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I ABSTRACT

The soils of the CSIRO National Cattle Breeding Station "Belmont" of 3600 ha near Rockhampton, Queensland, have been mapped and described. Their gross morphological characteristics, their chemistry and their fertility have been discussed.

Few of the soils present major problems for the development of improved pastures. They contain adequate amounts of calcium and magnesium but potassium deficiencies may become evident in some areas. Phosphorus may need to be supplied to the soils of the upland area to maintain satisfactory pasture growth. The soils of the alluvial plain, particularly those of the two lower and younger alluvial terraces, contain high levels of available phosphorus. Pasture improvement should be possible on these soils without the use of phosphatic fertilizers.

II INTRODUCTION

The CSIRO National Cattle Breeding Station, "Belmont", is situated on the inside of a large meander of the Fitzroy River 30 km upstream of Rockhampton and 10 km west of the Bruce Highway (Fig. 1). It occupies an area of about 3600 ha, most of which has been cleared. An extensive program of pasture improvement was initiated in 1959 and about half of the property now supports legume-based pastures.

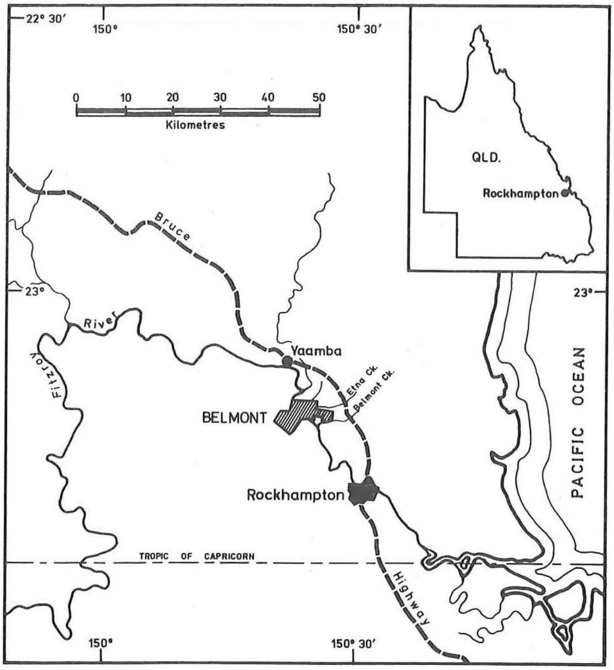

Figure 1. Location map.

This report discusses the climate, geology, geomorphology, vegetation, chemistry and fertility of the soils of Belmont. A soil map is included and the soil mapping units are discussed in some detail. The major morphological and chemical characteristics of the more important soils are listed in an Appendix.

Previous soil mapping in the Belmont area has all been at a broad scale (e.g. Isbell *et al.*, 1967, scale 1:2,000,000; Isbell and Hubble, 1967, 1:1,000,000; Perry *et al.*, 1968, 1:1,140,000). For this survey the soil boundaries were plotted in the field on aerial photographs enlarged to 1:20,000 scale.

III CLIMATE

The climate of the Fitzroy region has been described and analysed in detail by Fitzpatrick (1965, 1968). Only those climatic features related to pasture production will be discussed here.

A subtropical climate prevails with a marked summer rainfall of high variability. The mean annual rainfall and standard deviation from the mean at Rockhampton and Yaamba is 943 ± 342 mm and 911 ± 311 mm respectively. The mean summer (November to April) rainfall constitutes 75% and 78% respectively of the mean annual totals. The mean monthly rainfall at these stations varies from 15 mm to 207 mm (Table 1). Monthly rainfall data for 21 years are available for Belmont and these indicate a similar rainfall distribution pattern to that of Rockhampton and Yaamba with slightly lower monthly and annual averages (Table 1).

TABLE 1.

Mean monthly and annual rainfall (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
BELMONT*	146	160	101	36	35	36	29	25	19	42	65	116	810
ROCKHAMPTON**	167	207	112	63	42	54	46	18	22	48	64	98	943
YAAMBA**	170	200	116	58	37	49	43	15	21	42	61	97	911

* Unpublished data for 21 year period 1953 - 1973

** Data from Fitzpatrick (1968).

Mean monthly maximum temperatures range from about 23°C to 32°C and mean monthly minimum temperatures from 10°C to 22°C. Frosts are rare in the Belmont area.

The climate of the Fitzroy region controls pastoral or agricultural production primarily by its regulation of the availability of soil moisture. Because of the seasonal distribution and the high variability of rainfall, pastures must be able to withstand considerable periods of moisture stress. The occurrence of low temperatures during winter is a much less important control over production.

The mean number of weeks per year of useful native pasture growth (i.e. growth adequate to supply some green feed to stock) has been estimated by

TABLE 2

Major flood levels at Yaamba since 1896 (metres).

Information from records at "Belmont"

YEAR	RIVER HEIGHT	YEAR	RIVER HEIGHT
1896	16.50	1940	14.41
1898 Feb	15.48	1954	16.60
1898 Mar	13.19	1955	14.86
1906	12.20	1956	14.73
1908	15.48	1956/7	12.81
1910 Feb	14.13	1958 Feb	13.50
1910 Mar	14.79	1958 Apr	14.89
1911	14.16	1959	13.85
1917	14.72	1963	11.96
1918 Jan	15.86	1968	12.20
1918 Jan	17.33	1973 Dec	14.46
1922	14.11	1974 Jan	12.89
1928	15.07	1974 Feb	12.81
1929	12.96		

TABLE 3.

Chief characteristics of the Fitzroy River terrace sequence at Belmont

Terrace Name	Relative Age	Depositional Environment	Soil Series	Dominant Sediment Type	Altitude (metres)	Morphology
CAMPBELL	Youngest	Floodplain	Cotton	Clay	6 - 13	Oxbow lakes common; many shallow floodplain scour routes (< 1 m deep)
		Levee	Oxbow	Gravel, coarse sand	10 - 16	Gravelly ridges up to 2 m high infilling floodplain scour routes
FIG TREE	Young	Floodplain	Lily	Clay	12 - 15	Floodplain scour routes to > 3 m below surface common
		Levee	Larrup	Medium-coarse sand	14 - 16	Few degraded levee crevasses to < 3 m below surface
BULL	OLD	Floodplain	Windsock, Belmont	Clay	14 - 16	Few degraded floodplain scour routes usually < 2 m below surface
		Levee	Homestead	Medium-coarse sand	16 - 17	Little microrelief
ETNA	Oldest	Floodplain	Etna	Clay	15 - 18	Round type gilgai with depressions 4-5 m across and up to 0.5 m microrelief

Fitzpatrick (1965) at 25.4 ± 3.9 for Rockhampton over the 35 year period 1926-1960. 88% of all years had at least a 20 week season while over 50% of years had in excess of 25 weeks of useful pasture growth. Fitzpatrick excluded the 17 week period from 14th May to 17th September in this assessment of growing season because periods of low temperatures substantially reduce the growth of native species. However at Rockhampton 12.2 weeks of this period had estimated soil moisture within the available range and the potential for plants that can utilize this moisture by making more active growth during the cooler months has been recognised by Fitzpatrick (1965) and Perry (1968).

IV GEOLOGY AND GEOMORPHOLOGY

Belmont is readily divided into two distinct physiographic units: an eastern, upland area and the alluvial plain of the Fitzroy River and its tributaries (Fig. 2). In the following discussion of these areas all heights are related to the Australian Height Datum unless otherwise indicated.

(a) THE UPLAND AREA

The upland area is underlain by the Devonian - Carboniferous rocks of the "Yarrol Basin Sequence" (Malone, 1966; Wright, 1968). These rocks consist dominantly of marine mudstones and sandstones with some interbedded acid to intermediate volcanics and minor amounts of limestone. They have been strongly folded, cleaved and jointed with the finer textured rocks usually breaking readily into flattish chips to 5 cm long. The strike of these rocks is approximately NE/SW. They are very steeply dipping and outcrop in the dip direction varies in width from less than one metre to hundreds of metres.

The upland area is hilly with most ridge crests rising to between 35 and 90 m. Slopes are moderate to steep (8^o to 20^o) and short, narrow, V-shaped valleys abound in the higher parts. Longer, gentler slopes of less than 5^o are more common in the lower western part of the upland area where broader ridge crests rise to less than 35 m.

(b) THE ALLUVIAL PLAIN

About 70% of Belmont lies on the flat alluvial plains of the Fitzroy River and of Etna and Belmont Creeks (Fig. 2). Thicknesses of alluvium of between 10 and 30 m have been reported from water bores near the Belmont homestead.

