile.
SOIL FAMILIES.

The soil families have been classified largely according to the system proposed by Aldrick (1972). The families found to occur in the survey area and their coding are as follows:

Loamy red and brown earths
- T Tippera family
- O Ooloo family
- S Shallow soils (family identification not possible)

Sandy red earths
- B Blain family

Loamy yellow earths
- E Elliott family

Within the Tippera and Ooloo families some soils were found to exhibit slightly heavier surface textures than normally encountered. These variants have been assigned an asterisk above the family name coding, e.g. T* designates Tippera "heavy". Similarly within the shallow soils an asterisk has been used to designate those soils with heavier surface textures of clay loam to fine sandy clay loam (texture group 4) compared with those having the lighter textures of loam to sandy clay loam (texture group 3). The asterisk above the B for Blain family (sandy red earth) again indicates a heavier texture variation, but this time occurring in the subsoil. This variation is sufficient to result in a duplex primary profile form compared to the gradational profile form exhibited by the lighter textured soils.

Soil family descriptions are as follows:

Loamy Red Earths

Tippera family.

Soils of the Tippera family (Plates 2, 3) are gradational textured, with...
massive, porous earthy profiles, and are well drained. They frequently occur in association with limestone and have been subdivided into two groups on the basis of texture variance within the 0-30 cm depth interval. The majority of Tippera soils exhibit textures of sandy clay loam or lighter within this depth interval. Soils with textures heavier than sandy clay loam within this depth interval have been designated as heavy texture variants; Tippera (heavy). A typical soil profile is:

Factual Key Gn2.14

0-15 cm Dark reddish brown (5YR 3/3), sandy clay loam, dry hard, massive and earthy, pH 6.1.

15-40 cm Dark reddish brown (2.5YR 3/4), clay loam, dry hard, massive and earthy, pH 6.1.

40-110 cm Dark red (2.5YR 3/6), light clay, slightly moist friable, massive and earthy, pH 6.2, less than 10% ferruginous gravel.

110-160 cm Dark red (2.5YR 3/6) light to medium clay, slightly moist friable, massive and earthy, pH 6.5, less than 10% ferruginous gravel.

Within this family some degree of variation may occur with respect to colour and gravel content. Soils in which yellowish red subsoil colours (5YR 4/6, 4/8) are exhibited, have been designated loamy brown earths. Gravel content may vary from less than 10% to 40%, either throughout the profile, within the subsoil only, or within a distinct band.
Plate 2. Loamy Red Earth: Tippera family (Lr/Td2/0).

Plate 3. Loamy "brown" soil: Tippera family (Lb/Td2/0).
Oolloo family.

Soils of this family may be uniform or gradational textured and are well drained. Within the survey area they are closely associated with the occurrence of limestone. These soils differ from those of the Tippera family in that their maximum B horizon textures reach clay loam to fine sandy clay loam rather than sandy clay to light-medium clay (group five).

Oolloo soils have been subdivided in a similar manner to those of the Tippera family, on the basis of texture variance within the 0-30 cm depth interval. Heavy texture variants with textures heavier than sandy clay loam within this depth interval, have been designated Oolloo (heavy).

Typical soil profiles are:

Factual Key Gn2.11 (Gradational Series)

<table>
<thead>
<tr>
<th>Depth Interval</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10 cm</td>
<td>Dark reddish brown (2.5YR 3/4), sandy loam, dry hard, massive and earthy, pH 5.8, less than 5% fine ferruginous gravel.</td>
</tr>
<tr>
<td>10-30 cm</td>
<td>Dark red (2.5YR 3/6), sandy clay loam, dry hard, massive and earthy, pH 6.0, less than 5% fine ferruginous gravel.</td>
</tr>
<tr>
<td>30-100 cm</td>
<td>Dark red (2.5YR 3/6), clay loam with fine sand, dry hard, massive and earthy, pH 6.0, less than 5% fine ferruginous gravel.</td>
</tr>
<tr>
<td>100-140 cm</td>
<td>Dark red (2.5YR 3/6), clay loam with fine sand; slightly moist friable, massive and earthy, pH 5.8, less than 5% fine ferruginous gravel.</td>
</tr>
</tbody>
</table>
Factual Key Um5.52 (Uniform Series)

0-10 cm  Dark reddish brown (5YR 3/3), sandy clay loam, dry hard, massive and earthy, pH 6.0, 5% fine ferruginous gravel.