The water level of the river is controlled by a barrage at Rockhampton and at Belmont the river level usually lies near 4 m. The levels of major floods since 1896 at Yaamba (approx. 10 km upstream of Belmont) are listed in Table 2. All these floods have caused moderate to severe flooding of the alluvial plain. The more extensive occurred in 1896, 1918 and 1954 when virtually the whole of the alluvial plain was inundated.

Four phases of alluvial terrace formation have been recognised in this study. All but the oldest terrace (the Etna Terrace) display both fine textured floodplain and coarser levee deposits; their chief characteristics are listed in Table 3.

(i) The Etna Terrace

The Etna Terrace occupies two small areas in the Etna Creek and Near Farm paddocks. It is much more extensive to the north of Belmont where its

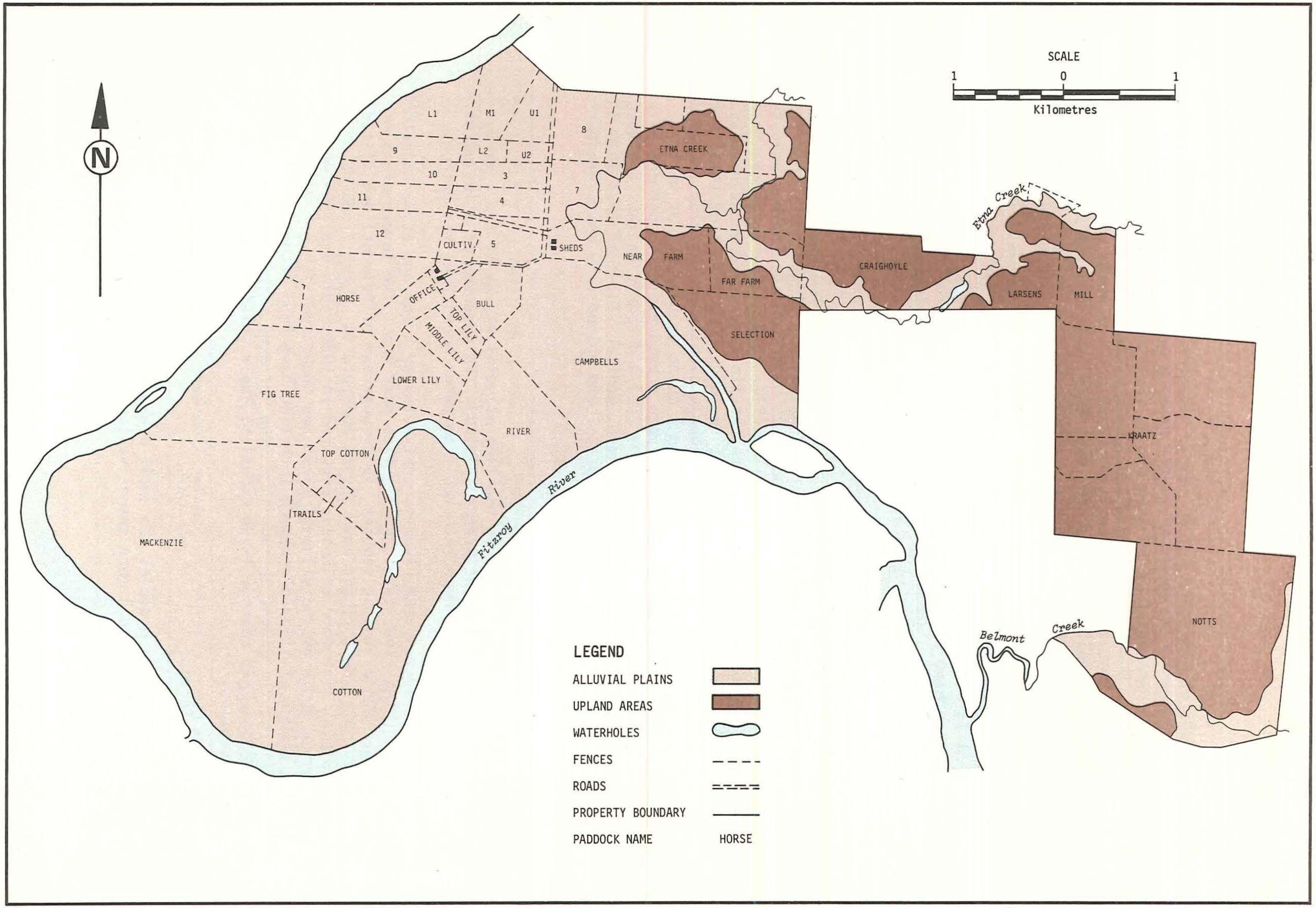

FIGURE 2. Map of Belmont.

western margin has been eroded by a former channel of the Fitzroy River. This channel had a north-south orientation and defines the eastern margin of the lower, more extensive Bull Terrace; its definition decreases towards the south. The Etna Terrace is inundated only occasionally by the very high floods of the Fitzroy River and Etna Creek.

Gilgai microrelief and remnants of formerly extensive brigalow vegetation aid in the recognition of the Etna Terrace. The round gilgai microrelief (Hallsworth and Beckmann, 1969) ranges from very weak to moderate with puffs and depressions 2 to 5 m in diameter and up to 0.5 m in relief.

(ii) The Bull Terrace

The Bull Terrace occupies the majority of the small paddocks in the vicinity of the Belmont homestead and sheds. Etna Creek is deeply incised into this terrace (7 m below the terrace) but the terrace has little other relief. Several flood plain scour routes (Thornbury, 1954) occur but these are considerably shallower, with gentler slopes, more irregularly distributed, and less well defined, than those of the lower Fig Tree Terrace. They have been incised less than 2 m below the terrace.

The clay of the Bull Terrace floodplain is overlain by a small area of sands in the vicinity of the Cultivation and Bull paddocks. Owing to erosion, geomorphic evidence of the depositional origin of these sands is lost. By analogy with the floodplain and levee deposits of the lower Fig Tree and Campbell Terraces, however, they are thought to be remnants of a former river levee which was active at the time of deposition of the Bull Terrace.

The western margin of the Bull Terrace is marked by a major floodplain scour route westwards of which lies the lower (at least 2 m), more extensive Fig Tree Terrace.

(iii) The Fig Tree Terrace

The Fig Tree Terrace occupies a major part of the Fig Tree, Horse, Lily, Top Cotton, Cotton, and Mackenzie paddocks. It is characterised by clay-rich floodplain sediments with well-defined sets of arcuate depressions and ridges that mark the positions of floodplain scour routes. They are often more than 3 m below the floodplain surface and do not normally contain much non-clay sediment. In the west the clays are overlain by up to 2 m of levee sands. These sands are stabilized and well vegetated. In several places floodwaters have cut crevasses (Tanner, 1968) in lower parts of the levee deposits. Several of these crevasses, now degraded, are continuous with some of the floodplain scour routes. The large number of scour routes across the Fig Tree Terrace implies that erosion is a more dominant process than deposition under the present climatic regime.

Most of the floodplain scour routes are inundated by major floods. Floods above about 12.5 m at Yaamba (Table 2) fill the large floodplain scour route separating the Bull and Fig Tree Terraces and cut off access to the southwestern part of the alluvial plain.

(iv) The Campbell Terrace

The Campbell Terrace occupies most of the Campbell and River paddocks and much of the Cotton and Mackenzie paddocks. The clay-rich sediments of the Cotton soil series constitutes the Campbell Terrace floodplain deposits, and the much coarser sediments of the Oxbow soil series, the associated Campbell Terrace levee deposits. Several oxbow lakes, former channels of the

Fitzroy River, occur on the Campbell Terrace floodplain which is flooded approximately biennially by the Fitzroy River. Many shallow (less than 1 m) floodplain scour routes are evident. Recent sheet erosion of the eastern part of this terrace has resulted in a few areas being left at a slightly higher (1 to 1.5 m) elevation.

The gravelly levee sediments of the Campbell Terrace are the coarsest deposits found on the alluvial plain. They occur inside a meander of low sinousity as a small terrace on the northwest of Belmont and inside the large meander of the Fitzroy River along the western side of Mackenzie paddock. Stringers of these coarse sediments occur in floodplain scour routes in both Mackenzie and Cotton paddocks and there is a small deposit of them at the end of an oxbow lake in River paddock. Other similar deposits occur along most of the river frontage but most are too small to delineate at the mapping scale employed here. Where they occupy former floodplain scour routes, these levee deposits are usually more than 2 m thick but they may be considerably thinner in the areas between such depressions.

Modern deposition on these levees is well illustrated by partial, and in one case, almost total burial of fence posts in River and Campbell paddocks.

(v) Terrace Genesis

The stratigraphic relationships of the sediments of the four terraces have not been investigated in this study. It is possible that successively lower terraces are erosional modifications of the adjacent, higher terrace. However, each terrace could well have formed by deposition of fresh sediment as an inset in an erosional remnant of pre-existing terraces. The erosional modification concept gains support from the increasing number and definition of floodplain scour routes on successively lower and younger terraces. This may, however, be a reflection on the greater susceptibility of the lower terraces to flooding, hence scour. Whatever their origins, the soils are more strongly differentiated on successively higher terraces.

(c) OTHER ALLUVIAL DEPOSITS

Where Belmont and Etna Creeks traverse the upland areas they have constructed significant floodplains between 1 m and 4 m thick. On Belmont Creek two sets of matched terraces are evident where the upper set is 1-2 m higher than the lower set. Floodplain scour routes, usually incised considerably less than half a metre below the floodplain and subparallel with the stream channel, have developed extensively along the Etna Creek floodplain but are only poorly defined on the lower terraces on Belmont Creek.

Most of the small streams draining the upland area have narrow alluvial benches up to 2 m thick but they are too small to delineate at the mapping scale used here.

V VEGETATION AND PASTURES

(a) NATIVE VEGETATION

Belmont, like most of the adjacent properties, has been extensively cleared. Eucalypt forests, brigalow forests, softwood scrubs and some open grasslands appear to have covered the area prior to clearing, but only small, depauperate areas of the original communities remain. Much of the once timbered areas now support improved pastures and the grasslands to the north of Belmont have been extensively cultivated.

Small amounts of the more dense eucalypt forest (including narrow-leaved ironbark *E. crebra*, grey bloodwood *E. polycarpa*, carbeen *E. tessellaris*, poplar box *E. populnea*, and blue gum *E. tereticornis*) remain on the Bull Terrace north of paddocks M1, U1, and 8 and at the southwestern end of Selection paddock. Remnants of more open eucalypt forests (dominantly *E. tereticornis* and *E. tessellaris*) occur on the lower terraces on the alluvial plain.

Brigalow (*Acacia harpophylla*) forests with some belah (*Casuarina cristata*) are restricted to the gilgaied clays of the Etna Terrace. Brigalow and belah are also associated with the softwood scrubs common on much of the upland country. The only evidence of the former extent of most of these scrubs is the bottle trees (*Brachychiton australe*) that remain after clearing.

Black spear grass (*Heteropogon contortus*) is the dominant grass under the eucalypt forests and is the dominant volunteer native grass on the cleared country. Kangaroo grass (*Themeda australis*) is the major associated component of the eucalypt forest ground cover while Queensland blue grass (*Dichanthium sericeum*) was probably once dominant on the heavier textured soils of the lower terraces. Ground cover was very sparse under the brigalow forests and softwood scrub.

Two introduced pest species may require some control measures. Lantana (*Lantana camara*) has invaded most of the softwood scrubs and is not eradicated on clearing. Noogoora burr (*Xanthium pungens*) is particularly prevalent on the lower parts of the alluvial plain where growth of the burr may be so prolific as to exclude all other plants.

(b) IMPROVED PASTURES

A continuing program of pasture improvement was initiated at Belmont in 1959. Prior to this survey about 1750 ha (45% of the area of Belmont, Fig. 3) had been seeded with a mixture of Green Panic (*Panicum maximum* var. *trichoglume*), Buffel (*Cenchrus ciliaris*), and Siratro (*Macroptilium atropurpureum*). Some small areas were also seeded with Phasey bean (*Macroptilium lathyroides*), Centro (*Centrosema pubescens*) and Townsville stylo (*Stylosanthes humilis*). The standard seed mixture used was 2.44 kg of Buffel and 1.22 kg of Siratro per hectare. Plantings in 1971 and earlier were accompanied by dressings of 125 kg/ha of superphosphate (with added molybdenum) and, unless topdressed in 1972-73 (Fig. 3), have received no subsequent fertilizer. Higher initial fertilizer rates have been used on areas seeded since 1972 (Fig. 3).

At the time of this survey (May 1974) good improved pastures were evident on all the areas that had been seeded and fertilized. Their quality contrasted strongly with the native pastures occurring in adjacent paddocks on the same soil type and in similar topographic positions.

The relationship between legume persistence over 10 years since planting and soil type within a 4 ha area of the Fig Tree Terrace was examined. The current legume distribution pattern is more closely related to the physical properties of the soils (e.g. texture, drainage) than to their chemical properties (e.g. salinity, acid extractable phosphorus). A more detailed account is available on request (CSIRO Aust. Div. Soils Tech. Mem. 29/1975).

VI SOILS

Because of the limited time available for field work and the complexity of the soil distribution pattern over parts of Belmont, it was impractical to maintain a uniform mapping scale over the whole of the area. Where possible, soils have been described at series level and in most cases the soil mapping units shown in Figure 4 are associations of series named after the dominant

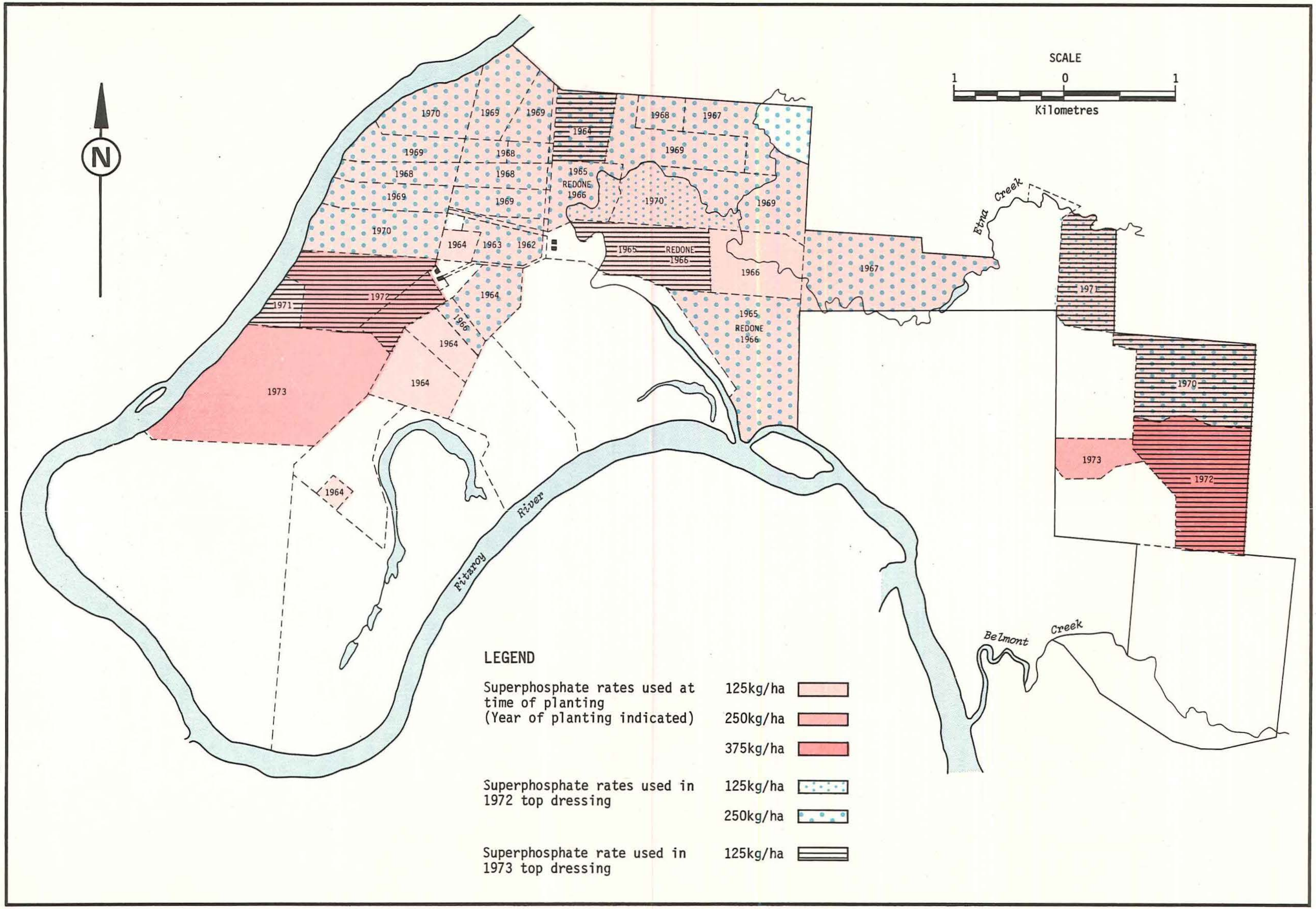

FIGURE 3. Improved pasture development at Belmont.