10-25 cm  Dark reddish brown (2.5YR 3/4), clay loam with gravel, dry hard, massive and earthy, pH 6.0, 5% fine ferruginous gravel.

25-90 cm  Dark red (2.5YR 3/6), gravelly clay loam, dry very hard, massive and earthy, pH 6.5, 15% fine ferruginous gravel.

Within the survey area little variation was found in soil morphology with the exception of gravel content in the soils of the uniform textured series. This may vary from less than 5% to 10% in the upper subsoil and from 5 to 25% in the lower subsoil.

Sandy Red Earths.

Blain family.

Soils of this family may be gradational textured, or duplex, texture contrast profiles. These soils are usually deep, well drained and may be associated with isolated outcrop of weathering sandstone which is probably their parent material.

Typical profiles are as follows:

Factual Key Dr4.51 (Duplex Series)

0-10 cm  Dark reddish brown (5YR 3/3), sand, dry soft, single grained with sandy fabric, pH 6.8.

10-25 cm  Dark red (2.5YR 3/6), loamy sand, dry slightly hard, massive and earthy, pH 6.5.

25-120 cm Dark red (2.5YR 3/6), light medium clay with fine sand, dry extremely hard, massive and earthy, pH 6.5.
120-130 cm  Fragments of weathering sandstone.

130-140 cm  Dark red (2.5YR 3/6), sandy clay, dry very hard, massive and earthy, pH 6.0.

Factual Key Gn2.11 (Gradational Series).

0- 12 cm  Dark reddish brown (5YR 3/4), organic loamy sand, dry slightly hard, single grained with sandy fabric, pH 6.0.

12- 30 cm  Dark red (2.5YR 3/6), loamy sand, dry hard, massive and earthy, pH 6.0.

30- 65 cm  Dark red (2.5YR 3/6), sandy loam, slightly moist friable, massive and earthy, pH 6.5.

65-150 cm  Dark red (2.5YR 3/6), sandy clay loam, slightly moist friable, massive and earthy, pH 6.5.

Loamy Yellow Earths.

Elliott family.

Yellow earth soils are commonly associated with loamy red earths in the Katherine area. Soils of the Elliott family (Plate 4) are gradational and superficially like those of the Tippera family except for their yellowish colour. The yellow colour has been attributed to the concentration of free iron oxides in concretions and mottles and to some hydration of these oxides due to imperfect drainage (Stewart, G.A. 1956, van de Graaff, R.H.M., 1965). These soils generally have moderately slow subsoil permeabilities and may be partially waterlogged and boggy in the wet season.
A typical soil profile is:

Factual Key Gn2.64

0-10 cm  Dark brown (10YR 3/3); light sandy clay loam, dry hard, massive and earthy, pH 6.2.

10-45 cm  Yellowish brown (10YR 5/6), fine sandy clay loam, dry hard, massive and earthy, pH 6.2.

45-85 cm  Yellowish brown (10YR 5/8), gravelly clay loam with fine sand, dry hard, massive and earthy, pH 6.5, 5% fine Fe/Mn gravels.

85-145 cm Yellowish brown (10YR 5/6), gravelly light clay, moist friable, massive and earthy, pH 6.5, 15-20% Fe/Mn gravels, common red brown and black mottles.
Plate 4. Loamy Yellow Earth: Elliott family (ly/Ed/C).
SOIL DEPTH

Three soil depth categories have been defined as follows:

<table>
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<th>Category</th>
<th>Depth Range</th>
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<tr>
<td>Shallow</td>
<td>(&lt; 40 cm)</td>
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<tr>
<td>Moderately Deep</td>
<td>(40 - 80 cm)</td>
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<tr>
<td>Deep</td>
<td>(&gt; 80 cm)</td>
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</table>

Shallow soils are separated in the preceding "soil family" section, as those soils which, because of their lack of depth, are impossible to accurately assign a family name to. They are identified by the letter S. Moderately deep and deep soils belonging to the various soil families are indicated by the lower case letters m and d respectively, written immediately after the letter representing the soil family. For example Tm represents a moderately deep soil of the Tippera family.