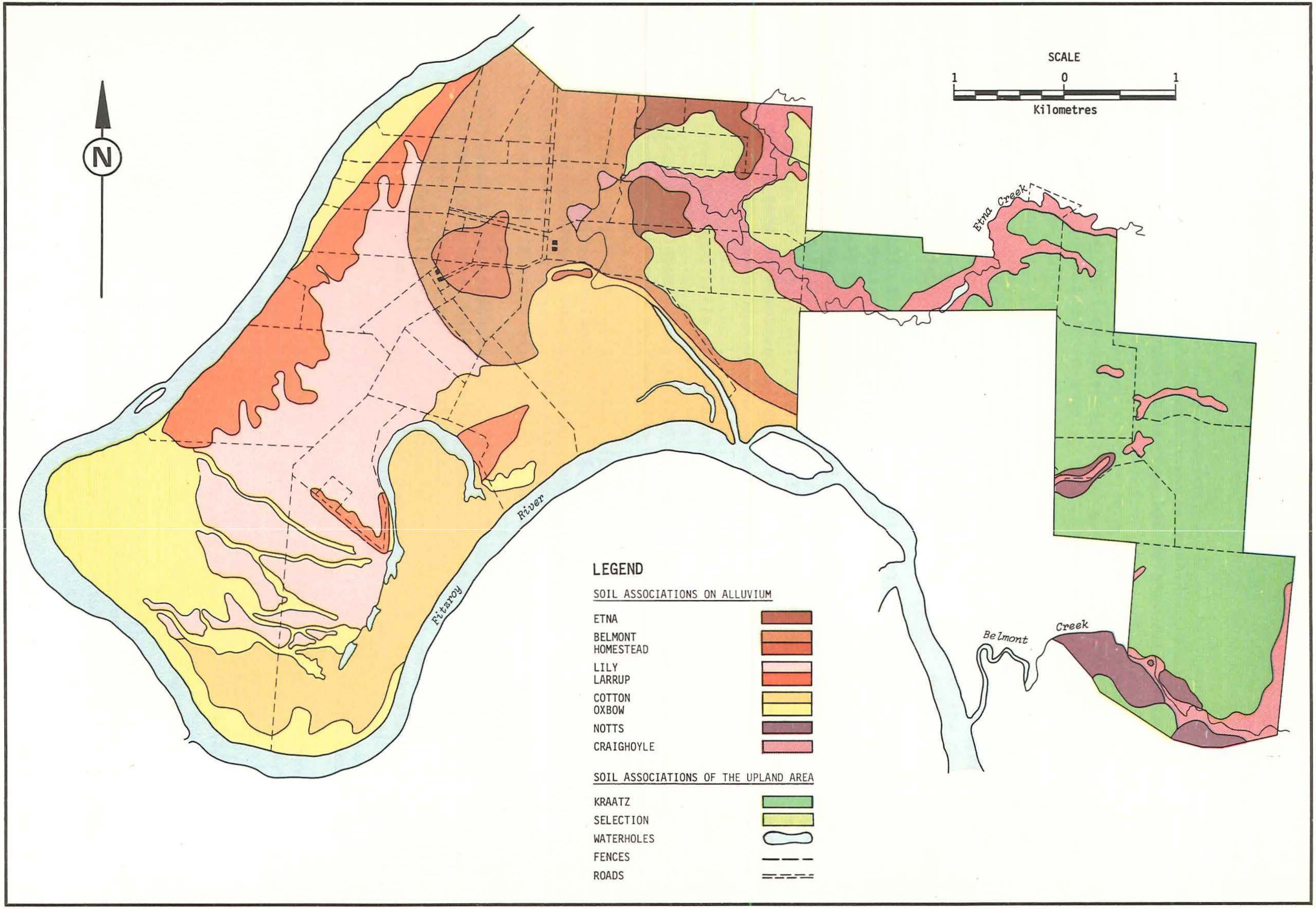

FIGURE 4. The soils of Belmont.

soil. The chief exception is the upland area where the soil distribution pattern is complex; major differences occur over very short distances. This area has been mapped as a complex and subdivided into two units on the basis of topography.

A brief outline of each soil mapping unit is presented below. Detailed descriptions of, and analytical data for the related soil series are listed in the Appendix. The soil classification systems of Stace *et al*, (1968) and Northcote (1971) have been used.

(a) SOIL MAPPING UNITS

(i) SOIL ASSOCIATIONS ON ALLUVIUM

1. Etna association

The Etna association is restricted to the highest and oldest terrace (Etna Terrace) of the alluvial plain and occupies an extensive area to the north of Belmont.

The soils are all deep grey clays (Ug5.28) of the Etna series and are associated with round gilgai microrelief and brigalow vegetation. There is little difference between soils in puff and depression sites. The structure of the surface of the depression soil is slightly coarser than that of the surface of the puffs, where carbonate nodules and rock fragments may occur.

2. Belmont association

The Belmont association occurs on the Bull Terrace floodplain deposits and, like the Etna association, is flooded only very occasionally (e.g. in 1896, 1918, and 1954).

Brown podzolic-solodic intergrade soils (Db1.32) of the Belmont series and similar, darker coloured soils (Dd1.33) of the Windsock series are predominant. Although the evidence is poorly preserved, the Belmont series seems to occur on the sandier areas (possibly relic levees) while the Windsock series tends to be more abundant on the finer textured (possibly floodplain or backswamp) areas of the Bull Terrace.

A variety of soils occur in the floodplain scour route depressions. They range from black earths to very strongly bleached yellow, grey and brown duplex soils akin to those of the Notts association (see below). These soils usually exhibit some weak gley features such as fine, dark yellowish brown mottles or root tracings in the surface soil and abundant ferromanganiferous segregations in the lower horizons.

3. Homestead association

The Homestead association is limited to a small, flat, sandy area in and near Cultivation paddock. It is slightly higher (less than half a metre) than the general level of the Bull Terrace and it probably represents a moderately well preserved levee deposit of that terrace. The soils are all deep siliceous sands (Uc4.21) of the Homestead series.

4. Lily association

There is a marked difference in particle size characteristics and soils of the fine-textured, floodplain deposits and the related sandier, levee deposits of the Fig Tree Terrace. The Lily association is found on the former and the Larrup association on the latter.

Black earths (Ug5.4) of the Lily series are the dominant soils of the Lily association. They tend to be restricted to the nearly flat areas between floodplain scour routes. A dark, duplex profile variant (Dd1.13) occurs in minor depressions on the terrace surface. The surface 2-10 cm of both soils tends to form a massive to coarse blocky crust on drying.

In the floodplain scour route depressions, however, a variety of soils are found. Black earths and grey clays are predominant but alluvial soils are common and range in texture from coarse sands overlying dark clays to clays overlying coarse sands.

Black earths and grey clays also occur on the slopes of the floodplain scour routes. These have a strongly developed, fine to medium blocky structure at the surface and probably represent an eroded phase of the crusted soils of the terrace surface.

5. Larrup association

Mappable areas of the Larrup association are restricted to the levee deposits of the Fig Tree Terrace where Um6.21 soils (see Appendix) are dominant. There is no provision for the classification of these soils in the system of Stace *et al.* (1968).

The texture of the levee deposits is variable ranging from sands or sandy loams to sandy clays. The finer components are dominant where the levee merges with the clay soils of the Lily association on the Fig Tree Terrace floodplain.

Finer textured soils with gradational texture profiles (Gn3.21, Gn3.41) occur on the mid parts of the back slope of the levee deposits. These usually have a clay loam surface overlying dark brown, light clay B horizons that grade into sandy loams, sandy clays or light clay (sandy) B/C horizons.

Near the base of the levee backslope, adjacent to the fine-textured floodplain soils of the Lily series dark brown duplex soils (Db1.12) have formed. The duplex profile occurs where sandy levee deposits thinly mantle finer floodplain deposits.

6. Cotton association

The Cotton association occurs on the floodplain of the Campbell Terrace and is flooded by the Fitzroy River about every second year. Deep black earths (Ug5.1; see Appendix) of the Cotton series occur throughout.

Active deposition is a common occurrence over the terrace; 4-6 cm of silty clay loam-light clay were deposited by the January 1974 floods. These recent deposits exhibit prominent stratification but they are readily incorporated into the soil mass as no bedding is evident in the Cotton series soils.

7. Oxbow association

The Oxbow association is found on the coarse, levee and floodplain scour route deposits of the Campbell Terrace. There is little evidence of pedogenesis in most of the poorly sorted, often stratified sandy gravels. Dark grey to brown alluvial soils (Uc5.11) of the Oxbow series are dominant but areas of nonvegetated, stratified coarse sandy gravels are common. These are the coarsest and youngest materials to be deposited in a mappable unit on the alluvial plain.

8. Notts association

The Notts association occurs in the south-eastern part of Belmont on the high level alluvial terraces of Belmont Creek and of several small creeks draining the upland area. In many cases the terraces are too small to be shown on Figure 4. Solodic to grey-brown podzolic intergrade soils (Dy 2.42) of the Notts series are dominant on the clay-rich alluvium.

9. Craighoyle association

The Craighoyle association is found on the lower alluvial terraces of Etna and Belmont Creeks and occurs extensively on the alluvium of small streams in the upland area. The latter occurrences however, are often too small to be shown on Figure 4.

Uniform, gradational, and occasionally duplex soils have been recognised (see Appendix) but they have not been assigned to soil series because of their variability and minor occurrence. The variety of soils occurring in this unit reflects differences in texture, source and possibly age of their parent materials.

Although sand and gravel occur throughout the Craighoyle association, clay is dominant and the majority of soils are dark grey to brown cracking clays. Alluvial stratification is often evident low in the profile and buried soils are occasionally encountered in these sedimentary sequences. Sub-angular to rounded rock fragments occur in all these soils but are more abundant in alluvium of the steeper upland area.

(ii) SOIL ASSOCIATIONS OF THE UPLAND AREA

Although series could be established for most of the soils of the upland area, the complexity of their distribution pattern is such that the mapping or individual treatment of any particular soil would be quite impractical. This area has been subdivided into two units on the basis of topography. The two soil associations (Kraatz and Selection) are therefore not related to any specific soil series; descriptions of, and analytical data for some of their soils are listed in the Appendix.

1. Kraatz association

The Kraatz association occupies the higher and steeper eastern part of the upland area where local relief ranges from 50 m to 70 m and slopes range from 4^{o} to 20^{o}. A wide range of soils have developed in place on the highly variable, steeply dipping parent rocks. Although rock outcrop is rare, there are many rock fragments on the surface and most soils are stony and usually less than 0.5 m deep.

Lithosols and solodic-podzolic (red and yellow) intergrades are the dominant soils. The very gravelly lithosols have formed on fine grained, non-calcareous, sedimentary rocks. The common forms (Um2.12 and Um3.12) have dark brown (7.5YR 4/2m) clay loam A1 horizons with weak blocky structure overlying very gravelly, sporadically to conspicuously bleached, clay loam A2 horizons. These grade into weathered rock at 15 to 20 cm depth. Closely associated with these are a range of red and yellow duplex soils (chiefly Dr2.3, Dy2.3, and Dy2.4; see Appendix). The A1 and A2 horizons are similar to those of the lithosols but at about 20 cm there is an abrupt change to heavy clay (gravelly or gritty) B horizons. These range in colour from light olive-brown (2.5 Y 5/4 m) to dark red (2.5YR3/4m) and may be whole coloured or mottled. The clays have moderate to strong blocky structure and are rarely more than 30 cm thick before grading rapidly into weathered rock.

Red clays (Ug5.37) and red duplex soils (Dr2.2) occur on small areas of intermediate volcanics and limestones.

2. Selection association

The Selection association occurs in the western part of the upland area where the topography is much more subdued. Slopes rarely exceed 4° and local relief is less than 15 m. The range and distribution of soils is similar to that of the Kraatz association although the lithosols are less common and red gradational-textured soils (Gn3.1) and red clays (Ug5.37) associated with limestones are more abundant. The duplex soils are slightly deeper, and this is probably a function of the more subdued relief.

(b) SOIL CHEMISTRY AND FERTILITY

Sufficient samples were collected to indicate trends in soil chemistry over Belmont and to highlight any major nutrient problems associated with improved pasture development. Chemical data for representative profiles of the major soils are given in the Appendix.

(i) Total soluble salts and chloride

Most soils on Belmont have low (0.02 to 0.05%) total soluble salts and chloride contents throughout the profile; the chief exceptions are the moderately high values obtained in the deeper subsoils of some of the profiles of the Etna and Notts series. The salt content of these soils is not likely to be a factor of agronomic importance.

(ii) pH and exchangeable cations

Most surface soils are mildly acid to neutral although the puff profiles of the Etna series are mildly alkaline at the surface where carbonate nodules are common. The heavier textured soils, such as those of the Windsock, Lily and Cotton series tend to increase in pH with depth but none are highly alkaline in the subsoils.

Calcium is the dominant exchangeable basic cation in all the surface soil samples and in many of the subsoils. Exchangeable magnesium is dominant in the B horizon of the Etna series soils and of some of the duplex soils of the Kraatz association. Exchangeable sodium contents are low in most of the soils except for the B horizon of the Etna series. The duplex soils are not characterised by high sodium contents in their B horizons.

Exchangeable potassium contents, though variable, are mostly moderate and occasionally high in the surface soils. In contrast, however, the surface soils of the Notts and Windsock series (and possibly the Belmont series) and of some of the duplex soils of the Kraatz association have low exchangeable potassium contents. In these soils potassium deficiencies could arise.

(iii) Organic carbon and nitrogen

Organic carbon contents of the surface soils range from about 2% to 6% in all except the sandier surfaced soils (e.g. the Homestead series) where values are less than 1%. Total nitrogen values for surface soils show a similar pattern; the heavier textured soils range from about 0.1% to 0.4% and the lighter-textured soils from about 0.05% to 0.2%. C:N ratios range from 9 to 12 hence the soils should mineralise nitrogen readily. In the long term, however, a legume would have to be incorporated in any pasture or a nitrogenous fertilizer employed in order to maintain production.

(iv) Phosphorus (extractable with 0.01N H_2SO_4)

Most of the soil samples analysed were collected from areas that have been fertilized with at least 125 kg/ha and up to 500 kg/ha of superphosphate. This must be borne in mind when interpreting the extractable phosphorus contents of the soils as 100 kg/ha of superphosphate will supply approximately 10 ppm of phosphorus to the surface 10 cm of soil, some of which must be expected to be recovered by the extractant used.

It is usually considered that with extractable phosphorus levels of less than 20-30 ppm responses to applied phosphorus are likely in most tropical legumes, though a critical level has not been established specifically for Siratro.

The soils of the alluvial plain are very much better supplied with phosphorus than those of the upland area. This probably reflects the great variety of rocks and soils in the Fitzroy River catchment that have been eroded to give rise to the terrace sequence investigated here. In general, the heavier textured surface soils of the alluvial plain have higher extractable phosphorus contents (values of 90-260 ppm common) than the lighter textured surface soils of the levee deposits (values of 33-150 ppm common). With increasing depth in both soil types there is a rapid decrease in extractable phosphorus where values of less than 30 ppm occur. The younger soils of the Cotton association have not been fertilized and have high (120-290 ppm) values throughout the profile.

Much lower values have been obtained from the soils of the upland area. Surface soil phosphorus contents may rise to 40 - 60 ppm but values of 12-30 ppm are much more common. These relatively low values decrease rapidly with depth and at about 40 cm values of less than 4 ppm are common. Despite these upland soils having the lowest extractable phosphorus levels of all the Belmont soils studied, good Green Panic - Buffel - Siratro pastures have been established on them using phosphatic fertilizer (Fig. 3). However, it is anticipated that additional applications of phosphorus will be required to maintain these pastures.

(v) Summary of nutrient status

Few of the Belmont soils present any major problems for the development of improved pastures. They have adequate levels of calcium and magnesium and, although their trace element status has not been investigated, no major problems are anticipated. Potassium deficiencies may become evident on the Notts, Windsock, and possibly the Belmont series and on some of the duplex soils of the upland area.

Phosphorus will be a limiting factor for pasture growth on most of the soils of the upland area. However, the soils of the alluvial plain, especially those of the Cotton and Lily series, seem to be well supplied with phosphorus. The results of this survey suggest that pastures might be established and maintained on these soils without the use of any phosphatic fertilizer at all. Such a cost-saving establishment procedure could be tested by simple experimentation.