GRAVEL DISTRIBUTION

The distribution of gravel throughout the soil profile has been designated by a number which follows the depth rating. The lack of a subscript number indicates that no significant amounts of gravel occurred throughout the profile. However it is important to note the meaning of the word "significant" differs according to the soil family considered. For example within the Tippera family, up to 10% gravel commonly occurs within the subsoil and hence only soils with gravel amounts in excess of this value have been designated a number, indicating the presence of significant gravel amounts. The following numbers are used in the codes:

1. this indicates the presence of significant amounts of gravel throughout the whole of the soil profile;
2. this indicates the presence of significant amounts of gravel within the subsoil only;
3. this indicates the presence of significant amounts of gravel occurring as a distinct band within the soil profile.
3RD DIVISION

The coding in this division indicates the relative amounts of surface limestone observed within the mapping unit. The limestone ratings are as follows:

0  no rock observed
1  rare occurrence
2  common occurrence
3  abundant rock observed
4  massive outcrop observed.

Since the occurrence of limestone in the survey area is largely in the form of individual surface rocks and "floaters" within the soil, rather than as continuous outcrop, the ratings tend to be rather subjective and correlate poorly with soil depth.
REFERENCES


BARROW, N.J. (1967) - Studies on extraction and on availability to plants of adsorbed plus soluble sulphate. Soil Science 104 : 242-249.


HOOPER, A.D.L. (1970) - "Mapping Land Resources" Turnoff 2(2) 1-6, a publication of the Northern Territory Administration, Animal Industry and Agriculture Branch, Darwin, N.T.


APPENDIX I. Particle size composition and chemical properties of selected profiles (Table 1).

Comparing these 6 profiles with analytical data for other loamy red earths of the Daly Basin:

- particle size proportions conform well;
- pH values are a little higher in the subsoil, reflecting the influence of underlying limestone and resulting in a considerable number of neutral soil reaction trends compared with the normal acid trend and exchangeable calcium values remain relatively constant with depth instead of the usual marked reduction with depth in other areas;
- C:N ratios are very high (mean 30.5, range 28-36) but conform with high values found elsewhere;
- bicarbonate extractable P values are generally slightly lower and phosphate extractable sulphur values lower than found elsewhere (although limited data exists);
- total P, K and S values conform;
- exchangeable K and C.E.C. values are higher than normally expected;
- D.T.P.A. extractable Zn and Cu levels are low, in particular Zn is lower than normal.
Table 1. Particle size and chemical analyses for 6 representative profiles - C.S.I.R.O. - Manbullo Grazing Experiment.

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<td>Ca Mg Na K</td>
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<td>Zn Cu</td>
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<td></td>
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<td>Fine</td>
<td>Coarse</td>
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<td>CS/Mn 2</td>
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<td>13.4 5.4 53.2 28.0 6.1 0.029</td>
<td>1.34</td>
<td>0.037 1.0 135 1.0</td>
<td>0.02 0.38 0.008</td>
<td>4.2 1.6 2.4</td>
<td>49 10.4</td>
<td>0.25 0.5</td>
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<td>12 - 30</td>
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<td>30-110</td>
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<td>30.9 4.3 43.6 21.2 6.4 0.035</td>
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<td>13 10.0</td>
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<td>110-160</td>
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<td>30.5 4.0 45.2 20.4 6.3 0.048</td>
<td></td>
<td>neg</td>
<td>0.01 0.47 0.006</td>
<td>3.0 1.7 1.7</td>
<td>15 9.8 0.25 0.25</td>
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<td>0.034 2.0 125 neg</td>
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<td>3.7 1.1 0.4</td>
<td>56 10.2</td>
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<td>6 - 25</td>
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* neg - negligible amount detected

adjacent to the red earth soil fertility site

Exchangeable cations extracted with IN-NH₄Cl (pH 7.0); C.E.C. determined as ammonium adsorbed at pH 7.0; phosphate extr. S by Barrow (1967); total P, K and S by x-ray fluorescence spectroscopy; Zn and Cu extracted with 0.005M-DTPA after Fowlett and Lindsay (1971).