With suitable phosphorus and potassium treatments the soils of most of Belmont should allow the establishment and maintenance of adequate improved pastures. Problems of waterlogging and weed infestation will still remain in the areas subject to regular flooding.

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APPENDIX

REPRESENTATIVE SOIL PROFILE DESCRIPTIONS AND ANALYTICAL DATA

Detailed descriptions and laboratory data for the major soils of Belmont are listed below. They have been classified according to Stace *et al.* (1968) and Northcote (1971).

The descriptions are of representative profiles of individual soil series and the range in characteristics of the major attributes within the mapping unit is also given. In most cases analytical data from a single profile only is available although additional surface samples were collected for some soils. Where more than one sample was available the range in values obtained has been given. Munsell colour notations are used for moist soil unless otherwise specified.

All analytical data are reported on an oven dry basis. The following analytical methods were employed and the abbreviations in parentheses are used in the following tables.

pH	pH was determined on a 1:5 soil/water suspension using glass and calomel electrodes and a Philips direct reading pH meter.
Total soluble salts (TSS):	Calculated from conductivity measurements on a 1:5 suspension at 25°C using a factor of 336 x conductivity.
Chloride (Cl):	Potentiometric measurements with Ag/AgCl and calomel electrodes on a 1:5 soil/water suspension at 25°C.
Total nitrogen (N):	Determined by the Honda (1962) modification of the Kjeldahl method.
Organic carbon (C):	Readily oxidizable organic matter was determined by the method of Walkley and Black (1934). No factor has been applied.
Extractable phosphorus (P):	Extracted with 0.01N H_2SO_4 for 16 hours (Kerr and von Steiglitz, 1938) and determined by the method of Murphy and Riley (1962).
Exchangeable cations:	Exchangeable basic cations were extracted with 1N ammonium chloride at pH 7.0.

1. ETNA SERIES

(i) Classification: Grey Clay; Ug5.28

(ii) Profile morphology (Very weakly gilgaied site):

0 cm	Dark greyish brown (10YR4/2); heavy clay; moderate coarse blocky structure with weakly self mulching surface; very hard when dry. Diffuse change to:
15 cm	Greyish brown (2.5Y5/2); heavy clay; strong coarse blocky structure; few 1 mm Fe/Mn nodules; hard when dry. Diffuse change to:
65 cm	Olive grey (5Y5/2); heavy clay; strong coarse blocky structure. Diffuse change to:
110 cm	Distinct, fine, common mottle: light brownish grey (2.5Y6/2) and yellowish brown (10YR5/6); heavy clay; strong coarse blocky structure; few hard, 1-2 cm carbonate nodules to 130 cm. Continues to 2 m.

(iii) Range in characteristics:

In areas of stronger gilgai microrelief brownish grey (2.5Y5/2) and olive grey (5Y5/2) clays, carbonate nodules and rock fragments may be exposed at the surface of the puffs. The surface of the depression site soil has much coarser blocky structure and has no self mulching properties.

(iv) Analytical data:

Fertilized site with 2 additional surface samples from non-fertilized sites

Depth	pH	TSS	Cl	C	N	P	Ex. Cations (meq%)			
cm		%	%	%	%	ppm	Ca	Mg	K	Na
0-10 (a)	6.1 to 8.0	<0.02 to 0.02	<0.01 (d)	1.3 (b)	0.14 (b)	12 to 93 (c)	13.6 to 29.7	9.3 to 14.9	0.6 (d)	0.3 to 1.3
40-50 (b)	6.2	0.13	0.09	-	-	4	11.9	17.0	0.2	4.3
90-100 (b)	7.4	0.27	0.16	-	-	-	-	-	-	-
160-170 (b)	6.5	<0.02	<0.01	-	-	-	-	-	-	-

(a) Three surface soil samples analysed.
(b) One sample only analysed, all samples from same profile (with added fertilizer).
(c) Values of 12 and 20 ppm for weakly gilgaied puff sites, the former with added fertilizer and the latter without. Value of 93 for a depression site without added fertilizer.
(d) Same value for all samples analysed.

2a. BELMONT SERIES

(i) Classification: Brown podzolic - solodic intergrade: Db1.32 with Db1.21 and Db1.22.

(ii) Profile morphology (Db1.32):

0 cm	Very dark grey brown (10YR3/2, 10YR5/2d); fine sandy clay loam to sandy loam;
A1	massive to very weak subangular blocky structure, occasionally thin platy structure near surface; friable when moist. Gradual change to:

10 cm A2	Sporadically bleached, dark grey brown (10YR4/2) and greyish brown (10YR5/2, 10YR7/1d); sandy loam to fine sandy clay loam; weak subangular blocky structure; friable when moist. Clear or abrupt change to:
25 cm B2	Brown (10YR4/3); medium to heavy clay (fine sandy); moderate to strong blocky structure (2-3 cm); firm when moist; few fine Fe/Mn nodules. Gradual or diffuse change to:
50 cm	Strong brown (7.5YR5/6); sandy clay loam decreasing with depth to sandy loam or to loamy sand; massive; friable when moist; few fine Fe/Mn nodules and soft segregations. Continues to 1 m.

(iii) Range in characteristics: A1 horizons range from 4 to 25 cm thick. A2 horizons vary from very strongly developed sporadic bleach to very weakly developed A2 without any bleach. Depths to the B horizon range from 20-40 cm. Occasional profiles may show alluvial stratification beyond 50 cm depth.

(iv) Analytical data: none available.

2b. WINDSOCK SERIES

(i) Classification: Brown podzolic-solodic intergrade; Dd1.33 with Db1.13 Db1.33, and in depressions Dy2.41.

(ii) Profile morphology (Dd1.33);

0 cm A1	Dark grey brown to dark grey (10YR4/2); fine sandy clay loam; massive; firm when moist. Gradual change to:
15 cm A2	Patchy dark grey-brown (10YR4/2) and grey (10YR5/1, 10YR7/1a); fine sandy clay loam; massive; firm when moist. Abrupt change to:
25 cm B2	Very dark grey brown (10YR3/2); medium to heavy clay; moderate to strong blocky structure (1-3 cm, smooth ped); very firm to hard when moist. Gradual change to:
45 cm BC	Dark yellowish brown (10YR3/4); medium or heavy clay (fine sandy) decreasing gradually to fine sandy clay loam; weak coarse blocky structure; few 1-2 cm carbonate nodules from 40-60 cm and few 1-2 mm Fe/Mn nodules. Diffuse change to:
80 cm C	Yellowish brown (10YR5/6); light sandy clay loam grading to loamy sand; massive, very friable. Continues to 1 m.

(iii) Range in characteristics:

A1 horizon thicknesses vary from 8-15 cm. The abrupt change to the B2 horizon ranges in depth from 18 to 30 cm. The B/C horizon is occasionally mottled (light brownish grey 10YR6/2) and may contain some soft Fe/Mn segregations up to 2 cm. In slightly depressed sites gley features are prominent in the surface horizons and the top of the B2 horizon lies deeper at 30 cm to 65 cm.

(iv) Analytical data:

Fertilized site - one sample per depth interval, all samples from same profile.

Depth	pH	TSS	Cl	C	N	P	Ex. cations (meq%)			
cm		%	%	%	%	ppm	Ca	Mg	K	Na
0-10	6.0	<0.02	<0.01	1.1	0.10	106	6.0	3.6	0.2	0.3
25-35	6.8	0.02	<0.01	-	-	-	10.9	10.0	0.2	1.8
60-70	8.9	0.07	0.02	-	-	-	7.7	5.2	0.1	1.2

3. HOMESTEAD SERIES

(i) Classification: Siliceous sand; Uc4.21 with some Uc4.22

(ii) Profile morphology (Uc4.21):

0 cm A1	Very dark grey brown (10YR3/2); loamy sand; massive; very friable when moist. Gradual change to:
20 cm A2	Dark yellowish brown (10YR3.5/4); loamy sand; massive; very friable when moist. Diffuse change to:
40 cm B	Brown (7.5YR5/6) or reddish brown (5YR5/4); loamy sand; massive; very friable when moist. Continues to 1 m.

(iii) Range in characteristics:

Al horizons range in depth from 20-30 cm and may occasionally have weak subangular blocky structure.

(iv) Analytical data:

Fertilized site - one sample per depth interval, all samples from same profile

Depth	pH	TSS	Cl	C	N	P	Ex. Cations (meq%)			
cm		%	%	%	%	ppm	Ca	Mg	K	Na
0-10	6.8	<0.02	<0.01	0.6	0.06	33	3.4	1.0	0.4	<0.1
50-60	6.6	<0.02	<0.01	-	-	-	2.7	0.9	0.3	<0.1
80-90	6.2	<0.02	<0.01	-	-	-	-	-	-	-

4. LILY SERIES

(i) Classification: Black earth; Ug5.4 and Dd1.13 with Ug5.15 and Ug5.17.

(ii) Profile morphology:

(i) The Ug5.4 form -

0 cm A1	Very dark grey brown (10YR3/2) to black (10YR2/1); light to medium clay; massive to very coarse blocky structure; may be platy for top 2-3 cm; very hard when dry. Clear change to:
10 cm	Black (10YR2/1); heavy clay; strong blocky structure (2-3 cm smooth ped); firm when moist. Diffuse change to:
50 cm	Brown (10YR4/3); medium-heavy clay (fine sandy); moderate blocky structure (2-3 cm); firm when moist; few 1-2 cm carbonate nodules. Diffuse change to:
160 cm	Yellowish brown (10YR5/6); medium clay (fine sandy); weak coarse blocky structure; firm when moist. Continues to 2 m.

(ii) The Dd1.13 form -

0 cm A1	Very dark greyish brown (10YR3/2); fine sandy clay loam to clay loam; massive to weak coarse blocky structure; very hard when dry. Clear change to:
10 cm B2	Very dark grey (10YR3/1.5) to very dark greyish brown (10YR3/2); medium clay; strong angular blocky structure (3 mm - 3 cm); firm when moist. Gradual to diffuse change to:
70 cm	Dark grey (10YR3/1) to dark greyish brown (10YR3/2); heavy clay; strong angular blocky structure (5 mm - 5 cm); very firm when moist. Continues beyond 1 m.

(iii) Range in characteristics:

The light to medium clay surface crust of the Ug profile ranges from 5-15 cm thick. Rarely there may be a very weak, sporadically bleached A2 horizon evident in the Dd variant.

(iv) Analytical data (Ug5.4 form):

Non-fertilized site with 8 additional surface samples from fertilized sites.

Depth	pH	TSS	Cl	C	N	P	Ex. Cations (meq%)			
cm		%	%	%	%	ppm	Ca	Mg	K	Na
0-10	6.3	<0.02	<0.01	2.2	0.18	108	13.6	9.6	0.6	0.2
	to	to	to			to	to	to	to	to
	6.6	0.02	0.01			260	16.9	12.4	1.3	0.3
(a)				(b)	(b)	(c)	(d)	(d)	(d)	(d)
30-40	7.0	<0.02	<0.01	-	-	146	-	-	-	-
(b)										

(iv) Continued

Depth cm	pH	TSS %	Cl %	C %	N %	P ppm	Ex. Cations (meq%) Ca	Mg	K	Na
60-70 (b)	7.9	0.77	0.04	-	-	-	18.6	17.7	0.2	0.7
90-100 (b)	8.2	0.99	0.05	-	-	-	-	-	-	-
120-130 (b)	8.1	0.10	0.05	-	-	-	-	-	-	-

(a) Nine surface soil samples analysed.
(b) One sample only analysed. All samples from same profile.
(c) Value of 163 ppm at non-fertilized site.
(d) Five samples only analysed.

5. LARRUP SERIES

(i) Classification: No provision in the system of Stace *et al.* (1968); Um6.21 with Gn3.21, Gn3.41 and Db1.12.

(ii) Profile morphology (Um6.21):

0 cm A1	Very dark grey brown (10YR3/2); fine sandy clay loam; massive to weak subangular blocky structure (2-3 cm); firm when dry. Gradual change to:
15 cm B2	Dark brown (10YR3/3); fine sandy clay loam; weak to moderate blocky structure; firm when moist. Gradual to diffuse change to:
35 cm	Dark yellowish brown (10YR3.5/4); light sandy clay loam grading to loamy sand; massive; very friable when moist. Continues to 1 m.

(iii) Range in characteristics:

The textural profile of this series varies considerably and gradational textured soils (e.g. Gn3.21, Gn3.41) are common. In Fig Tree and Horse paddocks where recent sediment deposition has occurred, coarser, sandy loam and light sandy clay loam textures predominate at the surface.

(iv) Analytical data:

Surface soil samples for 4 fertilized sites

Depth cm	pH	TSS %	Cl %	C %	N %	P ppm	Ex. Cations (meq%) Ca	Mg	K	Na
0-10	6.2	<0.02	<0.01	-	-	117	9.2	4.7	0.8	0.1
	to					to	to	to	to	
	6.6					216	10.3	5.9	0.9	
							(a)	(a)	(a)	(a)

(a) Two samples only analysed

6. COTTON SERIES

(i) Classification: Black earth; Ug5.1 (value/chroma rating of 1 in the subsoil; rock not encountered before 150 cm) with Ug5.16 and Ug5.17)

(ii) Profile morphology (Ug5.1):

0 cm A1	Very dark grey brown (10YR3/2); heavy clay; moderate to strong angular blocky structure (1-2 cm); firm when moist. Diffuse change to:
25 cm	Very dark grey brown (10YR3/2); heavy clay; moderate to strong coarse blocky structure (2-3 cm); few 1 mm Fe/Mn nodules; few diffuse dark yellowish brown (gley) mottles. Structure becomes slightly coarser but otherwise profile remains unchanged to beyond 3 m.

(iii) Range in characteristics:

Recent depositional layering is common on the surface of those areas of the Cotton series subject to frequent inundation. (The lower areas received 4-6 cm of silty clay loam to light clay in the January 1974 floods). In the areas subject to prolonged flooding the surface soils are strongly gleyed with prominent bright yellowish brown tracings and fine mottles.

(iv) Analytical data:

Three non-fertilized profiles - three samples per depth interval

Depth cm	pH	TSS %	Cl %	C %	N %	P ppm	Ex. Cations (meq%) Ca	Mg	K	Na
0-10	6.1	<0.02	<0.01	1.8	0.18	132	15.4	10.5	0.9	0.2
	to	to	to	to	to	to	to	to	to	to
	6.6	0.04	0.02	2.7	0.23	267	19.6	13.4	1.4	0.3

(iv) Continued

Depth cm	pH	TSS %	Cl %	C %	N %	P ppm	Ex. Cations (meq%) Ca	Mg	K	Na
40-50	7.1 to 7.2	<0.02	<0.01 to 0.02	-	-	146 to 220 (a)	17.5 to 18.9	12.3 to 15.1	0.5	0.2 to 0.6
90-100	7.3 to 7.7	<0.02 to 0.04	<0.01 to 0.02	-	-	289 (b)	-	-	-	-

(a) Two samples analysed
(b) One sample analysed.

7. OXBOW SERIES

(i) Classification: Alluvial soil; Uc5.11 with Um6.21, Uf6.11 and Uf6.13.

(ii) Profile morphology (Uc5.11)

0 cm A1	Very dark grey (10YR3/1); sandy loam; massive to very weak sub-angular blocky structure; firm when dry. Gradual change to:
30 cm	Dark grey brown (10YR3/2); sandy loam to loamy sand; massive; friable when moist. Gradual change to:
50 cm	Brown (10YR4/3); sand; massive; some rounded siliceous gravel (2-3 cm). Continues to 1 m.

(iii) Range in characteristics:

The Oxbow series consists of young alluvial soils with little profile development beyond organic matter accumulation in the surface 50 cm. The grain size of the sand fraction of these soils ranges from very fine to very coarse, and there may be moderate to high amounts of siliceous gravel throughout the profile.

(iv) Analytical data: none available.

8. NOTTS SERIES

(i) Classification: Solodic to grey-brown podzolic intergrade; Dy2.42.

(ii) Profile morphology (Dy2.42):

0 cm A1	Very dark grey brown (10YR3/2); fine sandy clay loam to clay loam; massive or very weak blocky structure; hard when dry. Gradual change to:
7 cm A2	Patchy dark greyish brown (10YR4/2) and greyish brown (10YR5/2, 10YR7/2d); fine sandy clay loam; massive. Abrupt change to:

15 cm B21	Dark grey (10YR4/1) or dark greyish brown (10YR4/2); heavy clay; moderate coarse blocky structure; very hard when dry; few fine Fe/Mn nodules. Gradual change to:
50 cm B22	Brown (10YR4/3); heavy clay; moderate blocky structure (2-3 cm); few fine Fe/Mn nodules and occasional small, rounded quartz pebbles.

(iii) Range in characteristics:

The bleaching of the A2 horizons ranges from weak and sporadic to very strong and conspicuous. The upper B horizons vary in colour from grey to brown to yellowish red.

(iv) Analytical data:

Non-fertilized site, one sample per depth interval, all samples from same profile.

Depth	pH	TSS	Cl	C	N	P	Ex. Cations (meq%)			
cm		%	%	%	%	ppm	Ca	Mg	K	Na
0-10	6.0	<0.02	<0.01	1.5	0.13	7	6.2	7.2	0.2	0.5
15-25	5.6	0.08	0.04	-	-	6	27.4	6.3	0.9	0.3
60-70	6.9	0.34	0.14	-	-	-	7.5	11.9	0.1	2.8

9. CRAIGHOYLE ASSOCIATION

(i) Classification: Black earth; Ug5.14 with Ug5.16, Ug5.17, Gn3.22, Gn3.4, Dd2.2 and Dy3.3.

(ii) Profile morphology (Ug5.14):

0 cm	Very dark greyish brown (10YR3/1.5); heavy clay; weak coarse blocky structure; hard when dry. Diffuse change to:
10 cm	Dark grey (10YR4/1.5); heavy clay; moderate coarse blocky structure (smooth ped); few 1-2 cm carbonate nodules. Continues to 180 cm.

(iii) Range in characteristics:

Stratified sediments and buried soils are commonly encountered at depths of 80 - 100 cm.

(iv) Analytical data:

Fertilized site - one sample per depth interval - all samples from same profile

Depth	pH	TSS	Cl	C	N	P	Ex. Cations (meq%)			
cm		%	%	%	%	ppm	Ca	Mg	K	Na
0-10	6.6	0.02	0.01	4.4	0.40	132	31.4	12.8	0.8	0.3
40-50	8.3	0.02	<0.01	-	-	39	31.0	17.3	0.1	2.0
90-100	8.3	0.27	0.12	-	-	-	-	-	-	-
160-170	8.2	0.44	0.15	-	-	-	-	-	-	-

10. KRAATZ ASSOCIATION

As described in the text, there is a wide array of soils occurring in very close association on the upland area. They are dominantly lithosols and solodic to red and yellow podzolic intergrades (Um2, Dr2.3, Dy2.3 and Dy3.3 forms). The following group of profile forms were also recognised: Um2.12, Um2.21, Um3.12, Ug5.37, Db2.42, Dd2.3, Dd2.4, Dr2.2, Dr2.4, Dr3.31, Dr3.4, Dy2.2, Dy2.42, Dy3.2 and Dy3.43. Descriptions and analytical data for four profiles are listed below.

(i) Red clay (Ug5.37) on intermediate volcanics.

(a) Profile morphology:

0 cm A1	Very dark greyish brown (10YR3/1); heavy clay; strong blocky structure (1-2 cm, smooth ped); firm when moist. Gradual change to:
30 cm B2	Dark reddish brown (5YR3/4) to yellowish red (5YR4/6); heavy clay; strong blocky structure (2-3 cm); firm when moist. Angular yellowish brown fragments of parent rock increase in abundance from 50 cm. Gradual change to parent rock at about 60 cm.

(b) Analytical data:

Fertilized site - one sample per depth interval, all samples from same profile.

Depth	pH	TSS	Cl	C	N	P	Ex. Cations (meq%)			
cm		%	%	%	%	ppm	Ca	Mg	K	Na
0-10	7.5	0.02	<0.01	3.0	0.32	40	33.1	10.0	0.6	0.2
30-40	6.9	<0.02	<0.01	-	-	11	-	-	-	-
50-60	7.4	<0.02	<0.01	-	-	-	20.4	14.8	<0.02	0.4

(ii) Podzolic-solodic intergrade (Dy2.32) on felspathic sandstone.

(a) Profile morphology:

0 cm A1	Very dark greyish brown (10YR3/2); gravelly loam; moderate coarse blocky structure. Many angular rock fragments on the surface and throughout the A1 and A2 horizons. Gradual change to:
15 cm A2	As above with sporadic bleach. Abrupt change to:
30 cm B2	Olive brown (2.5Y5/4); heavy clay; moderate coarse blocky structure. Gradual increase in rock fragments to weathered felspathic sandstone at 60 cm.

(b) Analytical data:

Fertilized site with one additional surface sample from a non-fertilized site and another from a fertilized site.

Depth cm	pH	TSS %	Cl %	C %	N %	P %	Ex. Cations (meq%) Ca	Mg	K	Na
0-10 (a)	6.6 to 7.1	0.02 to 0.03	<0.01	4.2 (b)	0.32 (b)	17 to 51 (c)	11.8 to 16.7	2.4 to 4.0	0.6 to 0.7	0.1 to 0.2
30-40 (b)	7.2	<0.02	<0.01	-	-	-	15.3	17.7	0.1	0.6
60-70 (b)	8.6	0.04	<0.01	-	-	-	-	-	-	-

(a) Three samples analysed.
(b) One sample only analysed, all from same profile.
(c) Value of 17 ppm from non-fertilized site; fertilized sites yielded values of 34 ppm and 51 ppm.

(iii) Yellow podzolic-solodic intergrade (Dy2.32, Dy2.42, Dy3.32) on felspathic sandstone.

(a) Profile morphology:

Profile morphology is similar to that described in (ii) above but B horizons may be whole coloured or mottled and dominantly yellowish brown (10YR5/6). A2 horizons range from sporadic to conspicuously bleached.

(b) Analytical data (Dy2.42).

Non-fertilized site with one additional surface sample from a fertilized site.

Depth	pH	TSS	Cl	C	N	P	Ex. Cations (meq%)			
cm		%	%	%	%	ppm	Ca	Mg	K	Na
0-10 (a)	7.0 to 7.1	<0.02 to 0.3	<0.01 to 0.1	2.8 (b)	0.29 (b)	43 to 61 (c)	13.6 to 19.2	2.1 to 3.1	0.6 to 0.8	<0.1 to 0.1
25-35 (b)	5.9	<0.02	<0.01	-	-	2	11.1	14.5	0.2	1.2
60-70 (b)	6.7	0.02	0.02	-	-	-	-	-	-	-

(a) Two samples analysed
(b) One sample analysed, all from same profile.
(c) Value of 43 ppm from non-fertilized site.

(iv) Red podzolic-solodic intergrade (Dr3.31, Dr2.32, Dr3.42) on felspathic sandstone.

(a) Profile morphology

Profile morphology is similar to that described in (ii) above, but B horizons may be whole coloured or mottled and dominantly dark red (2.5YR3/4) in colour. A2 horizons may be sporadically or conspicuously bleached.

(b) Analytical data (Dr3.31):

Non-fertilized site - one sample per depth interval, all samples from same profile.

Depth	pH	TSS	Cl	C	N	P	Ex. Cations (meq%)			
cm		%	%	%	%	ppm	Ca	Mg	K	Na
0-10	7.0	0.03	0.01	2.8	0.29	43	19.2	3.1	0.6	0.1
25-35	5.7	<0.02	<0.01	0.4	0.07	3	8.7	9.8	0.1	0.4
35-45	5.8	<0.02	<0.01	-	-	-	-	-	-	-

11. SELECTION ASSOCIATION

The soils of the Selection association are similar in most respects to those of the Kraatz association. The duplex soils tend to be slightly deeper, and there is a slightly greater occurrence of red clays (Ug5.37) and some red gradational-textured soils. The latter is the only soil described below.

(i) Classification: Euchrozem; Gn3.11-Gn3.12; developed on intermediate volcanics with limestone nearby.

(ii) Profile morphology:

0 cm	Dark reddish brown (5YR3/3); clay loam increasing to light clay; weak coarse blocky structure; hard when dry. Diffuse change to:
20 cm	Dark red (10R3/8); medium to heavy clay; strong coarse blocky structure; firm when moist. This grades to yellowish friable parent material at 60 cm.

(iii) Analytical data:

Fertilized site - one sample per depth interval, all samples from same profile.

Depth	pH	TSS	Cl	C	N	P	Ex. Cations (meq%)			
cm		%	%	%	%	ppm	Ca	Mg	K	Na
0-10	7.8	0.23	0.17	1.5	0.10	12	12.8	3.6	0.2	0.1
40-50	5.9	<0.02	<0.01	-	-	2	12.0	6.2	0.1	0.3
60-70	6.4	<0.02	<0.01	-	-	-	-	-	-	-